

Monitoring the water stock using two vertically distributed superconducting gravimeters help to quantify evapotranspiration at daily time scale.

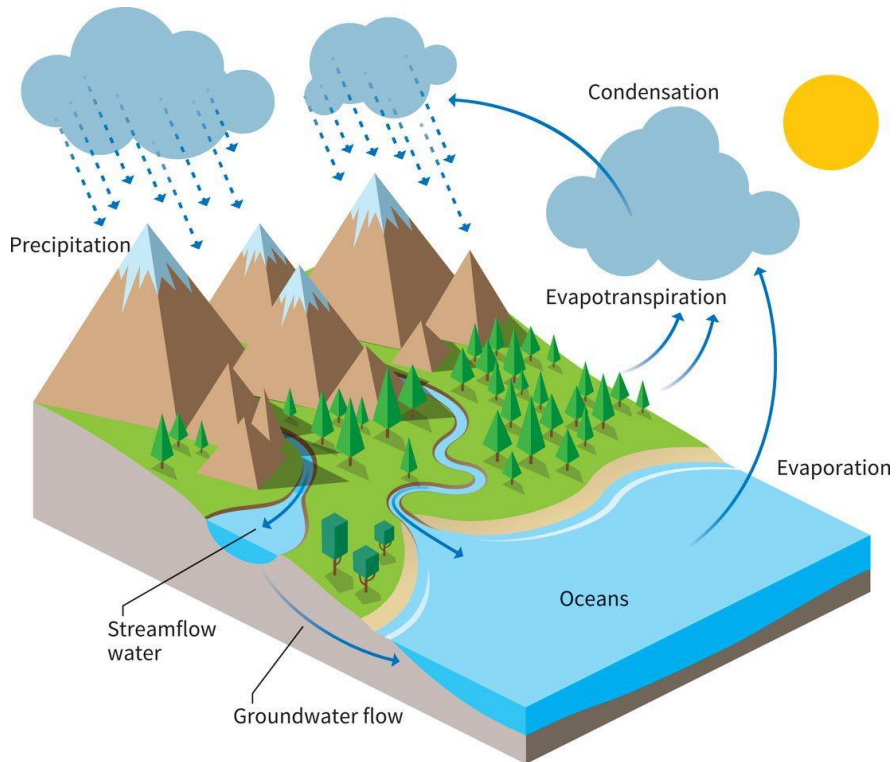


Loiseau.B, Carrière.D.S, Jougnot.D, METIS ;
Lesparre.N, Hinderer.J, ITES ;
Champollion.C, Géosciences Montpellier ;
Ollivier.C, CESBIO ;
Martin.N, Oliosio.A, URFM ;
Mercier.V, EMMAH

i-DUST - 08/06/2022



$$\text{Evapotranspiration}$$
$$\uparrow$$
$$\text{Water balance : } P - ET - R - \Delta S = 0$$
$$\downarrow \quad \downarrow \quad \downarrow$$
$$\text{Precipitation} \quad \text{Runoff} \quad \text{Change in storage}$$

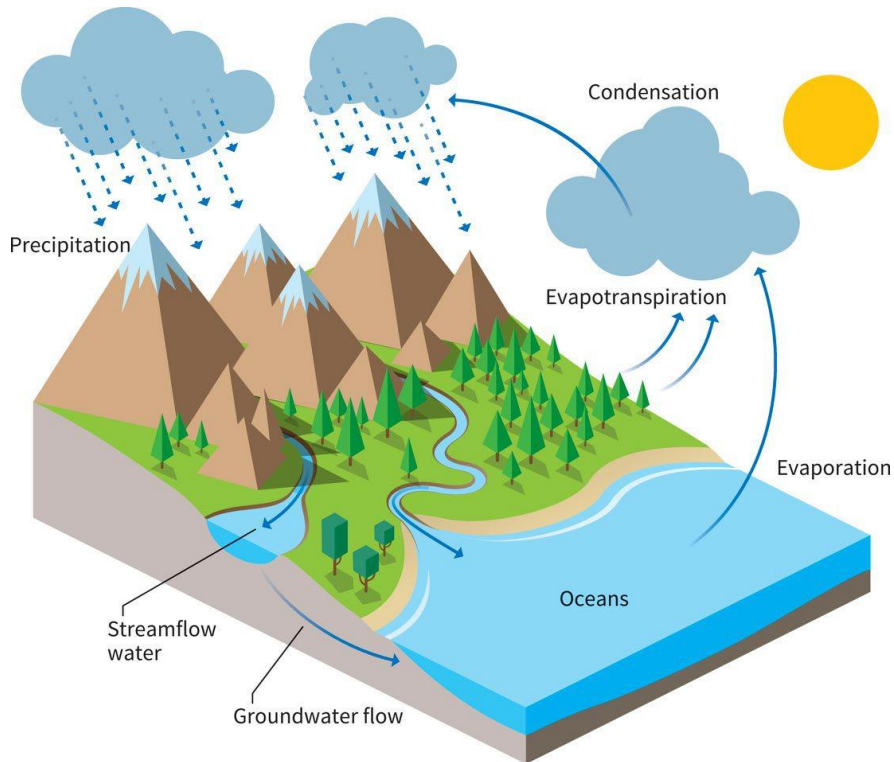


$$\text{Water balance : } P - ET - R - \Delta S = 0$$

↑
Evapotranspiration

↓ ↓ ↓
Precipitation Runoff Change in storage

$$ET = \text{Evaporation} + \text{Transpiration}$$



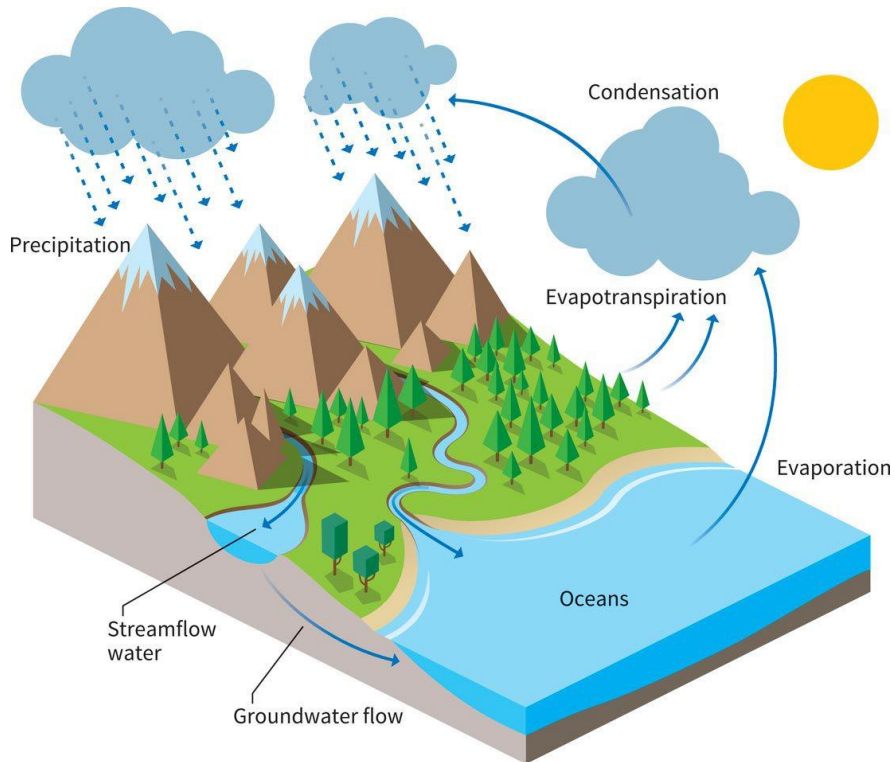
Evapotranspiration

$$\text{Water balance : } P - ET - R - \Delta S = 0$$

Precipitation

Runoff

Change in storage



$ET = \text{Evaporation} + \text{Transpiration}$

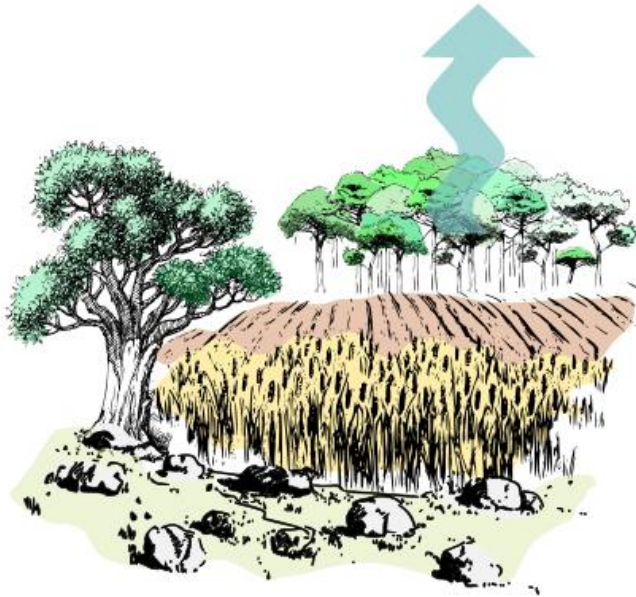
➤ **70%** of continental precipitation [Fisher et al. 2017; Oki et Kanae 2006]

In Mediterranean :

➤ **ET ≈ 80%** of precipitation [Brutsaert 2005]

➤ **Transpiration ≈ 75%** of ET

Evapotranspiration (ET)
= Evaporation + Transpiration

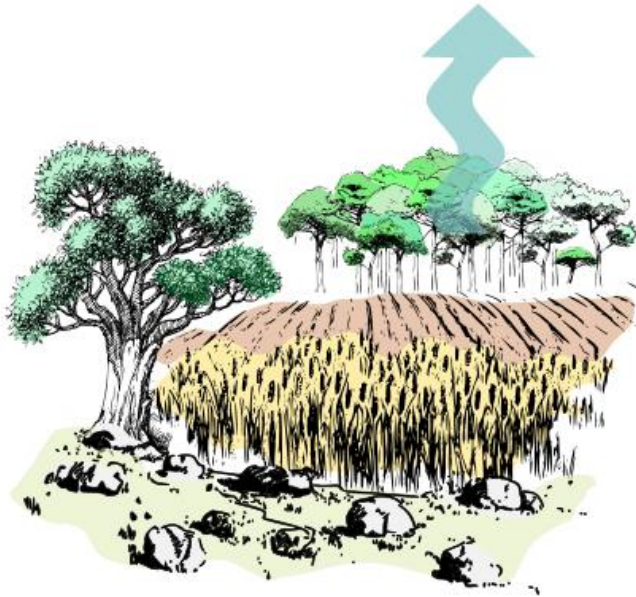


Geophysic → Gravimetry

[Van Camp et al. 2016]



Evapotranspiration (ET)
= Evaporation + Transpiration



Geophysic → Gravimetry

[Van Camp et al. 2016]



Can we link ET and gravity **day by day**?



