Evaluation of soil moisture products and Sentinel 1- 2 data from THEIA platform for monitoring water status of agricultural plots and orchard in the Vaucluse department.

RÉPUBLIQUE FRANÇAISE
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INRAE

UMR 1114 EMMAH AVIGNON

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Context and objectives:

Recurrent droughts and water restrictions occur more and more often in SouthEastern France. It's crucial to assess the available water resources according to the crop development. The THEIA[1] platform provides free soil moisture maps (S^2MP) computed every 6 days from Sentinel 1 & 2 images[2].

The study objectives were to: -1) **evaluate the accuracy of this new S^2MP product** from different soil moisture measurements recorded at plot scale; -2) **analyse the correlation between soil moisture measurements in orchards and Sentinel 1 and 2 spectral variations**, in order to monitor their water needs.

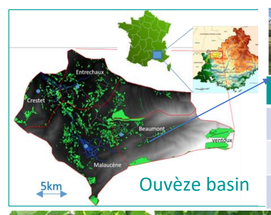
Sites & Data

2 sites: 1 plot at Avignon INRAE (43°55'12'', 4°52'41) with continuous soil moisture measurements recorded since 2016 (TDR and capacitive probes at 5-7 cm) with crop rotation (wheat (2017),corn (18),wheat (19), fallow (2020).

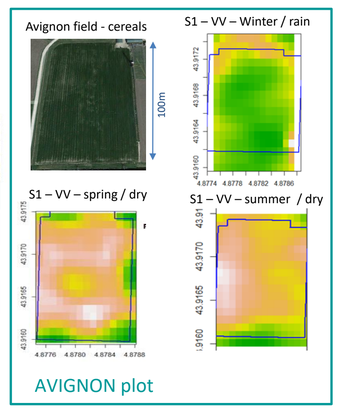
The Ouvèze basin (44°13', 5°8.5'E), mainly orchards (cherry and plume trees with drip or micro-sprinkler irrigation, and cereals and meadows with punctual TDR points).

Data: Sentinel images (pixel 10m) from 2016 to 2022,

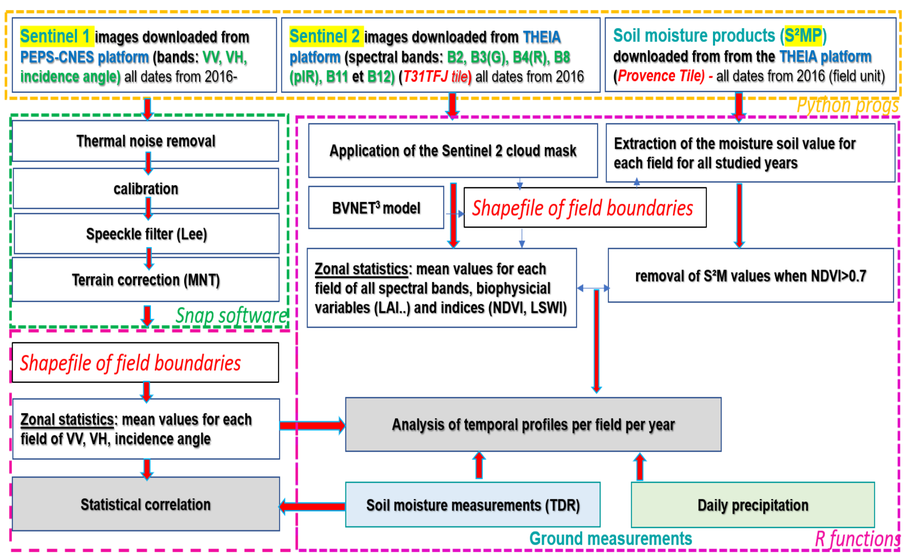
1 image every 6 days with Sentinel 1 & S^2MP (1 value/field), 1 image every 3-5 days with Sentinel 2



Field number	1401	3347	1824	50	3099
crop	cherry	cherry	Young plume	cherry	cherry
irrigation	no	Micro-sprinkler	drip	drip	drip
Dose (m3/year)	0	5041	871	1918	4069



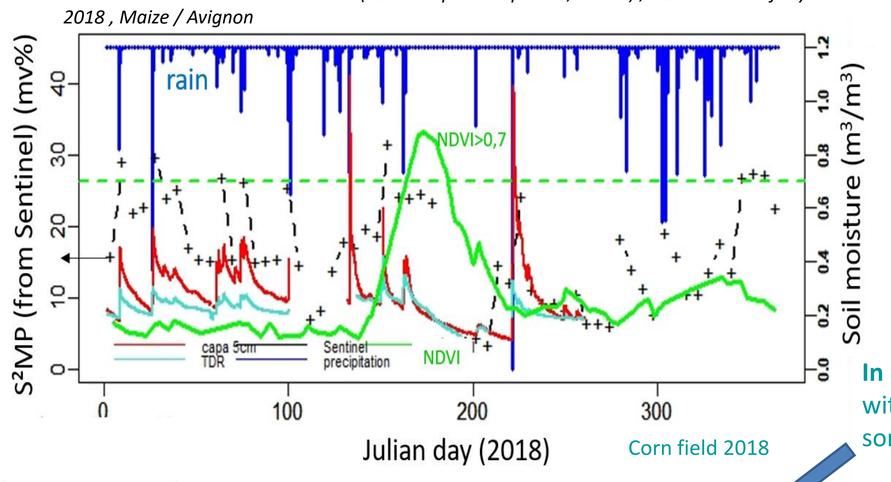
Methodology



Results

Sentinel soil moisture product (S^2MP)

