Polar Winds from VIIRS

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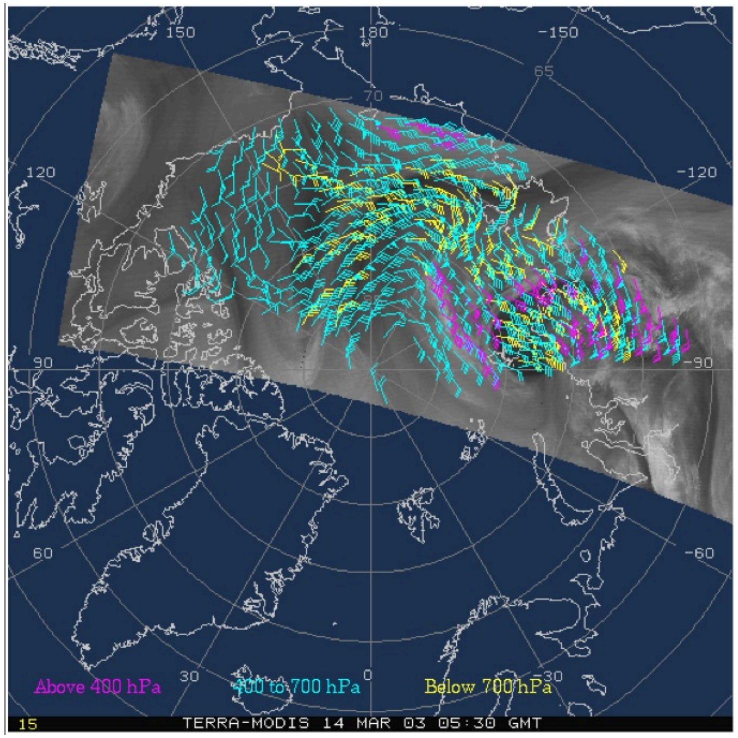
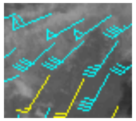


11th International Winds Workshop, Auckland, 20-24 February 2012



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, Aqua)
  - Tromsø, Norway (Terra only)
  - Sodankylä, Finland (Terra only)
  - Fairbanks, Alaska (Terra, from UAF)

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.

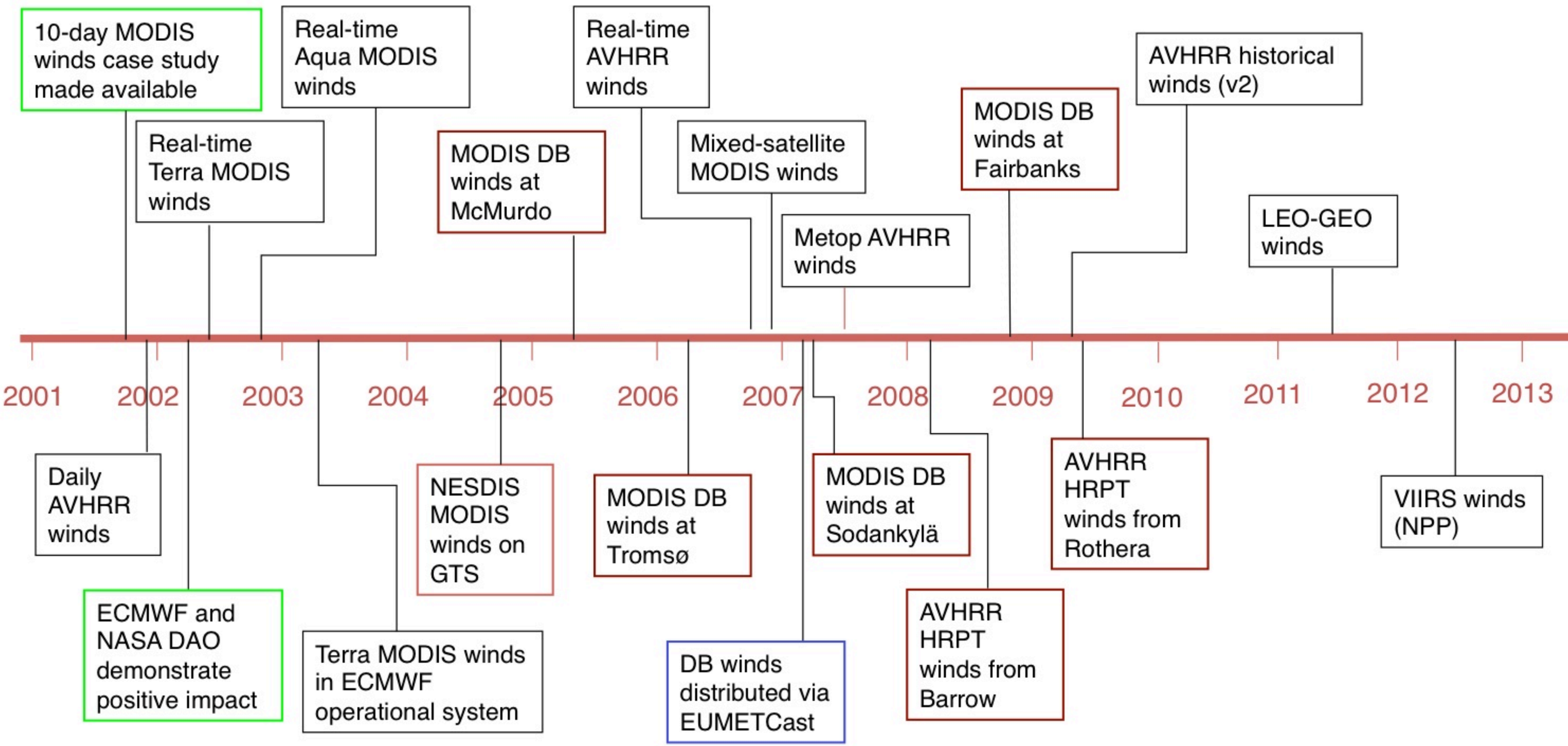
LEO-GEO Polar Winds

- Combination of may geostationary and polar-orbiting imagers
- Fills the 60-70 degree latitude gap

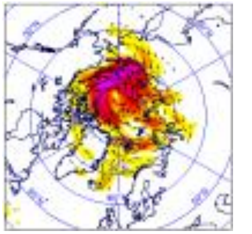
VIIRS Polar Winds

- (Details on following slides)

Polar Wind Product History



Operational NWP Users of Polar Winds



13 NWP centers in 9 countries:

- 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
- China Meteorological Administration (CMA) – since mid-2009
- Hydrological and Meteorological Centre of Russia (Hydrometcenter) – since 2010

Unique Characteristics of VIIRS

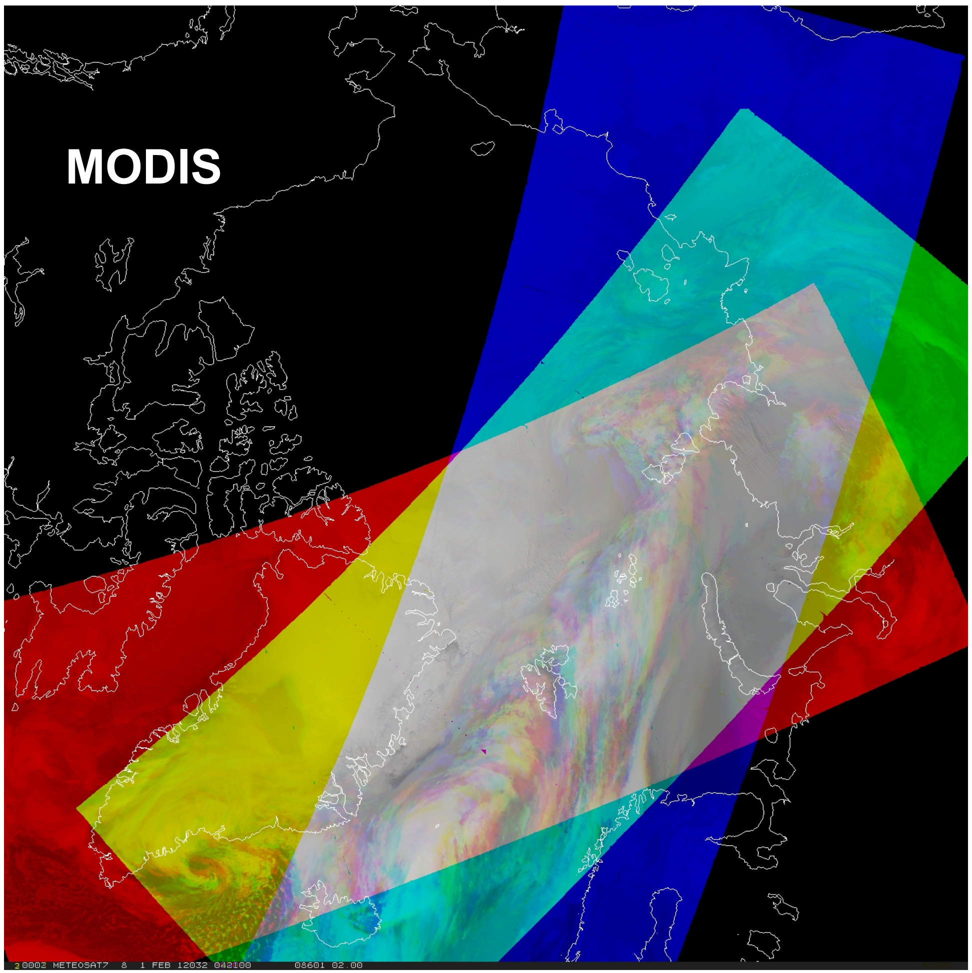
- The Visible Infrared Imaging Radiometer Suite (VIIRS) is on the Suomi National Polar-orbiting Partnership (NPP) satellite (formerly the NPOESS Preparatory Project).
- NPP was launched 28 October 2011.
- VIIRS is a 22-band imaging radiometer that is a cross between MODIS and AVHRR, with a little OLS (Operational Linescan System on DMSP satellites).

