Impact of the 2018 drought on the CO_2 exchanges of a seed potato crop (*Solanum tuberosum* L.)

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1. Framework

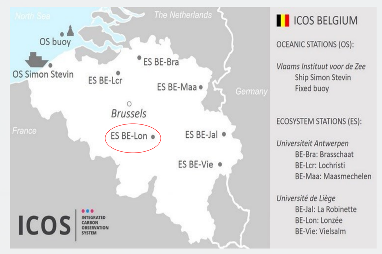
Broad context

- Impact of climate change on the supply of ecosystem services such as carbon storage and food production
- Impact of drought length and frequency changes on agrosystem performances

Objectives

- To quantify the edaphic water stress that occured during 2018 in Lonzée
- To evaluate the consequences on CO_2 fluxes (photosynthesis and respiration)
- To compare those fluxes with a renference year without pronounced drought events (2006)

2. Methodology



Study site

ICOS Lonzée Station (BE-Lon)

- Temperate climate (mean annual T and P: 10 °C, 800 mm)
- Land cultivated for more than 80 years
- Four-year rotation typical of central Belgium and including seed potaoes
- Soil type : loamy soil with plowed horizon over the 30 first cms

Experimental set-up

- CO_2 fluxes with Eddy-Covariance (EC) tower : Sonic anemometer (Solent Research Gill R3) and Infrared gas analyzer (Li-COR Li-7200 in 2018 ; Li-7000 in 2006)
- Water content measurements with Campbell CS616 (2006) and EnviroScan Sentek (2018) probes at several depths and locations
- Meteorological and soil variable measurements

Data treatment

- Eddy covariance data filtering, gap filling and partitioning of CO_2 fluxes by the REddyProc package. The Gross Primary Productivity (GPP) is computed as the substraction of the Net Ecosystem Exchange (NEE) and the Ecosystem Respiration (R_{eco}). R_{eco} is computed based on NEE night fluxes, modeled from Lloyd & Taylor (1994).
- GPP, R_{eco} and NEE are positive if emission of CO_2 from the ecosystem and negative if storage of CO_2.
- Quantification of edaphic water stress through cumulative Relative Extractable Water (REWc) up to 50 cms depth. SWC_{wp} and SWC_{fc} correspond respectively to the soil water content at the wilting point and at the field capacity. When REWc < 0.6 : hydric stress (FAO, 1979).

$$GPP = NEE - Reco$$

$$REWc = \frac{\sum_{surf}^{root\ depth} SWC - SWC_{wp}}{\sum_{surf}^{root\ depth} SWC_{fc} - SWC_{wp}}$$

