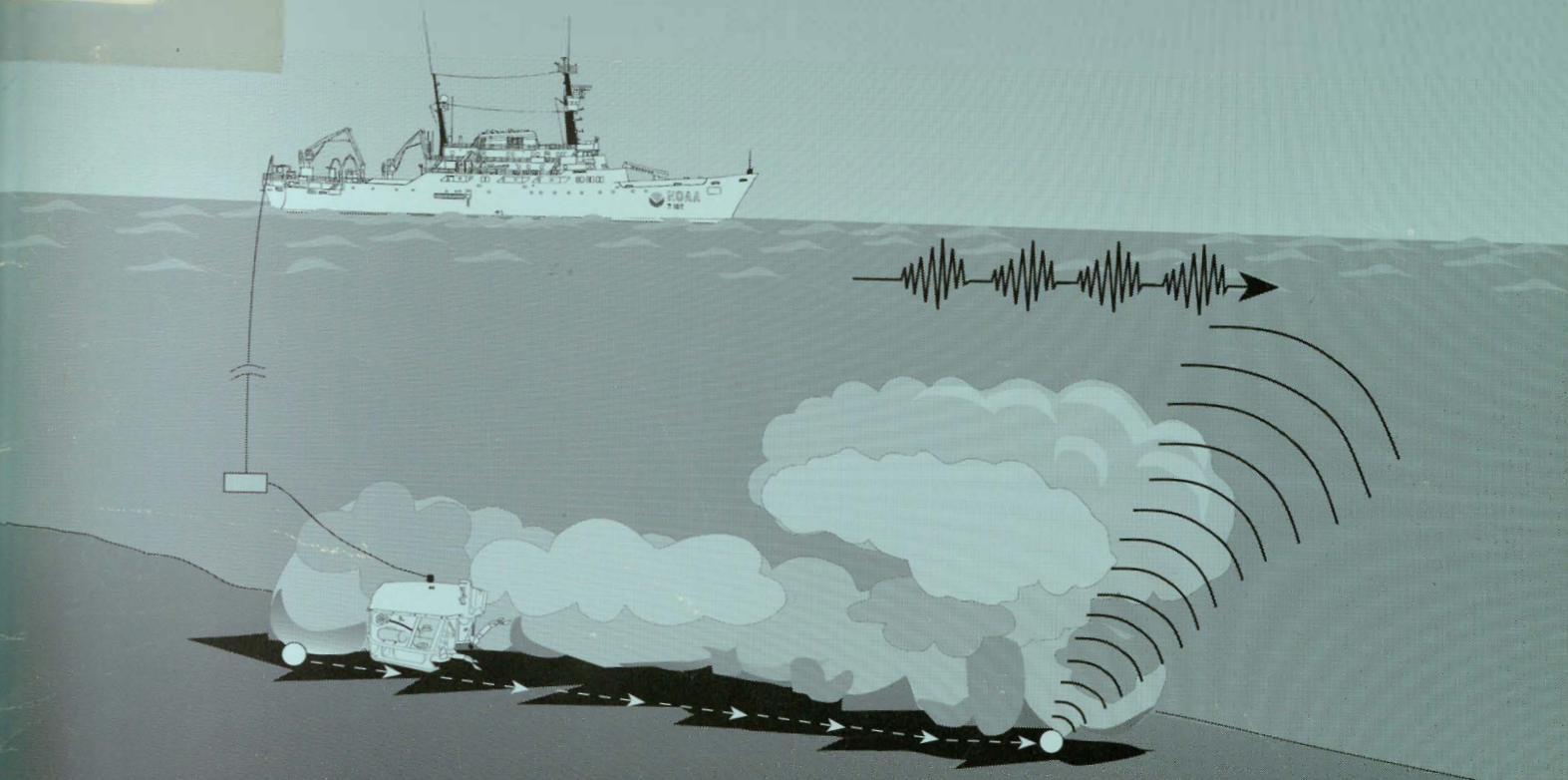
# *Pacific Marine Environmental Laboratory*

# Summary Report for FY 93



United States Department of Commerce

# PACIFIC MARINE ENVIRONMENTAL LABORATORY
# SUMMARY REPORT FISCAL YEAR 1993



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Pacific Marine Environmental Laboratory
7600 Sand Point Way NE
Seattle, WA 98115

**UNITED STATES DEPARTMENT OF COMMERCE**

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# INTRODUCTION

E.N. Bernard, Director

The Pacific Marine Environmental Laboratory (PMEL) carries out interdisciplinary scientific investigations in oceanography, marine meteorology, and related subjects. Current PMEL programs focus on coastal and open ocean observations in support of prediction of the ocean environment on time scales from days to decades. Studies are conducted to improve our understanding of the complex physical and geochemical processes operating in the world oceans, to define the forcing functions and the processes driving ocean circulation and the global climate system, and to improve environmental forecasting capabilities and other supporting services for marine commerce and fisheries.

PMEL complements its research efforts through two ERL cooperative institutes: the Joint Institute for Study of the Atmosphere and Ocean (JISAO), with the University of Washington; and the Joint Institute for Marine and Atmospheric Research (JIMAR), with the University of Hawaii. PMEL also conducts complementary research programs with NOAA's National Marine Fisheries Service (NMFS) and the Cooperative Institute for Marine Resources Studies (CIMRS), a joint organization with Oregon State University.

# OCEAN CLIMATE RESEARCH

## *Accomplishments FY 93*

### TOGA TAO Observing Array in Tropical Pacific

The Tropical Ocean-Global Atmosphere (TOGA) Tropical Atmosphere Ocean (TAO) array of Autonomous Temperature Line Acquisition System (ATLAS) moorings and Profile Telemetry of Upper Ocean Currents (PROTEUS) moorings grew from 49 to 65 sites during FY 93. The array includes five sites specific to the TOGA Coupled Ocean-Atmosphere Response Experiment (TOGA-COARE) in the western Pacific. The time series at 0°, 110°W is now more than 13 years long. The Pacific array is supported by five nations (United States, Japan, Korea, France, and Taiwan). In addition, two TAO moorings were deployed in the Indian Ocean in July 1993 in collaboration with Commonwealth Scientific and Industrial Research Organization (CSIRO) of Australia and the Institute of Meereskunde in Germany. The Indian Ocean moorings were deployed to study wind and temperature variability associated with the monsoons during the Indian Ocean World Ocean Circulation Experiment (WOCE).

The Pacific Array will be completed by the end of 1994. A TOGA-TAO Implementation Panel was instituted in FY 93 under sponsorship of the International TOGA Scientific Steering Group to ensure a coordinated multinational approach to implementation. TAO has been identified in national and international climate program plans as a high priority for continuation when TOGA ends in December 1994, after which the array will be maintained in support of the Climate Variability and Prediction Program (CLIVAR), Global Ocean Observing System (GOOS), and Global Climate Observing System (GCOS).

In FY 93, PMEL signed a memorandum of understanding with Japan Marine Science and Technology Center (JAMSTEC) for the study of short-term climate studies with an initial focus on the tropical Pacific. As part of this agreement, JAMSTEC has pledged 50 days of shiptime per year for the next 10 years to support the TAO Array west of the international dateline.

A major breakthrough occurred in November 1992 in the transmission of the TAO Argos data stream on the Global Telecommunication System (GTS). Data throughput from TAO Array buoys to the GTS increased from 10–30% to 80–90% of the data available at the buoys. Operational centers, e.g., National Meteorological Center (NMC), European Centre for Medium-Range Weather Forecasting (ECMWF), and FNOC, are now assimilating TAO data into numerical weather prediction models in much larger numbers than previously, and impact studies are under way to assess resultant improvements in operational analyses and predictions.

The TAO Display Software is an interactive system for distributing and displaying the real-time data from the TOGA-TAO buoys in a modern, point-and-click, UNIX or x-window, workstation environment. In FY 93, new graphics displays were added, including time-longitude plots, objectively analyzed fields of sea surface temperature (SST) and dynamic height, new animations, and access to the previous 12 months of data. Under development is a new release of the software that will include access to historical TAO data and displays of related data sets, such as the National Aeronautics and Space Administration's (NASA) Topographic Experiment (TOPEX), POSEIDON (French component of joint U.S./French

TOPEX/POSEIDON sea surface topography satellite mission; not an acronym), and European Satellite Agency (ERS) Remote Sensing Satellite-1 (ERS-1) data, in addition to basic display and analysis tools.

In FY 93, approximately 15 refereed journal articles were published using TAO data, in addition to approximately 25 technical reports, articles in meeting proceedings, published abstracts, and news articles. About 60% of these involve PMEL authors. Research at PMEL has focused in part on a description of the 1991-1993 El Niño-Southern Oscillation (ENSO) that evolved differently from any previous ENSO in the past 40 years (i.e., the period over which sufficient data exist to make meaningful comparisons). An analysis of ocean-atmosphere coupling on intraseasonal time scales has shown that surface winds associated with atmospheric convection propagating from the Indian Ocean to the Pacific Ocean excites equatorial Kelvin waves, which can be traced into the eastern Pacific Ocean. These linked Indo-Pacific phenomena may play an important role in the dynamics of ENSO. Other studies include examination of the role of shallow haloclines in the heat budget of the western Pacific; the statistics of rainfall variability and its relationship to rainfall west of the dateline; a basin-scale description of the diurnal cycle in the tropical Pacific; the relationship between diurnal heating, surface heat fluxes, internal mixing, and internal waves in the cold-tongue region; descriptive and diagnostic studies of the annual cycle of currents and temperature in the tropical Pacific; the importance of trade wind fetch in determining the strength of the Equatorial Undercurrent; validation of sea level measurements from the TOPEX/POSEIDON altimeter; the role of instability waves in determining the distribution of $CO_2$ gas concentrations in the equatorial cold tongue; the importance of clouds versus evaporative heat flux in limiting maximum SSTs in the western equatorial Pacific warm pool; and scale analyses of upper ocean thermal variability using moored time series data, with a view toward improving thermal field sampling strategies for short-term climate studies.

## Carbon Dioxide Program

The primary objective of NOAA's Ocean Atmosphere Carbon Dioxide Exchange Study is to assess quantitatively the fate of $CO_2$ in the atmosphere and oceans. To do this, the natural sources and sinks of $CO_2$ must be determined. During FY 93, the PMEL $CO_2$ group continued to participate in the U.S. Joint Global Ocean Flux Study (JGOFS) Equatorial Pacific Process Study. The goal of this study was to determine the relationship between the biogeochemical cycles of carbon and nitrogen species and physical forcing in the upper ocean. The fall cruise on NOAA ship *Discoverer* was a companion to the spring cruise aboard NOAA ship *Malcolm Baldrige*, during which time the 1991-1992 ENSO was occurring. These cruises were integrated with the National Science Foundation (NSF)-funded process studies along 140°W aboard the R/V *Thompson*. $CO_2$ partial pressures and wind data from the spring and fall cruises indicated significant reductions (0.5-0.7 gigatonnes of carbon per year) in the air-sea exchange of $CO_2$ in the eastern tropical Pacific during the ENSO period as compared with non-ENSO periods. This resulted in an appropriate slowdown in the rate of growth of $CO_2$ in the atmosphere. The data from the JGOFS cruises provide the first comprehensive data source that substantiates this important process in the global carbon cycle. The $CO_2$ group also participated in a joint Atlantic Oceanographic and Meteorological Laboratory (AOML)/PMEL cruise aboard NOAA ship *Malcolm Baldrige* to determine the source and sink regions of $CO_2$ in the equatorial and North Atlantic.

## Chlorofluorocarbon Tracer Program

Data from six earlier cruises were published in a NOAA Data Report. A report also was published that discusses the chlorofluorocarbon (CFC) Tracer group's techniques for preparing CFC intercomparison standards, and that presents the results of a multinational CFC intercomparison program for WOCE.

For the second year, CFCs and helium and tritium were used as tracers to monitor variability of a dense water formation and ventilation process in the Greenland-Iceland-Norwegian Seas as part of NOAA's Atlantic Climate Change Program (ACCP).

A system was constructed for the sealing and long-term storage of seawater samples for CFC analysis.

A UNIX-based computer system for acquiring and processing data at sea was implemented. This system will speed the processing and interpretation of future datasets.

Oceanographic expeditions to the western Pacific and North Atlantic were conducted to repeat CTD and tracer sections occupied in these areas in 1987 and 1988, respectively.

## Radiatively Important Trace Species/Aerosol Program

As part of the Radiatively Important Trace Species (RITS)/Analysis Program, PMEL scientists conducted a cruise in 1993 from Antarctica to the Gulf of Alaska to measure radiatively important trace gases in the surface ocean and overlying atmosphere and aerosols in the marine boundary layer. Work continued on assessing the ocean-atmosphere flux of methane, carbon monoxide, and dimethylsulfide. A major addition to the program was the initiation of daily chemical aerosol sampling at the new NOAA aerosol monitoring stations in North America. The results from this study will be used to assess the anthropogenic impact of aerosol particles on the radiative forcing of Earth's climate.

## Thermal Modeling and Analysis Project

The Thermal Modeling and Analysis Project continued to be involved in the enhancement of the integrated model-observations gridded dataset analysis system (called FERRET) in a variety of satellite and in situ data analysis projects associated with tropical ocean-atmosphere variability and in model studies of the forced tropical ocean.

Data analysis work centered on trying to determine the space-time structure of westerly wind events in the western tropical Pacific to see if it is possible to introduce a taxonomy for westerly wind events based on quantitative criteria and to construct various statistics including composites. Both satellite wind datasets and analyses of surface winds from NMC, FNOC and ECMWF were used. Also a detailed study of the characteristics of ENSO at the ocean surface since 1951 has begun. This study is motivated by the fact that ENSO events since 1972 have tended not to resemble the composite ENSO evaluated by other researchers.

Numerical modeling work has involved studies of both the 1986-1988 and 1991-1993 ENSO. Hindcasts have been made of all the ENSO events since 1957 using the Florida State University pseudo-stress fields

to examine the similarities and differences between events according to the model. This effort is motivated by the very serious lack of subsurface observations for ENSO periods during most of this period. A number of idealized studies have also been made to explore the processes responsible for the seasonal evolution of upper ocean SST and currents in the tropical Pacific.

New features added to FERRET in FY 93 include a state-of-the-art, color, on-screen animation capability; compatibility with EPIC (not an acronym), which is PMEL's system for management, display, and analysis of oceanographic data; and a port to the Macintosh computer. Progress also was made in developing a point-and-click, graphical user interface (GUI) and output through the Generic Mapping Tools (GMT) package, which provides publication-quality mapping projections. Sites actively using FERRET are the National Center for Atmospheric Research, Massachusetts Institute of Technology, Los Alamos National Laboratory, National Marine Fisheries Service, University of Hawaii, University of Rhode Island, University of British Columbia, Texas A&M University, University of Washington (6 departments), and numerous others.

## Western Boundary Currents

Estimates of the transport variations in the Florida Current continue to be made from cross-stream voltage measurements using an abandoned cable between Key West, Florida, and Havana, Cuba, and an in-service telephone cable between West Palm Beach, Florida, and Eight Mile Rock, Grand Bahamas Island. The Key West voltages have been calibrated by the use of downstream estimates of the transport derived from current meter mooring data. These transport measurements show a 3- to 6-sverdrup (Sv) increase in transport between Key West (the southern end of the Straits of Florida) and West Palm Beach (the northern end of the Straits of Florida) due to transport into the Straits through the side channels. The long-term mean transport is 32 Sv at West Palm Beach. Almost no correlation exists in the transport variations between Key West and West Palm Beach. The lack of correlation probably is due to eddy and meandering motions being transported downstream as the Straits of Florida shoals and changes direction.

Voltage measurements have been started using one of the abandoned undersea telephone cables extending northeast from Hampden, White Bay, Newfoundland, into the Labrador Sea. The measurement of the cable resistance indicates the cable extends about 270 nautical miles to the edge of the continental shelf (200–300 km depth) where it is broken. Historically, cable breaks due to trawlers usually have occurred at the edge of the shelf. Because of the present moratorium on fishing, this cable is likely to remain intact for a very long time. This cable, therefore, is suitable for long-term monitoring of cross-stream voltages and, thereby, the transport of the Labrador currents on the shelf. These observations will be carried out in collaboration with Memorial University, St. John's, Newfoundland, Canada.

# *Plans FY 94*

## TOGA-TAO Observing Array in the Tropical Pacific

- Continue implementation of the TOGA TAO Array.

- Continue and expand TAO-related studies of ocean-atmosphere interaction, short-term climate variability, and ENSO dynamics.
- Continue development of the TAO workstation.
- Participate, as required, in the effort to convert a U.S. Navy T-AGOS class submarine surveillance vessel to service 49 moorings east of the dateline beginning in mid-1995.

## Carbon Dioxide Program

- Complete the analyses of data from the FY 93 cruises in the central and eastern Equatorial Pacific and publish the results in the JGOFS special issue of *Deep-Sea Research*.
- Complete the analyses of North Atlantic data.
- Conduct a survey of $CO_2$ distributions in the eastern South Pacific along 110°W. Determine the interannual variability of $CO_2$ gas distributions in surface waters and provide new data for total inorganic carbon species and $CO_2$ gas distributions in subsurface waters.

## Chlorofluorocarbon Tracer Program

- Complete the processing of earlier CFC datasets and release these data in a series of NOAA technical reports.
- Complete a series of interpretive manuscripts utilizing CFC data, including validation studies that compare computer-generated numerical model simulations with observations of CFCs and other oceanographic data.
- Continue to document the invasion of CFCs and other tracers into the world ocean by playing a lead role in a NOAA-supported 1994 oceanographic expedition in the southeastern Pacific as part of the WOCE program.
- As a NOAA contribution to the international WOCE program, perform CFC analyses on additional WOCE oceanographic expeditions.
- Improve the analytical capability of PMEL's CFC Tracer Program by designing new CFC analytical instruments and calibration systems.

## Radiatively Important Trace Species/Aerosol Program

- Repeat the Antarctica-Gulf of Alaska cruise track to assess the seasonal variability of trace gases and aerosol particles in the marine environment.
- Participate in the International Global Chemistry Program planning for the first Aerosol-Climate Experiment (ACE-1).

## Thermal Modeling and Analysis Project

- Publish results of accomplishments reported here.
- Develop an understanding of the unusual evolution of the 1991-1993 ENSO event in the ocean, using our model hindcasts; explore the model response to the different sorts of composite westerly wind events that have come from our wind analysis.
- Carry out studies of the seasonal cycle and interannual variability of the Indian Ocean.
- Create, using funding from the Earth System Data and Information Management (ESDIM) program, an Internet-wide gridded data server based on a working version of the GUI.
- Continue to enhance FERRET's mapping options.

- Develop ports to IBM and Digital/Alpha computers.
- Develop a new and more thorough set of documentation to assist new FERRET users.

