

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

INGV Environment Department strategic project 2019



Igino Coco on behalf of TROPOMAG Team

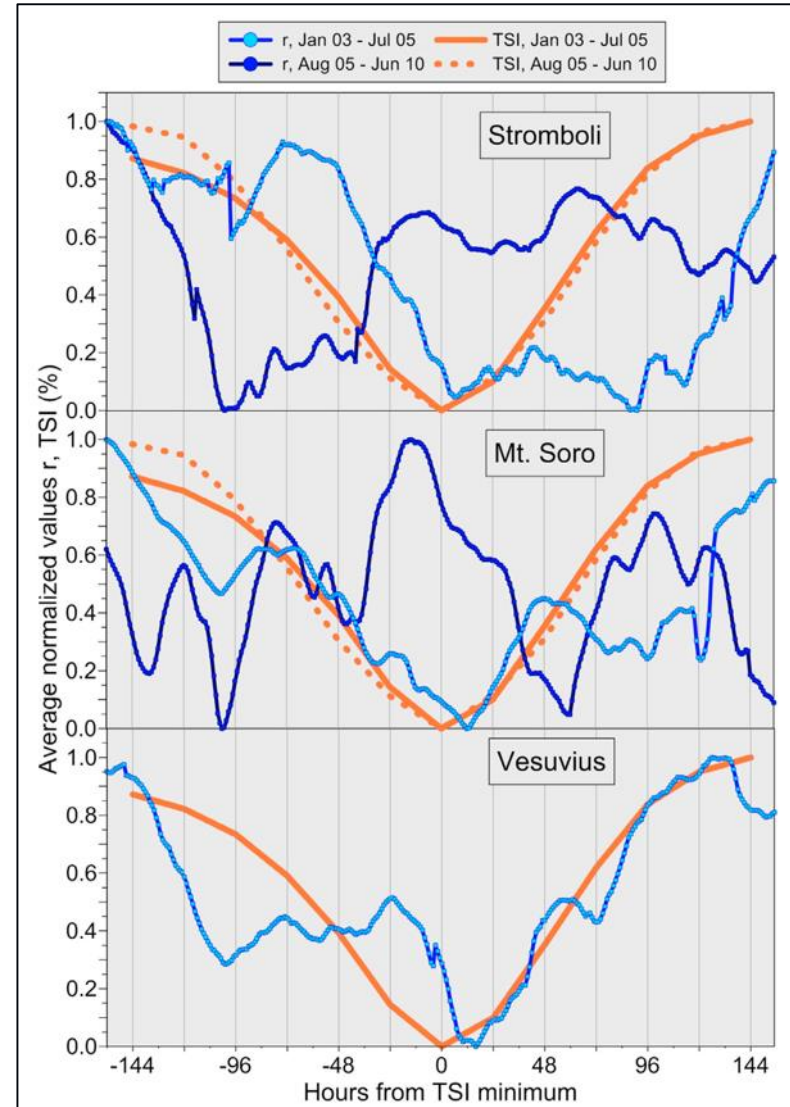
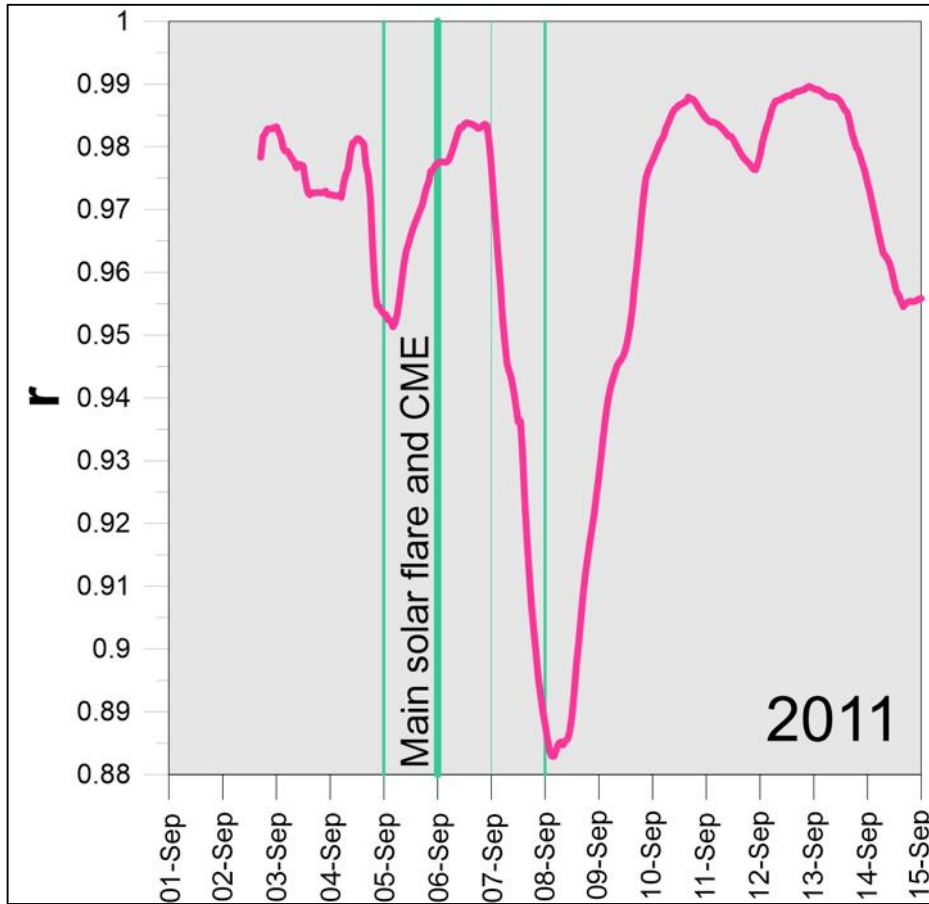


