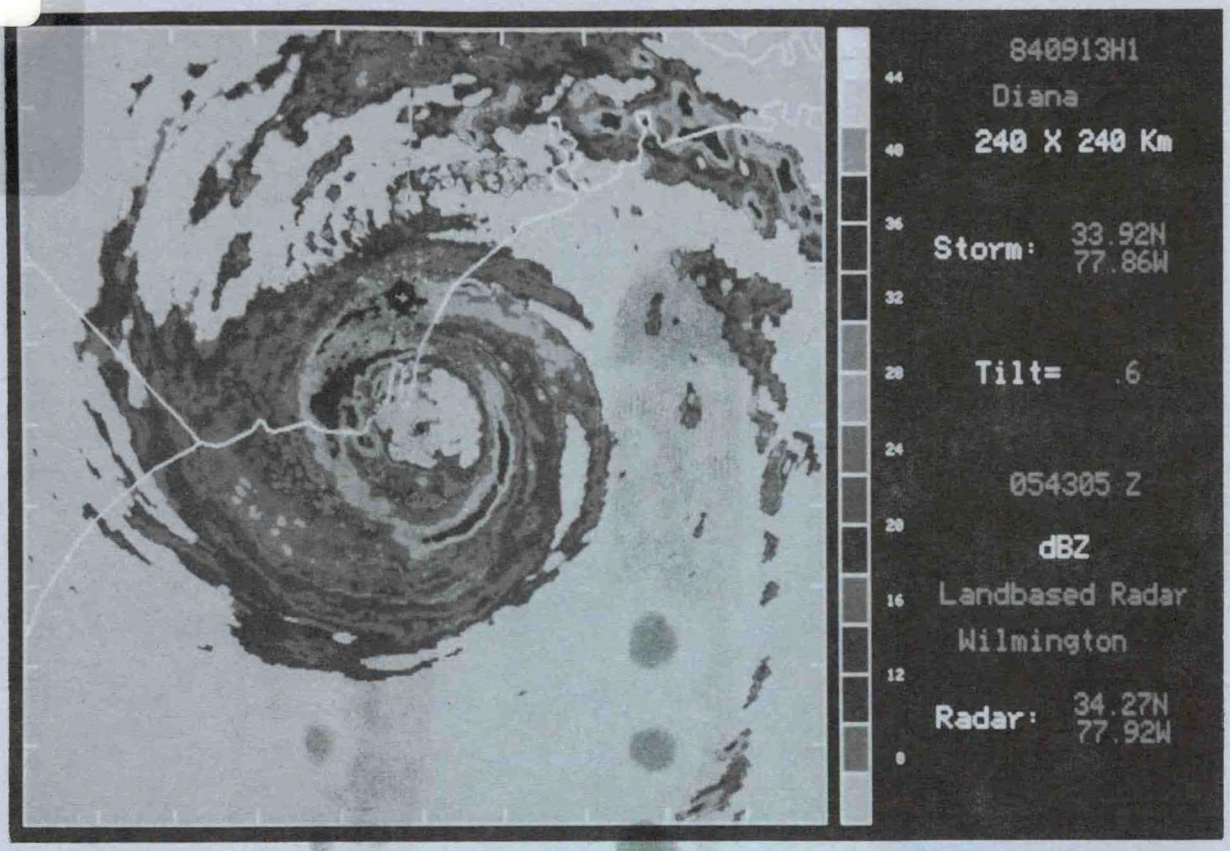
AOML ANNUAL REPORT

FISCAL YEAR 1984



HURRICANE DIANA: Color display of landbased digital radar showing major precipitation features as Diana approaches landfall at Wilmington, N.C.

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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FISCAL YEAR 1984

January 1985

Atlantic Oceanographic and Meteorological Laboratory
4301 Rickenbacker Causeway
Miami, Florida

UNITED STATES
DEPARTMENT OF COMMERCE

Malcolm Baldrige,
Secretary

NATIONAL OCEANIC AND
ATMOSPHERIC ADMINISTRATION

Environmental Research
Laboratories

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ATLANTIC OCEANOGRAPHIC AND METEOROLOGICAL LABORATORY

FY-1984 ANNUAL REPORT

PREFACE

This document presents the major accomplishments and plans of NOAA's Atlantic Oceanographic and Meteorological Laboratory (AOML) for fiscal years 1984-85. This is the second annual report that has been published by AOML, and it follows the same basic format as the 1983 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-1984-85.

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-1984 accomplishments and FY-1985 plans within the context of the ERL program structure; (3) the Appendix section includes a listing of AOML publications, with abstracts, for FY-1984. Also included is a listing of AOML staff.

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OVERVIEW

FY-1984 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.

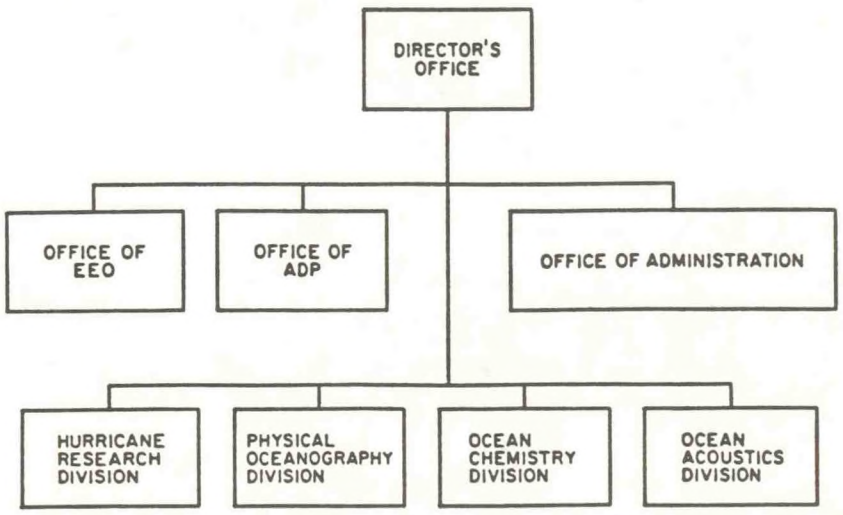

Figure 1: AOML Organizational Chart.

The total AOML research program during FY-1984 was approximately 134 staff-years of effort, with funding support of $8.4 million. A comparison with similar figures for FY-1983 (129 staff-years and $8.6 million, respectively) indicates that the total program level remains relatively stable. Indeed, the primary output of the Laboratory - publications - was relatively stable during FY-1983 and FY-1984 as well. A total of 74 publications were reported during each of the past two fiscal years.

One item of organization significance occurred at AOML during FY-1984-85. The Sea-Air Interaction Division (SAID) was dissolved at the beginning of FY-1985. This division had diminished in size during recent years, and the remaining personnel were reassigned, in approximately equal proportions, to PhOD and HRD, to better integrate their research efforts into the major program areas of climate research and hurricane research.

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-1984 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 37% and 30%, repsectively, of the total funding support. These program areas are also quite stable when compared with FY-1983 funding levels.

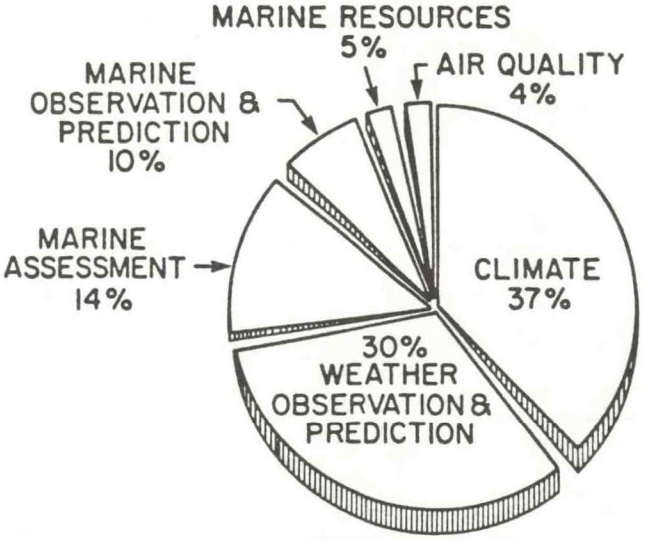

Figure 2: Program Funding Distribution (total FY-1984 funding $8.4 million).

The major programmatic changes that have occurred at AOML during FY-1984, and will continue into FY-1985, have occurred in the smaller program areas. In particular, Marine Assessment Research is being de-emphasized at AOML, having undergone a reduction from approximately 22% of the total program funding in FY-1983 to 14% in FY-1984. On the positive side, the marine chemistry effort is being redirected towards Marine Resources Research and Air Quality Research. Both of these program areas showed moderate growth in FY-1984 relative to the previous year, and this trend is expected to continue during FY-1985. Marine Observations and Predictions Research remains a fairly 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 94% of the work that is done by AOML is funded by NOAA, either by ERL directly (86%), or by NOAA Program Offices (8%) - only 6% of the AOML effort goes for reimbursable projects with outside agencies.

At the individual program level, only two programs receive any significant level of funding support from other than ERL: (1) Marine Assessment Research and Services was funded jointly by ERL (58%) and by the National Ocean Service/Ocean Assessments Division (42%). This program level was somewhat lower than the FY-1983 level primarily due to loss of reimbursable (other agency) funding. In FY-1985, the program is expected to be further reduced due to reductions in both ERL and NOS funding levels. (2) Marine Observation and Predictions was funded jointly by ERL (62%) and by the Department of Interior/Minerals Management Service (38%). The remaining program areas are almost exclusively funded by ERL program funds.

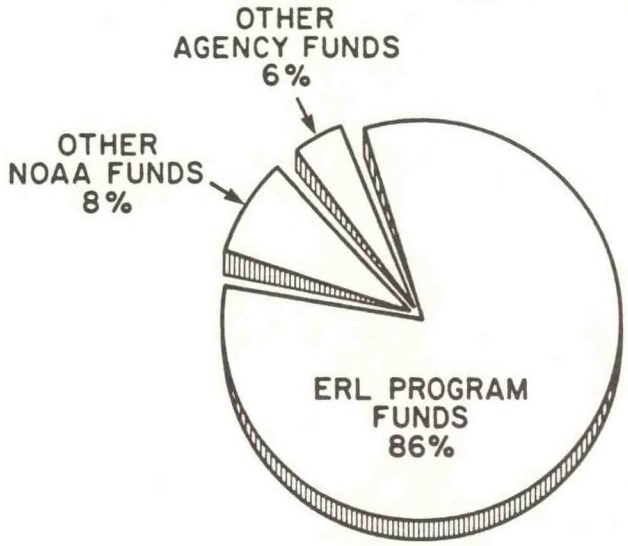

Figure 3: Funding Source Distribution (total FY-1984 funding $8.4 million).

As 1984 draws to a close and we look forward to 1985, 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-1984 ACCOMPLISHMENTS/FY-1985 PLANS

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. Increasingly, AOML activities in these areas must be seen as part of the NOAA contribution to national and international programs for climate research. The scope of problems being addressed more and more 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. There is, however, increasing use of numerical models for making interpretations and predictions based on the observations. The AOML program in climate research is conveniently described within the two categories of tropical ocean climate studies and subtropical Atlantic climate studies.

Accomplishments FY-1984

Tropical Ocean Climate Studies

Tropical ocean climate studies at AOML consist of participation in the continuing NOAA EPOCS (Equatorial Pacific Ocean Climate Studies) 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 TOGA (Tropical Ocean Global Atmosphere), which has objectives on the global scale very similar to those of EPOCS on the scale of the tropical Pacific. 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 phenomenon.

During 1984, intensive effort was committed to compilation and processing of extensive data sets collected for description and analyses of the historic El Niño event of 1982-83. The data sets available include the following:

- CTD (conductivity-temperature-depth) and current measurements from 13 cruises along 85°W from 1981 through 1983. A draft manuscript on descriptive aspects of these sections has been completed. An early conclusion is that it appears possible to describe the thermocline variations in the eastern tropical Pacific during El Niño in terms of a small number of normal modes.

- More than 3,000 temperature profiles taken by XBT (expendable bathythermograph) from ships of several countries and the NOAA research aircraft. Analyses of these data show isotherm patterns suggestive of Kelvin and Rossby waves.

- Approximately 7,000 buoy days of data from satellite-tracked drifting buoys that, in companion with about 18,000 buoy days of data collected prior to the event, reveal that major changes in the surface currents are in fact associated with El Niño. The earlier data were used also to complete a major investigation showing that prominent long waves, of 20-30 day period, intermittently observed in satellite SST (sea surface temperature) data, are

due to shear instability of the zonal currents, and appear to have a strong influence on the equatorial ocean heat budget.

An international workshop was convened at AOML to review observations of the El Niño shortly after its passing, and a draft atlas summarizing observations from many observers and institutions was completed. AOML has also made special effort to foster cooperative data collection and research activities with colleagues in Latin America. During FY-1984, two scientists from Ecuador were guests of the laboratory and CIMAS.

Using data obtained during the 1979 FGGE (First GARP Global Experiment), analyses and interpretation were continued to document the processes that are most important in the heat budget of the surface layers of the equatorial Indian and Atlantic Oceans.

An investigation was also initiated into the reality of and possible mechanisms for an apparent negative correlation between El Niño in the Pacific and hurricane frequency in the Atlantic region.

In connection with all of these activities, scientists of AOML participated in numerous scientific meetings, seminars and workshops convened to review and share progress on understanding of larger scale tropical air-sea interaction and for formulation of plans for the international TOGA program.

