INTERPRETING PARAMETER SENSITIVITIES AND WATER-CARBON TRADE-OFFS IN DAISY CROP MODEL

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GLOBAL SENSITIVITY ANALYSIS (GSA)

The GSA was composed of (1) a parameter screening with Morris method, going from 200 to 57 model paramters, and (2) a variance-based GSA using **Sobol** method.

We considered four growing seasons of winter wheat (monitored at **BE-Lon**) with contrasted environmental conditions. SAH was a season with heavy rainfall and high soil water content until May, whereas SKY had the driest conditions with soil water content at 15-cm depth below 20% during several weeks.

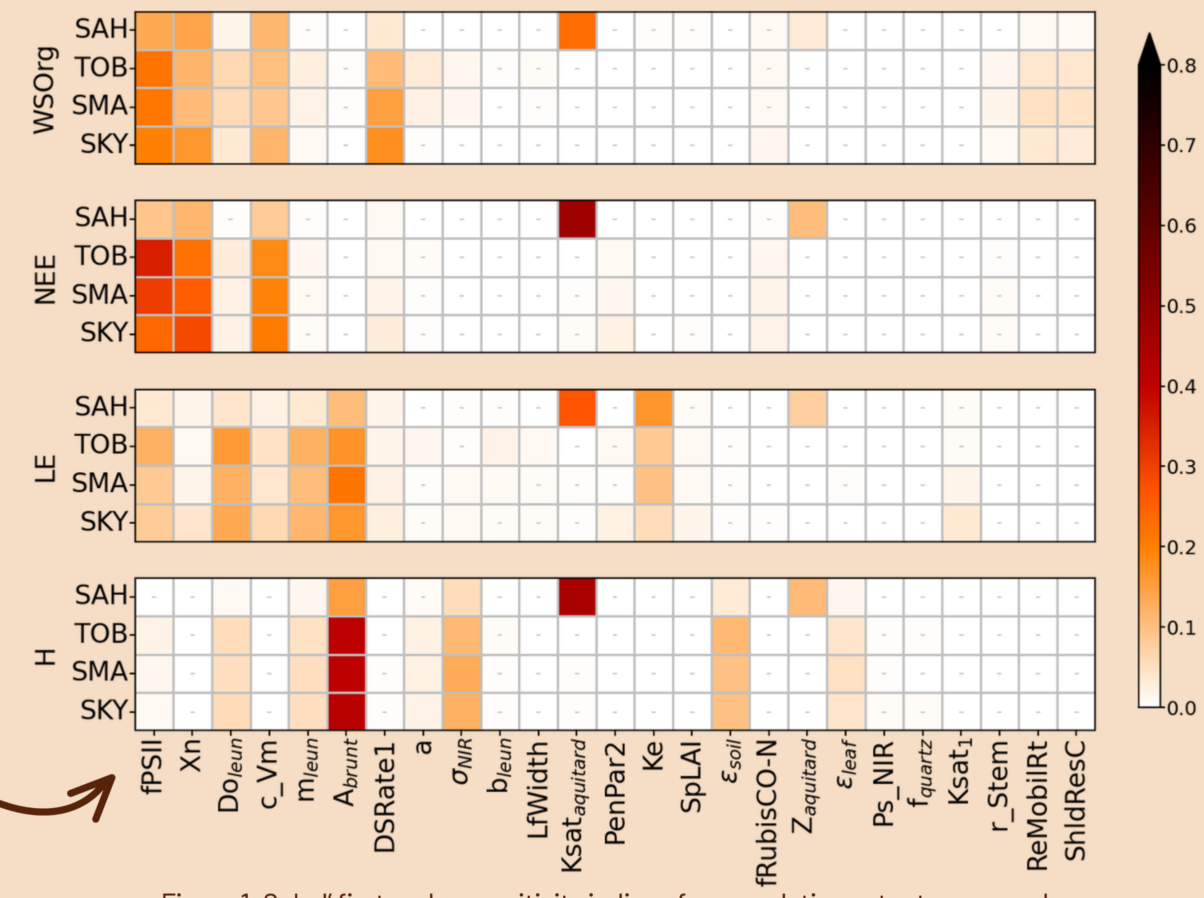

Figure 1: Sobol' first-order sensitivity indices for cumulative outputs over each growing season. Non-signficant indices (S_i>0.01) are labelled with a grey dash.

The Sobol method was applied to multiple model outputs (here: ear dry matter WSOrg, NEE, LE and H) under various forms:

- Outputs aggregated into a scalar using an **objective function** (RMSE or cumulative);
- Vector outputs analysed at each time step (**hourly** or **weekly**).

