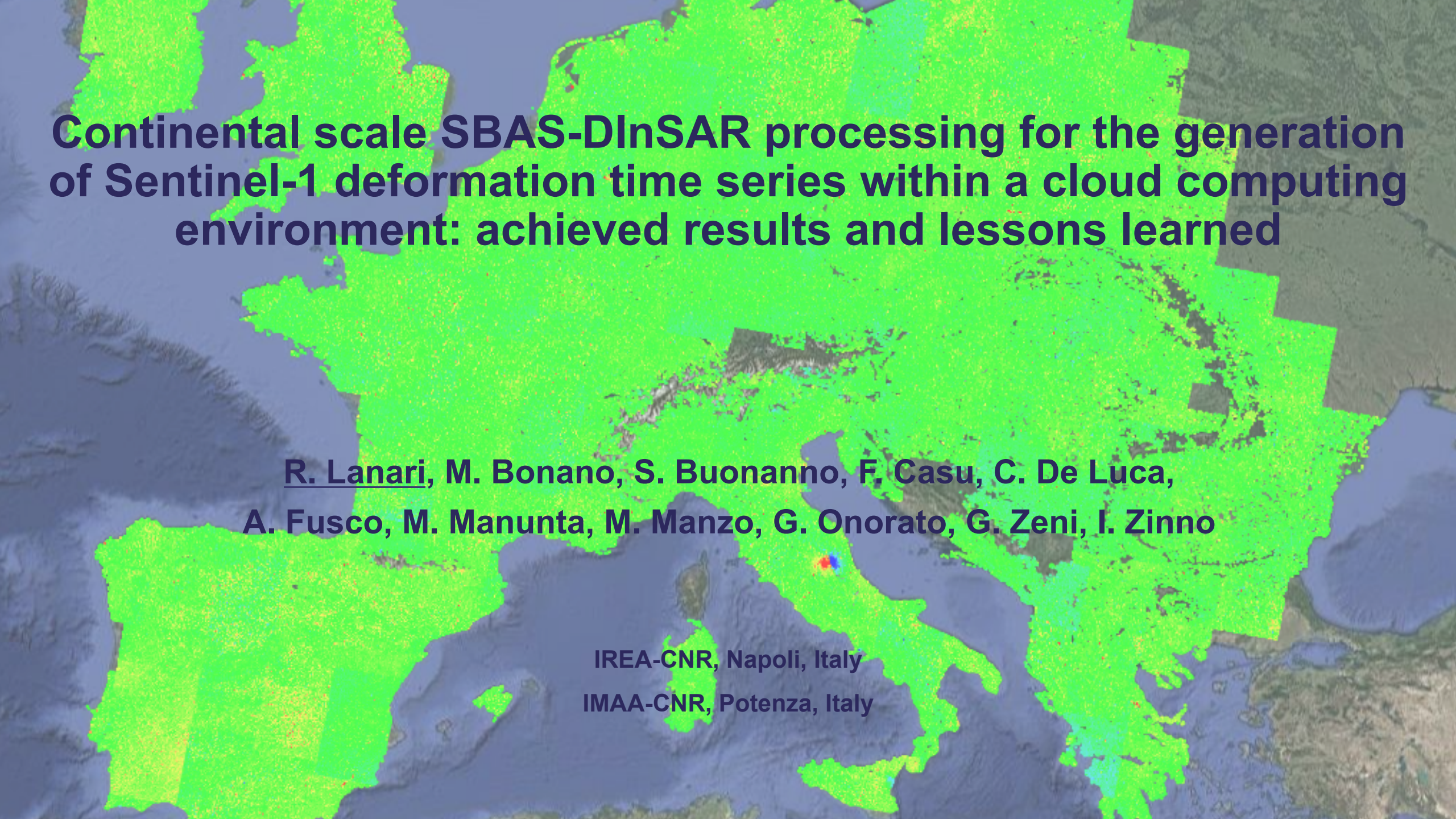


Continental scale SBAS-DInSAR processing for the generation of Sentinel-1 deformation time series within a cloud computing environment: achieved results and lessons learned

R. Lanari, M. Bonano, S. Buonanno, F. Casu, C. De Luca,

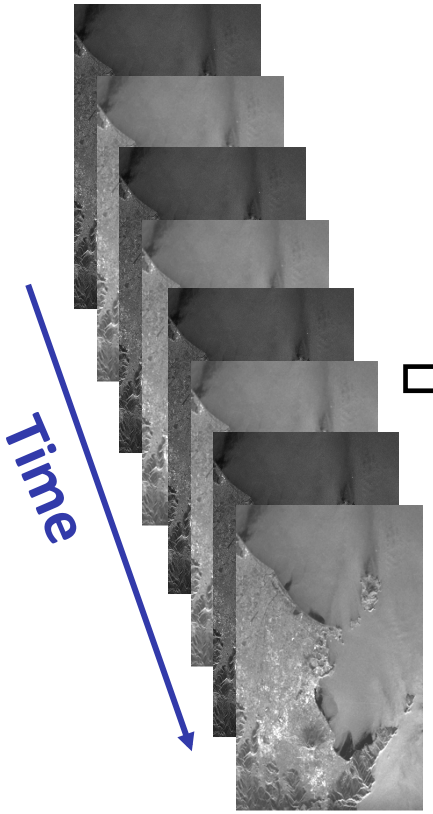
A. Fusco, M. Manunta, M. Manzo, G. Onorato, G. Zeni, I. Zinno