Subtropical Atlantic Climate Studies

The North Atlantic Ocean is believed to be particularly important for the large-scale meridional heat transport processes required by the prevailing climate of the earth. Knowledge of the ocean heat transport and its mechanisms are required for understanding changes of weather and climate on decadal time scales, and probably for modeling larger scale long-term ocean circulation processes of all kinds. During the past two years, work has concentrated on observational studies of the Florida Current, which have the objective of developing economical means of monitoring both the mass and heat transport of this limb of the North Atlantic subtropical gyre over extended time periods. A two-year time series of directly measured flow was used to evaluate and calibrate potential monitoring methods for the current. Both induced electrical potential difference and sea level differences were shown to offer excellent potential as monitoring techniques, the former with probably somewhat greater accuracy, and the latter with greater reliability. Both are economically and logistically attractive monitoring technologies, and work was initiated for transferring the monitoring operation to NOS (National Ocean Service).

More detailed investigations of the variation of the current using EOF (empirical orthogonal function) analyses revealed a definite winter/summer pattern in the EOF intensities, and showed the strongest EOF to be associated with a change in the flow on the western side of the current.

The priority goals of the Florida Current having been met, observational resources were shifted to new focus with a research cruise to investigate the importance of flows along the topographic rise east of the Bahamas.

Plans FY-1985

Tropical Ocean Climate Studies

The main emphasis in these studies during FY-1985 will continue to be on documenting and analyzing the El Niño event of 1982-83. The El Niño oceanographic atlas summarizing NOAA and other observations will be published. Analyses will be made and reports written on variations of hydrographic structure observed in the eastern tropical Pacific during the event. Analysis of normal surface currents as determined by satellite-tracked drifting buoys will be completed as a basis for quantifying the circulation anomalies experienced during El Niño. Hypotheses concerning the effects of circulation anomalies on SST during the onset of El Niño will then be tested.

Data collected during FGGE will be used to compute the relative importance of various physical processes in the mixed layer for the Indian Ocean, to produce an atlas of the marine meteorological and heat budget fields in the Indian Ocean, and to estimate the temporal and spatial scales of variability in the equatorial Atlantic and Indian Ocean sea surface temperature and surface wind fields.

A major acceleration of climate-related research into the tropical oceans will occur with implementation of the TOGA program in FY-1985. Present plans are for a major U.S. thrust in the tropical Pacific, where AOML has been active with EPOCS in recent years. Among the priority activities to which AOML will contribute in this region are a "Real Time Component," and a "Rapid Response Experiment." For the Real Time Component, special effort will be made to compile and interpret observations of atmospheric and oceanic variations on time scales of a few days to a very few weeks in order to make projections of climate anomalies both to guide research and to provide a basis for advisories to the socio-economic sector. One of the principal scientific uses of the projection will be to trigger the Rapid Response Experiment in which observational resources will be focused on obtaining more detailed information on the development of El Niño in the ocean. AOML scientists will contribute to planning and implementation of both of these activities. Cooperative relationships with institutions in Latin America will be used for deployment of satellite-tracked drifting buoys and collection of temperature data from regional vessels to provide data input to the Real Time Component, and contribute to the Rapid Response Experiment. Drifting buoys are well suited to these uses as their data are routinely reported in real time. Temperature data also will be telemetered via satellite as soon as the formatting and transmitting equipment can be purchased and installed on the observing vessels. It is planned that Latin American scientists will continue to be given opportunity to visit AOML for training and cooperation in analysis of the data collected in the cooperative observing programs.

AOML will participate in two different approaches to use of models for integration and interpretation of data from the Real Time Component. The GFDL ocean model will be set up on a computer at the National Meteorological Center (NMC) and used for simulation studies of the 1982-83 event, and to compute the ocean response to surface winds for comparison with data compiled in the real-time component. A scientist from AOML will participate in and guide these numerical modeling experiments at NMC. The GFDL model is large and produces very detailed output. Analysis of the model results is itself a major task.

At AOML, work will begin on development of a four-dimensional data assimilation procedure capable of assimilating observations of oceanographic-atmospheric fields into simpler numerical models of the relevant systems, whatever the distribution of those observations in space and time.

Subtropical Atlantic Climate Studies

Analysis of the direct measurements of the Florida Current will be completed to provide as complete a kinematic and dynamic description as possible of the temporal and spatial variations of this major current. New observations will be made in the Caribbean Sea and the Windward Passage to determine in more detail the sources of the Florida Current transport and variability. Data analysis on sea level and pressure gauge data will continue with a view toward optimizing the use of sea level data and of extending the sea level observing network throughout the Antilles and the Caribbean Sea. This network is expected to be accomplished in the context of the sea level program of the Intergovernmental Oceanographic Commission.

Work will continue on application of EOF and other kinds of statistical analysis and modeling procedures to all of the data from the Florida Straits to identify the active modes of variation as quantitatively as possible. Optimal interpolation methods will be used to evaluate each of a number of candidate observing systems.

It is envisaged that climate-related studies of AOML in the subtropical North Atlantic will gradually evolve into a major NOAA commitment to a larger national or international program such as the TOPEX [Ocean] Topography Experiment program or the World Ocean Circulation Experiment (WOCE), which are currently in discussion and preliminary planning for the next decade.

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 makes use of NOAA research aircraft to acquire unique data sets.

AOML interacts with the National Hurricane Center (NHC) and 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 GFDL in the area of hurricane modeling.

Accomplishments FY-1984

Observational Studies of Hurricanes

Microphysics

The results of a study on drop size distributions in tropical convection in hurricanes indicate some departure from the Marshall-Palmer fit to the drop

size distributions. A gamma distribution functional fit was found to give the best fit to the observed data set. A simple parameterization of rain was formulated on the basis of this fit.

The gamma fit to drop size distributions and a recently reported new fit to the Gunn and Kinzer drop terminal velocity data were used to derive a relationship between the Doppler mean velocity and the radar reflectivity factor. This relationship is required in the most common method of separating the terminal fall speed motion from the air motion in Doppler radar data.

A study on the distribution of ice in the convection of Hurricanes Ella (1978), Allen (1980), and Irene (1981) showed that above the 0°C isotherm level, only updrafts > 5 m s^{-1} contained liquid precipitation. Downdrafts contained very high (> 150 l^{-1}) concentrations of ice particles. These downdrafts were always adjacent to updrafts > 5 m s^{-1}. Graupel was the predominant particle type in the convective regions, and irregular particles similar in appearance to aggregates predominated elsewhere.

An analysis correlating particle type and concentration with radar displays for Hurricanes Allen (1980) and Irene (1981) was completed. This study documented that the regions of high (>30 dBZ) radar reflectivity above the 0°C isotherm were positively correlated with both strong updrafts and the occurrence of liquid precipitation. Strong negative radial gradients of radar reflectivity at the outer edge of the eyewall were often associated with downdrafts and high concentrations of ice particles.

Convective and Mesoscale

The analyses of the airborne Doppler radar data from Hurricane Debby (1982) were completed and the results clearly indicate that the NOAA airborne pulse-Doppler radar is a very good tool for determining mesoscale wind fields over large regions in a hurricane environment.

Following the success of the Debby analysis, a similar analysis of the airborne Doppler data for Hurricane Alicia (1983) was started. From Alicia, we have some of the first examples of vertical incidence Doppler radar data from aircraft. These data give a direct measurement of the vertical air motion (plus the particle fall speed) at different altitudes above and below the aircraft along the flight track. A technique was developed for removing the particle fall speeds from the vertical incidence data. The vertical velocity cross sections constructed using this technique show details of the vertical air motion in and around the eyewall. For the first time, mesoscale updraft motion (0.5-1.0 m s^{-1} on average) was actually measured above the bright band in the nonconvective region adjacent to the eyewall.

A major accomplishment was the production of a color movie of the digital radar data recorded during the landfalls of Hurricanes David and Frederic. The movie has been shown at numerous conferences and meetings during the year and is an excellent vehicle for showing the time evolution of the more important precipitation features of these storms. A similar movie for the landfall of Hurricane Alicia is in production.

Synoptic-Scale

Omega dropwindsonde (ODW) data gathered during Hurricane Debby (1982) were analyzed. The impact of the data on the operational objective analyses and the dynamical hurricane track models was evaluated as part of a cooperative effort with NHC and NMC. The dynamical Movable Fine Mesh (MFM) hurricane track model can be initialized with either the operational Hough analysis or an optimum interpolation analysis. The shortest wave resolved by the analyses has an east-west wavelength of about 1500-2000 km. Both analyses were unable to resolve the hurricane vortex or a cutoff low located about 500 km to the north of Debby's center. Each of these circulations had a horizontal scale of about 500 km. The cutoff low was clearly defined by the ODW data, and it had a significant influence on Debby's track. The resolution of the objective analyses that initialize the MFM must be improved if circulation features with scales of 500 km are to be resolved. MFM track forecasts were found to be very sensitive to small variations in the initial analyses.

Final processing of the ODW data for Hurricane Olivia (1982) was completed, and the data were distributed to scientists at several laboratories and universities.

A study aimed at gaining a better understanding of the effect of aircraft turns on the accuracy of ODW winds was completed. Data collected by the Office of Aircraft Operations (OAO) during test flights in 1982 and 1983, when one of the P-3's made several turns near a stationary ODW on the ground, were analyzed for this purpose. The capabilities of three wind-finding algorithms were evaluated and the advantages of each algorithm were determined.

Air-Sea Interactions

Software was developed for viewing Doppler radar radial velocities in the hurricane boundary layer in a range-height mode and for properly detecting and removing surface contamination of the data. Boundary-layer wind structure in a developing principal rainband in Hurricane Debby (1982) was investigated using airborne Doppler radar data as well as aircraft measurements of wind and the thermodynamic variables at several levels. Preliminary results indicate that the airborne Doppler radar is an effective tool for study of the hurricane boundary layer. Detailed vertical profiles of the horizontal wind are possible from the 200-m level upward with a resolution of 150-200 m. Even more detailed profiles may be obtained through adjustments to flight legs.

A data base of more than 100 land and ocean observation platforms was developed for Hurricane Alicia, which struck the Texas Gulf coast in August 1983. These data have been composited with respect to the storm center for three analysis periods: (1) over the open Gulf of Mexico, (2) at landfall, and (3) several hours after landfall. During landfall, the outer rainbands on the east side of the storm continued to develop in a preferred area of mesoscale low-level confluence and spiral northwestward, contributing to heavy rainfall and damage in the Galveston Bay coastal region.

A preliminary, color version of the sea-state catalog (in loose-leaf form) was begun. The catalog consists of color Hasselblad photos taken during reconnaissance overfights of in Hurricanes Alicia and Dean during 1983. Surface wind speeds from 12 to 33 m s^{-1} are represented. The purpose of this

project is to improve the accuracy of sea-level wind speed estimates based on visual observations of sea-state taken by U.S. Air Force weather reconnaissance observers.

Detailed slide sets of vertical sea-state photos (mostly black and white) were prepared and presented to the 54th Weather Reconnaissance Squadron at Anderson Air Force Base, Guam, and the 53rd and 920th Weather Reconnaissance Squadrons at Keesler Air Force Base, Miss., for their use in training programs. Workshops on sea-state wind estimation were given at each location. In addition, an overview of the efforts to improve sea-state surface wind estimation as well as the potential of remote microwave sensing of surface winds was presented at the Pacific Command Tropical Cyclone Conference in Tokyo.

Hurricane Track Prediction

This program is conducted jointly with the National Hurricane Center. A final version of the scan analysis for deep-layer mean (DLM) winds to be used to initialize the SANBAR (Sander's Barotropic) model was completed and tested. Forecasts were run using this analysis package, combined with the old prognostic model, using archived data for the 1979 to 1982 hurricane seasons. This new package demonstrated an improvement over the former operational package at the 12- to 72-h forecast intervals (error reduced by 22 km at 72 h) for the 4-year sample. The reduction in average forecast errors was shown to be significant (at the 95% level) from 24 to 48 h.

With a fine-grid version of SANBAR, forecasts were made for Debby (1982) using the ODW data available on 15 and 16 September. On 16 September, the ODW data had a much greater effect than on 15 September, both in the analysis and in the forecast. The scan analysis was able to assimilate the extra data accurately, resulting in the reduction of the 24- to 72-h forecast errors.

The DLM scan analysis is now on the AFOS (Automated Field Observing System [NWS]) and FAX circuits. In addition, at the requests of forecasters at the San Francisco and Hawaii Weather Service Forecast Offices, the scan analysis has also been implemented for the eastern Pacific to generate upper layer (200-600 mb), lower layer (600-1000 mb), and deep-layer (100-1000 mb) mean and shear (upper layer minus lower layer) maps for the AFOS and FAX circuits.

Testing was done using DLM wind data derived from the VISSR (Visible Infrared Spin Scan Radiometer) Atmospheric Sounder (VAS) in cooperation with the National Environmental Satellite, Data, and Information Service/Development Laboratory in Madison, Wis. The VAS-derived winds were used for eight of the Hurricane Debby (1982) cases and for nine cases (Hurricanes Alicia, Barry, and Chantal) from the 1983 season. The small number of cases available for the 1982 and 1983 hurricane seasons prohibits conclusive results.

Recent research with statistical hurricane track prediction models has produced results dealing with the orientation of grid systems in statistical tropical cyclone track prediction models, and with sampling errors in statistical models of tropical cyclone motion. The orientation method developed is being applied to a revised operational forecast model at NHC. Preliminary

tests indicate that the new method has a strong potential for significantly reducing forecast errors, particularly by substantially reducing the slow speed bias characteristic of previous models.

Hurricane Vortex Dynamics

Studies involving the performance of our prototype nonhydrostatic hurricane model were conducted and have shown a vortex-scale evolution of the model when the model is integrated with a conventional Kessler-type microphysical parameterization and a bulk ice-phase microphysics parameterization. They have also shown mesoscale features in the ice model that were forced by melting of ice particles. These studies have established the important role of ice-phase processes in the model simulation and have indicated the potentially important role of cloud microphysical processes in the mesoscale structure of tropical cloud systems.