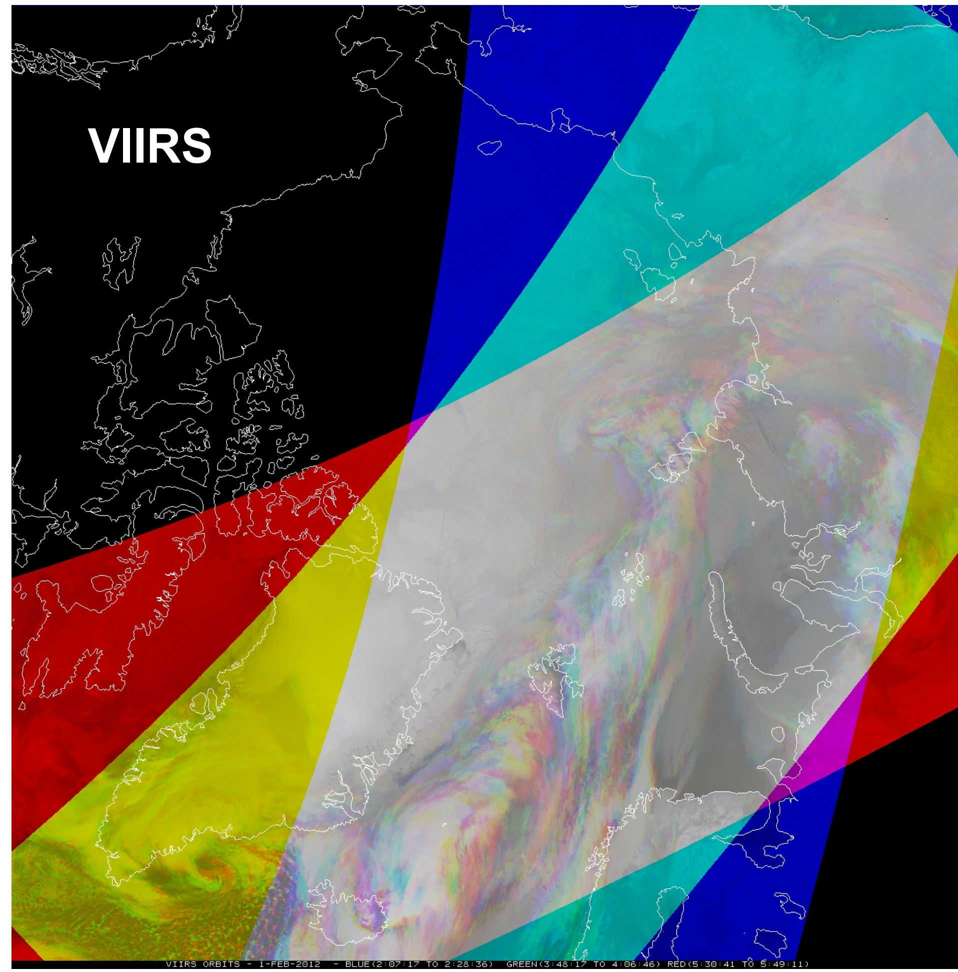
- Its unique characteristics that might have an impact on a VIIRS polar winds product include:
  - **Higher resolution (750 m for most bands; 375 m for some)**
  - **Wider swath**
  - **Constrained pixel growth: better resolution at edge of swath**
  - **Day-night band (DNB)**
  - Disadvantage: No thermal water vapor band so no clear-sky WV winds

- Additionally, the VIIRS polar winds processing **will utilize the new GOES-R AMV algorithm**.

VIIRS Coverage: Wider Swath

VIIRS has a wider swath (3000 km) than MODIS (2320 km), so the coverage will be better. AVHRR swath width is somewhere between (2600 km).

