	EUROPEAN COMMISSION RESEARCH AND INNOVATION DG	Periodic Report

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Project Acronym: ECLAIRE

Project Full Name: Effects of Climate Change on Air Pollution Impacts and Response Strategies for European Ecosystems

Periodic Report

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Project coordinator name:
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NATURAL ENVIRONMENT RESEARCH COUNCIL

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Periodic Report

PROJECT PERIODIC REPORT

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Project acronym:	ECLAIRE
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Name	
Date	16/09/2013

This declaration was visaed electronically by Agnieszka ELJASZ (ECAS user name neljasag) on 16/09/2013

Effects of climate change on air pollution impacts and response strategies for European ecosystems

ÉCLAIRE Project First Periodic Report

Figures and References for the Publishable Summary in the Participant Portal

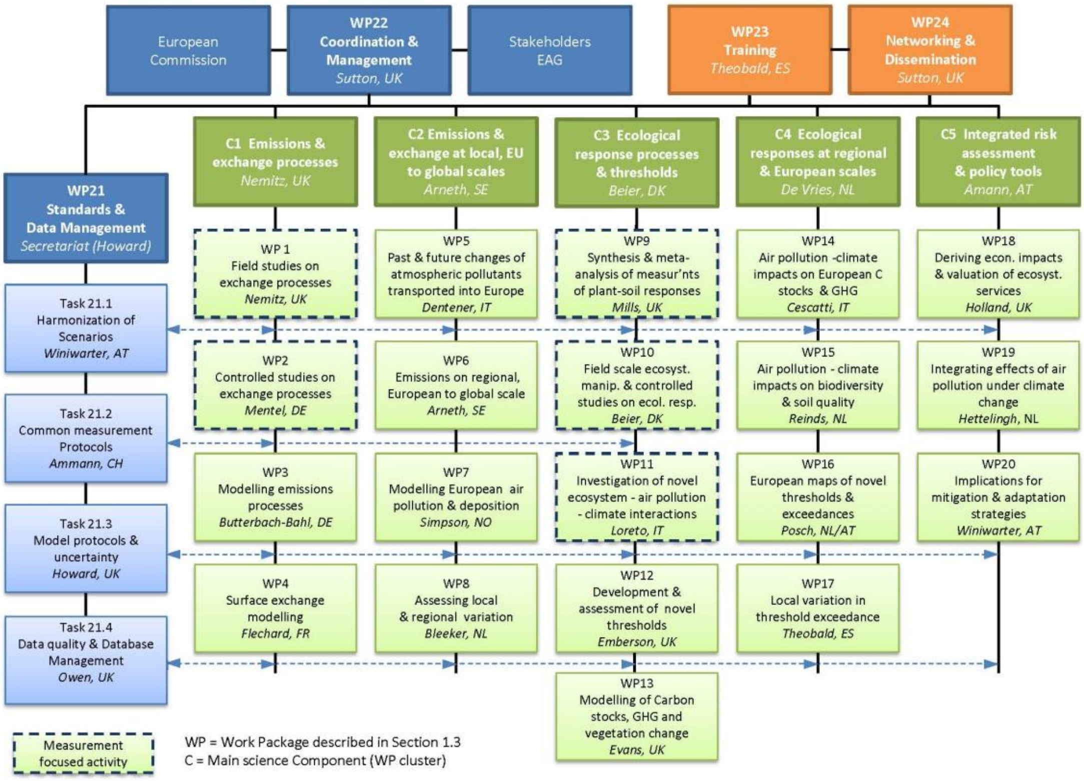

Figure S1. Schematic of ÉCLAIRE highlighting the main science Components and Work Packages.

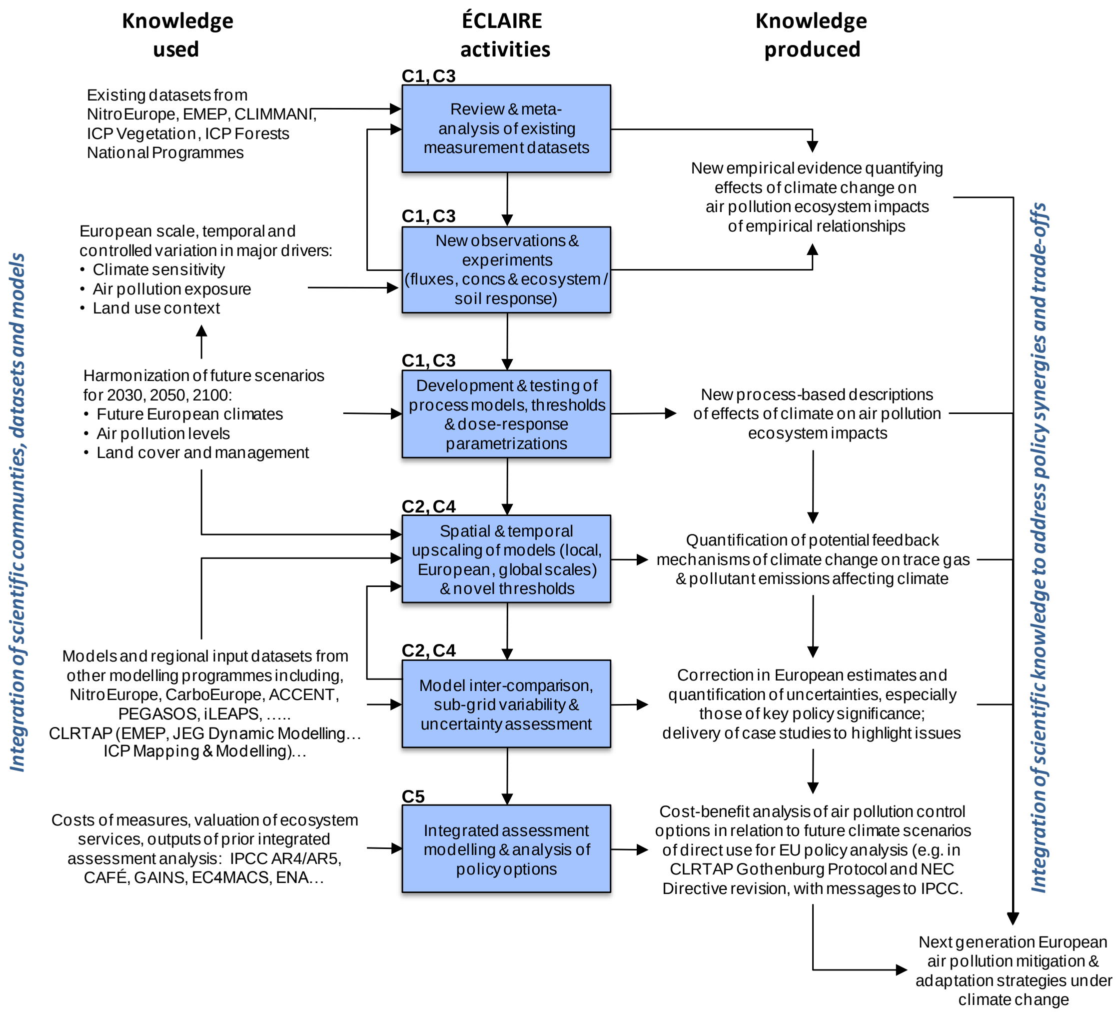

Figure S2: Summary of the impact of ÉCLAIRE highlighting the pathway of knowledge use and generation. The main science components (C1-C5) are shown according to Figs 1.1 and 1.6. In order to simplify the knowledge pathway shown here issues related to air pollutant fluxes, concentrations and ecosystem effects are combined.

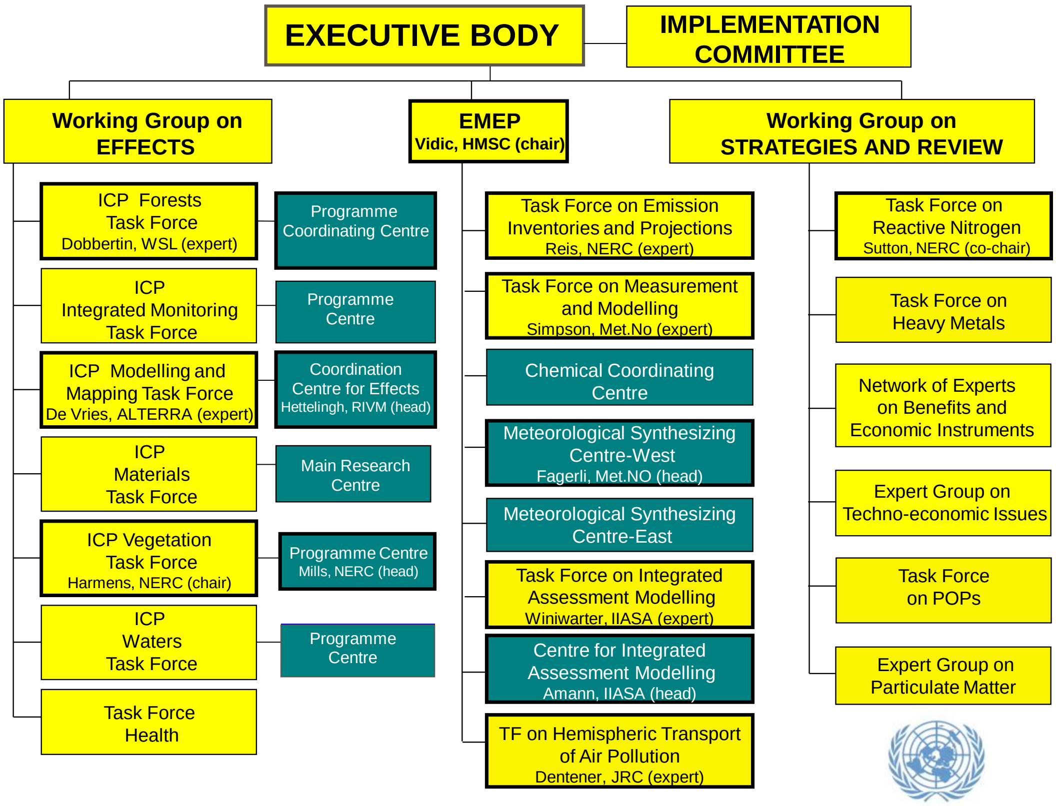

Figure S3: Organizational structure of the UNECE Geneva Convention on Long-range Transboundary Air Pollution (CLRTAP) highlighting the central contribution of the ÉCLAIRE consortium. The convention is organized as three main pillars containing Task Forces, Coordinating Centres and International Cooperative Programmes (ICP) (the last two are dark shaded). Activities relevant to ÉCLAIRE are shown with a bold border, with the name of the lead person from ÉCLAIRE and their role within the activity. EMEP is the European Monitoring and Evaluation Programme.

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2. Core of the report for the period: Project objectives, work progress and achievements, project management

2.1 Project objectives for the period

The ÉCLAIRE project is working to improve the understanding of the interactions and feedbacks in the coupled biosphere-chemistry-climate system and develop novel approaches to quantifying ecosystem effects and threats together with improved tools for upscaling to Europe and extrapolating to future climates. The integration of these issues focusses on the following **Specific Objectives** (for Work Package numbers see Fig. S1 – 'Month', refers to the completion month for work concerning each Specific Objective):

S1. To develop improved process-based emissions parameterization of NH_3, NO and VOCs from natural and agricultural ecosystems in response to climate and pollutant deposition for incorporation into atmospheric Chemistry-Transport Models (CTMs), based on existing and new flux measurements in the field and laboratory, applying these to develop spatially resolved emission scenarios in response to climate, CO_2 and air pollutant change [WPs 1, 2, 3, 6./Month 42].

S2. To determine the chief processes in atmospheric chemistry that respond to climate and air pollution change and the consequences for ozone and aerosol production and atmospheric lifetimes, in the context of the global O_3 background [WPs 5, 7/Month 36 & through collaboration with PEGASOS FP7 project].

S3. To develop improved multi-layer dry deposition / bi-directional exchange parameterisations for O_3, NO_x, NH_3, VOCs and aerosols, taking into account near-surface chemical interactions and the role of local/regional spatial interactions, based on existing and new flux measurements and high resolution models and to estimate European patterns of air concentrations and deposition under climate change [WPs 1, 2, 4, 7, 8/Month 42].

S4. To integrate the results of meta-analyses of existing datasets with the results of targeted experiments for contrasting European climates and ecosystems, thereby assessing the climate-dependence of thresholds for land ecosystem responses to air pollution, including the roles of ozone, N-deposition and interactions with VOCs, nitrogen form (wet/dry deposition) and aerosol [WPs 9, 10, 11, 12/Month 30].

S5. To develop improved process-based parameterizations in dynamic global vegetation models (DGVMs) and soil vegetation models (DSVMs) to assess the combined interacting impacts of air quality, climate change and nutrient availability on plant productivity, carbon sequestration and plant species diversity and their uncertainties [WP13; WP14; WP15, WP17/Month 44].

S6. To develop novel thresholds and dose-response relationships for air pollutants (especially for O_3 and N) under climate change, integrated into process-based models verified by experimental studies at site scales and mapped at the European scale, quantifying the effect of climate change scenarios [WPs 12, 13, 14, 15, 16/Month 44].

S7. To assess the extent to which climate change alters the transport distance and spatial structure of air pollution impacts on land ecosystems considering local, regional, continental and global interactions, focusing on nitrogen and ozone effects [WPs 5, 6, 7, 8, 9/Month 44].

S8. To apply the novel metrics to quantify multi-stress response of vegetation and soils, including effects on carbon storage and biodiversity to improve the overall risk assessments of pollution-climate effects on ecosystems at the European scale as the basis for development of mitigation options [WPs 12, 13, 14, 15, 16, 19, 20/Month 44].

S9. To quantify the overall economic impacts of air pollution effects on land ecosystems and soils, including the valuation of ecosystem and other services, and the extent to which climate change contributes by altering emissions versus ecosystem vulnerability [WPs 3, 4, 6, 7, 12, 14, 15, 16, 18/Month 42].

S10. To reassess the current recommendations regarding air pollution emission abatement policies, considering the interactions between ecosystem and other effects under conditions of climate change and to perform cost-benefit analysis of policy options under different scenarios [WPs 18, 19, 20/Month 48].

These Specific Objectives are the culmination of work under several components and a variety of activities. Therefore they are not due to be completed until later in the project. During this reporting period, all work packages have commenced and the following deliverables were planned under the five main components (Table 0.1, see Figure 0.1 for a diagram of components and work packages). In cases where a deliverable is delayed, further information is provided after the table.

Table 0.1: Deliverables due during the first period of the project (18 months). Updated with delivery status, September 2013 (Month 24).

No.	Description	Due Date (project month)	Status
D1.1	First 6 months of continuous flux data of CO_2, H_2O, O_3 and meteorological variables at 9 sites	18	Delayed to M24
D1.4	NH_3 fluxes over Mediterranean semi-natural surfaces	15	Delayed to M27
D1.5	Integrated dataset of canopy scale flux and in-canopy gradient measurements at a forest site	16	Delayed to M26
D2.5	Manuscript on constitutive emission considered for ozone balance	13	Completed

D5.1	Assessment of current GCMs and CTMS to reproduced recent trends models by comparison with selected observations	18	Delayed to M25
D6.1	Initial dynamic biogenic emissions, based on synthesis of existing work and mainly for test and set-up of ÉCLAIRE atmospheric model experiments WP2.3 and in 4.1. Test for compatibility of file format & establish appropriate resolution for use in atmospheric models	8	Completed
D7.1	Maps of current air pollution metrics (APMs) across Europe, from the EMEP model and five other CTMs in order to provide a best-estimate and uncertainty range on vegetation effects metrics	18	Completed
D8.1	Synthesis report on the different local scale models dealing with atmosphere-biosphere exchange and their relevance for describing the climate change / air pollution interactions	12	Delayed to M34
D8.3	Concentration and deposition maps, for the regions mentioned above, at 5 x 5 km^2, 1 x 1 km^2, down to 50 x 50 m^2 resolution for different components (e.g. NH_3, NO_x, O_3)	16	Delayed to M29
D9.1	Progress report on availability of data for use in Activities 3.4 and 3.5	6	Completed
D9.2	First phase database for use in initial modelling and identification of data gaps for experiments being conducted in WP3.2 and WP3.3	12	Completed
D10.1	Ecosystem and plant characteristic data for model application	12	Completed
D10.2	One year ecosystem response data on plant responses to experimental changes	18	Completed
D11.1	Parameterization of the impact of reduced and oxidised wet and dry N deposition on GHG and NOx fluxes, N immobilisation, natural vegetation types, species physiology, soil chemistry, and losses and allocation of C and N	18	Completed
D12.1	Summary report describing key response parameters derived from empirical studies and suitable for use in the first phase of the ecosystem valuation work	12	Completed
D13.1	Finalised list of models for use in C3, and list of data requirements for each model	6	Completed
D13.2	New version of DO_3SE model to simulate the combined effects of O_3, N, S, diffuse radiation	18	Completed

	and climate on plant CO_2 uptake		
D14.1	Synthesis of applicable data on impacts of ozone on photosynthesis, stomatal conductance and plant functioning	6	Completed
D14.2	Updated versions of DGVMs and DSVMs that include O_3 uptake model and N deposition on carbon uptake	18	Completed
D16.1	Indicators for geo-chemical and biological endpoints	12	Completed
D17.1	Database of soil and vegetation data for the regional (5 x 5 km and 1 x 1 km) and landscape (~ 50 x 50 m) domains	12	Delayed to M26
D17.2	Database of ammonia concentration and nitrogen deposition data (from A2.4) for the regional (5 x 5 km and 1 x 1 km) and landscape (~ 50 x 50 m) domains, where available	18	Delayed to M30
D18.1	Report on existing applications of the ESA in Europe and prioritisation of ecosystems and ecosystem services for detailed assessment	12	Delayed to M24
D19.1	progress report on the implementation of new effect indicators and critical thresholds in the GAINS modelling system	12	Completed
D20.1	Report from stakeholder workshop	9	Completed
D20.2	Detailed description of model integration to establish 2050 scenarios	14	Completed
D21.1	Initial scenario guide as an updatable, internal web page	6	Completed
D21.3	Agreement on common measurement protocols for components C1 and C3	8	Completed
D21.4	Agreement on common modelling and uncertainty documentation protocols across components C1-5	9	Completed
D21.7	ÉCLAIRE Data Management Plan & Data Policy Documents	6	Completed
D21.8	ÉCLAIRE Data Portal	6	Completed
D21.9	Database training sessions for users – online tutorials	8	Completed
D21.10	Database documentation and guides for users	8	Completed
D21.11	First database report on intermediate and final database content, including QA/QC report	13	Completed
D22.1	Annual progress report year 1	13	Completed
D23.1	ÉCLAIRE training plan	6	Completed

D23.5	Concept for ÉCLAIRE Summer School	12	Completed
D24.1	A project web portal for internal and external project communication	1	Completed
D24.2	First dissemination and communication plan	18	Completed
D24.5	First report to the GA on networking activities	18	Completed

Delayed deliverables (update September 2013, Month 24)

A small number of deliverables are still delayed at this stage, further details below. None of the delays reported will have an effect on the final delivery of the project objectives. In most cases the delays do not have significant impacts on following workpackage tasks/deliverables, in the one case where this might have been the case (WP8), this issue has been addressed and an alternative approach to this aspect of the work is already being planned.

D1.1 First 6 months of continuous flux data of CO_2, H_2O, O_3 and meteorological variables at 9 sites

There has been some delay with this deliverable, as reported earlier. The measurements commenced later than planned, mainly because of the necessary servicing of instruments after the Bosco Fontana experiment. Extra time was also needed to ensure that the templates for data upload were fit for purpose. This has been achieved and the data from several sites has been uploaded – full upload is anticipated by end of this month (24).

D1.4 NH3 fluxes over Mediterranean semi-natural surfaces

This activity was rescheduled, in response to the availability of instrumentation and to target the most relevant periods (growing season vs. dormant season). The measurements have now been made, and are undergoing analysis. As reported at the end of the first period, delivery is expected in month 27.

D1.5 Integrated dataset of canopy scale flux and in-canopy gradient measurements at a forest site

The measurement campaign (Task 1.4) has been very successful. Data processing is being finalised. Due to the high complexity of the dataset, individual data upload templates had to be developed for the upload of the data from each instrument. It is important that the templates are fit for purpose, but this has taken longer than expected, data is now expected to be fully uploaded by Month 26.

D5.1 Assessment of current GCMs and CTMS to reproduced recent trends models by comparison with selected observations

This work has taken longer than planned, however first estimates of these trends have been produced and progress has been made. A final synthesis of the results is required and will be finished by month 25. Interim reports on the work can be supplied on request.

D8.1 Synthesis report on the different local scale models dealing with atmosphere-biosphere exchange and their relevance for describing the climate change / air pollution interactions

Work has started on this deliverable, but its' delivery is delayed. Although the activity is important for the overall understanding of air pollution-climate interactions in the various models, this does not pose a problem for the work in the other work packages. It is foreseen that this literature study will be finalized around the second quarter of 2014, month 34 (NOT 2013, this was a typing error).

D8.3 Concentration and deposition maps, for the regions mentioned above, at 5 x 5 km2, 1 x 1 km2, down to 50 x 50 m2 resolution for different components (e.g. NH_3, NO_x, O_3)

There have been some delays in generating the regional and landscape data for work towards this deliverable. Regional scale data will be available very soon, however landscape scale data provision has been more complex. In order to select the best models and approaches to generating the necessary data, the issue will be discussed at the project meeting in Zagreb next month. As progress cannot be made until this meeting, the deliverable is expected to be completed by month 29.

D17.1 Database of soil and vegetation data for the regional (5 x 5 km and 1 x 1 km) and landscape (~ 50 x 50 m) domains

Data collection is ongoing, but this deliverable is delayed until the end of this year (month 26).

D17.2 Database of ammonia concentration and nitrogen deposition data (from A2.4) for the regional (5 x 5 km and 1 x 1 km) and landscape (~ 50 x 50 m) domains, where available

As this deliverable is dependent on the results from D8.3, it is also delayed. Expected delivery is now March 2014 (month 30).

D18.1 Report on existing applications of the ESA in Europe and prioritisation of ecosystems and ecosystem services for detailed assessment

There has been a delay with respect to this deliverable which was due to unforeseen difficulties in providing robust results. However, due to this, a more profound analysis is planned than originally foreseen. Delivery will be this month (24).

2.2 Work progress and achievements during the period

Table 0.2 provides an overview of person months by beneficiary and work package, 'budgeted' and 'actual'. Please note that the 'budgeted' figure is an indicative one only; derived by multiplying person months by the length of the first period, over the total length of the project (i.e. budgeted person months = total person months x 18/48).

Table 0.2: Person months by work package and beneficiary, 'Budget' (in italics) and 'Actual'. Please note that budgets are strictly proportional to project time i.e. budgeted man months for the first 18 months are as following: Budget man months for

WP	1		2		3		4		5		6		7		8		9		10		11		12	
1 - NERC	*9.0*	13.9	*0.4*	0.9	*0.8*	0.5	*1.5*	2.2			*0.6*	1.1			*2.6*	0.3	*2.6*	3.6	*5.3*	2.6	*7.1*	15.0	*2.3*	0.2
2 - ULUND											*0.0*	0.0												
3 - DTU																	*0.8*		*9.8*	15.6			*0.8*	
4 - ALTERRA											*0.8*	2.6					*0.7*	1.7						
5 - IIASA																								
6 - met.no							*0.4*	2.7	*0.4*	1.6			*6.4*	5.2	*0.4*	0.3								
7 - Juelich	*1.0*	2.1	*8.0*	16.4																				
8 - ECN	*3.8*	7.9													*2.6*	1.3								
9 - CNR	*0.8*	2.0	*6.8*	14.0																	*9.0*	3.0		
10 - KIT	*0.4*	1.0	*0.4*	1.0	*4.5*	6.0			*1.5*		*3.6*	5.0	*3.4*	1.0	*0.8*	1.0								
11 - JRC	*4.5*	0.4							*2.6*	0.1			*1.5*	0.3										
12 - SEI-Y,UoY							*2.3*	8.0									*1.1*	3.2					*4.1*	3.5
13 - INRA	*18.4*	24.3			*4.1*	2.6	*10.1*	10.6							*7.9*	7.1								
14 - RIVM																							*0.3*	0.4
15 -FDEA-ART	*13.5*	9.5																	*0.8*	1.5				
16 - UGOT							*1.1*	1.2									*1.1*	1.6					*2.3*	2.2
17 - ERTI - FRI	*11.3*	18.0																						
18 - FMI	*1.9*	0.0					*2.6*	4.0																
19 - UHEL	*4.9*	11.0																						
20 - UNICATT	*8.3*	11.5																	*13.5*	13.8				
21 - ONU	*6.8*	7.5																						
22 - BOKU			*9.0*	15.6																	*2.6*	0.0		
23 - UPM	*2.3*	1.1			*1.5*	0.5									*1.1*	0.3								
24 - CIEMAT																			*8.3*	8.3				
25 - CNRS									*6.0*	0.3	*1.9*	2.2	*3.0*	0.1										
26 - SMHI													*1.9*	2.2										
27 - DHMZ							*6.0*	11.3																
28 - UEDIN											*1.1*													
29 - UBO																					*9.0*	16.0		
30 - WSL																	*1.9*	3.7						
31 - IVL																	*0.7*	0.6					*0.4*	0.6
32 - MPG																								
33 - IPBPSS																								
34 - EMRC																								
35 - AU											*1.5*	1.3			*0.6*	0.6								
36 - WU							*2.3*	2.1					*0.8*	0.0										
37 - ULB	*0.5*	0.7													*1.5*	2.2								
38 - BAS - IFRG			*4.9*	5.0																				
39 - TNO													*1.5*	1.7										
Total	*87.0*	**111.0**	*29.4*	**52.9**	*10.9*	**9.6**	*26.3*	**42.0**	*10.5*	**2.0**	*9.4*	**12.1**	*18.4*	**10.6**	*17.4*	**13.1**	*8.9*	**14.3**	*37.5*	**41.7**	*27.8*	**34.0**	*10.1*	**6.9**

WP	13		14		15		16		17		18		19		20		21		22		23		24		Total	
1 - NERC	*4.5*	3.0	*20.3*	10.3	*2.6*	1.3			*1.9*	2.4	*0.3*	0.5	*0.3*	0.0	*1.1*	0.8	*4.9*	13.1	*19.5*	15.8	*0.4*	0.0	*0.4*	1.5	*88.2*	**88.7**
2 - ULUND																									*0.0*	**0.0**
3 - DTU																							*0.2*		*11.4*	**15.6**
4 - ALTERRA	*2.3*	3.1	*3.4*	6.0	*2.6*	1.6	*1.9*	0.8	*1.5*	0.4			*0.8*	0.1	*0.3*	0.0	*1.1*	1.1					*0.1*	0.0	*15.4*	**17.4**
5 - IIASA			*0.4*	0.4			*0.4*	0.4			*1.1*	1.1	*2.6*	2.6	*6.8*	6.9	*1.1*	1.1					*0.2*	0.4	*12.6*	**12.9**
6 - met.no							*1.1*	0.5					*1.1*	0.4											*9.8*	**10.8**
7 - Juelich																									*9.0*	**18.5**
8 - ECN															*1.1*	0.0									*7.5*	**9.2**
9 - CNR																									*16.5*	**19.0**
10 - KIT	*4.5*	3.0	*3.8*	3.0													*3.0*	0.0					*1.9*	0.0	*27.6*	**21.0**
11 - JRC			*3.0*	1.0													*1.5*	0.2							*13.1*	**2.0**
12 - SEI-Y,UoY	*3.4*	0.2									*0.8*	0.0									*0.1*	0.0			*11.7*	**14.9**
13 - INRA																									*40.5*	**44.6**
14 - RIVM	*0.3*	0.3	*1.1*	1.1	*1.1*	1.1	*1.9*	1.9			*1.1*	0.0	*1.5*	1.4	*0.3*	0.7									*7.7*	**6.9**
15 -FDEA-ART																	*0.4*	1.5							*14.6*	**12.5**
16 - UGOT																									*4.5*	**5.0**
17 - ERTI - FRI																									*11.3*	**18.0**
18 - FMI																									*4.5*	**4.0**
19 - UHEL																									*4.9*	**11.0**
20 - UNICATT																									*21.8*	**25.3**
21 - ONU							*0.8*	0.0																	*7.5*	**7.5**
22 - BOKU																					*0.1*	0.0			*11.7*	**15.6**
23 - UPM									*3.0*	2.1											*0.8*	1.5			*8.6*	**5.5**
24 - CIEMAT																									*8.3*	**8.3**
25 - CNRS																									*10.9*	**2.6**
26 - SMHI																	*0.4*	0.5							*2.3*	**2.7**
27 - DHMZ																									*6.0*	**11.3**
28 - UEDIN								7.0									*0.5*	0.3	*9.0*	5.4	*0.5*	0.3			*11.1*	**13.0**
29 - UBO																									*9.0*	**16.0**
30 - WSL																									*1.9*	**3.7**
31 - IVL											*0.8*	1.0													*1.8*	**2.1**
32 - MPG			*4.5*	0.0																					*4.5*	**0.0**
33 - IPBPSS			*9.0*	10.0			*9.0*	8.0																	*18.0*	**18.0**
34 - EMRC											*3.0*	2.4													*3.0*	**2.4**
35 - AU											*1.1*	0.0													*3.2*	**1.9**
36 - WU																									*3.0*	**2.1**
37 - ULB																									*2.0*	**2.9**
38 - BAS - IFRG																									*4.9*	**5.0**
39 - TNO																									*1.5*	**1.7**
Total	*14.9*	**9.6**	*45.4*	**31.8**	*6.4*	**4.0**	*15.0*	**18.6**	*6.4*	**4.9**	*8.2*	**4.9**	*6.3*	**4.5**	*9.7*	**8.4**	*12.9*	**17.8**	*28.5*	**21.2**	*1.8*	**1.8**	*2.7*	**1.9**	*451.4*	**479.5**

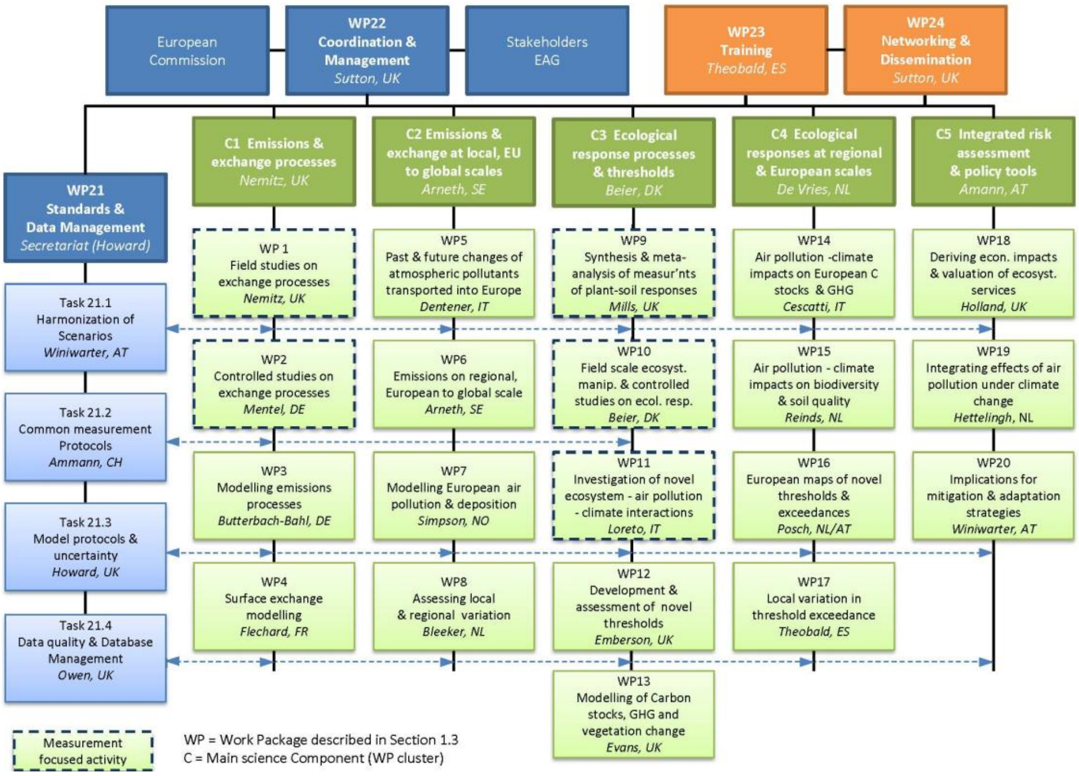


Figure 0.1: Schematic of ÉCLAIRE highlighting the main science Components and Work Packages.

2.1.1 Component 1: Emissions and Exchange Processes

Lead contractor: NERC

Component objectives

ECLAIRE has nine ‘Specific Objectives’ (see Section 2.1), those stated below rely directly on Component 1:

S1. To develop improved process-based emissions parameterization of NH_3, NO and VOCs from natural and agricultural ecosystems in response to climate and pollutant deposition for incorporation into atmospheric Chemistry-Transport Models (CTMs), based on existing and new flux measurements in the field and laboratory, applying these to develop spatially resolved emission scenarios in response to climate, CO_2 and air pollutant change [WPs 1, 2, 3].

S3. To develop improved multi-layer dry deposition / bi-directional exchange parameterisations for O_3, NO_x, NH_3, VOCs and aerosols, taking into account near-surface chemical interactions and the role of local/regional spatial interactions, based on existing and new flux measurements and high resolution models and to estimate European patterns of air concentrations and deposition under climate change [WPs 1, 2, 4].

S9. To quantify the overall economic impacts of air pollution effects on land ecosystems and soils, including the valuation of ecosystem and other services, and the extent to which climate change contributes by altering emissions *versus* ecosystem vulnerability [WPs 2, 3, 4].

Progress and Results

WP 1: Field studies on exchange processes

The focus of WP 1 is to make targeted measurements of the surface/atmosphere exchanges of O_3, NO, NH_3, VOCs and to some extent aerosols, together with data on meteorological, chemical and biological drivers of the quality required to improve process-parameterisations of the emission, deposition and bi-directional exchange processes for inclusion into chemistry and transport models (CTMs) in support of S1 and S3. A nine-site European flux network has been established and is providing long-term measurement data on the surface atmosphere exchange of O_3 and NO, which will form the key dataset with which exchange parameterisations (S1 & S3) will be improved. This forms the largest co-ordinated network to date for eddy-covariance measurements of O_3 deposition. To realise their full potential for the development of mechanistic parameterisations, the flux measurements are accompanied by a unique suite of auxiliary measurements, which not only includes measurements of CO_2/H_2O flux, but also advanced leaf wetness measurements with clip sensors and measurements of reflected (and at selected sites also absorbed) PAR. The long-term measurements will be expanded for key periods, through flux measurements of other pollutants of key interest to ÉCLAIRE, reflecting site characteristics and measurement technology available at the different sites. The focus is on a fuller characterisation of NO_x exchange (above canopy in addition to soil NO), VOCs and NH_3. Analysis is ongoing, but first results confirm the importance of non-stomatal O_3 removal as a loss mechanism for tropospheric O_3. The first half of the dataset will become available to the modellers in July 2013.

In June 2012 an international campaign was conducted at the oak-hornbeam forest at Bosco Fontana, Po Valley, Italy. The emphasis was the assessment of in-canopy chemistry on fluxes of NO-NO_2-O_3–VOC and NH_3-HNO_3-aerosol, a task that requires multiple sets of instrumentation and which can therefore only be realised in collaboration between several partners. The measurements were conducted by eight groups and included soil flux measurements, leaf-scale measurements of VOC and CO_2 exchange, in-canopy gradients as well as canopy-scale fluxes. Furthermore, the Bosco Fontana campaign was co-ordinated with the measurements of the FP7 PEGASOS projects, which operated supersites at San Pietro Capofiume, Bologna, Monte Cimone and also made spatial measurements (inc. to Bosco Fontana) by zeppelin and mobile laboratory. ÉCLAIRE added a spatial network of passive samplers for NH_3, NO_2, HNO_3 and O_3 to assess the spatial variability in concentrations and for the verification of earth observation products. The measurements provide a thorough characterisation of the pollution in this polluted region of Europe. Aerosol fluxes demonstrate the importance of near-ground airborne volatilisation as an important loss mechanism for volatile aerosol components. Background soil NO fluxes were very high and responded strongly to a rain event, while above-canopy fluxes of NO were downwards throughout the study. Fluxes of isoprene were large, while fluxes of some other VOCs showed a pronounced bi-directional pattern. The measurements are still being evaluated fully, but it is already clear that they will provide a highly valuable dataset to support further development of multi-layer exchange routines (S3).

Ammonia flux measurements have now been initiated at a further (Spanish) semi-natural grassland sites to fill an important data gap on NH_3 exchange with a southern European ecosystem and the influence of droughts. Fluxes of O_3 and CO_2/H_2O are being measured in parallel, beyond project commitments, to investigate the drought effects also on O_3 uptake and plant function.

WP 2: Controlled studies on exchange processes

This WP complements the experimental work of WP1, by quantifying biospheric emission processes under controlled laboratory conditions, including their coupling with chemistry.

Inorganic trace gases
One ÉCLAIRE study (BOKU, NERC) is measuring response curves of the emissions of NO, NH_3, CO_2, CH_4 and N_2O from the soils and litter from the sites of the ÉCLAIRE flux network as a function of soil moisture and temperature. Initial results highlight for the first time the importance of the leaf litter in dominating the ground emissions of NO at some sites (inc. Bosco Fontana).

A further new semi-automatic laboratory system has been implemented at KIT to determine gas emissions (NO, NO_x, NH_3, CO_2, RH) from 18 incubated soil cores. The setup will be used from summer 2013 to study the effect of rewetting cycles on soil emissions of NO.

Volatile organic compounds
Using pyruvate-2-^{13}C leaf and branch feeding at the branch and mesocosm scale, CNR further elucidated the mechanism of isoprene emissions from plants and its potential for protecting against oxidative ozone damage. The results show that a significant fraction of isoprene is oxidised to vinyl ketone and/or methacrolein (i_{ox}) within the leaves, with this fraction increasing with temperature. This has implications for the quantification of primary isoprene generation in plants, the interpretation and attribution of ecosystem-scale fluxes of isoprene and i_{ox} as well as for the assessment of the role of isoprene generation in guarding the plant against oxidant damage.

In the polluted (NOx-rich, VOC-limited) atmosphere, VOC emissions can lead to O_3 formation. Thus, the net effect of vegetation on the O_3 budget of the atmosphere depends on the relative magnitude of their deposition sink and the O_3 precursor gas emissions, and this balance might change in relation to changes in climate and chemical composition. Using the Juelich coupled plant-atmosphere chamber, *Quercus ilex* was found to be a net O_3 producer (three molecules of O_3 produced for each molecule of VOC emitted) under well water conditions, but changed to a net O_3 sink under drought conditions, even under high NO_x conditions. With increasing drought stress the VOC emissions decreased more rapidly than the stomatal O_3 uptake.

Impacts of (i) heat and drought stress, (ii) biotic stress and (iii) ozone stress on constitutive VOC emissions and their potential for secondary organic aerosol (SOA) formation were studied for a number of tree species. Severe heat/drought irreparably decreased de-novo emissions, especially of sesquiterpenes and phenolic bVOCs, but increased pool emissions. Overall, only the emission of green leaf volatiles increased. Because these compounds are inefficient SOA precursors, overall SOA formation decreased and so did the O_3 formation potential. Decreases in relative soil water content (RWC) had similar effects, but moderate stress increased the emission from Holm oak. Biotic stress (studied in parallel with funding from the FP7 project PEGASOS), i.e. aphid attack, increased bVOC emissions of compounds with a high SOA yield.

While O_3 exposure caused a slight inhibition in isoprene emissions it significantly increased i_{ox} emissions and greatly stimulated NO emissions, at the same time decreasing photosynthesis. The response of VOCs and NO to O_3 exposure were also studied through in vitro experiments (CNR & ENTECRA). Concentrations of i_{ox} increased with increasing relative humidity and further under elevated NO and O_3 concentrations.

This work on the stress-response of bVOC emissions (in terms of total and speciation) and their potential for O_3 and SOA formation provides important information on the positive and negative feedback mechanisms in the coupled biosphere-atmosphere-chemistry system and on the processes by which plant emissions may protect against O_3 damage. While some of the experiments are insufficiently comprehensive to derive robust parameterisations of the interactions they nevertheless provide the parameter space to estimate uncertainties and allow the feedbacks to be tested as scenarios and support S1 and S9. In addition, they inform future research priorities.

WP 3: Modelling emissions processes

The aim of this work package is to improve key aspects of the model descriptions of emission processes relevant to the work of ÉCLAIRE (i.e. NH_3, NO and VOCs). While the emission of biogenic VOCs is usually calculated online by Chemistry and Transport Models (CTMs) and Earth System Models (ESMs), in relation to meteorology, NH_3 emissions are usually prescribed from static annual emission inventories. These do not account for the climatic response of the biogenic and physic-chemical processes that control the emission from plants, soils, fertilisers but also from agricultural point sources. For meteorological controls of NO emissions from soils very simple relationships are usually applied. In a paper setting out a climate-dependent paradigm for NH_3 emission modelling (Sutton et al., 2013), a first estimation of the effect of temperature rise on NH_3 emissions has been derived.

Responding to the increasing realisation of the importance of climate dependence of NH_3 emissions, additional resources are being mobilised to put more emphasis on developing the first elements for online modelling of NH_3 emissions at the European scale: (i) the Volt'Air model which predicts NH_3 emission from mineral fertilisers is being improved against existing flux data and is being tested at the French national scale before it will be applied at the European scale; (ii) an additional studentship has started to work on the modelling of grazing emissions in response to climate; (iii) agricultural management data is being reviewed to improve the input for modelling the emissions from point sources.

The DNDC model that predicts soil emissions of NO and N_2O has been completely restructured and updated for application at the European scale. The new, modular, structure will make it much more applicable for calibrations, to test new parameterisations and for Bayesian uncertainty assessment.

For bVOC, a compilation of flux datasets contained within the ÉCLAIRE measurement community, will provide a new resource to optimise bVOC emission models at the European scale, adding to the new bVOC flux data that are being collected within WP1. The two DGVMs used to predict bVOCs within ÉCLAIRE have been developed further: LPJ-GUESS has been extended by implementing the effect of O_3 uptake on photosynthesis and a coupled C-N cycle and is presently being coupled with a detailed canopy model to account for in and near-canopy chemical interactions. By contrast, ORCHIDEE's emission factors have been updated and it is currently being evaluated against measurement data.

All these activities contribute directly to S1.

WP 4: Surface exchange modelling

During internal ÉCLAIRE meetings and also supported by an international open expert workshop organised by ÉCLAIRE and COST Action ES0804 (ABBA), the decision was made to develop a new coupled multi-layer exchange / chemistry / transport (Éclaire Surface eXchange; ESX) model. This community model will be designed to be compatible with the EMEP chemistry and transport model, where it can be run at various scales (European, global, country). At the same time the model will be available as an offline tool to simulate fluxes for individual sites, driven either by modelled or measured meteorology. It is being constructed in a modular format, which allows the different processes to be treated at varying levels of complexity, incorporating state-of-the-art process descriptions, as well as simplifications that are sufficiently efficient computationally for implementations into CTMs. This will allow verification and traceability of simplified exchange schemes against more complex approaches.

The basic modelling framework has been developed in collaboration between met.no and FMI, is currently populated with modules from the EMEP model and will be distributed in August for other groups to add further specialised model components. ESX will be the primary tool to interpret and assimilate the flux measurements that are being made across the ÉCLAIRE network, and it thus forms a key link between WPs 1, 4 and 7.

A parallel development has focussed on the improvement and re-coding of a state-of-the-art model (DEWS) for leaf water chemistry to account mechanistically for interactions of various pollutants (co-deposition) on leaf surfaces. The DO3SE model, used to assess the stomatal ozone dose both in the EMEP model and for the manipulation experiments, has been improved by changing the stomatal conductance parameterisation to a photosynthesis-based formulation. This now allows CO_2 concentration and nitrogen availability to be taken into account and thus predicts photosynthesis more accurately in relation to global change. Both, DEWS and the new DO3SE stomatal conductance routine will be implemented into ESX.

DO3SE is being compared with two alternative models (SurfAtm-O3 and MuSica), initially using data from the Grignon field site, with the particular emphasis on improving the representation of ozone deposition to leaf surfaces in the models.

ESX is being developed as a multi-layer model, which simulates chemistry within and near the canopy air space. In parallel, an existing simpler multi-layer canopy exchange model (MLC-CHEM), focussed on the modelling of NO-NO_2-O_3 interactions within CTMs, has been developed further, and coupled to the DGVM LPJ-GUESS to assess the importance of O_3 deposition impacts on BVOC emissions, which in return feed back on O_3 concentrations and deposition.

The work has made good progress towards achieving Objective S3, and provides tools towards achieving Objective S9.

Progress towards the milestones and deliverables, use of resources and deviations from DoW

A detailed description of progress towards milestones and deliverables is provided in the WP reports. Here only major changes to the work plan are noted. Two WP1 network sites were changed: the Swiss site changed from Oensingen to Posieux, as the former was no longer in operation, while the Po Valley site was changed from an arable site to the Bosco Fontana forest site, to allow the intensive campaign measurements to be interpreted in the long-term annual context (this will also make full use of the excellent infrastructure ÉCLAIRE has invested at this site). Both changes will not affect delivery of the overall project. In addition, power constraints at the Bugac field site prevent additional intensive measurements from being implemented. Resources will be redirected to support additional measurements at the other sites.

Task 4.4 had intended to derive atmospheric N inputs to selected manipulation sites using a combination of monthly concentration measurements and modelling. After selection of the manipulation sites it became evident that these N inputs were either not needed (e.g. agricultural sites) or already available. Thus, Task 4.4 was terminated and the chemical analytical resources were re-allocated to extend the passive measurements during the Po Valley campaign (Task 1.3), which provided a two-month intensive study across 20 sites in the Po Valley, exposing and analysing about 200 samples. As a result Deliverable 4.5 and Milestones 14, 20 and 21 have been cancelled.

There have been slight delays (3-4 months) in providing the templates for the capture of the data from the Po Valley campaign and the 9-site ÉCLAIRE flux network, due to the complexity and heterogeneity of the data. Flux templates will be circulated in May 2013 and data will be uploaded to the database by July 2013.

Some resources initially allocated to Partner 13 (INRA) were transferred to Partner 29 (UBO) to support a post-doctoral researcher to work on the DEWS module for ESX.

The idea to develop the Éclaire Surface eXchange (ESX) model as an identifiable key output of ÉCLAIRE developed during the first 6 months of the project. This approach has major advantages, such as:

- Ability to treat in and near-canopy chemistry within the framework of a chemistry and transport model.
- Consistency between the modelling framework used to interpret the field data, estimate pollutant effects and for chemical transport modelling.
- Traceability of the simplified parameterisations used in the CTM against a state-of-the-art model that is process based wherever possible.
- Pooling of the expertise of a large number of ÉCLAIRE participants and integration of developments across the project.

- Transfer of ÉCLAIRE work into the EMEP model and the ESX community model will guarantee a legacy beyond the lifetime of ÉCLAIRE.

However, because the coding of ESX is centrally controlled by FMI and met.no, it increases the dependency of other tasks on the basic ESX development to progress timely and smoothly. A clear timetable has been agreed at a recent meeting. Parallel activities are using alternative deposition parameterisations to minimise the risk further.

Component 1 work was further supported with allocations from the unallocated project budget in four ways: (a) UNICATT was awarded additional funding to compensate for the increased cost associated with the construction of a measurement tower at Bosco Fontana, sufficiently strong to support the joint measurement campaign. (b) An external partner (Univ. Lisbon) was funded to provide a lichen survey across the monitoring sites of the Po Valley diffusion tube network; (c) BOKU received an additional allocation for the purchase of an ammonia sensor to be linked into their experimental setup. (d) NERC received additional funding to part-fund a PhD studentship to work on the climate-dependent emission of inorganic trace gases.