Two new sets of experiments were performed to confirm and elucidate the role of ice-phase microphysics in the structure and evolution of this axisymmetric model. In the first set, two key factors in the ice-phase physics, production rate of precipitating ice and bulk fallspeed of the various types of ice particles, were isolated by judicious simplification of the original ice-phase parameterization. Results show that melting ice always creates a characteristic downdraft signature below the zero-degree isotherm, and that the strength and horizontal extent of the downdrafts depends on the terminal fallspeed of the ice particles. In the second set of experiments, the transient growth of parameterized ice particles in the earliest stages of cloud formation is being examined for a different parameterization of suspended ice crystal nucleation.

Observations from Hurricanes David of 1979 and Gert of 1981 have led to formulation of a conceptual model of the asymmetric structure of hurricanes. In this model, a stationary band of convection, termed the Stationary Band Complex (SBC), extends outward toward the east side of the vortex. The SBC lies in a part of the vortex where the Rossby number (defined in terms of the local azimuthal mean wind and the distance from the storm center) is of order unity. It coincides with a convergent asymptote in the streamline analysis and marks the innermost limit to which relative environmental flow can penetrate the highly rotational core of the vortex. An axisymmetric convective ring can develop from the SBC as it becomes more circular and wraps around the core of an intensifying hurricane. The cyclic intensity changes associated with these latter features are, however, confined largely to the vortex core where the Rossby number can be of order 10^2. Thus, an intense hurricane may be characterized as an axisymmetric, cyclicly varying core embedded within an asymmetric, largely steady-state envelope that resembles a weaker hurricane or a tropical storm.

On 17 and 18 August 1983, 30 h of continuous aircraft and radar observations were collected in Hurricane Alicia. Analysis of these data is largely complete and shows contraction of the original eyewall, formation of an outer convective ring, and track variations associated with moving reflectivity features in the eyewall.

Hurricane Modeling (Quasi-Spectral Model)

This modeling work is based on a long-range plan to understand and predict the motion of a hurricane. Although there are several operational models for hurricane prediction, it is recognized that basic studies of various physical and dynamical factors affecting the motion, as well as changes in intensity, are needed to make substantial improvements in the accuracy of prediction. The major question is to understand interactions among various scales of atmospheric motions and between different dynamic regimes. Progress in such understanding requires further tests with numerical models. To facilitate individual studies, which may range from the cloud scales of hurricane internal dynamics to the synoptic scales of tropical circulations, and also to ensure an efficient synthesis of these studies, a general-purpose base model is under development, using an accurate and flexible numerical method for grid-nesting. The method, tentatively called QSTING (Quasi-Spectral Time Integration on Nested Grids), can also be applied to other meteorological models that require high resolution in limited domains.

Of the mathematical-numerical problems in grid nesting, one is the Gibbs phenomenon, which may manifest itself as small, but far-reaching, oscillations of a field variable, when a sharp peak that is well resolved in a high-resolution domain is projected on outer domains of lower resolution. This is a serious problem with a hurricane model, where sharp wind maxima and a pressure minimum are expected to occur in the inner mesh of the highest resolution. We have found that a filter on fine-mesh fields, at the time of projection to the coarse-mesh domain, can adequately attenuate false oscillations, without damping the explicitly time-carried fields of the fine-mesh domain. Note that terms "fine" and "coarse" are used in a relative sense. In our multiple-nested model, a mesh is fine and coarse in relation to its supermesh and submesh, respectively. By moving inner domains as a hurricane moves, the Gibbs phenomenon arising from the intense hurricane core can be thus controlled.

Even with the moving-mesh model, however, signals of various scales still cross the interfaces of nested domains, because of local advection and wave propagation. The limits imposed by the change of resolution cannot be overcome by choice of a numerical method. Those small-scale signals that could not be resolved or would be severely distorted in the coarse mesh must be dissipated within the fine mesh, before they reach the interface. The practical limit of transmissible short waves further depends on the computational dispersion property of particular numerics employed by a model. The QSTING method allows four times more usable information to be carried than the finite difference method would for the same resolution. Even then, short waves below the limit must be removed before they reach the interface. To achieve the desired effect, we have introduced spatially variable filters with filtering power increasing outwards to the interface. Since theoretical means to help the design of such filters are limited, we have had to depend on empirical tests with a one-dimensional model, and our present solution to this problem is not as definitive as we wish it to be. It is believed, however, that we have reached the point that further studies should be made in the context of physically more realistic spectral mix, which is not available in the one-dimensional test model.

The question of the physical validity of using a nested-grid model for hurricane prediction studies is not trivial, when we consider the role of cumulus convection in the hurricane and the need for incorporating mesoscale dynamics. There are many studies in the meteorological literature where nested-grids or variable resolution models have been used. In most of them, however, the outer region of coarser resolution is merely a buffering space of inner activities. With the present model of superior numerics, there is a greater possibility of simulating truly two-way interactions between the hurricane inner core and its synoptic environment, provided that the major portion of predictable information is carried in the scales that are comparable with, or greater than, locally defined radii of Rossby deformation. The deformation radii vary from a few tens of kilometers in the hurricane core to a thousand in the tropical synoptic environment, and the resolution of a model may vary in proportion. A convincing test of this simple speculation requires a three-dimensional nested-grid model. The present version being two-dimensional, there is still much work to be done.

Observational Studies of the South Florida Sea-Breeze

The field phase of the sea-breeze experiment was designed to provide a description of the mixed layer, cloud layer, and evolution of the sea-breeze circulation from shortly after sunrise until midafternoon when deep convection is normally prevalent. The role of the sea breeze in organizing the development of deep convection is being examined. Airborne Doppler radar data were collected on two days. These data are being used to specify the kinematic structure of mesoscale precipitation lines that were initiated by the sea-breeze circulation.

The analyses of the flight-level data have concentrated on comparing and contrasting the structure of the sea-breeze circulation on one day in 1980 with a second 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. Interpretation of the data is aimed at understanding the role of the sea-breeze circulation in the timing of deep convection.

A paper that descibes peninsula-scale rainfall variations on sea-breeze days in south Florida was published.

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. Westward propagation of the line and its vertical structure may have contributed to the rainfall production. The representativeness of this case is being examined through study of FACE (Florida Area Cumulus Experiment) radar data.

Plans FY-1985

Observational Studies of Hurricanes

Microphysics

The analysis of microphysical data in conjunction with radar data from a hurricane water budget experiment will dominate FY-1985 activities if the experiment is completed this hurricane season as planned. Detailed analyses of the water contents and fluxes and transports will be completed for all flight segments and coordinated with Doppler radar and conventional radar data analyses.

Documentation of the two-dimensional image processing will treat the artifact rejection and the ice/water discrimination in detail, and a complete program listing will be included.

The ice data sample that has been reduced and surveyed will be analyzed in relation to dynamical features of the storm. An attempt will be made to composite the data with respect to updrafts in the eyewall. The data will be interpreted according to where the source regions of the ice occur, and the nucleation and/or multiplication processes necessary to produce the observed ice particle distributions.

Convective and Mesoscale

The analyses of the convective and mesoscale features of Hurricanes David, Frederic, and Alicia will be completed. During the landfall of Hurricane Alicia, radar data were recorded at several elevation angles approximately three times each hour. Software will be written to display these data in constant altitude plan position indicator format. The three-dimensional structure of the convective-scale and mesoscale features in Hurricane Alicia will be examined with both land-based and airborne radars.

If nature supplies a suitable storm during the 1984 hurricane season, a hurricane eyewall experiment will be carried out. Analysis of the resulting data will begin in 1985.

Synoptic-Scale

Cooperative studies with NHC and NMC will continue to examine the effect of the ODW data on the operational analyses and hurricane track models. ODW data collected during the 1984 hurricane field program will be processed and distributed to other institutions. The data will be used in diagnostic and prognostic studies of hurricanes and in the evaluation of remote soundings from VAS.

Air-Sea Interactions

The Doppler radar study of Hurricane Debby's boundary layer will be completed.

The landfall study of Hurricane Alicia will be continued with analyses of the gust and damage fields and their relationship to the precipitation struc-

ture. The surface temperature dew point, and sea surface temperature fields will be investigated for evidence of adiabatic cooling, dry air intrusion, and upwelling.

It is planned to acquire additional color sea-state photographs for use in developing color-related descriptors of sea-state corresponding to Beaufort categories 3 through 19. In addition, high altitude photos will be acquired as part of other experiments and added to the sea-state catalog.

During the Air-Sea Interaction Experiment planned for the 1984 hurricane season, photos will be compared with stepped-frequency microwave radiometer measurements as well as with surface winds measured by air-deployed drifting buoys. This study will also use highly reliable inertial navigation system flight-level wind measurements made near cloud base, and models of the planetary boundary layer (PBL), to reduce flight-level winds to the surface. Airborne Doppler radar measurements in the PBL will also be used for estimating surface winds.

Hurricane Track Prediction

With the revised operational barotropic model, forecasts using ODW and VAS-derived wind data available from the 1984 hurricane season will be verified. The results for the 1984 season, combined with the results from the 1982 and 1983 seasons, will be used to suggest and/or make appropriate modifications to the model for best use of the additional data sources.

Research to develop an objective analysis scheme for the large-scale environment of hurricanes, which incorporates ODW and other available data such as rawinsondes, NOAA P-3 data, and Air Force reconnaissance data, has started. Gridded temperatures, moisture, and wind fields for Hurricane Debby (1982) will be produced at 50-mb intervals using a spline analysis package (SAP) coupled with a vertical filtering scheme. Horizontal filtering with the SAP will make it possible to remove the larger scale components of the data fields and examine the smaller scale components that will be subjected to statistical optimum interpolation. Development of this optimum interpolation scheme will be based on simple statistical assumptions and dynamical constraints. The goal is to retain information on the vortex scale and synoptic scales while filtering out information on the gravity wave and convective scales.

Hurricane Vortex Dynamics

Analysis of the ice nucleation experiments with the prototype nonhydrostatic hurricane model will be completed. Some time will be devoted to modification and simplification of the original ice-phase microphysics that will make it more economical and realistic.

The details of a set of numerical experiments, including initial and boundary conditions, have been formulated to investigate the interaction between an isolated vortex and its environment, and its effect on hurricane asymmetry and motion. A quasi-spectral multinested-grid numerical model will be used in a barotropic, primitive equation (one-layer, shallow-water) form on

a beta plane. The influence of divergence and advective nonlinearities will be evaluated in a parameter range, relevant to hurricanes, that has not previously been investigated. Near the vortex center, the local Rossby radius of deformation will be of the same order as the vortex scale, and the Rossby number will be very much greater than one.

The analysis of the Hurricane Alicia data will be completed. These data appear to confirm earlier work on convective rings and the SBC. They also provide insight into the origin of convective rings.

Hurricane Modeling (Quasi-Spectral Model)

Procedures for moving the nested grids will be tested. The model will be used in a theoretical study of vortex motion on a beta plane. Studies of the hurricane boundary layer will be carried out.

Observational Studies of the Florida Sea-Breeze

The airborne Doppler radar observations of the development of deep convection in the sea-breeze convergence zone will be completed and published. The analyses of the 1980 and 1981 aircraft data will be completed and documented.

Tropical Wind Analysis

New research directed at objective analysis of ATOLL (Analysis of the Tropical Ocean Lower Layer) and 200-mb winds to extract information on the Atlantic tropical circulation is under way. The ATOLL analysis is an invaluable, virtually untapped data source. Objective analysis techniques will be applied to these data for the development of both a climatology and a history of quasi-steady and propagating disturbances for 1975 through 1983. During 1985, it is planned to complete the transfer of grids to AOML's mainframe computer system; the evaluation of raw data coverage; and the 10-day and monthly means for individual years and composites (9-year averages). This climatology will be issued as a technical report in collaboration with NHC.

MARINE ASSESSMENT

A major goal of the AOML research program in marine assessment is to develop an understanding of ocean processes, their variations, and the effect of these variations on ocean resources, especially living marine resources. Present research projects include (1) Transformation and Assimilation of Pollutants [by Natural Processes] (TAP) and (2) Pollutant-Particle Relationships in the Marine Environment (P-PRIME), in which natural processes are studied to develop information essential to addressing specific environmental problems.

Accomplishments FY-1984

TAP

In FY-1984 AOML continued the development of interactive biological-chemical models of metal speciation as it relates to effects on ocean planktonic populations that serve as food sources to larval fish.

In cooperation with the SEFC (Southeast Fisheries Center), AOML conducted a cruise to the New York Bight aboard the NOAA Ship Researcher in January 1984. The purpose was to apply AOML-SEFC toxic metal/organic matter/plankton interaction models to highly anthropogenically impacted waters and to test hypotheses regarding kinetics of formation of organic ligands in temperate, rather than tropical or subtropical, waters. Cruise results include the following:

- The New York Bight, although it appears to have a substantial chelation capacity for trace metals, appears to have an unusually small overall buffering capacity for acids.

- Sewage sludge, regardless of age and pretreatment, does not appear to be necessarily deleterious to either plankton or bacterial populations. In fact, under some conditions, e.g., nitrogen limitation, the addition of sludge may be beneficial to the productivity of the planktonic community.

- Present, commonly used, analytical methods for "Total Metal Concentrations" may be inherently artifactual in that they appear to be dependent upon the quality of dissolved organic material in the seawater sample analyzed. Methods tested included Anodic Stripping Voltammetry and Co-precipitation Atomic Absorption Spectrophotometry.

- Organic compounds (triglycerides) formed in cold waters are not inherently different than those formed in subtropical and tropical waters and their autoxidation and condensation result in fulvic and humic materials with significant chelation capacity for metals. In fact, waters in the New York Bight Apex, near Montauk Point, Long Island, and off Georges Bank all had an excess of chelation capacity; i.e., dissolved metals were 100% complexed.

- Although complete, the complexing of metals in New York Bight waters is fragile in that almost any perturbation of the system releases free metal. These perturbations include collection and storage of samples and addition of triglycerides in the form of fish liver oil. Both of these procedures resulted in the release of free metals in samples collected.