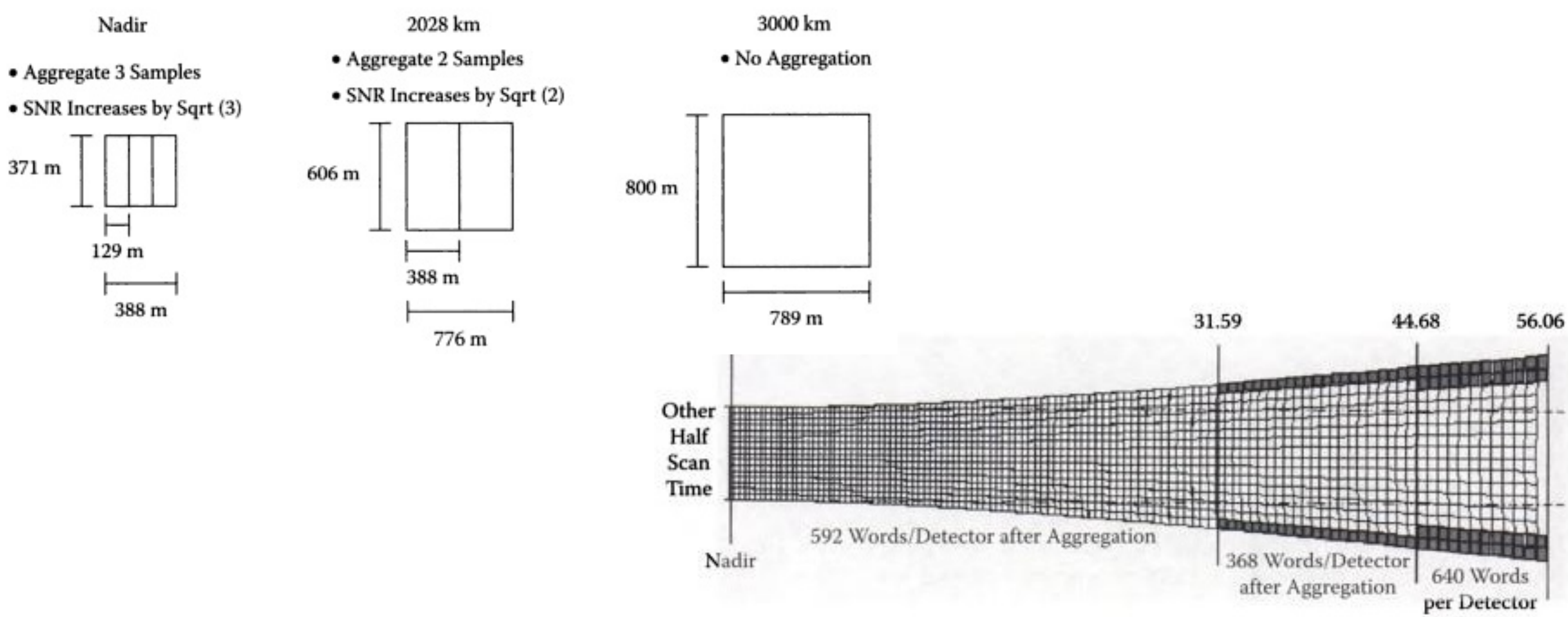


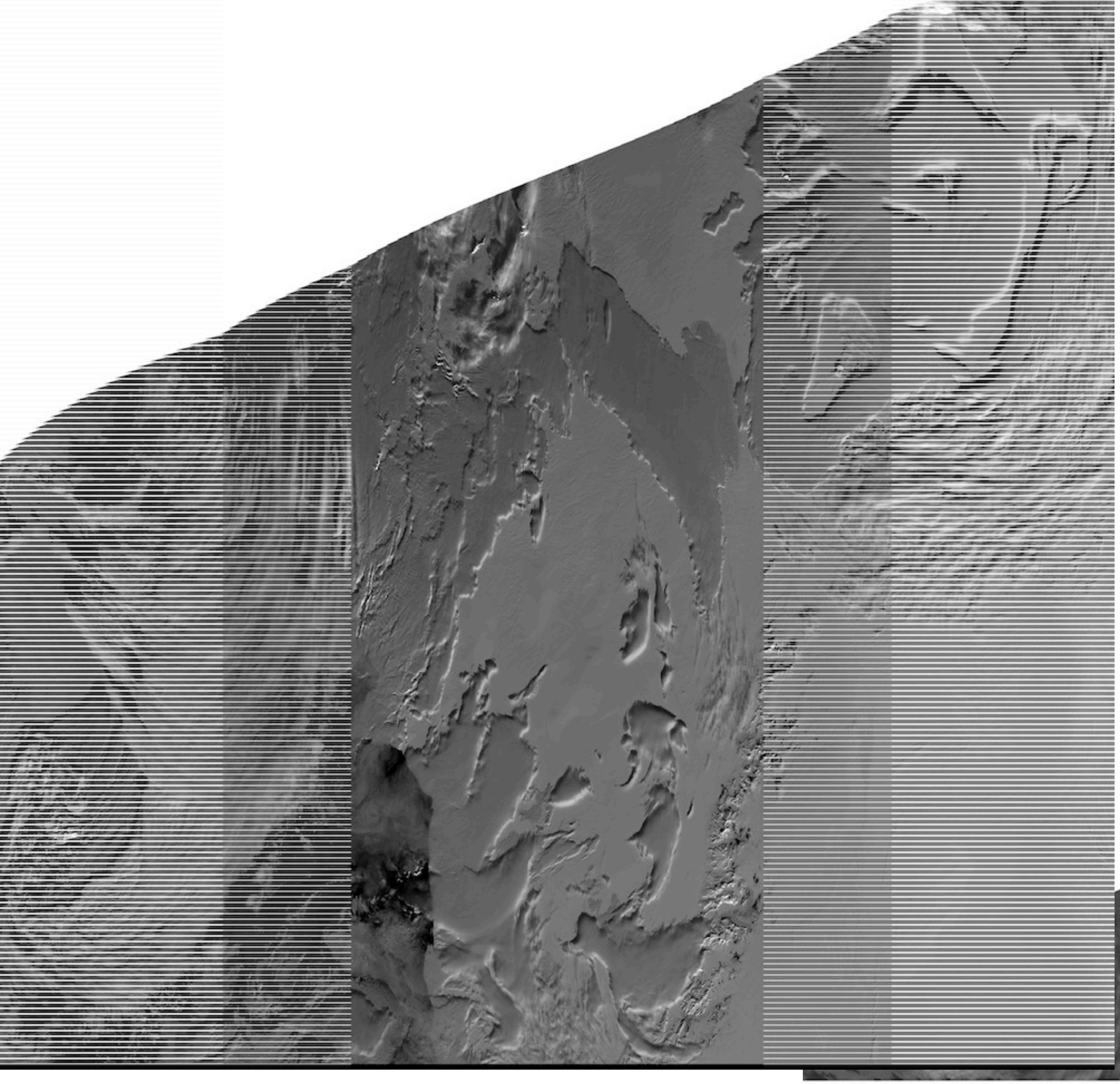


A wider swath means more winds with each orbit triplet.

Improved Resolution at Edge of Swath

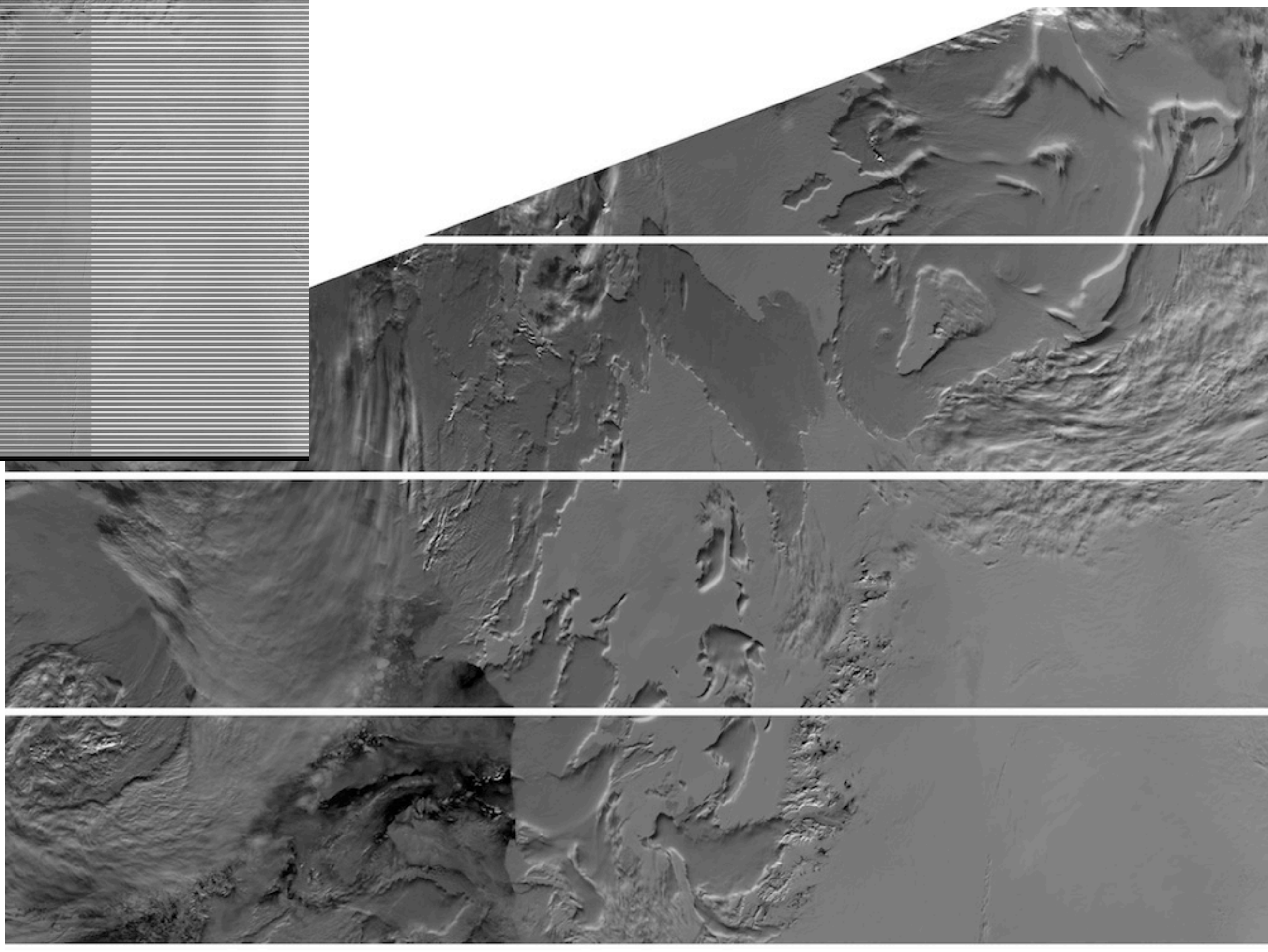
- VIIRS method of aggregating detectors and deleting portions of the scans near the swath edge results in smaller pixels at large scan angles.
- For thermal bands, VIIRS is 0.56 km^2 (0.75 x 0.75 km) at nadir and 2.25 km^2 at the edge of the swath (0.37 -> 0.8 km for imager bands; 0.74 -> 0.74 km for DNB)
- In contrast, AVHRR and MODIS are 1 km^2 at nadir and 9.7 km^2 at edge of swath.
- Additionally, VIIRS scan processing reduces the bow-tie effect.



