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Trends in net ecosystem fluxes for the Iberian Peninsula: a bottom–up approach addressing steady state

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Terrestrial biogeochemical models often require long term initialization routines that drive ecosystem carbon fluxes until steady state, when biosphere–atmosphere carbon exchange is balanced. Steady state assumptions stem from assumptions on internal ecosystem dynamics and from insufficient information on ecosystem states at wider spatial scales. Forcing model initial conditions to equilibrium can significantly differ from observed conditions and affect simulation results at different temporal scales. Here, we follow a bottom-up approach to track down the implications of the steady state assumption in ecosystem fluxes at regional scales, for the Iberian Peninsula (IP). For such, we select a set of eddy covariance sites from the CARBOEUROPE–IP network with Mediterranean characteristics or that may be present in the IP. The Carnegie Ames Stanford Approach (CASA) biogeochemical model [*Potter et al.*, 1993] is optimized at site level driven by local weather data and remotely sensed normalized difference vegetation index (NDVI) time series at biweekly temporal resolution. The optimization focuses on parameters governing net primary production (NPP) and heterotrophic respiration (RH) responses to temperature and water availability, as well as on maximum energy to mass conversion rates. Additionally, one parameter (η) is introduced to relax the steady state assumption at the end of the spin up routines, which is also optimized [*Carvalhais et al.*, 2008]. Parameters are further spatially prescribed on a per pixel basis for the IP following plant functional type (PFT) and the similarity in climate and phenology variables between all sites and each pixel. Regionally explicit time series of net ecosystem production (NEP) are estimated from 1982 to 2006 at biweekly time steps, following the native temporal and spatial resolution of the NDVI dataset [8x8km, *Tucker et al.*, 2005]. The implications of different initial conditions on the IP net ecosystem fluxes are addressed through a sensitivity analysis that focuses on the changes in inter annual variability and trends in NEP for different distances to equilibrium, which are prescribed by variations in spatially homogeneous η values. But the first order recovery dynamics explain most of the differences between the different runs since any prescribed distance to equilibrium yield a dynamic response towards the equilibrium conditions at the end of the spin up routine. Consequently, in order to explore the climate and phenology driven dynamics, we remove the inherent first order dynamics subtracting a time series of ecosystem fluxes estimated with constant drivers to the original fluxes time series - yielding a decomposed flux.

In general, CASA model *in situ* optimizations yield significant model performance throughout sites, showing model efficiency (MEF) of 0.79 (median for all sites). The regional weighted MEF for the IP is 0.73. Although there is a general confidence in the eddy covariance sites representativeness for the IP, the existence of poorly represented areas emphasize the local limitations of the selected set of sites (e.g. in representing the north-western region of the IP). The decomposed fluxes time series estimates allows the estimation of long term trends in fluxes quasi–independently from the initial conditions i.e. caused solely by the model drivers. Further analysis of the decomposed fluxes reveals the underlying dynamics of net ecosystem fluxes trends. Partitioning the decomposed NEP fluxes into NPP and RH reveals that most positive trends in NEP are associated to positive trends in NPP and RH, where NPP slopes are higher that RH's. Furthermore, NPP trends are mostly associated with trends in the fraction of photosynthetically active radiation absorbed by vegetation (fAPAR, driven by NDVI). The strong association between trends in RH and in leaf pools is consistent with the significant role of substrate availability in driving the long term RH fluxes. Our results emphasize the importance of minimizing the effects of initial conditions embedded in NEP time series in order to explore the dynamics of ecosystem fluxes on longer temporal scales.