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Quantifying Seasonal Patterns in Disparate Environmental Variables using the PolarMetrics R Package

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Certain environmental processes, while influential, are inherently difficult to quantify and detect using traditional time series analyses, particularly among variables with different seasonal progressions. Disturbances that only manifest in part of a season (e.g., spring defoliation) or subtle climate shifts can pose detection challenges when they occur in the presence of other variability. Increasing sampling rates or even adding new sensors may not reveal the anticipated patterns. Eddy covariance tower data are a useful example for which various environmental drivers influence the overall signal, contributing noise and seemingly discordant variation. While eddy flux data are a rich representation of information, distinguishing expected seasonal responses within a signal can be challenging, especially where drivers may have either fast or lagged responses. A conventional solution might be to analyze and effectively smooth the data over daily to monthly intervals. However, such smoothed data will not exhibit the same variance, and subsequent regressions may not isolate relationships and anomalies to specific seasons. This paper introduces and demonstrates the use of a newly developed R software package, PolarMetrics, which is used to analyze 20 years of data from one AmeriFlux tower using a polar (circular) approach that reduces data volume to a smaller set of derived seasonal timing and magnitude metrics. Polar metrics quantify the annual cycle of input variable, and permit direct comparison of the strength and timing of seasonality. While performing the analysis over all years produces a synoptic result, analyzing year-by-year characterizes interannual variability.