P1.8 ASSESSING THE FORECAST IMPACT OF WINDSAT/CORIOLIS DATA IN THE NCEP GDAS/GFS

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1. INTRODUCTION

Sea surface wind vectors have been estimated with active remote sensing instruments, such as QuikSCAT (Yu and McPherson 1984), and have been proven to have a positive impact on forecasts. The future polar system NOPESS will be relying on passive techniques from instrument such as CIMS (Conical scanning Microwave Imager/Sounder). Passive polarimetric microwave radiometry is being introduced as an alternative vector wind measurement approach to the active remote sensing approach of QuikSCAT and other instrument. To demonstrate the capability of such passive techniques for measuring surface wind speed and directions, WindSat/Coriolis (reference) was placed into polar orbit by NASA in January 2003. WindSat is the first polarimetric microwave radiometer to measure ocean surface wind speed and direction. The U.S WindSat/Coriolis mission is a proof of concept mission. The follow-on CMIS polarimetric microwave radiometer instrument on NPOESS is tasked with providing accurate vector wind measurements over a 1,700 km swath. Early evaluation of the accuracy and utility of the CMIS surface vector wind measurements by operational meteorological centers have been requested by NOAA to assure rapid and efficient post-launch operational use of the data.

The projected capabilities of the WindSat mission are to demonstrate spaceborne remote sensing of ocean surface wind vectors (speed and direction). Wind direction measurement with polarimetric instruments, which sense the polarity of light, can also demonstrate how ocean surface properties change with wind and boundary layer conditions. Ocean wind speed and direction affect a broad range of navel missions, such as ship movement and positioning. WindSat will aid with forecasting short-term weather, issuing timely weather warnings and gathering general climate data.

In collaboration with NASA, NRL, NOAA and NCEP personnel, the JCSDA (Joint Center for Satellite Data Assimilation) has been evaluating the forecast impact of assimilating WindSat data in the NCEP GDAS/GFS (Global Data Assimilation/Forecast System).

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Wind roughening the surface of the ocean causes an increase in the brightness temperature of the microwave radiation emitted from the water's surface. From the brightness temperature measured by satellite radiometers, wind speed and direction can be retrieved. The NRL WindSat Version 2 wind vector retrieval algorithm is used in this study (Bettenhausen et al., 2006). WindSat measures not only the principal polarizations (vertical and horizontal), but also the cross-correlation of the vertical and horizontal polarizations. Except for the product of wind speed and direction, WindSat also shows potential to measure SST's, water vapor, cloud liquid water, rain rate, sea ice and snow cover.

Several advantages of these global studies have been shown compared to regional studies. First, global experiments remove contamination from the lateral boundary conditions of the model. Second, the global studies also allow investigation of data types not available within a regional model domain. Third, the global studies have already identified results of interest about existing data types. Finally, perhaps the greatest advantage of these global studies is that EMC provided adequate computer resources to complete the simulations at the operational resolution of the model.

For this poster, forecast impacts will be compared with that of QuikSCAT surface winds. QuikSCAT winds have been proven to provide a positive forecast impact in the GFS during both seasons and in each hemisphere (Le Marshall et al 2007).

2. EXPERIMENTAL DESIGN

In collaboration with JCSDA, studies have been done to evaluate the impact of assimilating WindSat data in the NCEP GDAS/GFS. A November 2005 version of the SSI and GFS were used and run at T254L64. The time period studied is from 1 Jan to 15 Feb, 2004. Forecast impacts will be compared with QuikSCAT data from the same time period.

The first part of this forecast impact experiment is to demonstrate forecast impact with QuikSCAT data in the NCEP GDAS/GFS. This part of the experiment requires running the GFS with QuikSCAT data (cntrl254) and without QuikSCAT data (noqscat254). By default, QuikSCAT data use a 0.5 degree superobing in the assimilation system.

The second part of this forecast impact experiment is to demonstrate forecast impact with WindSat data in the NCEP GFS. This requires running the GFS with WindSat and QuikSCAT data at a 1 degree superob (windsob1º254) and at a 0.5 degree superob (windsob0.5º254). The denial experiment is running the GFS model with WindSat and no QuikSCAT data (windnoq254).

Some QC (Qualify Control) for WindSat data have been done in the retrieval process. Observations that are flagged for rain, land, sun glint, RFI (Radio Frequency Interference) or sea ice contamination are omitted. WindSat processing uses the median filtering technique to smooth the final wind field. The NCEP GDAS model wind fields are used for WindSat processing initialization. Additional WindSat QC is also used for this experiment. Data is used at 6 hour synoptic times with a plus/minus 3 hour window. If the absolute value of the observed wind component is more than 6 m/s from the corresponding background wind component the observation is eliminated. This QC check only removed the extreme outliers (approximately 2% of the observations per 6 hour window).

