Novel Earth Observation products to characterise Wetland Extent and Methane Dynamics: The ESA ALANIS-Methane Project

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5th April 2011

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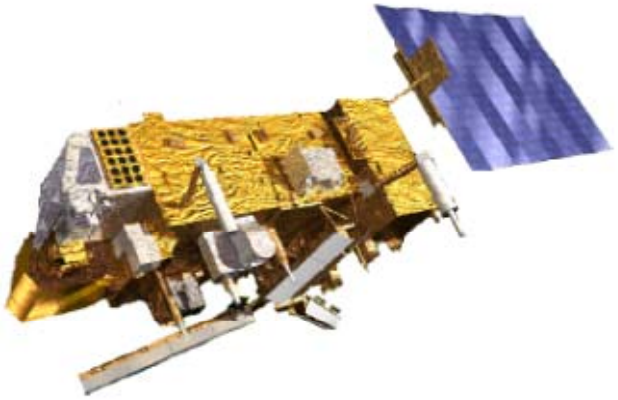

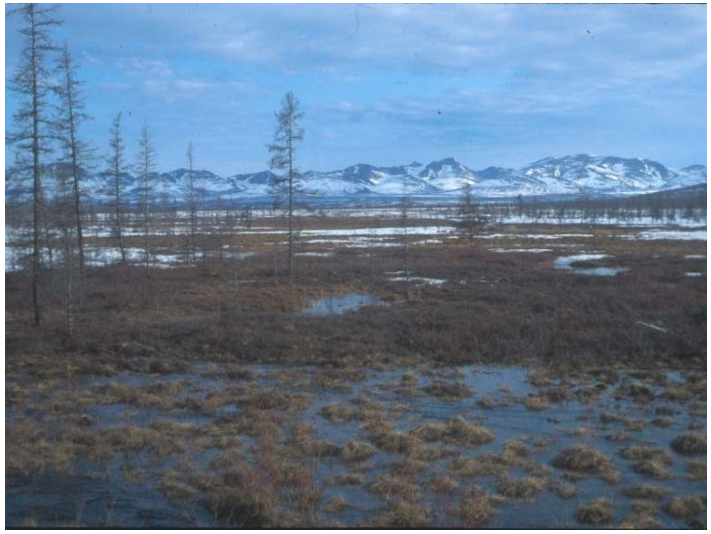

Acknowledgements

- European Space Agency
- iLEAPS

Background

- CH_4 second most important greenhouse gas after CO_2
- Wetlands are largest natural source but there are large uncertainties
- CH_4 wetland emissions by diffusion across the soil or water interface, by ebullition (bubbling), and by plant-mediated transport
- Key parameters for land surface and climate modelling:
  - wetland extent
  - temperature
  - soil carbon

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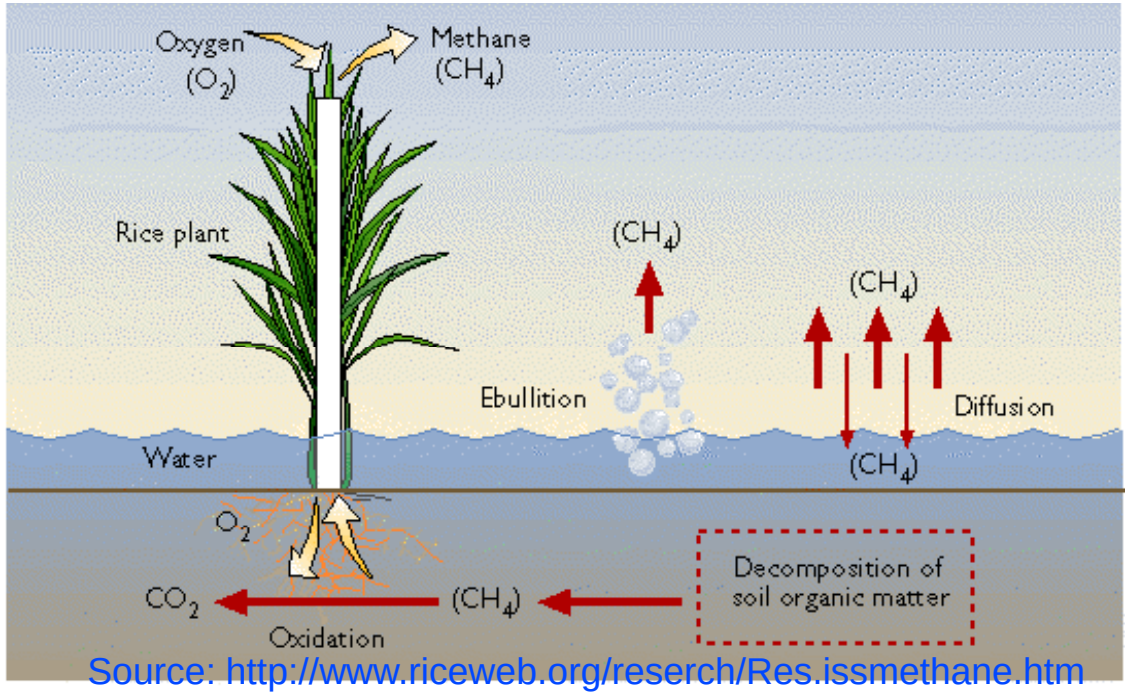
Table 2-5. Summary of Estimated Wetland CH_4 Fluxes by Technique (Tg CH_4/Year)

