URBAN GEO BIG DATA
Meeting
Turin, 18 July 2018

- CNR
- R. Lanari, A. Pepe
  - M. Bonano, M. Manzo, P. Imperatore, F. Calò

PRIN PROJECT: *URBAN GEOmatics for Bulk Information Generation, Data Assessment and Technology Awareness*

MINISTERO DELL'ISTRUZIONE DELL'UNIVERSITA' E DELLA RICERCA

Istituto per il Rilevamento Elettromagnetico dell'Ambiente

IREA-CNR Three-Year Activities

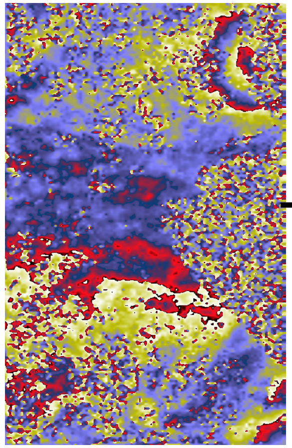
- Generation of InSAR products from historical (ERS-ENVISAT) SAR data
- InSAR data and metadata
- Development of a web-based tool relying on the use of open-source GET-IT platform
- Generation of InSAR products with new Sentinel-1 SAR data. Preliminary SBAS results on some test-site areas have produced. Atmospheric and residual phase artefacts have to be corrected.
- Development of new methods for the calibration of SAR images (research activity)
- Evaluation of SAR backscattering changes in urban areas with Sentinel-1 data (research activity)

Advanced DInSAR technique: Results on Milan Area

- CNR
- M. Bonano, M. Manzo, R. Lanari, A. Pepe

SBAS: A two scale approach

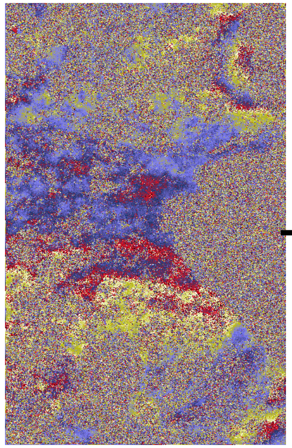
Multi-look Interferogram



SBAS

- 80x80m Spacing
- Atmospheric artifacts
- DEM errors
- Ground Deformation

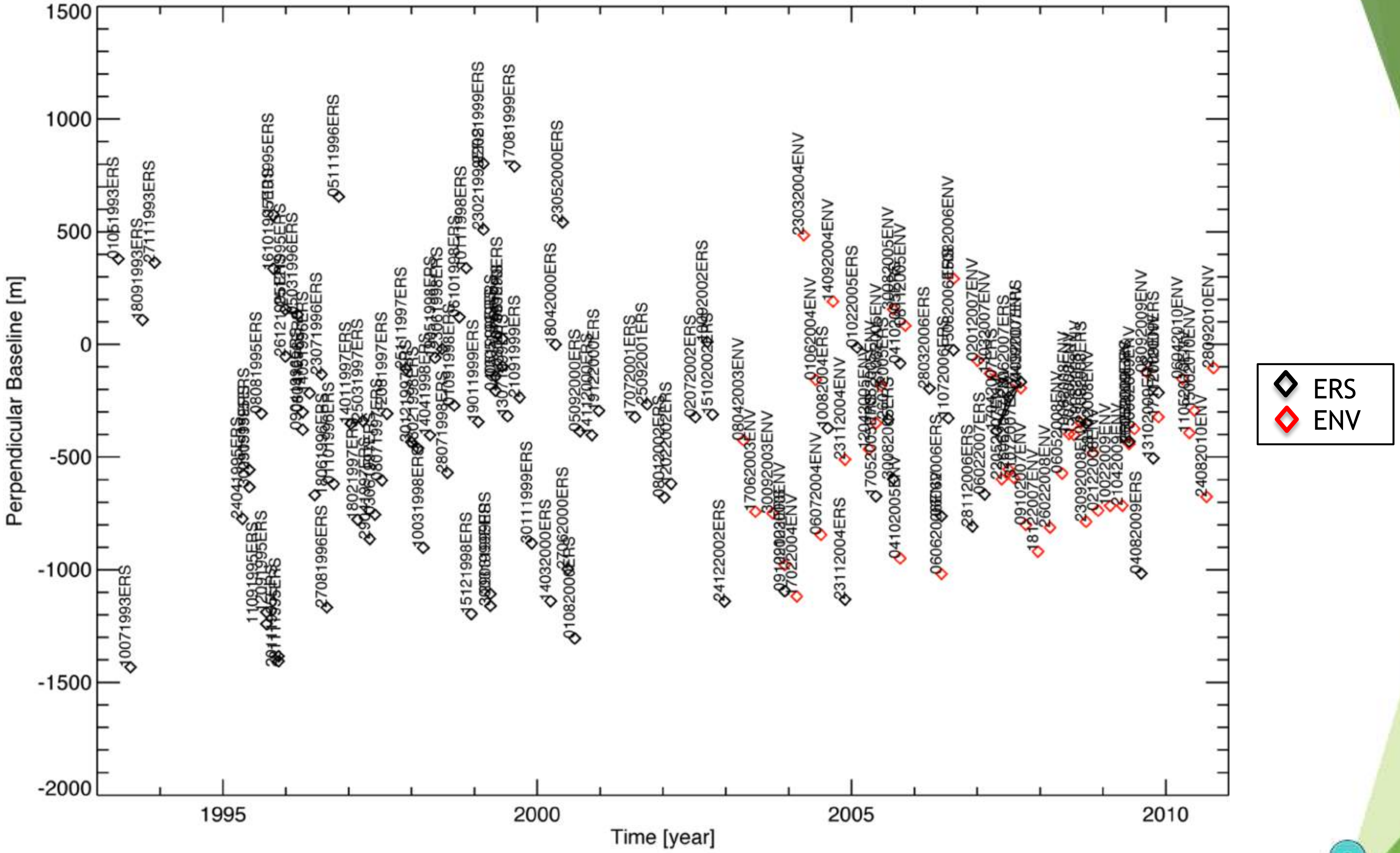
Single-look Interferogram



SBAS

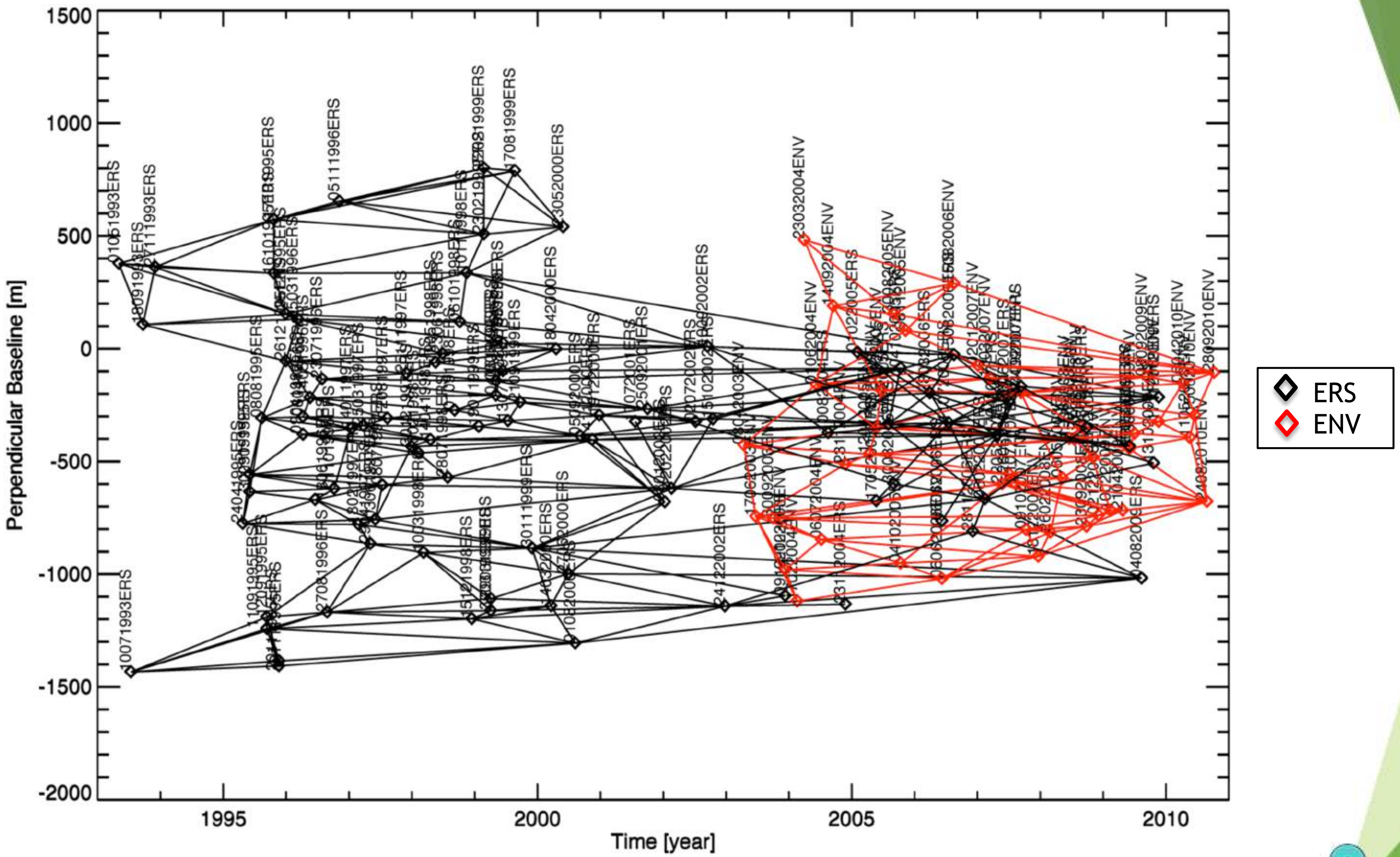
- 10x10m Spacing
- Single structure deformation
- Topography with respect to used DEM

