New Products for a Better Characterisation of Smoke Plume and Gas/Aerosol dispersion from Boreal Eurasian Forest Fires

STSE ALANIS Theme 2
Smoke plumes

ALANIS Conference

Maarten Krol, WUR + ALANIS Theme 2 members

ESA/ESRIN, Frascati, Italy

November, 3, 2010

Team composition

University College of London (UCL)
Coordination of development and validation of EO novel SPIH products
Jan-Peter Muller, Peter Yuen

LATMOS
Coordination of development and validation of EO novel Plume Dispersion Tracking products
Cathy Clerbaux

JRC-IES (LMNH and GEM Units):
Coordination of development and validation of :
-EO novel BA products ;
-emission models
Jesús San Miguel, Jean-Marie Grégoire, Ilaria Palumbo + postdoc position

Wageningen University
Coordination of development of injection height model, direct chemistry-transport model and assimilation scheme
Scientific coordinator of project and link to ILEAPS community
Maarten Krol, Wouter Peters

NOVELTIS
Project manager
Technical coordinator
Website
Jérôme Helbert, Bruno Guillaume

Understanding of project objectives

- **The approach will :**
  - ✓ propose state-of-the-art product retrieval algorithms and land-atmosphere modeling system;
  - ✓ make use of state-of-the-art assimilation systems, able today to potentially address integration of multi-mission EO-based land-atmosphere products;
  - ✓ be able to give pertinent guidelines to ESA for future EO missions in order to cope with ILEAPS future EO data needs;
  - ✓ be able to make the link with other scientific communities relevant on that scientific theme and also using EO-based ESA data (e.g. ACCENT/GEIA) ;
  - ✓ demonstrate its ability to generate long-term experimental dataset, providing guarantee on its quality (quality of validation plan).

Preliminary scientific requirements (1)

- Scientific context
  - ✓ Numerous in-situ and airplane measurements combined with atmospheric modelling already have helped to better characterize the variability of some fire plume characteristics (nature of emitted species, plume size, chemical evolution inside the plume).
- How to better characterise boreal fire plumes ?

4 major elements having high space and time variability have sub-optimal quantification:

- ✓ injection height of fire plumes ;
- ✓ amounts of emitted species ;
- ✓ fire intensity ;
- ✓ fire plume fine scale dispersion.

Preliminary scientific requirements (2)

- Current scientific approaches to reduce uncertainties on these elements:
  - ✓ Smoke Plume Injection Height (SPIH):
    - ➢ Satellite products: use stereo-view to retrieve SPIH of single-fire (Val Martin et al., 2009, MISR 5yr climatology Northern American forests) : high impact of atmospheric stability and fire intensity ;
    - ➢ Modeling : great improvement in models compared to observations when taking into account diurnal variations of plume rise in link with buoyancy flux and extra-buoyancy flux due to cloud formation (Freitas et al., 2006;2007)

