Applications of Global MODIS Evapotranspiration Algorithm at AmeriFlux Tower Site and Global Scale

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1. Methodology

Global ET algorithm developed by Mu et al. (2007) based on Cleugh et al. (2007) using the Penman-Monteith equation was improved (Mu et al., 2011).

$$LE = \frac{sA + \rho C_p (e_{sat} - e) / R_a}{s + \gamma (1 + R_s / R_a)}$$

Major refinements include 1) the canopy and soil surfaces are divided into wet and dry surfaces. ET consists of evaporation from soil, intercepted water by canopy and plant transpiration; 2) ET comprises daytime and nighttime parts, 3) Soil heat flux is estimated; 4) the methods to estimate stomatal conductance, aerodynamic resistance and boundary layer resistance have been improved.

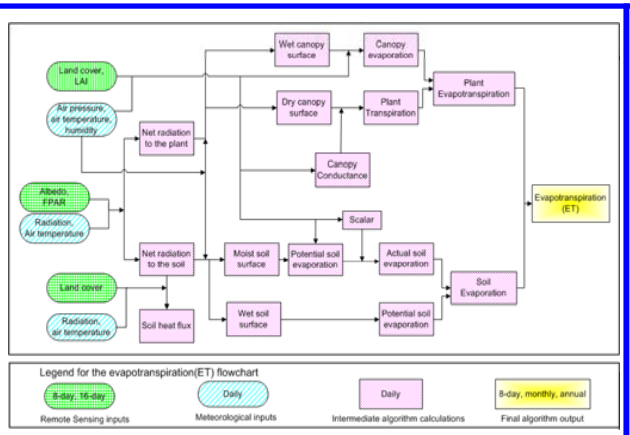


Fig. 1 The ET flowchart of the improved MODIS ET algorithm.

2. Validation of Improved MODIS ET Algorithm at Eddy Flux Towers

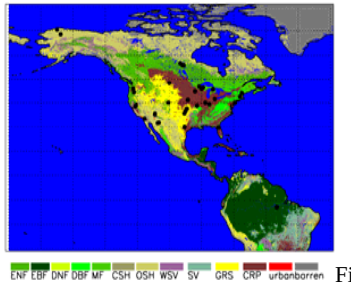


Fig. 2 Distribution of the 46 AmeriFlux eddy flux towers.

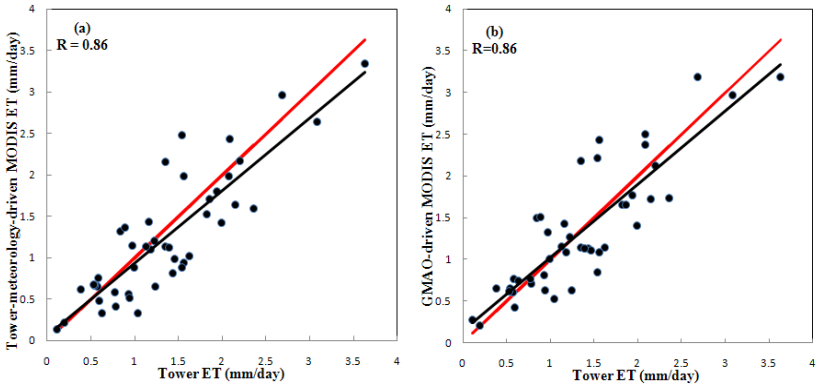


Fig. 3 Comparison of daily evapotranspiration (ET, mm/day) observations from the 46 flux tower sites and the ET estimates averaged over the MODIS 3x3 km cutout. These data were created using (a) tower-specific meteorology and (b) the global GMAO meteorology.

