→ FRINGE 2015 WORKSHOP

Advances in the Science and Applications of SAR Interferometry
and Sentinel-1 InSAR Workshop

The FP7 Marsite Project as a Supersite Initiative: Exploitation of X-Band InSAR Results for Surface Deformation Analysis over the Istanbul Area

Manuela Bonano[1], Giuseppe Solaro[1], Adriano Nobile[2], Stefano Salvi[3],
Mariarosaria Manzo[1], John Peter Merryman Boncori[3]

1 *IREA-CNR, Napoli, Italy* **2** *Royal Museum for Central africa, Tervuren, Belgium* **3** *INGV, CNT, Roma, Italy*

23–27 March 2015 | ESA–ESRIN | Frascati (Rome), Italy

New Directions in Seismic Hazard assessment through Focused Earth Observation in Marmara Supersite

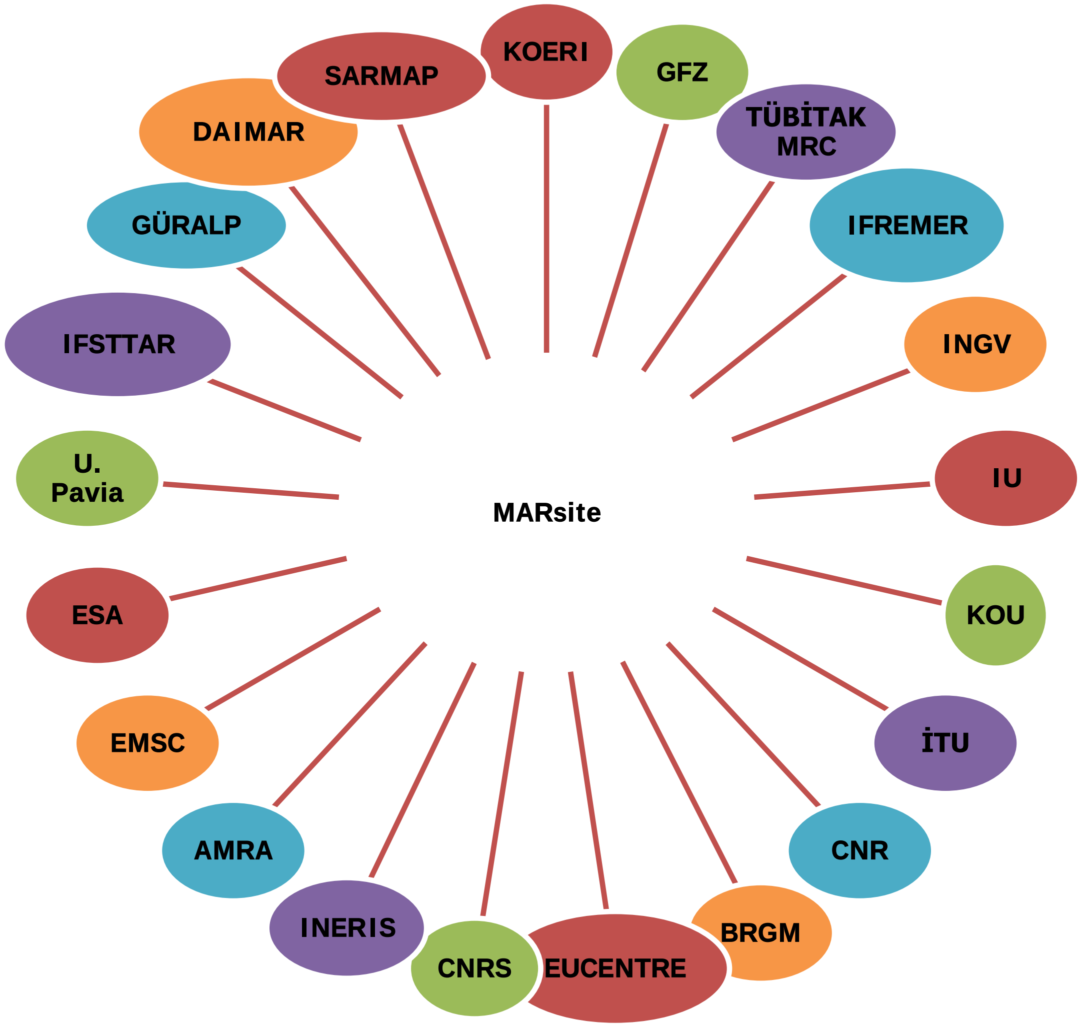
MARsite is aimed at providing the most complete geodetic records of crustal deformation for any major continental earthquake occurred and/or occurring in the Marmara region through:

- repeat GPS
- InSAR
- Gravity and seismological observations.

bonano.m@irea.cnr.it

The FP7 MARsite Project

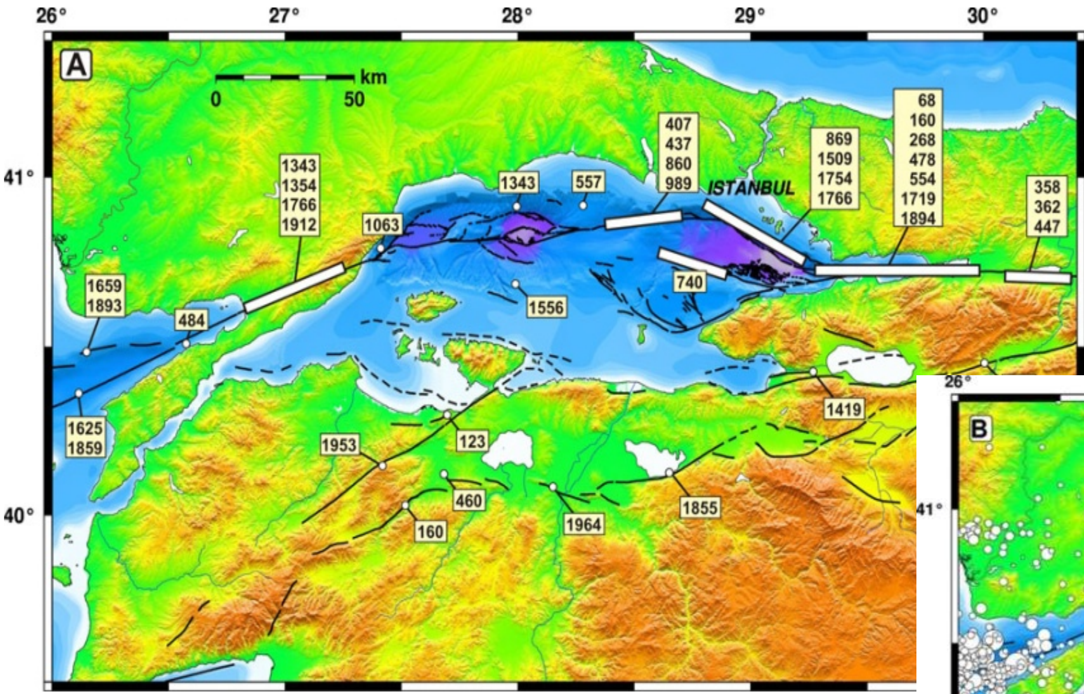
6 Countries
21 Organizations



bonano.m@irea.cnr.it

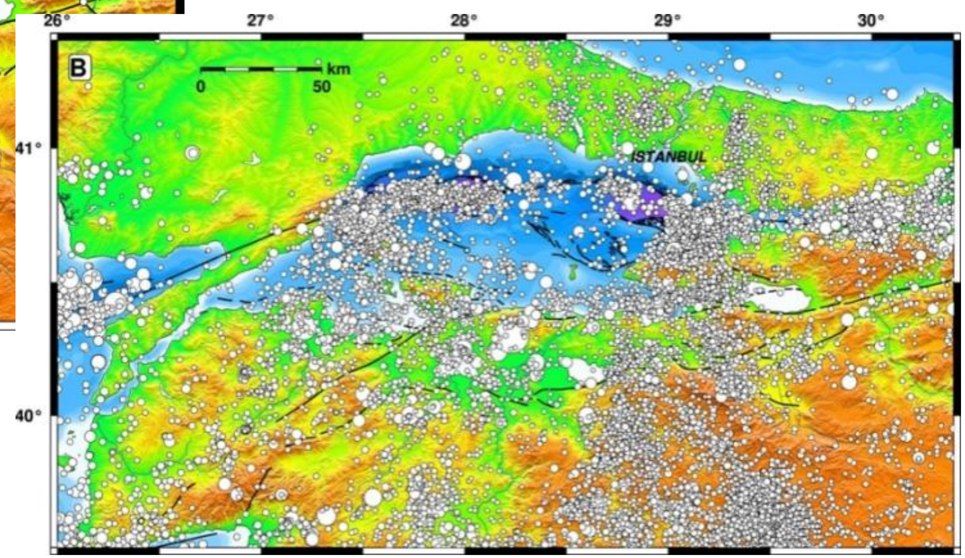
Why Marmara as a supersite?

esa



The occurrence years and possible locations of earthquakes (redrawn from Ambraseys, 2002).

It is one of the highest seismic risk region in Europe!



The seismicity of the Marmara Region from combined catalogues (1964-2011, M!2.5).

bonano.m@irea.cnr.it

The FP7 MARsite objectives

Long-term earth, sea and space monitoring of: earthquakes, tsunamis, landslides, displacements, chemical-radioactive emission and physical variables

Improve existing **earthquake early-warning and rapid-response** systems

Improve **ground shaking and displacement modelling** through source models

Interact with end users and contribute to the improvement of existing policies and programs on **preparedness, risk mitigation and emergency management**