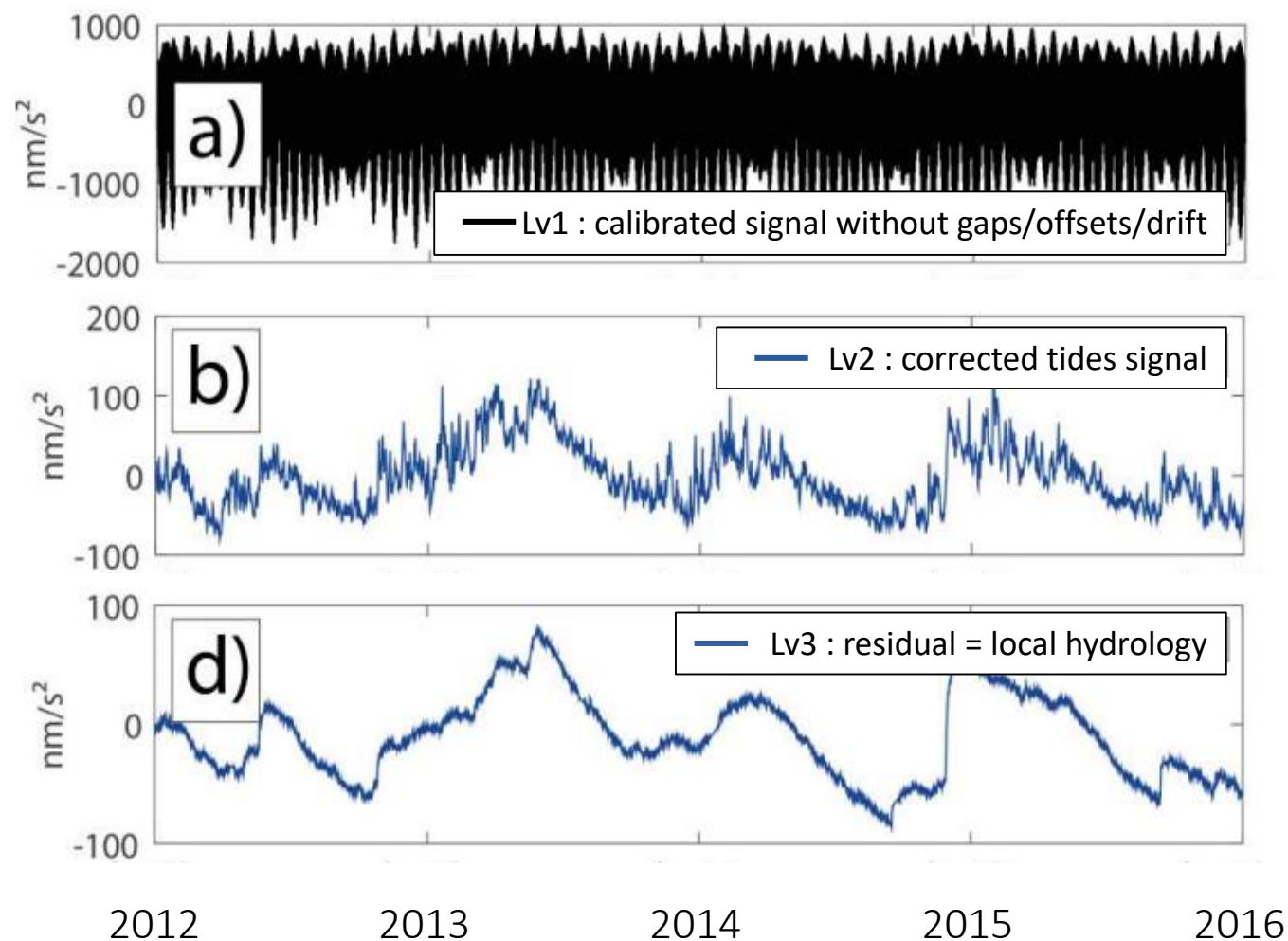
- Measures the variations of the earth's gravity field "g" in nm/s^2
- **Superconducting gravimeters** : Continuous measurements and very precise ($\approx 1 \text{ nm/s}^2$)
- **Water table relationship (Bouguer plateau)** :
 $1 \text{ nm/s}^2 \approx 2.4 \text{ mm of water}$

Gravimetry

ET modelling

ET measured

Study site



← Raw signal

Correction : tides

Corrections : pressure, polar motion, non-local hydrology

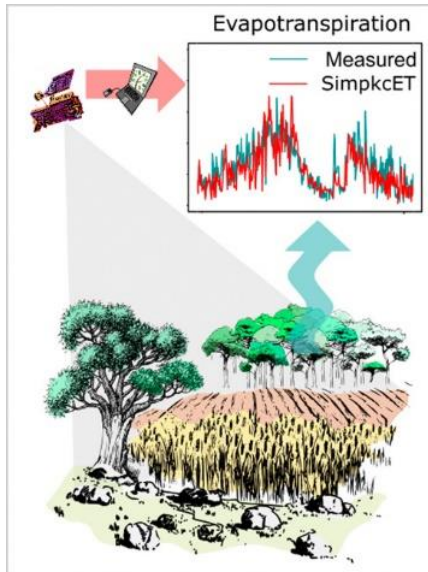
← Residual signal = Signal related to hydrology



Can we link ET and gravity day by day?

Comparison
gravimetry/ET modelling

Comparison
gravimetry/ET measured



Ollivier et al. 2021

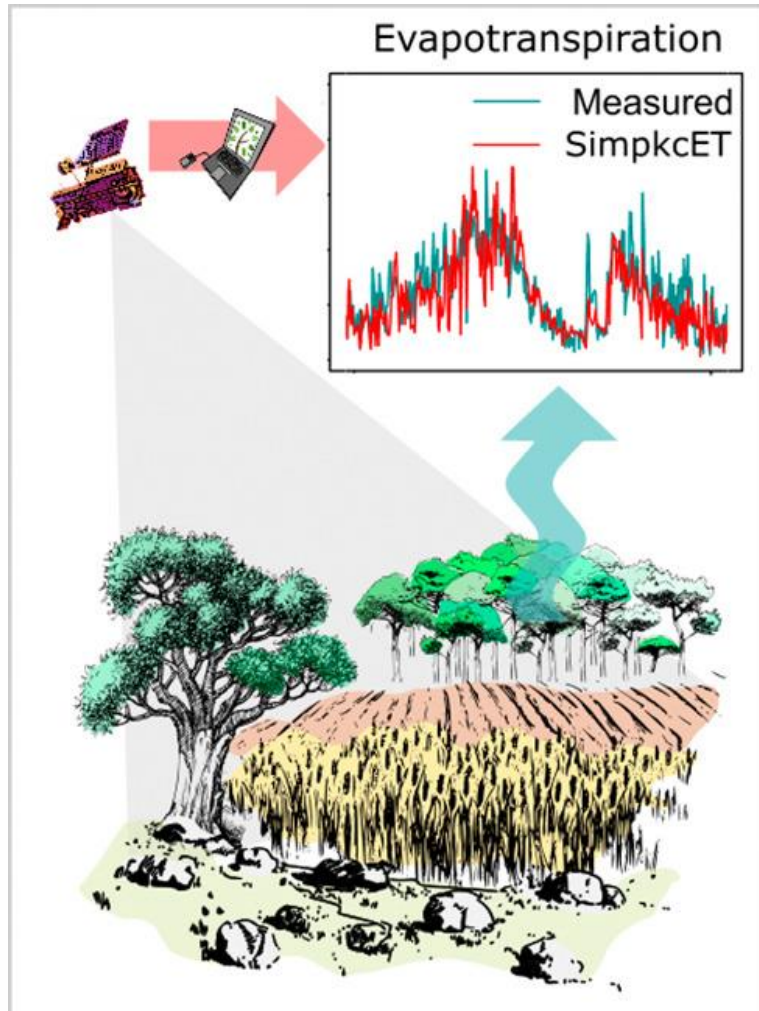


Gravimetry

ET modelling

ET measured

Study site



Ollivier et al. 2021

SimpKcET model :

- Water balance
- ET simulation
- Evaluated on 3 flux towers close
- Calibrated to the flows at the outlet of Fontaine-de Vaucluse hydrossystem



Sapflow sensors :

- 2 probes equipped with thermocouples
- Heat dissipation
- **Transpiration** measurement
- On 6 holm oaks



Gravimetry

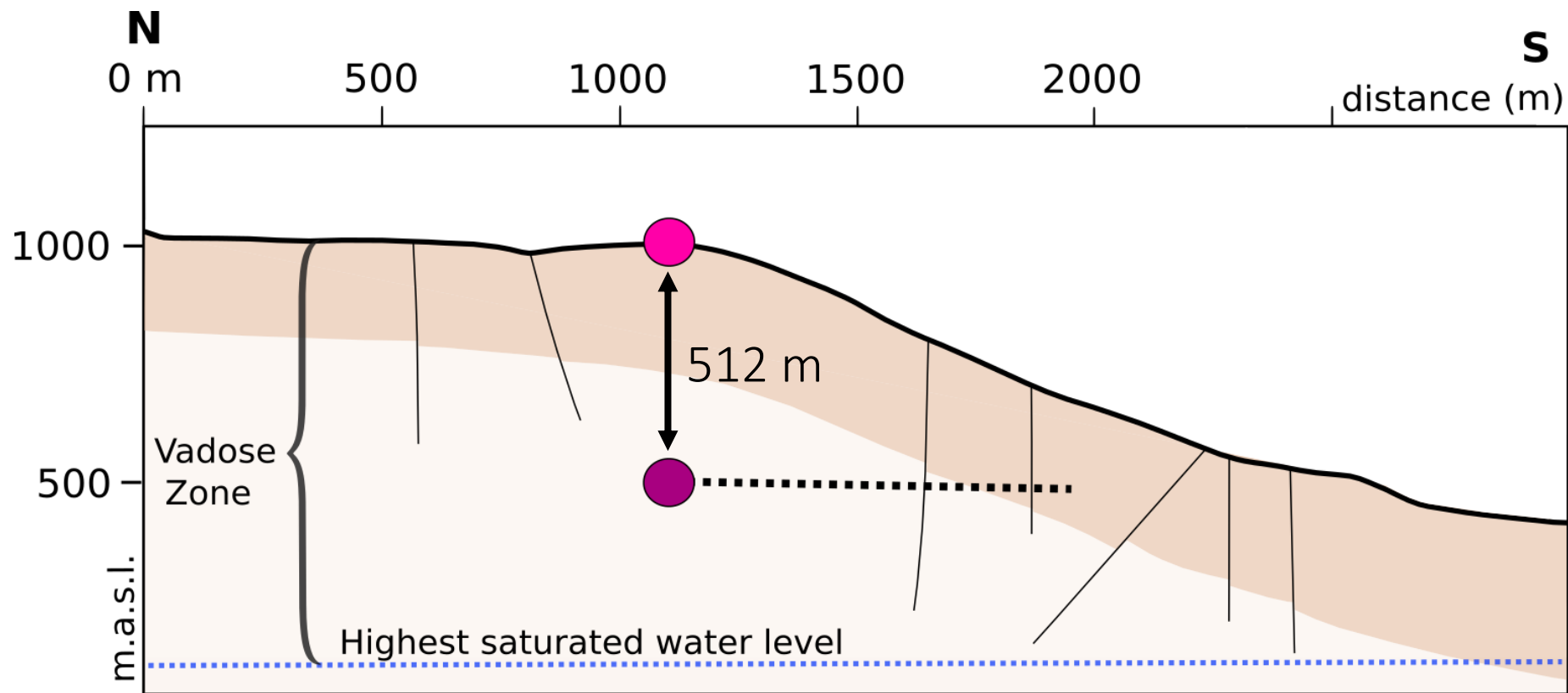
ET modelling

ET measured

Study site



The Low Noise Underground Laboratory (LSBB)

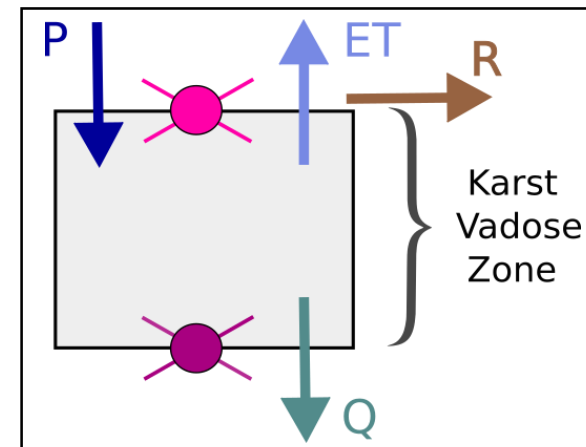
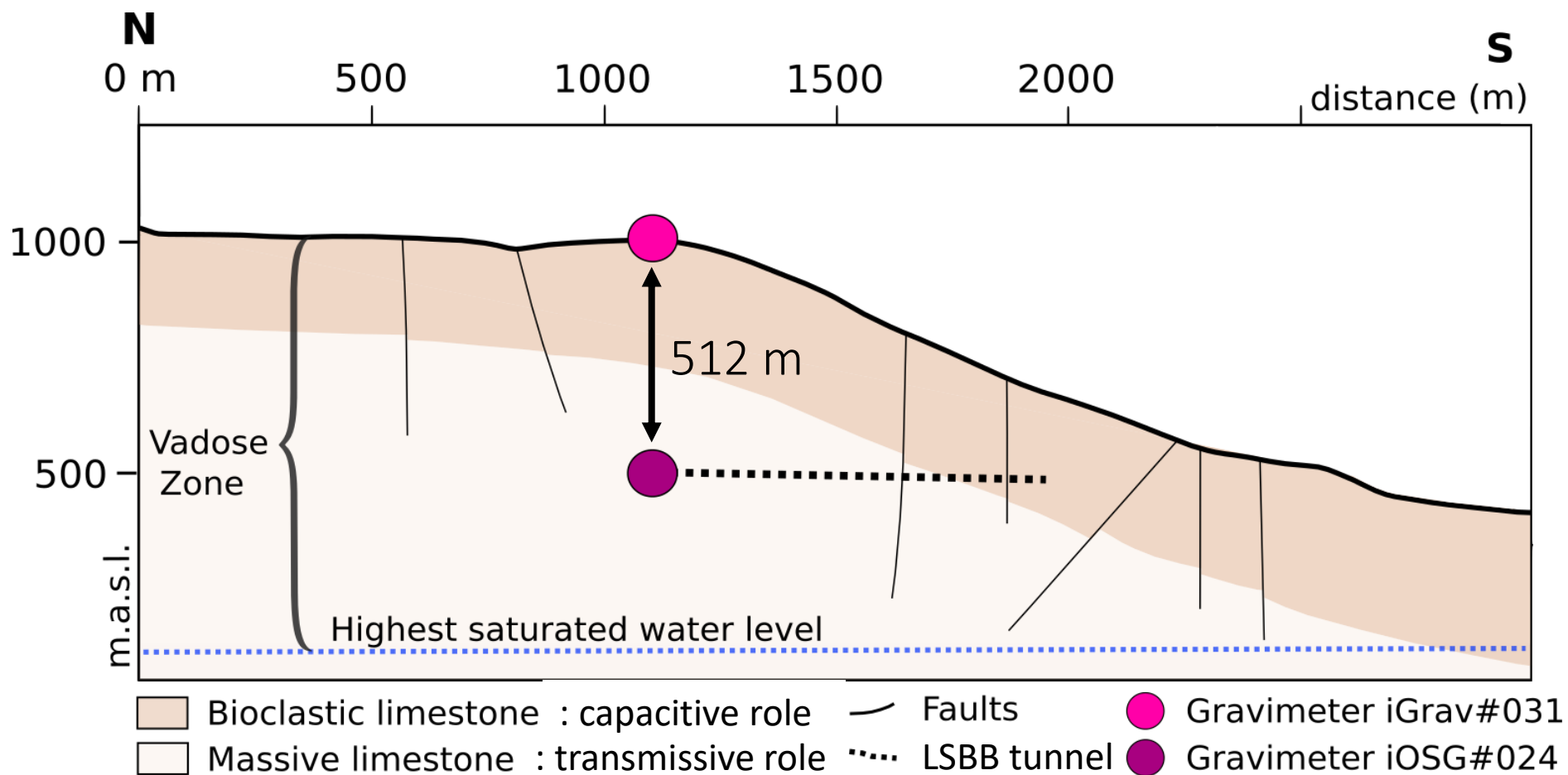


