# Simulated response of the AMOC and Northern Hemisphere climate to NAO variations on interannual to centennial time scales

Thomas L. Delworth and Fanrong Zeng
Geophysical Fluid Dynamics Laboratory/NOAA
201 Forrestal Rd. Princeton, NJ 08540 USA
tom.delworth@noaa.gov

We conduct a large suite of simulations with a coupled climate model (GFDL CM2.1) to explore the impact of interannual to centennial scale variations of the North Atlantic Oscillation (NAO) on the AMOC and large-scale climate, and to explore the role of the NAO and AMOC in observed decadal-scale climate variations. We use both medium and high-resolution versions of the model. In the first part of the work we explore the response of the AMOC and large-scale climate to idealized changes in the NAO. We define an NAO forcing pattern by computing the regression coefficient of surface fluxes (heat, water, stress) in the North Atlantic versus an NAO time series. We use these spatial patterns of flux anomalies to force the ocean component of a coupled model. The flux patterns are modulated in time according to idealized formulations. Experiments include abrupt switch-ons of the flux forcing, as well as forcing with sinusoidal variations of the NAO. We conduct separate ensembles of experiments with forcing periods of 2, 5, 10, 20, 30, 50, and 100 years.

We show that the AMOC responds most clearly to NAO forcing with timescales comparable to, or longer than, the inherent AMOC variability of the model. Further, the adjustment to the switch on of the NAO forcing shares many aspects with the internal AMOC variability of the model, including modulation of Labrador Sea convection and the propagation of density anomaly signals. These NAO-induced AMOC changes translate into hemispheric scale temperature variations by modulating poleward oceanic heat transport, which is amplified through climate feedbacks involving shortwave radiation fluxes. For example, a warmed North Atlantic reduces sea ice and snow cover, thereby leading to enhanced absorption of shortwave radiation and further warming. Further, idealized experiments suggest an asymmetry, such that the temperature response to negative NAO excursions (and thus AMOC decreases) has larger amplitude than the response to positive NAO excursions (and thus AMOC increases).

In the second part we conduct ensembles of experiments in which we force the coupled model with NAO variations that are based on the observed record over the period 1901-2013. We show that NAO-induced AMOC changes have a significant impact on hemispheric-scale temperature variations. For example, aspects of the widespread Northern Hemisphere cooling of the late 1960s through early 1980s are reproduced in these simulations in response to NAO and AMOC changes.