Work Package 1: Field studies on exchange processes

Lead contractor: NERC
Contributors: JRC, FDEA-ART, FRI, ECN, UHEL, FMI, ECN, INRA(G), UNICATT, ONU, CNR, Juelich, KIT, ERTI-FRI, UPM, ULB

Work package objectives

The aim of the WP is to make field flux measurements across the ÉCLAIRE flux network and during campaigns, to provide targeted high-quality data to derive mechanistic parameterisations of biosphere/atmosphere exchange in response to environmental drivers, utilising the natural climate variability at and between sites. The specific objectives are:

1. To obtain 15 months of high temporal resolution flux data of key trace compounds (O_3, NO, CO_2, H_2O) across a 9-site European flux network for the study of fluxes in relation to climatic drivers, using changing meteorological conditions at the sites as a proxy for climate.
2. To study the exchange of additional compounds (NH_3, NO_x, VOCs) through synchronised intensive measurement periods across the 9-site flux network, in relation to meteorological drivers, and to provide a test database for the evaluation of European chemical transport models.
3. To quantify the effect of aerosols on gross primary productivity through modulating in-canopy light levels for three forest ecosystems.
4. To quantify the importance of in-canopy chemical transformations on the deposition mechanism and effective emission of biogenic compounds into the atmosphere, through an integrated intensive measurement campaign above/within a polluted forest.
5. To make targeted measurements of NH_3 exchange with Mediterranean semi-natural vegetation during distinct growth phases (active vs. dormant).

Progress and Results

Task 1.1: Long-term flux measurements across a 9-site European flux network.

Two site changes were made: firstly, the location of the Swiss (FDEA-ART) grassland site was changed from Oensingen to Posieux (the former was no longer operational). Secondly, the Italian cropland site was changed to the forest site Bosco Fontana, this enables the results of the measurement campaign of Task 1.3 to be interpreted in the context of long-term measurements (this also maximises the use of ÉCLAIRE's infrastructure investment at that site). Because of the larger number of instruments involved in the Po Valley campaign of Task 1.3, the start of some measurements was delayed across the 9-site network, but the mandatory measurements were running at the end of 2012 at all sites. It has been decided to extend the long-term measurement period to cover the entire year of 2013. This will provide 12 to 17 months of measurements, depending on the site. Mandatory measurements that were installed at these sites in particular for ÉCLAIRE include:

- Leaf wetness clips were provide by UBO and NERC for all sites, to provide a more realistic leaf wetness measurement which will be used to analyse the controls of the deposition rate of O_3 and water soluble compounds.
- Photosynthetically active radiation (PAR) measurements were upgraded to include direct and diffuse PAR as well as reflected PAR and averaging intervals were reduced to 1 minute, to aid the interpretation of CO_2 fluxes to changing light conditions (in support of Task 1.3).
- Eddy-covariance measurements of O_3 were installed at all sites, providing the largest co-ordinated flux network for O_3 to date. An expert workshop was organised as a collaboration between ÉCLAIRE and the COST Action ES0804 (ABBA) to integrate the existing methodological knowledge on O_3 and NO_x biosphere-atmosphere exchange measurements, and to work towards a standardisation and optimisation of the applied measurement techniques as well as processing, correction, evaluation and data reporting of O_3 flux data (see also Taks 21.2). The results will be published as a standardised methodology to serve the community beyond ÉCLAIRE.
- NO soil or canopy fluxes were initiated by chambers, eddy-covariance or gradient technique.

Table 1.1 summarises the NO and O_3 flux instrumentation installed at the different sites.

Table 1.1: Summary of key instrumentation for 15-month long-term measurements installed at the nine-site ÉCLAIRE network to measure fluxes of O_3 and NO.

Site	**O_3 flux instrument**	**NO measurement system**	**Start of measurement**
Hyytiala forest	LOZ-3	SMEAR-style automated soil chamber	16/11/2013 O_3 01/05-26/06/2012 & from 22/04/2013 NO
Speuld forest	Sextant FOS	ECN autochamber (2) + $NO/NO_2/O_3$ gradient	15/01/13 O_3 flux 01/09/12 gradients
Ispra forest	Sextant FOS	KIT-style automated dynamic soil chamber system (5 replicates)	31/07/2012 O_3 15/08/2012 NO
Bosco Fontana forest	COFA	NO/NO_2 gradient	16/07/2012
Grignon arable	NOAA Fast-O_3	Eddy covariance – Ecosphysics CLD780TR	17/08/2012
Petrodolinskoye arable	CEH ROFI	KIT autochambers (5 replicates)	21/09/2012

Auchencorth grassland	CEH ROFI	KIT-style autochamber (4 replicates) + NO/NO_2 gradient	26/03/12 O_3 flux; 30/07/12 soil NO
Posieux grassland	Enviscope	NO/NO_2 gradient	01/08/2012
Bugac grassland	Enviscope	NO/NO_2 gradient; 1 chamber	01/08/2012

As an example, data from the dynamic chamber system for NO/NO_2 flux determination (from Sep 2012) at Petrodolinskoye arable site are shown in Figure 1.1. The system continuously measures concentration and fluxes of NO_x with resolution of 3 min and O_3 (slow analyser) with resolution of 10 s.

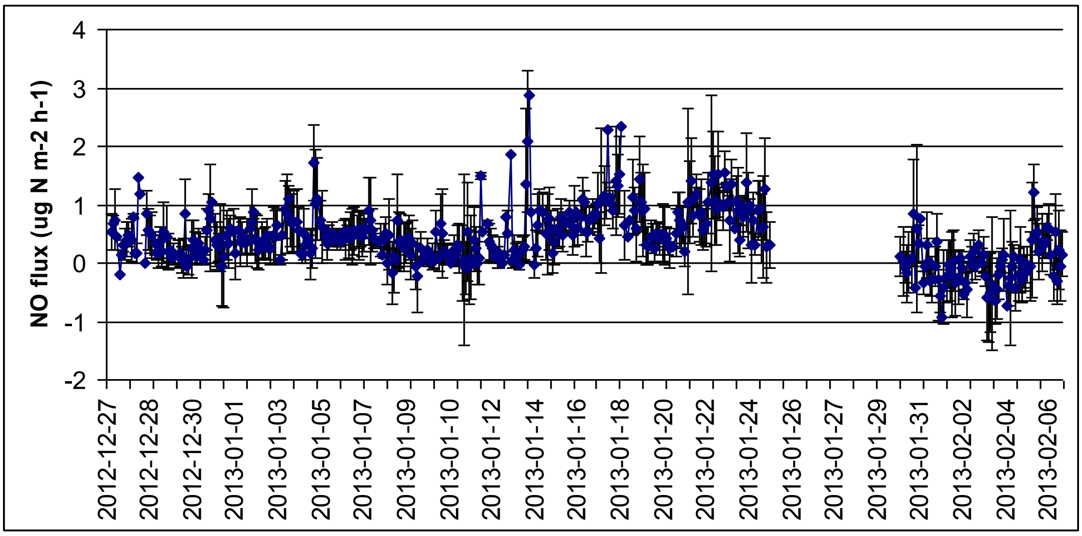


Figure 1.1: Example of the automated flux measurement of soil NO, at the Ukrainian arable site at Petrodolinkoye.

As a further example, Figure 1.2 shows the average ozone fluxes and concentration [O_3] at the Bosco Fontana site, which also includes data from the joint field campaign (see Task 1.4 below). Even though ozone concentrations in the first three months (June, July and August) were very similar with peaks around 75 ppb, the ozone deposition was markedly different. The largest deposition was observed in July with 15 nmol m^{-2} s^{-1} in the central hours of the day and 7 nmol m^{-2} s^{-1} on average. Relative similar average fluxes were observed in June, July and September, even though concentrations were significantly reduced in September. In October both fluxes and concentrations further decreased. The stomatal fraction of the ozone fluxes, that is the part of the total ozone fluxes taken up by plants through stomata, the most harmful way for the vegetation, was between 30% and 40% in the first four months, when there was active vegetation and dropped to 13% in October when the leaves started to fall. The highest stomatal fraction was observed in June (40%). A large non-stomatal peak was derived for the early morning for all the months, a possible explanation is the destruction of in-canopy ozone during calm night-time conditions and the build-up of in-canopy concentrations of NO and some biogenic VOCs. When turbulent mixing starts in the morning, chemistry with these in-canopy compounds provides an additional O_3 sink, while the in-canopy ozone also needs to be replenished. A more comprehensive analysis of this process is ongoing.

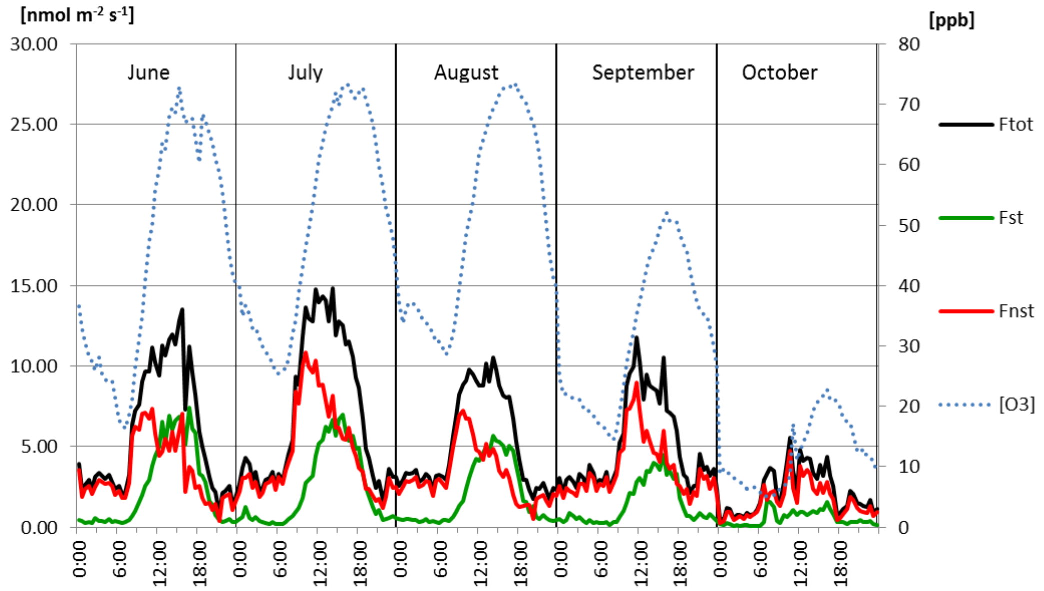


Figure 1.2: Ozone fluxes and concentrations observed at Bosco Fontana, from June to October 2012. The black line (Ftot) is the total ozone deposition, the red line (Fnst) is the non-stomatal part while the green line (Fst) is the stomatal part; the dotted blue line (O3) is the ozone concentration.

Task *1.2: Intensive measurement periods across the flux network*

The project team decided a change to the strategy of the intensive measurement periods (IMPs), compared with intentions of the DoW. Initially, it had been anticipated that the IMPs would take place during two specified periods, simultaneously across the 9-site network. In dialogue with the ÉCLAIRE modelling teams, it was decided that it was more important to target periods of key interest at the different sites, which depends on climate, ecosystem and management, than to synchronise measurements. As outlined, the ambition is to add canopy-scale flux measurements of VOCs, NH_3, NO and NO_2 to as many sites as possible, although the exact deployment depends on the site and available instrumentation. In response to emerging research needs, it was decided to add in-canopy O_3 flux measurements to selected forest sites to determine the importance of ground deposition and to constrain multi-layer exchange models. Table 1.2

summarises the timing and focus of the intensive measurement periods planned at the different sites. Results are not yet available.

Table 1.2: Summary of the measurements envisaged for the Intensive Measurement Periods at the various sites.

Site	IMP-I		IMP-II	
	Timing	Scientific focus	Timing	Scientific focus
Hyytiälä forest	Apr/May 2013	VOC & trunk-space O_3 fluxes	Jun/Jul 2013	VOC & trunk-space O_3 fluxes
Speuld forest	Jul 2013	NH_3 gradients	Sep 2013	NH_3 gradients
Ispra forest	Feb/Mar 2013	Isoprene fluxes	Jul/Aug 2013	Isoprene fluxes, VOCs
Bosco Fontana forest	May/Jun 2013	Fluxes of NO, NO_2	Sep/Oct 2013	Fluxes of NO, NO_2, possibly others
Grignon arable	Jun/Jul 2013	Fluxes of NH_3	TBC	
Petrodolinskoye arable	May/Jun 2013	Fluxes of NH_3 Full suite of N compound concentrations	Sep/Oct 2013	Fluxes of NH_3 and NO_2 by eddy covariance; concentrations of N compounds, aerosols & VOCs
Auchencorth grassland	Jul/Aug 2013	Fluxes VOCs, NH_3/HNO_3	Mar 2014	Full suite of N compounds (aerosol, NH_3, HNO_3, HONO, organic); CIMS
Posieux grassland	Feb/Mar 2013	Fluxes of NH_3 and NO_y	TBC	

Task 1.3: Assessment of the effect of aerosol on gross primary productivity

The scientific work on the quantification of the effect of aerosol on gross primary productivity will only commence once the measurements from the flux network are available. A protocol has been developed and distributed to measure direct/diffuse, reflected and absorbed PAR in addition to total incident PAR. The measurement of direct/diffuse and reflected PAR as well as data recording at 1-minute time-resolution has been made compulsory for the ÉCLAIRE flux network sites. To obtain a robust measure of absorbed PAR, a large number of measurements are required which exceeds the equipment budget for the network sites. Several of the sites are being upgraded to ICOS standard (e.g. Hyytiala, Grignon, Auchencorth) which includes absorbed PAR and, depending on the date of implementation, ÉCLAIRE might benefit from these upgrades. Sun photometer measurements are available at Hyytiala and

JRC and these data may further aid the interpretation between the link between aerosol optical depth, radiation and gross primary productivity.

Task 1.4: Intensive measurement campaign

The study of interactions between chemistry and surface/atmosphere exchange requires the collocation of a larger set of equipment than can be achieved by a single institute. For this purpose an integrated intensive measurement campaign was performed at the Bosco della Fontana, Mantova province, Lombardy, Po Valley, Italy. This formed a key activity of WP1 in the first project year. A total of ten institutes from six countries took part in the campaign. To host this large campaign, UNICATT established a major new 42 m tall measurement walk-up tower with a 100 A mains power supply, in a remnant natural mixed oak-hornbeam forest (*Querco-Carpinetum boreoitalicum*) at the LTER site and nature reserve of Bosco Fontana. Flux measurements were installed on the tower (with most instrumentation placed in two cabins at the base of the tower) and at two nearby in-canopy locations (in-canopy eddy covariance tower & soil chamber flux system). Aerosol concentrations were also measured in a turret of the hunting castle of Bosco Fontana and a ceilometers atmospheric profiling system was operated in the car park of the park office. In addition, weekly passive diffusion samplers for NH_3, NO_2, O_3 and HNO_3 were maintained at various sites around the forest and across the Po Valley. This spatial activity also linked the BF measurements of ÉCLAIRE to concurrent measurements of chemical composition operated by the FP7 project PEGASOS, with supersites at San Pietro Capofiume, in Bologna and at the Monte Cimone observatory, and also serve as ground-truthing of the ÉCLAIRE Earth observation products. The PEGASOS Zeppelin was operated during the period 11-Jun to 9-July out of Ozzano airport near Bologna and visited Bosco Fontana on 3-July.

The measurements attracted additional contributions, partly provided in kind and partly supported marginally by the ÉCLAIRE unallocated budget: Dr Silvana Munzi (Univ. of Lisbon) sampled lichens at the locations of the diffusion sampler network. UGOT, in collaboration with IVL and technically supported by NERC, performed additional aerosol number flux measurements using EEPS, in a pioneering study. The Univ. d'Aquila had agreed to make canopy-scale flux measurements of NO_2 using LIF, but had to pull out at short notice due to concerns relating to the seismic activity in the region at the time.

Table 1.3 summarises the measurements that were performed at Bosco Fontana. The final processing of the flux data is currently taken place and example files of all data formats have been collected by NERC to develop data submission templates for upload of the data into the ÉCLAIRE database.

Due to the complexity of the different data formats this is a larger task than anticipated and data upload has been delayed.

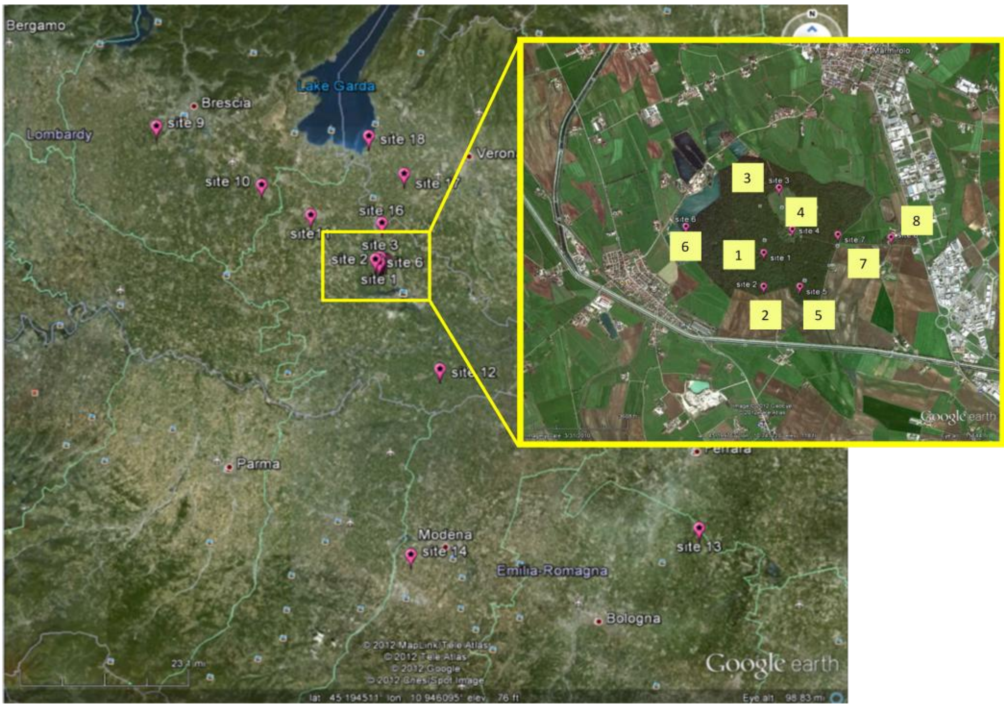


Figure 1.3: Maps of the measurement locations around Bosco Fontana and the Po Valley, including collaborating measurements performed with the PEGASOS project.

Table 1.3: Summary of the measurements performed at and around Bosco Fontana

Entity	Instrument	Location	Institute
Aerosol			
Size distributions 5 nm – 20 mm	DMPS / APS	Turret	UHEL / NERC
Size segregated aerosol flux 6-300 nm	EEPS / UHSAS	Tower	UGOTH / NERC
Submicron non-fractory chemistry & fluxes	HR-ToF-AMS	Tower	NERC
Total water soluble inorganic aerosol gradients	GRAEGOR	Tower	NERC / ECN
Black carbon $PM_{2.5}$	Ethalometer	Turret	NERC
Gases			
Reactive inorganic gas gradients (NH_3/HNO_3/SO_2/HCl)	GRAEGOR	Tower	NERC / ECN
VOC concentrations and fluxes	PTRMS / PTR-ToF-MS	Tower	NERC / ULancaster / UHEL / Juelich
In-canopy VOC gradients	PTRMS	Tower	NERC / ULancaster
Leaf-level VOC & CO_2 exchange	Li-COR cuvette	Canopy clearing	CNR / UNICATT
O_3 flux gradients	Chemiluminescence	Tower / in-canopy tower	UNICATT / NERC / INRA(G) / CNR
O_3/NO/NO_2/CO_2/CH_4 concentrations	Gas analysers	Tower	NERC
Soil flux NO/NO_2/O_3/N_2O/CH_4/CO_2	Chambers	Forest floor	KIT
CO_2 / H_2O flux	Li-COR	Tower	UNICATT
In-canopy flux of CO_2 / H_2O / O_3	Li-COR / NOAA	In-canopy tower 5 m	INRA (G)
NO canopy flux	Ecophysics	Tower	INRA(G)
Diffusion tube network NH_3/NO_2/HNO_3/O_3	Diff tubes	various	NERC / INRA(R) / DHMZ
Satellite retrieval of column NH_3, O_3, CO, HNO_3	IASI	MetOp satellite	UBL
Meteorology			
Turbulence at 5 heights	Sonic anemometer	Tower / in-canopy tower	NERC / UNICATT / INRA(G)
T & RH gradients in &	RH/T probes	Tower / in-	INRA(G) /

above canopy		canopy tower	NERC
T & SWC along vertical soil profile	T/SWC probes	Forest soil	KIT
Turbulence profile	ceilometer	Park office car park	KIT
Vegetation sampling			
Lichen survey across diffusion tube network		various	Uni. Lisbon

Data analysis is ongoing and the full scientific results are still to emerge. However, some highlights already becoming clear include:

a) High quality fluxes of biogenic VOCs are emerging from the analysis of the PTRMS (NERC/Univ. Lancaster) and, as a novelty, of the PTR-ToF-MS (UHel/Juelich). Isoprene emissions were very high (Fig. 1.4 and agreed well between both instruments. The leaf-level VOC emission measurements clarified that isoprene emissions were dominated by the oaks (*Quercus spp*.), while monoterpene emissions were dominated by limonene from hornbeam (*Carpinus betulus*) and hazel (*Corylus avellana*).

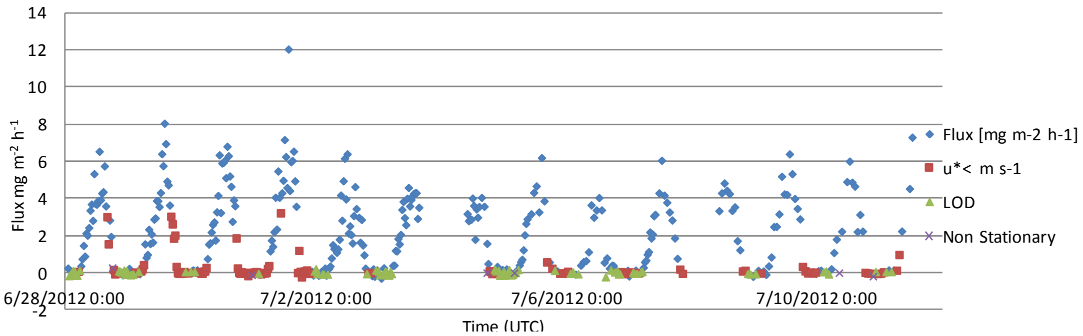


Figure 1.4: Preliminary time-series of isoprene emission fluxes above Bosco Fontana measured by PTRMS in collaboration between NERC and Univ. Lancaster and with FP7 project PEGASOS. [Blue - high quality data, red - data compromised by low turbulence, green - data below limit of detection (LOD), x - data affected by non stationarities.]

b) Concentrations of inorganic nitrogen compounds in aerosol (NO_3^-, NH_4^+) and gas-phase (NH_3, HNO_3) were very high, also compared with the PEGASOS supersite at San Pietro Capofiume. Flux measurements indicate that the forest is an efficient sink for all these compounds. Flux measurements by Aerosol Mass Spectrometer and GRAEGOR wet chemistry gradient (NERC, ECN) demonstrate that deposition rates of nitrate (Figure 1.5a) greatly exceeded the efficiency of the physical deposition processes and indicate that much of the NH_4NO_3 evaporates during deposition, increasing its effective removal rate by the forest. And this effect contributes to the decrease in NO_3^- concentration in the morning. The high aerosol deposition rates are also reflected in the size-segregated particle number flux measurements (Figure 1.5b) by NERC and UGOT.

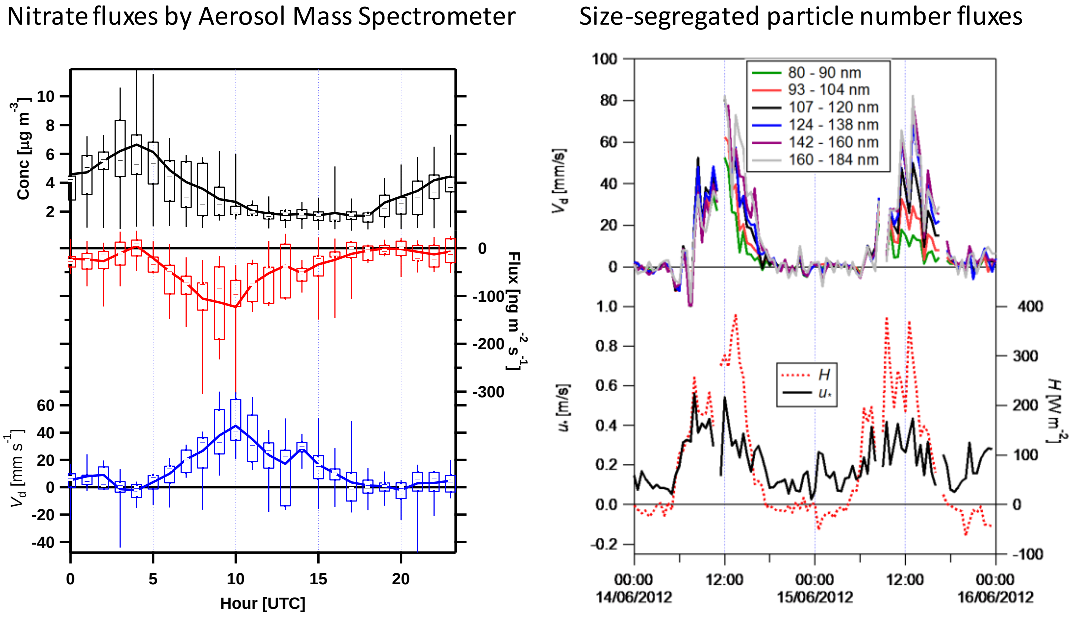


Figure 1.5: (a) Preliminary time-series of the concentrations, flux and deposition velocity of aerosol nitrate as measured by the Aerosol Mass Spectrometer flux system operated by NERC. (b) Preliminary time-series of the size segregated deposition velocity derived from particle number fluxes with an optical particle spectrometer (NERC, UGOT), in relation to heat flux (*H*) and friction velocity (u_*).

c) Mean NO soil emissions at Bosco Fontana site measured by KIT were with an average of 130 µg NO m^{-2} h^{-1} extremely high and at the higher end of values found for forest ecosystems. Rewetting of the soil resulted in a very large increase in NO emissions from around 100 before the rain and up to 800 µg N m^{-2} h^{-1} after the rain event. NO_2 deposition was on average 86.5 µg N m^{-2} h^{-1} (Fig. 1.6). In consequence, the soil of Bosco Fontana forest site functioned as a net source for NO_x of about 40 µg N m^{-2} h^{-1}. It must be highlighted, that due to high NO concentrations in ambient air in 15 cm height (mean value: 15.2 ppbv) and taking photo chemical reaction triade between NO, NO_2 and O_3 into account, low ozone mixing ratios of O_3 in ambient air were detected (mean value: 17.9 ppbv). The laboratory measurements of BOKU (Task 2.1), using soil cores from this site, indicate that most of this NO emission originates from the leaf litter. Above-canopy flux measurements of NO by INRA showed net deposition throughout the campaign, including after the rain. Thus, the NO emitted from the soil is fully converted to NO_2 in the canopy air space. A model will be used to quantify the fractions of the NO_2 taken up by the over-storey and released to the atmosphere, respectively.

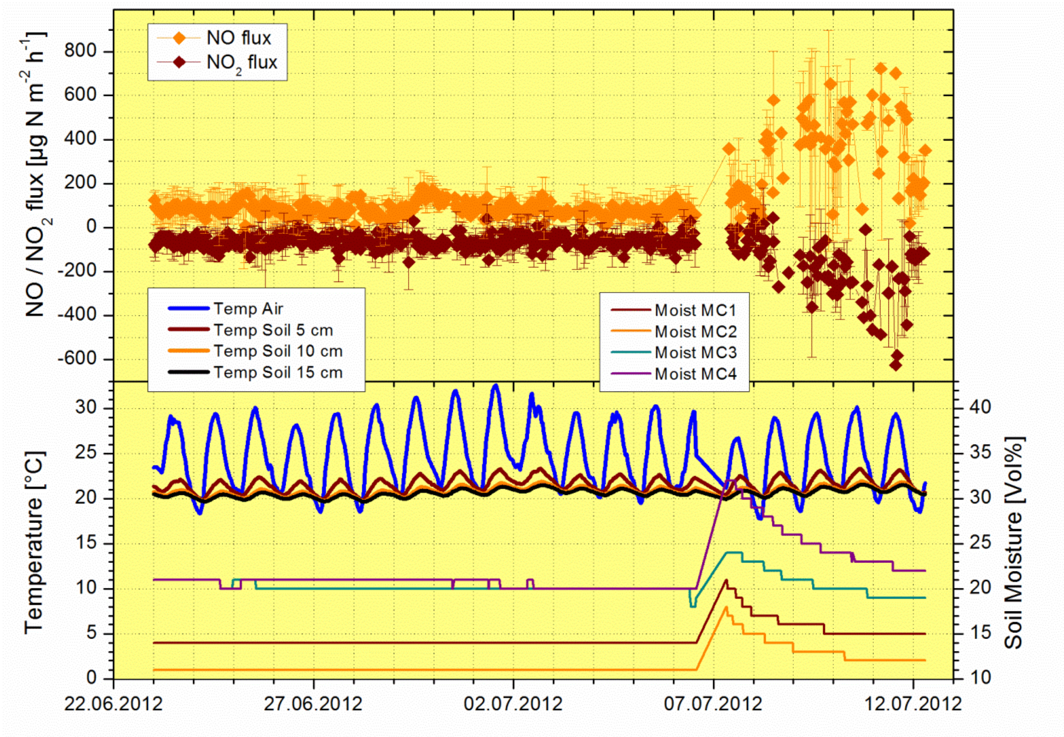


Figure 1.6: Dynamics of NO and NO_2 flux (± SD) at the soil-atmosphere interface, air and soil temperature across soil profile and volumetric soil water content (0-8 cm) for the period June 22nd to July 12th 2013 at Bosco Fontana Forest site. The increase in the fluxes is related to a precipitation event on 7-July.

d) Comparison of the time-series of total column integrated concentration of NH_3 derived from the IASI satellite by ULB shows good qualitative agreement in the temporal structure for most of the time, but also some differences (Figure 1.7), which still remains to be explained fully. The satellite retrievals (also of the other chemical compounds such as CO and O_3) corroborate the findings that Bosco Fontana is situated in a much more polluted area than the PEGASOS supersites at San Pietro Capofiume, Bologna and Monte Cimone.

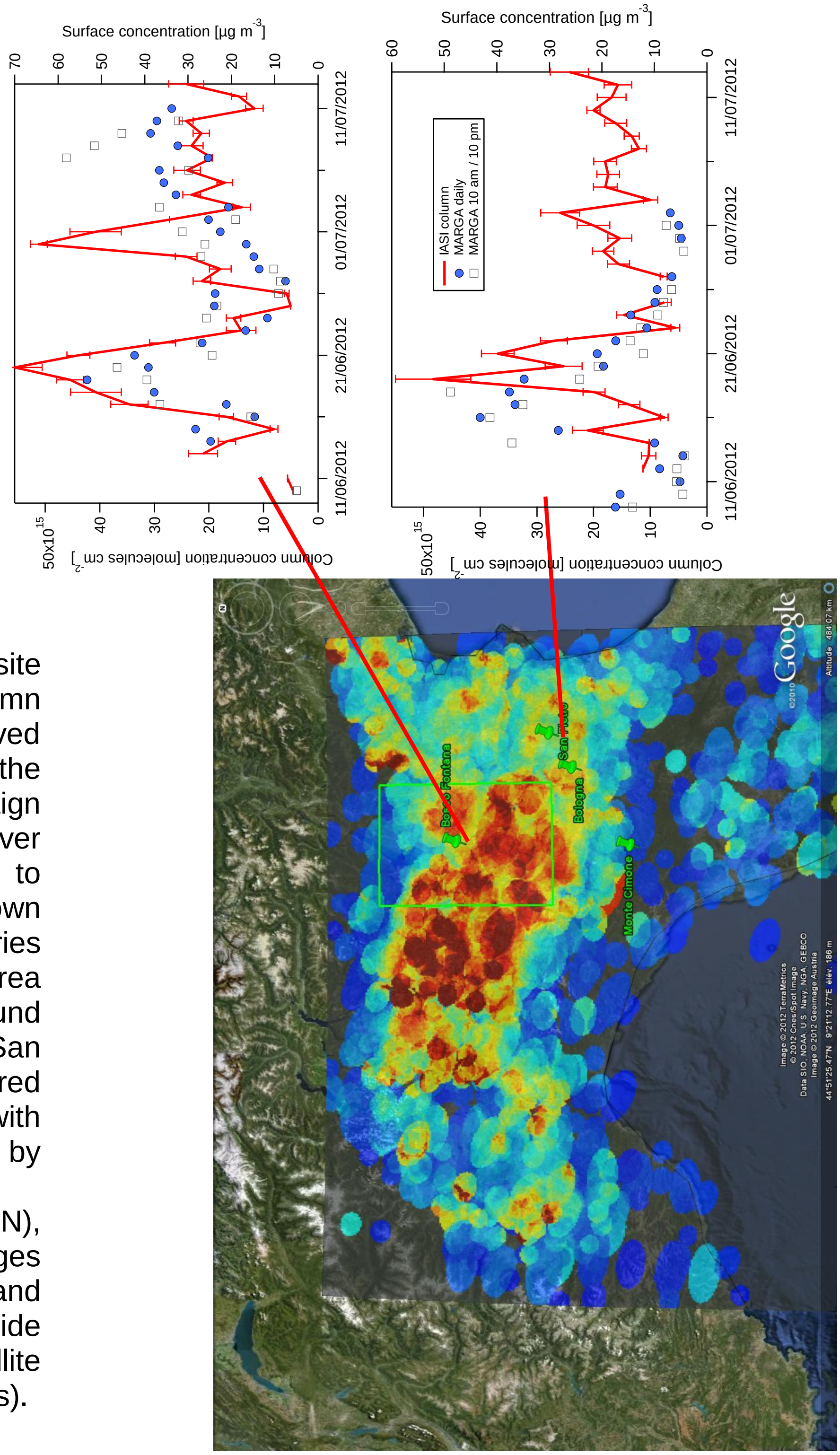


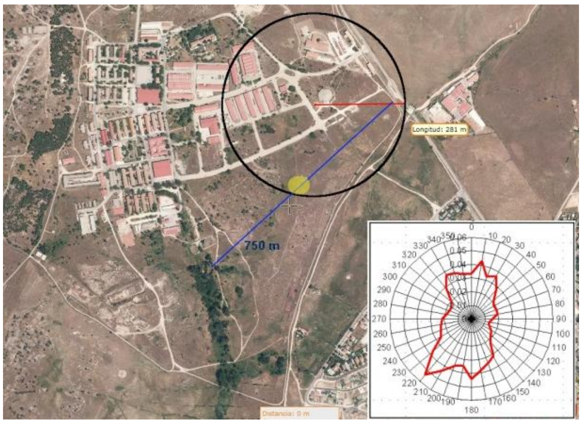
Figure 1.7: Composite image of the NH_3 column concentration field derived from IASI by ULB for the measurement campaign (total column averaged over 3 months: from June to August 2012). Also shown are the daily time-series averaged over an area (green box) centred around Bosco Fontana and San Pietro Capofiume (red lines), compared with ground-observations by MARGA/GRAEGOR (operated by NERC/ECN), comparing full-day averages (blue symbols) and measurements that coincide with the 10:30 am satellite pass over (empty symbols).

Task 1.5: Targeted measurements of NH_3 exchange with Mediterranean vegetation

The measurements have been postponed compared with the DoW in response to access restrictions to the favoured sites, availability of the instrumentation and the most interesting growing season. Measurements are planned to commence in April 2013 and cover an active vegetation period (April/May) and a dormant period after the vegetation has been scorched (July/August). UPM have visited NERC for training and instrumentation has been shipped from NERC to UPM and has just been set up (Fig. 1.8). Measurements include fluxes of NH_3 but also of O_3, CO_2 and H_2O.

A

C



B

Figure 1.8: Photograph (A) and aerial map (B) of the Spanish measurement site. The green dot indicates the location of the measurement tower (C).

Progress towards the milestones and deliverables

D1.1 *First 6 months of continuous flux data of CO_2, H_2O, O_3 and meteorological variables at 9 sites (Month 18)*

Measurements are now operating smoothly at all sites. Since measurements started a little later than expected at most measurement sites, mainly because instruments had to be serviced after returning from the Bosco Fontana experiment. Thus, the data upload template will now be circulated at the beginning of May 2013 (Month 20), and data for the period up to April 2013 (Month 19) will be uploaded by the end of June 2013 (Month 21).

Update September 2013: Extra time was also needed to ensure that the templates for data upload were fit for purpose. This has been achieved and the data from several sites has been uploaded – full upload is anticipated by end of this month (24).

D1.2 *Final 9 months of continuous flux data of CO_2, H_2O, O_3 and meteorological variables at 9 sites (Month 24)*

Due to the slight delay in starting the network measurements, it has been decided to continue these measurements until the end of 2013. Upload of the final 8 months of data (May - Dec 2013) will be requested to be uploaded by the end of Feb 2014 (Month 29).

D1.3 *2 x 6 weeks of campaign-based fluxes of VOCs, NH_3 and NO_x at selected sites (Month 24)*

Originally, it had been envisaged that the intensive campaigns at the flux sites would be aligned in time. This was revised, however, because the most important measurement periods depend on ecosystem and climate and therefore differ between sites. The intensive campaign data will be captured with the two data uploads described in D1.1 and D1.2. Thus, it is envisaged that some data will be uploaded early (Month 21 rather than 24) and some data late (Month 29 rather than 24).

D1.4 *NH_3 fluxes over Mediterranean agricultural and semi-natural surfaces (Month 15)*

This activity has been rescheduled, in response to the availability of instrumentation and to target the most relevant periods (growing season vs. dormant season).

Update September 2013: The measurements have now been made, and are undergoing analysis. As reported at the end of the first period, delivery is expected in month 27.

D1.5 *Integrated dataset of canopy scale flux and in-canopy gradient measurements at a forest site (Month 16)*

The measurement campaign (Task 1.4) has been very successful. Data processing is being finalised. Due to the high complexity of the dataset, individual data upload templates are being developed for the upload of the data from each instrument.

Update September 2013: It is important that the templates are fit for purpose, but this has taken longer than expected, data is now expected to be fully uploaded by Month 26.

D1.6 *Four publications on integrated campaign (Month 30)*

Plenty of high quality data have been obtained and are being analysed. It is likely for the envisaged minimum number of papers to be exceeded.

MS1 *First 6 months data from flux network in database (Month 18)*

See D1.1. ***Update September 2013:*** This has been delayed until Month 24.

MS2 *Final 9 months data from flux network in database (Month 24)*

See D1.2. This has been delayed until Month 29.

MS3 *Data from 1st synchronised campaign in database (Month 20)*

MS4 *Data from 2nd synchronised campaign in database (Month 24)*

These campaigns are no longer synchronised, for scientific reasons. Data will be submitted with the submissions in Months 21 and 29.

MS5 *Data from integrated forest campaign in database (Month 16)*

See D1.5. ***Update September 2013:*** This has been delayed until Month 26.

Use of resources and deviations from DoW

A total of 111 person months were spent on this work package. Overall, the use of resources was as was anticipated in the DoW. Issues to note include:

- *NERC* spent more person months on the intensive campaign at Bosco Fontana than anticipated, due to the increased activities there.
- *UNICATT*. As mentioned earlier, it was decided that the network measurements of Tasks 1.1 & 1.2 would be made at Bosco Fontana. This change will allow the Bosco Fontana campaign measurements to be interpreted within an annual context. Due to the large effort of installing a tower and the earlier start of the long-term measurements at this site, person months spent in this period are running ahead of the agreed breakdown.
- *INRA(R)*. As less deposition samples needed to be analysed as part of Task 4.4 than originally anticipated, effort was reallocated to Task 1.4 for purchasing, preparation and analysis of a larger number of diffusion tubes.
- *FRI.* This partner entered into an agreement with SZIU (Szent István University) to obtain access to their CO_2 fluxes made under the EU FP7 Project 'Animal Change', which allows all ÉCLAIRE partners to use these data. This means that a 2nd CO_2 flux system was not necessary, which saves on both time and budget.
- *JRC* had to delay the installation of the FaPAR system for technical reasons, now envisaged for May 2013.
- *ONU* team have spent more time than originally planned on this work package as there was a lot of preparatory work required to start the NO/NO_x flux measurements. There was also a small delay with AMANDA installation, which was related to customs problems in Ukraine.
- *INRA (G):* Alternative equipment for NO_2 measurements was employed, due to the failure of delivery of the original set of equipment.
- *ECN:* In this reporting period ECN spent more person months on this work than anticipated. This is due to additional preparatory work for the O_3 flux measurements, setting up the FaPAR and the Italy field campaign. As the overall measurement period is now shorter the total amount of man months spent in this WP will be roughly on track.
- *FDEA-ART*: The Oensingen site is no longer operational, therefore the location of the Swiss grassland site was changed to Posieux in the western part of Switzerland. It is also an intensively managed productive grassland. As described earlier this has moved the time of the measurement periods and subsequent data delivery, therefore less person months have been used thus far. However this will be balanced by the increased use of person months in the next phase.

Publications and Presentations

1. **Misure alla torre micrometeorologica della RNO del BOSCO della FONTANA in Marmirolo (MN).**

Written presentation at the Local meeting of the first ÉCLAIRE results at Bosco Fontana, Forest Police, 28 December 2012, Marmirolo (I)

2. **Ozone fluxes to different vegetated surfaces and first results of ozone flux partition at a mature forest ecosystem in the Po Valley, Bosco Fontana**. Oral presentation, COST Action ABBA Meeting, Paris, 25th-27th February 2013.
3. **Ozone removal by a peri-urban mixed oak-hornbeam forest.** Accepted abstract at the XVI° European Forum on Urban Forestry to be held in Milan 2013 in May 2013.
4. **Six months of Ozone flux measurements above a small forest in Ispra, Italy - setup and first data.** Oral presentation, COST Action ABBA Meeting, Paris, 25th-27th February 2013.
5. Medinets S., Medinets V., Bilanchin Ya., Kotogura S., Pitzyk V., Rezvaya S. (2011) Study of role of Nitrogen use efficiency for restoration of arable land area. Proceeding of the V International young scientists conference “Biodiversity. Ecology. Adaptation. Evolution”, Odessa, 2011, p. 266-267.
6. Medinets S., Skiba U., Kotogura S., Medinets V., Drewer J., Pitzyk V. (2011) Soil GHG (N_2O/CH_4) emissions in the fertilised arable land. Proceeding of the V International young scientists conference “Biodiversity. Ecology. Adaptation. Evolution”, Odessa, 2011, p. 267-268.
7. Medinets S.V., Medinets V.I., Gruzova I.L., Kotogura S.S., Soltys I.E. (2012) The role of atmospheric input in N balance of Delta part of Dniester and Dniester estuary. Conf. proceedings of All-Ukrainian research-practical conference “Estuaries of the North-Western Black sea region: urgent hydrological problems and ways to solve them”, OSEU, TEC, p. 99-102 (in Ukrainian)
8. Medinets S.V., Medinets V.I., Kotogura S.S., Pitsyk V.Z., Skiba U.M., Sutton M.A. (2012) Global Nitrogen problem: reasons, consequences, research on territory of Ukraine. Conf. proceedings of research-practical conference “Ecology of the cities and recreation areas” (Odessa, 31st of May – 1st of June, 2012), INVATs, p. 210-213 (in Russian)
9. Bilanchyn Ya., Rezvaya S., Medinets S., Pitsyk, V. (2012) Trends of current dynamics of chemical processes in the soils of Odessa region. General, Industrial and Ecological Chemistry, Chemistry Journal of Moldova, 1 (7): 129-132
10. Medinets S., Medinets V. 1st year activity report of Petrodolinskoe (PTR_UA), Ukraine. PowerPoint presentation. In: “ÉCLAIRE 2nd General Assembly”, Edinburgh, 15-18th October 2012, UK.
11. Medinets S., Medinets V., Skiba U., Butterbach-Bahl K. (2013) The role of nitrification and denitrification in soil nitric oxide production. Proceeding of the VI International young scientists conference “Biodiversity. Ecology. Adaptation. Evolution” (Odessa, May, 13-17, 2013) [in press]
12. Medinets S., Medinets V., Skiba U., Butterbach-Bahl K. (2013) Potential mechanisms of soil nitric oxide production. Proceeding of the VI International young scientists conference “Biodiversity. Ecology. Adaptation. Evolution” (Odessa, May, 13-17, 2013) [in press]
13. Medinets S., Medinets V., Butterbach-Bahl K., Gasche R., Pitsyk V., Skiba U. (2013) Surface ozone concentration measurement episode above bare soil in the southern

Ukraine. Proceeding of the VI International young scientists conference “Biodiversity. Ecology. Adaptation. Evolution” (Odessa, May, 13-17, 2013) [in press]

14. Medinets S., Medinets V., Butterbach-Bahl K., Gasche R., Pitsyk V., Skiba U. (2013) Ambient NO_x concentration above bare soil in southern Ukraine. Proceeding of the VI International young scientists conference “Biodiversity. Ecology. Adaptation. Evolution” (Odessa, May, 13-17, 2013) [in press]
15. Medinets S., Medinets V., Butterbach-Bahl K., Gasche R., Pitsyk V., Skiba U. (2013) NO/NO_2 fluxes measurement experience in arable land in Dniester catchment. Proceeding of the VI International young scientists conference “Biodiversity. Ecology. Adaptation. Evolution” (Odessa, May, 13-17, 2013) [in press]

Dissemination

1. [***Newspaper article***] “Clima, vertice di esperti in Cattolica”, Giornale di Brescia, 24/10/2011,
2. [***Newspaper article***] “La lotta all’inquinamento atmosferico inizia da quello che mettiamo nel piatto”, Corriere della Sera - Brescia, 25/10/2011,
3. [***Newspaper article***] “I cicli climatici secondo l’esperto”, Giornale di Brescia, 26/10/2011,
4. [***Newspaper article***] “Progetto ÉCLAIRE, oggi gli ultimi appuntamenti”, BresciaOggi, 27/10/2011,
5. [***Newspaper article***] “Sarà la tecnologia a battere lo smog”, Corriere della Sera-Brescia, 27/10/2011,
6. [***Newspaper article***] “L’aria di Bosco Fontana sotto la lente”, Gazzetta di Mantova, 11/5/2012, http://gazzettadimantova.gelocal.it/cronaca/2012/05/11/news/l-aria-di-bosco-fontana-sotto-la-lente-1.4495702
7. [***Newspaper article***] “Una torre di quaranta metri misura i polmoni di Bosco Fontana”, Roberto Bo, Gazzetta di Mantova, 12/6/2012, http://gazzettadimantova.gelocal.it/cronaca/2012/06/12/news/una-torre-di-40-metri-misura-i-polmoni-di-bosco-fontana-1.5254573
8. [***Webarticle***] “ÉCLAIRE, vedetta dell’ecosistema”, A. Olivari, CattolicaNews, 28/6/2012, http://www.cattolicanews.it/studi-e-ricerche-eclaire-vedetta-dell-ecosistema
9. [***WebTV video***] “La torre di Éclaire misura lo smog”, 4/7/2012, Video Interview on Youcatt.it, http://www.youcatt.it/2012/07/04/la-torre-di-eclaire-misura-lo-smog/
10. [***Newspaper article***] “Bosco Fontana polmone malato”, Elena Caracciolo, Gazzetta di Mantova, 12/7/2012, http://gazzettadimantova.gelocal.it/cronaca/2012/07/12/news/bosco-fontana-polmone-malato-1.5398945

Work package 2: Controlled studies on exchange processes

Lead contractor: Juelich
Contributors: NERC, Juelich, CNR, KIT, BOKU, BAS-IRFG

Work package objectives

Study and quantification of key emission mechanisms to provide targeted data that can be used to derive parameterisations of the emission processes in WP1.3.

