# POLAR WINDS FROM MODIS: PROJECT STATUS

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## ABSTRACT

The near real-time generation of winds over the polar regions from Moderate Resolution Imaging Spectroradiometer (MODIS) data have been produced at CIMSS for two years. The wind information is retrieved by several numerical weather prediction (NWP) centers worldwide and is used in both operational and experimental forecast systems. The generation of winds is not done in a true operational sense at CIMSS, but it is being done routinely and the results are archived. The status of the project will be presented from several perspectives: the timeliness of the data, improvements to the algorithm, and future efforts.

The timeliness of the winds is critical for assimilation by NWP models. The current delay of up to 5 hours is too long for some assimilation systems. We are reducing that time by using data from MODIS Direct Broadcast receiving stations in the high latitudes and by deriving winds from alternating passes of Terra and Aqua. The improved timeliness will be reported.

Recent improvements to the retrieval algorithm have also been made. A correction for the effect of parallax has been introduced. This is expected to improve the quality of the winds from single-satellite derived winds, but more importantly, it will allow for the derivation of winds from alternating passes of Terra and Aqua. This reduces the time required for a triplet of images from 200 to 100 minutes, but also has an affect on coverage. The software was also updated to use the higher bit-depth of MODIS, which we expect to have a positive effect on the cloud height determination. Previously, the data bit depth was reduced from 12 to 8 bits.

Future work includes deriving winds from additional MODIS channels, AVHRR, and possibly AIRS radiance data.

## 1. INTRODUCTION

The near real-time generation of winds from MODIS has been produced at CIMSS since 2002. These polar winds have shown a positive impact in forecast models (Key et al. 2003; Bormann and Thepaut 2004). But, the current version of the winds software and processing has not been significantly updated since that time.

A similar winds product is being produced by NOAA/NESDIS, using the same input satellite data. This began in November 2003 using a slightly scheme from what is done at CIMSS. The differences are:

- Middle image targeting, instead of targeting with the first image of the triplet
- The background guess is from the GFS model instead of the NOGAPS model
- The use of more frequent model runs, shorter forecasts, and time-interpolated background fields.

November 2003 was also the beginning of the MODIS Winds Special Acquisition Period (MOWSAP). This was a three-month period to generate winds at both CIMSS and NESDIS, so a comparison of results from the NWP centers could more easily be compared. Previously, each center evaluated the impact on their models using different time periods.

This paper describes the status of the MODIS winds processing from a technical point-of-view, including upcoming changes that are currently in testing.

## 2. TIMELINESS

The MODIS data is received at a NOAA workstation located at the GSFC. It is generally delayed by two to five hours from real-time. We are investigating the use of Direct Broadcast sites at high latitudes to improve the timeliness. A one-week test showed that the MODIS data could be acquired about 1.5 hours sooner, on average, when retrieved from DB sites. Fig. 1 is an example of a Terra pass from Kiruna, Sweden. This figure also shows the location of Fairbanks, Alaska on the opposite side of the Arctic. The dashed lines show the regions where the satellite is in view of the groundstations and data can be received.