IREA-CNR, Napoli, Italy

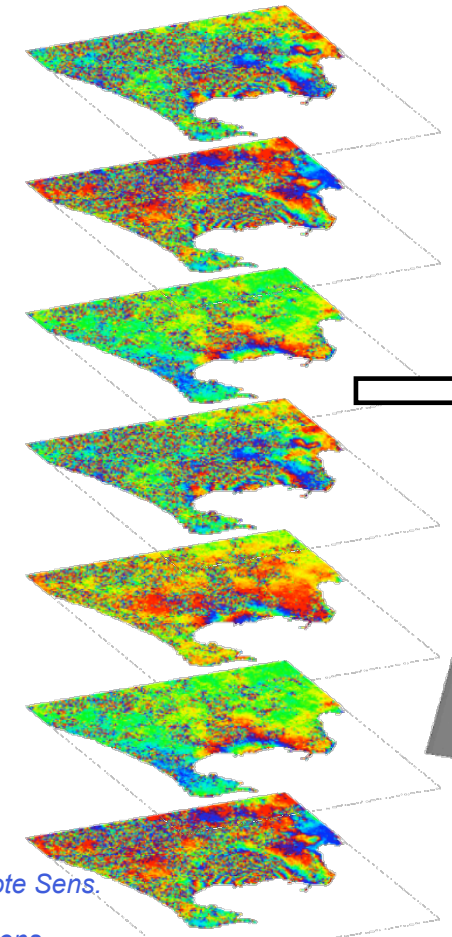
IMAA-CNR, Potenza, Italy

Exploited advanced DInSAR technique: Small BAseline Subset (SBAS) approach

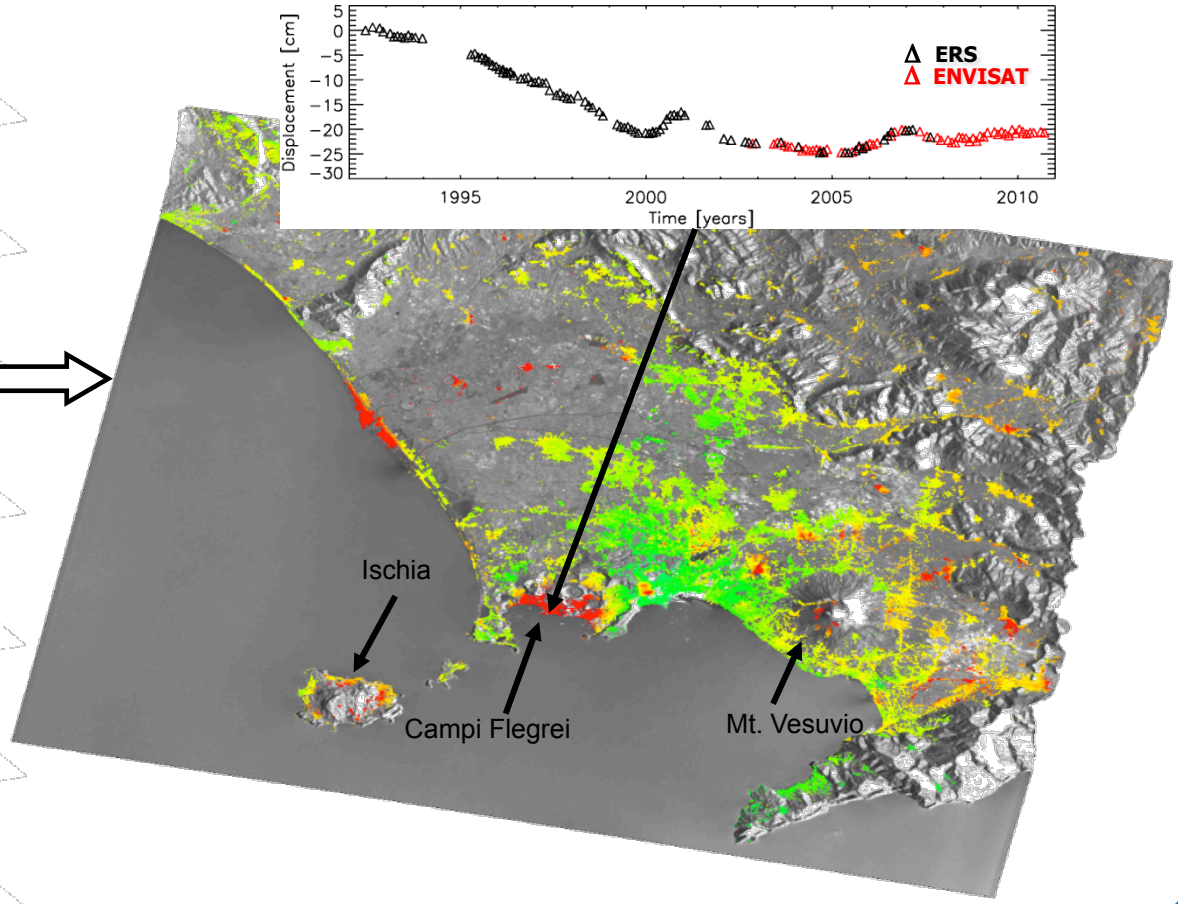
SAR Images

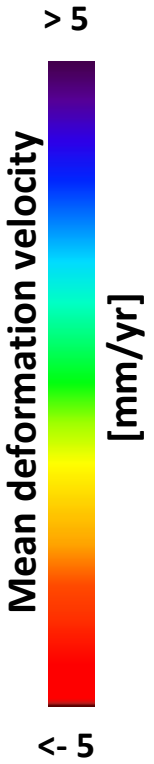


SB Interferograms



ERS/ENVISAT images (1992 – 2010)

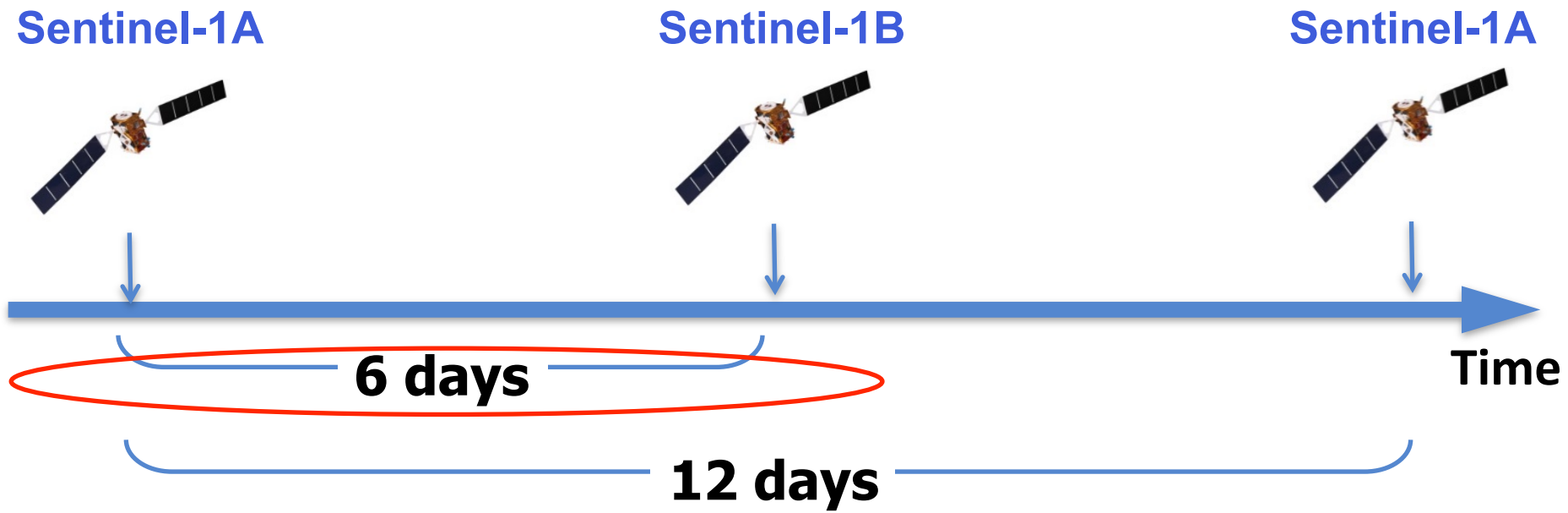




Berardino et al., 2002, IEEE Trans. Geosci. Remote Sens.

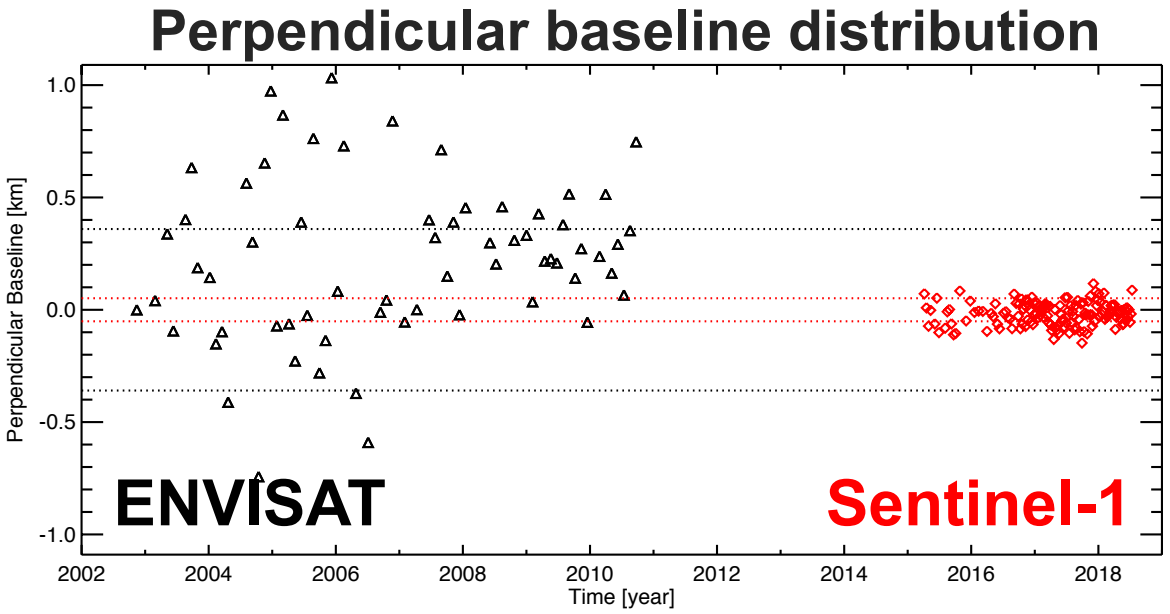
Pepe et al., 2005, IEEE Trans. Geosci. Remote Sens.

Exploited SAR sensors: Sentinel-1 constellation



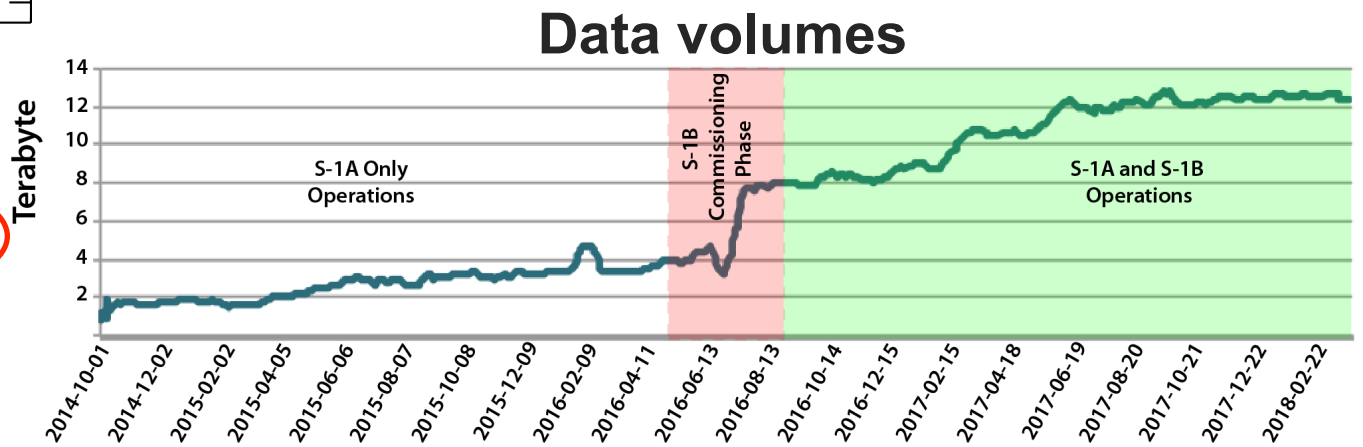
- IWS mode spatial resolution: 15 m x 4 m
- IWS mode swath extension: 250 km
- C-band
- Global coverage
- Free and open data access

