Geophysical Research Abstracts
Vol. 17, EGU2015-6402-5, 2015
EGU General Assembly 2015

Relative impact of climate indicators and aerosols on tropical cyclones

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This study assesses the most important environmental variables modulating tropical cyclone (TC) frequency in six different oceanic basins such as the East Pacific, West Pacific, North Atlantic, North Indian Ocean, South Indian Ocean, and South Pacific. To determine their influence, we used multiple linear regression between TC frequency and variations in meteorological variables and circulation indices as well as aerosol optical depth (AOD) anomalies over the tropical cyclone development areas for the period 1980-2009 (where the AOD was separated into the compounds black and organic carbon, sulfate dust and sea salt). Overall the low-level relative humidity in the North Atlantic, stratospheric aerosol burden in the East Pacific, and the black carbon burden in the North Indian basin showed the greatest relation with TC activity and were all with statistically significant and explained variances of 28%. Amongst the circulation modes of variability, the Atlantic Multidecadal Oscillation (AMO) and the El Nino Southern Oscillation (ENSO) appeared to be most important to TC activity with significant variances of 29% in the South Indian Ocean and 25% in the East Pacific basins, respectively. We also examined the inter-basin relationship between the different environmental variables in one basin and the cyclone frequency in another basin. Overall the strongest connections were found between North Atlantic basin variables and North Indian TCs while the weakest links were found between West Pacific basin variables and South Pacific TCs. Lastly, because the strongest cooling of the lower stratospheric temperature was found over the North Atlantic since the last few decades and because the cooling could explain a variance of 15% of TC frequency in that same basin, we investigated five global climate models from the historical runs of the CMIP5 archive to determine whether they were able to capture this cooling in the lower stratosphere. Although the models were able to properly simulate the timing of the warming and cooling of the lower stratosphere that follows a volcanic eruption, they showed, for example, about a factor of two stronger cooling compared to the reanalysis. If the TC activity over the North Atlantic is indeed influenced by lower stratospheric cooling following a volcanic eruption, this result warrants the need for a better representation of such physical processes in models so that more accurate projections of TC activity can be made.