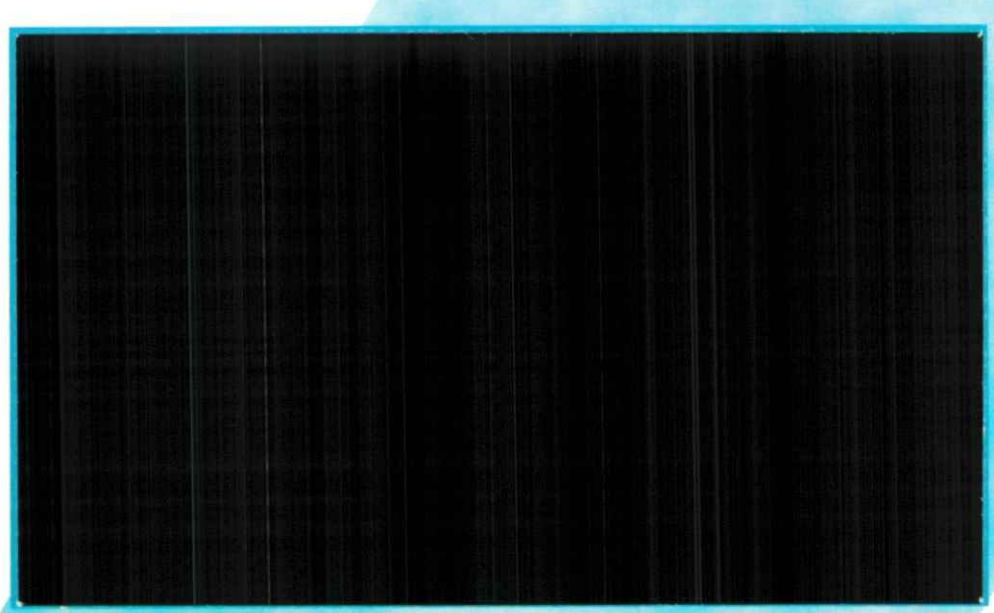

Institute of Terrestrial Ecology

Centre for Ecology & Hydrology

Natural Environment Research Council

ITE has six Research Stations throughout Britain, which allows the efficient use of resources for regional studies and provides an understanding of local ecological and land use characteristics. The Institute's administrative headquarters is at Monks Wood.

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Centre for Ecology & Hydrology

Remote Sensing in the Institute of Terrestrial Ecology

Summary of the Research Programme of the Section for Earth Observation

ITE, Monks Wood

September, 1998

Institute of Terrestrial Ecology

CONTENTS

SUMMARY

- Since its formation at the beginning of FY 1997-98[1], the SEO has begun building an integrated programme of remote sensing research, in which EO science and technology both stimulates and responds to a range of current and potential applications in the terrestrial environmental sciences.

- The goal of the research is the operational use of remote sensing, drawing on both established and novel techniques, to generate scientifically valuable information in support of the CEH Science Programme and the wider NERC community.

- The SEO programme is designed to be responsive to the needs of terrestrial and freshwater ecologists for spatial-temporal information on species, communities, habitats, their energetics and the external processes which impact on these. It also addresses the use of remote sensing to measure solar radiation and to quantify the soil-vegetation-atmospheric processes that control the water cycle.

- Methodological developments in SEO have evolved from procedures designed simply to map and measure the land cover, through more quantitative methods of estimating vegetation biomass and structure, to procedures which aim to estimate and / or measure biophysical variables pertaining to the land surface and the water column.

- The general approach is to develop algorithms to allow quantitative estimation of environmental states and fluxes from remote sensing. By calibrating these estimates against *in situ* observations, the remotely sensed data can then be used to extrapolate field observations to local, regional, national and global scales.

- The remote sensing programme is increasingly influenced by 'user pull', rather than the 'technology push' which has too often driven remote sensing research in the past. There is a readiness and enthusiasm on the part of applications scientists and customers alike to collaborate in research and to fund the generation of remotely sensed information products.

- Nevertheless, we should recognise that the EO programme that the Section inherited from RSADU has its origins in Earth observation research, rather than in the terrestrial and freshwater science application area. It is therefore inevitable that there are opportunities that have yet to be exploited to modify this programme to ensure that its objectives fully match the scope of CEH research interests as a whole. This re-alignment needs to be considered in the context of:

  a) the requirement for EO data across the complete CEH science programme and the immediate and likely potential of remote sensing data to meet these requirements;

  b) the impending re-structuring of the NERC EO programme and, in particular, the proposed establishment of Centres of Excellence in EO applications.

[1] with responsibility for RSADU from 1 July 1997

- This document sets out the 1997-98 SEO programme with a brief forward look to 1998-99. The definition and description of longer term objectives for remote sensing within CEH is the subject of a separate paper for discussion by the Programme Management Group.

INTRODUCTION AND OVERVIEW

The Institute of Terrestrial Ecology maintains an active programme of research in Remote Sensing because it considers the technology important, both as a source of information on the terrestrial environment and as an aid to understanding and predicting ecological processes at the patch scale and above. Remote Sensing is thus regarded primarily as a technological means to a scientific end. Nevertheless, the Institute recognises the need for research into fundamental scientific issues that underpin the practical application of Earth observation and, to that end, has established a specialist Section for Earth Observation (SEO), located at ITE, Monks Wood. Staff in SEO[2] possess a range of skills, from physics and instrument engineering through to applied ecology, supporting a balanced programme of research that includes:

- Analysis of the requirements of ecology for remotely sensed data, leading to inputs into the design and specification of EO systems,
- Understanding and modelling interactions between incident radiation, land surfaces (including vegetation) and the atmosphere, with the aim of improving methods for estimating biophysical variables of ecological significance,
- Calibration and validation of remotely-sensed datasets to deliver estimates of radiation fluxes to known accuracy,
- Application of the results of the foregoing research, leading to generic algorithms and spatially-referenced datasets in support of research across the Institute.

Organisation and Relationship to the CEH Science Programme

The Section has a staff complement of 14 (as of September, 1998); it is led by a Grade 7 (Mr Robin Fuller) and is managed as one of five scientific Sections within the Monks Wood station of ITE. SEO was formed in April, 1998, when NERC's Remote Sensing Applications Development Unit (RSADU) was disbanded and its Monks Wood-based staff joined ITE remote sensing scientists to create the new Section (see Figure 1 for a description of the present manpower and internal organisation of the Section).

Most of the activities of SEO map directly to the Remote Sensing project within the CEH Integrating Generic Science Programme (Project 10.2). However, because the objectives of the Section extend to cover the use of these techniques and datasets, it is not surprising that its work also contributes to other areas of the CEH Science Programme. Indeed, the extent to which the Section is involved with projects other than 10.2 is a measure of its success in bringing experimental techniques through to the operational stage in support of practical ecological applications. CEH programmes to which SEO makes a significant contribution are Land Use Science (Programme 2) and Biodiversity and Population Processes (Programme 5). There have been important contributions to Global Change (Programme 9) in the past, and there is potential to resume such applications, although the Section has no active sub-Projects in this programme at present.

The terrestrial science components of the ex-RSADU research programme form a major a major facet of the work of SEO. The scientific content of this programme is determined

[2] A golssary of acronyms and abbreviations appears at the end of this report.

by negotiation between the Head of NERC Earth Observation (representing NERC EO Expert Group) and CEH (represented by the leader of CEH Project 10.2). Funding for this activity is by cash transfer between NERC EO and CEH, through a Service Level Agreement (SLA), covering a five-year programme of work for 5.5 staff. ITE manages this programme, on behalf of CEH and the individual sub-Projects fall predominantly within CEH Project 10.2. The balance of the work of the Section is financed in varying degrees from research contracts, from NERC awards and from Core Strategic funds.

Table 1 lists currently active sub-Projects and indicates the staff involved, the relationship of the sub-project to the CEH Science Programme and the funding source. Note that the SLA with NERC EO does not designate named members of staff. Although the ex-RSADU personnel have primary responsibility for delivery of this programme, CEH is free to deploy these individuals to other projects, or to designate other members of staff to contribute to the NERC EO programme.

Structure and Content of Report

The remainder of this Report is given over to a summary of currently active sub-Projects, organised in line with the structure of the CEH Science Programme. The first section describes underpinning EO science activities within Project 10.2. This is followed by a similar résumé of sub-Projects within programmes 2, 5 and 12. Each sub-project description records the overall objectives, summarises progress towards their achievement, including specific milestones in FY 1997-98, and identifies milestones for the current year (1998 – 99). Finally, the Report lists the Section's scientific publications and identifies key external contacts and joint activities.

Figure 1. Staff and Internal Organisation of the Section for Earth Observation

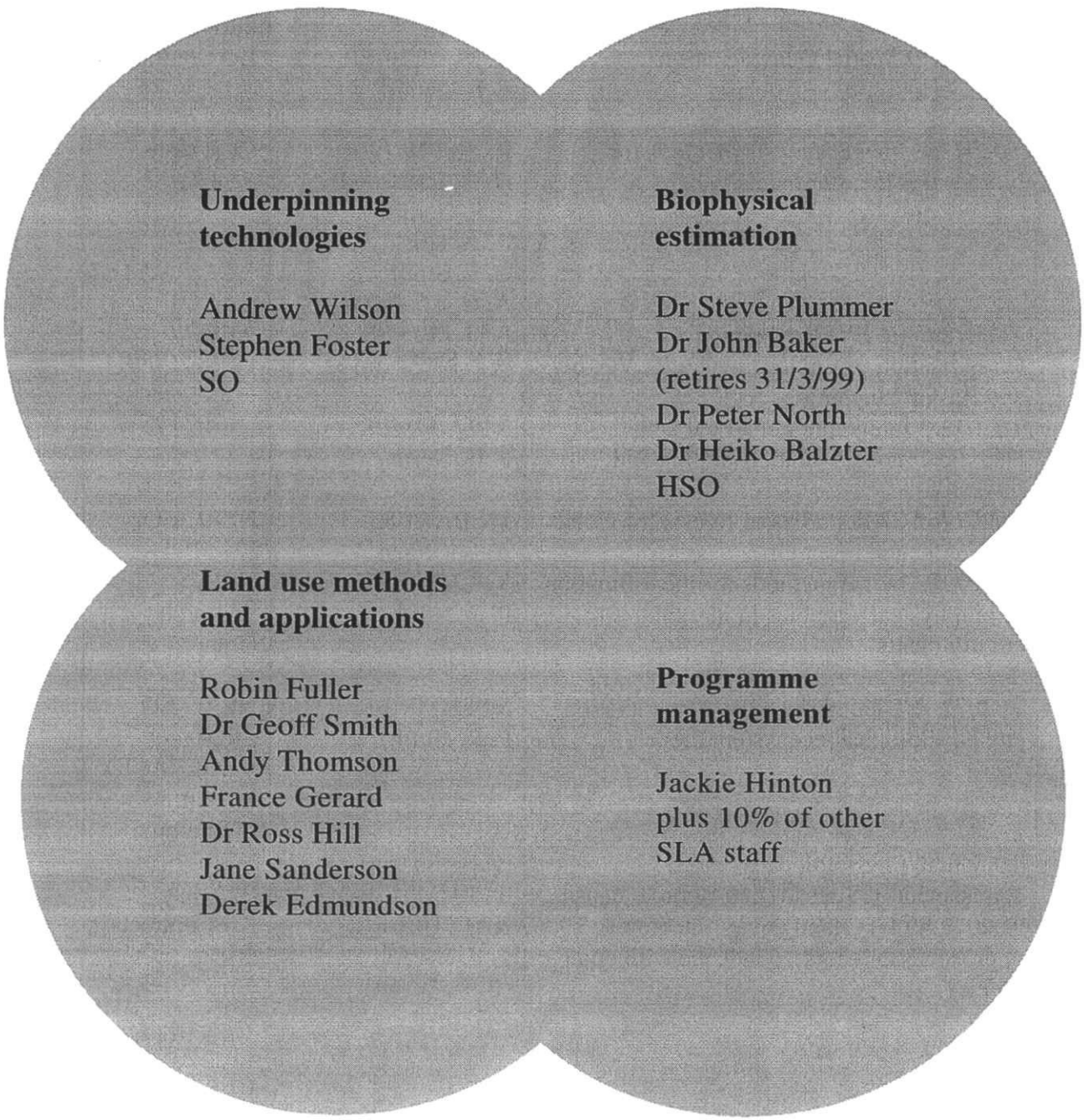

Table 1 SEO sub-Projects

CEH PPI	Sub-Project Number	Staff	Funding
10.2.1	T02072q2 - Cal/Val & Sensor Technology	A. K. WILSON	NERC EO
	T02072z2 Atmospheric correction - aerosol studies	S. E. PLUMMER P. R. North	NERC EO
	T02085a2 Atmospheric Retrievals & Instrumentation	A. K. WILSON	NERC EO
	T02072w2 Airborne Remote Sensing	A. K. WILSON	NERC Scientific Services
	T02072O9 Spatial Generalisation	R. M. FULLER F. F. Gerard	EU Contract
10.2.2	T02072c2 Image analysis methods for biophysical measurements	R. M. FULLER (J. A. Eastwood) F. F. Gerard R. A. Hill G. E. Smith A. G. Thomson	CEH Core Science
	T02072n5 CLEVER-Mapping: Classification of Environment with Vector- and Raster-Mapping	**R. M. FULLER** **G. E. Smith**	NERC / BNSC LINK
	T02072r2 Integrated numerical and analytical models - understanding and inversion	S PLUMMER P. R. North	NERC EO
	T02072u2 SAR studies of forests for global environmental research	J R BAKER A. Luckman	NERC EO, EU FP-4
	T02072y2 Novel methods for the estimation of biophysical variables in marginal environments	S PLUMMER P. R. North	NERC Research Grants
10.2.3	T02072x2 The interface between radiation and physiological/ecosystem models	S PLUMMER P. R. North	NERC-EO, SPOT-VEGETATION Prep. Programme
	T02086a6 Physiologically-based Assessment of Stress Using Remote Sensing	(C BARTON) S PLUMMER	NERC (DAEC)
10.2.4	T02072m9 ETC land cover: integrated approaches and correspondence with other themes	R M FULLER, F. F. Gerard (B. K. Wyatt)	EU Contract

