Oceanography Department

Captain Joseph W. Swaykos, USN
Instructor and Chair

The U.S. Naval Academy's Oceanography Department executes the largest undergraduate physical oceanography program in the nation. Within this context, the department's Academic Year 2002-2003 research productivity of meteorology, oceanography, and pedagogical research, was especially noteworthy. The department's five tenure track faculty, one Permanent Military Professor, and one externally funded research chair authored 3 refereed articles for publication and made 14 conference presentations, many of which included midshipmen as co-authors.

Nine midshipmen completed Independent Research courses under the mentorship of faculty advisors. These midshipmen formally presented their project results to the faculty and members of the Academic Dean's staff at the end of each semester. Some of these midshipmen went on to present their results at national conferences.

The 15th annual Oceanography Summer Yard Patrol (YP) Cruise aboard YP686 was conducted in June 2003. The cruise instructed 24 midshipmen in the rudiments of oceanographic data collection in the littoral environment, while simultaneously covering the seamanship and navigation requirements of the Professional Development Division. Two separate transects across portions of the southern Chesapeake Bay together with one 72-hour continuous sampling period at one station yielded over 110 biological samples as well as extensive chemical and physical oceanographic data and meteorological observations. This was the department's fifth consecutive annual summer cruise where research-quality data was acquired for use by faculty to support publishable research.

In July 2003, the department hosted the ninth Maury Project Summer Workshop for twenty-four K-12 science teachers nationwide. Enhancing the scientific foundations and teaching methodology for K-12 science teachers in the area of physical oceanography continued as the project's primary focus.

Our Commander, Naval Meteorology and Oceanography Command (COMNAVMETOCCOM), externally funded chair in Remote Sensing continued his strong research efforts with several scientific articles submitted for publication in refereed journals.

Sponsored Research

TerraBase II: Computerized Terrain Analysis Training System

Researcher: Professor Peter L. Guth
Sponsor: U.S. Army Engineer School

TerraBase II is a training system to expose soldiers to the nature and types of digital terrain data, procedures for visualizing terrain, and integrating terrain into tactical planning. The program runs on standard desktop, laptop, and notebook computers with the Windows 95 or better operating system, and uses standard terrain data from the National Imagery and Mapping Agency. The program provides base maps for tracking situation, terrain computations (e.g. line of sight, slope for cross country mobility, sunrise/sunset), and 3D visualizations. The program integrates digital elevation models and satellite imagery. Version 6.0 and 6.03 of the program was fielded this year There were over 65,000 downloads of the program from the USNA web site during the last year.

GEOSYM Display and Evaluation

Researcher: Professor Peter L. Guth
Sponsor: Topographic Engineering Center, Corps of Engineers

This project developed algorithms and software to display GEOSYM symbology for Vector Product Format (VPF) data sets. GEOSYM has been proposed by the National Imagery and Mapping Agency (NIMA) as the standard for the display of all VPF data. TerraBase II was modified to display VPF with GEOSYM, and an editor allows changing the GEOSYM protoype symbology to explore alternatives and improvements. Further work awaits renewed interest and funding from NIMA to develop GEOSYM as an automated display for land maps.

GIS/Remote Sensing Education for Midshipmen

Researcher: Professor Peter L. Guth
Sponsor: National Imagery and Mapping Agency

The researcher continued to improve the GIS/Remote Sensing education provided to midshipmen at the U.S. Naval Academy and provided outreach to the Department of Defense (DOD) through: 1) continued development of algorithms and techniques to merge and display geospatial data in an intuitive way; 2) purchase equipment, data, and software to use in classes and for midshipman research projects. Midshipmen honors students majoring in Oceanography used components of the research and associated equipment in their honors independent research projects and were given the opportunity to present their findings at professional scientific conferences.

Swimming Behavior of Crab Larvae in Response to Prey Patches

Researcher: Assistant Professor Cecily C. Natunewicz
Sponsor: Naval Academy Research Council (NARC)

This research uses larvae of the mud crab Rhithropanopeus harrisii as a model organism to investigate the role of biological cues in maintaining patches of meroplanktonic invertebrate larvae. The principal objective of this study is to determine the potential of larvae to change potential food source. Unlike previous work that has primarily focused on swimming behavior in response to physical parameters (*e.g.,* temperature and salinity) in the vertical plane, this investigation examines the influence of a biological parameter on both horizontal and vertical larval swimming behavior.

The specific questions being addressed in this work include the following: 1) Do larvae change their swimming behavior to remain near or in a food patch? 2) What is the threshold concentration of food required to alter larval swimming behavior? 3) What is the maximum horizontal swimming speed that larvae can sustain to move toward a potential food source? 4) How does the behavior of larvae relative to food patches created in the laboratory translate to the spatial and temporal scales of larval patches observed in the field?

The work incorporates observations of behavior of laboratory-reared larvae to investigate the role of swimming in forming and maintaining larval patches. Swimming behavior of two larvalstages (zoea-I, zoea-IV) and post larvae are being monitored in order to assess ontogenetic changes in swarming capability. Larvae are reared from hatching and maintained in the lab at environmental conditions until at the desired age (molt stage) for the experiments. Experiments are run in small cylindrical plexiglass aquaria, and swimming behavior is monitored with a low-light video camera and a video recorder. Results are being analyzed with appropriatenonparametric statistics.

This work is unique in that it is one of few studies of the ability of meroplanktonic invertebratelarvae to orient themselves to discrete prey patches, and is the first known investigation of this behavior for larval crabs. By assessing larval movement in both the vertical and horizontal planerelative to prey patches, the research provides important information on the propensity of biological processes to drive the spatial and temporal dynamics of crab larvae in estuaries and the coastal ocean. The results from this study will not only increase fundamental understanding of the population dynamics of both ecologically and commercially-important invertebrate species, but may also ultimately facilitate forecasting of population dynamics of estuarine taxa.

The Maury Project - Exploring the Physical Foundations of Oceanography

Researchers: Associate Professor David R. Smith
with I.W. Geer, American Meteorological Society
Sponsors: Commander, Naval Meteorology and Oceanography Command (CNMOC),
NOAA National Environmental Satellite, Data and Information Service,
and the Office of Naval Research

The Maury Project is a teacher enhancement program on the physical foundations in oceanography for pre-college educators. Each year approximately twenty-four teachers are brought to the United States Naval Academy to attend a summer workshop where they learn about fundamental concepts in physical oceanography. This includes a combination of lectures, hands-on laboratory exercises, field experiences, and tours of oceanographic facilities. Upon completion of the summer workshop, these teachers return to their respective states where they conduct peer-training sessions for other teachers using materials developed by project staff.

