3.2 Testing Hurricane WRF with alternate radiation and partial cloudiness schemes

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Prior to the 2015 hurricane season, the Hurricane WRF (HWRF) used the Geophysical Fluid Dynamics Laboratory (GFDL) radiation scheme in operations at NCEP. The Developmental Testbed Center (DTC) has recently been involved in testing HWRF with an alternate radiation package -- the Rapid Radiation Transfer Model for Global Circulation Models (RRTMG) radiation scheme with scale-aware partial cloudiness – with the goal of transitioning the new developments to operations.

Since 2013, ongoing work at the Environmental Modeling Center (EMC) and at the DTC to transition the operational HWRF configuration from the GFDL scheme to the RRTMG scheme has been motivated by findings of Dr. Robert Fovell and his graduate student, Peggy Bu, of UCLA. They showed that the RRTMG radiation scheme represents cloud radiative forcing more realistically than its GFDL counterpart in semi-idealized simulations. The GFDL deficiency is especially apparent for long wave tendencies at cloud top, and has a large impact on storm structure, intensity, and motion.

In tests conducted by the EMC Hurricane team in 2013, RRTMG was used as an alternate, more sophisticated radiation parameterization for HWRF. Ultimately, RRTMG was not adopted at EMC for operations for the 2014 hurricane season because it degraded intensity and track forecasts when combined with several other physics-related upgrades. During the same time period, DTC conducted tests of HWRF using an alternate physics suite consisting of Thompson microphysics and a version of the RRTMG scheme that had been coupled with Thompson microphysics, ensuring consistency of hydrometeor parameters between the packages. Although case studies indicated hurricane track and intensity forecast improvement when using the Thompson/RRTMG package, larger tests at the DTC mostly revealed statistically neutral-to-negative impacts on track and intensity forecasts especially in the northern Eastern Pacific basin.

Analysis of the DTC large-scale test resulted in a significant finding: there was an overabundance of shortwave radiation reaching the ground for the Thompson/RRTMG experiment. DTC discovered that this was due to two reasons: a) only explicit clouds from the microphysics parameterization interact with the radiation scheme while the sub-grid scale clouds produced by the Simplified Arakawa Schubert (SAS) deep- and shallow-convection parameterization used in HWRF are transparent to the RRTMG scheme; and b) the coarse horizontal and vertical grid spacing in the HWRF parent domain, (much like other models) does not produce as many stratus clouds as observed.

The radiation imbalance led Greg Thompson of DTC to implement a scale-aware partial cloudiness scheme for RRTMG, which acts to simulate liquid- and ice-water content based on humidity and temperature thresholds to represent a “cloud” with radiative properties. The DTC performed a multi-storm HWRF test in which the RRTMG with partial cloudiness scheme replaced the operational GFDL radiation, but the operational Ferrier microphysics scheme was left unchanged. While the impact of RRTMG with partial clouds on track and intensity forecasts is primarily neutral-to-positive, the large-scale evaluation of the test shows a more significant redistribution of heat and moisture, especially at lower levels.