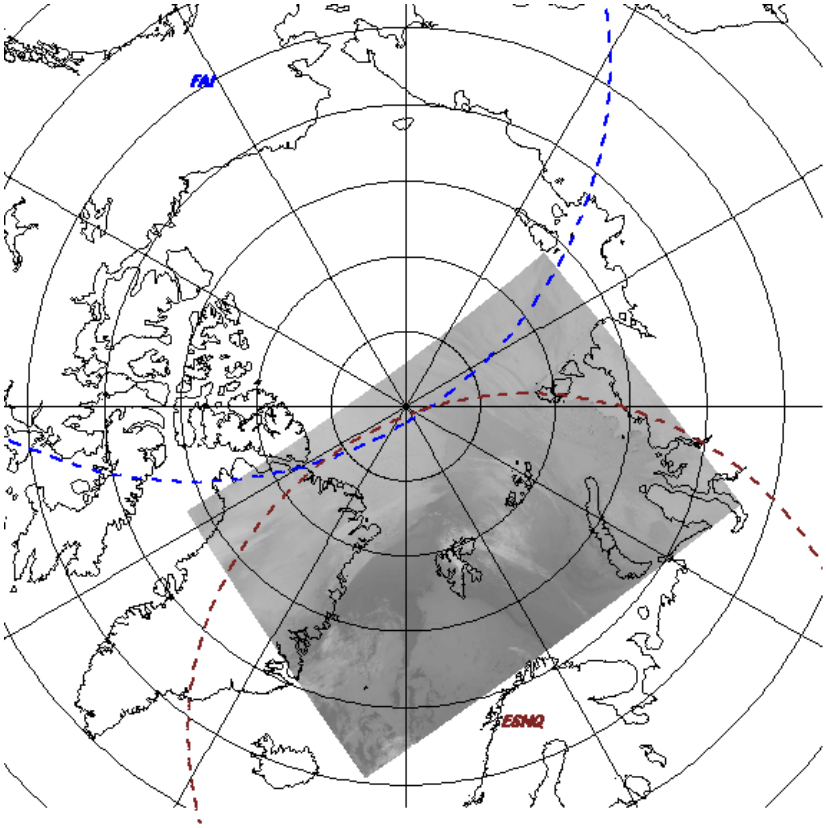


**Figure 1. An example of a pass acquired from Kiruna, Sweden (ESNQ). The dashed line shows the approximate region where the groundstation is in view of the satellite. In the upper left corner is Fairbanks, Alaska (FAI) and its data acquisition area.**

These two sites provide good coverage from their location poleward, but there are significant gaps in the western Greenland and northern Russia regions. In the southern hemisphere the coverage is much less due to the lack of DB sites. Also, Fairbanks and Kiruna can generally only receive data from Terra as there is a conflict with Aqua data to the main downlink sites located nearby. We continue to investigate acquiring this data routinely, in order to reduce the delay for at least some of the time periods.

## 3. ALGORITHM IMPROVEMENTS

A number of improvements are planned for the summer of 2004.

A correction of parallax is in testing. This change will account for changing viewing geometry of clouds and features from successive MODIS passes. Fig. 2 shows the error in cloud placement as a fraction of its height. A normalized cloud offset of 1.0 means the cloud location error is the same as the cloud height. This occurs at about 700 km from nadir.

