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The role of aerodynamic resistance in thermal remote sensing-based evapotranspiration models

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‘Aerodynamic resistance’ (hereafter r_a) is a preeminent variable in the modelling of evapotranspiration (ET), and its accurate quantification plays a critical role in determining the performance and consistency of thermal remote sensing-based surface energy balance (SEB) models for estimating ET at local to regional scales. Atmospheric stability links r_a with land surface temperature (LST) and the representation of their interactions in the SEB models determines the accuracy of ET estimates.

The present study investigates the influence of r_a and its relation to LST uncertainties on the performance of three structurally different SEB models by combining nine OzFlux eddy covariance datasets from 2011 to 2019 from sites of different aridity in Australia with MODIS Terra and Aqua LST and leaf area index (LAI) products. Simulations of the latent heat flux (LE, energy equivalent of ET in W/m^2) from the SPARSE (Soil Plant Atmosphere and Remote Sensing Evapotranspiration), SEBS (Surface Energy Balance System) and STIC (Surface Temperature Initiated Closure) models forced with MODIS LST, LAI, and in-situ meteorological datasets were evaluated using observed flux data across water-limited (semi-arid and arid) and radiation-limited (mesic) ecosystems.

Our results revealed that the three models tend to overestimate instantaneous LE in the water-limited shrubland, woodland and grassland ecosystems by up to 60% on average, which was caused by an underestimation of the sensible heat flux (H). LE overestimation was associated with discrepancies in r_a retrievals under conditions of high atmospheric instability, during which errors

in LST (expressed as the difference between MODIS LST and in-situ LST) apparently played a minor role. On the other hand, a positive bias in LST coincides with low r_a and causes slight underestimation of LE at the water-limited sites. The impact of r_a on the LE residual error was found to be of the same magnitude as the influence of errors in LST in the semi-arid ecosystems as indicated by variable importance in projection (VIP) coefficients from partial least squares regression above unity. In contrast, our results for mesic forest ecosystems indicated minor dependency on r_a for modelling LE (VIP<0.4), which was due to a higher roughness length and lower LST resulting in dominance of mechanically generated turbulence, thereby diminishing the importance of atmospheric stability in the determination of r_a.