SATELLITE-DERIVED WINDS AT DIRECT BROADCAST SITES IN THE POLAR REGIONS

Jeffrey R. Key[1], William Straka III[2], David Santek[2], Christopher S. Velden[2], and Randal Pauley[3]

[1]Office of Research and Applications, NOAA/NESDIS
1225 West Dayton Street, Madison, Wisconsin, 53706
[2]Cooperative Institute for Meteorological Satellite Studies, University of Wisconsin-Madison
1225 West Dayton Street, Madison, Wisconsin
[3]Fleet Numerical Meteorology and Oceanography Center
Monterey, California

Abstract

At least eight numerical weather prediction centers worldwide have demonstrated that the Moderate Resolution Imaging Spectroradiometer (MODIS) winds have a positive impact on global weather forecasts, and now assimilate these winds in their operational systems. However, much of the wind information is not available soon enough to be used in early model runs. This is primarily because of the delay in obtaining the MODIS data. Direct broadcast reception sites located in the polar regions provide the opportunity to improve the timeliness of the wind data for numerical weather prediction applications, and to provide local forecasters with real-time products. As of March 2005, polar wind information covering much of Antarctica has been generated with MODIS data received in McMurdo, Antarctica. All the processing is done in McMurdo, and only the wind data are transferred back to mainland U.S. A similar system was implemented at Tromsø, Norway, in February 2006. McMurdo and Tromsø direct broadcast winds are generated about two hours faster than with the bent pipe MODIS data source, and all winds are generated within the 3-hour cutoff commonly used in model assimilation. Comparisons show that direct broadcast and bent pipe winds are of similar quality and quantity. Additional sites are being investigated, particularly Sondankylä, Finland, and Fairbanks, Alaska.

1. INTRODUCTION

Routine production of the Moderate Resolution Imaging Spectroradiometer (MODIS) polar winds began in 2002. The MODIS data are acquired from the National Oceanic and Atmospheric Administration's (NOAA) Real-Time System, or "bent pipe", at NASA's Goddard Space Flight Center Distributed Active Archive Center (Goddard DAAC). Winds are estimated by tracking cloud and water vapor features in the imagery using basically the same methodology as that developed for geostationary satellites. Numerical weather prediction (NWP) centers have demonstrated a positive impact of the MODIS winds on weather forecasts, and now NWP centers in five countries are assimilating the MODIS polar winds in their operational forecast systems.

However, typical delays in acquiring the MODIS data are such that much of the wind information is not available in time to be used in operational production runs of NWP models. To provide the MODIS winds in a more timely manner, the use of direct broadcast (DB) MODIS data is being explored. There are well over 100 DB sites worldwide, some of which are in the polar regions, e.g., Alaska, Norway, Sweden, Finland, Russia, and Antarctica. These sites receive data directly from NASA's Terra and, in some cases, Aqua satellites as they pass overhead.

2. DIRECT BROADCAST IMPLEMENTATION

In early 2005, the U.S. National Science Foundation (NSF) installed a dual-band (X and L) satellite antenna at McMurdo, Antarctica, for the purpose of utilizing Terra and Aqua direct broadcast data for flight forecasting and field operations, weather prediction, sea ice research, cloud physics, ship operations in sea ice, and ocean color, chlorophyll and primary production monitoring. This provided the capability needed to test a direct broadcast MODIS winds system. The existing MODIS winds software was adapted to the direct broadcast environment, and programs were added to handle low-level processing of the MODIS data and to generate additional products. Since March 2005 polar wind data covering much of Antarctica have been generated in real-time. Because of limited communications capabilities to/from the Antarctic continent, all the processing is done in McMurdo, and only the wind data and plots are transferred back to the Cooperative Institute for Meteorological Satellite Studies (CIMSS) in Madison, Wisconsin. An example of the product is shown in Figure 1.

