Oceanography Department

Captain Jessie C. Carman, USN
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 2004-2005 research productivity of meteorology, oceanography, and pedagogical research was especially noteworthy. The department's five tenure-track faculty, two Permanent Military Professors, and one externally funded research chair authored 5 refereed articles for publication, 4 conference proceedings and made 15 conference presentations, many of which included midshipmen as co-authors.

Twelve midshipmen completed research project courses under the mentorship of faculty advisors. These midshipmen formally presented their project results at the Naval Academy at the end of each semester. Some of these midshipmen also presented their research at regional or national conferences.

The Oceanography Department conducted its sixteenth annual summer oceanography cruise from 04 August to 12 August 2005. The midshipmen navigated nearly 600 nautical miles through the Delaware and Chesapeake Bays, the C&D Canal, and the Delaware River. This included two overnight transits, one from Philadelphia to Norfolk through the C&D Canal (239 nm) and one from Norfolk to Annapolis (148 nm). The midshipmen also collected oceanographic data throughout the Chesapeake Bay during this period, including one night evolution. Significant maneuvering evolutions consisted of 1 precision anchorage, 4 pierside underways and moorings, and 14 on-station data collection evolutions.

In July 2005, the department hosted the eleventh Maury Project Summer Workshop for twenty-three 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

MicroDEM UAV Development Work

Researcher: Professor Peter L. Guth
Sponsor: Boeing Corporation

The intent of this research and development activity is to transform MicroDEM into a reliable, high performance mission planning tool tailored to the specific terrain analysis and visualization requirements of Future Combat Systems, Homeland Security Services, and other allied applications. This enhanced product, when integrated into Boeing's optimization and role-based access control framework, will become a key enabler of M&CT's vision for Adaptive Autonomous Networks.

GIS/Remote Sensing Education for Midshipmen

Researcher: Professor Peter L. Guth
Sponsor: National Geospatial-Intelligence Agency

In this research, the effort was continued improvement to the GIS/Remote Sensing education provided to midshipmen at the U.S. Naval Academy. Outreach to the DOD was also undertaken 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 development of algorithms and techniques to merge and display geospatial data in an intuitive way projects. Midshipmen honors students majoring in Oceanography will use components of the proposed research and associated equipment in their honors independent research projects and will be given the opportunity to present their findings at a professional scientific conference

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

Researcher: Commander Henry Jones, USN
Sponsor: Naval Postgraduate School (NPS)

As the focus of Navy attention shifts to littoral regions, higher resolution and re-locatable nested models have been developed to improve shallow-water operations. One of the scientific and technical challenges is to determine how much detail and accuracy in ocean wind data is needed to meet operational requirements. A series of experiments, each one of a 14-day duration, are performed to evaluate the sensitivity of a regional ocean model to low Navy Ocean Global Atmospheric Prediction System (NOGAPS) versus high-resolution Couple Ocean Atmospheric Model Prediction System (COAMPS) wind forcing including scatterometer data insertion into COAMPS using synthetic QuikSCAT (quick scatterometer mission) observations. Atmospheric model wind stress/wind stress curl and Pacific West Coast ocean model (PWC) surface and subsurface current/temperature model results are compared and analyzed. The results show that there is significant sensitivity in sea surface current and wind stress variability to the choice of atmospheric model grid resolution and the insertion of high-resolution satellite data. In coastal areas, increasing atmospheric model produces a finer depiction of the variability observed near capes and promontories. Insertion of QuikSCAT data produces a statistical difference but no significant difference model fields. The ocean model runs have the expected climatological features and variability. The higher wind stress in COAMPS is translated to the ocean model in the form of higher velocity currents, closed circulations, higher EKE and better defined structure in vorticity. Comparisons to real observations, point to the fact that the approach, in which all regions are run with the same resolution, may not be an efficient use of computer resources.

Operational Modeling of the Marginal Ice Zone

Researcher: Adjunct Assistant Professor Edward L. Maksym
Sponsor: Commander, Naval Meteorology and Oceanography Command (CNMOC)

Forecasting and analysis of sea ice conditions is the most difficult in the marginal ice zone, but due to the proximity to maritime traffic, arguably the most important. This project aims to improve operational analysis and forecasting sea ice products produced at the National/Naval Ice Center (NIC) through the assimilation of satellite ice concentration and drift.

Passive microwave observations of sea ice concentration are assimilated into a free-drift sea ice model to drive the ice thermodynamics. Model tuning and validation are carried out using a suite of synthetic aperture radar, visible and infrared satellite imagery, and in-situ observations of ice conditions from a 2001 cruise in the Barents Sea. Comparisons of the modeled ice growth and drift are compared with satellite derived ice drift from both visible and passive microwave, NIC ice charts, and drift vectors from the Navy's Polar Ice Prediction System (PIPS). The model is shown to perform very well – episodes of new ice growth are well detected and predicted concentrations of new and young ice typically match observations to within the accuracy of the SAR interpretation.

