Atlantic Oceanographic and Meteorological Laboratory

AOML is an environmental research laboratory of the federal government located on Virginia Key in Miami, Florida

U.S. Department of Commerce
National Oceanic and Atmospheric Administration
Office of Oceanic and Atmospheric Research

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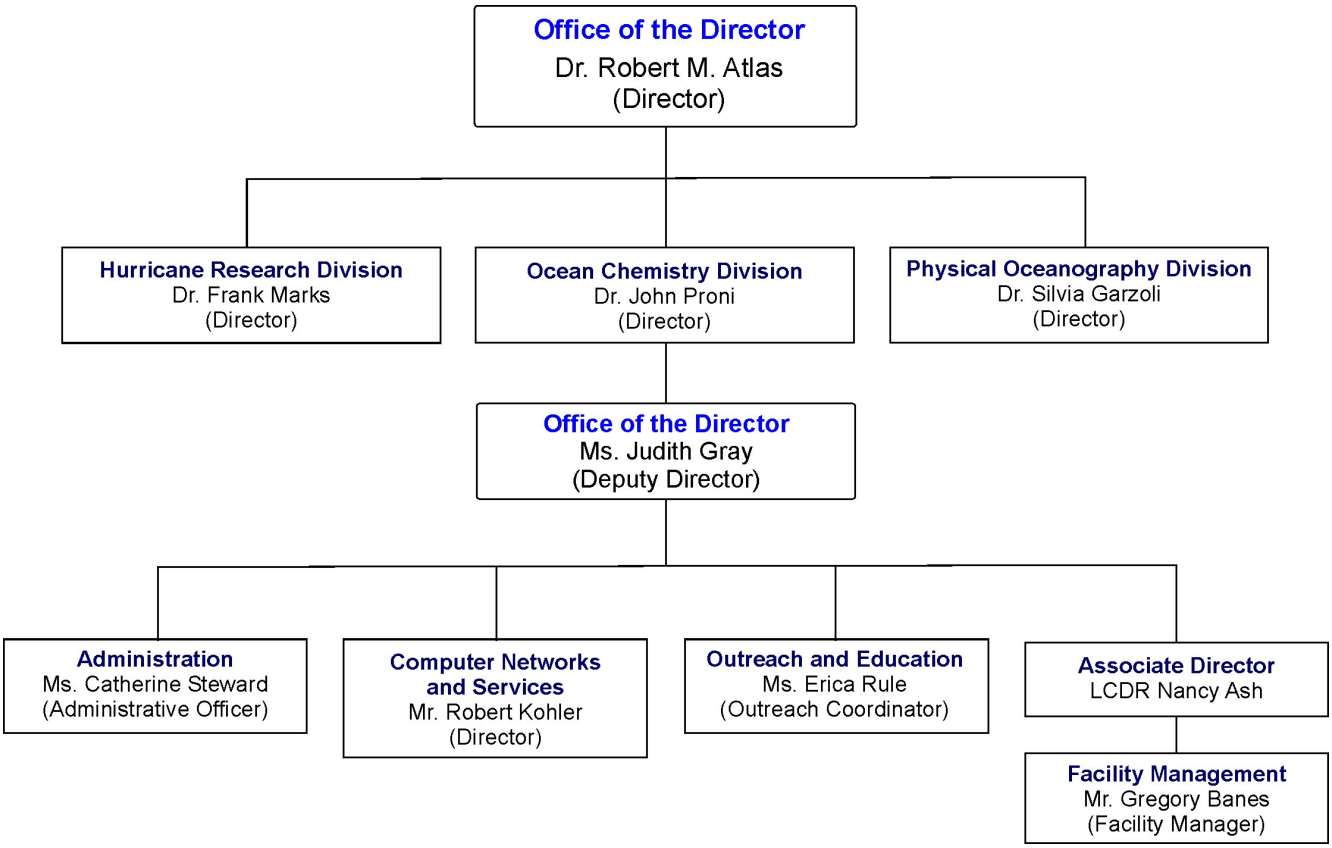
Mission

The Atlantic Oceanographic and Meteorological Laboratory conducts research that seeks to understand the physical, chemical, and biological characteristics and processes of the ocean and atmosphere, both separately and as a coupled system. The principal focus of these investigations is to provide knowledge that will ultimately lead to more accurate forecasting of severe storms, better utilization and management of marine resources, better understanding of the factors affecting both climate and environmental quality, and improved ocean and weather services for the nation.

Organizational Structure

The Atlantic Oceanographic and Meteorological Laboratory (AOML) fits within the Executive Branch of the United States Federal government under the National Oceanic and Atmospheric Administration (NOAA). NOAA is one of several agencies housed within the Department of Commerce.