Table 1 continued

10.2.5	T02072s2 BNSC Earth Observation LINK Programme Co-ordination	J. HINTON	NERC EO
	T02072t2 Programme Management Support to EOSTB	J. HINTON	NERC EO
	T02072V2 To provide support to the Head of the EO programme	J. HINTON	NERC EO
	T13061Q9 Authorship of Chapter 2.4 (Land Use and Land Cover Change) of the European Environment Agency State of the Environment Report	(B K WYATT)	EU Contract
2.1.1	T02080k2 CS2000 Planning Group	R. M. FULLER R. A. Hill G. E. Smith	DETR contract, CEH core science
	T02080n5 Patterns of biodiversity in the landscape	(C B BARR) R. M. Fuller F. F. Gerard R. A. Hill	DETR contract, CEH core science
2.1.2	T02072l1 R&D on the application of predictive models for support in nitrate policy	R. M. FULLER A. G. Thomson	MAFF Open Contract
	T02072v9 Land cover map of Jersey	G. E. SMITH R. M. Fuller	Contract
2.1.4	T02073r5 Ecological effects of land use changes on European terrestrial mountain ecosystems (ECOMONT)	(N BAYFIELD) F.F. Gerard G. E. Smith R. M. Fuller	EU FP-4
2.2.5	T05060j2 LOIS BIOTA	(A.J. GRAY J. GOSS-CUSTARD) A.G. Thomson, (J.A. Eastwood) R.M. Fuller	NERC (LOIS)
	T08074f5 ISLED Influence of Rising Sea Level on Ecosystem Dynamics of Salt Marshes - Work Package 3 - Tasks 3 & 4	(R A WADSWORTH) A. G. Thomson	
5.1.2	T02055o7 The impact of military training on the ecology of Salisbury Plain A	**R F PYWELL** F. F. Gerard	

PROGRAMME 10 INTEGRATING GENERIC SCIENCE

PROJECT 10.2 REMOTE SENSING

Issue 10.2.1 Development, calibration and validation of remote sensing systems and data products

This Issue addresses needs for basic developments to underpin operational applications of remote sensing and derived products.

T02072q2 Cal/Val & Sensor Technology

A. K. WILSON

Progress towards objectives

The prime objective of this sub-project is the provision of more accurate and consistent EO data, relevant to the needs of the EO community. This includes the development of vicarious calibration and validation strategies, and techniques for the long-term monitoring of optical sensors to improve the accuracy of information retrieval from such data over a range of spatial scales. An important element is the promotion of EO data technologies that are increasingly related to user-pull rather than technology lead. An example is the promotion of low-cost dedicated small satellites for specific environmental research and monitoring requirements versus the large and costly multi-sensor, multi-tasking platforms, that are prone to hold-ups, cost over-runs, and are developed as a compromise between technology and requirements.

Steady progress is being made on the promotion, in the UK and internationally, of long-term calibration / validation strategies and sensor technologies consistent with the EO requirements within the UK and NERC. Work carried out under this sub-project has lead to the award to UK industry of a contract valued at around £1M to build a small imaging spectrometer for testing on an ESA 'smallsat' platform (PROBA) being used to test autonomous satellite operations.

Milestones achieved

1. Completion of project on the development of a calibration / validation strategy for the European Space Agency PRISM satellite sensor, in collaboration with UK industry, with submission of the Executive Summary and Final Report on the PRISM project to ESA (31, 32).
2. Development of a joint proposal with UK industry, to BNSC Space Foresight AO, for the development of an imaging spectrometer for the ESA PROBA Mission. The initial user requirement and instrument design specification was provided which has lead to funding, by BNSC, of SIRA to build the CHRIS instrument for ESA PROBA mission.
3. Review of Algorithm Theoretical Basis Documents (ATBDs) for ESA Envisat satellite mission for the pixel discrimination and atmospheric correction of Level 2 land products from MERIS data.
4. Invited attendance at MERIS Cal / Val workshop as ESA algorithm reviewer to progress algorithm specification for the ATBDs.
5. Initiation of collaboration with University of Leicester on the production of a Validation Plan for the AATSR instrument.

Programme plan and milestones for next year

1. Deployment of ICARUS during international campaign(s) for vicarious calibration / validation of optical satellite sensors launched by NASA (MODIS / MISR), and / or ESA (AATSR / MERIS) in 1998 / 1999 - this may include deployment of ground-based instrumentation at a NASA / ESA vicarious test site (East Anglia and Western USA).
2. Further development, in collaboration with EO unit at Leicester University, of a Validation Plan for AATSR.
3. Promotion of the use of dedicated smallsats for Earth Observation with further technical contributions on the instrument design requirements and calibration / validation strategy to the CHRIS-PROBA project.

T02072z2 Atmospheric correction - aerosol studies

S. E. PLUMMER & P. R. North

Progress towards objectives

The prime objectives of this sub-project are the development and testing of an atmospheric correction procedure for the ATSR sensor series, and the examination of methods for the determination of aerosol characteristics from remotely sensed data.

The atmospheric correction procedure for the ATSR sensor series has been fully developed and tested over the BOREAS field sites with good results and this work is currently being written up. Progress on methods of determining aerosol characteristics from remotely sensed data has been made as part of the atmospheric correction procedure. However, more rigorous testing is required than so far undertaken.

Milestones and deliverables achieved

1. The ATSR-2 atmospheric correction procedure was demonstrated to the ATSR-2 Core Team Meeting on 20 May 1997 and the approach has been written-up and accepted in IEEE Transactions on Geoscience and Remote Sensing. Documentation of ATSR-2 atmospheric correction software has been undertaken but it is not yet at a release stage because it relies on external software packages. The methodology has been taken up by collaborators on the ATSR-2 research grant as part of work on the PROBA-CHRIS instrument. Development of a new proposal has been hindered by progress in the areas above.
2. 2 peer-reviewed papers have been submitted and accepted for publication (11, 12).

Programme plan and milestones for next year

1. Work on evaluation of the correction algorithm will continue through use of field observations of aerosol optical depth and BRDF for boreal forest (BOREAS) – it will be implemented on imagery of Southern Africa for the DFID grant above.
2. A proposal for the ESA ENVISAT Data AO will be submitted to extend this work to AATSR and compare it with MERIS data (June 1998).
3. Submission to *JGR* of a peer reviewed paper on *Comparison of dual view and dark target methodologies of atmospheric correction for ATSR-2* (North, Plummer, Settle, Leroy, Bicheron)
4. IGARSS'98 Conference paper on *Dual view operational atmospheric correction for ATSR-2 imagery* (North) (July 1998).
5. ESA ENVISAT Data AO Proposal *Validation of AATSR algorithms for retrieval of aerosol opacity and land surface bi-directional reflectance and potential synergy with MERIS* (North, Plummer, Wilson, Wyatt) (June 1998).

T02085a2 Atmospheric Retrievals & Instrumentation

A. K. WILSON

Progress towards objectives

The prime objective of this sub-project is to develop an understanding of the role of atmospheric aerosols in the radiative transfer of optical radiation in the atmosphere, which effects EO measurements from airborne and satellite sensors, and to improve the accuracy of information retrieval from such data. An additional objective, required to reduce the uncertainties in predictive modelling, is an understanding and quantitative measurement of the role of atmospheric aerosols in radiative forcing for climate change studies. These objectives include provision of the necessary quantitative measurement capability through development of novel instrumentation.

Progress is being made on the development of an advanced technology instrument, ICARUS, to retrieve a variety of important atmospheric optical parameters for aerosols, water vapour and ozone. Although rescheduled to allow the prime contractor to complete priority work for the NERC ARS Facility, the ICARUS prototype will be completed shortly and be ready for evaluation. Final installation of the SEO CIMEL sunphotometer on the AERONET network is awaiting licensing by the UK Radio communications Agency for the use of the satellite transmitter. When operational, the system will provide a UK node within a 60+ world-wide network of sunphotometers for validation of satellite retrievals and for local, regional, and global climate studies. Membership of the network enables access to the global dataset of atmospheric aerosol characteristics, important to a number of ongoing and future SEO programmes. The Monks Wood data will provide an important long-term dataset for use by the whole UK science community. Substantial progress is being made on the development of a series of software modules to handle, calibrate, display, analyse and interpret data, retrieved by sunphotometers, on the radiative characteristics of the atmosphere. This work is being carried out primarily in collaboration with the Plymouth Marine Laboratory and in association with EPFS at Southampton, who will be able to use the software to support the UK community who apply for, and use, the CIMEL sunphotometer in the NERC equipment pool.

Milestones achieved

1. Completion of a software module to calibrate data from sunphotometers using the Langley Plot method or via laboratory calibration coefficients, for use with the SEO CIMEL and ICARUS sunphotometers.
2. Completion of a software module to retrieve aerosol size distributions from angular scattering measurements from sunphotometers (implementation of Nakajima code).
3. Completion of a software package to simultaneously control two OPCs from a PC and display the resultant size distributions, in 11 size bins, for operational use.
4. Upgrade of the SEO CIMEL sunphotometer for compatibility with the AERONET global sunphotometer network by installation of three new interference filters to enable retrieval of atmospheric optical loading at 340, 380, 440, 500, 670, 870, 940 and 1020nm.
5. Presentation of paper at the 3rd International Airborne Remote Sensing conference on the design of the ICARUS instrument (27).

Programme plan and milestones for next year

1. Completion of the prototype version of ICARUS with laboratory radiometric calibration at EPFS and validation through deployment at Monks Wood.

2. Installation of upgraded CIMEL sunphotometer on the global AERONET network and operational production of atmospheric optical characteristics as part of the global AERONET sunphotometer network.
3. Use of two OPCs for direct measurement of aerosol size distributions.
4. Validation of retrieval algorithms of atmospheric optical characteristics (primarily aerosol size distribution) using the prototype ICARUS.
5. Participation in an atmospheric closure experiment at Plymouth involving ground, sea and airborne measurements.
6. Completion of a software module to retrieve aerosol size distributions from solar extinction measurements from sunphotometers (implementation of King code).
7. Submission of two journal papers on ICARUS and its use in aerosol characterisation.
8. Attendance at the international IGAC atmospheric chemistry conference to present a paper on aerosol characterisation using ICARUS.
9. Collaboration on the implementation of an operational atmospheric correction algorithm for Landsat Thematic Mapper data to be used in the ITE LCM2000 project.

T02072w2 Airborne Remote Sensing

A. K. WILSON

Progress towards objectives

The prime objective of this sub-project is to enable the operational use of geophysical data products (for example surface reflectance, temperature or derived biophysical properties) from airborne remote sensing in support of thematic science programmes that promote the use of ARS data in terrestrial ecology and fresh water sciences. To enable this objective to be met, the development of a radically enhanced airborne remote sensing facility is required that can solve the main problems with the use of ARS data, namely geometric rectification, atmospheric and terrain correction, ease of data distribution and ease of usage by the non-remote sensing specialist.

The timescale for Integrated Data System (IDS) project has been extended into 1998 by the early requirement of an interim system by the LOIS user community, by difficulties with suppliers of advanced technology components and by the need to upgrade the initial design specification to meet enhanced expectations by the user community during the project. An initial flight trial of the IDS has been successfully carried out and operational use of the new system is expected during the 1998 flying campaign. Through the use of advanced GPS and inertial navigation systems, the accurate geo-location and geo-referencing of high spatial resolution airborne data addresses the requirements for geometric rectification and enables both atmospheric and terrain corrections to be performed. Implementation of a data processing strategy enables the standardisation of data product and data format generation for widespread use of ARS data in GIS by the non-specialist.

