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Jet stream position connected to atmospheric blocking drives regional anomalies in European forest productivity

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European forests stock 30% of the total carbon stored in the biomass of temperate forests globally. As essential components of the biosphere, these forests are highly influenced by land–atmosphere interactions and climate extremes that may alter carbon uptake and storage. In order to identify broad patterns of ecosystem responses to climate, changes in European forest productivity have been linked to the strength and phase (i.e., positive or negative) of large-scale atmospheric circulation patterns. However, a robust characterization of the physical coupling between ocean-atmosphere variability and terrestrial ecosystem productivity requires a more tangible and physically measurable representation of the atmospheric state. We propose that the latitudinal position of the jet-stream in the European-Atlantic sector (JSL) is such a measure and allows directly linking anomalies in terrestrial carbon fluxes with climate extremes. Importantly, JSL integrates not only co-variability between multiple climate parameters, but also the underlying atmospheric configuration.

In this study, we combine a network of 344 tree-ring width (TRW) chronologies, simulated ecosystem carbon uptake (i.e., gross primary production; GPP) from Dynamic Global Vegetation Models and atmospheric reanalysis data to characterize the spatiotemporal connection between forest productivity at the earth surface and summer JSL variability in the upper troposphere. The focus on extremes in both the atmospheric driver (JSL) and the ecosystem response (TRW, GPP) allows us to diagnose the synoptic-scale configuration and climatic fluctuations that trigger the most substantial carbon anomalies across temperate forests in Europe.

The impact of summer JSL migrations on the productivity of European forests is not uniform across the continent and shows a northwest-southeast polarity. Regional tree growth and GPP dipoles across Europe, particularly in extreme years, are tightly coupled to the position of the JSL and the occurrence of persistent and stationary weather patterns connected to persistent and strong anticyclonic anomalies (i.e., atmospheric blocking events). Productivity, and particularly forest growth, are the most impacted by changes in summer JSL over the continent, where atmospheric blocking frequency is the highest during summer. We observed synchronized changes in growth and GPP during summer JSL extremes, denoting common climatic constraints

to both processes.

Our study emphasizes that JSL variability can trigger regional changes of up to 30% and 50% during extreme years in forest carbon uptake and growth of European forests, respectively. More importantly, these extremes on productivity are not uniform across Europe resulting in a continental productivity imbalance. Current and future net effect on continental forest productivity may depend on differences in forest resilience, forest density and rate of forest productivity across the continent.