The Polar Wind Product Suite

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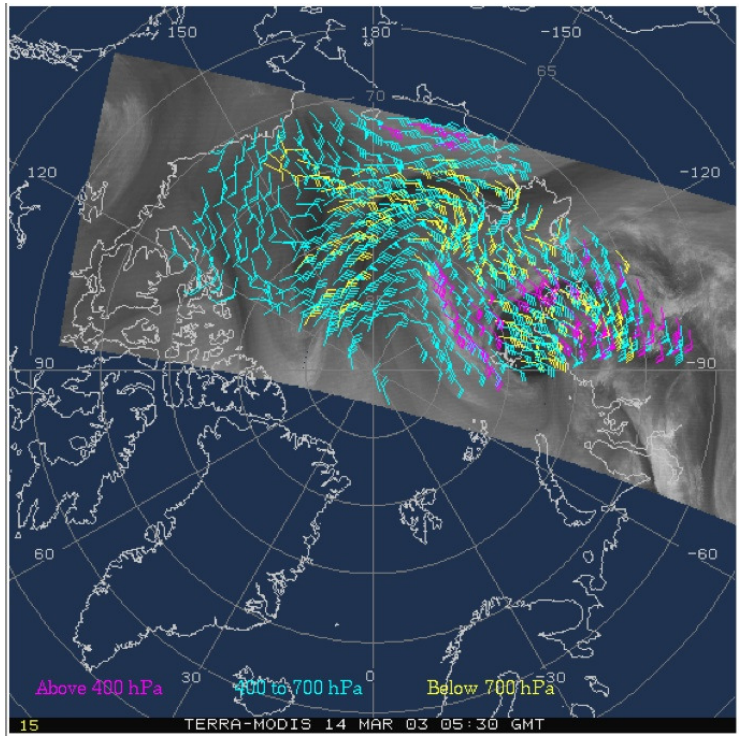
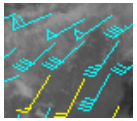


10th International Winds Workshop, Tokyo, 22-26 February 2010



The Polar Wind Product Suite

MODIS Polar Winds

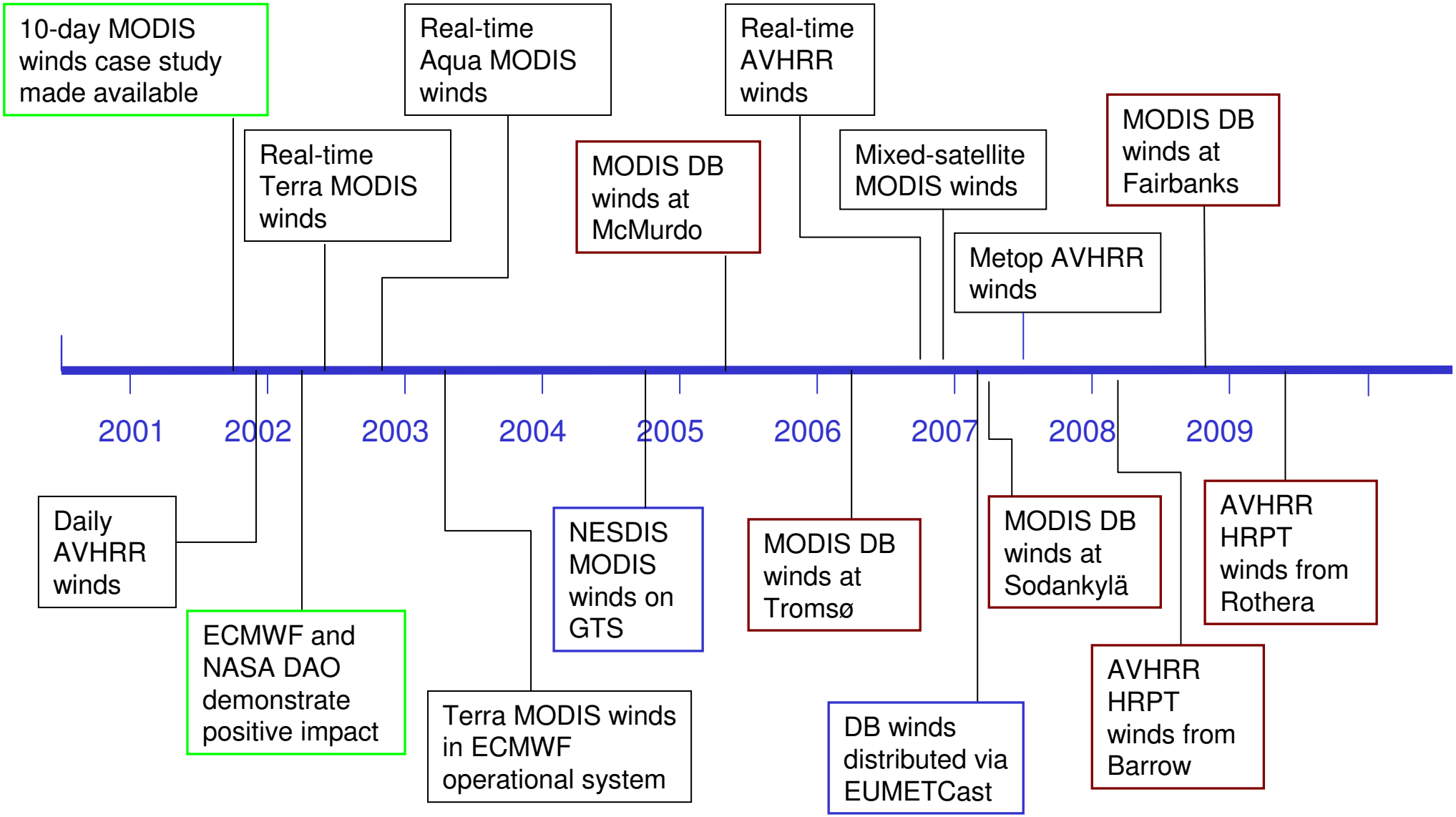
- Aqua and Terra separately, bent pipe data source Operational
- Aqua and Terra combined, bent pipe
- Direct broadcast (DB) at
  - McMurdo, Antarctica (Terra and Aqua separately)
  - Tromsø, Norway, antenna on Svalbard (Terra only)
  - Sodankylä, Finland (Terra only)
  - Fairbanks, Alaska (Terra, from UAF, is reliable; Aqua is not)

AVHRR Polar Winds

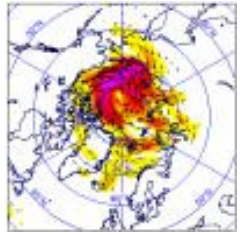
- Global Area Coverage (GAC) for NOAA-15, -16, -17, -18, -19 Operational
- Metop Operational
- HRPT (High Resolution Picture Transmission = direct readout) at
  - Barrow, Alaska, NOAA-16, -17, -18, -19
  - Rothera, Antarctica, NOAA-17, -18, -19
- Historical GAC winds, 1982-2009. Two satellites throughout most of the time series.

Note: Red items are new since IWW9 (April 2008).

