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 2001-2002 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 15 refereed articles for publication and made 6 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 fourteenth annual Oceanography Summer Yard Patrol (YP) Cruise aboard YP686 was conducted in June 2002. The cruise instructed 23 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 fourth consecutive annual summer cruise where research-quality data was acquired for use by faculty to support publishable research.

In July 2001, the department hosted the eighth Maury Project Summer Workshop for twenty-four K-12 science teachers from the nation and overseas. 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, 98 or NT operating system, and uses standard terrain data from the National Imagery and Mapping Agency. The program provide 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. There were over 54,000 downloads of the program from the Naval Academy 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. There is no software that can display Geosym, making an honest evaluation of the standard impossible. This project will produce stand alone program to evaluate Geosym, as well as incorporate the display into TerraBase II. As a result of this effort, the Army officially notified NIMA that further work was needed before the prototype Geosym symbology could be adapted.

Investigation of the Assimilation of Ice Motion Data in Sea Ice Models

Researchers: Adjunct Assistant Professor Walter N. Meier
Commander, Naval Meteorology and Oceanography Command Research Chair
with T. Arbetter, University of Colorado
Sponsor: National Aeronautical and Space Administration (NASA)

The accuracy of sea ice models is constrained by the complexity of the model physics and the accuracy of the forcing. This limits the usefulness of important model outputs such as ice extent and ice thickness, both for operational forecasting and climate studies. Model improvements still must deal with these fundamental constraints. Data assimilation provides a methodology to investigate model shortcomings, reduce model biases and improve model spatial and temporal response. This project investigated the following issues targeted at assimilation of ice motion data in sea ice models:

- assess the time/space resolution of sea ice motion data needed in assimilation for accurate sea ice simulations
- assess the utility of the assimilation model in providing a synthesized and more accurate ice motion product
- investigate the impact of assimilation of sea ice motion data on improvements to model simulation of sea ice thickness
- assess the tradeoffs in efficiency of time/space resolution of the assimilation data, the sophistication of the sea ice model used in the assimilation, and the sophistication of the data assimilation scheme in developing an efficient simulation model.
- investigate strategies to use assimilation of sea ice motion data to target deficiencies in parameterizations of sea ice motion and concentration/extent and ice thickness distribution

The target model for this study was the MultICE model developed at the University of Colorado, which is configured for a variety of different sea ice rheologies and consistent treatments of the ice thickness distribution. This project took advantage of a variety of sea ice motion products, including surface pressure buoys, Pathfinder products that use AVHRR and SSM/I data, and RGPS products. In this study, we assessed the costs versus benefits of combining four types of data assimilation methods with four types of ice dynamics models. Factors such as accuracy with respect to observations and computational cost and efficiency were considered. We also considered the impact on datasets of sea ice properties directly observable via remote sensing (ice motion, ice extent) as well as derived properties (ice thickness, mass transport).

The Maury Project - Exploring the Physical Foundations of Oceanography

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

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 were brought to Madison, WI 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 is 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 exists. 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. We therefore propose to validate and refine the SAR flux/speed algorithm extensively against buoy data, 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 focuses 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 Nino. Turbulence data taken during the cruises provide eddy correlation fluxes for comparison to those derived from SAR. As well, wind speed from the ship is compared to non-neutral wind speed obtained from SAR. This work has two central goals. First, it improves algorithms that ultimately make high-resolution surface fluxes and wind speeds available to the climate research community. Second, it addresses 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 are estimated. Fluxes throughout the estuary are computed for the following parameters: chlorophyll, bacteria, planktonic viruses, nutrients, ammonia. The analysis of the results revealed areas of the estuary that function as sources and sinks of these parameters.

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Independent Research

Sensitivity of a Navy Regional Ocean Model to Nested High-Resolution Atmospheric Model and Scatterometer Wind Forcing

Researcher: Commander Henry Jones, USN

The Navy's Pacific West Coast (PWC) ocean circulation model is a sigma coordinate, Princeton Ocean Model (POM) configured for the Eastern Pacific Ocean between 30°N and 49°N. A series of experiments, each one of a 14-day duration, were performed to evaluate the sensitivity of the ocean model to Couple Ocean Atmospheric Model Prediction System (COAMPS) low *vs* high resolution grid wind forcing and scatterometer data insertion. The initial experiments showed that the sensitivity of the ocean variability in the model to the choice of COAMPS grid resolution is significant.

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

Researchers: Adjunct Assistant Professor Walter N. Meier
Commander, Naval Meteorology and Oceanography Command Research Chair
and Søren Andersen, Danish Meteorological Institute

Sea ice concentration fields from several different passive microwave algorithms are compared with Advanced Very High Resolution Radiometer (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 National Aeronautical and Space Administration (NASA) Team 2 algorithm appears to perform the best, with a lower bias and lower Root Mean Square (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 Special Sensor Microwave Imagery (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.

Operational Case-Study Comparisons of SSM/I-Derived Sea Ice Concentrations from the National Ice Center

Researchers: Adjunct Assistant Professor Walter N. Meier
Commander, Naval Meteorology and Oceanography Command Research Chair
and Paul McKenna and Michael L. Van Woert, National Ice Center (NIC)

The National Ice Center (NIC) routinely provides weekly global sea ice analyses, daily analyzed and forecasted ice edge products, and tailored high-resolution satellite imagery in support of various U. S. Government agency requirements. Heavy reliance is placed on visible and infrared imagery from the civilian and defense meteorological satellites; however, in areas of persistent cloud cover the NIC takes advantage of passive microwave satellite data to fill these gaps. Currently the NIC analysts use the NIC Hybrid sea ice algorithm in the Northern Hemisphere and the Bootstrap sea ice algorithm in the Southern Hemisphere to complete their products. This particular choice of algorithms was initially based on the personal preference of

individual analysts, and was then perpetuated through ongoing training programs. No rigorous assessment of the merit of each algorithm was undertaken. In July 2001 the NIC began an ongoing evaluation of the National Aeronautical and Space Administration (NASA) Team, Bootstrap, NIC Hybrid, and NASA Team II sea ice algorithms. The evaluation was performed by comparing available, time-coincident, visible and infrared satellite imagery with the Special Sensor Microwave Imagery (SSM/I) products. To date, 13 cases have been collected and analyzed. The NASA Team II provides the consistently best estimate of the ice edge and the 90% concentration boundary. This paper discusses the study undertaken by the NIC and presents select case studies to illustrate the performance characteristics of the various algorithms.

