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Use of Mohid-Land to model water balance for implementation of deficit irrigation in vineyards

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3 deimos elecnor group

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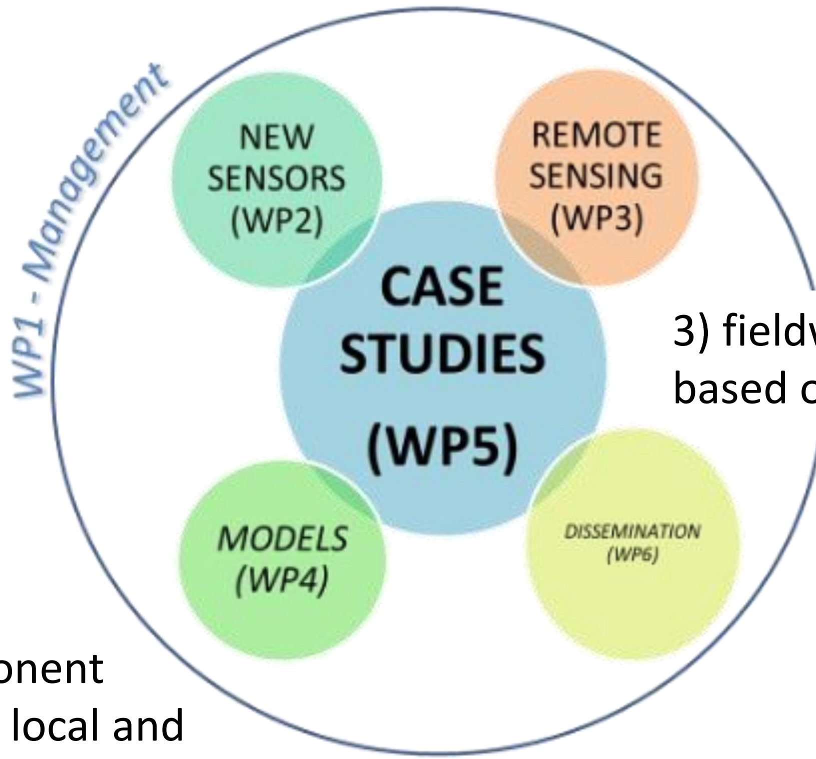
Water4Ever - Optimizing water use in Agriculture to preserve soil and water resources

The Water4ever project aims to increase irrigation water and fertilization efficiencies through precision irrigation. The project has 3 major components:

1) technological component devoted to the development of **new measuring technologies** based on **optical sensors**



2) **modelling** component addressing both the local and the catchment scales

3) fieldwork component based on **case studies**

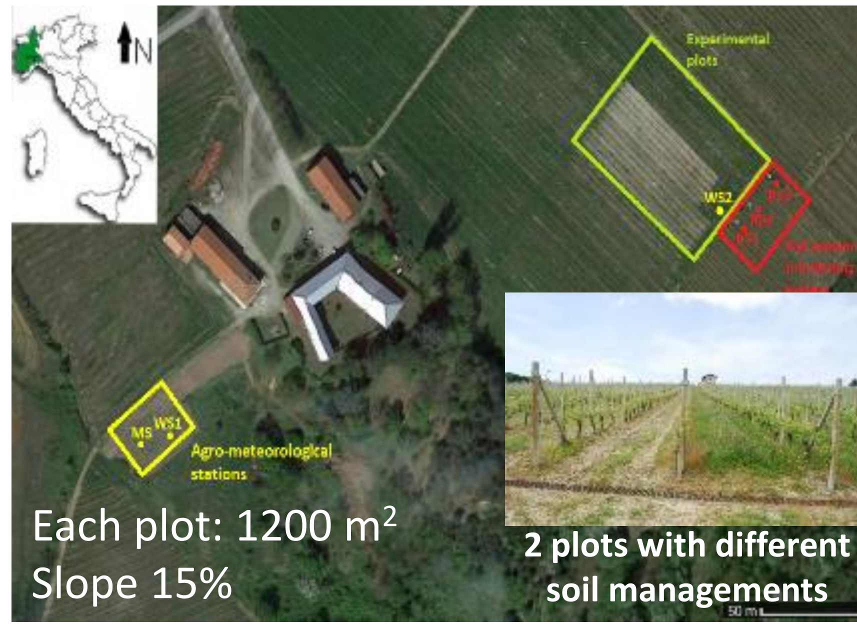
The project aims also to improve modelling at plot and catchment scale in order to quantify the effect of agriculture practices on water availability and quality.