Polar Wind Product History



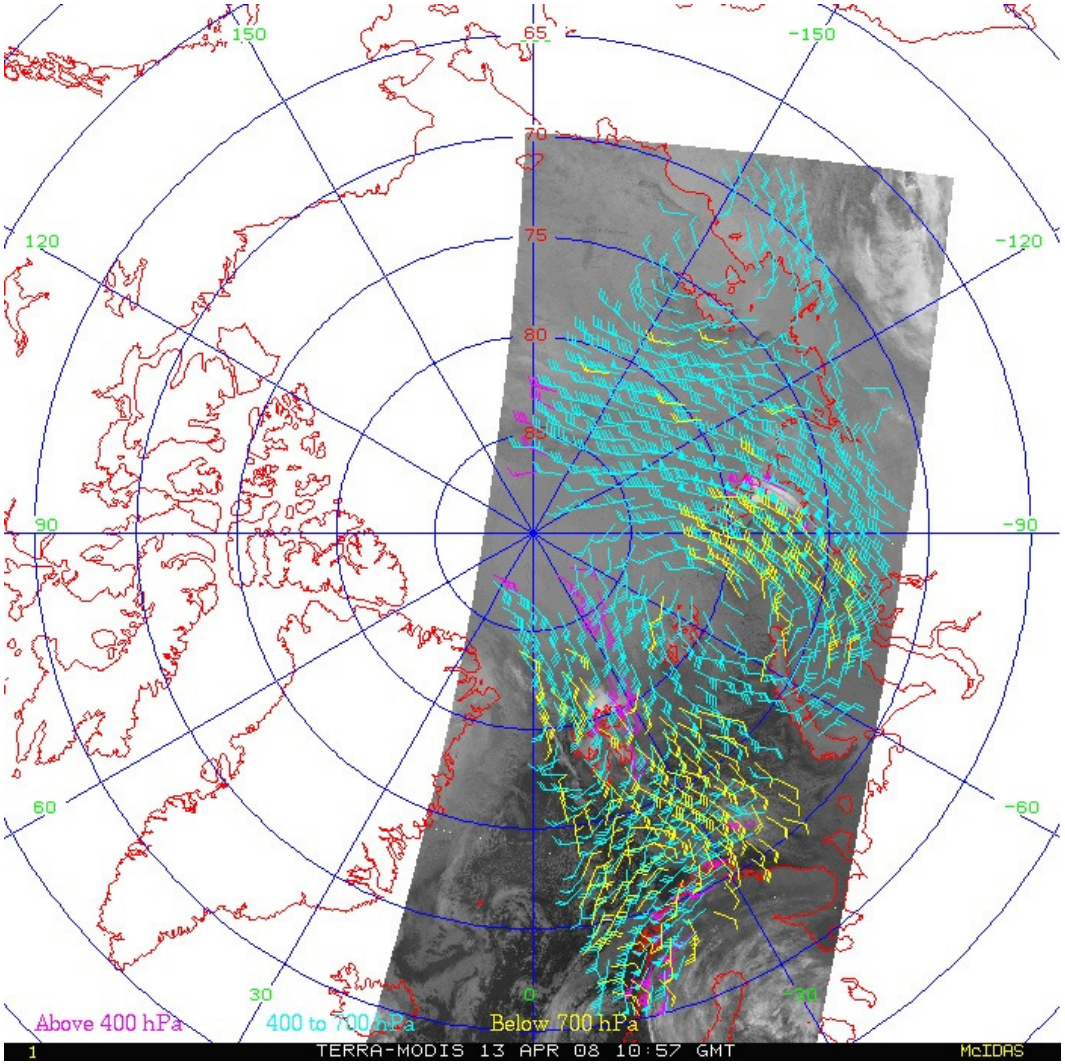
MODIS Winds in NWP



Current <u>Operational</u> Users:

- European Centre for Medium-Range Weather Forecasts (ECMWF) - since Jan 2003.
- NASA Global Modeling and Assimilation Office (GMAO) - since early 2003.
- Deutscher Wetterdienst (DWD) – MODIS since Nov 2003. DB and AVHRR.
- Japan Meteorological Agency (JMA), Arctic only - since May 2004.
- Canadian Meteorological Centre (CMC) – since Sep 2004. DB winds since Mar 2009.
- US Navy, Fleet Numerical Meteorology and Oceanography Center (FNMOC) –since Oct 2004. DB winds since Apr 2006. AVHRR GAC and Metop since Nov 2007.
- UK Met Office – MODIS since Feb 2005. DB since Feb 2009. AVHRR GAC since May 2008.
- National Centers for Environmental Prediction (NCEP) and the Joint Center for Satellite Data Assimilation - since Nov 2005.
- MeteoFrance - since Jun 2006.
- National Center for Atmospheric Research (NCAR), Antarctic Mesoscale Model (AMPS) - since Oct 2006.
- Australian Bureau of Meteorology – since late 2007

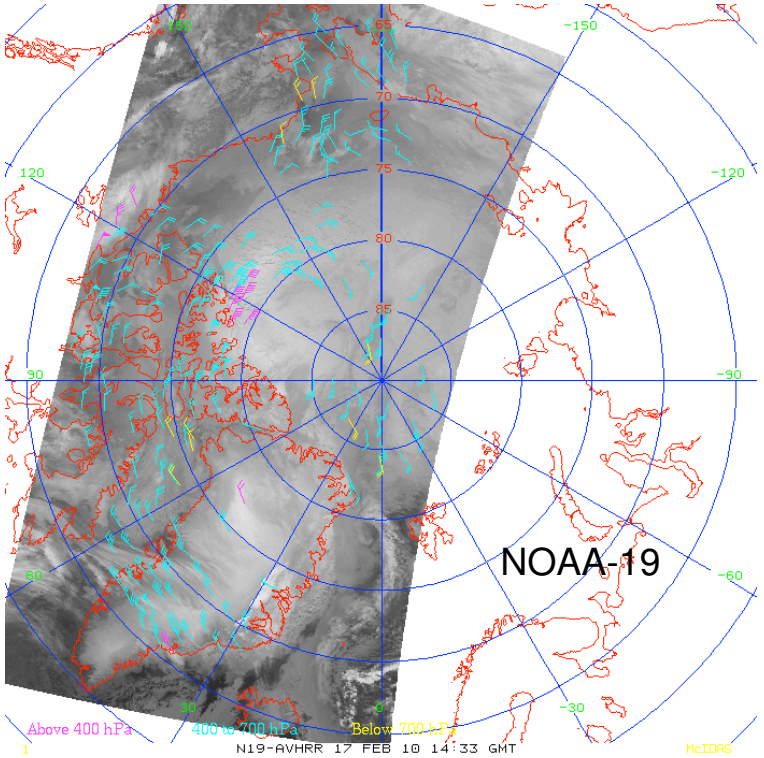
MODIS Winds: Single Satellite

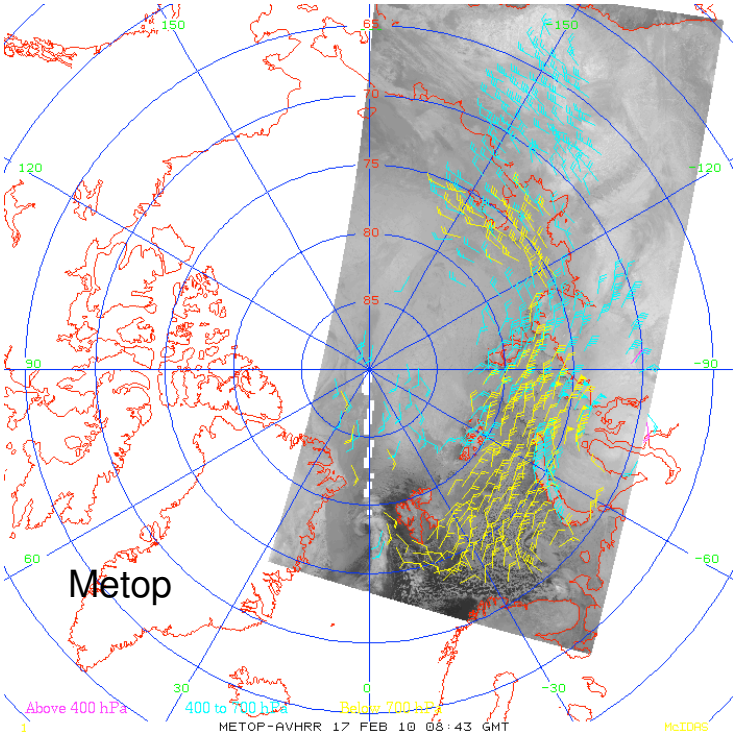


- Aqua and Terra winds are generated separately
- Data from the NOAA Real-Time System (aka “bent pipe”), composites of two or three 5-min granules.
- 1 km MODIS product (MOD021KM) is remapped to 2 km
- Cloud-track and water vapor winds
- NCEP’s GFS is used as the background
- Pros: Complete polar coverage
- Cons: Some MODIS granules arrive (very) late

AVHRR GAC and Metop Winds

- Six satellites: NOAA-15, -16, -17, -18, -19, and Metop
- 4 km for GAC; 2 km for Metop
- Cloud-track winds
- NCEP's GFS is used as the background.



