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

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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 third year of this project include:

- Continue analyses of satellite measurements, directions being guided by results from Years 1and 2; 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 additional ancillary data sets of in situ measurements and model results as appropriate

WORK COMPLETED

The focus of the second year's activities has been on the continued 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. Particular focus has been on the Labrador Sea area (40-60^{o}W 55-65^{o}N). Daytime data were used as these are expected to have more confident cloud-screening, given the availability of reflected sunlight that is absent for the night-time data.

A five year time series of weekly SSTs over the Labrador Sea area from the V5 Pathfinder from the AVHRR on the NOAA Polar Orbiters has been analyzed to determine the length and severity of the winters that might be a diagnostic of deep-water formation. Two metrics were used: the length of the winter defined by a) the number of weeks for which the minimum SSTs were <-1^{o}C, and b) the time interval between the first and last incidences of minimum SSTs <-1^{o}C. The length of winter, as determined by the presence of SST<-1^{o}C is rather invariant from year to year averaging 25 weeks, with a range of 22 to 28 weeks, but the number of cold weeks does show interannual variability, ranging from 17 to 26 weeks.

To assess whether the variations in SST are related to deepwater formation, the ARGO profiler data set was assembled for the Labrador Sea area and, after additional quality control, time series of profiles of measured temperature and salinity, and calculated density (σ_0) were analyzed, and the

RESULTS

While the remotely-sensed SST signals are indicative of possible interannual variations in surface heat fluxes that could indicate variability in surface-drive deep water convection, the connection to signals of deep convection in the ARGO data in the Labrador Sea area is not straightforward. The seasonal heating and cooling cycle are clearly evident in the ARGO measurements in the upper 50-200m of the water column, the convincing signals of deep convection of cold water to >1000m are not apparent in the data analyzed thus far. Wintertime convection of water close to the freezing point reaches only about 500m, but where the water column sampled by the ARGO profilers as isothermal to depths of ~1000m, the temperatures are not so cold, and there is residual salinity-induced stratification indicating a limit to the depth of convection and the limited extend and occurrence of deep-water formation events.

The processing of V6 Pathfinder SSTs is currently underway at RSMAS and it is anticipated the SST retrieval accuracies at high latitudes will have been improved. The time series of SSTs across multiple satellite sensors is also expected to be more consistent. We will extend the analysis of SST and ARGO profiles over the entire range of ARGO data, and apply the techniques to other areas of possible deep-water formation, such as the western Greenland Sea and the Irminger Sea.

Our results indicate that it is conceivable that the SST time series by themselves are inadequate predictors of deep water formation, and so we will incorporate the wind fields from a range of sources into he analyses, as high winds during the winter months are also potential indicators of deepwater formation.

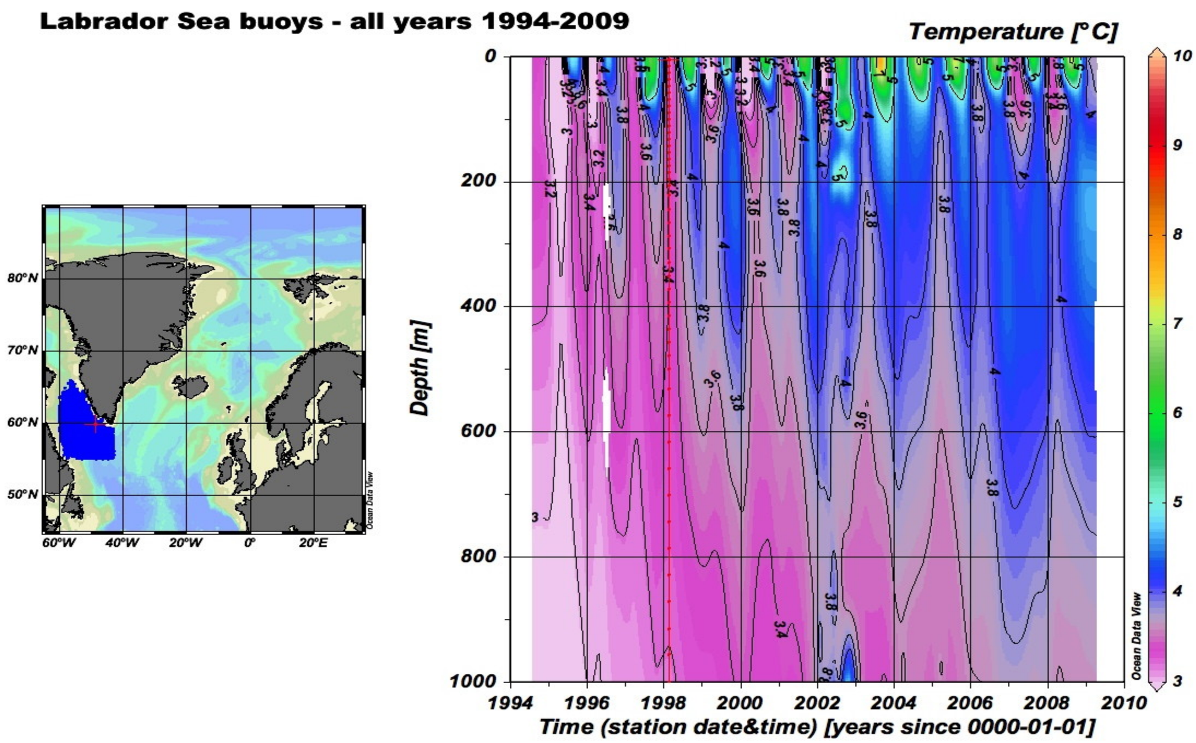

Figure 1. Time series of temperature profiles in the Labrador Sea region (dark blue in map to the left) derived from all available ARGO profiles. The seasonal warming and cooling is apparent in the upper 100m, but deep convection is not so obvious, with the last event captured in these data likley being in 1998.

IMPACT AND APPLICATIONS

Quality of Life

Early identification of changes in the strength of the AMOC, as a 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 study of 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.