

Extensive Analysis of the Built-up Environment Deformations through the Full Resolution P-SBAS DInSAR Processing of COSMO-SkyMed and SAOCOM-1 Data



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FRINGE 2023

University of Leeds, UK | 11 - 15 September 2023.



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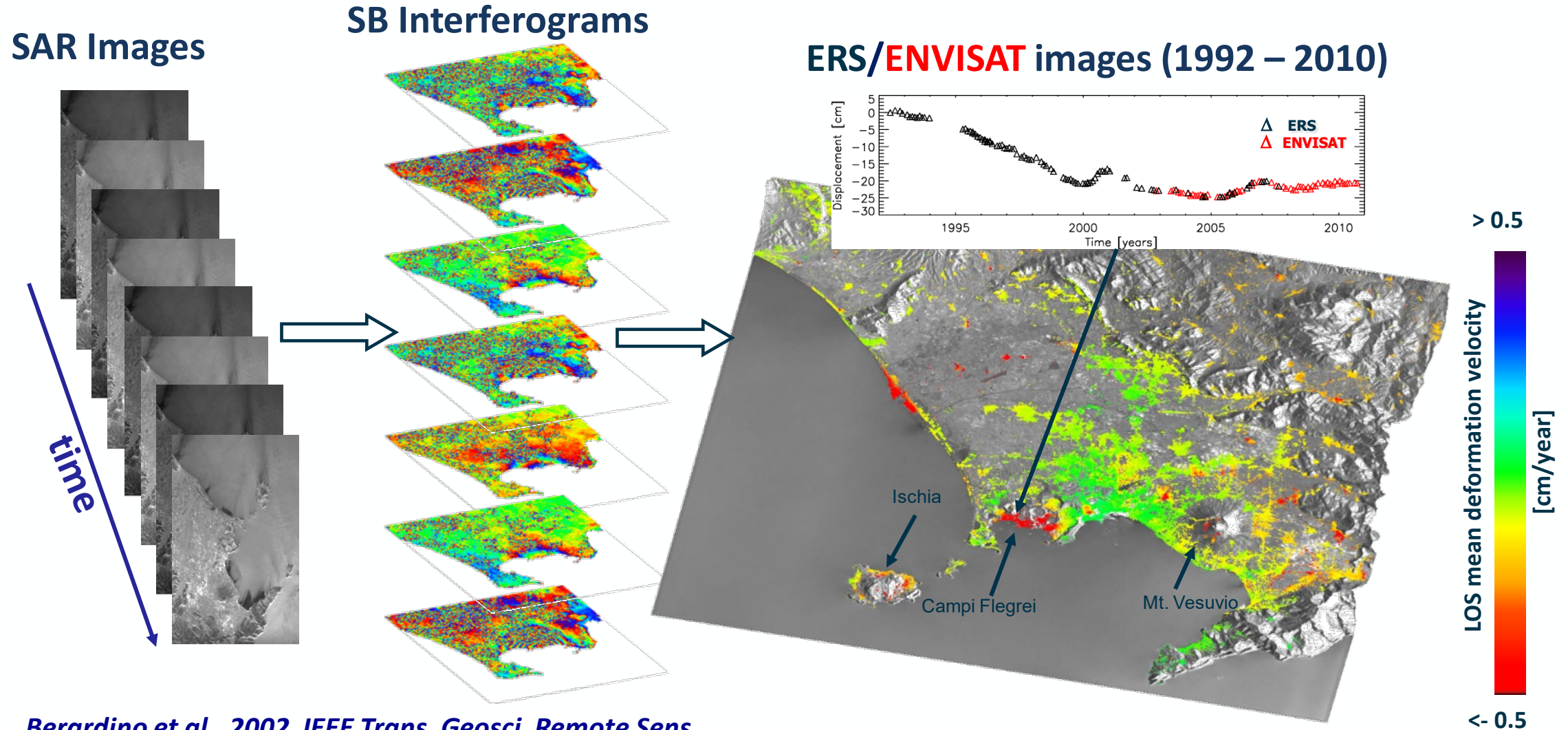


→ THE EUROPEAN SPACE AGENCY

Outline

- **The Full Resolution P-SBAS processing chain**
- **Experimental results achieved on some Italian cities**
- **Further developments**

Advanced DInSAR techniques: the Small BAseline Subset (SBAS) approach



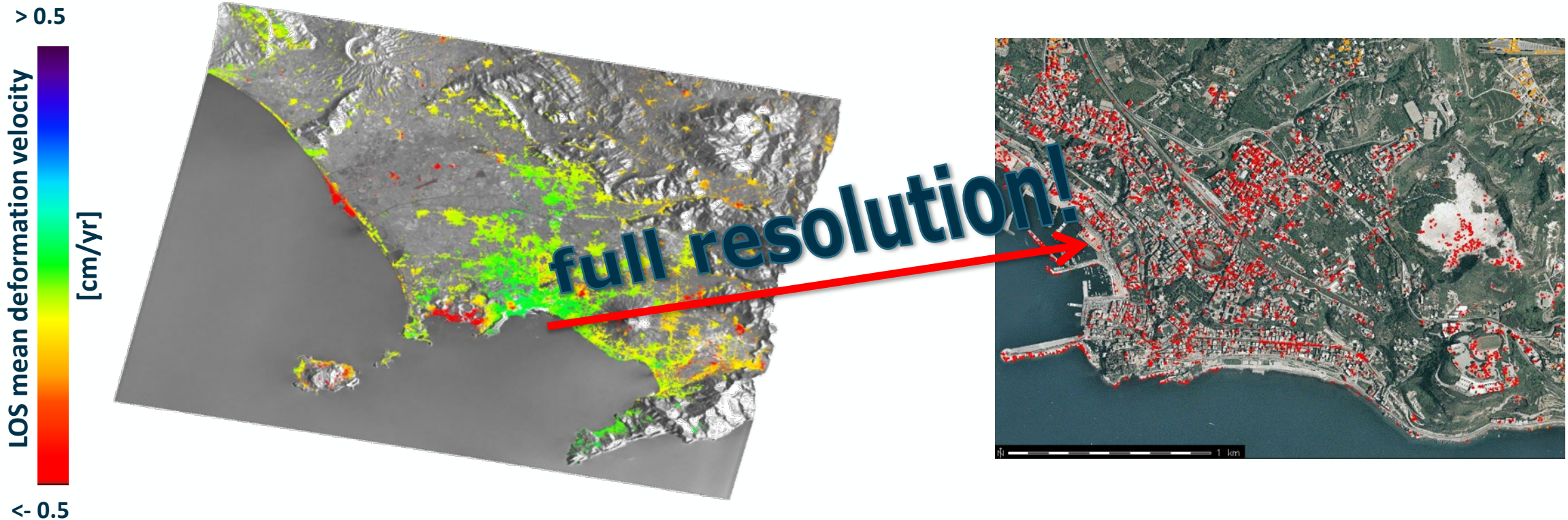
Berardino et al., 2002, IEEE Trans. Geosci. Remote Sens.

Pepe et al., 2005, IEEE Trans. Geosci. Remote Sens.

SBAS-DInSAR analysis at different spatial resolution scales

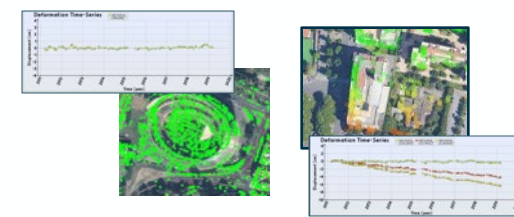
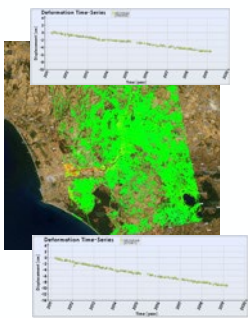
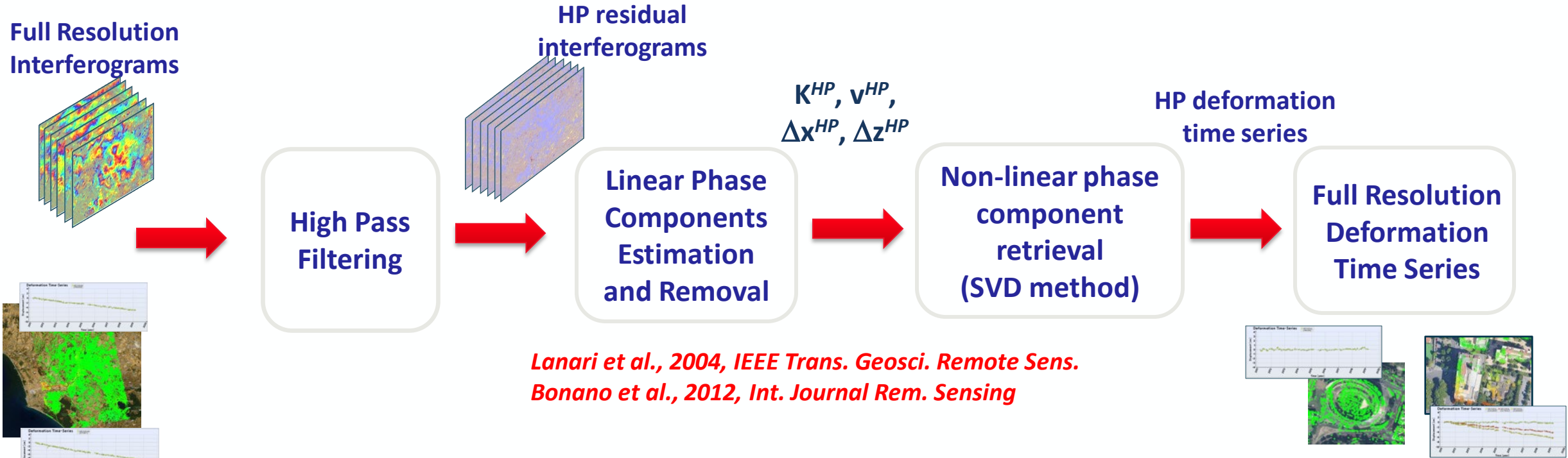
Medium spatial resolution analysis
(pixel size of about 30-100 m)

Full spatial resolution analysis
(pixel size of about 3-10 m)



Lanari et al., 2004, IEEE Trans. Geosci. Remote Sens.
Bonano et al., 2012, Int. Jour. Remote Sens.

The full resolution SBAS-DInSAR technique

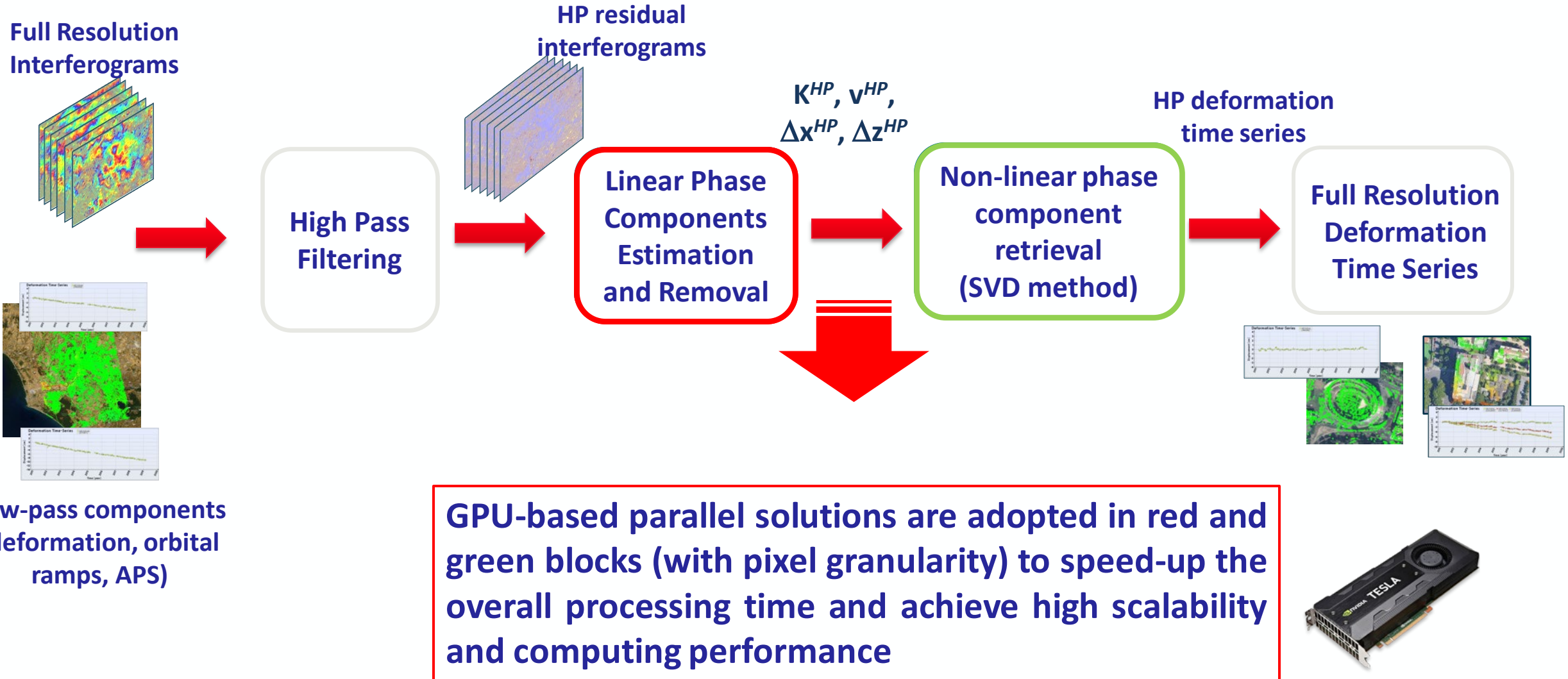


Low-pass components
(deformation, orbital
ramps, APS)

The increase (in number and size of images) of the available full resolution interferometric data stacks implies:

- drastic increase of data processing load and complexity
- exponential growth of the processing time
- need of advanced HPC and Cloud Computing solutions

