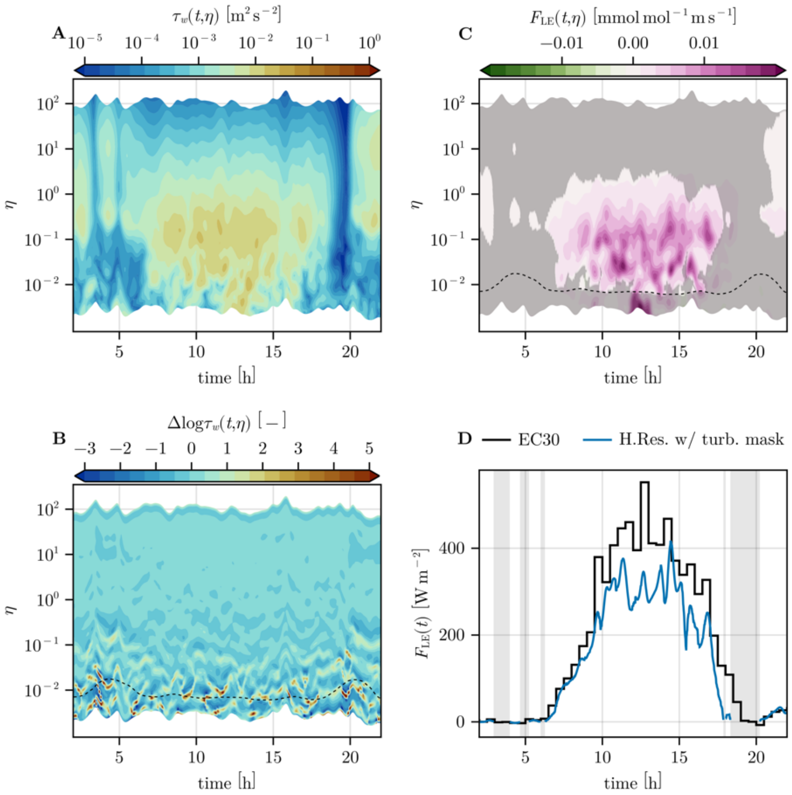
INTERPLAY



Resilience to drought of mixed-species ecosystems resulting from the interplay between plant hydraulics and species interactions

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Thematic action concerned : *WP2*

Context —

Flux estimation from eddy-covariance flux tower measurements faces the problem of integrating fluxes only in the case of fully developed turbulence and in non-stationary environments with advective components. The standard eddy-covariance method operates on fixed-length signals, requiring the knowledge of a maximum correlation time-length as well as post- processing steps assessing the suitability and quality of the data. Statistical tests are carried out to assess if flux estimates were performed during sufficiently developed turbulence and if they were corrupted by advective components.

Tests with friction velocity u* or σ_w, steady-state tests, and flux variance similarity are now standard during and after flux calculations. More elaborate methods such as ogive optimisation are used to deal with advection. An important disadvantage of all these statistical tests is that they discard the whole time interval such as half an hour if they detect failure.

Objectives —

Time-scale (time-frequency) analyses have been used as an alternative to the standard time-analysis approach to estimate ecosystem fluxes. In particular, wavelet analysis, which is well adapted to the study of non-stationary and scale invariant processes such as turbulence, has been used in previous works. It presents the ability of separating the different components of the flux in time-scale space and as such could be an efficient alternative for flux estimation avoiding the above statistical tests.

Approaches —

To address this problem, we propose a general framework for analysing fluxes in time-scale space, and propose a new method for identifying and extracting turbulent transport that avoids advective components and does not need statistical tests after the flux calculations. The new method is based on the analysis in time-scale domain of the amplitude of the vertical component of the Reynold stress tensor and can be seen as a time-scale transposition of all the standard tests evoked above.

Key results —

- As a direct consequence, we are able to estimate fluxes at high time resolution over times and scales with sufficiently developed turbulence.
- We show application of the framework at the beech forest site FR-Hes and demonstrate its relation with standard eddy covariance calculations.

Main conclusions including key points of discussion —

- We are able to calculate ecosystem fluxes at much higher temporal resolution than standard approaches.
- Several postprocessing steps become obsolete with the time-frequency approach.

Perspectives —

- Our methodology is implemented in the Julia package TurbulenceFlux.jl and is hence available for the whole FLUXNET community.
- The proposed framework and its code implementation are fully differentiable and hint to further investigations, such as the study of flux ecosystem response times, or sensitivity analysis against wavelet and averaging window parameters.

Valorization —

Publication: Gabriel Destouet, Nikola Besic, Emilie Joetzjer, and Matthias Cuntz, Time-Scale turbulence extraction and high-resolution flux estimation, *Atmospheric Measurement Techniques* (manuscript in preparation)

Talk: Gabriel Destouet, Nikola Besic, Emilie Joetzjer, and Matthias Cuntz, Time-Scale turbulence extraction and high-resolution flux estimation, Solicited talk at the EGU General Assembly 2024, 14-19 April 2024, Vienna, Austria

Leveraging effect of the project —

The Julia package TurbulenceFlux.jl is on a Github repository and will get an DOI upon publication of the article: https://github.com/gabdst/TurbulenceFlux.jl