



GROUND-BASED operational monitoring in support of space applications

Most application services based on space data need to be integrated or validated with observations gathered on the Earth's surface by instrumental networks. INGV develops and maintains regional scale monitoring networks over Italy and the Mediterranean area, as well at polar and equatorial latitudes, able to provide real time streams of various geophysical parameters and observations. Some of the measured parameters are openly accessible in real time through web services, while others are subject to specific provision conditions.

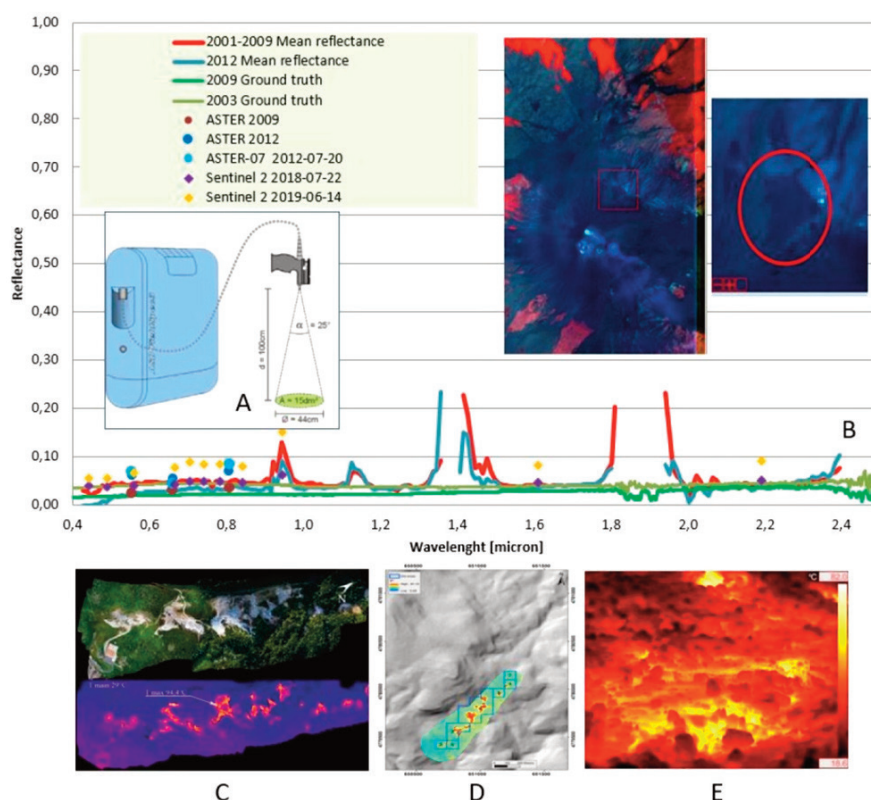
Measurement of ground data can also be carried out during campaigns organized ad hoc for validation or calibration, or for high resolution monitoring of specific geophysical events or hazards.

