Explaining closure-phase temporal signals over vegetation: The role of soil moisture and NDVI variability

Giovanni Nico(1), João Catalão(2), Rocco Miglionico(3)

(1) CNR-IAC, Bari, Italy,

(2) Instituto Dom Luiz (IDL), Faculdade de Ciências, Universidade de Lisboa, Lisbon Portugal

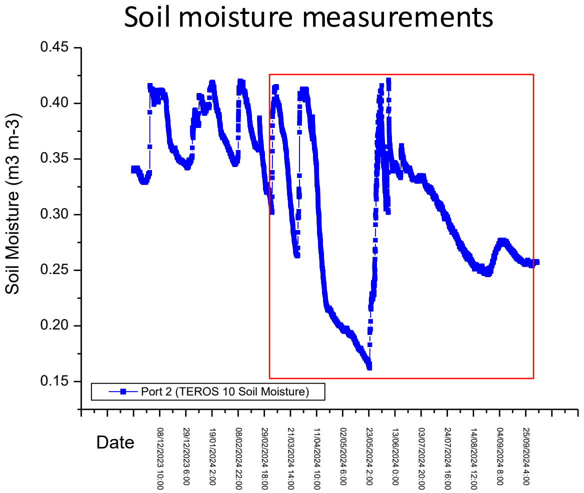
(3) DIAN Srl, Matera, Italy

Outline

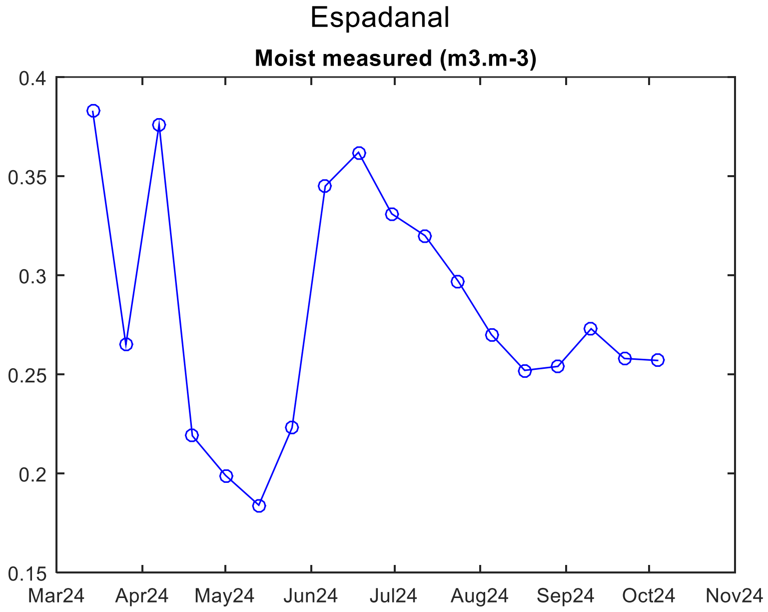
- Study areas
- Data processing
- Results
- Conclusions

Site 1

Lisbon (Espadanal)



Soil Moisture measurements at the Sentinel-1 acquisition time



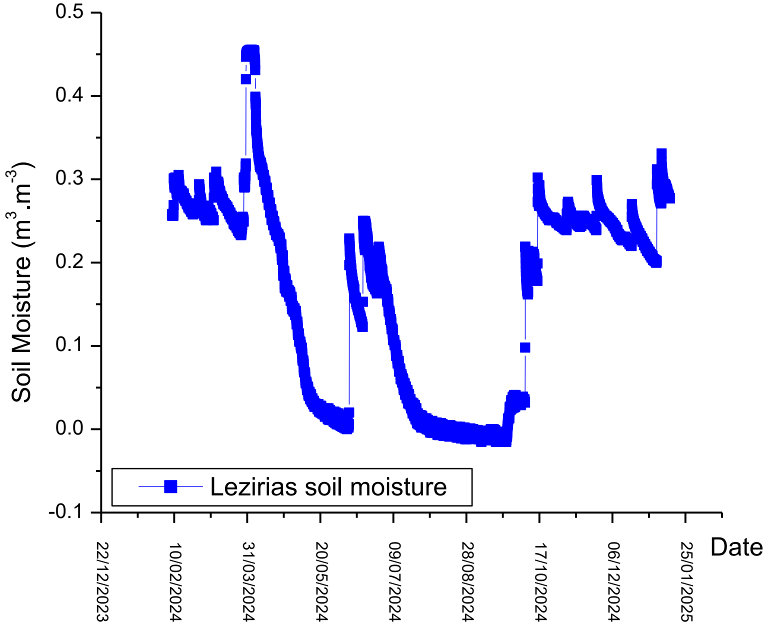
DataLogger: EM 34679
Sensors: 2 x TEROS 10; GS1
Time interval: 1 hour

Site 2

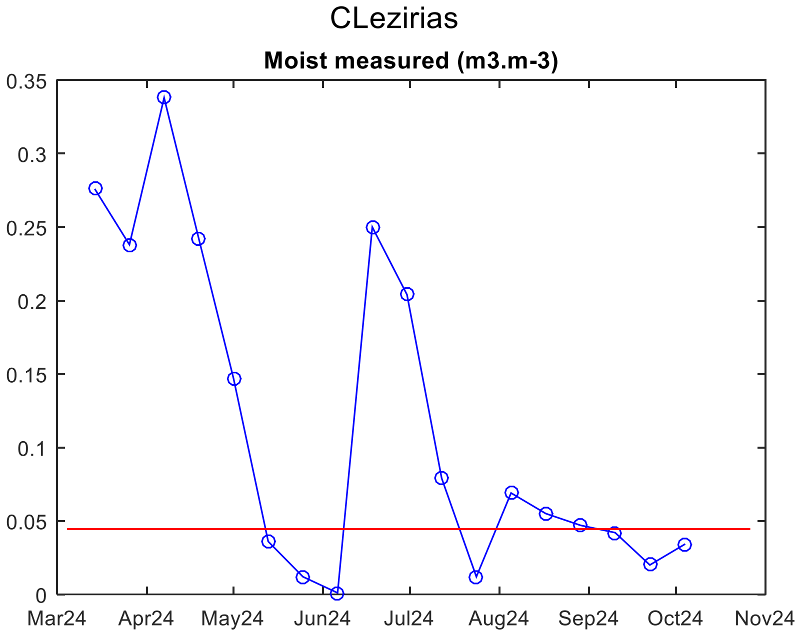
Lisbon (Lezirias)

DataLogger: EL 14629
Sensors: 2 x 10 HS soil moisture
Time interval: 2 hours

Soil Moisture measurements timeseries between 2024 February and 2025, January



Soil Moisture measurements at the Sentinel-1 acquisition time (6 am)



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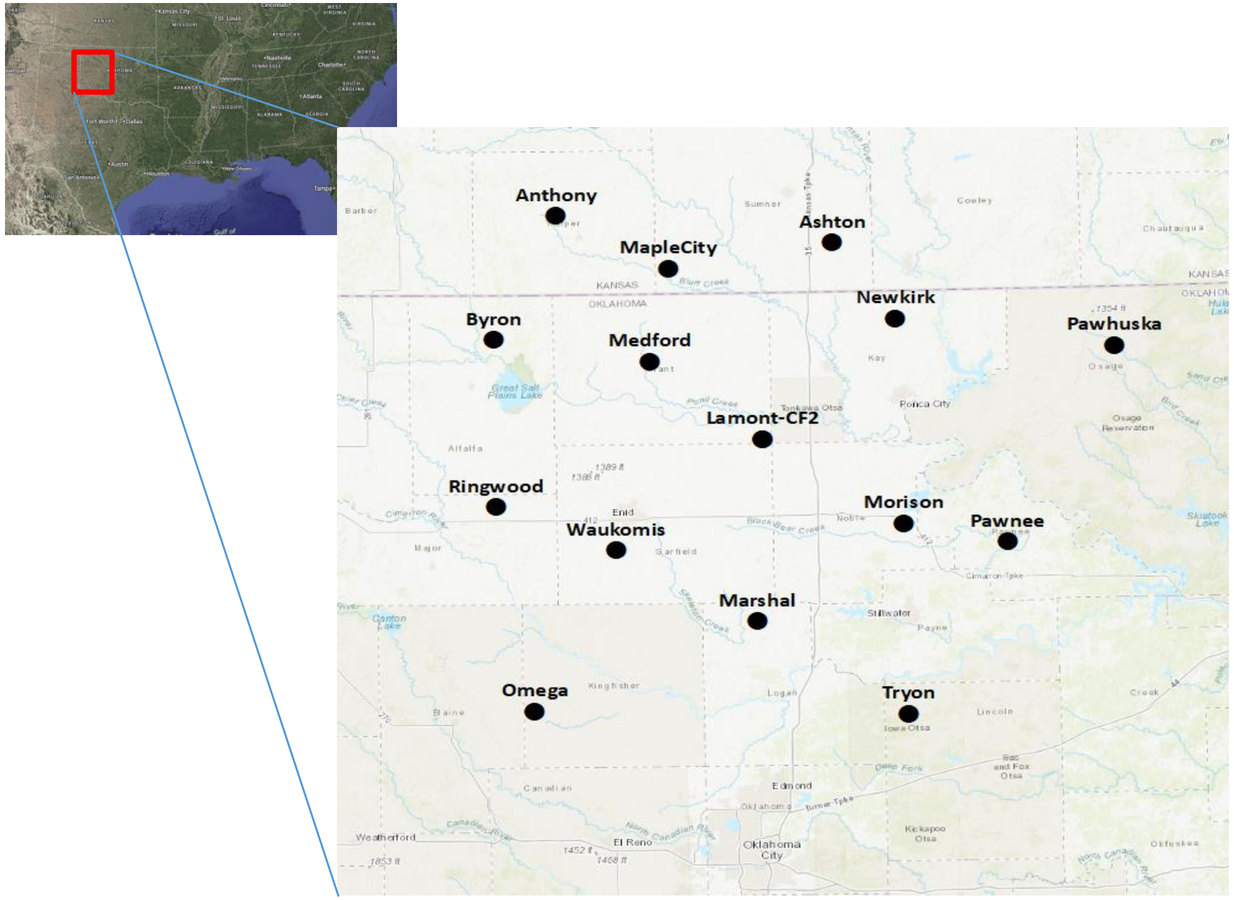
Site 3

Oklahoma

Soil Moisture data from U.S. Department of Energy's Atmospheric Radiation Measurement (ARM) User Facility (https://www.arm.gov/)



Station	longitude	latitude	Land cover
Ashton	-97.26600	37.13300	Grass land
Byron	-98.28500	36.88100	Grass Land
Lamont-CF1	-97.48500	36.60500	Grass Land
Lamont-CF2	-97.48800	36.60700	Grass Land
MapleCity	-97.76060	37.06940	Grass land
Marshal	-97.51120	36.11660	Grass land
Medford	-97.81990	36.81900	Grass land
Morison	-97.06905	36.37354	Grass land
Newkirk	-97.08200	36.92600	Grass land
Omega	-98.17300	35.88000	rainfed
Pawhuska	-96.42700	36.84100	Grass land
Pawnee	-96.76203	36.31937	Grass land
Ringwood	-98.28400	36.43100	Grass land
Tryon	-97.06950	35.86150	Grass land
Waukomis	-97.92800	36.31100	Grass land