Establishment of **novel borehole observation system** in western Marmara

bonano.m@irea.cnr.it

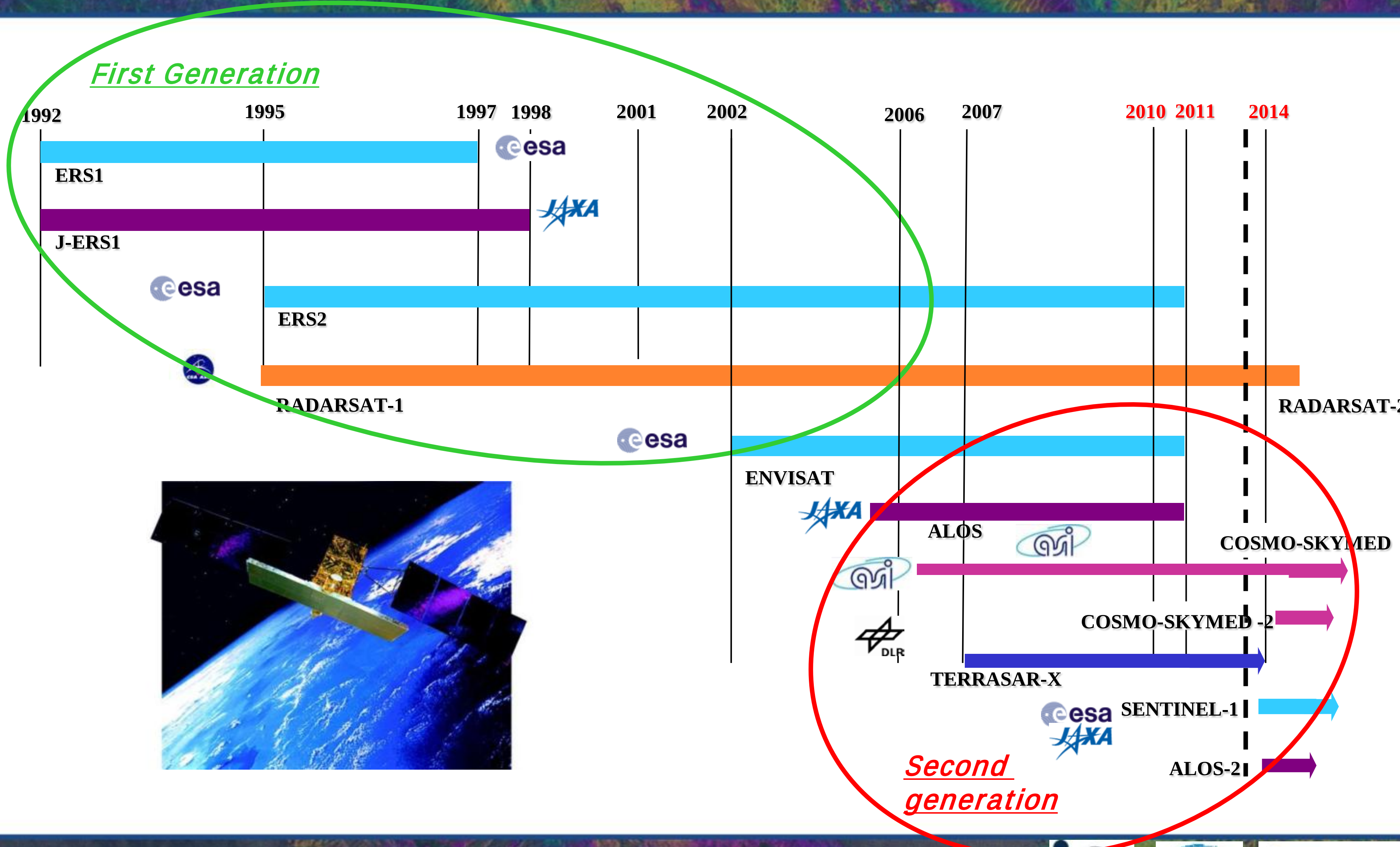
Remote sensing and MARsite

Satellite remote sensing plays a key role in the near-fault Marmara Observatory context. Indeed, it allows to:

- perform long-term and wide area deformation analyses relevant to earthquakes, compaction-induced subsidence and landslides;
- support ground shaking and displacement modelling through source model development;
- move a step-forward on new concepts of preparedness, risk mitigation and emergency management.

bonano.m@irea.cnr.it

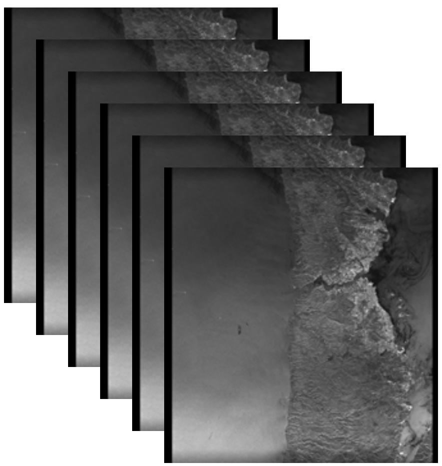
Temporal development of radar satellites for earth observation



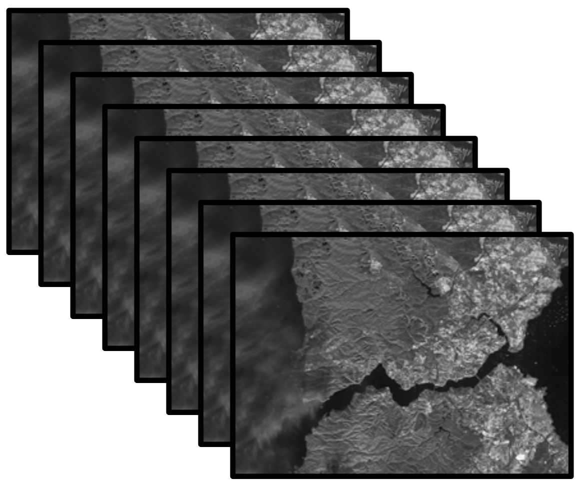
bonano.m@irea.cnr.it

Long-term InSAR monitoring: the Istanbul area

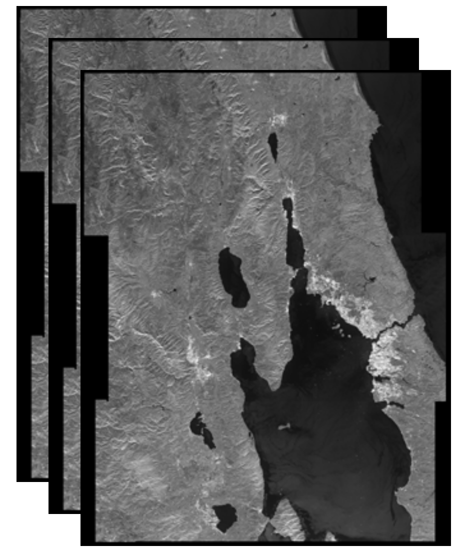
We perform a long-term continuous geodetic monitoring of the crustal deformation affecting the Istanbul area by benefiting from large archives of satellite SAR data, made available through the Supersites Initiatives.



