Seeking AMOC signals in satellite data

Peter J. Minnett , Chelle L. Gentemann* & Elizabeth Williams

Meteorology & Physical Oceanography
Rosenstiel School of Marine and Atmospheric Science
University of Miami, FL 33149

pminnett@rsmas.miami.edu

*Remote Sensing Systems
438 First Street, Suite 200
Santa Rosa, CA 95401

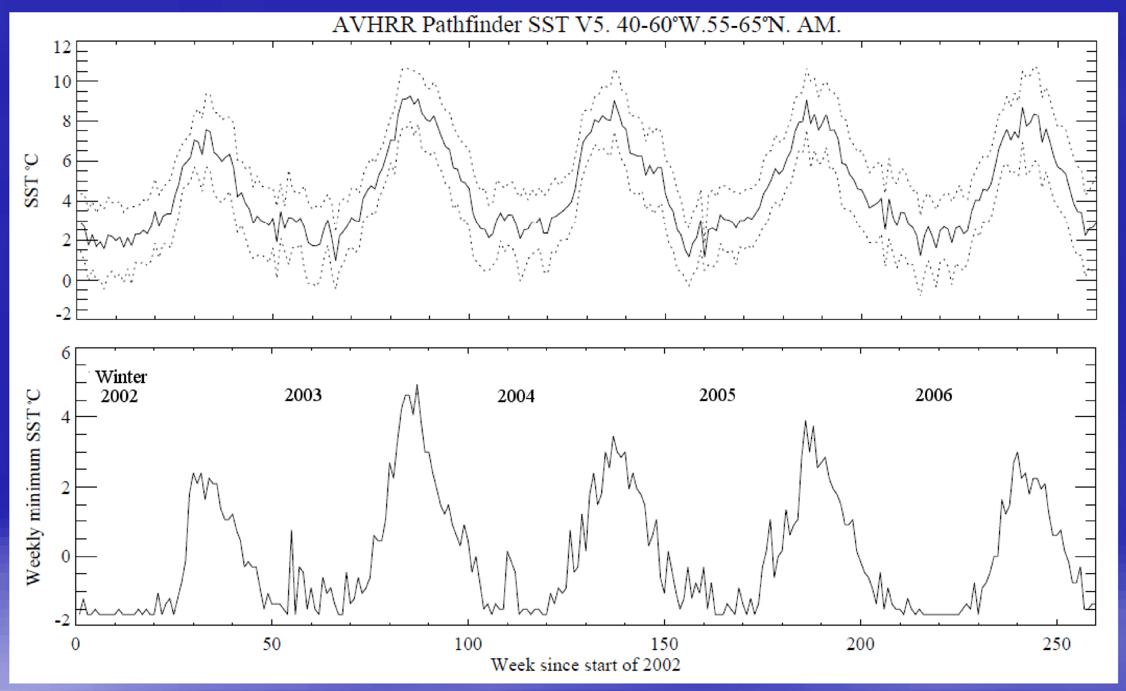
gentemann@remss.com

Introduction

A targeted analysis of long time series of satellite data sets over the Atlantic Ocean are being conducted to lay the foundation for the identification of signatures of changes in the AMOC. The satellite data sets are multi-decadal time series of sea surface temperature from infrared radiometers, surface wind speeds and the ice edge. During the period spanned by these measurements there have been several generations of satellite sensors, but recently reprocessed data sets are believed to minimize, as far as possible, the artifacts that result from changing sensors and orbital drift. Additional shorter data sets, such as vector winds and microwave sea surface temperatures, as well as modeled NWP fields as necessary, are being used to enhance the scientific merit of the analyses. Focus is being directed to areas of deep water formation in the North Atlantic.

