Department strategic project 2019

# TROPOMAG

Influence of geomagnetic storms on the **TROPO**sphere dynamics: Can the Earth's **MAG**netic field be considered a proxy of climate changes?

# Aims and short description



- Investigations (observations) on the effects of changes of the Earth's magnetic field (geomagnetic storms) on the atmosphere and weather conditions;
- Possible relationship between electrically neutral (troposphere) and charged (ionosphere) atmospheric layers;
- Meteorological variability induced by geomagnetic storms as an accelerated time scale model of the mutual interactions between climate and geomagnetic field on longer time scales.

# References



**The «Wilcox» effect [Wilcox et al, 1974]**

Vorticity Area Index (VAI) = ratio between N-S and E-W dimensions of winter low pressure (cyclonic) areas in the northern emisphere. VAI minima 1 day after the Magnetic Sector passage (black box model)

**Solar modulation of atmospheric electrification [Markson, 1978]**

«Solar controlled variation of stratospheric ionisation explains atmospheric electrical variations and possibly other meteorological responses»

«With an atmospheric electrical mechanism it is unnecessary to couple energy from the upper to the lower atmosphere as the entire electric field from ionosphere to Earth would be affected»

**Stratospheric volcanic aerosol as condition for the Wilcox effect [Tinsley, 1994]**

«A correlation between tropospheric dynamics and solar wind magnetic fields that disappeared in the early 1970s reappeared with a new injection of volcanic aerosols into the stratosphere. A similar pattern of correlation has been found for changes in current density in the global electric circuit and for changes in relativistic electron precipitation»

# Why volcanoes?



- Active (magmatic & hydrothermal) volcanic areas (Etna, Stromboli, Vulcano and Vesuvio) able to generate thermal anomalies and to input in the atmosphere solid and gaseous particles, creating a vertical corridor connecting different atmospheric layers;
- Volcanoes (Etna & Vesuvio) inside wide conurbations allow the evaluation of vertical circulation cells ("urban island" thermal effect) in sustaining the flux of particulate produced by fossil fuel combustion;
- Areas instrumented with multiparametric acquisition networks operating since the first 2000s';
- Preliminar study indicating the possible existence of a ground level, Wilcox-like, solar perturbation of the troposphere [Madonia et al., 2014]

# Decoupling of lower troposphere pressures & Sun storms [Madonia et al, 2014]

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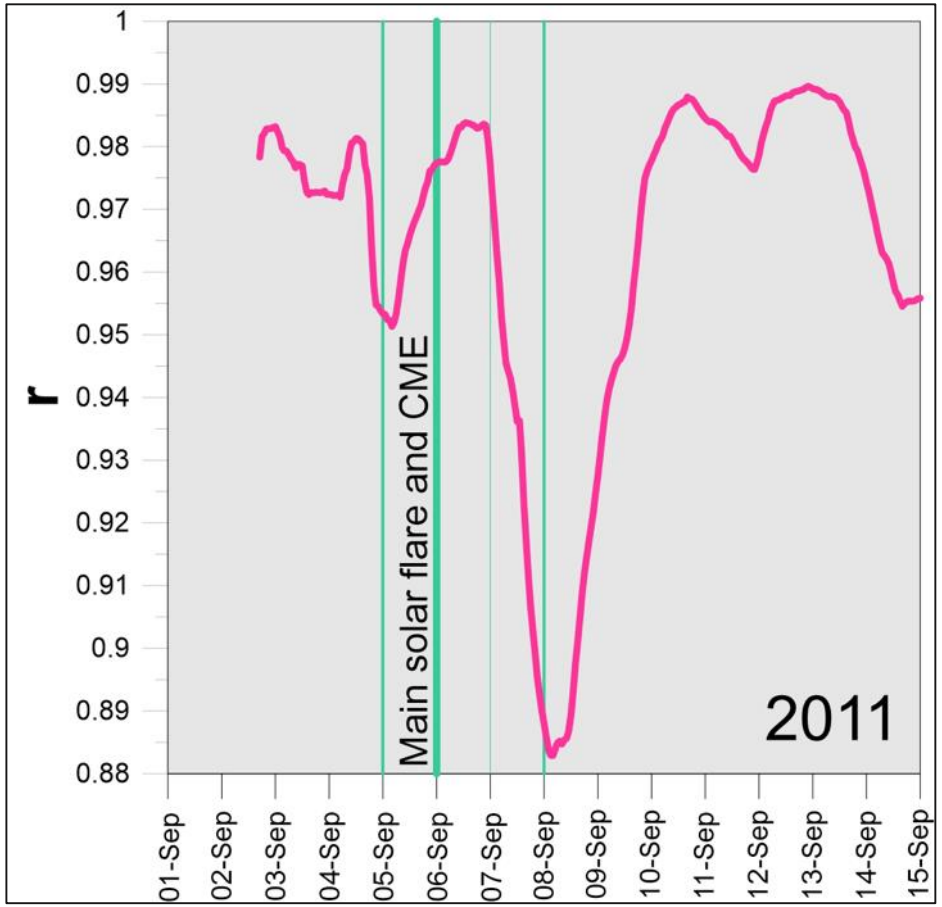


