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The seasonal behaviour of carbon fluxes in the Amazon: fusion of FLUXNET data and the ORCHIDEE model

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Eddy covariance measurements at the Santarém (km 67) site revealed an unexpected seasonal pattern in carbon fluxes which could not be simulated by existing state-of-the-art global ecosystem models (Saleska et al., Sciece 2003). An unexpected high carbon uptake was measured during dry season. In contrast, carbon release was observed in the wet season.

There are several possible (combined) underlying mechanisms of this phenomenon: (1) an increased soil respiration due to soil moisture in the wet season, (2) increased photosynthesis during the dry season due to deep rooting, hydraulic lift, increased radiation and/or a leaf flush.

The objective of this study is to optimise the ORCHIDEE model using eddy covariance data in order to be able to mimic the seasonal response of carbon fluxes to dry/wet conditions in tropical forest ecosystems. By doing this, we try to identify the underlying mechanisms of this seasonal response.

The ORCHIDEE model is a state of the art mechanistic global vegetation model that can be run at local or global scale. It calculates the carbon and water cycle in the different soil and vegetation pools and resolves the diurnal cycle of fluxes. ORCHIDEE is built on the concept of plant functional types (PFT) to describe vegetation. To bring the different carbon pool sizes to realistic values, spin-up runs are used.

ORCHIDEE uses climate variables as drivers together with a number of ecosystem parameters that have been assessed from laboratory and in situ experiments. These parameters are still associated with a large uncertainty and may vary between and within PFTs in a way that is currently not informed or captured by the model. Recently, the development of assimilation techniques allows the objective use of eddy covariance data to improve our knowledge of these parameters in a statistically coherent approach. We use a Bayesian optimisation approach. This approach is based on the minimization of a cost function containing the mismatch between simulated model output and observations as well as the mismatch between a priori and optimized parameters. The parameters can be optimized on different time scales (annually, monthly, daily).

For this study the model is optimised at local scale for 5 eddy flux sites: 4 sites in Brazil and one in French Guyana. The seasonal behaviour of C fluxes in response to wet and dry conditions differs among these sites. Key processes that are optimised include: the effect of the soil water on heterotrophic soil respiration, the effect of soil water availability on stomatal conductance and photosynthesis, and phenology. By optimising several key parameters we could improve the simulation of the seasonal pattern of NEE significantly. Nevertheless, posterior parameters should be interpreted with care, because resulting parameter values might compensate for uncertainties on the model structure or other parameters. Moreover, several critical issues appeared during this study e.g. how to assimilate latent and sensible heat data, when the energy balance is not closed in the data? Optimisation of the Q10 parameter showed that on some sites respiration was not sensitive at all to temperature, which show only small variations in this region. Considering this, one could question the reliability of the partitioned fluxes (GPP/Reco) at these sites. This study also tests if there is coherence between optimised parameter values of different sites within the tropical forest PFT and if the forward model response to climate variations is similar between sites.