Oceans and Climate

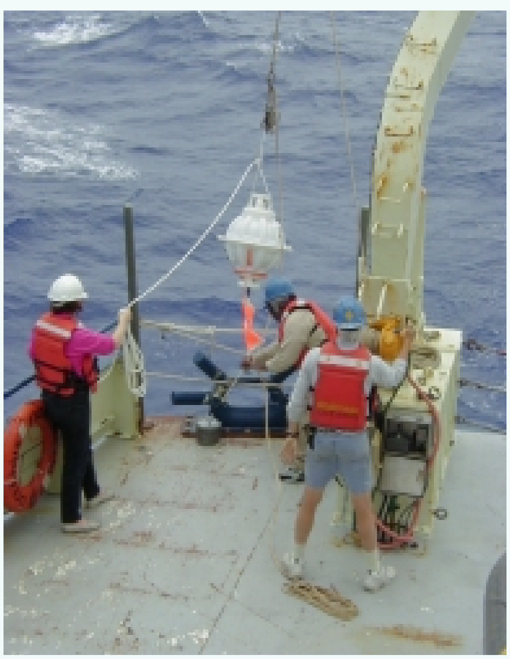
Background:

AOML is conducting climate studies with global scope to better understand the global setting for regional signals, and how the regional signals contribute to global phenomena. Multi-institutional efforts include studies of the El Niño-Southern Oscillation (ENSO) and the North Atlantic Oscillation (NAO), research on the global ocean carbon cycle, atmospheric chemistry, and western boundary currents including the Gulf Stream, Deep Western Boundary Current, North Brazil Current, tropical Atlantic circulation, and Caribbean oceanography. Techniques vary from shipboard-conducted process studies, models, long-term continuous time series, and satellite-derived products. In addition, AOML is the home of the NOAA Global Ocean Observing System (GOOS) Center, as part of the new paradigm for operational oceanography which places operational activities within research laboratories.

Launch of a drifting buoy.

Challenges:

One of the major challenges that we impose upon ourselves is the search for new indices that will allow us to predict and forecast long-term climate changes. By collecting long-term, excellent-quality observations in the ocean and the atmosphere, we will be able to confirm or modify the results derived from model predictions. We have a unique opportunity in the study of the Atlantic. The Atlantic Ocean is responsible for over half of the heat transported by the global ocean due to the Meridional Overturning Circulation (MOC) and thus plays a major role in the global circulation and heat transport budget. Another challenge is collecting oceanic and atmospheric data and distributing these data in real time. A fast response of quality-controlled data is crucial to the improvement of forecasts. We intend to improve the existing technology, the data acquisition systems, and the distribution of data.



Launch of an inverted echo sounder.

Priorities:

Our main priority is to collect high-quality observations for climate studies. The effort should be divided into research and operations. Operations should be guided by scientific needs (*e.g.,* we need sea surface temperatures to run the forecast models; therefore, we deploy drifters and collect other shipboard observations). Research programs that we plan for the near future are given in what follows.

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Research Goals and Actions for 2002-2007:

Goal:
Determine the role of the Atlantic Ocean in the "multidecadal mode," low frequency climate fluctuations

Actions:

- Improve understanding of large scale interactions between the ocean and atmosphere (so-called teleconnections) logged in space and time
- Determine regional impacts of changes in precipitation/drought patterns; hurricane genesis, intensification, and landfall; and atmospheric circulation (*e.g.,* storm tracks)
- Provide oceanic data for continued improvements in predictions of the atmosphere-ocean coupled system

Preparing for the launch of a float.

Goal:
Improve estimates of the exchange of heat and fresh water between the south and north Atlantic Oceans

Actions:

- Define a network of observations to assess heat transport and variability across key regions (*e.g.,* the subtropical Atlantic Ocean)
- Determine circulation features and variability associated with these transports (*e.g.,* the role of Brazil Current rings versus interior oceanic pathways)
- Continue high resolution expendable bathythermograph (XBT) networks to determine heat transport and circulation

Launch of a conductivity-temperature-depth (CTD) sounder.

