Hydrological measurements and modelling in FVG - part 1

6th Workshop on Water Resources in Developing Countries

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summary

observations

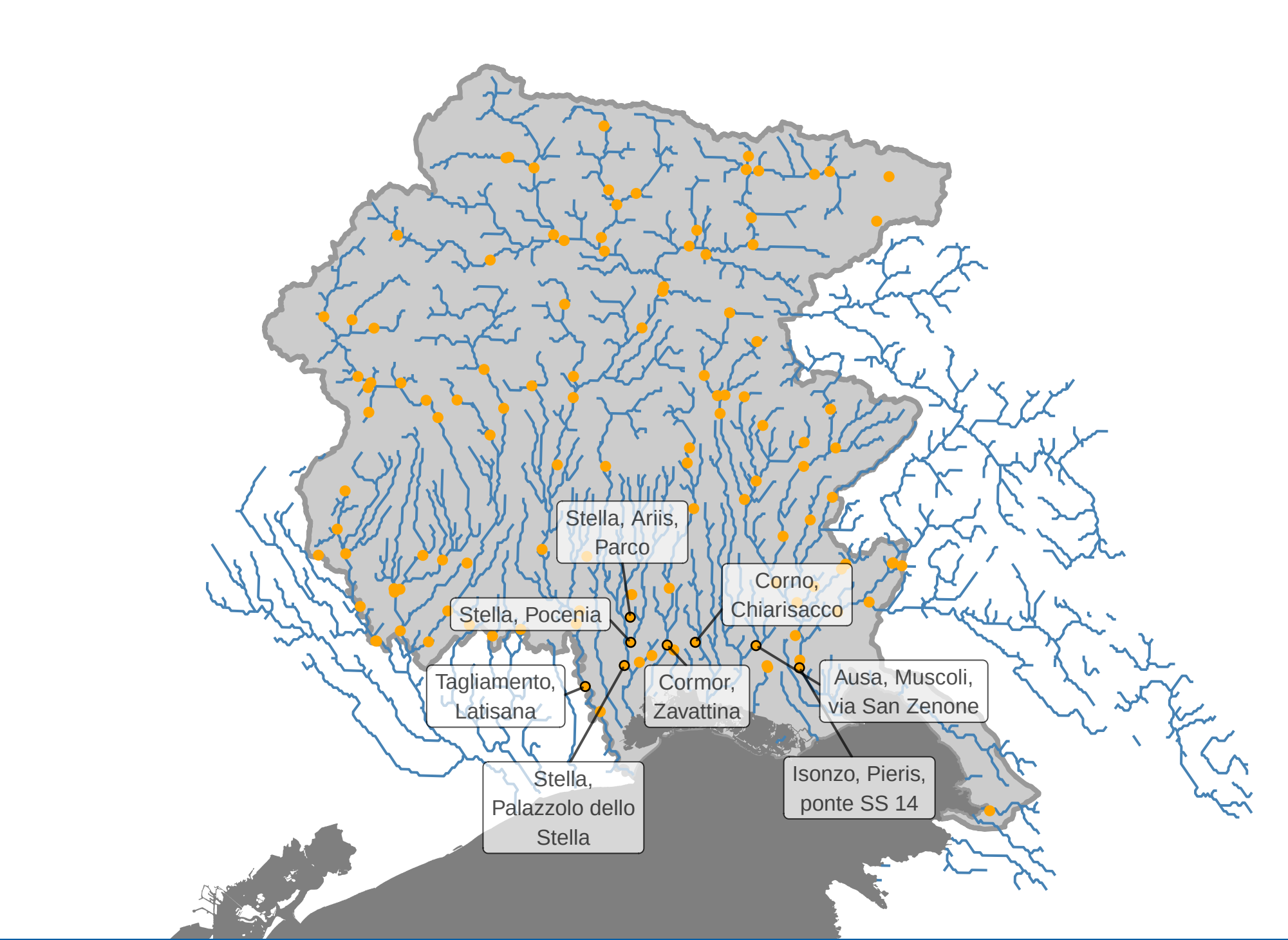
discharge estimation

evapotranspiration

hydrological balances

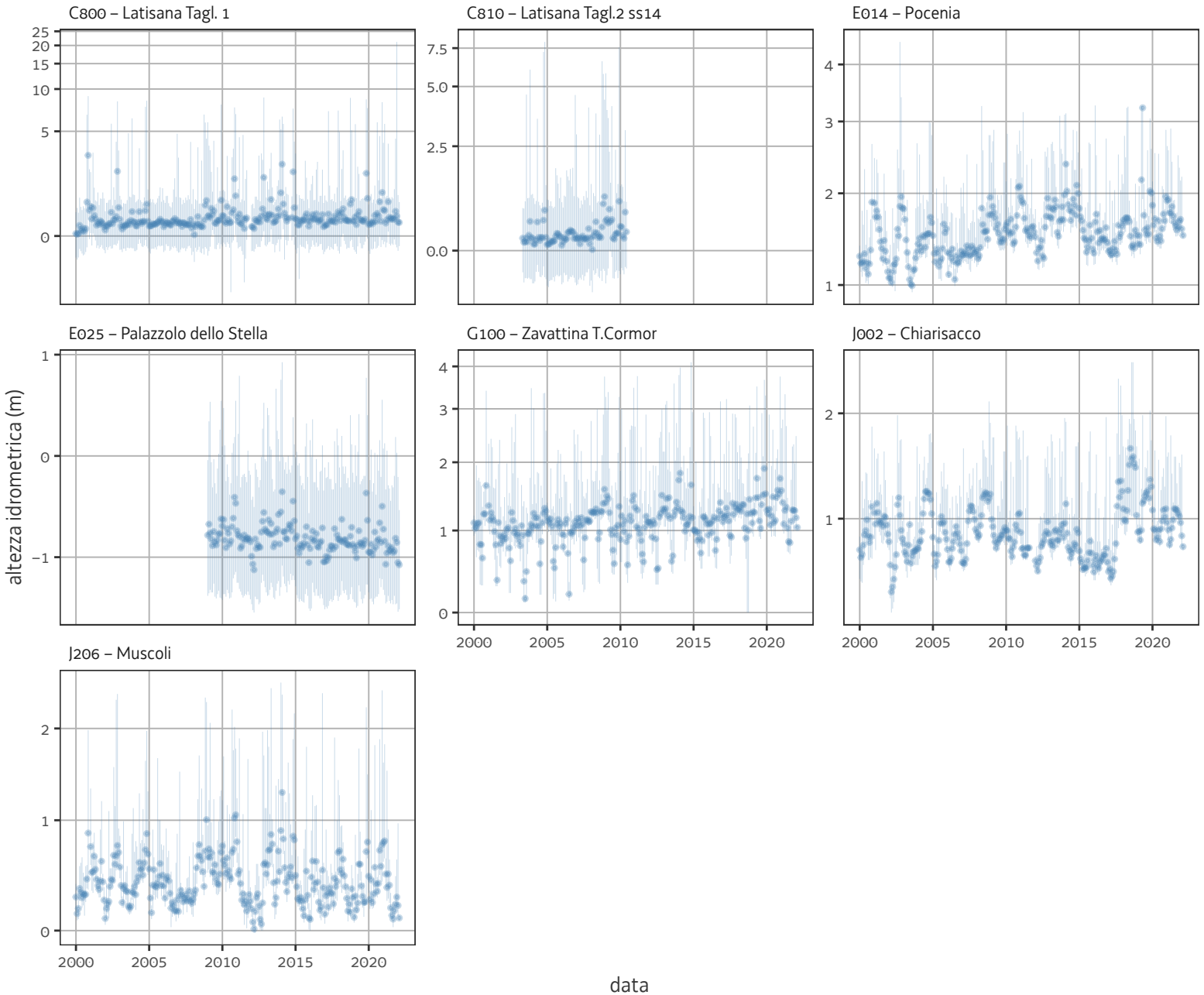
observations