Evaluation of SSM/I-Derived Sea Ice Motions

Researchers: Adjunct Assistant Professor Walter N. Meier
Commander, Naval Meteorology and Oceanography Command Research Chair
and Kyle Dedrick and LCDR Doug Lamb, USNR, National Ice Center (NIC)

An operational sea ice motion product from Special Sensor Microwave Imagery (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 Advanced Very High Resolution Radiometer (AVHRR) visible and infrared imagery, *in situ* buoy observations, and model fields.

Assimilation of Sea Ice Motions in an Operational Sea Ice Forecast Model

Researchers: Adjunct Assistant Professor Walter N. Meier
Commander, Naval Meteorology and Oceanography Command Research Chair
and Donald Stark, Naval Postgraduate School (NPS)

Current sea ice forecast models are limited by the complexity of the model physics and the accuracy of initial conditions and atmospheric and ocean forcing fields. These limitations reduce the accuracy of forecasts and the usability of such forecasts by sea ice analysts and customers (submarines, surface ships, etc.). A new sea ice forecast is being developed at the Naval Postgraduate School. To improve initialization fields, data assimilation techniques are being developed. Sea ice motions derived from Special Sensor Microwave Imagery (SSM/I) 85 GHz imagery are input into the model via an optimal interpolation method to constrain the model to observations.

This research provided information about sea ice motion using satellite-measured information (SSM/I85) as input for a numerical model used to generate sea ice predictions. From the results obtained, a technique that enables the model to utilize the SSM/I data input is being developed.

Comparison of Passive Microwave and Scatterometer Sea Ice Motion Fields

Researchers: Adjunct Assistant Professor Walter N. Meier
Commander, Naval Meteorology and Oceanography Command Research Chair
and Jørg Haarpainter, National Ice Center (NIC)

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 Special Sensor Microwave Imagery (SSM/I) 85 GHz passive microwave imagery were 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) is 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 is used to run the statistics. Preliminary results suggest the magnitude of larval ingress is correlated with the SOI. Specifically, Atlantic croaker (*Micropogonias undulatus*) larvae show higher ingress during El Niño years, while spot (*Leiostomus xanthurus*), Atlantic menhaden (*Brevoortia tyrannus*), and pinfish (*Lagadon rhomboides*) larvae show higher ingress during La Niña years. Additionally, the data suggest that timing of ingress is related to phase of the ENSO cycle. The project is a continuation of my post-doctoral research sponsored by the National Research Council from November 2000-November 2001.

Gravity Waves can Directly Influence 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 Johns 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, and 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
and Nathaniel S. Winstead and Steven M. Babin
(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 (AVHRR) 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.

Research Course Projects

Using Pathfinder Satellite-Derived SSTs to Represent *in situ* Data: Comparisons on the Florida Keys, Bahamas, and Great Barrier Reef

Researcher: Midshipman 2/C Jonathan Shannon, USN
Advisers: Adjunct Assistant Professor Walter Meier
Commander, Naval Meteorology and Oceanography Command Research Chair
with Marguerite Toscano and Kenneth S. Casey,
National Oceanic and Atmospheric Administration (NOAA)

In 1998, mass bleaching and mortality of coral reefs worldwide, related to anomalously high sea temperatures, highlighted the necessity of monitoring and understanding the effects of oceanic temperature changes on coral reefs and whether these changes are indicators of global climate change. The NOAA/NASA Advanced Very High Resolution Radiometer (AVHRR) Oceans Pathfinder program has collected and calibrated 17 years (1985-2001) of global satellite sea surface temperature (SST) data. Comparison of Pathfinder data to *in situ* data from three locations has shown how biases differ with geography and oceanography, time of satellite retrieval, and time of year. Day/Night satellite returns possessed the greatest correlation and least bias. Each region showed their own biases that were factors of oceanography, climate, and other factors. To substitute Pathfinder SST data for *in situ* data, scientists need to recognize these factors and take them into account.

An Analysis of Columbian Coca Cultivation Via Remote Sensing

Researcher: Midshipman 2/C Robert D. Holt, USN
Adviser: Adjunct Assistant Professor Walter N. Meier
Commander, Naval Meteorology and Oceanography Command Research Chair

Cocaine trafficking from Colombia is an issue that the United States military and drug-enforcement agencies deal with daily. They have had moderate success in reducing the supply of raw coca in the past; however, production-monitoring techniques must be modernized in order to combat the increasingly sophisticated cultivation methods of 21st century cartels. Satellite remote sensing provides the means to improve these techniques. Four conditions: radiance lambda, cost, periodicity, and resolution are essential in assessing the usefulness of a particular satellite to the crop-monitoring project. The best spectral band for distinguishing coca from other vegetation was near IR. A survey of satellites meeting those criteria was conducted, with the ETM+ of LANDSAT-7 and the SPOT-4 multispectral sensor outperforming a host of others. Acquiring an image of a known coca field from coordinates given to the satellite company was not accomplished, resulting in the incompleteness of that phase. The various satellites were analyzed using pre-existing and experimental algorithms to provide the best possible accuracy of the field. Finally, the transfer of the database and image into a GIS format that the law enforcement agencies can utilize is discussed in depth. This was done to improve the current techniques of mapping and analyzing the cultivation of coca in Colombia. Integrating the improved satellite imagery into a GIS database will increase the accessibility and the ease of analysis of the data collected by the satellites.

An Evaluation of the Validity of an Automated Sea Ice Classification System for Interpreting SAR Imagery

Researcher: Midshipman 2/C Sarah L. Heidt, USN
Adviser: Adjunct Assistant Professor Walter N. Meier
Commander, Naval Meteorology and Oceanography Command Research Chair

ARKTOS (Advanced Reasoning using Knowledge for Typing Of Sea ice) is a sea ice classification system that utilizes image processing and knowledge based rules to interpret RADARSAT SAR images, based on the Dempster Shafer Algorithm. The system was created by the University of Kansas and is currently undergoing evaluation by the National Ice Center (NIC) and the Naval Research Laboratory (NRL). The evaluation uses NIC charts, manually produced by ice analysts, as comparative data to determine the accuracy of ARKTOS products. Although the initial attempt at making such a system, which can classify, open water, new ice, first year ice, and multiyear ice is impressive, there is still much to be done before ARKTOS can become operational. This evaluation, although preliminary, indicates that there are many errors in the ARKTOS classification scheme and that the proficiency of ARKTOS appears to be limited in most circumstances. Careful modification of its knowledge-based rules may be required on a case-by-case basis in order to improve concurrence between ARKTOS and NIC analyses.