Sentinel-1 constellation characteristics



A "small baseline" constellation

with very large data volumes

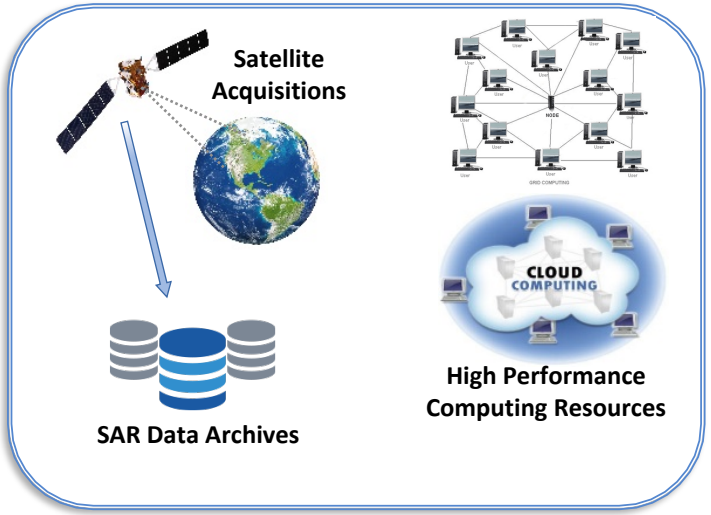


Courtesy of ESA

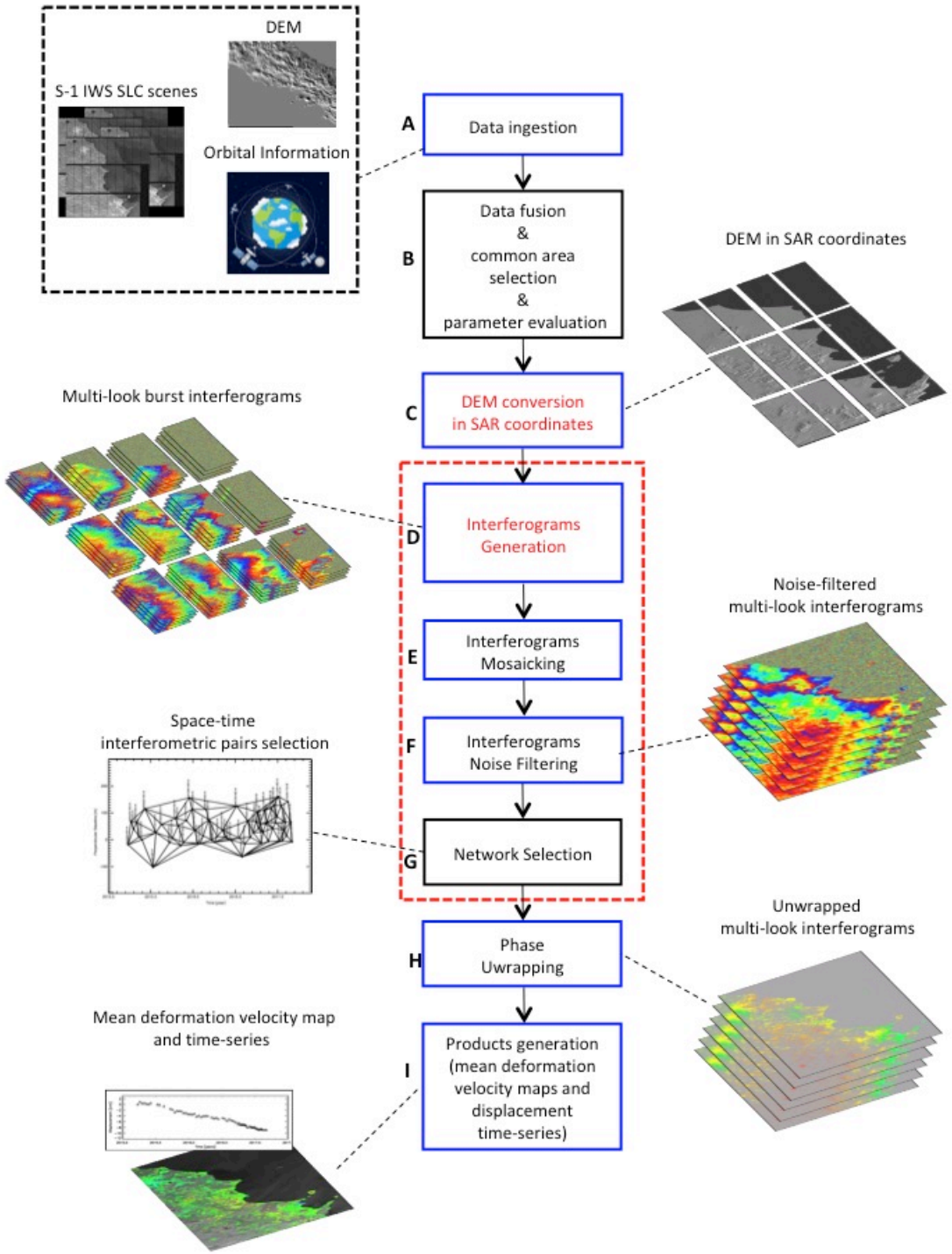
Main requirements for massive DInSAR processing of Sentinel-1 data archives

Efficient Processing Tools:
parallel algorithms for HPC platforms
to minimize the processing times

Computing Resources & Data Proximity:
distributed HPC infrastructures and in
proximity to data



Sentinel-1 Parallel SBAS (P-SBAS) workflow



The parallelization strategy is based on Multi-Node and Multi-Core architectures

The granularity is essentially based on two levels:

- Burst Level
- Interferograms Level

The PhU step uses a dedicated parallelization strategy (Open MP)

