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Towards unravelling complex land-atmosphere processes in boreal Eurasia: the ALANIS study

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Determining the role of boreal Eurasia is essential in understanding the global Earth system as it represents the largest terrestrial ecosystem on the planet. Its size and remoteness, however, pose a challenge to quantification of radiative, hydrological, and biogeochemical processes characterizing the region and their feedbacks to global climate. Furthermore, human activities and climate changes have altered the natural equilibrium, thus strengthening the need for an effective monitoring of surface-atmosphere exchange interactions resulting in complex exchanges of energy and matter.

In the last few years, Earth Observation (EO) data have demonstrated the potential to become a major tool for estimating key variables and characterizing main processes governing the land-atmosphere interface over the extremely wide and often unreachable northern areas of boreal Eurasia. In such context, the European space Agency (ESA) in collaboration with iLEAPS has launched the ALANIS activity (Atmosphere-LANd Interaction Study) to advance towards the development and validation of novel EO-based multi-mission products and their integration into suitable land-atmosphere coupled models responding directly to the specific scientific requirements of the iLEAPS community.
The study encloses three different projects, each addressing a specific thematic area, namely ALANIS – methane, ALANIS – smoke plumes, and ALANIS – aerosols.

The increasing number and extent of biomass burning events in boreal Eurasia (such as those occurred during summer 2010 in the Moscow area) has proven a significant impact on atmospheric chemistry. Indeed, due to high atmospheric instability and high energy release typical of the region, fire emissions can be injected even up to lower stratosphere, where the effect of most trace gases and aerosols last longer affecting greater regions.
The ALANIS smoke plumes project aims at exploiting the complementary capabilities offered by multi-mission EO data for improving large-scale dispersion forecasts of emitted compounds. In particular, a smoke-plume injection height (SPIH) product is being developed (combining Envisat AATSR and ERS-2 ATSR-2 stereo retrievals with plume-height information extracted from the Envisat MERIS O2 band) and used for constraining a novel land-atmosphere coupled model based on the TM-5 model.

Methane (CH4) is one of the most dangerous greenhouse gases and plays a crucial role in atmospheric chemistry with a relative global warming potential 21 times greater than CO2. Accordingly, understanding and modelling the natural variability of methane fluxes from boreal Eurasian lakes and wetlands is of paramount importance in the light of the size of the region and the dramatic warming that it is experiencing.
The goal of ALANIS methane is to investigate the potential of EO data to contribute to reduce current uncertainties in CH4 emissions through the synergistic use of land and atmosphere EO-based products in a coupled land-atmosphere model based on the JULES model. A number of specific EO-based products is being developed which characterise both land surface processes (regional and local wetland dynamics, ground freeze/thaw and snowmelt onset derived from Envisat AATSR and ASAR, MetOp-A ASCAT, and SSM/I data from DMSP satellites) and atmospheric CH4 concentrations (derived from Envisat SCIAMACHY data).

Nowadays, there is a growing interest in investigating atmospheric aerosols in northern Eurasia. Hence, the aim of the ALANIS aerosols feasibility study is to investigate the possibility of discriminating anthropogenic from natural aerosols emitted by boreal Eurasian forests with existing multi-mission EO-based products. In the first phase, the objective is to develop novel algorithms solely exploiting currently available EO-based products. Then, the goal is to investigate novel strategies for assimilating already existing EO data and products (e.g., derived from ERS-2 ATSR-2, Envisat MERIS and SCIAMACHY, or other satellites) into suitable chemical transport models currently available in the literature.