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Northern Adriatic Response to a Wintertime Bora Wind Event

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During winters, the northern Adriatic Sea experiences frequent, intense cold-air outbreaks that drive oceanic heat loss and imprint complex but predictable patterns in the underlying waters. This strong, reliable forcing makes this region an excellent laboratory for observational and numerical investigations of air-sea interaction, sediment and biological transport, and mesoscale wind-driven flow.

Narrow sea surface wind jets, commonly known as "bora," occur when cold, dry air spills through gaps in the Dinaric Alps (the mountain range situated along the Adriatic's eastern shore). Horizontal variations in these winds drive a mosaic of oceanic cyclonic and anticyclonic cells that draw coastal waters far into the middle basin. The winds also drive intense cooling and overturning, producing a sharp front between dense, vertically homogenous waters (North Adriatic Dense Water, or NAdDW) in the north and the lighter (colder, fresher), stratified waters of the Po River plume. Once subducted at the front, the NAdDW flows southward in a narrow vein following the isobaths (contours of constant depth) of the Italian coast. In addition to governing the basin's general circulation, these processes also influence sediment transport and modulate biological and optical variability.

Building on a long history of scientific investigations [*Cushman-Roisin et al.*, 2001], scientists from several countries conducted intensive multi-disciplinary studies of the northern and central Adriatic during 2002 and 2003. The U.S. Office of Naval Research, NATO, the Croatian Ministry of Science and Technology, and the Italian Ministry of the Environment and Ministry of Universities and Research supported large observational and numerical modeling programs.

The Dynamics of Localized Currents and Eddy Variability in the Adriatic (DOLCEVITA) program investigated the mesoscale and submesocale response to strong atmospheric and riverine forcing within the context of large-scale circulation studies conducted by the Adriatic Circulation, West Istria, and East Adriatic Coastal Experiments (ACE, WISE, EACE). European Margin Strata Formation (EUROSTRATAFORM) investigators worked to understand how sediment transport processes produce observed deposition patterns off the Po and Apennine river systems.

The Mucilage Adriatico-Tirreno (MAT) project conducted monthly physical and biological measurements along three northern Adriatic sections, while other studies focused on bottom-layer hypoxia. The Adriatic Sea Integrated Coastal Area and River Basin Management System (ADRICOSM) pilot project employed measurements and extensive modeling to establish a near-real-time forecast system. High-resolution ocean and atmosphere simulations conducted by the U.S. Naval Research Laboratory supported many of the projects.

The combination of these large, multi-investigator programs and numerous smaller efforts provide a unique, multi-faceted view of the northern Adriatic. Measurements included half-year moored time series at several locations, extensive surface drifter deployments, coastal high-frequency radars, regular hydrographic surveys, high-resolution towed profiler surveys during bora events, microstructure profiles, remote sensing (advanced very high resolution radiometer (AVHRR), ocean color,

Bora cont. on page 163

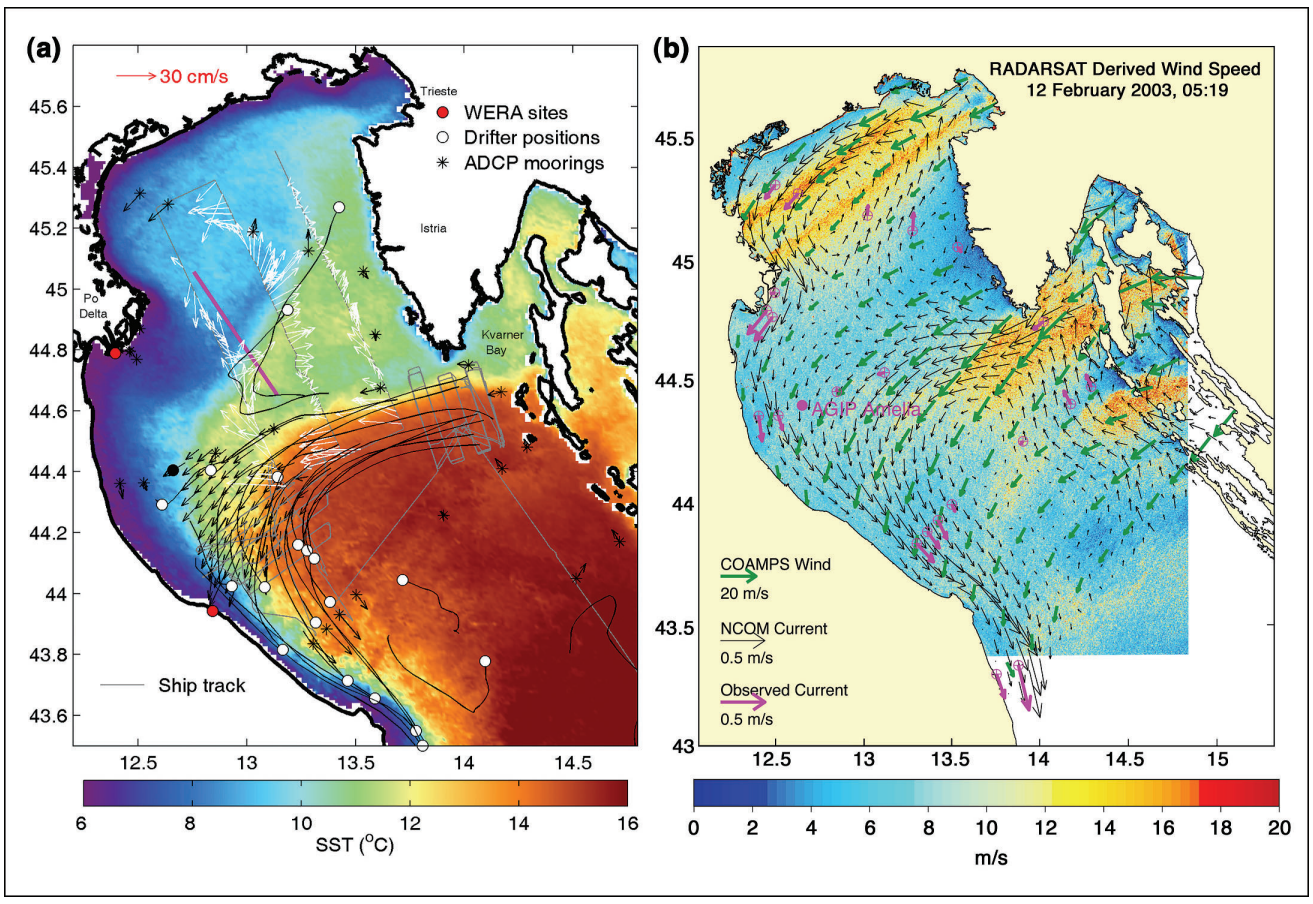

Fig. 1. (a) Nine-day mean AVHRR sea surface temperature with current vectors and drifter tracks illustrating many of the observations collected during the 11–19 February 2003 bora. Gray lines mark part of the R/V Knorr *cruise track, with white arrows showing 12-m velocity measured from the shipboard acoustic Doppler current profiler (ADCP). Black lines trace drifter tracks, with white circles marking locations at the end of this period. Black asterisks and arrows indicate near-surface, 9-day mean velocities measured by bottom-mounted ADCPs and current meter moorings. The field of black arrows between 44°N and 44.4° N depicts the 9-day mean surface velocity field measured by two Wave Radar (WERA) high-frequency coastal radars (located on the Italian coast at the red circles). A black dot marks the AGIP Amelia platform, and a magenta line marks the location of the section shown in Figure 2. All velocity vectors are scaled according to the red vector in the upper left corner. (b) RADARSAT wind speed (color) on 12 February with 48-hour average (12–14 February) Coupled Ocean/Atmosphere Mesoscale Prediction System (COAMPS) wind vectors (black), near-surface (5 m) Navy Coastal Ocean Model (NCOM) currents (green), and measured currents (magenta). A magenta circle marks the AGIP Amelia platform. The 4 km (1 km) COAMPS (NCOM) vectors are shown at 16 km (6 km) intervals for clarity. Large-scale bora winds from the northeast are intensified by coastal topographic gaps into sea surface wind jets that can extend across most of the Adriatic.*

The Earth Sciences, Human Well-Being, and the Reduction of Global Poverty

BY J. C. MUTTER

Poverty is not solely a social or political matter, nor is it caused simply by population pressures as Thomas Malthus postulated in 1798. A new understanding of poverty is emerging in which natural and environmental drivers, together with social, political, and demographic causes, underpin livelihoods. The Earth sciences, therefore, play a critical role in identifying the deep causes of human suffering and in identifying solutions.

The State of the Planet: Why Are So Many So Poor?

For far too many, the state of human well-being is bleak. Around one in six human beings—1 billion people—live in extreme poverty, struggling to survive on less than $1 a day; another one sixth of humanity ekes out existence on $2 per day (U.N. Development Programme (UNDP) Human Development Report, 2004; http://hdr.undp.org/2004/). The extreme poor lack all normal attributes of a decent, dignified life: adequate food, housing, sanitation, health care, education, and employment. Some 800 million people lack sufficient nourishment almost every day. It stunts their mental and physical development and shortens their lives, making them susceptible to common illnesses that attack their hunger-weakened bodies. Poor nutrition in mothers and infants is the leading cause of reduced disability-adjusted life years in poor countries [*Economist,* 2004].

Poverty worldwide claims 30,000 lives every day—one life lost about every 3 seconds—and in places like Sub-Saharan Africa, the situation worsens daily.

How can our world be this way? Population pressures, as Malthus described, surely make a difference. In areas of high rural population density, farm households tend to be extremely poor, and landless rural peasants are even poorer. Yet some places, like Japan, also have low land areas per person and are rich, while other places, like Bolivia, have large land areas per rural household and are extremely poor.

Governance and political institutions matter a lot, as seen in the striking differences between North and South Korea, but countries in extreme poverty lack the resources to combat basic causes of hunger and illness and cannot simply "govern" themselves out of poverty.

The root causes of poverty are complex, involving a suite of time-variable determinants, contingent influences, and internal feedbacks, many of which are location-specific. Economists and other social scientists have sought to understand the basic causes of, and solutions to, poverty [*Landes,* 1998], but the extent to which the condition of Earth's natural systems determines the state of the human condition has remained largely unanswered, and is only rarely incorporated into poverty studies. Studies by Jeffrey Sachs [*Sachs et al.*, 1999; *Sachs,* 2005], who is the author's colleague and director of the Earth Institute at Columbia University, offer one exception, but even Sachs emphasizes how little of such research is currently under way in the economics profession.

Earth's Extremes and Human Well-Being

As seen from the tragedy of the Sumatra-Andaman tsunami of 26 December 2004, the poorest suffer disproportionately at the hands of nature. That tsunami followed the catastrophe in Haiti caused by storms in 2004. Beyond the immediate death toll, poor countries affected by disasters have the least capacity to recover, and few resources available for programs that stimulate long-term economic growth.

Whether reconstruction aid from outside comes as loans to be repaid, which diverts

Poverty cont. on page 164

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NEWS

RADARSAT-1 Interferometric Baseline Catalog at the Alaska Satellite Facility

Interferometric synthetic aperture radar (InSAR) techniques are used in numerous applications, especially in long-term monitoring of surface deformations. For these studies, a large data volume is needed and the issue of careful data selection is critical. One of the main parameters to decide whether a particular data set is suitable for a certain application is the interferometric baseline. The knowledge of the baselines limits the extra processing efforts required to determine the usefulness of data sets for the application project.

While the European Space Agency (ESA) makes available the interferometric baseline information for the ESA Remote-Sensing Satellites (ERS) 1 and 2 and the Envisat satellite, the baseline information for the Canadian Space Agency's RADARSAT-1 satellite is not available. With the development of the RADARSAT-1 baseline catalog at the Alaska Satellite Facility (ASF) in the University of Alaska Fairbanks' Geophysical Institute, this knowledge gap is closed.

RADARSAT-1 acquires data at different look angles that define the various beam modes. An interferometric image pair consists of two SAR images acquired in the same beam mode with almost identical image geometry. The repeat-pass geometry for the RADARSAT-1 satellite is ensured by choosing imagery over the same geographic area that is acquired 24 days apart (or multiples of 24 days apart). For each potential interferometric image pair, a baseline is estimated based on state vectors that describe the satellite orbit, slant range distance, and Doppler frequency. All the relevant information for a baseline estimation is retrieved from a scan results file in the ASF archive that is generated while ingesting raw telemetry signal into the processing system.

The baseline information is calculated on an image frame-by-frame basis. Baseline information is stored related to its orbit number that unambiguously determines the time of the acquisition. The interferometric baselines are stored separately for all InSAR capable beam modes, fine beam 1 (FN1) to fine beam 5 (FN5), and standard beam 1 (ST1) to standard beam 7 (ST7). For each beam mode, the orbits are organized by month and year of acquisition.

For each interferometric image pair, several parameters are provided. The sensor, the beam mode, the frame number, and the individual orbit numbers uniquely identify the two image scenes of the pair. The orbit direction identifies whether the imagery is part of an ascending or descending orbit. The sequence numbers for the orbits simplify the ordering process of the data sets. The interferometric baseline is described spatially by its parallel and perpendicular component and by its temporal component, indicating how many days apart the two data sets have been acquired.

In addition to the Web pages the baseline information is available in two alternative formats that can be downloaded. First, the user can analyze the baseline information offline in tab delimited ASCII text files. Second, a more advanced way of searching interferometric baselines is provided by shape files that contain the location of the frame and the relevant data and baseline information as attribute tables. This allows the direct use of the baseline information in a geographical information system with all its enhanced analysis capabilities.