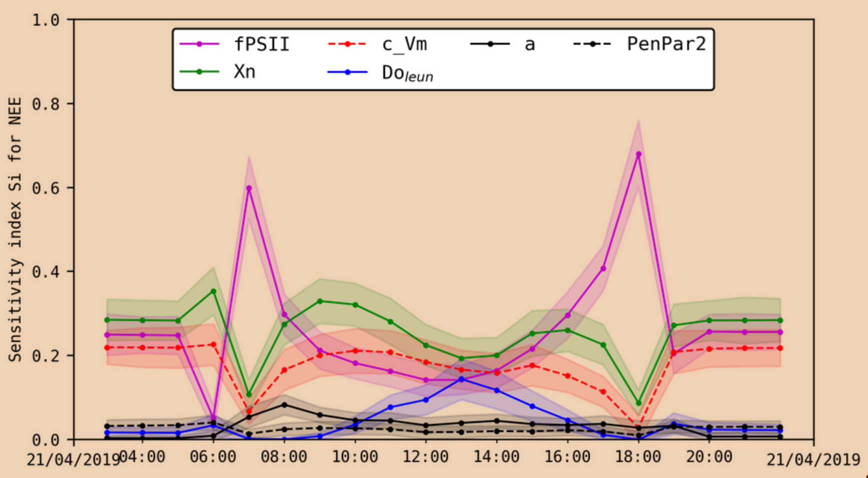

Figure 2: Hourly evolution of first-order sensitivity indices for NEE outputs (SMA growing season) during a sunny day.

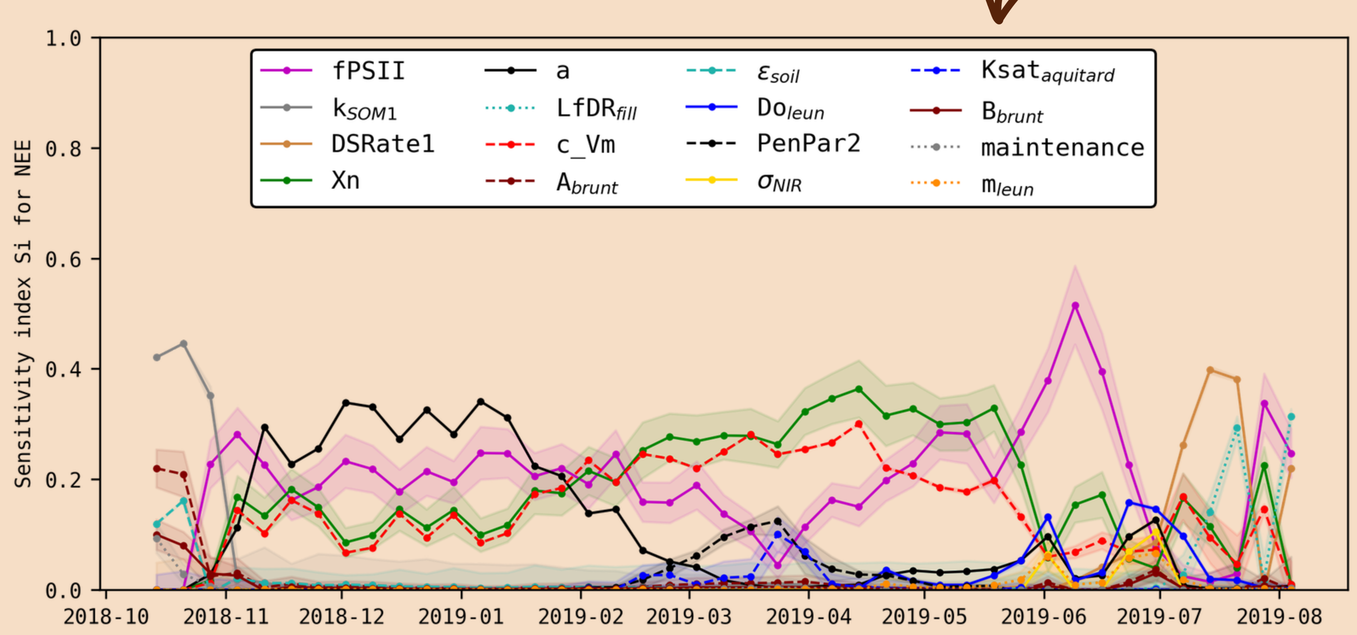

Figure 3: Weekly evolution of first-order sensitivity indices for NEE outputs (SMA growing season).

