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Biosphere-atmosphere exchange of carbon dioxide in relation to climate: a cross-biome analysis at multiple time-scales

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The biosphere-atmosphere flux of carbon dioxide responds to climatic variability at time scales from seconds to years. Orthonormal wavelet transformation (OWT) can quantify the interaction between flux and climate at multiple frequencies while controlling for inherent data gaps in eddy covariance measurement records and expressing time series variance in few energetic wavelet coefficients, offering a low-dimensional view of the measured climate-flux interaction. Here, we discuss the variability of net ecosystem exchange (NEE), gross ecosystem productivity (GEP) and ecosystem respiration (RE), and their co-variability with dominant climatic drivers, using eddy covariance data from 250 sites and nearly 1000 site-years from the global FLUXNET database. Results demonstrate that the NEE and GEP wavelet spectra are similar amongst plant functional types (PFTs) at weekly and shorter time scales, but significant divergence appears among PFT at the biweekly and longer time scales, when NEE and GEP also dampen climatic variability, on average. The RE spectra rarely differ among PFT across scales; they have greater low frequency variability, on average, and are amplified with respect to climatic variability at monthly to interannual time scales. Both measurements and theory demonstrate that 'multi-annual' spectral peaks in flux may emerge at low (4+ year) time scales. Biological responses to climate and other internal system dynamics, rather than climate itself, provides the likely explanation for the observed multi-annual variability.