CLIMATE VARIABILITY: DEFINING THE SCOPE, IMPACT ON HUMAN SYSTEMS, AND RESPONSE TO GLOBAL CHANGE

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In between "weather" and "climate" lie a number of climate phenomena that cause departures in temperature and rainfall from average values. The best-known examples of these anomalies are the El Nino-Southern Oscillation (ENSO) and North Atlantic Oscillation (timescales of 4-7 years and 8-15 years, respectively). While these phenomena play out as regional redistributions of atmospheric pressure systems and temperature patterns at the earth's surface, modern climatology has increasingly recognized their large "footprint". The persistence and strength of decadal to centennial climate disruptions have great implications for decision making in human systems. They occur at a scale short enough to greatly affect societal vulnerability to drought, flooding, heat, and cold waves on the individual lifetime. Furthermore, the presence of climate anomalies on this time scale affect planning decisions: what appear to be trends over several years and perhaps decades may in fact be part of a natural (and only partially predictable) cycle which will return to another state shortly.

Our working group brought together a diverse Brown-MBL contingent to consider the consequences to human systems of climatic variations on the timescales of individual, powerful events to century-long anomalies. We noted that variability carries two senses: on a local-regional scale, it encompasses deviations in temperature, rainfall, storm frequency, etc. from average 'climatic" values over time. Between regions, "variability" connotes not-uniform responses to large-scale climate change. For example, under global warming scenarios, the predicted rise in temperatures and trends in rainfall differ significantly across the globe.

Among the significant intellectual questions that emerged, we discussed:

- The likelihood of non-normal distributions of variability. The spectrum of variability may be tilted toward relatively rare, but powerful events and anomalies.
- The existence of strong feedbacks between climate variability, ecological, and human responses. For example, climate variability may lead to significant ecological feedbacks, including altered fluxes to the atmosphere of biologically produced greenhouse gases, changes in soil moisture mediated by plants, and changes in surface albedo (reflectivity to incoming sunlight) driven by changes in vegetation. Since human decisions also significantly affect many of these same feedbacks, their response to climate variability should also be considered in an integrated view.
- The question of how much climate variation arises from internal variability to the climate system, and how much is forced from outside. The substantial climate anomalies of the ENSO and the NAO phenomena are generally

considered to arise from instabilities inherent to the climate system; they do not require an external "cause" (other than the normal seasonal cycle). Other factors known to produce rapid climate change do come from outside the climate system. For example, volcanic eruptions and variations in solar activity have played and will continue to play a role in climate variability.

- The fact that world populations have not been and will not be in the future at equal risk to climate variability. Some regions have inherently higher degrees of climate variability, and this variability may not match well to social resilience. We also recognized the challenge of assessing risk: do we value potential loss of wealth over loss of life and/or community?
- The degree to which human perceptions may be poorly adapted to incorporate climate variability into decision-making. As one example, during a recent visit to campus, the geographer Emilio Moran related the experience of interviewing farmers in Brazil in a region that is heavily affected by droughts during El Nino. He found that a few years after the last major drought, the farmers discounted the experience as "unusual" or "unlikely", despite the fact that El Ninos will recur (with varying intensities) every 3-7 years.

We recognized significant strengths of the Brown-MBL community in approaching these questions:

- Strengths in environmental sociology that can tackle questions about perception of risk and decision making, and the distribution of risk relative to human demography
- Strengths in geosciences in remote sensing, geochemistry and paleoclimatology that can help monitor present and past environmental change
- Strengths in ecosystems research, both empirical and modeling, that can help to define responses of ecosystems to disturbances and the feedbacks of ecosystem changes to climate and human well-being
- Strengths in archeology that can link past environmental change to human responses as potential analogues to future change
- Strengths in environmental economics that can help the ECI relate climate variability to its economic consequences

As a result of the discussion, four themes emerged that the group would like to explore further in a future retreat devoted to climate variability

Taking information from the natural sciences that characterizes climate variability and connecting it more closely with human decision-making. One can think that variability, unless it is recognized and incorporated into economic and social planning adds "noise" or poor information, resulting in inefficient decisions. This strand would connect Geology, EEB, the Ecosystems Center at the MBL, Sociology, and Economics.

Choosing a region such as New England as a model system to look at the complex interactions between climate variability, ecological feedbacks, and human-induced changes in the landscape. The group recognized that Brown and MBL have substantial expertise in working with coastal and forest ecosystems in the region, and that the region has an abundance of data that characterize change (both environmental and demographic) since the arrival of Western Europeans. Furthermore, an extensive paleoclimate data base exists, largely generated by research at Brown. This working group would include EEB, Geology, and the MBL.

Combining archeological studies with paleoenvironmental characterizations to explore the consequences of climate variations on cultural and technological changes in societies. Here we would focus on case histories of regions with a rich set of archeological data and well-developed and well-dated archives of past climate, vegetation, and fauna. Participating groups might include Archeology, Classics, the Joukowsky Institute, Geology, EEB, Economics, and Sociology.

Generating assessments of climatic risk to regions of the developing world. Here, we expect that climate variability has been monitored very ineffectively, yet the populations may be some of the most vulnerable. We have considerable expertise at Brown in tropical ecosystems and paleoclimate that could help to reduce the knowledge gap considerably. Participating groups would include Sociology, Economics, EEB, the Ecosystems Center, and Geology.