- Bioclastic limestone : capacitive role
- Massive limestone : transmissive role
- Faults
- LSBB tunnel
- Gravimeter iGrav#031
- Gravimeter iOSG#024

Gravimetry/ET modelling

Gravimetry/ET measured

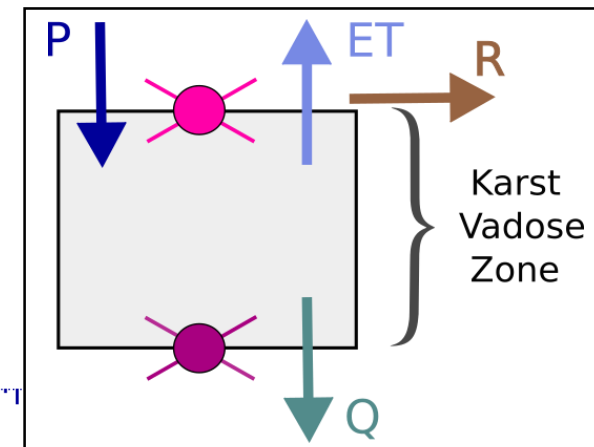
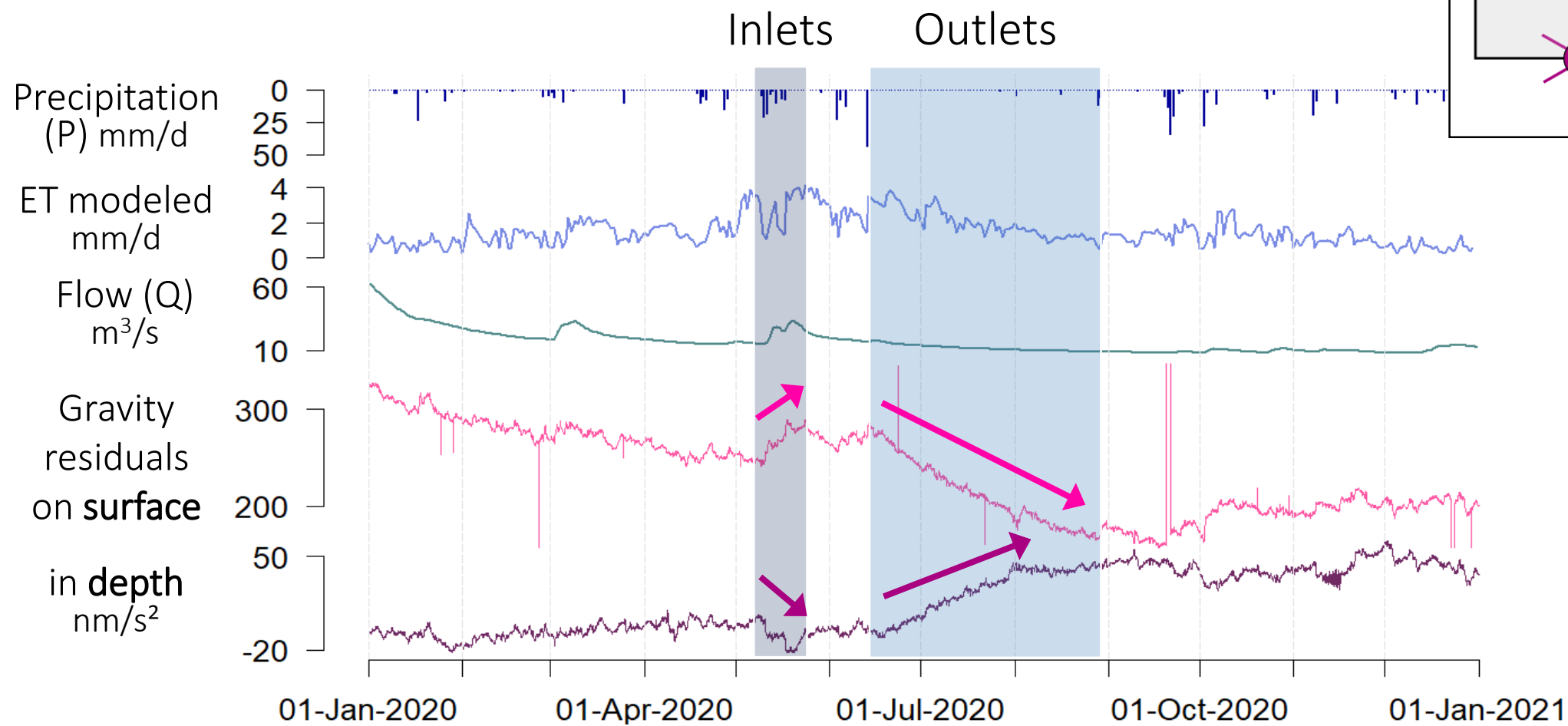
LSBB cross-section



Gravimetry/ET modelling

Gravimetry/ET measured

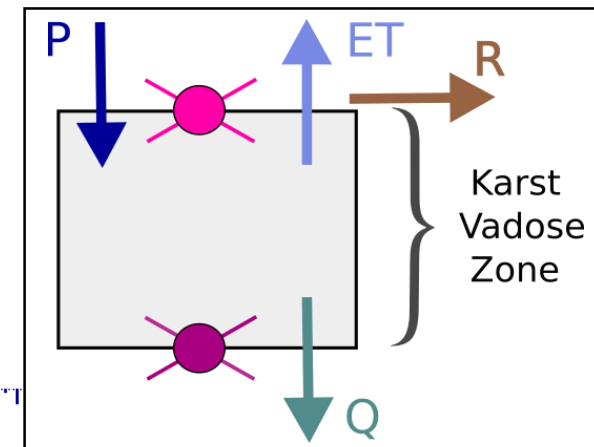
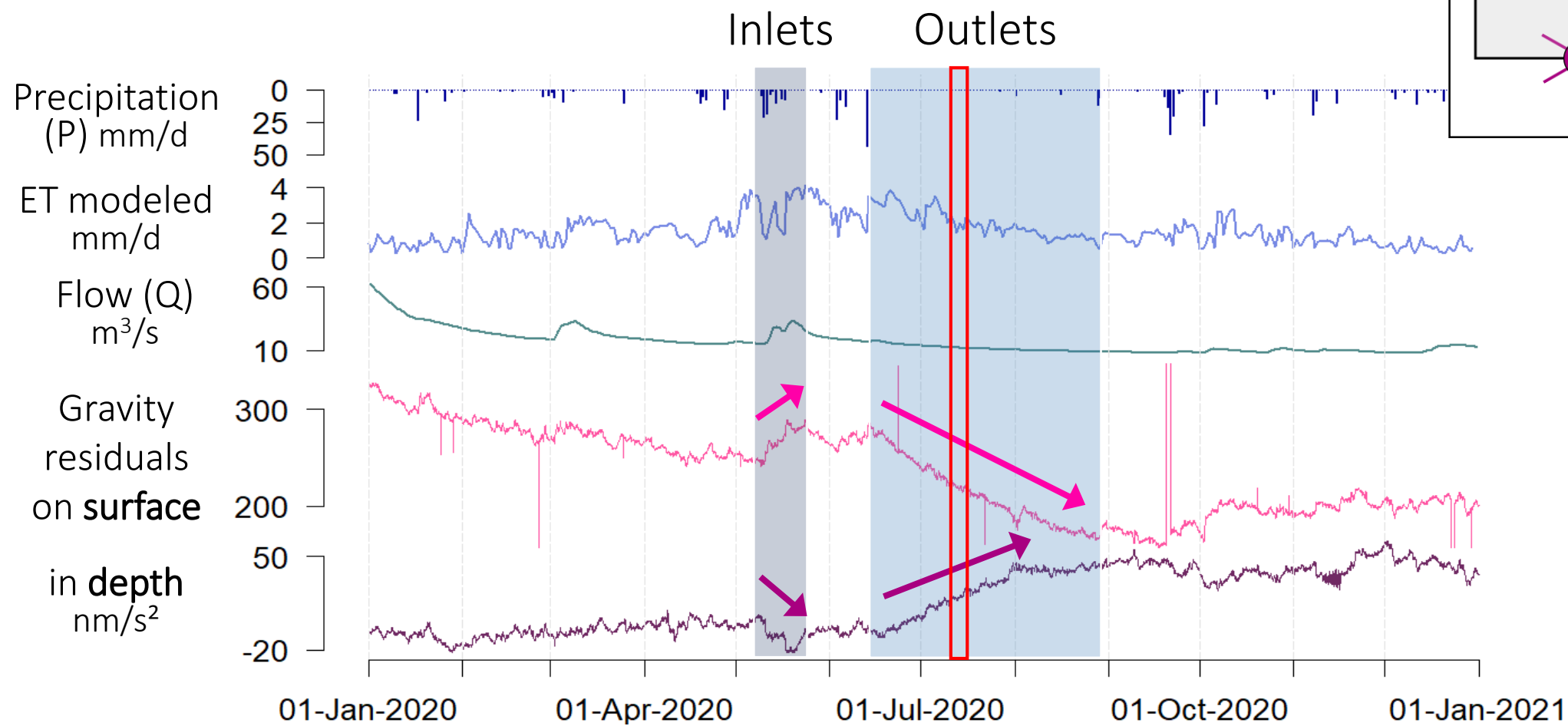
Gravimetric residue over the year 2020



