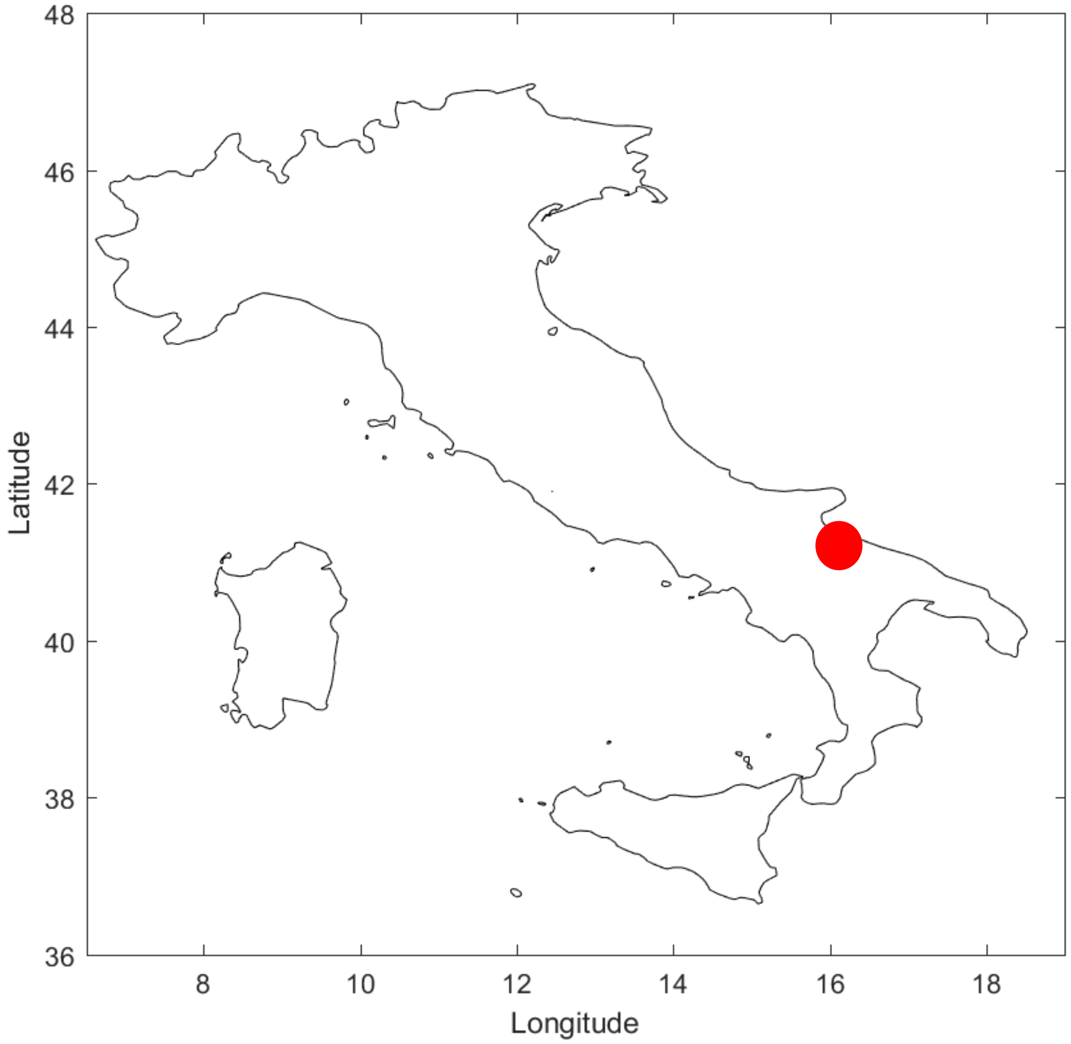
Synergic use of Sentinel-1, Sentinel-2 and PRISMA images to estimate soil moisture: a case study in the Capitanata area, southern Italy