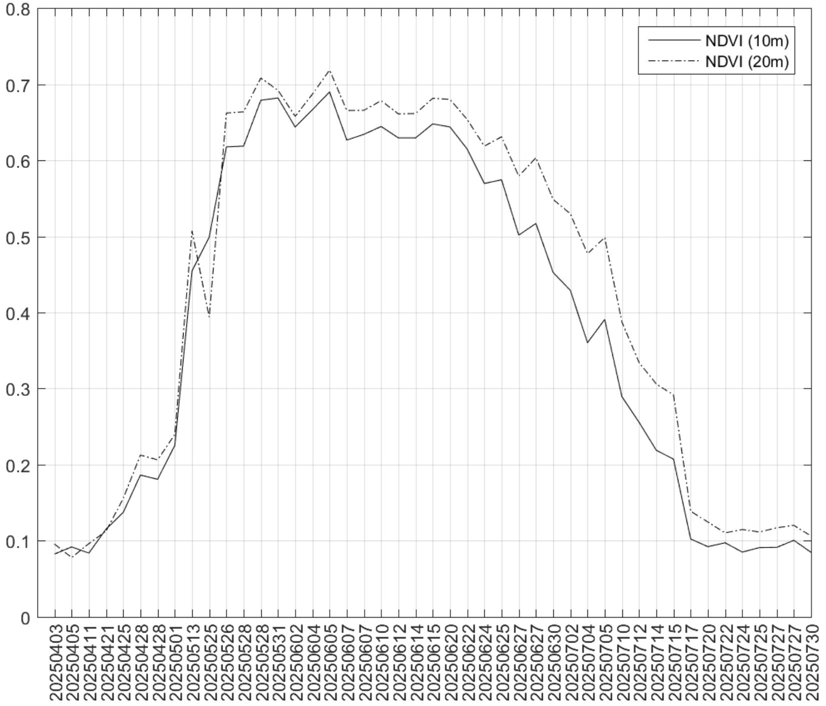
Hydraprobe II Sdi-12 E; 0.05 m

Site 4

Bari, Italy

Potato

15/04/2025 → 15/07/2025

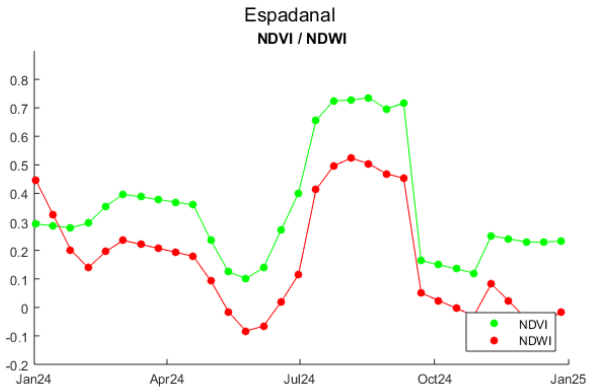


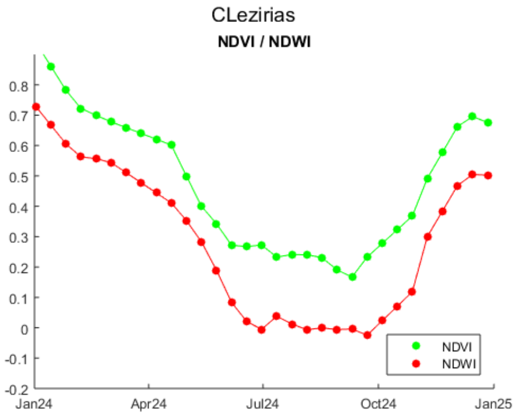
Data processing

Sentinel-2

24 jan 2024 ➔ 29 dec 2024

Compute NDVI for each date
NDVI Interpolated for S1 dates





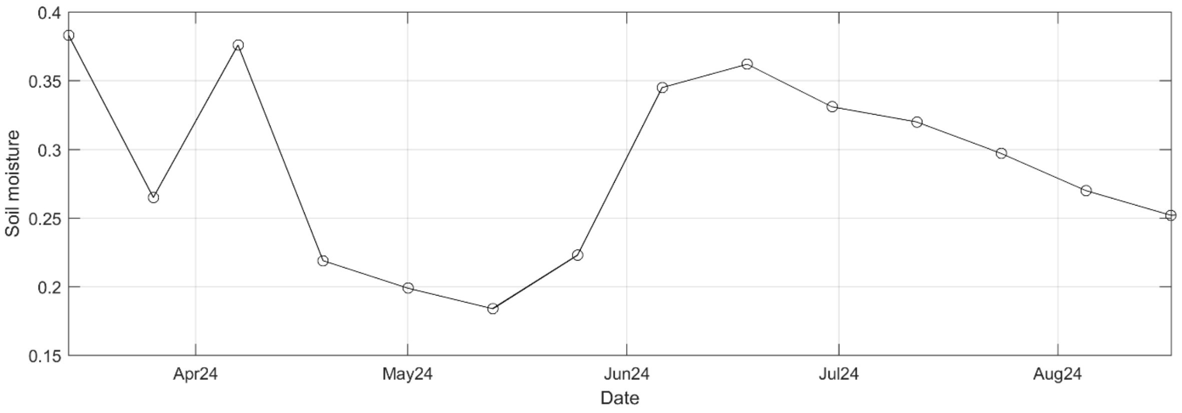
Max (dif NDVI))

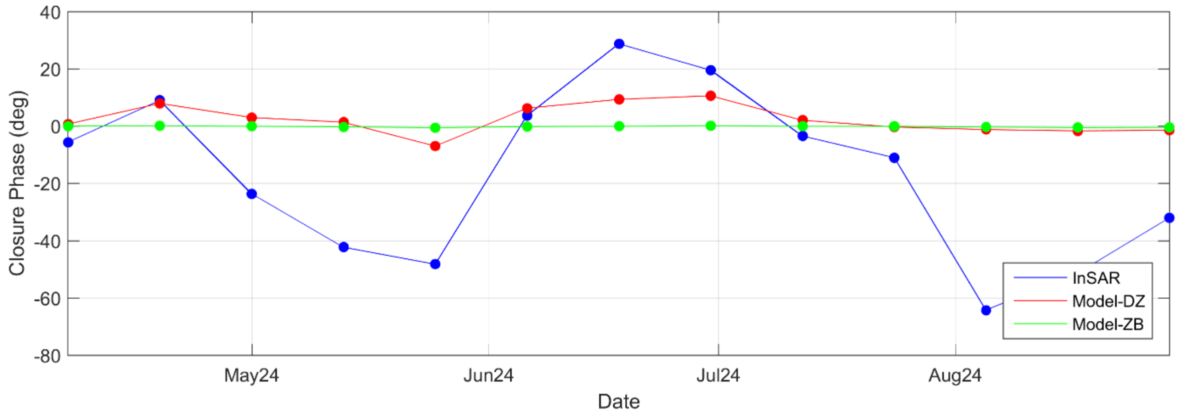
Sentinel-1

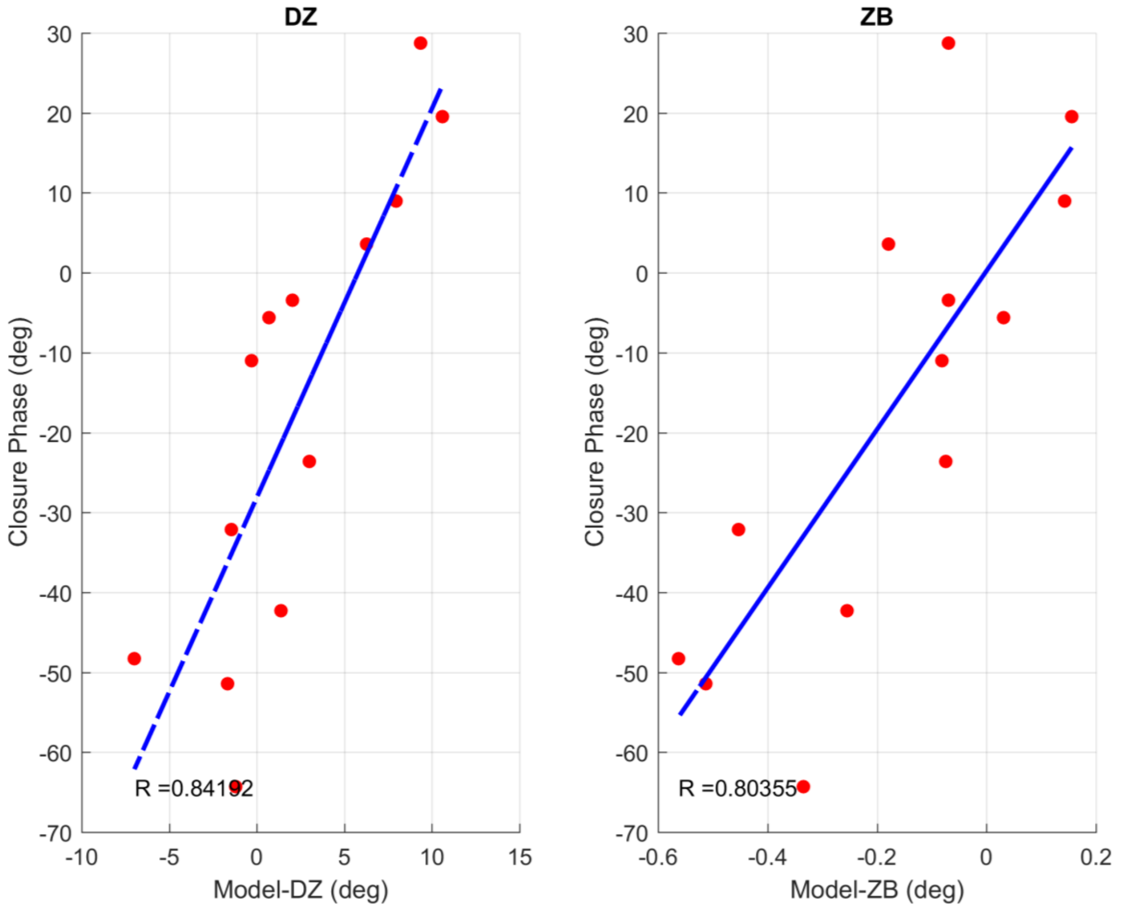
- Multiple Interferograms with different temporal baseline (max time lag =3)
- Topographic phase removal
- Multilook: 8x32
- Goldstein filter
- Terrain Correction (georeferenced images)

- Decorrelation phases
- Closure phases for every three consecutive interferograms

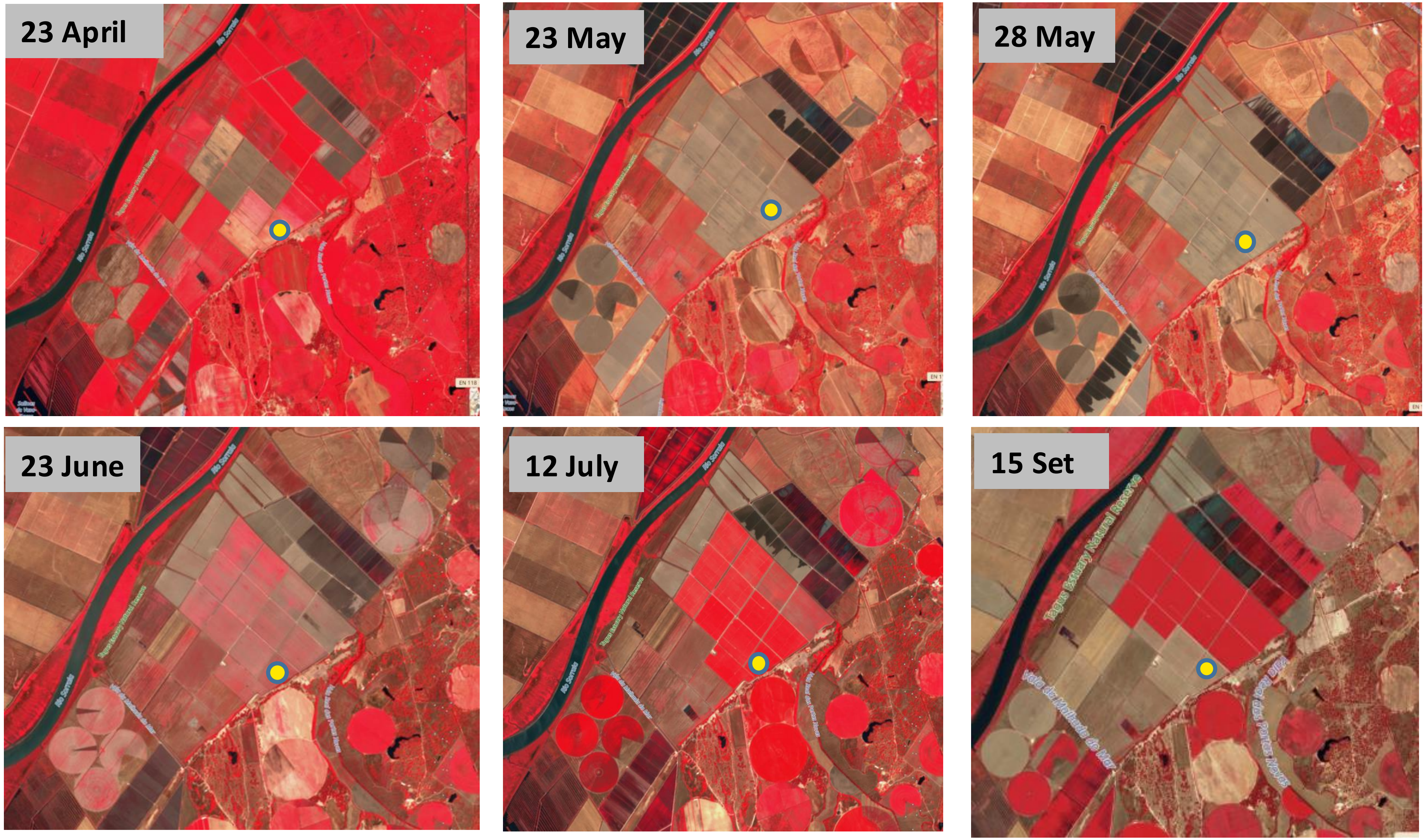
Espadanal (corn)



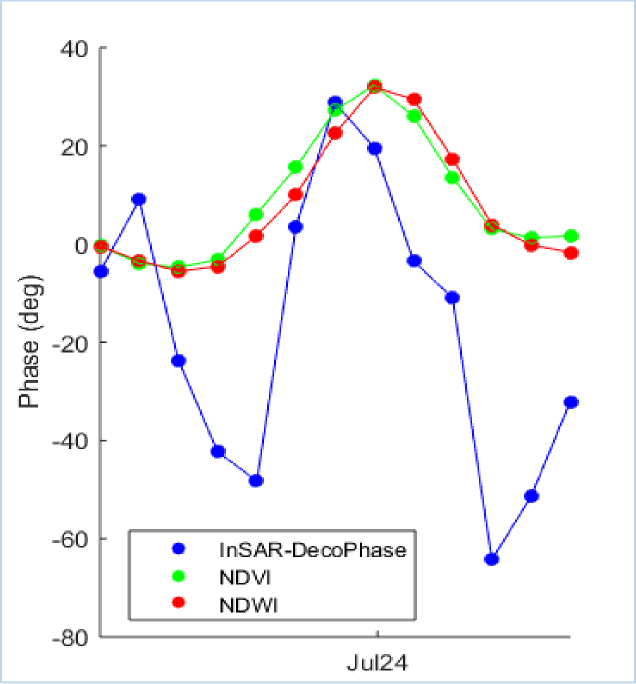


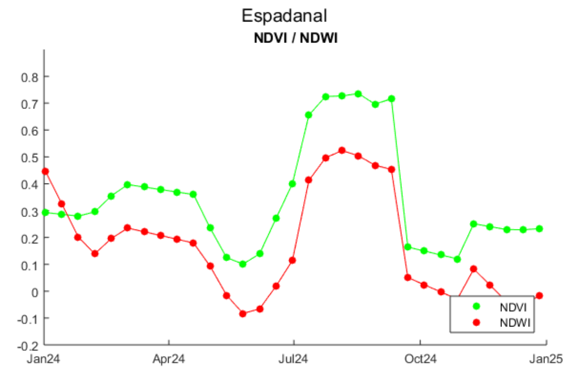


Espadanal (corn)

