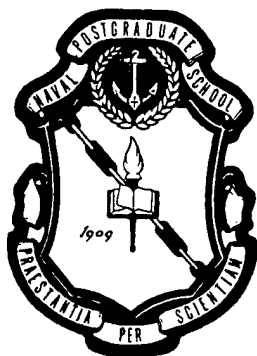


Naval Postgraduate School
Monterey, California 93943-5138



SUMMARY OF RESEARCH 1998

Department of Meteorology

**Carlyle H. Wash
Chair**

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Prepared for: Naval Postgraduate School
Monterey, CA 93943-5000

NAVAL POSTGRADUATE SCHOOL
Monterey, California

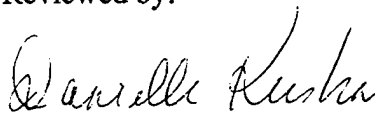
Rear Admiral R.C. Chaplain, USN
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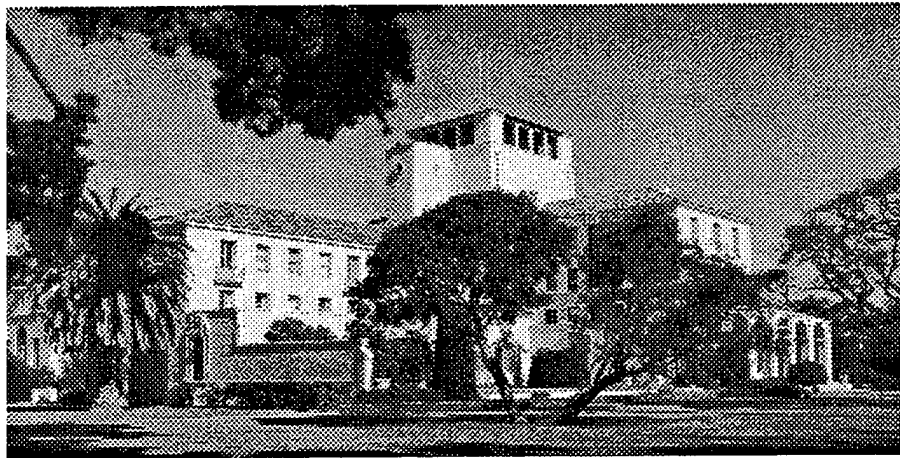
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**DEPARTMENT OF
METEOROLOGY**

**Carlyle H. Wash
Chair**

THE NAVAL POSTGRADUATE SCHOOL MISSION

The mission of the Naval Postgraduate School is to increase the combat effectiveness of U.S. and Allied armed forces and enhance the security of the USA through advanced education and research programs focused on the technical, analytical, and managerial tools needed to confront defense-related challenges.



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PREFACE

Research at the Naval Postgraduate School is carried out by faculty in the School's eleven academic departments, seven interdisciplinary groups, and the School of Aviation Safety. This volume contains research summaries for the projects undertaken by faculty in the Department of Meteorology during 1998. Also included is an overview of the department, faculty listing, a compilation of publications/presentations, and abstracts from theses directed by the department faculty.

Questions about particular projects may be directed to the faculty Principal Investigator listed, the Department Chair, or the Department Associate Chair for Research. Questions may also be directed to the Office of the Associate Provost and Dean of Research. General questions about the NPS Research Program should be directed to the Office of the Associate Provost and Dean of Research at (831) 656-2099 (voice) or research@nps.navy.mil (e-mail). Additional information is also available at the RESEARCH AT NPS website, <http://web.nps.navy.mil/~code09/>.

INTRODUCTION

The research program at the Naval Postgraduate School exists to support the graduate education of our students. It does so by providing militarily relevant thesis topics that address issues from the current needs of the Fleet and Joint Forces to the science and technology that is required to sustain the long-term superiority of the Navy/DoD. It keeps our faculty current on Navy/DoD issues, permitting them to maintain the content of the upper division courses at the cutting edge of their disciplines. At the same time, the students and faculty together provide a very unique capability within the DoD for addressing warfighting problems. This capability is especially important at the present time when technology in general, and information operations in particular, are changing rapidly. Our officers must be able to think innovatively and have the knowledge and skills that will let them apply technologies that are being rapidly developed in both the commercial and military sectors. Their unique knowledge of the operational Navy, when combined with a challenging thesis project that requires them to apply their focussed graduate education, is one of the most effective methods for both solving Fleet problems and instilling the life-long capability for applying basic principles to the creative solution of complex problems.

The research program at NPS consists of both reimbursable (sponsored) and institutionally funded research. The research varies from very fundamental to very applied, from unclassified to all levels of classification.

- **Reimbursable (Sponsored) Program:** This program includes those projects externally funded on the basis of proposals submitted to outside sponsors by the School's faculty. These funds allow the faculty to interact closely with RDT&E program managers and high-level policymakers throughout the Navy, DoD, and other government agencies as well as with the private sector in defense-related technologies. The sponsored program utilizes Cooperative Research and Development Agreements (CRADAs) with private industry, participates in consortia with other government laboratories and universities, provides off-campus courses either on-site at the recipient command or by VTC, and provides short courses for technology updates.
- **NPS Institutionally Funded Research Program (NIFR):** The institutionally funded research program has several purposes: (1) to provide the initial support required for new faculty to establish a Navy/DoD relevant research area, (2) to provide support for major new initiatives that address near-term Fleet and OPNAV needs, (3) to enhance productive research that is reimbursable sponsored, (4) to contribute to the recapitalization of major scientific equipment, and (5) to cost-share the support of a strong post-doctoral program.
- **Institute for Joint Warfare Analysis (IJWA) Program:** The IJWA Program provides funding to stimulate innovative research ideas with a strong emphasis on joint, interdisciplinary areas. This funding ensures that joint relevance is a consideration of research faculty.

In 1998, the overall level of research effort at NPS was 145 faculty workyears and exceeded \$35 million. The Department of Meteorology's effort was 14.99 faculty workyears and exceeded \$2.8 million. The sponsored research program has grown steadily to provide the faculty and staff support that is required to sustain a strong and viable graduate school in times of reduced budgets. In FY97, over 81% percent of the NPS research program was externally supported. In the Department of Meteorology 95% was externally supported.

The department's research sponsorship in FY98 is provided in Figure 1.

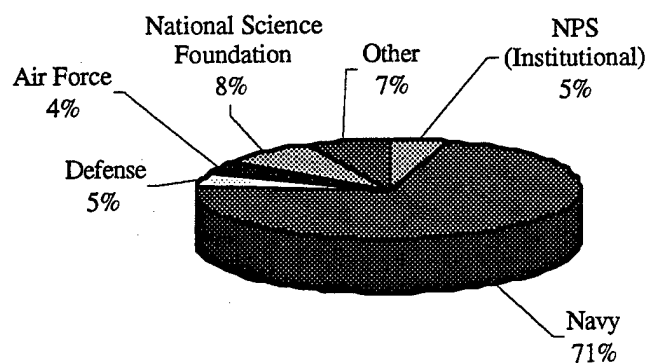


Figure 1. FY98 Sponsor Profile of the Department of Meteorology

These are both challenging and exciting times at NPS and the research program exists to help ensure that we remain unique in our ability to provide graduate education for the warfighter.

DAVID W. NETZER
Associate Provost and Dean of Research

October 1999

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DEPARTMENT SUMMARY

The Department of Meteorology has a broad research program to address scientific questions important to tactical support of both operational commanders and individual forces at sea with regard to high impact weather. For high impact weather, the Navy is turning increasingly to Rapid Environmental Assessment (REA) for tactical support, recently described by our curriculum sponsor, Oceanographer of the Navy (OP-096). Of essence in Rapid Environmental Assessment is the detailed and timely Meteorology and Oceanography (METOC) characterization of a limited objective area. REA will call for sequential application of old and new techniques as operation start time (H-hour) nears. This will require enlarging the emphasis from large-scale, predictive, numerical models to include "nowcasting" quick-reaction survey, direct exploitation of remote and in situ observations, innovative processing techniques for satellite data and through-the-sensor environmental measurements.

The Department's currently supported and planned research is designed to meet evolving Navy requirements and also to meet two basic motivations for METOC support. These are to ensure the safety of the Fleet and the shore establishments in the face of adverse weather and ocean conditions and to provide warfighters a decisive tactical edge by providing environmental parameters for weapons system performance predictions.

The present areas of research support are described in these summaries:

- a) Development of a unified view of the mesoscale, synoptic-scale, and large-scale environment components of atmospheric circulation that impact Naval operations, including tropical and extratropical cyclones, coastal circulation, and upper-troposphere circulation;
- b) Development and motion of extra-tropical and tropical cyclones, including formulation and testing of a systematic approach to tropical cyclone track forecasting throughout the globe;
- c) Analysis and modeling diurnal, synoptic, intraseasonal, and interannual variations of tropical and monsoon weather systems;
- d) Formulation of methods for using remote sensing to estimate overwater coastal region radar/radio refraction conditions and aerosol/visibility conditions;
- e) Formulation/evaluation of physical models for near-surface turbulence and gradients affecting near-horizon optical propagation;
- f) Perform selection and evaluation of commercial equipment to use in integrated shipboard systems that would describe electro-magnetic/electro-optical (EM/EO) conditions;
- g) Innovative observation and data analysis techniques and modeling method for boundary layer studies that lead to improved representation of boundary layer turbulence and clouds in global and regional models;
- h) Development of frontal models for application over the oceans and the land, including topography;
- i) Development of real-time mesoscale observing, data management, and mesoscale data assimilation techniques applicable to the coastal environment;
- j) Development of local modeling and mesoscale forecasting techniques to improve coastal atmospheric prediction; and
- k) Description of air-sea-ice interactions in Polar Regions through in situ measurements.

DEPARTMENT SUMMARY

RESEARCH FACILITIES

The Department of Meteorology has facilities for both measurements (in situ and remote sensing) of atmospheric phenomena and for numerical modeling/analyses development. In situ measurement devices are in the Marine Atmospheric Measurements Laboratory (MAML) and within a suite designed to be installed on ships of opportunity. MAML has meteorological ground stations, 405 and 915 MHz Doppler-radar wind profilers, a radiosonde system, and a SODAR, at either the NPS or at a Presidio of Monterey (POM) Annex location. Ground stations with airflow sensors and real-time transmission capabilities are located at the Point Sur Lighthouse. A major center for Interdisciplinary Remotely Piloted Aircraft Studies (CIRPAS) was established in coordination with the California Institute of Technology with field programs in progress. Its instrumentation for atmospheric studies is being carried out with ONR funding. A shipboard system consisting of rawinsonde and sensors for airflow properties has been developed with necessary real-time acquisition and calculation support systems. Buoy systems have been developed for measuring air-sea fluxes and surface thermal and wave properties. The modeling/analysis facilities are contained within the Interactive Digital Environmental Analysis (IDEA) Laboratory with 12 Workstations and the Remote Sensing Laboratory with 4 workstations. Both laboratories provide modern computer technology, including computations and display software, and real-time databases. Recently, the Department of Meteorology obtained a second SGI Origin 2000 multi-processor Computer Server. This allows both research and real-time mesoscale modeling of atmospheric dynamic processes, particularly for coastal regions.

