living planet symposium | BONN 23–27 May 2022

TAKING THE PULSE OF OUR PLANET FROM SPACE

Multi-scale monitoring of actual evapotranspiration: Use of Copernicus for consistent estimation of agricultural water use from field to continental levels

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25/05/2022

STUDY OUTLINE

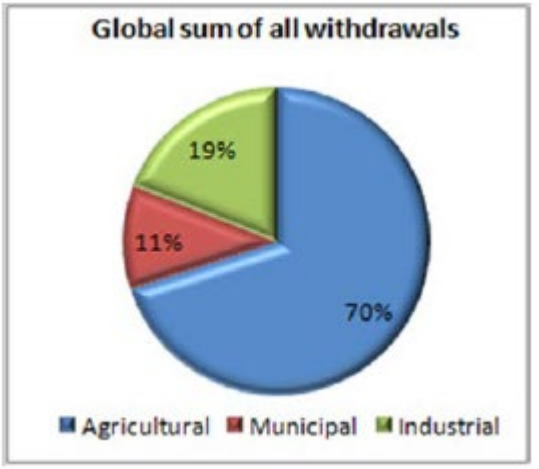
Water use in agriculture

- SDG 6.4.1 – Water use efficiency
- Evapotranspiration (ET) is a direct proxy of crop water use

FAO WaPOR portal - wapor.apps.fao.org

- Dekadal (10-days) evapotranspiration products
- Three spatial scales
  - Continental – 250 m
  - National – 100 m
  - Local – 30 m

Can similar products be achieved with Copernicus data?



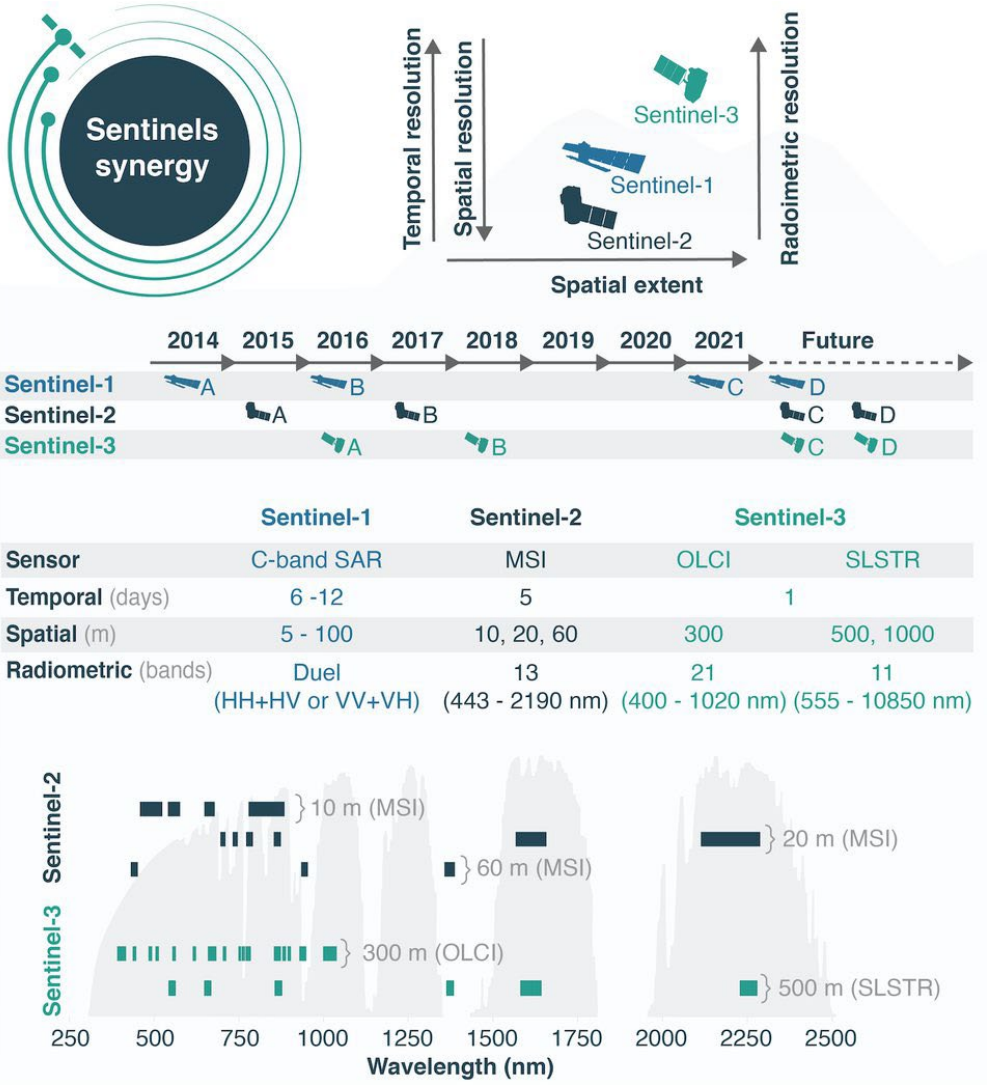
FAO Aquastat

Spatial Scale	Spatial resolution and sensors used currently in WaPOR	Spatial resolution and sensors when using Copernicus data
Continental	250 m – MODIS on Terra and Aqua	300 m – SLSTR and OLCI on Sentinel-3A/B
National	100 m – MODIS on Terra and Aqua and Vegetation on PROBA-V	100 m – SLSTR on Sentinel-3 A/B and MSI on Sentinel-2 A/B
Local	30 m – OLI on Landsat 8 and ETM+ on Landsat 7 and TM on Landsat 5	20 m – SLSTR on Sentinel-3 A/B and MSI on Sentinel-2 A/B

COPERNICUS SENTINEL DATA

Sentinel constellation highly suitable for parcel-scale agricultural monitoring

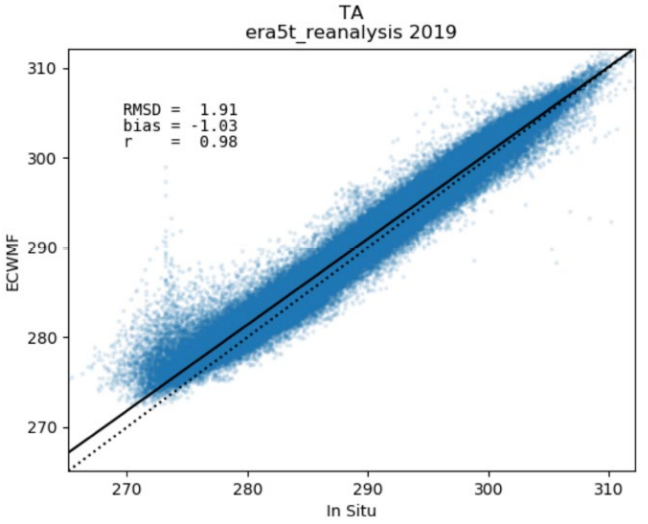
Satellite	Sentinel-2	Sentinel-3	Constellation
Spatial resolution	10 m - 60 m	300 m – 1 km	10 m
Temporal resolution	1 – 5 days	Daily	Daily
Spectral coverage	VIS, NIR, SWIR	VIS, NIR, SWIR, TIR	VIS, NIR, SWIR, TIR

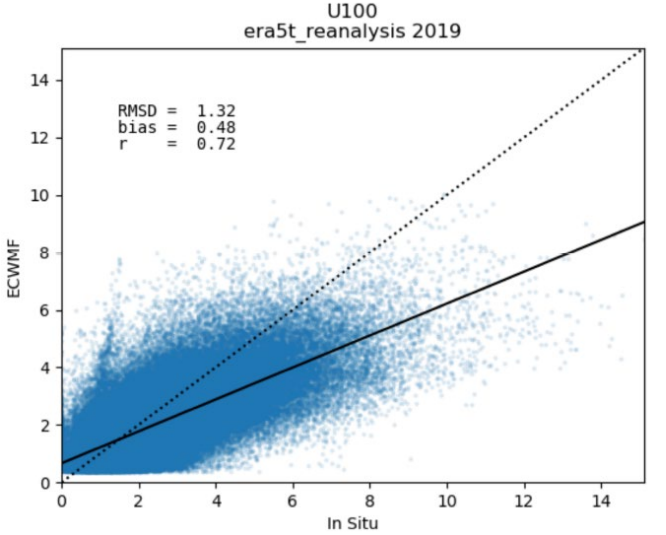


OTHER COPERNICUS DATA

Meteorological data

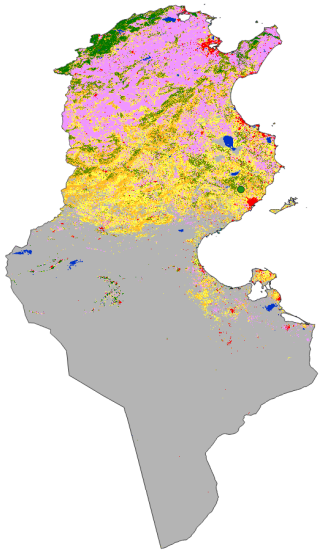
- Available from Copernicus Climate Data Store
- ERA5 climate model
  - Land-surface meteorological parameters
  - 30 km spatial resolution
  - Hourly temporal resolution
  - 5-day timeliness (ERA5P)
  - Global coverage

