An integrative information aqueduct to close the gaps between global satellite observation of water cycle and local sustainable management of water resources

iAqueduct

Water Works 2017

Water JPI

Zhongbo Su, Yijian Zeng, Nunzio Romano, Salvatore Manfreda, Félix Francés, Eyal Ben Dor, Brigitta Szabó, Giulia Vico, Paolo Nasta, Ruodan Zhuang, Nicolas Francos, János Mészáros, Silvano Fortunato Dal Sasso, Maoya Bassiouni, Lijie Zhang, Donald Tendayi Rwasoka, Bas Retsios, Lianyu Yu, Megan Leigh Blatchford, Chris Mannaerts

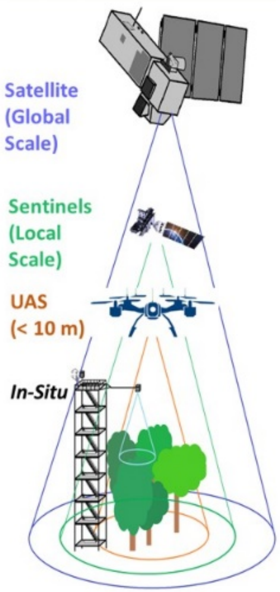
OBJECTIVES

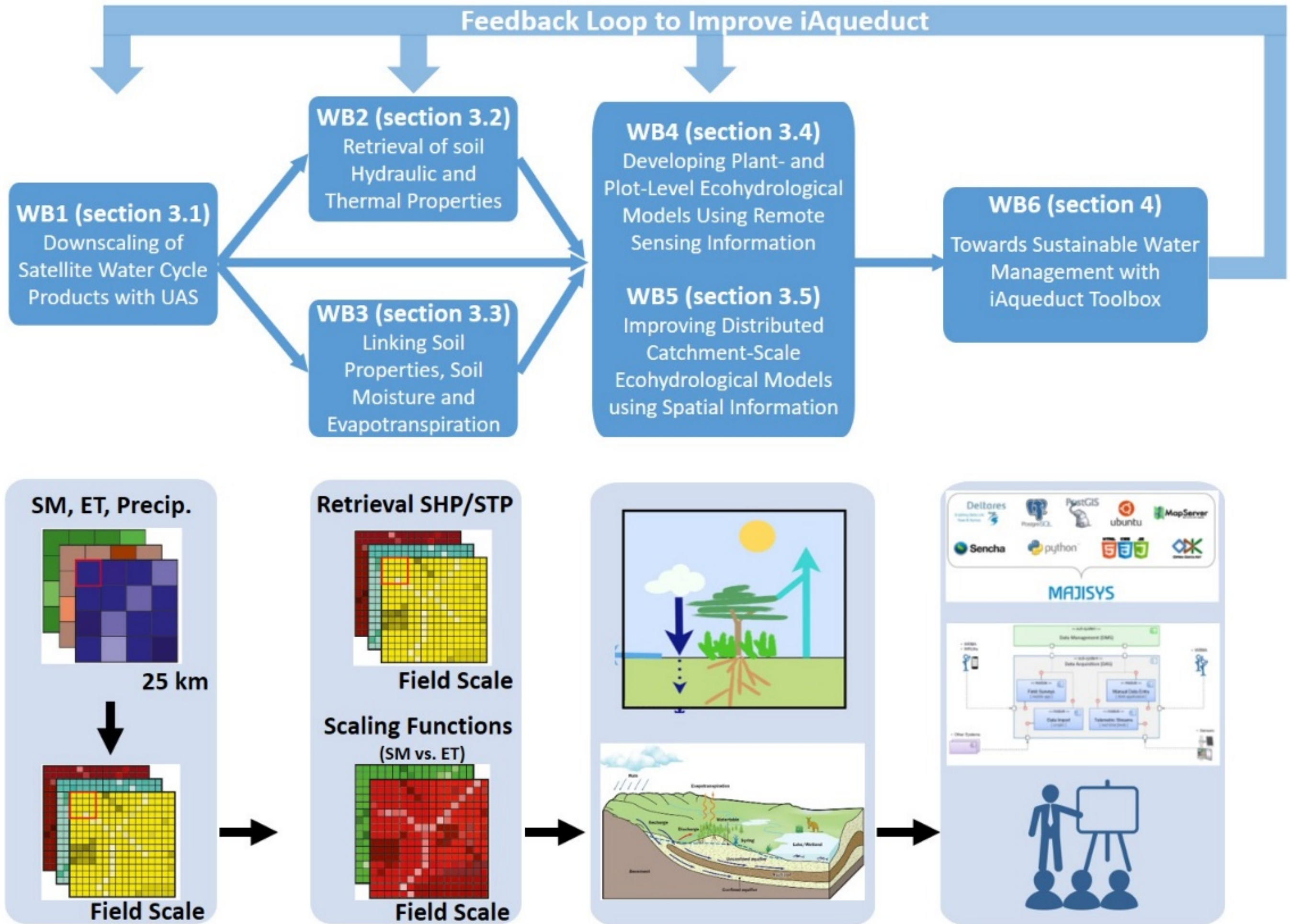
iAqueduct will integrate the various components ***from the global water cycle observation to local soil and water states*** in an open-source water information system and test and demonstrate their utility on pan-European scale at a set of carefully selected research sites for sustainable management of water resources.

CONSORTIUM DESCRIPTION

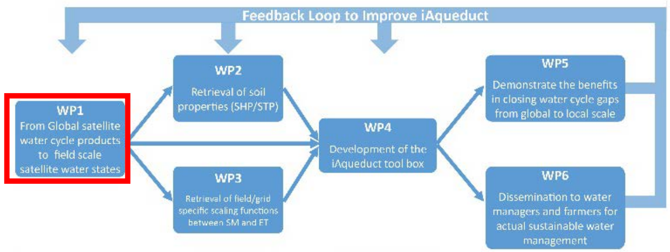
WP DESCRIPTION

Site1. Twente. NL
Temperate, Hot Summer
Site2. Zala, HU
Cold, Humid, Warm Summer
Site3. Alento, IT
Temperate, Dry Hot Summer
Site4. Corleto, IT
Temperate, Dry Warm Summer
Site5. Barranco del Carraixet, ES
Arid, Steppe, Cold
Site6. K.S. Yoav & Afeka, IL
Arid, Dry Hot Summer





(Su et al. 2020, Water, under review)



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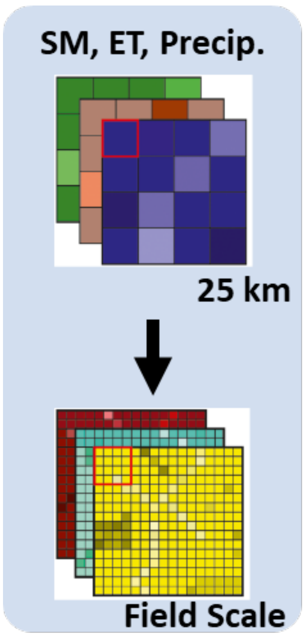
WP1 From Global satellite water cycle products to field scale satellite water states



Task 1.1 Spatial downscaling procedures and data products

1) Bayesian statistical bias correction of satellite data based on in-situ observation;
2) Development of downscaling methods by the use of Copernicus Sentinel1-2-3 data (concerning evapotranspiration and soil moisture);
3) Generation of high resolution water cycle products of soil moisture, vegetation patterns and vegetation stress, using UASs;
4) Characterization of the spatio-temporal distribution of soil moisture and evapotranspiration processes (UAS results vs. in-situ measurement);
5) Downscaling of the remote sensing data up to the field scale.

Task 1.2 Derive profile soil water content from surface soil moisture information

1) Prediction of root-zone SWC with the SMAR-EnKF, from Satellite and UASs;
2) The STEMMUS model to analyze the sensitivities of the predicted root-zone SWC.

