2012 Project Summary

**Atlantic Multidecadal Variability: Mechanisms, Impact, and Predictability: A Study Using Observations and IPCC AR4 Model Simulations**

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This project aims to study the physical characteristics of SST variability associated with Atlantic Multidecadal Oscillation (AMO) and to determine the mechanisms governing the AMO especially in relation to AMOC variability. The project also seeks to study the mechanisms by which the Atlantic multidecadal variability affects climate in other parts of the world. The methodological approach is based on diagnostic analysis of coupled and uncoupled global climate models and observations.

**Recent Results**

1. Investigating the mechanisms of decadal variability in the GFDL CM2.1 model with output from a couple thousand years of the GFDL CM2.1 pre-industrial control, we were able to conduct a robust diagnostic study of Atlantic decadal variability. In particular we focused on a ~20 year quasi-periodic cycle in subpolar and subtropical SSTs. Here we identified and study the link between the Basin’s meridional overturning circulation (AMOC) variability and SST changes. We were able to show that the variability is forced by stochastic atmospheric wind stress and heat flux forcing associated with the interannual variability of the North Atlantic Oscillation (NAO). The NAO generates SST anomalies through surface forcing such that when it is in a positive (negative) phase it forces negative (positive) anomalies in the subpolar gyre and positive (negative) in the subtropics. At the same time the NAO forces barotropic and baroclinic responses in the deep ocean which set up a slow process of northward ocean heat transport that acts as a negative feedback on the surface forcing. This interaction creates the quasi-periodic oscillation.

2. Using Linear Inverse Modeling (LIM) to identify dynamical modes of variability and their potential predictability, we formulated a LIM based on the three-dimensional (X, Y, and Z), Atlantic ocean state variables – temperature and Salinity from the 2000 years CM2.1 output. To identify the dynamical modes of the system we used the LIM setting to calculate the Basin’s principal oscillation patterns (POPs). The POPs were classified by the relationship between their periods and decay time and the patterns that have long decay times were examined. The ~20-year quasi-period oscillation described in item above is clearly identified in the POP analysis, suggesting that it is an important internal mode of the North Atlantic. Using the POP decomposition we were able to show that in a mix of identifiable group of modes, the ~20-year patterns can exhibit rapid non-normal growth, which entails amplitude doubling in five years and is potential predictable for about a decade.

3. Begin application of LIM to study predictability of AMV: We developed a collaboration with GFDL to study the application of our LIM representation of the GFDL CM2.1 ocean component for prediction. We are basing our analysis on a set of perfect model experiments conducted at GFDL a year or so ago. Our current goal is to study what makes some initial states more predictable than other. We are currently studying the mix of POPs (see (ii) above) in the initial conditions and also experimenting with LIM predictions from these initial states using different subsets of the full POP-based state representation.
Global impacts of AMV: We continued our investigation to look at the global impacts of Atlantic multi-decadal SST variability. A paper summarizing our Recent Results was published in GRL (Ting et al., 2011). In the paper we compare the observed and modeled AMV impacts during the 20th century and compare these with the modeled AMV under pre-industrial greenhouse gas concentrations and under the A1B scenario of the 21st century. Our study conclusively finds that the models simulate well the AMV spatial pattern and that the latter does not vary with varied greenhouse forcing.

Bibliography