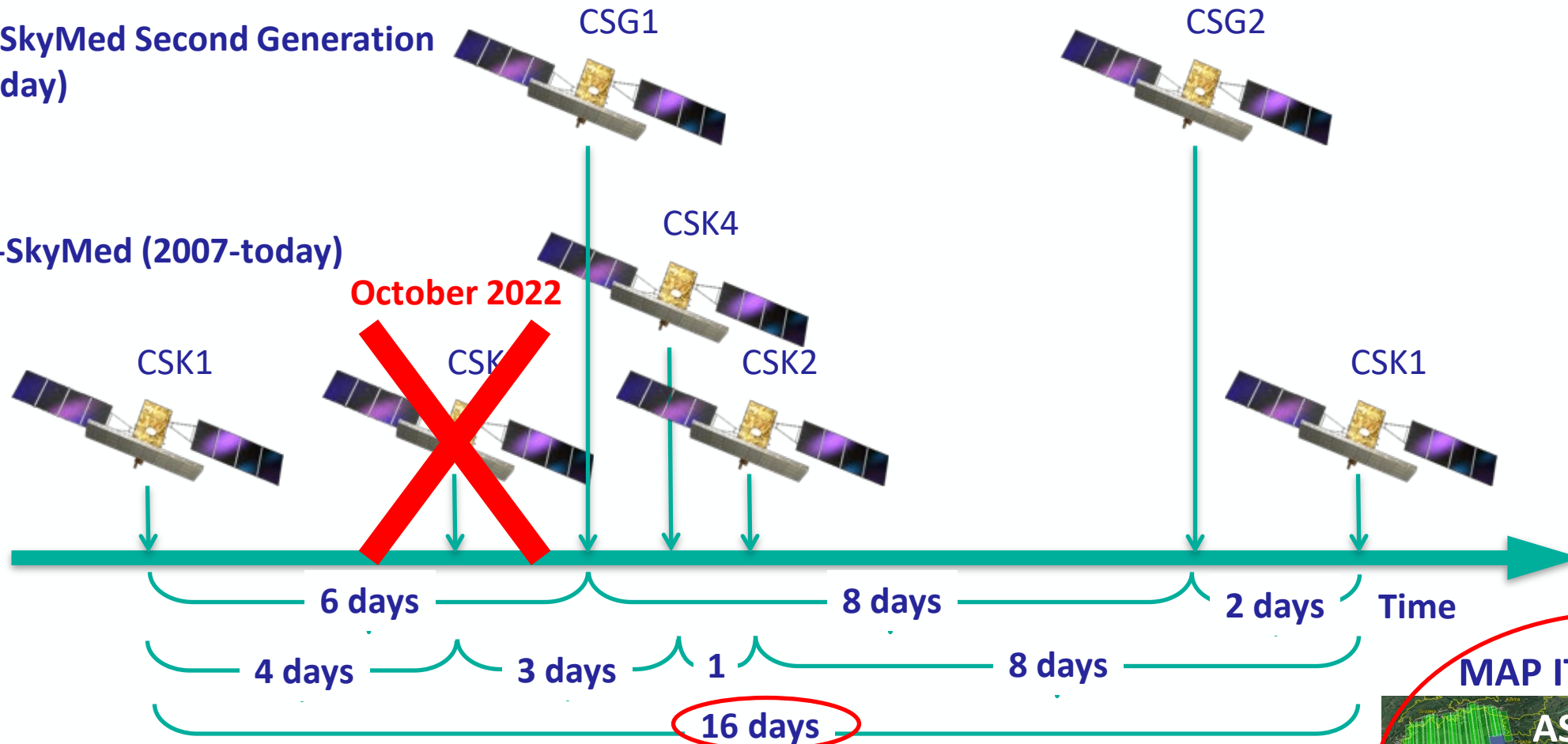
The parallel full resolution SBAS-DInSAR technique (FR P-SBAS)



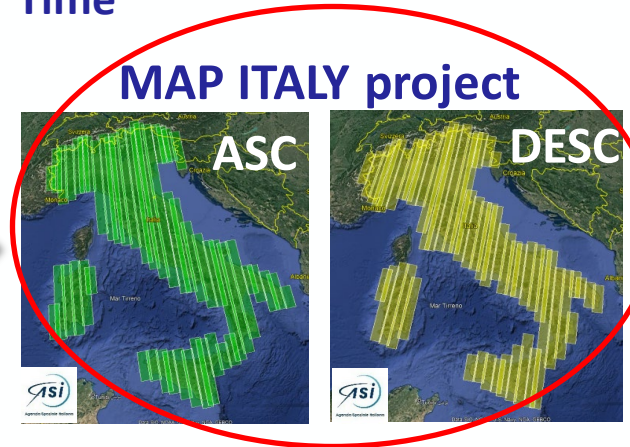
COSMO-SkyMed First (CSK) and Second (CSG) generation

COSMO-SkyMed Second Generation (2019-today)

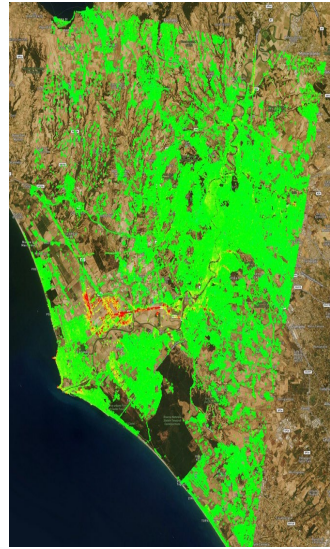
COSMO-SkyMed (2007-today)



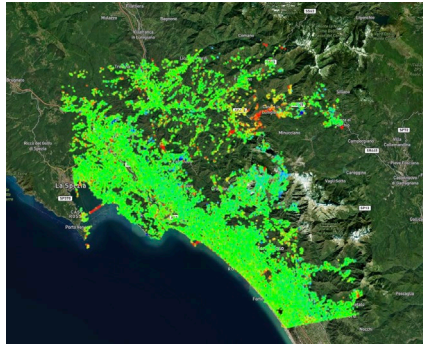
- Spatial resolution (StripMap): ~ 3 m x 3 m
- Ground coverage (StripMap): ~ 40 km x 40 km
- X-band ($\lambda \sim 3.1$ cm)
- Dual mission



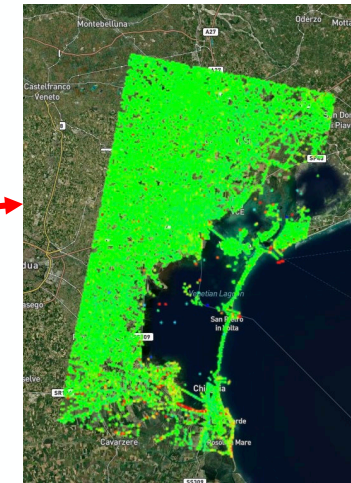
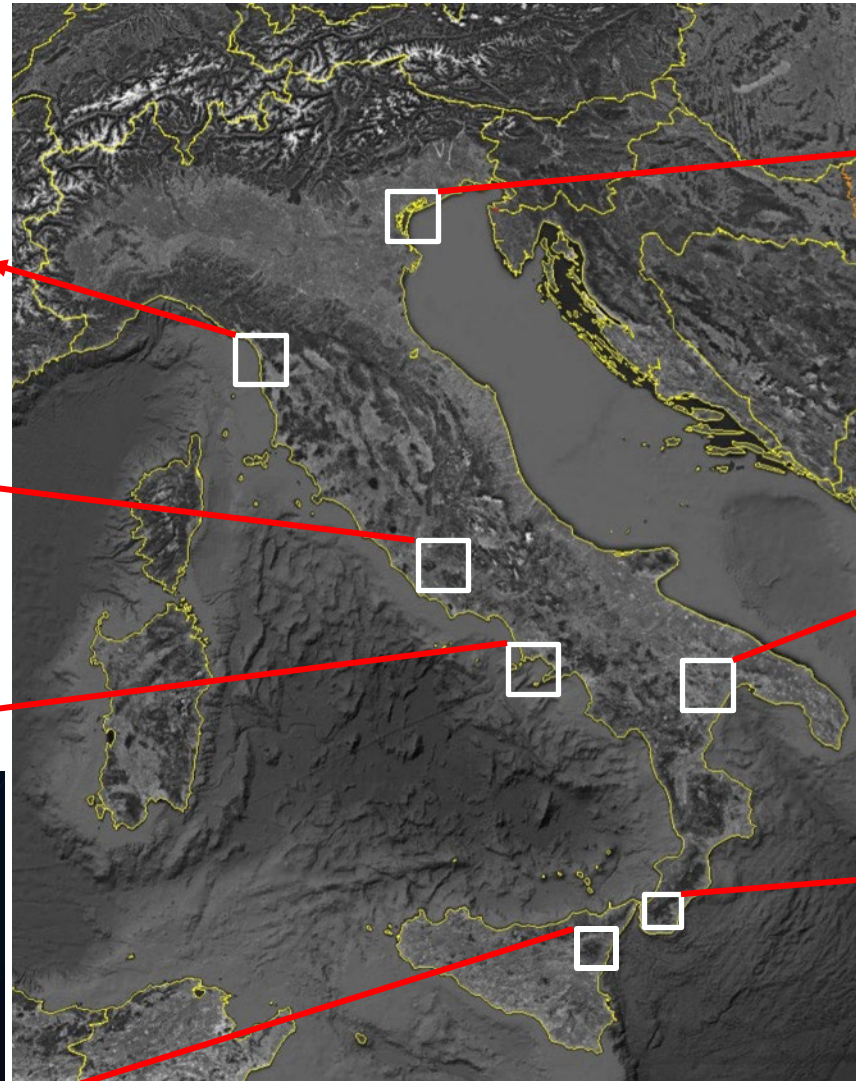
Extensive experimental FR P-SBAS analysis over the Italian territory with CSK/CSG data