89 desc C-band ERS/ENV
Revisit time: 35 days
Time int: 1992-2009



101 desc X-band TSX
Revisit time: 11 days
Time int: 2010-2014



11 asc C-band Sentinel-1A
Revisit time: 12 days
Time int: Oct2014-Mar2015

bonano.m@irea.cnr.it

esa

ERS-ENVISAT results

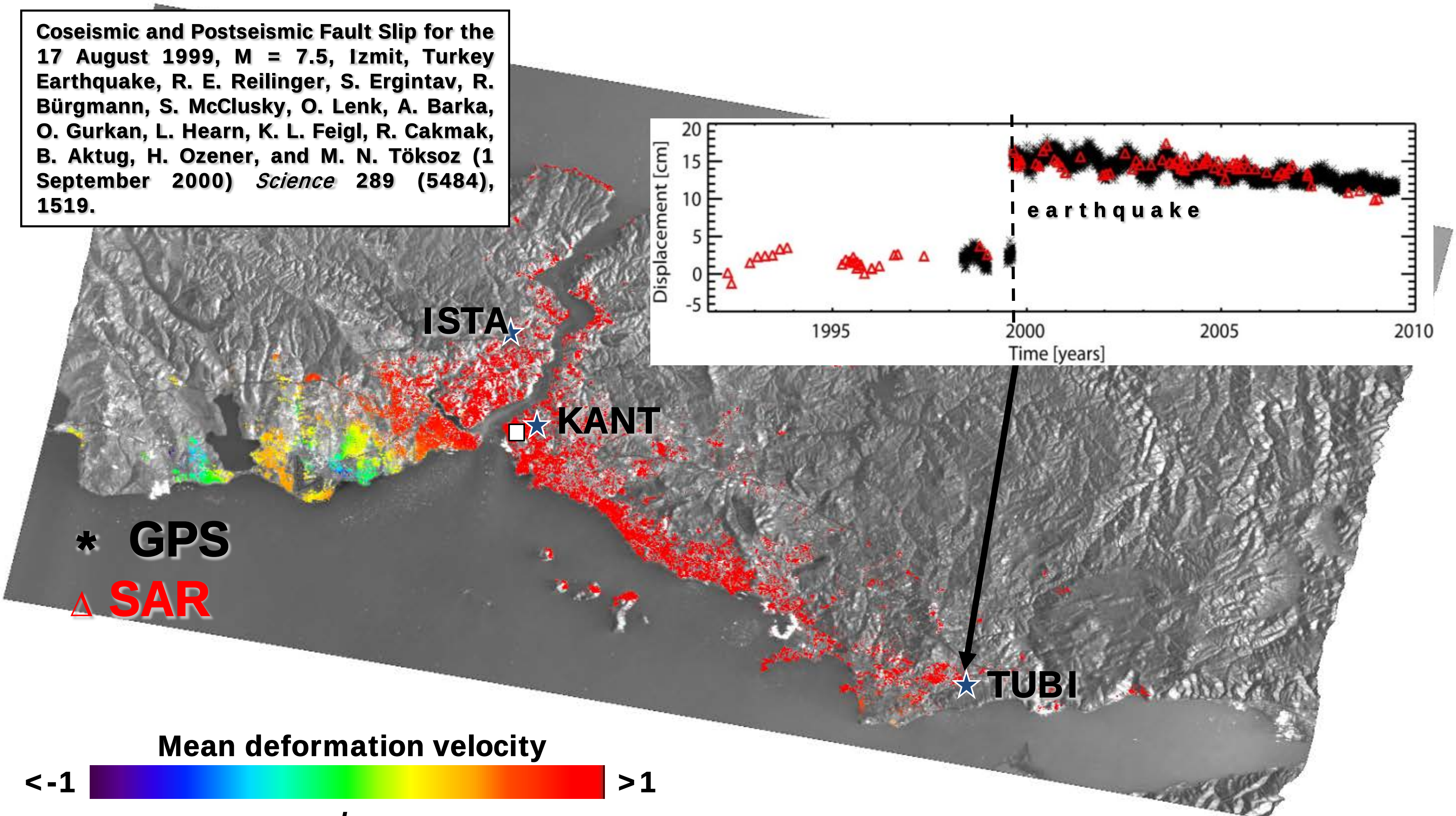
bonano.m@irea.cnr.it

INGV

MARsite

ERS/ENVISAT SBAS-DInSAR results

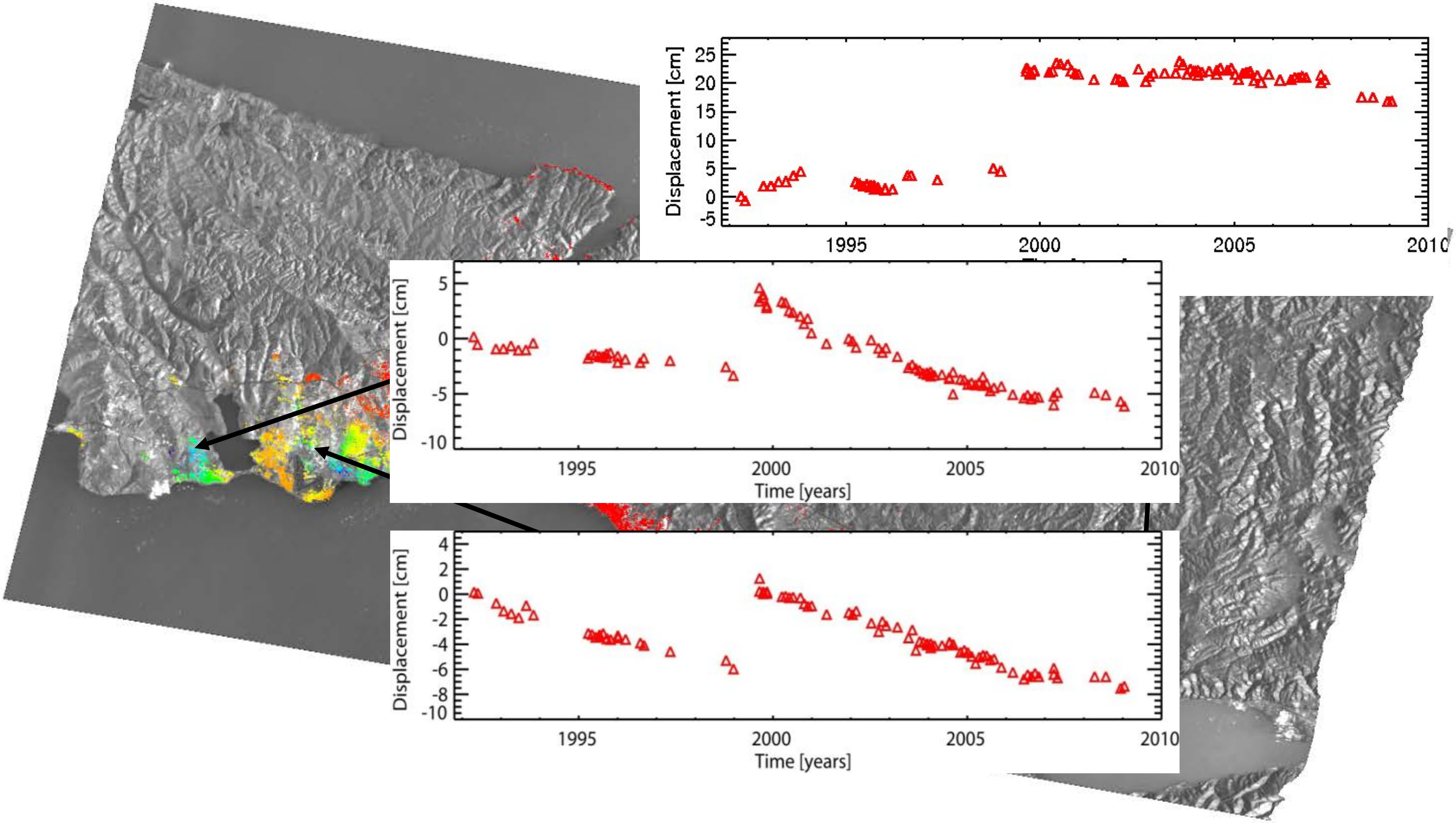
Coseismic and Postseismic Fault Slip for the 17 August 1999, M = 7.5, Izmit, Turkey Earthquake, R. E. Reilinger, S. Ergintav, R. Bürgmann, S. McClusky, O. Lenk, A. Barka, O. Gurkan, L. Hearn, K. L. Feigl, R. Cakmak, B. Aktug, H. Ozener, and M. N. Töksoz (1 September 2000) *Science* 289 (5484), 1519.



(Berardino et al., 2002)

bonano.m@irea.cnr.it

ERS/ENVISAT SBAS-DInSAR results



bonano.m@irea.cnr.it

X-band results

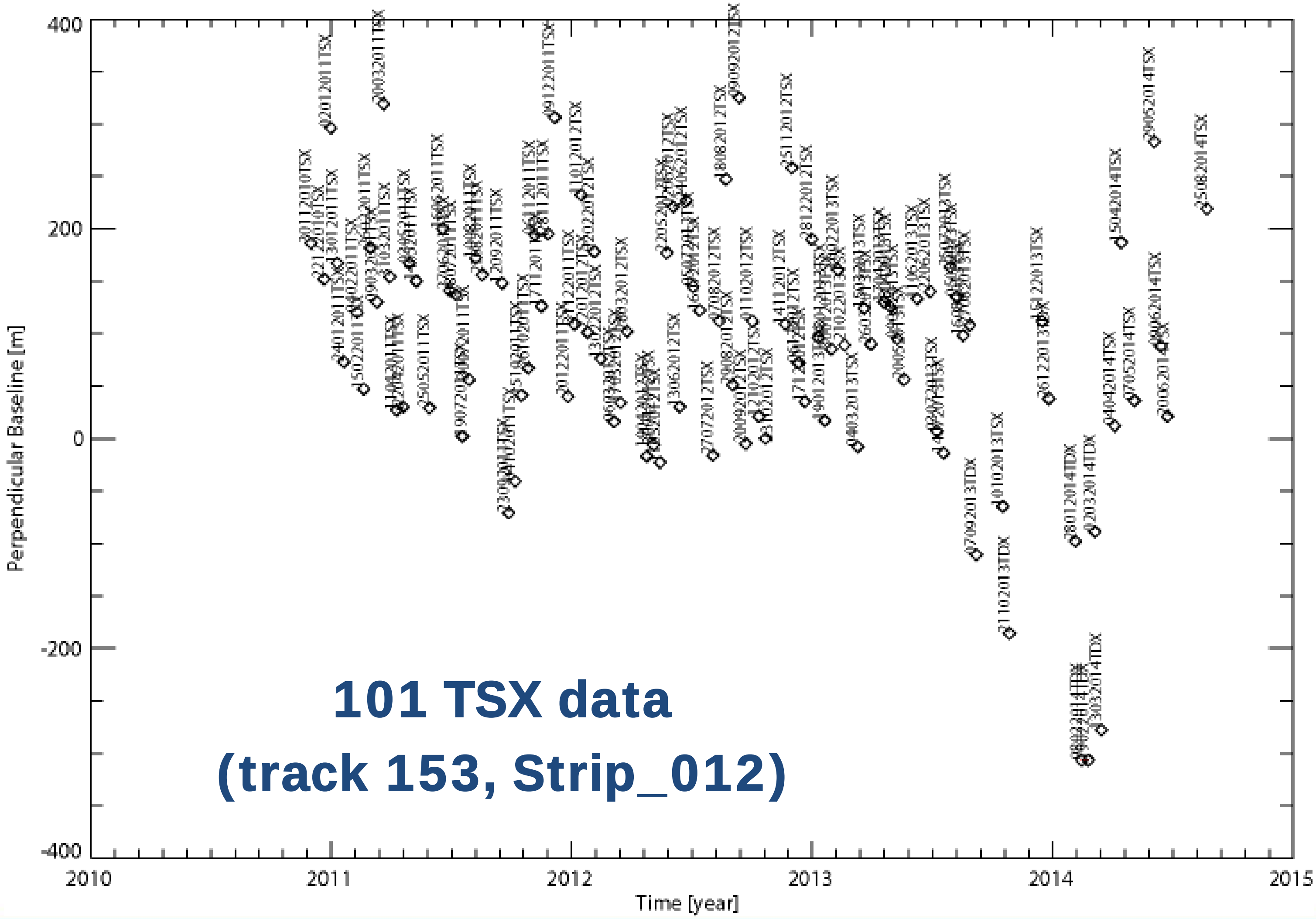
bonano.m@irea.cnr.it

TSX data available through the Supersite Initiatives

Descending TSX frame (track 153, Strip_012, $\theta \approx 41°$)

bonano.m@irea.cnr.it

TSX data available through the Supersite Initiatives

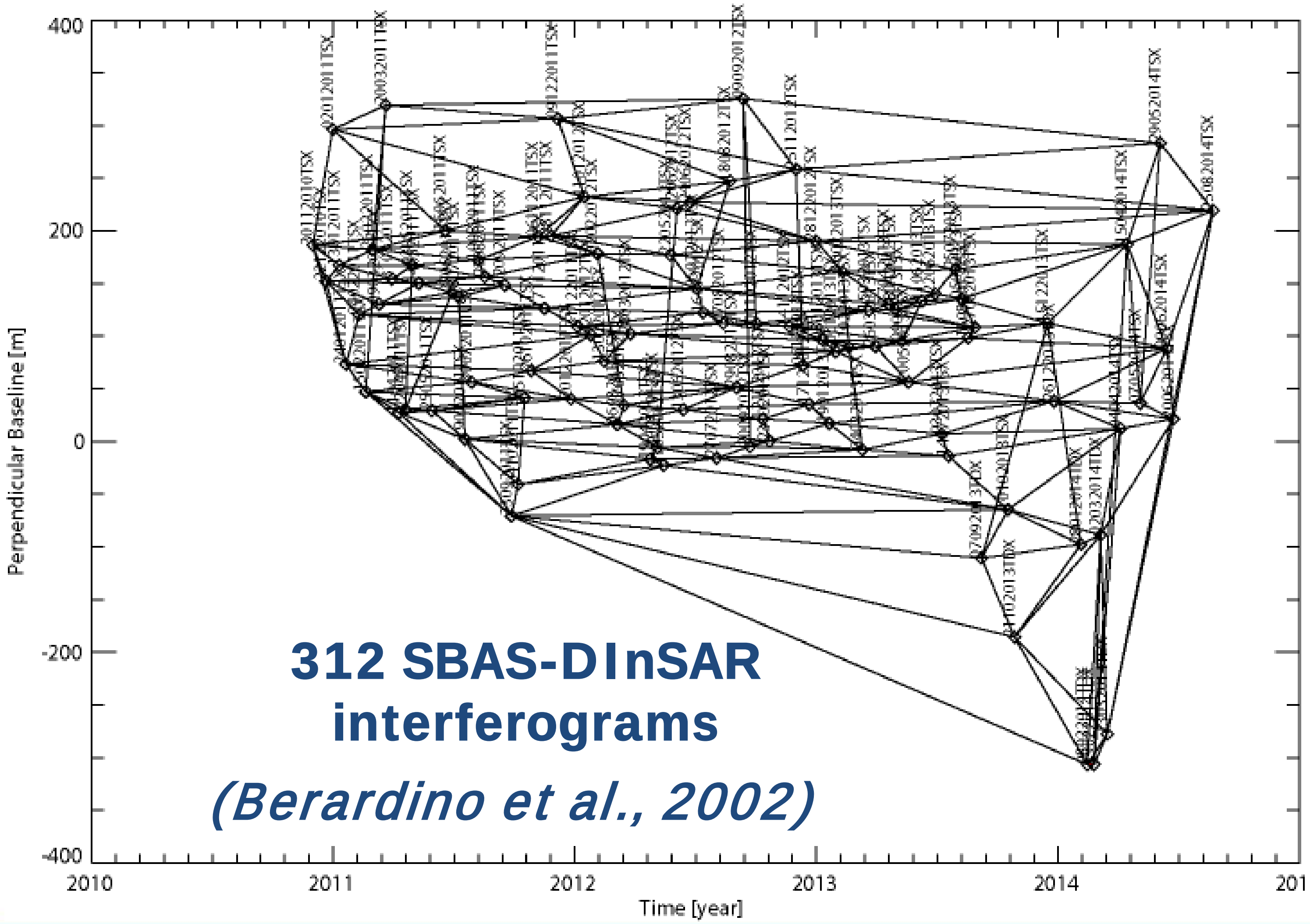


101 TSX data

(track 153, Strip_012)