The **case studies (CS)** are dedicated to **vineyards** and fruit trees where the **new sensor** and modelling tools will be combined with **field data obtained by conventional monitoring** and **remote sensing.**

CS Portugal – Irrigated vineyard - Vinha do Nilo (Companhia da Lezirias)

Climate: Dry sub-humid **MAP**: 669 mm
Soil: Haplic Fluvisol
Precipitation: 527 (2017) – 370 (2018)
Irrigation: 358 (2017) – 242 (2018)

CS Italy – Rainfed vineyard – Tenuta Cannona



Climate: Mediterranean **MAP**: 852 mm
Soil: Dystric Cambisol
Precipitation: 778 (2016) – 493 (2017)

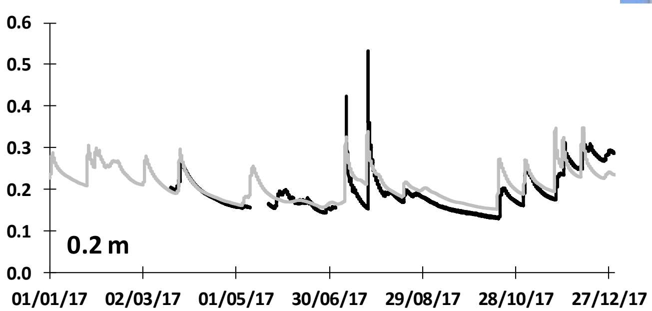
Vinha do Nilo: (a) Vegetative season – (b) Dormancy season

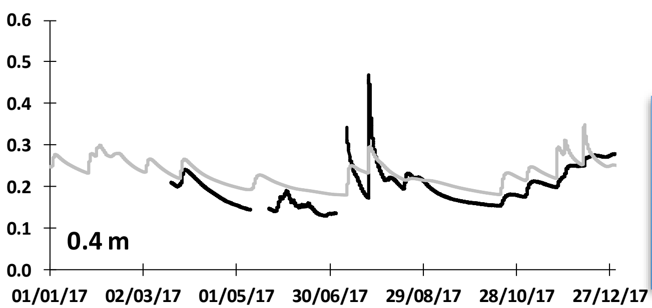
Tenuta Cannona: (c) Conventional tillage plot – (b) Grass cover plot(GC)

The **MOHID-Land model** has been **calibrated** and implemented at plot scale to obtain **water balance estimation** for the vineyards

Water inputs (**precipitation** and **irrigation**), **meteorological** variables and **soil water content** at different depths have been monitored in both plots during two years (2017-2018), using field sensors.

Vinha do Nilo
- Climate data
- Irrigation data
- SWC probes (-10, -20, -30,- 40, -50, -60, -70, and -80 cm).