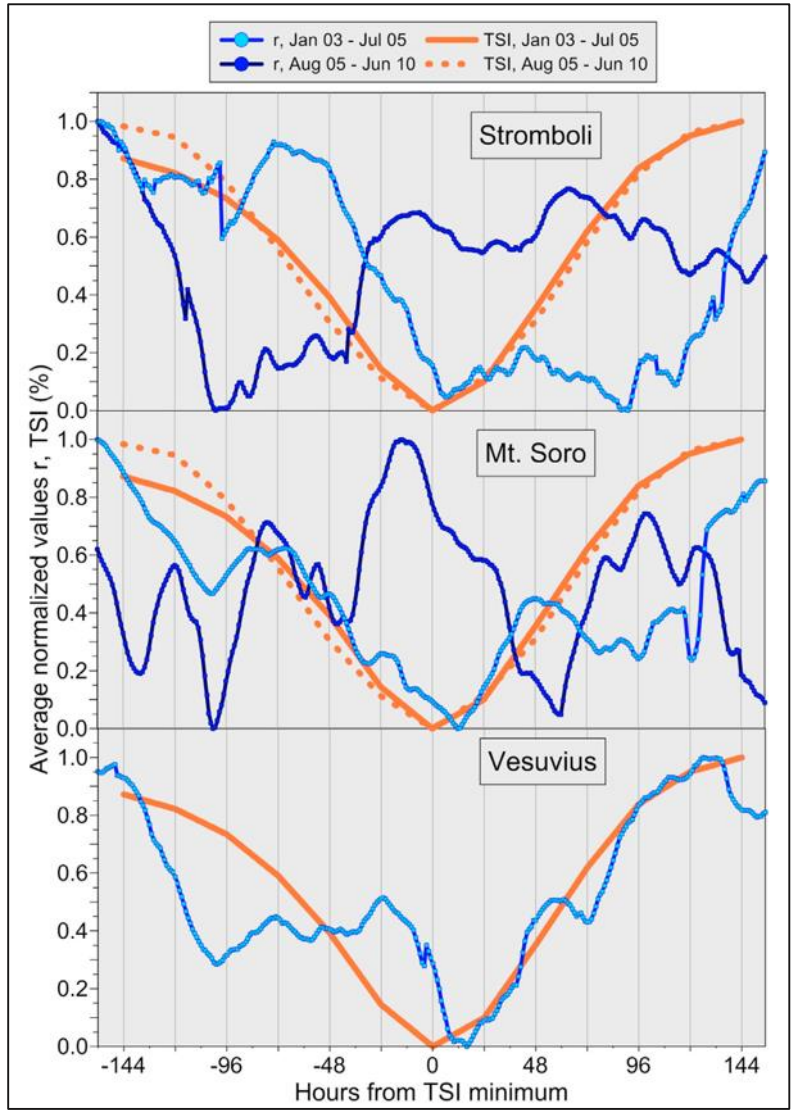

# Participants and work packages

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| Participants | Affiliation |
|---|---|
| Giovanni Benedetti, Igino Coco, Paola De Michelis, Fabio Giannattasio, Paolo Madonia, Michael Pezzopane, Giovanna Lucia Piangiamore, Marco Pietrella, Lucia Santarelli, Roberta Tozzi, Simone Vecchi, Achille Zirizzotti | Roma 2 |
| Sofia De Gregorio, Vincenzo Francofonte | Palermo |
| Valentina Bruno, Massimo Rossi | Osservatorio Etneo |

| Work Package (Responsible) | | |
|---|---|---|
| **WP1** - New data acquisition (2021-23) (Sofia De Gregorio PA) | **WP2** - Data interpretation & modeling (2003-23) (Valentina Bruno OE) | **WP3** - Scientific Outreach (Giovanna L. Piangiamore RM2) |

