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Ecophysiological responses to drought in Mediterranean forest ecosystems: data analysis and the evaluation of model predictions in drought prone environments.

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Seasonal drought is characteristic of Mediterranean ecosystems, imposing significant constraints on ecosystem productivity. The sensitivity of vegetation to drought stress is key to understand the seasonality of land-atmosphere fluxes of energy, water and carbon, which in turn can have important effects on regional and global climate. However, projections of potential effects on forest growth and changed land-atmosphere fluxes are subject to very large uncertainty, because current ecosystem models have a limited capacity to correctly account for the drought effects on vegetation growth. Improving our understanding of the ecophysiological response to extreme drought is therefore of utmost importance for a better assessment of the effects of global change on Mediterranean ecosystems.

Carbon and water fluxes at different level of water stress were analysed at one Californian and three European sites with Mediterranean climates, covering both deciduous and evergreen species - *Quercus cerris, Quercus ilex*, *Pinus ponderosa*, and *Fagus sylvatica*, and varying degrees of water stress and corresponding ecosystem responses. The effectiveness of two process-based ecosystem modelling approaches, a Dynamic Global Vegetation model (ORCHIDEE), and a Forest Growth Model (GOTILWA+) was assessed, and both observed and modelled canopy responses to stressed condi-

tions were analysed, by confronting the models with eddy-covariance based data from each site.

Soil moisture at each site was reconstructed through inversion of observed latent heat flux using a soil water budget model. Canopy conductance was calculated through the inversion of the McNaughton and Black equation. The response of canopy conductance to soil water stress was evaluated and the stomatal control on photosynthesis quantified by solving of the Ball-Berry & Leuning model to attain values for the Ball-Berry slope and intersect for different levels of soil moisture. The relative roles of stomatal versus non stomatal limitations on photosynthesis under soil moisture stress were assessed from the eddy-covariance measurements for different soil water levels. From these analyses, new process descriptions for the responses of canopy conductance and photosynthetic capacity to soil water stress were developed for the two modelling approach.

The results give a detailed look at how the carbon and water balances are affected by water stress. Applying the new process descriptions, particularly the non-stomatal limitation of photosynthetic capacity, significantly improved the capacity of the models to simulate carbon and water fluxes for Mediterranean ecosystems: these fluxes can now be modelled to an equal degree of accuracy in both stressed and non stressed conditions. This work helps to provide an accurate assessment of limitations to photosynthesis arising from the complex interactions between environmental factors and leaf physiology. This work contributes thus to an improved assessment of the current drought effect on Mediterranean forest growth and climate change effects on Mediterranean forest ecosystems.