TERENO OZCAR International Conference 25-28 Sept 2023, Bonn

PHENOROB

JÜLICH Forschungszentrum

Unmanned Aircraft Systems (UAS) Evapotranspiration Estimates Evaluated in Comparison with TERENO Eddy Covariance Measurements

Jordan Bates[1], Carsten Montzka[1], Harry Vereecken[1], François Jonard[1,2]

1. Institute of Bio- and Geosciences (IBG-3) Forschungszentrum Jülich

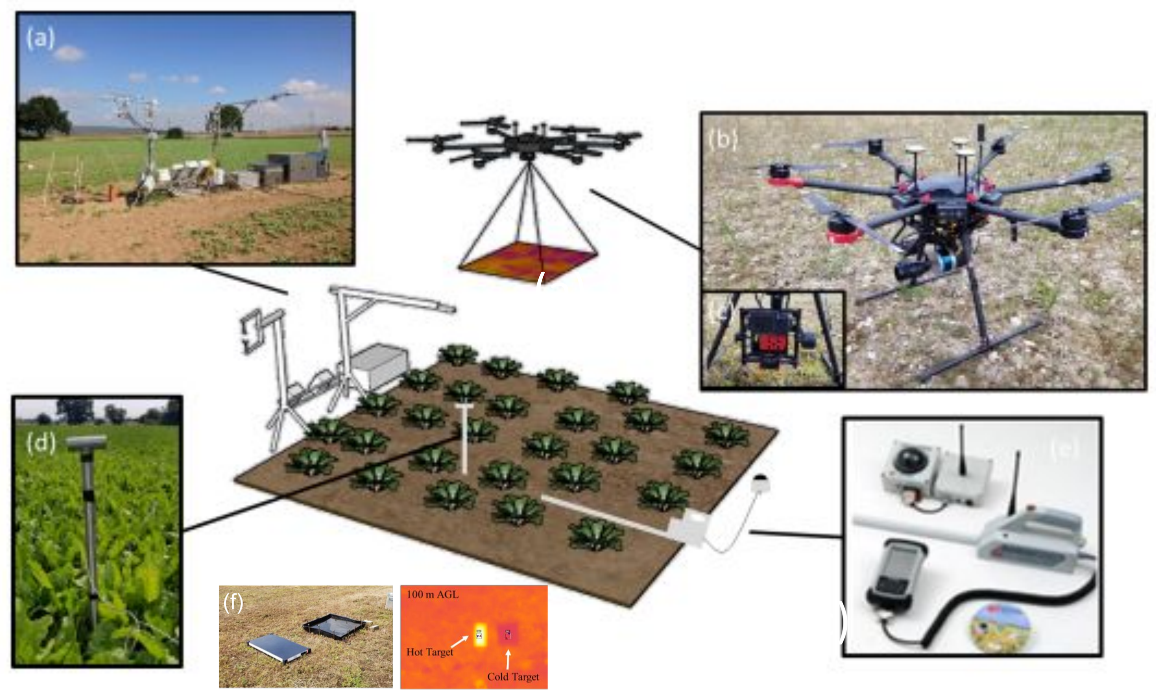
2. Earth Observation and Ecosystem Modelling Laboratory, SPHERES Research Unit, Université de Liège

Introduction

Evapotranspiration (ET) is important for understanding water use and demand. More complete and frequent depictions of ET would allow for improved precision and responsive irrigation planning furthering the farmer's resource efficiency. Unmanned aircraft systems (UAS) offer the ability to collect data at unprecedented spatial resolutions while also allowing on-demand collection for flexibilities in temporal resolutions. More traditional means of ET estimations are performed with lysimeters and flux towers, but these methods only provide limited coverage of the area with limited to no information on the true range and variability, leaving much to be assumed. Satellite remote sensing provides feasible regional scale estimations but can still be considered coarse in cases of smaller scales. Additionally, satellites can only provide data on a fixed schedule which is further complicated with cloud coverage. The greater possibilities in spatial and temporal resolution make UAS the ideal means for ET estimations at scales in the field level and smaller. Most ET models being used with UAS data are those that were created around satellite remote sensing including the two source energy balance (TSEB) model that is used in this study. The experiment included a 10 hectare sugar beet field which has little canopy coverage at the beginning of the growing season to practically complete convergence in the later stages. This allowed for testing of the TSEB model robustness in a dynamic canopy.

