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Interannual variations in tree-rings' width and isotopic signatures (18O and 13C) combined to optimize ORCHIDEE land surface model

Thomas Launois (1), Philippe Peylin (1), Valérie Daux (1), Valérie Masson-Delmotte (1), Thomas Eglin (1), Valentin Bellassen (1), and Camille Risi (2)

(1) LSCE (Orme des Merisiers), IPSL, CEA, Paris, France (thomas.launois@lsce.ipsl.fr), (2) LMD, IPSL, UPMC, CNRS, Paris, France

Terrestrial ecosystem models are used to predict the response of energy, water and carbon balances of Earth's ecosystems to environmental changes. However, the estimated fluxes remain subject to large uncertainties, mainly because of model weaknesses but also partly because of unknown or poorly calibrated parameters. Assimilation of in situ data should help constraining these parameters and improving simulations of the carbon balance and thus climate predictions. Using a state of the art mechanistic vegetation model ORCHIDEE, involved in the next AR5-IPCC report, we investigated the benefit of new tree-rings datasets to improve the model and particularly the representation of soil hydrological stress. ORCHIDEE computes the energy, carbon and water balances on a half-hourly basis, depending on the meteorological forcing and the biome composition of the ecosystem. We have used ORCHIDEE at several forest sites from Marocco to Northern Europe, over 9 different sites.
The objective is to promote long time series of 3 physiological and climatic tracers: tree-rings widths, and their composition in carbon (13C) and oxygen (18O) isotopes. These tracers were measured on tree-rings records covering more than 150 years with different tree species. They provide pieces of information on trees' growth in general but more specifically on the photosynthetic activity. Year-to-year variations in 13C signal reflect variations in stomatal conductance wich is partly controlled by the soil water stress applied to photosynthesis. The 18O signal is more complex as it reflects both isotopic variations in precipitations and water vapor and physiological state of leaves during photosynthesis. Both isotopic tracers were modeled within ORCHIDEE following the standard Farquhar et al. (, Planta, 1980) equation for 13C discrimination and Risi et al. (, Journal of Geophysical Reasearch, 2010) for 18O.The three tracers reflect strongly different responses of the photosynthetic activity towards hydric conditions.
We will first present the comparison of the standard model simulations with the observations for the three tracers. The results show encouraging features, but also underline some weakness of the model under particular conditions. The agreement will be quantified for the interannual variations in terms of correlation and standard deviation.
In a second step, we show the results after having optimized three parameters of ORCHIDEE controlling the soil water stress function applied to the photosynthetic model (soil depth, 2 parameters shaping the stress function). Using a classical assimilation procedure (based on a least square minimization) we were able to substantially optimize the amplitude of the three tracers' interannual variations. Analysis of the separate contribution and potential of each tracer to constrain a process-based ecosystem model will be discussed.

As a final objective, a better understanding of the key drivers of carbon and oxygen isotopes' ratio in the tree-rings may help us to better analyze paleoclimatic and paleoenvironmental conditions changes.