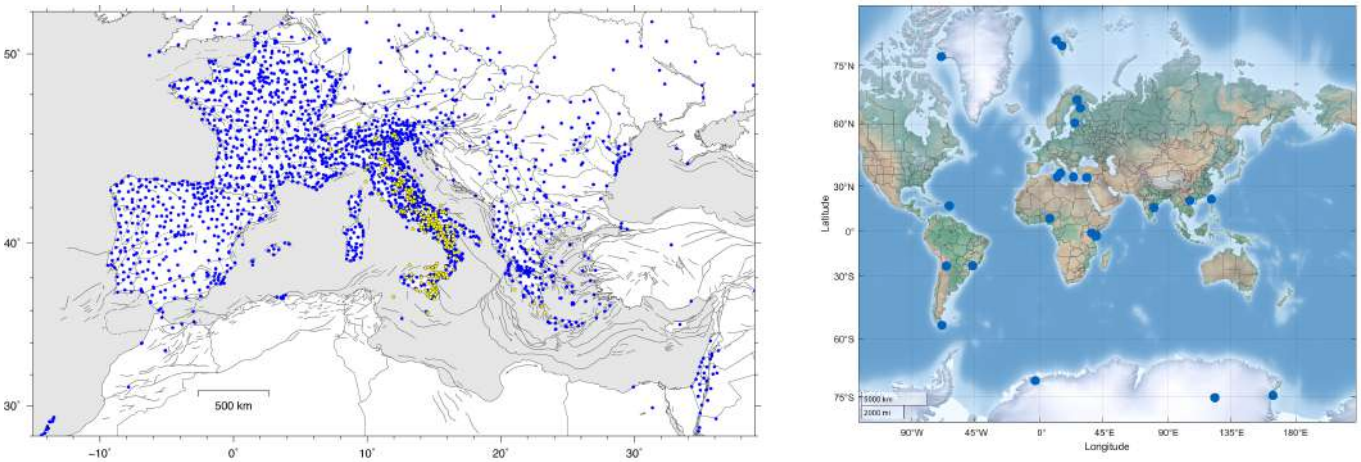
GALILEO DATA IN THE GEOPHYSICS STUDIES AND APPLICATIONS

GNSS data is extensively exploited by INGV scientists to monitor a variety of geophysical parameters to learn, for instance, about geodesy and physics of the lower and upper atmosphere. The advent of Galileo provides additional capability in terms of spatial coverage and spectrum extension. In this framework, the former GPS networks are now being upgraded with GNSS (multi-constellation) receivers, capable to track Galileo satellites.

The INGV NETWORKS

The INGV network of GNSS stations, called **RING** (Rete Integrata Nazionale GNSS), is a nation-wide network of over **200 permanent stations**, established **since 2004**. Raw data at 30-sec and 1-sec sampling rates are available to the public. **In the next two years we plan a basic receiver upgrade to acquire full constellation data, including Galileo.** We also collect and archive all GNSS data for stations all over Europe and Africa. The raw GNSS data are archived on a dedicated database and processed routinely by three INGV Analysis Centers using different approaches and scientific software. Position time series of all European stations are also available to the public. Additionally, INGV manages directly **28 permanent stations** established **since 2003**, located **all over the world** and configured to monitor the **disturbance induced by the upper atmosphere** on GNSS signals.



RING network highlighted in yellow, European stations in blue (left panel) and upper atmosphere network (right panel).

INGV SKILLS

INGV personnel matured **ICT skills** to design and realize **data archives** and data bases collecting INGV data and gathering **GNSS data** acquired by other networks or single stations.
INGV scientists have a long expertise on **GNSS data handling and analysis** addressed to **scientific uses** and to the development of **products and services** supporting a broad spectrum of **GNSS-based operations**.
INGV collaborates with several **institutions, academies and private bodies** to provide **consultancy, services and products** based on GNSS data.
INGV makes use of GNSS data for **validation and calibration** of other **satellite-based products.** INGV deploys and manages **low-cost receivers** to monitor **landslides, slope deformations** and **strategic infrastructures**.
INGV makes use of GNSS data to monitor, forecast and mitigate **space weather** events.INGV collaborates with GNSS receivers' **manufacturers** to assess the receivers' **performance** under **space weather events** and under **extreme environmental conditions**.INGV collaborates **with Software-Defined Radio** GNSS receivers' developers to assess the actual capability to monitor the upper atmosphere.
INGV is deeply involved as data provider and it is appointed as **GNSS analysis center** of **EPOS** (European Plate Observing System), the **European Research Infrastructure** on solid earth.