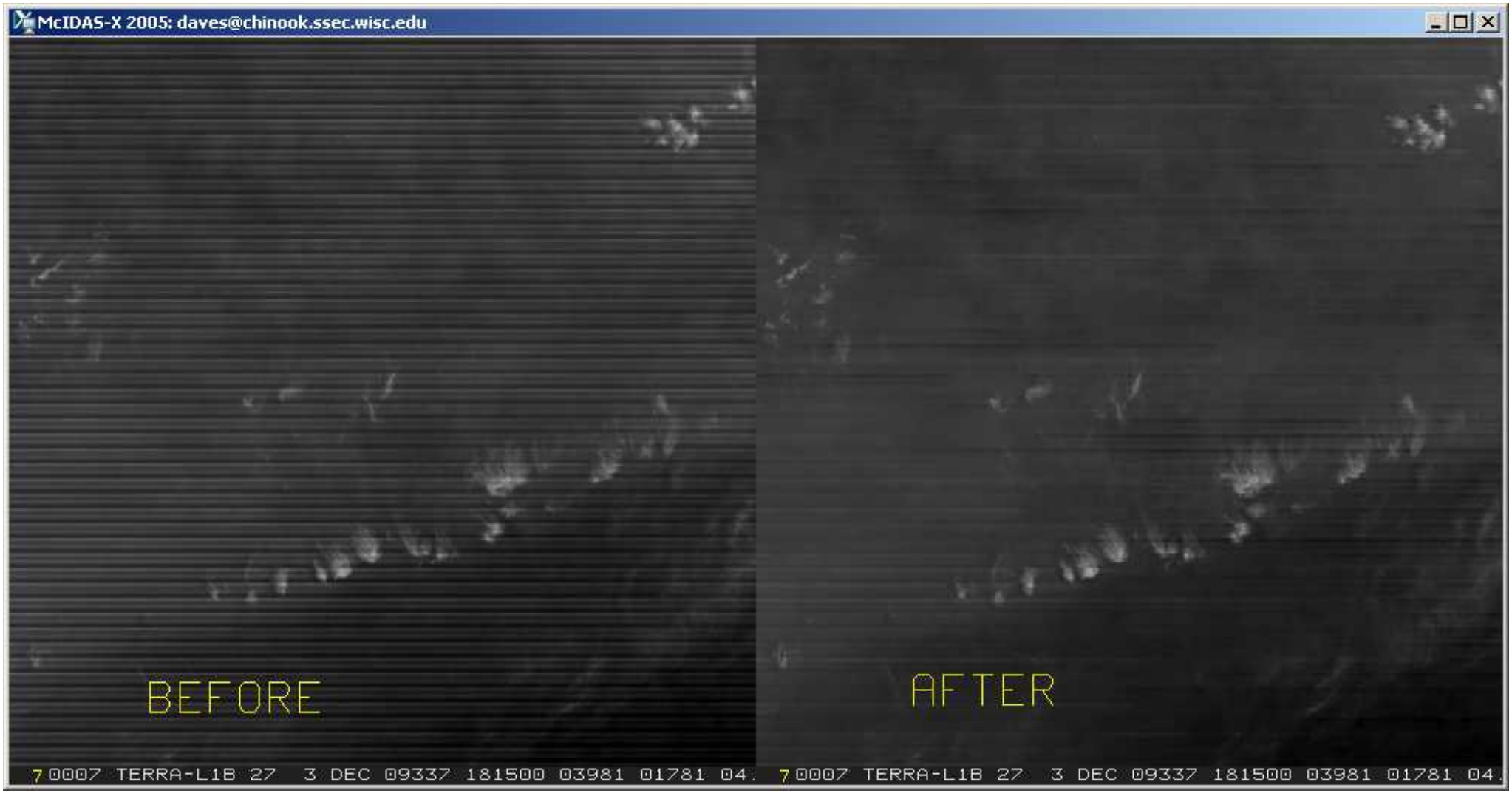


- Pros: Complete polar coverage; excellent temporal sampling with all satellites. Good preparation for NPOESS VIIRS.
- Cons: No water vapor clear winds (no clear sky). Lower spatial resolution (GAC) yields fewer vectors. Height assignment uncertainty for thin clouds.

Recent Updates

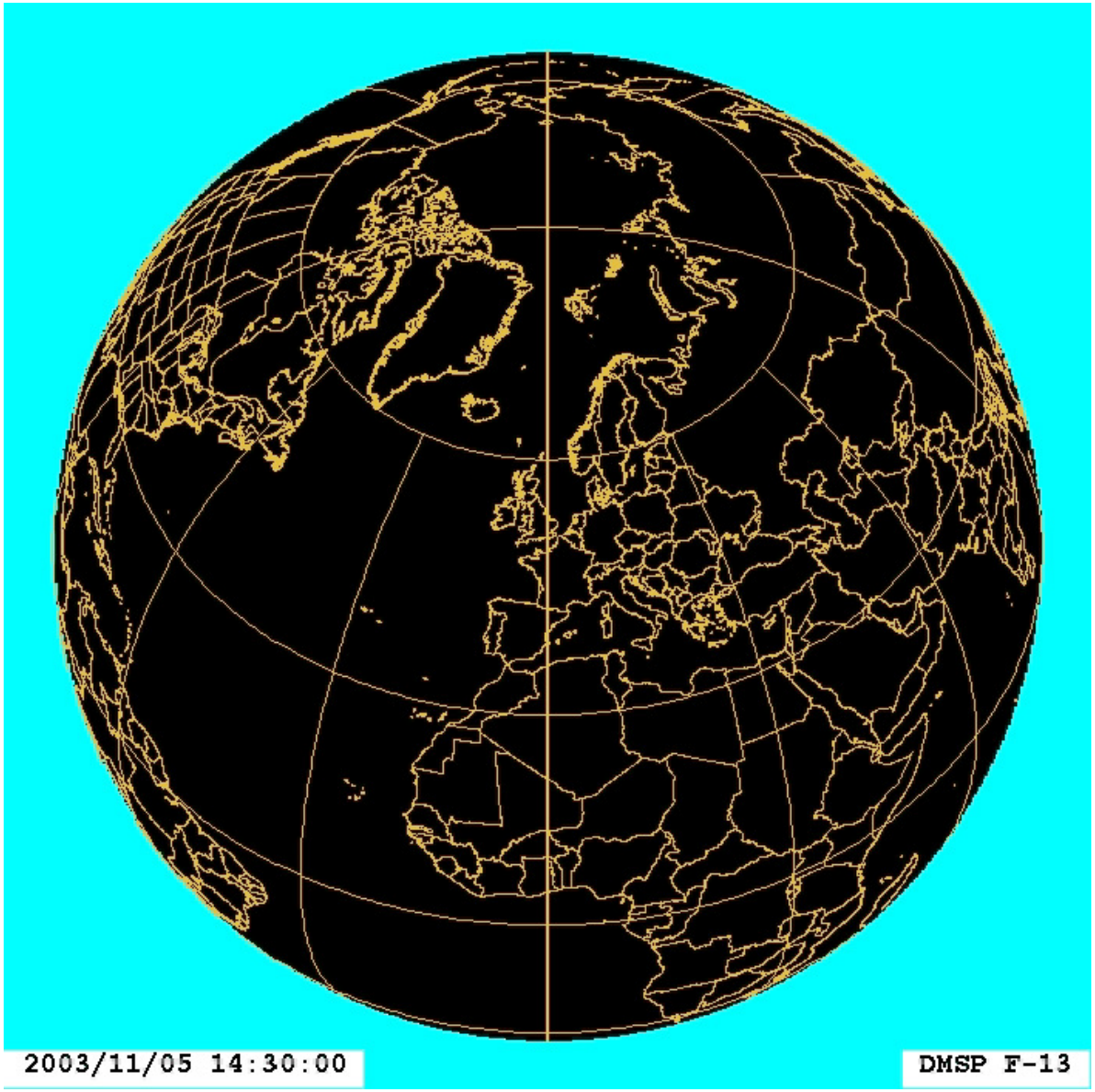
- The **surface pressure and elevation** are now used. The impact is minimal.
- **Parallax correction** (not in ops). Result for mixed satellite winds: slight improvements in the quality with parallax correction; largest improvements at high levels (above 400mb) and decreasing to no improvement at low (below 700mb) levels.
- MODIS **destriping** code updated at DB sites. Bent pipe wind destriping is pending.
- A couple of bug fixes (e.g., QI).
- **BUFR changes**:
  - The QI with and without the forecast are both available.
  - The originating center code has changed
- ***Per-pixel time*** *information is being tested*. (More about this later.)

MODIS Destriping, WV Band



Issue: How to improve coverage

Coverage of multiple polar-orbiting satellites is extensive

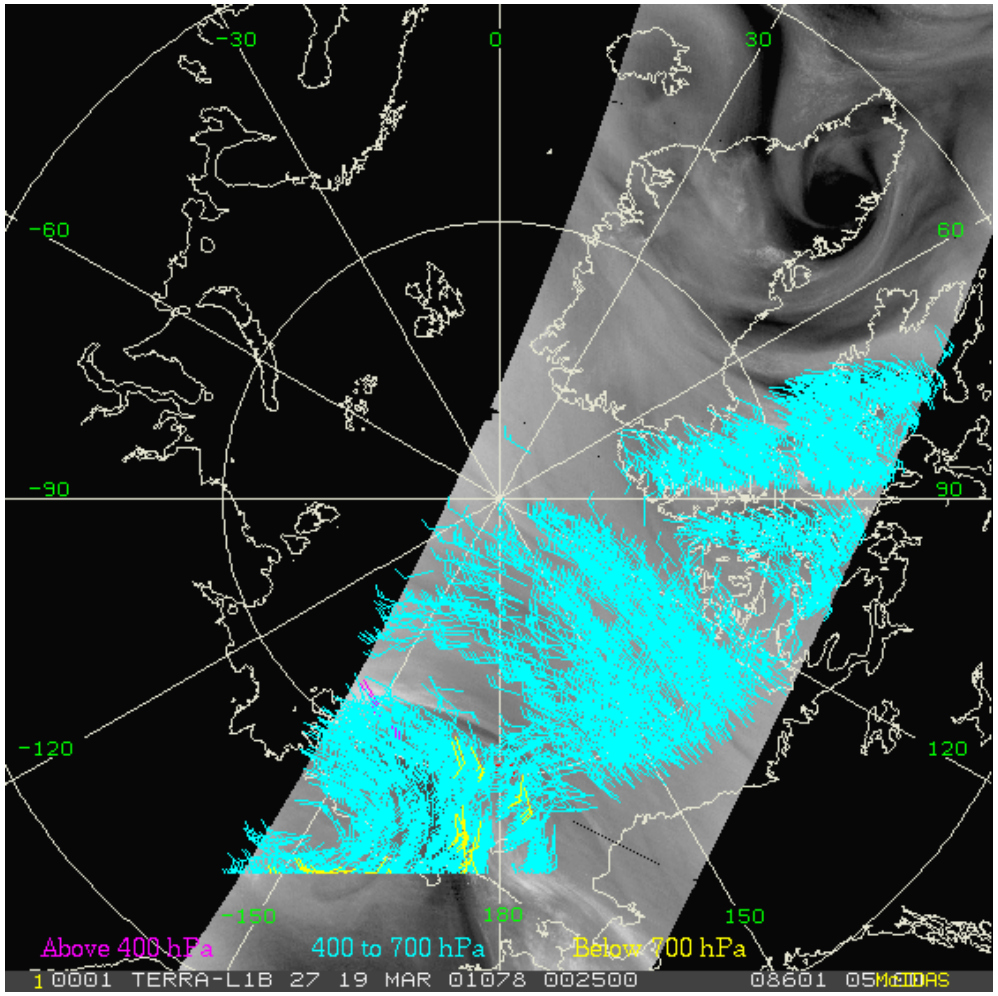


(animation)