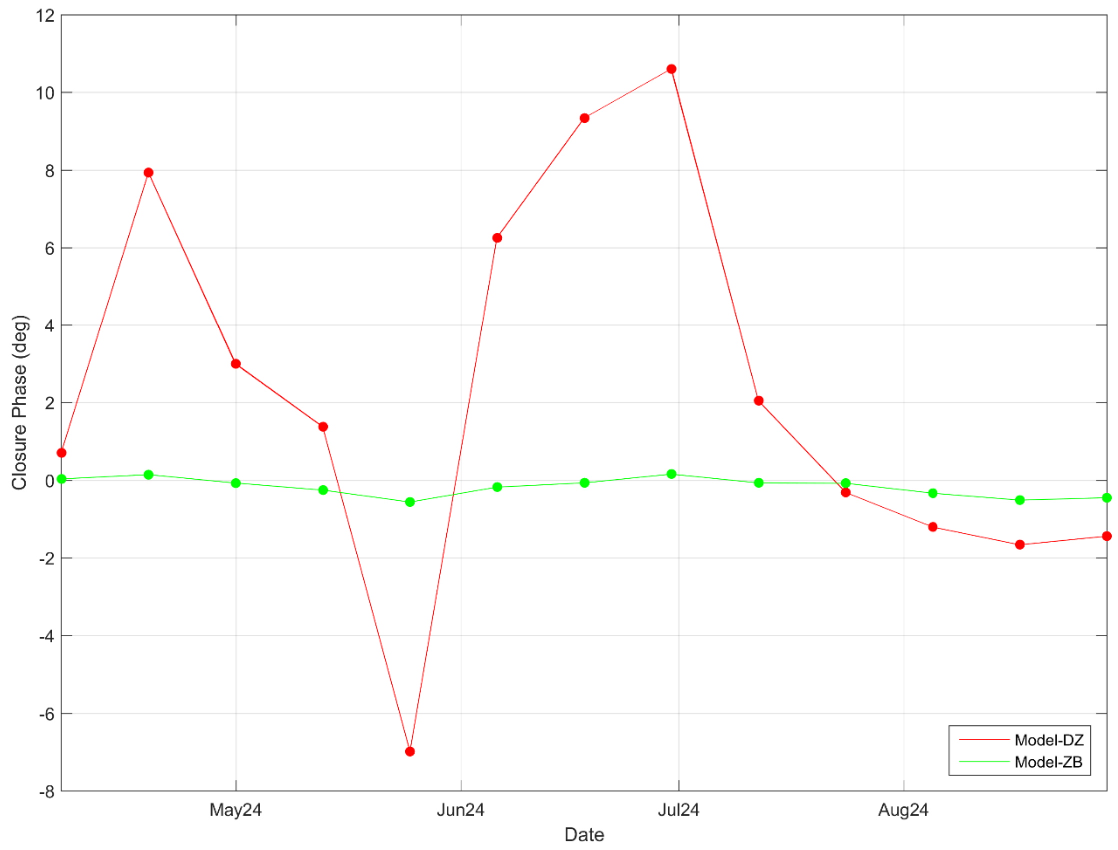


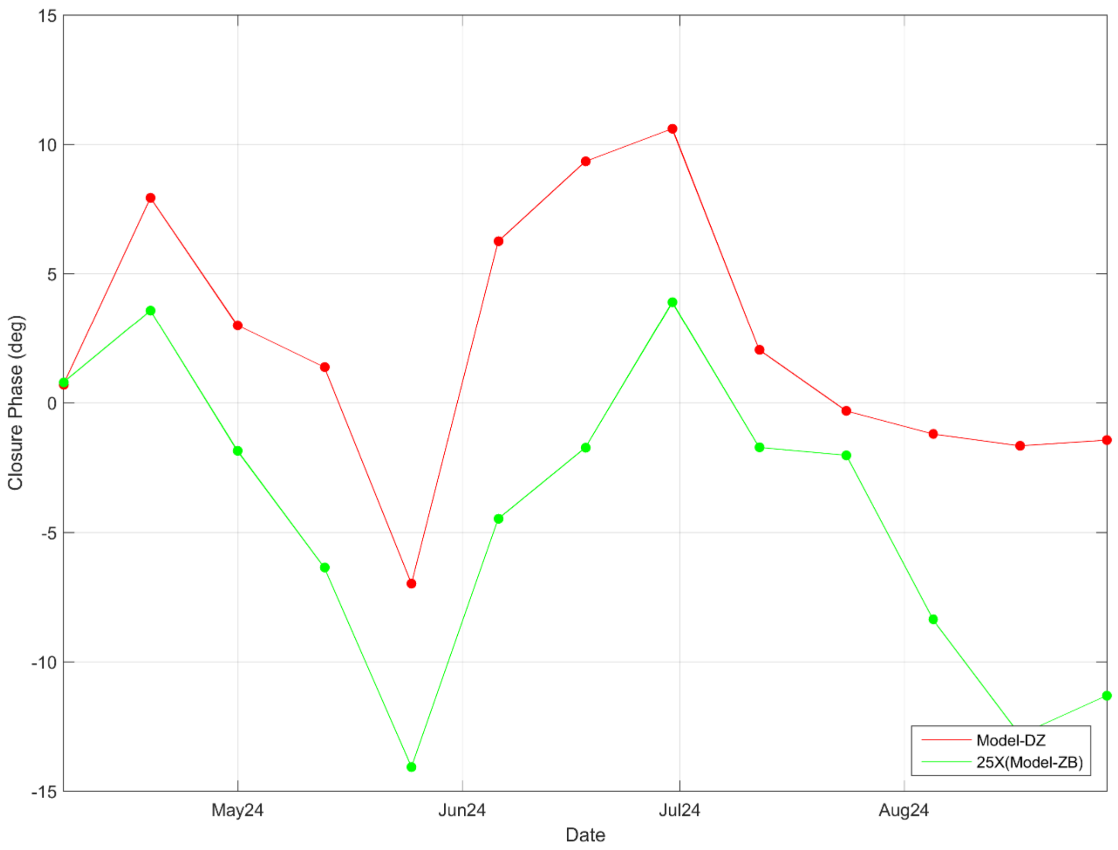
False color (IV, R, G)





Espadanal (corn)





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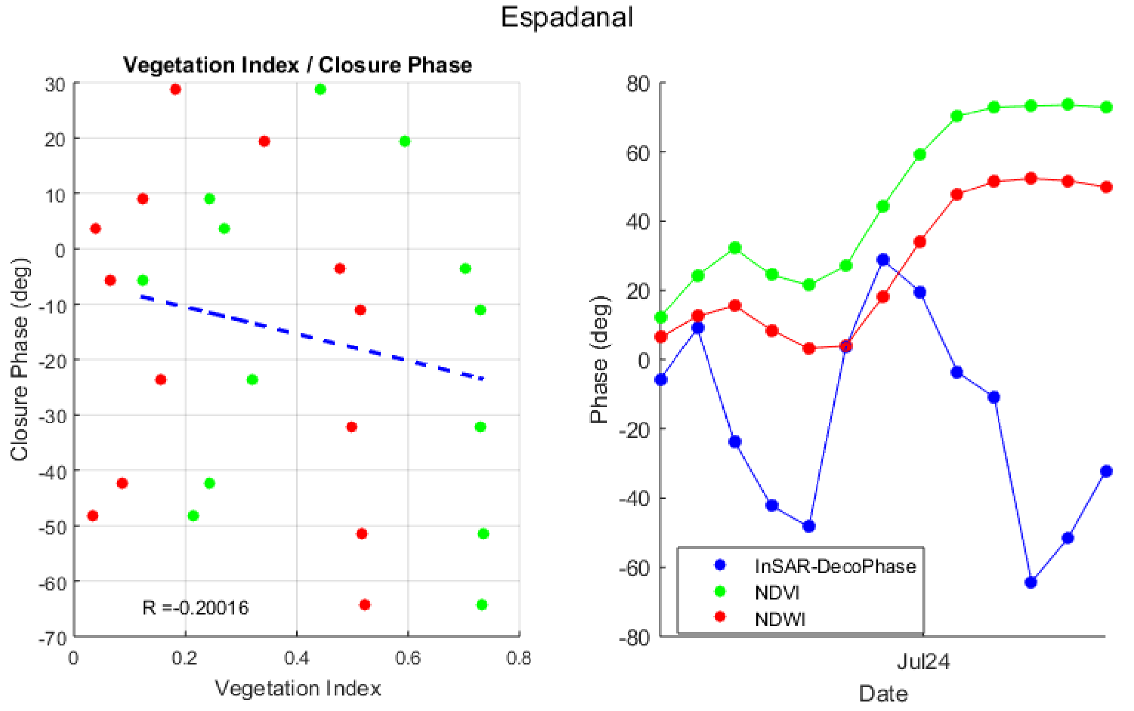
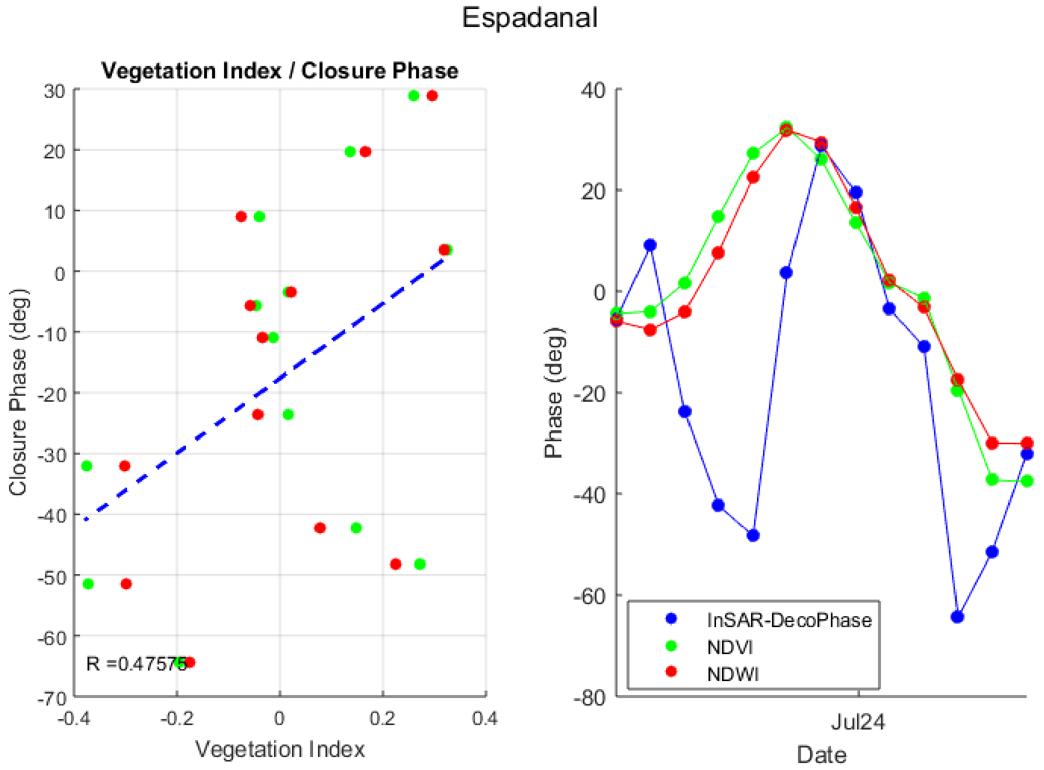
Espadanal (corn)

Comparison with the max (NDVI (1,2,3))