Wind Direction Estimates from Synthetic Aperture Radar Imagery of the Sea Surface

Researchers: Associate Professor Todd D. Sikora and George S. Young (The Pennsylvania State University)
Sponsor: Office of Naval Research (ONR)

Recently, there has been much effort put into the attempt of extracting sub-kilometer scale wind speed estimates from SAR imagery using CMOD-like transfer functions. Many researchers have based their determination of the near-surface mean wind direction, a critical input into their transfer functions, on the orientation of the synthetic aperture radar (SAR) signatures of quasi-two dimensional marine atmospheric boundary layer (MABL) phenomena, simply equating one to the other. Other researchers have relied on numerical models as a basis for their wind direction input. Both of these wind-direction-determination techniques can fail to produce a proper analysis of the wind direction. These analysis errors can lead to significant errors in the wind speed retrieval of CMOD-like algorithms.

We are investigating the range of near-surface mean wind directions with respect to the orientation of common marine atmospheric boundary layer MABL quasi-two dimensional phenomena seen in synthetic aperture radar SAR imagery. We are also developing empirically-derived guidelines on how to distinguish the SAR-signature of one feature from another. In addition, we are investigating the impact of position errors in model analyzed synoptic scale storms and fronts on the wind-direction dependent retrieval of wind speed from SAR via a thorough error analysis of CMOD-4 with an emphasis on wind direction errors at varying incidence angles, and varying locations along the upwind/downwind/cross-wind quadrants.

The Maury Project - Exploring the Physical Foundations of Oceanography

Researchers: Associate Professor David R. Smith and I.W. Geer (American Meteorological Society)
Sponsors: Commander, Naval Meteorology and Oceanography Command,
National Oceanic and Atmospheric Administration (NOAA), 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.

DataStreme Ocean

Researchers: Associate Professor David R. Smith, and
I.W. Geer, J.M. Moran and R.S. Weinbeck (American Meteorological Society)
Sponsor: National Oceanic and Atmospheric Administration (NOAA)

DataStreme Ocean is a teacher enhancement program for oceanography. This is a distance-learning course which uses the Internet to deliver instruction to pre-college educators. This summer, approximately 50 teachers were brought to Silver Spring, MD to attend a summer training workshop where they learn about fundamental concepts in physical oceanography. 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.

Independent Research

Effective Thermal Conductivity of Snow on Antarctic Sea

Researchers: Adjunct Assistant Professor Edward L. Maksym and Martin Jeffries (University of Alaska, Fairbanks)

A statistical determination of the effective thermal conductivity of snow was calculated using over four thousand point temperature measurements of snow and sea ice from four cruises in the Ross, Amundsen, and Bellingshausen Seas. The effective thermal conductivity was determined to be 0.4 W m^{-1} K^{-1}, significantly higher than both in-situ measurements (~ 0.15 W m^{-1} K^{-1}) and those used in large-scale models (~ 0.30 W m^{-1} K^{-1}). There was also significant variation between cruises, indicating a possible dependence on snow properties that is not captured by the simple snow parameterizations used in current large-scale sea-ice models. Unlike at the SHEBA site in the Arctic, the analysis showed no evidence for enhanced heat flow through ridges. We suggest that the discrepancy between measured and effective thermal conductivity may be due to the presence of icy layers within the snow cover, and brine at the base of the snow, both of which can enhance the heat flow. This suggests that to accurately predict the response of Antarctic sea ice to environmental change may require more sophisticated treatment of processes within the snow cover.

Modeling of Melt Pond and Ice Albedo Evolution

Researchers: Adjunct Assistant Professor Edward L. Maksym and Hajo Eicken (University of Alaska, Fairbanks)

Sea ice albedo is directly connected to the fraction of melt ponds covering the surface in the summer. For accurate predictions of ice extent and thickness under climate change scenarios, precise predictions of summer ice albedo are required. Yet no model is capable of realistically predicting the extent and distribution of melt ponds. Using new observations of melt pond fraction and ice morphology, a statistical description of melt pond dynamics will be coupled with an ice growth and hydrological model. This pilot study aims to determine the effects of variable snow deposition and meteorological conditions on the ice thickness and evolution of the ice albedo. This work will form part of the groundwork for a larger project to be proposed as part of the International Polar Year 2007-2008.

3D Simulation of Tidal Currents in Monterey Bay

Researchers: Commander Emil Petruncio, USN,
Jeff Paduan and Leslie Rosenfeld (Naval Postgraduate School), and Igor Shulman (Naval Research Laboratory)

The Navy requires accurate 3D forecasts of coastal ocean currents. Accurate representation of baroclinic (or "internal") tides presents a major challenge to achieving this goal. The Naval Postgraduate School and the Naval Research Laboratory are collaborating on a 3D numerical simulation of ocean circulation in the Monterey Bay region, where very energetic internal tides have been observed. Although the model includes tidal forcing, an assessment of model accuracy in reproducing internal tides has yet to be conducted. This project will assess the performance of open boundary specifications, which will aid efforts to simulate tidal currents in other coastal areas, and will identify internal tide "hot spots", which may guide the design of future shipboard data collection efforts. This work is just underway, although much of the ground work of model development is already complete.