Once the 45 day WindSat experiments were completed, several diagnostics were performed on the archived data. In addition to the anomaly correlation statistics traditionally performed by NCEP, geographical distributions of the magnitude of surface wind difference (control – WindSat) and SLP (Sea Level Pressure) difference (control – WindSat) were evaluated. The anomaly correlation statistics were performed using the traditional NCEP algorithms (NWS 2006).

3. RESULTS

Figure 1 presents WindSat assimilation statistics of 1000 hPa and 500 hPa geopotential height anomaly correlation at day 5 for 20-80ºN and 20-80ºS (7 Jan – 15 Feb 2004). The four experiments NoQuikSCAT, control, WindSat1.0 and WindSat 0.5 are compared in this bar chart. The control simulation is better than the NoQuikSCAT experiment for most of the cases, which suggests QuikSCAT data provide positive forecast impact. WindSat 1.0 has better AC score compare to WindSat 0.5. The control and WIndSat1.0 are close to each other for most of the cases, except for SH 1000 which can be associate with sparse observation distributions in the southern hemisphere.

Figure 2 is a snapshot of the 1000 hPa magnitude of wind difference (control – WindSat). The wind magnitude difference can be greater than 8m/s in some regions. Most of the differences are over ocean since all WindSat measures is ocean surface wind speed distributions.

Figure 3 displays a snapshot of the SLP difference (control – WindSat). As with Fig. 2, all the differences are in oceanic regions. The maximum difference is larger than 3 hPa near Antarctica. Further regional studies will be done in this area to isolate the long term impacts.

Figure 4 presents the 7-day die off curves of anomaly correlation for the control versus WindSat 1.0º superob experiment. Evaluation reveals that the WindSat 1.0º superob anomaly correlation is slightly higher than the control simulation anomaly correlation by day 7. The combination of WindSat and QuikSCAT data provided the largest positive forecast impacts.

Figure 5 is the 7-day die off curves of the WindSat 1.0º superob versus WindSat 0.5º superob experiments. The northern hemisphere AC results look nearly identical; however, in the southern hemisphere, the WindSat 1.0º superob results display better AC's from days 5 to 7, with nearly identical AC scores at other times.

Figure 6 shows the 850hPa AC distributions in the tropics (20ºN - 20ºS). Evaluation over tropical regions reveal that there is dominant benefit of the combination of WindSat and QuikSCAT data compared to the control simulation after day 3.

Figure 7 displays the 1000 hPa wind speed anomaly correlations at day 5 for 20-80°N (7 Jan–15 Feb 2004) for the control and WindSat 1.0º superob experiments. In the Northern Hemisphere the mean values are close to each other, with the daily curves nearly identical for most of the cases. In the Southern Hemisphere there are cases where the WindSat 1.0º superob experiment displays AC's more than 0.1 better than its counterpart and vice versa. These time periods also provide good cases for future case studies.

Figure 8 presents a profile of geopotential height anomaly correlation of Windsob1.0º and QuikSCAT0.5º at day 5 for 20-80°N and 20-80°S (7 Jan–15 Feb 2004) from 1000 hPa to 200 hPa. Different from the traditional way of evaluating AC at a single level, this profile reveals the changes of geopotential height anomaly correlation with height. The Northern Hemisphere results of WindSat and QuikSCAT look very close. QuikSCAT results show higher AC in the Southern Hemisphere at 1000hPa, 850hPa, 700hPa. This demonstrates that the surface wind observations have an impact to forecast quality throughout the atmosphere.

4. SUMMARY

This paper summarized the forecast impacts of WindSat data and QuikSCAT data in the NCEP GDAS/GFS. Unique to this study are that the 45 day denials were completed at the operational resolution of the time and that it evaluated a relatively new (non-operational) data type. The conditions of the assimilation experiments were outlined by the authors with the help of NCEP personnel.

Key findings of the denials completed thusfar, some of which extend beyond the results presented in this paper, are that:

- Cumulatively, satellite data proves more important to forecast quality than conventional data.
- Preliminary results indicate that QuikSCAT data improved the forecast more than WindSat data for a majority of the cases examined.
- The combination of WindSat and QuikSCAT data provided the largest positive forecast impact by day 7.
- At T254, WindSat data demonstrated larger AC gains with a 1º superob than with a 0.5º superob.
- Many more data denials/additions are planned, including examining the direct assimilation of the WindSat radiances into the GFS by switching from the Spectral Statistical Interpolation (SSI) algorithm (Derber et al. 1991; Parrish and Derber 1992) to the pre-operational (Gridpoint Statistical Interpolation (GSI) algorithm. WindSat data have also been under going real time testing at T382 during the summer and fall of 2006.