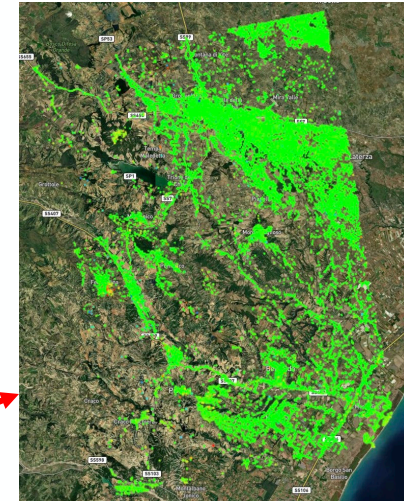
Roma



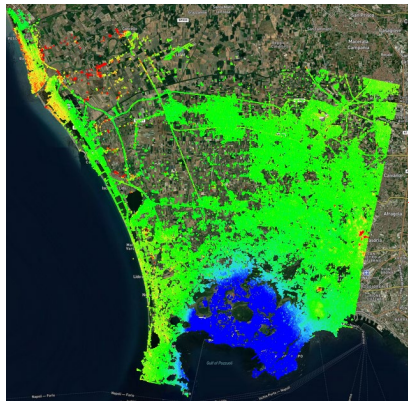
La Spezia



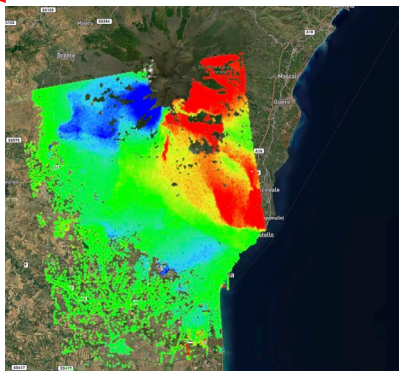
Venezia



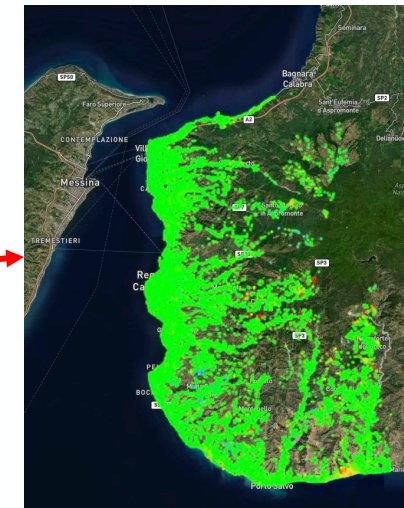
Matera



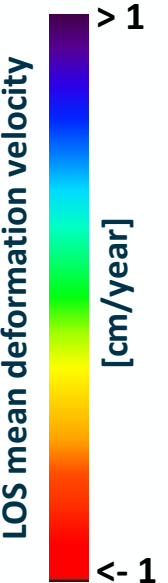
Napoli



Catania



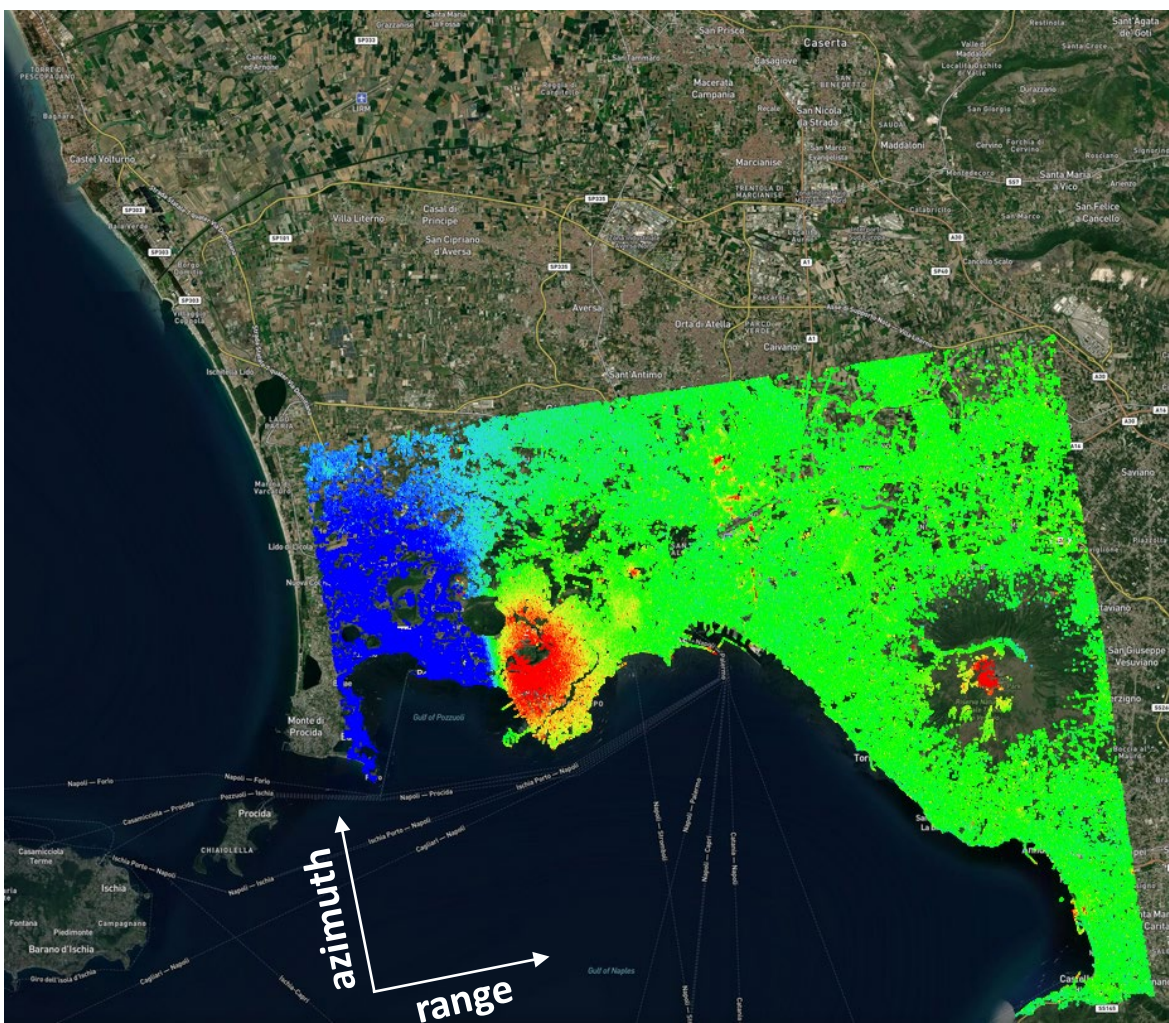
Reggio Calabria



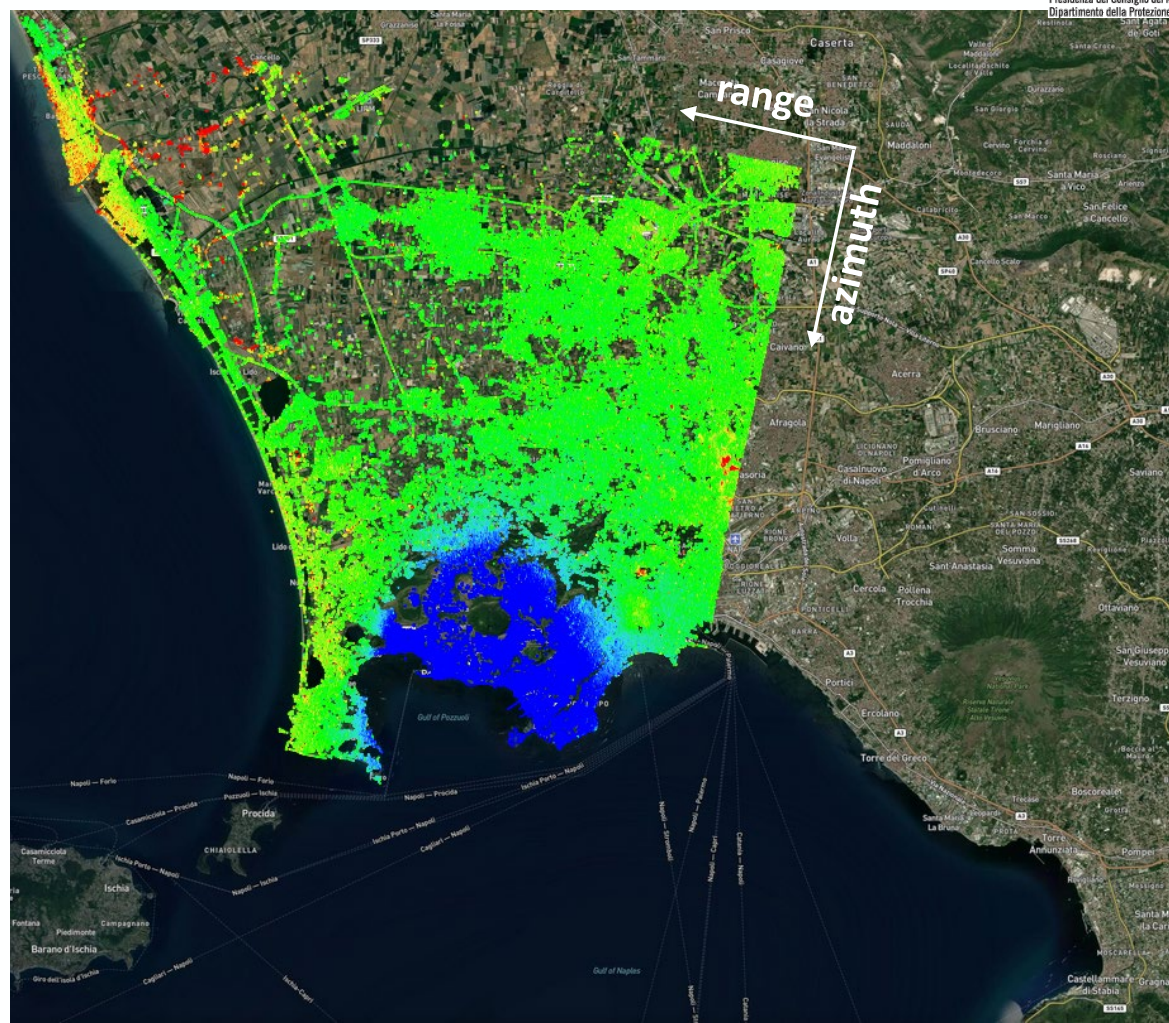
FR P-SBAS analysis with CSK/CSG SAR data: the Napoli (southern Italy) case study



> 0.5
LOS mean deformation velocity [cm/year]
< -0.5



249 SAR images (ascending orbits, 2009-2022)

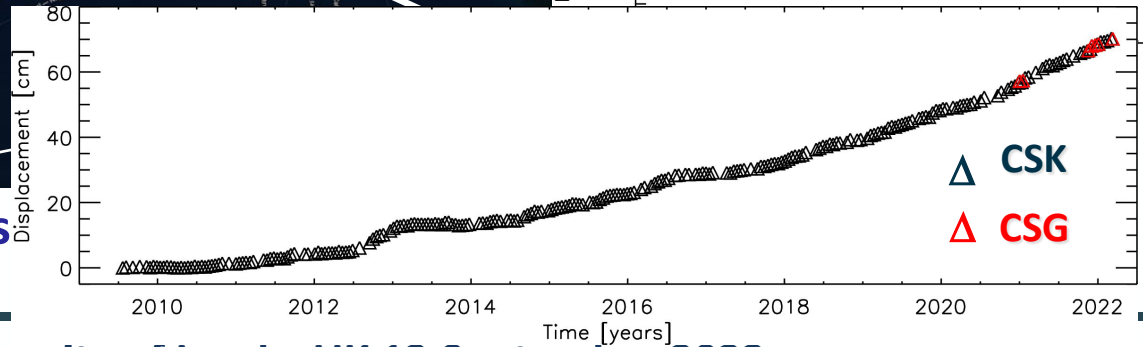
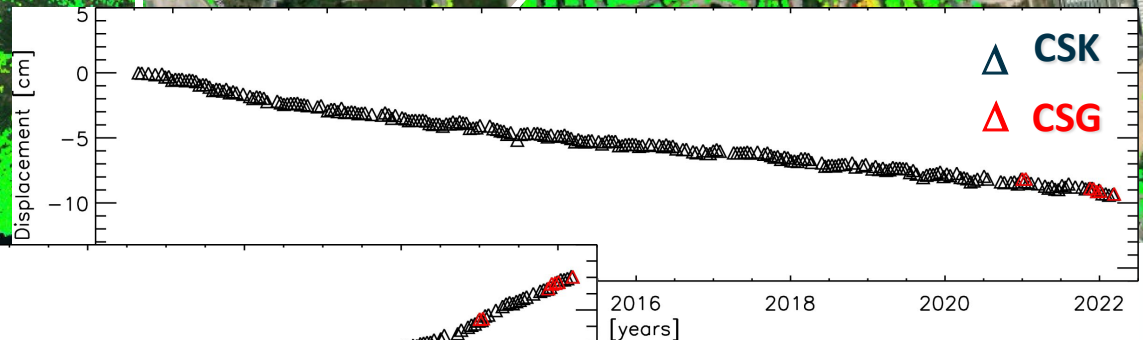
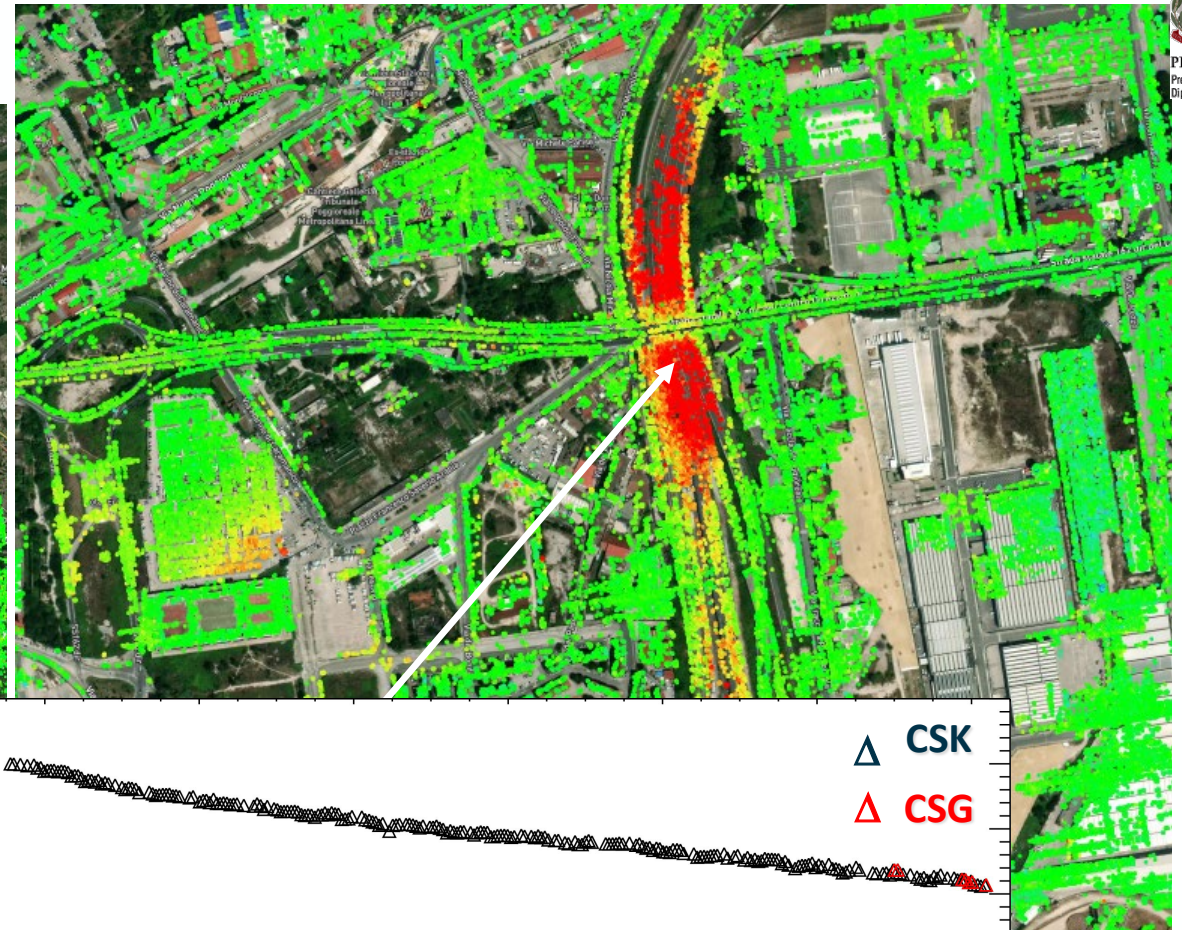
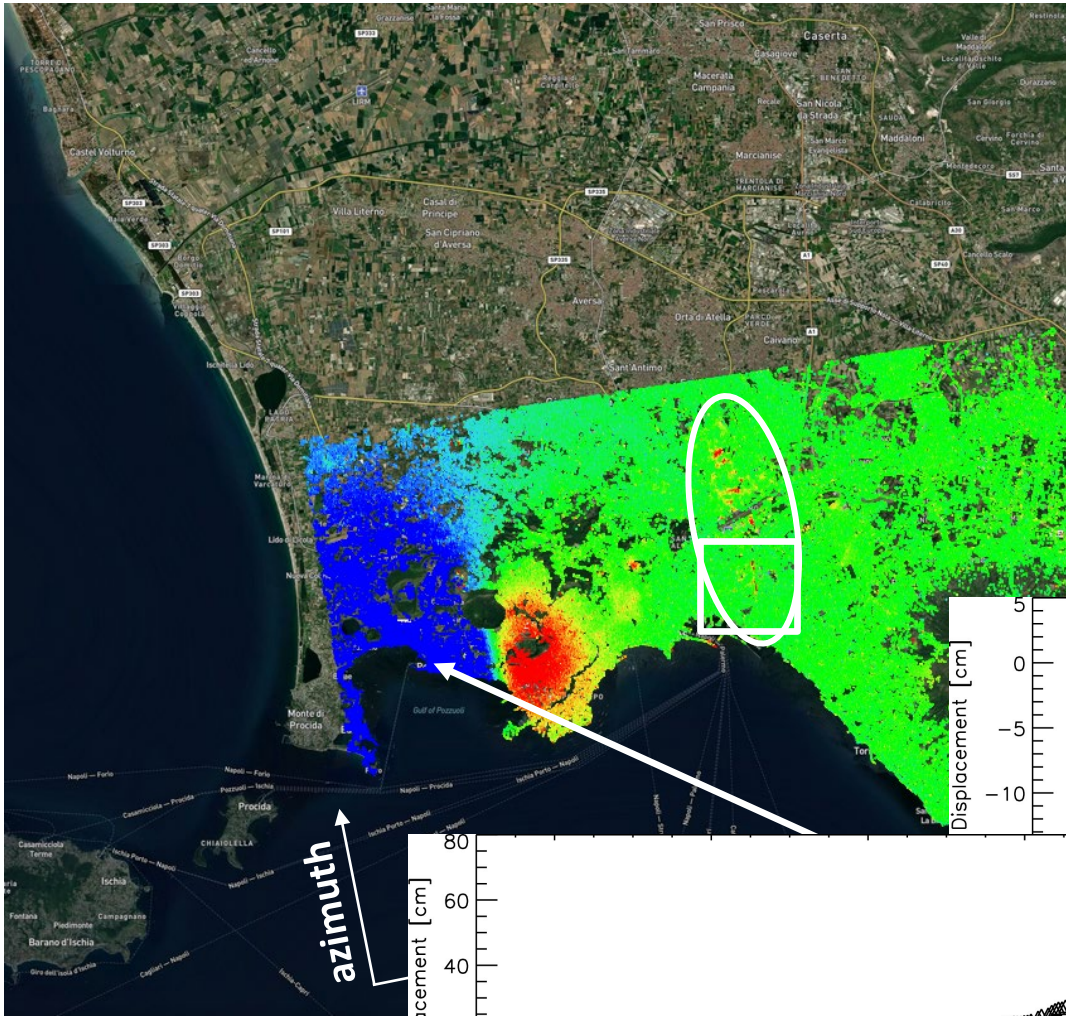


