VIIRS - A Better Look at Polar Winds

The Visible Infrared Imager Radiometer Suite (VIIRS) onboard NASA's newest Earth-observing satellite, Suomi NPP, acquired its first measurements on 21 November 2011, and is already providing a bridge between previous satellite technologies and those to come.

Fully automated cloud-drift wind production from Geostationary Orbital Environmental Satellites (GOES) became operational in 1996. The resulting wind vectors are routinely used in operational numerical models of the National Centers for Environmental Prediction (NCEP) and other numerical weather prediction centers.

Since 2001, wind products from over the polar regions have been generated at CIMSS with Moderate Resolution Imaging Spectroradiometer (MODIS) instruments on NASA's Terra and Aqua satellites and the Advanced Very High Resolution Radiometer (AVHRR) on NOAA and Metop satellites. These same products have been produced operationally by the National Environmental Satellite, Data, and Information Service (NESDIS) using MODIS since 2005, and since 2007 using AVHRR. A timeline of polar wind product development is shown in Figure 1.

Real-time generation of polar winds products from Terra and Aqua MODIS and AVHRR on NOAA-15 through -19 and Metop-A continues, but since the launch of the Suomi National Polar-orbiting Partnership (Suomi NPP) on 28 October 2011, a new focus is on developing a method to generate winds from the Visible Infrared Imaging Radiometer Suite (VIIRS) instrument on board the new satellite.

Unique Characteristics of VIIRS

VIIRS is a 22-band imaging radiometer that, in terms of features, is a cross between MODIS and AVHRR, with some characteristics of the Operational Linescan System (OLS) on Defense Meteorological Satellite Program (DMSP) satellites. It has several unique characteristics that will have an impact on a VIIRS polar winds product. These include:

- a wider swath,
- higher spatial resolution (750 m for most bands; 375 m for some),
- constrained pixel growth that yields better resolution at the edge of swath, and
- a day-night band (DNB).

VIIRS has a wider swath (3000 km) than MODIS (2320 km), so the coverage is better. The AVHRR swath width is between that of VIIRS and MODIS (2600 km). A wider swath means more winds with each orbit triplet. Figure 2 shows the overlap of three orbits, which are needed for wind derivation, for MODIS and VIIRS. The figure illustrates the improved coverage of VIIRS, with a larger area of overlap. Consecutive VIIRS swaths overlap even near the equator, so the area for which polar winds can be derived extends somewhat further south than for MODIS.

The VIIRS method of aggregating detectors and deleting portions of the scans near the swath edge results in smaller pixels (higher spatial resolution) at large scan angles. Additionally, VIIRS scan processing reduces the bow-tie effect. The impact of these on a wind product is that tracking features will be better defined, resulting in more good winds toward the edges of the swath.

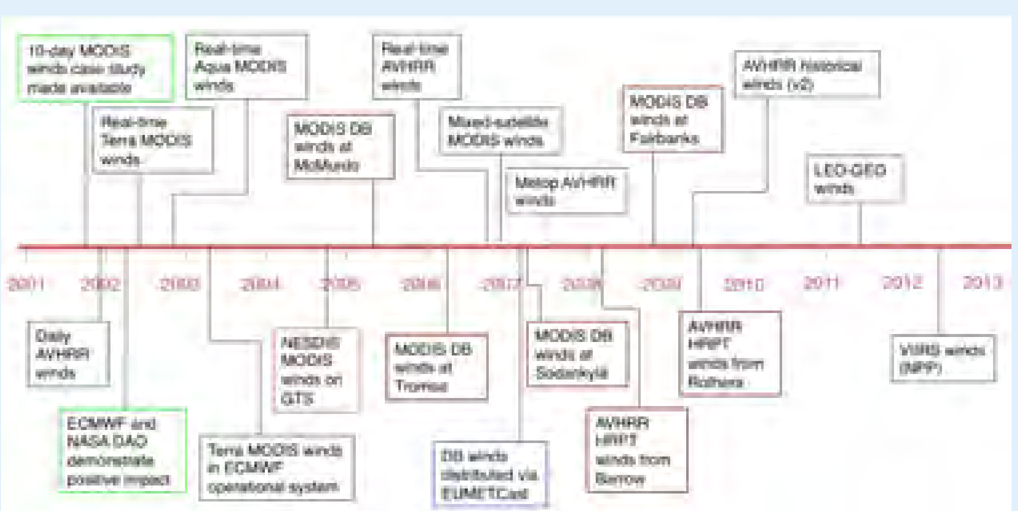

Figure 1. The polar winds product history, from 2001 to the present.

One disadvantage of VIIRS is that, unlike MODIS but similar to AVHRR, it does not have a thermal water vapor band. Therefore, no clear-sky winds can be retrieved.

The VIIRS day/night band offers an intriguing possibility for wind retrieval during the long polar night (winter). Visible information exists at night, but requires highly sensitive instrumentation to measure it. Satellite-based low light detection was pioneered by the OLS, which has flown continuously on the DMSP platforms since 1967. The winds algorithm will be used to track clouds illuminated only by moonlight.