The RADARSAT-1 baseline catalog is currently limited to the data archive of the ASF, which holds nearly 2.7 million potential interferometric pairs. Apart from real-time data collected within the ASF station mask (Figure 1), defining the area for which data can be acquired by the ASF antennas, the ASF archive contains SAR data acquired from the McMurdo ground station in the Antarctica, data downlinked at ASF from the RADARSAT-1 onboard recorder, and other data acquisitions requested for the satellite. The inclusion of additional RADARSAT-1 archive data from other ground stations into the baseline catalog is being investigated. The baseline catalog is updated on a monthly basis. It is accessible at Web site: http://www.asf.alaska.edu/baselines/.

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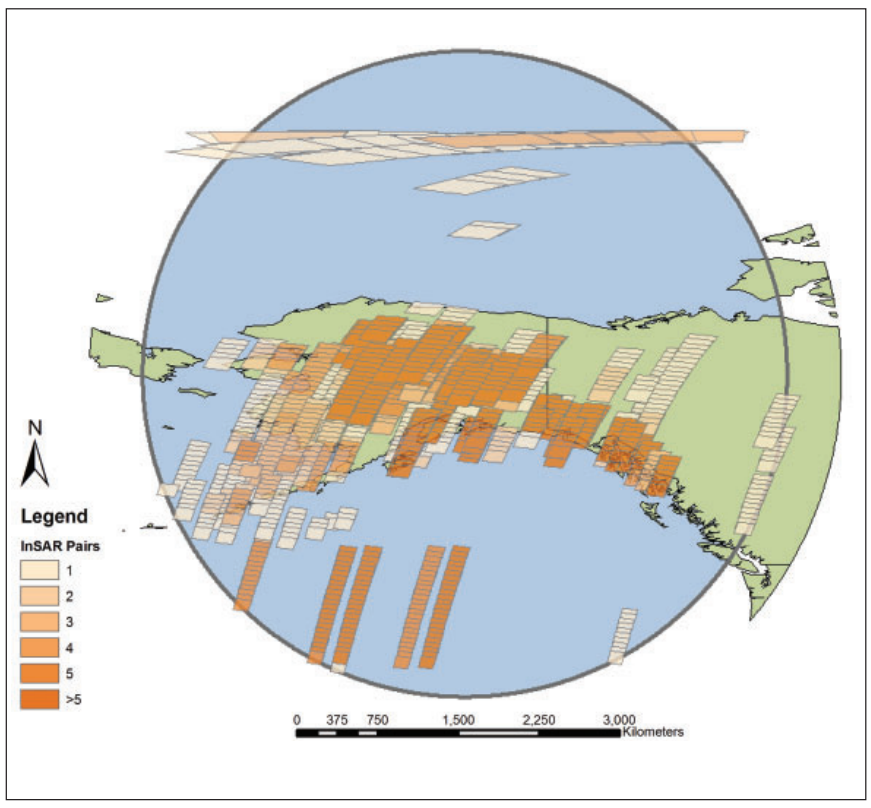

Fig. 1 Real-time RADARSAT-1 InSAR coverage for the ASF station mask. This figure shows an example of descending ST2 orbits with 24 days repeat cycle. The frames drawn on the map indicate areas where interferometric imagery is available. The color scheme represents how many image pairs have been acquired for a certain area.

NSF Geosciences Advisory Committee Solicits Input

The Geosciences Advisory Committee of the U.S. National Science Foundation (NSF) is soliciting the views and concerns of the geosciences community in advance of the committee's spring meeting scheduled for 11– 12 May at NSF Headquarters in Arlington, Virginia. At this meeting, the committee will consider current and future geoscience plans and programs and additional issues of relevance to the community.

The chair and members welcome and solicit the views and concerns of the geosciences community so they may better represent their constituencies at upcoming meetings of the committee.

To contact current members or to obtain additional information about the Geosciences Advisory Committee, including meeting summaries and agenda, visit the committee Web site at: http://www.nsf.gov/geo/advisory.jsp.

The NSF Directorate for Geosciences, through its divisions of atmospheric, earth, and ocean sciences, supports a broad range of innovative research focusing on understanding and predicting Earth's environment and its habitability. The Advisory Committee consists of representatives of the geosciences community who serve terms of three years. The current chair is Robert Detrick of the Woods Hole Oceanographic Institution, Woods Hole, Massachusetts.

SECTION NEWS

GEOMAGNETISM & PALEOMAGNETISM

10th Generation International Geomagnetic Reference Field

The International Association of Geomagnetism and Aeronomy (IAGA) released the 10th Generation International Geomagnetic Reference Field (IGRF) on 12 December 2004. This is the latest version of a standard mathematical description of the Earth's main magnetic field, and is used widely in studies of the Earth's deep interior, crust, ionosphere, and magnetosphere. The coefficients were finalized by a task force of IAGA, Division V, Working Group V-MOD: Geomagnetic Field Modeling. The IGRF is the product of a large collaborative effort between magnetic field modelers and the institutes around the world involved in collecting and disseminating magnetic field data from satellites and observatories.

The IGRF is a series of mathematical models of the Earth's main field and its annual rate of change (secular variation). The sources of the main magnetic field are electric currents in the Earth and the magnetization of crustal rocks. In source-free regions at the Earth's surface and above, the main field, with sources internal to the Earth, can be represented as the negative gradient of a scalar potential V, expanded into spherical harmonics as

$$V(r,\ \ ,\lambda,t) = R\sum_{n=1}^{n_{\max}}\left(\frac{R}{r}\right)^{n+1}\sum_{m=0}^{n}\left(g_n^m(t)\cos m\lambda + h_n^m(t)\sin m\lambda\right)P_n^m(\theta)$$

where r, θ, λ are geocentric coordinates (r is the distance from the center of the Earth, θ is the colatitude, i.e., 90° minus latitude, and λ is the longitude); R is the magnetic reference radius (6371.2 km); $g_n^m(t)$ and $h_n^m(t)$ are the coefficients at time t; and $p_n^m(\theta)$ are the Schmidt seminormalized associated Legendre functions of degree n and order m. The main field coefficients are functions of time.

For the IGRF, the change is assumed to be linear over 5-year intervals. For the upcoming 5-year epoch, the rate of change is given by predictive secular variation coefficients $\dot{g}_n^m$ and $\dot{h}_n^m$. For more details on main-field modelling, the reader is referred to *Chapman and Bartels* [1940)] and *Langel* [1987].

The coefficients of the 10th Generation IGRF are available from the IAGA Web site (www.iugg.org/IAGA) and the World Data Centers listed at the end of this article, as is software to compute magnetic field values from the coefficients. The new coefficients are the preliminary main-field coefficients for 2005.0 and the predictive secular-variation coefficients for 2005.0–2010.0. The previous (9th) generation IGRF with the definitive coefficients for 1995.0 and 2000.0 was finalized at the XXIII General Assembly of the International Union of Geodesy and Geophysics, held at Sapporo, Japan, in July 2003 [*Macmillan et al.,* 2003].

The satellite magnetic missions of the International Decade of Geopotential Research (Ørsted launched 1999, CHAMP launched 2000) are providing an unprec- edented wealth of highly accurate magnetic field measurements. In order to ensure that the accuracy of the IGRF reflects the high quality of available data, IAGA decided in 2001 that the main-field coefficients of the IGRF from the year 2000 onward should extend to degree n_{max} = 13 and be quoted to 0.1-nT precision (to reflect improved spatial resolution and instrument precision). Pre-2000 coefficients extend to degree 10 and are quoted to 1-nT precision. The predictive secular variation coefficients $\dot{g}_n^m$ and $\dot{h}_n^m$ for the upcoming 5-year epoch are given to degree 8 with a precision of 0.1 nT/yr.

With the 9th Generation IGRF, there was an update in the nomenclature. Table 1 provides this new nomenclature, as well as a summary of the history of the IGRF. It is important to specify the generation of the IGRF to establish which coefficients were actually used. For example, one cannot recover the original full-field data from an aeromagnetic anomaly data set in order to connect it with adjacent surveys if one does not know which generation of the IGRF was used. Finally, it is now recommended to use the World Geodetic System 1984 (WGS84, a = 6378.137 km, b = 6356.752 km) when specifying the IGRF in geodetic coordinates.

The new coefficients of IGRF-10 are taken from an average of selected candidate models, produced by T. Chernova, S. Choi, D. Dater, V. Golovkov, V. Lesur, F. Lowes, H. Lühr, S. Macmillan, S. Maus, W. Mai, S. McLean, N. Olsen, M. Rother, T. Sabaka, A. Thomson, and T. Zvereva. Details of the geomagnetic modelling methods will be published later this year in a special issue of *Earth, Planets and Space*.

Acknowledgments

Continuing support for the IGRF project has been provided by the modelers' institutes, other organizations involved in operating magnetic survey satellites, observatories, and World Data Centers.

Table 1. Summary of Nomenclature and IGRF History

Full Name	*Short Name*	*Valid for*	*Definitive for*
IGRF 10th generation (revised 2004)	IGRF-10	1900.0–2010.0	1945.0–2000.0
IGRF 9th generation (revised 2003)	IGRF-9	1900.0–2005.0	1945.0–2000.0
IGRF 8th generation (revised 1999)	IGRF-8	1900.0–2005.0	1945.0–1990.0
IGRF 7th generation (revised 1995)	IGRF-7	1900.0–2000.0	1945.0–1990.0
IGRF 6th generation (revised 1991)	IGRF-6	1945.0–1995.0	1945.0–1985.0
IGRF 5th generation (revised 1987)	IGRF-5	1945.0–1990.0	1945.0–1980.0
IGRF 4th generation (revised 1985)	IGRF-4	1945.0–1990.0	1965.0–1980.0
IGRF 3rd generation (revised 1981)	IGRF-3	1965.0–1985.0	1965.0–1975.0
IGRF 2nd generation (revised 1975)	IGRF-2	1955.0–1980.0	…
IGRF 1st generation (revised 1969)	IGRF-1	1955.0–1975.0	…

World Data Centers

WDC for Solid Earth Geophysics, National Geophysical Data Center, 325 Broadway, Boulder, CO 80303-3328, USA; E-mail: Susan.McLean@noaa.gov; Internet: www.ngdc.noaa.gov

WDC for Geomagnetism, Data Analysis Center for Geomagnetism and Space Magnetism, Graduate School of Science, Kyoto University, Kyoto 606-8502 Japan; E-mail: iyemori@kugi.kyoto-u.ac.jp; Internet: swdc-www.kugi.kyoto-u.ac.jp

WDC for Geomagnetism, British Geological Survey, Murchison House, West Mains Road, Edinburgh EH9 3LA, UK; E-mail: smac@bgs.ac.uk; Internet: www.geomag.bgs.ac.uk

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OPPORTUNITIES

Decadal Study: Request for Information

The U.S. Space Studies Board, in consultation with other units of the U.S. National Research Council (NRC), has begun a study to generate prioritized recommendations from the Earth and environmental science and applications community regarding a systems approach to the space-based and ancillary observations that encompasses the research programs of NASA and the related operational programs of NOAA.

The two-year study will consider cross-agency issues such as the development of an operational capability for land remote sensing. The study seeks to establish plans and priorities within the subdisciplines of the Earth sciences as well as an integrated vision and plan for the Earth sciences as a whole. It will also consider Earth observations requirements for research and for a range of applications with direct links to societal objectives.

A number of outreach activities are planned, including community forums in conjunction with AGU meetings and meetings of the American Meteorological Society.

Ideas and concepts for missions or programs that are directly linked to societal needs and benefits are encouraged. Those received will be reviewed by study panels, which are addressing the following themes: Earth science applications and societal needs; land-use change, ecosystem dynamics, and biodiversity; weather (including chemical weather and space weather); climate variability and change; water resources and the global hydrologic cycle; human health and security; and solid-Earth hazards, resources, and dynamics.

The deadline for submissions is 16 May 2005. For more information, see the Web site, http://qp.nas.edu/decadalsurvey.

Three-Dimensional Model for the Crust and Upper Mantle in the Barents Sea Region

BY H. BUNGUM, O. RITZMANN, N. MAERCKLIN, J.-I. FALEIDE, W. D. MOONEY, AND S. T. DETWEILER

The Barents Sea and its surroundings is an epicontinental region which previously has been difficult to access, partly because of its remote Arctic location (Figure 1) and partly because the region has been politically sensitive. Now, however, this region, and in particular its western parts, has been very well surveyed with a variety of geophysical studies, motivated in part by exploration for hydrocarbon resources. Since this region is interesting geophysically as well as for seismic verification, a major study [*Bungum et al.*, 2004] was initiated in 2003 to develop a three-dimensional (3-D) seismic velocity model for the crust and upper mantle, using a grid density of 50 km.

This study, in cooperation between NORSAR, the University of Oslo (UiO), and the U.S. Geological Survey (USGS), has led to the construction of a higher-resolution, regional lithospheric model based on a comprehensive compilation of available seismological and geophysical data. Following the methodology employed in making the global crustal model CRUST5.1 [*Mooney et al.,* 1998], the new model consists of five crustal layers: soft and hard sediments, and crystalline upper, middle, and lower crust. Both *P*- and *S*-wave velocities and densities are specified in each layer. In addition, the density and seismic velocity structure of the uppermost mantle, essential for *Pn* and *Sn* travel time modeling, are included.

The general motivation for developing this model is basic geophysical research. A more specific goal is to create a model for research on the identification and location of small seismic events in the study region, and for operational use in locating and characterizing all seismic events in the region. Along with the development of the model, a calibration and validation program is also included, aimed at quality controlling the model through comparisons between observed and synthetic travel times, and at improving regional event locations.