144 SAR images (descending orbits, 2011-2022)

FR P-SBAS analysis with CSK/CSG SAR data: the Napoli (southern Italy) case study



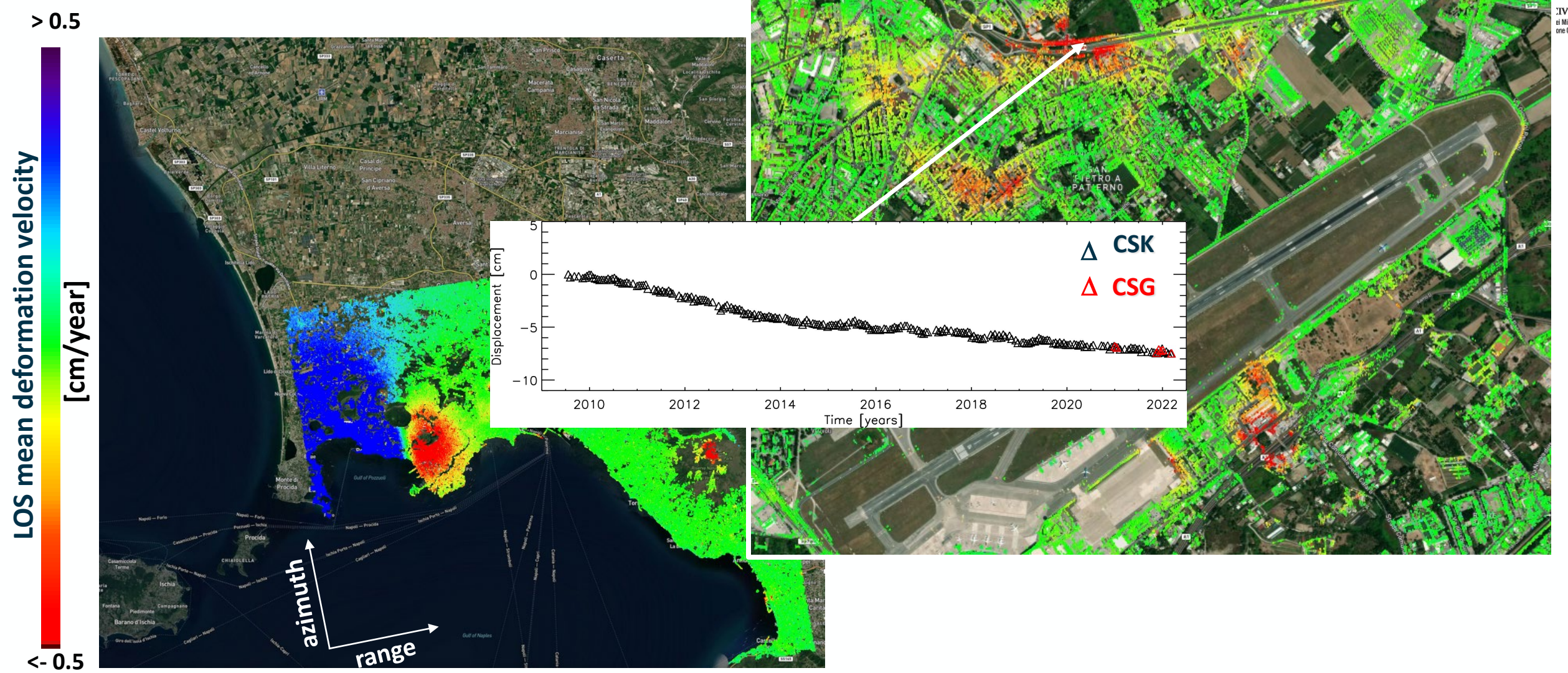
> 0.5
 LOS mean deformation velocity
 [cm/year]
 < - 0.5



249 SAR images

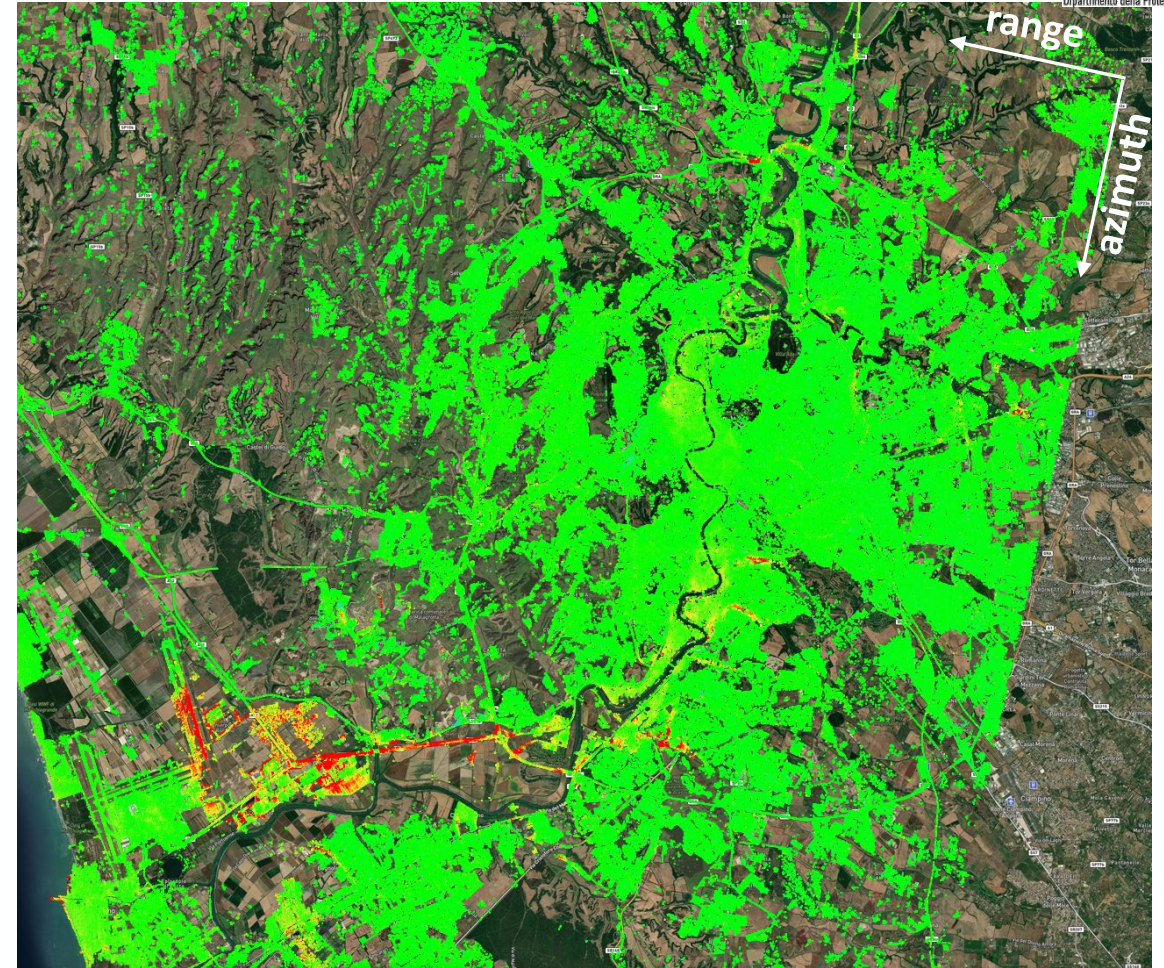
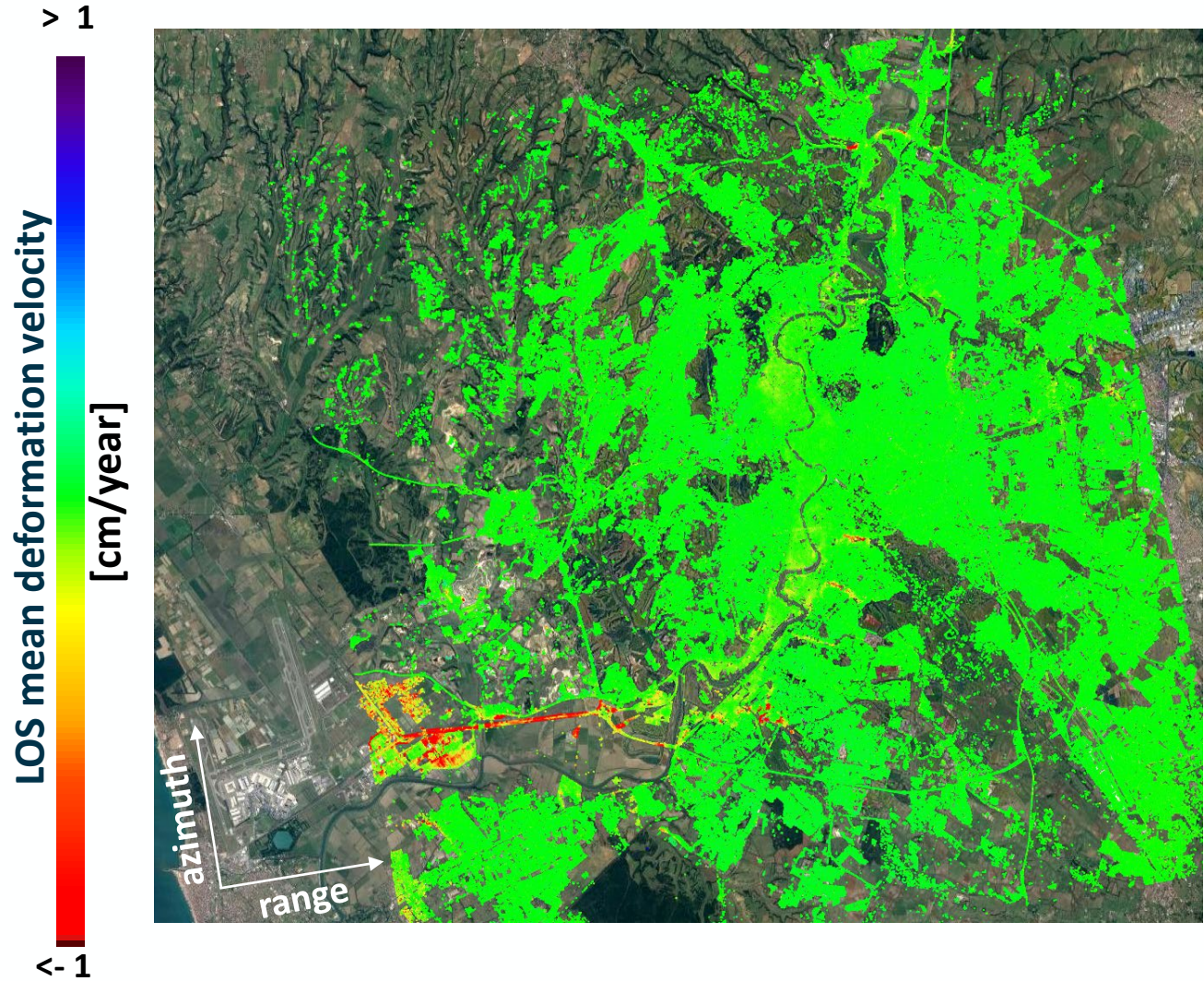


FR P-SBAS analysis with CSK/CSG SAR data: the Napoli (southern Italy) case study



249 SAR images (ascending orbits, 2009-2022)

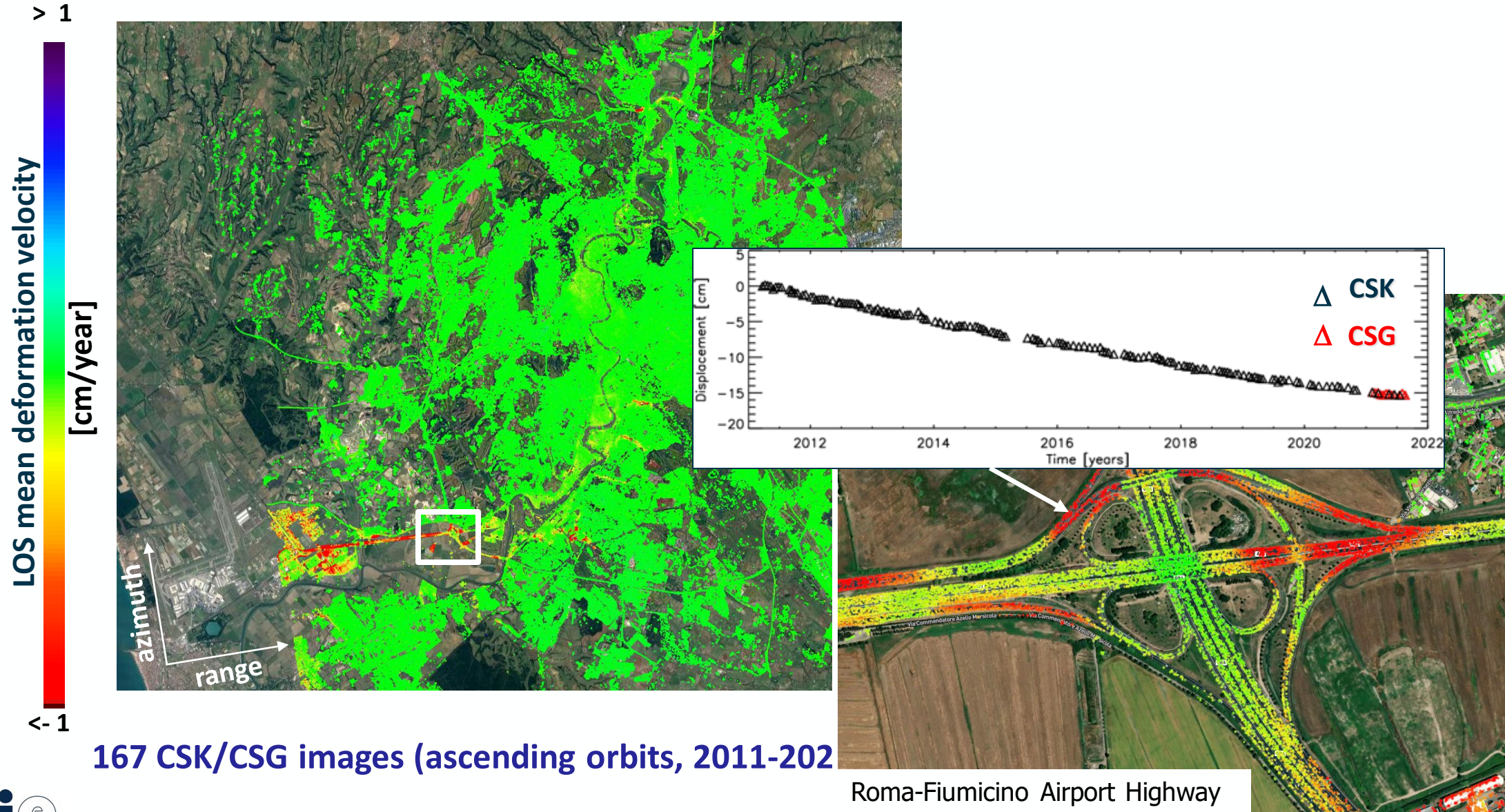
FR P-SBAS analysis with CSK/CSG SAR data: the Roma (central Italy) case study



