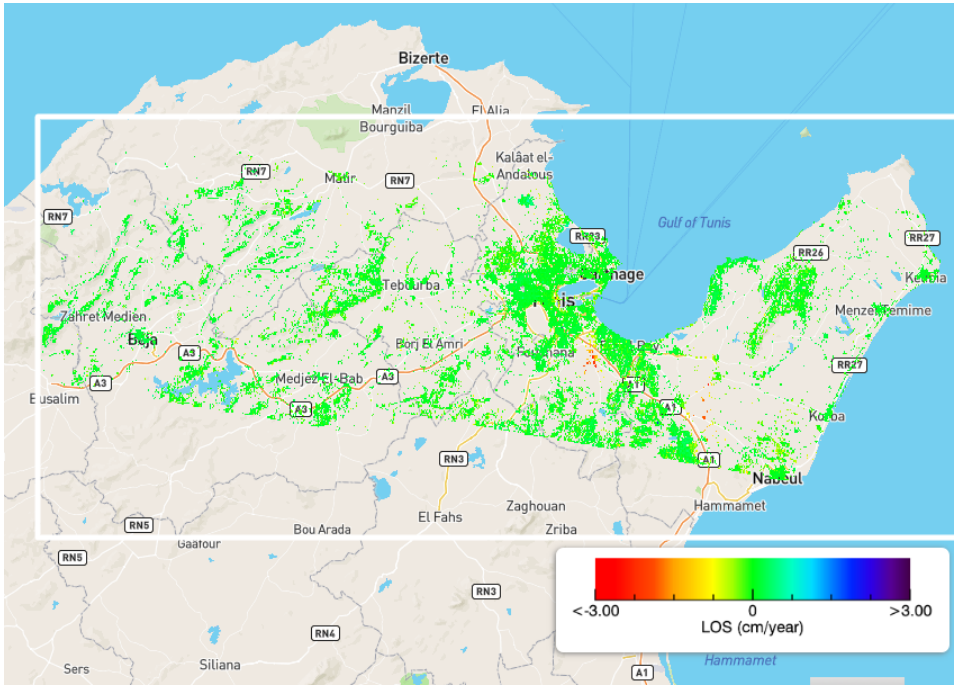
Managing water resources within Mediterranean agrosystems: Contribution of the Interferometric products



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Interest in surface water and groundwater resources mapping

Spanish Police/Handout/Reuters

Spanish police officers document illegal water pipes in Malaga province, Spain in this screen grab from an undated handout video.

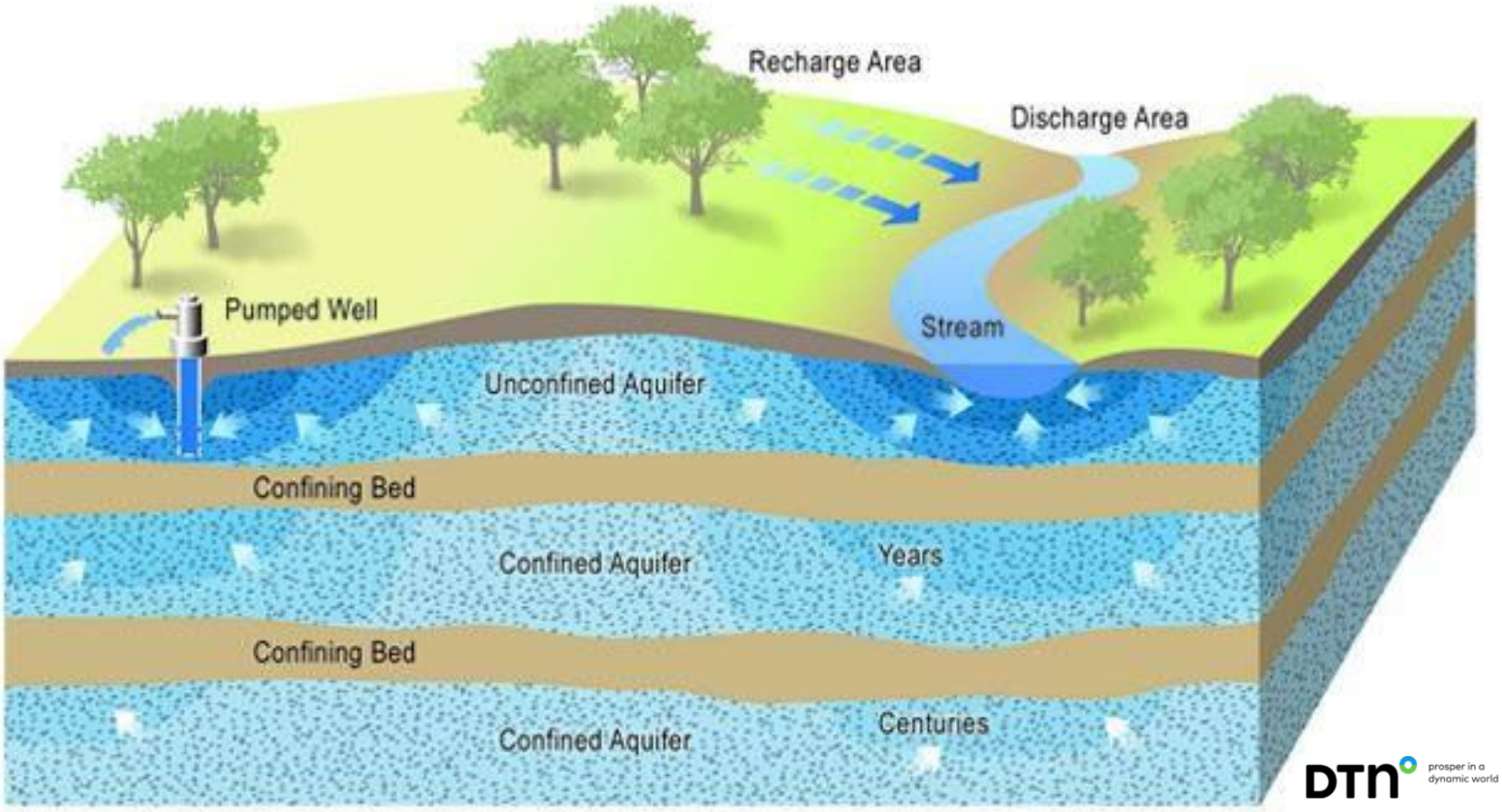
Interest in surface water and groundwater resources mapping

Illegal extensions and pumping stations are "mushrooming". The ground is perforated and gets transformed into a kind of "Swiss cheese", Antonio Santos (16/05/2023): *"In the past four years, we have closed 1116 illegal waterholes".*