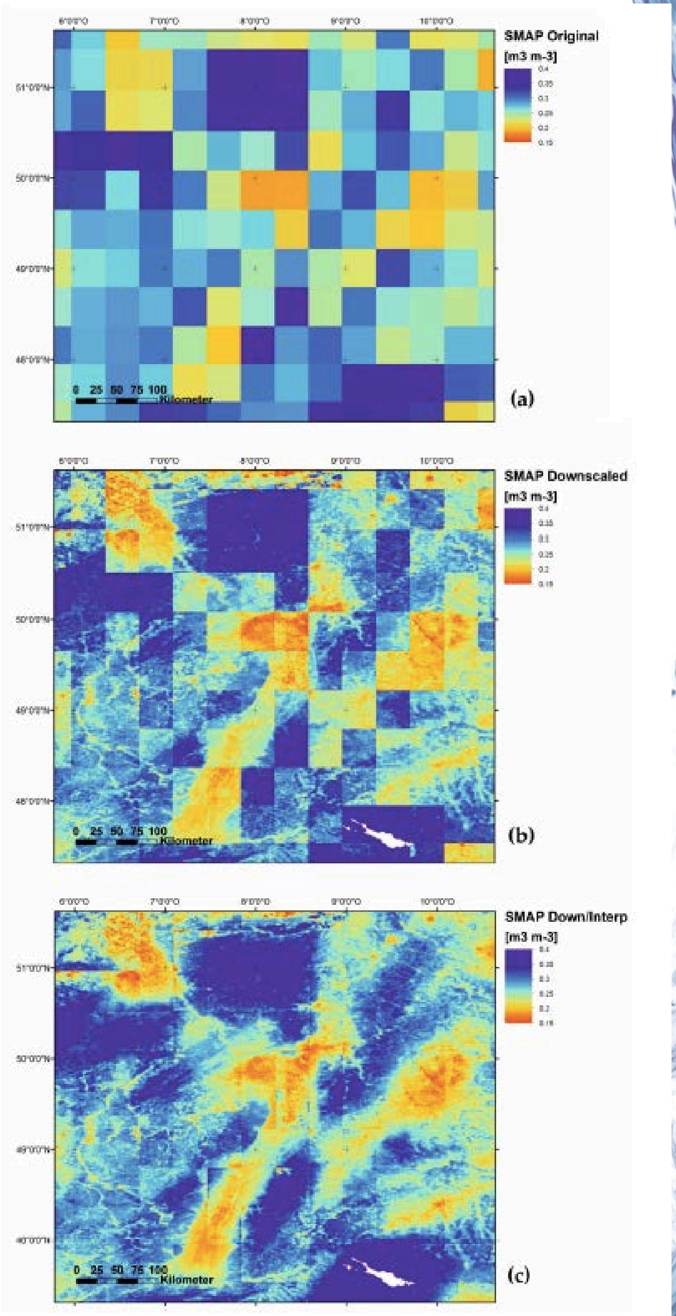
Example 1: Sub-Grid Soil Moisture Variability Data for Downscaling

Earth observation data with a proven relationship to soil moisture variability such as surface temperature, vegetation, a combination of both, radar backscatter, or even soil texture.

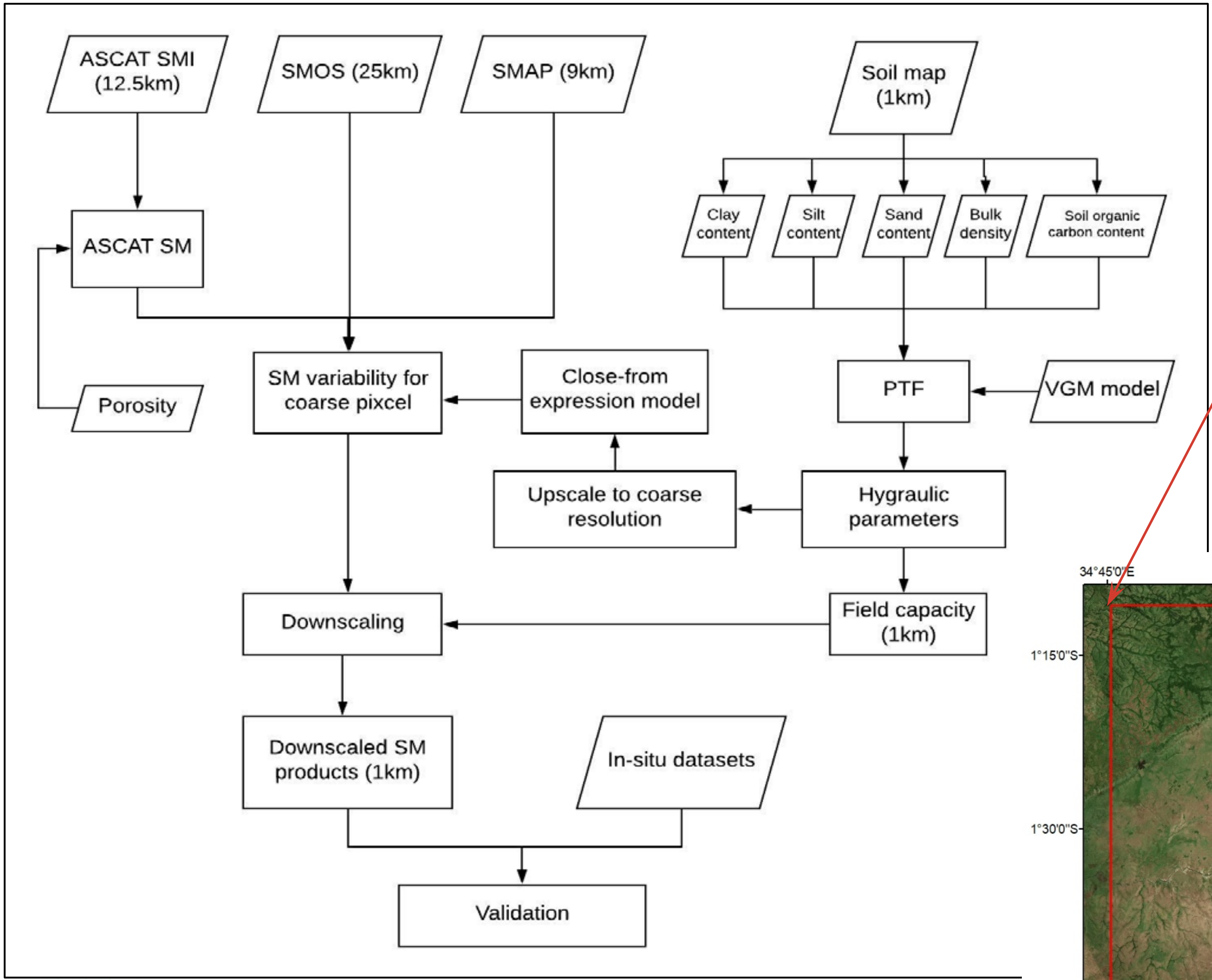
$$\widehat{\theta_{i,j}} = \overline{\theta} + \sigma_\theta\left(\overline{\theta}\right)\frac{P_{i,j} - \overline{P}}{\sigma_P}$$

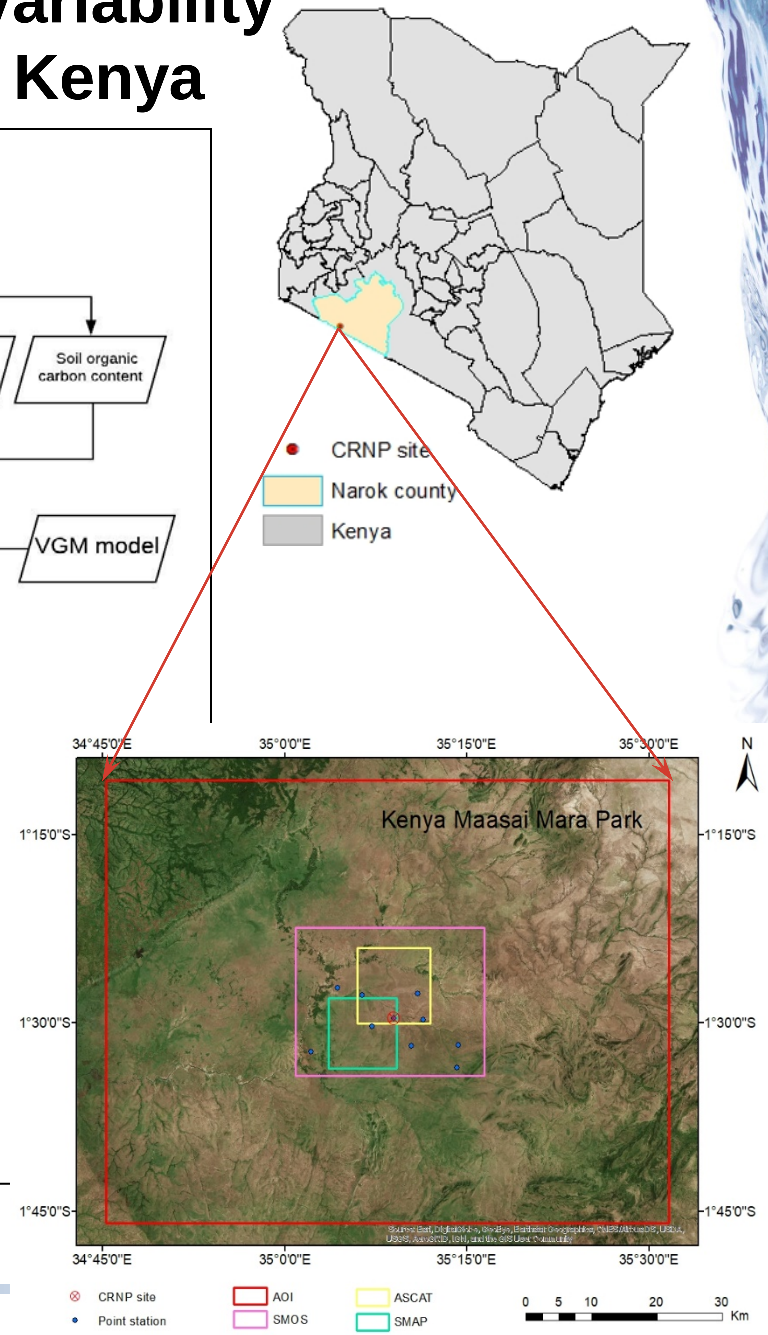
where $P_{i,j}$ is the proxy data at fine scale sub-grid y-location i and x-location j, P is the mean of the proxy, and σ_P is the standard deviation of the proxy