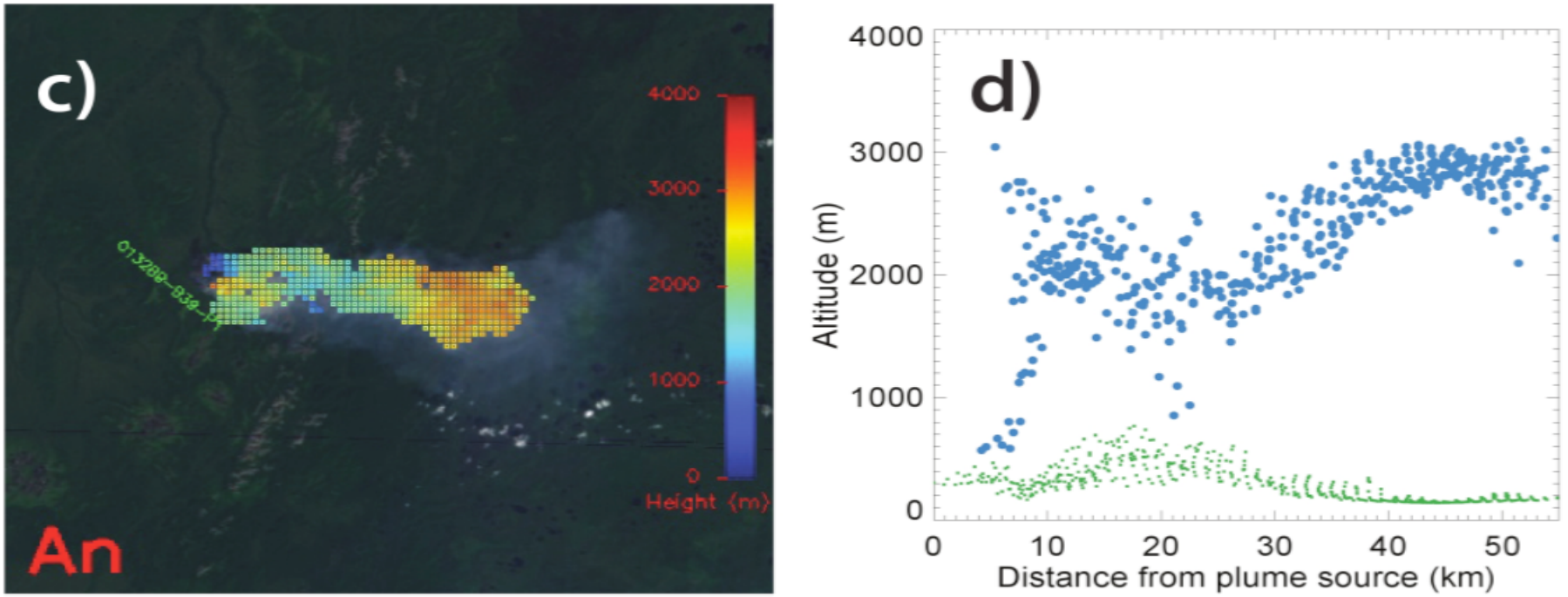
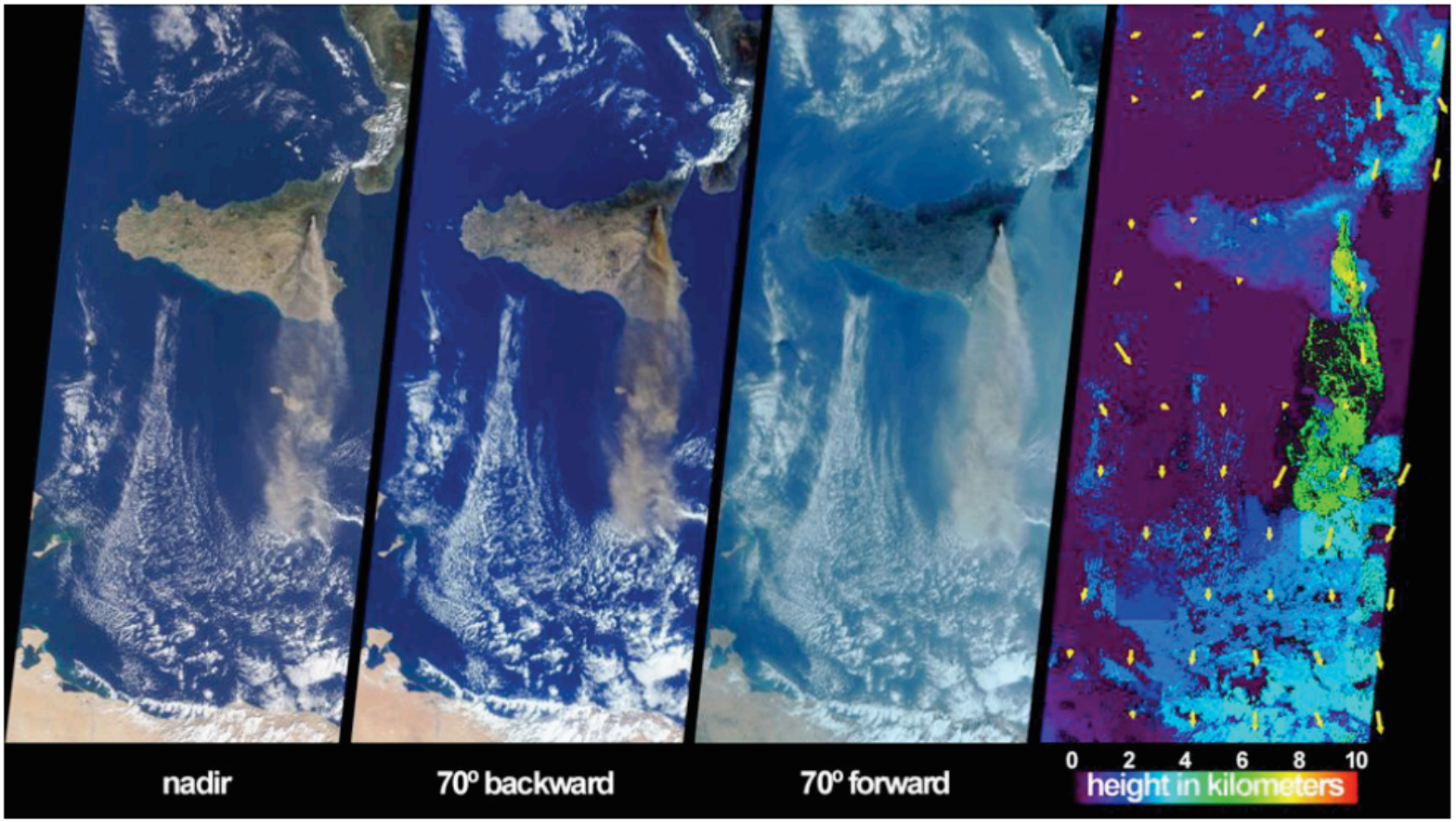
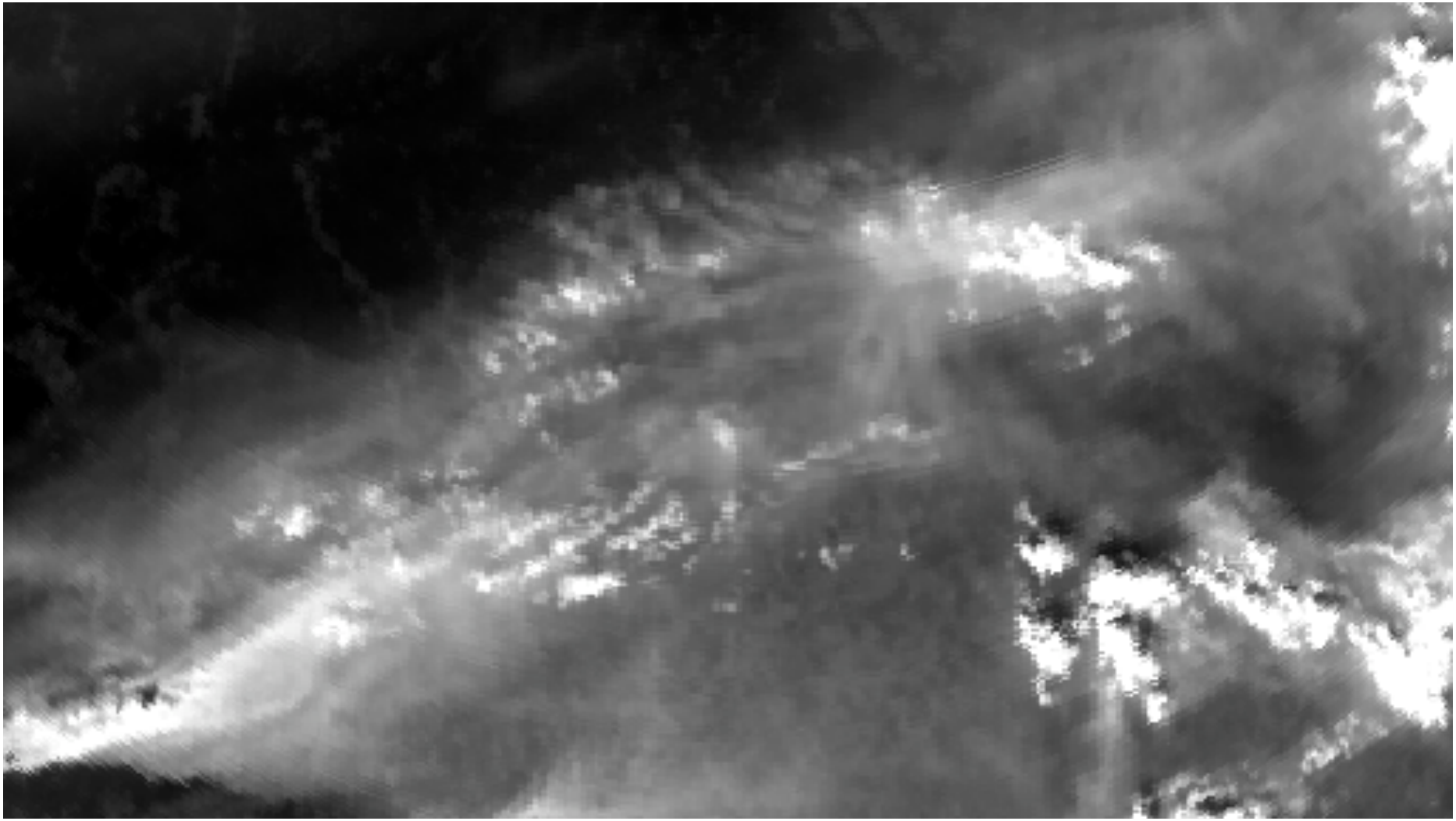


