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Workshop on Tropical Cyclones and Climate

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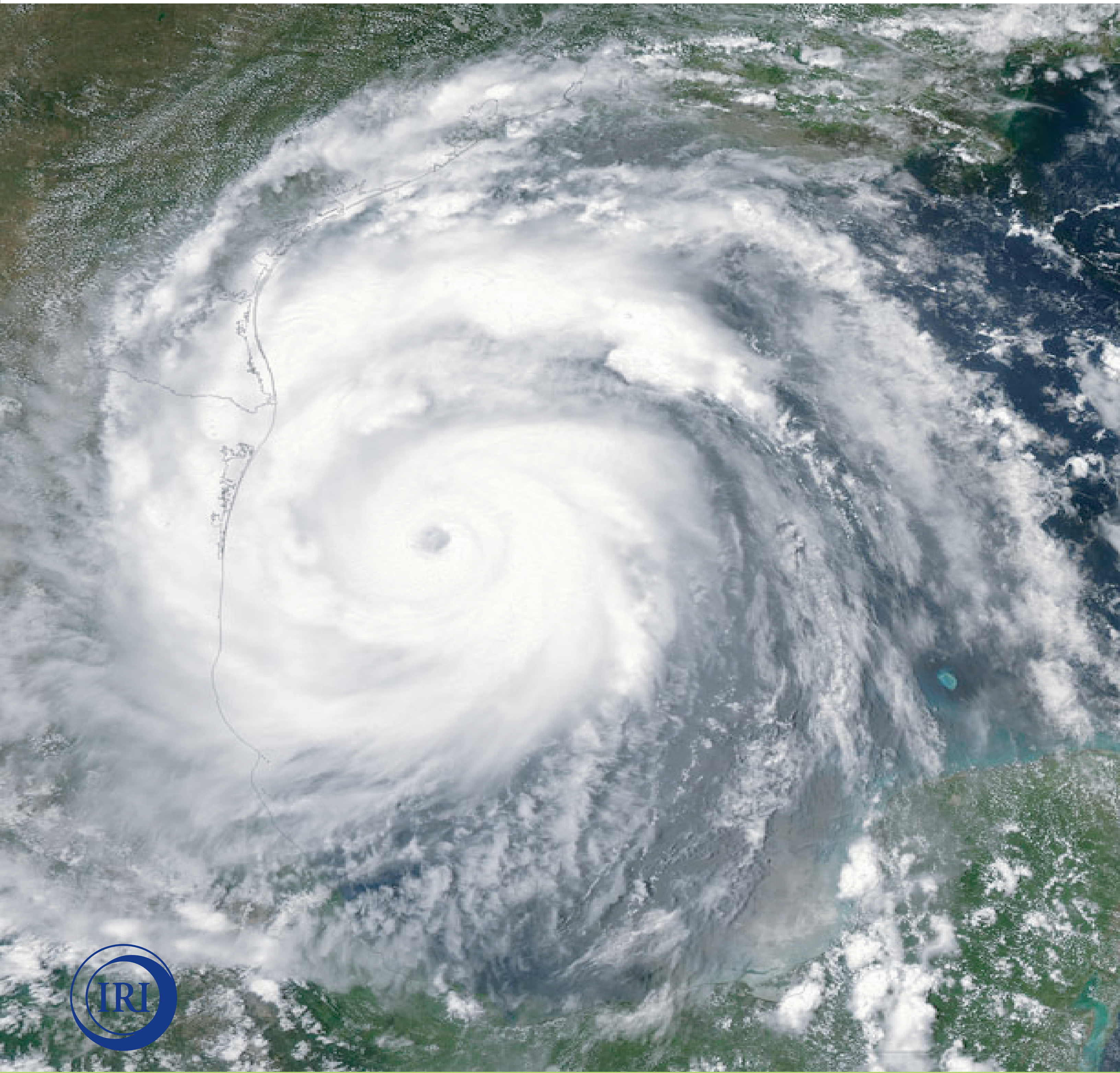

The International Research Institute for Climate & Society
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Cover: NASA image of Hurricane Emily. The Moderate Resolution Imaging Spectro-radiometer (MODIS) on NASA's Aqua satellite captured this image at 14:20 p.m. local time in Cancun, Mexico, roughly one day after Emily returned to open waters. At this time, the storm was a Category 1 storm with winds of 150 kilometers per hour (85 knots), slightly stronger than when it first moved off the Yucatan Peninsula the day before. It left a wide swath of damage behind it, but with no reported casualties attributed to the storm.