ERS-ENVISAT SAR data Distribution: the Milan case study



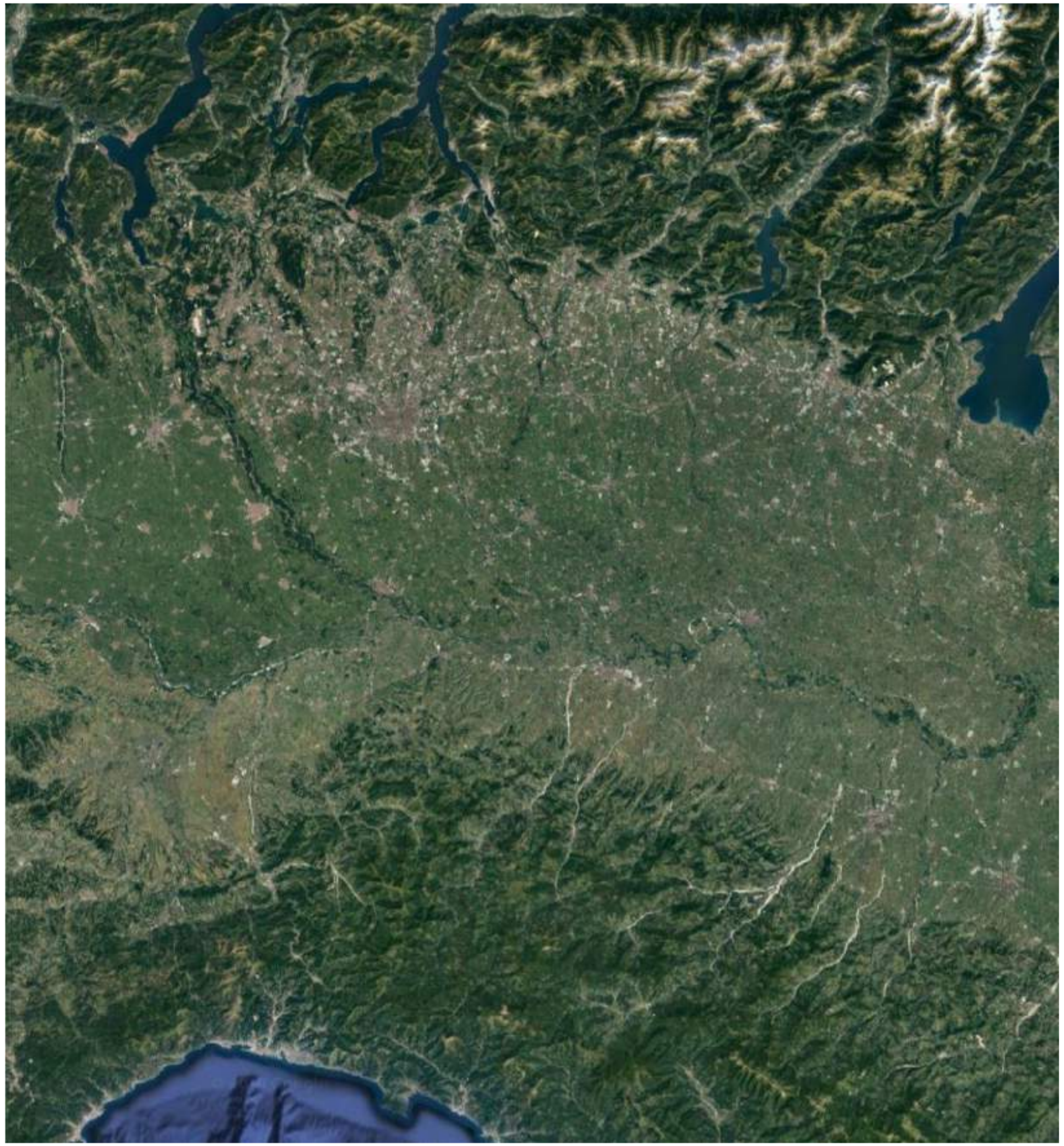
96 ERS and 45 ENV SAR images

ERS-ENVISAT interferometric SAR data pairs: the Milan case study

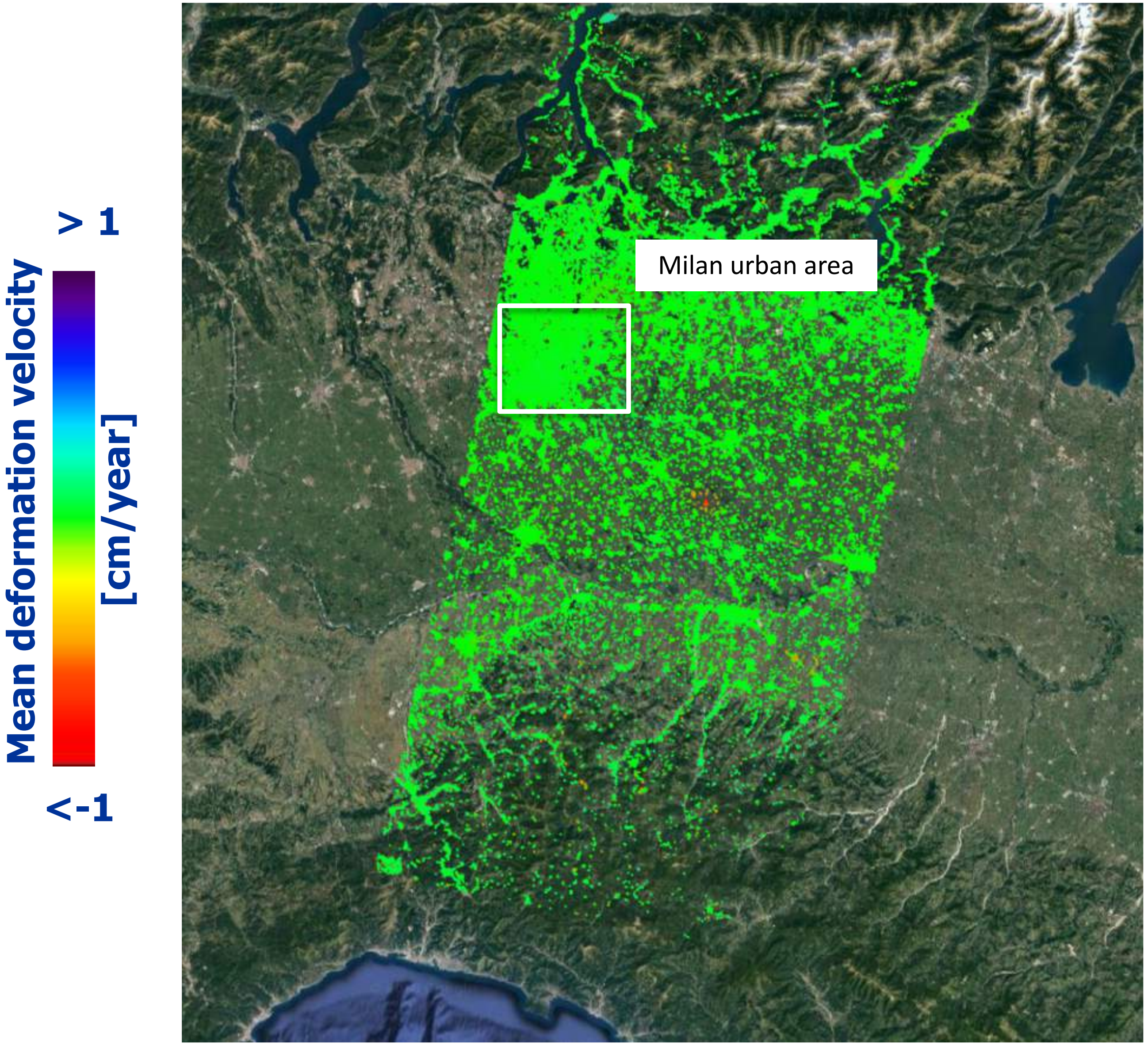


282 ERS and 130 ENV DInSAR interferograms

ERS-ENVISAT Low Resolution SBAS-DInSAR results: the Milan case study

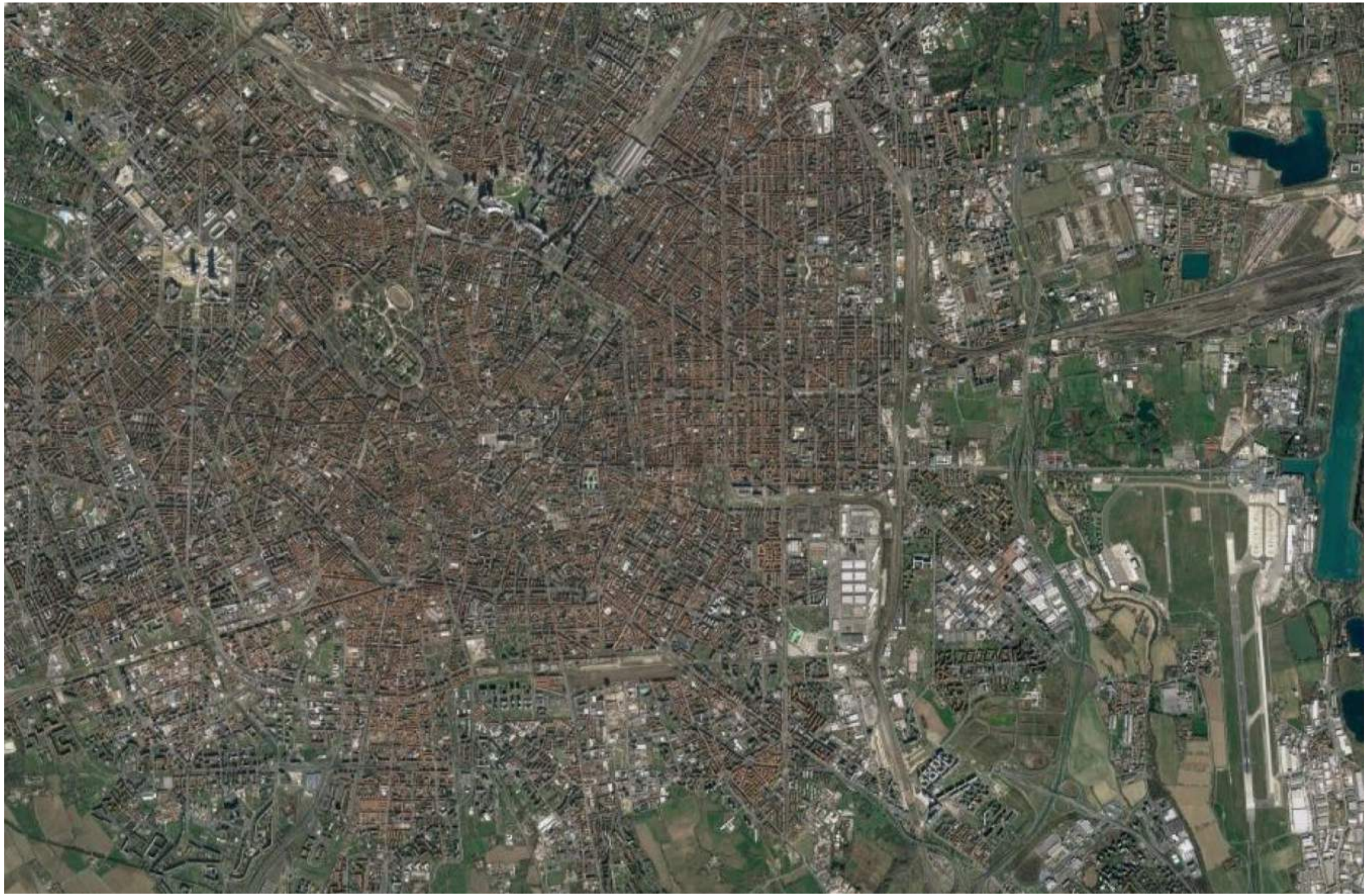


ERS-ENVISAT Low Resolution SBAS-DInSAR results: the Milan case study

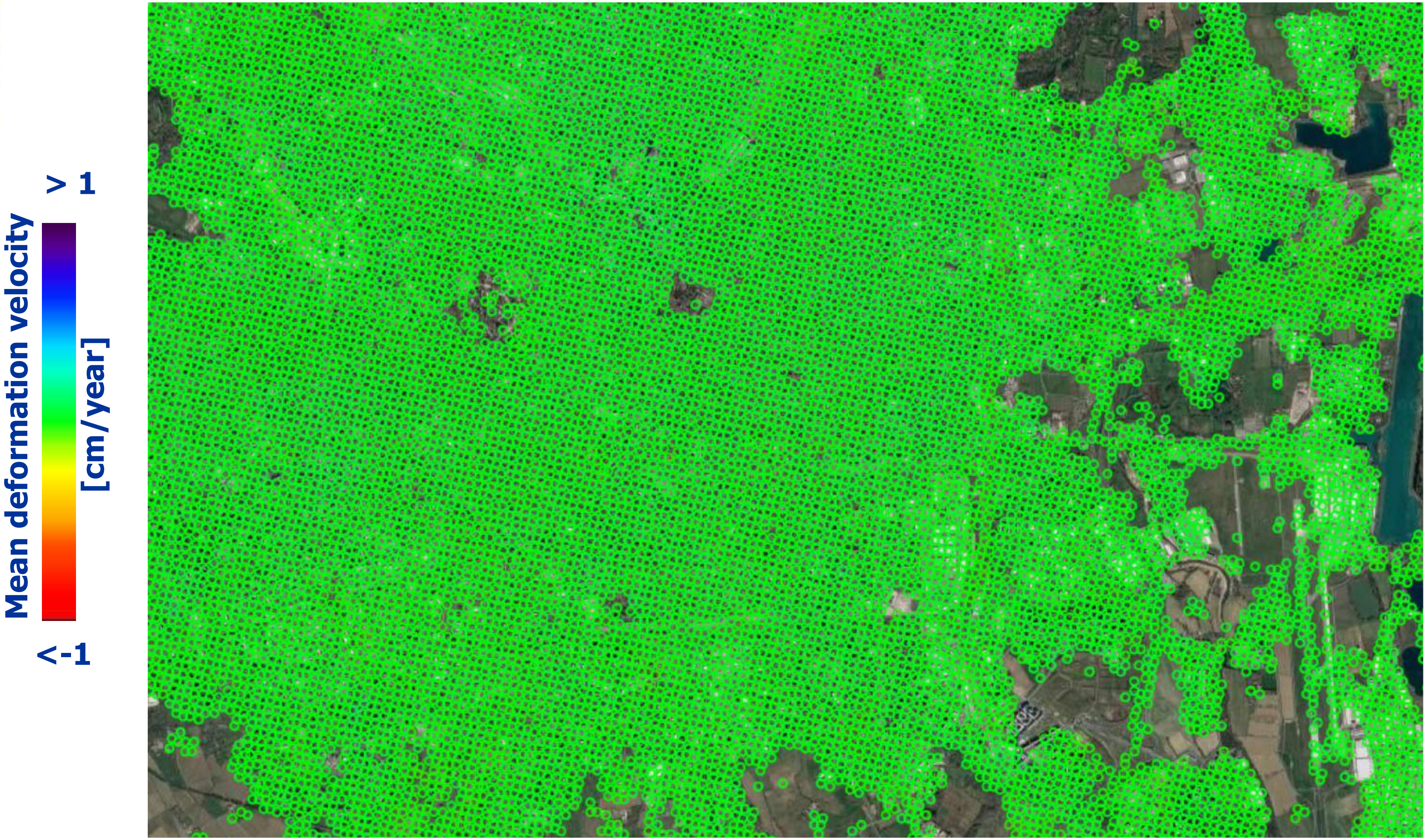


Milan area (T 208, descending orbits)	
#Images	141 (96 ERS, 45 ENV)
Sensor	ERS/ENVISAT
Spatial Resolution [m]	80x80
Time span	01/05/1993 - 28/09/2010
#Pixels	45200x 4300 (200 M)
#Interf	412 (282 ERS,130 ENV)

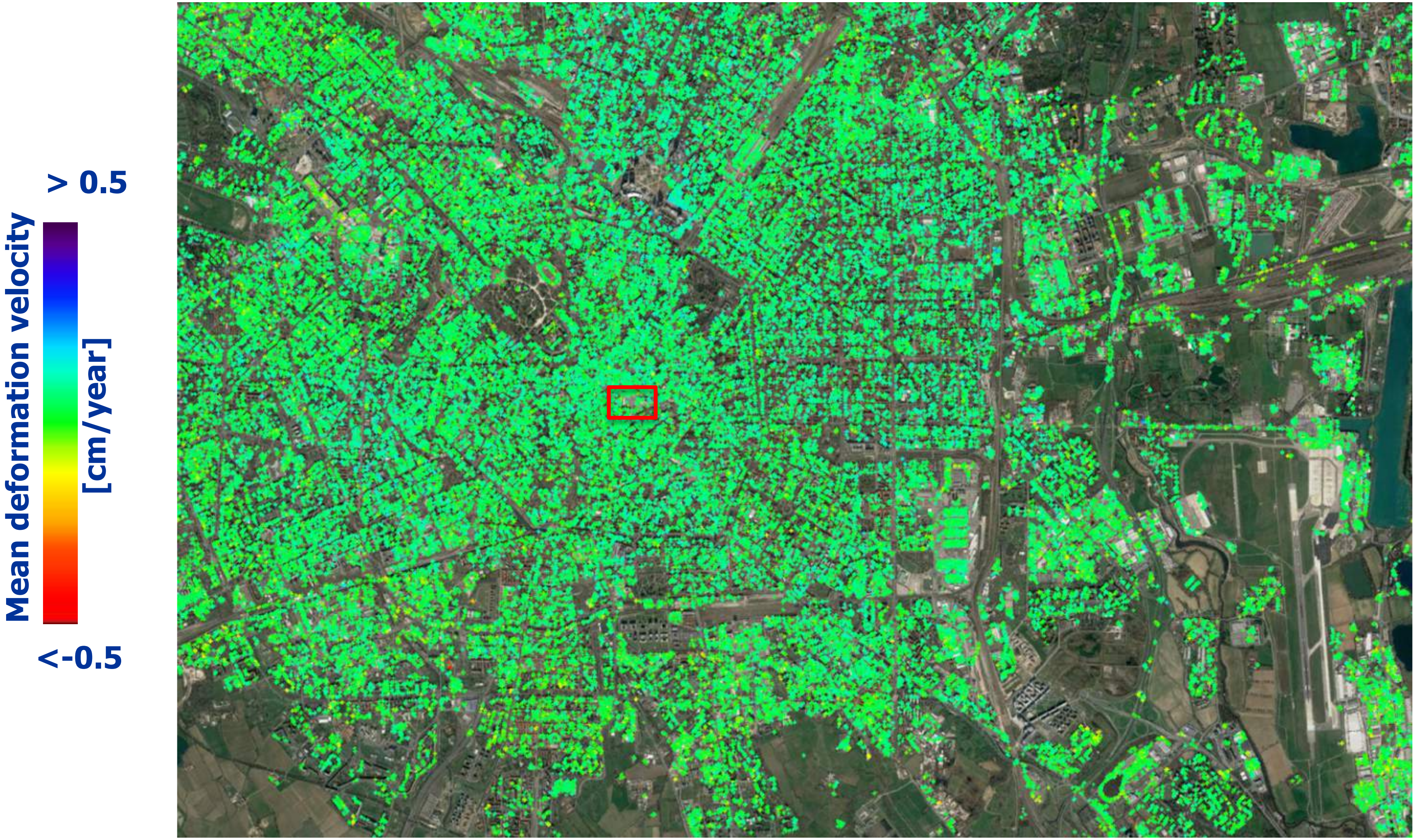
ERS-ENVISAT Low Resolution SBAS-DInSAR results: the Milan case study



