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Toward a New Generation of Ice Sheet Models

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Tsunamis rank among the most devastating and unpredictable natural hazards to affect coastal areas. Just 3 years ago, in December 2004, the Indian Ocean tsunami caused more than 225,000 deaths. Like many extreme events, however, destructive tsunamis strike rarely enough that written records extend the record of tsunami occurrence but mark rare events. In some cases, however, oral histories provide information on ancient tsunami. Quantifying paleotsunami size by modeling onshore flow depth and speed from tsunami deposits would provide a key for determining the deadliness and destructiveness of past events. Ideally, such a key could allow us to inform long-term hazard assessments based on tsunami source mechanisms (e.g., fault slip or submarine landslide), interpreted from the geologic record.

Developing quantitative tools to estimate flow depth and speed from tsunami deposits requires interdisciplinary collaboration among the coastal geomorphology, sedimentary geology, sediment transport, hydrodynamics, remote-sensing, and seismology communities. This article presents a strategy for using “sedimentology benchmarks” to enhance this collaboration. Promising preliminary work, based on a tsunami sedimentology workshop held in spring 2007 in Friday Harbor, Wash., suggests that benchmarks will lead to an improved understanding of tsunami physical processes and allow us to use our knowledge of tsunami paleo-records in our ability to quantify paleotsunami magnitudes by interpreting the geologic record.

The State of the Science

Tsunamis deliver highly energetic, sustained flows that can erode everything from large blocks to fine sediment and transport them up to thousands of meters across coastal plains. The long-period waves of a tsunami approach the shore at speeds of tens of kilometers per hour, causing nearshore water to become highly turbulent with amplitudes of several to tens of meters. The leading wave of a tsunami can erode much of the coastal land profile. Travel times and inundation distances can be estimated from tsunami runup and topography collected along the sample transect.

While tsunami propagation models have been in existence for more than 4 decades and have been shown to be fairly accurate at predicting basin-scale travel times and deep-water wave amplitudes, models of tsunami inundation—where waves approach shore and flood the land—are less common and have not been adequately tested against field data. Recent inundation models consider wave evolution by summing both linear and highly nonlinear processes of various length scales and timescales [e.g., Liu et al., 2007]. Model predictions are useful for estimating the relationship between grain size (grain settling velocity) and shear stress. Deposition occurs when an oncoming wave converges or when deceleration permits sediments to fall out of suspension. Empirical relationships to infer deposit characteristics from flow velocities and, conversely, flow velocities from deposits have been derived from steady channel flow experiments.

This suggests that it should be possible to combine tsunami hydrodynamics and knowledge of the sediment available for transport to predict the structure and texture of tsunami deposits or to reconstruct tsunami flow histories from deposits. However, fundamental questions remain regarding tsunami turbulent flow structure and the applicability of existing sediment-transport models to a tsunami’s timescale and initial dry-bed conditions.

Benchmark Strategy for Collaboration

Benchmarking tsunami sedimentology models entails developing test cases that can be treated using data-based approaches, allowing the model results to be compared to problems that we can solve in an efficient, coherent manner. Given the limitations of existing tsunami inundation and sediment transport models, two key challenges are well suited for such an approach: (1) closing the knowledge gap in linking modern events to their deposits with an improved understanding of tsunami sediment transport, and (2) adapting that relationship to interpret the geologic record.

Traditionally, benchmarks rely on analytical solutions or controlled experiments of known initial conditions with which to test and compare models or laboratory equipment. Our working definition of a benchmark is somewhat different for several reasons. First, there is no adequate analytical solution available for “tsunami sediment” problems even for a case with simplified boundary conditions (e.g., planar beach topography) and uniform homogeneous sediment. Second, while initial conditions of laboratory experiments can be specified in detail, comparing these small-scale transport experiments with nature is limited by scaling difficulties. Most important, while conventional benchmarks are used to rank model fit in well-established fields of study, tsunami sedimentology is at such an early stage that benchmarking serves instead to enhance collaboration in exploring physical processes and making improved model predictions. Such collaboration has already resulted from benchmark exercises that are feeding the hydrodynamic models on which tsunami runup models are based [Yeh et al., 1996].