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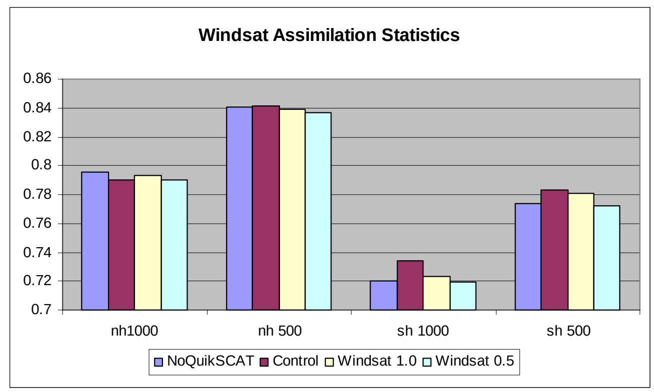


NoQuikSCAT - (no AMSU, no AQUA AIRS, with QuikSCAT)
Control - (no AMSU, no AQUA AIRS, no QuikSCAT)
WindSat 1.0 - (control + WindSat + QC and 1º superob)
WindSat 0.5 - (control + WindSat + QC and 0.5º superob)

Fig.1. WindSat assimilation statistics of 1000 hPa and 500 hPa geopotential height anomaly correlation at day 5 for 20-80ºN and 20-80ºS (7 Jan – 15 Feb 2004).

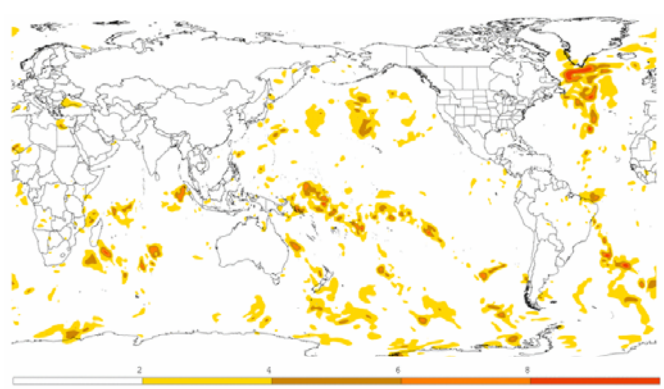


Fig. 2. 1000 hPa magnitude of wind difference 2004011806 (control – WindSat).

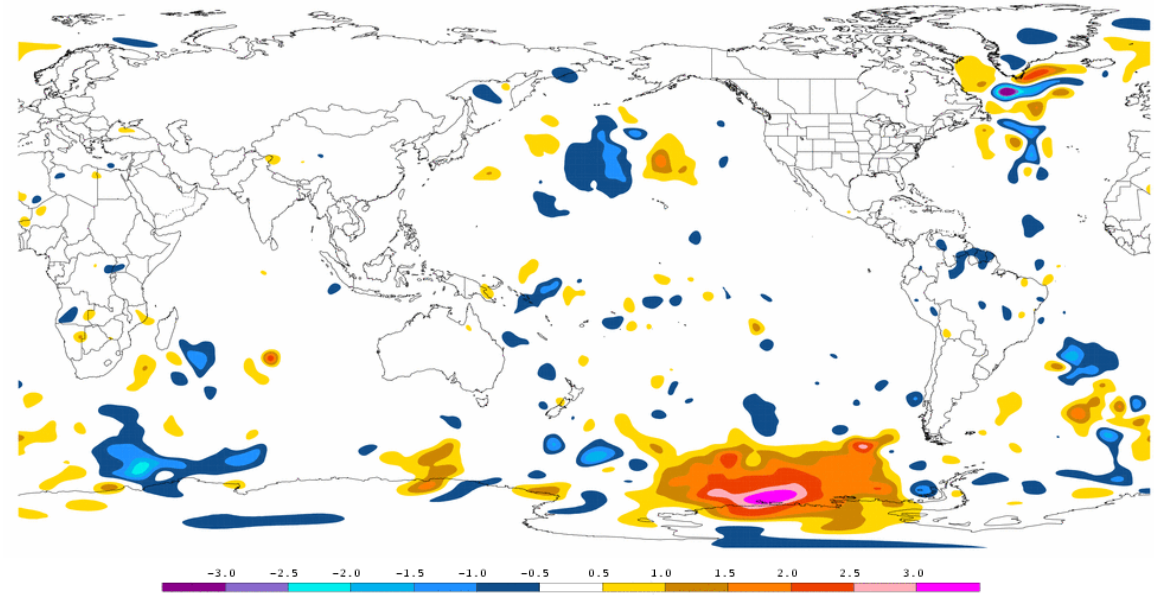


Fig. 3. SLP difference 2004011806 (control – WindSat).

