An Atmospherically Corrected DInSAR SBAS network and its Decomposition into a 3D Field Vector for tectonic deformation detection over the Hyblean Plateau, Italy

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Andreas Vollrath [1], David Bekaert [2], Alessandro Bonforte [3], Francesco Guglielmino [3], Andy Hooper [2], Salvatore Stramondo [4] & Francesco Zucca [1]

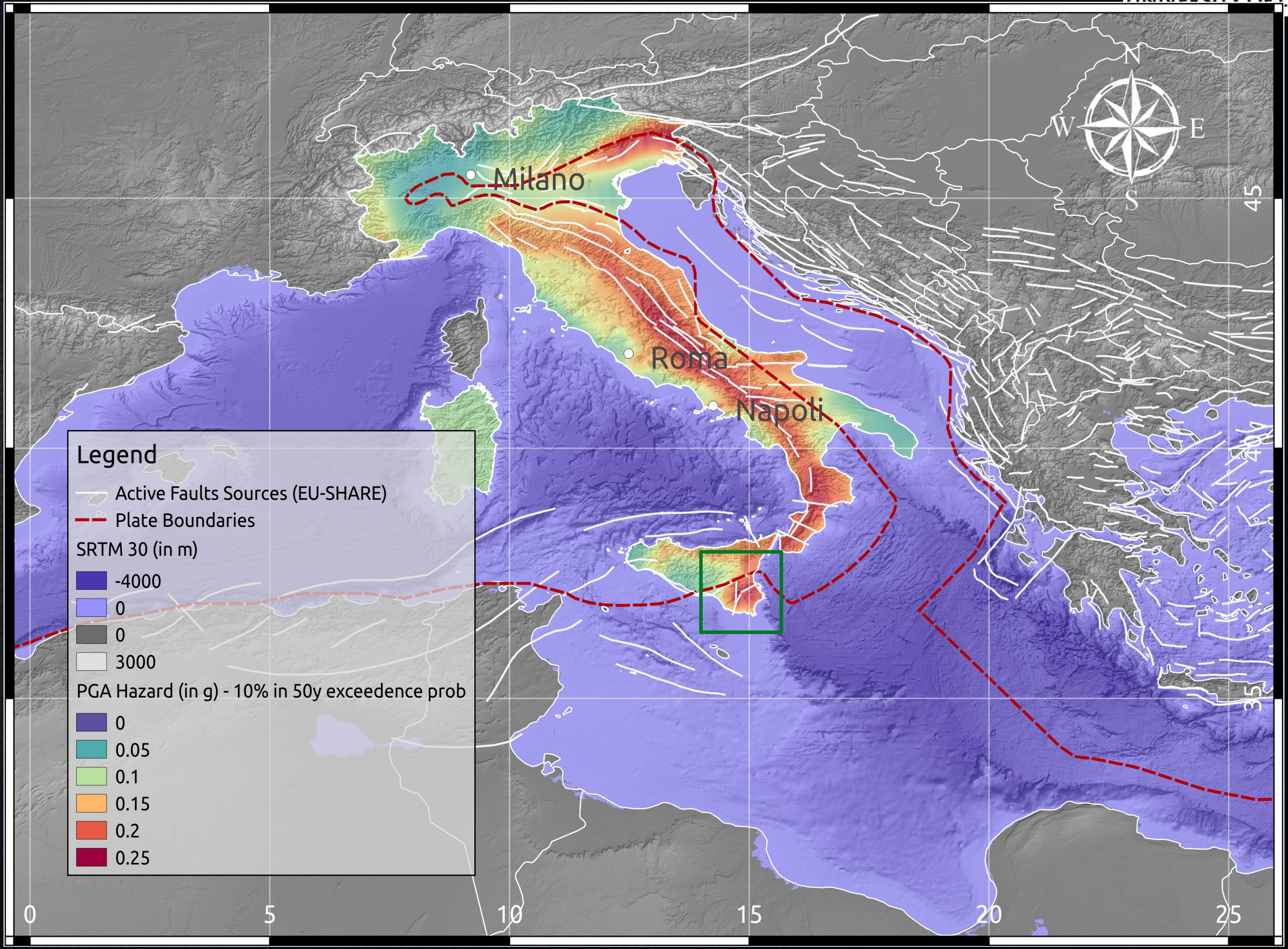
[1] University of Pavia, Dept. of Earth & Env. Science, Via Ferrata 1, 27100 Pavia, Italy
[2] University of Leeds,COMET, School of Earth and Environment, Leeds LS2 9JT, United Kingdom
[3] Istituto Nazionale di Geofisica e Vulcanologia INGV, Osservatorio Etneo, Piazza Roma 2, 95125 Catania, Italy
[4] Istituto Nazionale di Geofisica e Vulcanologia INGV, Via Vigna Murata 635, 00143 Roma, Italy

Outline

- Study Area
- Data & Methodology
- Results
- Conclusion & Outlook

Study Area

- South-east Sicily
- Hyblean Plateau, north Pelagian block of Nubia Plate
- Late-Miocene Orogenesis
- Maghrebian belt
- Highly Exposed to seismic hazard
- UNESCO Cultural heritage Sites, Oil Refineries



PGA Hazard Data taken from Montaldo & Meletti (2006): INGV-DPC

Study Area

„Within this area, Italy is the result of a complex geodynamic evolution and is now characterized by a set of different crustal blocks trapped ***between the Eurasian and African rigid plates*** *(Fig. 1),whose* ***kinematic and lateral variation in thickness and rheological parameters****, make the convergence zone* ***fragmented and irregularly shaped****."* (Angelica et al., 2013)

„ [...] However, the way the observed internal deformation of Sicily is presently accommodated by faults and the number of faults that may take up this deformation is ***unclear****. Improved understanding of the* ***regional block kinematics*** *and* ***strain accumulation*** *rates across faults is important for the evaluation of the* ***seismic hazard*** *of the region, which is among the highest in the mediterrenean."* (Ventura et al., 2014)

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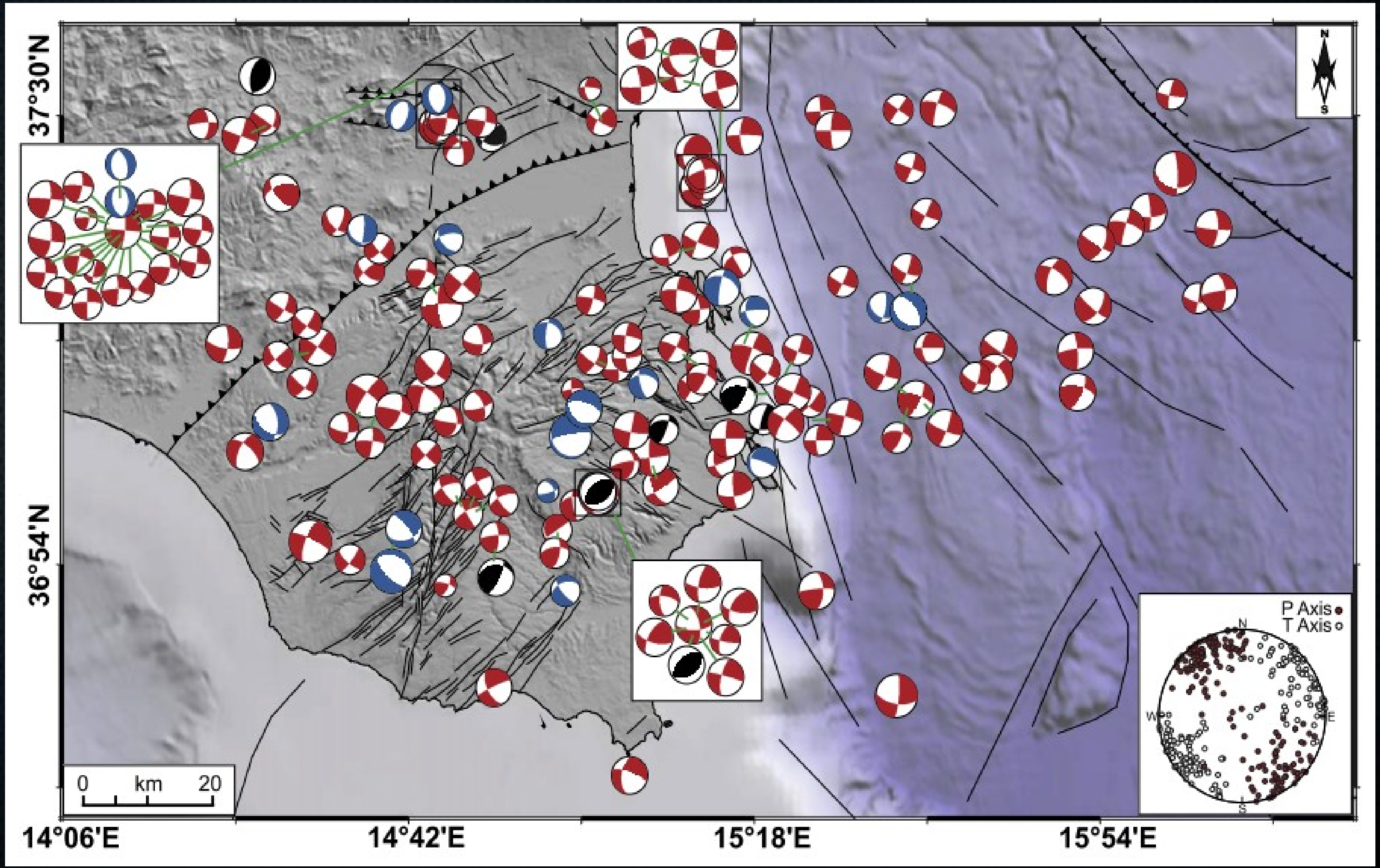
Study Area

- Major historical EQs (1169, 1542, 1693)
  - Controversial scientific opinions
  - Mostly strike-slip faulting
  - Recent EQ activity only of small magnitude earthquake



Taken from: Musumeci et al. 2014

Study Area

- Tectonic signal of deformation overlaid by:
  - Subsidence:
    - Water pumping (Canova et al. 2012, Carloni 2011)
    - Karst (Di Maggio et al. 2012)
    - (Sea wedging – seasonal)
  - Strong turbulent atmosphere due to nearby sea

