eurac research

Potential of Sentinel-3 LST downscaling for estimating evapotranspiration from two-source energy balance model at sub-kilometer spatial resolution

International Workshop on High-resolution Thermal EO

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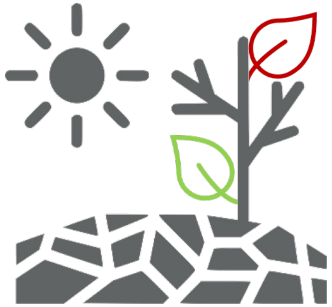
4DMED HYDROLOGY

esa

1 | Context and Motivation

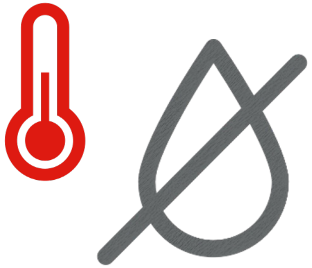
Why Evapotranspiration ?

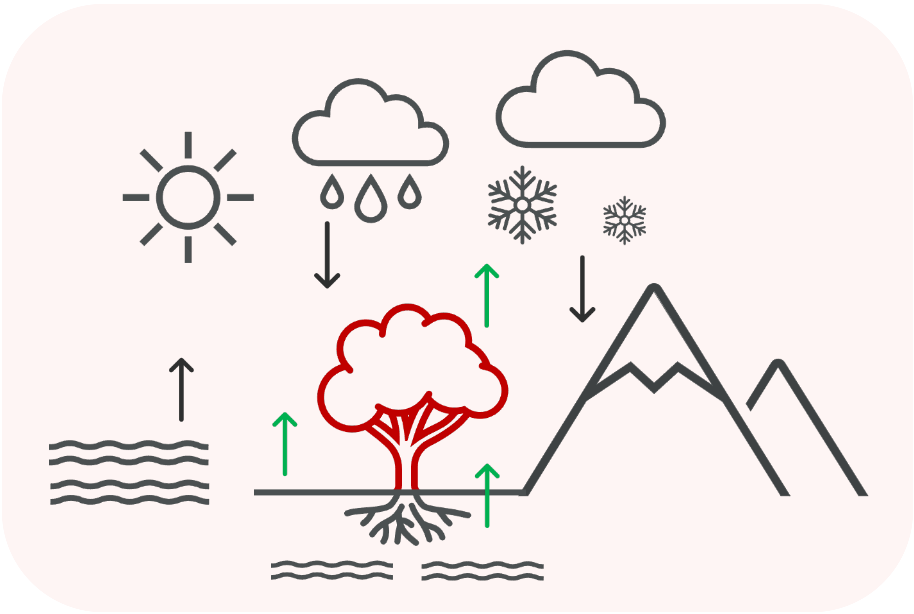


Water monitoring 01

Environment

Climate change 02



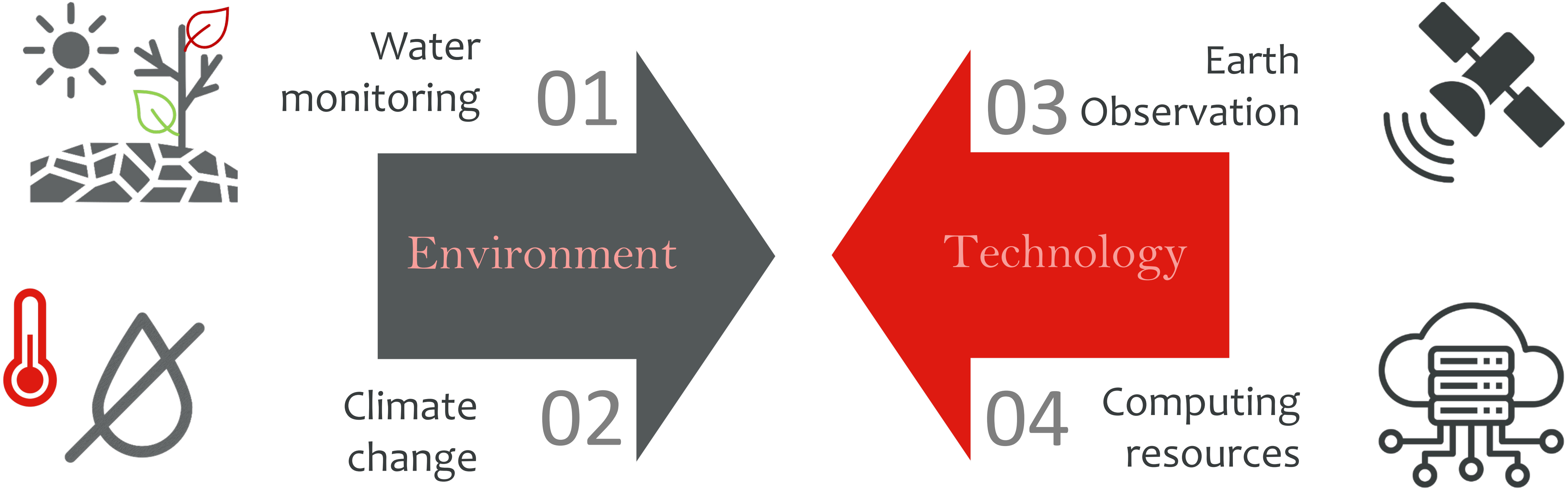


ET around 60% of yearly terrestrial precipitation*

Evapotranspiration is an important ecohydrological variable

* Oki, T. and Kanae, S., 2006. Global hydrological cycles and world water resources. *science*, *313*(5790), pp.1068-1072