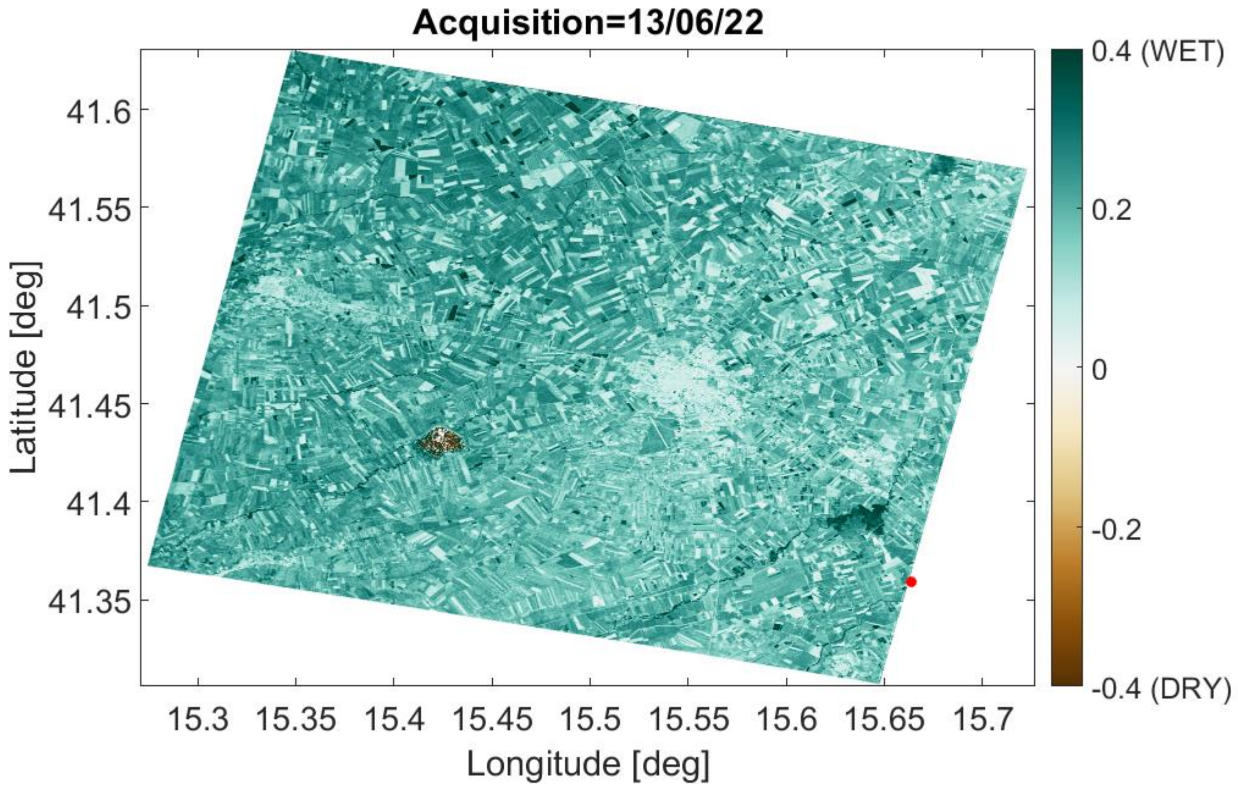
Giovanni Nico[1], Marcella Michela Giuliani[2], Olimpia Masci[3],
Delia Pia Caldarola[2], Giuseppe Gatta[2],
João Catalão[4], Nuno Cirne Mira [4,5]

[1] National Research Council of Italy, Institute for Applied Mathematics, Bari, Italy
[2] University of Foggia, Dpt. of Agricultural Sciences, Food, Natural Resources and Engineering, Foggia, Italy
[3] DIAN Srl, Matera, Italy
[4] University of Lisbon, Geographic Engineering, Geophysics and Energy, Lisbon Portugal
[5] Military Academy Research Center (CINAMIL), Amadora, Portugal

ESA Symposium on Earth Observation for Soil Protection and Restoration

Study area


48
46
44
42
40
38
36
Latitude
8
10
12
14
16
18
Longitude


Acquisition=13/06/22
41.6
41.55
41.5
41.45
41.4
41.35
Latitude [deg]
15.3
15.35
15.4
15.45
15.5
15.55
15.6
15.65
15.7
Longitude [deg]
0.4 (WET)
0.2
0
-0.2
-0.4 (DRY)
Normalised Soil Moisture Index (NSMI)

Motivation

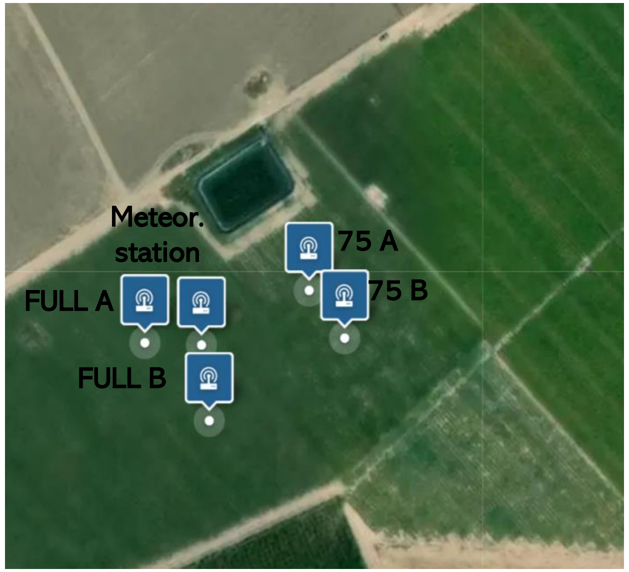
- Why do we use SAR to estimate the SM?