ERS-ENVISAT Low Resolution SBAS-DInSAR results: the Milan case study



ERS-ENVISAT Full Resolution SBAS-DInSAR results: the Milan urban area



ERS-ENVISAT Full Resolution SBAS-DInSAR results: the Duomo of Milan

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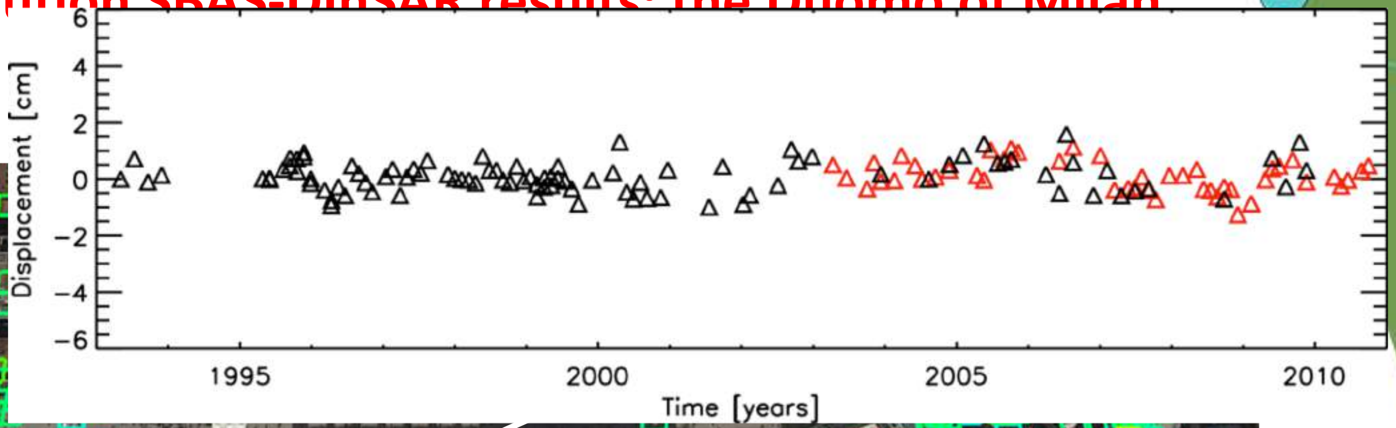

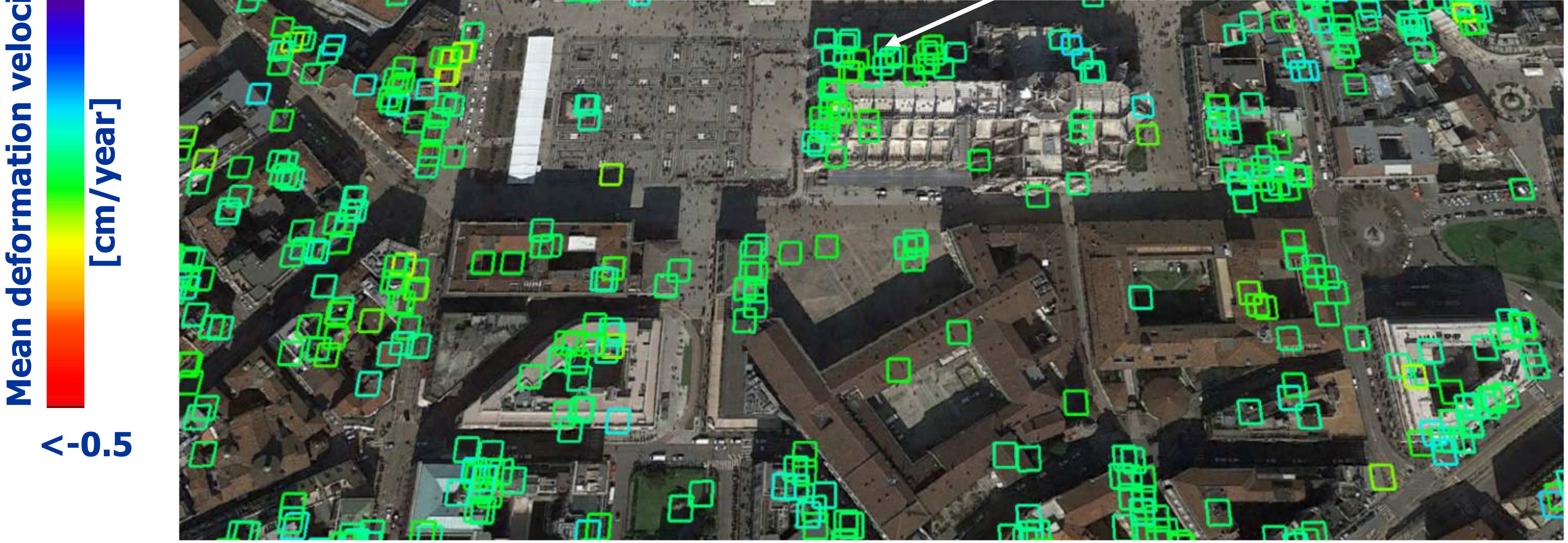

ERS-ENVISAT Full Resolution SBAS-DInSAR results: the Milan urban area

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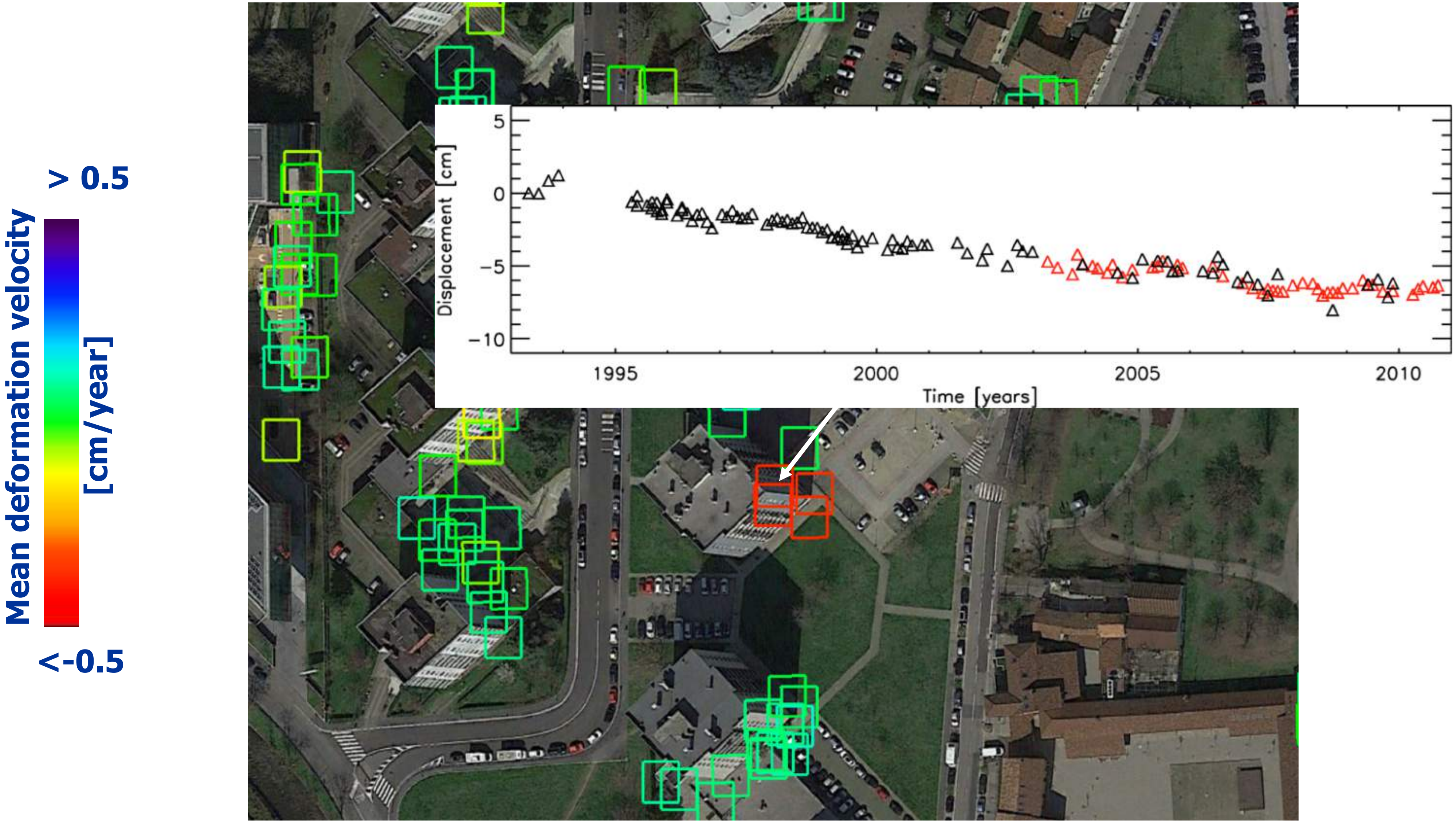

Additional Problems Had to be Faced

- ERS data are now provided using ASAR/ENVISAT format
- ERS raw data have been extracted and focused
- Orbital Parameters have to be extracted and interpolated

Sentinel-1 SBAS results on the Napoli Bay area: Preliminary Results

descending orbits

LOS

<-6 **>6**

cm/year

07 October 2014 – 06 April 2017
81 SLC

Atmospheric artefacts are difficult to be removed (very large swath, wider beams, etc …)

Accurate estimates require a (stable) population of more than three years, thus facilitating the removal of all the disturbances affecting Sentinel-1 Deformation Time-Series

CHANGE DETECTION ANALYSES WITH SAR DATA

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Radiometric Calibration of di SAR Images: A New Formulation

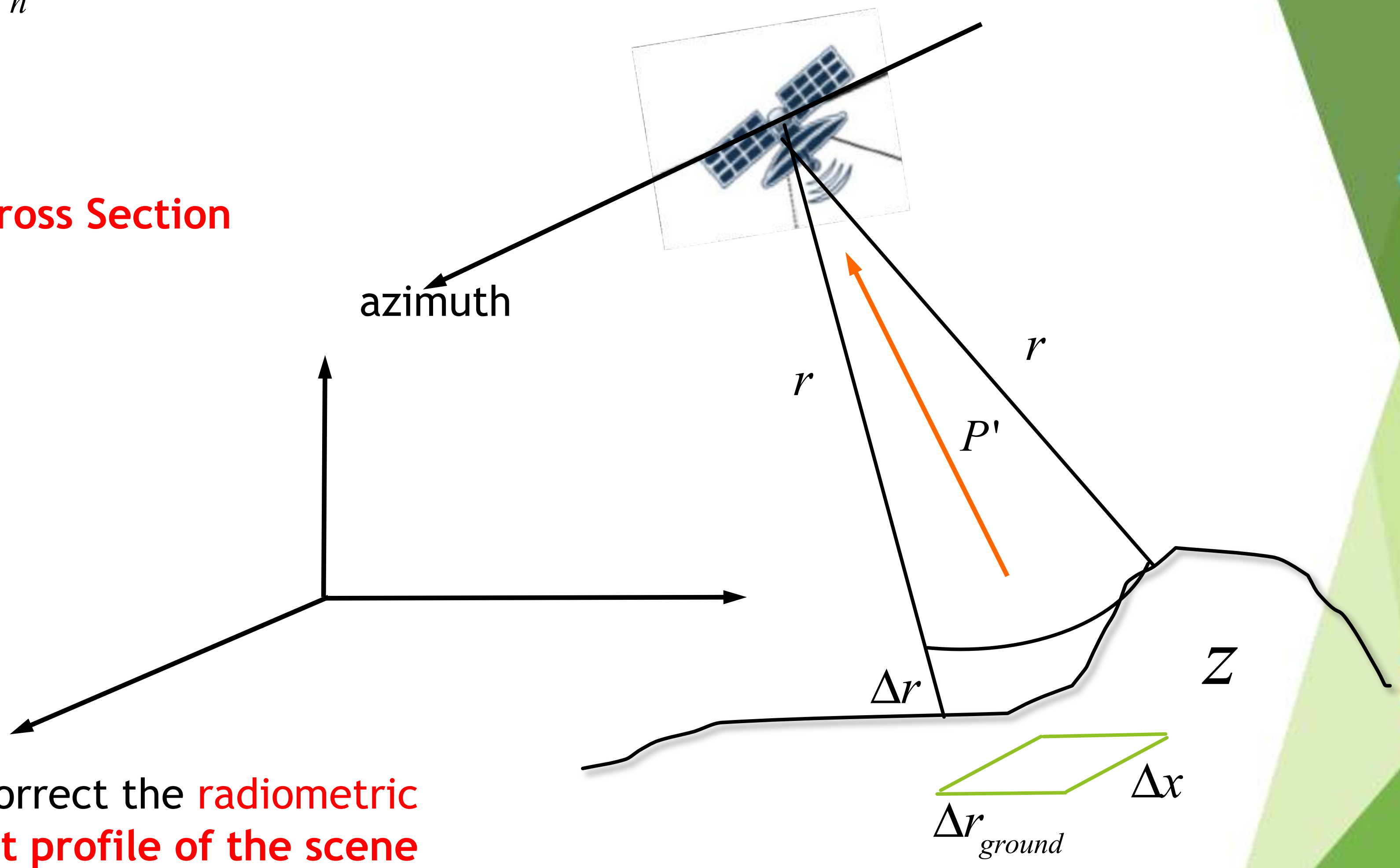
$$P' = P_r + P_n = K\sigma^0 + P_n$$

Intensity of the backscattered signal at a given pixel

Normalized RADAR Cross Section

$$K = \frac{PG^2\lambda^2 \Delta x \Delta r}{(4\pi)^3 r^4}$$

RADAR Equation



We are facing the problem to correct the radiometric distortions related to the **height profile of the scene**

