On soil moisture representation in thermal remote sensing based evapotranspiration modeling

Mallick, Kaniska; Jarvis, Andrew J.; Boegh, Eva; Drewry, Darren; Hoffmann, Lucien

Publication date:
2014

Document Version
Publisher's PDF, also known as Version of record

Citation for published version (APA):
Mallick, K., Jarvis, A. J., Boegh, E., Drewry, D., & Hoffmann, L. (2014). *On soil moisture representation in thermal remote sensing based evapotranspiration modeling*. Poster session presented at 7th International Scientific Conference on the Global Water and Energy Cycle, Hague, Netherlands. http://gewex.org/2014conf/pdfs/Mallick_16-10.pdf

On soil moisture representation in thermal remote sensing based evapotranspiration modeling

Kaniska Mallick[1] | Andrew Jarvis[2] | Eva Boegh[3] | Darren Drewry[4] | Lucien Hoffmann[1]

[1]Dept. Environment & Agrobiotechnologies, CRP-Gabriel Lippmann, [2]Lancaster Environment Centre, Lancaster University, UK
[3]Dept. Environmental, Social & Spatial Change, Roskilde University, Denmark, [4]Climate Physics Group, Jet Propulsion Laboratory , NASA, US

Questions?

How sensitive are the terrestrial evapotranspiration (*E or λE*) models to the surface wetness (*W*) representation?

Introduction

The sensitivity of *E* to soil moisture (θ) (or *W*) is central in thermal remote sensing based surface energy balance modeling and also within the coupled land-atmosphere modeling studies. The sensitivity mainly arises due to the high response of the stomatal conductance (g_S) to the moisture stress and response of the aerodynamic conductance (g_B) to moisture induced convection. However, little is known on the magnitude of the sensitivity, due to the lack of concomitant observations of *W* and *E* at same spatio-temporal scales. In water controlled ecosystems, the heterogeneous nature of rainfall creates a non-linear *W* - *E* interaction to form a complex surface-atmosphere interaction dynamics.

Radiometric surface temperature (T_R) measured via thermal infrared (TIR) remote sensing provides direct information on *W* (Anderson et al., 2007) and surface energy balance partitioning. Although recent advancements in TIR remote sensing have led to the improvements in the direct retrieval of *W*, not much efforts are given towards establishing a framework which accommodates the feedback of *W* on *E*.

Recognizing this and motivated by the advent of TIR remote sensing, we have developed a novel *E* retrieval scheme in the framework of **Surface Temperature Initiated Closure (STIC)** **(Mallick et al., 2014)** that incorporates the effects of *W* on *E*.