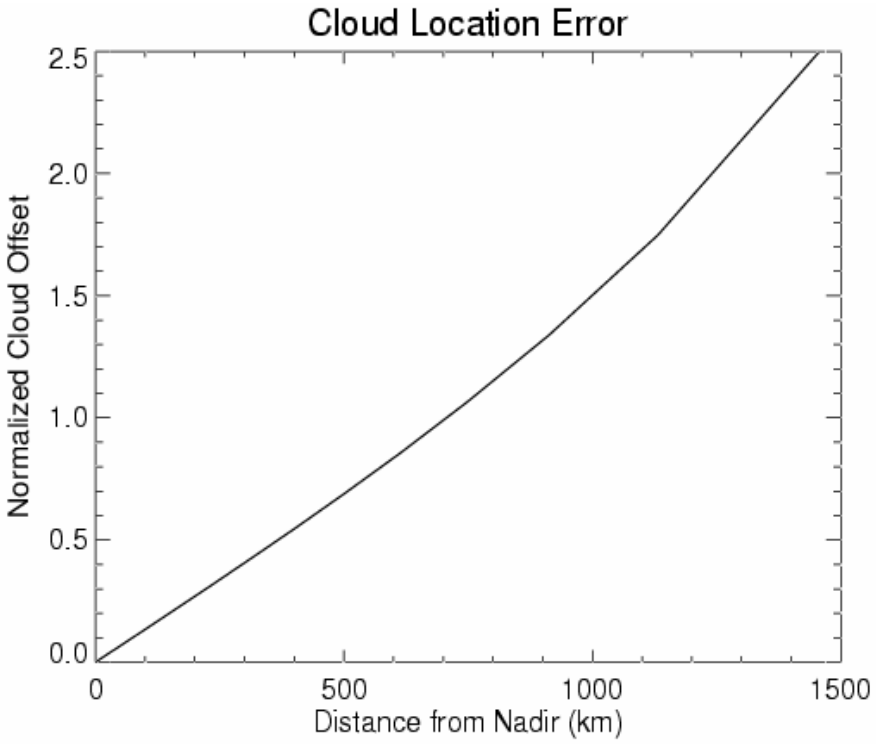


**Figure 2. Error is ground position due to parallax as a function of distance from nadir. This error is expressed as a Normalized Cloud Offset, where 1.0 represents an error in geolocation is the same as the cloud height.**

This correction should not only reduce the error in the wind measurements, but also allow the use of mixed-satellite tracking. The current method uses three successive passes from one satellite, which spans 200 minutes. By tracking on alternating passes of Terra and Aqua, the time interval between passes will be 25 and 75 minutes, for a total of 100 minutes for a triplet. This will also improve the timeliness by 25 or 75 minutes, depending on the combination of Terra, Aqua, Terra or Aqua, Terra, Aqua. For example, in Fig. 3 the central time is 9:54 GMT. Using Terra only, the 3$^{rd}$ image in the triplet is 11:33 GMT, but using Aqua, Terra, Aqua the 3$^{rd}$ image is at 10:19 GMT; a savings of about 75 minutes. But, the geographic coverage will be reduced for each triplet, also seen in Fig. 3.

Modifications were recently made to use the full 12-bit MODIS data for computing radiances and brightness temperatures, instead of a reduced 8-bit data. We expect this increase in precision, and use of the MODIS calibration, to help with cloud height determination, especially with the $H_2O$ intercept and $CO_2$ slicing techniques. Note: $CO_2$ slicing is not being used for the MODIS winds at this time.

Based on the improved results using the GFS model as the background (elsewhere in these proceedings), we will be moving to using the GFS instead of the NOGAPS at CIMSS. This includes using more frequent model runs, shorter forecasts, and time interpolating the grids.

None of these changes are in the production code at this time, but they are all in testing. We expect these changes to be in place this summer for the generation of the CIMSS winds product.

