

NAO/NAM–Related Trends in Coupled Models

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Background

Trends over the last few decades of the 20th century in various surface, tropospheric and stratospheric fields bear a very strong resemblance to the spatial patterns of variability of the leading mode of wintertime Northern Hemisphere variability, the North Atlantic Oscillation/Northern Hemisphere Annular Mode (NAO/NAM). Besides this recent trend, other periods with NAO/NAM trends of substantial magnitude and duration may also be discerned in the available climate record. Though earlier data are largely limited to sea level pressure (SLP) and surface air temperature (SAT) observations, they show these earlier trends appear to be more regional in nature and have a spatial structure with much less overall resemblance to the patterns of the leading mode.

These differences in spatial structure might be indicative of different causes for the earlier and more recent observed trends. It has been hypothesized that anthropogenic forcing has played a role in driving the recent NAO/NAM trend. Conversely, the more regional trend patterns of earlier in the century may be due to localized interaction with the oceans.

Objectives

This research aims to analyze the monthly average output of both control and forced runs from the CMIP2+ coupled GCM simulations for trends associated with the NAO/NAM. Ideally the unperturbed model runs could be considered proxy records of the natural variability of the climate system, and the transient runs could be considered extended iterations of the suspected current climate change. Rather than searching explicitly for cycles or periodicities this work will attempt to assess the changes associated with shifts in this mode. Besides an intercomparison of the models, it is hoped this will lead to improved understanding of the trends in the observational record. Similar analysis of trends may also be performed using as bases the other primary modes of extratropical variability, the Pacific–North America pattern (PNA) and the Southern Hemisphere annular mode (SAM).

Methodology

This study would be analogous to a recent study using observational data. In that work indices including a typical two–station NAO index (difference between standardized seasonal average SLP anomalies of Lisbon and Iceland) and a typical hemispheric NAM index (leading empirical orthogonal function of Northern Hemisphere SLP) were computed from data for 1900–2000. Maximum long–period trends in those indices are seen in the recent period from

1969 to the present and the 50 year period ending with 1969. There was however variation among the time series as the earlier trends had greater magnitude in the more localized indices while the recent trends had greater magnitude in the larger-scale indices. Maps of the trends over these periods in gridded and high latitude station SLP and SAT confirmed that the earlier trend patterns appear regional in nature while the recent trend patterns appear more hemispheric.

A necessary first step is to establish that the models are able to simulate the leading modes. Many recent studies have explored this and shown that GCMs in general do a reasonably good job, particularly with the NAO/NAM and SAM.

Index time series for the modes are calculated as is done using observational data. These mode indices are used to determine the periods over which to calculate trends for analysis. Trends over those periods are then computed in the available fields of model output. Various trends may then be compared and contrasted:

- *Within individual control runs*
 - ◆ What is the range of trend magnitudes and spatial patterns within each model?
- *Between control and scenario runs*
 - ◆ Do the scenario runs exhibit secular trends that appear driven by the prescribed forcing?
 - ◆ Are there differences in the magnitudes and spatial patterns between the internal "natural" trends of the control runs and forced trends of the scenario runs?
- *Between different models*
 - ◆ What is the range of trend magnitudes and spatial patterns across all of the models in the control runs? In the scenario runs?
- *Between models and available observational data*
 - ◆ Are trends with large magnitude and strong spatial similarity to the mode pattern, like the recent observed NAO/NAM trends, produced in the scenario runs? In the control runs? Does this provide any additional insight on the recent observed trends?
 - ◆ Do the models produce trend patterns with less resemblance to the mode patterns, like the earlier 20th century NAO/NAM trends? If so, do the models give any indication of what causes these trends and why their patterns differ from the mode patterns?

References

Ostermeier, G. M., and J. M. Wallace, 2001: Trends in the North Atlantic Oscillation/Northern Hemisphere Annular Mode during the Twentieth-Century. *J. Clim.*, submitted.