However, combining multiple satellites into a single data stream can be complicated because of parallax and timing. (*Courtesy of J. Purdom*)

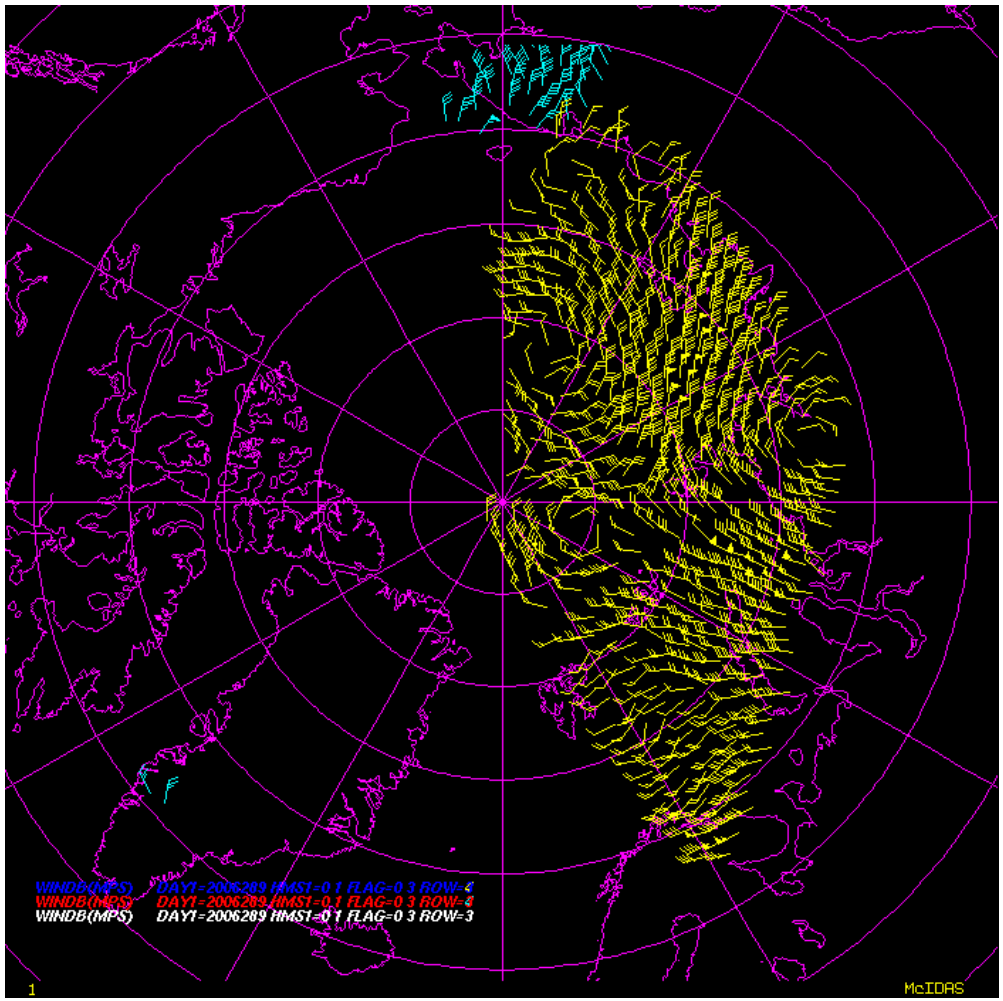
24 hr Wind Coverage, One and Two Satellites

Terra only, one day, all orbits



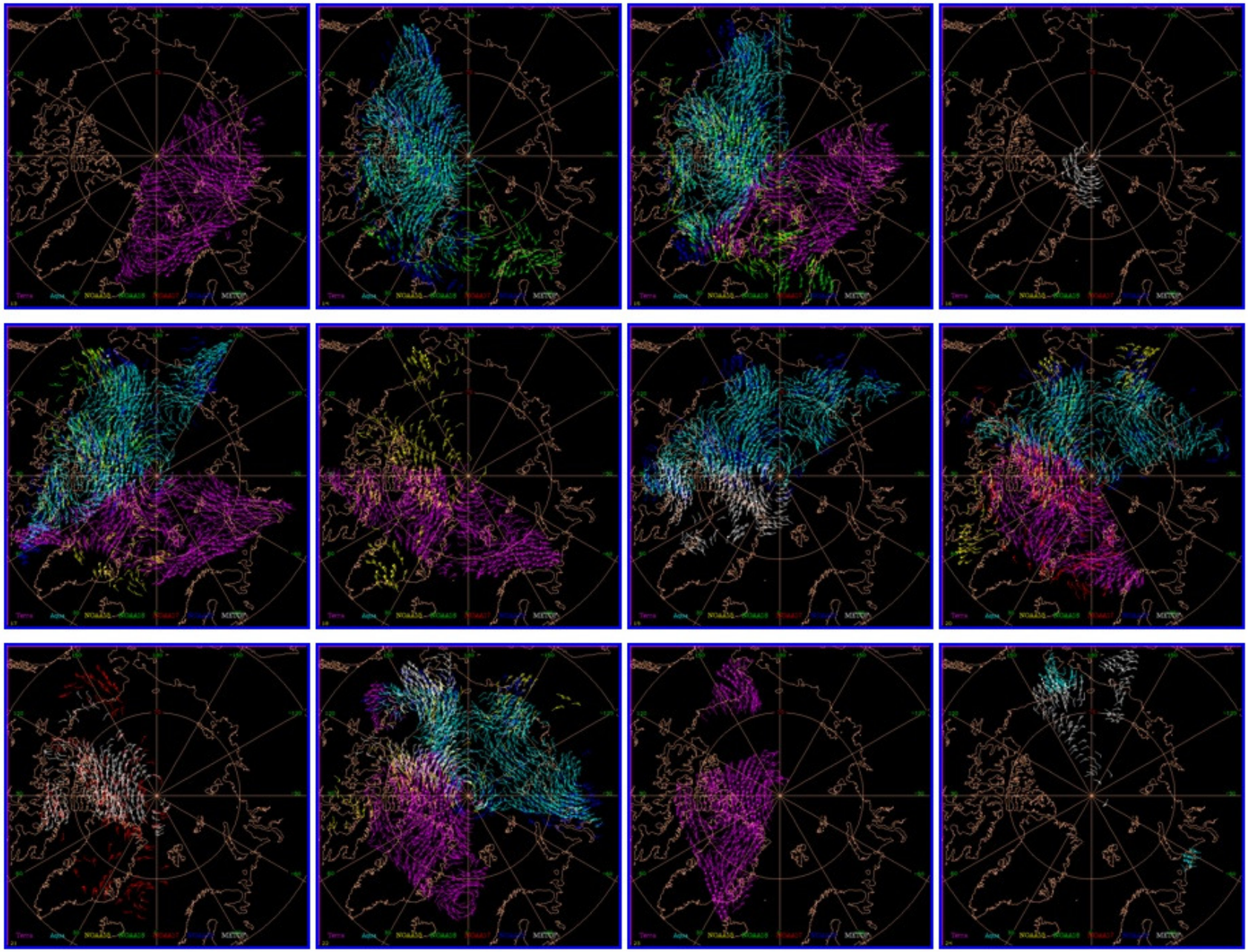
(animation)

Terra and Aqua (separately), hourly



(animation)

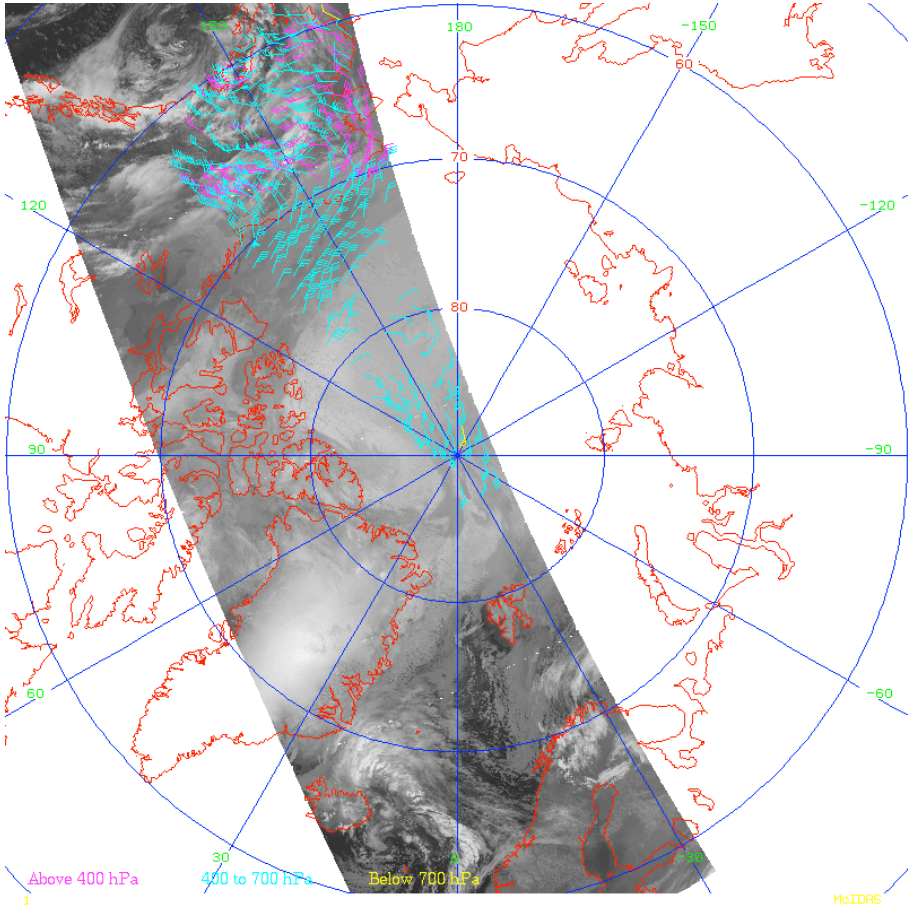
Hourly Wind Coverage, Seven Satellites: Hours 12-23