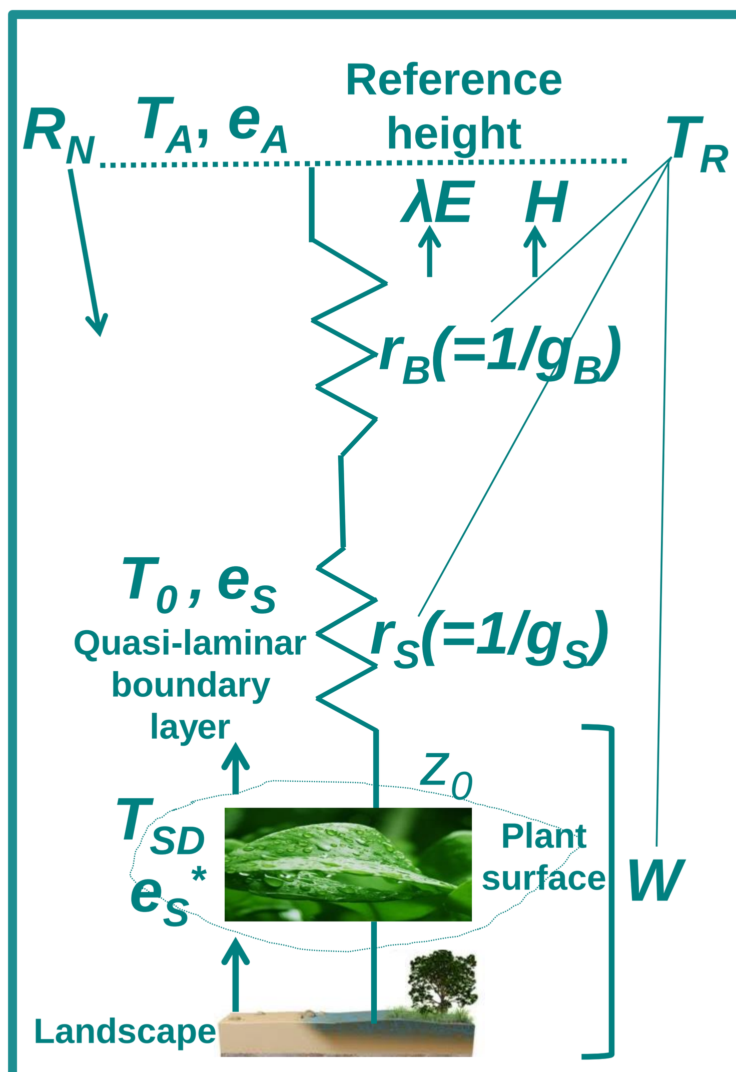
Objectives

- Representing *W* as an internal state in T_R based *E* retrieval framework and developing a holistic framework of *W* retrieval.
- Quantifying the impact of *W* representation on the error structure of *E*.

Acknowledgements
We thank FLUXNET site PIs for the eddy covariance data, ORNL for harmonized MODIS data, NASA NEO for CERES data and BADC for the CRU data.

