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Understanding in and above canopy-atmosphere interactions by combining large-eddy simulations with a comprehensive observational set

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The vegetated canopy plays a key role in regulating the surface fluxes and, therefore, the global energy, water and carbon cycles. In particular, vulnerable ecosystems like the Amazonia basin can be very sensitive to changes in vegetation that exert subsequent shifts in the partition of the energy, water and carbon in and above the canopy. Despite this relevance, most 3D atmospheric models represent the vegetated canopy as a flat 2D layer with, at most, a rough imitation of its effect in the atmospheric boundary layer through a modified roughness length. Thus, the representations often describe quite crudely the surface fluxes. In this work, particular emphasis is placed in the biophysical processes that take place within the canopy and its impact above. Our approach is to represent the coupling of the flow between the canopy and the atmosphere including the following processes: radiative transfer, photosynthesis, soil evaporation and CO2 respiration, combined with the mostly explicit atmospheric turbulence within and above the canopy. To this end, we implemented in LES a detailed multi-layer canopy model that solves the leaf energy balance for sunlit and shaded leaves independently, regulating the exchange of heat, moisture and carbon between the leaves and the air around. This allows us to connect the mechanistically represented processes occurring at the leaf level and strongly regulated by the transfer of diffuse and direct radiation within the canopy to the turbulent mixing explicitly resolved at the meter scale.

We test and validate this combined photosynthesis-turbulence-canopy model by simulating a representative clear day transitioning to shallow cumulus. We based our evaluation on observations by the GoAmazon2014/5 campaign in Brazil in 2014. More specifically, we systematically validate the in-canopy radiation profiles; sources, sinks and turbulent fluxes of moisture, heat and CO2, and main state variables within the canopy, and also study the effects of these in the air above. Preliminary results show an encouraging satisfactory match to the observed evolution of the profiles. As a first exploration and demonstration of the capabilities of the model, we test the effects of a coarser in-canopy resolution, a different radiation scheme and the use of a more simple 2D canopy representation.