The modeling approach to describe H_2O and CO_2 exchange in mire ecosystems

A. Oltchev[1], E.Novenko[2], E. Volkova[3]

[1] A.N. Severtsov Institute of Ecology and Evolution of RAS, Leninsky Pr. 33, Moscow, Russia (aoltche@gmail.com)

[2] Institute of Geography of RAS, Moscow, Russia

[3] L.N. Tolstoy Tula State Pedagogical University, Tula, Russia

Introduction: The modern climatic conditions is strongly influenced by both internal variability of climatic system, and various external natural and anthropogenic factors (IPCC 2007). Significant increase of concentration of greenhouse gases in the atmosphere and especially the growth of atmospheric CO_2 due to human activity are considered as the main factors that are responsible for global warming and climate changes. A significant part of anthropogenic CO_2 is absorbed from the atmosphere by land biota and especially by vegetation cover. The role of different land ecosystems and especially forests and mires in the global H_2O and CO_2 cycles as well a sensitivity of these ecosystems to climate changes is still not completely clear and need complex experimental and theoretical studies.

The main goal of the study is to estimate the spatial and temporal variability of H_2O and CO_2 fluxes for different types of mire ecosystems of the forest-steppe zone in European part of Russia using modeling approaches and results of field measurements.

Study area. Tula region was selected as a key region for this experimental and modeling study. The area is located mostly in the forest-steppe zone and it is unique area for such studies because almost all existed types of mire ecosystems of Northern Eurasia distinguished by a geomorphological position, water and mineral supply can be found there (Fig. 1).

Methods:

To derive the H_2O and CO_2 exchange between forest mire ecosystems and the atmosphere an aggregated approach including a 3D Forbog-3D model and field flux measurements were applied. Most mires in Tula region have a relatively small size and surrounded by very heterogeneous forests that make not possible to apply for flux estimation in such sites any classical measuring and modeling approaches e.g. an eddy covariance technique or one-dimensional H_2O and CO_2 exchange models. Forbog-3D model is a version on Mixfor-3D model (Olchev et al. 2009) and it was developed especially to describe CO_2/H_2O exchange processes between heterogeneous mire ecosystems and the atmosphere.

For field measurements of the H_2O and CO_2 fluxes between the forest mires and the atmosphere the portable chamber integrated with infra-red gas CO_2/H_2O analyzer LI-840 (Li-cor, USA) was used.

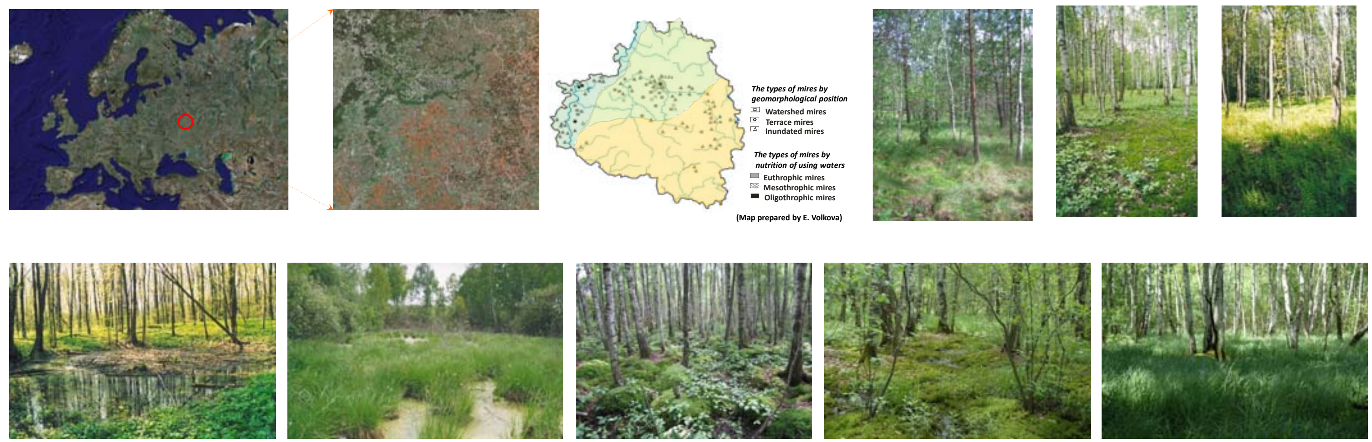

Fig. 1: Geographical location of the study area and the areal distribution of the different types of mire ecosystems within the Tula region.