Based on Qu et al. Predicting subgrid variability of soil water content from basic soil information. Geophys. Res. Lett. 2015, 42, 789–796. [CrossRef]

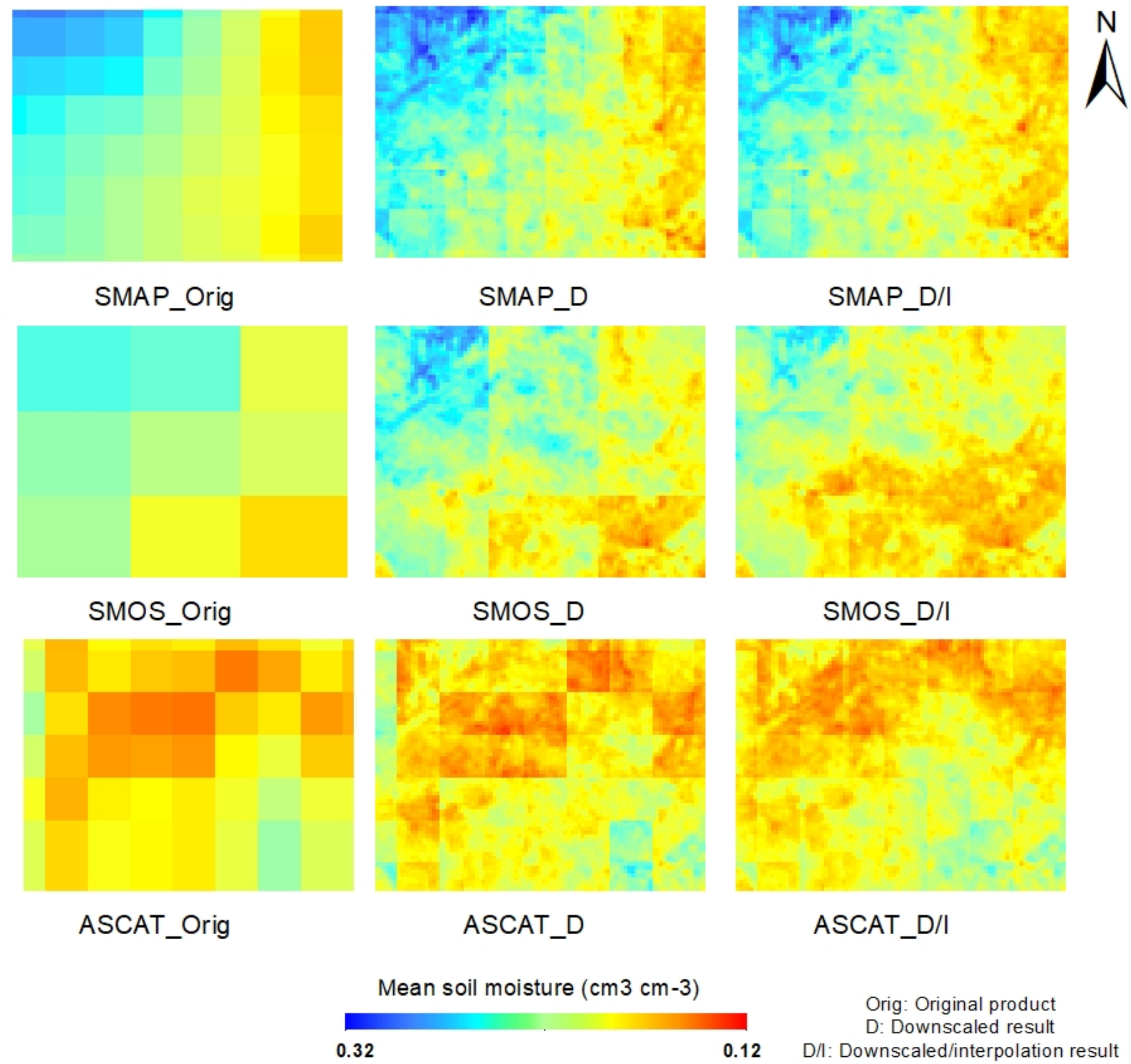


Example 1: Sub-Grid Soil Moisture Variability Data for Downscaling, Maasai Mara, Kenya





Example 1: Sub-Grid Soil Moisture Variability Data for Downscaling, Maasai Mara, Kenya

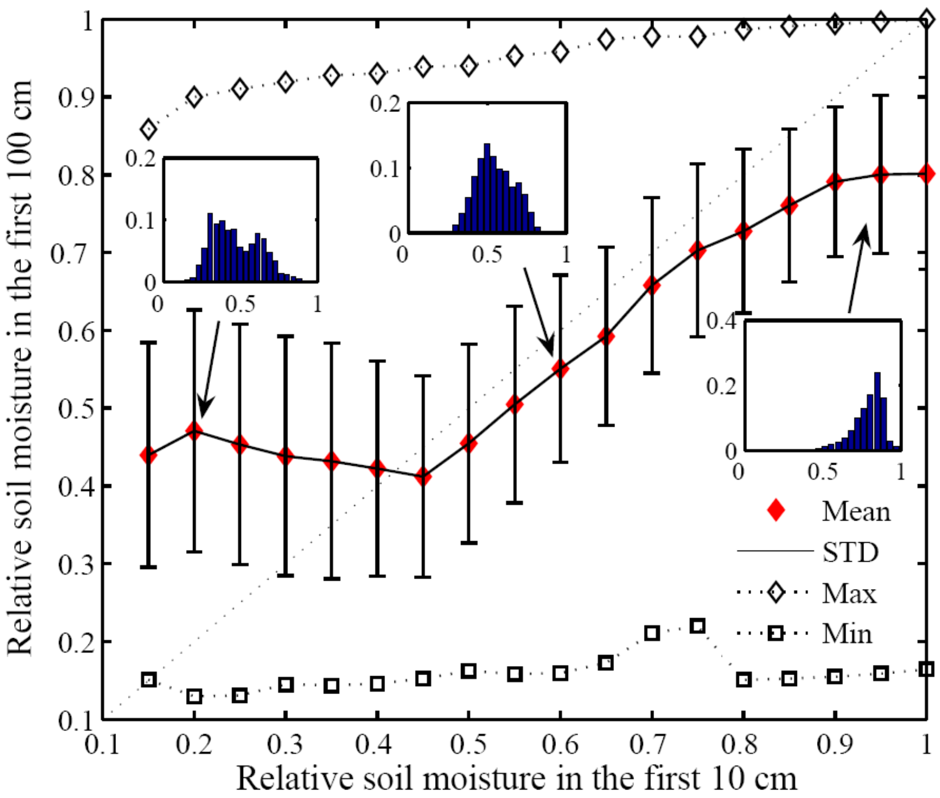


(Liu, et al. 2019, ITC, University of Twente)

Characteristics of relative soil moisture in deep and shallow layers

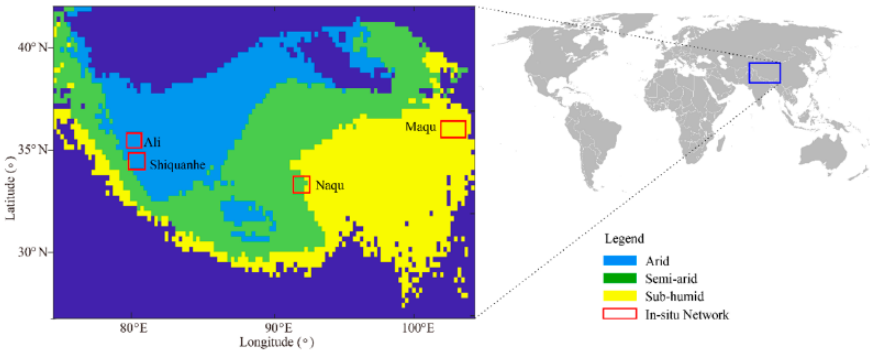
- Developing a relationship between the relative soil moisture at the surface to that in deeper layers of soil would be very useful for remote sensing applications.