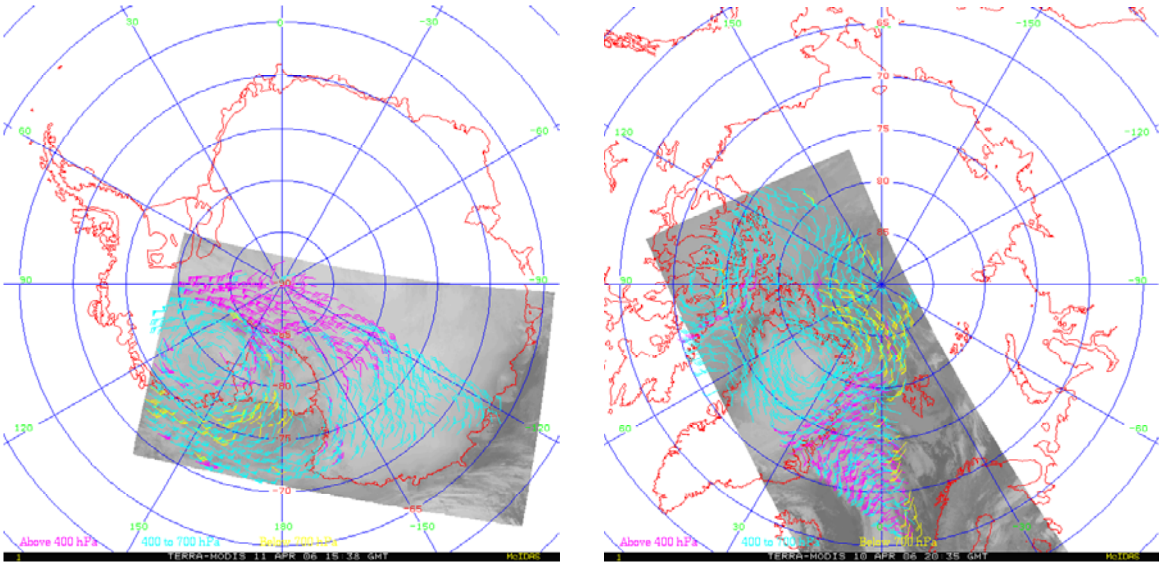

Figure 1: Example of MODIS winds generated at McMurdo, Antarctica (left) and Tromsø, Norway (right).

In February 2006, a similar system was implemented at Tromsø, Norway, using the U.S. Integrated Program Office's (IPO) antenna on Svalbard. Kongsberg Satellite Services (Ksat) operates the IPO antenna and houses the MODIS winds system. An example of the Tromsø (Svalbard) winds is shown in Figure 1.

Is there a time savings for the direct broadcast implementations of the MODIS winds? Figure 2 shows the MODIS data acquisition times over a 10-day period for the bent-pipe and DB data sources. Data acquisition times refer to the difference between the MODIS image time and the time when Level-1B calibrated and geolocated data are available on the wind processing computer. For the bent-pipe winds, processing to Level-1B is done at the DAAC. For the McMurdo winds, processing to Level-1B is done on the winds system. The figure shows that the bent-pipe MODIS data are typically available 100 or more minutes after the image time. For McMurdo, data are available in 15-30 minutes. For Tromsø (not shown), data are available in 20-40 minutes. Therefore, the DB data are available for wind generation at least one hour sooner than the bent-pipe data, and often 2 or more hours sooner.

This translates into a time savings for the overall wind processing, as shown in Figure 3. Processing times are for the middle image in a 3-orbit triplet. Actually processing time from image acquisition to availability of wind vectors is 100 minutes (1.67 hrs) less than shown. At McMurdo and Tromsø (not shown), winds are available in a little over two hours. The bent-pipe winds are typically available in 3-4 hours, or one or more hours more than the DB winds.

