Carbon balance of agricultural lands – comparison of a conventional and an indirect measurement method

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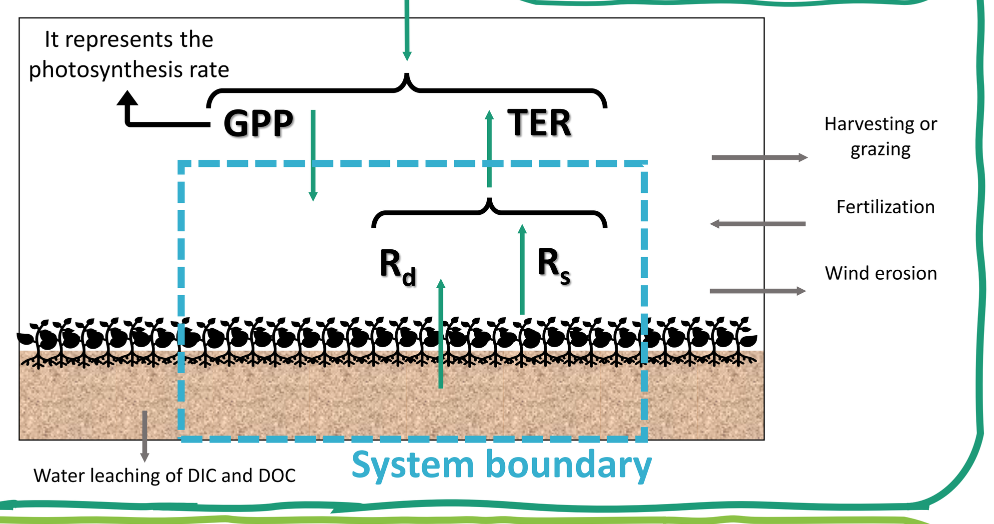
1 Introduction

Agricultural soil plays a crucial role in climate change mitigation as it provides the most important reservoir of carbon after oceans [c]. Therefore it is necessary to monitor how management practices affect the **capacity of agricultural ecosystems of sequestering carbon**. This is made possible by computing the **ecosystem carbon balance**, which is commonly performed with Eddy Covariance (EC) techniques.

Nonetheless an alternative indirect and low-cost method has been tested and compared with EC. A **combination of dark chamber measurements and Sentinel-2 Gross Primary Production (GPP) estimates** was used in order to obtain the **Net Ecosystem Exchange (NEE)**. The investigated site is Haltiala, a barley cropland located in the north of Helsinki, Finland, and the data collection campaign was conducted over the growing season 2021.

