Contribution of wavelets to decrease gap filling in turbulent surface fluxes measurements

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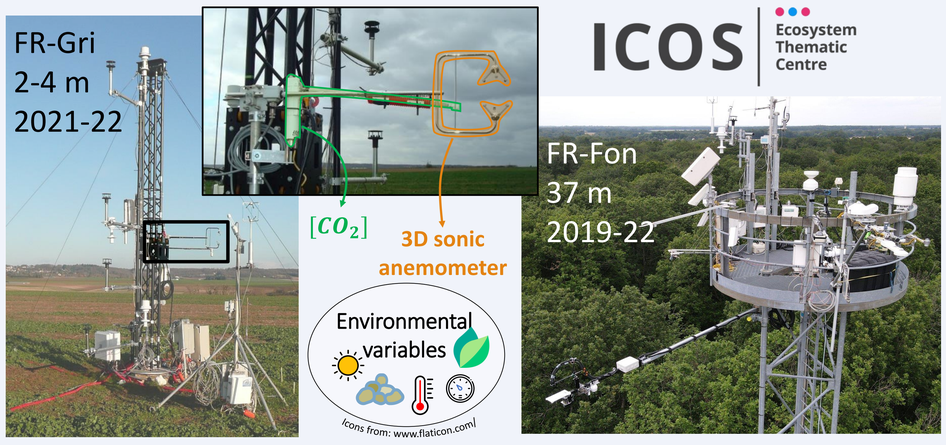
INTRO

• Starting in the 90's, flux towers became the most direct and continuous ecosystem monitoring tool.

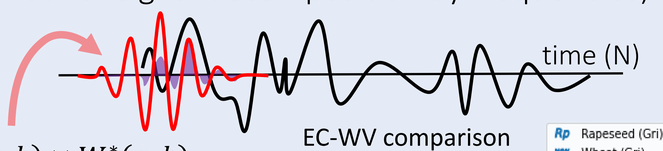
• Quality control selects unreliable data to be replaced using gap-filling methods (commonly MDS).

• Often data is non-stationary, a requirement for eddy-covariance, but not for wavelets.

Material



Wavelet (WV, method for signal decomposition by frequencies)



$$E_{x,y} = \frac{\delta t}{C_\delta}\frac{1}{N}\sum_{n=0}^{N-1} W_x(a,b) \times W_y^*(a,b)$$