1. To obtain response curves of soil and litter emissions to meteorological drivers (temperature, moisture) for CO_2, CH_4, O_3, N_2O, NO, NO_2 and NH_3 across a wide range of soils.
2. To provide data on NO emissions after rewetting events as a basis to improve the mechanistic understanding and predictive capability, through novel laboratory experiments.
3. To quantify VOC emission responses under combined environmental change scenarios and develop a process understanding of the controls.
4. To investigate the effect of stresses (drought, heat) on BVOC emissions and the impact on O_3 deposition and formation.
5. To quantify deposition rates of VOCs and their controls.

Progress and Results

Task 2.1: Controlled emission measurements of CO_2, CH_4, N_2O, NO and NH_3 using monoliths and litter from the ÉCLAIRE flux network (BOKU, NERC(EDI)).

Controlled emission measurements of CO_2, CH_4, N_2O, and NO have been obtained using soil monoliths and leaf litter samples from the ÉCLAIRE flux network. The task aims to determine accurate relationships between soil trace gas fluxes and simulated climate conditions. The results will improve our understanding of the couplings between climate change (warming and precipitation change), air pollution, and surface-atmosphere fluxes
Eighteen boxes, 2 per site, that contained sampling material (standardized steel cylinders, ice accumulators, plastic bags, etc.) were sent to 9 research institutes that are in charge of the sites in the ÉCLAIRE flux network (Hyytiälä / Finland; Auchencorth Moss / United Kingdom; Speulderbos / Netherlands; Grignon / France; Posieux / Switzerland; Bugac / Hungary; Petrodolinskoye / Ukraine; Ispra Forest / Italy; Bosco Fontana / Italy) and were sent back from the ÉCLAIRE site managers containing soil and leaf litter samples after reaching a weekly averaged soil temperature of 8°C.

A fully automatic laboratory incubation system (Schaufler et al., 2010) was created at BOKU. It analysed CO_2 and NO fluxes with an open flow system using a PP SYSTEMS WMA-2 infrared CO_2 analyser, and NO using a HORIBA APNA-360 chemiluminescence analyser. Methane and N_2O were quantified by a closed chamber technique with an AGILENT 6890N gas-phase chromatograph (ECD, FID).

The intact soil monoliths and litter samples received were incubated in the laboratory for 22 hours at each temperature in a two factorial design of different soil moistures (20, 40, 60, 80, 100% water filled pore space for the Auchencorth Moss Peatland site and 5, 20, 40, 60, 80 % water filled pore space for all other sites); and different litter moistures (20, 40, 60, 80 % mass weighted average water for the Auchencorth Moss Peatland site and 20, 40, 60, 80, 100, 150, 200 % mass weighted average water for all forest sites). The second variable was soil temperature (5, 10, 15, 20, 25°C), and all of the treatments were analysed for trace gas fluxes. Partner BOKU measured 6 replicates for each moisture content, with every moisture content matching with every temperature for all soil monoliths and for all litter samples.

Measurements have been completed, and fluxes will be estimated for N_2O, NO, CO_2 as well as CH_4, to obtain response curves of soil and litter gas emissions to meteorological drivers (temperature, moisture).

Ammonia measurement technology is being added to the setup, with the help of additional funding from the ÉCLAIRE unallocated budget, and NH_3 emission measurements will be included in the next runs.

Task 2.2: Quantifying the effect of re-wetting on NO emissions (KIT)

Partner KIT focused on effects of extreme climate events on NO, NO_x, N_2O, CH_4 and CO_2 emissions from intensively managed soils.

State of affairs

To better understand effects of re-wetting on gaseous fluxes from agricultural soils, partner KIT designed and now run a laboratory experiment. In this experiment, soil fluxes of NO, NO_x, N_2O, NH_3, CH_4 and CO_2 are measured before, during and following cyclical drying-wetting events. In the experiment with intact soil cores (4 replicates per treatment) partner KIT simulated several scenarios of soil re-wetting (increasing intensity, decreasing intensity and homogenously distributed) to evaluate the effect of precipitation distribution; tillage practices (conventional / no tillage) and fertilization (0, 50 and 100 kg-N ha^{-1}) on soil trace gas fluxes.

In order to do that, an innovative semi-automatic system has been developed to be used in laboratory experiments, which allows for reliable gas emission determination with high temporal resolution (Fig. 2.1). The system, with capacity for 18 soil cores, is located within an incubator for accurate temperature and moisture control. It can automatically follow a given sampling sequence, measuring NO, NO_x, NH_3, CO_2 and relative humidity under a dynamic chamber approach. Manual sampling for N_2O, CH_4 and CO_2 is also possible (static chamber approach). The first results of the study with simplified parameterization schemes for estimating re-wetting events effect on soil trace gas fluxes will be ready by summer 2013.

Perspectives

The experiment will continue running, with final results being expected by the start of 2014. During this time, steps will be taken to localize another appropriate sampling site for a subsequent laboratory incubation using the system.

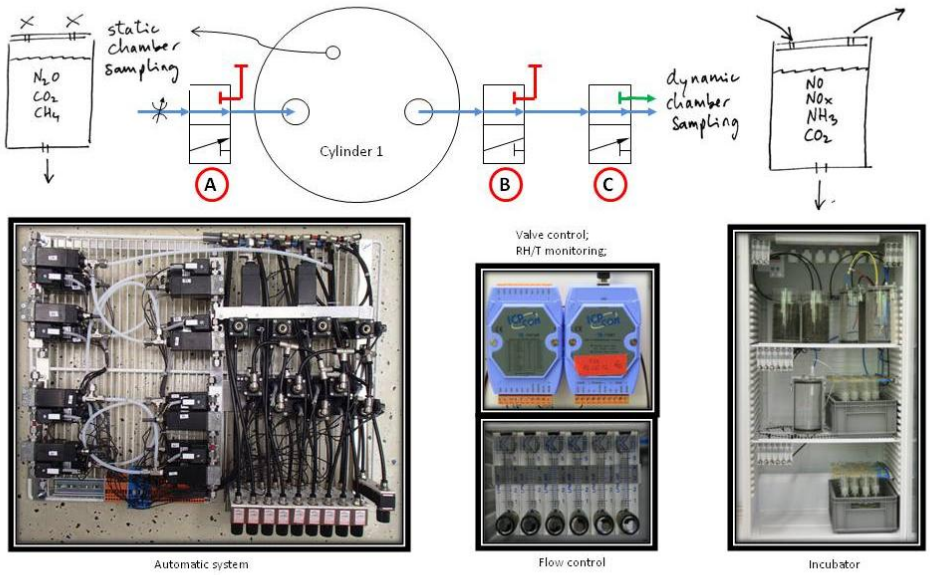


Figure 2.1: New semi-automatic system for reliable gas emission determination with high temporal resolution

Task 2.3: Quantifying BVOCs exchanges in field experiments and in response to combined environmental change and pollution scenarios (CNR, BAS-IFRG)

BVOC oxidation products

The functional basis for plant production of isoprene is still elusive. It has been hypothesized that in the cell isoprene mitigates oxidative damage during the stress-induced accumulation of reactive oxygen species (ROS), but the products of isoprene-ROS reactions in plants have not been detected. Using pyruvate-2-^{13}C leaf and branch feeding and individual branch and whole mesocosm flux studies, partner CNR gathered evidence that isoprene (i) is oxidized to methyl vinyl ketone and methacrolein (i_{ox}) in leaves and that i_{ox}/i emission ratios increase with temperature, possibly due to an increase in ROS production under high temperature and light stress. These observations suggest that carbon investment in isoprene production is larger than that inferred from emissions alone and that models of tropospheric chemistry and biota–chemistry–climate interactions should incorporate isoprene oxidation within both the biosphere and the atmosphere with potential implications for better understanding both the oxidizing power of the troposphere and forest response to climate change. IPP-CNR is performing a new experiment in 2013, for investigating the compensation point of $i_{ox.}$

Ozone-forming potential of Quercus ilex

The evergreen Holm oak (*Quercus ilex*) is among the most representative of the Mediterranean tree species. Experiments are being carried out to quantify total ozone deposition to the canopy of Holm oak ecosystems in the Presidential Estate of Castelporziano, central Italy. In a polluted atmosphere, also defined as VOC-limited atmosphere, VOC emitted by Holm oak, primarily reactive monoterpenes, may contribute to ozone formation "ex-situ", depending on the meteorological conditions (UV intensity, air temperature, wind speed and direction, relative humidity) but also on the atmospheric concentrations of NO_x. Quantifying this negative feedback of biogenic VOC emission is critical to achieve information on the capacity of Mediterranean ecosystems to control tropospheric ozone concentration.

In this first 18 months, the ozone balance for *Quercus ilex* plantlets from Castelporziano was assessed in controlled chamber experiments in the Juelich plant atmosphere chamber (partner Juelich) by measuring the plant's stomatal ozone uptake and ozone depletion/production in the gas phase due to reactions of ozone with volatile organic compounds emitted by the plant in the presence of nitrogen oxides. In well-watered conditions, ozone losses were observed. The major ozone sinks were stomatal uptake and gas phase depletion. At chamber conditions of 25 ^{o}C and an air retention time of 20 minutes, thus simulating fast vertical mixing in the canopy environment, partner CNR estimated that most of the measured ozone flux in the plant chamber was due to stomatal uptake, and only a limited amount (less than 10%) was due to gas-phase reactions. However, gas-phase depletion represented the major ozone sink under low NO_x conditions when the retention time of the air in the reaction chamber was 2 hrs, thus suggesting that accounting for the air retention time is a fundamental issue for understanding the role of VOC in the tropospheric ozone balance. Under VOC-limited conditions, when NO_x were high, partner CNR observed ozone production (3-4 ozone

molecules were formed from one BVOC molecule, with BVOC/NOx=0.1-0.2 ppb/ppb and 150 ppb O_3). Under increasing water stress conditions, both stomatal ozone uptake and BVOC emission decreased. The decrease in ozone uptake, however, was lower than the decrease in gas-phase losses/production, so that *Q. ilex* switched from a net ozone producer to a net ozone sink even under high NO_x conditions.
A replicate experiment is planned in 2013, continuing the collaboration with partner Juelich. The results will be finally used to parameterize a chemical transport model of a natural *Q.ilex* forest (Castelporziano), where continuous observation of stomatal ozone deposition are been carried out.

A highly sensitive chemiluminescence NO – NO_2 – NO_x analyzer (model 42i-TL, Thermo Fisher Scientific, Franklin, MA, USA) with detection limit of 50 ppt was used to measure NO emission from poplar leaves.
Results: Exposure to ozone caused a slight inhibition of isoprene emission (Fig. 2.2A) in poplar leaves and at the same time a significant increase of isoprene oxidative products (methyl vinyl ketone [MVK] and methacroline [MACR]) in response of ozone fumigation (Fig. 2.2B). Poplar leaves that are maintained under optimal conditions emitted a negligible amount of NO. However, exposure to acute ozone fumigation dramatically stimulated the production and emission of NO (Fig. 2.2 C, D). Ozone treatment reduced photosynthesis of poplar leaves (Fig. 2.3 A). Decrease in photosynthesis was correlated with reduction in stomatal conductance (g_s), which was significantly reduced after O_3 fumigation (Fig. 2.3B). Upon ozone exposure poplar leaves emitted more LOX products and accumulated higher level of MDA (Fig. 2.3 C,D).
The direct isoprene – nitric oxide interaction in conditions simulating those inside the leaf was examined in ***in vitro* experiments**. A static glass cuvette was used as photochemical reactor during the experiments. The experiments were performed at different relative humidity (5%, 50% and 80%) and 700 µmol m^{-2} s^{-1} of light intensity. Isoprene and nitric oxide concentrations used were about 3 ppm and 300 ppb, respectively, to simulate the concentrations inside the leaves. Ozone concentration used was 350 ppb. The formation of oxidative products of isoprene (methyl vinyl ketone and methacroleineboth measured as mass 71, and isoprene hydroperoxide isomers measured as mass 101) was followed. It was established that isoprene oxidative products increased with increasing of relative humidity inside the cuvette, and this increase was further accelerated by the presence of NO or ozone in the cuvette (Fig. 2.4).

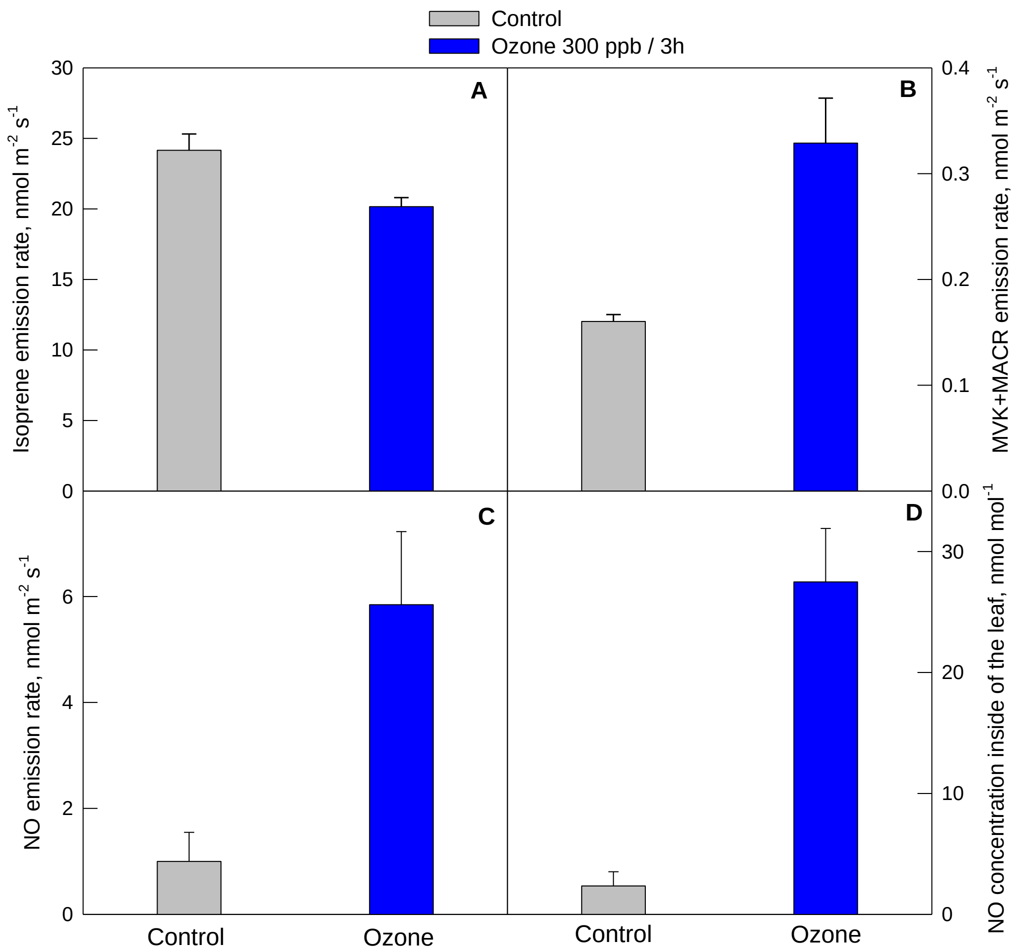


Figure 2.2: Isoprene emission rate (A), production of isoprene oxidative products (B), NO emission rate (C) and NO concentration inside of the leaf (D) in poplar leaves under control (grey bars) and ozone stress conditions (blue bars).

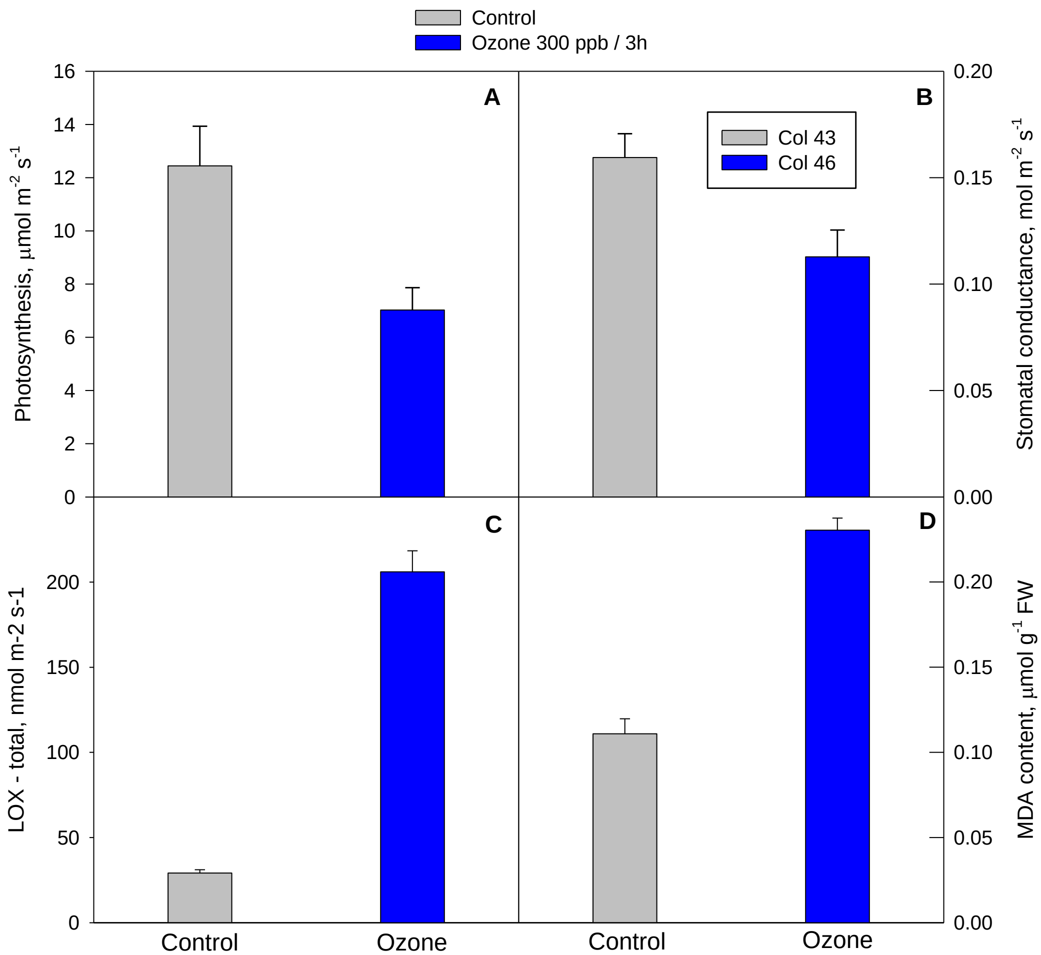


Figure 2.3: Photosynthesis (A), stomatal conductance (B), LOX production (C) and MDA content (D) in poplar leaves under control (grey bars) and ozone stress conditions (blue bars).

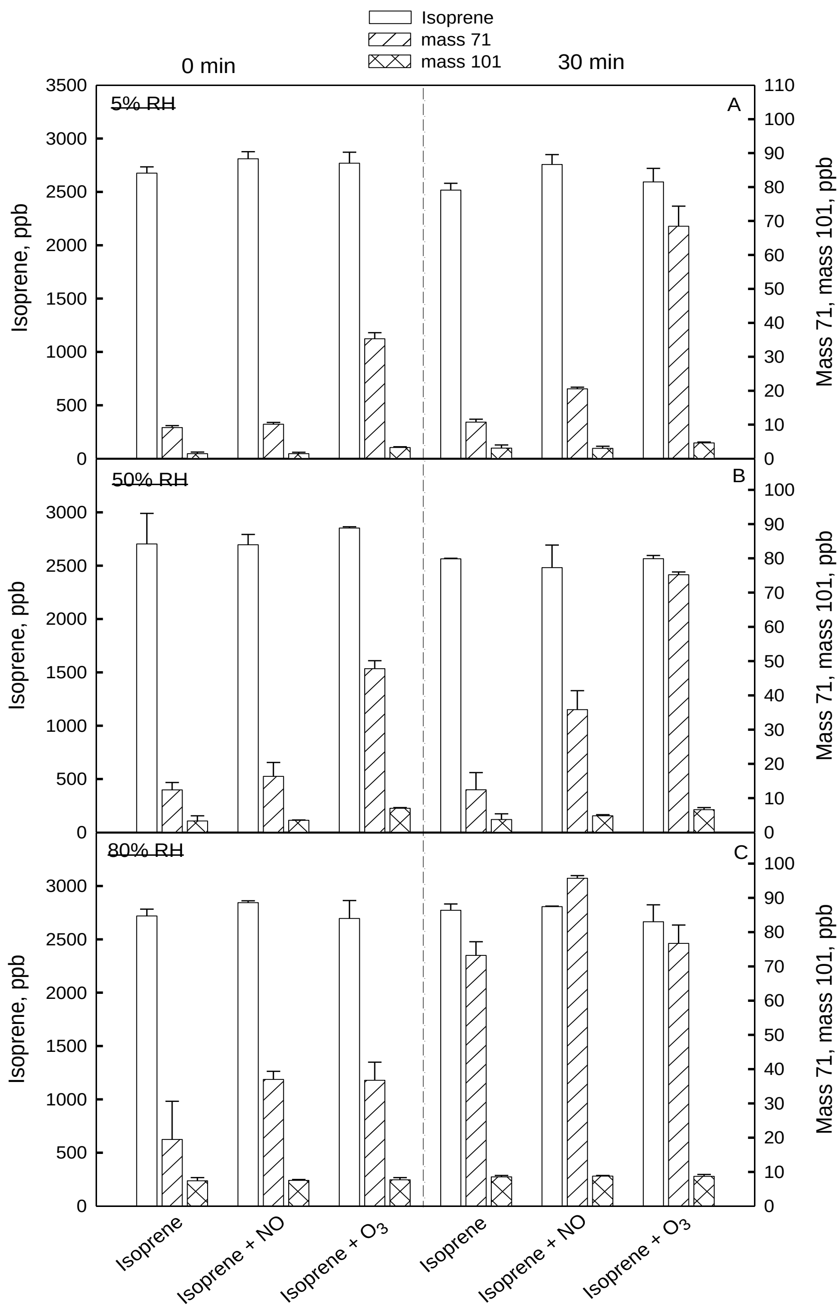


Figure 2.4: Formation of isoprene oxidative products – MVK MACR (mass 71) and isoprene hydroperoxides (mass 101) at different relative humidity (A – 5%, B – 50% and C – 80%) and different gaseous mixtures (only isoprene, isoprene + NO and isoprene + O_3)

Task 2.4: Coupling between climate change induced stresses on vegetation, BVOC emissions, O_3 and NO_x uptake, and O_3 forming potential (JUELICH)

Introduction

BVOC emissions have positive and negative effects on O_3 exposure and uptake. On the one hand, gas phase reactions of ozone with BVOC have the potential to destroy O_3 locally and therefore decrease exposure. On the other hand, their participation in atmospheric photochemistry can cause O_3 formation at the scale some 10 km thereby increasing exposure downwind. Main objective within task 2.4 therefore is the determination of the O_3 balance for plants: Ozone uptake by the plants themselves, O_3 losses in gas phase reactions with BVOC, and O_3 formation in the presence of NO_x and BVOC have to be determined. Impacts of heat- and drought stress for plants on the ozone balance have to be characterized by determining their impacts on the individual processes affecting the O_3 balance.

Experiments

Impacts of heat stress on constitutive emissions as well as on biotic stress induced emissions were studied using European beech (*Fagus sylvatica*), Norway spruce (*Picea abies*), and Scots pine (*Pinus sylvestris*). Furthermore, impacts of biotic stress on the formation potential of secondary organic aerosol were determined as well as impacts of heat and drought stress on top of the biotic stresses.

Impacts of drought on constitutive emissions were studied using Holm oak (*Quercus ilex*), European beech, Norway spruce and Scots pine. Both, experiments regarding impacts of heat and drought were conducted in the laboratory under well-defined conditions. In case of Holm oak most experiments were made in collaboration with Silvano Fares and Giulia Carriero.

Uptake of O_3 was investigated for plants without and with drought stress. Species Holm oak, Aleppo pine (*Pinus halepensis*) and Grey poplar (*Populus x canescens*) were used. Ozone destruction in gas phase reactions with plant emitted BVOC was investigated using Holm oak.

The O_3 formation potential was determined in one experiment using Holm oak and in another experiment using a set of 5 different plants (two Aleppo pines, one Holm oak, one Palestine oak (*Quercus calliprinos*), and one Pistachio (*Pistacia palestina*)).

Results

In many cases elevated temperatures had irreversible impacts on BVOC emissions whereby the impacts on *de-novo* emissions (i.e. emissions generated by the VOC biosynthesis itself) differed from the impacts on pool emissions. Most *de-novo* emissions decreased and did not recover within days to weeks. This behaviour was independent of the *de-novo* emissions being constitutive or induced by biotic stress. Examples of BVOC emissions where heat impacts decreased the emissions were those of sesquiterpenes and phenolic BVOC originating downstream of the shikimarte pathway. The only *de-novo* emissions increasing with heat were those of green leaf volatiles (GLV). However, the heat-induced emission pulses were roughly two orders of

magnitude lower than the parallel drops in *de-novo* emissions of sesquiterpenes and phenolic BVOC (measured for Norway spruce and Scots pine).
Pool emissions were strongly increased during and after heat application. Such increased emissions were caused by membrane damage of resin ducts and the increases were irreversible on time scales of days to weeks. Heat induced emission pulses stayed for weeks and the integral emissions during such pulses could be as high as constitutive pool emissions over a whole vegetation period.

Impacts of soil moisture on BVOC emissions were investigated for European beech, Norway spruce, Scots pine, and Holm oak. For all investigated species soil moisture expressed as relative water content (RWC) had no significant impacts on BVOC emissions as long as the RWC varied between 80% and 50%. Under conditions of drought when RWC fell below 40%, pool emissions as well as *de -novo* decreased with decreasing RWC for European beech, Norway spruce, and Scots pine. For Holm oak an increase was observed when RWC dropped from 40% to 20% and at the RWC lower than 20% the emissions dropped to zero.
Rates of transpiration and net photosynthesis also decreased with decreasing RWC and vice versa but no relationship was found between both quantities and BVOC emissions. The temporal behaviour of the plants responses in transpiration and net photosynthesis differed from the temporal behaviour in BVOC emissions preventing of the use of one of these quantities as a reference for describing the impacts of drought on BVOC emissions. So far RWC has proved to be the best reference for describing impacts of drought on BVOC emissions.

The dominant process of O_3 uptake by plants was found to be the diffusion through the plants' stomata. Ozone destruction on the plant surfaces was negligibly low and, for the strong monoterpene emitter Holm oak, O_3 losses due to gas phase reactions were lower than losses due to diffusion through stomata. As stomatal aperture decreased with proceeding drought stress, also O_3 uptake decreased with proceeding drought.

At elevated NO_x concentrations in the atmosphere plants may be a net source for O_3 because photochemical ozone formation from plant emitted BVOC is more efficient than ozone uptake by plants and ozone destruction in gas phase reactions together. Ozone formation from constitutive emissions was studied for a set of Mediterranean plants (two Aleppo pines, one Holm oak, one Palestine oak, and one Pistachio). In another experiment the O_3 formation was studied using an individual Holm oak. The results obtained in these measurements differed strongly and the reason for this difference is not yet understood.

In addition O_3 formation from atmospheric oxidation of the constitutive emissions from Holm oak was studiedwith respect to dependence of drought stress. As expected, the ozone formation potential of the plant decreased with increasing drought due to the decreasing BVOC emissions.

Deviations from workplan and compensations
It was aimed to publish our data on the ozone formation potential of constitutive plant emissions. So far we did not submit a manuscript because the results obtained in different experiments using either an individual plant or a set of plants as BVOC sources were inconsistent to each other. Obviously some basic processes leading to O_3 formation from BVOC are not understood yet. We will submit a manuscript on that item when the discrepancy is understood.
Results on impacts of heat and drought on constitutive and stress induced emissions were obtained earlier than expected. We therefore first published our results of the impact of heat stress on BVOC emissions and impacts of heat and drought on the potential of plant emitted BVOC to form atmospheric aerosols. We propose to accept these two publications, the master thesis of Iida Pullinen as compensation for the still missing publication on the ozone formation potential.

Progress towards the milestones and deliverables
Deliverable 2.5 was delivered by partner Juelich. There were no other deliverables due during the first 18 months.

D2.1 Initial database of controlled emission measurements on soil and litter, due at delivery date 24 and Milestone 6 Data on soil and litter emissions under changing climate conditions in database, due at delivery date 44 are progressing well.

IPP-CNR is on track to deliver its main milestone and deliverable (see below), although delays cannot be excluded in case of technical challenges.

D2.3 Assessment of primary and secondary BVOC exchange rates: Assessment of primary and secondary BVOC exchange rates in controlled conditions under simulated climate change and pollution scenarios [month 22]

The results of partner BAS-IRFG obtained during the 1st reporting period contribute to an improved scientific understanding of the response of BVOC and NO emissions under ozone pollution.

MS8 BVOC exchange rates under simulated combined climate change and pollution available to modelers [month 24] – in progress.

Use of resources and deviations from DoW
A total of 52.9 person months have been spent on this work package and significant deviations from DoW are not foreseen. The work was carried out by collaborations between Juelich and CNR and also BAS-IFRG with CNR.

Work package 3: Modelling emission processes

Lead contractor: KIT
Contributors: NERC, ULUND, UPM, KIT

Work package objectives

The aim of this work package is to provide improved parameterisations of biogenic and agricultural emissions to the modelers which include a robust response to climatic conditions that are predicted to change in the future.
The individual objectives are:

1. To improve the climate response characteristics of NH_3 emission models for agricultural sources and vegetation,
2. To improve the climate response characteristics of soil NO emission models,
3. To improve European BVOC emission models and their response to meteorological drivers and stresses

Progress and Results

Task 3.1: Improve agricultural NH_3 emission modules

The Volt'Air model has been used to assess ammonia emissions from mineral fertilizers at the French national level, coupled with an atmospheric chemical model by Hamaoui-Lagel et al. (2012). It is intended to apply the same approach at the European level in the MACC-II European project. Collaboration between ÉCLAIRE and MACC-II is being anticipated.
In order to provide a simple emission model able to be run across the whole of Europe for hourly time step as required by EMEP, INRA EGC is carrying out a sensitivity analysis coupled with an uncertainty analysis at the scale of one country (France) in a project supported by ADEME (Génermont et al, 2012; Ramanantenasoa et al., 2013).
Two options are still under evaluation for incorporation within ÉCLAIRE:

- Development of simple response functions by using the simulations of the sensitivity analysis. The experimental studies carried out using a specifically designed laboratory set-up (Génermont et al., 2011) will help in identifying the most relevant factors and may also provide such simple functions.
- simplification of the process-based model, using simplified input data (e.g. default parameters for each soil type, default fertiliser/slurry parameters) and a simplification of time-limiting processes (e.g. diffusion/infiltration within the soil) in order to reduce model run time.

Task 3.2: Improve bi-directional exchange parameterisation of NH_3 with vegetation

The work undertaken in the Biosphere-Atmosphere Team of INRA EGC deals with the improvement of Volt'Air, inclusion of vegetation (Volt'Air-Veg) and testing on datasets already available (coming from Graminae, NitroEurope and other projects):

- for volatilization from the soil surface, various agro-pedo-climatic conditions have been tested using Volt'Air (going on with the work presented in Garcia et al., 2011); to better account for dry soil conditions, an extrapolation of the retention curve for water transfers has been implemented following Schneider and Goss (2011) (Garcia et al., in preparation);
- Improvement of the bi-directional exchange model coupling Darcy approaches for the soil transfer description (Volt-Air) and resistive approaches for soil-vegetation-atmosphere transfers (SurfAtm) with a special focus on the dry domain for soil surface is being implemented and tested (going on with the work presented in Noirot-Cosson, 2012).

Task 3.3: Improvement of mechanistic parameterisations of NO soil emissions

Model improvements within the reporting period did focus on restructuring the model code of DNDC (into landscape DNDC) and to transfer all model and process parameters into an external library. Using this approach, the model parameterization can easily be altered giving the possibility to do a variety of parameterization assessments of the modelling processes with various tools, like calibrating, Bayesian uncertainty estimation and assessments.

Task 3.4: Improvement of the European BVOC modelling framework

bVOC emission factors

Existing bVOC emission estimates from the project partners were synthesised into a single table outlining the details (e.g. temporal and spatial resolution, and time period) of the datasets. The availability of and access to the data for WP partners is included in this table. A document describing the scientific research and development underpinning this data, as well as further information regarding the sources of the data has also been produced. Similarly, details of agricultural and anthropogenic emissions were also included in these documents. The table and the accompanying document are both available to all project partners via the ÉCLAIRE website.

ÉCLAIRE bVOC emissions modelling

LPJ-GUESS: (1) An improved process description of O_3 uptake and phytotoxic effects has been incorporated following the parameterisation described by Sitch et al. (2009) and is currently being evaluated against data from the FACE sites. Preliminary emissions estimates from the new model will become available to ÉCLAIRE partners over the next few weeks; (2) A new version of the LPJ-GUESS model incorporating coupled C-N cycles has also been developed and is currently undergoing evaluation and testing. Results from this model will be available to ÉCLAIRE partners in late 2013;

(3) LPJ-GUESS is currently being coupled with a detailed canopy model to simulate in-canopy processes such as emissions, chemistry, dynamics and deposition, including fluxes of bVOCs, N and O_3 and the uptake of O_3. Emissions estimates from the canopy exchange model will be compared with data from ÉCLAIRE field measurement sites. It is anticipated that site-specific emissions estimates from this model will be available to project partners in 2014.

ORCHIDEE: (1) The bVOC emission factors used in the model have been compared against measurement data from recent campaigns. The emission factors for some species and plant functional types have been updated in light of this; (2) Algorithms describing the effects of O_3 deposition and uptake on plant productivity and C assimilation have been included in ORCHIDEE. The ORCHIDEE DGVM is currently being evaluated against measurement data. The first emissions estimates from the improved model will be made available to project partners during summer 2013.

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Progress towards the milestones and deliverables

Within the reporting period, this WP does not include any deliverables from any tasks. All work in progress is focused towards the fulfillment of the deliverables and milestones.

Use of resources and deviations from DoW

A total of 9.6 person months were spent on this work package, which is roughly what was expected.

Task 3.1 deviations from DoW

The work of producing a simple model was initially planned for WP11. The shifting in terms of the team involved and timing required a reorganization of our initial plans. As a consequence, this work is not yet achieved.

Any other significant deviations from DoW are not foreseen.

Work package 4: Surface exchange modelling

Lead contractor: INRA
Contributors: NERC, met.no, SEI-Y, UoY, UGOT, FMI, DHMZ, WU

Work package objectives

The general aims of this work package were:

- To improve the description and modelling of surface/ atmosphere exchange processes for atmospheric pollutants under variable climatic conditions (*Tasks 4.1, 4.2 & 4.3*).
- To develop parameterisations for incorporation into European-scale chemistry and transport models (CTM) in Component 2 and for use in the derivation of dose-response relationships in Component 3 (*Tasks 4.1 & 4.2*).
- To investigate the effect of chemical- and gas-aerosol transformations that occur near and within plant canopies in relation to emission, deposition and bi-directional exchange for each of the pollutants considered (*Task 4.3*).
- To use improved exchange models to estimate atmospheric N inputs and O_3 deposition for the ecosystems being investigated at the effect study sites in Component 3 (*Task 4.4*).

Progress and Results

Task 4.1: Surface exchange routines for inorganic reactive nitrogen (N_r) compounds

Objectives

- improvement of dry deposition/emission routines for NH_3, HNO_3, NO_2, NO_3^- and NH_4^+ (including effect of NH_4NO_3 volatilisation near warm surfaces).
- emphasis on the response of the parameterisations to environmental change (meteorology & atmospheric composition).
- integrating analysis of the reactive nitrogen fluxes from the ÉCLAIRE flux network (WP1).
- parameterisations suitable for translation into European atmospheric transport models, including the EMEP model.

Overall strategy and progress

- Given the coupling between individual pollutant N_r gases and the aerosol phase through turbulence and chemistry in and above the canopy air space, WP4 contributors agreed (Edinburgh WP4 meeting, 20-21 March 2012) that a comprehensive and self-consistent exchange modelling approach was needed, which should treat within- and above-canopy turbulence, diffusion and chemistry explicitly and dynamically (including gas and aerosol phases, as well as the aqueous phase for leaf surface water films), rather than dealing with each chemical species individually as in conventional models.

- Foundations were laid by Partners 18 (FMI) and 6 (met.no) for a new multi-layer, multi-species, bi-directional surface exchange model, which was provisionally named ESX (ÉCLAIRE Surface eXchange). ESX will be a community model and is intended to serve as a tool for interpreting field flux measurements and for improving parameterisations employed in atmospheric chemistry-transport models (e.g. EMEP), not only for gaseous and volatile aerosol N_r, but also for O_3 and VOCs. Thus the development of ESX contributes to the fulfillment of different objectives within Tasks 4.1, 4.2 and 4.3.

- Key to the interpretation of fluxes of reactive compounds are in-canopy turbulence and reaction rates. The ESX model is thus formulated as a one-dimensional diffusion equation with general sink/source terms. Atmospheric diffusion is parameterised based on the first-order turbulence closure, with the vertical eddy diffusivity profile reflecting in-canopy mixing characteristics. The model equation is solved using a standard finite difference method. A simplified NO_x-O_3 chemistry was included for testing the diffusion-chemistry coupling. The coupled model was shown to produce expected concentration and flux profiles above and within the canopy.

- So far the ESX model represents a framework for inclusion of mechanistic process sub-models, such as a more complete chemistry scheme to be incorporated as a next step. An example of such a component sub-model is the provisionally-named DEWS (Dynamic pollutant Exchange with Water films on leaf Surfaces) model, which treats the bi-directional exchange and chemistry of water-soluble pollutant gases such as NH_3 and SO_2 on wet plant cuticles; DEWS is intended to be coupled dynamically to ESX, and to be upgraded to further treat cuticular deposition, deliquescence and evaporation of aerosols.

Task 4.2: Ozone deposition parameterisations

Objectives

- improvement of the formulation and parameterisation of an existing O_3 deposition model (DO3SE)
- more accurate descriptions of the mechanisms controlling stomatal and non-stomatal deposition of O_3
- parameterize in particular the effects of meteorology, canopy wetness, phenology, atmospheric CO_2 concentrations, and BVOC emissions
- feedback effect of O_3 on stomatal function through the inclusion of a photosynthesis-driven carbon based growth model

Progress and results

- The treatment of stomatal conductance (gsto) has been improved in the DO3SE model, which now incorporates a module that allows leaf level gsto to be estimated according to a photosynthetic-based method. This estimates assimilation according to Farquhar et al. (1980), and calculates gsto according to the equations of Ball et al. (1987). This model is now referred to as version 5 of the DO3SE model.

  This new photosynthetic algorithm now allows stomatal conductance to be estimated as a function of CO_2 concentration as well as other prevailing environmental conditions, i.e. relative humidity, irradiance (provided as diffuse and direct irradiance which can be influence by atmospheric aerosol load), leaf temperature (using energy balance equations to estimate leaf from air temperature) and soil moisture deficit (using methods developed for the original DO3SE model). The resulting model is therefore a hybrid photosynthetic / multiplicative model (since the influence of soil moisture on stomatal conductance is still estimated according to empirical relationships that modify the relative stomatal conductance value). The model also requires an estimate of leaf N since this determines the maximum carboxylation capacity at any given time. By providing N deposition and knowledge of soil N, estimates of leaf N availability can be made. This then allows stomatal flux (and therefore exchange of pollutant gases such as O_3, NO_x and SO_2) to be estimated according to N deposition, producing a deposition and effects model that is capable of estimating deposition and subsequent damage under a variety of pollutant and environmental conditions.

- Partners SEI and INRA are hosting a student intern to compare existing O_3 deposition models (DO3SE, SURFATM and MUSICA) with observations collected from wheat and beech stands in France. This comparison will focus on key variables influencing O_3 deposition and explore the different model formulations and parameterisations that are responsible for variations in model estimates.

- The experimental data at the Grignon site have been used to examine soil deposition and derive a parameterization for soil (Stella et al., 2011a). This parameterization has been included and tested in the model “SurfAtm-O3” for large periods of time (Stella et al., 2011b). Currently, two approaches are explored : a) multi-site flux data collection allows an investigation of cuticular deposition by two different models, a multi-layer model (MuSica) and a big leaf model (SurfAtm-O3); b) the distribution of O_3 deposition annual cycles (Stella et al., 2013). The first approach should improve cuticular deposition from a better identification of controlling variables and parameters, while the second approach integrates O_3 deposition over annual cycles of agro-eco-systems (crops and forests). A comparative study of an annual cycle for wheat and for forest by using three models has been initiated (DO3SE, SurfAtm-O3 and Musica).

Task 4.3: In-canopy chemical processing

Objectives

- Evaluation and improvement of a computationally efficient coupled multi-layer exchange and chemistry model for site- to global-scale simulations of in-canopy interactions and net exchange fluxes
- Extension of an existing scheme for the NO-NO_2-O_3-VOCs system and the dependence on in-canopy turbulence, to treat the phase partitioning of the NH_3-HNO_3-NH_4NO_3 system
- Assessment and fine-tuning of the model framework against data from the ÉCLAIRE intensive campaigns (WP1) and other suitable datasets and compared against the single-layer approaches
- multi-layer model investigations of the vertical distribution of O_3 concentration and sinks within the canopy, resulting from gradients in irradiance, stomatal conductance and surface wetness

Progress and results

- In parallel to the development of ESX, an existing multiple-layer canopy exchange model implemented in a 1-D chemistry-climate model system (MLC-CHEM) has been coupled to the DGVM LPJ-GUESS to assess the relevance of O_3 deposition impacts on BVOC emissions feeding back on O_3 concentrations and deposition.

- The application of MLC-CHEM to a boreal forest site (Hyytiala, Finland) allowed an extensive evaluation of some of the involved land-atmosphere interaction components. It turned out that model misrepresentation of site-scale surface hydrology, more particularly soil moisture regulation of stomatal uptake, poses a main limitation in this assessment of O_3 deposition and BVOC emission interactions.

Task 4.4: Estimating deposition at the ÉCLAIRE effect study sites by combining measured concentrations with a bi-directional exchange model

Original objectives

- Monthly measurements of atmospheric concentrations of the inorganic reactive nitrogen compounds NH_3, HNO_3, NO_2, NH_4^+ and NO_3^-, using low-cost denuder and filter samplers, and of bulk(wet) deposition, at field-scale experiments effects study sites of WP10.
- Modelling of reactive nitrogen and O_3 dry deposition at these sites using improved inferential models from Tasks 4.1-4.2.

Task 4.4 Cancelled

- The selection of manipulation experiments and study sites within WP10, following the project kick-off meeting (October 2011), resulted in most studies being conducted within open-top chambers or other forms of controlled environments. The original objective of atmospheric monitoring of background dry and wet deposition using low-cost methods at field-scale manipulation experimental sites thus became irrelevant and the task was cancelled.

- The laboratory analytical resources of Partners 13 (INRA) and 27 (DHMZ) for the management (preparation, shipping, extraction, analysis of low-cost atmospheric samplers), originally assigned to WP4, Task 4.4, were therefore re-allocated to WP1, Task 1.4 (the Bosco Fontana / Po Valley 2-month intensive measurement campaign). Here weekly mean concentrations of NH_3, HNO_3, NO_2 and O_3 were monitored using ALPHA samplers and diffusion tubes for a duration of 10 weeks in a 20-site monitoring network across the Po Valley. Note that this initially unscheduled activity within Task 1.4 was decided upon at a later stage, with the objective of providing ground truthing data for the satellite column trace gas observations made by Partner 37 (ULB) as part of the campaign.

Progress towards the milestones and deliverables

Deliverables

D4.1 Improved pollution- and climate-sensitive exchange parameterisations: Improved pollution- and climate-sensitive exchange parameterisations for the main inorganic Nr compounds, suitable for inclusion in CTMs [*month 36*]

- The scheduled provision (Month 36) of improved pollution- and climate-sensitive exchange parameterisations for reactive nitrogen (D4.1) and for O_3 (D4.2) will require the analysis of flux data from the ÉCLAIRE network, which are only starting to become available. The parallel development of the ESX model will provide a tool to help interpret these field data.

D4.2 Ozone dry deposition parameterisations: Ozone dry deposition parameterisations, improved with respect to changes in climate and environmental conditions, suitable for inclusion in CTMs [*month 36*]

- The newly derived parameterization for soil deposition is the first step before a detailed analysis of cuticular deposition. This has been carried out for soil at the Grignon site (Stella et al., 2011a) but it needs to be tested on a wider range of soil types and climates. The analysis of flux data from the ÉCLAIRE network, which are only starting to become available, will be a usefull tool for such testing.

D4.3 A coupled pollutant deposition and carbon based growth model: A coupled pollutant deposition and carbon based growth model (DOSE_C), based on the existing DO3SE model for O_3 deposition [*month 36*]

- The newly implemented photosynthesis-based stomatal conductance in DO3SE is a first step towards a coupled pollutant deposition and carbon-based growth model.
- Algorithms have been selected from dynamic vegetation models that will allow the estimate of Carbon allocation between different plant parts (leaves, shoots, roots). This will allow the photosynthesis model (or C assimilation model) to be developed to estimate plant growth according to standard principles used in ecosystem models, integrating the modelled assessment of the exchange of matter across the whole canopy-atmosphere interface *via* stomatal conductance, photosynthesis, respiration.

D4.4 Chemical processing model of NO-NO_2-O_3-VOCs and NH_3-HNO_3-NH_4NO_3: A vertically-resolved, multi-layer in-canopy chemical processing model of NO-NO_2-O_3-VOCs and NH_3-HNO_3-NH_4NO_3 exchange [*month 36*]

- Models for the chemical processing of NO-NO_2-O_3-VOC and NH_3-HNO_3-NH_4NO_3 (e.g. ESX, MLC-CHEM) are being evaluated with respect to their sensitivity to the number of air/canopy layers.
- The parameterisation of in-canopy turbulent mixing in ESX is being tested against a more detailed Lagrangian stochastic trajectory model. Concentration and flux profiles calculated with these two models are compared for different stability conditions and canopy structures.

D4.5 Current and future estimates of N_r and O_3 deposition: Inferential model current and future estimates of N_r and O3 deposition at effects study sites of Component 2 [*month 42*]

- Deliverable 4.5 was cancelled as a result of Task 4.4 being cancelled (see above).
- The measured ALPHA sampler and diffusion tube data from the Bosco Fontana / Po Valley monitoring network of WP1, Task 1.4 have mostly been submitted to the Bosco Fontana database, or are still in the validation and finalization process.

Milestones

MS14 Measurement network established for monthly Nr concentrations at the ÉCLAIRE effect study sites [*month 12*]

- MS14 was cancelled as a result of Task 4.4 being cancelled (see above).

MS15 Literature review on the effects of O_3 and Nr deposition on stomatal functioning and on the influence of surface wetness on total O_3 deposition: [*month 12*]

- The literature review has not been performed, but we have been investigating the influence of N deposition on stomatal conductance through the effect on leaf/canopy photosynthesis and how to incorporate this effect in the models.

MS16 New ÉCLAIRE experimental datasets [*month 18*]

- The new version 5 of the DO3SE model will be tested with the ÉCLAIRE experimental datasets collected in WPs 10 and 11 of C3 over the summer of 2013, once these data are quality-checked and uploaded onto the ÉCLAIRE data management portal. This testing will assess the ability of the model to estimate key variables (i.e. stomatal conductance, photosynthesis, leaf N content, respiration and biomass) and try to understand the influence of polluting conditions (e.g. elevated CO_2, O_3 and N availability) on the plant physiological response of these parameters. Once fully tested and validated the model can then be used to develop novel thresholds for these different pollutants under a range of environmental conditions for a number of different species.