3. Results

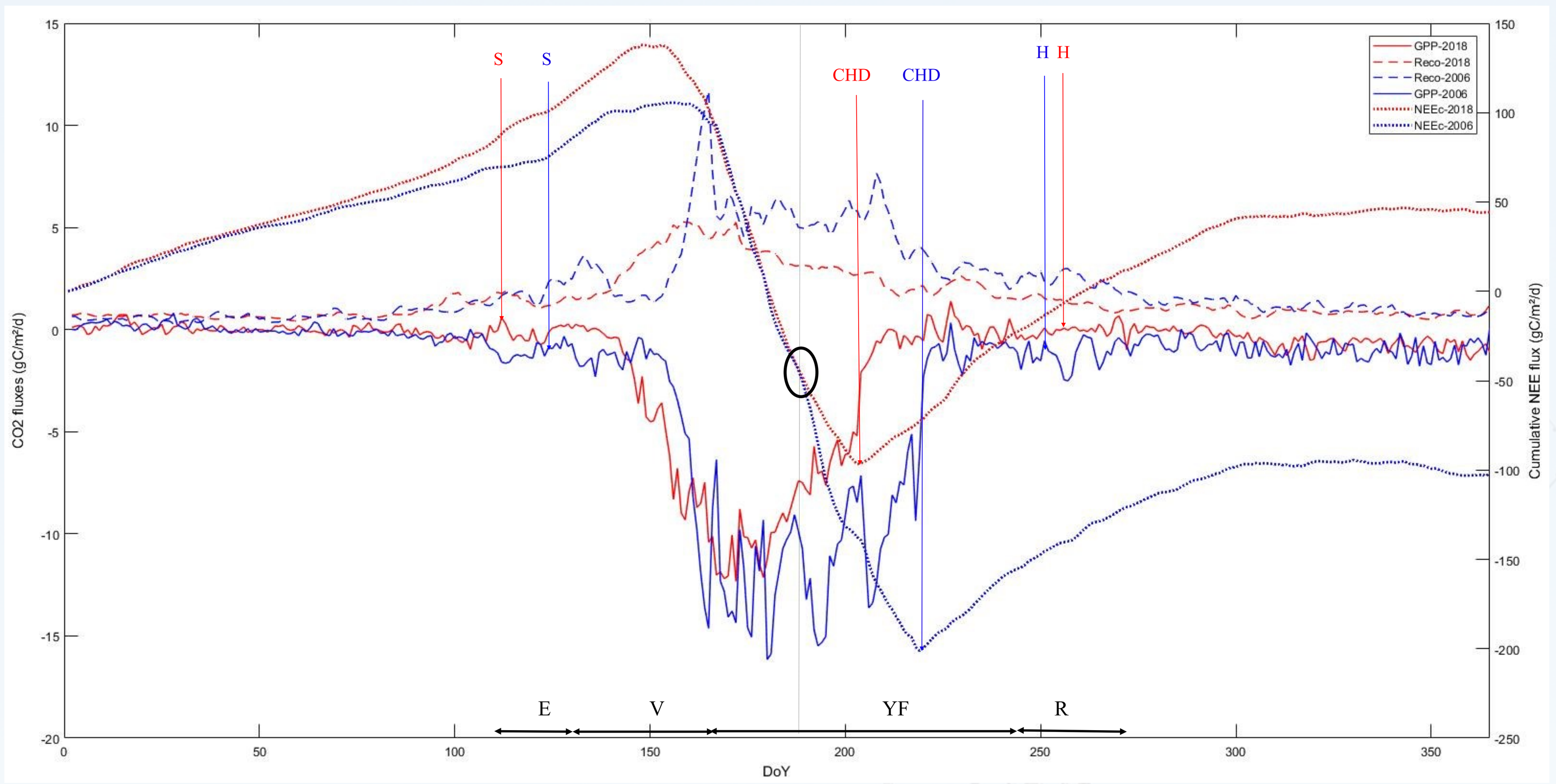


Figure 1: GPP, Reco fluxes and NEE cumulative flux (mean per day) during the years 2006 and 2018 (dashed and filled curves for GPP and Reco ; dotted curves for NEE). « H » means Harvest, « S » Sowing and « CHD » Chemical Haulm Destruction. « E » means Establishment stage period, « V » means Vegetative stage period, « YF » Yield Formation stage period and « R » Ripening stage period, abreviations of growth development stages from FAO nomenclature and determined by GLAI and height measurements.