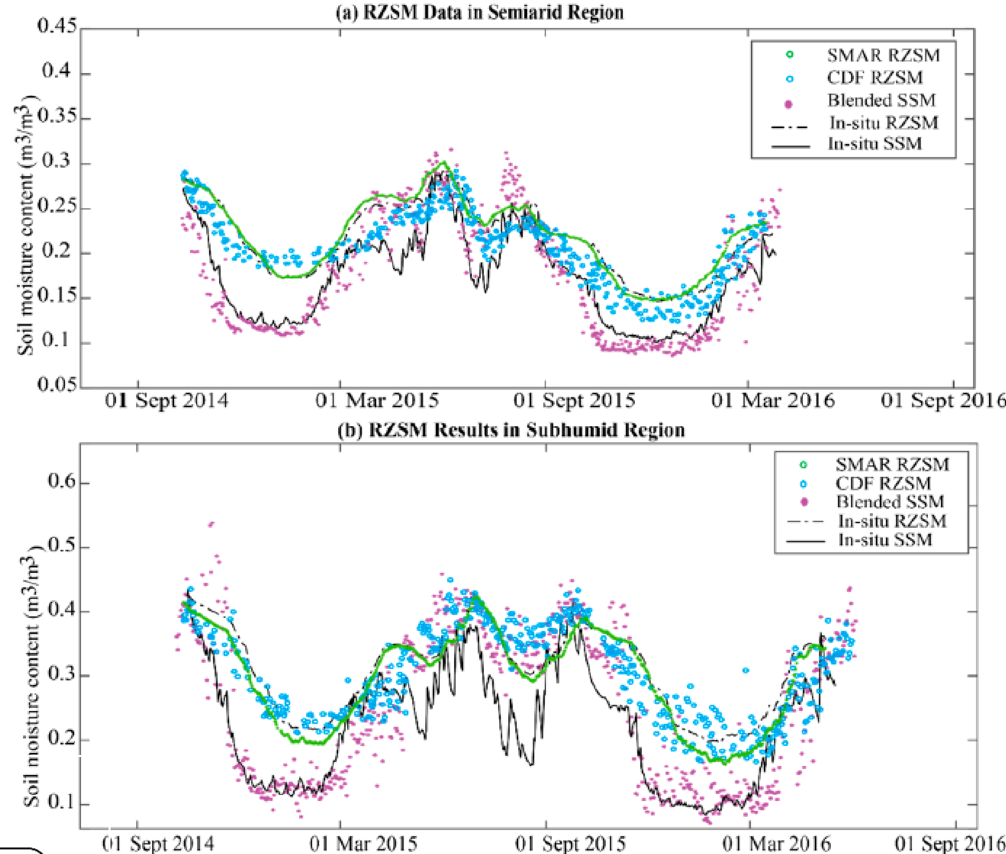
- This implies that prediction of soil moisture in the deep layer given the superficial soil moisture, has an uncertainty that increases with a reduced near surface estimate.

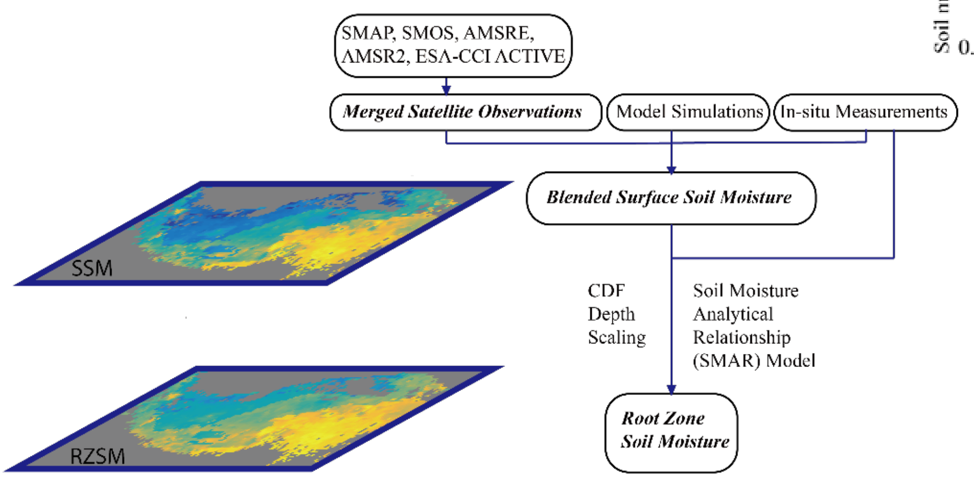


Manfreda et al. (AWR – 2007)

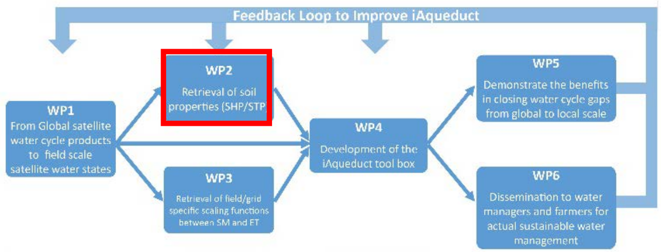
Example 3: RZSM over Tibetan Plateau







(Zhuang et al. 2020, Remote Sensing)



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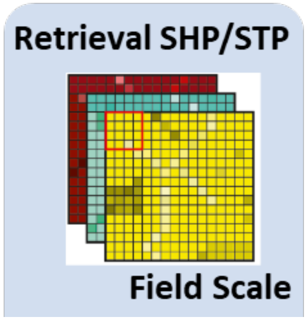
WP2
Retrieval of soil properties (SHP/STP)

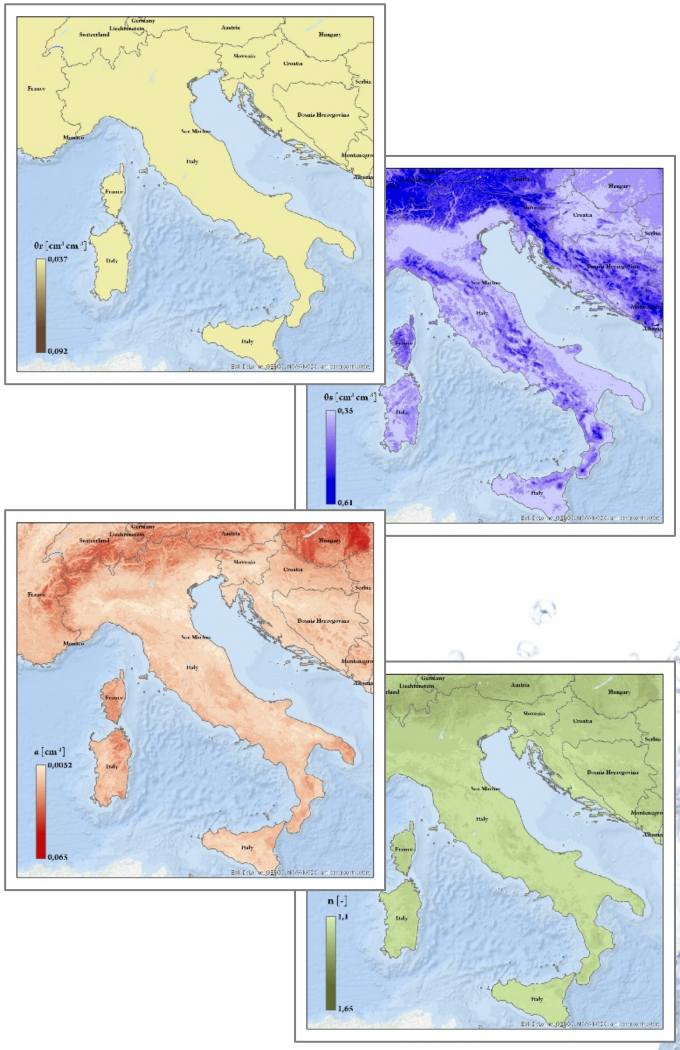
- **Task 2.1 Collection of field scale data**
- **Task 2.2 Soil spectroscopy and hyperspectral remote sensing**
- **Task 2.3 Basic PTF functions**
- **Task 2.4 Advanced PTF functions**