The study area is shown in Figure 1. The principle grid points of the velocity model are shown, with 1490 nodes spaced 50 km apart. The input database consists of 712 1-D velocity-depth profiles that are based on various kinds of surveys, including onshore and offshore wide-angle experiments, and density modeling along deep seismic reflection profiles with subsequent density-to-velocity conversion. Most of the data sets are published as 2-D crustal velocity cross sections, and these were sampled every 25 km to obtain the 1-D velocity-depth profiles.

For each of the grid points in Figure 1, the lithosphere is represented by two sedimentary layers separated at a *P*-wave velocity of 3.0 km/s, while the crystalline crust consists of an upper, a middle, and a lower part that are separated at 6.0 and 6.5 km/s, respectively (6.5 and 7.0 km/s for oceanic crust). The upper mantle velocity is also specified at each grid point. Values for each of the tiles located along the wide-angle profiles (Figure 1) are constrained based on primary data.

For regions not constrained by primary data, an interpolation scheme was developed, based on the definition of geological provinces that are characterized by individual tectono-sedimentary histories. Analyses of the compiled database demonstrated strong correlations between sediment thickness and the thickness of the crystalline basement within each of the continental provinces. Depth-to-basement maps were compiled to use this quantitative correlation as a basis for filling the unconstrained nodes. Within each geological province and each of the crustal layers, the velocities are fixed and represented by a mean value calculated from the velocity database. This scheme is valid for at least 80% of the target region, but is not applicable within the oceanic crustal domain, sediment-free cratons, and regions overprinted by convergent tectonics. For these areas, a simple nearest-neighbor interpolation is applied.

An alternative interpolation approach applies a continuous curvature gridding algorithm for horizontal interpolation of seismic velocities within each of the defined provinces. Both of these approaches will be tested in terms of travel time modeling and calibration to explore their potentials and limitations with respect to seismic velocity model construction.

To provide a complete lithospheric model, the crustal model was complemented with an upper mantle velocity structure based on the work of *Shapiro and Ritzwoller* [2002], thereby covering depths sufficient for the tracing of far-regional wave paths. The final representation of the 3-D model will include depth maps for the interfaces and the lateral velocity variation within each layer. For example, the depth to Moho varies from 4 to 5 km (including 2-km water column) off western Svalbard (see Figure 1) to 54 km below the northern Scandinavian craton. The *P*-wave velocities below the Moho range from 7.4 km/s west of Svalbard to 8.35 km/s below Scandinavia.

Figure 2 shows an example of a set of geological and geophysical data compiled in this study along the 1800-km-long, west-east transect A-A' in Figure 1. Figure 2a shows a cross section along A-A', and incorporates most of the geophysical data available. The thickness of the sedimentary cover in the Barents/Kara Sea regions may exceed 20 km. Late Permian to Early Triassic convergent movements along southwestern Novaya Zemlya (the Uralian orogeny, see Figure 1) resulted in uplift and subsequent erosion of sedimentary rocks. Currently, Middle to Late Paleozoic rocks outcrop on Novaya Zemlya.

The velocity structure of the crystalline crust and the Moho topography is well known (solid line) from Norwegian and Russian contributions [e.g., *Breivik et al.,* 2002; *Sakoulina et al.,* 2003]. Whereas the depth to Moho to the west of the continent-ocean transition (COT) exhibits local variations, the lower crystalline crust is rather homogeneous with a velocity of 6.8 km/s.

A closer view of the COT along the transect (Figure 2b) [*Breivik et al.,* 2002] presents the detailed 2-D seismic velocity structure derived from wide-angle profiles in the target region. Almost every profile of the input database is available as a continuous 2-D velocity cross section as is shown here. This was achieved either by obtaining digital models or by digitizing published contour plots. The interpretation of seismic velocities was facilitated in particular by deep seismic reflection lines, which are available especially for the western Barents Sea region. Figure 2c shows a data example with a prominent crustal root structure (arrows), and Figure 2b a line drawing of the entire line [e.g., *Gudlaugsson et al.,* 1987].

Regional potential-field data taken along transect A-A' reveal features that support the geological interpretation (Figure 2d). The comparison of the free-air gravity field with the field calculated from the model will be part of its final validation. Figure 2e shows seismic wave fronts (black, 5 s steps) and rays (white) from an initial first arrival travel time modeling using a finite difference method, and Figure 2f compares the corresponding travel time curve (black) with the 1-D models IASPEI91 (blue [*Kennett and Engdahl*, 1991]) and BAREY (red [*Schweitzer and Kennett*, 2002]). Reflecting the large lateral inhomogeneities along these profiles, the figure shows significant deviations from the 1-D travel time models, albeit, as expected, a lot less for the regional model (BAREY) than for the global model (IASPEI91).

Validation of the velocity model includes forward modeling of observed travel times and relocation of seismic events. For this purpose, a set of reference events with known or well-located epicenters was compiled. Such events are referred to as "ground truth" (GT) events. These events are taken from *Hicks et al.* [2004] and *Bondar et al.* [2004], supplemented by additional data from NORSAR.

The GT events comprise quarry blasts located mainly in Scandinavia and the Kola Peninsula, nuclear explosions in NW Russia and on Novaya Zemlya, and natural earthquakes. With these events, good travel path coverage is obtained in the western half of the model region and in the SE Barents Sea. The coverage is weaker to the NE, due to a lack of recorded seismicity and man-made events from that part of the target region.

This new model of the crust and upper mantle in the greater Barents Sea region is now undergoing further refinement and will be completed by the end of 2005. Documentation of the model and insights into the structure and evolution of the Barents Sea region will be published in forthcoming papers, and the final model will be made available for use by the scientific community.

Acknowledgments

We thank Anatoli Levshin for providing the *Shapiro and Ritzwoller* [2002] mantle velocity model, and William S. Leith and Johannes Schweitzer for their valuable contributions. This research has been sponsored by the U.S. Department of Energy under contracts DE-FC52-03NA995081, DE-FC52-03NA995092, and DE-FC52-03NA995313.

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Barents Sea cont. on next page

Barents Sea

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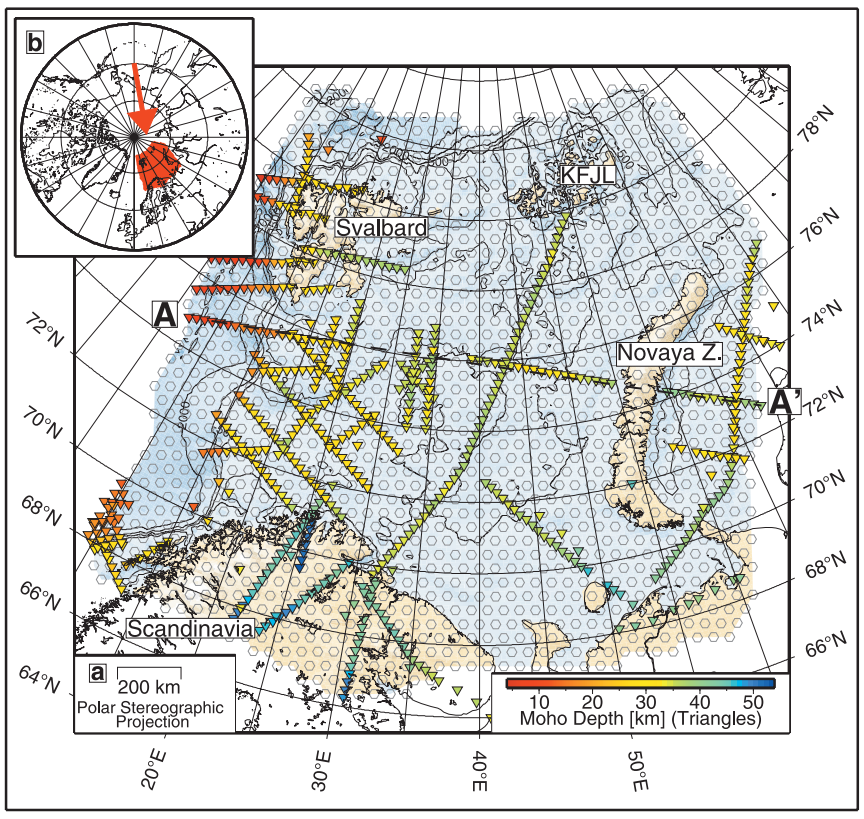

Fig. 1. Map of the greater Barents Sea region, shown in red in the inset map. The lines marked with triangles are wide-angle profiles where the color coding indicates the Moho depth. The small hexagons are tiles spaced 50 km apart that will be filled with crustal and upper mantle velocities. The profile A-A' is the one for which detailed results are shown in Figure 2. KFJL, Kaiser Franz Josef Land.

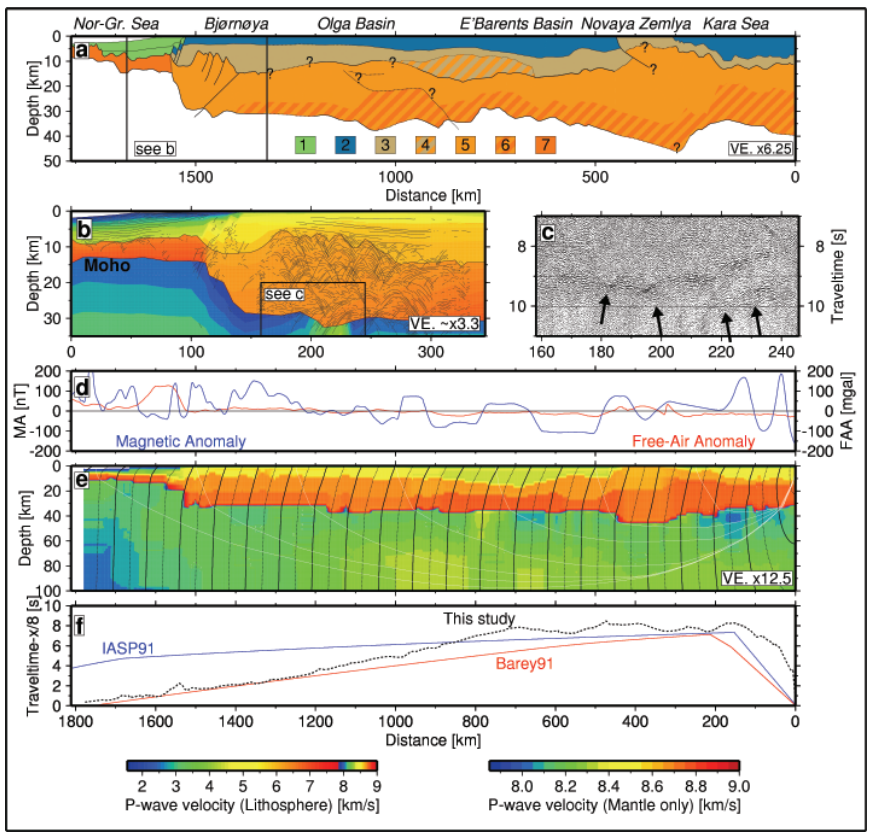

Fig. 2. Observations, interpretations, and modeling for the Barents Sea A-A' transect shown in Figure 1. Figure 2a shows the geological units along the transect ranging from the oceanic crustal domain in the very west to Novaya Zemlya and the Kara Sea in the east. Along the 1800-km-long transect, all available data were used to display the distribution of sedimentary and crystalline crustal rocks: 1, Cenozoic sediments; 2, Mesozoic sediments; 3, Paleozoic sediments; 4, Paleozoic sediments and/or crystalline rocks; 5, continental crystalline rocks; 6, lower crustal crystalline rocks with v_p 6.6–6.8 km/s; and 7, oceanic crystalline rocks. Figures 2b and 2c illustrate database examples along this transect, i.e., a P-wave velocity model (with line drawing) and deep seismic reflection data, respectively (see insert boxes for along-transect location). Figure 2d shows potential-field data along the profile, Figure 2e shows the 3-D model with superimposed seismic wave fronts, and Figure 2f shows travel times in comparison with two 1-D models. For the velocity models in Figures 2b and 2e, the lower color scales apply, where the left scale covers the entire range of lithospheric velocities and the right scale covers the mantle velocities only. Note that at 7.8 km/s, the scale shows repeating colors (crust-mantle transition).

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MEETINGS

Environmental Sensor Networks

This report is based on the 2004 AGU Fall Meeting's session entitled "Special Focus: Advances in Data Acquisition, Management, Analysis and Display: Cyberinfrastructure for Earth Systems Science IV: Sensor Networks."

An environmental sensor network comprises an array of sensors that gather data autonomously and automatically forward the data to a central server. What differentiates modern sensor networks from previous techniques is an emphasis on "intelligence" in the sensor packages as well as the data network. Modern sensor networks also typically publish the data on the server to the World Wide Web and allow real-time access to the data. These networks require a unique combination of technological and environmental understanding, and have the potential of creating a revolution in environmental monitoring, similar in impact to satellite remote sensing in the 1970s.

Within an environmental sensor network, the sensor nodes gather data autonomously and a network is used to pass the data to one or more base stations (Figure 1). While wired networks can be used, for many applications the aim is to move toward a wireless networks (wire is expensive, obtrusive, and can disturb the environment being monitored). When the sensor nodes dynamically intercommunicate in order to establish a network, this is termed an ad hoc network.

Different types of data are collected by the sensor nodes. These include specific environmental parameters (e.g., soil moisture, stress, tilt) as well as generic data such as meteorological or dGPS (differential GPS). These data can be in different forms, digital and analogue, spatial and temporal, database or image, fixed or moving. At the server level the data can be visualized and analyzed within a geographic information system (GIS), combined with a satellite image and/or map, and published via the Web to give researchers seamless access to information.