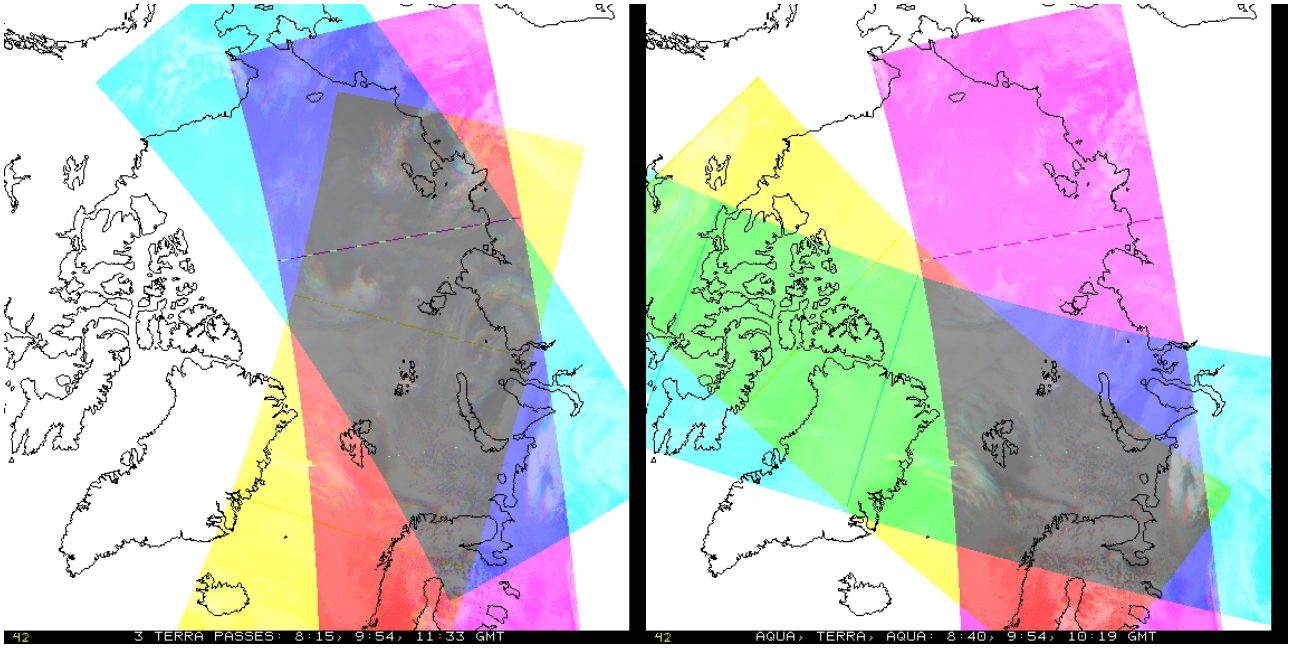


**Figure 3. The left figure is the overlap of three successive Terra passes. The right figure is centered on the time of same Terra pass, with the overlap of time-adjacent Aqua passes.**

## 4. NWP CENTERS

The MODIS-derived winds are currently used by the following NWP centers:

- **European Centre for Medium-Range Weather Forecasts** (ECMWF; Lueder von Bremen and Jean-Noel Thepaut) - Used in the operational model since January 2003.
- **NASA Global Modeling and Assimilation Office** (GMAO; Lars Peter Riishojgaard and Yanqiu Zhu) - Used in operational system.
- **Japan Meteorological Agency** (JMA; Masahiro Kazumori) – Used in operational model since 27 May 2004.
- **UK Met Office** (Mary Forsythe and Howard Berger) – Used in experimental system
- **Canadian Meteorological Centre** (CMC; Real Sarrazin) – Used in experimental system
- **US Navy, Fleet Numerical Meteorology and Oceanography Center** (FNMOC; Pat Pauley and Chuck Skupniewicz ) – Used in experimental system
- **NCEP/EMC** (Jim Jung) – Impact studies begun.
- **Deutscher Wetterdienst** (DWD; Alexander Cress) –Experimenting with real-time winds.

Results and status are reported by some of the centers elsewhere in these proceedings.

## 5. ADDITIONAL SENSORS

We have been producing winds from AVHRR on a daily basis for the last 2 years, but we have not done any statistical comparisons to RAOBS nor have we attempted to run this in near real-time. We will look into this more after the MODIS changes are in place. The use of mixed satellites with a parallax correction will be implemented before evaluating the AVHRR-derived winds.

We have examined one day of deriving winds from the Atmospheric Infrared Sounder (AIRS) sensor on the Aqua satellite (Fig. 4).

