Improving yield and fluxes prediction for agroecosystem through modelling: Identifying ancillary measurements at ICOS-Lonzee

DELHEZ Laura[(1)*] & LONGDOZ Bernard[(1)]

ICOS Integrated Carbon Observation System

LIÈGE université Gembloux Agro-Bio Tech

[(1)] University of Liege, Gembloux Agro-Bio Tech, TERRA – Teaching and Research Centre * Contact: laura.delhez@uliege.be

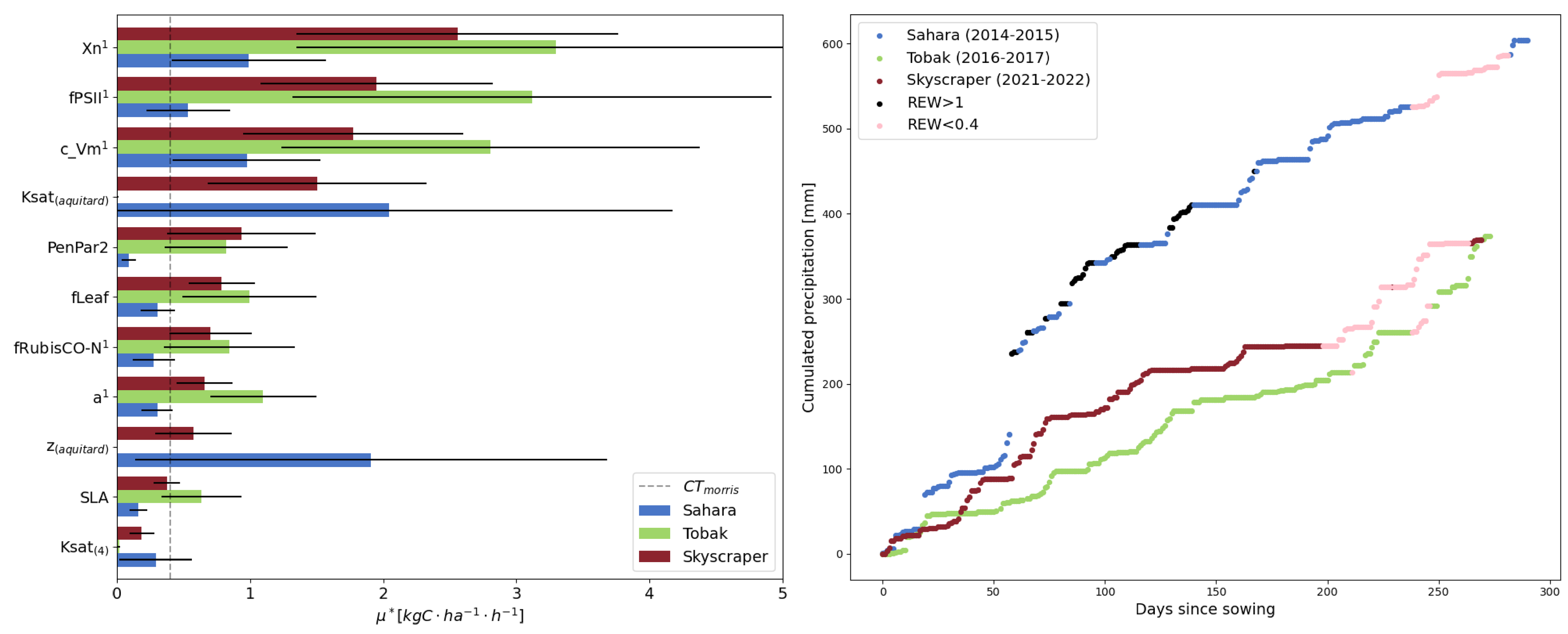
INTRODUCTION

Aim of study – In the context of more severe and frequent droughts and waterlogged periods, the objective of this work is to study how edaphic water stress impacts agrosystems functioning using a modelling approach. Before adjusting parameters requiring calibration in order to obtain a fitted model and achieve this objective, we must determine which parameters have the greatest impact. This poster focuses on this procedure through global sensitivity analysis (GSA) performed on data from Lonzée ICOS site.