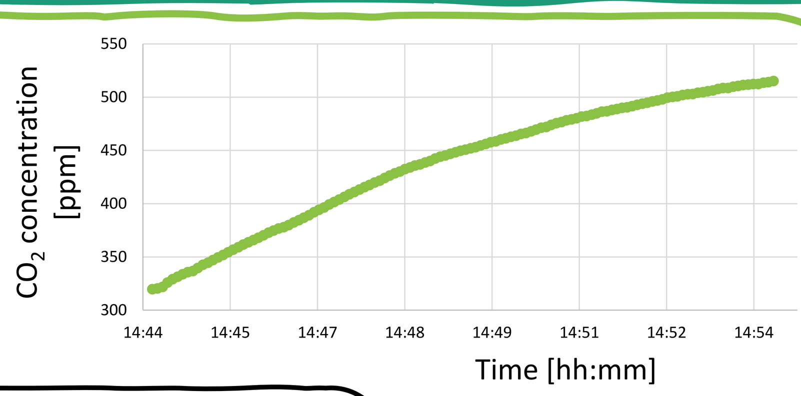
TER – GPP = NEE

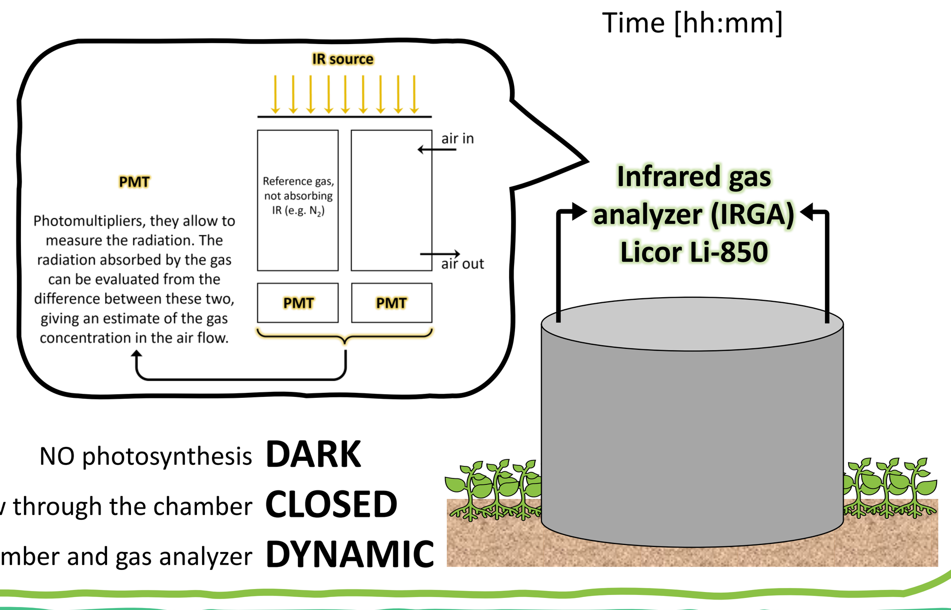
TER = Total Ecosystem Respiration
R_d = Root respiration
R_s = soil respiration



2 Chamber measurements

- 48 chambers
- 8 clusters
- 5 sec resolution
- biweekly campaign





NO photosynthesis **DARK**
NO air flow through the chamber **CLOSED**
Continuous air flow between chamber and gas analyzer **DYNAMIC**

3 Flux calculation

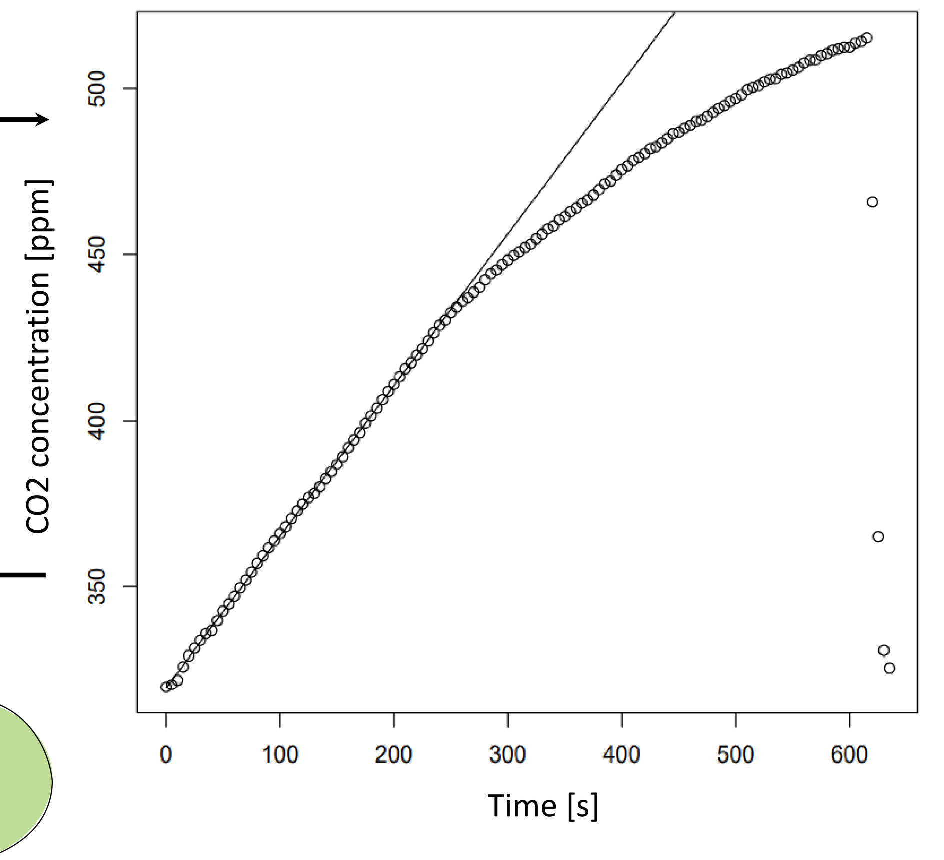
$$F(t) = \frac{dc}{dt}(t)\frac{V}{A} \quad [b]$$

$F(t)$ = mass flux rate ($kg\ m^{-2}\ s^{-1}$)
$dc/dt\ (t)$ = mass concentration change in time ($kg\ m^{-3}\ s^{-1}$)
V = chamber volume (m^3)
A = chamber area (m^2)