Casu et al., 2014, IEEE JSTARS

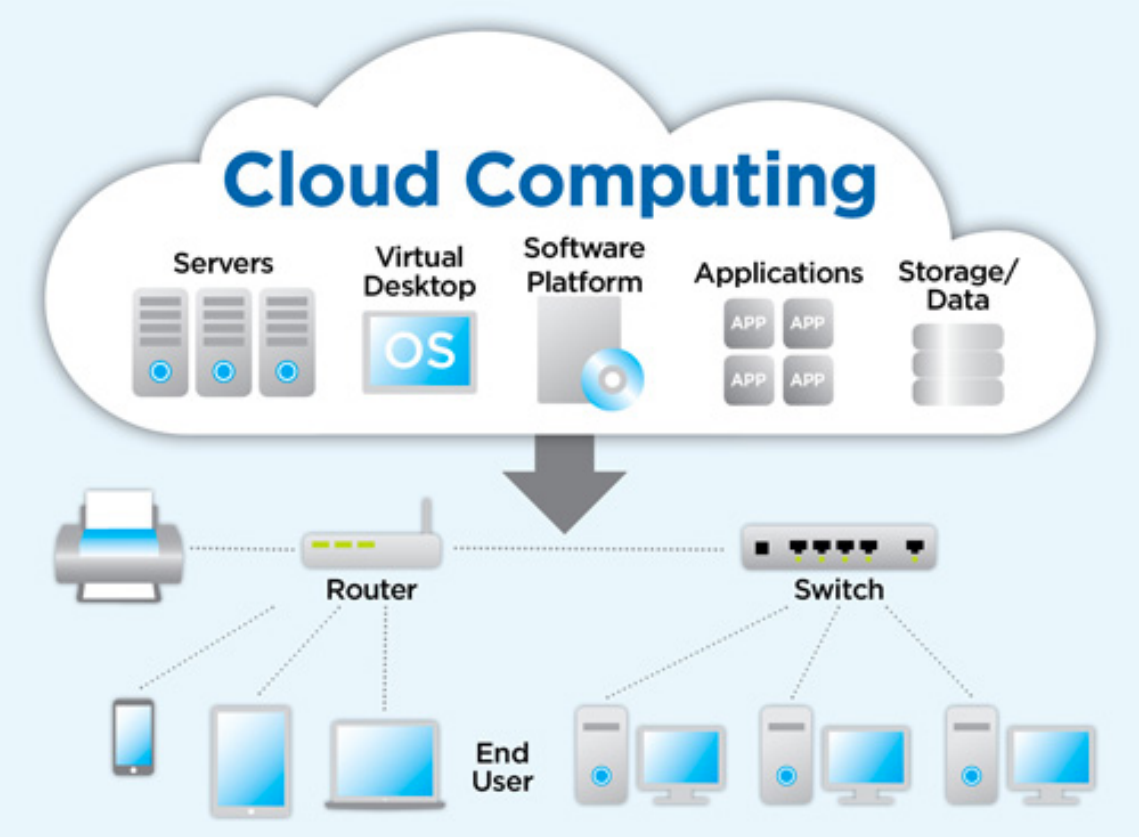
Pepe et al., 2015, IEEE TGRS

Zinno et al., 2015, IEEE JSTARS

Zinno et al., 2015, IEEE Trans. Cloud Computing

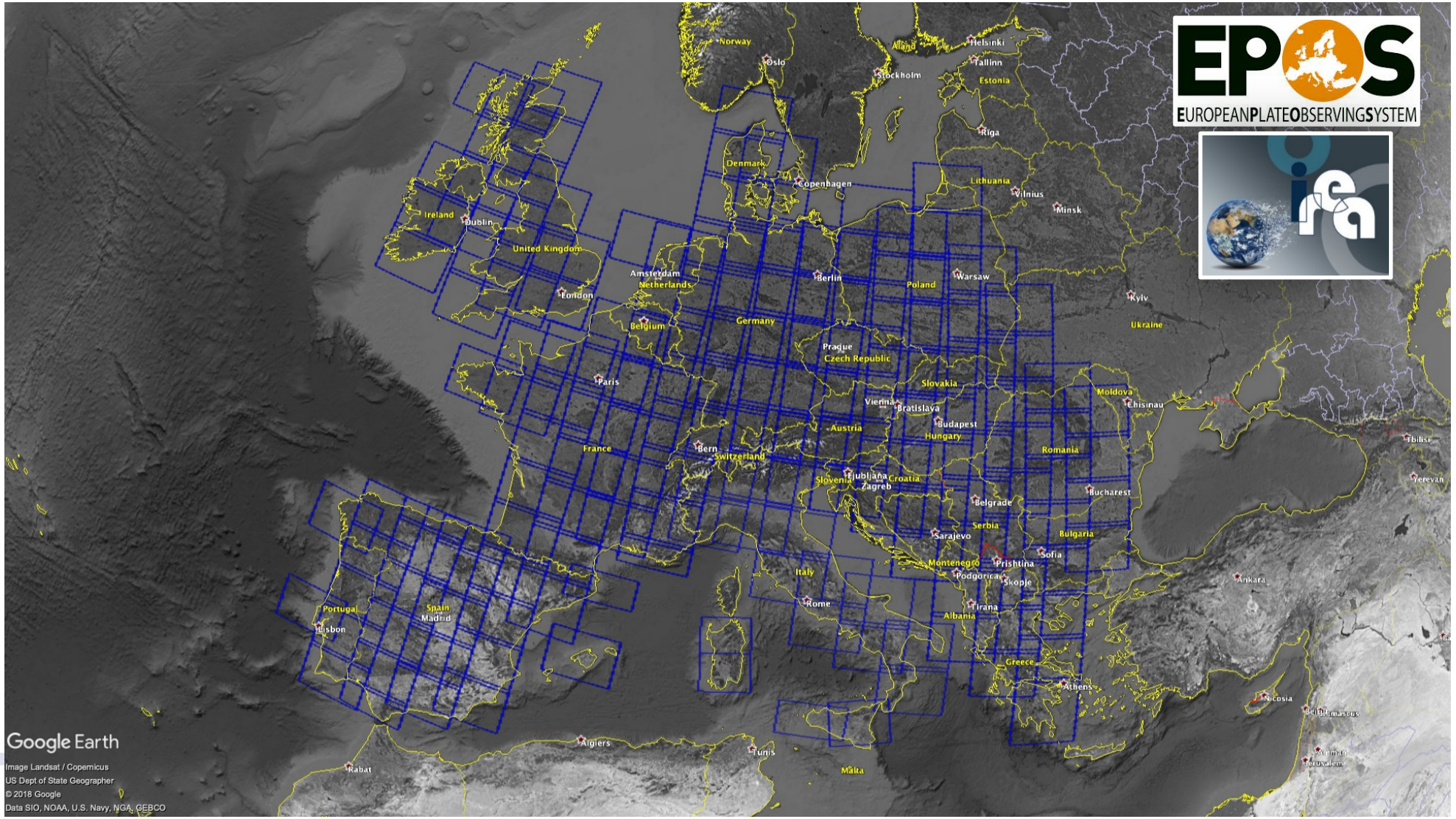
Manunta et al., 2019, IEEE TGRS

Cloud Computing basic rationale



Cloud Computing is a computing paradigm that provides flexible resource allocation on demand with the key objective to realize elastic, Internet-accessible, computing on a pay-per-use basis (*Zeid et al., 2014, DOI: 10.4018/978-1-4666-5788-5.ch002*)

Continental scale Sentinel-1 P-SBAS DInSAR analysis: investigated area



Continental scale Sentinel-1 P-SBAS DInSAR analysis: computing resources

How to do that?

ONDA
#peopleondata
serco
opernicus

6 Nodes each one equipped with:
CPU's: 64
RAM: 512 GB RAM
Storage: 20 TB

Experiments Start Date: 14/01/2019
Experiments duration: ~6 months

EPOS
EUROPEANPLATEOBSERVINGSYSTEM

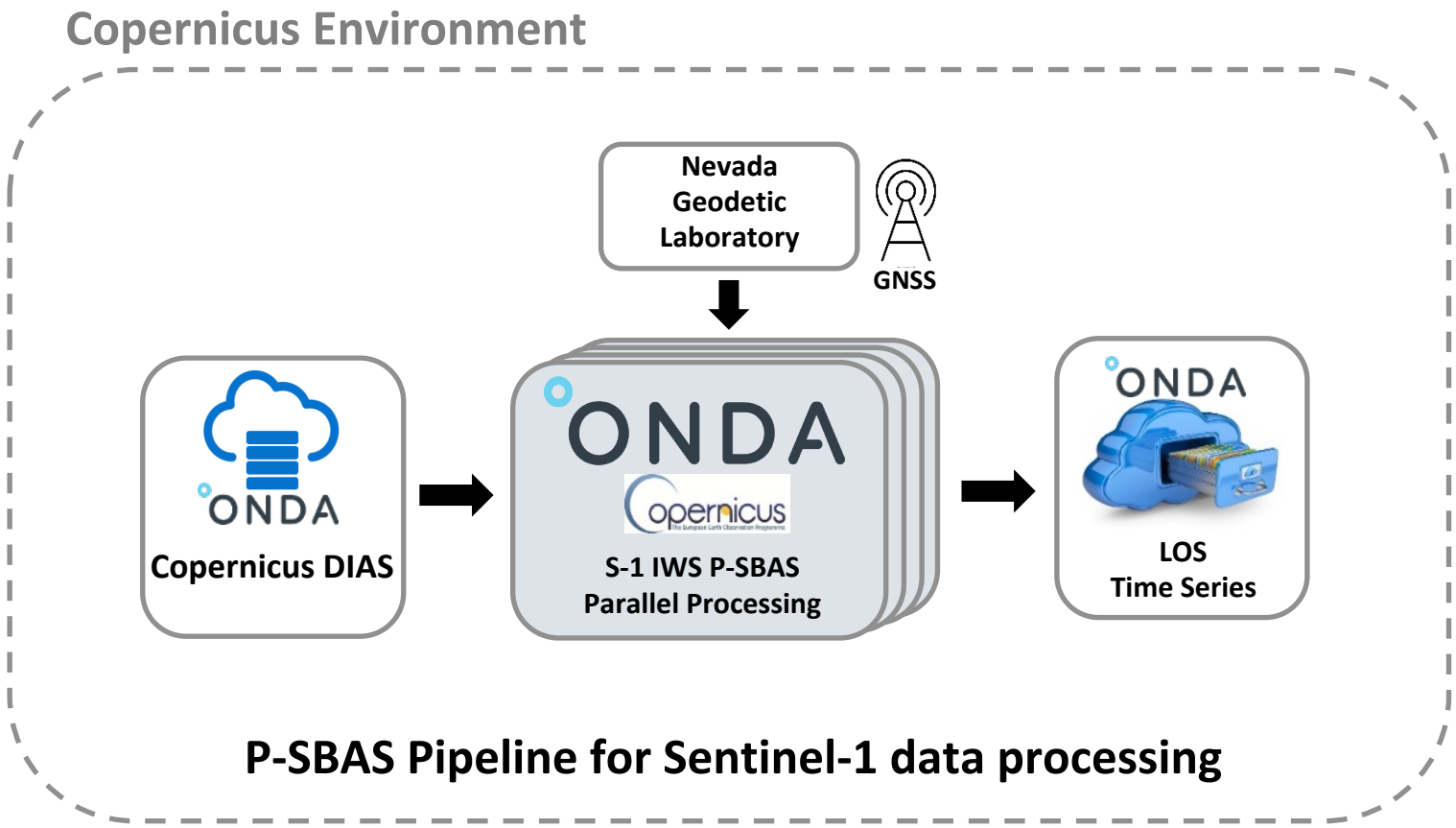
irea

Google Earth
Image Landsat / Copernicus
US Dept of State Geographer
© 2018 Google
Data SIO, NOAA, U.S. Navy, NGA, GEBCO

