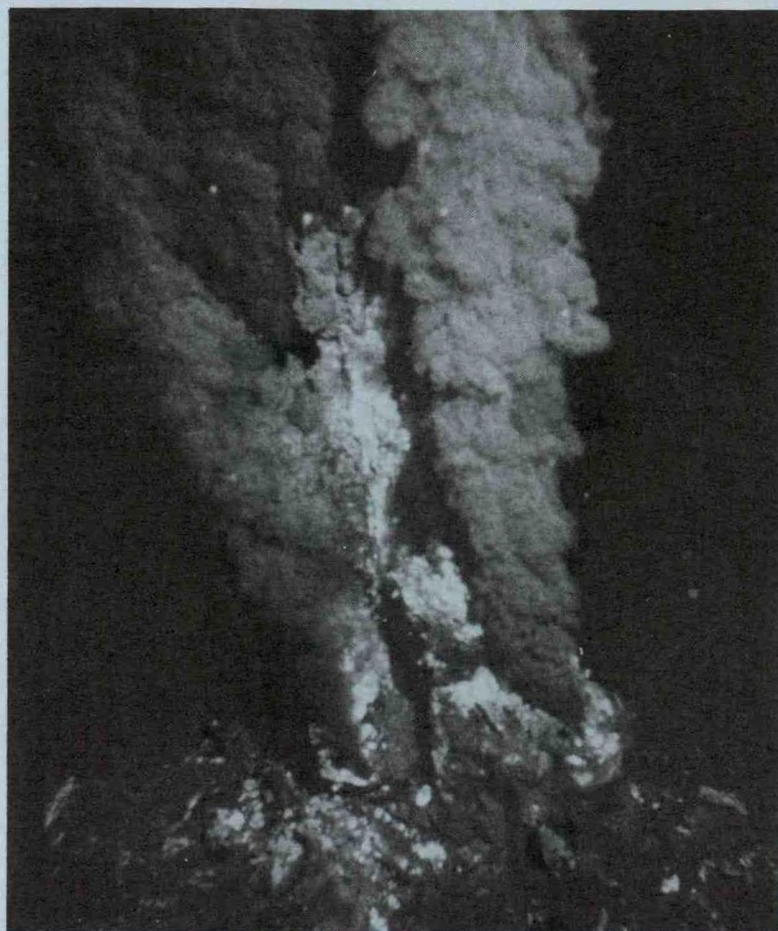


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FISCAL YEAR 1985



A field of black smokers venting metal-rich high-temperature solutions like the one shown above was discovered on the Mid-Atlantic Ridge by the NOAA VENTS Program.



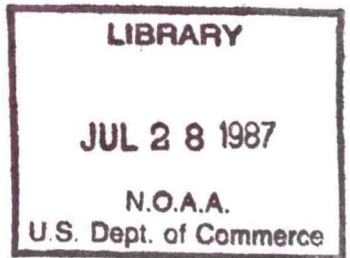
U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
Office of Oceanic and Atmospheric Research
Environmental Research Laboratories
Atlantic Oceanographic and Meteorological Laboratory

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AOML ANNUAL REPORT
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January 1986

Atlantic Oceanographic and Meteorological Laboratory
4301 Rickenbacker Causeway
Miami, Florida



**UNITED STATES
DEPARTMENT OF COMMERCE**

**Malcolm Baldrige,
Secretary**

NATIONAL OCEANIC AND
ATMOSPHERIC ADMINISTRATION

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ATLANTIC OCEANOGRAPHIC AND METEOROLOGICAL LABORATORY

FY-1985 ANNUAL REPORT

PREFACE

This document presents the major accomplishments and plans of NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML) for fiscal years 1985-86. This is the third annual report that has been published by AOML, and it follows the same basic format as the 1984 report. For information concerning AOML accomplishments during prior years, the reader is referred to the AOML Collected Reprint Series, which was published annually by AOML during FY-1970-79. During FY-1980-82 there was no such report but AOML accomplishments during this period were, as always, widely published in the open literature (further information is available through the AOML Director's Office, upon request).

AOML is located in Miami, Florida, and is one of nine Environmental Research Laboratories (ERL) which are housed within NOAA's Office of Oceanic and Atmospheric Research (OAR). The collected plans and accomplishments of all nine Environmental Research Laboratories are jointly published in two separate volumes: the annual ERL Plans and Programs Document and the ERL Collected Abstracts Volume. This document supplements these publications and provides a more detailed view of the AOML Program during FY-1985-86.

The document is organized into three major sections: (1) the Overview section is concerned primarily with management information - such as the AOML mission statement and organization chart, the program structure, and information on resources; (2) the Accomplishments/Plans section discusses major FY-1985 accomplishments and FY-1986 plans within the context of the ERL program structure; (3) the Appendix section includes a listing of AOML publications, with abstracts, for FY-1985. Also included is a listing of AOML staff.

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OVERVIEW

FY-1985 ANNUAL REPORT

ATLANTIC OCEANOGRAPHIC AND METEOROLOGICAL LABORATORY

MISSION

The mission of NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML) is to conduct a basic and applied research program in oceanography and tropical meteorology. The program seeks to understand the physical characteristics and processes of the ocean and the atmosphere, both separately and as a coupled system. Oceanographic investigations center on the fluxes of energy, momentum, and materials through the air-sea interface; the transport and composition (thermal and chemical) of water in the ocean volume; and hydrothermal processes of mineralization at seafloor spreading centers. Meteorological research is carried out to improve the description, understanding, and prediction of hurricanes. The principal focus of these investigations is to provide the knowledge that will ultimately lead: to improved prediction and forecasting of severe storms; to better utilization and management of marine resources; to a better understanding of the factors affecting both climate and environmental quality; and to improved ocean and weather services for the nation.

Organizational Structure

The AOML organization structure (Figure 1) features four research divisions, organized according to scientific discipline as follows: (1) Hurricane Research Division (HRD); (2) Physical Oceanography Division (PhOD); (3) Ocean Chemistry Division (OCD); and (4) Ocean Acoustics Division (OAD). Hurricane research and physical oceanography are the major disciplines represented at AOML, with HRD and PhOD each comprising approximately one-third (34%) of the total laboratory effort. The remaining one-third is split between OCD and OAD, with chemistry comprising approximately 23% and acoustics approximately 9% of the total effort.

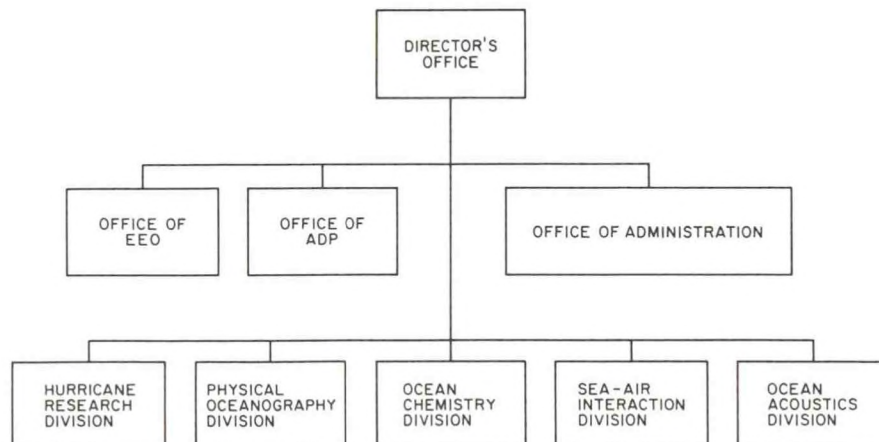


Figure 1: AOML Organizational Chart.

The total AOML research program during FY-1985 was approximately 130 staff-years of effort, with funding support of \$8.5 million. When compared with similar figures for FY-1983 (129 staff-years and \$8.6 million) and FY-1984 (134 staff-years and \$8.4 million) this indicates that the total program level remains relatively stable. The primary output of the Laboratory - publications - has remained stable during the last several fiscal years (FY-1983, FY-1984 and FY-1985). A total of 70 publications were reported during this fiscal year.

Program Structure

The Environmental Research Laboratories conduct a broad spectrum of environmental research. The collective activities of the ERL have been concentrated into seven major program areas. AOML actively pursues research in six of these programs as follows:

- 1) Climate Research
- 2) Weather Observation and Prediction
- 3) Marine Assessment Research and Services
- 4) Marine Observation and Prediction
- 5) Marine Resources Research and Services
- 6) Air Quality Research and Development

The relative distribution of FY-1985 AOML funds by program area is shown in Figure 2. As might be expected from the AOML mission statement and organization structure, Climate Research and Weather Observation and Prediction are the major program areas, with 38% and 30%, respectively, of the total funding support. These program areas are also quite stable when compared with FY-1984 funding levels.

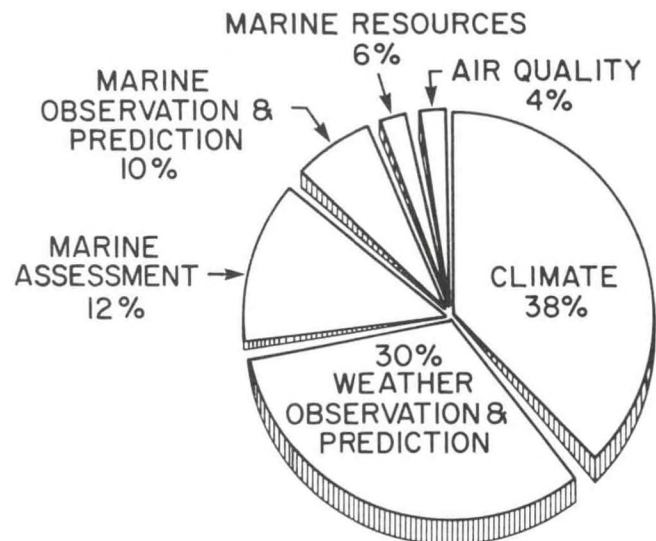


Figure 2: Program Funding Distribution (total FY-1985 funding \$8.5 million).

Marine Assessment Research continues to be de-emphasized at AOML, with a reduction from 22% of the total program funding in FY-1983 to 14% in FY-1984 and 12% in FY-1985. The marine chemistry effort continues to be redirected towards Marine Resources Research and Air Quality Research. Marine Resources Research grew by 1% in FY-1985. Marine Observations and Predictions Research continued as a stable program with approximately 10% of the total program funding.

An analysis of program funding sources provides additional insight into the AOML program structure. The distribution of funding sources for the total AOML program is shown in Figure 3. It is significant that nearly 95% of the work that is done by AOML is funded by NOAA, either by ERL directly (89%), or by NOAA Program Offices (6%) - only 5% of the AOML effort goes for reimbursable projects with outside agencies.

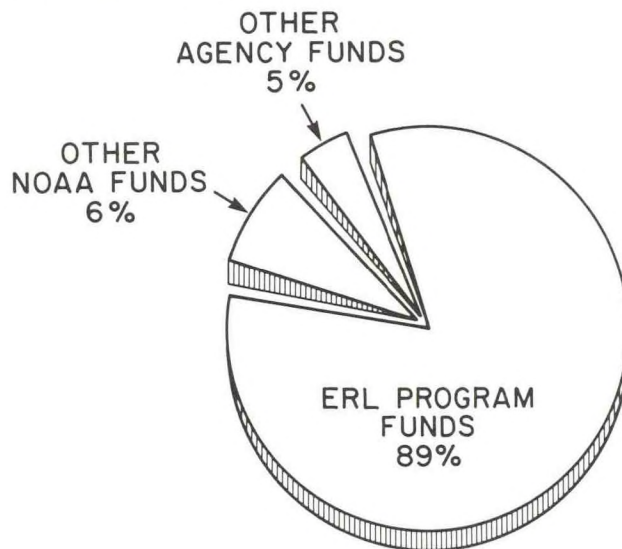


Figure 3: Funding Source Distribution (total FY-1985 funding \$8.5 million).

As 1985 draws to a close and we look forward to 1986, AOML remains proud - both of its people and its many scientific accomplishments. The past year has seen a continuing high-level of scientific productivity, both in terms of quality and quantity of data collection and analysis, as well as in the record of publications and presentations. Many of these achievements are discussed in detail in the following section, along with major plans for the coming year.

FY-1985 ACCOMPLISHMENTS/FY-1986 PLANS

The Atlantic Oceanographic and Meteorological Laboratory (AOML) is organized to pursue basic and applied research programs in oceanography and tropical meteorology. Oceanographic investigations center on fluxes of energy, momentum, and materials through the air-sea interface; the transport and composition (thermal and chemical) of water in the ocean volume; and hydrothermal processes of mineralization at seafloor-spreading centers. Meteorological research is carried out to improve the description, understanding, and prediction of hurricanes. The research program is enlarged by the Cooperative Institute for Marine and Atmospheric Studies (CIMAS), a joint enterprise with the Rosenstiel School of Marine and Atmospheric Science of the University of Miami. CIMAS enables NOAA and university scientists to collaborate on problems of mutual interest, and facilitates the participation of visiting scientists. AOML's current research program concerns processes relating to climate, weather observation and prediction, marine assessment, marine observation and prediction, marine resources, and air quality.

CLIMATE RESEARCH

Climate research at AOML continues to focus on aspects of ocean heat transport and storage in relation to interannual and longer-term variations of atmospheric weather and climate. AOML activities in these areas are part of the NOAA contribution to national and international programs for climate research.

More and more, the scope of problems being addressed requires extensive cooperation and coordination between groups, especially for oceanographic field programs. Tradition and convenient access to sea-going research facilities result in a research program with emphasis on collection and analysis of oceanographic data. The ultimate goal of the work is to improve forecasting of oceanic and atmospheric variations using predictive models. Model development per se is not a major part of the climate research program at AOML, but focus is provided by the data needs of models, model-data interaction, and observations for parameterization of physical processes in models and for evaluation of models.

The AOML program in climate research is conveniently described within the two categories of tropical ocean climate studies and subtropical Atlantic Ocean climate studies.

Accomplishments FY-1985

Tropical Ocean Climate Studies

Tropical ocean climate studies at AOML consist of participation in the continuing NOAA Equatorial Pacific Ocean Climate Studies (EPOCS) program, analysis and interpretation of tropical ocean data collected during the First GARP Global Experiment (FGGE) of 1979, and beginning work in connection with the international program Tropical Ocean and Global Atmosphere (TOGA), which has objectives very similar to those of EPOCS, but which concerns all the tropical oceans rather than just the equatorial Pacific Ocean. The common focus of this work is to describe, understand, and predict the large-scale air-sea interaction processes associated with the major mode of interannual

large-scale climate variation--the El Niño/Southern Oscillation (ENSO) phenomenon.

An investigation was completed into the physical nature and implications for modeling of prominent long waves regularly observed in the equatorial oceans. Major results are that these waves effect a remarkably large equatorward heat transfer, which could be parameterized as a Fickian diffusion process but which has extraordinarily large coefficient, and a significant momentum transfer that cannot be parameterized in any conventional way because it is partially countergradient in direction.

An intensive investigation was conducted into the accuracy of linear models which represent the observed variations of the tropical oceans in terms of vertical modes. The principal results are that such models appear to be capable of reproducing the variations that normally occur on relatively short time scales, but that the important variations (such as ENSO events, which occur on longer time scales and whose prediction is of the highest priority) are fundamentally nonlinear, and are not likely to be quantitatively representable with linear models.

Surface meteorological data and surface and subsurface oceanographic data collected during the FGGE (1979) in the tropical Atlantic and Indian Oceans were used to estimate the heat balance of the ocean surface mixed layer. Results show that surface heat fluxes account for 75% of the variations observed in many areas. In the Atlantic, addition of estimated zonal advection does not significantly improve the estimation. It was concluded that seasonal variation in the intensity of vertical mixing across the base of the mixed layer is an important process in equatorial regions.

An oceanographic atlas was published describing the El Niño event of 1982-83. This atlas contains a broad comprehensive set of observations by U.S. scientists and those of other nations. It will serve for many years as the definitive summary of oceanographic observations that will be used for testing models and diagnostic studies of this historic event.

Drifting buoy data collected from 1977 to 1983 in the eastern tropical Pacific were used to estimate the rate of equatorial upwelling from the horizontal divergence of near-surface currents. An average upwelling rate of 1.5 ± 0.3 m/day was found for the region 1.5°N - 1.5°S , 80° - 130°W . (This is the first estimate of equatorial upwelling with attendant error bars.) Substantial annual and semiannual modulation, agreeing in phase with previous analyses of isotherm depth, were also found.

The mean dynamic topography of the Gulf of Mexico was computed from all available Nansen bottle, CTD, and XBT data for investigation of the uses of satellite altimetry. More than 26,000 stations were used to determine the mean dynamic height at 25 km resolution. The dynamic topography is dominated by the 150 dynamic centimeter high associated with the Gulf Loop Current in the eastern basin, and by a cyclone/anticyclone pair in the western basin. The standard error of the mean is less than 2 dynamic cm.

