Long-term solar activity variations as a stimulator of abrupt climate change

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Received 20 October 2007; accepted 18 November 2007; published 15 December 2007.

Analysis of solar forcing of climate on long time scales has shown that it is necessary to take into consideration the influence of long-term solar cyclicity, such as 200 and 2300–2400-year cycles, on climate. Even in the relatively warm climate of the last 10,000 years, a tendency to climate cooling at deep minima of long-term solar cyclicity is observed. Along with this, a long-term solar forcing of climate manifests itself not only as an external factor due the influence of solar irradiance variations on the atmosphere-ocean system, but also as a stimulator of internal processes in the climatic system, which, in turn, can lead to abrupt climate change. Large-scale abrupt climate oscillations – warmings and subsequent coolings (Dansgaard-Oeschger cycles) – have been revealed in cores of Greenland ice for the interval 60,000–10,000 years BP. They are attributed to the ice-rafting events in the North Atlantic. A comparative analysis of the development of Dansgaard-Oeschger events and solar activity variations (variations in the 10Be concentration in Greenland ice) has shown that these climatic and solar processes developed simultaneously. It is evident that ice-rafting events were stimulated by an increasing ambient temperature and, hence, they are associated with a high solar activity level. A similar effect of solar activity has been revealed for the time interval of the Holocene. Thus, not only a low, but also a high level of solar activity was in the past a stimulator of abrupt climate changes. INDEX TERMS: 1616 Global Change: Climate variability; 1650 Global Change: Solar variability; 7536 Solar Physics, Astrophysics, and Astronomy: Solar activity cycle; KEYWORDS: solar activity variations, abrupt climate change, ice-rafting events.


1. Introduction

Extreme weather conditions observed at present that occur on the background of global warming, which is typically interpreted as a result of anthropogenic effects, can be a manifestation of a global rearrangement in the atmospheric circulation. Attention should also be paid to development of extreme solar events in recent years [see, e.g., a special issue of Geomagnetism and Aeronomy, 2006, vol. 45, no. 1], which can be attributed to the fact that now we are in the vicinity of the maximum of the quasi-two-hundred-year solar cycle [Raspopov and Dergachev, 2005]. Thus, anthropogenic and long-term natural factors simultaneously affect large-scale atmospheric processes. A natural question then arises as to whether the development of extreme meteorological conditions converts into variations in climatic parameters on the global scale under these conditions. In this respect it is reasonable to inquire into the effects of solar activity and its variability on large-scale climate changes in the past. Analysis of climatic data and effects of both the 200- and 2300–2400-year solar cycles has shown that they indeed can result in abrupt climate change. Note that there is a tendency to cooling or abrupt climate change at deep solar minima [Dergachev et al., 2005; Eddy, 1976; Mayewsky et al., 2004; Raspopov et al., 2005, 2007; Soon and Yaskell, 2003]. A striking example is the Little Ice Age in 1600–1880-ies.