Three-Dimensional Real-Time Mesoscale Analysis (3D-RTMA) Quality Assessment for Aviation Applications

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To alleviate the impact of missing METAR observations on aircraft operations (e.g., delays or cancellations), the Environmental Modeling Center (EMC) began providing pseudo-observations of 2-m temperature, derived from the operational Real-Time Mesoscale Analysis (RTMA), at select airport sites in July 2015. The overarching goal of this work is to inform the Federal Aviation Administration (FAA) of whether the RTMA could be used as a substitute for additional weather elements (e.g., wind speed, ceiling). In the first phase of this work, data denial experiments were used to perform a quality assessment of the RTMA (Morris et al. 2020). In the second phase, a real-time quality monitoring system was developed at EMC for the future 3D-RTMA system. Due to the high computational cost of data denial experiments, an adjoint-based observation impact computation approach was adopted in this work (e.g., Baker 2000; Baker and Daley 2000; Zhu and Gelaro 2008; Tyndall and Horel 2013; Todling 2013). This system can be used to ascertain the 3D-RTMA analysis quality when a METAR observation is missing and help inform decisions about whether interpolated 3D-RTMA products would be a reliable substitute for missing METAR observations.

Using the adjoint-based observation impact code in the Gridpoint Statistical Interpolation (GSI) system, which is used as the analysis scheme for 3D-RTMA, the quality monitoring system was successfully integrated into the workflow of the experimental 3D-RTMA system. This system was run every 3 hours over a 2-month period, from 00Z on 1 October 2021 to 21Z on 30 November 2021, and provided the observation sensitivity, innovation, impacts, and impact-related derivatives (e.g., the fractional impact) of METAR observations at select airports simultaneously for each analysis cycle in real-time. Figure 1 shows an example of the impact analysis results for the temperature reports at and around the METAR site KDFW (Dallas/Fort Worth International Airport). One sees that the absolute value of the relative impact of KDFW is comparable to that at several nearby observations, which suggests that it would be feasible to replace a missing KDFW report with the RTMA analysis. As expected, the relative impacts around KDFW are significantly smaller than in areas of sparse observation density, such as around KBIL (Billings-Logan International Airport in Montana; not shown).

A long-term time series of the results (e.g., sensitivity, impact, fractional impact, etc.) can be generated for any METAR station of interest by continuously running this system and be used to quantify the impact of missing observations. Approximate analytical and graphical-derived relationships between the observation impact (and fractional impact) of a given METAR observation and the expected change to the local analysis increment should the METAR be absent from the assimilation were investigated for various observation types (e.g., 2-m temperature and moisture). Current results show that this adjoint-based quality monitoring system for 3D-RTMA is very promising. It is expected that with additional tuning over a longer run period, the system will be able to provide reliable information to the FAA regarding the feasibility of using the analysis products in lieu of missing METAR reports.

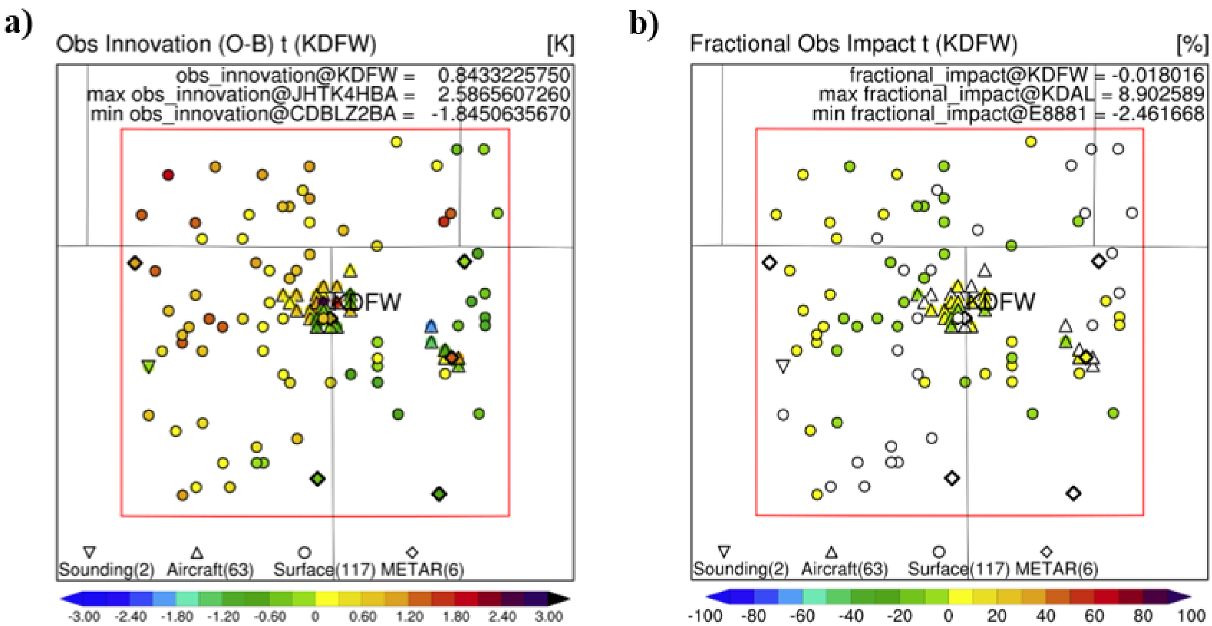

Figure 1 Observation a) innovations and b) fractional impacts for temperature observations around KDFW (Dallas/Fort Worth International Airport) for the 00Z cycle on 11 October 2021. Hollow markers represent observations that contribute negligible values to the specific quantity being displayed.

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