A new design was completed for a drifting buoy for measuring sea surface currents and temperature in the tropical oceans. This buoy is characterized by improved (and better documented) Lagrangian performance. It can be con-

structed and transported for less than one-third the cost of previous buoy designs and can be deployed easily from smaller vessels. It also is designed to take advantage of recent progress in development of data processing procedures that is expected to reduce the cost of data collection by at least one-half. It is anticipated that this drifting buoy will be used extensively in the EPOCS and TOGA programs.

Further progress was made also in development of ocean sampling, in cooperation with research institutions in Latin America. Subsurface thermal sampling was begun from an Ecuadorian vessel operating between South America and Japan, and the equipment now used aboard two Ecuadorian vessels was upgraded to provide capability for real-time transmission of data for use in evaluating predictive models of the El Niño phenomenon.

Subtropical Atlantic Climate Studies

Analysis of data collected during the two-year intensive observing period in the Straits of Florida indicates that variability occurs on many spatial and temporal scales. Variability at periods ranging from days to several weeks occurs in both the baroclinic and barotropic components of the flow and frequently takes the form of continental shelf waves. These waves are generated by local and/or regional wind forcing. The phase of the annual signal in total transport closely resembles the phase of the annual signal generated by a wind-driven numerical model of the North Atlantic. The observed amplitude of the annual signal is approximately twice the amplitude of the model annual signal. The amplitude of the interannual signal in transport as derived from sea level observations calibrated for transport is less than one-half the annual signal.

In two cruises to the western North Atlantic Ocean, over-the-side observations were taken, and in-situ recording instruments were placed, following the philosophy adopted in the Straits of Florida of using direct observations of transport to calibrate indirect observations. The North Atlantic Deep Undercurrent was observed directly for the first time at 26.5°N. Geostrophic observations show that this equatorward flow, which apparently has a large role in meridional heat flux, exists as far south as San Juan, Puerto Rico.

Particular success was achieved also in implementing a system for acoustic remote sensing of currents from the R/V RESEARCHER. Both the hardware and the data-processing software place this system at the fore, in both reliability and accuracy, of the several similar systems that exist throughout the world. It is notable that development of this system was not implemented primarily as an engineering task at AOML, but rather was driven by scientist-users who interacted with the engineering staff. Unprecedented views of the three-dimensional ocean current structure have already been obtained using this device, and it is serving as the model for installation on other NOAA ships, and even research vessels of other nations.

Plans FY-1986

Tropical Ocean Climate Studies

The main focus of these studies will continue to be with the EPOCS and TOGA programs. A closer association with model developments is planned. Strategy will be developed for four-dimensional data assimilation in models; that is, an investigation will be made of the use of observations to "update" model simulations in optimal ways. AOML has detailed a senior research oceanographer to the NOAA National Meteorological Center to participate in implementing and evaluating a general circulation model of the tropical Pacific Ocean for simulation and experimental predictions of El Niño phenomena.

Collection of surface current and sea surface temperature data by means of satellite-tracked drifting buoys will be substantially increased, using the new drifting buoy design. An intensive program for observing and mapping the surface currents in the region of the South Equatorial Current and North Equatorial Countercurrent will be conducted in the eastern tropical Pacific Ocean as part of EPOCS. Deployments of drifting buoys are planned also in the western Pacific Ocean in association with United States/Peoples' Republic of China for the TOGA cooperative agreement program, and in the Arabian Sea and Bay of Bengal as part of the TOGA program in the Indian Ocean. Initial deployments will be used to explore the nature of these regions. Plans for future work will be based on results from initial deployments.

Two research cruises are planned to investigate the currents and hydrographic conditions in the southeastern tropical Pacific, farther offshore than has been studied heretofore in the EPOCS program. This is the region in which precursory indications of El Niño are seen in some historical data, and from which some of the anomalous conditions observed near the coast during El Niño are presumed to be derived. Cooperation with scientists in oceanographic institutions in Latin America will continue, with the objective of assisting them to improve the quality and quantity of their observing projects for mutual benefit.

If an El Niño event occurs during the year, AOML scientists will be intensely involved in augmentation of observations, using the NOAA research aircraft as well as all the observing systems mentioned above.

Subtropical Atlantic Climate Studies

The program for long-term monitoring of the Florida Current using the methods developed during the first phase of the work will be continued. The major emphasis for research during Phase 2, however, is to develop knowledge of the currents along the topographic rise on the eastern side of the Bahama Islands and in the Antillean passages. Continued observations of currents, sea level, pressure, and water properties will be made with shipboard and in-situ instrumentation.

It is planned that in the more distant future this work will evolve into a substantial part of the NOAA contribution to the World Ocean Circulation Experiment (WOCE). Although the particulars of the objectives and observing

strategies for WOCE are still undecided, it is certain that measurements such as those currently being changed to operational status on the Straits of the Florida will be critical.

WEATHER OBSERVATION AND PREDICTION

AOML is NOAA's primary focus for research in tropical meteorology and hurricanes. Research teams concentrate on field programs, numerical hurricane modeling, and theoretical studies of hurricanes. The Laboratory's hurricane field program uses NOAA research aircraft to acquire unique data sets. AOML interacts with the National Hurricane Center (NHC) and the National Meteorological Center (NMC) of the National Weather Service (NWS) in problems of hurricane prediction, with the National Center for Atmospheric Research (NCAR) on scientific investigations of the inner cores of hurricanes, and with the Geophysical Fluid Dynamics Laboratory (GFDL) in the area of hurricane modeling.

Accomplishments FY-1985

Observational Studies of Hurricanes

Microphysics

A study on the distribution of ice in the convective elements of Hurricanes Ella (1978), Allen (1980), and Irene (1981) showed that above the 0°C level only updrafts greater than 5 m/s contained liquid precipitation. Downdrafts contained very high concentrations of ice particles and were always adjacent to updrafts greater than 5 m/s. Graupel was the predominant particle type in the convective regions. Irregular particles, similar in appearance to aggregates, predominated elsewhere.

An analysis that correlated particle type and concentration with the PPI radar display for Hurricanes Allen (1980) and Irene (1981) showed that regions of high (> 30 dBZ) radar reflectivity above the 0°C isotherm were positively correlated with strong updrafts and with the presence of liquid precipitation. Strong radial gradients of radar reflectivity in the outer edge of the eyewall were frequently associated with downdrafts and high concentrations of ice particles.

Convective-Scale and Mesoscale Features

Analysis of airborne Doppler radar data from Hurricane Alicia (1983) neared completion. It was possible to map the secondary circulation in the eyewall, including the radial inflow at low levels, the updraft along the inside edge of the eyewall, and the radial outflow at the top of the eyewall. The radial outflow was concentrated in a relatively narrow layer, 2-3 km thick, at the top of the storm.

The airborne Doppler system provided direct measurements of the mesoscale up- and downdrafts in the nonconvective or stratiform region surrounding the eyewall. Both updraft and downdraft air motions were found to originate at

the 0°C level. This is consistent with recent modeling results obtained at AOML. The magnitude of these mesoscale up- and down- drafts was 30-80 cm/s, which is comparable with those in other tropical systems.

AOML's land-based radar project is concerned with analysis and interpretation of digital land-based radar data recorded at NWS offices during the landfall of hurricanes. The emphasis is on the description of important changes in the patterns of rainfall that are caused by land influences, the statistical properties of the convective-scale and mesoscale features of hurricane rainbands, and the life history and three-dimensional structure of the convection. During FY-1985, the project produced a color time-lapse movie of the digital radar data that were recorded during the landfall of Hurricane Alicia (1983). A second movie of landfalling Hurricane Diana (1984) neared completion.

Detailed observations of supercell activity were obtained in eastern Pacific Hurricane Norbert (1984). Doppler radar data, lower fuselage reflectivity data, cloud microphysical data, aircraft wind and thermodynamical data, and remotely measured surface wind data were obtained. Preliminary analysis reveals a remarkable similarity with a previous supercell case--Hurricane Gladys (1975). Supercell locations (with respect to the low-level circulation center), as well as horizontal scales and magnitudes of reflectivity features, were nearly identical. Both cases were characterized by intense downdrafts (> 15 m/s) downwind of the convective cores (some with reflectivity > 50 dBZ) extending through 500 and 700 mb levels. This resulted in relative humidities of less than 30% and temperature anomalies of nearly 200°C at 700 mb.

Synoptic-Scale Environment

The steering currents on the periphery of mature hurricanes are determined by Omega dropwindsondes (ODWs), which are deployed from NOAA WP-3D aircraft. The ODWs measure temperature, relative humidity, and pressure and transmit data to the aircraft. They also receive and retransmit Omega navigational signals, which allow horizontal winds to be computed. With the ODW observations, the synoptic-scale flow around a hurricane can be determined from the surface to 400 mb more accurately than is possible with the current operational data sources.

Experiments were conducted on three days during flights in the periphery of Hurricane Josephine in October 1984. The spatial scale of Josephine's circulation was slightly larger than 1000 km. The operational objective analysis at NMC, however, is able to resolve only scales that are generally greater than 1500 km. The analysis resolved the larger scale aspects of Josephine's circulation but did not respond well to ODW observations within 500 km of the storm center. Differences between the analyses computed with and without the ODW data were very small. Track forecasts computed by the Movable Fine Mesh (MFM) model were also not changed significantly by the ODW data.

The MFM errors in the track forecasts at 12 h were particularly large in comparison with climatology-persistence forecasts made by the CLIPER model. Since the MFM became operational, its 12-h track forecasts have consistently been worse than those made by CLIPER. It was previously thought that poor

performance of the MFM forecasts at 12 h was the result of the lack of data near the center of hurricanes. It now appears that the insensitivity of the MFM track forecasts to the ODW data and the consistently poor track forecasts at 12 h are a result of the inability of the operational objective analysis to adequately resolve the hurricane circulation.

We are attempting to develop an objective analysis scheme for the large-scale environment of hurricanes which incorporates ODW and other available data such as rawinsondes, NOAA WP-3D and Air Force reconnaissance data. A set of horizontal analyses of winds, temperature, relative humidity, and geopotential height for Hurricane Debby (1982) was completed. The analyses are at 50-mb intervals from 100 mb to the surface. Data input for the analyses come from ODWs, Caribbean and U.S. rawinsondes, NOAA WP-3D and Air Force reconnaissance aircraft, surface ships, commercial aircraft, University of Wisconsin satellite data and derived products, and NMC operational analyses. The raw data were carefully edited to promote consistency between the various data sources before input to the analysis package. An iterative scheme was developed to couple the horizontal analyses vertically by creation of bogus data where the analyzed fields are noisy. This occurs most often in data-void regions. Results of the first tests were very encouraging.

Air-Sea Interaction

Two hurricane air-sea interaction experiments were conducted in 1984. Systematic measurement of ocean currents, using airborne expendable current probes (AXCPs), was carried out in Hurricane Norbert. Ocean current profiles were obtained which enabled patterns of mixed layer and sub-thermocline currents to be mapped. Vertical wind profiles in the Hurricane Planetary Boundary Layer (HPBL) were obtained using airborne Doppler radar; surface winds were obtained using the University of Massachusetts stepped-frequency microwave radiometer (SFMR).

The experiment was repeated in Hurricane Josephine, where three drifting buoys were also deployed by USAF aircraft immediately ahead of the storm. Measurements of surface winds and pressures, sea temperatures at four depths, and data obtained from AXCPs and research aircraft during Hurricane Josephine made it one of the most thoroughly observed storms from an air-sea interaction viewpoint.

SFMR data were taken in Hurricanes Norbert, Josephine, and Isidore. Data quality was excellent for all cases. Calibration constants for converting output voltages to microwave brightness temperatures and surface wind speed are being derived.

Hurricane Track Prediction

Research to improve the barotropic hurricane track forecast model (SANBAR) used operationally at NHC has been in progress for several years. In FY-1985, a revision was made to the method by which the model calculates the vorticity and the stream function in the vicinity of the hurricane. The revision reduced discontinuities in the fields near the storm and produced a definite improvement that resulted in reduction of average forecast errors

using a fine-grid version of the model. The average errors showed a statistically significant reduction from 10 to 14 percent for the 12 to 48 h forecast intervals.

Hurricane Vortex Dynamics

Data collected in Hurricanes Diana (1984) and Alicia (1983) offer substantial confirmation for the convective ring model in which tropical cyclones undergo cyclic changes of intensity and eye size. The observations also document Diana's intensification from a tropical storm to a category-four hurricane.

Research to understand the nonhydrostatic convective dynamics of hurricanes is in progress. A fine-resolution (2 km horizontally and 1 km vertically) axisymmetric model is being used to examine factors that affect the structure and evolution of the simulated storm. Recent emphasis has been on the role of ice-phase microphysics. Statistical analyses of four versions of the model with different microphysical parameterizations show a definite "ice-phase signature" in the strength and horizontal scale of downdrafts near the melting level. Frequencies of stronger downdrafts with larger horizontal scales increase at and below the melting level, whereas no vertical variation is present when the ice phase is not included.

Quasi-Spectral Hurricane Modeling

To achieve substantial improvement over existing operational models, it is necessary to understand various physical and dynamic factors affecting the motion of a hurricane, and to test new ideas with a quantitatively accurate numerical model. A general purpose base model on nested grids is under development, utilizing an accurate and flexible numerical method, QSTING (Quasi-Spectral Time Integration on Nested Grids).

Spectral representation of field variables by cubic B-splines is the basis of QSTING. It combines the numerical accuracy of spectral methods with the freedom of specifying boundary conditions to a finite domain. To nest a series of finite domains of differing resolution is a modeling assumption that forces compromise on the obtainable mathematical solutions. Our concern is to reduce the compromise to a physically acceptable level. The acceptable level depends on the physical problem. Its achievability depends on numerical techniques.

The problem of wave propagation across an interface, from a fine-resolution domain to a course-resolution domain and vice versa, was solved earlier by dynamically matching spatially variable filters at the interface. We were aware of another problem with Gibbs phenomena, which arose from a strong stationary disturbance in a fine-resolution domain when the disturbance was projected on the same area embedded within the next larger domain. The projection entails spectral truncation due to a change in resolution. By carefully designing projection filters, we reduced the error to a level that we had once thought to be acceptable. However, as soon as the plane QVADIS was tested with a balanced free-spinning hurricane-like vortex, we were shown to be wrong. Although the error at each time step was small, it accumulated,

and after 8 h (2880 time steps) the vortex was noticeably out of the original shape and definitely unacceptable.

A solution to the problem is to eliminate the projection entirely. That is, we accept each nested domain with a hole in the middle where no information exists. (Earlier, there was no hole of information, since the area was filled with the projection, or "shadow", of the subdomain fields.) The new procedure technically implies performing spectral transforms in a domain with a hole, without knowing the explicit inside boundary conditions. Because of this and other technical complications associated with holed domains, we had stayed with the projection method too long. When proper algorithms were developed and the new QSTING-anumbra (meaning "without shadow") was reprogrammed, the model worked beautifully. The free-spinning vortex now keeps spinning with very little change.

Objective Analysis of Tropical Winds

NHC has archived twice-daily objective analyses of ATOLL (Analysis of the Tropical Ocean Lower Layer) (nominally about 900 mb) and 200 mb winds over the tropical Atlantic for June through November since 1975 and for the entire year since 1981. Spectra of selected locations in the tropics show substantial variation in the 3-5 day "easterly wave" band. In the "data-rich" subsection of the grid from 40°W to 100°W and 10°N to 30°N, the analyses were sampled on an approximate 3° grid, and filtered in time to isolate energy in the 3-5 day band. Complex tensor covariance statistics were used to analyze the spatial structure and temporal (month to month) variability within the band. Complex Empirical Orthogonal Functions (EOFs) were used to extract the dominant spatially coherent signal. The complex EOFs include information on the three-dimensional structure, including phase propagation, for the individual modes.

Considerable temporal variability and spatial inhomogeneity were found in the monthly statistics. In July-September of 1975-1977, only July 1975 and one month in 1976 had dominant EOF modes that were statistically distinct from the lower ones. In July 1975 there was a repeated series of strong easterly waves in the Atlantic and Caribbean that were well defined over a large portion of both the 200 mb and ATOLL analyses. The first EOF, explaining 25% of the total variance, had large amplitude at both levels. The phase lines of the dominant meridional wind component sloped somewhat from southwest to northeast at the ATOLL level and tilted westward with height against the mean westerly wind shear. The zonal wavelength at both levels was about 3500 km, corresponding to a westward phase speed of about 9 m/s. Vorticity amplitude and phase were also computed. The extension of the mode to the west showed vorticity phase propagation continuing across the Atlantic, the Caribbean, Central America, and Mexico, and into the region of tropical storm formation in the eastern Pacific.

GALE

The Genesis of Atlantic Lows Experiment (GALE) should provide new information on coastal frontogenesis and cyclogenesis and the mesoscale structure and evolution of cyclones. The field experiment is scheduled for the Carolina coastal region from 15 January to 15 March 1986. During 1985, AOML's portable

radar recorder was taken to the NWS office in Wilmington, North Carolina. Weather Service personnel operated the recorder and recorded data in four weather events between 30 January and 22 March. PPIs were recorded every 6 min. The data were processed and a color time-lapse movie was completed and distributed to interested GALE scientists. The movie is being used to plan observing strategies for the field experiment.