Approach	Northern/Bogs	Tropical/Swamps	Total
Flux extrapolation	31–48[a] avg = 38 (37%)	49–80 avg = 65 (63%)	80–115 sum of avgs = 103 n = 4
Process modeling	20–72[b] avg = 44 (31%)	41–133 avg = 90 (64%)	92–156 sum of avgs = 134 n = 8 (bogs); 5 (swamps)
Inverse modeling	21–47 avg = 36 (20%)	81–206 avg = 144 (78%)	145–237 sum of avgs = 180 n = 6
Current best guess (process and inverse modeling since 2004)	24–72 avg = 42.7 (25%) std. dev. = 16.6; n = 10	81–206 avg = 127.6 (75%) std. dev. = 44.0; n = 8	170.3 range = 105–278 by summing minima and maxima

[a] For flux extrapolation, temperate emissions are split equally between bogs and swamps. Values in parentheses indicate percentage contribution to wetland total emissions.
[b] Walter et al. (2001) estimates excluded.

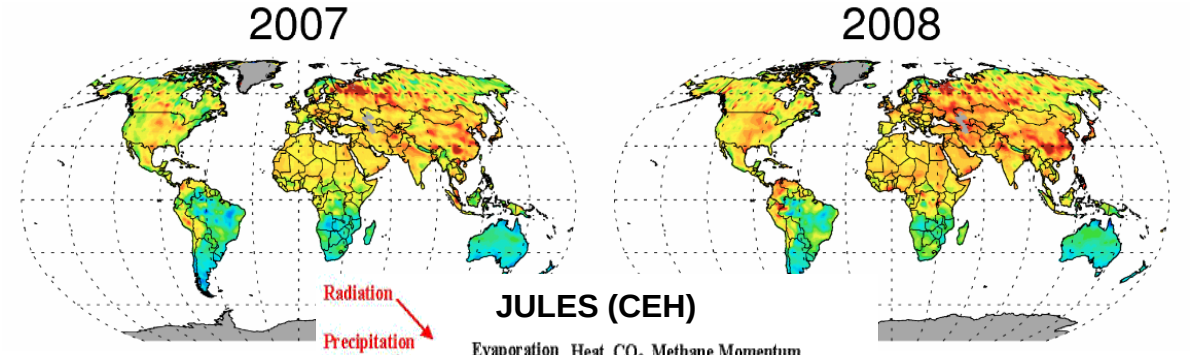
US EPA, 2010



Source: http://www.riceweb.org/reserch/Res.issmethane.htm

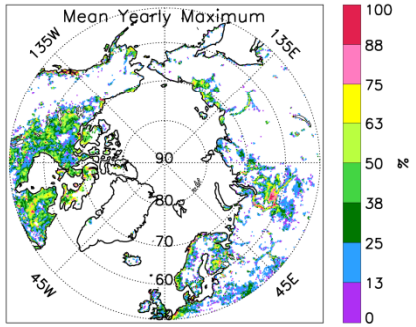
ALANIS Methane

Linking Earth Observation and Land Surface Modelling

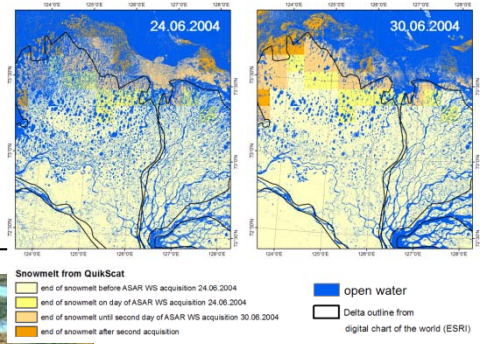


JULES (CEH)