In some remote or hazardous environments, data on basic environmental processes can be measured for the first time. In addition, sensor nodes can store data (to be released on instruction), make decisions about what data to pass on (e.g., local area summary), and even make decisions about when and what to sense (when conditions are appropriate). The network may be able to respond to data sent by the sensor nodes and act as a vital hazard warning system; e.g., if an oil spill happens or a weather forecast suggests a storm will occur, then the nodes can switch on or change their behavior. The aim of future sensor networks would be the monitoring of the environment at all scales, with the data automatically forwarded to the Internet where it would be integrated and analyzed with different data sets within an "intelligent" cyberinfrastructure.

The development of environmental sensor networks (which have evolved from automated loggers that record data at specific intervals and require manual downloading by a maintenance team) has occurred because of the miniaturization of electronics and wireless technology. In particular, *Chong and Kumar* [2003] have argued that sensor networks integrate research advances from sensors, communication, and computing. In addition, *Martinez et al.* [2004] have argued that understanding environmental processes is another vital component in sensing the environment.

Sensor nodes need to be low cost (so that many can be deployed to sense the environment at a small scale), low power (otherwise they do not run without constant battery maintenance), robust (due to the hostile nature of most environments), and non-polluting, and preferably need to be camouflaged. Sensor nodes also need to be specifically designed for the environment they are sensing. They also need to be at the appropriate scale, record the necessary environmental parameters at a suitable time interval, and, if possible, behave like a natural part of the environment.

Two examples are the GLACSWEB project [*Martinez et al.,* 2004], which senses glacier behavior, uses sensors embedded in a probe shaped like a clast, and the Berkeley habitat modeling at Great Duck Island, Maine, which analyzes bird nesting habits and uses camouflaged nodes in bird burrows [*Szewczyk et al.,* 2004]. In the future, sensors on a sub-millimeter scale (tiny wireless microelectromechanical sensors (MEMS) known as "smart dust") [*Kahn et al.,* 2000] may be available to monitor water flow patterns or quality.

However, new data collection methods can generate their own research problems. One inevitable consequence of continuous data from numerous sensor nodes is the generation of enormous amounts of data. This will need to be handled within a GIS and/or cyberinfrastructure system which allows other systems to find out what types of data are available and how to get them automatically. This is where semantic Web technologies (http://www.w3.org/2001/sw/) will be indispensable, as common ontologies can evolve which will help to unify differently named data on the servers. In principle, these Web services would allow a sensor network to fetch weather data from a completely different provider and allow researchers to have one view of data even though the data come from many sources.

The 2004 AGU Fall Meeting provided an opportunity to present results from sensor networks from different scales and environments. This was one of the first times that researchers have discussed this new theme within a general geoscience conference; prior to this, some projects reported technical aspects at recent inaugural conferences (e.g., the First ACM (Association for Computing Machinery) Conference on Embedded Networked Sensor Systems 2003; the First IEEE (Institute of Electrical and Electronics Engineers) Communications Society Conference on Sensor and Ad Hoc Communications and Networks 2004), while the environmental aspects have been discussed within their separate subject fields. So, it was the first time that both speakers and audience had a chance to meet, listen, and share ideas outside their own immediate research areas.

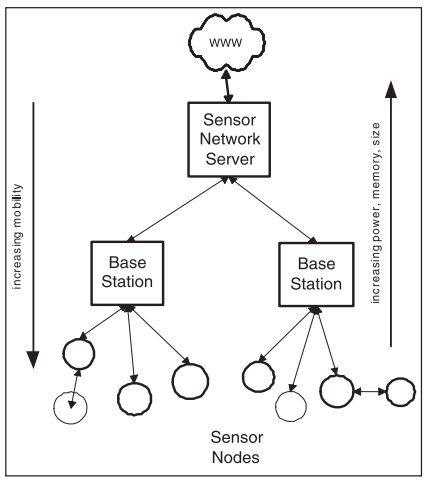

Fig. 1. Schematic diagram of an Environmental Sensor Network.

The session had an unusual name but still generated an impressive audience. The session brought together researchers working on the technological aspects of sensor networks as well as practitioners. Kevin Delin from NASA's Jet Propulsion Laboratory introduced the session with a summary of his pioneering research on sensor webs from different environments (from Huntington Gardens, Antarctica, and future Mars projects) [*Delin,* 2004]. He outlined the advances in sensor networks research as well as the challenges.

Jonathon Lees of the University of North Carolina spoke about a wireless sensor network of seismic stations for monitoring the Tungurahua volcano in Ecuador. Lees and his colleagues showed how an array of inexpensive geophones could be used as a volcano hazard alert system. On a similar scale, Kirk Martinez of the University of Southampton, U.K., described the GLACSWEB project, which uses sensor nodes inserted beneath the ice that record stress, tilt, temperature, and water pressure to better understand glacier dynamics (and ultimately glacier response to climate change).

On a larger scale, Richard Holmen of Oregon State University described the Argus video system for nearshore monitoring. The Argus video system illustrates the evolution from passive logging to an active environmental sensor network which began simply as video recording in 1992. Since data reduction is necessary, images are "intelligently" processed; otherwise, video data would overload the communications infrastructure.

This system provides exciting new data to understand nearshore wave processes.

George Thomas of the University of Washington concluded the session by describing large-scale monitoring projects such as the Tropical Atmosphere Ocean Project to monitor the El Niño, and the Pacific Northwest Seismograph Network to monitor seismology around Mount St. Helens. Although these systems are not currently ad hoc sensor networks, they have the potential to be networked in a more "intelligent" way now that the expensive infrastructure (fixed buoys, etc.) has been installed.

The sessions made it clear that there is a need to collect basic data about many environments, since this has not previously been available, and also a need for more focused data collection and data for hazard alerts. Although this field is in its infancy, significant first steps have been made, and many generic problems have been solved or debated. In particular, projects are now up and running using off-the-shelf and custom designs, and the challenges of power management and communications have been investigated and are better understood.

Acknowledgments

We thank the AGU organizers for accepting this special session, the speakers for their contributions, and participants for making this event such an exciting inauguration.

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Bora

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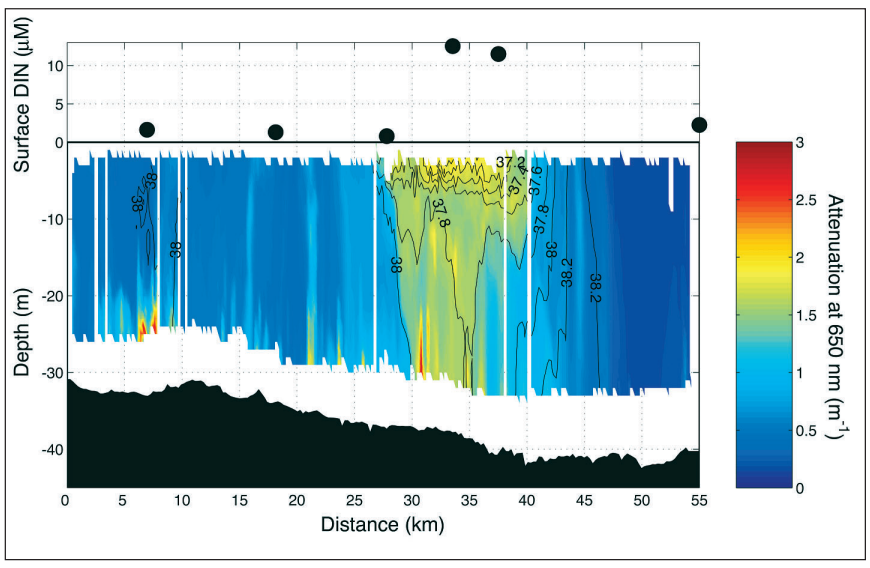

Fig. 2. Salinity (contours) and 650-nm beam attenuation (color) from a high-resolution towed profiler section across the Po plume (20 February 2003, magenta line in Figure 1a). Black dots (top panel) mark surface dissolved inorganic nitrogen (DIN; nitrate + nitrite + ammonium) measured from bucket samples along the survey track.

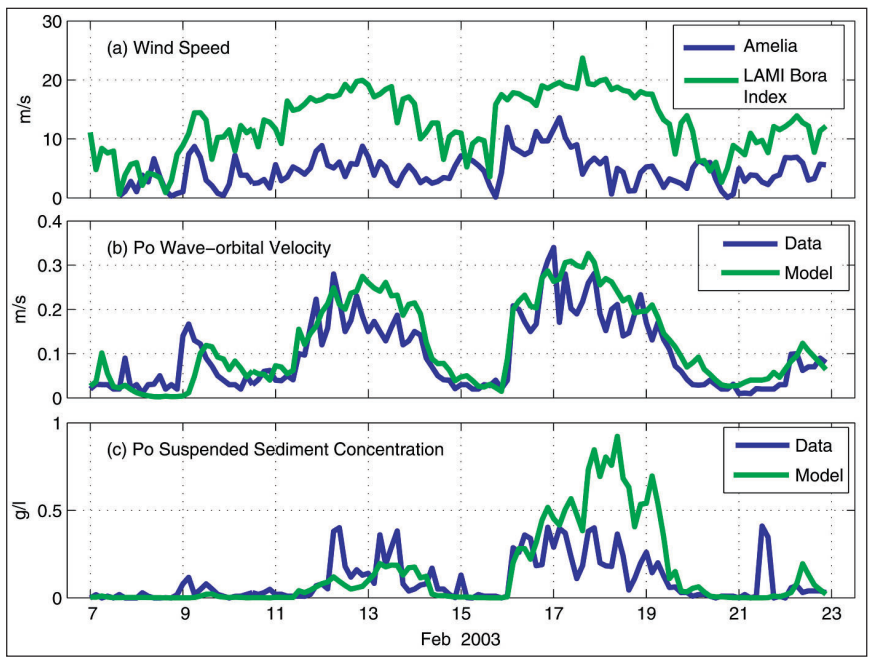

Fig. 3. (a) Maximum wind speed in the bora jet of Kvarner Bay (modeled) and maximum observed wind speed at the AGIP platform Amelia (see Figure 1a for location). (b) Wave orbital velocity from the Po 12-m tripod data and from the Simulating Waves Nearshore (SWAN) wave model. (c) Suspended sediment concentrations from the Po 12-m tripod data and from the Regional Ocean Modeling System (ROMS) sediment transport model.

and synthetic aperture radar) and meteorological sampling conducted from midbasin gas drilling platforms, moorings, and shore stations (Figure 1a).

Most significant, this observational activity documented, with an unprecedented level of detail, the response of the northern Adriatic to a bora event. Many of the projects intentionally focused on the response to bora, and the suite of measurements and numerical simulations provides physical, meteorological, biological, optical, and sediment transport perspectives.

The February Bora

A bora event from 11–19 February 2003 characterizes the scope of these efforts. A synthetic aperture radar (SAR) image taken on 12 February 2003 (Figure 1b) reveals the swift wind bands of the bora (red) interleaved with relatively quiescent areas. Generally, the highest winds were on the eastern side of the Adriatic, although bora jets often maintain their shape and intensity across most of the northern basin. Both SAR and 4-km Coupled Ocean/Atmospheric Mesoscale Prediction System (COAMPS™) model winds (Figure 1b) depict narrow, sea surface wind jets extending from the eastern boundary at the Gulf of Trieste, Senj, and Sibenik. In contrast, surface winds close to the Italian coast were weaker and less organized.

At Zadar (on the Croatian coast), high-velocity bora flow extended from the surface to 1200 m, with peak speeds of 15 m s^{-1} at 200 m. Wind speed then weakened with height to 2500 m, and increased above this level.

Surface winds at Zadar averaged 11 m s^{-1} between 11and 14 February, with ~2°C mean air temperature during this period. After a brief slackening, Zadar winds strengthened through 19 February and subsided shortly thereafter. As the strong downslope winds associated with the bora penetrated to the surface, an unstable boundary layer developed due to the approximately 10°C cooler air overlying the relatively warmer sea. This drove strong oceanic heat loss and produced both oceanic and atmospheric convective mixing.

This suite of measurements allows a comparison of the February event with a canonical bora. Although the February bora produced only moderate winds, it continued for an extraordinarily long period, exceeding 9 days. Wintertime bora events typically span a single day, although in rare circumstances they may extend as long as 10 days [*Penzar et al.*, 2001]. On 12 February, R/V *Knorr* recorded wind speeds in excess of 20 m s^{-1} off Senj, suggesting that the 11–19 February bora was of moderate intensity relative to the historical maximum (60 m s^{-1} gusts). The statistical quantification of bora characteristics, including characterization of atmospheric boundary layer evolution, is a novel feature of this research.

Ocean Circulation and Mesoscale Response

Strong wind and buoyancy forcing produced by the 11–19 February event drove distinct circulation patterns in the northern Adriatic. Intense wind stress curl associated with the bora jets extending from Trieste and Senj (Figure 1b) drew a cold, fresh plume of Po River water across the northern basin, traversing beneath the wind minimum nearly to the Istrian coast (Figure 1a). The plume separated a northern cyclonic gyre from anticyclonic circulation to the south (Figure 1a).

Another front extended westward from the southern tip of Istria, separating the anticyclonic gyre (cold, fresh waters) from a large cyclonic gyre (warmer, more saline waters) to the south. The West Adriatic Current (WAC) formed the western side of this cyclonic gyre, and its transport was intensified threefold by this bora event. Temperature-salinity contrasts across the Istria front largely compensated, producing only weak density gradients. Nonetheless, strong easterly winds drove downwind (westward) currents along the front. With the exception of those areas influenced by riverine discharge, strong wind-driven mechanical mixing and convective overturning ensured that the northern Adriatic remained vertically homogenous. Lateral variations in winds and net surface heat flux, modulated by the presence of surface-trapped, buoyant river discharge, produced horizontal variations in temperature, salinity, and stratification.