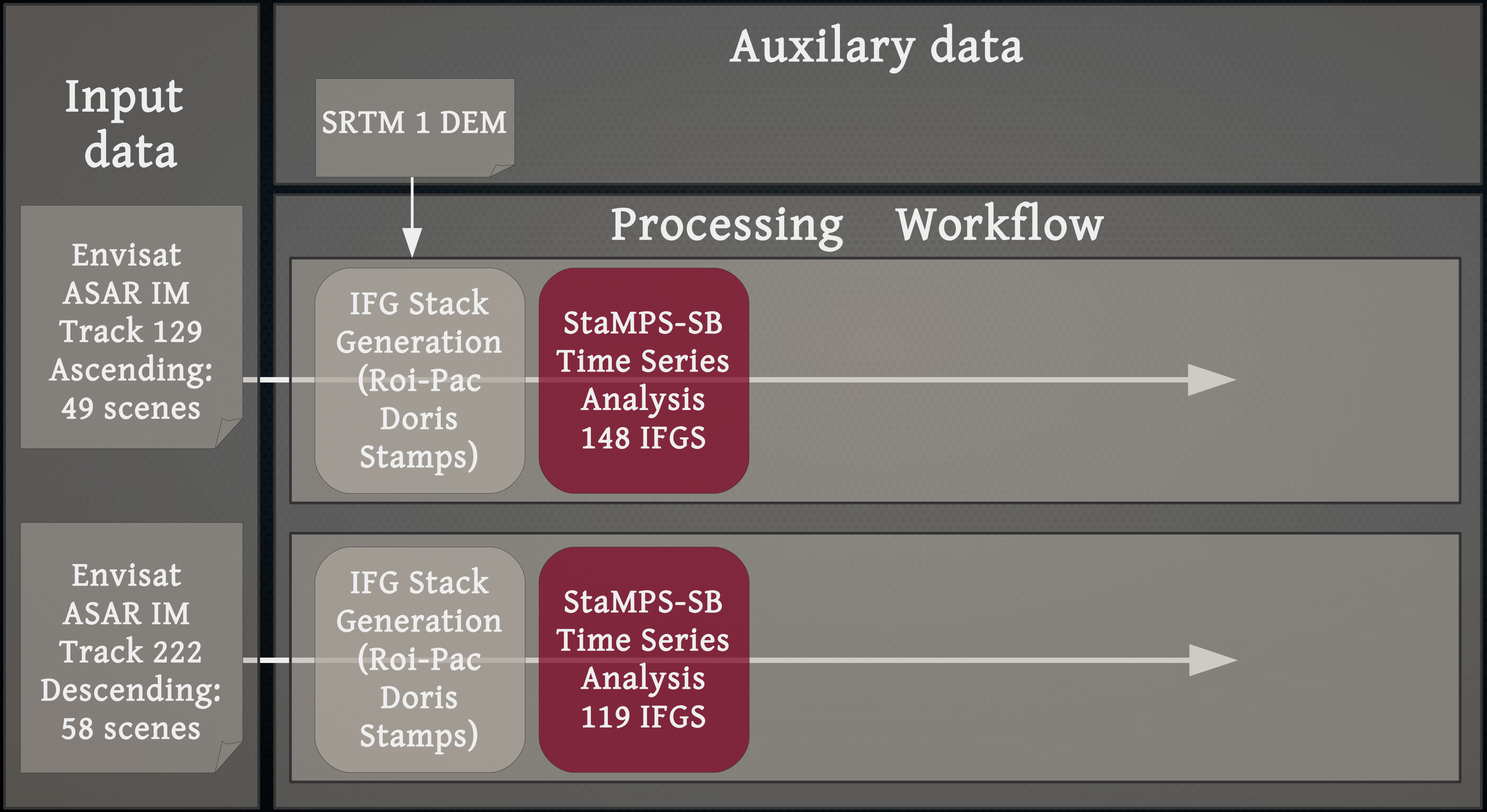
Data & Methodology

Input data

Envisat ASAR IM Track 129 Ascending: 49 scenes

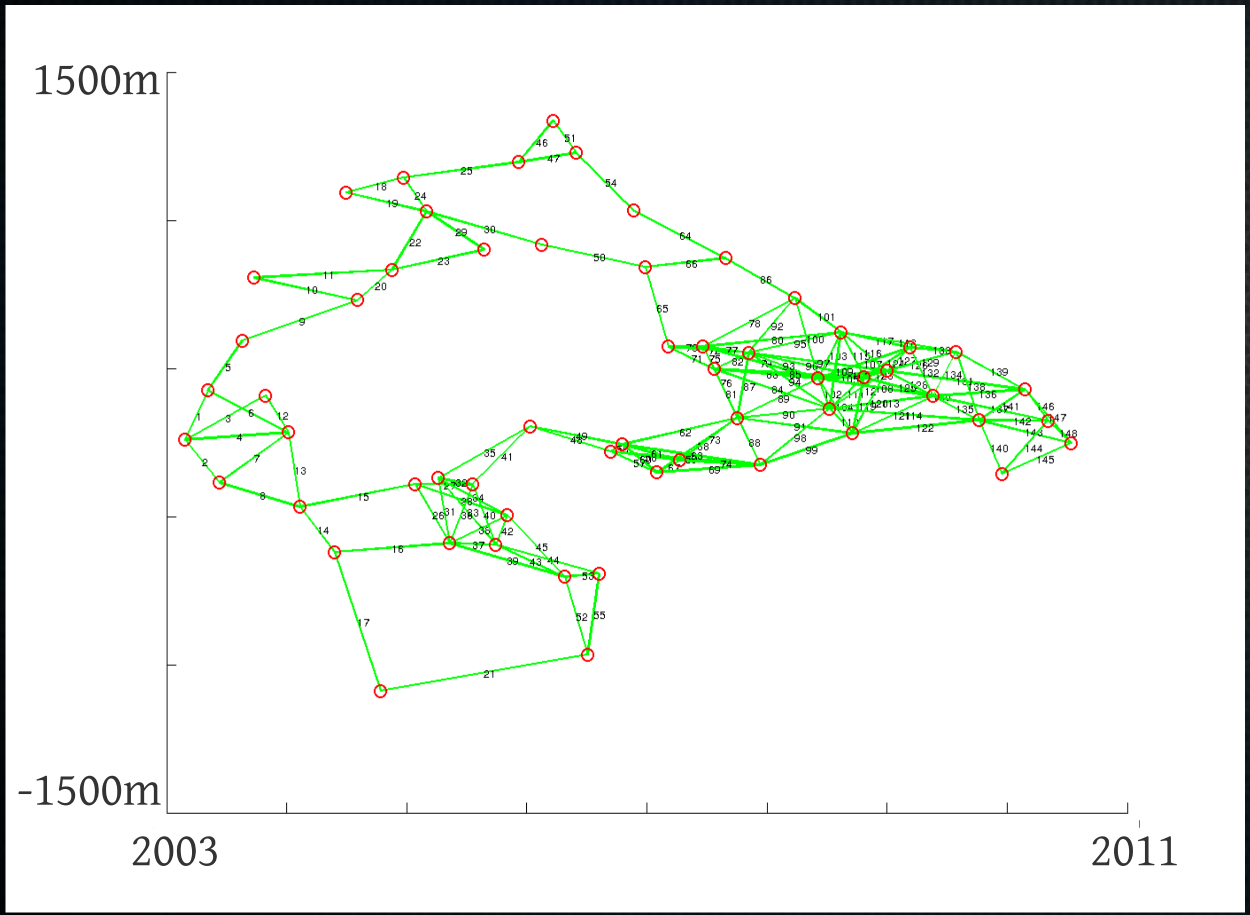
Envisat ASAR IM Track 222 Descending: 58 scenes