P-PRIME

In FY-1984 AOML continued to contribute to understanding of the fate of river-borne pollutants at river/ocean interfaces. The basic hypothesis tested was that river deltas act as irreversible sinks for some pollutants that are scrubbed from the river outflow by biogenic and inorganic particles. Efforts were focused on the outflow of the Mississippi River, which represents the drainage from 41% of the contiguous United States. Specific results from the FY-1984 program include the following.

- Determination of the combined particulate and dissolved river burden for lead clearly indicates a reduction of approximately 40% from levels in the mid-1970's. This is an apparent result of legislated reduction of lead in gasoline (gasoline additives account for 10%-12% of lead consumed in the United States and is the major source of pollutant lead) that was effected in the mid-1970's.

- A model was developed using distribution coefficients (K_D's) to define the partitioning of pollutants, e.g., lead and cadmium, between river-dissolved and particulate fractions. This model allows definition of the dissolved load at a river outfall for a given total pollutant burden. K_D's developed for the Mississippi River have been demonstrated to be generic, and are transferable to other river systems, e.g., the Brazos.

- It was demonstrated, by analysis of interstitial water, that rapid particulate removal and burial of lead in sediments results in irreversible removal of it from the overlying water column. This is not the case with cadmium and manganese since diagenetic processes in the sediment remobilize these metals and allow diffusion back into the overlying water.

- Suspended particulate matter (SPM) flux from rivers varies on an hourly and daily basis as well as on a seasonal one. This is controlled to a large degree by tidal forces, which also control whether the major escape of SPM is by surface flow or near bottom flow.

- SPM not removed near the river mouth is removed from the water column by biopackaging, i.e., ingestion by marine organisms and formation of fecal pellets.

Plans FY-1985

TAP

In FY-1985 AOML activities conducted in the TAP program will be dependent upon NOS/OAD (National Ocean Service/Ocean Assessment Division) decisions regarding proposals submitted to them. Present plans are centered on three basic activities:

- Conducting a second research cruise to the New York Bight area to study the speciation of metals and effects of sewage sludge input on this speciation when warm, stratified conditions exist and biological production is at or near maximum.

- Continue analysis of data and samples collected in the TAP program with the goal of (1) conducting a statistical analysis of biological samples relative to metal speciation, and (2) understanding the kinetics and binding constants of natural metal-organic complexes and their relationship to environmental variables such as temperature, light, salinity, etc.

- Developing biochemical methods for determining secondary productivity and the effects of environmental changes in this productivity.

P-PRIME

No further activity is planned in the P-PRIME program, owing to withdrawal of NOS/OAD funding.

MARINE OBSERVATION AND PREDICTION

AOML research in marine observation and prediction is described within three areas: (1) acoustical measurements of ocean currents, bottom topography for charting and navigation, particulate distribution and transport processes; (2) development of new techniques to observe atmosphere, ocean, and surface parameters and application of remote sensing techniques to study the physical processes of importance to maritime interests of the United States; and (3) research into improvement of current vectors and sea state maps using two CODAR (Coastal Ocean Dynamics Applications Radar) units deployed in the Miami/Fort Lauderdale, Fla., area as a fully developed operational system in collaboration with the U.S. Coast Guard, the National Hurricane Center (NHC), and WPL.

Accomplishments FY-1984

Acoustical Measurements

Data from the Chesapeake Bay experiment were analyzed; successful transverse Doppler measurements of the vertical component of the flow field associated with short-period internal waves were made. A theoretical explanation of anomalous experimental measurements of the acoustic backscatter from sets of different diameter particulates was derived using the concept of total acoustic cross section.

A cooperative program was established with elements of NOS to carry out the research that is required to understand the complex interaction of sound, including its transmission and reflection, with the diverse types of bottoms encountered in U.S. coastal and near-coastal waters. Ultimately, improved navigational charts and improved bottom topography and bottom-type maps will result.

Techniques Development

Recent emphasis has been on the effects of wave refraction by ocean currents and the growth of waves in complicated geometries. The fundamental limiting factor to existing wave prediction models is the process of wave growth for a strongly curving windfield such as a hurricane or severe winter cyclone. Such storms, moreover, annually claim many lives. Radar-derived directional wave spectra have been obtained, which reveal some new insight into this process and suggest that most numerical models do not properly predict the direction and hence the height of waves for extreme conditions. This implies that other types of ocean models that attempt to predict the momentum transferred to the ocean by the atmosphere (storm surge models, for example) may be significantly in error for storms that are outside the class of calibration storms.

CODAR Operational Demonstration

During FY-1984 AOML has been working with the Coast Guard, NHC, and WPL for the purpose of developing an operational demonstration of a two-unit CODAR observing system in the Miami/Ft. Lauderdale area. The system would provide, on a regional scale, in near real-time, observations of ocean surface currents and sea state. If shown to be operationally feasible, the system would be turned over to a planned NOS Ocean Services Center beginning in FY-1986. Progress during FY-1984 consisted primarily of planning and coordination activities between the various groups that would be involved. The necessary equipment and personnel were all identified, and the site selection process was initiated.

Plans FY-1985

Acoustical Measurements

- Deploy and operate a coherent transverse Doppler current measurement system at the Port of Miami in conjunction with the deployment of an Ametek-Straza Doppler current profiler by NOS personnel and with the Port of Miami circulation survey to be conducted by a contractor.

- Upgrade data analysis equipment and continue processing of data from previous year experiments.

- Continue analysis of Chesapeake Bay experiment acoustical data.

- Continue development of estuarine and oceanic particulate and pollutant transport models.

- Conduct laboratory experiments on the acoustic cross section of naturally occurring sand grains as well as field experiments using high-frequency acoustics to measure sediment in the benthic boundary layer in cooperation with Canadian and University of Miami investigators.

- Explore the possibility of cooperation with NASA to utilize zero-g environment for scattering experiments to avoid problem of particle settling in gravitational field.

- Develop a model or models of echo formation from various bottom types.

- Implement these models on the AOML computer system.

- Design an experimental program to provide data for model development and for model validation.

Techniques Development

Hurricane imagery will be processed to yield two-dimensional wave spectra for comparison with model hindcasts. Ice imagery will be processed to yield ice concentrations and compared with in-situ results to determine type sensitivity. Laser profilometer data will be processed to yield spectra of the roughness elements corresponding to the imagery.

CODAR Operational Demonstration

All WPL CODAR equipment will be transferred to AOML by the start of FY-1985. Sufficient equipment exists to establish two shore stations and a data dissemination station at NHC. Additional equipment purchases are necessary for the telecommunication links between stations and NHC, and for routine maintenance. AOML will establish shore stations at the Navy site in Fort Lauderdale, and at the Coast Guard site on Fisher Island. Data processed into current vector maps will be disseminated by NHC, and development of sea-state maps will begin at AOML.

MARINE RESOURCES

AOML conducts research in marine resources in two specific areas. One program studies the effects of venting of fluids within hydrothermal areas along seafloor spreading centers on the ocean environment. This research is part of the NOAA/VENTS program. The second consists of research as to environmental controls on the year-class-strength of commercial U.S. fisheries. This project is a lead-in effort to the developing NOAA Fisheries Oceanography Cooperative Investigations (FOCI) initiative.

Accomplishments FY-1984

VENTS

In FY-1984 AOML spent considerable effort in a NOAA-wide task of developing the NOAA/VENTS program. This included the development of relevant and testable hypotheses, devising means of testing them, and the definition and allocation of resources. This was done through AOML participation on the VENTS Council. As part of this effort, AOML defined a research program on slow-spreading hydrothermal centers designed to determine the quality and quantity of hydrothermal venting and its effect on ocean systems. A major, multidisciplinary cruise was conducted to a representative section of a slow-spreading ridge (the Mid-Atlantic Ridge between 11°N and 26°N). By use of geophysical models developed during a FY-1982 cruise, four sites of hydrothermal venting were confirmed by use of chemical indicators in the water column, near-bottom temperature measurements, hydrothermal constituents in sediments, and hydrothermal minerals on the seafloor.

In addition, previous work conducted in the TAG (Trans-Atlantic Geotraverse) hydrothermal area at 26°N was synthesized and published, including clear evidence that episodic "black smoker" type hydrothermal venting has been occurring in this area at a frequency of approximately every 10,000 years for the past million years.

Fisheries-Oceanography Research

AOML is conducting research with a goal of understanding environmental controls on the year-class-strength of commercial fisheries so that such control can be predicted, thus allowing (1) better management of these fisheries and (2) better investment planning for their exploitation. Present

efforts are directed to understanding how offshore (shelf) fronts control the feeding success of larval fish and thus, their survival and postlarval recruitment in estuaries where juvenile stages develop. The hypothesis being tested is that a major control on the feeding success of larval menhaden and shrimp is the position, timing, and quality of offshore oceanic fronts such as those at the Mississippi River outflow to the Gulf of Mexico and at the Gulf-stream boundary with southeast U.S. shelf waters. In FY-1984, AOML research, conducted cooperatively with the Southeast Fisheries Center, documented a relationship between growth of Gulf menhaden, spot, and croaker larvae and the distribution of their food along hydrographic fronts at the Mississippi outflow. In addition, a biochemical tool (nucleic acid analysis) was perfected for determining the potential protein growth rate of larval fish, allowing us to establish the suitability of specific ocean fronts as feeding environments for larval fish.

Plans FY-1985

VENTS

Work will continue on determining the quality and quantity of hydrothermal venting along slow-spreading centers and the effect of venting on the ocean environment. In FY-1985 a second cruise will be conducted along the 11°N to 26°N section of the Mid-Atlantic Ridge to complete analysis of hydrothermal activity at the four sites positively identified during the FY-1984 cruise. In addition, a cruise will also be conducted to the Gorda Ridge off the west coast of the United States. The ridge is another representative slow-spreading ridge completely within the U.S. Exclusive Economic Zone. This cruise will be dedicated to developing geophysical criteria for locating hydrothermal activity on that ridge as well as for searching for geochemical signatures resulting from such activity.

Fisheries-Oceanography Research

In FY-1985 AOML will continue to work cooperatively with SEFC to determine the environmental controls at oceanic fronts on feeding success and survival of larval fish. The FY-1985 effort will be focused on fronts created at the Mississippi outflow to the Gulf of Mexico and their effect on the feeding success of brown shrimp and Gulf menhaden larvae. A cooperative AOML-SEFC cruise will be conducted to the outflow area aboard the NOAA Ship Researcher in May-June 1985.

AIR QUALITY

AOML conducts research on air quality in two specific areas. These are (1) mature oceanic sources of acid rain precursors, and (2) radiatively important trace substances in the atmosphere. The latter is a lead-in effort to the developing NOAA/RITS (radioactively important trace species) program.

Accomplishments FY-1984

Acid Rain

In FY-1984 AOML continued research on oceanic sources of compounds that are injected into the troposphere and react to form chemical species that produce acid rain. AOML's work was conducted on the premise that the production of these compounds is controlled by biological processes in the photic zone. The existence of a significant concentration of 1-alkenes in the upper ocean was documented, and it was further demonstrated that the transfer of these compounds across the air-sea interface, and subsequent oxidation, could account for the formic acid anomaly existent in the troposphere. This process is a significant contributor to the acidity of rain in remote regions. A joint ship-aircraft sampling program was completed in the equatorial Pacific along 150°W between 10°N and 10°S to study both biological and photochemical processes as they relate to the distribution of atmospheric gases. During this cruise a distinct vertical distribution in the turnover rates of sulfur-containing amino acids in the water column was documented. In addition, the existence of a diel cycle in these turnover rates was confirmed. These findings are important to understanding the biological processes that release sulfur-containing acid rain precursors, such as dimethyl sulfide and dimethyl sulfone, to the troposphere. In addition, AOML identified a maximum in the concentration of ammonia in precipitation in the equatorial Pacific Ocean.

RITS

AOML research in oceanic sources of radiatively important trace substances in the atmosphere is conducted as a lead-in effort to the developing NOAA/RITS program. Research in FY-1984 was conducted as a piggy back operation to the AOML Acid Rain research effort. Part of this effort was an investigation of the existence of volatile components in the upper ocean and lower troposphere that are infrared absorbers (or which, when transferred to the lower troposphere from the ocean, could react to form such absorbers). A large suite of volatile samples was collected during the AOML joint ship-aircraft equatorial Pacific study along 150°W and are being analyzed. As part of this cruise effort, AOML also confirmed the existence of an ozone minimum in the equatorial Pacific in May-June 1984.

Plans FY-1985

Acid Rain

AOML will continue to conduct research on oceanic sources of compounds controlling the acidity of rain. A significant part of the FY-1985 effort will consist of analysis of samples on hand from the 1984 effort and synthesis of the results of research conducted to date. AOML will also conduct a cruise to the trade wind region of the Atlantic to study the interaction of continentally derived tropospheric species with trace gases produced in the upper ocean of the subtropical North Atlantic Ocean.

RITS

During FY-1985, AOML will continue to conduct lead-in research to the NOAA/RITS program. A major emphasis will be placed on analyzing volatile samples collected in the upper ocean during the FY-1984 cruise and correlating their chemistry with that of tropospheric samples collected during the same operation. Similar studies will be conducted during the AOML Acid Rain research cruise to the subtropical North Atlantic in FY-1985.

FY-1984 PUBLICATIONS

ATLANTIC OCEANOGRAPHIC AND METEOROLOGICAL LABORATORY

AO-001-84

ATWOOD, D. K., S. R. PIOTROWICZ, and G. A. BERBERIAN. Rapid response of coastal waters of southern Peru at 15°S to relaxation of the 1982-83 El Niño. Tropical Ocean-Atmosphere Newsletter 21:29-30 (1983).

