Integrating Sentinel-2 Imagery with AquaCrop for Dynamic Assessment of Tomato Water Requirements in Southern Italy

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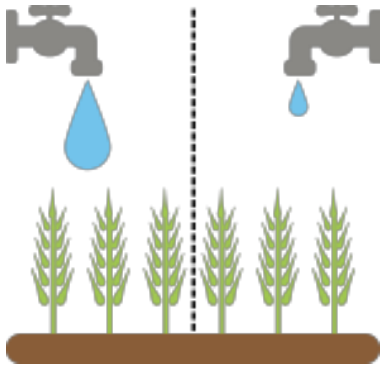
Water resource and water requirement

The rational management of water resources in agriculture is becoming more and more a crucial issue for the environmental and economic sustainability.



The availability of reliable, objective and timely information about the spatial and temporal variability of crop water requirements is essential to reduce water losses and to increase water productivity.

Significant progresses in saving irrigation volumes can be attained by assessing crop water requirements through an optimal combination of crop satellite images with a crop growth model.

Satellite provides information concerning the current state of the canopy.

Crop growth model is able to simulate the biophysical processes of the growing crop.

Aim of the study

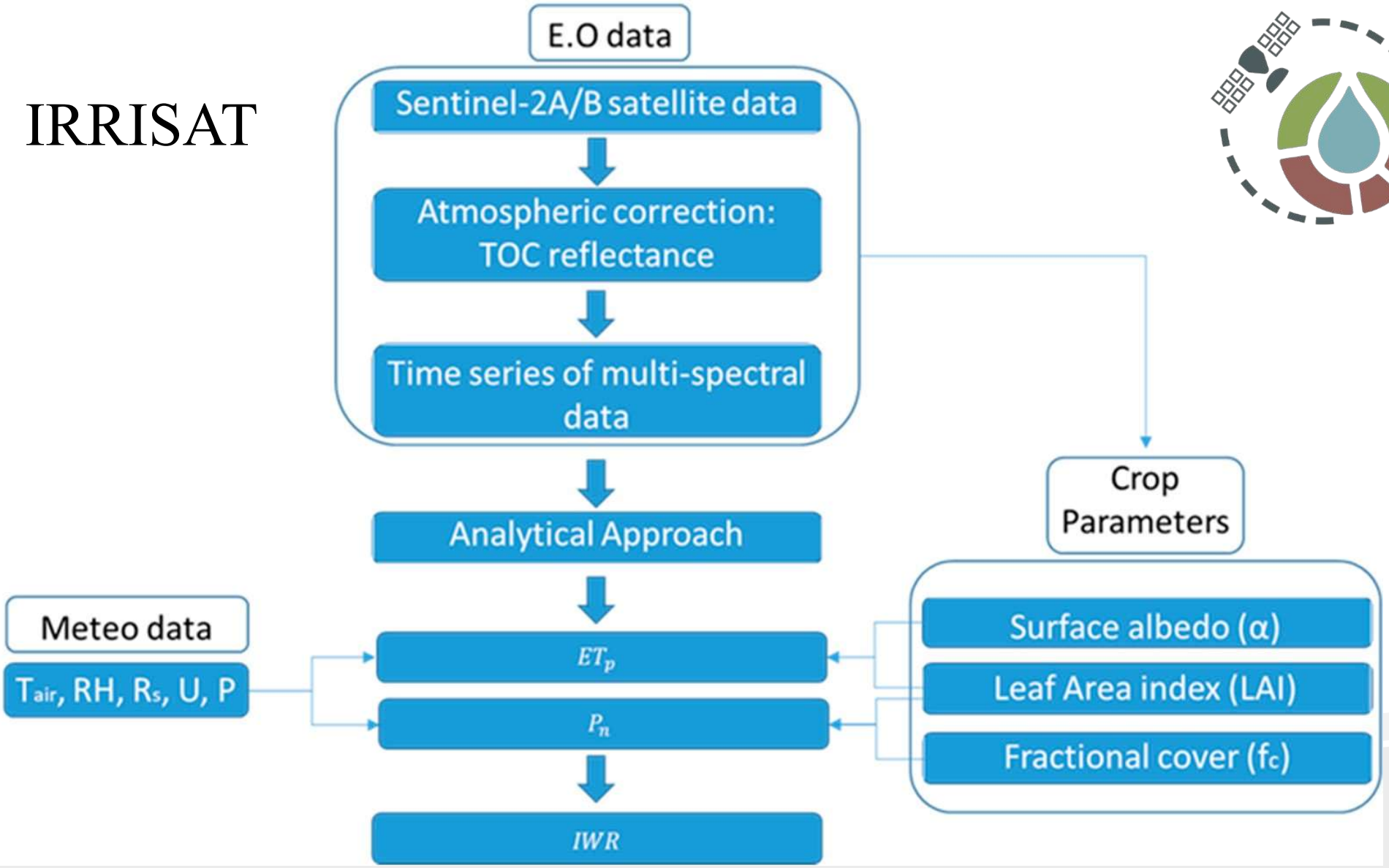
To estimate the real **CROP WATER REQUIREMENT** of processing tomato.