AOML consists of an Office of the Director and three science divisions (Hurricane Research, Ocean Chemistry, and Physical Oceanography). The Office of the Director oversees the Laboratory's scientific programs, as well as its administrative, financial, computer, outreach/education, and facility management services.



Research conducted by AOML scientists encompasses a broad range of environmental topics: hurricanes, ocean current and temperature structures, ocean-atmosphere chemical exchanges, and the coastal ocean via the use of research ships and aircraft, satellite remote sensing techniques, numerical and statistical models, radar, acoustics, and drifting buoys. Additionally, AOML's science programs are augmented by the Cooperative Institute for Marine and Atmospheric Studies (CIMAS), a joint enterprise with the University of Miami's Rosenstiel School of Marine and Atmospheric Science. CIMAS enables AOML and university scientists to collaborate on research areas of mutual interest and facilitates the participation of students and visiting scientists.

AOML's workforce is comprised of both Federal and non-Federal (CIMAS and contractor) employees. The Laboratory's staff also includes several NOAA Corps officers and the National Environmental Satellite, Data, and Information Service librarian and staff.

Hurricane Research Division

The Hurricane Research Division's (HRD) mission is to advance the understanding and prediction of hurricanes and other tropical weather systems. HRD addresses issues that have direct impact upon NOAA's ability to provide tropical cyclone weather forecasting and warning services to the public. Much of HRD's research is based on in situ and remotely-sensed observations in the inner core of tropical cyclones and their surrounding environment. These observations are primarily collected during the hurricane season using two NOAA turboprop aircraft and a Gulfstream-IV jet operated by NOAA's Aircraft Operations Center. Data sets gathered on these flights in all stages of the storm's lifecycle are used to support operational needs and form the cornerstone of research in HRD. Because of this extensive field experience, HRD scientists are recognized internationally for their knowledge of tropical cyclones, as well as their expertise in technological areas such as airborne Doppler radar, dropsondes, cloud microphysics, and air-sea interaction, to name a few. These assets make HRD unique worldwide, and provide NOAA a unique capability.

CURRENT RESEARCH PROJECTS

Tropical Cyclone Intensity and Structure Change

The next hurricane catastrophe will almost certainly happen through rapid intensification, an event that can transform a category 2 hurricane into a category 4 hurricane overnight. Although the physical processes that control intensity change are understood in general terms, operational predictions seldom outperform the simplest statistical extrapolations. Often extrapolation is good enough, but not during rapid intensification. Although it appears that warm underlying ocean water and absence of vertical shear of the surrounding wind play key roles, meteorologists need to understand intensity change more deeply before reliable forecasts of rapid intensification can become a reality. HRD researchers seek to improve the basic physical understanding and forecasts of tropical cyclone intensity/structure change and develop forecast and process models to test against observations. *(Principal Investigators: Sim Aberson, Peter Black, Joseph Cione, Jason Dunion, John Gamache, John Kaplan, Mark Powell, Robert Rogers, Eric Uhlhorn)*

Hurricane Track Forecasting

Historically, errors in track forecasts have improved about 1% a year. The decrease in errors has accelerated recently through better numerical forecast models and generally-improved procedures. Beginning in the early 1980s, HRD has used NOAA's two WP-3D aircraft to measure the winds that control storm motion. Since 1997, NOAA's Gulfstream-IV SP jet has flown similar missions routinely. Through careful "targeting" of locations of observations, the additional data can reduce errors by as much as 40%. If warning areas can be reduced by 25%, the reduction in "overwarning" costs could be as much as $100M per year. If more accurate and timely warnings reduce property losses by as little as 1%, another $100M could be saved in recovery costs. Ultimately, better track forecasts, along with skillful intensity forecasts, reduce the likelihood of hurricane disasters. *(Principal Investigator: Sim Aberson)*

Hurricane Impacts

Meteorologists at HRD strive to enhance NOAA's ability to diagnose and predict the impact of tropical cyclones on life and property through wind, rain, waves, and storm surge. HRD scientists routinely prepare real-time analyses of hurricane surface winds based upon remotely-sensed, aircraft, and conventional observations that are made available to forecasters at the Tropical Prediction Center/National Hurricane Center as guidance for warnings. Extrapolation of the winds onshore can provide a vital preview of damage patterns for emergency managers and other officials. HRD researchers are also developing guidance for tropical cyclone rainfall forecasts and model evaluation. Working closely with scientists of the Geophysical Fluid Dynamics Laboratory and the Environmental Modeling Center, HRD researchers are evaluating the rainfall produced in the operational models. *(Principal Investigators: Frank Marks, Mark Powell, Robert Rogers)*