Study Area & Experimental Design

Equipment used in this study with (a) climate station / flux tower located in the center of the field for model inputs and validation of ET estimations (b) DJI Matrice 600 multirotor UAS with LiDAR for crop height (c) thermal IR and multispectral sensors used for land surface temperature and leaf area index (d) measuring stick for crop height validations (e) SunScan SS1 comptometer for LAI calibrations and validations (f) ground thermal targets for thermal sensor accuracy assessment and calibration.



Methods

UAS Sensor derived data model inputs

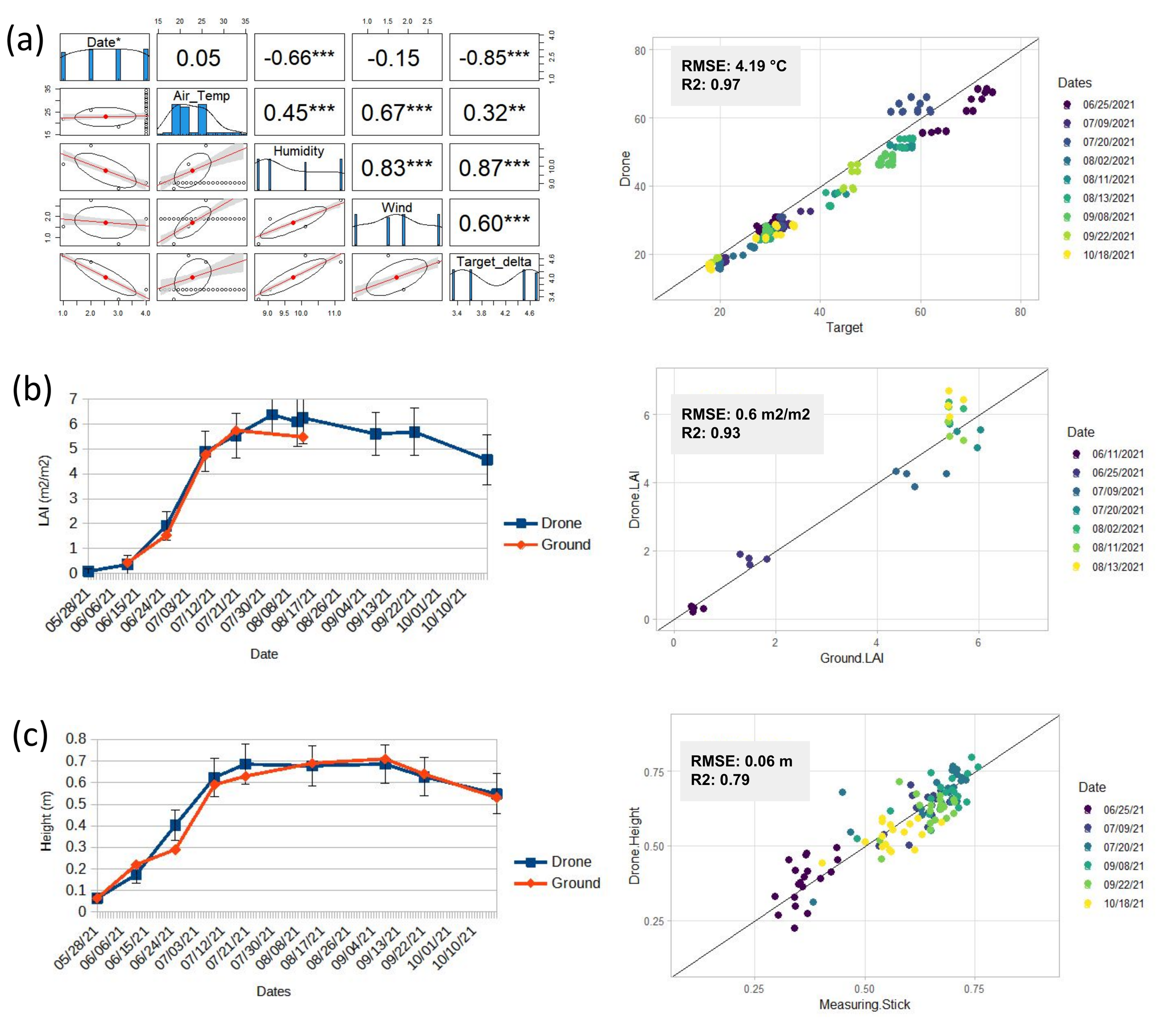


Figure 1. Data collected via drone for inputs and their associated accuracies and temporal trends if relevant with (a) thermal IR data accuracy considerations and comparison to thermal calibration targets (b) LAI accuracy to ground ceptometer measurements (c) LiDAR height to measuring stick

