EGU2020-19809 | Displays | NH4.5

Systematic worldwide statistical correlation of physical and chemical atmospheric parameters before large earthquakes in the last four decades

Dedalo Marchetti, Alessandro Piscini, Angelo De Santis, Caroline Ganglo, Gianfranco Cianchini, Saioa A. Campuzano, Claudio Cesaroni, Roger Haagmans, Shuanggen Jin, Luca Spogli, Maurizio Soldani, and Alessandro Ippolito

Fri, 08 May, 14:00–15:45 | D1645

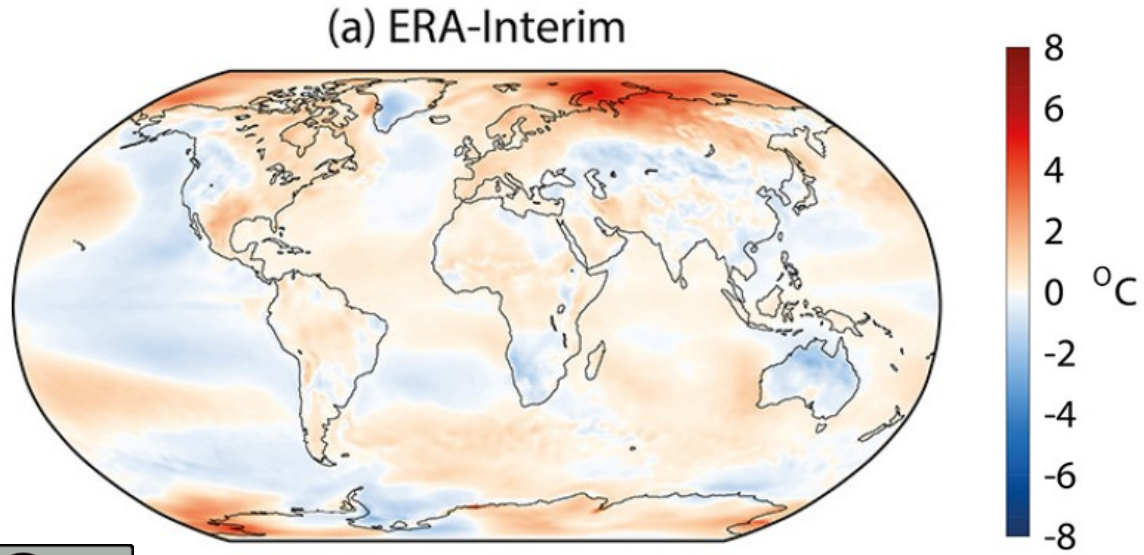
ISTITUTO NAZIONALE DI GEOFISICA E VULCANOLOGIA

Nanjing University of Information Science & Technology

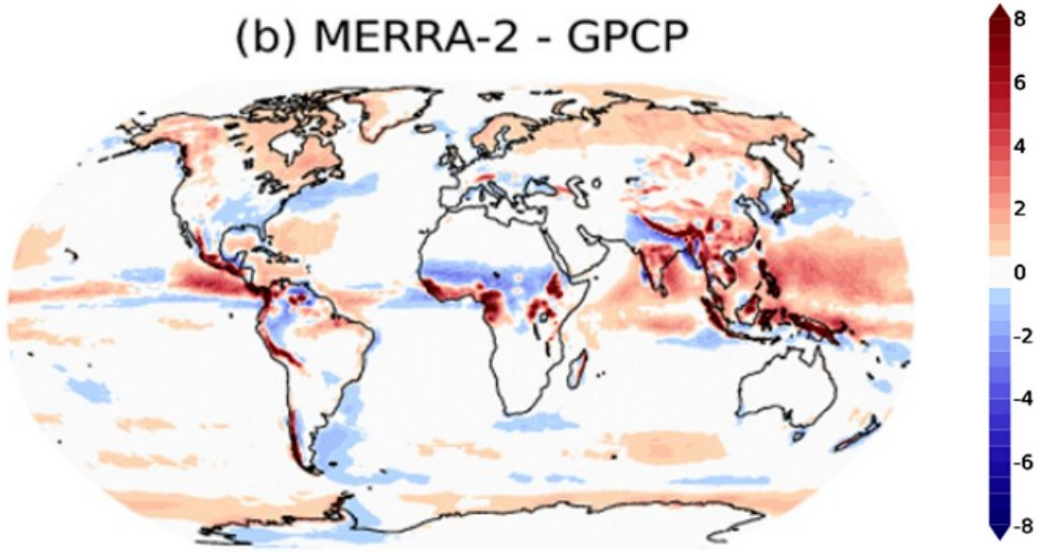
UNIVERSITÄT KOBLENZ · LANDAU

Climatological datasets

- Principal weather agencies like European Center for Medium-range Weather Forecast (**ECMWF**) and National Oceanic and Atmospheric Administration (**NOAA**) produce and continuously update some climatological models based on real observations, from ground stations, aircraft sensors, radiosonde, and overall satellites, of the atmosphere characteristics all over the world from several decades (~40 years) .
- The main goal of these projects, like **ERA-Interim** (ECMWF) or **MERRA-2** (NOAA) is to understand the possible climate change, the impact of human activity on the emission and possible consequences for the environment and future Earth climate.



Example of variation of Surface temperature in 2011 w.r.t. 1980-2010
From Simmons et al. ERA-Report Series N.25, 2016



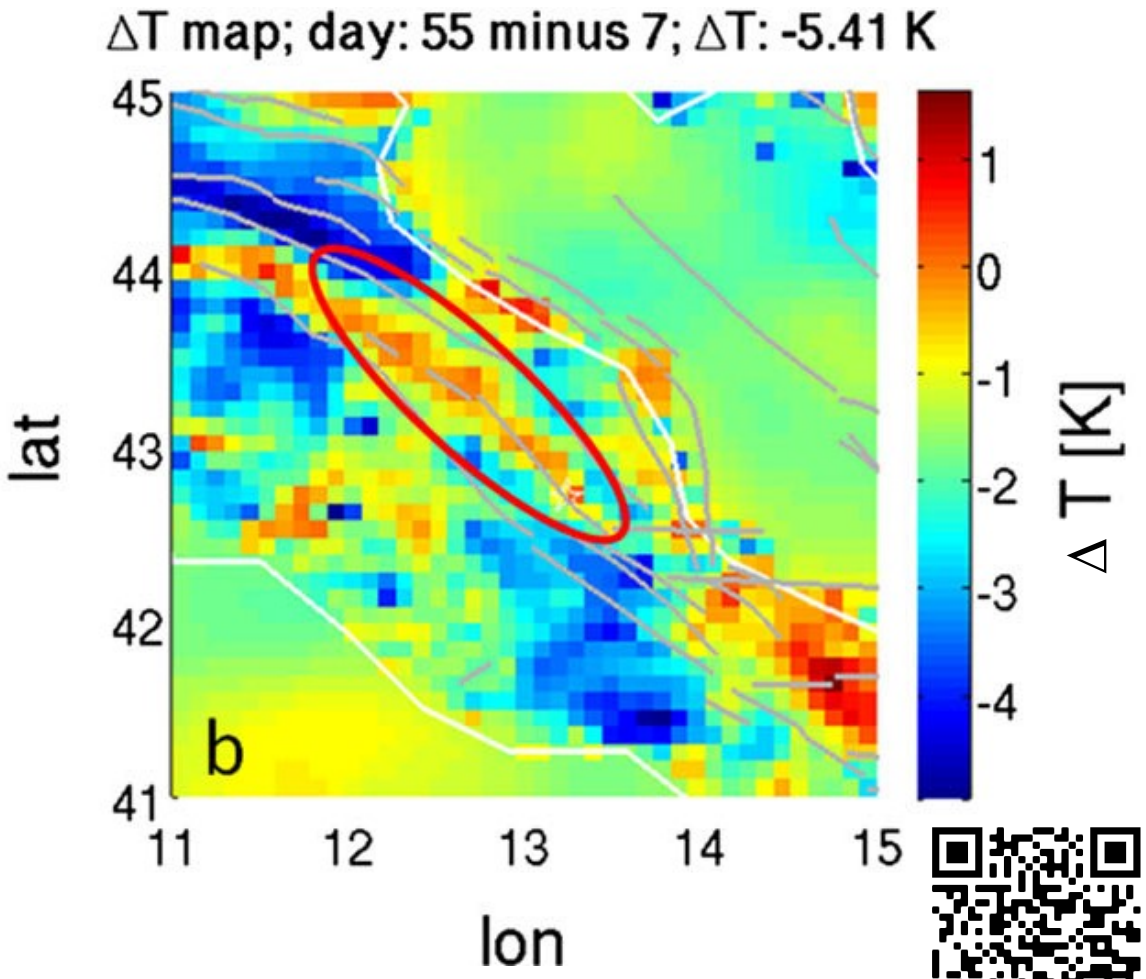
Example of variation of daily precipitation (mm/day) in July-August between MERRA-2 and GPCP 1980-2015 From Gelaro et al. JCLI, 2017

