Process-based estimates of terrestrial CO2 assimilation and evapotranspiration using MODIS at continental scale: a bottom-up approach

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1. Background

Most satellite based GPP and ET studies heavily rely on coarse forcing meteorological variables (e.g. solar radiation, temperature) or simple empirical relation with vegetation indices. Here we propose a novel process-based approach to couple land CO2 assimilation with evaporation using MODIS. We explicitly couple the atmosphere and land surface by introducing MODIS derived atmospheric radiative modeling. Element spatial and temporal units are 1 km and instantaneous images. We aim to produce 5-km resolution with 8-day interval products over the entire global land from 2001 to 2009 in support of the cloud computing system of Microsoft Azure Platform to explore spatial and temporal pattern of terrestrial carbon and water cycle.

2. Methods

2. 1. Developing Cloud Computing System

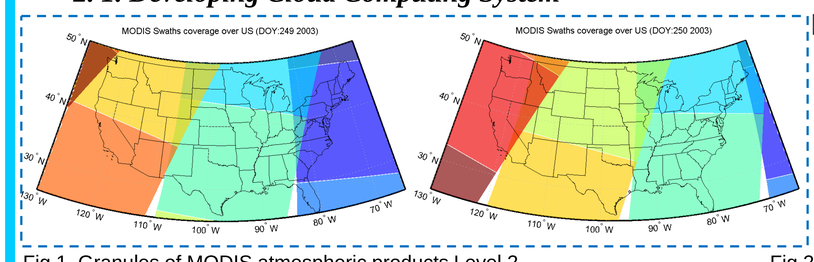


Fig 1. Granules of MODIS atmospheric products Level 2

Convert L2 Swaths to standardized SIN tiles

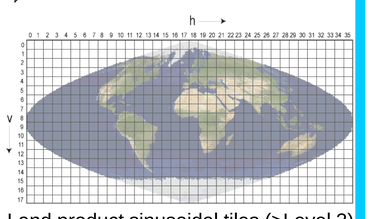


Fig 2. Land product sinusoidal tiles (>Level 3)

Integrating MODIS atmosphere and land products to better understand land-atmosphere interactions

support

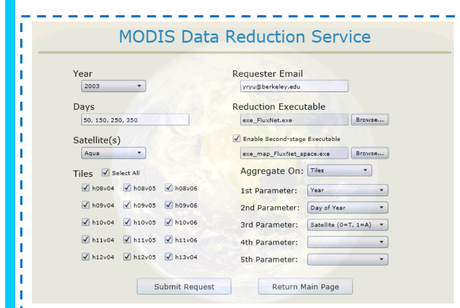
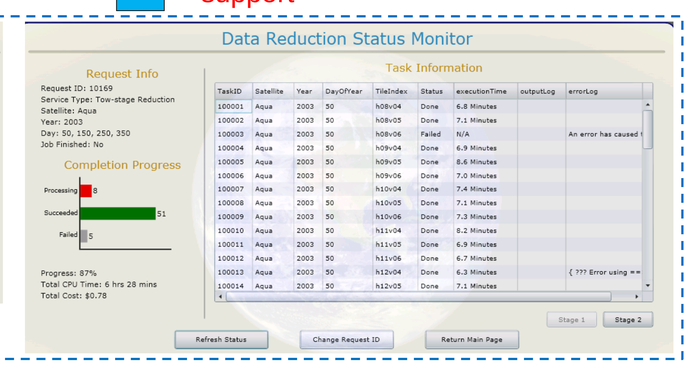


Fig 3. Web interface of the Cloud Computing
http://modisdataservice.cloudapp.net/



For more information, visit NOW:
H51H-0857. A Cloud Computing Service for Remote Sensing Data Reprojection and Science Reduction (Li et al).

