Retrieving ice microphysical information from radar measurements for comparison with tropical cyclone numerical models

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In mid-2013, the upgrade of the United States Weather Surveillance Radar—1988 Doppler (WSR-88D) operational network to dual-polarization scanning was completed. This capability allows us to retrieve ice particle types, sizes, and amounts in landfalling tropical cyclones (TCs). Remote observations of ice microphysics in TCs are particularly valuable, since reconnaissance missions with the WP-3D Lockheed Orion aircraft are not currently flown above the melting layer. Such results may be used to evaluate TC model microphysics schemes, which have traditionally struggled to represent the expected fall speeds and concentrations of ice crystals within the TC anvil.

As a first step towards performing these evaluations, we demonstrate the use of scanning and vertically profiling radar measurements, air temperature soundings, and a particle identification scheme to estimate the ice particle fall speeds and ice water paths (IWPs) in Hurricanes Arthur (2014) and Irene (2011) at landfall. Vertically profiling radar data from Hurricane Arthur suggest that the ice crystals detected by the scanning radar have fall velocities mostly greater than 0.25 m s^{-1} and that the particle identification scheme accurately distinguishes between the ice crystals and snowflake aggregates. On the basis of this assessment, the scanning radar estimates of IWP are separated into the contribution from small ice (i.e., ice crystals), termed small-particle IWP, and large ice (i.e., graupel and snow), termed large-particle IWP. The IWP maps and probability density functions (PDFs) reveal that the total and large-particle IWPs range up to 10 kg m^{-2}, with the largest values confined to intense convective precipitation within the rainbands and eyewall. Small-particle IWP remains mostly < 4 kg m^{-2}, with the largest small-particle IWP values collocated with maxima in the total IWP. PDFs of the small-to-total IWP ratio have shapes that depend on the precipitation type (i.e., intense convective, stratiform, or weak precipitation). The IWP ratio distribution is narrowest (broadest) in intense convective (weak) precipitation and peaks at a ratio of about 0.1 (0.3). These distributions can be readily compared to corresponding output from numerical model microphysics schemes to evaluate their performance.

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