Radar sensor (microwave) on Torre in Tarcento (station N105)


Stella, Ariis, Parco
Corno, Chiarisacco
Stella, Pocenia
Tagliamento, Latisana
Cormor, Zavattina
Ausa, Muscoli, via San Zenone
Stella, Palazzolo dello Stella
Isonzo, Pieris, ponte SS 14

altezze idrometriche

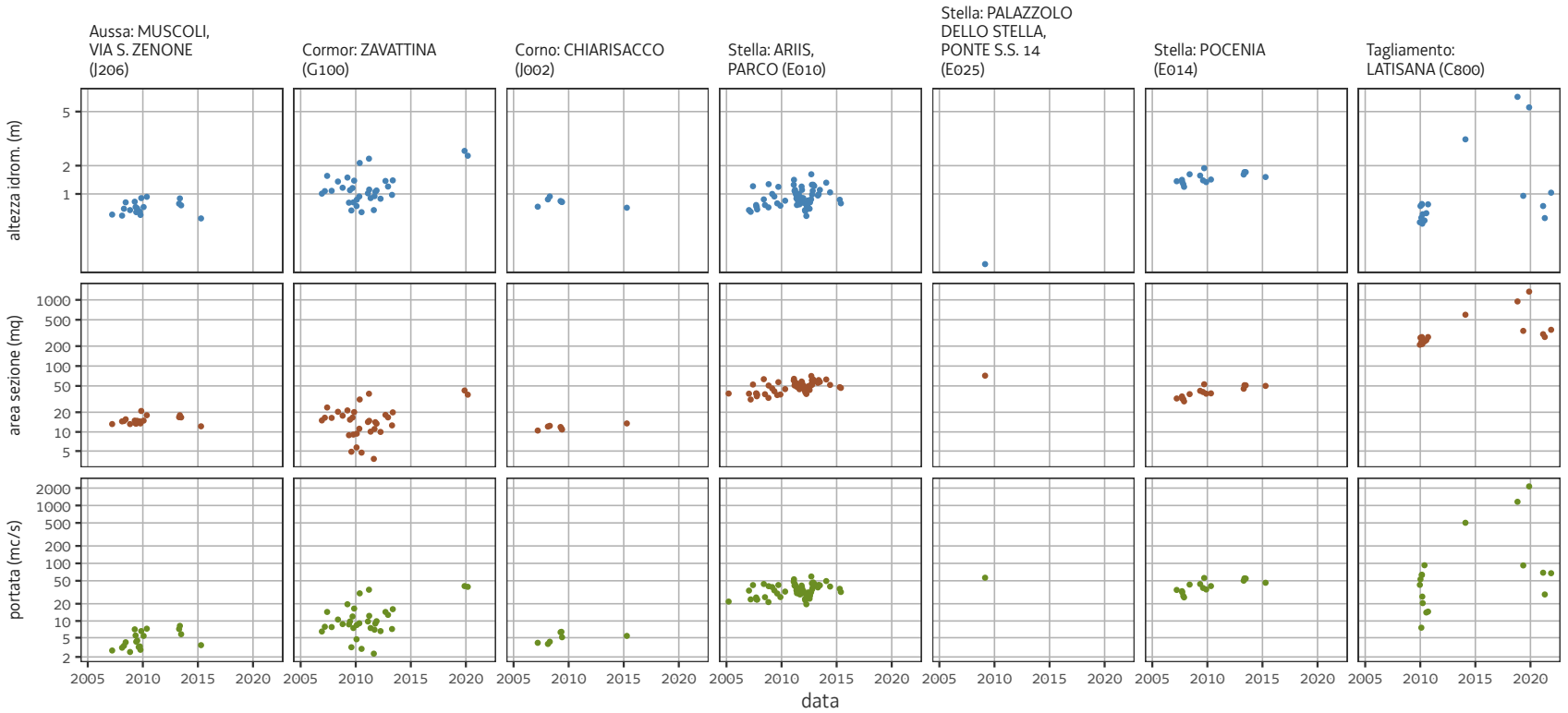
medie, minimi e massimi mensili di misure orarie
gennaio 2000 – febbraio 2022