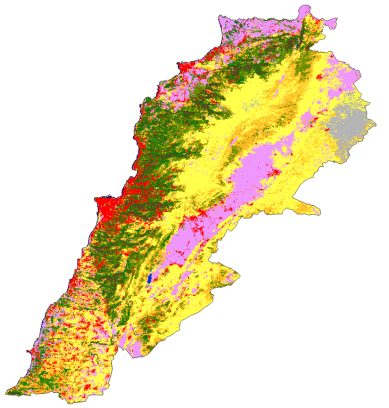




Landcover data

- Produced by Copernicus Land Monitoring Service
- 100 m spatial resolution
- Yearly temporal resolution
- Overall mapping accuracy – 80 %

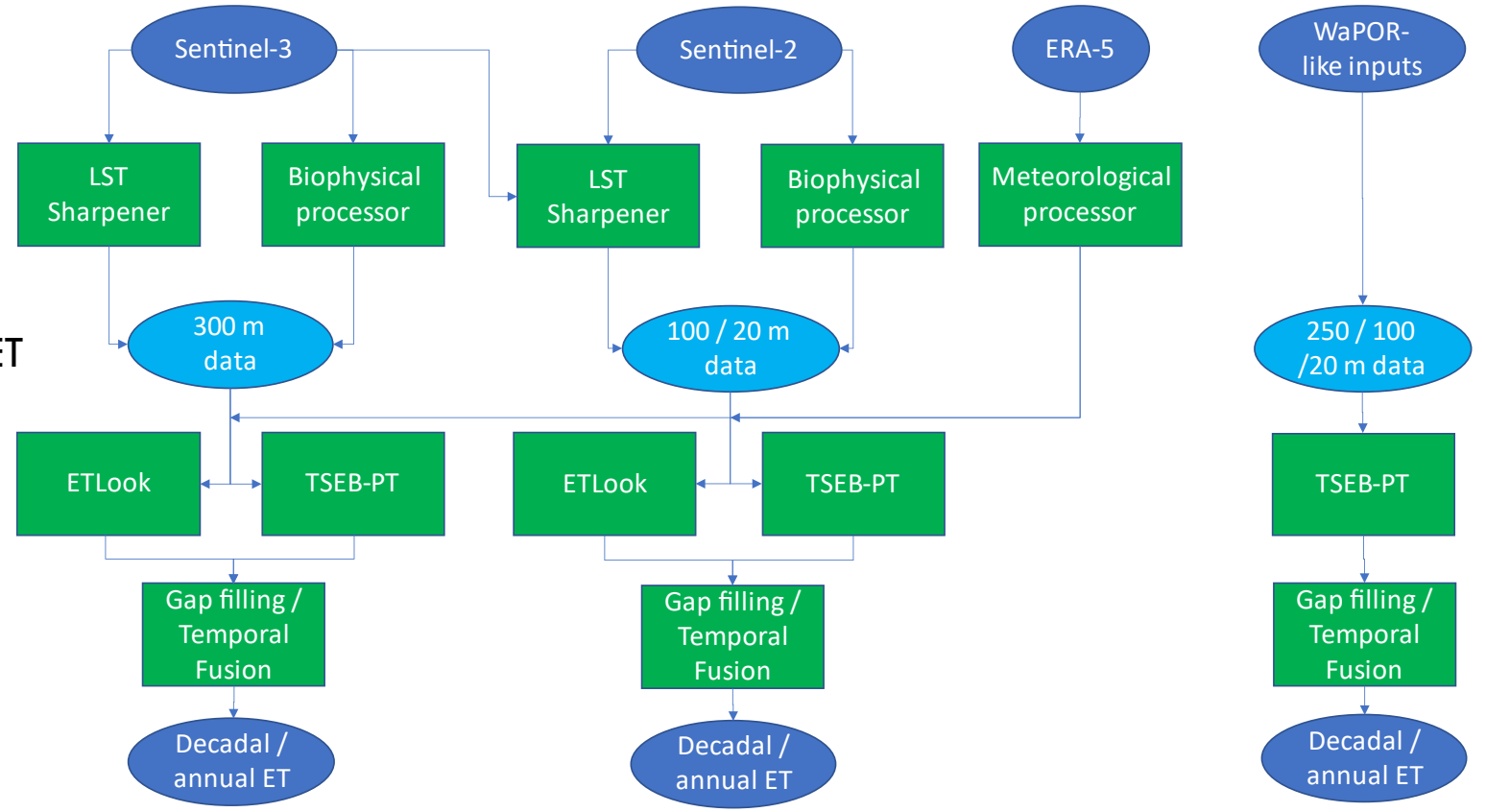




EXPERIMENT DESIGN

Aims:

- Demonstrate feasibility of using Copernicus data for operational (historical and NRT), detailed, large scale ET mapping which is consistent across spatial scales
- Compare WaPOR and WaPOR-like ET products to Copernicus-based equivalents through validation and assessment of ET maps
- Demonstrate practical usage of method developed in Sen-ET project (esa-sen4et.org)