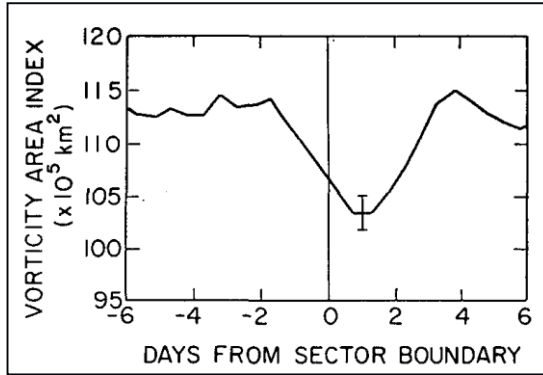
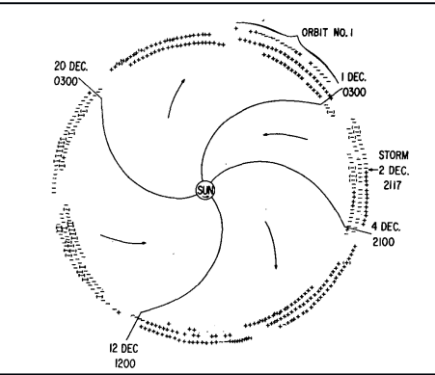
- Investigations (observations) of the effects of changes of the Earth's magnetic field and ionospheric conditions on the atmosphere and weather conditions;
- Possible relationship between tropospheric disturbances and changes in the Earth's magnetic field;
- Meteorological variability induced by geomagnetic storms as an accelerated time scale model of the mutual interactions between climate and geomagnetic field on longer time scales;
- Active volcanic areas as an ideal test bench for investigating phenomena acting in different atmospheric layers but possibly interconnected.

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’;
- Preliminary study indicating the possible existence of a ground level, Wilcox-like, solar perturbation of the troposphere [Madonia et al., 2014]

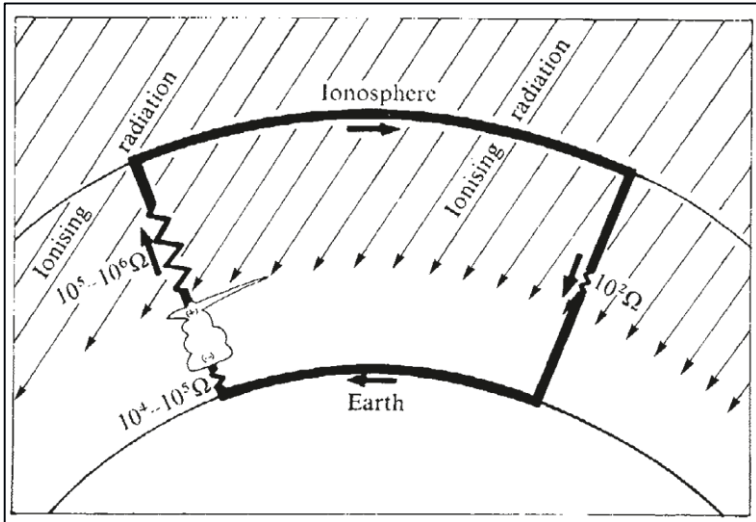
Decoupling of lower troposphere pressures & Sun storms [Madonia et al, 2014 - [link](#)]