A Comparison of Passive Microwave Algorithms for Sea Ice Concentration

Researcher: Midshipman 2/C Nathan Bastar, USN
Adviser: Adjunct Assistant Professor Walter N. Meier
Commander, Naval Meteorology and Oceanography Command Research Chair

Accurate measurement of sea ice concentration is important for shipping and maritime travel in the Arctic and Antarctic Oceans. Also, having a long-term record of sea ice concentration can aid scientists who study climate change and it's effect on sea ice concentration. Passive microwave imagery from the DMSP SSM/I sensor is the preferred method to study sea ice concentration because passive microwaves can be detected through clouds and most weather conditions. The brightness temperatures obtained from different microwave frequencies are incorporated into an algorithm that determines the concentrations. In this study six different algorithms - Bristol, Bootstrap, Cal/Val, NASA Team 2, NIC Hybrid and NASA Team - are compared with AVHRR imagery from June to early July 2001 and late December through January 2002. These data were taken over 3 different regions: the East Greenland Sea, the Barents Sea and Baffin Bay. This study found that there are differences in the performance of the different algorithms at the different times of year and in the different seasons. The NASA Team and Bootstrap algorithms consistently produced the results with the smallest errors. The Bristol works well in the winter and the NASA Team 2 works well in the summer.

A Comparison of the Weather in U.S. Cities During the 1982-83 and 1997-98 El Niño Events

Researcher: Midshipman 1/C Heather L. Honnette, USN
Adviser: Associate Professor David R. Smith

The El Niño phenomenon 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 patterns. In this study, the temperature and precipitation observations for the winter months, December through March, are examined for fourteen cities across the United States. This study will explore the effects of the 1982-'83 and 1997-'98 El Niño's on these fourteen cities to determine the impact of El Nino on temperature and precipitation patterns across the nation. Monthly averages for each of the cities will be compared with the data from these two major El Niño events as well as with each event's respective 30-year normals. This comparison and analysis will help determine the relative strength of these El Niño events and the magnitude of change they induced on normal weather conditions throughout the country.

A Comparison of the Stedman's Heat Index and the WBGT Heat Index

Researcher**:** Midshipman1/C Steven D. Hacker, USN
Adviser**:** Associate Professor David R. Smith

Human comfort level is measured in terms of environmental factors. Temperature, humidity, wind, and radiant energy all contribute to how the body feels and responds. Excess heat and moisture can result in physiological stress, perhaps thermal exhaustion or even death. There are several indices that quantify human comfort levels, relating environmental factors to physiological response. Most involve empirical algorithms that are functions of various environmental parameters. The Stedman's Heat Index is one of the more common comfort indices that is a function of temperature and relative humidity. The National Weather Service, among other organizations, routinely report values of the Stedman's Heat Index as guidance for stressful situations. Another index, the Wet Bulb Globe Temperature (WBGT) is used by the military to measure environmental factors and then determine an appropriate level of physical training.

This study focused on developing an algorithm to transform from the Wet Bulb Globe Temperature (WBGT) Index to the Stedman's Heat Index. While WBGT may be relatively easy to determine using a simple instrument that measures ambient, wet-bulb, and a radiant temperature which are combined to yield the index, it is somewhat labor intensive. An automated system currently in place at the United States Naval Academy provides up-to-date Steadman Heat Index values available on the web. The purpose of this month long study was to provide the a database to make the transformation between the two indices and apply the same (or closely similar) criteria for physical exertion.

A Comparison of the Weather in U.S. Cities During the 1983-'84 and 1998-'99 La Niña Events

Researcher: Midshipman1/C Heather L. Honnette, USN
Adviser: Associate Professor David R. Smith

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.

ENSO-Based Forecasting of Seasonal Tropical Cyclone Trends from Historical Analyses of Genesis and OLR Oscillations

Researcher: Midshipman1/C Colin R. Kennedy, USN
Adviser: Associate Professor David R. Smith

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, a well-known means of approximating 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 and then the seasonal OLR trends are analyzed to see if they behave in a similar manner in accordance with the seasonal ENSO index value.

Nonlinear Acoustic Techniques for Landmine Detection

Researcher: Midshipman1/C Mathias Roth, USN
Advisers: Associate Professor David R. Smith,
Professor Murray S. Korman (USNA Physics Department),
and Dr. James Sabatier, National Center for Physical Acoustics, University of Mississippi

A nonlinear acoustic technique for detecting buried landmines has been suggested by Donskoy [SPIE *Proceedings,* Vol. 3392, 211 (1998), Vol. 3710, 239 (1999)]. Airborne sound at two primary frequencies f1 and f2 undergo acoustic-to-seismic coupling and a superimposed "slow" compressional wave interacts with the compliant mine and soil. The nonlinear mechanism involves a simple model of the top surface of the mine-soil planar surface separating two elastic surfaces. During the compression phase of the wave, the surfaces stay together and then separate under the tensile phase due to a relatively high compliance of the mine. This "bouncing" soil-mine interface is thought to be a bi-modular oscillator that is inherently nonlinear.

An apparatus called the soil-mine oscillator has been built which involves a layer of soil in a large tube, terminated by a thin elastic plate. This apparatus is used to model the bi-modular nonlinearity of a buried landmine. The amplitude dependent frequency response curves of the acceleration at the center of the elastic plate will be measured using an accelerometer for two cases: (1) a single primary source is swept in frequency near resonance or (2) a response curve near the difference frequency will be measured when two primary frequencies are used. An acoustic impedance measurement taken on the underside of the plate will be used to identify the effects of the bi-modular nonlinearity. In order to understand the soil/mine oscillator a variety of linear acoustic measurements have been made at particular resonances of the system under conditions of different amounts of soil loading.

Air-Sea Fluxes from Satellite SAR Imagery

Researcher: Midshipman 1/C Matthew Burich, USN
Adviser: Assistant Professor Todd D. Sikora

Air-sea buoyancy flux (B) has important implications on atmospheric stability over the oceans and is an important factor in the growth or decay of large-scale storm systems. Traditional methods of determining B through in situ buoy data are insufficient to be employed operationally due to a lack of instrumentation. Research has shown, however, that B can be estimated from synthetic aperture radar (SAR) generated wind images. For the present research, 53 cases are considered employing SAR imagery off the United States East Coast over areas where data buoys are present. Values for B are derived from the SAR imagery through the use of a SAR algorithm and then compared to B values computed from the in situ buoy data via the TOGA COARE algorithm. The resultant values for B differ by several orders of magnitude. The frictional velocity (u*, a quantity required for the calculation of B) calculated using the TOGA COARE and SAR algorithms closely match. One possible reason for the error in B may be that the SAR images do not have the proper resolution. This could, in turn, lead to inaccurate determination of the variance of wind speed that feeds into the series of equations used to determine B. Future research may be able to minimize the effects of such error and provide a consistently accurate way to assess B for all possible environmental conditions.