Use of Synthetic Aperture Radar in Fine-Scale Analysis of Synoptic-Scale Fronts at Sea

Researchers: Associate Professor Todd D. Sikora, George S. Young (The Pennsylvania State University),
and Nathanial S. Winstead (The Johns Hopkins University)

The viability of synthetic aperture radar (SAR) as a tool for fine-scale marine meteorological surface analyses of synoptic-scale fronts is demonstrated. In particular, it is shown that SAR can reveal the presence of, and the mesoscale and microscale sub-structures associated with, synoptic-scale cold fronts, warm fronts, occluded fronts, and secluded fronts. The basis for these findings is the analysis of some 6000 RADARSAT-1 SAR images from the Gulf of Alaska and from off the east coast of North America. This analysis yielded 158 cases of well

defined frontal signatures: 22 warm fronts, 37 cold fronts, 3 stationary fronts, 32 occluded fronts, and 64 secluded fronts. The potential synergies between SAR and a range of other data sources are discussed for representative fronts of each type.

The Correction of Surface Layer Wind Speeds for Atmospheric Stratification and Height

Researchers: Associate Professor Todd D. Sikora, Ralph C. Foster (University of Washington), and George S. Young (The Pennsylvania State University)

The comparison of SAR-derived wind speeds from scatterometer-based transfer functions and *in situ* or model wind speeds requires that both data sets represent the presence of equivalent atmospheric stratification and measurement height. We discuss the atmospheric surface layer dynamics underlying corrections to equivalent atmospheric stratification and measurement height. In addition, we review available methods for carrying out the corrections focusing on bulk flux algorithms available in the literature.

On the Discrimination between the SAR Signatures of Oceanic and Atmospheric Fronts

Researchers: Associate Professor Todd D. Sikora, Werner Alpers (University of Hamburg), Andrei Ivanov (Russian Academy of Sciences), Jochen Horstmann (Institute for Coastal Research), and Leonid Mitnik (Pacific Oceanological Institute)

The SAR imaging mechanisms by which the signatures of atmospheric and oceanic fronts are manifested are discussed. This is followed by presentation of a series of cases of atmospheric and oceanic fronts, taken from the refereed literature. Finally, criteria for correctly distinguishing between both types of fronts from SAR imagery are provided.

Attempting to Improve Communications Skills: Assessment of a Senior Capstone Seminar Course in Meteorology

Researchers: Associate Professor David R. Smith, Associate Professor Todd D. Sikora, Barbara B. Yoakum (Nimitz Library Reference Department), and Assistant Professor Ronald M. Kyhos (USNA English Dept.)

A common criticism by employers is the need for better communication skills, both written and oral. While most quality undergraduate programs in the atmospheric and related sciences prepare their students well in the technical aspects of their discipline, sometimes they neglect to develop the ability of their students to communicate their technical knowledge to others. The justification for this omission is that the curriculum is already too full or that it should be the responsibility of the Humanities Division faculty to cultivate such skills. Unfortunately, this attitude removes the individuals with the technical expertise from the process and sends the message to the students that the communication of the scientific knowledge is less important.

To promote better research and communications skills of its majors, the Oceanography Department at the United States Naval Academy has a public speaking and scientific writing continuum within its Oceanography and Meteorology-based curriculum. Each course in the major curriculum has a requirement for either oral or written presentation about a topic in that particular course. This process culminates in a Senior Capstone Seminar Course.

The objective of the Senior Capstone Course is for students to write a senior thesis on a topic that builds upon the complete coursework in the major. Further, each student prepares a 25-minute oral presentation describing the salient points of their research. There are four versions of the Senior Capstone Seminar Course (Physical Oceanography, Biological Oceanography, Geographical Information Systems, and Meteorology). This work focused on the systematic assessment of the Meteorology Capstone Course. The data presented were compiled from several assessment tools aimed at evaluating the course's effectiveness from a student's perspective.

Midshipman Research Project Courses

New Lab Exercises for SO244, Basic Atmospheric Processes

Researcher: Midshipman 1/C Matt Wilckens, USN
Advisers: Associate Professor Todd D. Sikora and Lieutenant Commander Ron Piret, USN

Three new laboratory exercises were created for SO244, Basic Atmospheric Processes. They are:

1. Introduction to Meteorological and Oceanographic Instruments—an introduction to the use of scientific instrumentation in meteorology and oceanography, including the METOC Mast Sensor Package onboard YP686.

2. Air Stability- A further study of the Skew-T Log-P chart looking at the surface layer characteristics and their affects at higher elevations.

3. Isoplething- An introduction to isoplething while analyzing the relationship between surface temperature, barometric pressure and wind velocity.

These new laboratory exercises will enhance the education of students by:

1. Incorporating a wide variety of instruments and facilities available within the oceanographic department.
2. Incorporating methods of locating, importing, and manipulating quality field data from the World Wide Web.
3. Introducing material that later courses (i.e. SO345 and SO414) will expand, thereby promoting students' retention of classroom material through repetition.

New Lab Exercises for SO231, General Oceanography I

Researcher: Midshipman 1/C Dan J. Brendel, USN
Advisers: Associate Professor Todd D. Sikora and Lieutenant Commander Ron Piret, USN

Four new laboratory excercises were created for SO231, general Oceanography I. They are:

1. Introduction to Meteorological and Oceanographic Instruments - an introduction to the use of scientific instrumentation in meteorology and oceanography, including the METOC Mast Sensor Package onboard YP686.
2. Fundamentals of Operational Sonar - an introduction to the basic laws governing sound propagation in the ocean, with particular focus on deriving sound speed profiles from real experimental data and learning the effect of sound refraction on the range of naval sonar.
3. Fundamentals of Wave Mechanics - an introduction to the basic laws governing the propagation of surface waves in the ocean, as well as Fourier analysis.
4. Fundamentals of Remote Sensing - an introduction to the basic laws governing electromagnetic radiation, as well as the design considerations and use of current environmental satellites.