MS17 Improved representation of the influence of environmental drivers on stomatal conductance and the partitioning between stomatal and non-stomatal deposition of O_3 and their incorporation in EMEP model [*month 24*]

- The issue of stomatal versus non-stomatal conductance is envisaged as one of the first priorities of the ESX described above.
- Once the new DO3SE model version 5 is evaluated against experimental data, selected algorithms will be incorporated/integrated with the ESX model to improve the canopy stomatal deposition term.

MS18 Incorporation of results from flux monitoring data generated within ÉCLAIRE into modelling framework [*month 24*]

- The flux monitoring data generated within WP1 will be investigated once a first operational version of ESX becomes available (before month 24).

MS19 Calibration of model parameterisation completed [*month 30*]

- ESX model parameterisations will be derived from ÉCLAIRE and other (e.g. FP6 NitroEurope IP) flux monitoring data once a first operational version of ESX becomes available.

MS20 Estimates of N_r and O_3 fluxes at the effects study sites inferred from monitored concentrations [*month 30*]

- MS20 was cancelled as a result of Task 4.4 being cancelled (see above).

MS21 Comparison of inferential model estimates with EMEP model results [*month 33*]

- MS21 was cancelled as a result of Task 4.4 being cancelled (see above).

MS22 Provision of site based estimates of NH_3/NO and VOC exchange for ÉCLAIRE core sites, for present and future environmental conditions [*month 44*]

- This requires first the development and parameterization of the ESX model, the submission and validation of the final ÉCLAIRE core site data, and the establishment of climate scenarios.

Use of resources and deviations from DoW

A total of 42 person months were spent on work package 4.

Deviations from DoW

- The analytical resources of Partners 13 (INRA) and 27 (DHMZ) for the management (preparation, shipping, extraction, analysis of low-cost atmospheric samplers), originally assigned to WP4, Task 4.4, were re-allocated to WP1, Task 1.4, the Bosco Fontana / Po Valley 2-month intensive measurement campaign.
- A two-month intensive study started at the beginning of June (8.6.2012) at 20 locations in Bosco Fontana and ended mid-August (10.8.2012), implementing a weekly protocol on sample exposure and collection. Low-cost atmospheric samplers were used to analyse concentrations of O_3, NO_2, HNO_3 and NH_3. INRA was responsible for samples of O_3 and HNO_3, while DHMZ analysed NO_2 and NH_3 samples. A total of around 200 samples were exposed and analysed. For the analytical work in the DHMZ chemical laboratory, the time allocation/manpower resources were: 4.4 month-technician and 3.2 month-analytical chemist. Data have been analysed, validated and are ready for use in other simulations and experiments.

Shift in Resources

- A budget transfer was made between INRA and UBO, to cover the costs of hiring a post-doctoral researcher to work on the development of the DEWS model and a canopy surface aerosol module for inclusion in ESX.

Publications arising from WP4

Four review papers were written as background documents for a joint **COST-ABBA (ES0804) / ÉCLAIRE workshop** held in Paris, September 2012, focussing on advances in knowledge and models of surface/atmosphere exchange for NH_3, O_3, NO_x, acid gases, volatile aerosols and VOC (see: https://colloque.inra.fr/ cost_eclaire/Background-documents). These reviews covered the following topics:

1. Advances in understanding, models and parameterisations of biosphere-atmosphere ammonia exchange, by C.R. Flechard, R.-S. Massad, B. Loubet, E. Personne, D. Simpson, E. Nemitz and M.A. Sutton (also published in *Biogeosciences Discussions*, http://www.biogeosciences-discuss.net/10/ 5385/2013/)

2. Bidirectional exchange of volatile organic compounds, by Alex Guenther.
3. Review on modelling atmosphere-biosphere exchange of Ozone and Nitrogen oxides, by L. Ganzeveld, C. Ammann and B. Loubet
4. Surface / atmosphere exchange of atmospheric acids and aerosols, including the effect and model treatment of chemical interactions, by E. Nemitz.

Other papers arising from WP4

- Cieslik, S., Tuovinen, J.-P., Baumgarten, Matyssek, R., Wieser, G., 2013. Gaseous exchange between forests and the atmosphere. *Developments in Environmental Science*, in revision.
- Stella, P., Loubet, B., Lamaud, E., Laville, P., Cellier, P., 2011a. Ozone deposition onto bare soil: A new parameterisation. *Agricultural and Forest Meteorology* 151, 669–681.
- Stella, P., Personne, E., Loubet, B., Lamaud, E., Ceschia, E., Béziat, P., Bonnefond, J.M., Irvine, M., Keravec, P., Mascher, N., Cellier, P., 2011b. Predicting and partitioning ozone fluxes to maize crops from sowing to harvest: the Surfatm-O3 model. *Biogeosciences* 8, 2869–2886.
- Stella, P., Personne, E., Lamaud, E., Loubet, B., Trebs, I., Cellier, P.,(2013), Assessment of the total, stomatal, cuticular, and soil two-year ozone budgets of an agricultural field with winter-wheat and maize crops. To be submitted to Journal of Geophysical Research, Biogeosciences.

2.1.2 Component 2: Emissions & exchange at local, European to global scales

Lead contractor: KIT
Contributors: met.no, CNRS, JRC, ECN

Component objectives
Component 2 addresses the currently still poor understanding of both spatial and temporal variation in emissions of precursor substances of relevance for air pollution and climate. Biogenic and anthropogenic emissions contribute in complex emission patterns and atmospheric reactions and transport to pollution locally, regionally and across large-distances. How climate change affects emissions and chemical interactions is a large uncertainty in projections of the climate change-pollution interplay. Component 2 aims to

(1) provide past to future simulations of European to global-scale level pollution-climate change interactions, accounting for local and long-distant pollution source contribution; (2) assess how biogenic pollutants and precursors from natural, semi-natural and agricultural ecosystems vary in space and time; (3) apply the analyses of climate change-pollution interplay to combine novel knowledge into pollution metrics across Europe; (4) investigate climate-pollution interplay at high spatial resolution to take into consideration effects of landscape heterogeneity.

Progress and Results

WP 5 Past and future changes of atmospheric pollutants transported into Europe

The main WP5 objectives are (1) To assess our current understanding of ozone and other air pollution trends; (2) To evaluate the transport of atmospheric pollutants (ozone and precursors, aerosols) into Europe, provide boundary conditions and (3) To examine the relative contributions and impacts on air pollution of future biogenic and soil and fire emissions.

Progress and Results

- HTAP (including TM5) boundary conditions are evaluated and propagated to EMEP model (both for 1960-2010) as future scenarios.
- The LMDZ-INCA model has been utilized to evaluate future scenarios with ACCMiP (so-called RCP scenarios; see above).
- Fixed climate simulations have been made.
- It is planned that this model is used to perform future simulations of emerging new scenarios available through HTAP/ECLIPSE/PEGASOS; including evolving climate.

WP 6 Emissions on regional, European, to global scale

WP6 will provide emission patterns for model experiments on European and global scale, focussing terrestrial biogenic and pyrogenic emissions, and will provide improved temporal resolution of non-agricultural anthropogenic emissions. Specifically, the WP (1) quantifies how trace gas emissions from natural, semi-natural, and agricultural ecosystems vary in response to interactions of weather and climate, atmospheric CO_2 burden and N deposition, vegetation and soil carbon and nitrogen dynamics, and land use/land cover change and (2) provides improved temporal dis-aggregation of non-ecosystem, anthropogenic European (pollutant emission patterns for selected source sectors

Progress and Results

- Representations of emissions of biogenic pollutant precursors have been improved, in particular regarding wildfire emissions (see Fig. 2.1 below) and nitrogen. These improvements allow us to now investigate separately and jointly the effects of climate change and changes in socioeconomic conditions on wildfire emissions. A manuscript is in preparation.
- Assessment of O_3 toxic effects has progressed by improving uptake routines in dynamic global vegetation models.
- Within-canopy processes that determine (a) escape of pollutant precursors into the troposphere and (b) deposition of pollutants to plants and soils will be quantified over the next reporting period. To do so, a coupled canopy meteorology/chemistry – vegetation model scheme will be further developed.

---Progress includes also dynamic emission algorithms for agricultural ammonia, which are likely to increase in response to warmer temperatures. These algorithms can be included into CTMs

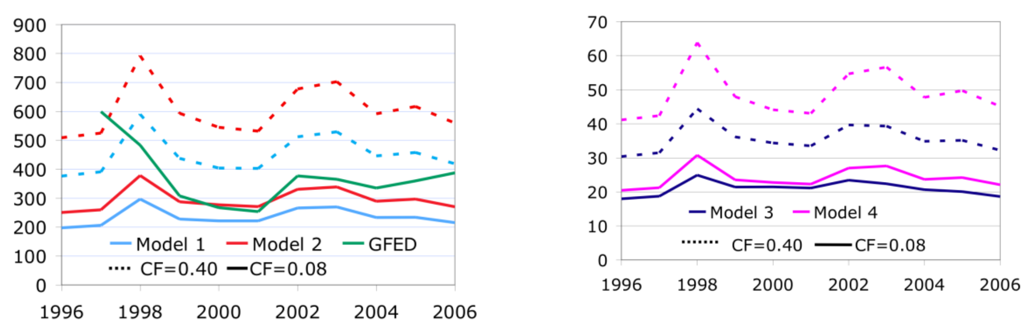

Figure 2.1: Emissions in MtC of CO and Mt of aerosol particle mass computed with LPJ-GUESS global ecosystem model and GFED burned area according to different emissions models. CF: combustion factor for woody litter.

WP 7 Modelling European air pollution and deposition

For WP7 the main objectives are to provide maps of O3-damage metrics and N-deposition over Europe, for current and future scenarios, as inputs to the ecological response and effects packages (C3 and C4) and to integrated assessment modelling (C5). Activities ranging from global to local scale, and linking meteorological, chemical and ecological models will interact with each other and be merged to fulfil these objectives.

Progress and Results

- An ensemble of five CTMs was used to examine the effects of climate change on ozone fields across Europe up to 2050. The EMEP MSC-W, MATCH, DEHM, SILAM and EnvClimA models and the response of ozone to climate change over the years 2000 to 2050. This work suggested that climate change has likely only a small impact on O3 concentrations, although the effect on ozone-uptake (fluxes) remains to be investigated. This work (Atmos. Chem. Physics, Langner et al., p10423-, 2012) also highlighted the large differences associated with the models emissions for biogenic VOC.
- The MATCH model was also used to study the relative impact of emissions and meteorological changes on summertime ozone over the period 1990 2100. This work (Langner et al. ACP, p10097-, 2012) and similar studies involving WP7 partners) clearly shows that emission changes, rather than climate change, are the main factor controlling ozone changes in the 21st century.
- Downscaled climate (meteorological) data from the SMHI RCA3 model have been delivered to C2 and C4 partners for the period 1960-2050. Bias-corrected data have also been delivered where possible. These data will drive ecosystem models and CTMs.
- Maps of nitrogen deposition for the period 1990-2010 have been delivered to C4, for comparison with forest biomass damage indicators. Maps of ozone flux (POD1, POD6) have been delivered to several partners. This kind of delivery will be continued through the project.

WP8 Assessing local and regional variation

The main objective for WP8 is to develop a better understanding of the air pollution and climate change relationships at regional/local/landscape-scale and sub-grid approaches for inclusion in large-scale models. These objectives will be reached by literature study, Nitroscape-model developments and application to test areas and sub-grid developments, testing and application

Progress and Results

The overall progress for the different activities in WP8 is listed here:

- The literature study in Task 8.1 is delayed. Although the activity is important for the overall understanding of air pollution-climate interactions in the various models, this does not yet pose a large problem on the work in the other work package s. It is foreseen that this literature study will be finalized in the second quarter of 2013.

- For Task 8.2 the main activities are related with the further development of the NitroScape model. From the beginning of the project, it was clear that there were many challenges with respect to this activity. After an initial delay due to a missing PhD student, activities have started but first real results for the ÉCLAIRE test areas are not foreseen for the first half of 2013.

- Another activity within Task 8.2 is the delivery of deposition and concentration fields to Work Package 17 for the evaluation of critical loads exceedances at different spatial resolutions. These fields are calculated by means of the EMEP4UK model, for which the meteorological information is available. Subsequently, the model has run successfully for the agreed ÉCLAIRE domain at a resolution of 5x5km (Fig. 2.2). Next steps will be to perform the calculations on a 1 km resolution for Scotland and The Netherlands. Initially the calculations will use emissions derived from EMEP 50 km emission. In a later stage more detailed emissions for The Netherlands may be required. The delivery of the depositions to WP17 is foreseen for end of May 2013. This completely fits within the time schedule for WP17 and has been verified with the WP17 leader.

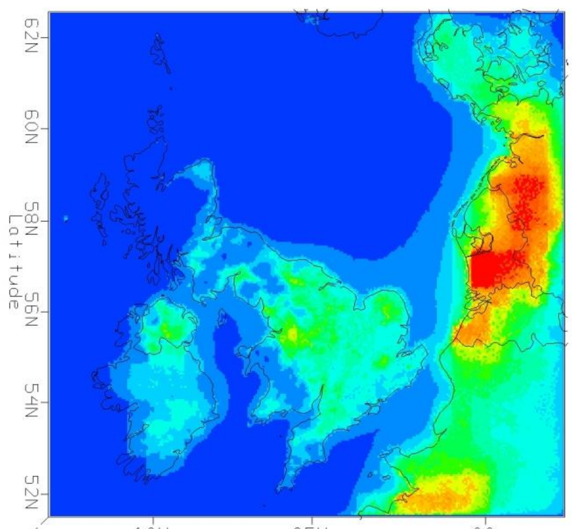

Figure 2.2: Modelled nitrogen deposition at a 5x5 km resolution for the ÉCLAIRE modelling domain, using the EMEP4UK deposition model.

- The Task 8.3 activities are related to developing a sub-grid module for inclusion in large-scale models. Initial discussions (ECN, NILU, UEDIN) on the way forward with respect to this development have been initiated. The final decision on the approach to follow for this Task is foreseen to be taken in the coming months, after which the actual development will commence.

Progress towards the milestones and deliverables, use of resources and deviations from DoW

Several elements of D5.1 are well on track but the final deliverable is foreseen with a few months delay. All other WP5 deliverables are on track.

WP6 is progressing at this stage according to plan. Deliverable 6.1 was submitted in time. Milestone 25 (WP meeting) was broadened into a larger cross-WP and component meeting, and conducted at IIASA, Laxenburg in March 2011. There are some complications in relation to the soil properties and fertiliser application data within the NitroEurope database, however plans are underway to address this (see under WP 6 report) and a meeting will take place in 2013 to further discuss these issues. So far this is not expected to hinder delivery of D6.2. Progress has also been made towards Task 6.4 (and therefore D6.3) with the initial synthesis of current best practice completed; work has now started to evaluate various methods of improving the temporal profiles of key source sectors such as transport emissions and to determine the necessary level of detail for use in CTMs. A discussion with all WP members (as well as partners in C4) is planned for the General Assembly in October.

WP7 is progressing well. Early ambitions to deliver maps of pollutant metrics has been modified to some extent by all the activities (TFMM, ED3) on multi-model comparisons requested by the EU and UNECE policy activities. On the other hand, these activities have created a larger pool of models within the ensembles. Within ÉCLAIRE we will expand on these study results with a specific study on model performance for N-compounds compared to measurements. As a result of this work, model results from an ensemble of models (milestone 29) for the year 2009 have been collated by JRC and TNO.

WP8 has a few delays. However most of these delays are foreseen to be solved in the coming months of 2013. The main issue of concern at the moment is related to the development of the NitroScape system and its application to the ÉCLAIRE areas.

Highlights

Provision of future European pollutant boundary conditions that include best estimate and uncertainty range of present and future O3 and aerosol precursors as boundary conditions to regional models

Cross-CTM ensemble experiment on effects of climate change on O_3 in Europe. This work suggested that climate change has likely only a small impact on O_3 concentrations, although the effect on ozone-uptake (fluxes) remains to be investigated.

Dynamic agricultural ammonia algorithms in response to climate change as conditions to be included into CTMs.

Work Package 5: Past and future changes of atmospheric pollutants transported into Europe

Lead contractor: JRC
Contributors: ULUND, met.no, CNRS

Work package objectives

1. To assess our current understanding of ozone and other air pollution trends, based on knowledge acquired within the UNECE TF HTAP, work for IPCC-AR5 and other projects, with a focus on the inflow regions of Europe.

2. To evaluate the transport of atmospheric pollutants (ozone and precursors, aerosols) into Europe, evaluate the relative contributions of long-range-transported and European pollution on atmospheric composition and deposition to the ecosystems in Europe and in other regions, and provide a range of chemical boundary conditions to regional models within ÉCLAIRE (WP7), taking into account changes in global anthropogenic and natural emissions under current and future climate change conditions.

3. To examine the relative contributions and impacts on air pollution of future biogenic and soil and fire emissions produced in WP15 of ozone and aerosol precursors on European pollutants levels and their export to the hemispheric and large scale atmosphere.

Progress and Results

Most work focussed on Task 5.1 and Task 5.4, while work for 5.2 and 5.3 are being prepared

Task 5.1: Understanding pollutant trends and model predictions

A selected set of IPCC-AR5 historical (1960-2010) simulations, FP7 PEGASOS simulations, and dedicated sensitivity simulations will be analysed for their ability to reproduce recent ozone trends, satellite derived NO2 columns and nitrogen and sulphur deposition, focussing on the role of anthropogenic (TM5) and natural emissions (LMDZ), to provide a best estimate and uncertainty of ozone and other air pollutant inflows at the boundary of Europe.

Progress of work

- The TM5 model contributed to providing boundary conditions from ensemble model simulations of HTAP Phase 1 (O. Wild et al. 2010), which are further evaluated in the context of new IPCC assessments of O_3 changes from 1960-2010 (Fig. 2.3).

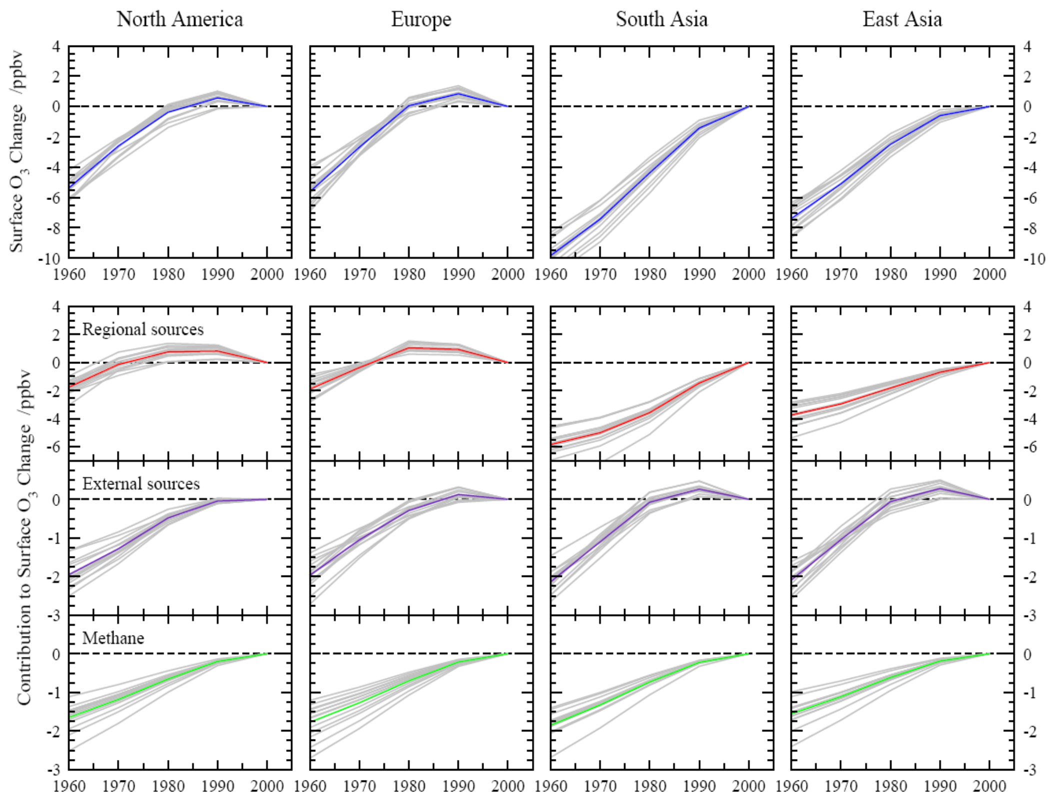

Figure 2.3: The HTAP model attribution of O_3 changes to Europe, North America, South Asia, and East Asia, to regional (domestic) sources; Rest-of-the-World and methane changes in emissions (Wild et al. 2010). This parameterisation was further developed to estimate future changes in ozone boundary conditions.

- The LMDZ-INCA model has been used to evaluate ACCMIP results (Szopa et al.; 2012) for the period 1860-2100; specific analysis will be performed for the period 1960-2010. The simulations will be rerun for 1960 and 1980 including the NH_3 cycle, and show the evolution of O_3, CO, NO_X and N deposition map for the global and for the Europe area. Figure 2.4 shows the evaluation of O_3 (Szopa et al. Climate Dynamics in press, 2013) for past and future conditions.

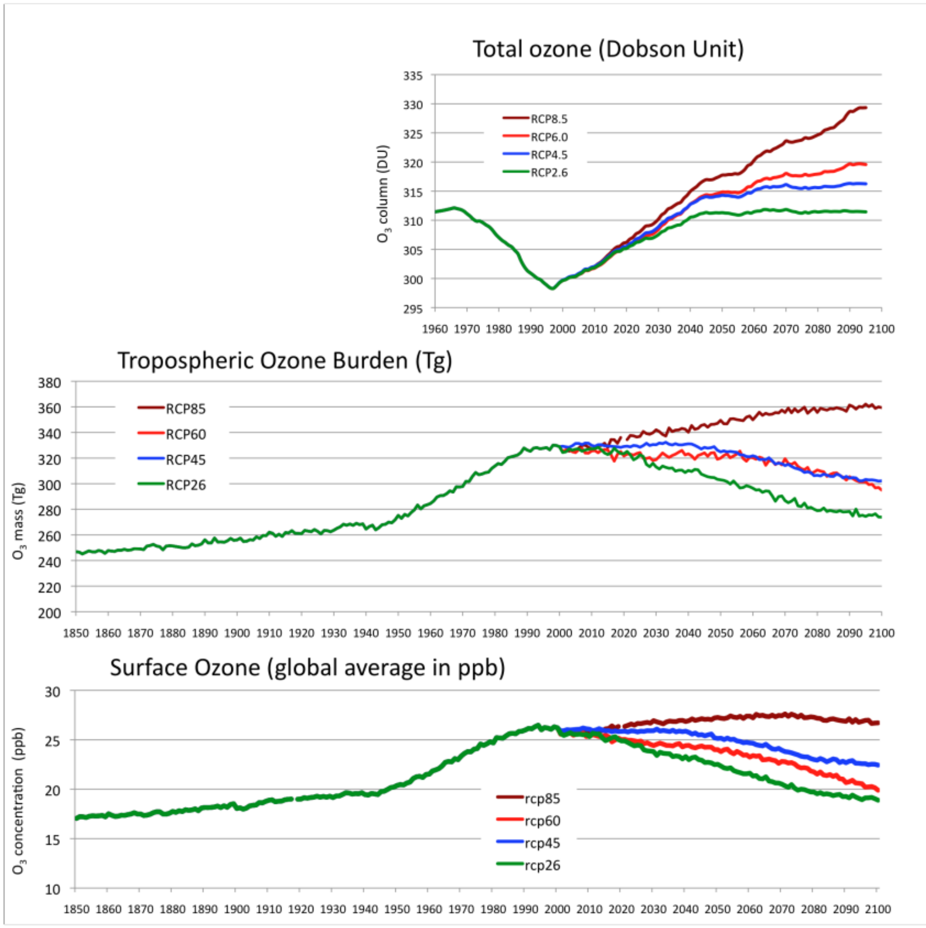

Figure 2.4: Evaluation of O_3 for past and future conditions.

- A summary overview of these specific works in the light of the wider body of literature is foreseen as a final deliverable.

Task 5.2: Predicting future pollutant trends

Task description

Selected scenarios of future emissions provided by IPCC AR5 RCPs, and possibly other scenarios, will be used to evaluate the possible global, hemispheric and European evolution of ozone and other air pollutants for 2030, 2050 and 2100. LMDz-INCA-ORCHIDEE will be used to simulate the future impact of biogenic and soil emissions of ozone and aerosol precursors on future levels of pollutants, especially O_3 and reactive N-compounds. The uncertainty of these emissions will be estimated using emission datasets developed in WP6, accounting for future climate and changes in land use a well as anthropogenic and biogenic emissions. Sensitivity simulations will be carried out in order to discriminate the relative contributions of the various changes on the level of pollutants in Europe and interactions with pollution on global scale (TM5, LMDz and, up to 2050, EMEP).

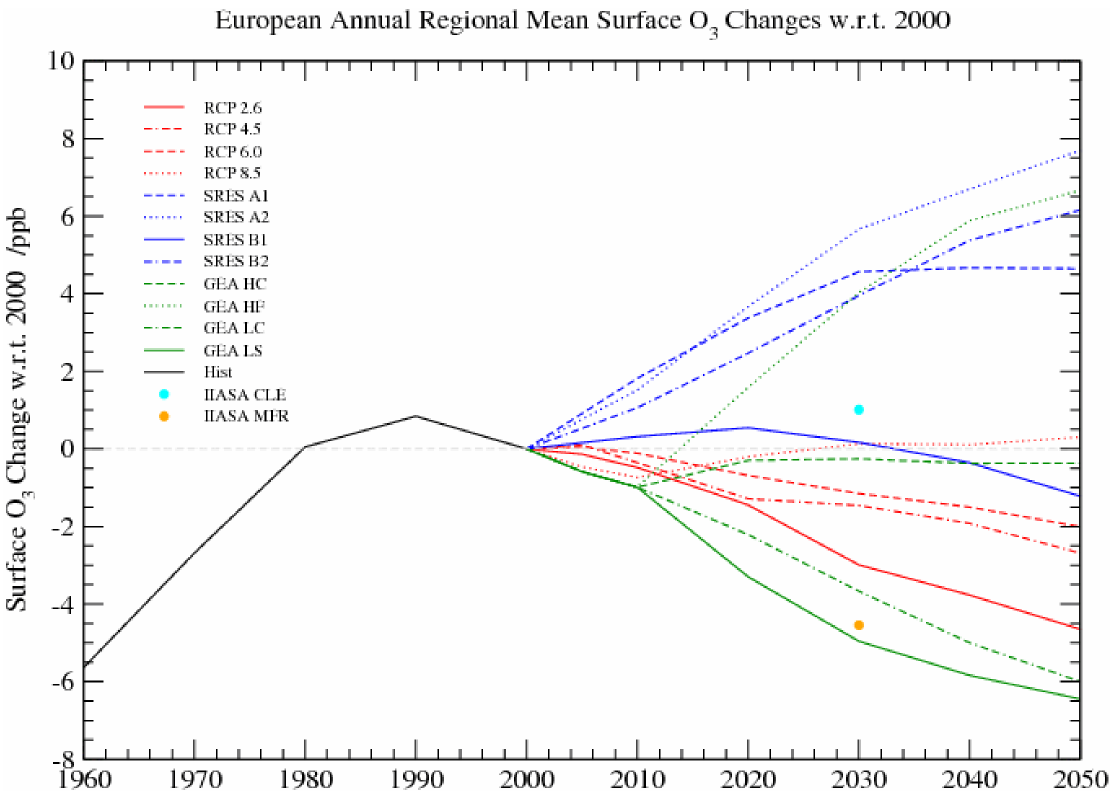

Figure 2.5: The HTAP evaluation of future ozone under emissions scenarios from the RCP, SRES and GEA exercises.

Task 5.3: Quantifying the importance of long-range transport for ecosystem impacts

This task will analyze the evolution of key environmental variables impacting ecosystems (ozone levels, PM levels, N and S deposition) under the various emission and climate scenarios and isolate the role played by long range transport of pollution, climate change and changing variability, biogenic/emissions, lightning emissions, and anthropogenic emissions in Europe and other regions.

Work in this package has not yet started. In this task LMDZ-INCA will be used to redo simulations with an interactive biosphere.

Task 5.4: Provision of future European pollutant boundary conditions

This task will provide a best estimate and uncertainty range of present and future O_3, O_3 precursors and aerosol as boundary conditions to regional models, for further impact assessment on ecosystems.

Works is in progress on coupling HTAP boundary conditions to the EMEP model evaluating various literature scenarios (for example Fig. 2.6).

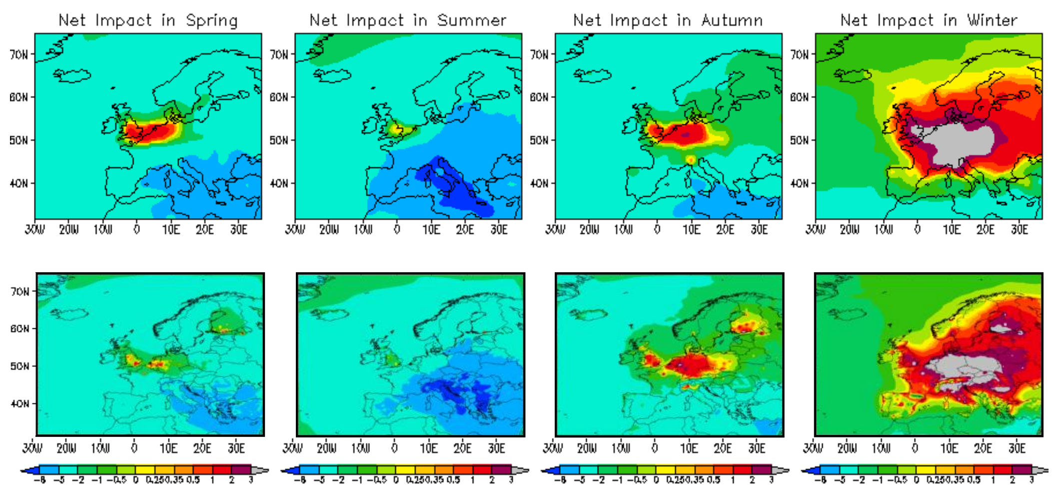

Figure 2.6: HTAP multimodel boundary conditions coupled with the EMEP model (scenario RCP2.6). This evaluates only the ‘anthropogenic signal’.

The LMDZ-INCA model has been utilized to evaluate future scenarios with ACCMiP (so-called RCP scenarios; see above). Fixed climate simulations have been made. It is planned that this model is used to perform future simulations of emerging new scenarios available through HTAP/ECLIPSE/PEGASOS; including evolving climate.

In the context of Task 5.3 The LMDZ-INCA sensitivity studies are isolating climate change and anthropogenic emission effects.

Progress towards the milestones and deliverables

D5.1 Assessment of current GCMs and CTMS to reproduce recent trends models by comparison with selected observations [month 18]

- First estimates of these trends have been estimated, simulations will be redone including a more robust comparison to measurements. ***Update September 2013:*** Final synthesis required, estimated delivery month 25.

D5.2 Report describing the range of future evolutions of global, hemispheric and European ozone Report describing the range of future evolutions of global, hemispheric and European ozone, ozone precursors, and aerosol using a range of anthropogenic and natural emissions [month 36]

- Work has started and is well underway no delays expected.

D5.3 Report describing the contributions of regions and processes on key environmental variables under future conditions [month 36]

Work has started.

D5.4 Boundary conditions for regional conditions: [month 24]

- Work has started and initial tests with boundary conditions are underway.

Use of resources and deviations from DoW

A total of 2 person months have been spent on this activity and there are no major issues at this point.

Work package 6: Emissions on regional, European, to global scale

Lead contractor: KIT
Contributors: NERC, ALTERRA, ULUND, CNRS, UEDIN, AU

Work package objectives

The objectives of WP6 are to:

1. quantify how trace gas emissions from natural, semi-natural and agricultural ecosystems vary in response to interactions of weather and climate, atmospheric CO_2 burden and N deposition, vegetation and soil carbon and nitrogen dynamics, and land use/land cover change;
2. provide improved temporal dis-aggregation of non-ecosystem, anthropogenic European pollutant emission patterns for selected source sectors.

Progress and Results

Task 6.1: Model improvement and linking to databases

This task includes the "synthesis of existing terrestrial biogenic and pyrogenic emission estimates from the consortium partners (from the regional, European, to global scale), bringing together relevant previous and ongoing simulation results (e.g. for bVOC, NO_x, NH_3, fire) that are available from ÉCLAIRE partners, in order to establish and test for suitable input format and resolution and file exchange strategies with atmospheric chemistry and carbon-cycle models". The progress and results are described below.

A spreadsheet of currently available biogenic, pyrogenic and agricultural emissions estimates was produced, highlighting the format, resolution (temporal and spatial), time period and domain covered and accessibility of the data. This, together with a document outlining the methodologies used to generate these data, was made available to ÉCLAIRE project partners via the ÉCLAIRE website. The accompanying document also provided information on existing anthropogenic emissions data that are available to project partners.

A protocol for modelling was agreed between WP partners to ensure consistency between the model simulations to be undertaken as part of Tasks 6.2 and 6.3.

- Forcing data: identification of the source, spatial and temporal resolution of climate date, CO_2 concentration, land-use dataset, nitrogen and ozone deposition fields.
- Grid: regular 0.5 by 0.5 degree grid with centre coordinates *.25 and *.75
- Simulations: model spinup to equilibrium in 1960, followed by a core of 2 modelling experiments with fixed or transient O_3 and 4 further desirable experiments with varying land cover and emission response to CO_2 changes (1960-2050).

In addition, the required output variables, and appropriate temporal resolution (monthly) and file format (netcdf) was specified.

Task 6.2: Improved emissions estimates

This task includes "emission model simulations, using the dynamic global vegetation models LPJ-Guess and ORCHIDEE and dynamic soil vegetation model DNDC, driven by past, present-day and future climate, CO_2 and N deposition scenarios (as applied in WP7) for a consistent, process-based analysis of vegetation emissions that takes into account the tight coupling between biogeochemical cycles of carbon, water, and nitrogen, atmospheric chemistry and climate, using process descriptions and parameterisations that have been updated using the most recent information from WP1."

The dynamic global vegetation models (DGVMs) and dynamic soil vegetation models (DSVMs) have been developed through the inclusion of process-based algorithms for the impact of ozone exposure and/or nitrogen deposition on productivity and emissions as described below. Model simulations have begun in order to provide emissions estimates to ÉCLAIRE project partners as defined in this Task. Details of progress for the individual models are given below.

LPJ-Guess

Algorithms describing the impacts of accumulated O_3 fluxes to plant cells through the stomata on photosynthesis and hence carbon assimilation over the growing season have now been implemented in the LPJ-GUESS (Sitch et al., 2003; Smith et al., 2001) dynamic global vegetation model (DGVM). The approach taken follows that of Sitch et al (2007), but uses a stomatal conductance model to calculate the flux of ozone into the leaf interior (Jarvis, 1976; Emberson et al., 2000) with parameter values for individual species or plant functional types (PFTs) based on experimental and field measurements for a number of vegetation types (Pleijel et al., 2004; Karlssen et al., 2004; Gruters et al., 1995; Mills et al., 2011 and references therein).

The newly implemented ozone algorithms are currently undergoing rigorous testing. Preliminary checks indicate that the damage from accumulated exposure to ozone simulated with LPJ-GUESS is in line with that projected by other models (Sitch et al., 2007; Felzer et al., 2005). Initial results suggest that while regions dominated by grassland are relatively unaffected (grasses have been observed to be highly resilient to ozone exposure – Mills et al., 2011 and references therein), forest growth may be substantially reduced (up to around 80%) in both tropical and boreal regions. Data from field measurement sites, notably the Aspen FACE experiment site, are now being used to further test the model output.

As part of the model testing and evaluation process, the use of different threshold values of ozone uptake is being investigated (Mills et al., 2011 and references therein). While not physiologically explicable, field measurement data suggests that statistically significant relationships between accumulated ozone exposure and measurable reduction in plant functioning (i.e. photosynthesis and carbon assimilation) only emerge above certain threshold levels of ozone flux, the values of which are species-dependent (Pleijel et al., 2004; Karlssen et al., 2004; Mills et al., 2011 and references therein).

Preliminary simulations of bVOC emissions for EMEP are about to commence and will be completed by early May. Further simulations incorporating the impact of O_3 deposition and uptake will be completed by the end of the summer. Site-specific evaluations, including the use of measurements from the ÉCLAIRE network of sites, to identify the optimum value of this parameter for European species and environmental conditions, will commence later this year.

A parameterisation of the effects of N deposition on C uptake and assimilation, including representations of soil processes affecting nitrogen availability (microbial activity and leaching of mineral nitrogen), deposition to the land surface, nitrogen uptake via fixation and losses through respiration, has been incorporated in LPJ-GUESS. The nitrogen cycle algorithms and the performance of the coupled carbon and nitrogen cycle in LPJ-GUESS have been extensively checked and evaluated against both outputs from other model simulations (Zaehle et al., 2010 and references therein) and site-specific data from both the FACE experimental sites and the FLUXNET network of monitoring stations. Preliminary results from the coupled nitrogen and carbon cycles in LPJ-GUESS suggest that nitrogen limitation has a significant impact on regions where vegetation is dominated by crops and grasses. In forested areas, increased nitrogen availability due to increased deposition is sufficient to balance losses of soil nitrogen due to leaching and carbon assimilation and plant growth are relatively unaffected.

This will shortly become the standard version of LPJ-GUESS and will be available for use during the ÉCLAIRE project to model the interactions between the macro-nutrient cycles and air pollutants such as reactive nitrogen species and ozone. Data from these simulations will be available to project partners early in 2014.

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ORCHIDEE

The emission factors (EF) for biogenic VOCs used in model parameterisations represent one of the most significant uncertainties in the emissions estimates (Niinemets et al., 2011). The EF used in ORCHIDEE have been compared with those used in the state of the art models [MEGAN (Guenther et al., 2012, Guenther et al., 2006, Karl et al., 2009, Fu et al., 2012), se-BVOC (Steinbrecher et al, 2009), CCSM (Levis e al., 2003), LPJ-GUESS (Arneth et al 2011), BVOCEM (Lathière et al., 2010) and Swiss model (Oderbolz et al. 2013)], and against measurement data from recent field campaigns [Steinbrecher et al., 2012, Klinger et al., 2002, Padhy et al., 2005, Smiatek et al., 2006, Oderbolz et al., 2013, Tsui et al., 2009, He et al., 2000, Leung et al., 2010, Geron et al., 2006, Bai et al., 2006]. In addition, the effect of seasonal variations in EF and variations due to water stress have been explored (Dominguez-Taylor et al., 2007, Lim et al., 2011, Grote et al., 2010, Lavoir, et al., 2009). While there was generally good agreement between ORCHIDEE EFs and the reference EFs, some EFs were updated. Emissions of compounds, such as dominant individual mono- and sesqui-terpenes will also be included in the ORCHIDEE model for the ÉCLAIRE simulations.

In addition, algorithms accounting for the impact of ozone on vegetation have been included in ORCHIDEE. Testing and evaluation of the ORCHIDEE model incorporating these changes is currently underway. These will then be included in the LMDz-ORINCA coupled model to be used for global present-day and future simulations to be run in the framework of ÉCLAIRE project. Improved emission estimates generated by these simulations will shortly be available to project partners.

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DNDC

Model developments are progressing and include:

(1) a revision of the model structure to facilitate computation of inventories at continental scale (Haas et al., 2012); other papers are in preparation, firstly explaining the processes in LandscapeDNDC for all ecosystems, and secondly containing a validation of the model for arable sites.

(2) implementation of routines and database approaches needed for assessing model parametric uncertainty (Rahn et al., 2013). We are also running an uncertainty analysis for the model parameters as part of the validation of the arable sites, with the outcomes of this analysis (parameter likelihood distributions) to be applied to a regional uncertainty analysis for a GHG inventory assessment. This is ongoing work which will be published in a book chapter in August 2013.

(3) as mentioned earlier, initial runs with LandscapeDNDC at EU scale have revealed some complications in relation to the soil property and fertilizer application data contained within the NitroEurope database. There is also a need to further improve the parameterization scheme. These issues have been discussed by the relevant work package and component leaders. Work continues to resolve the issues in relation to the data in the NitroEurope database and in parallel KIT is using QC methods to analyse the data, in order to develop the inventory needed.

(4) meta-analysis of soil NO emissions has started and will be used for testing new process descriptions and parameterization schemes.

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Task 6.3: Emissions from agricultural sources

This task involves “the modelling of agricultural emissions in response to their key drivers, in a similar approach as Task 6.2, with improvements in process understanding gained from WP3 integrated into the emissions models DEHM and DNDC.”

AU and **ALTERRA –**

A dynamic method for simulating the temporal variations (down to hourly time scales) of ammonia emissions based on a combination of gridded meteorological and emission data (Skjøth et al. 2004 and 2011) has been used to investigate the spatiotemporal variability of ammonia emissions (from a standard Danish pig stable with 1000 animals) across northern and central Europe with respect to atmospheric temperature (Skjøth et al., 2013). Potential future changes in emission driven by temperature projections from an ensemble of climate models were also investigated.

The key findings of this study were:

(1) Emissions vary by up to 20% for different locations within individual countries due to variations in climate, with larger uncertainties for large countries such as France, Germany and the UK;
(2) Annual variations in climate at a single location result in similar levels of uncertainty;
(3) Climate change may increase emissions by 0–40% in central and northern Europe (see Fig. 2.7, where projected emissions in 2087 are shown relative to emissions in 2047 and 2010. The years 2047 and 2087 are projected to be relatively warm years, while 2010 represents a cold year under current conditions. Our study points towards higher ammonia emissions everywhere in the model domain in 2087 relative to both 2010 and 2047;
(4) Apparently steep gradients in existing emission inventories between neighbouring countries are reduced by using a dynamic methodology for calculating emissions.
Emissions inventories are among the largest uncertainties in CTM and CCM model projections, and efforts to reduce uncertainties are therefore highly necessary. Our study clearly shows the need to implement a dynamic methodology for simulating ammonia emissions in CCMs and CTMs.

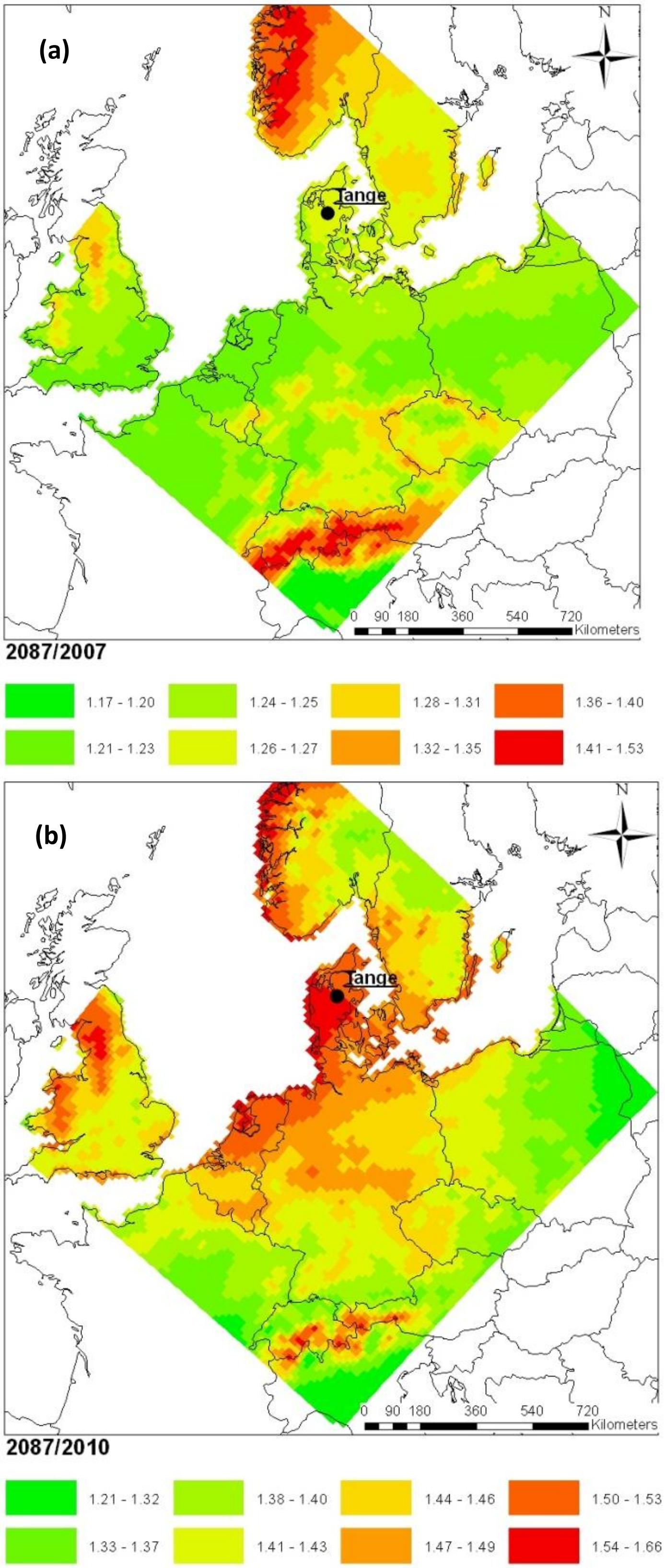

Figure 2.7: Annual emissions from a pig production facility with 1000 animals using average Danish production methods under projected climate conditions in the year 2087 (a) relative to 2047, (b) relative to 2010.

Model development is now underway to modularise the model (to allow attribution by source), to extend the model domain and to increase the grid resolution. Datasets of calculated NH_3 emissions for housing systems, grazing animals and fertiliser and manure application are currently being used for evaluation of these improvements. These emissions have been generated by the INTEGRATOR model (ALTERRA) on the NitroEurope multi-part polygon grid, with higher resolution data (1km x 1km) to be made available later this year. The improved model will incorporate new methods and parameterisations, e.g. of soil NO emissions following fertiliser application, developed by ÉCLAIRE project partners.

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Task 6.4: Emissions profiles from anthropogenic sources

This task involves “the development of temporal (hourly, daily, monthly or seasonal) European emission profiles for key source sectors (road transport, other mobile sources, power generation, industrial production, agriculture) and sub-sectors, based on highly detailed national scale work and accessible national statistics, to enable modellers in ÉCLAIRE to implement these profiles and run models for a wide range of years/scenarios.”

The focus of task 6.4 is on reviewing existing approaches and datasets available for the temporal disaggregation of emission inventories used for atmospheric modelling. The expected result of this task is a consistent set of reference temporal profiles to either pre-processed (offline) emission data as input to models, or to provide parameters to allow models to temporally distribute emissions online in the model code.

Review of existing approaches and datasets:

Anthropogenic emissions profiles and inventories (e.g. EMEP CEIP, EDGAR) used in existing models (e.g. EMEP, CHIMERE etc.) as well as available documentation, have been reviewed to identify the state-of-the-art with regard to the temporal disaggregation of emission profiles for anthropogenic sources. Most datasets can be traced back to data provided by the EUROTRAC GENEMIS project (Schwarz et al., 2000; Friedrich and Reis, 2004) and subsequent refinements (Reis et al., 2008), and are available at a low temporal resolution (monthly or annual). The resolution of emission profiles has been shown to have a large impact on small timescales, regional effects, episodes and the projection of individual source contributions (van der Gon et al., 2011). In addition, van der Gon et al. urge the use of more dynamic, meteorology driven functions rather than fixed profiles for sectors (primarily agriculture – see Task 6.3) where non-anthropogenic drivers determine the timing and magnitude of emissions.

