THE ECCO CONSORTIUM: IMPORTANCE OF GENERAL CIRCULATION CHANGES TO ATLANTIC OCEAN HEAT STORAGE RATES[1]

Atmospheric and Environmental Research, Inc.

Christopher G. Piecuch (cpiecuch@aer.com) and Rui M. Ponte (rponte@aer.com)

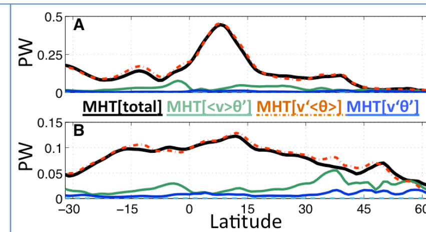
Atmospheric and Environmental Research, Inc., Lexington, MA USA

WCRP OSC
Session: C9
Poster: M108A

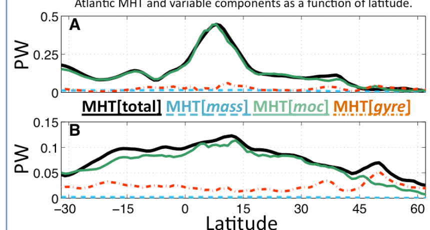
I. INTRODUCTION. The Atlantic meridional overturning circulation (**AMOC**) and its variability have been the subject of much attention. This is partly motivated by the notion that overturning changes could impact northern hemisphere climate via direct influence on Atlantic Ocean sea surface temperatures (**SSTs**). However, links between ocean circulation and meridional heat transport (**MHT**) variability, sea surface temperature variations, and ocean heat storage rates (**OHSRs**) are not well understood. Hence the potential impacts of overturning circulation changes on Atlantic sector climate cannot be anticipated at present. To work towards closing this knowledge gap, in this study we seek to answer the question:

How is overturning circulation variability related to changes in ocean heat storage?

To this end, ocean heat budgets and meridional heat transports are diagnosed across the tropical and subtropical Atlantic Ocean on seasonal and interannual timescales using an estimate of the ocean state over 1993-2004. The ocean state estimate was produced by the Estimating the Circulation and Climate of the Ocean (ECCO) consortium, generated by a coarse-resolution (1°×1°) general circulation model, and optimized through assimilation of millions of observations of the ocean and the atmosphere (ref 2); the ECCO state estimate satisfies all governing dynamics and conservation laws, allowing for formulation of heat budgets that close exactly.



↑**Figure 1**: RMS of (A) seasonal and (B) interannual time series of Atlantic MHT and variable components as a function of latitude.

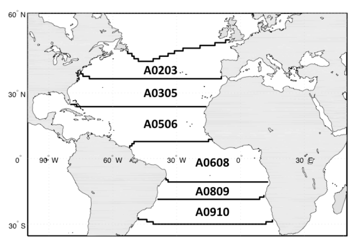


II. MHT VARIABILITY. We begin by studying Atlantic Ocean MHT variability on climate timescales. MHT is separated into mean seasonal-cycle and interannual-anomaly time series (**Figs. 1-2**), and the underlying contributing processes and mechanisms are studied.

(1) Variable decomposition: we studied the roles of meridional velocity (v) variability [v'<θ>], potential temperature (θ) variability [<v>θ'], as well as v-θ co-variability [v' θ'] (**Fig. 1**).

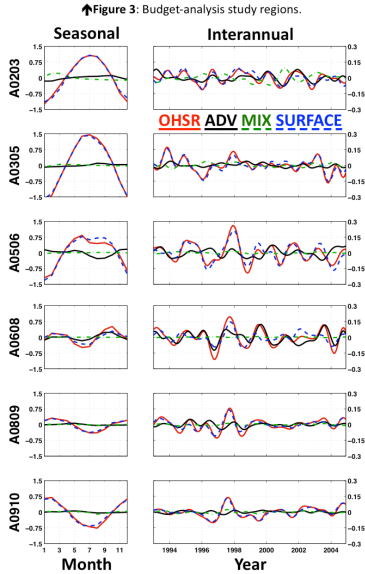
(2) Circulation decomposition: following ref. (3), we examined the influence of barotropic net mass fluxes [*mass*], baroclinic overturning circulations [*moc*], and horizontal flows [*gyre*] on MHT variability (**Fig. 2**).

←**Figure 2**: RMS of (A) seasonal and (B) interannual time series of Atlantic MHT and circulation components as a function of latitude.