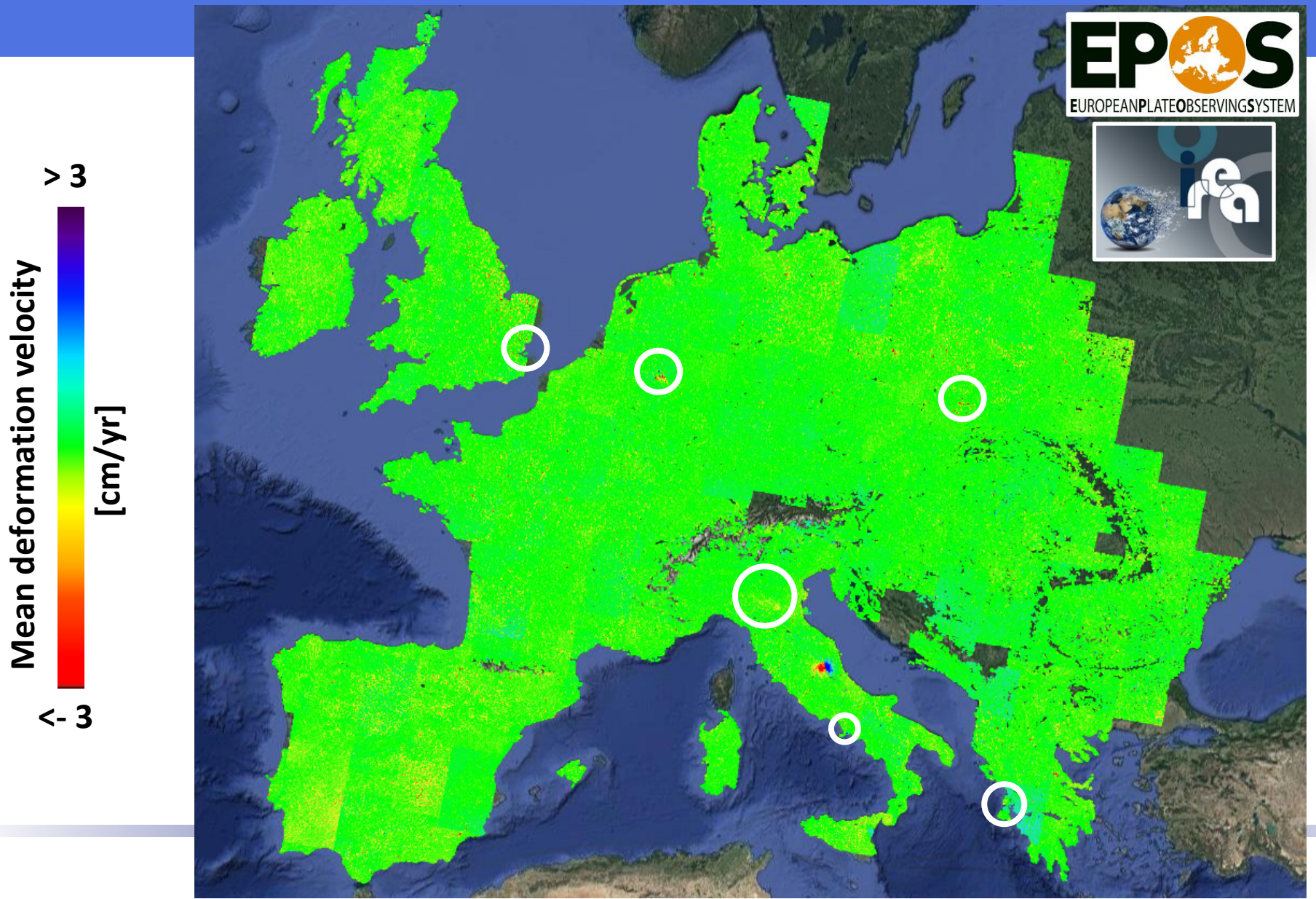
irea
institute for electromagnetic sensing of the environment

EGU

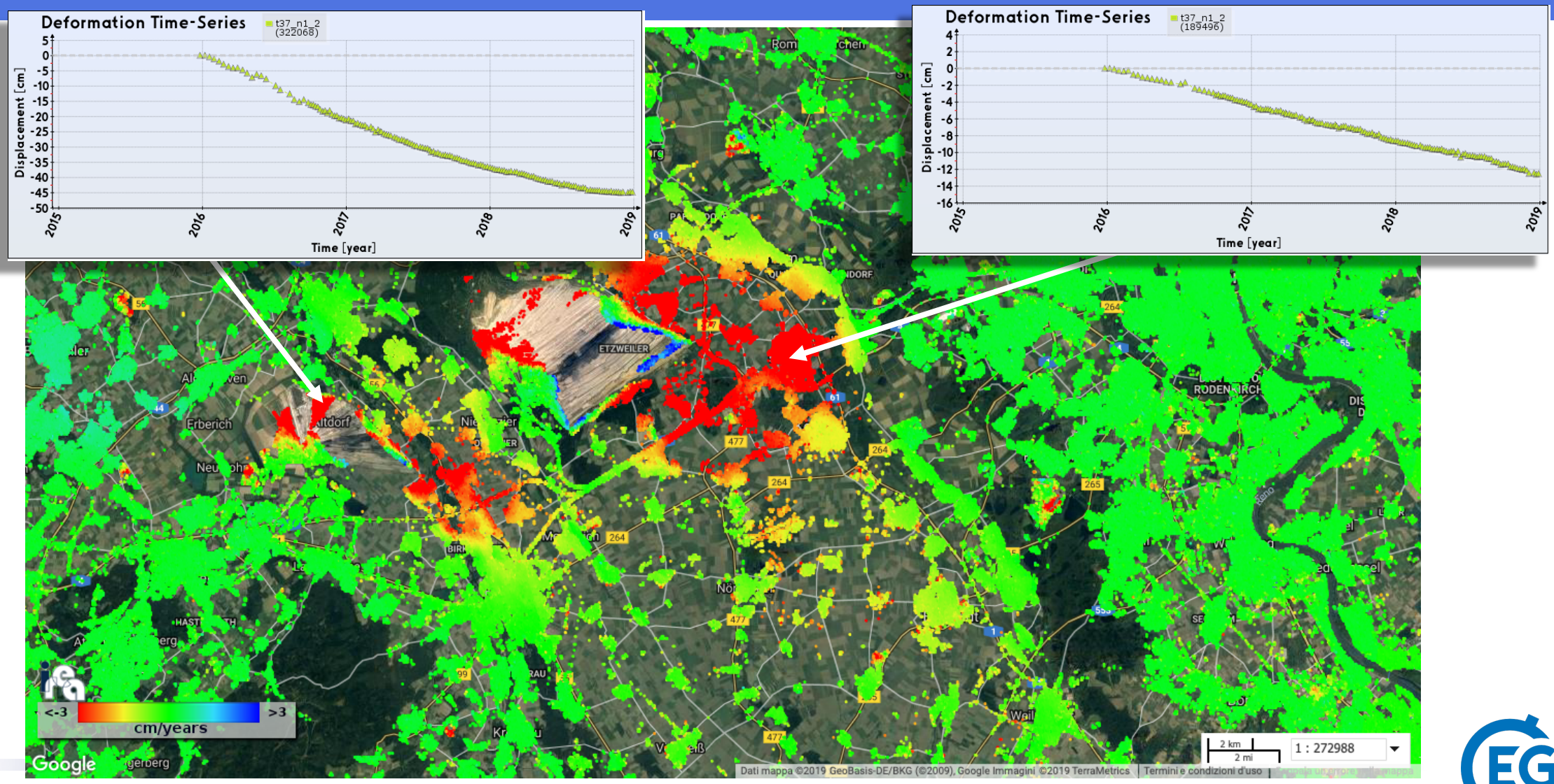
Exploited Cloud Computing scenarios for massive P-SBAS DInSAR processing



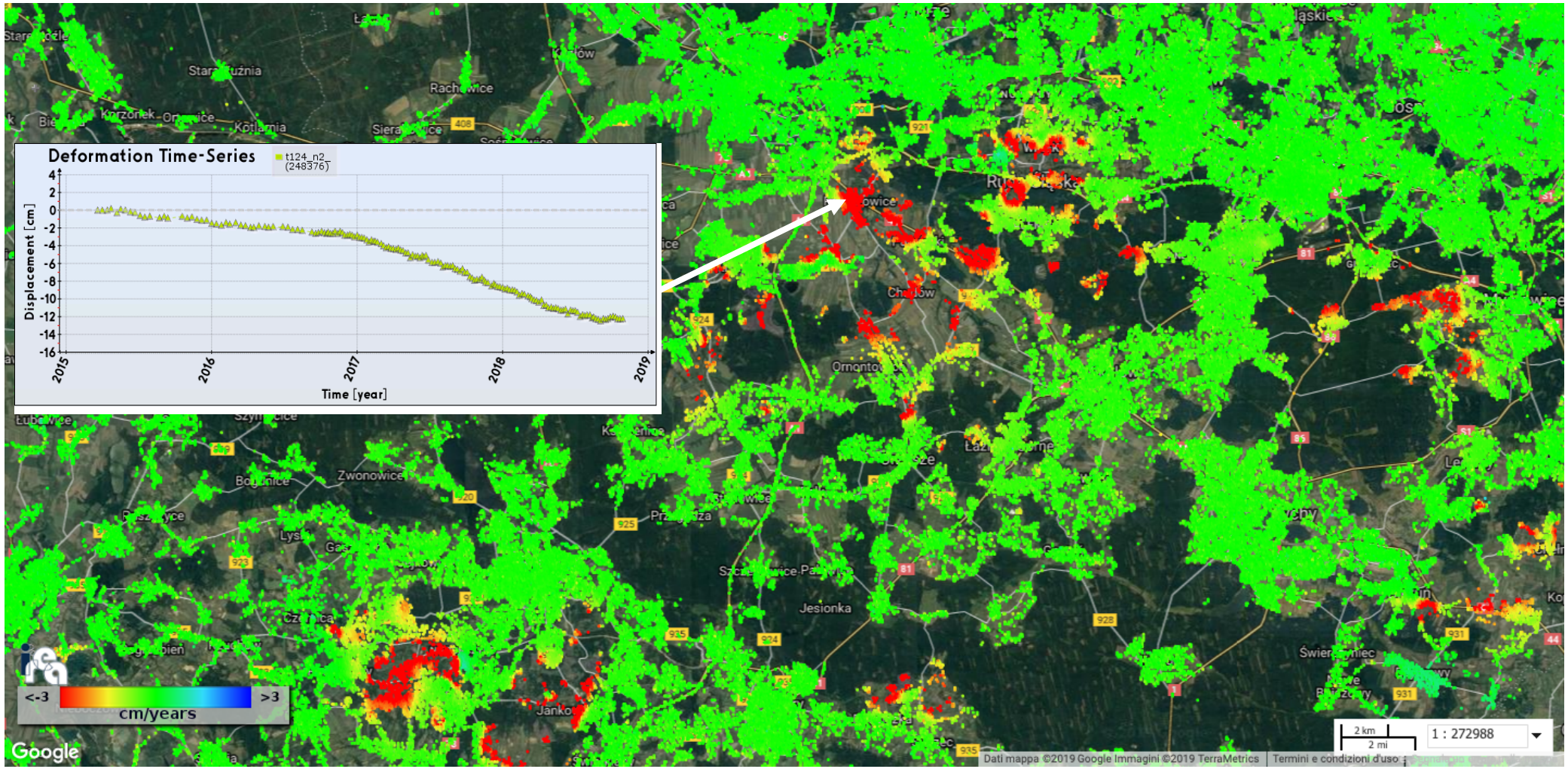
Continental scale Sentinel-1 P-SBAS DInSAR results



