Evaluation of potential benefits of outer-loop iteration for all-sky microwave imager radiance assimilation at JMA's global NWP system

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In numerical weather prediction (NWP), assimilation of cloud and precipitation affected radiance is essential to obtain accurate initial fields in cloudy areas. Cloud and precipitation phenomena have non-linear behaviors in their formation and dissipation. To consider such non-linearity in an incremental four dimensional variational (4D-Var) data assimilation, outer-loop iteration is necessary for re-computation of departures from the observations and updates of trajectory in minimizations of the 4D-Var.
The impacts on tropical cyclone prediction from all-sky microwave imager radiance assimilation using JMA’s global NWP system were presented at the last conference in 2016. The system used in the experiment had no use of the outer-loop iteration as same configuration of JMA’s operational global NWP system. In this research, we investigated impacts of the outer-loop iteration for the all-sky microwave imager radiance assimilation. Three data assimilation experiments were performed to compare with a control run whose configuration was same to current operational JMA’s global NWP system: all-sky microwave imager radiance assimilation experiment (EXP1), outer-loop introduced experiment (EXP2), and their combined experiment (EXP3). The EXP1 results indicate the positive impacts on tropical cyclone’s track and intensity predictions from the all-sky assimilation by improving analyses in the cloudy areas which are meteorologically sensitive and where no useful information is obtained from current clear-sky assimilation. The EXP2 results demonstrated large positive impacts from the outer-loop introduction on analysis and forecast accuracy of geopotential height, tropospheric temperature, humidity, and wind fields.
The comparison between the EXP1 and EXP3 which can indicate the impact of the outer-loop iteration on the all-sky radiance assimilation reveals that the introduction of outer-loop iteration increased assimilated existing humidity sensitive observations (e.g., microwave humidity sounder radiances) and improved the analysis accuracy. However, the gains from the all-sky assimilation for the forecast skill were similar. One possible reason of this result is a discrepancy of cloud and precipitation representation between inner and outer model in the 4D-Var system. To get further benefits from the outer-loop iteration in the all-sky assimilation, a consistent cloud and precipitation representation between the models would be necessary.
The details of the latest experiment results and the issues are discussed in the conference.

