SlowStom

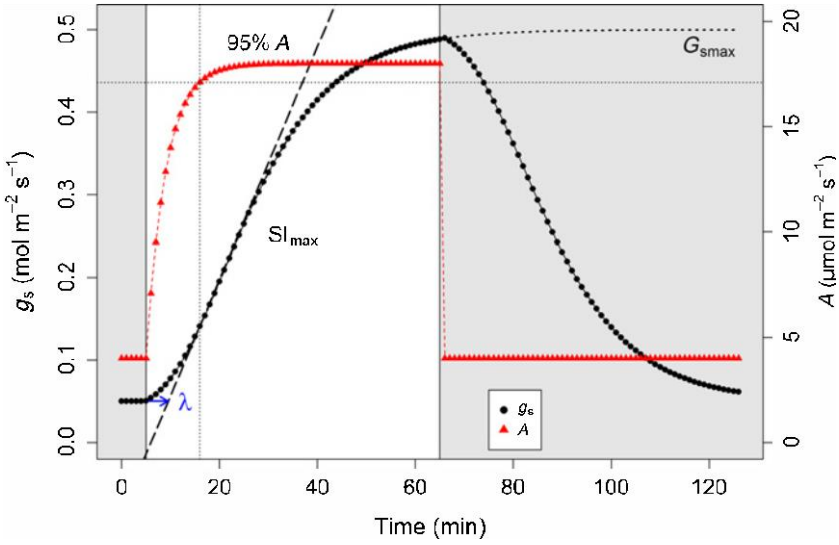

Figure 1: Theoretical temporal response of stomatal conductance (g_s) and photosynthesis (net assimilation A) to a step change in PPFD from 100 to 1000 µmol m^{-2} s^{-1} and back (McAusland et al. 2016).

Influence of slow stomatal responses on ecosystem fluxes and water-use efficiency

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Thematic action concerned:WP2

Context —
Plants constantly adapt photosynthesis and stomatal conductance to prevailing environmental conditions. Photosynthesis can adjust in seconds to changes in irradiance while stomatal conductance responds lagged by a few minutes up to almost an hour. There is a fundamental difference between shade flecks (sudden decrease in irradiance) and sun flecks (sudden increase of irradiance). In the former case, stomata are open, CO_2 is (mostly) not limiting, and photosynthesis can immediately respond to the drop in irradiance. In the latter case, stomata are more closed, limiting the supply of CO_2 to photosynthesis so that it also shows a lagged response to increased irradiance, even though still faster than stomatal conductance (cf. figure 1).

Objectives —
Hence, the questions on ecosystem scale about this well-known phenomenon on leaf scale are:

- Can uncoupled photosynthesis and stomatal conductance of the canopy due to sun/shade flecks be detected on ecosystem scale?

- Are there situations with uncoupled canopy photosynthesis and canopy conductance for example on partly overcast days?

Approaches —

1. Use Fourier analysis (**spectrograms)** of high-frequency data of eddy covariance (20 Hz) to analyse **maximum time** scales of **contributing** turbulent **eddies** to observed eddy covariances.
2. Use continuous **wavelet** transforms to calculate **ecosystem fluxes** with **one-minute resolution**.
3. Use high-frequency meteorologic data (20 s) together with the one-minute ecosystem fluxes for the calculation of **canopy conductance**.
4. Use **coupled neural networks** on the calculated ecosystem fluxes to derive canopy **photosynthesis** with **one-minute resolution**.
5. Use irradiance to **classify** stable and intermittent **meteorological conditions**.
6. Analyse the **coupling of photosynthesis and canopy conductance** under different meteorological conditions.
7. Implement transient and integral formulations of **non-steady-state stomatal conductance in** the ecosystem model **MuSICA**.
8. Analyse the performance of **different** descriptions **of stomatal conductance** and **different time stepping** schemes on ecosystem fluxes under diverse meteorological conditions.

Key results — (presented as separated bullet points)

The slowstom project started on December 2022 when Gabriel Destouet was hired. Therefore, we show only preliminary, but promising results, tackling tasks 1 to 3. Gabriel successfully developed the method to compute the fluxes with a 1-minute resolution using the FR-Hes station as a testbed. Preliminary result indicates (i) we are able to compute the fluxes at one minute resolution and (ii) temporal structures are revealed when looking at the flux scalogram (Fig. 2) showing the superposing of eddy from various size.