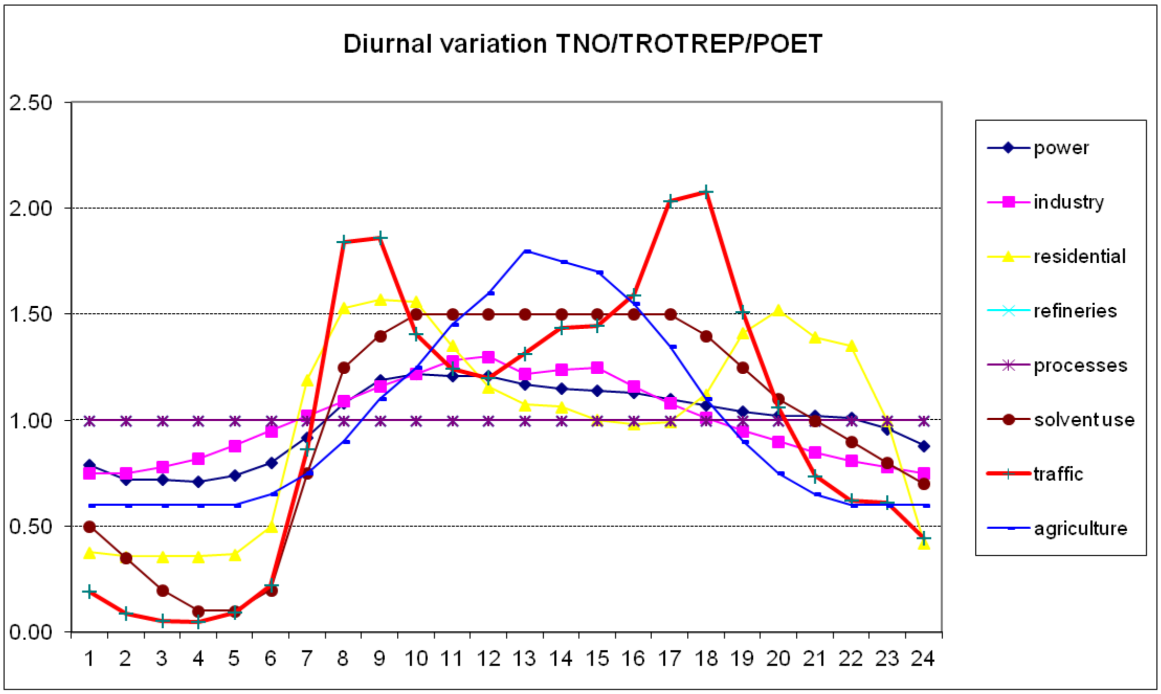
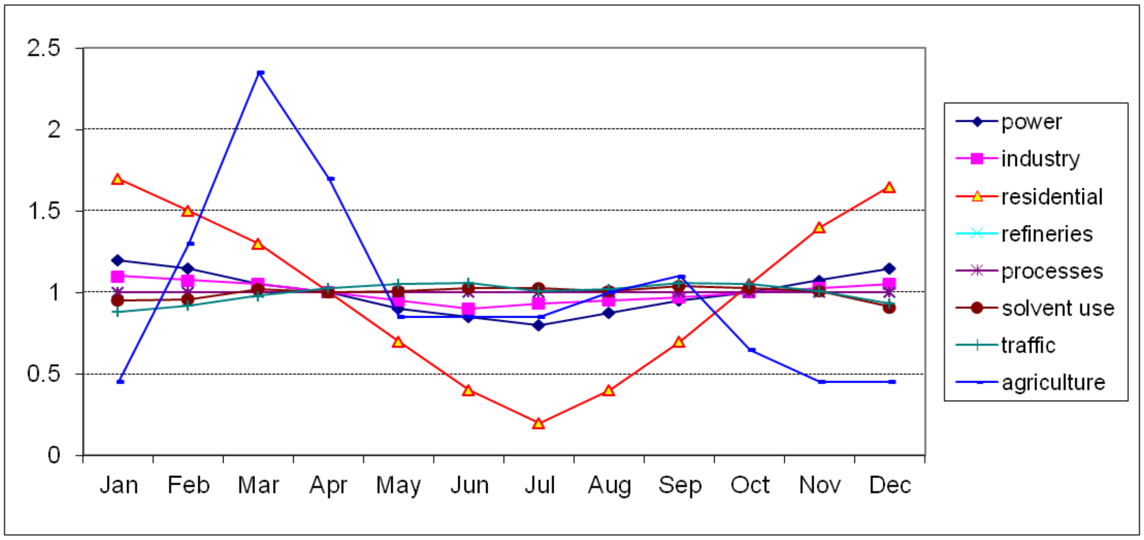


Figure 2.8: Examples for sectoral temporal profiles (based on SNAP 1 level) provided with the EDGAR v3.2 dataset. Profiles are available for diurnal variation (hourly, top left), monthly (bottom left) and weekly (bottom right) variations and are partly based on previous work within GENEMIS, LOTOS/Veldt et al. (1995) and Asmann et al. (1992) for agricultural emissions. ***Source:*** TNO-MEP for TROTREP/POET , online accessible at EDGAR/PBL

(a)



(b)

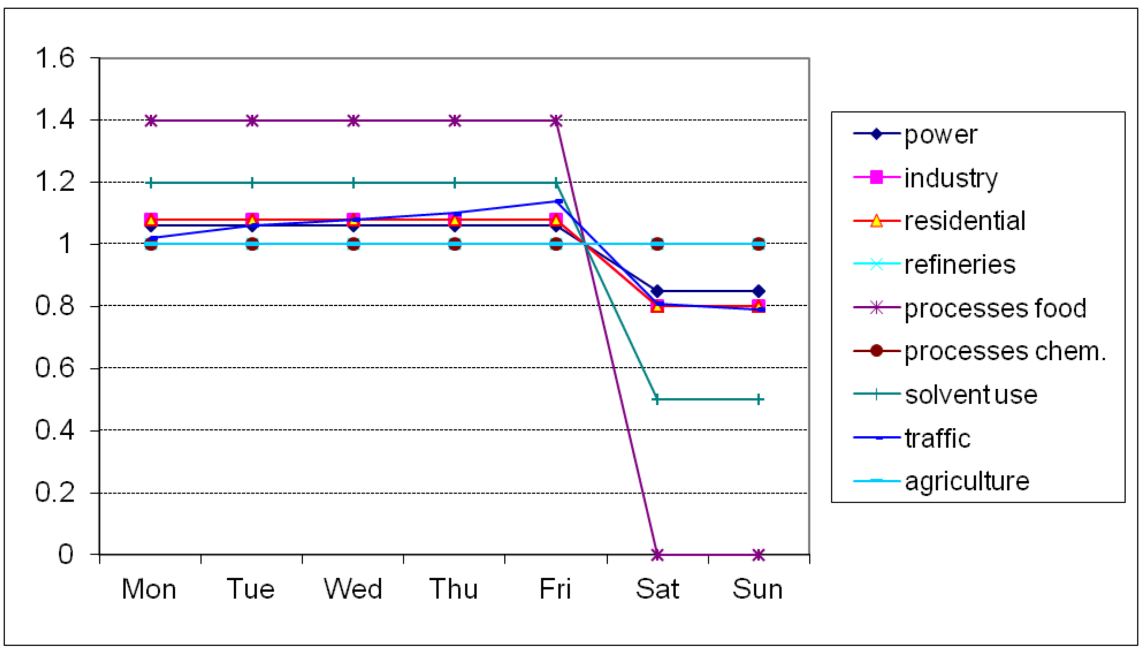


Figure 2.9: Temporal curves for currently accessible datasets (a) by month, (b) by week.

Figure 2.9 shows exemplary temporal curves for currently accessible datasets. However, as shown in Figure 2.10 there can be considerable variability within single sources across Europe, reflecting differences in climatic regions, and national activities (e.g. holiday periods), suggesting the need to gather country-specific statistical data.

Such a time consuming activity (see Reis et al., 2008; van der Gon et al., 2011), would only be of merit if the resulting variations were large enough to affect overall modelling outcomes.

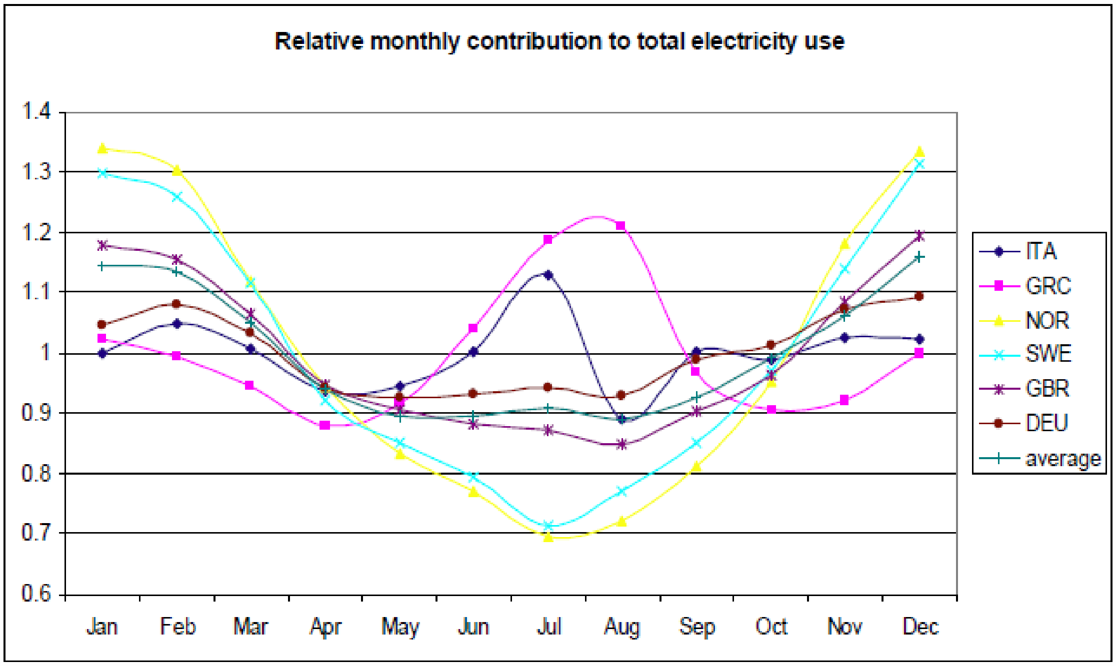


Figure 2.10: Illustration of regional/national differences for the power generation sector (SNAP 1), reflecting different climatic regions as well as annual activity patterns. ***Source:*** van der Gon et al., 2011)

The next step is to provide a set of temporal profiles for ÉCLAIRE project partners based on available profiles as a starting point and focusing improvement efforts on updating key sectors (e.g. using on-going work on road transport emissions within the CARBONES (http://www.carbones.eu/) project and by Menut et al., 2012). These profiles will provide the basis for discussions on the appropriate level of detail required by ÉCLAIRE modelling groups at the next annual meeting in October 2013.

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Progress towards the milestones and deliverables

WP6 is scheduled to deliver 3 milestones (see Table 2.1) and 3 deliverables (see Table 6.2).

Milestones

Table 2.1: Planned Milestones of WP6

Milestone	Milestone Title	Month
MS25	WP meeting and decision on emission model experimental protocol	8
MS26	First improved emissions estimates, based on model development	24
MS27	Improved emissions estimates, evaluated against ÉCLAIRE results	30

MS25 An experimental protocol for Tasks 6.2 and 6.3 has been agreed between WP partners, details of which are reported above.

MS26 DGVM and DSVM models involved in WP6 have been developed as reported above. Model simulations have commenced to deliver the improved estimates. Climate scenario input data are available both in original and bias-corrected version. No delays are expected in the delivery of this Milestone.

MS27 Model evaluation can commence once ÉCLAIRE data from field campaigns and controlled experiments are made available to project partners. At present, no delays are expected in the delivery of this Milestone.

Deliverables

Table 2.2: Planned Deliverables of WP6

Deliverable	Deliverable Title	Month
D6.1	Initial dynamic biogenic emissions, based on synthesis of existing work and mainly for use for testing and set up of ÉCLAIRE atmospheric model experiments, and to test for compatibility of format and resolution of data.	8
D6.2	Improved terrestrial (semi)natural and agricultural emissions in response to integrated effects of climate change, changes in atmospheric CO_2 and N burden, and land use/management change.	30
D6.3	Sectoral emission profiles for selected source sectors and countries for application local-to-regional models.	30

D6.1 A spreadsheet of currently available biogenic, pyrogenic and agricultural emissions estimates was produced, highlighting the format, resolution (temporal and spatial), time period and domain covered and accessibility of the data. This, together with a document outlining the methodologies used to generate these data, as well as giving details of current anthropogenic emissions inventories, was made available to ÉCLAIRE project partners via the ÉCLAIRE website.

D6.1 was delivered on time in May 2012.

D6.2 Models have been developed and improved in order to account for the combined effects of ozone and nitrogen as described in Sections 6.2 and 6.3 (Tasks 6.2 and 6.3) above.

No delays are anticipated in the delivery of D6.2 in month 30 (May 2014).

D6.3 Sectoral emissions profiles are currently being produced from model output and, where available, detailed national inventories of anthropogenic and agricultural emissions. Progress towards D6.3 is described in Section 6.4 (Task 6.4) above.

*No delays are anticipated in the delivery of D6.*3 in month 30 (May 2014).

Use of resources and deviations from DoW

A total of 12 person months were spent on this work package in the past 18 months. The milestone (MS25) and deliverable (D6.1) due during this reporting period were duly delivered on time in Month 8 (May 2012). Progress towards the remaining milestones and deliverables is good and, in spite of the issues previously mentioned , no delays are foreseen in their delivery in Months 24 (MS26) and 30 (MS27, and D6.2 and D6.3).

Work package 7: Modelling European air pollution and deposition

Lead contractor: met.no
Contributors: ULUND, Juelich, JRC, CNRS, SMHI, WU, TNO

Work package objectives

The aim of this WP is to provide maps of O_3-damage metrics and N-deposition over Europe, for current and future scenarios, as inputs to the ecological response and effects packages (C3 and C4) and to integrated assessment modelling (C5). Activities ranging from global to local scale, and linking meteorological, chemical and ecological models will interact with each other and be merged to fulfil these objectives. In particular, new process understanding of biosphere-atmosphere exchange and changes associated with increased CO_2 levels and future climate will be incorporated into CTMs. A small ensemble of CTMs and regional climate-model results will be used to illustrate the robustness and uncertainty of the AQ metrics, in current and future scenarios. Model developments and provision of results will be continuous, in order to make best use of C1 updates at any given time, but also to provide provisional data to C3-C5 as early as possible.

1. To map current air pollution metrics (APMs, mainly ozone damage indicators, POD & AOTx, and N-deposition) using a small ensemble of CTMs, in order to provide a best-estimate and uncertainty range on vegetation effects metrics.

2. To implement on the European scale new modules for stomatal uptake, in-canopy-chemistry, and emissions and sub-grid effects into the EMEP chemical transport model, able to take account of changes in CO2, N deposition, BVOC emissions and climate over coming decades.

3. To estimate changes in APMs to specific ecosystems up to year 2030 and 2050, accounting for climate-changed induced changes in meteorology, vegetation, and biosphere-atmosphere exchange processes.

Progress and Results

Task 7.1: Implementation of advanced exchange models into European CTMs

- In cooperation with WP4, development work has begun on the ÉCLAIRE surface exchange model, which combines chemistry from the EMEP code with in-canopy emission, dispersion and deposition processes in a 1-d model.

Task 7.2: Scenario calculation of climate effects for assessment of air pollution transport and deposition

- An ensemble of five CTMs was used to examine the effects of climate change on ozone fields across Europe up to 2050. The EMEP MSC-W, MATCH, DEHM, SILAM and EnvClimA models and the response of ozone to climate change over the years 2000 to 2050 (Fig. 2.11). This work suggested that climate change has likely only a small impact on O3 concentrations, although the effect on ozone-uptake (fluxes) remains to be investigated. This work (Atmos. Chem. Physics, Langner et al., p10423-, 2012) also highlighted the large differences associated with the models emissions for biogenic VOC.
- The MATCH model was also used to study the relative impact of emissions and meteorological changes on summertime ozone over the period 1990 2100. This work (Langner et al. ACP, p10097-, 2012) and similar studies involving WP7 partners) clearly shows that emission changes, rather than climate change, are the main factor controlling ozone changes in the 21st century.
- Downscaled climate (meteorological) data from the SMHI RCA3 model have been delivered to C2 and C4 partners for the period 1960-2050. Bias-corrected data have also been delivered where possible. These data will drive ecosystem models and CTMs.

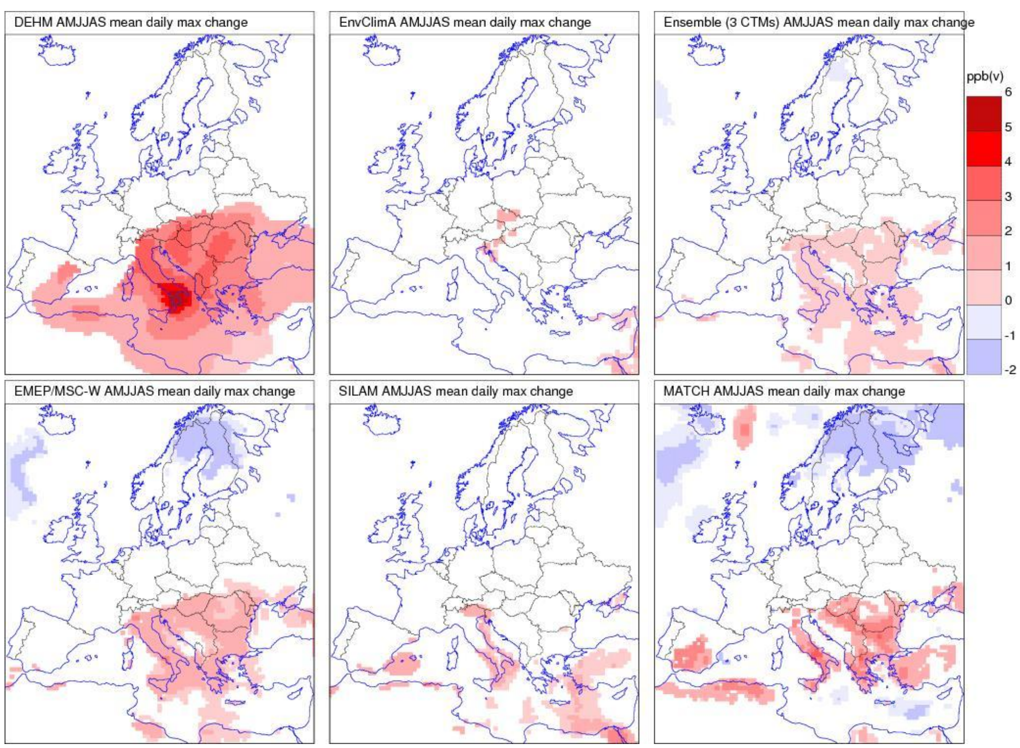


Figure 2.11: Simulated April-September change 2000-2009 to 2040-2049 in average daily maximum O3 concentration at the first model level. Only changes that are statistically significant at the 95% level are plotted. Units ppb(v). (Langner et al., " A multi-model study...", ACP, 2012).

Task 7.3: Assessing the importance of biogenic emissions and in-canopy chemistry on pollutant deposition at the European scale

- The development of the ESX model has started, with a major aim being to investigate the impact of biogenic emissions and in-canopy deposition on deposition fluxes.

Task 7.4: Calculation of European fields and source-receptor matrices for deposition and pollution metrics/thresholds under future climate change

- Maps of nitrogen deposition for the period 1990-2010 have been delivered to C4, for comparison with forest biomass damage indicators. Maps of ozone flux (POD1, POD6) have been delivered to several partners. This kind of delivery will be continued throughout the project.

Task 7.5: Ensemble calculation of maps of deposition and pollution metrics and analysis of uncertainty

- As noted above, ensemble calculations of the effects of climate change on ozone from 5 CTMS for the year 2050 have been published.

- A second major effort, initiated by the Task Force on Measurements and Modelling, has been the project: "ScaleDep. Performance of European chemistry-transport models as function of horizontal spatial resolution", in which the EMEP MSC-W, LOTOS-EUROS, CHIMERE, RCGC and CMAQ models have been run at spatial resolutions of 7, 14, 28 and 54 km across Europe. This project has focused on maps of O_3, NO_2 and PM, comparing model performance across Europe at these different resolutions. A report on this work has been prepared and will be presented at the Task Force on Integrated Assessment modelling in April 2013. In order to complete the ÉCLAIRE analysis, further CTM model results are being submitted within the same framework, and all models will be compared with a database of measurements collected within WP7.
- A third multi-model exercise which is underway is the EuroDelta-3 (ED3) study, which focuses on shorter time-periods in more detail.

Progress towards the milestones and deliverables

D7.1 Maps of current air pollution metrics (APMs) across Europe, from the EMEP model and five other CTMs (M18)

The originally planned work for D7.1 has been replaced (delayed) to some extent by all the activities (TFMM, ED3) on multi-model comparisons discussed above. Within

ÉCLAIRE we will expand on the TFMM study with a specific study on model performance for N-compounds compared to measurements, and also to deliver the ozone maps envisaged for D7.1. The modelling groups from the TFMM study have also agreed to allow the analysis of their data in support of ÉCLAIRE. ***Update September 2013:*** This deliverable has now been completed.

D7.2 Improved EMEP model with climate-change and canopy-chemistry capabilities, able to predict the impact. (M40)

– Work on the ESX model discussed above has started, lead by met.no and FMI as a WP4-WP7 cooperation.

D7.3 Report on effects of in-canopy BVOC and NO emissions on in-canopy O3 and POD estimates (M44)

- No problems foreseen.

D7.4 Report on effects of changes in global climate, chemistry, emissions and landcover changes on APMs (M48)

- No problems foreseen.

D7.5 Source-receptor matrices of APMs for current and future conditions (M36)

- No problems foreseen, although it is questionable if there will be a demand for this as early as M36. A later deliverable would allow more use of ÉCLAIRE advances.

MS28 Implementation and initial testing of coupled model system (M24)

- Started. No problems foreseen

MS29 Initial ensemble runs for current conditions (M18).

- Achieved. In fact, many ensemble results are available and currently in analysis.

MS30 Incorporation of sub-grid methodology from WP4 into EMEP model (M30)

- No problems foreseen

MS31 Future scenario data-sets ready (M30)

- No problems foreseen

MS32 “Final” model-system ready. Commencement of source-receptor calculations (M36)

- No problems foreseen, but see comments to D7.5.

Use of resources and deviations from DoW

A total of 10.5 person months have been spent on this activity, the modifications to the work of D7.1 have been described already above and no deviations have occurred or are foreseen with the rest of this work package.

Work package 8: Assessing local and regional variation

Lead contractor: ECN
Contributors: NERC, met.no, KIT, INRA, UPM, AU, ULB

Work package objectives
The aim of WP8 is to develop a better scientific understanding of the air pollution and climate change relationships at regional/local/landscape-scale and sub-grid approaches for inclusion in large-scale models that enable a good representation of the multitude of processes that play a role on smaller scales (e.g., landscape-scale). By doing this, large-scale concentration and deposition patterns will better represent the local-scale interactions and provide more relevant input, e.g., for European scenario studies that involve one or more of the affected parameters. The objectives are:
1. To synthesize the available knowledge on local interactions in relation to climate and air quality, as well as the way this knowledge is included in local-scale atmosphere-biosphere modelling systems;
2. To analyse the sensitivity of the landscape scale effects on changing pollutant fluxes, especially as affected by climate change;
3. To include local/landscape-scale effects of climate change and air pollution interactions into large scale/European scale models by means of sub-grid representation of the most important processes.

Progress and Results

Task 8.1 – Synthesis of existing local-scale transport models with atm-bios exchange

The literature study in Task 8.1 is delayed. Although the activity is important for the overall understanding of air pollution / climate interactions in the various models, currently this doesn't pose a large problem for the work in the other work packages. It is foreseen that this literature study will be finalized in the second quarter of 2013.

Task 8.2 – Improved scientific understanding of air quality and climate change relations at the landscape scale

For Task 8.2 the main activities are related with the further development of the NitroScape model. From the beginning of the project, it was clear that there were different challenges with respect to this activity. After an initial delay due to a missing PhD student, activities have started but first real results for the ÉCLAIRE test areas are foreseen in the latter half of 2013.

Another activity within Task 8.2 is the delivery of deposition and concentration fields to Work Package 17 for the evaluation of critical loads exceedances at different spatial resolutions. These fields are calculated by means of the EMEP4UK model, for which the meteorological information is available. Subsequently, the model has run successfully for the agreed ÉCLAIRE domain at a resolution of 5x5km (Fig. 2.12). Next step will be to perform the calculations on a 1 km resolution for Scotland and The Netherlands. Initially the calculations will use emissions derived from EMEP 50 km emission. In a later stage more detailed emissions for The Netherlands may be required. The delivery of the depositions to WP17 is foreseen for end of May 2013. This completely fits within the time schedule for WP17 and has been verified with the WP17 leader.

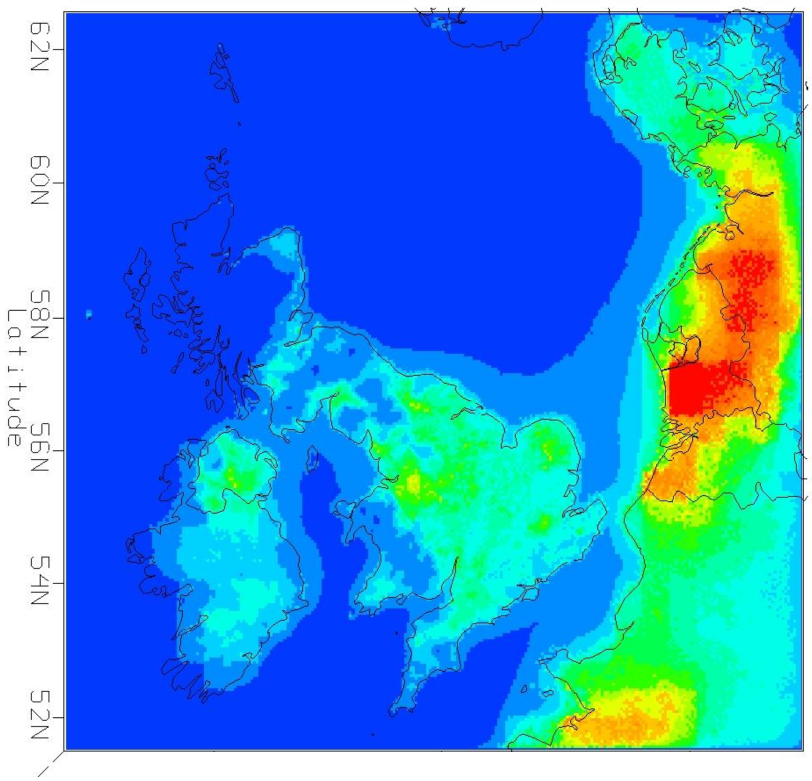


Figure 2.12: Modelled nitrogen deposition at a 5x5 km resolution for the ÉCLAIRE modelling domain, using the EMEP4UK deposition model.

Task 8.3 – Development of sub-grid parameterisation/corrections for European scale CTMs

The Task 8.3 activities are related to developing a sub grid module for inclusion in large-scale models. Initial discussions (ECN, NILU, UEDIN) on the way forward with respect to this development have been going on. The final decision on the approach to follow for this Task is foreseen to be taken in the coming months, after which the actual development will commence.

Progress towards the milestones and deliverables

MS 33 Inventory of relevant local scale models (Month 10)
The inventory of different relevant local scale models used in Europe has been performed. The list of models is used for further analyses under Task 1 (see next MS).

MS 34 Report on local scale models inventory (Month 12)
As mentioned under section 2.1 (Task 8.1), this literature study is delayed. Work has started, but is not fully finalized yet. ***Update September 2013:*** It is foreseen that this study will be finalized in the second quarter of 2014 (month 34), as listed in the participants portal. NOT 2013 as per the typing error in the previous version of this report.

MS 35 update of Nitroscape to reflect ÉCLAIRE needs (Month 16)
The update of Nitroscape to reflect ÉCLAIRE needs has not yet been accomplished. Currently the following steps in the Nitroscape update are foreseen:

April-July 2013: testing NitroScape on virtual landscapes with:

- the updated version of FASSET (with the FASSET-initiator) or use of the routine FARM-EF which uses farm emission factors only, according to available information.
- the updated version of OPS including the use of a receptor mask, or the use of the version of OPS without mask (longer simulations).

May-October 2013: applying NitroScape on the French landscape (NEU landscape with the most complete dataset)
November 2013 - end 2014: applying NitroScape on other NEU landscapes (including Scotland and the Netherlands), contributes to ÉCLAIRE WP8 deliveries/milestones (MS36 and D8.3)
November 2013 - October 2016: PhD position on sub-grid variability, contributes to D8.4. First results expected from 2015. ***Update September 2013:*** There has been some progress here and overall delivery is on schedule with that reported above. However in order not to delay the progress of D8.3 and MS36, alternative methods of landscape scale data generation are being employed, which are to be discussed further at the next project meeting (in Zagreb, month 25).

MS 36 Concentration/Deposition maps (Month 16)
As mentioned before under Task 8.2, the work for the work on this topic is progressing well. The delivery of the depositions to WP17 is foreseen for end of May 2013. Although this is a delay compared to the initial plan (Month 16), this delay was communicated with the WP Leader for WP17 and it was decided that this still completely fits within the time schedule for WP17. ***Update September 2013:*** Generating the landscape scale data has caused further challenges, and the best way forward is to be discussed at the next project meeting, next month in Zagreb. Consequently delivery is not expected until month 29. However, there has been close communication with the leader of WP17 and it is agreed that this will not have any negative impacts on the overall delivery of WP17.

MS 37 Description of local scale interactions between air quality and climate change (Month 30)
No problems foreseen

MS 38 Sub-grid module available for implementation in EMEP model (Month 40)
No problems foreseen

D8.1 As mentioned in section 2.1 (Task 8.1), work has started. ***Update September 2013:*** It is foreseen that this study will be finalized in the second quarter of 2014 (month 34), as listed in the participants portal. NOT 2013 as per the typing error in the previous version of this report.

D8.2 Report on local scale interactions between air quality and climate change (Month 30)
No problems foreseen.

D8.3 Concentration and deposition maps (Month 16)
See MS 36. ***Update September 2013:*** Discussions will be held in Zagreb next month regarding the landscape scale data, consequently delivery will not be until month 29.

D8.4 Sub-Grid module for inclusion in the EMEP model (Month 30)
No problems foreseen, although we might have to reconsider the delivery date for this deliverable. In the discussion with the modellers we have to determine if the initial delivery date is early enough for the sub-grid module to be still relevant in the planned modelling work.

2.1.3 Component 3: Ecological response processes and thresholds

Lead contractor: DTU

Component objectives

- A new database and results of meta-analysis on air pollution impacts on land ecosystems including soils.
- Ecosystem response data on plant responses and ecosystem C balance to experimental changes in air pollution and interacting drivers, including climate and land use differences.
- Parametrization of the fraction of O3 that is taken up by leaves due to detoxification by constitutive BVOC, under associated environmental constraints and during leaf development, assessment of the relative effects of wet/dry and NOy/NHx deposition and the role of aerosol deposition in exacerbating drought stress.
- Novel thresholds for key dose-response relationships for application in regional scale modelling and mapping relevant for ecosystem service assessment.
- Assessments of the effects of combined air pollution and climate change scenarios on ecosystem C/GHG balance, soil quality and vegetation change at the experimental sites, based on integrated models.

Progress and Results

WP 9 Synthesis and meta-analysis of measurements of plant-soil responses

A database has been compiled that includes modelled data on N and S deposition and phytotoxic ozone dose (POD) provided by EMEP, drought stress indicator (WATBAL model) and meteorological data, and tree growth and soil parameters from the ICP Forests database for over 300 plots. Data cover the periods 1995-2000, 2000-2005, 2005-2010 and 1995-2010, although only 65 plots have data over the whole time period. Empirical analysis of this data has commenced.

A database with data from data mining of the literature is 60-90% completed for shrublands, agriculture and grasslands.

WP 10 Field scale ecosystems manipulation and controlled studies on ecological responses

Protocols for experimentation and documentation of the experiments have been done and all sites are producing data to be uploaded and used for ecosystem modelling. All experiments have collected data on plant responses to experimental treatments and in most cases the data are or will soon be uploaded to the ÉCLAIRE database system.

WP 11 Investigation of novel ecosystem – air pollution - climate interactions

Measurements on plant responses to N-exposure were delivered for 2012 and additional measurements for 2013 are programmed. These will be targeted at outstanding questions concerning the role of N dose and form on C cycling on a peatland site, which will be in its 11th year of continuous N addition.

Measurements of canopy-level ozone fluxes have been setup and will be continuously measured at the eddy-covariance site of Castelporziano, in order to compute several episodes of extreme events: drought, high tropospheric ozone, high temperatures. This also includes NO_x gradient from soil to above the canopy and particle measurents of PM 2.5 and PM 10, which will be measured to investigate bi-directional fluxes in the continuum soil-plant-atmosphere and the interaction of particles on C exchange in the Oak forest of Castelporziano. Monitoring of carbon and ozone fluxes as well as BVOC gradients will be carried out in a Picea abies forest, in order to investigate the role of BVOC in the gas-phase reactions of ozone, determine the impacts of ozone uptake on canopy-level carbon exchange, and study canopy exchanges due to extreme climatic events. In 2014, fluxes of isoprene, monoterpenes and oxidation products will be measured by GC-MS and PTR-MS.

The reported experimental results from the first measurement period during spring/summer 2012 are the basis to quantify the effects of different salt types and concentrations on minimum epidermal conductance and on transpiration. The measurements will be partly repeated and further extended during spring/summer 2013. The difference in vapour pressure deficits (VPD) between different ventilation speeds in the greenhouses was smaller than anticipated. During 2013 measurements, one VPD regime will therefore be established by keeping plants under a roof, but without walls. A quantification of pollutant dependent influences on plant transpiration and water use efficiency will be summarized end of March 2014.

WP 12 Development and assessment of novel thresholds

A report which describes ‘The development of ‘ecosystem service’ relevant responses has been delivered **(D12.1)** and shared with C5. A new method to estimate loss in C stocks due to ozone exposures for forests growing across Europe (see Task 12.4) is defined. This has required a new forest response parameter (% change in net annual increment) to be defined from re-analysis of the existing data describing ozone losses on total tree biomass.
A new version 5 of the DO3SE model has been developed incorporating a photosynthetic algorithm allowing g_{sto} to be estimated as a function of CO_2 concentration as well as other prevailing environmental conditions. The DO3SE model is rather unique in that it is capable of simulating conditions of the experiments performed in closed or open top chamber conditions. This means that DO3SE can provide an interface between the ÉCLAIRE experimental data and some of the key

model processes used by many of the ÉCLAIRE ecosystem models (e.g. An, g_{sto}, respiration (R) and carbon (C) allocation.

An experimental data template for data upload from the experiments has been developed in consultation with the ÉCLAIRE data management team. This template (and associated documentation) allows experimentalists to record empirical data according to common measurement protocols and upload data into a standardised format that will allow storage on the ÉCLAIRE data management site in a format that can be readily downloaded and used by modellers. Currently the uploading and quality checking of the ÉCLAIRE data is ongoing, but running a little behind schedule. This has delayed the data analysis within the DO3SE model which is the main focus of this task and will be conducted over the coming months.

Progress has also been made in defining a new method to estimate loss in C stocks due to ozone exposures for forests growing across Europe. This method performs a re-analysis of existing forest flux-response relationships to enable application with forest growth data expressed as net annual increment (rather than total standing stocks).

WP 13 Modelling of carbon stocks, GHG and vegetation change

The MADOC model, which comprises linked models describing carbon-nitrogen dynamics (N14C), acid-base chemistry (VSD) and organic matter solubility (DyDOC) has been fully implemented, and tested on a set of UK experimental and monitoring datasets. Mechanisms for ozone impacts on processes in MADOC have been identified and equivalent mechanisms added within the model, using parameter values derived from a preliminary analysis. Initial sensitivity assessments have been undertaken. These processes will be fully implemented in the model following completion of the data mining activity.

Developments of LPJ-GUESS model, and the development of the Forspace model together with its coupling to VSD+, are described in the activity report for WP14. These models will form a part of the model testing and application against experimental sites for WP13.

MADOC model testing has been initiated for the Branbjerg site following a site visit and liaison with the experimental team. The experiment is fully factorial for temperature (night-time warming), drought (rain exclusion) and elevated CO_2. Ozone treatments are being superimposed on shoots of the two main vascular plants on the site, *Deschampsia flexuosa* and *Calluna vulgaris*. As well as establishing model parameter values that encapsulate the experimental treatments, key measurements that can be used to test model outputs have been identified, such as plant productivity data. Important seasonal dynamics have also been ascertained. For example, the drought treatments have affected annual water flux (which governs dissolved-organic-matter flux in MADOC) rather little, whereas large differences were observed in autumn moisture content. The latter measurement may therefore be suitable as a driver of habitat suitability in the MultiMOVE niche model. A full model set up for selected treatments is now under way, and will be followed by parameterisation and testing for the other experimental sites.

Progress towards the milestones and deliverables, use of resources and deviations from DoW

Milestones and deliverables are described under each WP.

The general picture is, that all activities are running as planned, but with some delays. The major delays are associated with:

Data mining – The data mining is ongoing and almost completed. The activities have been slightly delayed because the design of guidelines and templates for conducting data mining has been much more demanding than anticipated in order to meet the high standards required for the final database in order to be used for meta analyses or other syntheses.

Experiments – The experiments have delays in producing the data originally planned because it has been time consuming to harmonise the measurements across already ongoing and existing experiments and have these aligned with the model requirements. All experiments are now producing the data anticipated and are uploading these to the ÉCLAIRE database and are also in direct contact with modellers for model setup and application

Modelling – Model application is dependent on data from the experiments and is ongoing on a site-model specific interaction level. The modelling is delayed because of the abovementioned delays in data delivery, but this is now running.

Work package 9: Synthesis and meta-analysis of measurements of plant and soil responses

Lead contractor: NERC
Contributors: DTU, ALTERRA, SEI-Y, UoY, UGOT, WSL, IVL

Work package objectives

- To conduct a pan-European data mining exercise compiling data from previous survey, field-scale manipulation and controlled exposure experiments on air pollution impacts on ecosystem function and services, including interactions with other drivers such as climate change
- To conduct a meta-analysis on the compiled data to inform modelers of the most important effects
- To analyse the data to develop a database of response-relationships for key ecosystem processes, functions and services to air pollutants (singly, and where available, in combination) including the influence of climate change, for use in activities WP12 and WP13.
- To identify key knowledge gaps that can be filled by experimentation in WP10 and WP11.

Progress and Results

All tasks
Data mining comprises of three main activities: compilation of data from long-term exposure experiments for testing models, empirical analysis of a long-term monitoring data set (see Task 9.1) and data compilation from published papers for analysis of responses for model development. For each, a data template was developed, tested and applied.

Data mining from long-term experiments: After consideration of all data sets available, the following were identified as suitable for initial model testing:

- Whim bog, UK: N form experiment on peat bog
- Brandbjerg, Demark: Dry heath exposed to CO_2, warming, drought, N
- Alp Flix, Switzerland: montane grassland exposed to ozone and nitrogen

A data template was compiled and the process of collecting data has begun.

Empirical analysis of a long-term monitoring data set using the extensive monitoring data from the ICP Forests, data compilation commenced in the first year of the contract.

However, very sadly, the lead scientist involved from WSL passed away suddenly in the autumn, 2013. After an appropriate time interval, data analysis is now resuming.

Data mining from scientific papers: The main focus of the literature-based data mining activities is to acquire response functions for the first stage improvement in model parameterisation being used in C3 and C4 modelling. We are focussing on the effects of ozone, alone and in combination with other pollutants and environmental stressors, on leaf-scale, season-long dynamics and ecosystem processes, particularly those associated with stomatal conductance, photosynthesis and carbon allocation. The first phase of the work, completed in late 2012, was to develop a template appropriate for all suitable physiological, growth and ecosystem-scale data available in the scientific literature. The aim was to produce one template that would feed data into one database in a standardised way to enable unique analysis of relationships between for example effects on photosynthesis and growth, and across species and vegetation types. However, this activity took considerably longer to complete than planned as when this template was developed it became apparent that there were a large number of fields to handle, with complex relationships between them. After investigating the applicability of the ÉCLAIRE database software for this type of template it was decided that a more effective approach would be to use an MS ACCESS system to store the data. This also meant that the templates in development had to be further modified. For completeness, metadata and a link to the ACCESS database will then be added to the ÉCLAIRE database, so that all project data can be discovered through one site. At the same time as template development was taking place, a series of research questions and expected endpoints were agreed by the group for leaf-scale, season-long dynamics and ecosystem processes. These were used to specify search terms for use in Web of Knowledge, with searches conducted by Zhaozhong Feng, Gina Mills and Felicity Hayes and combined within one EndNote database. After removal of duplicates, there were 2838 potential papers of interest. Using strict rejection criteria based on the content of the abstract, this was reduced to 1205 papers for more detailed consideration by looking at the paper itself. At this stage, the list of papers was sent to contributors for completion of templates. It was anticipated that a further one half of the papers would not meet the criteria for inclusion. Figure 3.1 shows the distribution of papers, by vegetation type and theme. In the individual task descriptions, we provide an update on current progress.

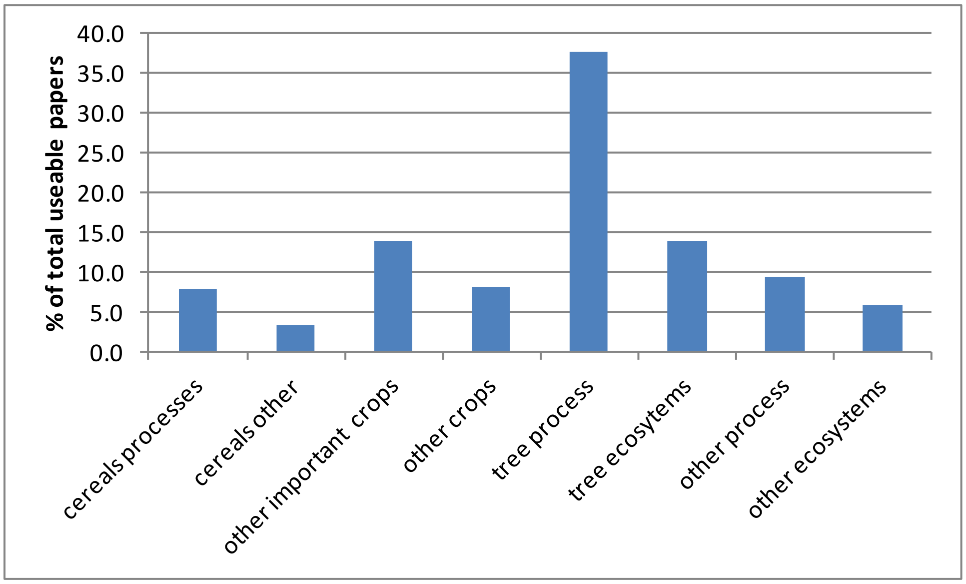


Figure 3.1: Percentage of relevant papers within each category (out of the 1205 included for more detailed analysis)

Task 9.1: Forest ecosystems

As described above, there has been some delay in empirical analysis due to the sad loss of one of the lead persons. Nevertheless, significant progress has been made. A database has been compiled that includes modelled data on N and S deposition and phytotoxic ozone dose (POD) provided by EMEP, drought stress indicator (WATBAL model) and meteorological data, and tree growth and soil parameters from the ICP Forests database for over 300 plots. Data cover the periods 1995-2000, 2000-2005, 2005-2010 and 1995-2010, although only 65 plots have data over the whole time period. Empirical analysis of this data has commenced.

For the literature-based data mining, there has been very limited progress for forest trees so far, in part due to staffing issues at participating sites.

Task 9.2: Grassland ecosystems

Data mining from the literature is around 60% completed.

Task 9.3 Agricultural ecosystems

Data mining from the literature is around 90% completed.

Task 9.4: Wetland and dry heath ecosystems

Data mining from the literature is ca. 60% completed.

Progress towards the milestones and deliverables

D9.1 Progress report on availability of data for use in WPs 12 and 13: Completed

D9.2 First phase database for use in initial modelling and identification of data gaps for experiments being conducted in WPs 10 and 11. Completed by having a meeting at the ICP Vegetation Task Force Meeting (January, 2013) to discuss data needs for the 2013 experiments.

Use of resources and deviations from DoW

A total of 14.3 person months have been used on this work package, including the extra time spent on developing the template for literature-based data mining. This was more than originally anticipated as a more complex template was considered beneficial for future analysis. As a result, this aspect is running around 6-9 months behind schedule, however it is not anticipated that this will delay further work packages significantly.

Work package 10: Field-scale ecosystem manipulation and controlled studies on ecological responses

Lead contractor: DTU
Contributors: UNICATT, CIEMAT, FDEA-ART, NERC

Work package objectives

1. To conduct relevant field-scale and controlled-exposure experiments on impacts of air pollution components on plant and ecosystem processes including interactions with climate change.

2. To use these experiments to quantify impacts of air pollution, in particular ozone and nitrogen components on key ecosystem processes, greenhouse gas exchange and ecosystem carbon balances

3. To provide inputs for developments and parameterization for modeling (WP13).

Progress and Results

Task 10.1: Forest site experiments

Brescia – Italy
UNICATT is performing a two-year Open-Top Chambers experiment on *Quercus robur* and *Carpinus betulus* saplings. The experiment is conducted in the CRINES O.T.C facility of Curno (Northern Italy) and started in April 2012. Plants were grown in 12 Open-Top Chambers and treated with 4 different levels of ozone (-50%, -5%, +35% and +70% of ambient ozone) and two different levels of nitrogen wet deposition (control and +70Kg/ha year-1). A split-plot design with randomized blocks and two nested factors (ozone and nitrogen) was specifically conceived in order to have 3 replicates for each different ozone/nitrogen treatment. Continuous measurements of ozone and the main agrometeorological variables were performed between April and October 2012 inside the Open-Top Chambers. Ecophysiological measurements on plants' leaves included:
- Leaf stomatal conductance with a diffusional dynamic porometer.
- Gas-exchange measurements with a portable IRGA analyser (CIRAS II) of net photosynthesis and response curves (A/Ci and A/PAR)
- Chlorophyll a fluorescence of Photosystem II with a portable fluorimeter.
- Leaves and Soil analysis on total nitrogen content.

At the end of the first year of experiment (October 2013) half of the plants investigated were harvested for evaluations of biomass losses (separating between roots, stems and leaves).
Results are a database of the measurements taken.