167 CSK/CSG images (ascending orbits, 2011-2021)

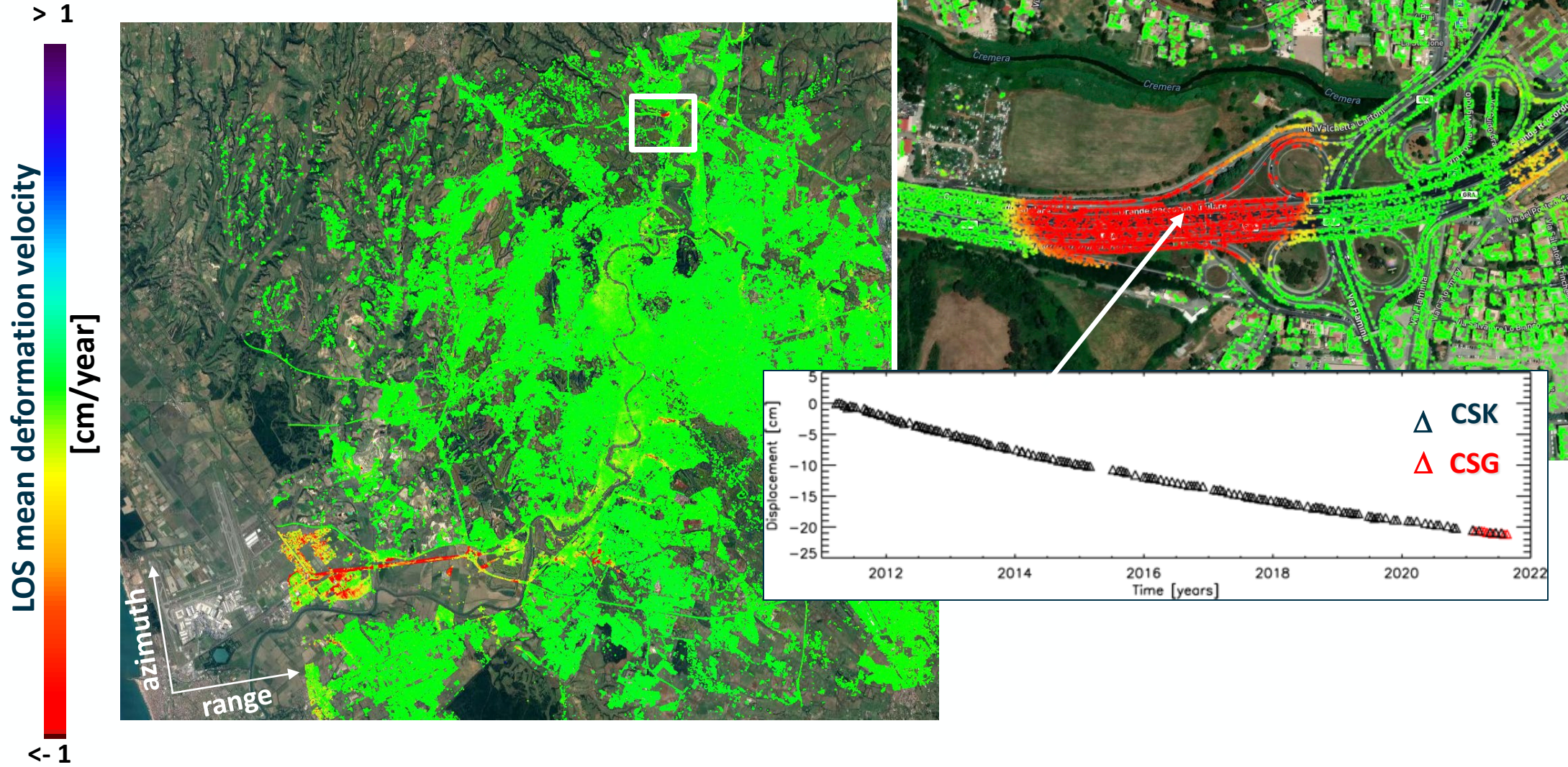
107 CSK images (descending orbits, 2011-2019)

FR P-SBAS analysis with CSK/CSG SAR data: the Roma (central Italy) case study



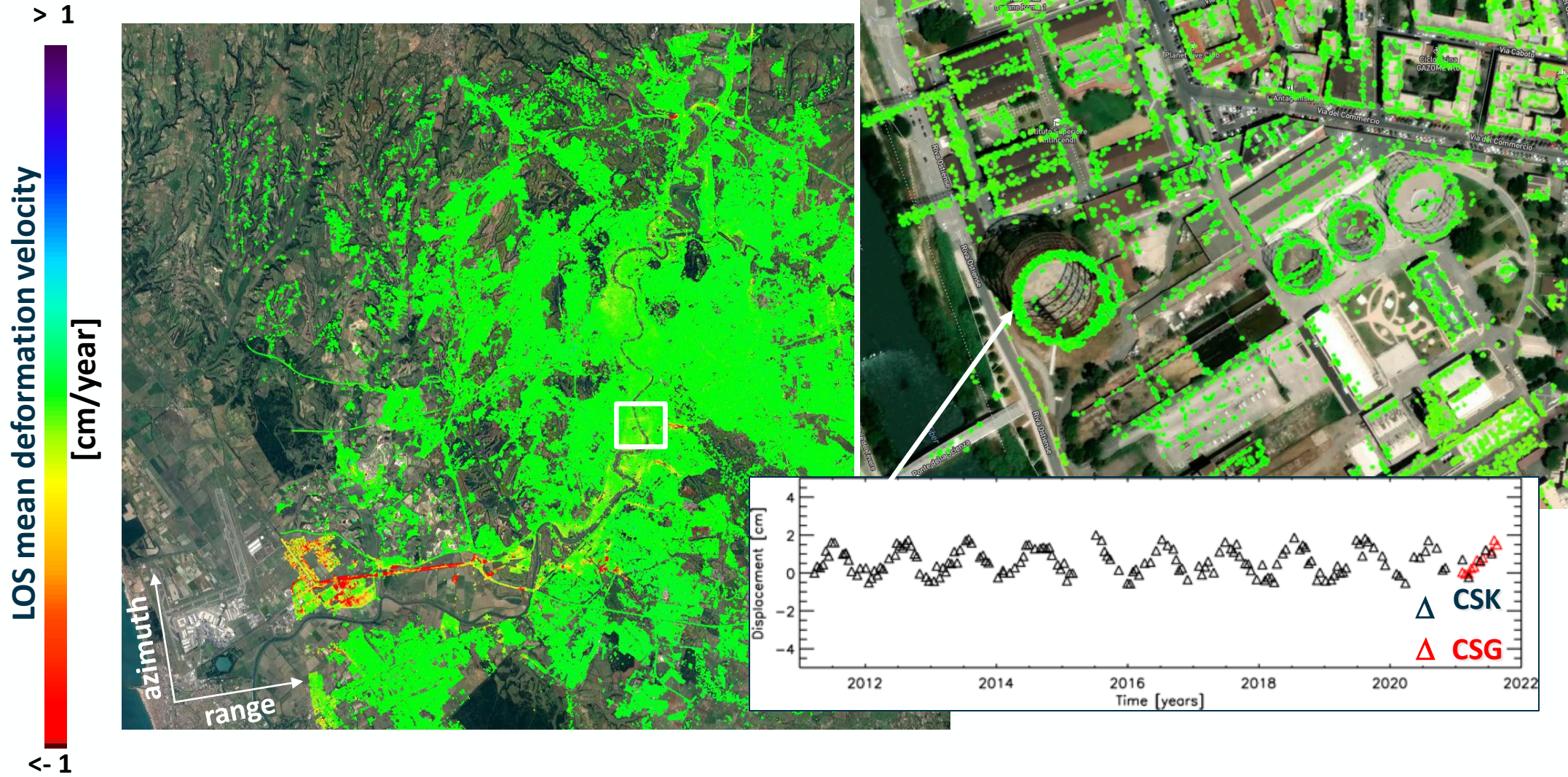
167 CSK/CSG images (ascending orbits, 2011-2022)

FR P-SBAS analysis with CSK/CSG SAR data: the Roma (central Italy) case study



167 CSK/CSG images (ascending orbits, 2011-2021)

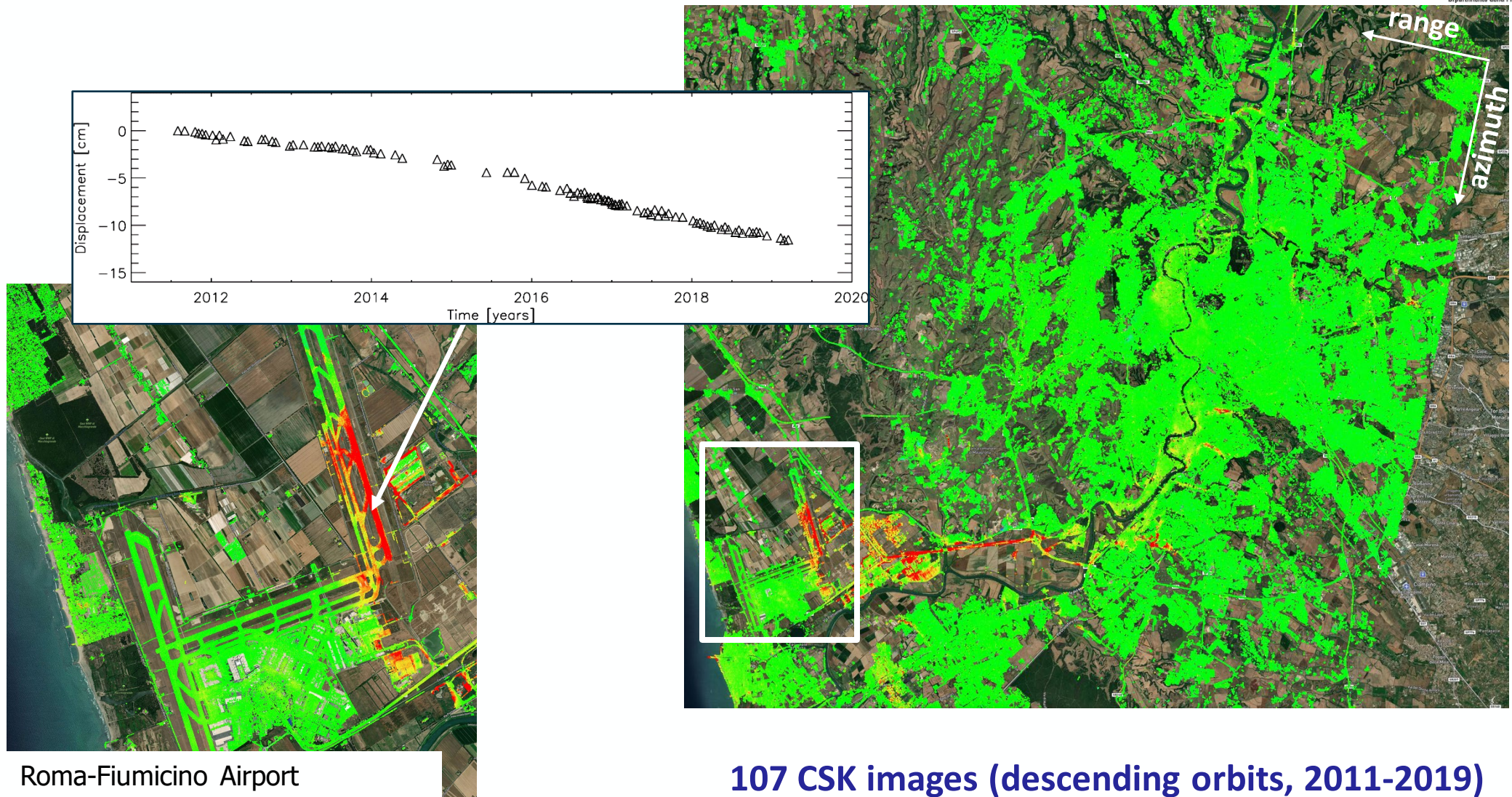
FR P-SBAS analysis with CSK/CSG SAR data: the Roma (central Italy) case study



167 CSK/CSG images (ascending orbits, 2011-2021)

FR P-SBAS analysis with CSK/CSG SAR data: the Roma (central Italy) case study

> 1



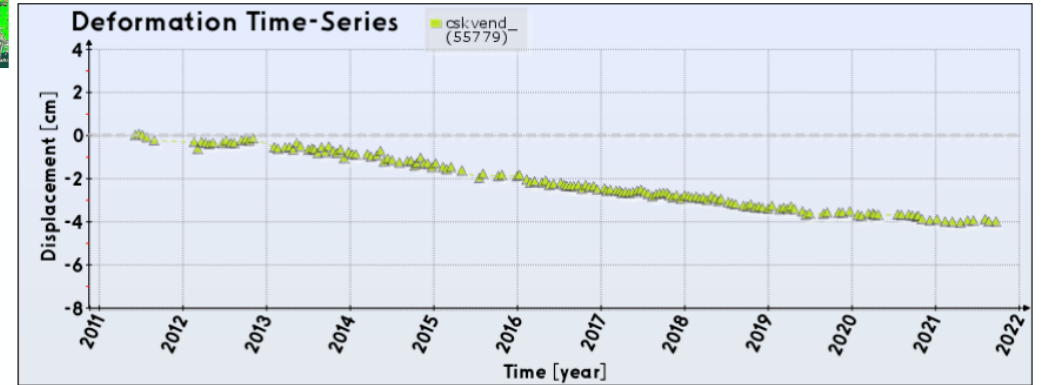
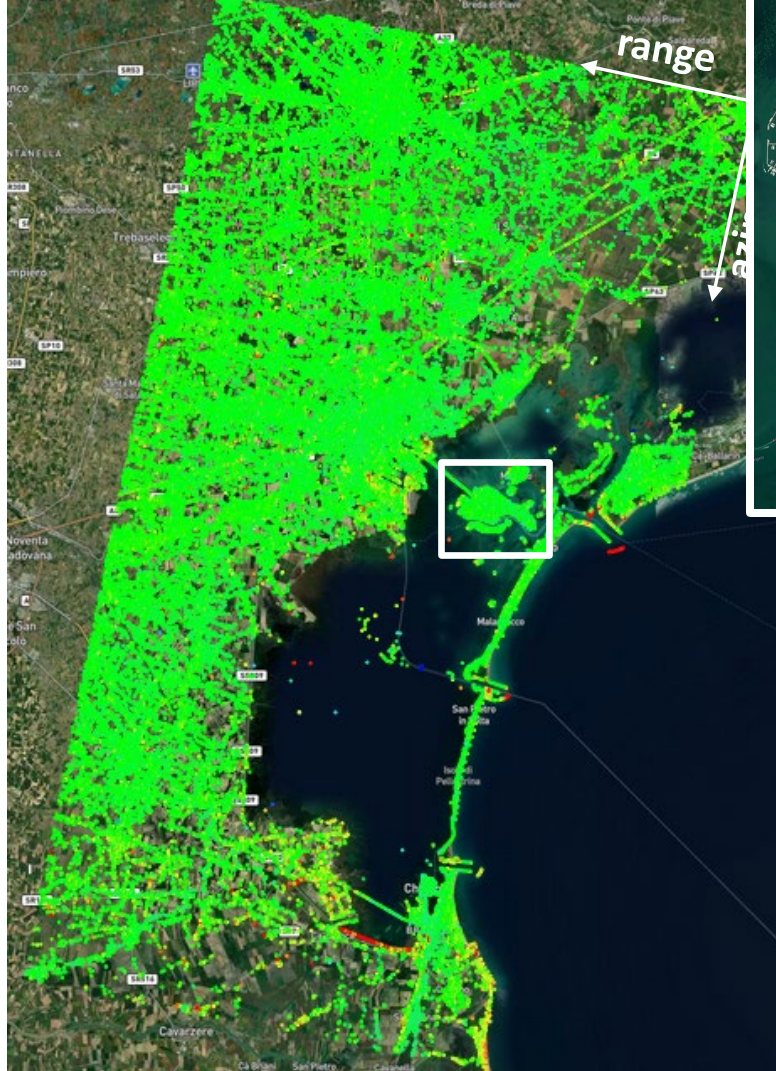
107 CSK images (descending orbits, 2011-2019)