## Western Boundary Currents

- Continue making plans to start voltage recording on the cable extending from Greenland southwest into the Labrador Sea.

# COASTAL AND ARCTIC RESEARCH

## *Accomplishments FY 93*

### Fisheries-Oceanography Coordinated Investigations

The goal of Fisheries-Oceanography Coordinated Investigations (FOCI) is to understand the coupled physical-biological interactions that affect survival of walleye pollock (*Theragra chalcogramma*) in Alaskan waters and ultimately lead to variations in recruitment. Recruitment is the process by which young fish are added to the adult or fished stock. Research has been conducted in support of the paradigm that such fluctuations largely are a result of events during early life history. Our understanding of processes affecting recruitment has advanced to the degree that last year FOCI provided U.S. fishery management with recruitment information independent of that gathered from the commercial fishery for establishing pollock fishing quotas in the Gulf of Alaska. In fall 1993, FOCI again will supply estimates of pollock biomass for the Gulf of Alaska.

Since the inception of FOCI in 1985, an interdisciplinary team of scientists has focused its research on Shelikof Strait, which is the spawning locale for the commercially important Gulf of Alaska pollock. In FY 92, a Bering Sea component was added to FOCI under the auspices of NOAA's Coastal Ocean Program. Bering Sea research identifies the different aggregations of pollock, their relation to dominant circulation features of the Bering Sea, and the effects of basin, slope, and shelf habitats on the early life stages of pollock.

#### *Shelikof Strait, Gulf of Alaska*

FOCI made predictions in fall 1992 for the 1989, 1990, 1991, and 1992 year classes (year when fish were spawned) of walleye pollock recruiting to the Shelikof Strait fishery. The preliminary prediction scheme used objective statistical analyses of spawner-recruit data and the FOCI-extended recruitment time series. Predictions were modified subjectively by researchers' knowledge of the environment. FOCI's predictions helped the Resource Ecology and Fisheries Management (REFM) division of NOAA's Alaska Fisheries Science Center define recruitment scenarios for their stock projection model. Analysis of stock projections and catch scenarios by REFM results in fishing quota recommendations to the North Pacific Fishery Management Council.

The following were FOCI's predictions for year-class recruitment to the Shelikof Strait fishery: 1989, weak; 1990, weak to average (modified to weak by REFM based on the hydroacoustic survey); 1991, weak (modified to weak or average by REFM based on the hydroacoustic survey); and 1992, strong (downgraded to average by REFM for conservation). The predictions of weak 1991 and strong 1992 year classes are supported by analyses of sea-bird diet and by the character of the local ocean circulation. Because REFM depends solely on surveys and FOCI predictions to design recruitment scenarios, FOCI's predictions thus double the available information for decision making.

Modeling studies are being used to help assess the impact of interannual changes in circulation on the survival of pollock larvae. The circulation model used is the Semispectral Primitive Equation Model

(SPEM), suitably modified for this region. The model currently is driven with daily wind stress, from Fleet Numerical Meteorology and Oceanography Center (FNMOC) surface analyses adjusted for local topographic effects, and with seasonal patterns of freshwater runoff. The model has a horizontal resolution of 4 km and nine vertical levels to replicate the observed current shear. Model code is designed to take advantage of vector-processing computer architecture.

Coupling of the circulation model with an individual-based model (IBM) of egg and larval growth has been achieved. This coupled model tracks large numbers of developing eggs and larvae as they migrate vertically and are advected by the circulation. The biological model is probabilistic; feeding and mortality are stochastic functions of time and the local physical environment. Our motivation for such an approach is the observation that wide variability exists within natural fish populations, and models of the "average" individual are likely to be misleading. As a result of tracking the unique spatial, temperature, salinity, and feeding histories of representative individuals, more of the natural variance within the population can be reproduced. For example, analysis of statistics from a coupled model experiment suggested how the unique spatial histories of different individuals can yield a bimodal distribution of weights and lengths within a single year class. In contrast, a model with no spatial information yielded a simple unimodal distribution.

Thus far, model runs have succeeded in reproducing the general spatial features of the circulation field as inferred from drifting buoy data and hydrographic surveys. A comparison of model output with moored current meter data for 1989 has yielded exceptional agreement. Model-generated spatial patterns of larval density on specific days in 1989 compare well with field surveys for that year. Such biophysical simulations suggest physical causes for part of the interannual variability in pollock survival. Potentially, they will be used to help forecast recruitment success under changing physical conditions.

Currents and eddies in Shelikof Strait and its accompanying sea valley were examined. Analysis of the transport along the Alaskan coast has improved the understanding of the dynamics of the Alaska Coastal Current (ACC). Larval survival, at least in part, is related to the strength of the ACC. The ACC is forced not just in Shelikof Strait but also to the east. Physical conditions that retain larvae on the continental shelf, as opposed to transporting them into deeper waters, are believed to enhance survival of pollock in Shelikof Strait. The formation of mesoscale eddies on the shelf helps to retain (on the shelf) larvae, plankton, and nutrients associated with shelf waters in particular areas. Such processes vary from year to year as physical conditions change. A careful examination of the dynamics within an eddy observed in 1989 in the Shelikof region was completed. The 1989 eddy was associated with a larval patch, and apparently, larval mortality was less within the eddy than outside. To discover how common these mesoscale eddies are, a census of number of eddies in Shelikof Sea valley was completed. Eddies were most common in the spring, when up to four occurred each month.

## *Bering Sea*

Bering Sea FOCI has acquired considerable knowledge of the basin-wide circulation in the Bering Sea. Prior to Bering Sea FOCI, barely more than anecdotal information existed. In August 1991, on a cruise conducted in both U.S. and Russian waters, operations included 112 CTD casts, release of 25 satellite-tracked drifters, and deployment of 3 current moorings in Near Strait, the wide opening between the Aleutian and Komandorski Islands. During this cruise, no Alaskan Stream water was flowing into the Bering Sea through Near Strait; furthermore, the Kamchatka Current outflow was only half its normal

value. A year later, however, CTD and drifter data showed well-developed inflow through Near Strait, and current meters in Near Strait recorded the evolution of this inflow. Thus, a major, interannual variation in the inflow to the Bering Sea was documented. In other respects, however, circulation in the western and central Bering Sea seems more organized and simpler than in many historical schemes of circulation. Flows exist that connect the western, central, and eastern basins. These results also are supported by use of the U.S. Navy ocean layer (one-eighth degree) model, which shows eddy variability in Near Strait and in the west-central Aleutian Basin, but a more regular annual signal in the eastern basin.

FOCI studies in the eastern Bering Sea, mainly with drifters, have revealed distinct currents that may be relevant to pollock larval drift. Flow along the North Aleutian Slope appears capable of transporting larvae onto the eastern shelf in less than 3 weeks. A pathway across the northern basin has also been identified. This flow could transport larvae or immature fish to the Russian coast in about 3 months. Thus, a time-scale match exists between drift velocities and the potential requirement for pollock larvae to advect onto the shelf to have strong year classes. Water temperature north of the middle front on the Bering Sea shelf also may play a role in the rate of larval growth, which also contributes to survival and fisheries recruitment.

Eddies and high concentrations of pollock larvae often are coincident in Shelikof Strait, and a similar relationship exists in the eastern Bering Sea. Mesoscale (80–150 km diameter) eddies are common features in both circulation schemes and dynamic topographies of the oceanic waters of the eastern Bering Sea. The typical separation of CTD stations and lack of adequate sea surface temperature gradients have left the smaller eddies unresolved. Between 1988 and 1993, 12 satellite-tracked buoys were deployed in four eddies in the southeastern Bering Sea basin. Our success in finding eddies resulted from placing buoys in high concentrations of pollock larvae. Similar biophysical processes may be occurring in both the Gulf of Alaska and Bering Sea that increase the likelihood of larval survival within eddies.

A time-series mooring was placed north of the eastern Aleutian Islands during spring and summer 1992 and 1993 in an area of known pollock spawning. Meteorological measurements are wind, humidity, solar insolation, and air and sea temperature; oceanographic measurements are current, salinity, bio-optical properties, and backscatter from zooplankton. For the first time, measurements have been obtained of the mixed-layer's development and the hourly zooplankton abundance throughout the spring bloom. The steady trend of mixed-layer shoaling was punctuated by one strong storm event that deepened the mixed layer near the time of the pollock larval spawning. The data will be used to test the hypothesis that larvae are food limited in the spawning grounds of the Aleutian basin and must be advected to the Bering Sea shelf to produce a strong year class.

## Sea Ice-Troposphere Interaction

### *Chukchi Sea*

In FY 93, analyses were completed of oceanographic, meteorological, and sea ice data obtained from the northern Bering Sea and Chukchi Sea region during the autumns of 1987 to 1991 in cooperation with Russian scientists. These data were acquired as part of a program designed to compare air, sea, and ice conditions during the autumn in the western Arctic. The ice edge was significantly farther north

in 1987 and in 1989 to 1991 than in 1988, when ice existed along the coastline from Barrow to Icy Cape. In 1987 the ice edge was anomalously far to the north as late as October, and the autumn ice edge advance was later than in 1988 or 1989 and later. Interannual variations were observed throughout the region but were greatest in the northern Chukchi Sea. There, surface oceanic isotherms and isohalines were shifted nearly 2° latitude farther south in 1988, coincident with the southward displacement of the ice edge. However, the subsurface water at 20 m and 35 m deep in the same region was actually warmer in 1988 than in other years. From mid-August until mid-October 1988, the wind blew mainly from the north, averaging nearly 10 m $s^{-1}$ across the Chukchi Sea. Although other years had northerly wind events that were as strong, the persistence of this pattern was striking. Also embedded in this northerly wind regime was a 2-week period in September with westerly winds that caused the pack ice to be pinned against the beach along the northwest coast of Alaska, leading to the infamous media event of three trapped whales near Barrow. By contrast, other years had higher variances in the wind and significantly fewer instances of northwesterly winds than 1988. There is no evidence for a sea water temperature anomaly upstream, southward of the ice edge during 1988. Ice continually eroded along the southern front until the surface mixed layer reached a thermally quasi-stable state near the freezing point, which was the result, not the cause, of the extreme presence of ice in the Chukchi Sea in 1988.

### *Barents Sea*

A harmonic analysis of tidal and inertial motion was applied to observations of position of Argos buoys (buoys that transmit data via Argos, a satellite-based data telemetry and geolocation system) deployed on drifting multiyear sea ice in the Eastern Arctic-Barents Sea during the Coordinated Eastern Arctic Experiment (CEAREX) in 1988–1989. An Argos positioning-data screening protocol was developed and a constrained least-squares algorithm was constructed for separate estimation of mean tidal and inertial currents. This analysis provides estimates of individual tidal components at 15-day intervals along the sea ice buoy drift tracks. This technique shows a reasonable qualitative distinction between tidal and inertial oscillations at nearby semidiurnal frequencies. Estimates of errors due to sampling and colinearity are derived directly from model statistics. Estimates of velocity produced from the unequally time-based data are then used for interpolation to a regular time grid for spectral analysis and ice motion studies. Computed velocities of up to 70 cm $s^{-1}$ for the principal lunar component ($M_2$) of tidal motion over Spitsbergen Bank southeast of Svalbard are in reasonable agreement with the regional Norwegian tidal model.

## West Coast Wind Forecasting

A major multiyear research program, Coastal Observations and Simulations with Topography (COAST), was established in FY 92 and is starting in the fall of 1993. The objective of this program is to identify and understand the influence of terrain on coastal weather phenomena, with the ultimate goal of improving weather, wind, and sea state forecasting in the coastal zone. It is sponsored by NOAA's Coastal Ocean Program and the Office of Naval Research, and also involves ERL's Environmental Technology Laboratory (formerly Wave Propagation Laboratory), the National Weather Service (NWS), and various universities.

A case study was completed on an unanticipated coastal wind storm near Yakutat, Alaska. This study showed that intense winds were caused by a propagating pressure surge associated with a damming of the onshore-directed flow by the coastal terrain. NWS is sponsoring a follow-up study of the climatology and dynamics of these events in collaboration with forecasters from Juneau and Anchorage, Alaska.

A remote-sensing wind and temperature profiler was obtained for the Puget Sound region by a consortium including NWS, PMEL, the Puget Sound Air Pollution Control Agency, the Washington State Department of Ecology, the Environmental Protection Agency, and the University of Washington. This instrument will be used for climatological and mesoscale meteorological research in collaboration with the Seattle office of NWS.

These activities represent the beginning of a 5-year program involving a blend of observational, modeling, and theoretical work. COAST will address a fundamental research issue with important implications for operational forecasting anywhere there is significant terrain.

# *Plans FY 94*

## Fisheries-Oceanography Coordinated Investigations

### *Shelikof Strait, Gulf of Alaska*

- Measure Shelikof Strait and northwestern Gulf of Alaska winds, currents, and chlorophyll from moorings to address questions of coastal transport and phytoplankton blooms.
- Collect biological samples to determine relationships between spawner and egg distributions, duration of spawning, the fate of spawned eggs, larval and food conditions, and predators.
- Continue development of the SPEM-IBM model.

### *Bering Sea*

- Continue development of molecular techniques to analyze the genetic architecture of Bering Sea pollock.
- Integrate available physical information on Bering Sea currents with existing fisheries population models for Bering Sea pollock to explore model sensitivity to physical information.
- Examine the availability of prey (standing stock and production), larval feeding mechanisms, and larval feeding condition (gut fullness, prey type, and physiological condition). Develop a polyclonal or monoclonal antibody specific to larval pollock muscle tissue that can be used to probe gut contents of invertebrate predators. Collect samples in the Bering Sea to analyze the incidence of invertebrate predation, the abundance of predators and larvae, and the diel distributional overlap of predator and prey.
- Conduct a site-intensive, process-oriented study of juvenile pollock to examine their diel vertical distribution in relation to physical conditions such as temperature, density, and light as well as biotic influences such as prey densities, jellyfish abundance, and predator distribution.
- Observe smaller, regional physical processes important to pollock production in the southeastern Bering Sea. Examine transport and eddies in the regions where pollock spawn. Measure the flux of water from the slope onto the shelf. Record seasonal and event-scale processes using a biophysical mooring placed on the slope.

- Observe the spring bloom to determine if the larval critical period matches the initial production of larval prey. Also, investigate the affect of wind events on the feeding conditions for larvae. Use model to generate and evaluate alternative hypotheses and mechanisms affecting larval growth and survival.

## Sea Ice-Troposphere Interaction

- Instrument 15 adjacent sea ice floes in September 1993 in the Beaufort Sea with innovative position-tracking buoys. Describe the sea ice deformation field on scales of 1 to 10 km over an entire season and compare these observations with candidate ice rheologies for next-generation climate and operational forecasting.
- Complete a manuscript analyzing Chukchi Sea circulation.

## West Coast Wind Forecasting

- Use the NOAA WP-3D research aircraft in December 1993 to observe landfalling storms and fronts along the coasts of Oregon and Washington.
- Conduct observations with a remote-sensing wind and temperature profiler in collaboration with the Seattle office of NWS.

# OCEAN ENVIRONMENT RESEARCH

## *Accomplishments FY 93*

### VENTS Program

The VENTS Program is in its tenth year of research focused on determining the oceanic impacts and consequences of submarine hydrothermal venting. The program directs most of its efforts toward achieving an understanding of the chemical and thermal effects of venting along northeast Pacific Ocean seafloor spreading centers. The understanding obtained from this relatively isolated system will eventually be extended to a prediction of the impact of seafloor hydrothermal systems on the global ocean. The attainment of the overall program goal requires a long-term interdisciplinary approach.

VENTS research during FY 93 was concentrated, as in past years, on (1) determining patterns and pathways for the regional transport of hydrothermal emissions, as well as source strengths of the emissions, and their relationships to the geology and tectonics of spreading centers, and (2) further developing capabilities for monitoring hydrothermal activity at a wide range of temporal and spatial scales. Research results continue to augment the case for hydrothermal venting at seafloor spreading centers having global significance in terms of the chemical and thermal state of the ocean. Researchers continued to document quantitatively these effects as they occur in the ocean over a very wide range of temporal and spatial scales.

#### *Hydrothermal monitoring*

T-phases are acoustic signals that are generated by, among other things, submarine earthquakes and submarine volcanic eruptions. The T-phase event detection system is a long-range acoustic surveillance tool that provides the means to monitor such events continuously in the northeast Pacific and virtually the entire Pacific basin through the use of the U.S. Navy's Integrated Undersea Surveillance System (IUSS). Real-time detection of clusters of T-phases (earthquake swarms), which often accompany volcanic eruptions, provides scientists the ability to study associated, concurrent episodic hydrothermal activity. Initial results are showing that the volcanic system off the northwest coast of North America is at least 2 to 3 orders of magnitude more seismically active than previously hypothesized on the basis of land-based seismic monitoring networks.

Accomplishments include implementation of real-time monitoring for T-phase events on the Juan de Fuca Ridge (JDFR), modification of data collection and processing software, and the collection of over 100 gigabytes of data. The recent placement of a long-term moored acoustic sound source at Axial Seamount will improve the accuracy of event location.

The highlight of FY 93 was the first ever detection, verification, and investigation of a volcanic eruption on a midocean ridge. Four days after the real-time T-phase system was activated, several swarms of T-phase events were detected on the JDFR. The swarms, which migrated northward over a period of 36 h, occurred on a 30- to 40-km-long ridge segment recently named CoAxial. The Canadian research

vessel *Tully*, which fortuitously was working nearby, conducted water column surveys that revealed the presence of a large warm-water plume in the area of T-phase swarm activity.

NOAA ship *Discoverer* sailed a week later on a scheduled VENTS Program cruise to support dives by the Remotely Operated Platform for Ocean Science (ROPOS) at the northern Cleft Segment and the Middle Valley hydrothermal field on the northern JDFR. ROPOS is a remotely operated vehicle (ROV) operated by the Institute of Ocean Sciences (IOS), Sidney, British Columbia. PMEL and Canadian scientists on *Discoverer* modified their cruise plan to respond to the CoAxial event. *Discoverer* and ROPOS were utilized to map, photograph, and sample the eruption site after extensive water-column work verified the presence of a "megaplume" and low-temperature venting. Fresh lava mounds were found along a 2.2-km ridge crest, and a new fissure system extended for an additional 5 km. Diffuse venting was present all along this crest with a maximum observed temperature of 51°C. A rumbleometer for measuring vertical crustal motion was deployed. Several current meter and temperature moorings and a RAFOS float were deployed at the CoAxial event site during VENTS leg 3. RAFOS (SOFAR spelled backwards) floats receive positioning signals from a moored sound source in contrast to sound fixing and ranging (SOFAR) floats that send signals to a moored listening station.