Water in the Earth System

Researchers: Associate Professor David R. Smith
with I.W. Geer and J.M. Moran, American Meteorological Society
Sponsor: National Science Foundation (NSF)

Water in the Earth System is a teacher enhancement program on the role of water and water processes in the Earth system. This is a distance-learning course which uses the Internet to deliver instruction to pre-college educators. This summer, 35 teachers traveled to Madison, Wisconsin to attend a summer training workshop where they learn about fundamental concepts in meteorology, physical oceanography, and hydrology. Upon completion of the summer workshop, these teachers will return to their respective states where they will serve as the leaders for the local implementation teams that will mentor other teachers taking the distance learning course.

The Influence of Boundary Layer Dynamics and Thermodynamics on the Diagnosis of Near-Surface Wind Speed by Synthetic Aperture Radar

Researcher: Assistant Professor Todd D. Sikora
Sponsor: Office of Naval Research (ONR)

An algorithm has been developed to extract marine atmospheric boundary layer statistics, such as the Obukhov length and the surface buoyancy flux, from wind images derived from RADARSAT synthetic aperture radar (SAR) data. The algorithm has been tested against bulk-derived statistics from coincident buoy data from off the east coast of the United States. Agreement is encouraging. The rate of acquisition of RADARSAT SAR-derived wind imagery available to the investigators of the proposed research is scheduled to increase. Imagery will be available over the Gulf of Alaska as well as off the east coast of the United States in conjunction with the National Oceanic and Atmospheric Administration-sponsored Storm Watch program. Therefore the potential for robust testing of the SAR algorithm will exist. It is proposed that this testing take place. The proposed research should be viewed as a test of an algorithm that, if successful, can compete with bulk estimates of MABL statistics from buoy data. Questions to be addressed include the influence of the surface wave state, the synoptic and mesoscale meteorological environment, pixel size, and the averaging window size of the SAR wind imagery on the performance of the SAR algorithm.

Surface Wind Speed and Fluxes from Synthetic Aperture Radar

Researcher: Assistant Professor Todd D. Sikora (Co-PI)
Sponsor: National Aeronautical and Space Administration (NASA)

Exchanges between the ocean and atmosphere play an important role in moderating climate. A newly developed algorithm obtains surface buoyancy flux, friction velocity, and Obukhov length from Synthetic Aperture Radar (SAR) backscatter over (10-25 km) square areas of the ocean's surface. As well, non-neutral mean wind speed over (1-10 km) square regions can be derived from SAR backscatter. Due to its high spatial resolution and global coverage, SAR offers the potential for the development of air-sea flux climatologies. Validation and refinement of the SAR flux/speed algorithm

against buoy data is being studied extensively, starting with moderately convective conditions found in the Gulf of Mexico and off of the U.S. coasts (but concentrating on the tropics). The latter comparison will focus on the 95W line of TAO buoys spanning the equator, during the time of two research cruises. This region in the eastern equatorial Pacific plays an important role in such climate phenomena as El Niño. Turbulence data taken during the cruises will provide eddy correlation fluxes for comparison to those derived from SAR. As well, wind speed from the ship will be compared to non-neutral wind speed obtained from SAR. The proposed work has two central goals. First, we will improve algorithms which will ultimately make high-resolution surface fluxes and wind speeds available to the climate research community. Second, we will address the role of SAR-observed atmospheric variability, such as tropical rain cells, in modifying surface exchange. We therefore seek to improve the research community's understanding of and ability to quantify the inhomogeneous nature of tropical air-sea exchange.

A Study of Water Quality in the Douro River Estuary (Portugal)

Researchers: Associate Professor Mário E. C.Vieira
and Associate Professor Adriano Bordalo, Porto University, Portugal
Sponsor: Porto University, Portugal

Based on the data collected in 1995 and a box model of the hydrodynamics of the Douro River estuary exchange coefficients were estimated. Fluxes throughout the estuary were computed for the following parameters: chlorophyll, bacteria, planktonic viruses. The analysis of the results is discussed in a paper being prepared for publication.

A Survey of the Oceanography of the Lima River Estuary (Portugal)

Researchers: Associate Professor Mário E. C. Vieira
and Adriano Bordalo, Porto University, Portugal
Sponsor: Porto University

Observations of salinity, temperature, currents and oxygen concentration were made at several stations throughout the lower Lima estuary (Portugal) over one complete tidal cycle in June of 2002. Longitudinal cross-sections of density and flow velocity elucidated the oceanographic behavior of this waterway. Vertical profiles allowed the study of stratification and its relationship to tidal forcing.

Independent Research

Evaluation of SSM/I Sea Ice Concentration with AVHRR Visible and Infrared Imagery

Researchers: Adjunct Assistant Professor Walter N. Meier
and Soren Andersen, Danish Meteorological Institute

Sea ice concentration fields from several different passive microwave algorithms are compared with AVHRR visible and infrared imagery. AVHRR imagery is obtained over a several month period for the Barents Sea, Greenland Sea, and Baffin Bay regions. These encompass a variety of different ice and weather conditions. Of the algorithms evaluated, the NASA Team 2 algorithm appears to perform the best, with a lower bias and lower RMS difference when compared to AVHRR concentrations. The NASA Team 2 algorithm is also employed to compare the effect of running the algorithms on daily averaged SSM/I brightness temperatures versus running the algorithms on the SSM/I swath data. The effects of using the swath data can be significant, especially for the NASA Team 2 where atmospheric corrections are employed.

Evaluation of SSM/I Sea Ice Concentration Algorithms in the Barents Sea with Synthetic Aperture Radar

Researchers: Adjunct Assistant Professor Walter N. Meier
and Ted Maksym, U.S. National Ice Center

Microwave satellite imagery products are an important resource for characterizing the sea ice environment because of their frequent, all-weather coverage of the polar regions. They are, however, limited by spatial resolution, atmospheric effects, and surface ambiguities in the microwave signal. New SSM/I ice concentration algorithms are now available in near real-time for operational forecasting and analysis. The Barents Sea is a region of operational interest, but is characterized by complex ice formation processes and a mixture of several different ice types. In October 2001, the U.S. Coast Guard icebreaker Healy collected information on ice conditions in the region and coincident high resolution Radarsat and DMSP OLS imagery were also obtained. The high-resolution imagery were used evaluate and interpret the microwave imagery. The evaluations indicate that the new SSM/I algorithms yield improved characterization of thin ice near the ice edge, without noticeable weather contamination.