Milestones achieved

1. Provision of technical consultancy to NERC Science Programmes Directorate on the development of the NERC Airborne Remote Sensing Facility.
2. Provision of strategic direction on ARS matters and peer-review of proposals through membership of the NERC ARSFSC.
3. Research on the suitability of terrain LIDAR in combination with airborne remotely sensed data to serve a wide variety of ecological and hydrological science applications with co-ordination of a UK airborne campaign to test an advanced terrain mapping LIDAR instrument.
4. Submission of two NERC small research grant proposals to obtain terrain LIDAR data for evaluation by demonstration of utility of high precision elevation data in ecological applications, and in support of the NERC URGENT Thematic Programme.
5. Development of a strategy to make the EO satellite and airborne remote sensing data holdings more accessible and useable by the UK EO community. Support for the implementation of this work was obtained through a successful proposal to NERC SEEDCORN fund to archive, over the next 2 years, the entire EO data holding onto new media and development of a online browse facility.
6. Publication of a peer-reviewed journal paper on the NERC Integrated Data System (13).
7. Presentation of two conference papers at the 3rd International Airborne Remote Sensing Conference (25, 26).
8. Submission of contract report to the MoD on the use of ARS data in the ecological classification of Salisbury Plain (30).

Programme plan and milestones for next year

1. Management of the ARSF prototype data processing facility to process and deliver 1998 data products from the new NERC Integrated Data System to the UK institute and academic community.
2. Provision of strategic direction and peer-review of proposals as member of the NERC ARSFSC.
3. Development and implementation of a strategy for application products of Level-2 (surface reflectance/ temperature, Vegetation Indices, fAPAR, LAI etc.) and Level-4 (mosaicked and/or classified, multi-date, multi-sensor) from the airborne processing facility to provide operational geophysical data products for the terrestrial and freshwater remote sensing community.
4. Demonstration of the applications potential of ARS data through development and participation of commercial contracts, supporting CEH / ITE environmental research and monitoring activities.
5. Generation of a definitive database covering the historical ARS ATM data holdings (1982-1993), and provision of consultancy on the implementation of an online browse facility for NERC EO satellite and ARS data (SEEDCORN project).

T02072o9 Spatial Generalisation

R. M. FULLER & F. F. Gerard

Progress towards objectives

This project, funded by the European Environmental Agency, through its Topic Centre on Land Cover (ETC/LC), aimed to test and compare generalisation procedures for use in the semi-automated production of CORINE Land Cover. In overseeing CORINE production and using its products, the European Environment Agency and European Topic Centre on Land Cover (ETC/LC) required to better understand the methods and consequences of map generalisation.

The techniques were developed independently by ITE, the Environmental Satellite Data Centre (MDC) in Sweden, and the Finnish Geodetic Institute (FGI). Rules of generalisation depend upon complex interactions between the size and patterns of ground features, the user objectives, the operator, the form of input information and output scales and formats.

After earlier comparison of the methods in workshop in 1996, the three generalisation procedures were improved and tested on the Murcia region in Spain; data and field knowledge for Murcia was provided by the Instituto Geografico Nacional (IGN), Spain.

Milestones achieved

1. Completion of project on the comparison and testing of three generalisation procedures.
2. Submission of final contract report to ETC/LC and to JRC (July 1997).
3. Development of an operational semi-automated generalisation procedure.

Programme plan and milestones for next year

1. The generalisation of the Land Cover map of Great Britain to CORINE Land Cover
2. Incorporation of relevant generalisation procedures into the production of Land Cover Map 2000.

Issue 10.2.2 Algorithms and models for estimation of biophysical variables

This Issue is concerned with research and development to design, test and bring to operation analytical techniques for measurement of key variables required by CEH applications' scientists.

T02072c2 Image analysis methods for biophysical measurements

R. M. FULLER, J. A. Eastwood, F. F. Gerard, R. A. Hill, G. E. Smith & A. G. Thomson

This project aims to underpin specific needs identified in CEH's applications programmes funded by SB and CR income. Much of the earlier work underpinned applications of satellite multispectral data in land use studies. Work has most recently concentrated on the use of airborne remote sensing, especially multi-spectral imaging and imaging spectrometry, in the coastal zone. Very recently, new work has focused on use of LiDAR in terrestrial and coastal zones.

Satellite remote sensing of land use

Progress towards objectives

The aims have been to propose, design, test and demonstrate methodological developments for operational applications in mapping and measuring land cover and use. Much of the R&D has transferred to specific projects like LINK CLEVER-Mapping and CS2000 Planning. As a result, earlier work has reached the publications stage. The project has also reviewed new R&D needs.

Milestones achieved

1. A report has been produced following completion of a desk study into intelligent / integrated methods of digital image classification.
2. Completion of publications on LCMGB and field survey integration, Bala Lake/Llyn Tegid, Sango Bay, from earlier R&D and applications work.

Coastal imaging spectrometry

Progress towards objectives

This project aims to assess airborne remote sensing for monitoring ecological processes and community composition in the inter-tidal zone.

Salt marshes perform significant energy dissipation and ecological functions and are thus an important component in sustainable coastal management. Recent evidence for accelerated salt marsh loss, and the uncertainty of response to near-future sea level rise, has focused attention on the mass balance of these sedimentary systems. A better knowledge of hydrodynamic processes, and the rate of decay of sedimentation away from within-creek sediment sources, is required to i. predict the response of existing marshes to sea level rise and ii. aid in the design of marsh restoration schemes on eroding coasts. Unlike temporal marsh development, data on the spatial patterns of sedimentation and the interaction of marsh surface flows, sediment transport, marsh surface topography and vegetation are sparse.

The project is studying dynamic systems with high frequency, multi-temporal, airborne remote sensing to observe phenomena occurring on the scale of minutes to hours. It is intended to collect multiple images of a salt marsh system during a single tidal cycle to study differential flooding and draining and inform the development of models of salt marsh surface sedimentation. Images recorded by the ***casi*** and ATM, flown by the NERC ARSF, will be used to provide information on the marsh surface as it floods and drains around high water, using the sequence of different aged salt marshes at Scolt Head Island, North Norfolk, as a test site. Airborne data will be collected during a period, centred on high tide, from just prior to creek bankfull stage until after the majority of the marsh surface drainage has taken place, at approximately 10 minute intervals. Concurrent measurements will be made in the field for water movement, tidal height, suspended sediment concentration and total surface sedimentation.

The character of the salt marsh surfaces will be classified using a pre-flooding image, ground data and conventional classification procedures to create maps of vegetation cover type, substrate type and the creek system. The maps will be used as baseline information for later analyses. A simple time sequence of images, processed to emphasise the extent of the water surface, will be used to show the patterns of flooding and draining and identify the controlling features within the salt marsh system. Elevation models for the salt marsh surfaces can be derived, either conventionally from the stereo aerial photographs collected on the pre-flooding overflight, or from the images recording the inundation of the water. During inundation of the salt marsh surface, the sediment is both remobilised and deposited requiring a knowledge of suspended sediment concentrations as well as the extent of inundation.

A model for sub-aqueous vegetation will be used to estimate the response of clear water. The difference between the modelled response and the actual response will give a measure of the suspended sediment concentration which can be calibrated with the actual suspended sediment concentrations recorded by water samplers.

Milestones achieved

1. Regularly acquired airborne remotely sensed imagery from a single year was used in a reconnaissance study to identify and map seasonal vegetation changes on intertidal surfaces in back barrier environments on the north Norfolk coast. These seasonal vegetation changes included: growth patterns in response to periods of hypersalinity away from creeks; location and phenological relationships on an area of proto-marsh and the annual remobilisation of sediments and thus vegetation removal in an area of high tidal flows.
2. Publications on airborne remote sensing of seasonal change in coastal wetlands.

<u>*Research on LiDAR*</u>

Progress towards objectives

The LiDAR work has aimed to make an initial evaluation of the potential for use in quantitative, 3-dimensional studies of terrain and landscape features, prior to contribution of CR-funding by DETR for a joint ITE-Environment Agency, R&D programme under CS2000.

Milestones achieved

1. Images have been acquired and assessed showing clear potential for quantitative estimation of terrain and vegetation structures, matching CS2000 objectives.
2. Preliminary analyses have processed LiDAR for estimation of above-ground height and the extraction of landscape features (such as hedges, tree belts and ditches) using knowledge-based methods.
3. A joint specification has been drafted by ITE and EA, approved by the DETR and is scheduled for 1998-2000 funding as a module of CS2000.

T02072n5 CLEVER-Mapping: Classification of Environment with Vector- and Raster-Mapping

R. M. FULLER & G. E. Smith

Progress towards objectives

CLEVER-Mapping, a BNSC Earth Observation LINK-funded project which began in May 1996, aimed to develop an operational, semi-automated system for land cover mapping and map revision, which would integrate information on the land parcel structure of the landscape with remotely sensed images. The project was undertaken by a consortium of four organisations headed by ITE, including the Cambridge University Geography Department, Laser-Scan Limited and the Ordnance Survey. The novelty of CLEVER-Mapping was in the integration of diverse functional elements into a seamless system.

Approaches were developed to segment the landscape into land parcels using existing vector linework in digital cartography and/or raster images. DEMs were incorporated using a Minnaert model to minimise topographic shading and to concentrate segmentations on real cover differences. The land resulting parcels were formed into vector polygons for further analysis. A per-parcel classification procedure extracted reflectance data for the land parcel using a shrunken vector geometry to avoid image edge pixels. The procedure calculated per-parcel statistics, eliminating problems with mixed pixels along parcel margins and smoothing out within-parcel variation. A conventional classification procedure was used to attach a class to the land parcel. Capture of probabilities for all potential training classes allowed intelligent, knowledge-based, contextual corrections, using map and image data, to refine the per-parcel classifications. The procedure was built around the Laser-Scan integrated GIS, IGIS, an object-oriented database which was particularly well suited to the task.

The procedures were developed and tested in sample areas covering: large field arable farming and urban land (Cambridgeshire); small field mixed farming with semi-natural and urban/suburban cover (Jersey); and uplands with complex mosaics of semi-natural vegetation, plantations and limited agriculture (Cairngorms). Validation of the classification results showed accuracies greater than 90%, which were substantially better than those for conventional per-pixel classifiers.

Milestones achieved

1. Completion of the pre-operational CLEVER-Mapping procedures, as planned under LINK.
2. Delivery of the *Quarterly Report* (to May 1997), the *Progress Reports* (to September 1997 and December 1997) and the *Final Report.*
3. Presentations and publications in of the BNSC launch of LINK 4, *GISRUK97*, the *Proceedings of the Remote Sensing Society conference*, and the *IEE Coloquium Digest - Integrated systems for commercial remote sensing applications.*

And, beyond LINK objectives:

4. Development to operational application in producing the Land Cover Map of Jersey (see below).
5. The per-parcel classification procedure was incorporated by Laser-Scan into IGIS and marketed in early 1998.

Programme plan and milestones for next year

1. New modules, with origins within the CLEVER-Mapping project, are planned for testing by SEO and incorporation in newer releases of IGIS: i. segmentation software, ii. collection of probabilities for all possible classes.
2. CLEVER-Mapping will be developed for use in the production of Land Cover Map 2000.

T02072r2 Integrated numerical and analytical models - understanding and inversion

S PLUMMER & P. R. North

Progress towards objectives

The objectives of this sub-project are to develop an integrated model of radiation interaction suitable for use in either microwave or optical wavelength domains or both, and further to rigorously test the model against both optical and microwave data as part of the NASA-INPE Large-Scale Biosphere Atmosphere (LBA) Experiment. In addition methods for model inversion using neural network approaches are being developed.

The central model code has been validated and documented. Progress has been made towards inversion strategies through PhD studentships and other collaborations. Progress has towards developing an integrated microwave / optical model has this year being focused on the optical developments and improving understanding of microwave domain. In this context an ESA proposal towards integrating vegetation growth, microwave and optical models has been submitted.

Milestones and deliverables achieved

1. The LBA proposal was submitted to NASA as part of consortium involving JPL, CCRS, INPE and the University of Swansea and, although it was unsuccessful, there may be a possibility of involvement in LBA in collaboration with the European contribution to the programme.
2. The CASE PhD studentship on 'Estimation of canopy biochemistry from high spectral. resolution remote sensing' was successfully delivered and awarded (Dawson, Southampton), and a new CASE PhD student (Rowland) at Salford is making good progress.
3. The Monte Carlo code for reflectance modelling has been validated using data collected as part of the FEDMAC and BOREAS field experiments. The code has been documented and is available to the HEI community under licence through ITE, and has to date been used by collaborators at Southampton, Leicester, Salford, Sheffield and Durham.
4. 5 peer-reviewed papers have been co-authored and accepted for publication (2, 3, 4, 5 & 7).

Programme plan and milestones for next year

The research on canopy / light interaction will be extended by further testing and validation on boreal forest species including analysis of the effects of canopy structure. This will dovetail with a CASE PhD studentship at Salford on 'Determining forest biophysical properties by canopy model inversion'; a further studentship will be sought on extending the model to the microwave domain (December 1998 submission). This work will be written up for journal submission titled 'Validation of a BRDF model on boreal forest' (December 1998). A by-product of the modelling work has been development of an incident radiation model at the landscape scale at the request of colleagues in ITE. This work is being continued with the emphasis on validation over UK sites and a journal submission is envisaged (July 1998). Despite the failure of the NASA-led proposal we will endeavour to be involved in the LBA experiment through collaboration in the UK under European FP5 funding (Swansea / Bush), within a timescale yet to be determined.