Multi-Year Observations of Cloud Lines Associated with the Chesapeake and Delaware Bays

Researcher: Midshipman 1/C David M. Halverson, USN
Adviser: Assistant Professor Todd D. Sikora

Satellite and corresponding near-surface in situ observations have been made of single and dual-band cloud events (dubbed anomalous cloud lines or ACLs) associated with the Chesapeake and Delaware Bays. A previous study developed the basis for two hypotheses concerning the mechanism responsible for ACLs. One explanation is that ACLs are forced in the same manner as Great Lakes lake-effect midlake cloud lines. An alternate explanation is that at least some ACLs are a special type of ship track that forms in statically unstable marine boundary layers. The time period examined in the present research is January 1997 to December 2000. National Oceanic and Atmospheric Administration (NOAA) Advanced Very High Resolution Radiometer imagery served as the satellite data set while NOAA buoy 44009 and Coastal-Marine Automated Network station CHLV2 provided the *in situ* data. Our findings from the satellite portion of this research show that ACLs associated with both the Chesapeake and Delaware Bays were observed on roughly 3% of the days examined and were more frequent during the onset of the cold season. The data also show that single-band ACLs were, in general, more frequent than dual-band ACLs. Turning to the near-surface *in situ* portion of this research, the average ACL for both bays was associated with a negative air-sea temperature difference and a larger down-bay wind component than cross-bay wind component. On a month-by-month basis, both bays' ACLs tended to be associated with abnormally large down-bay wind speeds and negative air-sea temperature differences compared to the corresponding weighted monthly norms.

Publications

Journal (Refereed) Manuscripts

GUTH, Peter L., Professor, "Quantifying Terrain Fabric in Digital Elevation Models," in Ehlen, J., and Harmon, R.S., (eds.), The Environmental Legacy of Military Operations, *Geological Society of America Reviews in Engineering Geology*, Vol. 14, pp.13-25 (2001).

Eigenvector vector analysis of the topographic landform reveals a directional fabric consisting of surface roughness or slope, organization or fabric strength, and preferred orientation. This analysis uses a digital elevation model (DEM) to compute slope and aspect at all points in a region, and uses those values to define the surface normal. Standard techniques contour the distributions, extract eigenvectors and eigenvalues from the matrix of the sum of cross products of the directional cosines, and compute eigen value ratios. The terrain fabric at a point depends on the size of the region used for the computation, and reveals different scales over which directional fabrics operate. With large-scale DEMs, the directional fabric varies in a systematic manner and proves relatively insensitive to the horizontal resolution of the DEM or its quality and creation method. Quantitative measurement of terrain fabric belongs in all studies of terrain analysis and geomorphometry.

GUTH, Peter L., Professor and Johnson, M.C., "Using GPS to Teach More Than Accurate Positions," *Journal of Geoscience Education*, Vol.50, No.2, pp. 241-246 (2001).

Undergraduate science majors need practice in critical thinking, quantitative analysis, and judging whether their calculated answers are physically reasonable. We have developed exercises using handheld GPS receivers that expose students to this recent technology and promote larger goals that transcend the simple use of a tool for precision location. Using the GPS to calculate the volume of sand in the dunes at Great Sand Dunes National Monument in Colorado requires traversing the dunes, plotting a topographic profile, calculating the volume of sand traversed, and then extrapolating to estimate the volume in the entire dune field. This exercise serves to reinforce students' abilities to think quantitatively, to make realistic "back of the envelope" assumptions, and to

determine whether their final answers make physical sense. Using the GPS to measure the running track at an outdoor track and field stadium requires students to gather data, import the data into Microsoft Excel, plot it and perform an error assessment. This exercise reinforces concepts from statistics, and allows students to estimate the precision of GPS measurements both quantitatively and qualitatively. Together these two exercises promote quantitative analysis in a geologic context.

MEIER, Walter N., Adjunct Assistant Professor and Maslanik, J.A., "Improved Sea Ice Parcel Trajectories in the Arctic Via Data Assimilation," *Mar. Pollution Bull.*, Vol. 42, No. 6, pp. 506-512 (2001).

An assimilated sea ice motion product is used to track ice parcels in several regions of the Arctic over time periods of one day to several weeks during 1992 and 1993. Motions simulated using a two-dimensional, dynamic-thermodynamic sea ice model are combined with motions derived from daily 85 GHz Special Sensor Microwave/Imager (SSM/I) imagery using an optimal interpolation method that minimizes error covariance. Assimilation attenuates the tracking error over the stand-alone model in comparison to buoy trajectories with the same starting location and time. The average fourteen-day assimilated trajectory's displacement error is as much as 34% lower than the model trajectory, while the RMS direction error is decreased by up to 10 degrees (24%). Assimilation can also yield an estimate of dispersion, which is not retrievable by point buoy observations. An assimilation approach improves estimates of ice drift and has the potential to further the understanding of ice mass flux, freshwater flux, and pollutant transport in the polar regions.

MEIER, Walter N., Adjunct Assistant Professor, Van Woert, M.L., Zou, C.Z., Beesely, J.A. and Hovey, P.D., "Satellite Validation of the May 2000 Sea Ice Concentration Fields From the Polar Ice Prediction System," *Can. J. Rem. Sensing*, Vol. 27, No. 5, pp. 443-456 (2001).

The National Ice Center relies upon a coupled ice/ocean model called the Polar Ice Prediction System (PIPS) to provide guidance for its 1-5 day sea ice forecasts. Here we present results on the forecast skill of the sea ice concentration (C) fields from this system for the highly variable month of May 2000. Consistent with previous work on weather model verification, we used the root mean square error, the anomaly correlation and the index of agreement to assess the forecast skill of the system. In all cases, the skill of the model was high (e.g., anomaly correlations >0.7) and, for times out to 72 hours, significantly better than persistence at the 95% confidence level. However, in spite of the overall high hemispheric forecast skill of PIPS, considerable spatial variability exists in the statistics. A threat index, patterned after methodologies developed for tornado forecasting, was also used to assess changes in ice concentration. Specifically, it was used to assess how well PIPS forecasts ice-free regions (C<0.15). Consistent with previous results, it was found that PIPS does better than persistence. It is suggested, but by no means demonstrated, that these forecast errors arise due to deficiencies in the meteorological fields used to force the ice/ocean model.