SAH growing season stands out due to the significant influence of the aquitard layer (i.e. water blocking layer below soil profile; Fig. 1).

Compared to the aggregated analysis, temporal GSA (Fig. 2 and 3) deepens our comprehension of the simulated processes and model behaviour, and allows to verify the model correctness (e.g., the two photosynthetic limitations through the day in Fig. 2).

In an ideal world, what else do crop models need from ICOS network ?

- Frequent observations of **crop development** during the entire season (BBCH stages);
- Continuous measurements of water table depth with a **characterisation of the deepest soil layer** (hydraulic conductivity and thickness);
- **Ancillary measurements** such as chlorophyll fluorescence, allowing to directly estimate photosynthesis parameters and to quantify plant water stress.

MULTI-OBJECTIVE CALIBRATION

Using the same four growing seasons, we applied the Speed-constrained Multi-objective Particle Swarm Optimisation (SMPSO) algorithm to estimate the influential parameters. This algorithm, based on **Pareto optimality**, seeks trade-offs among three objectives: dry matter of all organs (DM), Net Ecosystem Exchange (NEE) and latent heat flux (LE).

Trade-off between DM and NEE (Fig. 4b)

Dry matter and NEE cannot be accurately reproduced simultaneously by Daisy, as shown by the curved Pareto front. When NEE is well captured (low values of F_{NEE}), the rRMSE of DM is high (greater values of F_{DM}) and DM is significantly underestimated. This can be due to multiple factors:

- Underestimation of heterotrophic respiration;
- Unsuitable partitioning coefficient for biomass allocation;
- Biases in NEE (and DM) measurements.