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Workshop on Tropical Cyclones and Climate

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In March 2006, the International Research Institute for Climate and Society (IRI) hosted a two and a half day workshop on "Tropical Cyclones and Climate". The centerpiece of the workshop was a set of invited lectures, with a modest number of contributed oral presentations and a small poster session. Relatively lengthy discussion periods were built into the schedule[1], allowing in-depth discussion of the presentations and related issues. A special issue of *Tellus* is planned, featuring papers based on presentations given at the workshop.

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[1]The complete agenda can be found at http://iri.columbia.edu/outreach/meeting/TropicalCyclones/agenda.html.

The presentations were loosely classified into four areas: the influence of climate on tropical cyclones (TCs), the influence of TCs on climate, paleotempestology, and risk management and impacts. The second and third of these areas are ones in which little research has been done, and one goal of the workshop was to stimulate interest in these areas.

The planning of the workshop began in late 2004. At that time, the relationship between TCs and climate did not appear to be a hot topic. The extreme Atlantic hurricane season of 2005, and the disastrous consequences of Katrina in particular, as well as two high-profile papers published during the summer of 2005 (Emanuel 2005; Webster et al. 2005) changed that. Presumably due at least in part to these developments, the workshop attracted more interest than we had expected. 83 registered attendees participated, mainly from universities (76%) and government (13%), with some representatives of the insurance industry (6%) and the press (4%). 23% of the registrants were female, and 12% were from foreign institutions. 20 were graduate students and one was a high school student. In addition to these registered participants, a small number of scientists from the Columbia community attended informally for some or all of the workshop.

Much research has looked at the influence of climate variability on tropical cyclones properties (e.g. Nicholls (1979); Gray (1984); Liebmann et al. (1994)). ENSO (El Niño/Southern Oscillation), for instance, is observed to have an important impact on the number, location and tracks of tropical cyclones in some regions. On shorter, sub-seasonal time-scales, the MJO (Madden-Julian Oscillation) phase may suppress or enhance the formation of tropical cyclones. A variety of other phenomena also influence tropical cyclone activity, including the QBO (Quasi-biennial

Oscillation), decadal variability of the sea surface temperature in the North Atlantic, and others.

Not as much attention has been given to the influence of tropical cyclones on the larger-scale climate. This influence has been emphasized in a few studies studies (e.g. Emanuel (2001)). Tropical cyclones, for instance, alter the surface temperature of the ocean over which they pass (Price 1981).

The influence of climate variability on TCs was one theme of the meeting, emphasized on the first day. Fréderic Vitart (European Center for Medium-Range Weather Forecasts - ECMWF), Lennart Bengtsson, and Kevin Hodges (University of Reading) discussed the simulation of TCs in general circulation models (GCMs), using the ECMWF and ECHAM5 models, respectively. This is a thorny question, as GCMs, particularly when run in climate mode, have resolutions too low to represent TC physics with high fidelity. Yet, such low-resolution models are the only ones which are usable for long climate simulations, and they do form TC-like vortices whose statistics (such as the climatological annual cycle in some basins, and some aspects of interannual variability) can to some degree resemble those of observed TCs. The ECMWF model shows a small but significant of impact of greenhouse gases, with an overall decrease of the tropical cyclone frequency in most basis. The ECHAM5 model also shows a slight reduction in the number of tropical storms, but no overall increase in intensity in spite of a SST warming by 2-3°C, and a reduced activity in the Atlantic sector accompanied by a southward movement of the east Pacific storm track.

Suzana Camargo (International Research Institute for Climate and Society) analyzed various aspects of the TC activity response to ENSO, including typhoon intensity, track changes in the western North Pacific using a novel cluster analysis and an index of the likelihood of tropical cyclogenesis, based on large-scale environmental factors (sea surface temperature, wind shear, etc.) developed by Kerry Emanuel.

Johnny Chan (City University of Hong Kong) discussed the interannual and interdecadal variability of typhoon activity in the western north Pacific. Chan showed that ENSO influences typhoon activity in this basin mainly through the atmosphere, as the interannual variations in intensity which are observed are opposite in sign to what would be expected based on the local SST anomalies in the region of TC genesis.

Clearly, the distinction between decadal variability and trends due to climate change was the most controversial theme of the workshop. Gerald Bell (NOAA Climate Prediction Center) presented the leading tropical modes associated with multi-decadal fluctuations in Atlantic hurricane activity. G. Bell showed that active/inactive seasons and decades result from an inter-related set of atmospheric and oceanic conditions that are a response to recurring convective rainfall patterns along the equator.

Impacts of TCs was another theme of the meeting. Richard Murnane (Risk Prediction Initiative) provided the perspective of the insurance industry, for whom TCs are the most important natural disasters. One topic of interest to the insurance industry is extratropical transition, as this is difficult to predict and can lead to large impacts in New England and Europe. Roger Pielke Jr. (Colorado State University) analyzed the role that urban development and population increases in coastal areas have on the losses due to hurricanes. Pielke argued persuasively that long-term increases in economic damage have been and will continue to be overwhelmingly due to these factors, with the influence of climate change being a distant second. María Uriarte (Columbia University) studied the impacts of TCs on ecology, rather than economy. Uriarte used data from field work in Puerto Rico, as well as an individual-based model of a tropical forest ecosystem, to show how hurricanes influence forests by setting them back to an earlier successional stage.

