The solar cycle signal in Northern Hemisphere winter in ensemble simulations with a comprehensive decadal prediction system

Tobias Spiegl[1] and Ulrike Langematz[1]

[1] *Freie Universität Berlin – Institut für Meteorologie, Berlin, Germany*

Numerous studies suggest a modification of tropospheric weather patterns by solar variability via a stratospheric pathway. This pathway includes complex interactions between the intensity of the UV forcing, a modification of tropical shortwave heating rates, zonal mean temperatures, zonal winds and the propagation conditions for planetary waves (Kodera and Kuroda, 2002). The initial signal in the stratosphere can propagate downwards into the lower atmosphere and project onto tropospheric weather patterns caused by the internal variability of the North Atlantic Oscillation (NAO), which is responsible for most of the winter variability in the North Atlantic / European sector. In addition, a lagged response of the ocean to the 11-year solar cycle was found recently which might lead to a decadal synchronization of the NAO with the solar forcing and thus have implications for decadal climate prediction (Thiéblemont et al., 2015).

In this study, we used 1,200 years of model simulations including solar forcing to evaluate the above described mechanisms and to provide a robust estimate of the uncertainty of the decadal solar signature in climate. For our study we used historical ensemble simulations with the Max Planck Institute Earth System Model (MPI-ESM) that were conducted within the medium-term climate forecast framework (MiKlip). The model is coupled to the 3D Max Planck Institute ocean model (MPIOM) and comprises a high spatial and vertical resolution (T127L95) as well as a proper resolution in the shortwave part of the solar spectrum. Our evaluation of the utilized model system shows a positive NAO-like response under solar maximum conditions which is known from other model studies (e.g., Gray et al., 2013). This particularly applies to tropospheric variables like the sea level pressure, the near surface temperature and wind as well as precipitation patterns. The main goal of this study was to analyze the multidecadal imprints on surface climate in the coupled ocean-atmosphere system.

Key words: 11-year solar cycle, middle atmosphere, top-down, bottom-up, NAO synchronization

References

Gray, L. J., Scaife, A. A., Mitchell, D. M., Osprey, S., Ineson, S., Hardiman, S., ... & Kodera, K. (2013). A lagged response to the 11 year solar cycle in observed winter Atlantic/European weather patterns. *Journal of Geophysical Research: Atmospheres*, *118*(24).

Kodera, K., & Kuroda, Y. (2002). Dynamical response to the solar cycle. Journal of Geophysical Research: Atmospheres, 107(D24).

Thiéblemont, R., Matthes, K., Omrani, N. E., Kodera, K., & Hansen, F. (2015). Solar forcing synchronizes decadal North Atlantic climate variability. Nature communications, 6, 8268.