Bangor – UK

Ozone x nitrogen interaction experiments were conducted in the solardomes at CEH Bangor from May to October, 2013. Three year old silver birch (Betula pendula) were exposed to a full factorial design of 7 x O3 and 4 x N treatments throughout their growing season, and photosynthesis, stomatal conductance and growth measurements were made. The ozone profile represented likely ozone pollution control scenarios with increasingly larger reductions in peak size together with small decreases in background ozone. The average weekly profile is indicated in Figure 3.2, where the highest treatment was an ozone episode recorded at a UK rural monitoring site (Aston Hill) and repeated weekly. This experiment has generated data for model development, including for DO_3SE and JULES. Most of the data has already been transferred to the ÉCLAIRE template and is ready for uploading. Some key results from this first of two seasons of ozone exposure were:

- Increasing ozone concentration decreased leaf number, tree height and tree diameter; the N signal was not very clear at the end of this first exposure season (Fig. 3.3a)
- Across all ozone treatments, increasing N increased stomatal conductance (Figure 3.23b) and leaf chlorophyll content
- Including N treatment in the DO_3SE model increased the fit to growth parameters
- There was a decrease in V_{cmax} and J_{max} with increasing ozone in younger leaves but not older leaves
- A_{sat} was not affected by ozone or N in young leaves, but decreased with increasing ozone in older leaves
- NEE decreased with increasing ozone, with no clear N interaction

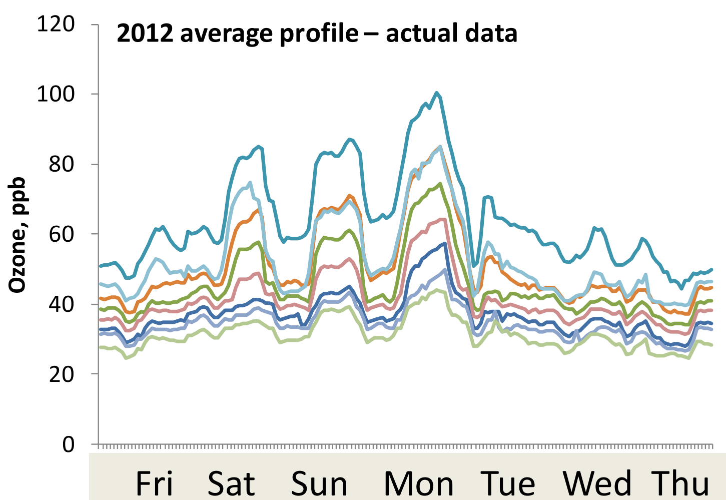
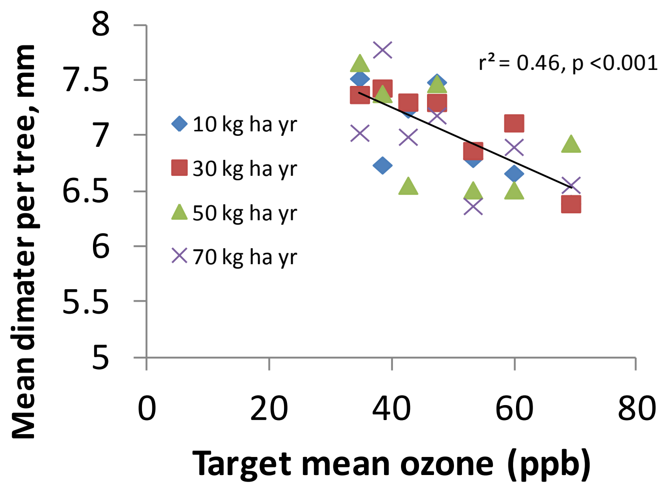
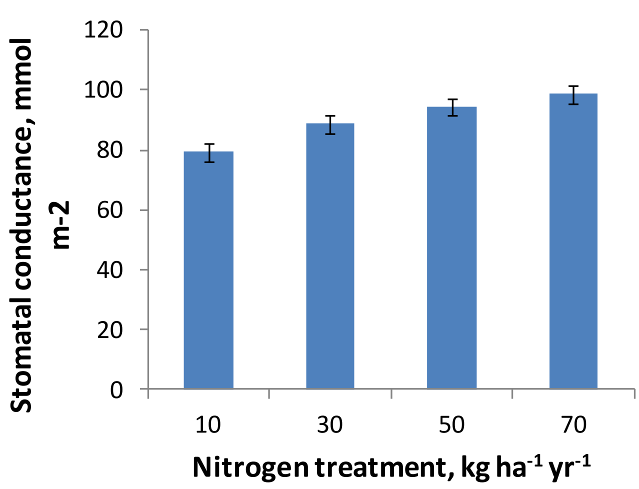


Figure 3.2: Average weekly ozone profiles for the 7 ozone treatments used in the 2013 growing season



(a)



(b)

Figure 3.3: (a) Effects of ozone and N treatment on silver birch stem diameter, and (b) Effects of increasing N treatment on mean stomatal conductance.

Task 1.2: Agricultural site experiments.

Madrid – Spain

CIEMAT has set an O_3 sensitivity screening experiment at field scale of different leafy crop cultivars of lettuce, spinach, escarole and chard. Leafy crops are horticultural products of high economic value in the Mediterranean area. This experiment is currently running (spring 2013) and it aims to evaluate O_3 sensitivity of different cultivars and species: 4 cultivars of lettuce, 3 of spinach, 3 of escarole and 2 of chard. The experiment will be repeated in 2014 using the most sensitive cultivars/crops to O_3 and including the evaluation of interactions with nitrogen (N) addition. The experiments are conducted in an Open-Top Chamber experimental facility located in central Spain. Meteorological variables, air pollution levels and bulk N atmospheric deposition are being continuously monitored during the growing cycle. Four O_3 treatments have been established: below ambient O_3 concentration using charcoal filtered air; ambient O_3 concentrations; ambient + 40 ppb of O_3; ambient + 60 ppb of O_3. In 2014, three N addition treatments will be evaluated combined with the O_3 treatments: background N deposition, background + 20 Kg N ha-1 y-1; and background + 40 Kg N ha-1 y-1. Ozone and N effects will be evaluated on important variables of economic significance for leafy crops: foliar visible injury appearance and yield. Additionally, plant physiological variables related to gas exchange (stomatal conductance, net assimilation, light curves) involved in the response to O_3 and N interactions are being measured intensively. This dataset will provide the information for modelling the response of horticultural crop growth to ozone pollution under current and future climatic conditions. Results will also be used for assessing the role of nitrogen availability (deposition + fertilization) on crop responses to ozone. Effects on yield and foliar visible injury will be used for O_3 damage risk assessment on horticultural crops and for defining novel thresholds to protect crops from excessive air pollution levels. Results will also be a valuable source of information on assessing whether N fertilization strategies can be used to mitigate O_3-induced effects in agricultural systems. The current experiment is planning to end in May 2013. Database construction, data filtering and upload of 2013 experimental results will be finished in autumn 2013. Programmed dates for the second experimental campaign on leafy crops: February to May 2014.

Task 1.3: Shrubland site experiments.

Brandbjerg – Denmark

A Free Air Shoot Ozone (FASO) fumigation system was developed to conduct the fumigation within in the long term treatments (7 years) at the CLIMAITE site. Treatments at the site are un-manipulated control (A), elevated CO_2 (FACE, 510 ppm, CO_2), passive night time warming (IR reflective curtains, 1-4 ^oC, T) and periodic spring/summer drought (rain excluding curtains, D) and all combinations replicated in 6 blocks (see Figure 3.4 for outline). The ozone was generated from an UV- lamp ozone generator (UV PRO 1100 AT, Crystal air, Langley, BC, Canada), distributed through a manifold to each experimental plot. Then ozone was distributed through PTFE tubes (3 mm dia) with small holes (<0.5 mm wide, 5 mm apart) coiled around the shoot forming a cylinder (7 cm diameter and 22 cm height) (see picture). This system allowed local exposure of leaf samples and excluded the remaining part of the experimental plot to be fumigated. A double manifold air sampling system connected to an ozone analyser allowed for measurements of the ozone concentration in each experimental unit. This increased the average ozone from 27 ppb in the ambient air (maximum 79 ppb, AOT40 0.874 ppm per hour) with 21 ppb to 48 ppb in elevated ozone (maximum 143 ppb, AOT40 4.393 ppm per hour) across the exposure period of 4 weeks.

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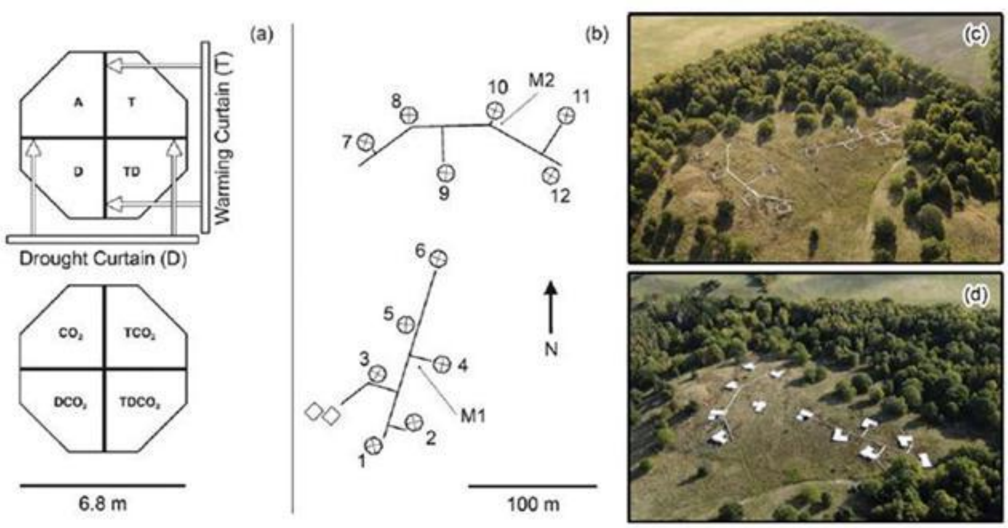

Figure 3.4: Brandbjerg site treatment layout.

Episodes of ozone fumigation have been applied to the grass (Deschampsia flexuosa) within the treatments at the CLIMAITE site. We tested the impact of ozone (O_3) interactions on leaf level photosynthesis within the treatments of elevated CO_2 (CO_2), passive nighttime warming (T) as a full factorial experiment with 4 replicates, in total 8 treatments (A, T, CO_2, T+CO_2, O_3, T+O_3, CO_2+O_3, T+CO_2+O_3). We conducted CO_2-response curves and have derived maximum rate of RuBP regeneration (Jmax), maximum rate of Rubisco carboxylation (Vcmax) and leaf respiration (Rd) at in the beginning, middle and end of the experiment. We conducted light curves at ambient CO_2 (380 ppm CO_2 in ambient plots and 510 ppm CO_2 in elevated CO_2 plots) 10 times during the campaign period (4 weeks). After end season harvest leaf carbon, nitrogen and leaf delta13C was determined.

The preliminary results show that elevated CO_2 increases the intercellular CO_2 concentration (Ci) but light saturated net photosynthesis (Pn) is not stimulated due to down-regulation of Jmax and leaf nitrogen dilution. Warming increased photosynthesis. The effects on photosynthesis to warming and elevated CO_2 was additive in the T + CO_2 combination. Exposure to ozone reduced photosynthesis via down-regulation of

Jmax and increased leaf respiration. Surprisingly the stomatal conductance was higher after exposure to ozone and this probably increases the ozone flux into the leaf above expected. When the negative effects of ozone were combined with the positive effect of warming antagonistic and synergistic effects occurred. In the O_3 + T combination the photosynthesis was reduced to a similar level as in the control. This took place via down-regulation of Jmax and the high ozone leaf influx due to the high stomatal conductance. Interestingly the delta 13C was synergistically affected. Hence, over a longer time period than the snapshot of the leaf gas-exchange characteristic could show, the leaf carbon uptake is being synergistically reduced in the O_3 + T combination. Additive effect of ozone and elevated CO_2 are seen in the O_3+ CO_2 in the combination. Antagonistic effects were seen in the full O_3 +CO_2 + T combination with net photosynthesis levelling the control. In conclusion, it seems that interactive effects of ozone can counterbalance the photosynthetic stimulation of warming and elevated CO_2 during autumn in temperate Deschampsia flexuosa. Data are being processed for publication together with leaf ozone dose calculations based on the DO3SE model. The raw data measured have been delivered to the ÉCLAIRE database together with a number of metrological and site specific data.

We plan to expose plants to ozone during the summer, before, during and after the drought period. We plan to make CO_2 and light response curves and some ambient measurements of stomatal conductance and photosynthesis to improve the DO3SE modelling of stomatal conductance.

Brescia – Italy
Formerly UNICATT was committed to perform a 1-year Open-Top Chambers experiment on macchia species, investigating the effects of high levels of ozone and nitrogen deposition.
According to what was suggested during the Component 3 Kick-off Meeting (10^{th}-11st January 2012, Dragor, Denmark) and in agreement with the Component Lead Contractor, UNICATT focussed on broadleaf species with a two-year long experiment on *Quercus robur* and *Carpinus betulus*.

During the kick-off meeting the importance of quantifying the biomass losses due to ozone and nitrogen was stressed. As it is doubtful that these effects can be detected on macchia species (especially with a short-term experiment) UNICATT decided to extend the duration of the Task 10.1 experiment from one year to two years.

Task 10.4: Grassland site experiments

Swiss Alps – Switzerland
To investigate the combined effects of increased nitrogen and ozone (O_3) deposition on productivity, species diversity, as well as on the water, carbon, and nitrogen budgets of a subalpine Geo-Montani-Nardetum pasture, 180 turf monoliths were exposed for seven years (2004-2010) to five N loads (0, +5, +10, +25, +50 kg N ha-1 yr-1) in combination

with three O_3 levels (ambient, 1.2 or 1.6x ambient concentration) in a free-air fumigation experiment at 2000 m a.s.l. in the Swiss Central Alps.

The experimental activities have been finished, soil and plant material was analyzed. Data upload to the ÉCLAIRE database has been completed.

The following data have been analyzed and are accepted for publication:

- Effects on functional group composition and species diversity (Bassin et al., 2013).

Ongoing data analyses:

- Effects on vegetation productivity and stomatal O_3 uptake
- Effects on CO_2 exchange and ecosystem carbon balance
- Effects on ecosystem nitrogen budgets

First results

N addition caused strong changes in community composition and slightly reduced Shannon diversity: Sedges tripled their fractional biomass at the expense of legumes, grasses, and forbs. Compositional changes were significant with +5 kg ha-1 yr-1; at all levels of N however, changes ceased after five years. Elevated O_3 and the combined O_3 x N exposure had no effect on functional group productivity. Overall the results reveal high N sensitivity of the subalpine grassland, but low sensitivity to O_3, singly or in combination with N.

Madrid – Spain

CIEMAT has conducted an O_3 fumigation experiment on a sown community of annual Mediterranean pasture species in an Open-Top Chamber facility over two growing seasons (2011 and 2012). The experiments also included interactions with nitrogen availability. Six representative species of legumes, grasses and forbs from Mediterranean annual pastures (Trifolium striatum, Trifolium cherleri, Ornithopus compressus, Cynosurus echinatus, Briza maxima and Silene gallica) were sown in the field. Plants were exposed to four O_3 treatments for 30 days: below ambient O_3 concentration with charcoal filtered air; ambient O_3 concentration; ambient + 40 ppb of O_3; ambient + 60 ppb of O_3. Additionally, three N treatments were established through applying four fortnightly N additions to reach three doses: background N deposition, background + 20 Kg N ha-1 y-1; and background + 40 Kg N ha-1 y-1. During the 2011 season, isotopically marked 15N was added to study the distribution of N within the pasture. Meteorological parameters, soil humidity, soil nitrogen concentration, bulk atmospheric N deposition and O_3, NO_x and SO_2 concentrations were continuously monitored during the growing cycle. Physiological parameters were monitored throughout the experiment on all the species studied: gas exchange at the leaf and canopy levels under different environmental conditions, gas exchange response to light intensity and CO_2 concentration at the leaf level, leaf chlorophyll content and leaf and canopy level BVOC emissions. Ozone induced foliar visible injury was also monitored throughout the experiment. Soil respiration and soil emissions of NO, NO_2 and N_2O have also been measured during the experiment. Three biomass harvests were performed from plant emergence to senescence in each growing season. Response variables measured on the harvest include green and senescent aboveground biomass, belowground biomass, flower and seed production, seed hardiness and viability (one season), leaf elemental composition, 15N isotope distribution in plant tissues (one season) and in the soil, biomass nutritive quality for herbivorous animals and species composition of the pasture.

Results from the 2011 growing season show that O_3 affected the carbon balance of the annual pasture and interactions with N availability were observed. Above ambient O_3 levels induced a decrease of pasture green biomass up to 25% and increased the production of senescent biomass. Total biomass was also decreased by O_3. As a result of a lower green biomass, pasture net carbon assimilation was reduced per surface unit area, as indicated by the canopy net assimilation measurements. Furthermore, soil respiration increased under O_3 exposure. Other effects of O_3 on the carbon balance of the pasture are still under investigation such as effects on the photosynthetic activity of the pasture and on the emission of volatile organic compounds.

There are also indications that O_3 may affect the N cycle in the pasture since soil N_2O emissions were significantly increased under high O_3 concentrations. Interestingly, high O_3 levels in the experiment were able to offset the fertilization effect of N addition on green biomass, although the differences between N doses were weak due to the high background N concentration in the soil.
Nitrogen addition tended to increase the biomass growth, but not under high O_3 concentrations, and increased soil NO emissions.

Ozone affected the structure and potentially the biodiversity of the annual pasture. Differences in species O_3 sensitivity caused a shift in species abundance, mediated by changes in the abundance of a resistant legume (Ornithopus compressus) and two sensitive legumes (Trifolium striatum, Trifolium cherleri) and a sensitive grass (Briza maxima). Ozone also reduced the flower and seed production of the sensitive legume Trifolium striatum, meaning that carry-over effects on species composition in the following growing season might be happening under ozone pollution.

Progress towards the milestones and deliverables

- **D10.1.** Ecosystem and plant characteristic data for model application. (Month 12) All sites have started the process of uploading the basic plant characteristics data, or are in contact with modellers to make sure that the data are formatted and transferred. This procedure is not fully complete yet. ***Update September 2013:*** This deliverable has now been completed.
- **D10.2.** One year ecosystem response data on plant responses to experimental changes.(Month 18)
  All experiments have data on plant responses to experimental treatments and in

most cases the data are or will soon be uploaded to the ÉCLAIRE database system. ***Update September 2013:*** This deliverable has now been completed.

- **D10.3.** Response data on ecosystem carbon balance responses to experimental changes. (Month 24)
These data follow the Del 10.2.
- **MS42.** Completed
- **MS43.** Protocol for experimental approaches and interactions has been defined and applied.
- **MS44.** Protocol for response measurements has been defined and applied

Agricultural experiments (CIEMAT): the databases collected during the 2013 and 2014 experimental campaigns on gas exchange (deliverable 10.1) and leafy crop responses to O_3 (deliverable 10.2) will provide models with information to evaluate the response of horticultural crop growth to ozone pollution under current and future climatic conditions. Results will also be used to assess the role of nitrogen availability (deposition + fertilization) on crop responses to ozone (deliverable 10.2). Databases will be uploaded and made available for modelling after each of the two experimental campaigns (deliverable 10.1).

Grassland experiments (CIEMAT): the databases of meteorology and physiological variables collected in the 2011 experimental campaign are ready to be uploaded for their use in modelling (deliverable 10.1). Response data on growth and species composition to O_3 and N in 2011 are also ready for upload (deliverable 10.2). Databases of the 2012 experimental campaign will be ready for uploading in the coming weeks.

Use of resources and deviations from DoW

A total of 41.7 person months have been spent on this activity. It has been agreed upon to conduct a two-year experiment in two broadleaf tree species has in place of the one-year experiment on one broadleaf tree and one Mediterranean evergreen species already planned (*cfr* 2.2 Task 1.3 – Shrubland site experiments).

Shrubland experiments (Denmark): The development of the dosing system for field dosing of O_3 has taken more time than expected but is now up and running, and the delay is not expected to have major impacts on the final outcome.

Meetings

1. ÉCLAIRE Kick-Off meeting, Brescia (I) 24-27/10/2011
2. ÉCLAIRE C3 meeting, Dragør, Copenhagen (DK), 10-11/1/2012
3. ÉCLAIRE GENERAL MEETING, Edimburgh (UK), 15-18/10/2012
4. ICP VEGETATION meeting, Halmstad (S), 28-31/1/2013

5. Joint ÉCLAIRE and COST-ABBA Workshop on O3 and NOX Flux Measurements, 25-27/2/2013 Paris (F)

Dissemination

1. Bassin S, Volk M, Fuhrer J. 2013. Species composition of subalpine grassland is sensitive to nitrogen deposition, but not to ozone, after seven years of treatment. Ecosystems, accepted.
2. **[Newspaper article]** “Clima, vertice di esperti in Cattolica”, Giornale di Brescia, 24/10/2011,
3. **[Newspaper article]** “La lotta all’inquinamento atmosferico inizia da quello che mettiamo nel piatto”, Corriere della Sera - Brescia, 25/10/2011,
4. **[Newspaper article]** “I cicli climatici secondo l’esperto”, Giornale di Brescia, 26/10/2011,
5. **[Newspaper article]** “Progetto ÉCLAIRE, oggi gli ultimi appuntamenti”, BresciaOggi, 27/10/2011,
6. **[Newspaper article]** “Sarà la tecnologia a battere lo smog”, Corriere della Sera-Brescia, 27/10/2011,
7. **[Webarticle]** “ÉCLAIRE, vedetta dell’ecosistema”, A. Olivari, CattolicaNews, 28/6/2012, http://www.cattolicanews.it/studi-e-ricerche-eclaire-vedetta-dell-ecosistema

Work package 11: Investigation of novel ecosystem – air pollution – climate interactions

Lead contractor: CNR
Contributors: NERC, BOKU, UBO

Work package objectives
The aim of this WP is to conduct studies on three novel concepts in order to establish new empirical relationships for vegetation-air pollution interactions needed to establish novel thresholds (WP12) and ecological modelling (WP13). The specific objectives are:

1. To quantify how climate change, including increasing background ozone concentration will enhance greenhouse gas and NO release and exacerbate the threat to vegetation caused by dry or wet N deposition, including the distinction between oxidized (NO_y) and reduced (NH_x) nitrogen forms.
2. To assess if BVOC emissions from vegetation will increase the potential for O_3 and NO_x uptake by plants, and detoxification of reactive oxygen species, leading to improved antioxidant properties and reduced emission of other stress-induced, reactive BVOC (e.g., LOX compounds).
3. To demonstrate if hygroscopic particles accumulating on leaves from aerosol and trace gas deposition may attract water and lead to enhanced transpiration and reduced drought tolerance.

Progress and Results

Task 11.1: Peat bog experiment on N-climate-O_3 interactions

To quantify how climate change, including increasing background ozone concentration will enhance greenhouse gas and NO release and exacerbate the threat to vegetation caused by dry or wet N deposition, including the distinction between oxidized (NO_y) and reduced (NH_x) nitrogen forms.

Activities:

- Field work, installation of new static chambers and dipwells 3 per plot was completed in April 2012, but the very wet weather in 2013 limited the number of gas exchange measurements made in the field.
- Several challenges have been highlighted in conducting long-term manipulations on a peatland: the high level of between plot variability, reflecting the relatively small scale variation in water table and structure of the vegetation, notwithstanding establishing the most appropriate techniques to evaluate C and N fluxes.
- To address these issues in 2012 we adopted a range of methodologies aimed at addressing inconsistencies in C fluxes in particular, in order to better understand the processes. In 2007/8, in situ measurements made on *Sphagnum capillifolium*

indicated that C fluxes were dominated by heterotrophic respiration (Kivimaki et al 2013). The inference from this is that Sphagnum is losing more C than it fixes, so should not be growing and have disappeared from the N56 plots. In fact growth was recorded and although there has been a reduction in cover, the amount is less than would be predicted from the in situ measurements. In situ measurements on *S. capillifolium* clumps do not appear to properly represent C fluxes in Sphagnum.

- A variety of different types of gas exchange measurement were made to try and address such inconsistencies: real time using a LICOR system for CO_2 and CH_4 and clear chambers; clear chambers sampled 0, 10, 20, 30 min for CO_2, CH_4 and N_2O; leaf cuvette measurements on *Calluna* and *Eriophorum vaginatum* in the field, field measurements of NEE on *Sphagnum capillifolium* Nox8, Nox24, Nred8, Nred24 and control. These measurements were supplemented with LICOR cuvette measurements using small pots of S. capillifolium from the N56 treatments and control. CO_2 and isoprene measurements were made on *S. capillifolium* collected from 3 of the 4 high wet N and control plots, discriminating between the pigmented forms, red (open grown) versus green (growing under *Calluna*).
- Peatlands owe their existence to the fact that C fixation rates exceed rates of decomposition, enabling C to accumulate. In addition to examining N form and dose effects on C fixation through gas exchange, photosystem II activity and pigments, we have also looked at decomposition, C losses (dipwells, and gases) and C content of different litters and peat.
- Tea bags were buried to look at effects of different N forms on the environment for decomposition and the amount of water soluble phenol, substrate pH and CN were measured on the main vegetation types (*Calluna, E. vaginatum* and *S. capillifolium*).
- Monthly measurements of dipwell water chemistry have been undertaken to look at C and N cycling. Also one set of soil resin probes has been analysed to look at the effects of different N forms on the availability of a range of anions and cations (exposed August to September 2012). A second set will be put out in May.

Measurements have focussed on determining the effects of different N forms on C fluxes. **Highlights** include:

- Dipwell C measurements, most months (May 2012 to February 2013) showed significant differences in DOC between NO_x (~ 60 mg C l^{-1}) > Nred (~ 40 mg C l^{-1}), with values for control and ammonia in between. Winter values were more similar, with no treatment effects, however, because of subfreezing temperatures from mid November to present there has been no treatment added during this time. DIC values were all low and similar irrespective of treatment during the winter. Nred had the least DIC and NO_x most.
- Nitrate appears to increase the amount of soluble C in peatlands whereas ammonium has the opposite effect and ammonia only a small non significant effect
- DOC concentrations were not obviously related to dipwell pH which increased during the winter.
- The resin probes which accumulate cations and anions present in the soil solution indicated 5000 % more inorganic N than the control in the 12m NH_3 treatment but

no other treatment effects. The site appears to support nitrifying bacteria particularly on the NH_3 transect. Ca and Mg were highest in the Nred and Namm treatments whereas K was highest with NO_x. Fe, Mn and Zn were mostly reduced by all N forms in comparison to the control. Cu and SO_4 were higher with Nred and Namm.

- This peatland when exposed to NH_3 has a huge nitrifying potential.
- Deposition of different N forms will differentially affect metal solubility.
- LICOR measurements conducted on *S. capillifolium* taken from the plots in July were able to show that evaluation of NEE insitu in the field is misleading. Earlier measurements (Kivimaki et al.) 2013 and in 2012 showed higher respiration losses of C than were being fixed by photosynthesis, i.e. the values included a large proportion of CO_2 from heterotrophic respiration. This element was missing from the lab LICOR measurements, demonstrating conclusively that fixed C exceeds respired C. Both Nred and NO_x reduced the amount of C fixed, in particular NO_x but not significantly different from Nred. Respiration was 26% higher with Nred relative to the control, as well as with NO_x, but not significantly**.**
- These LICOR results undertaken on small pots of S. capillifolium contrast the field findings , cf Kivimaki et al 2012 which suggested NO_x increased respiratory C losses from *S. capillifolium***,** but were unable to detect C fixation because of the apparent large soil C flux. The results confirm the need to use a combination of field and laboratory techniques to understand how different N forms influence the components of C fluxes on this peatland.
- The results show that after 10 years of 56 kg wet N inputs, i.e. > 5 times the Critical Load for N for bogs the capacity of *S. capillifolium* to fix C is reduced by ~ 25 to 40% depending on the form of N. The largest reduction was measured with NO_x, so not obviously linked to N accumulation. These results confirm that although such high N loads are debilitating for *Sphagnum*, this reduction in C fixation is sustainable, at present. These results in the context of the large literature on N effects, also point to the huge additional understanding of such systems that can be gained from long-term studies.
- NEE measurements were made in late summer and autumn 2013 in the field on patches of *S. capillifolium* receiving either 8 or 24 kg N ha^{-1y-1} as ammonia, Nred or NO_x and controls. These data showed no significant treatment effects on CO_2 fluxes except in the dark
- As found previously the density of *S. capillifolium* decreases with N dose and here the N24 treatments had lower density than N8 or control, which will lower the ability of the hummock to withstand drought.
- Soil respiration in the N56 plots was 30% lower in the Nred56 and amm56 plots than control or NOx56 plots. Fluxes exceeded those measured in *Sphagnum*, providing anecdotal evidence of C uptake by *Sphagnum*.
- Strong positive relationships between CO_2 fluxes and air / peat temperature were observed in the dark (R^2 > 0.9) and light (R^2 > 0.8).
- No significant effects of N dose or form on C fluxes, CH_4 and CO_2 were found using static chambers that contained mixtures of *E. vaginatum, Calluna, S. capillifolium* and pleurocarpous mosses. Real time C fluxes have yet to be worked up.

- There were no significant effects of N dose or form on CN ratios in the top 0-10 cm of peat. After 10 years of N deposition there is no consistently significant increase in peat % N.
- Effects of N deposition on litter %N varied by species: %N varied from 0.82 to 1.65 by dose in *S. capillifolium* ($p = < 0.001$), likewise %C and CN; *E. vaginatum* litter N, C or CN were not significantly affected by N treatment; *Calluna* litter ranged from 1.33 to 1.7 % N and C, N and CN were significantly affected by N dose and form ($p< 0.05$). Thus N form and dose improve the quality of *Sphagnum* and *Calluna* litter but not *E. vaginatum*.
- No consistent effects on the amount of soluble phenols in peat and litter were found.
- Decomposition rates could be increased by N dose through CN but concentrations of soluble phenol also increase in *Sphagnum* with N dose, which may offset the CN effect, Kivimaki (2011) found reduced decomposition in *S. capillifolium* treated with N.
- Neither N dose nor form affected tea bag decomposition rates suggesting the environment for decomposition has not changed significantly. However, tea bags in NOx24 plots consistently showed significantly higher mass loss than other treatments.
- Overall our data on C fluxes and decomposition suggest a complex web of interactions between both C and N above and below ground in response to different N forms and dose. Given the effects of the different N forms on pH (vegetation, litter and soil) we need to determine the significance of these induced pH changes in the role of ammonia, ammonium and nitrate in this peatland.

Task 11.2: Physiological controls of climate change and pollutant exposure on exchange of BVOCs, NO and O_3 (CNR, Loreto).

To assess if BVOC emissions from vegetation will increase the potential for O_3 and NO_x uptake by plants, and detoxification of reactive oxygen species, leading to improved antioxidant properties and reduced emission of other stress-induced, reactive BVOC (e.g., LOX compounds).

Activities

- **Ozone effects on in-planta isoprene oxidation products**. Isoprene (i) is oxidized to methyl vinyl ketone and methacrolein (i_{ox} = MVK + MAC) in leaves and i_{ox}/i emission ratios increase with temperature (Jardine et al., 2012). Wild-type (isoprene non-emitting, INE) and transgenic isoprene-emitting (IE) tobacco plants were exposed to 240 ppb of O_3 for 6 h in a 18 L cuvette and were either watered or not watered for 3 days before the experiment in order to induce a severe oxidative stress. CO_2 and water vapour (Li-840A), O_3 (Model 1008-RS Dasibi), isoprene, MVK and MAC, methanol and other oxygenated compounds (PTR-TOF 8000 Ionicon), NO/NO_2 fluxes (42i-TL, Thermo Electron) as well as pigment concentration and H_2O_2 content in leaf tissue were measured.

- **Effects of isoprene on stress-induced reactive species and membrane damage**. Arabidopsis plants were transformed to introduce the gene encoding for isoprene synthase, the enzyme that makes isoprene from its substrate, dimethylallyl diphosphate, DMADP. NO and H_2O_2, two key molecules in plant signaling of hypersensitive responses to stress were measured in wild-type and transgenic plants before stress at growth temperature (22°C) and after exposure to heat (38°C) for 48 h.
- **Ozone deposition under environmental (drought and temperature) and biological (seasonality, leaf development) changes**. Ozone fluxes have been measured continuously at an eddy-covariance site in central Italy (Castelporziano, over a mixed pine-oak forest). We identified periods in which ecophysiological properties may have been influenced by different environmental constraints: either heat and drought or cold.
- **Translating stomatal O_3 uptake into O_3 damage.** Ozone effects on GPP (Gross Primary Productivity), measured at canopy level at the eddy-covariance site of Castelporziano, were investigated by applying sophisticated statistical approaches (wavelet coherence, random forest, G causality, multiple linear and non-linear models) and comparing the results with previous data-bases in Mediterranean ecosystems (*Pinus ponderosa* and *Citrus sinensis*).

Main highlights:

- **New sources of methyl vinyl ketone in planta**. Isoprene-ROS reactions did not produce a measurable amount of methyl vinyl ketone (MVK) in plants exposed to long-term ozone fumigation and drought. However, ozone exposure induced a transient peak of MVK emission, both in INE and IE tobacco plants, suggesting an isoprene-independent pathway of MVK production.
- **Heat-stressed, isoprene-emitting** transgenic Arabidopsis **plants produce a lower pool of reactive oxygen species, and this is especially due to a lower accumulation of H_2O_2.** It remains difficult to disentangle whether in heat stressed plants isoprene also directly reacts with and quenches Reactive Oxygen Species (ROS), or reduces ROS formation by stabilizing thylakoids, thus making photosynthesis able to run and consume electrons also under stress conditions. The latter hypothesis is considered more realistic due to kinetic reactions of isoprene – ROS, that do not support large capacity of ROS scavenging by isoprene.
- **Ozone fluxes are higher during warm days, when non-stomatal sinks** (e.g. gas-phase chemistry due to high monoterpene and isoprene fluxes during the warm days of September) **are also higher**. Fluxes peak during the day because primary emitted BVOC depend on light and temperature.
- **Reduction in canopy-level carbon assimilation was more related to stomatal ozone deposition than to ozone concentration. The negative effects of ozone occurred within a day of exposure/uptake**. Decoupling between carbon assimilation and stomatal aperture increased with the amount of ozone pollution. **Up to 12-19 % of the carbon assimilation reduction** in *Pinus ponderosa* and in the *Citrus* plantation **was explained by higher stomatal ozone deposition**. In

contrast, the pine-oak forest did not show reductions in gross primary productivity either by ozone concentration or stomatal ozone deposition, mainly due to the lower ozone concentrations in the periurban site over the shorter period of investigation.

- **Seven publications** have resulted from the Task activities:
- Danielewska A, Clarke N, Olejnik J, Hansen K, de Vries W, Lundin L, Tuovinen J, Fischer R, Urbaniak M, PAOLETTI E 2013, A meta-database comparison from various European Research and Monitoring Networks dedicated to forest sites. iForest-Biosciences and Forestry. 6: 1-9.
- FARES S, Vargas R, Detto M, Goldstein AH, Karlik J, PAOLETTI E, Vitale M 2013, Tropospheric ozone reduces carbon assimilation in trees: estimates from analysis of continuous flux measurements. Global Change Biology accepted
- Fineschi S, LORETO F 2012. Leaf volatile isoprenoids: an important defensive armament in forest tree species. iForest-Biosciences and Forestry. 5: 13-17.
- Jardine KJ, Monson RK, Abrell L, Saleska SR, Arneth A, Jardine A, Ishida FY, Serrano AY, Thomaskarl A, FARES S, Goldstein A, LORETO F, Huxman T 2012, Within-plant isoprene oxidation confirmed by direct emissions of oxidation products methyl vinyl ketone and methacrolein. Global Change Biology. 18: 973–984.
- Matyssek R, Wieser G, Calfapietra C, de Vries W, Dizengremel P, Ernst D, Jolivet Y, Mikkelsen TN, Mohren GMJ, Le Thiec D, Tuovinen J-P, Weatherall A, PAOLETTI E 2012, Forests under climate change and air pollution: Gaps in understanding and future directions for research. Environmental Pollution. 160: 57-65.
- PAOLETTI E, Cudlin P 2012, Ozone, Climate Change and Forests. Environmental Pollution. 169: 249.
- Velikova V, Sharkey TD, LORETO F 2012. Stabilization of thylakoid membranes in isoprene-emitting plants reduces formation of reactive oxygen species. Plant Signaling & Behavior. 7: 139-141.

Task 11.3: Effects of aerosol deposition on stomatal functions

To demonstrate if hygroscopic particles accumulating on leaves from aerosol and trace gas deposition may attract water and lead to enhanced transpiration and reduced drought tolerance.

Activities

- Droplets containing different concentrations of NaCl, $NaNO_3$, $(NH_4)_2SO_4$, KI, with or without surfactant were sprayed on pine needles and beech leaves. Minimum epidermal conductance was measured by drying curves of excised leaves/needles. Transpiration water loss and photosynthesis were measured by porometry, and water use efficiency was calculated.

Main highlights

- **Pine needles treated with hygroscopic salts showed higher minimum epidermal conductance (g_{min}) than the control needles. Because g_{min}**

describes the uncontrollable water loss, this indicates reduced drought tolerance by deposition of hygroscopic particles.

- For salt treated beech leaves, the mean g_{min} values were also higher than for the control leaves, but results were not significant.
- Transpiration water loss of treated leaves generally tended to be higher compared to control leaves, although this was only significant for some salts.
- No differences were observed for water use efficiency.
- The **main objective of this task is thus met** by these **experimental results** : They demonstrate that particle accumulation on leaf surfaces can enhance transpiration and reduce drought tolerance of plants.
- The **theoretical background** is further strengthened by two publications of our group within the reporting period:
  - Plants grown in particle free air show lower transpiration than plants grown in normal air (Pariyar et al. 2013)
  - The penetration of salts into stomata in spite of cuticular hydrophobicity probably reflects the (salt specific) influence of highly concentrated solutions on water surface tension, which is linked to the Hofmeister series (Burkhardt et al., 2012).

Progress towards the milestones and deliverables

A re-evaluation of deliverables and milestones date of delivery was carried out in October 2012 as follows:

D11.1 Parameterization of the impact of reduced and oxidised wet and dry N deposition on GHG and NOx fluxes, N immobilisation, natural vegetation types, species physiology, soil chemistry, and losses and allocation of C & N [month 24 rather than 18]
Update September 2013: This deliverable has now been completed.
D11.2 Predictive modelling of GHG fluxes, especially CO_2 under different N deposition regimes [month 30 rather than 24]
D11.3 Quantification and parameterization of foliar O_3 deposition under progressing drought and temperature stress [Month 24 rather than 16] and during leaf development and seasonal metabolic changes [month 24]
D11.4 Measurement and parameterization of the fraction of O_3 that is taken up by leaves due to detoxification by constitutive BVOC, under associated environmental constraints and during leaf development [month 34]
D11.5 Quantification of minimum epidermal conductance under different loads of particles [Month 24 rather than 12] and estimation of transpiration increase by specified amounts of aerosols [month 24 rather than 20]
D11.6 Parameterization of water use efficiency for model use (WP12) under conditions of particle pollution [month 30]

MS47 Completion of experimental set-up [month 9 rather than 6] – completed

MS48 Completion of data collection on NEE, GHG, soil pore water C and N [month 30 rather than 12]
MS49 Completion of measurements of ozone uptake, water exchange, chemical analysis [month 34 rather than 18]
MS50 Submission of data to database for modeling purposes [month 34 rather than 24]
MS51 Completion of analysis of water use efficiency, water deficit, analysis of gas fluxes [month 34 rather than 24]
MS52 Assignment of thresholds of O_3 damage and BVOC-mediated O_3 detoxification capacity [month 34 rather than 33]

Specific progress for each Task is as follows:

Task 11.1

- Sampling of soil and litter for analysis of NO and NH_3 emissions in Austria has been arranged for May 2013. Soil mesocosms for Bangor will now be removed in March 2014 when Bangor solar domes have more space, allowing larger diameter cores, (which are more representative of the vegetation), to be accommodated.
- 2013 measurements will be targeted at outstanding questions concerning the role of N dose and form on C cycling on this peatland, which will be in its 11th year of continuous N addition.
- All promised measurements were delivered for year 1 (2012), additional measurements for 2013 are programmed. These include litter (collectors put out on March 1 2013); species composition changes in permanent quadrats and whole plots, will be undertaken in August/September 2013, NDVI and vegetation height will be undertaken regularly. Previous data collected for NEU up to 2011 were updated on the NEU website in January 2013.

Task 11.2

- Canopy-level ozone fluxes will be continuously measured at the eddy-covariance site of Castelporziano, in order to compute several episodes of extreme events: drought, high tropospheric ozone, high temperatures.
- NO_x gradient from soil to above the canopy will be measured to investigate bi-directional fluxes in the continuum soil-plant-atmosphere in the Oak forest of Castelporziano.
- A particle sensor will be used to measure concentration of PM 2.5 and PM 10 above the Oak canopies in Castelporziano, and test whether particle deposition can have negative effects on carbon assimilation.
- Monitoring of carbon and ozone fluxes as well as BVOC gradients will be carried out in a *Picea abies* forest, in order to investigate the role of BVOC in the gas-phase reactions of ozone, determine the impacts of ozone uptake on canopy-level carbon exchange, and study canopy exchanges due to extreme climatic events. In 2014, fluxes of isoprene, monoterpenes and oxidation products will be measured by GC-MS and PTR-MS.

Task 11.3

- The reported experimental results from the first measurement period during spring/summer 2012 are the basis to quantify the effects of different salt types and concentrations on minimum epidermal conductance and on transpiration. The measurements will be partly repeated and further extended during spring/summer 2013. The difference in vapour pressure deficits (VPD) between different ventilation speeds in the greenhouses was smaller than anticipated. During 2013 measurements, one VPD regime will therefore be established by keeping plants under a roof, but without walls.
- The overall g_{min}, gas exchange and sap flow results will be summarized until end of September 2013. Together with further investigations, partly from other projects of our group, a quantification of pollutant dependent influences on plant transpiration and water use efficiency will be summarized until end of March 2014.

Use of resources and deviations from DoW

A total of 34 person months have been spent on this work package. A change in date for delivery of a number of milestones and deliverables has been agreed with the component leader (as detailed above), as being more realistic. However it is not envisaged that these will cause a significant delay in other work packages and the activities laid out in the description of work. A number of minor issues and information on the use of resources are detailed below:

Task 11.1

- Treatments have been maintained and all activities at the site are documented electronically.
- A decision was made to maintain measurements on the high N and control treatments (Nox56, Nred56, Namm56 (12m)), started under NITROEUROPE to provide a baseline for comparison and taking into account that even in the high wet treatments N_2O fluxes are low, hovering round GC detection limits. In the proposal the medium N treatment was identified.
- Time wise the project is on schedule, problems encountered with the system we designed for NEE measurements proved insurmountable under the extremely wet summer / autumn of 2012.
- 1450 hours were used, the unused 350 hours will be needed for the additional 2013 measurements to assess species cover (44 wet plots, 12 distances along the ammonia transect).
- We have experienced some problems with analytical equipment (IC and ANTEK for DON): the monthly dipwell IC samples are all analysed, but the data is not yet fully worked up. DON/DIN samples remain frozen and await analysis once the ANTEK is repaired.

- Two years of data collection were identified as being the minimum to detect climate interactions. Effort for 2013 will concentrate on real time measurements of CO_2 and CH_4 as C fluxes appear to dominate GHG fluxes from plots manipulated with wet N deposition. The dry deposition transect maintains significant N_2O emissions.
- The previous 4 years measurements, did not detect significant N_2O fluxes from the wet treatments. 2013 measurements of N_2O will focus on the ammonia transect. The aim will be to identify the ammonia dose below which N_2O fluxes are not significantly different from control levels. The same protocol and equipment used to collect samples during the NEU work programme will be employed (static chambers, opaque lids, samples removed at 0, 10, 20 and 30 min).

There are no issues currently with Task 11.2 and 11.3.

References

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Pariyar S, Eichert T, Goldbach HE, Hunsche M, Burkhardt J (2013) The exclusion of ambient aerosols changes the water relations of sunflower (*Helianthus annuus*) and bean (*Vicia faba*) plants. *Environmental and Experimental Botany*, 88, 43-52.

Work package 12: Development and Assessment of Novel Thresholds

Lead contractor: SEI UoY
Contributors: NERC, DTU, RIVM, UGOT, IVL

Work package objectives

The general aims of this work package were:

1. To define pollutant-response relationships relevant for ecosystem service evaluation
2. To define intermediate plant processes that relate pollutant deposition and uptake to plant responses
3. To apply the DO3SE model to simulate deposition and uptake for key ÉCLAIRE experimental effect studies
4. To develop and apply other necessary conceptual and quantitative modelling frameworks as a basis for investigating dose response relationships (especially relevant for the novel interactions addressed under WP11)
5. To analyse these data to develop new dose-response relationships and novel thresholds

Progress and Results

Task 12.1: Definition of pollutant response parameters relevant for ecosystem service valuation

This task was intended to inform the development of 'ecosystem service' relevant responses that can be used in the integrated risk assessment and policy analysis in C5, ensuring consistency with the responses that can be modelled using the methods developed in C3.

A report which describes 'The development of 'ecosystem service' relevant responses has been delivered **(D12.1).** This report has been shared with our C5 collaborators.

Progress has also been made in defining a new method to estimate loss in C stocks due to ozone exposures for forests growing across Europe (see Task 12.4). This has required a new forest response parameter (% change in net annual increment) to be defined from re-analysis of the existing data describing ozone losses on total tree biomass.

Task 12.2: Definition of intermediate plant processes determining response to pollutant deposition

This task aims to identify the key plant processes determining response to pollutant deposition and uptake and uptake and the eventual 'ecosystem relevant' response. This will make use of data collected in C3 in the data-mining activity of WP9 and the experimental data collection activities of WP10 and 11.

There is uncertainty as to how pollutant deposition might affect key plant processes such as photosynthesis (An), stomatal conductance (g_{sto}), respiration (R) and C allocation. This task has focussed on creating close interaction between the experimentalists and modellers within C3 to design experimental protocols that can be applied to collect new data to improve the representation of these fundamental plant processes within the ÉCLAIRE models. The focus here is on understanding how these fundamental plant processes are affected by pollutants and climate change acting in combination.

The DO_3SE model (which has been further developed under activities on-going in C1) is well suited to simulating within chamber experimental conditions, and will be used to integrate the ÉCLAIRE experimental data e.g. using knowledge of O_3 concentrations, plant physiology and within chamber environmental conditions to simulate g_{sto}, An and O_3 deposition and ultimately biomass responses.

A new version 5 of the DO3SE model has been developed. This model incorporates a photosynthetic algorithm allowing g_{sto} to be estimated as a function of CO_2 concentration as well as other prevailing environmental conditions (i.e. relative humidity, irradiance, leaf temperature, leaf N and soil moisture deficit. These algorithms are based on those included in the ÉCLAIRE set of dynamic vegetation growth models (DVGM) (e.g. JULES and LPJ). The DO3SE model is rather unique in that it is capable of simulating conditions of the experiments performed in closed or open top chamber conditions. This means that DO3SE can provide an interface between the ÉCLAIRE experimental data and some of the key model processes used by many of the ÉCLAIRE ecosystem models (e.g. An, g_{sto}, respiration (R) and carbon (C) allocation.

Such an 'interface' allows information gathered from experiments, describing e.g. the action of O_3 and drought on An, to be analysed and synthesised using DO_3SE leading to an improvement in how these key vegetation processes are modelled. Because each of the vegetation models will use the same, or very similar, methods to model these key processes, the modifications in DO3SE can also be used to inform suggested modifications to these processes in other models that will be used for regional scale applications in C4 and C5.

The following tasks have been achieved:

1. The An, gsto and R modules required for the estimation of pollutant uptake and deposition have been incorporated into DO3SE v5. These modules are based on those currently used by the ÉCLAIRE DVGM ecosystem models
2. Protocols for the measurement of particular plant processes relevant for the accurate modelling of An, gsto and R have been defined and circulated to all ÉCLAIRE WP10 and 11 experimentalists.
3. The DO_3SE v5 has undergone preliminary testing to ensure the coding is bug free.

Task 12.3: Apply DO3SE model to analyse ÉCLAIRE experimental data

This activity will collate and transform the ÉCLAIRE experimental data and the data mining into the format for DO3SE modelling. These data will be processed using the new DO3SE v5 to provide estimates of pollutant deposition and uptake.

To ensure this activity can be completed efficiently an experimental data template has been developed in consultation with the ÉCLAIRE data management team. This template (and associated documentation) allows experimentalists to record empirical data according to common measurement protocols and upload data into a standardised format that will allow storage on the ÉCLAIRE data management site in a format that can be readily downloaded and used by modellers.

Currently the uploading and quality checking of the ÉCLAIRE data is running a little behind schedule. This has delayed the data analysis within the DO3SE model which is the main focus of this task and will be conducted over the coming months.

Task 12.4: Development of new dose-response relationships and novel thresholds

Empirical data analysed using the DO3SE v5 model will be used to develop interim (An, gsto and R) and ultimate (e.g. biomass) dose-responses for different cover types and species investigated within ÉCLAIRE. 'Interim' dose-responses relationships will be used to inform the development of the ÉCLAIRE ecosystem scale models and to understand the effect of a range of pollutants and environmental conditions on plant response. 'Ultimate' dose-responses will be used to further develop the critical load/level type of dose-response for application in regional risk assessment mapping conducted in C5.