PROJECT SUMMARIES

DEVELOPMENT OF AN EXPERT SYSTEM BASED ON THE SYSTEMATIC APPROACH TO TROPICAL CYCLONE TRACK FORECASTING

Lester E. Carr, III, Research Associate Professor

Russell L. Elsberry, Professor

Department of Meteorology

Sponsor: Office of Naval Research

OBJECTIVE: The long-term goals of this project are the same as those for the related project entitled, "Systematic Approach to Tropical Cyclone (TC) Track Forecasting," summarized elsewhere. The specific objectives of this project are to conduct exploratory research to: (i) develop a prototype expert system that is based on the systematic approach concept, and which methodically leads the TC forecaster through a sound forecast formulation process, exposes the forecaster to key information, prompts and assists the forecaster to make pivotal decisions, and accomplishes basic tasks for the forecaster wherever feasible and (ii) demonstrating the feasibility of such an expert system for improving the accuracy and meteorological utility of official tropical cyclone track forecasts.

SUMMARY: This project is a continuation of work from 1997, when the focus was on developing that part of the expert system that assists the forecaster in understanding and characterizing the meteorological environment that is affecting the current motion of the TC. This year the emphasis has been on developing that part of the expert system that permits the forecaster to effectively display and interpret the forecast tracks and fields from available numerical models. The expert system is being designed to proactively analyze the individual model forecast tracks among an ensemble of tracks for indications of erroneous physical processes that may be degrading the accuracy of one of more models. The forecaster then uses the field display and animation capability of the expert system to make the final decision as to which models (if any) are being degraded and what the principal error mechanism is. A "selective" consensus forecast, based only on models for which no error mechanism is identified, is then computed. The effectiveness of the expert system is measured by how much smaller the average error of the selective consensus is than a non-selective consensus of the numerical model track forecasts for a sufficiently large sample. Such a test of the effectiveness of the expert system is being planned for the upcoming western North Pacific tropical cyclone season.

PUBLICATION:

Carr, L.E., III and Elsberry, R.L., "Objective Diagnosis of Binary Tropical Cyclone Interactions for the Western North Pacific Basin," *Monthly Weather Review*, 126, pp. 1734-1739, 1998.

CONFERENCE PRESENTATIONS:

Carr, L.E., III, Schnabel, R.G., and Elsberry, R.L., "Development of a Model Traits Knowledge Base," USPACOM Tropical Cyclone Conference, Tokyo, Japan, 24-27 February 1998.

Carr, L.E., III, Peak, J.E., and Elsberry, R.L., "Systematic Approach to Tropical Cyclone Track Forecasting Expert System (SAES)," USPACOM Tropical Cyclone Conference, Tokyo, Japan, 24-27 February 1998.

THESIS DIRECTED:

Schnabel, R.G., "A Comparison of the NOGAPS and GFDN Dynamical Track Prediction Models During the 1997 Western North Pacific Typhoon Season," Master's Thesis, Naval Postgraduate School, March 1998.

DoD KEY TECHNOLOGY AREA: Battlespace Environment

KEYWORDS: Tropical Cyclone Prediction, Expert Systems

PROJECT SUMMARIES

APPLICATIONS OF THE SYSTEMATIC APPROACH TO TROPICAL CYCLONE TRACK FORECASTING IN THE WESTERN NORTH PACIFIC AND EXTENSIONS TO OTHER TROPICAL CYCLONE REGIONS

Lester E. Carr, III, Research Associate Professor

Russell L. Elsberry, Professor

Department of Meteorology

Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: The focus of this project is the development of specific tropical cyclone track forecasting tools, as well as the extension of the systematic approach concept to various regions of the world where tropical cyclones form. Thus, this project is the transition of an ONR project entitled, "Systematic Approach to Tropical Cyclone Track Forecasting," which has to do with the formulation of the overall systematic approach to tropical cyclone forecasting "concept," particularly the development of a comprehensive meteorological knowledge base to explain tropical cyclone motion in the western North Pacific.

SUMMARY: In a continuation of a collaborative effort with the Australian Bureau of Meteorology, the meteorological knowledge base of the Systematic Approach was further refined for use in providing dynamically based explanations for TC motion in both the South Pacific and South Indian Ocean regions (Bannister et al., 1998). A statistical-synoptic track prediction technique based on CLImatology and Persistence (CLIPER)-type regression equations developed for the western North Pacific will be published (Chen et al., 1998). A statistical post-processor has been developed that objectively modifies TC track forecasts made by the Navy Operational Global Atmospheric Prediction System (NOGAPS) to account for the misplaced vortex (Elsberry, et al., 1999).

PUBLICATIONS:

Bannister, A.J., Boothe, M.A., Carr, L.E., III, and Elsberry, R.L., "Southern Hemisphere Application of the Systematic Approach to Tropical Cyclone Track Forecasting, Part II: Climatology and Refinement of Meteorological Knowledge Base," Naval Postgraduate School Technical Report, NPS-MR-98-004, 1998.

Elsberry, R.L., Carr, L.E., III, and Boothe, M.A., "Progress Toward a Generalized Description of the Environment Structure Contribution to Tropical Cyclone Track Types," *Meteorology and Atmospheric Physics*, 67, pp. 93-116, 1998.

Elsberry, R.L., Boothe, M.A., Ulses, G.A., and Harr, P.A., "Statistical Post-Processing of NOGAPS Tropical Cyclone Track Forecasts," *Monthly Weather Review*, in press.

CONFERENCE PRESENTATIONS:

Carr, L.E., III, Bannister, A.J., Boothe, M.A., and Elsberry, R.L., "Application of the Systematic Approach to the Southern Hemisphere," USPACOM Tropical Cyclone Conference, Tokyo, Japan, 24-27 February 1998.

Elsberry, R.L., Boothe, M.A., and Carr, L.E., III, "Application of the Systematic Approach in the Central and Eastern North Pacific," USPACOM Tropical Cyclone Conference, Tokyo, Japan, 24-27 February 1998.

Elsberry, R.L., Boothe, M.A., and Carr, L.E., III, "Application of the Systematic Approach in the Central and Eastern North Pacific," Interdepartmental Hurricane Conference, St. Petersburg, FL, 26-30 January 1998.

Elsberry, R.L., Carr, L.E., III, and Boothe, M.A., "Progress Toward a Generalized Description of the Environment Structure Contribution to Tropical Cyclone Track Types," USPACOM Tropical Cyclone Conference, Tokyo, Japan, 24-27 February 1998.

PROJECT SUMMARIES

THESIS DIRECTED:

Ulses, G.A., "Statistical Post-Processing of NOGAPS Tropical Cyclone Track Forecasts," Master's Thesis, Naval Postgraduate School, March 1998.

DoD KEY TECHNOLOGY AREA: Battlespace Environment

KEYWORDS: Tropical Cyclone Motion, Tropical Cyclone Prediction

MONSOON DISTURBANCES OVER THE CHINA SEAS

Chih-Pei Chang, Professor

Department of Meteorology

Sponsors: Office of Naval Research and Naval Postgraduate School

OBJECTIVE: This research is to use operational Naval regional models to study the development of the southwest monsoon over the South China Sea and East China Sea, and its effects on weather disturbances over Southeast and East Asia.

SUMMARY: Significant rainfall of the East Asian summer monsoon is produced by low-level disturbances that originated from mainly stationary vortices east of the Tibetan Plateau. Many previous studies found latent heating to be the dominant energy source for the development of these vortices during mature monsoon. This work uses the Navy's regional forecast model to study the development of a disturbance system during 15-17 May 1992, around the beginning of the monsoon season. The system was characterized by a preexisting stationary vortex in the Sichuan basin and the subsequent development of another vortex that propagated eastward along a pre-Meiyu front that moved into the Yangtze River valley.

The numerical simulation, in conjunction with a potential vorticity analysis of the ECMWF data, indicates that during the first 24 h the stationary vortex was maintained by terrain effects. On 16 May, the forcings of an upper-level jet and a shortwave 500 hPa trough, along with latent heat release that may have been triggered by the upper forcings, intensified this vortex temporarily. Afterward, the vortex continued to develop by a low-level front-terrain interaction in which the frontal secondary circulation turned the basin-scale east-west overturning counterclockwise while the low-level vertical easterly shear was enhanced. This configuration tilted the vertical shear into a source of cyclonic vorticity. The upper-level forcings and the associated latent heat release also spun up the eastward propagating vortex, whose subsequent intensification was mainly the result of latent heat release along the front.

Sensitivity experiments indicate that forcing of the cold air southward by the terrain, and enhancement of the secondary frontal circulation by condensation heating were required for the low-level front to move sufficiently southward into the Yangtze River region to produce the interactions for the development. If the front stayed in a more northerly position, the stationary disturbance would not be strengthened by the terrain-front interaction and even had the propagating disturbance developed, it would move eastward too fast to accumulate the moisture for heavy rainfall.

PUBLICATIONS:

Chang, C.-P., Chan, J.C., and Wang, J.T., (eds.), *East Asia and Western Pacific Meteorology and Climate*, III, World Scientific Publication Company, 562 pp., 1998.

Chang, C.-P., Lin, S.C., Liou, C.S., and Liu, W.T., "An Experiment Using NSCAT Winds in the Numerical Prediction of Tropical Mesoscale Rainfall Systems Under the Influence of Terrain," *Geophysical Research Letter*, 26, 1999, in press.

Chang, C.-P., Yi, L., and Chen, G.T.J., "A Numerical Simulation of Vortex Development During the 1992 East Asian Summer Monsoon Onset Using the Navy's Regional Model," *Monthly Weather Review*, 1999, under revision.

PROJECT SUMMARIES

CONFERENCE PRESENTATIONS:

Chang, C.-P., Yi, L., and Chen, G.T.J., "A Numerical Simulation of Vortex Development During the 1992 East Asian Summer Monsoon Onset Using the Navy's Regional Model," Symposium on Asia-Pacific Monsoon and Typhoon Meteorology, IX Pacific Science Intercongress, Taipei, Taiwan, 11-14 November 1998.