Model description – DAISY is a mechanistic model simulating the carbon, water and nitrogen processes in the soil-plant-atmosphere continuum. This 1D/2D open-source model quantifies sensible heat, CO_2, H_2O and N_2O fluxes with an hourly time resolution, allowing forthcoming comparison against eddy-covariance data from ICOS sites. Necessary input data are weather data (air temperature, relative humidity, wind velocity, global radiation and precipitation), soil data (texture, bulk density and humus), management actions and water table depth. Soil water dynamics are based on Richards' equation, photosynthesis processes are described according to Farquhar biochemical sun/shade model which is combined with Leuning stomatal conductance and transfert between soil-plant-atmosphere are computed based on the resistance concept.

GSA methodology – The Morris screening method was applied to assess the influence of DAISY parameters, depicted by the quantity called μ^*. This GSA was performed on 4 outputs – Net Primary Productivity (NPP), Heterotrophic Respiration (HR), latent heat flux (LE) and sensible heat flux (H) – for three winter wheat varieties (Sahara, Tobak, Skyscraper) cultivated in three different years (respectively 2014-2015, 2016-2017 and 2021-2022).

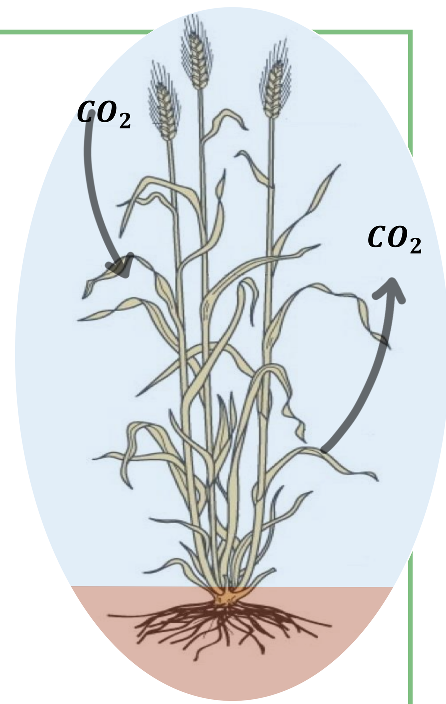
Influence of parameters on NPP around stem elongation (left) and cumulated precipitation (right)



Left – Vertical line corresponds to the cut-off threshold; minimal value to have a significant impact on NPP. Error bars refer to standard deviations, ¹ to Farquhar photosynthesis model and subscripts to soil layer.

Right – Colored extreme soil water conditions (pink and black) are based on SWC measurements, REW is the Relative Extractable water (value of 1 corresponds to field capacity)

NET PRIMARY PRODUCTIVITY

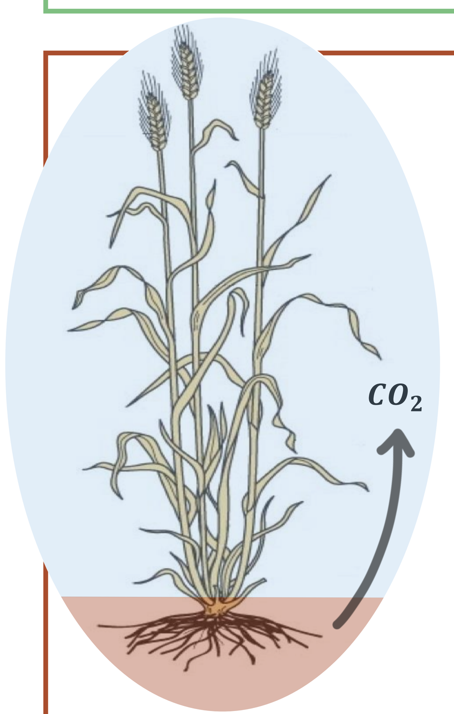


Photosynthesis – *Xn* represents the proportionality coefficient between leaf RubisCO-N and Vcmax, *c_Vm* is a temperature scaling constant for Vcmax and *fPSII* is the fraction of PAR effectively absorbed by PSII. As these photosynthetic parameters have great impact on NPP, it is essential to accurately determine Vcmax and its dependence to nitrogen content and temperature as well as the absorbance of PSII.

