Quantifying carbon fluxes of forests in Northern Eurasia: Integration of eddy flux towers, remote sensing and biogeochemical model

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I. Introduction

In this poster we introduce a new 3-year project (1/1/2005 – 12/31/2007) under the support of NASA, as part of NASA Carbon Cycle Science and Northern Eurasia Earth System Science Partner Initiative (NEESPI) programs.

A limited number of CO_2 eddy flux tower sites, distributed over vast terrain of Northern Eurasia, provide valuable continuous observations of net ecosystem exchange (NEE) between forests and the atmosphere. It is a grand challenge to scale-up the *in-situ* flux data across landscape and region. We proposed to combine an innovative satellite-based Vegetation Photosynthesis Model (VPM) and a process-based biogeochemical model (DNDC) for conducting diagnostic analysis of spatial and temporal variation of CO_2 flux from forests in Northern Eurasia. Our major objectives include (1) improving quantification of CO_2 fluxes of forests in Northern Eurasia and (2) developing and evaluating a data-model assimilation system for biogeochemical analysis at large scales.

II. Leaf chlorophyll, leaf water content and leaf age ----- beyond the LAI – FAPAR – NDVI paradigm

We have been developing innovative algorithms and models that are based on understandings of seasonal dynamics of leaf chlorophyll, leaf water content and leaf age (Figure 1), taking full advantage of advanced optical sensors (e.g., MODIS, VEGETATION). In this project we focus on the coupling of VPM and DNDC models for CO_2 flux of forests in Northern Eurasia.

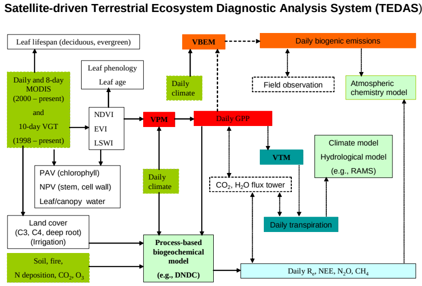

Figure 1. Framework of satellite-driven TEDAS

III. Temporal variability of CO_2 fluxes at individual flux tower sites

This project will conduct synthetic analysis of CO_2 flux data from several eddy flux tower sites in Russia in relation to vegetation indices (LSWI, EVI and NDVI), and use CO_2 and H_2O flux data to evaluate both satellite-based VPM model and process-based DNDC model. Intensive temporal sampling of leaf chlorophyll, nitrogen and water content over the plant growing season will also be conducted in an effort to improve algorithms that uses satellite images for retrieval of biophysical and biochemical parameters of forest canopy. We will quantify relative contribution of individual driving factors to temporal variability of gross primary production (GPP), ecosystem respiration and NEE.

IV. Spatial and temporal variability of forests at landscape scale

For individual CO_2 eddy flux tower sites, we will establish a multiple-scale, multi-temporal and multi-sensor image database (including Landsat, ASTER, IKONOS, Hyperion, MODIS and VGT sensors). Land cover classification at landscape scale (~100 x 100 km^2) will be conducted to quantify spatial and temporal variability of vegetation. Spatial sampling of leaf chlorophyll, nitrogen and water content will also be conducted. The resultant landscape-scale products will be used to support simulations of DNDC model.

V. Description of satellite-based Vegetation Photosynthesis Model (VPM)

The VPM model, which is based on light absorption by chlorophyll ($FAPAR_{chl}$), leaf water content and leaf age, estimates daily GPP of vegetation (Xiao et al., 2004a,b,c; Xiao et al., 2005):

$$GPP = \varepsilon_g \times FAPAR_{chl} \times PAR$$

$$FAPAR_{chl} = f(EVI); \qquad \varepsilon_g = \varepsilon_0 \times T_{scalar} \times W_{scalar} \times P_{scalar}$$

where ε_0 – maximum radiation use efficiency (μmol CO_2/μmol PAR); W_{scalar} – scalar for leaf water content, P_{scalar} – scalar for leaf phenology; and T_{scalar} – scalar for air temperature. We use the Enhanced Vegetation Index (EVI, Huete et al., 1997) and Land Surface Water Index (LSWI, Xiao *et al*., 2002, 2004a). LSWI is sensitive to leaf and canopy water content, and is used to estimate W_{scalar} *and* P_{scalar}, respectively (Xiao *et al*., 2004a, b) . The VPM model is a major innovation over other Production Efficiency Models that are built upon leaf area index (LAI) -- fraction of PAR absorbed by vegetation canopy (FAPAR) -- NDVI paradigm.

VI. Description of the process-based DNDC biogeochemical model

DNDC model estimates daily GPP, autotrophic respiration and heterotrophic respiration as well as trace gases emissions (e.g., N_2O, CH_4). The DNDC model has been evaluated for forests, cropland, and wetlands, and used worldwide by scientists. This project will assemble and organize the improved geospatial databases (climate, soil, land cover, management) to support the landscape-scale and regional simulations with the DNDC model; the resultant geospatial databases will also be available to the broader scientific communities.

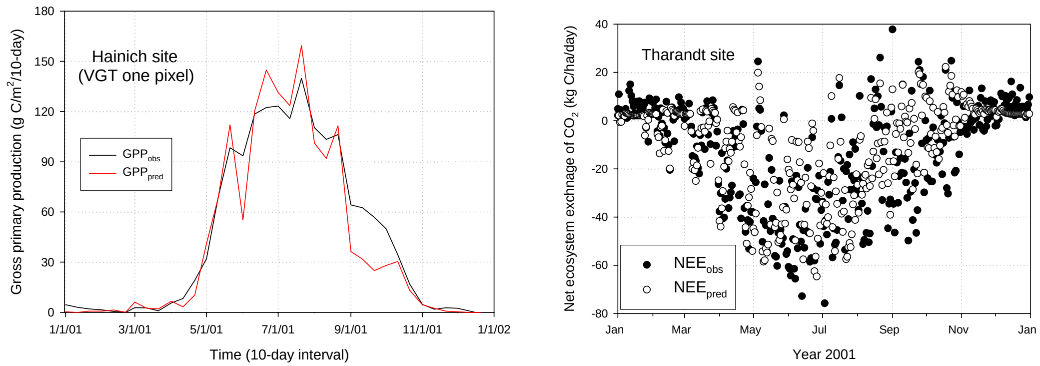

Figure 2. A comparison of GPP and NEE between models (VPM and DNDC) and flux towers.

VII. Data documentation and distribution

We will distribute the data and products from this project through http://eos-webster.sr.unh.edu website.

VIII. International collaboration:

This project involves leading in-country scientists in eddy flux measurement and remote sensing. Eddy flux tower sites in Russia are currently clustered in three geo-locations: western Russia (led by N. Vygodskaya in Russia), Central Siberia (led by E.D. Schulze in Germany) and Eastern Siberia (led by Takeshi Ohta in Japan). Both Russian group and Germany group are the team members of this project, and we have also begun to develop collaboration with Japanese group (Takeshi Ohta). Dr. Sergey Bartalev (Russian group) involves the effort in remote sensing. A group of Russian soil scientists in Russian Academy of Sciences will also be involved in this project.