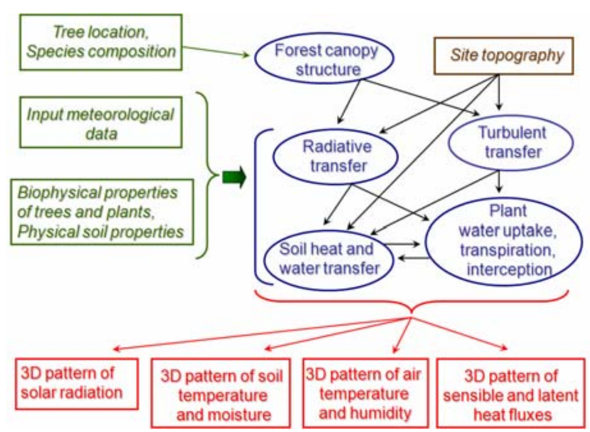

Fig. 2: The general scheme and the main relationships between different sub-models in the Forbog-3D model.

Forbog-3D model: The developed Forbog-3D model consists of several closely coupled sub-models describing: 3D structure of a forest stand; 3D radiative transfer in a forest canopy; 3D turbulent transfer of sensible heat and water vapour between ground surface, trees and the atmospheric surface layer; 3D heat and moisture transfer in soil (Fig. 2). The horizontal grid resolution of the model is varied from 1×1 to 2×2 meters, vertical resolution - 1 m and time step – 1 hour.

The main concept used in the model is an aggregated description of the physical and biological processes on the different spatial levels of a forest and mire plant ecosystem, i.e. from individual leaf and plant (tree) to the entire ecosystem.

For simulation of three-dimensional patterns of plant (PAD) and leaf (LAD) area densities of a forest stand Forbog-3D uses data about coordinates of each individual tree in the forest stand, mean height, crown and stem diameters of the trees (Fig. 3). The model assumes that all trees of the same species have the same height, crown length, crown shape, vertical distributions of LAD and PAD. The algorithm for modelling of solar radiation regime describes transfer of direct and diffuse solar radiation including radiation which penetrates through gaps in the canopy, transmitted by leaves and reflected from leaves, bark and soil surface. The turbulent regime within and above a forest stand in Forbog-3D was described using the dynamical algorithms of a 3D atmospheric boundary-layer model SCADIS (Sogachev *et al.* 2002, 2005).

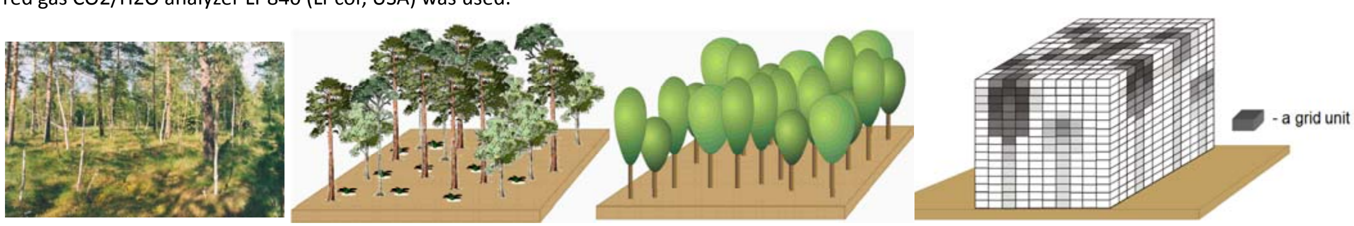

Fig. 3: Approximation of vegetation structure in the Forbog-3D model. Darkness of each grid unit indicates local LAD.

Acknowledgements: *The study was supported by grants (11-04-97538-r_center_a, 11-04-01622-a and 11-05-00557-a) of the Russian Foundation of Basic Research (RFBR).*

Home page: https://sites.google.com/site/aoltchev/