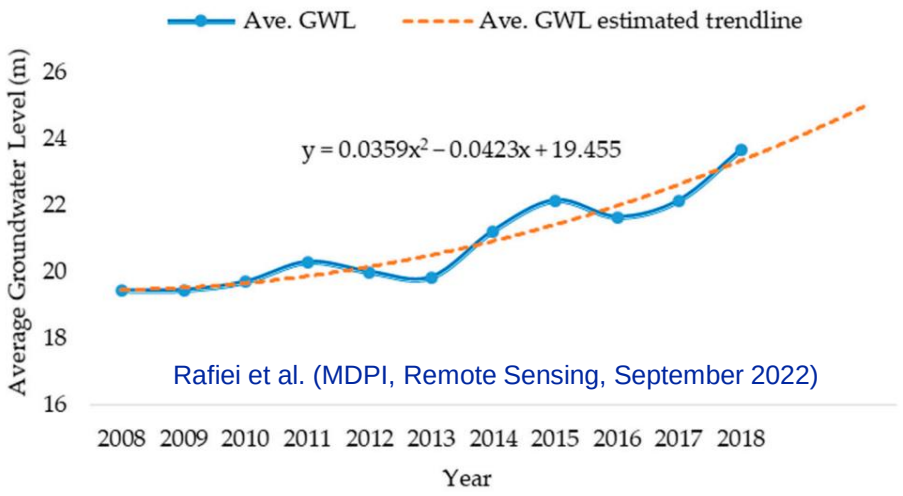
Overexploitation of groundwater resources has been reported in many different parts of the world: How we could manage that ?

Remote sensing data processing and analysis is a relevant challenge in order to address Sustainable Development Goal (SDG)

Interest in surface water and groundwater resources mapping

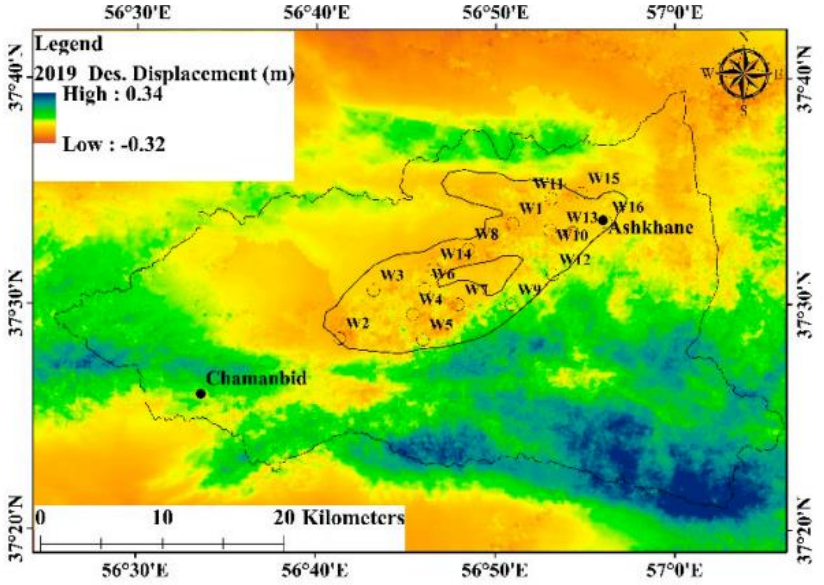


Interest in surface water and groundwater resources mapping



Rafiei et al. (MDPI, Remote Sensing, September 2022)

Fig.1: Average depth of groundwater (GWL: Ground Water level) in Iran



Rafiei et al. (MDPI, Remote Sensing, September 2022)

Fig. 2: Cumulative annual vertical displacement maps for 2015–2020 (Iran)

- Land subsidence is in proportion to changes in the groundwater table and the compatible layer thickness (Rafiei et al., 2022).

Problem:

But, how is the recharge rate with respect to the rate of groundwater extraction ?

Interest in surface water and groundwater resources mapping

- The solution for this problem has been studied for a critic arid study area in Tunisia.
- The study period was between july 2017 and July 2022. Thus 154 interferometric Sentinel-1 SLC images were selected for more accurate change detection.
- More than 1300 interferogram were generated. This was not possible without a powerfull tool like Geohazards-TEP. Such tool was offered for us thanks to the NoR sponsored project (27280f).

Outline

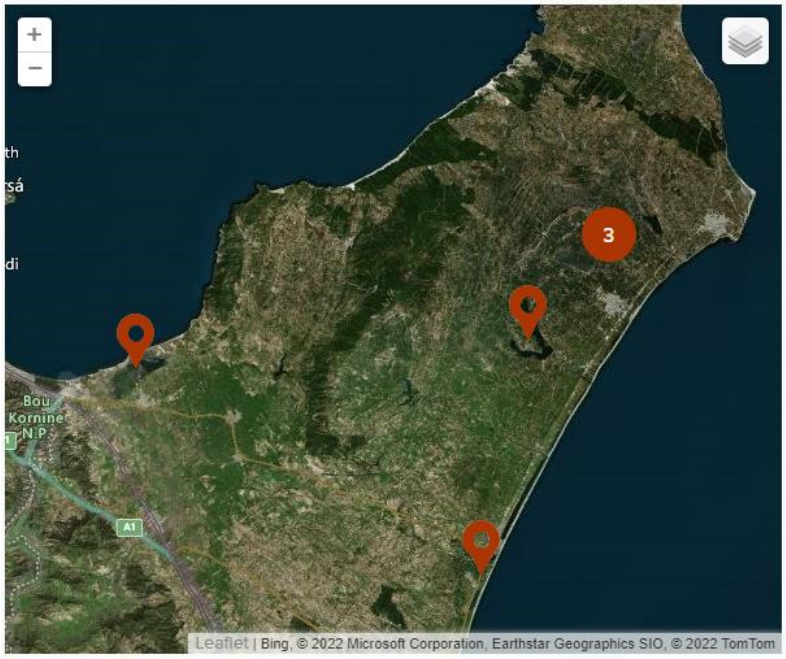
I. Study area

II. Methodology

III. Experimental results

IV. Summary & Discussions

I. Study area



- An important agricultural region located in the Cap-Bon peninsula in the North-East of Tunisia in North Africa,
- This region of plains is endowed with six aquifers counted among the main aquifers of the Tunisian coastal plains,
- It has mainly shallow groundwater resources. Thus, this resource is very much in demand by pump irrigation for the development of crops,
- Furthermore, the development of excessive pumping has led to the overexploitation of the aquifer which has consequently favored land subsidence and marine intrusion into aquifer systems

I. Study area

- Two watersheds were considered for this study: El Masri Dam (red rectangle A, Grombalia watershed) and Lebna dam (red rectangle B, Lebna watershed).
- Constitutes a reference experimental basin to study and analyze research questions on global changes affecting cultivated and natural hydro-systems, both on the regime and on the quality of water and soil resources.