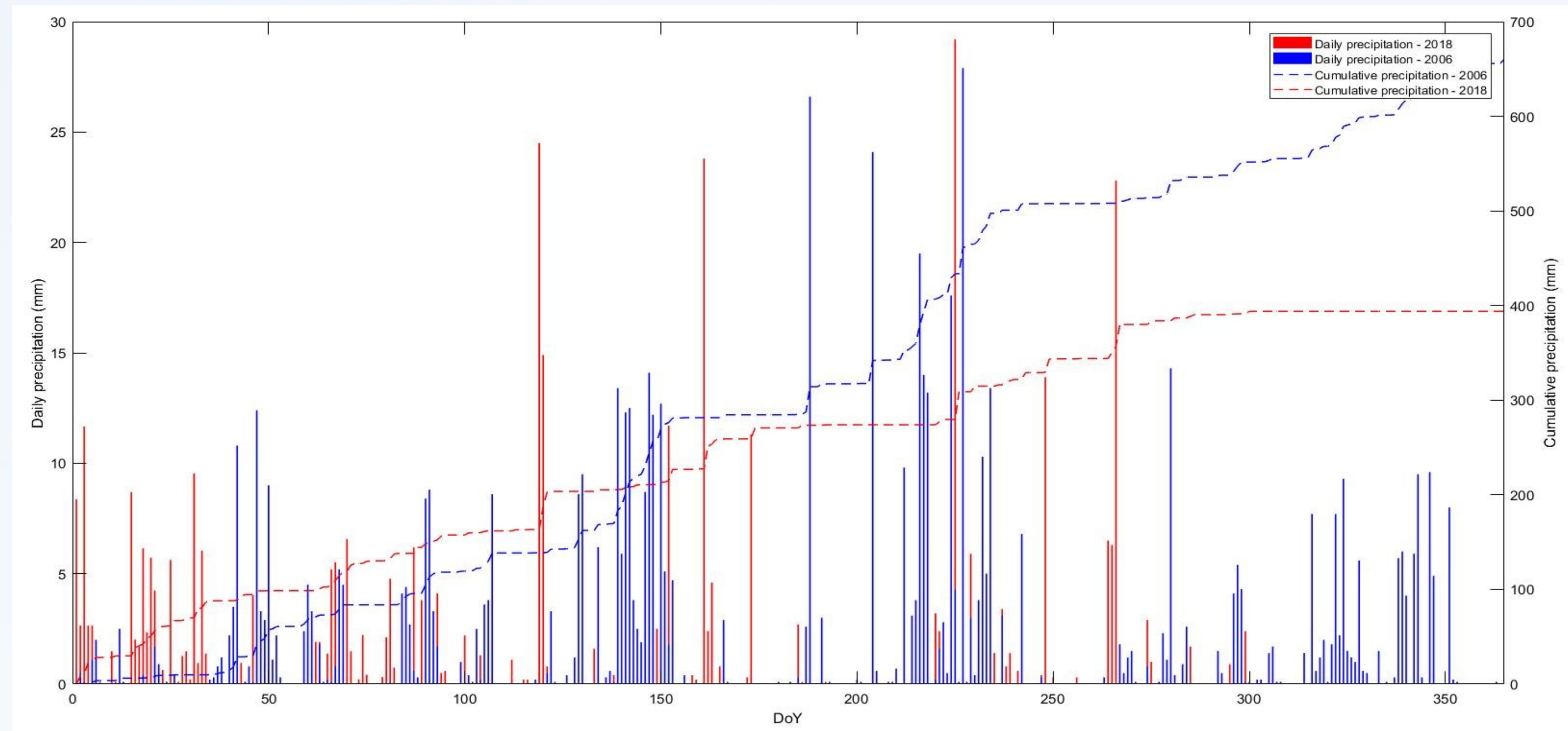


Figure 2: Daily sum precipitations (bars) and cumulative precipitations (dashed lines) in 2006 and 2018. The data also includes sprinkler irrigation events.