BIOPHYSICAL PROCESSING – SENTINEL-2

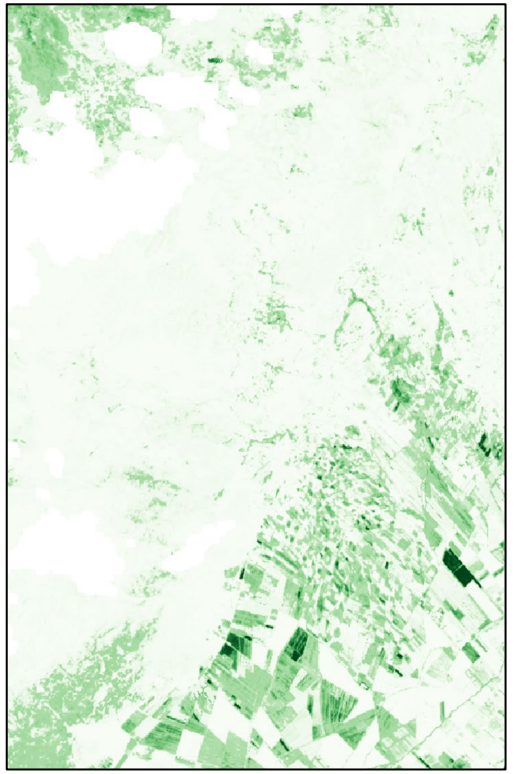
L1C

Download

L2A

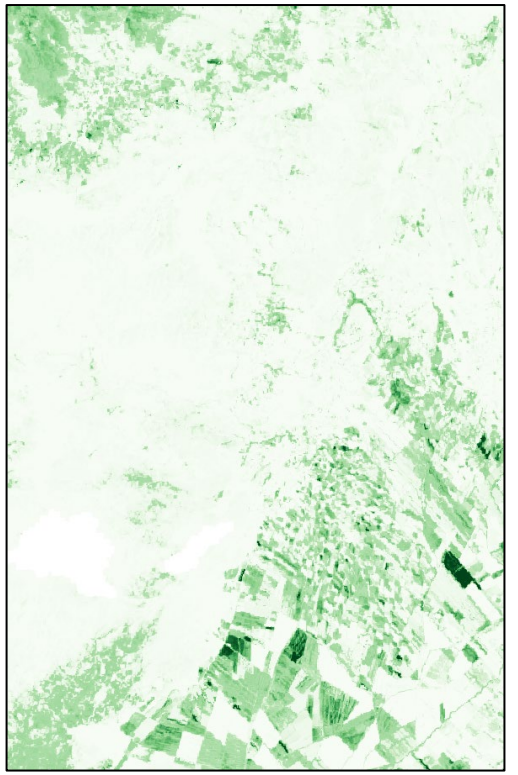
Sen2Cor & Fmask

L2B - LAI



SNAP & Python

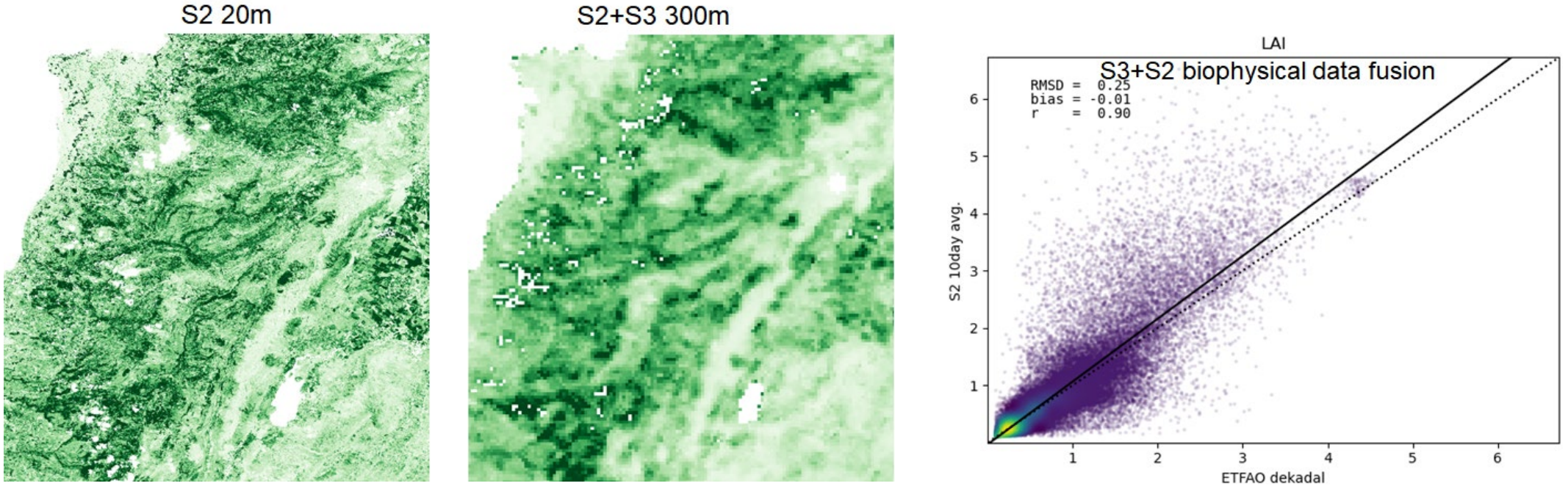
L3



SNAP / Python

BIOPHYSICAL PROCESSING - SENTINEL-3 SYN

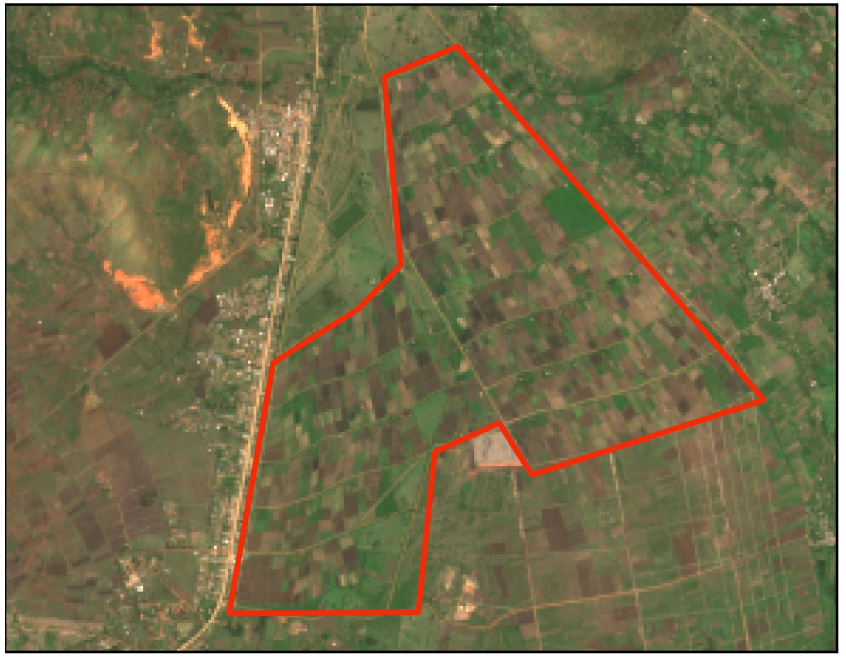
- 10-day minimum view zenith angle composite of SYN reflectance
- Train model between S2 biophysical property and SYN composite reflectance
- Apply model to SYN composite
- Training area can be smaller than application area



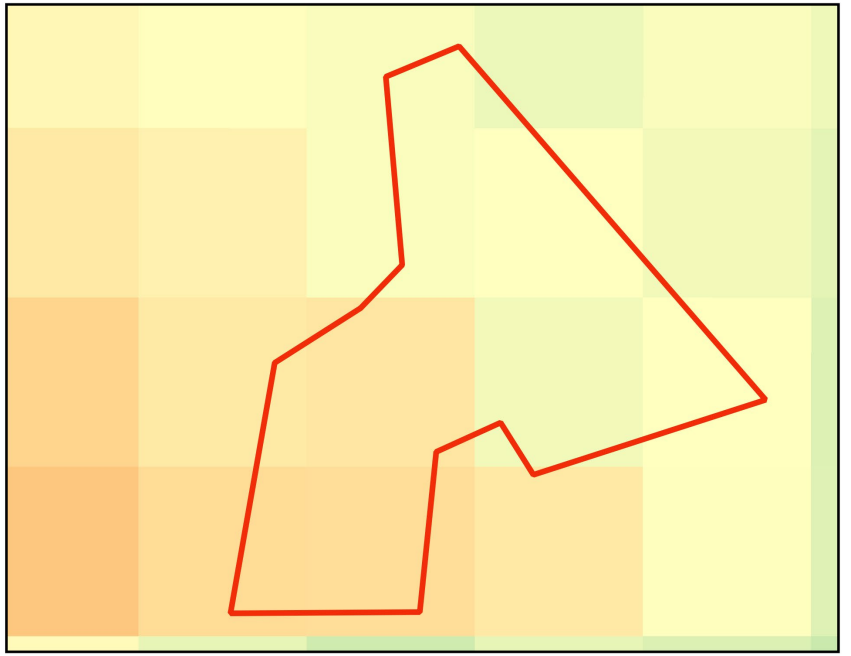
CHALLENGE

Lack of high-resolution thermal data

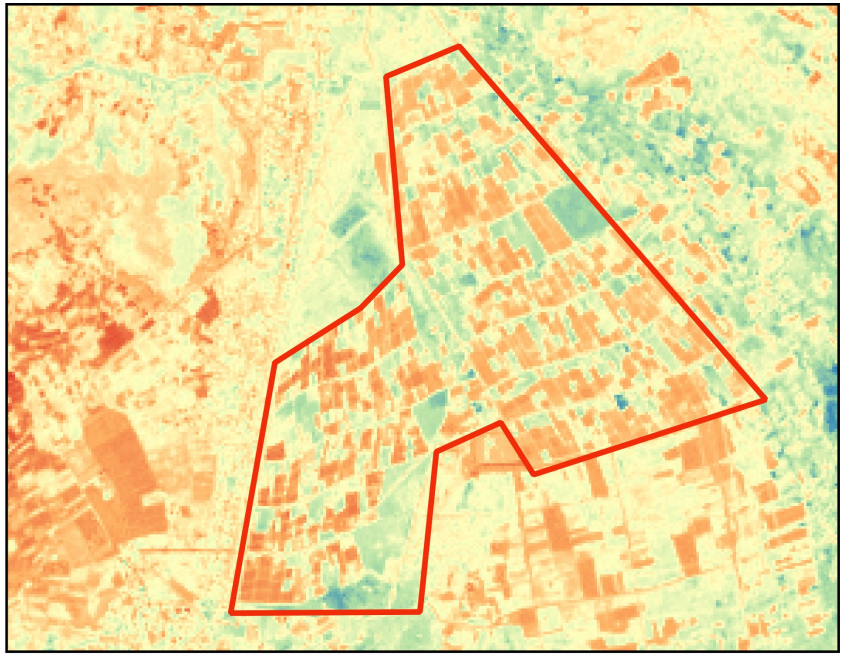
Sentinel-2 reflectance



Sentinel-3 LST



Fused LST



0 1000 2000 m

LST

295 300 305 310 315

DATA FUSION - THERMAL SHARPENING

Bagging ensembles of modified decision trees

Works on pairs on optical and thermal images

- Up to 10-days offset
- Unique model trained and applied for each pair

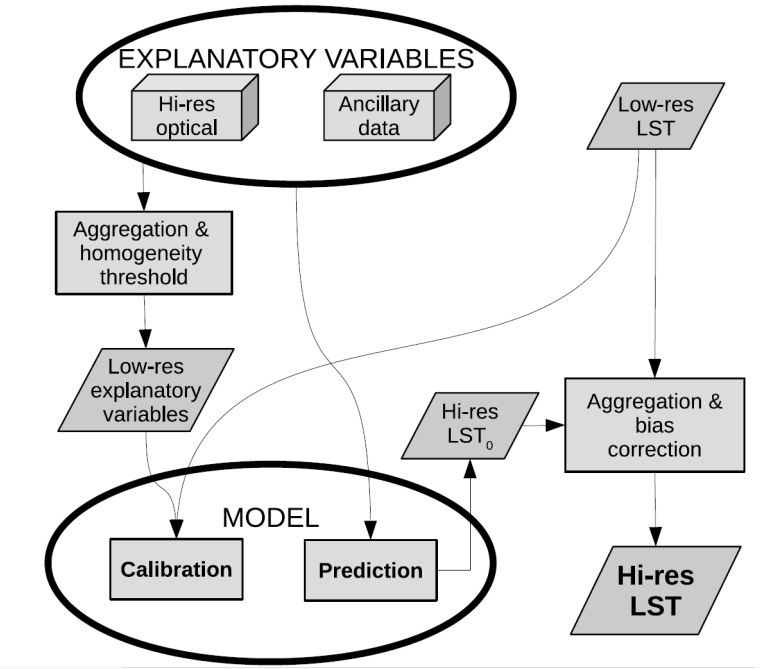
Conservation of thermal energy

Assumptions:

- Relation exists between optical and thermal images
- This relation is scale-independent

Limitations:

- LST range
- Temporal offset between thermal and optical

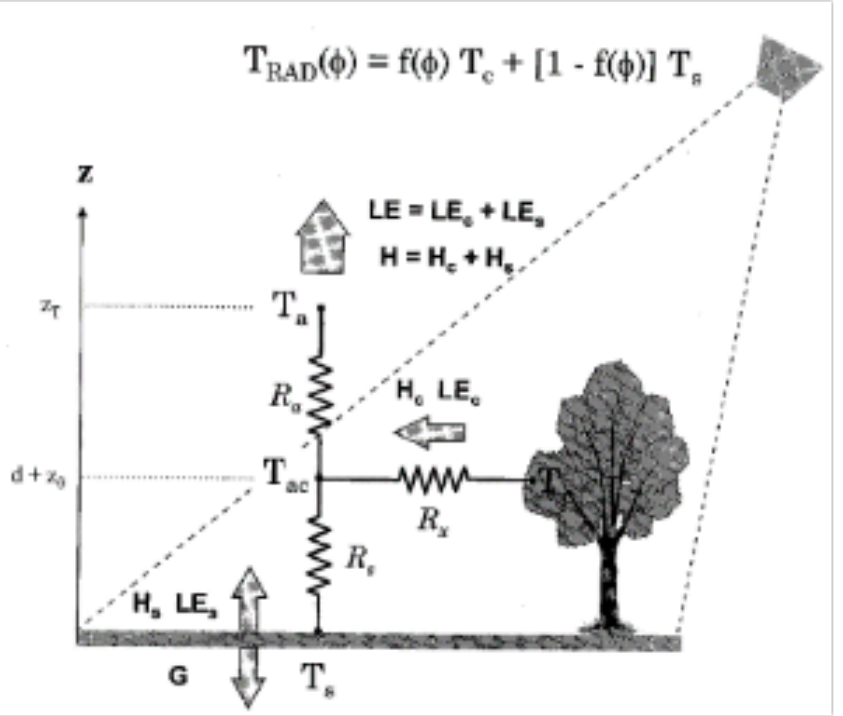


ET MODELLING - TSEB

Two Source Energy Balance

- Physical model
- Models instantaneous land-surface energy fluxes (W/m2)
- Partitions Evaporation and Transpiration with resistances in series
- Flux interaction between canopy and soil
- Robust in many environments
- Continually developed

Extrapolation to daily ET (mm/day)



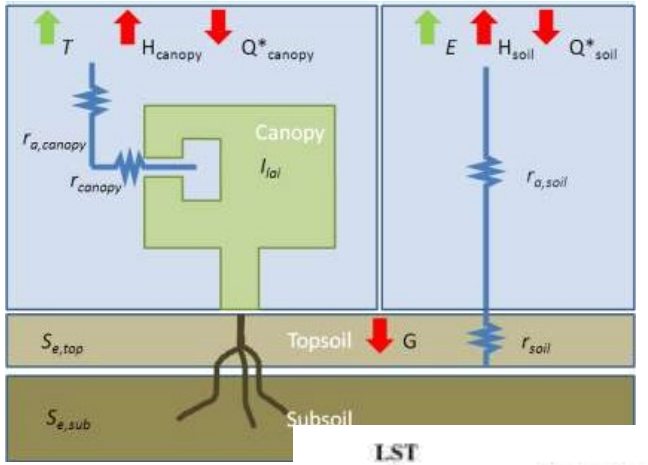
Source: Mecikalski et al., 1999

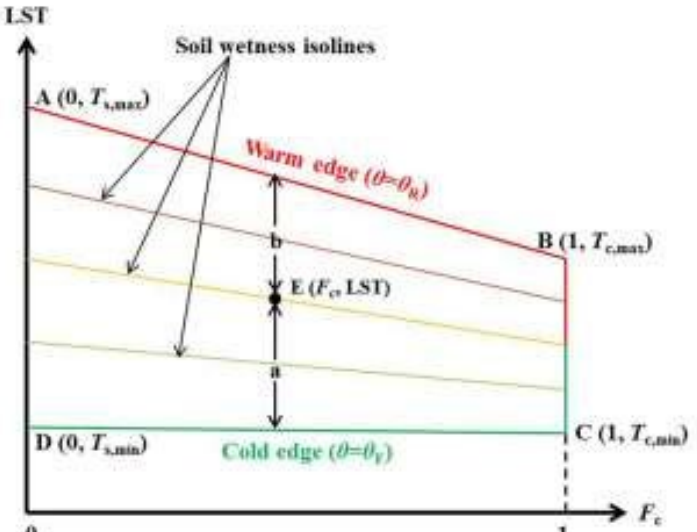
ET MODELLING - ETLOOK

ETLook

- Physical/contextual model
- Models daily land-surface energy fluxes (W/m2)
- Partitions Evaporation and Transpiration by radiation partitioning
- No flux interaction between canopy and soil
- Requires definition/calculation of extreme temperatures
- Less sensitive to input uncertainty

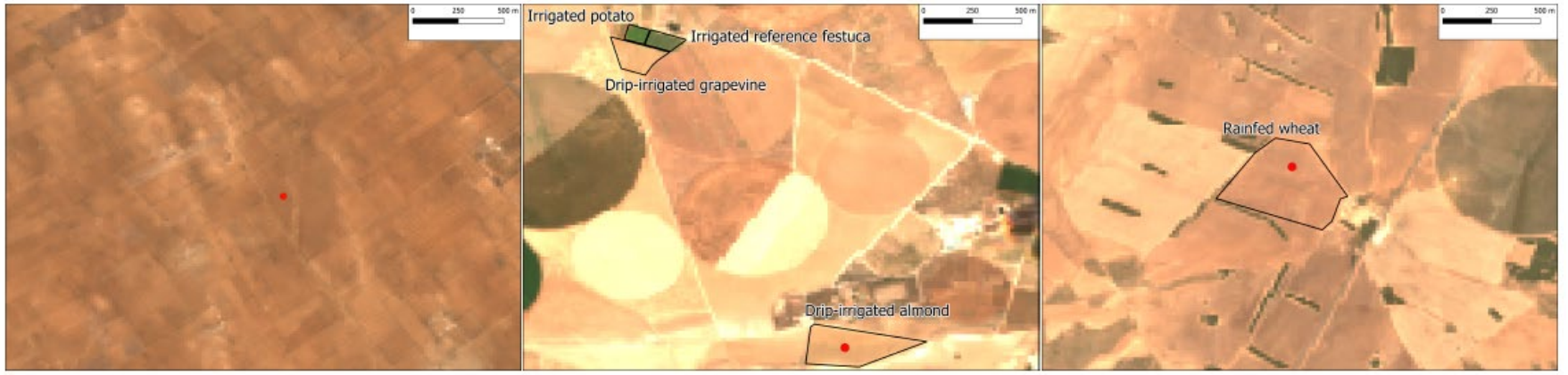
ETLook code was developed by WaPOR FRAME consortium