bonano.m@irea.cnr.it

TSX SBAS-DInSAR interferometric pairs

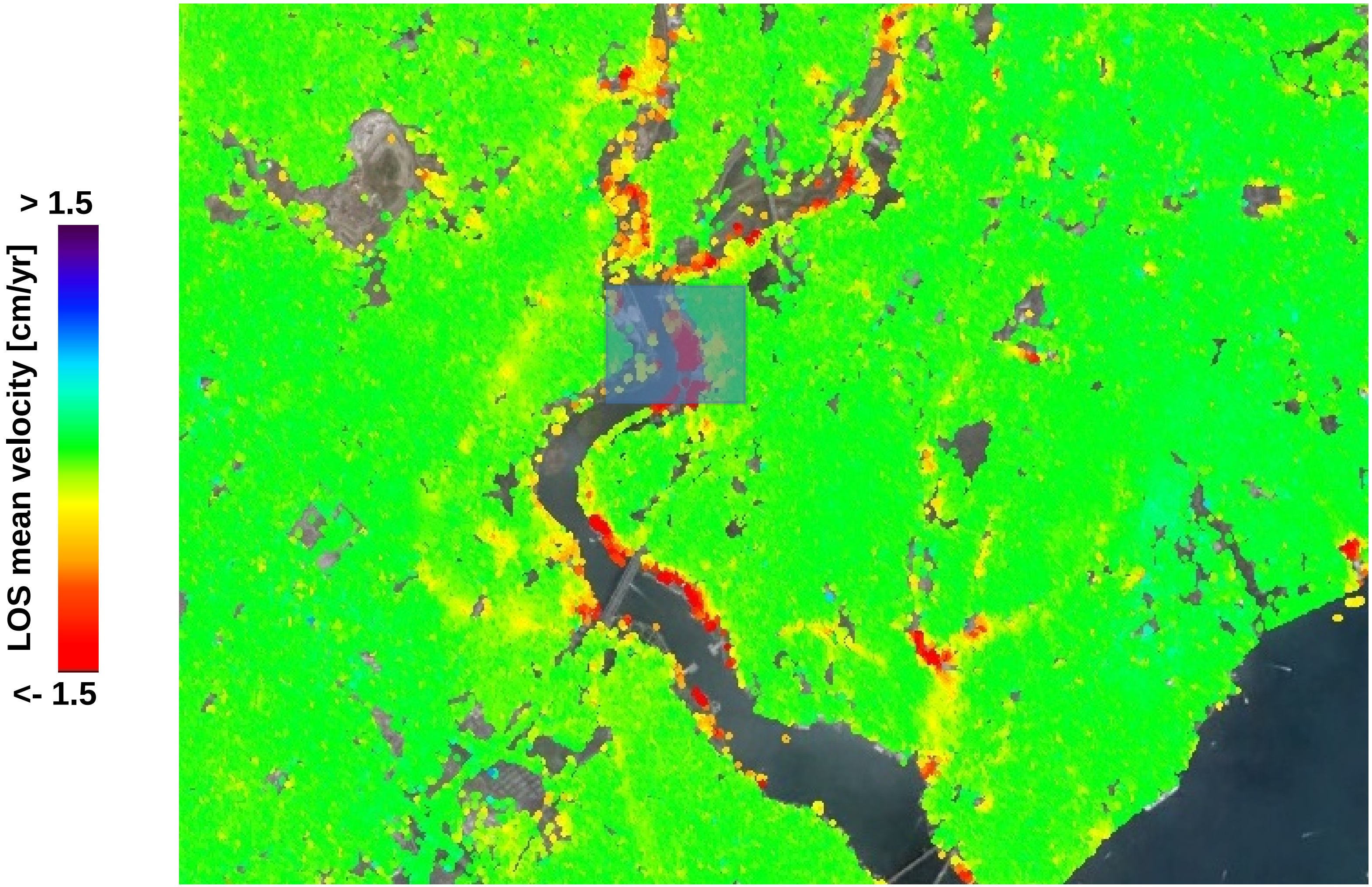


312 SBAS-DInSAR interferograms

(Berardino et al., 2002)

