One perspective on GeoSciences Data and Coastal Science and Sustainability: A brief to NSF's EarthCube

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A substantial percentage of the world population lives within 10-100 kilometers of the ocean and in low-lying, flat coastal regions (Small and Nicholls, 2003; United Nations Ocean Atlas, 2010). This population segment, the land, and the supporting infrastructure represent a complex and diverse system that is particularly vulnerable to coastal hazards including storm surge inundation, precipitation-based flooding, waves, and coastal erosion. Further, this coastal zone (CZ) is also the buffer and filter between terrestrial and oceanic waters, through which most international commerce is transported. It also supports a vibrant economy that mixes together, among other ingredients, tourism, military assets, critical fisheries, and environmentally sensitive areas. Furthermore, in many cases, CZ population density continues to increase. In the coming decades and centuries, the CZ and its population and resources will become increasingly more at risk as the consequences of a changing climate (e.g., elevated sea levels, increased precipitation, potentially increased storm intensity and frequencies (Najjar, et al, 2000; Nicholls, 2004)) are felt throughout coastal systems. Ensuring the long-term sustainability and increasing the resiliency of the CZ and its economies, cultures, and ecosystems is thus one of the greatest challenges faced by the United States and the world in general.

The United States and NSF is uniquely positioned to meet this challenge and lead research into climate change and its impacts. The historical long-term investment in science and applications in addition to the wealth of data on the earth as a complex and interconnected system have led already to substantial understanding of the earth system and how it responds to natural and anthropogenic forces. However, there is critical and important work ahead, focused not only on science and research but also on communication and policy. Indeed, the latter aspects are probably more important since it is through policy and planning that our behavior as resource consumers will be modified. This will ***require*** crosscutting and transformative research and applications into sustainability, resiliency, and natural sciences to guide future policy and decision-making.

This is particularly important given potential impacts in the CZ from sea level rise. The United States east coast, for example, has several large metropolitan areas (Norfolk/Hampton Roads, NYC, e.g.) that will be substantially affected by sea level rise. The sustainability of the CZ, including the human population, critical infrastructure, environmental and ecological niches, will be ensured (or not) nearterm policy and management strategies that will impact the longer-term evolution of the CZ. Many of the difficult policy decisions must be made now to have positive impact in the future.

Policies and plans geared toward long-term community sustainability and resiliency, in the larger human community context, should be underpinned by science. Indeed, key policy decisions will need to be made on the basis of well-understood science and scientific conclusions. NSF's GeoSciences initiatives will clearly play a critical role in our scientific understanding of critical issues. This includes sustainability initiatives like the Sustainability Research Network (SRN) program, cyberinfrastructure initiatives like the SI2 software innovation programs, and the evolving EarthCube.

The role of data (encompassing data acquisition, cataloging, archival, management, and discovery) in underpinning GeoSciences research cannot be overstated. Data is needed to characterize and describe our physical environment, ecological communities, and even the social structure of human communities pre- and post-disaster. Of equal importance, data is needed to confirm hypotheses, validate prediction models, and develop regressions and parameterizations of complex interactions. While research communities occasionally use a common data model, in general the data are described in ad hoc ways, lacking consistent (or any) metadata, and it is frequently not discoverable by others outside the community or even outside a single research laboratory. This barrier to truly transformative science, across the diversity of scientific disciplines, must be overcome in the relatively near future if policy decisions are expected to use such knowledge.

Several federal initiatives have made substantial progress in diminishing the interoperability barrier by improving the state of data and data management in the past two decades. NOAA's Integrated Ocean Observing System activities and its regional associations (RA) have spearheaded this effort, at least as far as coastal data is concerned. The RAs themselves have acquired much data and facilitated access to existing data sources, and contributed these to the national data collection; methods have been developed to enable access to these data. The overall effort has highlighted many of the issues in handling diverse data types and the middleware necessary to enable discover, access, etc. Additionally, federal data repositories, such as NOAA's NCDC, have massive volumes of data that are being mined for climate-related signals. Undoubtedly, there are lessons learned from these types of activities that should inform and guide EarthCube.

GeoSciences data acquired in the CZ spans the disciplines of atmospheric physics and meteorology; physical, chemical, geological, biological oceanography; ecology; social sciences, and engineering, to name just a few. Within this disciplinary diversity, the types of data are equally diverse, from aircraft and satellite remotely sensed fields (e.g., LIDAR, SST); in situ measurements of scalars and vectors (e.g., temperature and velocity) including field programs that collect time- and space-dependent observations of specific phenomena or events; pre- and post-disaster property/life loss; pre- and post-disaster community social bond strengths; and species-level ecological community analyses. Development of, and adherence to, discipline-specific ontologies and meta-ontologies, as well as

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software layers to negotiate the ontologies and underlying data, is critical to enabling transformative research.

In this context, NSF's EarthCube should not initially support specific research projects (e.g., specific field programs or community model development). There are several different NSF, NOAA, ONR, DOE, and DOD programs that fund such applications. Rather, EarthCube should focus on building the cyberinfrastructure components and framework to enable transformative research, applications, and education in GeoSciences.

The issues associated with integrating science into policy and decision-making for sustainability and risk reduction in the coastal zone are not restricted to this part of the Earth system. Indeed, strong connections to information from watersheds, the open ocean and social sciences are required to fulfill expectations. This topical breadth imposes a requirement on the reach of EarthCube. It is possible that the OOI innovations for cyberinfrastructure are the proper starting point for a broader GeoSciences data perspective. However, it is not clear how this would be scaled up and out into a broader, more encompassing framework. Regardless of the ultimate architecture of EarthCube, incorporating existing data (such as within NOAA, USGS, EPA, state resource agencies, etc) is critical, particularly given the coastal zone's importance to our future as well as the historical and on-going focus on coastal sciences and policy by these agencies.

References:

Najjar, R., H. Walker, P. Anderson, E. Barron, R. Bord, et al., 2000: The potential impacts of climate change on the mid-Atlantic coastal region. *Clim. Res.*, 14, 219–233.

Nicholls, R., 2004: Coastal flooding and wetland loss in the 21st century: changes under the SRES climate and socio-economic scenarios. *Global Environmental Change*, 14(1), 69–86.

Small, C. and R. Nicholls, 2003: A global analysis of human settlement in coastal zones. *J. Coastal Res.*, 19, 584–599.

United Nations, 2010: United Nations Atlas of the Oceans: Human Settlements on the Coast. http://www.oceansatlas.org/id/1877.

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