Data & Methodology

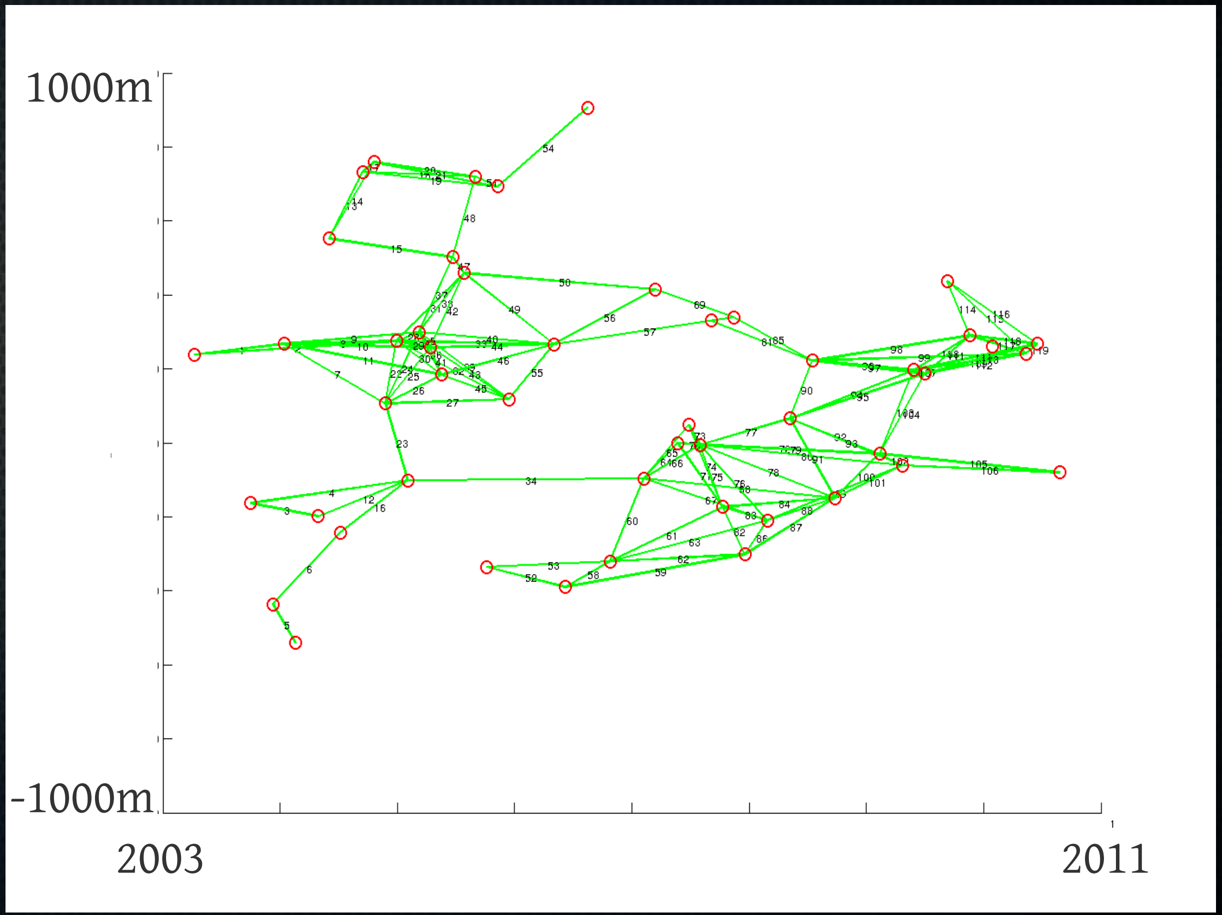


Data & Methodology

Track 129 (49 scenes): Ascending



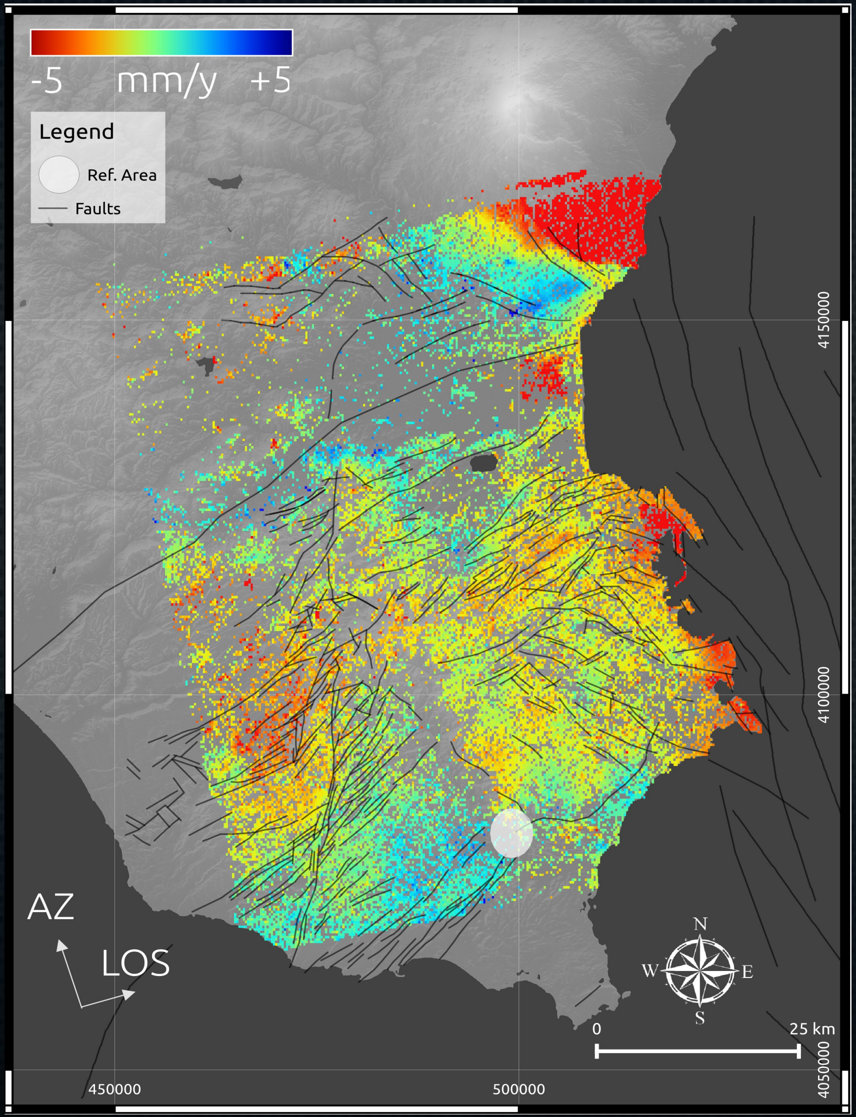
Track 222 (58 scenes): Descending

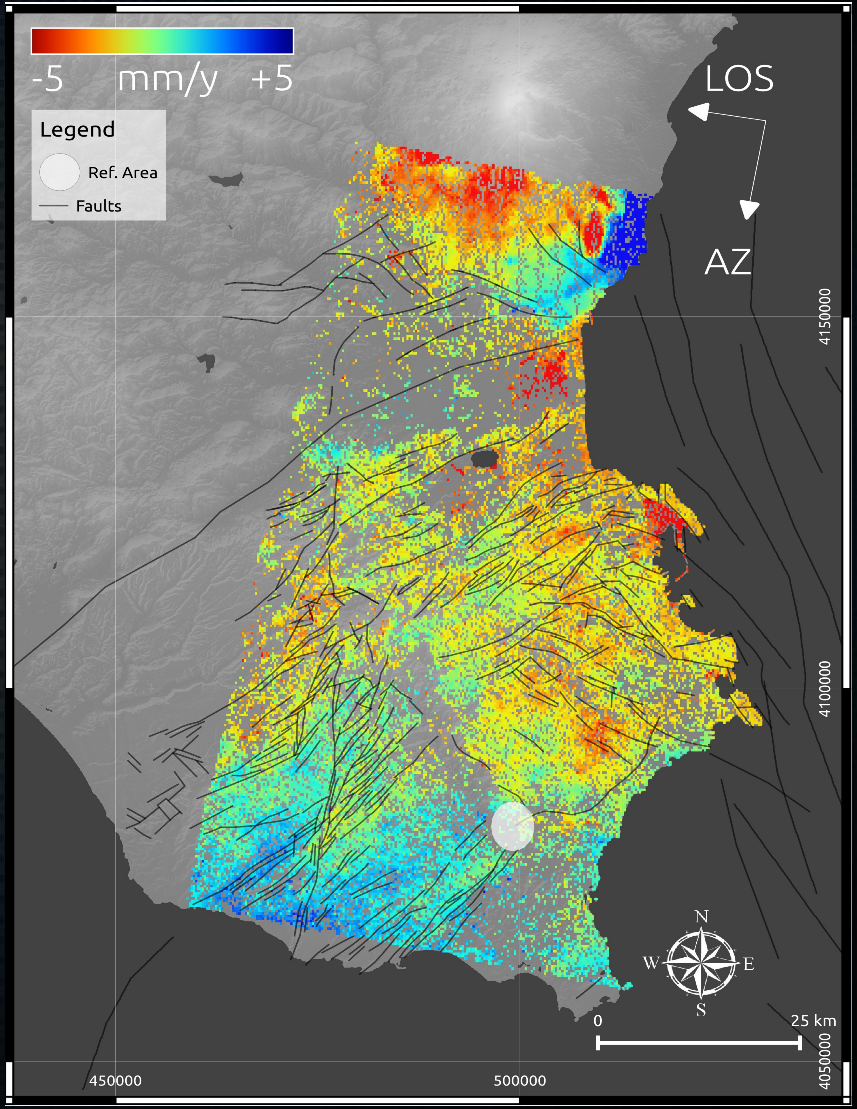


Data & Methodology

- In accordance with:
  - Dynamics of Etna (Bonforte et al. 2011, Froger 2001)
  - Subsidence Area of Augusta (Canova et al. 2012)
  - Industrial area south of Catania

Small tectonic deformation obscured by spatio-temporal filtering?





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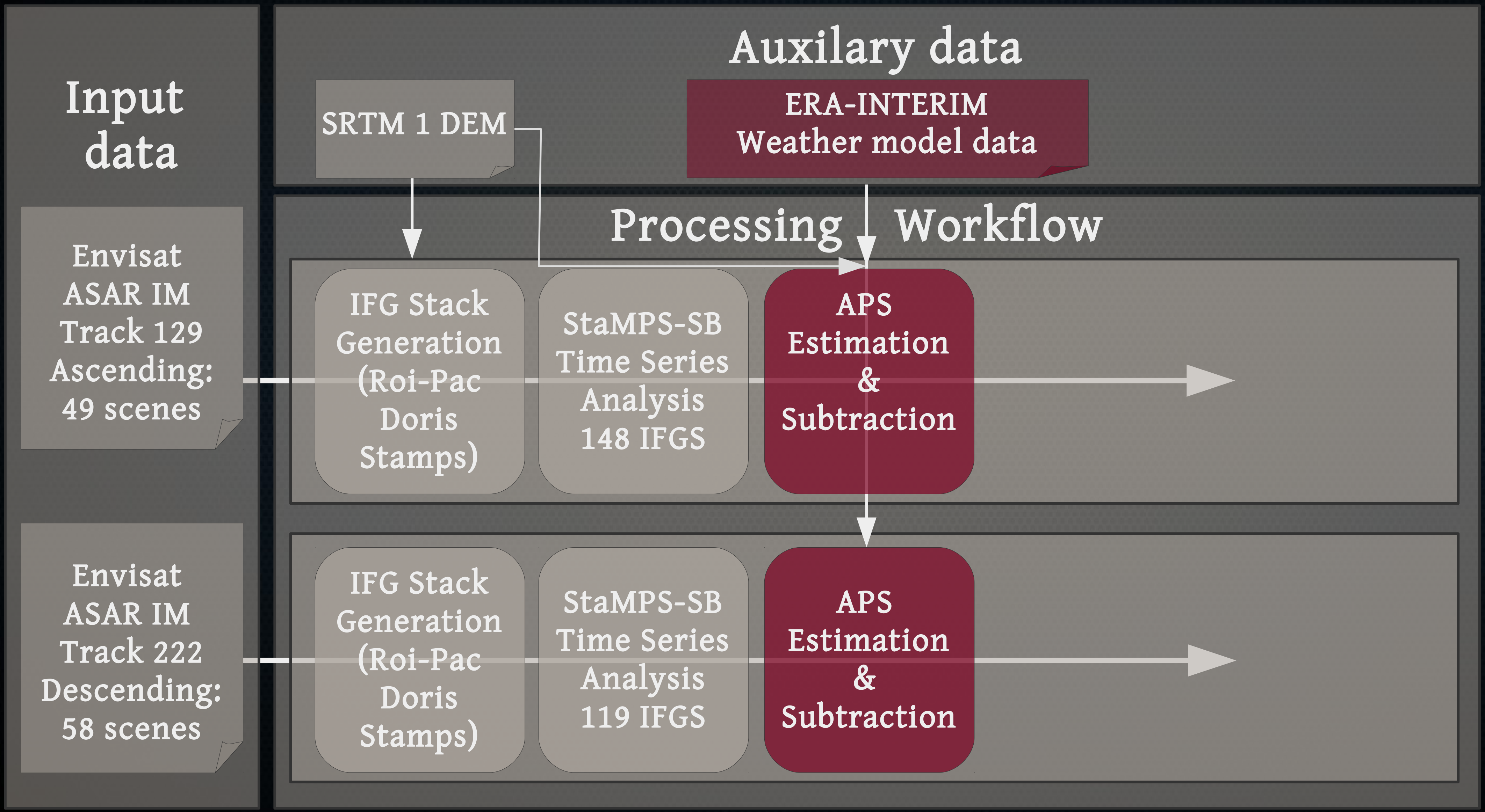

Data & Methodology

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- ERA-INTERIM atmospheric correction (Doin et al., 2009):
  - Part of TRAIN toolbox (Toolbox for Reducing Atmospheric InSAR Noise)
  - Bekaert et al., 2015 & *http://davidbekaert.com/#links*
  - Tropospheric delay maps calculated
  - refractivity along radar wave travel path
  - Based on: Temperature, pressure, water vapour
  - Ideally removes topography-correlated atmosphere signal
    - Temporally (seasonality)
    - Spatially (topography)

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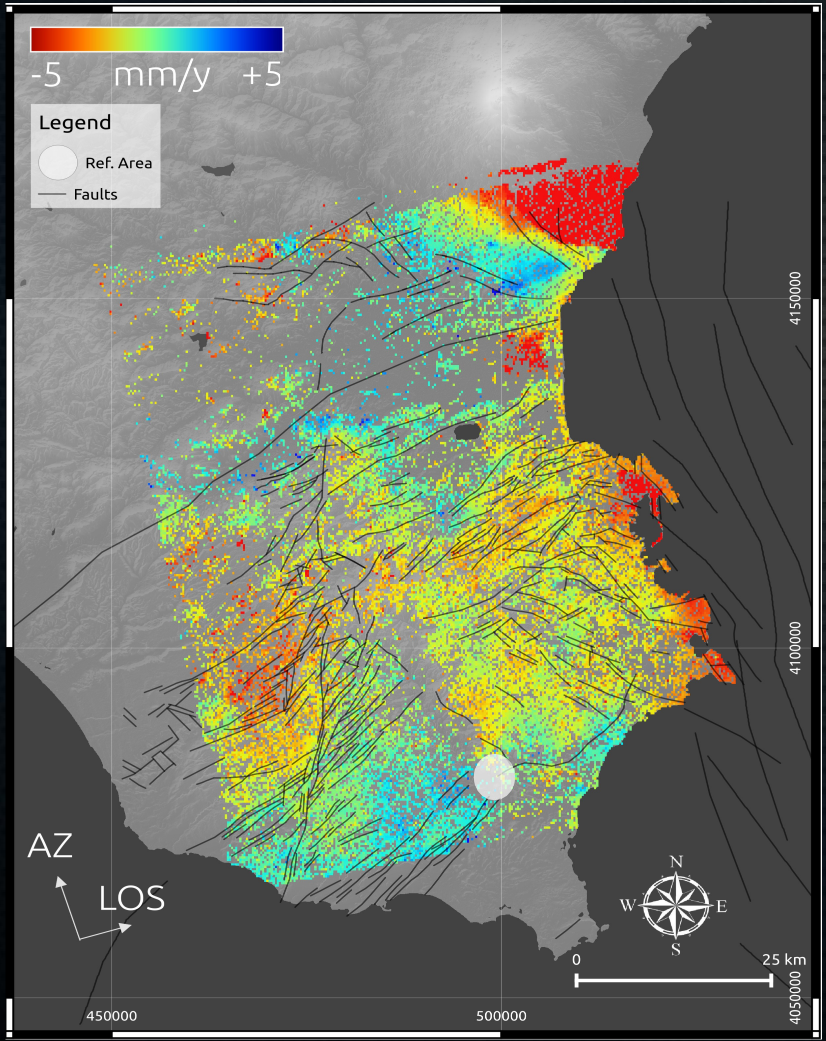
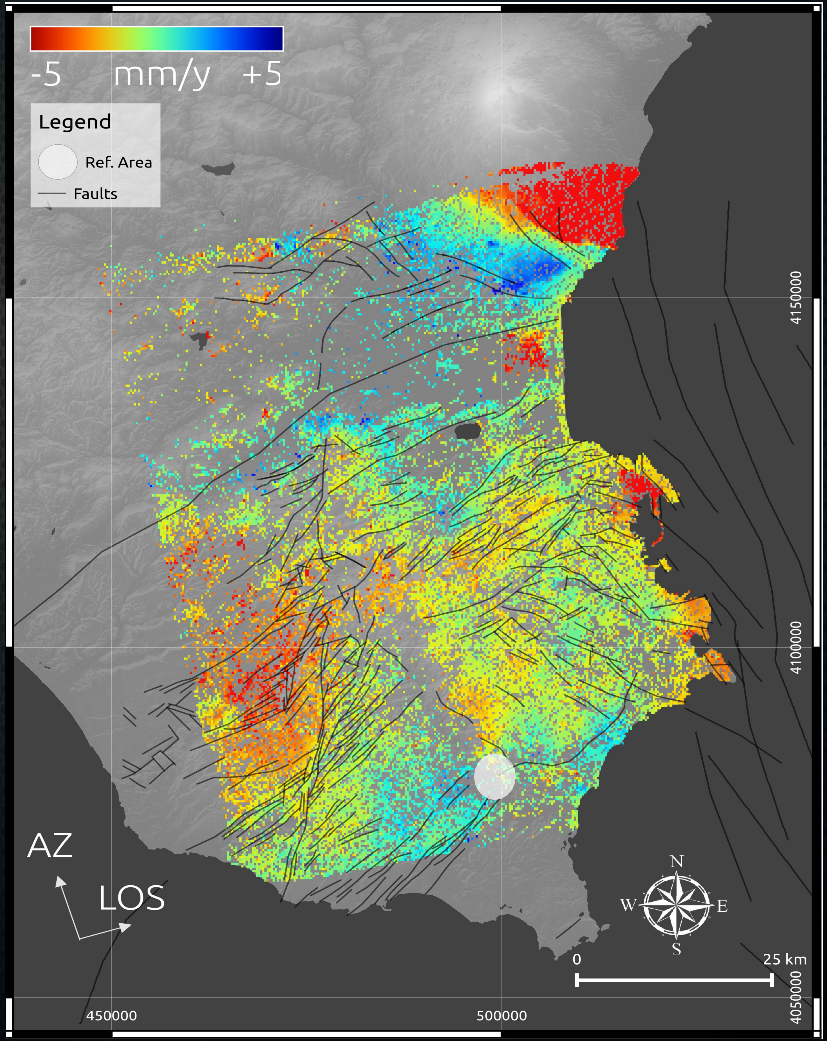
Results

