Spring 1995

Circulation, Spring 1995

Center for Coastal Physical Oceanography, Old Dominion University

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The NOAA/NASA Pathfinder Program

NASA's Mission to Planet Earth is a multi-faceted program to monitor the environment of our planet from space on a long-term basis. The centerpiece of Mission to Planet Earth is the Earth Observing System (EOS). Within the decade, EOS will enable multidisciplinary study of the Earth's critical, interrelated processes involving the atmosphere, oceans, land surface, and solid Earth. A primary oceanographic variable for global change research is sea surface temperature (SST). For the investigation of dramatic oceanic anomalies such as El Nino, as well as for the validation of atmospheric general circulation models, SST is needed on large, temporal, and spatial scales, with known errors. Because SST will not be monitored by EOS instruments until 1998 or later, NASA, in a joint effort with NOAA, conceived the Pathfinder Program.

Pathfinder data sets take advantage of currently archived earth science data. Where necessary, sensors have been intercalibrated, algorithms improved, and processing procedures revised in order to produce long time-series, global measurements of ocean, land, and atmospheric properties essential for climate research. These data of the Earth's system are available to researchers now, nearly a decade before the advent of EOS, so they may become familiar with the handling of enormous volumes of the satellite data they will routinely analyze in just a few years. The lessons learned from the pathfinder programs will pave the way for the processing and management of terabytes of EOS data.

The National Environmental Satellite and Data Information Service (NESDIS) of NOAA has been producing estimates of SST operationally for more than a decade using high-resolution, multispectral infrared data from space-borne instruments. The primary sensor, flown on NOAA polar orbiting satellites, is the Advanced Very High Resolution Radiometer (AVHRR). Multichannel SST (MCSST) algorithms developed by NOAA/NESDIS produced the longest global record of satellite-derived SST we know (McClain et al., J. Geophys. Res., 90(C6), 11,587-11,601, 1985). However, because of known biases in the MCSST data, their utility for climate and global change research is questionable (Bates, *Adv. Space Res.*, 14. 3, (3)5-(3)14, 1994), especially during episodes of high volcanic aerosol concentration in the troposphere and stratosphere.

The NOAA/NASA Pathfinder AVHRR SST project is providing an important new collection of AVHRR-derived SST data suitable for global change research. Daily (both day and night), global SST fields at 9 kilometer spatial resolution are being produced at the Jet Propulsion Laboratory. A joint effort between NOAA and NASA has resulted in an improved calibration of the AVHRR sensors and a better SST retrieval algorithm. Technological advances in computing in the past decade make it possible to process more and more data very efficiently. This, in turn, enables more sophisticated cloud detection and quality assurance methods to be applied, which results in a dramatic increase in believable SST retrievals for the Pathfinder SST data relative to its predecessor, MCSST. Preliminary analyses show that the Pathfinder SST data preserve more of the spatial and temporal variability found in the surface thermal expression of the oceans than does the MCSST data.

With a grant from NASA's Pathfinder Program office, ELIZABETH SMITH, research associate, has begun to assess the quality and validity of the Pathfinder SST data set. Are these estimates of SST more accurate than previous satellite-derived SSTs, or are there simply more data? According to data archivists at NASA and NOAA, the MCSST data have been used by hundreds of researchers since the early 1980's. This level of use of MCSST suggests the practicality of a thorough analysis of the spatial and temporal differences between the Pathfinder SST and the MCSST data. Preliminary analysis shows, in addition to the dramatic increase in the number of retrievals (see figure), that the MCSST data are about 1 warmer than the Pathfinder data (for weekly averaged data for 1987 and 1988). Future work will concentrate on comparisons between the satellite-derived SSTs and in situ measurements with known errors.

To obtain Pathfinder Sea Surface Temperature data, contact the Jet Propulsion Laboratory Physical Oceanography DAAC at podaac@podaac.jpl.nasa.gov, (818) 354-9890, or visit JPL's WWW site at http://sst-www.jpl.nasa.gov.