These new laboratory exercises will enhance the education of students by:

1. Incorporating a wide variety of instruments and facilities available within the oceanographic department.
2. Incorporating methods of locating, importing, and manipulating quality field data from the World Wide Web.
3. Relating classroom material more closely and clearly to applications in the operational Navy.
4. Introducing material upon which later courses (i.e. SP411, ES419, SO413, EE301, and SO431) will expand, thereby promoting students' retention of classroom material through repetition.

The Impact of Weather on Water Quality in the Severn River

Researcher: Midshipman1/C Buddy Ellis, USN
Advisers: Associate Professor David R. Smith and Associate Professor Mario E.C. Vieira

The quality of fresh water resources is a very important environmental consideration. Many rivers and streams currently experience high levels of pollutants which can kill plants and fish as well as pose a serious threat to humans who reside nearby. Clearly, there are numerous factors which can contribute to this problem. One such factor is the natural flushing mechanism in which rain and subsequent runoff enter these water systems, providing new sources of fresh water to dilute and possibly pollute the rivers or streams. The purpose of this project was to determine how effective weather conditions might be in this process.

This project monitored water quality in the Severn River. During the fall semester, ten sites along the Severn River were selected as locations for sampling. Observations of a variety of parameters were made weekly to determine the quality of the water in the river. In addition, weather charts and data were collected to provide the local and synoptic conditions during the water sampling periods. Through analyzing this data, a relationship between weather conditions and water quality is determined.

Analysis of the Effect of Major Meteorological Events on Water Properties of the Severn River

Researcher: Midshipman 1/C Mark Hebert, USN
Advisers: Associate Professor David R. Smith and Associate Professor Mário E. C. Vieira

Due to the economic importance of the fishing industry within the Chesapeake Bay, recent attention has been focused to the issues of water quality. The water quality is important to maintaining the future of the fishing industry in the Chesapeake Bay. Changes in water properties, both natural and anthropogenic, affect the quality of the water. This study observed how the water properties in the Severn River changed with changes of meteorological events. It specifically focused on the time from January 2005 until early April 2005. During this time period, the focus was on winter time processes, which bring about a large percentage of the yearly precipitation. These winter time processes bring new sources of water that eventually feed into the Severn River. The purpose of this project was to determine how influential these processes are to the cleansing or flushing cycle.

Ten stations, spaced approximately 2 miles apart, extend from the mouth to the head of the Severn River. A team took a portable Conductivity-Temperature Device (CTD) up the Severn River weekly during the Spring Semester to measure water properties of dissolved oxygen, temperature, and salinity. Water samples were taken and were analyzed for concentrations of nitrates and phosphates under laboratory conditions. Weather charts, as well as data from a weather station at the mouth of the river, were collected four days in advance of the trips of the Severn River. By compiling the data gathered from the weather station and from collected charts, numerical data were compared to observed measurements to determine correlation between major meteorological events and changes in water properties. While there were six cases, due to the amount of data and the requirements of this paper, only two cases were looked at in detail. These cases showed the influence that weather had on the water properties. However, the hypothesis that changes to water property were instantaneous was proven incorrect. Instead, an apparent lag time is suggested. Importantly, this research shows many of the items that still need to be researched and provided an excellent insight for additional research on this subject.

The Effects of DEM Re-Interpolation on Viewshed Computations

Researcher: Midshipman 1/C Kyle Franklin, USN
Adviser: Professor Peter L. Guth

Viewsheds, or weapons fans, represent one of the most important military applications of digital elevation models (DEMs) because many radars, radios, and direct fire weapons rely on line-of-sight. Because of the importance of this function, and the number of computations required, optimization of intervisibility computations has been a goal for military terrain analysis software. One common optimization requires the source DEM to use

Universal Transverse Mercator (UTM) coordinates because a square, rectangular grid simplifies computations. Unfortunately, the best DEMs currently available use geographic coordinates. Several programs require reinterpolation of such DEMs to a UTM grid before use in intervisibility computations. The researcher investigated the effects of DEM reinterpolation, which shifts grid points at variable distances, both horizontally and vertically. Because peaks and ridges largely control intervisibility, and most interpolation algorithms will tend to displace the location of these high points and drop their elevations, reinterpolation affects intervisibility computations. The effects of this reinterpolation should be analyzed for better situational awareness, most importantly in military applications.