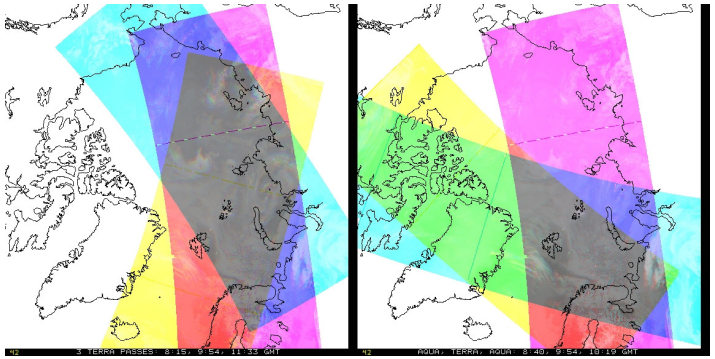
magenta: Terra, cyan: Aqua, yellow: N15, green: N16, red: N17, dark blue: N18, white: Metop

(*A potential solution to the coverage issue in talk by L. Garand*)

MODIS Winds: Mixed Satellite (Aqua and Terra)



Terra only

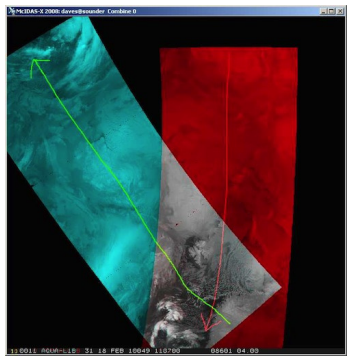


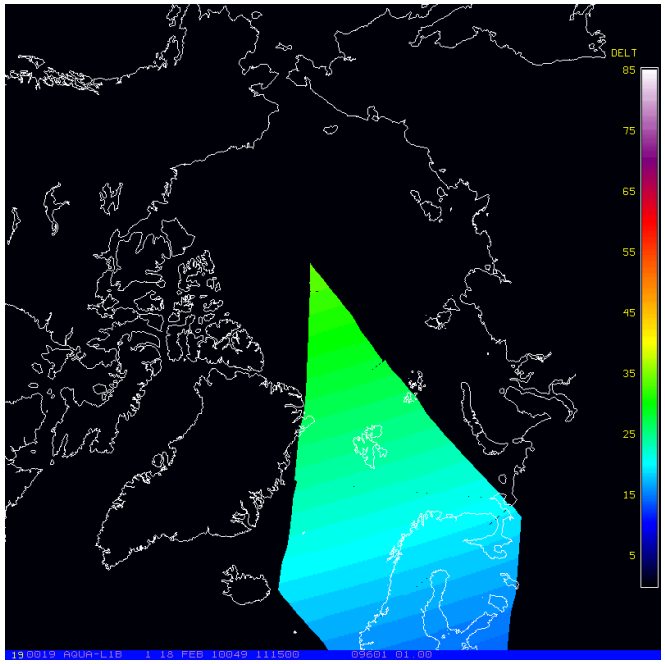
Aqua, Terra, Aqua

- Aqua and Terra data streams combined. Could be A-T-A, T-A-T, T-T-A, etc.
- 1 km MODIS product (MOD021KM) remapped to 2 km
- Cloud-track and water vapor winds
- NCEP's GFS is used as the background.
- Statistics are nearly identical to single-satellite MODIS winds.
- Pros: Complete polar coverage; lower latency (100 min rather than 200 for a triplet); somewhat lower latitude coverage (poleward of 65^{o} or less).
- Cons: Smaller area of overlap so fewer vectors each pass. Parallax correction and per-pixel times are necessary.

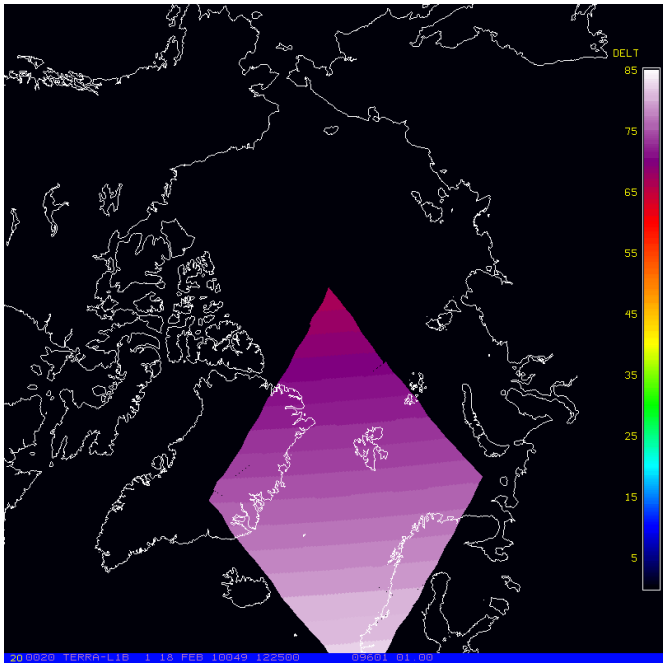
Combining satellites into a single stream

Time difference for first pair (T-A): 14-33 min



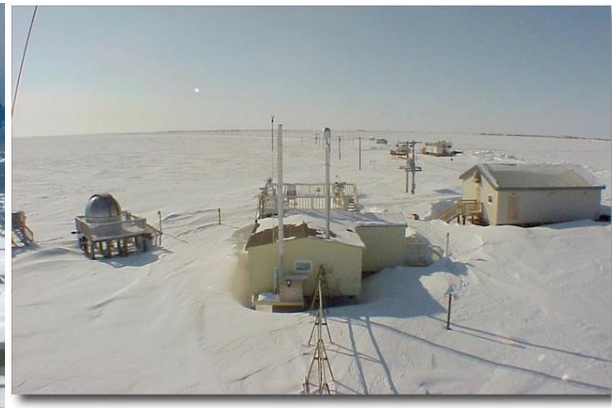


Time difference for second pair (A-T): 67-82 min



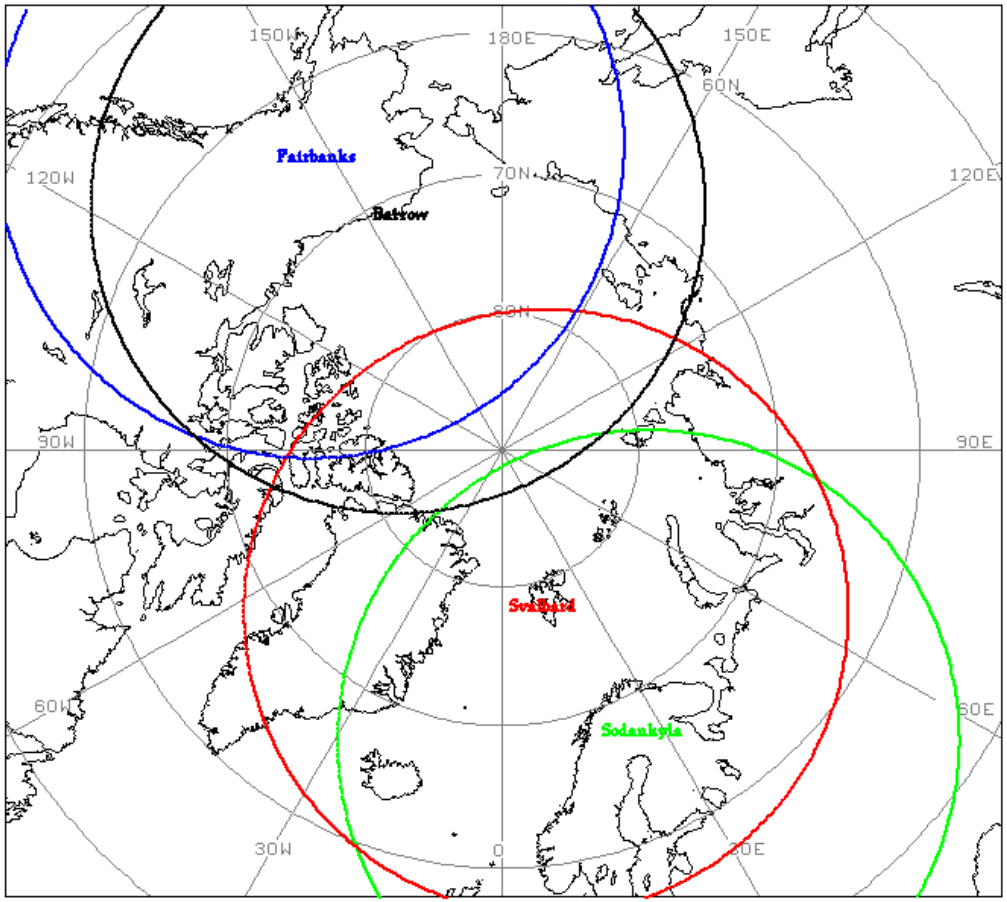
- For a Terra-Aqua-Terra sequence, there is a 30 min pole crossing time difference for the first pair (T-A), and a 70 min difference for the second pair (A-T).
- Terra and Aqua cross the pole from different directions, so the time difference changes as a function of latitude.
- Impact: For the first pair, if a constant time difference of 30 min is used, wind speeds can be off by up to a factor of 2. For the second pair, if we use a 70 min difference, the error is up to 17%.
- The time used affects the number of wind vectors and, to a lesser degree, the overall accuracy. (*More on this in talk by R. Dworak*)