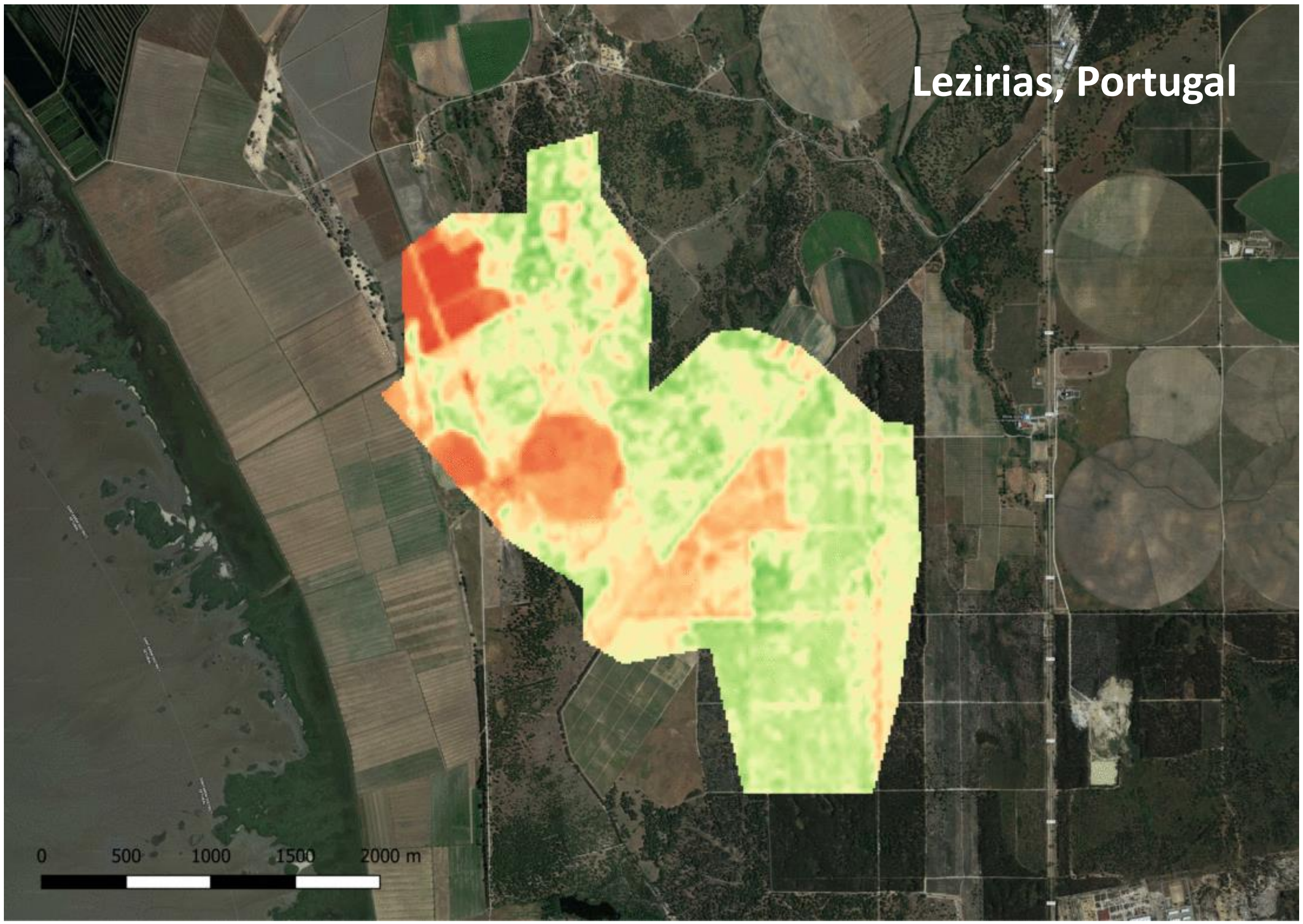


Tenuta Cannona
- Meteorological data
- SWC in the CT and GC plot in the inter-rows:
2 positions: T & NT
4 depth (-10 cm; -20 cm; -30 cm; -40 cm)
- Runoff monitoring

Irrigation was monitored with a flow meter installed on the irrigation pipe.

The **vegetative development** of the vineyards has been estimated from remote imagery provided by Deimos using their service4EO platform.

LAI maps (30m) were obtained from Landsat 8 satellite images



$$LAI = -\frac{1}{a_2}\ln\left(\frac{a_0 - SAVI}{a_1}\right)$$

where

$$SAVI = \frac{(\rho_{850} - \rho_{650}) * 1.5}{\rho_{850} + \rho_{650} + 0.5}$$

is the "Soil Adjusted Vegetation Index"

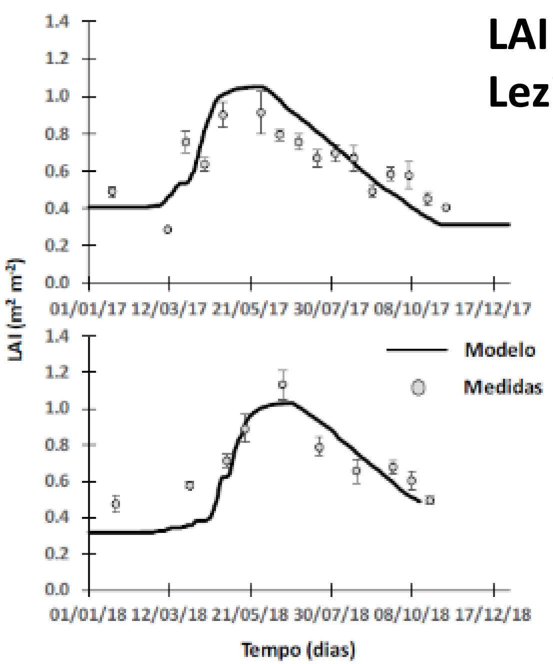
MOHID-Land is a physically-based, spatially distributed, continuous, variable time step model: water flows in porous media are calculated using a finite volume method by means of Richards equation.