GOES-R ABI and VIIRS Algorithm

VIIRS polar winds processing will utilize the new GOES-R Advanced Baseline Imager (ABI) atmospheric motion vector (AMV) algorithm. Unique features of the ABI wind retrieval methodology include:

Feature Tracking

The Sum-of-Squared Differences (SS) method is used in conjunction with a "nested tracking" algorithm. This combination is very effective at capturing the dominant motion in each target scene and to track the feature backward and forward in time.

Target Height Assignment

Externally generated cloud heights are used. This approach leverages experience and expertise of those involved in cloud property retrievals. It also takes advantage of pixel-level cloud heights contained within a target scene that offer the best opportunity to assign the most representative heights to targets being tracked in time and contain diagnostic performance metrics. It offers potential for future enhancements to target height assignment algorithms.

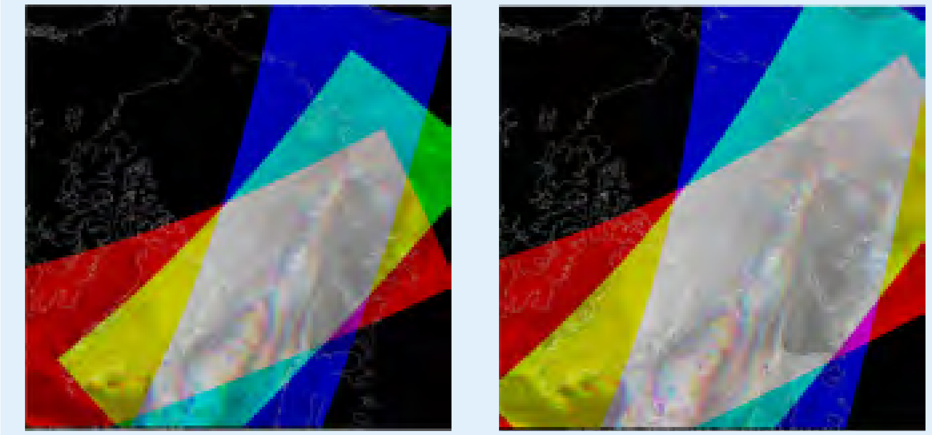

Figure 2. The gray region represents the overlap in three orbits where the polar winds are derived for MODIS (left) and VIIRS (right).

The first polar winds case study generated using the ABI algorithm with MODIS data is shown in Figure 3.

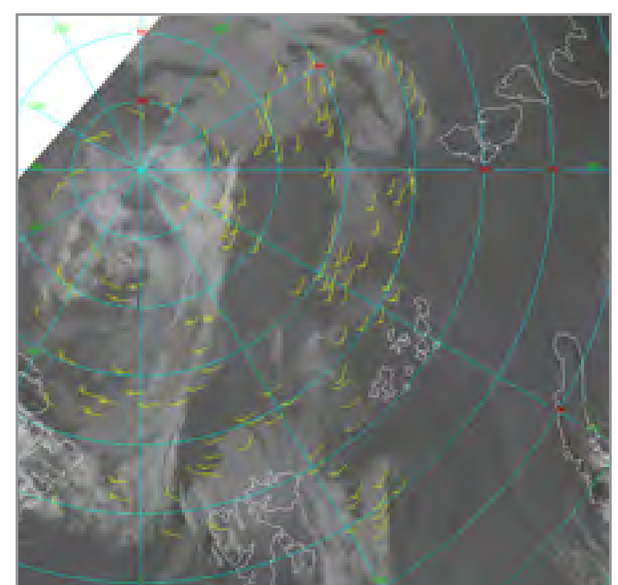

Figure 3. Polar winds based on MODIS data using the VIIRS/ABI processing system.

Use of Polar Winds in NWP

Work continues with numerical weather prediction (NWP) centers regarding product quality, use, and future enhancements. At present, MODIS and AVHRR polar wind products are used operationally by 13 NWP centers in nine countries:

- European Centre for Medium-Range Weather Forecasts (ECMWF),
- NASA Global Modeling and Assimilation Office (GMAO),
- Japan Meteorological Agency (JMA), Arctic only,
- Canadian Meteorological Centre (CMC),
- US Navy, Fleet Numerical Meteorology and Oceanography Center (FNMOC),
- (UK) Met Office,
- Deutscher Wetterdienst (DWD)
- National Centers for Environmental Prediction (NCEP/EMC),
- Meteo France,
- Australian Bureau of Meteorology (BoM),
- National Center for Atmospheric Research (NCAR, USA),
- China Meteorological Administration (CMA), and
- Hydrological and Meteorological Centre of Russia (Hydrometcenter).

The VIIRS polar winds product is scheduled to be operational in NESDIS in October 2012. It is expected that many of these centers will include the VIIRS winds in their operational systems.

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