### *Transport and source strengths of hydrothermal emissions*

Temporal and spatial monitoring of the effects of hydrothermal venting from midocean ridges continued during FY 93 for the eighth consecutive year. This effort, concentrated in the northeast Pacific Ocean on the Cleft Segment of the JDFR, represents the longest time series available anywhere on the midocean ridge. This time series has documented substantial changes in hydrothermal discharge patterns that evidently are related to the cooling history of magma beneath the ridge axis.

Miniature temperature recorder (MTR) mooring arrays established during FY 92 were recovered, serviced, and redeployed for another year. The MTR moorings continue full-time hydrothermal plume monitoring that began in FY 91.

The effects of heating at the Juan de Fuca Ridge may be seen at least as far as 1000 km to the west, as previously observed by conductivity, temperature, and depth (CTD) observations. Chemical traces have been mapped to a longitude of 180°. These chemical traces are in the form of a helium isotope (helium-3) that originates from hydrothermal venting on the JDFR. Analyses of samples taken on several recent cruises have shown that the core of the effluent off the coasts of Oregon and Washington trends due southwest as it mixes into the north Pacific basin.

## Tsunami Project

The PMEL Tsunami Project, as part of the Coastal Hazards element of NOAA's Coastal Ocean Program, seeks to mitigate tsunami hazards to Hawaii, California, Oregon, Washington, and Alaska through the application of research results to operational products. Research efforts involve three tightly coupled programs–instrumental, observational, and modeling–that are designed to improve our fundamental understanding of tsunami generation, propagation, and inundation dynamics. Application of this research to hazard mitigation focuses on two primary activities: generating improved, site-specific, tsunami inundation maps and developing a real-time-reporting tsunami measurement system.

### *Field work*

Bottom pressure recorders (BPRs) of the Pacific Tsunami Observation Program (PacTOP) network were recovered and redeployed successfully on three cruises.

The Tsunami Project responded with a field effort to three major tsunamis that occurred in Nicaragua, Indonesia, and Japan. The project participated in surveys by international scientific teams to measure the vertical and horizontal extent of tsunami inundations ashore, and to assess tsunami-inflicted damage. Aerial photographs of the affected regions also were acquired for each of these disasters.

### *Modeling and analysis*

A paper was published on the application of a spectral evolution technique to BPR data. This report clearly identifies and quantifies the effects of linear dispersion in the deep-ocean tsunami records.

A report was published on a simulation of the 1960 tsunami inundation of Hilo Harbor. This work employed a state-of-the-art inundation model developed by the Japanese, coupled with a special nested-grid system developed for transoceanic propagation and very fine resolution inundation computations.

A database of 50 years of sea level observations at Hilo, Hawaii, has been developed. The data were used as a basis for establishing objective criteria to assess the effects of background sea level on tsunami inundation. An empirical model has been developed to explore inundation as a function of background sea level, tsunami amplitude, and tsunami duration.

An analysis of multiyear West Coast sea level and Axial Caldera bottom pressure records was completed. Results indicate a lack of interseasonal fluctuations at Axial, and that some effects are due to the passage of weather systems; furthermore, atmospheric pressure compensation at Axial is 80%, compared with 100% at the coast.

## *Plans FY 94*

### VENTS Program

- Reduce, analyze, and interpret physical, chemical, and geological oceanographic data obtained during the FY 93 VENTS *Discoverer* field season.
- Conduct the FY 94 VENTS *Discoverer* field season.
- Continue the decadal-scale monitoring of hydrothermal venting variability on the Cleft Segment of the JDFR including relationships between helium-3, heat, and silica.
- Continue annual and continuous monitoring of hydrothermal plumes at the Cleft Segment in conjunction with in situ and remote geophysical monitoring of volcanic activity.
- Continue with numerical models of physical and chemical processes in the water column around hydrothermal vents and spreading ridges.
- Continue development of equipment, procedures, and software to effectively collect, process, and evaluate T-phase signals in the northeast Pacific and on the East Pacific Rise (EPR).

- Collaborate with Japanese scientists on the first plume mapping and sampling expedition to a super-fast-spreading segment, the EPR from 13°S to 21°S.

## Tsunami Project

- Maintain the Tsunami Project network of observational stations.
- Develop an acoustic link for the tsunami real-time reporting system.
- Prepare inundation maps for Crescent City, California; Eureka, California; and Hilo, Hawaii.
- Extend the West Coast sea level analysis to Southern California.
- Assess wavelet analysis techniques as a sea level assessment tool.
- Assess the importance of background sea level to tsunami inundation at Crescent City, California.

# JIMAR

The Joint Institute for Marine and Atmospheric Research (JIMAR) was formed in 1977 by a Memorandum of Understanding between NOAA and the University of Hawaii (UH). The purpose of JIMAR is to increase the effectiveness of oceanic, atmospheric, and geophysical research of mutual interest to NOAA and the University of Hawaii by promoting multidisciplinary collaboration between scientists and technologists affiliated with, or visiting, these two institutions. JIMAR is located at the University of Hawaii Manoa Campus and is part of the School of Ocean and Earth Science and Technology. The principal research interests of JIMAR are equatorial oceanography, tsunamis, fisheries oceanography, and climate and global change.

## *Accomplishments FY 93*

### Equatorial Oceanography

JIMAR scientists continued to work on major programs in equatorial oceanography, such as the Tropical Ocean-Global Atmosphere (TOGA) program and the World Ocean Circulation Experiment (WOCE). Acoustic Doppler Current Profiler (ADCP) observations were carried out in the intensive observing periods of the TOGA Coupled Ocean-Atmosphere Response Experiment (COARE) program to help quantify advective contributions to the heat and salt balances in the upper tropical ocean. ADCP work also was done as part of WOCE on the Hydrographic Program Pacific Sections. Theoretical studies on deep equatorial circulation continued as well.

A major component of the equatorial oceanography program at JIMAR is the UH Sea Level Center. The UH Sea Level Center continued three major projects: the Indo-Pacific Sea Level Network (IPSLN), the International Global Ocean Services System (IGOSS) Sea Level Project in the Pacific (ISLP-Pac), and the TOGA Sea Level Center (TSLC). The IPSLN operates 41 tide gauges in the tropical Pacific and Indian Oceans. The ISLP-Pac project produces maps of Pacific sea level variability. These maps are produced monthly, with a 1-month lag, and incorporate data from 92 gauges in 28 countries. The TSLC collects, processes, archives, and distributes sea level data from the global tropics. The TSLC archive now contains 2650 station-years of data from 239 stations.

### Tsunamis

The tsunami research effort includes a compilation of historical Hawaiian tsunamis, feasibility studies of new methods of tsunami detection, numerical modeling, and development of improved mitigation strategies. A study of historic Hawaiian tsunamis, based on reports in both English and Hawaiian language newspapers, has been undertaken. The purpose of this study is to make the compiled record of Hawaiian tsunami events as complete and accurate as possible.

The work on the possible use of T-phase signals in the ocean as a means of enhancing detection of tsunamigenic earthquakes was completed. T-phases are low frequency acoustic signals that are

generated by, among other things, submarine earthquakes. It was concluded that T-phase information may be useful for helping decide if a given earthquake has generated a tsunami.

JIMAR researchers use numerical modeling techniques to study various tsunami generation, propagation, and inundation problems. Tsunami inundation modeling calculations for Eureka and Crescent City, California were carried out using a hypothetical offshore disturbance as input. Model results are being used to develop tsunami evacuation maps for these communities. Further analyses of tsunami inundation model results for Hilo Bay were carried out. A number of different models have been run and the results compared to assess how well tsunami flooding can be modeled.

## Fisheries Oceanography

Work continued on the development of an integrated information system containing pelagic fishery and oceanographic data from the North Pacific Transition Zone (NPTZ). Both hardware and software were added to the system, and NPTZ drift net fishery data and sea-surface temperature data were loaded into the database.

A workshop on physical and biological changes in the Northwest Hawaiian Islands was held. The focus was on interdecadal variability. A manuscript was produced describing the impact of a recent climate event.

Advanced Very High Resolution Radiometer (AVHRR) sea surface temperature data were acquired and archived as part of the CoastWatch Program. Software routines were written to store and retrieve these data, and a "ftp" distribution system was created to distribute CoastWatch data and data products to INTERNET users.

A proposal for a major Pelagic Fisheries Research Program was submitted, and initial funding for 10 projects was received.

## Climate and Global Change

JIMAR was the host for two important climate meetings. In October 1992, JIMAR and the Pacific Basin Development Council jointly sponsored a Pacific El Niño-Southern Oscillation (ENSO) Applications Workshop. The result was a decision to develop a proposal for a Pacific ENSO Applications Center involving the University of Hawaii, the University of Guam, and the Pacific Basin Development Council. In March 1993, a second meeting was held in Guam. A proposal was developed and submitted in August 1993.

In February 1993, JIMAR acted as host for the study conference on the Global Ocean, Atmosphere, Land System (GOALS) program. GOALS is to be the follow-on to the TOGA program. Approximately 150 scientists from the United States and other nations attended this meeting.

Research on the annual and interannual variability of the coupled tropical climate system continued. The purpose is to analyze the annual cycle and ENSO variability of the tropical Pacific Ocean and atmosphere, and to understand the ocean-atmosphere-continent interaction associated with the annual

cycle and interannual variation. Work has concentrated on diagnosing and understanding the transition of the ENSO cycle from a cold to warm phase, and on the climatic regimes of tropical convection. Two types of warm events were distinguished. Type I starts with a coastal warming off Peru, propagating first northwestward and then westward along the equator to the central Pacific. Type II is preceded by equatorial western Pacific warming, developing either nearly synchronously in the equatorial eastern-central Pacific or first in the equatorial central Pacific, followed by an eastward propagation.

Modeling work on the dynamics of the ENSO mode continued. The purpose is to develop an intermediate tropical atmospheric model of relevance to short-term climate variability. A conceptual thermodynamic equilibrium climate model for the tropical Pacific was developed and tested. The model suggests that the tropical atmosphere on a monthly mean time scale is, to the lowest order approximation, in a thermodynamic-equilibrium state in which sea level pressure is controlled primarily by sea surface temperature, and the effects of dynamic feedback on sea level pressure may be parameterized by an empirical sea surface temperature lapse rate relationship. Further studies are needed to establish a firm physical basis for the proposed parameterization.

Work on the dynamics of the carbon cycle in the north Pacific subtropical gyre continued. Dissolved inorganic carbon and titration alkalinity were measured routinely as part of the Hawaii Ocean Time series project. High-precision pH and $CO_2$ gas concentration measurements also were made.

## *Plans FY 94*

### Equatorial Oceanography

- Analysis of TOGA COARE data, and gathering and analysis of ADCP data for WOCE, will continue. Two new ADCP projects will be started. One is to develop an archiving system for shipboard ADCP data; this system is to be compatible with the data-handling capability of the National Ocean Data Center (NODC). The other project is to begin development of a global database of shipboard ADCP data.
- The UH Sea Level Center will undertake a new project, the WOCE Sea Level Center (WSLC). The plan is to extend the TSLC activity to make data available to other researchers in near-real time, within a month or two of collection. The other activities of the UH Sea Level Center will continue.

### Tsunamis

- The work on the historic database on Hawaiian tsunamis will continue.
- In the tsunami modeling area, a workshop is planned to assess the technical capability of a variety of tsunami inundation models currently being used for research in the United States. The question of using one or more of these models in a more operational mode, to make tsunami predictions for a variety of locations based on hypothetical tsunamigenic earthquakes occurring in likely source regions, will be explored.
- A broad-scale model to understand the interaction of tsunami disturbances with the Hawaiian Islands will be developed. Tsunami events generated by local land slides will be included in these studies.

## Fisheries Oceanography

- Enhancement of the NPTZ database will continue. The database will be expanded to include AVHRR, ocean color, and small-scale fishery data. The CoastWatch Program will expand to include Sea Wide Field Sensor (SeaWIFS) and Advanced Earth Observing System (ADEOS) data as well as AVHRR data. New studies in the fisheries oceanography area will be undertaken, including work on stock dynamics, biology, and habitat of pelagic fishes; satellite remote sensing; the influence of oceanographic conditions on protected marine species; and operational aspects of fisheries oceanography.
- The Pelagic Fisheries Research Program is directed toward obtaining an understanding of the dynamics of tuna and billfish fisheries in the Pacific. Work will begin on the following 10 projects:
  - Analysis of pelagic catch and fishing data and integrated modeling, to quantify the effects of local fisheries on fish availability.
  - Design of tag-recapture experiments for estimating yellowfin tuna stock dynamics, movements, and fishery interactions.
  - Analysis of Pacific blue marlin and swordfish population structure using mitochondrial and nuclear deoxyribonucleic acid (DNA) technologies.
  - Automated monitoring of yellowfin tuna at Hawaiian fish aggregation devices (FADS) and the relationship to water mass dynamics based on satellite imagery.
  - Physical characteristics of the environment influencing pelagic fishes.
  - Hawaii pelagic fishing vessel economics.
  - Social aspects of the Hawaiian pelagic troll fishery.
  - Contributions of tuna fishing and transshipment operations to local economies.
  - Development of an assessment model for western Pacific yellowfin tuna.
  - Review of a set of proposals for second-year funding.

## Climate and Global Change

- The study of the transitions of the ENSO cycle will be continued by examining cold events. A new, intermediate coupled ocean-atmosphere model will be developed and used to study the Southern Oscillation.
- In the carbon cycle project, a continuous sampling system for the measurement of $CO_2$ gas concentrations in surface waters will be developed.
- Plans for the move of the National Weather Service Forecast Office to the UH campus continue. A new research theme on tropical meteorology will continue to be developed in conjunction with this move.

# JISAO

The Joint Institute for the Study of the Atmosphere and Ocean (JISAO) fosters collaboration between NOAA and the University of Washington, Department of Atmospheric Sciences and School of Oceanography. JISAO's Director reports to the Vice Provost for Research at the University. The 23 Senior Fellows who constitute the ongoing membership of JISAO are divided almost evenly between University faculty and NOAA Pacific Marine Environmental Laboratory (PMEL) staff who hold affiliate faculty appointments in the University. JISAO is governed by a council whose members are selected from among the Senior Fellows. An administrative board meets biannually to review the JISAO program.

JISAO emphasizes four core research areas: climate, environmental chemistry, estuaries, and fish stock recruitment. Of these four areas, only climate has enjoyed the benefit of ongoing block funding. Fifteen Senior Fellows are involved in various aspects of climate research. Most of the visitors and all but two of the postdoctoral fellows who have been funded through this program over the past 15 years have had primary interests in climate. Five Senior Fellows currently are involved in the environmental chemistry core program. The main research themes have been marine aspects of the carbon dioxide ($CO_2$) problem, organic carbon dynamics, and chemical processes involving the deposition of heavy metals.

During the past 6 years JISAO has played an active role in University and NOAA efforts to establish interdisciplinary research on the global climate system and its sensitivity to human activities. The Institute's Experimental Climate Forecast Center (ECFC) falls within the scope of this effort.

JISAO's climate research focuses on two main themes: large-scale atmosphere-ocean interaction in the tropics, and planetary-scale wave-mean flow interaction. JISAO has increased substantially the level of activity in these areas at the University, and it has promoted collaboration between PMEL scientists involved in Equatorial Pacific Ocean Climate Studies (EPOCS) field programs and University scientists and postdoctoral fellows involved in theoretical and modeling studies of the phenomena under investigation in EPOCS. JISAO activities also have led to increased interaction between atmospheric scientists and physical oceanographers of the University faculty.

The Institute's core (Task I) program, to which the University contributes by waiving indirect costs, supports postdoctoral fellows on 2-year appointments (three currently are in residence); postdoctoral fellows whose salary is paid through fellowships, grants from their home institutions, or grants and contracts from national agencies (JISAO provides space, computer time, administrative services, and other services for this group); distinguished visitors; and a varying number of short-term visitors. JISAO's Task II and Task III programs serve as a vehicle for funding research scientists, graduate research assistants, and grants and contracts that support either collaborative research efforts between NOAA and University scientists or other research in areas compatible with the Institute's major research themes.

# *Accomplishments FY 93*

## Postdoctoral Fellows' Research

Using carbon isotopes (e.g., carbon-14) as tracers, JISAO scientists are investigating the possible sources of decadal to century-scale variations in atmospheric and oceanic circulation during changes in climate regimes. In a project funded in part by a grant from the NOAA Climate and Global Change Program, JISAO used three new sets of atmospheric $^{14}CO_2$ observations derived from high-precision tree-ring measurements to investigate the role of atmosphere-ocean interactions in natural climate variability and atmospheric $CO_2$ uptake. JISAO continued to collaborate with the Goddard Institute for Space Studies (GISS) to simulate the observed meridional $^{14}CO_2$ gradient using the GISS three-dimensional atmospheric transport model. The modeling results help define the strengths and geographic distributions of natural (preindustrial) oceanic $CO_2$ sources and sinks, a subject of intense debate with implications for the ocean's role in removing anthropogenic $CO_2$. JISAO researchers were involved in identifying and quantifying trends in century-scale variability of oceanic circulation using spectral analyses, filtering techniques, and global carbon reservoir modeling with another new $^{14}CO_2$ database (a continuous high-resolution atmospheric time series spanning 12,000 years in bi-decadal time steps). Researchers compared the variability in a new high-precision annual atmospheric $^{14}CO_2$ time series (continuous from A.D. 1510 to A.D. 1954) with known El Niño-Southern Oscillation (ENSO) spectral features and proxy records to assess the value and limitations of this detailed $^{14}CO_2$ information to reveal long-term ENSO behavior.

JISAO research associated with the Consortium Project included several studies using model runs from the NOAA Geophysical Fluid Dynamics Laboratory (GFDL)-University consortium. The mean evolution over 40 years of northern summer monsoons was studied in an experiment using Version R30 of the GFDL general circulation model (GCM), and the findings were compared with well-known large-scale features documented in various observational studies. Researchers also examined the relationships between synoptic-scale disturbances and prominent summertime intraseasonal oscillations in the western Pacific and the Indian sectors using analyses from the European Centre for Medium-Range Weather Forecasting (ECMWF) and NOAA outgoing longwave radiation data. Results have not been reported yet.

JISAO continued working on the development of a new global atmosphere model for climate studies in collaboration with Lamont-Doherty Earth Observatory in New York. The new atmosphere model is solved in terms of model normal modes, which allows use of an analytical time integration scheme that is unconditionally stable and does not introduce phase errors or computational dispersion. Long time steps are hence allowed without introducing unacceptable numerical error. The new model is both accurate and computationally efficient, allowing the long integrations needed for study of interannual and longer term variability.