Mean Velocity in LOS

Raw Stack

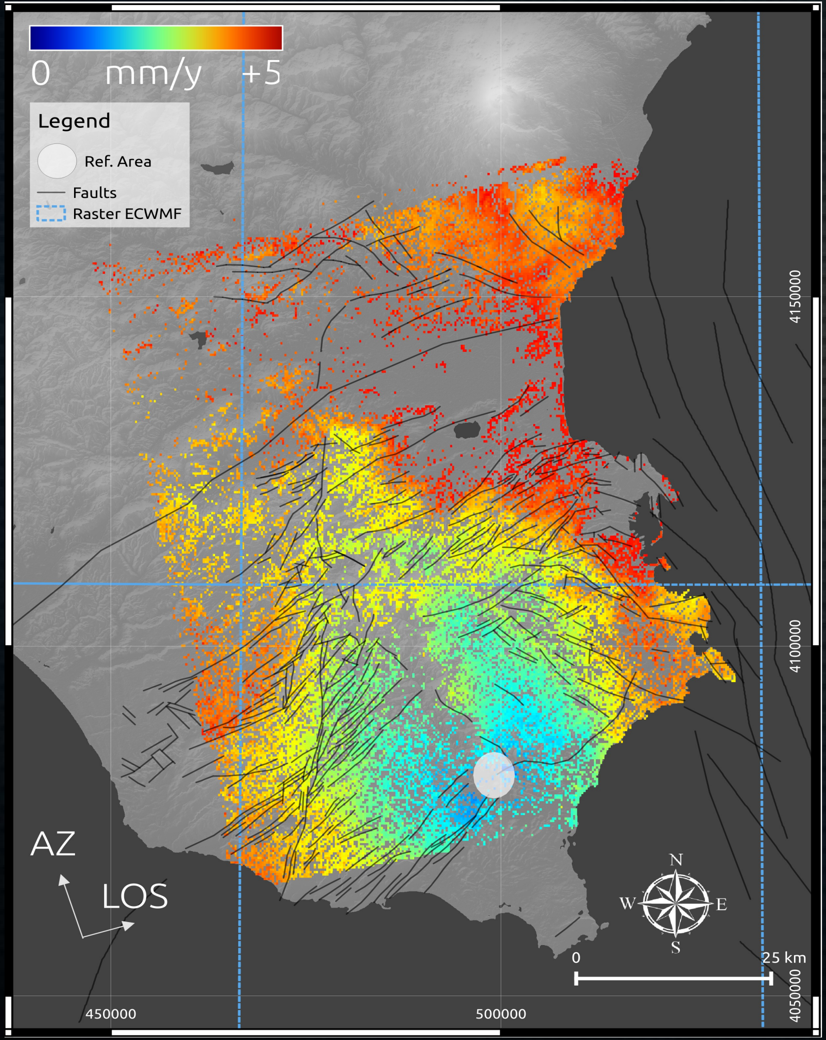


Raw Stack - APS



Results
Standard Deviations

Raw Stack



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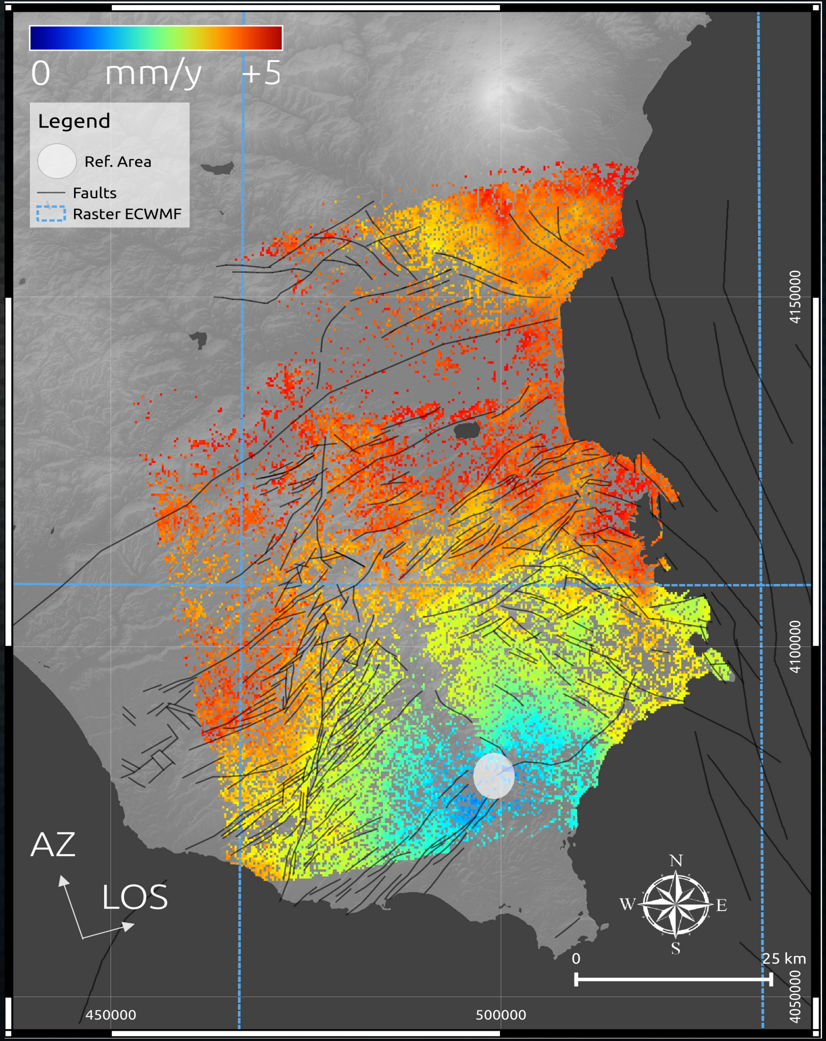

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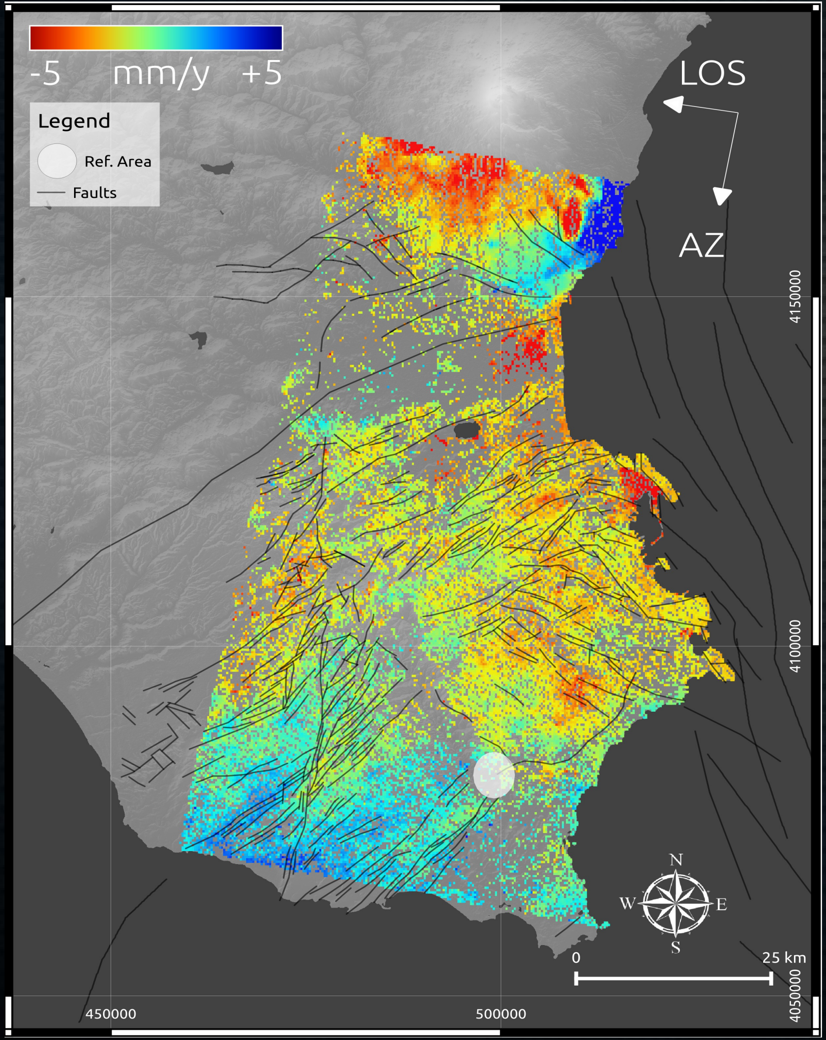

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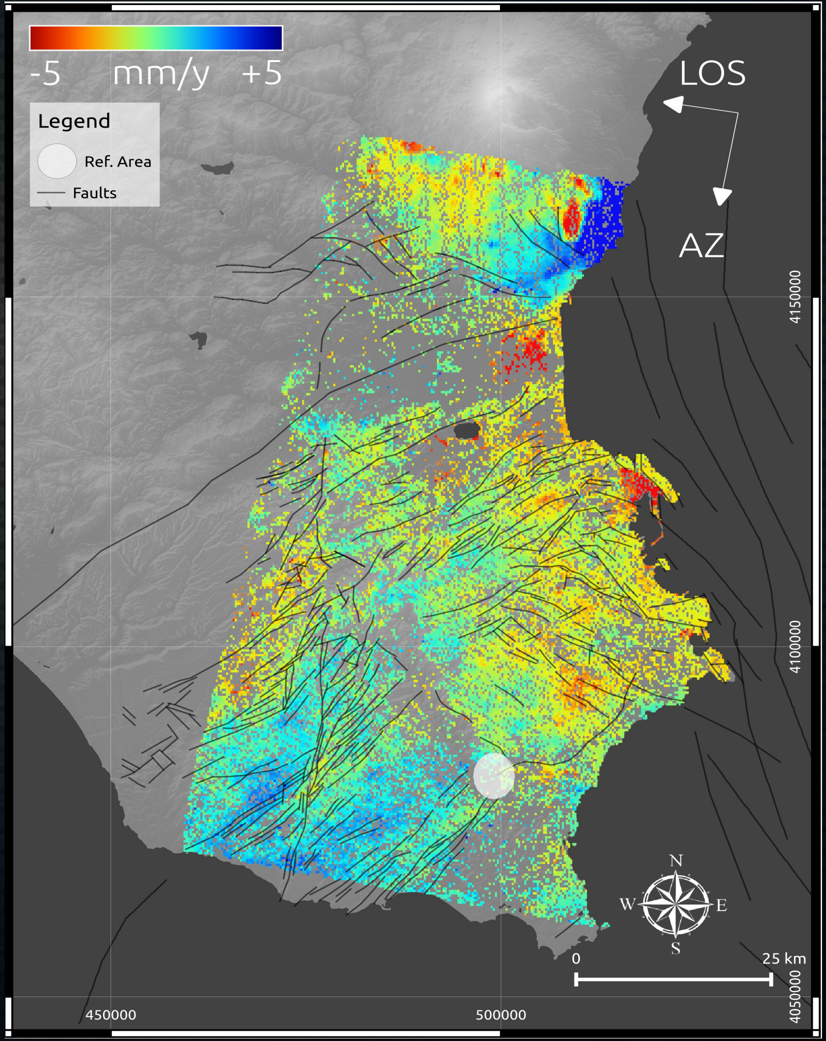