Chang, C.-P., Taylor, S., and Jeng, B.-F., "Tropical Large-Scale Interactions and Tropical Cyclone Development During the 1996-97 Australian Monsoon," IX Pacific Science Intercongress, Taipei, Taiwan, 11-14 November 1998.

THESIS DIRECTED:

Taylor, Sylvia, "Interactions of Large-Scale Tropical Motion Systems During the 1996-1997 Australian Monsoon," Master's Thesis, Naval Postgraduate School, September 1998.

DoD KEY TECHNOLOGY AREA: Other (Environmental Effects, Modeling)

KEYWORDS: Tropical Meteorology, Monsoon, China Seas

EAST ASIAN MONSOON AND TROPOSPHERIC BIENNIAL OSCILLATIONS

Chih-Pei Chang, Professor
Tianming Li, Research Assistant Professor
Department of Meteorology
Sponsor: National Science Foundation

OBJECTIVE: To study the structure of the interannual variations of the East Asian summer monsoon and the relationship between the Asian-Australian monsoon and the tropospheric biennial oscillation that include wind and SST over the Pacific and Indian Oceans.

SUMMARY: The key questions of how the tropospheric biennial oscillation (TBO) maintains the same phase as the monsoon convection moves from northern summer in South Asia to southern summer in Australia, and how the reversed phase can last through three locally inactive seasons to the next monsoon, are studied by a simple tropical atmosphere-ocean-land model. The model has five boxes representing, respectively, the South Asian and Australian monsoon regions and the equatorial Indian, and western and eastern Pacific oceans. The five regions interact with each other through the SST-monsoon, evaporation-wind, monsoon-Walker circulation, and wind stress-ocean thermocline feedback.

A biennial oscillation emerges in a reasonable parameter regime, with model SST and wind variations resembling many aspects of the observed TBO. A warm SST anomaly in July in the equatorial Indian Ocean causes an increase of surface moisture convergence into South Asia, leading to a stronger monsoon. The monsoon heating on one hand induces a westerly wind anomaly in the Indian Ocean, and on the other hand intensifies a planetary-scale east-west circulation leading to anomalous easterlies over the western and central Pacific. The westerly anomaly over the Indian Ocean decreases the local SST, primarily due to evaporation-wind feedback. The easterly anomaly in the central Pacific causes a deepening of the ocean thermocline therefore increases the subsurface and surface temperatures. This effect overwhelms those of the cold zonal advection and anomalous upwelling. The net result is an anomalous warm SST persisting in the western Pacific through the northern fall, leading to a stronger Australian monsoon.

Meanwhile, the warming in the western Pacific also induces a stronger local Walker cell and thus a surface westerly anomaly over the Indian Ocean. This westerly anomaly helps the cold SST anomaly to persist through the succeeding seasons, leading to a weaker Asian monsoon in the following summer. During the northern winter the westerly anomaly associated with the stronger Australian monsoon, through anomalous ocean downwelling, reinvigorates the warm SST in the western Pacific, which has been weakened by the slow cold advection from the eastern Pacific. This further intensifies the eastern Walker cell and helps to keep the eastern Pacific cold.

PROJECT SUMMARIES

PUBLICATIONS:

Chang, C.-P., Chan, J.C., and Wang, J.T., (eds.), *East Asia and Western Pacific Meteorology and Climate*, III, World Scientific Publication Company, 562 pp., 1998.

Li, T., Hogan, T.F., and Chang, C.-P., "Dynamic and Thermodynamic Regulation of Ocean Warming," *Journal of Climate*, 1999, submitted.

Chang, C.-P. and Li, T., "A Theory for Tropical Tropospheric Biennial Oscillation," *Journal of Atmospheric Sciences*, 1999, submitted.

CONFERENCE PRESENTATIONS:

Chang, C.-P. and Li, T., "Tropospheric Biennial Oscillation in a Simple Tropical Atmosphere-Ocean-Land System," Western Pacific Geophysical Meeting, American Geophysical Society, Taipei, Taiwan, 15-24 July 1998.

Chang, C.-P. and Li, T., "Tropospheric Biennial Oscillation," Monsoon Workshop, St. Michaels, MD, 29-31 July 1998.

Chang, C.-P. and Li, T., "A Theory for the Tropospheric Biennial Oscillation," Symposium on Asia-Pacific Monsoon and Typhoon Meteorology, IX Pacific Science Intercongress, Taipei, Taiwan, 11-14 November 1998.

Chang, C.-P., Zhang, Y., and Li, T., "Interannual Variability of Meiyu Rainfall and Tropical SST During the East Asian Summer Monsoon," Symposium on Asia-Pacific Monsoon and Typhoon Meteorology, IX Pacific Science Intercongress, Taipei, Taiwan, 11-14 November 1998.

Li, T. and Chang, C.-P., "Tropical Interactions Between the Tropospheric Biennial Oscillation and ENSO," Symposium on Asia-Pacific Monsoon and Typhoon Meteorology, IX Pacific Science Intercongress, Taipei, Taiwan, 11-14 November 1998.

DoD KEY TECHNOLOGY AREA: Other (Environmental Effects, Modeling)

KEYWORDS: Monsoon, Air-Sea Interactions, Biennial Oscillations, El Nino

COASTAL AEROSOL AND MARINE ATMOSPHERIC BOUNDARY LAYER (MABL) PROPERTY INVESTIGATION WITH REMOTE SENSING AND IN SITU DATA COLLECTION

Kenneth L. Davidson, Professor

Carlyle H. Wash, Professor

Department of Meteorology

Sponsor: Space and Naval Warfare Systems Center-San Diego

OBJECTIVE: To provide the capability to model of near-surface optical propagation and to obtain remote sensing derived estimates of coastal marine atmospheric boundary layer (MABL) properties, including coastal aerosol.

SUMMARY: Existing buoy and shipboard data of the near-surface transmission properties were analyzed and satellite images were interpreted for aerosol properties of the coastal boundary layer. The toroid buoy was prepared with instrumentation for turbulent and mean airflow properties (wind, temperature, and humidity) and for surface wave measurements during the long-term IR transmission collection experiment. The buoy was deployed in San Diego Bay at the mid-point of a 7 km over water path for two periods, 7 May - 8 July and 12-21 September. In these deployments, optical turbulence, was examined which is affected by humidity and temperature fluctuations. Satellite-derived aerosol optical depth estimates were evaluated using aircraft and shipboard aerosol measurements, a ship-based lidar and rawinsonde profiles of the MABL. Results from California coast experiments in April 1996 and March 1997 have been analyzed and reported in collaborative papers.

PROJECT SUMMARIES

PUBLICATION:

Davidson, K.L. and Wash, C.H., "Describing Coastal Optical Properties With In Situ and Remote Measurements," *Naval Research Reviews*, Office of Naval Research, Two/1998, Vol. L, pp. 2-7, 1998.

Frederickson, Paul, Davidson, Kenneth L., Zeisse, Carl, and Bendall, Ike, "Estimating Near Surface Scintillation (C_n^2) for Overwater Littoral Paths," *Proceedings of Battlespace Atmospheric and Cloud Impacts on Military Operations (BACIMO) Conference*, Hanscom AFB, MA, 1-3 December 1998.

Wash, C.H., Jordan, M.S., Durkee, P., Veefking, Pepijn, de Leeuw, G., Smith, M.J., and Hill, M.K., "Satellite Estimates of Optical Depth During EOPACE," *Proceedings of Battlespace Atmospheric and Cloud Impacts on Military Operations (BACIMO) Conference*, Hanscom AFB, MA, 1-3 December 1998.

CONFERENCE PRESENTATIONS:

Frederickson, P., Davidson, K.L., and de Jong, A., "Near-Surface Scintillation (C_n^2) Estimated From a Buoy During EOPACE," NATO Research and Technology Agency, Sensors and Electronics Technology Panel (RTA-SET) Symposium: E-O Propagation, Signature, and System Performance Under Adverse Meteorological Conditions Considering Out-of-Area Operations, Naples, Italy, 16-19 March 1998.

Wash, C.H., Jordan, M., and de Leeuw, G., "Satellite and Ship-Based LIDAR Measurements of Optical Depth During EOPACE," NATO Research and Technology Agency, Sensors and Electronics Technology Panel (RTA-SET) Symposium: E-O Propagation, Signature, and System Performance Under Adverse Meteorological Conditions Considering Out-of-Area Operations, Naples, Italy, 16-19 March 1998.

de Jong, Arie, de Leeuw, G., Fritz, P.J., Moeman, M., Davidson, K.L., Frederickson, P., Gathman, S., Littfin, K., and Jensen, D., "Long-Range Transmission at Low Elevations Over the Ocean," NATO Research and Technology Agency, Sensors and Electronics Technology Panel (RTA-SET) Symposium: E-O Propagation, Signature, and System Performance Under Adverse Meteorological Conditions Considering Out-of-Area Operations, Naples, Italy, 16-19 March 1998.

Frederickson, Paul, Davidson, Kenneth L., Zeisse, Carl, and Bendall, Ike, "Estimating Near Surface Scintillation (C_n^2) for Overwater Littoral Paths," *Battlespace Atmospheric and Cloud Impacts on Military Operations (BACIMO) Conference*, Hanscom AFB, MA, 1-3 December 1998.

Wash, C.H., Jordan, M.S., Durkee, P., Veefkind, Pepijn, de Leeuw, G., Smith, M.J., and Hill, M.K., "Satellite Estimates of Optical Depth During EOPACE," *Battlespace Atmospheric and Cloud Impacts on Military Operations (BACIMO) Conference*, Hanscom AFB, MA, 1-3 December 1998.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Sensors

KEYWORDS: Meteorological Measurement, Marine Atmosphere Boundary Layer, Optical Transmission, Optical Depth

OPERATIONAL METOC MEASUREMENT SYSTEMS

Kenneth L. Davidson, Professor

Carlyle H. Wash, Professor

Department of Meteorology

Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: To provide technical guidance in MORIAH ORD/RFP preparations, to perform special analysis and interpretation on sensor and model requirements, and to evaluate merging of technologies for regional EM/EO assessments.

PROJECT SUMMARIES

SUMMARY: METOC systems are being evaluated for use on operational ships. Systems were evaluated during buoy and shipboard deployments. Deployments and analyses were designed for evaluation of measurement accuracy, acquisition adaptability and field performances. Hardware and software systems for MORIAH are being selected for focusing further analyses and evaluations. Accomplished comparison with SMOOS® and familiarity with SEAWASP has been achieved. Participated in MORIAH IPT/WG during 10 different meetings with MORIAH program management and IPT/WG members. Created a web site for MORIAH for the METOC community. Related to MORIAH several items from the Monterey Evaporation Duct Modeling and Measurement Workshops. Directed evaluation of Pennsylvania State University (PSU) Lidar Atmospheric Profile Sensor (LAPS). Directed evaluation of SEAWASP performance during the first unattended deployment (BaltOps'97) and with a deployment on small vessel in Wallops'98.