Using both an ocean GCM and a conceptual two-box model, JISAO has been working on understanding the physical mechanism for interdecadal ocean thermohaline oscillations. Temperature and salinity budget analyses reveal that these oscillations are a manifestation of advective and convective processes. A proposed scenario is that horizontal advective heat transported from subtropical regions warms up the subsurface water in subpolar regions and enhances convection. Convection induces surface cyclonic and equatorward flows, which, together with horizontal diffusion, transport subpolar fresh water into convective regions to weaken or suppress convection. These advective and convective interdecadal

oscillations result mainly from halocline and inverted thermocline structures in the subpolar region, which are maintained by horizontal advective subsurface heating and surface freshening. Advective and convective processes associated with interdecadal oscillations can be characterized as "intermediate ventilation" because heat and salt are released to the surface from the subsurface.

## Experimental Climate Forecast Center

The ECFC investigates the existence of and mechanisms for predictability of climate variations on time scales ranging from a season to 100 years and beyond. Since most long-term climate variability involves the ocean, the ocean and its role in climate form the major thrust of ECFC's work. On longer time scales, the ocean's thermohaline circulation becomes dominant. The ECFC maintains and runs several simplified general circulation sector models of the thermohaline circulation and investigates the mechanisms for thermohaline variability and its effect on climate.

## TOGA-TAO Project

The implementation of the Tropical Ocean-Global Atmosphere (TOGA) Tropical Atmosphere Ocean (TAO) array has been proceeding on schedule. By the end of 1993, approximately 65 buoys will be in place in the Tropical Pacific. The array is enabling the surface wind field and the subsurface thermal structure in the equatorial Pacific to be observed with an increasing level of clarity and detail. Monthly mean winds for the individual moorings in the TOGA TAO array are being compared with monthly mean wind fields derived from the scatterometer carried aboard the European Research Satellite. Instantaneous, pointwise comparisons also are being made at times when the satellite passes over individual moorings. In addition, monthly mean and instantaneous outgoing longwave radiation fields derived from NOAA polar-orbiting satellites are being matched with corresponding wind fields to corroborate the TAO and scatterometer measurements and to delineate the empirical relationship between convection and the surface wind fields over the tropical Pacific.

The impact of the TAO array data on the ECMWF operational analysis is being assessed in collaboration with PMEL and ECMWF. The array measurements are compared with corresponding first-guess and analyzed fields produced at the ECMWF, and the usage and rejection statistics are being examined. Similar analyses also are planned for the operational products generated at the National Meteorological Center (NMC).

## Collaborative Research

JISAO contributed to a variety of projects related to the Fisheries-Oceanography Coordinated Investigations (FOCI) of PMEL and NOAA's Alaska Fishery Science Center. A meteorological study of the Gulf of Alaska focused on the winds in the vicinity of Shelikof Strait, and the implications for the local atmospheric forcing of the ocean. A climatological study of the Bering Sea has shown that a substantial portion of the variability in the basin circulation can be attributed to variability in the wind forcing.

Other FOCI-related activities centered on physical and biological modeling of the northern Gulf of Alaska. A combined physical-biological model has been developed which traces the life histories of individual larvae through space and time.

Numerical modeling of the Bering Sea circulation was conducted using the Navy's layered-ocean model, and the climatological circulation was predicted. Additional model runs, forced by real wind data rather than the Hellerman-Rosenstein climatology, are being undertaken with the aim of simulating an observed circulation anomaly.

Work continued on the development of the FOCI Interactive Network (FIN), an advanced ocean workstation for the research visualization and analysis of environmental datasets. Recently, continuing support and cooperative guidance has been provided by Scripps Institution of Oceanography toward the creation of a "Global FIN" platform with a more generalized geographical mapping component. This unique facility will prove invaluable for accessing a wide variety of data types in studying diverse areas of the world ocean. Finally, field work conducted during the last year included cruises to obtain water property, volume transport, surface chlorophyll, and larval distribution data from the Shelikof Strait FOCI study area.

JISAO scientists contributed to PMEL's Tsunami Project, which is funded in part by NOAA's Coastal Ocean Program. Activities have included analysis of bottom pressure recorder (BPR) data from the Pacific Ocean, and research has focused on the understanding of the accuracy and limitations of the BPR system as it relates to oceanographic signals of interest. These signals include a variety of time scales, from minutes in the case of tsunamis, to months in the case of oceanic disturbances related to meteorological and climatological forcing.

JISAO scientists contributed to PMEL's VENTS Program by conducting research on the chemistry of midocean ridge hydrothermal fluids from several sites on the Juan de Fuca Ridge and East Pacific Rise. The particulate elemental concentrations in more than 500 samples from these two areas were determined by x-ray fluorescence spectrometry. Scanning electron microscopy was used to analyze individual particles from many vent samples. Samples of plume water were analyzed at sea for various major and trace species using flow injection analysis-visible spectrometry.

JISAO scientists contributed to various air-sea interaction and upper ocean mixing studies in the tropical Pacific. Some of these activities fall under the auspices of EPOCS and TOGA. Scientists analyzed time series data of wind, current, temperature, and salinity from Autonomous Temperature Line Acquisition System (ATLAS) and Profile Telemetry of Upper Ocean Currents (PROTEUS) moorings. Quality control has been incorporated into the processing of these data, and they have been disseminated and archived. JISAO scientists were also involved in the development and maintenance of the basic driver program, the graphical user interface, the distribution and installation routines, and the user documentation for the TAO software display system. This system was developed for the distribution and graphical display of the real-time TOGA TAO data, in a modern, point-and-click workstation environment, to the international oceanographic and meteorological community. In addition, JISAO scientists maintained the underlying Epic System Library, to which a major upgrade was completed during the past year.

JISAO scientists continued research activities in ocean chemistry. Two systems to measure $CO_2$ gas concentrations in seawater were set up aboard NOAA Ship *Discoverer*, and $CO_2$ analyses were conducted while the ship was under way during the U.S. Joint Global Ocean Flux Study (JGOFS)-NOAA Equatorial

Pacific Process Study. Temperature, $CO_2$, and wind data were processed to provide maps of $CO_2$ distributions in the equatorial Pacific. An automated Winkler titration system for determining dissolved oxygen concentration in seawater was developed and used on a World Ocean Circulation Experiment (WOCE) cruise aboard the R/V *John V. Vickers*. Approximately 3200 oxygen concentrations from 86 different stations were measured on this cruise; they provided valuable insight into increasing the accuracy of Winkler titration.

Several other analytical instruments were automated. A seawater gas chromatograph was automated to include valve switching, temperature and pressure measurement, and sample selection; as a result, this system allows hands-off operation and reduces operator error. An automated carbon tetrachloride gas chromatograph was developed. Work continued on automating instrumentation for oceanographic measurements of atmospheric and oceanic carbon monoxide, and software was developed for the operation of a continuous data system. Both the sampling equipment and software were used on a recent cruise, and the data that were collected are being analyzed. JISAO also was involved in the design, assembly, and testing of analytical systems for the quantification of chlorofluorocarbons (CFCs) and other halocarbons in the ocean and atmosphere.

Another line of research focused on the production and growth of particles in the marine atmosphere and the effect of these particles on climate. Two approaches were taken. First, an instrument to measure gas phase ammonia was developed. Gas phase ammonia may be important in the formation of marine aerosol particles. The instrument shows promise of being able to measure low levels of ammonia on a time scale of a few minutes. Second, measurements were made of the size-dependent chemical composition of marine aerosol particles. Measurements were accomplished during the Pacific Sulfur/Stratus Investigation (PSI) cruise in 1991, the Marine Aerosol and Gas Exchange (MAGE) cruise in 1992, and the Radiatively Important Trace Species (RITS) cruise in 1993. The first part of the year was spent reducing the PSI and MAGE data. The second part of the year was spent making measurements from Antarctica to Seattle on the RITS cruise.

Field and laboratory work was undertaken to contribute to an understanding of the role of the Arctic in the global climate system. During the reporting period, a variety of oceanographic and sea ice measurements were made on four separate oceanographic cruises on board vessels of Canada, Norway, and the United States. Other contributions included a study to assess the variability of atmospheric energy flux into the Arctic; analysis of air-sea interactions in the Bering Sea, and spatial and temporal characteristics of wind forcing in the Bering Sea basin at intermediate to annual time scales; analysis of tidal and inertial motion of the ice pack in the eastern Arctic Ocean, as measured by Lagrangian drifting buoys, and statistical methodology for analysis of irregularly time-sampled drifting buoy data; and maintenance of a meteorological database used by PMEL researchers in the FOCI program for extracting winds derived from NMC surface pressure fields.

JISAO continued to work on the Thermal Modeling and Analysis Project (TMAP) data analysis routine (FERRET) and supported its use in the research community. FERRET is a computer program for the interactive visualization and analysis of gridded datasets. Activities to enhance FERRET's capabilities included adding the capability for creation and display of animations, using a standard from the National Center for Supercomputing Applications; providing additional mapping projections for better data visualization in extra-tropical regions; managing TMAP's collection of environmental datasets; and adding to the collection.

## Other Projects

JISAO continues to study the coupled ocean-atmosphere system. One project is to examine the interaction between the boundary layer physics and the large-scale dynamics or synoptic-scale disturbances in the tropics. Of particular interest is how this interaction leads to the maintenance of the mean climatological low-level atmospheric circulation and anomalies in this circulation that last for upwards of a season or more. Another project is a multiphase modeling study of the coupled atmosphere-ocean system. This study emphasizes the interannual variability in the tropical Pacific basin, including the ENSO phenomenon. A third project is a modeling study of the midlatitude Pacific atmosphere-ocean system. The purpose of this study is to define the inherent variability in the atmosphere and ocean that is due to localized interactions between the atmosphere and ocean on seasonal to interannual time scales. The objectives of this project include an examination of the hypothesis that the midlatitude upper ocean can recall sea-surface temperature anomalies from one winter season to the next, with the anomalies being sequestered below the thermocline in the intervening summer.

Temperature data collected at four depths in the upper 30 m of the Pacific along 165°E at 5°N, 5°S, and the equator were analyzed in association with wind and outgoing longwave radiation data in order to investigate the diurnal variation. Mixing effects appear in progressively deeper layers for stronger winds, and the diurnal range of the sea-surface temperature is almost proportional to the outgoing longwave radiation. Relatively light winds in the western equatorial Pacific results in a shallow mixed layer unlike deep mixed layers in the subtropics of midlatitudes in the northern Pacific or the eastern equatorial Pacific. Research on mixing mechanisms under light winds is in progress.

JISAO continued to study the physics and chemistry of particles in the marine boundary layer. Year-round measurements were made of key aerosol parameters at the University of Washington's Cheeka Peak Research Station located on the northwest coast of Washington. This project seeks to develop a remote marine Northern Hemisphere aerosol monitoring station and to collect the observational data needed to model properly the climatic effects of anthropogenic aerosols on a global scale. The purchase and installation of a radon detection system was arranged to determine the extent of continental influence on aerosols collected at Cheeka Peak.

The program to study CFCs as environmental tracers matured rapidly during the past year. Marine CFC measurements made during the past year's field activities are expected to yield information on the penetration of anthropogenic gases and ventilation processes for water masses. Laboratory studies continued to improve analytical techniques for measuring dissolved CFCs in seawater. Ocean general circulation modeling of CFC transient tracers continued.

Work continued on a project to determine dissolved organic nitrogen concentration in the equatorial Pacific. Seawater samples were collected for determination of total dissolved nitrogen concentrations along a north-south transect across the equator in the Pacific. Surface samples were collected at 22 stations. Samples for determining the water column profiles of total dissolved nitrogen were collected at three of the stations. The samples were analyzed by high-temperature combustion.

JISAO continued to analyze over 800 seawater samples from the western portion of the south Atlantic Ocean for the $^{13}C/^{12}C$ ratio of dissolved inorganic carbon. The objective is to use the measured change in the $^{13}C/^{12}C$ ratio of the oceanic and atmospheric $CO_2$ pools to determine the amount of $CO_2$ taken

up by the oceans. Preliminary results indicate that the surface water $^{13}C/^{12}C$ ratio has decreased since 1972 by ~0.33‰. Depth profiles of $^{13}C/^{12}C$ indicate a depth-integrated decrease of ~145‰, somewhat lower than the value of 208‰ measured in the Pacific Ocean. The largest $^{13}C/^{12}C$ decreases were observed in the subtropical gyre (22°S) and the northern equatorial ocean (4°N).

JISAO made a detailed comparison of the major continental monsoon circulations as represented by the ECMWF operational analyses and as determined by the results of an extended integration of the R30 version of the GFDL GCM. On the whole, the GCM results successfully captured the structure and evolution of the monsoons. The most serious defect was the tendency for the simulated monsoons to be larger in horizontal scale, particularly over Asia. The study revealed a number of interesting similarities between the structures of various regional monsoon circulations.

JISAO investigators collected data on cloud condensation nuclei (CCN) from Antarctica to Alaska as part of the RITS and marine sulfur program. These data were reduced and will continue to be analyzed along with CCN and size distribution data acquired during another cruise under the auspices of the International Global Atmospheric Chemistry (IGAC)-MAGE program to study the growth and formation of CCN. Knowledge of CCN as controllers of cloud properties is important because the extent and properties of clouds strongly can influence global climate.

The relationship between hemispheric circulation patterns and wintertime sea-ice anomalies in the marginal ice zones over the North Atlantic and North Pacific sectors was investigated using data at 1-week intervals. Clear relationships emerge, even on intraseasonal time scales, with the atmosphere leading the ocean in all cases.

## *Plans FY 94*

- A series of numerical simulations of the climatological mean annual cycle will be carried out in collaboration with GFDL to better understand the pronounced differences between the tropical and Northern Hemisphere circulations in April-May versus October-November. A hypothesis is that these differences are linked to atmosphere-ocean interaction over the equatorial cold tongues and intertropical convergence zones in the eastern Pacific and Atlantic. Over the course of the next year, the results of these experiments will be analyzed and prepared for publication.
- The ECFC will continue its work on the physical basis for the predictability of climate systems. In the tropics, JISAO will continue to examine the time-dependent thermohaline circulations of the world's oceans and try to understand how these time dependencies lead to predictability of the climate system and to the instability of climate.
- JISAO will continue to analyze the impact of TAO array wind data on operational forecasts. JISAO will seek to enhance its collaboration with PMEL in the quality control and data distribution of the buoy observations. Furthermore, taking advantage of the enhanced coverage of the array during the last year, JISAO will study empirically the surface and boundary layer processes over the equatorial Pacific and will try to document the spatial and temporal atmospheric variability in the region.

# CIMRS

The Cooperative Institute for Marine Resources Studies (CIMRS) was established in 1982 to foster collaborative research between NOAA and Oregon State University in the areas of oceanography, fisheries, aquaculture and other marine-related fields and to serve as a center at which researchers may address problems of mutual interest relating to the living and non-living components of the marine and estuarine environment and their interrelationships. Oregon State University is currently involved in research efforts that parallel NOAA/PMEL's VENTS Program objectives in the area of assessing the effect of spreading-center hydrothermal vents on the marine environment and defining the tectonic and volcanological processes producing oceanic crust at the Juan de Fuca Ridge. The research that CIMRS is involved with in NOAA's VENTS Program falls into three main areas: photogeologic characterization of seafloor; acoustic imaging and interpretation of the seafloor; and T-phase event detection. Specifically, studies include the interpretation of geologic structure via seafloor remote-sensing techniques, determining seafloor physical properties from acoustic backscatter data, and the understanding of plate boundary mechanics from acoustical/seismological investigations.

Six CIMRS research assistants and three research associates collaborate directly with VENTS Program scientists in various components of scientific research on the Juan de Fuca Ridge. Institute fellows are assisting in the collection, measurement, and analysis of trace elemental gasses in hydrothermal fluids, particularly $^{3}He$, using ultra high vacuum gas chromatography. The objective of this work is to assess the mechanisms, rates and age of active hydrothermal systems along seafloor spreading centers with the eventual end result of quantifying and predicting large-scale spatial and temporal effects of venting on ocean chemical and thermal budgets. In the T-phase project, CIMRS researchers are processing and interpreting acoustic seismic signals using the U.S. Navy's SOSUS system. The signals are used to detect and locate tectonic and/or volcanic events occurring along the Juan de Fuca Ridge.

In the newest project, CIMRS researchers are taking the lead in developing a VENTS Program Geographical Information System using ARC/INFO software. This integrated database will include attributes of bathymetry, photography, chemistry, physical oceanography and locations of T-phase events and will be especially important over the next several years as the North Cleft segment of the Juan de Fuca Ridge has been designated as the site for the NSF-funded RIDGE Observatory Experiment. The goal is to develop a user-friendly system that can easily retrieve the targeted data for a diverse user group.

Development of a real-time detection system operating at the Newport laboratory was the key element in a major breakthrough in 1993. One week after CIMRS and VENTS researchers installed the prototype system, a swarm of events was detected. CIMRS researchers located over 500 earthquakes along the "CoAxial" segment of the southern Juan de Fuca Ridge in the first real-time detection and location of oceanic earthquakes. A repeat SeaBeam survey conducted from the NOAA Ship *Discoverer* 2 weeks later verified the location of the eruption and quantitatively mapped the entire 2000 m-long fissure system. Post-processing of the data showed a well-defined depth change of approximately 30 m at the site of the new lava flow. During Leg 3 of the cruise, CIMRS researchers collected water-column samples in the plume area for helium trace analysis.

## *Accomplishments FY 93*

- Developed software programs for computing refined locations for T-phase events.
- Operationalized the 32-channel real-time detection system at the Newport laboratory.
- Located over 500 earthquakes in the first real-time detection of an oceanic eruption in an area previously thought to be aseismic.
- Verified and quantitatively mapped the site of new lava flow from the June eruption.
- Determined relationship between acoustic energy and observed seismic energy from Mendocino earthquakes which will allow estimation of the size of oceanic earthquakes.
- Improved efficiency of processing water-column samples to test for helium isotopes by 5%.
- Compiled working reference document of mooring locations presently at North Cleft site and remaining anchors from prior instruments.

## *Plans FY 94*

- Continue development of models and signal processing software for analysis, detection and location of T-phase events along the Juan de Fuca Ridge.
- Develop and deploy low-frequency acoustic beacon used to improve event location and provide amplitude corrections to recorded T-phase events.
- Develop more accurate model of transmission of sound from crust to water column.
- Modify extensometer instrumentation to buffer ambient noise and redeploy in '94 field season.

- Develop software for portable PC system to do "at sea" comparisons of repeat SeaBeam surveys.
- Using Navy ATV and submersible, map seismogenic zones along a submarine strike/slip fault on the Blanco Transform Fracture Zone.
- Upgrade deep-sea camera system to incorporate new technological advances.
- Develop portable GIS system for shipboard use.
- Continue development of numerical models of chemical processes in the water column around hydrothermal vents and spreading ridges.
- Continue annual and continuous monitoring of hydrothermal plumes at Cleft segment in conjunction with in situ and remote geophysical monitoring of volcanic activity.