dati: Regione Autonoma FVG, Servizio gestione risorse idriche

altezze idrometriche e portate

misure saltuarie tra marzo 2005 e novembre 2021



dati: Regione Autonoma FVG, Servizio gestione risorse idriche
elaborazioni: ARPA–FVG, Centro Regionale Modellistica Ambientale

Observations

- We have at least twenty-year historical series for the main watercourses near the mouth.
- For Aussa, we lack data downstream of the Corno confluence.
- For the Isonzo, we also have hourly flow estimates, but we do not know when flow measurements were actually taken.
- We lack information on sediments and vegetation, which would allow us to assess the representativeness of flow measurements over time.
- In the years 2015–2020, few flow measurements have been taken (except for the Tagliamento).
- In more recent years, new observational campaigns have been carried out (data not shown here).

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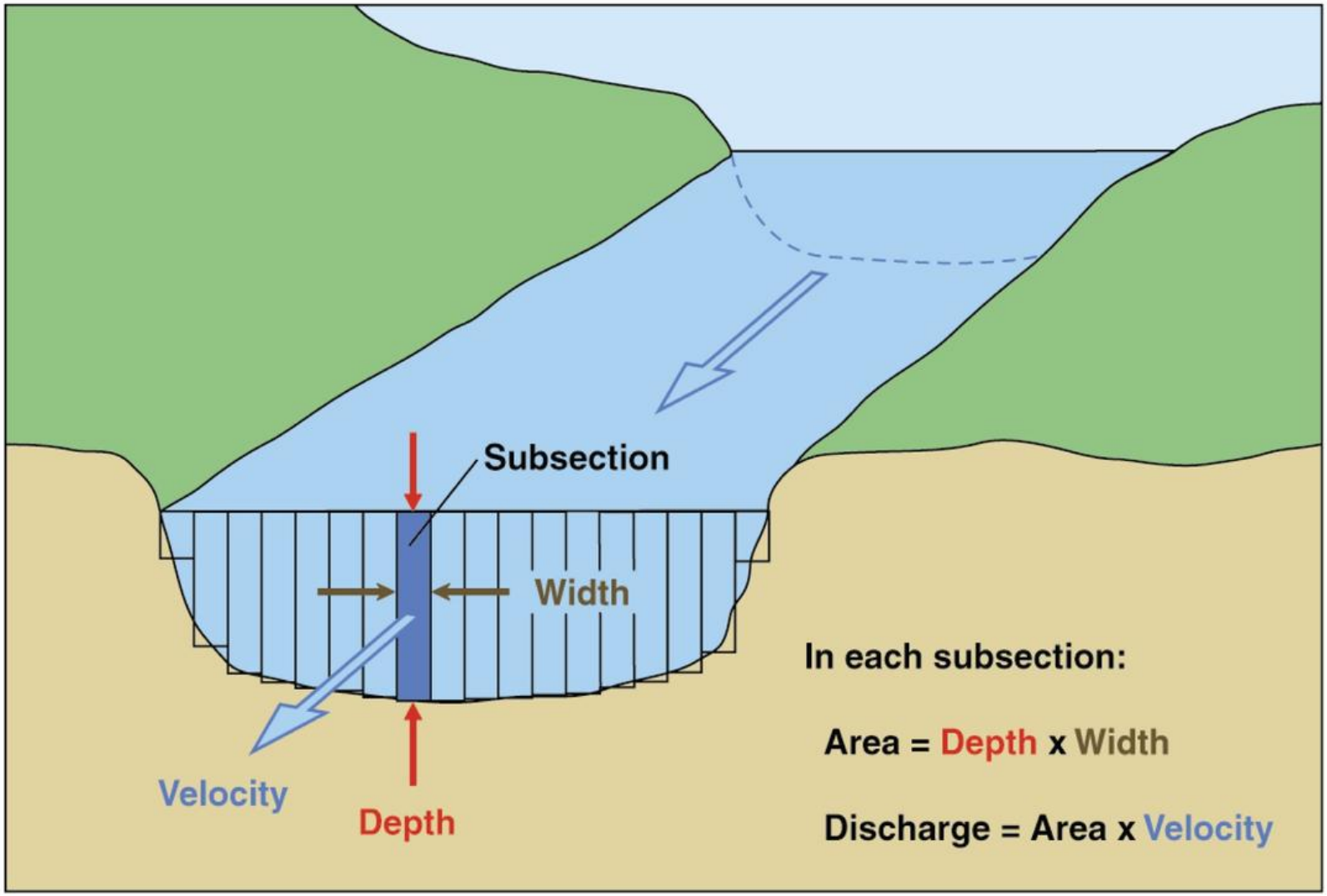
Subsection
Width
Velocity
Depth
In each subsection:
Area = Depth x Width
Discharge = Area x Velocity

