EGU2020-19809
https://doi.org/10.5194/egusphere-egu2020-19809
EGU General Assembly 2020

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

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Applying a multi-parametric approach, we already investigated the preparatory phase of several medium and large (M6.0 ~ M8.3) earthquakes occurred in the last 6 years in different locations in the World. In some cases, a chain of processes from the lithosphere to atmosphere and ionosphere has been successfully detected (e.g. M7.8 Ecuador 2016: Akhoondzadeh, 2018, ASR, https://doi.org/10.1016/j.asr.2017.07.014; Italian seismic sequence (M6.5) 2016-2017: Marchetti et al., 2019, RSoE, https://doi.org/10.1016/j.rse.2019.04.033; M7.5 Indonesia 2018: Marchetti et al., 2019, JAES, https://doi.org/10.1016/j.jseaes.2019.104097). These analyses underline the importance to study all the “spheres” that surround the Earth as suggested by a Geosystemic approach (De Santis et al., 2019, Entropy, https://doi.org/10.3390/e21040412). To analyse the anomalies that occur in the atmosphere we typically calculate the mean and standard deviation of the “historical time series” of the investigated parameter based on around 40 years of data, and then we superpose the value of the same quantity in the earthquake year. If the value overpasses two standard deviations of the historical time series, we define this day/parameter as anomalous. Applying the same methodology presented in previous works that studied climatological parameters such as skin temperature, total column water vapour, aerosols, and SO_2, which seem to provide anomalies possibly related to the earthquake preparation phase (e.g. Piscini et al., 2017, PAGeoph, https://doi.org/10.1007/s00024-017-1597-8), here we investigate more atmospheric parameters proposed as possible precursors in the Lithosphere Atmosphere Ionosphere Coupling (LAIC) models (Pulinets and Ouzounov, 2011, JAES, https://doi.org/10.1016/j.jseaes.2010.03.005) such as methane and surface concentration of carbon monoxide. Other parameters, such as dimethylsulfide could be useful in other geophysical events, such as the volcano eruptions (Piscini et al. PAGeoph 2019, https://doi.org/10.1007/s00024-019-02147-x).

In this study, we also apply a Worldwide Statistical Correlation (WSC), as it was successfully applied

to Swarm satellites electromagnetic anomalies and earthquakes, providing some statistical evidence for such perturbations in ionosphere before the occurrence of M5.5+ earthquakes (De Santis et al., 2019, Sci. Rep., https://doi.org/10.1038/s41598-019-56599-1).

The statistical approaches applied to these climatological data, provided by meteorological agencies such as ECMWF and NOAA, provides some interesting concentrations of atmospheric anomalies, preceding from days to several weeks the occurrence of the largest earthquakes from 1980 to 2017.

The study of several chemical and physical (e.g. aerosol particles) components in the atmosphere, the involved physical processes, the chemical reactions and chemical constraints (such as the elements lifetime and interactions in the atmosphere) can help to distinguish which LAIC model is more reliable to produce the observed anomalies before the occurrence of a large earthquake.