Goal:
Quantify the role of the oceans in modulating climate through study of the global balance of CO_2 and other radiatively important gases

Actions:

- Develop technology for automated CO_2 measurements from ships
- Establish baseline estimates of anthropogenic carbon storage in the oceans and assess change through continued monitoring efforts
- Collect observations of important gases in key choke points (*e.g.,* the Deep Western Boundary Current and the Gulf Stream)
- Improve understanding of air-sea exchanges, ventilation, and mixed layer dynamics including nutrient cycling

Oceans and Climate

Goal:
Study tropical Atlantic Ocean variability and its influence on climate and weather of the surrounding continents

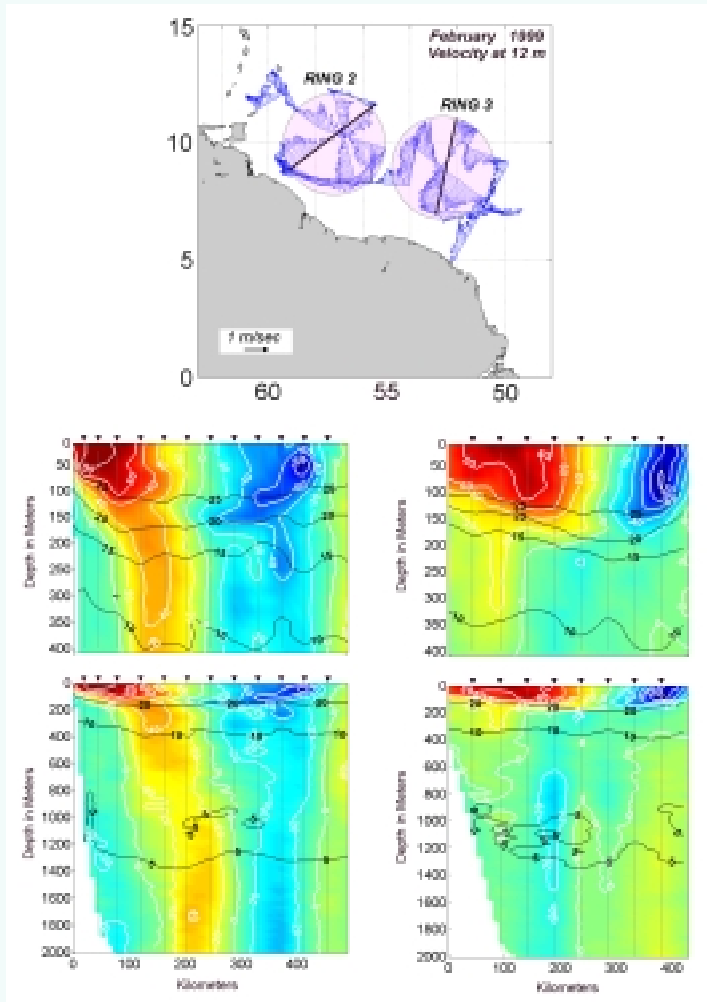
Actions:

- Improve our understanding of the Atlantic Ocean El Niño and the tropical Atlantic Ocean meridional gradient mode
- Understand the relationship between the Intra-Americas Sea and the tropical Atlantic Ocean
- Define dominant pathways into and out of the Caribbean basin (*e.g.,* through the Windward Island Passages)

Goal:
Understand the circulation pathways in the tropical Atlantic Ocean and their effect on climate

Actions:

- Measure the role of subtropical cells and the Brazil Current in ventilation of the equator
- Determine dominant pathways of the meridional overturning circulation return flow and associated heat transport across the equator
- Improve uses of altimetry to monitor mesoscale oceanic features
- Continue profiling float and drifter deployments to determine circulation pathways



First observations of the surface (top) and vertical (bottom left and right) velocity structure of two North Brazil Current rings.