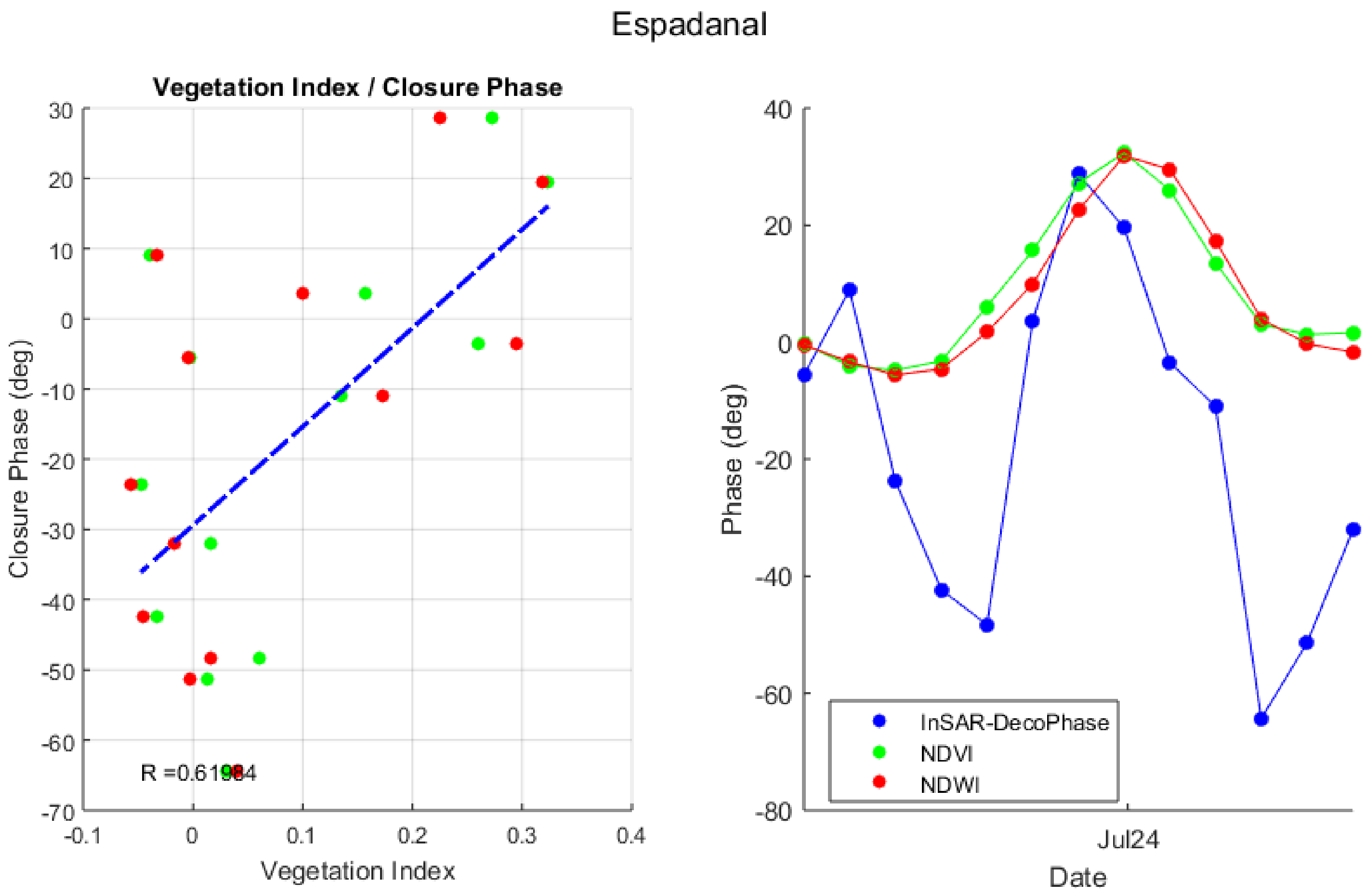


Comparison with NDVI difference (1-3)



N. Mira et al, IEEE JSTARS, 17, 3850-3859, 2024

Espadanal (corn)

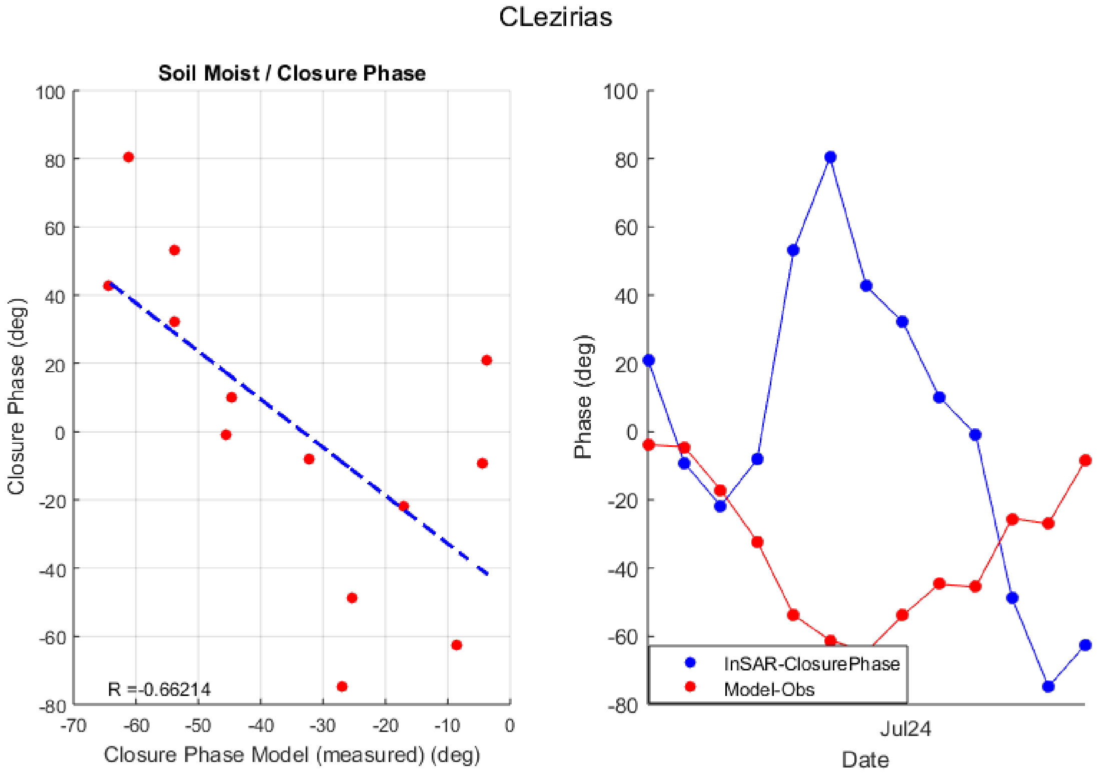


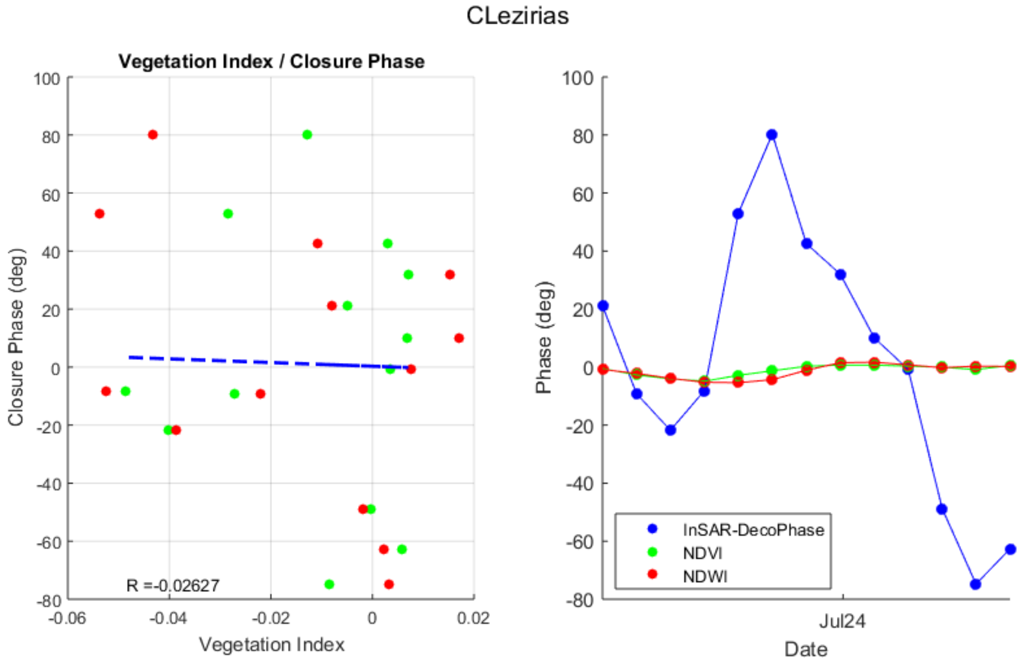
Comparison with NDVI

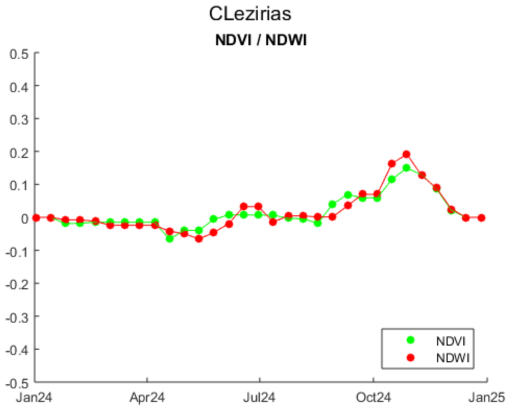
maximum difference
(1-2; 1-3; 2-3)

Lezirias (grass – bare soil)

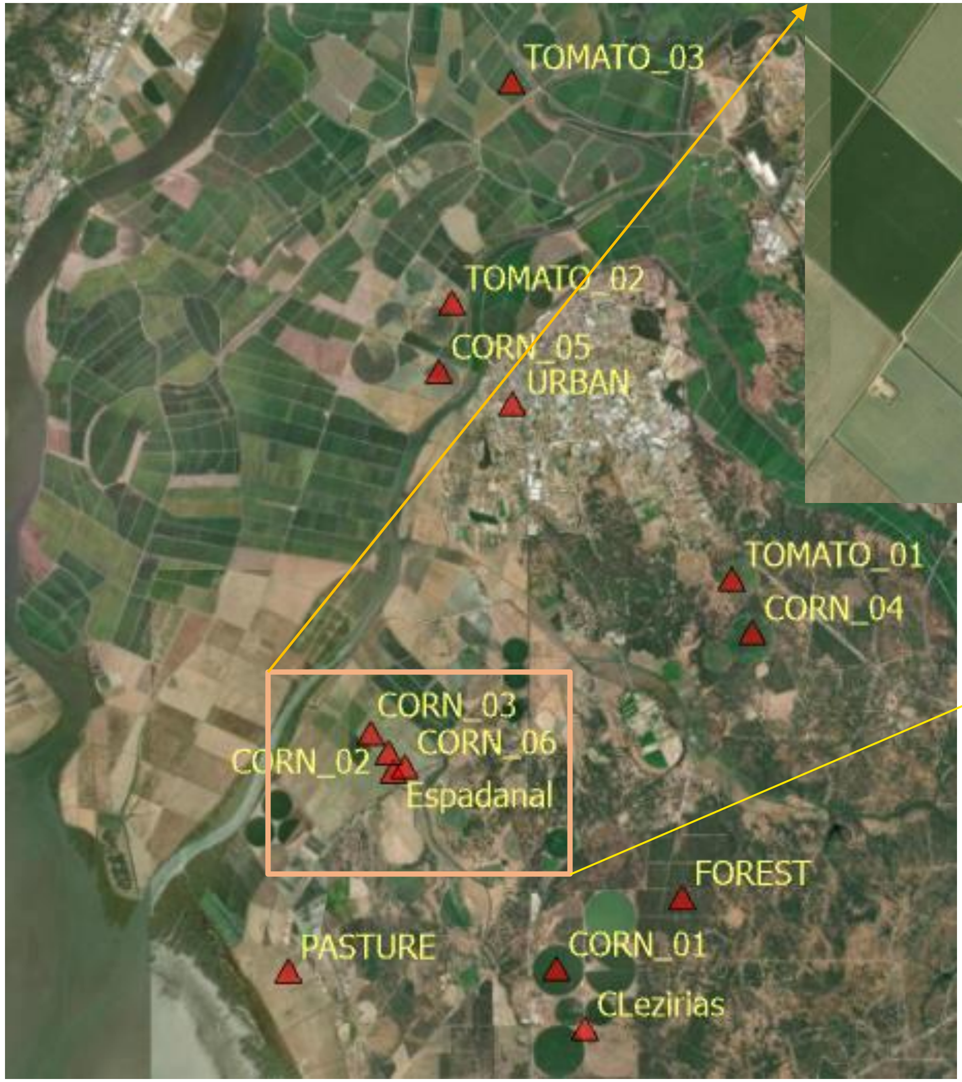
(grass - bare soil)







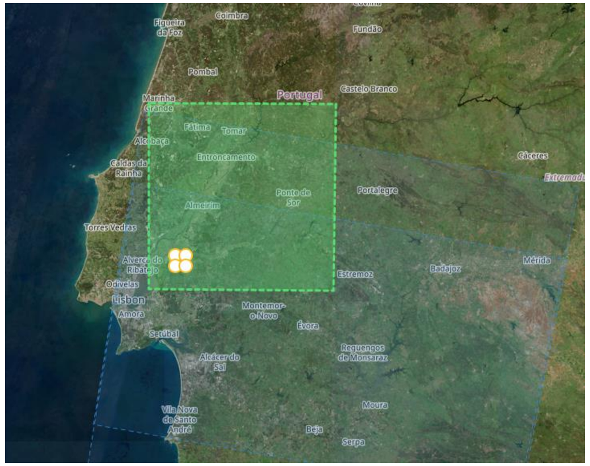
Lisbon area: vegetation



Sentinel-1

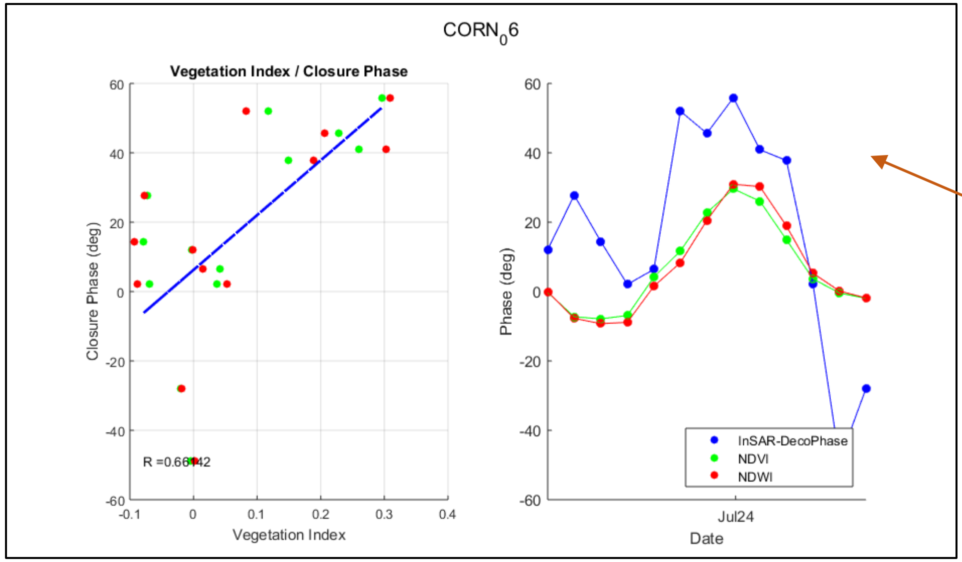
Path 52, Descending, 03 Nov 2023 to 04 Oct 2024