Evaluation of SSM/I-Derived Sea Ice Motions

Researchers: Kyle Dedrick and LCDR Doug Lamb, USN of the National Ice Center,
and Adjunct Assistant Professor Walter N. Meier

An operational sea ice motion product from SSM/I 85 GHz imagery has been implemented for operational support at the Naval/National Ice Center in Suitland, MD. In situ ice motion observations are very sparse and model outputs are unreliable. Remotely-sensed ice motions have the potential to provide dense fields of motion over much of the Arctic and Antarctic regions as frequently as once per day. The new motion product is evaluated in an operational context via comparisons with AVHRR visible and infrared imagery, in situ buoy observations, and model fields.

Comparison of Passive Microwave ad Scatterometer Sea Ice Motion Fields

Researcher: Adjunct Assistant Professor Walter N. Meier

Both scatterometers and passive microwave radiometers have demonstrated the ability to retrieve fields of sea ice motion via cross-correlations between image pairs. Here ice motions from QuikScat scatterometer imagery and SSM/I 85 GHz passive microwave imagery are compared. While both imagery products are of similar frequency and spatial resolution and both are dependent on the microwave character of the sea ice, there is the possibility of unique information within each data set. Both sensor retrievals are affected by changes in the surface characteristics, but some of the changes are likely mutually exclusive, yielding independent information. In addition, passive microwave imagery is often affected by thick clouds while scatterometers are susceptible to wind contamination near the ice edge. The products are compared to determine the independence of each and to investigate optimal methods for combining the two products.

The Effect of El Niño Events on Winter-Spawned Fish Larvae

Researcher: Assistant Professor Cecily C. Natunewicz

El Niño/ Southern Oscillation (ENSO) cycles can significantly alter the population dynamics of marine organisms. Previous studies of the effects of El Niño on fisheries have focused primarily on Pacific populations, yet the phenomenon may also influence Atlantic fish stocks. Via a complex set of teleconnections, El Niño events increase precipitation and modify winds in the southeastern United States during winter months. These anomalous patterns subsequently alter the circulation on the continental shelf and have the potential to reduce the survival of shelf-spawned species by inhibiting larval transport to suitable habitat inshore.

A 13-year weekly time series of larval ingress to a coastal inlet (Beaufort Inlet, North Carolina USA) was examined in relation to the southern oscillation index (SOI), to assess the potential for ENSO events to affect larval supply to coastal habitats. Physical data (river discharge, currents, winds, water temperature) were obtained from USGS and NCDC. MATLAB® software was used to run the statistics. Preliminary results suggest the magnitude of larval ingress was correlated with the SOI. Specifically, Atlantic croaker (Micropogonias undulatus) larvae showed higher ingress during El Niño

years, while spot (Leiostomus xanthurus), Atlantic menhaden (Brevoortia tyrannus), and pinfish (Lagadon rhomboides) larvae showed higher ingress during La Niña years. Additionally, the data suggested that timing of ingress is related to phase of the ENSO cycle.

Direct Influence of Gravity Waves on Surface-Layer Stress During a Cold Air Outbreak, as Shown by Synthetic Aperture Radar

Researchers: Assistant Professor Todd D. Sikora,
with Nathaniel S. Winstead and Donald R. Thompson
(The John Hopkins University Applied Physics Laboratory),
and Pierre D. Mourad (University of Washington Applied Physics Laboratory)

Synthetic aperture radar (SAR) images of oceans and the Great Lakes have provided a highly detailed means of observing atmospheric boundary layer phenomena such as convection, land breezes, and internal gravity waves. This is possible because the backscattered radiation detected by SAR can be dominated by scattering from wind-driven capillary waves whose spatial variation is visible as patterns in the SAR images. In this paper, we present two case studies in which SAR images taken over Lake Superior demonstrate spatial variability in the surface wind stress created over the lake by coincident gravity waves and boundary layer convection during cold air outbreaks. Of particular interest is the direct influence of the gravity waves on the lake-surface stress despite the intervening highly convective atmosphere as well as the detailed view of the fetch dependence of that stress.

A Case Study of Satellite Synthetic Aperture Radar Signatures of Spatially Evolving Atmospheric Convection over the Western Atlantic Ocean

Researchers: Assistant Professor Todd D. Sikora
with Steven M. Babin and Nathaniel S. Winstead
(The Johns Hopkins University Applied Physics Laboratory)

A case study of a particularly intense cold air outbreak over the north Atlantic Ocean extending from the northeast coast of the United States to the Gulf Stream is described. A RADARSAT satellite synthetic aperture radar (SAR) image of this outbreak dramatically illustrates the spatial evolution of convection. Nearly coincident images from the National Oceanic and Atmospheric Administration's Advanced Very High Resolution Radiometer are used to compare many interesting features. In addition, National Weather Service rawinsonde data, National Data Buoy Center buoy data, and Woods Hole Oceanographic Institute Coastal Mixing and Optics mooring data are presented. We use these data to help describe the spatial evolution of the atmospheric boundary-layer processes involved in this outbreak. Rows of cellular convective clouds begin to appear some distance offshore and then slowly increase in horizontal diameter and wavelength in the downwind direction, with a subsequent jump in cloud diameter downwind of the Gulf Stream North Wall (GSNW). The SAR image shows a similar evolution of sea-surface footprints of these boundary-layer features. This change in boundary-layer structure is attributed to corresponding changes in static stability. About 300 km south of the GSNW in the SAR image, an even larger jump in cell diameter appears and the cells become non-uniform with bright crescents and filled semi-circles on the downwind sides of the cells. These are believed to be surface effects of gust fronts induced by the mesoscale cellular convection and enhanced by the overall northwesterly flow.

Mesoscale Stratocumulus Bands Caused by Gulf Stream Meanders

Researcher: Assistant Professor Todd D. Sikora

Examination of visible and infrared imagery from geosynchronous and polar orbiter satellites reveals the occasional existence of mesoscale cloud bands of unusual width and area, originating over the open Northwest Atlantic Ocean during cold-air outbreaks. This phenomenon is of both dynamic and synoptic interest. As a dynamic phenomenon, it represents a mesoscale flow that is driven by transient surface features, meanders in the Gulf Stream. The forcing geometry and the resulting cloud pattern are similar in many respects to the anomalous cloud lines observed downwind of Chesapeake and Delaware Bays in similar conditions. These open ocean cloud bands are often of a larger scale however, because the Gulf Stream meanders represent the largest-scale high-amplitude "coastal features" in the western North Atlantic. These cloud

bands are of synoptic interest because, when present, they play a major role in determining the cloud pattern over much of this oceanic region.

