Assimilation of Synthetic Aperture Radar (SAR) wind information in Environment Canada's high-resolution 3D-Var analysis system

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1. Introduction

The potential benefit of assimilating SAR data into an atmospheric model is generally difficult to take advantage of in conventional assimilation cycles. One challenge lies not so much with the O[1-km] resolution of the numerical model itself, but with the resolution employed when combining observations with a previous forecast to produce the next set of initial conditions (i.e., the analysis increments that define the state vector in our assimilation approach). This resolution is determined largely by the model error covariance matrix. Here, we employ a limited-area version of the Global Environmental Multiscale (GEM) model (Cote et al. 1998).

2. A limited-area 3D-var system

Data assimilation at Environment Canada has traditionally been global with analysis increments at about 180-km resolution. The newest operational system (Fillion et al. 2010) will employ a 55-km limited-area grid. Experimental subdomains with analysis grids at close to 2.5-km resolution are also now possible within the unified 3D-Var code. These employ a bi-Fourier representation of the GEM errors that is analogous to the spectral representation used for global assimilation.

3. High-resolution model errors

The GEM 3D-var error correlations are horizontally homogeneous and isotropic for all wavenumbers of a limited-area domain. They have non-separable vertical and horizontal components for the Helmholtz wind decomposition (***ψ, χ***), temperature (**T**), and humidity (**logQ**). Error structures are derived using the so-called NMC method (Parrish and Derber 1992), which assumes that a difference in two forecasts (both valid at the same time, but starting from 12-h and 36-h beforehand, for example) is representative of a model error. Ensembles of high-resolution GEM forecasts (~120) have been employed in experiments to date.

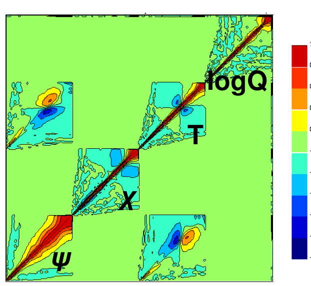

Fig. 1a: Typical vertical correlation matrix at the 2000-km (synoptic) scale (lower left corner of each block is at the GEM model top). Geostrophic and hydrostatic balance is reflected (in spite of the fact that no error balance is assumed).

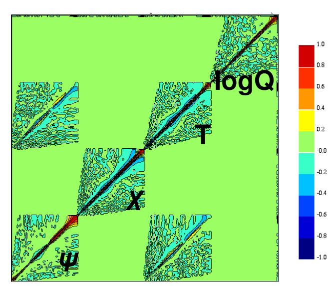

*Fig. 1b: At a scale of 200-km, there is much less spatial autocorrelation and the larger scale balance is not as evident (this is expected). Not yet included here is the cross-correlation of Helmholtz variables (**ψ, χ**) to capture low-level Ekman pumping.*

4. Analysis example

A Radarsat-2 ScanSAR HH-polarized scene (Fig. 2a) captured the signature of high winds south of Newfoundland on 10 February 2009, in the wake of a cyclone. Wind streaks are apparent in the SAR image, but only backscatter was considered in an analysis experiment that set SAR errors at 2% of backscatter in dB and neglected spatial error covariance (which was likely important). The impact of surface SAR backscatter on the analysis increments of temperature and wind are shown in Fig. 2b at about 2km above the surface. Maximum values are ¼ degrees (colours) and 5 knots (vectors). The SAR impact here is to increase the wind speed and produce quasi-balanced large-scale temperature changes.

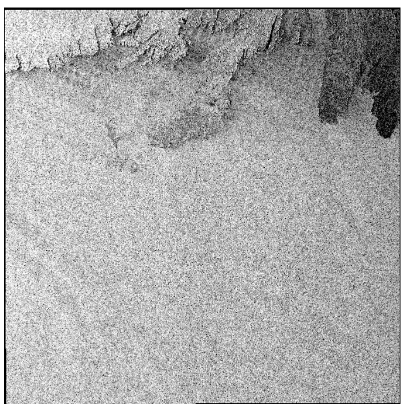

Fig. 2a: Radarsat-2 SAR backscatter

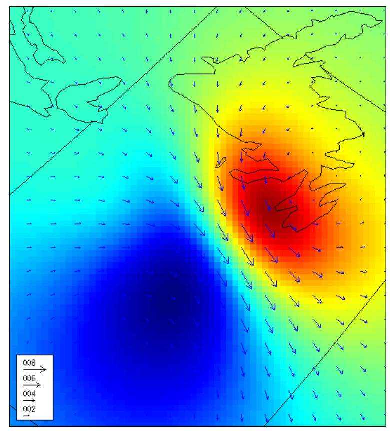

Fig. 2b: Analysis increments

5. Conclusions

An appropriate framework exists for testing the impact of SAR assimilation in Environment Canada's limited-area variational data assimilation system (Fillion et al. 2010). This system is being employed to define the GEM error covariance matrix (B). Incorporation of previous offline results (Danielson et al. 2008) in an experimental assimilation system is now being conducted. Tests of SAR (versus other satellite) impacts on analyses and forecasts for an east coast region are planned.

6. References

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7. Acknowledgements

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