*A paper has been submitted for publication to Transactions on Geoscience and Remote Sensing (TGRS)

Radiometric Calibration of SAR Images: Development of Novel Theoretical Formulations and Processing Techniques

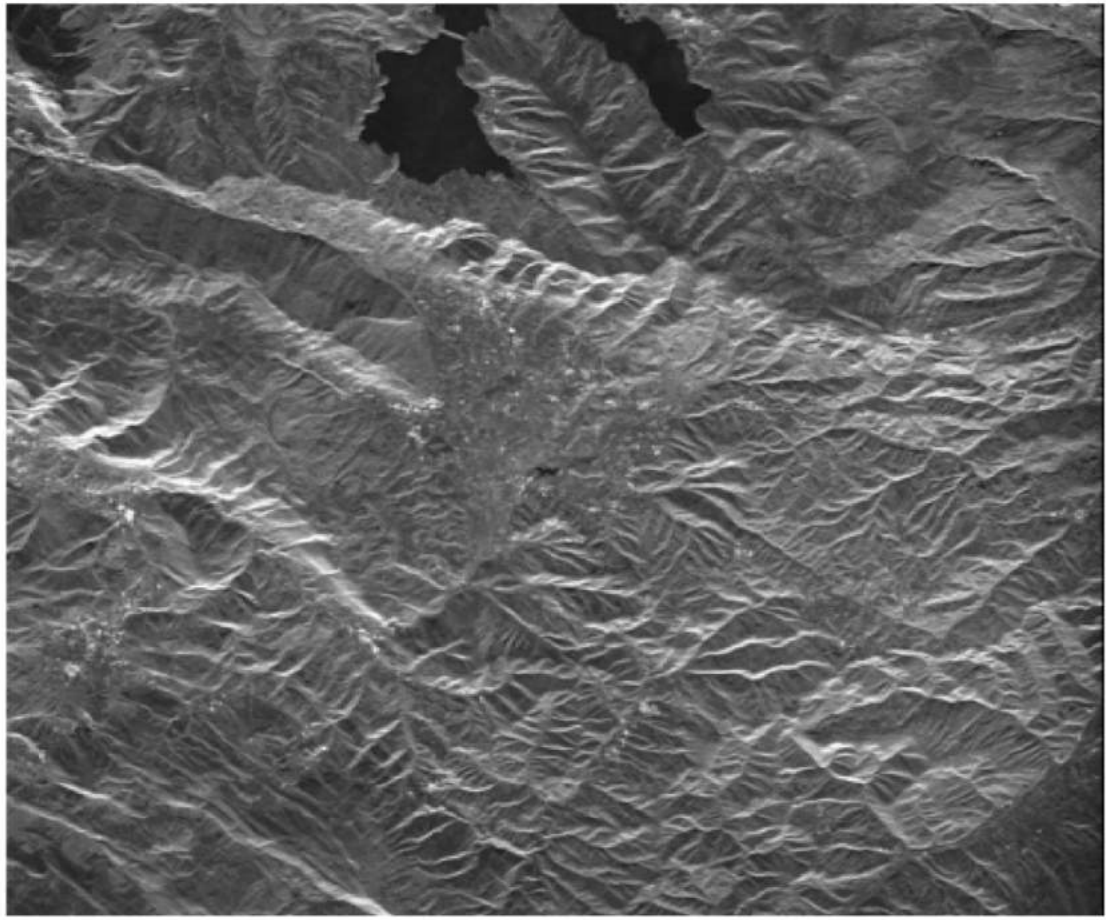


Fig.1. SLC COSMO-Skymed SAR amplitude image.

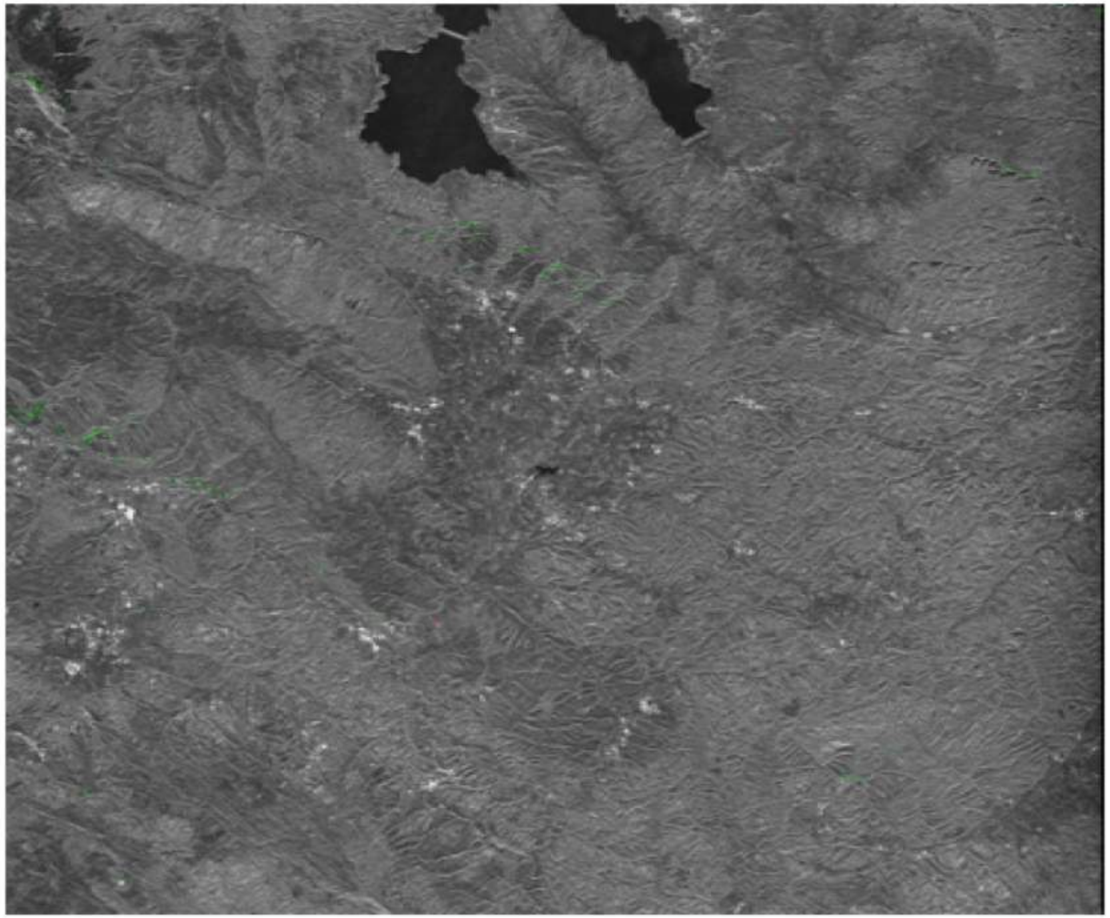
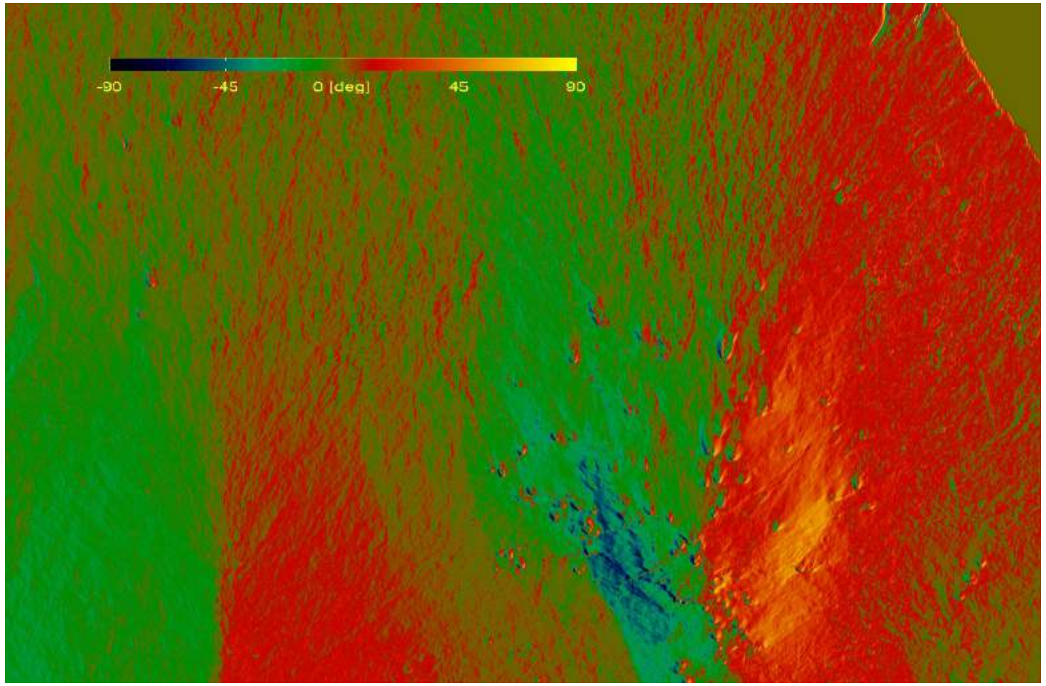
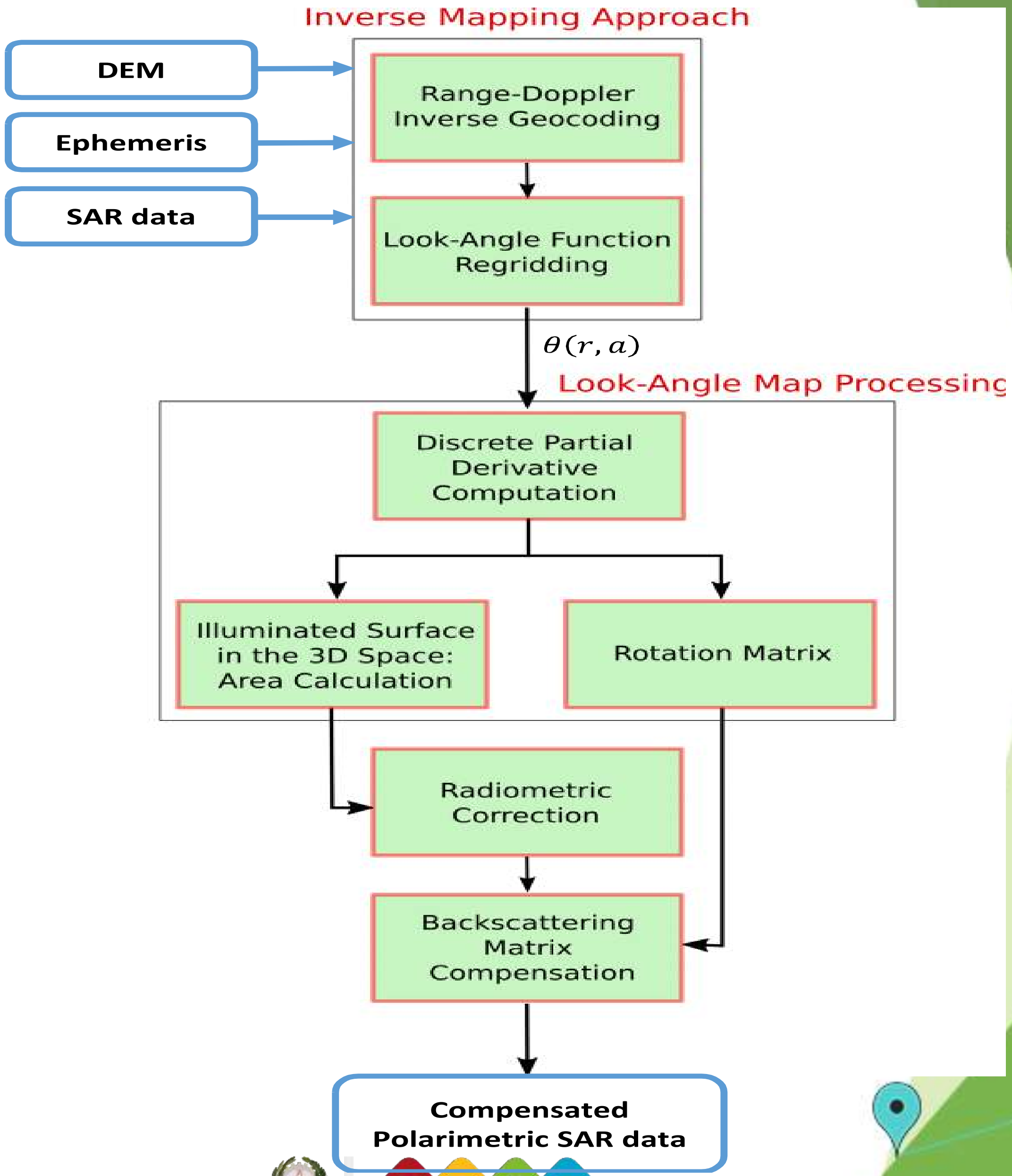


Fig. 2. Calibrated COSMO-Skymed SAR image obtained by applying the GICAL processing scheme. A layover mask (in green) is also superimposed.

