Remote Sensing and Modeling LENA2006

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Abstract:
Quantifying sources and sinks of climatological relevant trace gases as well as understanding their exchange between atmosphere and land surfaces has become essential research topics in atmospheric sciences during the last years. High latitude ecosystems are most critically influenced by a changing climate. Modeling the terrestrial carbon cycle - net CO_2 uptake by vegetation (Net Primary Productivity, NPP) as well as methane emissions from natural wetlands – is a powerful tool to study the impact of climate change. Uncertainties in the carbon budget of arctic ecosystems remain partly due to difficulties in assessing the spatially and temporally highly variable methane emissions of permafrost soils.
At the German Aerospace Center (DLR), the vegetation model BETHY/DLR (Biosphere Energy Transfer Hydrology Model, Knorr 1997, Wisskirchen 2005) and a Methane Model (Walter 1998) are used to perform simulations of carbon exchange. In the past NPP studies are mainly performed for Europe, while methane fluxes are modelled for permafrost regions (Lena River Delta, Siberia). Combining both approaches for the Northern part of Siberia the coupled models will yield quantitative methane fluxes. The models are driven by ECMWF (European Center for Medium-Range Weather Forecasts) meteorological input as well as remote sensing data of Leaf Area Index (LAI) and Land Cover Classification (LCC). The latter is derived from MERIS data by using a novel automatic approach based on coupled radiative transfer models. In situ measurements of carbon fluxes and vegetation characteristics are used to validate model results.

HELMHOLTZ RESEARCH NETWORK - INTEGRATED EARTH OBSERVING SYSTEM (EOS)

The network is intended to facilitate the work of scientists in depicting and modeling environmental processes spatially and temporally at high resolution and in monitoring the status and trends of the Earth system.
The physical and chemical tolerances of processes critical for human life also need to be defined, and long-term monitoring undertaken of global, regional and local changes. Thanks to their expertise, science infrastructure and major facilities the Helmholtz centers **AWI, GKSS, DLR and GFZ** have the necessary preconditions for jointly pursuing crucial research topics in this context and achieving added value. The Helmholtz Research Fields “Earth and Environment“ and “Transport and Space” are being linked to create an “Integrated Earth Observing System.” Its purpose is to concentrate expertise and share infrastructure and data, initially in three research programs: **Ocean and Cryosphere**, **Disaster Management**, and **Land Surface Processes**. These activities are financed from the resources each participating center contributes toward the work it carries out in the individual research programs of the network.
Networking of Helmholtz centers is supported by a common educational program, a specific PhD Program. End of 2004 twelve PhD positions were offered at AWI, GKSS, DLR and GFZ.

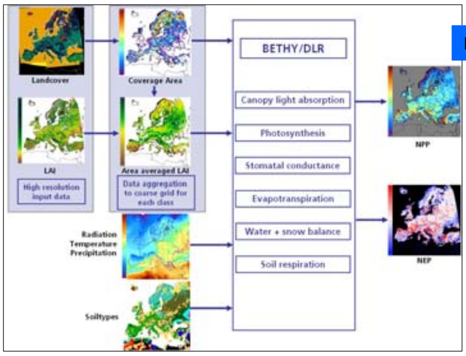

Figure 1: Flowchart of current NPP processing at DLR-DFD: For simulations on continental scale a data aggregation technique is used to reduce resolution in order to keep the different resolutions of input data compatible and to keep calculation time low. For each land cover class the coverage area on the coarse grid is calculated. This information is used to calculate an area weighted average LAI for each class. Information on the coverage area is also used to calculate the overall sum of carbon uptake on each grid cell for each land cover class.

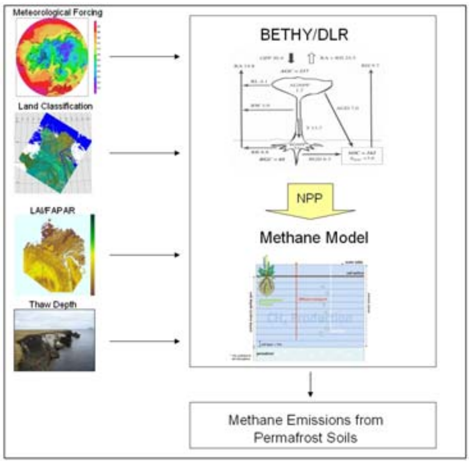

Figure 2: Flow chart illustrating the coupling of the vegetation model BETHY/DLR which is used for calculating NPP and the Methane Model which subsequently simulates methane fluxes. The required input data for the two models are shown on the left side. Meteorological forcing consists of temperature, radiation and precipitation data. LAI is derived from MERIS-FR data.