Filling Holes in SRTM DEMS Using Aster DEMS

Researcher: Midshipman 1/C Kyle Obrock, USN
Adviser: Professor Peter L. Guth

The Shuttle Radar Topography Mission (SRTM) collected elevation data. Over 80% of the Earth's land area. For most locations this represents the best quality, freely available digital elevation models (DEMs) with horizontal resolution of 1-3 arc seconds. SRTM DEMs have data gaps caused by steep terrain or unfavorable surfaces. In contrast to the short SRTM mission, the ongoing Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) is slowly collecting DEMs using stereo near infrared imagery with a horizontal resolution of 30 m.Statistical measures show extremely high correlations between ASTER and SRTM DEMs. Because ASTER and SRTM represent independently produced DEMs, ASTER can fill holes in SRTM data. ASTER data requires horizontal and vertical shifts to match SRTM data. We assume SRTM data is correct, and after shifting we fill SRTM holes with an interpolated ASTER elevation ASTER cannot fill all holes in SRTM ata, but offers a reasonable quality, fully automated mechanism to fill many voids.

Vegetation Density and Westward Migration of Assateague Island: LIDAR Analysis and Field Study

Researcher: Midshipman 1/C A.D. Lee, USN
Adviser: Professor Peter L. Guth

This project examined the relationship between vegetation density, coastal erosion and barrier island migration at Assateague Island National Seashore (AINS). Analysis of LIDAR data collected from 1995 to 1998 (both spring and fall surveys each year) confirms the migration of AINS to the west, suggests motion of the dunes, and shows the decreasing beach slope. The findings relate the vegetation density as well other important variables to the massive erosion. The amount of vegetation is only an issue if the erosion on the dune is due solely to the wind and traffic. The percent of vegetation on the study area had no effect on dune height; this was proven by the lack of measurable dune height variation over a ten-month period. The overriding variable in the westward migration is the long shore currents lack of deposition on the northern end of Assateague Island. The combination of LIDAR, photography and field measurements creates a better understanding of rapid change in barrier island topology.

Assessment of a 3D Simulation of Tidal Currents in Monterey Bay

Researcher: Midshipman 1/C Kendra McClellan, USN
Adviser: Commander Emil Petruncio, USN

The Naval Postgraduate School and the Naval Research Laboratory are collaborating on a 3D numerical simulation of ocean circulation in the Monterey Bay region, where very energetic internal tides have been observed. Although the model includes tidal forcing, an assessment of model accuracy in reproducing internal tides has yet to be conducted. This project used ray tracing techniques to compare theoretical internal tide propagation to model output. The primary focus was on internal tides in Monterey Submarine Canyon, where previous field observations can also be used for comparison. MATLAB was used to produce graphical depictions of model output and ray traces.

Development of Nor'easters during El Nino years

Researcher: Midshipman 1/C Lynne Hoppe, USN
Adviser: Associate Professor David R. Smith

A significant wintertime event along the East Coast is a marine cyclone called the Nor'easter. These storms occur when cold air from the continent interacts with warm air and water just offshore, associated with the Gulf Stream. This paper investigates whether El Nino events have any influence on the development of such storms. This paper looks at tracks of winter storms for the 1983-84, 1997-98, and 2004-05 events. The number of extratropical cyclones, intensity of these cyclones and the central and minimum pressures of the cyclones were gathered. By comparing these data, conclusions were made regarding the generation and movement of Nor'easter storms. The storms during El Nino events were pushed further south due to the jet stream being pushed further south. The frequency of storms increased during strong El Nino years (e.g., 1983-'84 or 1997-'98). Although predicting when or where these storms will occur is difficult at best, this study provides clues to better understand the effect of El Nino on these extratropical marine cyclones.

An Investigation of Antarctic Polynyas and their Relationship to Climate Patterns

Researcher: Midshipman 1/C Sarah Mooney, USN
Adviser: Adjunct Assistant Professor Edward L. Maksym

Recent studies have shown that Antarctic sea ice extent is influenced by the Southern Oscillation (SOI) and the Antarctic Circumpolar wave (ACW) [*Kwok and Comiso, 2001*]. Because of the importance of coastal polynyas in controlling ice production, water mass properties and biological activity, the connection between these climate oscillations and the development of several polynyas was investigated. In this study, I focus specifically on the breakout period of the Henry, Amundsen, Ross, Prydz and Ronne polynyas from 1987-2002 to discern the impact of the SOI, ACW, thermodynamics and dynamics on polynya formation. This period was chosen because of the significant impact that the breakout period has on biological activity and ice production. The results of this study indicate that large scale parameters such as the SOI and ACW play a role in larger more exposed polynyas, and even at that, have little impact on the breakout of polynyas that are conducive to such parameters. For the Ross Sea Polynya, the temperature in the period prior to breakup was most correlated with the subsequent ice concentration, even more so than ice drift. This suggests that temperature might be a useful indicator to forecast breakout. The Ross Sea Polynya mirrored the Henry Polynya in length of season but were inversely proportional with respect to the southern oscillation relationship. There was little relationship between the opening of polynyas and the large scale climate oscillations except for the Ross Sea Polynya, indicating that the SOI may influence larger scale patterns in the Pacific sector of the Southern Ocean, but for smaller polynyas, the forcing is probably almost entirely local.