THESES DIRECTED:

Harrison, Daniel E., "Comparison of Lidar and Mini-Rawinsonde Profiles," Master's Thesis, Naval Postgraduate School, June 1998.

Whalen, J.D., "Comparison of Evaporation Duct Height Measurement Methods and Their Impact on Radar Propagation Estimates," Master's Thesis, Naval Postgraduate School, March 1998.

Seijas, Douglas F., "Refractive Conditions in the Caribbean Sea and Its Effects on Radar Systems," Master's Thesis, Naval Postgraduate School, September 1998.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Sensors

KEYWORDS: Meteorological Measurement, Marine Atmosphere Boundary Layer, Optical Transmission, Optical Depth

METOC SPECIFICATION FOR MORIAH

Kenneth L. Davidson, Professor

Carlyle H. Wash, Professor

Department of Meteorology

Sponsor: Naval Air Warfare Center-Aircraft Division

OBJECTIVE: To support acquisition strategy of a shipboard Meteorology and Oceanography parameter sensor system, MORIAH, by providing specifications based on validation, verification, and integration procedures.

SUMMARY: Provided technical guidance in the MORIAH ORD preparation. Participated in system design, contractor reviews, and PDR meeting preparation. Collected and analyzed METOC data for comparison/validation of SEAWASP algorithms.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Sensors

KEYWORDS: Meteorological Measurement, Marine Atmosphere Boundary Layer, Optical Transmission, Optical Depth

EVALUATION OF TDROP FOR USE IN THE MARINE ATMOSPHERIC BOUNDARY LAYER

Kenneth L. Davidson, Professor

Department of Meteorology

Sponsor: Space and Naval Warfare Systems Command

OBJECTIVE: To validate and verify the technical operation of the Tactical Drop-sondes (TDrop) to meet requirement that the assembled/deployed sensors provide accurate and tactically significant measurements of temperature, moisture, and pressure within the lower marine atmosphere.

PROJECT SUMMARIES

SUMMARY: Extended and completed analyses/interpretation of rawinsonde and available TDrop data that was obtained in the at-sea test in March 1977. The additional results obtained from these extended analyses established the value of the necessary fall-rate of the sensor. Analyses of the fall-rate with candidate sensor responses and observed in situ gradients that led to the conclusion that a critical feature of TDrop design, as presented by manufacturer, is the fall-rate possible with the parachute. Participated in planning and specifications for static tests to be performed at NIST and in dynamic tests to be performed at the NASA Wallops Island Range. A sequence of 22 events was established for completion of the at-sea tests. Ten events have been completed and six are in progress. A contract was put in place for system engineering support "test-direction" for an at-sea test scheduled for the fall of CY 1998.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Sensors

KEYWORDS: Meteorological Measurement, Marine Atmosphere Boundary Layer, Optical Transmission, Optical Depth

SCALING NEAR-SURFACE ATMOSPHERE AND WAVE INFLUENCES ON RADAR PROPAGATION OVER THE SEA

Kenneth L. Davidson, Professor

Department of Meteorology

Sponsor: Office of Naval Research

OBJECTIVE: To improve models for describing near horizon radar propagation thorough evaluation of the Monin-Obukhov surface-layer scaling for near surface gradients of refractivity and to characterize the surface roughness for radar backscatter and propagation within evaporation ducting.

SUMMARY: Near-surface refractive gradients, turbulent transport, and surface wave data were obtained from buoys and vessels during a coordinated one-month experiment. The combined collection of in situ and remote (radar) data occurred off Wallops Island, VA, from March to April 1998. The experiment was coordinated by the Naval Surface Warfare Center, Dahlgren Division (NSWC-DD). Other field collection participants were groups from the SPAWAR Systems Center-San Diego (SSC-San Diego), and the Johns Hopkins University, Applied Physics Laboratory (JHU/APL). The experiment was called Wallops'98. Defining features of the experiment were its coordinated surface layer and surface and radar field strength (NSWC-DD) and backscatter inversion (SPAWAR-SSC-San Diego) measurements. There are necessary steps: formation of a merged data set for multi-group collection, estimating near-surface refraction, and atmospheric forcing, and wave descriptions for clutter. All field collection participants began exchanging buoy and ship data immediately after the experiment for comparison and merging purposes. Final arrangements for collaboration on the merged data was made at a one-day participants' workshop held on 22 July at NSWC-DD, Dahlgren, VA. Initial comparisons, the application of bulk models to estimate evaporation duct and surface fluxes, and the filling of "gaps" have begun with all data sets. Completing the merging of NPS and other groups (NSWC-DD, JHU/APL) surface-layer and surface wave data and with other groups (NSWC-DD, SSC-San Diego) radar data were begun in FY98 and will be near completion in the FY99 analysis/interpretation phase.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Sensors

KEYWORDS: Meteorological Measurement, Marine Atmosphere Boundary Layer, Optical Transmission, Optical Depth

PROJECT SUMMARIES

COASTAL AEROSOL CHARACTERIZATION

Philip A. Durkee, Professor

Department of Meteorology

Sponsors: Office of Naval Research and Naval Postgraduate School

OBJECTIVE: This project will combine model and observational studies to: 1) test the feasibility of integrating a full featured, process-oriented model with a meteorological model and 2) investigate initialization schemes for numerical models using data from remote sensing and point measurements. This is a joint project between NRL and NPS.

SUMMARY: To date the emphasis on this study has been on validation of aerosol optical depth retrievals from satellites with in situ measurements of the aerosol physical properties and integration of optical depth into model initialization schemes. In order for information about the horizontal aerosol distribution to be incorporated into a model, the information must be distributed in the vertical dimension. This requires assumptions since the satellite-retrieved value is a column integral of the aerosol properties. To first order the aerosol extinction is determined by concentration and relative humidity. A scheme has been developed as part of this project to distribute the aerosol extinction according to the vertical distribution of relative humidity. The scheme has been compared to aircraft and radiosonde measurements of relative humidity from several experiments including the Atlantic Stratocumulus Experiment (ASTEX), the Aerosol Characterization Experiment (ACE-1), Tropospheric Aerosol Radiative Forcing Observational Experiment (TARFOX), EOPACE and most recently ACE-2 (included two desert dust cases).

Information about the aerosol size distribution is also available from multispectral satellite measurements. The NPS optical depth retrieval uses this information to estimate the scattering phase function required for optical depth retrieval. The NPS approach has been compared to in situ data from field the programs described above. The results have also been compared with the NOVAM, a model of aerosol optical properties from parameterized size distributions. Early analysis indicates that the size information retrieved from satellite measurements can improve the NOVAM size distribution parameterization.

DoD KEY TECHNOLOGY AREAS: Sensors, Environmental Quality

KEYWORDS: Marine Boundary Layer, Aerosol Process, Aerosol/Cloud Interaction

ATMOSPHERIC FORCING OF OCEAN CONVECTION IN THE LABRADOR SEA

Peter Guest, Research Associate Professor

Department of Meteorology

Sponsor: Office of Naval Research

OBJECTIVE: The long-term goal of this research is to understand the relation between atmospheric forcing and ocean deep convection.

SUMMARY: This research was based on data obtained from two cruises of the R/V *Knorr* during the winters of 1997 and 1998. The vertical fluxes of total heat flux (turbulent and radiational) and momentum flux were extremely large during these cruises. During the winter 1997 cruise, the PI and colleagues successfully performed 217 rawinsonde (weather balloon) soundings of the atmosphere. These represented the only rawinsonde measurements ever performed in the central part of Labrador Sea. This information was used in studies of how surface fluxes affect the dynamics and structure of both the atmosphere and the ocean during periods of intense air-sea interactions.

PUBLICATIONS:

Guest, P.S., "Surface Longwave Radiation Conditions in the Eastern Weddell Sea During Winter," *Journal of Geophysical Research*, in press.

PROJECT SUMMARIES

Renfrew, I.A., Moore, G.W.K., Holt, T.R., Chang, S.W., and Guest, P.S., "Mesoscale Forecasting During a Field Program: Meteorological Support of the Labrador Sea Deep Convection Experiment," *Bulletin of the American Meteorological Society*, in press.

The Lab Sea Group (includes P. Guest), "The Labrador Sea Deep Convection Experiment," *Bulletin of the American Meteorological Society*, Vol. 79, No. 10, pp. 2033-2058, 1998.

CONFERENCE PRESENTATIONS:

Guest, P., "A Comparison of Atmospheric Forcing Conditions During the 1997 And 1998 Cruises of the R/V *Knorr*," Workshop on the Labrador Sea Deep Convection Experiment, Bigfork, MT, 9-11 September 1998.

Bramson, L., Guest, P., and Garwood, R., "The Effect of Atmospheric Forcing on the Labrador Sea on the Mixed Layer in the Winter of 1997," American Geophysical Union, 1998 Ocean Sciences Meeting, San Diego, CA, 13 February 1998.

Guest, P., "Atmospheric Forcing Conditions in the Labrador Sea: Results From the 1997 R/V *Knorr* Cruise," American Geophysical Union, 1998 Ocean Sciences Meeting, San Diego, CA, 13 February 1998.

DoD KEY TECHNOLOGY AREA: Other (Meteorology, Physical Oceanography)

KEYWORDS: Convection, Polar Meteorology, Air-Sea Interactions

MEASURING, PARAMETERIZING, AND MODELING ATMOSPHERIC SURFACE FLUXES DURING THE SURFACE HEAT BUDGET OF THE ARCTIC (SHEBA) EXPERIMENT

Peter Guest, Research Associate Professor

Department of Meteorology

Sponsor: National Science Foundation

OBJECTIVES: To provide direct estimates of the surface energy, momentum, and mass budgets over different surface types (i.e., new ice, first-year ice, multiyear ice, deformed ice, open water, melt ponds, etc.) and area averages of these for the SHEBA region for the duration of the experiment. To investigate parameterizations of the turbulent transfer coefficients and modifications to Monin-Obukhov similarity theory necessary in a stably stratified atmospheric surface layer. To obtain high quality radiative flux and albedo data at multiple locations for investigating ice-albedo and cloud-albedo feedback.