In the MOHID-Land model, the partition of the cultural evapotranspiration (ETc) in transpiration potential (Tp) and potential evaporation (Ep) is done in function of the LAI.

$$T_p = ET_c \left(1 - e^{(-\lambda LAI)}\right)$$

$$E_p = ET_c - T_p$$

The **field** and **remote datasets** were used to **calibrate** and **validate** the MOHID-Land model



LAI
Lezirias, Portugal

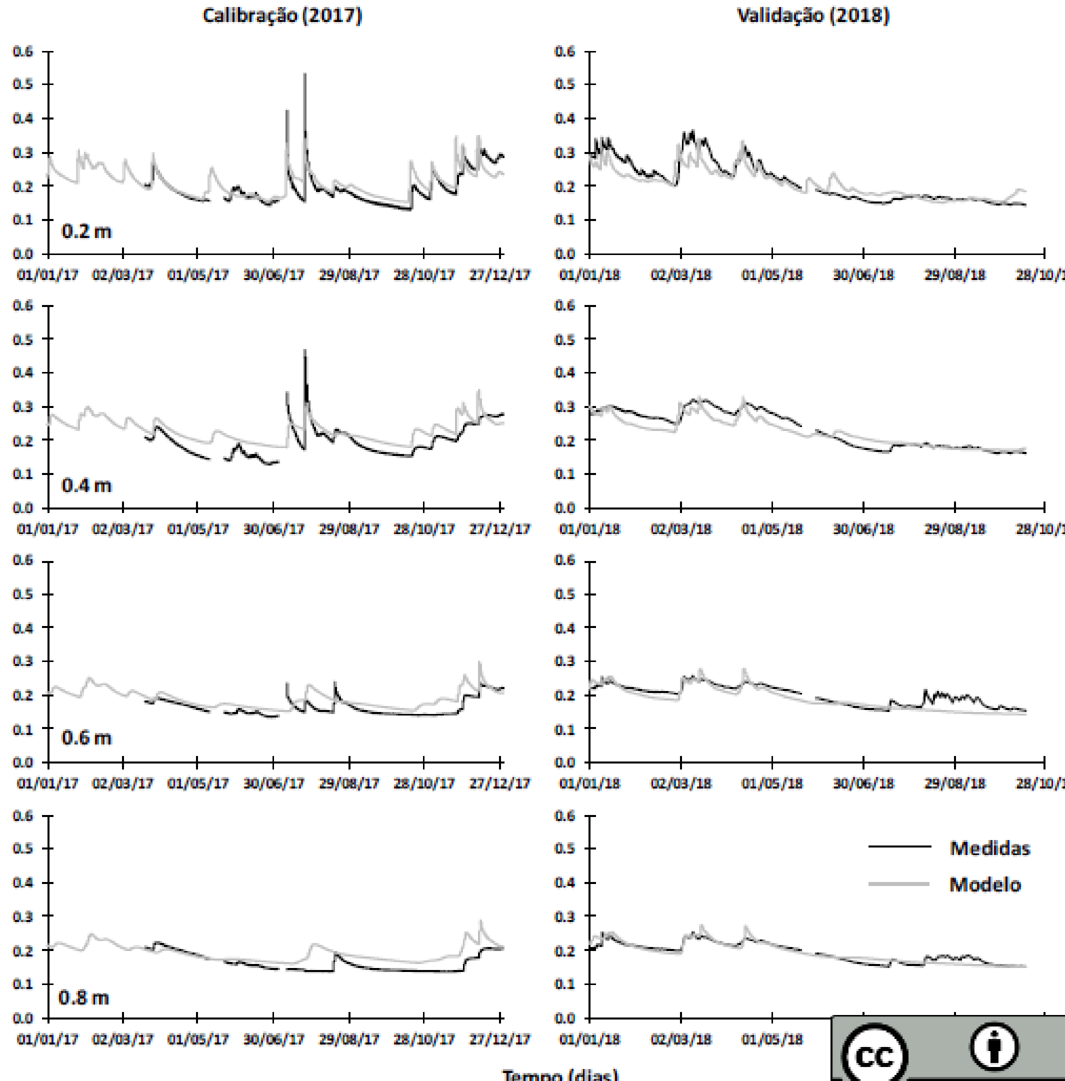
	LAI	
	2017 (cal)	2018 (val)
R^2	0.846	0.896
RMSE	0.139	0.125
NRMSE	0.206	0.210
PBIAS	-4.22	7.10
NSE	0.365	0.602

