Understanding the diurnal variation in evaporation using pattern-based evaluation of evaporation schemes: a case study in Luxembourg

Maik Renner (1), Claire Brenner (2), Kansika Mallick (3), Hans-Dieter Wizemann (4), Ivonne Trebs (3), Jianhui Wei (4), Volker Wulfmeyer (4), Karsten Schulz (2), and Axel Kleidon (1)

(1) Max-Planck-Institute for Biogeochemistry, Biospheric Theory and Modelling Group, Jena, Germany (mrenner@bgc-jena.mpg.de), (2) Universität für Bodenkultur Wien, Institut für Wasserwirtschaft, Hydrologie und konstruktiven Wasserbau, (3) Luxembourg Institute of Science and Technology (LIST), Department ERIN - Environmental Research and Innovation, (4) Universität Hohenheim, Institut für Physik und Meteorologie

The diurnal forcing of solar radiation is the largest signal within the land-surface system and dominates the diurnal cycle of the turbulent heat fluxes and evapotranspiration ($\lambda E$). Thus to first order, $\lambda E$ should linearly respond to incoming solar radiation ($R_{sd}$), while the influence of other drivers, in particular heat storage and land-atmosphere interactions would lead to consistent deviations. For example a lag in time would form a loop (hysteresis) when plotted against solar radiation. Here we evaluate simple evaporation schemes in their ability to reproduce the diurnal course of observations under sunny conditions comparing wet and dry days. Observations from an Eddy Covariance site over grassland in Luxembourg show a remarkable linear relationship of $\lambda E$ with $R_{sd}$, which tends towards a counter-clockwise (CCW) hysteresis with higher values in the afternoon during wetter periods. This CCW hysteresis in $\lambda E$ is compensated by a clockwise (CW) hysteresis of sensible heat flux. Under dry conditions when atmospheric boundary layer growth is larger we observe a higher aerodynamic conductance and a more linear relationship of the fluxes to $R_{sd}$. We find that single and a two source energy balance model which both use a gradient - resistance scheme for the derivation of the sensible heat flux reproduce the patterns relatively well for both wet and dry conditions. However, a scheme based on the Penman-Monteith equation which typically also use vapor pressure deficit (VPD) as input variable is less able to reproduce the reduction of hysteresis in $\lambda E$ under dry conditions. This may arise from the conceptual difficulty to compensate for the strong CCW hysteresis in VPD which reflects the influence of temperature and boundary layer development on $\lambda E$. We conclude that a pattern-based evaluation on the diurnal response to solar radiation provides physical insights into land-atmosphere coupling to improve existing land-surface schemes.