The Summer North Atlantic Oscillation (SNAO) since the 18th Century

Chris FOLLAND[1]
(chris.folland at metoffice.gov.uk)
David FEREDAY[1], Hans LINDERHOLM[2], Jim HURRELL[3], Sarah INESON[1], Jeff KNIGHT[1] and Adam SCAIFE[1]
1Hadley Centre, Met Office, Exeter, UK
[2]Göteborg University, Göteborg, Sweden
[3] National Centre for Atmospheric Research, Boulder, Colorado, USA

Eigenvector analysis carried out over the annual cycle in the North Atlantic and Arctic region on seasonal NCEP mean sea level pressure data gives a set of dipole patterns including the familiar winter North Atlantic Oscillation. In summer, the scale of the EOF is smaller and its southern node stretches from near UK to Scandinavia rather than the Azores – Spain region seen in winter. In much of the work presented here, we use a new daily data set of pressure at mean sea level, EMSLP, created over 1850-2003. Its domain is limited to 70°N at its northern-most latitude. An EOF analysis over 1881-2003 in summer recreates mainly the southern part of the full summer EOF node seen in NCEP data. Here we concentrate on July and August or "high summer" as the temporal variation of pressure patterns at this time is more similar than in June. In high summer, cluster analysis gives two nearly opposite modes which strongly reflect the SNAO. Furthermore, an EOF analysis of daily, ten day mean and two month mean data for 1881-2003 in July and August gives similar patterns, though there is a small westward shift and westward extension in the pattern as averaging time increases. Their time series from 1850-2006 (updated using NCEP data) are highly correlated; regression against 500hPa and 300hPa heights using NCEP data gives nearly equivalent barotropic patterns.

Regressions of the SNAO pattern (chosen to be the daily EOF pattern) with surface temperature and rainfall in high summer show a strong influence of the southern node of the SNAO for a region stretching from the UK to Scandinavia. When the southern node has higher pressure (positive SNAO), warmth and dryness is seen. Not surprisingly, the SNAO shows up strongly in cloudiness data. The SNAO varies strongly interannually but also interdecadally, particularly in the twentieth century. Relatively low SNAO values over 1920-1960 were followed by a sharp rise in the 1960s to 1970s with a relatively high level maintained until the 1990s. This period had several extreme UK summer droughts. Regression analysis of the SNAO with sea surface temperature (SST) suggests that its interdecadal variations can be related to the Atlantic multidecadal oscillation, a periodic warming and cooling of the North Atlantic that has been associated with variations in the thermohaline circulation. Experiments with the Hadley Centre atmospheric model conducted as part of the CLIVAR Climate of the Twentieth Century experiments generally support this link. Interannually, SST influences are less clear but there may be other influences from the North Atlantic and from El Nino.

Because the SNAO strongly affects temperature and rainfall in Scotland and Scandinavia, paleoclimate data based on tree rings can be used to reconstruct an index of the SNAO back to the eighteenth century with some skill on decadal time scales. The likely skill of the reconstructions is shown.

Finally, simulations with a version of the Hadley Centre coupled model forced by enhanced concentrations of atmospheric carbon dioxide show a tendency for more positive future values of the SNAO. Thus the SNAO might amplify future effects of global warming in summer in North-West Europe, enhancing a tendency to both drought and warmth.