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Solar Minima, Earth's rotation and Little Ice Ages in the past and in the future: The North Atlantic–European case

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Abstract

The past Solar Minima were linked to a general speeding up of the Earth's rate of rotation. This affected the surface currents and southward penetration of Arctic water in the North Atlantic causing “Little Ice Ages” over northwestern Europe. At around 2040–2050 we will be in a new major Solar Minimum. It is to be expected that we will then have a new “Little Ice Age” over the Arctic and NW Europe. The mechanism proposed for the linkage of Solar activity with Earth's rotation is the interaction of Solar Wind with the Earth's magnetosphere; the decrease in Solar Wind at sunspot minima weakens the interaction with the magnetosphere that allows the Earth to speed up, and the increase in Solar Wind at sunspot maxima strengthens the interaction with the magnetosphere that slows down the spinning of the Earth.

Introduction

The concept of geoid changes (Mörner, 1976) seemed to imply that there would hardly be any order in the eustatic differentiation over the globe. Despite this, I observed that there were some regularities, viz. correlation and anti-correlation between certain regions. Furthermore, those regions were strongly affected by ocean surface currents. The Kuro Siwo Current and the Gulf Stream seemed to beat in pace, and the Equatorial Current seemed to record an East–West beat. This could, in my opinion, only be understood in terms of a feedback interchange of angular momentum between the oceanic surface currents and the solid Earth (Mörner, 1984, Mörner, 1987, Mörner, 1988, Mörner, 1990, Mörner, 1992, Mörner, 1993). The Gulf Stream seemed to exhibit 16 major pulses or beat within the Holocene (Mörner, 1984). In the climatic–eustatic cyclicity diagram of Mörner (1973) there are 23 Holocene pulses recording frequency-changes pulses ordered in three larger waves fitting well with oceanic circulation pulses (Mörner, 1995a). The concept is further analysed elsewhere (Mörner, 1995b, Mörner, 1996a, Mörner, 1996b, Mörner, 2005). In this paper I will address the question of Solar Minima in the last 600 years and the next one to be expected at around 2040–2050.

Section snippets

Major frames and boundary conditions

Mass, energy and momentum — what I called “the holy trinity” in terrestrial and planetary physics (Mörner, 1995b, Mörner, 1996a) — are usually all considered as “constant”. This is illustrated in Fig.1 with respect to our terrestrial situation. Earth's energy could be altered by changes in Solar irradiance (Fig.1, right). Despite the fact that the variation during a sunspot cycle is small (e.g. Foukal & Lean, 1990, Willson, 1997, Pap & Fröhlich, 1999), hypothetical larger Solar irradiance…

Solar variability

The 11-year sunspot cycle and its longer cycles are well known phenomena. The search for those cycles in terrestrial variables has a long and intense history, which lies beyond the scope of this paper, however (e.g. Lean et al., 1995, Willson, 1997, White et al., 1997, Bard et al., 2000, Rind, 2002). For the last 150 years, there seems to be a good correlation between changes in the length of the sunspot cycle and general changes in global mean temperature (Friis-Christensen and Lassen, 1991),…

Earth's rotation

The Earth's spin rate (angular momentum) varies on the long-term basis as well as on the short-term basis. It is usually measured and expressed in changes in the length of the day (LOD). Changes in the total angular momentum (like deceleration due to tidal friction) are compensated within the Earth–Moon system (e.g. Marsden and Cameron, 1966). Differential changes, on the other hand, imply the interchange of angular momentum between the different layers and sub-layers of Planet Earth (Mörner,…

The Gulf Stream beat

The Gulf Stream is a remarkable system bringing hot equatorial water to higher latitudes. It implies the redistribution of mass (affecting Earth's rotation as recorded in sea level changes) and energy (as recorded in regional climate).