II. Methodology

1. Mapping land subsidence due to groundwater extraction: Differential SAR interferometry (Sentinel – 1)

   - Estimating the amount of subsidence that occurred in the Cap-Bon plain using DInSAR based on an analysis of 154 Sentinel-1 descending SAR images, in VV-mode (2017-2022).

2. Surface water extent determination using Sentinel-1 and 2 data: NDWI (Sentinel – 2)

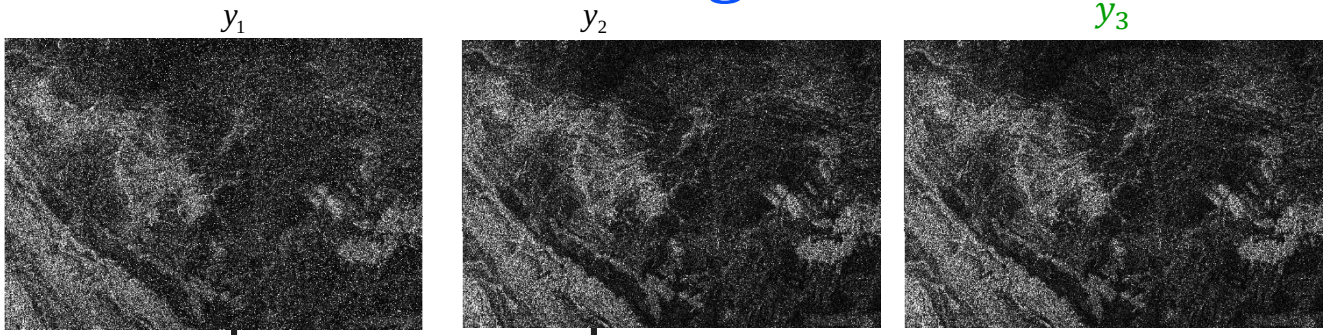
   - Computing the NDWI,
   - Considering the InSAR coherence maps for the same periods of the computed NDWI

3. Quantifying surface water extent change and land subsidence

   - Compute the equivalent resulting surface of water for the different considered dates of land subsidence.

II. Interferometric SAR coherence generation

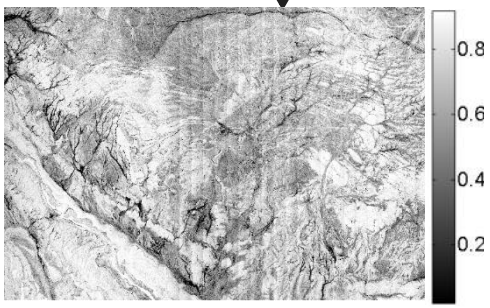
1. SAR interferometry:



Preprocessing

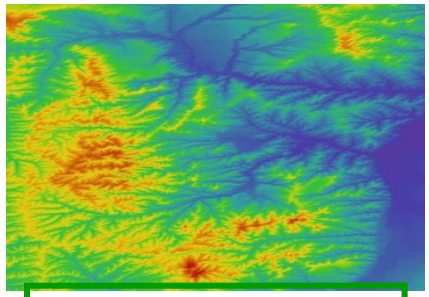
$$\gamma = y_1 y_2^* = |y_1||y_2| e^{j(\varphi_1 - \varphi_2)}$$

Coherence map $|\gamma|$



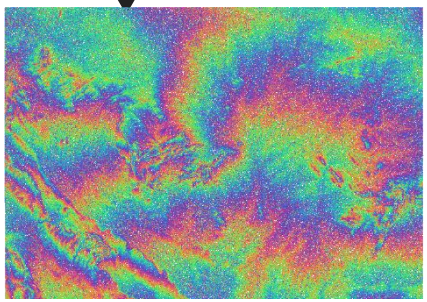
2. Differential SAR interferometry (D-InSAR):

Or DEM



Differential interferogram

Mapping displacement



Interferogram $\varphi = \varphi_1 - \varphi_2$

II. Interferometric SAR coherence generation

y_1 y_2

3. Small BAseline Subset (SBAS) interferometry:

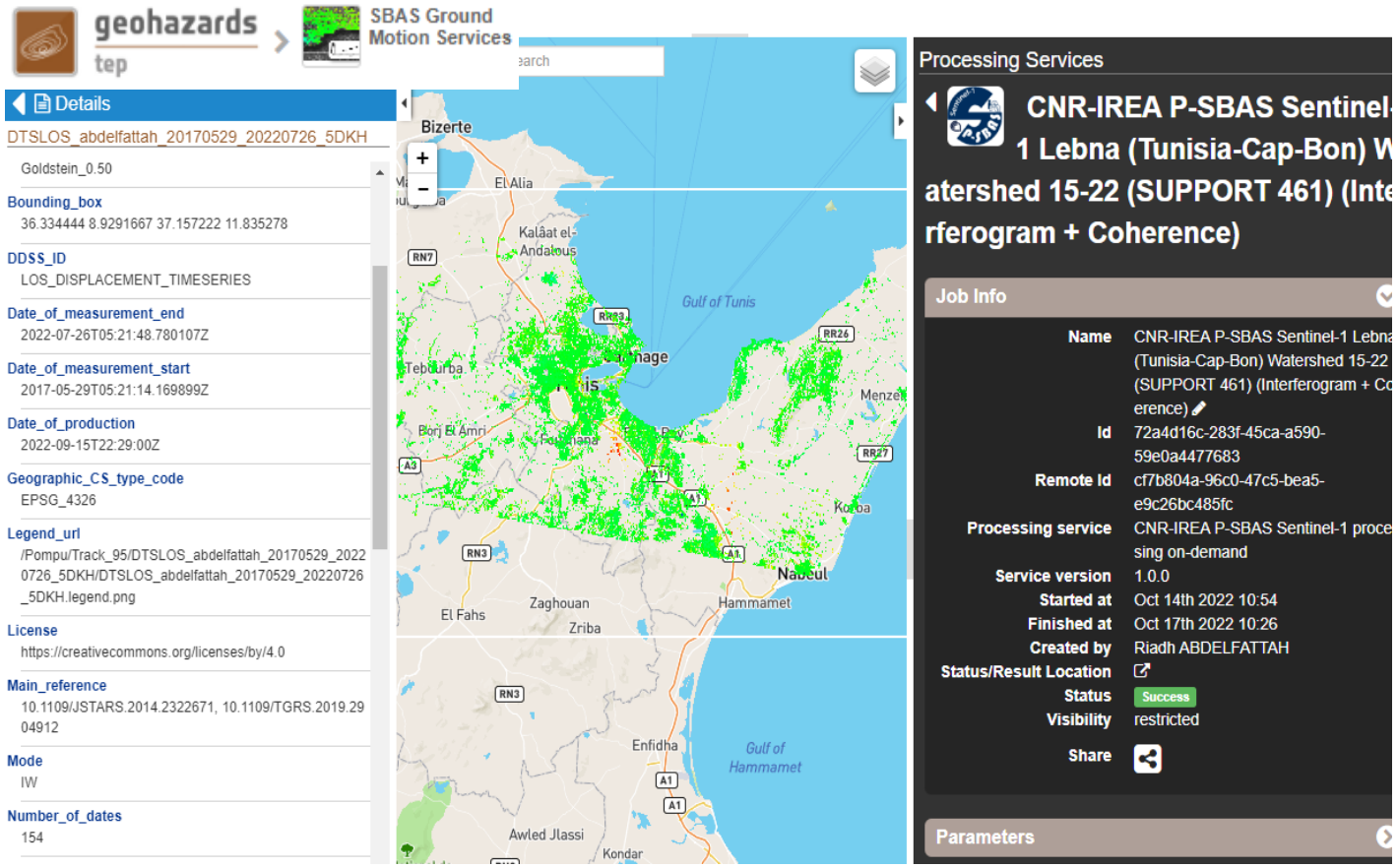
geohazards tep > SBAS Ground Motion Services