discharge estimation

Estimation of discharge

- Measuring the discharge Q of a watercourse requires resources (personnel, time, instruments).
- We have sporadic measurements of Q, but continuous automatic measurements of water levels h.
- We can calibrate rating curves, which are empirical functions that relate water level to discharge

$$Q = Q(h)$$

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- Extrapolating rating curves to low-flow or flood regimes not covered by discharge measurements can lead to errors.
- Significant changes in roughness, slope, or cross-section due to sedimentation or vegetation may invalidate the rating curves.

Method

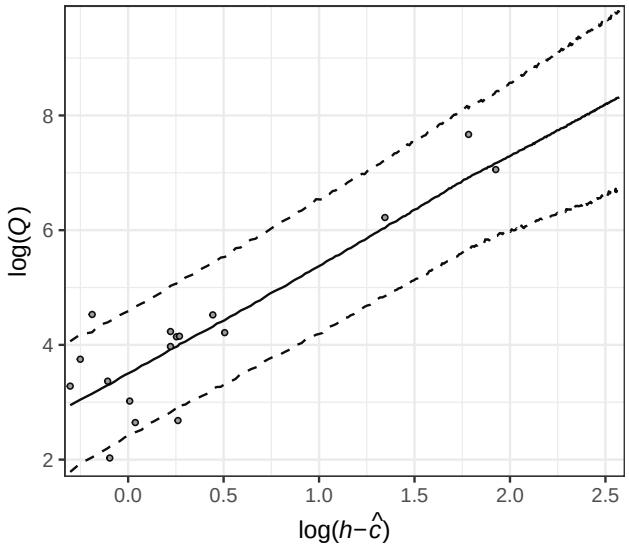
- We assume that the rating curves follow a generalized power law form

$$Q = a(h - c)^{f(h)}$$

- We calibrate a hierarchical Bayesian model for each watercourse [Hrafnkelsson et al., 2022]
- We utilize the R package `bdrc` [Hrafnkelsson et al., 2021]

