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Can stable isotope measurements constrain a canopy-scale model of carbon and water budgets?

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A multi-layer canopy model for the fluxes of solar radiation, heat, water vapour and carbon dioxide (including D/H and $^{13}C/^{12}C$ fractionation) is combined with a model for atmospheric transport to examine whether within-canopy profiles of isotopic ratios in H_2O and CO_2 provide useful constraints on model predictions. The canopy model includes: (1) radiation distribution within a clumped canopy, (2) a leaf-level model that couples stomatal conductance, photosynthesis and energy partitioning in response to atmospheric water vapour pressure deficit and water availability from the soil, (3) a multi-layer soil model for fluxes of heat into the soil and air and soil evaporation, (4) heat storage fluxes in the canopy air and biomass, (5) parameterizations for soil and biomass respiration rate, and (6) evaluation of $\delta^{13}C$ and δD in CO_2 and water fluxes at the leaf and soil levels. Lagrangian dispersion theory is used to calculate concentration profiles from the modeled source/sink distributions.

Non-linear parameter estimation is used to minimize the difference between model predictions and measurements of fluxes above the canopy and vertical profiles of concentrations and isotopic fractionations within the canopy of a tall temperate eucalyptus forest in south-eastern Australia. The value of including isotopic profiles in the parameter estimation is assessed, in terms of the additional constraint which they impose on model parameters, and hence on modeled CO_2 and H_2O budgets.

Measurements and new techniques are detailed in separate papers in this session (Grif-

fith et al., Tadros et al.): they include continuous vertical profiles of concentrations and isotopic fractionations of H_2O and CO_2 using real-time FTIR spectroscopic analysis, the isotopic signatures of water and CO_2 exchange in soil and leaf chambers, and the isotopic characterisation of water from important soil, tree and leaf reservoirs.