In June 1982 a warm episode, commonly called an El Niño, began to develop in the eastern equatorial Pacific Ocean (Rasmusson et al., 1983). This resulted in a significant warming of surface waters in that region and deepening of isotherms (Leetmaa, 1983), with the 15°C isotherm for 85°W between 2°N and 2°S being deeper than 200 m in December 1982 as compared to approximately 75 m in December 1981. By October 1982 these changes had caused a change in nutrient-nitrate levels at 2°N, 85°W. Barber et al. (1983) hypothesized that although these changes were apparent in temperature versus nitrate profiles for the upper 100 m, the nitrate supply available for entrainment in coastal upwelling had not been significantly reduced compared to previous years because the warmer water in 1982 contained significantly more nitrate than waters of the same temperature had contained in previous years, e.g., 15 µM nitrate at 22°C in 1982 compared to 5 µM for the same temperature in 1981.

AO-002-84

BEHRINGER, D. W. Equatorial modes in the eastern Pacific (85°W). Journal of Geophysical Research 89(C3):3729-3731 (1984).

Isopycnal displacements between early March and early December of 1982 are shown for a section traversing the equator at 85°W. This time period includes the onset of the 1982/83 El Niño. The section is analysed in terms of both empirical orthogonal functions and dynamical modes derived from linear equatorial wave theory. Only a few functions, whether empirical or dynamical, are needed to describe most of the variance in the section. In particular, functions representing the Kelvin and first mode Rossby waves associated with the first three baroclinic modes of linear theory, when fitted to the section in a least squares sense, can describe 86% of the variance. These waves may have been generated by a failure of the trade winds in the vicinity of the dateline sometime prior to mid-June 1982.

AO-003-84

BEHRINGER, D. W. Modal analyses of isopycnal displacements in the eastern Pacific. Papers from 1982/83 El Niño/Southern Oscillation Data Display Workshop, December, 1983, 117-124 (1983).

No abstract.

AO-004-84

BLACK, P. G., and C. T. Swift. Airborne stepped-frequency microwave radiometer measurements of rainfall rate and surface wind speed in hurricanes. Preprints, 22nd Conference on Radar Meteorology, September 10-14, 1984, Zurich, Switzerland. American Meteorological Society, Boston, Massachusetts, 433-438 (1984).

No abstract.

AO-005-84

BLACK, P. G., and C. T. Swift. Mesoscale ocean response to tropical cyclone forcing. EOS, Transactions of the American Geophysical Union 65(16):220 (1984).

The distribution of sea surface temperature (SST) and mixed-layer depth (MLD) in the vicinity of hurricanes is described for a variety of storm intensities, translational speeds, and ocean conditions. This study represents the first time that the detailed distributions of SST and subsurface thermal structure data have been collectively analyzed within the hurricane inner core. Schematic models of the horizontal distribution of SST and MLD for slow- and fast-moving storms are discussed. Schematic models of subsurface temperature changes along and across the direction of storm motion for slow- and fast-moving storms, as well as for different subsurface thermal stratifications, have led to some insight concerning the mechanisms responsible for these changes. The importance of concurrently measuring the hurricane wind field and ocean response in assessing the various mechanisms is illustrated. Possible feedback effects of the SST decreases on hurricane intensity are discussed for some of the cases. The relaxation time required for hurricane-induced anomalies to disappear is shown to range from 10 days for early season storms to almost 2 months for mid- and late-season storms.

AO-006-84

BLACK, R. A. Distribution of ice particle types above 6.0 km in two Atlantic hurricanes above 6.0 km. Postprints, 15th Conference on Hurricanes and Tropical Meteorology, January 9-13, 1984, Miami, Florida. American Meteorological Society, Boston, Massachusetts, 537-542 (1984).

No abstract.

AO-007-84

BURPEE, R. W., J. FRANKLIN, and D. G. Marks. Omega dropwindsonde observations of the environmental flow around hurricanes. Postprints, 15th Conference on Hurricanes and Tropical Meteorology, January 9-13, 1984, Miami, Florida. American Meteorological Society, Boston, Massachusetts, 551-558 (1984).

No abstract.

AO-008-84

BURPEE, R. W., and L. N. Lahiff. Area-average rainfall variations on sea-breeze days in south Florida. Monthly Weather Review 112(3):520-534 (1984).

Summer convective regimes over south Florida can be broadly classified as either sea breeze or disturbed. Sea-breeze circulations develop on one or both coasts on most days with relatively little high cloudiness during the morning hours. The sea breeze strongly modulates the development of deep convection and produces a sharp midafternoon peak in rainfall. Disturbed days, which are characterized by extensive high cloudiness near sunrise, also have a rainfall maximum during the afternoon. Relationships between rainfall and thermodynamic and kinematic variables on disturbed and sea-breeze days have some significant differences. Comparison of rainfall records from the the south Florida peninsula with observations from the Florida Keys, where sea-breeze circulations are relatively weak, indicates that the sea breeze accounts for about 35-40% of south Florida peninsula rainfall during the summer months. Area-averaged rainfall and the time variations of peninsula-scale surface divergence and hourly rainfall on sea-breeze days are affected by the value of midtropospheric humidity, and lower tropospheric lapse rate, wind speed, and wind direction measured at 0700 EST. Days with relatively high humidity and steep lapse rates typically have deep convective activity that tends to develop sooner and reach its peak earlier than normal. Also, on such days surface convergence is significantly less than average in the late afternoon and early evening. Physical and dynamical processes that might account for the smaller values of surface convergence in the late afternoon are discussed. The magnitude of the low-level wind speed (1000-800 mb) observed at 0700 EST does not greatly affect the timing of peninsula-scale rainfall. Sea-breeze days with weaker than average low-level wind speeds have relatively large values of surface convergence and more rainfall during the afternoon. There are two sea-breeze regimes for low-level wind speeds > 5 m s^{-1}. When the low-level wind blows parallel to the peninsula, the sea-breeze circulation is strong and area rainfall is greater than average. When the wind blows across the peninsula, the sea breeze is absent or weak and rainfall is below average.

AO-009-84

BURPEE, R. W., and F. D. MARKS, JR. Analyses of digital radar data obtained from coastal radar during Hurricanes David (1979), Frederic (1979), and Alicia (1983). Proceedings, 10th Conference on Weather Forecasting and Analysis, June 25-29, 1984, Clearwater Beach, Florida. American Meteorological Society, Boston, Massachusetts, 7-14 (1984).

No abstract.

AO-010-84

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(10):1050-1058 (1984).

Omega dropwindsondes (ODW's) were released from 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-011-84
CLARKE, T. L. Limitations of physical theory. Nature 308:20 (1984).

No abstract.

AO-012-84
CLARKE, T. L. The formation of mud patches by non-linear diffusion. Continental Shelf Research 3(1):1-7 (1984).

Deposits of mud on an otherwise sandy continental shelf floor commonly occur in the form of patches a few hundred meters in size. A model for the formation of these patches is proposed that is based on a resuspension mechanism that is a non-linear function of the percentage of fines in the surficial sediment. A diffusion equation governing the time evolution of the percentage fines is derived which for a certain range of fine sediment concentrations becomes unstable. Numerical solution of this equation shows that the spatial distribution of fine sediment breaks into two components in a manner qualitatively similar to observed mud patches.

AO-013-84
CLARKE, T. L., and J. R. PRONI. Comparison of acoustic Doppler profiler techniques: Chesapeake Bay results. NOAA Technical Memorandum, ERL AOML-58, 28 pp. (1984).

The possible types of Doppler acoustic current profilers are outlined, and the distinction between the "classic" Janus/single pulse system and "radical" systems is made. The Chesapeake Bay Experiment designed to evaluate

an AMETEK profiler is described. A radical acoustic profiler could be produced from data recorded during the experiment. This OAD Janus/coherent profiler is compared to the AMETEK and found to produce equally good measurements in only 1/30 the time.

AO-014-84
CLARKE, T. L., and J. R. PRONI. The development of the transverse Doppler current profiler. Proceedings of the Acoustic Current Profiling Symposium, November 2-3, 1983, Washington, D.C., 13-15 (1984).

No abstract.

AO-015-84
CLARKE, T. L., R. A. Young, and D. J. P. Swift. A stochastic modelling approach to the fine sediment budget of the New York Bight. Journal of Geophysical Research 88(C14):9653-9660 (1983).

A stochastic model of fine sediment transport on the continental shelf is modified to incorporate the effects of storm flows. The model, based on surface gravity wave resuspension, now includes transport by both tides and episodic storm flows. Effects of gravity wave/storm flow correlation as deduced from near bottom current meter measurements are also included. Sediment dispersion is significantly faster when the effects of storm flows are included. The effects of the gravity wave/storm flow correlation and the regional net flow pattern are small. The model is solved numerically for equilibrium dispersal patterns for sediment entering at estuary inlets bordering the New York Bight region. Additional dispersal patterns are found for upcoast and downcoast sources as well as the dredge spoil dump site. Combinations of these dispersal patterns are least squares fit to the observed fine sediment distribution in the New York Bight to evaluate the magnitudes of the sources of sediment; negative source magnitudes are interpreted as sediment sinks. The results are consistent with other estimates of sediment sources and sinks in the New York Bight.

AO-016-84
Cuhel, R. L., P. B. ORTNER, and D. R. S. Lean. Night synthesis of protein by algae. Limnology and Oceanography 29(4):731-744 (1984).

Dunaliella tertiolects in culture showed rates of net protein synthesis at night equal to those during the day. In night protein synthesis carbon stored in carbohydrates and metabolite pools was used, whereas sulfate was assimilated from the medium as needed. As a result, whole cell C:S ratios varied systematically over the diel cycle, while the C:S ratio of isolated protein remained constant. In the stationary phase, sulfate incorporation into protein, unlike carbon incorporation, measured net protein synthesis rather than turnover. Diel experiments with natural populations of marine and freshwater algae demonstrated that night protein synthesis is a general phenomenon in phytoplankton. For samples previously exposed to saturating light, day and night rates of protein synthesis were similar. The use of carbohydrate and metabolic pool carbon for night protein synthesis not only increased protein to the food web, but also altered ratios of protein, carbohydrate, and lipid to one another. The latter might result in changes in the nutritional value of phytoplankton to herbivores.

AO-017-84

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. Proceedings, International Conference on School and Popular Meteorological Education, July 2-4, 1984, Oxford, England. American Meteorological Society, Boston, Massachusetts (1984).

No abstract.

AO-018-84

FRIEDMAN, H. A. School-based and community-wide education and public information programs to increase tropical cyclone awareness and preparedness. Proceedings, International Conference on School and Popular Meteorological Education, July 2-4, 1984, Oxford, England. American Meteorological Society, Boston, Massachusetts (1984).

No abstract.

AO-019-84

FRIEDMAN, H. A., and P. Krumpe. International efforts to increase tropical cyclone awareness and preparedness in at-risk coastal communities. Postprints, 3rd Conference on Meteorology of the Coastal Zone, January 9-13, 1984, Miami, Florida. American Meteorological Society, Boston, Massachusetts, J59-J64 (1984).

No abstract.

AO-020-84

Gloersen, P., D. J. Cavalieri, A. T. C. Chang, T. T. Wilheit, W. J. Campbell, O. M. Johannessen, K. B. Katsaros, K. F. Kunzi, D. B. ROSS, D. Staelin, E. P. L. Windsor, F. T. Barath, P. Gudmandsen, E. Langham, and R. O. Ramseier. A summary of results from the first NIMBUS-7 SMMR observations. Journal of Geophysical Research 89(D4):5335-5344 (1984).

Selected data obtained during the first year of operation of the scanning multichannel microwave radiometer (SMMR) on board the NIMBUS 7 satellite (launched in late October 1978) have been used to calculate, on a global basis, various geophysical parameters over open oceans, polar regions, and terrain. Over open oceans these calculations have provided values for sea surface temperatures, near-surface winds, atmospheric water vapor in a column, and rainfall rates. In polar regions, sea ice concentration, multiyear ice fraction, and radiating temperatures have been obtained. Finally, the extent and water equivalence of snow cover over terrain have been calculated. These parameters have been compared with in-situ measurements of the same geophysical parameters, where available, and the results of these comparisons are described. The self-consistency of the global displays of all the parameters is discussed along with the plans for archiving them for subsequent research purposes. A description of the SMMR calibration and data processing scheme is also given.

AO-021-84

Guaraglia, D. O., and C. A. LAUTER, JR. Implementation of a new method to record pulsed analog signals. 1983 IEEE Proceedings of the Third Working Symposium on Oceanographic Data Systems, 22-26 (1983).

The implementation of a new method to record pulsed analog signals having useful frequency components from DC to 100 KHz is described. Detailed information on the Signal Conditioner (SC) designed for this purpose is included. This SC is used to condition the signal from a 3 MHz high resolution echo sounder. The use of the SC decreases by five times the amount of tape required by an analog instrumentation tape recorder and allows the recording of signals with DC components in the Direct Recording Mode. Basically, the functions performed by the SC are: sample and hold; analog to digital conversion; temporary storage; simple processing; digital to analog conversion and modified double side band modulation. The SC's main components are two 8-bit microboard computers built around the CDP 1802 COS/MOS microprocessor, working in a master slave arrangement. The SC has been successfully tested in field experiments.

AO-022-84

HANSEN, D. V. Anomalies of zonal advection observed during the 1982-83 El Niño. Papers From 1982-83 El Niño/Southern Oscillation Data Display Workshop, December 1983, 99-102 (1983).

No abstract.

AO-023-84

HARVEY, G. R., D. A. BORAN, S. R. PIOTROWICZ, and C. P. WEISEL. Synthesis of marine humic substances from unsaturated lipids. Nature 309:244-246 (1984).

