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Latitude dependency of solar flare index–temperature relation occuring over middle and high latitudes of Atlantic–Eurasian region

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Abstract

By applying multitaper methods and Pearson test on the surface air temperature and flare index used as a proxy data for possible solar sources of climate-forcing, we investigated the signature of these variables on middle and high latitudes of the Atlantic–Eurasian region (Turkey, Finland, Romania, Ukraine, Cyprus, Israel, Lithuania, and European part of Russia). We considered the temperature and flare index data for the period ranging from January 1975 to the end of December 2005, which covers almost three solar cycles, 21st, 22nd, and 23rd.

We found significant correlations between solar activity and surface air temperature over the 50–60° and 60–70° zones for cycle 22, and for cycle 23, over the 30–40°, 40–50°, and 50–60° zones.

The most pronounced power peaks for surface air temperature found by multitaper method are around 1.2, 1.7, and 2.5 years which were reported earlier for some solar activity indicators. These results support the suggestion that there is signature of solar activity effect on surface air temperature of mid-latitudes.

Research Highlights

► Space weather. ► Solar–terrestrial ınteractions. ► Climate.

Introduction

The relationship between solar activity, weather, and climate still appears as a controversial topic. The source of this controversy seems to result from an apparent uncompromising fact. To briefly resume, on the one hand, some authors claim that the temperature increase observed over the last hundred years can be explained solely by solar output variations (Friis-Christensen and Lassen, 1991, Cliver et al., 1998, Haigh, 2001, Lean and Rind, 2001, Shindell et al., 2001) while, on the other hand, others claim that it is solely anthropogenic (Levitus et al., 2001, Barnett et al., 2001 and many others). Lefebvre and Rozelot (2006) tried to separate the two components by analyzing the cross-correlation found between reconstructed total solar irradiance (TSI) and earth global temperature (EGT) data, over three independent periods of time (1856–1910, 1910–1945, 1946–1975) as defined in the Intergovernmental Panel in Climate Change report, and two non-independent (1856–1887, 1856–1975). The conclusion is that large UV variability of solar irradiance, more than twice in amplitude than in other spectral ranges, has been underestimated in the Earth

temperature changes, and clearly remains still misjudged. Other effects have been poorly investigated, such as the influence of cosmic rays on cloudiness. Therefore, there is a great deal of interest in studying links between solar activity and changes in Earth's climate. Let us recall none but that has been known for some time a statistical relation between solar indicators as expressed for instance, by the sunspot number or flare index (FI) and the surface air temperature (see Fig. 1). *"In 1801 Herschel first proposed a relationship between climate and the level of solar activity"* (Hoyt and Schatten, 1997). A lot of scientific effort has been then exercised in trying to understand and qualify how much influence the Sun exerts on Earth's climate (see for instance Eddy, 1976, Hoyt, 1979, Reid, 1991). We may highlight some of the recent scientific researches on such solar linkages with surface air temperature. Soon (2005) obtained very high correlation between the decadally smoothed Arctic observational temperature data and TSI, even for the last decades. Kilcik (2005) comparing solar irradiance model data with the surface air temperature variations of two countries, USA and Japan, showed the influence of solar activity variations on the Earth's climate. Kilcik et al. (2008) investigating the effects of solar activity on the surface air temperature of Turkey found a significant correlation between solar activity and surface air temperature for solar cycle 23. The debate is not closed, and although climatic observations are well established and widely accepted, the mechanism(s) which stand behind a connection between weak solar activity and colder climate is far to be completely understood (Kallenrode, 2004).

On a global scale, the correlation between solar activity indices and surface air temperature may be positive, negative, or even zero. The correlation is always different for different areas, even if the same area is observed (Zhang and Li, 1989, Georgieva, 1998). For example the existence of a positive and negative correlation between the surface air temperature of the Northern hemisphere and the solar activity during the period 1881–1988 has been shown by Georgieva (1998). The author reported that the sign of the correlation changes from negative until 1920–1930 to positive afterwards. However, the same correlation over Canada area is negative (Bucha and Bucha Jr., 1998). Valev (2006) found statistically significant correlations between global and hemispheric temperature anomalies and geomagnetic *aa* indices for the time period running from 1856 to 2000. He also reported that the correlation between the temperature anomalies and the geomagnetic indices is about two times higher than the correlation between the temperature anomalies and the solar indices. These results support the suggestion that the geomagnetic forcing predominates over the solar activity forcing on the global and hemispheric surface air temperatures. These findings put in evidence that the relationship between solar activity and surface air temperature is not direct (some feedbacks may exist), varies with time and probably also with the considered geographic area. Therefore, the question of how exactly the solar variability can influence the climate is still open.

The present study offers the possibility to quantitatively evaluate the relationship between solar activity and surface air temperature over a well-defined geographic area. We specify the data used and describe the methods of analysis in Section 2. The results are given in Section 3, while discussion is reported in Section 4. The conclusion remarks are presented in Section 5

Section snippets

Data and methods

Data sets of (i) monthly and yearly surface air temperature data of mid-latitudes and (ii) monthly and yearly solar flare index (FI) are used, respectively, as climate parameter and solar activity indicator. Due to a good monitoring of the data, the time period of this study covers in general the last 31 years (1975–2006).

Temperature and altitude data set of Turkey is taken from Turkish State Meteorological Service. The temperature and altitude data sets out of Turkey are taken from web-site of …

Analyses and results

The latitudinal dependencies of the surface air temperature data sets are studied by comparing the 30–40° latitudinal zone's temperature data with all other zone's data. This comparison is given in Fig. 4.

This figure shows a high correlation only between the 30–40° and the 40–50° zones. The correlation coefficients decrease with the increase in the latitudes. This indicates that the change in the surface air temperature is strongly related with the latitude, indicating that Sun–climate…

Discussion

Climatic changes have been considered as composed of natural (solar, geomagnetic, and volcanic activities) and anthropogenic (human-induced factors such as concentration of greenhouse gases) influences. Many attempts have been made to connect climatic changes with variability of solar activity parameters (e.g. Friis-Christensen and Lassen, 1991, Cliver et al., 1998, Haigh, 2001, Haigh, 2007, Lean and Rind, 2001, Shindell et al., 2001), of volcanic activity (in connection with huge volcanic…

Conclusions

By correlative and spectral analysis of flare index and surface air temperature data over 31 years covering almost three solar activity cycles, overall conclusions are as follows:

- Surface air temperature of the studied geographic area is positively correlated with the solar flare index.…
- Signatures of solar activity effect exist on surface air temperature of mid-latitude zones according to our statistical analysis and over the considered period of time.…
- MTM analyses of surface air temperature show…

…

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Physics and Chemistry of the Earth (2006)

D. Valev
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