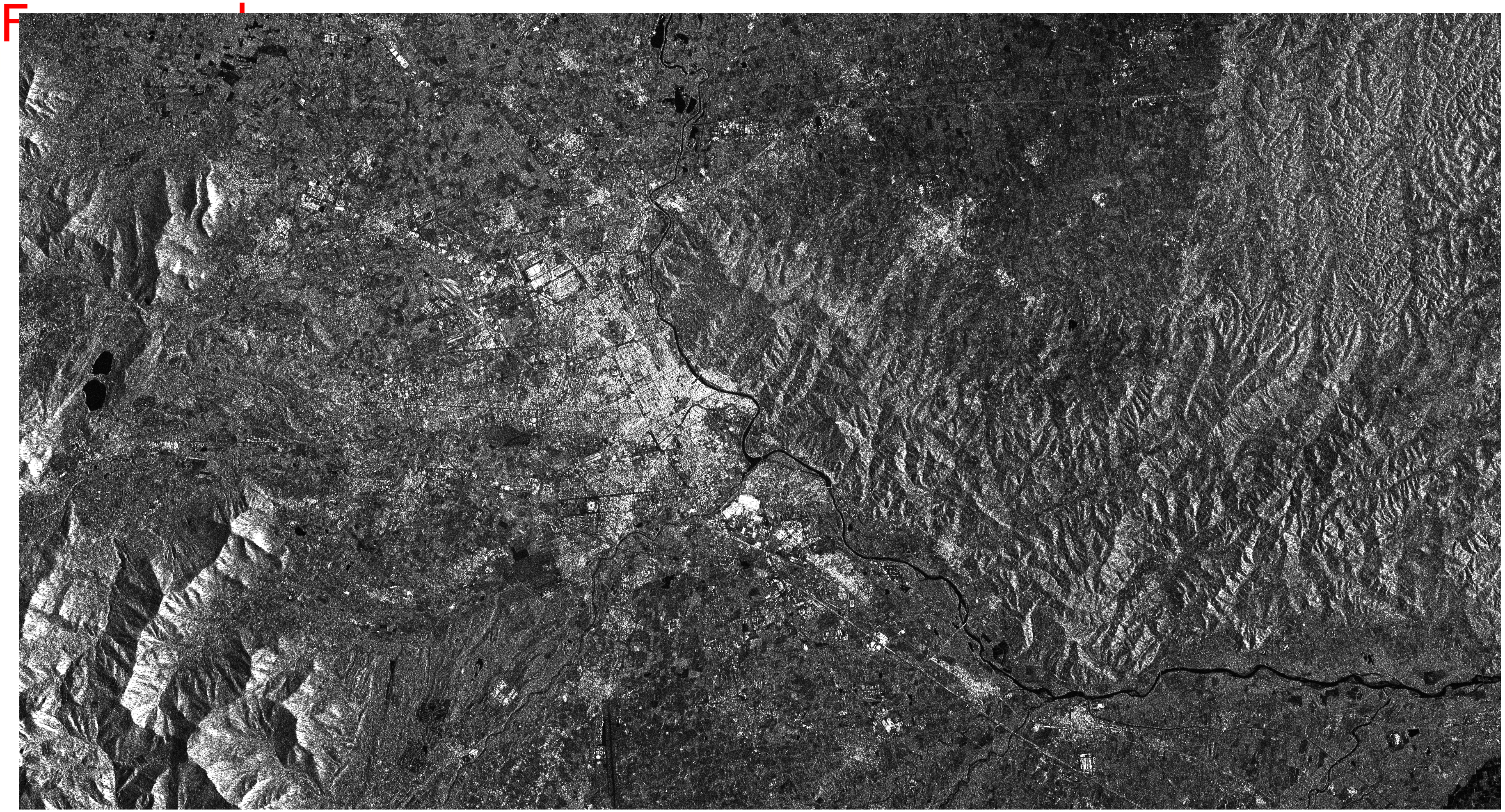
Polarimetric SAR Calibration Techniques

- Compensation of topography-induced polarimetric distortions



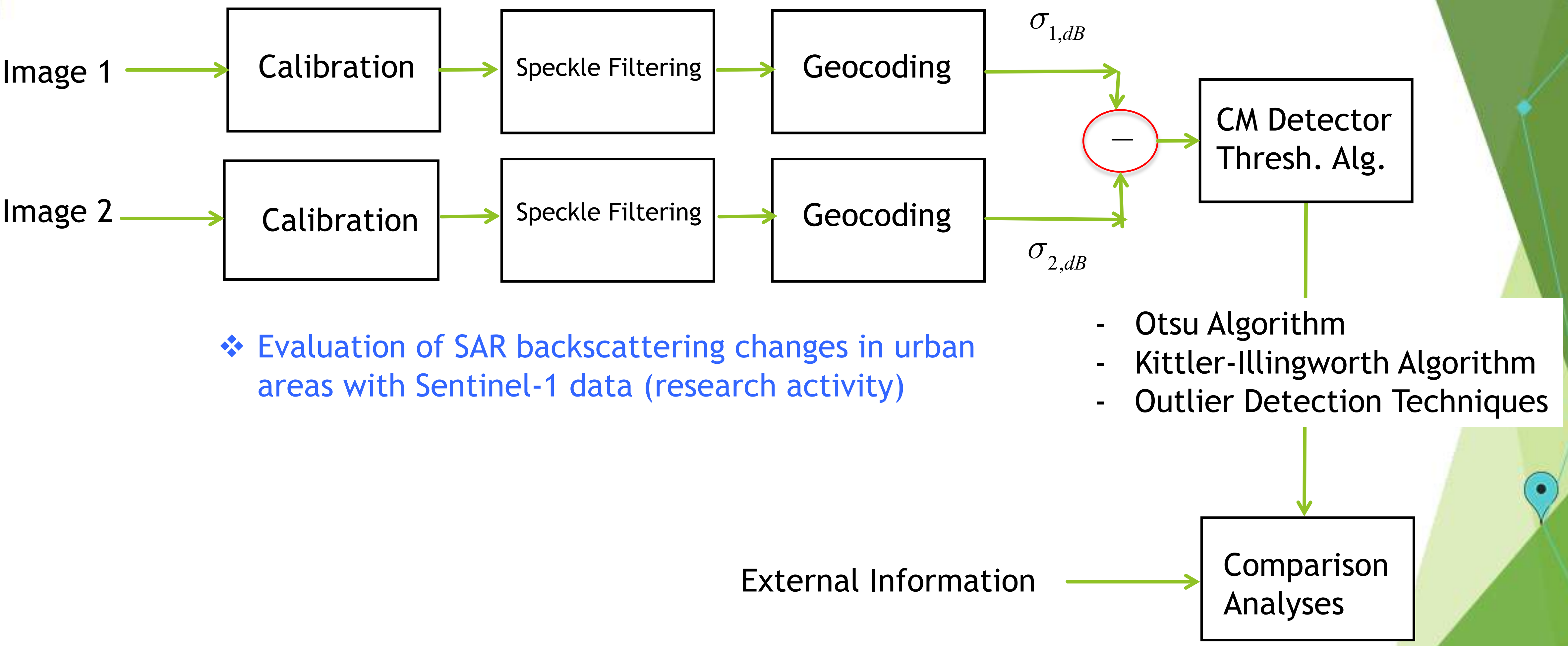


Experiments on Turin 2015-2018 Sentinel-1 Data: General F



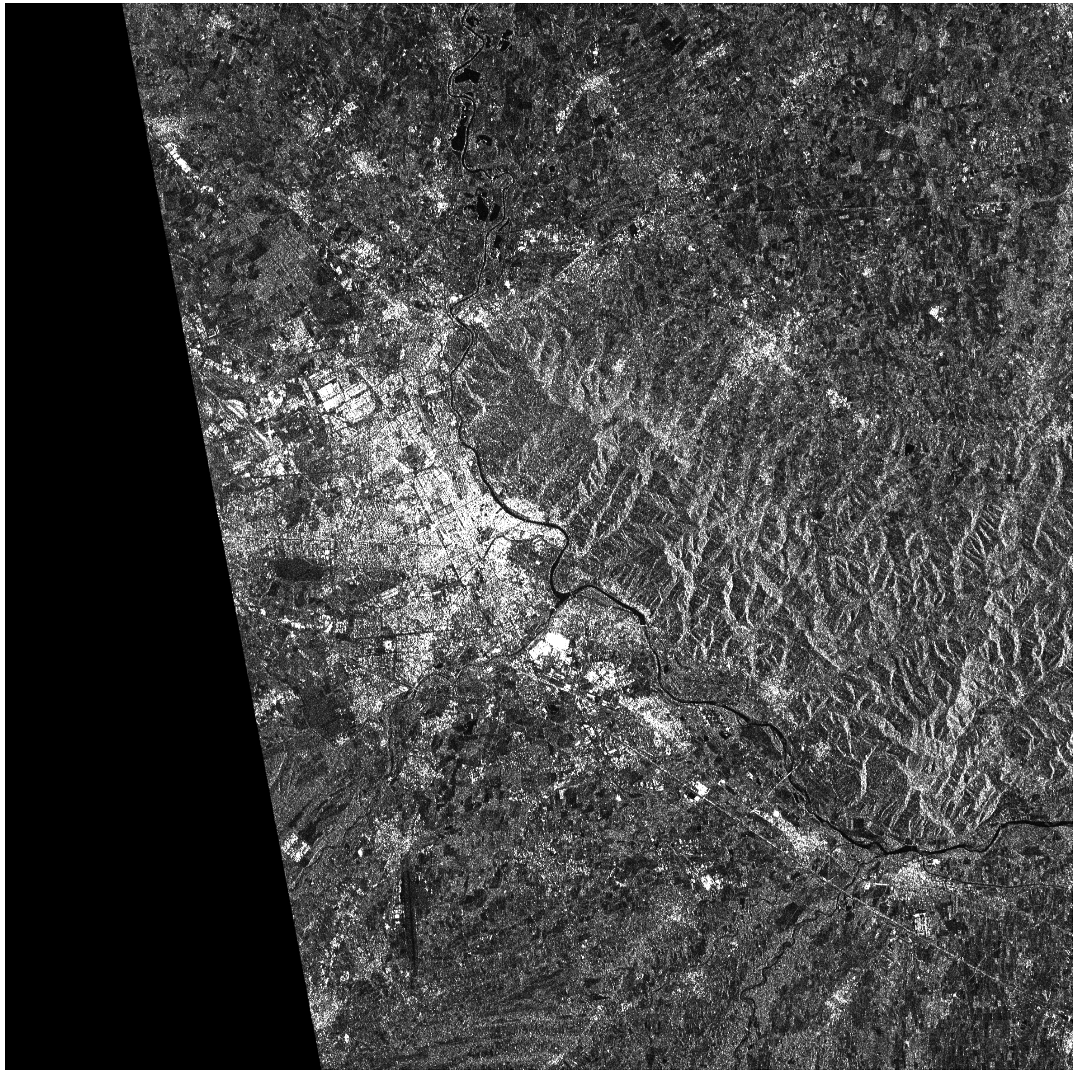
Sentinel-1 SAR Amplitude Image May 8, 2016

Change Detection: SAR Image Processing Diagram Block

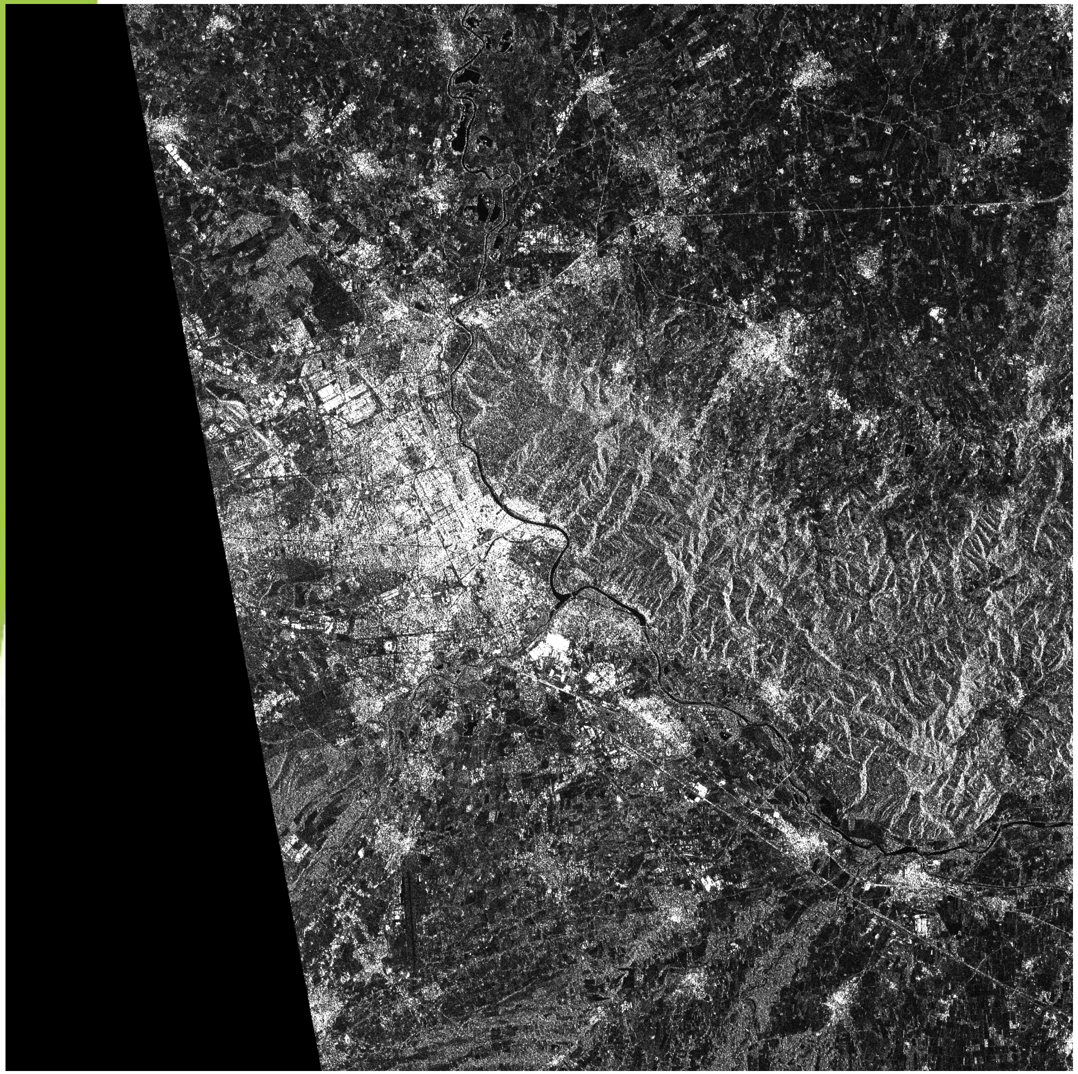


❖ Evaluation of SAR backscattering changes in urban areas with Sentinel-1 data (research activity)