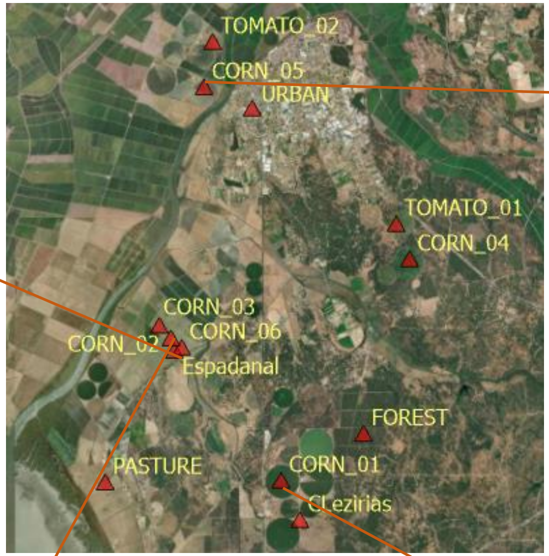
Sentinel-2

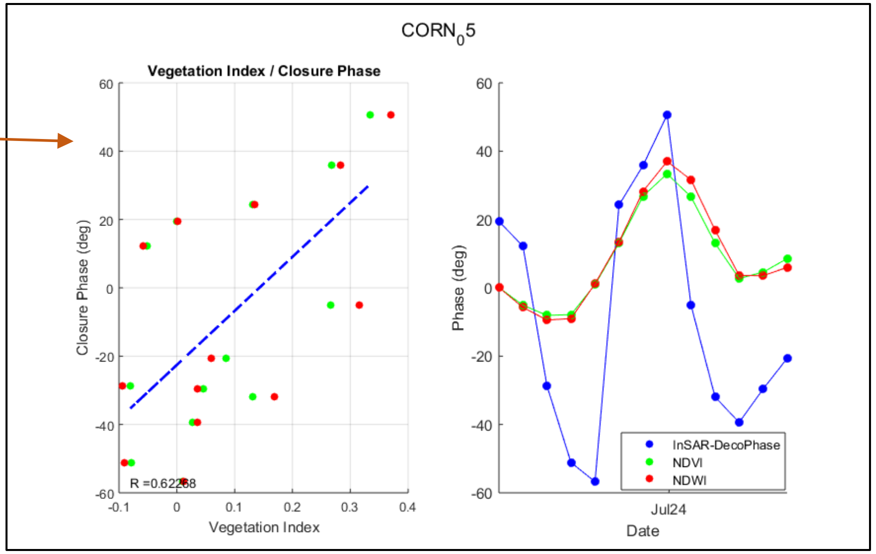


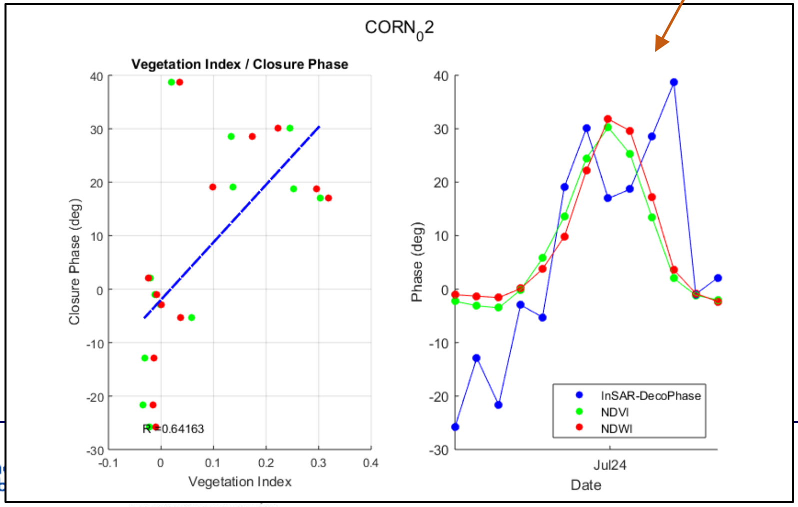
Lisbon area: vegetation

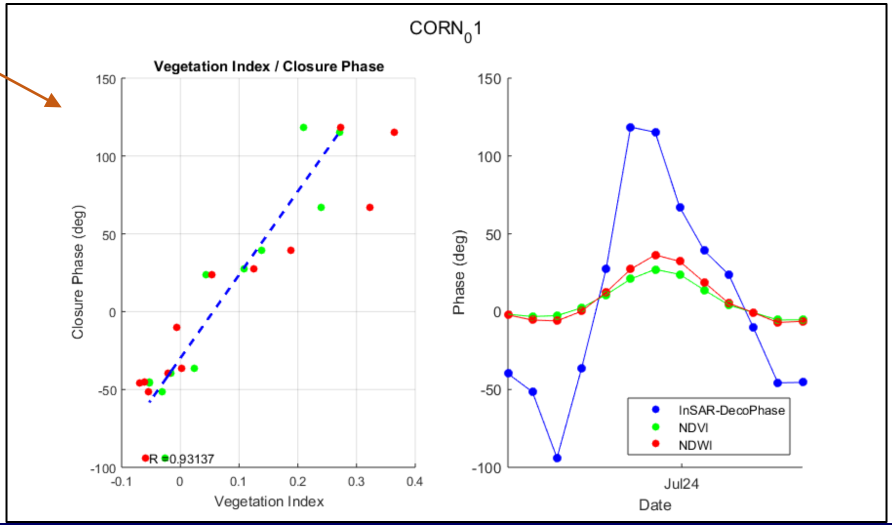
Vegetation



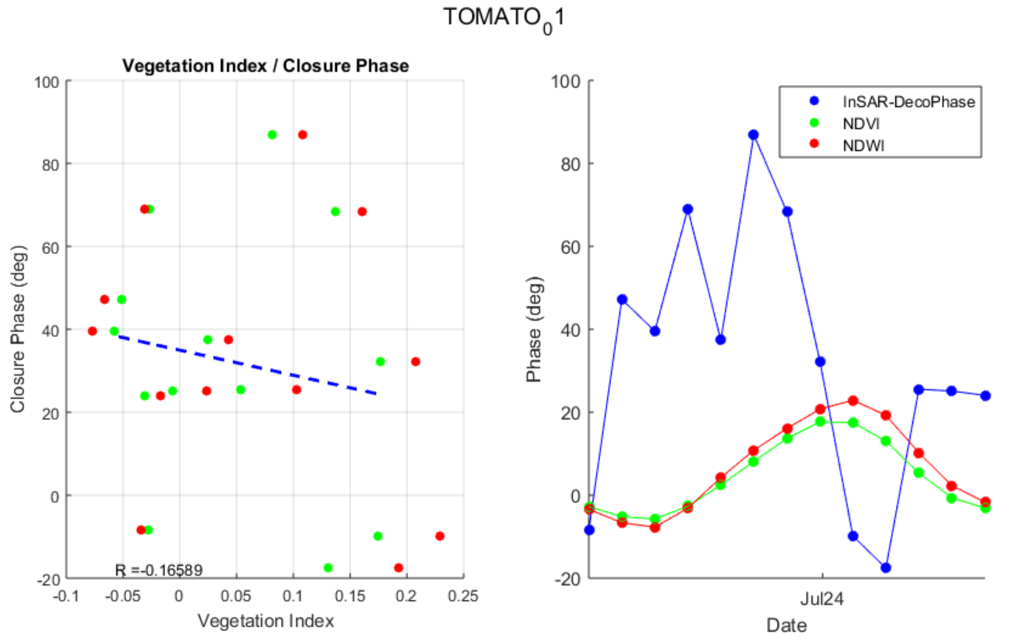


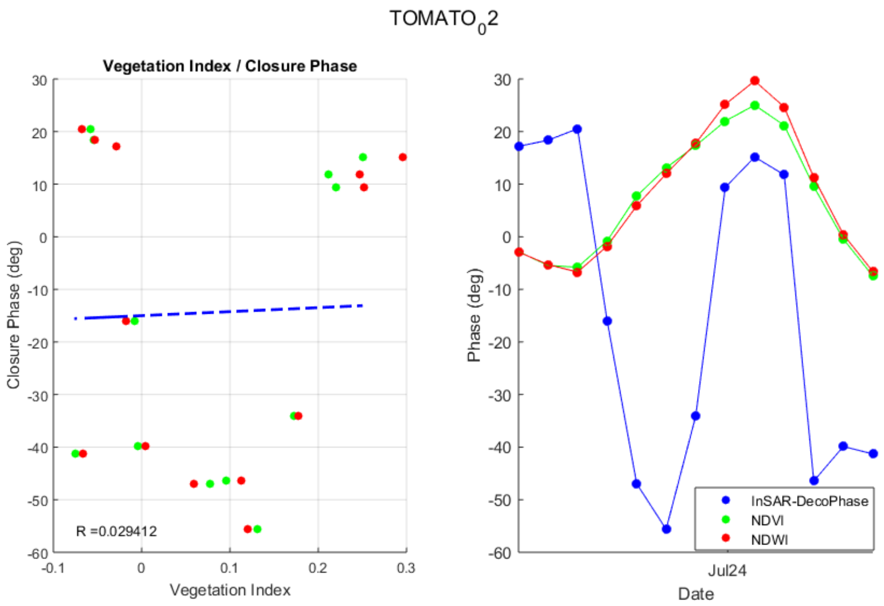


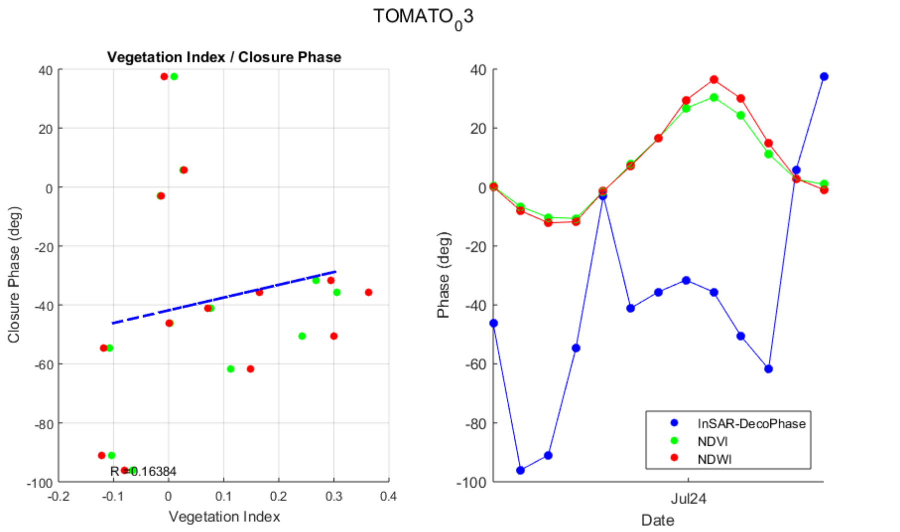


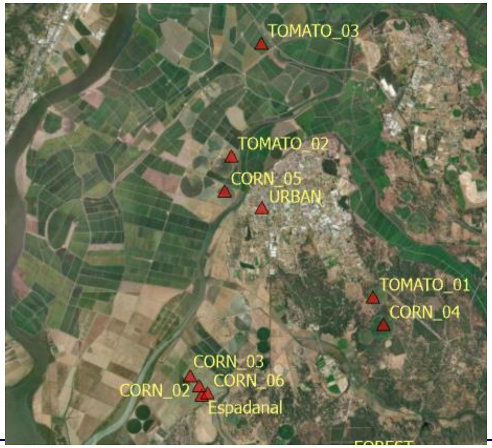


Lisbon area: vegetation

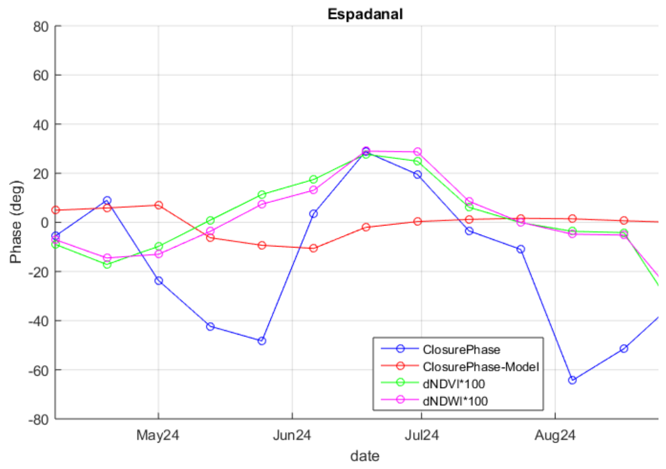


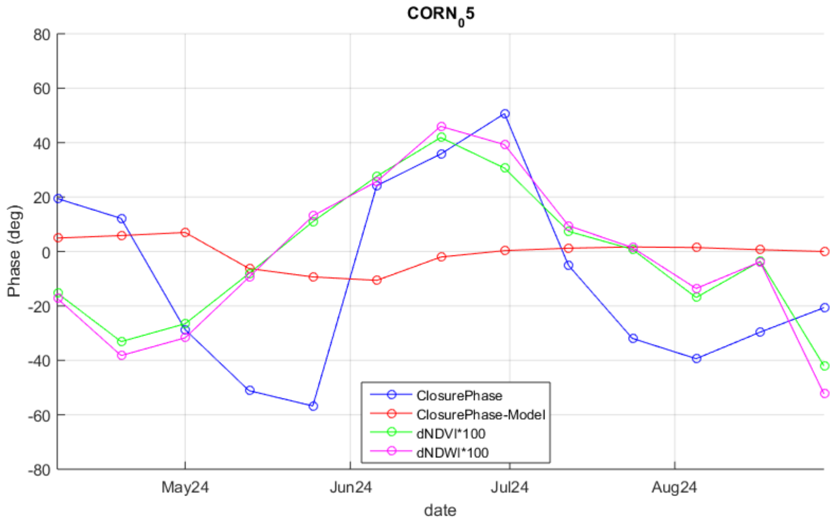


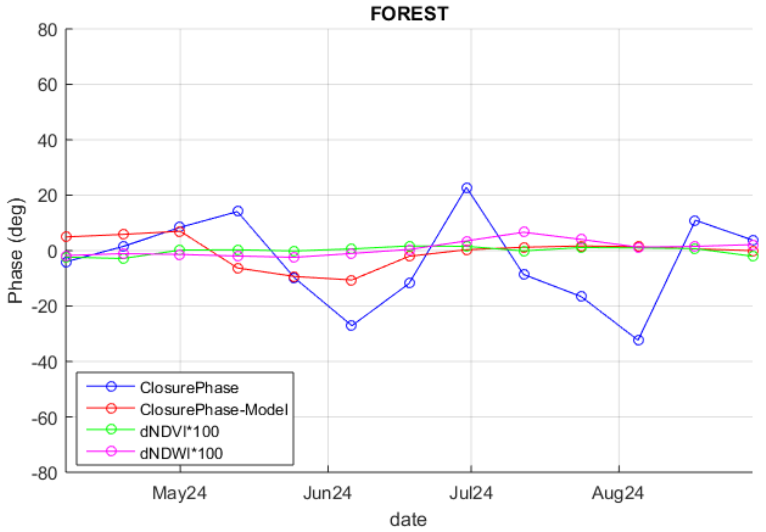


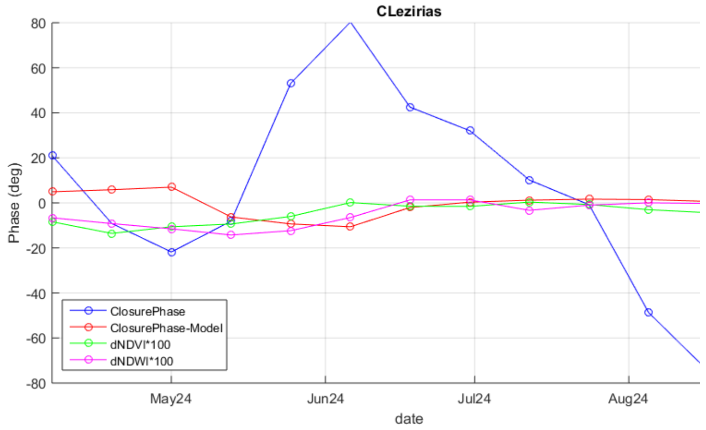


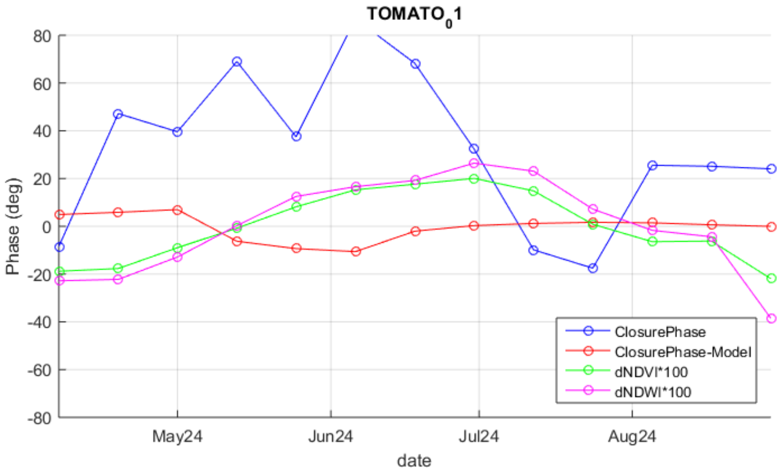
Lisbon area (vegetation): summary & remarks

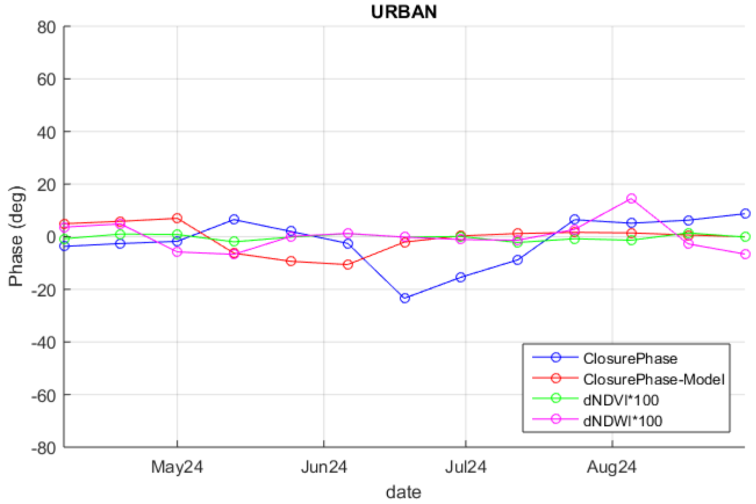








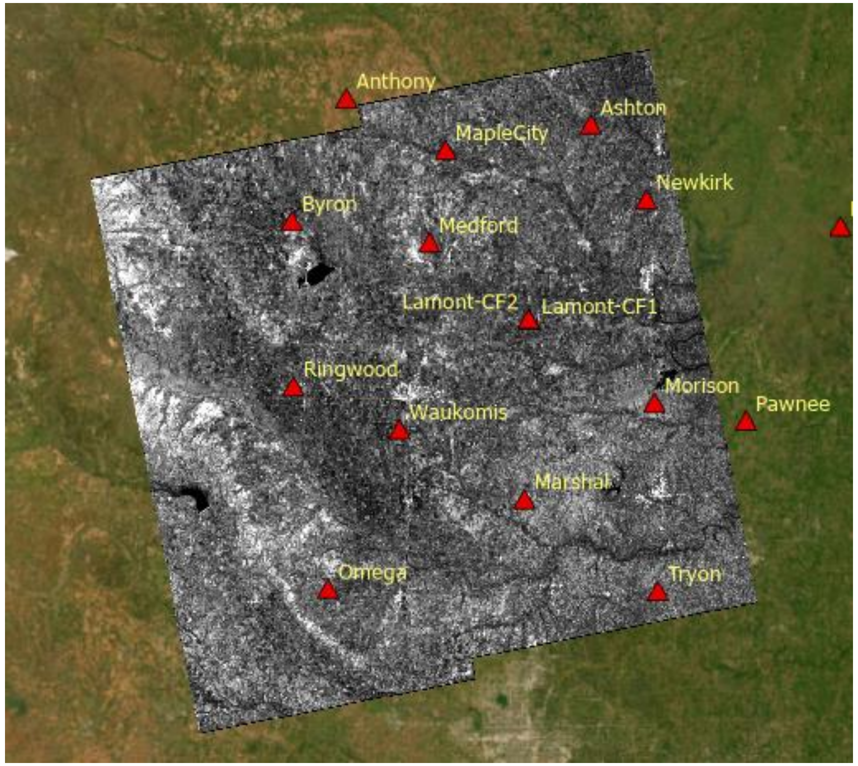




Oklahoma: results