STORM

Mesoscale convective systems (MCSs) produce significant rainfall and severe weather in the Midwest during the spring. Two of the main goals of the Stormscale Operational and Research Meteorology (STORM) Central research program are to improve understanding of the genesis, evolution, and structure of MCSs, and to improve forecasts of MCSs. The field phase of a preliminary regional experiment, PRE-STORM, took place in Oklahoma and Kansas (OK) in spring 1985. The goals of PRE-STORM were to investigate mesoscale convective systems. One of the sub-goals was to observe microphysical characteristics and radar characteristics of mesoscale convective systems. AOML participated in the field phase of PRE-STORM by recording digitized radar reflectivity at the Wichita NWS WSR-57 radar, and by collecting microphysical data on the NOAA/WP-3D aircraft. These data, and the data collected by the NCAR Doppler radars and the portable automated mesonet network (PAM), will be used to study the initiation and evolution of the stratiform precipitation region, the precipitation mechanism(s) in the stratiform region, and feedbacks into the dynamics of the mesoscale convective systems.

Observational Studies of the South Florida Sea Breeze

The analyses of the flight-level data have concentrated on comparing and contrasting the structure of the sea-breeze circulation on a day in 1980 with a day in 1981. The evolution of deep convection in the 1980 case was strongly influenced by a layer of very dry air between 850 and 700 mb. Deep convection occurred near the flight track, but the rainfall did not begin until very late in the day. On the other hand, the 1981 case was characterized by profiles of temperature and moisture that were near the typical climatological values.

Preliminary analyses of airborne Doppler radar data from two of the sea-breeze flights have been completed. On one of the two days, high-quality data were recorded of a mesoscale precipitation line that was initiated by the sea-breeze circulation.

Plans FY-1986

Observational Studies of Hurricanes

Microphysics

A study of the melting layer in Hurricane Alicia (1983) will be completed. Data taken in stratiform regions of hurricanes and PRE-STORM data from stratiform regions in MCSs will form the basis for a comprehensive study of stratiform precipitation. The analysis and interpretation of the microphysical data from the Hurricane Norbert (1984) water budget experiment will continue.

Convective Scale and Mesoscale Features

The primary emphasis will be on analysis of the water budget in Hurricane Norbert (1984). The airborne-Doppler analysis will be completed and integrated with the analysis of the flight level and microphysical data. The water budget equations will be formulated and the terms evaluated. Analysis of the visual and radar derived characteristics of Hurricane Diana's (1984) eyewall will be completed. The three-dimensional structure of the convective-scale and mesoscale features in Hurricane Alicia (1983) will be examined with both land-based and airborne-radar data.

Synoptic-Scale Environment

Cooperative studies with NHC and NMC will continue to examine the affect of the ODW data on the operational analyses and hurricane track models. The data will be used in diagnostic and prognostic studies of hurricanes and in the evaluation of remote atmospheric soundings.

Air-Sea Interaction

It is planned to acquire additional color photographs of sea state for use in developing color descriptions of sea state corresponding to Beaufort categories 3 through 19. Photos will be compared with SFMR measurements. This study will also use Inertial Navigation Systems flight level wind measurements made near cloud base and planetary boundary layer (PBL) models to reduce flight level winds to the surface. Airborne Doppler radar measurements in the PBL will also be used for estimating surface winds. It is planned to develop a surface wind speed algorithm for use with SFMR data in real time.

Hurricane Track Prediction

Further tests with the NESDIS/DL variational analysis will commence when their revisions to the water vapor wind scheme are completed. These additional experiments will be performed with the revised operational version of the SANBAR model.

In 1984, L. Shapiro published a paper on sampling errors in statistical models for forecasting tropical cyclone tracks. The techniques presented in the article have been applied by other investigators to studies of specifications of climatological data for the National Weather Service (NWS) Climate Analysis Center. Because of continued interest and discussion in the literature regarding these and similar techniques, at least one paper is planned, for formal publication, to clarify some of the statistical issues raised. The paper is in the form of a comment, correcting misinterpretations and misapplications in the literature on the use of Monte Carlo techniques for the evaluation of skill and significance of screening regression models in geophysical application. Continued research will give a more extended comparison, through example, of techniques developed by other investigators to establish model skill and significance when serial correlations are present in the geophysical data.

Hurricane Vortex Dynamics

Work will be directed toward preparation of the confirmatory concentric-eyewall observations for formal publication and toward exploration of additional aspects of Hurricane Alicia (1983), Arthur (1984), and Diana (1984) that relate to vortex motion and banded structure. Theoretical vortex-motion work will focus on detailed exploration of a barotropic model from which preliminary results indicate that it may be possible to explain trochoidal motion of the vortex through resonance between a normal mode oscillation and periodic forcing by rotating steering currents.

Quasi-Spectral Hurricane Modeling

It is necessary to understand, and extend, the concept of nonlinear diffusion. Some form of nonlinear diffusion that responds to in-situ needs for diffusion is desirable. The deformation-dependent diffusion, as originally proposed by Smagorinsky, is too indiscriminately diffusive. The need for diffusion depends on both the spectral resolution of the model and the physical problem to be solved. Therefore, the question straddles the border of numerics and physics. We must also examine inertial instability in the hurricane upper outflow layer. Upper level outflow jets associated with organized cumulus convection have attracted many diagnostic studies. We would like to provide a better theoretical explanation of these features.

It is hoped that QVADIS can be converted by October to the extent that it will run on the CYBER 205. However, vectorization of the program under the 205 rules requires extensive changes using nonstandard special routines of the 205. Also, the conversion of QVADIS's interactive output program must also be accomplished as soon as possible.

Objective Analysis of Tropical Winds

Analysis of the characteristics of the disturbances in the 3-5 day band will be completed for 1975-1977. Statistical analyses of rawinsonde station profiles will be made to describe the vertical structure of the disturbances. Spectral and EOF techniques will be used to investigate the long-term inter- and intra-annual variability in the wind data since 1975. The relationship of the wind variability to climatic fluctuations, such as the El Niño/Southern Oscillation, the 30-60 day global oscillation, and hurricane cycles will be examined. Work to provide a climatology of the winds, including monthly means, will be started.

GALE

AOML's existing radar recorder and two new recorders will record data at Weather Service stations during GALE. Five or six AOML scientists will participate in the field experiment for periods ranging from two weeks to a month. They will operate instruments on the NOAA WP-3D during flights, ensure that the portable radar recorders are operating properly, and provide advice in the design of Omega dropwindsonde flights. Plans are being developed for cooperative research on coastal fronts with Pennsylvania State University and

the State University of New York at Albany and on the mesoscale structure of oceanic rainbands with the University of Washington.

STORM

The PRE-STORM data set contains 1000 tapes of Doppler data from the two NCAR radars and 200 tapes of digitized radar data from the Wichita WSR-57. A necessary first objective for 1986 is to produce an overview of eight or nine notable weather events, using the digitized WSR-57 data. This overview should then help focus the subsequent analyses of the Doppler, the surface, and the aircraft data sets.

Observational Studies of the South Florida Sea Breeze

The field phase of the sea-breeze experiment, carried out in previous years, was designed to provide a description of the mixed layer, the cloud layer, and the evolution of the sea-breeze circulation from shortly after sunrise until midafternoon when deep convection is normally present. The role of the sea-breeze in organizing the development of deep convection is being examined. Airborne Doppler radar data, collected on two days, are being used to specify the kinematic structure of mesoscale precipitation lines that were initiated by the sea-breeze circulation. Analysis of the aircraft data will be completed as will analysis of airborne Doppler radar observations of the development of deep convection in the sea-breeze convergence zone.

AIR QUALITY

Air quality research at AOML has two foci. One is to develop an understanding of the geochemical cycles (horizontal and vertical distributions, sources, sinks, and transformation processes) of major trace constituents of the atmosphere. The second component concerns studies of the role that marine biological processes have in determining the composition of the atmosphere. At present, both programs are addressing those species (excluding carbon dioxide) that are significant in determining the Earth's radiation balance. The overall objective of this research is, in conjunction with AR, ARL, GFDL, and PMEL, to develop a validated diagnostic and prognostic ability to assess climate alterations resulting from observed or projected changes in the radiatively important trace species (RITS).

Accomplishments FY-1985

Acid Rain

AOML completed its interim assessment of the role of oceanic processes in determining the acidity of precipitation. This assessment was called for in the National Acid Deposition Assessment Program plan and was based on three years of research cruises to study chemical and biological processes in oceanic regions. Though emphasizing the biogeochemistry of sulfur, the research studied a wide variety of precursors of acidic species, such as the precursors of organic acids, and processes that transform precursors into

acidic species, such as oxidation. The major findings of the assessment were that the combined fluxes of reduced sulfur from marshes, estuaries, and oceanic regions to the conterminous 48 states were insignificant (< 10% and most likely only 1-5%) compared with the anthropogenic fluxes. On a regional scale, however, such natural sources could be significant to the sulfur budget of the west coast. It is also possible that marine sources of reduced sulfur may affect the immediate Gulf Coast but are rapidly removed within 100 miles or so inland from the coast. Marine sources are not significant on the east coast. On a global scale, no evidence was found indicating that published data on levels of reduced sulfur over oceanic regions are in error and, consequently, that fluxes derived from those measurements are incorrect. However, we cannot balance these fluxes on the basis of what we have learned about the biogeochemistry of sulfur. A large flux of biogenic sulfur from the marine environment to the atmosphere cannot be substantiated by our experimental evidence on inorganic sulfate assimilation by marine organisms and the subsequent partitioning within biochemical systems.

RITS

AOML continued its marine tropospheric chemistry program as part of the ERL RITS effort. Equipment and apparatus were built and acquired. Spectrometers, chromatographs, sampling systems and chemical standards were accumulated.

Work continued on the analyses of the volatile organic components in a suite of samples collected over the Pacific in 1984. These reactive and radiatively important trace substances have very large variability in concentration in both space and time. The different compositions of the mixtures are probably related to their biogenic source. Vertical profiles of the volatile organics, collected from the NOAA P-3, show that the chemistry of many of the components is confined to the lower few hundred meters over the sea surface. Other, more stable, constituents mix throughout the boundary layer. Ozone concentrations were measured constantly throughout the organic sampling on shipboard and on the aircraft. It is not clear from the data in hand whether the organics evaporating from the sea surface are sources or sinks of ozone. High concentrations of many organic oxidation products were identified in the boundary layer. These observations will be investigated in more detail in FY-1986.

Plans FY-1986

Acid Rain

AOML's research into the role of oceanic processes in determining the hydrogen ion content of precipitation ended in FY-1985. The principles and approaches developed in that program will continue to be applied within our overall research program into biosphere, hydrosphere, geosphere, and atmosphere interactions. Much of this will occur within the scope of our RITS program. Some specific questions that arose in the course of our acid rain research, such as balances between biological and geochemical cycles of atmospheric trace species, are generic components of biogeochemical research programs and are likely to be addressed within the RITS program.

RITS

The AOML tropospheric chemistry effort will concentrate on the tropical Atlantic. More chemical species will be measured synoptically along with all relevant meteorological data. Methane, carbon monoxide, ozone, nonmethane hydrocarbon gases, and the volatile organic liquids will be measured at the sea surface. In addition, detailed vertical profiles, up to cloud base, of ozone and the volatile organics will be determined with a new tethered sonde sampling package. Finally, if funds are sufficient, the biogenic origin of the reactive and radiatively important organics that evaporate from the sea surface will be investigated. The very large qualitative and quantitative differences observed in time and space indicate that the release of this broad array of compounds is intimately associated with biological cycles and ecological microcosms. The relationships between these living systems and the chemical/physical environment of the sea should be quantified.

MARINE RESOURCES

The AOML contribution to studies in Marine Resources is directed toward determining the chemical and thermal effects on the ocean of hydrothermal venting from representative sections of the slow-spreading Gorda Ridge and Mid-Atlantic Ridge. These efforts are central to the program objectives of the NOAA VENTS program.

Accomplishments FY-1985

Gorda Ridge

The objective of the FY-1985 program was to determine the state of hydrothermal activity on the Gorda Ridge. Toward this end, a number of investigators participated in a cruise of the NOAA Ship Surveyor (May 1985). Selected accomplishments are as follows:

- All existing NOAA and USGS geological and geophysical data on the Gorda Ridge were reviewed and applied to selecting target sites for the May 1985 VENTS Program cruise, in close collaboration with USGS scientists (Marine Geology and Geophysics Branch, Menlo Park).
- AOML participated in May 1985 Surveyor cruise to the Gorda Ridge, to collect suspended particulate matter, sediment cores, interstitial water, near-bottom water temperature profiles, seafloor imagery, and SEABEAM profiles at preselected target sites, in close collaboration with participating scientists from NOAA/PMEL and Oregon State University.
- Preliminary energy dispersive analysis (EDA) of the suspended particulate matter showed enrichment of particulate iron, manganese, calcium, and sulfur, suggesting the presence of anhydrite; the iron enrichment is in the form of relatively large (c. 10 5m) subhedral to euhedral particles, in contrast to iron particles in suspended particulate matter (SPM) of the Mid-Atlantic Ridge, which are in the colloidal range.

- Initial extractions of metals (Cr, Cu, Fe, Mn, and NiO) indicated distinct variations in concentration, which are being interpreted in terms of remobilization under changing redox conditions and variations in hydrothermal input to the sediment column. Copper, Fe, Mn, and Ni exhibit a strong positive correlation in their distribution; Cr is negatively correlated with these metals.
- Three camera-temperature profiles were run with SEABEAM bathymetry at sites where water chemistry indicated intermediate levels of hydrothermal activity on the central Gorda Ridge; review and reduction of these data are being coordinated with heat flow measurements (Oregon State University) and seismic reflection profiling (USGS) to determine relations between hydrothermal activity, heat transfer, and crustal structure.
- Shipboard analyses of interstitial water revealed high redox states and consequent remobilization of metals, particularly manganese, related to relatively high contents of organic matter in the sediments; this result indicates that remobilization of metals and expulsion of the metal-rich water during sediment compaction may have a significant effect on ocean chemistry, in contrast to the Mid-Atlantic Ridge where oxidizing conditions were found to prevail in the sediments and metal remobilization was negligible.

Mid-Atlantic Ridge

The objective of the FY-1985 program was to locate and characterize the actual venting zone at a site where active venting was identified on the VENTS Program FY-1985 cruise of the NOAA Ship RESEARCHER. Accomplishments of the cruise (9 July-7 August 1985) are as follows:

- High-temperature black smoker-type venting was discovered at the Trans-Atlantic Geotraverse (TAG) Hydrothermal Field in the rift valley of the Mid-Atlantic Ridge at latitude 26°N. This is the first high-temperature black smoker venting found on a slow-spreading oceanic ridge. Slow-spreading oceanic ridges constitute more than half the globe-encircling, 55,000-km oceanic ridge system. The implication of the discovery is that hydrothermal venting from slow-spreading oceanic ridges, including the Gorda Ridge, has a significant impact on the chemistry and heat budget of the oceans and offers potential for the occurrence of polymetallic sulfide deposits.
- In the search and discovery process, the FY-1985 cruise collected multi-disciplinary data sets at far-, intermediate-, and near-fields with reference to the black smokers. The data sets comprise water samples (suspended particulate matter, dissolved manganese, dissolved rare earth elements, dissolved gases), water properties (salinity and temperature and particulate light-scattering profiles), near-bottom temperature profiles, moored oceanic current meter arrays, bottom sediments (cores, grabs, sediment traps), rocks, imagery, and some biological material.

Plans FY-1986

Gorda Ridge

A NOAA cruise will be organized to examine a hydrothermal venting zone at what appears to be the most promising site or sites on the Gorda Ridge (an evaluation based on prior NOAA, USGS, OSU, and other work); the cruise will be a collaborative effort of NOAA (AOML, PMEL), USGS, OSU, and others. The objective of the FY-1986 cruise is to observe the active vents at close range and to characterize their effluents, building on findings from prior cruises.

Mid-Atlantic Ridge

The possibility of a modest series of dives with the submersible Alvin is being explored to follow through on the discovery of black smokers at the TAG Hydrothermal Field on the Mid-Atlantic Ridge. The scientific objective of the dives would be to sample the hydrothermal effluents and precipitates, measure their temperatures, and make related detailed investigations to determine chemical and thermal fluxes, mineralization, and associated geologic setting of the venting. A multidisciplinary, multi-institutional group to carry out the dive series and subsequent data reduction would include NOAA scientists (AOML, PMEL) with NOAA funding support, and MIT and WHOI scientists with outside funding (e.g., NSF).