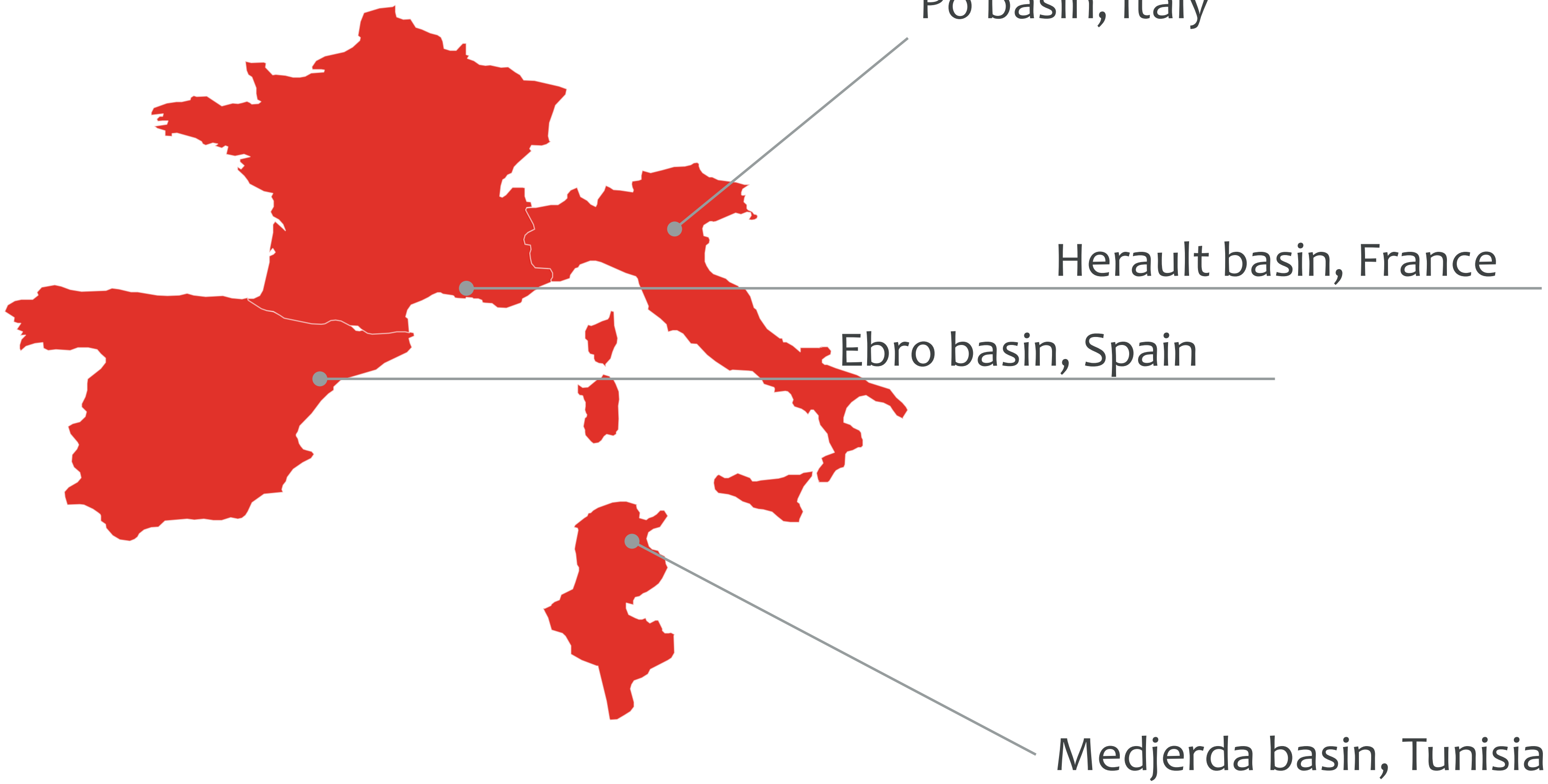
Why Evapotranspiration ?



Objective

ET estimation from ESA Copernicus data

- daily
- 100 m
- 2017-2021



2 | Methodology and processing workflow

2 a | Method

Evapotranspiration modeling

Two-source Energy Balance Model

$$R^{net} = G + H + LE$$
$$R^{net}_C = H_C + LE_C$$
$$R^{net}_S = G + H_S + LE_S$$

$$LST = (f_c LST^4_C + (1 - f_c) LST^4_S)^{1/4}$$

$$\mathbf{LE^{init}_C = f(\alpha_{PT}, f_g, R^{net}_C, VP, TA)}$$
$$\mathbf{H_C = LE_C - R^{net}_C}$$