DB Sites

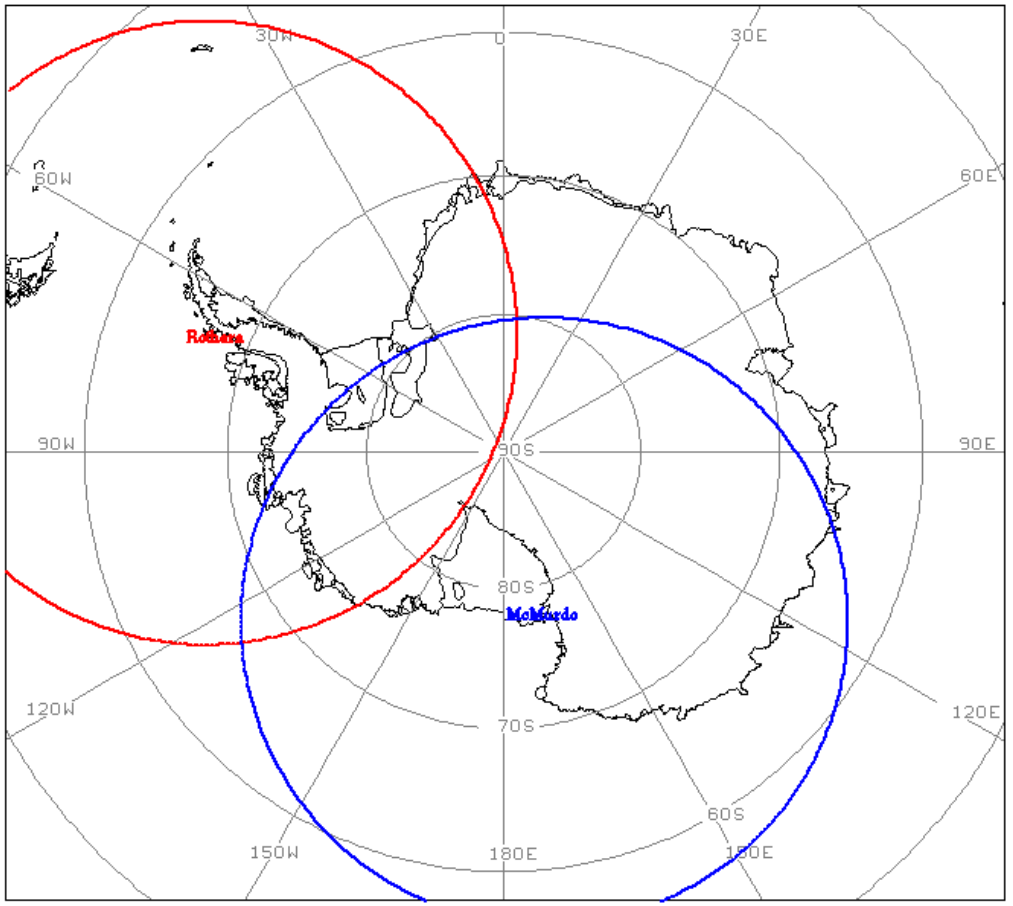


Clockwise from upper left: McMurdo, Rothera, Barrow, Sodankylä, Svalbard, Fairbanks

Direct Readout (Broadcast) Coverage in the Arctic and Antarctic

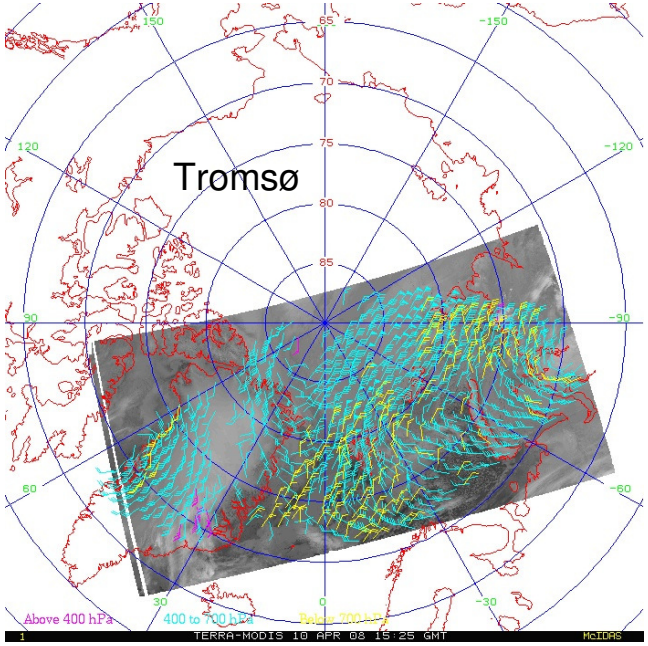


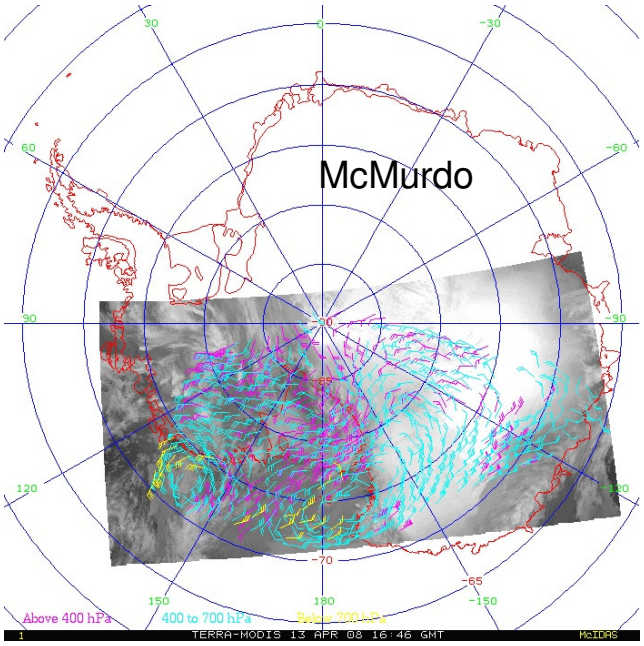
Station masks for
- Fairbanks, Alaska
- Barrow, Alaska
- Tromsø, Norway
- Sodankylä, Finland

