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Determine Forest Turbulent Transport and Evapotranspiration Partition With the Help of a new Soil Water Isotope Model

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We determine simultaneously the vertical profile of forest canopy turbulent transport and evapotranspiration ET partition in a Eucalypt forest in South-Eastern Australia for a two-week period in November 2006. We use non-linear parameter estimation to optimise agreement between modelled and measured vertical profiles of temperature, water vapour, carbon dioxide, and deuterium content of water vapour. Modelled temperature and concentration profiles are derived from Lagrangian dispersion theory together with a Soil Vegetation Atmospheric Transfer (SVAT) model, which was enhanced by a new isotopically enabled hydrologic scheme for coupled transport of heat, water and stable isotopes (HDO and $H_2{}^{18}O$) in soil and litter. We first present the new water isotope model, Soil-Litter-iso[1], which is suitable for use as part of a SVAT scheme but also as part of an isotopically enabled land surface model. We show that it is sufficiently efficient for use at regional scale, yet includes the complexity of coupled heat and water transport enabling decomposition of the total moisture flux into liquid and vapour components. The model permits the isotopic calculations to be performed with thick soil layers and large times steps, resulting in significantly improved computational efficiency compared with existing isotopically-enabled soil models of similar complexity.

Deuterium contents of soil evaporation and vertically-resolved transpiration as *a priori* estimates for the optimisation are then derived using the SVAT model with Soil-Litter-Iso for the isotopic composition of soil evaporates and an advection-diffusion model for leaf water and transpiration isotopes[2]. Predictions of deuterium in soil evaporate were validated using soil chamber measurements, while the transpirate predictions were validated using isotopic analyses of leaf and xylem water, combined with leaf-level gas exchange measurements. Hence, modelled temperature and concentration profiles are generated using Lagrangian dispersion theory combined with source/sink distributions of sensible heat, CO_2, H_2O and HDO coming from the SVAT model. Optimisation of turbulent transport and ET partition was then performed twice: once using only temperature, CO_2 and H_2O profiles[3] and a second time including deuterium content of water vapour δD as well[4]. The modelled vertical concentration profiles resulting from inclusion of δD demonstrate our ability to make consistent estimates of both the scalar source distributions and the deuterium content of the water vapour sources. However, introducing measurements of deuterium in water vapour does not significantly alter resulting estimates of turbulent transport (normalised Lagrangian time scale T_L at canopy top: 0.4 ± 0.1 vs. 0.5 ± 0.1 without δD) and the ET partition ($15 \pm 2\%$ soil evaporation vs. $17 \pm 2\%$), suggesting that the additional data and modelling required to use deuterium are not warranted for the purpose of partitioning ET using the framework presented here.

References

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