Small-scale variations in atmospheric forcing thus influenced dense water formation by imparting spatial structure through wind mixing and net heat flux and by generating mesoscale and sub-mesoscale features (such as the Po plume extension). Such features, in turn, advectively altered stratification and modulated the effects of atmospheric forcing.

The large suite of concurrent physical measurements provides a detailed, four-dimensional (spatial structure and temporal evolution) perspective that will facilitate upcoming dynamical investigations.

Biological and Optical Response

Po River inflow controls wintertime optical variability in the northern basin by influencing circulation and stratification and providing a continuous source of nutrients, suspended particulates, and colored dissolved organic matter (Figure 2). Fresh plume waters exhibit a near-surface nutrient maximum, enhanced phytoplankton activity, and elevated suspended particulate concentrations dominated by small, slowly sinking inorganic material. These biological and optical properties migrated with the plume as bora forcing drew it eastward over the course of the event, with phytoplankton maxima typically occurring near the outer boundaries.

Forced by much weaker riverine sources, the eastern basin exhibits reduced nutrient, particulate, and phytoplankton concentrations. Biological and optical properties trace the origins of the waters to either side of the Istria front. Low chlorophyll concentrations and elevated, vertically uniform suspended particulate concentrations characterize the

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Poverty

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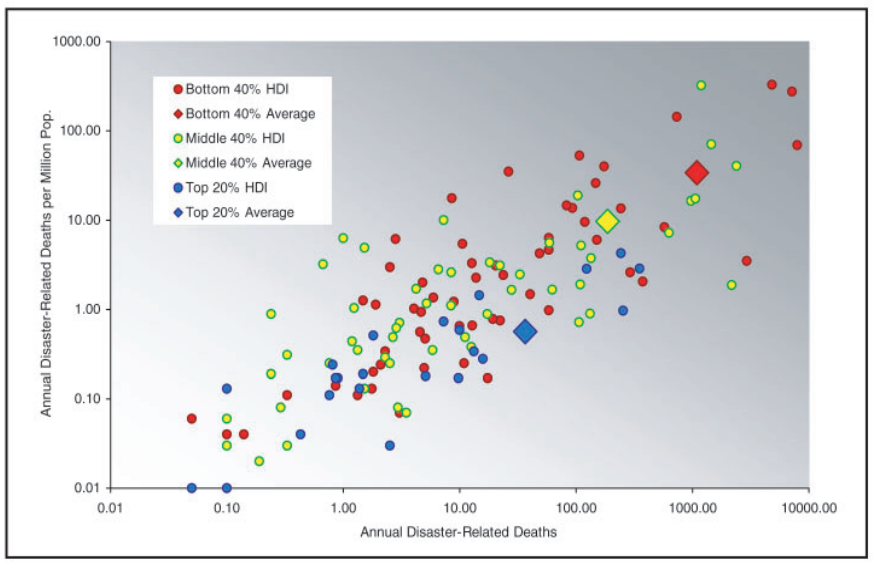

Fig. 1. Average annual death toll for all hazards against the death toll relative to population, 1980–2000. Highly impacted countries are in the upper right where many deaths occur, and those deaths are in high proportion to population. Countries are colored with the Human Development Index (HDI) that combines indexes of per capital income with health status (longevity) plus a measure of educational opportunities. A simple average is included. While there is a great deal of spread indicating that a variety of influences are important, there is a clear relationship between human development and mortality risk from natural hazards.

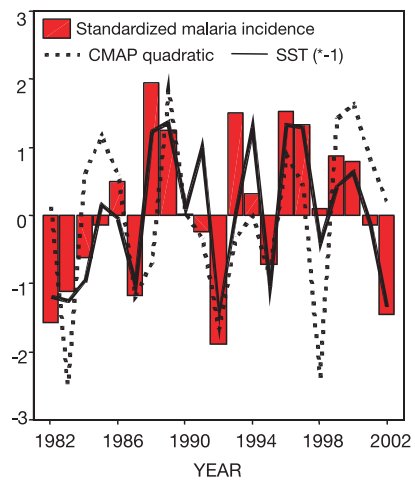

Fig. 2. Malaria incidence anomalies in Botswana related to climate anomalies. Anomalies in sea surface temperatures (Nino 3.4), December–February (DJF), a quadratic rainfall model (measured using Climate Prediction Center Merged Analysis of Precipitation (CMAP)) for the same months are overlaid on standardized malaria cases per 1000 population (incidence) anomalies (for the period 1982–2003; main transmission period January–May). The malaria data have been standardized to remove non-climate-related trends and the impact of a major policy intervention in 1997. There are many factors that can cause changes in malaria incidence data, including changes in reporting, drug resistance, and control initiatives. However, in the semi-arid areas of Africa, rainfall is a major driving force of inter-annual variability in malaria. Where sea surface temperatures are significantly related to these changes, it may be possible for health services to use seasonal climate forecasts to predict malaria anomalies, before rains have fallen.

funds from development programs, or as a donation, productivity losses and the disruption of lives that follow major disasters can impede growth and even destabilize governments. A 2004 UNDP report (http://www.undp.org/bcpr/) details how disaster risk reduction could be a key factor in achieving the U.N.'s Millennium Development Goals (http://www.un.org/millenniumgoals/).

Figure 1 depicts a clear relationship between human development and mortality risk from natural hazards. The causes that underlie the relationship are numerous. The urban poor have little choice but to live in high-risk, "informal settlements" around major cities close to work opportunities—in riverbanks subject to flooding, on the slump scars of landslides on denuded slopes, or in crowded coastal regions such as those where so many died around the Indian Ocean from the recent tsunami.

In Haiti, rural poor denude the land of trees to raise crops at low yields and to produce charcoal to sell cheaply. Cleared land promotes flash flooding and the disasters that took about 6000 lives there in 2004 compared with about 100 in the U.S. Gulf Coast from the very same storms.

Earthquakes, too, exact the greatest toll on the poorest people. *Zoback* [2004] points out that the 1989 Loma Prieta earthquake in California (magnitude 6.9) left 63 dead and more than 3700 injured, while the 2001 Bhuj quake in Gujarat, India (magnitude 7.6), killed over 13,000 and injured more than 100,000.

Poverty and disaster vulnerability are codependent: while vulnerability is an outcome of poverty, it is a likely cause as well. A feedback develops that traps the poor into a spiral of increasing deprivation. Poor countries in the front line of natural hazards are more likely to get stuck in poverty, and parts of the world subject simultaneously to several hazards, notably Central America, the Andean countries, and parts of Southeast Asia, are particularly hard hit and the most likely, it seems, to be trapped by hazards.

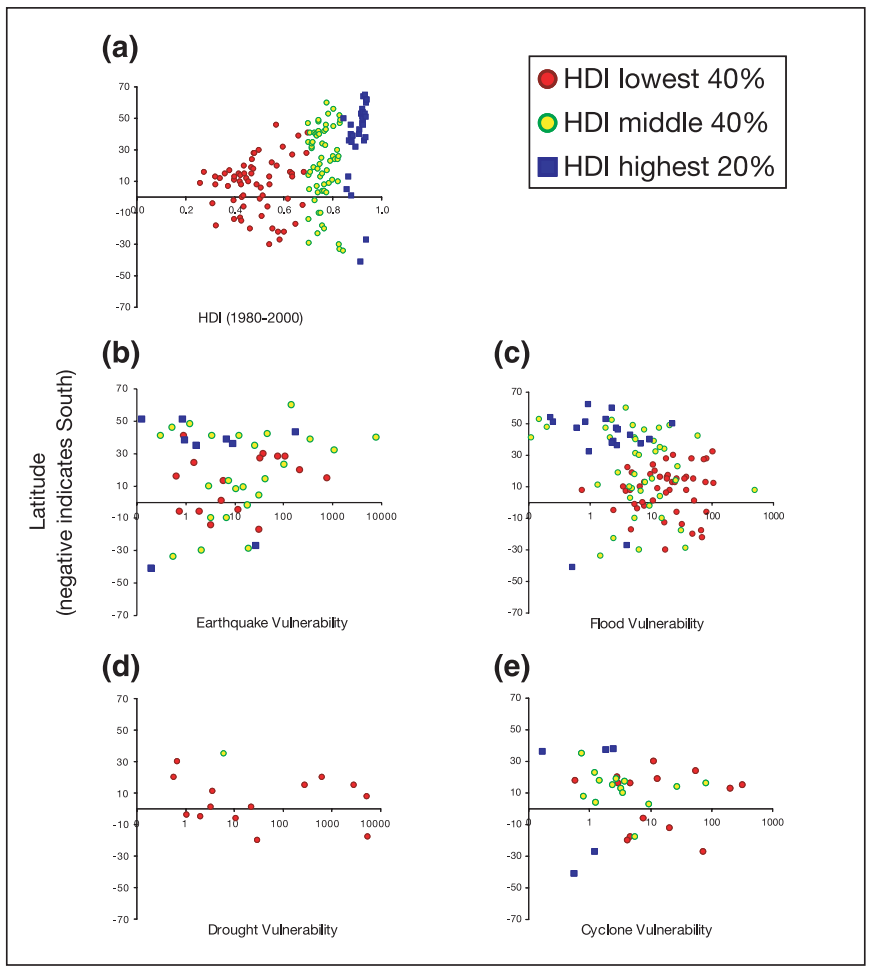

Fig. 3. (a) HDI against latitude (north positive) shows the great prevalence of low HDI countries in the equatorial regions. Countries with lowest HDI are generally located near the equator. The color division is the same as in Figure 1 and is used in the subsequent figures. Figures 3(b), (c), (d), and (e) show vulnerability (defined as the number of people killed per million exposed to a particular hazard) for earthquakes, floods, droughts and cyclones using data presented by the UNDP (2004; http://www.undp.org/bcpr/). For flood vulnerability (3c) there is a clear separation between high HDI countries (blue) and low HDI countries (red), with the lower countries generally being much more at risk. These plots do not account for the relative severity of the natural events. Rainfall, and hence floods, are more intense in the tropics, but low HDI countries are one or even two orders of magnitude more at risk than high HDI countries; a difference that greatly exceeds the relative severity of natural hazards in these regions. Droughts that cause mortality (3d) are almost exclusively a poor world phenomenon. Earthquake vulnerability (3b) should have no natural latitude dependence and the results are more scattered, but a tendency for the richest to be least vulnerable remains. Note that these compilations do not include recent earthquakes in Gujarat, India and Iran, flood deaths in Haiti, or the Asian tsunami disaster that would serve to enlarge the differences between rich and poor.

Variations Closer to the Norm

Cane et al.'s [1986] insight into the influence of El Niño–Southern Oscillation (ENSO) variations on grain production in Zimbabwe show a co-variance between sea surface temperature anomalies in the eastern equatorial Pacific and maize yield that has significance for large deviations from normal (El Niño years may bring drought and famine) and across much smaller variations. Similar relationships exist for agricultural production in northeastern Brazil, and fisheries off Peru.

Sub-Saharan Africa is home to about 90% of the world's malaria morbidity and mortality, the spatial and temporal dynamics of which relate to climate conditions. Underlying ecological conditions there have made the disease particularly difficult to control, much less to eliminate [*Gilles*, 1993; *Gallup and Sachs*, 2001]. Extreme rainfall anomalies may lead to major epidemics [*Brown et al.*, 1998], but ENSO-driven variations well within the range of normal conditions also have marked effects (Figure 2; M. C. Thomson et al., Climate monitoring for malaria early warning in Botswana, submitted to *Emerging Infectious Diseases*, 2004).

ENSO variations are a set of semi-periodic variations that dominate the climate signal in equatorial regions that are also host to the poorest in the world. Their susceptibility to these variations will amplify the consequences of relatively small changes into disasters.

Disease burden, like natural hazards, increases the resources needed for basic survival, diminishes opportunity for individuals, and encumbers scarce resources that could be used for economic growth (World Health Organization Commission on Macroeconomics and Health, 2001). Unhealthy people are less productive, cannot fully benefit from education to gain better jobs, and require more public expenditure (if available). Whether from a health or food security perspective, climate is indirectly, but certainly, an influence on human well-being.

Just as ENSO-driven climate variations imperil the livelihoods of the poorest and most vulnerable, global climate change, even by a small amount, puts poor societies under threat.

Poverty cont. on next page

Poverty

cont. from page 164

A Global Ecology of Poverty

The poorest often have few choices available to adapt to variations in natural conditions; they may not be able to harvest water, plant different crops, move to less stressed regions, or provide disaster-resilient infrastructures. Scarcity often means more time spent foraging for food and fuel. Haiti's deforestation is one example of a feedback loop in which attempts to cope with poverty themselves amplify the conditions that produce further poverty [*Mutter,* 2004].

Countries caught in or near this feedback amplification have a suite of characteristics that *Sachs et al.* [2004] identify as an ecology of the human condition. They point out that most of the world's poorest people live in tropical or arid countries, due neither to historic accident nor the fault of government (Figure 3a). These people are vulnerable to tropical climate extremes, diseases, pests, soil nutrient depletion, land degradation, and, in some regions (mountainous sites of high population density and the interior of sub-Saharan Africa), very high transport costs of needed goods and products to market.

Vulnerability to natural variations in Earth's behavior preferentially affects the lives of the poorest concentrated in equatorial regions (Figure 3), and suggests that Earth's natural processes contribute to an ecology of poverty. Many consequences of ENSO, for instance, have their greatest impact in tropical countries. In Central America, multiple hazards suppress growth opportunities.