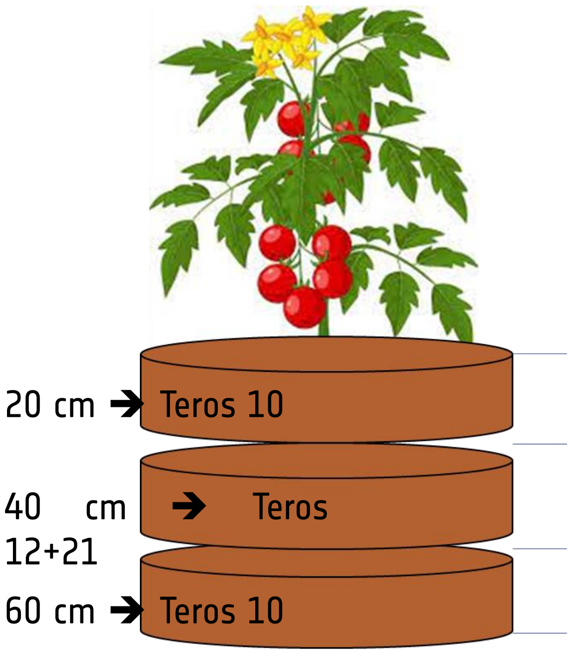
  Can provide an estimate of SM in any weather and sun-illumination conditions

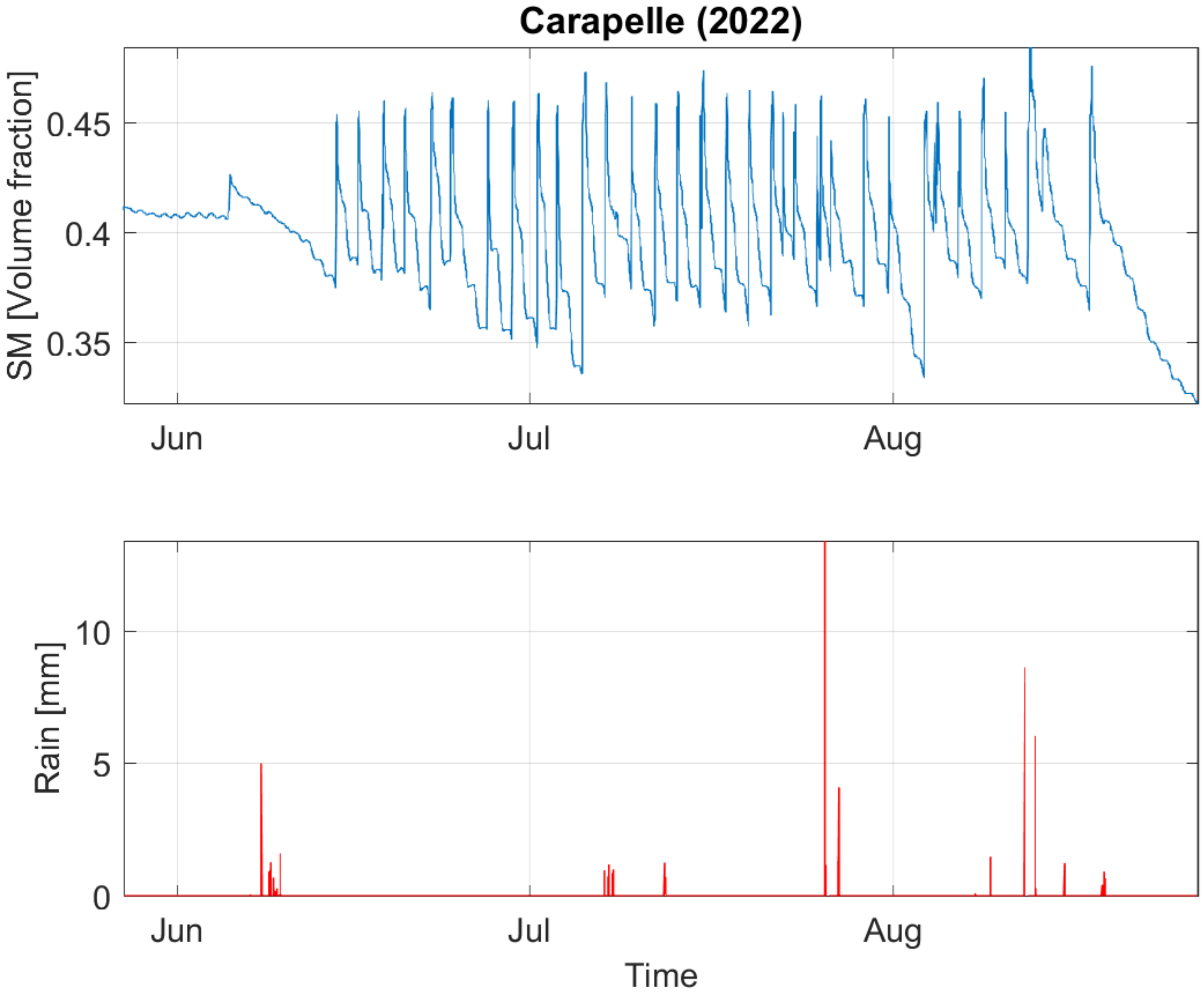
- Why do we use the InSAR phase to estimate the SM instead of the RCS?