- IRRISAT, an irrigation advisory service based on Sentinel-2 imagery.
- AquaCrop, the crop growth model developed by the Land and Water Division of FAO to simulate yield response to water of herbaceous crops.
- Assimilation of fractional cover value (fc) estimated by Sentinel-2 imagery into AquaCrop model.

- To evaluate the capability of Sentinel-2 imagery to assess the canopy growth of processing tomato and its irrigation water requirements.

- To explore the possibility to predict crop water requirements of processing tomato by assimilating the fractional cover estimated by Sentinel-2 imagery into AquaCrop model.

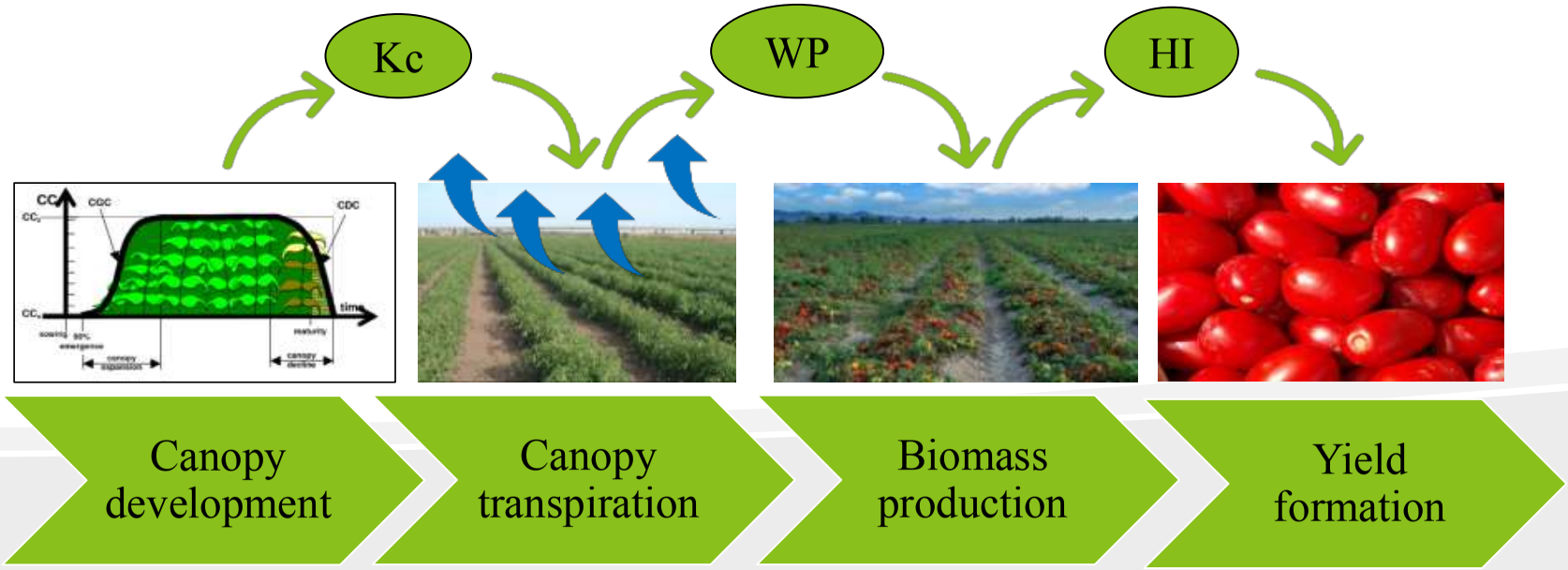
IRRISAT

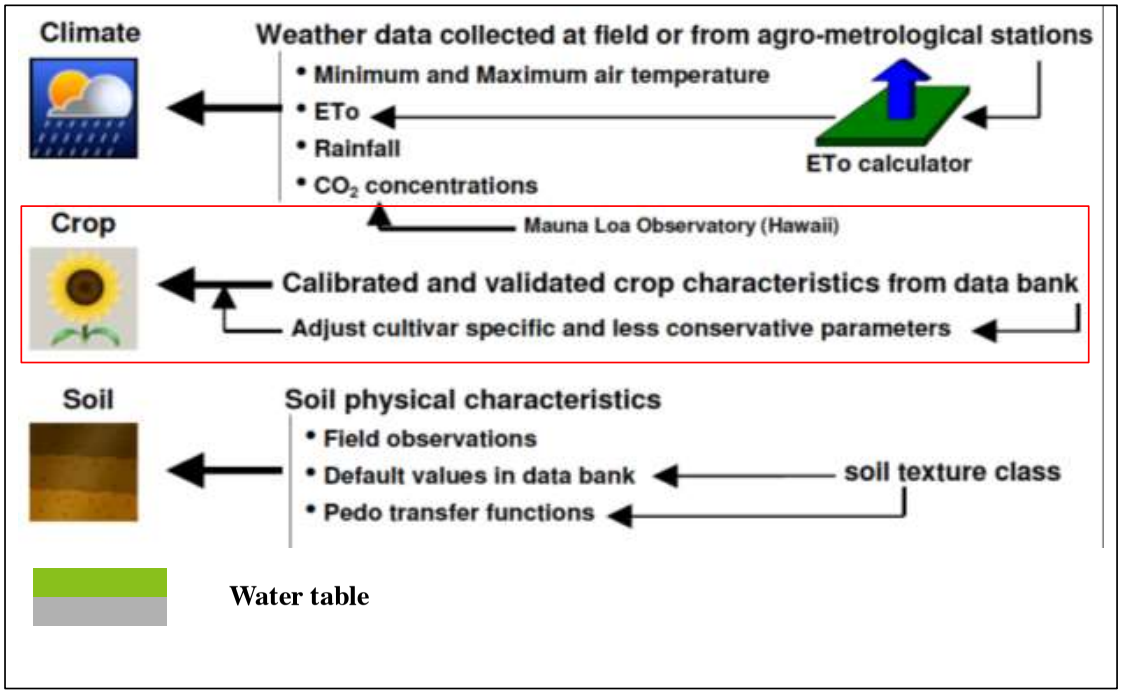

E.O data
Sentinel-2A/B satellite data
Atmospheric correction: TOC reflectance
Time series of multi-spectral data
Analytical Approach
Crop Parameters
Meteo data
Tair, RH, Rs, U, P
ET_p
P_n
IWR
Surface albedo (α)
Leaf Area index (LAI)
Fractional cover (fc)

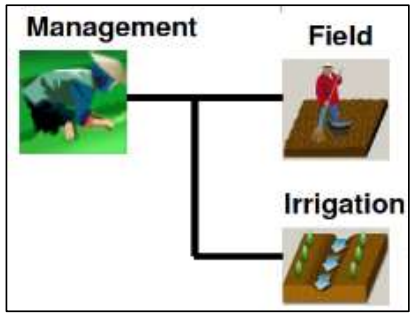
AQUACROP

AquaCrop is a crop water productivity model based on Canopy Cover (CC) coefficient.

It calculates the daily soil water balance and divides evapotranspiration in soil evaporation and crop transpiration.