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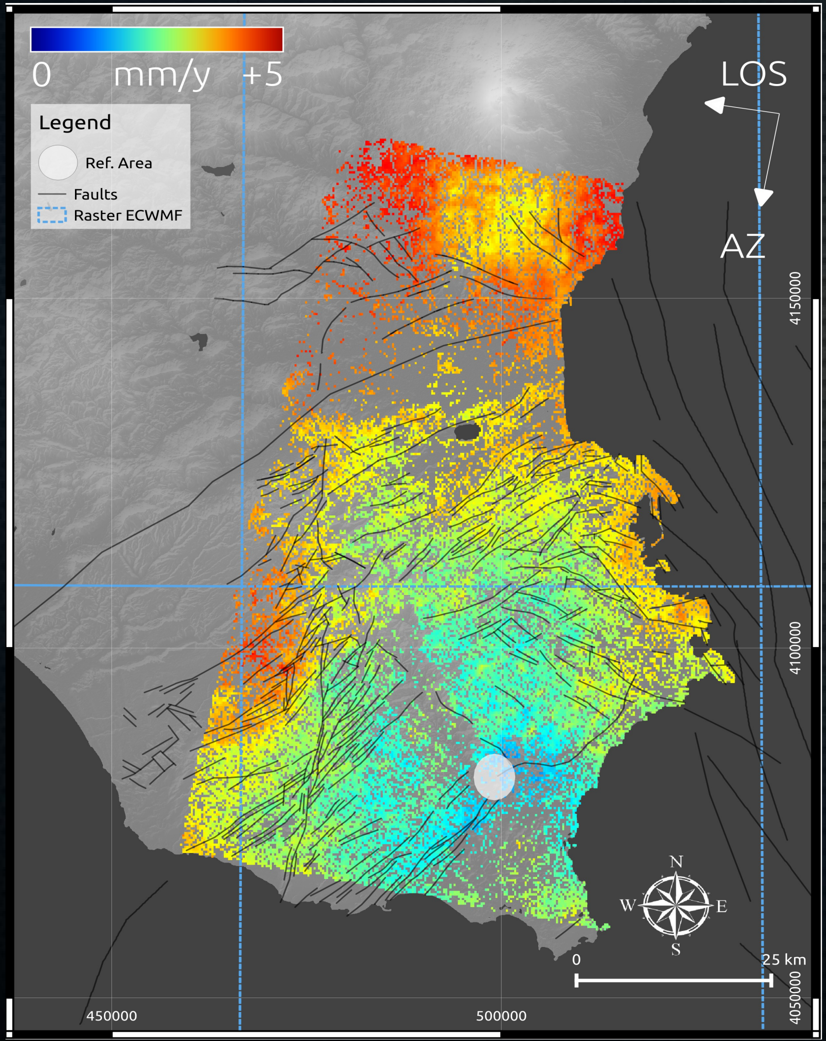

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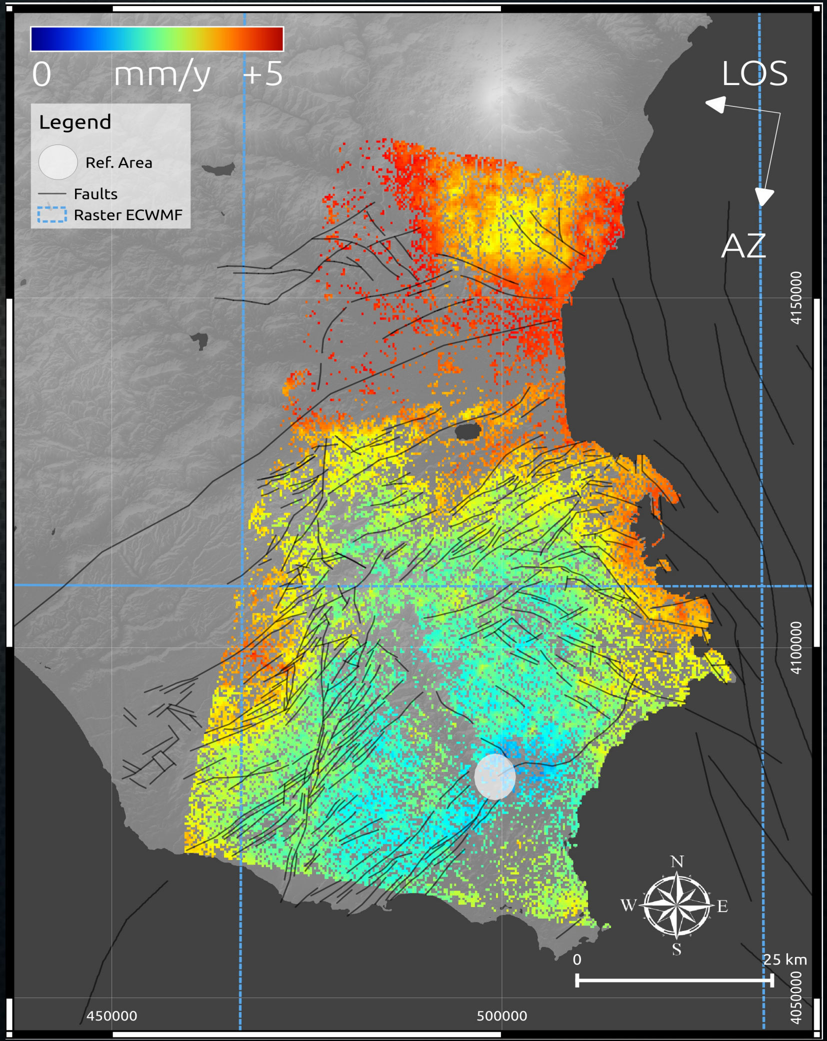

Data & Methodology

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Auxilary data

SRTM 1 DEM

ERA-INTERIM
Weather model data

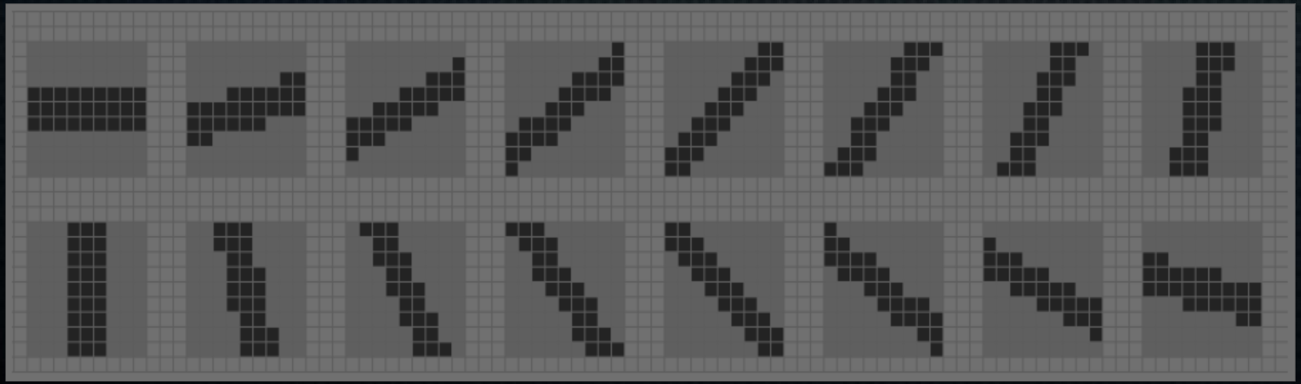
Processing Workflow

IFG Stack Generation (Roi-Pac Doris Stamps) → StaMPS-SB Time Series Analysis 148 IFGS → APS Estimation & Subtraction → Filtering of Mean LOS Velocity

IFG Stack Generation (Roi-Pac Doris Stamps) → StaMPS-SB Time Series Analysis 119 IFGS → APS Estimation & Subtraction → Filtering of Mean LOS Velocity

Data & Methodology

- Spatial Enhancement (SAGA GIS):
  - Closing gaps (Spline Interpolation; < 100 Pixels)
  - Multi-directional local-statistics Lee Filter (Lee, 1998)
    - Preserves degrees and ditches
    - Calculates the variance in 16 different directions
    - Local mean filters for the area with the lowest variance
    - Original values remain for high variance areas



Taken from:
Selige et al. 2006

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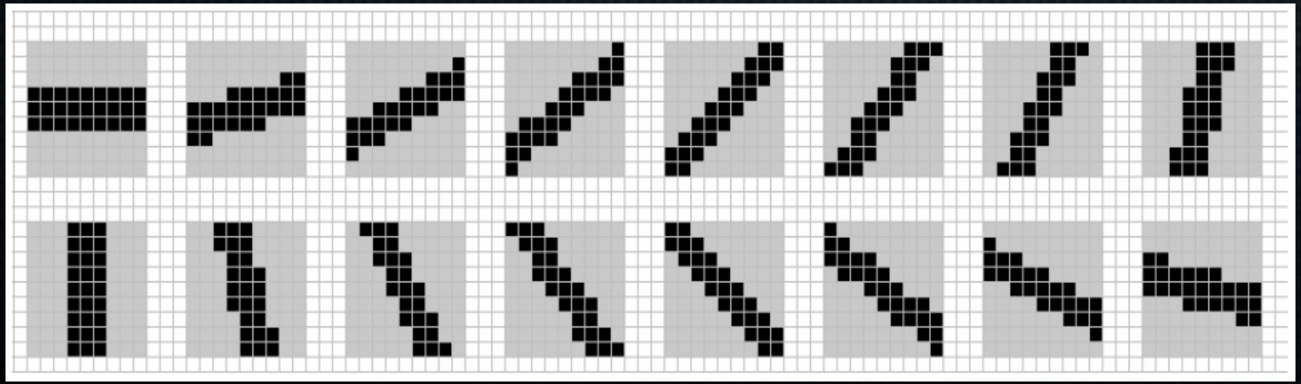