Statistical Evaluation of the Los Alamos Sea Ice Model using Observed Sea Ice Thicknesses in the Arctic Basin

Researcher: Midshipman 1/C Samuel Chase Mills, USN
Adviser: Adjunct Assistant Professor Edward L. Maksym

Two versions of the Los Alamos Sea Ice Model (CICE) used for the Arctic Ocean Model Intercomparison Project (AOMIP) are evaluated using observed data from the Arctic Ocean. One run used a Gent McWilliams (GM) mixing scheme and the other used a biharmonic (BH) mixing scheme. Observations collected with submarines, moored buoys, and satellite altimetry allow good spatial and temporal coverage of the Arctic basin. The models were able to match the ice thickness distribution very well when averaged over the entire Arctic, however there were significant discrepancies both spatially and temporally. Specifically, the models seem to over predict the thickness of ice in the Beaufort Sea by about a meter, and underpredict the thickness of ice being exported across the Arctic and out the Fram Strait by about half a meter. The discrepancies in ice thickness distribution persist when the data is examined seasonally, with anomalously thick ice in the Beaufort Sea in both the end of winter and end of summer, with correspondingly thin ice predicted in the central Arctic. This suggests that it is unlikely that the disagreement could be entirely due to thermodynamic effects. The BH mixing scheme did seem to perform better than the GM

mixing scheme, however the difference is small compared to the differences between the models and the observed data. The data indicate that the major source of error is dynamic in nature and may be the result of errors in the forcing data, or the model itself.

Publications

Journal (Refereed) Manuscripts

SIKORA, Todd D., Associate Professor (co-author), "Use of Synthetic Aperture Radar in Fine-scale Surface Analysis of Synoptic-scale Fronts at Sea", *Weather and Forecasting*, 2005, in press.

> The viability of synthetic aperture radar (SAR) as a tool for fine-scale marine meteorological surface analyses of synoptic-scale fronts is demonstrated. In particular, it is shown that SAR can reveal the presence of, and the mesoscale and microscale sub-structures associated with, synoptic-scale cold fronts, warm fronts, occluded fronts, and secluded fronts. The basis for these findings is the analysis of some 6000 RADARSAT-1 SAR images from the Gulf of Alaska and from off the east coast of North America. This analysis yielded 158 cases of well defined frontal signatures: 22 warm fronts, 37 cold fronts, 3 stationary fronts, 32 occluded fronts, and 64 secluded fronts. The potential synergies between SAR and a range of other data sources are discussed for representative fronts of each type.

VIEIRA, Mario E.C., Associate Professor (co-author), "Spatial Variability of Phytoplankton, Bacteria and Viruses in the Mesotidal Salt Wedge Douro Estuary (Portugal)", *Estuarine Coastal Shelf Science*, Vol. 63, pp. 143-154.

> In order to assess the variability of phytoplankton, bacteria and viruses, a box model was applied to the mesotidal saltwedge Douro estuary (NW Portugal). The estuary was divided into boxes with two vertical layers and was driven by salinity and freshwater discharge data acquired during cruises in the Spring, Summer and Fall of 1995. Model runs yielded estimates of the vertical non-advective exchange coefficients for each box, which were then used to establish balance equations for the microbial variables. Such equations allowed calculation of horizontal and vertical fluxes of phytoplankton, bacteria and viruses as well as their respective rates of production or consumption. Bacterial numbers peaked at intermediate salinities (12 – 18 psu) whereas freshwater phytoplankton biomass decreased linearly down to 15 psu salinities, and estuarine communities increased at intermediate salinities. Virus-like particles had a similar behavior. The lower layer in the Douro's vertically stratified water column was always a sink for phytoplankton, bacteria and viruses, giving way to negative or close to zero microbial fluxes. In the upper layer of the lower estuary, close to the coastal end where nutrients are abundant, water transparency was high, bacterial generation times were shorter and microbial fluxes were always positive, *i.e.*, net growth occurred. The freshwater end of the estuary was a source of phytoplankton, irrespective of season, whereas it was a source of bacteria and viruses only in summer and spring, respectively. It is suggested that salinity acts as a boundary between different microbial communities, especially on a vertical scale.

Conference Proceedings

SMITH, David R., Associate Professor, Geer, I. W., Moran, J. M., and Weinbeck, R.S., "The Maury Project and DataStreme Ocean: Teaching Teachers about the Coastal Zone", Preprints of the *14th Symposium on Education,* American Meteorological Society (AMS) Meeting, Boston, MA [CD-ROM, J1.8], 2005.

The Maury Project was the first AMS education program focusing on ocean education. In its nearly eleven-year tenure, approximately 275 educators from kindergarten through university levels have attended one of its two-week summer workshops at the U.S. Naval Academy. This unique partnership of AMS, the Naval Academy, SUNY College at Brockport with significant support from the National Science Foundation, the Navy and NOAA, has provided a program of instruction that focuses on the physical foundations of oceanography. This paper summarizes how the Maury Project promotes the study of the marine and coastal environments, areas of vital interest to the agencies sponsoring this program.

The unique feature of the Maury Project is its focus on physical processes. 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 measuring 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 shallow ocean water waves, ocean tides and coastal upwelling. To date, over 1200 Maury peer-training sessions have reached over 20000 teachers both nationally and internationally. This partnership comprised of a professional society, scientific and operational agencies working as colleagues with the pre-college educational structure provides an excellent model for enhancing the study of the marine and coastal environments.