AVHRR Pathfinder SSTs

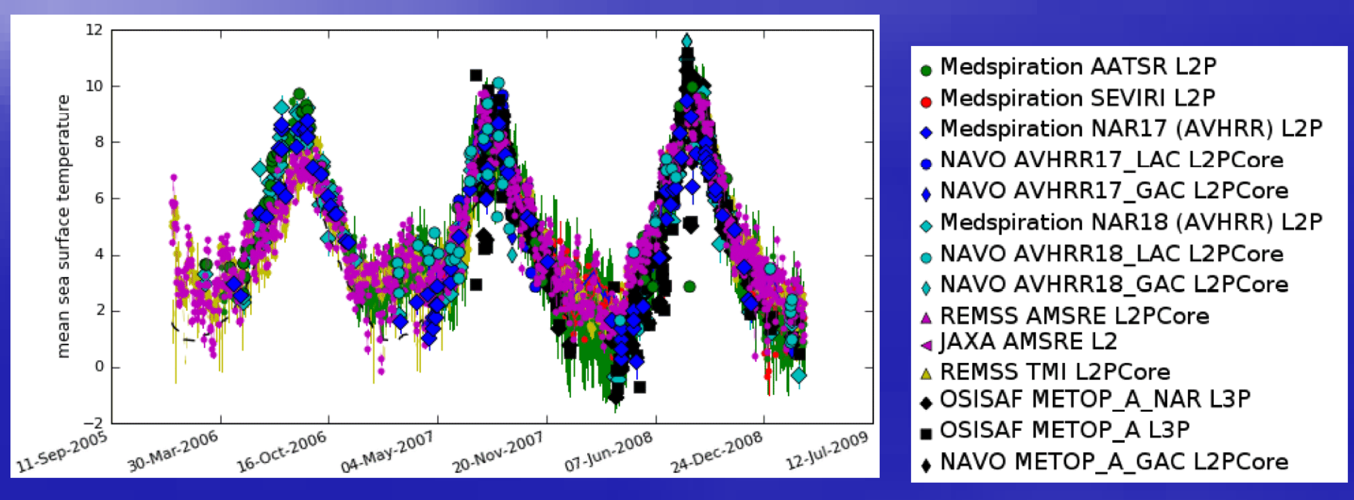
A five year time series of weekly SSTs over the Labrador Sea area (blue in the bottom right panel to the right) from the latest version (V5) of the global SST fields from AVHRR on the NOAA Polar Orbiters is shown below. The upper panel is mean SST (± one standard deviation) and the lower panel is the minimum temperature in the area in each week. These are derived from the highest quality flagged night-time data. When data from later years become available (see below), this analysis will be extended to cover the more recent years when a stronger SST appears to be present.



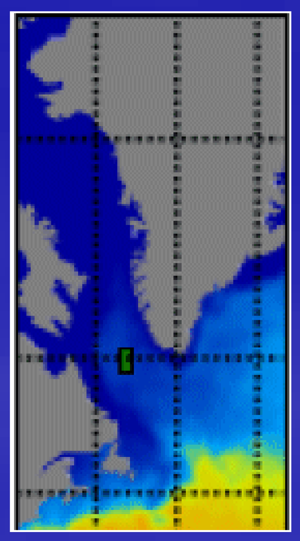
AVHRR Pathfinder SSTs – Labrador Sea area					
Winter of:	2002*	2003	2004	2005	2006
Weeks between first and last sample of SST<-1°C	26	26	22	25	28
Number of weeks with SST <-1°C	26	18	17	18	24