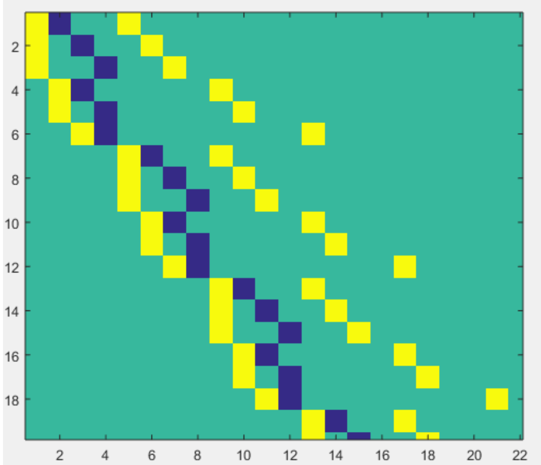
Sentinel-1

Path 34, Ascending, 14 March 2017 to 27 Dec 2017



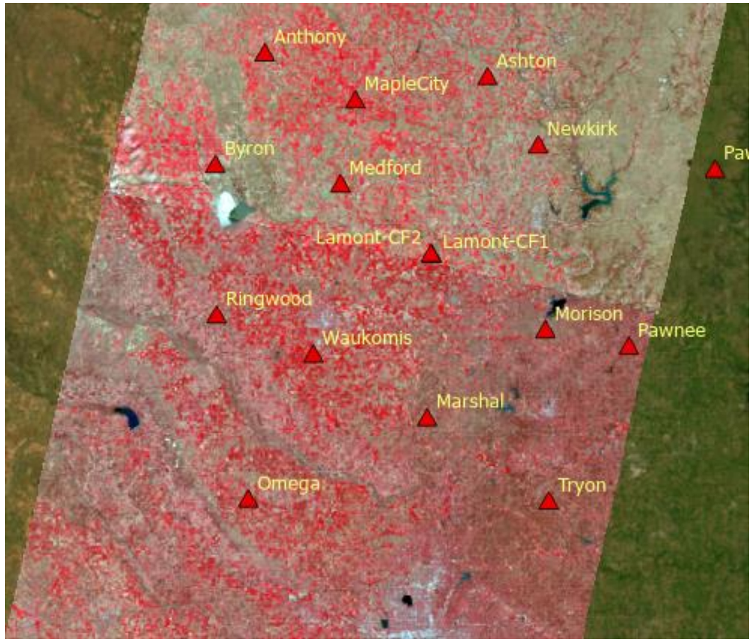
Sentinel-1 Processing

- Multiple Interferograms with different temporal baseline (max time lag =4; 72 interferograms)
- Topographic phase removal
- Multilook: 8x 32
- Goldstein filter
- Terrain Correction (georeferenced images)
- Decorrelation phases
- Closure phases for every three consecutive interferograms



Landsat

Path 28 , row 34 and 35



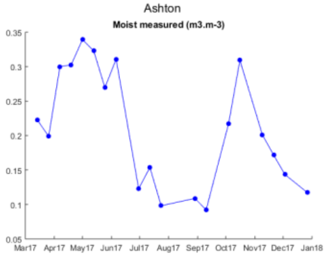
Landsat Images

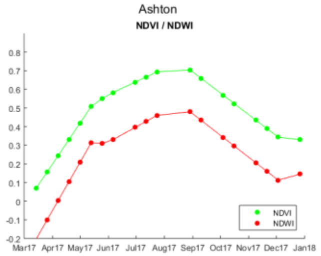
10.03.2017 to 19.07.2018

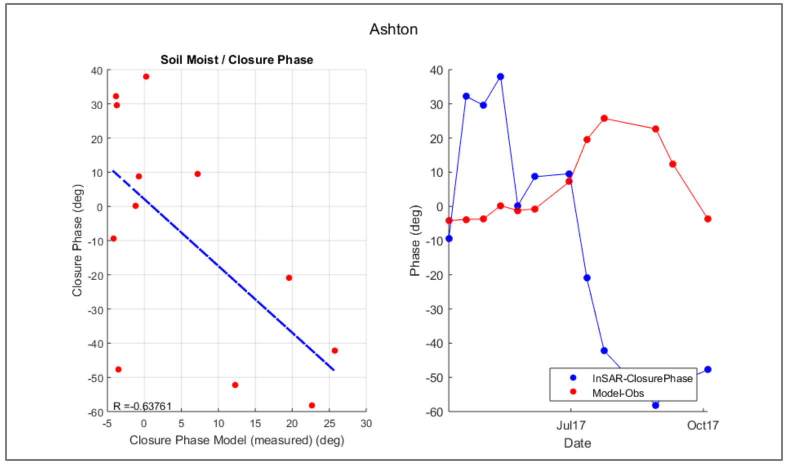
- Mosaic of rows 34 and 35
- Collocation with S1 images
- Interpolation of the vegetation index on the S1 dates