Peer review papers:

Journal of Geophysical Research submission on 'Validation of a BRDF model on boreal forest' (North, Plummer, Deering, Leroy, Bicheron) (December 1998)

Journal of Climatic Change submission 'Modelling short wave radiation from global to landscape scale' (North) (July 1998)

Conference papers:
RSS'98 paper on 'Canopy reflectance models and the effect of structure' (Rowland, Danson, North, Plummer) (September 1998)

Databases:
Revision of documentation for BOREAS datasets on LAI and foliar chemistry.

Studentships:
Supervision of EOSI CASE PhD studentship on 'Determining forest biophysical properties by canopy model inversion' (Rowland, Salford)
Submission of CASE studentship application (December 1998) looking at extension of the model to the microwave domain.

T02072u2 SAR studies of forests for global environmental research

J R BAKER & A. Luckman

Progress towards objectives

The prime objective of this radar programme is to develop the techniques of microwave remote sensing for large scale vegetation studies using data from airborne and satellite platforms, with verification from ground data and interaction models, for application to the inventory and monitoring of forests in studies of the carbon cycle and of climate change.

The project on SAR radiometry for boreal, temperate and tropical forests aims to characterise the interaction of microwave radiation with vegetative canopies through satellite and preparatory aircraft campaigns. For the tropical forests, the current key objectives were to liaise with NASDA / NASA / JRC to procure data for JERS-1 mosaic of central Amazon basin, for analysis and a future paper on regeneration mapping - NASDA have supplied the mosaic for central Amazonia and have generated that for one pass over the entire drainage basin. For the boreal forests, the current key objectives were to liaise with TUD / DLR / FFRI to procure aircraft radar and ground data for Sodankyla, Finland within a GIS for the EC-funded WINTEX project and to report on progress to the EC - the aircraft data have been selected and procured but the ground data are currently incomplete awaiting delivery from FFRI.

The project on SAR interferometry for northern and tropical forests aims to transfer the InSAR technique into an operational applications tool for microwave studies of vegetation. The key objectives were (i) the practical evaluation of 3 interferometry packages, which has lead to the purchase of software from Gamma Remote Sensing, (ii) collaborative work with Gamma on the evaluation of L-band InSAR for tropical forest monitoring, which has demonstrated the ability to measure altitude over vegetated areas, for a future paper, (iii) collaborative work with the University of Swansea on evaluation of ERS Tandem Mission and JERS-1 data for studies of tropical and northern forests, which has led to a paper on tropical forests (24), (iv) collaborative work with JPL to determine applicability of the polarimetric interferometry technique, initially for temperate forests using SIR-C data, to assess the capability to measure tree / terrain heights, which is still at an early stage.

Within both is a data analysis project aiming to generate geo-coded databases of selected test sites within a GIS and to perform statistical analyses and modelling. In particular, this year, the key objectives were (i) to assemble polygon database of microwave backscatter at Sodankyla-Finland for the EC-WINTEX project and (ii) to assemble polygon databases of interferometric coherence and phase at Siggefora-Sweden, Tapajos-Brazil and Thetford-UK. For reasons of staffing referred to below (1.2.4), significant progress has only been made in some areas, for example a preliminary version of the database has been generated for Tapajos-Brazil and used in the IGARSS paper (24).

There have been a number of responses to Announcements of Opportunities related to the aims of the radar programme. As part of an international consortium lead by DLR, a successful proposal (SIBERIA) was submitted to the EC Environment and Climate Programme - Framework 4 which aims to produce a large scale forest map of Central Siberia using multi-temporal SAR radiometry and interferometry from ERS and JERS1. The EC will provide 50% of the FEC of an additional HSO in the radar group over a 2 year period. In addition, in conjunction with commercial and

academic partners in the UK, 2 successful outline proposals were submitted to the BNSC LINK Programme Round 4, 3 successful proposals were submitted in response to the ESA third announcement of opportunity for the exploitation of ERS data, and 1 CASE studentship proposal was submitted the result of which is pending.

The overall programme of work in 1997 / 1998 was impacted by the resignation of Dr Luckman in August 1997. The first recruitment round was unsuccessful but a recruitment was made at the second attempt of a newly graduated PhD, Dr Balzter, who is due to commence work in July 1998.

Milestones achieved
A further peer-reviewed paper on the TIGER radar work has appeared in Remote Sensing of Environment (9), a final paper bringing together all aspects of the TIGER work has been submitted to Global Change Biology (10), and the paper on NOPEX work has been submitted to the Special Issue of Agriculture and Forest Meteorology (now accepted) (1). A paper is in preparation on SAR-Interferometry over Brazil for IEEE-TGRS and a preliminary version has been accepted for presentation at IGARSS'98 (24).

Papers have been presented at 5 international conferences - ISPRS Courcheval (8), ESA-ESTEC (16), PIERS'97 (17), IGARSS '97 (23) and JPL GRFM (18). A draft for the Final Report on NERC-TIGER programme project 1.4.3 has been written although some figures remain to be completed. Databases have been generated for the UK and Brazilian sites (Thetford ERS Tandem Mission, Thetford large scale SIR-C and Forestry Commission, Tapajos ERS and JERS-1 InSAR). The Scandinavian site databases (Sweden - Siggefora ERS Tandem Mission, Finland - Oulu EMISAR and JERS-1) have been hindered by a slow response from FFRI for supply of additional ground data.

Programme plan and milestones for next year
The EC WINTEX project, in conjunction with a predominantly Scandinavian consortium led by the University of Uppsala, concludes on 31 December 1998 and requires submission of an ITE contribution to the Final Report. The EC SIBERIA project commences on 1 August 1998 and requires submission of a number of ITE intermediate reports. This project is carried out in conjunction with UK collaborators at the Universities of Swansea and Sheffield together with a wide range of EC and Russian collaborators and is led by DLR.

Possible future AO bids, where appropriate, in partnership with complementary groups in universities or industry, include BNSC (LINK), ESA (ERS AO3), ESTEC on modelling and retrieval of biophysical parameters and ESA on exploitation of data from the Envisat satellite.

There will be a number of staff changes within the year - those foreseen comprise (i) H Balzter starting on 15 July 1998, (ii) a 2-year HSO appointment to work on the SIBERIA programme, (iii) J Baker leaving on 31 March 1999, (iv) a possible replacement for J Baker starting from a date yet to be decided. It should be noted that Dr Balzter does not have a background in remote sensing or radar and will require a substantial investment of time for training.

- Peer reviewed papers:
  Edit and resubmit NOPEX paper to Agriculture and Forest Meteorology Special Issue.

Submit paper to IEEE-TGRS on "Measurement of vegetation biomass using the technique of SAR-Interferometry at C- and L-bands".
Submit paper to IEEE-TGRS on "Determination of terrain height in heavily forested areas of the Brazilian Amazon".

- Reports and conference papers:
  Conference paper at IGARSS '98 on "Repeat-pass interferometric coherence measurements of tropical forest from JERS and ERS satellites".
  Conference paper at JPL GRFM / GBFM meeting on "JERS-1 multi season mapping of regenerating tropical forest with GRFM image mosaics and SAR interferometry".
  Complete Final Report on NERC-TIGER programme project 1.4.3 on "Radar remote sensing for tropical forest inventory and carbon balance investigation".
  Complete ITE contribution to Final Report on WINTEX project on "A survey of the potential of Synthetic Aperture Radar (SAR) remote sensing for the study of boreal forests, including the effects of changing snow cover".
  Complete Intermediate Report for SIBERIA project on "Classification accuracy assessment of radar forest map".
- Generation of databases:
  Continuation of the compilation and refinement of the following GIS databases, in support of the above scientific outputs and particularly of statistical analyses and modelling:
  Brazil - Tapajos JERS-1 InSAR
  Russia - Baikal ERS and JERS-1 InSAR
  UK - Thetford ERS Tandem Mission plus large scale SIR-C and Forestry Commission
  Sweden - Siggefora ERS Tandem Mission
  Finland - Oulu EMISAR and JERS-1 and FFRI

List of collaborating organisations
The radar programme is conducted in collaboration with a wide range of national and international partners including:

Industrial organisations (GEC-Marconi Research Centre);
UK Universities (Edinburgh, Sheffield, Swansea, Southampton);
NERC Institutes (ITE Bush);
Overseas Universities (Amsterdam, Uppsala, Utrecht, Zurich);
International Space Agencies (NASA, ESA, NASDA, INPE, DLR).

T02072y2 Novel methods for the estimation of biophysical variables in marginal environments

S PLUMMER & P. R. North

Progress towards objectives

The prime objective of this sub-project is the development of methods for the determination of fraction of vegetation cover and f_{APAR} in semi-arid environments. A related objective is the development of methods for the detection and determination of leaf area index of sub-aqueous vegetation.

Significant progress has been made on development of methods for the determination of fraction of vegetation cover and f_{APAR} in semi-arid environments and this will be continued through the DFID proposal. The seagrass project was completed and a British Council proposal awarded to extend the work to further sites. The invertible model is currently being re-coded. A pilot project was conducted for a kelp processing firm and an outline bid accepted under the LINK Programme.

Milestones and deliverables achieved

The focus of the work has been on completion of project reports and further data processing, in preparation for journal submissions. Both the NERC grant reports were duly completed: the ATSR-2 grant received a rating of 'good' for science while the appraisal of the Small grant is still awaited. The British Council proposal is being led from Edinburgh and the report is in preparation with a due date of end of May. Documentation of the two models has been undertaken although the seagrass model is now being substantially revised. Data processing for two test sites (Turks and Caicos, and Sicily) was undertaken by our collaborators at Sheffield and Edinburgh, while the data for Mac Spain were not delivered before the end of the grant. The seagrass work has generated involvement in a contract with a kelp processing firm and the LINK outline proposal was given the go-ahead. Because of secondment of staff to the EO Programme, journal submission of the two papers has been postponed. Finally a joint proposal to DFID on semi-arid environments with Sheffield has been funded and will begin in June.

Programme plan and milestones for next year

The successful completion of both the ATSR-2 Final Report and the Seagrass Final Report means that new initiatives will be started in the forthcoming year which aim to build on the results of this work. In collaboration with the University of Sheffield a DFID proposal on the social and environmental consequences of desertification was successful. This three year project is due to start in June 1998 and will involve operational evaluation of algorithms developed under the NERC ATSR-2 grant for estimation of vegetation cover at locations in Namibia, Botswana and South Africa. Funding has been obtained for the fieldwork element of this work and the first visit will be September 1998. ATSR-2 data will be required for these areas. The seagrass research is continuing through a British Council award with Edinburgh, Palermo and Sheffield and an EU proposal is under discussion. The LINK proposal on kelp mapping and assessment (with Kelco and the University of Sheffield) was accepted at the outline stage but, based on results from a pilot contract with Kelco, was later withdrawn.

- Peer reviewed papers:
  Submission to Remote Sensing of Environment of 'The angular vegetation index - an atmospherically resistant vegetation index for ATSR-2: Definition and sensitivity analysis' (Plummer, North and Briggs)
  Submission to Marine Ecology Progress Series of 'Adaptation of a land surface reflectance model for sub-aqueous vegetation: definition and sensitivity analysis' (Plummer, Clark, Malthus)

- Conference papers / Reports
  5th International Marine Conference 'Comparison of an invertible reflectance model for sub-aqueous vegetation with detailed Monte Carlo computations' (abstract July 1998) (Plummer, Mobley, Malthus, Clark).
  British Council Exchange Award Final Report (Malthus, Plummer, Clark, La Loggia) (June 1998)
  DFID Award Annual Report (Feb 1999).

Issue 10.2.3 Use of remote sensing for distributed hydrological and ecosystem modelling

This Issue is concerned with novel approaches to the use of remote sensing in applications research.

T02072x2 The interface between radiation and physiological/ecosystem models

S PLUMMER & P. R. North

Progress towards objectives

The prime objective of this sub-project is the methodological development of an existing global physiology model to provide inputs for reflectance models and to test predictions of the model over grassland, savannah and boreal forest test sites. Further objectives are the development of methods for detection of disturbance in forest and the development and testing of methodologies for assessing vegetation stress using reflectance and plant physiology models. Progress on the development of plant physiology models has been mainly through the SPOT-VEGETATION project and the studentship at Sheffield. Possible collaborations with staff working on plant physiology at ITE Bush are under development. The combined plant physiology-reflectance model has been tested over the FIFE and BOREAS sites and a further site (Jaru) in the Amazon. The development of methods for detection of disturbance in forests has resulted in a journal submission, and the stress assessment will start with the award of the NERC Fellowship. In addition, the ESA proposal has been submitted on linking a variety of plant physiology models with microwave and optical models, and a further PhD studentship has been obtained to study the evolution of tolerance and its effect on reflectance.

Milestones and deliverables achieved

1. A University scholarship at Sheffield (Luker-Brown) on 'Development of an integrated physiology model for use with remotely sensed data' has continued; the student is writing-up, with an expected completion date of 30 June.
2. A journal submission entitled 'Estimation of forest fire disturbance from remotely sensed data' was based on work under the SPOT-VEGETATION project (6), but owing to loss and secondment of staff the contract report for this project has been put back. However the report is virtually complete and CNES have been kept informed of progress.
3. The proposal submitted to NERC Environmental Diagnostics Special Topic Programme was not successful but a revision of the proposal resulted in the award of a NERC Fellowship (Barton, ITE Bush) to start on 1 June 1998.
4. Submission of a NATO Fellowship was aborted owing to lack of response from the identified candidate.