Column CH_4 (Bremen)



Wetland Extent (Estellus)



Snowmelt (Vienna)

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ALANIS Methane:

Key EO Datasets

1. **Wetland Extent**
   - Need to capture the rapid spring inundation, implying 10-day timescale
   - Include all wetland and lake areas (may require aggregation of small features)
   - Use as driving dataset or constraint
2. **Freeze/thaw**
   - 1-10-day timescale
   - Used to validate soil thermodynamics
3. **Snow melt**
   - 1-10 day timescale needed to capture the spring melt event
   - Use for evaluation
4. **Atmospheric column CH_4**
   - Assessment of methane wetland emissions against atmospheric measurements

5. Land Cover (input)

6. Leaf Area Index (input)

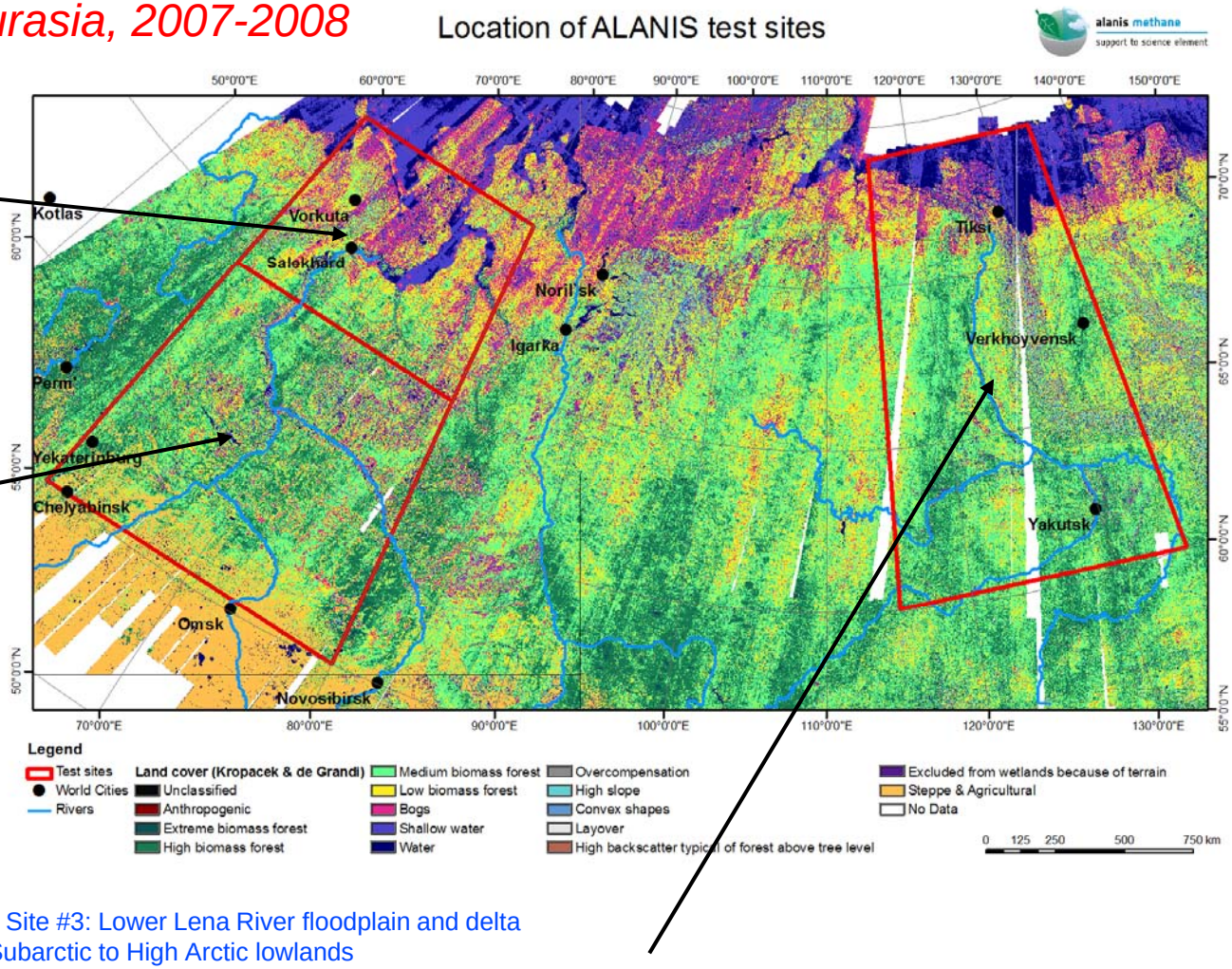
7. Land surface temperature

ALANIS Methane

Focus on Northern Eurasia, 2007-2008

Test Site #1: Western Siberia (N)
- Subarctic-Arctic
- continuous to discontinuous permafrost
- hotspot of lake change

