Institute of Geodynamics
Romanian Academy

Scientific report

Project

„**The solar and geomagnetic activity and their influences on the terrestrial environment. Case study – climate**”

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Synthesis

In this stage of the project, entitled „***Analysis of solar/geomagnetic signature in data from meteorological stations at local, regional and continental scale”***, we aimed at studying, based on statistical correlation analysis, the effect of the external forcing by the solar/geomagnetic variability on climate parameters. The long term correlation analysis has been carried out using indices that describe the solar/geomagnetic activity and the surface air temperature recorded at meteorological stations both on the Romanian territory and on the European continent.

The present report is structured in chapters, according to activities for the stage II 2012 of the working plan.

In *Chapter 1*, entitled **"Determining trends in the surface air temperature evolution and of precipitation using various spectral analysis techniques"**, results of applying classical and non-linear spectral analysis methods on data series recorded at meteorological stations are described.

Assessing the climate variability depends on the existence and accuracy of records of climatic parameters, such as air temperature or precipitation. As it was presented in the report to the previous stage of the contract in the chapter concerning the data base of the project, for Europe a set of data from more then 40 weather stations approximately uniformly distributed in the mid-latitude area is available. To find tendencies and periodicities in data, both standard spectral analysis and non-linear analysis techniques were used: the Fast Fourrier Transform (FFT) or the Multi-Taper Method (MTM) and, respectively, the Detrended Fluctuations Analysis (DFA). In the following we present, as an example, results obtained by means of FFT and MTM, in case of one of the longest record with instrumental data (1706-2011), station De Bilt, Netherlands and those obtained by DFA for stations in Romania and Arctic Canada.

The spectral analysis of time series indicates the presence of short period variations (2-7 years), variations with a period of ~11 years, as well as longer periods, of 22-30 years, or even longer, of ~80 years, which superpose in the analyzed signal.

In the following we describe in somewhat more detail the non-linear method DFA applied, on daily temperature data from several stations in Romania and Arctic Canada. The results are presented in Fig. 1 and, respectively, Fig. 2. The method is used to identify patterns in air temperature time series from a multi-scale perspective, because it has the capacity to identify scaling aspects in time series even in the presence of trends which origin and form are unknown. One determines a scaling exponent, denoted k or H, that characterizes the scaling behaviour of the pattern in data. The *k* value indicates persistence ($k > 0.5$), antipersistence ($k < 0.5$), or uncorrelated noise in data ($k = 0.5$). The analysis of *k* for chosen stations and territories allows to study effects of various processes that influence climate at the given points.

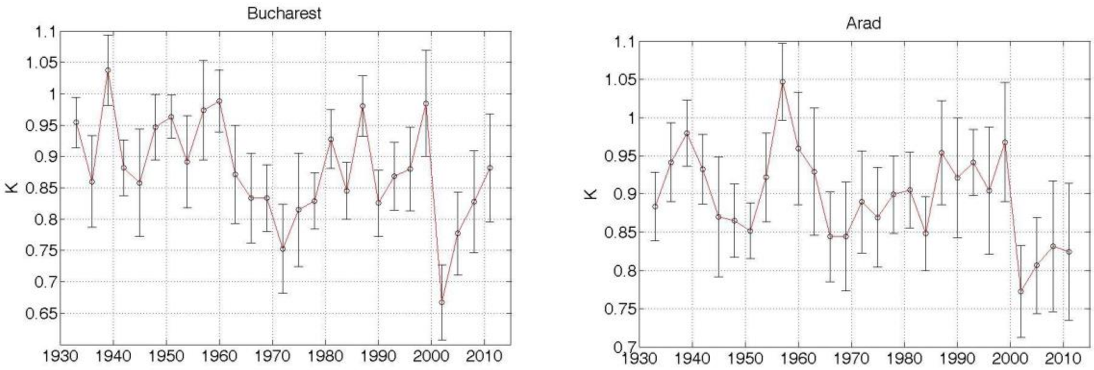

Fig. 1 The scaling exponent for the weather station Bucharest (left) and Arad (right) for daily average temperatures

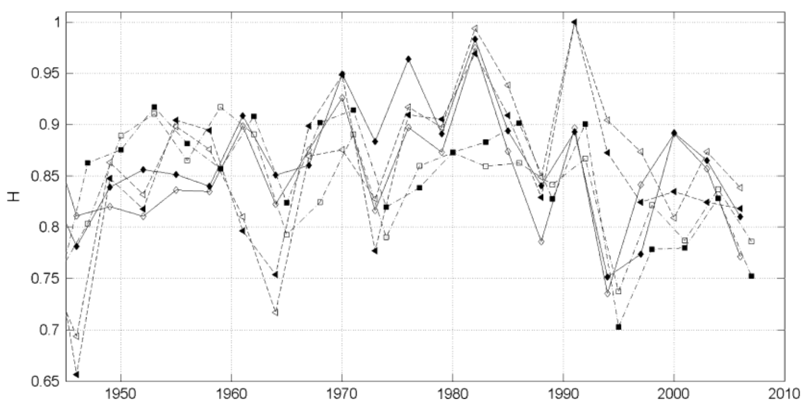

Fig. 2 The scaling exponent for 3 weather stations in Arctic Canada in case of daily minimum (full symbols) and maximum (empty symbols) temperature