Gravimetry/ET modelling

Gravimetry/ET measured

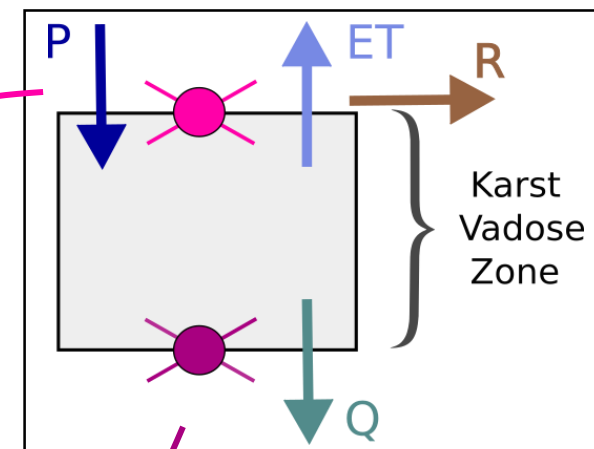
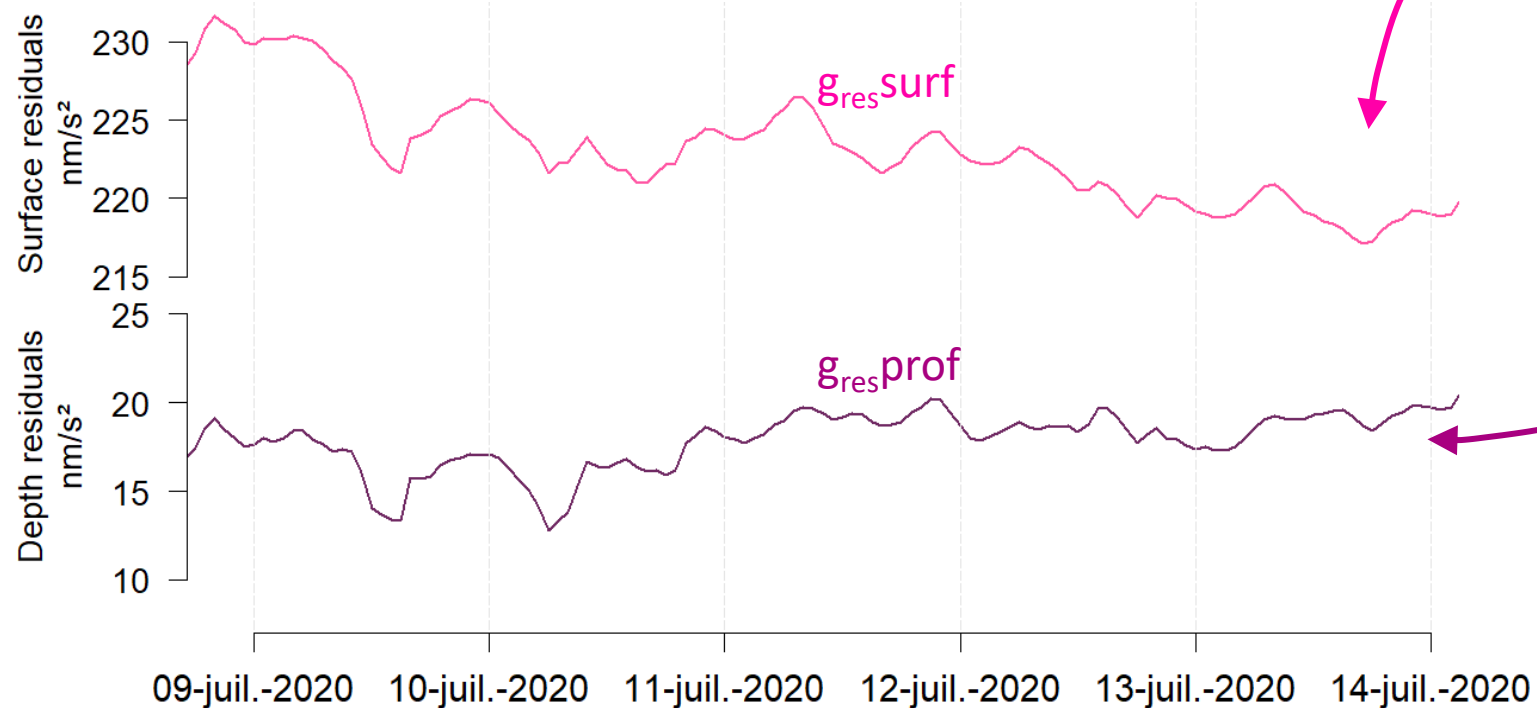
Gravimetric residue over the year 2020



Gravimetry/ET modelling

Gravimetry/ET measured

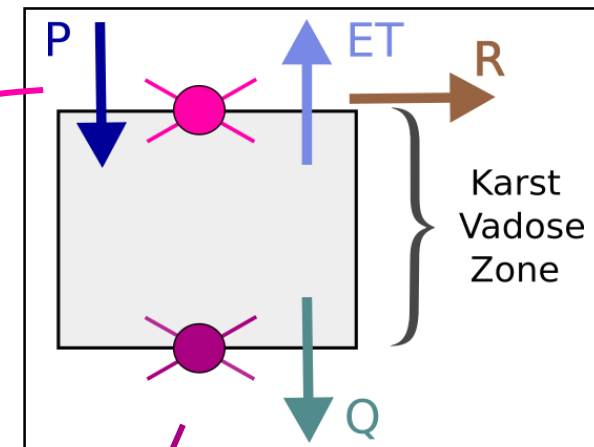
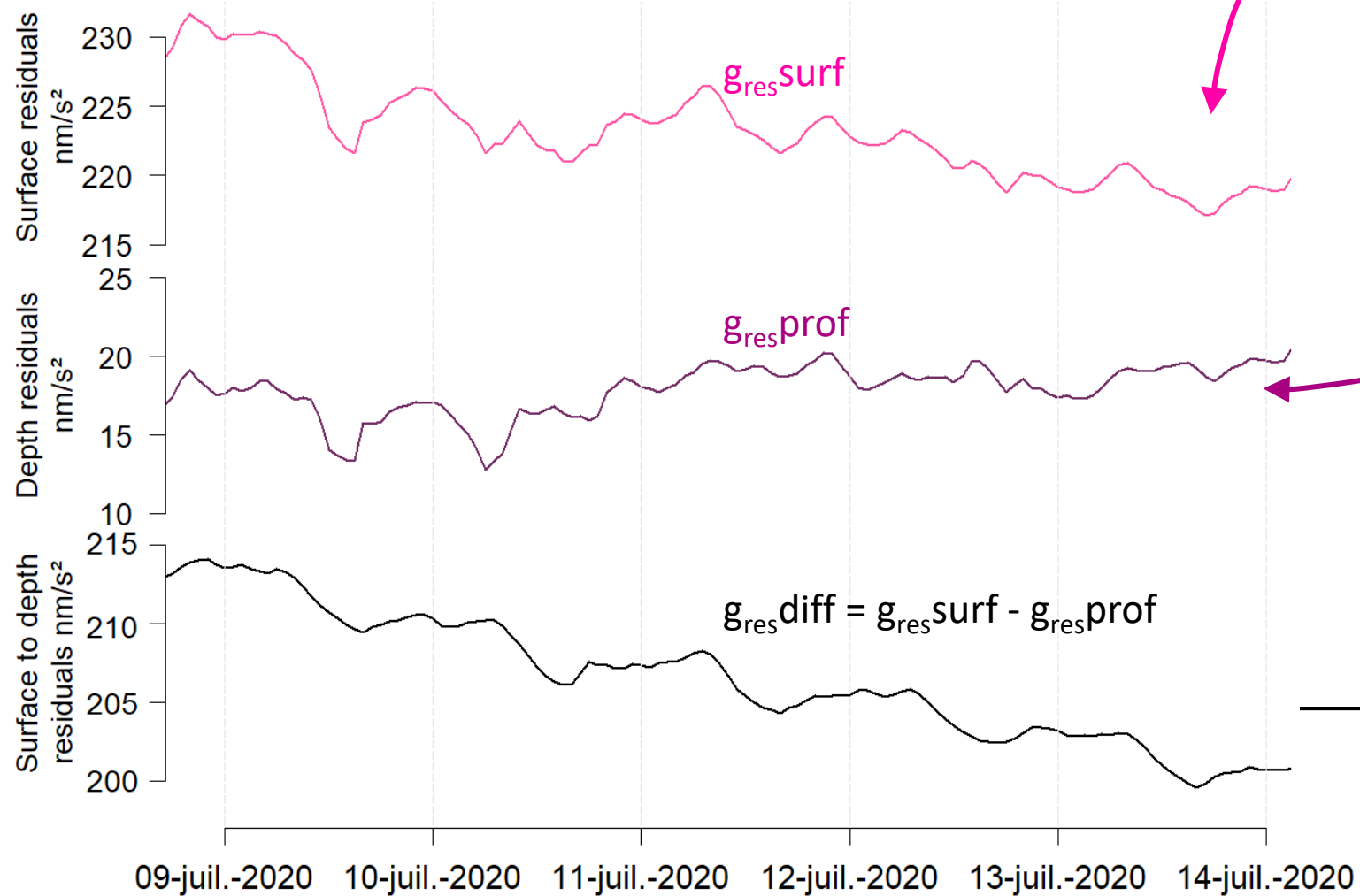
Focus on 5 days of summer 2020



Gravimetry/ET modelling

Gravimetry/ET measured

Focus on 5 days of summer 2020

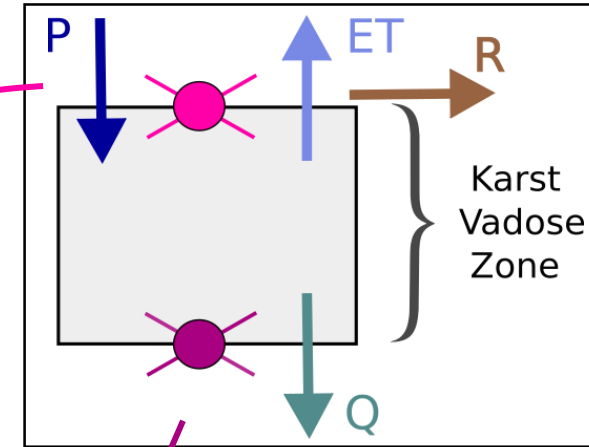
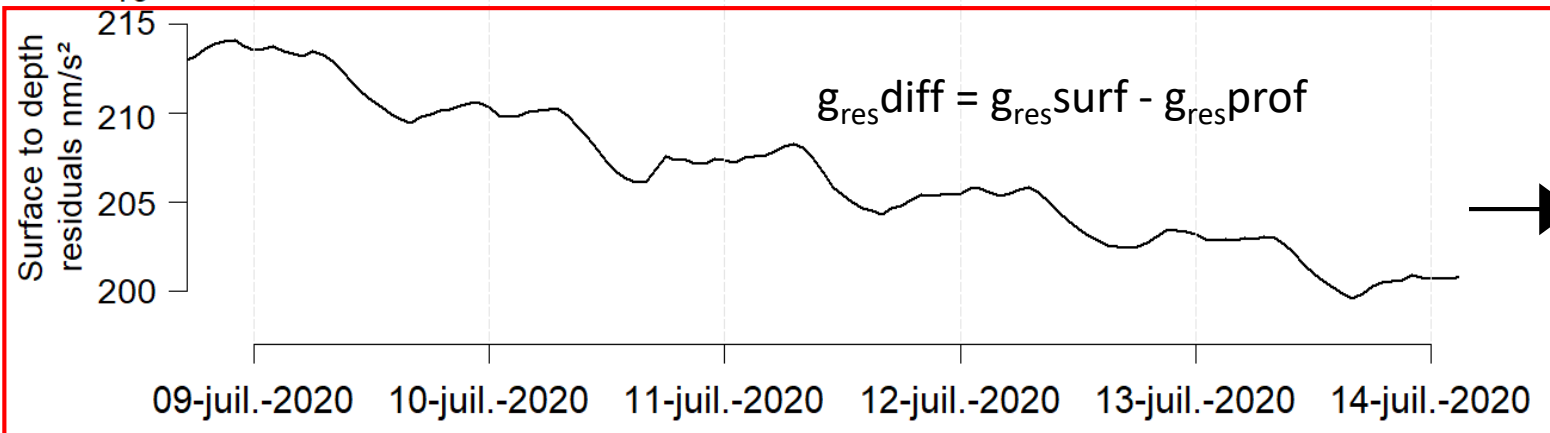


→ Signals difference

Gravimetry/ET modelling

Gravimetry/ET measured

Focus on 5 days of summer 2020



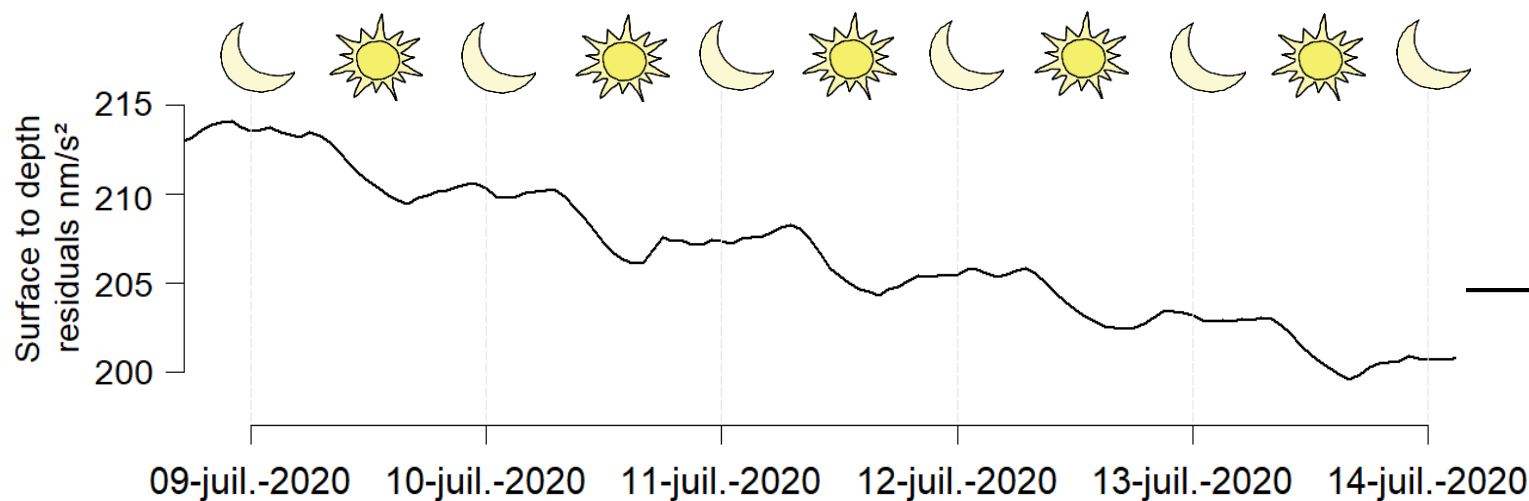
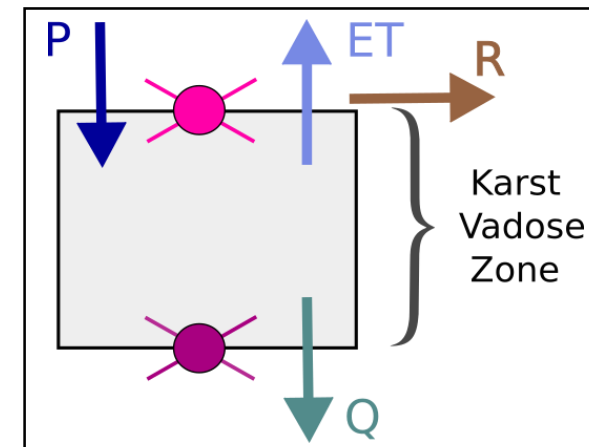
Signals difference