Benchmarking for tsunami sedimentology requires agreed-upon goals that promote interdisciplinary collaboration and development of appropriate data sets. For example, the community must identify key parameters to be estimated (e.g., wave height and speed) and set sensitivity studies targets (e.g., effect of grain size on deposit thickness). These actions will ensure that the focus and scope of modeling studies are compatible. Identifying these parameters also helps to determine the minimum amount of information a benchmark data set must contain.

Proof of Concept

As a test of this approach, we performed pilot benchmark exercises on two data sets of tsunami deposits, one modern (1998 Papua New Guinea tsunami) [Lynett et al., 2007] and the other ancient (Südertal, Mutnaya Bay, Kamchatka, Russia) [Gelfenbaum, 1995]. Detailed treatment of the modern case (Figure 1) was aimed at linking modern events to their deposits and improving the understanding of tsunami sediment transport. The application of the models to the ancient case allowed us to evaluate how this understanding might be adapted to interpret the geologic record. Models were used to estimate tsunami characteristics such as flow depth, flow speed, number of waves, and where possible, tsunami source for each benchmark. The data sets included grain-size distribution, deposit thickness, topographic profiles, and bathymetry. In the case of the modern deposit, additional information (from field estimates and eyewitness accounts) on the tsunami was available [Gelfenbaum and Jaffe, 2003]. Paleotsunami modeling efforts were complicated by incomplete deposit preservation, lack of flow depth or inundation limit indicators, and poorly constrained pre-tsunami topography at Mutnaya Bay.

Forward modeling of tsunami inundation was based on high-resolution bathymetry and topography collected along the sample transect. The application of the models to the ancient case allowed us to evaluate how this understanding might be adapted to interpret the geologic record. Models were used to estimate tsunami characteristics such as flow depth, flow speed, number of waves, and where possible, tsunami source for each benchmark. The data sets included grain-size distribution, deposit thickness, topographic profiles, and bathymetry. In the case of the modern deposit, additional information (from field estimates and eyewitness accounts) on the tsunami was available [Gelfenbaum and Jaffe, 2003]. Paleotsunami modeling efforts were complicated by incomplete deposit preservation, lack of flow depth or inundation limit indicators, and poorly constrained pre-tsunami topography at Mutnaya Bay.

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transact for each benchmark. For the PNG case, some model constraints were provided by tsunami inundation limits. An example of how these may be identified in the field and by the number of waves reported by eyewitnesses. Modelled and measured inundation limits were completely re-parable (Figure 1c). The modelled, veriﬁed and measured inundation limits (Figure 1d) show that the tsunami model test is a snapshot (Figure 1e) shows flow accelerations and decelerations as the wave cascade over a topographic high, illustrating the complexity of flow-topography interactions.

Estimates of maximum flow speed from inverse modeling were based on assumptions of simplified particle and water level models and the number of waves left standing after the tsunami. These estimates are of the same order of magnitude, but they exceed the flow speeds predicted by the forward model. Discrepancies between models may be due to missing processes (such as sediment and momentum extracted from the flow by dense vegetation), other simplifying assumptions (such as particle reentrainment), or poorly characterized initial conditions. 

Results of the PNG case highlights the potential for future tsunami inundation studies and the need for dynamic tsunami models for tsunami deposits and its deposit for benchmarking inverse models. For forward models, however, the results of this type of benchmark is that initial conditions are poorly known for tsunami deposits. A benchmark for forward modeling would be a detailed laboratory experiment data set with well deﬁned initial conditions. Where treating a paleo tsunami deposit basin would be a valuable step toward interpreting the geologic record for hazard assessment, problems with preservation limit available information for ancient cases like Mutnaya Bay Nature is not simple, but initial benchmark models and experimental studies are needed.