Examination of surface and 850 hPa analyses demonstrates that these open ocean cloud bands occur during cold-air outbreaks and that they align approximately with the boundary-layer wind. Comparison of visible and infrared satellite imagery with contemporaneous sea surface temperature analyses derived from infrared polar orbiter satellite imagery reveals that the open ocean cloud bands originate at the upwind end of Gulf Stream meanders. Climatological data and synoptic observations from land and sea indicate that these events occur only during that part of the spring season in which coastal temperature differences are small but cold-air outbreaks continue to reach the Gulf Stream. Examination of this observational evidence suggests that these open ocean cloud bands result from mesoscale solenoidal circulations driven by the horizontal gradients in sea surface temperature caused by Gulf Stream meanders.

Midshipman Research Course Projects

Looking for the USS Alligator

Researcher: Midshipman 1/C Quincy Hochard, USN
Advisers: Ms. Michiko Martin (National Ocean and Atmospheric Administration (NOAA)
and Professor Peter L. Guth
Sponsors: Naval Research Laboratory (NRL)
and the NOAA National Marine Sanctuary Program

The Navy's first submarine, the USS Alligator, was lost in bad weather off Cape Hatteras in 1863. The purpose of this independent research is to study the general oceanography of the Gulf Stream in this region and attempt to develop a search model of where the Alligator might be found based on what information can be compiled of the specific meteorological and oceanic event at the time, as well as gathering as much information as possible from other ships that might have experienced the storm. Moving on to a climatic analysis, and, finally, a look into search and rescue (SAR) modeling, this information is hoped to refine the final resting place of the Alligator in order to reduce the search area as much as possible.

In Search of the *USS Alligator*: Bathymetry, Geology, Sedimentation off the Coast of North Carolina

Researcher: Midshipman 2/C Colleen Maloney, USN
Adviser: Professor Peter L. Guth
Sponsors: Naval Research Laboratory (NRL)
and the NOAA National Marine Sanctuary Program

The *USS Alligator* was the first U.S. Navy submarine. It was built during the Civil War by the French inventor Brutus de Villeroi. The Union Navy had hopes that the submarine would aid in destroying the Confederate ironclads. Unfortunately, before proving her merit, the Alligator was lost in a storm April 2, 1863 off the coast of Cape Hatteras. By examining the bathymetry, geology, and sedimentation in that area, an accurate model of the ocean floor was produced. Because of North Carolina's narrow continental shelf, it is most likely that the *USS Alligator* is in the deep waters of the continental slope and rise, or even the abyssal plain. Unfortunately, this area will not be easy to search due to its complex pattern of canyons, ridges, and slides. The sediments deposited on the seafloor are mainly silty clay and clayey silt. Although these fine-grained sediments will provide sharp contrast to the metal submarine's profile, they will also complicate the excavation of the wreck. After being disturbed, silt and clay remain suspended in the water column longer than larger sediments, thus greatly reducing visibility. Preparing for these possibilities will aid in creating an efficient and effective search plan to locate the *USS Alligator*.

A New Model: Evaluating the Coupled Ocean Atmosphere Prediction System (COAMPS 3.0)

Researcher: Midshipman 1/C Lisa Morgan, USN
Adviser: Adjunct Assistant Professor Walter N. Meier

The computer-based model presently employed by the United States Navy for meteorological forecasting is the Coupled Ocean Atmosphere Prediction System, or COAMPS 3.0. This model is simple, and based is principally upon primitive equations including non-hydrostatic effects. Unlike the even more basic Navy Ocean Global Atmospheric Prediction System (NOGAPS), it does, however, take into account interactions between ocean, air, and terrestrial components; thus it does not assume a uniform ocean void of landmasses, as did its predecessor. Variables taken into account include wind components, potential temperature, mixing ratio, surface pressure, ground temperature, ground wetness, and sea-surface temperature. The objective of this study is to expand the categorical statistics of COAMPS to include heavy rainfall threshold, temperature, surface pressure variations, and gale force winds. This is done by conducting isolated satellite observations over the area bounded by 30˚ to 40˚N Latitude and 60˚ to 70˚ W Longitude in the Northwest Atlantic Ocean. Observations are conducted via the use of SSM/I and DMSP visible and infrared data collected from the Fleet Numerical Meteorology and Oceanography Center in Monterey, California. These images are examined using ImageJ (Image Processing and Analysis in Java) software, and statistical verification is conducted to determine the effects of these parameters on weather modeling accuracy out to 72 hours.

Evaluaton of the Accuracy of SSM/I Ice Concentration Products near the Ice Edge

Researcher: Midshipman 1/C Meghan Poukish, USN
Adviser: Adjunct Assistant Professor Walter N. Meier

Among other remote sensing sources, composite imagery from SSM/I swaths is relied on daily by ice analysts to predict the ice edge in the polar regions. It is imperative for maritime operations in those regions to have accurate forecasts, but many sources of error exist. Imagery from SSM/I sensors near the ice edge is inaccurate primarily due to resolution, temporal averaging, and weather effects. There is also potential error in the transfer of data from individual swaths to composite imagery. Variables such as weather and location affect the degree of this error. This project will analyze the inaccuracies of sea ice concentrations derived from SSM/I composite imagery as compared to averaged satellite swaths and individual swaths and consider solutions for improving accuracy. Possible solutions include subtracting weather effects from the raw data to obtain atmospheric emission-free values and changing averaging procedures for the creation of composites.

Comparison of Arctic Sea Ice Motion from QuikScat ad SSM/I

Researcher: Midshipman 1/C Theodore Vermeychuk, USN
Adviser: Adjunct Assistant Professor Walter N. Meier

Arctic sea ice motions for January through March 2002 derived from QuikSCAT and SSM/I data are generally well correlated over the Arctic Ocean as a whole. Special Sensor Microwave/Imager (SSM/I) passive microwave data has been available for several years, but QuikSCAT, which uses active microwave and measures backscatter, is relatively new and few in-depth studies have been done. Although both data sources utilize microwave imaging to measure the same parameter, preliminary observations suggested that each data set is independent. More thorough tests indicate that the two data sources are not statistically independent, but each has different strengths, biases and errors. Examining both data sets yields a more thorough picture of Arctic sea ice motion than either satellite alone. The data examined is limited to points where data for both satellites is available (for correlation purposes). In some cases, one of the satellites provided better coverage for particular areas than the other satellite. (This study did not examine this scenario.) Developing an algorithm for fusing the two data sets, or some other appropriate method of using both in conjunction for sea ice motion modeling purposes, is work yet to be completed.