Gravimetry/ET modelling

Gravimetry/ET measured

Focus on 5 days of summer 2020

→ Signal decay during the summer = water outflow



Signals difference

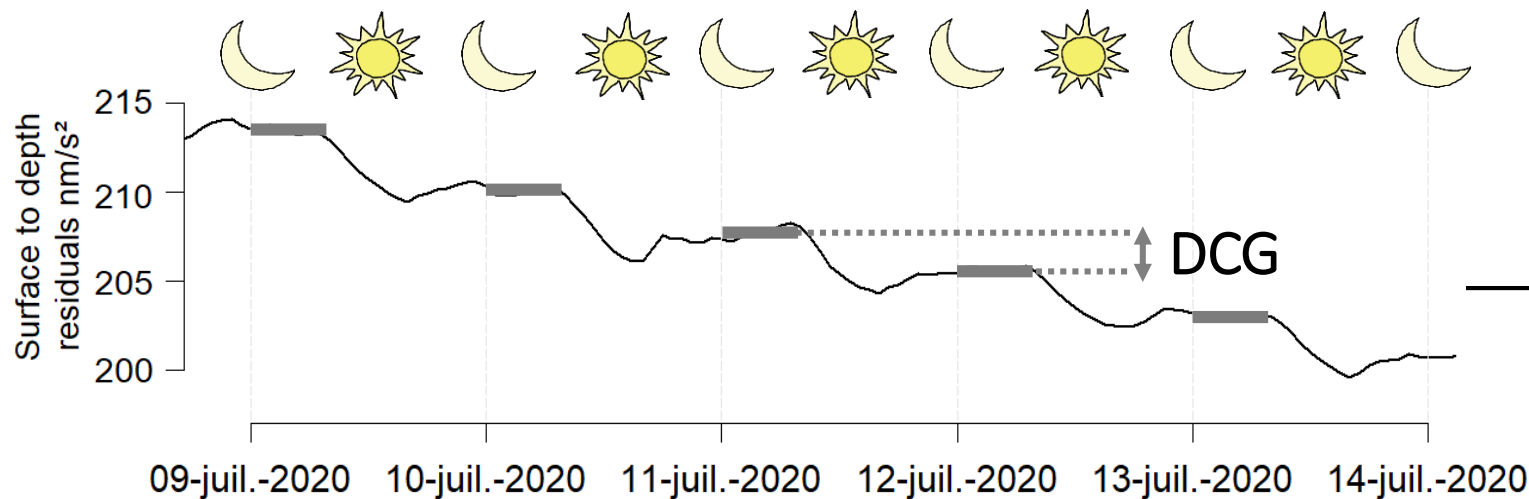
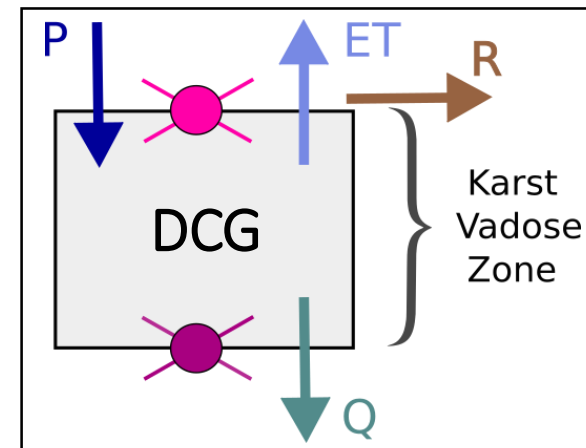
Gravimetry/ET modelling

Gravimetry/ET measured

Focus on 5 days of summer 2020

→ Signal decay during the summer = water outflow

DCG = Daily Change Gravity

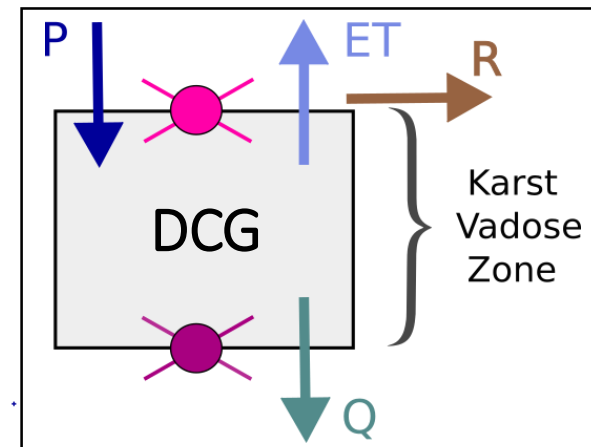
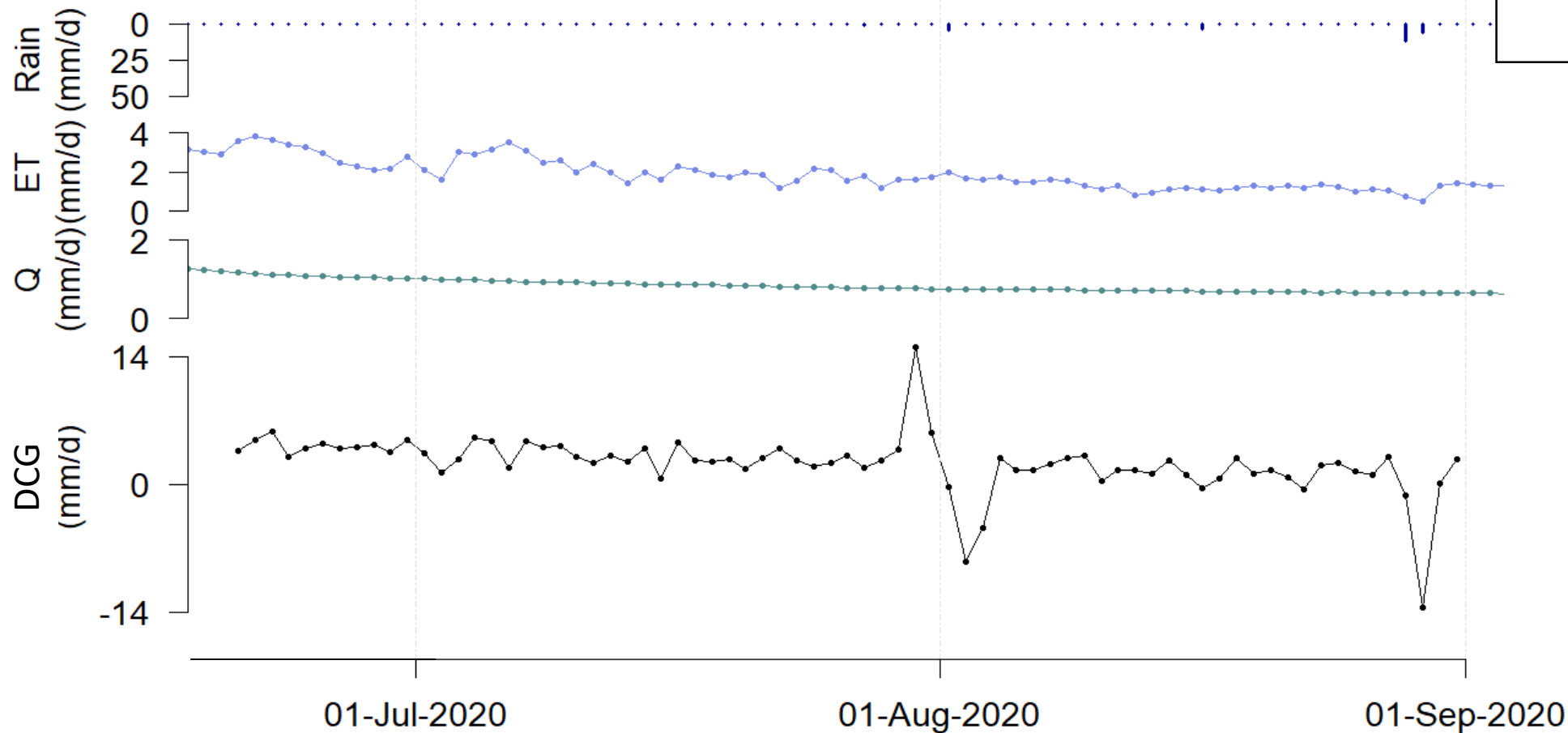


Signals difference

Gravimetry/ET modelling

Gravimetry/ET measured

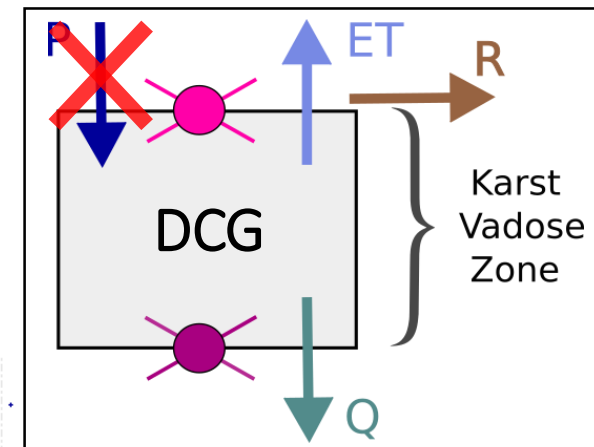
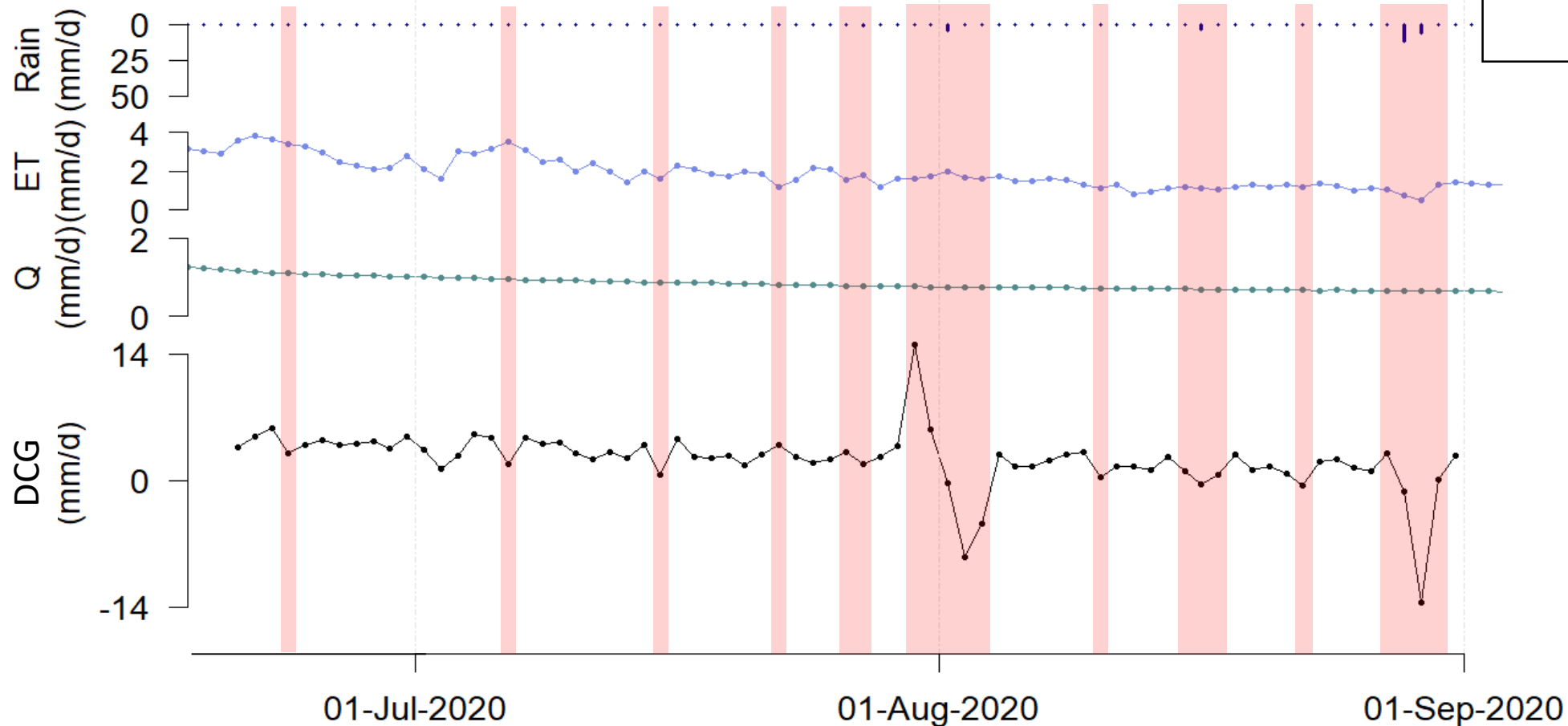
Selection of a summer period with little rain and strong ET