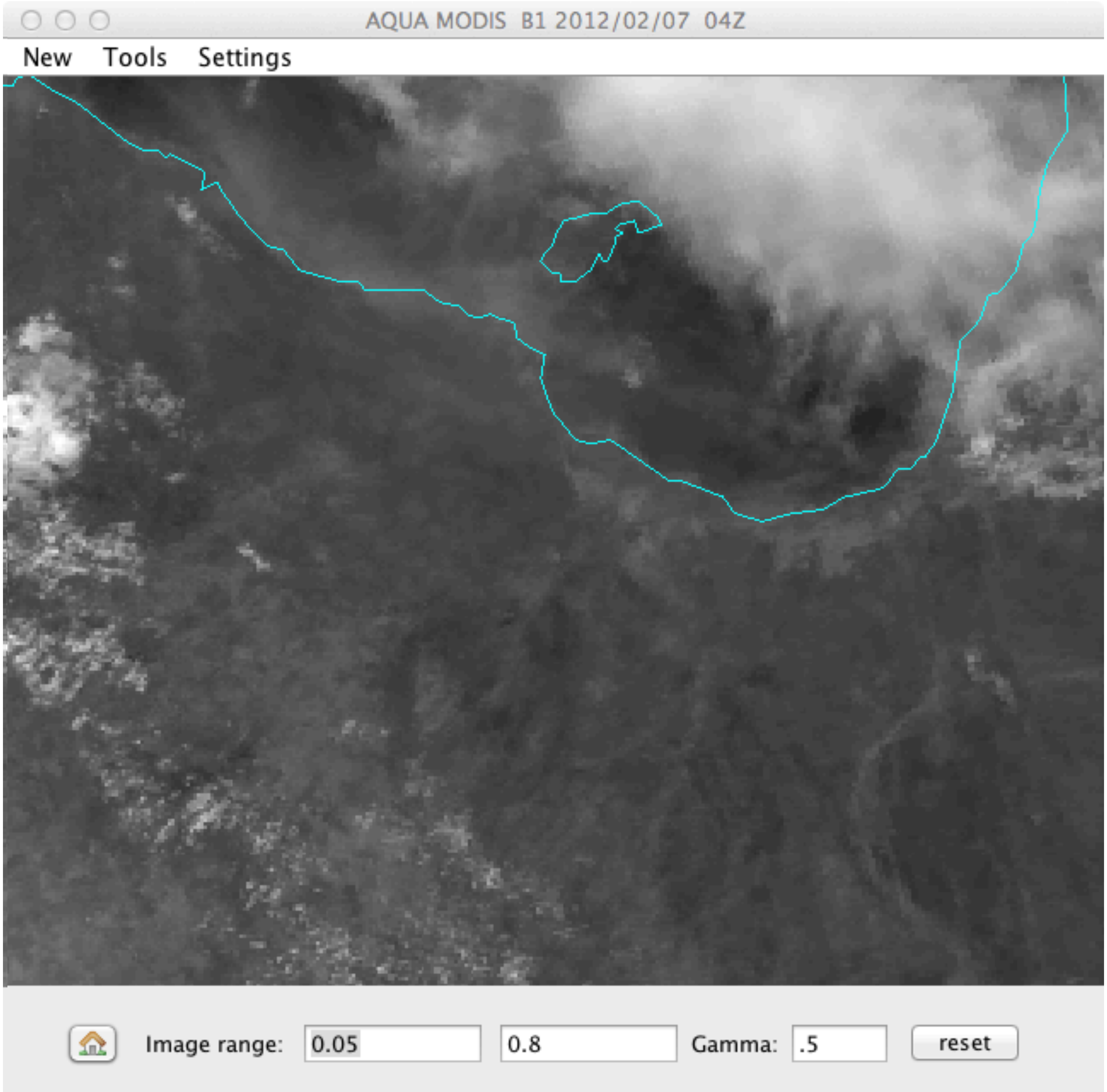


Left: Original showing dropped portions of scan to reduce bow-tie effect

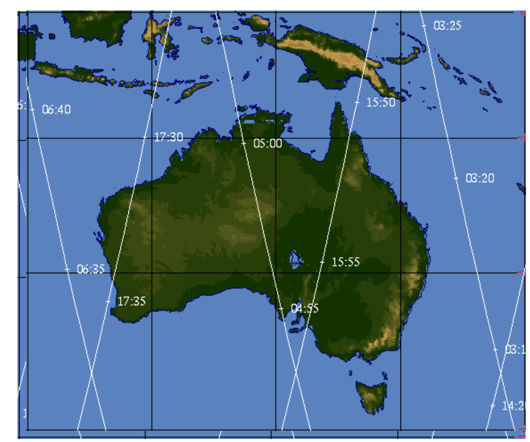
Below: Proper regridding removes bow-tie problems
(Gaps are between granules)



Aqua MODIS Band 1, 2012/02/07 04:55 UTC



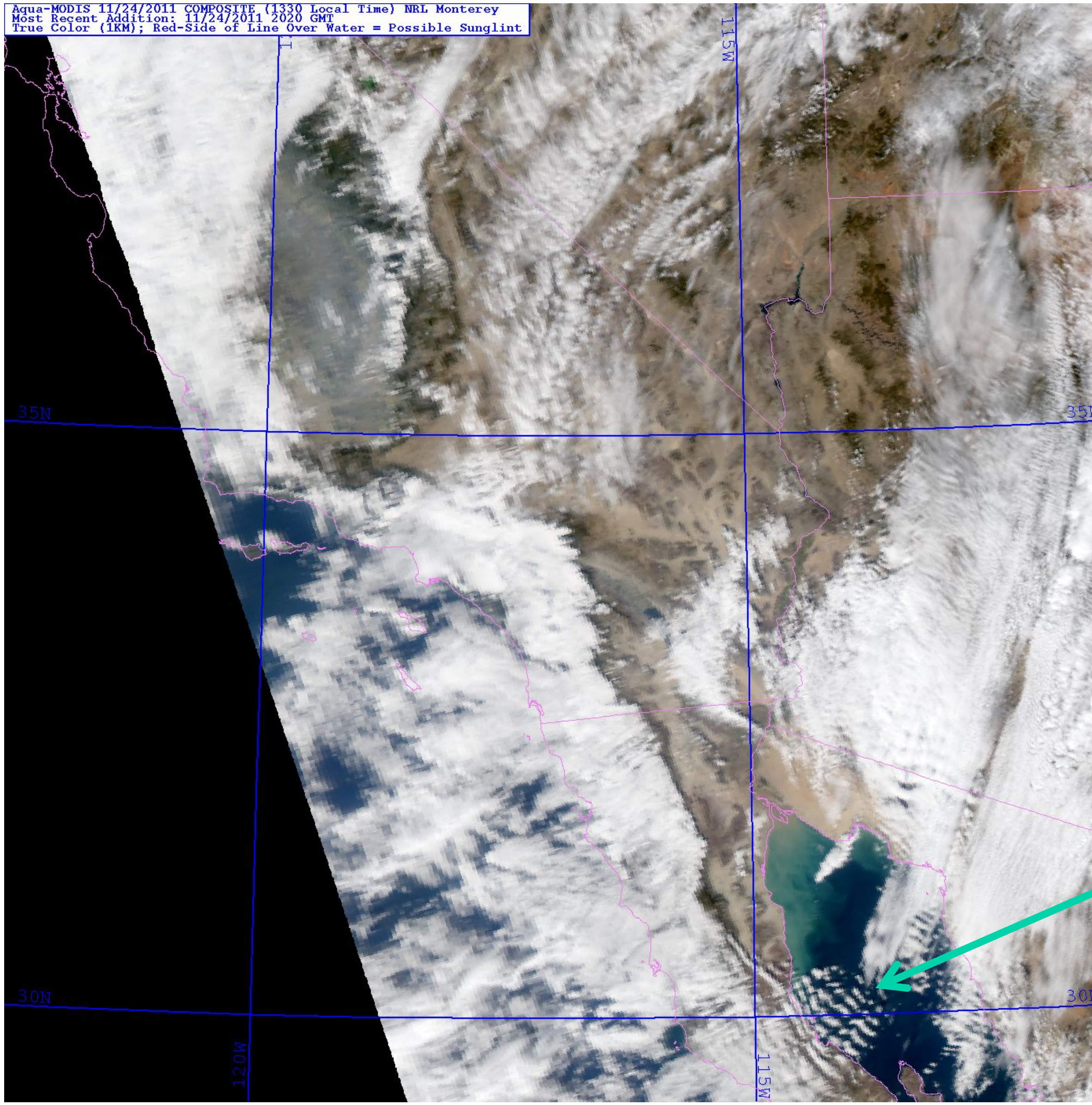
Eastern edge of granule (this side, but off map)



(Courtesy of Liam Gumley, CIMSS)