graphic design **Laboratorio Grafica e Immagini | INGV**

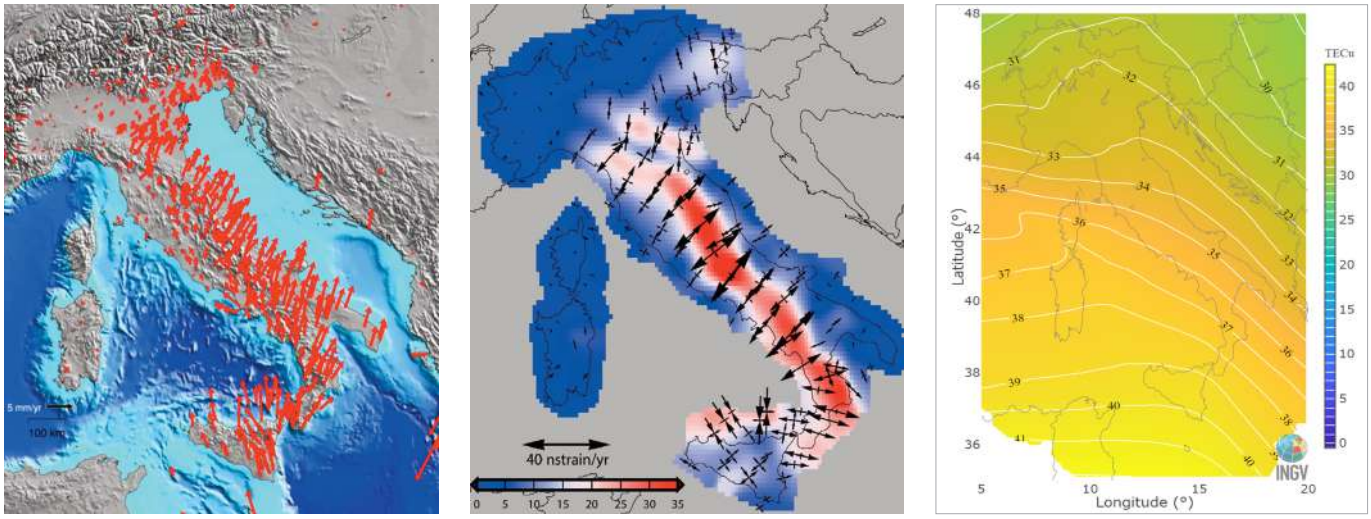
INGV products

INGV provides a number of products based on GNSS data.

Here follows an overview not exhaustive but representative of the broad spectrum of applications.

Precise daily positions are computed routinely for all the archived stations. These time series allow the estimation of the **crustal deformation** and the establishment and maintenance of a **reliable reference system** for the whole area.

Velocity field and strain-rate maps are computed periodically for the Italian and European area. These products are input for **tectonic studies** and regional **seismic hazard** evaluations. RING data and other GNSS data contribute to the estimation of the regional **coseismic deformation** pattern observed after major earthquakes. Full 3D position estimates are used for **calibrating** other geodetic techniques, e.g., InSAR and terrestrial surveys



Map of velocities (left panel), crustal deformation (mid panel) and Total Electron Content in the ionosphere (right panel) from GNSS data.

INGV provides assistance to monitor, forecast and mitigate the **space weather** impact on **GNSS precision positioning**. Space Weather events induce perturbations in the ionized part of the atmosphere, the ionosphere, that increase the degradation, already caused by the ionosphere under quiet conditions, of GNSS signals. This results into an increase of the positioning error provided by GNSS.

INGV is partner of the **Partnership of Excellence for Civil Aviation Space weather User Services** (PECASUS; pecasus.eu). **PECASUS** is one of the four global centers providing a Space Weather Service to the International **Civil Aviation Organization** (ICAO). On November 7th, 2019 PECASUS started its 24/7 operations to provide civil aviation with information on space weather that has the potential to affect communications, navigation and the health of passengers and crew.

INGV participates with the GNSS-based data products to the **Space Weather Service Network Development and pre-Operation** (SWESNET) project, funded by the European Space Agency, aimed at the improvement of the federated Space Weather services, available in the ESA Space Weather Service Network portal **(https://swe.ssa.esa.int/)**

All the space-related INGV flyers are here!