Project: **1148**

Project title: **SOLCHECK**

Principal investigator: **Holger Pohlmann**

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1. Project overview

Observational and modeling studies indicate a significant influence of solar variability on climate and in particular on internal climate variability modes in the coupled atmosphere-ocean system. However, the understanding of the relevant processes as well as the quantification of solar contributions to global and regional climate change remains a difficult task due to the limited availability of observations and the non-linearity of the involved processes. SOLCHECK aims at significantly advancing the understanding and quantification of the solar contribution to past, present, and future climate evolution in the Northern Hemisphere from decadal to centennial timescales. The research questions of SOLCHECK will be addressed using German community models. In addition to the German decadal climate prediction system MiKlip (Marotzke et al. 2016), we will apply chemistry-climate models that account for atmosphere-ocean feedback processes and include advanced schemes for the ozone response to solar variability, partially developed in ROMICI. Our approach is unique in several aspects: 1) the realization of ensemble simulations with advanced chemistry climate models for different combinations of fixed or transient anthropogenic and solar forcing conditions provides an unprecedented statistical basis for the assessment of solar forcing contributions to decadal climate variability and climate change, 2) performing ensemble simulations with the MiKlip system with and without solar forcing provides for the first time a robust estimate of solar contributions to decadal climate prediction skill, and 3) a range of the potential impact of a future Grand Solar Minimum and other extreme solar events under different greenhouse gas scenarios will be provided. The outcome of SOLCHECK is highly relevant to the WCRP Near-term Climate Prediction Grand Challenge and the upcoming IPCC report, and will provide the German contribution to the international WCRP/SPARC-SOLARIS/HEPPA initiative.

2. Achievements

SOLCHECK aims at identifying and better understanding the processes of solar signals from the middle atmosphere to the surface, with a special focus on solar cycle effects to internal climate variability modes. We have therefore performed a set 9 ensemble members of CMIP6 historical-like sensitivity experiments with MPI-ESM-HR (Müller et al., 2018) model over the period 1850-2014 all driven by identical external anthropogenic forcing (greenhouse gases, …) but differing in the solar forcing fixed to 1850 preindustrial conditions (no solar contribution to climate variability). The internal variability and the solar forcing are disentangled and their individual contributions to the overall variability are assessed by contrasting the scenarios to the CMIP6 historical simulations performed in the MiKlip project including the long-term solar variability and the 11-year solar cycle (Figure 1).

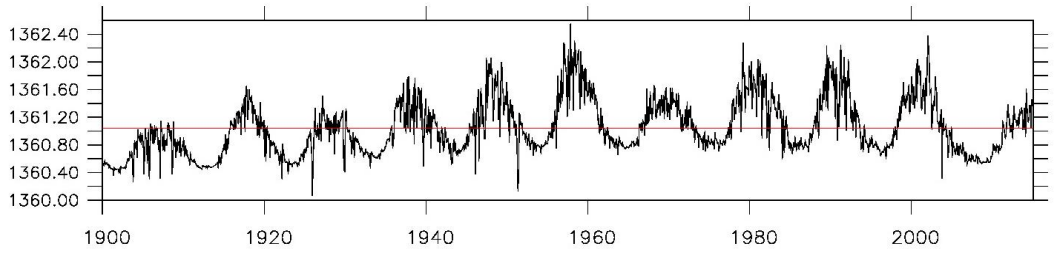

Figure 1: Time series of total solar insolation (black) [W/m^2] and its mean value (red line).

The results are analyzed in terms of composite sections of zonal mean zonal wind (u) and

temperature (T). For the composites, years with maximum solar activity and minimum solar activity are considered as well as the year before and following the extrema. Figure 2 illustrates that the solar cycle has an influence on the quasi-biennial oscillation (QBO) in the stratosphere (Fig. 2a), with this pattern being almost absent when the solar cycle is removed in the sensitivity simulations (Fig. 2b). Additionally, the warming signal is associated with the solar variability in the upper stratosphere (Fig. 2c) typically found as the annual temperature response due to an 11-year solar cycle (Mitchell et al., 2015), and is no longer present in the sensitivity simulations when the solar cycle is removed (Fig. 2d). The analysis of these experiments are still ongoing.

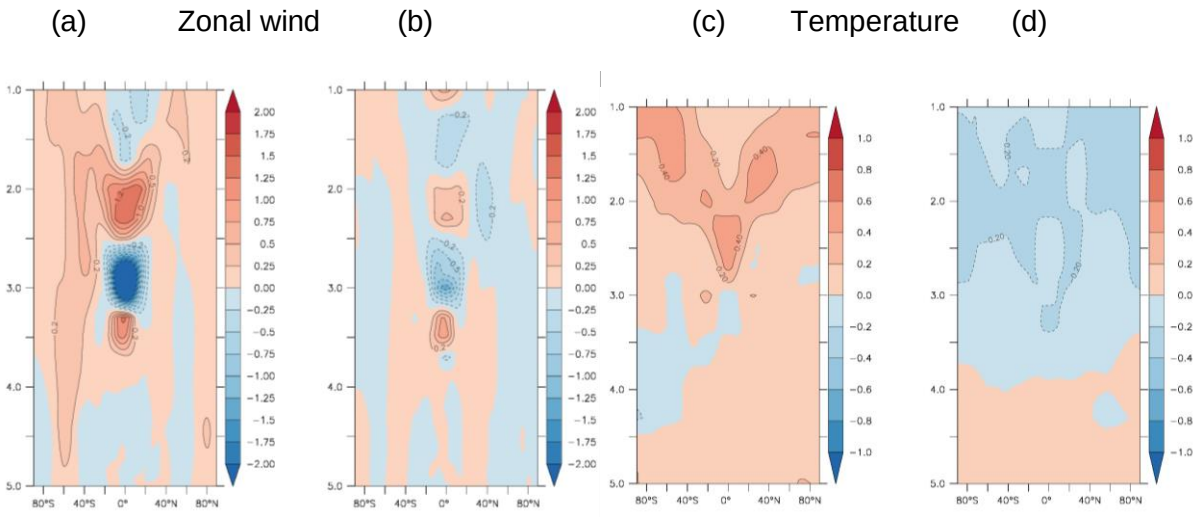

Figure 2: Latitude/height [10^x Pa] sections of zonal mean values of the ensemble mean of 9 historical simulations with MPI-ESM-HR inclusive (a, c) and exclusive the solar cycle (b, d) for u-wind [m/s] (a, b) and temperature [K] (c, d).

Our next tasks in SOLCHECK are to repeat the historical simulations with only long-term solar variability excluding the 11-year solar cycle (solar low-frequency contribution to climate variability) to better disentangle the long-term and short-term impact of the solar variability. In addition, the effect of increasing anthropogenic forcing on the interaction of internal and solar variability will be studied by comparing periods with and without anthropogenic forcing (earlier and later part of the historical simulations as well as the existing preindustrial control simulations).

3. Data Lifecycle

Central aim of SOLCHECK is the long-term storage of the experiments. The historical-like sensitivity simulations performed in this project will be converted into the CMOR data format and stored in the CERA data archive at DKRZ. Due to Covid19, this project is behind its schedule and needs to postpone the historical-like sensitivity simulations including the solar low-frequency contribution to climate variability. These simulations are now planned for 2021.

References

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