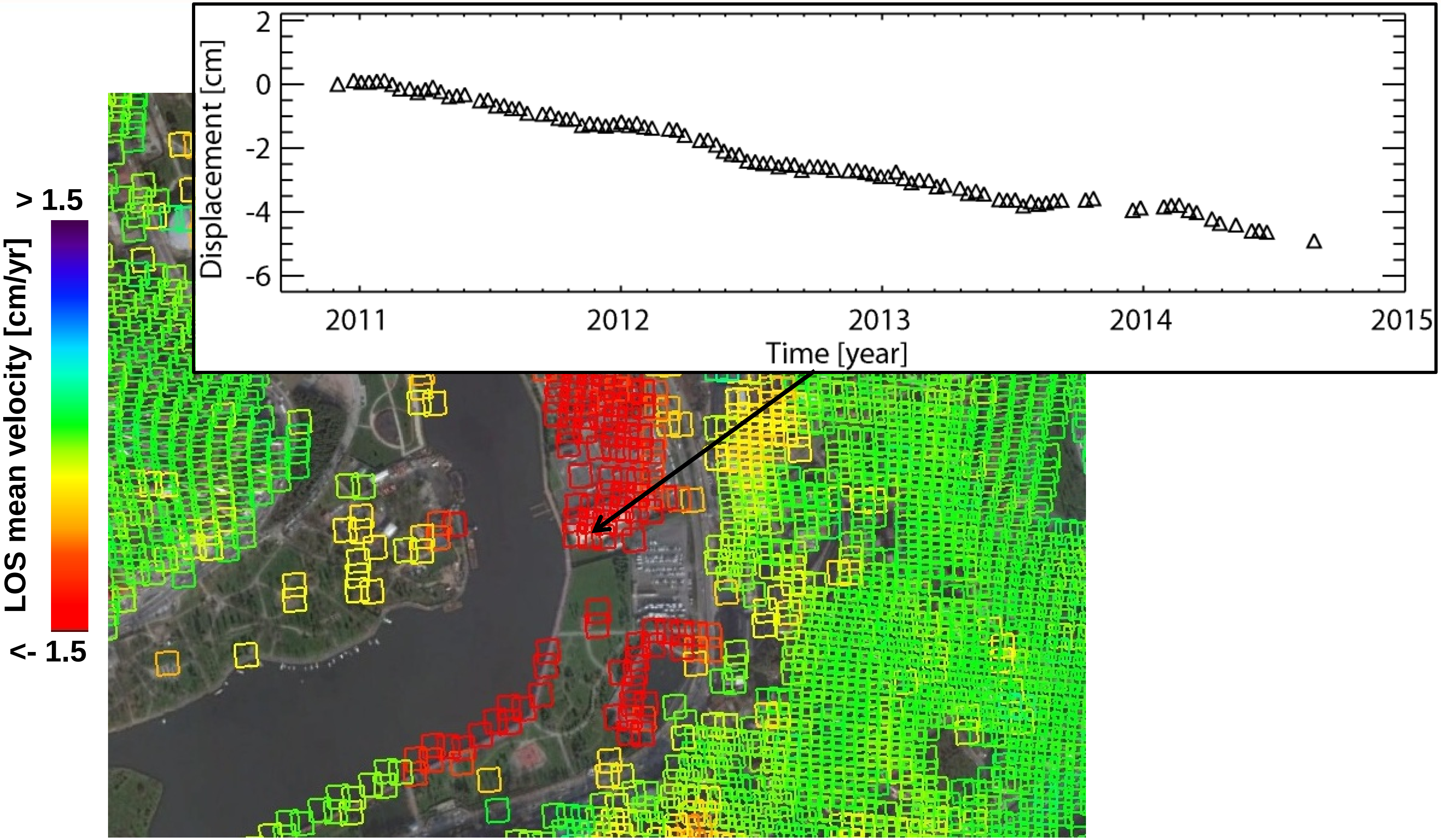
bonano.m@irea.cnr.it

TSX results retrieved through the SBAS-DInSAR method



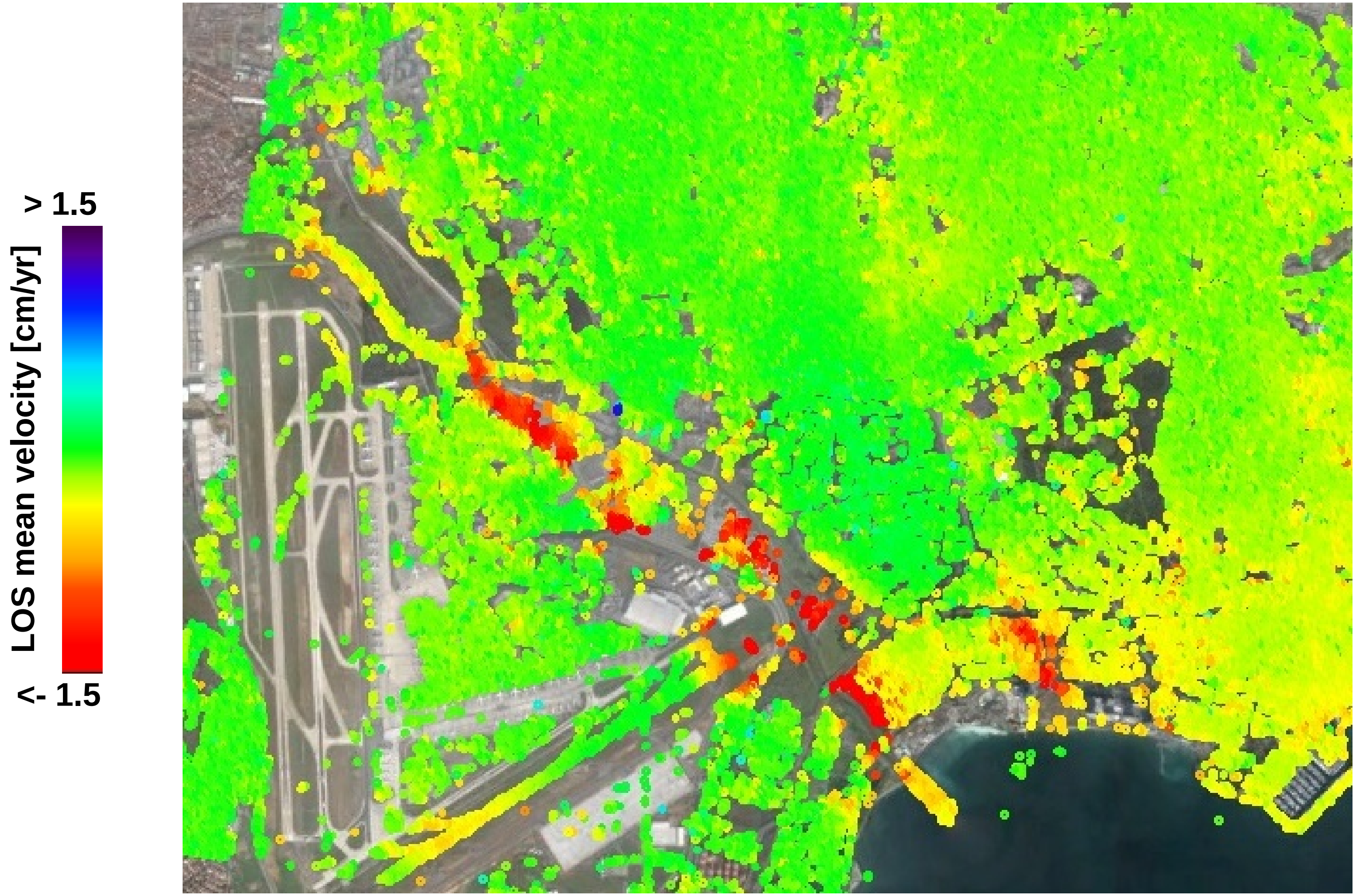
bonano.m@irea.cnr.it

TSX deformation time series retrieved through the SBAS-DInSAR method



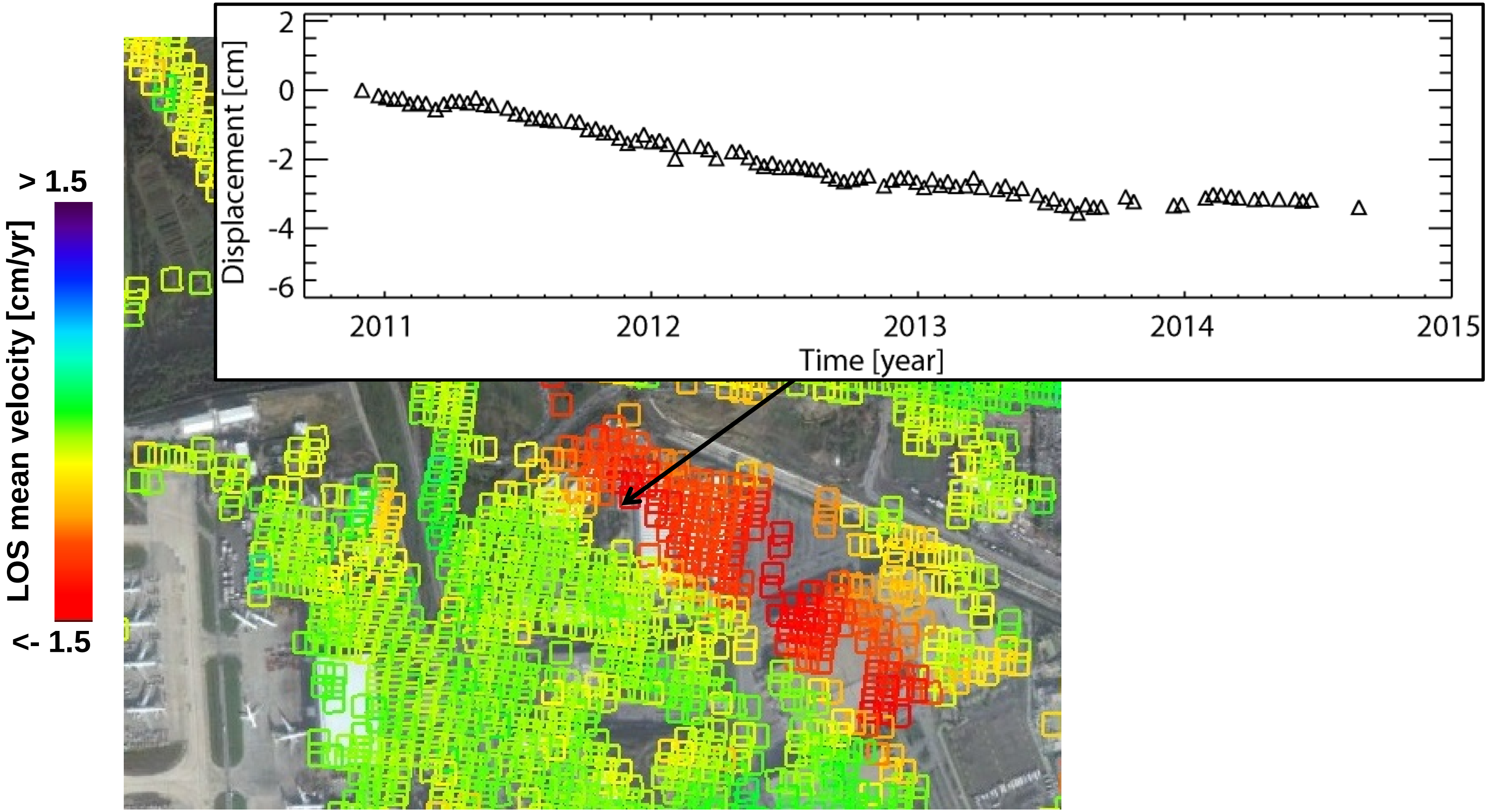
bonano.m@irea.cnr.it

TSX results retrieved through the SBAS-DInSAR method



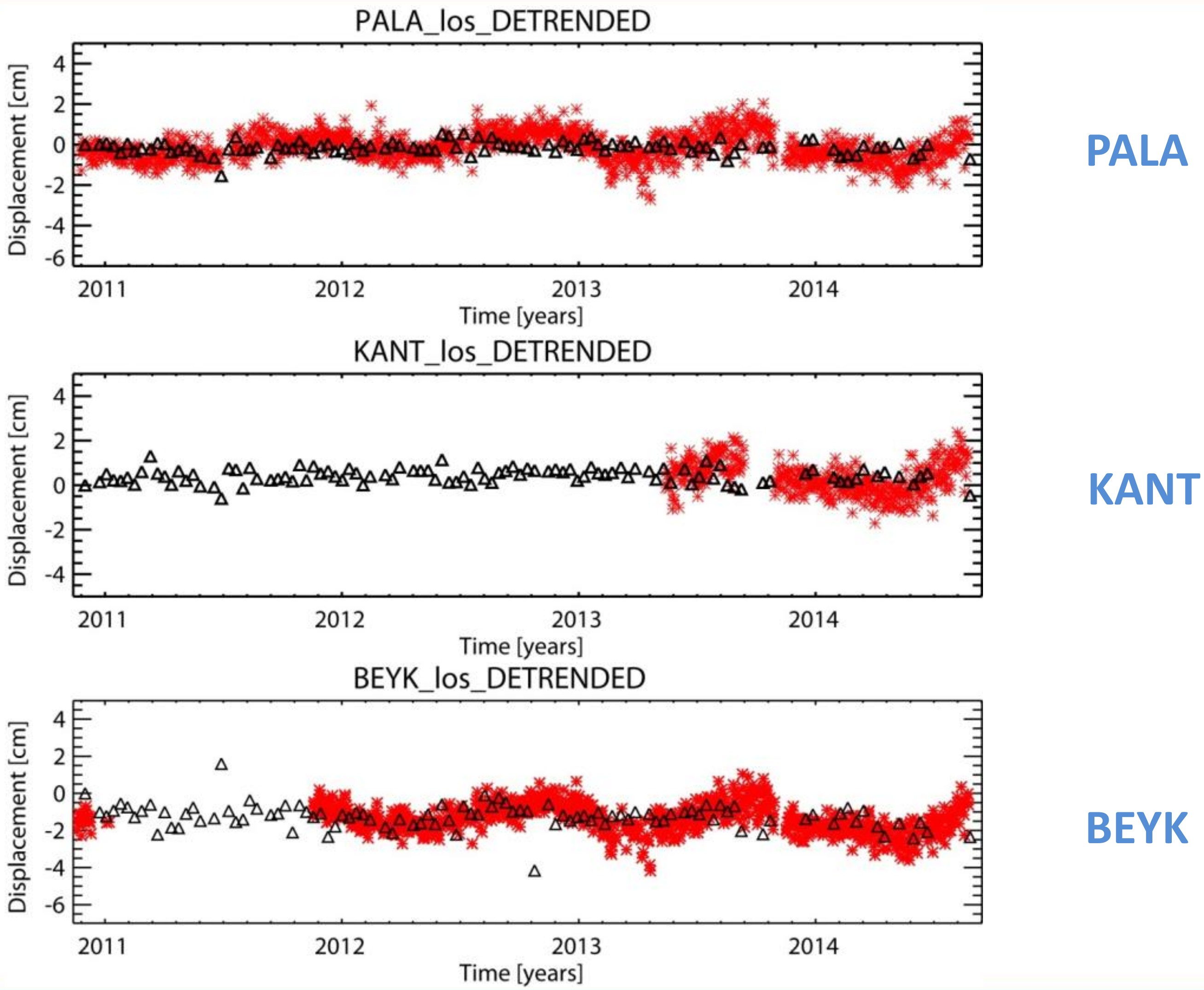
bonano.m@irea.cnr.it

