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Canopy structure is one of the most important vegetation characteristics for land-atmosphere interactions as it determines the energy and scalar exchanges between land surface and overlay air mass. In this study we evaluated the performance of a newly developed multi-layer energy budget (Ryder et al., 2014) in a land surface model, ORCHIDEE-CAN (Naudts et al., 2014), which simulates canopy structure and can be coupled to an atmospheric model using an implicit procedure. Furthermore, a vertical discrete drag parametrization scheme was also incorporated into this model, in order to obtain a better description of the sub-canopy wind profile simulation. Site level datasets, including the top-of-the-canopy and sub-canopy observations made available from eight flux observation sites, were collected in order to conduct this evaluation. The geo-location of the collected observation sites crossed climate zones from temperate to boreal and the vegetation types included deciduous, evergreen broad leaved and evergreen needle leaved forest with maximum LAI ranging from 2.1 to 7.0. First, we used long-term top-of-the-canopy measurements to analyze the performance of the current one-layer energy budget in ORCHIDEE-CAN. Three major processes were identified for improvement through the implementation of a multi-layer energy budget: 1) night time radiation balance, 2) energy partitioning during winter and 3) prediction of the ground heat flux. Short-term sub-canopy observations were used to calibrate the parameters in sub-canopy radiation, turbulence and resistances modules with an automatic tuning process following the maximum gradient of the user-defined objective function.

The multi-layer model is able to capture the dynamic of sub-canopy turbulence, temperature and energy fluxes with imposed LAI profile and optimized parameter set at a site level calibration. The simulation result shows the improvement both on the nighttime energy balance and energy partitioning during winter and presents a better Taylor skill score, compared to the result from single layer simulation. The importance of using the multi-layer energy budget in a land surface model for coupling to the atmospheric model will also be discussed in this presentation.

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