Migration Patterns of the Invasive Japanese Shore Crab Hemigrapsus Sanguineus

Researcher: Midshipman 1/C Rebecca Baldwin, USN
Adviser: Assistant Professor Cecily C. Natunewicz

The Japanese shore crab, Hemigrapsus sanguineus was introduced to the Cape May, NJ East Coast in the late 1980's, and has subsequently spread throughout the United States east coast. Although this species is outcompeting native mud crabs in many rocky intertidal habitats, little is known about how it has dispersed so rapidly. The goal of this project was to examine the potential biological and physical mechanisms of transport of Japanese shore crab larvae to determine the potential of the species to spread to mesohaline regions of Chesapeake Bay. This work is vital to the Bay because H. sanguineus is a voracious predator of oysters and has the potential to seriously damage oyster restoration projects in the mesohaline region of the Bay.

For this component of the project, biological data (= hourly zooplankton samples) from a three-day time series of biophysical sampling (Lynnhaven Roads, VA 1-3 June, 2002) aboard YP-686 were analyzed. 48 samples of zooplankton collected at 0 and 2 m depth were sorted. Larvae were identified to species and larval concentrations were calculated. To determine whether or not larvae could move up-estuary via selective tidal stream transport, larval concentrations were compared with tidal phase. The results of this project proved inconclusive because relatively few H. sanguineus larvae were found, and only one day of the three day time series was able to be sorted in the time allotted. This work was continued by Midshipman Ehret in the spring semester.

Transport of the Invasive Japanese Shore Crab Hemigrapsus sanguineus in Chesapeake Bay

Researcher: Midshipman 1/C Melissa Ehret, USN
Adviser: Assistant Professor Cecily C. Natunewicz

This project supplemented the work Midn Baldwin began in the fall of 2002. For this component of the project, more biological data (= hourly zooplankton samples) from a three-day time series of biophysical sampling (Lynnhaven Roads, VA 1-3 June, 2002) aboard YP-686 were analyzed. 48 more samples of zooplankton collected at 0 and 2 m depth were sorted. Larvae were identified to species and larval concentrations were calculated. To determine whether or not larvae could move up-estuary via selective tidal stream transport, larval concentrations were compared with tidal phase. The results of this project illustrated that xanthid crabs (= mud crabs) were likely retained in the bay while blue crabs (Callinectes sapidus) and H. sanguineus larvae were likely exported. If this is in fact the case, it is likely that H. sanguineus has rapidly spread because the larvae are exported to the coastal ocean to develop. Nevertheless, only two of the three days of the time series data have been sorted, so no formal conclusions can be made.

Physical Factors Affecting the Migration of the Invasive Japanese Shore Crab Hemigrapus Sanguineus

Researcher: Midshipman 1/C David Riley, USN
Adviser: Assistant Professor Cecily C. Natunewicz

This project supplemented the research of Midshipmen Baldwin and Ehret with physical data collected on the YP-686 summer research cruise in 2002. Namely, CTD and ADCP data collected on board the cruise were analyzed in conjunction with NOAA tide tables and the "CAP'N Current Program" to provide accurate timing of tidal currents. This enabled the times that high larval concentrations occurred in the time series to be compared to tidal flow, to determine whether or not H. sanguineus used a behavioral mechanism (selective tidal stream transport) to be retained in the bay or exported to the continental shelf. Kruskall Wallace tests of significance suggested that the blue crab C. sapidus and H. sanguineus larvae may use a behavioral mechanism to be exported to the continental shelf for development, facilitating their spread, but the third day of zooplankton data must be analyzed to strengthen this conclusion.

The Effect of the La Niña Event of 1988-'89 on the Weather of U.S. Cities

Research: Midshipman 1/C Matthew Edwards, USN
Adviser: Associate Professor David R. Smith

Previous research has revealed the significant effects that El Niño and La Niña have on global weather patterns. These effects can be determined through analyzing deviations from the normal climatic conditions of fourteen U.S. cities spread across the nation during marked La Niña years. Variations occur in the respective temperature and precipitation measurements taken at each location. The time period to be examined in this study is the months of December 1988 through March 1989, a period with a strong La Niña event. Both temperatures and precipitation amounts at 14 U.S stations are analyzed over this time period, and the results can then be compared to previous research. Included in this comparison will be results for the 1983-1984 La Niña [Honnette and Smith 2002] as well as the 1998-1999 La Niña [Wood et al. 2000], to determine if any generalized patterns exist in weather changes in the U.S. during La Niña events.

Publications

Journal (Refereed) Manuscripts

MEIER, Walter N., Adjunct Assistant Professor and Maslanik, J.A., "Effect of Environmental Conditions on Observed, Modeled, and Assimilated Sea Ice Motions," *Journal of Geophysical Research*, 108(C5), 1352, (2003).

Previous evaluations of ice motion have primarily consisted of comparisons with in situ observations and general sensitivity studies with wind speed and direction. An assimilation framework allows the quality of ice motions to be studied as an explicit function of model and model forcing parameters. Here, we investigate the effects of local conditions on remotely sensed, modeled and assimilated motions. We use local conditions, as given by the ice model, to examine ice motion errors based on (1) proximity to the coast, ~~(2) ice concentration,~~ (2~~3~~) ice thickness, and (3~~4~~) wind forcing. In comparison to buoy observations, both modeled and remotely sensed ice motions have lowest errors in moderately thick ice, in low winds and away from coastal regions. Wind speed plays the largest role in the errors and higher winds speeds lead to substantially higher motion error standard deviation. However, higher wind speeds also increase the correlation of modeled and remotely sensed motions with buoy observations. An optimal interpolation assimilation methodology, which led to substantial improvements in ice motion quality on a regional and seasonal basis, was employed in this study. Assimilation improved the quality of the ice motions (lower error, higher correlation) throughout ~~all~~ most ranges of wind speed and ice thickness and both near the coast and in the central ice pack. This study suggests that adjusting assimilation weights based on local model conditions could efficiently yield even higher quality assimilated motion fields.

SIKORA, Todd D., Assistant Professor, Babin, S. M., and Winstead, N.S., "A Case Study of Satellite Synthetic Aperture Radar Signatures of Spatially Evolving Atmospheric Convection over the Western Atlantic Ocean," *Boundary-Layer Meteorology*, 103, 527-546 (2003).