FIGURE CAPTION: The weekly average data coverage as a percent of the total number of oceanic pixels is shown for

1987 Pathfinder SST data (red) and MCSST data (blue) for both daytime and nighttime retrievals. Pathfinder SST data coverage is improved dramatically compared to MCSST data coverage due to better cloud detection algorithms and increased computing efficiency.

Notes From the Director....Remote Sensing the Coastal Ocean

The feature article on Elizabeth Smith's research in this issue brings to mind how little we use remote sensing in coastal ocean studies. You are probably thinking we do use it, but I disagree. Part of the reason for the lack of use may be the 1 km footprint of many systems. But I think the larger reason is a lack of good demonstration projects and, until recently, lack of easy access. Another reason may be that students are not routinely taught how to use this tool--and tool it should be. When starting a project, we should immediately think of what remote sensing system can be used to aid in planning and execution. Images are an excellent way to determine correlation length scales before planning begins. After a study, they provide a way to unravel what the external forcing (eddies, coastal currents, frontal movements) may have been.

I believe the funding agencies should consider some demonstration uses of remote sensing in coastal waters. Innovative uses of the AVHRR visible bands would be especially interesting.

Larry P. Atkinson
Director, Center for Coastal Physical Oceanography

Physical Oceanography of the Southwestern Atlantic

A multinational group of 21 oceanographers with expertise in the South Atlantic and/or western boundary currents recently convened a workshop on the physical oceanography of the southwestern Atlantic, the western Brazil and Argentine Basins between the origin of the Brazil Current near 10[degrees]S, and the northern Antarctic Circumpolar Current near 50[degrees]S. This region is marked at all depths by circulation patterns and exchange processes that are centrally important to the regional marine resources and local economies and to the global distributions of heat and dissolved substances. The workshop was hosted by the Oceanographic Institute of the University of Sao Paulo, Brazil, from November 28--December 1, 1994.

The four primary objectives of the workshop were: (1) to urge international cooperation among Argentine, Brazilian, and Uruguayan oceanographers, with additional cooperation by U.S. and European scientists, for developing an observational and modeling program concerned with the physical oceanography of the marginal and open ocean regimes of the western South Atlantic; (2) to assess recent and ongoing programs by the participating countries and other nations in the southwestern Atlantic; (3) to develop an overview of the outstanding scientific issues not presently being addressed but which can be addressed by the international forum; and (4) to recommend future field and laboratory research.

JERRY MILLER was an invited participant in the workshop and gave a talk entitled, ``Modeling of Santos Bight with the Princeton Ocean Model." Jerry also chaired the working group on ``Shelf and Western Boundary Current Dynamics" and is a co-author of the workshop proceedings which will be published in early 1995. The proceedings are available on-line via Jerry's home page at URL http://www.ccpo.odu.edu/~jerry/.

Community Outreach

On October 22, 1995, the Department of Mechanical Engineering of ODU, hosted a demonstration for the Institute for Young PhD's (Persons having Dreams) In Science and Engineering with the cooperation of CHROME (Corporating Hampton Roads Organizations for Minorities in Engineering). CHROME is an organization for underrepresented minorities (including women) to pursue non-traditional technical career fields. Dr. Gregory Selby, associate professor of mechanical engineering, is responsible for initiating the Institute for Young PhD's In Science and Engineering program at ODU, and he was fundamental in coordinating demonstrations for approximately 40 CHROME students (grades 6--8) to participate in hands-on demonstrations on engineering design/computers, robotics, and oceanography at

CCPO.

At CCPO, GLEN WHELESS fascinated the students with a Virtual Reality demonstration consisting of a trip through the Chesapeake Bay without ever leaving CCPO's computer room. The journey was a computer-based flythrough simulation using a graphics program developed by Glen, ARNOLDO VALLE-LEVINSON, and Bill Herman, a computer scientist at the National Center for Supercomputer Applications. The virtual Chesapeake Bay environment consisted of a 3D graphical representation of a Chesapeake Bay bathymetry dataset which was colored according to depth and upon which transparent 3D isosurfaces of salinity derived from numerical modeling results were overlaid. The students were able to get hands-on experience working in a virtual environment as each had a chance to take the controls and fly through the Bay. Students were shown the main shipping channels of the Bay and the abrupt topographic variations. Glen explained the concepts of estuarine circulation and rotationally controlled flow, and he also explained the Bay's seasonal salinity cycle, demonstrated by the animated salinity fields.