NPP VIIRS True Color Examples

Southwest US and Baja California Zoom-In
Aqua MODIS and NPP VIIRS

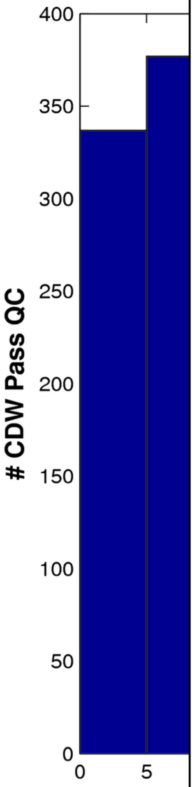


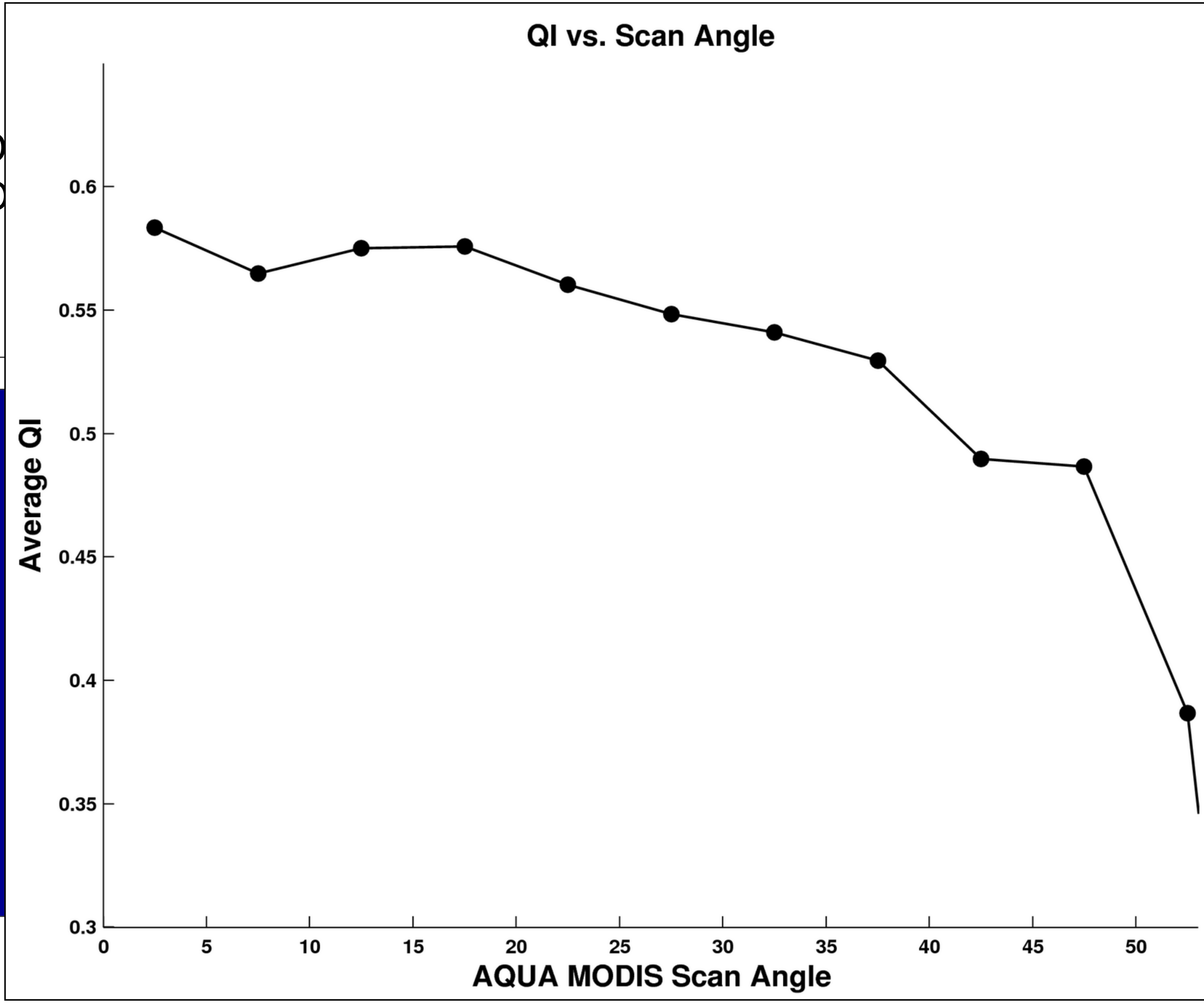
Orographic
Wave Clouds

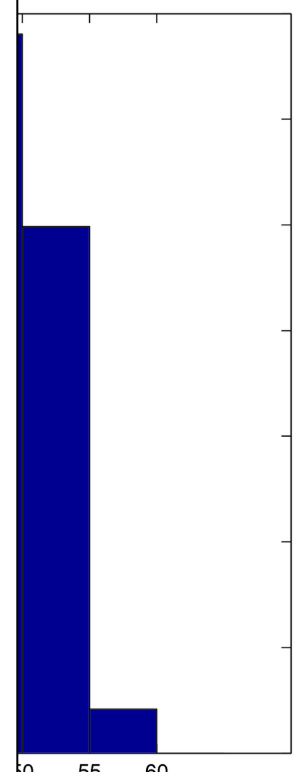
(Courtesy of Steve Miller, CIRA)

• D … al?
• O … angle.

(QI < 0.6)







So it clear that many of the winds toward the swath edges are filtered out by QC.

GOES-R ABI and VIIRS Algorithm

Unique features of the ABI wind retrieval methodology:

Feature Tracking

– The Sum-of-Squared Differences (SS) methodis used in conjunction with a "**nested tracking**" algorithm that is very effective at capturing the dominant motion in each target scene being tracked to track the feature backward and forward in time. *(Jaime Daniel's talk yesterday afternoon.)*

Target Height Assignment

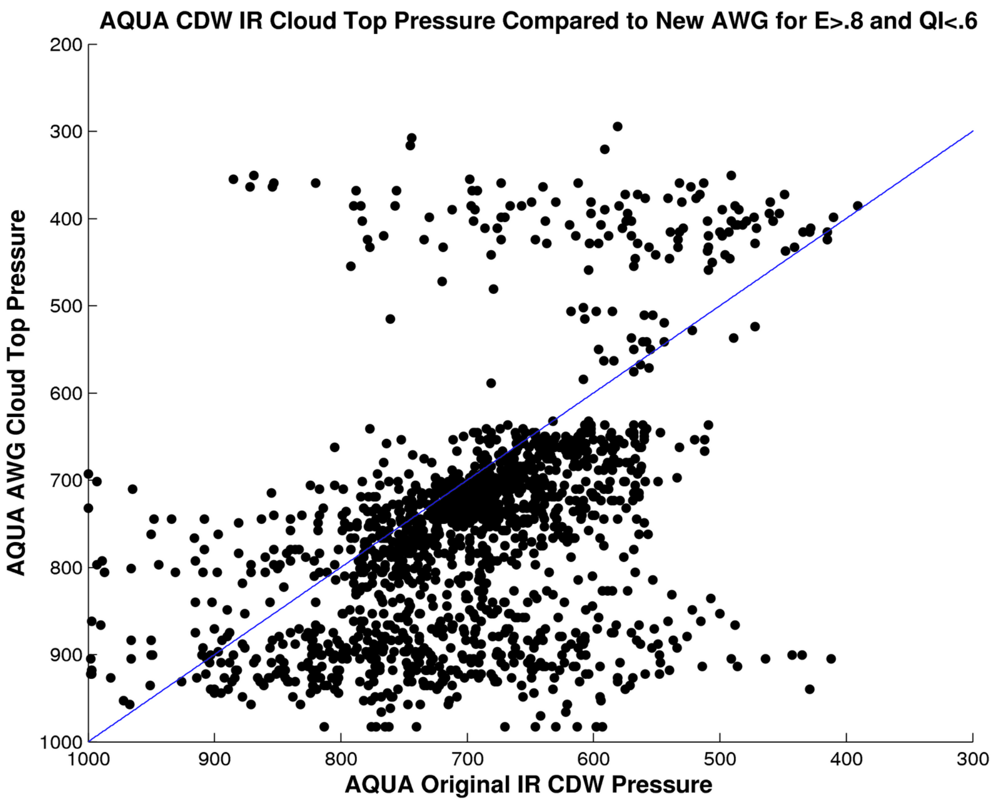
– **Externally-generated cloud heights** are used. This approach:
  - Leverages experience and expertise of those involved in cloud property retrievals
  - Takes advantage of pixel-level cloud heights contained within a target scene that:
    - Offer the best opportunity to assign the most representative heights to targets being tracked in time
    - Contain diagnostic performance metrics
  - Offers potential for future enhancements to target height assignment algorithm

Clouds Heights: Externally-Generated vs Windco

- How do cloud heights generated with the GOES-R ABI algorithm compare to cloud-drift wind vector heights from the traditional winds method? Not well.