# PMEL STAFF

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CAPT Michael A. McCallister*, Associate Director
CAPT Robert C. Roush, Associate Director

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| Zhu, Willa H. | JISAO/Research Scientist |
| Zimmerman, David K., LT | NOAA Corps |

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# PMEL SEMINARS

## *1992*

| | | |
|---|---|---|
| 9 October | Dr. Laurence Padman<br>College of Oceanic and Atmospheric Sciences<br>Oregon State University<br>Corvallis, OR | Observations of mixing in the polar ocean |
| 12 November | Dr. Josko Catipovic<br>Woods Hole Oceanographic Institution<br>Woods Hole, MA<br>*and*<br>Harry Maxfield<br>Datasonics | Acoustic modems developed at WHOI and commercialized by Datasonics |
| 19 November | Nancy Soreide<br>Ocean Climate Research Division<br>PMEL | TAO workstation display software for the TOGA TAO array of moored ATLAS and current meter buoys |
| 3 December | Dr. Mark Morrissey<br>Oklahoma Climatological Survey<br>University of Oklahoma<br>Norman, OK | Comparison of raingauge data from atolls and moored buoys |
| 17 December | Dr. Kuh Kim<br>JISAO/PMEL<br>Seattle, WA | Diurnal variation of sea surface temperature with wind and OLR along 165°E in the equatorial Pacific |

## *1993*

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|---|---|---|
| 12 January | Dr. Eric Skyllingstad<br>Battelle Marine Science Laboratory<br>Sequim, WA | The role of internal gravity waves in the equatorial current system |

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| 14 January | Dr. James Ingraham, Jr.<br>NOAA/National Marine Fisheries Service<br>*and*<br>Dr. Curtis Ebbesmeyer<br>Evans-Hamilton, Inc.<br>Seattle, WA | The great sneaker spill in the North Pacific |
| 15 January | Dr. Robert Embley<br>NOAA/PMEL/OERD<br>Newport, OR | Volcanic and hydrothermal systems of Iceland: An informal overview of a recent field trip and relationships to ridge crest studies |
| 19 January | Dr. Witold Krajewski<br>University of Iowa<br>Iowa Institute of Hydraulic Research<br>Iowa City, IA | A new method for estimation of open-ocean rainfall |
| 11 February | Jim Richman<br>Oregon State University<br>Corvallis, OR | Heat and freshwater advection in the Ekman layer: How does it force the interior of the ocean? |
| 24 February | Dr. J. McCreary<br>Nova University<br>Dania, FL | A numerical investigation of dynamics, thermodynamics and mixed-layer processes in the Indian Ocean |
| 25 February | Dr. Meghan Cronin<br>University of Rhode Island<br>Narragansett, RI | Eddy-mean flow interaction in the Gulf Stream at 68°W |
| 11 March | Dr. Ray F. Weiss<br>Scripps Institution of Oceanography<br>La Jolla, CA | Vertical mixing and biological production in deep temperate lakes: Lake Baikal and Crater Lake |
| 16 March | Frederick Bingham<br>Joint Institute for Marine and Atmospheric Research<br>University of Hawaii at Manoa | Intermediate water in the western equatorial Pacific |
| 18 March | Dr. Tom Braziunas<br>Joint Institute for the Study of Atmosphere and Ocean (JISAO)<br>University of Washington | Atmospheric $^{14}CO_2$ as a constraint on Antarctic ocean $CO_2$ uptake and as a proxy for interannual to century-scale ocean variability |

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|---|---|---|
| 25 March | Eric Johnson<br>University of South Florida<br>St. Petersburg, FL | Zonal momentum balance in the tropical mid-Pacific during the Hawaii-to-Tahiti shuttle |
| 1 April | Drs. Otto W. Thiele and David A. Short<br>NASA/Goddard Space Flight Center<br>Greenbelt, MD | COARE observations of tropical rainfall variability from optical and conventional gages |
| 6 April | Duane E. Waliser<br>UCLA/NOAA PostDoc in Climate and Global Change<br>Los Angeles, CA | Convective cloud systems and warm pool SSTs: Coupled interactions and self-regulation |
| 8 April | Susan Hautala<br>Scripps Institution of Oceanography<br>La Jolla, CA | Is the north Pacific in Sverdrup balance at 24°N? |
| 20 May | Dr. Alexander Rabinovich<br>Institute of Marine Geology and Geophysics<br>Russian Academy of Sciences<br>Yuzhno-Sakhalinsk, Russian Federation | Shelf zone dynamics and an examination of seiches in bays and inlets of the Kuril Islands |
| 27 May | Dr. Daifang Gu<br>Atmospheric and Oceanic Sciences<br>Princeton University<br>Princeton, NJ | Variations of ENSO and annual cycle in the tropics during the past century |
| 3 June | Dr. John Gould<br>Institute of Oceanographic Sciences<br>Beacon Laboratory<br>Wormley, United Kingdom | The subpolar north Atlantic: Changes since the 60s and 80s |
| 10 June | Dr. William Asher<br>Battelle Marine Sciences Laboratory<br>Sequim, WA | Estimation of air/sea gas transport velocities from remote measurements of whitecap coverage: laboratory and field results |

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| 21 June | Dr. V.K. Gusiakov<br>Head, Tsunami Laboratory<br>Novosibirsk Computing Laboratory<br>Siberian Division<br>Russian Academy of Sciences | Tsunami modeling and databases: overview of recent research at Novosibirsk computing center |
| 24 June | Greg Crawford<br>Graduate Research Fellow<br>University of British Columbia/NCAR<br>Boulder, CO | The resonant response of the ocean to storms |
| 15 July | Dr. Robert Weisberg<br>University of South Florida<br>St. Petersburg, FL | Equatorial upwelling |
| 19 July | Dr. Pedro Ripa<br>CICESE<br>Ensenada, Mexico | Annual circulation and heating in the Gulf of California |
| 26 July | Dr. Shusheng Luan<br>Oregon State University<br>Corvallis, OR | Long-term balances of momentum and heat and turbulent mixing in the upper equatorial ocean |
| 12 August | Dr. Dudley Chelton<br>Oregon State University<br>Corvallis, OR | Surface velocity variance and Reynolds stresses from altimeter data |
| 13 August | " | The resolution capability of altimeter data, with application to the study of large-scale, wind-forced sea level variability in the south Atlantic |
| 19 August | Drs. Andrew Walden and Emma McCoy<br>Imperial College, London | The discrete wavelet transform and time series: some uses and problems |
| 24 September | Dr. Steve Esbensen<br>Oregon State University<br>Corvallis, OR | Mesoscale enhancement of large-scale evaporation estimated from TOGA-TAO buoy data |

# PMEL PUBLICATIONS


Baker, E.T. and G.A. Cannon (1993): Long-term monitoring of hydrothermal heat flux using moored temperature sensors, Cleft Segment, Juan de Fuca Ridge. *Geophys. Res. Lett., 20*, 1855-1858.

Baker, E.T., G.J. Massoth, S.L. Walker and R.W. Embley (1993): Quantitative estimates of diffuse and discrete hydrothermal discharge. *Earth Planet. Sci. Lett., 118*, 235-249.

Bates, T.S., K.C. Kelly and J.E. Johnson (1993): Concentrations in fluxes of dissolved biogenic gases (DMS, $CH_4$, CO, $CO_2$) in the equatorial Pacific during the SAGA 3 Experiment. *J. Geophys. Res., 98*(D9), 16,969-16,978.

Bates, T.S. and B.K. Lamb (1992): Natural sulfur emissions to the atmosphere of the continental United States. *Global Biogeochemical Cycles, 6*(4), 431-435.

Bernard, E.N. and F.I. Gonzalez (1993): Tsunami devastates Japanese coastal region. *Eos, Trans. Am. Geophys. Union, 74*(37), 417, 432.

Bernard, E.N., F.I. Gonzalez and K. Satake (1993): The Cape Mendocino Tsunami, 25 April 1992. Tsunami '93, Proceedings of the IUGG/IOC International Tsunami Symposium, Wakayama, Japan, August 23-27, 1993, 461-467.

Bond, N.A. and S.A. Macklin (1993): Aircraft observations of offshore-directed flow near Wide Bay, Alaska. *Mon. Wea. Rev., 121*(1), 150-161.

Bullister, J.L., F. Menzia and D.P. Wisegarver (1993): WOCE 1991 chlorofluorocarbon standard intercomparison report. NOAA Data Report ERL PMEL-45 (PB93-234326), 65 pp.

Cannon, G.A. and D.J. Pashinski (1992): Moored ADCP measurements near hydrothermal venting. Proceedings, MTS '92 Conference, Marine Technology Society, Washington, D.C., Oct. 19-21, 1992, 542-548.

Cannon, G.A., D.J. Pashinski and M.R. Lemon (1993): Hydrothermal effects west of the Juan de Fuca Ridge. *Deep-Sea Res., 40*(7), 1447-1457.

Covert, D.S., V.N. Kapustin, T.S. Bates and P.K. Quinn (1992): New particle formation in the marine boundary layer. *J. Geophys. Res., 97*, 20,581-20,589.

Devany, M.S., E.T. Baker, R.A. Feely, D.J. Pashinski, G.T. Lebon, S.L. Walker and K.A. Krogslund (1993): The VENTS 1989 Cleft Segment Plume Monitoring Experiment: Physical and Chemical Data, NOAA Ship *Discoverer*, August 1989. NOAA Data Report ERL PMEL-48 (PB94-109345), 100 pp.

DeWitt, C. and J. Clark (1993): Fisheries-Oceanography Coordinated Investigations: 1991 Field Operations Report. NOAA Data Report ERL PMEL-41 (PB93-188290), 112 pp.

DeWitt, C., W. Floering and R.K. Reed (1993): An observation of spurious salinity data. *MTS Journal, 26*(3), 56-57.

Doney, S.C. and J.L. Bullister (1992): A chlorofluorocarbon section in the eastern North Atlantic. *Deep-Sea Res., 39*(11/12), 1857-1883.

Dziak, R.P., H. Matsumoto and C.G. Fox (1993): Estimation of seafloor roughness spectral parameters from multi-beam sonar acoustic backscatter data: Axial Seamount, Juan de Fuca Ridge. *Geophys. Res. Lett., 20*(17), 1863-1866.

Fox, C.G. (1993): Five years of ground deformation monitoring on Axial Seamount using a bottom pressure recorder. *Geophys. Res. Lett., 20*(17), 1859-1862.

Fox, C.G. (1993): Reply to Commentary of Scholl, Ingebritsen, and Essaid. *J. Geophys. Res., 98*(B2), 1817-1818.

Freitag, H.P., M.J. McPhaden and P.E. Pullen (1992): Fish-induced bias in acoustic Doppler current profiler data. Proceedings, Oceans '92, Mastering the Oceans Through Technology, October 26-29, 1992, Newport, RI, 712-717.

Gendron, J.F., J.P. Cowen, R.A. Feely and E.T. Baker (1993): Age estimate for the 1987 Megaplume on the Southern Juan de Fuca Ridge using excess radon and manganese partitioning. *Deep-Sea Res., 40*(8), 1559-1567.

Gonzalez, F.I. and E.N. Bernard (1993): The Cape Mendocino Tsunami. *Earthquakes and Volcanoes, 23*(3), 135-138.

Gonzalez, F.I. and Ye.A. Kulikov (1993): Tsunami dispersion observed in the deep ocean. In: *Tsunamis in the World,* S. Tinti (ed.), Kluwer Pub. Co., 7-16.

Gonzalez, F., S. Sutisna, P. Hadi, E. Bernard and P. Winarso (1993): Some observations related to the Flores Island earthquake and tsunami. Tsunami '93, Proceedings of the IUGG/IOC International Tsunami Symposium, Wakayama, Japan, August 23-27, 1993, 789-801.

Graedel, T.E., T.S. Bates, A.F. Bouwman, D. Cunnold, J. Dignon, I. Fung, D.J. Jacob, B.K. Lamb, J.A. Logan, G. Marland, P. Middleton, J.M. Pacyna, M. Placet and C. Veldt (1993): A compilation of inventories of emissions to the atmosphere. *Global Biogeochem. Cycles, 7*(1), 1-26.

Grim, M.S., T.E. Chase, G.I. Evenden, M.L. Holmes, W.R. Normark, P. Wilde, C.G. Fox, C.J. Lief and B.A. Seekins (1993): Map showing bottom topography of the U.S. Pacific Continental Margin, Strait of Juan de Fuca to Cape Mendocino. Miscellaneous Investigations Series, Map-I-2091-C, U.S. Geological Survey.

Hankin, S. and D.E. Harrison (1993): FERRET: A Mathematica-style visualization and analysis tool for gridded oceanographic and meteorological data. Ninth International Conference on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology, 73rd AMS Annual Meeting, 17-22 January 1993, Anaheim, California, 168-171.

Harrison, D.E. and A.P. Craig (1993): Ocean model studies of upper-ocean variability at 0°, 160°W during the 1982-1983 ENSO: Local and remotely forced response. *J. Phys. Oceanogr., 23*(3), 425-451.

Hayes, S.P., L.J. Mangum and O.F. Steffin (1992): The Tropical Atmosphere Ocean Array. Proceedings, MTS '92 Conference, Marine Technology Society, Washington, D.C., Oct. 19-21, 1992, 451-456.

Hayes, S.P. and M.J. McPhaden (1992): Temporal sampling requirements for low frequency temperature variability in the eastern equatorial Pacific Ocean. NOAA Tech. Memo. ERL PMEL-96 (PB93-136422), 17 pp.

Hermann, A.J. and H. Hsu (1993): A vertical coordinate mapping technique for semi-spectral primitive equation models of oceanic circulation. *J. Atmos. Ocean. Tech., 10*(3), 381-396.

Hermann, A.J. and W.B. Owens (1993): Energetics of gravitational adjustment for mesoscale chimneys. *J. Phys. Oceanogr., 23*(2), 346-371.

Herzfeld, U.C., I.I. Kim, J.A. Orcutt and C.G. Fox (1993): Fractal geometry and seafloor topography: Theoretical concepts versus data analysis for the Juan de Fuca Ridge and the East Pacific Rise. *Annales Geophysicae, 11*, 532-541.

Hinckley, S., K. Bailey, S. Picquelle, M. Yoklavich and P. Stabeno (1993): Age-specific mortality and transport of larval walleye pollock *Theragra chalcogramma* in the western Gulf of Alaska. *Mar. Ecol. Prog. Ser., 98*, 17-29.

Huebert, B.J., S. Howell, P. Laj, J.E. Johnson, T.S. Bates, P.K. Quinn, V. Yegorov, A.D. Clarke and J.N. Porter (1993): Observations of the atmospheric sulfur cycle on SAGA 3. *J. Geophys. Res., 98*(D9), 16,985-16,995.

Johnson, G.C. (1993): A deep inertial jet on a sloping bottom near the equator. *Deep-Sea Res. I*, 40(9), 1781-1792.

Johnson, J.E., V.M. Koropalov, K.E. Pickering, A.M. Thompson, N. Bond and J.W. Elkins (1993): Third Soviet-American Gas and Aerosols (SAGA 3) Experiment: Overview and meteorological and oceanographic conditions. *J. Geophys. Res., 98*(D9), 16,893-16,908.

Johnson, E.S., and M.J. McPhaden (1993): Structure of intraseasonal Kelvin waves in the equatorial Pacific Ocean. *J. Phys. Oceanogr., 23*, 608-625.

Johnson, E.S., and M.J. McPhaden (1993): Effects of a three-dimensional mean flow on intraseasonal Kelvin waves in the equatorial Pacific Ocean. *J. Geophys. Res., 98*(C6), 10,185-10,194.

Johnson, G.C. and J.M. Toole (1993): Flow of deep and bottom waters in the Pacific at 10°N. *Deep-Sea Res. I, 40*, 371-394.

Kessler, W.S. and J.P. McCreary (1993): The annual wind-driven Rossby wave in the subthermocline equatorial Pacific. *J. Phys. Oceanogr., 23*, 1192-1207.

Lamb, M.F., L. Moore, R.A. Feely and D.A. Atwood (1993): Total $CO_2$ and nitrate measurements in the southwest Pacific during austral autumn, 1990. NOAA Data Report ERL PMEL-42 (PB93-188415), 62 pp.

Lavelle, J.W. (1993): A model for estuarine sedimentation involving marine snow. In: *Nearshore and Estuarine Cohesive Sediment Transport*, A. Mehta (ed.), Coastal and Estuarine Study Series, American Geophysical Union, Washington, D.C., Springer-Verlag, 148-166.

Lupton, J.E., D.W. Graham, J.R. Delaney and H.P. Johnson (1993): Helium isotope variations in Juan de Fuca Ridge basalts. *Geophys. Res. Lett., 20*(17), 1851-1854.

Macklin, S.A., P.J. Stabeno and J.D. Schumacher (1993): A comparison of gradient and observed over-the-water winds along a mountainous coast. *J. Geophys. Res., 98*, 16,555-16,569.

Mader, C.L. and E.N. Bernard (1993): Modeling tsunami flooding of Crescent City. Tsunami '93, Proceedings of the IUGG/IOC International Tsunami Symposium, Wakayama, Japan, August 23-27, 1993, 321-326.

Mangum, L.J., S.P. Hayes and L.D. Stratton (1992): Sampling requirements for the surface wind field over the tropical Pacific Ocean. *J. Atmos. Ocean. Tech., 9*(5), 668-679.

Mangum, L., J. Lynch, L. Stratton and K. McTaggart (1993): CTD/$O_2$ measurements during 1987 and 1988 as part of the Equatorial Pacific Ocean Climate Studies (EPOCS). NOAA Data Report ERL PMEL-46 (PB94-109915), 620 pp.

McCarthy, R.J., E.N. Bernard and M.R. Legg (1993): The Cape Mendocino Earthquake: A local tsunami wakeup call?. Proceedings of the Eighth Symposium on Coastal and Ocean Management, Vol. III, 2812-2828.

McCarty, M.E. and M.J. McPhaden (1993): Mean seasonal cycles and interannual variations at 0°, 165°E during 1986-1992. NOAA Tech. Memo. ERL PMEL-98 (PB93-186195), 64 pp.

McTaggart, K., L. Stratton and L. Mangum (1993): CTD/$O_2$ measurements during 1989 and 1990 as part of the Equatorial Pacific Ocean Climate Studies (EPOCS). NOAA Data Report ERL PMEL-47 (PB94-103249), 466 pp.

McTaggart, K.E., D. Wilson and L.J. Mangum (1993): CTD measurements collected on Climate and Global Change Cruise along 170°W during February-April 1990. NOAA Data Report ERL PMEL-44 (PB93-226041), 265 pp.

Mock, D.R. and S. Hankin (1993): Data access techniques using UNIX utilities. Ninth International Conference on Interactive Information and Processing Systems for Meteorlogy, Oceanography, and Hydrology, 17-22 January 1993, Anaheim, California, 281-286.

Mofjeld, H.O. (1992): Subtidal sea level fluctuations in a large fjord system. *J. Geophys. Res., 97*(C12), 20,191-20,199.

