Spatial and temporal variations of gross primary productivity and evaporation over the global land from 2000 to 2009 using MODIS and FLUXNET

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Background

Gross primary productivity (GPP) and evaporation are the key components in the carbon-water cycles, yet our understanding on the spatial (local to global) and temporal (daily to decadal) variation of those fluxes is still lacking. Several studies proposed continental-scale GPP and evaporation estimates using empirical machine-learning techniques (Jung et al. 2009; Xiao et al. 2010). They are useful to constrain large scale GPP and evaporation estimates whereas they do not reveal underlying mechanisms. The MODIS science team provides the global GPP and evaporation products (Mu et al. 2007; Running et al. 2004) yet they suffer from inaccurate and coarse-resolution forcing-meteorological data (Zhao et al. 2006). Notably, there have been few efforts to couple GPP and evaporation mechanistically at continental scales. Thus developing a process-oriented model that couples GPP and evaporation and is applicable to the global land is warranted to better understand ecosystem processes in a changing climate.

Objectives

1. Develop a process-oriented model that couples GPP and evaporation.
2. Test and improve the model using FLUXNET data
3. Produce global maps of GPP and evaporation 8-daily with 1 km resolution over the global land from 2000 to 2009

Methods

1. **Model:**

   First we apply an atmospheric radiative transfer model to calculate whole-sky-condition incoming solar irradiance, direct beam PAR, diffuse PAR and net radiation at the top of canopies. Using the albedo-Nitrogen relation (Ollinger et al. 2008) with the global survey of nitrogen:Vcmax25C relations (Kattge et al. 2009), we quantify the values of Vcmax25C from space. Then we apply a two-leaf canopy photosynthesis model (dePury and Farquhar 1997) and use the canopy photosynthesis to calculate canopy conductance via Ball-Berry equation (Collatz et al. 1991). All the biophysical variables quantified

above enable us to use Penman-Monteith equation for canopy evaporation. Soil evaporation is calculated using equilibrium evaporation with soil moisture stress function. Figure 1 shows the schematic diagram.

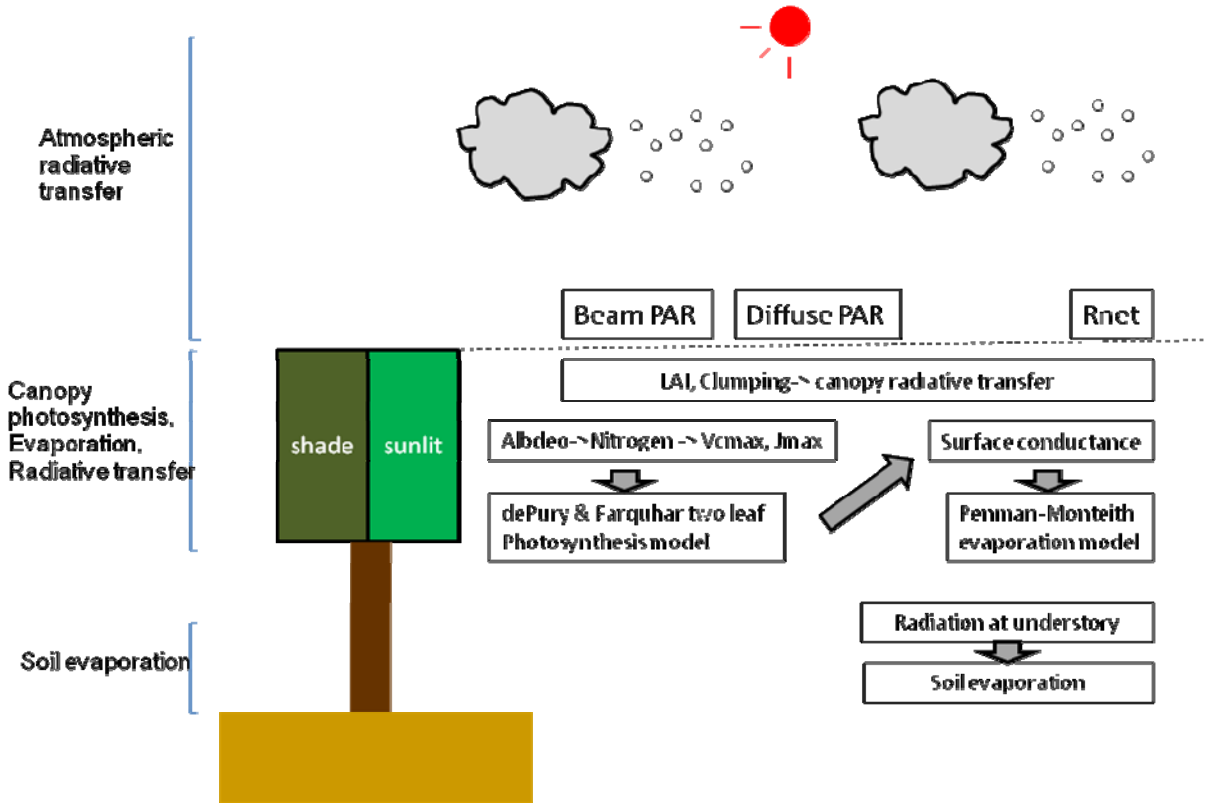

Figure 1. Model description

2. Data preparation and processing:

We use both atmosphere and land MODIS products to model atmospheric radiative transfer and canopy processes (Figure 2). To process large MODIS data (~ 100 TB), we use an innovative Cloud Computing System powered by the Microsoft Azure platform. All MODIS data are directly downloaded, reprojected, and processed in the Cloud system, and the final results are delivered to the user. Currently, we have downloaded, reprojected 10-years data of US, and are downloading other continents data.