The afternoon of the second day focused on TCs in past climates. This session featured three presentations on paleotempestology, the study of past hurricane activity using proxies in the geologic record. Kam-biu Liu (Louisiana State University) analyzed coastal lake sediments, which record past hurricane strikes through microfossil data. Using proxy records from the Gulf Coast, Liu finds that the return period for catastrophic Atlantic hurricanes is approximately 300 years and that a hyperactive period occurred 3,800-1,000 years ago.

Jeffrey Donnelly (Woods Hole Oceanographic Institution) described new proxies that his group has been developing. Fossil trees, for instance, may be able to provide high-resolution archives of tropical cyclone strikes dating back many millemnia. Preliminary results from Long Island, NY and the northwestern Caribbean indicate several active intervals for intense tropical cyclones activity in millenium time scales.

Amy Frappier (University of New Hampshire) proposed a new methodology to obtain a high-resolution proxy record of TC events from stalagmites using stable isotopes. Using Oxygen 18, A. Frappier could identify 80% of storms signals in the Central America region. This new proxy method can be useful to identify tropical cyclone frequency with seasonal to decadal variability and could potentially be used to indentify tropical cyclone intensity and complement other hurricane proxys.

Besides paleotempestology, the influence of TCs on climate was the other under-investigated area which the workshop specifically targeted. Most climate research implicitly assumes that TCs are irrelevant to the larger scale climate, but it is not clear that this is necessarily the case. Robert Korty (California Institute of Technology) described a mechanism by which TCs may influence the thermohaline circulation of the ocean by promoting vertical mixing in the upper ocean, and argued that this mechanism could explain the warm climate of the Eocene. Claudia Pasquero (California Institute of Technology) discussed a possible mechanism for a positive feedback between hurricanes and upper ocean warming, involving year-to-year persistence of warm anomalies at the base of the thermocline which are produced by TCs. These same anomalies can allow the next seasons TCs to become stronger, since further vertical mixing will not cool the surface as much as it would without the anomalies.

Finally, the workshop featured a set of talks on the possible influence of climate change, including anthropogenically induced trends, on TCs.

Kerry Emanuel (Massachusetts Institute of Technology) showed that various measures of TC activity have been increasing since the mid-1970s, particularly in the the Atlantic. Emanuel found no evidence for a natural multi-decadal cycle in the tropical Atlantic SST. When the trend is included, the time series associated with the spatial structure of the multi-decadal oscillation tracks the northern hemisphere surface temperature. Emanuel thus argued that the northern hemisphere surface temperature and late summer tropical Atlantic sea surface temperature variations are both part of the climate systems response to natural and anthropogenic forcings, including solar variability, volcanoes, and anthropogenic emissions of aerosols and greenhouse gases.

Thomas Knutson (Geophysical Fluid Dynamics Laboratory) analyzed the TC intensity response to global warming using simulations with a high-resolution regional nonhydrostatic hurricane model whose boundary conditions were provided from coupled GCM simulations forced by increasing greenhouse gases. Using a variety of different GCMs for the forcing and different convection schemes in the hurricane model, Knutson finds a robust increase in storm intensity in a warmer climate, though one significantly smaller than that implied by Emanuel's observational analysis (per degree of SST warming). The sources of this disagreement were the subject of considerable discussion.

Christopher Landsea (National Hurricane Center) addressed the quality of the TC best track data, especially in the Atlantic, with particular attention to what can and cannot be inferred about trends in intensity during the 20th century as discussed in recent papers (Emanuel 2005; Webster et al. 2005). Landsea pointed out the increase in the number of in situ measurements per storm over time as one factor confounding the detection of trends. Other issues are the evolution of the Dvorak technique, which makes the intensity estimates inhomogeneous, and the variable amount of satellite coverage throughout the years. All these problems point to the strong necessity for a reanalysis to be performed over all basins, leading to a new best track dataset appropriate for climate studies.

This workshop brought together scientists working on different aspects of the relationship of TCs to climate, including segments of the community who typically have little contact with each other. Discussions were stimulated between climate scientists and TC experts, modelers and paleoclimatologists, physical and social scientists. It focused on issues of great interest to the media, the public, and the broader scientific community, but also drew attention to relatively unexplored areas where much more attention is warranted. We hope that some of the graduate students and post-docs who attended the workshop will constitute part of the next generation of scientists who will tackle these important problems.

Acknowledgments

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