- Displacement time series maps were generated using the SBAS DInSAR algorithm.
- P-SBAS is the parallel computing solution developed by CNR-IREA for the SBAS processing chain to deal with huge SAR archives.
- We generated more than **1357 interferograms and InSAR coherence** maps on the Peninsula of Cap-Bon. The Multi-Temporal Analysis (MTA) processing mode was selected and P-SBAS DInSAR geocoded (Lat/Lon WGS84) LOS (Line of Sight) vertical displacement time series maps and temporal Coherence were derived.

III. Experimental results

- **InSAR coherence map generation and landslide mapping using P-SBAS**

- We used the P-SBAS InSAR S-1 service implemented in GEP to generate more than **1357 interferograms** and InSAR coherence maps on the Peninsula of Cap-Bon.



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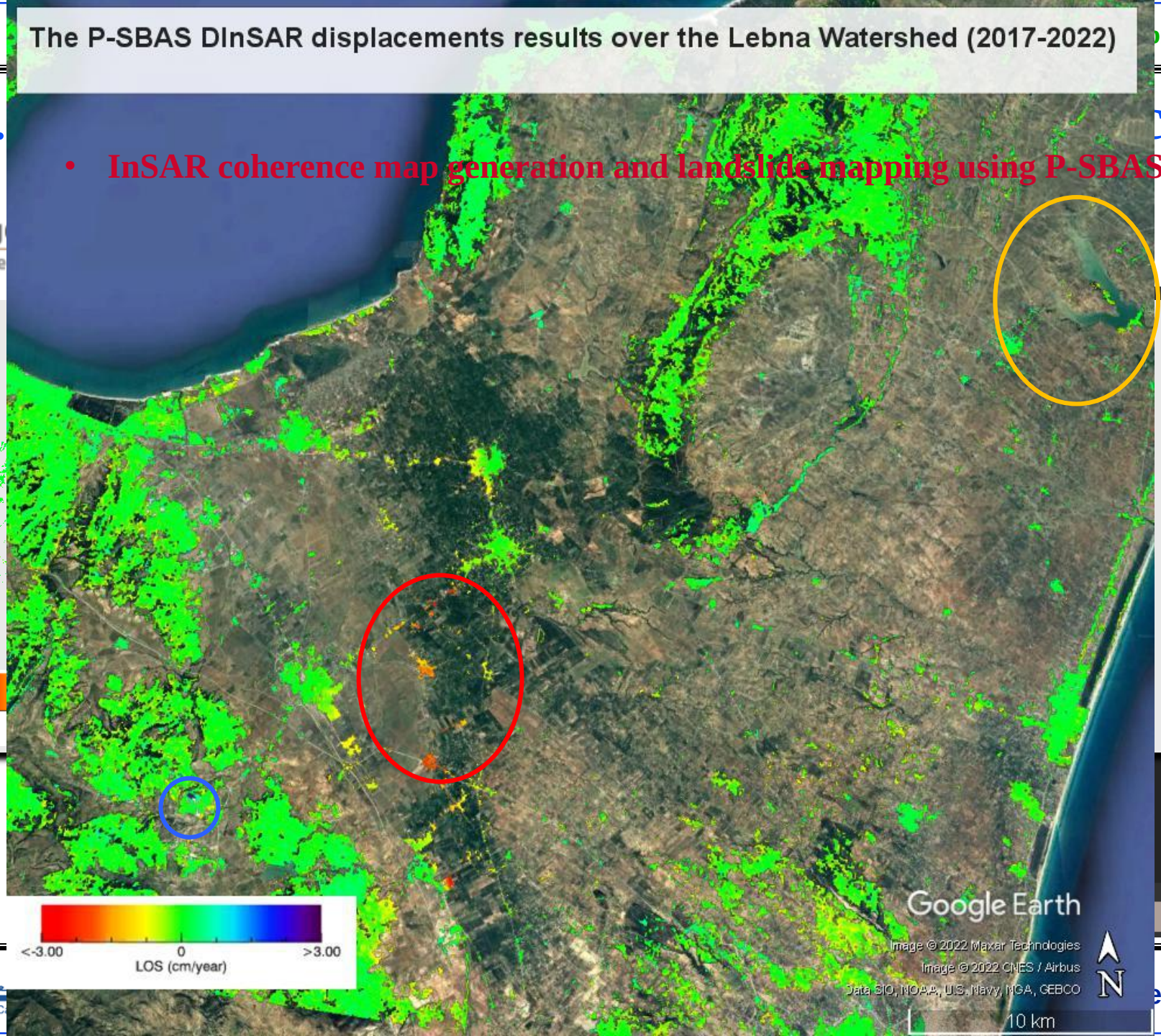
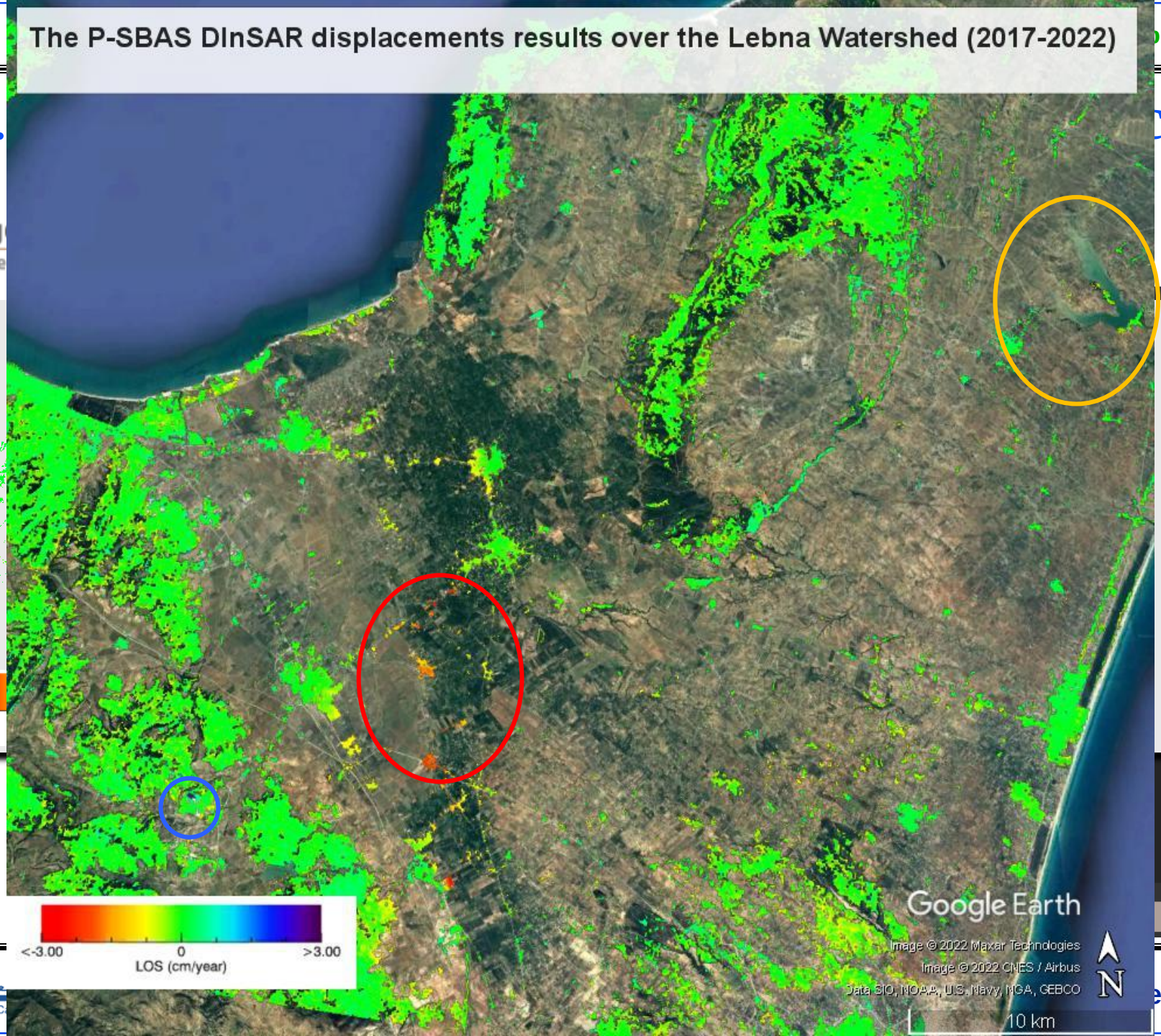
III.

