SISTEM
EO-SAR and Ground deformation DATA FUSION

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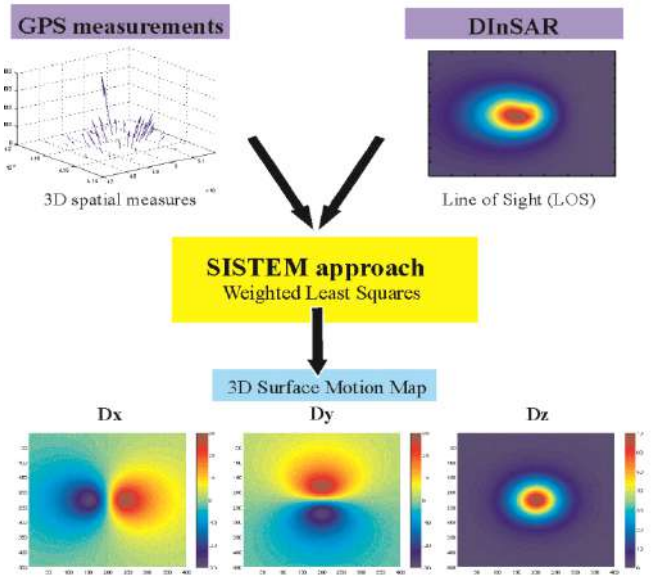
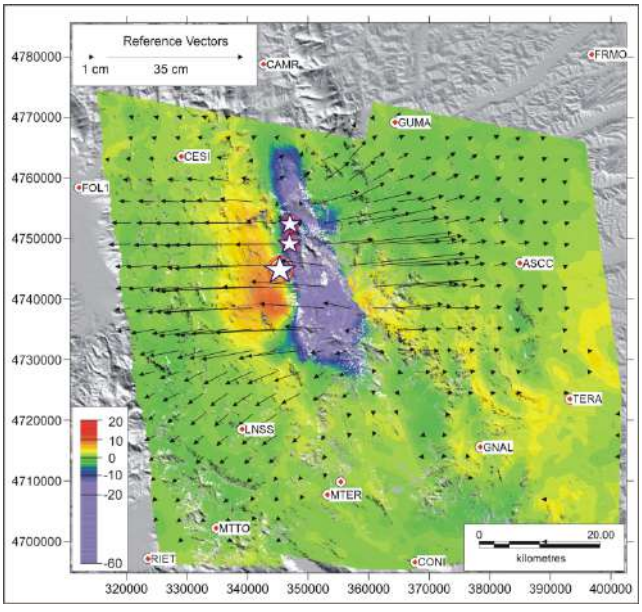
HOW DOES IT WORKS?

The SISTEM approach combines geodetic and satellite data in order to derive the 3D ground displacement components and the complete strain tensor.
The increasing availability of ground deformation data from both ground and space techniques encouraged to develop methods to integrate both types of data to increase the information both spatially and temporally. By nature, the ground based techniques (namely, the geodetic measurements, such as GNSS, levelling or tilt) produce point-wise measurements on a network of benchmarks or stations located in the investigated area, spacing hundred of meters or kilometers each others. Vice versa, by nature, satellite observations typically produce an information continuously covering a wide area.

The SISTEM approach merges ground-based and satellite-based data in order to derive the 3D ground displacement components and the complete strain tensor. Combining GPS/GNSS and DInSAR data allows us to take advantage of their complementary nature. Indeed, GPS measures are point-wise three dimensional data characterized by high time resolution. On the other hand, DInSAR measures provide mono-dimensional spatially distributed data characterized by a low time resolution. By using a Weighted Least Square algorithm, SISTEM integrates these data to produce high resolution three dimensional ground deformation maps over the whole investigated area.





The left panel shows the "Concept" of the SISTEM integration approach.
The right panel shows the SISTEM displacements map relevant to October 20th - November 01th 2016 time spanning. The vertical displacements are represented with a saturated color scale between -20 and 20 cm, and the vectors represent the horizontal displacements. The white stars represent the epicenters of the Oct. 26th (M=5.4 and MW=5.9) and Oct. 30th (M=6.5) earthquakes.
The map also shows the GPS stations used for SISTEM integration.