The origin and structure of the dissolved blue-fluorescent yellow organic substances (Gelbstoff) in seawater have long eluded characterization. The fact that this class of organic matter, which comprises 10-50% of the organic carbon in the sea, became known as marine humus (fulvic and humic acids) has led to much confusion because of the implied relationship with soil humus. Based on chemical and spectral studies of oceanic and coastal humus, we recently proposed a class structure and a mechanism by which these marine humic substances could form. The hypothesis was that they are water soluble, aliphatic organic acids formed by the autoxidative cross-linking of two or more unsaturated lipids released into seawater. We have now confirmed that hypothesis by allowing pure marine lipids and a diatom to autoxidize in seawater in the laboratory. We report here that the yellow substances obtained are similar in all respects to marine humus.

AO-024-84

JONES, R. W. Some aspects of convection in a hurricane simulation model. Postprints, 15th Conference on Hurricanes and Tropical Meteorology, January 9-13, 1984, Miami, Florida. American Meteorological Society, Boston, Massachusetts, 350-353 (1984).

No abstract.

AO-025-84

JORGENSEN, D. P. Mesoscale and convective-scale characteristics of mature hurricanes. Part I: General observations by research aircraft. Journal of the Atmospheric Sciences 41(8):1268-1285 (1984).

The analysis of instrumented aircraft data from recent mature hurricanes reveals common mesoscale and convective-scale features. The structure and organization of the convection, precipitation, and wind flow are studied by combining the airborne observations, using basic instrumentation, with quantitative radar measurements. Three predominant precipitation features seen are 1) the eyewall, 2) a stratiform rain region adjacent to and outside the eyewall, and 3) rainbands that contain both convective and stratiform regions. The eyewall is so named because it surrounds the rain-free eye, but several additional features distinguish it from other convective bands in the hurricane. In particular, the updraft, tangential wind maximum, and highest rainfall have preferred locations relative to each other, with the updraft being radially inward from the rain and wind maxima. The 10 dBZ radar reflectivity contour (indicative of the inner edge) slopes substantially outward with height, and there is evidence that the eyewall becomes more vertical with decreasing eye diameter. The inner eyewall edge is a region of cyclonic wind shear and substantial radial convergence. Of the four storms studied here, three had "double" eyewalls (concentric convective rings) during part of their lifetimes. The precipitation outside the eyewall is predominantly stratiform and is characterized by a "bright band" of enhanced radar reflectivity just below the melting level. Embedded within this uniform rain region are spiral and circular rainbands containing convective cells. Radar reflectivity is seen to decrease fairly rapidly with height above the 0°C level, even within the convective cores of the rainbands. Rainbands are distinguished from eyewalls by the absence of a pronounced tangential wind maximum, and the general lack of consistently observed updraft location. Radar reflectivity maps of outer rainbands show a more "cellular" structure in the embedded convective elements when compared with eyewalls.

AO-026-84

JORGENSEN, D. P. Mesoscale and convective-scale characteristics of mature hurricanes. Part II: Inner core structure of Hurricane Allen. Journal of the Atmospheric Sciences 41(8):1287-1311 (1984).

The eyewall structure of Hurricane Allen is examined from analyses of multiple aircraft data on two days, 5 and 8 August 1980. These data sets are unique in that, for the first time, three instrumented aircraft executed coordinated radial penetrations of the eyewall at multiple levels. The data collected on 5 August illustrate the persistence of various features on horizontal scales > 10 km over several hours. Composite cross sections

constructed from the 8 August data show similar structure, although the eye diameter had decreased to less than half that of 5 August. The convergence of air in the eyewall was highly two-dimensional. This convergence supported organized ascent that was along the inner edge of the high reflectivity region and displaced inward several kilometers from the radius of maximum wind (RMW). A mean eyewall updraft of 5-6 m s^{-1} is compounded from integration of the two-dimensional continuity equation. Embedded within the two-dimensional eyewall were cores of high reflectivity that were 2-5 km in diameter, three-dimensional, and generally not traceable from pass to pass (~ 20 min intervals). These convective-scale entities had highest updraft velocities of 7-9 m s^{-1}. Upward mass flux in the eyewall was 4-5 times greater than that diagnosed by Zipser and others for a GATE slow-moving convective line. This greater flux was accomplished not through larger vertical velocities within convective cores, but by a greater area covered by active updrafts within the low-level convergence zone.

AO-027-84

JORGENSEN, D. P., and F. D. MARKS, JR. Airborne Doppler study of the structure and three-dimensional airflow within a hurricane rainband. Preprints, 22nd Conference on Radar Meteorology, September 10-14, 1984, Zurich, Switzerland. American Meteorological Society, Boston, Masschusetts, 572-577 (1984).

No abstract.

AO-028-84

Krumpe, P., H. A. FRIEDMAN, and J. Sanders. Education programs in support of disaster preparedness and prevention. Postprints, 3rd Conference on Meteorology of the Coastal Zone, January 9-13, 1984, Miami, Florida. American Meteorological Society, Boston, Massachusetts, J51-J54 (1984).

No abstract.

AO-029-84

LAWSON, L. M., and D. R. PALMER. Acoustic ray-path fluctuations induced by El Niño. Journal of the Acoustical Society of America 75(5):1343-1345 (1984).

This paper represents a first step in determining the degree to which an El Niño event can be monitored using acoustic tomographic techniques. In tropical waters an acoustic ray entering the near-surface region from below usually is strongly refracted because of the steep gradient in the sound speed and therefore turns over very rapidly. Since the temperature perturbation associated with an El Niño event is restricted to this near-surface region, there has been some concern that ray-path travel-time fluctuations would be too small to be easily detected. In this note we address this concern using data measured during the 1982-1983 event. We conclude that the travel-time fluctuations are large enough to be easily measured for almost all ray-path configurations of interest. We also discuss the direction future efforts might take.

AO-030-84
LAWSON, L. M., and D. R. PALMER. Acoustic ray-path fluctuations induced by El Niño. NOAA Technical Memorandum, ERL AOML-56, 9 pp. (1984).

The report represents a first step in determining the degree to which an El Niño event can be monitored using acoustic tomographic techniques. In tropical waters an acoustic ray entering the near-surface region from below usually is strongly refracted because of the steep gradient in the sound speed and therefore turns over very rapidly. Since the temperature perturbation associated with an El Niño event is restricted to this near-surface region, there has been some concern that ray-path travel-time fluctuations would be too small to be easily detected. In this report we address this concern using data measured during the 1982-1983 event. We conclude that the travel-time fluctuations are large enough to be easily measured for almost all ray-path configurations of interest. We also discuss the direction future efforts might take.

AO-031-84
LEETMAA, A. An overview of the physical oceanography report. Reviews of Geophysics and Space Physics 21(5):1105-1107 (1983).

No abstract.

AO-032-84
LEETMAA, A. Changes along 85°W in the thermocline structure with the 1982/1983 El Niño. Papers From 1982-83 El Niño/Southern Oscillation Data Display Workshop, December 1983, 109-116 (1983).

No abstract.

AO-033-84
LEETMAA, A. The 1982 El Niño as seen at 85°W. Tropical Ocean-Atmosphere Newsletter, 16:15 (1983).

No abstract.

AO-034-84
LEETMAA, A., D. W. BEHRINGER, J. Toole, and R. L. Smith. Observations of the 1982/83 El Niño at 85°W. Tropical Ocean-Atmosphere Newsletter 21, 11-12 (1983).

No abstract.

AO-035-84
LEETMAA, A., and R. L. MOLINARI. Two cross-equatorial sections at 110°W. Journal of Physical Oceanography 14(2):255-263 (1984).

A section along 110°W in the eastern Pacific from about 6°N to 6°S was occupied in March and June of 1981. Measurements consisted of absolute

velocity profiles and CTD casts. The large-scale structure of the subsurface zonal flow remained relatively invariant between these cruises. The Equatorial Undercurrent and North and South Equatorial Undercurrents appear as strong eastward flows, separated by westward currents. Away from the equator, comparison of currents estimated geostrophically with the direct observations indicate that the two techniques are in agreement within estimated errors except close to the surface. In the vicinity of the equator the geostrophic technique in general fails and the directly measured currents must be used. During March, within 3° of the equator from the surface to 700 m, the flow was more eastward by about 0.15 m s^{-1} than in June. In March, the flow and temperature fields were relatively symmetric about the equator. By June, strong asymmetries had developed. In the top 100 m, eastward flow extended from the Undercurrent to about 3°S. A strong, shallow westward flow was situated over and to the north of the Undercurrent. A shallow southward flow developed from 4°N to 2°S. Order-of-magnitude estimates suggest that this can advect westward momentum onto the equator in the top 50 m and modify the Undercurrent. Asymmetry also developed in the near-surface thermal field. In June, upwelling was primarily located south of the equator. This resulted in a cold band lying south of the equator at the core of which the flow was predominantly eastward. A strong meridional temperature gradient at the equator separated the colder water from warmer water to the north. These asymmetries develop presumably in response to the seasonal increase from March to June of the winds. Computations of zonal transports in various classes in the near-surface layers suggest that the bulk of the Undercurrent water does not return west on the same density surfaces, but does so in the surface layers.

AO-036-84

LEETMAA, A., and J. Witte. Papers from the 1982/83 El Niño/Southern Oscillation Workshop. GPO, 1984-748-818, 229 pp. (1983).

No abstract.

AO-037-84

LORD, S. J., H. E. WILLOUGHBY, and J. M. PIOTROWICZ. Role of a parameterized ice-phase microphysics in an axisymmetric, nonhydrostatistic tropical cyclone model. Journal of the Atmospheric Sciences 41(7):1169-1186 (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 10's 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-038-84
LORD, S. J., H. E. WILLOUGHBY, and J. M. PIOTROWICZ. Role of a parameterized ice-phase microphysics in an axisymmetric, nonhydrostatic tropical cyclone model. Postprints, 15th Conference on Hurricanes and Tropical Meteorology, January 9-13, 1984, Miami, Florida. American Meteorological Society, Boston, Massachusetts, 338-343 (1984).

No abstract.

AO-039-84
MARKS, F. D., JR, and R. A. Houze, Jr. Airborne Doppler radar observations in Hurricane Alicia. Preprints, 22nd Conference on Radar Meteorology, September 10-14, 1984, Zurich, Switzerland. American Meteorological Society, Boston, Massachusetts, 578-583 (1984).

No abstract.

AO-040-84
MARKS, F. D., JR., and R. A. Houze, Jr. Airborne Doppler radar observations in Hurricane Debby. Bulletin of the American Meteorological Society 65(6):569-582 (1984).

A pulse-Doppler radar on board a National Oceanic and Atmospheric Administration (NOAA) WP-3D research aircraft has been used to map the wind in the vicinity of the developing eyewall of Hurricane Debby, which occurred in 1982. The Doppler-derived winds in the eye wall region compare favorably with winds measured aboard the aircraft. The Doppler radar allowed the wind field to be documented in much more detail than has been possible in previous hurricane studies. The maximum winds were found radially, just inward of the band of maximum radar reflectivity, and were concentrated in two mesoscale maxima. A mesoscale trough associated with the developing eye wall sloped upwind and radially outward through 1-5 km layer. The trough was best defined at 2-3 km, where it contained a closed mesocyclonic circulation.

AO-041-84
MARKS, F. D., JR., and R. A. Houze, Jr. Airborne Doppler radar observations of the mesoscale air motion field in the developing inner core of Hurricane Debby. Postprints, 15th Conference on Hurricanes and Tropical Meteorology, January 9-13, 1984, Miami, Florida. American Meteorological Society, Boston, Massachusetts, 95-102 (1984).

No abstract.

AO-042-84
MAUL, G. A. Editorial: International scientific communication - a stepwise solution. Marine Geodesy 7(1-4):1-5 (1983).

No abstract.

AO-043-84

MAUL, G. A. Book Review. Remote sensing applications in marine science and technology, edited by Arthur P. Cracknell. Bulletin of Marine Science 34(3):494-495 (1984).

No abstract.

AO-044-84

MAUL, G. A. Zenith angle effects in multichannel infrared sea surface remote sensing. Remote Sensing of Environment 13:439-451 (1983).

Several approaches to infrared multichannel sea surface temperature retrievals propose using a universal set of constraints. It is shown that the single-angle technique (NOAA-n) are similar concepts with a common derivation from radiative transfer theory. It is also shown that the linear correlation factor between surface temperature minus satellite temperature in one channel versus the difference in satellite temperatures in two channels is not independent of the difference in satellite sensed equivalent blackbody temperature. The 3.7-μm, and 12-μm channels on the NOAA-n AVHRR can be used in combination to compute atmospheric transmissivity and average atmospheric temperature, but a better combination would be substituting three 0.5-μm-wide channels centered on 11.25 μm, 11.75 μm, and 12.25 μm. A triple window multispectral scanner in the 11-12.5 μm region allows determination of diffuse surface reflectance which can bias sea surface temperatures -0.4°K ± 0.3°K.

AO-045-84

MAUL, G. A., and N. J. BRAVO. Fitting of satellite and in-situ ocean surface temperatures: Results for POLYMODE during the winter of 1977-1978. Journal of Geophysical Research 88(C14):9605-9616 (1983).

During the POLYMODE experiment, infrared and visible data from GOES were the only satellite data permanently archived in digital form. GOES data lack onboard calibration capability and were fitted, using least squares and other methods, to XBT, buoy, tide gage, and ship of opportunity reports to remove atmospheric effects and calibration offset. For the experiment period considered, December 1977 through February 1978, bivariate Gaussian discriminant function cloud identification showed more than 93% of the 8-km resolution GOES infrared pixels to be cloud contaminated. Cloud-free in-situ calibration points were distributed in nonrandom groups, which resulted in systematic errors when using least squares techniques. Surfaces and regression lines were least squares fitted between satellite and in-situ data; differences and ratios were also used. Best results were obtained with a regression in the form of the infrared radiative transfer equation but were no better than ±0.9°K. As a result of extensive cloudiness the linear regressions were seldom useful, and temperature ratios with ±1.3°K experimental errors best represent the applicability of GOES data to sea surface temperatures. A composite of all cloud-free data for the three months left 5% of the area unobserved, but the mean surface temperature map and the standard deviation map are an improvement over atlas maps because of higher spatial resolution.