In the central North Atlantic, the Gulf Stream (North Atlantic Current) splits into individual branches (Fig.3); the main NE-branch (the North Atlantic Drift with Irminger Current, branches into the North Sea and the Norwegian–N. Cape Currents), an E-branch…

Climatic changes: N–S along West Europe

The St. Jérôm database (nowadays known as the European Pollen Data Bank, EPDB) of annual climatic changes over the last 900 years in a grid of every 10° Long. and 5° Lat. (Guiot, 1992) was kindly put at my disposal. The database is built on pollen records from land and sea cores. The conversion into temperature is achieved by the transfer–function methodology of Peyron et al., 1998, Peyron et al., 2006; cf. Guiot, 1990) implying that the values obtained are not true temperature values but…

AD 1672–1708 and the Maunder Minimum

The 17th century is especially interesting because it is the time of the famous Maunder Minimum and the main “Little Ice Age”. In the data set, there is a very clear and obvious signal within the period 1676–1704 (Mörner, 1995b). Fig.7 gives the records from the 8 stations from 1672 to 1798. In 1676 a warming begins in stations 5–8. From 1677 to 1679, there is a short cooling event in the North with a clear East to West decrease. From 1687 to 1703 there is a drastic cooling in the North. The…

Discussion

At all the three Solar Minima, the temperature signal in Europe was quite clear (Fig.6, Fig.7, Fig.8); viz. a cooling event spreading, with a maximum in the North Sea, down along the coast of Europe all the way to central Portugal (station 6). At the same time, the South Iberian and North African region (stations 7–8) experienced warming during the Spörer

and Maunder Solar Minima. This can only be understood in terms of a shift in the main flux of the Gulf Stream (Fig.3) and a southward…

Solar Wind and Earth's rate of rotation

Having noted that all the three major Solar Minima in the last 600years coincided with the Gulf Stream stage 4 situation of Fig.11, it seemed logical as a driving force to infer a general acceleration of the Earth's rate of rotation; in this case, not an interchange of angular momentum between the hydrosphere and the solid Earth (e.g. Mörner, 1988), but a speeding-up of the entire Earth.

Knowing that the Solar Wind beats with a tremendous force between Solar Maxima and Minima, varying its flow…

The Future Solar Minimum

The Solar activity follows cyclic patterns. Consequently, what happened in the past will also happen in the future. The combination of cycles can be done in different ways. Originally, I used a combination of the Gleissberg and De Vries cycles for the past 600years and extended into the Future giving a new Solar Minimum at around 2040–2050 (Mörner, 2005, Mörner, 2006a, Mörner, 2006b). In this paper, I use the Solar Irradiance curve of Bard et al. (2000), noting that this curve, in fact, rather…

Conclusions

All of three last Solar Minima (Dalton, Maunder and Spörer) correspond to periods of significant changes in surface heat distribution over Western Europe and the adjacent part of the North Atlantic. At the same time, the area of Gibraltar and Northwest Africa experienced periods of warming. The origin must predominantly be temporal and spatial changes in SST, and the driving mechanism for this has to be the changes in intensity and distribution of the transport of warm, saline water along the…

Acknowledgements

Professor Hugues Faure was an outstanding scientist. We met in the late 60s and immediately became friends, a friendship which grew into brotherhood within the years. Together, we draw up the lines for the INQUA Neotectonics Commission and started the annual issuing of the Neotectonics Bulletin (1977–1996). In 1979/80, we worked side by side when I stayed at his institute in Luminy setting up a paleomagnetic laboratory. It was a very creative and brainstorming period. Very early did Hugues…

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References (69)

R. Abarca del Rio *et al.*
Solar activity and earth rotation variability
J. Geodynam. (2003)

J. Guiot
Methodology of the last climatic cycle reconstruction from pollen data
Palaeogeogr., Palaeoclimatol., Palaeoecology (1990)

H.H. Lamb
Climatic variations and changes in the wind and ocean circulation: the Little Ice Ages in the Northeast Atlantic
Quaternary Res. (1979)

J. Lean *et al.*
Evaluating sun–climate relationships since the Little Ice Age
J. Atmosph. Solar—Terrest. Physics (1999)

N.-A. Mörner
Global Change: the last millennia
Global Planet. Change (1993)

N.-A. Mörner *et al.*
Carbon degassing from the lithosphere
Global Planet. Change (2002)

J.M. Pap *et al.*
Total solar irradiance variations
J. Atmosph. Solar–Terrest. Physics (1999)

O. Peyron *et al.*
Climatic reconstruction in Europe for 18000year B.P. from pollen data
Quatern. Res. (1998)

Impact of a warm arctic: arctic climate impact assessment

E. Bard *et al.*
Solar irradiance during the last 1200years based on cosmogenic nuclides
Tellus (2000)

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Cited by (26)