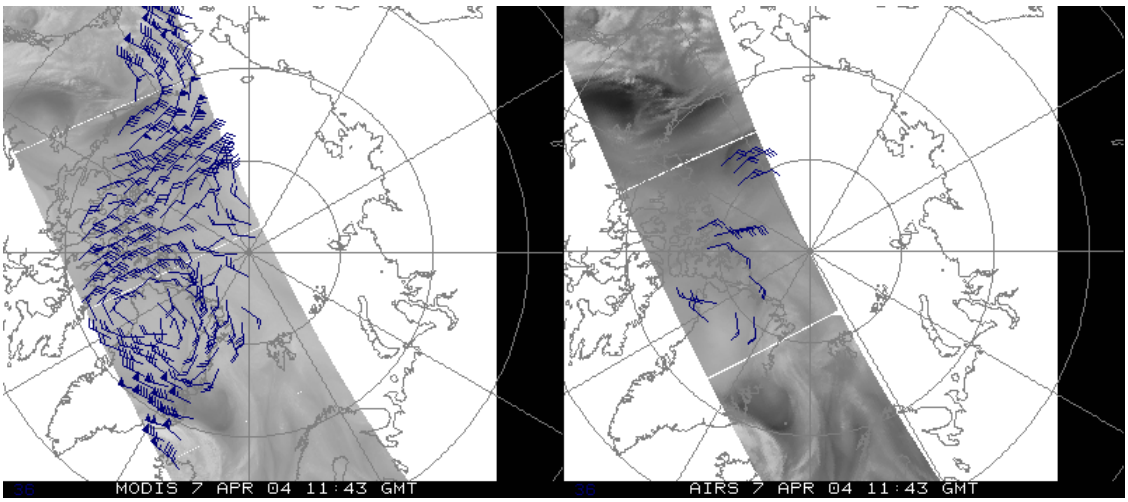


**Figure 4. MODIS winds (left) contrasted with winds derived from AIRS radiance data (right).**

There are two main issues with tracking AIRS radiance data:

1. The resolution is 13 to 20 km per pixel, varying from nadir to the edge of the pass. In this test, the data were remapped to 16 km. This is an 8x reduction in resolution from MODIS. A one-pixel error at 16 km resolution over 100 minutes is nearly a 3 m/s error. The quality control step may have filtered out many winds because of the coarse resolution. This is still being investigated.
2. The AIRS pass is narrower than MODIS; therefore, there is less overlap for the triplets (Fig. 5). This will result in fewer winds (Fig. 4).

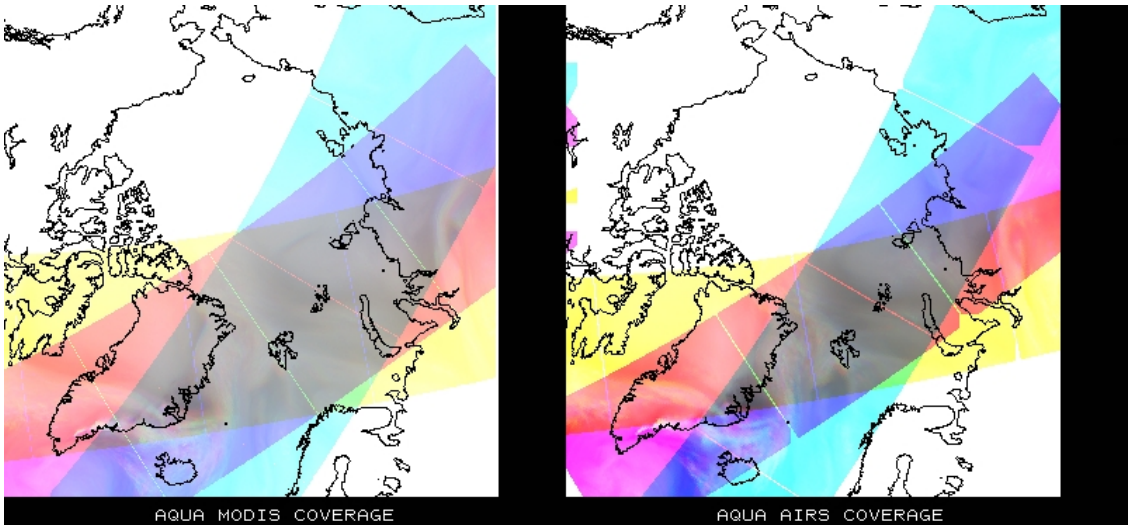


**Figure 5. The left figure is the overlap of three successive Aqua MODIS passes. The right figure are the same passes as viewed by AIRS. The diamond-shaped central regions are where the three passes overlap. Note the reduced area coverage with the AIRS.**

## 6. REFERENCES

Bormann, N., J.-N. Thépaut, 2004. Impact of MODIS Polar Winds in ECMWF's 4DVAR Data Assimilation Sytem. *Mon. Wea. Rev.*, 132, 929-940.

Key, J. R., D. Santek, C. S. Velden, N. Bormann, J.-N. Thépaut, L. P. Riishojgaard, Y. Zhu, and W. P. Menzel, 2003. Cloud-Drift and Water Vapor Winds in the Polar Regions from MODIS. *IEEE Transactions on Geoscience and Remote Sensing*, 41, 482-492.