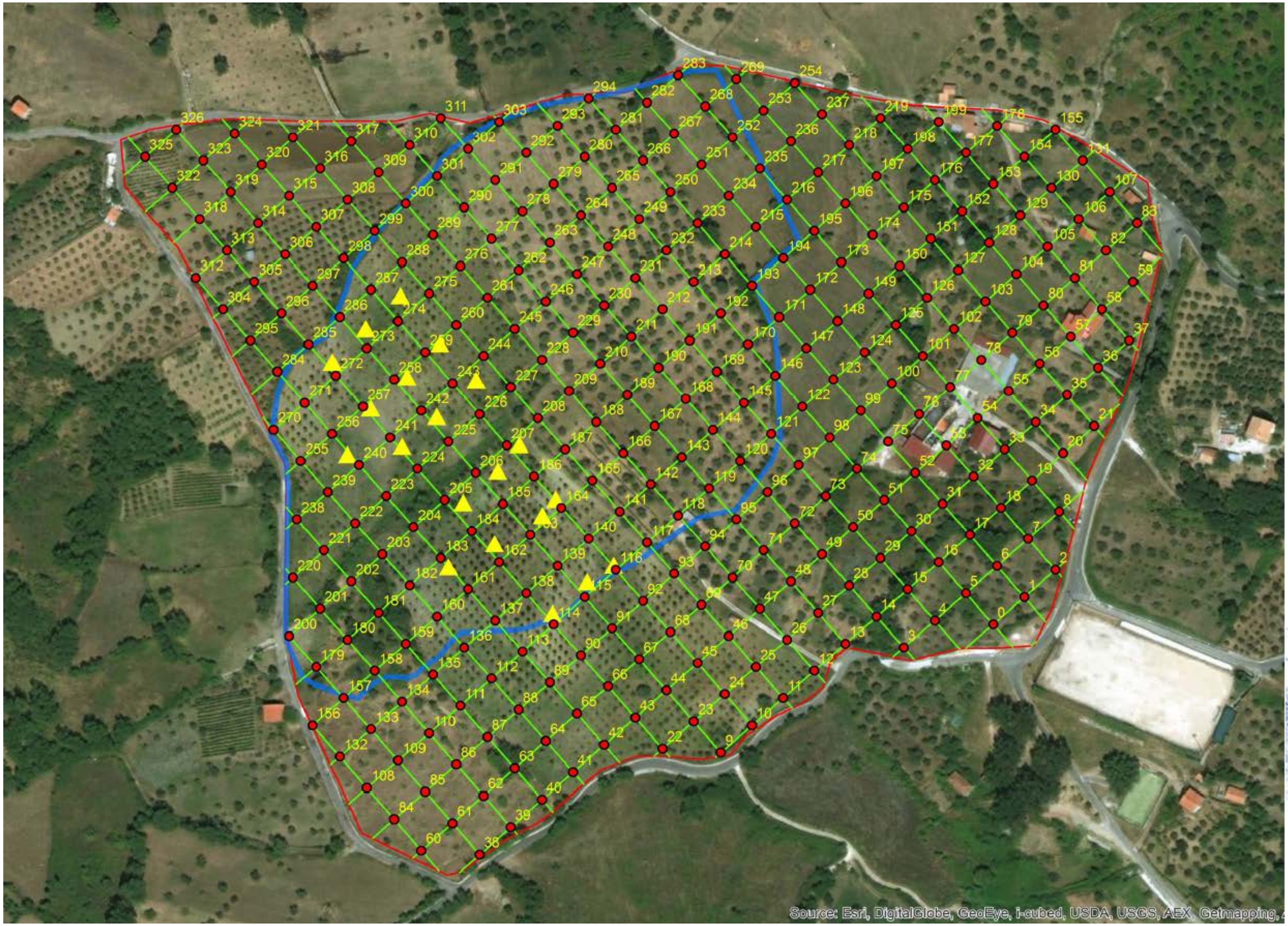
STF - spectrotransfer functions
SPTF - spectral pedotransfer functions
PTF - Pedotransfer functions
EU-STF - LUCAS
EU-PTF - EU-HYDI

a) 3D Soil Hydraulic Database of Europe at 250 m resolution

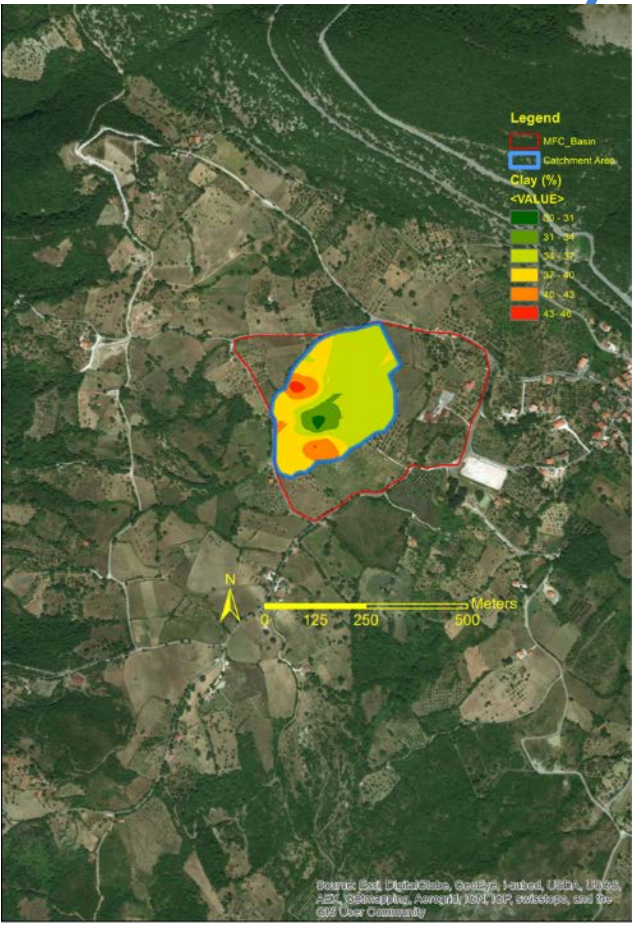
	EU-SoilHydroGrids
Predicted soil hydraulic property	THS, FC, WP, KS, MRC (VG), MRC + HCC (MVG)
Horizontal coverage	Europe
Vertical coverage	0, 5, 15, 30, 60, 100, 200 cm
Resolution	250 m, 30 arcseconds (~ 1 km at the Equator)
Projection	ETRS-LAEA
Format	GeoTIFF
Input soil information	SoilGrids 250 m and 1 km (Hengl et al., 2017)
Soil property considered for the calculations	clay, silt and sand content, organic carbon content, bulk density, pH in water, depth to bedrock
Pedotransfer functions (PTFs) used for the calculations	EU-PTFs: PTF6 (THS), PTF9 (FC), PTF12 (WP), PTF16 (KS), PTF22 (MRC), PTF 19 (MRC+HCC) (Tóth et al., 2015)
Database used to derive PTFs	EU-HYDI (Weynants et al., 2013)
Availability of the dataset	http://mta-taki.hu/en/eu_soilhydrogrids_3d https://esdac.jrc.ec.europa.eu/
Information about the dataset	Tóth et al. (2017)