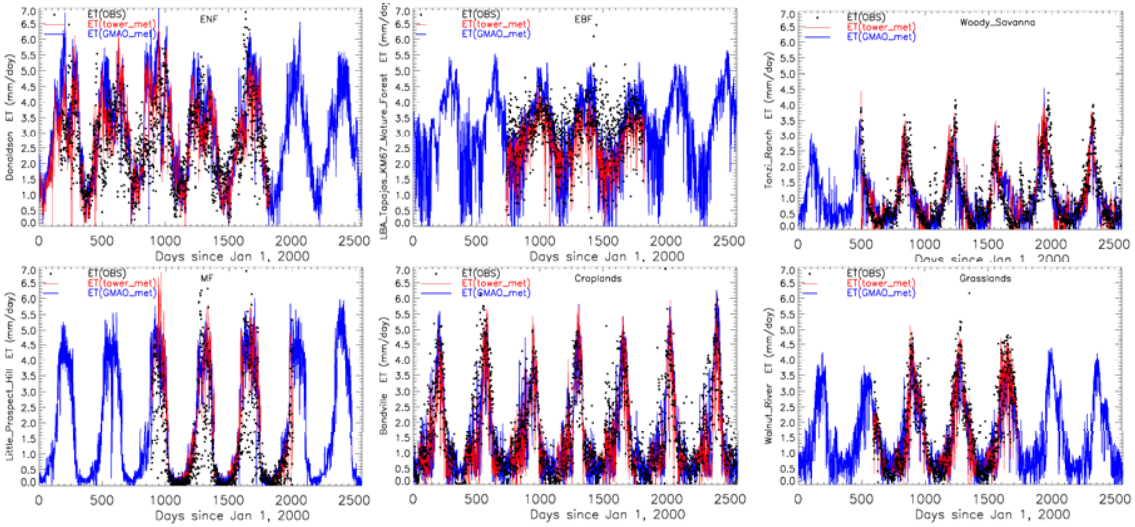


Fig 4 Comparison of ET measurements (OBS) versus the ET estimates driven by flux tower-specific meteorological data and GMAO meteorological data over 2000-2006 at Donaldson (ENF), LBA Tapajos KM67 Mature Forest (EBF), Tonzi Ranch (Woody Savanna), Little Prospect Hill (MF), Bondville (Cropland) and Walnut River (Grassland)

3. Validations at Global Watersheds

Annual precipitation was subtracted by stream flow to get the pseudo ET observations (ET OBS) for the watersheds. We assume that the soil water is at equilibrium in at least five years. The MODIS ET estimates can explain 84% of the variations of the pseudo ET observations at the 232 watersheds.

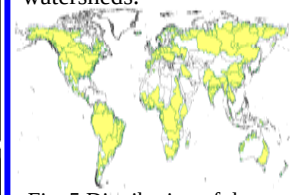


Fig. 5 Distribution of the 232watersheds. Each watershed is depicted in yellow.

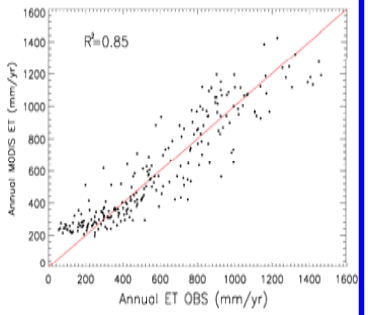
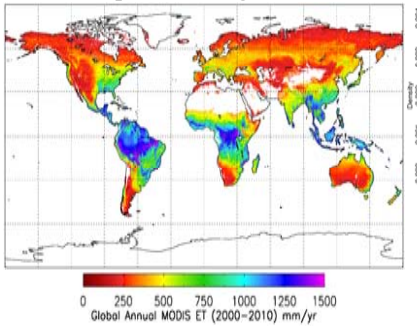


Fig 6. Comparison of annual pseudo ET observations (ET OBS) from the 232 watersheds and the ET estimates averaged over each watershed with improved MODIS ET algorithm over at least five years during 2000-2006.

4. Global Annual MODIS ET

Improved MODIS ET algorithm was applied globally over 2000-2010 with global MERRA GMAO reanalysis data. The 1km global ET was smoothed to 0.05-degree. The global mean annual ET is 575.9 mm yr^{-1} over vegetated areas. **Precipitation is not an input to the algorithm!**



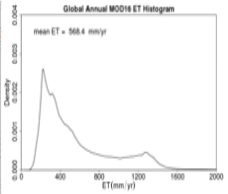


Fig. 7 b) Histogram of global annual ET over 2000-2010 .

Fig. 7 a) Global annual ET over 2000-2010. Global average annual ET over 2000-2010 is 575.9 ± 381.6 mm yr^{-1} over vegetated areas. Barren/deserts take up 24% of the Earth's land surface, global average annual ET 576*(100-24)/100=437.76 mm yr^{-1}; average annual precipitation ~750 mm yr^{-1}, about 750*60%=450mm yr^{-1} of which returns to the atmosphere as ET. **(http://ntsg.umt.edu/project/mod16)**