Programme plan and milestones for next year

The SPOT-VEGETATION work is near completion with the Phase I Final Report under the direction of Dr B K Wyatt (ITE) (June 1998). Phase II is dependent on satisfactory completion of Phase I. The work initiated under this Contract will continue in conjunction with Sheffield and ITE Bush through the PhD studentship and the successful Fellowship proposal under the DAEC Special Topic. The fellowship will investigate methodologies for assessing vegetation stress using reflectance and plant physiology models and extends work done under the studentship at Sheffield.

It is based at ITE Bush and will start in June 1998. In addition to this work a DAEC studentship was also awarded jointly with University of Edinburgh on 'Evolution of tolerance: influence on ability of remote sensing to detect vegetation stress'. The candidate has been appointed subject to successful completion of undergraduate studies and will start in October 1998. The result of an ESA Tender bid linking vegetation growth and remote sensing is awaited.

- Peer reviewed papers:
  Journal submission on 'Strategies for linking remote sensing and plant physiology models' (Plummer *et al.*) (February 1999)
  International Journal of Remote Sensing submission on 'The potential of SPOT-VEGETATION data for fire scar detection in boreal forests' (6, in review).
- Conference papers / Reports:
  SPOT-VEGETATION Phase I Final Report (Plummer, Wyatt, Woodward, Quegan) (June 1998)
- Studentships
  Completion of PhD Thesis entitled 'Linking plant physiology and reflectance models' (Luker-Brown, Sheffield) (July 1998)
  Supervision of CASE PhD Thesis entitled 'Evolution of tolerance: influence on ability of remote sensing to detect vegetation stress' (Edinburgh) (start October 1998)

T02086a6 Physiologically-based Assessment of Stress Using Remote Sensing

(C BARTON) & S PLUMMER

Progress towards objectives

This project aims to extend a complex model of plant physiology to include contaminant inputs and, by coupling it to detailed reflectance models, to conduct a rigorous assessment of the radiative response of vegetation to air and metal pollution.

Milestones and deliverables achieved

1. Project proposal submitted and funding approved under DAEC.

Programme plan and milestones for next year

1. Rigorously assess existing pollutant simulation models to determine how they can be integrated into the Plant Acclimation Prediction for Radiation Interaction Kinetics and Attribution (PAPRIKA) model
2. Develop modules for inclusion in PAPRIKA

Issue 10.2.4 Generic data products from earth observation

This Issue is concerned with developing and implementing methods for data required by end-users.

T02072m9 ETC land cover: integrated approaches and correspondence with other themes

R M FULLER, F. F. Gerard & B. K. Wyatt

Progress towards objectives

The prime objective of this sub-project, funded by the European Topic Centre on Land Cover, is developing an objective method for inter-comparing land cover / land use classification systems. Presently there is confusion on what constitutes land use or land cover, and on how to define them. As a result, many classification systems and innumerable map legends exist; and maps and statistics from different countries are incompatible with each other and incomparable in use. A major factor contributing to the observed problems stems from differences in nomenclature, and in the precise way in which class boundaries are defined. A first aim of this project was to address the question of how to improve the inter-compatibility of datasets. A second aim is to implement the conceptual idea into an operational system, allowing input and comparison of classification systems. Finally, a series of national, European and Global land cover/use classification systems will be included in this operational system.

Milestones achieved

1. A conceptual framework was designed that allows land units to be described uniquely, unambiguously and systematically.
2. A nomenclature needed to record attributes of land use and land cover within the conceptual framework was assembled taken the form of a structured glossary of defined terms.
3. A database was organised which reflects the conceptual framework and land cover categories from 10 classification systems (national, European and Global) were included in the database.
4. Prototype software was designed supporting:
   i. compilation and management of the glossary of defined terminology
   ii. compilation and management of the database of land use and land cover categories
   iii. interrogation of the database to explore inter-relationships between the different categories of land use and land cover
5. The prototype software was presented at the ETC/LC consortium meeting (November '97) and at the workshop organised by LANES (November '97).
6. Completion of software user manual.
7. Completion of interim report to ETC/LC.

Programme plan and milestones for next year

1. Completion of the software tests.
2. The prototype software will be further improved based on the test results and user-manual will be up-dated.
3. At least five more classification systems will be entered in the data base and these revisited for input consistency.
4. Final report to ETC/LC will be completed.

Issue 10.2.5 Infrastructure and facilities

This Issue is concerned with Management activities within the NERC Earth Observation programme and with the provision of specialist technical support and advice in the area of remote sensing within CEH and externally.

T02072s2 BNSC Earth Observation LINK Programme Co-ordination

J. HINTON

Progress towards objectives

The BNSC Earth Observation LINK programme aims to couple the interests and expertise of industry and the science and engineering base in order to develop new methodologies and applications for EO data. To capitalise on UK investment in satellite instrumentation, the programme aims to identify and stimulate new user-communities and markets for EO data, and to foster for the UK an international lead in the exploitation of EO-derived information and services. The programme is responsive to the outcomes of the Technology Foresight programme, particularly the findings of the Agriculture and Natural Resources and the Environment sector panels. All supported projects have clear end-user involvement, with 50% of projects in rounds 1-3 involving an end-user organisation new to EO. £690k was invested by industry in rounds 1-3 of the programme. Exploitation plans are in place in all projects. Two completed projects have already demonstrated effective transfer of technology from the science base to industry:

(i) A per-polygon image classification methodology defined by ITE will be included in the next commercial release of Laser-Scan Ltd's IGIS software

(ii) The image processing software enhancements developed by Salford University for the flood potential project have been transferred to Matra Marconi Space Ltd.

All projects continue to be monitored against agreed milestone payment plans, with a PMC member on the board of all projects. In all, 86% of projects include a university or HEI department. Streamlining of programme and financial management arrangements are keeping timescales for reviewing, selecting and starting projects to a minimum and significantly faster than any other LINK programme.

Milestones achieved

Round 3 of the LINK programme closed in April 1997. Two selected projects commenced in September 1997. Changes to Government and the Comprehensive Spending Review caused a postponement in approval for the launch of round 4 to November 1997. A BNSC sponsored workshop was held in London, opened by the Minister at the Department of Trade and Industry Mr John Battle, at which LINK round 4 was launched; 38 outline proposals were received by the deadline in February 1998.

All current projects were monitored regularly and six-monthly progress meetings were attended on all projects. Two projects successfully completed in March 1998.

A world-wide web site for the programme has been developed (33). All projects have produced publicity material (text and pictures) and BNSC organised the production of colour promotional flyers which were distributed at the November event. The Programme Co-ordinator continues to maintain an up to date set of OHPs for each project. Items publicising the programme have appeared in the Foresight LINK newsletter (January 1998) and NERC News (March 1998) (19).

An invited presentation was given at the Annual Remote Sensing in Scotland Conference in Dundee in May 1997 (34). A LINK special session was held at the Remote Sensing Society Annual Conference in September 1997 at which three supported projects gave presentations.

Milestones for next year

1. Co-ordinate Round 4 full proposal review and grant award process - ensure new guidelines and objectives are achieved. Initiate 5 projects by October 1998 and a further 5 by March 1999.
2. Assist Programme Manager in development of the case for additional funding to allow further rounds. Agree procedure / timescale for further outline bid submissions.
3. Monitor funded projects - attend project meetings on all projects at least six-monthly. Liaise with PMC-assigned monitor on progress. Monitor project outputs and keep Access database up to date.
4. Publish programme achievements in general access literature (for example NERC news, LINK Newsletter), maintain programme Web page with up to date information (monthly).
5. Prepare input to annual reports on programme to LINK Board, NERC and DTI in August 1998.

T02072t2 Programme Management Support to EOSTB

J. HINTON

NERC has made considerable investment in satellite instrumentation. ATSR sensors are currently flying on board ESA's ERS satellites and AATSR is planned for launch on the Envisat satellite. To maximise the benefit of this investment, NERC aims to increase awareness and use of ATSR data within the user communities. RAL are contracted to maintain the sensors in-flight, process the data from them, and provide science advice to NERC users. An on-line data catalogue and browse facility has been commissioned to simplify the image product request process and to reduce workload on RAL. Arrangements for NERC user access to AATSR data are currently the subject of negotiation.

Part 1. ATSR Post-Launch Support

Progress towards objectives
Significant effort has been focussed this year on promoting ATSR data to increase awareness of the data in the UK and international user community and an increasing number of new users have been supplied with data. The RAL Web page and the ABF are simplifying the data ordering and selection process.

Milestones and deliverables achieved
RAL have continued to follow the agreed ATSR PLS PMP. Some adjustments have been necessary to allow for unforeseen circumstances such as the damage to ERS-1 solar arrays. Core Group meetings have been attended quarterly. In the last six months, focus was placed on ATSR promotion activities by RAL.

The ABF was completed, delivered to NERC and installed at RAL in June 1997 to the agreed price. A maintenance contract for the ABF was agreed and placed with EOS in August 1997. This is a 'pay as you use' contract, with an upper limit of £4k per year. This has been used by RAL for help with early maintenance but there has not been much call for maintenance work under the contract, as the ABF has been relatively trouble free.

Priorities for population of ABF with ATSR data were agreed with RAL and the Core Group. The schedule is published on the ATSR and ABF web pages and is updated weekly to show progress against schedule. RAL are currently about 2 weeks ahead of schedule. A new Programme Management Plan for 1998 - 2001 is being negotiated.

Milestones for next year
1. Negotiate a new Programme Management Plan for the period April 1998 to March 2001 and liaise with core group to agree plan by August 1998.
2. Monitor RAL's progress against agreed PMP.
3. Attend, provide input to and obtain guidance from ATSR Core Group meetings quarterly.
4. Monitor use of the ATSR browse facility and of NERC's support contract with EOS Ltd and ensure population of ABF according to the schedule agreed by the Core Group.

Part 2. AATSR Ground Segment Co-ordination

Progress towards objectives

Despite announced delays to the original planned launch date for Envisat and also hardware problems with AATSR, negotiations between interested parties in the UK have been progressing to schedule. A co-ordinated ground segment for AATSR data is likely to evolve in the next 1-2 years, with clear guidelines for NERC users to obtain data.

Milestones achieved

Negotiations have been conducted with DETR / ESA for suitable data delivery mechanisms for NERC AATSR data users. Agreement was reached with DETR and ESA for a limited amount of AATSR data to be provided direct to named NERC users at no cost. Other NERC users will be able to obtain their data via 'category 1' status under the terms of the Envisat data policy. Mechanisms for data delivery will be dependent on arrangements at the PACs.

Discussions have been held with DETR and BNSC. BNSC support the setting up of a UK PAC by NRSC / DERA. DETR will be contracting out the management of their AATSR archive, for which the PAC host will be able to bid, but are otherwise not contributing to the PAC. NERC have been considering the benefits of a UK PAC and will assess the case for financial input in the next financial year.

Two bilateral NERC / DETR meetings have been held to discuss co-ordination of ground segment plans for AATSR. The AATSR NERC / DETR Agreement is in draft form but further negotiations await finalisation of the ESA Data Policy. AATSR Programme Steering Panel Meetings were attended quarterly.

Milestones for next year

1. Attend AATSR PSP Meetings quarterly and ensure NERC user interests are upheld.
2. Liaise with BNSC, DETR and NERC Users on UK PAC.
3. Finalise NERC / DETR AATSR agreement.
4. Finalise AATSR data distribution arrangement for NERC users with DETR / ESA.

Part 3. EO Requirements Database

As a result of reorganisations in NERC EO and spending reviews in BNSC, planned use and development of the database has not been required. Therefore no milestones and deliverables were agreed and staff effort was transferred to the AATSR ground segment activities reported earlier.

T02072v2 To provide support to the Head of the EO programme

J. HINTON

Progress towards objectives

The objective of this sub-project is to provide support to the EO programme as requested by Dr S A Briggs. This level of support is up to a maximum of 10% of the staff effort funded under the SLA within projects 1, 2 and 5. The single greatest item during this financial year was the secondment of S. Plummer to the EO Programme as a temporary replacement for C. Boalch. This lasted for from December 1997 to March 1998 and continues into April 1998 and his responsibility has been for:

(i) NERC Earth Observation Programme - Financial Management / Forward Look
(ii) NERC / CCLRC SLA - EO Programme Liaison
(iii) UK EO Science / EC Programme Opportunities
(iv) NERC / BNSC Interface

Milestones achieved

1. S. Plummer:

(i) NERC Earth Observation Programme - Financial Management / Forward Look

Ongoing items:

(a) Management of programme project lines
(b) Development of NERC forward look as input to BNSC EOPB and prepare material for EOEG as requested.
(c) Liaison between NERC Central Finance, NSS Finance, BNSC Finance and RAL Finance Sections

(ii) NERC / CCLRC SLA - EO Programme Liaison

(a) Establishment of project milestone and payment mechanisms for 1997 / 1998 and 1998 / 1999 CCLRC SLA
(b) Monitoring of out-turn statements and associated reconciliation
(c) Supervision of project review mechanisms

(iii) UK EO Science / EC Programme Opportunities

(a) Analysis of EU reports and proposals especially with respect to Framework 5 where necessary, primarily through comments on drafts produced by Head of EO.
(b) To co-ordinate with BNSC partners (especially DETR)

(iv) NERC / BNSC Interface

(a) monitoring and advice on ENVISAT exploitation and UK ground segment development (watching brief on AATSR with J Hinton, HLOP / DOSTAG items)
(b) representation of NERC views on UK Earth Explorer position (comments on drafts from Head of EO, attendance at and report on Land Surface Mission Seminar to BNSC).
(c) monitoring and advice on UK Small Satellites Initiative (attendance at VHR meeting Smith Systems)
(d) ad-hoc items as required (e.g. SLR, NLR bilateral)

(v) Support to Head of EO

(a) development of briefing and publicity materials (NERC News article (18), EO web page development, EOEG documents)
(b) representation of NERC at external meetings (e.g. VHR meeting Smith Systems, UTLS Town Meeting, GERB PSG)

2. J. Baker:

Member of the GB-SAR PSG for the NERC grant to the University of Sheffield

3. P. North:

Represented BNSC and NERC at meetings of the GOFC group organised by CEOS in Tokyo and Ottawa and contributed to the production of a major requirements document which has been published through CEOS (15).