Water conditions – Parameters *Ksat* and *Z* describing the aquitard layer properties (below soil profile) have significant impact, especially for Sahara. During 2014-2015 winter, soil profile was regularly saturated due to precipitation. On the contrary, these parameters have no influence in dry conditions (see Tobak).

Thermal conditions – *PenPar2* is a parameter descibing the impact of temperature on root penetration. The latter is reduced and even stopped during cold periods. Late frosts occured for Tobak and Skyscraper while root system was growing

HETEROTROPHIC RESPIRATION

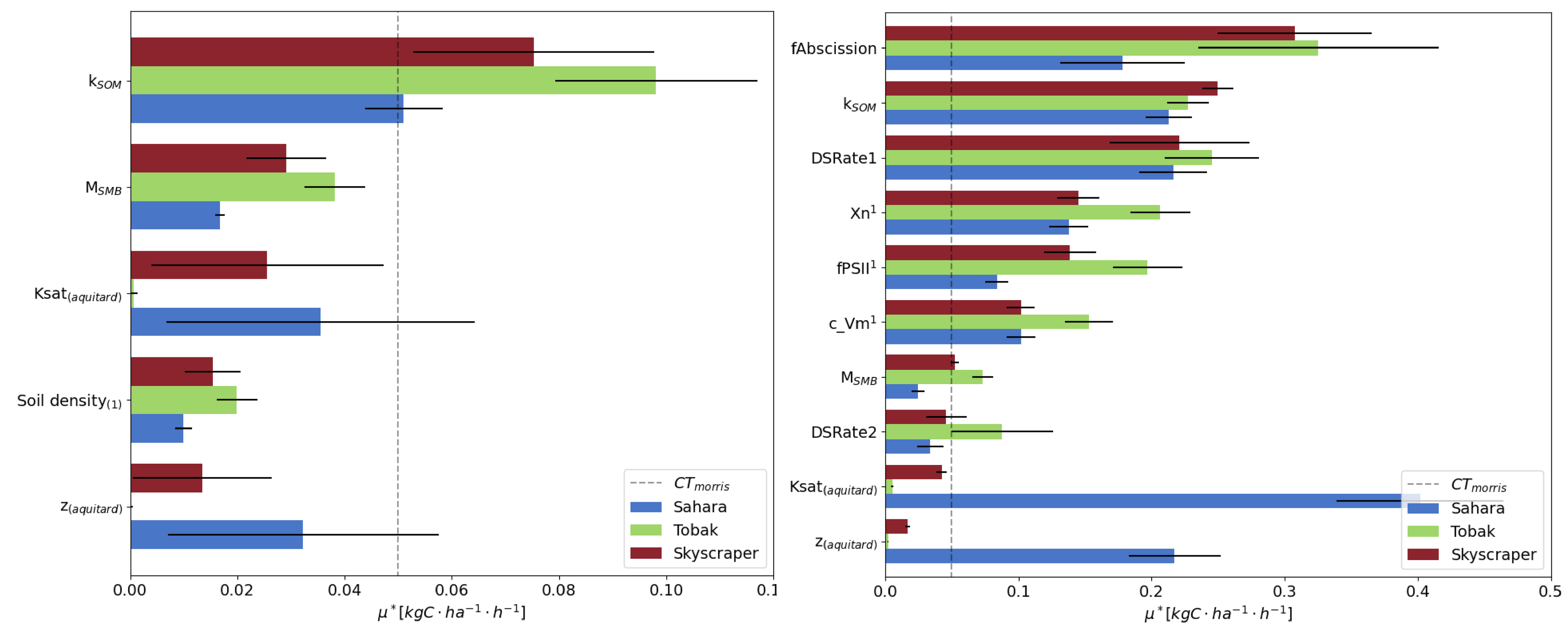


Stem elongation – *kSOM*, the turnover rate of SOM pools (fast and slow), have the only significant impact on HR.

Grain filling – As the crop is growing, residues are increasingly added to soil which eventually lead to decomposition and respiration. This is depicted in the GSA results; *fAbscission* determines the fraction of dead leaves falling to the ground and have the greatest impact. Likewise, parameters involved in photosynthesis processes (Xn, fPSII, c_Vm) gain influence as it can also affect residues quantity.