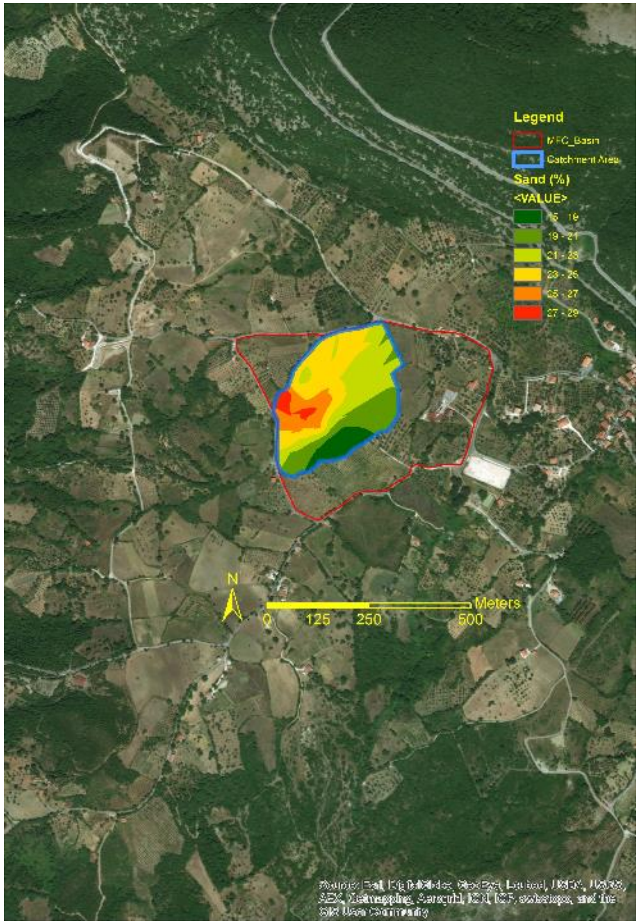


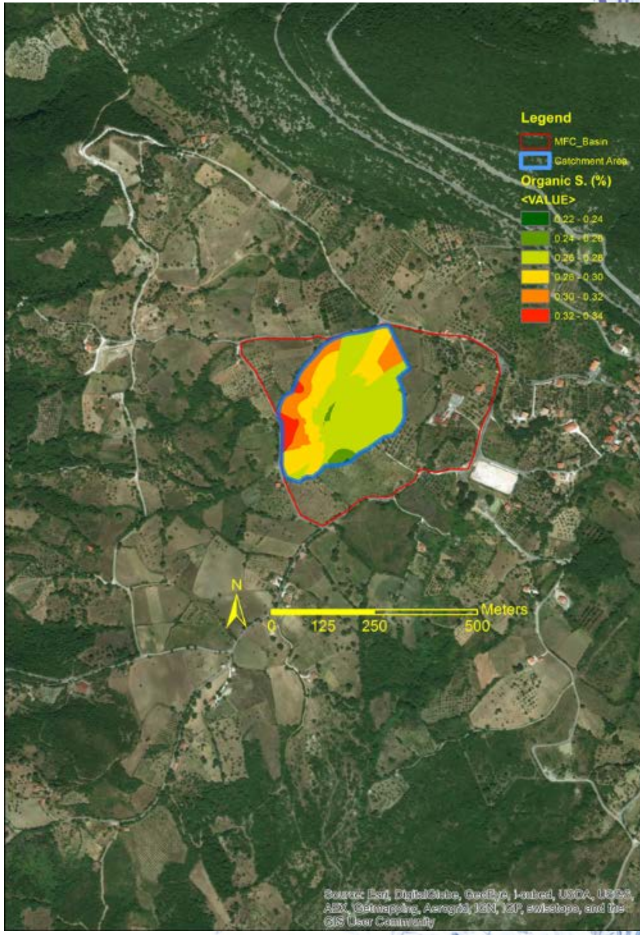
- To provide soil physico-chemical and hydraulic parameters for running models of different complexity. (Nunzio Romano, 2019)



Preliminary Results: Soil Texture







(Romano et al, 2019)

- *a) shows a Spectral Measurement through ASD spectrometer, and b) shows a measurement of Temperature using a FLIR camera* (Eyal et al, 2019)

www.waterjpi.eu

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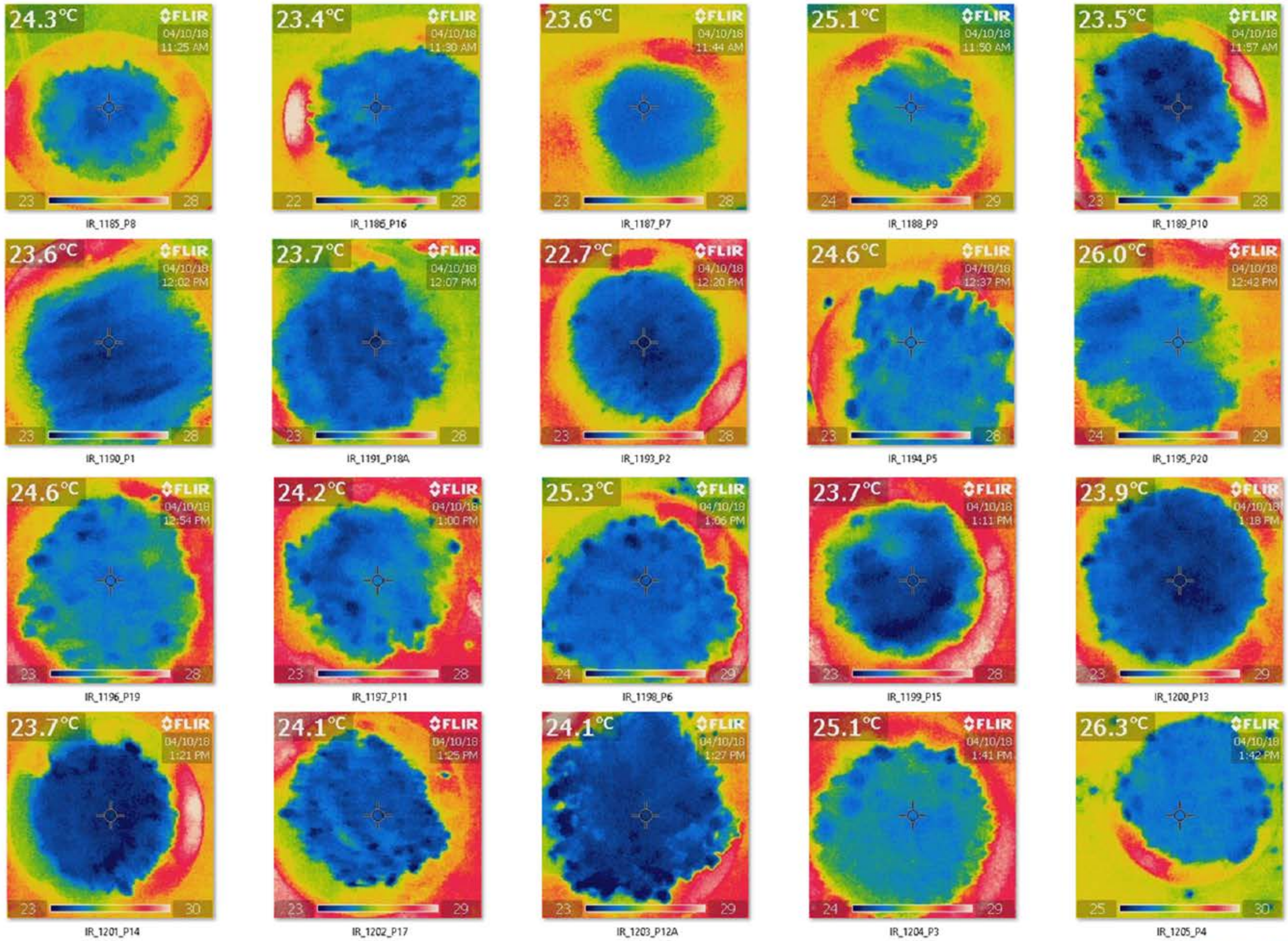

The thermal images and the temperature of the soil samples (Eyal et al, 2019)

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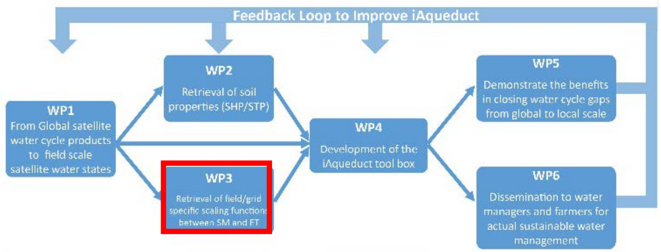

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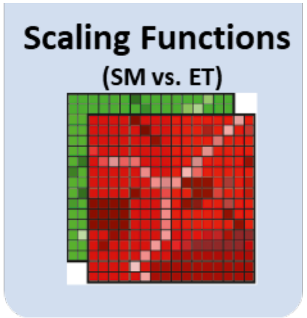
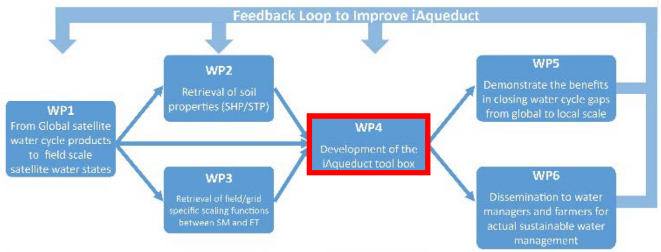
WP3
Retrieval of field/grid specific scaling functions between soil moisture and evapotranspiration

Task 3.1 Field/grid specific scaling functions between soil moisture and evapotranspiration

Task 3.2 Generalizing scaling functions between soil moisture and evapotranspiration





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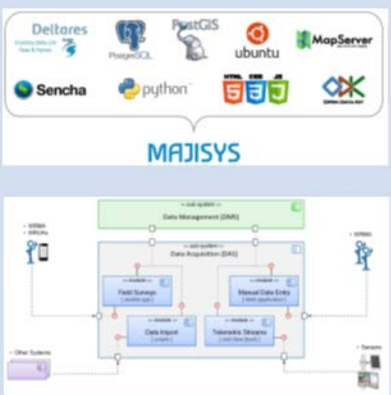
WP4 Development of the generic (iAqueduct tool box)



Task 4.1 Intercomparison of models, soil and vegetation parametrizations and soil parameters

1) A minimalist soil-vegetation-atmosphere model will be developed;
2) The coupling of the soil moisture dynamics and plant activities (ET and carbon fixation);
3) For crops, yield will be determined from the total accumulated crop biomass employing the harvest index, with biomass growth rate depending on the growing conditions;
4) machine leaning algorithms will be experimented to speed up the usually computational intensive process-based computations.