MARINE OBSERVATION AND PREDICTION

AOML research in Marine Observation and Prediction is concentrated in the following areas: (1) improving the definition and measurement of the ocean bottom depth for charting, navigation, and bathymetric purposes; (2) determining optimum measurement system configurations for flux of volume, heat, particulates, and other parameters as they are used in NOAA Climate Programs and Marine Assessment Programs; (3) potential operational system evaluation and demonstrations. This research is aimed at improving the observational equipment and techniques that are used to collect data on the marine environment; particular emphasis is placed on the use of new, advanced, high-technology systems.

Accomplishments FY-1985

Echo Formation Models

AOML personnel developed an initial bottom-echo-formation model. When given a set of input parameters characterizing a bottom environment, the model will produce the echo signal to be expected from such a bottom. The signal thus produced is extremely detailed and is used to evaluate different methods of echo signal processing and displays. Thus far the model has indicated that the identification and classification of different bottom types is feasible.

Operational System Evaluation

Establishment of an initial theoretical basis for optimum flux and other measurement systems and arrays was carried out. The theoretical framework produces the basis for determining an optimum set of instruments and their placement in strategic regions in order to achieve specific measurement goals.

An experiment to evaluate the performance of the AOML transverse Doppler current-profiling technique in a highly turbulent channel, the entrance to the Port of Miami, was carried out. Data from this equipment are being evaluated.

A plan for AOML to participate in an operational demonstration of Coastal Ocean Dynamics Applications Radar (CODAR) in the Straits of Florida between Miami and Fort Lauderdale was approved by the directors of AOML, WPL, NWS, NOS, and the USCG. A contractor was hired by NOS to refurbish, update, install, and operate the NOAA furnished equipment for the first two months.

Florida Atlantic Coast Transport Study (FACTS)

Field measurements of satellite-tracked Lagrangian drifters and inverted echo sounder/pressure gauges (IES/PGs) near Cape Canaveral were completed in May. Three areas west of the Gulf Stream were identified as locales where drifters tend to come ashore: south of Cape Canaveral, Florida; near Jacksonville, Florida; and near Charleston, South Carolina. Data from two of the three deployed IES/PGs were recovered; the linear correlation with the STACS cable transport was 0.83, and as in the Subtropical Atlantic Climate Study (STACS), most of the signal was on the western side of the Gulf Stream: IES/PG pairs are viable indicators of volume transport when cables and/or surface tide gauges are not available.

Plans FY-1986

Echo Formation Model

AOML intends to continue the development of the bottom-echo-formation model. A field experiment for model validation is planned. It will probably be conducted within Chesapeake Bay, and will be designed to obtain actual data on echo formation by different bottom types. A comparison will be made between the echos recorded in the field and the echos predicted to exist by the AOML echo-formation model.

Operational System Evaluation

Research into optimum measurement system configurations will continue, using a mixture of local, integral, and remote measurement systems. Application of empirical orthogonal function theory to climate and other program dictated measurement sections is planned. Continued reduction of sediment and particulate transport data obtained using acoustical systems, is anticipated. Routine operation of the CODAR at Straits of Florida sites will be turned over to NOAA by the contractor, CODAR Technology Inc., in February. AOML will transfer the day-to-day processing and public information broadcasts to NWS,

and will continue to conduct verification tests jointly with the USCG. Research into the use of operational CODAR data for monitoring the Florida Current and for nowcasting of sea state will begin at AOML.

Florida Atlantic Coast Transport Study (FACTS)

Analysis of the AOML-obtained Lagrangian drifter data and the IES/PG data will be completed. In addition to the AOML data, information from 44 moored current meters, numerous Pegasus casts, sea level/weather gauges, and a submarine cable are available for multi-input linear and spectral analysis. In addition to assessing the impact on Florida of minerals mining operations between Palm Beach and Jacksonville, the FACTS section will be subjected to a synergistic systems analysis to determine the optimum combination of measurements for an initiative in monitoring critical ocean regions.

MARINE ASSESSMENT

The ocean, particularly the coastal ocean, is an invaluable environmental resource. Among its many uses, it is at one time a source of food and a receptacle for anthropogenic wastes. It is vital to our national interests to ensure maximum compatibility of our various uses. We believe that trace metal speciation processes in environments receiving waste inputs may play a major role in determining what, if any, ecological cost will be associated with pollution. The most economically significant living resources in coastal waters are fisheries; however, owing to the time and space scales of actual and probable pollutant inputs, the most critical ecological events concern phytoplankton. Perturbations once initiated, however, can cascade through the food web and indirectly effect fisheries.

It is important to recognize that stress from pollution may not be inherently pernicious. We have reason to believe that it will be possible to develop effective strategies not only to minimize bad effects but perhaps to optimize desirable ecosystem transformations. Because of the potential impact on the coastal zone environment, we are faced with a need for developing intelligent choices for waste disposal; one option is ocean dumping. However, problems at active bulk dump sites like those in the New York Bight have turned many people against the ocean disposal alternative. We hypothesized that major rivers with high suspended sediment loads can adequately handle a significant pollutant burden and that river deltas are a reasonable choice for controlled, passive waste disposal. Rivers are the major pathway by which the products of natural geological erosion processes and the pollutant inputs of mankind are added to the oceans. Since most river-borne chemical pollutants are favored to partition onto suspended particulates, pollutant pathways are likely to vary with the particle pathways. Study of pollutant dispersal into the marine environment thus becomes very much a study of particle-pollutant dynamics on river deltas. Furthermore, when massive sediment deposition occurs on a river delta, anthropogenic inputs may be obscured and diluted to innocuous levels. If these sediment pollutants are not reintroduced into the water column by chemical, physical, or biological processes prior to "deep" burial, then delta sediment depositories become permanent reservoirs for enormous annual burdens of industrial and municipal wastes.

Accomplishments FY-1985

Fisheries Oceanography

Data Analysis

Catch data from Japanese longline bluefin tuna fishing in the Gulf of Mexico during 1979-1980 were analyzed relative to in-situ oceanographic data and satellite remote sensing data. A three-fold increase of catch per unit effort in 1980 compared with 1979 appears to be associated with the area fished, and seems to reflect a change in fishing strategy. The higher catches were made primarily in proximity to the surface thermal front of the Gulf Loop Current. Correlations with other environmental factors such as sea surface temperature, temperature differences, and current patterns, and with age of the fish, were generally inconclusive.

Fisheries Oceanography Cooperative Investigation (FOCI)

For the past several years, AOML has conducted research in cooperation with the National Marine Fisheries Service with the long term goal of understanding direct and indirect environmental controls on the year class strength of commercial fisheries. Research cruises with this specific objective have been conducted aboard the F/V OREGON II and the R/V RESEARCHER in the northern Gulf of Mexico, particularly in and near the frontal plume of the Mississippi River. In this last year, a series of publications and presentations resulted, detailing the relationship between larval fish growth and abundance and the concentration of their planktonic food resource by physical process. Preparatory to renewed field studies extending this work to new areas and fish species, a project was initiated through CIMAS to improve sampling technology in regard to synopticity, real-time feedback, and the integration of physical and biological sampling. AOML investigators led a team of ONR-funded university investigators in a physical/biological study of the Gulf Stream core and western wall. Systems developed previously were substantially re-engineered for this effort, particularly in regard to the incorporation of fluorescence sensors and computer interfacing capability. For the first time, zooplankton data were gathered by traditional, acoustic, and optical methods in conjunction with continuous acoustic records of current shear.

TAP

AOML continued its studies into the mechanisms of metal/organic interactions in seawater, especially the mechanisms of metal chelation by naturally occurring organic ligands. The objective was the development of interactive biological/chemical models of metal speciation as it affects ocean planktonic populations that serve as food sources to larval fish. Results of this work include the following:

- Zooplankton samples collected in the northern Gulf of Mexico were analyzed for species composition in areas where AOML has characterized the chelation capacity of near-surface seawater.

- Chemical analyses showed that some marine organics can chelate metals strongly enough to compete with artificial chelators, thereby impacting so called "total" metal determinations.

The above discovery on chelation suggests that models of the thermodynamic equilibrium speciation of a trace metal of important in biological processes may, therefore, incorrectly assess the potential impact of the introduction of a trace metal contaminant to an ecosystem. These results suggest that future work in the field must assess such an impact, in order to correctly model this process, through a thorough evaluation of the stability constants of naturally occurring organic ligands with metals.

P-PRIME

The P-PRIME (Pollutant-Particle Relationships in the Marine Environment) program is being completed in FY-1985 with publication of the following information:

- A NOAA data report, in press, entitled "Pollutant-Particle Relationships in the Marine Environment Program: Methods and Data From the Mississippi River and Adjacent Shelf." This report contains tables and illustrations detailing such items as station locations, summaries of data types and amounts thereof including dates of collection and geographical position, depth etc., suspended particulate matter size distributions, concentrations and trace metal analysis results.
- A manuscript, in press, in Science entitled "A Decline in Lead Transport by the Mississippi River." This paper presents compelling evidence that over the last decade a measurable decline in lead transport and deposition in and around the Mississippi River and Delta is related and proportional to the decreased consumption of lead in the United States resulting from environmental regulations such as the deleading of gasoline.

Plans FY-1986

Fisheries Oceanography

Data Analysis

Continuing work will require identification of new funding.

Fisheries Oceanography Cooperative Investigation (FOCI)

Data analysis will occupy much of this next fiscal year. Publications will continue to result from the Gulf of Mexico data, albeit at a reduced rate. The results of the sampling technology cruise will have to be assimilated so that they may be taken into consideration in designing the new field studies. Two separate field studies are being planned in cooperation with the National Marine Fisheries Service. The first will be aboard the F/V OREGON II in February 1986, in collaboration with the Beaufort Laboratory of the Southeast Fisheries Center. The second will be in the Shelikof Straits in May

1987, in collaboration with PMEL and the Northeast and Alaska Fisheries Center.

TAP

No additional activity is anticipated in this program unless new funding is identified.

P-PRIME

No additional activity is anticipated in this program unless new funding is identified.

FY-1985 PUBLICATIONS

ATLANTIC OCEANOGRAPHIC AND METEOROLOGICAL LABORATORY

AO-001

Almagor, G., R. H. BENNETT, D. N. LAMBERT, E. B. FORDE, and L. S. Sheperd. Analysis of slope stability, Wilmington to Lindenkohl Canyons, U.S. Mid-Atlantic margin. Proceedings, 1983 IUTAM Conference on Seabed Mechanics, Eds., Graham and Tratman, Ltd., 77-86 (1985).

The continental slope gradient in the study area averages 7-8°. Many valleys, canyons and occasionally large sediment slumped masses occur. Moderate to steep slopes (19-27°) as well as very steep to precipitous slopes (> 27°) are abundant and occupy about 7% of the investigated area. The surficial sediments are predominantly terrigenous silty clays of medium to high plasticity ($I_p = 10-35\%$, $\omega_L = 30-70\%$), but contain varying quantities of sands. Angles of internal friction are $\bar{\phi}_d = 27-32^\circ$, $\bar{\phi}_{cu} = 30-33^\circ$ and $\phi_{cu} = 14-17^\circ$. The sediments are normally to slightly overconsolidated, but some unconsolidated sediments also were indentified. c_u/\bar{p}_0 values range from 0.12 to 0.78. An analysis of force equilibrium within the sediments reveals (a) that the gentle slopes in the study area are mostly stable; (b) that the stability of some steep slopes (19-27°) is marginal; and (c) that on precipitous slopes (> 27°) only a thin veneer of sediments can exist. Observations of these slopes during deep dives support these results. The analysis shows that additional accumulation of sediments and small shocks caused by earthquakes or internal waves can cause the slopes to fail. Collapse resulting from liquefaction in the uppermost slope along the canyons and valleys axes, where fine sands and silt accumulate, also is likely.

AO-002

BEHRINGER, D., S. Hayes, and G. Meyers. Report of the low latitude working group. World Ocean Circulation Experiment, U.S. WOCE Planning Report Number 2, 25-31 (1985).

No abstract.

AO-003

BENGGIO, B. L., and T. A. NELSEN. "SLABBER": A useful device for subsampling box cores. Sedimentology 31:879-882 (1984).

The "SLABBER", a plexiglass device designed for subsampling box cores, was used at sea with excellent results. The SLABBER allowed visual inspection of any existing sedimentary features, and also provided storage, when necessary for subsamples. When the features were present, X-radiography of the SLABBER subsamples clearly showed sediment layering, evidence of bioturbation and orientation of shell material, all with apparent minimal disturbance of these structures.

AO-004

BENGGIO, B. L., and T. A. NELSEN. Technical note: Successful instrument array deployments in soft mud bottoms adjacent to the Mississippi Delta. Applied Ocean Research 7(1):58-60 (1985).

An anchor design for instrument arrays was developed for use in the very soft muddy sediments adjacent to the Mississippi Delta. Because of the low sediment shear strengths and high sensitivities combined with large dynamic loadings due to strong currents, problems in successful deployments and recoveries were anticipated. A total of six deployments were attempted; four were sediment trap arrays and two were current meter/transmissometer arrays. All six deployments and recoveries were successful. The array design presented herein is a safe, easy and cost effective method for deploying instrument arrays in areas where soft bottoms and strong currents are a consideration.

AO-005

BENNETT, R. H., L. LEHMAN, M. H. HULBERT, G. R. HARVEY, S. A. BUSH, E. B. FORDE, P. CREWS, and W. B. SAWYER. Marine Chemistry 6(1):61-99 (1985).

Total organic carbon content (TOC) and selected geotechnical properties were measured in submarine sediments of the U.S. central east coast and the Mississippi Delta. TOC values in the near-surface Delta sediments were approximately 1% (dry weight). TOC in surficial sediments from the U.S. east coast outer continental shelf upper slope, and upper rise was generally less than 1%, but between the upper slope and the upper rise, values ranged from 1 to 3% and exceeded 3% in patches associated with Norfolk and Washington Canyons. TOC displayed positive linear correlations with water content, liquid limit, plastic limit, plasticity index, and the amount (percent) of fine-grained material. Nevertheless, there appeared to be no strong dependence of geotechnical properties on TOC in these sediments. This was in accord with previously reported studies on terrestrial soils with TOC values of less than 5%. Carbohydrate content was strongly correlated with water content and plasticity index, suggesting that measurement of individual components of the organic material may provide more sensitive indications of the effects of organics on geotechnical properties than measurement of bulk TOC. Selected geotechnical properties and TOC content of U.S. continental margin surficial sediments displayed regional trends related to water depth and morphological setting. These trends are probably related to recent biological, sedimentological, and oceanographic processes active on the outer shelf, slope and rise.

AO-006

BITTERMAN, D. S. Use of ARGOS tracked drifting buoys in the equatorial Pacific Ocean. 1984 Drifting Buoy Workshop, Marine Technology Society Gulf Coast Section, November, 1984, 19-111 (1985).

No abstract.

AO-007

BLACK, P. G., R. L. Elsberry, L. K. Shay, and R. M. Partridge. Hurricane Josephine (1984) surface winds and ocean response determined from air-deployed drifting buoys and concurrent research aircraft data. Extended Abstracts, 16th Conference on Hurricanes and Tropical Meteorology, May 14-17, 1985, Houston, Texas. American Meteorological Society, Boston, Massachusetts, 22-24 (1985).

No abstract.

AO-008

BLACK, P. G., R. C. Gentry, V. J. Cardone, and J. Hawkins. Seasat microwave wind and rain observations in severe tropical midlatitude marine storms. In Advances in Geophysics 27, Academic Press, New York, 197-277 (1985).

This overview presents initial results of studies concerning Seasat measurements in and around tropical and severe midlatitude cyclones over the open ocean and provides an assessment of their accuracy and usefulness. Sensors flown on Seasat provided complementary measurements of surface wind speed direction, rainfall rate, significant wave height and wave length, and sea surface temperature. These measurements were made with the Seasat-A Satellite Scatterometer (SASS), the Scanning Multichannel Microwave Radiometer (SMMR), the Seasat altimeter, and the Seasat Synthetic Aperture Radar (SAR). This is the first time that such a sophisticated array of microwave instruments has been used to study tropical cyclones.

AO-009

BURPEE, R. W., R. E. KOHLER, and D. G. Marks. An evaluation of Omega dropwindsonde data in track forecasts of Hurricane Josephine. Extended Abstracts, 16th Conference on Hurricanes and Tropical Meteorology, May 14-17, 1985, Houston, Texas. American Meteorological Society, Boston, Massachusetts, 162-163 (1985).

No abstract.

AO-010

BURPEE, R. W., D. G. Marks, and R. T. Merrill. An assessment of Omega dropwindsonde data in track forecasts of Hurricane Debby (1982). Bulletin of the American Meteorological Society 65:1050-1058 (1984).