Vertical line corresponds to the cut-off threshold. Error bars refer to standard deviations, ¹ to Farquhar photosynthesis model and subscripts to soil layer.

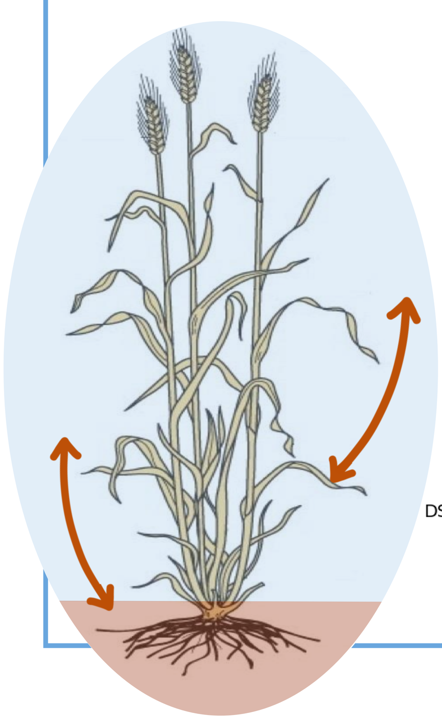
Influence of parameters on HR around stem elongation (left) and during grain filling (right)

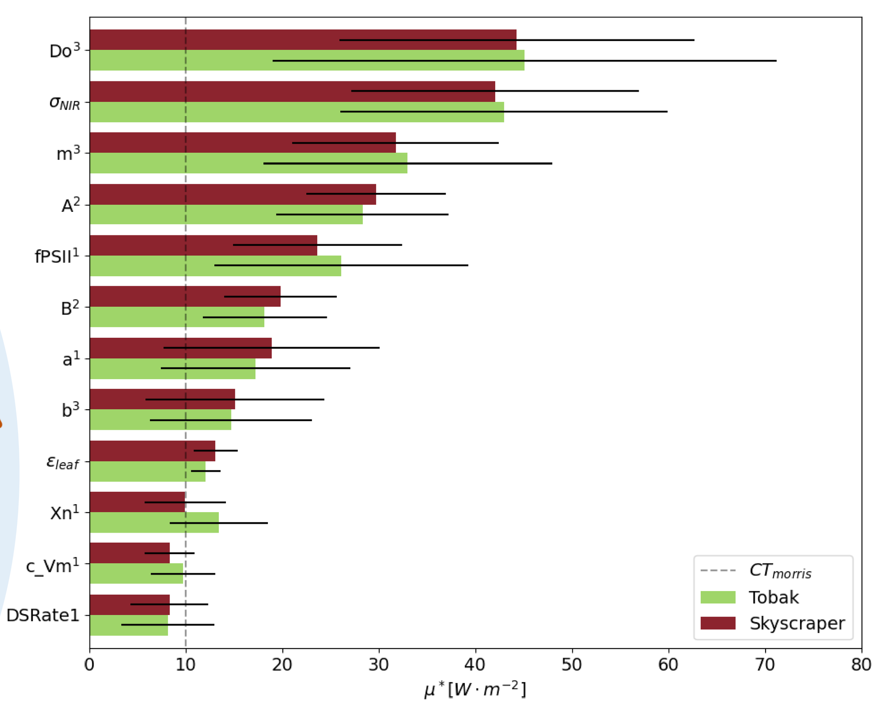


LATENT AND SENSIBLE HEAT FLUX

Vertical line corresponds to the cut-off threshold. Error bars refer to standard deviations, ¹ to Farquhar photosynthesis model, ² to Brunt radiation model and ³ to Leuning stomatal model.