$$LST_C = f(H_C, TA, r_C) \qquad LST_S = LST - LST_C$$

$$\mathbf{H_S = f(LST_S, TA, r_S)}$$
$$\mathbf{LE_S = R^{net}_S - G - H_S}$$

LE_C iteratively reduced until $LE_S = 0$

… and its practical retrieval

Two-source Energy Balance Model

sentinel-3
SLSTR
1 km

sentinel-2
MSI
20(10) m

ECMWF
ERA5
31 km

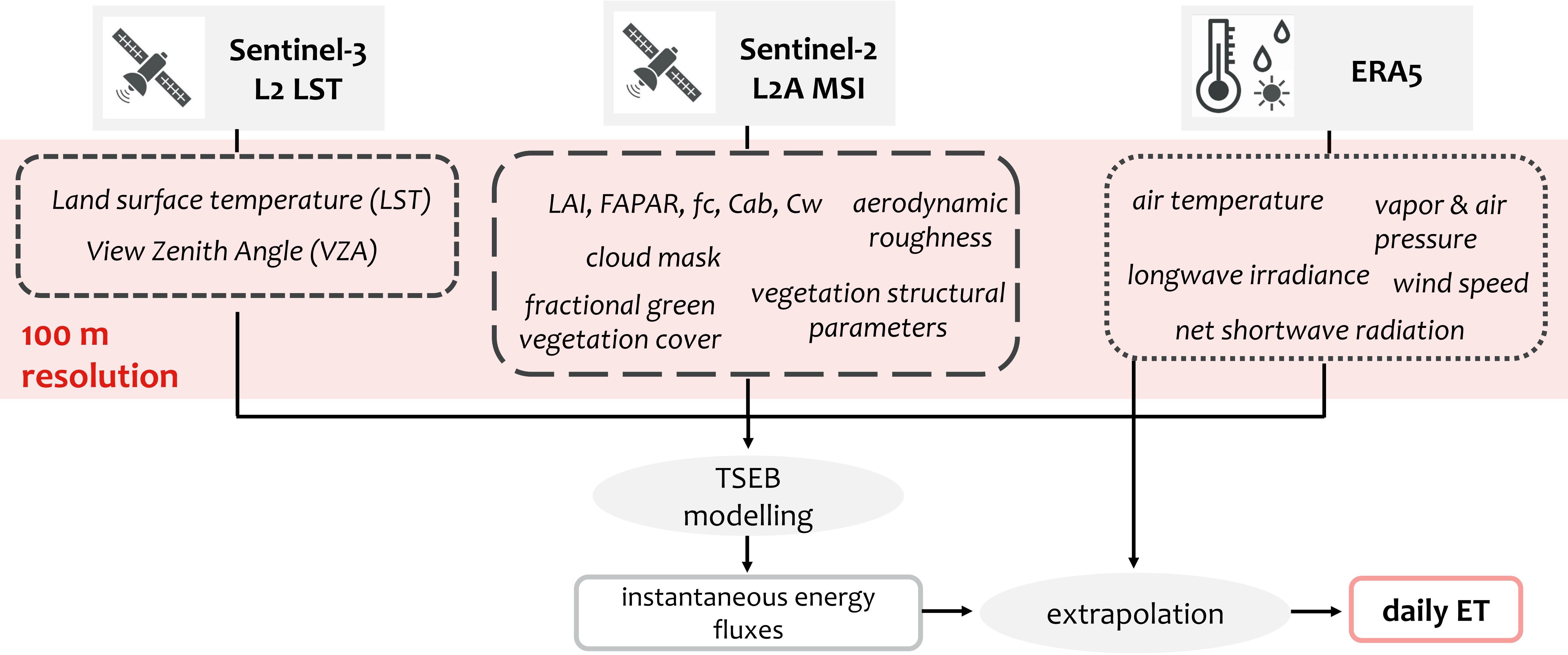
TSEB implementation*

SNAP gpt

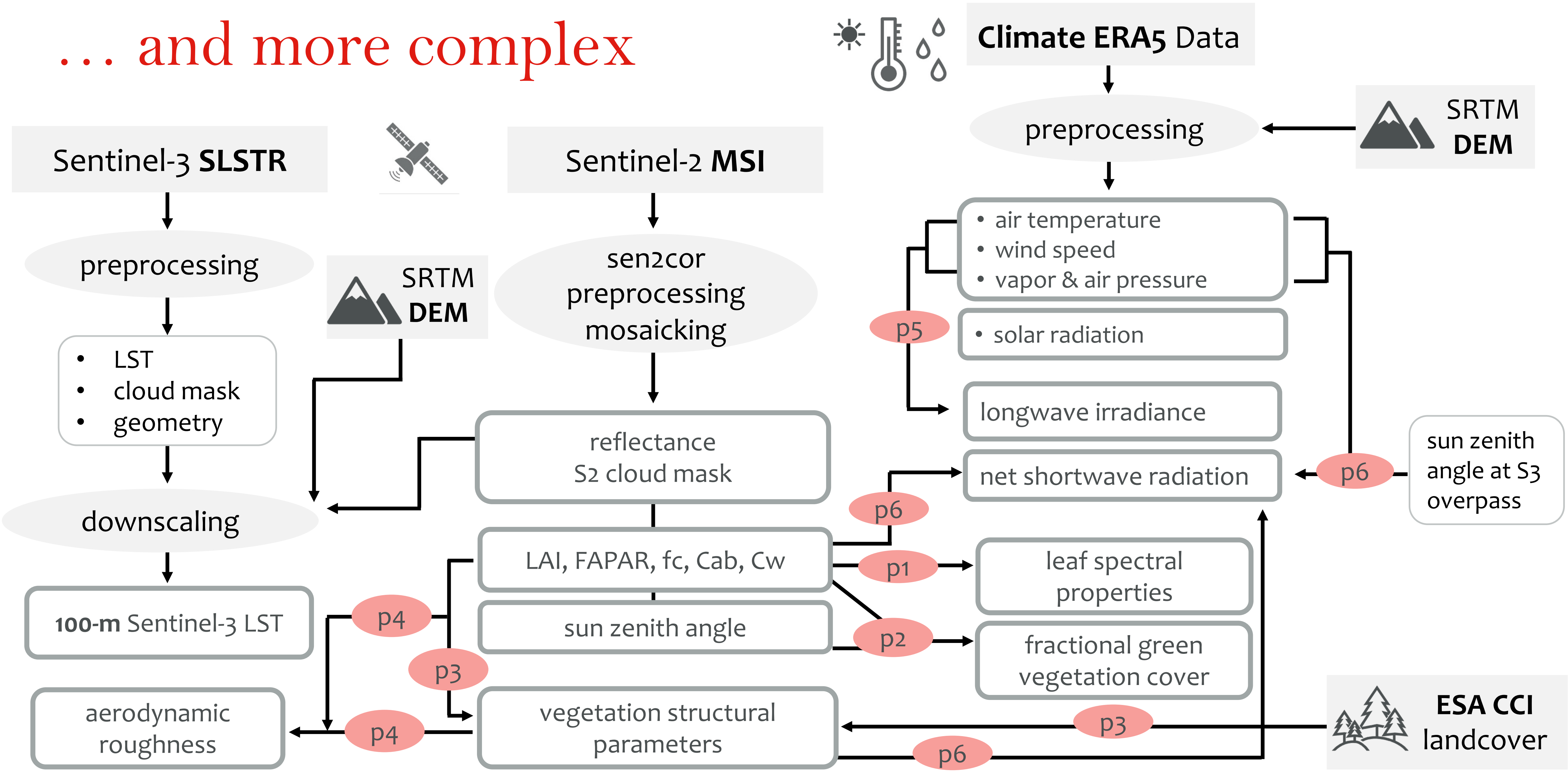
* Guzinski, R., & Nieto, H., 2019. Evaluating the feasibility of using Sentinel-2 and Sentinel-3 satellites for high-resolution evapotranspiration estimations. *Remote sensing of environment*, 221, 157-172