LIZ SMITH talked with students about using satellites to study the oceans. With the students ``at the helm'' of a MacIntosh computer, Liz and the students explored two important ocean variables measured from space, sea surface temperature and color/pigments. Together, they examined the temperature and pigments of various parts of the world's oceans in different seasons, and they talked about the strengths and limitations of using satellites to study ocean phenomena. Students were impressed by the varied amount of oceanographic information available from studying satellite images.

To top off CCPO's demonstration, LARRY ATKINSON showed students all of the amazing things available to the students on the Internet World Wide Web.

Picture Caption: Liz Smith guides a student in the use of a MacIntosh computer to examine the oceans' temperature and color.

Student Profiles

CATHY MEYER LASCARA received her B.S. in marine biology from Florida Institute of Technology in 1978 and her M.S. in marine science from the College of William and Mary in 1982. She then worked for two years as a research associate for McNeese State University, investigating the impact of high salinity brine discharge on zooplankton in the north central Gulf of Mexico. In 1983, Cathy shifted careers and took a job as a computer programmer for The Jonathan Corporation in Norfolk, VA. After progressing from programmer to application designer, she became the software development manager and was responsible for several marketed software products including a design and drafting CAD package and a graphical user interface management system.

In 1991, Cathy decided to combine her computer and science background and enrolled in the physical oceanography program at ODU under Eileen Hofmann. Her dissertation topic is entitled, ``Distribution and dynamics of Antarctic krill, Euphausia superba, in relation to environmental variability.'' Cathy's research involves analysis of a multi-disciplinary data set collected in the region west of the Antarctic Peninsula and the development of time- and space-dependent models of krill growth. As part of her dissertation research, Cathy participated in two cruises to the Antarctic Peninsula region. After graduation, Cathy plans to continue pursuing her primary research interests in the capacity of a postdoctoral associate.

G. V. R. K. VITTAL received his B.S. in mechanical engineering from the Osmania University, Hyderabad, India. His M.S., from IISc, Bangalore, India, is in mechanical engineering, specializing in fluid mechanics applied to turbomachines. He worked as a scientific officer at IISc for one year carrying out experiments to measure 3D boundary layers using hot wire anemometry. Vittal enrolled in the Ph.D. program at ODU in the fall of 1991 under the direction of G. T. Csanady.

Vittal's dissertation work focuses on circulation in an isopycnal layer of the subtropical thermocline driven at the surface outcrops. Density surfaces which outcrop towards higher latitudes are the potential regions where the surface processes influence the interior thermocline layers. These processes are parameterized in terms of potential vorticity fluxes which forces the interior circulation in the present study. To elucidate the above form forcing, a constant layer depth and

nonlinear, quasigeostrophic model is studied for simplicity and forced on the northern boundary by the PV gradient flux. The results obtained reflect, to a certain extent, the features in the eastern boundary currents, such as in the Azores frontal area.

Upon completion of Vittal's Ph.D. work, he intends to obtain a postdoctoral position for a few years before returning to India. His main interests focus on large-scale circulation problems and coupled ocean-atmosphere models.

Chaos and the Environment

In popular jargon, ``chaos'' refers to a class of nonlinear processes that describe erratic behavior of a system. Chaotic systems have many of the visual attributes of stochastic or random systems but in fact are produced by deterministic nonlinear processes. The field has achieved an exceptionally high level of popular awareness and public allure, partly from flamboyant claims made by early practitioners. In fact, dynamical systems (the correct title for this area) has produced substantial advances in some branches of mathematics, physics, and engineering. However, its record in the environmental sciences has not been nearly so successful, as the problems are much harder and the simple techniques so successful with small degrees of freedom problems generally are not adequate for most realistic environmental problems. After a decade of hard work, however, there is evidence that this situation is changing due to the large number of national/international conferences and workshops and by the recent increase in the number of papers on application of dynamical systems in standard environmental journals. In addition, a new journal was started by the European Geophysical Society entitled, Nonlinear Processes in Geophysics.