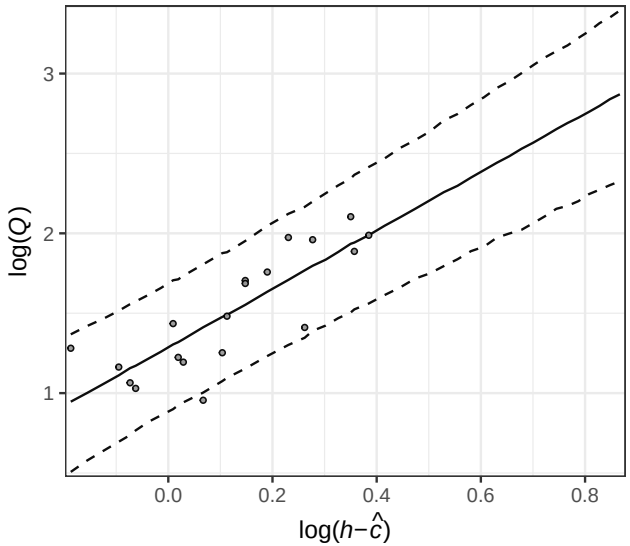
Tagliamento

station C800



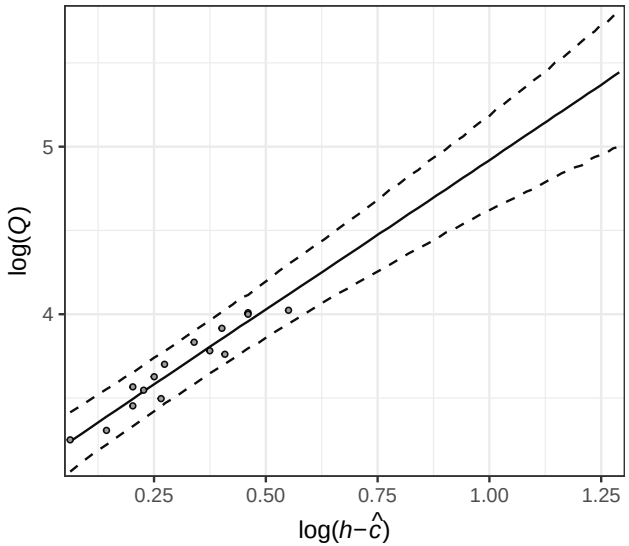
Aussa

station J206



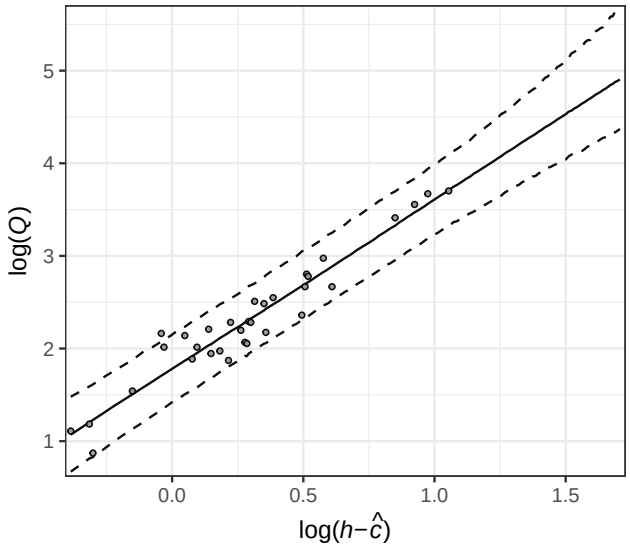
Stella

station E014



Cormor

station G100



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medie, minimi e massimi mensili di dati orari
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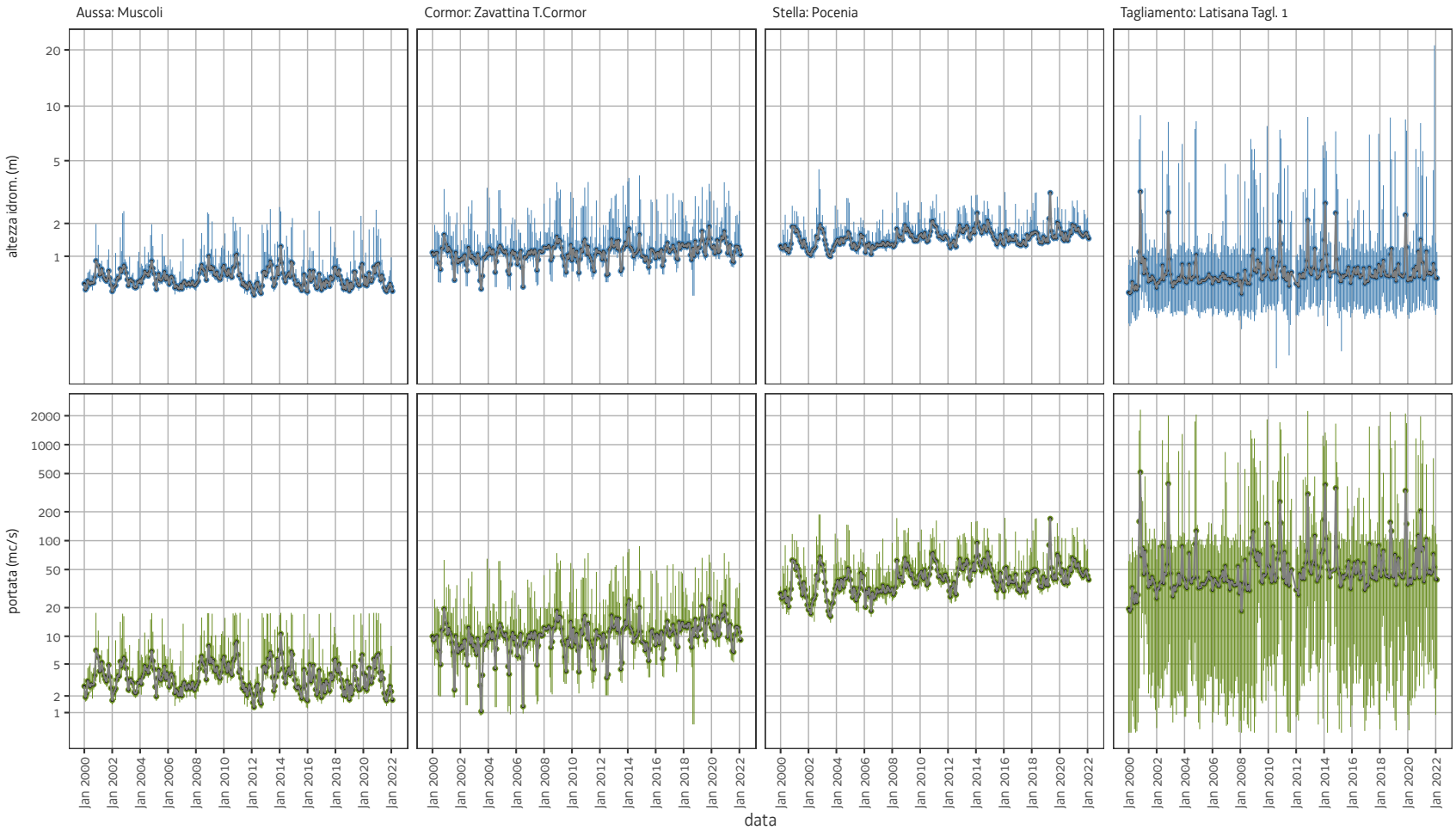


dati: Regione Autonoma FVG, Servizio gestione risorse idriche
elaborazioni: ARPA–FVG, Centro Regionale Modellistica Ambientale

