A NOPP Partnership for Atlantic Meridional Overturning Circulation (AMOC): Focused Analysis of Satellite Data Sets

Peter J Minnett
Meteorology and Physical Oceanography
Rosenstiel School of Marine and Atmospheric Science
University of Miami
4600 Rickenbacker Causeway
Miami, FL 33149-1098
Phone: (305) 421-4104 FAX: (305) 421-4622 E-mail: pminnett@rsmas.miami.edu

Chelle L. Gentemann
Remote Sensing Systems
438 First Street, Suite 200
Santa Rosa, CA 95401-8303
Phone: (707) 545-2904 FAX: (707) 545-2906 E-mail: gentemann@remss.com

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LONG-TERM GOALS

The Atlantic Meridional Overturning Circulation (AMOC), is a major component of the global thermohaline circulation and is generally considered to be driven by the deepwater formation at high latitudes, specifically the Labrador Sea and the Greenland-Iceland-Norwegian Seas. The rates of deep water formation are known to exhibit significant variations on seasonal and decadal time scales, and are believed to be sensitive to a changing climate. Variations in the strength of the AMOC will have a significant impact on the compensating surface flow, which facilitates the northward heat transport in the upper Atlantic Ocean, and consequently a significant impact on weather and climate in the area. Our goal is to incorporate satellite data sets into the study of the AMOC.

OBJECTIVES

Our objective is to explore satellite datasets to provide a baseline for future AMOC analyses, and to determine levels of variability associated with other causes, such as seasonal signals, dependences on the North Atlantic Oscillation, on the intensity of the Atlantic hurricane seasons, etc. Establishing reliable baselines, and variability, is a necessary first step to being able to identify “fingerprints” of changes in the strength of the AMOC in satellite data sets, especially those that will extend into the future.

APPROACH AND WORK PLAN

Our focused analyses of satellite data sets to determine variability of surface conditions that might be sensitive to AMOC fluctuations is directed towards the long time series of sea-surface temperature (SST) and more recent high resolution vector wind fields. Additional variables being examined are the interannual changes in the ice edge development and retreat, and surface insolation.

This NOPP project comprises two partners – the University of Miami, an academic institution, and Remote Sensing Systems Inc., a commercial business. At the University of Miami, the effort is led by Dr Peter Minnett, Professor of Meteorology and Physical Oceanography, and at Remote Sensing Systems Inc. by Dr Chelle Gentemann, Research Scientist.

Plans for the second year of this project include:
- Continue analyses of satellite measurements, directions being guided by results from Year 1; update climatologies as needed
- Establish temporal, interannual variability in the satellite data sets; including SST response to wind events, and migration of the ice edge
- Incorporate ancillary data sets of in situ measurements and model results as appropriate

WORK COMPLETED

The focus of the first year's activities has been on the compilation of the relevant satellite data sets and the focused preliminary analysis of sea-surface temperature time series in areas associated with deep water formation in the North Atlantic Ocean and adjacent seas.

Several data sets of satellite measurements have been assembled. The 4 km daily AVHRR Pathfinder version 5.0 data set has been acquired. This new version of AVHRR Pathfinder data includes an improved land mask, 4 km data (rather than 9 km as available previously), and sea ice information. The data from 1985 through mid-2008 have been processed into a climatology and geo-referenced time series. In April 2009, data from 1981 – 1985 became available and are now being added to the existing climatology and time series. Although climatologies are provided by NODC, they only include data from 1981 – 2001. We have decided to create our own climatologies using time periods that cover the AMSR-E SST data availability.

AMSR-E SST data from the entire mission were processed into a climatology (day, night, combined, 2002 – 2007). Several methods are being investigated for forming the climatology. The simplest method, to simply average the data in a given area is problematic in regions with seasonal ice cover and in regions with swath overlap, which is common above 50° latitude. We have attempted to address this problem by including two SST measurements each day. If less than two measurements were present, a fit to the data was used instead. These methods are all being compared as part of this research.

RSS has also been downloading orbital MODIS SSTs from both the Terra and Aqua satellites. These SSTs are currently being processed and, once finished, will be included in a joint MW/IR climatology.

For comparison, several SST climatologies have been collected, including: JPL pentad AVHRR climatology (1985 - 1999), Erosion AVHRR climatology (1985 - 1997), NODC Pathfinder v5 climatology (day, night, and combined for 1985 - 2001), and the NCDC Reynolds (1985 - 2007) climatology. We have calculated a Pathfinder v5 climatology (1985 - 2007 and 2002 - 2007) and an AMSR-E climatology (2002 - 2007).