SUMMARY: There were three other PIs from other institutions involved in this project. A highly-successfully field program was performed from September 1997 to September 1998. The data set obtained represented the most comprehensive information on surface-layer properties ever obtained in the central Arctic. The 20-meter tower used to make measurements was the tallest ever constructed on sea-ice and it remained intact throughout the experiment despite vigorous lead activity and extreme ice melting. Although the field program was just completed a variety of research topics have already been addressed by the PIs. Also several other SHEBA participants have used the data for a wide variety of ocean, ice, and atmospheric studies.

PUBLICATIONS:

Guest, P., Andreas, E.L., Fairall, C.W., and Persson, P.O.G., "Problems With Surface Layer Similarity Theory in the Arctic," Preprints of the *Fifth Conference on Polar Meteorology and Oceanography*, American Meteorological Society, Boston, MA, January 1999.

Andreas E.L., Fairall, C.F., Guest, P.S., and Persson, P.O.G., "An Overview of the SHEBA Atmospheric Surface Flux Program," Preprints of the *Fifth Conference on Polar Meteorology and Oceanography*, American Meteorological Society, Boston, MA, January 1999.

PROJECT SUMMARIES

Andreas E.L., Fairall, C.F., Guest, P.S., and Persson, P.O.G., "An Overview of the SHEBA Atmospheric Surface Flux Program," Preprints of the *13th Symposium on Boundary Layers and Turbulence*, American Meteorological Society, Boston, MA, January 1999.

Andreas E.L., Fairall, C.F., Guest, P.S., and Persson, P.O.G., "Comparing Eddy-Correlation and Scintillometer Measurements of Momentum and Sensible Heat Fluxes During SHEBA," Preprints of the *Fifth Conference on Polar Meteorology and Oceanography*, American Meteorological Society, Boston, MA, January 1999.

Claffey, K.J., Andreas, E.L., Fairall, C.W., Guest, P.S., and Persson, P.O.G., "Surface Temperature Measurements at SHEBA," Preprints of the *Fifth Conference on Polar Meteorology and Oceanography*, American Meteorological Society, Boston, MA, January 1999.

Fairall, C.W., Persson, P.O.G., Guest, P.S., and Andreas, E.L., "The Role of Surface-Layer Turbulent Interactions in Longwave Flux/Surface Temperature Feedback During SHEBA," Preprints of the *Fifth Conference on Polar Meteorology and Oceanography*, American Meteorological Society, Boston, MA, January 1999.

Fairall, C.W., Persson, P.O.G., Guest, P.S., and Andreas, E.L., "The Role of Surface-Layer Turbulent Interactions in Longwave Flux/Surface Temperature Feedback During SHEBA," Preprints of the *13th Symposium on Boundary Layers and Turbulence*, American Meteorological Society, Boston, MA, January 1999.

Persson, P.O.G., Fairall, C.W., Andreas, E.L., Guest, P.S., and Uttal, T., "The Surface Energy Budget During the Onset of the Melt Season on the Arctic Ice Pack," Preprints of the *Fifth Conference on Polar Meteorology and Oceanography*, American Meteorological Society, Boston, MA, January 1999.

Persson, P.O.G., Uttal, T.A., Intrieri, J., Fairall, C.W., Andreas, E.L., and Guest, P.S., "Observations of Large Thermal Transitions During the Arctic Night From a Suite of Sensors at SHEBA," Preprints of the *Fifth Conference on Polar Meteorology and Oceanography*, American Meteorological Society, Boston, MA, January 1999.

Persson, P.O.G., Uttal, T.A., Intrieri, J., Fairall, C.W., Andreas, E.L., and Guest, P.S., "Observations of Large Thermal Transitions During the Arctic Night From a Suite of Sensors at SHEBA," Preprints of the *Third Symposium on Integrated Observing Systems*, American Meteorological Society, Boston, MA, January 1999.

Pinto, J.O., Maslanik, J.A., Guest, P.S., Stone, R.S., Andreas, E.L., Fairall, C.W., and Persson, P.O.G., "Surface Energy Budget and Atmospheric Effects of a Freezing Lead at SHEBA," Preprints of the *Fifth Conference on Polar Meteorology and Oceanography*, American Meteorological Society, Boston, MA, January 1999.

Pinto, J.O., Maslanik, J.A., Guest, P.S., Stone, R.S., Andreas, E.L., Fairall, C.W., and Persson, P.O.G., "Surface Energy Budget and Atmospheric Effects of a Freezing Lead at SHEBA," Preprints of the *13th Symposium on Boundary Layers and Turbulence*, American Meteorological Society, Boston, MA, January 1999.

Russell, C.A., Fairall, C.W., Persson, P.O.G., Andreas, E.A., Guest, P.S., Lindsay, R., Eide, H.A., and Horst, T., "Intercomparison of Eppley Pyrgeometer Measurements of Downward Longwave Flux During the First Two Months of SHEBA," Preprints of the *Fifth Conference on Polar Meteorology and Oceanography*, American Meteorological Society, Boston, MA, January 1999.

CONFERENCE PRESENTATIONS:

Guest, P., Andreas, E.L., Fairall, C.W., and Persson, P.O.G., "Problems With Surface Layer Similarity Theory in the Arctic," American Meteorological Society Annual Meeting, Dallas, TX, to be presented 10-15 January 1999.

Andreas, E.L., Fairall, C.F., Guest, P.S., and Persson, P.O.G., "An Overview of the SHEBA Atmospheric Surface Flux Program," American Meteorological Society Annual Meeting, Dallas, TX, to be presented 10-15 January 1999.

PROJECT SUMMARIES

Andreas, E.L., Fairall, C.F., Guest, P.S., and Persson, P.O.G., "Comparing Eddy-Correlation and Scintillometer Measurements of Momentum and Sensible Heat Fluxes During SHEBA," American Meteorological Society Annual Meeting, Dallas, TX, to be presented 10-15 January 1999.

Claffey, K.J., Andreas, E.L., Fairall, C.W., Guest, P.S., and Persson, P.O.G., "Surface Temperature Measurements at SHEBA," American Meteorological Society Annual Meeting, Dallas, TX, 10-15 January 1999.

Fairall, C.W., Persson, P.O.G., Guest, P.S., and Andreas, E.L., "The Role of Surface-Layer Turbulent Interactions in Longwave Flux/Surface Temperature Feedback During SHEBA," American Meteorological Society Annual Meeting, Dallas, TX, 10-15 January 1999.

Persson, P.O.G., Fairall, C.W., Andreas, E.L., Guest, P.S., and Uttal, T., "The Surface Energy Budget During the Onset of the Melt Season on the Arctic Ice Pack," American Meteorological Society Annual Meeting, Dallas, TX, 10-15 January 1999.

Persson, P.O.G., Uttal, T.A., Intrieri, J., Fairall, C.W., Andreas, E.L., and Guest, P.S., "Observations of Large Thermal Transitions During the Arctic Night From a Suite of Sensors at SHEBA," American Meteorological Society Annual Meeting, Dallas, TX, 10-15 January 1999.

Pinto, J.O., Maslanik, J.A., Guest, P.S., Stone, R.S., Andreas, E.L., Fairall, C.W., and Persson, P.O.G., "Surface Energy Budget and Atmospheric Effects of a Freezing Lead at SHEBA," American Meteorological Society Annual Meeting, Dallas, TX, 10-15 January 1999.

Russell, C.A., Fairall, C.W., Persson, P.O.G., Andreas, E.A., Guest, P.S., Lindsay, R., Eide, H.A., and Horst, T., "Intercomparison of Eppley Pyrgometer Measurements of Downward Longwave Flux During the First Two Months of SHEBA," American Meteorological Society Annual Meeting, Dallas, TX, 10-15 January 1999.

DoD KEY TECHNOLOGY AREA: Other (Meteorology)

KEYWORDS: Polar Meteorology, Air-Sea-Ice Interactions, Surface Fluxes

CALIFORNIA CURRENT SIMULATIONS AND DATA ASSIMILATION

Robert L. Haney, Professor

Department of Meteorology

Sponsors: Office of Naval Research and Naval Postgraduate School

OBJECTIVE: The broad objective of this research is to aid in the development of a reliable modeling capability for eastern boundary current regions. Specifically, primitive equation ocean model simulation and sensitivity studies of the annual cycle in the California Current will be carried out and verified and data assimilation studies in both the California Current and the Alboran Sea will be performed.

SUMMARY: Studies were carried out in several areas: (1) the deflection and division of an oceanic baroclinic jet when it impinges on a coastal boundary; (2) the upper layer circulation in the Alboran Sea; (3) the use of digital filter initialization in diagnostic studies in the California coastal region; and (4) the annual cycle of the California Current.

PUBLICATIONS:

Viudez, A., Haney, R.L., and Vazquez-Cuervo, J., "The Deflection and Division of an Oceanic Baroclinic Jet by a Coastal Boundary: A Case Study in the Alboran Sea," *Journal of Physical Oceanography*, 28, pp. 289-303, 1998.

PROJECT SUMMARIES

Viudez, A., Pinot, J.-M., and Haney, R.L., "On the Upper-Layer Circulation in the Alboran Sea," *Journal of Geophysics Research*, 103, pp. 21,653-21,666, 1998.

CONFERENCE PRESENTATIONS:

Haney, R.L., "The General Circulation in the California Current: Observations and Simulations," Akio Arakawa Fest: Symposium on General Circulation Model Development: Past, Present, and Future, Los Angeles, CA, 20-22 January 1998.

Haney, R.L., Dietrich, D.E., and Hale, R.A., "The Role of Headland Wind Jets in the Annual Cycle of the California Current System," 1998 Ocean Sciences Meeting, San Diego, CA, 9-13 February 1998.

THESIS DIRECTED:

Donato, J., "The Seasonal Cycle of Mesoscale Variability in the California Current: A DieCAST Model Simulation," Master's Thesis, Naval Postgraduate School, December 1998.

DoD KEY TECHNOLOGY AREA: Other (Physical Oceanography)

KEYWORDS: Numerical Ocean Modeling; Coastal Oceanography, California Current, Alboran Sea

IMPACTS OF THE EXTRATROPICAL TRANSITION OF TROPICAL CYCLONES ON PREDICTIONS OF MIDLATITUDE CIRCULATION SYSTEMS

Patrick A. Harr, Research Associate Professor

Russell L. Elsberry, Professor

Department of Meteorology

Sponsor: Naval Research Laboratory-Monterey

OBJECTIVE: The primary objective is to improve understanding and prediction of the extratropical transition of a decaying tropical cyclone.

