## Atlantic hurricanes and climate change: Examining some uncertainties

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A recent assessment of tropical cyclones (TCs) and climate change (Knutson et al., Nature Geoscience, 2010) concluded that it remains uncertain whether past changes in TC activity have exceeded the variability expected from natural causes. The TC projections for the late 21st century, assuming IPCC AR4/A1B scenario climate change, include: likely increase in globally averaged TC intensity (+2 to 11%); likely decrease (or essentially no change) in global TC frequency (-6 to -34%); more likely than not a substantial increase in the frequency of the most intense TCs in some basins; and likely increase in TC-related precipitation rates. The TC projections were more uncertain for individual regions than for the global mean. Here we consider some issues that could potentially cause these assessment statements to be seriously in error, specifically focusing here on ones that could lead to a substantial under-prediction of future Atlantic TC changes. 1) The sensitivity of Atlantic hurricane activity to greenhouse warming could possibly be seriously underestimated by models, such that a sensitivity more like that extrapolated from local SST/hurricane activity relationships actually applied (in contrast to dynamical model projections). If true, this could lead to a revised projection of order +300% for TC power dissipation by 2100. An example is given of a modeling issue (tropical atmospheric temperature profiles) that could potentially contribute toward a substantial underprediction. Current research on this issue is reviewed, indicating why we consider this outcome unlikely. For example, some studies indicate likely inhomogeneity problems with the radiosonde- and reanalysis-based temperature trends. In addition, the lack of robust long-term increasing trends in Atlantic TC metrics, despite increases in global mean and tropical Atlantic SSTs, is not consistent with a greatly underestimated sensitivity of TC activity to climate warming. In our studies, the key source of uncertainty for Atlantic hurricane projections is the spread among different climate model projections of tropical Atlantic warming relative to the tropical mean warming. 2) An anthropogenic signal could exist in past TC data that has not yet been detected. We speculate that this could arise, for example due to: a) aerosol-induced cooling of Atlantic SSTs during the 1970s and 80s, temporarily reducing TC activity; b) lower stratospheric and/or upper tropospheric temperature changes, perhaps associated with ozone depletion, that may have increased Atlantic hurricane activity over the period since about 1980; or c) over-estimation of the impact of changing observing capabilities on long-term TC-related trends. Relevant to second of these issues (b), the GFDL HIRAM 50-km grid global model simulates the trends since 1980 in TCs in each Atlantic and Pacific basin fairly well when forced with specified SSTs. This demonstrates that a global atmospheric model can reproduce these TC trends without necessarily requiring a large tropics-wide increase of potential intensity or changes in the vertical profile of temperature like those in the NCEP reanalyses. In short, while it is conceivable that the conclusions of the WMO expert team report could be seriously in error owing to problems such as those discussed here, in our view the report's conclusions and likelihood levels still appear appropriate, based on currently available information.