FR P-SBAS analysis with CSK SAR data: the Venezia (northern Italy) case study

LOS mean deformation velocity
[cm/year]

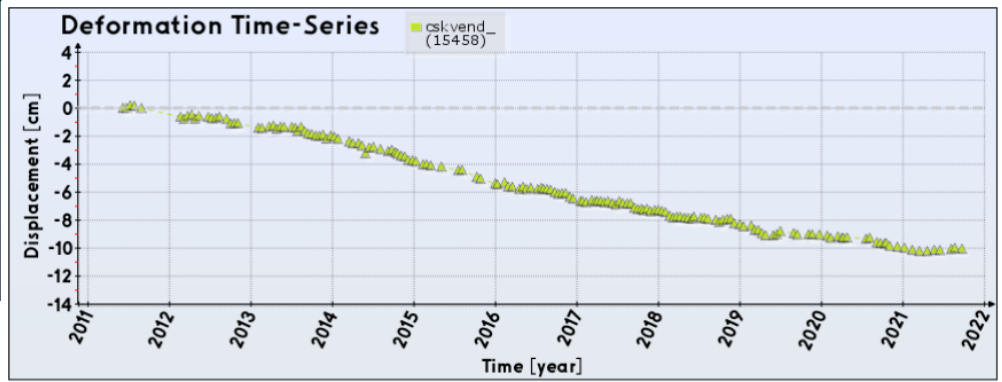
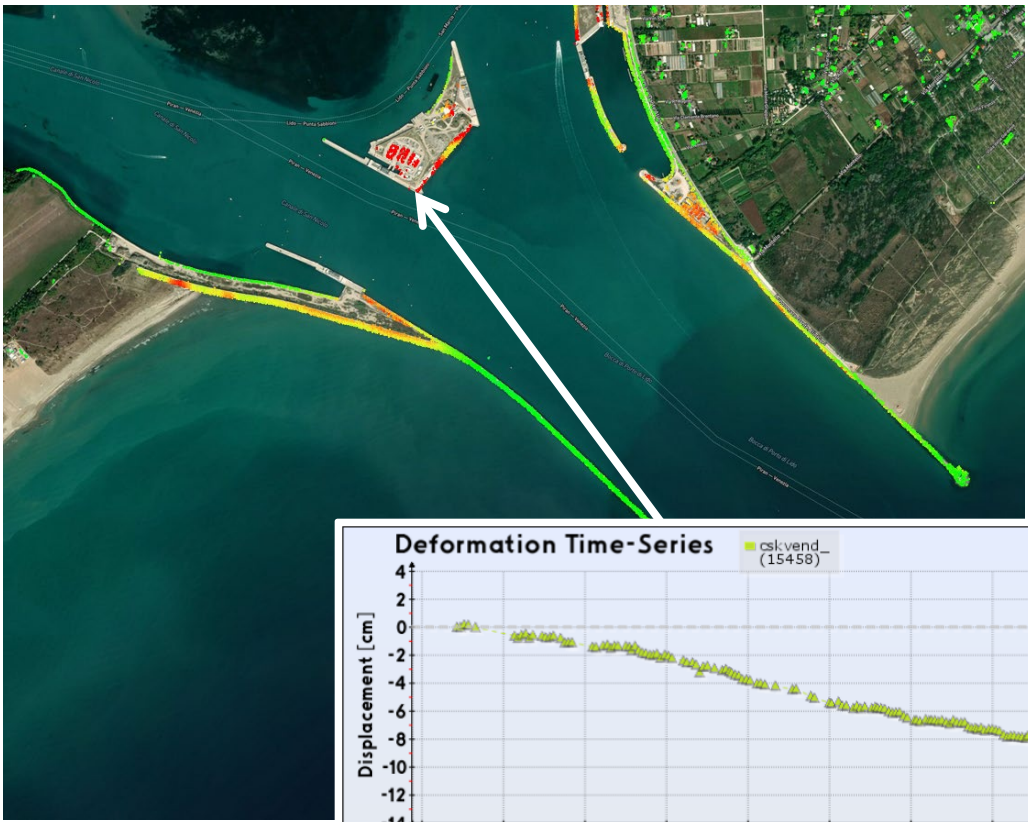
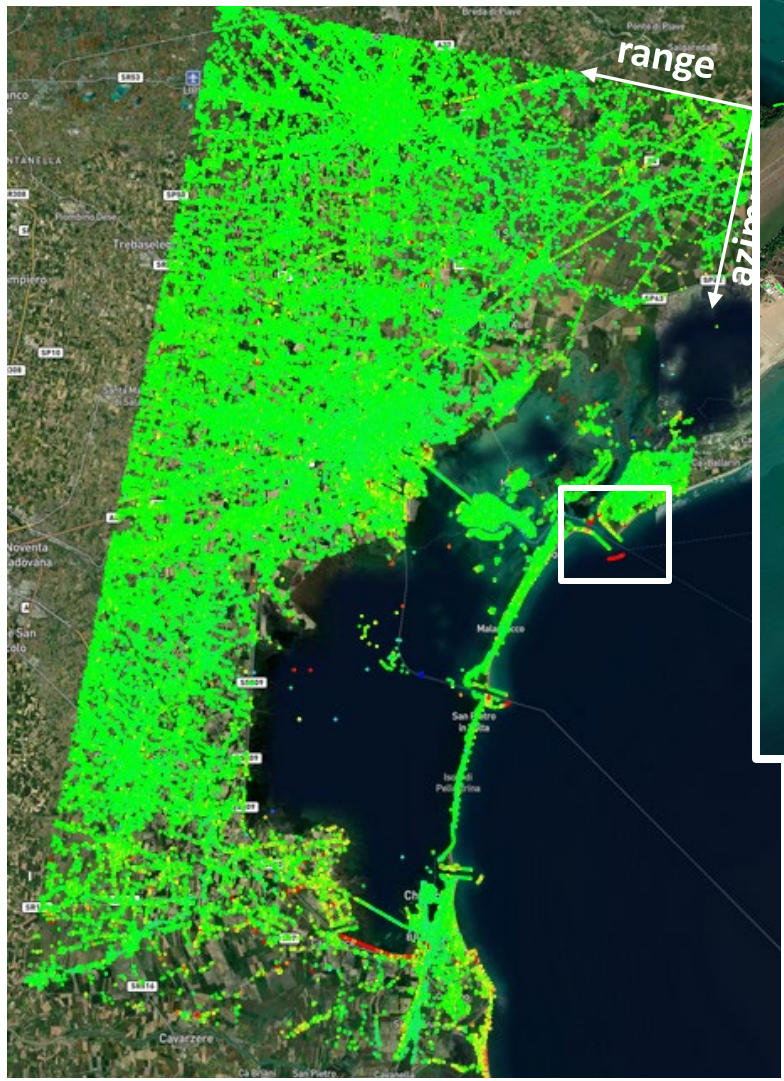
> 1

< -1



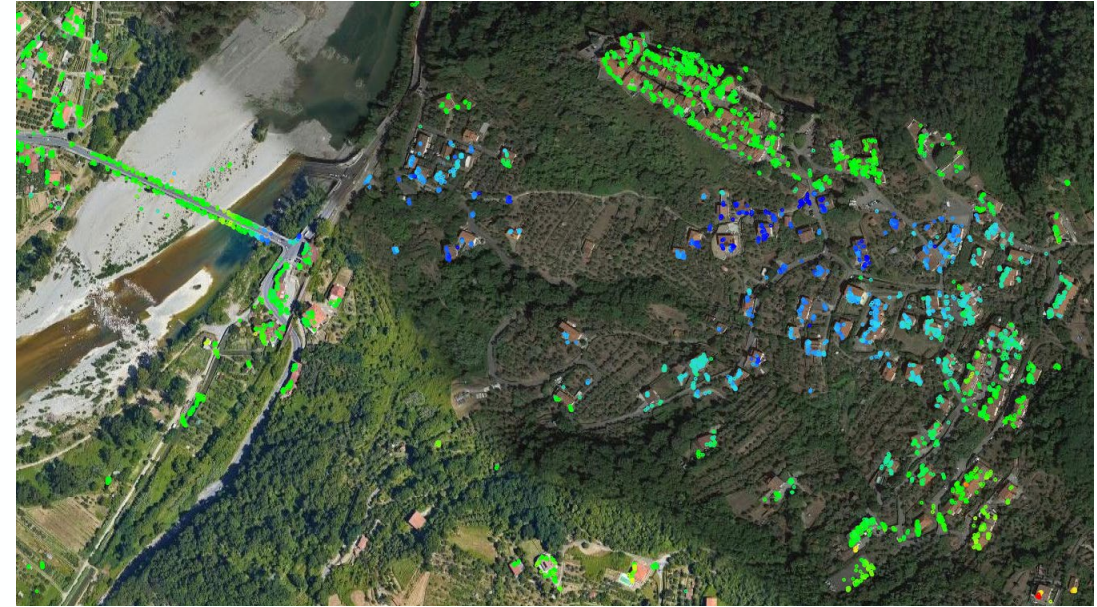
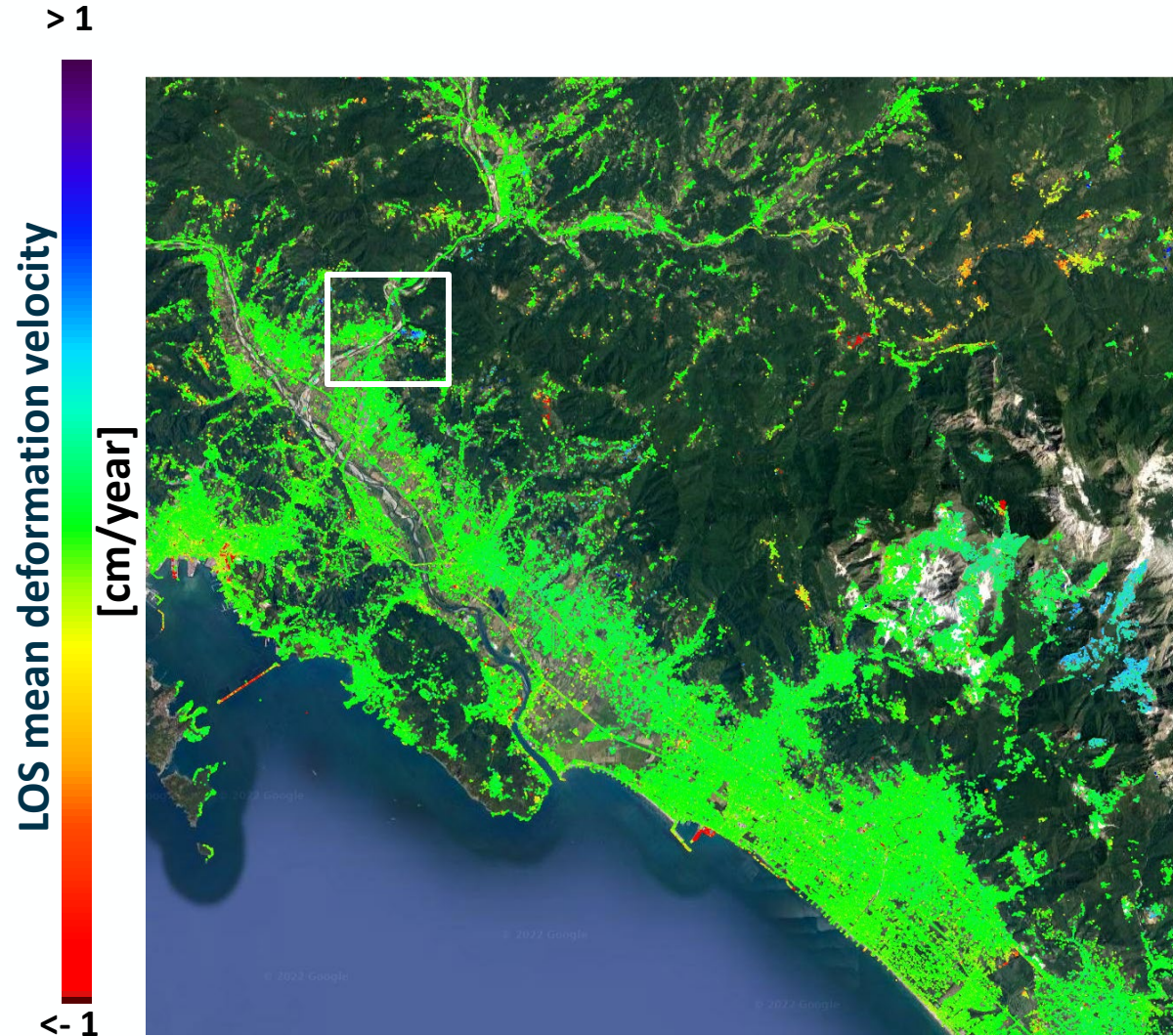
165 CSK images (descending orbits, 2011-2021)