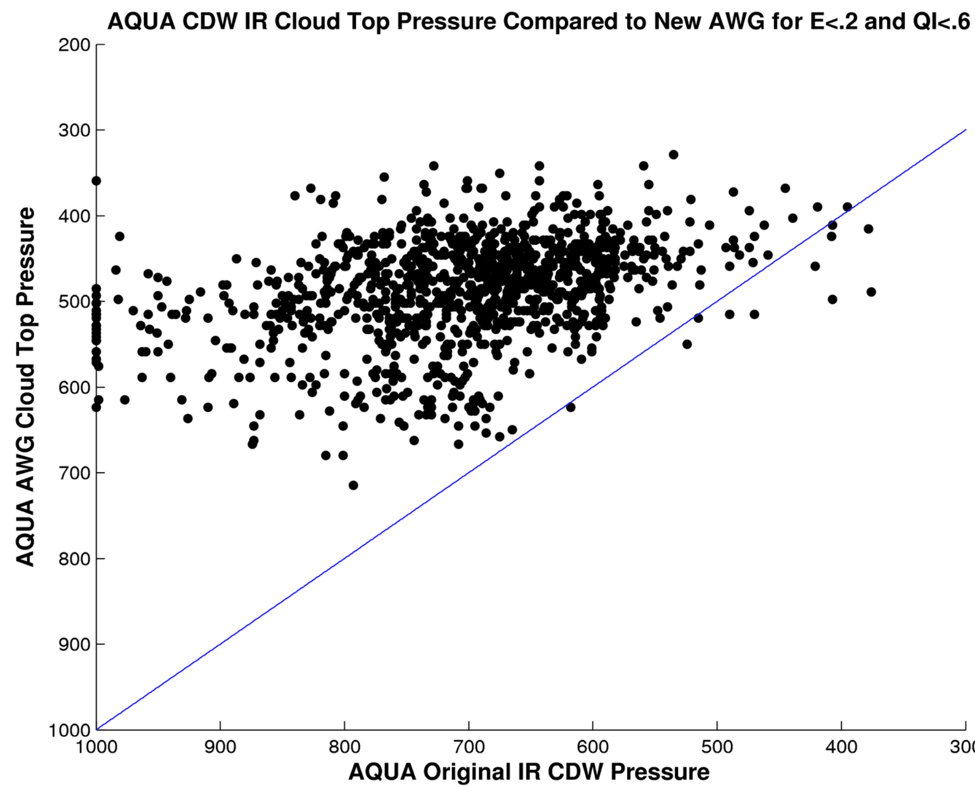
Thick Clouds, QI < 0.6

Externally-generated MODIS CTH



windco CTH

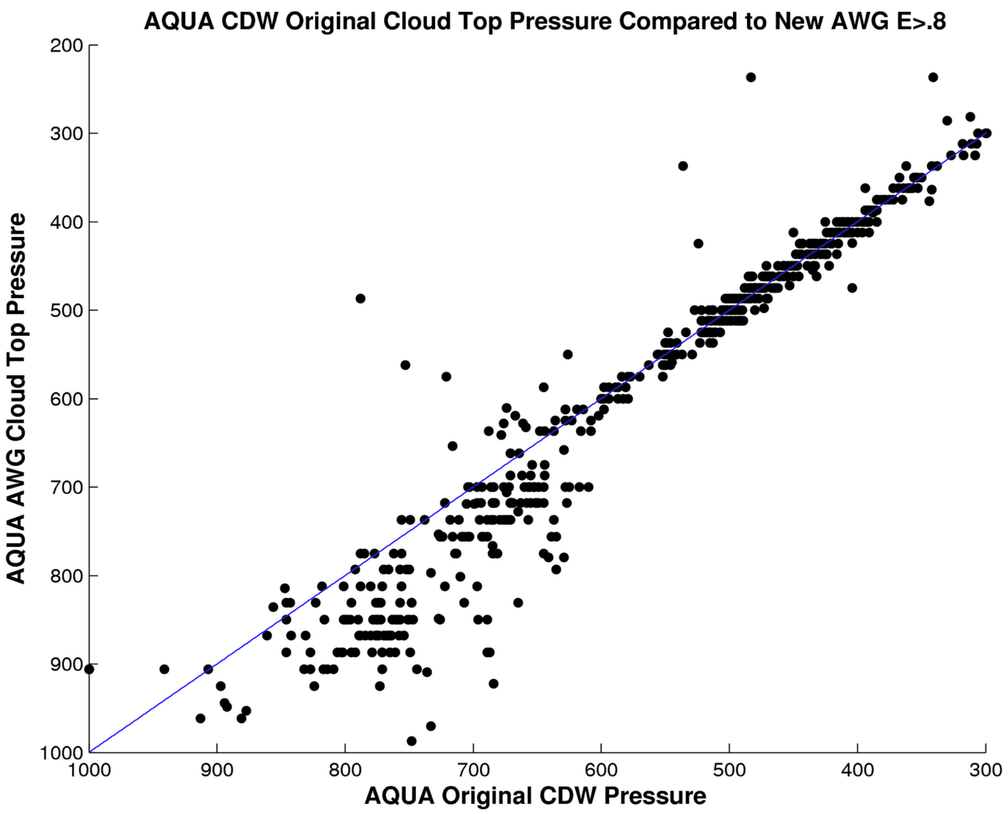
Thin Clouds, QI < 0.6



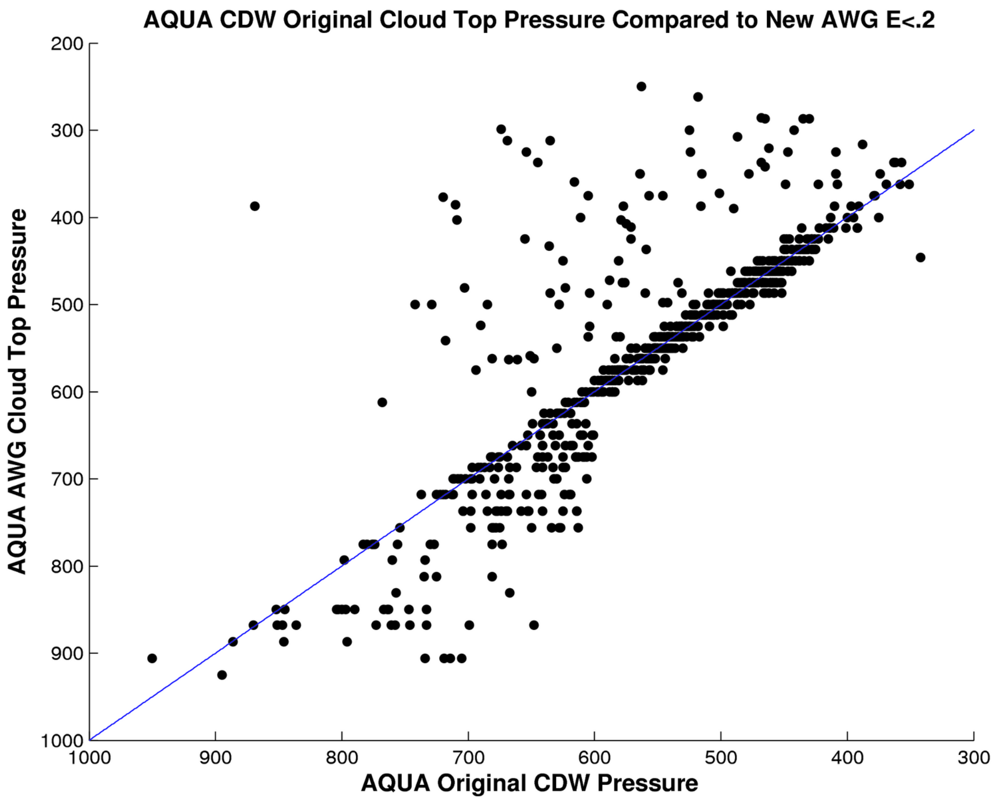
Clouds Heights: Externally-Generated vs Windco

- Windco quality control eliminates many of the cases where heights are significantly different, but biases remain