INPUT

OUTPUT

Crop production

Crop water use

$$WP_{ET} = \frac{\text{Yield (kg)}}{\text{ET (m}^3\text{)}}$$

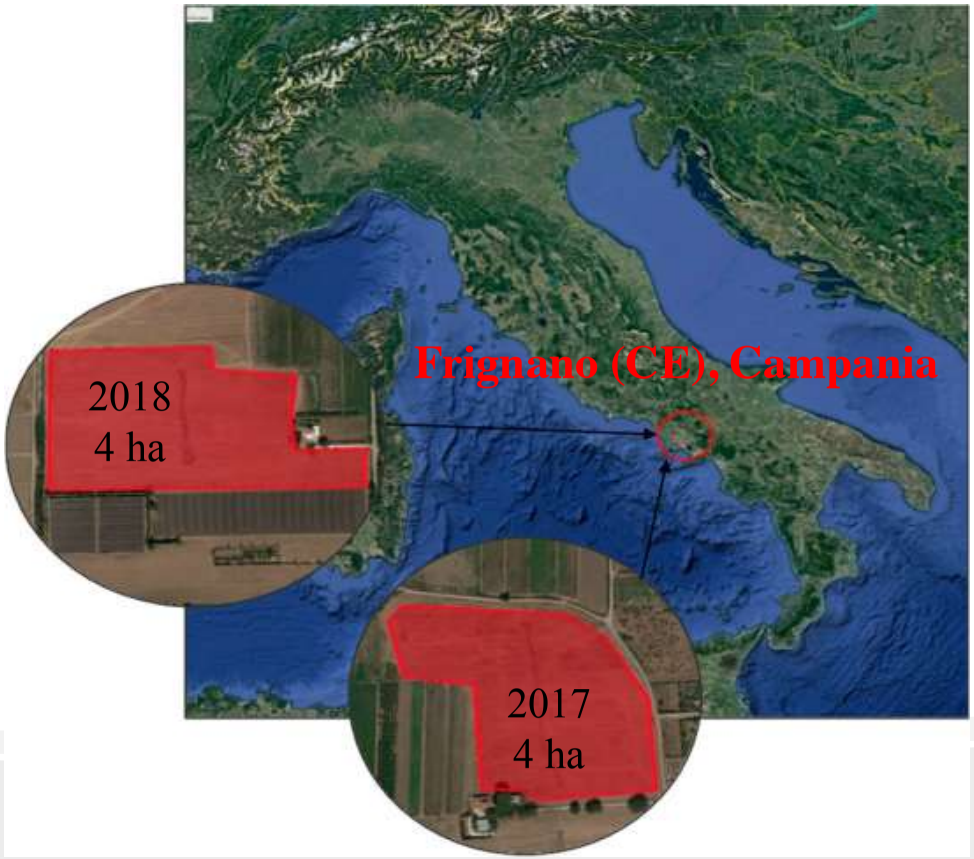
ASSIMILATION

The fc estimated by Sentinel-2 has been sequentially assimilated into AquaCrop, by direct insertion, in place of the CC value simulated by the model.

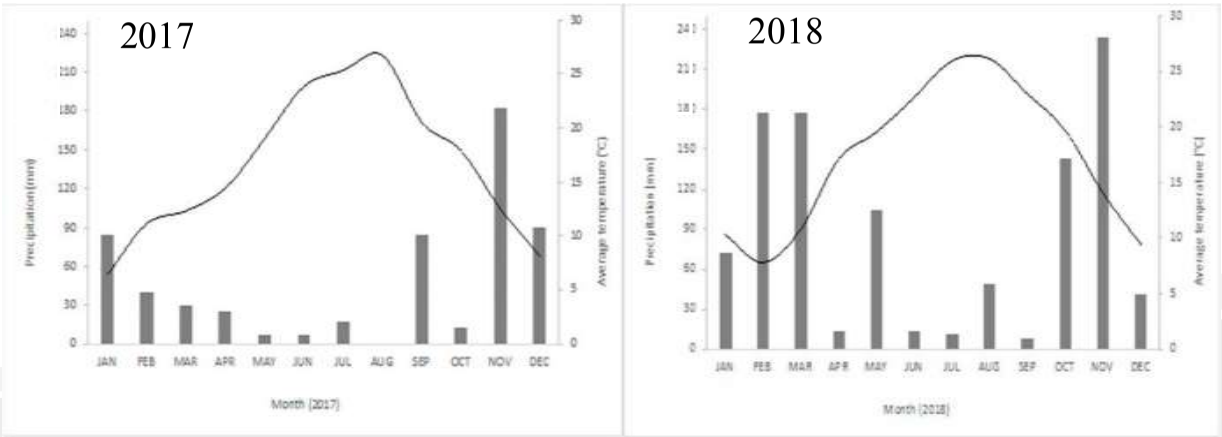
The sequential direct insertion was applied under the assumption that a continuous update of crop model state with remote observations can reduce the biases induced by the model simplifications of the processes.

