Satellite Multi-Sensor Studies of Deep Ocean Convection in North Atlantic Ocean

PI: X.-H. Yan[1] and Y.-H. Jo[1]
Collaborator: T. Lee[2]
[1]University of Delaware, Newark, DE
[2)]NASA Jet Propulsion Laboratory, Pasadena, CA

The objective of this project was 1) to analyze air-sea interaction and meridional heat and freshwater transport estimations to identify regions associated with preconditioning and lateral exchange prior to and post deep convection, 2) to analyze horizontal flow field and vertical water column analysis, and 3) to find linkage between deep ocean convection and subsurface thermal structure estimated from satellite multi-sensor data. The following objective was added: 4) to find the relationships of the deep convection, the AMO (Atlantic Multi-decadal Oscillation), and the AMOC together, with the slowdown of the warming in the upper layers in the central Labrador Sea as a local presentation of the current climate hiatus and their implications.

Recent results

Climate signals in the mid to high latitude North Atlantic from altimeter observations and the implications for recent global surface warming hiatus (Li et al. 2014a):

- The variability of the sea surface height anomaly (SSHA) in the mid- to high-latitude North Atlantic for the period of 1993–2010 was investigated using the ensemble empirical mode decomposition (EEMD) to identify the dominant timescales. Sea level variations in the North Atlantic subpolar gyre are dominated by the annual cycle and the long-term increasing trend. In comparison, the SSHA along the Gulf Stream is dominated by variability at intra-seasonal and annual timescales. Moreover, the sea level rise in the subpolar gyre developed at a reduced rate in the 2000's compared to rates in the 1990's, which was accompanied by rebound in SSHA variability following a period of lower variability in the system. These changes in both apparent trend and low-frequency SSHA oscillations reveal the importance of low-frequency variability in the subpolar gyre. To identify the possible contributing factors for these changes, the heat content balance (equivalent variations in the sea level) in the subpolar region was examined. The results indicate that horizontal circulations may primarily contribute to the interannual to decadal variations, while the air-sea heat flux is not negligible at annual timescale. Furthermore, the low-frequency variability in the subpolar gyre might be related to the propagation of AMOC variations from the deep-water formation region to mid-latitudes in the North Atlantic, which has the implications for recent global surface warming hiatus.

Thermal variability in the central Labrador Sea of 2003 – 2012 derived from Argo data, and a local presentation of the current climate hiatus (Li et al. 2014b):

- The dominant modes of variability in the temperature and ocean heat content (OHC; 0 ~ 1000 m) of the central Labrador Sea were investigated using the EEMD/Hilbert-Huang Transform based on Argo profiles collected during 2003-2012. Warming trends were observed in the entire water column. A strong annual cycle exists and dominates at the 500 m depth, while signals at the interannual timescales can explain most of the variability at the 1000 m and 1500 m depths. These interannual signals are closely correlated to the variability of deep convection in the Labrador Sea, which has wintertime mixed layer depth (MLD) of around 1000 m during the time period of this study with an intermittent enhancement of MLD > 1500 m. The Hilbert spectrum from the heat content (0 – 1000 m) in the Labrador Sea interior reveals two