Thick Clouds, QI > 0.6

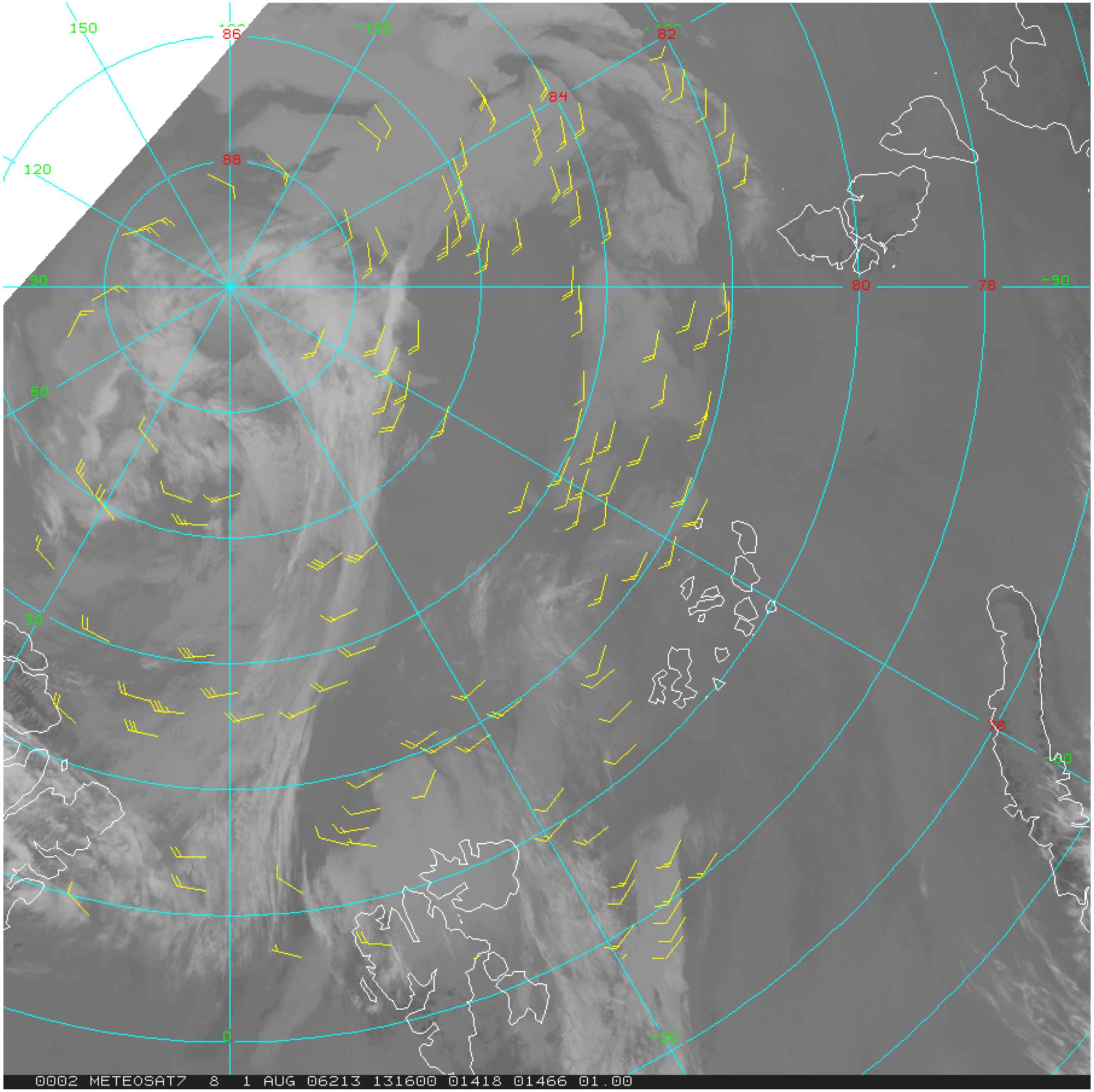


Thin Clouds, QI > 0.6

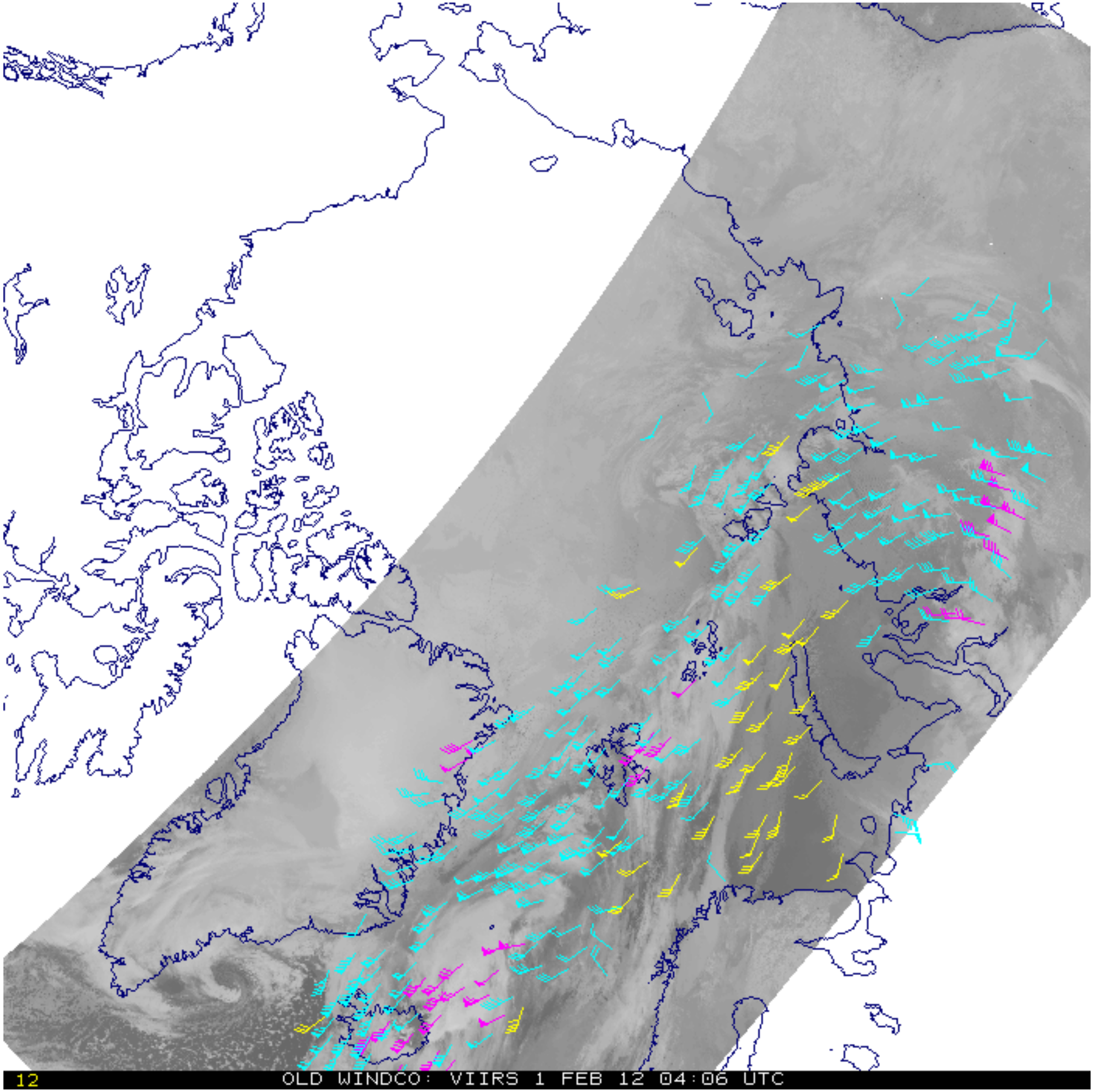


VIIRS Polar Winds Status

- The VIIRS polar winds product is scheduled to be operational in NESDIS this coming October (2012).
- Many changes to the processing have been made, including the conversion of VIIRS data to a polar stereographic projection, conversion to AREA files, and integration into GEOCAT, all without McIDAS.
- One case study using the new processing system with MODIS channel data and cloud properties has been performed (right).