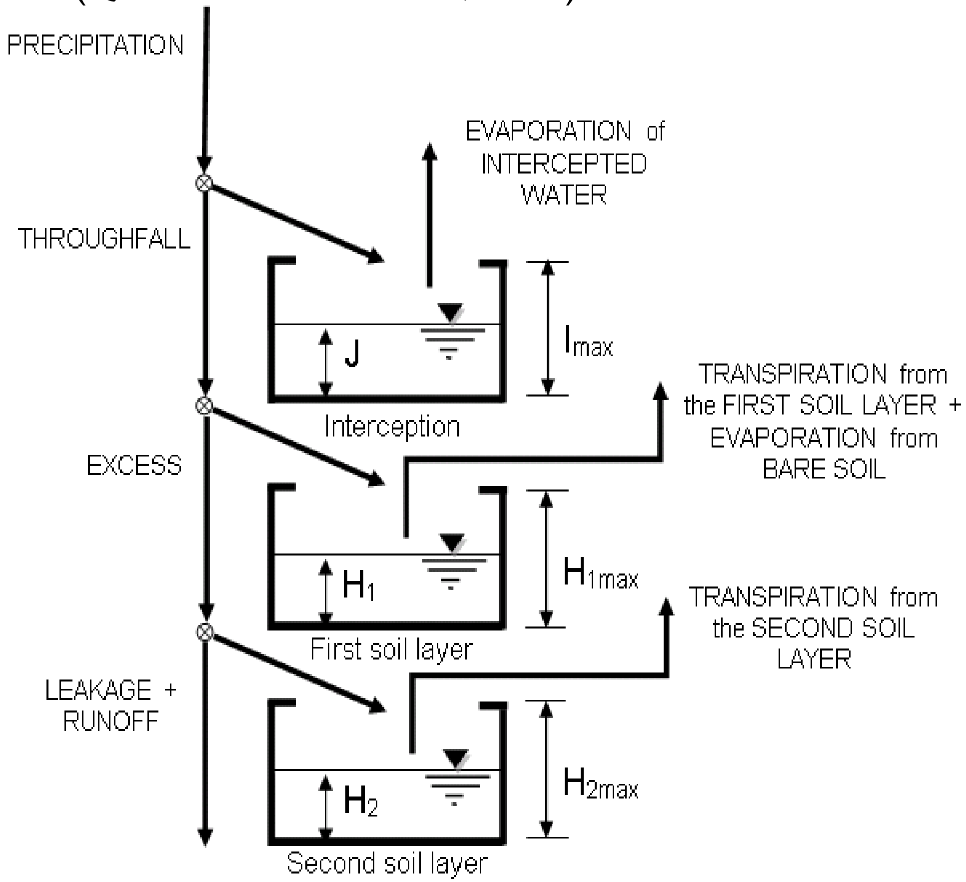
Task 4.2 iAqueduct toolbox

1) The existing open–source software system MajiSys water information system as the core ;
2) The iAqueduct toolbox which consists of water flow processes in relations to the models, soil and vegetation parametrizations and soil parameters as well as forcing fields.

What is the State-of-the-Art?

SPAC MODELS III – Minimalist approach

Hydrological sub-model
(Quevedo and Francés, 2012)



Dynamic Vegetation sub-model (Pasquato et al., 2014)

Based on the Light Use Efficiency

The ultimate goal is to explore the advantages and disadvantages of the different approaches to modelling soil-vegetation-atmosphere interactions when aiming at reducing the reliance on in-situ observations and at taking full advantage of UAS, airborne and satellite observations

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What is the State-of-the-Art?

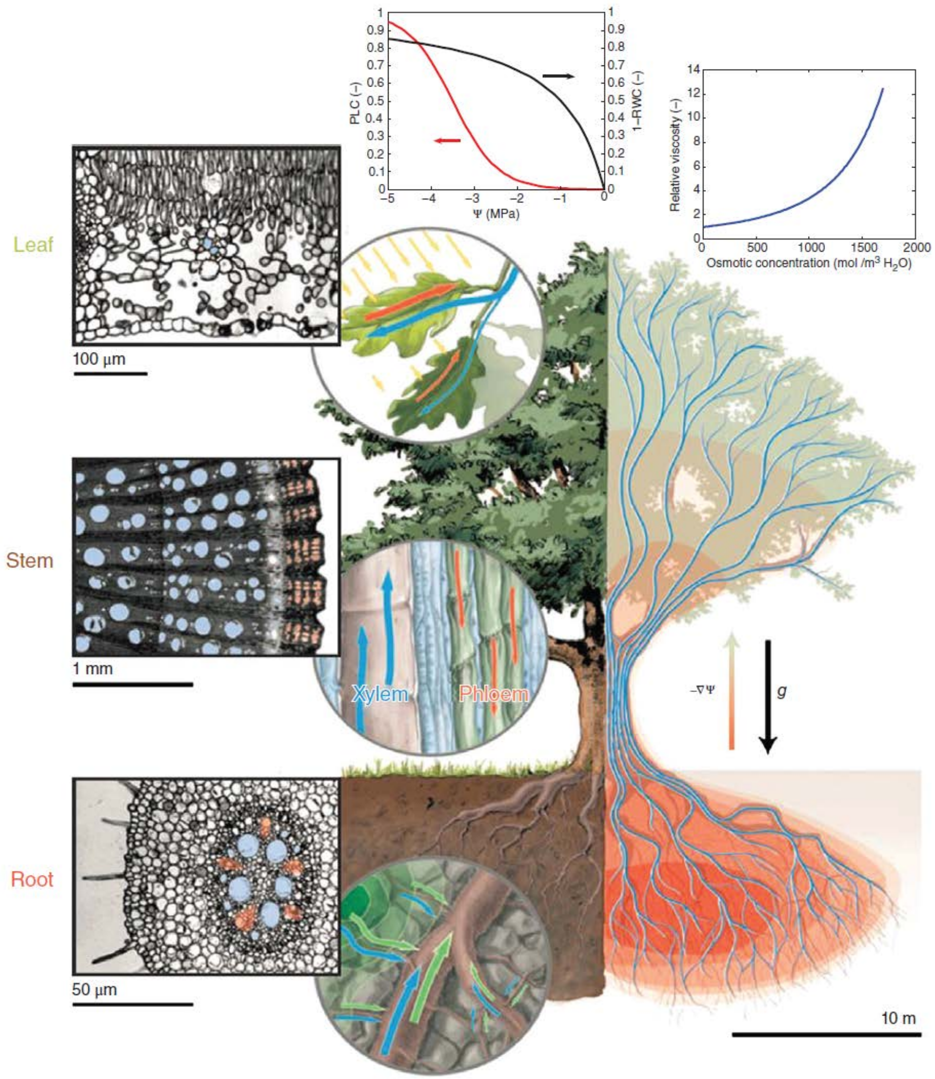
SPAC MODELS II – Leaf-to-plant, layered

Focus on water balances and fluxes

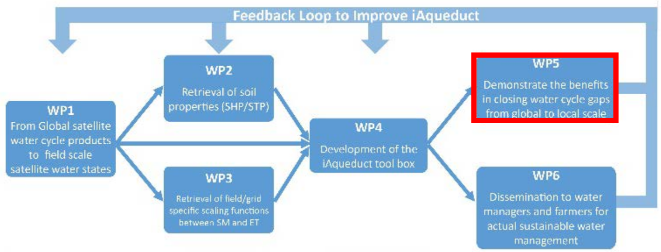
Energy in some (stomatal) models

Can be lumped (big leaf + soil bucket models) or resolved layers wise (two big leaves or canopy layers + soil layers)

(Manzoni, Vico, Porporato, Katul, 2013 AWR)



(Fatichi, et al. 2016)



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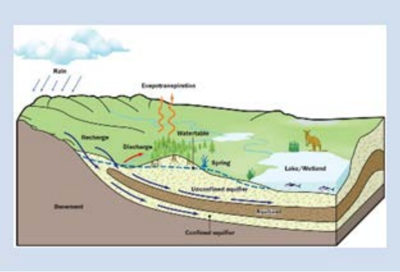
WP5 Demonstrate the benefits in closing water cycle gaps from global to local scale

- The aim of this WP is closing water cycle gaps by improving hydrological model implementations using spatial information;
- Discharge provides only limited insight on the spatial behavior of the catchment (Conradt et al., 2013 HESS);
- The development of distributed hydrological models and the availability of spatio-temporal data (WP1-3) appear as key alternative to overcome those limitations and can facilitate a spatial-pattern-oriented model calibration (Ruiz-Pérez et al., 2017 HESS);
- This WP will advance how to effectively handle spatio-temporal data when included in model calibration and how to evaluate the accuracy of the simulated spatial patterns;
- Numerical experiments will be conducted for calibration of a parsimonious distributed ecohydrological daily model in ungauged basins using exclusively spatio-temporal information obtained from WP1 and other remotely sensed information.