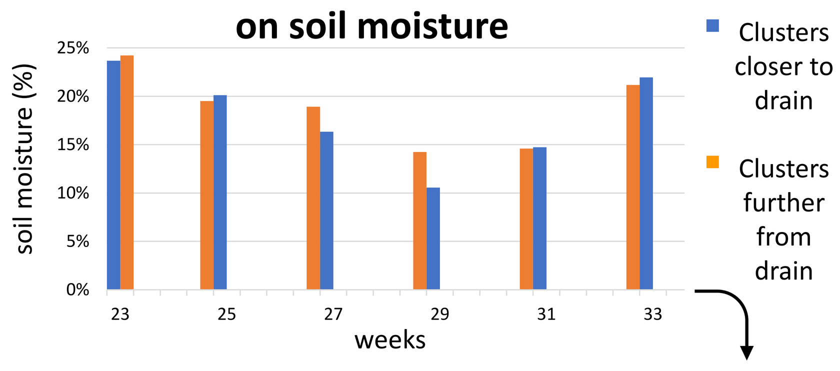
Normalized root mean squared error, to evaluate the goodness of the linear fitting

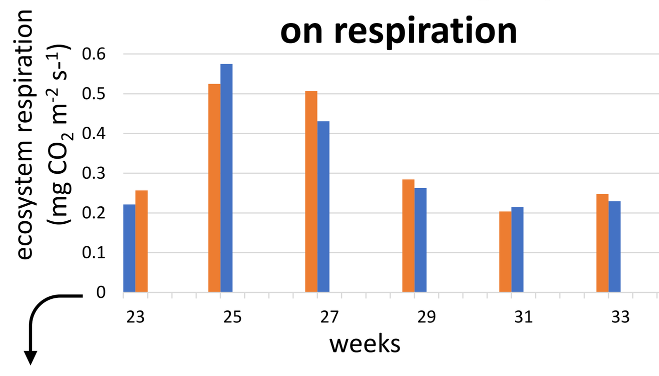
NRMSE < 20

Results: Flux value for each chamber and for each week

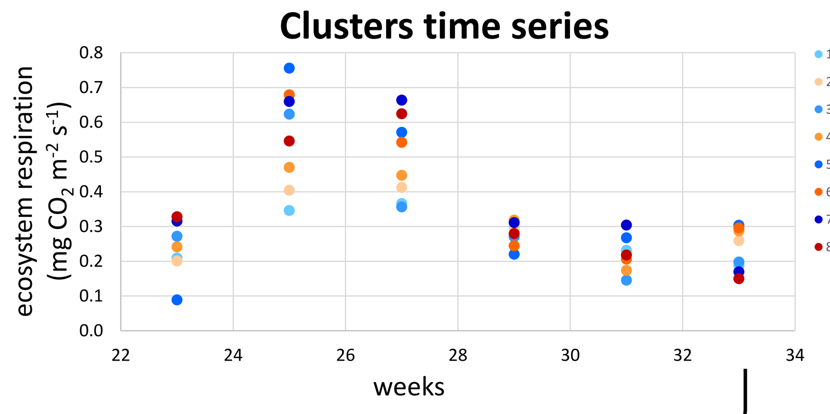


4 Spatial variability

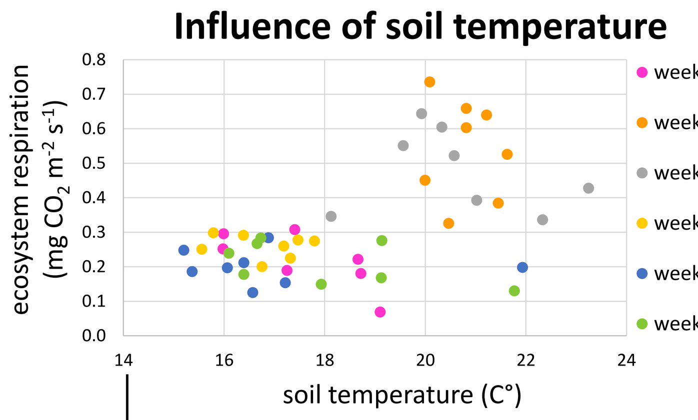




No significant differences due to location of the chambers



There was spatial variability but it was **not systematic**



Temperature was **not explaining all the spatial variability**

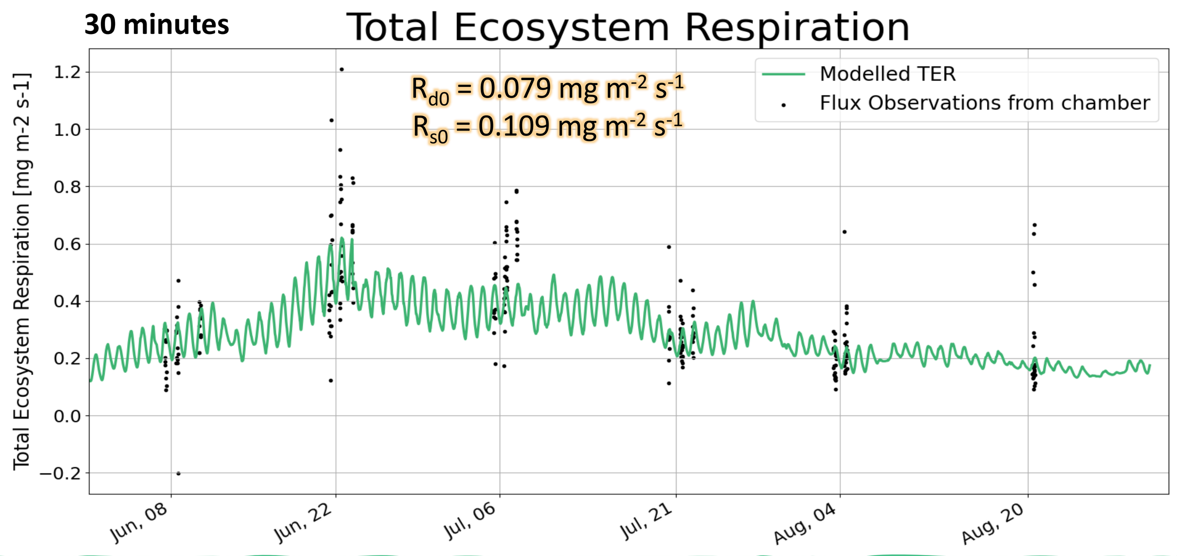
5 Respiration time series

$$TER = R_d + R_s = PI \cdot R_{d0} \cdot \exp\left[b_d\left(\frac{1}{T_0+273} - \frac{1}{T_l+273}\right)\right] + SA \cdot R_{s0} \cdot \exp\left[308.56\left(\frac{1}{56.02} - \frac{1}{T_s+46.02}\right)\right]$$

[a]

Total Ecosystem Respiration; Root respiration; Soil respiration; Measured variable; Open; Fixed: b_d = 5000, T_0 = 10°C; Measured variable; Open; Measured variable

PI: Related to photosynthetically active vegetation, replaced with **normalized Leaf Area Index (LAI)**
R_{d0}: Root respiration at reference temperature T_0
T_l: Leaf temperature (air temperature)
R_{s0}: Soil respiration at reference temperature T_0
T_s: Soil temperature at 5 cm