Mortlock, R.A., P.N. Froelich, R.A. Feely, G.J. Massoth, D.A. Butterfield, J.E. Lupton, and (1993): Silica and germanium in Pacific Ocean hydrothermal vents and plumes. *Earth Planet. Sci. Lett., 119*, 365-378.

Murphy, P.P., C. Cosca, D.C. Lee and R.A. Feely (1993): Temperature calibration and correction report for PMEL trace gas cruises 1986-1989. NOAA Tech. Memo. ERL PMEL-97 (PB93-175420), 192 pp. + 1 diskette.

Murray, J.W., M. Leinen, R.A. Feely, J.R. Toggweiler and R. Wanninkhof (1992): EqPac: A US-JGOFS process study in the central equatorial Pacific. *Oceanography Magazine, 5*(3), 134-142.

Oppenheimer, D., G. Beroza, G. Carver, L. Dengler, J. Eaton, L. Gee, F. Gonzalez, A. Jayko, W.H. Li, M. Lisowski, M. Magee, G. Marshall, M. Murray, R. McPherson and B. Romanowicz (1993): The Cape Mendocino, California, Earthquakes of April 1992: Subduction at the Triple Junction. *Science, 261*, 433-438.

Overland, J.E. and N. Bond (1993): The influence of coastal orography: The Yakutat Storm. *Mon. Wea. Rev., 121*, 1388-1397.

Paulson, A.J., H.C. Curl, Jr. and R.A. Feely (1993): The biogeochemistry of nutrients and trace metals in Hood Canal, a Puget Sound fjord. *Mar. Chem., 43*, 157-173.

Price, J.F., M.O. Baringer, R.G. Lueck, G.C. Johnson, I. Ambar, G. Parilla, A. Cantos, M.A. Kennelly and T.B. Sanford (1993): Mediterranean outflow mixing and dynamics. *Science, 259*, 1277-1282.

Pullen, P.E., M.J. McPhaden, H.P. Freitag and J. Gast (1992): Surface wave induced skew errors in acoustic Doppler current profiler measurements from high shear regimes. Proceedings, Oceans '92, Mastering the Oceans Through Technology, October 26-29, 1992, Newport, RI, 706-711.

Quinn, P.K., D.S. Covert, T.S. Bates, V.N. Kapustin, D.C. Ramsey-Bell and L.M. McInnes (1993): Dimethylsulfide/cloud condensation nuclei/climate system: Relevant size-resolved measurements of the chemical and physical properties of atmospheric aerosol particles. *J. Geophys. Res., 98*, 10,411-10,427.

Reed, R.K. and P.J. Stabeno (1993): Observations of velocity divergence in Shelikof Strait, Alaska. *Cont. Shelf Res., 13*(2/3), 225-232.

Reed, R.K. and P.J. Stabeno (1993): The recent return of the Alaskan Stream to Near Strait. *J. Mar. Res., 51*, 515-527.

Roach, A.T., K. Aagaard and F. Carsey (1992): Coupled ice-ocean variability in the Greenland Sea. *Atmosphere-Ocean, 31*(3), 319-337.

Schumacher, J.D., P.J. Stabeno and S.J. Bograd (1993): Characteristics of an eddy over a continental shelf: Shelikof Strait, Alaska. *J. Geophys. Res., 98*(C5), 8395-8404.

Soreide, N.N., D.W. Denbo, D.C. McClurg, W.H. Zhu and S.P. Hayes (1993): TAO workstation display software for the TOGA TAO equatorial array of moored ATLAS and current meter buoys.

Proceedings, Ninth International Conference on Interactive Information and Processing Systems for Meteorology, Oceanography, and Hydrology, 73rd AMS Annual Meeting, 17-22 January 1993, Anaheim, California, 315-320.

Soreide, N.N. and S.P. Hayes (1993): Data management, analysis and display of data from the TOGA-TAO array of moored ATLAS and current meter buoys. Proceedings, Workshop 1992 on Ocean Research Program, Ocean Circulation in the Pacific Subgroup, September 7-9, 1992, Yokosuka, Japan, Japan Marine Science and Technology Center, 98-112.

Soreide, N.N., D.C. McClurg, D.W. Denbo, W.H. Zhu, D.J. Doll, L.J. Mangum, L.D. Stratton and S.P. Hayes (1992): ATLAS data management and interactive display software for the TOGA TAO array of moored buoys. Proceedings, MTS '92 Conference, Marine Technology Society, Washington, D.C., Oct. 19-21, 1992, 457-463.

Soreide, N.N. and M.J. McPhaden (1993): The TAO workstation display software for real-time data from the TOGA TAO array. Proceedings, Fourth International Conference on Southern Hemisphere Meterology and Oceanography, 29 March-2 April 1993, Hobart, Australia, 422-423.

Tennant, D. and E. Baker (1992): A fast, high-precision multi-aliquot splitter. *Mar. Geol., 108*, 247-252.

Thompson, A.M., J.E. Johnson, A.L. Torres, T.S. Bates, K.C. Kelly, E. Atlas, J.P. Greenberg, N.M. Donahue, S.A. Yvon, E.S. Saltzman, B.G. Heikes, B.W. Mosher, A.A. Shashkov and V.I. Yegorov (1993): Ozone observations and a model of marine boundary layer photochemistry during SAGA 3. *J. Geophys. Res., 98*(D9), 16,955-16,968.

Turet, P., C.H. Pease, R.S. Pritchard and J.E. Overland (1993): Method for extracting tidal and inertial motion from ARGOS ice buoys applied to the Barents Sea during CEAREX. NOAA Tech. Memo. ERL PMEL-99 (PB93-190213), 63 pp.

Walker, D.A. and E.N. Bernard (1993): Comparison of T-phase spectra and tsunami amplitudes for tsunamigenic and other earthquakes. *J. Geophys. Res., 98*(C7), 12,557-12,565.

Wisegarver, D.P., J.L. Bullister, R.H. Gammon, F.A. Menzia and K.C. Kelly (1993): NOAA chlorofluorocarbon tracer program air and seawater measurements: 1986-1989. NOAA Data Report ERL PMEL-43 (PB93-190049), 417 pp.

# JISAO PUBLICATIONS


Bates, T.S., K.C. Kelly and J.E. Johnson (1993): Concentrations in fluxes of dissolved biogenic gases (DMS, $CH_4$, CO, $CO_2$) in the equatorial Pacific during the SAGA 3 Experiment. *J. Geophys. Res., 98*(D9), 16,969-16,978.

Bond, N.A., and S.A. Macklin (1993): Aircraft observations of offshore directed flow near Wide Bay, Alaska. *Mon. Wea. Rev., 121*(1), 150-161.

Bullister, J.L., F. Menzia and D.P. Wisegarver (1993): WOCE 1991 chlorofluorocarbon standard intercomparison report. NOAA Data Report ERL PMEL-45 (PB93-234326), 65 pp.

Covert, D.S., and J. Heintzenberg (1993): Size distributions and chemical properties of aerosols at Ny Alesund, Svalbard. *Atmos. Environ., 27A*, 2989-2997.

Covert, D.S., V.N. Kapustin, T.S. Bates and P.K. Quinn (1992): New particle formation in the marine boundary layer. *J. Geophys. Res., 97*(D18), 20,581-20,589.

Hermann, A.J. and H.M. Hsu (1993): A vertical coordinate mapping technique for semi-spectral primitive equation models of oceanic circulation. *J. Atmos. Ocean. Tech., 10*(3), 381-396.

Hermann, A.J. and W.B. Owens (1993): Energetics of gravitational adjustment for mesoscale chimneys. *J. Phys. Oceanogr., 23*(2), 346-371.

Johnson, J.E., V.M. Koropalov, K.E. Pickering, A.M. Thompson, N. Bond and J.W. Elkins (1993): Third Soviet-American Gas and Aerosols (SAGA 3) Experiment: Overview and meteorological and oceanographic conditions. *J. Geophys. Res., 98*(D9), 16,893-16,908.

Johnson, E.S., and M.J. McPhaden (1993): Effects of a three-dimensional mean flow on intraseasonal Kelvin waves in the equatorial Pacific Ocean. *J. Geophys. Res., 98*(C6), 10,185-10,194.

Lau, K.H., and N.C. Lau (1992): The energetics and propagation dynamics of tropical summertime synoptic-scale disturbances. *Mon. Wea. Rev., 120*(11), 2523-2539

Mangum, L.J., S.P. Hayes and L.D. Stratton (1992): Sampling requirements for the surface wind field over the tropical Pacific Ocean. *J. Atmos. Ocean. Tech., 9*(5), 668-679.

Mangum, L., J. Lynch, L. Stratton and K. McTaggart (1993): CTD/$O_2$ measurements during 1987 and 1988 as part of the Equatorial Pacific Ocean Climate Studies (EPOCS). NOAA Data Report ERL PMEL-46 (PB94-109915), 620 pp.

McCarty, M.E. and M.J. McPhaden (1993): Mean seasonal cycles and interannual variations at 0°, 165°E during 1986-1992. NOAA Tech. Memo. ERL PMEL-98 (PB93-186195), 64 pp.

McPhaden, M.J., and H. Peters (1992): Diurnal cycle of internal wave variability in the equatorial Pacific Ocean: Results from moored observations. *J. Phys. Oceanogr., 22*(11), 1317-1329.

McTaggart, K., L. Stratton and L. Mangum (1993): CTD/$O_2$ measurements during 1989 and 1990 as part of the Equatorial Pacific Ocean Climate Studies (EPOCS). NOAA Data Report ERL PMEL-47 (PB94-103249), 466 pp.

Murphy, P., C. Cosca, D. Lee, and R. Feely (1993): Temperature calibration and correction report for PMEL trace gas cruises 1986-1989. NOAA Tech. Memo. ERL PMEL-97 (PB93-175420), 192 pp.

Nakamura, H. (1993): Horizontal divergence associated with zonally-isolated jetstreams. *J. Atmos. Sci., 50*(14), 2310-2313.

Overland, J.E. and N. Bond (1993): The influence of coastal orography: The Yakutat Storm. *Mon. Wea. Rev., 121*, 1388-1397.

Quinn, P.K., D.S. Covert, T.S. Bates, V.N. Kapustin, D.C. Ramsey-Bell and L.M. McInnes (1993): Dimethylsulfide/cloud condensation nuclei/climate system: Relevant size-resolved measurements of the chemical and physical properties of atmospheric aerosol particles. *J. Geophys. Res., 98*, 10,411-10,427.

Schumacher, J.D., P.J. Stabeno and S.J. Bograd (1993): Characteristics of an eddy over a continental shelf: Shelikof Strait, Alaska. *J. Geophys. Res., 98*(C5), 8395-8404.

Soreide, N.N., D.C. McClurg, D.W. Denbo, W.H. Zhu, D.J. Doll, L.J. Mangum, L.D. Stratton and S.P. Hayes (1992): ATLAS data management and interactive display software for the TOGA TAO array of moored buoys. Proceedings, MTS '92 Conference, Marine Technology Society, Washington, D.C., Oct. 19-21, 1992, 457-463.

Stuiver, M., and T. Braziunas (1993): Modeling atmospheric $^{14}C$ influences and $^{14}C$ ages of marine samples to 10,000 BC. *Radiocarbon, 35*(1), 137-189.

Stuiver, M., and T. Braziunas (1993): Sun, ocean, climate and atmospheric $^{14}CO_2$: An evaluation of causal and spectral relationships. *The Holocene, 3*(4), 289-302.

Turet, P., C.H. Pease, R.S. Pritchard and J.E. Overland (1993): Method for extracting tidal and inertial motion from ARGOS ice buoys applied to the Barents Sea during CEAREX. NOAA Tech. Memo. ERL PMEL-99 (PB93-190213), 63 pp.

Wakata, Y., and E. Sarachik (1992): Effects of the meridional extent of mean equatorial upwelling on atmosphere-ocean coupled instabilities over an unbounded ocean. *J. Japan. Met. Soc, 70*(5), 843-854.

Weaver, A., J. Marotzke, P. Commins, and E. Sarachik (1993): Stability and variability of the thermohaline circulation. *J. Phys. Oceanogr., 23*, 39-60.

Winton, M. (1993): Deep decoupling oscillations of the oceanic thermohaline circulation. *Ice in the Climate System* (proceedings). NATO ASI Series, Series I, Global Environmental Change, Vol. I, 12, 417-432.

Winton, M., and E.S. Sarachik (1993): Thermohaline oscillations induced by strong steady salinity forcing of ocean general circulation models. *J. Phys. Oceanogr., 23*(7), 1389-1410.

Yin, F.L., and E.S. Sarachik (1993): On the dynamics and heat balance of steady equatorial undercurrents. *J. Phys. Oceanogr., 23*(8), 1647-1669.

# JIMAR PUBLICATIONS


Boehlert, G.W., and B.C. Mundy (1992): Distribution of ichthyoplankton around southeast Hancock Seamount, central North Pacific, in summer 1984 and winter 1985: Data Report. NOAA Tech. Memo. NMFS-SWFSC-176, 109 pp.

Caldwell, P., G. Mitchum, and K. Wyrtki (1992): TOGA Sea Level Center: Data from the Atlantic Ocean. JIMAR Data Report, 92-257, University of Hawaii.

Caldwell, P., and B. Kilonsky (1992): Data processing and quality control at the TOGA Sea Level Center. *Joint IAPSO-IOC Workshop on Sea Level Measurements and Quality Control*, Paris, France, Oct. 12-13, 1992, IOC Workshop Report, No. 81, UNESCO, 122-135.

Caldwell, P. (1992): Building an archive of tropical sea level data. *Earth System Monitor, 3*(2), 4-6.

Hiyoshi, Y., D.A. Walker, and C.S. McCreery (1992): T-phase data and regional tsunamigenesis in Japan. *Bull. Seismol. Soc. Amer., 82*(5), 2213-2223.

Murakami, T., B. Wang, and S.W. Lyons (1992): Contrasts between summer monsoons over the Bay of Bengal and the eastern North Pacific. *J. Meteor. Soc. Japan, 70*, 191-210.

Murakami, T., and B. Wang (1993): Annual cycle of the equatorial east-west circulation over the Indian and Pacific Oceans. *J. Climate, 6*, 932-952.

Polovina, J.J., and G.T. Mitchum (1992): Variability in spiny lobster, *Panulirus marginatus*, recruitment and sea level in the northwestern Hawaiian Islands. *Fish. Bull (US), 90*, 483-493.

Wang, B., and T. Li (1993): A simple atmospheric model of relevance to short-term climate variation. *J. Atmos. Sci., 50*, 260-284.

Wilson, C.D., and G.W. Boehlert (1993): Population biology of *Gnathophausic longispina (Mysidacea: Lophogastridae)* from a central north Pacific seamount. *Mar. Biol., 115*, 537-543.

Winn, C.D., R. Lukas, D. Hebel, C. Carrillo, R. Letelier, and D.M. Karl (1993): Time-series measurements in the oligotrophic ocean: Resolving variability in the North Pacific Subtropical Gyre. In Saxen, N. (ed.), *Proceedings of the Pacific Congress on Marine Science and Technology*, 139-150.

Winn, C.D., R. Lukas, D.M. Karl, and E. Firing (1993): Hawaii Ocean Time-Series Data Report 3. SOEST Technical Report, 93-3.

Zhu, B., and B. Wang (1993): The 30-60-day convection seesaw between the tropical Indian and western Pacific oceans. *J. Atmos. Sci., 50*, 184-199.

# CIMRS PUBLICATIONS

Dziak, R.P. H. Matsumoto, and C.G.Fox. Estimation of seafloor roughness spectial parameters from multibeam sonar acoustic backscatter data: Axial Seamount, Juan de Fuca Ridge. *Geophys. Res. Lett.* *20*(17), 1863-1866, 1993.

# GLOSSARY OF ACRONYMS

| | |
|---|---|
| AARI: | Arctic and Antarctic Research Institute |
| A&P: | Analysis and Prediction [program] (FSL) |
| AABW: | Antarctic bottom water |
| AAOE: | Airborne Antarctic Ozone Experiment |
| AB: | asymmetric balance |
| AASE: | Airborne Arctic Stratospheric Experiment |
| ACARS: | ARINC Communications Addressing and Reporting System |
| ACATS: | Airborne Chromatograph for Atmospheric Trace Species |
| ACC: | Alaska Coastal Current |
| ACCP: | Atlantic Climate Change Program |
| ACE: | Advanced Composition Explorer (NASA satellite) |
| ACE: | Aerosol-Climate Experiment |
| ACG: | Advanced Computing Group (FSL) |
| AD: | Aviation Division (FSL) |
| ADCP: | Acoustic Doppler Current Profiler |
| ADEOS: | Advanced Earth Observing System |
| ADF: | Advanced Development Facility [Branch] (FSL) |
| ADIOS: | Asian Dust Input to the Oceanic System |
| AEROCE | Atmosphere/Ocean Chemistry Experiment |
| AES: | Atmospheric Environment Service (Canada) |
| AFGWC: | Air Force Global Weather Central |
| AFOS: | Automation of Field Operations and Services |
| AFPS: | AWIPS Forecast Preparation System |
| AFVP: | Aviation Forecast Verification Program |
| AFWG: | AFPS Forecast Working Group |
| AFTAD: | Analysis-Forecast Transport and Diffusion |
| AGASP: | Arctic Gas and Aerosol Sampling Program |
| AGFS: | Aviation Gridded Forecast System |
| AI: | artificial intelligence |
| AID: | Agency for International Development |
| AIRMoN: | Atmospheric Integrated Research Monitoring Network |
| AIV: | aviation impact variable |
| AL: | Aeronomy Laboratory (ERL) |
| AMIP: | Atmospheric Model Intercomparison Project |
| AMS: | American Meteorological Society |
| ANICA: | Atmospheric Nutrient Input to Coastal Areas [project] |
| ANS: | Aquatic Nuisance Species |
| AOD: | aerosol optical depth |
| AOML: | Atlantic Oceanographic and Meteorological Laboratory (ERL) |
| AOSP: | Atmospheric and Ocean Sciences Program |
| APARE: | East Asian-North Pacific Regional Experiment |
| APEX: | Arctic Polynya Experiment |
| APL: | Applied Physics Laboratory |
| APO: | AWIPS Program Office |
| ARCSS: | Arctic System Science [program] |
| ARGOS: | French satellite used to telemeter data to shore stations (not an acronym) |
| ARINC: | Aeronautical Radio Incorporated |
| ARL: | Air Resources Laboratory (ERL) |
| ARM: | Atmospheric Radiation Measurement [DOE program] |
| ARMA: | autoregressive moving average |
| ARO: | Army Research Office |
| ARPS: | Advanced Regional Prediction System |
| ARTCC: | Air Route Traffic Control Center (FAA) |
| ASCOT: | Atmospheric Studies in Complex Terrain (DOE) |
| ASG: | Administrative Support Group (PMEL) |

