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Towards a more detailed representation of the energy balance in a coupled land surface model

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Currently, the land-surface region sequesters 25% of global CO_2 emissions. In addition to climate change, increasing atmospheric CO_2 concentrations, fertilisation and nitrogen deposition, this sink is thought to be largely due to land management. When applied deliberately to enhance the terrestrial carbon sink strength, this land management may have unintended effects on the energy budget, potentially offsetting the radiative effect of carbon sequestration.

As with other land surface models, the present release of ORCHIDEE (the land surface model of the IPSL Earth system model) has difficulties in reproducing consistently observed energy balances (Pitman et al., 2009; Jimenez et al., 2011; de Noblet-Ducoudré et al., 2011). Hence, the model must be improved to be better able to study the radiative effect of forest management and land use change. This observation serves as a starting point in this research – improving the level of detail in energy balance simulations of the surface layer.

We here outline the structure of a new detailed and practical simulation of the energy budget that is currently under development within the surface model ORCHIDEE, and will be coupled to the atmospheric model LMDZ.

The most detailed simulations of the surface layer energy budget are detailed iterative multi-layer canopy models, such as Ogeé et al. (2003), which are linked to specific measurement sites and do not interact with the atmosphere. In this current project, we aim to create a model that will implement the insights obtained in those previous studies and improve upon the present ORCHIDEE parameterisation, but will run stably and efficiently when coupled to an atmospheric model.

This work involves a replacement of the existing allocation of 14 different types of vegetation within each surface tile (the 'Plant Functional Types') by a more granular scheme that can be modified to reflect changes in attributes such as vegetation density, leaf type, distribution (clumping factors), age and height of vegetation within the surface tile. There will be the implementation of more than one canopy vegetation layer to simulate the effects of scalar gradients within the canopy for determining, more accurately, the net sensible and latent heat fluxes that are passed to the atmosphere.

The model will include representation of characteristics such as in-canopy transport, coupling with sensible heat flux from the soil, a multilayer radiation budget and stomatal resistance, and interaction with the bare soil flux within the canopy space (and also with snow pack). We present how the implicit coupling approach of Polcher et al. (1998) and Best et al. (2004) is to be extended to a multilayer scenario, present initial sensitivity studies and outline future testing scenarios and validation plans.