2 b | Processing pipeline

ET estimation: General overview



… and more complex



Processing and Resources

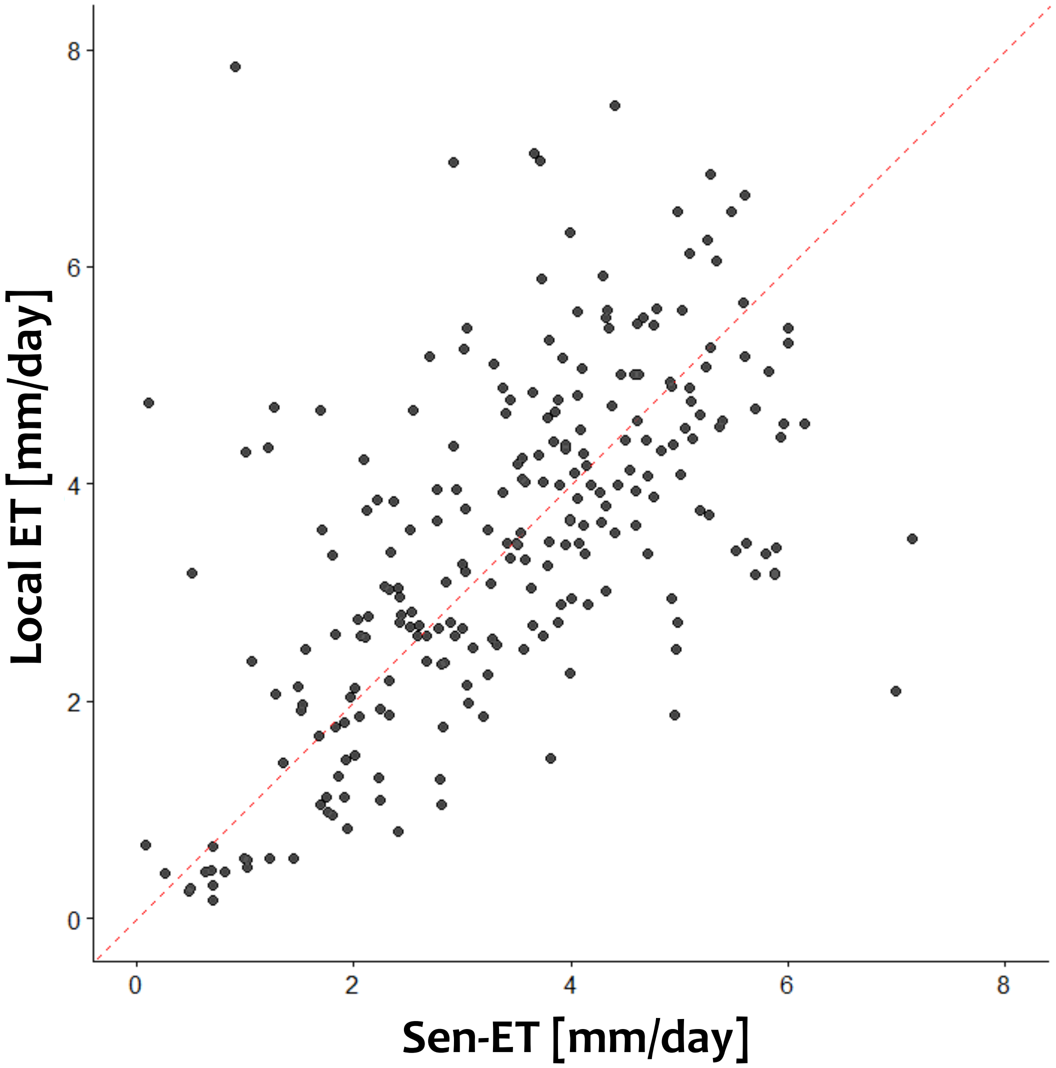
- Spatial extent of ET according to Sentinel-2 (S2) tiling system
- Spatial coverage of **52** S2 tiles
- One S2 tile-based output (all processed data) with 1400 dates ~ 600GB

3 | Results

Validation: Eddy Covariance

- Eight flux tower locations
  - Po basin 07
  - Herault basin 01
- Data providers
  - EFDC
  - ICOS
- Site landcovers
  - Grassland 04
  - Forest 03
  - Vineyard 01
- Terrain
  - 1 m – 2160 m
  - Plain
  - Mountain slope & plateau