TSEB-PT Model

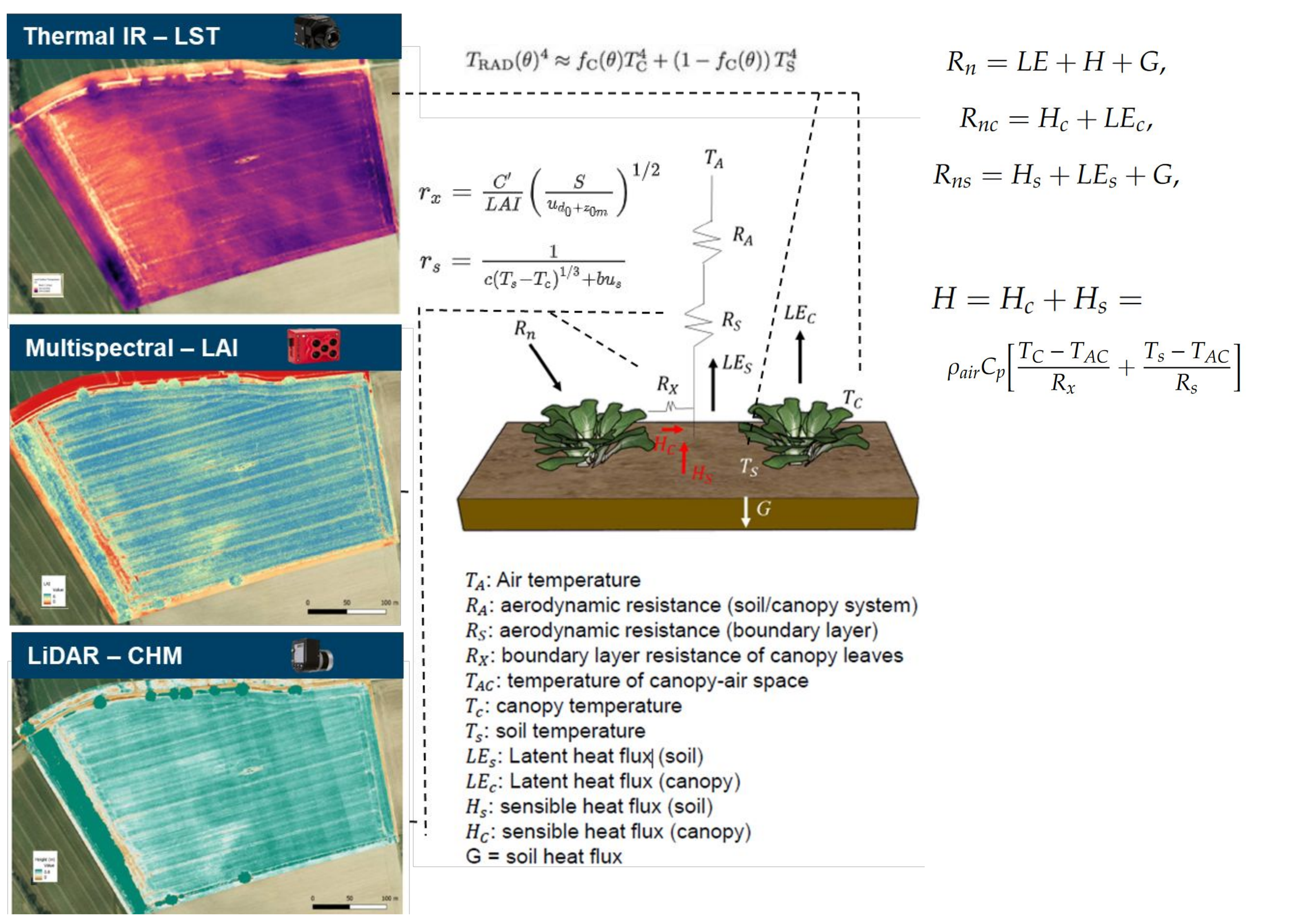


Figure 2. Schematic diagram and formulas illustrating the TSEB model and the drone data inputs involved. Rn is net radiation (W m−2), H is sensible heat flux (W m−2), LE is latent heat flux (W m−2), and G is soil heat flux (W m−2). Subscripts "s" and "c" represent the soil and canopy flux components, respectively.