On the basis of our pilot study, we developed a preliminary list of requirements for future tsunami sedimentology benchmarks (see http://tsunami.umd.edu/sedimentology/). This list is a work in progress, and we ask interested scientists to comment on it by prioritizing parameters to which their own research efforts can apply. What are the minimum bathymetric resolution, deposit-sampling density, and grain size detail required to test your model? Answers to these questions will vary over a broad range depending on model techniques, areas of application. Responses will help to guide data gathering, experimental design, and model campaigns and define objectives for the next generation of tsunami sedimentology benchmark experiments.

Acknowledgments

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References


However, ice sheet simulations assessed by the IPCC cannot reproduce these observations because the simulations fail to include sufficient interactions with glaciological, climatological, and oceanographic processes. These changes in iceberg calving, which is important in accelerating discharge near ice sheet margins, current computer-based projections of ice sheet response to warming climate are thus almost certainly biased against deliver- ing fast response to climatic warming in the rate of sea level rise. Key processes that should be incorporated into future model studies to include the following:

• Interactions in the ice sheet system involving required models of regional oceanic circula- tion, melting and shoving in subaerial cavities, a better understanding of continental ice sheet processes, and coupling to the global ocean;
• Improved mass balance requirements, including improved numerical algorithms (e.g., high-resolution with adaptable grid) and coupled models of inland and ice sheet flow, production and flow of water at the sur- face and within and beneath the ice;
• Ice streaming, whose modeling requires higher-order flow physics, a basal processes model, and a noted approach to modelled ice sheet collapse;
• Iceberg calving, which is important in ice shelf collapse as well as oceanic flow dynamics and which requires the application of fracture mechanics.

Insights From AOGCMs

Incorporating physically accurate stand- alone ISMs into an AOGCM requires aware- ness of current model capabilities, and a conservation of heat and freshwater. AOGCM-ready ISMs will need to include a

Tsunami

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Toward a New Generation of Ice Sheet Models

Large ice sheets, such as those presently covering Antarctica and Greenland, are an important driving changes of global climate. Ice sheet models, which have been developed to predict climate change and ice sheet-driven sea level fluctuations have substantial limitations. Predicted physical processes in the ice sheet component likely lead to an underestimation of sea level rise forced by a warming climate. The resultant uncertainty in sea level projections, and the implications for climate policy, have been widely discussed since the publication of the Fourth Assessment Reports (see Report of the Intergovernmental Panel on Climate Change (IPCC) [IPCC, 2007]. The assessments and current models do not include the “full effects of changes in ice sheet dynamics, because of the present state of the art of ice dynamics understanding is not acceptable to the model-coupling process.”

The comprehensive continental-scale ice sheet models used to predict global sea level change have not been substantially modified in the past decade. The models are based pri- marily on the assumption that glacier driving stresses are balanced locally by basal traction, resulting in flow dominated by ver- tex shear (i.e., that the horizontal transmis- sion of stress is unimportant) [e.g., Huybrechts et al., 2001]. This assumption is appropriate, for example, where the creep in the dominant ice flow mechanism and where the effects of subglacial water can be neglected. These ISMs have been par- tially coupled to AOGCMs (developed at lead- ing centers in the United States and around the world) to test their sensitivity to changes in basal tempera- ture and precipitation, to develop the projec- tions of land ice contributions to sea level change that have been included in the IPCC’s Third and Fourth Assessments.