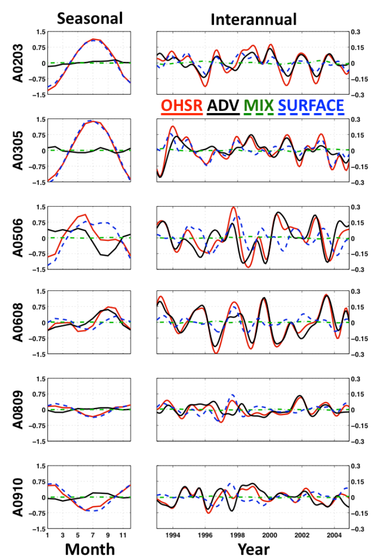


↑**Figure 3**: Budget-analysis study regions.

III. HEAT STORAGE RATE BUDGETS. To study causes of heat content changes, budgets of ocean heat storage rates (**OHSR**) were formed in terms of advection (**ADV**), diffusive mixing (**MIX**), and surface heating (**SURFACE**). Large spatial-scale regions (**Fig. 3**) were studied on seasonal and interannual timescales. Budgets were examined for the near surface ocean (0-100 m; **Fig. 4**), the upper ocean (0-1000 m; **Fig. 5**), and the full column (not shown).

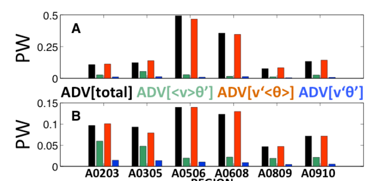


↑**Figure 4**: Time series of regional **near-surface** (A) seasonal and (B) interannual budget terms. Y-axes have units of PW.

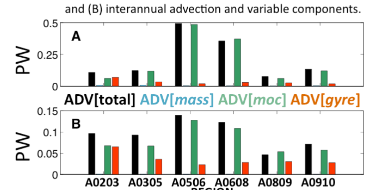


↑**Figure 5**: Time series of regional **upper-ocean** (A) seasonal and (B) interannual budget terms. Y-axes have units of PW.

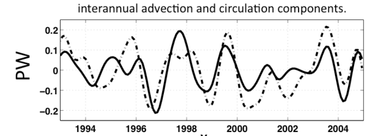
IV. DIAGNOSING THE ADVECTION. To link mechanisms of meridional heat transport (**Figs. 1-2**) to heat budgets (**Figs. 4-5**), we diagnose what variables (**Fig. 6**) and circulation processes (**Fig. 7**) most contribute to the full water column advection (**ADV**) in the study regions. Such analysis reveals a relationship between MHT driven by the AMOC and near surface OHSR variability along the equatorial Atlantic (i.e., region A0608; **Fig. 8**).



↑**Figure 6**: RMS of regional time series of (A) seasonal and (B) interannual advection and variable components.



↑**Figure 7**: RMS of time series of (A) seasonal and (B) interannual advection and circulation components.



↑**Figure 8**: Interannual time series of **near-surface OHSR** (solid) and **ADV[*moc*]** (dashed) from region A0608. Correlation between the series is 0.65.

V. SUMMARY AND CONCLUSIONS.

(1) Relation of MHT variations to AMOC changes depends on latitude and timescale (**Figs. 1-2**).

(2) AMOC-related advection contributes importantly to OHSR changes at low latitudes and on interannual timescales (**Figs. 4-7**).

(3) Near-surface OHSRs and AMOC-related MHT changes are correlated in equatorial regions on interannual timescales (**Fig. 8**).

(4) Any direct relation between SST-variations and intermediate/deep AMOC changes is not clear.

REFERENCES.

(1) Piecuch and Ponte (in press): Importance of circulation changes to Atlantic heat storage rates on seasonal and interannual timescales, *J. Climate*, doi: 10.1175/JCLI-D-11-00123.1.

(2) Wunsch et al. (2007): Decadal Trends in Sea Level Patterns: 1993-2004, *J. Climate*, **20**, 5889-5911.

(3) Bryden and Imawaki (2001): Ocean Heat Transport, *in Ocean Circulation and Climate: Observing and Modeling the Global Ocean*, Cambridge, 455-474.

ACKNOWLEDGMENTS. This work was supported by grant NNX08AV89G from the National Oceanographic Partnership Program and contract NA10OAR431019 from the National Oceanographic and Atmospheric Administration's Office of Global Programs.