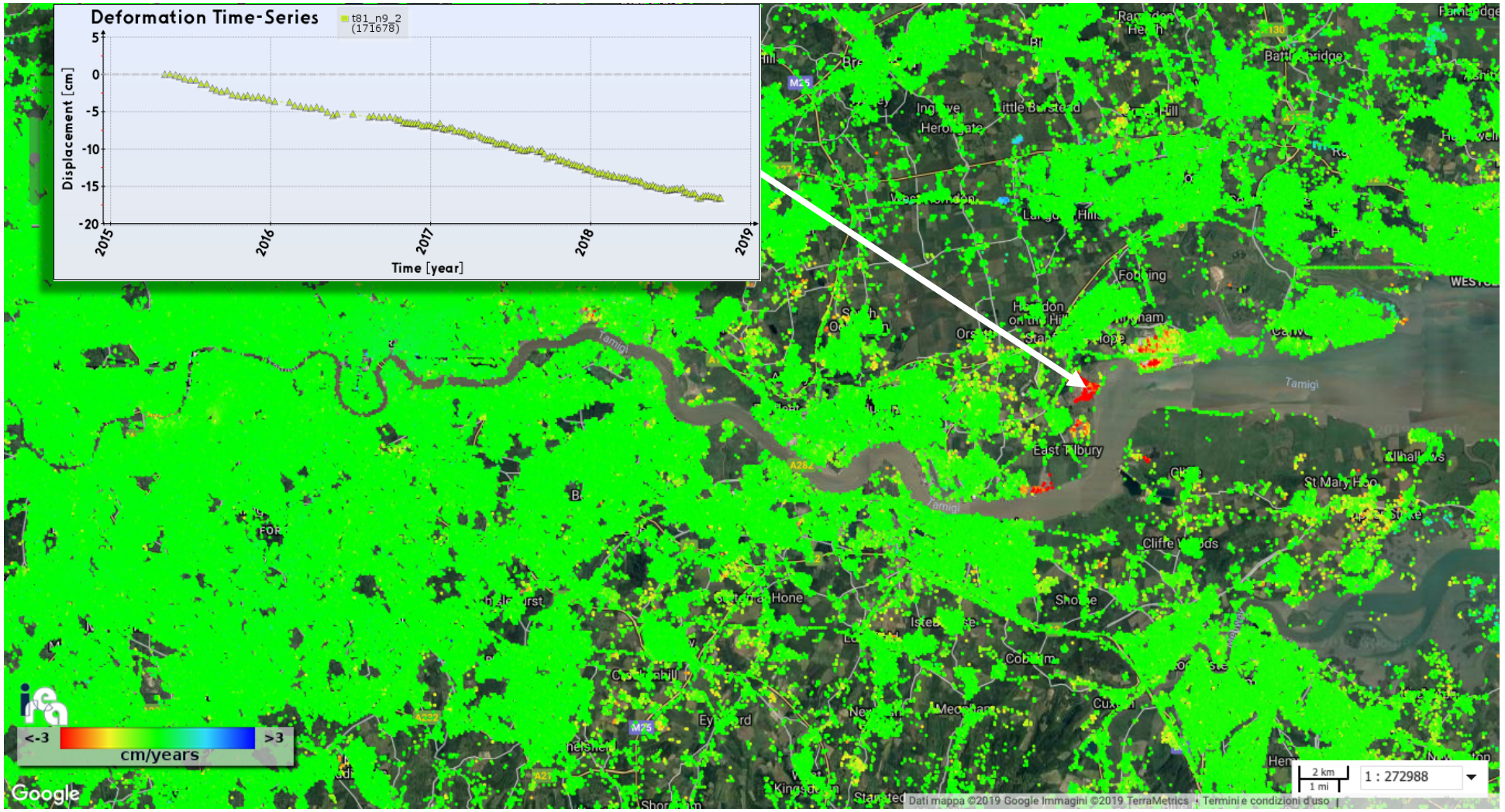
Deformations due to mining activities in western Germany



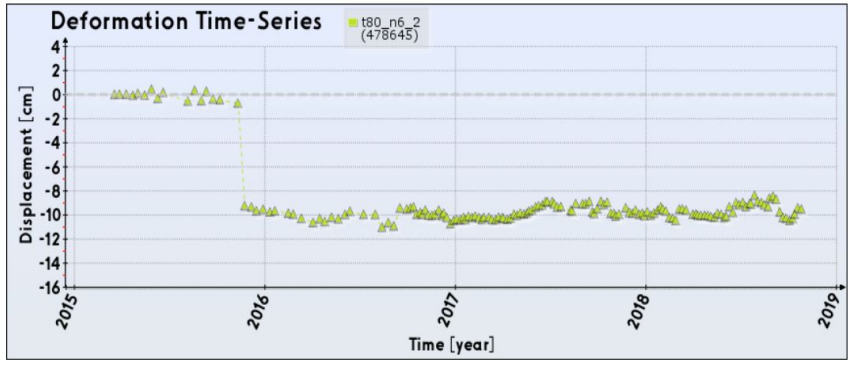
Deformations due to mining activities in southern Poland