A Role for Earth Science in Improving Human Well-Being

Human well-being and Earth's natural systems share a relationship that is complexly codependent, regionally diverse, often indirect, subtle, and nonlinear. Although clear correlations exist, they do not establish to what extent the correlations describe outcomes or causes of poverty. A basic research question is: How does the condition of the Earth govern and limit human well-being? This research domain lies on the boundary between natural Earth sciences and the social sciences, including economics. The research demands skills well known to Earth scientists, including spatial data analysis, time series analysis, inverse methods, observation and monitoring, and statistical analysis applied across data sets from both the natural sciences parameterizing Earth systems, and social science data that describe human systems.

The research, which is most pertinent to the world's poorest societies, is unlikely to occur there, where science of any sort is virtually absent. What is needed is an effort like the Commission on Macroeconomics and Health, launched by the World Health Organization in 2000. The commission produced a 2001 report, with Jeffrey Sachs as lead author, that established the dual nature (both cause and consequence) of disease burden on poor people.

Participation by stakeholders from poor countries is essential to building their capacity to conduct research. The U.S. National Science Foundation and other granting agencies must develop programs targeted toward issues of the poor world. The AGU and other scholarly societies can also take up the challenge (e.g., J. C. Mutter et al., Earth science, human well-being, and the alleviation of global poverty, session presented on 14 December at the 2004 AGU Fall Meeting, San Francisco, Calif.).

In addition, individual scientists in this rich society must develop research programs that will help to improve the condition of so many who have so little and need so much.

Acknowledgments

I appreciate the counsel and encouragement of Jeffrey Sachs, director of the Earth Institute at Columbia University, in preparing this work. Sachs offered valuable and substantive editorial improvements. I thank Madeleine Thomson of the International Research Institute for Climate Prediction at Columbia for Figure 2 and for discussions. Margarethe Lorenzi provided substantial editorial improvements, Ryan Meyer provided key technical assistance in the analysis of the data presented and Ravi Rajakamur provided critical assistance in preparing the figures. John W. Geissman provided superb editorial guidance for *Eos*.

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Bora

cont. from page 163

cold, fresh waters of the front's north side.

The absence of a near-bottom suspended particulate maximum suggests that these high concentrations were not produced by local resuspension, but may instead have been advected from the region surrounding the coastal islands to the east and southeast. The physical and bio-optical variables were highly correlated on either side of the front, indicating that the physical processes dominated the distributions of the bio-optical properties.

Sediment Transport

Bora winds affect sediment distribution by enhancing waves and strengthening currents. The Po River in the north and small, episodically flooding rivers that drain the Apennine Mountains to the Adriatic central basin are the major sources of sediment. Though most Po River sediment appears to settle on the bed within hours of reaching the coastal sea, much is redistributed before ultimately being buried. Transport within the bottom boundary layer (~10 m thick) usually dominates sediment flux. Although sediment flux variability is high, on average bora events drive sediment southward along the shelf with little across-shelf transport.

The 11–19 February bora produced sediment transport patterns consistent with larger bora events on record. Elevated sediment concentrations measured at sites along the Italian coast are associated with waves generated during bora events (Figure 3). Wave heights on the Po delta reached approximately 1.1 m, with peak suspended-sediment concentrations approaching 0.5 g/L at 30 cm above bottom (Figure 3).

Between 15 and 19 February, net sediment flux on the Po delta was dominated by a 22-hour period when the currents were consistently southward, along the bathymetry. Although sediment concentrations were equally high during the rest of the bora period, fluctuating current direction produced little net flux.

Synthesis Provided by Numerical Results

Several groups conducted high-resolution ocean (2 km), atmosphere (4 km), and sediment transport simulations that provide critical tools for assessing Adriatic dynamics. Counter-rotating gyres, cyclonic in the far north and anticyclonic nestled against the Istrian peninsula, are a generic response to bora forcing that strongly affects the biology and sediment (Figure 1b). The gyres help maintain frontal boundaries and drive cross-basin transport. The WAC acts as a conduit for riverine waters and sediment. A paucity of observations impedes the understanding of small-scale circulation along the Croatian coast, although these features may participate in wintertime dense water formation. The cyclonic gyre located off the Po mouth transports a small, but noticeable fraction of sediment to the northeast (not shown).

Modeled wave orbital velocities and sediment concentrations capture the dynamics of bora-induced transport (Figures 3b and 3c). Model results for the 9-month winter period show that several mechanisms contribute to southward alongshore sediment transport in a narrow coastal band in the western Adriatic. These include buoyancy-induced coastal flow associated with river-derived sediments, wind-enhanced coastal flow coupled with wave-resuspended sediments under both strong winds, and persistent counter-clockwise flow driven by basin-scale estuarine circulation and mean wind stresses. In these simulations, these mechanisms produced depositional patterns similar to the observed late Holocene deposits, suggesting that event scale models can provide insight about sedimentation on geologic timescales.

The unprecedented suite of research activities that focused on the Adriatic in winter 2003 provided a multi-faceted view of bora events and the resulting oceanic response. Observational and numerical efforts spanned a broad range of temporal and spatial scales, providing a "four-dimensional" (space and time) depiction of bora response that will facilitate detailed dynamical investigations of response to small-scale wind forcing, dense water formation, and Adriatic general circulation. Likewise, multi-disciplinary measurements and modeling promise to characterize the biological and sediment response to bora-induced dynamics.

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BOOK REVIEW

Hurricanes and Typhoons: Past, Present, and Future

RICHARD J. MURNANE AND KAM-BIU LIU, EDITORS

Columbia University Press, New York; ISBN 0-231-12388-4; xii + 462 pp; 2004; $89.50.

This is a topical book on tropical cyclones, known more popularly as hurricanes in the Americas and typhoons in eastern Asia. The subject may appeal to academics and researchers as well as to the general public.

The best way to predict the future variability of tropical cyclones is by examining their past record. Prehistoric records can be obtained from geological or archeological studies while historical records are provided by documentation and instrumentation. Of particular interest now are the changes in frequency and landfall pattern of tropical cyclones during El Niño years, La Niña years, and neutral years, extending back in time to cover the past 8,000 years for disaster planning.

Following an outline in the preface and an overview (chapter 1), the book is divided into four parts. Part I (two chapters) uses case studies to deal with prehistoric variability on millennial to centennial timescales. The editors claim that chapters 2 and 3 are state-of-the-art summaries on paleotempestology. However, the chapters only make use of coastal lake sediments and back-barrier sedimentary records, and ignore recent published material on the geological record of these events in shelf environments and rocky shorelines.

Part II (six chapters) deals with historic variability on centennial to annual timescales. Chapters 4–7 look at the analysis of documentation records of hurricanes in the Atlantic Ocean, while chapter 8 focuses on a 1000-year record in the Guangdong Province of southern China. In chapter 9, the problems in developing best-track data sets are examined.

Part III (four chapters) deals with present-day variability on interdecadal to intraseasonal timescales. Chapter 10 shows that real-time predictions of seasonal or annual tropical cyclone activity in the northwestern Pacific Ocean have been successful. Chapter 11 provides a review of El Niño–Southern Oscillation (ENSO) and tropical cyclone activity in the Pacific Ocean and the North Atlantic, revealing variable response. How climate variability can alter hurricane landfall probabilities along the U.S. coastline is shown in chapter 12. Chapter 13 shows the potential of dynamical methods for predicting seasonal tropical cyclone activity.

Part IV (three chapters) examines possible future changes. Chapter 14 shows a feedback relationship between tropical cyclone variability in response to climate, and chapter 15 provides model simulations for changes in tropical cyclone intensity under the influence of global warming. Chapter 16 provides a summary and discusses topics for future research.

This book is a valuable attempt to examine tropical cyclone variability on a variety of timescales since the Middle Holocene (circa 7000 years B.P.). Most chapters focus on the North Atlantic Ocean with a few on the Pacific. The examination of prehistoric records of tropical cyclones in coastal sediments is hindered by the lack of resolution of the radiocarbon dating method. In the Pearl River Estuary adjacent to the Hong Kong Special Administrative Region, beach-dune barriers formed by landfall typhoons were identified using a combination of radiocarbon dates and archeological ages, which is superior to radiocarbon dating alone [*Yim and Huang,* 2002]. An analysis of records of typhoons in the Guangdong Province, China, since 950 A.D. revealed an increase in activity since 1500 A.D. [*Huang and Yim,* 2001]. In the northwestern Pacific Ocean, there is a fall in the 5-year running mean of the total number of typhoons entering the South China Sea during El Niño years since World War II, with an accompanying fall in the total number of typhoons in the entire region.

The book is well illustrated with 113 figures, 29 tables, and 13 color plates. Some figures and plates, however, are difficult to read due to their small size. The page size of 15 × 22.8 cm has a maximum printable area of only 11.5 × 18.8 cm. The 12-page index at the back of the book is helpful for rapid searches.

Although the book falls short of a state-of-the-art study of paleotempestology, it is a worthwhile effort. In the book's present form, it is destined for libraries in academic, meteorological, and other research institutions. It is also useful for the reinsurance industry. There is a case for printing a less expensive paperback edition, as the book should also appeal to the general public, particularly those living in hurricane-affected parts of North America.

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—W.W.-S. YIM, The University of Hong Kong, China

MEETING ANNOUNCEMENTS

■ 10–11 May 2005 **Past Climate Variability and Change in the Arctic and at High Latitudes**, Lakewood, Colorado, USA. Sponsors: U.S. Climate Change Science Program; U.S. Geological Survey; others. (J. Fitzpatrick; E_mail: jfitz@usgs.gov)

The workshop objective is to scope the content and structure of the required prospectus and final report, and to identify appropriate technical leads to take the responsibility for specific content of the final product. The general public and private stakeholders are invited to attend.

■ 11–13 May 2005 **2005 NOAA Data and Information Users' Workshop**, Asheville, North Carolina, USA. Sponsor: National Oceanic and Atmospheric Administration (NOAA). (M.S. McCown, NOAA/NCDC, 151 Patton Ave, Asheville, North Carolina, USA 28801; Tel: +1-828-271-4800, ext 3174; Fax: +1-828-271-4876; E-mail: Sam.Mccown@noaa.gov; Web Site: http://www.ncdc.noaa.gov/usrswkshp)

The workshop theme is "User Requirements for NOAA's Data and Information." The workshop will describe NOAA's plans for new information, products, and services, and will establish a closer working relationship with NOAA's data and products users. Discussion will focus on the utility of NOAA data and data inventories supplied to users; the capabilities of existing NOAA interfaces; the requirements for new products and technologies to access and utilize data; and on how to measure NOAA's impacts upon society.

■ 17–22 July 2005 **Gordon Conference on Catchment Science**, Waterville, Maine, USA. Sponsor: Gordon Research Conferences. (D. Burns, U.S. Geological Survey, 425 Jordan Rd., Troy, NY, USA 12180; E-mail: daburns@usgs.gov; Web Site: http://www.grc.uri.edu/programs/2005/catch.htm)

The abstract deadline is 15 July 2005. The theme is "Biogeochemical Cycles in a Changing World: From Process to Practice." The conference provides a forum for the international exchange of cutting-edge research in catchment science. Discussions focus on disturbance, restoration, and long-term monitoring. A field trip is planned to catchment research sites in Acadia National Park.

■ 19–23 September 2005 **Oceans 2005**, Washington, DC, USA. Sponsors: Marine Technology Society; IEEE; Oceanic Engineering Society. (B. Stamey; Tel: +1-703-610-1652; E-mail: barry.stamey@mitretek.org; Web Site: http://www.oceans2005.org/)

The theme is "One Ocean." The conference will focus on homeland maritime security; global observation and exploration; emerging ocean science, technology, and engineering; ocean education and outreach; and proactive global cooperation and engagement.

■ 28–29 October 2005 **International Conference: Climate or Development?**, Hamburg, Germany. Sponsor: Hamburg Institute of International Economics. (H. Kern; E-ail: heike.kern@hwwa.de)

The abstract deadline is 31 May 2005. The conference will focus on poverty alleviation and climate policy in developing countries.

■ 21–24 May 2006 **Challenges in Coastal Hydrology and Water Quality**, Baton Rouge, Louisiana, USA. Sponsors: American Institute of Hydrology; Louisiana State University & Agricultural Research Center. (Y. Jun Xu, School of Renewable Natural Resources, Louisiana State University and Agricultural Research Center, Baton Rouge, Louisiana, USA 70803; Tel: 1-225-578-0897; Fax: 1-225-578-4227; E-mail: yjxu@lsu.edu; Web Site: http://www.aihydro.org/conference.htm)

The abstract deadline is 15 July 2005. The conference will provide an international forum for the dissemination and exchange of information in coastal hydrology, hydraulics, and water quality. Topics will include hydraulic engineering, structures, petroleum, and land subsidence in coastal areas.

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POSITIONS AVAILABLE

Atmospheric Sciences

Meteorologist, ZP-1340-III ($50,541 - $78,745), U. S. Department of Commerce, National Oceanic and Atmospheric Administration (NOAA), Idaho Falls, ID. Idaho Falls is a family-oriented city of 50,000. Yellowstone and Grand Teton National Parks are nearby. Hiking, skiing, camping, boating, and snowmobiling are just a few of the many recreational opportunities. The vacancy is located at the Field Research Division (FRD) of the Air Resources Laboratory. FRD has a world-class capability in the design and execution of field atmospheric dispersion studies involving nontoxic chemical tracers. The incumbent provides project leadership to these tracer studies, including project planning and execution, field equipment operation, data collection and analysis, interaction with other participating organizations, and preparation of publications. Travel from 3 to 5 weeks a year is expected. When appropriate, the incumbent also runs computer dispersion models either to support field operations or as part of tracer data analysis. Applicants must have an advanced level of knowledge (equivalent to a Ph.D.) in boundary layer meteorology and atmospheric dispersion. A secondary responsibility for the incumbent is to periodically assist local meteorological operations and research for the Dept. of Energy's Idaho National Laboratory (INL).

