The Rapid Intensification and Eyewall Replacement Cycles of Hurricane Irma (2017)

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Abstract:
The initiation of a rapid intensification (RI) event for a tropical cyclone (TC) at major hurricane intensity is a rare event in the North Atlantic basin. This study examines the environmental and vortex-scale processes related to such an RI event observed in Hurricane Irma (2017) using a combination of flight-level and tail Doppler radar aircraft reconnaissance observations, microwave satellite observations, and model environmental analyses. The onset of RI was linked to an increase in sea surface temperatures and ocean heat content toward levels more commonly associated with North Atlantic RI episodes. Remarkably, Irma's RI event was comprised of two rapidly-evolving eyewall replacement cycle (ERC) episodes that each completed in less than 12 h. The two ERC events displayed different secondary eyewall formation (SEF) mechanisms and vortex evolutions. The characteristics of the first SEF event were consistent with the stagnation and axisymmeterization of outward propagating vortex Rossby waves. Additionally, a secondary maximum in ascent and tangential wind was observed at the leading edge of a mesoscale descending inflow jet. During the ensuing ERC event, the primary eyewall weakened and ultimately collapsed, resulting in a brief period of weakening. The second SEF event displayed characteristics consistent with unbalanced boundary layer dynamics. During the second ERC event, the TC vortex displayed no signs of weakening or even steady-state intensity, and instead continued to rapidly intensify, which is a stark contrast to the paradigm described in the literature.