Test Site #2: Western Siberia (S)
- Boreal
- Ob river floodplains
- sporadic to discontinuous permafrost
- extensive peatlands



Test Site #3: Lower Lena River floodplain and delta
- Subarctic to High Arctic lowlands
- key region for understanding the basic processes of the dynamic and development of permafrost in the Siberian Arctic
- upstream basin with flood plains
- extensive delta area with several terraces

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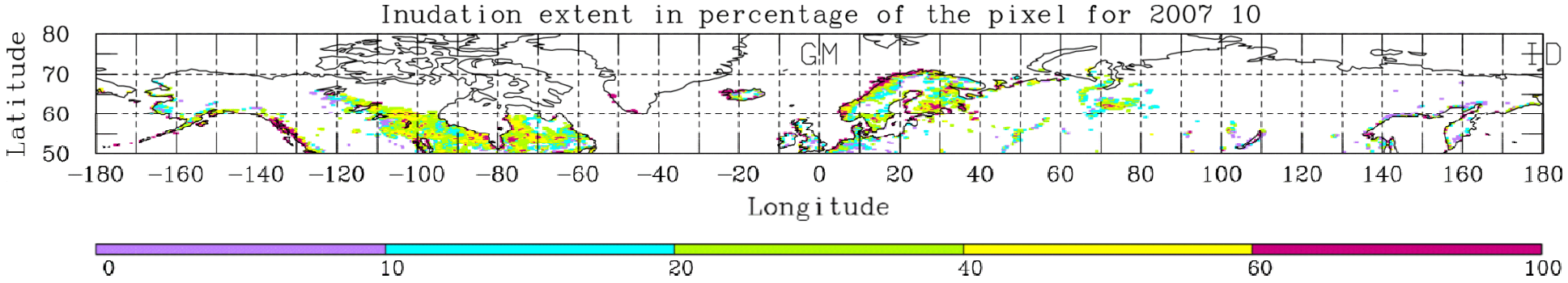
Regional Wetlands Extent and Dynamics

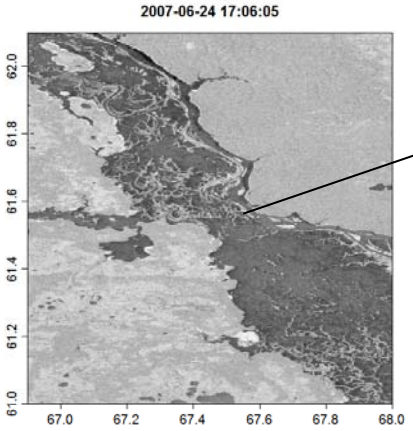
ESTELLUS

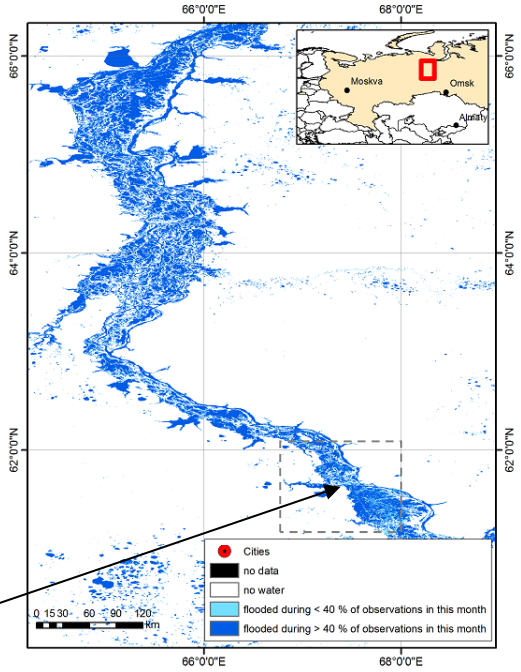
- Existing product
  - Use satellite data at different wavelengths (ERS scatterometer, SSM/I, AVHRR)
  - Global coverage with spatial resolution compatible with climate studies
  - Long time series (1993-2004)
- Several publications [Prigent *et al.*, GRL, 2001; JGR, 2007; Papa *et al.*, JGR, 2010]
- Adjustments in methodology
  - Use MetOP ASCAT scatterometer data
  - Higher temporal resolution (10 days from monthly)
  - Initial dataset for July 2007 to June 2008