Materials and Methods

Test site



	2017	2018
SOIL TEXTURE	loamy	loamy-sand
TOT PRECIPITATION (mm)	579	1047
AVERAGE TEMPERATURE (°C)	16.6°C	17.25°C

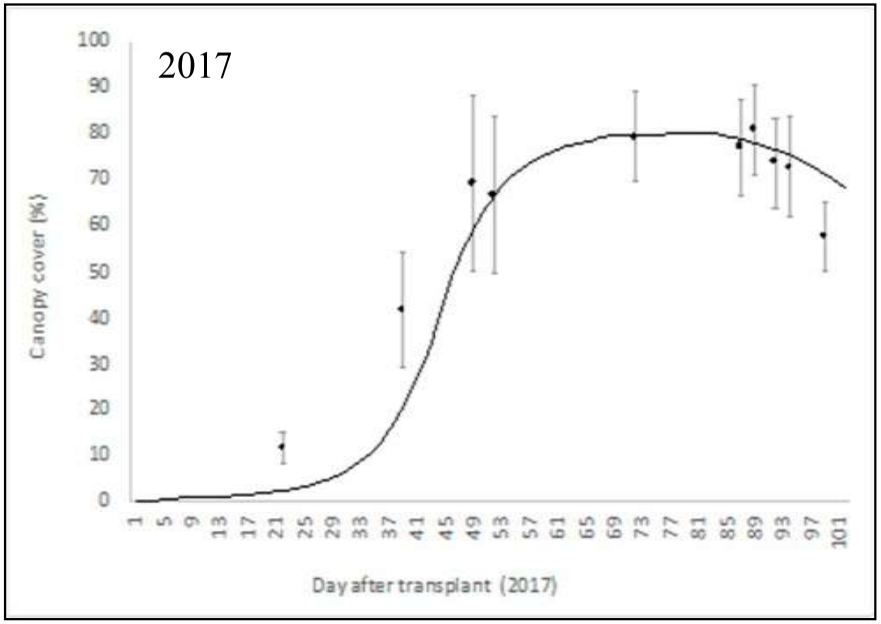


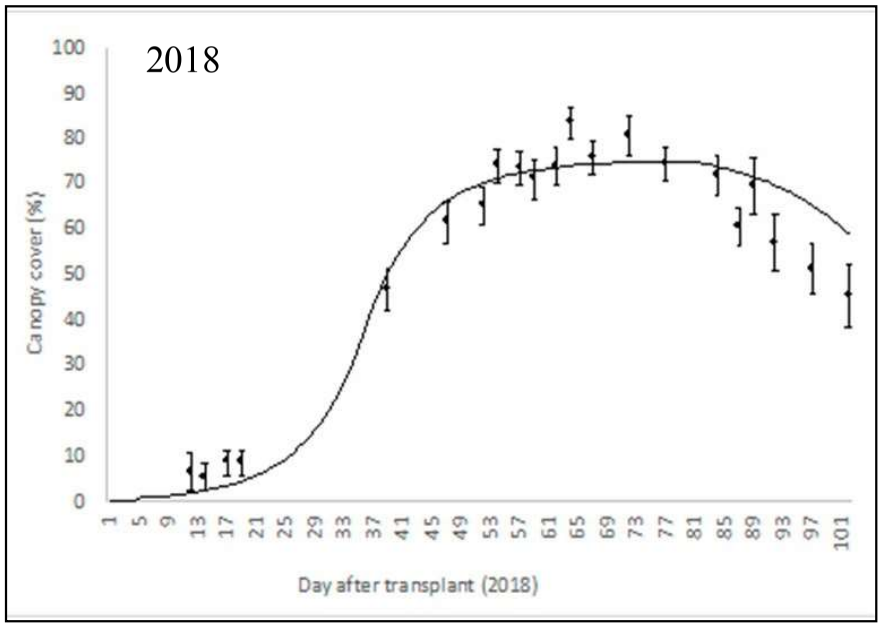
Temperature (line); Precipitation (bars)

Crop management

	2017	2018
TILLAGE DEPTH (m)	0.40	0.40
TRANSPLANTING DATE	April	April
PLAN DENSITY (p/ha)	32000	33500
IRRIGATION SYSTEM	drip	drip
IRRIGATION (L/p)	130	120
IRRIGATION (m^3/ha)	4160	4020
YIELD (t/ha d.m.)	7.20	7.35

