Assimilation of Synthetic Aperture Radar (SAR) wind information in Environment Canada's limited-area analysis system

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Introduction

New observational platforms can be challenging to incorporate into a weather forecast system. In part, this is because there is simply more data to assimilate and their weighting may be unclear, but observed scales and physical processes may not be fully resolved as well. Such is the case for satellite SARs that provide O[1-km] ocean wind, current (Chapron et al. 2005), and possibly wave breaking information (Hwang et al. 2010). A simplification (as in previous work) is to interpret SAR backscatter following established methods of scatterometer wind retrieval. Although we are motivated by the assimilation of such retrievals, we believe a more natural treatment of SAR observations follows an approach that is both direct (i.e., that assimilates backscatter instead of derived wind) and inclusive of smaller scales (i.e., that benefits from scales unresolved by more conventional observing platforms). The ongoing development of high resolution data assimilation methods facilitates an exploration of this approach.

Two analysis configurations

Fillion et al. (2010) introduce hemispheric (HEM) and bi-Fourier (BF) approaches to incremental 3-D variational analysis in the Global Environmental Multiscale (GEM) forecast system. Both approaches employ background error correlations that are horizontally homogeneous and isotropic for all wavenumbers, with non-separable vertical and horizontal structures. Error statistics are derived using lagged forecast differences (the so-called NMC method). Dynamical balance is dictated by the spectral cross-correlations, although these appear to be negligible at smaller scales (not shown). We choose to assimilate only observations within the smaller 15-km BF analysis domain (Fig.1a), even for the larger 55-km HEM domain (not shown), so that analysis impacts can be compared. Perhaps as expected, the wavelength of the response (in terms of analysis increments following SAR assimilation) tends to be shorter in our experimental BF configuration (Fig.1c) than in the operational HEM configuration (Fig.1b).

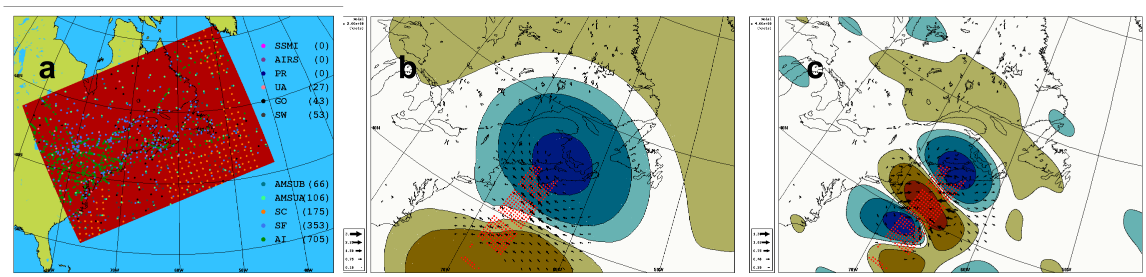

Fig. 2: A typical 6-h subset of observations (dots) within the BF analysis domain (red) from a) conventional platforms and b,c) Radarsat-2 SAR, with b) HEM and c) BF analysis increments of surface wind and temperature following SAR assimilation (note: temperature contour interval in b) is larger than in c)).

Assimilation experiments

Short-term GEM simulations at 15-km resolution were performed for 60 assimilation periods (centered at 00/12 UTC) between 10 Nov and 20 Dec 2009. These provided background trajectories for the assimilation of conventional observations and 209 east coast Radarsat-2 scenes (acquired around 10/22 UTC). Innovations (observation minus GEM background) were calculated relative to the appropriate time within these GEM 6-h trajectories. Buoy wind observations from 46 platforms were not assimilated so that SAR errors could first be postulated and the resulting analyses then validated. The HEM approach was found to be more sensitive to SAR wind information than our BF approach. The largest HEM analysis-buoy differences were obtained when conventional observations were assimilated alone (cf. Fig. 2c). Differences were reduced if SAR was included, but no assimilation (cf. Fig. 2a) seemed better. The smallest analysis-buoy differences were obtained for SAR-only assimilation (cf. Fig. 2d).

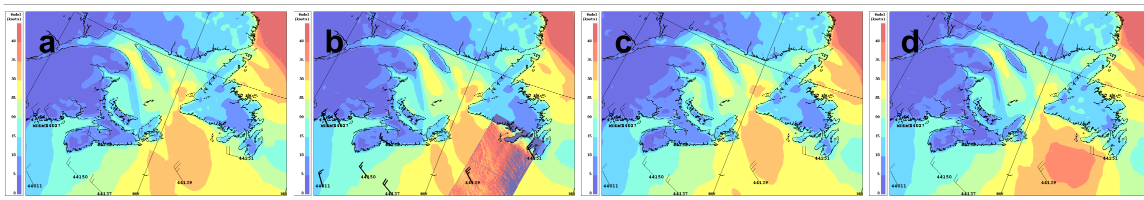

Fig. 2: Surface wind speed from a) a GEM forecast, b) direct SAR retrieval using GEM wind direction, and assimilation of c) conventional observations, and d) SAR backscatter

Conclusions

A new framework now exists for testing the impact SAR assimilation, perhaps for the first time, in a quasi-operational setting. Environment Canada's unified variational code has been employed to define a high resolution GEM error covariance matrix for bi-Fourier limited-area analysis (an approach not yet fully exploited). SAR assimilation may already be beneficial using a hemispheric assimilation scheme that has recently become operational. Once this impact can be confirmed to compare favourably with that of more conventional observation platforms, a formal assessment of short term forecasts may be undertaken.

References and acknowledgements

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