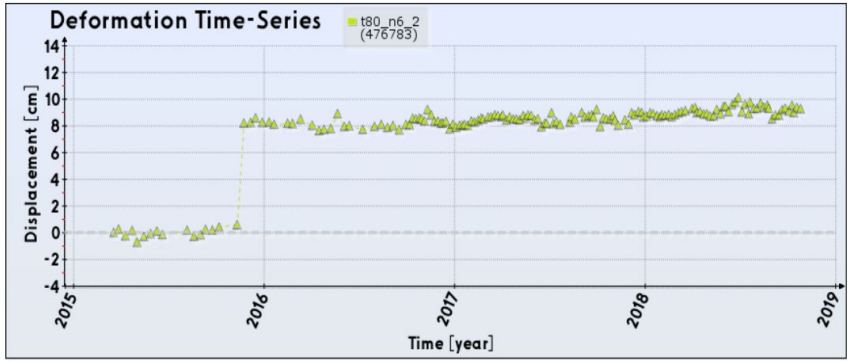


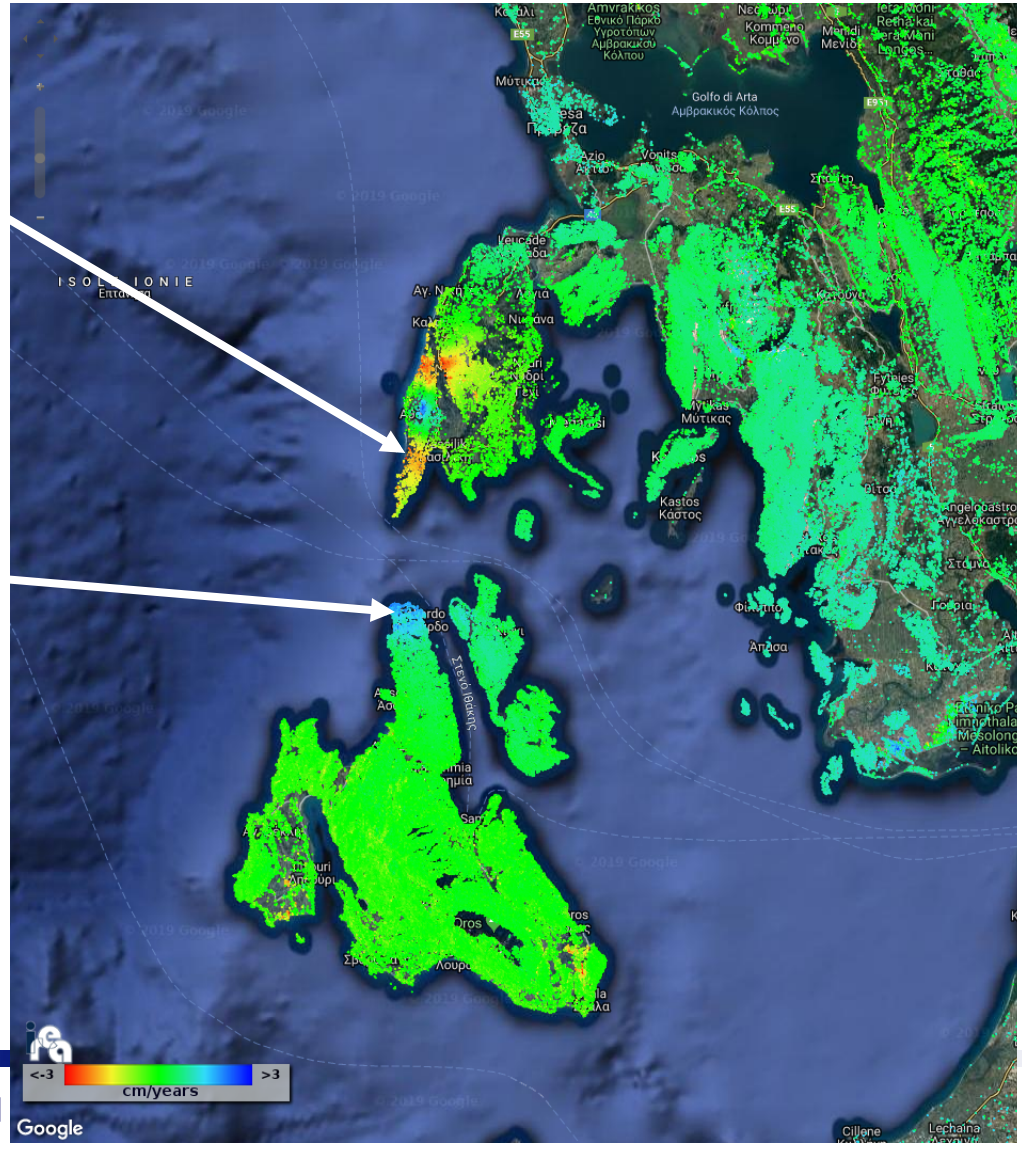
Deformations along the banks of the Thames river (United Kingdom)



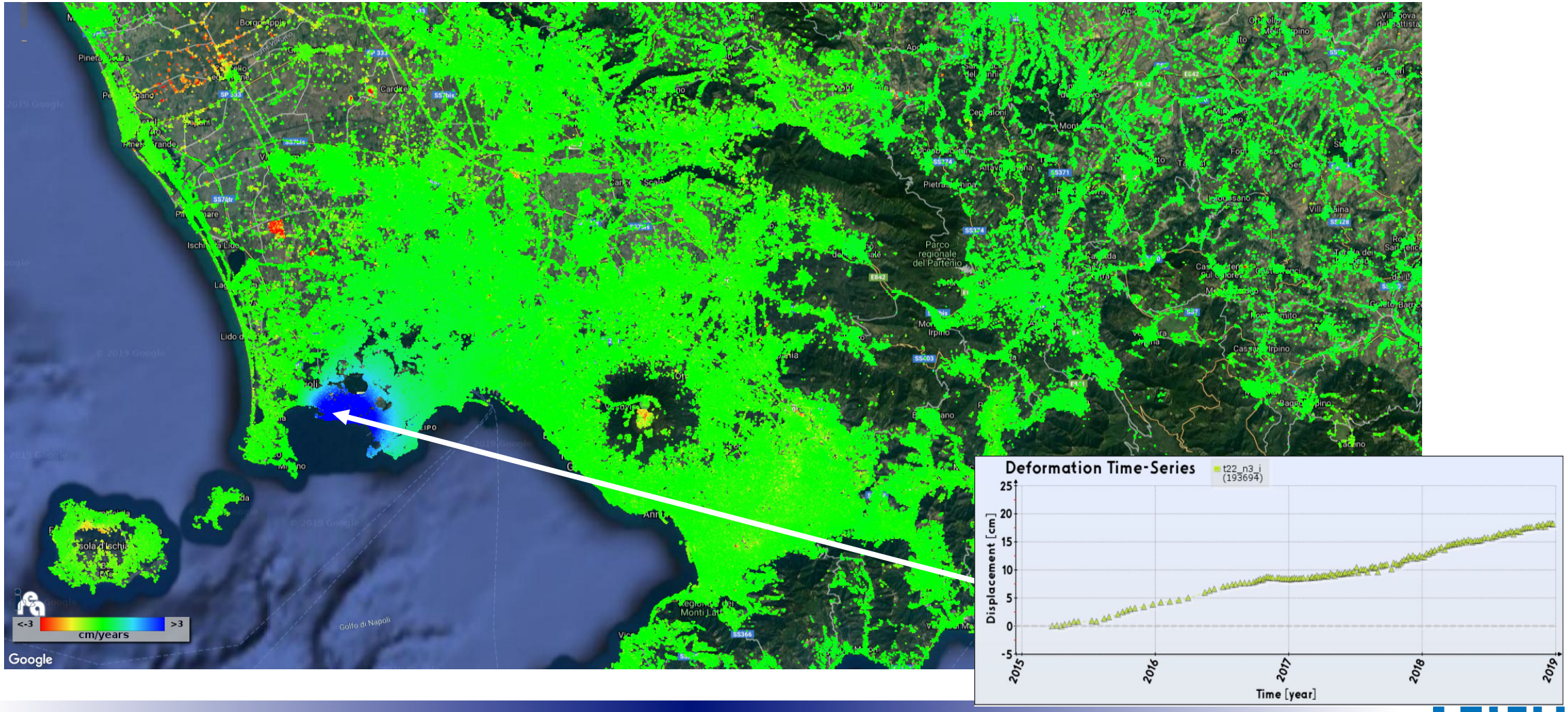
Deformations related to the November 2015 Lefkada earthquake (Greece)



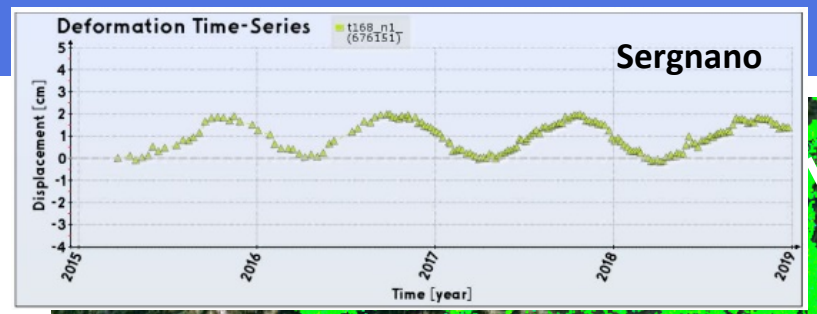


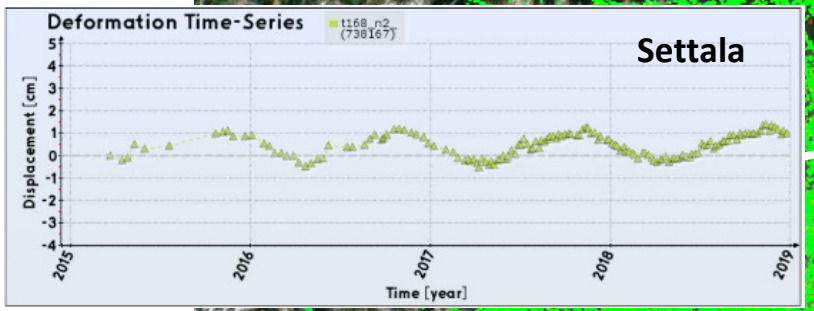


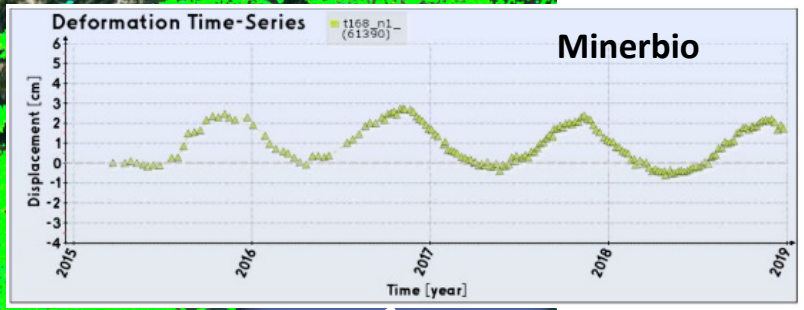
Deformations due to volcanic activity at Campi Flegrei caldera (Southern Italy)