Omega dropwindsondes (ODW's) were released from the two NOAA WP-3D aircraft to measure the environmental wind field in the middle and lower troposphere within 1000 km of the center of Hurricane Debby on 15 and 16 September 1982. The observations were coded in standard formats and transmitted from the aircraft to the National Hurricane Center (NHC) and the National Meteorological Center (NMC) before operational forecast deadlines. The ODW winds clearly indicated the location and strength of a midtropospheric trough in the westerlies that was the major synoptic-scale feature affecting Debby's motion. On 16 September, the dropwindsondes also identified a smaller scale cutoff low in the northern part of the trough. The cutoff low was centered about 500 km to the north-northwest of Debby. It affected Debby's

motion from midday on the 16th to midday on the 17th. The ODW's provided timely information to NHC that was used subjectively in determining the official forecasts of Debby's track. The potential of the ODW's to improve the track models that serve as guidance for the forecasters at NHC depends upon both the quality of the ODW data and the ability of the operational objective analyses to respond to the ODW data. In 1982, the objective analysis that initialized several of the track models was a spectral analysis with a global domain. At 500 mb, the scale of the wind circulations of Debby and the cutoff low was approximately 500 km. The global operational objective analysis did not resolve these important features. The ODW data can help to improve the objective guidance for the hurricane forecasters only if the operational objective analyses and the track models are designed to make use of the ODW information. To obtain the data needed to revise current models and to develop new models, ODW experiments are planned in the next few years when hurricanes threaten the Atlantic or Gulf coasts of the United States.

AO-011

CHEW, F., J. M. Bane, Jr., D. A. Brooks. On vertical motion, divergence, and the thermal wind balance in cold-dome meanders: A diagnostic study. Journal of Geophysical Research (90)C2:3173-3183 (1985).

Wavelike meanders are observed along the length of the Florida Current from the Florida Keys to Cape Hatteras. These propagating meanders are three-dimensional; each has a cold dome; and the meandering flow that overtakes the dome in a cyclonic turn is characteristically stronger when flowing offshore than when flowing onshore. We focus on vertical motion as a key to understanding the interdependence of the downstream propagation, the upwelling in the cold dome, and the skewness in the strength of the meandering flow. Inferred from a composite of drogue and temperature observations, the pattern of vertical motion is one of upwelling that extends throughout the water column formed by the forepart of the translating dome and its overlying on shore flow and a downwelling that similarly extends vertically through the rear part of the dome and its overlying offshore flow. It is shown that the vertical motion and the translation of the meander are interrelated, and both enter importantly in the acceleration of the water columns and hence in the skewness in the strength of the meandering flow component. As the thermal wind changes with the divergence accompanying the vertical motion, it also provides a twisting mechanism to help restore the thermal balance.

AO-012

CLARKE, T. L., J. R. PRONI, and J. F. CRAYNOCK. A simple model for the acoustic cross section of sand grains. Journal of the Acoustical Society of America 76(5):1580-1582 (1984).

Previous work on determining the acoustic cross section of sand grains [Geophys. Res. Lett. 9(2), 175-178 (1982)] identified a problem with the application of the simple compressible sphere model for the cross section. Use of the complete elastic sphere model [J. Acoust. Soc. Am. 34, 1582-1592 (1962)] failed to remove the conflict with observation. Application of the bistatic cross section theorem to the angle averaged cross section shows that the appropriate cross section is the total absorption cross section, not the backscatter cross section. The total absorption cross section for the fluid

sphere model is found to be in semiquantitative agreement with scattering data for sand grains.

A0-013

Cornuelle, B., C. Wunsch, D. BEHRINGER, T. Birdsall, M. Brown, R. Heinmiller, R. Knox, K. Metzger, W. Munk, J. Spiesberger, R. Spidel, D. Webb, and P. Worcester. Tomographic maps of the ocean mesoscale. Part 1: Pure acoustics. Physical Oceanography 15(2):133-152 (1985).

A field test of ocean acoustic tomography was conducted in 1981 for a two month period in a 300 km square at 26°N, 70°W in North Atlantic (just south of the MODE region). Nine acoustic deep-sea moorings with seafloor transponders for automated position keeping and with provisions for precise time keeping were set and recovered. From the measured travel times between moorings, various displays of the three-dimensional field of sound speed (closely related to temperature) have been obtained by inversion procedures. These procedures use historical ocean data as a reference, but all information from the in-situ surveys has been withheld; the "pure" tomographic results were then compared to direct in-situ observations. The tomographically derived spatial mean profile compares favorably to an equivalent profile from the in-situ observations; both differ significantly from the historical average. Maps constructed at three day intervals for a two-month period show a pattern of eddy structure in agreement with the direct observations within computed mapping errors, but these mapping errors are too large for many oceanographic purposes. The mapping errors are the result of an unexpectedly large noise variance in travel time. (A 1983 experiment using sources with larger bandwidth, reduced this variance to acceptable limits.) The 1981 tomographic results strongly suggest that the ocean sometimes undergoes transitions too rapid to be mapped over such large areas by shipboard observations.

A0-014

DODGE, P. P., R. W. BURPEE, and F. D. MARKS, Jr. Convective-scale and mesoscale structure of hurricanes during landfall. Extended Abstracts, 16th Conference on Hurricanes and Tropical Meteorology, May 14-17, 1985, Houston, Texas. American Meteorological Society, Boston, Massachusetts, 7-8 (1985).

No abstract.

A0-015

FORDE, E. B., S. D. Ulrich and B. Hecker. Biological disturbance and camouflage of sedimentary features on the northeast United States slope and rise. Geo-Marine Letters 4:49-53 (1984).

Evidence from over 200 sediment cores, numerous submersible dives, and bottom photographs prove that bioturbation and bioerosion are ongoing processes affecting northeastern U.S. continental slope and rise sedimentation. Evidence of biological activity was found in greater than 95% of the cores examined. Submersible dive observations reveal that the results of biological activity often dominate seafloor microtopography. Bioturbation can disturb sediments several centimeters deep in a matter of seconds and is in some areas the primary sediment transport mechanism. Many cores with sandy

intervals were profoundly disturbed by bioturbation. Biologically camouflaged sand-rich intervals can easily be missed by visual observation.

AO-016

FRANKLIN, J. L., and P. Julian. An investigation of Omega windfinding accuracy. Journal of Atmospheric and Oceanic Technology 2:212-231 (1985).

The major sources of error in Omega-derived wind estimates are examined and illustrated. Sample dropwindsondes and local Omega signals are used to illustrate the effects of several types of phase propagation anomalies. A stationary test sonde and synthetic Omega phases are used to determine the accuracy of three Omega phase-smoothing algorithms and their associated error estimates, and to determine the impact of base station motion for sondes released from aircraft. Omega windfinding errors can be classified as either "internal" or "external" errors. Internal errors are associated with signal quality and transmitter-sonde geometry, while external errors are caused by anomalous phase propagation. Estimates of wind error (wind uncertainties) are provided by the equations of Omega windfinding. These uncertainties, however, estimate only the effects of internal errors. Precise assessment of errors caused by anomalous phase propagation requires the measurement of phase data by a stationary receiver. Such measurements show that errors from external sources range from about 1 m s^{-1} for diurnal changes in ionospheric height to $20\text{-}30 \text{ m s}^{-1}$ for sudden ionospheric disturbances. Methods for dealing with these problems in sonde postprocessing are described. Data from a stationary test show that the effect of aircraft maneuvers on real-time Omega wind estimates is substantial; during turns, errors in real-time wind estimates increase by over 50%. The comparison of phase-smoothing algorithms shows that cubic-spline smoothing produces wind estimates 20-50% more accurate than those obtained with other methods. Hence, it is recommended that this smoothing algorithm be used in dropwindsonde postprocessing. It is estimated that such postprocessing will reduce errors by 60% during aircraft turns and by 30% at other times.

AO-017

FRANKLIN, J. L., S. J. LORD, L. J. SHAPIRO, and K. V. OYAMA. An objective analysis of Omega dropwindsonde data from Hurricane Debby (1982). Extended Abstracts, 16th Conference on Hurricanes and Tropical Meteorology, May 14-17, Houston, Texas. American Meteorological Society, Boston, Massachusetts, 186-187 (1985).

No abstract.

AO-018

FRIEDMAN, H. A. Educational program encourages students to seek hurricane precautions (instructional programs to encourage family involvement) - Perspectives on hurricane preparedness - Techniques in use today. In Hurricane Awareness Workbook. Federal Emergency Management Agency/National Oceanic and Atmospheric Administration, Washington, D.C., A27-A28 (1985).

No abstract.

AO-019

FRIEDMAN, H. A. Meteorological education as a window on science and technology: Activities of the AMS Board of School and Popular Meteorological and Oceanographic Education. In Weather Education. Proc., First International Conference on School and Popular Meteorological Education, J. M. Walker (ed.), 1984, Oxford. Royal Meteorological Society, Bracknell, Berkshire, England, 6-9 (1985).

Many U.S. scientists and educators have long held the belief that our educational system has failed to provide its students with the mathematics and science skills needed to compete successfully in today's technologically oriented society or to maintain our nation's position of technological leadership in the world. Only recently has this belief motivated members of the meteorological profession, through the American Meteorological Society (AMS) and other scientific organizations, to undertake a number of educationally related activities designed to reverse the disturbing trend toward math and science illiteracy in the nation's schools. The Board of School and Popular Meteorological and Oceanographic Education (BSPMOE) has joined with other boards of the AMS Education and Manpower Commission to develop a resource guide for use with school-aged children and the general public. The guide is designed to help promote an awareness of meteorology as a science and the importance of "weather" in everyday life. We believe that such awareness will serve as a "window" on mathematics, science, and technology, especially for school-aged children, and will awaken their scientific curiosity, enhance their scientific literacy, and heighten their enthusiasm for continued learning. The activities, accomplishments and programmatic goals of the BSPMOE are discussed.

AO-020

FRIEDMAN, H. A. School-based and community-wide education and public information programs to increase tropical cyclone awareness and preparedness. In Weather Education. Proc., First International Conference on School and Popular Meteorological Education, J. M. Walker (ed.), 1984, Oxford. Royal Meteorological Society, Bracknell, Berkshire, England, 79-85 (1985).

Education and public information are recognized as critical elements in the design, organization, and implementation of effective tropical cyclone warning systems. Decision-makers and citizens must have a clear understanding of the dangers associated with tropical cyclones. Otherwise, even in nations that have a high level of preparedness, citizens are likely to take all measures necessary to protect themselves, or to mitigate against, the destructive effects of future landfalling storms. In response to this recognition, a number of education, public information, and preparedness programs have been proposed or are now in progress. The goals and strategies of three such programs, namely, (1) a cognitive and affective learning model (CALM) to create an awareness of the hurricane problem in at-risk coastal communities of South Florida [HRD/AOML-NOAA], (2) Pan Caribbean Disaster Preparedness and Prevention Project [CARICOM, UNDRO, WHO], and (3) Tropical Cyclone Programme Project No. 14: Public Information and Education [WMO, UNDRO, LRCS], are discussed in this paper. These efforts represent, respectively, programs with local, regional, and international focus.

AO-021

FRIEDMAN, H. A., C. A. ARNHOLS, N. M. DORST, C. J. Nelson, and W. J. BROWN. Airborne research meteorological data collected by the National Hurricane Research Laboratory (Hurricane Research Division/ AOML) during the 1982-1983 hurricane seasons - inventory and availability. NOAA Data Report ERL AOML-3, 168 pp. (1984).

The history, nature, use, and availability of in-situ research meteorological data that have been gathered by specially instrumented aircraft have been described in several publications. In 1982, the National Hurricane Research Laboratory (NHRL), now Hurricane Research Division (HRD)/Atlantic Oceanographic and Meteorological Laboratory (AOML), published NOAA Data Report ERL AOML-2 (Friedman et al.) to document the airborne research meteorological data collected in support of its hurricane field programs during the WP-3D era (1976-1981). The present publication continues this documentation with an inventory and description of the research data that were obtained during the 1982 and 1983 hurricane seasons, and which are available at HRD/AOML.

AO-022

FRIEDMAN, H. A., P. Stephens, J. Williams, and O. E. Thompson. Guide to Establishing School and Public Educational Activities. First edition (for limited distribution), American Meteorological Society, Boston, Massachusetts, 21 pp. (1985).

The first edition of this guide to local AMS chapters and university departments is designed to help develop school and public educational outreach programs in their communities. The guide was produced cooperatively by the AMS Board of School and Popular Meteorological and Oceanographic Education and the Board on Women and Minorities. The authors invite readers of this document to comment on its usefulness in conducting and implementing community educational outreach programs. Formal publication of the guide is planned.

AO-023

GOLDENBERG, S. B., S. D. ABERSON, and R. J. KOHLER. Incorporation of Omega dropwindsonde data into SANBAR: An operational barotropic hurricane-track forecast model. Extended Abstracts, 16th Conference on Hurricanes and Tropical Meteorology, May 14-17, 1985, Houston, Texas. American Meteorological Society, Boston, Massachusetts, 44-45 (1985).

No abstract.

AO-024

GOVONI, J. J., A. J. CHESTER, D. E. HOSS, and P. B. ORTNER. An observation of episodic feeding and growth of larval Leiostomus xanthurus in the northern Gulf of Mexico. Journal of Plankton Research 7(1):137-146 (1985).

Four cruises were conducted in the northern Gulf of Mexico over two spawning seasons of the sciaenid fish Leiostomus xanthurus. On only one occasion did unusually high densities of larvae and their principal microzooplanktonic foods co-occur. Peak densities of larvae and microzooplankton were observed in a thin lens of cool surface water that characterized a

hydrographic discontinuity, and all larvae contained high numbers of food organisms in their guts. Instantaneous exponential growth rates, estimated from measurements of otolith growth increments, indicated accelerated growth on the day that larvae were collected. A laboratory experiment verified that larval L. xanthurus responds to an increased ration with accelerated growth that is detectable in otoliths. Together these data suggest that the spatial distribution of L. xanthurus larvae and their microzooplanktonic food is patchy and that interactions of larvae and microzooplankton may be episodic.

AO-025

HANSEN, D. V., and C. A. Paul. Genesis and effects of long waves in the equatorial Pacific. Journal of Geophysical Research 89(C11):10431-10440 (1984).

Data from 20 satellite-tracked drifting buoys deployed in the eastern equatorial Pacific Ocean during the summer of 1979 were used to investigate the nature, effects, and energetics of currents associated with cusp-shaped long waves that have been observed in satellite IR imagery of the sea surface during all except El Niño years. It is shown that the long waves are associated with a vigorous pattern of mesoscale eddies lying primarily between the equator and 7°N. The spatial structure of the eddy kinetic energy closely resembles the eigenfunctions obtained from Philander's (1978) investigation of barotropic instability of that part of the South Equatorial Current lying north of the equator. Computation of the energy exchange between the eddies and the mean field suggests an e-folding time of about two weeks for the eddies, and a braking effect on the mean flow comparable to a change of surface wind stress of a few tenths of a dyne per square centimeter. The eddies also effect an equatorward transport of heat that amounts to about two thirds the poleward heat transport of the divergent Ekman transport in the near surface waters.

AO-026

HANSEN, D. V. Eastern tropical Pacific thermocline topography during 1982-83. In El Niño Atlas, 1982-83, A. Leetmaa and J. Witte (eds.), December 1984, GPO Ch. 12, 131-134 (1985).

No abstract.

AO-027

HANSEN, D. V., M. PAZOS, and R. Allen. Movements of satellite-tracked drifting buoys in the eastern equatorial Pacific during 1982-83. In El Niño Atlas, 1982-83, A. Leetmaa and J. Witte (eds.), December 1984, GPO Ch. 8, 89-102 (1985).

No abstract.

AO-028

HANSEN, D. V. Aspectos a gran escala de condiciones atmosfericas y oceanicas asociadas con "El Niño" de 1982-1983. Large scale aspects of oceanic and atmospheric conditions associated with the 1982-1983 "El Niño." Rev. Com. Perm. Pacifico Sur (15):49-65 (1985).

An unprecedented set of oceanic and atmospheric data are available to complement those made in the ERFEN region for description of the "El Niño" of 1982-1983. These data show that anomalies of sea level atmospheric pressure, precipitation, and winds appeared in the western Pacific Ocean as early as May 1982, and moved eastward across the ocean to the coast of South America. These atmospheric anomalies were associated with observed sea surface temperature and circulation anomalies in the eastern Pacific Ocean. Movements of satellite-tracked drifting buoys reveal that the South Equatorial Current near the equator flowed with less than normal strength during the entire period from August 1982 through June, 1983, and actually reversed during December 1982, and from mid-April through early June 1983. The temporal evolution of near-equatorial water movements is similar to the sea surface temperature and sea level anomalies observed east of the Galapagos Islands. By December 1983, almost all of the anomalies associated with El Niño had returned to near normal values.

AO-029

HANSEN, D. V., and C. A. Paul. Vertical Motion in the eastern equatorial Pacific inferred from drifting buoys. Proceedings, Symposium on Vertical Motion in the Equatorial Upper Ocean and its Effects Upon Living Resources and the Atmosphere. 6-10 May 1985, Paris, France, SCOR (1985).

No abstract.

AO-030

HANSEN, D. V., and G. THOMAS. Thermocline displacements in the eastern tropical Pacific during the El Niño of 1982-83. EOS 65(45):946 (1984).