4. A. Wilson:

(i) Technical consultancy to BNSC / NERC on ESA EOPB briefings
(ii) Technical consultancy on the draft documents for Envisat data policy (HLOP)
(iii) Membership of the NERC ARSFSC and sub-committee on new instrumentation
(iv) Membership of the technical project team for the development of the NERC IDS
(v) Membership of the NERC tender evaluation board for the management of the ARSF
(vi) Membership of the NERC Expert Review Group for Atmospheric Research Using Small Aircraft

Programme Plan and Milestones for next year:

1. J. Baker, H. Balzter, P. North, S. Plummer, A. Wilson:

Representation of NERC and advice to BNSC as required.

2. S. Plummer:

April 1998 secondment (see above) plus ongoing management of NERC Earth Observation Web Site, including further development, information input and update.

3. P. North:

Contribution to UK co-ordination of GOFC project.

T13061Q9 Authorship of Chapter 2.4 (Land Use and Land Cover Change) of the European Environment Agency State of the Environment Report

(B K WYATT)

Progress towards objectives

This is a specific contract from the European Environment Agency, through its Topic Centre on Land Cover, to draft a brief review of the current status and future prospects and consequences for land use and land cover change in the EU and in the 10 Accession Countries of the EU.

Milestones achieved

December, 1997 – 'Story Line' for Chapter agreed with Topic Centre and editors in EEA
February, 1998 – attended meeting of Authors of EU98 in Copenhagen
March, 1998 – completed first draft outline of Chapter.

Programme Plan and Milestones for next year

July, 1998 – complete first full draft of Chapter
August, 1998 – complete final draft
September – December, 1998 – final editing stage, incorporating feed-back from EU consultative exercise.

PROGRAMME 2 LAND USE SCIENCE

PROJECT 2.1 LONG-TERM AND LARGE-SCALE MONITORING OF LAND USE

Issue 2.1.1 National-scale survey of land use and cover

This Issue is concerned with operational developments and applications of remote sensing for National surveys.

T02080k2 CS2000 Planning Group

R. M. FULLER, R. A. Hill & G. E. Smith

Progress towards objectives

The aim of this project was to research the needs, identify methods, plan the necessary R&D and develop a specification for Land Cover Map 2000, a component of the Countryside Survey 2000. The key aim was to win contractual funding, sufficient for operational mapping 1998-2000.

The project tested, developed and demonstrated methods suitable for operation. These were based upon CLEVER-Mapping, but adapted to the needs of a full national survey. Pre-operational outputs from CLEVER-Mapping needed to be developed to operational status, often by ITE's LINK Partners, Laser-Scan and Cambridge University Geography Department. ITE continued collaborative work, advising on, helping to develop and testing procedures.

Close collaboration with ITE Merlewood ensured the best possible complementarity and potential for integration with the CS2000 Field Survey. Consultations with end-users (customers and CEH) were designed to ensure that LCM 2000 will offer the maximum potential value to operations.

Milestones achieved

1. Analytical techniques, combining published procedures, LCMGB 1990 methods and CLEVER-Mapping techniques for operational use, were researched, developed, tested and demonstrated.
2. A Specification for Land Cover Map 2000 was completed
3. Joint funding of LCM2000 was negotiated and agreed with funds from NERC, Countryside Council for Wales, DETR, Environment Agency, MAFF, Scottish Natural Heritage, Scottish Office and Welsh Office.

Programme Plan and Milestones for next year

1. To implement the Specification to commence production of LCM 2000
2. To negotiate inclusion of Northern Ireland to give UK coverage

T02080n5 Patterns of biodiversity in the landscape

C B BARR including R. M. Fuller, F. F. Gerard & R. A. Hill

Progress towards objectives

The objectives outlined for this part of the ECOFACT study are i. to develop appropriate indices of landscape pattern at, and within, the 1 km scale; ii. to examine the relationship between pattern at the level of the ITE Land Cover Map in comparison with the field survey; iii. to describe landscape patterns and provide summary data for the CIS; iv. to indicate the ecological consequences of pattern changes between 1978 and 1990.

The following pattern measures were created in the earlier study of pattern: i. *diversity* - number of cover types per 1 km square or a diversity index; ii. *boundary length per cover-type per square* - some classes aggregated; iii. *pairwise boundary combinations* - number of pixels in adjoining aggregate-classes in each 1 km square.

The data on boundary lengths per cover-type per square were calculated using software which scanned the full resolution data, a cover type at a time, and marked those pixels which fell on the edge of the cover type. The total number of edge pixels were then scored per square per cover type; to give 700 x 1300 integer percentage values, one layer for each of the 25 cover types. Seven aggregate classes were also created, which, together with 3 classes which were not aggregated, gave 10 'major' types (Table 1). Boundary data were also collected for these classes.

Pairwise boundary lengths per square used a shortlist of 9 of the 'major' cover types (the 10 types of Table 1 but excluding the 'maritime' class). These gave 36 pairwise combinations. The procedure used the same software as above to identify the 9 major-class boundaries, which were then compared for overlap, one with another. The overlaps were then scored as 'percent per square'. The result was 36 layers of data, each of 700 x 1300 values, for all GB. A 'diversity' map was made by scoring the number of cover types per 1 km square. In addition, a map of dominant cover per 1 km square was made. Results were imported into the Countryside Information System (CIS).

CLEVER-Mapping based on image segmentation was applied to trial analyses in a sub-set of squares (one from each landscape) and to subject the data to pattern analyses. Direct comparison was made between spatial statistics (for woodland features) derived from the classified TM data and the field survey. The principal spatial statistics examined were: i. class area and perimeter, ii. the number of patches and their mean size, iii. the largest patch index, and iv. the landscape shape index, generated using the FRAGSTATS module of ARC/Info.

Milestones achieved

1. The above analyses gave 70 layers of information which were built into the CIS.
2. The CLEVER-Mapping results were submitted to the ECOFACT project team for comparison with vector-derived products.
3. A draft report on remotely sensed measures of pattern was sent to the ECOFACT project team for inclusion in the final report.

Programme Plan and Milestones for next year

1. To contribute to completing the Final Report.

Issue 2.1.2 Remote sensing of land use and cover

This Issue is concerned with a range of local and regional surveys to derive data on land use and cover, in response to the needs of customers, either directly for remotely sensed output data or for the results of their use in collaborative research.

T0207211 R&D on the application of predictive models for support in nitrate policy

R. M. FULLER & A. G. Thomson

Progress towards objectives

This work, part of a 3 year contract, conducted by a consortium led by IACR-Rothamsted, aims to develop a system of predictive models for support in MAFF's nitrate policy. The system simulates nitrate loss at farm, catchment, regional and national scales, to assess the impacts of changes in agricultural practice or land use on nitrate movement from soil to natural waters. The team is producing a decision support system based on a set of robust and well-validated models. The objectives for ITE are to supply land cover data for England and Wales from the satellite based Land Cover Map of Great Britain (LCMGB), to compile a demonstration of the potential for crop mapping by satellite remote sensing over an extensive area of eastern England, and to review the wider role of remote sensing for crop mapping.

The Land Cover Map of Great Britain (LCMGB) data derived from Landsat Thematic Mapper satellite images were re-interpreted to show 6 specific crops: underlying the general arable cover class of the LCMGB were *c.* 20 spectral subclasses per summer-winter composite scene. With reference to contemporary ground data, these subclasses were reallocated to show specific crop types. In comparison, a completely new reclassification of the summer/winter composite Landsat scene covering southern East Anglia was produced by identifying new training areas in arable crops and combining these with original training data for other LCMGB classes.

The LCMGB of 1990, in 1 km summary form, provided spatial detail on the extent of arable land, grassland and non-agricultural classes. It has been combined with the MAFF Annual Census giving the necessary temporal information, year-on-year, on crop types and agricultural land use.

Milestones achieved

1. The LCMGB in 1 km summary format and covering all of England and Wales was supplied to the consortium.
2. Sample outputs of detailed crop mapping (at 25 m spatial resolution and summarised at 1 km) for East Anglia have been compiled.
3. Completion of ITE contribution to final report.
4. A review of remote sensing for crop mapping is to be incorporated in a Technical Annex to be provided with the Decision Support System.

Programme plan and milestones for next year

1. Completion of Final Report by IACR and consortium, with inputs as needed from SEO/ITE.
2. A scientific paper describing crop mapping from satellite imagery will be published literature.
3. Crop-specific mapping, as developed in this project, will be incorporated in LCM 2000.

T02072v9 Land cover map of Jersey

G. E. SMITH & R. M. Fuller

Progress towards objectives

The States of Jersey commissioned the ITE to map the land cover of the Island from remotely sensed images recorded by satellite. CLEVER-Mapping using Ordnance Survey (OS) vector map data, was ideally suited to land cover mapping in Jersey. The aim, therefore, was to produce a parcel-based land cover map of Jersey, using CLEVER-Mapping procedures and, in the process, to assess the utility of widely applying such procedures.

OS digital cartography, comprising unstructured linework, was generalised and polygonised into a topologically structured land parcel data set. Multi-date and multi-resolution remotely sensed images (TM, IRS Pan and SPOT PAN) were combined into a single, resolution-enhanced, composite image for the land cover classification. The resulting high spatial resolution dataset was especially suitable for Jersey and with spectral detail sufficient for interpreting complex vegetation and crop types in a landscape with a complex, fine-grained pattern. Ancillary map data (e.g. topography and urban linework) were pre-processed to generate contextual information for each land parcel to aid in the classification procedure. The land parcel data set, composite image and ancillary data sets were integrated within the object-oriented GIS. CLEVER-Mapping assessed the land cover type for each land parcel by classifying on a per-parcel basis and then applied a knowledge-based corrections to refine the result. Land parcels with high within-parcel variation were further assessed by examining the results of a conventional per-pixel classification. Agricultural statistics, published by the States of Jersey for 1996, wee shown to match closely the summary statistics from the land cover map for spring 1997. Analysis of validation land parcels estimated the correspondence of the classification to be between 85 % and 90 %. When these results were weighted to take account of proportional land cover in Jersey, the correspondence was increased to beyond 90%, as the most extensive land cover types were the most accurately classified.

The land parcel data set represented a powerful data storage framework for developing applications with a spatial context. The spring 1997 land cover map of Jersey represented a base line survey from which to take stock and will form the basis for repeat monitoring and the development of further classification products.

Milestones achieved

1. Unstructured OS linework for Jersey was generalised and polygonised into a topologically structured land parcel data set, the first of its kind for Jersey.
2. Merging and 'resolution-enhancement' of TM data with SPOT PAN and IRS Pan datasets was novel in this applications context.
3. CLEVER-Mapping generated a parcel-based, land cover map of the Island with 21 land cover types and 9 arable sub-types.
4. An IGIS database and hard copy outputs were delivered to the States of Jersey.
5. A contract report was delivered to the States of Jersey.

Programme plan and milestones for next year

1. End-user support to the States of Jersey.
2. Production of spatially aggregated data.
3. Submission of a refereed paper.

Issue 2.2.4 Development of land use and water resource management strategies

This is an applications Issue where remote sensing has been brought in as a tool to derive baseline data and to extrapolate local field-based observations.

T02073r5 Ecological effects of land use changes on European terrestrial mountain ecosystems (ECOMONT)

N BAYFIELD including F.F. Gerard, G. E. Smith & R. M. Fuller

The SEO's main objective in this project is to provide the ECOMONT team (i.e. partners from Austria, Germany, Italy, Spain, Switzerland) with land cover information for three mountain test sites situated along a South/North-transect across the Eastern Alps, a fourth site in the Swiss Alps and a fifth site in the Cairngorms, Scotland. The total area covered will be 140 square kilometres. For each site, airborne ATM imagery, acquired and geo-corrected by the NERC IDS facility, will be classified into land cover classes and merged into a single land cover map. The cover mapping will be achieved through regular liasing with experts of these areas and field surveyors.

The delayed provision of geo-corrected ATM imagery by the NERC IDS facility has delayed the production of the land cover maps for all sites.