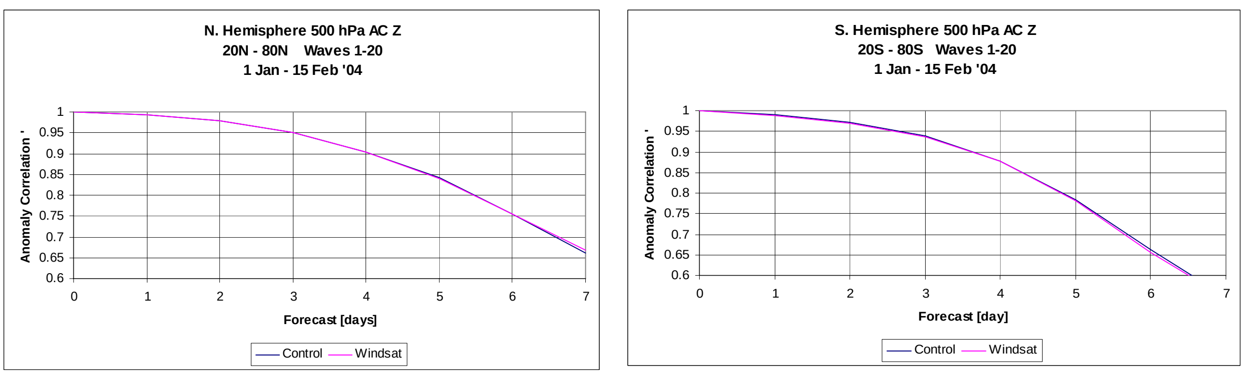


Fig. 4. 7-days die off plot of control vs. WindSat 1.0º superob.

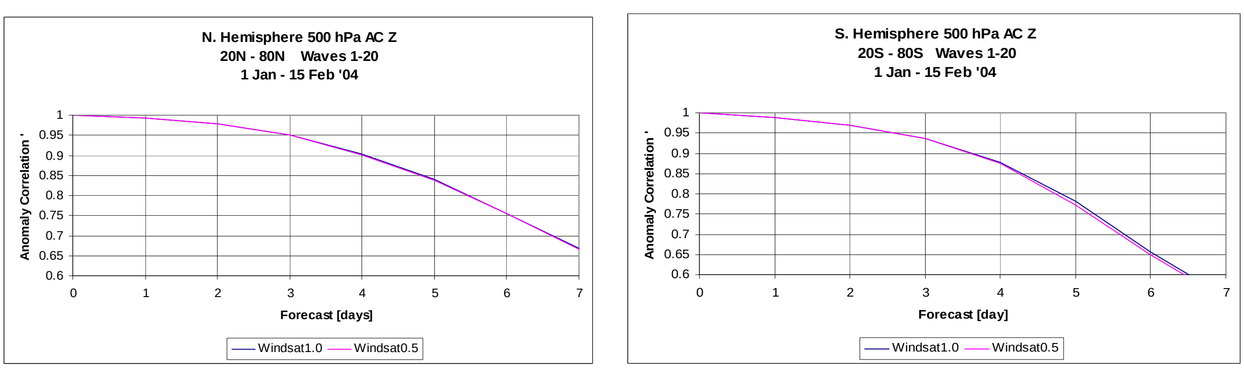


Fig. 5. 7-days die off plot of WindSat 1.0º superob vs. WindSat 0.5º superob.