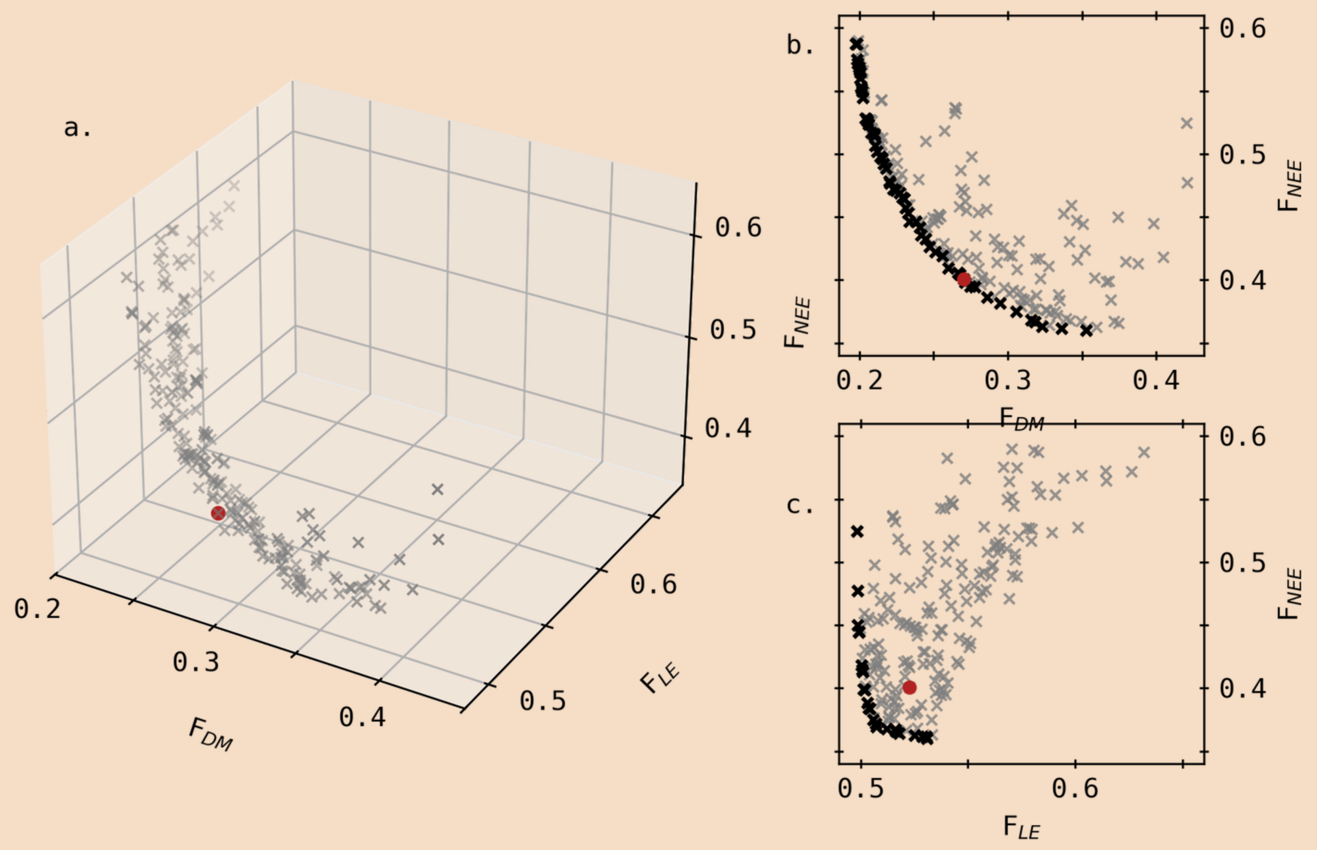

Figure 4: Non-dominated solutions in the objective space: (a) 3D Pareto front according to the rRMSE of DM, LE and NEE, and 2D projection of these solutions considering (b) DM and NEE, (c) LE and NEE. Red point highlights the most balanced compromise.

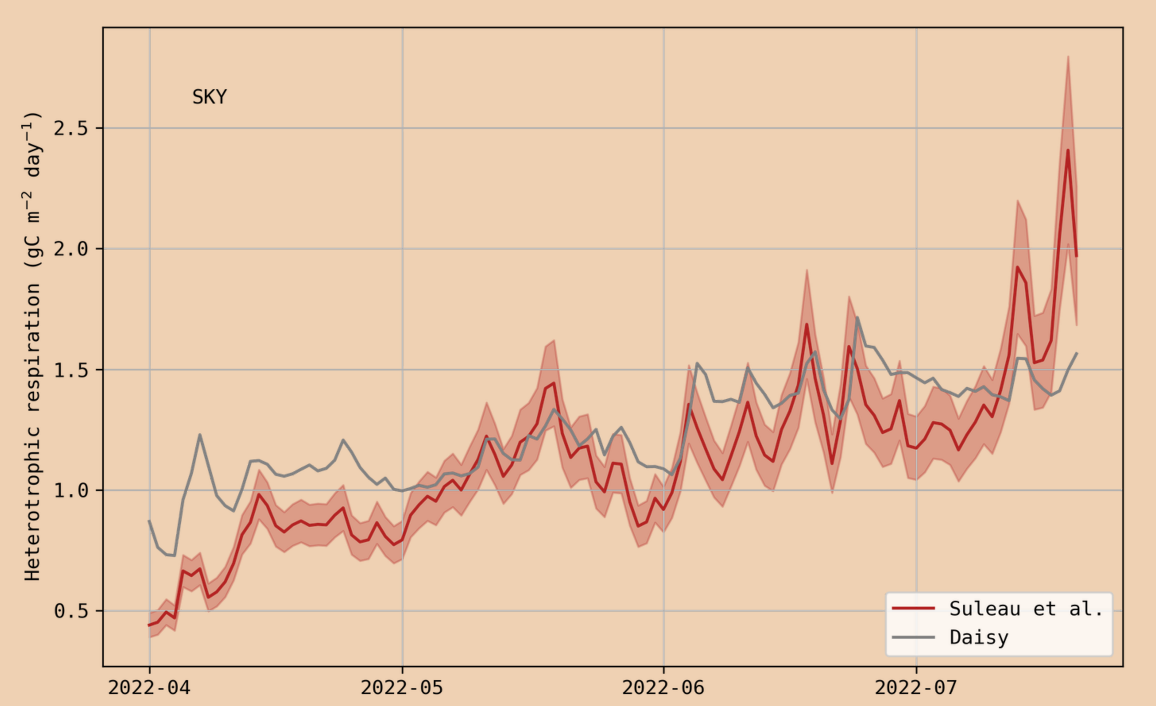

Figure 5: Heterotrophic respiration - model predictions (grey) and estimations based on the temperature function fitted by Suleau et al. (2011; red).

Why can't Daisy capture both DM and NEE ?

The trade-off between DM and NEE is visible for all growing seasons combined, but also for SKY only. During this season, biomass of all organs was measured, allowing to estimate the paritioning coefficients. Moreover, heterotrophic respiration doesn't seem to be underestimated when compared to a previous study conducted at BE-Lon (Fig. 5).
Could CO_2 fluxes be underestimated ? Do they need correction as energy fluxes ?

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ICOS Integrated Carbon Observation System