The human and economic costs of Hurricane Katrina in 2005 or Tropical Cyclone Nargis in 2008, coupled with growing coastal populations, highlight the need to know how tropical cyclone activity will respond to human-induced climate warming. This is not easy given the complexity of the processes that go into the making of a cyclone and the fact that we have a relatively poor handle on long-term (century-scale) variations in tropical cyclone activity around the globe. In the Atlantic some recent efforts have been made to quantify the uncertainty in long-term records of tropical cyclone counts (e.g. Vecchi and Knutson 2011).

A recent review (Knutson et al. 2010) points to a growing consensus regarding how tropical cyclone activity — particularly the globally averaged frequency, intensity and rainfall rates associated with tropical cyclones overall and an increase in the intensity of the storms that do occur. On balance, the model projections for the case of very intense storms, but this very competition implies that we have less confidence in this projection. Existing studies unanimously project an increase in the rainfall rate associated with tropical cyclones during this century (Knutson et al. 2010), although the range is considerable because of the uncertainties in estimating the regional climate response (for example, patterns of sea-surface temperature response). In the Atlantic basin, for example, 21st century hurricane activity projections depend, to first order, on the rate of warming of the tropical Atlantic compared to the rest of the tropical ocean, which is not well constrained by current climate models. In contrast to tropical cyclone frequency, theoretical considerations and high-resolution models support the plausibility of an increase in globally averaged intensity of tropical cyclones through the 21st century, with a range of 2-11% among different studies (Knutson et al. 2010). Interestingly, recent high-resolution modeling studies suggest that the frequency of the strongest storms — for example Atlantic Category 5 hurricanes — will increase significantly throughout the 21st century (e.g. Bender et al. 2010). In the model projections, there is a competition between the effect of fewer storms overall and an increase in the intensity of the storms that do occur. Balance, the model projections for the case of very intense storms, but this very competition implies that we have less confidence in this projection. Existing studies unanimously project an increase in the rainfall rate associated with tropical cyclones during this century (Knutson et al. 2010), although the range is considerable because of the uncertainties in estimating the regional climate response (for example, patterns of sea-surface temperature response). In the Atlantic basin, for example, 21st century hurricane activity projections depend, to first order, on the rate of warming of the tropical Atlantic compared to the rest of the tropical ocean, which is not well constrained by current climate models. In contrast to tropical cyclone frequency, theoretical considerations and high-resolution models support the plausibility of an increase in globally averaged intensity of tropical cyclones through the 21st century, with a range of 2-11% among different studies (Knutson et al. 2010). Interestingly, recent high-resolution modeling studies suggest that the frequency of the strongest storms — for example Atlantic Category 5 hurricanes — will increase significantly throughout the 21st century (e.g. Bender et al. 2010). In the model projections, there is a competition between the effect of fewer storms overall and an increase in the intensity of the storms that do occur.

Knutson et al. 2010)

Selected references


Paeohurricane reconstructions extend storm records further into the past to improve our understanding of the relationship between tropical cyclones and climate. Though several types of tropical cyclone proxies are under development, sediment-based records, which can span millennia, have thus far provided the longest storm reconstructions and have revealed the coarser temporal to millennial-scale features of hurricane climate (e.g. Donnelly and Woodruff 2007). New, high-resolution sediment records developed from coastal ponds along the Northeastern Gulf of Mexico and in the Northeastern USA document statistically-significant changes in storm activity in response to the modest climate variations of the late Holocene (Fig. 1A). These records provide evidence both for intervals with significantly elevated and depressed storm activity relative to the historic, instrumental period. The largest variability in these paleohurricane records occurs on multi-centennial and millennial timescales, which suggests that Atlantic hurricane activity is poorly constrained by the relatively short instrumental record. Late Holocene variations in storm activity have been dominated by changes in the frequency of intense hurricanes rather than the overall number of landfalling tropical cyclones (e.g. Lane et al. 2011). A comparison between a 4500-year storm surge record from the Florida Panhandle (Fig. 1A) and reconstructions of SST and Loop Current migration within the northeastern Gulf (Richey et al. 2007) suggests that intense storms were most frequent in the region when Gulf SSTs were cooled rather than when the high heat ocean content of the Loop Current was closest to the study site. Future, intense hurricane activity may similarly respond more sensitively to upper ocean thermal structure rather than SST. Larger-scale factors also may have driven basin-scale variability in Atlantic hurricane intensities, with more intense events occurring more often during periods of reduced (increased) ENSO variability (Conroy et al. 2008, Fig. 1B) and warmer (cooler) SSTs in the western North Atlantic (Keigwin 1996, Fig. 1C). This is consistent with the idea that the relative importance of the latter study may be a good, aggregate indicator of Atlantic hurricane activity on greater than inter-an- nal timescales.

Though the stochastic nature of hurricane landfalls at a given location, any trend in basin-wide hurricane activity during the late 20th century would not be detectable (3 to 33 years), such data does not provide a pathway to evaluate the predictive power of these emerging techniques and to identify the climatic causes of both the extremely active and very quiet storm regimes of the late Holocene.

Selected references