Why Sciences and Policy Makers Are Insatiated

In the past decade, our knowledge of ice sheet dynamics has improved dramati- cally, due to the application of satellite tech- niques such as radar altimetry and interfer- onometry, together with airborne and surface observations (reviewed by the For example, Wingham [2007]). New, unexpected obser- vations, such as the thinning and acceleration of Greenland outlet glaciers, rapid ice shelf melting and increased discharge in the grounded basins of the Antarc- tica, embayment, West Antarctica, and the acceleration of many upstream tributaries following the collapse of the Larsen B ice shelf on the Antarctic Peninsula. In addi- tion to this, the evidence of widespread ice sheet, paleo records suggest that sea level rise, overall, and its modifications over the past 150 years, occurred at least episodically, at rates not attainable by current ice sheet models.

However, ice sheet simulations assessed by the IPCC cannot reproduce these observations because the simulations fail to include sufficient interactions with glaciological, climatological, and oceanographic processes. These changes in ice volume and discharge occur rapidly enough to modify ice sheet bound- ary conditions, which have been summarised in a hindcast of current stand-alone ice sheet models—lethal atmospheric, oceanic, ice shelf and ice sheet timescales—is invalid if this behavior is widespread. Without coupling to an appropriate atmosphere model, we cannot assess the spatial and temporal extent of these potentially important feedbacks.

Underlying Problems

Continental-scale ice sheet models have the least skill at predicting the full range of freshwater production and flow, ice shelf buttress- ing, and subglacial sediment deformation are prominent. These processes can interact to accelerate discharge near ice sheet mar- gins. Current computer-based projections of ice sheet response to warming climate are thus almost certainly biased against deliver- ing fast response to climatic warming in the rate of sea level rise. Key processes that should be incorporated into future model studies to include the forthcoming regional oceanic circula- tion, melting and shoving in subaerial cavities, a better understanding of continental ice sheet processes, and coupling to the global ocean;
• Improved mass balance requirements, including improved numerical algorithms (e.g., high-resolution with adaptable grid) and coupled models of inland and ice sheet flow, production and flow of water at the sur- face and within and beneath the ice;
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How can Integrated Ocean Drilling Program (IODP) drilling contribute to understanding of highly hazardous geologic events, such as great earthquakes, submarine landslides, and volcanic collapse, of all which can generate devastating tsunami and threat huge amount of habitats of earth’s coastal? Eighty-nine scientists from 28 countries grappled with this topic for 4 days near Portland, Ore., in late August and spawned a number of working groups focused on generating proposals to gain such understanding.

Ideas included potential scientific targets and locations for drilling, predictive observatories to study active and potentially precursory processes, in situ measurement techniques, and methodologies for interpreting sedimentary records. A common theme was the unique opportunity afforded by IODP drilling to study active processes relevant to geohazards, especially at known points within the deformation cycle. The meeting also led to proposed additions to the IODPaddendum for inclusion.

Meeting participants discussed how geohazards can be evaluated through drilling in several ways. One way is to understand the preconditions for failure and the changes in physical properties that might signal an event. Preconditioning includes diagnostic and mineralogic changes that affect strength and permeability, as well as reservoir pressures, vacuum, stress on fault surfaces, injected sands, and gas contents. Triggering mechanisms include earthquakes, wave and tide action, rapid sedimentation, magmatic reworking, destabilization of hydrates, groundwater seepage, and glaciation. The array of mechanisms for excess fluid pressures is common to many of these mechanisms.

Secondly, it was decided to ensure that geohazards is in the group of careful understanding of their frequency and distribution, which can be established through drilling and dating the events. For example, conference sessions recognized that a late-stage example occurred in the Pacific Northwest region resulting from careful dating of turbidite sequences and crosscutting relationships, and such studies should be expanded to many other settings.

The combination of drilling and ocean observatories serves as a coordinated method important for understanding the processes responsible for slope and volcanic failure and earthquake. This, and also for documenting the changes in movement, rate, and style, is a place where improvements are needed.