OBSERVATIONAL INFRASTRUCTURE

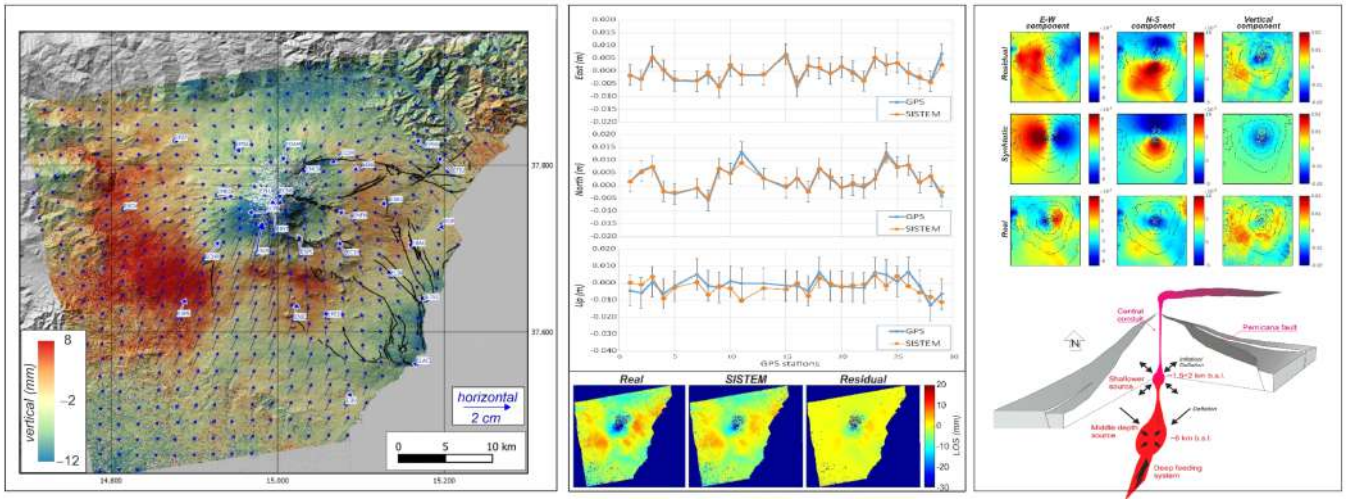
Observational infrastructure consists of: (a) EO and Ground SAR deformation products, generated with different techniques and using different SAR Sensor, and (b) Ground deformation data acquired with different instruments and techniques.
Different EO products (Ku-X-C-L band DInSAR interferograms), ground-based SAR products and UAVs can be used as inputs. At the same time, as Ground deformation data is possible to use data acquired with different instruments and techniques (GNSS, EDM, Levelling, Tilt, etc).

graphic design Laboratorio Grafica e Immagini | INGV

The COS-SISTEM module

The module will provide both the 3D ground deformation components and simultaneously provide the **EO product validation**.

Integration | **Validation** | **Modelling & Interpretation**



The EO data need to be validated with the data acquired on the ground, and thanks to SISTEM module is also possible to perform this validation easily.
The high resolution and validated SISTEM outputs will improve the knowledge of the geophysical phenomena involved during large earthquakes or during volcanic events, improving the geophysical source modelling. These enhanced results will provide a more constrained information to forecast initial eruption sites for potential lava flow pathways along the surface, and to depict the ground deformation due to large earthquakes.

In summary, the module is devoted to:
- Integrate the SAR data with available ground deformation
- Validate (EO vs. Ground deformation data)
- Modelling and interpretation of the SISTEM outputs

The SISTEM outputs can be exploited for several purposes and are applied in many application fields such as:
- Volcanic eruptions, volcanoes inflation/deflation movements, volcano-tectonics.
- Seismic cycle investigation: coseismic, postseismic and interseismic phases
- Landslides
- Urban or coastal subsidence

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These chains were implemented enabling the combined use of EO missions and ground data for the generation of value-added products such as high-resolution 3D ground deformation maps.
The SISTEM outputs are easy to read even for non-expert SAR users, and this solution will improve the use of satellite data and improve dissemination of results.