Methodology

STIC is a single-source approach which **physically integrates T_R into the Penman-Monteith (PM) equation**. STIC is formed by the simultaneous solution of four state equations and it uses T_R as an additional data source for retrieving *W* within a holistic framework.



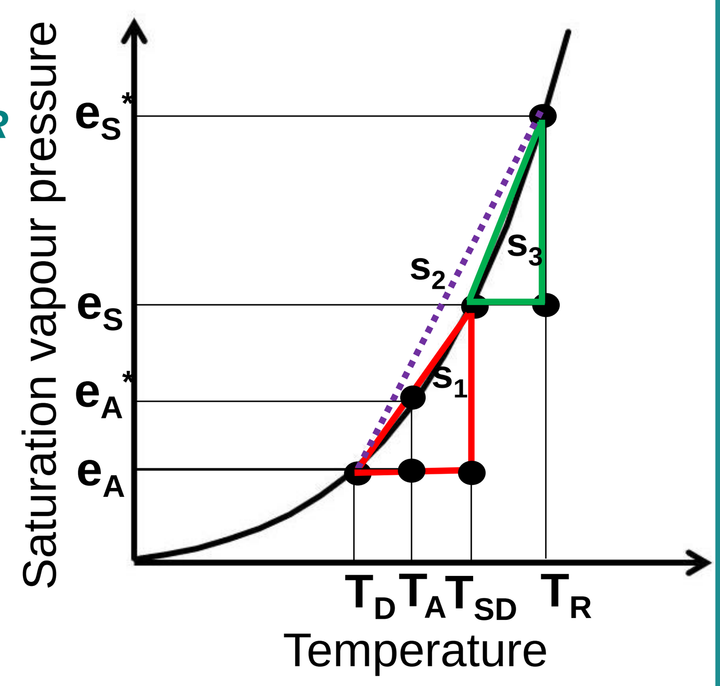
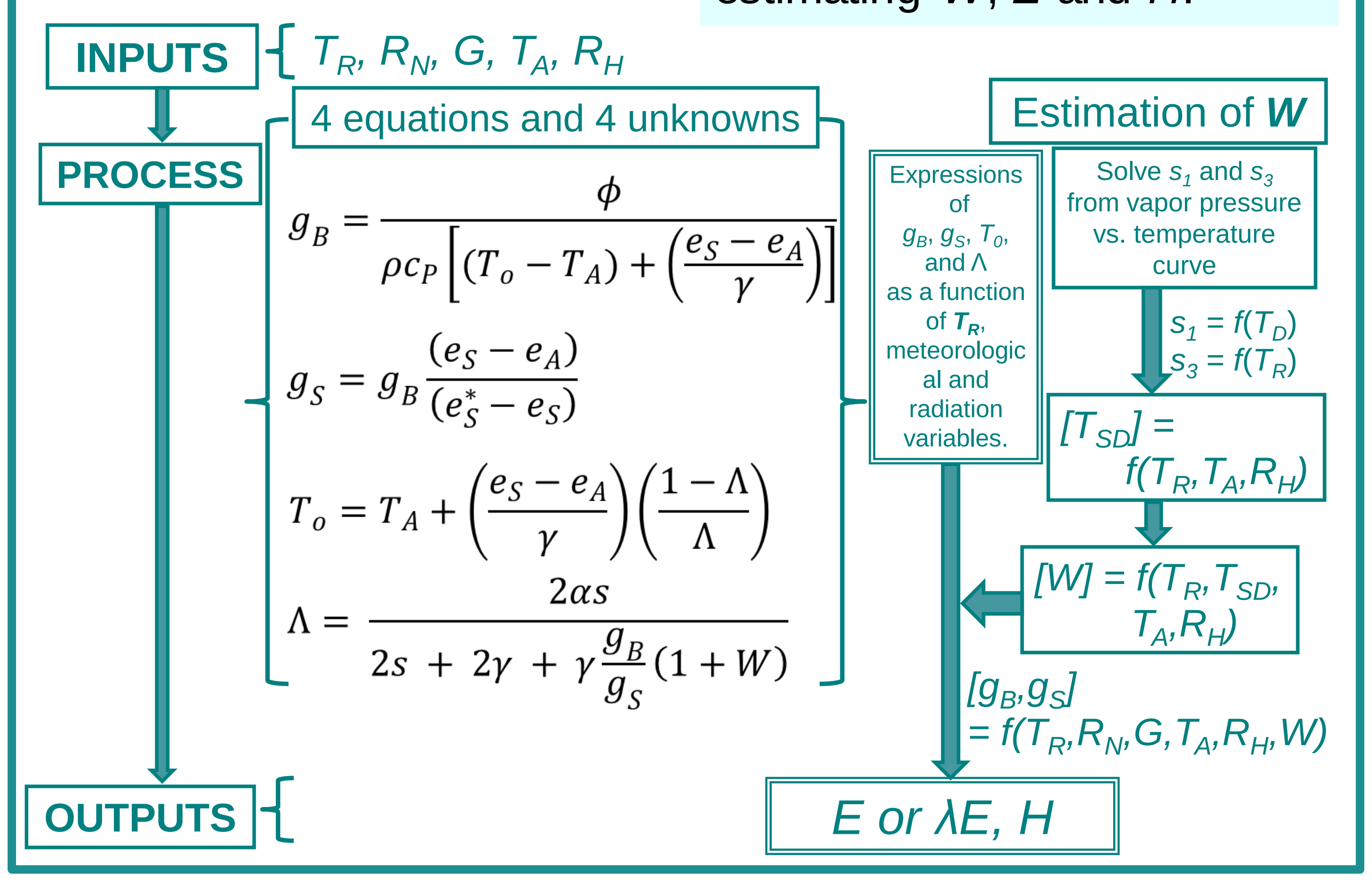