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Results

Spatial Enhancement

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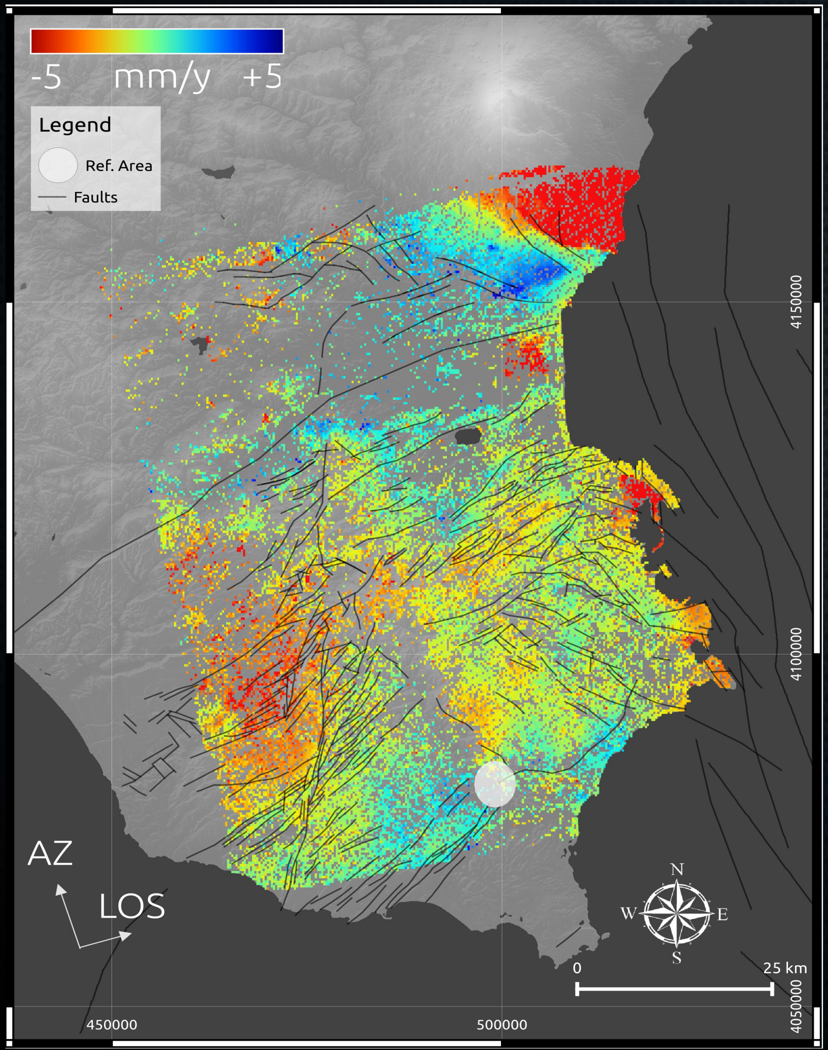
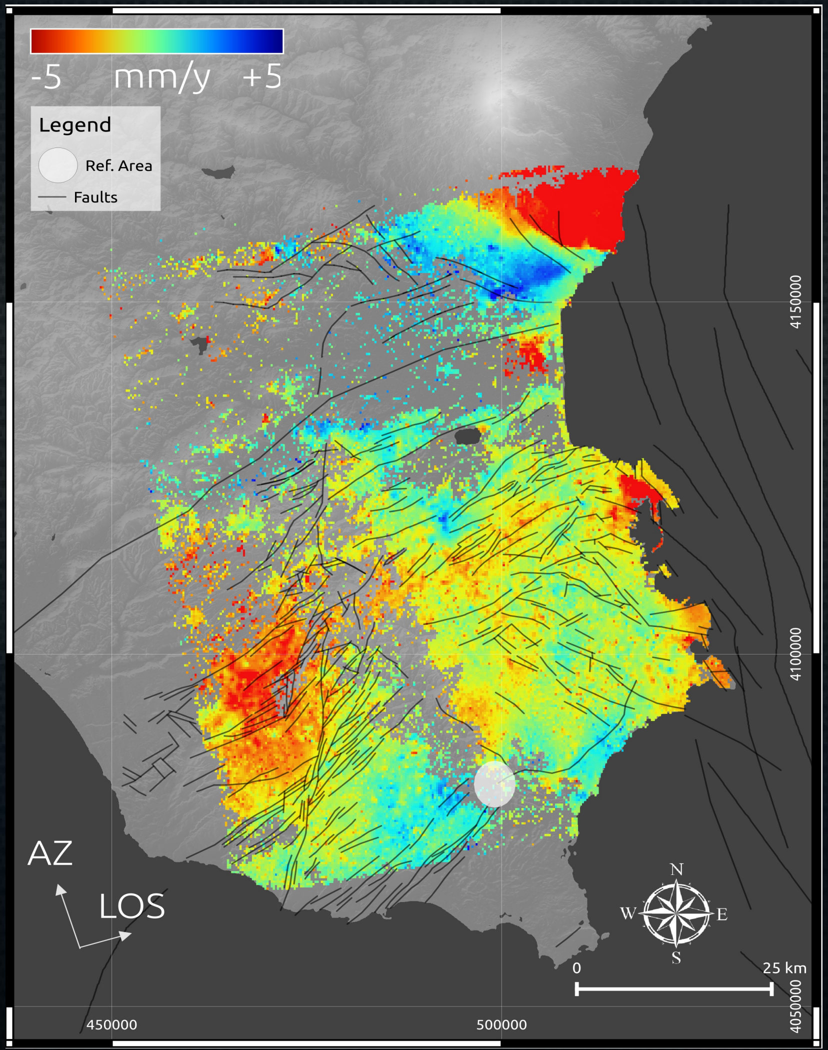
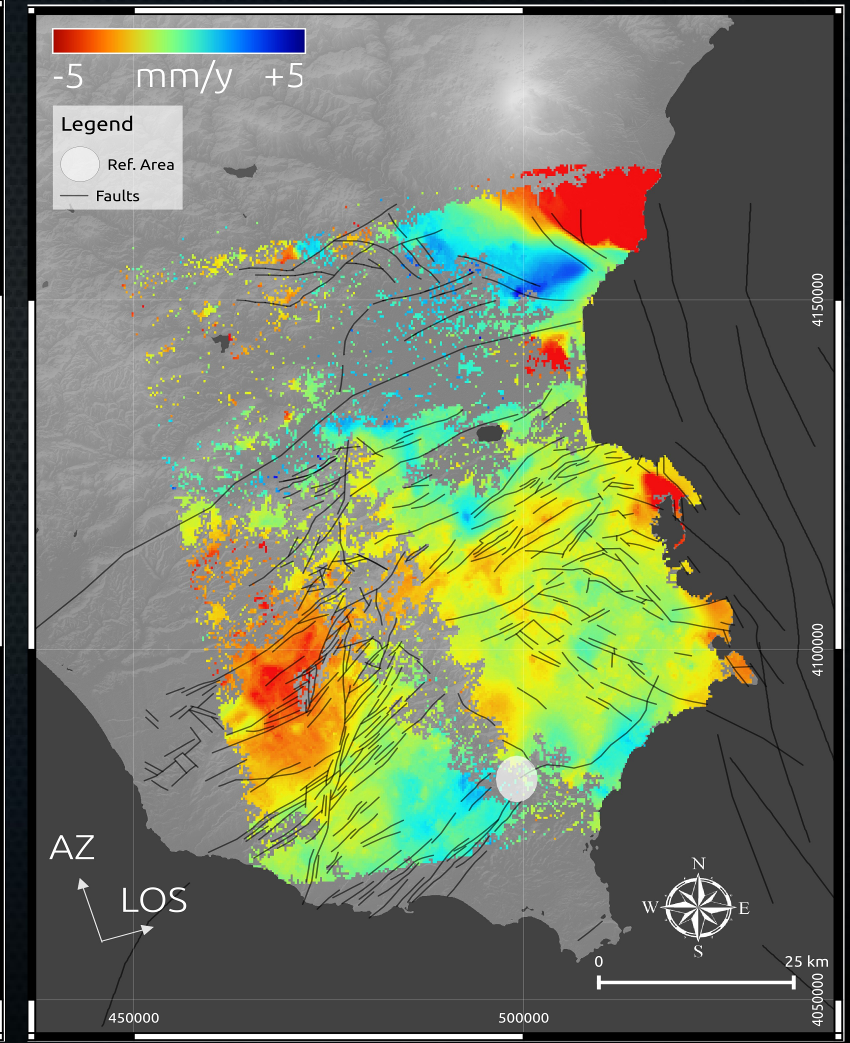