Among the conclusions of our analyses we mention:

- in case of daily temperature time series, the patterns are characterized by scaling properties between 1-2 months and 5-8 years;
- the scaling coefficients range in the interval 0.70 ± 0.05 for the great majority of stations in this study;
- the DFA analysis applied to successive temporal windows shows that scaling properties vary in time significantly;
- the patterns of the temporal changes underline common aspects between various stations, in spite of distances some times very large (in Arctic Canada) between stations and of different geographical characteristics of the corresponding areas;
- in general, the change of the persistence is seen at regional scale, depending only slightly on local factors.

The *Chapter 2* of this report, entitled **”Corrrelation analysis between climatic and solar/geomagnetic parameters”**, is dedicated to the statistical correlation analysis between the parameters. As we mentioned in the report to the previous research stage, the solar influence on climate cannot be directly measured, but correlations between the solar activity and climate parameters have been found.

The long term correlation analysis was performed using indices that describe the solar/geomagnetic activity (the sunspot number/the geomagnetic index aa) and the surface air temperature, parameters existent in the project data base. At the time scales of the Schwabe (11 years) and Hale (22 years) solar cycles, the research team found in climate parameters at regional and continental scales, coherent solar/geomagnetic signals with amplitudes of 2-3°C in case of the 11-year variation and of 0.6-0.8°C for the 22-year variation. The statistical correlation between the solar signal and that from the air temperature for the two spatial and temporal scales is presented in Fig.3. At the time scale of the 11-year cycle a good correlation with the solar activity in case of temperature at local scale (Romania, r = 0.4, statistical significance over 95%) is seen in comparison with the continental scale (Europe), while at the longer time scale (22 years) a delay of ~10 years between analyzed signals is present.

The effects of the Atlantic Ocean variability using climatic indices NAO (North Atlantic Oscillation) and AMO (Atlantic Multi-decadal Oscillation) on air temperature at continental scale have also been studied. An increased correlation (r=0.5, statistical significance over 95%), in phase, of the air temperature with NAO, one of the most important nodes of climate variability in Europe, was observed for both time scales. AMO, a variability mode al long time scale, of 60-80 years, shows its presence in the air temperature at a lower intensity (r=0.2, statistical significance over 95%) than NAO, with a delay of 6-8 years.

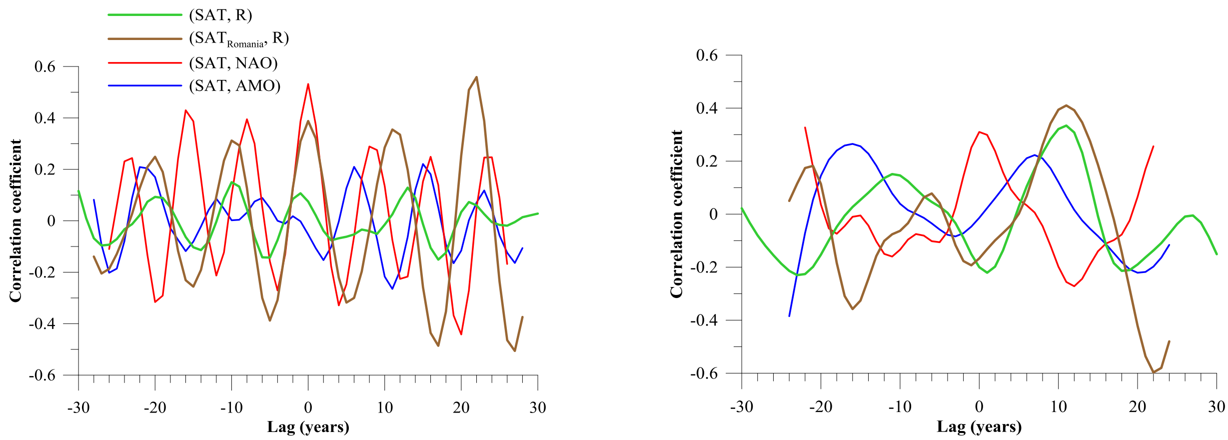

Fig. 3 Correlation coefficients between sunspot numbers, NAO and AMO indices, and the air temperature for Europe and Romania in case of 11-year (left) and 22-year (right) signals

In *Chapter 3*, **”Updating the project data base with data from NCEP/NCAR”**, the data base used to update the existing one is described.

The NCEP/NCAR data base is a result of a cooperation project between the National Centers for Environment Prediction (NCEP) and the National Center for Atmospheric Research (NCAR) in USA, called the Reanalysis Project NCEP/NCAR. The aim of this project was to produce a data bank with atmospheric fields for a 51-year interval starting with 1948, which is continuing at present by collecting a large volume of terrestrial, marine, atmospheric soundings, satellite data etc. and by control and assimilation of these data with an assimilation system (CDAS), the same for all the analyzed period.