The **calibration process** involved adjusting hydraulic parameters of the soil and growth of the culture, in order to reduce the deviations between simulations and observed values of **LAI** and **soil water content**

Vinha do Nilo - Portugal

	Soil water content	
	2017 (cal)	**2018 (val)**
R^2	0.800	0.853
RMSE	0.033	0.029
NRMSE	0.016	0.012
PBIAS	-11.25	3.25
NSE	0.425	0.706

The model showed **satisfactory to good efficiency**



Vinha do Nilo - Portugal

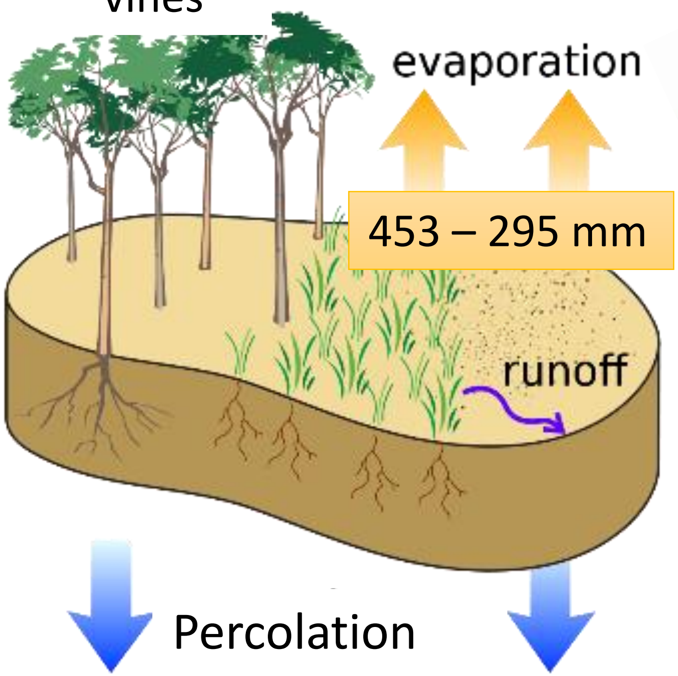
evapotranspiration =
transpiration + evaporation

transpiration

vines

166 - 112 mm

evaporation



453 – 295 mm

Percolation

287 - 330 mm

(credit: M.W. Toews, CC BY 4.0, modified)

Precipitation

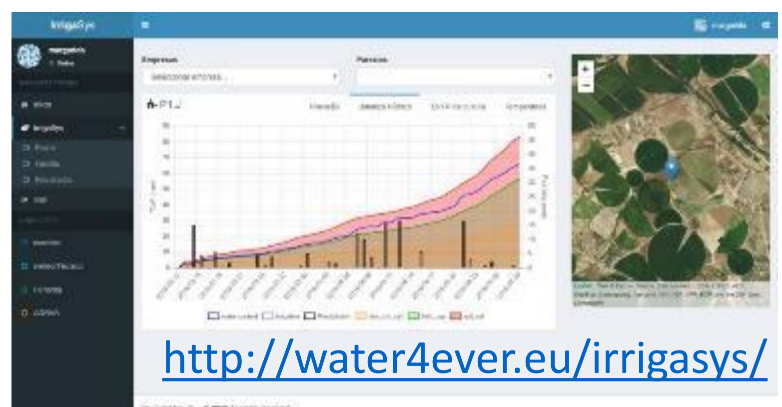
527 - 370 mm

Irrigation

358 – 242 mm

The applied irrigation induced water stress between 5 and 8%.