ce

- InSAR coherence map generation and landslide mapping using P-SBAS



The P-SBAS DInSAR displacements results over the Lebna Watershed (2017-2022)



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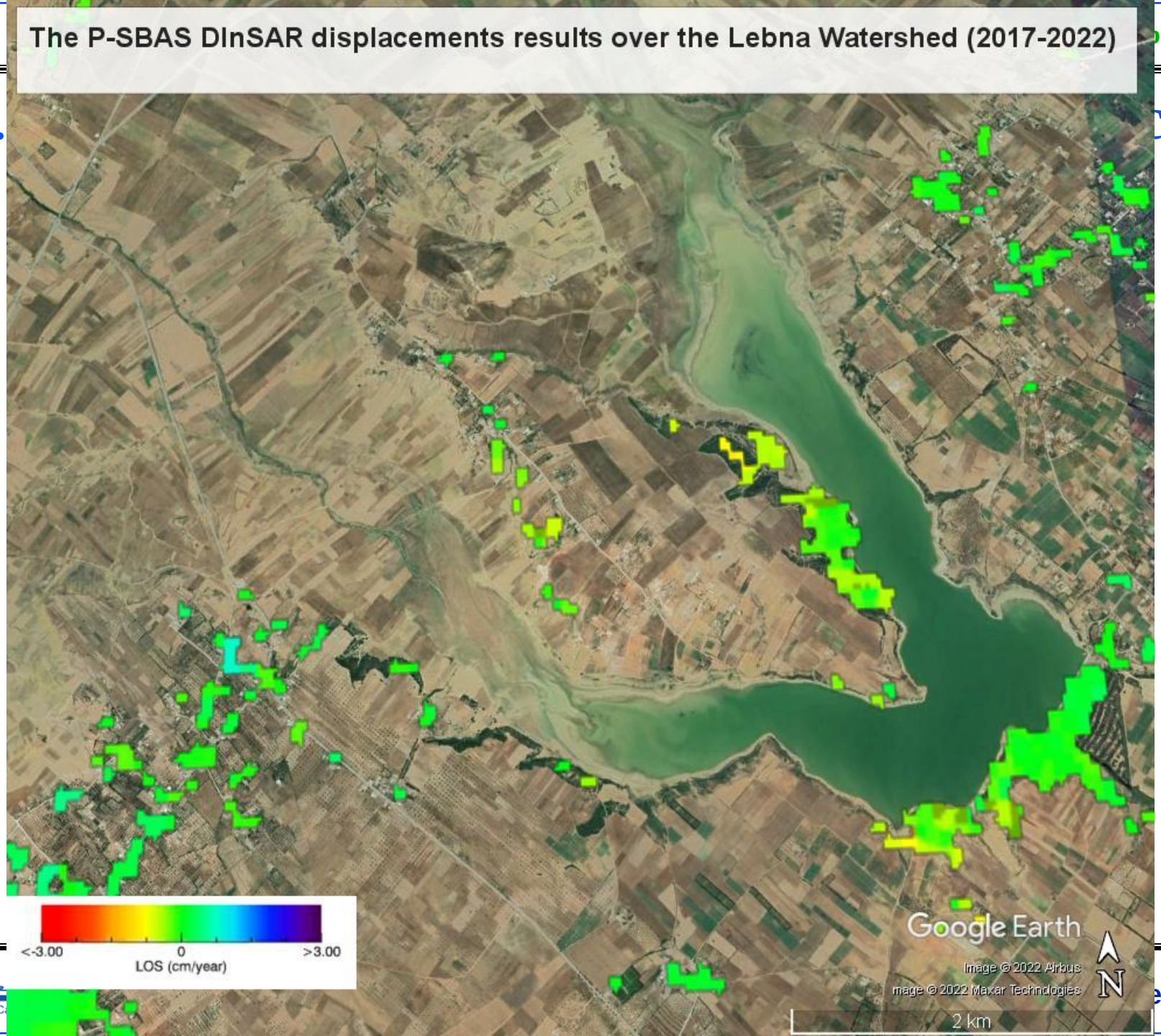

