

Solar Forcing – a new PAGES Working Group

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The Sun is the main driver of the climate system. However, its contribution to climate change is still highly uncertain despite the considerable scientific advances made in recent years. A large number of new paleoclimate records with high temporal resolution have been produced. Simultaneously, high precision measurements of the solar total (TSI) and spectral (SSI) irradiance have been performed using satellite bound radiation monitors. Attempts have been made to use proxies of solar activity to extend the instrumental records of TSI and SSI back in time for the past 10 ka. In order to link the solar forcing with the observed climate response, climate models have been improved to simulate dynamical couplings between stratosphere and troposphere, the effect of UV changes on the ozone, and the influence of solar energetic particles and cosmic rays on the upper atmospheric chemistry (Gray et al. 2010; Wanner et al. 2008).

In spite of these significant efforts many open questions remain; some of which will be addressed by the new PAGES working group on solar forcing.

Calibration of the instrumental TSI record

Since 1978 TSI is continuously measured most of the time simultaneously by several instruments on different satellites. Different research groups applying different corrections produced at least three different TSI composites with significant discrepancies. A new instrument points to a mean TSI that is about 5 Wm^{-2} lower than the often-assumed value of 1365 Wm^{-2} . Nevertheless, simple semi-empirical models of TSI are capable of reproducing the observed annual and shorter changes. However, the physical mechanisms that relate solar activity with TSI and SSI changes are still not well understood.

Past role of solar forcing

Even larger discrepancies exist between the long-term reconstructions that are based on proxy data such as cosmogenic radionuclides. These nuclides are produced by cosmic rays in the atmosphere and stored in polar ice (^{10}Be) and tree rings (^{14}C). Their production rate is to a large extent modulated by solar activity. However, the geomagnetic field intensity and the

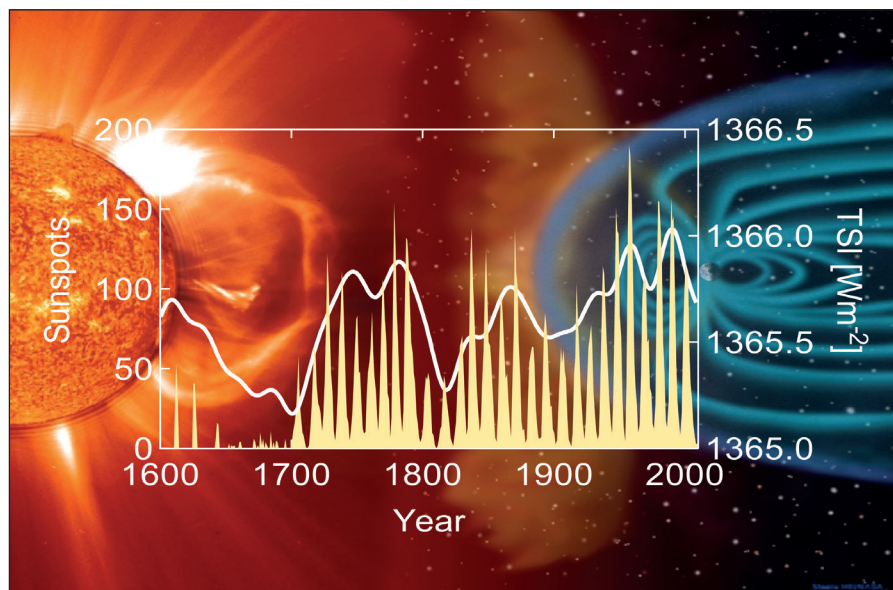


Figure 1: Background picture - The Sun emitting electromagnetic radiation and hot plasma (solar wind) carrying magnetic fields. While the radiation reaches the Earth directly solar particles are partly shielded by the geomagnetic field. Graph - Sunspot numbers reflect the solar magnetic activity which is dominated by the 11-year Schwabe cycle. The reconstructed smoothed total solar irradiance (TSI) follows the envelope of the sunspot record with minima at 1645-1715 AD (Maunder Minimum) and at 1790-1830 AD (Dalton Minimum) and a maximum in the second half of the 20th century.

transport from the atmosphere into the archive also play a role. The main problem is that these proxies need to be calibrated by the instrumental TSI data, which besides their own uncertainties only cover 30 years of high and relatively constant solar activity (grand maximum). The instrumental record is therefore not representative of the mean global solar activity of the Holocene. This raises the fundamental question of how much lower TSI and SSI were during grand solar minima such as the Maunder Minimum. There is general agreement on the shape of the past solar forcing record, which is characterized by specific cycles of 11, 87, 208 and 500 years and prolonged periods of solar minima (e.g. Maunder) and maxima. However, there is still considerable uncertainty regarding the amplitudes of these changes.

The solar cycle minimum of 2008

The 2008 solar minimum was lower (fewer sunspots, lower TSI) and lasted longer than previous ones. Are the current TSI models capable of explaining it? Does it point to an imminent new grand minimum?

Future role of solar forcing

The fact that the past six decades or so were a period of very high solar activity suggests that solar activity will decrease in

the near future. This expectation is corroborated by the last solar minimum of 2008. The possibility of an imminent new grand solar minimum has led to claims that the diminished solar activity will reduce global warming considerably. Although this is very unlikely, a solid quantitative estimate of such a scenario is very important.

To address all these questions an interdisciplinary working group has been set up (www.pages.unibe.ch/working-groups/solar-forcing). Solar physicists try to better understand the known physical processes and to identify potential new mechanisms responsible for solar forcing. Experts in atmospheric physics and climatology address the response of the Earth system to the solar forcing and in particular the effects of solar induced changes in the upper atmosphere on the climate. Paleoclimatologists provide observational data, which need to be explained by climate modelers complementing their models with additional processes and putting some important constraints on the role the Sun has played in the past and will possibly play in the future.

References

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Wanner H et al. (2008) *Quaternary Science Reviews* 27: 1791-1828