| | |
|---|---|
| ASHES: | Axial Seamount Hydrothermal Emissions Study |
| ASHOE: | Airborne Southern Hemisphere Ozone Expedition |
| ASMD: | Atmospheric Sciences Modeling Division (ARL) |
| ASOS: | Automated Surface Observing System |
| ASTEX: | Atlantic Stratocumulus Transition Experiment |
| ATAD: | atmospheric transport and dispersion [model] |
| ATC: | Air Traffic Control (FAA) |
| ATCSCC: | ATC Systems Command Center |
| ATDD: | Atmospheric Turbulence and Diffusion Division (ARL) |
| ATLAS: | Automated Temperature Line Acquisition System [moorings] |
| ATMS: | Advanced Traffic Management System |
| ATOC: | Acoustic Thermometry of Ocean Climate [program] |
| AVHRR: | Advanced Very-High-Resolution Radiometer |
| AVIRIS: | Airborne Visible and Infrared Imaging Spectrometer |
| AVS: | Application Visualization System [program] |
| AWIPS: | Advanced Weather Interactive Processing System |
| AWIPS-90: | Advanced Weather Interactive Processing System for the 1990s |
| AXBT: | Airborne XBT |
| AXCP: | Airborne Expendable Current Profiler |
| BLIPS: | Benthic Layer Interactive Profiling System |
| BMRC: | Bureau of Meteorology Research Center |
| BOREAS: | Boreal Ecosystem-Atmosphere Study |
| BPR: | bottom pressure recorder |
| BT: | bathythermograph |
| BUFR: | Binary Universal Form for Representation [of meteorological data] |
| CAC: | Climate Analysis Center (NOAA) |
| CalCOFI: | California Cooperative Oceanic Fisheries Investigations |
| CAPE: | Cape Kennedy Precipitation Experiment |
| CAPS: | Center for Analysis and Prediction of Storms |
| CARD: | Coastal and Arctic Research Division [formerly MSRD] (PMEL) |
| CART: | Cloud and Radiation Testbed [DOE network] |
| CASE: | Coordinated Air-Sea Experiment |
| CBOS: | Chesapeake Bay Observing System |
| CCCO: | Committee on Climate Changes and the Ocean |
| CCIW: | Canada Centre for Inland Waters |
| CCM: | community climate model |
| CCN: | cloud condensation nuclei |
| CCOPE: | Cooperative Convective Precipitation Experiment |
| CCRS: | Canada Centre for Remote Sensing |
| CCSR: | Center for Climate System Research |
| CDC: | Climate Diagnostics Center (ERL) |
| CDFC: | Cloud Depiction and Forecast System |
| CEAREX: | Coordinated Eastern Arctic Experiment |
| CEPEX: | Central Equatorial Pacific Experiment |
| CFC: | chlorofluorocarbon |
| CFM: | chlorofluoromethane |
| CG: | cloud to ground |
| CGCP: | Climate and Global Change Program (NOAA) |
| CHARM: | Coupled Hydrologic-Atmospheric Research Model |
| CILER: | Cooperative Institute for Limnology and Ecosystems Research |
| CIMAS: | Cooperative Institute for Marine and Atmospheric Studies |
| CIMMS: | Cooperative Institute for Mesoscale Meteorological Studies |
| CIMRS: | Cooperative Institute for Marine Resources Studies |
| CIMS: | Chemical Ionization Mass Spectrometer |
| CIMSS: | Cooperative Institute of Meteorology Satellite Studies |
| CIRA: | Cooperative Institute for Research in the Atmosphere |
| CIRES: | Cooperative Institute for Research in Environment Sciences |
| CITE-3: | Chemical Instrumentation and Test Evaluation (NASA) |
| CLASS: | Cross-chain LORAN Atmospheric Sounding System |
| CLICOM: | Climate Computing |
| CLIVAR: | Climate Variability and Prediction Program |

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|---|---|
| C-MAN: | Coastal Marine Automated Network (NWS) |
| CMDL: | Climate Monitoring and Diagnostics Laboratory (ERL) |
| CME: | coronal mass ejection |
| CMIST: | Configuration Management Integrated Support Tool |
| CN: | condensation nucleus |
| CNES: | Centre Nationale d'Etudes Spatiales |
| CNSD: | Computer and Network Support Division [formerly CSG] (PMEL) |
| COADS: | Comprehensive Ocean-Atmosphere Data Set |
| COAP: | Center for Ocean Analysis and Prediction |
| COARE: | Coupled Ocean-Atmosphere Response Experiment (TOGA) |
| COAST: | Coastal Observations and Simulations with Topography |
| COLA1D: | coupled ocean-land-atmosphere 1-dimensional [model] |
| COMET: | Cooperative Program for Operational Meteorology, Education, and Training (NCAR) |
| COPS-91: | Cooperative Oklahoma Profiler Studies-1991 |
| CPUE: | catch per unit [fish] effort |
| CRF: | cloud radiation feedback |
| CRRB: | Change Request Review Board |
| CRREL: | Cold Regions Research and Engineering Laboratory |
| C-SCAT: | C-band Scatterometer |
| CSES: | Center for the Study of Earth from Space |
| CSG: | Computer Support Group [now CNSD] (PMEL) |
| CSI: | conditional symmetric instability |
| CSIRO: | Commonwealth Scientific and Industrial Research Organization (Australia) |
| CSS: | Central Support Services (NWS) |
| CSU: | Colorado State University |
| CSU-RAMS: | CSU Regional Atmospheric Modeling System |
| CTD: | conductivity, temperature, depth |
| CTDMPLUS: | improved complex terrain dispersion model |
| CTMBL: | cloud-topped marine boundary layer |
| CTSCREEN: | complex terrain screening [model] |
| CU: | University of Colorado |
| CVS: | cathodic voltametry stripping |
| CWB: | Central Weather Bureau (Taiwan) |
| CWSU: | Central Weather Service Unit (FAA) |
| CZCS: | Coastal Zone Color Scanner |
| DAAC: | Distributed Active Archive Center |
| DARE-II: | Denver AWIPS Risk Reduction and Requirements Evaluation [workstation] |
| DD: | Demonstration Division (FSL) |
| DDIM: | dry deposition inferential method |
| DEC: | Digital Equipment Corporation |
| DM: | Data Management [Branch] (FSL) |
| DMS: | dimethylsulfide |
| DMSP: | Defense Meteorological Satellite Program (Air Force) |
| DNA: | deoxyribonucleic acid |
| DOC: | dissolved organic carbon |
| DOD: | Department of Defense |
| DOE: | Department of Energy |
| DOI: | Department of Interior |
| DOMSAT: | Domestic Satellite |
| DON: | dissolved organic nitrogen |
| DOT: | Department of Transportation |
| DRS: | Data Receiving System |
| D.U.: | Dobson Unit |
| DWBC: | Deep Western Boundary Current |
| EASE: | Equal Area SSM/I Earth [grid] |
| E-BPR: | Enhanced Bottom Pressure Recorder |
| ECB: | Environmental Chemistry and Biology |
| EC-GC: | Electron Capture Gas Chromatograph |
| ECMWF: | European Centre for Medium-Range Weather Forecasts |
| EDD: | Engineering Development Division (PMEL) |
| EEZ: | Exclusive Economic Zone |

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|---|---|
| EFF: | Experimental Forecast Facility (NWS) |
| EFT: | Enhanced Forecaster Tools [Branch] (FSL) |
| EIMWT: | Echo Integration-Midwater Trawl |
| EMVER: | Experimento Meteorologico del Verano |
| ENSO: | El Nino-Southern Oscillation |
| EOF: | empirical orthogonal function |
| EOS: | Earth Observing System (NASA) |
| Eos: | Eos, Transactions of the American Geophysical Union |
| EOSDIS: | EOS Data and Information System |
| EPA: | Environmental Protection Agency |
| EPR: | East Pacific Rise |
| EPRI: | Electric Power Research Institute |
| EPIC: | Extensive PMEL Information Collection (oceanographic data system) |
| EPOCS: | Equatorial Pacific Ocean Climate Studies |
| EPOS: | Earthquake Phenomena Observation System (Japan) |
| ERICA: | Experiment on Rapidly Intensifying Cyclones over the Atlantic |
| ERL: | Environmental Research Laboratories (NOAA) |
| ERS: | Earth Resources Satellite |
| ERS-1: | Earth Remote Sensing Satellite |
| ER2: | Earth Resources-2 [NASA Satellite] |
| ESA: | European Space Agency |
| ESDIM: | Earth System Data and Information Management (NOAA) |
| ETL: | Environmental Technology Laboratory (ERL) |
| EUV: | extreme ultraviolet |
| FAA: | Federal Aviation Administration |
| FACT: | Feasibility Ascension Cape Town [project] |
| FARA: | French American Ridge Atlantic [program] |
| FASCODE: | [radiative transfer code; not an acronym] |
| FASINEX: | Frontal Air-Sea Interaction Experiment |
| FAST: | fore-aft scanning technique |
| FAST: | Flow Actuated Sediment Trap |
| FD: | Facility Division (FSL) |
| FDDI: | Fiber-Distributed Data Interface |
| FERRET: | Interactive gridded data set analysis package (not an acronym) |
| FGGE: | First GARP Global Experiment |
| FIDES: | Forecaster's Intelligent Discussion Experiment System |
| FIFE: | First ISLSCP Field Experiment |
| FIN: | FOCI Interactive Network |
| FIRE: | First ISCCP Regional Experiment |
| FMO: | Flatland Meteorological Observatory |
| FNMOC: | Fleet Numerical Meteorology and Oceanography Center |
| FOCAL: | French Program Ocean-Climat Atlantique Equatorial |
| FOCI: | Fisheries-Oceanography Coordinated Investigations (NOAA) |
| FOCUS: | Fisheries Oceanography Cooperative Users System |
| FOX: | Fishery-Oceanography Experiment |
| FPGA: | Field Programmable Gate Array |
| FRC: | Federal Records Center |
| FRC: | Front-Range Consortium |
| FRD: | Field Research Division (ARL) |
| FRD: | Forecast Research Division (FSL) |
| FREEZE: | Name of arctic ice formation experiment (not an acronym) |
| FSL: | Forecast Systems Laboratory (ERL) |
| FTIR: | Fourier Transform Infrared Radiometer |
| FX-ALPHA: | FSL X-window system AWIPS-Like Prototype for Hydrometeorological Applications |
| 4DDA: | four-dimensional data assimilation [scheme] |
| GALE: | Genesis of Atlantic Lows Experiment |
| GARP: | Global Atmospheric Research Program |
| GC: | gas chromatograph |
| GCM: | general circulation model |
| GCOS: | Global Climate Observing System |
| GCPS: | Global Climate Perspectives System |

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|---|---|
| GDP: | Government Development Platform |
| GDR: | Geophysical Data Record |
| GDSIB: | Global Digital Sea Ice Data Bank |
| GEOSAT: | Geodetic Satellite |
| GEWEX: | Global Energy and Water Cycle Experiment |
| GFA: | gust front detection algorithm |
| GFDL: | Geophysical Fluid Dynamics Laboratory (ERL) |
| GHCN: | Global Historical Climate Network |
| GIS: | Geographic Information System |
| GISP: | Greenland Ice Sheet Project |
| GISS: | Goddard Institute for Space Studies |
| GLERL: | Great Lakes Environmental Research Laboratory (ERL) |
| GLOBE: | Global Backscatter Experiment |
| GMCC: | Geophysical Monitoring for Climatic Change (ARL) |
| GMT: | Generic Mapping Tools |
| GOALS: | Global Ocean-Atmosphere-Land System |
| GOES: | Geostationary Operational Environmental Satellite |
| GOES-Next: | next-generation GOES |
| GOOS: | Global Ocean Observing System |
| GO3OS: | Global Ozone Observing System |
| GPS: | Global Positioning System |
| GRASS: | Geographic Resources Analysis Support System |
| GRIB: | gridded binary [data format] |
| GS: | Gulf Shelf |
| GSE: | ground support equipment |
| GSFC: | Goddard Space Flight Center |
| GTN: | Global Trends Network |
| GTS: | Global Telecommunication System |
| GUFMEX: | Gulf of Mexico [project] |
| GUI: | graphical user interface |
| GvaP: | GEWEX Water Vapor Project |
| GWP: | global warming potential |
| HALOE: | Halogen Occultation Experiment |
| HARM: | hazardous atmospheric release model |
| HCBP: | hexachlorobiphenyl |
| HCFC: | hydrochlorofluorocarbon |
| HDA: | hail detection algorithm |
| HFC: | hydrofluorocarbon |
| HIBU: | Hydrological Institute and Belgrade University |
| HIFT: | Heard Island Feasibility Test |
| HIRIS: | High-Resolution Imaging Spectrometer |
| HIS: | High-Resolution Interferometer Spectrometer |
| HMSC: | Hatfield Marine Science Center |
| HOC: | hydrophobic organic compound |
| HOT: | Hawaiian Ocean Time series |
| HPD: | hourly precipitation data |
| HPLC: | High Performance Liquid Chromatography |
| HRD: | Hurricane Research Division (AOML) |
| HRPT: | High-Resolution Picture Transmission |
| HSRP: | High Speed Research Program (NASA) |
| HY-SPLIT | Hybrid Single Particle Lagrangian Integrated Trajectories [model] |
| IAEM: | International Atomic Energy Agency |
| IAMAP/IAPSO: | International Association of Meteorology and Atmospheric Physics/International Association for the Physical Sciences of the Ocean |
| IAMSLIC: | International Association of Marine Science Libraries & Information Centers |
| IBM: | individual-based model |
| ICES: | International Council for the Exploration of the Sea |
| ICG/ITSU: | International Coordinating Group for the Tsunami Warning System in the Pacific |
| ICSU: | International Council of Scientific Unions |
| ICWF: | Interactive Computer Worded Forecast |

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| IDL: | interactive data language |
| IEEE: | Institute of Electrical and Electronics Engineers |
| IFA: | Intensive Flux Array |
| IFREMER: | Institut Francais de Recherche pour l'Exploitation de la Mer |
| IGAC-MAGE | International Global Atmospheric Chemistry/Marine Aerosol and Gas Exchange Program |
| IGBP: | International Geosphere-Biosphere Program |
| IGM: | interplanetary global model |
| IGOSS: | International Global Ocean Services System |
| IGP: | Igneous & Geothermal Processes |
| IGS: | Inner Gulf Shelf |
| IGSP: | International Greenland Sea Project |
| IJC: | International Joint Commission |
| IM: | intermediate modeling |
| IMPROVE: | Interagency Monitoring of Protected Visual Environments |
| INSAT: | Indian Satellite |
| IOC: | International Oceanographic Commission |
| IOP: | intensive observing period |
| IOS: | Institute of Ocean Sciences |
| IPS: | interplanetary scintillation |
| IPSLN: | Indo-Pacific Sea Level Network |
| IR: | infrared |
| IRD: | International Radiation Detectors |
| IRICP: | International Research Institute for Climate Prediction |
| IRIS: | International Recruitment Investigations in the Subarctic |
| IRIS: | Incorporated Research Institutions for Seismology |
| ISCCP: | International Satellite Cloud Climatology Project |
| ISEE: | International Sun-Earth Explorer |
| ISLP-Pac: | IGOSS Sea Level Project in the Pacific |
| ISPAN: | Information Stream Project for AWIPS and NOAAPORT |
| ISPM: | interplanetary shock propagation model |
| ISS: | Integrated Sounding System |
| ITCZ: | intertropical convergence zone |
| IUGG: | International Union of Geodesy and Geophysics |
| IUGG/TC: | IUGG Tsunami Commission |
| IUSS: | Integrated Underwater Surveillance System (Navy) |
| JAMSTEC: | Japan Marine Science and Technology Center |
| JAPACS: | Japanese Pacific Ocean Climate Studies |
| J-COARE: | Japanese COARE |
| JDFR: | Juan de Fuca Ridge |
| JFSP: | Joint Forecast System Project |
| JGOFS: | Joint Global Ocean Flux Study |
| JIC: | Navy/NOAA Joint Ice Center |
| JIMAR: | Joint Institute for Marine and Atmospheric Research |
| JISAO: | Joint Institute for the Study of Atmosphere and Ocean |
| JOI: | Joint Oceanographic Institutions |
| JPL: | Jet Propulsion Laboratory |
| JSC: | Johnson Space Center |
| JTRE: | JIMAR Tsunami Research Effort |
| KH: | Kelvin-Helmholtz |
| KORDI: | Korea Ocean Research and Development Institute |
| LAHM: | Limited Area HIBU Model |
| Lamont: | Lamont Doherty Geological Observatory |
| LAN: | local area network |
| LAP: | Local Analysis and Prediction [Branch] (SFL) |
| LAPS: | Local Analysis and Prediction System |
| LASCO: | Large-angle Spectrometric Coronagraph |
| LDGO: | Lamont Doherty Geological Observatory |
| LEIFS: | Lake Erie Information Forecasting System |
| LFLOW: | linearized high-resolution wind-field flow [model] |
| LFP: | low-frequency prediction |
| LGFSTP: | Liquefied Gaseous Fuels Spill Test Facility |