SUMMARY: As a tropical cyclone moves poleward, the characteristic tropical cyclone structure changes to include large asymmetries in convection, and wind distribution. Depending on the interaction between environmental conditions and the internal tropical cyclone structure, the tropical cyclone may dissipate or transition into an extratropical cyclone that may include gale- or storm-force winds, high seas, and significant rainfall. Analysis of these interactions was conducted for several types of transitioning tropical cyclones. These analyses included use of microwave imagery for assessing the internal structure of the tropical cyclone as it moved into the midlatitudes. Also, the formation of extratropical cyclone structures such as frontal regions were examined for a variety of transition cases. Results define a large variability in the types of transitions that occur over the western North Pacific and this variability is linked to the extremely volatile physical conditions that occur during extratropical transition. Furthermore, when forecast sequences of individual transition cases are examined from the Navy Operational Global Atmospheric Prediction System (NOGAPS), a large variability is also found from one forecast to the next. It appears that the NOGAPS model is sensitive to the extreme physical attributes associated with extratropical transition and how these conditions are depicted in the initial analysis for each forecast sequence.

PUBLICATION:

Harr, P.A., Elsberry, R.L., and Hogan, T.F., "Mesoscale Aspects in Tropical Cyclone Structure Changes During Landfall and Extratropical Transition," Preprint of the *Sixteenth Conference on Weather Analysis and Forecasting*, American Meteorological Society, pp. 16-18, Boston, MA, 1998.

PROJECT SUMMARIES

CONFERENCE PRESENTATIONS:

Harr, P.A., Elsberry, R.L., and Klein, P.M., "Forecasts of Extratropical Transition," 1998 Tropical Cyclone Conference, MG USPACOM, Tokyo, Japan, 24-27 February 1998.

Harr, P.A., "Extratropical Transition of Tropical Cyclones: An Overview," Workshop on the Transition of Tropical Storms to High Latitude Storms, The Risk Prediction Initiative, Bermuda, 15-16 September 1998.

Harr, P.A. and Elsberry, R.L., "Numerical Model Forecasts of Extratropical Transition," Workshop on the Transition of Tropical Storms to High Latitude Storms, The Risk Prediction Initiative, Bermuda, 15-16 September 1998.

DoD KEY TECHNOLOGY AREAS: Environmental Quality, Modeling and Simulation

KEYWORDS: Tropical Cyclones, Midlatitude Cyclones, Numerical Weather Prediction, Extratropical Transition

EVOLUTION OF TROPICAL CYCLONE CHARACTERISTICS AND FORECAST ASSESSMENT

Patrick A. Harr, Research Associate Professor
Lester E. Carr, III, Research Associate Professor
Elizabeth A. Ritchie, Research Assistant Professor
Russell L. Elsberry, Professor
Department of Meteorology
Sponsor: Office of Naval Research

OBJECTIVE: The objective is to understand how variabilities in the environment and internal tropical cyclone structure influence tropical cyclone track and intensity characteristics and how these influence differ between developing, mature, and decaying tropical cyclones. As increased understanding leads to improved forecasts of tropical cyclone motion and structure characteristics, a second objective of this continuing project is to assess the utility of the tropical cyclone forecast products to shore- and sea-based assets.

SUMMARY: Co-located microwave and geostationary imagery were used to compile a detailed analysis of the evolution of Super Typhoon Bing (September 1997) in terms of the evolution of several mesoscale convective systems (MCSs) over several days. Characteristics associated with convective and stratiform cloud coverages and rain intensities associated with each cloud type were defined that related the longevity of the MCS and the evolution of the stratiform component, which is favorable for midlevel vortex development and potential formation of a tropical cyclone. Following a three-day period of repeated MCS formation and decay, an intense MCS formed near the center of a large circulation that had been slowly evolving due to the repeated MCS life cycles. This case appeared to be representative of the evolution of a tropical cyclone that forms through mutual interaction of MCS activity and synoptic-scale forcing.

A similar analysis was applied to a set of large and intense MCSs in the general monsoon trough environment of the western North Pacific, but were not related to any tropical cyclone development. In these cases, convective development was swift with equally rapid decay, in which stratiform cloud coverage and rain intensity decreased in conjunction with the convective coverage. Therefore, conditions were not favorable for midlevel vortex development and concentrated MCS activity.

A basic statistical model was defined to examine the concept of assessing forecast value in terms of the basic decision analysis problem of having to choose whether to protect assets under conditions of uncertainty about future events. Preliminary results from a sensitivity analysis conducted with this model indicate that accurate assessments of forecast value are extremely dependent on the utilities (values) that are assigned by operators or decision-makers concerning the assets that must be protected.

PROJECT SUMMARIES

PUBLICATION:

Elsberry, R.L., Boothe, M.A., Ulses, G.A., and Harr, P.A., "Statistical Post-Processing of NOGAPS Tropical Cyclone Track Forecasts," *Monthly Weather Review*, accepted.

CONFERENCE PRESENTATIONS:

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DoD KEY TECHNOLOGY AREAS: Environmental Quality, Modeling and Simulation

KEYWORDS: Tropical Cyclones, Mesoscale Convective Systems, Tropical Cyclone Structure

IMPROVEMENT AND EVALUATION OF THE MESOSCALE METEOROLOGICAL MODEL MM5 FOR AIR QUALITY APPLICATIONS IN SOUTHERN CALIFORNIA AND THE SAN JOAQUIN VALLEY

Douglas Miller, Research Assistant Professor

Department of Meteorology

Robert Bornstein, Professor

Keith Hutchison, Adjunct Professor

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Nelson Seaman, Professor

David Stauffer, Research Associate

Alain Clappier, Graduate Student

Pennsylvania State University

Sponsor: California Air Resources Board

OBJECTIVE: To extend, test, and evaluate the MM5 mesoscale model to ensure that it can simulate summertime South Coast Air Basin mixing depth patterns, vertical transport processes over heated topography, flow recirculation aloft, as well as wintertime diurnal evolutions of San Joaquin Valley fog and low speed synoptic and mesoscale conditions.

SUMMARY: The preliminary modeling work, started in the Autumn 1998, consisted of acquiring archived data for specific case studies and special datasets and MM5 modules from collaborators at the Pennsylvania State University. A preliminary run using basic MM5 source code and simple model initialization for an August 1997 case study was attempted in December 1998.

DoD KEY TECHNOLOGY AREA: Other (Numerical Mesoscale Modeling)

KEYWORDS: Air Quality, Numerical Weather Prediction, Mesoscale Modeling

PROJECT SUMMARIES

DECADAL TELECONNECTIONS IN THE NORTH PACIFIC

Tom Murphree, Research Assistant Professor

Department of Meteorology

Sponsor: National Oceanic and Atmospheric Administration

OBJECTIVES: This project is designed to analyze climatic variations of the Northeast Pacific atmosphere and ocean and the role of global teleconnections in producing these variations.

SUMMARY: This project is being conducted in collaboration with researchers at the Pacific Fisheries Environmental Laboratory (PFEL) of the National Oceanic and Atmospheric Administration in Pacific Grove, CA. The goal is to develop a better understanding of the decadal variations of the North Pacific Ocean, corresponding variations of the overlying atmosphere, and teleconnections between the North Pacific and remote parts of the global climate system. The project is part of a larger project titled, "Patterns, Sources, and Mechanisms of Decadal Environmental Variability in the Northeast Pacific: A Retrospective and Modeling Analysis," also being conducted in collaboration with PFEL. This larger project examines decadal changes in the northeast Pacific and their role in ecosystem changes. Both projects are part of the northeast Pacific component of the Global Ocean Ecosystems Dynamics (GLOBEC) program. The primary research for both projects involves dynamical analyses of observed, analyzed, and modeled oceanic and atmospheric data. During 1998, our focus was on dynamical analyses of: (1) the seasonal cycle in the northeast Pacific ocean and atmosphere, especially in surface wind stress curl, and in surface and subsurface ocean temperature; (2) the 1997-1998 El Niño event; (3) the 1998-1999 La Niña event; and (4) the similarities between the seasonal cycle, changes during El Niño and La Niña events, and decadal changes.

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DoD KEY TECHNOLOGY AREA: Other (Environmental Effects, Environmental Processes, Environmental Monitoring, Environmental Modeling)

KEYWORDS: Climate System, Decadal Variations, El Niño, GLOBEC, La Niña, North Pacific, Teleconnections

PROJECT SUMMARIES

PHYSICAL ASPECTS OF BIOLOGICAL VARIABILITY IN THE NORTHEAST PACIFIC OCEAN

Tom Murphree, Research Assistant Professor
Department of Meteorology

Sponsor: National Oceanic and Atmospheric Administration

OBJECTIVES: This project is designed to identify and develop indices based on oceanic and atmospheric variables that can be used to explain and predict climatic variations in the northeast Pacific.

SUMMARY: This project is a collaborative effort with scientists at the Pacific Fisheries Environmental Laboratory (PFEL) of the National Oceanic and Atmospheric Administration in Pacific Grove, CA. The main goal of this project is to develop indices of climatic fluctuations that can be used to understand biological variability, especially variability of marine populations, in the northeast Pacific. During 1998, we refined several indices based on variations of sea level pressure in the region of the North Pacific High, including an index we call the Northern Oscillation Index (NOI), the North Pacific equivalent of the Southern Oscillation Index (SOI). The variations of the NOI are similar to those of the SOI. However, the NOI has a number of advantages over the SOI for representing climatic change in the North Pacific and North American regions, including a better representation of changes during La Niña events and perhaps of decadal changes.

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DoD KEY TECHNOLOGY AREAS: Other (Environmental Effects, Environmental Processes, Environmental Monitoring, Environmental Modeling)

KEYWORDS: Biological Variability, Decadal and Interannual Variations, Oceanic and Atmospheric Indices, Marine Populations

MAURY PROJECT DEVELOPMENT AND IMPLEMENTATION

Tom Murphree, Research Assistant Professor
Department of Meteorology

Sponsor: United States Naval Academy

OBJECTIVES: This project is designed to develop and present educational materials on physical oceanography to pre-college teachers.

SUMMARY: This project is conducted in collaboration with colleagues in the Oceanography Department of the U.S. Naval Academy and the Education Program of the American Meteorological Society. The project is part of the larger national Maury Project administered by the AMS, and funded by the National Science Foundation, the Naval Meteorology and Oceanography Command, and the National Oceanic and Atmospheric Administration. The purpose of the national

PROJECT SUMMARIES

project is to develop and present educational materials on physical oceanography to pre-college teachers from around the country and other nations.

During 1998, several educational publications were developed on physical oceanography and a two-week intensive summer course at Annapolis, MD for 25 teachers was conducted. The topics for the summer course included: basic geophysical forces, Ekman processes, currents, waves, tides, light and sound in the ocean, air-sea interaction, and climatic change.

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Murphree, T., "El Niño, La Niña, and Global Weather," *Current: The Journal of Marine Education*, Vol. 15, No. 3, pp. 4-7, 1998.