RESULTS

Using data archived at the GHRSST(Group for High Resolution Sea-Surface Temperature High-Resolution Diagnostics Data Set time series of satellite-derived SST have been accessed over several areas in the North Atlantic Ocean and adjacent seas that are thought likely to be indicative of, or sensitive to, changes in the Atlantic Meridional Overturning Circulation (AMOC). Of particular note is the systematic progression of the amplitude of the annual cycles of SST in the Labrador Sea area (Figure 1). The data in this plot include several satellite data sets: including NOAA-17, NOAA-18 and MetOp-A AVHRRs processed by Navoceano, the NOAA-18 AVHRR Pathfinder SSTs, and analyses from NCDC, the UK Met Office, and ECMWF.

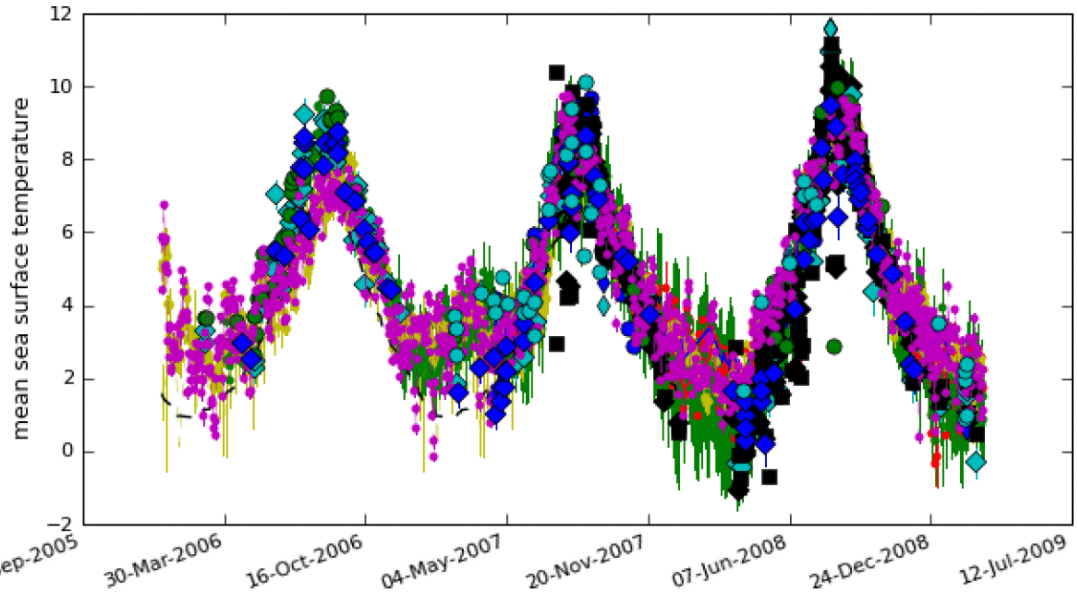

Figure 1. Time series of many satellite SST retrievals and analyses in the Labrador Sea area. All data sets show a trend of cooling winters and warming summers.

All data sets show a trend of cooling winters and warming summers. The cold winter sea-surface temperatures are associated with deep convection that has been identified in Argo profiler data (Yashayaev, 2009, pers. comm.). In the winter of 2006-7, a warming event kept the surface temperatures above zero and deep convection was not observed.

IMPACT AND APPLICATIONS

Quality of Life

Early identification of changes in the strength of the AMOC, as an quantitative indicator of a climate change, will potentially have great impact on the quality of life in the countries bordering the North Atlantic Ocean.

Science Education and Communication (Delete this section if there are none)

The preparatory analyses of the satellite measurements will make enhanced data sets available to the education and research communities.

TRANSITIONS

None yet

RELATED PROJECTS

This project benefits greatly from linkages with others being led by the PIs related to satellite measurements of sea surface variables. These include GHRSST/MISST project (PI Gentemann) and the MODIS and VIIRS SST projects (PI Minnett). A new project to study the effects of diurnal heating in satellite measurements of SST (PIs Minnett & Gentemann) has a direct relevance to the estimation of the limitations implicit in generating SST climatologies and time series from various satellite instruments.