No abstract.

AO-031

HARVEY, G. R., J. S. S. Damste, and J. W. De Leeuw. On the origin of alkybenzenes in biochemical samples. Marine Chemistry 16:187-188 (1985).

No abstract.

AO-032

Houze, R. A., Jr., F. D. MARKS, Jr., R. A. BLACK, P. T. WILLIS, and J. F. GAMACHE. Airborne Doppler and cloud microphysical measurements in Hurricane Norbert. Extended Abstracts, 16th Conference on Hurricanes and Tropical Meteorology, May 14-17, 1985, Houston, Texas. American Meteorological Society, Boston, Massachusetts, 5-6 (1985).

No abstract.

AO-033

JORGENSEN, D. P., E. J. Zipser, and M. A. LeMone. Vertical motions in intense hurricanes. Journal of the Atmospheric Sciences 42:839-856 (1985).

Hurricane vertical motion properties are studied using aircraft-measured 1 Hz time series of vertical velocity obtained during radial penetrations of four mature hurricanes. A total of 115 penetrations from nine flight sorties at altitudes from 0.5 to 6.1 km are included in the data set. Convective vertical motion events are classified as updrafts (or downdrafts) if the vertical velocity was continuously positive (or negative) for at least 500 m and exceeded an absolute value of 0.5 m s^{-1} . Over 3000 updrafts and nearly 2000 downdrafts are included in the data set. A second criteria was used to define stronger events, called cores. This criteria required that upward (or downward) vertical velocity be continuously greater than an absolute value of 1 m s^{-1} for at least 500 m. The draft and core properties are summarized as distributions of average and maximum vertical velocity, diameter and vertical mass transport in two regions: eyewall and rainband. In both regions updrafts dominated over downdrafts, both in number and mass transport. In the eyewall region, the draft and core strength distributions were similar to data collected by aircraft in GATE cumulonimbus clouds. Unlike GATE clouds, however, the largest updraft cores (larger than 90% of the distribution) were over twice as large and transported twice as much mass as did the corresponding GATE updraft cores. Eyewall ascent was highly organized in a channel several kilometers wide located a few kilometers radially inward from the radius of maximum tangential wind. As in GATE, the strongest hurricane updraft cores were weak in comparison with the strongest updrafts observed in typical midlatitude thunderstorms. Mean eyewall profiles of radar reflectivity and cloud water content are discussed to illustrate the microphysical implications of the low updraft rates.

AO-034

Klinkhammer, G., P. A. RONA, M. Greaves, and H. Elderfield. Hydrothermal manganese plumes in the Mid-Atlantic rift valley. Letters to Nature 314:727-731 (April 25, 1985).

The concentration of dissolved manganese in seawater can be used as a chemical tracer of hydrothermal activity on the underlying seafloor. Here we present vertical profiles of seawater manganese concentrations above the rift valley of the Mid-Atlantic Ridge (MAR). The values obtained indicate the presence of plumes that are presently active generated by hydrothermal vents in the rift valley. These plumes are confined to the rift valley and do not spill over into the adjacent deep ocean basins. Differences between them suggest that there are at least five hydrothermal sources along this 1,700-km-long section of mid-ocean ridge.

AO-035

LEETMAA, A. Hydrographic conditions along 85°W and 5°S and 10°S . In El Niño Atlas, 1982-83, A. Leetmaa and J. Witte (eds.), December 1984, GPO Ch. 10, 107-124 (1985).

No abstract.

AO-036

LEETMAA, A., and D. WILSON. Ametek-Straza data from the eastern Pacific. In El Niño Atlas, 1982-83, A. Leetmaa and J. Witte (eds.), December 1984, GPO Ch. 13, 135-148 (1985).

No abstract.

AO-037

LEETMAA, A., and D. WILSON. Characteristics of near surface circulation patterns in the eastern equatorial Pacific. Progress in Oceanography 14:339-352 (1985).

Since June 1981 several CTD and velocity profiler sections have been made across the equator at 85°W as part of the Equatorial Pacific Ocean Climate Studies (EPOCS). Two of these sections, those in June 1981 and December 1982, are discussed in order to characterize the circulation patterns that occur when the ocean is forced by meridional wind stress. In this area the winds are predominantly southerly. Use of an Ametek-Straza acoustic Doppler backscatter profiler during the 1982 cruise gave velocity data to a depth of 270 m every 5.5 km along the shiptrack. This allowed the shear and velocity fields to be examined in greater detail than had been possible before. Large areas had shears greater than 0.01 s^{-1} were observed. Greatest shears tended to coincide with regions of large vertical density gradients. Comparisons with geostrophic computations suggest that a large fraction of the shear was geostrophic. Richardson number computations indicated that over 40% of the area sampled by the CTD casts had values of less than one and about 5% had values less than one quarter. Values of less than one quarter were concentrated in the mixed layer but were not confined to it. Below the mixed layer, regions with low Richardson number were associated with regions where the vertical density gradient was quasi-linear. Since such regions were not confined to the vicinity of the equator these observations suggest shear mixing as an important mechanism over large areas of the upper ocean. Within the top 40 m of the water column there was a general tendency for motions in the mixed layer to be to the left of the wind in the southern hemisphere and to the right in the northern hemisphere. However, no clear examples were found of Ekman spirals. Most of the veering was confined to the mixed layer which was of relatively constant depth over the whole survey area. South of the equator a large fraction of the shear across the base of the mixed layer appeared to geostrophic, whereas north of the equator, these shears were ageostrophic. Estimates of the various terms in the momentum equation in the upper ocean indicated that near the equator non-linear effects, such as upwelling and northward advection, were as important as Coriolis forces, pressure gradients and wind stress. The pressure gradient, integrated over the depth quarter were concentrated in the mixed layer but were not confined to it. Below the mixed layer, regions with low Richardson number were associated with regions where the vertical density gradient was quasi-linear. Since such regions were not confined to the vicinity of the equator these observations suggest shear mixing as an important mechanism over large areas of the upper ocean. Within the top 40 m of the water column there was a general tendency for motions in the mixed layer to be to the left of the wind in the southern hemisphere and to the right in the northern hemisphere. However, no clear examples were found of Ekman spirals. Most of the veering was confined to the mixed layer which was of relatively constant depth over

the whole survey area. South of the equator a large fraction of the shear across the base of the mixed layer appeared to be geostrophic, whereas north of the equator, these shears were ageostrophic. Estimates of the various terms in the momentum equation in the upper ocean indicated that near the equator non-linear effects, such as upwelling and northward advection, were as important as Coriolis forces, pressure gradients and wind stress. The pressure gradient, integrated over the depth of the mixed layer, was larger than the stress in the vicinity of the equator and the relative importance of other terms varied from place to place. The horizontal scale of variation was as small as 10 km. Near surface upwelling occurred in shallow cells with horizontal dimensions of 100 km or less.

AO-038

Lewis, J. M., C. M. Hayden, C. S. Velden, T. R. Stewart, S. J. LORD, S. B. GOLDENBERG, and S. D. ABERSON. The use of VAS winds and temperatures as input to barotropic hurricane-track forecasting. Extended Abstracts, 16th Conference on Hurricanes and Tropical Meteorology, May 14-17, 1985, Houston, Texas. American Meteorological Society, Boston, Massachusetts, 40-41 (1985).

No abstract.

AO-039

LONG, R. B. Inverse modeling in ocean wave studies. In Wave Dynamics and Radio Probing of the Ocean Surface, O. M. Phillips and K. Hasselmann (eds.), Plenum Press, New York, NY, 700 pp. (1985).

A fundamental description of sea state is provided by the surface wave directional spectrum. Efforts to measure the directional spectrum with in-situ instrumentation generally yield data which represent estimates of integral properties of the spectrum. Extracting an estimate of the full, two-dimensional spectrum from such data presents a typical example of the so-called "inverse problem." The problem is solved by finding a model spectrum which is statistically consistent with the observations and, at the same time, satisfies a set of externally imposed constraints required to make the problem determinate.

AO-040

LONG, R. B. Out of the SWAMP to a more certain life on the ocean wave. Nature 313(5999):17-23 (1985).

No abstract.

AO-041

LORD, S. J., and J. M. PIOTROWICZ. Vertical velocity structures in an axisymmetric, nonhydrostatic tropical cyclone model. Extended Abstracts, 16th Conference on Hurricanes and Tropical Meteorology, May 14-17, 1985, Houston, Texas. American Meteorological Society, Boston, Massachusetts, 138-139 (1985).

No abstract.

AO-042

LORD, S. J., H. E. WILLOUGHBY, and J. M. PIOTROWICZ. Role of a parameterized ice-phase microphysics in an axisymmetric, nonhydrostatic tropical cyclone model. Journal of the Atmospheric Sciences 41:2836-2848 (1984).

Results of the axisymmetric, nonhydrostatic hurricane model of Willoughby et al. (1984) are analyzed with emphasis on the role of a parameterized ice-phase microphysics. Inclusion of ice processes produces dramatic differences in the structure and evolution of the simulated hurricane vortex. Mesoscale convective features are more plentiful with ice, and the simulated vortex grows more slowly. Time and space-averaged budgets of key model variables show that cooling due to melting ice particles can initiate and maintain model downdrafts on a horizontal scale of tens of km. This scale depends critically on both the horizontal advection of the parameterized snow particles detrained from the tops of convective updrafts and the mean fall speed of the particles toward the melting level. In-situ production of snow particles results from a wide variety of parameterized microphysical processes and is a significant factor in maintaining upper level snow concentrations. These processes are strongly height-dependent.

AO-043

MARKS, F. D., Jr. Evolution of the structure of precipitation in Hurricane Allen (1980). Monthly Weather Review 113:909-930 (1985).

Reflectivity data from the airborne radar systems on board the three NOAA aircraft were gathered during six consecutive days in Hurricane Allen of 1980. The data have been used to specify the horizontal and vertical precipitation distribution within 111 km radius of the hurricane center. The evolution of the structure and intensity of the precipitation in the storm is described from representative time composite radar maps for seven research flights made during the 6-day period. The eyewall was characterized by a narrow ring (12-15 km wide) of intense reflectivity (42-47 dBZ) surrounding the center of the storm at a radius that varied in time from 12-40 km. The eyewall had steep radial gradients of reflectivity (4-5 dB km⁻¹) and tilted radially outward in height. The rain bands were characterized by areas of enhanced reflectivity embedded in a region of stratiform rainfall that contained a distinct bright band at the height of the 0°C isotherm. The most striking changes in structure during the 6-day period were the rapid contraction in eyewall radius and the development of a secondary ring of intense reflectivity 80-100 km from the storm center. These changes in eye radius appeared to be related to the vortex evolution, as discussed by Willoughby and others. Changes in storm intensity, coincident with the eyewall radius changes, seemed to have little effect on the total storm rainfall or latent heat release. The maximum storm rainfall occurred when the storm had a double eyewall structure. After the period of the double eyewall, the mean rain rate in the eyewall increased as the storm approached maximum intensity. However, coincident with the increase in eyewall rain rate, the eyewall area decreased, resulting in little change in the total storm rainfall. The sequence of time composites provided the first opportunity to describe, quantitatively, the precipitation distribution within 111 km of the center of a mature hurricane that was away from land influences. The rainfall analysis showed that the mean rain rates in the eyewall were a factor of 6 greater than those outside the eyewall (11.3 mm h⁻¹ versus 1.8 mm h⁻¹), but because the

eyewall region encompassed such a small area, it only contributed 40% of the total rainfall within a radius of 1° latitude of the storm center. The precipitation distribution around the storm was asymmetric; more rainfall occurred ahead of the storm than behind. In general, the maximum precipitation in the eyewall region was within 15-20° of the storm track. The maximum rainfall in the rainband region was 40-50° to the right of that in the eyewall.

AO-044

MARMOLEJO, E., J. FESTA, and R. MOLINARI. Heat budget and climatic atlas of the equatorial Atlantic Ocean during FGGE (1979). NOAA-TM-ERL-AOML-61, 76 pp. (1985).

No abstract.

AO-045

MAUL, G. A., F. Williams, M. ROFFER, and F. Sousa. Remotely sensed oceanographic patterns and variability of bluefin tuna catch in the Gulf of Mexico. Oceanologica Acta 7(4):469-479 (1985).

Data from the Japanese longline bluefin fishery in the Gulf of Mexico for 1979 and 1980 were combined with in-situ oceanographic data from four research cruises and several ship-of-opportunity XBT transects, and with infrared and visible satellite imagery from GOES, TIROS-n, and NIMBUS-7. Catch per unit effort, CPUE, for Atlantic bluefin tuna (Thunnus thynnus thynnus) in 1979 was approximately one third that in 1980 and appears to be associated with the area fished. Using GOES infrared data, the boundary of the Gulf Loop Current was located and compared with the CPUE; the high 1980 catch was correlated with proximity to the surface thermal front of the current and appears to reflect a change in fishing strategy between years. Correlations with other environmental factors such as sea surface temperature, temperature differences, time (spectral estimates), and configuration of the Loop Current, were generally inconclusive. Polar orbiting satellite data, with at most twice-per-day observations, provided very few useful current boundary locations whereas GOES, with its hourly imagery schedule for oceanographic features, allowed comparisons almost every day during the fishing season. Operational application of satellite data to fisheries oceanography in the tropics and sub-tropics requires the high imaging frequency of geostationary vehicles because of cloud abundance, separation, and advection rates.

AO-046

MAUL, G. A., F. CHEW, M. BUSHNELL, and D. A. MAYER. Sea level variation as an indicator of Florida Current volume transport: Comparisons with direct measurements. Science 227(4684):304-307 (1985).

The first phase of STACS is directed toward developing a reliable and inexpensive means of monitoring volume transport in the Florida Current. To this end sea level measurements from tide gauges at Miami, Florida and Cat Cay, the Bahamas, and bottom pressure measurements from 50 m water depth off Jupiter, Florida and 10 m water depth off Memory Rock, the Bahamas, were obtained. Daily averaged sea level from either gauge on the Bahamian side of

the Straits of Florida was uncorrelated with transport, but bottom pressure off Jupiter had a linear coefficient of determination $r^2 = 0.93$, and Miami sea level when adjusted for weather effects had $r^2 = 0.74$; standard error of estimating transports were $\pm 1.2 \times 10^6$ m³/sec and $\pm 1.9 \times 10^6$ m³/sec respectively. A linear multivariate regression which combined bottom pressure, weather, and the submarine cable observations between Jupiter and the Bahamas, had $r^2 = 0.97$ with a standard error of estimating transport of $\pm 0.8 \times 10^6$ m³/sec. These results suggest that a combination of easily obtained observations is capable of adequately monitoring the volume transport of the Florida Current.

A0-047

MAUL, G. A. Book. Introduction to Satellite Oceanography. Martinus Nijhoff Publishers, Dordrecht/ Boston/Lancaster, 606 pp. (1985).

No abstract.

A0-048

MAUL, G. A., and A. HERMAN. Mean dynamic topography of the Gulf of Mexico with application to satellite altimetry. Marine Geodesy 9(1):27-44 (1985).

A new calculation of the mean dynamic sea surface topography for the Gulf of Mexico is presented. All available hydrographic, STD, and XBT data from the national archive and other sources are combined to calculate the mean dynamic height of the basin at 25-km horizontal spatial resolution, using 1000 db as the reference level. In all, over 26,000 stations were considered, approximately 15% of which were rejected for geographic, oceanographic, or instrumental reasons. Most of the observations were taken between 1969 and 1973, were equally spread over all seasons except winter, and were mostly in the eastern Gulf. Standard error of the mean surface is estimated at less than ± 2 dyn-cm (dynamic centimeters). The mean dynamic topography is dominated by the 150 dyn-cm high associated with the Gulf Loop Current in the eastern basin, and by a cyclone/anticyclone pair in the western basin. Standard deviation about the mean relative to 450 db accounts for 75% of the 1000-db variation, and shows that more than ± 20 dyn-cm are associated with the Loop Current and ± 10 to ± 14 dyn-cm with the western Gulf cyclone/anticyclone feature.

A0-049

MAUL, G. A. ERRATA: Fitting of satellite and in-situ ocean surface temperatures: Results for Polymode during the winter of 1977-1978 by George A. Maul and Nicolas J. Bravo. Journal of Geophysical Research 88(C14):9605-9616 (1985).

No abstract.

A0-050

Maul, G. A., and N. J. BRAVO. Correction to "Fitting of satellite and in-situ ocean surface temperatures: Results for Polymode during the winter of 1977-1978." Journal of Geophysical Research 90(C5):9211-9213 (1985).

No abstract.

AO-051

MAUL, G. A. FACTS: The Florida Atlantic Coast Transport Study. EOS 66(19):434-435 (1985).

No abstract.

AO-052

MAUL, G. A., D. A. MAYER, and S. R. Baig. Comparisons between a continuous three-year current-meter observation at the sill of the Yucatan Strait, satellite measurements of Gulf Loop Current area, and regional sea level. Journal of Geophysical Research 90(C5):9089-9096 (1985).