# Analysis of geomagnetic and solar data

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**COLLECTION AND PRE-PROCESSING OF:**

Solar data
(IMF, solar wind parameters)

Geomagnetic indices
(Sym-H, Kp, etc.)

Ground geomagnetic data
(Gibilmanna and Lampedusa)

**TO:**

- Select geomagnetically disturbed periods over which comprehensively investigating geomagnetic, GNSS and meteorological data;
- Characterise the possible external (to the Earth) drivers of observed tropospheric disturbances.

# Analysis of GNSS data for ionospheric TEC and tropospheric delays estimation

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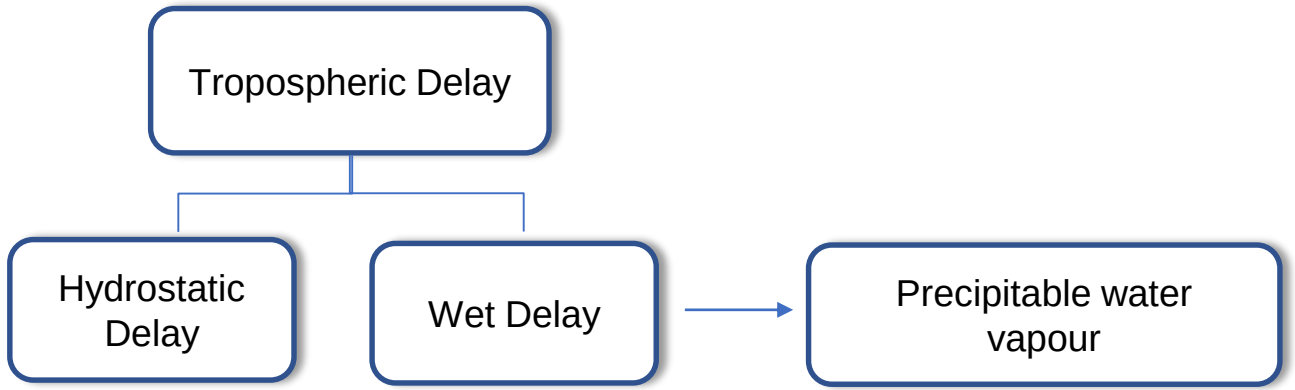
RINEX files containing code and carrier phase observables, acquired every 30 seconds, will be used to obtain calibrated TEC values. GNSS data will be analyzed to estimate tropospheric delays. The time-varying zenith wet delays (ZWD) will be transformed into estimates of the precipitable water vapor (PWV) to analyze atmospheric water vapor variability.

**GNSS**: Global Navigation Satellite System


SOUNDING OF NEUTRAL ATMOSPHERE




*Processing of Stromboli GNSS data in collaboration with (UR03) the department strategic project "**FIRST** – **F**orecast**I**ng e**R**uptive activity at **S**tromboli volcano: **T**iming, eruptive style, size, intensity and duration".*

# Acquisition & analysis of ground level parameters

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- Atmospheric pressure
- Air temperature
- Telluric current
- Soil and groundwater temperature
- Electric conductivity of groundwater
- $CO_2$ flux from soil

- Retrospective analysis of incomplete data series (2003-20, descending branch solar cycle 23, whole Cycle 24);
- New complete data (2021-23, ascending branch Cycle 25);

# Scientific Outreach



Starting from the pre-existing Earth Science Class Role Playing Game **GeoQuest** (http://www.evoquest.eu/), a new adventure based on the TROPOMAG topics will be implemented and tested in EvoQuest.

We'll design also an integrated a Tablet game.

The TROPOMAG Computer game adventure and mixed Table game will be tested in classes of different school grades.