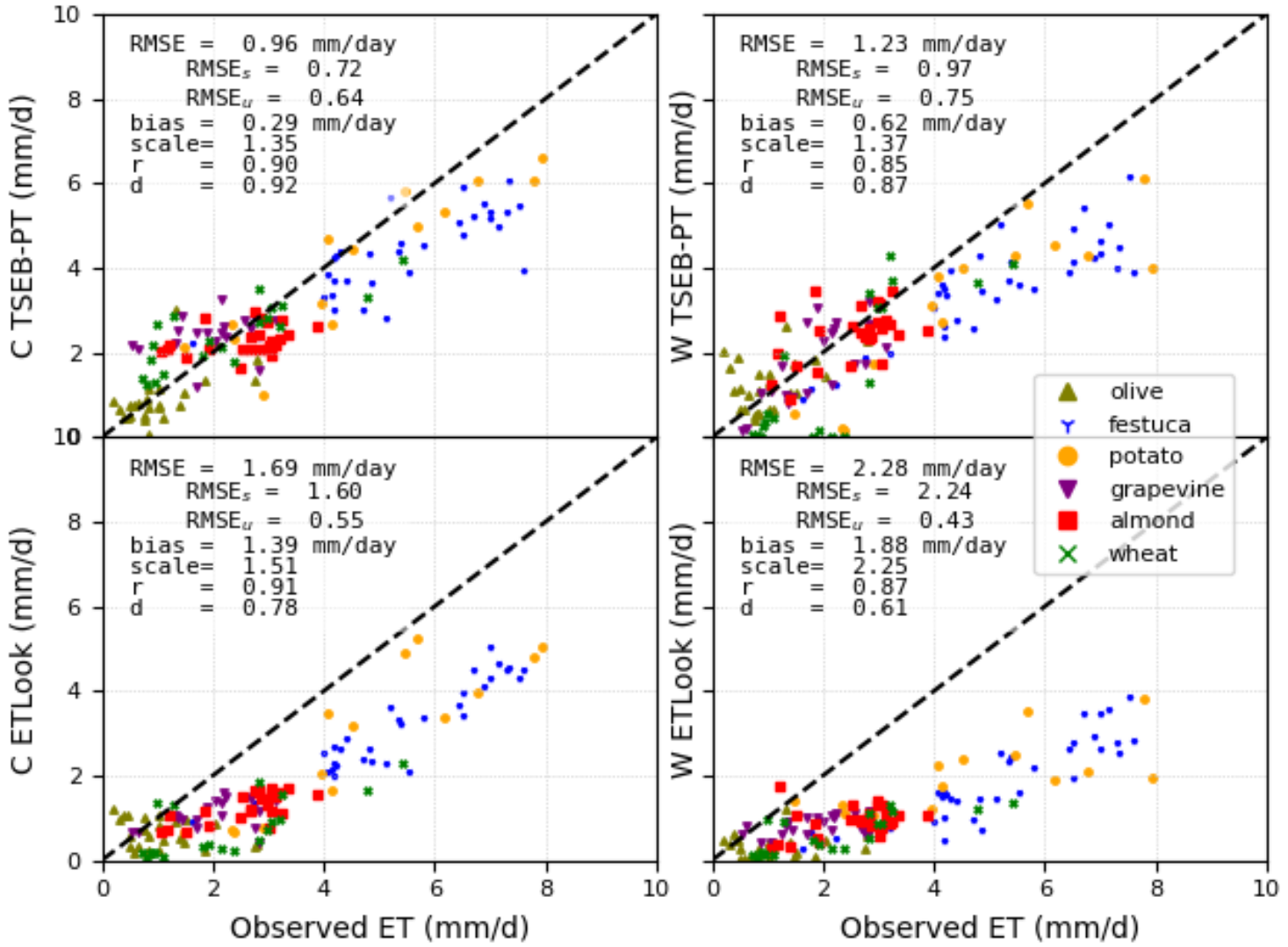
Source: WaPOR Database Methololgy, Level 3 Data

VALIDATION SITES

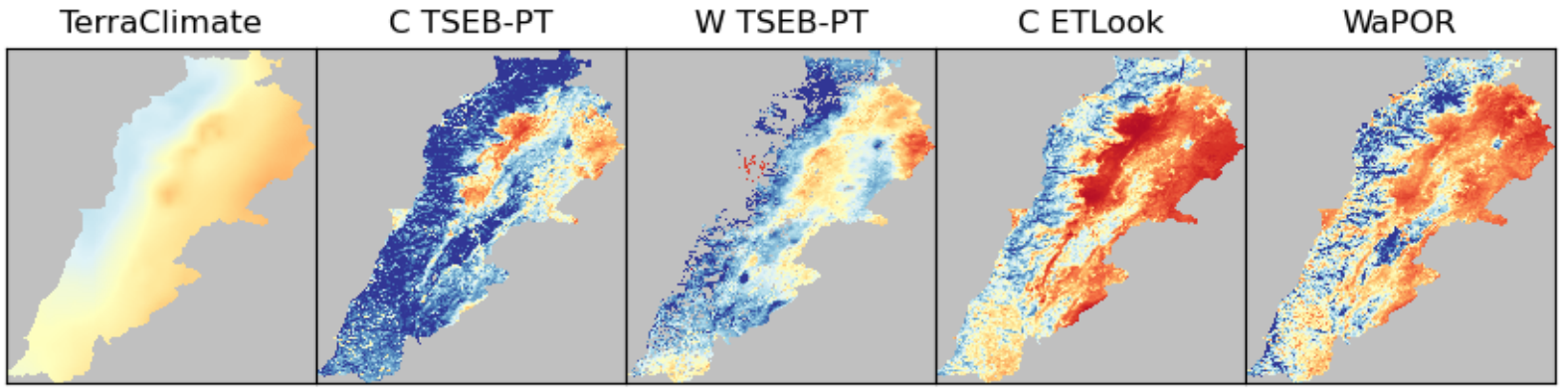


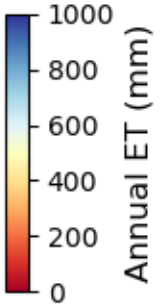
Site	Irrigation	Measurement	Notes	Location
Potato	Sprinkler	Lysimeter	Small parcel	SE Spain
Festuca / reference grass	Sprinkler	Lysimeter	Small parcel Frequently irrigated Clipped to 12 cm	SE Spain
Vineyard	Drip	Lysimeter		SE Spain
Almond	Drip	EC tower	Residual assigned to latent heat	SE Spain
Wheat	None	EC tower	No residual correction	SE Spain
Olive	None	EC tower	Low tree coverage	Central Tunisia