From October 1977 through November 1980 a current meter mooring was maintained in the Yucatan Strait. The meter was moored halfway between Mexico and Cuba 145 m above the sill or in 1895 m of water. Motions of low frequency ($< 14^{-1}$ cycles/day) are oriented approximately parallel to the isobaths, 0210-0300 true. Net drift for three years is to the SSW at an average velocity of 1.8 cm/s. Sustained southward flows at intervals of 8 months, which persisted for several months each, have average velocities of 5 cm/s, with randomly spaced bursts as high as 15 cm/s. Energy in subtidal frequency bands has significant peaks near 38^{-1} and 19^{-1} cycles/day, with a broad band of energy between 300^{-1} and 200^{-1} cycles/day. The later peak is consistent with the approximately 8-month interval between the southward flow events. Comparison with weekly areal coverage of the Gulf Loop Current from Geostationary Operational Environmental Satellite infrared observations shows little covariation, except that 8 months is typical of some anticyclonic eddy generation. There is little coherence of sill depth velocities with Naples sea level at subtidal frequencies, but with Miami there is coherence at several frequencies notably 38^{-1} and 19^{-1} cycles/day. In the higher frequencies, the principal tidal motions are diurnal and are oriented somewhat across the isobaths toward the northeast, 3460-3490 true, with counterrotating O1 and K1 constituents. No semidiurnal, inertial, or fortnightly energy is observed above the background continuum.

AO-053

MAYER, D. A., K. Leaman, and T. N. Lee. Tidal motions in the Florida Current. Journal of Physical Oceanography 14(10):1551-1559 (1984).

A linear relationship exists between sea level and the north component of the depth-averaged tidal velocity in the Straits of Florida. This relationship is used as a one-dimensional model to predict barotropic tidal currents across the Straits near 27°N. Predictions are independent of the choice of a sea-level reference site between Key West and Patrick Air Force Base. The model, when compared with three sets of depth-averaged velocity obtained from current profilers, can account for at least 70% of the variance in the diurnal and semidiurnal tidal bands. The predicted diurnal tidal current is dominant and can account for more than 80% of the predicted tidal energy. Twice a year the one-dimensional model yields a maximum amplitude of $12 \text{ cm s}^{-1} \pm 3.5 \text{ cm s}^{-1}$ (rms). This corresponds to a tidal transport of $5.1 \times 10^6 \text{ m}^3 \text{ s}^{-1} \pm 1.5 \times 10^6 \text{ m}^3 \text{ s}^{-1}$ (5.1 Sv).

AO-054

McGregor, B. A., T. A. NELSEN, W. L. STUBBLEFIELD and G. F. Merrill. The role of canyons in late quaternary deposition on the United States Mid-Atlantic continental rise. Reprinted from: Fine-Grained Sediments: Deep Water Processes and Facies. The Geological Society: 319-330 (1984).

The continental margin in the U.S. Mid-Atlantic region is dissected by many downslope-trending canyons, extending from near or at the shelf-edge out into the rise. Sediments from the shelf and slope are transported seaward through the canyon system to the rise. Sand-size material from the shelf is introduced by means of spillover into the canyons and onto the upper slope. A dendritic gully system dissecting the entire slope also provides pathways for slope sediments, mainly silts and clays, to be introduced into the canyons. Distinct grain-size distributions of the shelf sands which are interbedded or mixed with the fine-grained sediments of the slope and rise can be used as tracers for transport pathways on the continental margin. Canyon erosion on the rise also may provide a local source of sediment which must be considered. Sand-size sediment distribution and DSRV Alvin observations show that erosion and deposition take place periodically in the Mid-Atlantic canyons and on the rise seaward of New Jersey and Delaware.

AO-055

McLEISH, W., and D. Ross. Reply to comments on: F. Jackson and C. Peng, Comment on "Imaging radar observations of directional properties of ocean waves" by W. McLeish and D. Ross. Journal of Geophysical Research 90(C4):7371-7375 (1985).

No abstract.

AO-056

MOLINARI, R. L., J. F. FESTA, and E. MARMOLEJO. Evolution of sea-surface temperature and surface meteorological fields in the tropical Atlantic Ocean during FGGE, 1979: I. Description of surface fields and computation of surface energy fluxes. Progress in Oceanography 14:401-420 (1985).

Observations of surface oceanographic and meteorological fields collected during the First GARP Global Experiment (FGGE) in the equatorial Atlantic Ocean have been combined and averaged by month onto a 2° x 2° grid. Monthly distributions of sea-surface temperature, wind speed and direction, air temperature, specific humidity and cloud cover have been generated for the period from December 1978 through November 1979. Net short wave and long wave radiation, and sensible and latent heat flux distributions have been generated from the surface data using the bulk aerodynamic formulas. In 1979, large-scale patterns of all the climatic and heat budget variables are very similar to distributions determined from long-term climatological averages. Positive anomalies of SST in the region of the equatorial cold water tongue represent some region of systematic differences between the 1979 and climatological distributions. The positive SST anomalies are, in general, coincident with negative anomalies in the net oceanic heat gain. Negative heat gain anomalies are primarily caused by positive wind speed anomalies, through increased latent and sensible heat fluxes.

AO-057

MOLINARI, R. L., J. F. FESTA, and E. MARMOLEJO. Evolution of sea-surface temperature in the tropical Atlantic Ocean during FGGE, 1979: II. Oceanographic fields and heat balance of the mixed layer. Journal of Marine Research 43:67-81 (1985).

Surface meteorological and surface and subsurface oceanographic data collected during 1979 are used to describe sea-surface temperature, mixed layer depth, zonal current component and net oceanic heat gain fields and to estimate the terms in a heat balance relation for the mixed layer. The terms are evaluated monthly on a 6° of latitude by 10° of longitude grid which covers the equatorial Atlantic from 9°S to 9°N . The first balance tested is between changes in mixed layer temperature and surface energy fluxes. These fluxes can account for more than 75% of the variance in the original time series of the quadrangles along 6°S . Variance reductions are less along 10° (order of 50%) and 6°N (less than 25%). The addition of zonal advection improves some of the predictions but not significantly. Low variance reductions along 6°N , west of 20°W are attributed to the uncertainties in the estimates of observed temperature change and surface fluxes. The small variance reductions east of 20°W , at 6°N and along 0° may be related to the neglect of coastal and equatorial upwelling and meridional advection. A simple model is proposed which assumes an annual cycle for the intensity of mixing across the base of the mixed layer, most intense during summer, least intense during winter. Variance reductions at 0° , 5°W increase from 20% to 60% with the inclusion of mixing. Meridional advection may also account for a portion of the observed variability in mixed layer temperature.

AO-058

MOLINARI, R. L., G. A. MAUL, F. CHEW, W. D. WILSON, M. BUSHNELL, D. A. MAYER, K. Leaman, F. Schott, T. Lee, R. Zantopp, J. Larsen, and T. Sanford. Reports: Subtropical Atlantic Climate Studies: Introduction. Science 227(4684):292-294 (1985).

This report is an introduction to the accompanying collection of reports that present the results of a two-year period of intensive monitoring of the Florida Current. Both direct observing systems (ship-deployed current profilers and moored current meters) and indirect observing systems (coastal tide gauge stations, bottom pressure gauge arrays, a submarine cable, acoustic arrays, and radar installations) were used to measure temperature and volume transport.

AO-059

MOLINARI, R. L., D. WILSON, and K. Leaman. Volume and heat transports of the Florida Current: April 1982 through August 1983. Science 227(4684):295-297 (1985).

Absolute velocity and temperature profiles are used to estimate the volume transport through the Straits of Florida and, in combination with historical midbasin data, to estimate the total meridional heat flux through a section at 27°N . The mean annual volume transport of the Florida Current from April 1982 through August 1983 is $30.5 (+1) \times 10^6$ cubic meters per second. The net northward heat flux through the 27°N section is $1.2 (\pm 0.1) \times 10^{15}$

watts. The volume transport is characterized by high values in the late spring and early summer and low values in the late fall and early winter. There is a similar cycle in total heat flux.

AO-060

Oakley, S. A., I. W. Duedall, J. H. Parker, and J. R. PRONI. Continuous measurements of the dispersion of sewage sludge. In Wastes in the Ocean, Volume 6, I. W. Duedall, D. R. Kester, P. K. Parke, B. H. Ketchum (eds.), Wiley, New York (1985).

No abstract.

AO-061

OYAMA, K. V. The polar representation of tensor cross-spectra of winds. Extended Abstracts, 16th Conference on Hurricanes and Tropical Meteorology, May 14-17, 1985, Houston, Texas. American Meteorological Society, Boston, Massachusetts, 182-183 (1985).

No abstract.

AO-062

ORTNER, P. B., R. L. FERGUSON, S. R. PIOTROWICZ, L. CHESAL, G. BERBERIAN, and A. V. Palumbo. Biological consequences of hydrographic and atmospheric advection within the Gulf Loop Intrusion. Deep-Sea Research 31(9):1101-1120 (1984).

Dramatic changes in plankton productivity, abundance, vertical distribution, and relative sensitivity to added copper occurred during an 8-day station within the Gulf Loop Intrusion in February 1981. Passage of an atmospheric front associated with a continental high temporarily deepened the mixed layer from 20-40 m to 110-120 m but did not measurably increase inorganic nutrients within it. Primary productivity increased from 14 to 62 mg C m⁻² h⁻¹ and bacterioplankton increased from 4.3 x 10¹³ to 6.1 x 10¹³ cells m⁻². Vertical redistribution of biomass may have decoupled zooplankton grazing from primary production contributing to increases in phytoplankton and bacterioplankton standing stocks. Satellite thermal imagery indicated that the position was well removed from the active field of the Loop Current, but detailed analysis of hydrographic data revealed that wind-induced mixing had been superimposed upon an advective event - the passage of a warm, low-salinity lens. Phytoplankton in the low-salinity lens were remarkably insensitive to added copper (4 x 10⁻⁸ M) due to unusually high sequestering of added copper by qualitatively distinct marine humus. The observations were in marked contrast to previous ones at the same general location.

AO-063

PALMER, D. R., L. M. LAWSON, D. A. SEEM, and Y.-H. DANESHZADEH. Ray path identification and acoustic tomography in the Straits of Florida. Journal of Geophysical Research (90)C3:4977-4989 (1985).

The Florida Current, which flows through the Straits of Florida, transports a significant fraction of the heat which must be transferred from low to

high latitudes in order for the earth to remain in thermal balance. While ocean acoustic tomography is an attractive candidate for monitoring this heat transport, its use is dependent on being able to identify individual ray paths. All published investigations of tomography have been concerned with deep-ocean propagation where experience has shown that paths can be identified. Propagation in the Straits is quite different from deep-ocean propagation, however. The sound speed is such that a ray path which travels modest distances necessarily experiences bottom bounces. It is not clear, a priori, that paths can be identified in the Straits. We report the results of an investigation of this question. Using a fast, specialized ray-tracing program, we analyzed the fluctuations in ray path geometry resulting from small perturbations in the bathymetry. We found that the topographic features amplify these fluctuations to such a degree that identification of individual rays becomes impossible after only a few bottom bounces. Consequently, there is no adequate interpretive tool for relating an acoustic signal recorded more than a few tens of kilometers from a source to the heat transport, i.e., for carrying out the tomographic inversion. We propose a way of overcoming this identification problem based on the use of acoustic profilers.

AO-064

Paul, C. A., and D. V. HANSEN. The mean near surface circulation of the tropical Pacific and ENSO anomalies. EOS 65(45):944 (1984).

No abstract.

AO-065

Paul, C. A., and M. C. PAZOS. Data for EPOCS/FGGE drifting buoys: February 1979 through October 1980. NOAA Data Report ERL-AOML-4, 157 pp. (1985).

No abstract.

AO-066

PAZOS, M. C., and C. A. Paul. Drifting buoy data from the equatorial Pacific Ocean for the period of August 31, 1980 through April 30, 1982. NOAA-TM-ERL-AOML-60, 110 pp. (1984).

No abstract.

AO-067

Peterson, D. H., and J. F. FESTA. Numerical simulation of phytoplankton productivity in partially mixed estuaries. Estuarine, Coastal and Shelf Science 19:563-589 (1985).

A two-dimensional steady-state model of light-driven phytoplankton productivity and biomass in partially mixed estuaries has been developed. Effects of variations in river flow, suspended sediment concentration, phytoplankton sinking, self-shading and growth rates on distributions of phytoplankton biomass and productivity are investigated. Numerical simulation experiments show that biomass and productivity are particularly sensitive to variations in suspended sediment concentrations typical of natural river

sources and to variations in loss rates assumed to be realistic but poorly known for real systems. Changes in the loss rate term within the range of empirical error (such as from dark bottle incubation experiments) cause phytoplankton biomass to change by a factor of two. In estuaries with adequate light penetration in the water column, it could be an advantage for phytoplankton to sink. Species that sink increase their concentration and form a phytoplankton maximum in a way similar to the formation of the estuarine turbidity maximum. When attenuation is severe, however, sinking species have more difficulty in maintaining their population.

AO-068

Philander, G., D. Halpern, D. V. HANSEN, R. Legeckis, L. Miller, C. Paul, R. Watts, R. Weisberg, and M. Wimbush. Long waves in the equatorial Pacific Ocean. EOS 66(14):154 (1985).

Westward traveling waves with a period of three weeks and a wavelength of 1000 km appear in the central and eastern equatorial Pacific Ocean during periods of intense trade winds and strong surface currents. Recent measurements of the structure of these waves confirm that they are caused by instabilities associated primarily with the latitudinal shear of the surface currents.

AO-069

POWELL, M. D. Airborne Doppler radar observations of the hurricane boundary layer. Extended Abstracts, 16th Conference on Hurricanes and Tropical Meteorology, May 14-17, 1985, Houston, Texas. American Meteorological Society, Boston, Massachusetts, 3-4 (1985).

No abstract.

AO-070

RATNASWAMY, M., D. WILSON, and R. MOLINARI. Current velocity and hydrographic observations in the Straits of Florida: Subtropical Atlantic Climate Study (STACS) 1983-1984. NOAA Data Report ERL-AOML-5, 242 pp. (1985).

No abstract.

AO-071

RONA, P. A. Exploration for hydrothermal mineral deposits at seafloor spreading centers: U.S. activities. Second International Seminar on the Offshore Mineral Resources. Offshore Prospecting and Mining Problems: Current Status and Future Developments. GERMINAL, Brest, France, March 1984.

An active program of research by certain U.S. academic institutions and Federal agencies is directed to investigation of hydrothermal processes of mineralization in representative geologic settings of ocean basins. The hydrothermal mineral deposits presently known at seafloor spreading centers clearly are not commercial prospects with the exception of the stratiform

sulfide deposit in the Atlantis II Deep of the Red Sea, but are mineralized showing subject to further investigation. Definition of the specific conditions under which large deposits are formed remains an important research goal which will provide guidelines to explore for hydrothermal mineral deposits presently on the seafloor, as well as for those deposits formed on the seafloor in ancient times and presently preserved on land.

AO-072

RONA, P. A. Hydrothermal mineralization at slow-spreading centers: Red Sea, Atlantic Ocean and Indian Ocean. Marine Mining 5(2):117-145 (1985).

Hydrothermal mineralization along slow-spreading oceanic ridges and rift zones that comprise more than half the global length of the seafloor spreading-center system is related to anomalous physical and chemical conditions acting within the geologic settings that characterize early and advanced stages of opening is represented by the Atlantis II Deep of the Red Sea. There, hypersaline hydrothermal solutions, discharging as density-stratified brines into an axial basin, have formed the largest massive sulfide deposit (32.5 x 10 metric tons of metal) known at a spreading center. Mineralization at the advanced stage of opening is represented by two types of sites: (1) oceanic crust on the wall of a rift valley; and (2) oceanic crust exposed on the wall of transform fault zone. The first type of site is the TAG Hydrothermal Field, located on a wall of the rift valley of the Mid-Atlantic Ridge at the top of the basaltic layer of oceanic crust. Evidence is presented for multistage, high- and low-temperature hydrothermal activity that produces Cu, Fe and Zn enrichments within the thin sediment column and stratiform inter-layered deposits of Mn oxides, Fe oxides, hydroxides, and silicates on the seafloor. The second type of site occurs along walls of transform fault zones of the equatorial Mid-Atlantic Ridge and Carlsberg Ridge, which exhibit stockwork-type Cu-Fe sulfide mineralization within the basaltic layer of oceanic crust. The mineralization observed at these two types of sites is inferred to be the product of predominantly leaky hydrothermal systems in which primary hydrothermal solutions mix with normal seawater to precipitate stockwork deposits of Cu-Fe-Zn sulfides beneath the seafloor, and the depleted, low-temperature solutions discharge at the seafloor to precipitate stratiform Mn and Fe deposits. Review of the limited field evidence and thermal considerations indicates that sites at slow-spreading centers offer potential for the occurrence of many types of hydrothermal mineral deposits. However, the relative proportions, frequency of occurrence, and distribution of the various deposit types are expected to exhibit significant differences between slow-spreading centers and intermediate- to fast-spreading centers.