Long-term Changes of Overall Hurricane Activity

Gradual northward currents in the Atlantic Ocean alternate between a cooler, lower-salinity phase and a warmer, higher-salinity phase within a 40-70 year period. The cooler phase correlates with fewer landfalls by major hurricanes (winds >115 mph), while the warmer phase correlates with more. An increase in major hurricanes is a concern because they account for 80% of destruction, although they represent only 20% of U.S. landfalls. Despite the 1997 El Niño, the 1995 through 2005 hurricane seasons were the most active consecutive 10 years on record. This event appears to mark a return to the active phase after the lull that began in 1970. It raises concerns that architectural, land use, and other decisions made during the lull may be inappropriate to conditions during the first half of the 21st century. HRD researchers use objective techniques to analyze and understand hurricane climatic fluctuations for the North Atlantic basin on multidecadal time scales. *(Principal Investigator: Stanley Goldenberg)*

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Ocean Chemistry Division

The Ocean Chemistry Division (OCD) focuses on research studies that enhance basic understanding of the coupled ocean/atmosphere system and assess the current and future effects of anthropogenic activities on atmospheric and coastal/deep ocean environments. The Division's diverse staff is comprised of marine and atmospheric chemists, chemical, biological, and geological oceanographers, an environmental microbiologist, and coastal environment, fisheries, and acoustics scientists.

CURRENT RESEARCH PROJECTS

South Florida Ecosystem Restoration, Prediction, and Modeling

NOAA has taken a lead role amongst collaborating federal and state agencies in investigating the causes of observed changes in the Everglades/Florida Bay coastal ecosystem and in quantitatively predicting the coastal ecosystem consequences of upstream restoration activities associated with the Comprehensive Everglades Restoration Plan (CERP) and overall South Florida Ecosystem Restoration (SFER) effort. SFER is the largest and most ambitious ecosystem restoration project in U.S. history. AOML conducts biological, chemical, and physical studies in collaboration with university investigators and represents NOAA on CERP/SFER committees charged with planning, coordinating, and implementing the overall interagency scientific program and the input of scientific information into the adaptive management process. *(Principal Investigator: Peter Ortner)*

Global Carbon Cycle Studies

OCD's Global Carbon Cycle studies focus on the exchange of carbon dioxide (CO_2) across the air-sea interface and its eventual penetration into the water masses of the deep ocean. This work involves basic research to study the mechanisms of exchange, as well as sustained operational efforts to quantify decadal changes of carbon inventory in the ocean and seasonal air-sea CO_2 fluxes. (*Principal Investigator: Rik Wanninkhof*)

Atmospheric Chemistry

OCD's atmospheric chemistry program is an ongoing effort to understand the role of trace chemical species in the marine and continental troposphere. These investigations include the use of ozone as a tracer for the structure of tropical cyclones and the impact of ozone on the marine mesoscale ozone distribution. Another ongoing project is to obtain improved regional flux values of selected trace gases by the use of radon (^{222}Rn) measurements using improved instrumentation deployed on a tall tower and from aircraft. *(Principal Investigator: Thomas Carsey)*

Nutrient Dynamics in the Ocean

OCD's Nutrient Laboratory focuses on biogeochemical cycles of nutrients (nitrogen, phosphorus, silicon) in the coastal and open ocean environments. Current research includes: (1) biogeochemical cycles of nutrients which are coupled with carbon and oxygen cycles in the open oceans; (2) the sediment-water exchange of phosphorus in coastal carbonate environments; (3) the fate of nutrients in urban waste water discharged into coastal waters; and (4) method development for nanomolar levels of nutrient measurements in oligotrophic waters. *(Principal Investigator: Jia-Zhong Zhang)*

Environmental Microbiology

OCD's Environmental Microbiology Laboratory has several ongoing projects that fall under two main themes: (1) Environmental molecular microbiology, which focuses on the development of assays and biosensors to rapidly detect the nucleic acid signatures of harmful algae and microbes that indicate fecal contamination of coastal waters; and (2) microbial biogeochemistry, which focuses on the study of microbial processes that mediate the cycling of atmospheric trace gases such as halocarbons (e.g., methyl bromide and carbon tetrachloride). Research is performed in collaboration with academic and industrial partners. *(Principal Investigator: Kelly Goodwin)*

Anthropogenic Waste Disposal Studies

OCD's Coastal Environment Group works in cooperation with the U.S. Army Corps of Engineers and the U.S. Environmental Protection Agency to conduct studies on anthropogenic waste disposal in the coastal oceans. Disposed sewage effluents and dredged materials are tracked for their potential environmental impacts from their time of disposal through long-term transport and deposition. *(Principal Investigator: John Proni)*