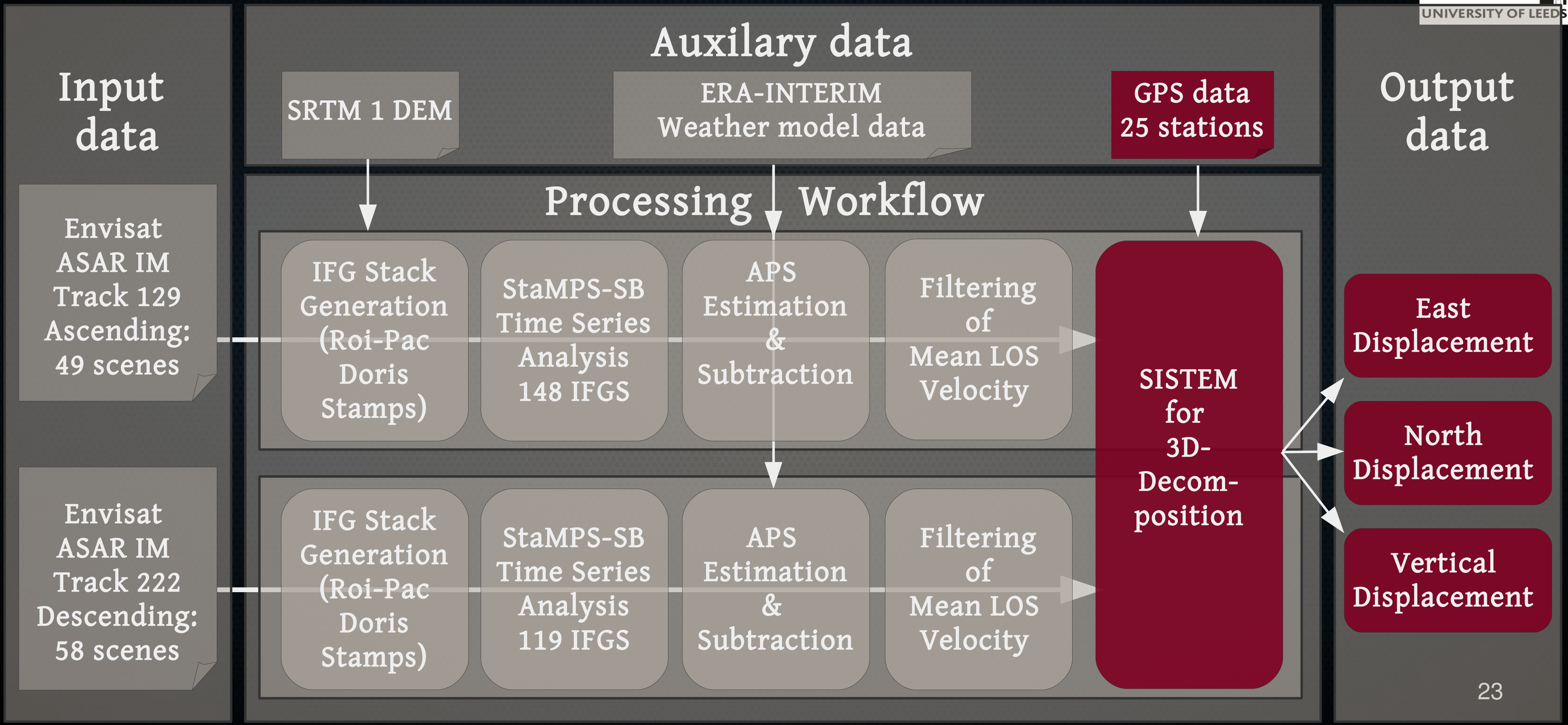
Closed Gaps



Multi-Directional Filtered



Data & Methodology



Data & Methodology

- SISTEM:
  - Simultaneous and Integrated Strain Tensor Estimation From Geodetic and Satellite Deformation Measurements (Guglielmino et al., 2011)
  - Simultaneous:
    - Based on elastic theory
    - No preliminary interpolation of sparse GPS necessary
  - Integrated:
    - GPS, multiple DInSAR, Levelling, tilt measurements
  - Output:
    - 3D-Displacement field
    - Strain Tensor, Rigid Body Rotation Tensor
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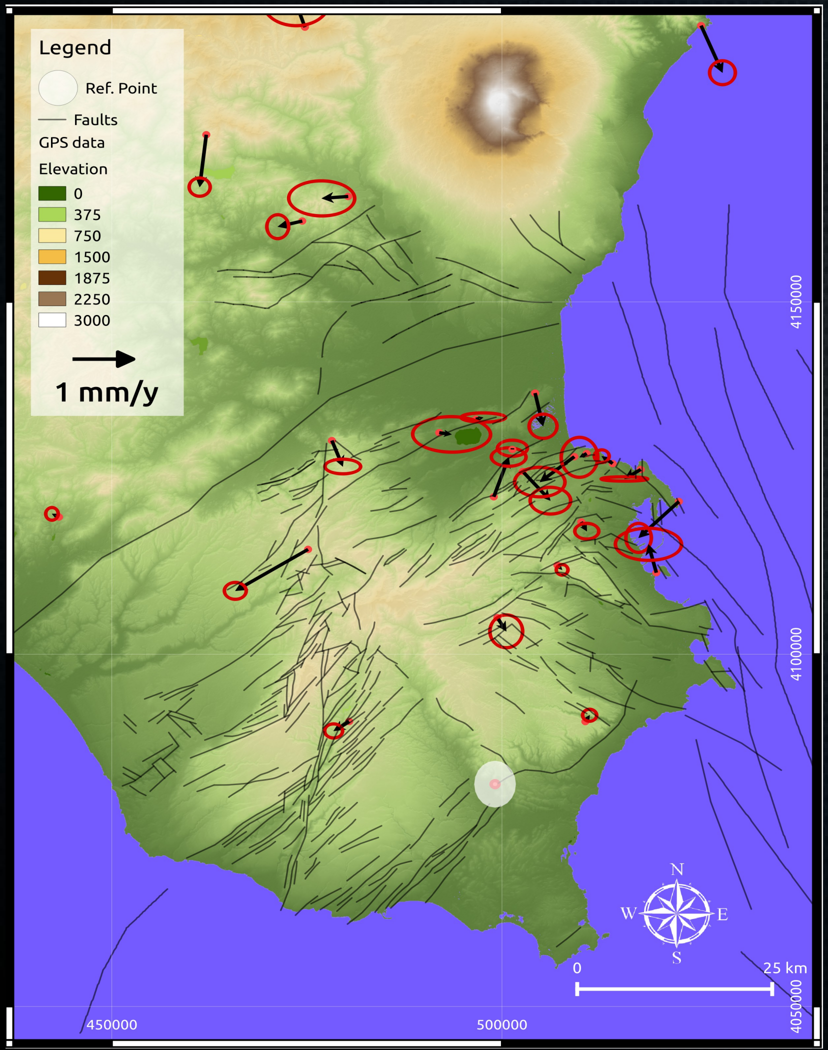
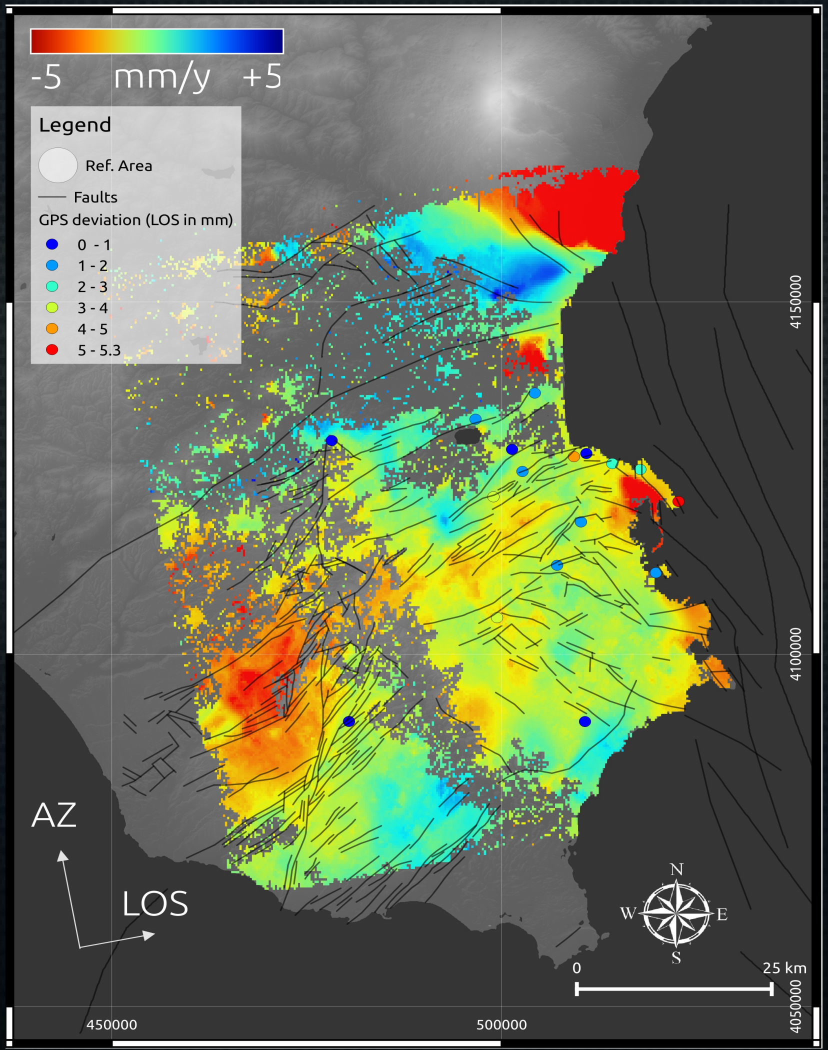
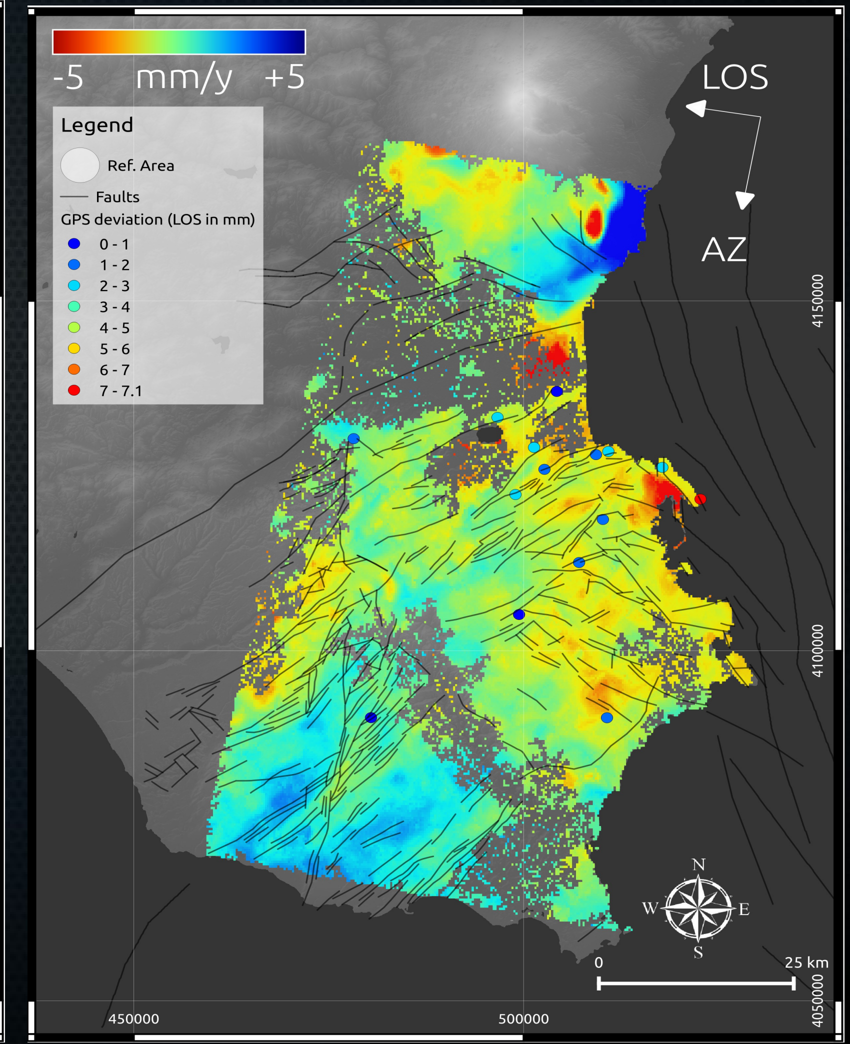
SISTEM input. - GPS



SISTEM input – Asc.

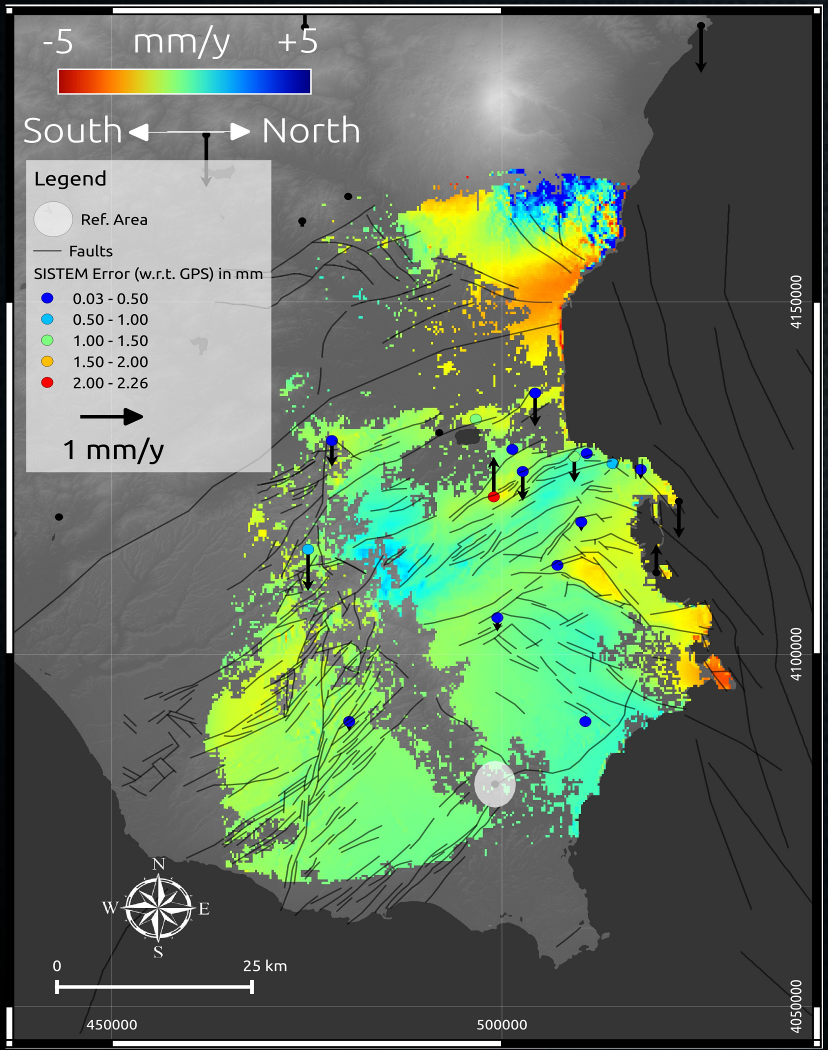


SISTEM input – Dsc.