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DoD KEY TECHNOLOGY AREA: Other (Environmental Effects, Environmental Processes, Environmental Monitoring, Environmental Modeling)

KEYWORDS: Physical Oceanography, Pre-College Science Education

MARINE ADVANCED TECHNOLOGY EDUCATION PROJECT
Tom Murphree, Research Assistant Professor
Department of Meteorology
Sponsors: National Science Foundation and Monterey Peninsula College

OBJECTIVES: This project is designed to develop and implement a national program in marine advanced technology education.

PROJECT SUMMARIES

SUMMARY: This project is part of a larger national project, the Marine Advanced Technology Education (MATE) Center, based at Monterey Peninsula College in Monterey, CA, with the Naval Postgraduate School (NPS) being one of several partner institutions from around the country. The MATE Center began operating in September 1997 with funding from the National Science Foundation. The MATE Center's overall goal is to develop a national consortium of educational, scientific, industry, military, and government organizations involved in advanced marine technology. The purpose of the consortium is to develop improved educational and professional development programs for students, faculty, scientists, engineers, and technicians in marine technology. The Center focus is on the first two years of college, but includes programs in marine science, engineering, and technology that involve high schools, technical schools, community and four-year colleges, maritime schools, graduate schools, military schools, and labor and industry schools. The Center emphasizes intensive interactions between educational institutions and industry, military, government, and labor organizations. During 1998, establishment of the Center continued. One aspect was developing links with related education programs in the U.S. Navy, Coast Guard, and Army. This led to preliminary work on the development of a new curriculum for the enlisted technicians who are educated at the Navy's meteorology and oceanography A and C Schools.

DoD KEY TECHNOLOGY AREA: Other (Environmental Processes, Environmental Monitoring, Environmental Modeling)

KEYWORDS: Marine Technology, Science and Engineering Education

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1998 THESIS ABSTRACTS

EXTENSION OF THE SYSTEMATIC APPROACH TO TROPICAL CYCLONE TRACK FORECASTING IN THE EASTERN AND CENTRAL NORTH PACIFIC

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This study extends an earlier study (White 1995) of the application of the systematic approach to tropical cyclone track forecasting of Carr and Elsberry to the eastern and central North Pacific, and contrasts these cases with those in the western North Pacific. The data sample is first expanded to seven years (1990-1996). Modifications to the environment structure conceptual models are: (i) introduction of two dominant ridge synoptic regions named Ridge Poleward and Ridge Equatorward based on the bowed orientation of the subtropical anticyclone; and (ii) combining the Weak Westerlies and Accelerating Westerlies into just one synoptic region called Midlatitude Westerlies. Only eight synoptic pattern/region combinations are needed to classify all of the 1,858 cases. Additions to the transitional mechanisms include: (i) the formation and dissipation of the mid-level low; (ii) monsoon trough formation; and (iii) orography. A new transition climatology reveals that a large fraction of transitions occur between the regions of the standard pattern. Subtropical Ridge Modulation and Vertical Wind Shear are determined to be the most important transitional mechanisms. Synoptic analysis sequences are provided to illustrate the synoptic pattern/regions and the primary transitions.

KEYWORDS: Tropical Cyclone Track Forecasting

DoD KEY TECHNOLOGY AREA: Battlespace Environments

COMPARISON OF LIDAR AND MINI-RAWINSONDE PROFILES

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Current Light Detection and Ranging (LIDAR) technology allows for remotely sensed, real-time measurement of most atmospheric properties including structure, dynamics and primary chemical constituents. The LIDAR Atmospheric Profile Sensor (LAPS) instrument, completed in April 1996 at the Applied Research Laboratory/Pennsylvania State University (ARL/PSU), was developed as a prototype sensor for continuous, automated atmospheric soundings aboard aircraft carriers, advanced-radar combatants and shore stations. These data can then be used to calculate the atmospheric refractivity profiles for electromagnetic propagation prediction and as input to system performance assessments.

This report shows the advantages and disadvantages of LAPS atmospheric data as compared to the MRS sounders currently in use. LAPS can provide an accurate, continuous on-demand real-time data, is able to characterize variations in the marine boundary layer, and does not require cumbersome logistic support (e.g., helium bottles and balloons). The present weaknesses of LAPS are its relatively coarse vertical resolution, degraded daytime data due to scattering, sometimes erratic temperature measurements, and ship's gas absorption.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Lidar, Laps, Mini-rawinsonde, USNS Sumner (T-AGS 61)

1998 THESIS ABSTRACTS

SHIP OPERATING CHARACTERISTICS AND THEIR IMPLICATION FOR SHIPTRACK FORMATION

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Shiptrack occurrence is restricted to a narrow range of environmental conditions and ship operating characteristics. Under environmental conditions favorable for shiptrack formation, not all vessels produce a track. Shiptrack producing diesel vessels are distinguished from non-shiptrack producing diesel vessels by a 17.7 percent higher rate of fuel use, 8.8 percent larger power plant size, and one knot higher transit speed. T-tests comparing these two populations indicate that power/transit speed, power*fuel/speed, power*fuel, tonnage/fuel use, power/hull cross-section, transit speed, power plant size, and rate of fuel use are tactically distinct (greater than 60% confidence level). These parameters and ratios of parameters may be useful in predicting the occurrence and non-occurrence of shiptracks.

DoD KEY TECHNOLOGY AREA: Other (Meteorology)

KEYWORDS: Shiptrack, AVHRR, T-Test, Level of Significance

CALCULATING TROPICAL CYCLONE CRITICAL WIND RADII AND STORM SIZE USING NASA SCATTEROMETER WINDS

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Subjective and objective analyses of satellite scatterometer near-surface winds are utilized to estimate tropical cyclone (TC) critical wind radii and size over a region of the western North Pacific. An outer wind profile assuming a linear slope dependent on the TC latitude is used to determine the radial extent of cyclonic winds beyond a set radius. Inside the set radius, a partial conservation of angular momentum is assumed into the TC maximum wind radius and the 35-, 50-, and 100-kt radii are calculated. Nine TCs were investigated during the operating period of the NASA scatterometer (NSCAT). Critical wind radii in four quadrants (front, right, rear, and left) of the TCs are found to be comparable to the Joint Typhoon Warning Center (JTWC) critical wind radii values issued in warnings. The radial extent of cyclonic winds are also comparable to the radius of zero winds estimated by determining where the cyclonic flow turned to anticyclonic flow in the NSCAT sea-surface wind swaths.

DoD KEY TECHNOLOGY AREA: Other (Meteorology)

KEYWORDS: Tropical Cyclone Wind Structure, NASA Scatterometer, Tropical Cyclonic Size

1998 THESIS ABSTRACTS

COMPARISON OF FLIR TACTICAL DECISION AIDS FOR INTER-SERVICE USE

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Electro-Optical Tactical Decision Aids (TDAs) have proven their utility as tools for range performance modeling and mission planning. However, several TDAs are in current use in the United States armed forces. In fact, the services use different TDA codes which differ in the input data files and their sources required, in the operator expertise required, and the hardware required to run the program.

Within the concept of Joint Operations, which has become crucial in the modern battlefield environment, all the services must share procedures, techniques, and often the same technology. This thesis presents a comparison between the Army FLIR TDA, (ACQUIRE), and the infrared module of the Navy/Air Force TDA, WinEOTDA. Differences in the modeling of underlying physical principles, input parameters, and predicted target detection ranges are presented. Despite differences in input and treatment of environmental effects this analysis indicates similar levels of accuracy for the two codes. For two scenarios selected average predictions for three "typical" sensors fall within 20% of published observations. With further analysis and an operational evaluation it may be possible to select one Electro-Optical Tactical Decision Aid for all branches of the military.

DoD KEY TECHNOLOGY AREA: Electronic Warfare

KEYWORDS: Tactical Decision Aids, ACQUIRE, WinEOTDA

COMPARISON OF THE NAVAL OPERATIONAL GLOBAL ATMOSPHERIC PREDICTION SYSTEM CLOUD ANALYSES AND FORECASTS WITH THE AIR FORCE REAL TIME NEPH ANALYSES CLOUD MODEL

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This thesis compares RTNEPH and NOGAPS analyses for high, middle, and low clouds during January 1998 and October 1997. We believe that the RTNEPH analyses are reasonably accurate except for in the polar regions and the low clouds. NOGAPS forecasts at 12, 24, 36, and 48h are compared with the appropriate RTNEPH analyses. The difference fields averaged over a month show a rapid increase in the first 12 h over the forecast, followed by a slow growth to 48 h. The rapid increase is caused by model adjustment. The RTNEPH and NOGAPS (including forecasts) are separated into nine categories: clear, 0-20%, 20-40%, 40-60%, 60-80%, and 80-100%. When the clear and 0-20% categories are combined the RTNEPH and NOGAPS analyses compare well for high and middle clouds. However the RTNEPH and NOGAPS analyses are distributed differently for the other categories, and the RTNEPH has many more occurrences for the cloudiest category (80-100%). For low clouds the RTNEPH and the NOGAPS are quite different, since the RTNEPH has difficulty analyzing clouds at night. The NOGAPS and the RTNEPH (except for low clouds) generally agree on the clear areas. However, it appears that NOGAPS underestimates the number of mostly cloudy cases and the distribution of categories is different.

DoD KEY TECHNOLOGY AREA: Other (Meteorology)

KEYWORDS: Cloud Cover Analysis and Forecast

1998 THESIS ABSTRACTS

MICROWAVE OBSERVATIONS OF MESOSCALE CONVECTIVE SYSTEMS DURING TROPICAL CYCLONE GENESIS IN THE WESTERN NORTH PACIFIC

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A better understanding of the role mesoscale convective systems (MCS) play in the genesis stages of tropical cyclones will increase the ability to predict their formation. This thesis studied polar-orbiter microwave and geostationary infrared satellite imagery to determine MCS structure and evolution during tropical cyclone genesis. Microwave imagery at frequencies of 19.35 GHz and 85.5 GHz were used to define convective and stratiform cloud areal amounts, percent coverage, and time-integrated rain rates. Collocations with geostationary infrared images are used to calibrate that imagery so that the hourly values may be calculated until another microwave image is available. Specifically, seven MCSs in two disturbances that eventually developed into tropical cyclones were analyzed. Two MCSs in non-developing storms are also described for contrast.