SMITH, David R., Associate Professor, Weinbeck, R.S., Geer, I. W., Moran, J.M., Hopkins, E. J., Mills, E.W., and Blair, B.A. Blair, "AMS Datastreme Courses - Preparing Teachers to Use Earth System Information", Preprints of the *14th Symposium on Education*, American Meteorological Society Meeting, Boston, MA [CD-ROM, 1.8]. 2005.

The American Meteorological Society's Education Program provides three teacher-enhancement courses to develop Earth system science competency. Following course participation teachers become Earth system science resource persons for their schools and districts. Participating teachers also report that students find the use of telecommunicated Earth system environmental information to be both exciting and highly motivational.

DataStreme Atmosphere, which began as the DataStreme Project in 1995, has served as the model for the AMS' DataStreme courses. In the DataStreme courses, participating teachers learn the subject content through a semester-long, blended learning course. A Local Implementation Team (LIT), typically consisting of three master teachers and scientists, recruits teachers locally to collegially learn the content through weekly mentoring and several meetings. The AMS Education Program provides learning materials with benchmark investigations, the first half of which are in a study guide and the second half written to current environmental information delivered in near real-time via Internet. The course emphasis is on using current environmental information to bring immediacy and interest to science, mathematics and technology studies in the classroom.

SMITH, David R., Associate Professor, SIKORA, T. D., Associate Professor, YOAKUM, B.B., Reference Librarian, and KYHOS, R. M. Assistant Professor, "Attempting to Improve Communication Skills: Assessment of a Senior Capstone Seminar Course in Meteorology", Preprints of the *14th Symposium on Education*, American Meteorological Society Meeting, Boston, MA [CD-ROM, 2.9], 2005.

A common criticism by employers is the need for better communications skills, both written and oral. While most quality undergraduate programs in the atmospheric and related sciences prepare their students well in the technical aspects of their discipline, sometimes they neglect to develop the ability of their students to communicate their technical knowledge to others. The justification for this omission is that the curriculum is already too full or it should be the responsibility of the Humanities faculty to cultivate such skills. Unfortunately, this attitude removes the individuals with the technical expertise from the process and sends the message to the students that the communication of the scientific knowledge is less important.

In order to promote better research and communications skills of its majors, the Oceanography Department at the United States Naval Academy has a public speaking and scientific writing continuum within its Oceanography and Meteorology-based curriculum. Each course in the major curriculum has a requirement for either oral or written presentation about a topic in that particular course. This process culminates in a Senior Capstone Seminar Course.

The objective of the Senior Capstone Course is for students to write a senior thesis on a topic that builds upon the complete coursework in the major. Further, each student prepares a 25-minute oral presentation describing the salient points of their research. There are four versions of the Senior Capstone Seminar Course (Physical Oceanography, Biological Oceanography, Geographical Information Systems, and Meteorology). This paper will focus on the systematic assessment of the Meteorology Capstone Course. The data presented were compiled from several assessment tools aimed at evaluating the course's effectiveness from a student's perspective.

SMITH, David R., Associate Professor, and Sweeny, M.E., "A Comparison of Weather in U.S. Cities during the Winter of 2002-2003 to the El Nino's of 1982-1983 and 1997-1998", Preprints of the *16th Conference on Climate Variability and Change*, American Meteorological Society Meeting, Boston, MA [CD-ROM, P5.8], 2005.

The El Niño weather phenomenon has a significant effect on the climate of regions around the world. El Niño has influenced storm tracks and weather patterns, resulting in deviations from normal temperature and precipitation patterns. In this study, temperature and precipitation values will be examined for fourteen U.S. cities in order to document the effects of the 2002-2003 El Niño. The monthly temperature and precipitation values of these cities during this El Niño event and their 30-year means will be compared to previous El Niño years (1982-83 and 1997-98) to determine its relative impact. In addition, the MEI (Multivariable ENSO Index) of the 2003-2003 El Niño will be examined and compared to other El Niño years to help evaluate the relative intensities of these El Niño years and to determine if there is any correlation between the index and deviations from normal temperatures and precipitation amounts.. The month of February 2003 will be examined in particular due to its unusually unseasonable and extreme weather. The result will be a better understanding and explanation of the weather associated with 2002 - 2003 El Niño season.

SIKORA, Todd D., Associate Professor, (co-author), "The Correction of Surface Layer Wind Speeds for Atmospheric Stratification and Height", Proceedings of the *2nd Workshop on Coastal and Marine Applications of SAR*, Svalbard, Norway, (held 2003 September), European Space Agency SP-565, 2004.

The comparison of SAR-derived wind speeds from scatterometer-based transfer functions and *in situ* or model wind speeds requires that both data sets represent the presence of equivalent atmospheric stratification and measurement height. We discuss the atmospheric surface layer dynamics underlying corrections to equivalent atmospheric stratification and measurement height. In addition, we review available methods for carrying out the corrections focusing on bulk flux algorithms available in the literature.

SIKORA, Todd D., Associate Professor, (co-author), "The SAR Measurement of Ocean Surface Winds: An Overview", *Proceedings of the Second Workshop on Coastal and Marine Applications of Synthetic Aperture Radar (SAR)*, Svalbard, Norway, (held 2003 September), European Space Agency SP-565, 2004.