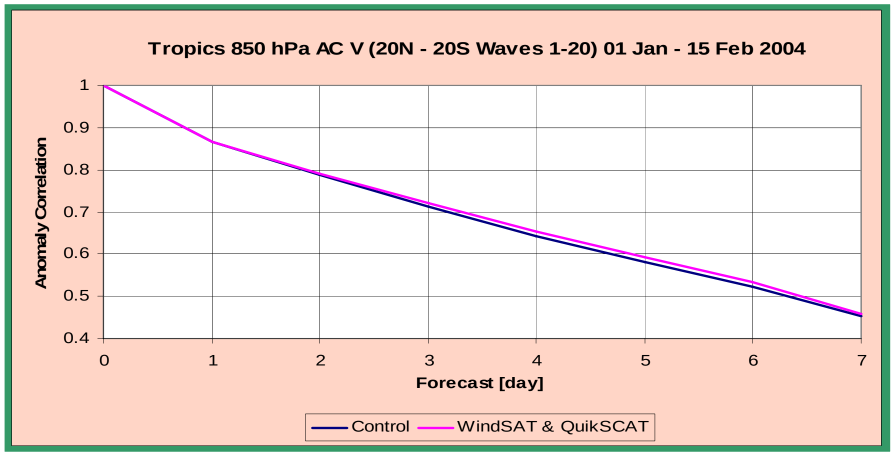
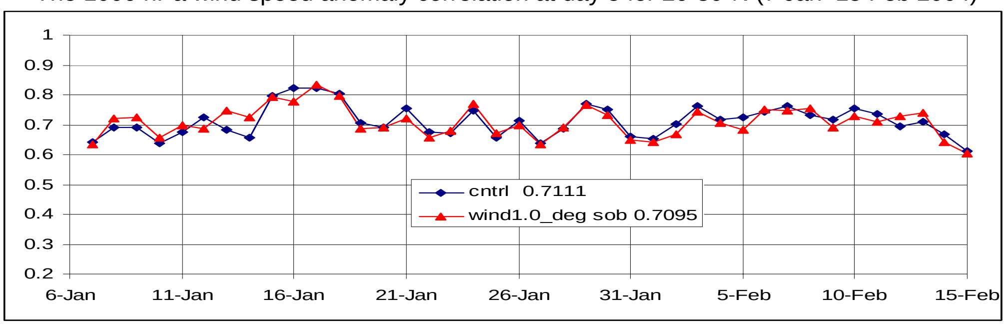


Fig. 6. Tropics 850 hPa AC V from 1 Jan to 15 Feb 2004.

The 1000 hPa wind speed anomaly correlation at day 5 for 20-80°N (7 Jan–15 Feb 2004)



The 1000 hPa wind speed anomaly correlation at day 5 for 20-80°S (7 Jan–15 Feb 2004)

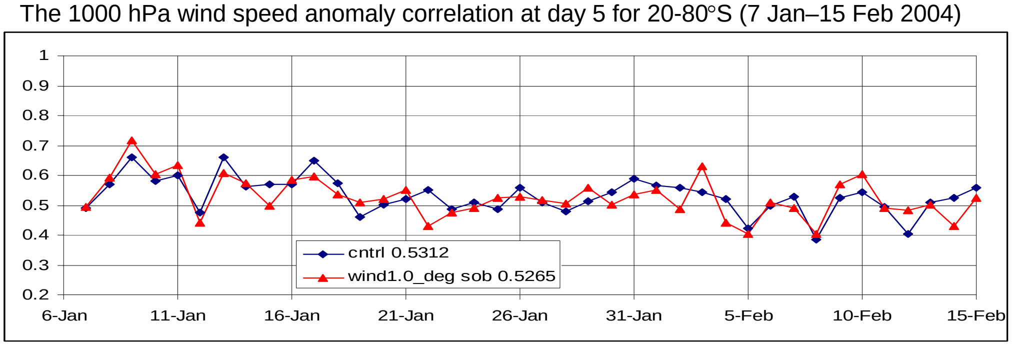


Fig. 7. 1000 hPa wind speed anomaly correlation at day 5 for NH and SH.

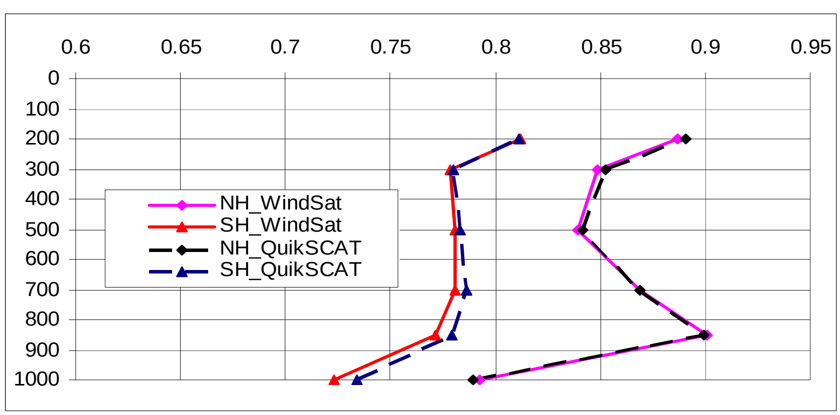


Fig. 8. Geopotential height AC of Windsob1.0° and QuikSCAT0.5° at day 5 for 20-80°N and S (7 Jan–15 Feb 2004).