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Multiple data stream assimilation with the ORCHIDEE land surface model to improve regional to global simulated carbon and water budgets

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Predicting the fate of land ecosystem carbon and water budgets and their sensitivity to climate change and land use/management strongly relies on our ability to accurately model the carbon/water fluxes exchanged with the atmosphere. However, simulated carbon and water fluxes remain subject to large uncertainties, partly because of unknown or poorly calibrated parameters.

Over the past ten years, we have used a carbon/water cycle data assimilation system at the Laboratoire des Sciences du Climat et de l'Environnement to investigate the benefit of assimilating multiple data streams into the ORCHIDEE LSM, the land surface component of the Institut Pierre Simon Laplace Earth System Model. These datasets have included FLUXNET eddy covariance data (net CO_2 flux and latent heat flux) to constrain hourly to seasonal time-scale carbon cycle processes, remote sensing of the vegetation activity (MODIS NDVI) to constrain the leaf phenology, atmospheric CO_2 concentrations to provide overall large scale constraints on the land carbon sink and in a first attempt satellite derived surface soil moisture (ESA-CCI product) to constrain the temporal dynamic of soil hydrology. Furthermore, we have investigated technical issues related to multiple data stream assimilation and choice of optimization algorithm. This has provided a wide-ranging perspective on the challenges we face in constraining model parameters and thus better quantifying, and reducing, model uncertainty in projections of the future global carbon sink and the evolution of evapotranspiration.

We review our past studies in terms of the impact of the optimization on key characteristics of the carbon cycle, and the link between the carbon and water cycles. We discuss our work in context of the abovementioned challenges, and propose solutions for the community going forward, including the potential of combining new observations (atmospheric COS concentrations; satellite-derived Solar Induced Fluorescence;…).