In brief, a paradigm shift seems to be taking place in environmental science. This will involve unprecedented collaboration between applied mathematicians and scientists. These developments also may be signaling a new direction for interdisciplinary studies. A core technology (in this case, dynamical systems) emerges and applications are made to several disciplines. No one individual masters all aspects of the problem; rather, people with different expertise join together.

As a result of this paradigm shift, four professors, with aid from the College of Sciences and the Center for Coastal Physical Oceanography at Old Dominion University, came together to develop a pilot course for students. The professors involved in this effort are John Adam, Mathematics Department; CHET GROSCH, Computer Science Department and CCPO; A. D. KIRWAN, JR., CCPO and Oceanography Department; and, JOHN KROLL, Mathematics Department and CCPO.

The theme of the course is chaos vs. stochasticity and application of nonlinear methods to time series. It emphasizes application of methods from dynamical systems to practical problems drawn mostly from, but not restricted to, the environment. The course lectures are presented by those who have been leaders in both developing the techniques and in the applications. The first distinguished lecturers for the spring 1995 semester are: Eric S. Posmentier, South Hampton College, Long Island University; Chris Jones, Brown University; Steve Wiggins, Cal Tech; Barry Saltzman, Yale University; and Al Osborne, University of Torino, Italy.

Photo Caption: Eric S. Posmentier: one of the distinguished lecturers of the Chaos and the Environment course.

Student Internships

During the 1994 fall semester, CCPO was pleased to have three student interns. The intern program is a new effort at CCPO designed to foster exchanges with graduate and undergraduate programs at other universities. The program provides the opportunity for the students to participate in ongoing research projects at CCPO. It is anticipated that the intern program will continue at a level of one to three students per academic year.

Two interns, CARRIE LEONARD, a Ph.D. student at the University of Maryland, and TONYA CLAYTON, a Ph.D. student at the University of South Florida, worked closely with EILEEN HOFMANN on a NASA funded project that is concerned with the use of satellite observations in circulation and biological models, a joint venture between scientists at NASA/Goddard Space Flight Center, the Virginia Institute of Marine Sciences, and CCPO. While at CCPO, Carrie

and Tonya took a course in mathematical modeling of marine ecosystems and participated in other Center activities. A primary outcome of the time Carrie and Tonya spent was the development of longer term collaborative research projects.

A third intern, MICHELLE (Shelly) PARASO, an undergraduate at Southampton College, worked primarily with ARNOLDO VALLE-LEVINSON on the processing of wind, temperature, barometric pressure, and tide gauge data sets from the lower Chesapeake Bay. She also analyzed some of the features (i.e., extreme events) and trends (i.e., correlations) in the various data sets. The results of that effort have been described in a draft manuscript. In addition, Shelly assisted in the production of data reports that present hydrographic measurements made in the lower Chesapeake Bay. These reports will be published as part of the CCPO technical report series, available upon request. In addition, Shelly participated in two oceanographic cruises to collect hydrographic data in the lower Chesapeake Bay.

Visiting Scientist Lecture Series

During the academic year, CCPO invites several distinguished scientists to present seminars on topics related to coastal oceanography. The lectures take place in Room 109, Crittenton Hall, Old Dominion University, on Mondays at 3:30 p.m. EILEEN HOFMANN, associate professor of oceanography, coordinates the lecture series with the assistance of BEVERLY SCOTT. Below is a schedule of lectures for the spring semester 1995. Please contact Beverly at (804) 683-4945 for more information or if you would like to be included on the mailing list for lecture announcements. Specific lecture topics are announced one week prior to each lecture.