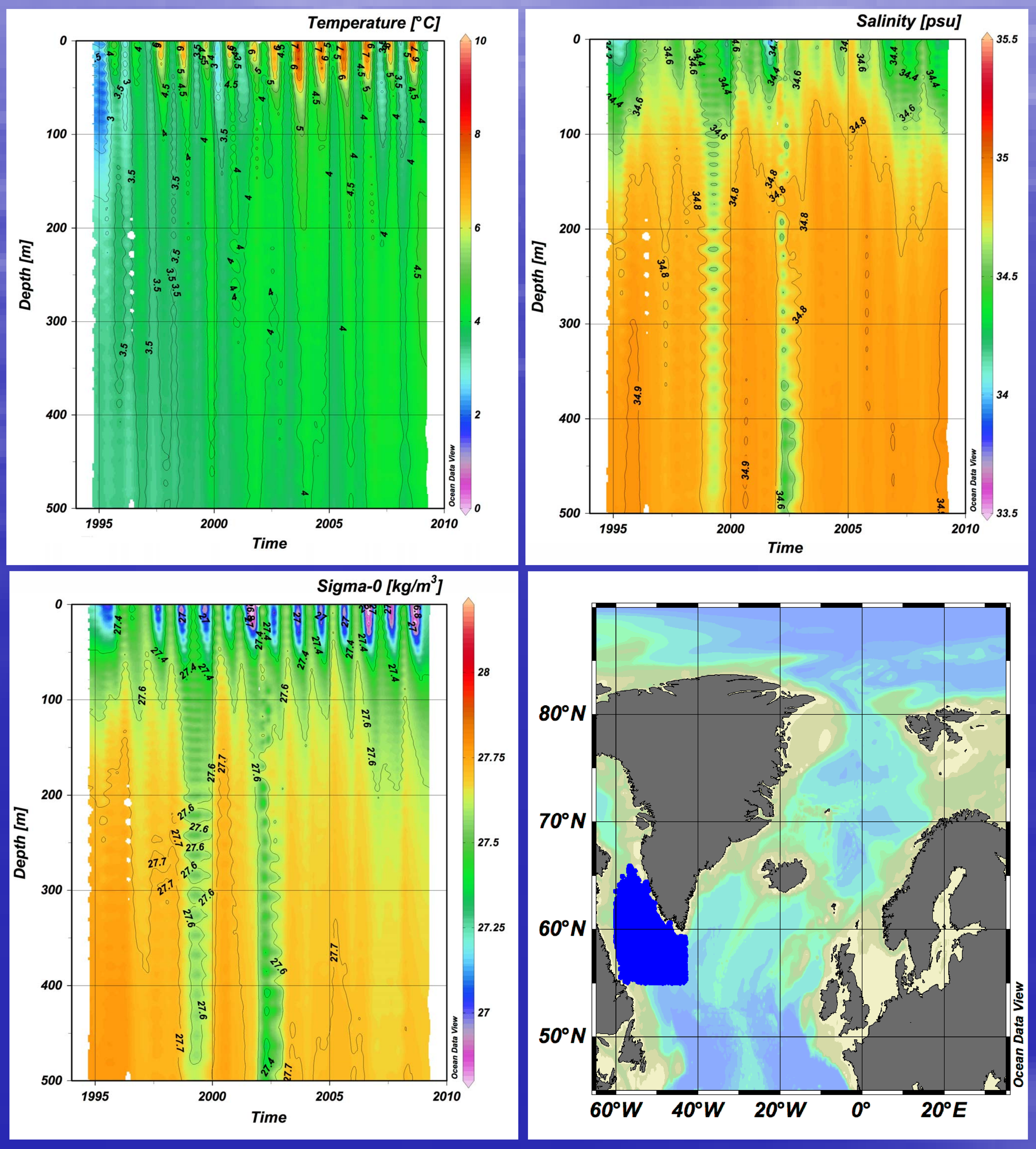
Based on weekly compilations of cloud-free SST retrievals.
* Starting 1 January, 2002.

Multiple SST time series in Labrador Sea



Using data stored in the GHRSST-DDS (Group for High Resolution SST-Diagnostics Data Set) time series of all available satellite-derived SSTs can be derived. Here we show several years of daily values of averaged SSTs in a 2°x2° box centered on the 60°N, 55°W. Although there is significant spread between the data sets – the causes of which are under investigation – the pattern of the annual cycles are replicated in all data sets. The amplitude of the seasonal cycle is increasing in all data sets.