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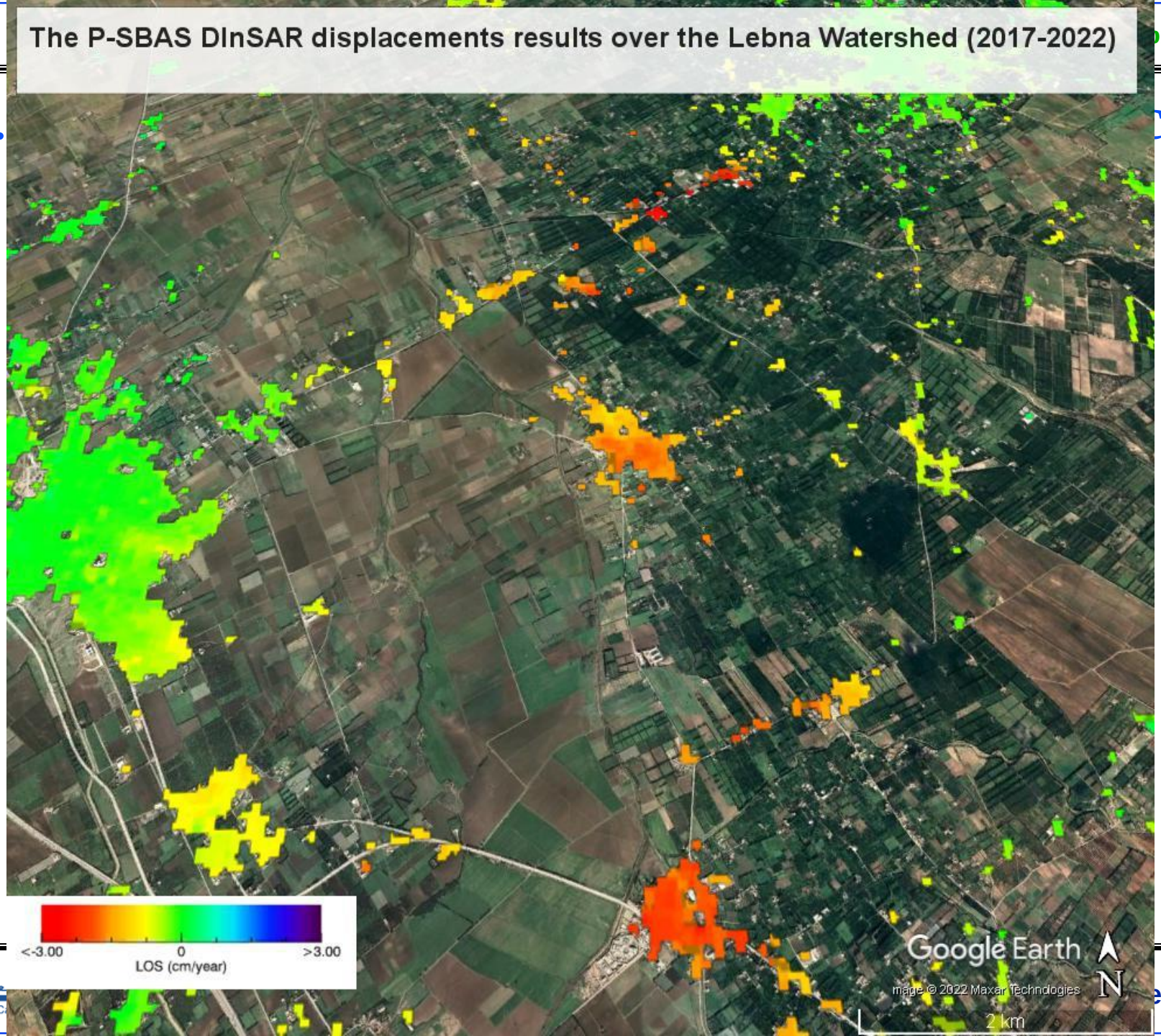

