

Observations for Climate: Evaluating the Global Ocean Observing System R. Lumpkin, M. Baringer, C. Schmid, G. Goni and S. Garzoli (NOAA's Atlantic Oceanographic and Meteorological Laboratory, Miami FL)

Introduction

Every year, NOAA publishes an Annual Report on the State of the Climate in the Bulletin of the American Meteorological Society. This Annual Report includes a chapter on the state of the oceans for the previous year and provides an overview of the ocean, its role in climate, and the connections between ocean observations and economic and societal impact, based on the observations collected and analysis performed as part of the NOAA Ocean Observing System.

NOAA/AOML contributes to the State of the Climate report through its varied data collection efforts. Starting in 2005, NOAA/OCO has funded Quarterly Reports on certain key ocean state variables:

- Global Surface Currents
- Global Heat Storage
- Atlantic Meridional Heat Transport

Global Surface Currents

NOAA/AOML provides quarterly reports on the state of the Global Ocean Observing System (GOOS) for near-surface currents. Surface currents carry massive amounts of heat from the tropics to subpolar latitudes, and reflect the upper limbs of the global meridional overturning circulation.



Right: Major surface currents of the world's oceans

Data sources: NOAA/AOML houses the Drifting Buoy Data Assembly Center and The Drifter Operation Center, components of NOAA's Global Drifter Program (GDP). A major goal of the GDP is to maintain an array of ~1250 satellite-tracked drifting buoys to measure mixed layer (near-surface) currents, sea surface temperature, air pressure, and winds. At several sites, fixed current meters also measure near surface currents; theses data are provided by the TAO Project Office at NOAA/PMEL.



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Left: Evaluation of surface current measurements by the GOOS for July—September 2011. Top left *panel*: the GOOS/GCOS requirements. *Top right* shows the surface current measurements in 2011 Q3. Undrogued drifters are not included as they do not meet the accuracy requirement. <u>Bottom</u> *left*: 5x5° bins that met the requirements for 0 (red), 1 (yellow), 2 (light blue) or all 3 (dark blue) months of the quarter. *Bottom right*: fraction of world covered by the surface current observing system. Reevaluation of drogue presence in the period ^{20%} 2005—2008 will likely lower the ^{0%} curve there in future reports.

Heat Storage

NOAA/AOML provides quarterly reports on the state of the Global Ocean Observing System (GOOS) for the heat storage. Oceanic temperature is important for monitoring the climate change as well as, for example, monitoring and predicting tropical cyclones.

Difference between the heat storage (Q) in the mixed layer from 2008 and 2009 (Q(2009)-Q(2008))



Data sources: Argo Global Data Centers and Global Temperature Salinity Profile Project. NOAA/AOML runs the US Argo Data Assembly Center which processes about half of the Argo data available globally. Argo is committed to maintain an array of 3000 floats to measure temperature and salinity profiles in the upper 2000m of the ocean as well as subsurface currents at the drift depth of the floats. This observation network is complemented by XBT and CTD profiles collected from ships.

Observing System Status: JFM, 2011 Heat Storage of the mixed layer (in situ estimates)



System
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•) at OGP/NOAA publishes an Annual Report on the State of imate . This Annual Report provides an overview of the ocean, observations and economic and societal impact, based on the of the NOAA Ocean Observing System. varied data collection efforts , and as of 2005, through bles:
stored in the upper ocean estimated using data from ARGO er Observing Ship (VOS) program, expendable nes, and satellite altimetry.
situ data coverage, sufficiency and error estimates using 15 /s and moored current meters .
ansport: Ocean heat transport by ocean currents, estimated bathythermograph (XBT) lines.
<u>AOML webmaster</u>

Accessing the quarterly evaluations

These quarterly evaluations can be accessed from NOAA/AOML's **State of the Ocean Observing System** web page, linked directly from the Physical Oceanography Division's page and available at http://www.aoml.noaa.gov/phod/soto/index.php.

Data underpinning these reports

•Quality controlled, interpolated drifter data from AOML. •Current meter data from various sites in the Tropical Moored Array (PIRATA, RAMA and TAO), quality controlled by the TAO project office at PMEL. •High-density expendable bathythermograph (XBT) data from five lines in the Atlantic Ocean, providing temperature profiles to depths of 850m, with horizontal spacing of 10— 50 km.

•US Argo profiles from a global array of floats distributed over the global oceans, measuring the temperature and salinity in the upper 1,000—2,000 m.

Evaluation of heat storage (Q)of the mixed layer for January through March 2011. *Top left*: Heat storage Q. <u>Bottom left:</u> the corresponding error of Q. <u>Top</u> *right:* data coverage color coded to indicate how many months (as %) in a quarter for which an estimation of the mixed layer thickness and temperature is possible. <u>Bottom</u> *right:* time series showing the evolution of the data coverage and the global error on a month by month basis.

Heat Transport

NOAA/AOML provides quarterly reports on the state of the Global Ocean Observing System (GOOS) for the heat transport in the North and South Atlantic. Heat transport is directly related to the role that this basin plays in the meridional overturning circulation and is an important benchmark for integrated air-sea fluxes and numerical model performance.

Right: Heat transport estimates for the Atlantic Ocean. AOML estimates provide new data every quarter for the North and South Atlantic near 30°N and 35°S.

Data sources: NOAA/AOML houses the Ship of Opportunity Program (SOOP) which is responsible for providing a global platform to deploy and operate and deploy oceanographic instrumentation from cargo ships or research vessels. SOOP operations include XBT transects and TSG. Two of these east-west oriented lines that span the North and South Atlantic are designed to measure the mesoscale structure of the ocean, to diagnose the ocean circulation responsible for redistributing heat and other water properties globally. These lines, designated AX7 and AX18, provide the bulk of the data used in this report. Satellite and national weather center weather prediction models provide estimates of surface winds, while Argo and other hydrographic data and analyses (e.g. Levitus climatology) provide salinity data and data below 850 m.









Left: Estimates of the northward heat transport is shown for the line in the North Atlantic for June 2011. A similar report is available for the line in the South Atlantic. Top left panel: XBT locations (red) used for this estimate. *<u>Top right</u>*: temperature section during this period. **Bottom left:** time series of heat transport estimates divided into Ekman (red) and geostrophic interior (green) and total (blue) heat transport values. *Bottom right*: seasonal cycle of heat transport.