The «Wilcox» effect [Wilcox et al, 1974 – [link](#)]:

Formation of wintertime **low pressure troughs**, developing or moving into North Pacific region and showing anomalous deepenings 2-4 days after a bright aurora or a **geomagnetically disturbed day**.



Solar modulation of atmospheric electrification [Markson, 1978 - [link](#)]:

Galactic Cosmic Rays collide with particles in atmosphere inducing electrical charges on them, and finally **nucleate clouds**. Solar modulated variations in ionising radiation, occurring in the volume above the thunderstorm generator, change its resistance, thus causing a **worldwide increase in electric field intensity**, which would explain enhanced electric fields following solar flares. Atmospheric electricity would influence thunderstorm development or cloud physical processes, producing stronger precipitation.



Project responsible: Paolo Madonia

Participants

Affiliation

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Roma 2

Sofia De Gregorio, Vincenzo Francofonte

Palermo

Work Package (Responsible)

WP1 - New data acquisition
(2021-24)

(Sofia De Gregorio PA)

WP2 – Data interpretation &
modeling (2003-24)

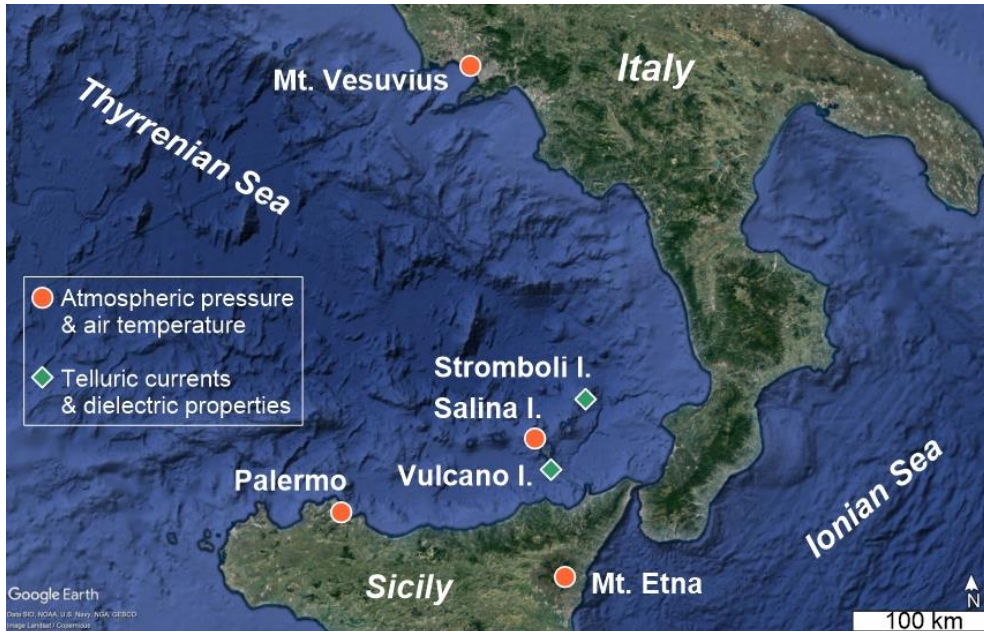
(Valentina Bruno OE)

WP3 - Scientific Outreach

(Giovanna Piangiamore RM2)



WP1 - Recently refurbished stations for atmospheric parameters acquisition



TROPOMAG atmospheric station on the top of Mt. Vesuvius.