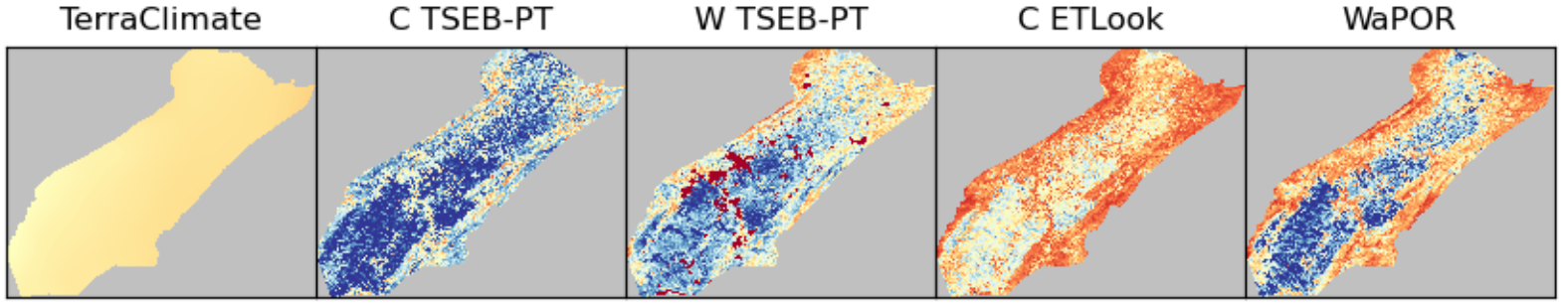
VALIDATION – ALL SITES

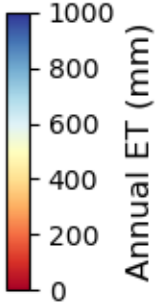


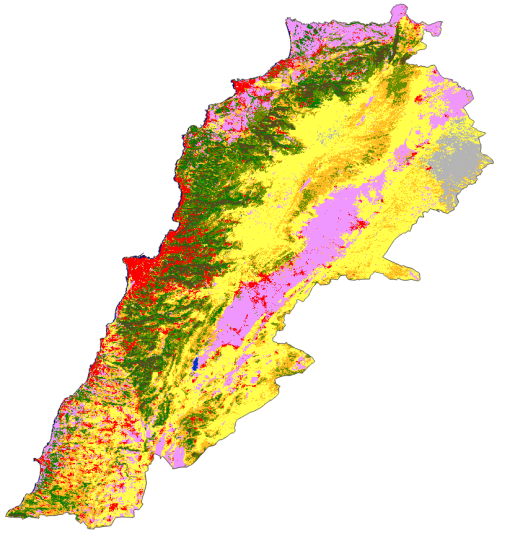
ANNUAL MAPS – LEBANON





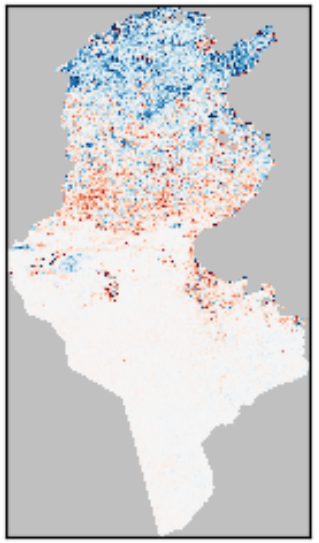




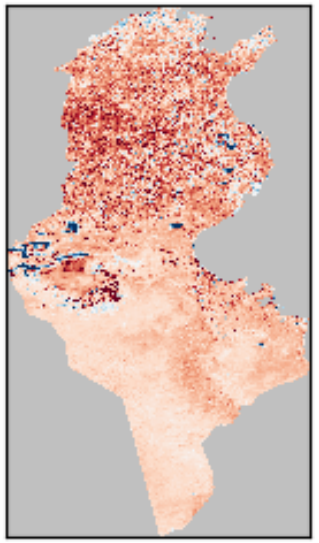


SCALE COMPARISON - TUNISIA

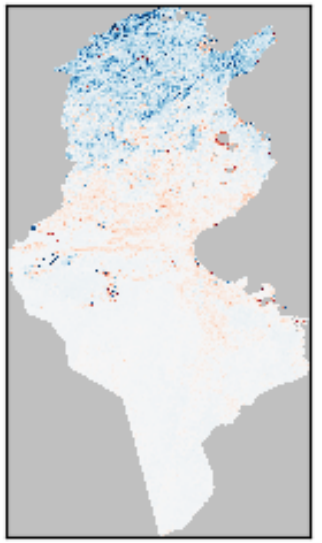
C TSEB-PT L1 - L2



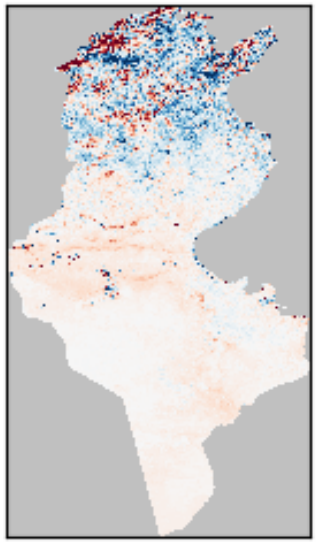
W TSEB-PT L1 - L2

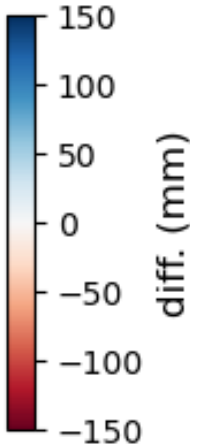


C ETLook L1 - L2

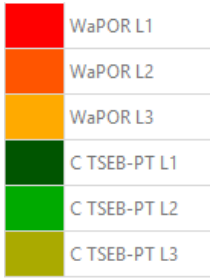


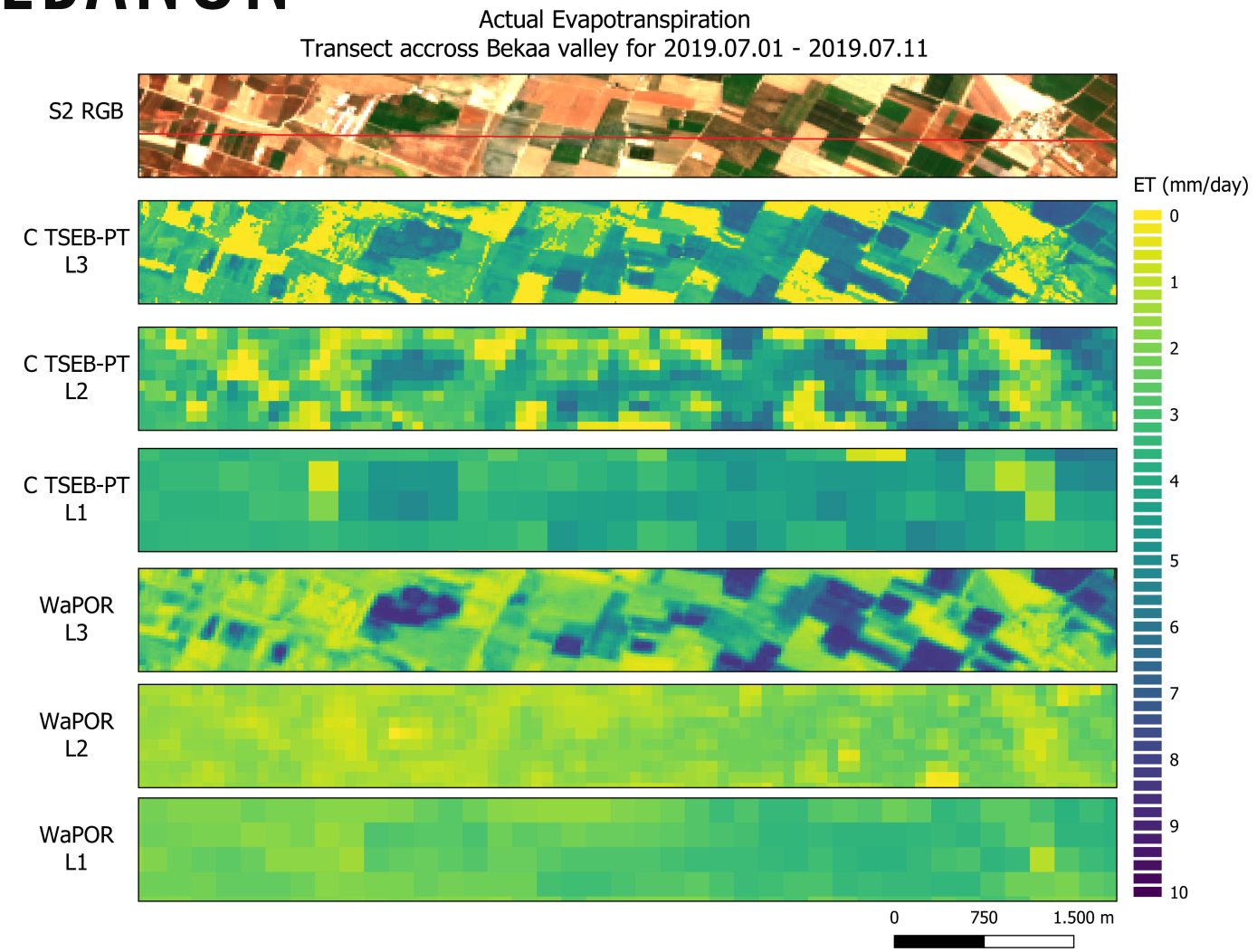