Milestones achieved

1. Cairngorm ATM data were acquired by the ARSF.
2. Ground reconnaissance surveys of the Cairngorm site by the SEO team has provided reference data for ongoing surveys.
3. Experiments with the Cairngorm site, using Landsat TM data and CLEVER-Mapping procedures, have been used to inform the team for airborne data analyses.
4. New procedures have been tested for correction of differences in illumination due to the effects of terrain geometry.

Programme Plan and Milestones for next year

1. Complete mapping for all ECOMONT sites.
2. Submit report on remote sensing in ECOMONT

Issue 2.2.5 Environmental impact, coastal zone survey and management

This Issue is applications driven, with remote sensing offering crucial data to help extrapolate local field based observations and contribute base data for environmental modelling in the context of coastal management.

T05060j2 LOIS BIOTA

A. J. GRAY (now J. GOSS-CUSTARD), including A. G. Thomson, J. A. Eastwood & R. M. Fuller

Progress towards objectives

Remote sensing of the coastal zone has been under the BIOTA programme (Biological Influences On interTidal Areas) within LOIS (Land-Ocean Interaction Study). Airborne remote sensing with ***casi*** is being used to map sediment types and biotic associations for the intertidal zone from the Humber Estuary to North Norfolk. Key aims of the project are to develop methods for extrapolating field-based observations on biotic and sedimentary processes, using airborne remote sensing, and thereby provide BIOTA with data and maps showing sediment types and vegetation categories for modelling the coastal processes of erosion and accretion.

Milestones and deliverables achieved

1. Development of techniques for unsupervised classification of airborne imagery with post-classification allocation of classes to provide a suitable methodology for extensive coastal zone mapping.
2. The use of vegetation indices to provide an indication of the amount of vegetation present, especially in the pioneer saltmarsh zone where cover is incomplete and the system is most dynamic. Integrated vegetation index and cover maps give a measure of comparative vegetation density within zones.
3. Preliminary classification of an extensive area of the North Norfolk intertidal zone and completion of the final classification of the Humber Estuary.
4. Completion of three papers for the *International Journal of Remote Sensing* describing results from the Development Phase of this project; covering ground radiometry and band selection for airborne radiometry, a comparison of supervised and unsupervised classification methods and the use of vegetation indices for assessing vegetation cover.
5. Poster display at the final annual meeting of LOIS at the University of East Anglia.

Programme plan and milestones for next year

1. Completion of the geo-registration and full classification of airborne remote sensing datasets covering the entire intertidal zone, from the Humber Estuary (East of Hull) to North Norfolk (Cley), and supplying the LOIS Data Centre and the BIOTA modellers with data and class maps showing categories of intertidal sediments and vegetation – suitable for modelling the coastal processes of erosion and accretion.
2. Completion of papers in the scientific literature describing the results of the project including contributing to a special LOIS issue of the Marine Pollution Bulletin.
3. Applying methods developed in BIOTA to the monitoring of saltmarsh vegetation in the Westerschelde estuary, Netherlands as part of the EU ISLED project.

4. To set up a joint coastal project within ITE Monks Wood to extend the BIOTA and Methods projects to develop object-orientated integrated GIS approaches to modelling coastal saltmarsh dynamics.

T08074f5 ISLED Influence of Rising Sea Level on Ecosystem Dynamics of Salt Marshes - Work Package 3 - Tasks 3 & 4

R A WADSWORTH including A. G. Thomson

Progress towards objectives

ISLED, a research project funded by the EC Commission on Environment and Climate, will focus on identifying, describing and defining the abiotic and biotic processes in salt marsh ecosystems resulting from and counteracting the effect of increased inundation frequencies. The overall aim is to get an comprehensive insight into the dynamics of the system counteracting sea level rise to model future management and conservation of salt marshes.

The objectives of the airborne remote sensing work involve classifying the cover in 3 salt marsh study sites, providing these data for GIS-based modelling and recording changes 1998-2000.

Milestones and deliverables achieved

1. Design of experiments, planning of project and approval for funding completed.

Programme plan and milestones for next year

1. Acquisition of ***casi*** data for 3 sites.
2. Collection of ground reference data for training the classifier.
3. Processing to complete 1998 classification.
4. Provision of data to GIS modellers and hard copy maps for customers/collaborators.
5. Presentation at a project workshop.
6. Contribution to the Annual Report.

PROGRAMME 5

BIODIVERSITY AND POPULATION PROCESSES

Issue 5.1.2 Biodiversity of communities and resilience to environmental change

In this Issue, remote sensing is integrated with field survey in studies of biodiversity.

T02055o7 The impact of military training on the ecology of Salisbury Plain A

R F PYWELL including F. F. Gerard

Progress towards objectives

The aim of the project was to record the composition of the vegetation communities present on Salisbury Plain Training Area and map their distribution using a combination of ground survey and remote sensing techniques. The type and extent of disturbance caused by military training activities was monitored, together with the ecological impact of the proposed track building programme. The information was used in the formulation of an integrated land management plan for the site.

Methodologies were derived for the rapid correction and normalisation of high resolution *casi* data collected for large areas (>30000 ha) of grassland. A supervised classification using a sub-set of contemporary field survey data created a mosaic cover map. Class correspondence of the classified *casi* data was compared to a further sub-set of the field survey data. The potential applications of *casi* data for land cover mapping, monitoring disturbance and change were investigated.

Milestones and deliverables achieved

1. Geo-registration achieved by combined INS and polynomial correction.
2. Normalisation methods developed, tested and operated.
3. Classifications achieved for *c.* 7 runs at a time.
4. Class maps merged to give a complete land cover map of the Training Area, delivered to MOD and Defence Estate Organisation.
5. Contribution to Final Report completed, incorporated and the Report delivered.

Programme plan and milestones for next year

1. Submission of one paper on Salisbury Plain work to *International Journal of Remote Sensing.*

PROGRAMME 12 NON-CORE CONSULTANCIES

T02072b4 Supply of land cover data

R M FULLER & S. M. Wallis

Progress towards objectives

The main aim is to provide Land Cover Map Great Britain data, currently from 1990, in accordance with the NERC Data Policy. This, under SEEDCORN means that data are free to academic users and charged for paying customers, the latter under a banding system reflecting the end use of the data (i.e. whether commercial or non-commercial).

Data, plots etc. from the Land Cover Map have been available under licence since 1993. Many potential users contact ITE having seen the information about our datasets on the WWW pages. Part of the data supply activities involves publicity, marketing, advise, and user support.

Milestones and deliverables achieved

1. In 1997/98, twelve 25m datasets were licenced to paying customers and two 1km datasets. Other fees received for re-licencing, royalties
2. In 1997/98, 34 academic and other research users were supplied with free data or plots under NERC arrangements, of this number 17 were supplied under the SEEDCORN programme which came into force in June 1997. Data supplied under SEEDCORN in that year would have had a notional value of £10,516 at non-commercial rates.
3. Data were also licenced for use within several EU funded contracts being undertaken by ITE.
4. Other (indirect) users include the 20 purchasers of the CIS who were accessing the Land Cover data within this system.
5. The main application areas ranged from weather prediction modelling, habitat distribution studies, study of nutrient losses from ecosystems, renewable resources potential, teaching GIS skills, studies for power line location, risk assessment in the insurance industry.
6. Many of the uses represent contributions to CEH Programmes not specifically identified in this document. Similarly, many of these and other uses contributed to ANRE issues.
6. In addition to LCM data, two items of original software were licensed from the SEO to other academic users: Peter North's FLIGHT software and France Gerard's tree distribution model.

Programme plan and milestones for next year

1. To continue LCM data sales and academic supplies.
2. To start to develop marketing and distribution policies for LCM2000 data.

SEO PUBLICATIONS 1997/98

PAPERS - REFEREED & ACCEPTED

1. **Baker, J.R. and Luckman, A.J.**, accepted subject to minor alterations. Microwave observations of boreal forests in the NOPEX area of Sweden and a comparison with observations of a temperate plantation in the UK. *Agriculture and Forest Meteorology – Special Issue.*
2. **Chen, J.M., Rich, P.M., Gower, S.T., Norman, J.M. and Plummer, S.E.**, 1997, Leaf area index of boreal forests: Theory, techniques and measurements, *J. Geophys Research*, **102**, D24, 29429-29443.
3. **Curran, P.J., Kupiec, J.A. and Smith, G.M.**, 1997, Remote sensing the biochemical composition of a slash pine canopy. *IEEE Transactions on Geoscience and Remote Sensing*, **35**, 415-420.
4. **Dawson, T.P., Curran, P.J. and Plummer, S.E.**, accepted. LIBERTY – modelling the effects of leaf biochemistry on reflectance spectra. *Remote Sensing of Environment.*
5. **Dawson, T.P., Curran, P.J. and Plummer, S.E.**, accepted. The biochemical decomposition of slash pine needles from reflectance spectra using neural networks. *International Journal of Remote Sensing.*
6. **Dawson, T.P., Curran, P.J., North, P.R.J. and Plummer, S.E.** "Analysing the reflectance spectra of conifer forests using a coupled leaf and canopy model", *Third International Airborne Remote Sensing Conference, Copenhagen*, Denmark, 7-10 July, 1997.
7. **Eastwood, J.A., Plummer, S.E., Wyatt, B.K. and Stocks, B.**, in press. Estimation of forest fire disturbance from remotely sensed data. *International Journal of Remote Sensing.*
8. **Eastwood, J.A., Yates, M., Thomson, A.G. & Fuller R.M.** 1997. The reliability of vegetation indices for monitoring saltmarsh vegetation cover. *International Journal of Remote Sensing* **18**, 3901-3907.
9. **Fuller, R. M., Groom, G. B., Mugisha, S., Ipulet, P., Pomeroy, D., Katende, A., Bailey R., & Ogutu-Ohayo., R.** In press. The integration of remote sensing and field survey for biodiversity assessment: a case study in the tropical wetlands of Sango Bay, Uganda. *Biological Conservation*, (accepted, 07/03/97).
10. **Fuller, R.M., Wyatt, B.K., and Barr, C.J.**, In Press. Countryside Survey from ground and space: different perspectives, complementary results. *Journal of Environmental Management.* (accepted 17.7.97).
11. **Gerard, F.F, & North, P.R.J.** 1997, Analysing the effect of structural variability and canopy gaps on forest BRDF using a geometric-optical model. *Remote Sensing of Environment*, **62**:46-62.
12. **Luckman, A. J., Baker, J. R., Honzák, M. H. & Lucas, R. M.**, 1998, Tropical forest biomass density estimation using JERS-1 SAR: Seasonal variation, confidence limits and application to image mosaics, *Remote Sensing of Environment*, **vol.63**, pp.126-139.
13. **North, P.R.J., Briggs, S.A., Plummer, S.E. and Settle, J.J.**, in press. Retrieval of land surface bidirectional reflectance and aerosol opacity from ATSR-2 multi-angle imagery. *IEEE Trans. Geoscience and Remote Sensing*, to appear Nov. 1998.
14. **Smith, G.M. and Spencer, T.**, In press, Assessing seasonal change in coastal wetlands with airborne remote sensing. *Mangroves and Salt Marshes.* (Accepted)
15. **Thomson, A.G. & Fuller, R.M.** In press. An investigation of land use change in the Llyn Tegid catchment using satellite remote sensing. Paper being revised after being refereed before being published in conference proceedings of *The Llyn Tegid Symposium* by the Snowdonia National Park Authority (accepted subject to alterations, now made).
16. **Thomson, A.G., Fuller, R.M. & Eastwood, J.A.** Supervised versus unsupervised methods for classification of coasts and river corridor from airborne remote sensing. Paper refereed and resubmitted for publication in *International Journal of Remote Sensing.*
17. **Thomson, A.G., Fuller, R.M., Sparks, T.H., Yates, M.G., & Eastwood, J.A.** Ground and airborne radiometry over intertidal surfaces - waveband selection for cover classification. **In Press.** *Paper accepted by International Journal of Remote Sensing.*
18. **Wadsworth, R.A., Cox, R. & Fuller, R.M.** 1997. Adjustment of frequency distribution of cover types within sections of the Land Cover Map of Great Britain. *International Journal of Remote Sensing*, **18 (17)**, 3569-3582.
19. **Wilson, A.K.**, 1997, An integrated airborne system for remotely sensed data acquisition, *International Journal of Remote Sensing*, **Vol 18**, No. 9 (June), p1889-1901.