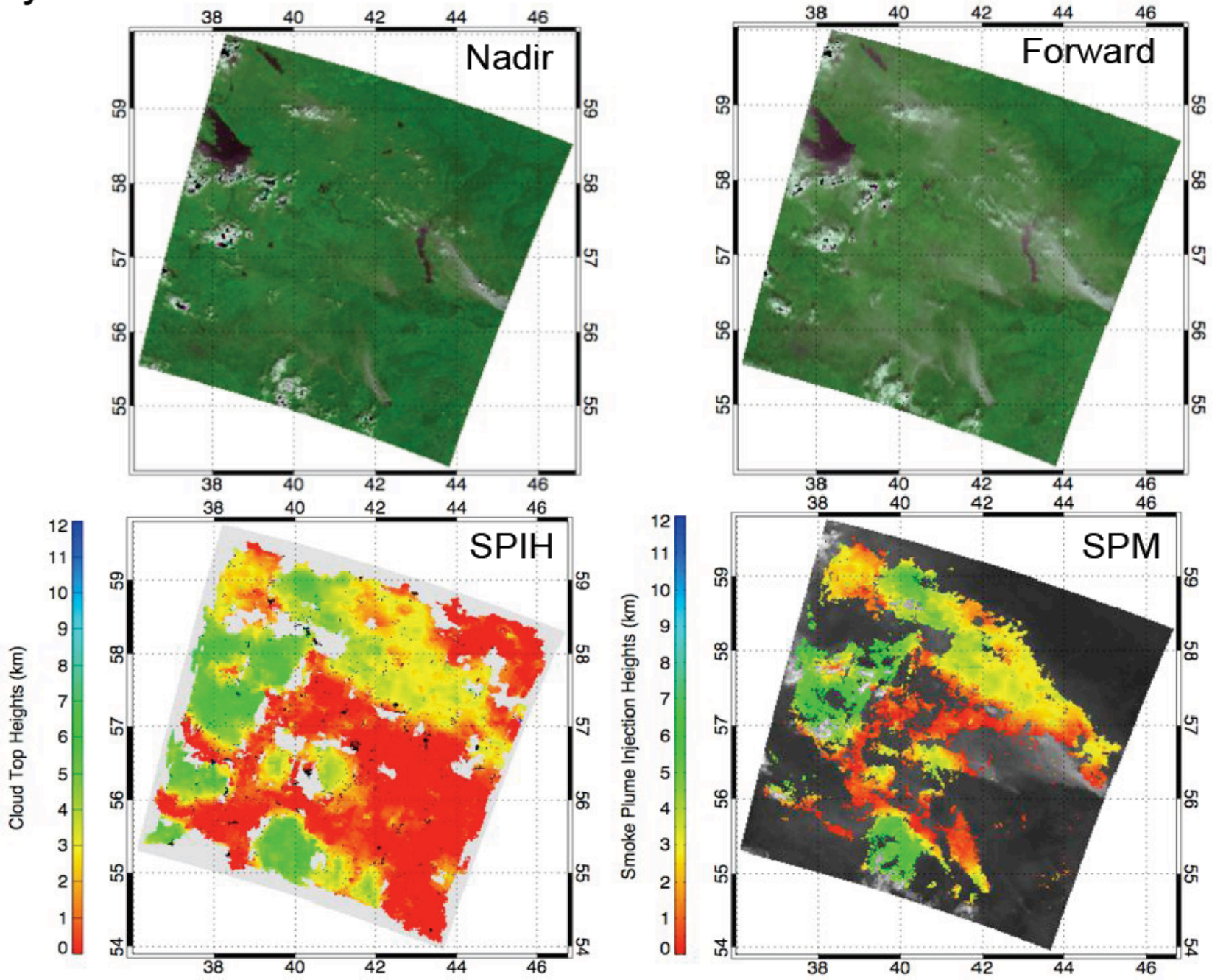
Figure 2 (from Val Martin (2009)): (c) Stereo-heights calculated and superposed on the plume image by the MINX tool; (d) Cross-sectional plot of the wind-corrected stereo-heights as a function of the distance from the fire (blue circles). Terrain heights are shown as green squares.

MISR aerosol-top heights and winds: Volcanic plumes over Mt Etna using UCL M2/3 matcher





26th July 2010



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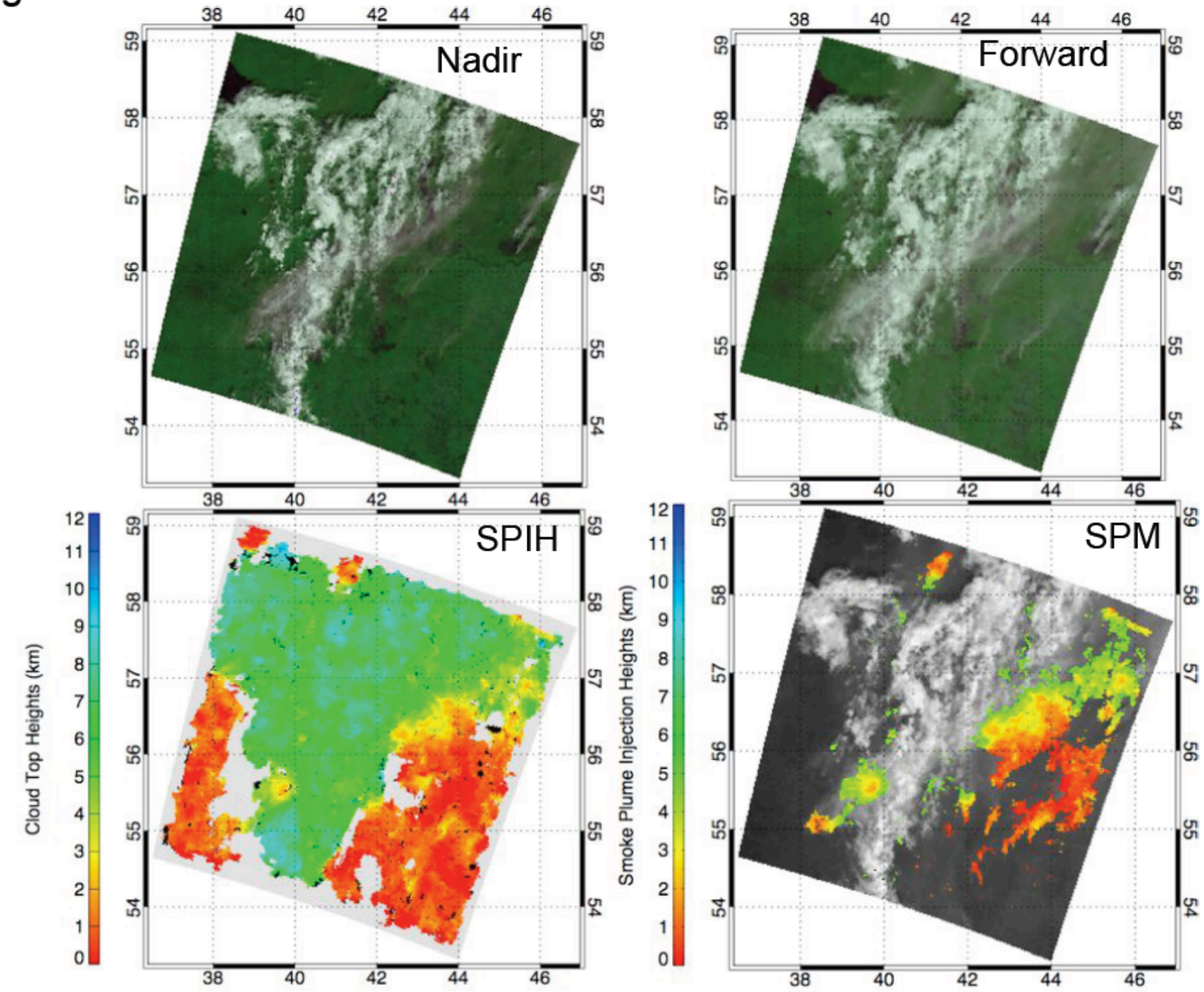
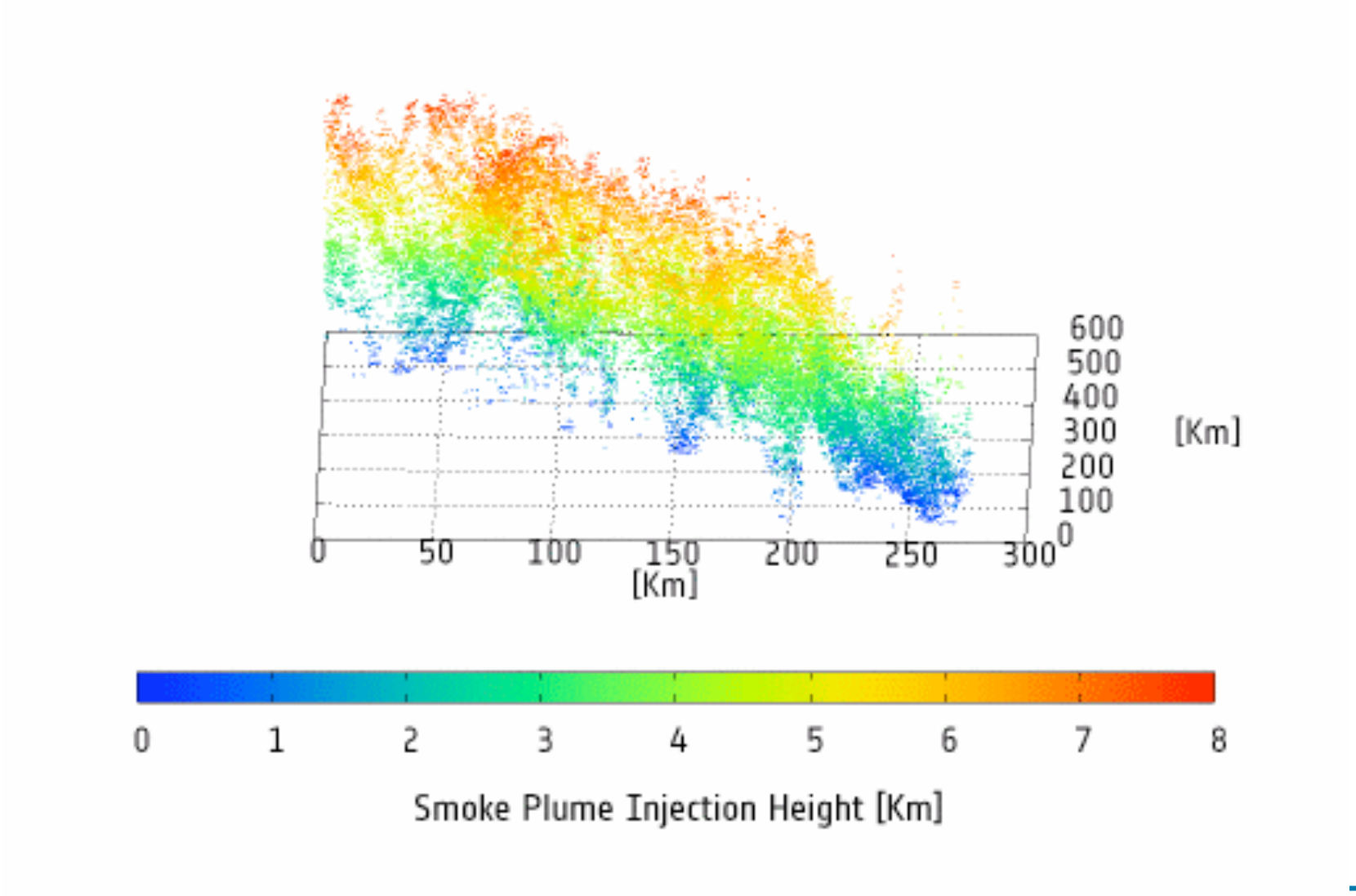




