HURRICANES AND CLIMATE CHANGE

BY JAMES B. ELSNER

Studies suggest that tropical cyclones are becoming more powerful with the most dramatic increase in the North Atlantic. The increase is correlated with an increase in ocean temperature. A debate concerns the nature of these increases with some studies attributing them to natural climate fluctuations, and others suggesting climate change related to anthropogenic increases in radiative forcing from greenhouse gases. A Summit on Hurricanes and Global Warming[1] brought together leading academics and researchers to discuss the issues and to address what research is needed to advance the science of hurricane climate. The summit[2] provided a venue for encouraging a lively, spirited exchange of ideas.

Traditionally tropical cyclones are analyzed as a passive response to climate forcing, the hurricane as a product of its environment. A warm ocean provides sustenance, a calm atmosphere nurturing, and a subtropical high pressure cell forward direction. An increase in oceanic heat will raise a hurricane's potential intensity, yet an increase in shearing winds could counter by dispersing the heat in a fledgling storm. This perspective is useful for identifying the mechanisms responsible for making some seasons active and others inactive. In this regard it was argued that data modeling is superior to data analysis as it avoids cherry-picking the evidence and provides a framework for making use of older, less reliable data.

For example, a Poisson distribution is useful for modeling tropical storm counts over time. The benefit of this approach is that it provides a context that is consistent with the nature of underlying physical processes, analogous to the way the laws of

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INTERNATIONAL SUMMIT ON HURRICANES AND CLIMATE CHANGE

WHAT: Seventy-seven academics and stakeholders from 18 countries participated in a summit on hurricanes and climate change for sustained discussions on the state of hurricane climate science and to elevate the discourse above the fray. In this spirit, it was appropriate to convene at the birthplace of the Socratic method.
WHEN: 27–30 May 2007
WHERE: Hersonissos, Crete, Greece

[1] The International Summit on Hurricanes and Climate Change was hosted by Aegean Conferences and supported by the Bermuda Institute for Ocean Sciences (BIOS) Risk Prediction Initiative and by the U.S. National Science Foundation. It was organized by James Elsner (The Florida State University) and Richard Murnane (BIOS).

[2] All sessions were plenary and attendance averaged greater than 90%. There were four days of talks with each day broken into an early and late morning session of four to five speakers each. The proceedings will be published by Springer as an edited volume.

physics provide a context for studying meteorology. Smoothing (filtering) the count data, however, introduces low-frequency patterns that may not be significant, while a data model of Atlantic hurricanes indicates a recent upswing in the number of strongest hurricanes with little multidecadal variation (Fig. 1). Although the question of whether we can ascribe a change in tropical cyclone intensity to anthropogenic climate change (attribution) is still open, it was argued based on data models for extreme winds that the difference in hurricane intensity for storms near the U.S. coast between globally warm and cool years is consistent in sign and magnitude with theory and simulations. In this regard it was noted that the apparent discrepancy between numerical model results and observations is likely due to a reliance on data analysis rather than data models.

The collective role that hurricanes play in changing the climate was a point of emphasis at the summit. Over the Atlantic, heat and moisture transport out of the tropics by an ensemble of hurricanes moving poleward in a given season was shown to have a detectable influence on the baroclinic activity at high latitudes the following winter, which in turn influences the preferred hurricane