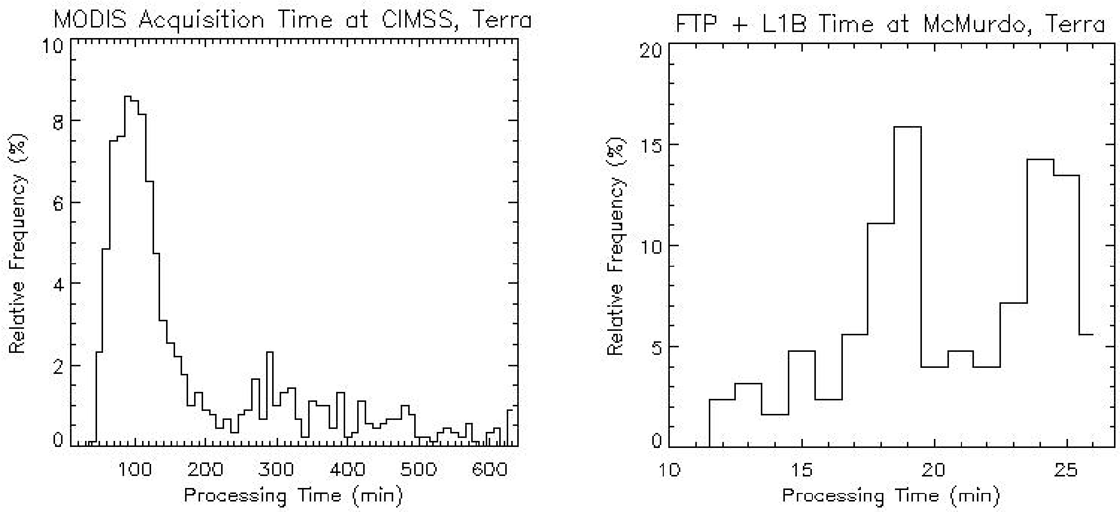

Figure 2: MODIS data acquisition times over a 10-day period for the bent-pipe data source (left) and the direct broadcast data at McMurdo (right). Data acquisition here refers to the time it takes to obtain Level-1B calibrated and geolocated data on the wind processing computer. Note the difference in horizontal scales.

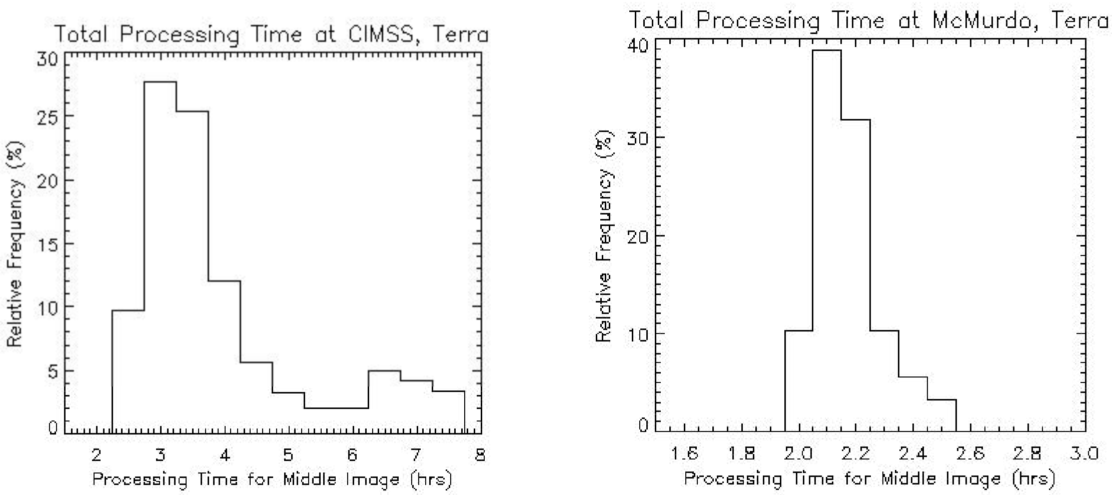

Figure 3: Total wind processing time over a 10-day period for the bent-pipe data source (left) and the direct broadcast data at McMurdo (right). Processing times are for the middle image in a 3-orbit triplet. Actually processing time from image acquisition to availability of wind vectors is 100 minutes (1.67 hrs) less than shown. Note the difference in horizontal scales.