A case study of a particularly intense cold air outbreak over the north Atlantic Ocean extending from the northeast coast of the United States to the Gulf Stream is described. A RADARSAT satellite synthetic aperture radar (SAR) image of this outbreak dramatically illustrates the spatial evolution of convection. Nearly coincident images from the National Oceanic and Atmospheric Administration's Advanced Very High Resolution Radiometer are used to compare many interesting features. In addition, National Weather Service rawinsonde data, National Data Buoy Center buoy data, and Woods Hole Oceanographic Institute Coastal Mixing and Optics mooring data are presented. We use these data to help describe the spatial evolution of the atmospheric boundary-layer processes involved in this outbreak. Rows of cellular convective clouds begin to appear some distance offshore and then slowly increase in horizontal diameter and wavelength in the downwind direction, with a subsequent jump in cloud diameter downwind of the Gulf Stream North Wall (GSNW). The SAR image shows a similar evolution of sea-surface footprints of these boundary-layer features. This change in boundary-layer structure is attributed to corresponding changes in static stability. About 300 km south of the GSNW in the SAR image, an even larger jump in cell diameter

appears and the cells become non-uniform with bright crescents and filled semi-circles on the downwind sides of the cells. These are believed to be surface effects of gust fronts induced by the mesoscale cellular convection and enhanced by the overall northwesterly flow.

Conference Proceedings

GUTH, Peter L., Professor, Thibaud, R., Brugiere, F., and Clad, P., "Target3D: Interactive Visualization over the World Wide Web," *Second International Workshop on Web and Wireless Geographical Information Systems (W^2GIS 2002)*, Singapore, 11 December 2002.

This paper describes a Java application, Target 3D, that creates an interactive VRML model to visualize real terrain configurations. The application requires an input elevation grid and a texture to drape on the elevation framework, which can be provided by the freeware MICRODEM program from a wide variety of grid, raster, and vector map data. The most important feature of this Java application is that users can interactively add target models to the scene, which allows recreating reality in detail. To deliver this interactive landscape visualization, the application uses a client–side architecture with a Java Applet technology, and requires only that the computer have a Java run time environment. The VRML output can be served via a network, and viewing it requires only a web browser with a plug-in to display VRML files.

GUTH, Peter L., Professor, "The Wheeler Survey and Theoretical Tectonics: The Basin and Range," Vol.34, no.7, paper 41-7., *National Meeting of the Geological Society of America,* Denver, CO, November 2002.

From 1869 to 1879 Lieutenant G. M. Wheeler led the US Geographical Surveys West of the 100th Meridian. Conditions after the Civil War reflected settling of the frontier and the rise of an independent scientific establishment, and led to four competing federal surveys. Wheeler's survey marked the last attempt by the Corps of Engineers to maintain the surveying role. By the 1870's scientists did not require the military to conduct research, and geologists did not enjoy army procedures. Wheeler's best geologist, G.K. Gilbert, served only a few years with Wheeler, but ultimately did the best theoretical tectonic work of any federal survey. Gilbert's theoretical success stemmed from several factors: the fast Army pace forced accurately summarized observations of the big picture; the survey took him through some of the best geological terrain; and he was one of the best geologists ever. Gilbert accurately recognized the normal faults creating the Basin and Range, providing a second model for orogenic tectonics to complement folding. The nature of normal faulting in mountain formation remains a key research area of theoretical tectonics, with the current debate concerning the relative roles of high-angle versus low-angle faults in creating the landscape Gilbert first accurately described.

MEIER, Walter N., Adjunct Assistant Professor, Maksym, T., and Van Woert, M., "Evaluation of Operational Microwave Products: A Case Study in the Barents Sea during October 2001," *Ice in the Environment: Proceedings of the International Association for Hydraulic Engineering. and Research*, Vol. 3, Dunedin, New Zealand, (2002) in press.

Microwave satellite imagery products are an important resource for characterizing the sea ice environment because of their frequent, all-weather coverage of the polar regions. They are, however, limited by spatial resolution, atmospheric effects, and surface ambiguities in the microwave signal. New SSM/I ice concentration algorithms are now available in near real-time for operational forecasting and analysis. The Barents Sea is a region of operational interest, but is characterized by complex ice formation processes and a mixture of several different ice types. In October 2001, the U.S. Coast Guard icebreaker Healy collected information on ice conditions in the region and coincident high resolution Radarsat and DMSP OLS imagery were also obtained. The high-resolution imagery were used evaluate and interpret the microwave imagery. The evaluations indicate that the new SSM/I algorithms yield improved characterization of thin ice near the ice edge, without noticeable weather contamination.

MEIER, Walter N., Adjunct Assistant Professor, Arbetter, T.E., Lynch, A.H., and Maslanik, J.A., "Effects of Data Assimilation of Ice Motion in a Basin-scale Sea Ice Model," *Ice in the Environment: Proceedings of the International Association for Hydraulic Engineering and Research*, Vol. 3, Dunedin, New Zealand, (2002) in press.

A sea ice thickness distribution model is modified to include data assimilation of satellite-derived sea ice motion. The model is applied to the Arctic basin for 1990 and 1998, two years with anomalously low summer sea ice extent and coverage. Daily ice area observations derived from SSM/I satellite data are used to initialize the model and for comparison with mode predictions. In both simulated years, the use of assimilated sea ice motion constrains the 15% sea ice extent closer to SSM/I-observed values, but excessive ice melt occurs within the central pack. Compared to the baseline, the assimilated ice motion field varies the dynamic transport of ice and thereby the production of open water and ridged ice, resulting in dramatic differences in the seasonal evolution of the ice pack. This suggests that the sea ice model is overly sensitive to changes in dynamic forcing. This has implications for the inclusion of data assimilation of sea ice motion in climate models.

MEIER, Walter N., Adjunct Assistant Professor, Van Woert, M., Zou, C.Z., Hovey, P. and Chase, M., "24-hour Forecast Validation of the Polar Ice Prediction System, *Ice in the Environment: Proceedings of the International Association for Hydraulic Engineering and Research*, Vol. 3, Dunedin, New Zealand, 445-452 (2002).

