Intercomparison of direct and indirect radar reflectivity assimilation methods under the 3DVar and hybrid 3DEnVar frameworks

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Abstract

Based on the current operational convective-scale radar data assimilation system (RWRF) at the Central Weather Administration, this study explores and compares the direct and indirect assimilation of radar reflectivity under the 3DVAR and the Hybrid 3DEnVar data assimilation frameworks. The current RWRF system employs indirect assimilation of radar reflectivity by first converting the radar reflectivity into hydrometeor mixing ratios and then calculating the observation innovations in the hydrometeor variables. In contrast, the direct assimilation of radar reflectivity uses the observation operator developed by Wang and Liou (2019) to calculate the radar reflectivity from the model hydrometeors, and the observation innovations are calculated in the reflectivity variable.

This study selects the mei-yu case in June 2022 to conduct four experiments, ViZ/VdZ/HiZ/HdZ, which assimilate radar reflectivity by indirect assimilation with the 3DVAR/direct assimilation with the 3DVAR/indirect assimilation with the Hybrid 3DEnVar/direct assimilation with the Hybrid 3DEnVar, respectively. Statistics of the background and analysis fields verified against radar reflectivity observations show that the background field of the indirect assimilation method (ViZ and HiZ) has an overestimation of the radar reflectivity within the lower model levels, and the analysis reflectivity is also overestimated in the lower level but underestimated in the upper levels. Preliminary results of the Fractions Skill Score (FSS) aggregated with 7 cases (from 0600 to 1200 UTC on 6 June) show that the direct assimilation method (VdZ and HdZ) has better quantitative precipitation forecast (QPF) during the first three forecast hours, and the hybrid 3DEnVar method (HdZ) is better than the 3DVAR (VdZ). However, with the indirect assimilation method, the 3DVAR (ViZ) is better than the Hybrid 3DEnVar (HiZ) in the QPF.

Keywords : Direct radar reflectivity assimilation, Hybrid 3DEnVar