TSX deformation time series retrieved through the SBAS-DInSAR method



bonano.m@irea.cnr.it

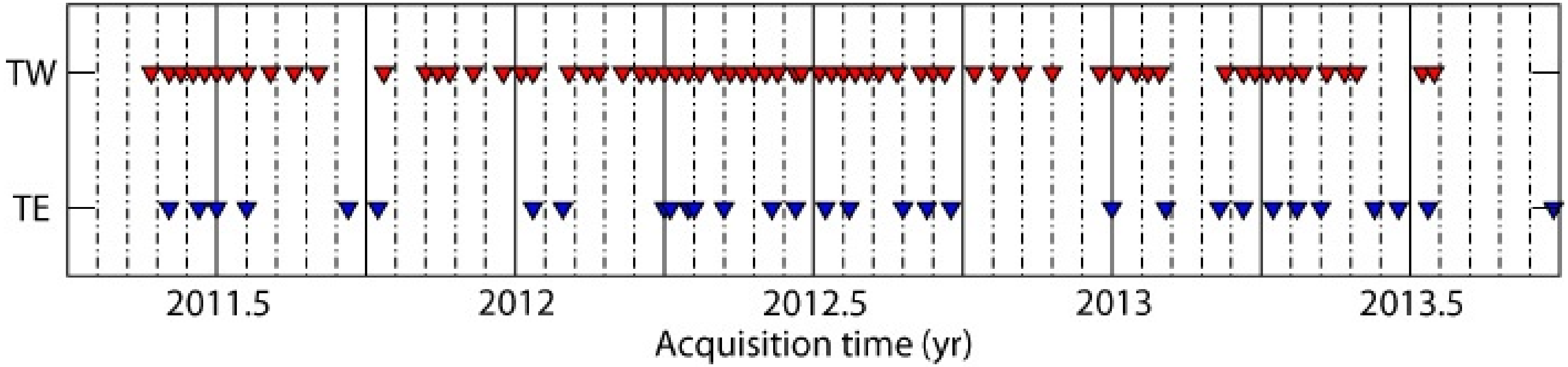
TSX SBAS-DInSAR time series validation



Ascending CSK datasets

Western Track:
64 CSK data
(05-2011/07-2013)

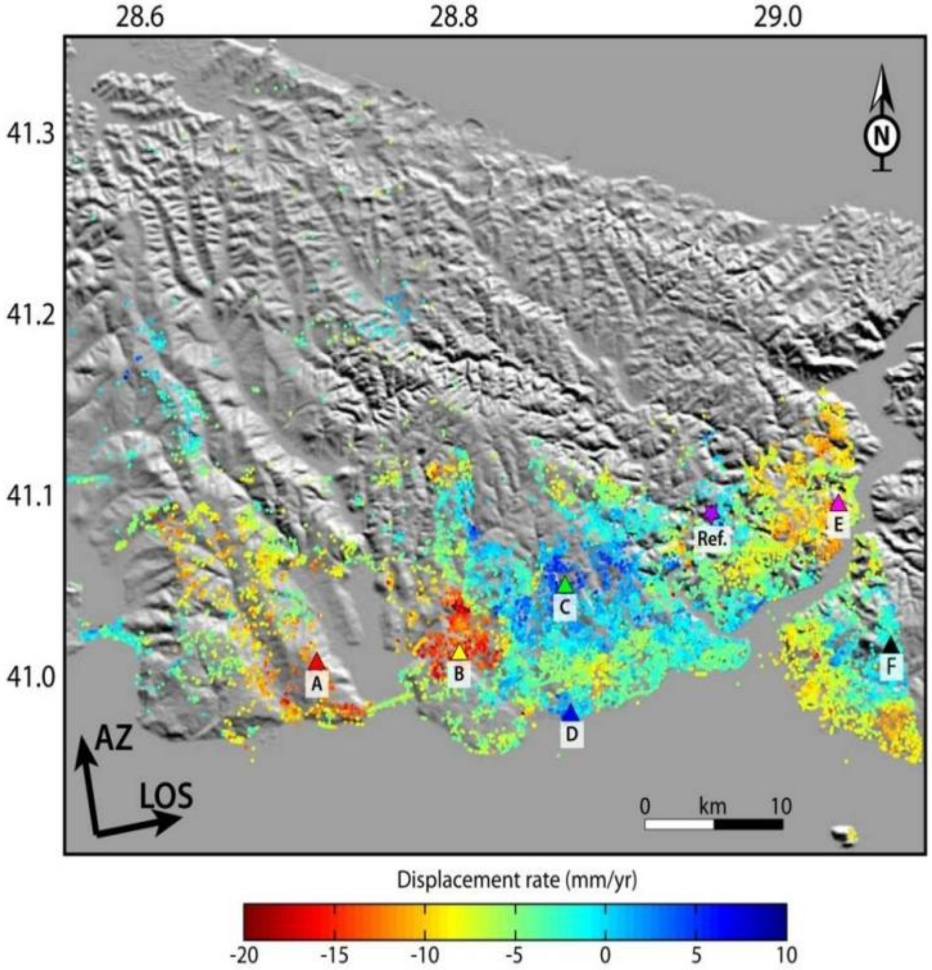
Eastern Track:
29 CSK data
(06-2011/09-2013)

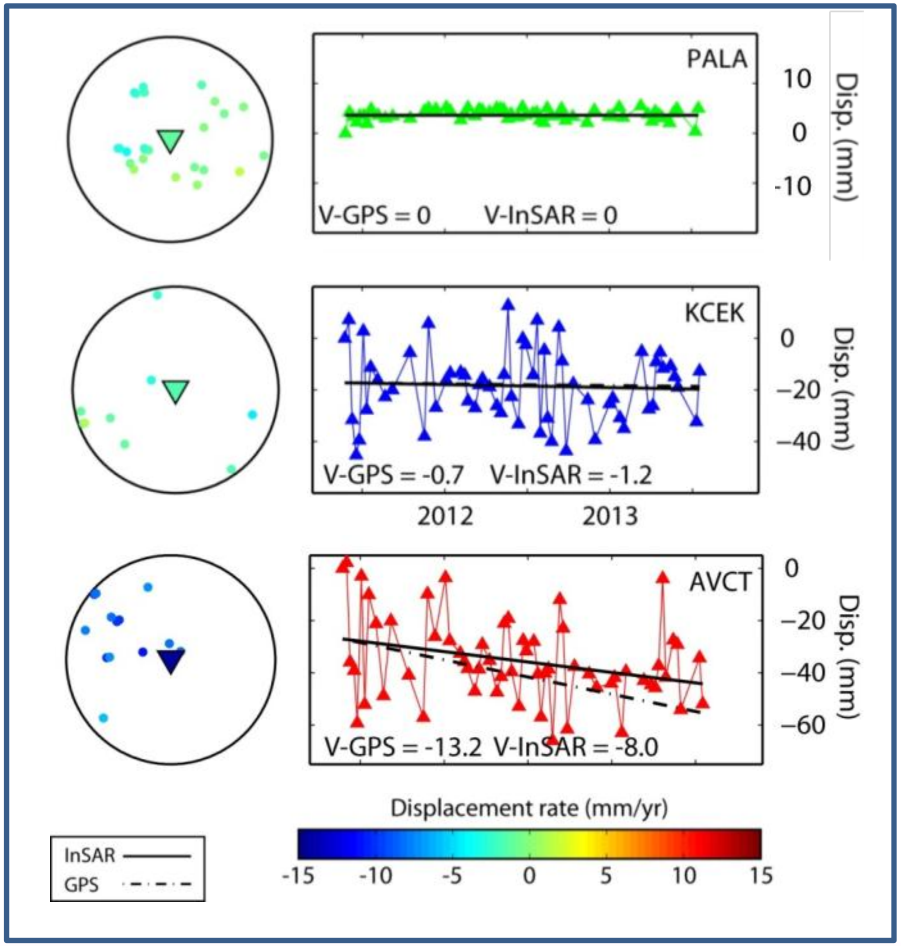


bonano.m@irea.cnr.it

CSK STAMPS results validation

(Hooper et al., 2007)