Change Detection: Geocoded Images 8 May 2016 – 7 May 2017



Extraction of the Change Map – Log Ratio Map



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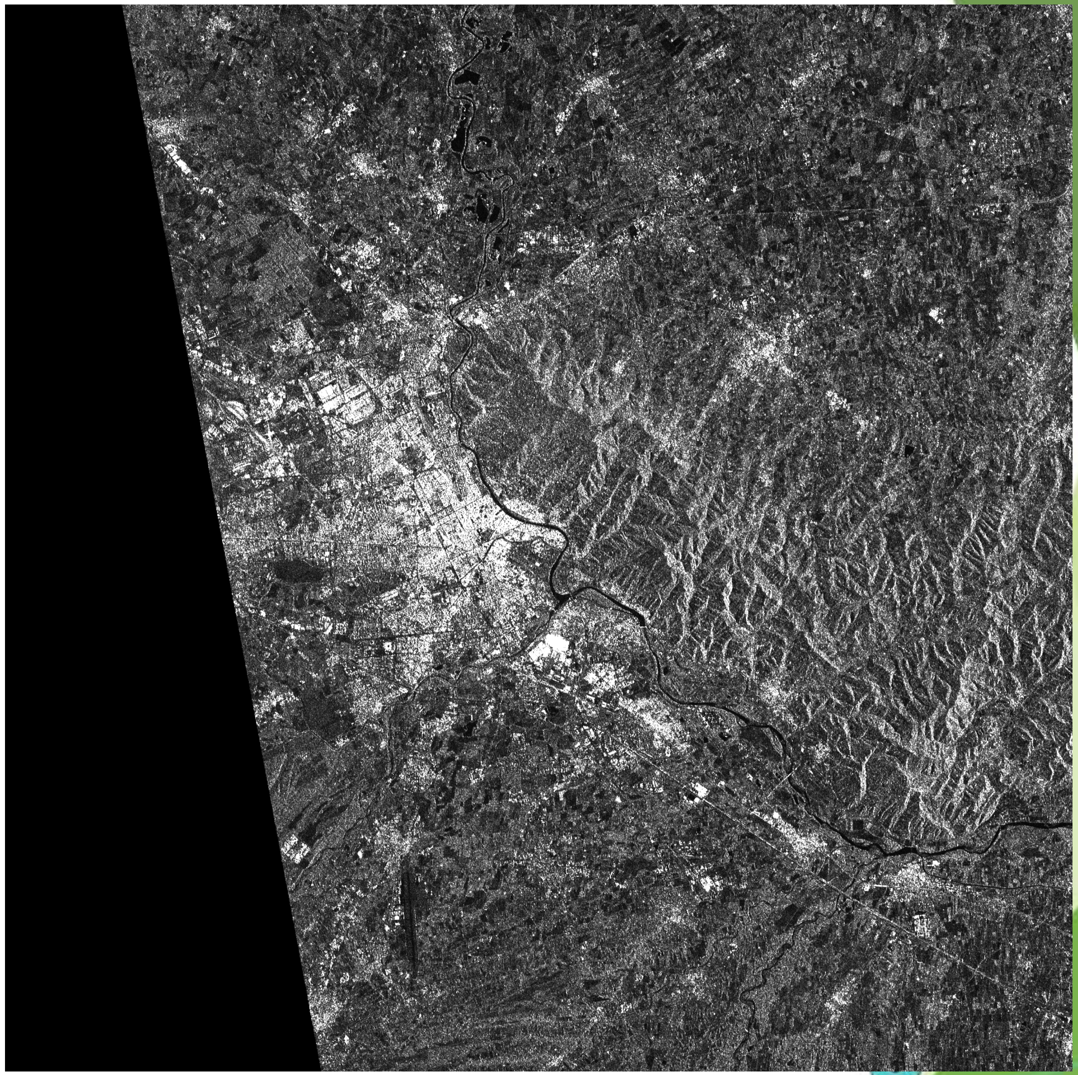
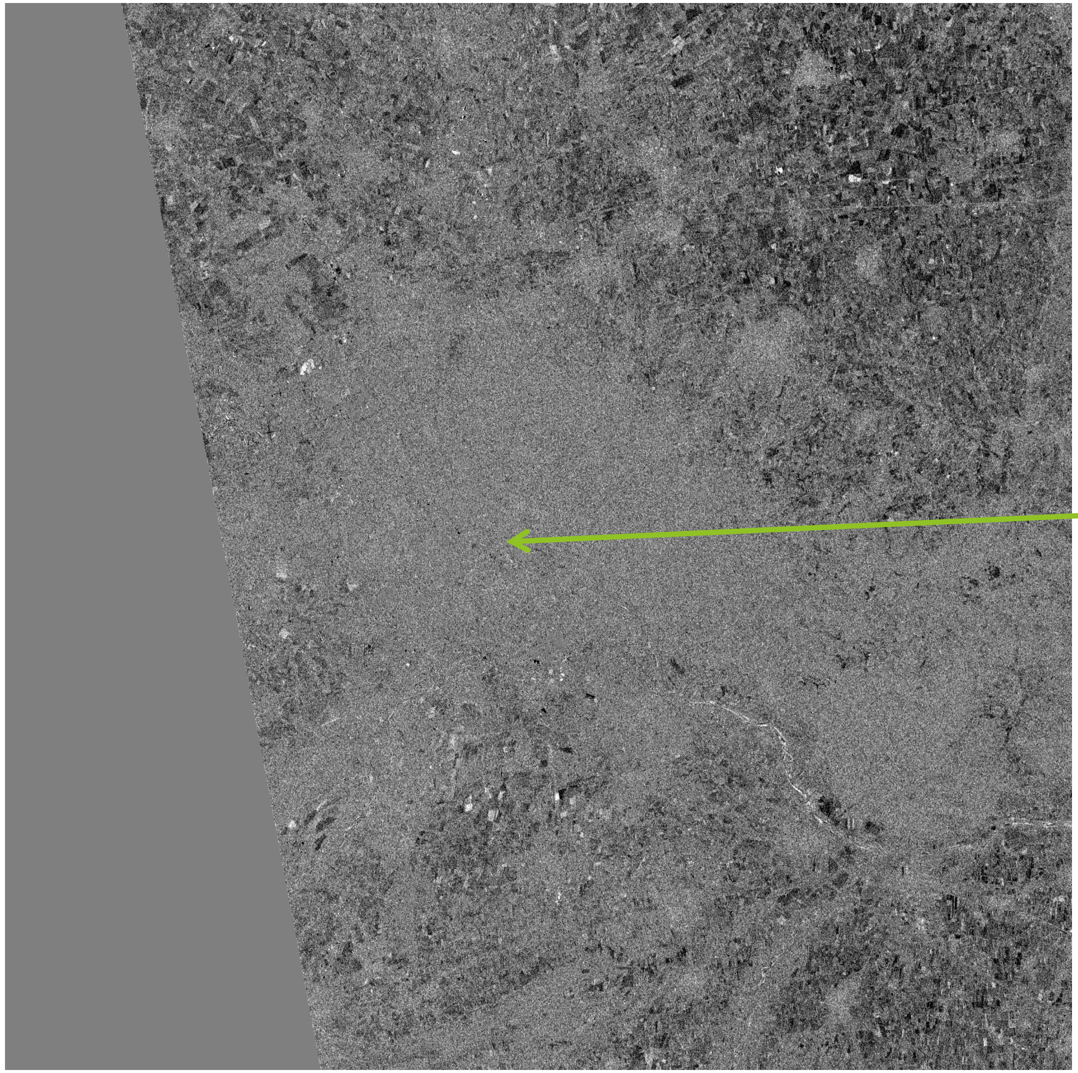
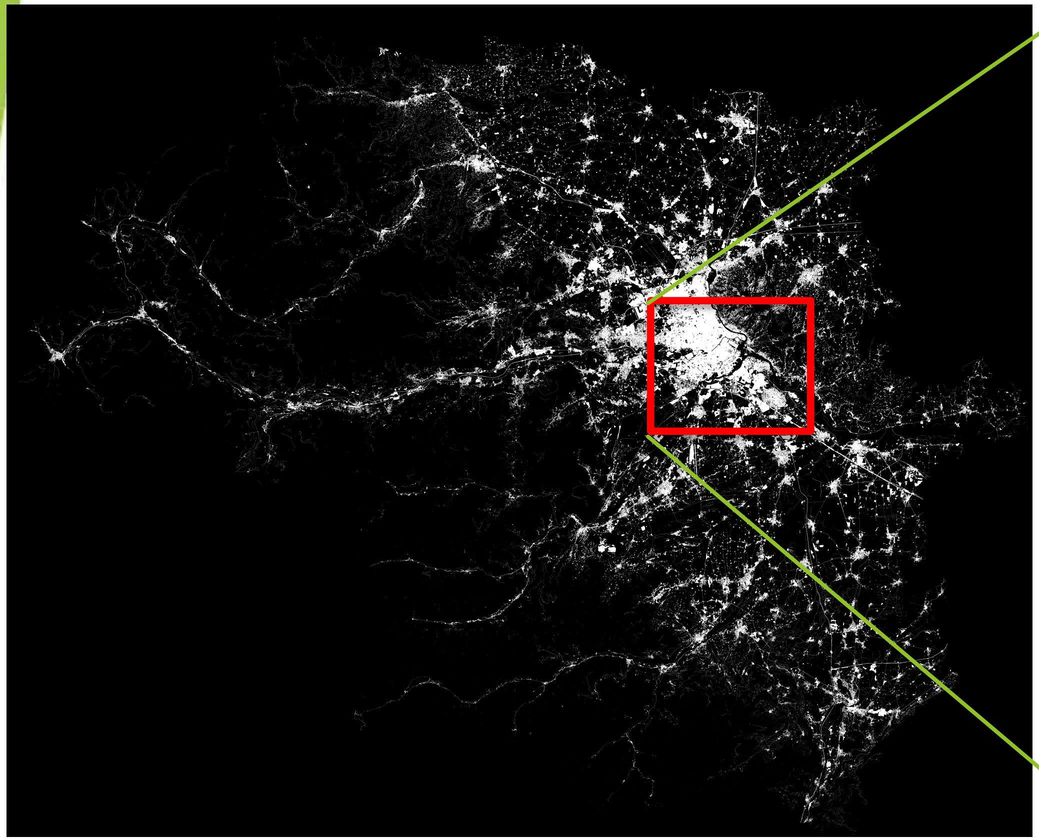


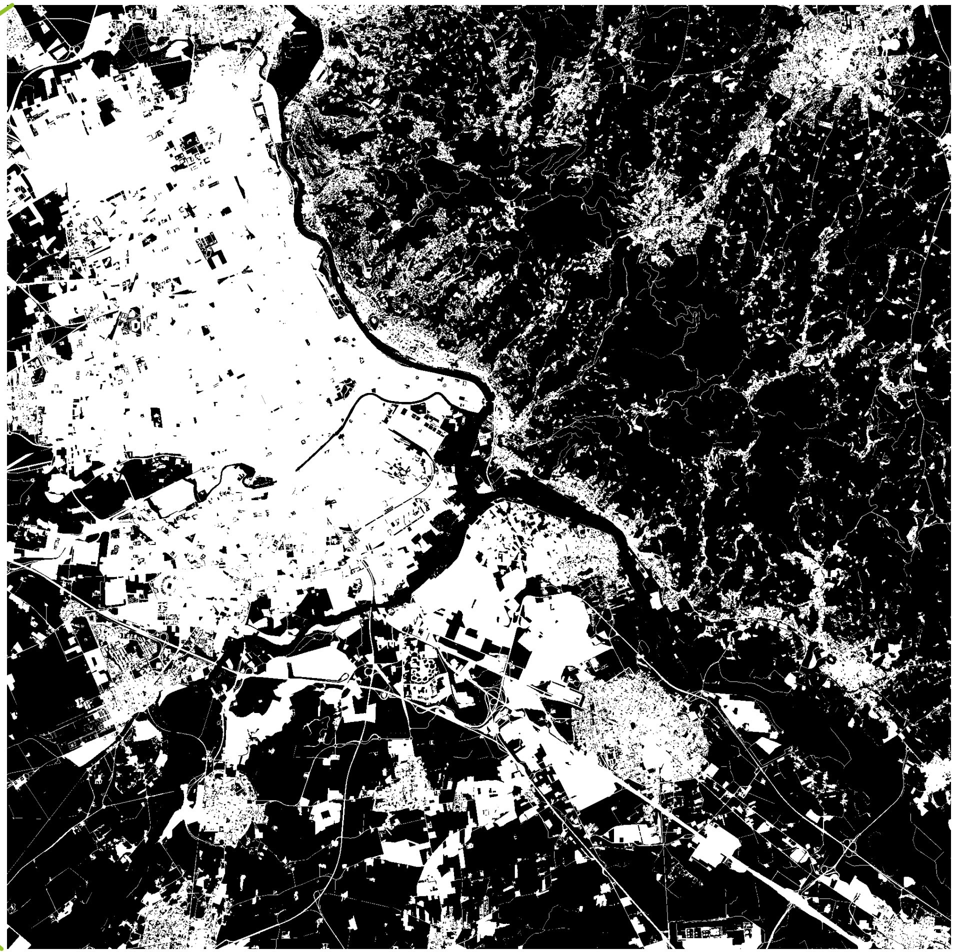
Extraction of the Change Map



City of Turin

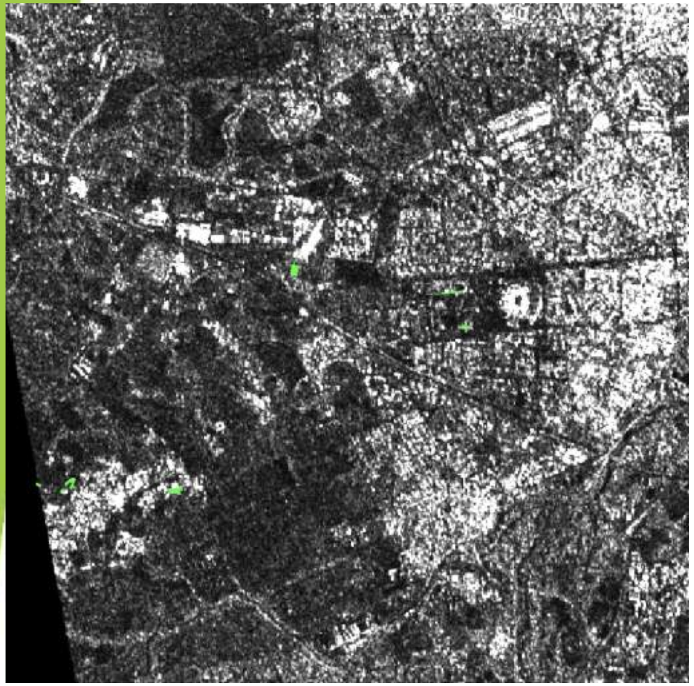
Soil Consumption Map on Turin (2016)