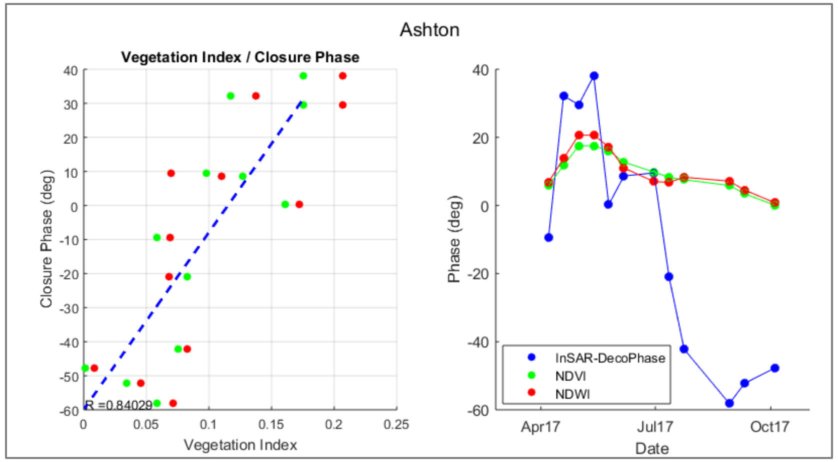
Oklahoma: results

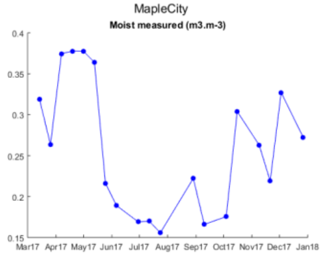
Oklahoma site

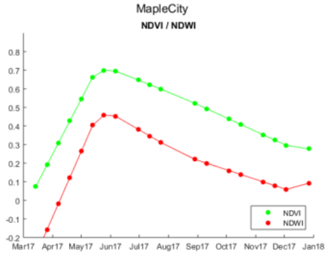


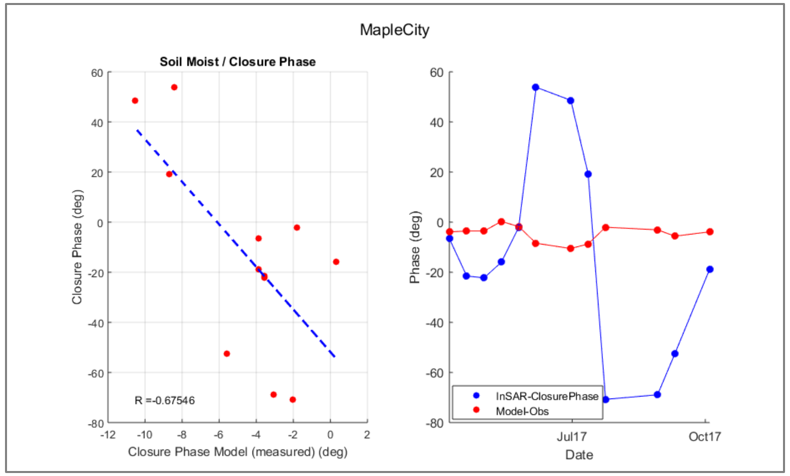


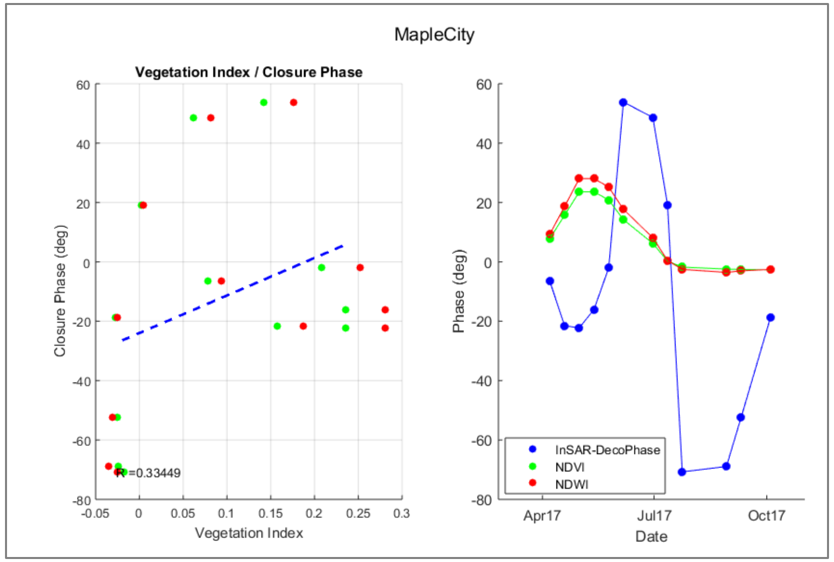




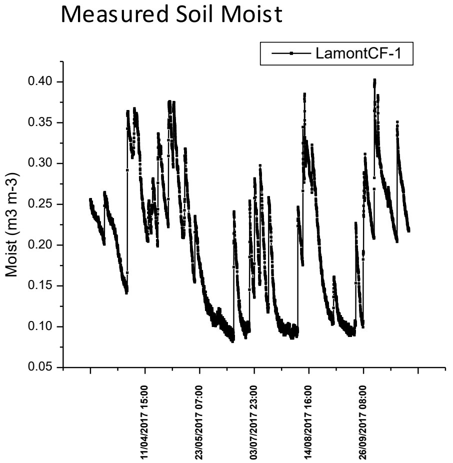


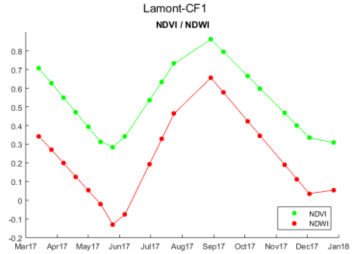


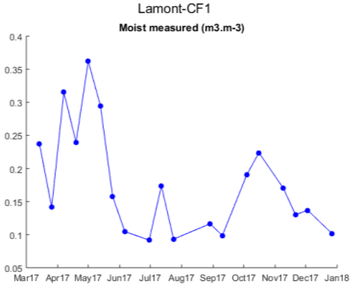


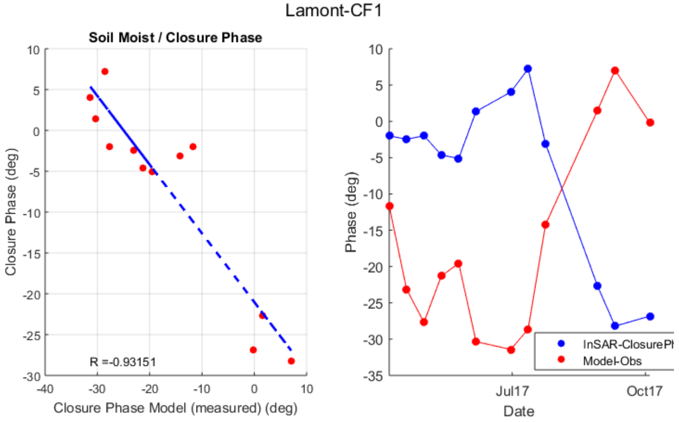


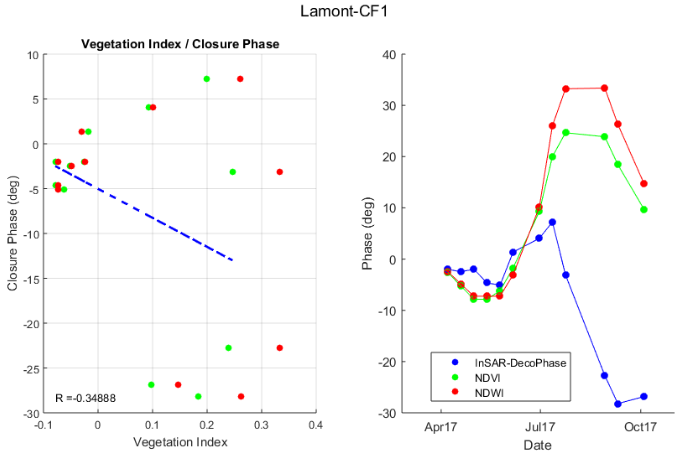
Oklahoma (grass)

