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First steps towards modelling the intra-canopy microclimate in the ORCHIDEE Land Surface Model

Julien Alléon[1], Catherine Ottlé[1], Nicolas Vuichard[1], Sebastiaan Luyssaert[3], Klara Bouwen[2], Jérôme Ogée[2], and Philippe Peylin[1]

[1]Laboratoire des Sciences du Climat et de l'Environnement (LSCE), Saint-Aubin, France
[2]INRA, UMR 1391 ISPA, Villenave d'Ornon, France
[3]Departement of Ecological Sciences, Vrije Universiteit Amsterdam, Amsterdam, Netherlands

Intra-canopy microclimate and regional climate are two highly related components of the Earth system. On one side, intra-canopy microclimate influences strongly the ecosystem itself by regulating the vegetation/atmosphere exchanges which further influence plant dynamics, carbon sequestration and soil water dynamics. It also influences the biodiversity below the canopy by offering microhabitats or temperature buffering, and the regional climate directly by regulating the water and energy exchanges with the lowest levels of the atmosphere. On the other side, regional climate has a strong impact on intra-canopy microclimate, especially in the context of climate change, by reducing temperature gradients or by controlling the vegetation phenology. Despite this apparent strong imbrication, intra-canopy microclimates are very poorly represented in Land Surface Models (LSMs) and climate models in general, making it complicated to study their impact on climate change mitigation or the impact of climate change on the forests and their microclimates. Because of their time computing requirements, LSMs usually prefer simple models such as the "Big-Leaf" representation. However, in front of the urgent need to represent complex ecosystems and microclimates in Earth system models, first steps in this direction can be made, especially to improve the energy and water fluxes in the soil-vegetation-atmosphere continuum. This study presents recent developments made in the ORCHIDEE LSM. Two models have been implemented in ORCHIDEE in order to move from the current big leaf approach at the grid-cell scale to a representation of vertical gradients associated to the microclimate. To do so, firstly, a representation of the water flow in the soil-plant-atmosphere continuum through a hydraulic architecture model has been introduced. Secondly, a previous multi-layer energy budget representation, including turbulent vertical exchanges within the canopy, has been updated to make it operational with the current trunk of ORCHIDEE. Those two models enable a better representation of the intra-canopy leaf-atmosphere exchanges at the Plant Functional Type (PFT) level. Lastly, a representation of the sub-grid heterogeneity is also being implemented enabling a global representation of each PFT intra-canopy microclimates. This presentation will mainly focus on the multi-layer energy budget representation and its applications for different ecosystems at larger scale. Firstly, a comparison between ORCHIDEE and the forest model MuSICA (Ogée et al. (2003)) was performed over several forest sites highlighting the potential benefits as well as the difficulties of modelling the vertical gradients of temperature, wind and humidity within the

canopy. Secondly, a first large scale representation of intra-canopy microclimate and its impact on ORCHIDEE energy and water budgets will be presented. Finally, opening perspectives induced by those developments in the ORCHIDEE LSM will be drawn.