2. 2. CO2 assimilation and evaporation models

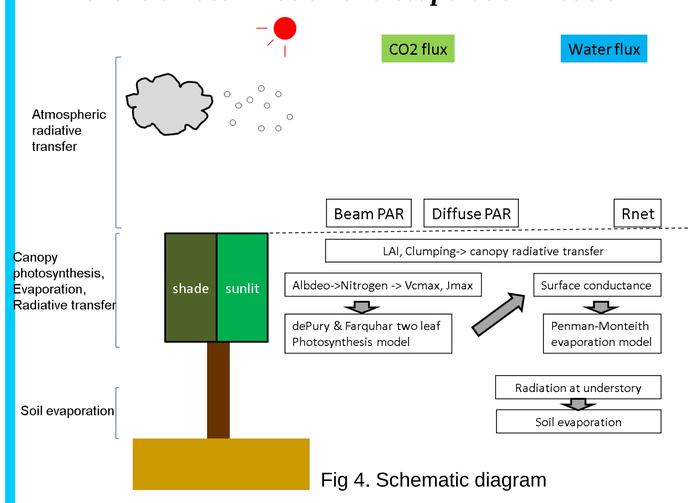


Fig 4. Schematic diagram

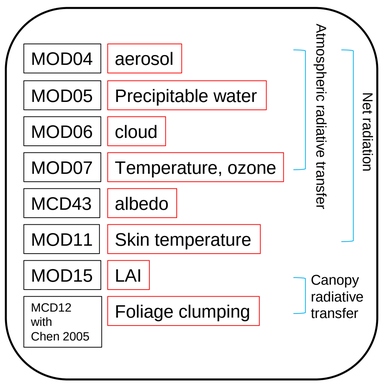


Fig 5. MODIS forcing data for radiation model

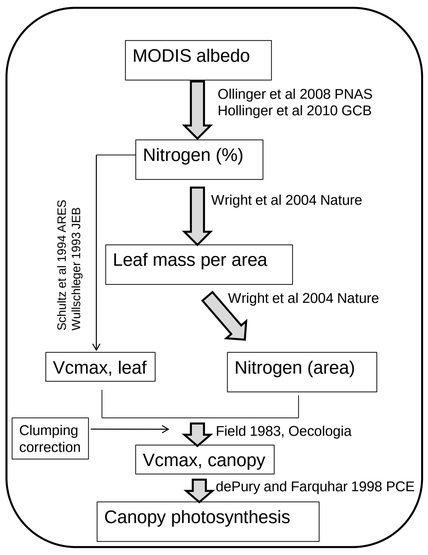


Fig 6. Albedo-Nitrogen-Canopy photosynthesis module

$$G_s = m \times \frac{GPP \times RH}{C_s} + b$$

Ball-Berry eq (Collatz et al. 1991. *Agri.For.Meteorol.)*

$$\lambda E = \frac{\Delta(R_n - G) + \rho_a C_p (e_s - e_a)/r_a}{\Delta + \gamma(1 + r_s / r_a)}$$ (Monteith 1965)

$a\lambda E^2 + b\lambda E + c = 0$

$$a = \frac{\rho_a \lambda G_s m_s}{2 m_w P(\rho_a C_p g_b + 4\sigma\varepsilon T_k^3)} \frac{d^2 e_s(T)}{dT^2}$$

$$b = -4 \cdot \varepsilon \cdot \sigma \cdot T_k^3 - \frac{\rho \lambda G_s m_s}{m_w P} \frac{de_s(T)}{dT} - \rho C_p G_b + \frac{\rho_a \lambda G_s m_s}{2 m_w P(\rho_a C_p g_b + 4\sigma\varepsilon T_k^3)} \frac{d^2 e_s(T)}{dT^2}\left[-2Q + 2\sigma\varepsilon T_k^4 + 2G_{soil}\right]$$

$$c = (\rho_a C_p G_b + 4\varepsilon \cdot \sigma \cdot T_k^3)\frac{\rho_a \lambda G_s m_s (e_s(T) - e_a)}{m_w P} + \frac{\rho_a \lambda G_s m_s}{m_w P}\frac{de_s(T)}{dT}(Q - \varepsilon \cdot \sigma \cdot T_k^4 - G_{soil}) + \frac{\rho_a \lambda G_s m_s}{2 m_w P(\rho_a C_p G_b + 4\sigma\varepsilon T_k^3)} \frac{d^2 e_s(T)}{dT^2}\left[Q^2 + (\sigma\varepsilon T_k^4)^2 + G_{soil}^2 - 2Q \cdot \sigma\varepsilon T_k^4 - 2QG_{soil} + 2G_{soil}\sigma\varepsilon T_k^4\right]$$

PM equation assumes small temperature difference between leaf and air
⇒Not true for dry region
⇒(e.g. ~15 C difference at Vaira)
⇒Solve analytic quadratic equation

(PawU and Gao 1988)