The National Ice Center relies upon a coupled ice/ocean model called the Polar Ice Prediction System (PIPS) to provide guidance for its 24-hour sea ice forecasts. Here we present results on the forecast skill of the sea ice concentration (C) fields from this system for the period June 1, 2000 – May 31, 2002. Methods of measuring the sea ice forecast skill are adapted from the meteorological literature. The PIPS forecast skill compared to a climatological reference was high (>0.85) for all months due to the highly variable nature of climatology relative to forecast variability. Thus, the PIPS forecasts are significantly better than using climatology as the sea ice forecast on any given day. The PIPS forecast skill was also compared to a persistence forecast. The skill was greater than 0 for all months except the freeze-up months of November – February. The variability was greatest near the marginal ice zone (MIZ) suggesting that ice growth during the winter months at the MIZ may not be properly parameterized in PIPS.

SMITH, D.R., Associate Professor, and HONNETTE, H.L., Midshipman 1/C (USN), "A Comparison of the Weather in U.S. Cities During the 1983-84 and 1998-99 La Niña's," *Preprints of the 14th AMS Symposium on Global Change and Climate Variations,* American Meteorological Society, Boston, MA, 2003, (CD-ROM).

The ENSO phenomenon, which stands for El Niño/Southern Oscillation, involves the fluctuation between El Niño and La Niña episodes. It has been shown to have a dramatic effect on the weather of locations worldwide. This air-sea interaction over the Tropical Pacific alters atmospheric wave patterns, thereby changing the movement of storm tracks, which modifies normal weather conditions. This study will explore the effects of the 1983-'84 and 1998-'99 La Niña's on fourteen U.S. cities to determine the impact of La Niña on temperature and precipitation patterns across the nation. Climatological monthly averages for each of the cities will be compared with the data from these two La Niña events as well as with each event's respective 30-year normals. This comparison and analysis will help determine the relative strength of these La Niña events and the magnitude of change they induced on normal weather conditions throughout the country. This study will also examine if there is a correlation between the magnitude of preceding El Niño episodes and the following La Niña events.

SMITH, D.R., Associate Professor, and KENNEDY, C. K., Midshipman 1/C (USN), "ENSO-based Forecasting of Seasonal Tropical Cyclones Trends from Historical Analysis of Genesis and OLR Oscillations", *Joint Preprints of the 19th Conference on Weather Analysis and Forecasting and the 15th Conference on Numerical Weather Prediction,* American Meteorological Society, Boston, MA, J99-102.

Although a great deal of study has been carried out with regard to low frequency, long-term oscillations in the tropics, there remain numerous unanswered questions regarding higher frequency short-term oscillations. In particular, the effects of high frequency intra-annual oscillations on regional and global tropical cyclogenesis have begun only recently to be examined in detail. A connection between low frequency oscillations such as the El Niño/Southern Oscillation (ENSO) and higher frequency inter-basin oscillations is thought to exist in the tropics. Here, some characteristics of tropical cyclogenesis in the East Pacific and Atlantic basins are examined. Seasonal temporal

positions of tropical cyclone genesis between 1950-1999 are recorded in both basins in a region confined from 5-45° N and 10-140° W. The genesis positions are separated into two datasets based on origin as either an East Pacific or North Atlantic system. Raw time series reveal the seasonal genesis frequencies for each region, and subsequent cross correlations yield periods of genesis oscillation between the two basins. These oscillation periods are then compared to various index values of ENSO to determine what, if any, effects the state of ENSO has on genesis oscillation. In subsequent tests, outgoing longwave radiation (OLR), a well-known proxy for tropical convection, is analyzed for similar oscillations in an attempt to substantiate the genesis analysis technique established above. In this case, daily OLR values for the entire area of concern are averaged for the tropical seasons 1974-1999 (with the exception of 1978 due to satellite failure). Whereas a cross correlation for two individual basins was used in the genesis technique, a set of power spectra is analyzed for the single larger region used in the OLR analysis. In the end, the apparent effect of ENSO on inter-basin oscillations is examined followed by analysis of the seasonal OLR trends to see if they behave in a similar manner in accordance with the seasonal ENSO index value.

SMITH, D.R., Associate Professor, Geer, I.W., Moran, J.R., Weinbeck, R.S., and Hopkins, Edward J., "Water in the Earth System (WES): A Midterm Evaluation of a Distance-learning Course on the Water Cycle," *Preprints of the 12th American Meteorological Society (AMS) Symposium on Education,* Boston, MA, (2003) (CD-ROM).

Water in the Earth System (WES) is a distance-learning course for precollege teachers partially delivered via the Internet, developed and coordinated by the American Meteorological Society's education program, and funded by the National Science Foundation. Central to WES is an innovative paradigm in which the global water cycle is a vehicle to explore Earth system science with special emphasis on (1) the flow of water mass and energy, (2) interactions among the hydrosphere, cryosphere, atmosphere, lithosphere, and biosphere, and (3) human/societal impacts on and responses to those interactions. WES is aligned with the goals of the *National Science Education Standards*. And the design of WES course components (i.e., investigations, homepage, customized text) models a science content-rich and highly motivational teacher enhancement experience.

The initial year of WES operation (1999-2000) was devoted to developing and critically reviewing course components and selecting and training 35 Local Implementation Team (LIT) leaders. WES LIT leaders (and many members) were formed from a cadre of teachers who had participated in Project ATMOSPHERE, DataStreme Atmosphere, or the Maury Project. These master teachers from around the nation attended three summer workshops (Annapolis, MD in 2000, Madison, WI in 2001, and State College, PA in 2002) where they received instruction on selected concepts in meteorology, oceanography, and hydrology. Pilot offering of WES took place in Spring 2001 with WES LIT members taking the course and providing ongoing constructive feedback on course components and operation. This feedback was the basis of course revisions made prior to national implementation in Fall of 2001.

Through the Fall of 2002, more than 900 teachers nationwide have successfully completed WES. The considerable feedback obtained from those teachers and WES LITs indicates that WES works and is achieving its stated objectives. Participant's written evaluations of the course are overwhelmingly positive. WES alumni exhibit significant growth in their understanding of water-related aspects of Earth system science, have gained valuable experience in working with online environmental data, and report meaningful applications of course resources in their classrooms and schools as they assume their roles as WES resource teachers.

SMITH, D. R., Associate Professor, Johnson, R.M., Henderson, S., Foster, S.Q., Mastie D.F., and Pennington, P.O., IV, "The NCAR Geosciences Education Workshop on Climate and Global Change: Enhancing Teachers' Perspectives of Earth System Science," *Preprints of the 12th American Meteorological Society (AMS) Symposium on Education,* Boston, MA, (2003) (CD-ROM).