January 23
Glen Gawarkiewicz
Woods Hole Oceanographic Institute

January 30
Gustav Paffenh["o]fer
Skidaway Institute of Oceanography

February 6
Hugh Ducklow
Virginia Institute of Marine Science

February 13
David Basco
Old Dominion University

February 20
Percy Donaghay
University of Rhode Island

February 27
Ray Alden
Old Dominion University

March 13
Larry Atkinson
Center Coastal Physical Oceanography

March 20
Leonard Walstad
Horn Point Environmental Laboratory

March 27
Igor Belkin
National Oceanic Data Center/NOAA

April 3
James Carlton
Williams College

April 10
Louis Codispoti
Center Coastal Physical Oceanography

April 17
Leonard Johnson
Texas AM University

ADK'S Words of Wisdom

Buckingham Theorem (*Phys. Rev. 4*, 345, 1914) determines the number of independent nondimensional parameters which can be formed from the dimensional parameters of a problem. Except for singular cases, the number of independent parameters is the total number of parameters less the number of fundamental dimensions (mass, length, and time for most oceanographic problems).

One classic example of the application of the theorem in oceanography is waves. Deep water waves can be described by four parameters: gravity, [eq]; wave number, [eq]; density, [eq]; and velocity, [eq]. Since there are three fundamental parameters, the theorem implies a single nondimensional relation between the four wave parameters. This is easily found to be

[check hardcopy for equation to go here].

Most will recognize this as the dispersion relation for deep water ocean waves.

Just the Facts...

Grants/Contracts Awarded

L. P. ATKINSON, ``Characterization of Water Circulation Over the Sandbridge Study Area Using Remote Sensing," 8,500, VIMS.

L. A. CODISPOTI, ``A Numerical Modeling Study of the Circulation and Transport in the Kara Sea," 9,160, ONR.

G. T. CSANADY, ``Air-Sea Coupling in the North Atlantic," 63,400, NOAA.

E. E. HOFMANN, ``Long-term Ecological Research on the Antarctic Marine Ecosystem: An Ice-dominated Environment," 64,765, NSF.

G. H. WHELESS and J. M. KLINCK, ``Effects of External Forcing and Turbulent Mixing on the Dynamics of an Estuarine Plume," 170,000, NSF.

G. H. WHELESS and A. VALLE-LEVINSON, ``Ballast Exchange Study: Consideration of Near-Coastal Backup Exchange Zones and the Environmental Effects of Open Ocean Ballast Exchange," 100,000, Mystic Seaport.

Presentations

P. BECKER and G. Bjork, University of Goteborg, ``Residence Times in the Upper Arctic Ocean," World Climate Research Program, Arctic Climate System Study (ACSYS), Scientific Conference on the Dynamics of the Arctic Climate System, Goteborg, Sweden, November 7-10, 1994.

C. E. GROSCH, ``Absolute Instability in a Quasigeostrophic Current-Undercurrent System," Fluid Dynamics Division, American Physical Society, Atlanta, GA, November 21, 1994.

E. E. HOFMANN, ``Examples of Assimilation of Biological Data," Modeling the Southern Ocean Ecosystem Workshop, Skamania Lodge, WA, January 17-19, 1995.

A. D. KIRWAN, JR., ``Modons: The Inside Story on Ocean Eddies," Brown University, September 26, 1994.

A. D. KIRWAN, JR., ``Hydrodynamic Aspects of Oceanographic Research," Department of Aerospace and Mechanical Engineering, Old Dominion University, October 14, 1994.

A. D. KIRWAN, JR., ``The Inside Story on Ocean Eddies," Alumni Research Symposium, Department of Marine Science, University of South Florida, St. Petersburg, FL, October 27, 1994.

J. M. KLINCK, ``Modeling the Southern Ocean Ecosystem: Overview of Physical Processes," Modeling the Southern Ocean Ecosystem Workshop, Skamania Lodge, WA, January 17-19, 1995.

A. KUMAR, ``Satellite Observations of Shelfwater Overrun in the Southern Middle Atlantic Bight," the 1994 Fall American Geophysical Union Meeting, San Francisco, CA, December 5-9, 1994.

J. L. MILLER, ``Modeling the Santos Bight with the Princeton Ocean Model," invited talk at the Physical Oceanography of the Southwest Atlantic Ocean workshop, Sao Paulo, Brazil, November 26-December 4, 1994.

J. L. MILLER, ``Interactions of the Delaware and Chesapeake Bay Plumes," the 1994 Fall American Geophysical Union Meeting, San Francisco, CA, December 5-9, 1994.

