The Sun and its role in climate change

Workshop of the PAGES Solar Working Group – Davos, Switzerland, 5-7 September 2012

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Better understanding the Sun and its role in climate change is an important but difficult goal. It is important because to properly assess the anthropogenic effect on climate change an accurate quantification of the natural forcing factors is required. But it is difficult because:
(1) natural forcing records are generally not well quantified;
(2) the response of the climate system to forcings is non-linear due to various feedback mechanisms and can only be estimated using complex climate models;
(3) in spite of their complexity models may not comprise all relevant processes and have to be validated, but the instrumental records of climate forcing and climate response are generally too short for this purpose and the data set needs to be complemented by proxy data;
(4) proxy data are derived from natural archives and are only indirectly related to the physical parameters of interest, and their calibration is based on assumptions that may not be fully valid on longer time scales;
(5) instrumental and proxy data reflect the combined response to all forcings, and not only the influence of the Sun. Furthermore, the climate system shows internal unforced variability. All this makes separation and quantification of the individual forcings very difficult.

The main aim of the first workshop of the solar forcing working group was to assess the present state of the art and identify knowledge gaps by bringing together experts from the solar, the observational and paleo-data, and modeling communities.

The workshop was organized jointly with FUPSOL (Future and past solar influence on the terrestrial climate), a multi-disciplinary project of the Swiss National Science Foundations that addresses how past solar variations have affected climate, and how this information can be used to constrain solar-climate modeling. FUPSOL also aims to address the key question of how a decrease in solar forcing in the next decades could affect climate at global and regional scales.

Here are some examples of open questions and problems that were identified in this workshop, and will be addressed in more detail in subsequent meetings:

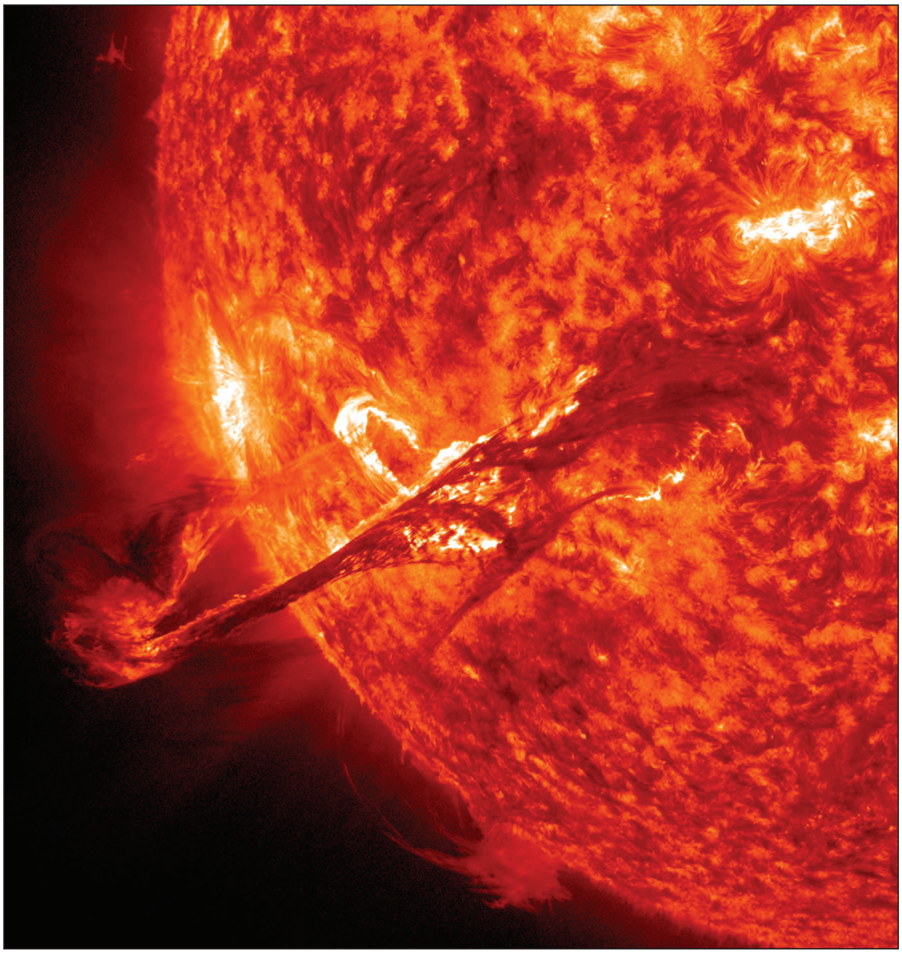
Figure 1: Image of a solar magnetic filament burst. Image by NASA.

- Physical solar models are not yet capable of explaining many observed features such as solar cycles and changes in total solar irradiance (TSI) and solar spectral irradiance (SSI).
- There are still unresolved discrepancies between different composites of TSI based on the same satellite data.
- Semi-empirical models are relatively successful in explaining short-term changes in TSI and SSI on time scales of days to years. However, on multi-decadal time scales input data and instrumental TSI and SSI data for comparison are missing.
- TSI and SSI reconstructions based on proxies suffer from large uncertainties in their amplitudes.
- The most recent minimum, between solar cycle 23 and 24, and probably also the upcoming minimum provide a glance of the Sun at its lowest activity level ever observed during the satellite era.
- UV forcing and possibly also precipitating particles have significant impacts on atmospheric chemistry and dynamics and need to be included in models.
- Detection and attribution of solar forcing is often hampered by volcanic eruptions occurring simultaneously. Strategies to separate solar and volcanic forcings could be to select periods of low volcanic activity (e.g. roman period), to consider regional effects that differ for different forcings, and to look for multi-decadal to centennial solar cycles with well-defined periodicities.

As an opening spectacle to the workshop, a medium-sized flare initiated a long, magnetic filament burst out from the Sun (Fig. 1). Viewed in the extreme ultraviolet light, the filament strand stretched outwards until it finally broke and headed off to the left. Some of the particles from this eruption hit Earth in September 2012, generating a beautiful aurora.