6 GPP time series

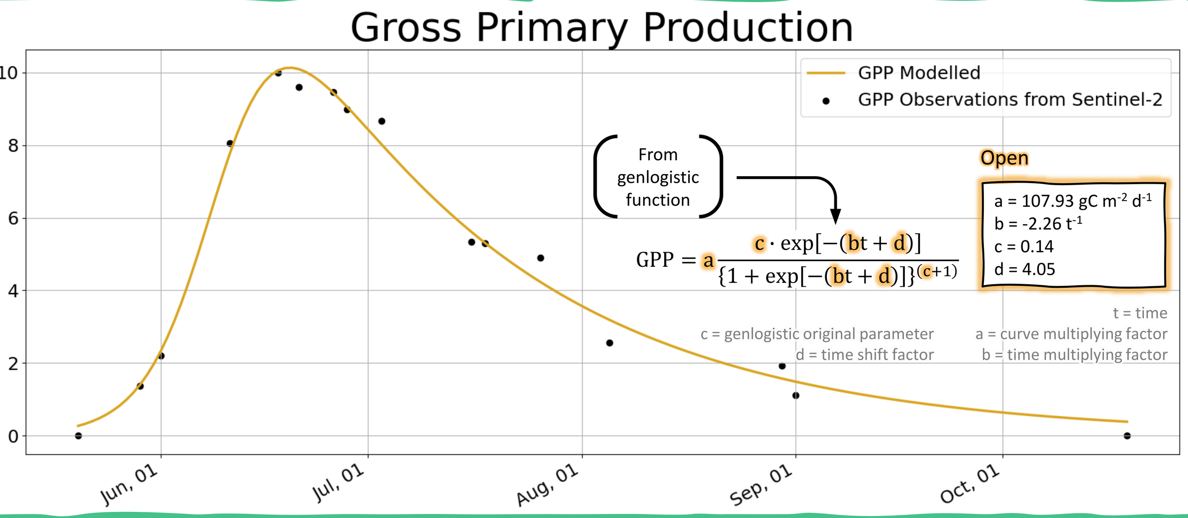
→ Estimates from empirical model

$$GPP = 4.80 \cdot \log(VI \cdot PAR \cdot 10^3) - 37.93 \quad [d]$$

PAR = Photosynthetically Active Radiation ($MJ\ m^{-2}\ d^{-1}$) from Copernicus Atmospheric Radiation Service (CAMS)
VI = vegetation index, in this case **Red-Edge Chlorophyll Index (CI red-edge)** from Sentinel-2 level 2A data

$$CI_{red_{edge}} = \frac{\rho_{NIR}}{\rho_{red-edge}} - 1 = \frac{\rho_{850nm}}{\rho_{730nm}} - 1$$

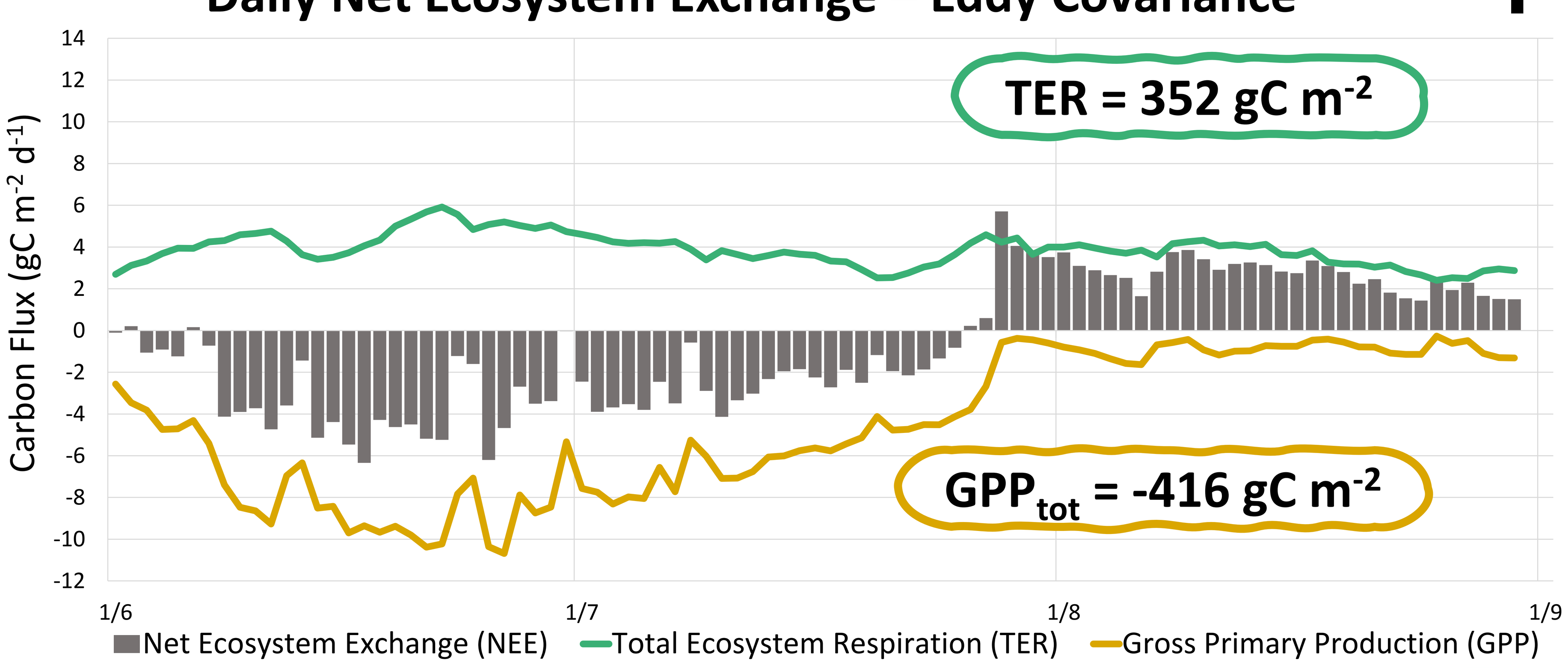
(ρ = reflectance of the site at a given wavelength)