WaPOR L1 - L2





SCALE COMPARISON - LEBANON



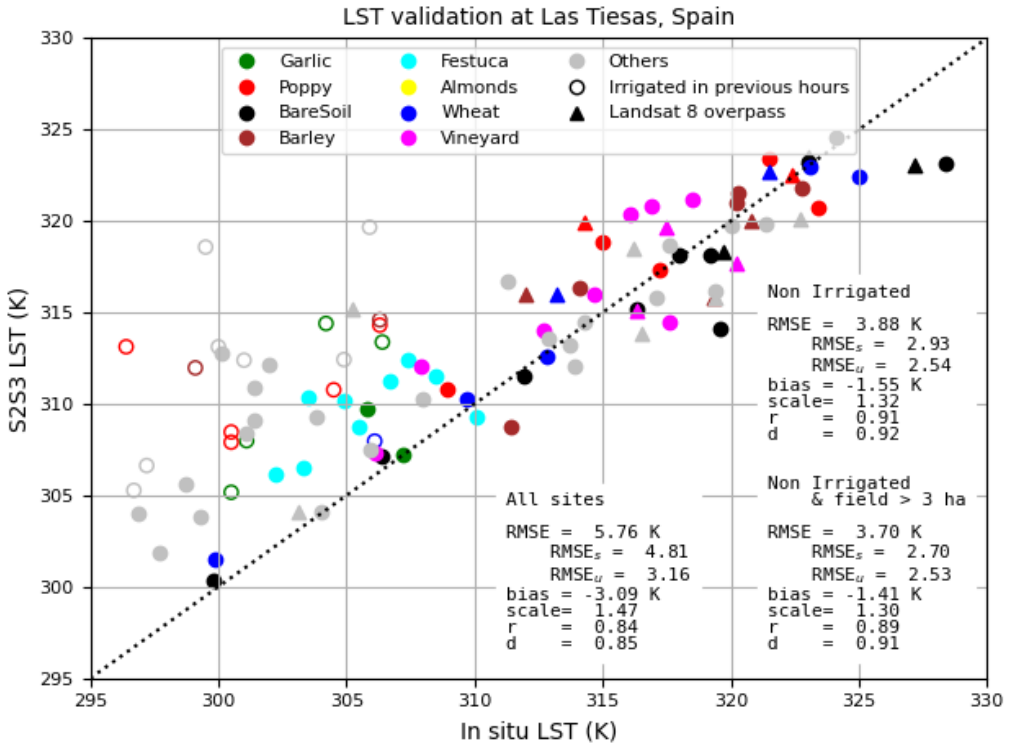


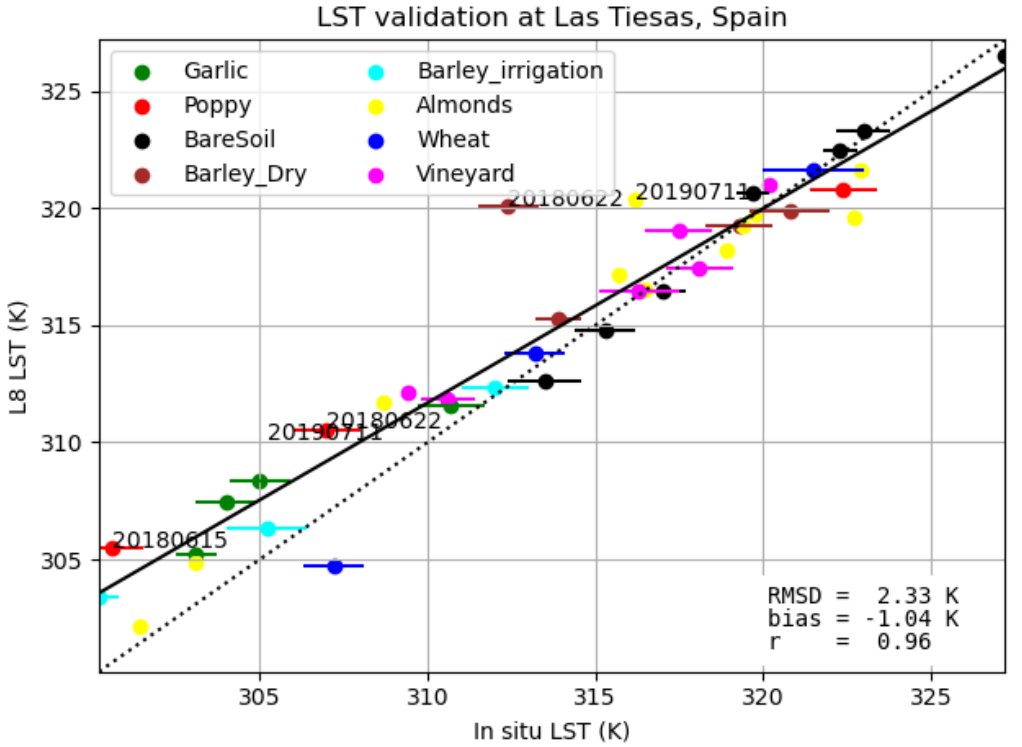
IMPROVEMENTS IN TIR SHARPENING

Issue: capture extreme (dry/wet) cases

Solution: include Landsat LST data

- Force Landast in TSEB when available
- Include Landsat LST during sharpening

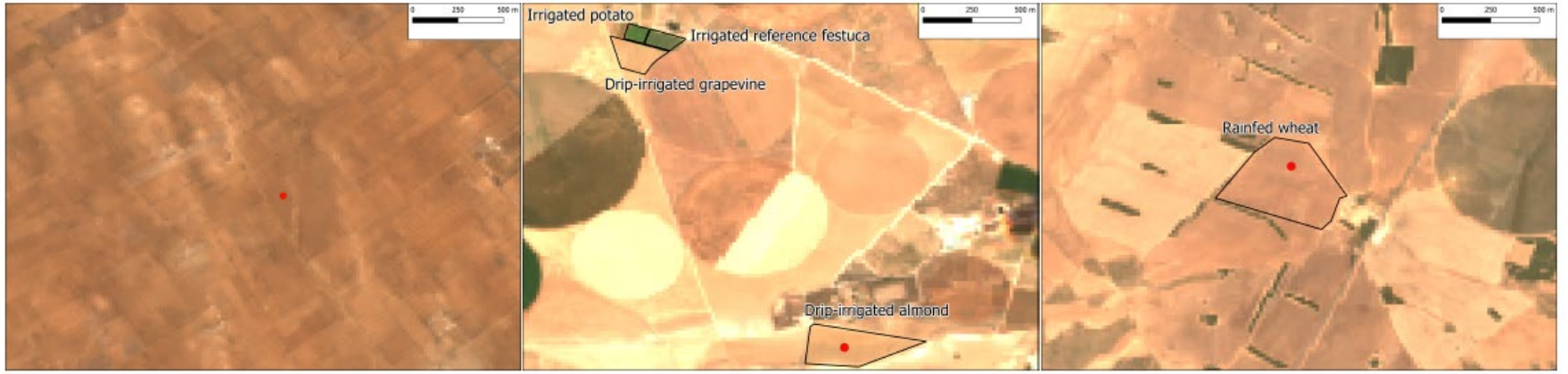




VALIDATION IN DIFFERENT CLIMATES

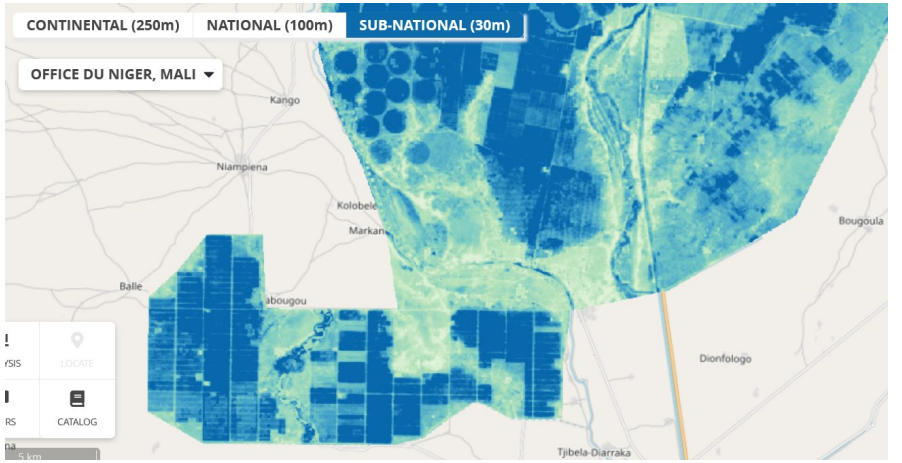
Current validation sites

- Tunisia – 2019
- Spain – 2018 & 2019
- Lebanon – (2019)