AO-073

RONA, P. A., and R. A. Koski. Introduction to theme on marine polymetallic sulfides. Marine Mining 5(2):101-102 (1985)

No abstract.

AO-074

RONA, P. A. The road to Jarmallo, critical years of the revolution in earth science. Bulletin of Marine Science 36(2):400-401 (1985).

No abstract.

AO-075

SHAPIRO, L. J. Objective analysis of winds in the 3-5 day band over tropical Atlantic. Extended Abstracts, 16th Conference on Hurricanes and Tropical Meteorology, May 14-17, 1985, Houston, Texas. American Meteorological Society, Boston, Massachusetts, 184-185 (1985).

No abstract.

AO-076

Stanley, D. J., T. A. NELSEN, and R. Stuckenrath. Recent sedimentation on the New Jersey slope and rise. Science 226:125-133 (1984).

Radiocarbon dating and sedimentological studies of closely spaced cores indicate movement during the Holocene of sediments in the New Jersey continental slope and upper rise between Wilmington and Lindenkohl Canyons. The uneven time-stratigraphic thickness of the late Quaternary sediment sections between cores and the nonuniform deposition rate at any given core site and among core sites show that the sediment blanket in canyon and intercanyon areas has been affected by downslope, gravity-driven processes during the Holocene to the present. The reduced rate of deposition on the slope and upper rise between the late Pleistocene and the present is largely due to decreased off-shelf transport in response to the eustatic rise in sea level. Very old radiocarbon dates at core tops result from emplacement of older reworked materials from upslope or from truncation of sections by mass wasting processes exposing older material at the seafloor. These processes also account for an irregular sequence of dated sections within cores and stratigraphic irregularities of the surficial cover from core to core. Marked variability in deposition rates on the slope and upper rise is largely a function of topographic configuration, proximity and accessibility to sediment source, and transport processes seaward of the shelf break. Moreover, higher accumulation rates on the upper rise are attributed primarily to slope bypassing. Bypassing, prevalent during the late Pleistocene, has continued periodically to the present.

AO-077

SWAMP Group (R. B. Long and others). Ocean Wave Modeling. Plenum Press, New York, NY, 256 pp. (1985).

No abstract.

AO-078

Swift, D. J. P., W. Stubblefield, T. L. CLARKE, R. A. Young, G. L. Freeland, G. R. HARVEY, and B. Hilliard. Sediment budget in the vicinity of the New York Bight dumpsites: Implications for pollutant dispersal. In Wastes in the Ocean, Volume 6, I. W. Duedall, D. R. Kester, P. K. Park, B. H. Ketchum (eds.), Wiley, New York (1985).

The apex area of New York Bight, Atlantic continental receives massive sewage sludge, dredged material, acid waste and construction debris discharges; a variety of contaminant effects have been documented. Dumped particles add directly to the fine sediment load, and contaminants become attached to both natural and introduced particles and are transported by them. It is possible to estimate the inputs, transports and outputs of fine sediment in the New York Bight apex, and arrive at a sediment budget. There are numerous sources of error in the estimate procedures, and it is not always possible to quantitatively evaluate these errors. Nevertheless, significant patterns emerge. The fine sediment transport system of the New York Bight apex is a highly dispersive one, in which the residence time of particles subject to storm current and tidal current transport (excluding those involved in the high-speed productivity cycle) is probably on the order of 300 days. In such a dispersive system, the fine sediment and its pollutant load will migrate to sinks, regardless of the point of entry. Transport in the Bight is tide-induced in estuaries, lagoon, and tidal inlets, but is storm-induced on the open shelf. Intense winter storms can resuspend 1.0×10^4 tons (t) km^2 of fine sediment over several hours, and the particles follow mean trajectories of tens of km for several days before settling out. Fine sediment transport may be modeled as a diffusion-advection system, in which time and space scales are on the order of tens of kilometers and hundreds of years. Three important pathways of the sediment transport system are the south westerly directed along-shelf flux, conservatively estimated at 1×10^6 t y^{-1} , the Hudson River input (1×10^6 t y^{-1}), and the portion of dumped materials that escape burial and join the transport system (0.3×10^6 t y^{-1}). The productivity cycle, from living organisms to organic matter and back overwhelms most other pathways at 14×10^6 t y^{-1} , 50 times the net input from the shelf to estuary (conservatively estimated at 0.4×10^6 t y^{-1}). Marshes, estuaries, and lagoons are important sinks (estimated to receive 2.4×10^6 tons y^{-1} of fine sediment). Coprostanol ratios reveal significant sewage sludge contamination of lagoons and estuaries, although the point of entry of the sewage cannot be established. At least 1.0×10^6 t y^{-1}) escapes south along the New Jersey coast. Other sinks for suspended fine sediment include the Christiaensen Basin where dumping occurs (2.3×10^6 t y^{-1}) and the floor of the adjacent shelf valley. Depositional rates away from the dumpsites are less important ($< 0.1 \times 10^6$ t y^{-1}) but the sediments reveal significant contamination.

AO-079

Thompson, G., M. J. Mottl. and P. A. RONA. Morphology, mineralogy and chemistry of hydrothermal deposits from the TAG area, 26°N Mid-Atlantic Ridge. Chemical Geology 49:243-257 (1985).

Metalliferous hydrothermal deposits have been observed and sampled by submersible from the TAG Hydrothermal Field on the Mid-Atlantic Ridge at 26°N. The deposits include surficial metal-rich staining on the surface of

carbonate ooze deposits over considerable areas of the seafloor as well as discrete massive layered deposits. The latter include hydrothermal precipitates of Fe-silicate (nontronite), Mn-oxide (birnessite) and Fe-oxide (amorphous). The deposits range in size from less than 1 m to ~ 15 m x 20 m. The composition and morphology of individual deposits varies from thick laminated crystalline birnessite precipitates, through Fe-rich tubular vents, to loose earthy birnessite, nontronite or amorphous Fe-oxide interlayered deposits. Fractionation and crystallinity are presumably controlled by local Eh conditions and the hydrodynamics of circulation in the upper crust. They are presumed to represent deposition from low temperature hydrothermal solutions which had originally reacted with basaltic oceanic crust at depth at high temperature and had precipitated metal-rich sulfides within the crust. Occasional short-duration high-temperature black-smoker-type venting is inferred to have occurred based upon Cu-Fe-Zn-rich layers in the sediments and observations of clams in bottom photographs.

A0-080

Thompson, O. E., P. Stephens, H. A. FRIEDMAN, and D. Houghton. Annual Report, 1984 - Commission on Education and Manpower. American Meteorological Society, Boston, Massachusetts. (Limited distribution) (1985).

The various boards and committees of the AMS Commission on Education and Manpower were active during 1984, conducting open meetings in conjunction with the annual AMS meeting and transacting business by telephone and mail. The various recommendations, initiatives, activities and appointments are briefly summarized in sections B-E of this report. Board annual reports and publications of the commission are included as sections F-G and I-K, respectively.

A0-081

Trefry, J. H., R. P. Trocine, and J. R. PRONI. Drilling-fluid discharges into the northwestern Gulf of Mexico. In Wastes in the Ocean, Volume 4, I. W. Duedall, D. R. Kester, P. K. Park, B. H. Ketchum (eds.), Wiley, New York, 196-222 (1985).

This chapter investigates the dispersion and fate of drilling-fluid components discharged into the marine environment with special focus on the Texas Flower Garden Banks (Flower Gardens) area of the northwestern Gulf of Mexico. Particulate Ba was found to be the best overall tracer of drilling-fluid dispersion; however, routine monitoring of raw effluent for dissolved and particulate Cr and Fe, total petroleum hydrocarbons, total solids, and one other representative particulate trace metal (As, Cd, Hg, or Pb) is also recommended. During field experiments, we observed: (1) differential settling of the barite and clay components; (2) that the barite component was less susceptible to resuspension than was normal sediment; (3) that natural particle-rich layers can be distinguished from drilling-related lenses; and (4) that the long-term, net directional movement of the released fluids can be established. Near the coral reefs of the Flower Gardens, drilling fluids are presently discharged to within 10 m of the bottom, a depth that is at least 100 m below the sea surface and at least 80 m below the top of the reefs. Resuspension processes, even during storms, do not carry bottom sediment, and thus the deposited matter from drilling fluid, onto the living reef. Although the drilling area to the north has higher than normal concentrations of Ba in

the sediment and in the suspended matter of the water column, no drilling-fluid movement from that area to the Flower Gardens was observed. In fact, observed Ba enrichment in some surficial sediment samples taken 3-10 km away from drilling areas may be due to a natural remobilization process. Drilling-fluid-related increases in sedimentation rate and input of different sediment types at the reef base remain as possible concerns.

AO-082

TSAI, J. J., and J. R. PRONI. Acoustic study of dredged-material dumping the New York Bight. In Wastes in the Ocean, Volume 6, I. W. Duedall, D. R. Kester, P. K. Park, B. H. Ketchum (eds.), Wiley, New York, 357-381 (1985).

In June 1979 an experiment on the disposal of dredged material in the New York Bight apex was performed in which acoustical, chemical, and hydrographic data were obtained. Prior to the disposal, the water column was clearly stratified, presenting both a potential dispersion floor and a dispersion ceiling. Immediately after the disposal operation, two surface sublayers with different salinities appeared on the temperature-salinity diagram, indicating a less saline surface layer at the dumpsite. The floor and ceiling effects were shown in the plume structure obtained by acoustic measurement. A two-process diffusion, calculated from the Joseph-Sendner model, was observed; each process exhibited a different diffusion velocity and spatial variation. The highest particle concentrations decayed by the second power of time. The variances were one order of magnitude larger than the average source diffusion, probably due to the larger settling velocity of dredged material during the measured period. The particle budget based on the acoustic calculations decreased exponentially as a function of time for each of the three water layers (surface, pycnocline, and bottom nepheloid) as well as for the water column as a whole. Direct relationships were found between observed acoustic intensity and calculated acoustic intensity and between measured total suspended matter and total suspended matter calculated by using numbers of particles and particle sizes.

AO-083

Vukovich, F. M., and G. A. MAUL. Cyclonic eddies in the eastern Gulf of Mexico. Journal of Physical Oceanography 15(1):105-117 (1985).

Cold domed cyclonic eddies juxtaposed to the cyclonic shear side of the Gulf Loop Current are observed in simultaneously obtained hydrographic data and satellite infrared data. The cyclones form from perturbations on the northern extreme of the current and grow either into a cold tongue or a quasi-stable meander off the Dry Tortugas, Florida. Areal shipboard surveys show closed isopleths of temperature and salinity, and geostrophic current speeds relative to 1000 db are in excess of 100 cm s^{-1} . The cyclonic eddies average 140 km in diameter when located off the Dry Tortugas, and appear to be locally generated rather than advected. Separation of large anticyclonic rings are always observed to be preceded by cyclonic eddies in the transition zone between Campeche Bank and the west Florida platform, but only on the eastern side. Not every cyclonic eddy off Dry Tortugas results in separation of an anticyclone; some are eroded away by the Florida Current, but they have never been observed in ten years of satellite data to advect eastward through the Straits of Florida.

AO-084

WILLIS, P. T. Microphysics of a stratiform melting layer in Hurricane Alicia. Extended Abstracts, 16th Conference on Hurricanes and Tropical Meteorology, May 14-17, 1985, Houston, Texas. American Meteorological Society, Boston, Massachusetts, 14-15 (1985).

No abstract.

AO-085

WILLIS, P. T. Reply. Journal of the Atmospheric Sciences 42:1349-1350 (1985).

No abstract.

AO-086

WILLOUGHBY, H. E. Confirmatory observations of concentric eyes in hurricanes. Extended Abstracts, 16th Conference on Hurricanes and Tropical Meteorology, May 14-17, 1985, Houston, Texas. American Meteorological Society, Boston, Massachusetts, 1-2 (1985).

No abstract.

AO-087

WILLOUGHBY, H. E. Structural changes in Hurricane Diana of 1984 near landfall. Abstracts, 1985 AGU Spring Meeting, May 27-31, 1985, Baltimore, Maryland, American Geophysical Union, Washington, D.C. (1985).

Research aircraft observations of Hurricane Diana as it approached the Carolina coast show that the principal convective band wrapped around the eye to form a ring of convection. Convective latent heat release in the ring forced a convergence of momentum and led to development of a secondary maximum of the swirling wind. The convective ring then constricted around the pre-existing eye and caused it to dissipate. This process led to a reduction of 20 m s^{-1} in the maximum wind and a 200 m rise in the height of the 85 kPa surface at the hurricane's center. Similar phenomena have been observed in Hurricanes Anita of 1977, David of 1979, Allen of 1980, and Alicia of 1983, but the present observations are more complete than the earlier ones and confirm both phenomenological descriptions and modeling results derived from them. The spontaneous sequence of events bears a striking similarity to that which was expected to result from artificial modification under the STORMFURY hypothesis.

AO-088

WILLOUGHBY, H. E., D. P. JORGENSEN, R. A. BLACK, and S. L. ROSENTHAL. Project STORMFURY: A scientific chronicle, 1962-1983. Bulletin of the American Meteorological Society 66:505-514 (1985).

Between 1962 and 1983, research in hurricane modification centered on an ambitious experimental program, Project STORMFURY. The proposed modification technique involved artificial stimulation of convection outside the eyewall

through seeding with silver iodide. The artificially invigorated convection, it was argued, would compete with the convection in the original eyewall, lead to reformation of the eyewall at larger radius, and thus produce a decrease in the maximum wind. Since a hurricane's destructive potential increases rapidly as its maximum wind becomes stronger, a reduction as small as 10% would have been worthwhile. Modification was attempted in four hurricanes on eight different days. On four of these days, the winds decreased by between 10 and 30%. The lack of response on the other days was interpreted to be the result of faulty execution of the experiment or poorly selected subjects. These promising results have, however, come into question because recent observations of unmodified hurricanes indicate: (1) that cloud seeding has little prospect of success because hurricanes contain too much natural ice and too little supercooled water; and (2) that the positive results inferred from the seeding experiments in the 1960's probably stemmed from inability to discriminate between the expected effect of human intervention and the natural behavior of hurricanes.

AO-089

WILLOUGHBY, H. E., F. D. MARKS, Jr., and R. J. FEINBERG. Stationary and moving convective bands in hurricanes. Journal of the Atmospheric Sciences, 41:3189-3211 (1984).

Aircraft observations in hurricanes indicate that the hurricane vortex may be subdivided into an inner gyre where the air trajectories form closed paths and an outer envelope where they do not. In the closed gyre, a core of air moves with the vortex; in the envelope, environmental air passes through the vortex and around the core. A system of spiral bands, termed the stationary band complex (SBC), forms near the boundary between the core and the envelope where the Rossby number is of order unity. The SBC differs dynamically both from convective rings because it is asymmetric and from propagating gravity-wave bands because its Doppler-shifted frequency is below the local inertia frequency. In more intense systems with stronger convective instability, the SBC may evolve into a convective ring and move into the vortex core. Outward propagating gravity-wave bands have also been observed. Such bands are often associated with track oscillations as the storm makes landfall or recurves. Spiral-shaped entities within the SBC tend to lie across the streamlines when the convective instability is small and along them when it is large. Storms moving through the environmental flow with a westerly vertical shear exhibit an east-to-west drift across the vortex. This phenomenon is expressed in the asymmetric streamfunction as an anticyclonic eddy northeast of the center and a cyclonic eddy south of the center. The velocity potential has a divergent cell west of the center and convergent cell that extends along the inside of the SBC east of the center. This pattern is apparently forced by potential vorticity conservation along the trajectories of the rotational flow and by heating in the SBC. The irrotational flow between the two cells substantially cancels the rotational drift within the vortex core.

AO-090

WILSON, D., C. ROFFER, and G. THOMAS. Pegasus current profiler measurements collected for EPOCS, 1980-1983. NOAA Data Report ERL AOML-6, 178 pp. (1985).

Current velocity profiles recorded on nine AOML EPOCS (Equatorial Pacific Ocean Climate Studies) cruises during 1980-83 using the Pegasus profiler are presented. The data were collected along several equatorial transects from 85°W to 110°W. Station locations and current profiles are shown for each cruise; the instrument and techniques of data acquisition and processing are also described.

AO-091

Young, R. A., D. J. P. Swift, T. L. CLARKE, G. R. HARVEY, and P. R. Betzee. Dispersal pathways for particle-associated pollutants. Science 229:431-435 (1985).

Particle-associated pollutants (totaling 10 metric tons per year) are introduced into the New York Bight by ocean dumping, estuarine discharge, sewage outfalls, eolian transport, and shipping waste and spillage. Oceanic and estuarine circulation processes dilute and transport the particles by a natural dispersal system that also tends to be highly distributive; particle-associated pollutants apparently seek the same sinks in the Hudson River shelf valley and intracoastal wetlands, regardless of their point of introduction.

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