AO-046-84

NELSEN, T. A., and D. J. Stanley. Variable deposition rates on the slope and rise off the Mid-Atlantic states. Geo-Marine Letters 3:37-42 (1983-1984).

Pronounced variations in slope topography and offshelf spillover have produced a three-fold difference (9 to 25 cm/1,000 yr) in Late Quaternary deposition rates among slope cores southeast of the Mid-Atlantic States. Upper rise cores revealed a high rate but lower core-to-core variability (20 to 44 cm/1,000 yr), largely the result of slope bypassing, i.e., effects of gravity-controlled downslope transport. A transport model suggests temporary slope sediment storage and higher accumulation of mud in more distal rise regions. Eustatic change accounts for the four-fold decrease in slope deposition rate between the Late Pleistocene and Holocene.

AO-047-84

Newman, F., and W. P. DAMMANN. Acoustic measurement of XBT fall rates. Science Applications, Inc., Technical Report, SAI-83/1200 (1983).

Questions have been raised concerning the accuracy of the empirical XBT depth equation as well as probe-to-probe variability of XBT fall rate. Direct acoustic at-sea measurements of XBT fall rate have been proven feasible to address some of these questions. This report summarizes acoustic measurements of XBT fall rate and results thus far. XBT probes have been tracked to depths of 300 m and estimates of their drag coefficient have been made from measurements of average fall rate with constant mass in a constant viscosity layer approximately 90 m deep. The mean drag coefficient for T-7 probes without wire was determined to be 0.121 ± 0.002 in 26°C seawater, in close agreement with an estimate of 0.125 by Green (1983). Recommendations for further work are included.

AO-048-84

OOYAMA, K. V. A numerical model for hurricane prediction. Postprints, 15th Conference on Hurricanes and Tropical Meteorology, January 9-13, 1984, Miami, Florida. American Meteorology Society, Boston, Massachusetts, 344-349 (1984).

No abstract.

AO-049-84

ORTNER, P. B., S. M. HOLZKNECHT, and S. R. CUMMINGS. Assessing the utility of partitioning primary productivity by density gradient centrifugation. Journal of Plankton Research 5(6):919-928 (1983).

We assess here a method for determining what contribution various components of natural phytoplankton assemblages make to measured community primary productivity. Following incubation with ^{14}C-bicarbonate-labelled plankton and unlabelled controls are physically separated into sets of parallel subpopulations by centrifugation in density gradients. The relative activity of the former subaliquots is determined by scintillation counting while the latter subaliquots are enumerated by a modified Utermöhl inverted

microscope method. Field and laboratory data are presented illustrating partitionings of coastal and oceanic plankton population carbon uptake. The described procedure could be used to partition the uptake of other isotopes or biomass parameters such as chlorophyll or ATP concentration. The advantages and disadvantages of the density gradient approach are discussed relative to available alternatives.

AO-050-84

PALMER, D. R. The coherent Green's function for acoustic propagation in a random ocean. Journal of the Acoustical Society of America 75(1):125-132 (1984).

We have derived an algorithm for calculating the coherent Green's function of an acoustic wave propagating in an ocean possessing index-of-refraction fluctuations. This function is related to the so-called strength parameter which can be used to characterize the statistics obeyed by the acoustic field. Since we are interested in a wave solution we do not make the geometric optics approximation. Consequently, it is necessary to generalize the usual form of the Markov approximation. This is done in analogy with Dashen's investigations. Our analysis accounts for the ocean boundaries and the depth dependence of the mean index of refraction. It is, however, restricted to convergence zone propagation. The phenomenological model of internal waves introduced by Garrett and Munk is used to describe the random fluctuations in the index of refraction. The analysis is based on the use of a Feynman path integral. The path integral formalism is particularly well suited to the approximations we consider. The algorithm consists of solving the parabolic equation using the split-step Fourier algorithm technique with an effective index of refraction term. The presence of the internal wave fluctuations are reflected in this term through an imaginary piece which attenuates the coherent Green's function.

AO-051-84

Parrish, J., R. W. BURPEE, F. D. MARKS, JR., and C. W. LANDSEA. Mesoscale and convective-scale characteristics of Hurricane Frederic. Postprints, 15th Conference on Hurricanes and Tropical Meteorology, January 9-13, 1984, Miami, Florida. American Meteorological Society, Boston, Massachusetts, 415-420 (1984).

No abstract.

AO-052-84

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 Technical Memorandum, ERL AOML-60, 110 pp. (1984).

No abstract.

AO-053-84

PIOTROWICZ, S. R., G. R. HARVEY, D. A. BORAN, C. P. WEISEL, and M. SPRINGER-YOUNG. Cadmium, copper, and zinc interactions with marine humus as a function of ligand structure. Marine Chemistry 14:333-346 (1984).

The interactions in seawater of cadmium, copper, and zinc with natural levels of marine humus (fulvic and humic acids) were studied using differential pulse anodic stripping voltammetry (DPASV). Interactions with Cu were also examined by ultraviolet spectrophotometry. The degree of interaction relates to the structure of the particular fulvic or humic acid tested. Marine fulvic and humic acids with different equivalent weights and varying degrees of aromaticity and heteroatom substitution were tested to assess the relative importance of these fundamental structural features in determining the degree of interaction. An index of heteroatom substitution, derived from proton magnetic resonance spectra of these materials, when combined with equivalent weights correlated with the nature and degree of metal interaction. Both marine fulvic and humic acids appreciably interacted with Zn. In contrast, the extent of interaction of fulvic acids with Cu appears to be related to their structure while humic acids appear to interact with Cu regardless of structure. Cadmium interacts only with mature, highly cross-linked humic acids.

AO-054-84

POWELL, M. D., and P. G. BLACK. Airborne Doppler radar observations of the boundary layer of Hurricane Debby (1982). Preprints, 22nd Conference on Radar Meteorology, September 10-14, 1984, Zurich, Switzerland. American Meteorological Society, Boston, Massachusetts, 584-588 (1984).

No abstract.

AO-055-84

POWELL, M. D., F. D. MARKS, JR., and P. G. BLACK. The asymmetric structure of Alicia's wind field and rainfall distributions at landfall. Proceedings, A.S.C.E. Specialty Conference, "Hurricane Alicia: One Year Later," August 16-17, 1984, Galveston, Texas. American Society of Civil Engineers, New York, New York (1984).

No abstract.

AO-056-84

ROFFER, C., D. W. BEHRINGER, and A. LEETMAA. Hydrographic data collected in 1982 and 1983 for EPOCS. NOAA Technical Memorandum ERL AOML-57, 259 pp. (1984).

Hydrographic data were collected on four cruises during 1982 and 1983 for the EPOCS program. The data were recorded with a Neil Brown Instrument Systems (NBIS) CTD/02. Descriptions of the CTD/02 instrument, and data acquisition, processing and calibration techniques are given. Cruise tracks and station position are shown. Profiles of temperature, salinity, sigma-t, and dissolved oxygen are plotted for each cast.

AO-057-84

RONA, P. A. Hydrothermal mineralization at seafloor spreading centers. Earth-Science Reviews 20:1-104 (1984).

The recent recognition that metallic mineral deposits are concentrated by hydrothermal processes at seafloor spreading centers constitutes a scientific breakthrough that opens active sites at seafloor spreading centers as natural laboratories to investigate ore-forming processes of such economically useful deposits as massive sulfides in volcanogenic rocks on land, and that enhances the metallic mineral potential of oceanic crust covering two-thirds of the Earth both beneath ocean basins and exposed on land in ophiolite belts. This paper reviews our knowledge of processes of hydrothermal mineralization and the occurrence and distribution of hydrothermal mineral deposits at the global oceanic ridge-rift system. Sub-seafloor hydrothermal convection involving circulation of seawater through fractured rocks of oceanic crust driven by heat supplied by generation of new lithosphere is nearly obiquitous at seafloor spreading centers. However, ore-forming hydrothermal systems are extremely localized where conditions of anomalously high thermal gradients and permeability increase hydrothermal activity from the ubiquitous low-intensity background level ($\leq$ 200°C) to high-intensity characterized by high temperatures (> 200-c. 400°C), and a rate and volume of flow sufficient to sustain chemical reactions that produce acid, reducing metal-rich primary hydrothermal solutions. A series of mineral phases with sulfides and oxides as high and low-temperature end members, respectively, are precipitated along the upwelling limb and in the discharge zone of single-phase systems as a function of increasing admixture of normal seawater. The occurrence of hydrothermal mineral deposits is considered in terms of spatial and temporal frames of reference. Spatial frames of reference comprise structural features along-axis (linear sections that are the loci of seafloor spreading alternating with transform faults) and perpendicular to axis (axial zone of volcanic extrusion and marginal zones of active extension) common to all spreading centers, regional tectonic setting determined by stage (early, advanced), and rate (slow, intermediate-to-fast) of opening of an ocean basin about a spreading center, and local tectonic sub-setting that incorporates anomalous structural and thermal conditions conducive to mineral concentration (thermal gradient, permeability, system geometry, leaky versus tight hydrothermal systems). Temporal frames of reference comprise the relation between mineral concentration and timing of regional plutonic, volcanic and tectonic cycles and of episodic local physical and chemical events (transient stress, fluctuating heat transfer, intrusion-extrusion, fracturing, sealing, etc.). Types of hydrothermal deposits are not uniquely associated with specific tectonic settings and subsettings. Similar types of hydrothermal deposits may occur in different tectonic settings as a consequence of convergence of physical and chemical processes of concentration. Local tectonic sub-settings with conditions conducive to hydrothermal mineralization at slow-spreading centers (half rate $\leq$ 2 cm y^{-1}; length c. 28,000 km), characterized by an estimated average convective heat transfer of $15.1 \cdot 10^{8}$ cal. cm^{-2}, deep-level (> 3 km), relatively narrow (< 5 km wide at base) magma chambers, and high topographic relief (1-5 km) are: (1) basins along linear sections of the axial zone of volcanic extrusion near transform faults at an early stage of opening, represented by a large stratiform sulfide deposit (estimated $32.5 \cdot 10^{6}$ metric tons) of the Atlantis II Deep of the Red Sea; (2) the wall along linear sections of the rift valley in the marginal zone of active extension at an advanced stage of opening, represented by encrustations

and layered deposits of manganese and iron oxides, hydroxides and silicates inferred to be underlain by stockwork sulfides at the TAG Hydrothermal Field at latitude 26°C on the Mid-Atlantic Ridge; (3) transform faults, especially those with large ridge-ridge offset (> 30 km) at an advanced stage of opening, represented by stockwork sulfides exposed in the walls of equatorial fracture zones of the Atlantic Ocean and Indian Ocean; (4) the axial zone of volcanic extrusion at an advanced stage of opening. Local tectonic sub-settings with conditions conducive to hydrothermal mineralization at intermediate- to fast-spreading centers (half rate > 2 cm y^{-1}; length c. 22,000 km) characterized by an estimated average convective heat transfer of $11.5 \cdot 10^8$ cal. cm^{-2}, relatively wide (up to 20 km at base), shallow-level (c. 1-3 km) magma chambers, and low topographic relief (< 1 km), are: (1) basins along linear sections of the axial zone of volcanic extrusion at an early stage of opening, represented by massive sulfide deposits of the Guaymas Basin of the Gulf of California; (2) the axial zone of volcanic extrusion at an advanced stage of opening, represented by individually small (c. $1 \cdot 10^3$ metric tons), massive sulfide mounds surmounted by chimneys of the East Pacific Rise at latitude 21°N; (3) the marginal zone of active extension at an advanced stage of opening represented by a large, massive sulfide deposit (preliminary tentative estimate c. $10 \cdot 10^6$ metric tons) at a double-rifted section of the Galapagos Spreading Center; (4) transform faults, especially those with large ridge-ridge offset (> 50 km) represented by manganese encrustations in a transform fault at the Galapagos Spreading Center; (5) volcanic seamounts related to persistent hot spots at spreading centers, represented by oxide and sulfide deposits on seamounts off the axis of the East Pacific Rise; (6) portions of spreading centers with anomalous configurations such as multiple, bent or extended rifts, represented by massive sulfide deposits at a double-rifted section of the Galapagos Spreading Center, suggesting the operation of a thermal-structural feedback mechanism indicative of the presence of hydrothermal mineralization; (7) discrete spreading centers in back-arc basins represented by hydrothermal deposits at sites in marginal seas of the western Pacific. Ore-forming processes appear to be least efficient in the axial zone of volcanic extrusion of oceanic ridges at an advanced stage of opening irrespective of spreading rate, where tight hydrothermal systems dissipate a major portion of contained metals by precipitation and dispersion in particulate form from "black smokers" that discharge into the water column. Ore-forming processes appear to be most efficient at sites in basins at linear sections of the axial zone of volcanic extrusion near transform faults during an early stage of opening, and at marginal zones of active extension along linear sections of spreading center during an advanced stage of opening, irrespective of spreading rate, where both tight and leaky hydrothermal systems may conserve their contained metals to concentrate large sulfide deposits. Resemblances in mineralization between stockwork sulfides at seafloor spreading centers and porphyry copper-type deposits in volcanogenic rocks on land suggest the possibility for the occurrence of large tonnage, low-grade porphyry copper-like deposits concentrated by leaky hydrothermal systems at spreading centers. Systematic applications of composite exploration procedures is leading to the discovery of numerous additional deposits. It is inferred from the limited data base available that the occurrence of hydrothermal mineral deposits is more frequent at intermediate-to-fast-than at slow-spreading centers, but the potential for the accumulation of large hydrothermal mineral deposits is greater at slow-spreading centers. Current knowledge of the distribution of hydrothermal mineral deposits at seafloor spreading centers is limited to about 55 sites at this early stage of

exploration. Estimates of the distribution of either fields of hydrothermal mineral deposits or high-intensity, ore-forming hydrothermal systems at seafloor spreading centers, deduced from various considerations, range from one such occurrence between 15 and 265 km along slow-spreading centers, and 1 and 100 km along intermediate- to fast-spreading centers. However, the distribution of sizable deposits will remain sporadic owing to the special structural and thermal conditions necessary to sustain and to retain high-intensity ore-forming hydrothermal systems.