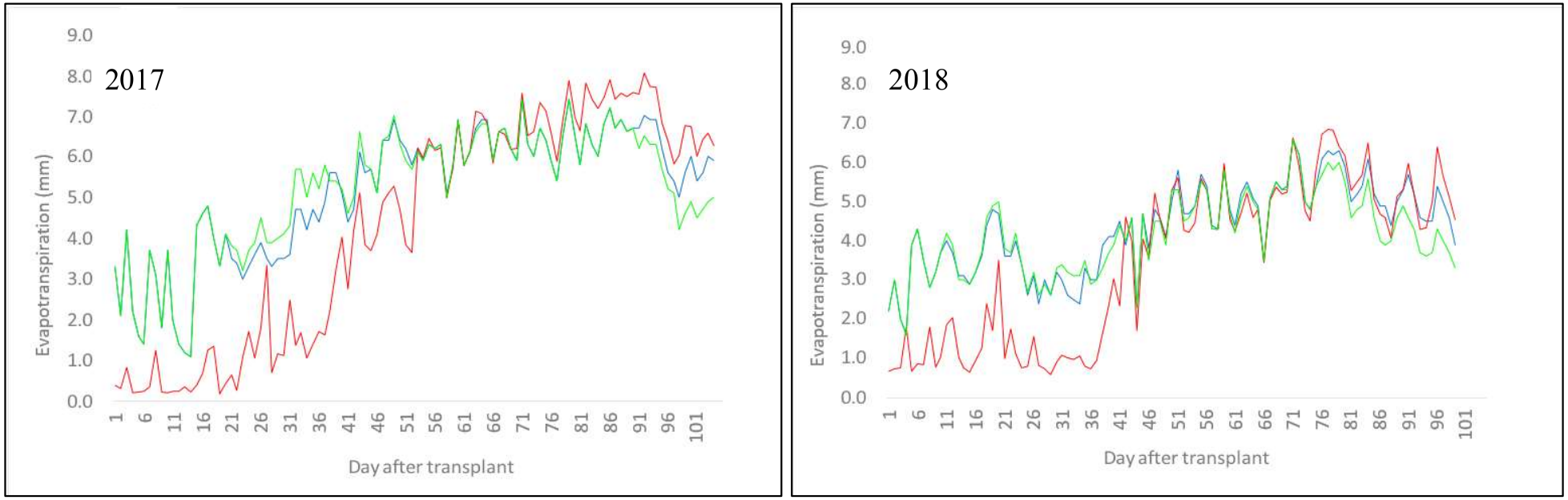
Main results





Canopy Crop growing curve simulated by AquaCrop (line) fitted well with the corresponding fc value (dots) retrieved by Satellite imagery.

Statistical analysis showed a very good agreement between simulated CC and fc value.



Tomato daily evapotranspiration series estimated by AquaCrop, IRRISAT and Assimilation.

The agreement between AquaCrop and IRRISAT is excellent in the mid-season stage, when the crop canopy is fully developed.

AquaCrop, using a crop coefficient approach based on soil and crop conditions instead of LAI at pixel scale, is able to better accounts the soil evaporation in the initial stage and the plants transpiration reduction associated with the senescence.

		Yield (t/ha)	Tr (mm)	E (mm)	Etp (mm)	IWR (mm)
2017	Observed	7.20				416
	IRRISAT				450	450
	AquaCrop	7.23	345	192	537	461
	Assimilation	8.23	372	165	537	461
2018	Observed	7.35				402
	IRRISAT				349	298
	AquaCrop	7.60	291	137	428	332
	Assimilation	7.34	273	139	412	317

Sequential assimilation of one state variable retrieved by Sentinel-2 imagery into AquaCrop does not guarantee an optimal model-data integration.

Conclusions

- Sentinel-2 imagery can be effectively exploited for monitoring canopy growth of processing tomato crops in open field.
- IRRISAT can provide a reliable assessment of tomato water requirements especially when crop canopy is fully developed.
- IRRISAT is entirely based on crop growth monitoring from space, an integration with a crop growth model such as AquaCrop can be an effective strategy for assessing crop water requirement in the initial and in the senescence growth stages.
- Being the satellite imagery a spatial information, the integration into a crop model can help in assessing crop water requirement at field or higher scales, i.e., at territorial level.
- More complex sequential assimilation techniques are needed.