Gravimetry/ET modelling

Gravimetry/ET measured

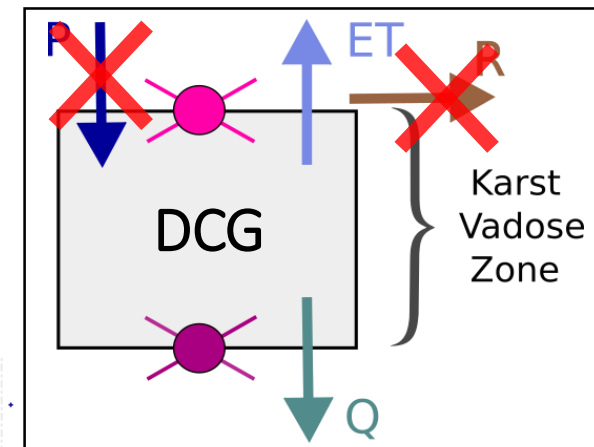
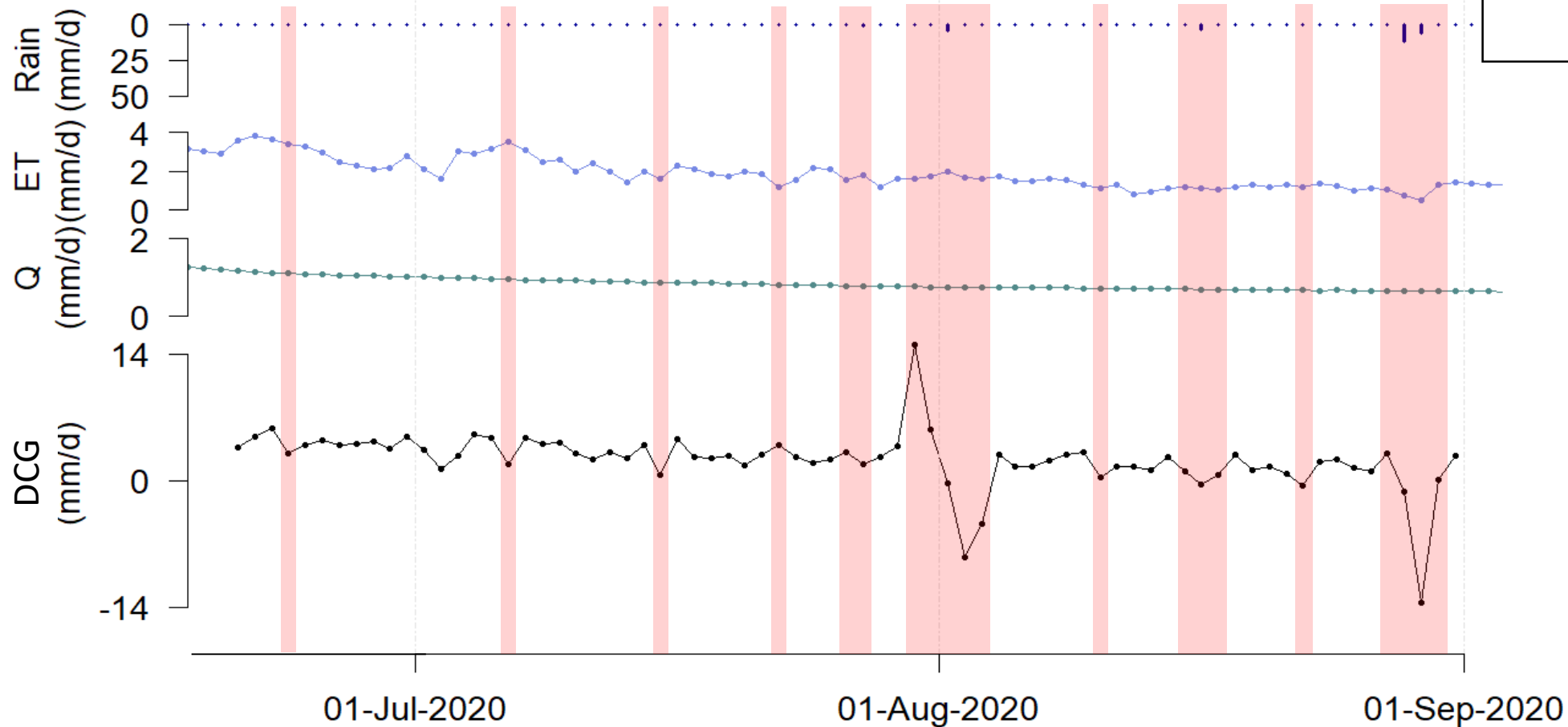
Removal of rainy days and with significant weather changes



Gravimetry/ET modelling

Gravimetry/ET measured

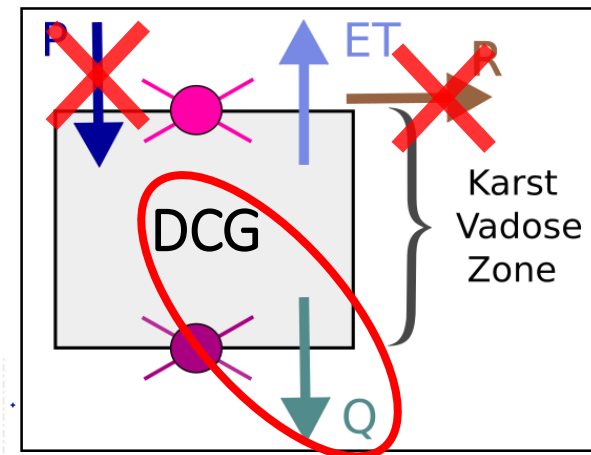
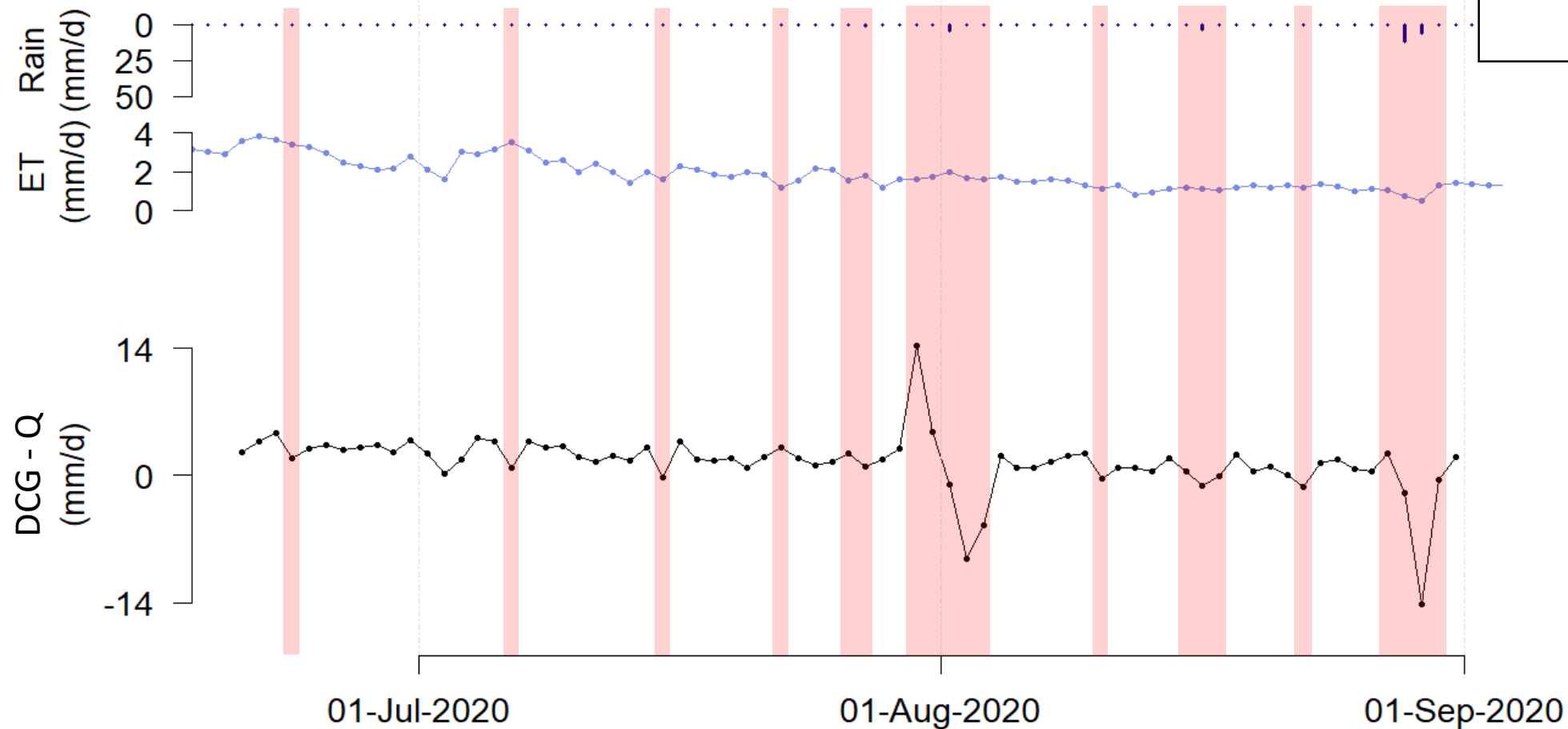
Karst system : neglected runoff



Gravimetry/ET modelling

Gravimetry/ET measured

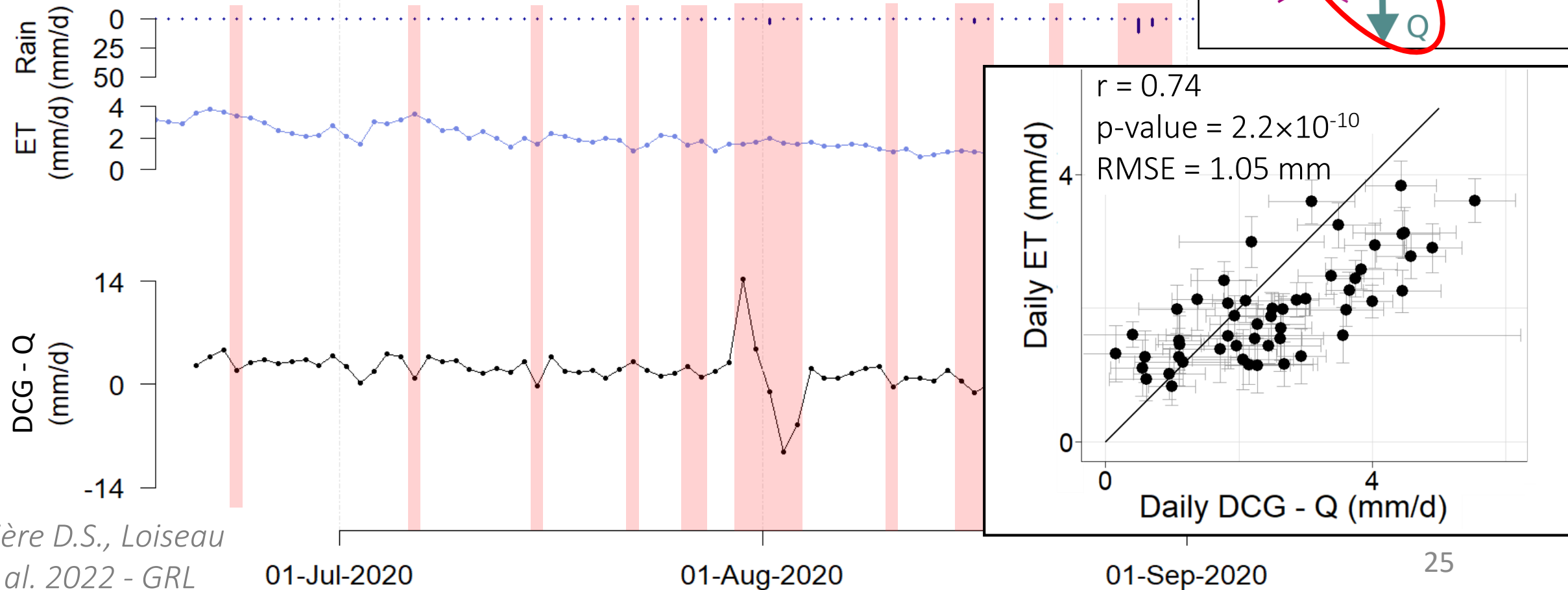
Subtract the flow (Q) from the daily change gravity (DCG)