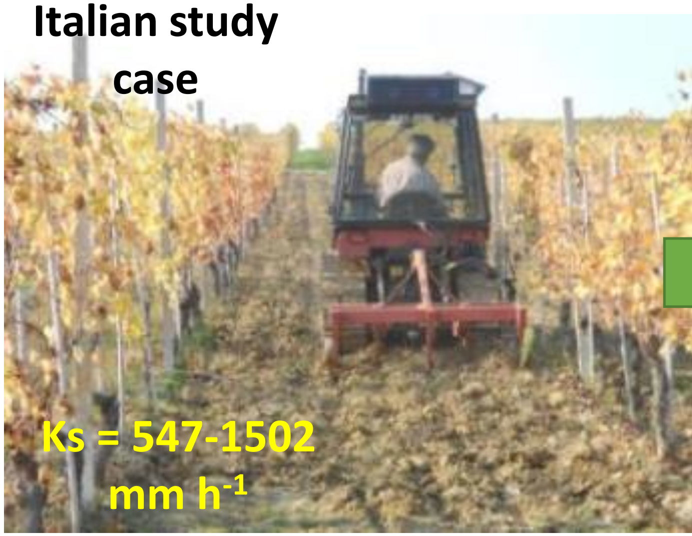
MOHID-Land model is used to compute the soil water dynamics in the IrrigaSYS Decision Support Irrigation System combining hydrological and meteorological modeling tools to improve irrigation water use.



http://water4ever.eu/irrigasys/

Italian study case

water4ever

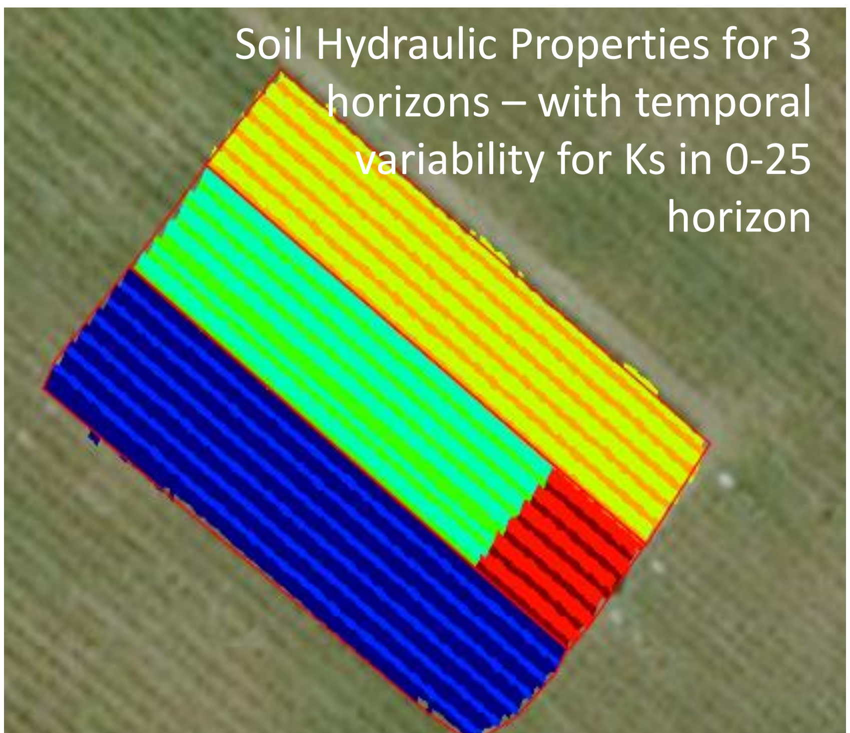


Just after tillage

After 1-3 tractor passages

Ks vary temporaly and according to soil management – influencing water infiltration

In the 2 plots with different management, field-surveys to obtain hydraulic properties with Ks seasonal values (surface) were conducted in **CT** and **GC**