7 Comparison with EC

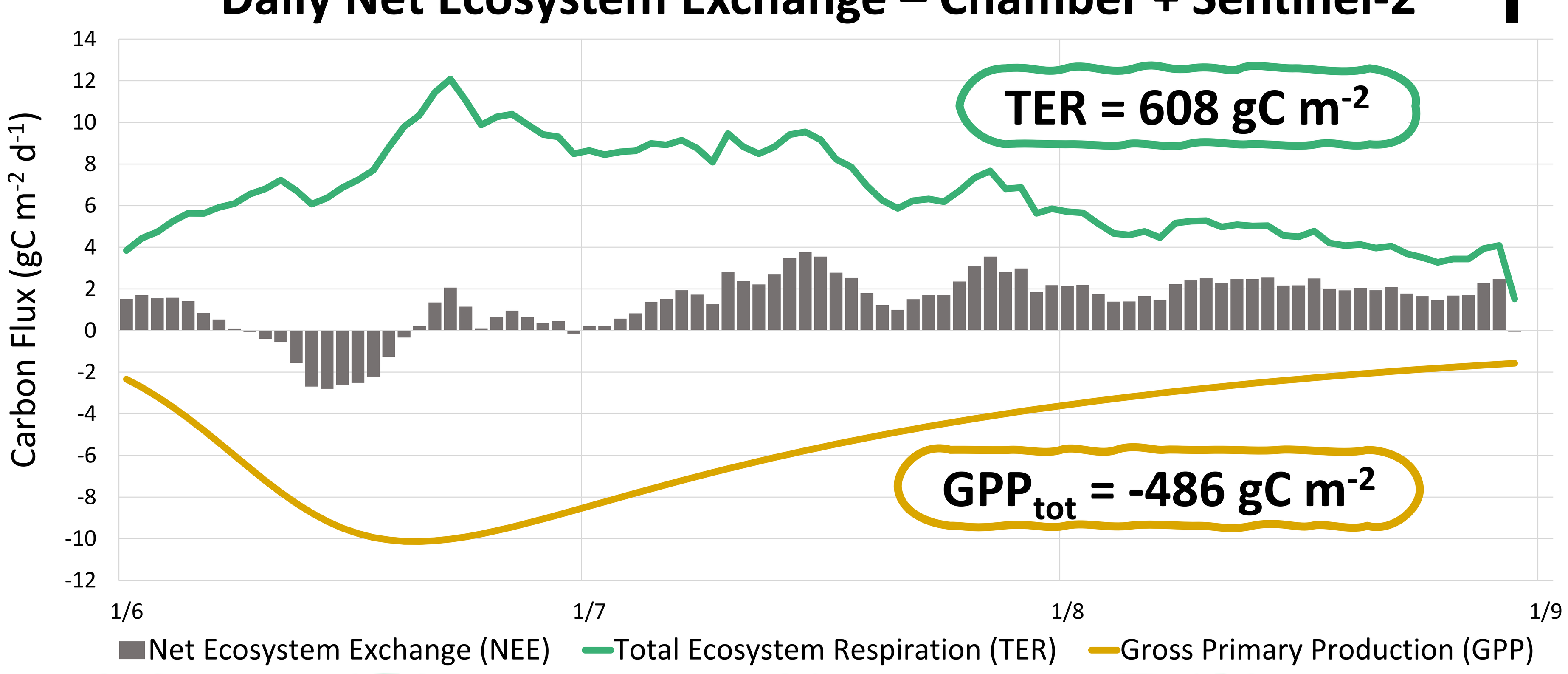
NEE_{tot} = -64 gC m^{-2}

Daily Net Ecosystem Exchange – Eddy Covariance



NEE_{tot} = 122 gC m^{-2}

Daily Net Ecosystem Exchange – Chamber + Sentinel-2



8 Conclusions and perspectives

- Chamber fluxes tend to **overestimate the respiration** with respect to EC
  → deeper comparative analysis are needed
- Necessity of **more chamber respiration data**
  → automatic chambers should be used
- **EC** dataset was strongly affected by **summer 2021 conditions**:
  low humidity and high pressure → no mixing wind during night time
  → **lack of night time data** → long period of gap-filling was needed
- **GPP satellite estimates** are fairly **consistent** with those from **EC**

References

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Carbon Action Field Observatory

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