Gravimetry/ET modelling

Gravimetry/ET measured

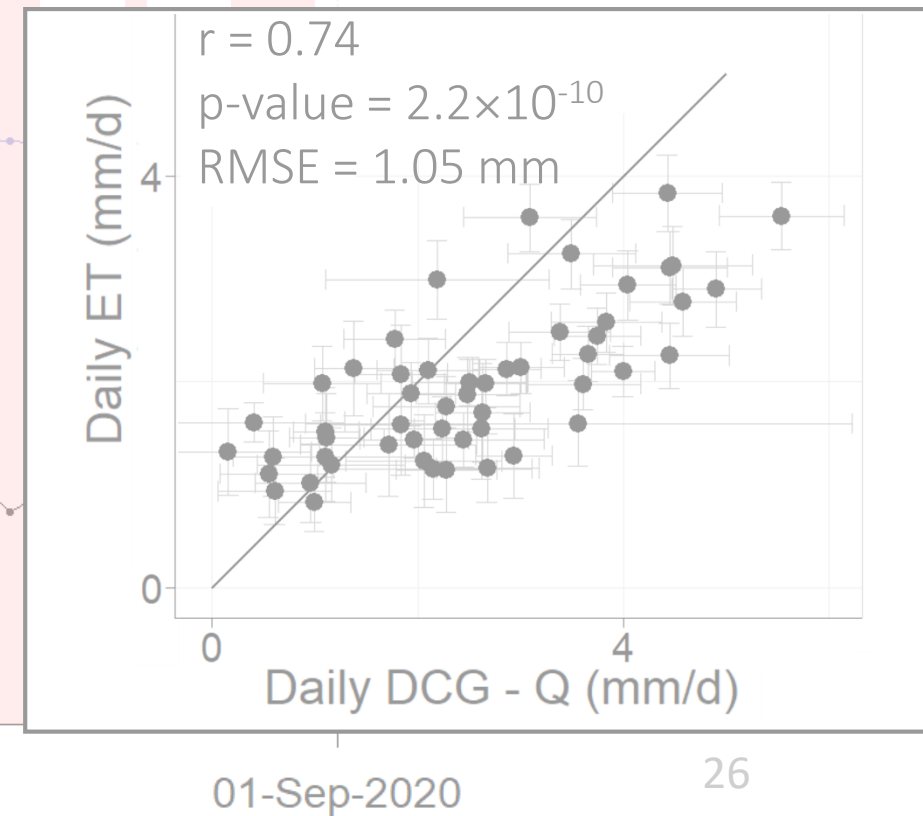
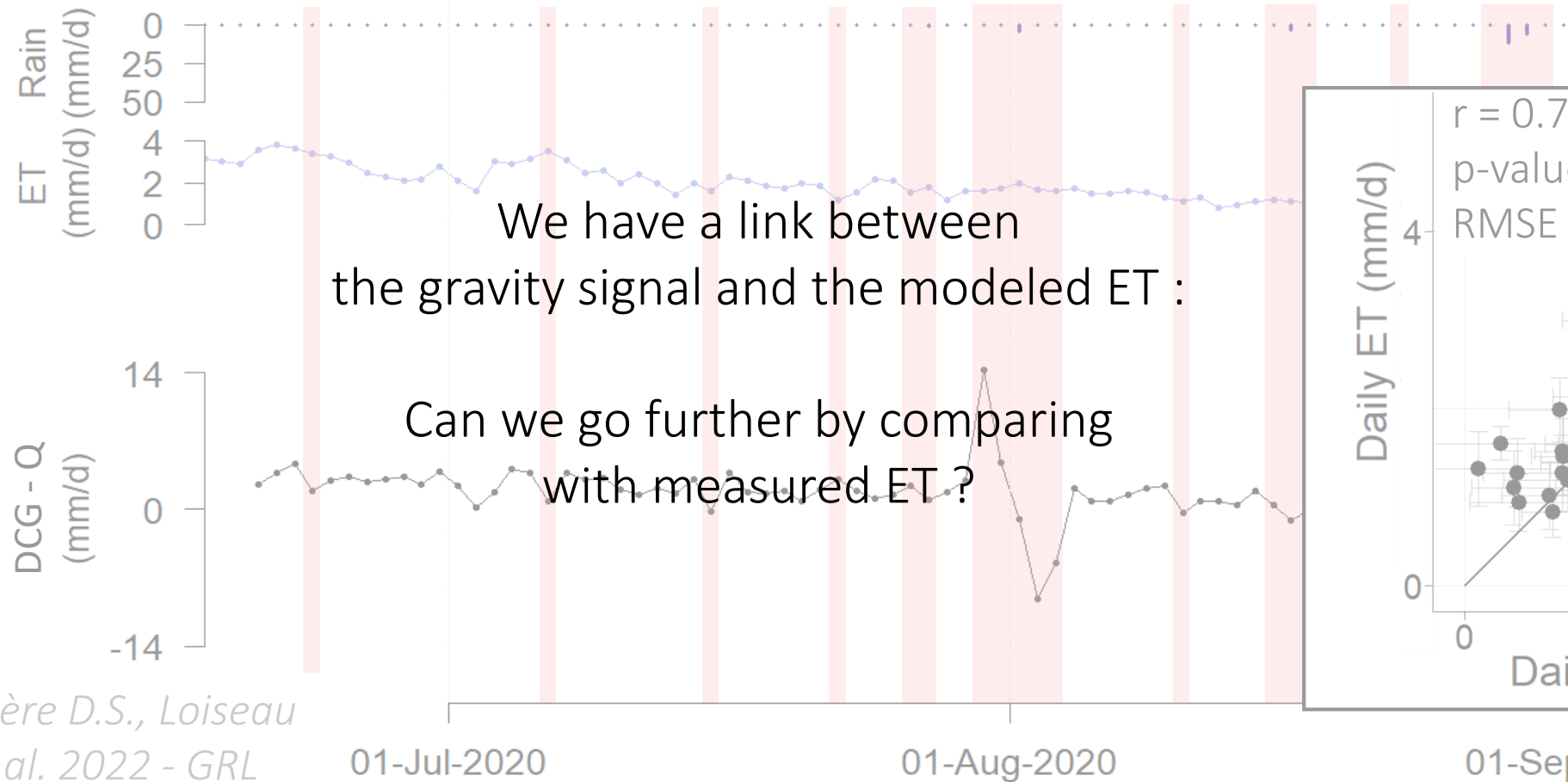
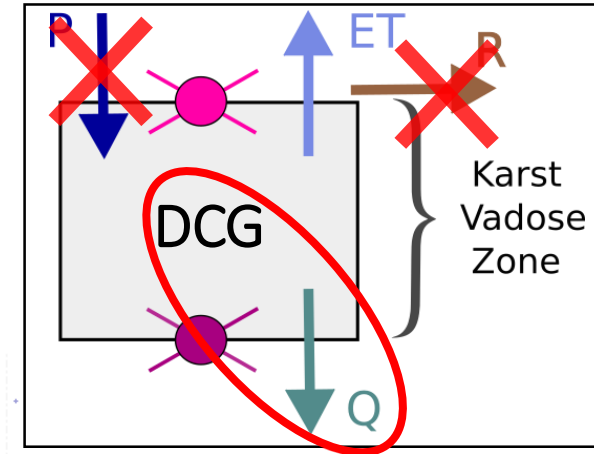
Correlation between the daily change gravity minus the flow and the modeled ET



Gravimetry/ET modelling

Gravimetry/ET measured

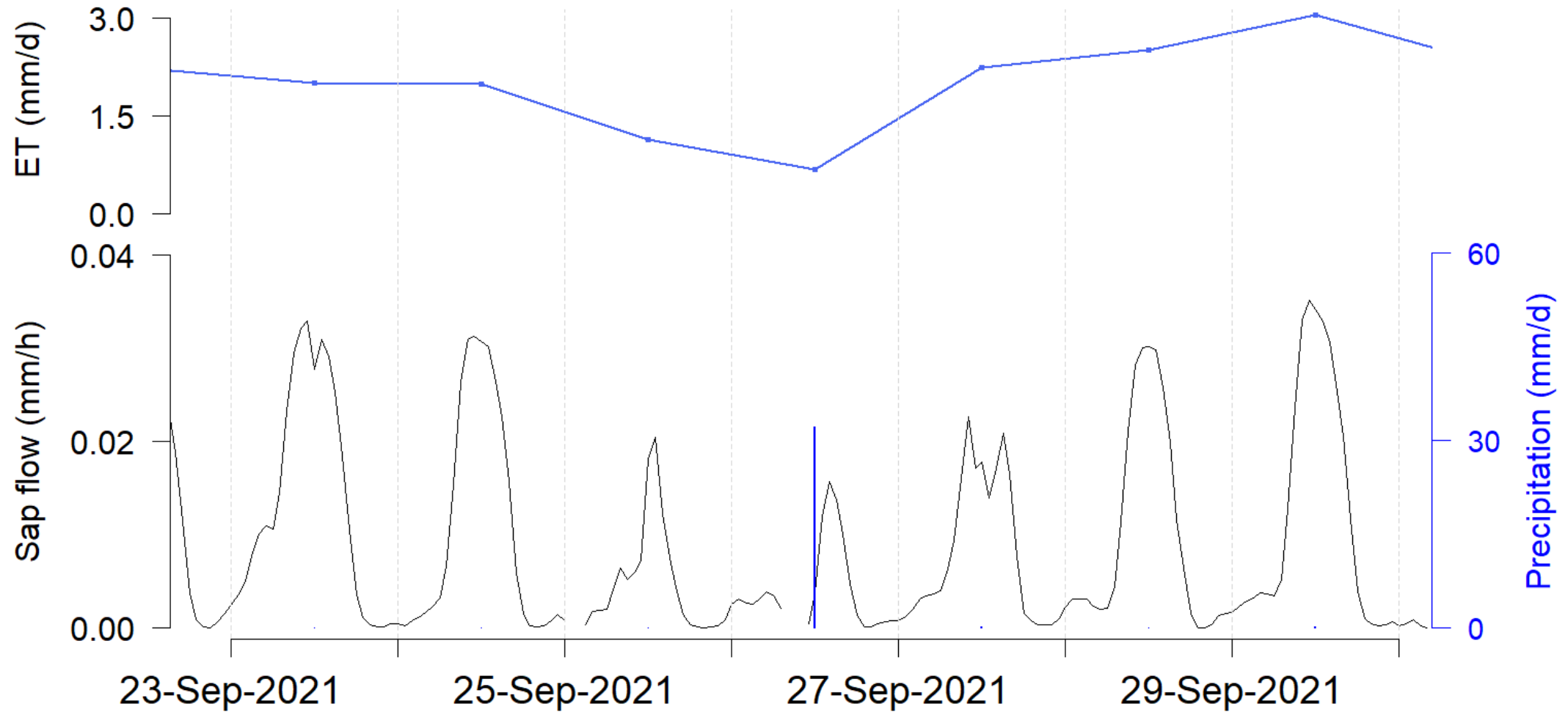
Correlation between the daily change gravity minus the flow and the modeled ET