ARGO Data in Labrador Sea area, 0-500 m depth.					
Winter of:	2002	2003	2004	2005	2006
Temperature profile	Some vertical gradients	Near isothermal	Isothermal	Some vertical gradients	Isothermal
Salinity Profile	Near surface salinity gradients	High salinity at the surface, largely isohaline	High salinity at the surface, largely isohaline	High salinity at the surface, largely isohaline	Near surface salinity gradients
Density Profile	Some near surface gradients	Some near surface gradients	Some near surface gradients	Denser water close to surface; quite well mixed	Denser water close to surface
Winter convection?	Unlikely	Possibly	Possibly	Likely	Possibly

Winter convection in the Labrador Sea

There are no convincing signals of winter convection in the ARGO data in the Labrador Sea. Is this because the convection is on small horizontal scales not sampled by the profilers, or was there no convection?

The length of winter, as determined by the presence of SST<-1°C in the AVHRR Pathfinder data , is rather invariant from year to year. The number of cold weeks does show interannual variability, but (on this small sample size) is not obviously related to the likelihood of winter-time convection.

Sea Surface Temperature s and Convection in the Labrador Sea.

Part of our focused analyses of satellite data sets is to determine variability of surface conditions that might be sensitive to MOC fluctuations. Using data from the AVHRR Pathfinder v5 global SST climatology in conjunction with profiles from the ARGO array, the characteristics of the upper water column in the Labrador Sea area are being studied in relation to the time-series of multi-year satellite data.

The figures (left) show time series of the ARGO measurements in the Labrador Sea (blue area, bottom right). Top left is Temperature, which is not a strong controller of density, but which can be measured from space, and top right is salinity, which is a strong controller of temperature, but which cannot be measured from space. Bottom left is derived density (σ_0).

Problems and concerns

Even though there is over a decade of ARGO data, the sampling in critical areas is quite sparse and spatially and temporally irregular. Are we capable of capturing accurately the deep convection?

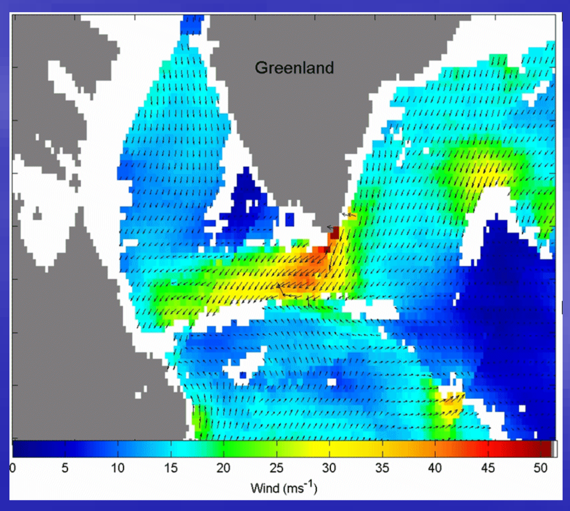
Because of cloud cover, sampling of SST by infrared sensors is irregular. How does this influence our description of interannual variability?

There is a known warm bias in cold SST retrievals – how does this influence the analysis?

The cold temperatures seen in the winter in the Labrador Sea are absent in the ARGO data. Why?

Next steps

- Identify a better metric for winter convection in the ARGO data in the Labrador Sea.
- Extend analysis of AVHRR Pathfinder SST time series, varying averaging areas.
- Include MODIS and AMSR-E SSTs into the analysis
- Study wind signals in the wintertime Labrador Sea area.
- Extend analysis to the West Greenland Sea



QuikSCAT wind speed and direction data reveal the reverse-Greenland tip jet 15 January 2004

Wind fields in AMOC critical areas

The emphasis of the analysis of the surface wind fields will be on the wintertime features in the areas of deep water formation. An example of a high wind speed event is the Greenland Tip Jet, which occurs to the south of Greenland from November to April, when low-pressure systems cross the south of Greenland where mountains divert the winds, accelerating them around the Southern tip of Greenland. Peak wind speeds reach well in excess of 20 ms^{-1}, but last for relatively short periods of a day or so.

Acknowledgements

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