Estimation of discharge

- In addition to hourly discharge estimates for the Isonzo (already available), we now have data for Aussa, Cormor, Stella, and Tagliamento.
- Since we employed a Bayesian method, we can also assess uncertainty and the probability of exceeding a threshold.
- The Tagliamento river exhibits significant variability (is it real?)

evapotranspiration

Evapotranspiration

- We will see that the FUSE software includes a wide range of hydrological models; all assume that the discharge Q of a watercourse at a point is a function of the precipitation P and evapotranspiration E affecting the upstream basin of that point.
- We calculate P and E from the outputs of WRF.
- P is the average precipitation in the basin.
- We compute E by averaging the estimates for each cell obtained with three different methods across the basin.

Methods

- From the latent heat flux *LHF*:

$$E = LHF/\lambda$$

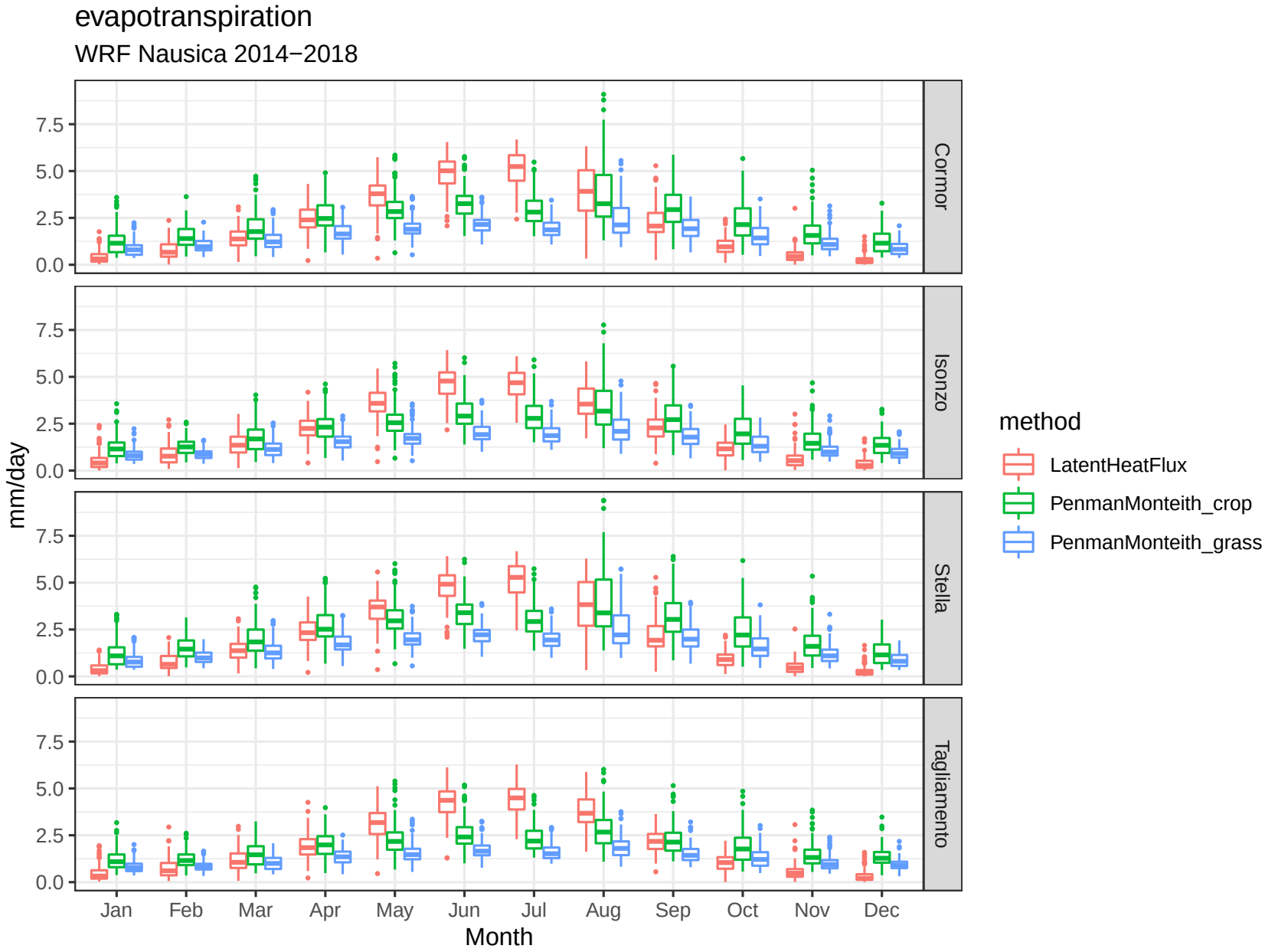
  where $\lambda = \lambda(T_a)$ is the latent heat of evaporation.
- Penman-Monteith formula for short vegetation [Richard et al., 1977]:

$$Q = Q_{grass}(T_a, RH, Rad, prec, ws)$$

- Penman-Monteith formula for tall vegetation [Walter et al., 2000]:

$$Q = Q_{crop}(T_a, RH, Rad, prec, ws)$$

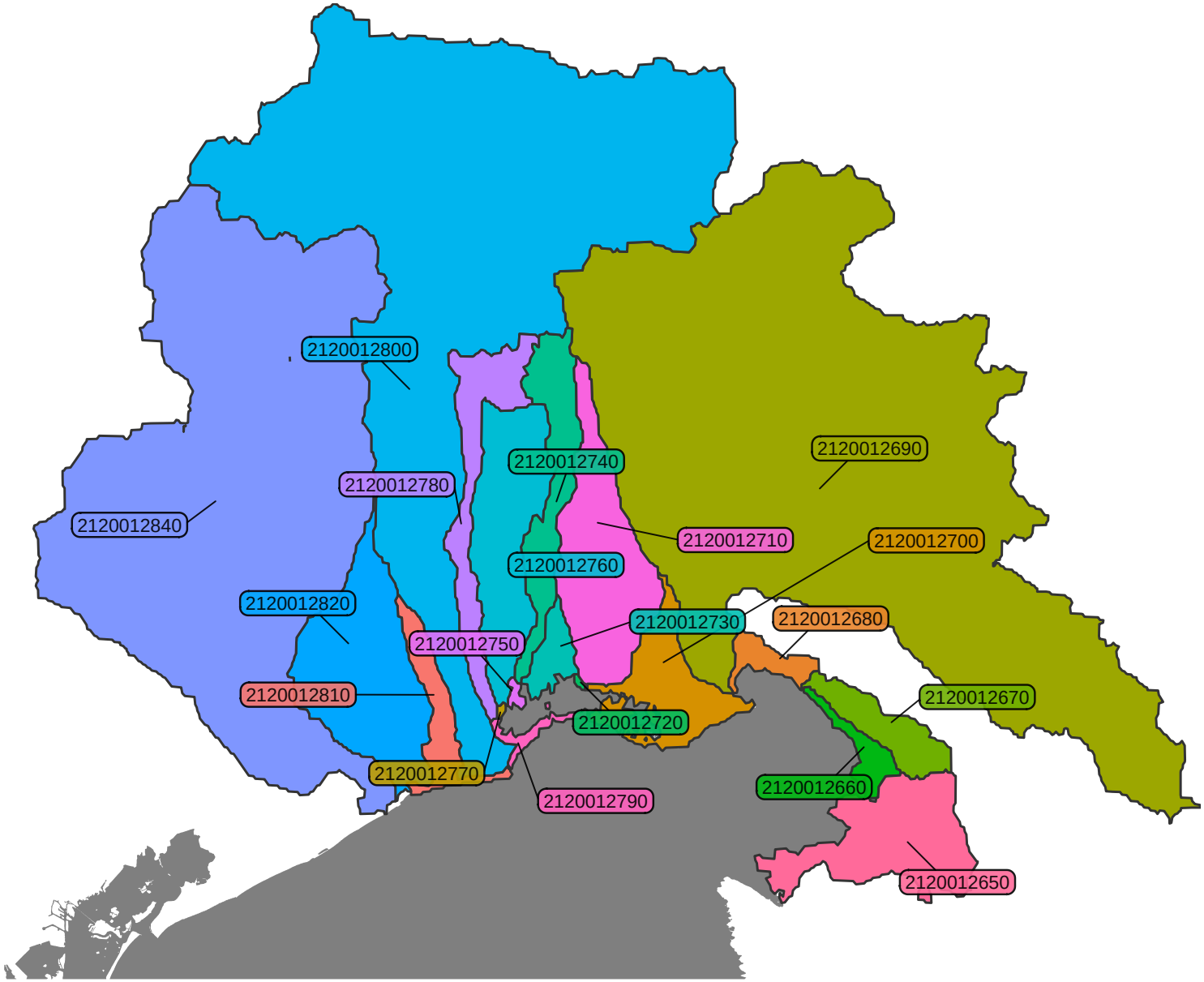
- We utilize the R packages `bigleaf` [Knauer et al., 2018] and `Evapotranspiration` [Guo et al., 2022].


evapotranspiration
WRF Nausica 2014−2018
mm/day
7.5
5.0
2.5
0.0
Cormor
Isonzo
Stella
Tagliamento
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Month
method
LatentHeatFlux
PenmanMonteith_crop
PenmanMonteith_grass

Evapotranspiration

- We can estimate the average evapotranspiration in a basin directly from the latent heat flux or from some variables typically measured at weather stations.
- We can compare predicted and measured ET.
- The Penman-Monteith method provides higher estimates if taller vegetation is assumed.
- The estimate from LHF is higher in summer and lower in autumn compared to the P-M method.