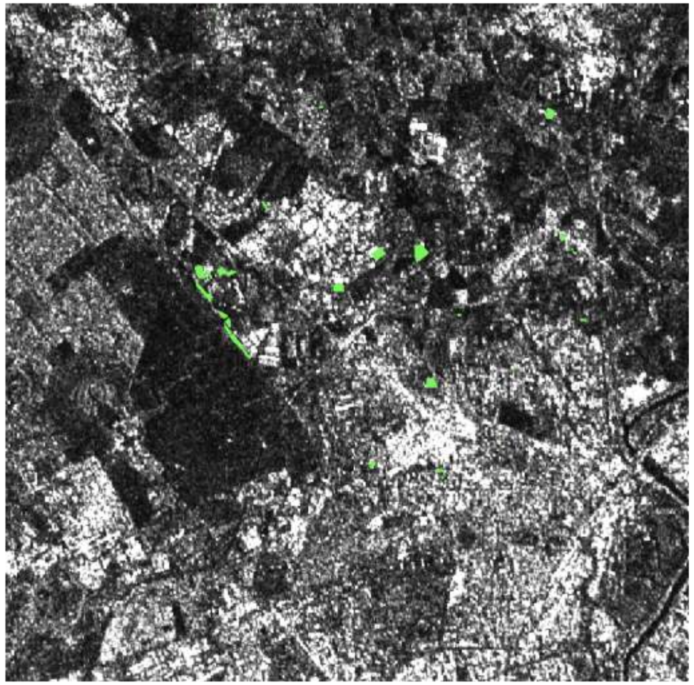


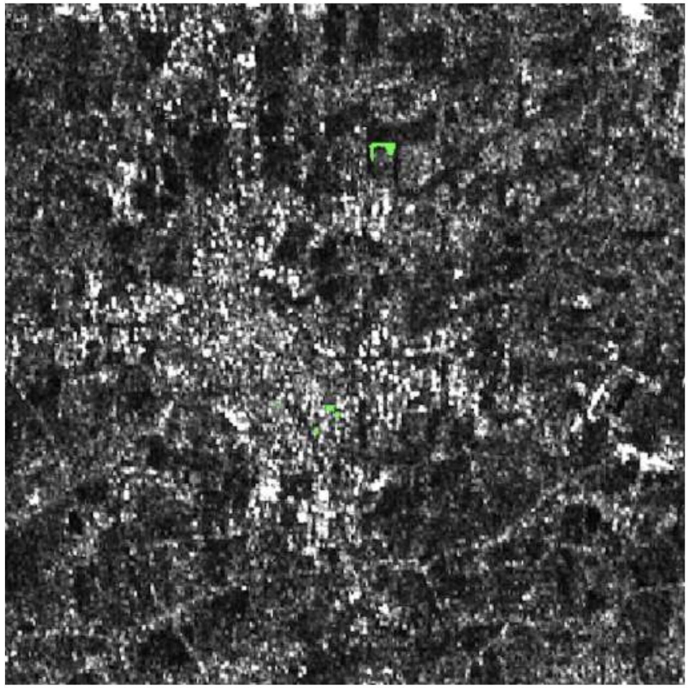


Data were provided to us by Michele Munafò (ISPRA)

Difference of Soil Consumption Between 2016 and 2017







Turin area has not been affected by a significant soil comsumption from 2016 to 2017

However, we have started developing some preliminary algorithms to be used in more favourable scenarios

Example: Using the kittler-Illingworth (KI) Algorithm

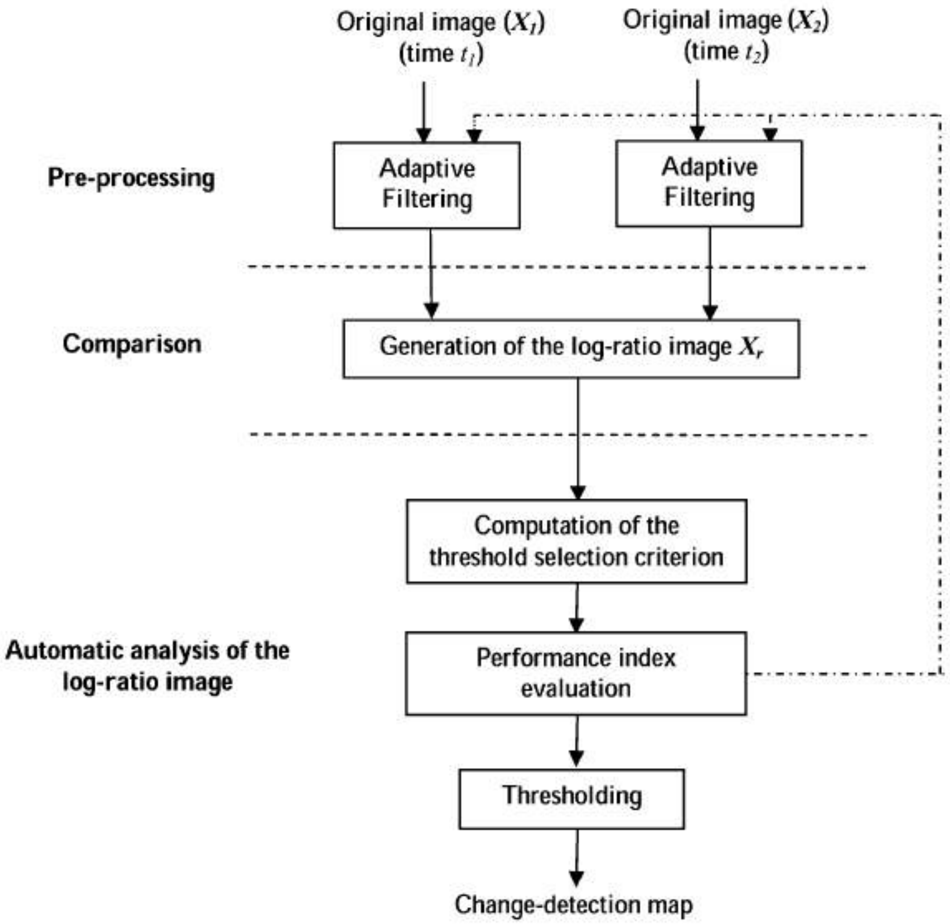


Fig. 1. General block diagram of the proposed change-detection approach.

874 IEEE TRANSACTIONS ON GEOSCIENCE AND REMOTE SENSING, VOL. 43, NO. 4, APRIL 2005

An Unsupervised Approach Based on the Generalized Gaussian Model to Automatic Change Detection in Multitemporal SAR Images

Yakoub Bazi, *Student Member, IEEE*, Lorenzo Bruzzone, *Senior Member, IEEE*, and Farid Melgani, *Member, IEEE*

$$p(X_l) = p(X_l \mid \omega_c)P(\omega_c) + p(X_l \mid \omega_u)P(\omega_u).$$

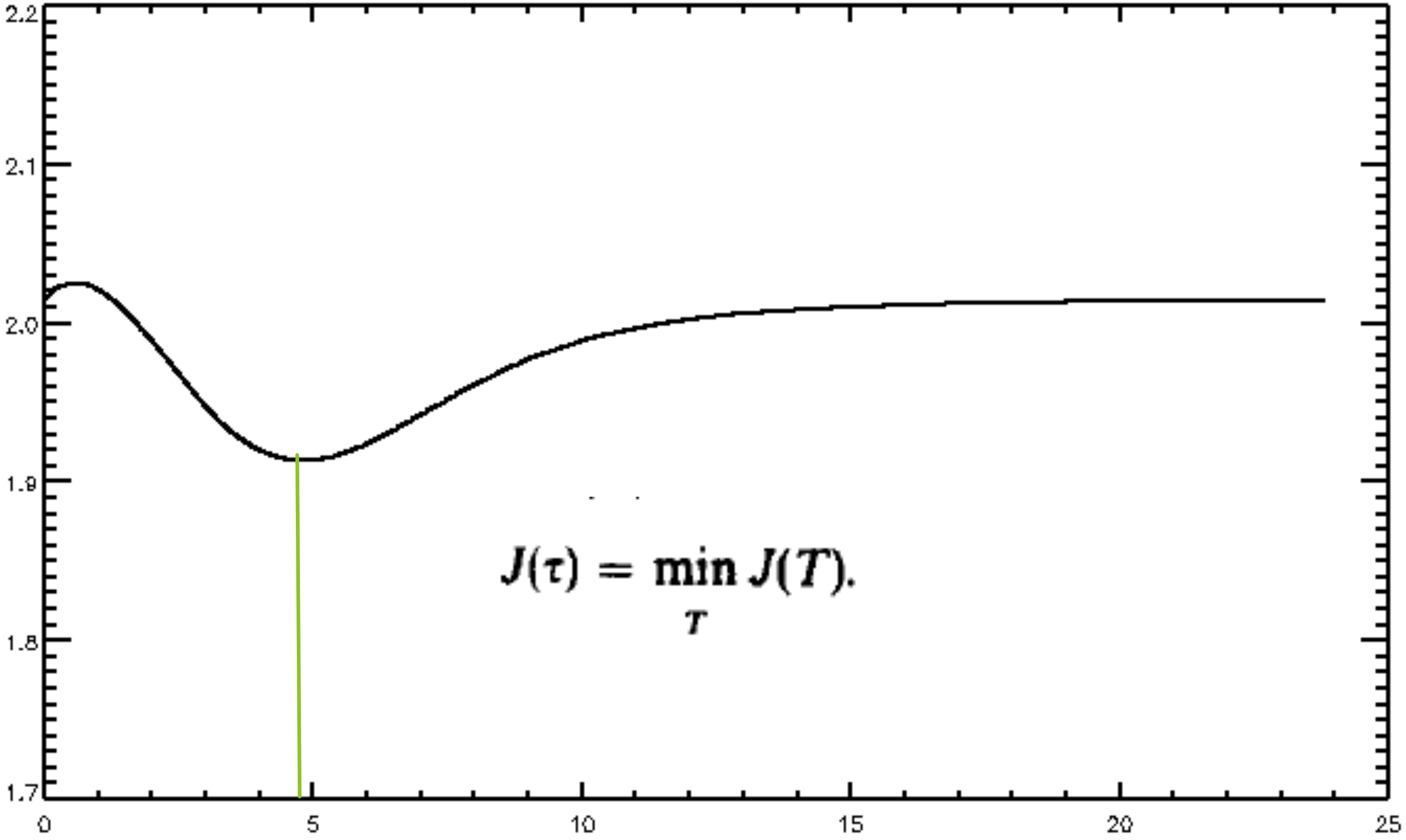
$$J(T) = 1 + 2\left[P_u(T)\ln\sigma_u(T) + P_c(T)\ln\sigma_c(T)\right] + 2H(\Omega, T).$$