Application under this announcement requires the completion and submission of a special online QuickHire application at https://jobs.quickhire.com/scripts/doc.exe. The reference vacancy number is OAR-LABS-2005-0083 (open to public) or OAR-LABS-2005-0084 (Federal status applicants only). To be considered for this position, your QuickHire application must be submitted by midnight (Eastern Standard Time) on April 29, 2005. The Department of Commerce is an Equal Opportunity Employer. U.S. citizenship is required.

Two Postdoctoral Openings in Aerosol Heterogeneous Chemistry and Phase Transitions in the Division of Engineering and Applied Sciences at Harvard University. (#1) The project is to study the oxidation kinetics of secondary organic aerosol particles, the related oxidation mechanisms, and the changes in hygroscopic properties arising from oxidation. A candidate is particularly sought who has expertise in either smog chamber studies or the operation of an aerosol mass spectrometer, although applications from any qualified candidate will be considered. (#2) The project is to study the phase transitions of atmospheric aerosol particles, including both field and laboratory measurements. A candidate is particularly sought who either has training in the study and concepts of phase transitions or in the operation and use of one or more of aerosol flow systems, an infrared spectrometer, an aerosol mass spectrometer, and a tandem differential mobility analyzer. Applicants for either position should send by email a curriculum vitae (a single PDF file) to Scot Martin (smartin//www.deas.harvard.edu/environmental-chemistry/.

Two Postdoctoral Positions. Harvard University invites applications for two postdoctoral positions in terrestrial ecosystem dynamics and land-atmosphere interactions in the laboratory of Paul R. Moorcroft. Positions are initially for one academic year with the possibility of extension. Applicants with previous experience in ecosystem and/or land-surface modeling, and knowledge of C/C++ or FORTRAN programming languages are strongly preferred. Candidates should email their CV, a summary of research interests, and the names of three references to Paul Moorcroft (paul_moorcroft@harvard.edu). Harvard University is an equal opportunity/affirmative action employer.

Geochemistry

Analytical Chemist. Analyze water samples for inorganic constituents for research at KS Geological Survey, U of KS. Apply new and modify existing analytical methods. Manage laboratory. Participate in research studies. M.S. with 2 yrs experience. Job available 6/20/05. Apply online https://jobs.ku.edu, first consideration date is 5/25/05 (search by title Chemist). Full details at www.kgs.ku.edu/General/jobs.html.

U of KS is an EO/AA employer.

Postdoctoral Research Associate/Geochemical Modeling/New Mexico Institute of Mining & Technology. The Geochemistry Program in the Department of Earth & Environmental Science at New Mexico Institute of Mining & Technology has an opening for a postdoctoral research associate in the area of geochemical modeling. A Ph.D. in earth sciences or a related field is required. The initial appointment is for one year, with the possibility of renewal for 1.5 additional years. The successful candidate performs geochemical modeling and runs and maintains a quadrupole gas analytical facility. Required knowledge and skills include proficiency with geochemical modeling programs, geothermal systems, vacuum systems and mass spectrometers. The position is funded by a DOE-EGS (Engineered Geothermal Systems) grant to study injection well permeability. Salary is $40K/year. For information (only) contact David Norman (dnorman CV, a letter describing research interests, and three referees contact information. E-mail applications are not accepted. Mail application packet to: New Mexico Tech, Human Resources, Weir Hall Box 32, 801 Leroy Place, Socorro, NM 87801. Visit http://www.ees.nmt.edu for general program information. AAEOE.

Hydrology

Faculty Position in Water Sciences and Hydrogeology, Department of Geological Sciences, Jackson School of Geosciences, The University of Texas at Austin. The Department of Geological Sciences, Jackson School of Geosciences, at The University of Texas at Austin seeks to fill a faculty position in water sciences and hydrogeology. The specific area of research is open, and might include studies in one or more of the following areas: modeling of flow, contaminant transport, and reactions on

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a variety of scales; groundwater/surface water interactions; theory and applications of geophysical and remote sensing methods; analysis of water resources and related policy; land-atmosphere interactions; and hydrologic impacts of climate variability and climate change. The rank is open, and candidates at all levels, including Chair level, will be considered. The successful candidate will join the Jackson School of Geosciences, which includes the Department of Geological Sciences, the Bureau of Economic Geology, and the Institute for Geophysics. The School has a large and diverse community of geoscientists, with excellent research facilities and support. Through other campus departments in science and engineering and research units, such as the Environmental Science Institute, Center for Space Research, Institute for Computational Engineering and Sciences, and Center for Research in Water Resources, there are opportunities to interact with faculty and scientists from many disciplines. The selected candidate will have demonstrated strong potential for conducting a vigorous externally funded research program, should be an enthusiastic teacher at the undergraduate and graduate levels and well qualified to direct the research of MS and Ph.D. students. The anticipated starting date for this position is August 31, 2005, but the position remains open until filled. A Ph.D. in an Earth science or related discipline is required at the time of appointment. Please refer to http://www.geo.utexas.edu for additional information. To apply: please send a curriculum vitae, statement of research and teaching interests, and names and contact information for four references to: Hydrogeology Search, Department of Geological Sciences, The University of Texas at Austin, Austin, Texas 78712-1101. Review of applications will begin March 1, 2005, and will continue until the position is filled. The University of Texas is an Equal Opportunity/Affirmative Action employer

Postdoctoral Research Associate in Hydrology, Center for Biocomplexity Studies, South Dakota State University. One year, full time position. Assist researchers on an EPA-funded study to numerically model the flow and Dissolved Organic Matter (DOM) content of streams in a relatively pristine watershed, the Ontonagon River in northern Michigan. Simulate the effects of projected climate change on stream flow and DOM concentrations. Use GIS data layers to model interaction between surface water runoff and terrestrial organic matter in wetlands and forest soils. Analyze, interpret, and summarize results. Write manuscript for publication in a scientific journal. Required qualifications: Ph.D. in hydrology or related field completed prior to appointment starting date. Excellent writing skills and experience in writing scientific articles. Effective communication and interpersonal skills. For full list of qualifications and position announcement, contact Dr. Carol A. Johnston, Center for Biocomplexity Studies, Box 2202, South Dakota State University, Brookings SD 57007-0896. Application deadline: Applications should be received by May 20, 2005 in order to receive full consideration in the initial screening. However, applications will be accepted until the position is filled. Email inquiries to carol.johnston (605) 688-4394.

Two Postdoctoral Positions/Research Associates in Hydrology. The New Mexico Institute of Mining and Technology invites applications for two postdoctoral associate positions in hydrology within the Department of Earth and Environmental Science (EES). We seek highly qualified individuals with research experience and interest in one of two separate fields: (1) micrometeorology including field instrumentation of evapotranspiration and energy balance components and remote sensing techniques; and (2) numerical modeling of distributed watershed processes and high performance computing. The three-year appointments (starting summer 2005) are funded by a National Science Foundation grant to the New Mexico EPSCoR program (http://www.nmepscor.org) and will provide enhanced capabilities for evapotranspiration estimation and hydrologic modeling in the state of New Mexico. A Ph.D. at the time of appointment in hydrology, earth and environmental science, micrometeorology or closely related field is required for these positions, as well as a significant record of research productivity. We especially seek individuals who complement existing department strengths and can work collaboratively in the hydrology research groups at New Mexico Tech (http://www.ees.nmt.edu/Hydro).

Remote Sensing of Evapotranspiration:

We seek a candidate with experience in micrometeorology, remote sensing analysis (MODIS, ASTER, LandSat) and validation using scintillometer and eddy covariance measurements.

Numerical Hydrologic Modeling:

We seek a candidate with experience in utilizing distributed hydrologic models of watershed processes, including code development, calibration techniques and verification with remote-sensing and field measurements. Candidates with skills in high performance computing (software and hardware) are particularly encouraged. Our research program offers competitive salaries and opportunities for career advancement. To apply, please send a CV, relevant publications and the contact information of three references to: New Mexico Tech, Human Resources, 801 Leroy Pl., Socorro, NM 87801-4796. Include Wells Hall Box 38 in address for micrometeorology/remote sensing position; Wells Hall Box 36 for hydrologic modeling position. Applications will be accepted until the positions are filled. Email applications are not accepted. For detailed inquiries, contact Jan M. H. Hendrickx for micrometeorology/remote sensing position (hendrick

Ocean Sciences

Geophysical Research Scientist. Information Systems Laboratories, an employee-owned research and development company, has an immediate opening in its San Diego office for individuals with expertise in physics or geophysics, with an emphasis in electromagnetics, for defense applications. Candidates must have a strong foundation in math and physics and an understanding of electromagnetic fields as applied to geophysical and/or marine environments. Experience with analytical methods, signal processing, oceanographic instrumentation and statistical data analysis is a plus. Excellent written and oral communication skills are required. Candidates must have a minimum of a B.S. degree with 10 years experience in Physics, Geophysics, Engineering, or Math (M.S. or Ph.D. is preferred). Candidates must have an active US Government Security Clearance and have been re-investigated within the last five years. To apply for this position, send a cover letter highlighting your qualifications for the position and your resume to humanresources@islinc.com. (Please refer to job code 05-8). Please visit our website at www.islinc.com.

ISL is an equal opportunity employer.

Oceanographic Research Technicians. The Bermuda Biological Station for Research, Inc. (BBSR) is an U.S. incorporated 501(c)(3) not-for-profit research and education institution employing a multi-national staff of approximately 80 people and based in Bermuda since 1903. Activities include oceanographic and marine biological research conducted by resident and visiting scientists, and university level courses on topics ranging from marine pollution to biogeochemical cycles in the Sargasso Sea.

Continued growth in the oceanography research programs at BBSR (Bermuda Atlantic Time-series Study (BATS) and affiliated programs) have led to a number of technical openings. For all of these openings BBSR seeks young energetic oceanographic technicians with prior sea-going and analytical laboratory experience. There are six technical positions available; 3 with the Bermuda Atlantic Time-series Study (BATS) and one each in dimethylsulfide, carbon dioxide, and dissolved organic phosphorus research programs.

Interested applicants should visit the BBSR website (http://www.bbsr.edu/involved/involved.html) to view the complete job descriptions and contact information for each technical position. Salaries will be commensurate with prior experience and BBSR offers a competitive benefits package and provides a stimulating and challenging work environment.

Solid Earth Geophysics

Instructor/Assistant Professor. The Dept. of Geography and Geosciences at Bloomsburg University of Pennsylvania offers a one-year, full-time temporary Instructor/Assistant Professor position (AA#41-4-127), starting August 2005. Ph.D. in Geography or related discipline by time of appointment preferred; exceptional A.B.D. applicants considered. Demonstrated ability to work with diverse populations required. Deadline for full consideration: Postmarked by May 13, 2005. For a detailed position description, including application process please see: www.bloomu.edu/jobs. AA/EEO employer

Interdisciplinary/Other

Associate Research Fellow, Faculty of Science. Fixed-Term, Full-Time Appointment (3 years)

UOW's Atmospheric Chemistry Research Group (ACRG) is seeking a skilled researcher to work as an Associate Research Fellow on an Australian Research Council (ARC) Discovery Grant project. The ACRG is involved in a wide range of atmospheric chemistry/physics issues in both the troposphere and stratosphere.

The abovementioned ARC Discovery Grant project will focus on improvements to estimates of biomass burning emissions from different Australian fires using ground based solar remote sensing data. The project will also investigate the transport of these plumes around the globe.

The successful candidate will be required to work in collaboration with the Atmospheric Chemistry Modelling Group (ACMG) at Harvard University, a partner investigator on the ARC grant that is funding this study.

To be successful, you will hold a Ph.D. degree in physics, chemistry, atmospheric sciences or related fields. You will also have experience with chemical transport modelling.

Candidates must address the criteria specified in the Position Description, which is available from our website. Please also refer to the Position Classification Standard. For further information about this position, please contact Dr Nicholas Jones on +612 4221 4296.

Applications close 17 April 2005

Quote Ref No: 21210

How to apply:

Please go to our website http://employment.uow.edu.au/ to submit your application online & for more information about the position and UOW.

Chief Scientist for Geography. The U.S. Geological Survey (USGS) seeks candidates for the full-time position of Chief Scientist for Geography. This is a Senior Executive Service (SES) position with a salary range of $107,550 - $149,200 per annum.

The Chief Scientist for Geography collaborates with the Associate Director for Geography in the overall planning and strategic direction of the science research programs of the Geography Discipline in support of the DOI Strategic Plan, USGS science goals and initiatives, and customer needs. This includes responsibility for the overall science direction of the Geography Discipline; program planning, review and evaluation; National program management; and coordinating the integration of science capabilities to address emerging issues at the National level.

Applications (Resumes and Questionnaire responses) must be received on-line via the USGS Online Automated Recruitment System (OARS) BEFORE midnight Eastern Time on the closing date of June 3, 2005.

It is important that all applicants view the Vacancy Announcement in its entirety to be sure that all required documents are submitted. Incomplete application packages cannot be considered.

The vacancy announcement can be found at OARS at http://www.usgs.gov/ohr/oars/ses.html.

For more information, contact Cindy Lonergan at clonergan@usgs.gov or (703) 648-7472.

