U.S. Atlantic Meridional Overturning Circulation (AMOC) Update
October 2011

Under the guidance and support of relevant federal agencies (NASA [lead], NOAA, and NSF), the US AMOC Program is coordinating research focused on the 4th near-term priority of the Ocean Research Priorities Plan, the Atlantic Meridional Overturning Circulation (AMOC). The AMOC Science Team continues development of the AMOC Program with annual meetings and strong collaboration with European, South American and South African colleagues.

The U.S. AMOC team will host a poster cluster within the "Ocean Circulation and Ventilation" Session at the World Climate Research Programme (WCRP) Open Science Conference in Denver, Colorado (24-28 October 2011). The 19 posters to be presented in the cluster will showcase recent advances in understanding AMOC variability, mechanisms and predictability as well as its role in global climate.

The AMOC Executive Science team will meet during the WCRP Open Science Conference to discuss the progress of the four newly established AMOC task teams and plans for a mid-point review process for the U.S. AMOC program.

The date for the next U.S. AMOC Science Meeting is scheduled for August 2012 in Boulder, Colorado. The meeting will focus on mechanisms and fingerprinting of the AMOC.

New Science Results

(J. Toole - *Line W: A Sustained Measurement Program Sampling the North Atlantic Deep Western Boundary Current and Gulf Stream at 39N*)

The array south of New England (named Line W in memory of L. Valentine Worthington) is quantifying changes in Deep Water Boundary Current water properties, stratification (potential vorticity), and transport. The high-spatial-resolution sampling possible from repeated ship surveys is helping to verify that the moored array resolves the structure of the boundary current as well as returning water samples for at-sea and shore-side tracer analyses. Encouragement of other researchers to build on the Station W infrastructure to augment the sampled fields is ongoing. One effort, focusing on biogeochemistry questions, is being led by T. Eglinton and M. Charette. The most recent Line W cruise (R/V Oceanus cruise Oc472, July 2011) occupied 26 stations ranging from the 90 m isobath on the continental slope to approximately 5000 m depth in the Sargasso Sea, where continuous CTD/O_2 and Lowered Acoustic Doppler Current Profiler (LADCP) profiles were acquired, along with water samples for F11, F12, F113, SF6, I129 and nutrient concentrations.

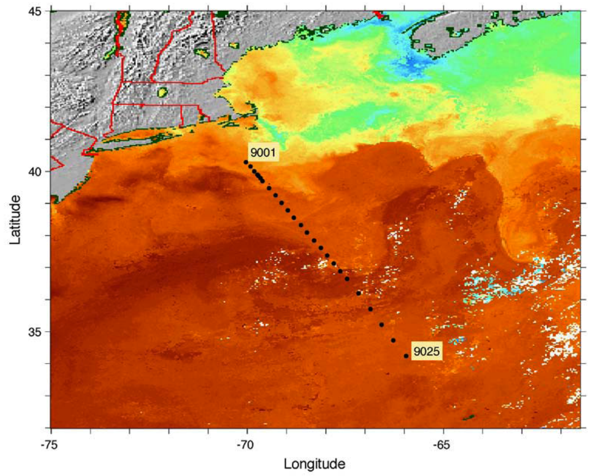

Figure 1. Composite satellite-derived sea surface temperature for the period July 30 - Aug 1, 2001 (obtained from http://fermi.jhuapl.edu/avhrr/index.html) with location of the hydrographic stations occupied during cruise Oc472 superimposed.

(G. Danabasoglu - *A Collaborative Investigation of the Mechanisms, Predictability, and Climate Impacts of Decadal-scale AMOC Variability Simulated in a Hierarchy of Models)*

The inclusion of parameterized Nordic Sea overflows in the ocean component of the Community Climate System Model version 4 (CCSM4) has resulted in a much-improved representation of the North Atlantic tracer and velocity distributions compared to a control CCSM4 simulation without this parameterization. As a consequence, the variability of the AMOC on decadal and longer timescale is generally lower, but the reduction is not uniform in latitude, depth, or frequency-space. While there is dramatically less variance in the overall AMOC maximum (at about 35N), the reduction in AMOC variance at higher latitudes is more modest. Also, the variance is somewhat enhanced in the deep ocean and at low latitudes (south of about 30N). The complexity of overturning response to overflows is related to the fact that, in both simulations, the AMOC spectrum varies substantially with latitude and depth, reflecting a variety of driving mechanisms, which are impacted in different ways by the overflows. The usefulness of describing the AMOC by a single index is thus called into question. Two main improvements in the ocean mean state associated with the overflow parameterization which tend to damp AMOC variability are identified: enhanced stratification in the Labrador Sea due to the injection of dense overflow waters, and a deepening of the deep western boundary current. Direct driving of deep AMOC variance by overflow transport variations is found to be a second order effect.

AMOC variability in CCSM4 shows a broad spectrum of low frequency variability covering the 50-200 year range with a peak period of about 67 years, contrasting sharply with the multi-decadal variability seen in the T85x1 resolution CCSM3 present-day control simulation. Furthermore, the amplitude of variability is much reduced in

CCSM4 compared to that of CCSM3. As in CCSM3, the CCSM4 AMOC variability is primarily driven by the positive density anomalies at the Labrador Sea deep water formation site, peaking 2 years prior to an AMOC maximum. Parameterized mesoscale and submesoscale eddy fluxes play a crucial role in the creation of salinity anomalies that dominate these density anomalies. Higher Nordic Sea densities do not necessarily lead to increased overflow transports, because the overflow physics is governed by source and interior region density differences. Increased overflow transports do not lead to a higher AMOC either, but instead appear to be a precursor to lower AMOC transports through enhanced stratification in the Labrador Sea. This has important implications for decadal prediction studies. Although the results suggest only a weak direct impact of the North Atlantic Oscillation (NAO) on AMOC variability, the NAO may play a role through setting the surface flux anomalies in the Labrador Sea and affecting the subpolar gyre circulation strength.

Recent Publications

- Blewitt, G., Z. Altamimi, J. Davis, R. Gross, C. Kuo, F. Lemoine, A. Moore, R. Neilan, H.-P. Plag, M. Rothacher, **C. Shum**, M. Sideris, T. Schöne, P. Tregoning, and S. Zerbini. Geodetic observations and global reference frame contributions to understanding sea-level rise and variability, *Understanding Sea-Level Rise and Variability*, 256-284, J. Church, P.L. Woodworth, T. Aarup, and S. Wilson, Eds., Wiley-Blackwell, ISBN: 978-1-443-3451-7, 2010.

- **Danabasoglu, G**., S. Yeager, Y.-O. Kwon, J. J. Tribbia, A. Phillips, and J. Hurrell, 2011: Variability of the Atlantic Meridional Overturning Circulation in CCSM4. *J. Climate* (submitted).

- **Shum, C.**, and C. Kuo. Observation and geophysical causes of present-day sea level rise, *Climate Change and Food Security in South Asia*, R. Lal, M. Sivakumar, S. Faiz, A. Rahman, and K. Islam, Eds., Part 2, Chapter 7, 85-104, doi: 10.1007/978-90-481-9516-9_7, 2011.
- **Willis, J.,** D. Chamber, C. Kuo, and **C. Shum, 2010:** Global sea level rise: Recent progress and challenges for the decade to come. *Oceanography*, 23(4), 26-35.

- Yeager, S. and **G. Danabasoglu**, 2011: Sensitivity of Atlantic Meridional Overturning Circulation variability to parameterized Nordic Sea overflows in CCSM4. *J. Climate* (in press).