Id	Lat	Lon	Elev (m)	Parameters	Start
STR-VLZ	38.806	15.221	219	Dielectric Properties (DP)	2021-Jun*
VES-GCO	40.824	14.426	1243	Atm. Press. & Air T + DP	2021-Sep
VES-TDG	40.778	14.378	49	Atm. Press. & Air T	2021-Sep
SAL-MFF	38.554	14.849	927	Atm. Press. & Air T	2021-Jul*
SAL-SMS	38.557	14.871	8	Atm. Press. & Air T	2021-Jul*
ETN-POZ	37.672	15.188	67	Atm. Press. & Air T	2021-Jun
ETN-TOP	37.719	14.998	2508	Atm. Press. & Air T	2021-Jun
PAL-MPP	38.162	13.358	569	Atm. Press. & Air T	2021-Aug
PAL-OTB	38.111	13.374	10	Atm. Press. & Air T + DP	2021-Jul
VUL-FOS	38.405	14.956	199	DP & Tel. Currents	2021-Jul*



Example: atmospheric pressure sensors, Resolution 0.14 hPa, memory 21,700 data



WP1 - Stations/observatories for geomagnetic field measurements

Maintenance of automatic instruments for geomagnetic field measurements located at the geomagnetic observatory of Lampedusa Island (AG) and the geomagnetic station of Gagliano (EN)



Magnetic sensor



WP2 - Analysis of geomagnetic and solar data

COLLECTION AND PRE-PROCESSING OF:

Solar data
(IMF, solar wind parameters)



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



Ground geomagnetic data
(e.g. Gagliano and Lampedusa)



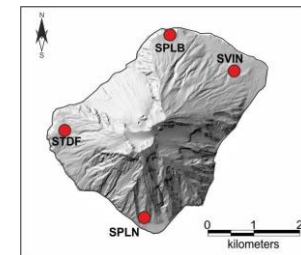
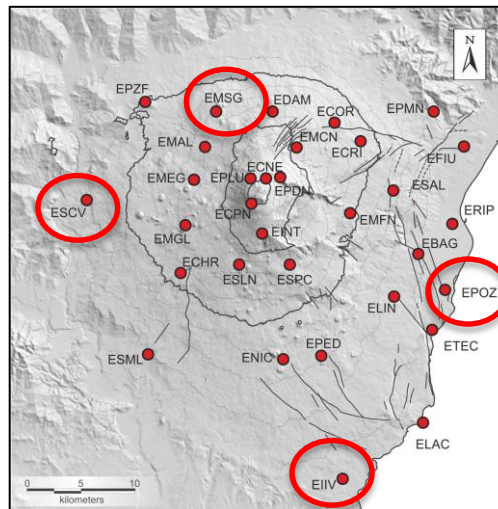
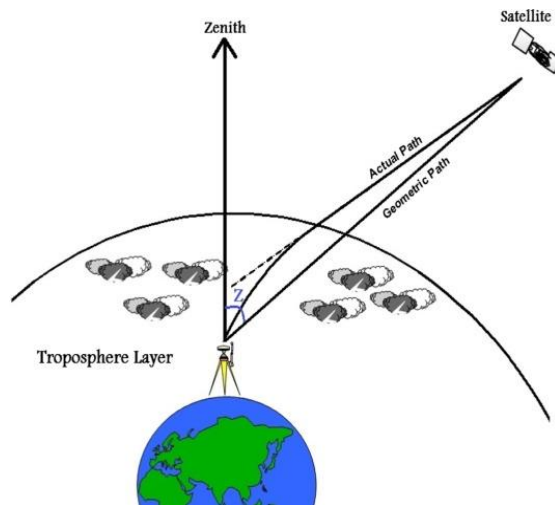
To:

- Select geomagnetically disturbed periods over which comprehensively investigate geomagnetic, GNSS and meteorological data;
- Characterise the possible external (to the Earth) drivers of observed tropospheric disturbances;
- Preprocessing and analysis of geomagnetic data from existing Italian observatories (L'Aquila, Duronia, Lampedusa), and newly deployed/refurbished stations (Gagliano)