A number of examples that were discussed at the meeting underscored the potential deviation that such events could have on coastal populations, remnants of the consequences of the 2004 Sumatra earthquake and tsunami. Collapse of Mount Etna, an active volcano on the coast of Sicily, could threaten much of the Mediterranean coastline, and failure of one of the large Hawaii volcanoes could affect huge portions of the Pacific Coast. A report of known landslides, submarine volcanoes, and tsunami in 1923 or the Shergotty slide of 1810 years ago, would also be devastating for the North Atlantic region. Large scale impacts, fortunately very rare, could change the world as we are know it.
Effect of Human Activities on the Atmosphere

Detecting the Atmospheric Response to the Changing Face of the Earth: A Focus on Human-Caused Regional Climate Forcings, Land-Cover/ Land-Use Change, and Data Monitoring

Boulder, Colorado, 27–29 August 2007

Human activities continue to significantly modify the environment. The impacts of these changes are highlighted, for example, by regional, local, and global-scale trends in modern atmospheric temperature records and other relevant atmospheric indicators. Studies using both modeled and observed data have documented these impacts. It is essential that we detect these changes accurately and understand the impacts on climate and predict the improved assess- ment of the predictability of future climate.

Therefore, the second International Scientific Foundation-funded workshop was twofold. First, the workshop highlighted landscape-land-cover and ecosystem change and subsequent impacts on weather and climate. Participants discussed both long-term systematic change (e.g., agricultural land-use change, deforestation) and short-term abrupt change (e.g., rapid, small-scale urbanization).

Second, the workshop addressed new observing systems and issues associated with using the national data archive to monitor climate changes. Temperature is one key indicator of impacts of land-use/land-cover change, and hence this workshop featured issues related to temperature observations. Model results and other relevant atmospheric indicators, biases associated with precipitation were also discussed.

Papers were organized under three sessions to discuss recent developments, including (1) observations of changes in ecosystems function and changes and their interactions with weather and climate; (2) model- ing effects of land-use/land-cover change and ecological processes on weather and climate; and (3) monitoring and quantifying ecological processes on weather and climate. More studies on land-use/land-cover change and ecological processes on their impacts on observa- tional data including mulitdecadal surface climate; and (3) monitoring and quantify- ing and ecological processes on weather and climate; more studies on the impacts of wetlands, man-made lakes, agricultural land uses, and urbanization on weather and climate; the monitoring of soil moisture, and the use of the CDR in con- junction with land-use/land-cover change studies and assessment of data quality in each of these formats. Details of the recommenda- tions will be published in the form of sev- eral journal papers. Participants also recom- mended publishing a journal special issue. Papers presented at the workshop will be found at http://ir.columbia.edu/ science/groups/pierke/links/Details/ and http://01.013.wiki.edu/

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Sediment Fluxes and Budgets in High and High-Altitude Cold Environments

Sediment Fluxes in Cold Environments (SEDIBUD) Second Workshop

Abisko, Sweden, 15–19 September 2007

Amplified-climate change and ecologi- cal processes in cold regions have been highlighted as key global environmen- tal issues. Projected climate change in cold environments will increase precipitation duration and intensity, along with total precipita- tion, and will change temperature between season and within the season. Similarly, changes to the reduced extent of perennial and increased urban and agricultural land-use data expected. These effects will undoubtedly change surface water interactions. Consequently, altered fluxes of the sediment, nutrients, and solu- tions, but the absence of data and analysis and an understanding of the importance of the surface water environment is acute in cold regions. A goal of the International Association of Geomorphologists (IAG) has been to address this key knowl- edge gap through the Sediment Budgets in Cold Regions (SEDIBUD) program. SED- IBUD represents a continuation of the pre- vious European Science Foundation SEDIFLUX (Sedimentary Source-to-Sink Fluxes in Cold Environments) program. The central research question of the working group is to assess the contemporary and also discussed.