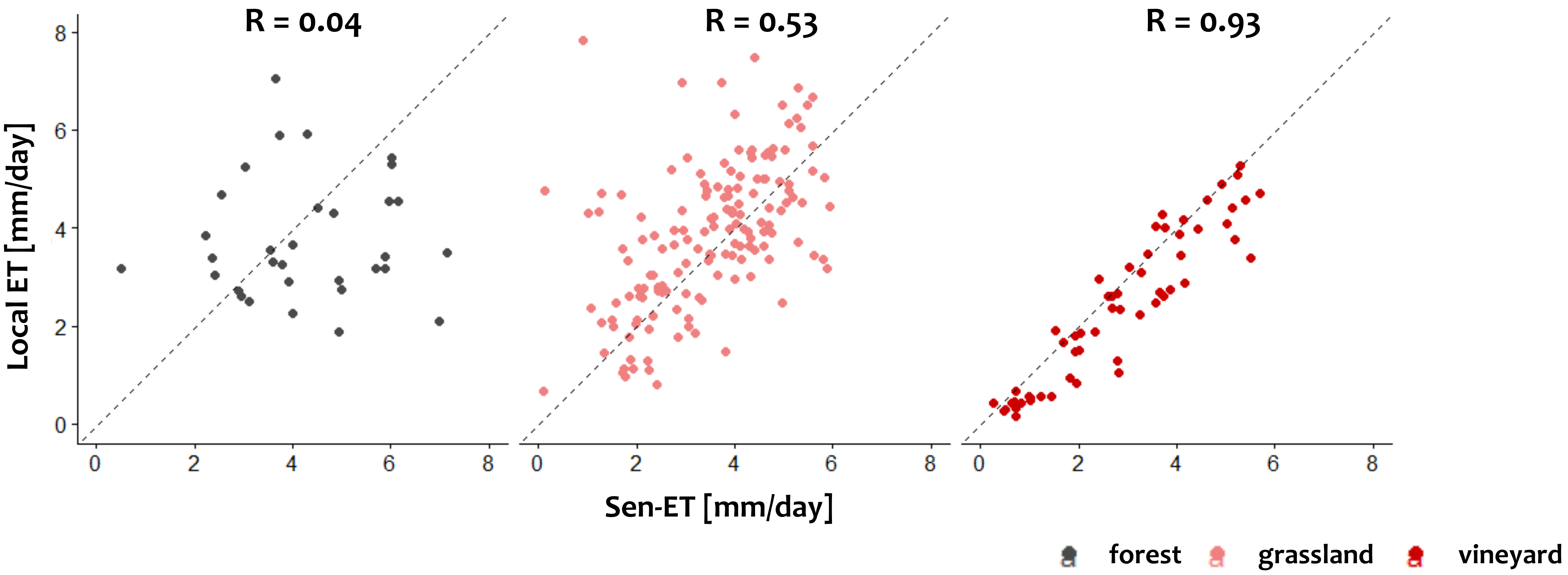
Validation: overall results



- Pixel-wise
- All sites after QC checks

R	RSE	RMSE	MAPE
0.60	0.88	1.38	0.57

Validation: LULC-based results



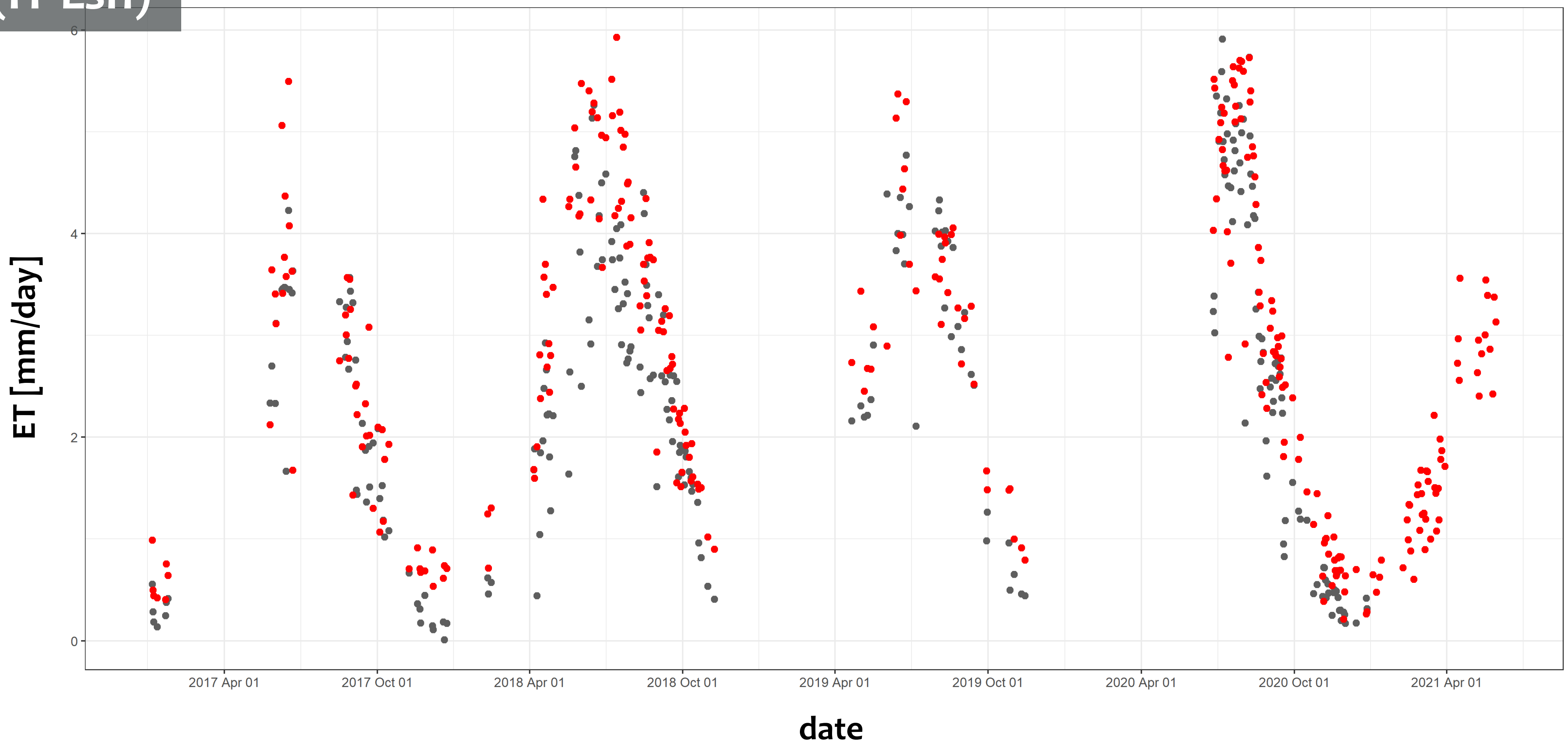
Validation: sites comparison

Vineyard in Lison (IT-Lsn)

