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International Year of Deltas 2013: A proposal

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Honors

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Three AGU members are among the 10 recipients of this year's Heinz Awards, announced on 13 September by Teresa Heinz and the Heinz Family Foundation. **Richard Alley**, Evan Pugh Professor of Geosciences at Pennsylvania State University, in University Park, was recognized for his polar ice

discoveries that showed that abrupt climate change is possible and for engaging his students, policy makers, and the public. **Joan Kleypas**, a marine ecologist and geologist at the National Atmospheric and Oceanic Administration's National Center for Atmospheric Research, was honored for conducting seminal research on how changes in temperature and in seawater chemistry and acidity have affected coral reefs and for identifying ways to bolster coral reef health. **Nancy**

Rabalais, executive director of the Louisiana Universities Marine Consortium, in Chauvin, was cited for her pioneering research of severe oxygen depletion in the Gulf of Mexico and her commitment to reducing water pollution through education and public policy. The awards program "recognizes individuals creating and implementing workable solutions to the problems the world faces through invention, research, and education while inspiring the next generation of modern thinkers," according to the foundation. Each recipient receives an unrestricted cash prize of \$100,000.

FORUM

International Year of Deltas 2013: A Proposal

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Marine and lacustrine deltas around the world are economic and environmental hot spots. They occupy approximately 1% of the Earth's land area but are home to more than 500 million people—a population density more than 10 times the world average [Ericson *et al.*, 2006]—all within 5 meters of sea level [Overeem and Syvitski, 2009]. This high density is supported by high productivity, rich biodiversity, and transport along a network of waterways. Yet deltaic systems are some of the world's most delicate and vulnerable natural systems, residing at the boundary between land and water, and are subject to upstream human control, local resource exploration, and climatic impacts.

Deltas act as filters, repositories, and reactors for a suite of continental materials on their way to the coast, including fresh water, sediment, carbon, nutrients, and pollutants [Vörösmarty *et al.*, 2009]. As hubs for urban development and ports of entry, deltas are focal points for human vulnerability to health risks such as infectious diseases. As important areas for agriculture, forest products, and fisheries production, deltas play a major role in regional and global resource chains. For example, because they are "rice bowls" to the world, deterioration of the megadeltas of Asia poses serious threats to food security for the more than half of the world's population that relies on rice as a staple food [Hoanh *et al.*, 2010]. This deterioration is caused by the increasing pace of human development, which alters the functionality of ecosystems and produces escalating economic and sociocultural impacts in these food-producing areas. The human dimension and ecological implications of deteriorating or disappearing deltas cannot be overstated.

There is an urgent need to rally the international community for a focused effort toward a holistic physical-socioeconomic understanding of deltas as critically delicate and vulnerable systems undergoing change. Such understanding is a basic requirement for their management, protection, and restoration.

We propose that 2013–2014 be designated as the International Year of Deltas (IYD) to (1) increase awareness of and attention to the value and vulnerability of deltas worldwide, (2) promote and enhance international and regional cooperation at the scientific, policy, and stakeholder levels, and (3) focus and accelerate a comprehensive research agenda toward understanding and modeling these complex socioecological systems as the cornerstone of ensuring preparedness in protecting or restoring them in a rapidly changing environment.

Understanding Delta Dynamics Requires a Team Approach

Delta dynamics can be viewed across three broad themes: (1) ecogeomorphology and delta function, e.g., the interplay of mangroves and grassy wetlands with the physics of flow and the creation and destruction of bars, channels, and beaches; (2) climate and delta function—the relative impacts of short but intense events (e.g., storms) versus broader changes such as subsidence and sea level rise; and (3) human influences on deltas—dams and sediment disruptions in the upstream basins, riverbed mining, diversions, stop banks, drainage canals, and discharges from domestic, industrial, and agricultural water use. Understanding delta dynamics and developing predictive models that can form the basis of delta restoration and protection strongly transcend disciplinary boundaries: At a minimum, the required fields include

geomorphology, ecology, sediment engineering, hydrology, coastal oceanography, stratigraphy, geography, history, anthropology, sociology, political sciences, and economics.

Basic research questions across these disciplines include the following:

1. What are the system dynamics of a delta, its main processes and reservoirs, feedback loops, system gains, and relevant parameters that govern dynamic equilibrium states? How strong is the two-way coupling between the ecological communities of the delta top and the geomorphic (physical) template?

2. How does the delta system (distributaries, wetlands, lakes, lagoons, and coastlines) self-organize into a dynamic structure capable of maintaining the subaerial delta over different time scales?

3. How do perturbations in the incoming sediment fluxes and types, relative sea level rise, salt and nutrient fluxes, wave energy and storm environment, and human interventions modify the delta system and change the delta's feedback factors and system gains?