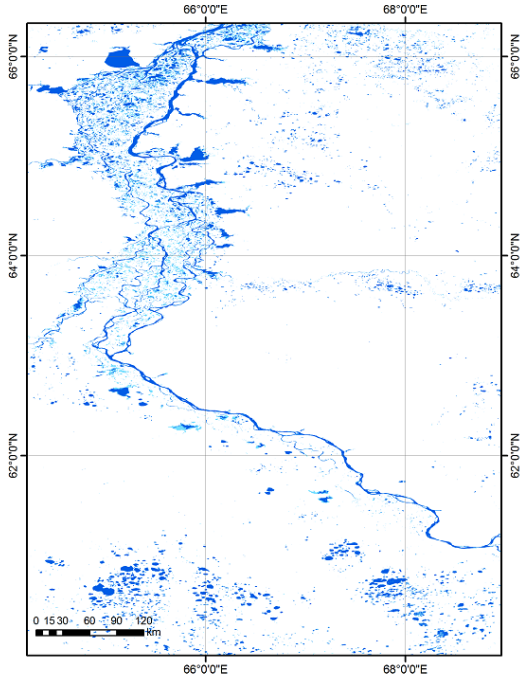
Local Wetlands Extent and Dynamics

- New product based on ENVISAT ASAR Wide Swath
- Classification of open water surfaces, 10-day updates for maps of wetland dynamics
- Implementation with NEST
- Cross-comparison with the regional wetland product





June 2007

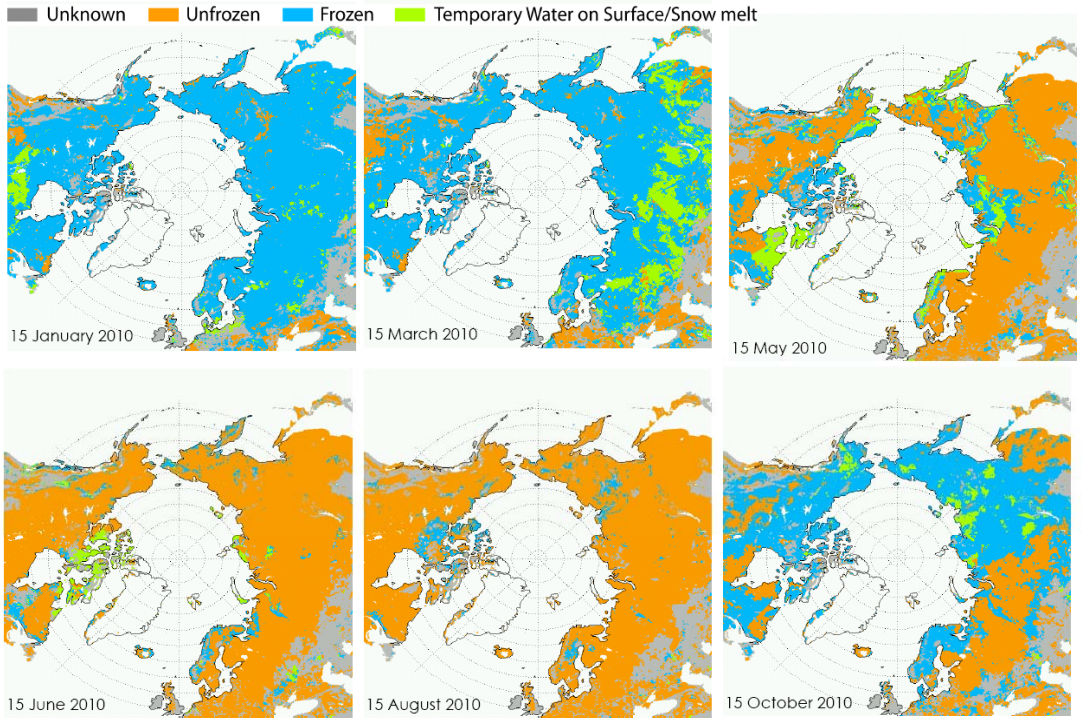


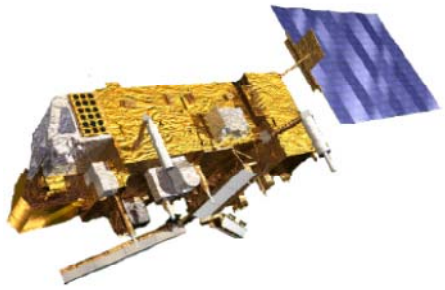
September 2007

See also poster

Snowmelt and Ground freeze/thaw

- New product based on resampled level 1b Metop ASCAT
- Algorithm development based on ECMWF ERA-Interim soil temperature
- Post-processing to identify day of year
  - Begin of thaw
  - End of thaw
  - Refreeze