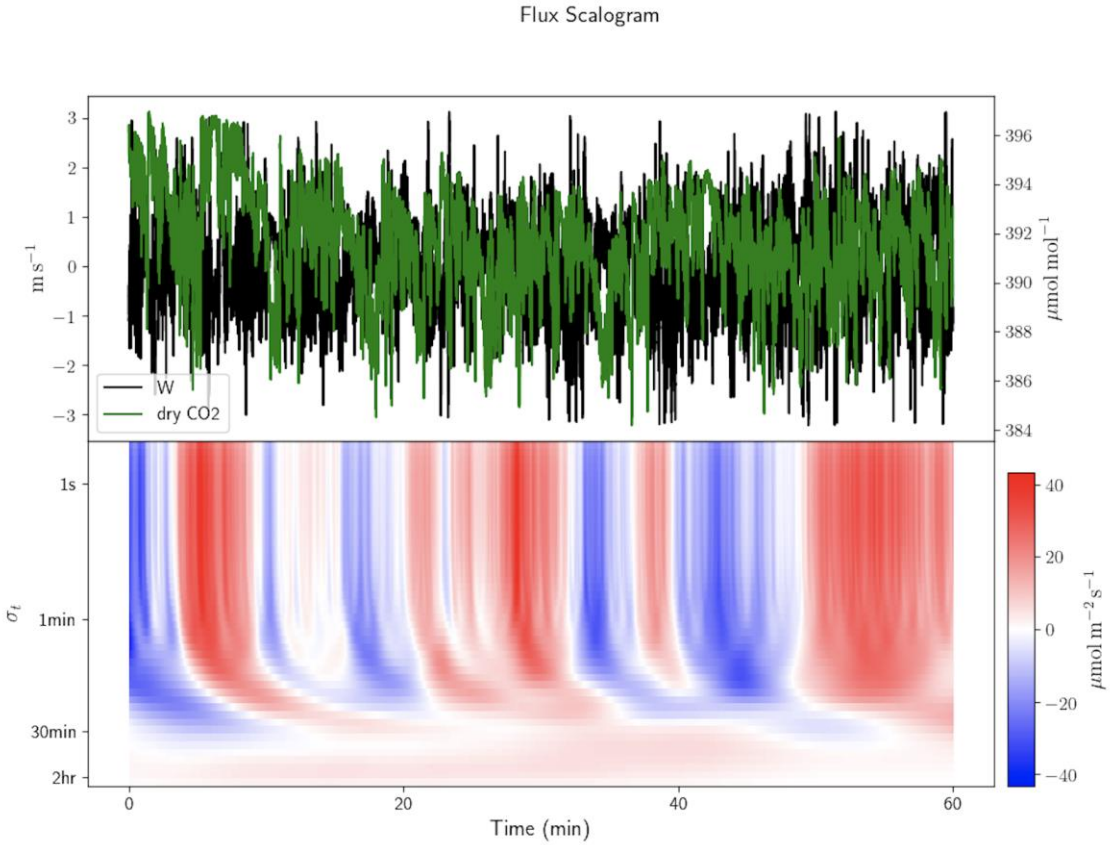

*Figure 2. Time series of the wind speed vertical component (W) and atmospheric CO2 concentration measured for one hour in April at the FR-Hes ICOS Ecosystem station (top). Flux scalogram (W*dryCO2) at different time scale obtained computed via a wavelet decomposition method (bottom).*

Main conclusions including key points of discussion —
We don't have any conclusions yet, we first need to adjust wavelet transform parameters over more time period and analyse the results at different period of the year to explore how the observed temporal patterns can be related to ecosystem processes at the interface surface atmosphere.

Perspectives —
In construction.

Valorization — (scientific: publications, book chapter, presentation at conferences,...); economic: Soleau envelope, patent, license,...; distribution: press release, interview,...)
The redaction of a scientific publication on the methods developed will start in a couple of months.

Leveraging effect of the project—
The method developed in Slowstom, if relevant, will be exported in the ICOS network.