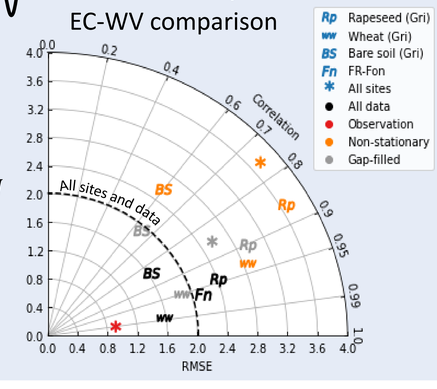
n: instant n out of N

$$\overline{x'y'} = \delta j \sum_{j=0}^{J} \frac{E_{x,y}(j)}{a(j)}$$

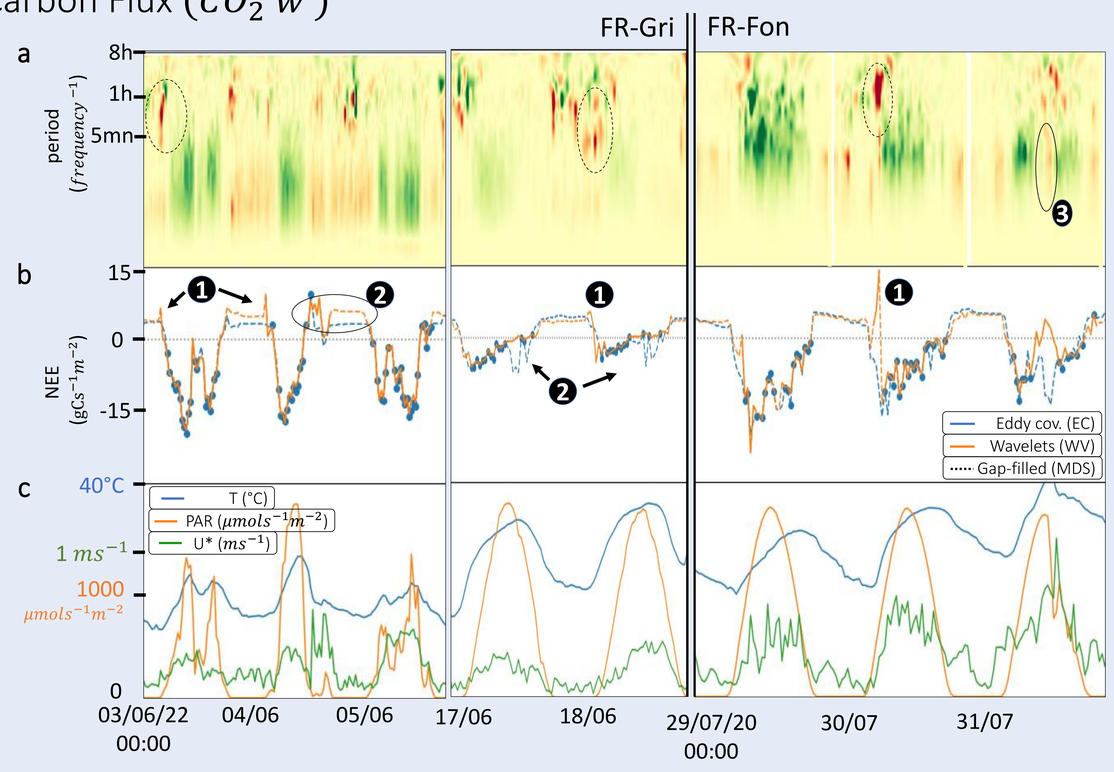
j: frequency j out of J

a: dilation factor (sets size and amplitude)
b: translation (set the origin)
δt: sampling interval (e.g.: 0.05 for 20Hz)
C_δ: normalization factor (wavelet-specific)
δj: spacing between discrete scales

EC-WV comparison



Carbon Flux (CO_2'w')



❶ Low wind and warm nights show a strong positive flux during early hours, most probably the release of night stock;

❷ Non-stationary observations help to constraint gap-filling.

❸ Extreme temperatures can strongly reduce photosynthesis. A feature not always captured by EC.

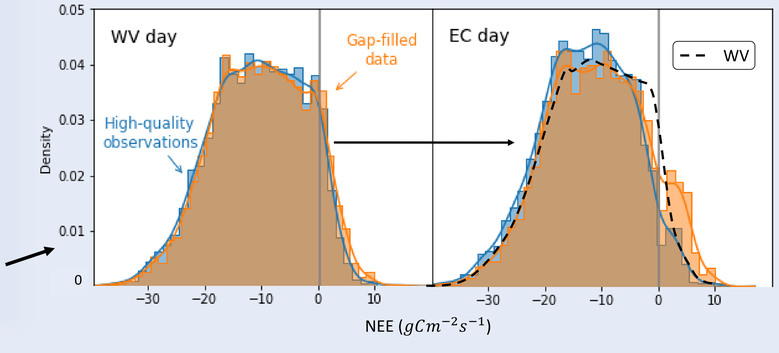
• FR-Fon, having a taller tower, shows most flux contributions at lower frequencies than FR-Gri.

• Turbulent but non-stationary moments are fully retrieved by wavelets.

• Some short events appear only at lower frequencies (above 30-min period), *to be further studied*.

•Observed and gap-filled distributions diverge for EC, while for daytime WV both have a similar progressive distribution (no skipping closer to zero values). *Possible bias to be further studied*.

FR-Fon (daytime, VPD > 3 KPa)



Discussion

Wavelets are a promising method to compute turbulent flux on several time resolutions and in non-stationary conditions. This could represent a gain of 20% more high-quality data useful for large-scale model inversions. This additional data coverage adds up information on respiration and photosynthesis useful for understanding ecosystems functioning. However, nigh-time stock release in the early morning proves to be hard to identify from wavelet fluxes for small towers as it is not expected to be significant. For large towers, it may help identifying advection situations.

Further work is needed on understanding fluxes on the frequency domain. We hypothesise that it could hide information on ecosystem's cycles as well as in the spatial domain, given that contribution farther away could come on lower frequencies. For the time being, simply retrieving non-stationary fluxes can benefit projects dealing with complex terrain and frequent non-stationarity, such as in tall towers and urban landscapes.

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