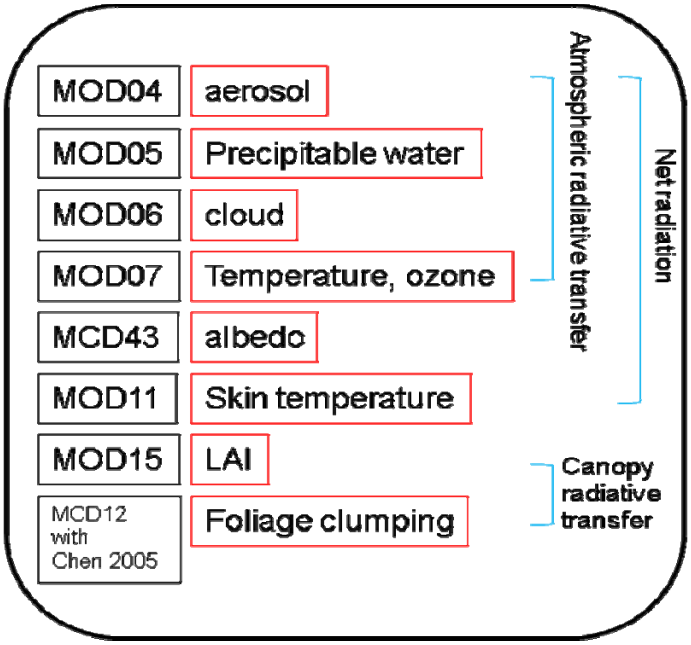

Figure 2. Data sources

3. Preliminary results

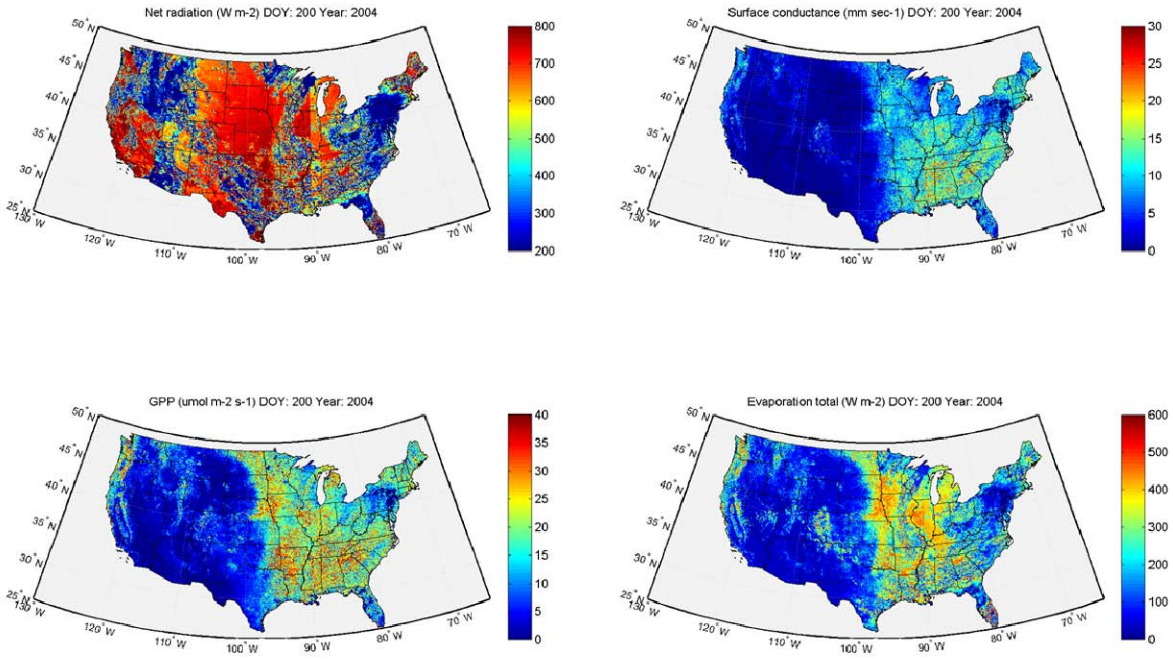

Figure 3. Instantaneous estimates of net radiation, surface conductance, GPP and evaporation over US (YR: 2004 DOY: 200 Platform: Terra) using MODIS. The snap shots will be upscaled to the 8-day-mean daily sum estimates.

4. Expected sites

Sites that have at least one-year good data of GPP, evaporation, net radiation, solar radiation, soil moisture will be considered in this project.

5. Authorship guidelines

All data providers are invited to give intellectual inputs to this study and *significant* intellectual inputs will lead co-authorship. Upon the approval of this manuscript, the first analysis results will be sent to the PIs and intellectual input can be considered from this stage. Authorship issue will abide by LaThuile ToR.

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