FR P-SBAS analysis with CSK SAR data: the Venezia (northern Italy) case study



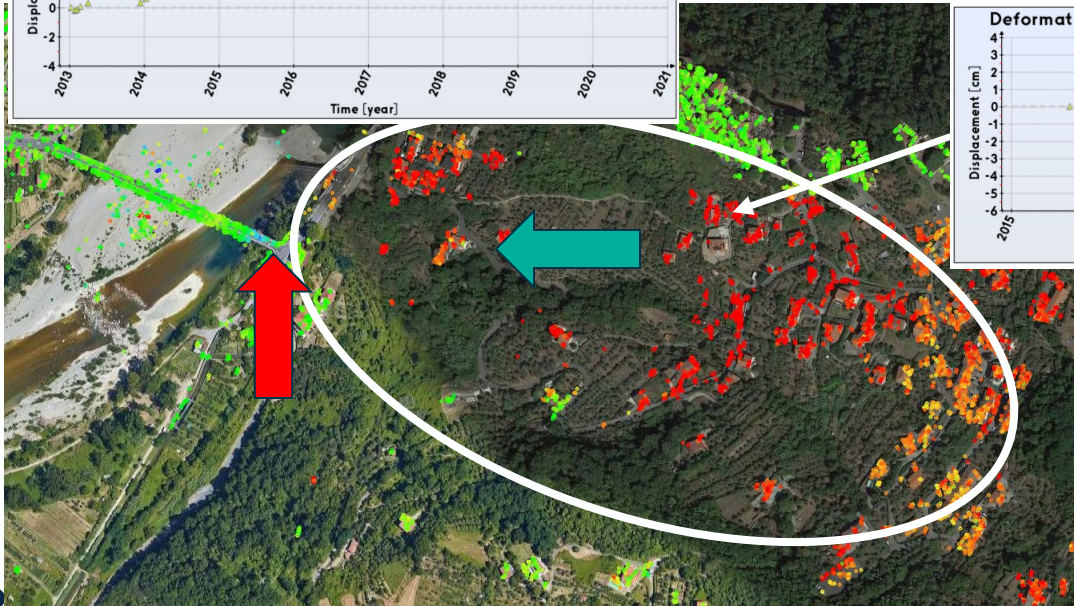
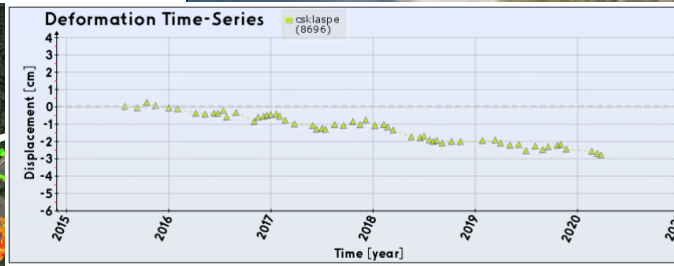
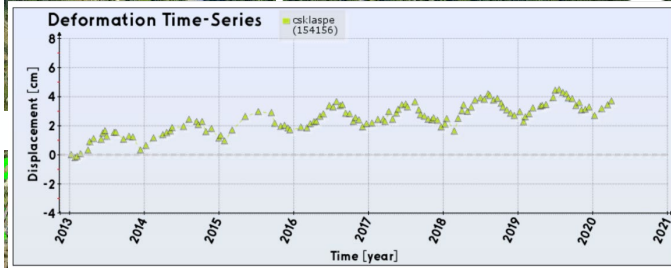
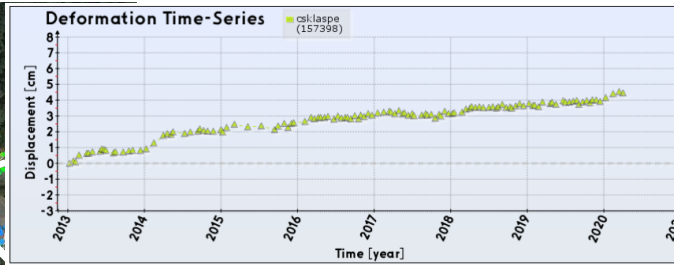
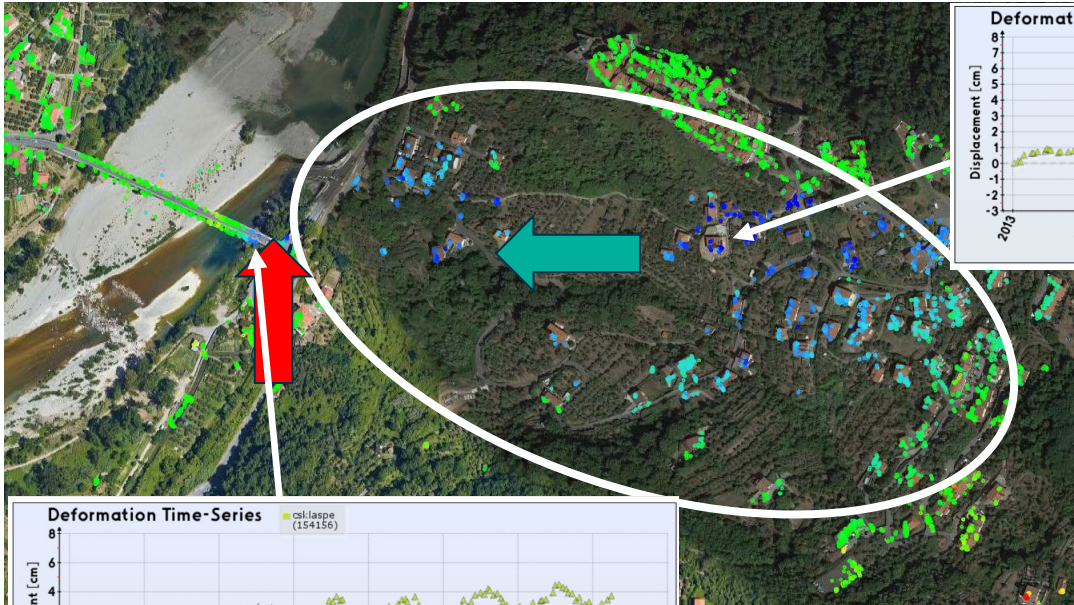
165 CSK images (descending orbits, 2011-2021)

FR P-SBAS analysis with CSK SAR data: the La Spezia (northern Italy) case study

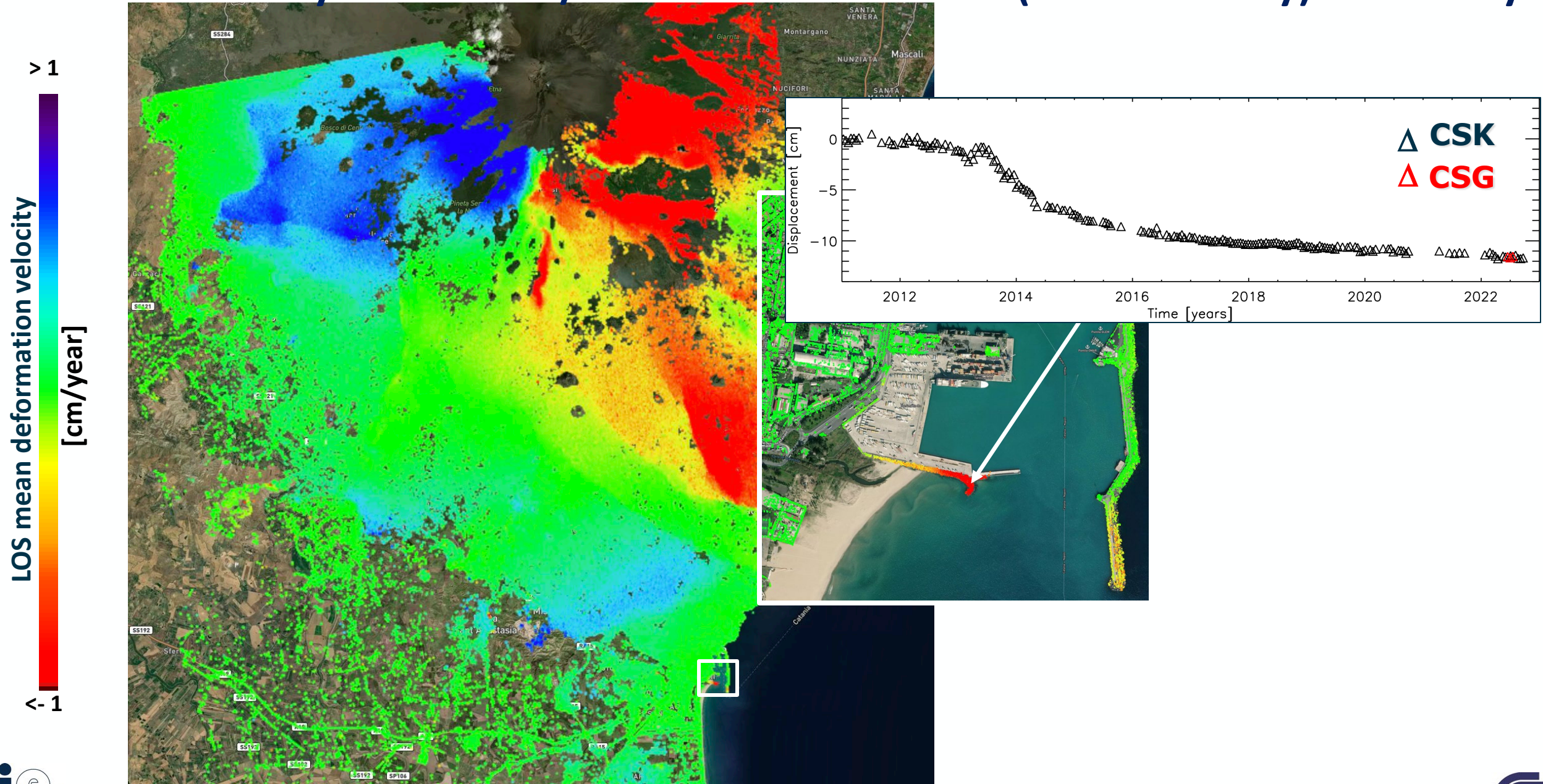


We investigate possible pre-collapse displacements on the River Magra bridge

FR P-SBAS analysis with CSK SAR data: the La Spezia (northern Italy) case study



FR P-SBAS analysis with CSK/CSG SAR data: Catania (southern Italy) case study



FR P-SBAS analysis over the “Ponte della Musica” bridge (Roma): CSK-CSG

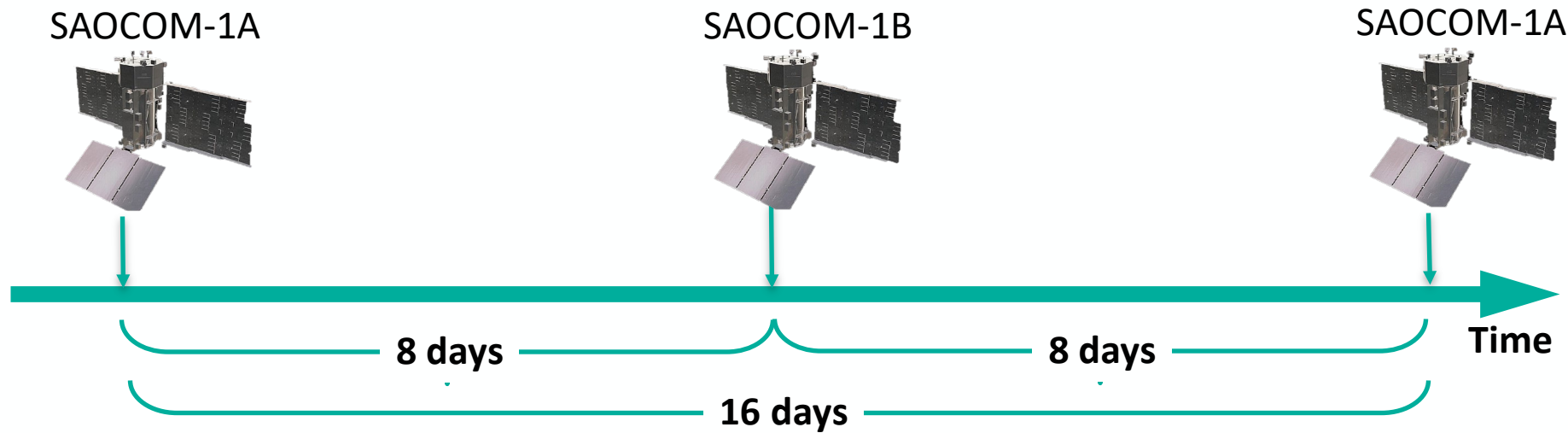
CSK-CSG 2011-2021 X-Band ($\lambda \sim 3.1$ cm)



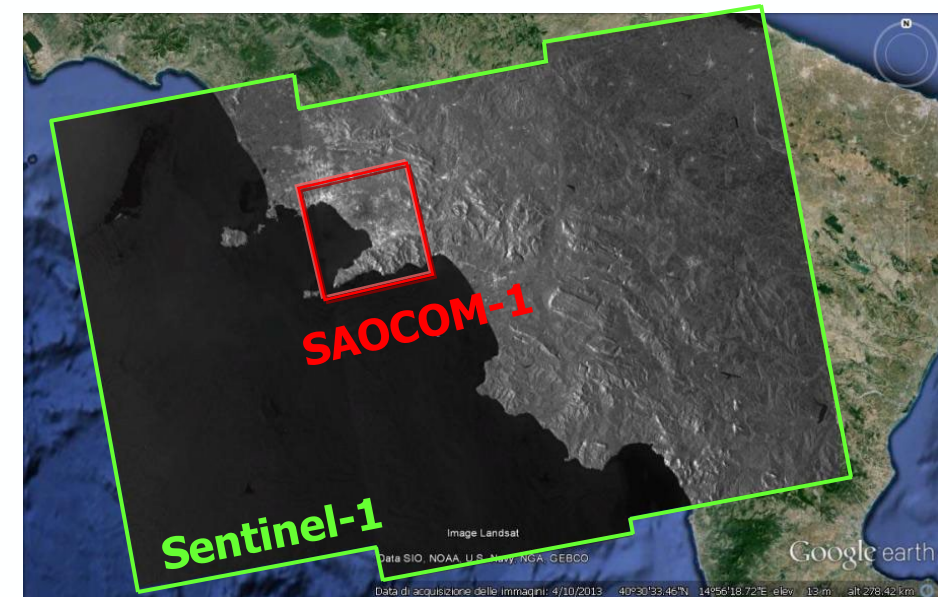
LOS mean deformation CSK-CSG velocity



SAOCOM-1 Constellation (SAOCOM-1A and 1-B)