MEIER, Walter N., Adjunct Assistant Professor and Maslanik, J.A., "Synoptic-scale Ice Motion Case Studies Using Assimilated Motion Fields," *Ann. Glaciology*, Vol. 33, pp. 145-150 (2001).

Observed and modeled sea ice motions, combined via an optimal interpolation assimilation method, are used to study two synoptic events in the Arctic. The first is a convergence event along the north Alaska coast in the Beaufort Sea during November 1992. Assimilation indicates stronger convergence than the stand-alone model, in agreement with AVHRR-derived ice motions and SSM/I-derived ice concentrations. The second event pertains to ice formation and advection in Fram Strait and the Barents and Greenland, Iceland and Norwegian (GIN) seas. Assimilation indicates export of thick, less saline ice out of the central Arctic into the East Greenland Sea. However, the model indicates little flow through Fram Strait, instead showing strong flow of thin, more saline first-year ice from the Barents Sea westward into the Greenland Sea. These results indicate that assimilation is a useful tool for investigating synoptic events in the Arctic and may be useful both for climate studies and operational analyses.

MEIER, Walter N., Adjunct Assistant Professor, Van Woert, M.L., and Bertoia, C., "Evaluation of Operational SSM/I Ice-concentration Algorithms," *Ann. Glaciol.*, Vol. 33, pp. 102-108 (2001).

The United States National Ice Center (NIC) provides weekly ice analyses of the Arctic and Antarctic using information from ice reconnaissance, ship reports, and high-resolution satellite imagery. In cloud-covered areas and regions lacking imagery, the higher-resolution sources are augmented by ice concentrations derived from Defense Meteorological Satellite Program (DMSP) Special Sensor Microwave Imager (SSM/I) passive microwave imagery. However, the SSM/I-derived ice concentrations are limited by low resolution and uncertainties in thin ice regions. Ongoing research at NIC is attempting to improve the utility of these SSM/I products for operational sea ice analyses. The refinements of operational algorithms may also aid future scientific studies. Here we discuss an evaluation of the standard operational ice concentration algorithm, Cal/Val, with a possible alternative, a modified NASA Team algorithm. The modified algorithm compares favorably with Cal/Val and is a substantial improvement over the standard NASA Team algorithm in thin ice regions that are of particular interest to operational activities.

SIKORA, Todd, D., Assistant Professor, and Thompson, D. R., "Air-Sea Turbulence Statistics from Synthetic Aperture Radar: An Update," *Can. J. Remote Sens.*, Vol. 28, pp. 517-523.

A similarity theory-based method for calculating turbulence statistics from SAR-derived 10 m neutral wind speed image sub-scenes was tested. We concentrated on the method's ability to yield proper estimates of the ratio of reference height to Obukhov length (z/L) and kinematic buoyancy flux (B). The Tropical Ocean Global Atmosphere-Coupled Ocean Atmosphere Response Experiment bulk flux algorithm, fed with buoy and mooring data corresponding in space and time to a particular sub-scene, provided a comparison data set. Thirteen cases studies were examined covering a wide range of negative air-sea temperature difference and wind speed. The statistics from the SAR method that we report herein are averages from a 3-by-3 sub-scene grid centered on a particular *in situ* station for each case study. The correlation coefficient for z/L is 0.77 while that for B is 0.95. The value of z/L produced by the SAR method, averaged over all 13 case studies, is –0.15. The standard deviation of z/L from the SAR method, averaged over all 13 case studies, is 0.12. The corresponding values for B are 0.046 $ms^{-1}K$ (average) and 0.034 $ms^{-1}K$ (standard deviation). The mean difference and root mean square difference (COARE results – SAR results) for the z/L comparisons are –0.008 and 0.119 respectively, while the same statistics for the B comparisons are 0.030 $ms^{-1}K$ and 0.039 $ms^{-1}K$. Potential sources of error and avenues for future research are briefly discussed. D.

SIKORA, Todd, D., Assistant Professor and Halverson, D. M., Midshipman 1/C (USN), "Multi-Year Observations of Cloud Lines Associated with the Chesapeake and Delaware Bays," *J. Appl. Meteorol.*, Vol. 41, pp. 825-831.

Satellite and corresponding near-surface in situ observations have been made of single and dual-band cloud events (dubbed anomalous cloud lines or ACLs) associated with the Chesapeake and Delaware Bays. A previous study developed the basis for two hypotheses concerning the mechanism responsible for ACLs. One explanation is that ACLs are forced in the same manner as Great Lakes lake-effect midlake cloud lines. An alternate explanation is that at least some ACLs are a special type of ship track that forms in statically unstable marine boundary layers. The time period examined in the present research is January 1997 to December 2000. National Oceanic and Atmospheric Administration (NOAA) Advanced Very High Resolution Radiometer imagery served as the satellite data set while NOAA buoy 44009 and Coastal-Marine Automated Network station CHLV2 provided the *in situ* data. Our findings from the satellite portion of this research show that ACLs associated with both the Chesapeake and Delaware Bays were observed on roughly 3% of the days examined and were more frequent during the onset of the cold season. The data also show that single-band ACLs were, in general, more frequent than dual-band ACLs. Turning to the near-surface *in situ* portion of this research, the average ACL for both bays was associated with a negative air-sea temperature difference and a larger down-bay wind component than cross-bay wind component. On a month-by-month basis, both bays' ACLs tended to be associated with abnormally large down-bay wind speeds and negative air-sea temperature differences compared to the corresponding weighted monthly norms.

SIKORA, Todd D., Assistant Professor, Winstead, N.S., Thompson, D. R., and Mourad, P. D., "Direct Influence of Gravity Waves on Surface-Layer Stress During a Cold Air Outbreak, As Shown by Synthetic Aperture Radar," *Monthly Weather Review,* Vol. 130, pp.2764-2776 (2001).

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, and the detailed view of the fetch dependence of that stress.

WHITFORD, Dennis J., Captain (USN) and Professor, "Teaching Ocean Wave Forecasting Using Computer-generated Visualization and Animation: Part 1, Sea Forecasting," *Computers and Geosciences,* Vol. 28, pp. 537-546.