  No need to separate the contributions of terrain roughness and SM

In-situ data

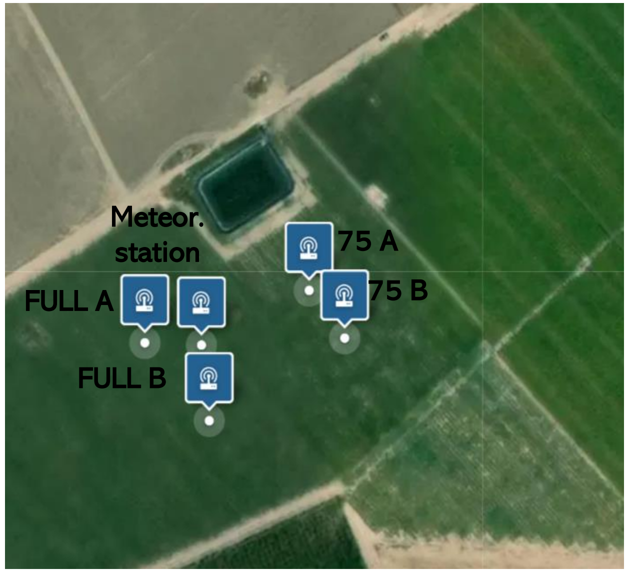


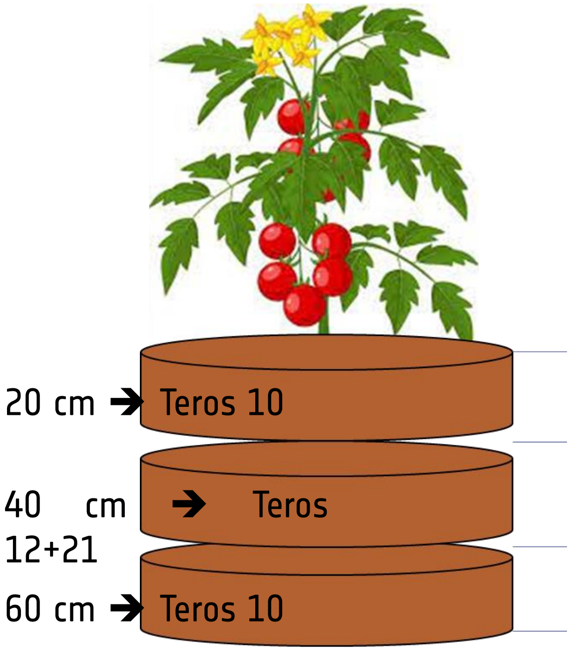


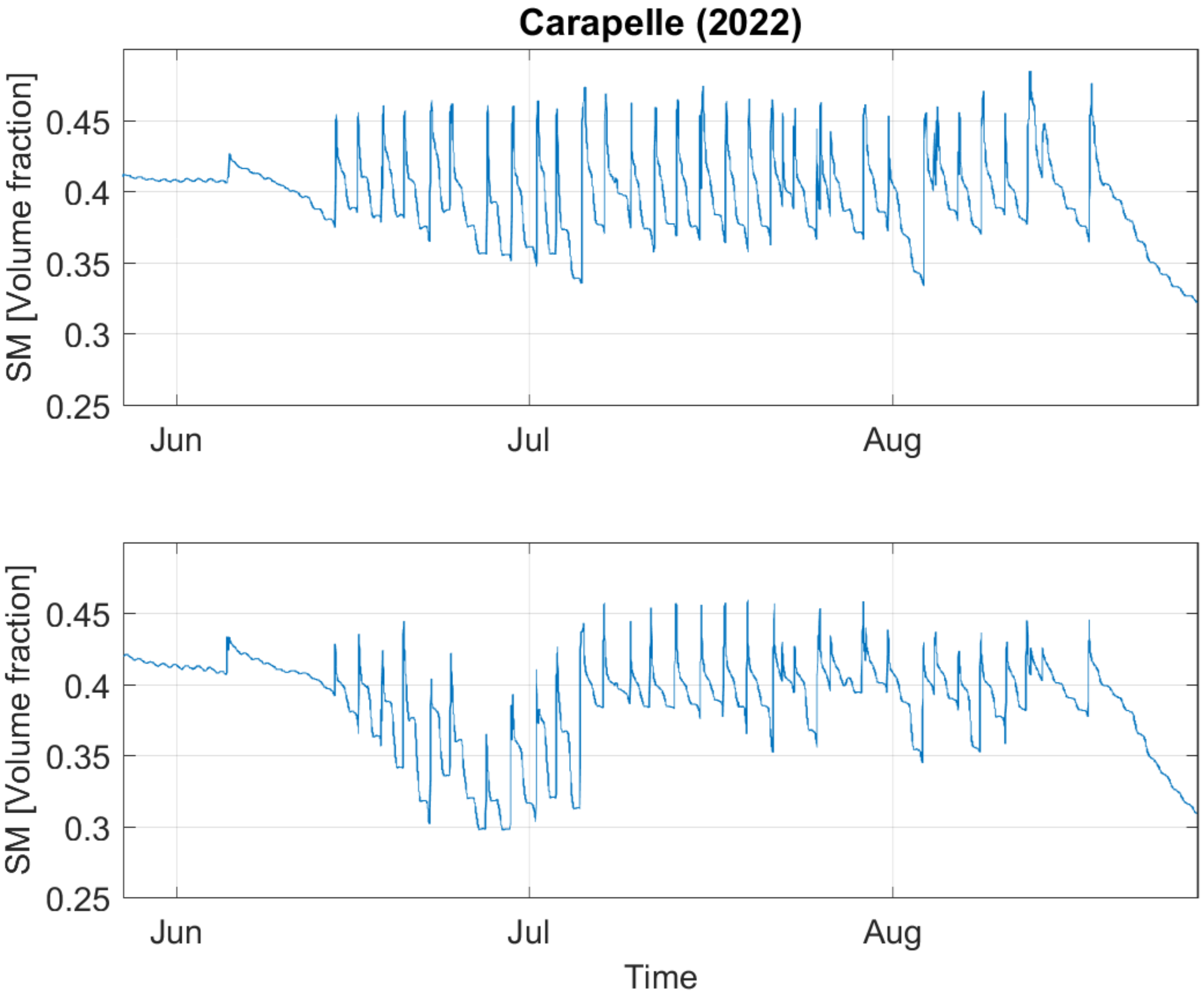


SM has been measured at a depth of 20, 40 and 60 cm with a sampling time of 15 min. In 