The reanalysis of data produced two types of information, namely:

- a data set regarding the distribution of parameters that describe the atmospheric fields in a 4-D network (horizontal resolution of 2.5x2.5° latitude and longitude), as a result of modeling the distribution of atmospheric parameters;
- the observed data set, organized in a coherent system (common format, BUFR), that includes also an information on data quality.

The model has a temporal coverage with 4 values a day, daily and monthly values beginning with 01/01/1948. On long term, monthly averages are derived from data for 1981 – 2010. The distribution on various levels is: at surface or close to the surface (0.995 sigma level), or the whole atmosphere (eatm). Data are divided in 7 separate files: pressure level, surface fluxes, other fluxes, tropopause, derived data, spectral coefficients.

The content of data base refers to:

a) for the interval 1958-1998: monthly averages of the latent heat, the net radiation of long wavelength at surface, the net solar radiation at surface, specific precipitation, the sensible heat flux, surface pressure, ground level temperature, specific humidity, temperature at 2 m, wind at 10 m, sea level pressure, precipitable water, for various levels;

b) monthly climatology of the fields mentioned above;

c) for the interval 1948-1957: monthly averages of the height of the 700 and 500 mb levels, temperature at 700 mb, winds at 200 and 850 mb levels, superficial temperature, pressure at the sea level;

d) other information for the United States and various softwares.

As an example of using the data base (the reanalysis model 1, 1948-present), in Fig.4 the mean air temperature in 1948 at the 1000 mb level, for Europe, is presented.

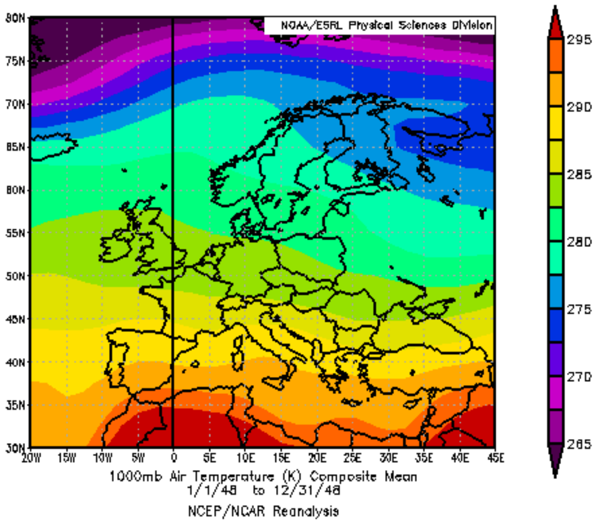

Fig. 4 Air temperature from NCEP/NCAR data, for Europe, at 1000mb level

In *Chater 4*, entitled "**Dissemination of results**", it is mentioned:

(1) updating the project web page: http://www.geodin.ro/PN_II_2011/engl/index.html, with the project stage II results. The page will be updated when appropriate during the project.

(2) presentations at national and international conferences:

- Dobrică V., Şuţeanu C., Demetrescu C., Solar/geomagnetic signature in climate parameters. A comparative analysis of the temperature evolution in Atlantic Canada and Central Eastern Europe, *European Geosciences Union (EGU) General Assembly*, Vienna, Austria, 22-27 April 2012.
- Şuţeanu C., Dobrică V., Demetrescu C., Space time variability in scaling aspects of surface air temperature records, *European Geosciences Union (EGU) General Assembly*, Vienna, Austria, 22-27 April 2012.
- Dobrică V., Demetrescu C., Long-term changes in the Romanian climate, *First International Conference on Moldavian Risks – From Global to Local Scale*, Bacău, Romania, 16-19 May 2012.
- Dobrică V., Demetrescu C., Ştefan C., Long-term variations of the 20th century European climate. Solar/geomagnetic signals. *Asia Oceania Geosciences Society (AOGS) Assembly*, Singapore, 13-17 August 2012.

- Dobrică V., Şuţeanu C., Demetrescu C., Long-term timescale interactions between solar/geomagnetic activity and European climate, *European Meteorological Society* (*EMS) Assembly*, Lodz, Poland, 9-14 September 2012.
- Dobrică V., Demetrescu C., Long-term solar and geomagnetic activity. Consequences on the terrestrial climate at regional scale, *International Conference on Solar and Heliospheric Influences on the Geospace*, Bucharest, Romania, 1-5 October 2012.
- Dobrică, V., Demetrescu, C., Maris Muntean, G., Relationship at long-term timescale between the solar and Atlantic Ocean variabilities and European climate, *9th European Space Weather Week*, Brussels, Belgium, 5-9 November 2012.
- Dobrică, V., Demetrescu C., On the evolution of precipitation in Central and South-Eastern Europe and the relationship with Lower Danube discharge, *Fall Meeting of the American Geophysical Union (AGU),*San Francisco, 3-7 December 2012.

(3) published papers: Suțeanu, C., Mandea, M., Surface air temperature in the Canadian Arctic: scaling and pattern change, Meteorol. Atmosph. Phys., 2012, doi : 10.1007/s00703-01200206-8.

Project Director,

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