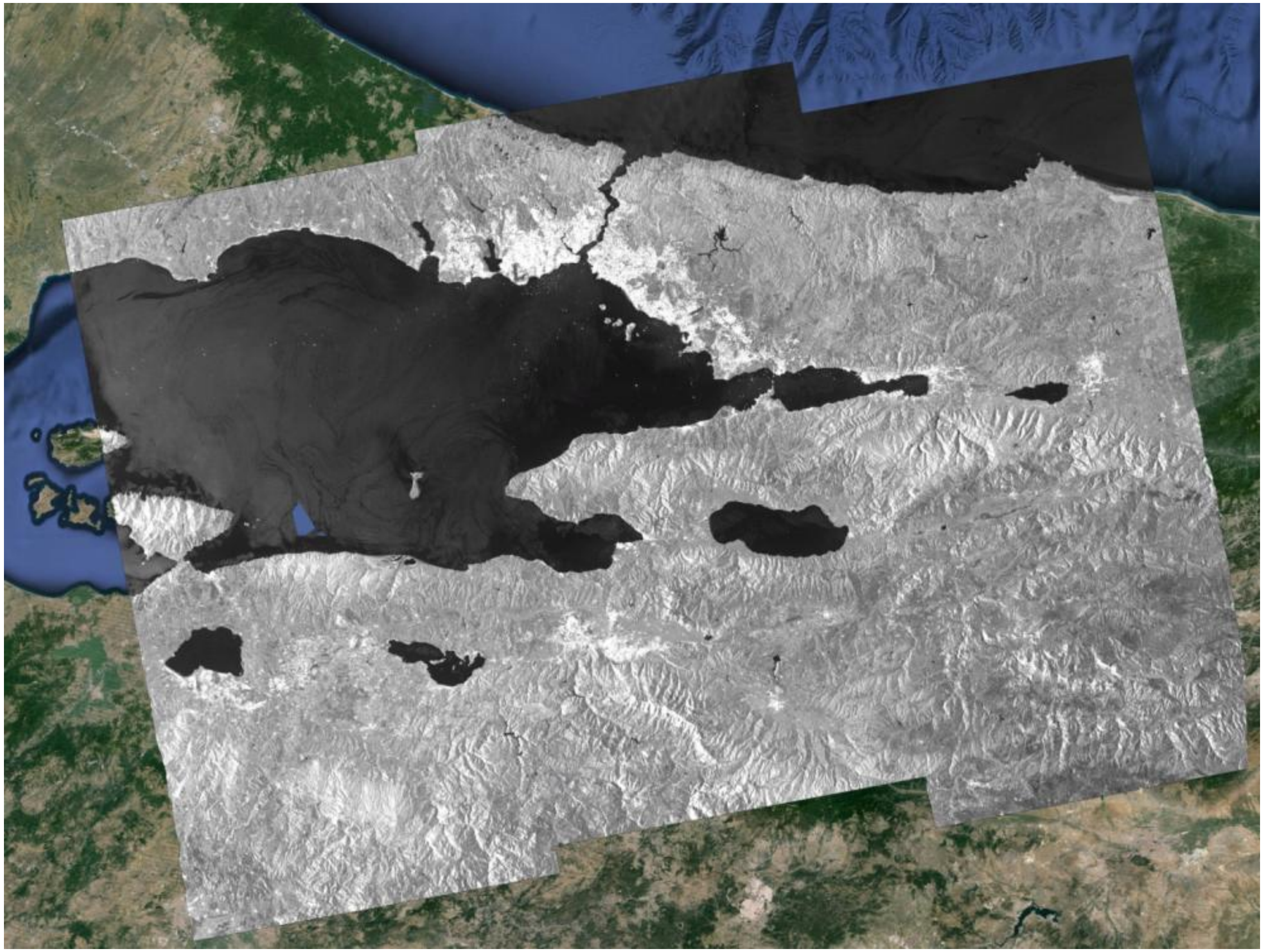


bonano.m@irea.cnr.it

Sentinel-1A first results

bonano.m@irea.cnr.it

Sentinel-1A first results



Mission: Sentinel1-A

Acquisition date: 21/10/2014

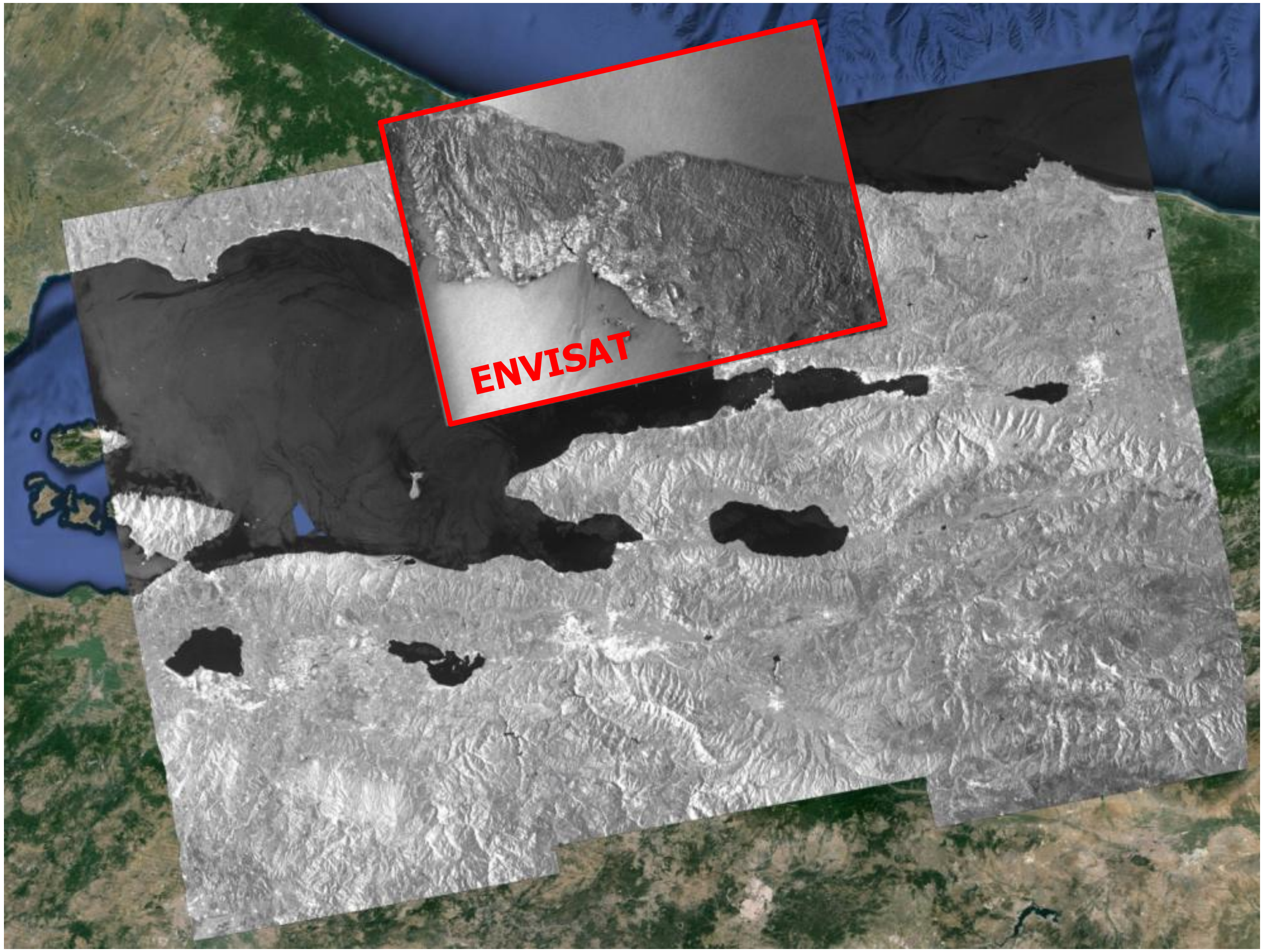
Polarisation: VV

Product Type: SLC

Orbit: Ascending

bonano.m@irea.cnr.it

Sentinel-1A first results



Mission: Sentinel1-A

Acquisition date: 21/10/2014

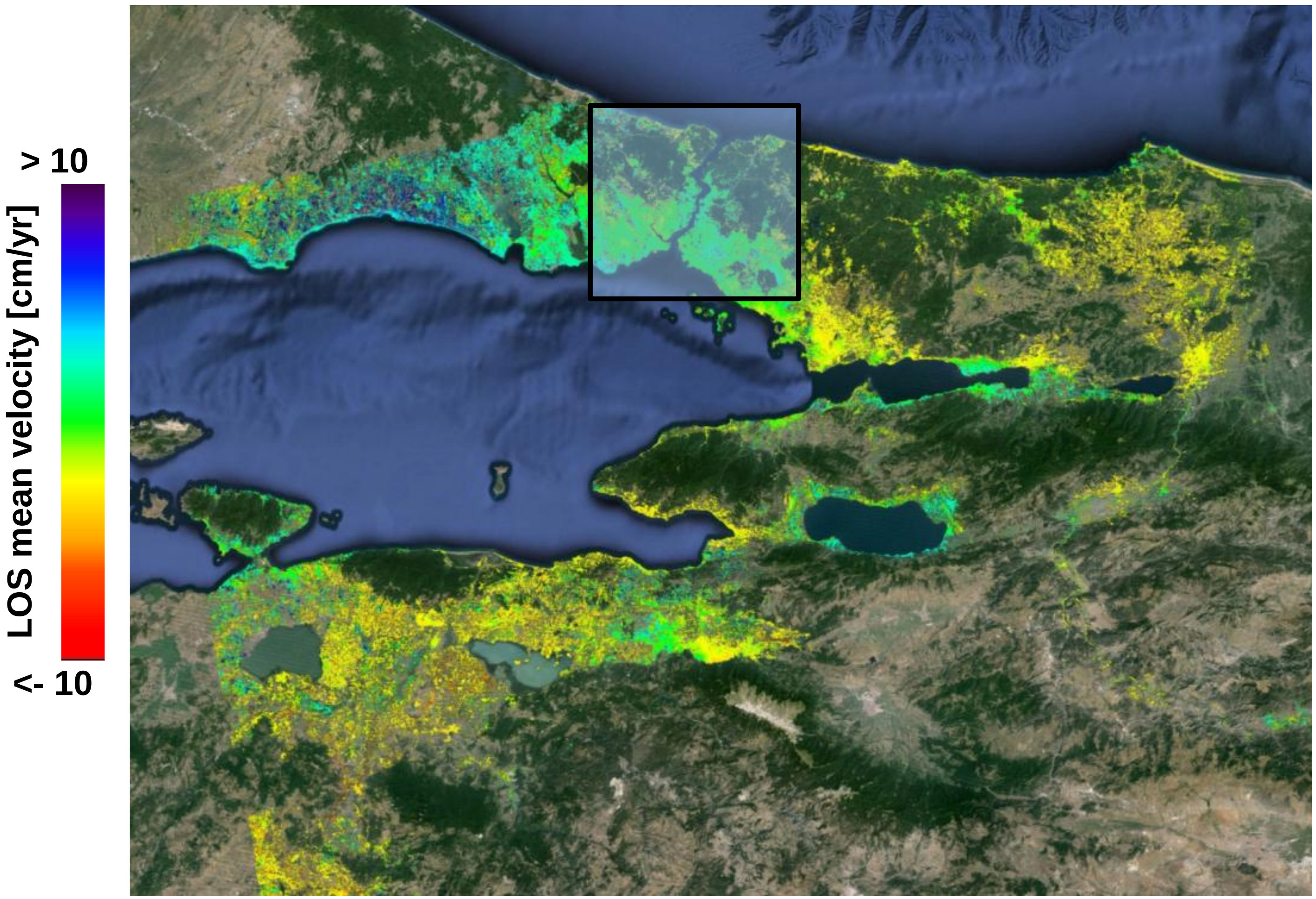
Polarisation: VV

Product Type: SLC

Orbit: Ascending

bonano.m@irea.cnr.it

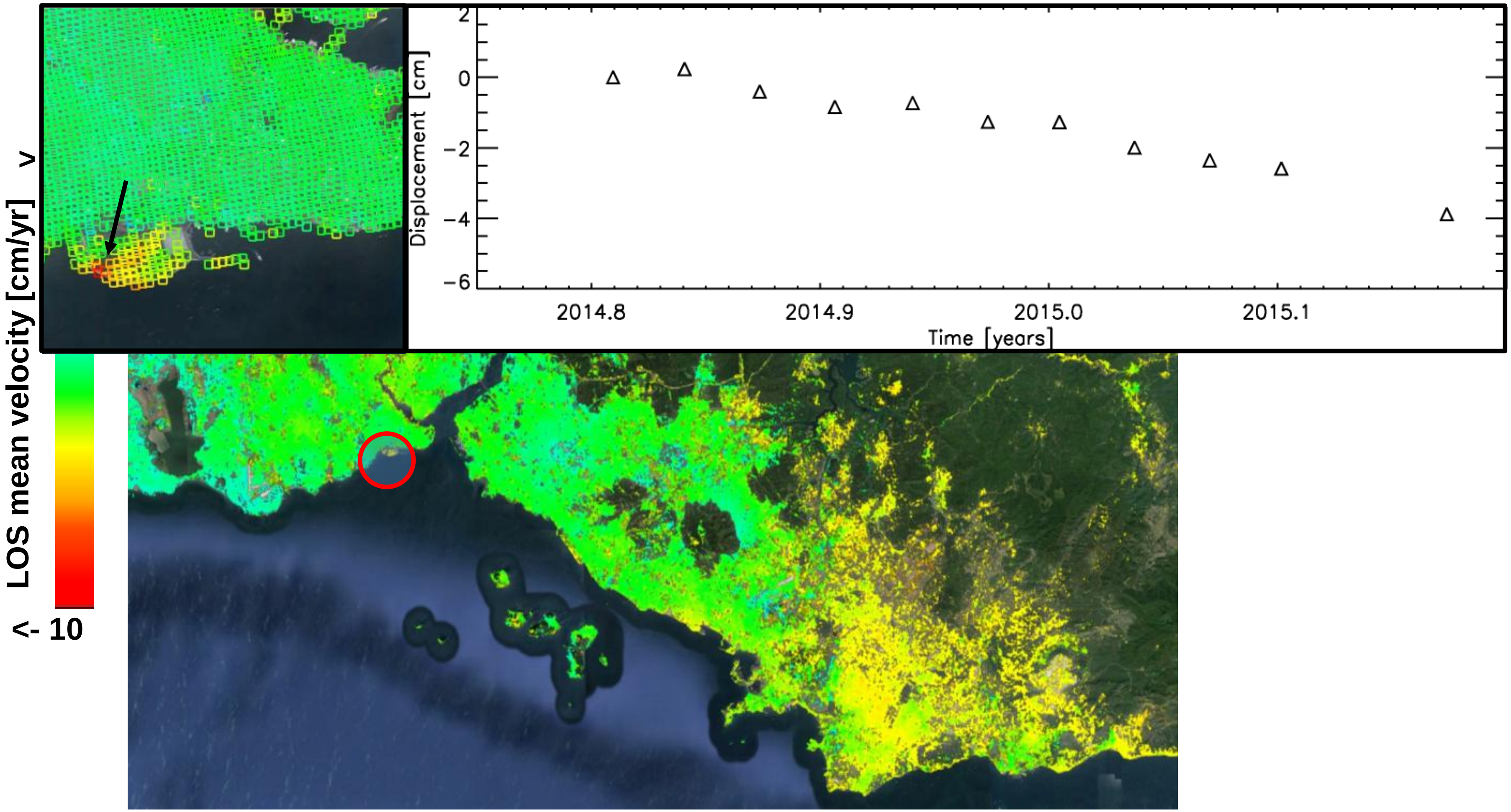
Sentinel-1A SBAS first results



Only 11 SAR acquisitions in 4 months and 27 SBAS interferograms

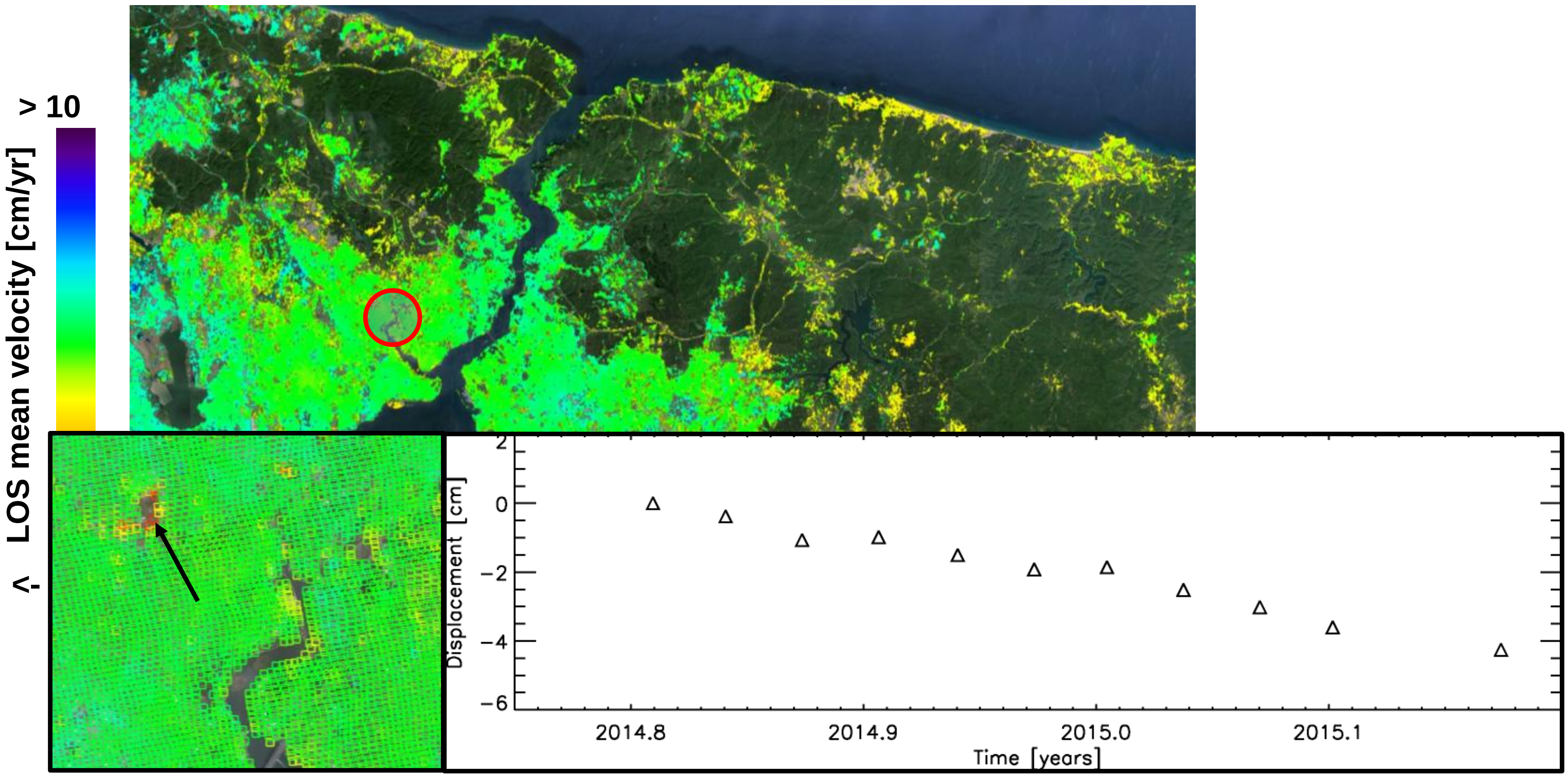
bonano.m@irea.cnr.it

Sentinel-1A SBAS first results



bonano.m@irea.cnr.it

Sentinel-1A SBAS first results



bonano.m@irea.cnr.it

Conclusions and further developments

✓ DInSAR deformation time series can be successfully exploited and integrated with other geodetic measurements to perform long-term deformation analyses, which are crucial for seismic hazard assessment.

✓ They provide space-time information on the ground displacements that can be effectively exploited to better understand/model/interpret the physical processes behind the observed deformation phenomena at different temporal and spatial scales.

✓ The effectiveness of such an integration is strictly connected with the availability of SAR data. In this context, the new Sentinel-1A/B satellite constellation reveals to be strategic for performing large scale deformation monitoring analyses, thanks to the global coverage as well as free, open-access policy.

bonano.m@irea.cnr.it

Thank you!!!

bonano.m@irea.cnr.it

Working plan

MARsite ID card

Project acronym: MARsite
Contract n° 308417
Project type: Collaborative project
Start date: 01/11/2012
Duration: 36 months
Total budget: 7.769.608.60 €
Funding from the EC: 5.965.286.45 €
Person-month: 763
Key words: Marmara Sea, Borehole Observation, Seismic Risk and Hazard
Coordinator: Prof. Nurcan Meral Ozel-KOERI

Website: www.marsite.eu

WP1 Consortium Management, assessment of progress and results obtained.

WP2 Collection and integration of seismological, geo-chemical, and geodetic data to detect and model the interactions between fluids, crustal deformation and ruptures of the active tectonic structures of the Marmara area and, thereby, to contribute to its seismic hazard assessment.

WP3 Long-term continuous monitoring of the crustal deformation by exploiting the existing land and space based geodetic crustal deformation monitoring systems.

WP4 Measure continuously the evolution of the state of stress of the fault zone surrounding the MMF and to detect any anomaly or change which may occur before earthquakes by making use of the data from the arrays already running in the eastern part of the Marmara Sea.

