MODIS- and AVHRR-derived Polar Winds Experiments
using the NCEP GDAS/GFS

NA10NES4400011

Year 4 First-half Progress Report
June 2013 through December 2013

30 December 2013

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Proposed Work

From the proposal:
Atmospheric Motion Vectors (AMV) are routinely generated from geostationary and polar orbiting satellites and they are incorporated into most global numerical weather prediction models throughout the world. However, advances to the AMV derivation process together with changes to assimilation systems and forecast models require the strategies for use of the satellite-derived winds to be continually evaluated.

The focus of the proposal is in three areas using AMVs generated from polar orbiting satellite data: (1) Quality control (QC) and thinning using the Expected Error; (2) Experiments assimilating polar winds derived from Advanced Very High Resolution Radiometer (AVHRR) images; and, (3) Experiments designed to simulate winds from the Visible/Infrared Imager/Radiometer Suite (VIIRS) instrument onboard the Suomi NPP satellite.

First Half of Fourth Year Progress

Experiments with the new quality control were run during this six months of the project. The first season experiment completed for the MODIS winds and AVHRR-only winds.

Also, these areas were addressed or identified:

- VIIRS polar winds status
- Personnel status
- Conferences and papers
- Upcoming activities

Quality Control Method

As documented in the previous semi-annual report, the Log Normalized Vector Departure (LNVD) is being used, instead of the Expected Error (EE), as the quality control for two polar winds experiments. The LNVD is defined as:

$$LNVD = SQRT\ (\ (U_o-U_b)^2 + (\ V_o - V_b)^2\ )\ /\ \log(ObsSpd)$$

where U_o, V_o is the observed AMV u- and v- components; U_b, V_b is the background; ObsSpd is the AMV speed. For the initial evaluation of the LNVD, we use a threshold that results in the same number of discarded winds as the control. Based on several weeks of assimilation statistics, the threshold was determined to be 3.

The operational screening discards AMVs if the u- or v- component differs by more than 7 ms^{-1} from the background. Therefore, most slow winds (< 5 ms^{-1}) are retained in the control because they will not exceed the 7 ms^{-1} threshold, even though they may be pointed in the opposite direction! The table below shows the allowable AMV departure from the background will vary using a LNVD threshold. Slow winds (speed < 3 ms^{-1}) must be within 3.3 ms^{-1} to be accepted. On the other end of the scale, a 50 ms^{-1} wind may deviate from the background by 11.7 ms^{-1} and still be retained.

LNVD threshold = 3

ObsSpd	Log(ObsSpd)	VecDiff
3	1.1	3.3
10	2.3	6.9
50	3.9	11.7
100	4.6	13.8

A graphical depiction of the operational screening (Figure 1) shows that slow winds (upper left panel) can vary substantially from the background, including pointing in the opposite direction. While, the LNVD quality control for the same wind speed (Figure 2 upper left panel) reduces the variability in the accepted AMVs.

For high-speed winds (60 ms^{-1}; lower right panels in both Figures 1 and 2) the LNVD will accept AMVs with speeds that deviate from the background by up to 12 ms^{-1} and with more variability in the direction than the control.

Overall, the LNVD QC provides a more consistent wind direction check across all wind speeds than the operational QC. Thus, the LNVD is more of a vector-based QC (corresponding to wind observations), than the current wind-component method.