Using the kittler-Illingworth (KI) Algorithm

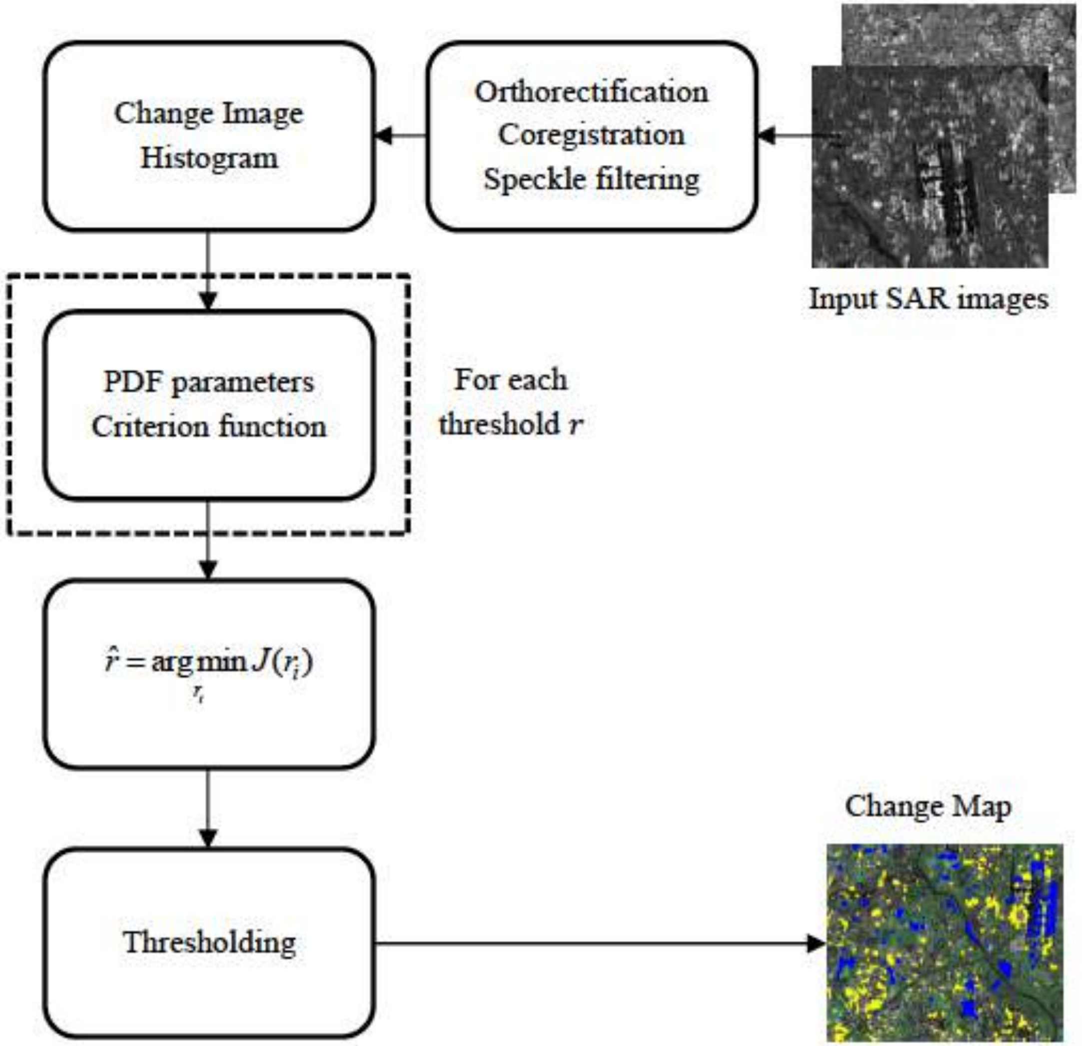
$$\begin{cases} P_u(T) = \sum_{X_l=0}^{T} h(X_l), \quad m_u(T) = \frac{1}{P_u(T)} \sum_{X_l=0}^{T} X_l h(X_l) \\ \sigma_u^2(T) = \frac{1}{P_u(T)} \sum_{X_l=0}^{T} [X_l - m_u(T)]^2 h(X_l) \\ P_c(T) = 1 - P_u(T), \quad m_c(T) = \frac{1}{P_c(T)} \sum_{X_l=T+1}^{L-1} X_l h(X_l) \\ \sigma_c^2(T) = \frac{1}{P_c(T)} \sum_{X_l=T+1}^{L-1} [X_l - m_c(T)]^2 h(X_l). \end{cases}$$

$$J(\tau) = \min_{T} J(T).$$

Using the kittler-Illingworth (KI) Algorithm



Using the kittler-Illingworth (KI) Algorithm

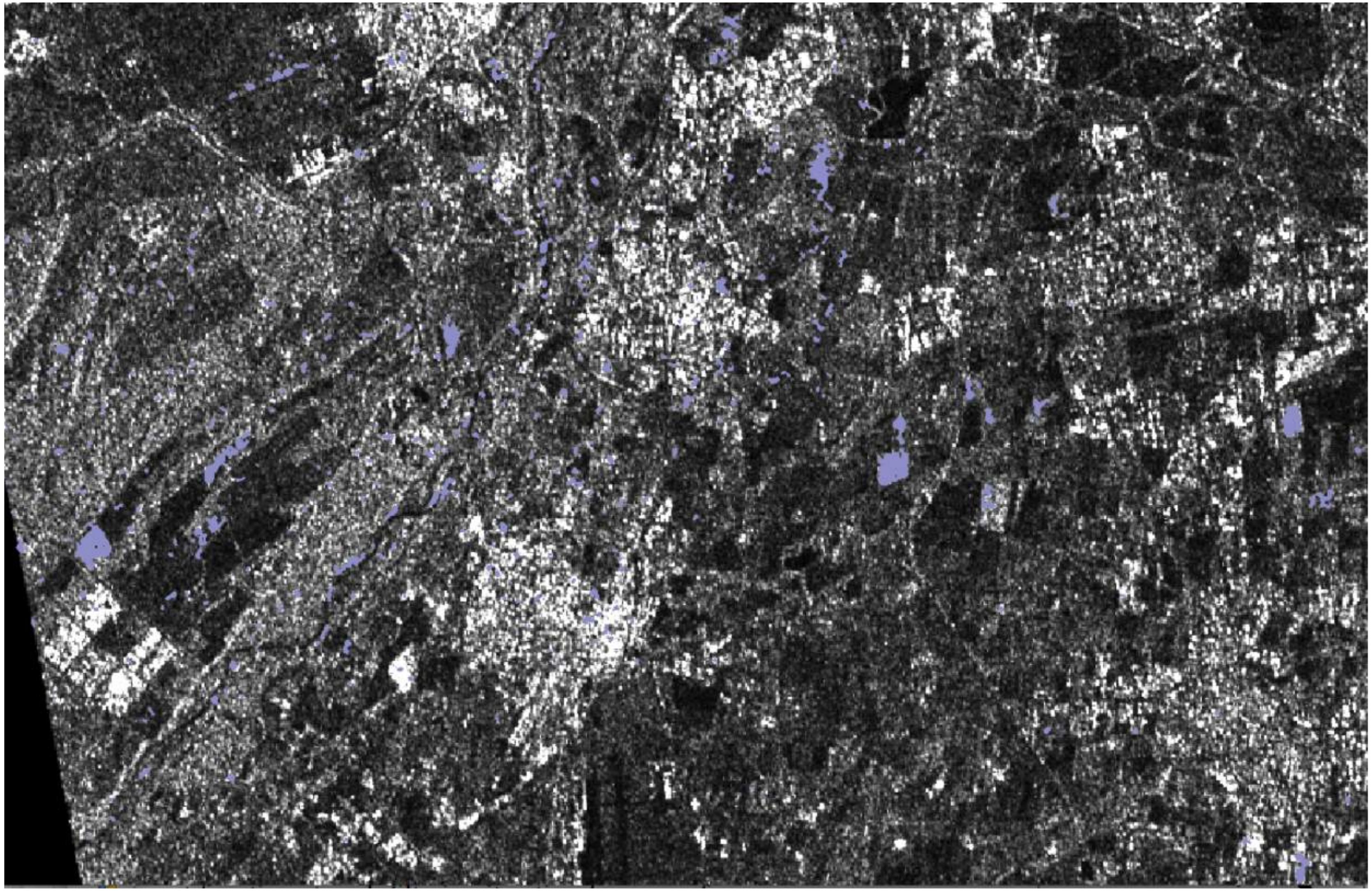


KI has been applied to overlapped patches

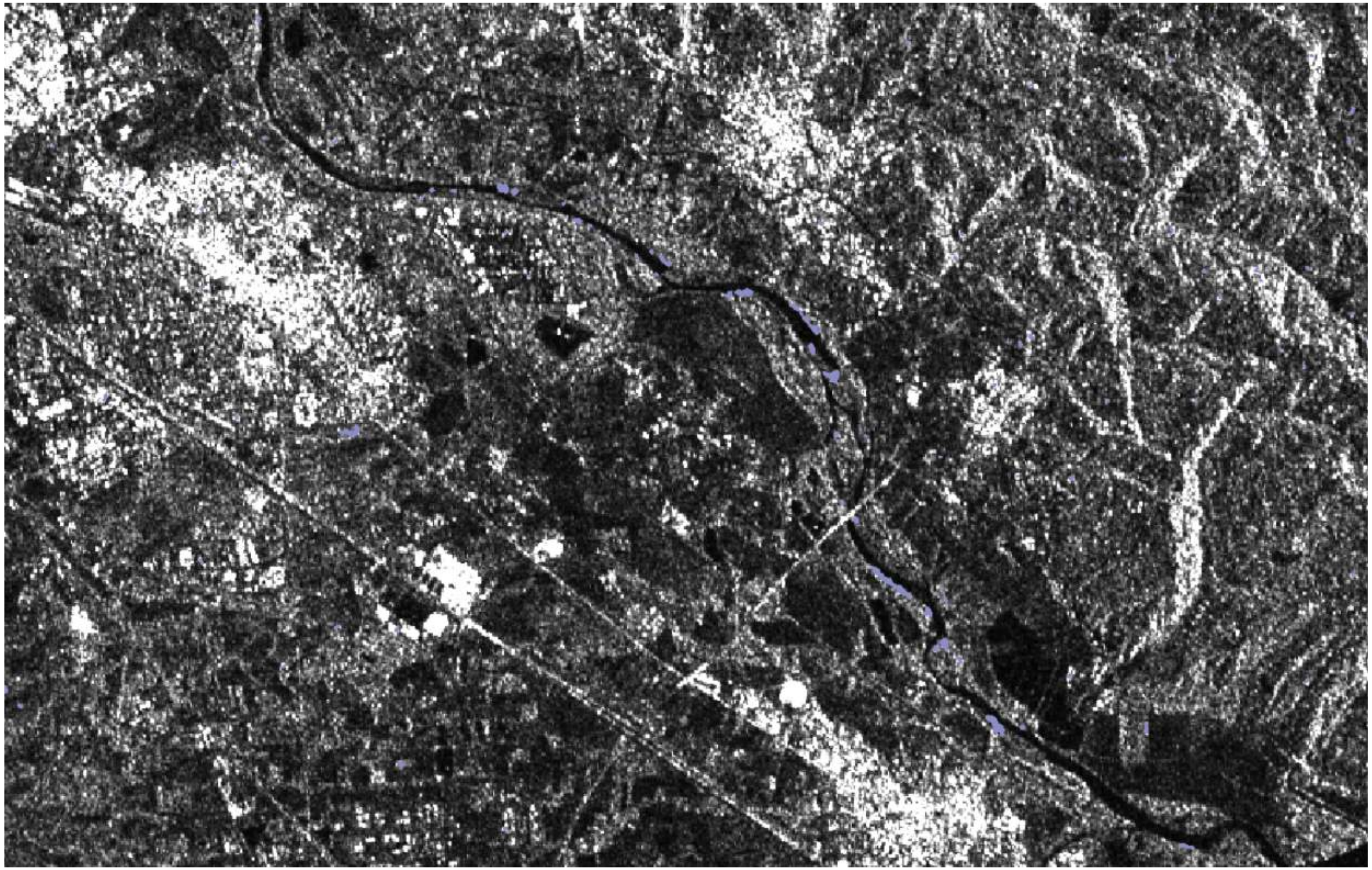
Only pixels that were classified
as changed in all patches
are shown in the following slides

Change Detection Map: Area 1

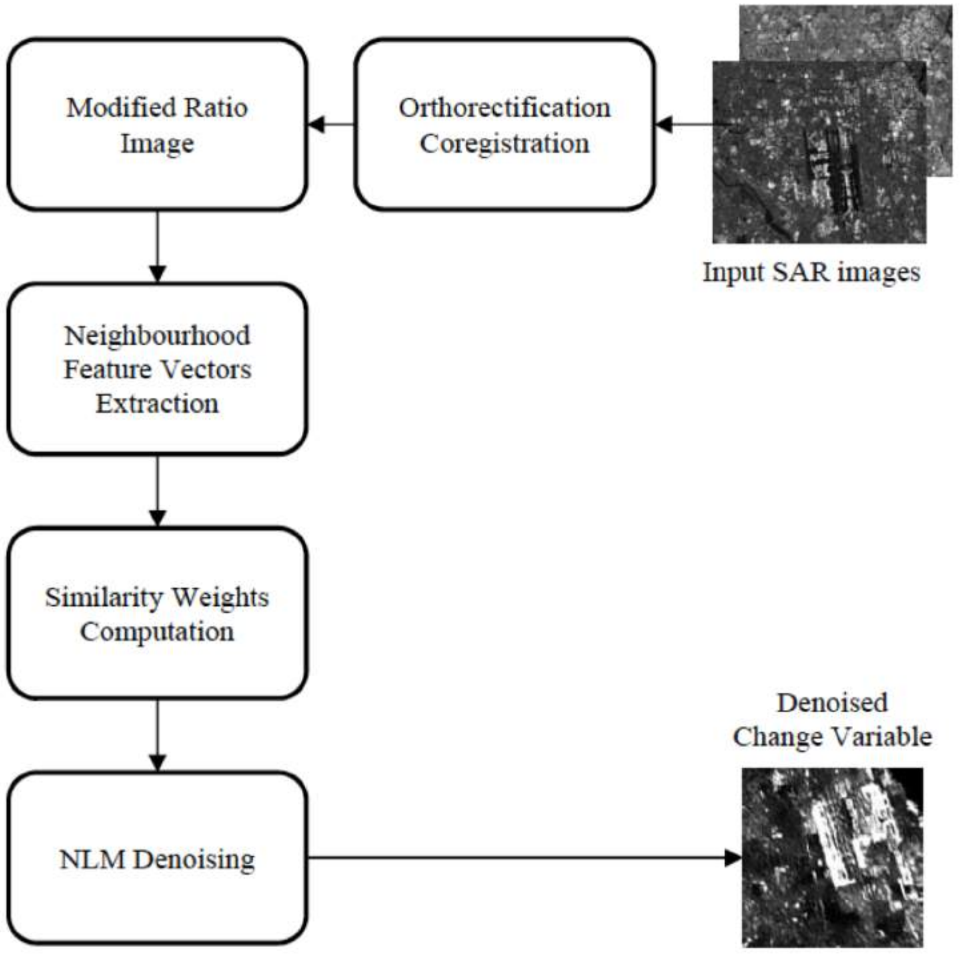
Change Detection Map: Area 2



Change Detection Map: Area 3



Next Step: Using Multi-Temporal SAR Images and Spatio-Temporal NLM Filters



Project Roadmap: IREA-CNR Contribution

- Historical ERS-ENVISAT Displacement Time-Series Products

- Napoli and Milan Time-Series are available. At time T0+24 (Turin), time T0+30 (Padua), Time T0+36 (Rome)

- Sentinel-1 DInSAR Time-Series on some selected cities

- Experimental Results on Change Detection in Urban Areas using Multi-Temporal SAR Images. Research Activity. Depending on the achieved results, they will be pubblished and presented.

- Developing and publishing papers on the calibration of multi-polarization SAR images is in progress