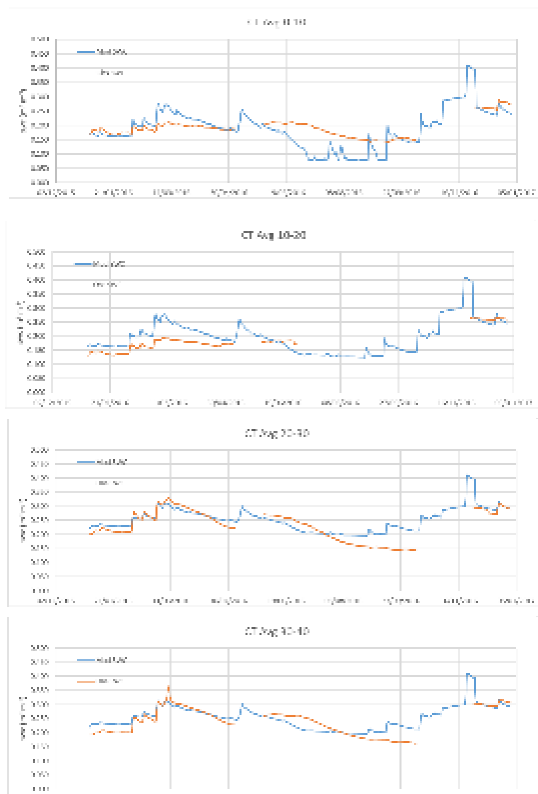
The Italian study case was also used to estimate the water balance in two growing seasons with warm conditions, in order to evaluate the different behaviour with respect to the adopted soil management and the needing to introduce irrigation in a region where vines are traditionally rainfed.

Tenuta Cannona - Italy

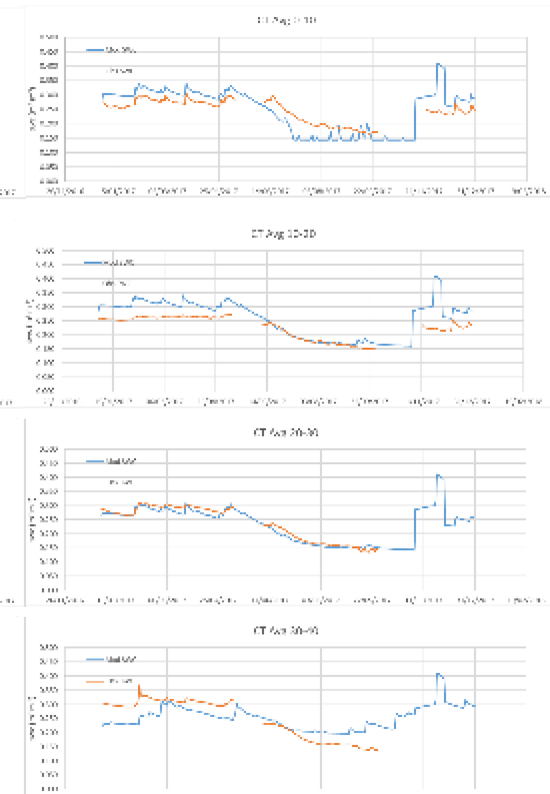
	Soil water content CT	
	2016 (cal)	**2017 (val)**
R^2	0.567	0.536
RMSE	0.037	0.025
PBIAS	2.199	1.108
NSE	0.443	0.787

Validations' results were **very good** for **CT**…

SWC CT 2016 (calibration)



SWC CT 2017 (validation)