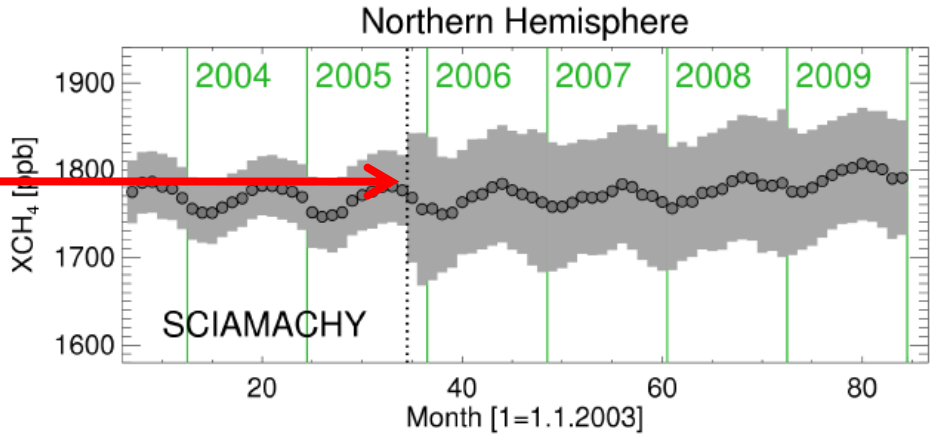


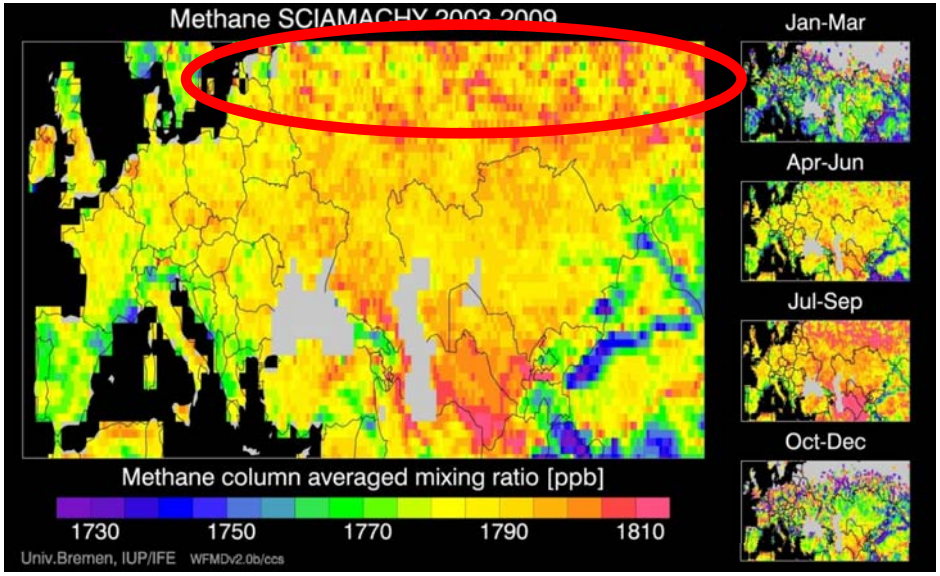
See also poster

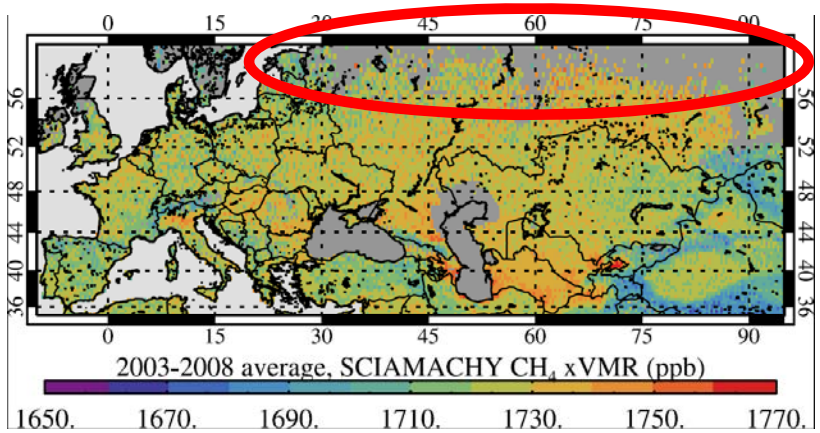
Sciamachy Column Methane

- Existing product for 2003-2005
- Dataset extended (to 2009) and retrieval algorithm adapted to address inter alia loss of key detector pixels
- Better coverage for boreal region

WFMD v2.0b





