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What can we learn from long-term CO2 exchange residuals?

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Modeling and observational studies report that the temporal variability in atmospheric CO2 concentrations is mainly driven by climatic variability. However, to fully understand the temporal variation in NEE (net ecosystem exchange), it is necessary to consider not only the temporal variation in climatic drivers but also the variation in the biotic response to these drivers. In this study we aim to quantify and characterize the component of gross photosynthesis (GPP) and ecosystem respiration (TER) due to biotic and random variation. We selected ten forest sites with more than 2500 daily CO2-flux observations, these time series were shown, through preliminary analysis, to be of sufficient length to result in robust estimates of the biotic and random variation. We trained, validate and tested an artificial neural network (i.e. self-organizing map) to predict GPP and TER on the basis of mean daily air temperature, precipitation, incident radiation and vapor pressure deficit. Consequently, the residual of the predicted and observed CO2 flux is the biological and random variation. Across the selected evergreen sites 25% of the daily CO2 flux was due to biological and random variation whereas 35% of the daily CO2 flux could not be explained by climatic variability at the deciduous sites. The importance of biological and random variability decreased with decreasing temporal resolution and at the interannual scale only 10% of the CO2 flux is due to biological and random variation. Much of this biological variation presumably arises from inadequacies in the ANN and our lack of potentially illuminating data such as canopy nitrogen content and LAI. Statistical characterization of the residuals and MODIS and FAPAR products and comparison of alternative ANN's is expected to help explaining the differences in biological and random variability between evergreen and deciduous forest in the temperate mesic climate zone.