Ocean waves are the most recognized phenomena in oceanography. Unfortunately undergraduate study of ocean wave dynamics and forecasting involves mathematics and physics and therefore can pose difficulties with some students because of the subject's interrelated dependence on time and space. Verbal descriptions and two-dimensional illustrations are often insufficient for student comprehension. Computer-generated visualization and animation offer a visually intuitive and pedagogically sound medium from which to present geoscience, yet there are very few oceanographic examples. A two-part article series is offered to explain ocean wave forecasting using computer-generated visualization and animation. This paper, Part 1, addresses forecasting of sea wave conditions and serves as the basis for the more difficult topic of swell wave forecasting addressed in Part 2. Computer-aided visualization and animation, accompanied by oral explanation, are a welcome pedagogical supplement to more traditional methods of instruction.

In this article, several MATLAB® software programs have been written to visualize and animate development and comparison of wave spectra, wave interference, and forecasting of sea conditions. These programs also set the stage for the more advanced and difficult animation topics in Part 2. The programs are user-friendly, interactive, easy to modify, and developed as instructional tools. By using these software programs, teachers can enhance their instruction of these topics with colorful visualizations and animation without requiring an extensive background in computer programming.

WHITFORD, Dennis J., Captain (USN) and Professor, "Teaching Ocean Wave Forecasting Using Computer-generated Visualization and Animation: Part 2, Swell Forecasting," *Computers and Geosciences,* Vol. 28, 547-554.

This paper, the second of a two-part series, introduces undergraduate students to ocean wave forecasting using interactive computer-generated visualization and animation. Verbal descriptions and two-dimensional illustrations are often insufficient for student comprehension. Fortunately, the introduction of computers in the geosciences provides a tool for addressing this problem. Computer-generated visualization and animation, accompanied by oral explanation, have been shown to be a pedagogical improvement to more traditional methods of instruction. Cartographic science and other disciplines using geographical information systems have been especially aggressive in pioneering the use of visualization and animation, whereas oceanography has not. This paper will focus on the teaching of ocean swell wave forecasting, often considered a difficult oceanographic topic due to the mathematics and physics required, as well as its interdependence on time and space. Several MATLAB® software programs are described and offered to visualize and animate group speed, frequency dispersion, angular dispersion, propagation, and wave height forecasting of deep water ocean swell waves. Teachers may use these interactive visualizations and animations without requiring an extensive background in computer programming.

WHITFORD, Dennis J., Captain (USN) and Professor, "Predicting the Depth, Across-Channel Location, and Speed Variability of Tidal Current Core Maxima at the Mouth of the Chesapeake Bay," *Journal of Coastal Research*, Vol. 17 (2), pp. 420-430.

Reasonable prediction of the depth, across-channel location, and speed variability of tidal current core maxima at the mouth of the Chesapeake Bay can be determined to first order without an extensive deployment of current meters. Fourteen tidal current data sets were acquired with a shipboard Acoustic Doppler Current Profiler (ADCP) on track lines across the Bay mouth. Data sets were representative of fortnightly tidal range variation (spring, neap, and transitional), as well as semi-diurnal tidal current cycle phases (ebb, flood, and slack) for the months of June and September in four different years. Dataindicated tidal current maxima were contained within a narrow jet-like core with a horizontal scale of O(1-2 km) and vertical scale of O(10 m). The depth, across-channel location, and speed of the maxima varied with the semi-diurnal tidal current cycle phase, and to a much lesser extent, with the fortnightly variation of tidal range. This temporal variability is modeled by least squares using a sinusoidal function, related to the dominant tidal current harmonic constituent, and a third-degree polynomial curve fit. Prediction algorithms from both models result in correlation coefficients for depth(0.95), across-channel location (0.97), and speed (0.93). National Oceanic and Atmospheric Administration (NOAA) tidal current tables had a speed correlation coefficient of only 0.79 when matched to observations. Comparison correlation coefficients for depth and across-channel location from NOAA tidal current tables could not be determined since the tables do not provide this information. This method provides a first-order, empirical means for predicting the depth, across-channel location, and speed variability of tidal current core maxima under conditions of similar atmospheric forcing and freshwater input without long-term deployment of current meters at multiple depths and locations. The method is not site-specific. Therefore, it may be applied at other locations and could be especially beneficial to estuaries where there are no tidal current meters or published tidal current information.

Conference Proceedings

GUTH, Peter L., Professor, "Terrain Organization Calculated from Digital Elevation Models," in a special publication of the Geographic Information Systems Association, Ohmori, H., (ed.), DEMs and Geomorphometry, *Proceedings of the Symposia on New Concepts and Modeling in Geomorphology and Geomorphometry, DEMs and GIS*, Tokyo, Fifth International Conference on Geomorphology, Vol.1, pp. 70-71, 24-26 August 2001.

Terrain organization represents the tendency for ridges and valleys to be oriented in the same direction. Organization can be quantified by a cardinal direction, and a magnitude representing the degree of organization. Calculation of organization from Digital Elevation Models (DEMs) uses an eigenvector method to extracts the orientation of the ellipse defined by the orientations of the normals to each point in the DEM. For unorganized terrain, the normals define a circle, while increasing organization creates elliptical patterns. Organization depends on DEM scale and size of the region considered. Calculated organization proves remarkably insensitive to DEM scale or quality. Organization appears to be a quantifiable, key terrain descriptor.

SIKORA, Todd, D., Assistant Professor, and Thompson, D.R., "Air-Sea Fluxes from Synthetic Aperture Radar: An Update," *Preprints, Eleventh Conference on Satellite Meteorology and Oceanography*, American Meteorological Society, Madison, WI, pp. 35-38, 15-18 October 2001.

A similarity theory-based method for calculating turbulence statistics from SAR-derived 10 m neutral wind speed image sub-scenes was tested. We concentrated on the method's ability to yield proper estimates of the ratio of reference height to Obukhov length (z/L) and kinematic buoyancy flux (β). The Tropical Ocean Global Atmosphere-Coupled Ocean Atmosphere Response Experiment bulk flux algorithm, fed with buoy and mooring data corresponding in space and time to a particular sub-scene, provided a comparison data set. Thirteen cases studies were examined covering a wide range of negative air-sea temperature difference and wind speed. The statistics from the SAR method that we report herein are averages from a 3-by-3 sub-scene grid centered on a particular *in situ* station for each case study. The correlation coefficient for z/L is 0.77 while that for β is 0.95.The

value of z / L produced by the SAR method, averaged over all 13 case studies, is –0.15. The standard deviation of z / L from the SAR method, averaged over all 13 case studies, is 0.12. The corresponding values for β are 0.046 $ms^{-1}K$ (average) and 0.034 $ms^{-1}K$ (standard deviation). The mean difference and root mean square difference (COARE results – SAR results) for the z / L comparisons are –0.008 and 0.119 respectively, while the same statistics for the β comparisons are 0.030 $ms^{-1}K$ and 0.039 $ms^{-1}K$. Potential sources of error and avenues for future research are briefly discussed.