The U.S. Geological Survey is an Equal Opportunity Employer. U.S. Citizenship is required.

Co-director, Antarctic Program/Hamilton College. The Hamilton College Antarctic Program is seeking applicants for an administrative position available to coordinate field logistics for Antarctic research cruises. Duties include managing communication between scientific support provider, principal investigators and other cruise participants, writing Antarctic Newsletter, working on papers for publication, analyzing samples in sediment lab. Antarctic fieldwork included. Position terms: full time, 1+ years, renewal after August 2006 dependant upon grant funding. For more information contact Eugene Domack at edomack@hamilton.edu.

Escape the City for a Small Town Atmosphere! Mendocino Redwood Company, LLC., located in Ukiah, California is a leading supplier of sustainable forest products. This position will be located

Classified cont. on page 168

Classified

cont. from page 167

in Fort Bragg, CA. We are looking for a Geologist to join our growing team. Great opportunities and excellent benefits available.

Education and/or Experience Required:

- Bachelor's Degree (BA) in Geology, Geomorphology, Soil Science, Watershed Science, or a closely related field of study from four-year college or university.
- Must be a Registered Geologist (or close to being registered) with the State of California.
- Experience in mass wasting hazard assessment in a forest management context.
- Must carry a valid California Driver's License and be eligible to operate a company vehicle under company policy guidelines.

The primary job responsibilities include providing technical support to our timber operations, mass wasting hazard assessment toward the management of private timberlands, and providing technical expertise on geological issues pertaining to long term forest management planning. Additional responsibilities include the following:

- Conducts mass wasting assessments for the study of watersheds within a watershed analysis process for the Mendocino Redwood Company lands.
- Conducts research and monitoring for soil erosion and mass wasting issues associated with conservation of habitat for endangered aquatic species.
- Prepares technical reports and interpretations of mass wasting hazard for site specific timber harvest issues.
- Ensures compliance with all local, state, federal regulation; and with company environmental standards.
- Assists in the preparation of grant applications for forest restoration projects.

Interested applicants please submit a cover letter and resume to: recruiter@mendoco.com. To learn more about the organization, please visit our website at www.mrc.com.

Ph.D. Scientist/Geophysicist, Stanford University. A three-year position, with a preferred start date before October 2005, is available for a Ph.D. Scientist/Geophysicist to work with the Consortium of Universities for the Advancement of Hydrologic Sciences (CUAHSI). In year one this person will be responsible for working with the community to develop a framework to address and support direct physical measurement, geophysics, and biogeochemistry through a community Hydrologic Measurement Facility (HMF). In the second year this person will lead the design and implementation of the prototype Geophysics Module of the CUAHSI HMF, the purpose of which is to support the use of geophysics in hydrologic research. The focus of activity will be on geophysical characterization of the subsurface at the two proposed long term hydrologic observatories. The overall Geophysics Module will be designed in response to community input and will include 1) facilitating the lending/rental of geophysical equipment, 2) providing needed expertise in geophysics, and 3) enhancing opportunities for collaboration between the geophysics and hydrology research communities. The Ph.D. Scientist/Geophysicist will spend the first year working with John Selker and those involved in the development of all aspects of the HMF. The work location in this first year is flexible. In the second and third years the person will be located in the Dept. of Geophysics, Stanford University, working with Rosemary Knight. The salary is $62,000/year. Applications are invited from persons holding or expecting to complete their Ph.D. by June 2005, or soon after. Specialization should be in Geophysics or Hydrology, with strength in both areas desirable. To apply please send your curriculum vitae, the names of three references (with contact information) to Prof. Rosemary Knight, Dept. of Geophysics, Stanford University, 397 Panama Mall, Stanford, CA 94305-2215, or by email to rknight

Postdoctoral Position/Isotopic Studies of Extraterrestrial Materials. Research on long-lived cosmogenic radionuclides measured by accelerator mass spectrometry and stable isotope abundances by other forms of MS. Emphasis on micrometeorites and unusual achondrites. Nuclear reaction analysis of cometary particles. Nuclear cross section measurements relevant to early solar system processes. Applicants should have a Ph.D. in chemistry, geochemistry, or a closely allied field.

Please send resume and the names of three references to Prof. Gregory Herzog, Dept. Chemistry & Chem. Biol., Rutgers Univ., New Brunswick, NJ 08854-8087 (herzog@rutchem.rutgers.edu).

Rutgers is an EO/AA employer.

Tenured Professor Within the College of Arts & Sciences/ University of New Mexico, Albuquerque, New Mexico. The University of New Mexico seeks an outstanding senior research professor in environmental science or a related area to assume a leadership role on campus and in the wider scientific community. This individual is expected to have an established, internationally conspicuous research program, proven ability to develop and manage large, multi-investigator, interdisciplinary research projects, and demonstrated experience working with diverse constituencies including scientists in other disciplines, political and business leaders, and philanthropists. We seek a candidate with vision, passion and energy, who can move UNM into greater prominence in ongoing and forthcoming funding opportunities at national and international levels. The successful candidate will hold a position as a tenured full Professor in UNM's College of Arts and Sciences.

Interested individuals are asked to visit our website: http://www.unm.edu/~fco/enter.htm for a complete job description. Applicants must send a signed letter of intent, a detailed curriculum vitae, and a 1-2 page description of teaching and research objectives. For best consideration, nominations and applications should be submitted by May 17, 2005; nominations and applications will be accepted until the position is filled.

Chair,
Tenured Professor in A&S Search
Attn: Juliette Lagassé-Martínez
Office of the VP for Research & Econ. Dev.
Scholes Hall 222, MSC05 3400
University of New Mexico
Albuquerque, NM 87131-1001

The University of New Mexico is a Carnegie Doctoral/Research University-Extensive and an Equal Opportunity/Affirmative Action Employer and Educator.

The Phoenix Mars Mission seeks a full-time Education and Public Outreach (E/PO) Coordinator. The selected individual will work under the supervision of the mission's E/PO Manager and other team members to implement an exemplary local, regional, and national E/PO program. The coordinator will help ensure that goals of the Phoenix E/PO program are accomplished in accordance within schedule and funding constraints. The position is funded through September 2008 by the NASA Scout Program Grant awarded to the University of Arizona.

Candidates must be US Citizens or Resident Aliens to be eligible to this position in accordance with NASA/JPL requirements and ITAR/EAR export control restrictions.

You can access a detailed job posting and application information for this position at the U of A's Career Track site (https://www.uacareertrack.com). To access the posting, click on Search Postings in the upper left, enter 32589 as the Job Number, click Search, and click View under the Position Title.

The University of Arizona is an AA/EEO employer - M/W/D/V

Two Visiting Professors. The Geology Department at Washington and Lee University seeks applications for 2 one-year visiting professors (Ph. D. or ABD). Teaching obligations for each position could include: 1) structural geology, introductory geophysics, planetary geology, introductory geology with field emphasis, and a topical seminar; and 2) oceanography, basin analysis, historical geology, introductory geology with field emphasis, and a topical seminar. W&L is a nationally ranked, highly selective liberal arts college. Our Department (http://geology.wlu.edu/) is a member of the Keck Geology Consortium, and makes great use of the Appalachians in field courses and labs. Apply via email with resume, statement of teaching interests/experience and 3 letters of reference to Elizabeth Knapp (knappe@wlu.edu), Geology Department, Washington and Lee University, Lexington, VA 24450. Review of applications will begin immediately and continue until the job is filled. We encourage applications from members of underrepresented groups. W&L is an Equal Opportunity Employer.

Visiting Assistant Professor. Bucknell University seeks to hire an entry-level visiting assistant professor of Geology to teach two introductory courses (Physical Geology and Engineering Geology), and two advanced courses (GIS and Geophysics) with accompanying four labs during the 2005-2006 academic year. Please visit the Bucknell Department of Geology on the web at http://www.bucknell.edu/Geology/ for full details.

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Forschungszentrum Jülich
in der Helmholtz-Gemeinschaft

For our Institute of Chemistry and Dynamics of the Geosphere, Agrosphere Department (ICG-IV), we are seeking a

PhD FELLOW
to work on a three-year PhD project
within the framework of a cooperative project with the Central Institute for Electronics (ZEL)

Subject: Magneto-electrical resistivity imaging technique for monitoring flow and transport processes in the subsurface.

In the magneto-electrical resistivity imaging technique (MERIT) electric potential and magnetic field responses to a low-frequency electric current are measured, from which the resistivity distribution inside an object of interest can be calculated by tomographic inversion techniques. This PhD project has the aim of applying MERIT on the field scale to monitor flow and transport processes in the subsurface.

Tasks: Participation in developing MERIT measuring technology for field-scale applications; definition of an optimal MERIT measuring design for field applications and assessment of the resolving power; monitoring of flow and transport processes with MERIT; quantitative analysis of the imaging results on the basis of flow and transport models.

Requirements: University degree in geophysics, physics, electrical engineering or a related subject with at least upper second honours (grade at least "good"); experience with electric and magnetic data acquisition and corresponding exploration methods; basic knowledge of numerical modelling and inversion theory; preferably experience with field work and interest in flow and transport processes in porous media; willingness to work in an interdisciplinary team.

And also a

PhD FELLOW
to work on a three-year PhD project

Subject: Determination of the hydraulic properties of unsaturated porous media from electrical spectral induced polarization measurements.

In the spectral induced polarization (SIP) method, which is methodologically equivalent to electrical impedance spectroscopy, electrical conduction and polarization properties are investigated in a frequency range typically between 1 mHz and 10 kHz. This PhD project has the aim of developing models for relating the structural and hydraulic properties of porous media (e.g. grain/pore size distribution, unsaturated hydraulic conductivity) to the measurable SIP signature.

Tasks: Development of models for linking the structural and hydraulic properties of porous media with the SIP signature; development of inverse models for determining the characteristics of the unsaturated hydraulic conductivity of soils and sediments from electrical impedance spectra; validation of the models on the basis of laboratory measurements on soil and sediment samples.

Requirements: University degree in geophysics, physics or a related subject with at least upper second honours (grade at least "good"); knowledge of soil or rock physics and /or the physics of porous media; basic knowledge of inversion theory; abilities in numerical programming; preferably experience in soil and/or rock physics measurements; willingness to work in an interdisciplinary team.

Contact for both positions: Dr. Andreas Kemna, tel.: +49 2461 614077
e-mail: a.kemna@fz-juelich.de.

You will find further information at our website:
http://www.fz-juelich.de/icg/icg-iv/index.php?index=47

Equal opportunities is a cornerstone of our staff policy, for which we have received the "TOTAL-E-QUALITY" accolade. Applications from disabled persons are welcomed. The salary will be based on BAT IIa/2 (federal employees collective salary agreement). Depending on the applicant's profile and the subject of the PhD project an additional allowance may be granted. Please send your application with supporting documents to: Mr Matthias Josef Schmitz, Institut für Chemie und Dynamik der Geosphäre (ICG), Forschungszentrum Jülich GmbH, 52425 Jülich, Germany.

Director, Institute for Water & Watersheds

Oregon State University

Oregon State University invites nominations and applications for the Director of the Institute for Water and Watersheds. The Institute for Water and Watersheds is one of six initiatives in OSU's Strategic Plan, and is a multi-college enterprise to coordinate water research, teaching, and outreach efforts at Oregon State University, and to enhance the visibility of one of the strongest Water Resource programs nationally and internationally. The University seeks candidates who are recognized as having distinguished careers, with demonstrated success in bringing innovative and entrepreneurial approaches to scientific research, teaching, and outreach, and who have broad research, education and policy experience in water resource-related fields. Preference will be given to candidates with experience in the successful development and management of large, complex interdisciplinary programs.

Job Description: The Director will be responsible for the development and coordination of research, teaching, and outreach programs in the area of water and watersheds through leadership of the Institute for Water and Watersheds. The mission of the Institute is to promote multidisciplinary and interdisciplinary approaches that will bring OSU science, engineering, and policy expertise to bear on issues associated with water resources and watershed management at the state, national, and international levels. The Director will coordinate and promote OSU activities with key state, regional, and national stakeholders with interests in water-related issues. Responsibilities will include 1) developing and facilitating existing cooperative linkages across multiple units, responsive to opportunities at the state, national and international levels in water-related efforts, 2) identifying and developing funding opportunities to support research, teaching, and outreach programs through partnerships with state, federal, and private organizations and supporters, and 3) providing an OSU presence with local, state, federal, and international government agencies and non-governmental organizations. This is a tenured position in an academic department appropriate to the appointee's disciplinary background. The Director will report to the Vice President for Research.

Qualifications:
Ph.D. or equivalent in a water resource-related field.
Distinction in professional achievements consistent with a senior rank within a university, agency, or other organization.
Demonstrated success in competitively-funded research programs.
Demonstrated leadership in developing and managing a growing organization, including budget and financial management, personnel management, public relations, and development.
Demonstrated ability to work cooperatively with internal and external partners.
Demonstrated success in liaison roles with State and Federal management and research agencies and programs, as well as a diverse array of communities, stakeholders, and individuals.
Record of demonstrated successful involvement in interdisciplinary programs and scholarship.
Strong record of, or demonstrated commitment to, advancing cultural diversity and equity.

How to Apply: Completed applications should include: a) letter of interest, including the candidate's statement of vision for the IWW. b) Curriculum Vitae; and c) contact information for at least five references (including name, title, address, phone number and email address). Nominations are welcome. Strict confidentiality will be maintained. For full consideration apply by May 15, 2005. Please send all materials to: Susan Dobbie, Oregon State University, IWW Search Committee, 116 Gilmore Hall, Corvallis, OR 97331. susan.dobbie@oregonstate.edu