Figure 1: (left) Schematic description of one-dimensional STIC, (above) Conceptual diagram of slope saturation vapor pressure vs. temperature that was used to retrieve *W*, and (below) Computational sequence for estimating *W*, *E* and *H*.



Study area and dataset

- MODIS Terra-Aqua T_R (MOD11A2 & MYD11A2), tower radiation and meteorology of FLUXNET sites (majorly semi-arid).
- **CERES radiation** and **CRU (Climate Research Unit, UEA) meteorology** for global E at 0.25° x 0.25° spatial resolution.

- **Why:** (1) Strong land-atmosphere coupling in the semi-arid regions.
- (2) Limited water in agricultural and urban sector is continuously increasing the pressure on the accessible groundwater.

7th International Scientific Conference on the Global Water and Energy Cycle, The Hague, The Netherlands, 14 – 18 July, 2014

Results

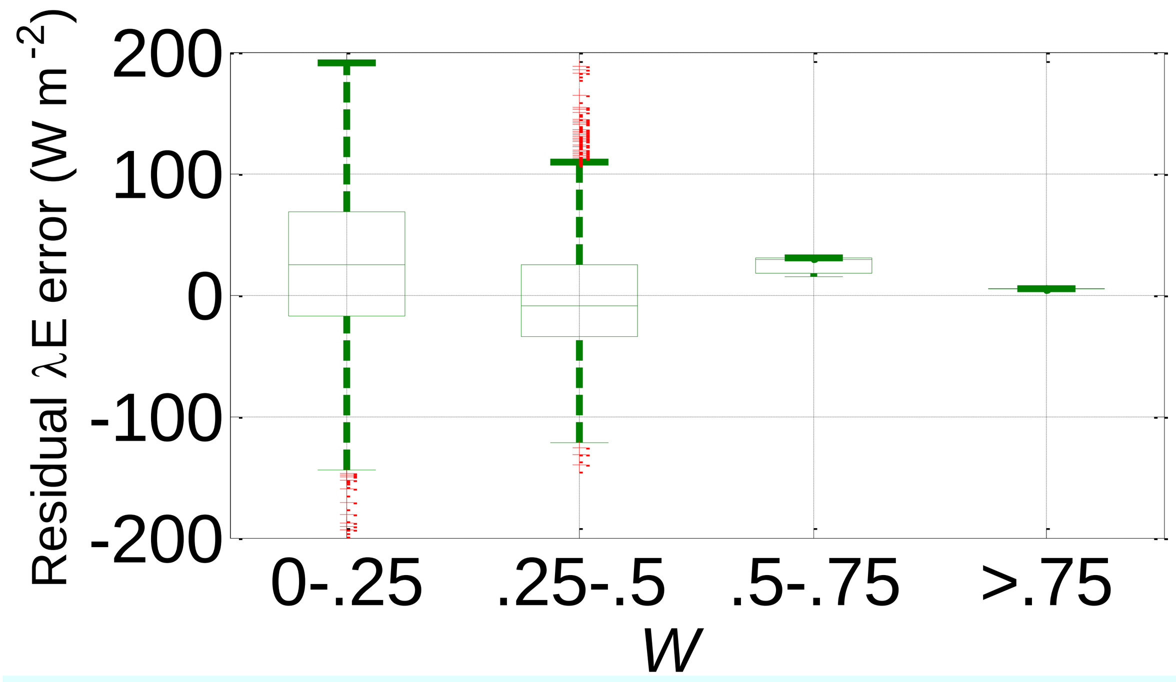


Figure 2: Box plots of statistical results on the impact of *W* retrieval on the residual error in STIC derived *λE.*

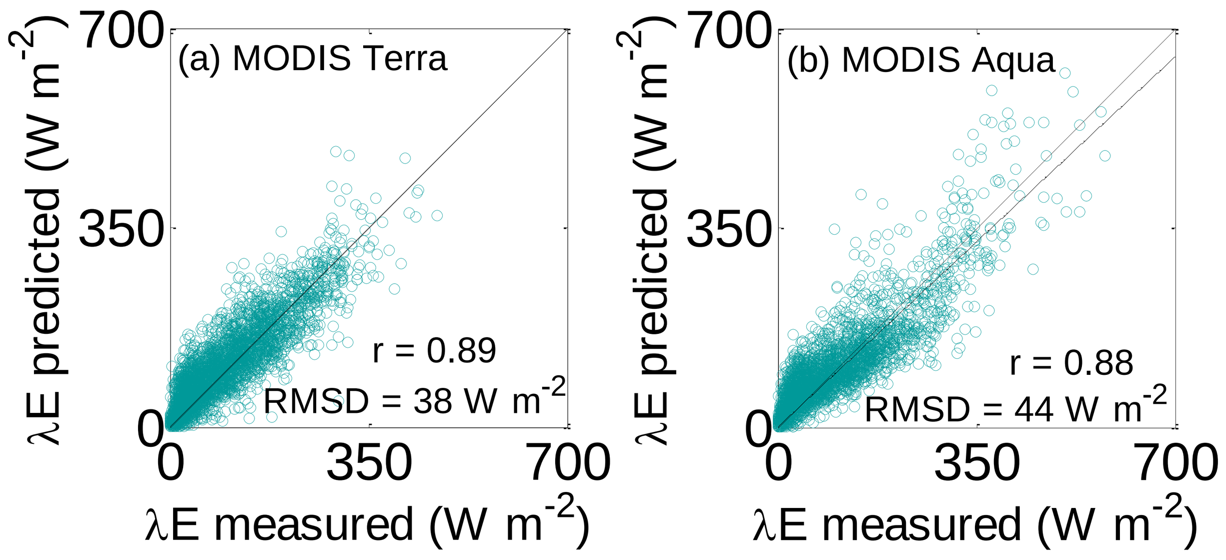


Figure 3: Comparison of measured versus STIC estimates of *λE* using MODIS Terra (a) and Aqua (b) T_R and tower meteorology over 30 FLUXNET sites.