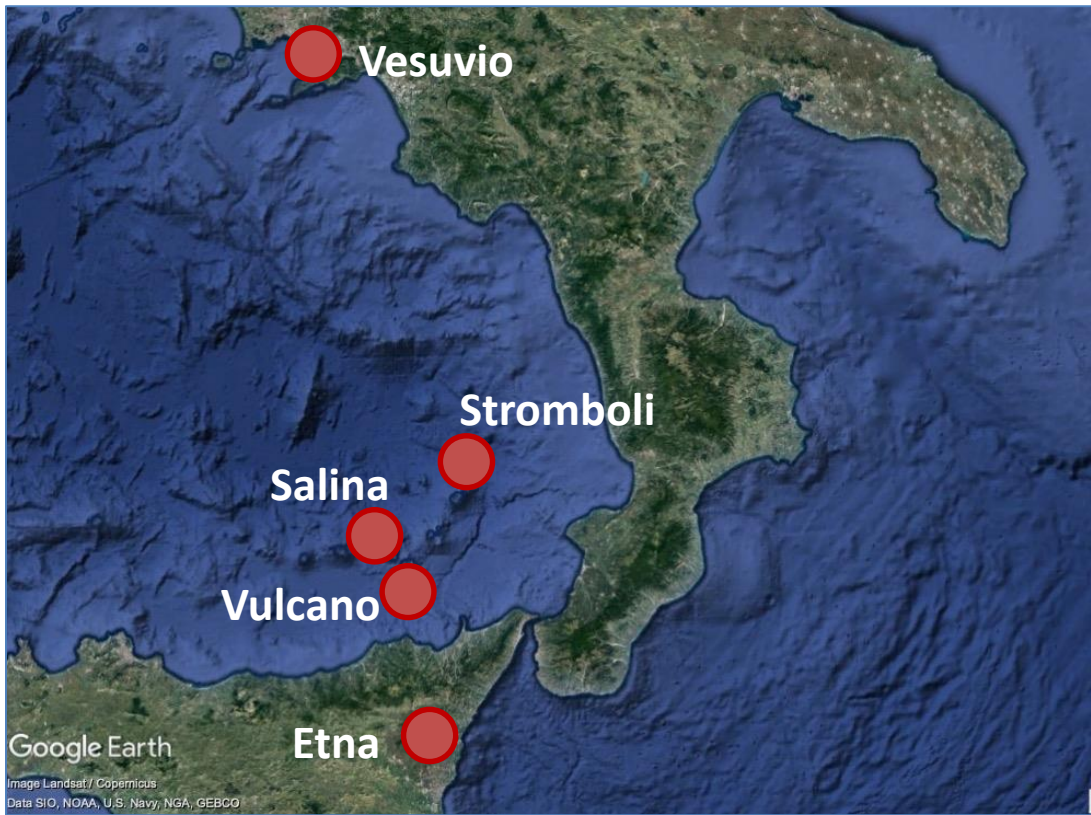
WP2 - Analysis of GNSS data for ionospheric TEC and tropospheric PWV

- RINEX files containing code and carrier phase observables, acquired every 30 seconds, will be used to obtain calibrated ionospheric **Total Electron Content** values, in order to investigate local ionospheric anomalies during geomagnetically disturbed periods.
- 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** to analyze atmospheric water vapor variability.



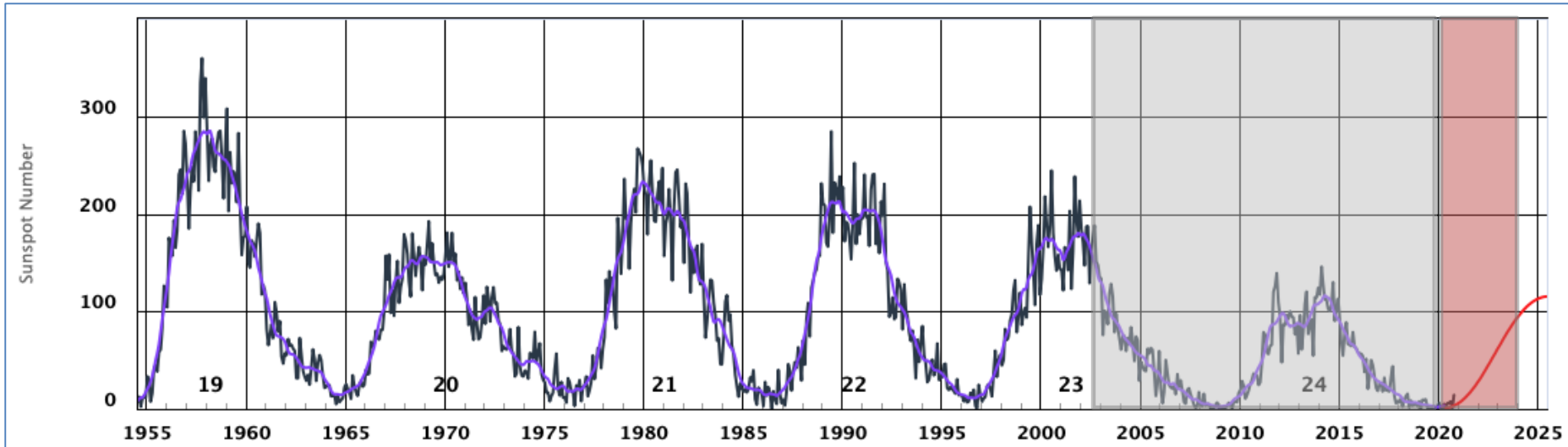
GNSS receivers used for determining PWV around Mt. Etna and Stromboli. Circled receivers are also used to determine ionospheric TEC