Progress has also been made in defining a new method to estimate loss in C stocks due to ozone exposures for forests growing across Europe. This method performs a re-analysis of existing forest flux-response relationships to enable application with forest growth data expressed as net annual increment (rather than total standing stocks). Application of these new flux–response relationships incorporates information on felling rates to allow an assessment of the ozone influence on C stocks within the context of annual felling rates and hence timber harvests.

Further progress will occur as the results of the analysis of Task 12.3 become available.

Progress towards the milestones and deliverables

D12.1 Summary report describing key response parameters derived from empirical studies and suitable for use in the first phase of the ecosystem valuation work (Month 12)

Report completed in month 12 and shared with C5

D12.4 Final Report describing new dose-response relationships and novel thresholds (Month 40)

Deliverable not yet due

Use of resources and deviations from DoW

A total of 6.9 person months have been used on this activity. The use of the DO3SE model to analyse the ÉCLAIRE experimental data collected in WPs 10 and 11 is running behind schedule due to delays in uploading and quality checking the empirical data to the ÉCLAIRE data portal. This work would ideally have started approximately 3 to 6 months ago. This should not affect the next and final deliverable of this WP12 which is not due until Month 40 but may slow contributions to other WPs in C5.

Work package 13: Modelling of carbon stocks, greenhouse gas and vegetation change

Lead contractor: NERC (BAN)
Contributors: ALTERRA, KIT, SEI-Y/UoY, RIVM, ULUND

1 Work package objectives

1. To develop a model describing the combined effects of O_3, other atmospheric pollutants and climate on plant CO_2 uptake, net ecosystem exchange (NEE) and C sequestration in soil and vegetation, suitable for linking to existing plant-soil biogeochemistry models.
2. To develop existing dynamic vegetation models to better simulate the impacts of different air pollutants on plant growth and competition, and feedbacks on ecosystem carbon cycling.
3. To incorporate CH_4 and N_2O, as well as dissolved C and N losses, into biogeochemistry models for relevant ecosystems.
4. To integrate models in order to simulate the combined response of soils and vegetation to N, S and O_3-exposure, diffuse radiation and climate change, suitable for application at a range of scales and for addressing a range of ecosystem impacts such as changes in C sequestration, vegetation diversity.
5. To undertake parallel testing of models with different process descriptions and levels of complexity against detailed data from experiments
6. To use the final tested models for prediction of future ecosystem responses to air pollution and climate change at a site level, and to deliver models for regional scale application in C4.

Progress and Results

Task 13.1: Model development and linking

A new photosynthesis algorithm has been added to the DO_3SE model, which allows stomatal conductance to be estimated as a function of CO_2 concentration as well as other prevailing environmental conditions including relative humidity, irradiance (including diffuse and direct irradiance, as influenced by atmospheric aerosol load), leaf temperature and soil moisture deficit. The model also incorporates leaf N content as a control on maximum carboxylation capacity. This model development permits stomatal flux, and therefore exchange of pollutant gases such as O_3, NOx and SO_2, to be estimated as a function of N deposition. The DO_3SE model therefore is therefore now capable of estimating deposition and subsequent damage under a variety of pollutant combinations and environmental conditions. These model developments have been described in Deliverable D13.2.

The MADOC model, which comprises linked models describing carbon-nitrogen dynamics (N14C), acid-base chemistry (VSD) and organic matter solubility (DyDOC) has been fully implemented, and tested on a set of UK experimental and monitoring datasets. During the last reporting period a paper on the N14C model has been published (Tipping et al., Ecological Modelling 2012, 247, 11-26) and a manuscript on the MADOC model submitted for publication (Rowe et al., submitted to Environmental Pollution). Mechanisms for ozone impacts on processes in MADOC have been identified and equivalent mechanisms added within the model, using parameter values derived from a preliminary analysis. Initial sensitivity assessments have been undertaken. These processes will be fully implemented in the model following completion of the data mining activity.

Developments of LPJ-GUESS model, and the development of the Forspace model together with its coupling to VSD+, are described in the activity report for WP14. These models will form a part of the model testing and application against experimental sites for WP13.

Task 13.2: Model testing

The testing of the models against experimental data for WP13 requires the prior collation of full datasets for model parameterisation in the earlier Component 3 WPs. The testing of DO_3SE will take place using data from all the C3 experiments, while the ecosystem models will focus initially on the three field manipulation experiments (Brandbjerg, Whim, Alp Flix).

MADOC model testing has been initiated for the Branbjerg site following a site visit and liaison with the experimental team. The experiment is fully factorial for temperature (night-time warming), drought (rain exclusion) and elevated CO_2. Ozone treatments are being superimposed on shoots of the two main vascular plants on the site, *Deschampsia flexuosa* and *Calluna vulgaris*. As well as establishing model parameter values that encapsulate the experimental treatments, key measurements that can be used to test model outputs have been identified, such as plant productivity data. Important seasonal dynamics have also been ascertained. For example, the drought treatments have affected annual water flux (which governs dissolved-organic-matter flux in MADOC) rather little, whereas large differences were observed in autumn moisture content. The latter measurement may therefore be suitable as a driver of habitat suitability in the MultiMOVE niche model. A full model set up for selected treatments is now under way, and will be followed by parameterisation and testing for the other experimental sites.

Task 13.3: Model application

The initial application of models is taking place as part of the model testing described under Task 13.2. Full model application and scenario assessment will take place after the conclusion of the development and testing phase. Model parameterisation data will also be made available to the other ÉCLAIRE modelling groups to enable them to undertake parallel model testing and application.

Progress towards the milestones and deliverables

Table 3.1: Milestones for the reporting period

Milestone	Milestone Title	Month	Status
MS56	Identification of priorities for model development, final list of models for inclusion, and data requirements for parameterisation and testing	6	Completed
MS57	Collation of preliminary data from experimental sites for initial model application	12	Completed
MS58	Initial application and testing of integrated models to simulate biogeochemical and vegetation changes at C3 experimental sites	18	MADOC and DO3SE model application and testing ongoing. Other models likely to be applied to comment test datasets later in project.

Table 13.2: Deliverables up to the reporting period

Deliverable	Deliverable Title	Month	Status
D13.1	Finalised list of models for use in C3, and list of data requirements for each model	6	Completed
D13.2	New version of DO3SE model to simulate the combined effects of O_3, N, S, diffuse radiation and climate on plant CO_2 uptake	18	Completed (report submitted)

Use of resources and deviations from DoW

A total of 9.6 person months were spent on this activity. Model application is in some cases delayed because data upload and data delivery has been delayed, but it is expected that the final work will be completed in time.

2.2.4 Component 4: Ecological impacts at regional and European Scales

Lead contractor: ALTERRA

Component objectives

The objectives of component 4 are to:

1. Develop improved process-based parameterizations in dynamic global vegetation models (DGVMs) and soil vegetation models (DSVMs) to assess the combined interacting impacts of air quality, climate change and nutrient availability on plant productivity, carbon sequestration and plant species diversity and their uncertainties (WPs 14, 15 and 17).
2. Develop novel thresholds and dose-response relationships for air pollutants (especially for O_3 and N) under climate change, integrated into process-based models verified by experimental studies at site scales and mapped at the European scale, quantifying the effect of climate change scenarios (WPs 14, 15 and 16)
3. Apply the novel metrics to quantify multi-stress response of vegetation and soils, including effects on carbon storage and biodiversity to improve the overall risk assessments of pollution-climate effects on ecosystems at the European scale as the basis for development of mitigation options (WPs 14, 15 and 16).

The essence of the specific objectives of the work packages 14-17 are to assess for terrestrial ecosystems the:

1. effects of combined air pollution and climate change scenarios on productivity and ecosystem carbon/greenhouse gas (GHG): WP14.
2. changes in soil quality and plant species diversity under different air pollution and climate scenarios for forests and semi-natural systems: WP15.
3. critical thresholds for nitrogen deposition and ozone uptake and their exceedances, based on impacts on plant species diversity and productivity, respectively: WP16.
4. uncertainty in critical N thresholds and their exceedances based on model simulations at several grid resolutions from 5 x 5 km^2 and 1 x 1 km^2 (regional scale) down to 50 x 50 m^2 (landscape scale): WP17.

The essence of the progress and results for each of these WPs is reported below while details are presented in the separate work package reports.

Progress and Results

WP 14: Air pollution-climate impacts on European carbon stocks and greenhouse gas emissions

The activities of WP14 are divided in two main tasks, i.e.:

- *Task 14.1: Model development*: Further develop dynamic global vegetation models (DGVMs) and dynamic soil vegetation models (DSVMs) by including interacting effects of nitrogen, ozone and climate on modelled ecosystem productivity

- *Task 14.2: Model application:* Apply the updated models by (i) linking the DGVMs and DSVMs to large scale European databases on meteorology, deposition, air quality, soils and vegetation and (ii) assessing the effects of combined air pollution and climate change scenarios on productivity and ecosystem C/GHG balance for forests, semi-natural and agricultural systems.

Task 14.1: The DGVMs, i.e. LPJ-Guess, JULES, CLM, O-CN and ORCHIDEE, and DSVMs, i.e. VSD+-Forspace and MADOC, were further developed by including process descriptions for the impact of ozone exposure and/or nitrogen deposition on productivity. A separate simple empirical forest growth and management model, GrowUp, was developed for rapid assessment of the interacting impacts of air quality and climate change making use of (meta-analysis of) literature information and published data.

Task 14.2: A protocol has been developed for an “ensemble model application and inter-comparison of the long-term impacts of various scenarios of climate change, air quality change (exposure to O_3 and CO_2 and deposition of nitrogen) on plant production/carbon sink strength and nutrient cycling of forests and semi-natural systems), using the following integrated DGVMs (CLM, Jules, O-CN, ORCHIDEE, LPJ GUESS) and DSVMs (VSD+-FORSPACE). The actual assessment of the effects of combined air pollution and climate change scenarios on productivity and ecosystem C/GHG balance for forests, semi-natural and agricultural systems was not yet part of this reporting period. However, some preliminary model applications were already carried out as described in detail in WP14

WP 15: Air pollution-climate impacts on biodiversity and soil quality

The activities of WP15 are also divided in two tasks, i.e.:

- *Task 15.1: Model development:* Further develop a plant species diversity model PROPS (formerly called EUMOVE) that links plant species occurrence in Europe to atmospheric deposition and climate.

- *Task 15.2: Model application*: Apply the updated models by (i) coupling VSD+ to EUMOVE and link the coupled model to large scale European databases on meteorology, deposition, air quality, soils and vegetation and (ii) forecast future changes in soil quality and plant species diversity under different air pollution and climate scenarios for forests and semi-natural systems.

Task 15.1: The multi-plant species niche models PROPS and MultiMOVE have been developed for application at European and national scale, respectively. A biodiversity indicator was also further developed based on the presence or absence of species or species combinations, weighting to the intrinsic 'importance' of each species from a nature conservancy point of view We have linked the integrated soil model VSD+ with Props and worked on coupling the biogeochemical MADOC model with MultiMOVE.

Task 15.2: The VSD+ model was linked to PROPS and a first tentative application to Europe was made for the period 1990-2050 evaluating effects of changing climate (constant climate after 1990; CON and the IPCC-SRES A1 storyline) and deposition (using two emission scenarios reflecting current legislation; CLE and technically maximum feasible reductions; MFR) on abiotic conditions and on two biodiversity indices, i.e. the Chekanowski index and the Simpson index.

WP 16: Air pollution-climate impacts on biodiversity and soil quality

The activities of WP16 are divided in three tasks, i.e.:

- *Task 16.1: Assessment of effect indicators for critical load mapping*
- *Task 16.2. Mapping model based critical N loads for plant protection and their exceedances*
- *Task 16.3. Mapping critical thresholds for ozone uptake and their exceedances*

Task 16.1: Documentation on indicators for geo-chemical and biological endpoints has been updated and summarised in two chapters of a book (edited by W. de Vries, J.-P. Hettelingh and M. Posch; C4 component leader, WP 19 leader and WP16 leader, resp.) planned to be published in 2013. Selected indicators are compiled in the GAINS system and the GAINS-model and documented in the CCE Status Report 2012.

Task 16.2: The dynamic soil-vegetation model VSD+ has been extended with a functionality that – based on selected targets in terms of pH, [N] and N availability – can identify appropriate depositions (critical loads). The planning is that those targets can in turn be derived by a plant species model, such as EUMOVE.

Task 16.3: Maps of critical phytotoxic ozone dose (POD) thresholds were derived, based on relationships between and relative yield data of forests distinguishing Norway spruce, Scots pine, Other conifers, Beech/Birch, Oak and Other broadleaves. The EMEP chemical transport model combined with an updated stomatal exchange component of the DO3SE model was used to assess maps of the phytotoxic ozone dose (POD) for generalised forest ecosystems (coniferous, deciduous and mixed forests) for the years 1990 and 1995–2005 and compared with the critical POD values to assess exceedances.

WP 17: Local variation in threshold exceedance

The activities of WP17 in the reporting period are divided in two tasks, i.e.:

- *Task 17.1: Data collection for regional and landscape scale assessments*
- *Task 17.2. Model application to assess of critical nitrogen thresholds and their exceedances at 5 x 5 km and 1 x 1 km for Scotland and the Netherlands and at 1 x 1 km and 50 x 50 m for two landscapes*

Task 17.1: During the reporting period, an extensive review of suitable soil and vegetation databases at 5 km x 5 km and 1 km x 1 km at the regional scale (Central Scotland and the Netherlands) and at 50 m x 50 m for two landscapes in those countries (Burnsmuir, and NFW) was carried out. This review resulted in the selection of datasets for the regional and landscape assessments as described in detail in WP17.

Task 17.2: For the impacts/critical loads assessment, we decided that we will for all regions use the VSD+ Inverse PROPS model chain, to be consistent with the approach in WP16. Work is ongoing to start linking databases and this model chain.

Progress towards the milestones and deliverables, use of resources and deviations from DoW

There are no serious delays in Component 4. More specifically:

- In WP 14, there has been a delay in updating the existing ozone formulations in the Jules model, which may lead to a small delay in model validation and model runs as far as this model is concerned.
- The WPs15 and 16 are on schedule or even in advance of the milestones and deliverables
- In WP 17, the assessment of existing soil and vegetation data was completed in December 2012 (Month 15), being later than planned but still in good time before they are needed for the modelling (which is due to start in Month 24). The regional scale concentration and deposition data, to be made available from WP8, are also delayed but still expected in Month 20, thus being in time for the modelling.

Work package 14: Air pollution-climate impacts on European carbon stocks and greenhouse gas emissions

Lead contractor: JRC
Contributors: NERC, ALTERRA, IIASA, JRC, KIT, RIVM, MPG, IPBPSS

Work package objectives
The objectives of WP14 are to:

- Further develop dynamic global vegetation models (DGVMs) and dynamic soil vegetation models (DSVMs) by including interacting effects of nitrogen, ozone and climate on modelled ecosystem productivity
- Link the DGVMs and DSVMs to large scale European databases on meteorology, deposition, air quality, soils and vegetation.
- Assess the effects of combined air pollution and climate change scenarios on productivity and ecosystem C/GHG balance for forests, semi-natural and agricultural systems.

Progress and Results

Task 14.1: Model improvement and linking to databases

This task includes the "improvement of process descriptions in dynamic global vegetation models (DGVMs) and dynamic soil vegetation models (DSVMs) to be applied within ÉCLAIRE, by applying knowledge derived from C2 model outputs, climatic parameters, soil and vegetation databases". The progress and results are described below.

The DGVMs, i.e. LPJ-Guess, JULES, CLM, O-CN and ORCHIDEE, and DSVMs, i.e. VSD+-Forspace and MADOC, were further developed by including process descriptions for the impact of ozone exposure and/or nitrogen deposition on productivity. A separate simple empirical forest growth and management model, GrowUp, was developed for rapid assessment of the interacting impacts of air quality and climate change making use of (meta-analysis of) literature information and published data. More specifically, the activities included:

Dynamic global vegetation models (DGVMs)

1. **LPJ-GUESS**: Algorithms to model the effects of O_3 on C uptake and assimilation have been implemented in the model. Preliminary model evaluation against previous LPJ output and other model results has been performed, and the final evaluation against data from specific sites and from leaf-level measurements is underway. Parameterisation of the effects of N deposition on C uptake and assimilation have been incorporated in the model. These algorithms have been fully evaluated against previous model output and site specific data from the FLUXNET and FACE sites.

2. **JULES**: A comprehensive dataset of experimental observations has been collected to improve the existing leaf level O_3 uptake model in JULES by: (i) updating the existing O_3 formulation with parameters derived from updated data sets and (ii) implement an updated stomatal conductance formulation. Although progress has been made on the stomatal conductance representation (close to completion), the O_3 effects on photosynthesis for European vegetation types still need to be re-parameterised with the latest data sets. When this is done, it will be linked with soil N and vegetation N uptake models within JULES.
3. **O-CN**: A flux scheme has been implemented into O-CN, to estimate surface ozone concentration and stomatal ozone uptake. Modules for calculating the differing impacts of ozone uptake on net assimilation and stomatal closure have been developed and the marginal effects of the two factors on plant production assessed. Generally, decoupling stomatal closure from productivity is most important in seasonally dry regions. A close collaboration with SEI in York is foreseen to evaluate the fully developed model. The ozone impact work links directly to the coupled carbon-nitrogen cycle parameterisation of O-CN to calculate the joint impacts of ozone and nitrogen deposition on the terrestrial C and N budgets.
4. **CLM**: A new routine for the assessment of the impacts of ozone on vegetation functioning has been recently introduced within CLM4 and applied at global scale. The new model is under testing at European scale forced by the meteorological drivers selected for the ÉCLAIRE project. CLM4 model developments include new routines for: (1) the computation of the cumulative O_3 uptake dependent by the O_3 concentration and leaf area index; 2) the simulation of the O_3 phytotoxic effects on photosynthesis and transpiration. The typical description of the O_3 effects on vegetation simulated by the state of the art terrestrial biosphere models couples the processes of photosynthesis and transpiration. The new routine implemented in CLM4 allows for decoupling the effects of O_3 on the two processes.

Dynamic soil vegetation models (DSVMs)

5. **Forspace**: the effects of O_3 uptake, base cation availability and soil pH on the photosynthetic machinery and plant growth were included and tested in terms of sensitivity analysis. The improved model was coupled to VSD+ as input for simulations of soil carbon sequestration while VSD+ output on base cation availability and soil pH is used by FORSPACE
6. ***GrowUp**:* An empirical model *GrowUp* has been developed, based on results of meta-analysis of literature data on the single and combined effects of changes in climate (temperature and water availability), nitrogen availability, carbon dioxide (CO_2) exposure and ozone (O_3) exposure in forests and forest soils*.*
7. **MADOC**: Ozone effects have been incorporated using simple functions derived from experiments and published literature. Two effects have been incorporated, both functions of mean ambient ozone concentration: limitation to plant production, parameterised initially using results from the Bangor solardomes experiment; and a reduction in the proportion of N translocated out of leaves

before senescence, parameterised using data from Uddling et al. (2006; Tree Physiology 26: 113-20). These response functions will be adapted and refined as results from data mining become available. Other mechanisms (e.g. effects on root vs. shoot allocation) may also be included if warranted by the results of the data mining exercise.

Task 14.2: Model application

This task includes an "ensemble model application and inter-comparison of the long-term impacts of various scenarios of climate change, air quality change (exposure to O_3 and CO_2 and deposition of nitrogen) on plant production/carbon sink strength and nutrient cycling of forests and semi-natural systems), using the following integrated DGVMs (CLM, Jules, O-CN, ORCHIDEE, LPJ GUESS) and DSVMs (VSD+-FORSPACE)".

A protocol for model application has been defined to address the following points.

- Forcing data: definition of the source, spatial and temporal resolution of climate date, CO_2 concentration, land-use dataset, nitrogen and ozone deposition fields.
- Grid: regular 0.5 by 0.5 degree grid with centre coordinates *.25 and *.75
- Simulations: spinup (equilibrium in 1960') and four modelling experiments with fixed or transient O_3 and N deposition (1960-2050).

In addition, the list, temporal resolution (monthly) and file format (netcdf) of output variables has been defined.

An actual assessment of the effects of combined air pollution and climate change scenarios on productivity and ecosystem C/GHG balance is not yet part of this reporting period. However, some preliminary model applications have already taken place.

The new CLM version, in which the parameterization of the impacts of O_3 on photosynthesis (CO_2 exchange) and conductance and thereby transpiration (water exchange) is uncoupled, show that the uncoupled photosynthesis and conductance caused substantially lower decreases in transpiration and CO_2 uptake in response to elevated O_3 than the coupled approach, being the typical approach in most DGVMs. In other words, impacts of O_3 appear to be less.

The combined effects of past and expected future changes in climate (temperature and water availability), nutrient (nitrogen, base cation) availability, carbon dioxide (CO_2) exposure and ozone (O_3) exposure on carbon sequestration in European forests for the period 1900–2050 were modelled. Forest inventory data around 2005 (EFI database) were used to assess reference forest growth rates, which were then modified for other years by factors accounting for deviations in climate and air quality compared to 2005.

Progress towards the milestones and deliverables

Below we describe the progress towards the milestones and deliverables for the first 18 -24 months.

Milestones
During the reporting period two milestones were planned as shown in Table 4.1.

Table 4.1: Planned Milestones for the reporting period of WP14

Milestone	Milestone Title	Month
MS61	Updated versions of DGVMs and DSVMs operational	18
MS62	ÉCLAIRE modelling platform linking DGVMs, DSVMs, climate and air pollution fields operational	18

MS61 Models have been updated in order to account for the combined effects of ozone and nitrogen. Details on model development are reported under "Task 14.1 Model improvement and linking to databases".

MS62 The improved version of DGVMs and DSVMs have been tested and are now ready to link with the ÉCLAIRE modelling chain. Climate scenario are available both in original and bias-corrected version. The modelling platform will be completed when the deposition scenarios for O_3 will be delivered (this activity has been delayed)

Deliverables
During the reporting period two deliverables were planned as shown in Table 4.2.

Table 4.2: Planned Deliverables for the reporting period of WP14

Deliverable	Deliverable Title	Month
D14.1	Synthesis of applicable data on impacts of ozone on photosynthesis, stomatal conductance and plant function	6
D14.2	Updated versions of DGVMs and DSVMs that include impacts of ozone uptake and N deposition on carbon uptake	18

D14.1 In connection to WP9, a contribution was made to a detailed data mining from the literature to improve process parameterisation within the models, focusing on detailed described effects of ozone and other stresses on photosynthesis, C partitioning, for use in DGVMs.

Data mining
The content and structure of the database, the template and the methodology for the data-mining exercise have been developed in cooperation between C3 and C4. For

reviewing purposes, C3 and C4 participants have first been testing the methodology by archiving a selected number of publications. Then a systematic search was made on ozone effects in combination with other drivers for forest, grasslands, and arable lands. Data mining for forests was carried out within WP14. Results are further described in WP9.

Meta-analysis. Partner 4 carried out a separate meta-analysis to assess the single and combined effects of changes in climate (temperature and water availability), nitrogen availability, carbon dioxide (CO_2) exposure and ozone (O_3) exposure in forests and forest soils. Combined effects, which were limited to the interactions of CO_2 x N, CO_2 x O_3, CO_2 x warming and N x precipitation change, were investigated to see whether effects are synergistic (amplifying), antagonistic (dampening) or neutral (no interaction). The meta-analysis was conducted on published manipulative field studies that reported above-ground C responses (above-ground net primary productivity-ANPP, leaf litterfall) and below-ground C responses (below-ground NPP, below-ground root litter, soil respiration) as well as total forests ecosystem CO_2 exchanges (NPP, net ecosystem productivity-NEP, net ecosystem exchange-NEE). We limited our study to boreal, temperate and Mediterranean regions particularly those in Europe, US and Canada. Results are used in the empirical GrowUp model.

Literature

Kongoi, Z. L. Bonten and W. de Vries, 2013. Interacting impacts of air quality and climate change on forest carbon sequestration: a meta-analysis, Wageningen, ALTERRA Wageningen UR, Rapport (in preparation).

D14.2 Models have been updated in order to account for the combined effects of ozone and nitrogen as described under "Task 14.1 (see also Milestone 61).

Use of resources and deviations from DoW

A total of 31.8 months were spent on this work package, although this is less than might be expected, it should be taken into account that partner MPG is using other funds this year and will use ÉCLAIRE funds in the next period.

For the JULES model, there has been a delay in updating the existing O_3 formulation with parameters derived from updated data sets as described under task 14.1. This is due to the illness of a PhD student, (the PhD is funded as part of ÉCLAIRE [1 year] to do this part of the work). To avoid further delay on this task, 4 months of an internally funded person has been organised to complete the model development work that is needed for this deliverable. The work is due to start during April 2013. The delay on this deliverable may imply a delay in D14.3 and D14.4: model validation and preliminary model runs as far as JULES is concerned, but we will monitor the situation to minimise any impact on other work. Furthermore, there are no deviations from the DoW.

Work package 15: Air pollution-climate impacts on biodiversity and soil quality

Lead contractor: Alterra
Contributors: NERC, RIVM-CCE

Work package objectives

The objectives for WP15 are to:

- Further develop a plant species diversity model PROPS (formerly called EUMOVE) that links plant species occurrence in Europe to atmospheric deposition and climate.
- Couple updated dynamic soil vegetation models (DSVM) to PROPS and link the coupled model to large scale European databases on meteorology, deposition, air quality, soils and vegetation.
- Forecast future changes in soil quality and plant species diversity under different air pollution and climate scenarios for forests and semi-natural systems.

Progress and Results

Task 15.1: Model linkage and linking to databases

According to the proposal description, this task includes the:

- Development of the plant species model PROPS.
- Linkage of the PROPS model with the updated FORSPACE-VSD+ and JULES-MADOC model. The JULES and MADOC models are both biogeochemical models of plant growth and soil processes, and are being applied in parallel rather than integrated as was implied in the proposal. Within WP 14 Jules will be applied and in WP15, MADOC will be applied.
- Linkage of the combined models to European databases on meteorology, deposition, air quality, soils and vegetation to predict the combined biodiversity and soil quality impacts of air pollution and climate change (in combination with task WP14).

The progress and results are described below.

Development of the plant species model PROPS
The PROPS model was further developed by relating measured plant species diversity at about 6000 sites in Europe to estimates of climate (temperature and precipitation based on CRU data), N and S deposition (EMEP model estimates), pH, moisture content and N availability (combined measurements and modelling).

A biodiversity indicator was further developed and described (Van Dobben et al., 2013, in prep) based on the presence or absence of species or species combinations, weighting to the intrinsic 'importance' of each species from a nature conservancy point of view (i.e. considering rareness, decline; the IUCN concept of 'Red Lists', lists of endemics etc).

Linkage of PROPS model with FORSPACE-VSD+ and MADOC
We have linked the integrated soil model VSD+ with the multi-plant species model PROPS, without including the linkage to FORSPACE. This was done since inclusion of FORSPACE makes the model chain unnecessarily complex and hardly affects the predicted long term impact of climate change and deposition of nutrients on plant species diversity and soil quality. In the model application (see Task 15.2), we also foresaw a role for the linked VSD+-PROPS model only and consequently, we did not include FORSPACE- in the with PROPS.

In WP15, the MADOC model is also being applied to assess air pollution effects on soil quality. Consequent effects on habitat suitability for plant species will be assessed by linking to the PROPS and MultiMOVE niche models. These changes in suitability for individual species will be interpreted in terms of biodiversity targets using the indicator described above, and/or other biodiversity indicators that are being developed to meet the current United Nations Economic Commission for Europe – Co-ordination Centre for Effects (UNECE-CCE) Call for Data on this topic.

Task 15.2: Model application

According to the proposal description, this task includes the:

- Parameterization of VSD+ and MADOC by including the novel use of a collated European dataset of radiocarbon (14C) data to constrain estimates of soil carbon turnover rates by vegetation and soil type.
- Assessment of long term impacts of climate change and deposition of nutrients on plant species diversity and soil quality, using PROPS linked with the soil model VSD+ and with the coupled JULES-MADOC model.

The progress and results are described below.

Constraining estimates of soil carbon turnover rates by vegetation and soil
The mean age of soil organic matter can be estimated using ^{14}C concentration, and this provides a useful constraint on models of soil C turnover. A^{14}C dataset has been collated from across Europe by Ed Tipping (CEH), and availability of further data will be investigated.

Long term impacts of climate change and nitrogen deposition on plant species diversity and soil quality
The MultiMOVE model has been developed as an R package, and was recently submitted to Methods in Ecology and Evolution. We are currently investigating methods for upscaling application of MultiMOVE, and for linking MADOC to PROPS. This would allow the alternative biogeochemical models (VSD+-FORSPACE; and MADOC) and alternative species models (PROPS and MultiMOVE) to be compared and evaluated independently.

The MADOC model is being used to drive the MultiMOVE plant species model, via relationships established between soil and vegetation properties (e.g. pH, plant-available N, standing biomass) and the floristic trait-means that determine habitat suitability. An article on the MADOC model has been submitted for publication in Environmental Pollution. The article includes a regional simulation of the UK on a 1 km^2 grid (Rowe et al submitted).

The VSD+ model was linked to PROPS and a first tentative application to Europe was made for the period 1990-2050 evaluating effects of changing climate (constant climate after 1990; CON and the IPCC-SRES A1 storyline) and deposition (using two emission scenarios reflecting current legislation; CLE and technically maximum feasible reductions; MFR) on abiotic conditions and on two biodiversity indices, i.e. the Chekanowski index and the Simpson index (Reinds, et al., 2012). As an example, the median Simpson Index is presented (Fig 16.1) showing a north-south gradient in Europe for all 4 climate-deposition scenarios: highest values (indicating high diversity) in the south and low values in parts of Scandinavia. A similar gradient was observed in this index when derived from observations at Intensive Monitoring Plots in Europe.

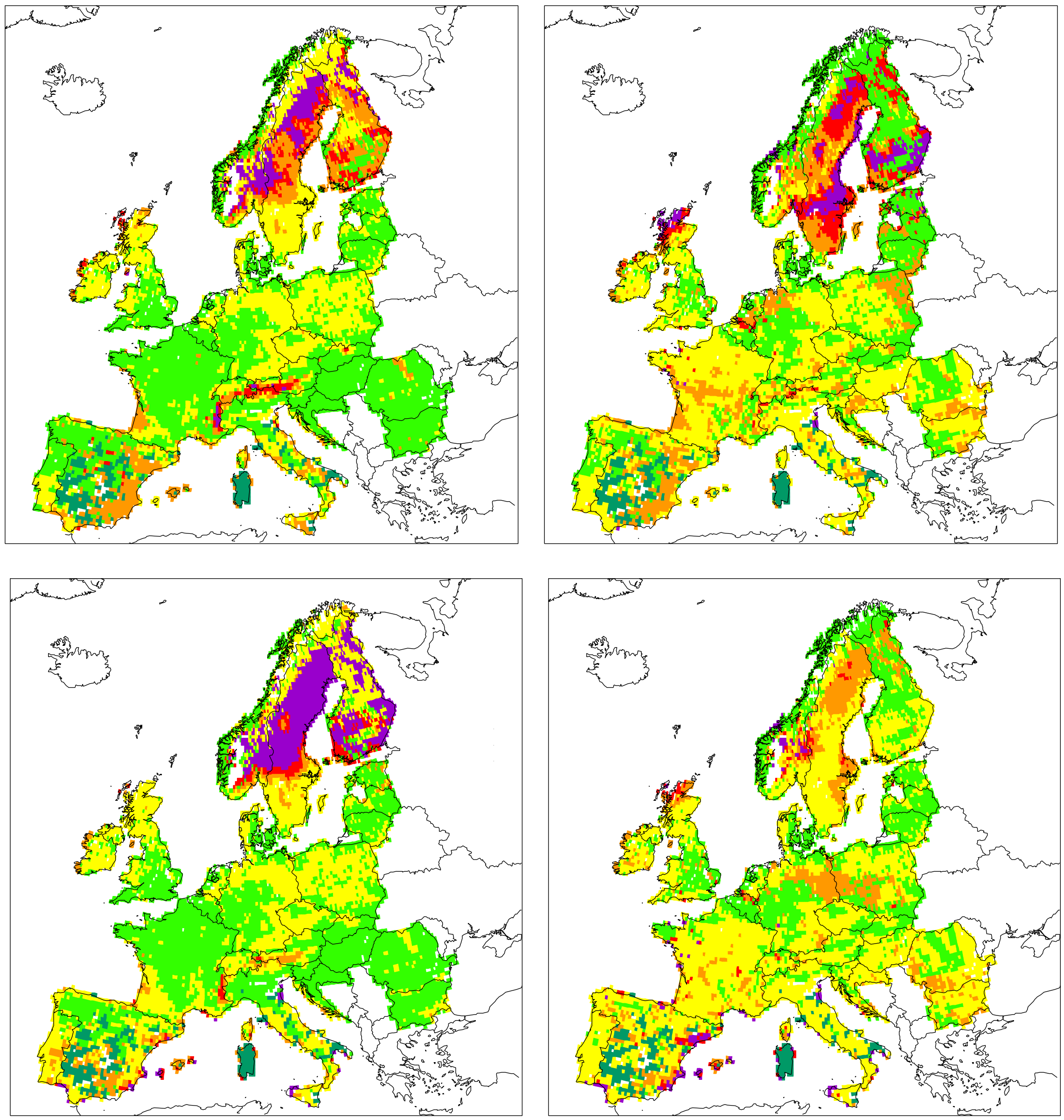

Figure 4.1 Maps of the median Simpson index per grid cell for forest computed by the VSD+-PROPS model for 2050 for the CLE-CON, CLE-A1, MFR-CON and MFR-A1 scenario (from left to right, top to bottom).

References

Reinds, G.J., Bonten, L., Mol-Dijkstra, J.P. & Wamelink, G.W.W. 2012. Combined effects of air pollution and climate change on species diversity in Europe: First assessments with VSD+ linked to vegetation models. In: CCE report 2012: 49-61.

Rowe EC, Tipping E, Posch M, Oulehle F, Cooper DM, Jones TG, Burden A, Hall J & Evans CD (submitted) Predicting nitrogen and acidity effects on long-term dynamics of dissolved organic matter. *Environmental Pollution.*

Progress towards the milestones and deliverables

Below we describe the progress towards the milestones and deliverables for the first 18 -24 months.

Milestones

During the reporting period one milestone was planned (month 12), but here we also report in relation to the second milestone (Table 4.3).

Table 4.3: Planned Milestones for the reporting period of WP15

Milestone	Milestone Title	Month
MS64	VSD+ and MADOC model developed for regional application using gridded European data	12
MS65	FORSPACE-VSD+ and JULES-MADOC models are coupled for prediction of air pollution and climate impacts on soil quality	24

MS64 The VSD predicting soil carbon sequestration has been linked to the Eugrow model and PROPS and has been applied for Europe (see Task 2.2). The MADOC model will not be applied at European scale but for the UK only. An article on the MADOC model has already been submitted for publication in Environmental Pollution including a regional simulation of the UK on a 1 km^2 grid (see above).

MS65 The FORSPACE-VSD+ model is coupled for prediction of air pollution and climate impacts on soil quality at site scale but not for the European scale (see Task 15.2).

The JULES and MADOC models will not be coupled. The MADOC model predicts effects of N, S and ozone pollution on aspects of soil quality such as pH, base saturation, C/N ratio and N availability.

Deliverables

During the reporting period no deliverables were formally planned, but here we report in relation to the two deliverables planned for month 24 (Table 4.4).

Table 4.4: Planned Deliverables for the reporting period of WP15

Deliverable	Deliverable Title	Month
D15.1	The model PROPS	24
D15.2	Collated dataset of European soil ^{14}C data used to define soil turnover times as a function of soil/vegetation type for VSD+ and MADOC model parameterisation	24

D15.1 The PROPS model was parameterized by carrying out a multiple regression analysis linking plant species occurrence to abiotic conditions such as temperature, rainfall, pH, N deposition and N availability. Restricting the analysis to species that occur in at least 50 relevees, response functions have been derived for about 260 species.

D15.2 The collation of a ^{14}C dataset at European scale is in progress.

Use of resources and deviations from DoW

Four person months have been spent on these activities. Until now, there are no real delays and we do not expect problems with knock on effects for future work or deliverables.

Work package 16: European maps of novel thresholds & exceedances

Lead contractor: RIVM
Contributors: ALTERRA, IIASA, met.no, ONU, IPBPSS

Work package objectives

The objectives for WP 16 are to map model-based:

- climate dependent critical nitrogen thresholds, based on criteria for impacts on plant species diversity and accounting for differences in NO_x and NH_y, and their exceedances.
- critical thresholds for ozone uptake, based on criteria for impacts on productivity, and their exceedances

Progress and Results

Task 16.1: Assessment of effect indicators for critical load mapping

According to the proposal description, this task includes the identification "of indicators for geo-chemical and biological endpoints and related critical limits of nitrogen and ozone to enable the mapping of critical loads". During the reporting period, documentation on indicators for geo-chemical and biological endpoints has been updated and summarised in two chapters of a book (edited by W. de Vries, J.-P. Hettelingh and M. Posch; C4 component leader, WP 19 leader and WP16 leader, resp.) planned to be published in 2013. Selected indicators are compiled in the GAINS system and the GAINS-model and documented in the CCE Status Report 2012 (Posch et al., 2012).

References

De Vries, W., M. Posch, H.U. Sverdup, T. Larssen and H. de Wit (2013). Geochemical indicators for the computation of critical loads and dynamic risk assessment of inputs of acidity, heavy metals and nitrogen. In W. de Vries, J.-P. Hettelingh and M. Posch (eds) Critical loads and dynamic risk assessments – nitrogen, acidity and metals in terrestrial and aquatic ecosystems. Springer

Posch M, Slootweg J, Hettelingh J-P (eds), 2012. Modelling and mapping of atmospherically-induced ecosystem impacts in Europe: CCE Status Report 2012. RIVM Report 680359004, Coordination Centre for Effects, Bilthoven, Netherlands, 141 pp

Van Dobben, H.F., G.W.W. Wamelink, S. Smart, E. Rowe, S. Belyazid, M. Jenssen and W. de Vries (2013). Biological indicators for the computation of critical loads and dynamic risk assessment of inputs of nitrogen and acidity. In W. de Vries, J.-P. Hettelingh and M. Posch (eds) Critical loads and dynamic risk assessments – nitrogen, acidity and metals in terrestrial and aquatic ecosystems, Springer

Task 16.2: Mapping model based critical N loads for plant protection and their exceedances

According to the proposal description, this task includes the

- Improvement of databases on soils and vegetation with a specific emphasis on Russia (IPBPS) and the Ukraine (ONU).
- Application of the combined dynamic soil-vegetation model VSD+, with the dynamic multi-plant species model EUMOVE in an inverse way, to assess climate dependent critical N loads.
- Mapping of critical thresholds for oxidized versus reduced nitrogen, based on identified thresholds and experimental data,
- Mapping of exceedances of critical nitrogen loads by comparing present nitrogen loads with updated critical nitrogen loads.
- Evaluation of the use of the newly acquired critical thresholds by the GAINS model.

The progress and results for the first three bullet points are described below (the last two points are not yet relevant in this reporting period).

Improvement of databases on soils and vegetation
The 'European background data base' has been updated (and extended to cover the northern hemisphere north of about 35ºN) and contains information on altitude, soil type and texture, land cover, parent material, distance to coast, forest growth on a 0.01º×0.01º (roughly 1×1 km^2) grid. An application is described in Reinds et al. (2013).

Assessing climate dependent critical N loads
The dynamic soil-vegetation model VSD+ has been extended with a functionality that – based on selected targets in terms of pH, [N] and N availability – can identify appropriate depositions (critical loads). The planning is that those targets can in turn be derived by a plant species model, such as EUMOVE.

Mapping of critical thresholds for oxidized versus reduced nitrogen
Already at the kick-off meeting of ÉCLAIRE in Brescia the group felt that differential critical loads (as opposed to critical levels) for reduced and oxidised N are not well supported by evidence, because the different forms are rapidly cycled within the terrestrial ecosystem and thus usually indistinguishable in terms of impacts. At that meeting it has thus been decided that work on novel thresholds for N should focus on deriving new biodiversity-oriented critical loads for N based on species models, and not on critical loads for oxidized versus reduced nitrogen. That said, the *methodology* for calculating critical loads for separate oxidised and reduced N criteria is available (Posch et al. 2011).

References

Posch M, Slootweg J, Hettelingh J-P (eds), 2011. Modelling critical thresholds and temporal changes of geochemistry and vegetation diversity: CCE Status Report 2011.

RIVM Report 680359003, Coordination Centre for Effects, Bilthoven, Netherlands, 186 pp

Reinds,GJ, Posch M, Aherne J, Forsius M, 2013. Assessment of critical loads of sulphur and nitrogen and their exceedances for terrestrial ecosystems in the Northern Hemisphere. In W. de Vries, J.-P. Hettelingh and M. Posch (eds) Critical loads and dynamic risk assessments – nitrogen, acidity and metals in terrestrial and aquatic ecosystems. Springer

Task 16.3: Mapping critical thresholds for ozone uptake and their exceedances

According to the proposal description, this task includes the

- Mapping of critical ozone uptake thresholds, based on a spatially explicit assessment of tree species and crop types with different ozone critical limits in view of adverse effects.
- Mapping present ozone uptake for specific tree species (focusing on birch, beech, Norway spruce, Holm oak) and crop types (focusing on wheat, and tomato) and related exceedances of critical ozone uptake thresholds for those vegetations by applying the updated photosynthesis-based DO3SE approach coupled to the EMEP model.

The progress and results are described below.

Maps of critical ozone uptake thresholds were derived, based on relationships between phytotoxic ozone dose (POD) and relative yield data of forests distinguishing Norway spruce, Scots pine, Other conifers, Beech/Birch, Oak and Other broadleaves.

The EMEP chemical transport model combined with an updated stomatal exchange component of the DO3SE model was used to assess maps of the phytotoxic ozone dose (POD) for generalised forest ecosystems (coniferous, deciduous and mixed forests) for the years 1990 and 1995–2005 and compared with the critical POD values to assess exceedances. Examples of POD exceedance maps are given in Figure 4.2.

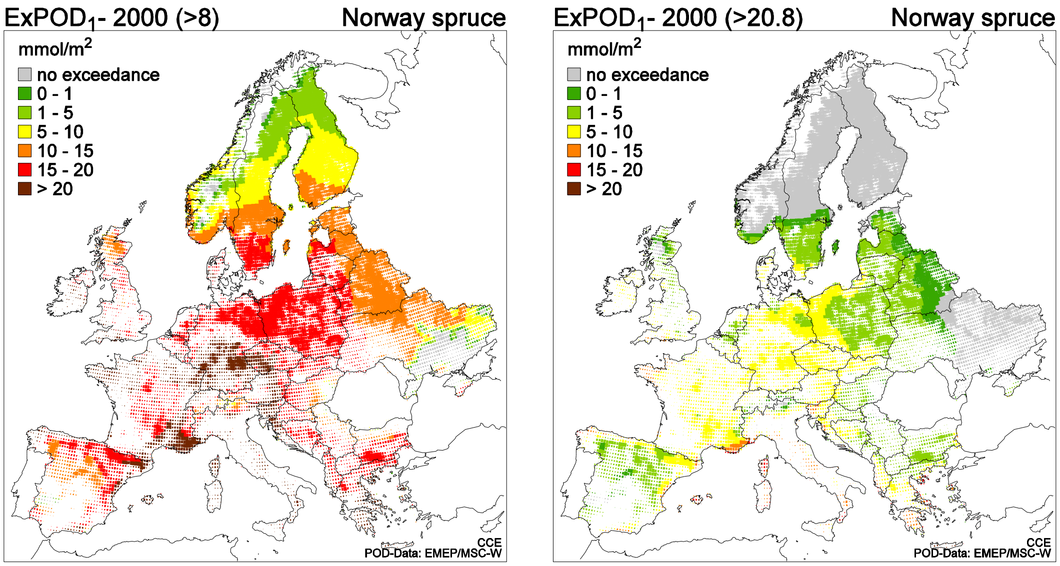

Figure 4.2: Exceedance of POD_1 for Norway spruce using the ICP-Vegetation limit of 8 mmol/m^2 (left) and the critical limit of 20.8 mmol/m^2 derived from a uniform 5% yield reduction (right) [grids are scaled to Norway spruce cover].

Progress towards the milestones and deliverables

Below we describe the progress towards the milestones and deliverables for the first 18 months, plus also milestones and deliverables for Month 24, as they have been reached (in preliminary form) ahead of time.

Milestones

Table 4.5: Planned Milestones for the reporting period of WP16

Milestone	Milestone Title	Month
MS67	Indicators for geo-chemical and biological endpoints are identified to enable the mapping of critical thresholds	12
MS68	Inverse updated model approaches are available relating indicators of natural endpoints to N deposition and concentration	18
MS69	An updated dataset of European soil and vegetation data is available for use in European scale model application	24

MS67 Indicators for geo-chemical and biological endpoints has been updated and summarised in two chapters of a book and selected indicators were compiled in the

GAINS system and the GAINS-model and documented in the CCE Status Report 2012 (see above).

MS68 The dynamic soil-vegetation model VSD+ has been extended with a functionality that – based on targets in terms of pH, [N] and N availability – can identify critical loads of N (and S).

MS69 Although not yet applicable (month 24), we updated the dataset of European soil and vegetation data and used it in a large scale model application (see above).

Deliverables

Table 4.6: Planned Deliverables for the reporting period of WP16

Deliverable	**Deliverable Title**	**Month**
D16.1	Database of soil and vegetation data for the regional and landscape domains	12
D16.2	A map of critical ozone uptake thresholds at European scale	24

D16.1 An updated 'European background data base' containing information on altitude, soil type and texture, land cover, parent material, distance to coast, forest growth on a 0.01º×0.01º (roughly 1×1 km2) grid is available for assessment.

D16.2 Although not yet applicable (month 24), we already made a preliminary map of critical ozone uptake thresholds and their exceedance at European scale (see Fig. 16.1)

Use of resources and deviations from DoW

A total of 18.6 person months have been spent on this work package and during the reporting period no significant delays were encountered.

Work package 17: Local variation in threshold exceedance

Lead contractor: UPM
Contributors: NERC, ALTERRA

Work package objectives

Mapping at a European scale with low resolution models hides a substantial amount of sub-grid variation, which may have significant policy consequences. The objectives of WP14 are to:

1. Establish common databases containing atmospheric concentrations of reactive nitrogen compounds and nitrogen deposition data for regional and landscape scales (from WP8)

2. Establish common databases containing current soil and vegetation data for the regional and landscape scales

3. Assess critical N thresholds and their exceedances at several grid resolutions from 5 x 5 km^2 and 1 x 1 km^2 (regional scale) down to 50 x 50 m^2 (landscape scale) and evaluate the uncertainty in these

During the reporting period, the objectives of the work package was to select and collate the available datasets in order to establish the common databases in Task 17.1 (Objectives 1 and 2).

Progress and Results

Task 17.1: Data collection for regional and landscape scale assessments

The regional scale domains to be used for each dataset were chosen in collaboration with WP8 and are shown in Figure 4.3. The domain containing both the UK and the Netherlands will be modelled at a resolution of 5 x 5 km^2 and the smaller domains for Scotland and the Netherlands will be modelled at a resolution of 1 x 1 km^2. The landscape scale assessments includes two landscapes, i.e. Burnsmuir in central Scotland and Noordelijke Fiese Wouden (NFW) in the Netherlands.

Task 17.1 includes the further improvement of existing soil and vegetation databases at 5 km x 5 km and 1 km x 1 km at the regional scale (Central Scotland and the Netherlands) and at 50 m x 50 m for the two landscapes (Burnsmuir, and NFW). During the reporting period, an extensive review of suitable datasets held by the task partners was carried out. This review resulted in the selection of datasets for the regional and landscape assessments summarised in Tables 4.7 and 4.8.