Research on climate and global change is a major focus at the National Center for Atmospheric Research NCAR). Since this phenomenon has potential for major societal impacts, educators at all grade levels must gain a working knowledge of this important field of science. During the summer of 2002 NCAR, in partnership with the Office of Education and Outreach at the University Corporation for Atmospheric Research (UCAR) convened the first Climate and Global Change Geoscience Education Workshop. At a two week summer workshop, 20 middle and high school teachers representing 16 states were introduced to the basic geoscience content necessary to understand climate and global change by means of lectures from distinguished scientists, hands on exploration or related educational resources, and field experiences. The workshop focused on an Earth System science perspective, incorporating

aspects of all components of Earth and Space sciences, with particular emphasis on the interactions across the boundaries of the various subsystems and the importance of models in understanding the relationships.
The new workshop builds upon available educational resources developed for Project LEARN (Laboratory Experience in Atmospheric Research at NCAR), an NSF-funded teacher enhancement program. A significant component of LEARN involved climate and global change. Additional materials developed by the American Meteorological Society (AMS), including Project Atmosphere and Project Maury encompassing meteorology, oceanography, and ground water hydrology, and the STELLA software created a foundation for the workshop.

Book Reviews

GUTH Peter L., 2001, review of Ferdinand V. Hayden: Entrepreneur of Science by James G. Cassidy: History of Earth Sciences Journal, Vol. 20, no. 2, pp. 196-197, July 2002.

Cassidy's book tells how one man molded the culture of science in Washington and the West during the decade of the 1870's. For the first time since the Coast Survey, Hayden got the federal government to fund a continuous survey. The book is well researched, well put together, and I can quibble with only one fact—Wheeler graduated from West Point in 1866, and not 1868 as stated on page 30. This book is required reading for anyone interested in the Great Surveys of the American West, or the development of science as a career and profession. The tale of the first career in federal geology makes interesting reading following the aborted "Contract with America" that sought to abolish the USGS in the 1990s and lead to a massive reduction in force of its geologic division.

DVD Publication

GUTH, Peter L., Professor, "MICRODEM Blue Marble Viewer: VIRTAS: Virtual Terrain Applications System," DVD2-2002, Standards, Applications, Technology Conference and Exhibition, National Institute of Standards and Technology (NIST),Gaithersburg, MD, 3-4 June 2002.

This DVD contains the GLOBE digital global topography, and the NASA Blue Marble global satellite imagery. Both have approximately 1 km grid spacings, and have been tiled for easy access to any area of th world. The Blue Marble has also been compressed to about one seventh size, with no apparent loss in quality because the ocean areas, 70% of the earth's surface, compress so well. The viewer opens the imagery and elevation data for any desired area, and allows 3D viewing and interactive fly-throughs.

Presentations

GUTH, Peter L., Professor, "Ambush Movies and the Weapons Fan Algorithm: Military GIS Operations and Theory," International Conference on Military Geology and Geography, West Point, NY, June 2003.

GUTH, Peter L., Professor, "The Wheeler Survey and Theoretical Tectonics: the Basin and Range," Geological Society of America National Meeting, Denver, CO, November 2002.

MEIER, Walter N., Adjunct Assistant Professor, Andersen, S., and BASTAR, N., Midshipman 1/C (USN), "Evaluation of SSM/I-derived Sea Ice Concentrations with AVHRR Imagery," 2002 International Geoscience and Remote Sensing Symposium, 24-28 June 2002, Toronto, Ontario.

MEIER, Walter N., Assistant Professor and VERMEYCHUK, T., Midshipman 1/C (USN), "Sea Ice Motion Products from Microwave Imagery," American Meteorological Society 7th Conference on Polar Meteorology and Oceanography, 12-16 May 2003, Hyannis, MA.

MEIER, Walter N., Assistant Professor and Arbetter, T.E., "Assimilation of Observed Ice Motions in a 2-dimensional Sea Ice Model," American Meteorological Society 7th Conference on Polar Meteorology and Oceanography, 12-16 May 2003, Hyannis, MA.

MEIER, Walter N., Assistant Professor, Arbetter, T.E., and Takeuchi, C., "An Investigation of Anomalously Low Arctic Sea Ice Extent Using Assimilated Sea Ice Motion," American Meteorological Society 7th Conference on Polar Meteorology and Oceanography, 12-16 May 2003, Hyannis, MA.

NATUNEWICZ, Cecily C., Assistant Professor and Hare, J., "The Effect of El Nino on Transport of Winter-spawned Fish Larvae," ASLO Spring Meeting, February 2003, Salt Lake City, UT.

NATUNEWICZ, Cecily C., Assistant Professor, "Physical Factors Driving Larval Transport in Coastal Waters: Case Studies of Fish and Crabs," University of Maryland, Chesapeake Biological Laboratory, Solomons Island, MD, February, 2003. (Invited lecture)

SIKORA, Todd D., Associate Professor, Foster, R., and Wyant, M., "Critical Examination of a Method for Estimating the Buoyancy Flux from SAR Imagery," Twelfth Conference on Interactions of the Sea and Atmosphere, American Meteorological Society, Long Beach, CA, 9-13 February 2003.

SIKORA, Todd D., Associate Professor, and Young, G. S., "Mesoscale Stratocumulus Bands Caused by Gulf Stream Meanders," Twelfth Conference on Satellite Meteorology and Oceanography, American Meteorological Society, Long Beach, CA, 9-13 February 2003.

SIKORA, Todd D., Associate Professor and Young G.S., "Wind-direction Dependence of Quasi-2D SAR Signatures," International Geoscience and Remote Sensing Symposium, Institute of Electrical and Electronics Engineers (IEEE), Toronto, CA, 24-28 June 2002.

SMITH, David R., Associate Professor and HONNETTE, H.L., Midshipman 1/C (USN), "A Comparison of the Weather in U.S. Cities During the 1983-84 and 1998-99 La Niña's," 14th American Meteorological Society (AMS) Symposium on Global Change and Climate Variations, February 2003, Long Beach CA.

SMITH, David R., Associate Professor and KENNEDY, C.K., Midshipman 1/C (USN), "ENSO-based Forecasting of Seasonal Tropical Cyclones Trends from Historical Analysis of Genesis and OLR Oscillations," 19th Conference on Weather Analysis and Forecasting and the 15th Conference on Numerical Weather Prediction (joint conferences), August 2003, San Antonio, TX.

VIEIRA, Mário E.C., Associate Professor, "What is an Estuary?", US Coast Guard Auxiliary, Magothy River Flotilla, Arnold, MD, 20 February 2003.