Sentinel and observed soil moisture (TDR & capacitive probes, 5-7cm) , NDVI and rain for year 2018 , Maize / Avignon

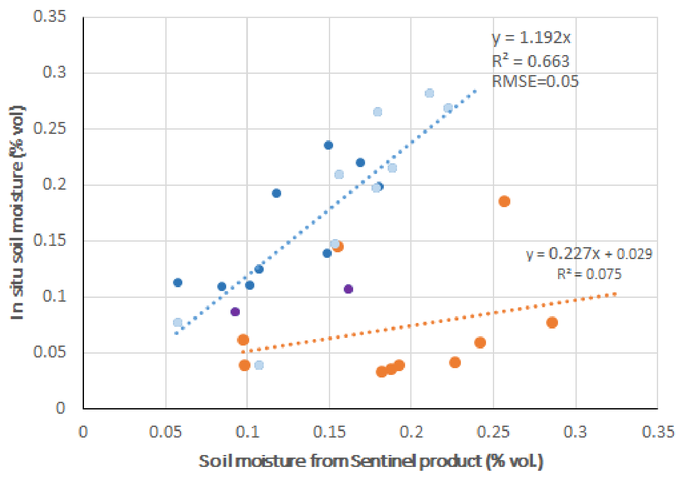


In Avignon field, The regression slopes between S^2MP and soil observations are quite different between years => A normalization is proposed to correct the S^2MP values from max and min of the year [$X_i=(X_i-Min(X)/(Max(X)-Min(X))$].

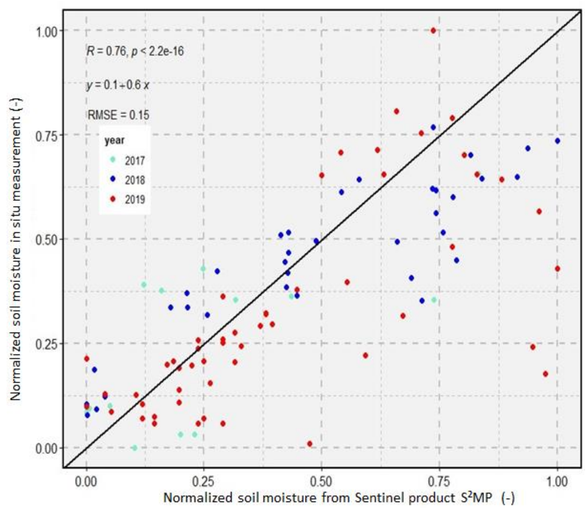
Correlation between S^2MP and ground measurements are improved after normalization from: **0.35 (before) to 0.66 (after)** using capacitive probes and from **0.50** to **0.63 using TDR measurements**

In Ouveze fields, correlation is strong without normalization, but vanishes on some fields.

Correlation between Soil moisture from S^2MP Sentinel product and in situ observations from 4 fields in Ouveze basin - Years 20121-2022 / bare soil, fallow and cereal depending on time of measurement

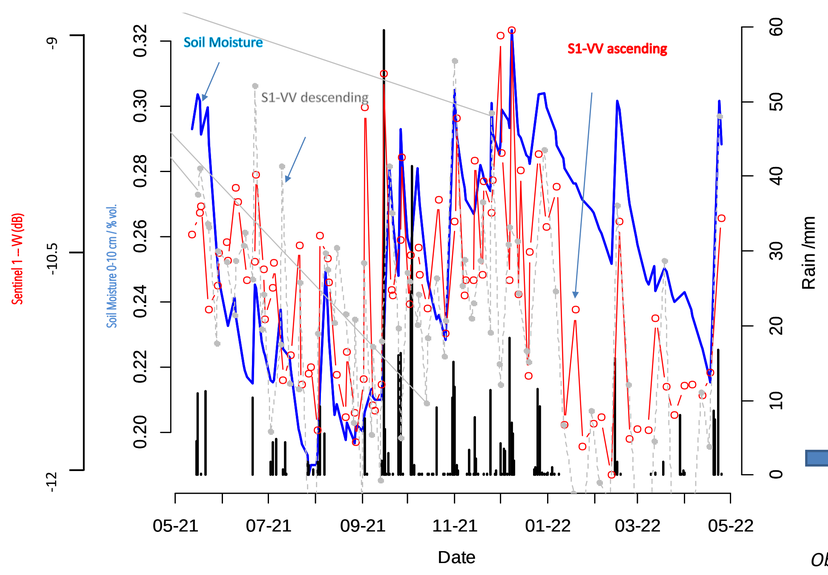


Correlation between Soil moisture from S^2MP Sentinel product and in situ observations after normalization for each year - Years 2017 to 2018 / Avignon field site.



