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 change in response 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 cyclones – will behave during the 21st century. Models suggest that when averaged globally, the frequency of tropical cyclones is likely to remain the same or decrease through the 21st century: the decreases in the most compelling modeling studies to date span 6- to 34% confidence in this projection is buttressed by the ability of several of the recent climate models or regional downscaling models to reproduce past tropical cyclone variability in several basins when forced with historical variations in boundary conditions (e.g. Emanuel et al. 2008; Zhao and Knutson 2009). Projected mechanisms include a weakening of the time averaged tropical circulation (Sugi et al. 2002; Held and Zhao 2011) or changes in the time averaged vertical profile of moisture in the middle and lower troposphere (Emanuel et al. 2008). Projections for individual regions are far less certain than global averages 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, first on 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- to 11% among different studies (Knutson et al. 2010). Interestingly, recent high-resolution modeling studies suggest that the frequency of the strongest storms – for example Caribbean basin hurricanes – will increase through 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. On balance, the simulations based on the assumption of the case of very intense storms, but this very competition implies that we have less confidence in this projection. Existing studies unanniously 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 averaging radius about the storm center that is used in constructing the storm precipitation measure.

In our view, more confident projections of 21st century tropical cyclone activity, including projections for individual basins, will require that climate models first reduce the uncertainty in projected sea-surface temperature patterns. This is challenging as it likely involves such difficult to model influences as cloud feedback and the climate response to changes in atmospheric aerosols (IPCC 2007). The potential importance of the latter is suggested by a recent study that concludes that aerosols have led to the recent increase in the intensity of Arabian Sea cyclones (Evan et al. 2011). The attribution of tropical cyclone changes to anthropogenic forcing, which has not yet been convincingly demonstrated, requires longer, homogeneous records of tropical cyclone activity and reliable estimates of the role of natural variability in observed tropical cyclone activity changes, among other things. Paleoclimate proxy records of tropical cyclone activity (e.g. Donnelly and Woodruff 2007; Nyberg et al. 2007) could help. For example, if a number of such reconstructions convincingly showed that the most recent 50-year period was highly unusual compared with the previous 1,000 years, this would be very suggestive of a detectable anthropogenic influence. However, such a clear signal remains to be demonstrated.

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