Goal:
Understand variability of the tropical Western Hemisphere warm pool (WHWP)

Actions:

- Investigate the seasonal cycle of the WHWP
- Study variability of the WHWP on interannual and longer time scales
- Improve our understanding of the relationships of the WHWP with eastern North Pacific and Atlantic hurricane activities and rainfall, from northern South America to the southern tier of the United States

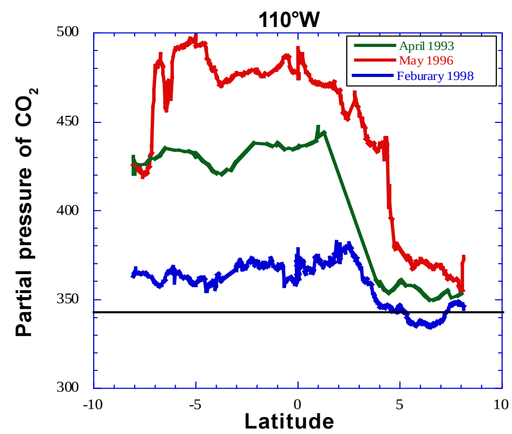
Oceans and Climate

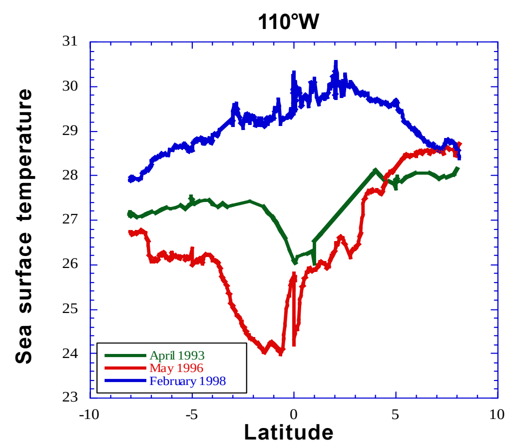
Goal:

Develop sustained ocean observing systems for understanding and predicting climate change

Actions:

- Provide the scientific background for designing observing systems
- Monitor the meridional overturning circulation at selected locations (*e.g.,* the Straits of Florida)
- Provide data for large-scale ocean state estimation using ARGOS profiling subsurface floats, surface drifters, expendable temperature profilers, *etc.*





The equatorial Pacific is the largest and most variable oceanic source of CO_2. NOAA investigators have monitored the trends of surface water CO_2 levels over the past decade and have determined a strong correlation with the El Niño cycle. As the figure shows, during El Niños (such as 1998) the amount of CO_2 emitted from the equatorial Pacific decreases dramatically. The opposite occurs during La Niñas such as 1996 when the amount of CO_2 released increases dramatically compared to normal years such as 1993. The trends of surface water CO_2 are opposite those of sea surface temperature.

Anticipated Impacts:

AOML will have improved significantly the understanding of the role of the global ocean in decadal and larger time scales of climate variability–in particular, the role of the Atlantic overturning circulation–and we will join other institutions in pioneering the extension of climate research to regional applications such as agricultural and water resources. AOML and cooperating institutions will have completed the first cruises of the global repeat hydrography survey and obtained the first decadal scale estimates of carbon sequestration in the South Atlantic and North Atlantic Oceans. AOML will lead the Atlantic alliance of surface pCO_2 measurers and will have established a comprehensive observing plan to determine basinwide air-sea CO_2 fluxes on seasonal time scales. We will also be at the center of a new frontier in oceanography, one in which ocean variability is sampled in real time and analyzed and predicted operationally much the way the atmosphere is today.

Beyond 2007:

As our understanding of climate processes and their indices, precursors, and impacts improve, as real-time *in-situ* and satellite measurements become *de rigueur*, and as we learn how to simulate and predict global ocean variability with our academic partners, we will be moving into exciting new areas of climate research and society-driven applications. The future research will likely still target the Atlantic overturning circulation and its role in climate variability, but will now move towards ways to predict its regime shifts. We will complete the global survey of anthropogenic CO_2 content in the ocean for the first decade of the 21st century, producing an operational product of seasonal air-sea CO_2 flux maps on global scales.