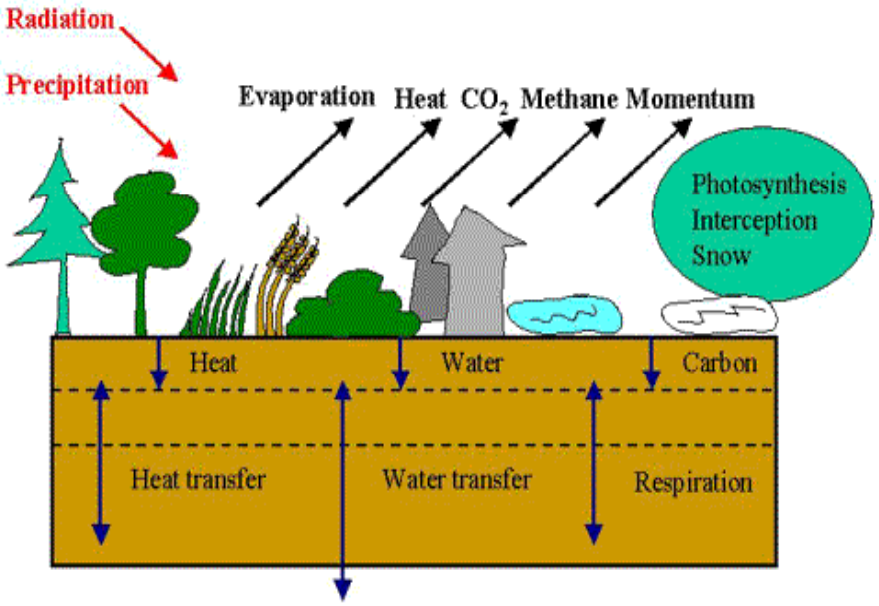


Land surface modelling with Joint UK Land Earth Simulator

- Process-based model
- Gedney et al [2003, 2004] parameterisations of large-scale hydrology and wetland biogeochemistry
- Use in 3 configurations:
  a. Point/Offline
  b. Gridded/Offline
  c. Coupled into atmospheric chemistry model
- Aims:
  - Validation of JULES
  - Improve emission estimates