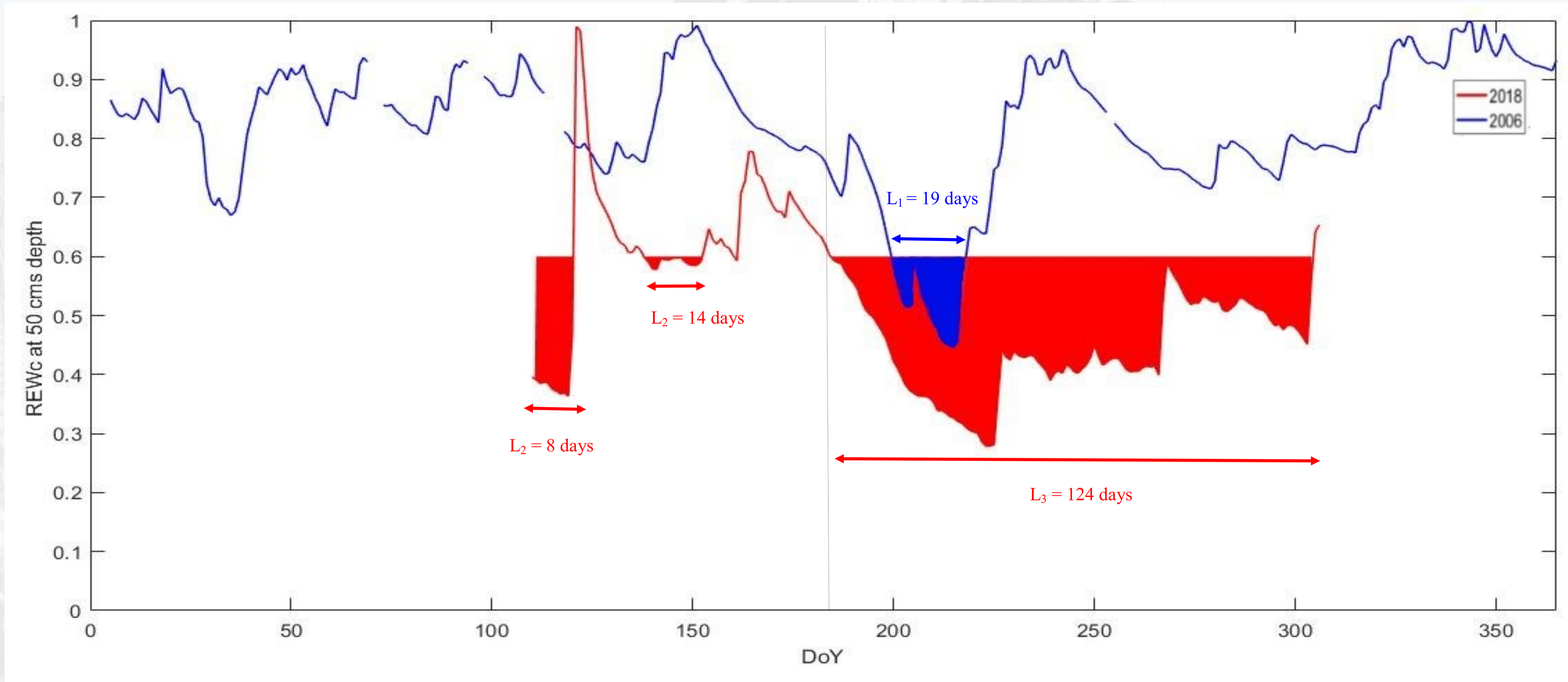


Figure 3: REWc up to 50 cms depth in function of time (DoY) during the years 2006 and 2018. The blue and red areas represent the water deficit. « L_i » represents the water stress duration.