EGU2020-19809 | Displays | NH4.5

Climatological datasets and earthquakes

- Beside the precious goals of these projects we would like to explore if these **big-data** resources of the atmosphere physical and chemical parameters could help in understanding the preparatory phase of medium-large **earthquakes** (M6/7+) in the world.
- We already explored this possibility successfully for several earthquakes in the world: M6.0-M6.5 2016 Italy, M7.8 2016 Ecuador, M7.3 2017 Iran and M7.5 2018 Indonesia earthquakes (Piscini et al. PAGeoph, 2017, Marchetti et al. RSoE, 2019, Akhoondzadeh et al. ASR, 2017, Akhoondzadeh et al. ASR, 2019 and Marchetti et al. JAES, 2019).
- In this paper we will extend this approach to all the shallow earthquakes occurred in a large time window (~40 years) with a minimum magnitude in the world.

Example of warming of central Italy above seismic fault line 1.5h before the M6.0 Amatrice 2016 EQ

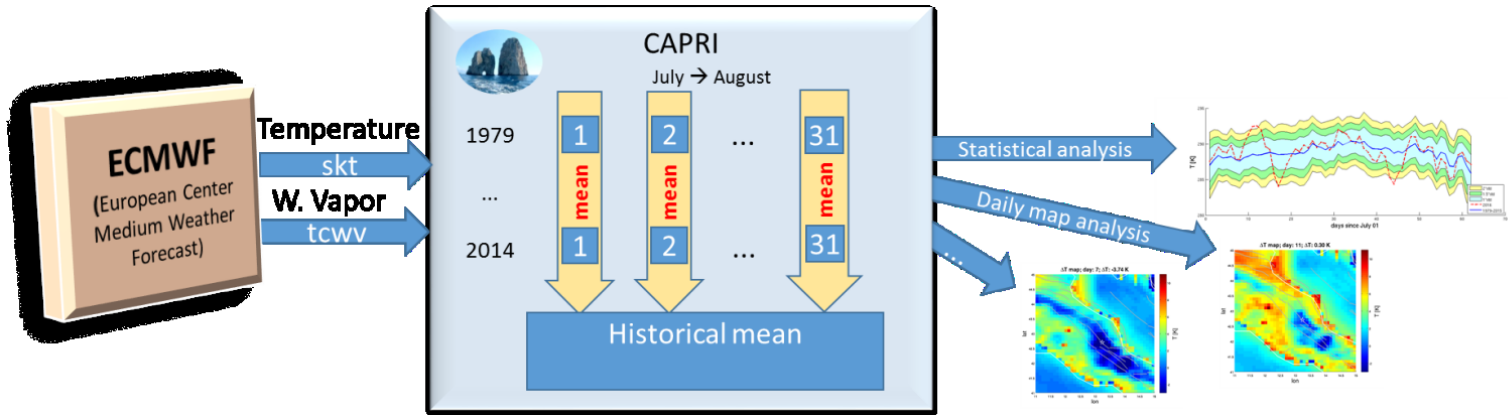


From Piscini et al. PAGeoph, 2017

CAPRI & MEANS algorithms

General Concept to extract the anomalies of an atmospheric parameter

- Characterize the typical value of the parameter under investigation for the region in the particular day in terms of mean and standard deviation over a period of about 40 years.
- Search if in the inspected year the value of the parameter overpasses at least K standard deviations above the mean (typical value is K= 2 or greater).



CAPRI

Spatial averaging

$$T_{ERA}(d)_y = \langle T_{ERA}(d,\lambda,\varphi)_y \rangle_{\lambda,\varphi}$$

"Global warming" removing

$$T'(d)_y = T_{ERA}(d)_y - m(d) \times (y - y_0)$$

Neglecting of spurious years

$$if\ [T(d)_y > 10\ \times \sigma_T]\ then\ y \to \bar{y}$$

MEANS

Historical mean:

$$T_h(d) = \frac{1}{N_y} \sum_{y=1979*}^{2017} T'(d)_y$$

Shifting to historical mean

$$T(d)_{\tilde{y}} = T'(d)_{\tilde{y}} - \left(\langle T'_{\tilde{y}} \rangle_d - \langle T_h \rangle_d\right)$$

* MEANS starts from 1980

Complete description of the algorithms:

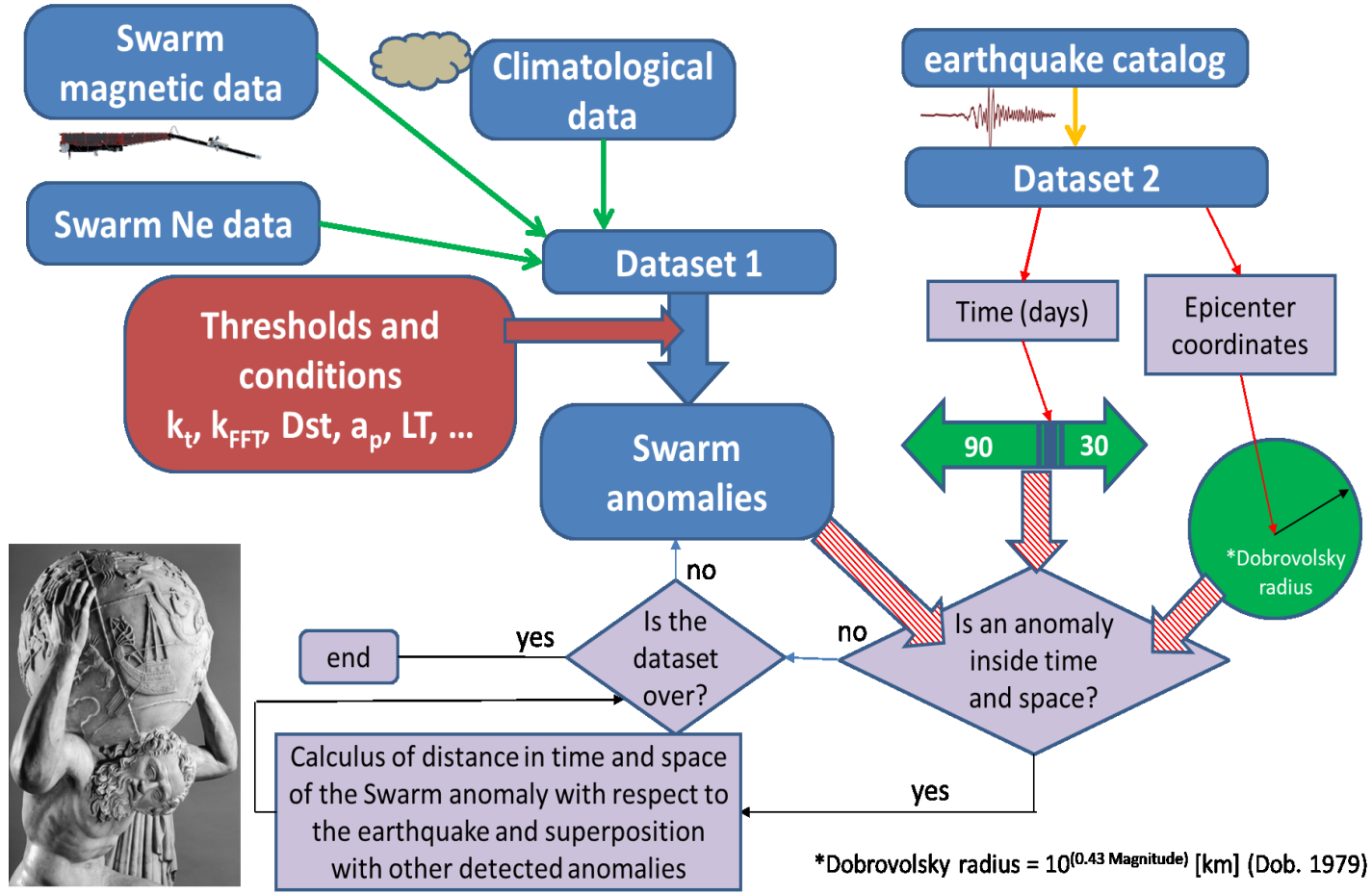
[Piscini et al. PAGeoph, 2017]

[Piscini et al. PAGeoph, 2019]

EGU2020-19809 | Displays | NH4.5

Worldwide Statistical Correlation algorithm

- The INGV within the **ESA SAFE**, **e-SAFE** and **ASI Limadou-science** projects developed a tool to correlate satellite anomalies and earthquake occurrences in terms of space and time by the method of the superposed-epoch approach.
- The tool is called WSC (Worldwide Statistical Correlation) algorithm and has been successfully applied to magnetic and electron density satellite data (De Santis et al. Sc.Rep, 2019).
- Here we applied the same tool to physical and chemical atmospheric parameters from climatological datasets.