E. A. SMITH and M. Hamilton, J. Vazquez, and A. Tran, all three of NASA/Jet Propulsion Laboratory, ``A Global, Statistical Comparison of Multichannel Sea Surface Temperature and NOAA/NASA Pathfinder Sea Surface Temperature Data," the 1994 Fall American Geophysical Union Meeting, San Francisco, CA, December 5-9, 1994.

G. V. R. K. VITTAL and G. T. Csanady, ``Nonlinear Model of the Subduction Driven Thermocline Circulation," the 1994 Fall American Geophysical Union Meeting, San Francisco, CA, December 5-9, 1994.

Book Reviews

E. E. HOFMANN and C. M. LASCARA, Review of Book: ``Towards a Model of Ocean Biogeochemical Processes," *Limnology and Oceanography*, 39, 1,780-1,781, 1994.

Publications

G.A. Paffenhofer, Skidaway Institute of Oceanography, L. P. ATKINSON, T. N. Lee, Rosenstiel School of Marine and Atmospheric Science, and P. G. Verity and L. R. Bulluck, III, both of Skidaway Institute of Oceanography, ``Distribution and Abundance of Thaliaceans and Copepods off the Southeastern U.S.A. During Winter," *Continental Shelf Research*, Vol. 15(2/3), 255-280, 1995.

J. W. Murray, University of Washington, L. A. CODISPOTI, and G. E. Friederich, Monterey Bay Aquarium Research Institute, ``Oxidation-Reduction Environments: The Suboxic Zone in the Black Sea," Aquatic Chemistry: Interfacial and Interspecies Processes, developed from a symposium sponsored by the Division of Environmental Chemistry, Inc., at the 203rd National Meeting of the American Chemical Society, San Francisco, CA, April 5--10, 1992, Eds. C. P. Huang, C. R. O'Melia, and J. J. Morgan, The American Chemical Societys, 1994.

M. A. M. FRIEDRICHS and M. S. McCartney and M. M. Hall, both of Woods Hole Oceanographic Institution, ``Hemispheric Asymmetry of Deep Water Transport Modes in the Western Atlantic," *Journal of Geophysical Research*, Vol. 99(C12), December 1994.

A. Dubey and M. Zubair, both of Computer Science Department, Old Dominion University, and C. E. GROSCH, ``A General Purpose Subroutine for Fast Fourier Transform on a Distributed Memory Parallel Machine," *Parallel Computing*, 20(1994), 1,697-1,710.

A. A. Tsonis and G. N. Triantafyllou, both of the University of Wisconsin-Milwaukee, J. B. Elsner, Florida State University, and J. HOLDZKOM II and A. D. KIRWAN, JR., ``An Investigation of the Ability of Nonlinear Methods to Infer Dynamics of Observables," *Bull. Am. Meteorol. Soc.*, 1,623-1,633, September 1994.

A. D. KIRWAN, JR., B. L. LIPPHARDT, JR., and K. L. GREGORY, ``Nonlinear Ocean Dynamics," *Chapter Three, The Oceans: Physical-Chemical Dynamics and Human Impact*, Eds. S. K. Majumdar, E. W. Miller, G. S. Forbes, R. F.

Schmatz, and Assad A. Panah, The Pennsylvania Academy of Sciences, 1994.

L. M. Ivanov, Marine Hydrophysical Institute of the Ukrainian, Sevastopol, Ukraine, A. D. KIRWAN, JR., and D. V. Melnichenko, Marine Hydrophysical Institute of the Ukrainian, Sevastopol, Ukraine, ``Prediction of the Stochastic Behavior of Nonlinear Systems by Deterministic Models as a Classical Time-Passage Probanbilistic Problem," *Non. Proc. Geophys.*, 1, 4, 224-233, 1994.

SANG-KI LEE and G. T. CSANADY, ``Instability Waves in the Gulf Stream Front and Its Thermocline Layer," *Journal of Marine Research*, Vol. 52, 837-863, 1994.

CCPO CIRCULATION is published quarterly.
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