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2019, Coastal Zone Management: Global Perspectives, Regional Processes, Local Issues

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2018, Coastal Zone Management: Global Perspectives, Regional Processes, Local Issues

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The influence of solar system oscillation on the variability of the total solar irradiance
2017, New Astronomy

> *Citation Excerpt :*
> …The axis of rotation is tilted with respect to the axes of the orbital plane, and the shape of the Sun is elliptical in the polar directions. Because the Earth also moves inside the solar wind, modulation of the solar wind by the four large planets may also be directly felt by the Earth, in addition to the exchange of angular momentum resulting in faster or slower rotation, which modulates the climate (Mörner, 2010). Other studies have identified stationary periods in the solar dynamo.…

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An econometric investigation of the sunspot number record since the year 1700 and its prediction into the 22nd century

2015, Advances in Space Research

> *Citation Excerpt :*
>
> …SSN has been analyzed from both the statistical and the econometric viewpoint (Yule, 1927; Granger, 1957; Yoon, 2006), and has undergone thorough data collection and reconstruction of its long-term past, as far as back as the year 1610 (Schove, 1948; Eddy, 1976; Hoyt and Schatten, 1993; Usoskin, 2013), as well as cyclical behavior analysis (Schwabe, 1843; Hathaway et al., 1994, 2002; Svalgaard et al., 2005; Usoskin et al., 2000, 2007; Svalgaard and Hudson, 2010; Hathaway, 2010). Moreover, the likely climatological effects of the SSN on planet Earth have been inspected (Petrovay, 2010; Scafetta, 2014), alongside with cyclical short- and long-run prediction by means of calibration-based computational techniques (Thompson, 1993; Hoyt and Schatten, 1998; Mörner, 2010, 2011; Love and Rigler, 2012; Solheim et al., 2012, Solheim, 2013; NASA, 2014; Krainev, 2013), by means of statistical extrapolation (Lomb and Andersen, 1980; Hiremath, 2007, 2008; Brajša et al., 2009; Barnhart and Eichinger, 2011; Werner, 2012; Lomb, 2013), and by means of harmonic-model analysis (Scafetta, 2012, 2013). Similar predictive research has been applied to solar proxies, among which Total Solar Irradiance (Velasco Herrera et al., 2011) and the Radio Flux (NOAA, 2015)….

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Marsh benthic Foraminifera response to estuarine hydrological balance driven by climate variability over the last 2000yr (Minho estuary, NW Portugal)

2014, Quaternary Research (United States)

> *Citation Excerpt :*
>
> …Marsh foraminiferal response firstly reflects the elevation change from tidal flat to high marsh and the hydrological balance inside the estuary. The hydrological balance is closely connected to climate variability during the last millennia and its dependant on the fluctuations in solar activity (e.g., Duhau, 2006; Jager and Duhau, 2009; Jager and Nieuwenhuijzen, 2013; Keller, 2004; Lean, 2010; Mörner, 2010; Shindell et al., 2001; Usoskin, 2013; Versteegh, 2005; Wanner et al., 2008), which drives the position, migration and stability of atmospheric systems (e.g., Haigh, 2007) and oceanic circulation (e.g., Mörner, 2010). According to Shindell et al. (2001) and Martín-Puertas et al. (2012), the modeling of climate response to periods of low solar activity coupled with low NAO index and led to a southward displacement of the westerlies….

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Solar irradiance modulation of Equator-to-Pole (Arctic) temperature gradients: Empirical evidence for climate variation on multi-decadal timescales

2013, Journal of Atmospheric and Solar-Terrestrial Physics

> *Citation Excerpt :*
>
> …This would be consistent with a reduced poleward heat and moisture transport during a relatively cold period of reduced TSI. Such an empirical deduction is not inconsistent with the qualitative scenarios sketched by Mörner (2010) concerning the multidecadal-to-centennial-scale modulation of the flow dynamics of the Gulf Stream, including even the increasing southward penetration of cold Arctic-originated water, during cold intervals of the Little Ice Age owing to the mass, energy and angular momentum readjustments from the increasing Earth rotation rate. However, the caution posited by Huybers and Wunsch (2010, p. 1) is clearly valid; namely, that “few features of the paleo-circulation in any period are yet known with certainty.”…

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