The Dynamic Land Ecosystem Model (DLEM) and Its Applications to Carbon and Ecosystem Studies

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The Dynamic Land Ecosystem Model (DLEM)

The DLEM is a highly integrated land ecosystem model which couples major biogeochemical cycles, hydrological cycle, and vegetation dynamics to make daily, spatially-explicit estimates of water, carbon (CO2, CH4) and nitrogen fluxes. DLEM builds on the experience and heritage of the existing Terrestrial Ecosystem Model (Raich et al. 1991; Melillo et al. 1993; McGuire et al. 1992; Tian et al. 1998, 1999, 2000, 2005; Felzer et al. 2004, 2005) and Biome-BGC (Running and Hunt 1993; Thornton, P.E. 1998, 2002). DLEM includes five core components: (1) biophysics, (2) plant physiology, (3) soil biogeochemistry, (4) dynamic vegetation, and (5) land use and management. DLEM also integrates algorithms of N2O emission from DNDC (Li and Aber 2000) and CH4 emission from other previous studies (Huang et al. 1998,2005; Zhuang et al. 2004). The biophysical component includes the instantaneous exchanges of energy, water, and momentum with the atmosphere. Plant physiology component simulates major physiologic processes such as photosynthesis, respiration, allocation among various parts (root, stem and leaf), nitrogen uptake, transpiration, physiology, etc. Soil biogeochemistry simulates mineralization, nitrification/denitrification, decomposition and fermentation. The dynamic vegetation component in DLEM simulates two kinds of processes: the biogeography redistribution when climate change, and the plant competition and succession during vegetation recovery after disturbances. The additional detail of model structure has been shown in Fig. 1b).

Calibration and Validation of the DLEM model:

The DLEM model has been calibrated against 18 plant functional types across China and USA. Most field data for model calibration are from CERN (Chinese Ecosystem Research Network) and LTER (Long-term Ecological Research in US). We also have worked on model validation against observations at field sites not used for model calibration/parameterization. Fig. 3 & 4 show the examples of model validation that we have done in wetland and plantation forest.

Plant Functional Types:

Like most DGVMs, DLEM builds on the concept of plant functional types (PFTs) to describe vegetation distributions. The DLEM has also emphasized the modeling and simulation of managed ecosystems including agricultural ecosystems, plantation forests and pasture. This model has been calibrated using field data from 18 plant functional types (PFTs) across China and USA (Fig. 2.). (type 3: Boreal needleleaf evergreen forest)

Regional Applications:

A) CO2 flux and its controls:

Net carbon storage in China shows substantial year-to-year variation. For the period of 1981-2000, DLEM simulation indicates that the land ecosystems were a sink of carbon to the atmosphere. Net carbon storage also shows substantial spatial variations across the China. During 1981-2000, China’s land-ecosystems as a whole acted as a sink of CO2, but some parts of the China still released carbon to the atmosphere. Interannual variations in net carbon storage were primarily caused by climate variability, the effect CO2 fertilization was primarily responsible for the increase in carbon storage in China’s terrestrial ecosystems.

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