Influence of parameters on H before anthesis

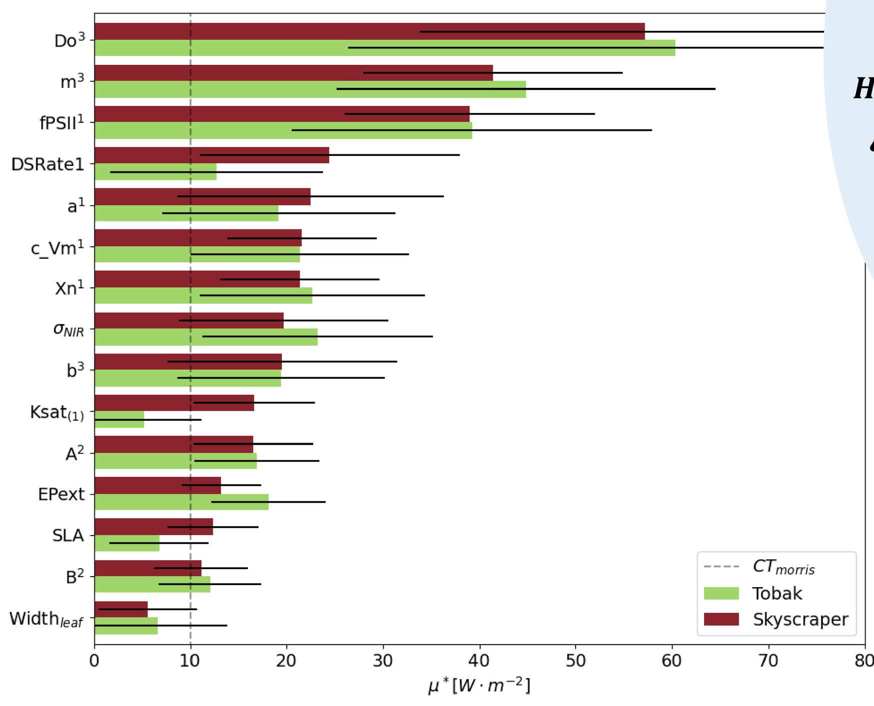




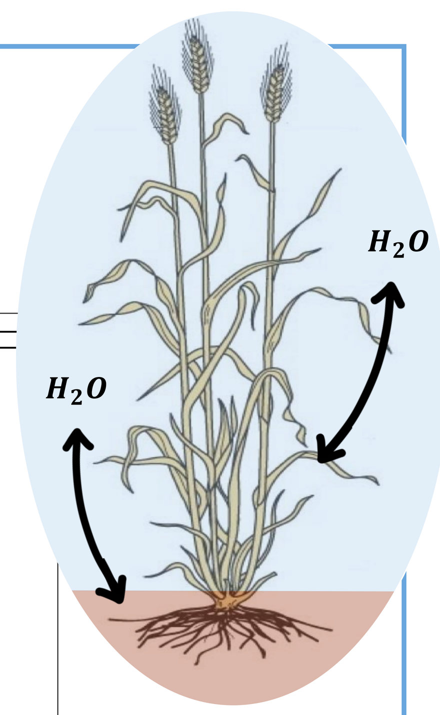
Stomatal conductance – These parameters, denoted by ³, are impactful on both H and LE fluxes (as well on NPP near and after anthesis, not shown here).

Radiation – Brunt parameters *(A* and *B)* are significant, particularly for H fluxes, as it distinguishes longwave and shortwave radiation from global radiation measurements. Moreover, photosynthetic parameter *a* determines diffuse and direct fractions and σ_{NIR} is the leaf scattering coefficient of NIR.

Photosynthesis – LE is impacted by these parameters as transpiration is strongly linked to carbon cycle.



Influence of parameters on LE before anthesis



WHICH MEASUREMENTS COULD IMPROVE FLUX MODELLING ?

Photosynthesis processes – Determination of maximum rate of carboxylation (Vcmax) and PAR absorbance of PSII is essential for all four outputs, through *Xn*, *c_Vm* and *fPSII* parameters. Additional leaf-level gas-exchange measurements and A-Ci curves can help to determine Vcmax and, besides, value and dependence of fPSII can be described with fluorescence measurements.

Vegetation data – Residues are only quantified at harvest, whereas temporal evolution of dead material falling to the ground is not considered but could improve the simulation of dry matter allocation and, via fAbscission, soil respiration. Moreover, SLA (Specific Leaf Area [m²/kg]) is also an important parameter in DAISY. However, it is measured only once (when LAI is maximum), even though small changes of SLA throughout the season could lead to significant changes in NPP or LE fluxes.