DoD KEY TECHNOLOGY AREA: Other (Meteorology)

KEYWORDS: Mesoscale Convective Systems, Microwave Satellite Imagery, Tropical Cyclone Genesis, Formation

A COMPARISON OF THE NOGAPS AND GFDN DYNAMICAL TRACK PREDICTION MODELS DURING THE 1997 WESTERN NORTH PACIFIC TYPHOON SEASON

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The performance of both the U.S. Navy (NOGAPS) and regional (GFDN) dynamical track prediction models during the 1997 western North Pacific typhoon season is documented. In the context of the Systematic Approach of Carr and Elsberry, a knowledge base of six conceptual models (summary in Table 8.1) is proposed that associates recurring tropical cyclone (TC) forecast track errors with various types of TC and environmental structures. Twenty-one storms of the 27 analyzed have periods in which at least one significant track error source was identified. More situations (23) were identified in the NOGAPS forecasts than in the GFDN forecasts (14). Individual case studies are presented to illustrate recurring scenarios with poor performance in either the NOGAPS model, GFDN model, or both. Use of these conceptual models and their supporting case studies may allow the JTWC forecaster to better understand how the NOGAPS model and GFDN model may perform in specified synoptic environments. It is hoped that the JTWC forecaster can use the information in this study to provide more accurate TC tracks by rejecting inappropriate model guidance during future typhoon seasons in the western North Pacific. In addition, this study may provide feedback to dynamical model producers as to situations in which large track errors have occurred, in hopes that the model might be improved in the future.

DoD KEY TECHNOLOGY AREA: Other (Meteorology)

KEYWORDS: Tropical Cyclone Track Forecasting

1998 THESIS ABSTRACTS

REFRACTIVE CONDITION IN THE CARIBBEAN SEA AND ITS EFFECT ON RADAR SYSTEMS

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Vertical gradients of pressure, temperature and humidity of the troposphere exert a strong influence over propagation of VHF, UHF, and SHF frequencies. These frequencies are associated with aircraft communications, radars and satellite communications, so it is important in military operations to collect precise and timely data from atmospheric conditions.

In this thesis programs from EREPS were used to assess refractive conditions in the Caribbean Sea against selected radar systems. Data given by SDS from radiosonde stations located in MS 43 and 44 were used as input for COVER and PROPR programs. Outputs from COVER are analyzed to find Optimal Altitude to Avoid Detection (OAAD) for a low-flying target. Outputs from PROPR using climatological data given by SDS and Optimal Altitude to Avoid Detection from COVER was used to verify OAAD against selected land- and ship-mounted radars operating in the Caribbean Sea. Finally, a system under development, TDROP is introduced in response to requirements for timely and exact data, in order to enhance the tactical data collection process.

DoD KEY TECHNOLOGY AREA: Electronic Warfare

KEYWORDS: Refractive Conditions, Air Defense, Radar Systems

LOW LATITUDE IONOSPHERIC EFFECTS ON RADIOWAVE PROPAGATION

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This dissertation provides experimental observations and analyses that associate low-latitude transionospheric signal scintillation with transequatorial VHF radio propagation and errors in transionospheric geopositioning.

The experiment observed equatorial-region ionospheric total electron content (TEC) derived from Global Positioning System (GPS) signals using receivers on Oahu, Hawaii, Christmas Island, and Rarotonga, Cook Islands. The experiment simultaneously measured VHF transequatorial propagation of VHF television signals from Hawaii to Rarotonga.

Analysis shows that a moving second moment of vertical-equivalent TEC strongly correlates to each VHF transequatorial radio propagation event. From experimental observation analysis, the author develops models for prediction of TEP and time-space distribution of low-latitude transionospheric scintillation.

The author also develops equations that show the potential errors in time, frequency, and angle used in geopositioning solutions. These three parameters are potentially correctable using these techniques.

DoD KEY TECHNOLOGY AREA: Sensors

KEYWORDS: Low-Latitude, Ionosphere, Equatorial, Scintillation, Geopositioning, Global Positioning System, GPS, Total Electron Content, TEC, Transequatorial Propagation, TEP

1998 THESIS ABSTRACTS

A CASE STUDY OF THE MONTEREY BAY SEA BREEZE ON 25 AUGUST 1997

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Master of Science in Meteorology-September 1998

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On 25 August 1997 a controlled burn on the former Fort Ord property raged out of control. The sea breeze was responsible for transporting the acrid smoke into the Salinas Valley. The PSU/NCAR mesoscale model, MM5, was run at 4 km grid resolution twice using two different PBL schemes (MRF and Burk-Thompson) and then verified by observations from several local mesoscale networks, including wind profiler data. The MM5 simulation was able to depict the 3-D structure of the sea breeze and differentiate between the local mountain-valley forcing and the large-scale sea breeze forcing. These two individual forcing mechanisms were responsible for an observed double surge in the time series of winds at Fort Ord. Further investigation is needed into the surface parameterization/land use tables to improve the surface forcing.

DoD KEY TECHNOLOGY AREAS: Modeling and Simulation, Other (Meteorology)

KEYWORDS: Sea Breeze, Mesoscale Modeling, MM5 Simulations, Monterey Bay, Salinas Valley, Land Breeze

INTERACTIONS OF LARGE-SCALE TROPICAL MOTION SYSTEMS DURING THE 1996-1997 AUSTRALIAN MONSOON

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During the northern winter monsoon, several large-scale tropical motion systems are active in the southern tropical region of the ITCZ and SPCZ, including the maritime continent, northern Australia and the West Pacific. Superimposed on the mean state are transient large-scale systems including the Madden-Julian Oscillation (MJO) propagating from the equatorial Indian Ocean, the northeasterly cold surges from the northern hemisphere, and the easterly waves from the central or western Pacific. This work studied the possible interactions among these large-scale systems and their roles in the development of tropical cyclones. GMS water vapor data and NCEP reanalysis data during December 1996 to March 1997 were used. Examination of daily maps revealed that most of the TC development requires the interaction of two or more large-scale transient systems. The most frequent occurrences involved the interaction of the MJO and cold surges, followed by the interaction of the MJO and easterly waves.

DoD KEY TECHNOLOGY AREA: Other (Meteorology)

KEYWORDS: Australian Monsoon, Northern Winter Monsoon, Madden-Julian Oscillation, MJO, Tropical Cyclone, Cold Surge

1998 THESIS ABSTRACTS

STATISTICAL POST-PROCESSING OF NOGAPS TROPICAL CYCLONE TRACK FORECASTS

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A statistical post-processing technique is developed and tested to reduce the Navy global model (NOGAPS) track forecast errors for western North Pacific tropical cyclones during 1992-1996. In addition to the basic storm characteristics, the set of 42 predictors includes various track segments in the 00-72 h NOGAPS forecast as well as a 00-36 h backward extrapolation that is compared with the corresponding best-track positions. Although a NOGAPS forecast to at least 36 h is required to calculate the critical backward predictors, a reduced set of forward predictors that did not include the 48- and 72-h NOGAPS positions still produced the same improvement in track forecasts. Separate sets of statistical regressions are developed and tested for three subsets of the synoptic pattern/region combinations defined by Carr and Elsberry. For cyclones in the standard/dominant ridge combination, the improvement relative to NOGAPS is 61% after 12 h, and remains 8% after 72 h. For cyclones in the poleward/poleward-oriented pattern/region, the improvement over NOGAPS is 55% after 12 h, and 6% after 72 h. For a combination of cyclones in all remaining pattern/regions, the improvement relative to NOGAPS is 61% after 12 h, and 10% after 72 h. Comparison of these subsets with a single set of regression equations for all synoptic combinations showed no advantage obtained from using separate equation sets, so the single set is recommended. An independent test with all available 1997 NOGAPS forecasts decreased forecast track error by 50, 22, 12, 9, and 6% at 12, 24, 36, 48, and 72 h.

DoD KEY TECHNOLOGY AREA: Battlespace Environments

KEYWORDS: Tropical Cyclone Track Forecasting

RESPONSE OF THE SOUTH CHINA SEA TO FORCING BY TROPICAL CYCLONE ERNIE (1996)

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The South China Sea (SCS) response to forcing by Tropical Cyclone Ernie (1996) was studied numerically using the Princeton Ocean Model (POM) with 20 km horizontal resolution and 23 sigma levels conforming to a realistic bottom topography. A fourteen-day experiment was conducted using a wind model that allowed for temporal variations of its translational speed, size and intensity. Restoring type salt and heat fluxes were used along with seasonal inflow/outflow at the open boundaries. The POM adequately simulated ocean responses to tropical cyclone forcing. Near-surface ocean responses simulated by the POM included strong asymmetrical divergent currents with near-inertial oscillations, significant sea surface temperature cooling, biased to the right of the storm track, and sea surface depressions in the wake of the storm. Subsurface responses included intense upwelling and cooling at the base of the mixed layer to the right of the storm track. Several unique features, caused by coastal interactions with storm forcing, were also simulated by the model. Along the coast of Luzon a sub-surface alongshore jet was formed, a warm anomaly off the northern tip of Luzon was significantly enhanced by surface layer convergence and storm surges simulated along the coasts of Luzon and Vietnam.

DoD KEY TECHNOLOGY AREA: Modeling and Simulation

KEYWORDS: South China Sea, Numerical Simulation, Tropical Cyclone Ernie (1996), Ocean Response to Tropical Cyclone Forcing

1998 THESIS ABSTRACTS

COMPARISON OF EVAPORATION DUCT HEIGHT MEASUREMENT METHODS AND THEIR IMPACT ON RADAR PROPAGATION ESTIMATES

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A study was performed to compare shipboard measurements of atmospheric parameters that impact the evaporation duct and its effect on the propagation of electromagnetic energy from the AEGIS AN/SPY-1 radars. Two ships, *USS Anzio* and *USS Cape St. George*, participated in the annual NATO exercise, BALTOPS, during the summer of 1997. They were equipped with an automated METOC sensor system, developed by Johns Hopkins University Applied Physics Laboratory, called SEAWASP. SEAWASP provided continuous measurement of parameters determining near surface refractivity and the evaporative duct throughout the cruise. SEAWASP data were compared with manual bridge observations in order to illustrate the difference in propagation conditions assessed by the two methods. Additionally, ERS-1 Scatterometer wind data were used in conjunction with SEAWASP data to determine the feasibility of incorporating satellite wind data in determining evaporative duct heights. The automated SEAWASP data was able to depict, with greater accuracy, the constantly changing duct height conditions whereas the bridge observations, made at hourly intervals, lacked temporal resolution, thereby missing much of the variation in duct height. The discrepancies in duct heights between the two measurement systems led to differing propagation ranges resulting in shorter reaction times to counter threats to the ship.

DoD KEY TECHNOLOGY AREAS: Battlespace Environments, Sensors

KEYWORDS: Environmental Data, Radio Physical Optics, Radar Performance Prediction, Refraction, Evaporative Duct, Engineer's Refractive Effects Prediction System

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