Gravimetry/ET modelling

Gravimetry/ET measured

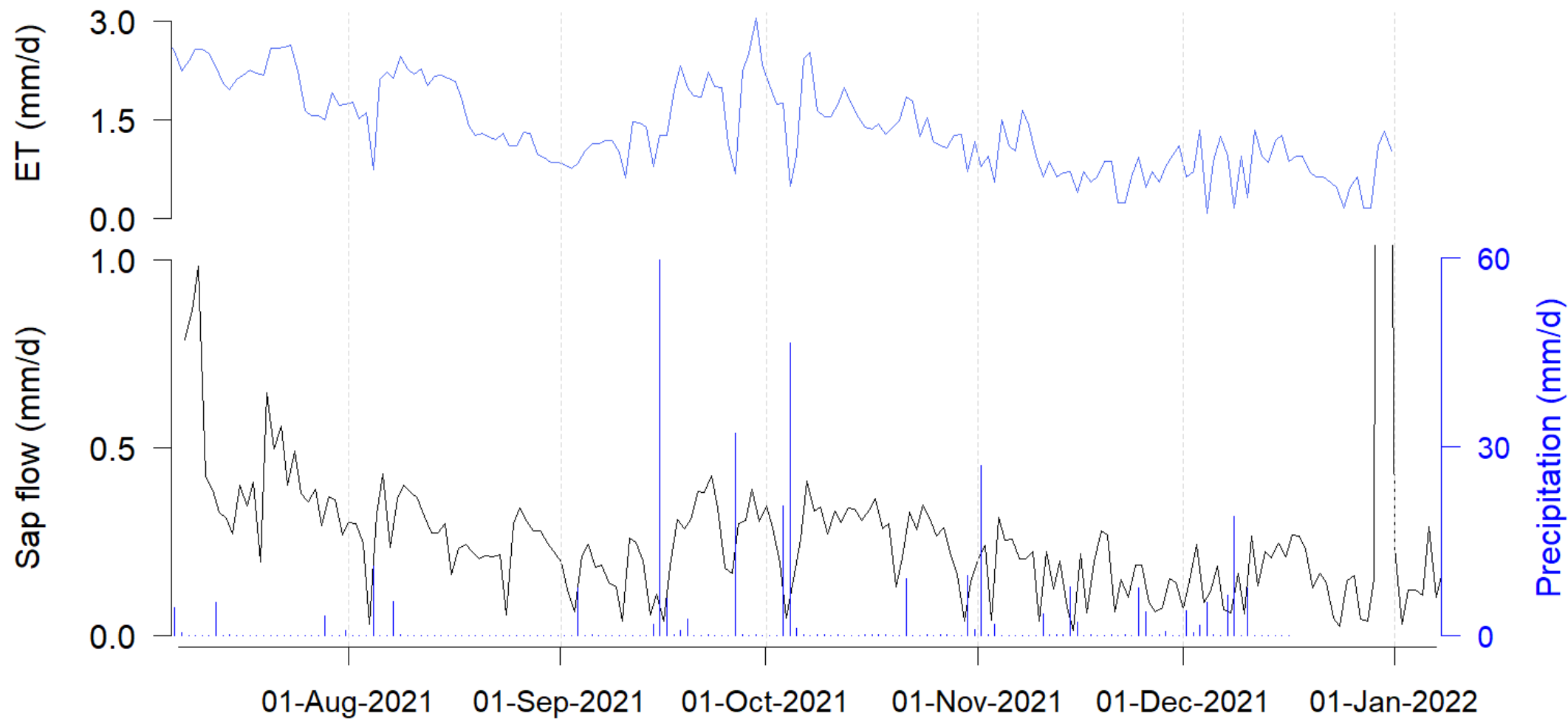
Sapflow data dynamics



Gravimetry/ET modelling

Gravimetry/ET measured

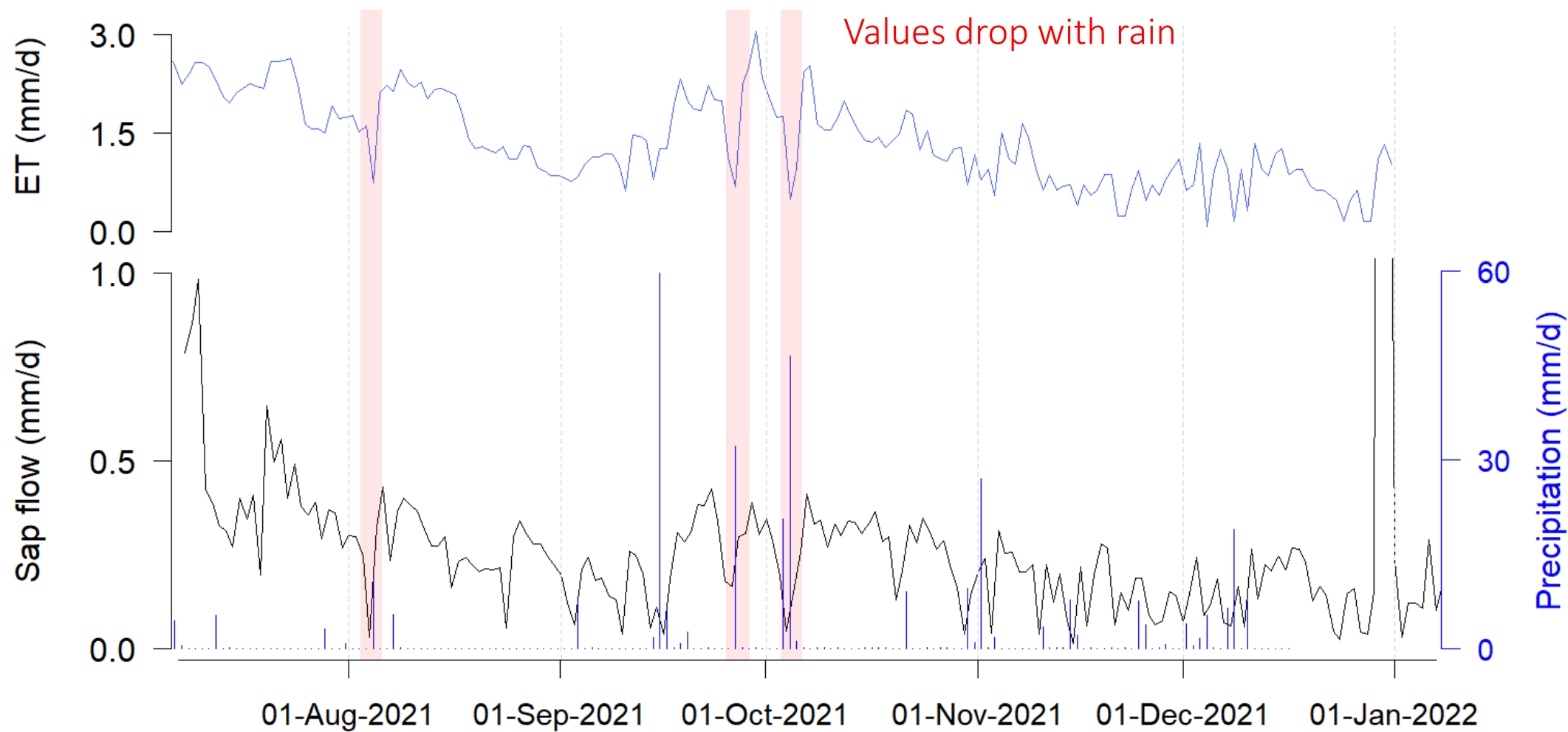
Sapflow data dynamics



Gravimetry/ET modelling

Gravimetry/ET measured

Sapflow data dynamics





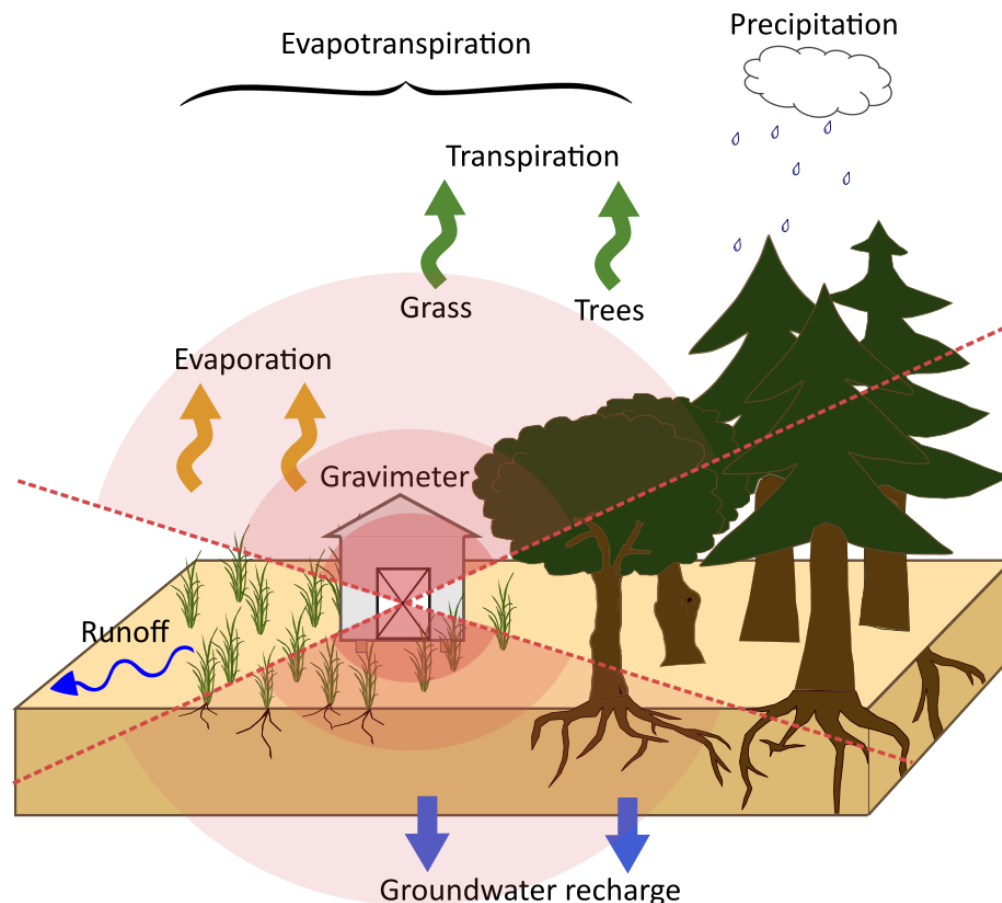
Result : There is a link between gravity and ET signals at daily time step

Outlook :

- Strengthen the relation with a more accurate ET estimation
- Obtain correlation results with a single gravimeter
- Extend the experience to other sites

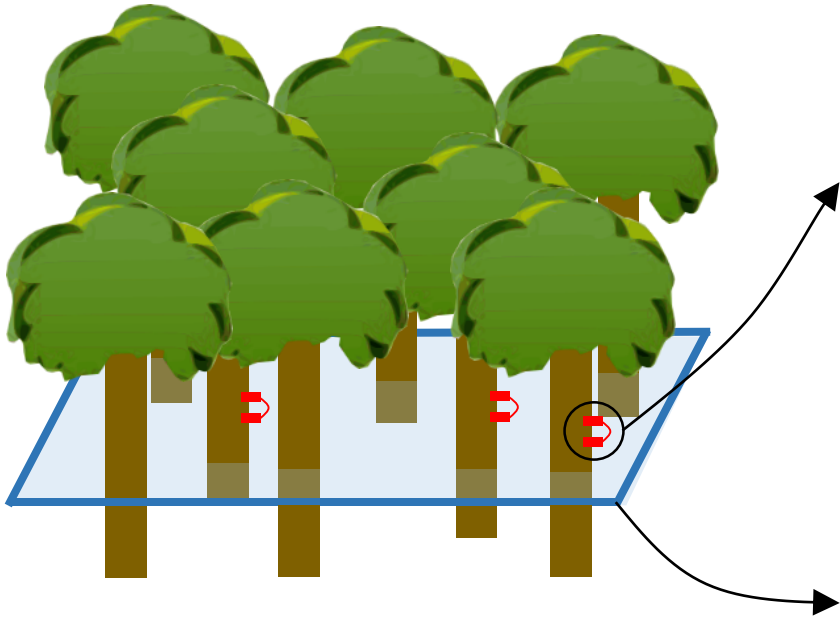
Thank you for your attention !

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Annexe

Use of sap flow data

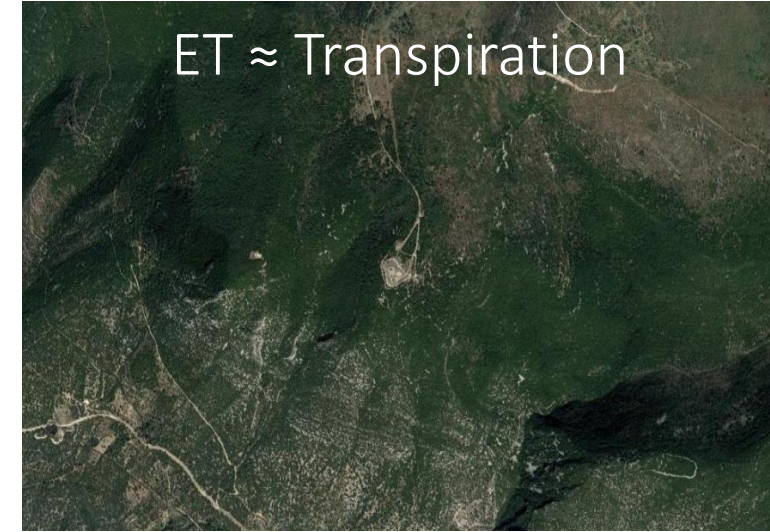


Tree's sapspeed

$$\rightarrow m \text{ d'eau/s}$$

Sapwood area per soil area

$$\rightarrow m^2 \text{ of sapwood/ha of soil}$$



Sapflow :
 $m^3/ha.s$

$$\rightarrow m^3/m^2.h$$