Lison vineyard https://www.icos-italy.it/lison-it-lsn/

1 m

R = 0.93 RMSE = 0.73 Bias = 0.45



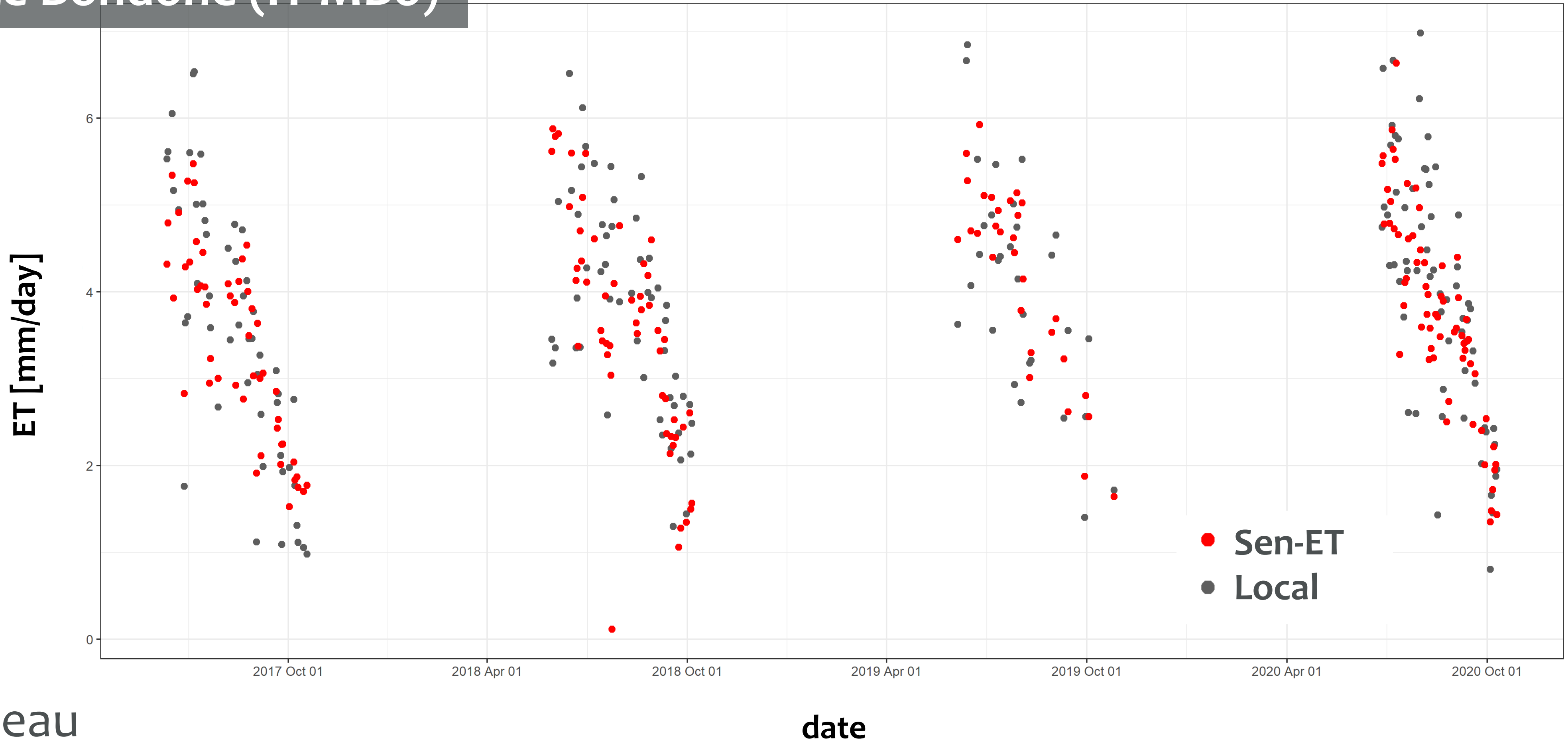
Validation: sites comparison

Grassland in Monte Bondone (IT-MBo)

