Monitoring the impacts of weather radar data quality control at the continental scale

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At ECCC, the first impact studies of assimilating weather radar data into a numerical weather prediction (NWP) model used aggressively configured quality controls with data from the Canadian network of 31 radars and all available NEXRAD radars from the continental United States and Alaska. The radar data assimilation approach used with these impact studies was latent heat nudging (LHN). Owing to LHN’s sensitivity to the presence of non-precipitation echoes (false positives), the radar data quality control was carried out with the understanding that removing the desired amount of non-precipitation echoes came at the cost of also removing a certain amount of real precipitation information. While this gave us a starting point for radar data assimilation, we were confident that it could be subsequently improved upon using better data quality control. However, the question facing us was: how do we know when we have an improvement?

To answer this question, we applied an ECCC framework called EMET, originally designed for NWP verification. Instead of using independent observations to verify forecast fields, observations are compared to radar data prior to and following quality control. The observations in question are hourly METAR reports, mostly originating from airfields. These METARs contain precipitation occurrence information when precipitation actually occurs, even if the intensities are very low. This is valuable when comparing with radar data, as weather radars are extremely sensitive and will also report very low intensities. Non-occurrence of precipitation is not reported explicitly, so non-occurrence is inferred in messages that contain explicit cloud and visibility information. This application of EMET allows us to match METARs with their corresponding uncorrected and corrected radar reflectivities both from single-site polar data and from Cartesian composite products. The advantage of doing this with polar data is that the same METAR can be compared with data from any radar that covers it, thereby maximizing the statistical sample size. In conducting our work, we have introduced precipitation occurrence as a standard verification variable in EMET. Standard contingency table based skill scores (probability of detection, false alarm rate, critical success index, Hanssen-Kuipers skill score, frequency bias index, and others) are produced by EMET. By producing these scores and summarizing them on a daily basis, we have the ability to monitor the impact of quality control over time, and because we are doing this at the continental scale, we have enough comparisons to generate more meaningful statistics. Therefore, when introducing new quality control methods, this approach using EMET will tell us if we have succeeded in achieving an improvement.

We have trialed this approach using two different quality control methods. The first method works with the continental scale composite products together with so-called Binary Cloud Mask (BCM) products from the GOES-16 and 17 satellites. This method works similarly to what is already being done in Europe, where the satellite product provides information on areas with and without cloud cover. Radar echoes in areas void of clouds, according to the BCM product, are removed. The impact to radar data quality control using the additional BCM filter is assessed using the EMET with both uncorrected and quality-controlled data.

The second quality control method is applied to the individual polar volumes. It uses dual-polarization

moments Z_{DR} and Rho_{HV} to produce depolarization ratio (DR), which is the basis for determining whether or not a given reflectivity is from precipitation. This simple and robust approach, recently reported on by McGill University, is here applied to several weeks of 2016 NEXRAD Level II data.

The aggressively configured algorithms for identifying and removing non-precipitation echoes used in our initial work resulted in greatly reduced false alarm rate (FAR) and probability of detection (POD), yielding sub-optimal aggregate skill scores. The hope is that replacing these methods with that based on DR will improve these scores, indicating improved data quality control that will benefit downstream radar data assimilation and quantitative precipitation estimation. With this approach, we also essentially have a framework for weather radar processing and data quality intercomparison.

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