A Virtual Research Environment-based analysis of the influence of atmospheric circulation types on seasonal carbon fluxes in a Mediterranean beech forest

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Beech forests (*Fagus sylvatica* L.) are important carbon sinks due to their ability to accumulate biomass and sequester atmospheric carbon. However, their dynamics are strongly influenced by seasonal biotic and abiotic factors, particularly in Mediterranean climates, where frequent droughts and heatwaves negatively affect photosynthesis, growth, respiration rates, and tree mortality. These regional extreme weather events are, in turn, influenced by large-scale meteorological patterns (cyclonic, anticyclonic, and zonal circulations). Despite their relevance, the influence of seasonal atmospheric circulation types on forest carbon fluxes remains largely unexplored. Accordingly, this study aimed to investigate how the seasonal frequency of each circulation type affected the seasonal variability of carbon dynamics in beech forests. The analysis was conducted using the programming facilities provided by the Virtual Research Environment for Essential Variables (EVs VRE), an open-access platform that supports ecological monitoring through the FAIR data principles and tools for reproducible research. Seasonal estimates of Gross Primary Production (GPP), Net Ecosystem Exchange (NEE), ecosystem respiration (RECO), and tree diameter (DBH) were derived using linear regression models applied to data collected from 1995 to 2014 at the Collelongo - Selva Piana forest LTER-Italy site (https://deims.org/9b1d144a-dc37-4b0e-8cda-1dda1d7667da). This 3000-hectare, over-125-year-old beech forest in central Italy is a founding site of the ICP Forests network and part of major European ecological research infrastructures (e.g., eLTER, ICOS). Preliminary results showed that atmospheric circulation types significantly influence seasonal trends of GPP, NEE and RECO. These insights demonstrate the potential of integrating atmospheric circulation data to better understand and anticipate seasonal carbon flux responses in beech forests. Combined with climate projections, this programming approach may support adaptive forest management strategies aimed at mitigating the effects of climate change in Mediterranean ecosystems.

Keywords: Virtual Research Environment, forest growth, large-scale weather