This paper presents a consensus on the state-of-the-art in wind field retrieval using synthetic aperture radar (SAR) as it emerged during the 2nd Workshop on Coastal and Marine Applications of Synthetic Aperture Radar in Longyearbyen, Spitsbergen, Norway, held on 8-12 September 2003. This paper documents the substantial progress that has been accompanied in SAR wind speed retrieval. The consensus is that SARs can estimate wind speed to better than 2 m/s and wind direction to 25 degrees with clear evidence that these values can be improved upon.

Book Chapter

GUTH, Peter L., Professor, The Geometry of Line-of-Sight and Weapons Fan Algorithms: in Caldwell, D.R., Ehlen, J., and Harmon, R.S., eds., Studies in Military Geography and Geology, Dordrecht, The Netherlands, Kluwer Academic Publishers, chapter 21, p.271-285, 2004.

Intervisibility algorithms with digital elevation models (DEMs) compute line-of-sight, weapons fans or viewsheds, and accurate three dimensional perspective views. While other factors such as data quality, atmospheric effects, vegetation and buildings contribute to final results, the simple geometric model has a major impact. No consensus exists on how to define this geometry, but seven parameters of the geometric model should be explicitly defined: (1) must viewer and target locations be restricted to DEM grid locations; (2) are the target and observer locations viewed as cells or points; (3) how are intermediate elevations interpolated; (4) how are points for interpolation selection along radials or the profile; (5) how are radials combined into a viewshed; (6) vertical earth curvature; and (7) horizontal earth curvature. The importance of horizontal earth curvature, or how the algorithm determines the straight line distance between observer and target, has not been sufficiently appreciated. For the general case, unless UTM approximations are valid, geodetic computations should be used. Because most DEMs available for military users have geographic point spacing, many established procedures that implicitly assume a conformal UTM grid will introduce errors.

Presentations at Professional Meetings and Conferences

GUTH, Peter L., Professor, "Shortcuts in the Line-of-sight and Viewshed Algorithms with Gridded Geographic DEMs: What's Permissible and What's Illegitimate", Proceedings ASPRS 2005 Annual Conference, Baltimore, MD, 7-11 March 2005.

GUTH, Peter L., Professor (co-author), "Fire Location from a Single Osborne Firefinder and a DEM," Proceedings of the ASPRS 2005 Annual Conference, Baltimore, MD, 7-11 March 2005.

GUTH, Peter L., Professor, "Military Terrain Analysis," in The Earth Sciences and National Security Symposium at the American Association for the Advancement of Science Annual Meeting, Washington, DC, 17-21 February 2005. (Invited presentation)

GUTH, Peter L., Professor, (co-author), "GIS to GEOWALL", Harnessing 3D Visualizations, Geological Society of America National Meeting, Denver, CO, November 2004.

GUTH, Peter L., Professor, "Computer Manipulation of Simple 3D Structures: Supplement, Complement, or Replace the Field Experience?" Geological Society of America National Meeting, Denver, CO, November 2004.

GUTH, Peter L., Professor (co-author), "Predicting Plant Presence/Absence across Landscapes: A Morphometrically Based Model using Publicly Available Data and the Geowall", Geological Society of America National Meeting Denver, CO, November 2004.

MAKSYM, Edward L., (co-author), "Role of Heat Flux through Snow in Antarctic Sea Ice Growth," Fall AGU Meeting, 13-17 December 2004.

SIKORA Todd D., (co-author), "Use of Synthetic Aperture Radar in the Fine-scale Analysis of Synoptic-scale Fronts at Sea", 13th Conference on Interactions of the Sea and Atmosphere, American Meteorological Society, Portland, ME, 9-13 August 2004.

SMITH, David R., Associate Professor, "Using Topics in Meteorology and Oceanography to Teach Physical Geography," Annual Meeting of the Pennsylvania Geographical Society, Harrisburg PA, November 2004.

SMITH, David R., Associate Professor, (co-author), "Hands-on Workshop on Teaching Wind-driven Ocean Currents", Annual Meeting of the Pennsylvania Geographical Society, Harrisburg PA, November 2004.

SMITH, David R., Associate Professor, (co-author), "The Maury Project and DataStreme Ocean: Teaching Teachers about the Coastal zone", Joint Session on Education Out Reach Activities on Living in the Coastal Zone and the 14th Symposium on Education, San Diego, CA, January 2005.

SMITH, David R., Associate Professor, (co-author), "Attempting to Improve Communication Skills: Assessment of a Senior Capstone Seminar Course in Meteorology", 14th AMS Symposium on Education, San Diego, CA, January 2005.

SMITH, David R., Associate Professor, (co-author), "A Comparison of Weather in U.S. Cities during the Winter of 2002-2003 to the El Nino's of 1982-1983 and 1997-1998", 16th AMS Conference on Climate Variability and Change San Diego, CA, January 2005.

SMITH, David R., Associate Professor, (co-author), "AMS Datastreme Courses - Preparing Teachers to Use Earth System Information", 14th AMS Symposium on Education, San Diego, CA, January 2005.

SMITH, David R., Associate Professor, (co-author), "The Maury Project – A Summer Workshop for Teachers on the Physical Foundations of Oceanography", American Society for Oceanography and Limnology 2005 Summer Meeting, Santiago de Compostela, Spain, June 2005.