Introduction

- General research question for hydrological modelling: **is it profitable to use RS info for model calibration?**
  - NDVI at plot scale:

Hydrol. Earth Syst. Sci., 12, 1175–1187, 2008
www.hydrol-earth-syst-sci.net/12/1175/2008/

Hydrology and Earth System Sciences

A conceptual dynamic vegetation-soil model for arid and semiarid zones

D. I. Quevedo[1] and F. Francés[1]
[1]Institute for Water Engineering and Environment, Polytechnical University of Valencia, Spain

ECOHYDROLOGY
Ecohydrol. 8, 1024–1036 (2015)
Published online 6 October 2014 in Wiley Online Library
(wileyonlinelibrary.com) DOI: 10.1002/eco.1559

Comparing two approaches for parsimonious vegetation modelling in semiarid regions using satellite data

Marta Pasquato,[1]* Chiara Medici,[1,3] Andrew D. Friend[2] and Félix Francés[1]
[1] *Research Institute of Water and Environmental Engineering, Universitat Politècnica de València, Valencia, Spain*
[2] *Geography Department, University of Cambridge, Cambridge, UK*
[3] *Civil and Environmental Engineering, Princeton University, Princeton, NJ, USA*

  - NDVI at catchment scale:

Journal of Environmental Management 231 (2019) 653–665
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Journal of Environmental Management
journal homepage: www.elsevier.com/locate/jenvman
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Research article

Managing low productive forests at catchment scale: Considering water, biomass and fire risk to achieve economic feasibility

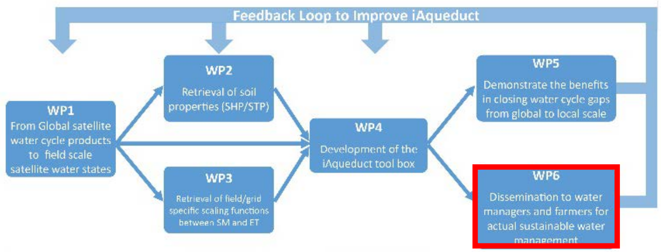
María González-Sanchis[a,*], Guiomar Ruiz-Pérez[b], Antonio D. Del Campo[a], Alberto Garcia-Prats[a], Félix Francés[c], Cristina Lull[a]

https://doi.org/10.5194/hess-21-6235-2017

Earth System Sciences
EGU

Calibration of a parsimonious distributed ecohydrological daily model in a data-scarce basin by exclusively using the spatio-temporal variation of NDVI

Guiomar Ruiz-Pérez[1,6], Julian Koch[2,3], Salvatore Manfreda[4], Kelly Caylor[5], and Félix Francés[6]



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WP6
Disseminate generated knowledge and tools for actual sustainable water management

- The aim of WP6 is to disseminate and communicate the generated knowledge and tools to water managers, companies and farmers for actual sustainable water management.
- In order to be effective, stakeholders will be engaged in the entire project for the effective transfer of the project achievements and will be consulted for the actual needs for real life water management.
- We will use the 2018 summer European drought as a concrete retrospective application to demonstrate the advantage of using detailed water cycle information for water management.

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Deltares
Enabling Delta Life
Fews & Hymos

PostgreSQL

PostGIS

ubuntu

MapServer

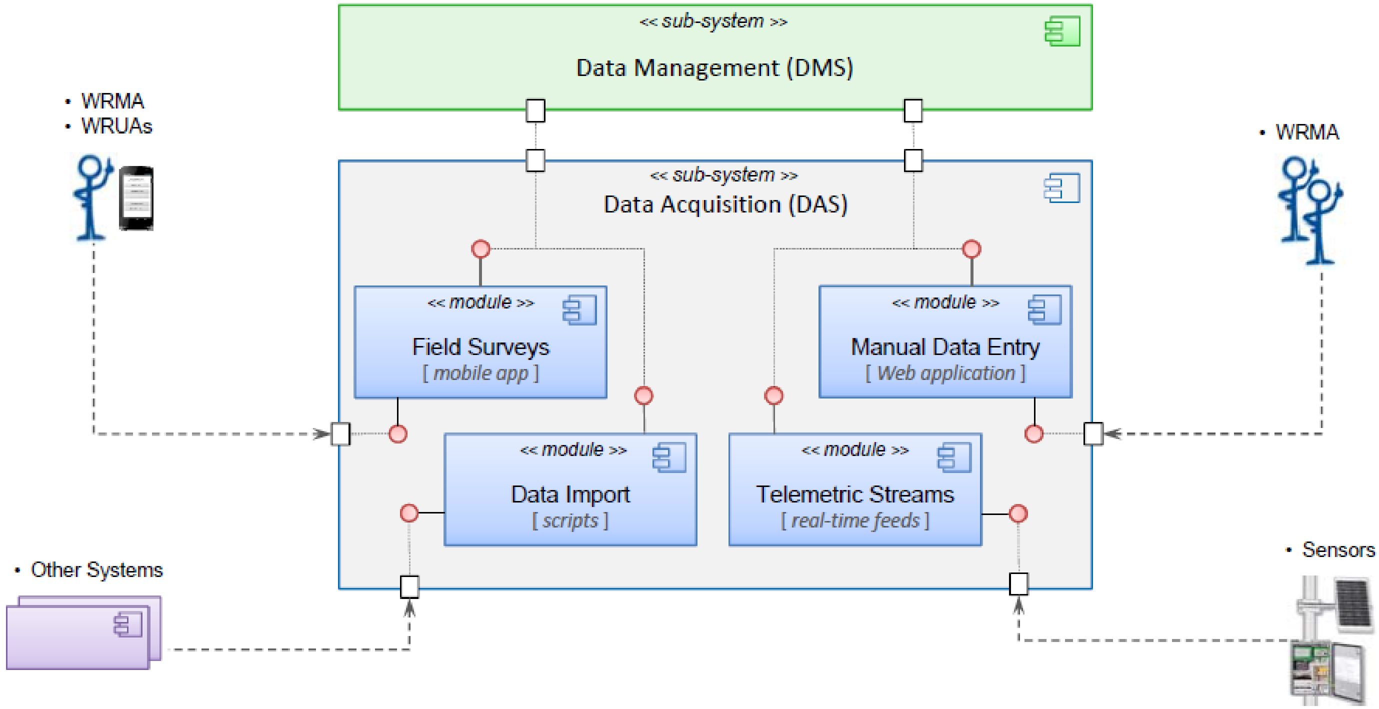
Sencha

python

HTML CSS JS

OPEN DATA KIT

MAJISYS

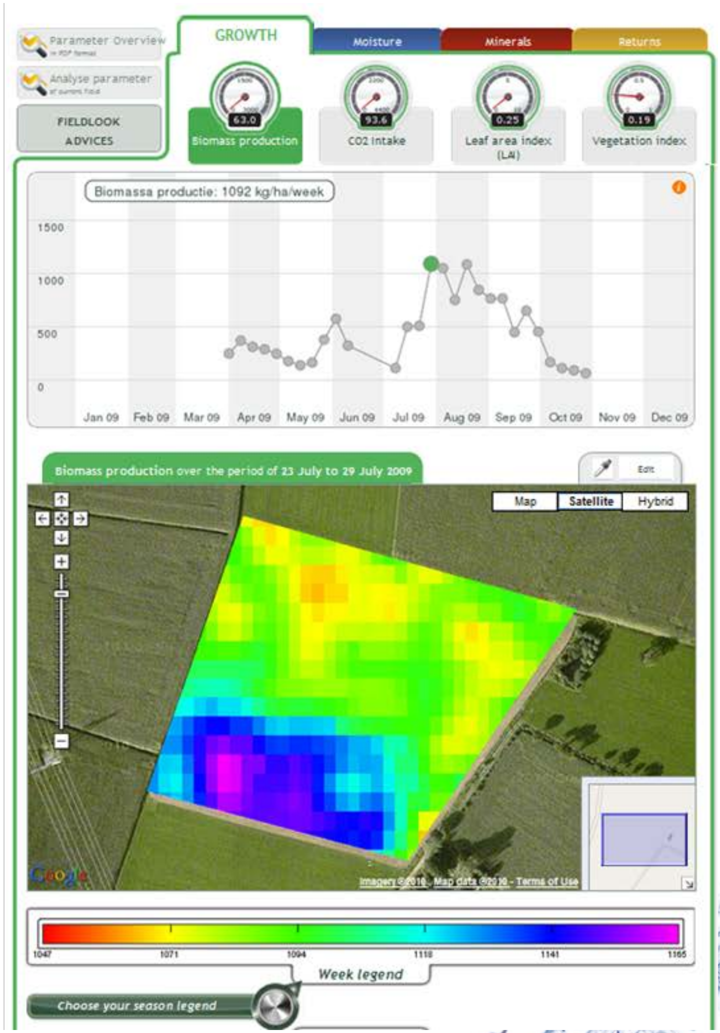


Growth

- biomass production (kg/ha)
- CO_2 intake (kg/ha)
- leaf area index LAI (m2 leaf/m2 ground)
- vegetation index NDVI

Moisture

- evaporation shortage (mm/week)
- current evaporation (mm/week)
- surplus rain (mm/2 weeks)
- reference evaporation



Thanks for your attentions!

https://www.costharmonious.eu/iaqueduct-water-jpi/

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