Picture adapted from Supplementary materials of De Santis et al. Sc.Rep, 2019

For details on Swarm results, and future trends see:

De Santis et al. Sc.Rep, 2019,
EGU Display EGU2020-13140 by De Santis and SAFE Team,
EGU Display EGU2020-20281 by Campuzano et al.

Results of the analysis

- Statistical correlation of MERRA-2 Aerosol(AOT), dimetilsulphide (DMS), Surface Air Temperature, SO_2 and CO 2σ anomalies with shallow M8+ earthquakes (max 50km depth) from 1980 to 2017.

Statistical results for each analysed parameter

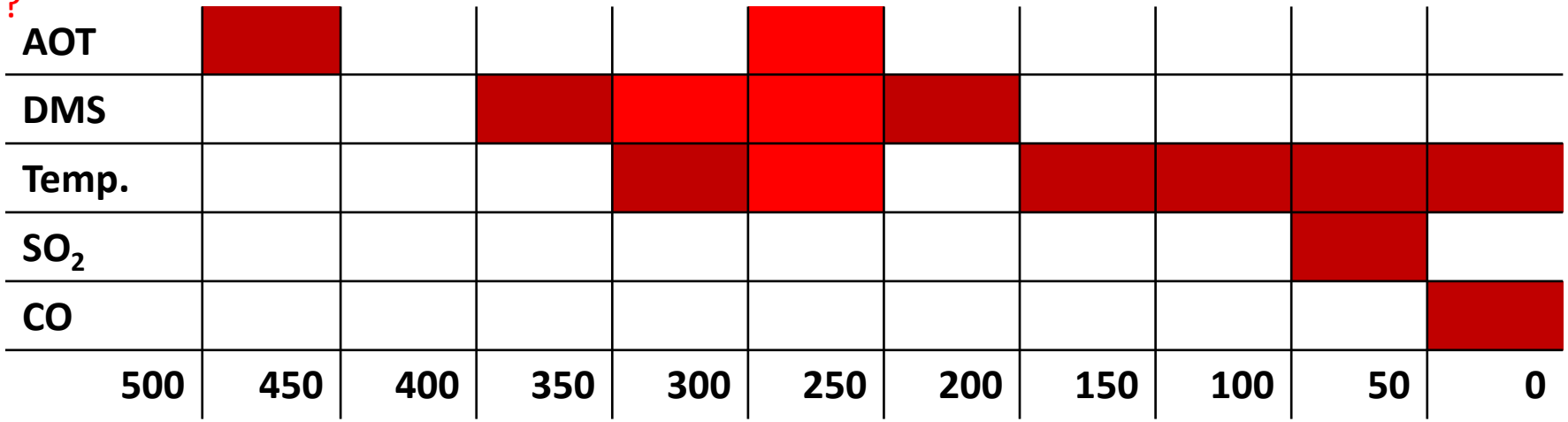
	d	n	Days before EQ of MAX (±5)	Number of anomalies in MAX	Number of EQs in MAX	%EQs in max	% anomalies associated to some EQs
AOT	1.2	6.8	345	197	23	72%	4.1%
DMS	1.7	23.0	175	237	22	69%	5.8%
Temp.	2.5	41.8	35	374	23	72%	6.9%
SO_2	1.9	24.3	55	254	18	56%	4.7%
CO	2.0	28.7	15	288	13	41%	5.1%

Ratio over random simulation

How many σ over random simulation?

The concentration is	
	very significant
	Significant

Temporal distribution of the more significant anomalies



Conclusions

- In the maximum concentration of anomalies generally these analyses found a large number of earthquakes (from 41% up to 72%).
- With respect to the random simulations, the real distributions are more concentrated in particular times (some times are the same for several parameters). The simulations are homogeneous in space and time.
- Each analysed parameter seems to give a contribution in the preparatory phase of these large (M8+) earthquakes, especially surface air temperature, CO and SO_2.
- It is possible to identify a sequence of processes that involve in the order: aerosol, dimetilsulphide, temperature, SO_2 and finally CO!
- On occasion, several alterations of atmosphere preceding a large earthquake could be produced by volcanic eruption in the same area as the seismic active regions tend to coincide with active volcano locations. Further studies could assess better the relation between the two phenomena.

EGU2020-19809 | Displays | NH4.5

Thank you for attention!

Please, your comments are welcome!

Picture on the background: Surface ground displacement of about 40cm on Vettoretto Mount – Central Italy caused by M6.0 24-08-2016 and M6.5 30-10-2016 EQs