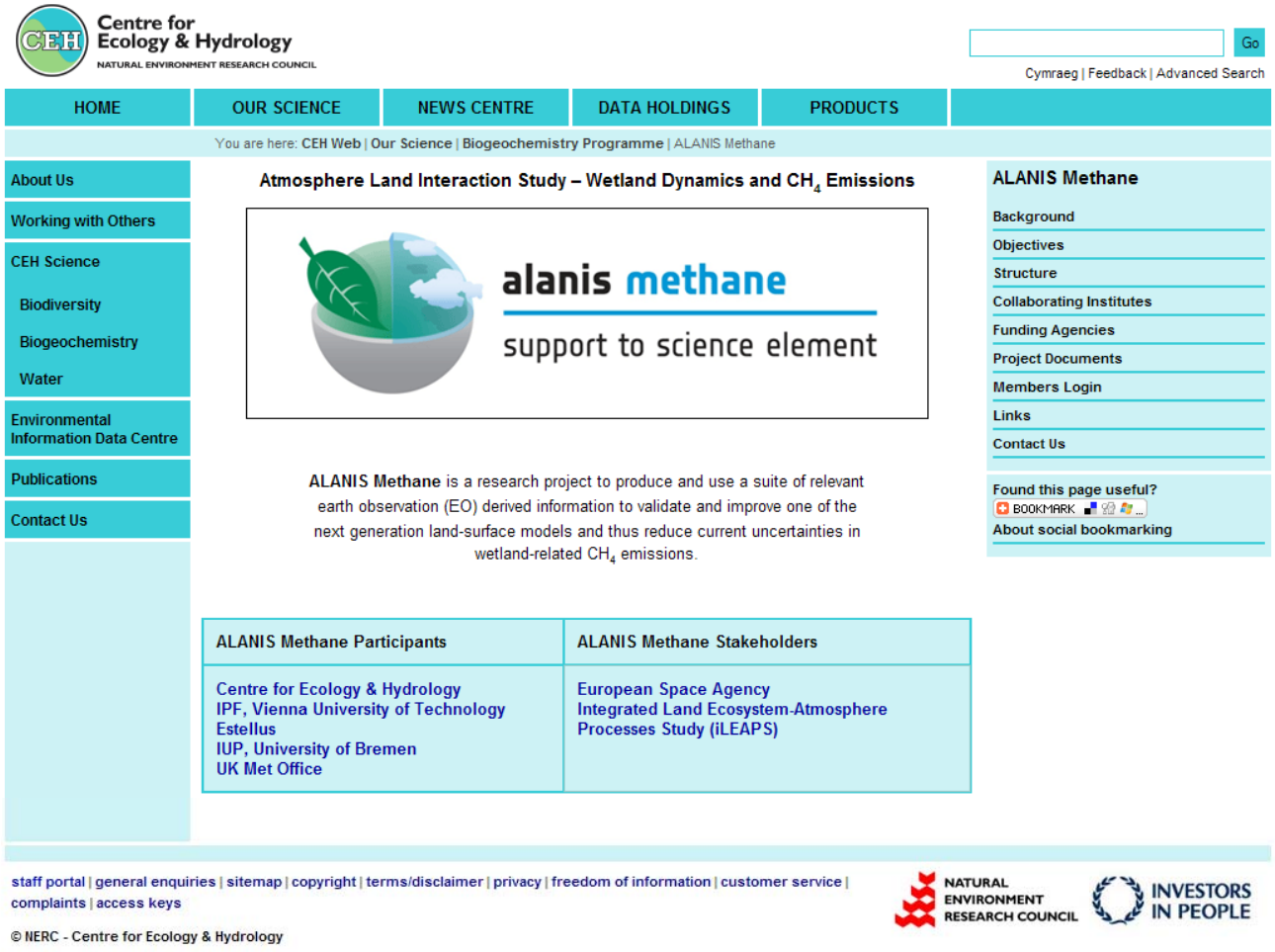
$$F^{w}_{CH4} = k_{CH4} * f_w * C_s * Q_{10}(T_{soil})^{(T_{soil}-T_0)/10}$$

F^{w}_{CH4} = methane flux from wetlands
k_{CH4} = scaling factor
f_w = wetland fraction
C_s = "substrate": fixed soil carbon content
Q_{10} = temperature sensitivity



http://www.jchmr.org/jules/

Website and Data Dissemination



http://www.alanis-methane.info

Future Work

- On going validation of EO target products
- Development, application and evaluation of JULES in different configurations
- Dissemination of EO datasets
- Workshop and promotion of project
- Roadmap for product exploitation
- Ongoing interaction with iLEAPS community

- Benchmarking of wetlands in land surface models (GEWEX-GLISS)

Summary

- Wetlands are the largest natural source of methane but the emission estimates have large uncertainties
- ALANIS methane project described
- Focus on the boreal region of Northern Eurasia
- Novel EO products being developed relevant for land surface modelling
- Future activities summarised

Related presentations and posters

- **Variability and long-term trends of carbon dioxide and methane column-averaged mole fractions retrieved from SCIAMACHY onboard ENVISAT** by Oliver Schneising, Michael Buchwitz, Maximilian Reuter, Jens Heymann, Heinrich Bovensmann, and John Burrows [Geophysical Research Abstracts, 13, EGU2011-2460, 2011]
- **Water body delineation from active microwave satellite data for improved modelling of methane emissions at high latitudes in the framework of the ESA project ALANIS** by Stefan Schlaffer, Daniel Sabel, Christoph Paulik, Annett Bartsch, and Wolfgang Wagner [Geophysical Research Abstracts, 13, EGU2011-10566, 2011]
- **Surface status information from scatterometer data for improved climate modelling at high latitudes** by Christoph Paulik, Vahid Naeimi, Annett Bartsch, Stefan Schlaffer, Wolfgang Wagner , Kirsten Elger, and Birgit Heim [Geophysical Research Abstracts, 13, EGU2011-7238, 2011]