3. MODEL USE

After nearly a year of testing and validation, the McMurdo DB winds are being made available to the NWP community. In addition to being posted on a public FTP site, the wind data are "pushed" to the Fleet Numerical Meteorology and Oceangraphy Center (FNMOC) for use in NOGAPS (Navy Operational Global Atmospheric Prediction System). Operational assimilation of McMurdo DB winds into NOGAPS began on 15 March 2006. NAVDAS (NRL Atmospheric Variational Data Assimilation System), the analysis component of NOGAPS, employs superobbing of MODIS winds. The McMurdo direct broadcast winds are superobbed together with the previously operational bent-pipe MODIS winds. Observation versus model background statistics for the DB winds in NAVDAS appear comparable to the bent-pipe winds. Figure 4 illustrates the data availability for the preliminary ("early") NOGAPS model run of 12Z 12 April 2006. The early run has a data cutoff of 1 hour and 10 minutes;the main run has a cutoff of 3 hours and 10 minutes. In this instance only DB winds were available for the early run. Receipt times vary from day to day and few bent-pipe winds are sometimes available for the early run. For the main run, both data sources are important, but the DB winds usually improve the coverage considerably.

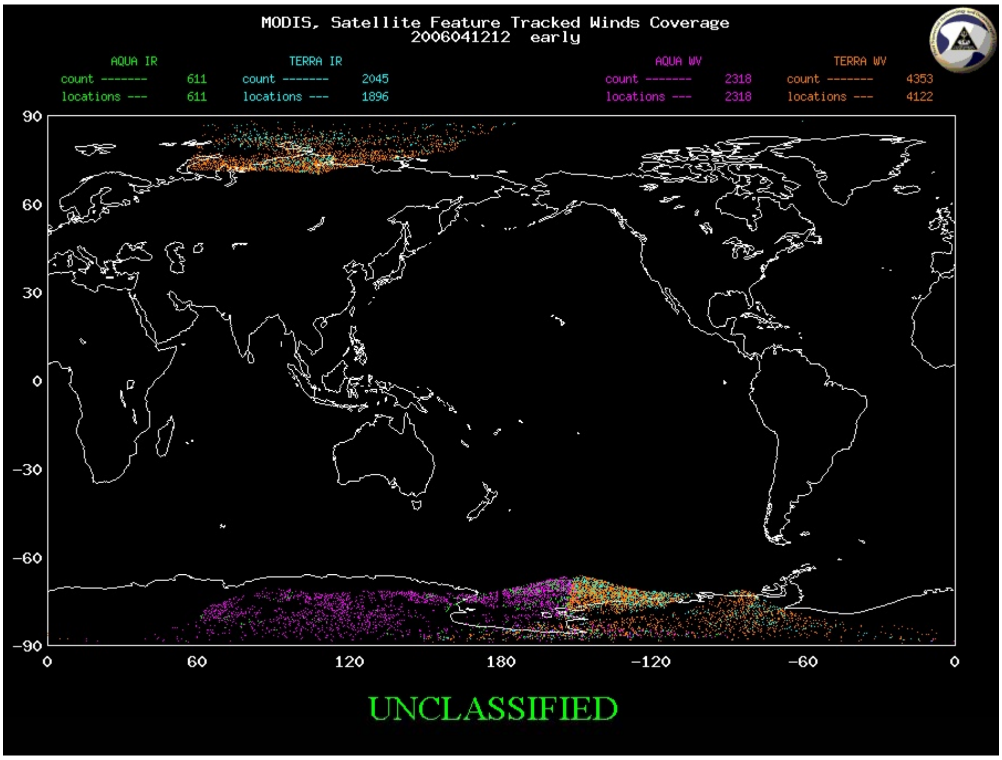

Figure 4: MODIS winds available for the preliminary ("early") NOGAPS model run of 12Z 12 April 2006. The McMurdo and Tromsø direct broadcast and bent-pipe wind data sources are included, though only the direct broadcast winds were available in time for the early data cutoff in this instance.

4. CONCLUSIONS AND RECOMMENDATIONS

With the early success of the McMurdo and Tromsø systems, additional sites in the Arctic and Antarctic are being explored. Another system is being configured for Sodankylä, Finland, and discussions are underway for systems in Fairbanks, Alaska, and Troll, Antarctica (Norway).

The MODIS direct broadcast processing system was also designed to provide information to local forecasters. Wind, cloud and surface products are useful for local forecasts that affect flight operations and field experiments. So in addition to winds, the McMurdo system generates a cloud mask, cloud thermodynamic phase and height, low-level temperature inversion strength and depth, and ice surface temperature and albedo. Additional snow and ice products will be added later this year. More information on the direct broadcast winds and other products is available at http://stratus.ssec.wisc.edu/products/db.

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