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Seasonal and inter-annual impact of meteorological variables on productivity and carbon sequestration in a Mediterranean cork oak woodland

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Oak woodlands (OW) are low impact agroforestry ecosystems with high biodiversity, social and economic value. Current climate change projections foresee a decrease in the amount and a change in the seasonality, of precipitation as well as an increase in temperature for the Mediterranean region threatening productivity and future carbon sequestration in these ecosystems.
Analyses of long-term observations of both the amount of carbon sequestered by the ecosystem (Net Ecosystem Exchange, NEE) and of meteorological variables allow for a better understanding of the response of OWs to climate drivers, and help foresee their potential resilience to anticipated climate change scenarios.
In this study, we investigated the impact of seasonal and inter-annual variation of different meteorological variables on carbon sequestration in a Mediterranean oak woodland, using eddy covariance data. Correlations between meteorological variables and fluxes were analyzed at different time step ranging from daily to 24 months.
The study period, from 2010 to 2017, was characterized by high intra- and inter-annual climatic variation, with the hydrological pattern driving the productivity of the ecosystem. The hydrological years of 2011–2012 and from 2014 to 2017 (3 years) had reduced precipitation (up to -55%, when compared to the 30 years average) which lead to a significant reduction (p-value < 0.001) in Gross Primary Productivity (GPP), ecosystem respiration (Reco) and NEE. . A generalized linear regression analysis evidenced that Seasonal patterns had an even stronger effect than inter-annual hydrological variation on the ecosystem carbon dynamics. The altered precipitation in the “wet season” (Fall+Winter) explained up to 95% (p-value < 0.001) of the variation observed in the “growing season” (Spring+Summer) NEE. We also found a strong effect of the precipitation from the previous year (up to 15 months) on the carbon balance of the current year, suggesting an important role of ground-water storage in the ecosystem. These inter-annual and seasonal patterns in precipitation, as well as the corresponding lagged effects on the local carbon dynamics, are not only relevant for the maintenance of the hydrological balance at the site but can have potential crucial implications on the ecosystem′s water-use-efficiency (WUE), determining the response and productivity of these OW under future climate change scenarios.