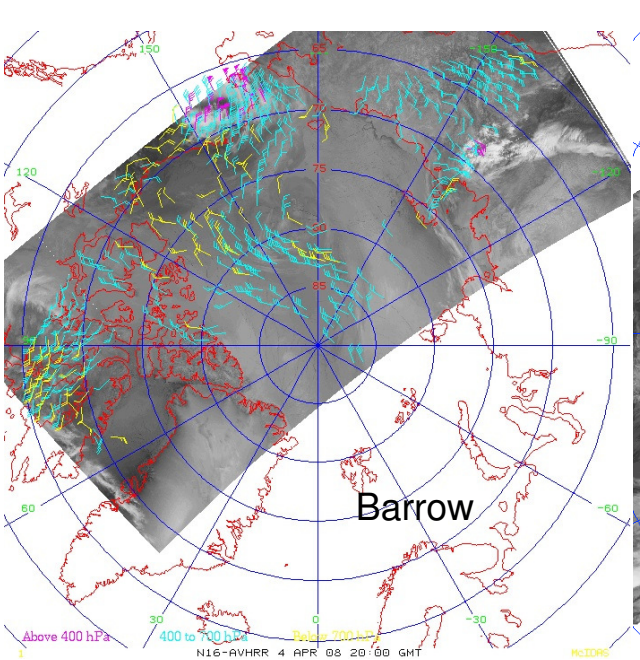


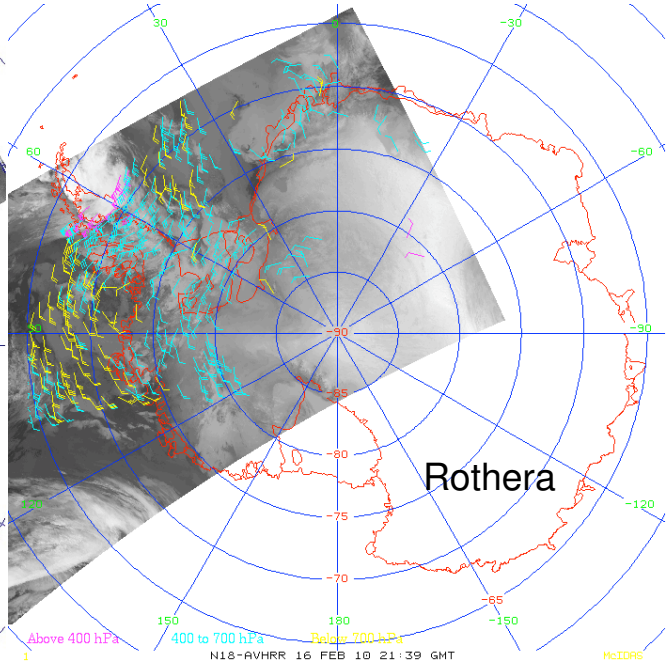
Station masks for
- McMurdo
- Rothera

Direct Broadcast (Readout) MODIS and AVHRR Winds



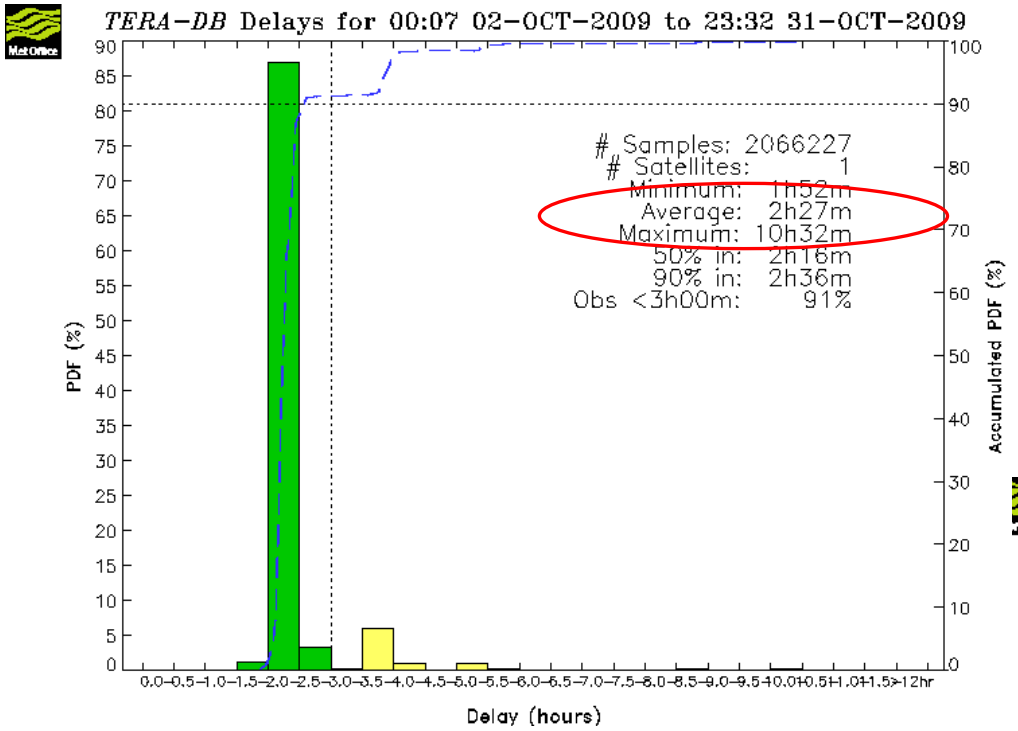


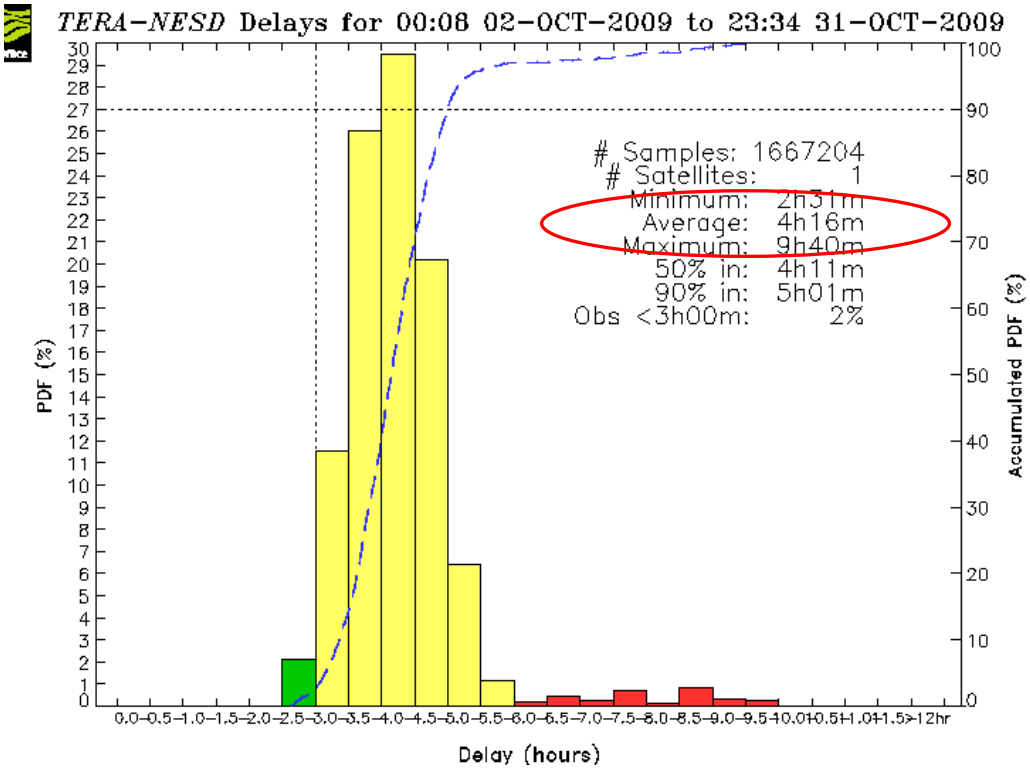




- Aqua, Terra, AVHRR winds are generated separately
- Data source is direct readout (broadcast)
- 1 km MODIS and AVHRR remapped to 2 km.
- Cloud-track and water vapor (MODIS) winds
- NCEP's GFS is used as the background.
- Pros: Low latency; high resolution.
- Cons: Incomplete polar coverage.