hydrological balances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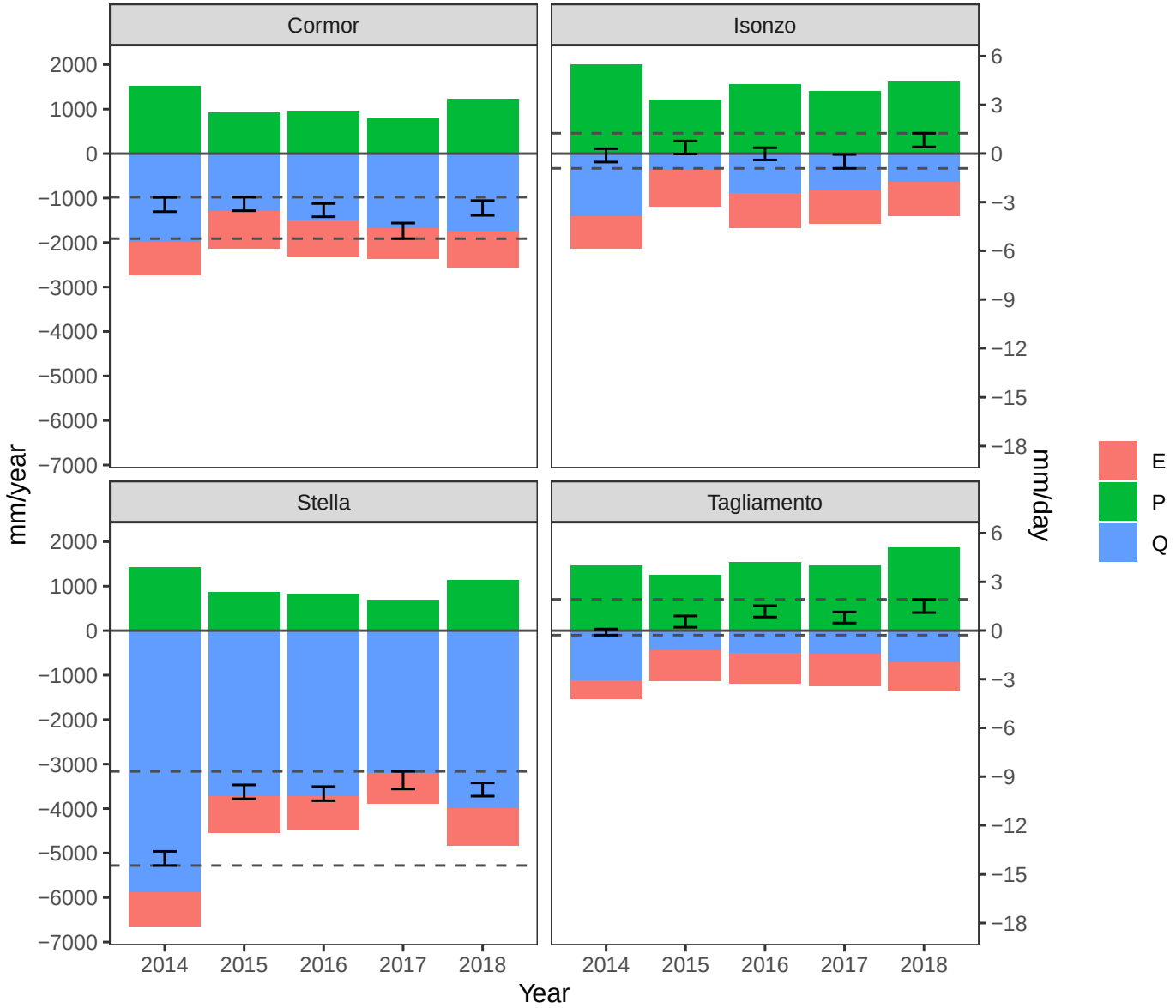
Watershed budgets

- If the watershed is closed

$$\text{Precipitation } (P) - \text{Evapotranspiration } (E) - \text{Change in Storage } (\Delta S) = \text{Discharge } (Q)$$

- Over a few years, the variation of reserves ΔS (glaciers, lakes, aquifers) should be relatively small compared to the other components


Cormor
Isonzo
Stella
Tagliamento
mm/year
mm/day
Year
2014
2015
2016
2017
2018
E
P
Q

Watershed budgets

- The Isonzo watershed budget closes within its own basin with precipitation, evapotranspiration, and outflow at the mouth
- The Tagliamento releases to the basins of other rivers a portion of the water precipitated within its own basin
- Stella and Cormor likely receive water from the Tagliamento basin via subsurface flow through the soil
- During the calibration phase of hydrological models, these factors need to be taken into account

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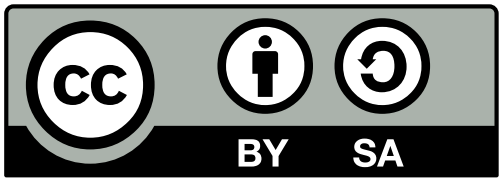
Tagliamento "is a remarkable floodplain river that retains the dynamic nature and morphological complexity that must have characterized most Alpine rivers in the pristine stage." [Tockner et al., 2003]

Thank you
for your attention



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