Comparison of Remote Sensing Evapotranspiration algorithms in the Northern Territory Savanna, Australia

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1. Aims

- Compare remote-sensing forms of the Priestley-Taylor and Penman-Monteith models to estimate evaporation (ET)
- Force models with 30-minute flux tower meteorology and compare with once daily regional meteorology
- Use MODIS Moisture Index (GVMI) to estimate evaporation from the soil fraction

2. Priestley-Taylor Model (PTG)

Model developed by Guerschman et al. 2009, J.Hydrol. 369, 107-119

(1) $$PET = \frac{1.26}{\lambda}\frac{\varepsilon}{\varepsilon+1}(R_{net}-G)$$

$\frac{\varepsilon}{\varepsilon+1}(R_{net}-G)$ = Equilibrium Evaporation

(2) $$AET = k_c PET + k_{E_i} Precip$$

PET = Potential Evapotranspiration
AET = Actual Evapotranspiration, scaled from PET using a function for crop factor (k_c) and interception evaporation (k_{Ei})

Method

- MODIS v5 NBAR-corrected reflectances used to calculate moisture index (GMVI) and greeness index (EVI).
- PTG model forced with 30-minute flux tower meteorology from the Howard Springs woodland savanna site and compared with observed fluxes
- PTG model also run with 0.05degree, once daily regional meteorology and results compared
- In both cases the models were run with published parameters for kc and kEi to determine universality of the model

3. Penman-Monteith-Leuning Model (PML)

Model developed by Leuning et al. 2008, Water Resource Res. 44, W10419

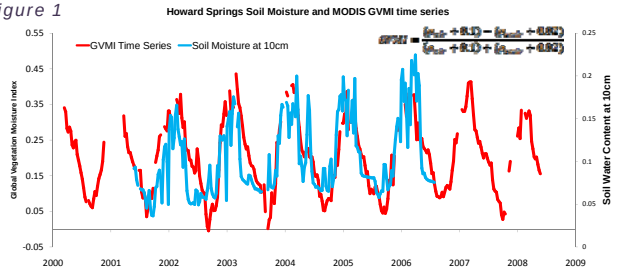
(3) $$\lambda E = \frac{\varepsilon A_{canopy} + (\rho c_p/\gamma)DG_a}{\varepsilon + 1 + G_a/G_c} + f\frac{\varepsilon A_{soil}}{\varepsilon+1}$$

- The PML model discriminates between transpiration from vegetation and evaporation from the soil surface. The fractional canopy cover is estimated via a function of Leaf Area Index (LAI) and the Available Energy (A) is partitioned accordingly.
- The left hand term of Eq (3) applies to the vegetation fraction and scales equilibrium evaporation by a function of vapor pressure deficit (D), aerodynamic conductance (Ga) and canopy conductance (Gc).
- The right hand term of Eq. (3) is a soil function and downward regulates the equilibrium evaporation term by a factor, f, that is related to soil moisture. Leuning et al. 2008 define f as a location-specific constant that requires calibration.

Method

- Canopy conductance at Howard Springs and Daly River was calculated using a function of leaf-level maximum stomatal conductance measured during a field campaign in September 2008 and upscaled to the canopy scale by MODIS LAI
- The soil moisture at Howard Springs shows an excellent correlation with MODIS moisture index (GVMI) as shown in Figure 1. We therefore scaled f by the GVMI to better capture the seasonal wet-dry character of the savanna.

Figure 1

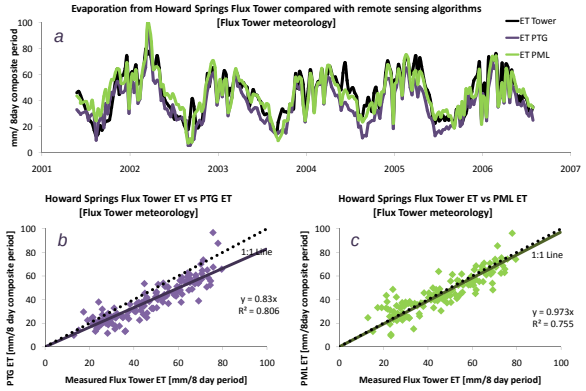


4. Howard Springs Results – meteorology

- Flux tower 30-minute meteorology was compared with spatially gridded (0.05 degree), once daily regional meteorology with no significant degradation of models

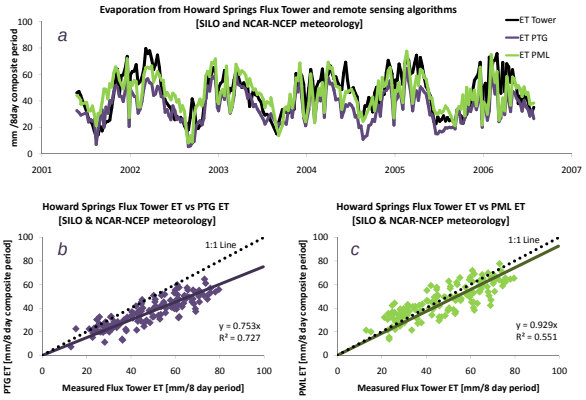
Flux Tower Meteorology

Figure 2



Regional Meteorology

Figure 3



5. Daly River Results

- For the PML model we achieve best results when parameters are locally optimised and the f-parameter is scaled by GVMI rather than being held constant (Figure 4).
- Both PML and PTG models underestimate ET and require local optimisation of model parameters (Figure 5).

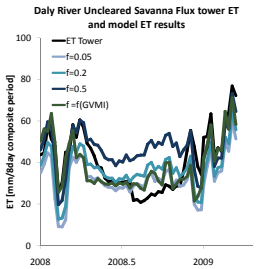


Figure 4

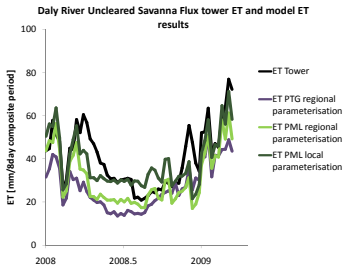


Figure 5

6. Conclusions

- Both PTG and PML ET models underestimate ET at Howard Springs and Daly River tropical woodland savanna sites when published regional scale parameters are used. Local optimisation of model parameters is therefore required to estimate ET.
- Regional scale meteorology can be successfully used in place of flux tower meteorology with only minor degradation of the model fit.
- PML model performance is improved by scaling soil evaporation rate (f) with MODIS Moisture Index (GVMI). This is particularly important for ET modelling in a highly seasonally dynamic wet-dry tropical savanna.

Howard Springs and Daly River flux towers are partially funded by two ARC Discovery grants: DP0772981
Beringer, Hacker, Paw U, Neininger and Hutley 2007-2009 and DP034474, Tapper, Beringer, Siems, Hutley and Lynch 2005-2005.

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