UAS based ET Estimation Validation

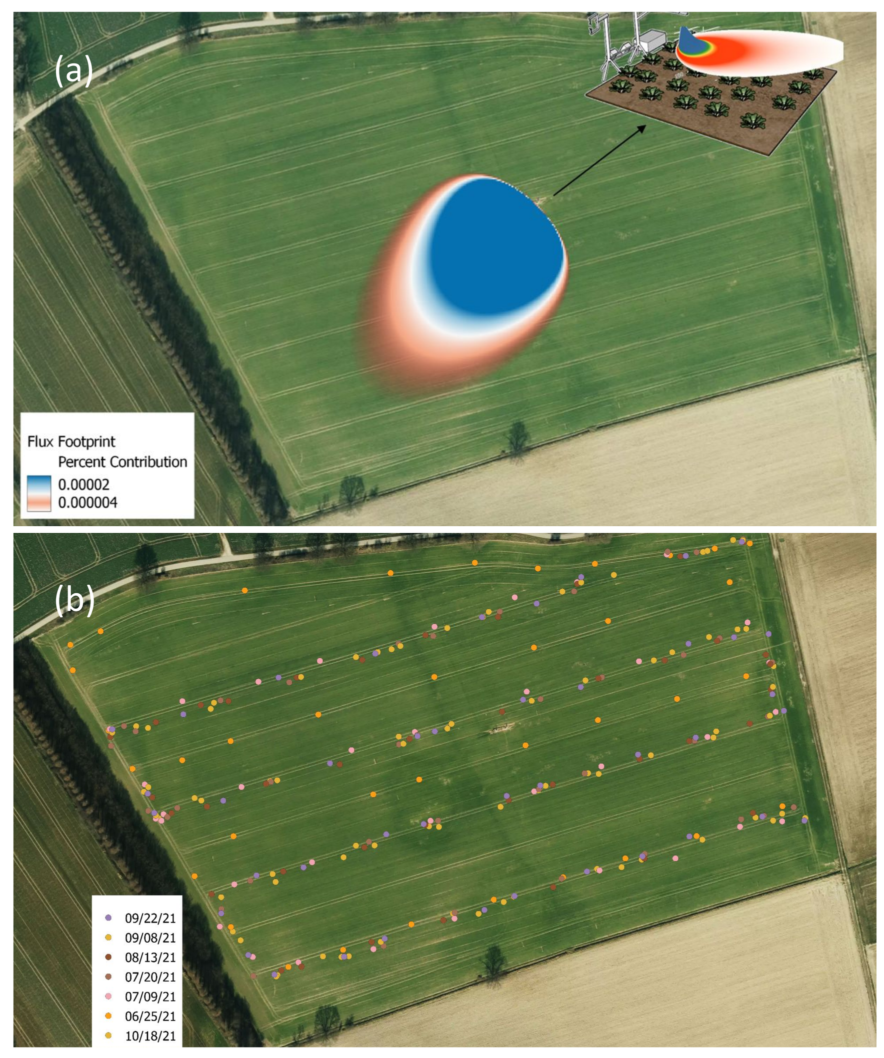


Figure 3. (a) Evaluated in comparison to eddy-covariance (EC) from the climate station where the weighted average of the footprint was take from the UAS data (b) HydraProbe locations of soil moisture and crop height