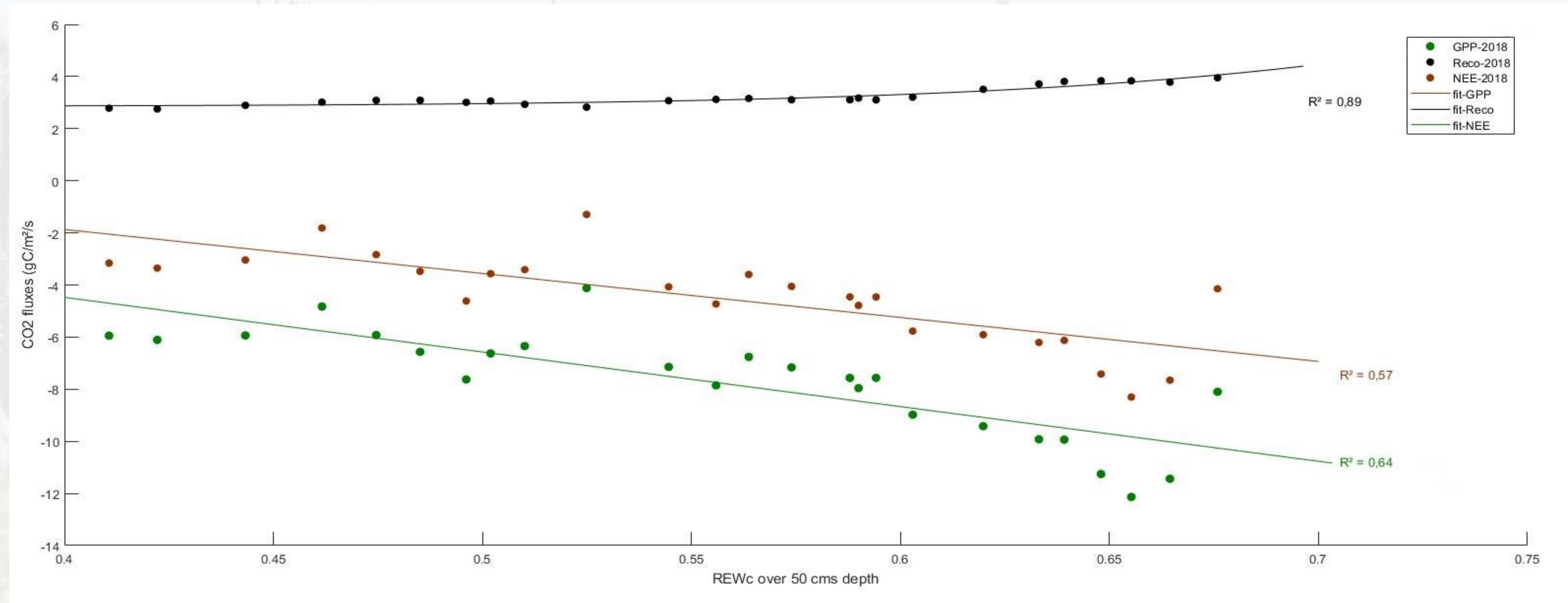


Figure 4: Regressions between GPP, NEE, Reco and REWc up to 50 cms depth (linear for GPP and NEE ; power for Reco). The data includes drought events (2 days after the last precipitation and with no precipitation during minimum 10 days) during the yield formation growth stage of the potato crop and before CHD in 2018 (between DoY 180 and 200). The CO_2 fluxes were filtered when PPFD > 1500 umol.m^{-2}s^{-1} to remove the impact of light on CO_2 fluxes variations.

4. Discussion

- Cumulative precipitations were lower in 2018 compared to 2006 (fig. 2).
- **3 water stress periods** occured during the **2018** crop period. The **summer one** had the longest **duration** and **intensity** compared to 2006 (fig. 3).
- **$NEE_{c,2018}$ > $NEE_{c,2006}$ during establishment and vegetative periods** : showing the predominance of R_{eco} on GPP at the beginning of the season in 2018 (fig. 1).
- Between DoY 180 and CHD time, the NEE_{2018} became higher than the NEE_{2006}. At the same moment the water stress started in 2018 (fig. 3).
- At the CHD time, the cumulative **NEE was lower in 2006** (-201.1 gC/m²) than in 2018 (-96.12 gC/m²) (fig. 1). At the harvest time, the ecosystem accumulated more carbon in 2006 than in 2018.
- **After CHD** : photosynthesis stopped, NEE became positive => source of CO_2 (fig. 1).

- **GPP, NEE and R_{eco} were correlated with REWc** up to 50 cms depth (R^2 = 0.64, R^2 = 0.57 and R^2 = 0.89 respectively) (fig. 4). The decrease in water availabilty led to a decrease in carbon assimilation and storage.

5. Conclusion and perspectives

- The carbon budget of the potato crop in 2018 was **correlated with water availabilty** at the Lonzée ICOS station through photosynthesis control during the yield formation stage.
- **A reduction of the NEE** in potato agrosystems is yet to be expected.
- However, **the crop yield didn't seem to be negatively impacted** (10.31 t/ha in 2018 ; 7.50 t/ha in 2006).

- How strong the relationship between **CO_2 fluxes and water availability is the same** for the other four-year rotation crops ? What's about the years 2010 and 2014 for the seed potato crops ?
- Can this relationship **be validated for the future climate** in Belgium ? (Ecotron perspective)