Title: Precipitable water retrieval through the analysis of decadal GNSS and meteorological data: prediction and warnings of heavy precipitation events in some flash flood-prone areas of Campania region

Tutor: Umberto Riccardi

Co-tutors: U. Tammaro (INGV), G. Dick (GFZ- Potsdam), C. Martino (INGV)

Research program

Severe weather events like hurricanes, extratropical cyclones or Mesoscale Convective System (MCS) are frequent for certain areas. Moreover, such phenomena are becoming more intense in Europe eventually due to climate change, without exception of Italy and Campania region. Reliable monitoring and predicting of such extreme weather events needs accurate and frequent observations of the most important troposphere constituent, water vapour, which is a gas transporting large amount of energy both vertically (convection) and horizontally (advection). To fully comprehend alluvial phenomena, it is necessary to analyse not only the purely ground hydrological aspects, but also the atmosphere dynamics leading to the heavy storms whose territorial distribution is generally complex and is tightly controlled by topography (Fortelli et al., 2019). Most of severe weather events in almost all climatic zones (including temperate and marine climate of Italy) is linked with excessive amount of water vapour. Since this gas content varies a lot, in-situ and remote measuring techniques are not reliable to monitor and predict water vapour content (Huang et al., 2010). Hence, each new observation technique that can bring a distribution of water vapor (WV) is strongly encouraged. Global Navigation Satellites System (GNSS) has demonstrated its ability to monitor the atmospheric water vapor content with an accuracy comparable to other techniques of measurements (e.g. radio soundings, microwave radiometers), even with good time resolution and under all meteorological conditions (e.g. Bevis et al., 1994; Song and Grejner-Brzezinska, 2009). The nowadays extensive use of permanent GPS stations, operating for geodetic purposes, offers a tool for a dense and reliable remote sensing of atmospheric WV. This can be a key achievement for prediction and warnings of heavy precipitation events in flash flood-prone areas. This goal is mainly fulfilled by "nowcasting".

Proposal for a PhD position

This research aims at using geodetic and meteorological data and techniques to investigate relationship of radio signals propagation and atmospheric conditions. We plan to analyse the tropospheric delay observed on some cGNSS (Continuous Global Navigation Satellite System) stations of the NeVoCGPS (Neapolitan Volcanoes Continuous GPS) network, managed by INGV for volcanic monitoring. Data collected at 3 stations, ad hoc installed for meteorological purposes, downtown Napoli and around Mt. Somma-Vesuvius in the framework of the EU Erasmus K2 Project TRYAT will be used too. In more detail, we are going to study the wet component of the tropospheric delay of the radio signals and the computation of the precipitable water (PW) and its time evolution during extreme weather events by using co-located GNSS and meteorological stations. By collecting meteorological and GNSS data at different altitudes on the network, we are expected to investigate the role of the main orographic elements (such as Mt. Somma-Vesuvius and Monte Epomeo) in the Neapolitan area on the genesis of MCS. The research will focus on the

possibilities of the assimilation of GNSS data into numerical weather prediction model as well as on the feasibility of developing an Early Warning or "Nowcasting" system to mitigate the societal impact of extreme weather events. The PhD candidate will follow a work schedule articulated as follows:

1st year: Bibliographic research on the subject; learning of software for GNSS and Meteorological data analysis and retrieval of Tropospheric delay; learning fundamentals of signal analysis.

2nd year: Data analysis; 4 months stage abroad (likely GFZ Potsdam) for learning advanced techniques for GNSS and meteorological data analysis. Participation as speaker to an International Congress. Learning techniques for Early Warning and "Nowcasting".

3rd year: Interpretation of results; writing of PhD thesis.