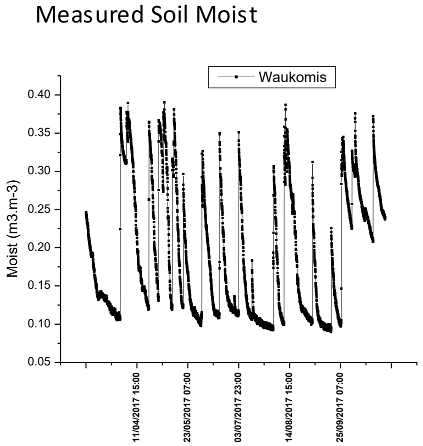


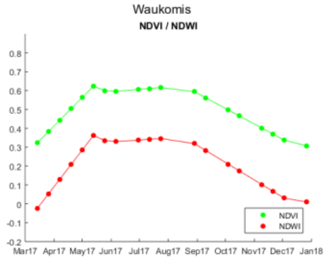


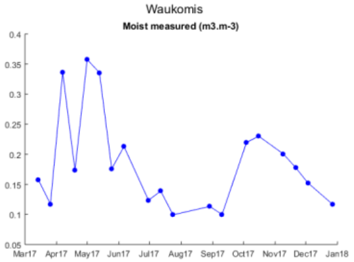


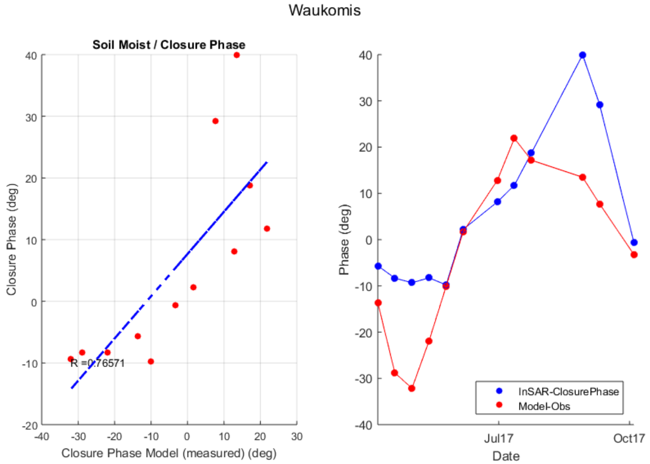


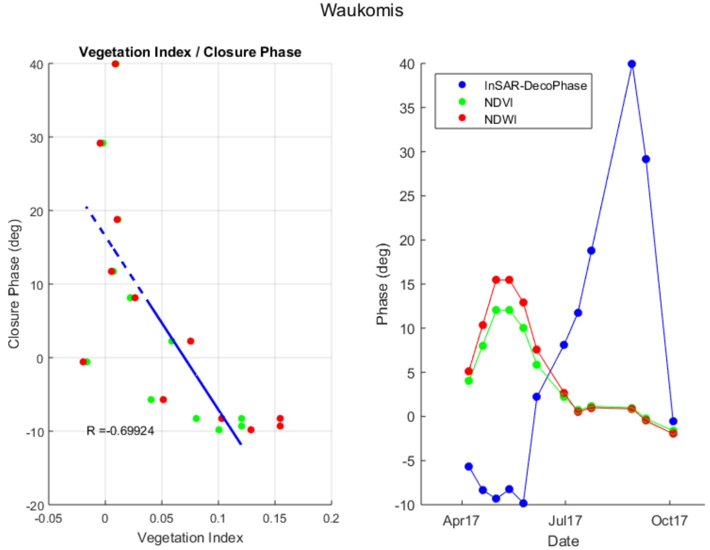




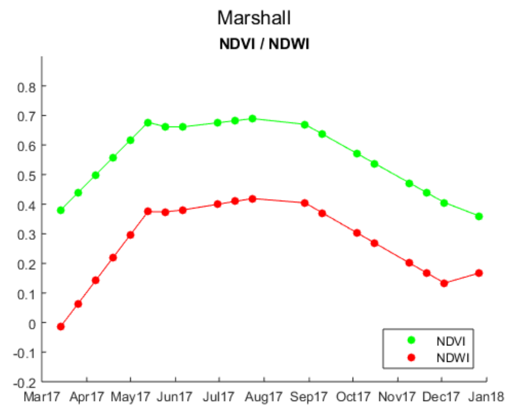


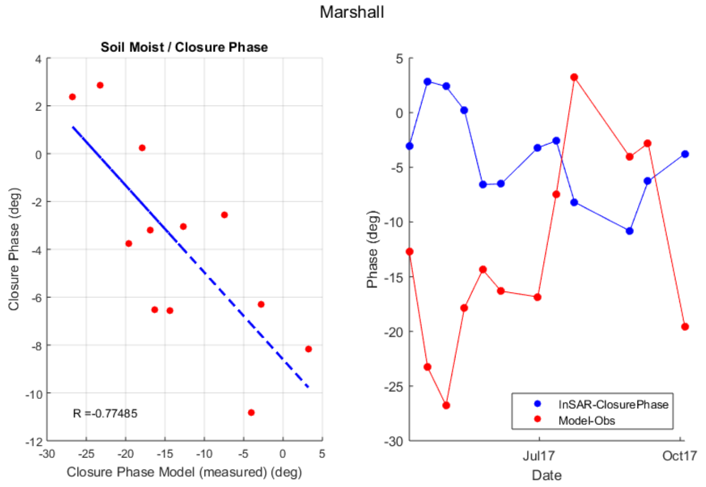


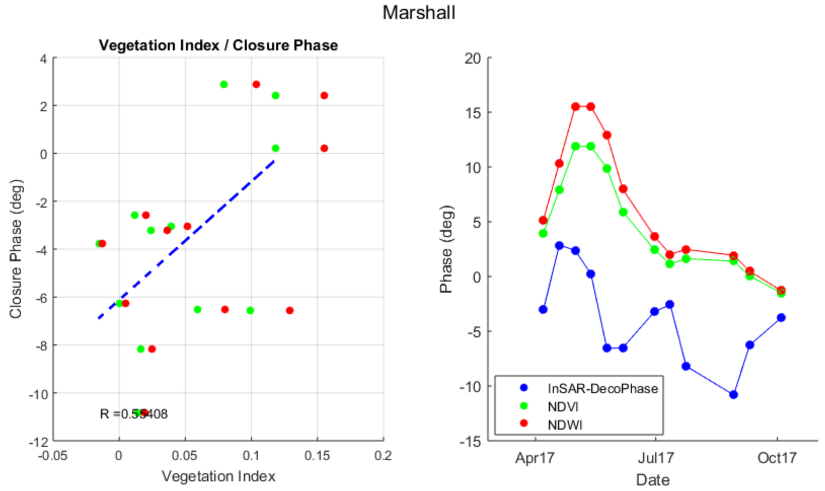


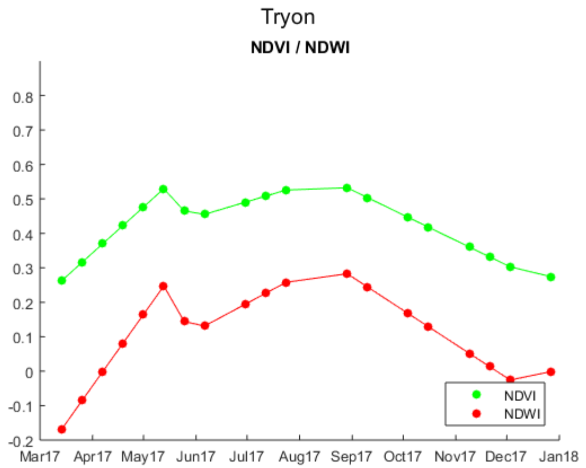


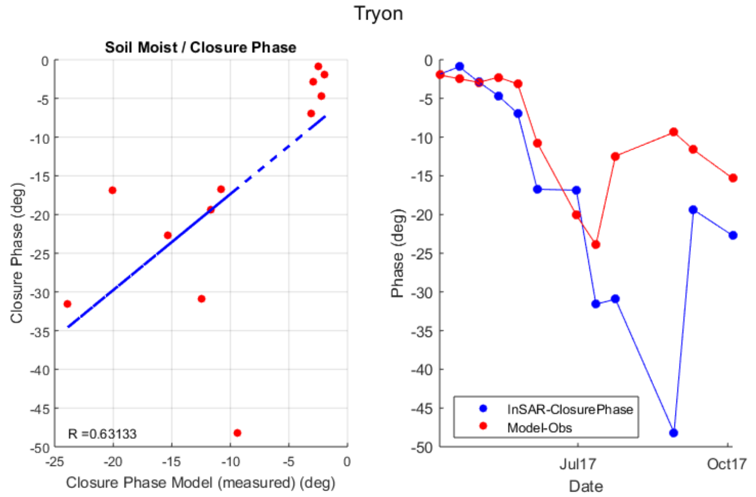
Oklahoma: results

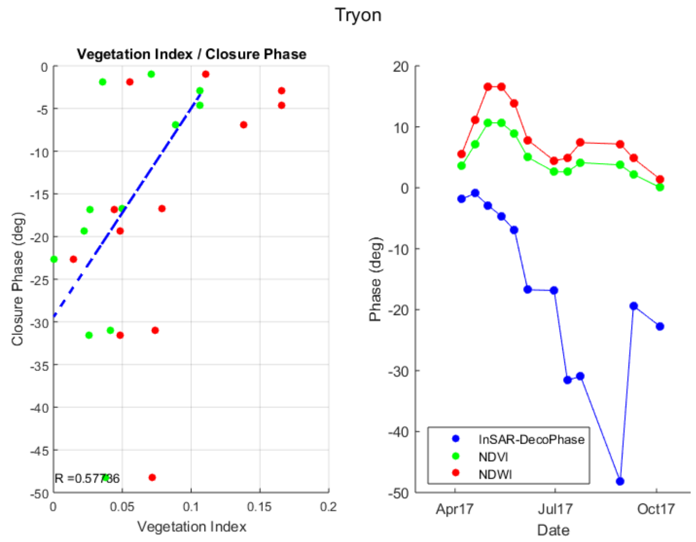












Comments about the models

E. Wig et al, IEEE TGARS, 62, 5212315, 2024

F. DeZan et al, IEEE TGARS, 52(1), 418-425, 2014

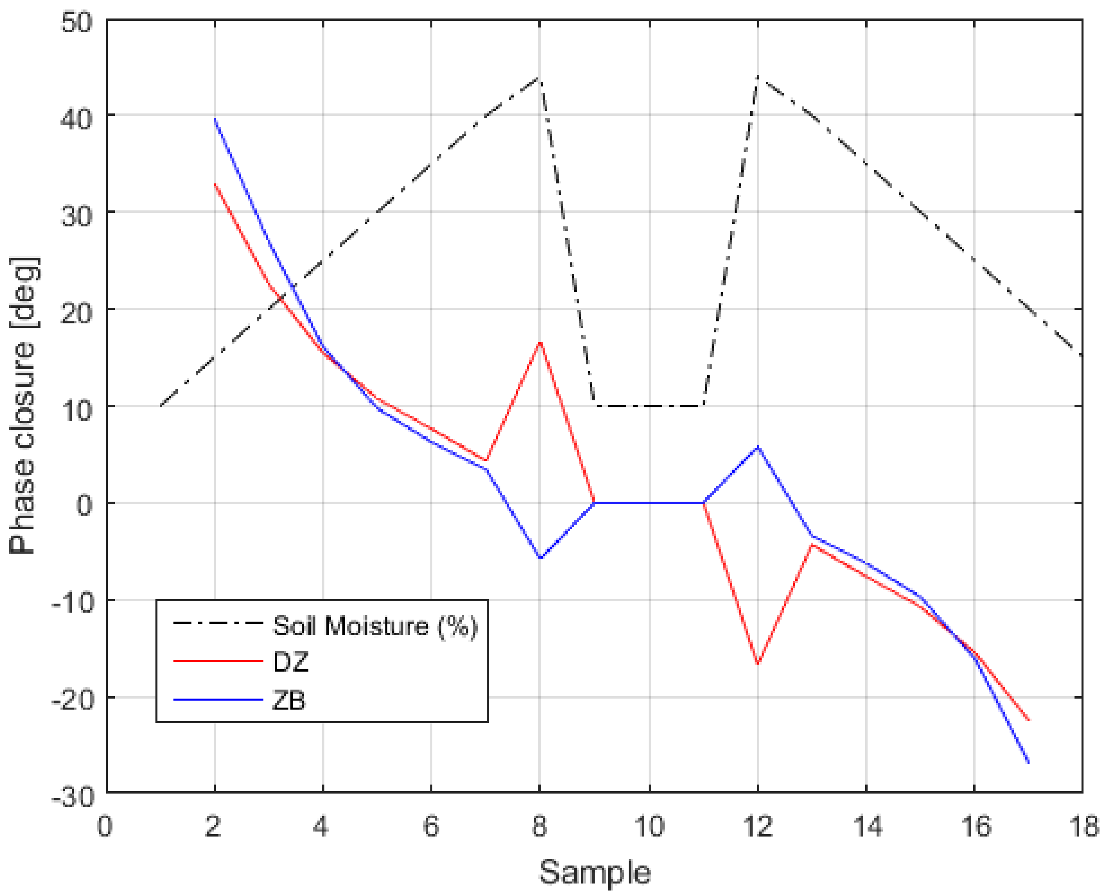
$$s = s_{surf} + s_d \cdot e^{-inx}$$

$$\langle s_1 \cdot s_2^* \rangle = \sigma_{surf}^0 + \sigma_d^0 \cdot e^{-in_1 x + in_2^* x}$$

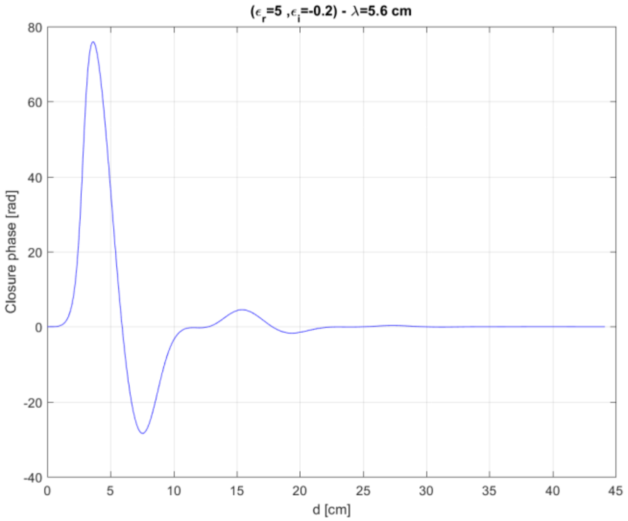
$\sigma_{surf}^0 = 5$

$\sigma_d^0 = 1$

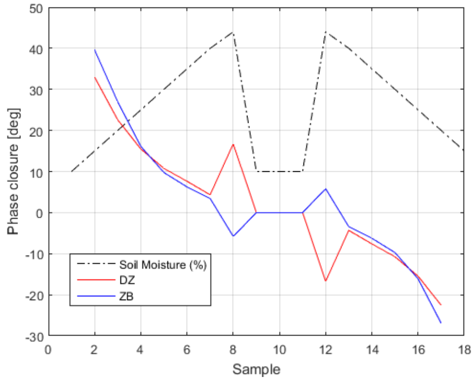
$$x = \frac{4\pi}{\lambda} \cdot d$$

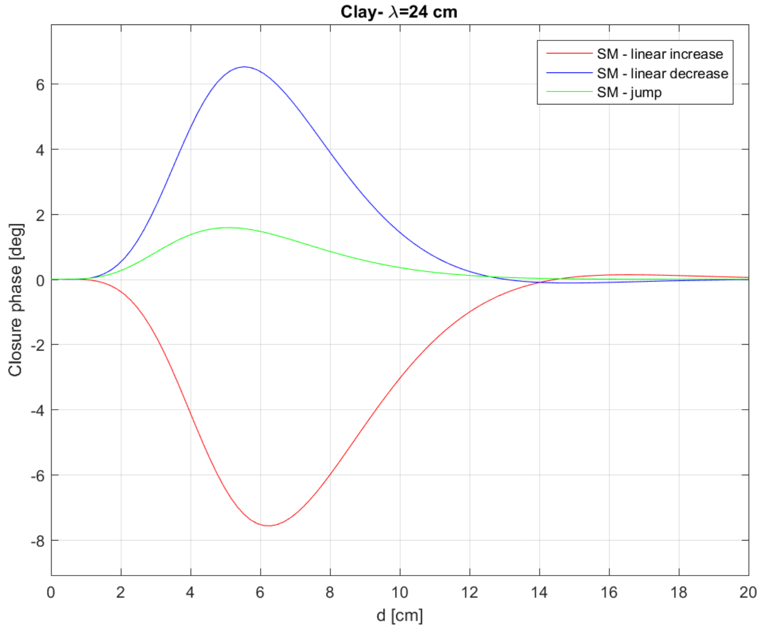


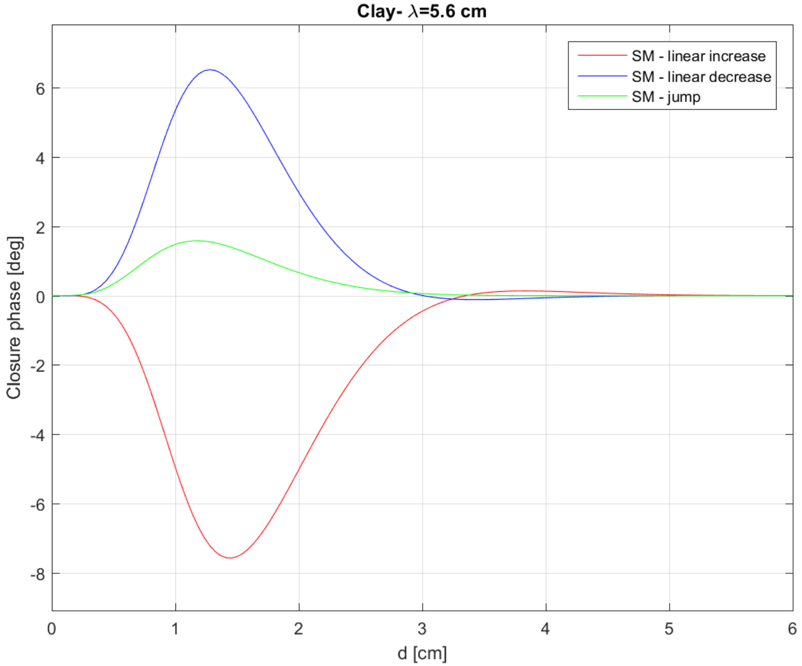
Comments about the models



E. Wig et al, IEEE TGARS, 62, 5212315, 2024







Conclusion and future work

- Phase closure seems to be correlated to soil moisture but only over bare soils
- Over vegetated areas is has been found a correlation between phase closure and the temporal change of vegetation indeces (e.g. NDVI)
- Need for a modelling of the vegetation layer (e.g. Y. Yuan et al. IEEE TGARS, 62, 4411412, 2024)
- Need for more advanced modelling for soil moisture (e.g. W: Gronnemose & B.T. Rabus. IEEE TGARS, 63, 2001612, 2025