Geophysical Research Abstracts
Vol. 19, EGU2017-10827-1, 2017
EGU General Assembly 2017

Potential and limitations of wavelet analysis to unravel complexity in CH4 and CO_2 flux time series

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Greenhouse gas fluxes measured continuously across the land-atmosphere interface are highly autocorrelated and characterized by complex temporal patterns. Wavelet analysis is a time series analysis tool that decomposes a signal in both, frequency and time domain which allows accounting for non-stationarity – a feature that is inherent to most natural processes.
Using time series of CH4 and CO_2 fluxes derived from both, automated chamber and eddy covariance measurements in different Fluxnet peatland types, we demonstrate the potential and limitations of wavelet analysis in the field of greenhouse gas exchange. More explicitly, we show how gas-specific time series characteristics express themselves in the wavelet spectrum and draw conclusions for the formulation of null hypotheses for wavelet significance testing. We further demonstrate how inevitable technical constraints of greenhouse gas in situ measurements (e. g. data gaps and varying instrumental performance between maintenance intervals) manifest in the flux time series and discuss their implications for the interpretation of wavelet results. Moreover, our multi-method approach allows to address method-inherent capabilities of the automated chamber and eddy covariance technique to resolve CO_2 and CH4 release processes on different time scales.
Despite some challenges, we consider the wider deployment of wavelet analysis and related time series analysis tools as promising to advance our mechanistic understanding in the field of greenhouse gas exchange across the land-atmosphere interface.