- Current scientific approaches to reduce uncertainties on these elements (continued):
  - ✓ Empirical Emission model: Fuelmap based
    - burnt areas (MODIS/MERIS)
    - Vegetation cover (EFFIS/GLC)
  - ✓ Empirical Emission model : FRP/FRE (Wooster et al., 2003; 2005).
    - Global product (MACC, Johannes Kaiser)
    - No thorough validation over boreal areas
  - ✓ Until now, no inter-comparison of « FRP-based » and « fuelmap-based » emissions
  - ✓ Can be done here (close connection to the ACCENT/GEIA community on this subject).

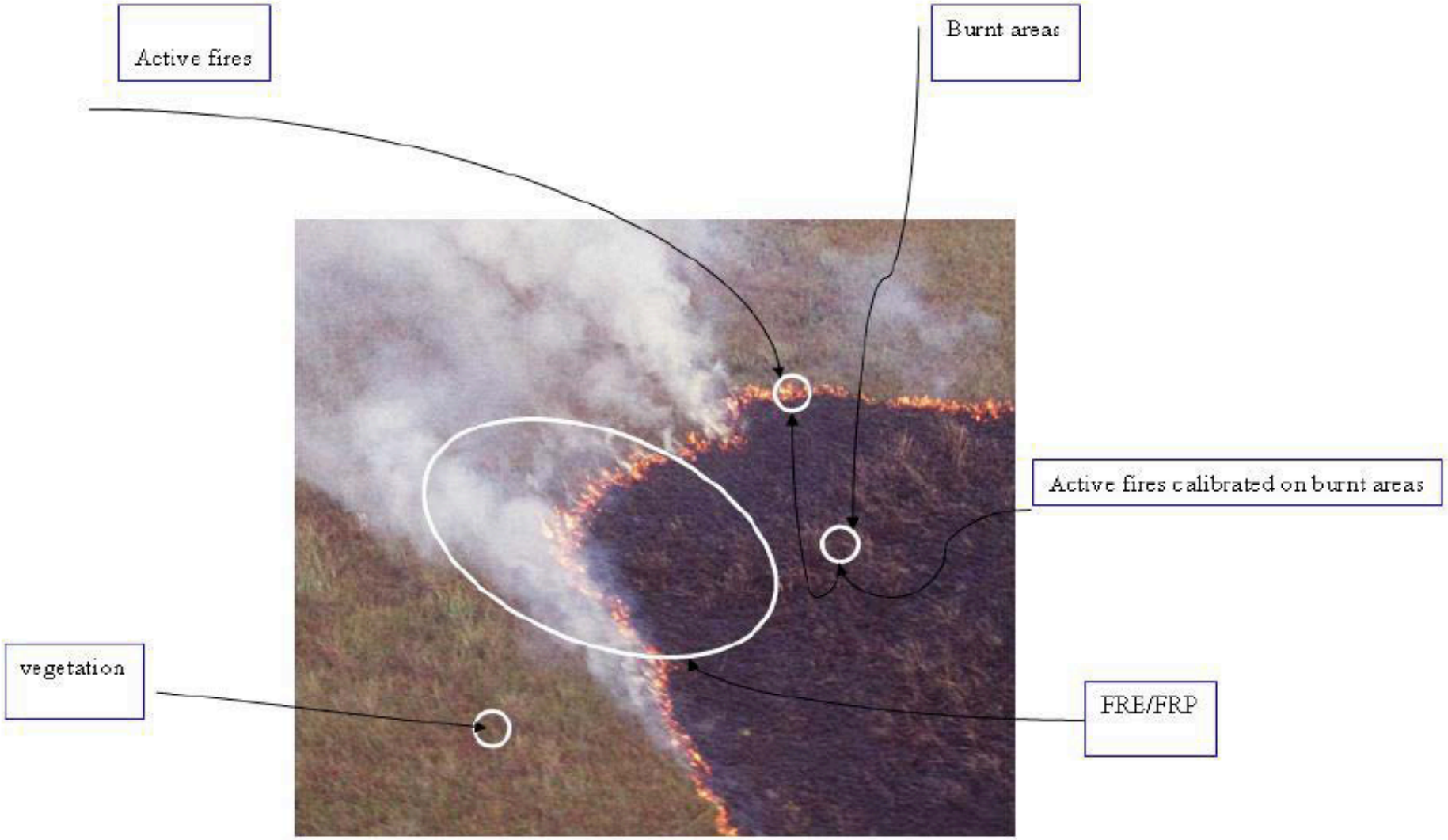


Figure 2– Different fire zones detected by the remote sensors (tribute: Jean-Marie Gregoire, INTERMEDE BBSO workshop, 18-19 Nov. 2009)

