Evaluating the impact of adaptive observations during ATREC-03 and WSR04

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Abstract

Several adaptive observing programs aimed at improving short- to medium-range forecasts over populated areas have taken place over the last few years. This study compares the influence of targeted observations between two programs: the Atlantic THORPEX Regional Campaign (ATReC) of Fall 2003, and the Pacific Winter Storm Reconnaissance (WSR) Program of Winter 2004. In both programs, the additional "targeted" data improved the NCEP Global Forecast System forecasts overall. Several differences between the overall data impacts in the two programs were found: (i) surface pressure forecasts showed the least improvement due to the targeted data during ATReC, and (ii) the ATReC data had a larger influence on surface pressure forecasts, while WSR-2004 data had larger overall influences on vector wind and temperature forecasts.

1. Introduction

The Atlantic THORPEX Regional Campaign (ATReC) was conceived as a collaborative effort between EUCOS (EUMETNET Composite Observing System) program and THORPEX to test the ability to target a wide range of observational platforms in a real-time quasi-operational environment. Through this program, regions deemed sensitive to supplemental observations were identified and targeted to mitigate forecast errors over a region selected for verification over Europe and the eastern U.S. from 15 Oct–17 Dec 2003. The program relied on a collaborative effort between the Met Office, ECMWF, Meteo-France, NRL, NASA, U. North Dakota, Meteorological Service of Canada, NCEP, FSL, NCAR, and U. Miami. This high degree of coordination and collaboration fostered the exchange of ideas as to where optimally to place adaptive observations.

Another program aimed at reducing forecast error over areas of societal significance is the Pacific Winter Storm Reconnaissance (WSR) program, which has been operational at NCEP since 2001. Although not tantamount in size to ATReC, the addition of WSR targeted data has consistently shown statistically significant forecast improvements. Although the ETKF technique played a role as one of several methods used to determine where to direct observations in ATReC, it was used exclusively in WSR. The larger amount of targeted data available during ATReC, different ocean basins, and use of additional targeting methods led to an interest in comparing and contrasting results from the programs.

2. Observations, Sensitivity and Data Impact

During ATReC, a wide variety of observing platforms were made available for targeted deployment. Among these were instruments aboard and released from aircraft, AMDAR, ASAP ships, GOES rapid-scan winds, and radiosonde ascents to supplement the routine observational network. In contrast, the WSR program uses only dropsonde observations collected using the NOAA G-IV and USAFR C-130s.

The ECMWF, UK Met Office, Meteo-France and NCEP provided sensitivity calculations during ATReC. ECMWF and Meteo-France used techniques based on singular vectors (Palmer et al. 1998), while the UK Met Office and NCEP used the Ensemble Transform Kalman Filter (ETKF, Bishop et al. 2001, Majumdar et al. 2002). The former used the ECMWF ensemble in ETKF sensitivity calculations, whereas the latter used both NCEP-only and the combined ECMWF and NCEP ensembles. During WSR-2004, only the ETKF combining both the NCEP and ECMWF ensembles was used.

For both the ATReC and WSR-2004, the data impact was evaluated with 2 parallel analysis-forecast cycles of the NCEP Global Forecast System (GFS) at T126L28 resolution. The "operational" cycle assimilated all operationally available data including data collected during ATReC and WSR, respectively. The "control" cycle excluded targeted observations collected during each program. Because not all of the observations taken during the ATReC were available at the time the analysis was run, only operationally available data were assimilated in the operational cycle.

3. Summary of Results

The overall impact of the additional ATReC data throughout the course of the experiment was strongly positive with most cases improved with the additional data. The GFS forecasts were verified over a 1000 km radius disk centered over the area selected for forecast improvement. The forecasts were compared against rawinsonde observations and the RMS error computed for each case.

Surface pressure forecasts were improved for 74% of all ATReC cases. Temperature forecasts were improved for 92% of ATReC cases, while vector winds were improved for 79%. Taking into account each variable (surface pressure, temperature, and wind) for each case, 84% of the ATReC cases were overall improved by the additional data.

During WSR 2004, 60% of all cases showed improvement for each surface pressure, temperature, and vector wind. Over all cases, 69% were improved in two of those categories.

Fig. 1 shows the degree of improvement in each ATReC and WSR-2004, as measured by reduction in RMS error (RMSE), obtained in surface pressure through the targeted data. Fig. 2 shows the reduction of RMSE in temperature between 1000-250 hPa, while Fig. 3 for vector wind between 1000-250 hPa. Each variable was overall improved with the addition of targeted data during each campaign. However, surface pressure reflected the smallest degree of improvement of these fields during ATReC , while showing a similar degree of improvement to temperature and vector wind in WSR-2004.

Another difference between the two datasets is the generally larger magnitude of differences between the two runs in the WSR-2004 dataset. In comparing the mean absolute RMS difference between the operational and control cycles for the GFS for each dataset, the ATReC had a larger mean difference for surface pressure, while WSR-2004 had larger mean absolute differences for vector wind and temperature. One explanation for this difference may involve the inclusion of targeted observations in forecast/analysis cycles at times other than the 1800 UTC forecast time used for verification. This practice is in contrast to those used during the WSR-2004 program, where the targeted observations were included only at 00 UTC for each observation date.

Further detailed investigations are ongoing, and case studies are forthcoming.

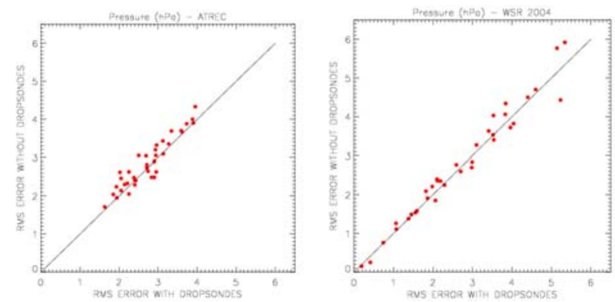

Figure 1. Surface pressure RMS error (hPa) for GFS cycles with (x-axis) and without (y-axis) targeted data for each case during ATReC (left) and WSR-2004 (right).

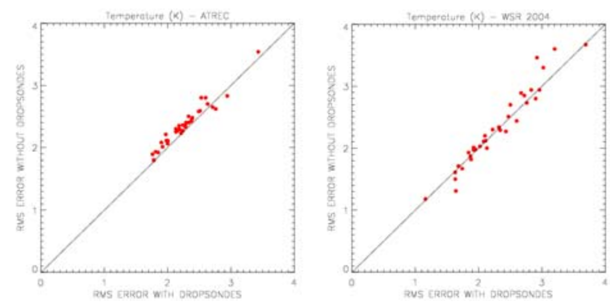

Figure 2. Same as figure 1, for Temperature (K).

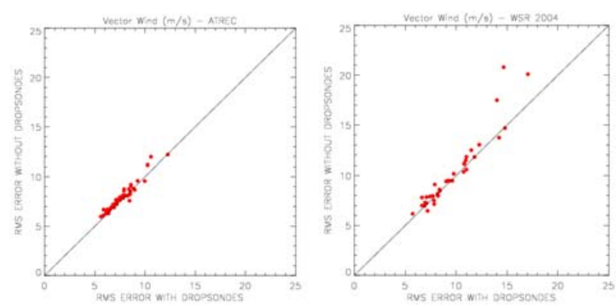

Figure 3. Same as Figure 1, for vector wind (m/s).

References

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