SEDIBUD has developed a key set of pri- mary research questions, which will be incorporated into results from these varied projects and allow analysis across the net- work. SEDIBUD will be highlighted on the findings of the previous workshop and will add an additional dimension of cold cli- matic conditions as well as a temporal and spatially dis- posed efforts, the first edition of the SEDIFLUX/ SEDIBUD manual (http://www.nico.nau/ SEDIBUD/SEDIBUDmanual2005.pdf) is due to be published. This has been produced to establish common methods and
data and standards. Ongoing revision will continue to improve the manual to facilitate intercomparison of research results.

SEDIBUD currently has identified 37 sites worldwide and over 50 scientists from at least 40 sites that cover the widest range of cold environments in the world. Scientists expected that collaboration within the group will act as a catalyst to develop new sites and also promote the exchange and cooperation and with a number of existing networks and research programs, including International Tundra Exper- iment (ITEX), Circumpolar Active Layer Monitoring Network (CALM), and Arctic Coastal Dynamics (ACD/ACCO Net), will provide fur- ther opportunities for collaborative research at the workshop to be the second SEDIBUD workshop at Abisko, Sweden, to pres- ent ongoing research efforts and discuss research goals and the field methods detailed in the SEDIFLUX/SEDIBUD man- ual. This successful workshop brought together 22 participants from 12 countries and built on the first SEDIBUD workshop in Tromsøe, Norway (2006), and previous SEDIFLUX meetings in Durban, UK (2005), Edinburgh, France (2005), and Aqsaqarleif, Iceland (2004). The next meeting will take place 9–13 September 2008 at the Ninow Ridge Field Station, Boulder, Colo. Interested researchers are encouraged to participate in this growing international ini- tiative. Further information on the SEDIFLUX/ SEDIBUD program, see http://www.geosrecipes.org/wp/gwpib.html or contact Achim A. Berg (achim.berg@snm.nrw.de) or Scott Lamoureux (vice-chair, scott.lamoureux@nico.nau.ca).

—SCOTT LAMoureux, Department of Geography, Queen’s University, Kingston, Ontario, Canada; Achim A. BERG, Norwegian Geological Survey, Trondheim, Norway; ARNOLD DEHAAS, Centre National de la Recherche Scientifique/GEOLAB, Clermont-Ferrand, France.
On 9 December, the chairs of the focus groups met at the AGU Council meeting to voice their common concerns, in particular, to assure that all members can participate fully in AGU activities regardless of their primary scientific affiliation with the Union. The chairs of the policy committee joined the others and discussed proposed changes to the AGU Statements on human rights, the concept of an estuary being the transition zone, and the impacts of ENSO and climate on regional marine system off Western Australia coast and the impacts of ENSO and climate change on the marine ecosystem off Western Australia and its eddy field have strong effect on the biogeochemical processes in the marine ecosystem. The Leeuwin Current and its eddy field are expected to be important. The Leeuwin Current and its eddy field are expected to be important.

AGI was the host of the American Geophysical Union Day in San Francisco. The AGU Day was held on the 14th December 2007 “American Geo- physical Union Day” in San Francisco. This event included the presentation of AGU’s membership and has been the 40 years of support the AGU membership has given to the city, which is greatly appreciated.

AGI Council also adopted a revised version of the AGU Statement on the responsibilities of the AGU for the protection of the marine environment. This statement will be updated and discussed at the next meeting of the AGU. The Committee on Ocean Sciences will work to develop a new version of this statement for presentation at the AGU Fall Meeting, which once again will consider the implications of the AGU’s role in ocean sciences.

The other two position statements deal with oceanography and environmental protection. The full text of all statements will be published in EOS and posted on AGU’s Web page in the near future.

At the Council meeting the last meeting of the 2008 Fall Meeting, which was attended by the AGU membership, was held on the 14th December and presented a summary of the major issues discussed at the meeting. The summary helped me get back on track.