- Current scientific approaches to reduce uncertainties on these elements (continued):

  - ✓ Plume Dispersion:
    - Satellite products: MetOp-A/IASI sensor
    - Dispersion of reactive trace species (i.e., CO, NH3, CH3OH, C2H4 and HCOOH) (Coheur *et al*, 2009; Turquety *et al.*, 2009) High spatial resolution (2x2 cells of 12km footprint at nadir) with 2 values/day ;
    - Modeling : Currently no assimilation system assimilates all fire ground products together with fire atmospheric products.
    - Assimilation with the aim to improve emission estimates

Project overall strategy

- Identify state-of-the-art algorithms and validation strategy to retrieve EO-based target products SPIH, Plume Dispersion Tracking, and additional EO-based product (Burnt Areas)

- Use a modeling system to simulate fire plume rise and dispersion, able to integrate or assimilate EO-based products:
  - ✓ SPIH
  - ✓ IASI CO
  - ✓ Emission estimates

- Target period: Aug/2008 - Aug/2011

- Validation with: surface measurements & aerosol products & ..

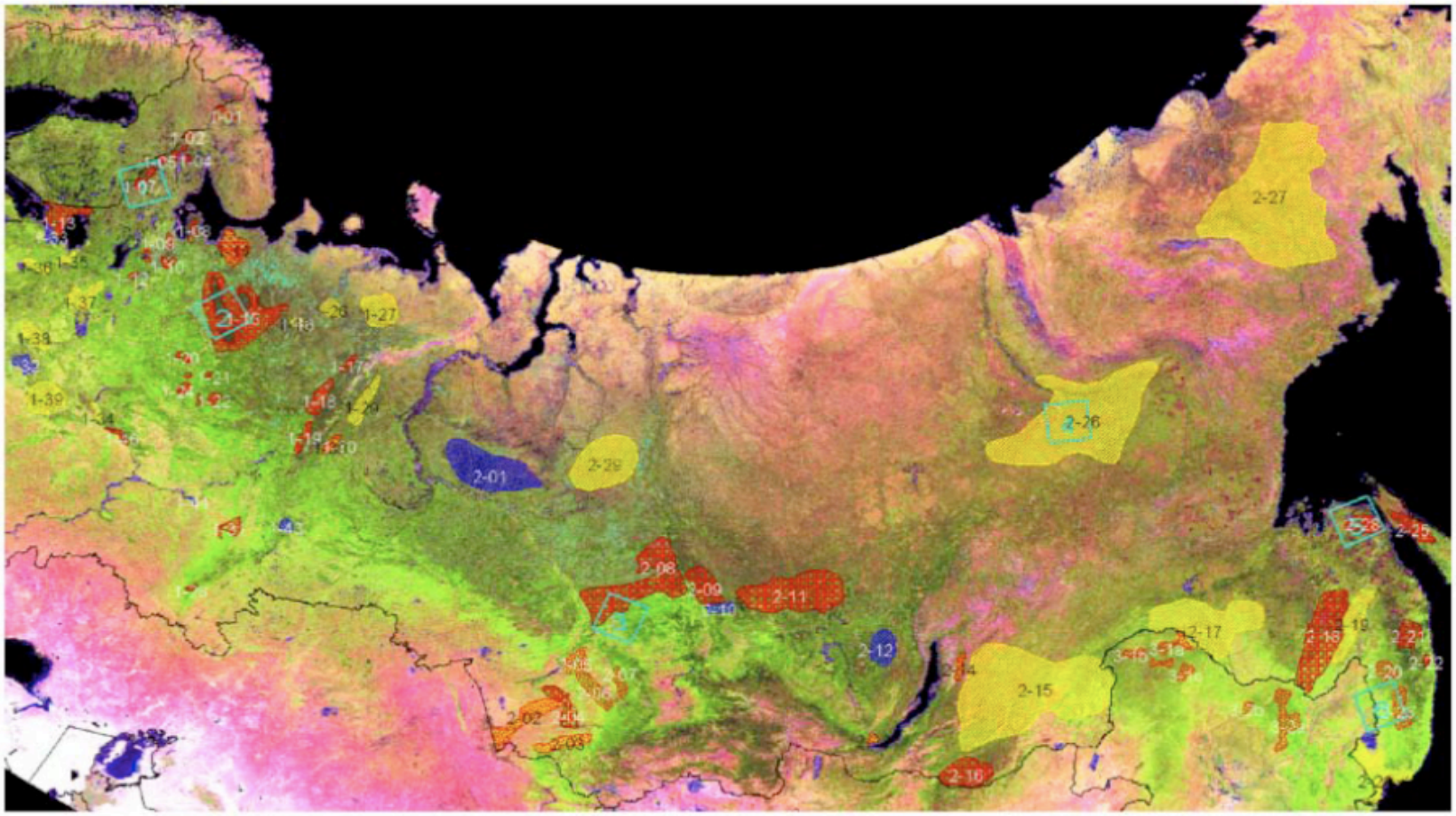
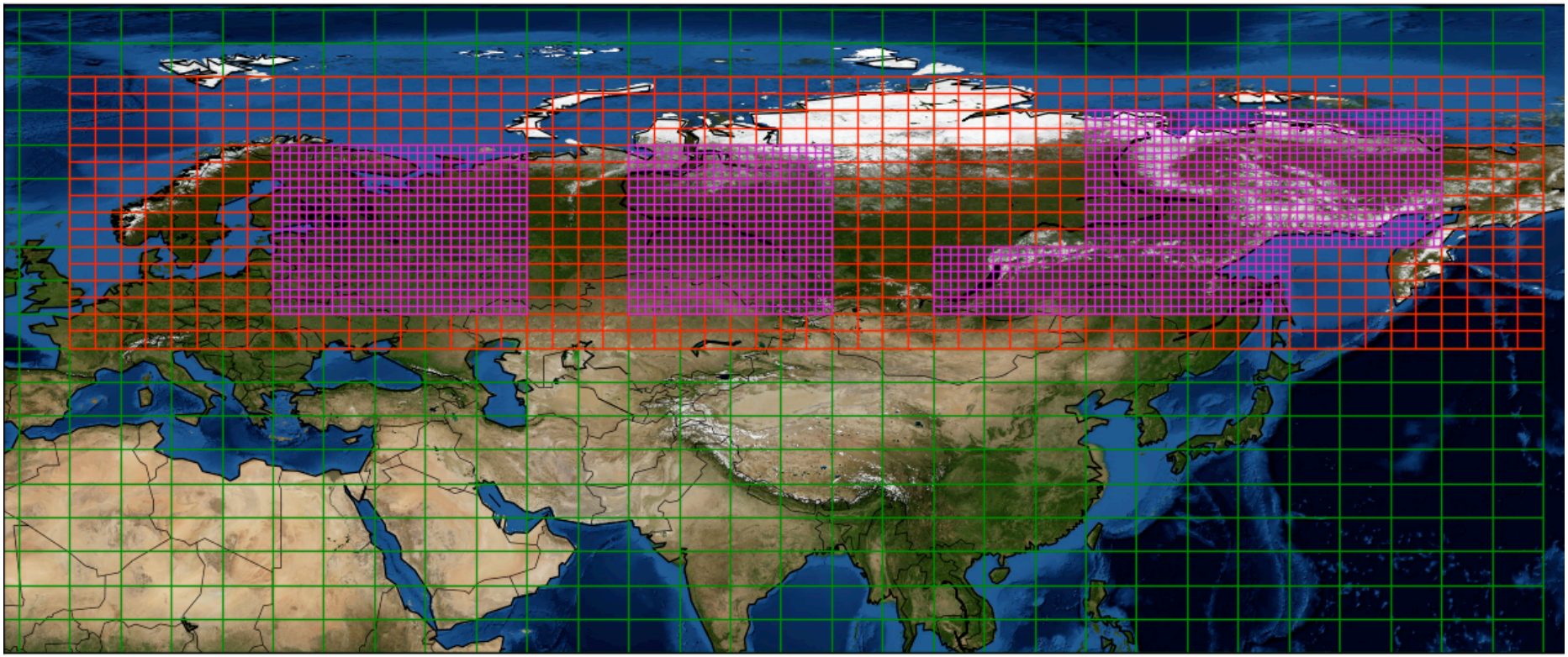
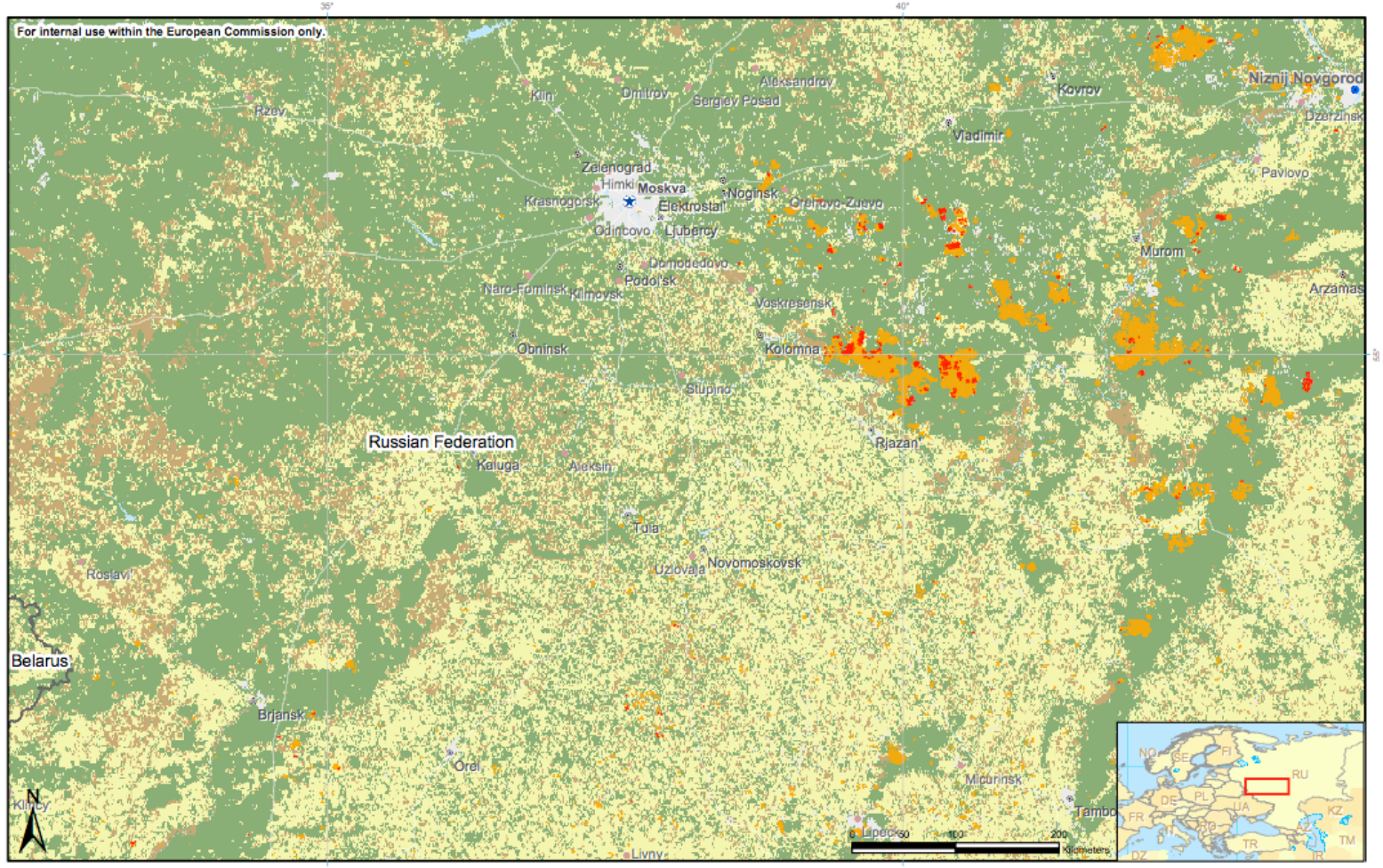


Figure 1. Regions where specific changes have been observed. See (Achard, *et al.* 2006) for further details.