Monte Bondone site, private photo

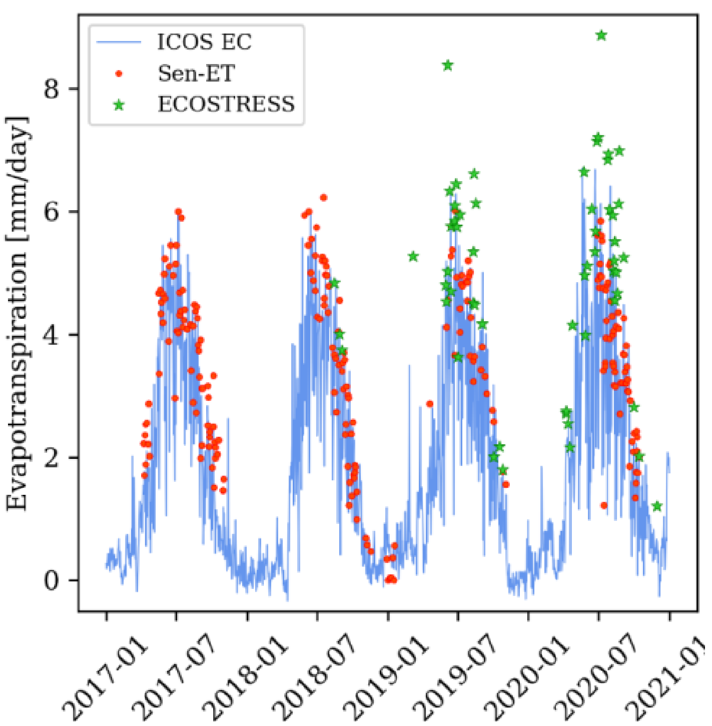
- 1550 m
- … but plateau

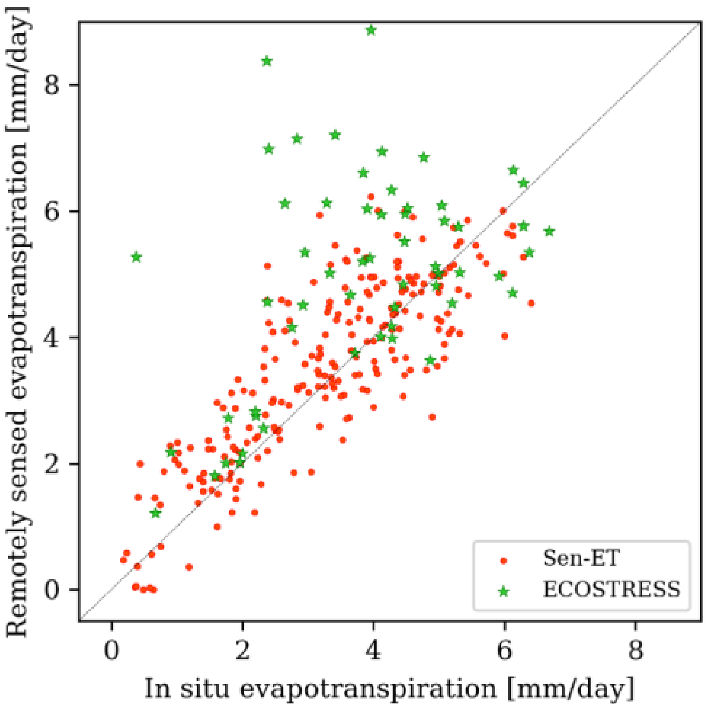
R = 0.71 RMSE = 1.02 Bias = -0.16



Validation: sites comparison

Grassland in Monte Bondone (IT-MBo) in other studies*



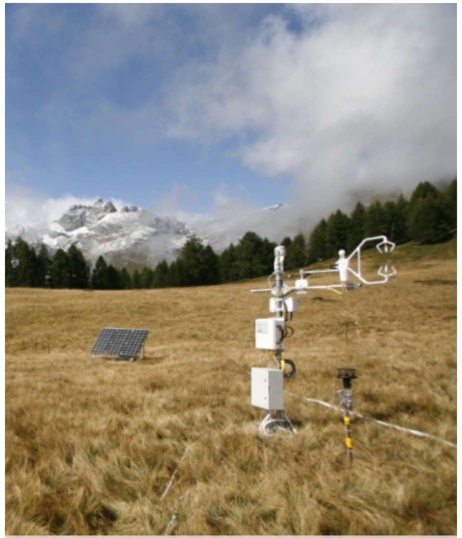


	MSG SEVIRI	Sen-ET	ECOSTRESS
R	0.83	0.83	0.46
RMSD ^{c}	1.19	0.89	2.02
Bias ^{c}	-0.70	0.25	1.16

* De Santis, D., D'Amato, C., Bartkowiak, P., Azimi, S., Castelli, M., Rigon, R. and Massari, C., 2022, November. Evaluation of remotely-sensed evapotranspiration datasets at different spatial and temporal scales at forest and grassland sites in Italy. In *2022 IEEE Workshop on Metrology for Agriculture and Forestry (MetroAgriFor)* (pp. 356-361). IEEE.

Validation: sites comparison

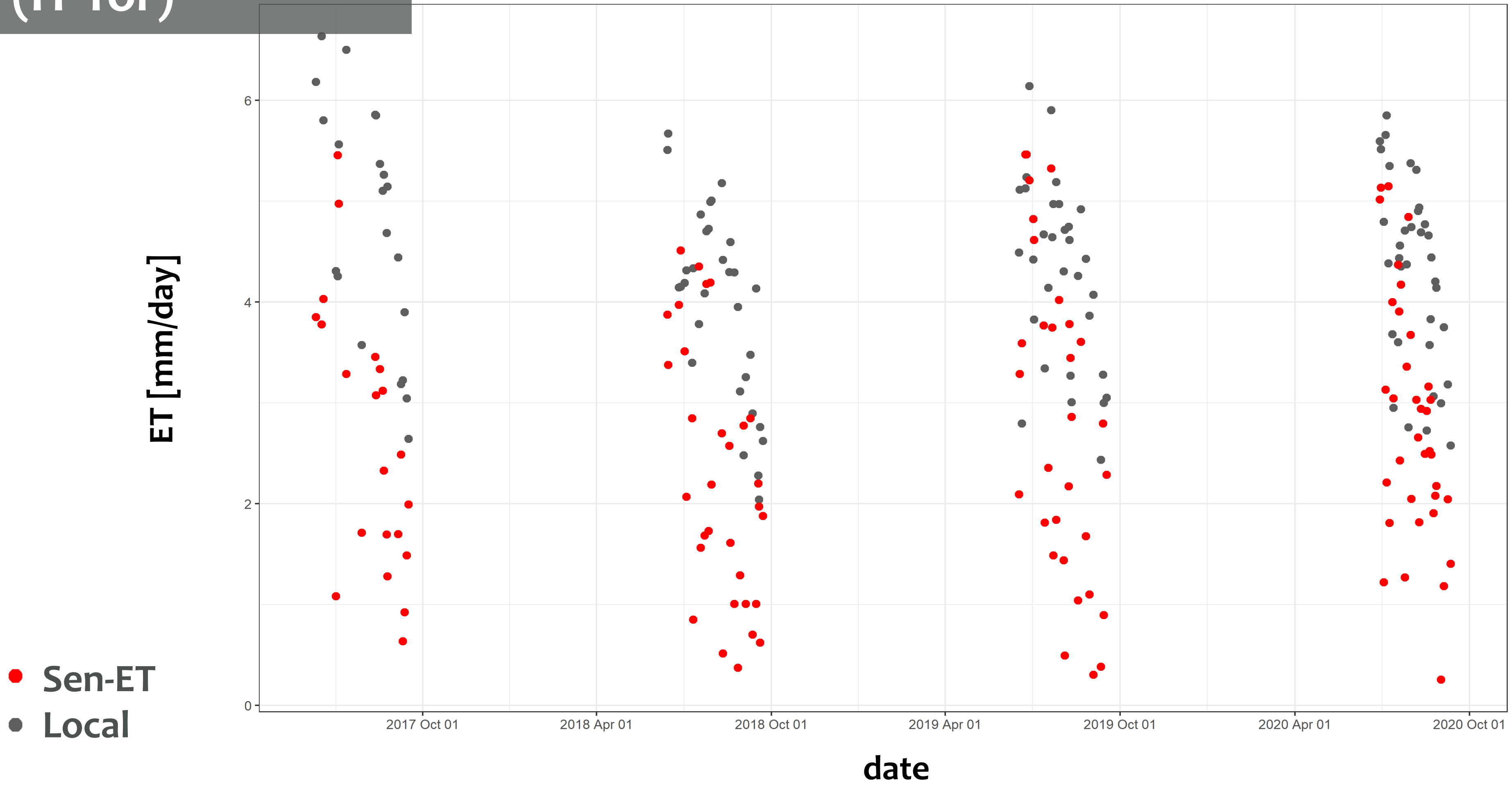
Grassland in Torgnon (IT-Tor)