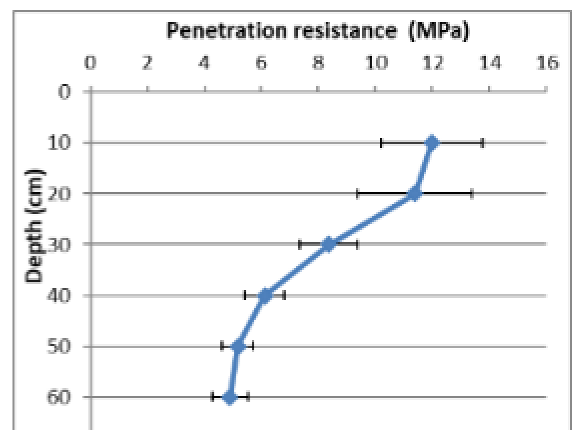


Tenuta Cannona - Italy

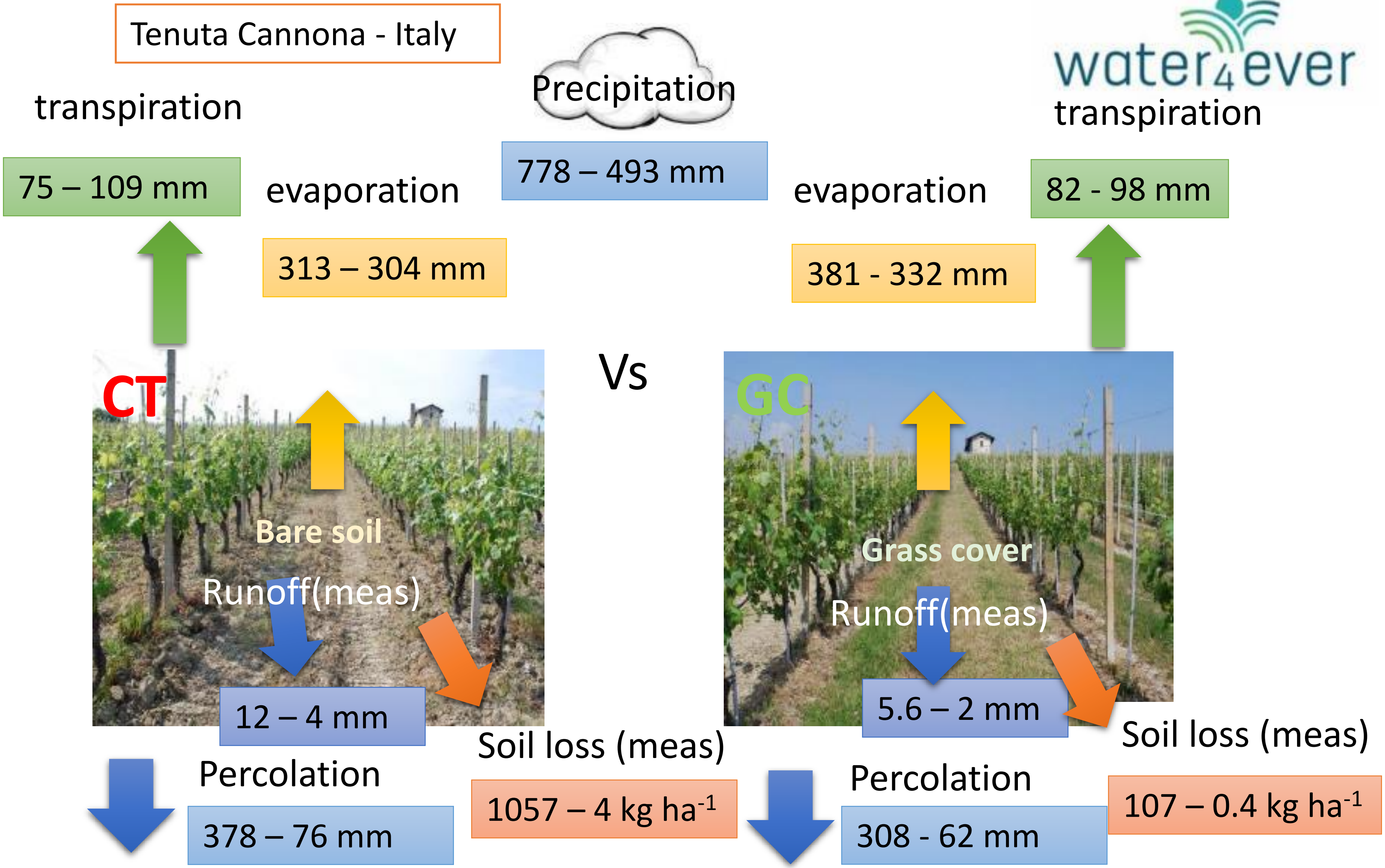
The performance was lower for **GC**

	Soil water content GC	
	2016 (cal)	**2017 (val)**
R^2	0.228	0.672
RMSE	0.029	0.048
PBIAS	-2.134	-8.745
NSE	0.971	-0.341

Preliminary results showed the needing of take into account , in modelling at field scale, the effects of inter-row's soil managements, because it directly affects water uptake, evapotraspiration and the seasonal variability of Ks due to soil compaction.



Evaluation of hydraulic conductivity and compaction along the soil profile



In 2017, a very dry season, the model calculated that water infiltration was 15% - 13% of precipitation in CT and GC, respectively.

Calibration of MOHID-Land model was performed using remote sensing data (LAI), and in-field monitoring (SWC and Ks)

The MOHID-Land model was able to reproduce successfully measured values of water content in the soil over two years in different study cases.

To obtain more accurate results in vineyards, it is necessary to consider the effects of the adopted inter-row's soil managements.

The performance of MOHIDLand in modelling soil water dynamics in a permanent culture like vines can be considered acceptable to support the IrrigaSys decision support system, using the Portuguese study case as reference for weekly irrigation recommendation in the region.

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