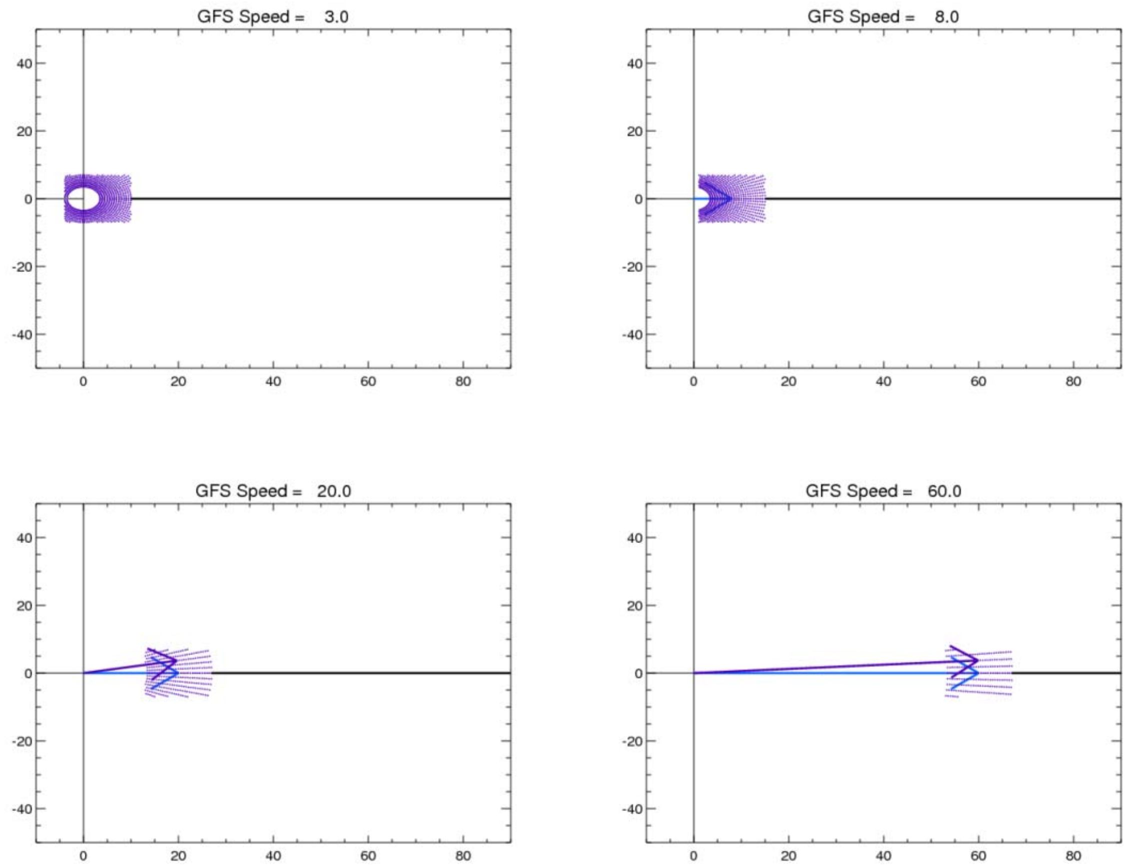

Figure 1. A graphical representation of retained winds using the operational quality control. The blue vector represents the wind vector at speeds: 3, 8, 20, 60 ms^{-1} shown in individual panels. The purple dots represent the end point of a vector (originating at 0,0) that will be retained; the purple vector is one possible AMV that would be retained.

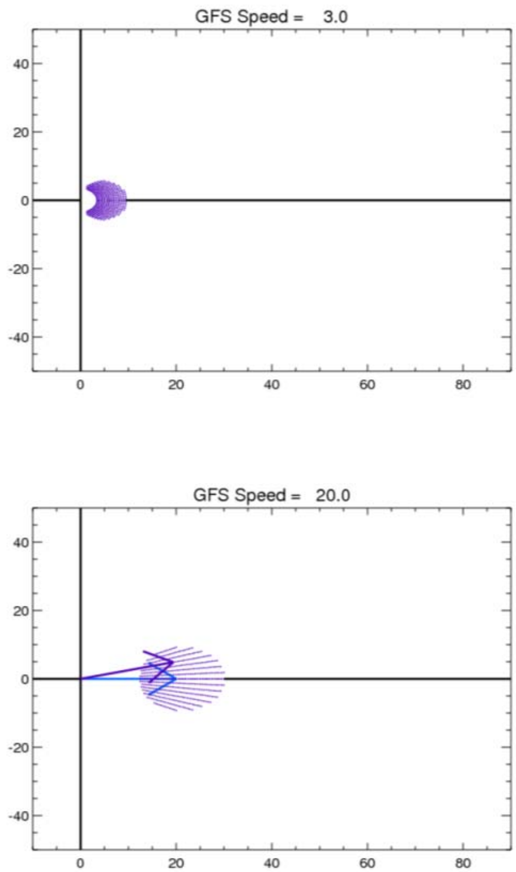

Figure 2. A graphical representation of retained winds with the threshold LNVD = 3. The blue vector represents the wind vector at speeds: 3, 8, 20, 60 ms^{-1} shown in individual panels. The purple dots represent the end point of a vector (originating at 0,0) that will be retained; the purple vector is one possible AMV that would be retained.

<u>MODIS experiment</u>

In previous experiments, the EE ratio is used for the quality control, which resulted in retaining more high-speed winds and discarding more low-speed winds, compared to the control. For a one-season experiment, the results were very favorable, especially in some forecast dropout events. The new QC method, LNVD, has similar characteristics as the EE ratio: retaining more high-speed winds and discarding more low-speed winds. An LNVD threshold of 3 is used in the following experiments, which run from 1 September to late October 2012. The control uses the operational QC for the MODIS winds.

Generally the impact of the LNVD is statistically neutral as compared to the control, although slight improvements are noted. For example, the vertical profile of the southern hemisphere wind RMSE (Figure 3) shows a reduction in the RMSE (right panel) using the LNVD vs. the control. The improvement is centered at the 300 hPa level beginning at about the 48-hour forecast and extending to later forecast times.