4. What are the demographic and urban trajectories in delta regions with respect to population growth, rates of poverty, and indicators of human well-being? What unique challenges do delta regions pose with respect to achieving the United Nations Millennium Development Goals (<http://www.un.org/millenniumgoals/>)?

5. The increasing connectivity of biophysical and socioeconomic processes in delta regions creates functional interdependencies with implications for the robustness and resilience of deltas as social-ecological systems. How may different types of governance arrangements help facilitate and/or limit solutions to intricate problems of management, protection, and mitigation?

Overeem and Syvitski [2009] suggest a scientific approach to delta research that involves both problem-driven research and action research. Problem-driven research means that rather than choosing a disciplinary-based method or a disciplinary perspective for research, a practical problem is identified and research is used for tackling that problem irrespective of the academic origins of the approaches selected. Action research helps to catalyze action rather than being for science

only and as such has relevance for people living in deltas. The IYD calls for developing an effective paradigm of basic research in service to society that demonstrates the power of research to improve conditions in these focused hot spots of vulnerability and change: deltas around the world.

A recent example of a “call to arms” was the International Polar Year (IPY) 2007–2008, which activated 50,000 researchers, local observers, educators, and students from more than 60 nations through 228 IPY projects [cf. *International Council for Science (ICSU)*, 2011]. IPY generated substantial new funding for polar research and monitoring, created a platform that demonstrated the power of integrated transdisciplinary research, trained next-generation polar researchers, and produced large-scale baseline data against which future changes could be assessed. IPY brought together nations, organizations, funding agencies, and stakeholders to advance polar research.

A similar effort is needed for advancing awareness and interdisciplinary research that support sustainable solutions to our world’s deteriorating deltas. The social and economic relevance of deltas represents an opportunity to link transformative science and innovative policy relevant to the larger global environmental change community. Deltas are indeed delicate sensors of change: They sense global changes (e.g., sea level rise), regional changes (e.g., upstream basin development, water withheld by dams, nutrient loadings intensified by agriculture), and local changes (e.g., resource use). These changes amplify each other and interact in ways we do not fully understand, let alone know how to predict.

Why an International Year of Deltas?

Despite the many meetings and reports calling for action on deltas worldwide, progress is slow, focus is lacking, and synergies are not fully realized. These meetings and reports speak for the urgency of the problem and for the desire of the scientific and policy-making communities to understand these threatened systems and to provide support for global, regional, and local plans for protection, mitigation, and response to change. Examples of recent delta forums include World Delta Dialogues, 2010, New Orleans, La., USA; Deltas: Coastal Vulnerability and Management, 2009, Chennai, India; Deltas in Times of Climate Change, 2010, Rotterdam, Netherlands; Impacts of Global Change on Deltas, Estuaries and Coastal Lagoons, 2011, Ebro, Spain; Deltas Under Climate Change—The Challenges of

Adaptation, 2011, Hanoi, Vietnam; LOICZ: Coastal Systems, Global Change and Sustainability Conference, Yantai, China, September, 2011; among many others. There is a surge of planned delta-oriented meetings, including World Water Forum v6, Marseille, France, March 2012 (“Enabling Delta Life”); 8th International Conference on Tidal Environments, Normandy, France, August 2012; and World Delta Dialogues, Hanoi, Vietnam, fall 2012.

The IYD is not proposed to be just another activity on deltas. Rather, it is proposed as a year of awareness, a year of focus, and a year for launching a 10-year committed initiative, in intellect and resources worldwide, toward practical and goal-oriented efforts to comprehensively address the predictive understanding of these vulnerable systems and to use this understanding to protect and restore them.

Coastal vulnerability, freshwater security, ecosystem services, and the most vulnerable societies have been identified as four of the five priority focus areas of the Belmont Forum (see http://www.igfagr.org/images/documents/belmont_challenge_white_paper.pdf), whose overarching goal is “to deliver knowledge needed for action to mitigate and adapt to detrimental environmental change and extreme hazardous events” [cf. *ICSU*, 2010]. Deltas can serve as showcases where science can indeed make a difference in protecting and enhancing societal and economic interests while protecting the environment under intense human and climate stressors. Deltas exemplify the much talked about “global change, local solutions” paradigm. Borrowing words from the megacities analogy [Romero-Lankao and Dodman, 2011], the IYD calls for transforming deltas from “hot spots of change and vulnerability to seedbeds of sustainability and resilience.”

The year 2012 will see coordinated international efforts on global sustainability. The “Planet Under Pressure” conference, March 2012, London, which focuses on stewardship of the coupled socioecological Earth system to meet energy, food, water, and ecosystem services, can form the platform for launching the IYD and establishing a scientific agenda on delta sustainability research. This agenda can be presented, discussed, and endorsed at the 2012 United Nations Conference on Sustainable Development Rio+20. The scientific community is here called to action to consider the proposed focused efforts on deltas and contribute ideas on how to move the IYD forward.

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