WP2 - Acquisition & analysis of ground level parameters



- Atmospheric pressure
- Air temperature
- Telluric current
- Soil and groundwater temperature
- Electric conductivity of groundwater
- CO₂ flux from soil

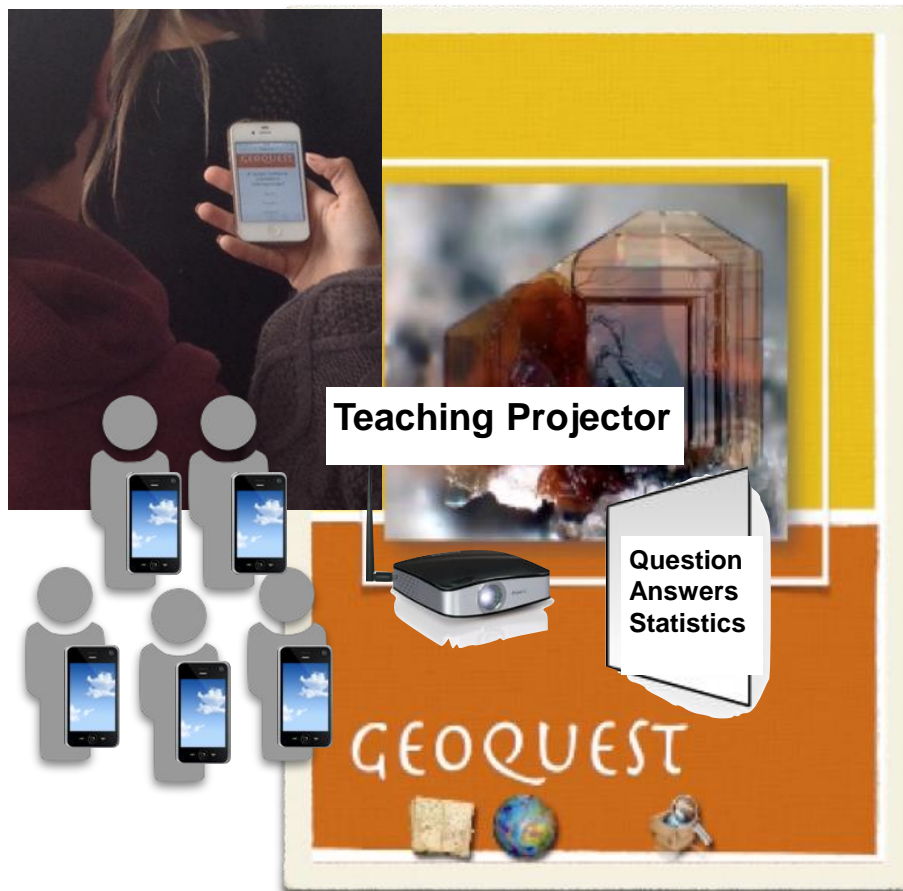




- Retrospective analysis of incomplete data series (2003-20, descending branch Cycle 23, whole Cycle 24);
- **New complete data (2021-24, ascending branch Cycle 25);**



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.

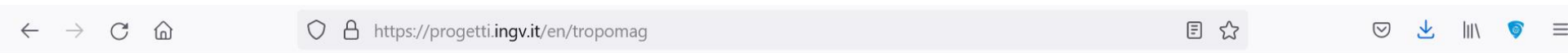


We'll design also an integrated mixed Tablet game.

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

Target:
Middle Schools and High Schools

<https://progetti.ingv.it/index.php/en/tropomag>



TROPOMAG

INFLUENCE OF GEOMAGNETIC STORMS
ON THE TROPOSPHERE DYNAMICS
CAN THE EARTH'S MAGNETIC FIELD
BE CONSIDERED A PROXY OF CLIMATE CHANGES?

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