The Roles of Climate Change and Climate Variability in the 2017 Atlantic Hurricane Season

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Abstract

The 2017 hurricane season was extremely active with six major hurricanes, the third most on record. This study investigates the causes of the strong 2017 TC activity in August/September (AS), when much of the activity occurred, with a focus on the long term trend and the leading modes of climate variability that impact seasonal TC activity over the Atlantic. The sea-surface temperatures (SSTs) over the eastern Main Development Region (EMDR), where a majority of the tropical disturbances that developed into strong TCs (Gert, Harvey, Irma, Jose, Lee, and Maria) had their genesis during active months of August/September, were ~0.96°C above the 1901–2017 average (warmest on record): about ~0.42°C from a long-term upward trend (i.e., climate change signal) and the rest (~80%) attributed to the Atlantic Meridional Mode (AMM), which usually characterizes the large portion of the Atlantic SST variations. The contribution to the SST from the North Atlantic Oscillation over the EMDR was a weak warming, while that from ENSO was negligible, as their magnitude was small in AS 2017. While the AMM produced the very warm ocean and enhanced atmospheric instability, ENSO, the NAO, and the AMM together provided the favorable wind shear conditions.

Compared with the strong hurricane years of 2005/2010, the ocean heat content (OHC) during 2017 was larger across the tropics, with higher SST anomalies over the EMDR and Caribbean Sea. On the other hand, the dynamical/thermodynamical atmospheric conditions, while favorable for enhanced TC activity, were less prominent than in 2005/2010 across the tropics. The results suggest that unusually warm SST in the EMDR together with the long fetch

of the resulting storms in the presence of record-setting OHC were key factors in driving the strong TC activity in 2017. This OHC acted to maintain the warm ocean surface and facilitated the strengthening of the TCs as they traversed the Atlantic.

Earlier studies suggest that, even in the presence of climate change characterized by increasing SST, it is the leading modes of climate variability that largely determine the extremes in seasonal TC activity, in that they are associated with both the thermodynamical and dynamical conditions favorable (or unfavorable) for TC development. Nevertheless, we can expect that climate change will play an increasingly important role in determining extremely active years in that it provides an increasingly warmer baseline in SST from which the major modes of climate variability deviate. The 2005 and 2017 hurricane seasons (both characterized by a positive AMM, and weak NAO and ENSO) appear to be consistent with such an interpretation. During those years, the tropical Atlantic SSTs and the major hurricane counts are comparable, despite a relatively smaller magnitude of the positive phase of the AMM in 2017 than in 2005, indicating an increasingly greater role for climate change.