2022, measurements were collected from May, 19 till Aug, 26.

In-situ data



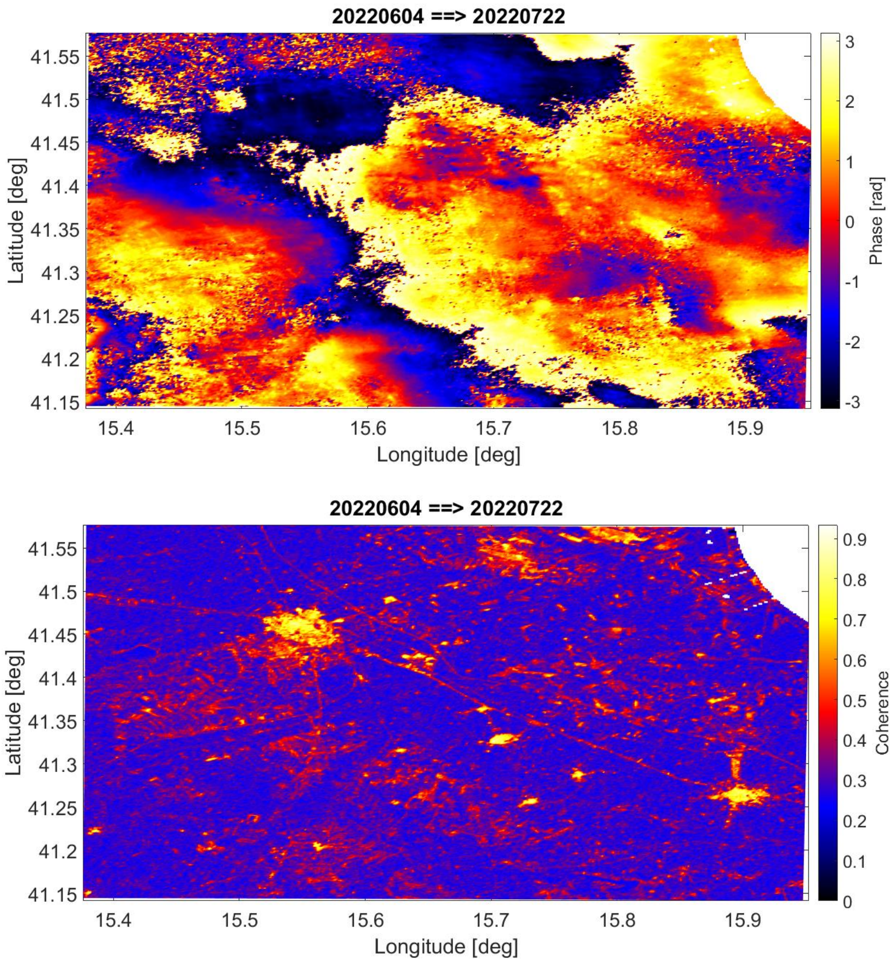




SM has been measured at a depth of 20, 40 and 60 cm with a sampling time of 15 min. In 2022, measurements were collected from May, 19 till Aug, 26.

Satellite data

InSAR data (S-1)