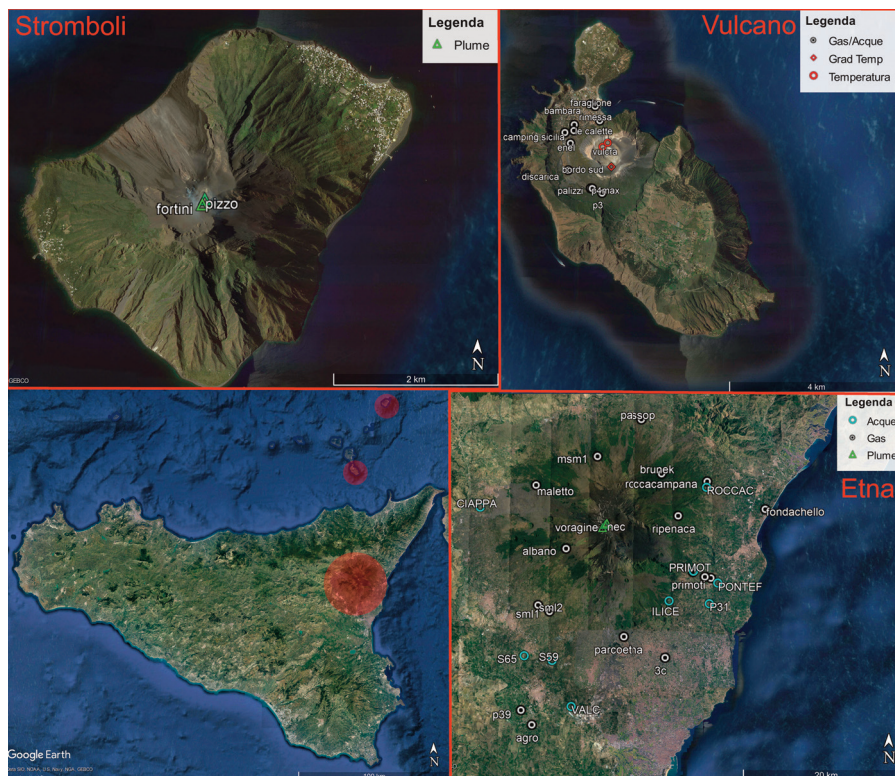
INGV owns and operates a large variety of geophysical instruments for use in the lab or in the field, and its personnel is able to measure nearly any geophysical and geochemical parameter. INGV also develops new geophysical and geochemical instruments and holds patents in this field.

Operational GNSS monitoring: the RING network

During EO satellite passes, calibrated instruments such as spectro-radiometers (A), thermal cameras (E) and other instruments are used to derive parameters like the spectral reflectance (B), surface temperature (D) and other atmospheric parameters over ground calibration/validation sites.

The INGV Optical Laboratory maintains and uses a number of field instruments (also mounted on drones, C) for validation of parameters retrieved by satellite observations, as spectral reflectance and surface temperature. A long-dated expertise in the deployment of field instrumentation and in measurement campaigns allows to spatially characterise the ground properties for effective validation of satellite data.





Multiparametric networks for geochemical observations on ACTIVE VOLCANOES

INGV deploys and maintains a variety of **monitoring stations** to sample gases and waters on the Italian active volcanoes and measure chemical and physical parameters related to volcanic and seismic activity. For instance, gas instruments measure the CO_2 diffuse degassing (on **Etna, Vulcano, Stromboli**); other networks measure chemophysical parameters in groundwaters (on **Etna, Vulcano**); temperature monitoring networks are used to identify thermal anomalies in the ground (Vulcano fumaroles); networks of MultiGAS instruments are used to monitor the ratio CO_2/SO_2 in the volcanic plume (on **Etna, Stromboli**) and the SO_2 flux in the hydrothermal cloud (on **Etna, Stromboli, Vulcano**). All data are downlinked via cellular network to the Palermo INGV branch and validated by the **monitoring network manager**. Ground-measured geochemical data are used for the validation of space-based synoptic products devoted to the monitoring of volcanic ash plumes, thermal anomalies, gas anomalies, etc.

Ionospheric TEC and SCINTILLATION MEASUREMENTS: the eSWua network

The ionosphere is the largest contributor to the error budget for navigation and precise positioning. The INGV develops and manages a global-scale GNSS network of high rate (50 Hz) multi-frequency receivers (in green in the figure) for the continuous monitoring of the ionosphere Total Electron Content and ionospheric scintillations. This monitoring facility allows the near Earth characterization of the ionized atmosphere, and the real time detection of ionospheric irregularities embedded in the regular plasma impacting GNSS integrity, accuracy and availability. Data and products are available on the dedicated Data Base eSWua-electronic Space Weather upper atmosphere-<http://eswuax.rm.ingv.it/>. Models of ionospheric dynamics, nowcasting and forecasting (from few seconds to hours in advance) based on these data are crucial to feed error mitigation tools against the ionospheric threats.

INGV expertise on TEC and scintillation monitoring and modelling contribute to the development of GNSS end user services (see, e.g. PECASUS -Pan- European Consortium for Aviation Space weather User Services, <http://pecasus.eu/>).



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