Results

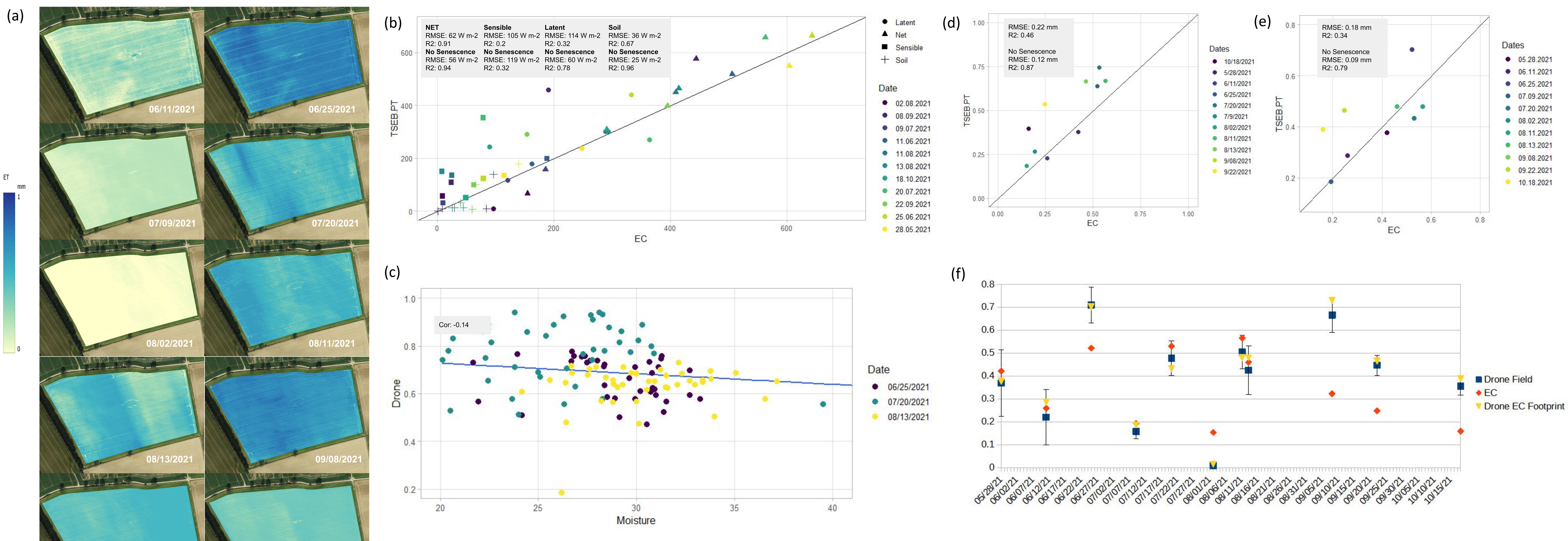


Figure 4. (a) Evapotranspiration (ET) maps produced from TSEB model for each date (b) TSEB fluxes estimations compared to EC fluxes (c) HydraProbe moisture data compared to TSEB ET for validation of the spatial variation depicted in the ET rasters (d) drone and eddy covariance ET comparisons with all dates and then senescence dates removed (e) drone and eddy covariance ET comparisons with all dates and then senescence dates removed with drone thermal data calibrated with thermal targets (f) the mean ET of the drone TSEB raster, drone TSEB weighted ET average within flux footprint, and EC ET average within flux footprint

[1] Norman, J.M.; Kustas, W.P.; Humes, K.S. Source approach for estimating soil and vegetation energy fluxes in observations of directional radiometric surface temperature. Therm. Remote Sens. Energy Water Balance Veg. 1995, 77, 263–293.

Contact Information: j.bates@fz-Juelich.de