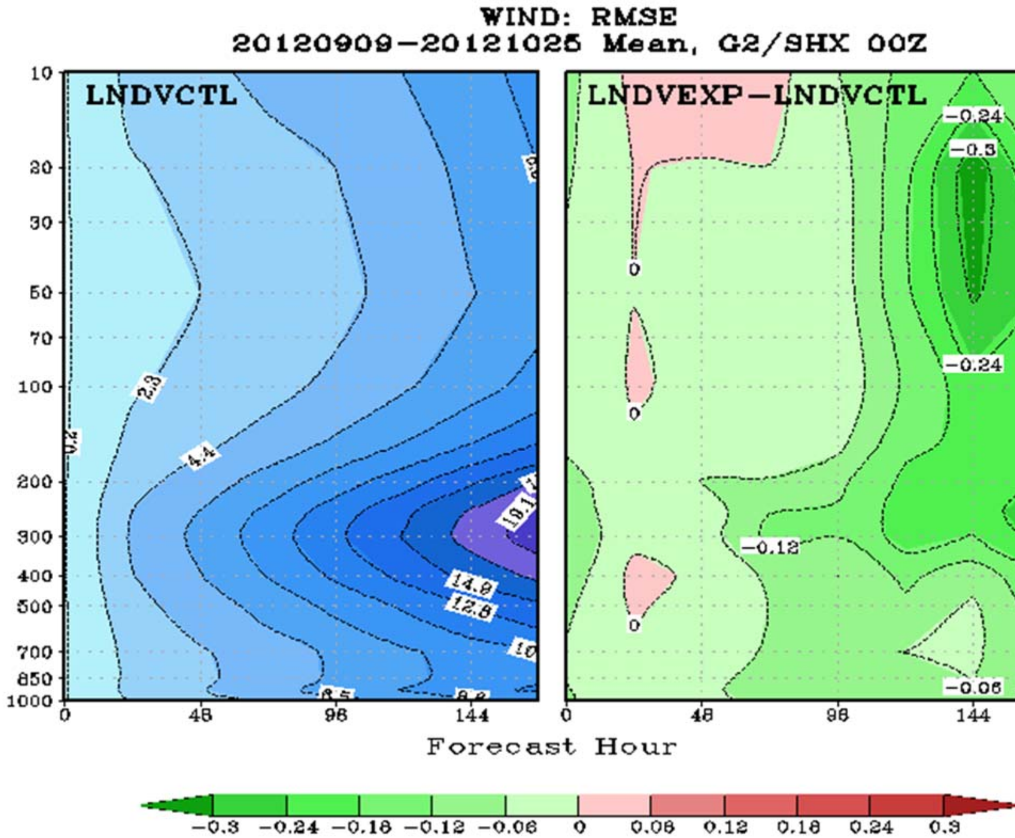

Figure 3. The vector wind RMSE for the control (left); the experiment minus control vector wind RMSE (right). The right panel depicts improved RMSE in shades of green; degraded RMSE as shades of red over the southern hemisphere (20°S-80°S), using the LNVD threshold of 3. Date: 9 September to 25 October 2012.

AVHRR experiments

The first season experiment is complete using AVHRR IR winds with the same LNVD settings as MODIS. The real-time AVHRR winds are from NOAA-15, -16, -18, -19, and Metop-A for this time period. For the NOAA satellites, features are tracked in 4 km resolution images (compared to 2 km for MODIS). However, for the Metop satellite the resolution is the same as MODIS. This results in more AVHRR IR winds as compared to MODIS, but MODIS has a substantial contribution from water vapor winds. However, Terra water vapor winds are no longer being produced by NESDIS since there are only two good detectors out of ten for band 27 (6.7 µm).

In this first experiment, the AVHRR winds replace the MODIS winds and the statistics presented are compared to their respective background and analysis. This scenario is important as the MODIS instruments on Terra and Aqua are well beyond their designed lifetimes, so AVHRR-only polar winds may be a reality in the near future.

This experiment compares the impact of the MODIS winds with operational quality control (Control) and AVHRR winds (Experiment) with the LNVD. For the most part, the impact is neutral. However, Figure 4 shows a statistically significant decrease (circles) in the 700 hPa height RMSE for the 4- and 5-day southern hemisphere forecasts using the AVHRR winds. This result is encouraging as AVHRR (and VIIRS) polar winds will be the replacement product for MODIS, which is operating beyond its designed life.