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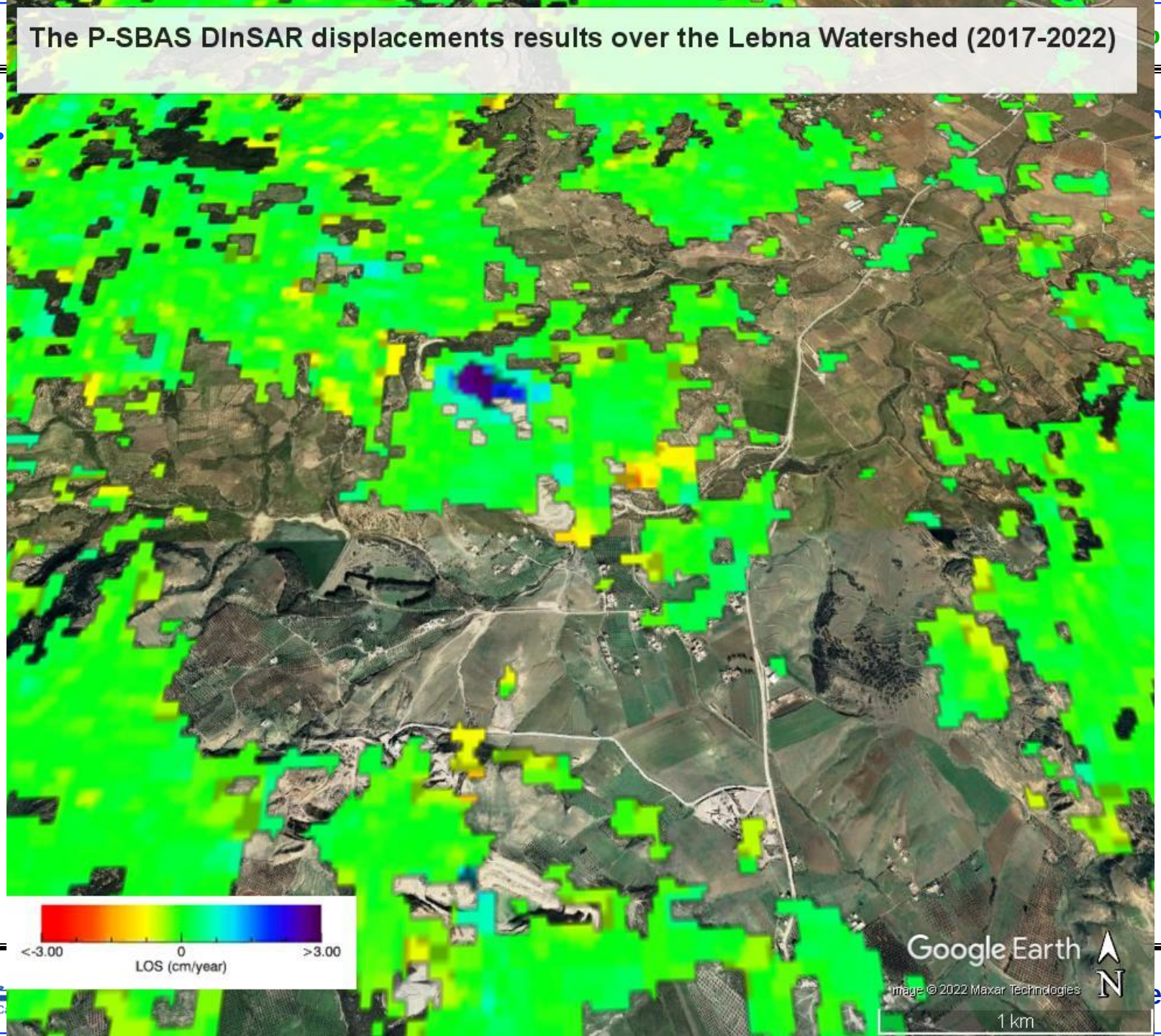
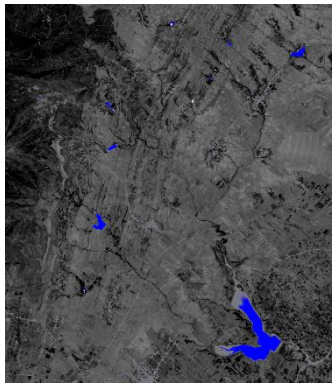


III. Surface water mapping using InSAR coherence

- **NDWI (B3-B8)/(B3+B8) computed on Sentinel-2 (L2A, Theia) data**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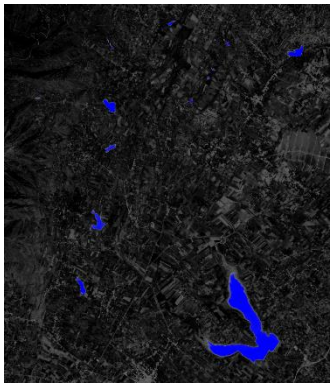
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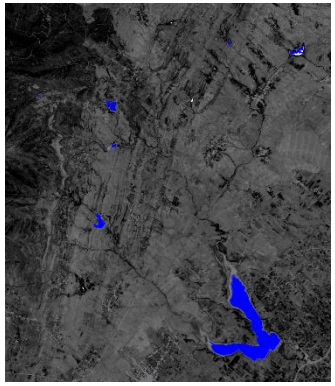
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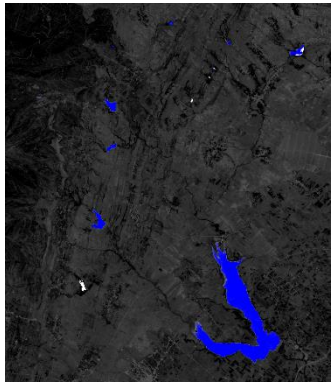
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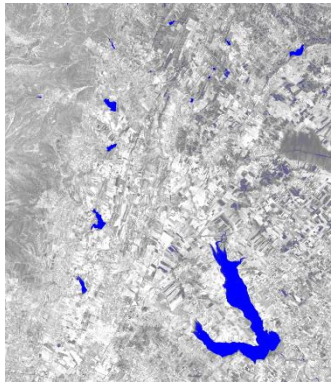
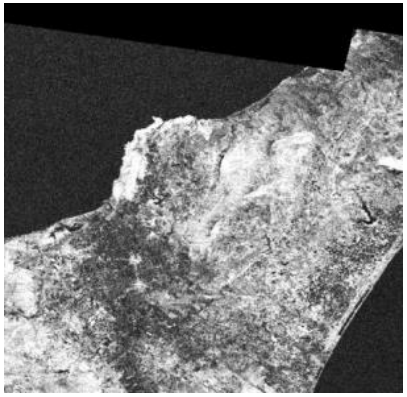
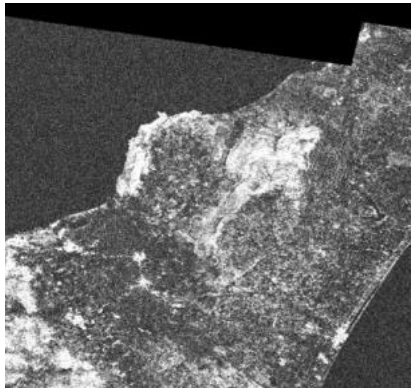
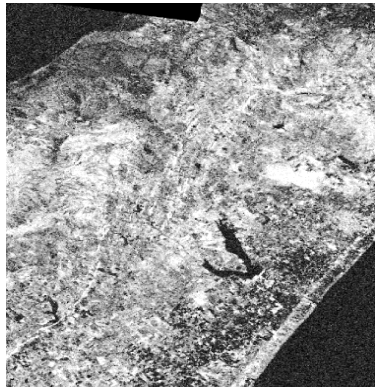
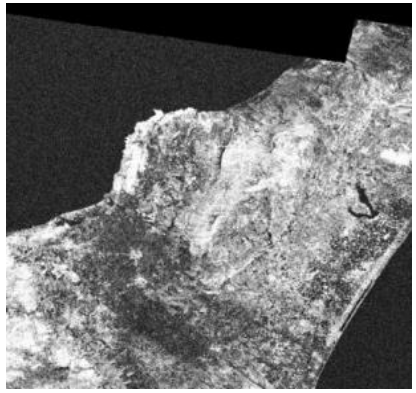