TM5: Krol et al., ACP, 2005



Fires in the Moscow region from July 1st to August 12th

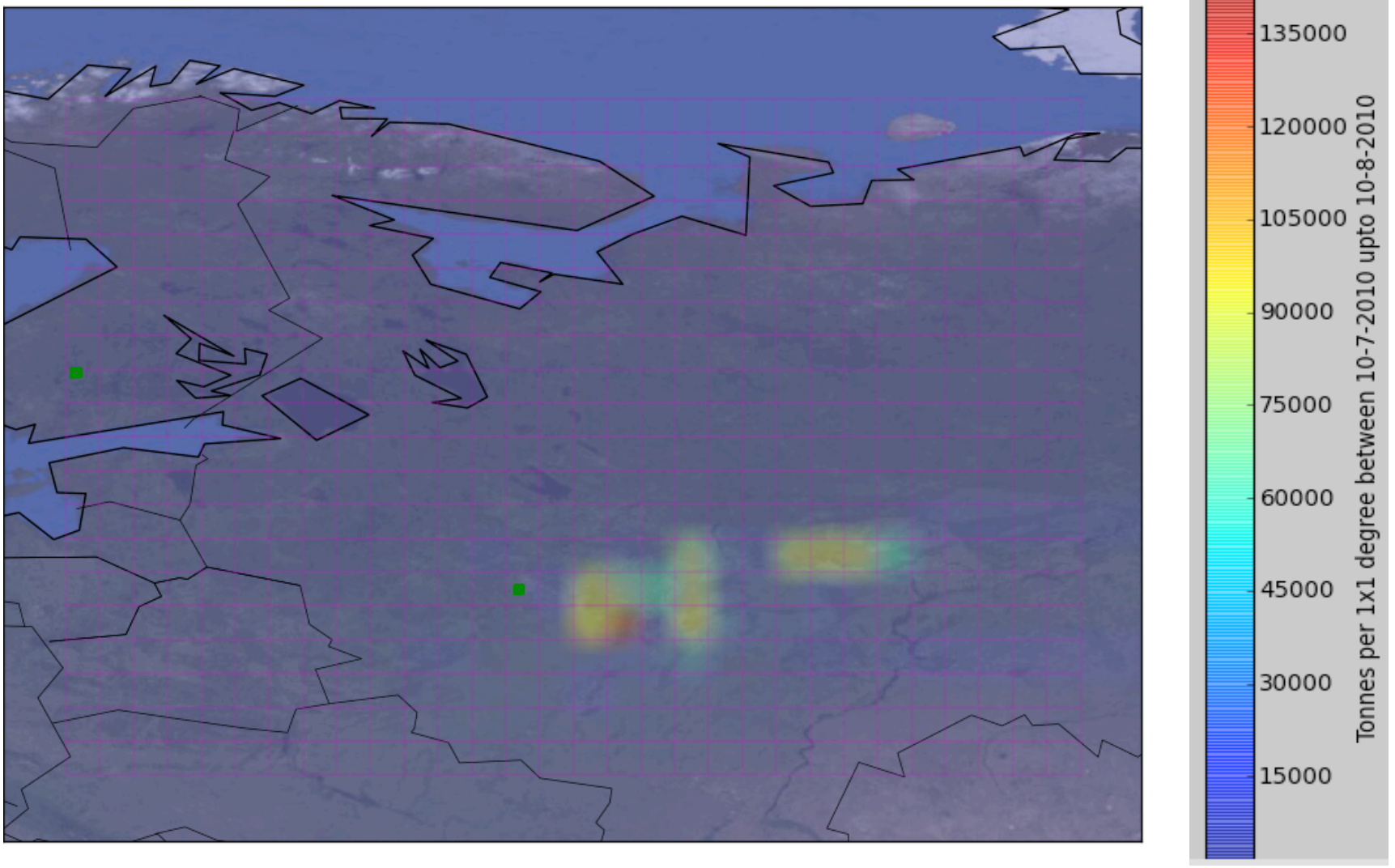
Burned areas and current active fires overlaid on the Global Land Cover 2000 dataset

Data Sources: National Air and Space Administration (NASA), Joint Research Centre (JRC), ESRI Inc.