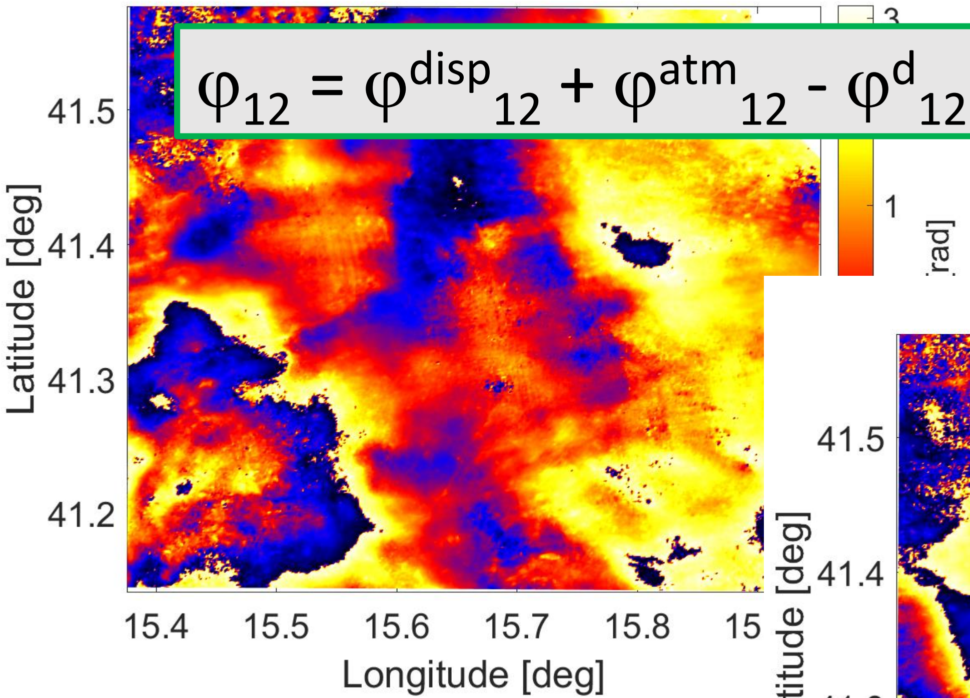


All S1-A images acquired in 2022 have been interferometrically processed

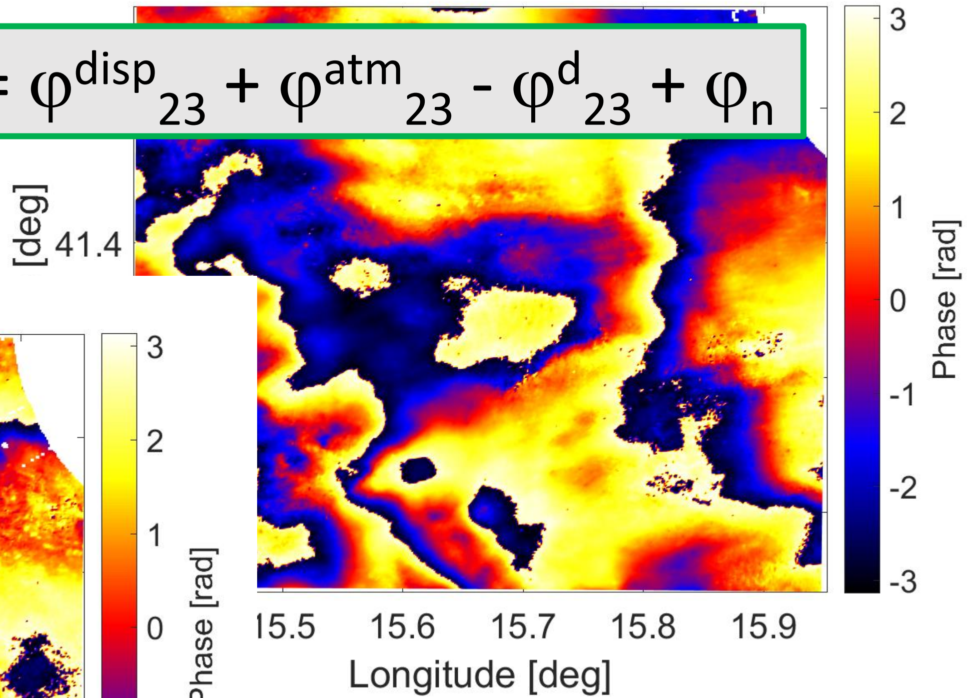
130 interferograms have been generated with temporal baselines of 12, 24, 36, 48 and 60 days