Integrated Coral Observing Network

An integrated coral observing network (ICON) is being developed at AOML through NOAA's Coral Reef Conservation Program in response to a U.S. Coral Reef Task Force recommendation to install environmental monitoring stations at all major U.S. coral reef areas (e.g., the Florida Keys, Hawaii, U.S. Virgin Islands, Puerto Rico, American Samoa, etc.) by 2010. The information architecture of the stations provides forecasting of marine events such as coral bleaching, which is governed by the physical and chemical marine environment. ICON stations also compile long-term data sets for use by Marine Protected Area managers and researchers. (*Principal Investigator: James Hendee*)

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Physical Oceanography Division

The Physical Oceanography Division (PhOD) conducts interdisciplinary studies to determine the role of the ocean in short- and long-term climate change and weather, as well as provide data analyses and assimilation tools for ocean prediction. PhOD is also a partner in the development of a sustained ocean observing system in support of NOAA climate mission requirements. As such, PhOD's overall mission is to provide quality research, ocean data, and products in a timely and cost-effective manner to satisfy NOAA nowcast, forecast, detection, attribution, and research mission requirements.

CURRENT RESEARCH PROJECTS

Studies of the Western Atlantic Warm Pool

In addition to El Niño, there are other elements that play an important role in determining weather and climate on seasonal to interannual time scales and beyond. For example, in the western Atlantic a pool of warm tropical water fluctuates in size and intensity from year to year and multidecadally, affecting land climates and intense hurricanes in the Western Hemisphere. Using global data sets and statistical-numerical models, PhOD conducts diagnostic studies of the multiscale behavior of the Atlantic and its impact on climate. (*Principal Investigators: David Enfield, Chunzai Wang*)

Upper Ocean Thermal Structure

Measuring the seasonal to interannual variability in upper-ocean heat content and transport is a critical aspect for improving the ability to predict important climatic fluctuations. PhOD scientists work with volunteer observing ships to deploy expendable bathythermographs and, in the context of the Argo project, deploy autonomous profiling floats. Both networks observe and provide data to increase understanding of the upper ocean thermal structure. *(Principal Investigators: Molly Baringer, Gustavo Goni, Claudia Schmid)*

North Brazil Current

The western boundary current that flows along the northern coast of Brazil plays a significant role in the meridional overturning cell and is a major source of heat transport into the Caribbean via rings which are shed by the North Brazil Current (NBC). AOML scientists study the size, depth, and movement of these rings from both satellite altimeter imagery and field measurements obtained from ships and fixed buoys. They have found that more rings separate from the NBC than previously thought and that there are at least three distinctly different kinds of rings. *(Principal Investigators: Silvia Garzoli, Gustavo Goni, Christopher Meinen)*

Subtropical Western Boundary Currents

East of Florida, the meridional overturning circulation is composed of the Florida Current (FC, warm and flowing northward) and the Deep Western Boundary Current (DWBC, cold and flowing southward). AOML scientists have implemented a real-time observing system for the FC and DWBC and are working with international partners to monitor the circulation in the central and eastern part of the basin. Measurement systems include a submarine cable, moored buoys, and regular ship observations. *(Principal Investigators: Molly Baringer, Christopher Meinen, Silvia Garzoli)*

CLIMODE

A large mass of water at 18° (i.e., Eighteen Degree Water, EDW) is formed each winter off the U.S. east coast. Interannual variations in the formation rate of EDW are associated with the North Atlantic Oscillation and other climate signals. Theoretical calculations of EDW formation rate driven by air-sea fluxes do not match the observed rate. During 2005-2009, PhOD investigators, in cooperation with scientists from other research groups, will examine how eddy fluxes modify EDW formation rates using in situ and satellite observations. *(Principal Investigator: Rick Lumpkin)*

Data Assimilation and Salinity Estimation

Data assimilation introduces information from observations into models for studying and predicting oceanic variability. Within the context of our participation in the National Oceanographic Partnership Program collaboration centered on the Hybrid Coordinate Ocean Model (HYCOM), PhOD is developing assimilation algorithms and improving empirical estimates of salinity. Salinity data are needed for assimilating expendable bathythermograph (XBT) data and for estimating heat transport from XBT observations. *(Principal Investigator: Carlisle Thacker)*

Florida Bay Circulation and Exchange Study

The Florida Bay Circulation and Exchange Study aims to describe and quantify the interaction and exchange of Florida Bay waters with the connecting coastal waters of the Gulf of Mexico and Atlantic Ocean to better protect the south Florida coastal ecosystem. *(Principal Investigator: Elizabeth Johns)*

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