SMITH, D.R., Associate Professor, and Hacker, S.D., Midshipman 1/C, (USN), "A Comparison of the Stedman's Heat Index and the WBGT Index," *Preprints of the 3rd AMS Symposium on Environmental Applications*, American Meteorological Society, Boston, MA, pp. 127-130.

Human comfort level is measured in terms of environmental factors. Temperature, humidity, wind, and radiant energy all contribute to how the body feels and responds. Excess heat and moisture can result in physiological stress, perhaps thermal exhaustion or even death. There are several indices that quantify human comfort levels, relating environmental factors to physiological response. Most involve empirical algorithms that are functions of various environmental parameters. The Stedman's Heat Index is one of the more common comfort indices that is a function of temperature and relative humidity. The National Weather Service, among other organizations, routinely report values of the Stedman's Heat Index as guidance for stressful situations. Another index, the Wet Bulb Globe Temperature (WBGT) is used by the military to measure environmental factors and then determine an appropriate level of physical training.

This study focused on developing an algorithm to transform from the Wet Bulb Globe Temperature (WBGT) Index to the Stedman's Heat Index. While WBGT may be relatively easy to determine using a simple instrument that measures ambient, wet-bulb, and a radiant temperature which are combined to yield the index, it is somewhat labor intensive. An automated system currently in place at the United States Naval Academy provides up-to-date Steadman Heat Index values available on the web. This month long study provided a database to make the transformation between the two indices and apply the same (or closely similar) criteria for physical exertion.

SMITH, D.R., Associate Professor and Honnette, H.L., Midshipman 1/C, (USN), "A Comparison of the Weather in U.S. Cities During the 1982-83 and 1997-98 El Niño's," *Preprints of the 13th AMS Symposium on Global Change and Climate Variations*, American Meteorological Society, Boston, MA, pp.117-118.

The El Niño phenomenon 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 patterns. In this study, the temperature and precipitation observations for the winter months, December through March, are examined for fourteen cities across the United States. This study will explore the effects of the 1982-'83 and 1997-'98 El Niño's on these fourteen cities to determine the impact of El Nino on temperature and precipitation patterns across the nation. Monthly averages for each of the cities will be compared with the data from these two major El Niño events as well as with each event's respective 30-year normals. This comparison and analysis helped determine the relative strength of these El Niño events and the magnitude of change they induced on normal weather conditions throughout the country.

SMITH, D.R., Associate Professor, Geer, I.W., Moran, J.R and Weinbeck, R.S., "Water in the Earth System (WES): Moving Toward National Implementation," *Preprints of the 11th AMS Symposium on Education*, American Meteorological Society, Boston, MA, pp. 77-80 (2002).

Water in the Earth System(WES) was instituted in 1999 as a web-based distance-learning course directed toward precollege teachers This program, funded by the National Science Foundation, examines water and global water cycle processes from an Earth System Science perspective. It utilizes an inquiry-based methodology consistent with the goals of the National Science Education Standards.

During the first year (2000), WES activities consisted of material development and the initial training session for WES local implementation team (LIT) leaders. The primary resource was a twelve chapter textbook and a study

guide covering a variety of topics on water in the Earth system. The WES study guide contains the first part of each week's learning activity, while the second part is delivered in near-real time via the course homepage. A key component of the WES instructional concept is the LIT, a team of teachers and scientists who serve as mentors for those enrolled in the WES course. Thirty-five LITs have been established across the country to facilitate national implementation.

This past year there were four primary activities. First, the WES homepage was developed. This homepage provides an essential vehicle for delivery of WES instructional material, including activities and ancillary resources. Second. WES was pilot tested on the 35 LITs as a mechanism to have the LIT members examine the WES coursework and recommend changes. Third, the materials were field tested and modified based on the suggestions of the participants in the pilot test.

In September 2001, WES began its fourth activity - national implementation. WES was offered to approximately 250 teachers each semester for the last three years. These teachers in turn assisted their colleagues and students with valuable instructional materials on water in the Earth system. The impact of the activities during the first year was to provide the necessary foundation which will enable the program to accomplish its long-term goals.

SMITH, D.R., Associate Professor, Geer, I.W. and McManus, D.E., "The Maury Project: A Partnership to Promote Educational Outreach on the Physical Foundations of Oceanography," *Preprints of the 11th AMS Symposium on Education*, American Meteorological Society, Boston, MA, pp.105-108 (2002).

In 1994, the American Meteorological Society in conjunction with the United States Naval Academy initiated the Maury Project. This unique partnership provides a teacher enhancement program that focuses on the physical foundations of oceanography. In its eight-year tenure, over 200 educators from kindergarten through university levels have attended one of its two-week summer workshops at the U.S. Naval Academy. This paper summarizes how the Maury Project promotes the study of the ocean environment.

The unique feature of the Maury Project is its focus on physical processes. Most teacher enhancement programs in oceanography have a strong biological component. Teachers who attend the Maury Project summer workshops are provided with a learning experience that enables them to understand the structure and dynamics of the oceans and methods for determining its physical properties. They learn about the agencies that are involved with oceanic research and operational activity and why the oceans are important to these agencies. In addition, resource materials in the form of modules are provided to the workshop participants so they can conduct workshops for their peers. These peer-training sessions have been a highly effective mechanism to distribute instructional materials to teachers both nationally and internationally. Modules include such topics as density-driven circulation systems, shallow ocean water waves, ocean sound and El Niño. To date, approximately 1200 Maury peer-training sessions have reached over 20,000 teachers both nationally and internationally.

This presentation examined the partnership comprised of a professional society, a university, scientific and operational agencies working as colleagues with the precollege educational structure. The Maury Project provides an excellent model for enhancing the study of the ocean environments, with an emphasis on the physical properties and processes of the world=s oceans.

SMITH, David R., Associate Professor, Hayes, M.C., Ramamurthy, M., Zeitler, J.W., Murphy, K.A., Croft, P.J., Nese, J.M., Friedman, H.A., Robinson, H.W., Thormeyer, C.D., Ruscher, P.A., and Pandya, R.E., "Meeting Summary of the Tenth American Meteorological Society Symposium on Education," *Bulletin of the American Meteorological Society*, Vol. 82, No. 11, pp. 2817-2823 (2001).