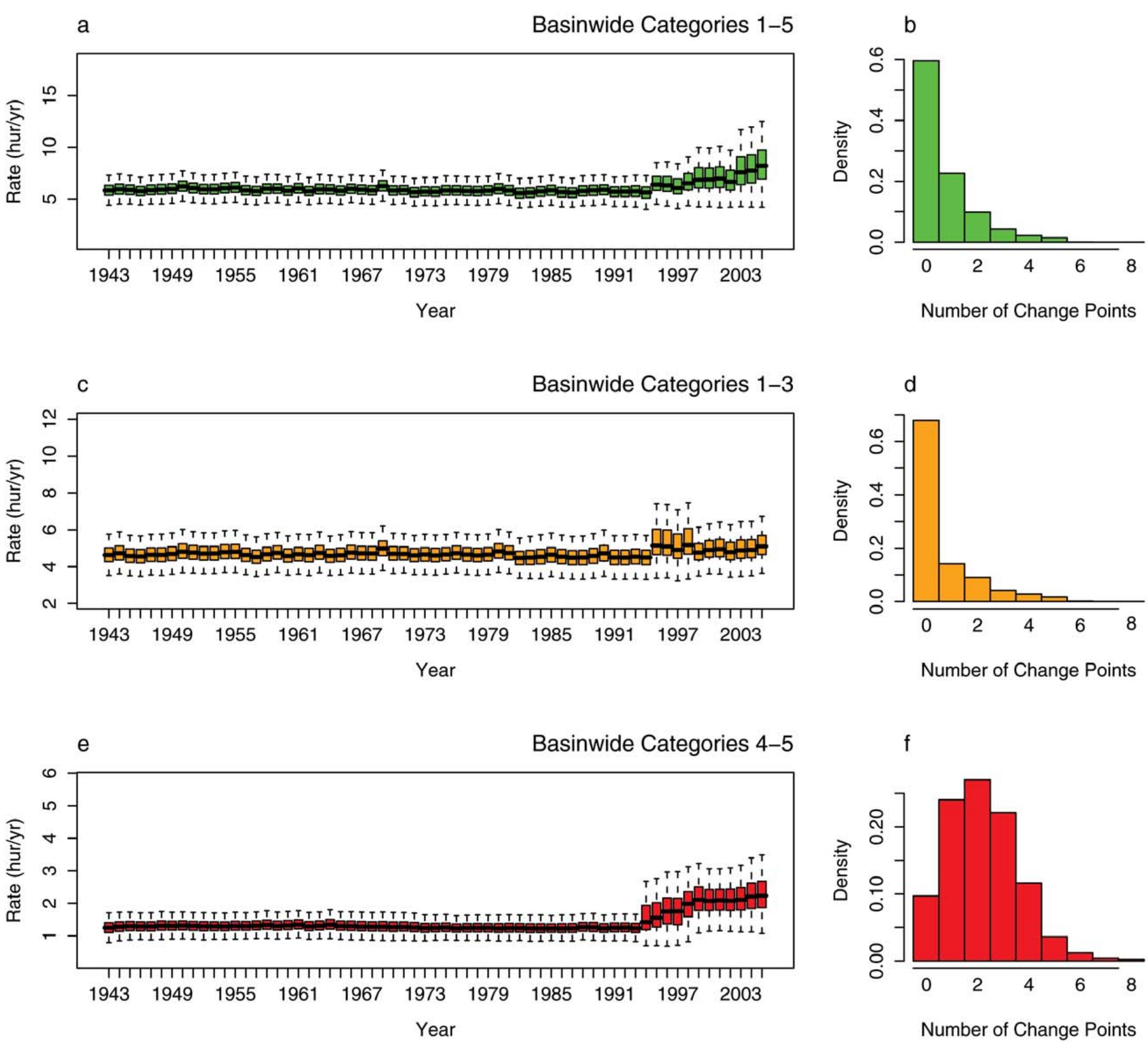

Fig. 1. Annual hurricane rates from a data model for basinwide Atlantic hurricane counts. Results are shown for different categories of hurricane intensity. Note that for each year the model provides a distribution on the estimated annual rate as indicated by a box plot. Rates are relatively constant for much of the later half of the twentieth century but show increases in the strongest hurricanes since the middle 1990s. The distribution of the number of rate changes over the 63-yr period (1943–2005) is also shown. The model is under development by Thomas H. Jagger and the author at The Florida State University.

track type (recurving or straight moving) during the subsequent hurricane season. Thus a communication between the tropics and the middle latitudes on the biennial time scale is accomplished through tropical cyclone track changes and middle latitude baroclinicity. On a longer time scale, the influence of ENSO on tropical cyclones especially over the western North Pacific and North Atlantic is well known, so global warming might have an indirect effect on tropical cyclones through changes to ENSO. These are intriguing hypotheses about climate change and tropical cyclones that merit further investigation. It was also demonstrated that high aerosol concentrations lead to an enhancement of the ice–water cloud microphysics, which, in turn, leads to the invigoration of the convection inside a tropical cyclone. Thus models used to study the influence of climate change on tropical cyclones must properly account for changes in aerosol loading as well.

Another important focus was paleotempestology—the study of prehistoric storms from geological and biological evidence. For instance, coastal wetlands and lakes are subject to overwash processes during hurricane strikes when barrier sand dunes are overtopped by storm surge. The assumption is that during landfall the waves and wind-driven storm surge reach over the barrier and deposit sand in the lake. In a sediment core taken from the lake bottom, a sand layer will appear distinct from the fine organic mud that accumulates slowly under normal conditions. Sediment cores taken from the northeastern Caribbean show more sand layers during the second half of the Little Ice Age when sea temperatures near Puerto Rico were a few degrees (Celsius) cooler than today, which provides some evidence that today's warmth is not needed for increased storminess. Not surprisingly, intervals of more hurricanes correspond with periods of fewer El Niño events. Sedimentary ridges in Australia left behind by ancient tropical cyclones indicate that activity from the last century underrepresents the continent's stormy past. It was argued that proxy techniques based on oxygen isotopes from tree rings and cave deposits also show promise for better understanding the relationship between tropical cyclone and climate. Rainwater from tropical cyclones is lighter than normal rainwater and, hence, isotope analysis of the annual layers can detect this difference.

While such studies are useful to identify periods of increased numbers of tropical cyclones, a spatially limited set of proxies or historical records is not able to distinguish changes in overall activity from changes in local activity due to shifts in tracks. While the northeastern Caribbean region is in the direct path of today's hurricanes, was it always? The answer is important as more hurricanes locally could mean changes in steering rather than changes in abundance. Proxy data from the U.S. Gulf Coast show a pattern of frequent hurricanes between 3,800 and 1,000 yr ago followed by relatively few hurricanes during the most recent millennium, which has been explained in terms of the position of the North Atlantic subtropical high. Over the past several decades the north–south pattern of variability in the atmosphere–ocean environment over the Atlantic explained a significant proportion of the interannual tropical cyclone activity in this region. Moreover, recent increases in typhoon intensities affecting Korea can be explained by an eastward shift in the subtropical North Pacific high, allowing the storms to recurve over the warmer waters of the Kuroshio Current rather than the colder subsurface waters of the Yellow Sea. To understand how climate influences local changes in tropical cyclone activity, more research is needed to identify factors influencing tropical cyclone tracks.

Results from various high-resolution numerical models, including a 20-km mesh model, were consistent in showing stronger tropical cyclones in a warmer future. Most models indicate an overall decrease in the number of storms, attributable in one study to greater atmospheric stability and to a decrease in the vertical mass flux. Not all models agree on the change in individual basin numbers with some models showing an increase in the Atlantic and others a decrease. Additional numerical model simulations with even higher resolution will likely lead to a better understanding of the nature of these discrepancies. Clearly more work in this area is needed.

The summit was unique in bringing together an international community of scholars working on the hurricane–climate change problem. The science was addressed from a variety of perspectives ranging from the microphysics of lightning to geological evidence of prehistoric storminess. The venue provided the opportunity for discussions and the tranquil shores of the Aegean Sea provided the perfect setting for what at times has been a turbulent debate. Plans are underway for a second summit to be held next year (2009).

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