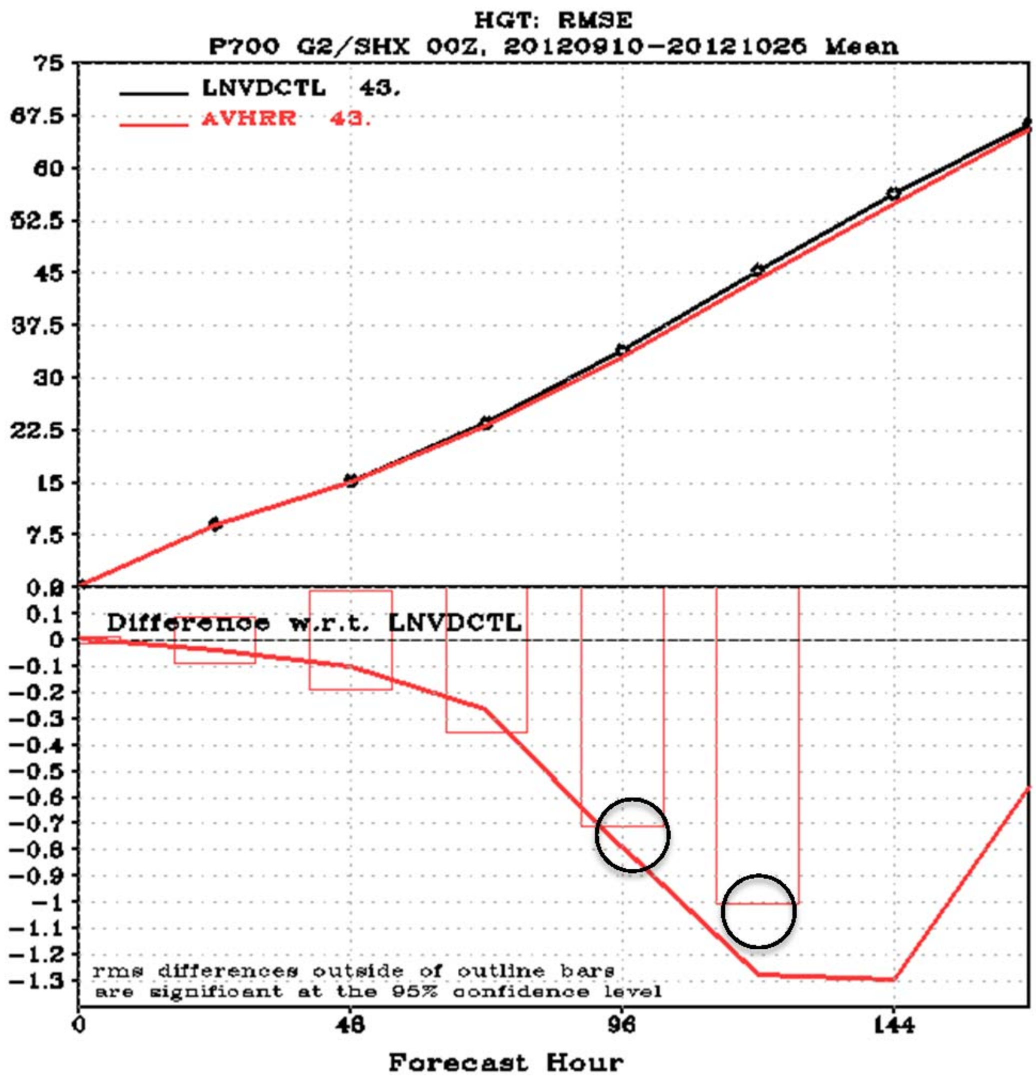

Figure 4. Southern hemisphere 700 hPa height RMSE for 10 Sept – 25 October 2012 for the control (black) and experiment (red). Control: Operational QC of MODIS winds. Experiment: LNVD QC with AVHRR winds (no MODIS winds). Circles represent statistically significant improvement for Day-4 and Day-5 forecasts.

VIIRS polar winds

Polar winds from the VIIRS instrument are not expected to be operational in NESDIS until early 2014. Since this current project to evaluate polar winds ends in May 2014, there will not be time to evaluate the VIIRS polar winds.

Personnel status

Brett Hoover continues to work on this project; Jim Jung has a consulting role.

Conferences and papers

An abstract was submitted and accepted for an oral presentation at the Second Symposium on the Joint Center for Satellite Data Assimilation during the 94th AMS Annual Meeting in February 2014: *Evaluation of a New Method to Quality Control Satellite-derived Polar Winds in the NCEP GDAS/GFS*

Upcoming activities

A second season experiment was begun, which covers the time period 1 April to 31 May 2012.

Upon successful completion of second season, we will incorporate the LNVD quality control code into the appropriate source code branch.