The American Meteorological Society held its Tenth Symposium on Education in conjunction with the 82nd Annual Meeting in Albuquerque, New Mexico. The theme of 2001's Symposium was "enhancing public awareness of the atmospheric and oceanic environments". Thirty-six oral presentations and 38 poster presentations summarized a variety of educational programs or examined educational issues at both the pre-college and university levels. There was a special session on increasing awareness of meteorology and oceanography through popular and informal educational activities, as well as a joint session with the 17th International Conference on Interactive Information Processing Systems for Meteorology, Oceanography and Hydrology on using the World Wide Web to

deliver information pertaining to the atmosphere, oceans, and coastal zone. Over 200 people representing a wide spectrum of the Society attended one or more of the sessions in this two-day conference. The program for the Tenth Symposium on Education can be viewed in the October 2000 issue of the *Bulletin*.

WHITFORD, D.J., Captain (USN) and Professor, SMITH, D.R., Associate Professor, Lawyer, D.T., and Heckman, B.E., "An Assessment of Interactive Video-Teleconference Sessions between the United States Air Force Academy and the United States Naval Academy," *Preprints of the 11th AMS Symposium on Education*, American Meteorological Society, Boston, MA, 131-133.

This paper and the accompanying presentation described the results of Interactive Video Teleconference (IVTC) sessions conducted between the United States Air Force Academy (USAFA) and The United States Naval Academy (USNA). Over the past three spring semesters, the USNA and the USAFA have conducted numerous video teleconference (VTC) sessions in a senior-level Geosciences course titled; Applications of the Geosciences to joint Naval and Air Force Operations. The sessions were designed to support a segment of the course on Marine Meteorology, specifically wave and swell forecasting. In addition, USAFA conducted additional IVTCs with a Navy senior-level independent study class on aviation weather hazards.

This method of IVTC was first introduced and explained at the 9th Symposium on Education in Long Beach, California in January of 2000. Since that time, new equipment was purchased, different rooms were utilized, various teaching techniques were incorporated, and additional sessions were conducted. This paper and presentation will illustrate the physical layout of the sessions, describe the lessons learned on behalf of the instructors, discuss the feedback from the Navy midshipmen and Air Force cadets, and most importantly, describe the future implications and challenges of this exciting new technology in the classroom.

Presentations

JONES, Henry, Commander (USN), Batteen, M., May, P., Collins, C., Nuss, W., Miller, D., and DeWitt, D., "Sensitivity of a Navy Regional Ocean Model to Nested High-Resolution Atmospheric Model and Scatterometer Wind Forcing," American Geophysical Union Sciences Meeting in Honolulu, Hawaii, 11-16 February 2002.

GUTH, Peter L., Professor, "Terrain Organization Calculated From Digital Elevation Models," Fifth International Conference on Geomorphology, Tokyo, Japan, 23-28 August 2001.

GUTH, Peter, L., Professor, "Geomorphic Analysis of Digital Elevation Models (DEMs) in a GIS: Terrain Analysis and DEM Quality Control," Forum on Landform Analysis at the Topographic Engineering Center, Alexandria VA, January 2002.
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GUTH, Peter L., Professor, "3-D Terrain Visualization Combining DEMs and Additional Cartographic Data," Science Day, Ecole Navale, France, May 2002.

MEIER, Walter N., Adjunct Assistant Professor, Van Woert, M.L., and McKenna, P., "Near Real-time Microwave Sea Ice Products for Operational Sea Ice Analysis," American Geophysical Union Fall 2001 Meeting, San Francisco, CA, 8-12 December 2001.

MEIER, Walter N., Adjunct Assistant Professor and Arbetter, T., "Current and Future State of Sea Ice Data Assimilation," Oceanology Conference 2002, London, UK, 7-8 March 2002.

SMITH, David R., Associate Professor, "Explosive Marine Cyclones – A Hazard to Mariners and Coastal Dwellers," Millersville State University, Millersville, PA, November 2001. (Invited presentation)

SMITH, David R., Associate Professor, and Honnette, H.L., Midshipman 1/C (USN), "A Comparison of the Weather in U.S. Cities During the 1982-83 and 1997-98 El Niño's," 13th American Meteorological Society Symposium on Global Change and Climate Variations, Orlando, FL, January 2002.

SMITH, David R., Associate Professor, and Hacker, S.D., Midshipman 1/C (USN), "A Comparison of the Stedman's Heat Index and the WBGT Index," 3rd American Meteorological Society Symposium on Environmental Applications, Orlando, FL, January 2002.

SMITH, David R., Associate Professor, "Factors Contributing to the Explosive Development of Marine Cyclones," United States Air Force Academy, Colorado Springs, CO, April 2002. (Invited presentation)

SMITH, David R., Associate Professor, Geer, I.W., Moran, J.R., and Weinbeck, R.S., "Water in the Earth System (WES): Moving Toward National Implementation," 11th American Meteorological Society Symposium on Education, Orlando, FL, January 2002.

SMITH, David R., Associate Professor, Geer, I.W., and McManus, D.E., "The Maury Project: A Partnership to Promote Educational Outreach on the Physical Foundations of Oceanography," 11th American Meteorological Society Symposium on Education, Orlando, FL, January 2002.

SMITH, David R., Associate Professor, Lawyer, D.T., WHITFORD, D.J., Captain (USN) and Professor, and Heckman, B.E., "An Assessment of Interactive Video Teleconference Sessions between the United States Air Force Academy and the United States Naval Academy," 11th American Meteorological Society Symposium on Education, Orlando, FL, January 2002.

SMITH, David R., Associate Professor, and Geer, I.W., "American Meteorological Society's Education Program: A Model for Geoscience Education," Conference of the Consortium for Earth Science Education, Greenbelt, MD, January 2002 and Meeting of the Colorado Science Education Network, Golden, CO, April 2002.

SMITH, David R., Associate Professor, "An Overview of the American Meteorological Society's Education Program," UCAR Office of Education and Outreach, Boulder, CO, April 2002.

VIEIRA, Mário E.C., Associate Professor, "Dynamics of Destratification in a Small Tributary Estuary," 16th International Estuarine Research Federation Conference, St.Petersburg, FL, 4-8 November 2001.

VIEIRA, Mário E.C., Associate Professor, "A Study of the Microbiology of the Douro Estuary, Portugal: a Progress Report," Spring Meeting of the Atlantic Estuarine Research Society, Lewes, DE, 4-6 April 2002.

VIEIRA, Mário E. C., Associate Professor, lectures on "Estuarine Dynamics" at Porto University, Porto, Portugal, June 2002.