WRF Atmospheric Data Assimilation: Lessons Learned from Arctic System Reanalysis

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The Arctic System Reanalysis (ASR) project is a collaborative US effort among OSU, NCAR, CU and UIUC to produce an 11-year (2000-2010) high-resolution (10-km) reanalysis over Arctic region. ASR adopted the OSU's polar version of the WRF model, the 3DVAR scheme of the NCAR's WRF data assimilation (WRFDA) system, and high-resolution land data assimilation system (HRLDAS) to perform analysis and forecast cycles in a 3-hour interval. This paper focuses on some aspects of atmospheric data assimilation component of WRFDA-3DVAR in the ASR, including the background error covariance statistics, satellite data usage (e.g., microwave radiances), and surface data assimilation. The experiments in a reduced resolution of 60km during a 2-year period (2007-2008) were performed to tune the system and obtain the optimal configuration. ECMWF's ERA-Interim global reanalysis data (79km resolution) were used as lateral boundary conditions for the experiments. The observations assimilated in the ASR contain the conventional observations from upper-air soundings (rawinsonde, pilot, profiler, and airep) and surface stations (synop, metar, ships, and buoy) and satellite observations such as atmospheric motion vectors from both geostationary and polar-orbiting satellites, QSCAT ocean winds, GPS radio occultation refractivity, and microwave radiances (AMSU-A/B and MHS).

It was firstly found that WRF model forecast errors exhibit seasonal variation with largest errors in winter and minimum errors in summer. Therefore, we generated the background error covariance statistics for 4 different seasons to better characterize the WRF model error feature. Variational bias correction (VarBC) was used to optimize the usage of radiances from microwave sensors. Some sensitivity experiments were conducted to find the optimal configuration. We found that it needs month-long spin-up to make VarBC coefficients stable when we start cycling from no knowledge of bias coefficients. Thus, a set of "pre-trained" bias coefficients allows radiance analysis stabilized more quickly. Some issues were also discovered for WRFDA's surface screen level analysis (T2m, T2m, U10, and V10). The relaxed quality control and more appropriate terrain correction for T2m and Ps observations allowed more surface observations being assimilated. This resulted in improved the analyses and short-term forecasts of surface parameters. It was also found that the polar WRF model is much better performed than the normal WRF model for high northern latitude region, particularly over Greenland.

More recently in preparation of 10-km resolution ASR production, we investigated different strategies of radiance bias correction. In particular, we found that the global statistics of radiance bias-correction coefficients are different from the regional statistics over the ASR or Antarctic-centered domain when using ERA-Interim reanalysis fields as the reference for coefficients regression. Several experiments were conducted in a 60-km resolution configuration during the period of August-December 2008 to evaluate the analysis and forecast performance when using different radiance bias correction strategies, including using global statistics versus using regional statistics and adaptively-updated bias correction versus variational bias correction. Field campaign observations from Arctic Summer Cloud Ocean Study (ASCOS) are used as an independent validation data source. The results will be reported in the presentation.

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