Correlation between S1 and S2 signals and water content variations in orchards (Ouveze basin)

Temporal variations of soil moisture at 5-7 cm, S1 retrodiffusion VV signal ,averaged over the 5 monitored orchards and rain – Years 2021 – 2022.

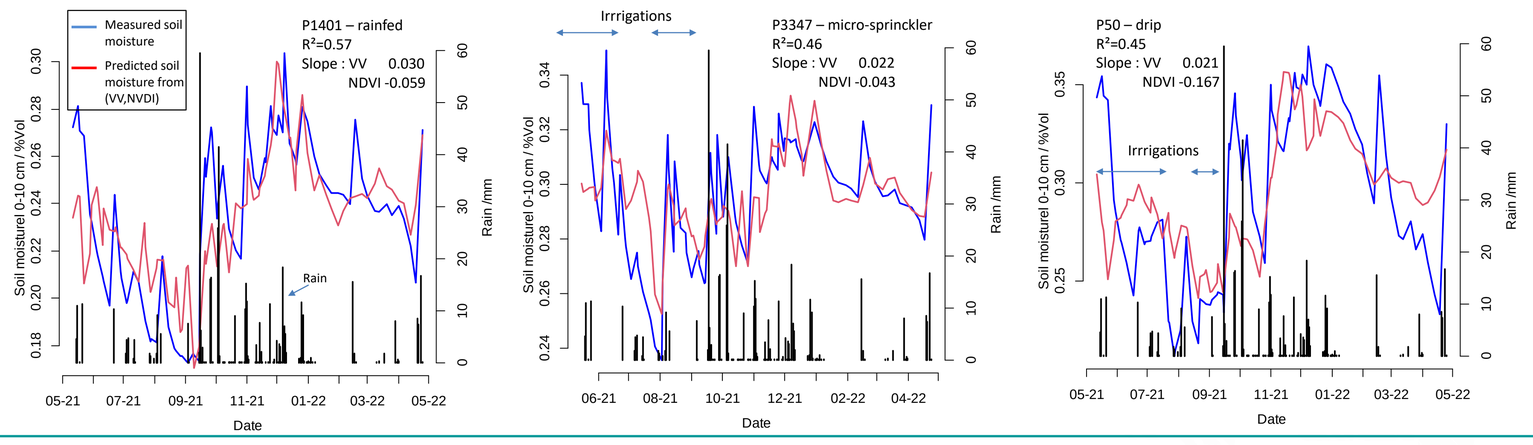


VV variations from these small fields (from 0.5 to 4 ha) appear noisy. Some peaks are linked to increase in soil moisture or rain but some other not. The S1-VV signal follow however the yearly trend in soil water content. This suggests to use a temporal smoothing of data. A local polynomial regression is used (*lowess* function in R, with f=5% of points influencing the local smoothing) and applied to S1-VV to further analyze data through correlations: Soil moisture ~ S1-VV + S2-NDVI

Results of correlation between observed Soil moisture in orchards and S1-VV signal + S2-NDVI over May 21 to April 22 . The fields present different pattern of water content variation due to different irrigation type sand rates. RMSE is about 0.02 – 0.03 vl%

Field id	Irrigation	R^2 (Moisture~S1-VV+S2-NDVI)	S1 data
P1401	rainfed	0.57	Ascending orbit
P3347	Micro-sprinckler	0.46	descending
P50	drip	0.45	ascending
P3099	drip	0.56	ascending
P1824	drip	0.24	ascending

Observed and predicted soil moisture variations for 3 orchards - from May 21 to April 22 – Predicted soil moisture is the result of the regression between observed soil moisture and S1 –VV , S2-NDVI smoothed (with lowess) variations . The first orchard is rainfed, the irrigated with micro-sprinckler and the third with drip (localized irrigation along the row of trees). The correlation gives the trend of soil moisture, but irrigations are also more or less visible. Some important rain events are missed with the correlation.



Conclusions

Sentinel moisture products (S^2MP) can give soil moisture for crops within +/- 5 % vol in a range of situations, but we observed that this accuracy can change / degrade with years and examined sites. In orchards, simple correlation of VV retrodiffusion signal from S1, combined with NDVI, for soil moisture can give the trend of soil moisture variations and a link with irrigation events is observed. These first results are encouraging, but need to be further refined to check if S1 data could be used at the small spatial scale of orchards to ascertain irrigation and water need at plot scale.

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Références

1. https://www.theia-land.fr/
2. El hajj et al, 2017. Remote Sensing, 9, 1292, doi.org/10.3390/rs9121292