All interferograms have been corrected for topography and geolocated

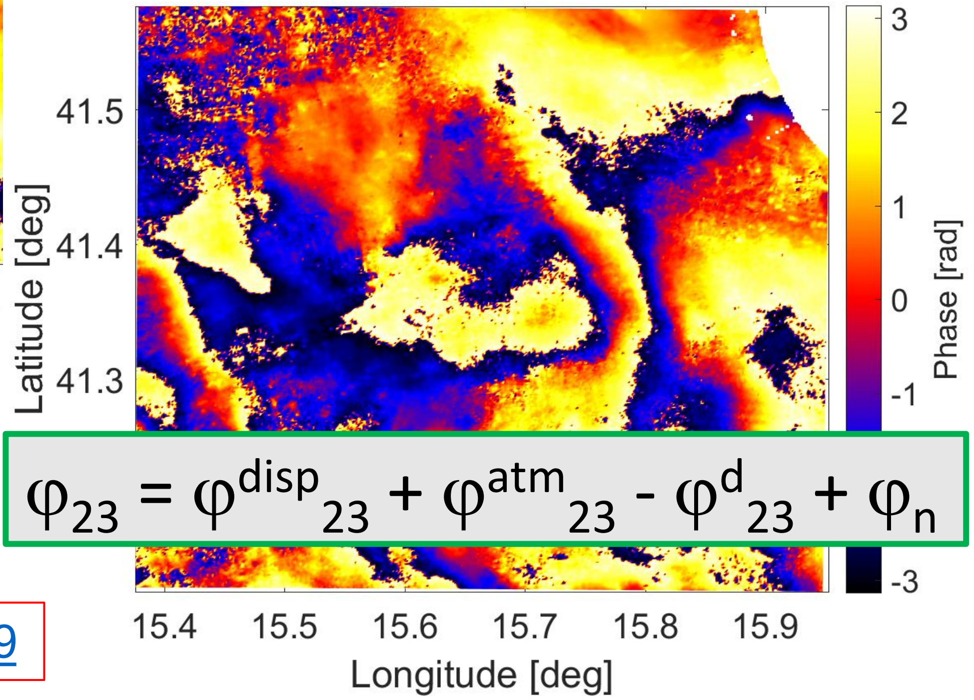
Satellite data



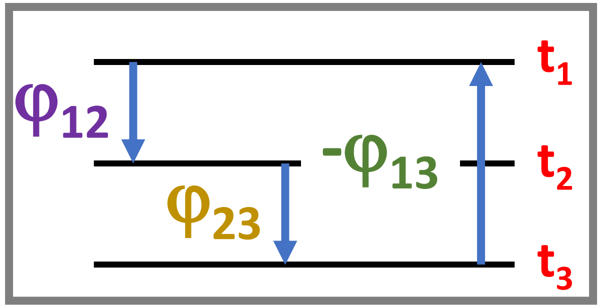
$$\varphi_{12} = \varphi^{disp}_{12} + \varphi^{atm}_{12} - \varphi^{d}_{12} + \varphi_n$$



$$\varphi_{23} = \varphi^{disp}_{23} + \varphi^{atm}_{23} - \varphi^{d}_{23} + \varphi_n$$



$$\varphi_{23} = \varphi^{disp}_{23} + \varphi^{atm}_{23} - \varphi^{d}_{23} + \varphi_n$$



DOI: 10.1109/TGRS.2013.2241069

Methodology

Closure phases ➔ $\xi_{123} = \varphi^d_{12} + \varphi^d_{23} - \varphi^d_{13} + \varphi_n$

N = # SAR images;

M = # interferograms φ

K = # phase triplets ξ

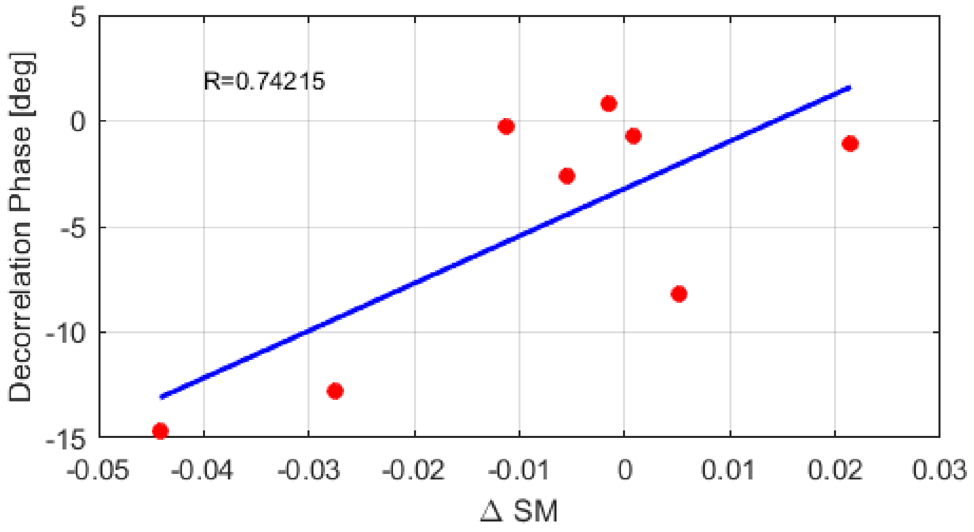
$$\frac{N}{2} \leq M \leq \frac{N \cdot (N-1)}{2}$$

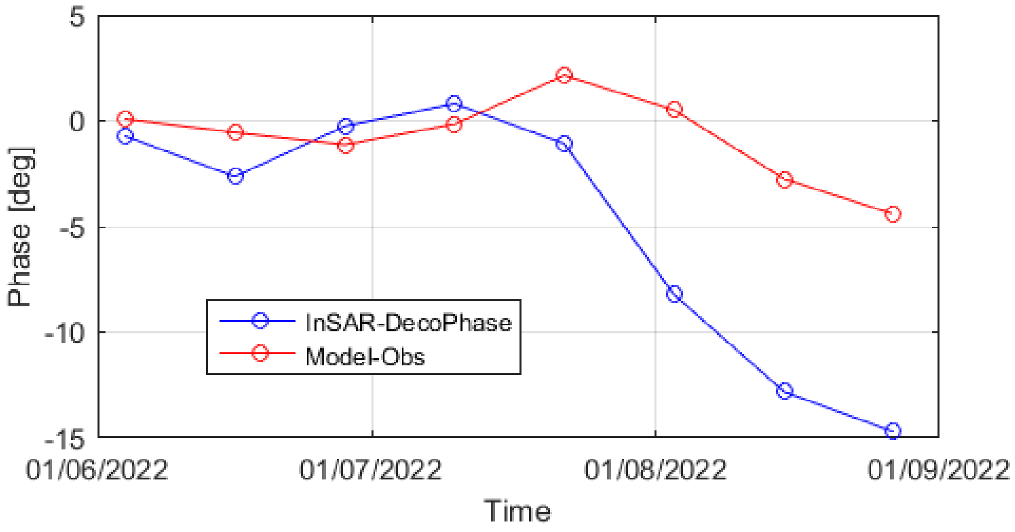
$$\frac{N}{3} \leq K \leq \frac{N \cdot (N-1) \cdot (N-2)}{6}$$