AO-058-84
RONA, P. A. Book Review: Mineral deposits and global tectonic settings. Economic Geology 78:1028-1032 (1983).

Mineral Deposits and Global Tectonic Settings is an exceptionally well-organized and comprehensive exposition of the relation of mineral deposits other than petroleum to the tectonic settings in which they occur. Tectonic setting is defined as "the location, relative to major features of the crust, within which the rocks including associated economic minerals of similar age were deposited, intruded, or less commonly formed as a result of deformation and metamorphism" (p.1). The authors contend that the tectonic setting exerts a major control on type of mineralization through magmatic activity, sedimentary framework, deformation history, geothermal gradient, and faulting characteristic of each tectonic setting.

AO-059-84
RONA, P. A. Perpetural seafloor metal factory. Sea Frontiers 30(3):132-141 (1984).

When the theory of plate tectonics gained acceptance about 15 years ago as a new way to interpret Earth, it brought both good news and bad. The good news was that the theory appeared to explain the way Earth works. The old concept of a static Earth on which continents and ocean basins were permanent features that has been fixed in their present positions throughout most of Earth history was replaced by the new concept of a dynamic Earth. According to the new concept, continents constantly moved, and ocean basins continually opened and closed as your seafloor was created and older seafloor was destroyed by remelting into Earth's interior. The bad news was that the prospect for metallic mineral deposits (other than manganese nodules) occurring in ocean basins was considered poor. This, it was thought, was due to the young age and homogeneous composition of volcanic rocks generated by seafloor spreading, in contrast to metal deposits on continents, which are associated with diverse ancient rocks.

AO-060-84
RONA, P. A. Potential mineral and energy resources at submerged plate boundaries. National Resources Forum 7(4):329-338 (1983).

The theory of plate tectonics is briefly reviewed with reference to the recognized association between types of mineral (metals) and energy (hydrocarbons, geothermal) resources that may occur at sites along plate boundaries submerged beneath the oceans. An immense gap in knowledge, technology and

economics exists between the potential for mineral or energy resources to occur and the development of the resource as a commercial prospect. The real benefit of mineral discoveries such as polymetallic sulfides at submerged plate bounderies is to feed back information from the seabed to guide exploration for analogous deposits on land. A world map is presented showing the location of submerged plate boundaries and a 200 nautical mile-wide offshore zone.

AO-061-84

RONA, P. A., K. Boström, L. Laubier, and K. L. Smith, Jr. (eds.) Hydrothermal Processes at Seafloor Spreading Centers. NATO Conference Series, Series IV, Marine Science, Volume 12, 796 pp. (1984).

The discovery of hydrothermal activity at seafloor spreading centers is viewed as the most exciting scientific discovery in a decade, with ramifications through the earth and life sciences. This is the first book to present an interdisciplinary overview of the subject including geological, geophysical, geochemical, and biological discoveries. Implications of the discoveries for understanding the earth's heat transfer, geochemical mass balances and cycles, mineralization, and biological adaptations are explored in thirty papers. Photographs, including full-color views of hydrothermal phenomena, and numerous line drawings complement the text. Written by a pioneering research community of marine geologists, geophysicists, geochemists, and biologists, this volume presents seminal work on the description and interpretation of hydrothermal and associated phenomena at seafloor spreading centers. Topics covered include: geologic setting, hydrothermal convection, basalt-seawater interaction, Iceland and oceanic ridges, geochemical mass balances and cycles, ferromanganese deposits, hydrothermal mineralization including polymetallic sulfides, and biological communities at hydrothermal vents. The papers reveal the state of the art and the immense potential of the study of hydrothermal processes at seafloor spreading centers for continued progress on both basic and applied levels.

AO-062-84

RONA, P. A., L. Widenfalk, and K. Boström. Ultramafic rock suite from the rift valley of the Mid-Atlantic Ridge near 15°N. EOS 64(45):724-725 (1983).

A relatively complete ultramafic suite comprising harzburgites, pyroxenites, lherzolites, whelites, gabbronorites, olivine gabbronorites, gabbropegmatites and alteration products of these rocks including serpentinites, bastite serpentinites and asbestos was dredged from a thin zone between 2,910 and 3,300 m below sea level located exactly at the intersection between a wall of the rift valley and a wall of a transform fault on the Mid-Atlantic Ridge at latitude 14°55.5'N longitude 44°54.4'W. Chromite is present as disseminated grains with chemical characteristics common to podiform and stratiform chromite deposits. The ultramafic section crops out in block faulted terrain on the upper portion of the rift valley wall and is inferred to have been recently emplaced by relative tectonic uplift from an ultramafic cumulate zone in the lower oceanic crust along faults that penetrate oceanic crust. Ongoing hydrothermal discharge evidenced by excess δ^3He in the near-bottom seawater over the ultramafic section supports the interpretation of recent emplacement of the ultramafic rocks in fault blocks along the crust-

penetrating faults that continue to tap degassing from mantle sources. The Ti-Zr-Y relations and relatively constant Zr/Ti ratio in basalts recovered with the ultramafic rocks evidence a cognetic relation from a common magmatic source. The occurrence indicates that ultramafic cumulates from beneath the rift valley and may be serpentinized and uplifted along crust-penetrating faults during the initial 1×10^6 y of generation of crust about a slowspreading oceanic ridge.

AO-063-84

ROSENTHAL, S. L. A review of some recent studies concerning structural and dynamical changes of landfalling hurricanes. Postprints, 3rd Conference on Meteorology of the Coastal Zone, January 9-13, 1984, Miami, Florida. American Meteorological Society, Boston, Massachusetts, 78-80 (1984).

No abstract.

AO-064-84

SHAPIRO, L. J. Review: Intense atmospheric vortices. L. Bengtsson and J. Lighthill, eds. Geophysical and Astrophysical Fluid Dynamics, 25:321-323 (1983).

No abstract.

AO-065-84

SHAPIRO, L. J. Sampling errors in statistical models of tropical cyclone motion: A comparison of predictor screening and EOF techniques. Monthly Weather Review 112(7):1378-1388 (1984).

Statistical model significance, sampling and forecast errors are compared between linear regression models developed from preselected and ordered Empirical Orthogonal Function (EOF) predictors and those selected by a forward stepwise screening technique. As a particular application, grid-point height predictors are used to forecast tropical storm displacements in a storm-heading oriented coordinate system. Critical correlations for model significance and upper bounds on expected sampling errors are derived from a Monte Carlo method. It is found that dependence among predictors selected by screening reduces expected sampling errors below those for the same number of independent screened predictors. For the given application, expected forecast errors for screened predictors are only slightly greater than those for EOFs.

AO-066-84

SHAPIRO, L. J., and C. J. Neumann. On the orientation of grid systems for the statistical prediction of tropical cyclone motion. Monthly Weather Review 112(1):188-199 (1984).

Statistical models for the prediction of tropical cyclone motion traditionally have been formulated in a coordinate system oriented with respect to zonal and meridional directions. An investigation is made here into the forecast error reducing potential of a grid system reoriented with respect to initial storm heading. The developmental data comprise Atlantic forecast situations from 1965 through 1980 on all storms initially north of about

25°N. Reorientation of the coordinate system reduces the total variance in 24 h storm motion by 40%, projects most of the motion onto one (along-track) component of displacement, and makes the components nearly independent of each other. For 48 and 72 h displacements, however, these advantageous effects are substantially diminished or eliminated. Synoptic predictors derived from current deep-layer mean heights on a grid of 1700 km radius are used to forecast storm displacements. For the developmental data, grid reorientation lowers the 24 h forecast error by 13%, and reduces the slow speed bias by a factor of 2/3. For 24 h forecasts the skill in the prediction of cross-track motion is small. Empirical Orthogonal Function and Principal Estimator Patterns provide insight into the role of reorientation in the reduction of forecast error, and the position of grid-point height predictors selected by a screening technique.

AO-067-84

SHAPIRO, L. J., and C. J. Neumann. Orientation of grid systems for the statistical prediction of tropical cyclone motion. Postprints, 15th Conference on Hurricanes and Tropical Meteorology, January 9-13, 1984, Miami, Florida. American Meteorological Society, Boston, Massachusetts, 567-573 (1984).

No abstract.

AO-068-84

TSAI, J. J. Acoustic remote sensing of waste disposal in the ocean. NOAA Technical Memorandum, ERL AOML-59, 99 pp. (1984).

Four ocean dumping experiments at three different locations of both shallow and deep water (30 to 3000 m) are discussed and used to illustrate the application of acoustic remote sensing in the study of waste disposal in the ocean. The dumped materials include pharmaceutical wastes, dredged matter, and drilling fluid. Relative isoconcentration maps based on acoustic back-scattered intensity measurements reveal plume structure and space-time particulate distribution of the dumped materials as well as the physical oceanographic features of the water column. Joseph and Sendner's model is applied to describe a two-process diffusion velocity, and the variance. Both the time dependence of the variance and the length scale dependence of the apparent diffusivity show good agreement with those from Okubo. On the basis of acoustic measurements, particle budget is found to decrease exponentially as a function of time in the shallow-water case. Direct and linear relation-ships are found among the observed acoustic intensity, measured total suspended material, theoretically calculated acoustic intensity, and total suspended material calculated from particle number and particle sizes. The analysis can be applied to other types of waste materials, and provide a new approach to monitor waste disposal in lakes, coastal zones, and open oceans.

AO-069-84

WILLIAMS, E. J., E. MARMOLEJO, D. WILSON and R. L. MOLINARI. Current velocity profiles in the Straits of Florida from the Pegasus current profiler: Subtropical Atlantic Climate Study (STACS) 1982. NOAA Technical Memorandum ERL AOML-55, 181 pp. (1984).

No abstract.

AO-070-84

WILLIS, P. T. Drop size distributions in hurricane rainfall. Postprints, 15th Conference on Hurricanes and Tropical Meteorology, January 9-13, 1984, Miami, Florida. American Meteorological Society, Boston, Massachusetts, 533-536 (1984).

No abstract.

AO-071-84

WILLIS, P. T. Functional fits to some observed drop size distributions and parameterization of rain. Journal of the Atmospheric Sciences 41(9):1648-1661 (1984).

A data sample of optical spectrometer measurements that were obtained in two tropical cyclones is analyzed. The resultant drop size distributions are normalized, and their shape is found to exhibit some curvature - departure from exponentiality. When the sample, ordered by rainfall rate, is divided in half, the shape (curvature) of the low rainfall rate half is found to be nearly identical to that of the high rainfall rate half. Five functional fits to the data are explored in detail; three are exponential fits - Marshall-Palmer, least-squares, and "analytical" - , and two are gamma distribution function fits - an analytical and a curvilinear least-squares. The goodness-of-fit is evaluated based on error squared, and on coalescence growth error and drop evaporation error. The coalescence growth and drop evaporation are computed using simple microphysical models. The fits that are based on minimizing squared error do not characterize coalescence growth and evaporation well. An analytical gamma distribution function fit to the measured distributions provided the most reasonable compromise between satisfactory squared-error fit, and realistic characterization of coalescence growth and drop evaporation. With this analytical gamma distribution function fit in mind, modifications to the widely used Marshall-Palmer-based microphysics parameterizations are proposed. These proposed simple modifications should provide a more realistic characterization of coalescence growth and drop evaporation in numerical simulations. Relations between several bulk parameters of the measured distributions and several parameters of the functional fits are derived. These relations are compared with those found by other investigators.

AO-072-84

WILLIS, P. T. Relations between mean Doppler velocity and radar reflectivity factor. Preprints, 22nd Conference on Radar Meteorology, September 10-14, 1984, Zurich, Switzerland. American Meteorological Society, Boston, Massachusetts, 338-339.

No abstract.

AO-073-84

WILLOUGHBY, H. E. The wavenumber-one asymmetry of hurricanes. Postprints, 15th Conference on Hurricanes and Tropical Meteorology, January 9-13, 1984, Miami, Florida. American Meteorological Society, Boston, Massachusetts, 89-94 (1984).

No abstract.

AO-074-84

WILLOUGHBY, H. E., H. L. Jin, S. J. LORD, and J. M. PIOTROWICZ. Hurricane structure and evolution as simulated by an axisymmetric, nonhydrostatic numerical model. Journal of the Atmospheric Sciences 41(7):1169-1186 (1984).

This paper reports numerical simulations of the hurricane vortex by an axisymmetric, nonhydrostatic numerical model with 2 km maximum horizontal resolution. Most convection is modeled explicitly using two different microphysical parameterizations. The first simulates liquid water processes only, whereas the second includes ice processes as well. Although concentric rings of convection associated with local maxima of the tangential wind form in both versions of the model, they are much more common when ice processes are included. As they contract about the vortex center, the outer ones supplant the inner. Their contraction follows the mechanism suggested by balanced-vortex models. Some of the rings appear to form through symmetric instability of the vortex, and others, particularly when ice processes are included, through interactions between precipitation-induced downdrafts and the boundary layer. Both the rings' evolution and the detailed structure of the vortex core are similar to recent aircraft and radar observations. Among the realistic features are: outward slope of the eyewall updraft and tangential wind maximum; relative location of the updraft, wind maximum, and precipitation maximum; stratiform precipitation and mesoscale downdrafts outside the eye; and midlevel radial inflow.

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