Final Report to the WHOI Ocean Climate Change Institute (November 2010)

Decadal Variability of the Atlantic Meridional Overturning Circulation and Its Impact on the Climate

Young-Oh Kwon and Claude Frankignoul
(Physical Oceanography Department)

What were the primary questions you were trying to address with this research? (Or, if more appropriate, was there a hypothesis or theory that you were trying to prove or disprove?)

We proposed to investigate the mechanisms of the decadal to centennial variability of the Atlantic meridional overturning circulation (AMOC) and its impact on the global climate using the Community Climate System Model version 3 (CCSM3), a state-of-the-art global climate model, simulation in present day conditions. The AMOC carries warm upper waters into northern latitudes and returns cold deep waters southward across the Equator. Its large heat transport has a substantial influence on the global as well as regional climate.

What have you discovered or learned that you didn't know before you started this work?

We have learned that two distinct regimes of decadal AMOC variability are apparent in the 700-yr long CCSM3 integration: a strong 20-year periodicity is seen for 300 years (: Regime I in Figure 1) before an abrupt transition to a red noise-like variability lasting for the last 250 years (: Regime II in Figure1).

What is the significance of your findings for others working in this field of inquiry and for the broader scientific community?

It became apparent that the distinct regimes of AMOC decadal variability are present in the other leading global climate model simulations and there are abrupt changes between these regimes. Therefore, it is crucial to understand what drives the differences and the transition between these regimes. In particular, the climate modeling community is recently investing a lot of effort in the decadal climate prediction. Understanding of the AMOC variability is a crucial part of this effort.

What is the significance of this research for society?

Most simulations with state-of-the-art climate models suggest that the global warming will result in a slowdown of the AMOC. Some observational evidence suggests a recent slowing of the AMOC, but other observations do not. This research suggests that the pronounced natural decadal variability of the AMOC should be understood to accurately project the future anthropogenic changes in AMOC and its impact on global climate.

What were the most unusual or unexpected results and opportunities in this investigation?

The two most unexpected results are: (1) the both regimes of decadal AMOC variability are primarily driven by the variability within the ocean as opposed to those forced by the atmospheric variability, and (2) the weak irregular regime (: Regime II) may have a greater impact on the atmosphere and global climate than the strong regular regime (: Regime I).

What were the greatest challenges and difficulties?

The greatest scientific challenge was to understand the reason for the differences between the two regimes and what drives the abrupt transition between the two regimes. These are not fully resolved issues and will be continuously investigated under the external funding for the next two years. The greatest practical challenge was to secure enough funding to purchase additional hard disk to store the vast output from the climate model simulation.

When and where was this investigation conducted? (For instance, did you conduct new field research, or was this a new analysis of existing data?)

This investigation was a new analysis of the climate model simulation separately conducted by the National Center for Atmospheric Research (NCAR; http://www.ncar.ucar.edu).

What were the key tools or instruments you used to conduct this research?

We have used the advanced statistical methods to understand the very long (700-yr long) simulation of the global climate model CCSM3.

Is this research part of a larger project or program?

Two PIs of this project (Y.-O. Kwon and C. Frankignoul) along with Gokhan Danabasoglu (NCAR) have obtained external funding from the National Oceanic and Atmospheric Administration (NOAA) Climate Program Office (CPO) in total amount of $357K for the next two years (Aug. 2010 - July 2012) to continue and expand this project. The lead-PI is a member of the US AMOC science team and serves as the vice chair of the task team for AMOC mechanism and predictability for the US AMOC Science Team (http://www.atlanticmoc.org/).

What are your next steps?

We will attempt to understand the driving force behind the abrupt transition between the two regimes and explore the predictability of the AMOC variability under the new NOAA funding.

Have you published findings or web pages related to this research? Please provide a citation, reprint, and web link (when available).

We have submitted a manuscript to the Climate Dynamics, a peer-reviewed journal, based on the findings from this project. The citation is as follows:

Kwon, Y.-O., and C. Frankignoul: Multi-decadal variability of the Atlantic meridional overturning circulation in Community Climate System Model Version 3. *Climate Dyn.*, submitted

Please provide photographs, illustrations, tables/charts, and web links that can help illustrate your research.

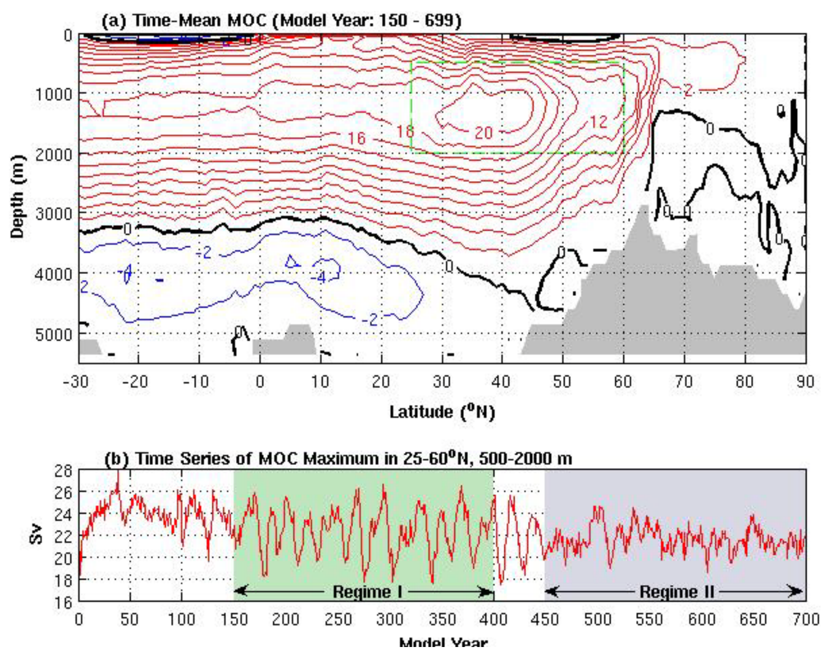

Figure 1. Atlantic meridional overturning circulation (AMOC) from the Community Climate System Model version 3 (CCSM3) present-day control integration. (a) Climatological mean for the model years 150-699. Contour interval is 2 Sv. Red (blue) contours indicate clockwise (counter-clockwise) circulation. (b) Time series of the maximum strength of annual mean AMOC within the green dashed box in (a).