WP5 Real- and quasi-real-time Earthquake &Tsunami Hazard Monitoring, where an integrated approach by harmonizing geodetic and seismic data to be used in early warning applications will be implemented.

WP6 Improve the preparedness of those seismically induced landslide geohazards, through the using and the improvement of monitoring and observing systems in hydrogeotechnical and seismically well-constrained areas within the supersite.

WP7 Re-evaluation of the seismo-tectonics of the Marmara Region.

WP8 Monitoring seismicity and fluid activity near the fault using existing cabled and autonomous multiparameter seafloor instrumentation.

WP9 Early Warning and Development of the real-time shake and loss information for the supersite.

WP11 Integration of data management practices and coordination with ongoing research infrastructures.

WP12 Dissemination activities and public outreach strategy.

MARsite

Objectives

To fulfil the requirements of the call, MARsite identifies a number of objectives that drive its implementation, the definition of the activities and the composition of the consortium.

The MARsite strategic objectives are to:

Achieve long-term hazard monitoring and evaluation by in-situ monitoring of: earthquakes, tsunamis, landslides, displacements, chemical-radioactive emission and other physical variables and; by the use of space-based techniques.

Improve existing earthquake early-warning and rapid-response systems by involving common activities, participants, competences, knowledge and experts from Europe.

Improve ground shaking and displacement modelling by development/updating of source models and the use of probabilistic and deterministic techniques with real-time and time-dependent applications.

Pursue scientific and technical innovation by including state-of-the-art R&D in developing novel instruments and instrumentation.

Interact with end users and contribute to the improvement of existing policies and programs on preparedness, risk mitigation and emergency management.

Motivation

In the last 12 years, Europe experienced destructive earthquakes such as 1999 Izmit (Turkey), 1999 Athens (Greece) and 2009 L'Aquila (Italy).

More destructive earthquakes happened earlier: Istanbul in 1509 and 1766, Izmir in 1688, Eastern Sicily in 1693 and Lisbon in 1755.

Such catastrophic event is now expected in the Marmara region, with a probability in excess of 65% in 30 years, due to the existing seismic gap and the post-1999 earthquake stress transfer at the western portion of the 1000km-long North Anatolian Fault Zone (NAFZ), passing through the Marmara Sea about 15 km from Istanbul.

Istanbul is fully aware of this impending problem and the authorities are in the process of taking all conceivable physical and social steps for preparedness and mitigation of the risk.

bonano.m@irea.cnr.it

INGV MARsite