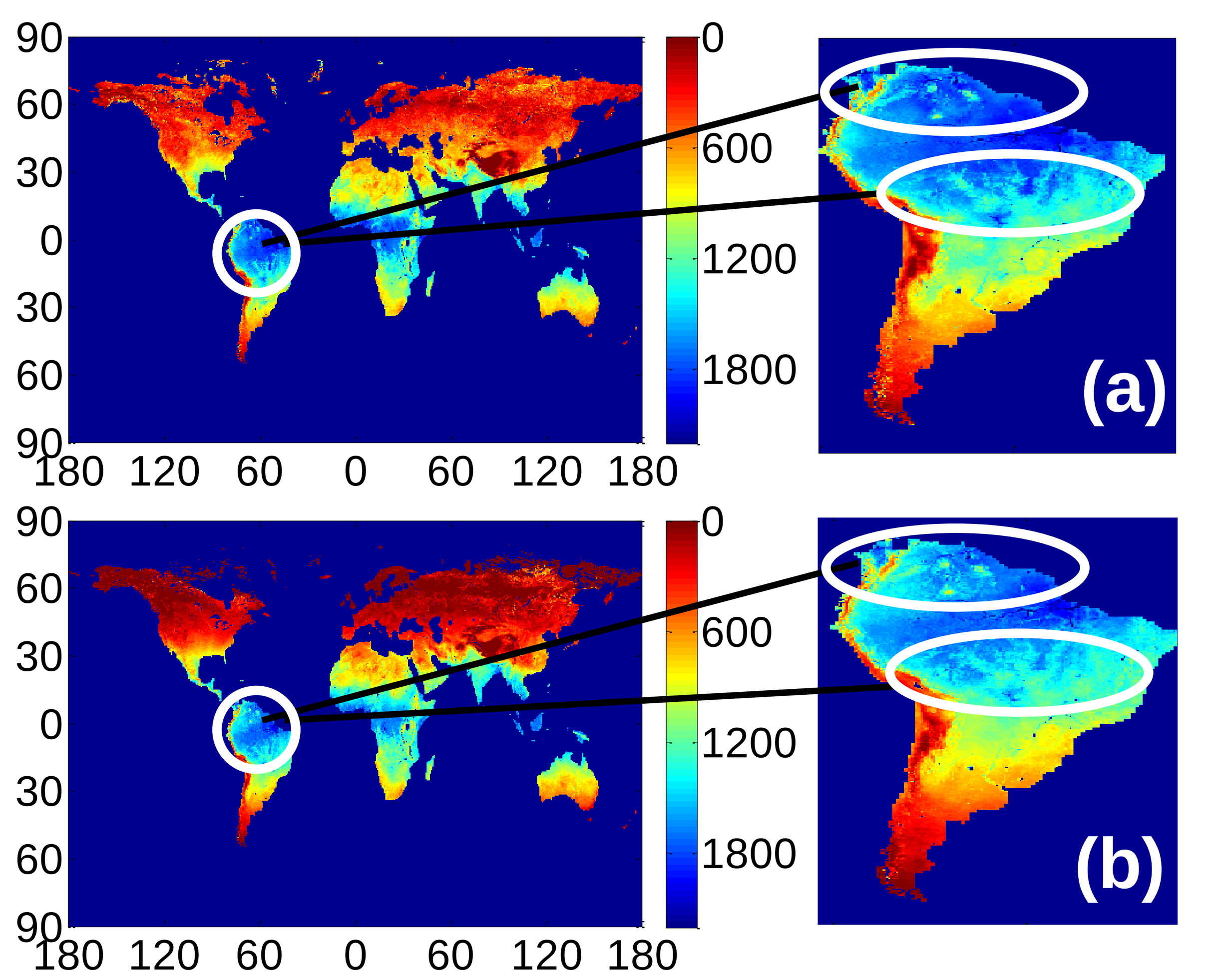


Figure 4: Spatial patterns of annual *E* (mm) over the Amazon river basin for (a) a normal (2007) year and (b) drought (2010) year combining CERES and CRU data at 0.25° x 0.25° spatial resolution.

Conclusion

- Systematic overestimation of *λE* (Fig.2) at low *W*, where *λE* is influenced by tight coupling between radiation, vapor pressure and θ.
- Could capture *W* induced changes in *λE*.
- **New global *E* based on CERES data for CMIP6 *E* evaluation.**.

Reference

Anderson MC, et al. (2007), A climatological study of evapotranspiration and moisture stress across the continental United States based on thermal remote sensing. 1: Model formulation. *Journal of Geophysical Research*, **112**(D10117), 1–17.

Mallick K, et al. (2014), A surface temperature initiated closure for the surface energy balance fluxes, *Remote Sensing of Environment*, **141**, 243-261.

Contact:
mallick@lippmann.lu
Phone: +352 470261425

Dept. Environment and Agrobiotechnologies
Centre de Recherche Public – Gabriel Lippmann
Belvaux, Luxembourg
www.lippmann.lu