- Argentinian SAOCOM-1 and Italian COSMO-SkyMed constellations compose the SIAGE system.
- Spatial resolution (StripMap mode): **5 m x 5 m** (Single and Dual Pol)
5 m x 6 m (Quad Pol)
- Ground coverage: **40-60 km** (Single and Dual Pol) **20-30 km** (Quad Pol)
- **L-Band ($\lambda \sim 23.5$ cm)**
- Europe is ASI Region of Exclusivity
- **Satellites launched: 10/2018 (A) – 08/2022 (B)**



FR P-SBAS analysis over the “Ponte della Musica” bridge (Roma): CSK-CSG vs SAOCOM-1

CSK-CSG 2011-2021 X-Band ($\lambda \sim 3.1$ cm)



LOS mean deformation CSK-CSG velocity
< -1  > 1
[cm/year]

SAOCOM-1 2020-2023 L-Band ($\lambda \sim 23.5$ cm)



LOS mean deformation SAOCOM-1 velocity
< -3  > 3
[cm/year]

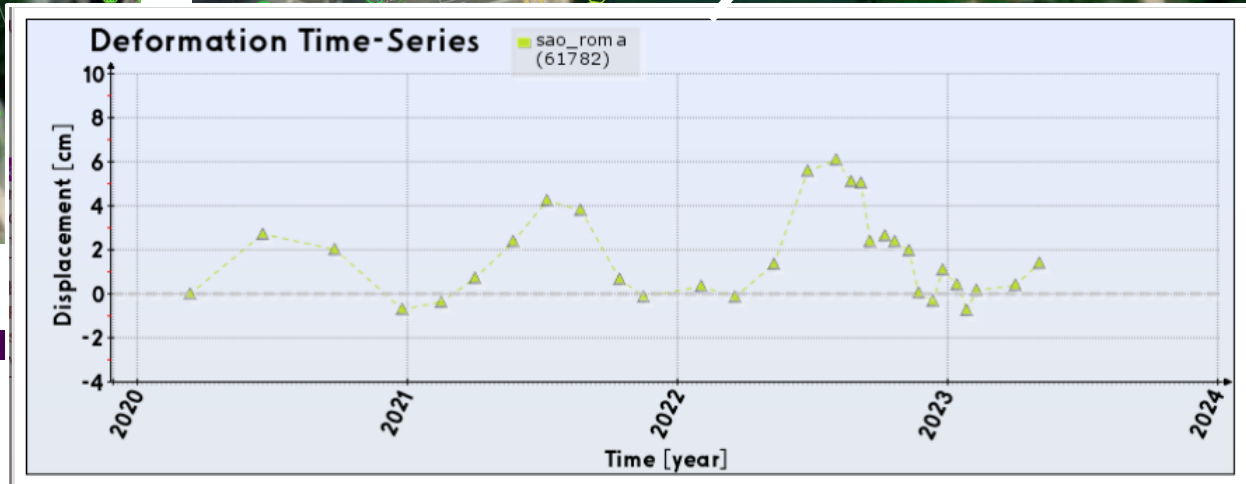
FR P-SBAS analysis over the "Ponte della Musica" bridge (Roma): CSK-CSG vs SAOCOM-1

CSK-CSG 2011-2021 X-Band ($\lambda \sim 3.1$ cm)

SAOCOM-1 2020-2023 L-Band ($\lambda \sim 23.5$ cm)



LOS mean deformation CSK-CSG velocity
<math><-1</math> [cm/year] >3

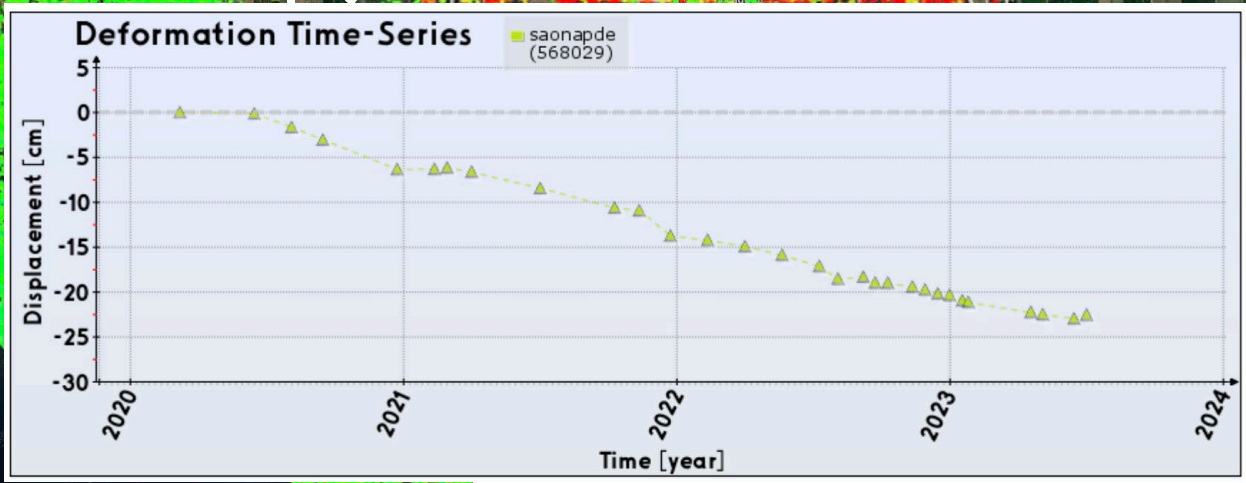
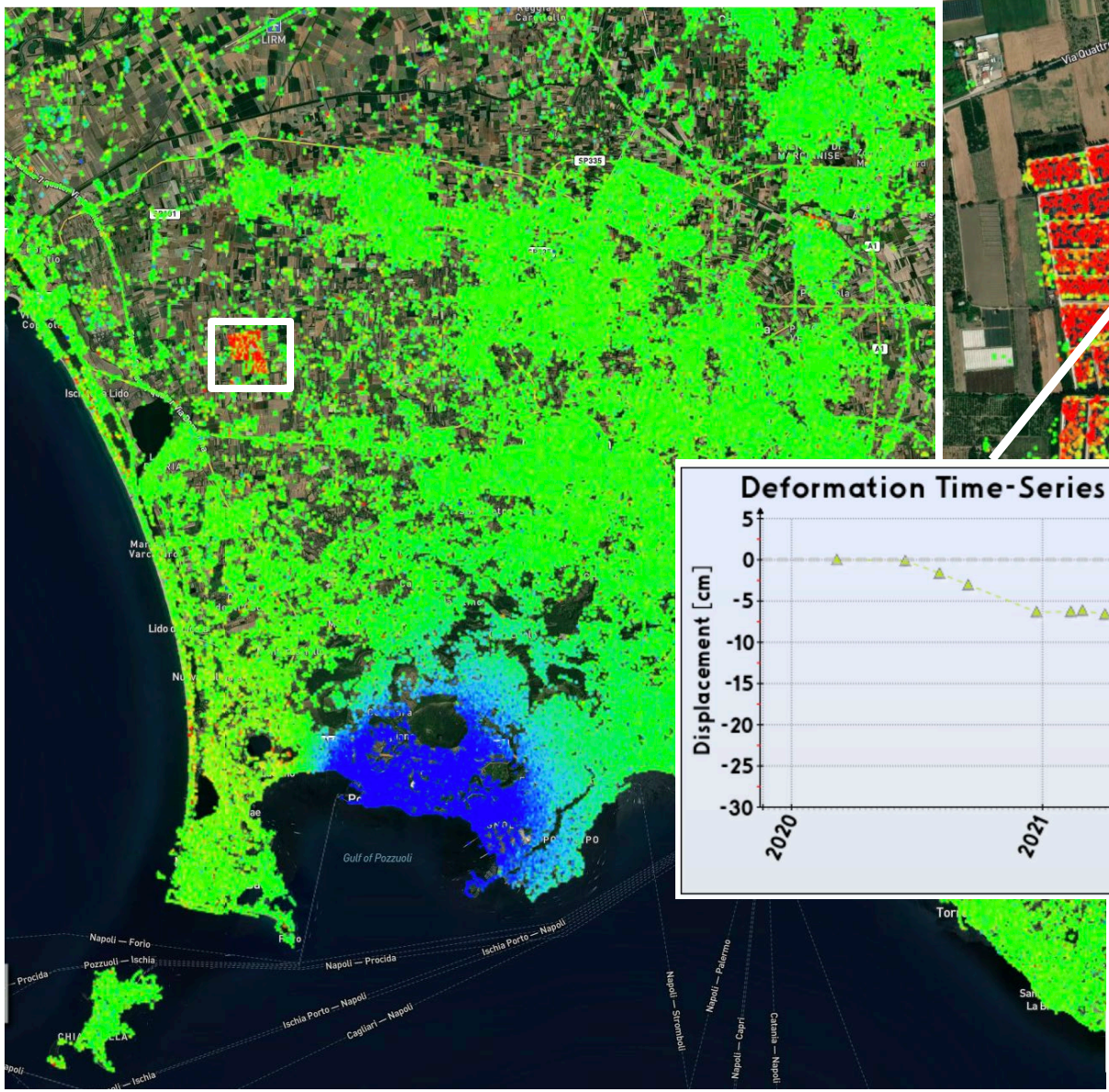


FR P-SBAS analysis with SAOCOM-1 images (descending orbits, 2020-2023) study

LOS mean deformation velocity [cm/year]

> 3

< -3



30 SAOCOM-1 images (descending orbits, 2020-2023)

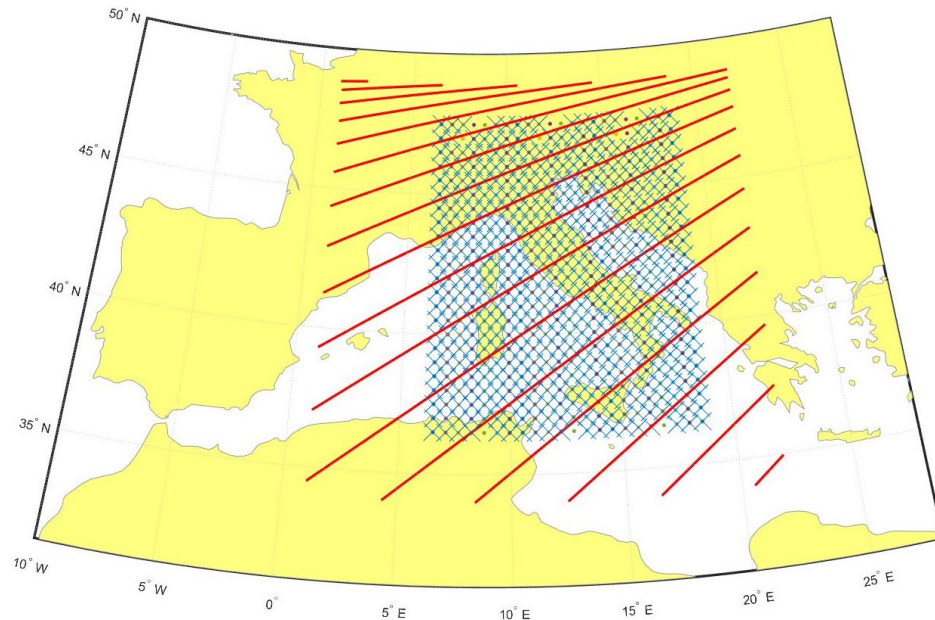
Further developments: the X-Band IRIDE constellation

In the PNRR framework, Italy will build the IRIDE constellation, including an X-Band SAR component.

IRIDE SAR (NIMBUS system):

- 10 Satellites (6 + 4)
- X-Band SAR with Interferometry capacity (orbital tube < 500 m)
- Spatial Resolution (StripMap mode): ~2.5 m x 2.5 m
- Ground Coverage: ~23-30 km
- Duty cycle: ~1-2 min
- SSO/MIO (min 44°) orbits, 520-550 km altitude

Ascending
passes



- Target Point
- Covered Point

Results of an IREA-CNR simulation, by considering:

- 6 satellites MIO 49° orbits
- 548 Km altitude, right-looking, 25 -30 km ground coverage
- full Italian coverage with a 6-days repeat pass

1 cm of VERTICAL deformation corresponds to: ~ 0.87 cm in LOS

1 cm of EAST deformation corresponds to : ~ 0.38 cm in LOS

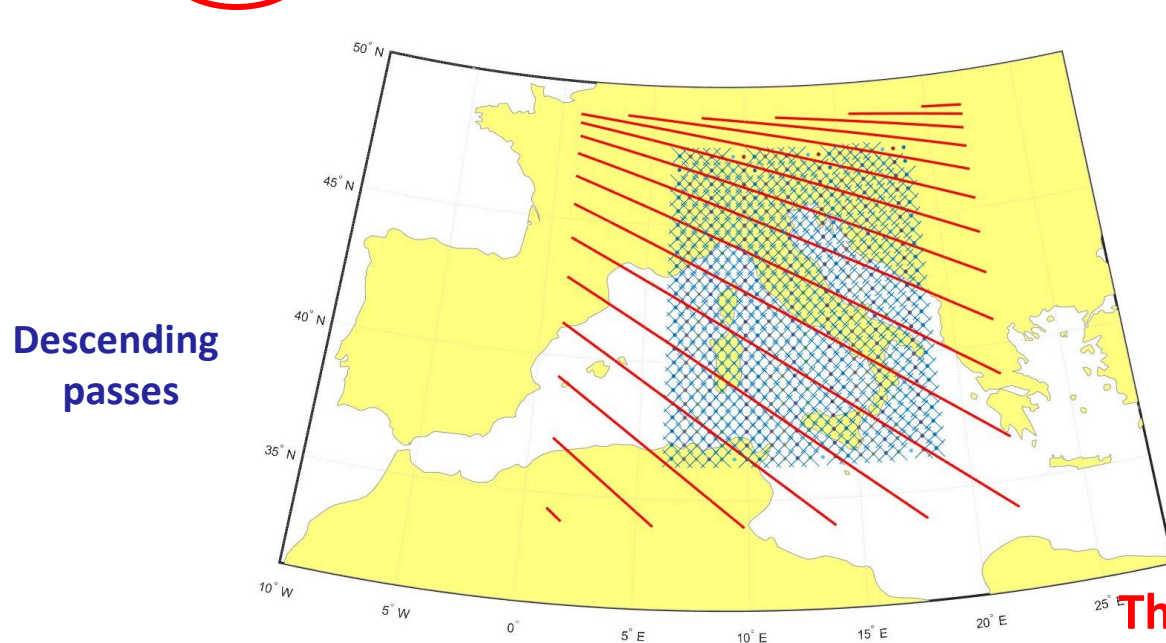
1 cm of NORTH deformation corresponds to : ~ 0.33 cm in LOS

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1 cm of EAST deformation corresponds to : ~ 0.38 cm in LOS

1 cm of NORTH deformation corresponds to : ~ 0.33 cm in LOS

The joint exploitation of CSK/CSG/IRIDE will make it possible to retrieve the full 3D deformation field!

Thank you!!!