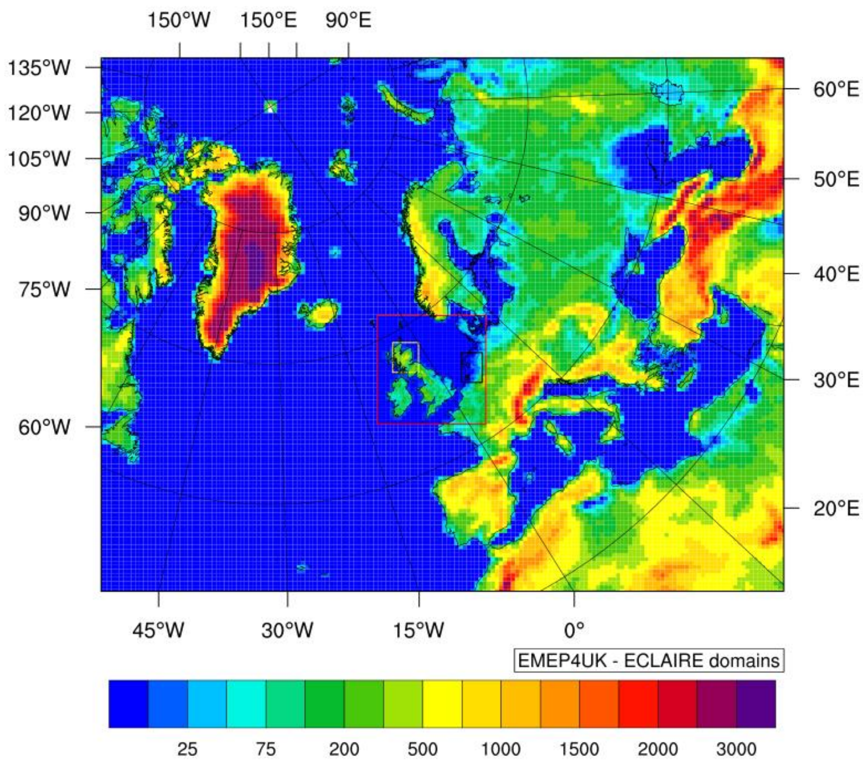

Figure 4.3: The regional modelling domains to be used by WP8 and WP17. Red box: Modelling at 5 x 5 km^2 resolution; Yellow and black boxes: Modelling at 1 x 1 km^2 resolution.

Regional scale assessments: For the UK, no suitable national soil datasets are available at the regional scale (1 x 1 km) and insufficient resources are available to derive them from other data sources (see also Table 4.7). It was decided, therefore, that the soil datasets for the UK regional scale modelling will be the same as those used in WP16 (European maps of novel thresholds and exceedances). The Critical Loads modelling at a regional scale for the UK will differ from that done in WP16 only through the use of a higher resolution land cover map (LCM2007). In addition to the selection of suitable datasets, the task participants have also had several discussions via teleconferences and at the project annual meeting, jointly with WP8, in order to agree on the best approaches to carry out the other tasks of this work package. It was decided that base datasets are those at 1 x 1 km resolution, which will be aggregated to create the 5 x 5 km datasets. The reason for this is so that we can analyse the effect of spatial resolution without combining the problem of dataset inconsistency.

Landscape scale assessments: The landscape-scale modelling (50 x 50 m resolution) will use high resolution datasets for the two study landscapes, i.e. the Scottish landscape Burnsmuir and the Dutch landscape NFW, partly obtained in the NitroEurope project.

Table 4.7: Selected datasets for the regional-scale modelling

Regional scale (1 x 1 km) – will also be aggregated to 5 x 5 km			
Dataset type	**Data source**		**Comments UK data**
	Netherlands	**UK**	
Land use	LGN (national data)	UK land cover map 2007 (LCM2007)	
Soil type map	Dutch soil map	European Soil Database (ESDB) v2 polygon map at scale 1:1M	European dataset used for UK. i.e. there is no difference between the soil datasets used in WP16 and WP17
Soil data	National soil database	WISE Spade database	See above
Soil Wetness	Dutch soil map	WISE Spade database	See above
Nature type	Dutch Nature types	Broad habitat classification from LCM2007 mapped to EUNIS classes	

Table 4.8: Selected datasets for the landscape-scale modelling

Landscape scale (50 x 50 m) – will also be aggregated to 250 m x 250 m			
Dataset type	**Data source**		**Comments Burnsmuir data**
	NFW landscape	**Burnsmuir**	
Land use	BRP (regional data)	Polygon land cover map	Created in the NitroEurope IP
Soil type map	Dutch soil map	JHI map plus soil sampling data	JHI data obtained through external licence (licensed data received by NERC February 2013)
Soil data	National soil database	JHI map plus soil sampling data	See above
Soil Wetness	Dutch soil map	Application of TNT hydrological model (part of NitroScape)	Dependent on progress with the NitroScape model (WP8)
Nature type	Dutch Nature types	EUNIS classes derived from LCM2007 and site visits	Site visits planned for Spring 2013, once vegetation grow has started

Task 17.2: Model application

This task includes the assessment of critical nitrogen thresholds and their exceedances at 5 x 5 km and 1 x 1 km for Scotland and The Netherlands and at 1 x 1 km and 50 x 50 m for the two landscapes in those countries. Work is ongoing, but for the impacts/critical loads assessment, we decided that we will for all regions use the VSD+ Inverse PROPS model chain (see WP16).

Progress towards the milestones and deliverables

Milestones

During the reporting period four milestones were planned to be reached (Table 4.9).

Table 4.9: Planned Milestones for the reporting period

Milestone	Milestone Title	Month
MS71	Assessment of existing soil and vegetation data resources and their availability	6
MS72	All requests for external soil and vegetation data submitted (if necessary)	9
MS73	Regional and landscape scale soil and vegetation databases complete	12
MS74	Database of atmospheric concentrations and deposition for the present period (2008)	16

MS71 Following several email and teleconference discussions, the assessment of existing soil and vegetation data was completed in December 2012 (Month 15). Although completed later than planned, it was still in good time to complete the regional and landscape scale soil and vegetation databases before they are needed for the modelling (which is due to start in Month 24).

MS72 During the assessment of existing data, one external licensed dataset (1:25,000 scale soil spatial data for Scottish landscape) was identified as necessary for the completion of WP objectives. This dataset was requested from the data providers (The James Hutton Institute) in December 2012 (Month 15) and was received in February 2013. Although the request was made later than planned, it will not delay the completion of the databases.

MS73 Due to the lengthy discussions that were needed to agree on the most suitable datasets to use, taking into account the project resources available, and a decision to ground-truth the landcover map used for the Scottish landscape study area after plant growth starts, in May 2013, the completion of the soil and vegetation databases has been delayed. This Milestone is now planned to be reached in May 2013 (Month 20), which should not delay the project since the databases are not currently planned to be used until Month 24.***Update September 2013:*** There has been some further delays, but delivery is expected not later than month 26. This may cause a short delay to the start of the following work, but this has been discussed and it is agreed that it will not cause further delays to the later work.

MS74 Regional scale modelling is currently being carried out in WP8 using the EMEP4UK model. The outputs from the model runs are planned to be made available to WP17 by May 2013 (Month 20). This delay is not anticipated to delay WP17, since these data are not due to be used until after Month 24. The availability of the landscape scale model output data from WP8 is determined by progress with the development of the NitroScape model. It is hoped that the delay to NitroScape will not affect the objectives of WP17. Contingency plans have been made, should delays with WP8 occur (see 'Use of resources and deviations from DoW' below). ***Update September 2013:*** It has been decided to use alternative models to generate the landscape data in WP8, more specific decisions will be made at the next project meeting (month 25 in Zagreb), this timing means that there will be some delay to the start of the work on MS74, however this is being taken into account to avoid any knock-on effects.

Deliverables

During the reporting period two deliverables were planned (Table 4.10).

Table 4.10: Planned Deliverables of WP17 for the reporting period

Deliverable	Deliverable Title	Month
D17.1	Database of soil and vegetation data for the regional and landscape domains	12
D17.2	Database of ammonia concentration and nitrogen deposition data for the regional and landscape domain	18

D17.1 As discussed above, the preparation of the soil and vegetation database has been delayed and is now planned for Month 20. ***Update September 2013:*** This work is ongoing, but is further delayed, delivery will be month 26.

The regional scale concentration and deposition data are expected to be made available from WP8 in Month 20 also, and it is expected that the regional scale part of **D17.2** will be complete by this date, too. These delays are not expected to affect the corresponding WP17 objectives. It should be noted that the landscape scale output from WP8 to WP17 are expected to be delayed depending on progress with the NitroScape model. It is hoped that this delay will not affect the objectives of WP17; however contingency plans have been made, as described in the following section.

Use of resources and deviations from DoW

A total of 4.9 person months have been spent on this work package. As discussed above, several delays have been encountered in this reporting period. One of the principal problems has been the realization that there are insufficient project resources to carry out the critical load modelling at a regional scale (5 x 5 km and 1 x 1 km resolutions) for the UK. Consequently, it was decided that the same soil dataset will be used for the UK in both WP16 and WP17. This means that it will not be possible to assess any uncertainty due to the spatial resolution of the soil data. However, it will be possible to assess the effect of the spatial resolution of the land cover data fully, since 1 x 1 km resolution data are available for the UK. The delays mentioned above are the result of longer-than-planned discussions on dataset suitability as well as dependencies on delayed model developments and simulations under WP8. These delays are not expected to affect the progress of WP17 for the reasons given above, nor are they expected to affect the attainment of future WP17 milestones or deliverables. The exception to this is the delay in the development of NitroScape under WP8, which is to provide the landscape scale concentration and deposition output for WP17 for the UK landscape. Further delays in this development may mean the use of contingency strategies in WP17, such as the use of the OPS model alone (instead of as part of the NitroScape framework). However, close links to WP8 will be maintained to minimise the possibility of having to use such a contingency strategy. ***Update September 2013:*** It has been necessary to employ the contingency plan of using alternative models to provide the landscape data at this stage. The details will be discussed at the project meeting in Zagreb, month 25, along with ensuring that there are no knock-on delays to work in WP17. The final delivery is expected in month 30 (March 2014).

2.2.5 Component 5: Integrated risk assessment & policy tools

Lead contractor: IIASA

Component objectives

ÉCLAIRE C5 intends to quantify and valuate ecosystem effects, implement new effect indicators and critical thresholds in the GAINS modelling system. Cost optimization of abatement measures under climate change conditions and Cost-benefit analysis (CBA) will allow relevant policy recommendations.

Progress and Results

WP18: Deriving economic impacts and valuation of ecosystem services

The review of the Ecosystem Service Approach indicated that existing concepts turn out not to be sufficiently robust to allow for an authorative result of a CBA under the conditions of climate change. In consequence a more thorough analysis is needed, using a more complex framework. The additional analysis, while not yet completed, is expected to be more useful such that the delay incurred now can be made up during the later project phase. In the meantime, a CBA to the current European situation has been established and published peer-reviewed literature, with a strong contribution from WP18.

WP19: Integrating effects of air pollution under climate change

Successful extensions of the GAINS model and the GAINS system were implemented. A new database on critical loads is available, and new dose-response relationship for nitrogen and ozone are available based on recent literature on the European scale. GAINS now can use flux based indicators (POD's) for ozone and biodiversity-related indicators. Results have been made available to the general public, or will be in the near future (reports in press). Dissemination activities to scientific and administrative bodies have been initiated successfully as planned.

WP20: Implications for mitigation and adaptation strategies

In order to allow the analysis of the effects of air quality under a future climate, GAINS scenarios have been extended to 2050, and efforts to interpret trends beyond 2050 are under way. Results have been shared with chemical transport modellers within the project to allow for establishing a source-receptor matrix, which will be used in future analyses. The ÉCLAIRE concept has been discussed with stakeholders to include their feedback in the further process.

Progress towards the milestones and deliverables, use of resources and deviations from DoW

Work in C5 is more focussed towards the second half of the project, therefore the activities of the past 18 months have involved dialogue with the other components and work packages on the needs and inputs required by C5.

However there has been a significant delay with respect to WP18 which was due to unforeseen difficulties in providing robust results. At this time the delay seems manageable, as the delayed deliverable (D18.1) is now expected to contain a more profound analysis than originally foreseen.

Successful work on establishing new indicators (flux indicators in the GAINS model, biodiversity indicators in the GAINS system) which provides the basis for assessing ecosystem damage (a key parameter in the final cost-benefit analysis of ÉCLAIRE under the conditions of climate change) has taken place. This work has been documented and is available. Also, the extension of GAINS scenarios towards 2050 has been implemented successfully and results have been made available to project participants. Activities to extend an analysis beyond 2050 are under way although it cannot be expected (and also was not included in the DoW) to be quantitatively included in the GAINS model. Dissemination activities of results have started successfully, and stakeholders have been invited to provide feedback to the foreseen project tasks. Also the process of the revision of the EU's Thematic Strategy on Air Pollution has been informed on the on-going activities of ÉCLAIRE and first results which, where possible, have been fed into the process.

Work package 18: Deriving economic impacts and valuation of ecosystem services

Lead contractor: EMRC
Contributors: NERC, IIASA, SEI-Y, RIVM, IVL, AU

Work package objectives

Work in WP18 aims to bring together information needed for Cost-Benefit analyses (CBA), one of the final outputs of ÉCLAIRE work. More specifically the objectives are:

1. To link the concept of ecosystem services with existing mapping of European ecosystems and pollutant impacts.
2. To characterise the links between pollutant exposure, impact and value to permit qualification of pollutant damage.
3. To assess changein the value of ecosystem services across different scenarios using a marginal approach to the extent possible.
4. To prioritise gaps in the existing knowledge base such that further research can be targeted on the parameters likely to have the greatest economic impact.

Progress and Results

Task 18.1: Review ESA for European application

The review of the Ecosystem Service Approach indicated that existing concepts turn out not to be sufficiently robust to allow for an authorative result of a CBA. Thus an extension of the review was initiated, using a more complex framework analysis, which is not yet completed. As a side-track, a CBA to the current European situation has been established and published in the peer-reviewed literature.

Task 18.2: Prioritisation

Dynamic modelling activities have been set-up but results are not available (in-line with project timeplan).

Task 18.3: Dose response relationships

Biodiversity indicators have been developed for possible future use at least in the GAINS system. These indicators will allow to quantify the response based on change in emission dose.

Task 18.4 – Task 18.7

Work on these tasks has not started yet.

Progress towards the milestones and deliverables

MS78 Prioritisation of ecosystems and ecosystem services is in place as a result of the C5 meeting of the Edinburgh general assembly. D18.1 is clearly delayed and needs to include results of a review of the Millennium Ecosystem Assessment (MEA) in order to render the results useful. ***Update September 2013:*** D18.1 will be delivered this month (24).

Use of resources and deviations from DoW

While WP18 mostly concerns the second half of the project, many activities have started already, albeit at a slower pace than initially expected. A total of 4.5 person months have been spent so far. The delay incurred may have consequences for WP19&20, therefore efforts will be extended to provide timely input.

Work package 19: Integrating effects of air pollution under climate change

Lead contractor: RIVM
Contributors: NERC, ALTERRA, IIASA, met.no

Work package objectives

In WP19, new indicators of ecosystems effects are developed for operational use in the GAINS model and/or the GAINS system. Robustness and magnitudes of these indicators under climate change conditions will be explored, in order to provide policy support.

Progress and Results

Task 19.1: Critical thresholds

In the GAINS-model a new database of critical loads (D16.1) has been implemented in 2012. This new database includes most recent county contributions, while the resolution of critical loads now enables assessments on a 5x5 km2 grid providing an improved focus on Natura 2000 areas.

Task 19.2: Dynamic modelling

Dynamic modelling activities have been set-up but results are not available (in-line with project timeplan).

Task 19.3: Dose response relationships

Regarding the GAINS-system two advances have been realized. The first is the implementation on a European scale (Hettelingh et al., in prep) of nitrogen-dose-response functions which have been developed on the basis of Gradient studies (Stevens, et al. 2010). The second involves the implementation of limits to assess impacts of ozone (first results under D16.5). In collaboration with ALTERRA, acquired/established a tree species database covering Europe (excl. RU) on a 0.01 by 0.001 degree grid. This database has been used to compute exceedances of POD, using POD1 computations from met.no, exploring different critical limits, obtained from the ICP Vegetation (CEH Bangor), and their consequences for 4 different tree species. This work is meant to guide further developments in this field: (a) review of critical limits; (b) extension of POD calculation for specific species (now only coniferous and deciduous PODs are available).

Task 19.4: Robustness

An assessment was performed by RIVM-CCE in collaboration with IIASA under the Convention on Long-range Transboundary Air pollution (and presented to its bodies) of the recently (May 2012) negotiated revision of the Protocol to abate acidification, eutrophication and ground-level ozone. Results including preliminary robustness analysis based on currently available indicators have been published in the CCE Status report 2012 (Posch et al., 2012).

Task 19.5: Workshops

The 28th meeting of the Task Force on Modelling and Mapping and the 22nd CCE workshop were held back to back at the National Centre for Emissions Management of the Environmental Protection Institute (Warsaw, Poland, 16-19 April 2012). The meetings were held under the auspices of the Convention and EC-programmes including ÉCLAIRE (MS82). The meeting was attended by 48 delegates from the following 23 countries: Austria, Azerbaijan, Bulgaria, Canada, Croatia, Czech Republic, Denmark, France, Germany, Ireland, Italy, Norway, P,R, China, Poland, Republic of Moldova, Russia, Slovenia, Sweden, Switzerland, The Netherlands, Ukraine, United Kingdom, United States, The bureau of the Working Group on Effects (WGE), the ICP Vegetation, the ICP Waters, the ICP Forests, the ICP Integrated Monitoring, the Coordination Centre for Effects (CCE), NEBEI and the UNECE secretariat were also represented. With respect to ÉCLAIRE, the meeting included the review of research progress on nitrogen (N) induced change of plant species biodiversity and their applications at local or regional scales (D16.1) and the review progress regarding methods and objectives for valuing air pollution effects (in conjunction with Task 20.4). Results have also been presented to the 41st Task force on Integrated Assessment Modelling (Bilthoven, 7-9 May 2012) and Working Group on Effects (Geneva, 19-21 September 2012).

Progress towards the milestones and deliverables

MS82 (presentation of progress to the Working Group on Effect) has been successfully completed. Agreement on MS 83 (effect indicators and critical thresholds) was reached at the C5 meeting of the Edinburgh general assembly. D19.1, a progress report on the implementation of indicators, has been provided as a part of the annual CCE report.

Use of resources and deviations from DoW

Most activities of WP19 are directed to the latter part of the project’s lifetime. So far, work proceeds successfully as planned. A total of 4.5 person months have been spent on this activity.

Work package 20: Implications for mitigation and adaptation strategies

Lead contractor: IIASA
Contributors: NERC, ALTERRA, ECN, RIVM

Work package objectives

WP20 aims to use the GAINS model to analyse effects of air pollution on ecosystems and the minimization of such effects under situations of climate change and climate adaptation.

Progress and Results

Task 20.1: Interact with policy makers

Scientists working on WP20 have used a number of channels to discuss priorities of work with policy makers at the EU and UNECE level. ÉCLAIRE was specifically discussed at a session of the NIAM (national integrated assessment modellers) meeting in Brescia, Italy, June 2012. Both the Task Force on Reactive Nitrogen and the Task Force on Emission Inventories and Projections have been informed and requested to provide feedback on their respective priorities.

Task 20.2: Extend GAINS into more distant future years

Using external activity projections from a variety of sources (energy models, agro-economic models as well as FAO projections) as well as establishing additional abatement technologies inside the GAINS model now allows to extend its range to 2050. First results, which moreover have been established in a gridded version have been made available to the ÉCLAIRE public. In order to extend the scope of activities even further into the future, a workshop explicitly aimed at N scenarios was organized at IIASA, October 2012.

Task 20.3: Analyze scenarios with respect to policy options

Communication interfaces with the DGVMs to handle that analysis have been explored at a workshop held at IIASA in March 2012 – scenario analysis has not yet started.

Task 20.4: Cost-benefit analysis and conclusions

While the activity on the specific ÉCLAIRE scenarios has not yet started, a CBA dealing with the current situation has been published as a peer-reviewed paper, comparing N related costs of different environmental effects and concluding the indeed high ecosystem effects to be attributed to N (considered as high or higher than the advantage to agriculture). The study may serve as a backdrop to a specific analysis for climate change conditions.

Progress towards the milestones and deliverables

MS89 (stakeholder workshop with NIAM) has been completed, a report of which (D20.1) is available. The “status workshop” (MS90) took place as planned during the Edinburgh Second General Assembly. D20.2, the detailed description of the implementation of 2050 scenarios (month 14) is delayed, its publication will be combined with the completion of D20.3 (considerations beyond 2050) due month 19. ***Update September 2013:*** This deliverable has now been completed.

Use of resources and deviations from DoW

WP20 performs its main activities in the second phase of the project, once results come in. Thus, the first 18 months is focussed on preparation activities and results are not so much visible yet. In that phase, the internal structures have been established successfully, and all indications are that the work package will continue as planned.
A total of 8.4 months have been spent on this work package.

2.2.6 Work Package 21: Standards and data management

Work package objectives

The overall aim of this cross-cutting work package is to ensure effective integration, communication, standardization, and management of data between the different Science Components of ÉCLAIRE. It has the following objectives:

1. To facilitate the selection and harmonisation of scenarios used throughout the project
2. To develop and implement common measurement protocols across all measurement activities within the project
3. To establish, document and implement common modelling protocols to ensure reliable and transparent model results
4. To establish and implement methods for assessing uncertainties in modelling
5. To ensure data quality and implement procedures for quality control
6. To set up a Data management Committee (DMC), consisting of a Data Manager for each of the ÉCLAIRE Science Components (C1 – C5), the ÉCLAIRE web portal manager, the consultancy services of the NERC(EDI) Informatics Liaison Team, the IP secretariat.
7. To produce a Data Policy and a comprehensive, working Data Management Plan.
8. To establish two Data Centres appropriate to (i) ÉCLAIRE Components 1-3, and (ii) ÉCLAIRE Components 4-5.
9. To establish a single data portal, to harmonize and make available spatial data and model output, and to provide easy, secure upload and data access facilities for the field and laboratory measurements.

The above objectives are addressed under four tasks:

- Task 21.1: Harmonization of scenarios (Objective 1)
- Task 21.2: Common measurement protocols (Objective 2)
- Task 21.3: Model protocols and uncertainty (Objectives 3 and 4)
- Task 21.4: Data quality and database management (Objectives 5-9)

Progress under each of these tasks is reported below. A total of 17.8 person months were spent on this work package. This total is higher than planned – mainly under Task 21.4. See ‘Use of resources and deviations from DoW’ for Task 21.4 for more detailed information.

Task 21.1: Harmonization of scenarios

Lead contractor: IIASA
Contributors: JRC, SMHI, NERC(EDI)

Task objectives

Task 21.1 (harmonization of scenarios) aims to ensure that the scenarios used in ÉCLAIRE (climate-affected meteorological scenarios, land use scenarios and emission scenarios) are consistent across the project. A "scenario team" is responsible for making available existing scenario data on each of these terms to ÉCLAIRE participants, and to advertise their activity.

Progress and Results

Instead of developing yet another set of scenarios, ÉCLAIRE intends to make use of available information. The scenario group guides this process by exploring the developments in the scientific literature and in related projects. Results are made available to the ÉCLAIRE community via the internal pages of the ÉCLAIRE web page.

A first version of such a scenario guidance tool has been completed and made available to ÉCLAIRE participants as planned. With scientific developments on scenarios continuing, especially in the context of activities of the Task Force on Hemispheric Transport of Air Pollutants as well as the IPCC 5th assessment report (RCP and SSP scenarios), the scenario group will continue to observe what is most useful for ÉCLAIRE and provide updated information.

Scenarios may be used generally, but the most profound users in ÉCLAIRE will be within the C2 and C4 components. A C2-C4 modellers group has been set up, with Task 21.1 actively participating. For that reason, a dedicated meeting C2-C4 was organized at IIASA in March 2012 and included representatives of Task 21.1. Also, the state of scenario recommendations was presented at the C2-C4 workshop within the ÉCLAIRE general assembly in Edinburgh, October 2012.

IIASA also organized a workshop in October 2012 (co-sponsored by ÉCLAIRE) on "Global nitrogen scenarios in the 21st century" in order to be able to include and impact the scientific developments on emission scenarios and their use in different international agendas.

Progress towards the milestones and deliverables

Milestones and deliverable scheduled for this task all have been achieved. "**D21.1** – Initial scenario guide as an updatable, internal web page" is available at http://www.eclaire-fp7.eu/scenario (for logged-in users only). "**MS99** – Information exchange between internal users and scenario team established" has been clearly demonstrated at the General Assembly – C2 and C4 modellers are aware of information available and address WP21.1 in case of questions.

Use of resources and deviations from DoW

No significant deviations from the planned activities need to be reported.

Task 21.2: Common measurement protocols

Lead contractor: FDEA-ART
Contributors: NERC, DTU

Task objectives

- Establishing common protocols for the network measurement activities in components C1 and C3 in close collaboration with the concerned WP leaders (WP1 and WP10)
- Ensuring that measurement protocols are consistent with the data requirements for initializing, driving, and validating the process models in collaboration with modellers - Link with Task 21.4 to ensure the consistency of measurement protocols and data reporting procedures.

Progress and Results

Intense information exchange and discussions between modellers and experimentalists took place in the first 12 project months, a.o. in dedicated meetings sessions (kick-off meeting in Brescia, C3 meeting in Dragor, COST/ÉCLAIRE modelling workshop in Paris) and a list of required and useful data/quantities with temporal resolution for initializing, driving, and validating various process models was produced.
Based on this and on standards previously defined in the NitroEurope-IP, lists of measured quantities and protocols have been formulated (partly site/experiment specific). The protocols have been distributed and were agreed by October 2012.
In WP1 (flux network), standardised leaf wetness measurements, leaf surface ion loading and detailed PAR radiation measurement with 1 min time resolution have been included in the measurement protocols based on modeller requirements. In order to improve the standardisation and quality control of ozone and NO_x flux measurements, a dedicated workshop (in collaboration with COST Action ABBA) was organised in Paris in February 2013, and corresponding recommendations were formulated.
The reporting and import procedure of WP10 data to the ÉCLAIRE database has been tested and established in Feb/Mar 2013 using the FDEA-ART dataset as pilot.

Progress towards the milestones and deliverables

The milestone MS100 (Common measurement protocols for C1 and C3 agreed and distributed) and the deliverable D21.3 (Agreement on common measurement protocols for components C1 and C3) have been completed in the reporting period. There are no further milestones and deliverables in this task.

Use of resources and deviations from DoW

There have been no deviations from the description of work for this task.

Task 21.3: Model protocols and uncertainty

Lead contractor: UEDIN

Task objectives

As mentioned earlier, the task objectives are:

- To establish, document and implement common modelling protocols to ensure reliable and transparent model results
- To establish and implement methods for assessing uncertainties in modelling

As a cross-cutting activity this task was designed to ensure that the modelling community developed and maintained a dialogue on modelling and uncertainty protocols within the project to ensure consistency in the use of data, the reporting of results and the handling of uncertainty.

Progress and Results

The issue of model protocols and uncertainty was highlighted at the project kick-off meeting in Brescia 2011, which led to cross-component discussions on the most appropriate ways to address the issue. It was decided that in the case of the ensemble CTM study (and linked models), a modelling/ensemble modelling protocol was required. This protocol was developed prior to a meeting in IIASA in March 2012, further developed at the meeting and then finalised in the months afterwards. To develop this protocol and the necessary information to harmonise the models involved, all modellers within the project were asked to supply input and output data, as well as information on more detailed uncertainty work they had undertaken on the models to be used and any planned during the project. The document 'Protocol for an ensemble model assessment of CTMs, DGVMs and DSVMs in scenario analysis in ÉCLAIRE' was authored by the leaders of components 2, 4 and 5 and was circulated to the community.

Progress towards the milestones and deliverables

MS101 'Modelling and uncertainty assessment protocols written and distributed' (Month 9) and associated deliverable **D21.4 '**Agreement on common modelling and uncertainty assessment protocols across components C1-5' (month 9) were both delivered on time. There were no further milestones or deliverables due within this reporting period.

Use of resources and deviations from DoW

There have been no deviations from the description of work for this task.

Task 21.4: Data quality and database management

Lead contractor: NERC

Task objectives

1. To set up a Data management Committee (DMC), consisting of a Data Manager for each of the ÉCLAIRE Science Components (C1 – C5), the ÉCLAIRE web portal manager, the consultancy services of the NERC(EDI) Informatics Liaison Team, the IP secretariat.

2. To produce a Data Policy and a comprehensive, working Data Management Plan.

3. To establish two Data Centres appropriate to (i) ÉCLAIRE Components 1-3, and (ii) ÉCLAIRE Components 4-5.

4. To establish a single data portal, to harmonize and make available spatial data and model output, and to provide easy, secure upload and data access facilities for the field and laboratory measurements.

Progress and Results

Deliverable 21.11 (First database report on intermediate and final database content, including QA/QC report)

Due to the unforeseen complexity of the data management associated with WP9 in particular, WP10, WP11 and some aspects of WP1, the construction of database forms and uploading of data was delayed for 6 months. The Data Management team acquired funding for a casual data assistant and we have made progress since January. We have been aware of the modellers' needs for data, and have encouraged communication so that we can respond to their needs as they arise.

The software developed for NitroEurope has been deployed and "branded" for the ÉCLAIRE project. The software has undergone some enhancements to improve performance and user-friendliness in particular with reporting data. Further enhancements are planned.

WP1

Field measurement data (WP1.1):
The template is almost ready for distribution. A recent meeting with the Component 1 leader (Eiko Nemitz) has clarified some points. The template will be edited and tested before distribution. We estimate that this task will be ready to start by the end of May 2013.

Bosco Fontana data (WP1.4):

WP1 Bosco Fontana data require a large number of different database forms to be constructed, which are unique for this task. The data management team are still developing EXCEL templates and database forms for this activity. It is anticipated that templates will be distributed and database forms will be uploaded by the end of June 2013.

QA/QC for WP1:
The database validations for duplicate fields, formatting of dates, field types and value ranges for individual fields will be in place.

WP9: Literature data mining
The demands of the WP9 literature data mining activity eventually exceeded the capability of the database system in terms of the complexities of the links between data and the querying needs. This activity had to be re-planned and those data are now being uploaded to a Microsoft ACCESS database, which will be accessible from the main ÉCLAIRE database with a metadata form. The task proved exceptionally complex, and a large amount of time and effort has been invested in preparing the data, designing the EXCEL template, and uploading the ACCESS database.

To date, there are 3032 records for "Leaf level processes", 1794 records for "Dynamic processes" and 5162 records for "Ecosystems processes". Pre-designed query forms are under construction and further files have been submitted for uploading. We will upload these files and complete the query forms by the end of June 2013.

QA/QC for WP9:
The structure of the key fields for each table safeguards against duplicate key field entries. The definition of field data types constrains numeric and text fields. Queries will be run to check final content for valid values of different fields.

WP10/WP11
The database templates, the database forms, site and user definitions, and preparation of the database for submissions are complete. Data have been uploaded for site "Alp-Flix" and site "Curno". A WP10/WP11 specific user guide has been posted on the ÉCLAIRE web portal, and the users informed of the task. We are communicating frequently with data providers, and offering as much support/help as they require.

A guide to data downloading specifically for WP10/WP11 has also been posted on the ÉCLAIRE web portal, and the C3 PI has been informed of this, and asked to distribute to the relevant modellers.

QA/QC for WP10 and WP11:
The database validations for duplicate fields, formatting of dates, field types and value ranges for individual fields will be in place.

Components 4 and 5: Afolu data centre – JRC
The Afolu database has been set up for ÉCLAIRE to accept spatial metadata for the C4-C5 components of the project. The system has been built and is ready to accept new records.

New detail project page (with logo, description and external links for each project)

New data documentation for completing meta-data forms have also been created to guide users on how to create their entry. Currently there are no records for the ÉCLAIRE project.

Progress towards the milestones and deliverables

Milestones

Milestone number	Milestone name	Lead beneficiary number	Date of delivery	Comments
MS104	Data Policy and Data Management Plan first drafts written and agreed	1	October 2012	Posted on the ÉCLAIRE web portal under the 'Data' pages.
MS106	Database software ready to accept data	1	March 2013	Database software ready to accept data for components C2, C4 and C5, Documentation and guides complete and posted on the portal

Deliverables

No.	Deliverable Title	WP	Lead beneficiary number	Date of delivery	Comments
D21.7	ÉCLAIRE Data Management Plan & Data Policy documents	21	1	May 2012	• ÉCLAIRE Data Policy: version 3 18th May 2012 • ÉCLAIRE Data Management Plan: version 3 18th May 2012
D21.9	Database training sessions for users – online tutorials	21	1	October 2012	Database training sessions were attended by 12 people at the 2nd GA in Edinburgh in October 2012.
D21.10	Database documentation and guides for users	21	1	March 2013	The following guides are on the website: • CEH database: Guide to uploading data • CEH database: Guide to reporting • CEH database: Self-help tutorial for downloading data • WP10 and WP11 Guide to uploading data • WP10 and WP11 Guide to downloading data

Use of resources and deviations from DoW

There have been delays as reported above mainly with time spent on WP9. However, this has now been rectified and templates for uploading data should begin over the next months.

Development on a new reporting system within the database is now in the testing phase after which it can be promoted to the production site. The reporting of data (getting data out) will be much faster and more efficient that the current method.

Mini-Milestones Planned

30/06/2013 - New reporting system to production site
30/09/2013 - First 18 months of data for WP1, WP10 and WP11 uploaded to database

2.2.7 Work Package 22: Co-ordination and management

This section summarises the activity within the management WP of the ÉCLAIRE project, however a more detailed 'Management Report' is also provided in Section 2.3 as per commission guidelines.

Work package objectives

The objectives of WP 22 are:
1. To establish and operate the ÉCLAIRE project office
2. To provide scientific coordination of the project
3. To provide financial and administrative coordination of the project
4. To facilitate and ensure comprehensive, complete and timely reporting to the EC
5. To facilitate and organise an annual report for policymakers on progress with the 'Objectives, Key Questions and Specific Questions' of the project
6. To organise the General Assembly and other project meetings
7. To support the Executive Steering Committee and the Scientific Advisory Board
8. To oversee the appointment of a Gender Action Committee and its associated activities

Progress and Results

Task 22.1: Scientific project co-ordination and management

A project office was in place for the start of the project, consisting of the project co-ordinator (Professor Mark Sutton), scientific project manager (Dr Clare Howard) and a finance officer (Mrs Agnieszka Becher). During the maternity leave of the scientific project manager (months months 9-15), Dr Stefan Reis took on the necessary responsibilities for the project office. The first annual stakeholders report was delivered in early 2013 in collaboration with the component leaders.

Communication has been developed and maintained between the Executive Steering Group (ESG), the Stakeholder Advisory Board, project PI's and the full ÉCLAIRE community. This includes organising regular teleconferences of the ESG and circulating the minutes and providing information through the ÉCLAIRE website and e-mail distribution lists.

Task 22.2: Project administration and financial management

During the current period the project office organised (in collaboration with any local hosts), the kick-off meeting in Brescia, Italy (October 2011), the 2nd General Assembly in Edinburgh, Scotland (October 2012) and have started preliminary work on the 3rd General Assembly, which will be held in Zagreb, Croatia (October 2013).

In advance of the first set of reporting, the project office provided information and support to the project partners on the requirements of financial and activity related reporting. Activity reports have been collected and collated and the procedure for the electronic signatures of financial statements has been implemented as part of the financial reporting. The pre-financing has been distributed between all project partners and the contract has been amended 3 times following changes to partners budgets, persons responsible for the work, changes to the implementation of the tasks.

Task 22.3 Gender Action Plan activities

The project office organised a Gender Action session at the kick-off meeting in Brescia, October 2011 and also at the 2nd General Assembly in Edinburgh, Scotland, October 2012 (young scientists were also encouraged to attend this session). A Gender Action questionnaire, which asked for information on the ratio of males and females working on the ÉCLAIRE project and the perception of gender issues in the workplace was developed and circulated to ÉCLAIRE scientists. The results of the questionnaire, which are posted on the project website, were also presented at the 2nd General Assembly and circulated to the ÉCLAIRE community.

Progress towards the milestones and deliverables

D22.1 Annual progress report year 1 (month 13).This report was developed in collaboration with the component leaders and included a synthesis for policymakers. Time commitments led to a delay in the delivery of this item, however the extra time allowed more recent developments to be included within the report and to be described in the context required for policymakers.

MS110 ‘Project office established and operational’ (month 1). The project office was established at the very start of the project.

MS111 ‘1st periodic project meeting held’ (month 18). After the start of the project it was decided that it would be more effective for project communication to have an annual project meeting (and General Assembly), instead of holding meetings in relation to the timing of the reporting periods (Month 19, 36 and 48). Therefore this milestone was reached ahead of time (month 13). This will mean that **MS112** ‘2nd periodic project meeting held’ (month 36) will also be completed ahead of time (month 25) and that another milestone will need to be added ‘3rd project meeting held’ (month 36), to reflect the extra meeting that will now be possible in the course of the project. This issue will be addressed after reporting for this period has ended.

MS114 ‘Gender Action Group established’. The first session of the Gender Action Group was held at the kick-off meeting (month 1).

Use of resources and deviations from DoW

A total of 21.2 months were spent on this work package. As mentioned above, there was a change to allow annual project meetings, rather than periodic ones, however this had no effect on other parts of the project and there were no significant deviations from the DoW in this work package.

2.2.8 Work package 23: Training

Lead contractor: UPM
Contributors: NERC, SEI-Y / UoY, BOKU, UEDIN

Work package objectives

This work package coordinates training activities across the ÉCLAIRE project. Its objectives are:

1. To organise specialised training events for postgraduate students and young scientists with the aim to train participants in advanced measurement techniques and modelling methodologies;
2. To develop a plan for and organise, run and evaluate a summer school for young scientists from within ÉCLAIRE and related projects around the topic of air pollution effects on ecosystems under climate change conditions.

Most of the budget of this Work Package is reserved for travel and subsistence to support young scientist training activities, including attendance from outside the ÉCLAIRE consortium. A reserve budget is also included to be able to respond to developments during the life of the project. The seed activities listed here will be conducted in the context of other training instruments (e.g. Marie Curie, COST 0804, European Science Foundation) in order to maximize synergies and overall effectiveness.

Progress and Results

Task 23.1: Co-ordination of ÉCLAIRE training activities

ÉCLAIRE training activities have been developed based on the Training Plan submitted in Month 9 (Deliverable D23.1).

This Training Plan was developed using the results of a young scientist (and supervisor) training survey conducted in Month 7 that collected information on the young scientists' role in the project and their training needs. The survey was designed and completed online through freeonlinesurveys.com (Fig. 23.1), which facilitated the tracking of responses and collation of data. Information obtained via the survey included personal information, academic qualifications and role within ÉCLAIRE (e.g. Work Package, PhD/research topic etc), previous training activities attended and training activities that are already planned. Information was also obtained on which specific scientific training activities the young scientists would be interested in and the interest level for a list of general training activities (e.g. scientific writing, statistics etc.)

Figure 8.1: Screenshot of the “General training activities” page of the online survey

The young scientist survey was completed by 19 scientists (53% female, age range 22-40). The results of the survey and the supervisor responses to a separate questionnaire were collated and grouped into common themes e.g. measurement-based, modelling-based, exchange processes, ecosystem impacts etc. Respondents listed 16 specific training activities in which they would be interested in participating. These suggested activities were fairly equally spread between training in modelling and measurement techniques. Many of the specific training needs identified by the young scientists were also identified by the supervisors/managers, suggesting good communication between them and/or a coherent understanding of their role in ÉCLAIRE. See Deliverable D23.1 (ÉCLAIRE Training plan) for a detailed analysis of the survey results.

The Training Plan developed from the survey results provides the basis for the training activities to be carried out throughout the project. These activities will take the form of a Summer School to be held in Year 2 (see Task 23.2), as well as an additional ecosystem modelling course (to be confirmed). In order to be aware of additional training needs that may arise during the course of the project, a training request form has been added to the ‘Training’ section of the project website. The WP coordinator (Mark Theobald) has also been involved in the coordination of the Young Scientists’ Forum in order to be in direct contact with ÉCLAIRE young scientists and publicise training activities via the online forum and has also been in touch with other organisations (COST ES0804, iLEAPS, AlterNet, PEGASOS) in order to discuss synergies between training needs of ÉCLAIRE and these other organisations.

Task 23.2: Organisation of Summer Schools and dedicated workshops

A common theme running through the young scientists’ suggestions of topics for a Summer School was the measurement and modelling of exchange processes and so this has been established as the core theme for the Year 2 Summer School. This core theme will be coupled with an analysis of up-scaling effects (plant, canopy, ecosystem, landscape, region, country, Europe, global) and advanced statistical analysis to cover two of the other identified training needs.

Following an open call for Summer School hosts in Month 12, INRA Thiverval-Grignon (France) was selected to host the activity. A concept for the Summer School was developed jointly with them and was submitted in Month 15 (Deliverable D23.5).

The Summer School will be entitled "Measurement and modelling of biosphere-atmosphere exchanges of trace gases and aerosols" and the suggested programme is shown in Table 8.1.

Table 8.1: Suggested programme for the ÉCLAIRE Summer School

Modules	Sessions	Type
1. Modelling soil-plant-atmosphere exchange of reactive trace gases	a) Basic theory (turbulent transfer, resistance analogy, stomatal and boundary layer resistances)	Theory
	b) Experience with a SVAT model: the Surfatm-O_3 model	Practical class using data from 2a
	c) Modelling NH_3 emissions from soils and slurry. The SAVA model for NH_3	Practical class
2. Advanced techniques in soil-plant-atmosphere exchange of reactive trace gases	a) NO_x and O_3 eddy covariance flux measurement	Lab and field work to provide data for 1b
	b) NH_3 volatilisation measurements by inverse modelling	Practical class
	c) Aerosol particle flux measurements	Lab and field work
3. Ecosystem functioning with emphasis on nitrogen and ozone	a) Ecosystem functioning, plant physiology and ozone impacts (Course)	Theory
	b) Modelling crops and nitrogen at the country scale (CERES-EGC)	Practical class
	c) Experience with another model from the ÉCLAIRE Community (e.g. Orchidee)	Practical class

4. Pollutants and GHG exchanges at several scales and validation methods	a) Modelling N transfer at the landscape scale	Theory
	b) Measuring NH_3 with badges at the landscape scale	Lab and field work
	c) Monitoring methods for NO_x, O_3, SO_2, NH_3, VOCs, aerosols (NEU methodology)	Theory + data analysis
5. Introduction to statistical methods	a) Basics statistics (course)	Theory
	b) Statistical methods for data analysis (course)	Theory
	c) Statistical method for model evaluation	Theory + practical

The Summer School will be held during the dates 1-12 July 2013 for a maximum of 40 students. See Deliverable D23.5 (Concept for the Summer School) for more details of the Summer School programme and funding.

Progress towards the milestones and deliverables

Two deliverables and two milestones were planned to be achieved during the reporting period (Table 8.2). The ÉCLAIRE Training Plan (D23.1) was submitted to the project coordinators in Month 9 and was adopted shortly after. The small delay incurred in the production of this deliverable was due to the completion and defence of the WP coordinators PhD thesis. The Summer School concept (D23.5) was submitted in Month 15 and was adopted for implementation shortly after. The small delay in the submission of this deliverable was due to the delay in the Training Plan. However, this small delay permitted a very useful discussion of the Summer School concept with young scientists at the 2nd General Assembly (Month 13).

Table 8.2: Planned Deliverables and Milestones for the reporting period

Month	Deliverable / Milestone	Description
6	Deliverable D23.1	ÉCLAIRE Training plan
7	Milestone MS118	ÉCLAIRE Training plan adopted
12	Deliverable D23.5	Concept for an ÉCLAIRE Summer School in year 2
13	Milestone MS119	Concept for an ÉCLAIRE Summer School in year 2 adopted for implementation

Use of resources and deviations from DoW

In general, time resources spent on this work package have been as planned (1.8 person months in total) and apart from the small delays incurred described above, the work package is on course to achieve the remaining milestones and deliverables within the planned schedule. No deviations from the DoW are expected.

2.2.9 Work Package 24: Networking and dissemination

Lead contractor: NERC
Contributors: ULUND, ALTERRA, DTU, IIASA

Work package objectives

The objectives of this work package are:
1. To coordinate networking activities with other projects and international bodies
2. To facilitate dissemination activities across the project
3. To develop and maintain a project web portal for project internal and external communication

Progress and Results

Task 24.1: Networking

This is an ongoing activity within the project. As outlined in the Description of Work several members of the Executive Steering Group hold other roles which are useful for integrating the work of ÉCLAIRE and other projects such as PEGASOS. ÉCLAIRE scientists are taking part in the PEGASOS project and are also part of the ACCENT+ network. Links are also maintained with the UNECE Convention on Long Range Transboundary Pollution (LRTAP Convention) including through the co-chair of the task Force on Reactive Nitrogen and members of the International Co-operative Programme (ICP) for Forests and Vegetation (and other groups under the LRTAP Convention). The project co-ordinator has also been involved in the Thematic Review of Air Quality Strategy, for the Commission.

Task 24.2: Dissemination

A project website was ready for the start of the project http://www.eclaire-fp7.eu which contains information for the project participants and the wider community. The website includes a section on dissemination which will continue to be updated with presentations made which highlight the work of the ÉCLAIRE project. A dissemination and communication plan has also been established which outlines more specifically the plans for effectively disseminating the work of ÉCLAIRE throughout the project. This includes ongoing plans for an open access special issue publication by the European Geophysical Union (EGU), on the project. The current proposal is that this would be between two journals - *Atmospheric Chemistry and Physics* and *Biogeosciences* – the publication would be open during the lifetime of the project.

Progress towards the milestones and deliverables

D24.1 A project web portal for internal and external project communication (month 1). Completed on time.

D24.2 First dissemination and communication plan (month 18) completed.

D24.5 First report to the General Assembly on networking activities (month18), completed.

MS121 ÉCLAIRE web portal launched (month 1), completed.

MS122 Established links with relevant research projects, (month 3), completed.

MS123 Established links with relevant policy bodies, (month 3), completed.

MS124 Dissemination and communication plan published (month 12), the date for this milestone has been updated (month 21) as it cannot occur until after the deliverable D24.2 (month 18). It will now be due for the second periodic report.

Use of resources and deviations from DoW

A total of 1.9 person months have been spent on this work package. There is a small amendment to one of the milestones (as noted above), apart from this there are no deviations from the DoW.

2.2 Project management during the period

As mentioned earlier (section 2.2.7), the management of the project is handled by a project office, which consists of a project co-ordinator, scientific project manager and a finance officer. Main events during the last reporting period are; the organisation and signing of the consortium agreement, distribution of the pre-financing and the holding of the kick-off meeting and 2nd General Assembly. During the first 18 months of the project the scientific project manager also took 6 months maternity leave (July 2012 – January 2013), however the necessary tasks were dealt with by other members of the project office and colleagues at partner NERC.

There have been no major changes within the consortium during the reporting period. One scientist has transferred to another partner within the project, for which the appropriate budget and task transfers were agreed with an amendment to the Grant Agreement, with the Commission.

The following meetings have been held in the last reporting period:

- Kick-off meeting, 24th-27th October 2011, Brescia, Italy
- Second General Assembly, 15th-18th October 2012, Edinburgh, Scotland

As mentioned in previous sections, a project website was created for the start of the project and provides information for project partners and the wider community http://www.eclaire-fp7.eu . ÉCLAIRE scientists and other interested parties can become members of the website if they would like more detailed information.

Most of the project (in terms of either delivering or working towards milestones and deliverables) is running according to schedule. Any deviations from this have been listed in the relevant work packages and components. However, no major issues are forseen and there have been no deviations which required any intervention from the management level (e.g. the Executive Steering Group- ESG) of the project. Any ongoing issues continue to be discussed at ESG meetings to minimise disruption to other work in the project.