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| LLJ: | low-level jet |
| LLWAS: | Low-Level Windshear Alert System |
| LORAN: | Long-Range Aid to Navigation |
| L-RERP: | Long-Range Effects Research Program |
| LROD: | long-range overwater diffusion |
| LSDM: | Lagrangian stochastic dispersion model |
| MA: | Meteorological Applications [Branch] (FSL) |
| MADER: | Management of Atmospheric Data for Evaluation and Research |
| MAGE: | Marine Aerosol and Gas Exchange |
| MAPS: | Mesoscale Analysis and Prediction System |
| MAR: | Mississippi-Atchafalaya River [system] |
| MARD: | Marine Assessment Research Division [now OERD] (PMEL) |
| MCC: | Midwest Climate Center |
| M-CLASS: | mobile CLASS |
| MCS: | Mesoscale Convective System |
| MCSST: | Multi-Channel SST |
| MCV: | mesoscale convectively generated vortices |
| MDA: | mesocyclone detection algorithm |
| MDD: | Meteorological Data Distribution |
| MEDS: | Meteorological and Environmental Data Services |
| MEP-91: | Mesoscale Evolution Project-1991 |
| METEOR: | [Russian satellite; not an acronym] |
| METEOSAT-3: | [European Space Agency weather satellite; not an acronym] |
| MFP: | Mobile Flux Platform |
| MHD: | magnetohydrodynamic [simulation] |
| MHMS: | Modular Hydrologic Modeling System |
| MIT: | Massachusetts Institute of Technology |
| MIUU: | Meteorological Institute of the University of Uppsala |
| MIZ: | Marginal Ice Zone |
| MIZEX: | Marginal Ice Zone Experiment |
| MLD: | Mixed Layer Depth |
| MM4: | Mesoscale Meteorological Model-Version 4 |
| MMS: | Minerals Management Service, U.S. Dept. of Interior |
| MOA: | Memorandum of Agreement |
| MOCNESS: | Multiple Opening and Closing Net Environmental Sampling System |
| MODIS: | Moderate Resolution Imaging Spectrometer |
| MOHAVE: | Measurement of Haze and Visual Effects [study] |
| MOU: | Memorandum of Understanding |
| MPIF: | Message Passing Interface Forum |
| MPIM: | Max-Planck-Institut für Meteorologie |
| MPP: | massively parallel processor |
| MRAO: | Mullard Radio Astronomy Observatory |
| MRC: | Marine Research Corporation |
| MRD: | Mesoscale Research Division (NSSL) |
| MRF: | medium-range forecast [model] |
| MRP: | Mississippi River Plume |
| MRRD: | Marine Resources Research Division [now OERD] (PMEL) |
| MRT: | Ministére de la Recherche et de la Technologie |
| MS: | mass spectrometer |
| MSA: | methane sulfonic acid |
| MSFC: | Marshall Space Flight Center |
| MSRD: | Marine Services Research Division [now CARD] (PMEL) |
| MST: | Mesosphere-Stratosphere-Troposphere |
| mtDNA: | mitochondrial deoxyribonucleic acid |
| MTPR: | Miniature Temperature Pressure Recorder |
| MTR: | miniature temperature recorder |
| MWSR: | Microwave Water Substance Radiometer |
| NADP: | National Atmospheric Deposition Program |
| NADW: | North Atlantic Deep Water |
| NARE: | North Atlantic Regional Experiment |
| NAS: | National Academy of Sciences |

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| NASA: | National Aeronautics and Space Administration |
| NATO: | North Atlantic Treaty Organization |
| NAWAU: | National Aviation Weather Advisory Unit (FAA) |
| NCAR: | National Center for Atmospheric Research |
| NCDC: | National Climatic Data Center (NOAA) |
| NDBC: | National Data Buoy Center |
| NDDN: | National Dry Deposition Network |
| NDSC: | Network for the Detection of Stratospheric Change |
| NDTE: | North Dakota Tracer Experiment |
| NDVI: | Normalized Difference Vegetation Index |
| NECC: | North Equatorial Counter Current |
| NECOP: | Nutrient-Enhanced Coastal Ocean Productivity [program] |
| NERC: | Natural Environment Research Council |
| NESDIS: | National Environmental Satellite, Data, and Information Service (NOAA) |
| NEXRAD: | Next-Generation Weather Radar |
| NGDC: | National Geophysical Data Center (NOAA) |
| NGM: | Nested Grid Model (NMC) |
| NHC: | National Hurricane Center (NOAA) |
| NIC: | NOAA Information Center |
| NIMBUS: | Network Information Management Climate-Based User Service |
| NIMBUS-7: | NOAA satellite |
| NIST: | National Institute of Standards and Technology |
| NLSST: | nonlinear SST |
| NMC: | National Meteorological Center (NOAA) |
| NMHC: | nonmethane hydrocarbon |
| NMFS: | National Marine Fisheries Service (NOAA) |
| NNT: | Nearest Neighbor Tool |
| NOAA: | National Oceanic and Atmospheric Administration |
| NOAAPORT: | Access to NOAA real-time data base system (not an acronym) |
| NOARL: | National Oceanographic and Atmospheric Research Laboratory |
| NOCN: | National Ocean Communications Network |
| NODC: | National Ocean Data Center (NOAA) |
| NORPAX: | North Pacific Experiment |
| NOS: | National Ocean Service (NOAA) |
| NOSC: | Naval Ocean Systems Center |
| NPI: | NEXRAD Product Interface |
| NPS: | National Park Service |
| NPTZ: | North Pacific transition zone |
| NRC: | National Research Council |
| NRC: | Nuclear Regulatory Commission |
| NRL: | Naval Research Laboratory |
| NSF: | National Science Foundation |
| NSIDC: | National Snow and Ice Data Center |
| NSIPS: | NRL Satellite Image Processing System |
| NSSL: | National Severe Storms Laboratory (ERL) |
| NURP: | NOAA Undersea Research Program |
| NUSC: | Naval Underwater Systems Center |
| NWAFC: | Northwest and Alaska Fisheries Center |
| NWP: | Numerical Weather Prediction |
| NWS: | National Weather Service (NOAA) |
| NWSFO: | NWS Forecast Office |
| NWSTG: | NWS Telecommunications Gateway |
| OACES: | Ocean-Atmosphere Carbon Exchange Study |
| OAR: | Oceanic and Atmospheric Research |
| OCD: | Ocean Chemistry Division (AOML) |
| OCEAN STORMS: | A JISAO field experiment for the assessment of weather fronts (not an acronym) |
| OCNMAP: | Ocean Map |
| OCRD: | Ocean Climate Research Division (PMEL) |
| OCS: | Outer Continental Shelf |
| OCSEAP: | Outer Continental Shelf Environmental Assessment Program |
| ODP: | Ocean Drilling Program |

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|---|---|
| ODP: | ozone depletion potential |
| ODW: | Omega Dropwindsonde |
| OERD: | Ocean Environment Research Division [formerly MARD and MRRD] (PMEL) |
| OLR: | Outgoing Longwave Radiation |
| OLS: | Operational Linescan System (DOD) |
| ONR: | Office of Naval Research |
| ORNL: | Oak Ridge National Laboratory |
| ORSTOM: | Office de la Recherche Scientifique et Technique Outre-Mer |
| OSCR: | Ocean Surface Current Radar |
| OSO: | Office of Systems Operations |
| OSS: | Observing Simulation System |
| OSSE: | Observing System Simulation Experiment |
| OSU: | Oregon State University |
| OT&E: | Operational Testing and Evaluation |
| OTH: | over the horizon [radar] |
| OU: | University of Oklahoma |
| PACTOP: | Pacific Tsunami Observation Program |
| PAH: | polycyclic aromatic hydrocarbon |
| PAN: | peroxyacetyl nitrate |
| PCB: | polychlorinated biphenyl |
| PCGRIDS: | Personal Computer Gridded Interactive Display and Diagnostic System |
| PCR: | polymerase chain reaction |
| PDAS: | photodiode array spectrophotometer |
| PEGASUS: | Current velocity profiling instrument (not an acronym) |
| PEM-West: | [Western Pacific tropospheric chemistry experiment; not an acronym] |
| PENTAFLUX: | Fifth Flux Experiment |
| PEQUOD: | Pacific Equatorial Ocean Dynamics |
| PFC: | perfluorocarbon |
| PICES: | North Pacific Marine Science Organization |
| PIREPS: | pilot reports |
| PM: | Process Manager |
| PMEL: | Pacific Marine Environmental Laboratory (ERL) |
| PNEDC: | Programme National d'Études de la Dynamique du Climat |
| POC: | particulate organic carbon |
| POD: | probability of detection |
| PON: | particulate organic nitrogen |
| POSEIDON: | French component of joint U.S./French TOPEX/POSEIDON sea-surface topography satellite mission (not an acronym) |
| POT: | Program for Operational Trajectories |
| POTAD: | Program for Operational Transport and Dispersion |
| ppmv: | parts per million by volume |
| ppt: | parts per trillion |
| PRC: | Planning Research Corporation, Inc. |
| PRE-STORM: | Preliminary Regional Experiment for STORM |
| PREVENT: | Pacific NW Regional Visibility Experiment using Natural Tracers |
| PRF: | pulse repetition frequency |
| PROBE: | Pilot Radiation Observation Experiment |
| PROFS: | Program for Regional Observing and Forecasting Services (FSL) |
| PROTEUS: | Profile Telemetry of Upper Ocean Currents |
| PSC: | polar stratospheric cloud |
| PSI: | Pacific Sulfur/Stratus Investigation |
| PTAP: | profiler triangle analysis package |
| PV: | potential vorticity |
| QBO: | Quasi-biennial Oscillation |
| QC: | quality control |
| QLM: | Quasi-Lagrangian Model |
| RADM: | Regional Acid Deposition Model |
| RADS: | Real-time Analysis and Display System |
| RAFOS: | [SOFAR spelled backwards; not an acronym] |
| RAMM: | Regional and Mesoscale Meteorology (NESDIS branch) |
| RAMS: | Regional Atmospheric Modeling System |

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| RAP: | Regional Analysis and Prediction [Branch] (FSL) |
| RASS: | Radio Acoustic Sounding System |
| RATCHET: | Regional Atmospheric Transport Code for Hanford Emission Tracking |
| rDNA: | ribosomal DNA |
| REFM: | Resource Ecology and Fisheries Management |
| REI.MAP: | Regional Lagrangian Model of Air Pollution |
| RFLP: | restriction fragment length polymorphism |
| Ri: | Richardson Number, a dimensionless number related to stability of stratified flow |
| RIM: | [a public-domain relational database; not an acronym] |
| RISC: | Reduced Instruction Set Computer [workstation] |
| RITS: | Radiatively Important Trace Species |
| RJE: | remote job entry |
| RNN: | Regional NOCN Node |
| ROM: | Regional Oxidant Model |
| ROPOS: | Remotely Operated Platform for Ocean Science |
| ROSE: | Rural Oxidants in the Southern Environment |
| ROV: | remotely operated vehicle |
| RPG: | Radar Product General |
| RPM: | Regional Particulate Model |
| RR: | Risk Reduction [Branch] (FSL) |
| RSMAS: | Rosenstiel School of Marine and Atmospheric Sciences |
| RSMC: | Regional Specialized Meteorological Centre |
| RUC: | rapid update cycle |
| S3T: | Sequentially Sampling Sediment Trap |
| SA: | spaced antenna |
| SA: | simple-adjoint [method] |
| SABRE: | South Atlantic Bight Recruitment Experiment |
| SAFER: | Spectral Application of Finite Element Representation |
| SAGA-3: | Third Soviet-American Gas and Aerosol [experiment] |
| SAGE: | Stratospheric Aerosol and Gas Experiment |
| SAIC: | Science Applications International Corporation |
| SANA: | Sanierung der Atmosphäre (Germany) |
| SAR: | Synthetic Aperture Radar |
| SATCOM: | Satellite Communications |
| SAVE: | South Atlantic Ventilation Experiment |
| SB: | semi-balance [model] |
| SBUV: | Solar Backscatter Ultraviolet |
| SCIT: | storm cell identification and tracking [algorithm] |
| SCOPE: | San Clemente Ocean Probing Experiment |
| SCOR: | Scientific Committee on Oceanic Research |
| SCOPE: | Scientific Committee on Problems of the Environment |
| SCOSTEP: | Scientific Committee on Solar-Terrestrial Physics |
| Scripps: | Scripps Institution of Oceanography |
| SDB: | Systems Development Branch (SEL) |
| SDD: | Systems Development Division (FSL) |
| SEABEAM: | A shipboard multi-transducer swath echo sounding system |
| SEACAT: | SeaBird Conductivity and Temperature Recorder |
| SEAS: | Shipboard Environmental Acquisition System |
| SeaWiFS: | Sea-viewing Wide Field-of-View Sensor |
| SEFC: | Southeast Fisheries Center |
| SEFCAR: | Southeast Florida and Caribbean Recruitment |
| SEL: | Space Environment Laboratory (ERL) |
| SELDADS: | SEL Data Acquisition and Display System |
| SELRAS: | SEL Retrieval and Analysis of Scientific data system |
| SEM: | Space Environment Monitor |
| SERF: | Solar Electromagnetic Radiation Flux [model] |
| SESC: | Space Environment Services Center (SEL) |
| SFC: | Space Forecast Center (USAF) |
| SFE: | supercritical fluid extraction |
| SFMR: | Stepped Frequency Microwave Radiometer |
| SFOSRC: | South Florida Oil Spill Research Center |

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| SHARE: | Software Help in Applications, Research and Education (international program to develop meteorological analysis and display software for developing countries) |
| SHIFOR: | [climatology and persistence model; not an acronym] |
| SHIPS: | statistical hurricane intensity prediction scheme |
| SIDAAC: | Snow and Ice Distributed Active Archive Center |
| SIO: | Scripps Institution of Oceanography |
| SKYHI: | GFDL stratosphere GCM (not an acronym) |
| SLAR: | Side-Looking Airborne Radar |
| SLEUTH: | System for Locating Eruptive Underwater Turbidity and Hydrography |
| SLP: | sea level pressure |
| SLW: | supercooled liquid water |
| SMB: | Systems Management Branch (SEL) |
| SMCC: | System Monitoring and Coordinating Center (NWS) |
| SMM: | Solar Maximum Mission |
| SMMR: | Scanning Multichannel Microwave Radiometer |
| SNMP: | Small Network Management Packet |
| SOFAR: | sound fixing and ranging (acoustical system/technique) |
| SOHO: | [satellite; not an acronym] |
| SOLERS22: | Solar Electromagnetic Radiation Study for Solar Cycle 22 |
| SOLTIP: | Solar Connections to Transient Interplanetary Processes [program] |
| SOON: | Solar Observing Optical Network (USAF) |
| SOONSPOT: | SOON's Solar Patrol on Tape |
| SOS: | Southern Oxidant Study |
| SOWEX: | Southern Ocean Waves Experiment |
| SPADE: | Stratospheric Photochemistry, Aerosols, and Dynamics Expedition |
| SPC: | Storms Prediction Center |
| SPECTRE: | Spectral Radiation Experiment |
| SPEM: | semispectral primitive equation model |
| SPWT: | SSM/I Products Working Team |
| SRA: | Scanning Radar Altimeter |
| SREH: | storm-relative environmental helicity |
| SRRB: | Solar Radiation Research Branch (ARL) |
| SSBUV: | Shuttle SBUV |
| SSD: | Scientific Support Division (NSSL) |
| SSF: | semi-Lagrangian and semi-geostrophic finite element [model] |
| SSG: | Scientific Steering Group |
| SSM/I: | Special Sensor Microwave/Imager |
| SST: | sea-surface temperature |
| ST: | stratosphere-troposphere [radar] |
| STA: | Japanese Science and Technology Agency |
| STACS: | Subtropical Atlantic Climate Studies |
| STEP: | Stratosphere-Troposphere Exchange Project |
| STORM: | Stormscale Operational and Research Meteorology |
| STORM-FEST: | STORM Fronts Experiment Systems Test |
| STT: | Small Tactical Terminal |
| SVP: | Surface Velocity Programme |
| SWAMP: | Southwest Area Monsoon Project |
| SXI: | Solar X-ray Imager |
| TA: | Technical Applications [Branch] (FSL) |
| TAG: | Trans-Atlantic Geotraverse |
| TAMU: | Texas A&M University |
| TAO: | Thermal Array for the Ocean; Tropical Atmosphere/Ocean |
| TASD: | Technical and Administrative Support Division (PMEL) |
| TDA: | tornado detection algorithm |
| TDWR: | Terminal Doppler Weather Radar |
| TELSAR: | Tracking and Evolution of Solar Active Regions |
| THEO: | System for predicting solar flare probabilities, named for Theophrastus (not an acronym) |
| THRUST: | Tsunami Hazard Reduction Using System Technology |
| TIROS: | Television and Infrared Observation Satellite |
| TIWE: | Tropical Instability Wave Experiment |
| TKE: | turbulent kinetic energy |

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| TMAP: | Thermal Modeling and Analysis Project |
| TO-AN: | Tropical Ocean-Atmosphere Newsletter (now TOGA Notes) |
| TOGA: | Tropical Oceans and Global Atmosphere |
| TOMS: | Total Ozone Mapping Spectrophotometer |
| TOPEX: | Topographic Experiment (NASA) |
| TOPS: | Total Ocean Profiling System |
| TOVS: | TIROS Operational Vertical Sounder |
| T-POP | TOGA Program on Prediction |
| TPPN: | Trans-Pacific Profiler Network |
| TRACIR: | Tracking Air with Circularly Polarized Radar |
| TRMM: | Tropical Rainfall Measuring Mission |
| TSLC: | TOGA Sea Level Center |
| TVS: | Tornado Vortex Signature |
| TWP: | Tropical Western Pacific |
| UARP: | Upper Atmospheric Research Program (NASA) |
| UARS: | Upper Atmospheric Research Satellite |
| UCAR: | University Corporation for Atmospheric Research |
| UCM: | Unresolved Complex Mixture |
| UCSD: | University of California at San Diego |
| UH: | University of Hawaii |
| UHF: | ultrahigh frequency |
| UM: | University of Miami |
| UNISYS: | United Information Systems |
| UNOLS: | University-National Oceanographic Laboratory System |
| URI: | University of Rhode Island |
| URSI: | Union Radio Scientifique Internationale |
| USAF: | U.S. Air Force |
| USGS: | United States Geological Survey |
| UTC: | coordinated universal time |
| UV: | ultraviolet |
| UW: | University of Washington |
| VAD: | Velocity-Azimuth Display |
| VAFTAD: | Volcanic Ash Forecast Transport and Dispersion [model] |
| VAS: | VISSR Atmospheric Sounder |
| VDUC: | VAS Data Utilization Center |
| VENTS: | Name of hydrothermal venting research program (not an acronym) |
| VHF: | very high frequency |
| VICBAR: | Code name for barotropic hurricane track prediction model (not an acronym) |
| VIL: | vertically integrated liquid |
| VISSR: | Visible and Infrared Spin-Scan Radiometer |
| VOC: | volatile organic compound |
| VORTEX: | Verification of the Origin of Rotation in Tornadoes Experiment |
| VOS: | volunteer observing ship |
| VP: | Verification Program [Branch] (FSL) |
| VSG: | viscous, semi-geostrophic [model] |
| WAM: | wave modeling |
| WATOX: | Western Atlantic Ocean Experiment |
| WDC: | World Data Center |
| WEPOCS: | Western Equatorial Pacific Ocean Circulation Study |
| WESTRAX: | Western Tropical Atlantic Experiment |
| WHOI: | Woods Hole Oceanographic Institution |
| WHP: | WOCE Hydrographic Experiment |
| WIA: | Weather Impacted Airspace |
| WIND: | [satellite; not an acronym] |
| WISP: | Winter Icing and Storms Project |
| WISPIT: | WISP Instrument Test |
| WMO: | World Meteorological Organization |
| WOCE: | World Ocean Circulation Experiment |
| WOTAN: | Weather Observation Through Ambient Noise |
| WPDN: | Wind Profiler Demonstration Network |
| WPL: | Wave Propagation Laboratory (ERL) |

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| WRIPS: | Wave Rider Information Processing System |
| WSLC: | WOCE Sea Level Center |
| WSFO: | Weather Service Forecast Office |
| WSR-88D: | Weather Surveillance Radar |
| XBT: | Expendable Bathythermograph |
| XCTD: | Expendable Conductivity-Temperature-Depth Probe |