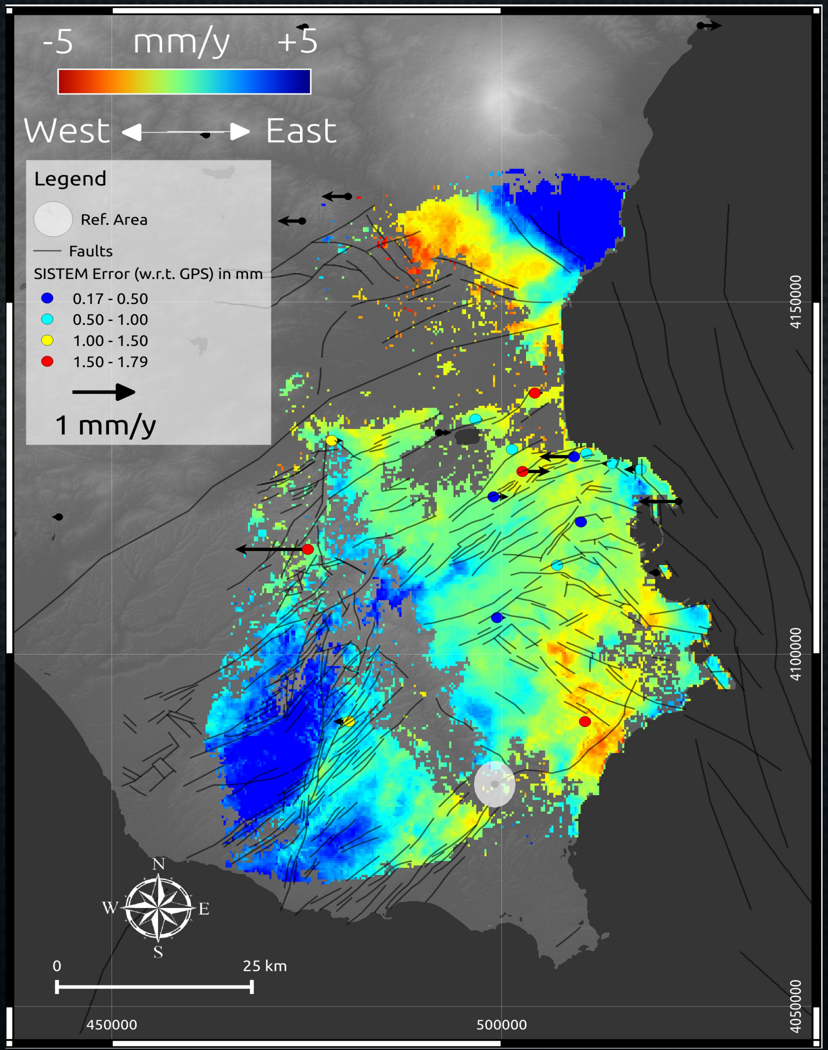


Results

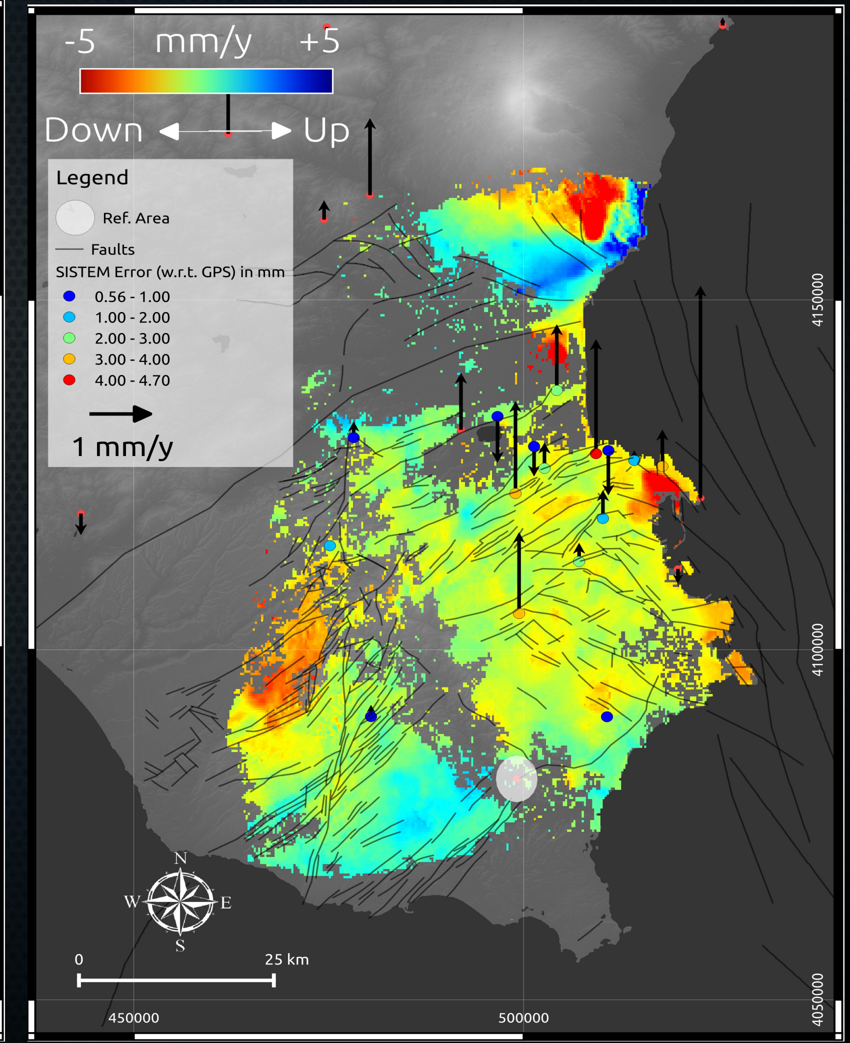
SISTEM vel. - north



SISTEM vel. - east

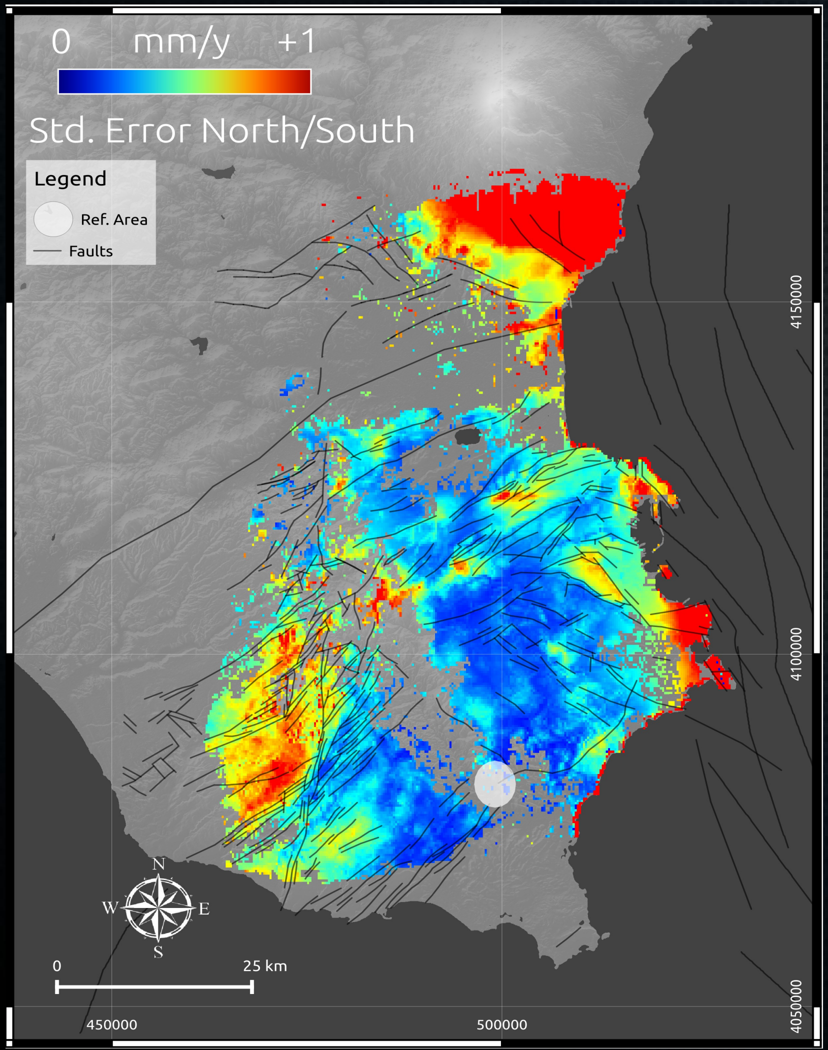


SISTEM vel. - Up

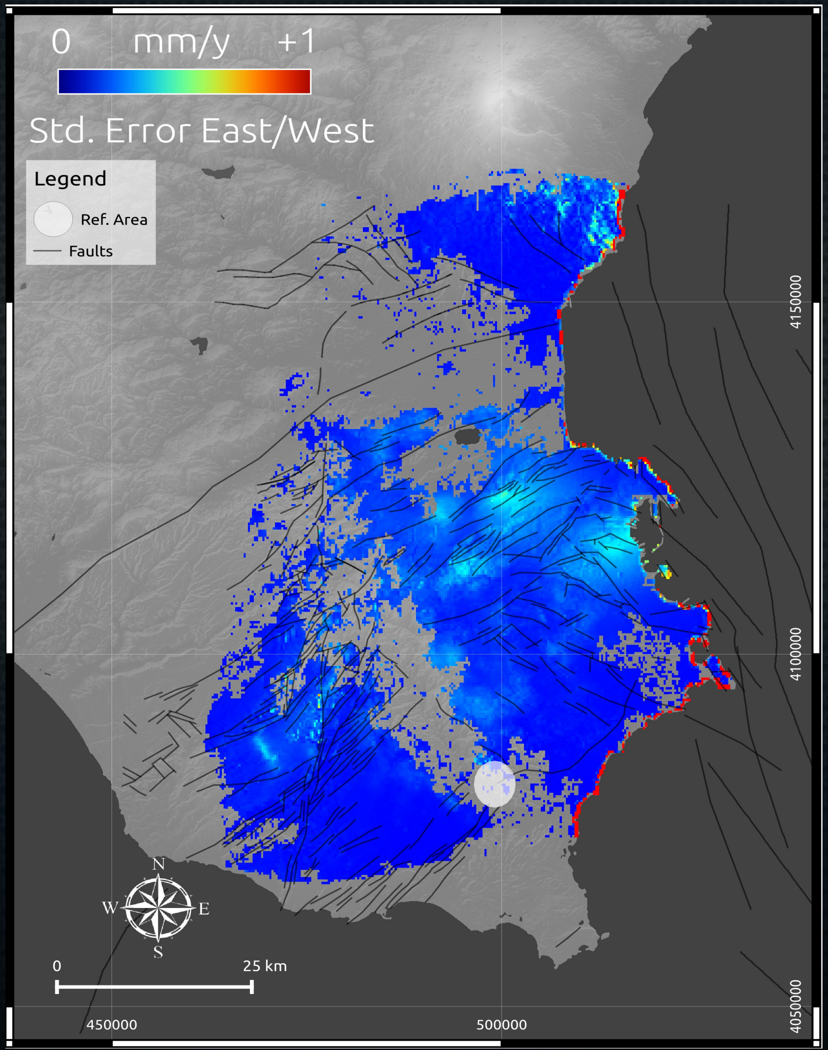


Results

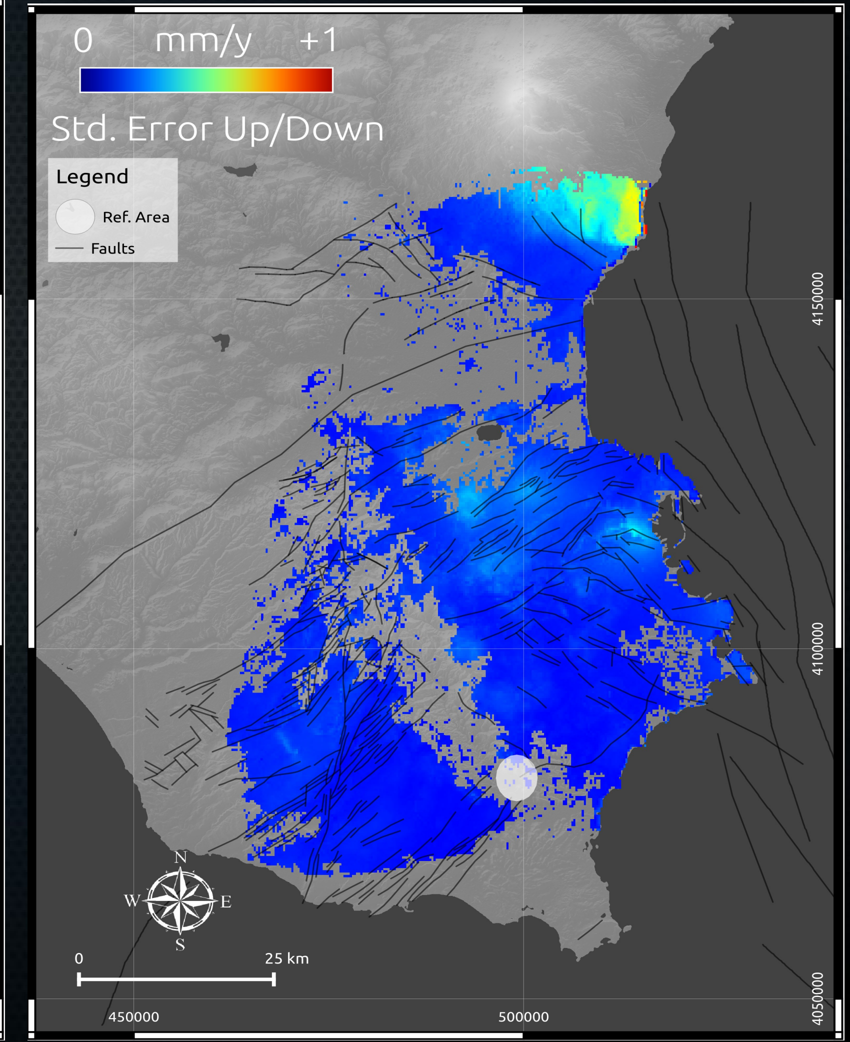
SISTEM Error - north



SISTEM Error - east



SISTEM Error - Up



Conclusions & Outlook

- Presented a methodology for tectonic ground deformations
  - Works also for other phenomena
- Proposed use of external weather model data
- Proposed filtering approach in order to:
  - better coverage (w.r.t. also to SISTEM)
  - no local peaks
- SISTEM approach for 3D decomposition of the velocity components
- SISTEM is able to retrieve known deformation really well
- north-south movement partly visible even away of GPS!

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Conclusions & Outlook

- Further validation needed (i.e. Corner Reflectors, GPS)
  - Karst ?
  - Movement along the Scicli-Ragusa fault ?
- Calculation of strain, shear stress and rigid body rotation sensor

Thank you for your attention !!!

Acknowledgements:

MIUR, University of Pavia

INGV Roma

INGV Catania

School of Earth and Environment at the Univ. of Leeds

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