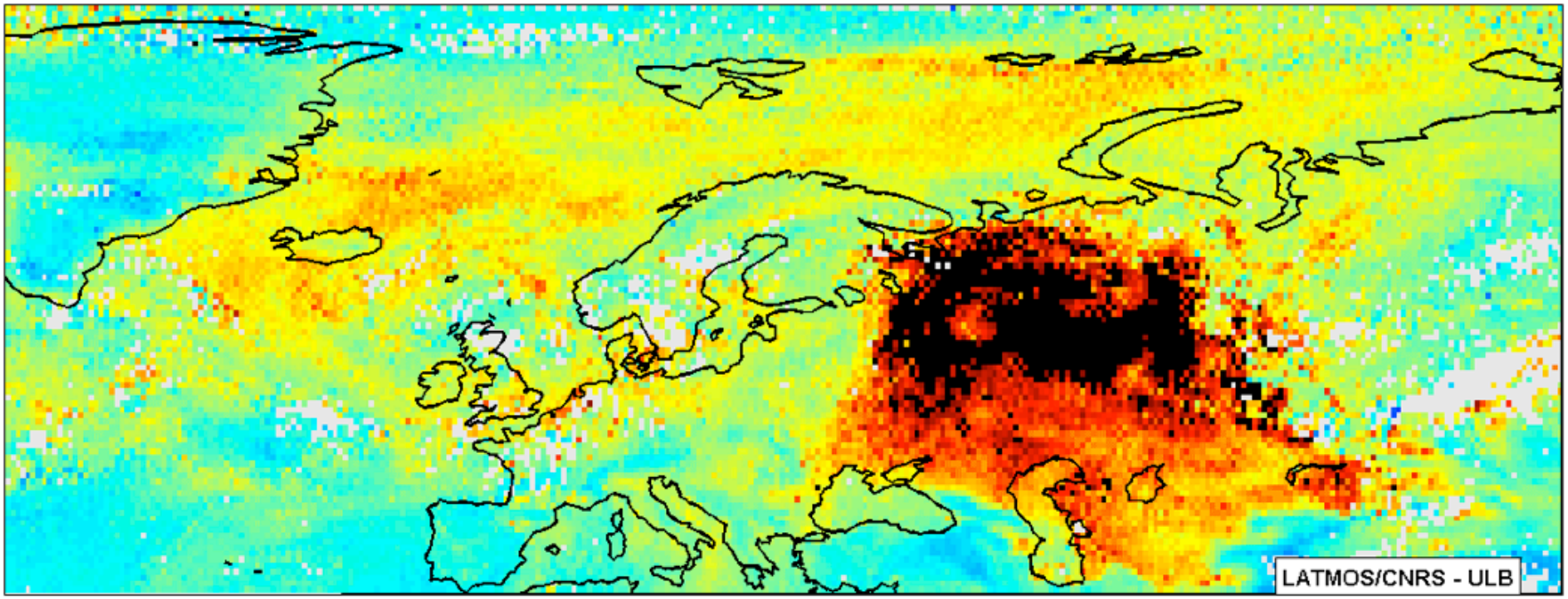
Map Legend

- Active Fires
- Burned Areas
- Grassland
- Cropland
- Forest and Shrubs

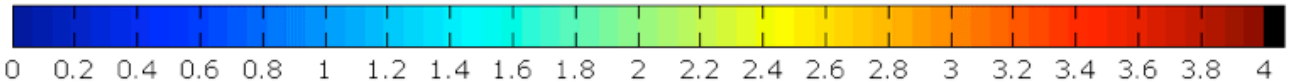
JRC EUROPEAN COMMISSION

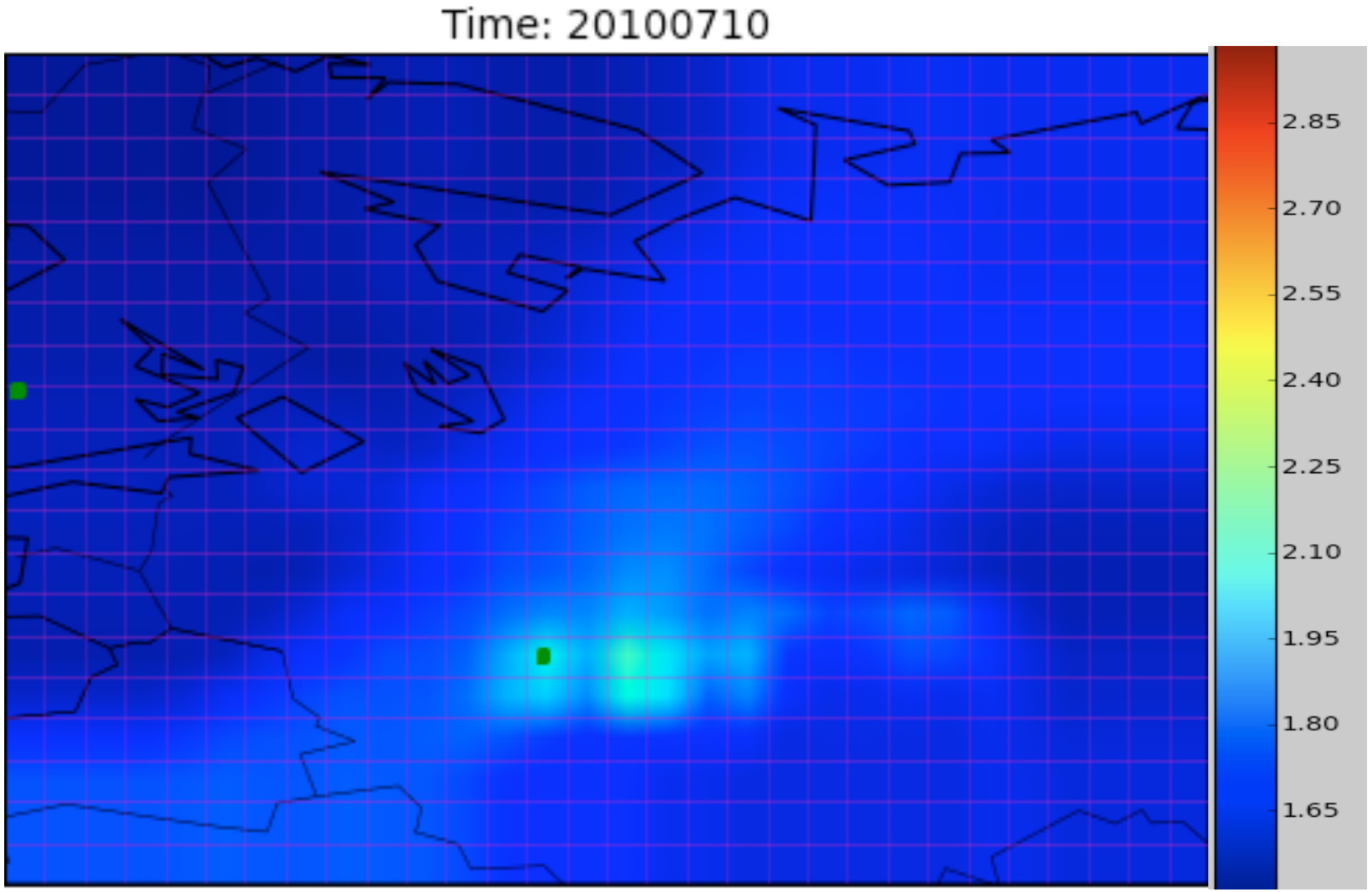


Total: 1.2 Tg CO/month



9-11 August, 2010





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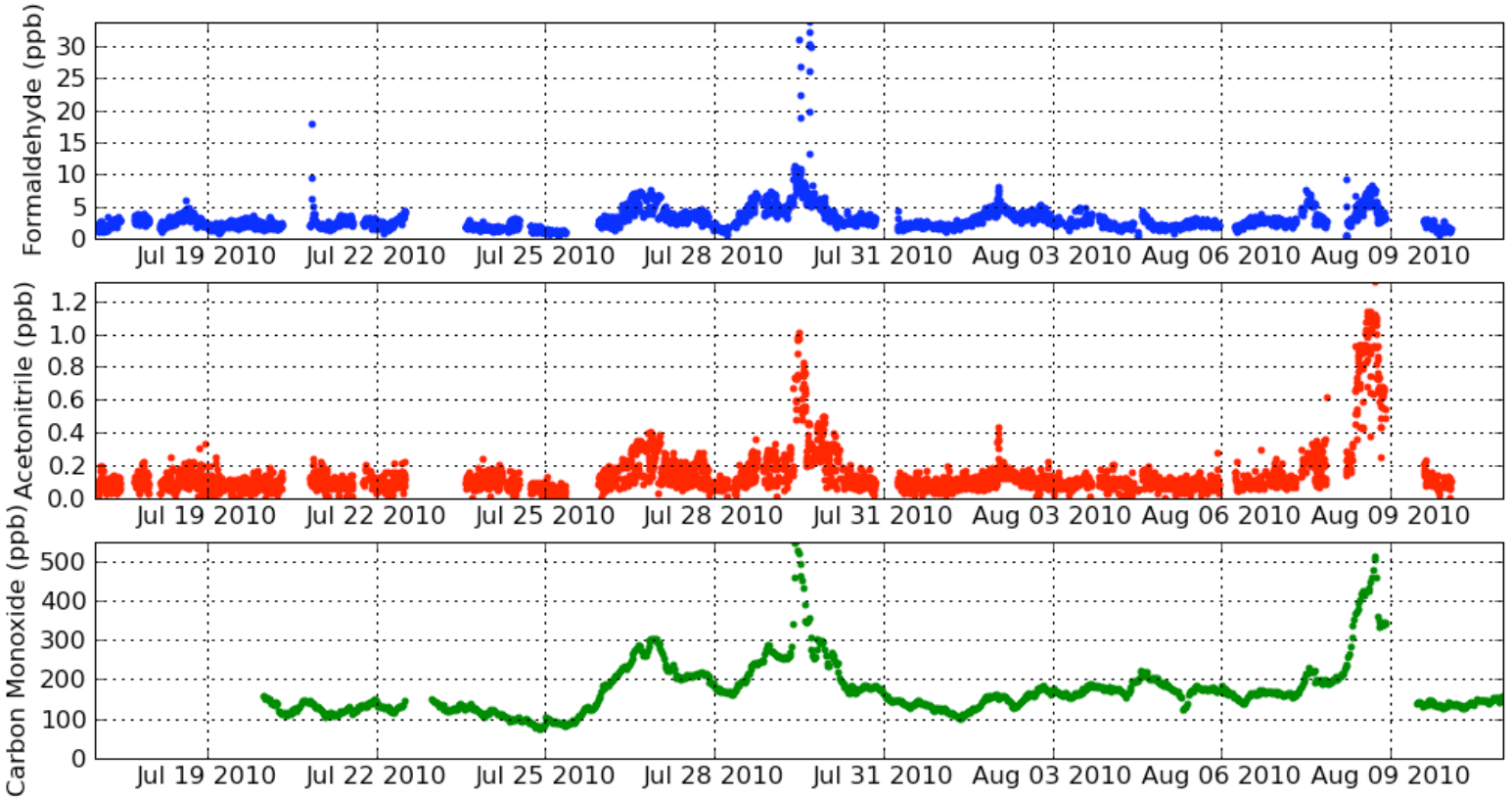
HUMPPA at Hyytiala, Courtesy Jonathan Williams



Conclusions

- ALANIS theme 2 successfully started
- Aim: a three year dataset over boreal Eurasia
- Assimilation / Optimization of
  - ✓ Emission Estimates
  - ✓ SPIH products
  - ✓ Plume tracking product (IASI)
- Full chemistry simulations of the impact of fires

- Cooperation welcome!