A likely outcome of the sunspot peaks’ influence on the North Atlantic Oscillation and Europe in winter

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Abstract
The effect on the North Atlantic Oscillation of 15 sunspot peaks depends on whether the Oscillation is in-phase or out-of-phase with the sunspot peaks. When it is in-phase the anomalies of sea-level pressure adds to the average pressure distribution, and when it is out-of-phase it subtracts from it. Consequently, the atmospheric conditions over Europe in a sunspot peak depends on whether the North Atlantic Oscillation is in- or out-of-phase with the sunspot peak.

Keywords: sunspot peaks, european winters

1 Introduction

One must distinguish between the connection of the atmosphere with the sunspot peaks (Van Loon and Meehl, 2008), and the connection between trends in the sun and trends in the atmosphere (Van Loon et al., 2012). The latter depends on the trend in insolation, and the former is associated with the sunspot peaks influence on the tropical convection (Van Loon, 2012).

In the following text I shall describe the North Atlantic Oscillation’s (NAO) probable association with the sunspot peaks, and the resulting effect on pressure and temperatures in Europe. Fifteen sunspot peaks are available in the records – the first one being in 1860 – which coincide with the observational data such as sea-level pressure (SLP, since 1850) and surface-air temperature (SAT, since 1880). The data are few when divided into being in-phase or out-of-phase with the sunspots, but the differences in pressure and sea-level pressure years are large so that one may assume that the differences are real.

The sunspot numbers are from SIDC of the Royal Observatory in Belgium; the sunspot maxima and minima are from a NOAA website: “Minima and Maxima of Sunspot Number Cycles”. The atmospheric quantities of SLP and SAT are from NOAA websites; and the NAO values are those from the Climate Research Unit at the University of East Anglia: Gibraltar minus southwestern Iceland (Jones et al., 1997).

2 The Atmospheric Differences over Europe between Sunspot Maxima and Minima

The circulation often changes in early winter over Europe and the months chosen for the differences are there-fore January–February, not that the inclusion of December makes much difference. The years when the NAO in January–February was in-phase with the sunspot peaks are: 1883 1894 1907 1928 1937 1957 1989 2000 2012; and those when they were out-of-phase are 1860 1870 1917 1947 1968 1979. Being in-phase means that a relative peak in the NAO coincides with a peak in the sunspots, and being out-of-phase means that a sunspot peak coincides with a relative minimum in the NAO.

Figure 1a shows a composite of the SLP anomalies for the nine years when the sunspot peaks and the NAO index were in-phase. The southern part of the figure is positive and the northern part is negative, like the shape of a positive NAO index; and nine hekto Pascal are then added to the largest mean, maximum pressure difference (in two points) of 23hPa – close to 40%. The opposite is the case in the six years when the NAO was in opposition to the sunspot peaks (Fig. 1b): North of a line at about 53° N the anomalies are positive, and to the south they are negative, in the sense of a negative NAO index. The negative difference of the anomalies are now 8 hPa reducing the average maximum SLP difference by 35%. It means that the geostrophic wind anomalies between the in-phase and out-of-phase anomalies would reverse from westerly in Fig. 1a to easterly in Fig. 1b.

This difference between the in-phase and the out-of-phase, about 17 hPa at its largest, is clearly observed in the temperature differences. When the SLP anomalies are indicative of geostrophic, anomalous westerly wind (Fig. 1a) and the anomaly wind comes from the ocean in the north, the temperature anomalies over the area there are positive, as much as 1.5 °C over northern Finland; but they are negative to the south where an anomalous east wind would blow. Conversely in Fig. 1d with easterly anomalies in the north where Russia and Central Europe, Finland and northern Sweden are more than 1–2 °C below normal. Over water the anomalies are smaller for the same strength of wind anomalies. The
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Figure 1a: SLP anomalies in years when the NAO is in-phase with the sunspot peaks.

Figure 1b: SLP anomalies in years when the NAO is out-of-phase with the sunspot peaks.

Figure 1c: Surface-air temperature in years when the NAO was in-phase with the sunspot peaks.

Figure 1d: Surface-air temperatures in the years when the NAO was out-of-phase with the sunspot peaks.

Anomaly patterns are those associated with the positive and negative phases of the NAO (Hann, 1890; Defant, 1924; Loewe, 1937, 1966; van Loon and Rogers, 1978).

3 Conclusion

The North Atlantic Oscillation’s origin is not well established, and it has none of the early to late persistence of the Southern Oscillation. It is probably an internally forced oscillation in the atmosphere, and in one winter can be both negative and positive. It is interesting to see how it interacts with an external forcing such as the sunspot peaks; and it may give a clue to how it is connected to the rest of the atmosphere. When we consider the whole hemisphere in winter, Figs 2a, b, in both the in-phase and the out-of-phase years, it is clear that the SLP anomalies reverse from the in-phase to the out-of-phase years over the hemisphere as a whole. It seems possible that the Atlantic-European anomalies in the peak sunspot years are, to a large extent, connected with the Pacific anomalies through the PNA pattern.

In the years of peak sunspots, the sun in the southern summer/northern winter apparently interferes with the convection over the monsoon region: Indian Ocean, Australia, Indonesia, and the Pacific Warm Pool, by allowing the convection to reach greater heights (van Loon, 2012). The outcome of this interference then depends on the state of the atmosphere which the solar peaks encounter, and it spreads downstream through the Pacific-North Atlantic pattern. This effect, which begins as an enhancement of the convection in the region of Newell and Gould-Stewart’s (1982) “Stratospheric Fountain”, can then be seen all the way to the NAO and Europe.

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