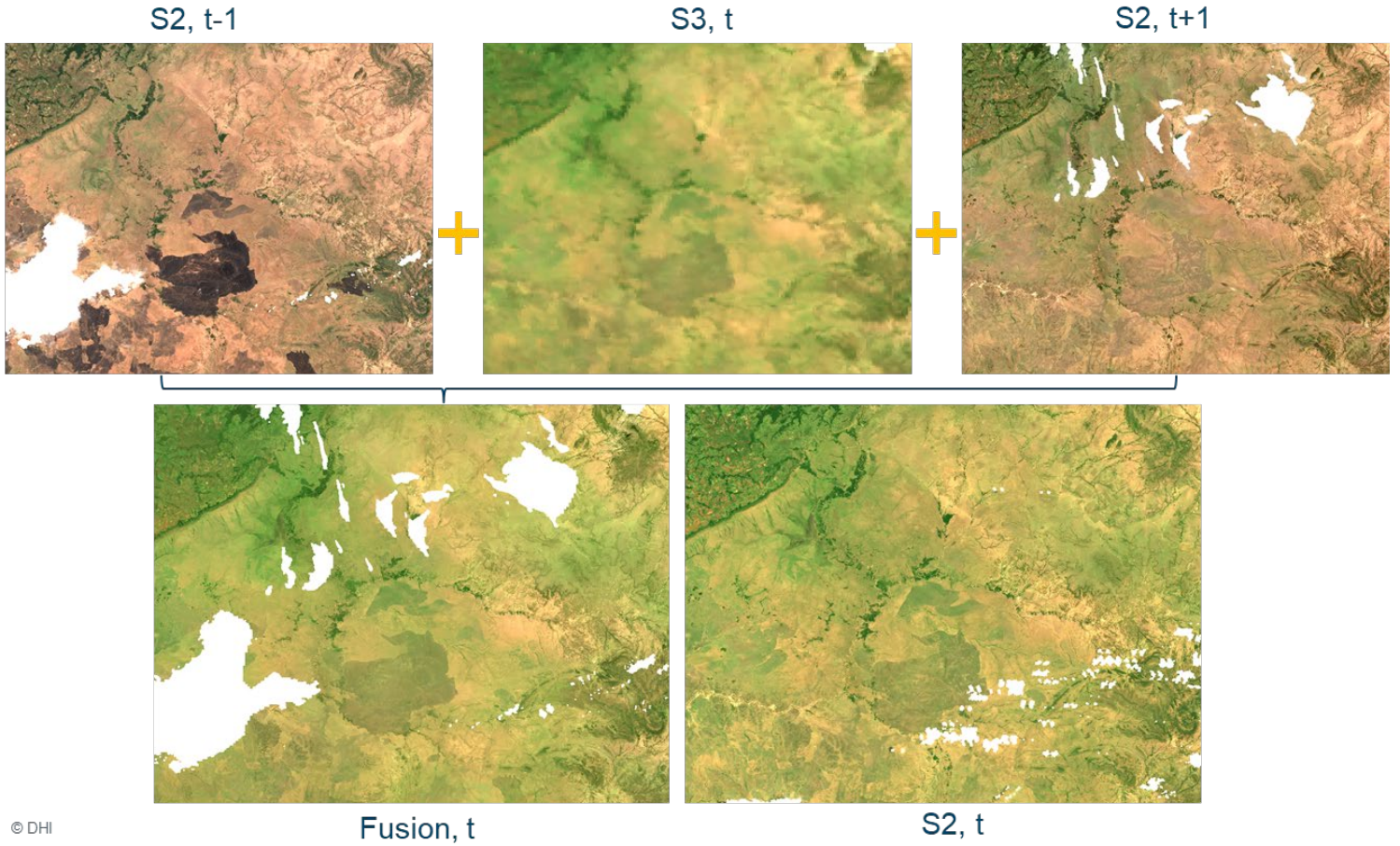


New validation sites

- 6 new sites
- Decided in consultation with FAO
- Focus on (irrigated) agricultural areas where:
  - Measurements are aviable – e.g. Lebanon (Tal Amara), Tunisia (Jendouba)
  - WaPOR L3 data is avaiable – e.g. Mozambique, Rwanda, Sudan, Ethiopia, Mali



DATA FUSION BETWEEN S2 AND S3 OPTICAL DATA



GAP-FILLING OF ET

Current approach:

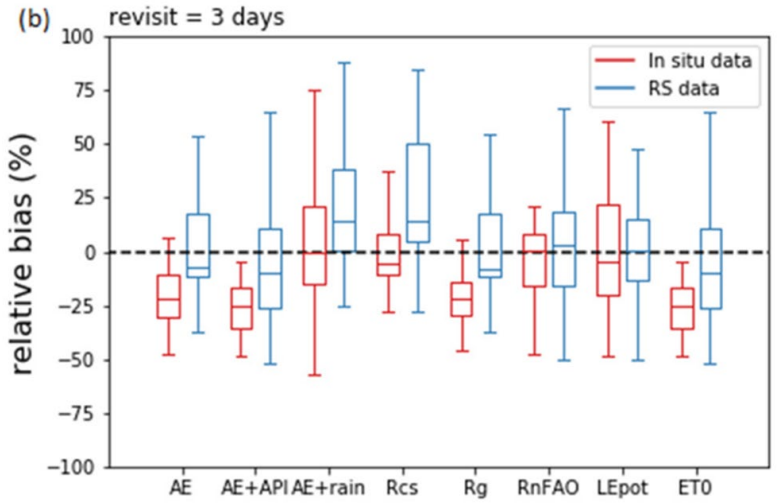
- Using reference ET

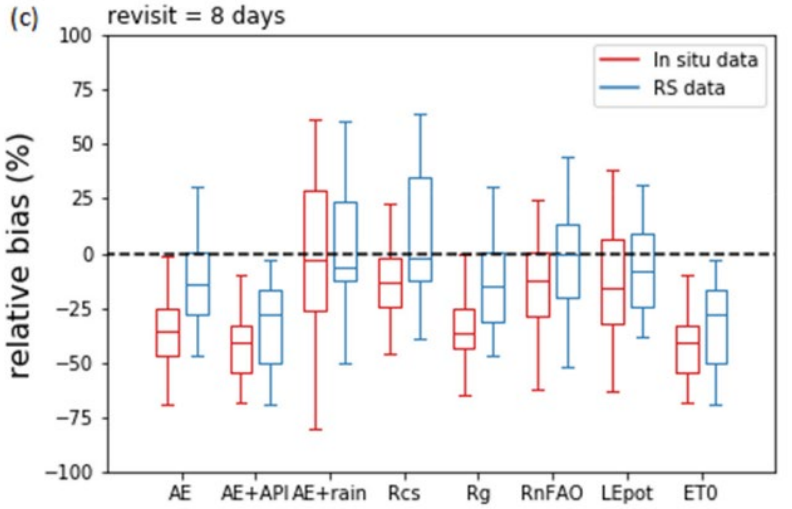
Other approaches might perform better with longer gap

Article

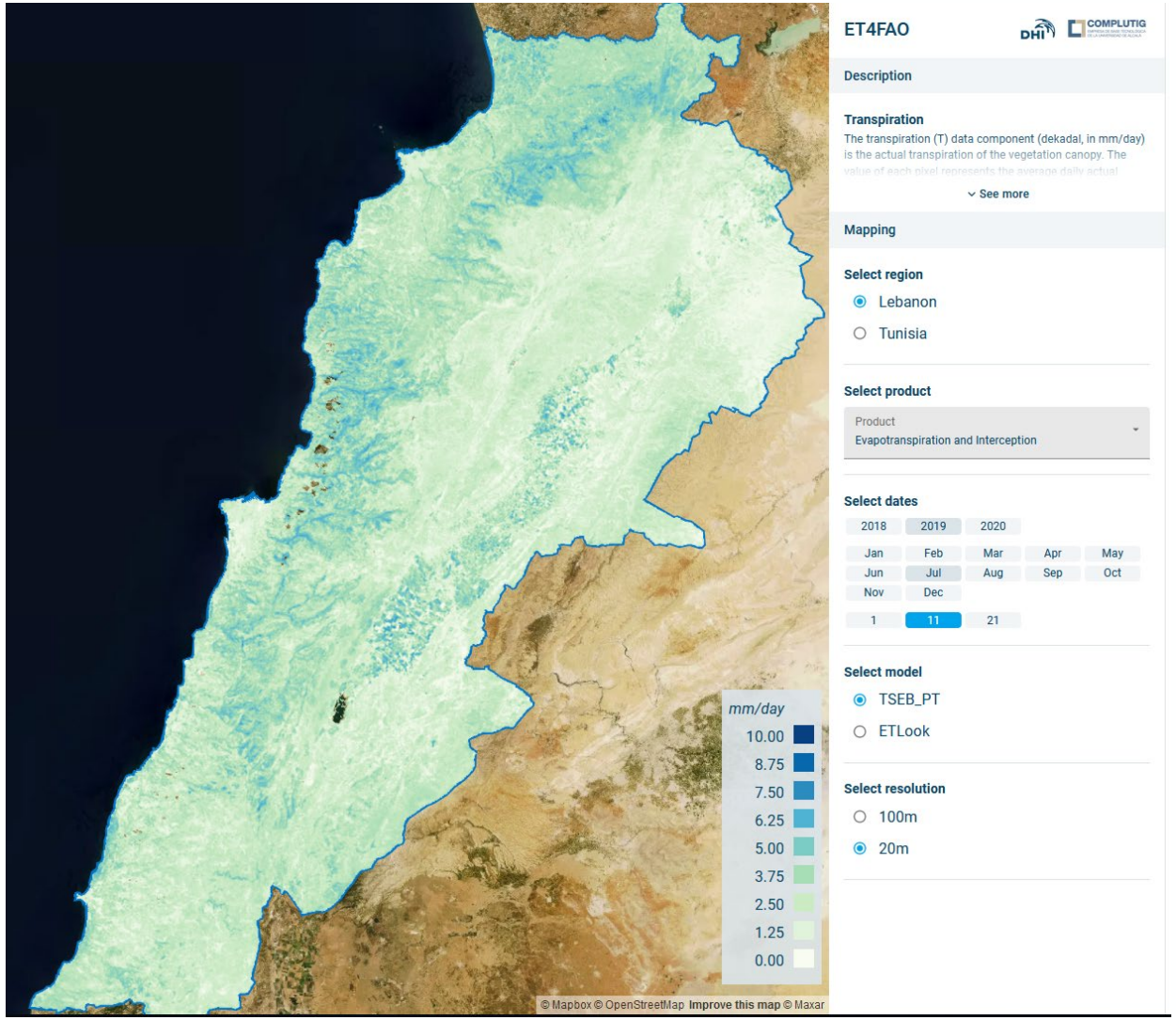
Evaluation of Multiple Methods for the Production of Continuous Evapotranspiration Estimates from TIR Remote Sensing

Emilie Delogu [1], Albert Olioso [2], Aubin Alliès [3], Jérôme Demarty [3] and Gilles Boulet [4,*]





Thank you



ET4FAO
sentinels for evapotranspiration

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COMPLUTIG
EMPRESA DE BASE TECNOLÓGICA DE LA UNIVERSIDAD DE ALCALÁ

Guzinski, Radoslaw, Hector Nieto, Juan Manuel Sánchez, Ramón López-Urrea, Dalenda Mahjoub Boujnah, and Gilles Boulet. 2021. “Utility of Copernicus-Based Inputs for Actual Evapotranspiration Modeling in Support of Sustainable Water Use in Agriculture.” *IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing* 14: 11466–84. https://doi.org/10.1109/JSTARS.2021.3122573.

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