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Different forcings and their effect on temperature variations in Portugal: volcanic eruptions, anthropogenic aerosols, atmospheric circulation and solar activity

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The aim of this study is to recognize the imprints of different forcings in portuguese climate variations using a better-quality temperature time series. Obtained results confirm the influence of the volcanic eruptions as well as solar and geomagnetic activities variations on the climate changes in this Iberian region. It is also shown how the character of the response depends on the type of studied temperature parameter, on the time period and on the season.

Series of monthly minimum (Tmin) and maximum (Tmax) temperatures measured in the three meteorological stations of Lisbon, Coimbra and Porto over more than 100 years were treated. Non-climatic breaks were identified and the series were homogenized. These series, together with monthly series of mean temperature (meanT) and temperature range (DTR) derived from them, were subjected to Principal Component Analysis to extract the leading principal components. The first principal component (PC1) accounts for as much of the variability in the original data as possible. In our case the PC1 series for Tmin, Tmax, meanT and DTR accounts for 78.8-96.1% of the variability depending on different temperature parameters and months. The PC1s were used to study the effect of different forcings on variations of the portuguese climate during the period from 1888 to 2001.

We focused our attention on four types of forcings: volcanic eruptions, anthropogenic greenhouse gases, global atmospheric circulation and solar and geomagnetic activity variations. To parameterize these forcings we used the following data: different ice core data sets which give us the information about volcanic activity and greenhouse gases variability; NAO index as the longest available data set to describe the atmospheric circulation in the studied region; sunspot number, cosmic ray flux and aa-index series to describe the variability of solar and geomagnetic activities.

Different statistical tests as correlation analysis, multiple regression analysis and superposed epoch analysis were used to identify the response of the temperature parameters to the forcings. The advantage of the new temperature series in use is their length. It allows to study separately the climatic variations during two periods of large volcanic eruptions (from 1888 to 1912 and from 1963 to 2001) and during a period of small eruptions (from 1912 to 1962). The analysis we made shows, in particular, that during the large eruptions periods Tmin, Tmax and meanT have often lower values and correlate better with atmospheric aerosol concentration than with solar and geomagnetic parameters. However, the variations of DTR are ambiguous and need additional investigation. Also, the length of the temperature series allows us to compare the significance of different forcings during pre-industrial and industrial periods.