Torgonon site https://www.icos-italy.it/elementor-2052/

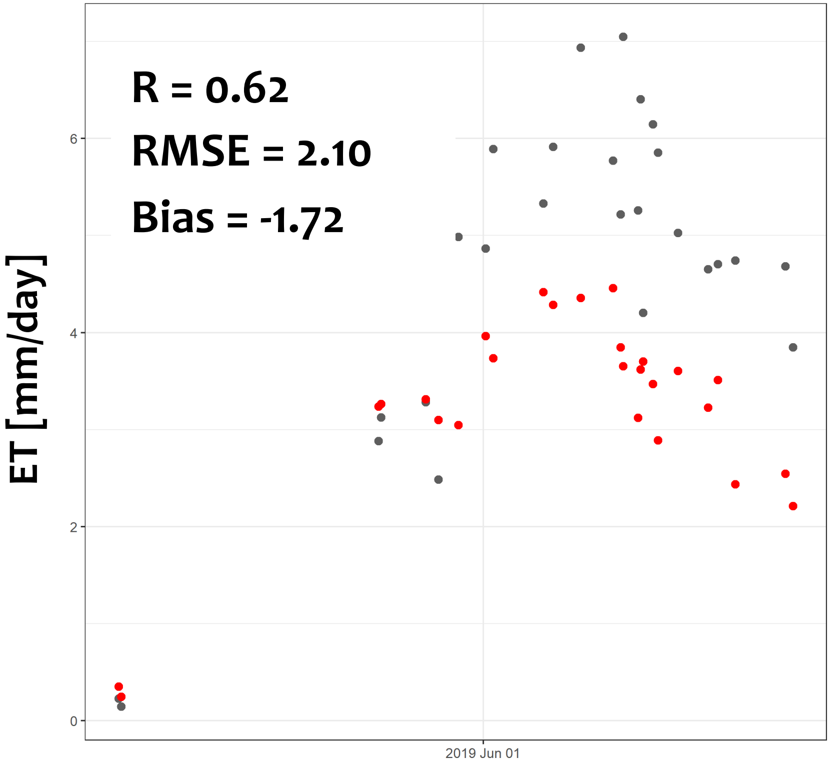
- 2160 m
- slope

R = 0.38   RMSE = 1.89   Bias = -1.51



Validation: sites comparison

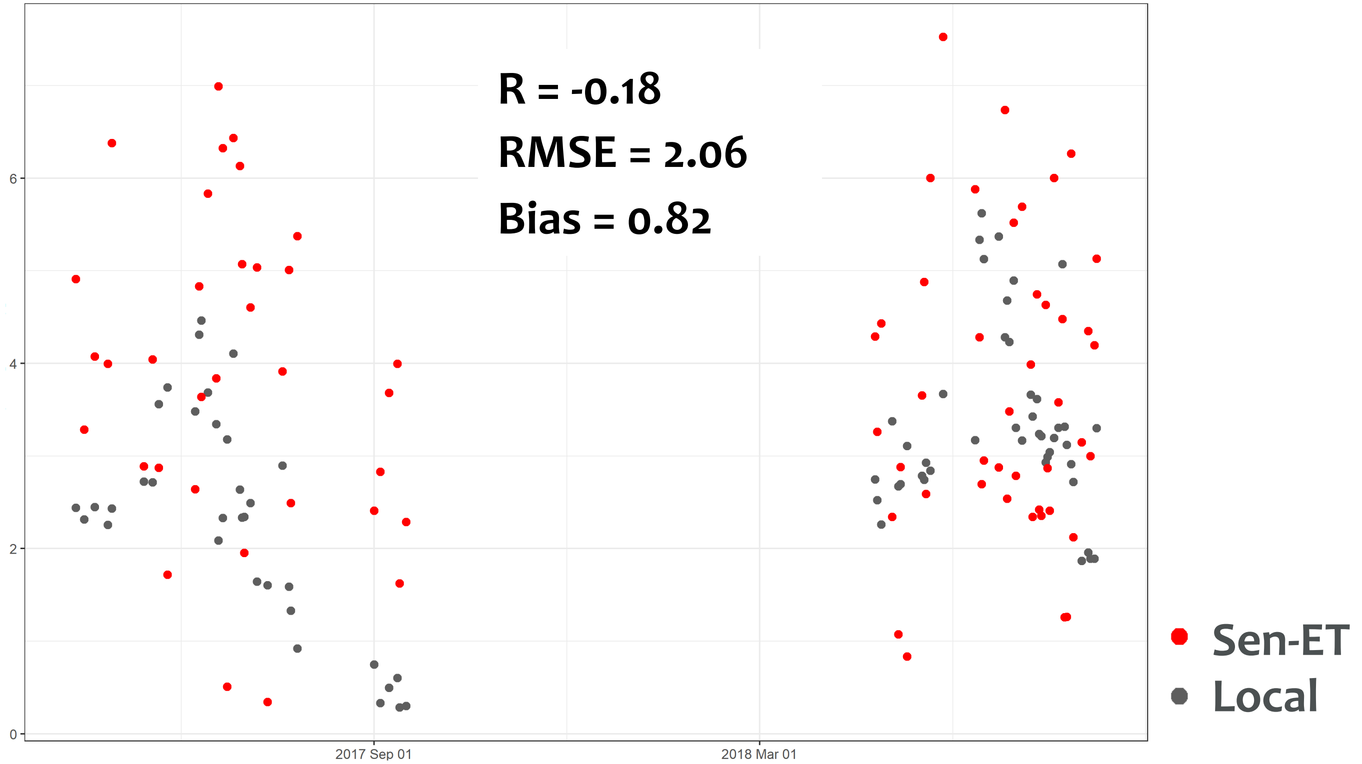
Forest in Renon (IT-Ren)



ENF

1730 m

Forest in Puechabon (Fr-Pue)



EBF

270 m

4 | Conclusions and Outlook

Conclusions

- TSEB is capable of modeling daily ET at relatively satisfactory accuracies

but …

- Model performance depends on landcover and terrain complexity
- Still existing heterogeneity with 100-m pixel
- High computational and disk space costs

Overlook

- ET data sharing
- Data paper
- Future research
  - TSEB improvements
  - ET gap-filling under cloudy skies

openEO Platform

zenodo

CALEIDOSCOPE project

Swiss National Science Foundation

eurac
research

Institute for Earth Observation

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https://www.cimafoundation.org/en/news/the-role-of-evapotranspiration-in-driving-the-water-balance-during-droughts/