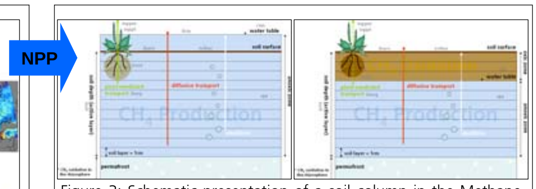

Figure 3: Schematic presentation of a soil column in the Methane Model (after Walter 1998).
a) In a water saturated soil (water level above soil surface), CH_4 is produced by methanogenic bacteria and transported to the atmosphere by diffusion, ebullition and plant-mediated transport.
b) When the water table drops below the soil surface, the produced CH_4 is transported upwards and – when reaching the unsaturated zone – is partly oxidised by methanotrophic bacteria. Plant-mediated transport through vascular plants plays an important role in that (i) CH_4 is directly transported to the atmosphere without passing the oxic zone and in contrast (ii) oxygen is transported down to the rhizosphere where an oxidising environment is maintained.
The model is driven by meteorological data (ECMWF) and additionally needs vegetation and soil input parameters (remotely sensed data such as land cover (LC) and Leaf Area Index (LAI)) as well as NPP, calculated by BETHY/DLR.

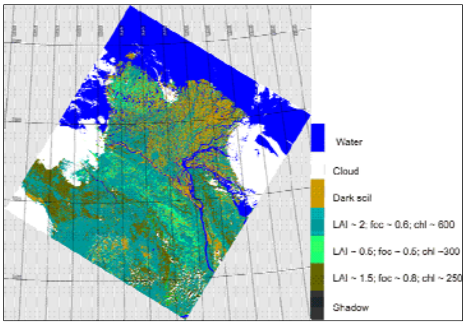

Figure 4: Result of an automatic land cover classification of the Lena River Delta using full-resolution MERIS level 2 data from August 26, 2006. Seven classes are assigned to the pixels.
Land cover classification is performed by applying a supervised Maximum-Likelihood algorithm. In contrast to classical classification, training sets are deduced from a combined radiative transfer calculation taking into account absorption and scattering in leaves (using the SLOP model of Maier & Günther, 1999, 2003), canopy (using the SAIL model of Verhoef (1984) and the Kuusks hot spot parameterization (1991)) and atmosphere (using the SMAC model from Dedieu (1994)). Training data are first grouped according to illumination and observation conditions and second to plant parameters (e.g. chlorophyll) and canopy parameters (e.g. LAI and fraction of cover, (foc)) . Each class is described by three parameters (LAI, foc and chlorophyll) describing the land cover.

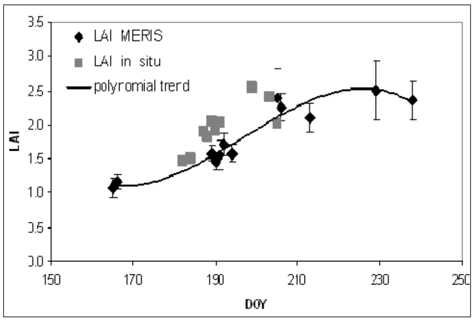

Figure 5: Time series of LAI for Samoylov Island for the growing season 2006. Diamonds: seasonal course of LAI derived from MERIS FAPAR values and polynomial fit (error bars indicate stdev); triangles: LAI derived from field spectral measurements.
Vegetation characteristics play an important role in the presented modeling approach where LAI is used to describe the seasonal development of vegetation. LAI was estimated from remote sensing data using FAPAR values derived from MERIS Global Vegetation Index (MGVI). Additionally, field spectral measurements of different vegetated surfaces were carried out during the expedition LENA2006 . Spectra were processed in order to calculate vegetation biophysical indices such as NDVI and LAI.

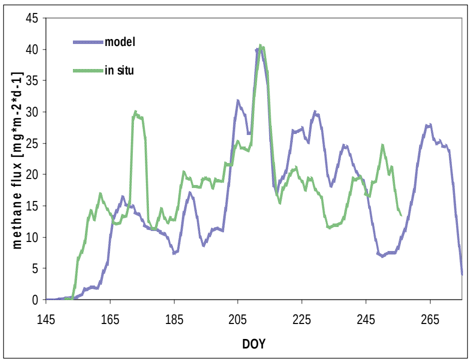

Figure 6: Measured and modeled methane fluxes (5-day running means) from a one-dimensional model run for the growing season 2006 and model coordinates 72°N, 126°E (Samoylov Island).
Methane flux was modeled one-dimensionally for the growing season 2006. Flux measurements on the landscape scale using eddy covariance technique were carried out in the Lena Delta from June through September 2006. Measurements were used to validate model results and to adjust model parameters. Time-integrated fluxes for both time series compare reasonably well.

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