The book contains 16 chapters divided into seven sections. Each section is devoted to a specific area of research focusing on estuarine hydrography. The sections cover topics such as biological processes, chemical processes, and physical processes. The chapters are written by experts in each area and provide a comprehensive overview of the research in each field. The chapters are well-organized and easy to follow, making it a valuable resource for both researchers and students in the field.

The book is thoroughly referenced, containing over 1,000 references. This is an important feature of the book, as it allows readers to follow up on specific topics or research areas.

Overall, Biochemistry of Estuaries is an excellent textbook for an upper-level course in biogeochemistry and is an exciting addition to the field of estuarine science. Students and researchers will find this book to be a valuable contribution to their personal work and to the scientific community.

This book is not intended to be a comprehensive review of all aspects of estuarine science, but rather, it is a focused, up-to-date survey of the most important research areas in the field.

Biogeochemistry of Estuaries

Whether you are interested in material fluxes from the continents to the oceans or the chemical processes that go on in the ocean, a water- front restaurant may have come from polluted waters, know estuaries are impor- tant places. However, anyone attempting to summarize and synthesize the long and rich literature of estuarine research is presented with a daunting task. This is one of the reasons why the AGU’s Biogeochemistry of Estuaries section is so important. Thomas Bianchi, a leading researcher in this field, has been involved in the development of this book for many years. This book, written in collaboration with international colleagues, provides a comprehensive overview of the current state of knowledge in estuarine research.

The way the author discusses topics should make this an excellent textbook for an upper level class in estuarine biogeochemistry. Assuming only some basic knowledge of chemistry and biology, the book is accessible to advanced undergraduates or beginning graduate students across a broad range of scientific disciplines. At the same time, the book is written for professionals and should be useful to researchers who are more interested in different aspects of the study of estuaries. Such individuals will find this book to be a valuable contribution to their personal research and to the scientific community.

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Classified

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nature

Climate Scientist

Nature, the international weekly journal of science, seeks a Climate Scientist to join a team of editors dedicated to publishing the world’s best original research in the Earth & Environmental Sciences in Nature. We also have a key role in determining how these fields are represented in the selection and preparation of manuscripts for publication and as Nature’s interface with the relevant research communities. It is a demanding and challenging role involving stimulating positions, and calls for keen interest in the practice and commitment to excellence.

The ideal candidate will have research experience in climate science, but highly qualified candidates from other areas of the Earth sciences should not be deterred from applying. Applicants should hold or expect shortly to receive a PhD or equivalent degree.

The job is based in Nature’s modern London offices but will involve regular travel within the United Kingdom and occasional international travel.

Applicants should send a CV (including their class of degree and a brief account of their research and other relevant experience), a concise discussion of which recent developments in the Earth sciences they have found interesting, and a covering letter, quoting reference number NPG/CLN/780 to Karrie Willsher, Head of Recruitment, Publishers at London:personnel@macmillan.co.uk

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APPLICATIONS: 

A Ph.D. in environmental engineering or related fields is required. Applicants should send a single PDF document including a cover letter, curriculum vitae, and statements of research and teaching goals to: Dr. Paul Moorcroft (paul_moorcroft@harvard.edu). Harvard University is an equal opportunity/affirmative action employer.
We seek exceptional candidates from the mathematical, physical, biological and engineering sciences to complement our existing faculty, including national research and engineering initiatives. Target research topics this year include: coastal oceanography, Underwater Vehicles and glider technology for chemical, acoustic, and other sensing applications; coastal, estuarine and nearshore modeling and data analysis and assimilation; signal processing and geophysical inverse methods.

Candidates are expected to develop their own independent externally funded and nationally and internationally recognized education and research programs. Faculty members have the option of advising graduate students and teaching courses through the MIT-WHOI Joint Program in Oceanography and Oceanographic Engineering.

Sea Duty is expected at this level. Ph.D. and experience commensurate to rank required.

Education and experience will dictate position level. The selection process will begin January 15, 2008.

For more information or to apply, please visit http://jobs.whoi.edu

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