25/07/2019

- **InSAR coherence map (date1, date2)**

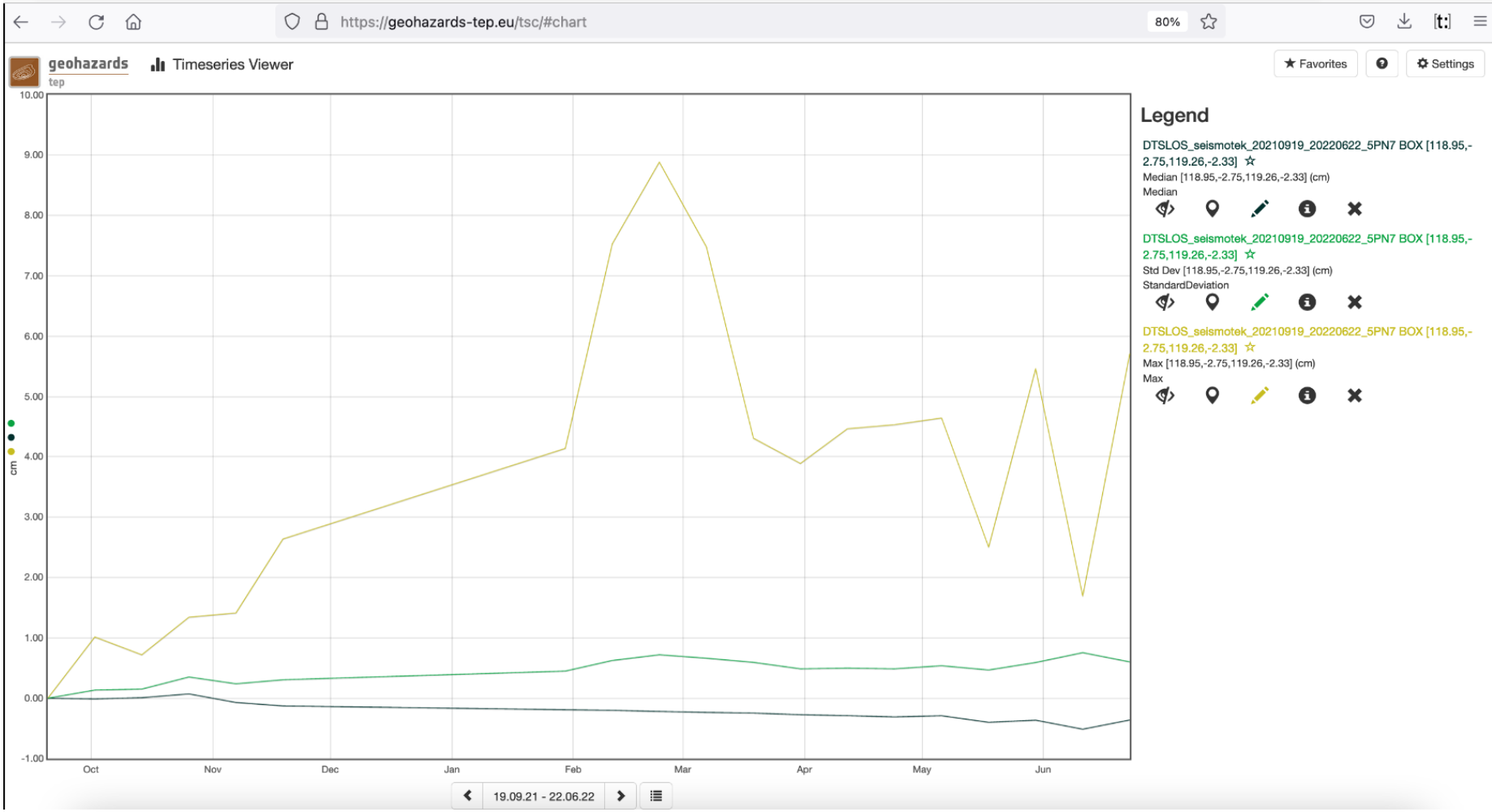

Coh (14/07/2022, 26/07/2022)


Coh (15/1/2022 – 20/2/2022)


Coh(04/07/2017, 16/07/2017)


Coh (30/7/2019 – 18/7/2019)

III. Surface water mapping using InSAR coherence



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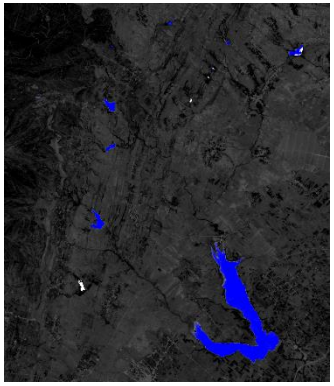

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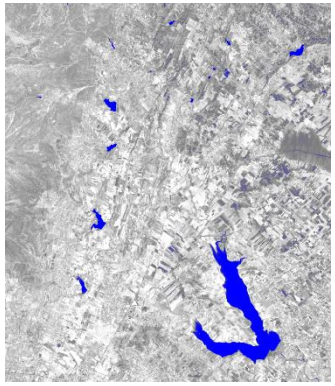
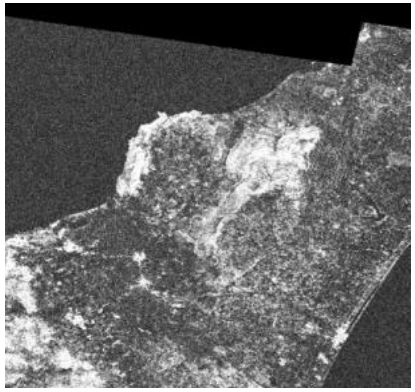


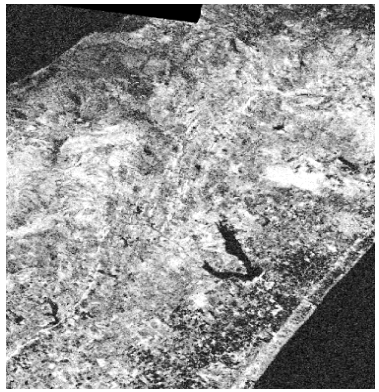
25/07/2019

- **InSAR coherence map (date1, date2)**

- the highest average land subsidence occurring in 2022 (**9 cm**)



Coh (15/1/2022 – 20/2/2022)



Coh(04/07/2017, 16/07/2017)

- The lowest average land subsidence occurring in 2017 and 2020 (< 1 cm)

Summary & Discussions

- ✓ Potential of the InSAR coherence time series for water surface mapping: change detection and measurements (quantification),
- ✓ Needs for a periodic, low temporal baseline analysis of coherence images for close monitoring of changes in the Earth's hydrosphere,
- ✓ Potential of the InSAR P-SBAS landslide mapping for water points (wells and boreholes) detection,