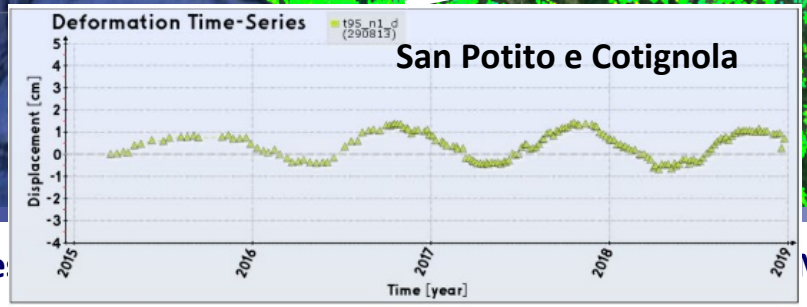


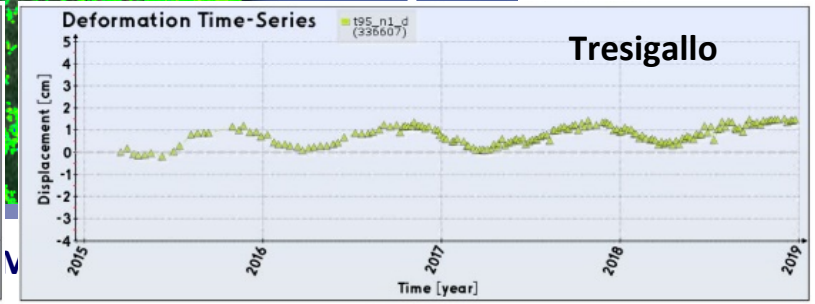
Deformations related to natural gas storage activities (Northern Italy)







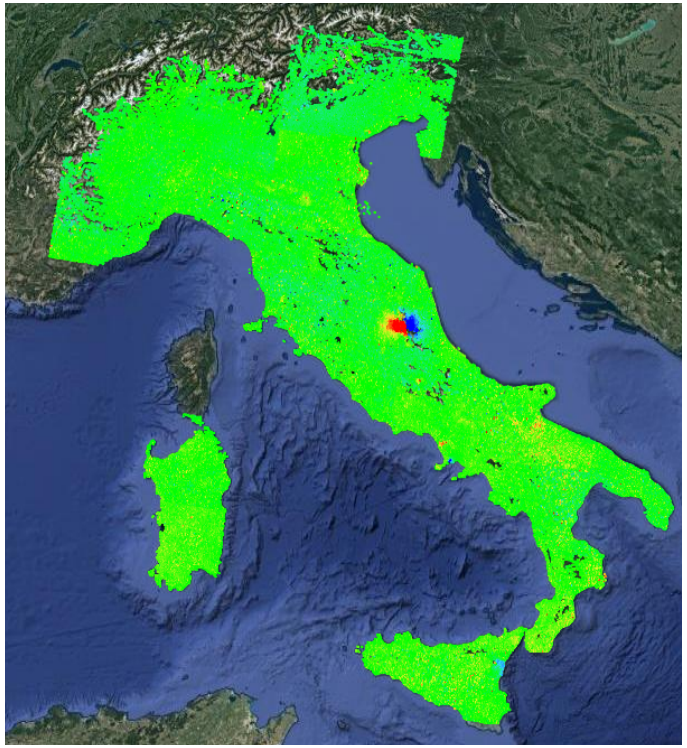




European Geoscience

institute for electromagnetic sensing of the enviroment

Sentinel-1 DInSAR time series validation: comparison with 434 GPS stations (NLG processing)

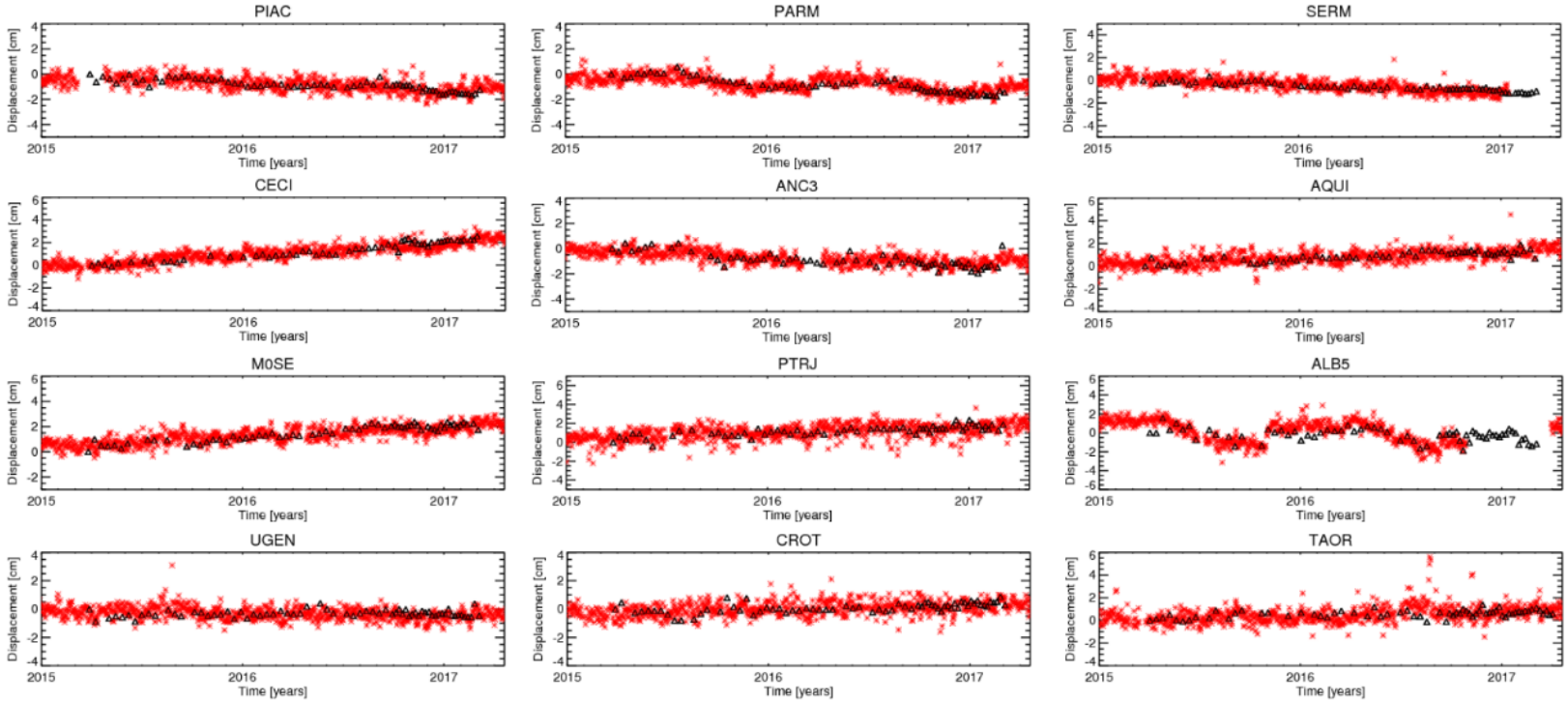


Sentinel-1 DInSAR time series validation: comparison with 434 GPS stations (NLG processing)

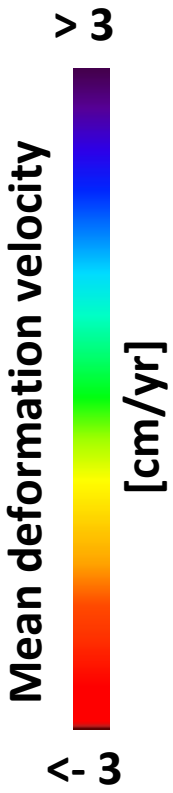
σ_{def} ~ 4 mm

Δ SAR

✱ GPS



Manunta et al., 2019, IEEE Trans. Geosci. Remote Sens.



P-SBAS processing summary

Processing flows: 154 tiles

Sentinel-1 exploited data : ~72,000

Final product pixel dimension: ~80 m

Covered Area: ~4,500,000 km^2

Coherent (multilook) pixels: ~120,000,000

Elapsed time : ~6 months

Processing costs: ~ 60,000 euro

Conclusions

- **The availability of *i)* efficient processing tools and *ii)* distributed HPC infrastructures in proximity to data confirmed to be essential for massive DInSAR processing of Sentinel-1 data archives**
- **The reliability and compliance with defined formats of the Sentinel-1 data has proved to be suitable for automatic massive DInSAR processing**
- **The Parallel SBAS (P-SBAS) workflow has shown to be fully suitable for continental scale Sentinel-1 DInSAR time series generation**
- **The presented analysis has been carried out by exploiting averaged (mooltilooked) interferograms but it can be efficiently extended to the full resolution spatial scale by also using Graphics Processing Units (GPUs)**
- **The DIAS infrastructure (ONDA, in particular) has confirmed to be a very effective option to carry out continental scale Sentinel-1 DInSAR analysis, at least through the P-SBAS approach**
- **The presented results are relevant for the Satellite Data Thematic Core Service of the European Plate Observing System (EPOS), implemented within the European Strategy Forum on Research Infrastructure (ESFRI), and may have a positive impact on the future development of the European Ground Motion Service, which is expected to start in the near future**


Thank you!
EPOS
EUROPEANPLATEOBSERVINGSYSTEM
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US Dept of State Geographer
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