BOOK CHAPTERS – REFEREED

20. **Brookes, A.M., Furze, M.T. & Fuller, R.M.** In press. An assessment of the Land Cover Map of Great Britain within headwater stream catchments for four river systems in England and Wales. In: *Vegetation from patch to planet*, edited by R.W. Alexander & A.C. Millington. Chichester: Wiley.
21. **Gerard, F.F., Wyatt, B.K., Millington, A. and Wellens, J.,** In Press. Mapping Tropical forest types on a continental scale using remote sensing: The role of data from intensive sample plots. In: *Forest Biodiversity Research, Monitoring and Modelling: Conceptual Background and Old World Case Studies*, F.Dallmeier & J.A. Comiskey (Eds.), Parthenon Press, Washington DC.
22. **Hinton J.C.** Image Classification and Analysis using Integrated GIS. In *Advances in Spatial Data Analysis*. Edited by P.Atkinson, Wiley Press. (in press)
23. **Smith, G.M. and Curran, P.J.,** In press. Methods for estimating image signal-to-noise ratio (SNR). *Proceedings of meeting Spatial Analysis in GIS and Remote Sensing*. (Accepted)

OTHER ARTICLES – NON-REFEREED

24. **Ahern et al, including North, P.R.J.**"CEOS Pilot Project: Global Observations of Forest Cover (GOFC)", 32pp, *CSRC*, Ottawa, Canada, July 1997.
25. **Baker, J. R., & Luckman, A. J.,** 1997, J-ERS-1 mapping of regenerating tropical forest with GRFM image mosaics and SAR interferometry, *Paper presented at JPL GRFM/GBFM conference*, Pasadena, California, November 4-7, 1997 (see also: Report of visit to Jet Propulsion Laboratory, Pasadena, California, J. R. Baker).
26. **Baker, J. R., & Luckman, A. J.,** 1997, Retrieval of biophysical information from polarimetric SAR observations of temperate and boreal forests, Abstract and paper presented at the *Progress in Electromagnetics Research Symposium (PIERS '97)*, July 7 - 11, 1997, Cambridge, Massachusetts, USA.
27. **Baker, J. R., & Luckman, A. J.,** 1997, Saturation of the microwave return over Swedish boreal forests, *EMAC 94/95 Final Results - Workshop Proccedings*, ESTEC, Noordwijk, The Netherlands, 14-16 April 1997, **ESA-WPP-136**, pp. 115-121.
28. **Briggs, S.A., Hinton, J.C. and Plummer, S.E.,** 1998, Changing the View: Earth observation in NERC. *NERC News*, March 1998
29. **Brown, N. J., Cox, R., Pakeman, R., Thomson, A. G., Wadsworth, R. A. & Yates, M.** 1997. Developments of the BIOTA GIS. *CoastGIS'97, Aberdeen August 1997.*
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COLLABORATION

UK Universities:

Cambridge University (Geography, Education, Cambridge Coastal Research Unit)
Durham (Environmental Research Centre)
Edinburgh (Geography, Centre for Environmental Change and Sustainability,BioSS)
Imperial College London
Leicester (Geography)
Newcastle
Oxford (Environmental Change Unit)
Salford (Geography, Telford Institute)
Sheffield (Animal & Plant Science, Geography, SCEOS, Psychology)
Southampton (Geography)
Swansea (Geography)
University College London

Other UK Institutions:

British Council
Environmental Systems Science Centre, Reading
IACR-Rothamsted
ITE Bush
ITE Merlewood
NERC Earth Observation Programme
Southampton Oceanography Centre
Unit of Comparative Plant Ecology, Sheffield
Geographical Association

UK Industry:

Laser-Scan Limited

UK Government:

Countryside Council for Wales
Defence Estate Organisation
DETR
Environment Agency
Ministry of Agriculture, Fisheries and Foods
Ministry of Defence
Scottish Natural Heritage
Scottish Office
States of Jersey
Welsh Office

International:

Canada Centre for Remote Sensing
Canadian Forestry Service
CESBIO - France
DFID (Natural Resource Services - Botswana, University of Namibia, University North West - South Africa, University of Witswatersrand - South Africa, Agriculture Research Council - South Africa)
European Space Agency
NASA (JPL, Goddard, Ames)
Departamento De Biologia Vegetal, Faculdade De Ciências De Lisboa, Portugal (FFCUL)
European Commission
Environmental Satellite Data Centre (MDC)
Finnish Geodetic Institute (FGI)
Institute of Biology, Odense University, Denmark (OU)
International Institute for Aerospace Survey and Earth Sciences (ITC) in Enschede, Netherlands
Instituto Geografico Nacional (IGN), Spain
Laboratory of Plant Ecology, University of Ghent (RUG), Belgium.
Makerere University, Kampala, Uganda
Netherlands Institute Of Ecology - Centre for Estuarine and Coastal Ecology (NIOO) Ordnance Survey
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University of Palermo (Institute of Hydrology)
University of Tasmania
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Recipients of ITE Land Cover Data:

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ADAS, Wolverhampton
ADAS. Leeds
ADAS.Cambridge
AEA Technology
Anglia Polytechnic
AON UK
Aspinall & Co
Bedfordshire County Council
Berks County Council
Bradford University
British Assoc. for Conservation & Shooting
British Geological Survey
British Trust for Ornithology
Cambridge ArchitecturalResearch Ltd
Central Vet. Laboratory
Countryside Commission
Countryside Council for Wales
Cranfield University
Cumbria County Council
Defence Research Agency
Dept. of the Environment
Devon County Council
Dorset County Council
Dunn R.
EA Technology
East Sussex County Council
Ecotec Ltd
English Nature
Environment Agency
ESSC, University of Reading
Essex County Council
Forestry Commission
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Humberside County Council
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Imperial College
Institute for Freshwater Ecology
Institute of Agricultural Crop Research,
Rothamsted Nitrate
Institute of Hydrology
Ipswich County Museum
Isle of Wight County Council
ITE / British Gas
ITE / Institute of Hydrology
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Kingston University
Kirklees Met. Council
Landcsape Design Associates
Leics. County Council
Lincs. County Council
Liverpool Inst. of Higher Education
London Research Centre
Macaulay Land Use Research Institute
MAFF
MAFF/ADAS
MAFF/ADAS
Manchester Metro. University
MDC satellite station Kiruna Sweden
Meteorological Office
Mott McDonald
National Museum of Wales
NERC Centre for Population Biology
North West Water
NRA Northumbria
NRA Thames
Open University
Oxford Brookes University
Plymouth Marine Laboratory
R Frith Assoc
RSADU (NERC)
RSPB
Scottish Natural Heritage
Scottish Office
SERCON
SERPLAN
Silsoe College
Sunderland County Council
Surrey County Council
UMIST Manchester
University College, London
University College, London
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University of Wales
University of York
W S Atkins
Water Resource Centre
Wellcome Trust
Welsh Institute of Rural Studies
Willis Faber and Dumas
World Conservation Monitoring Centre
Yorkshire Water

GLOSSARY OF ACRONYMS

AATSR	Advanced Along Track Scanning Radiometer
ABF	ATSR Browse Facility
AERONET	AEROsol (sunphotometry) NETwork
AO	Announcement of Opportunity
ARSF	Airborne Remote Sensing Facility
ARSF(SC)	Airborne Remote Sensing Facility (Steering Committee)
ATBDs	Algorithm Theoretical Basis Documents
ATM	Airborne Thematic Mapper
ATSR	Along Track Scanning Radiometer
BIOTA	Biological Influences On interTidal Areas
BNSC	British National Space Centre
BOREAS	BOReal Ecosystem Atmosphere Study
BRDF	Bi-directional Reflectance Distribution Function
Cal / Val	Calibration / Validation
CASE	Co-operative Award in Sciences of the Environment
CCLRC	Council of the Central Laboratories of the Research Councils
CCRS	Canada Centre for Remote Sensing
CCW	Countryside Council for Wales
CEH	Centre for Ecology and Hydrology
CEOS	Committee on Earth Observing Satellites
CHRIS	Compact High Resolution Imaging Spectrometer
CLEVER-Mapping	Classification of Environment with Vector- and Raster-Mapping
CLRC	Central Laboratory for the Research Councils
CNES	Centre National des Etudes Spatiales
CR	Contract Research
CS2000	Countryside Survey 2000
DAEC	Detection and Assessment of Environmental Contamination
DERA	Defence and Evaluation Research Agency
DETR	Department of Environment, Transport and the Regions
DETR	Department of the Environment, Transport and the Regions
DFID	Department For International Development
DLR	Deutsche forschungs institut fuer Luft und Raumfahrt
DOSTAG	Data Operations Scientific and Technical Advisory Group
EA	Environment Agency
EC	European Commission
ECOFACT	Ecological factors controlling biodiversity in the British countryside
ECOMONT	Ecological Effects of Land Use on European Terrestrial Mountain Systems
EMISAR	ElectroMagnetics Institute SAR
ENVISAT	ENVIronmental SATellite
EO	Earth Observation
EOEG	Earth Observation Expert Group
EOPB	Earth Obersvation Programme Board
EOSI	Earth Observation Science Initiative
EPFS	Equipment Pool for Field Spectroscopy
ERS	European Remote sensing Satellite
ESA	European Space Agency
ESSC	Environmental Systems Science Centre
ESTEC	European Space and TEchnology Centre
ETC/LC	European Topic Centre on Land Cover
EU	Euopean Union
fAPAR	fraction of Absorbed PAR

FEC	Full Economic Cost
FEDMAC	Forest Ecosystem Dynamics Multiple Aircraft Campaign
FFRI	Finnish Forest Research Institute
FGI	Finnish Geodetic Institute
FIFE	First ISLSCP Field Experiment
FP4	European Fourth Framework
FP5	European Fifth Framework
GBFM	Global Boreal Forest Mapping project
GBSAR	Ground-basedSAR project
GERB	Global Earth Radiation Budget
GIS	Geographic Information System
GOFC	Global Observation of Forest Cover
GPS	Global Positioning System
GRFM	Global Rain Forest Mapping project
HEI	Higher Education Institute
HLOP	High Level Operations Plan
IACR	Institute for Arable Crop Research, Rothamsted
ICARUS	Instrumentation Characterising Aerosol Radii Using Sunphotmetry
IDS	Integrated Data System
IEEE	Institute of Electrical and Electronic Engineers
IGAC	International Global Atmospheric Chemistry
IGARSS	IEEE Geoscience And Remote Sensing Symposium
IGIS	Integrated GIS
IGN	Instituto Geografico Nacional, Spain.
INPE	Instituto Nacional de Pesquisas Espaciais
INS	Inertial navigation System
InSAR	Interferometric SAR
IRS	Indian Resarch Satellite
ISLED	Influence of Rising Sea Level on Ecosystem Dynamics of Salt Marshes
ISLSCP	International Satellite Land Surface Climatology Project
ISPRS	International Society for Photogrammetry and Remote Sensing
ITC	International Institute for Aerospace Survey and Earth Sciences, Enschede, NL
LANES	Land cover/use Earth observation Data Systems,
ITE	Institute of Terrestrial Ecology
JERS-1	Japanese Earth Resources Satellite - 1
JGR	Journal of Geophysical Research
JPL	Jet Propulsion Laboratory
JRC	Joint Research Centre
LAI	Leaf Area Index
LANES	Land cover/use Earth observation Data Systems
LBA	Large-Scale Biosphere Atmosphere
LCM2000	Land Cover Map 2000
LCMGB	Land Cover Map of Great Britain
LiDAR	Light Distance and Ranging
LINK	The BNSC LINK programme
LOIS	Land-Ocean Interaction Study
LOIS	Land Ocean Interaction Study
MAFF	Ministry of Agriculture, Fisheries and Foods
MDC	Environmental Satellite Data Centre
MERIS	MEdium Resolution Imaging Spectrometer
MISR	Multi-angle Imaging Spectro-Radiometer
MOD	Ministry of Defence
MODIS	MODerate Resolution Imaging Spectroradiometer
NASA	National Aeronautics and Space Administration

NASDA	NAtional Space Development Agency of Japan
NATO	North Atlantic Treaty Organisation
NERC	Natural Environment Research Council
NLR	Netherlands Aerospace Laboratory
NOPEX	Northern hemisphere climate Processes land-surface EXperiment
NRSC	National Remote Sensing Centre Ltd
OPC	Optical Particle Counter
PAC	Processing and Archiving Centre (for Envisat Data)
PAPRIKA	Plant Acclimation Prediction for Radiation Interaction Kinetics & Attribution
PAR	Photosynthetically Active Radiation
PIERS	Progress In Electromagnetics Research Symposium
PMC	Programme Management Committee
PRISM	Process Research by an Imaging Spectrometry Mission
PROBA	Project for On-Board Autonomy
PSG	Programme Steering Group
PSP	Programme Steering Panel
RAL	Rutherford Appleton Laboratory
RSS	Remote Sensing Society
SAR	Synthetic Aperture Radar
SB	Science Budget
SEEDCORN	The Stewardship of Environmental Data via a Core NERC programme
SEO	Section for Earth Observation
SIBERIA	SAR Imaging for Boreal Ecology and Radar Interferometry Applications
SIR-C	Shuttle Imaging Radar - third mission
SLA	Service Level Agreement
SLR	Satellite Laser Ranger
SNH	Scottish Natural Heritage
SO	Scottish Office
SPOT	Système Probabtoire de l'Observation de la Terre
SPTA	Salisbury Plain Training Area
TGRS	Transactions on Geoscience and Remote Sensing
TIGER	Terrestrial Initiative in Global Environmental Research
TM	[Landsat] Thematic Mapper
TUD	Technical University of Denmark
URGENT	Urban ReGENeraTion (NERC Thematic Programme)
UTLS	Upper Troposphere Lower Stratosphere
VHR	Very High Resolution
WAU	Wageningen Agricultural University
WINTEX	WINTertime boreal EXperiment on land-surface atmosphere interactions
WO	Welsh Office