Fig 7. Evaporation module

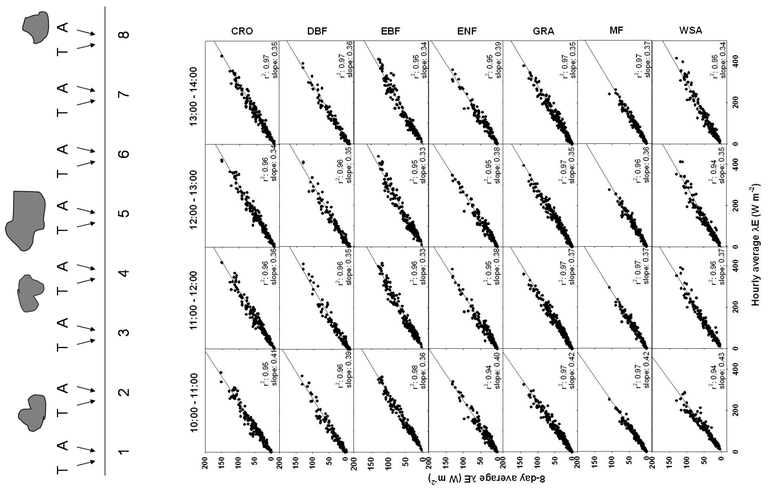
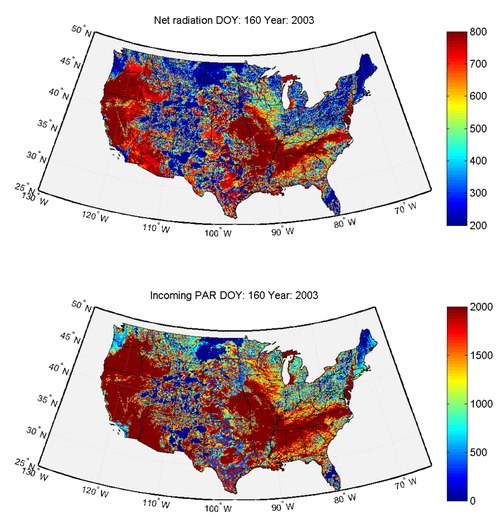


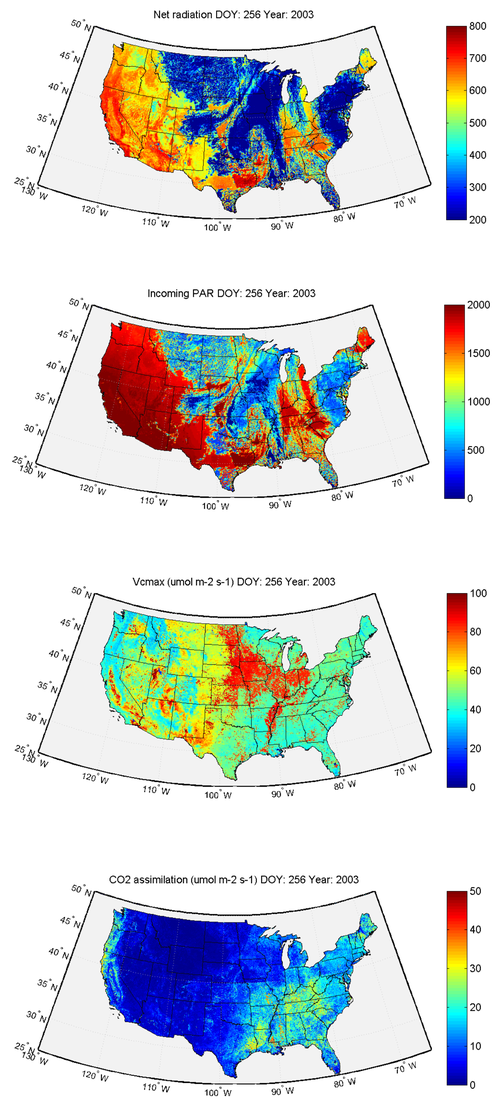
Fig 8. Developing an temporal upscaling factor using FLUXNET database

3. Preliminary results

Snap shot DOY160 (Aqua)



Snap shot DOY256 (Aqua)



4. Next steps

1. Evaluation against FLUXNET database
2. Improving radiation modules
3. Refining Albedo-N relation
4. Incorporating soil moisture effect
5. Extending to entire global land from 2001 to 2009

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