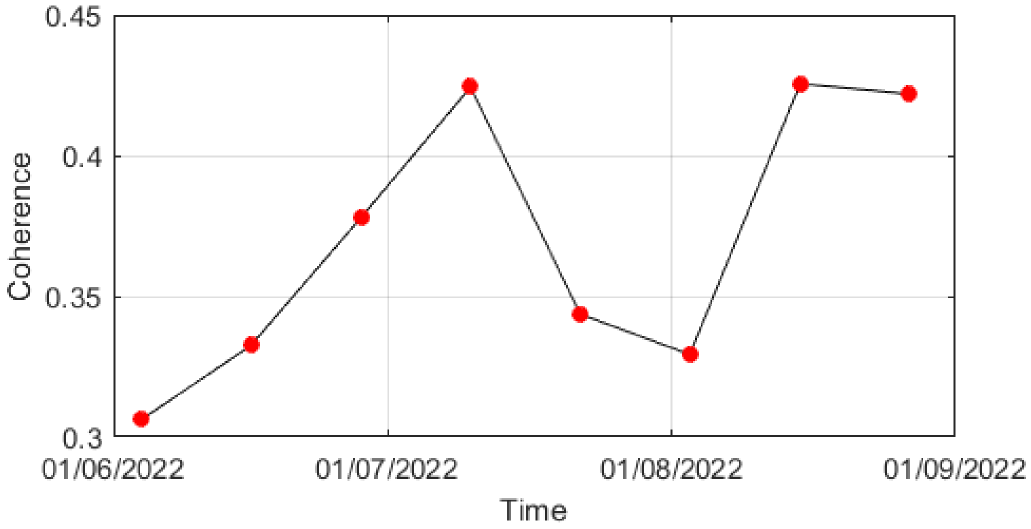
$$\underset{[K\text{x}1]}{\xi} \equiv \underset{[K\text{x}M]}{\mathbf{M}} \cdot \underset{[M\text{x}1]}{\varphi^d}$$

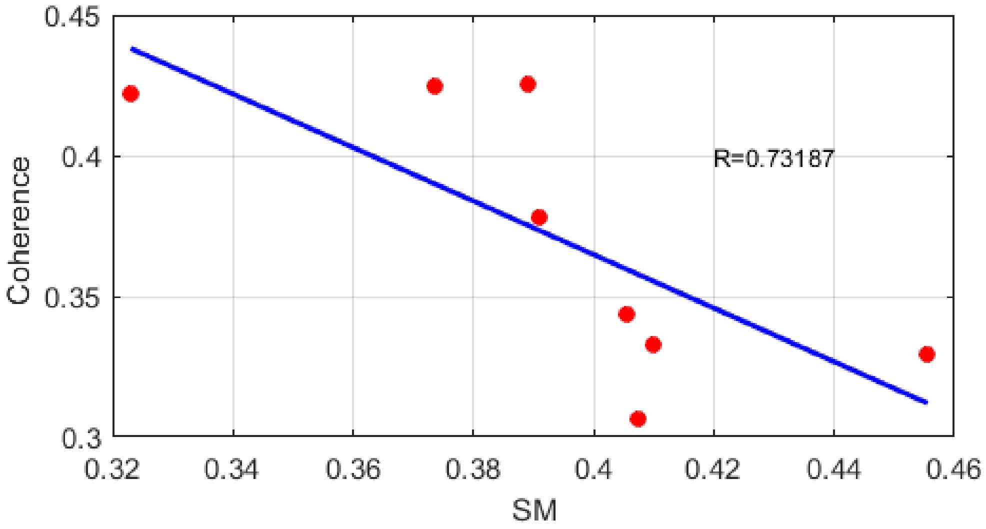
DOI: 10.1109/TGRS.2019.2934362

Results


R=0.74215
Decorrelation Phase [deg]
Δ SM


InSAR-DecoPhase
Model-Obs
Phase [deg]
Time


Coherence
Time


R=0.73187
Coherence
SM

Take-away message and future work

- The (InSAR) decorrelation phase can provide a further means to estimated the SM

- Need to better understand if the decorrelation phase depends only on the temporal changes of SM or also on the plant evapotranspiration

DOI: 10.1109/JSTARS.2024.3357699

- How do we compare the InSAR estimates of SM to the in-situ measurements collected at depths of 40 and 60 cm?