Influence of solar magnetic activity on the global climate: relations with local surface temperature and Arctic oscillation

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Introduction. The effect of solar magnetic activity on the climate is reportedly [1] first suggested by Ney [2]. Since then, several mechanisms have been proposed [3, 4]. A value of climate sensitivity was recently estimated as 0.35 K/Wm^{-2} considering the solar modulation of cosmic ray [1]. This value is less than half the consensus value based on climate models (e.g. 0.8 K/Wm^{-2}), but close to those of recent observation-based estimation [5-7]. Moreover, a good correlation was observed between the solar magnetic activity (aa index) and the Arctic oscillation (AO index) [8].

We have proposed a method to reconstruct the aa index from Wolf"s sunspot number, and have shown that the method can be applied to sunspot forecast [9]. The reconstructed aa index showed a good correlation with the past temperature [10]. We also independently showed a high correlation between the aa index and the AO (Fig. 1) [11].

While there is sufficient observational evidence for the influence of the solar magnetic activity on the climate, its mechanism is not as detailed as it can be incorporated into climate models. Thus, our aim here is to propose a new guiding principle.

Approach and Method. While globally-averaged and long-term-averaged indices are usually employed, this may be not enough because climate changes have the largest impacts in local and short time scale. Thus, we propose here a local-based approach using local weather data. All the data were obtained from open data sources [12-14], and correlations were evaluated.

Results and Discussion. Correlation between monthly local temperatures and the aa index were rather high (e.g., R = 0.6) for places such as the Scandinavian region (Sodankyla, Finland etc.), for certain periods of time (after 1960, in particular) with suitable combinations of months or seasons (January or Winter for the aa index, and March or Spring for the surface temperature).

Figure 2 shows correlation between the temperature in spring (March-May) and the aa index in winter (December-February) during 1960-2001. Regions such as Scandinavia and Eastern Europe showed highest correlation, and relatively strong anticorrelation was observed for the vicinity of Greenland. Regions such as Siberia and middle Atlantic showed moderate correlations, and moderate anticorrelation was observed for tropical Atlantic.

These patterns resemble those for the AO. Thus, the solar magnetic activity affects the surface temperature likely through the AO. There is a time lag, however, between the aa index and the temperature, which may suggest a memory effect due to such as snow/ice.

Thus, the influence of the solar magnetic activity on the climate became evident further. It is necessary to design future analyses so as to incorporate this into the climate models. For instance, the following observation might be useful; with the results above and upper atmosphere data [14], it appears that high solar activity tends to accompany stable westerly wind flow and less blocking phenomena.

References.

1) N. J. Shaviv, J. Geophys. Res. -Space, 110, A08105 (2005).
2) E. P. Ney, Nature, 183 (1959) 451.
3) H. Svensmark and E. Friis-Christensen, J. Atmos. Solar-Terres. Phys., 59 (1997) 1225.
4) B. A. Tinsley, J. Geomag. Geoelect., 48 (1996) 165.
5) P. M. Forster and J. M. Gregory, J. Climate, 19 (2006) 39-52.
6) S. E. Schwartz, J. Geophys. Res., 112, D24S05 (2007).
7) P. Chylek et al., J. Geophys. Res., vol. 112, D24S04 (2007).
8) D. R. Palamara and E. A. Bryant, Annales Geophysicae, 22 (2004) 725-731.
9) K. Itoh, Japanese patent No. 3789736 (Applied on July 27, 2000)
10) K. Itoh, 2001 Meeting of Japan Geoscience Union, Abstract En-P001 (2001).
11) K. Itoh, "Global Warming" (in Japanese), Nihon-Hyoron-Sha Publ. Co., 2003, p. 129.
12) http://data.giss.nasa.gov/gistemp/maps/
13) http://www.geomag.bgs.ac.uk/gifs/aaindex.html14) http://www.cdc.noaa.gov/cdc/data.ncep.reanalysis.html

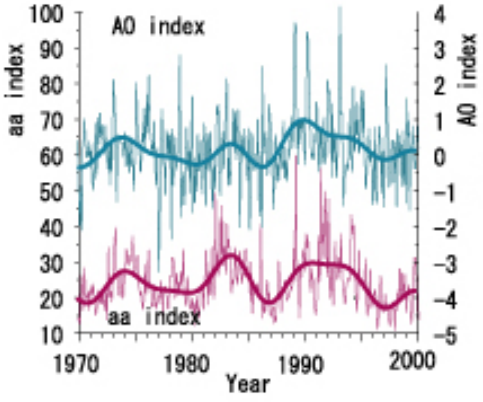

Fig. 1. aa index vs AO (Arctic Oscillation) index. Monthly and 5y-Fourier-filtered values.

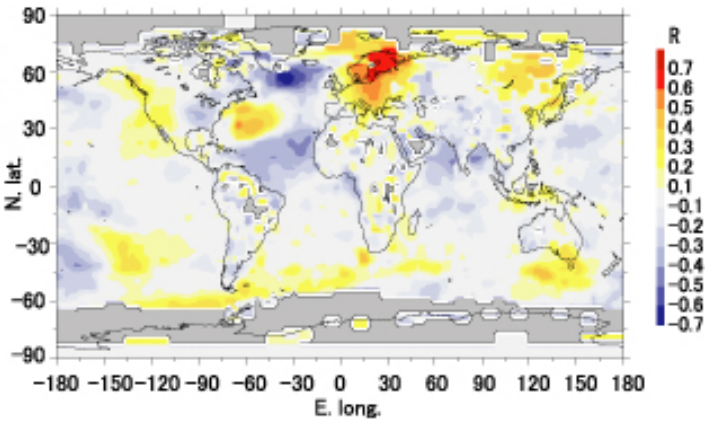

Fig. 2. Correlation between aa index (winter) and surface temperature (spring) for 1960-2001.