Latency: Wind Data Availability

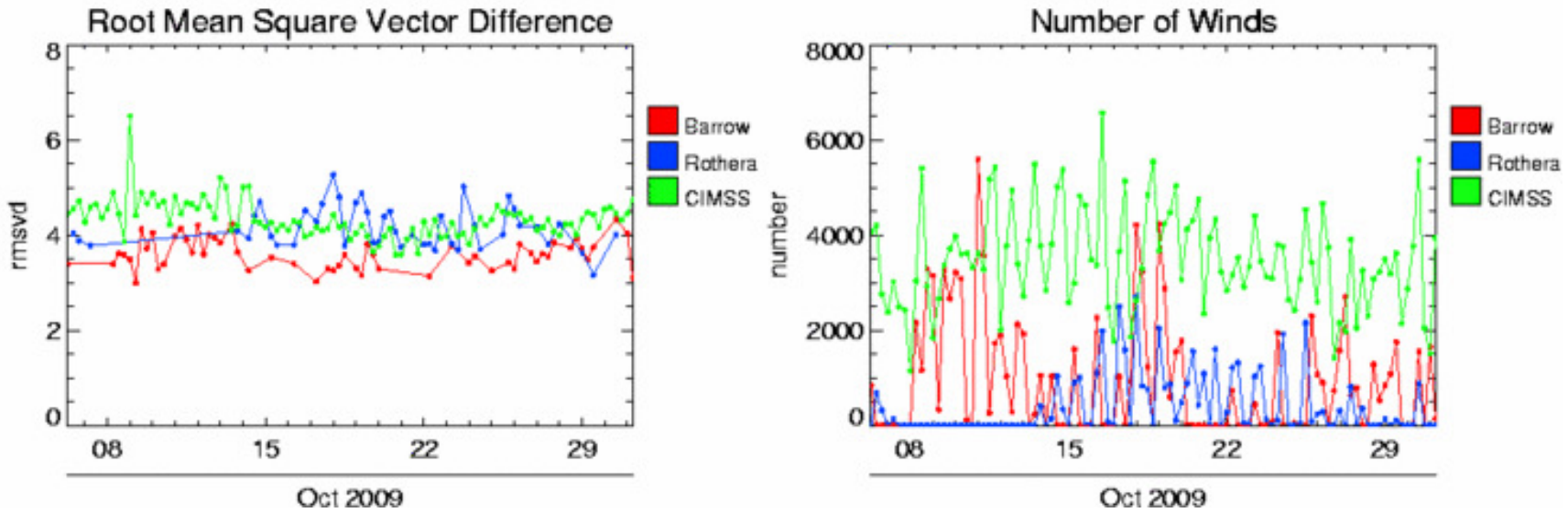




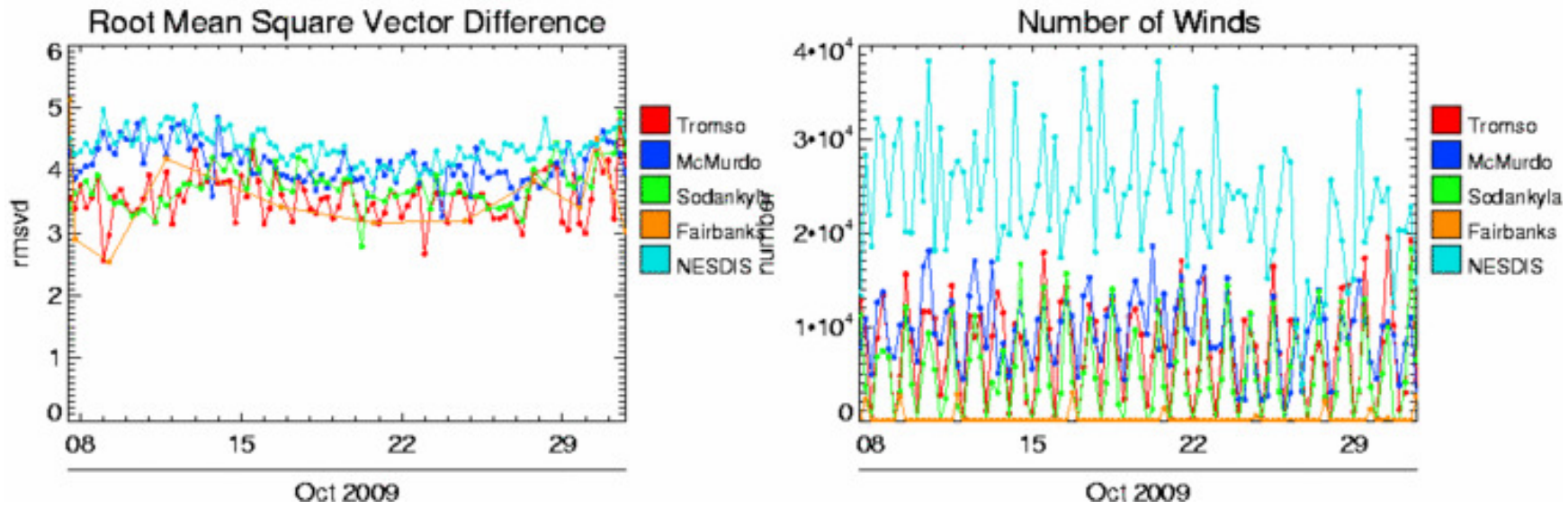
Histogram plots showing the delay between observation time and receipt time for (above) direct broadcast Terra data and (right) NESDIS Terra (not DB) data for October 2009. (*Courtesy of M. Forsythe*)

DB/Bent-Pipe Wind Comparison

AVHRR

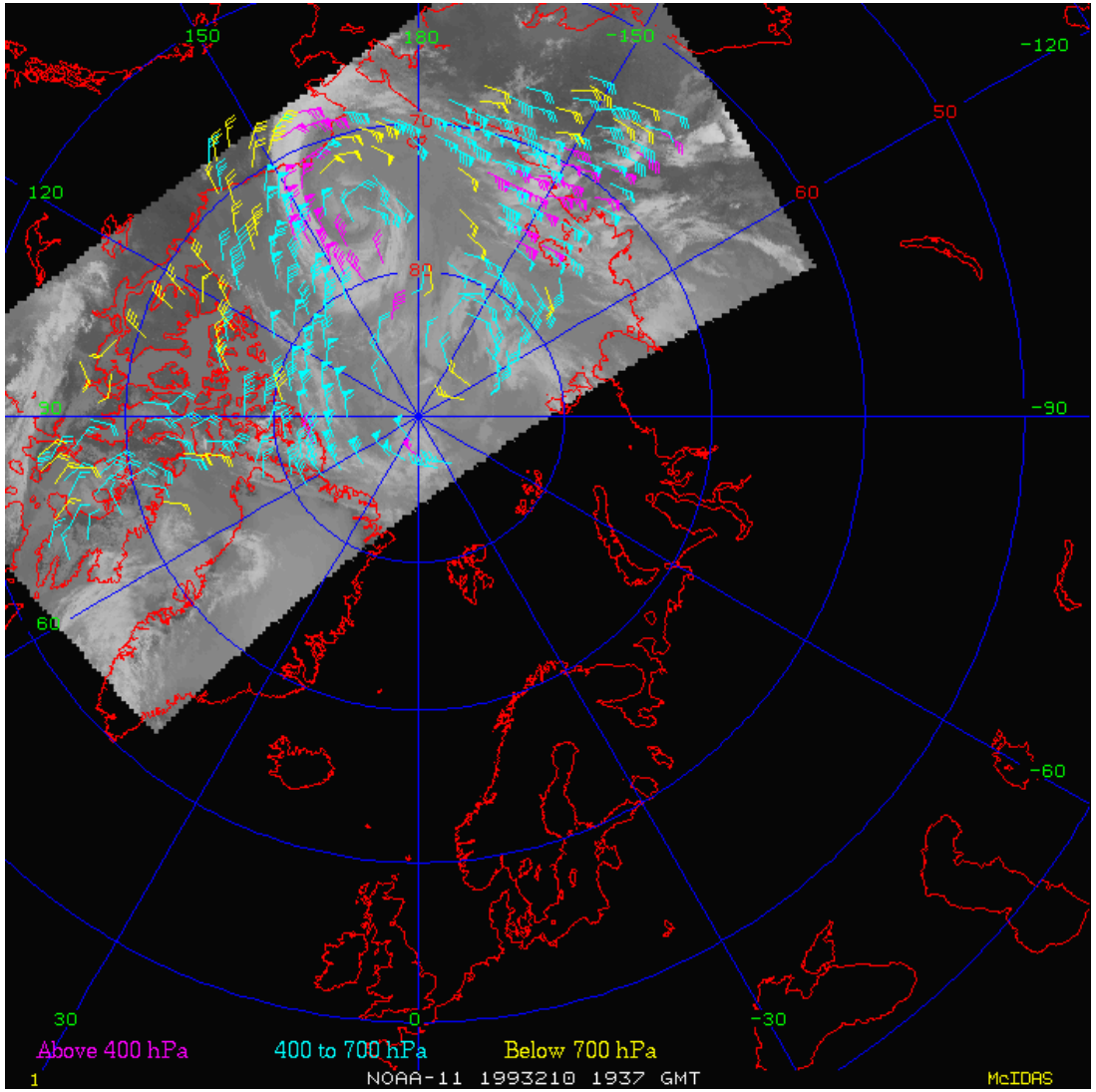


MODIS



Time series plots showing the root mean square vector difference and number of winds for (top) AVHRR winds and (bottom) MODIS winds from different sites. *(Courtesy of M. Forsythe)*

Historical AVHRR Polar Winds

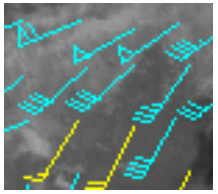


- 1982 - 2009
- Generally two satellites at any given time, NOAA-7 through -19
- Global Area Coverage (GAC) data gridded at 5 km.
- Cloud-track winds using IR channel only (no water vapor channel).
- NCEP Reanalysis is background.
- Pros: An essential product for reanalysis projects.
- Cons: Low resolution. Height assignment uncertainty for thin clouds.

(More on this in talk by D. Santek)

Product Comparison

Product/Feature	Spatial Coverage	Spatial Resolution	Latency (middle image)	Relative Accuracy	Operational NESDIS Product
MODIS, bent pipe, separate satellite	Entire Arctic and Antarctic	2 km	3-5 hrs	Similar to GOES	✔
MODIS, bent pipe, combined Terra & Aqua	Entire Arctic and Antarctic	2 km	2-4 hrs	Similar to GOES (additional tests needed)	✔ (mid-2010)
MODIS DB, single satellite	Portions of Arctic and Antarctic	2 km	2 hrs	Same as bent pipe winds	Maybe never
AVHRR GAC	Entire Arctic and Antarctic	4 km	3-5 hrs	Good, but not as good as MODIS bent pipe	✔
Metop AVHRR	Entire Arctic and Antarctic	2 km	3-5 hrs	Same as bent pipe winds	✔
HRPT AVHRR	Portions of Arctic and Antarctic	2 km	2 hrs	Same as bent pipe winds	Maybe never
Historical AVHRR	Entire Arctic and Antarctic	5 km	N/A 1982-2009	Good, but not as good as bent pipe	Not applicable



Plans

- Incremental improvements are planned, e.g., per-pixel time stamps.
- Preparations for winds from the VIIRS instrument on NPP and JPSS (formerly NPOESS) satellites have begun.
- Other possibilities:
  - Winds from two images (rather than three) would allow for a broader latitudinal range
  - Orbital pairs (same orbits, separation < 1 hr): NOAA-18 + NOAA-19, Terra + NOAA-17, Aqua + NOAA-18, NPP + Aqua/NOAA-18/NOAA-19, Metop-A + Metop-B
- We would like to hear your thoughts on polar wind products, including current problems and future directions.

Acknowledgements: The success of the polar winds project is largely a result of work done at the NWP centers. In particular, we thank Mary Forsythe, Randy Pauley, Niels Bormann, Lars Peter Riishojgaard, John LeMarshall, Jim Jung, Real Sarrazin, Alexander Cress, Koji Yamashita, Masahiro Kazumori, Christophe Payan, Yan-Qiu Zhu, Claire Delsol, Lueder von Bremen, Iliana Genkova, Antonio Irving, Hongming Qi, and Andrew Bailey. Paul Menzel suggested exploring MODIS polar winds in 2000.