VIIRS Winds from Windco

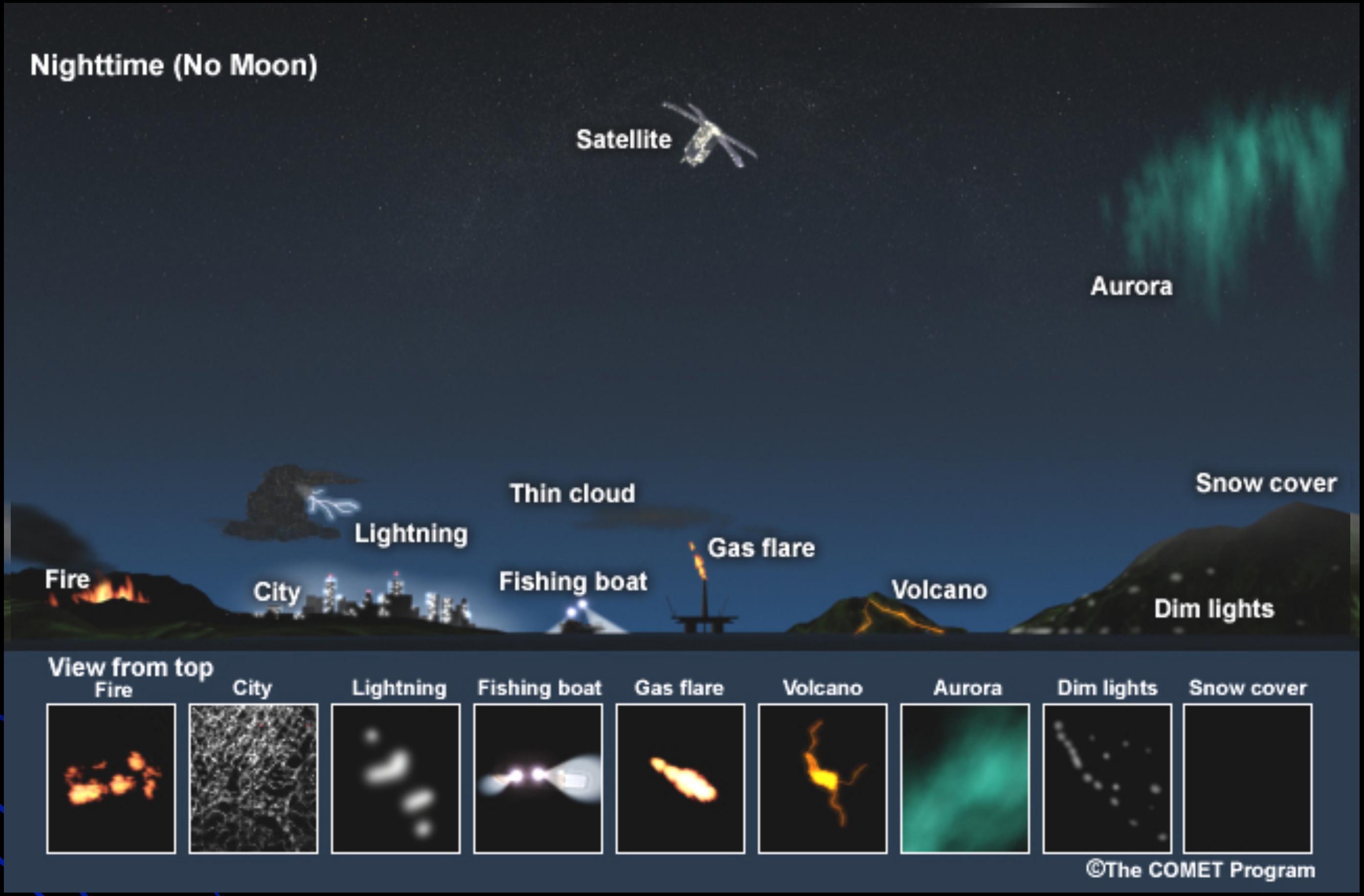


VIIRS Day-Night Band (DNB)

- Knowledge of environmental properties *at night* is important to a wide array of users (e.g., land/sea/air transportation).
- Satellite-based methods of detection/characterization are limited at night—many parameters require solar reflectance measurements.
- Visible information exists at night, but requires highly sensitive instrumentation to measure.
- Satellite-based low light detection was pioneered by the Operational Linescan System (OLS), which has flown continuously on the Defense Meteorological Satellite Program (DMSP) since 1967.
- VIIRS has a new "Day/Night Band" (DNB), which offers marked advances over the heritage DMSP/OLS.

Low-light visible imagery is one of the most novel and important capabilities of the next-generation operational civilian satellites

Sources of Low-Light Visible



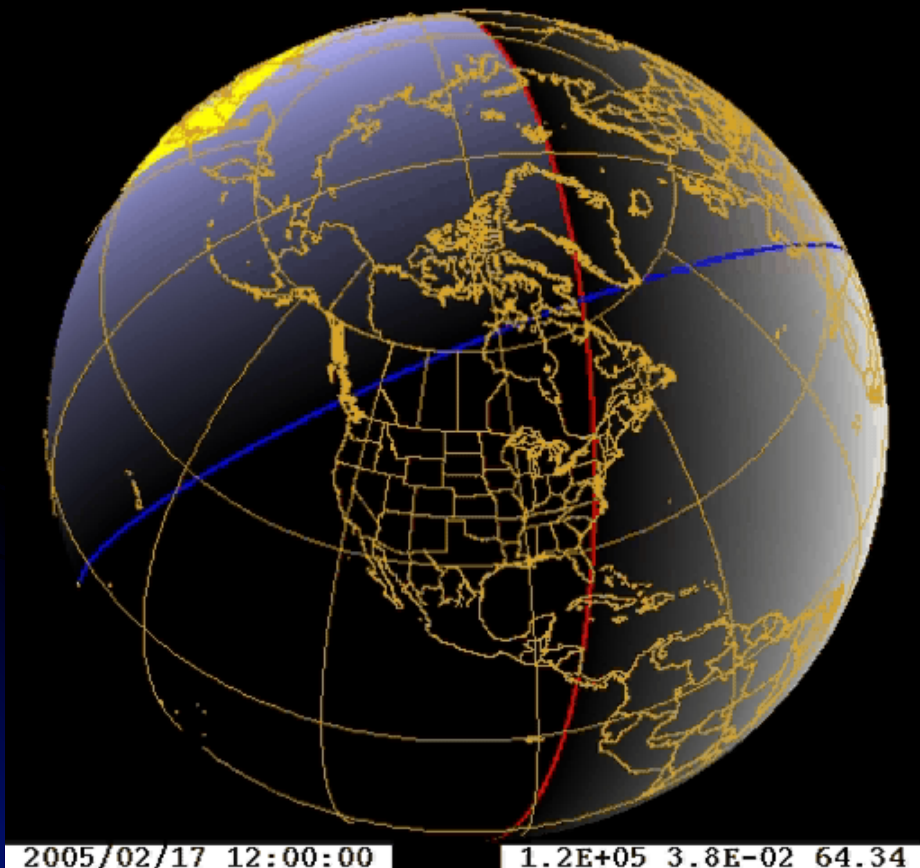
→ Both lunar reflection and terrestrial emission based applications are possible

(Courtesy of Steve Miller, CIRA)

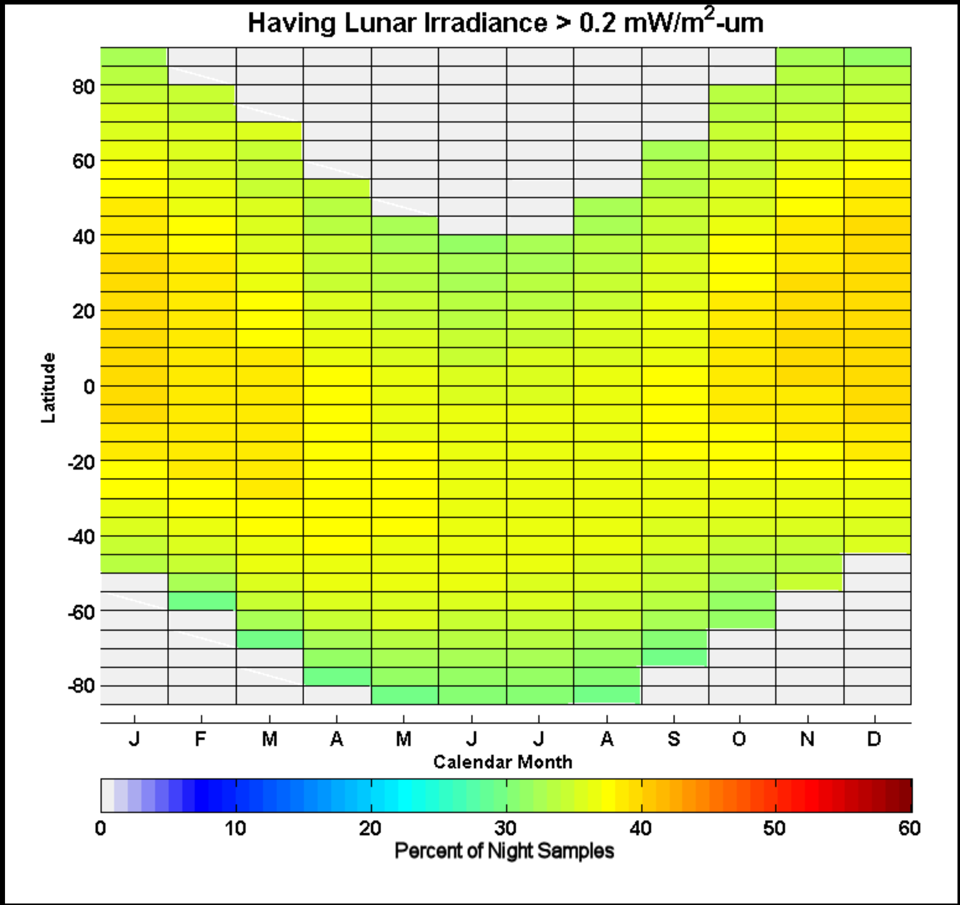
Moonlight Availability

Gray Shading = *solar zenith angle*, ***Red Line*** = *solar terminator*
Blue Shading = *lunar zenith angle*, ***Blue Line*** = *lunar terminator*

Simulated Satellite Orbits



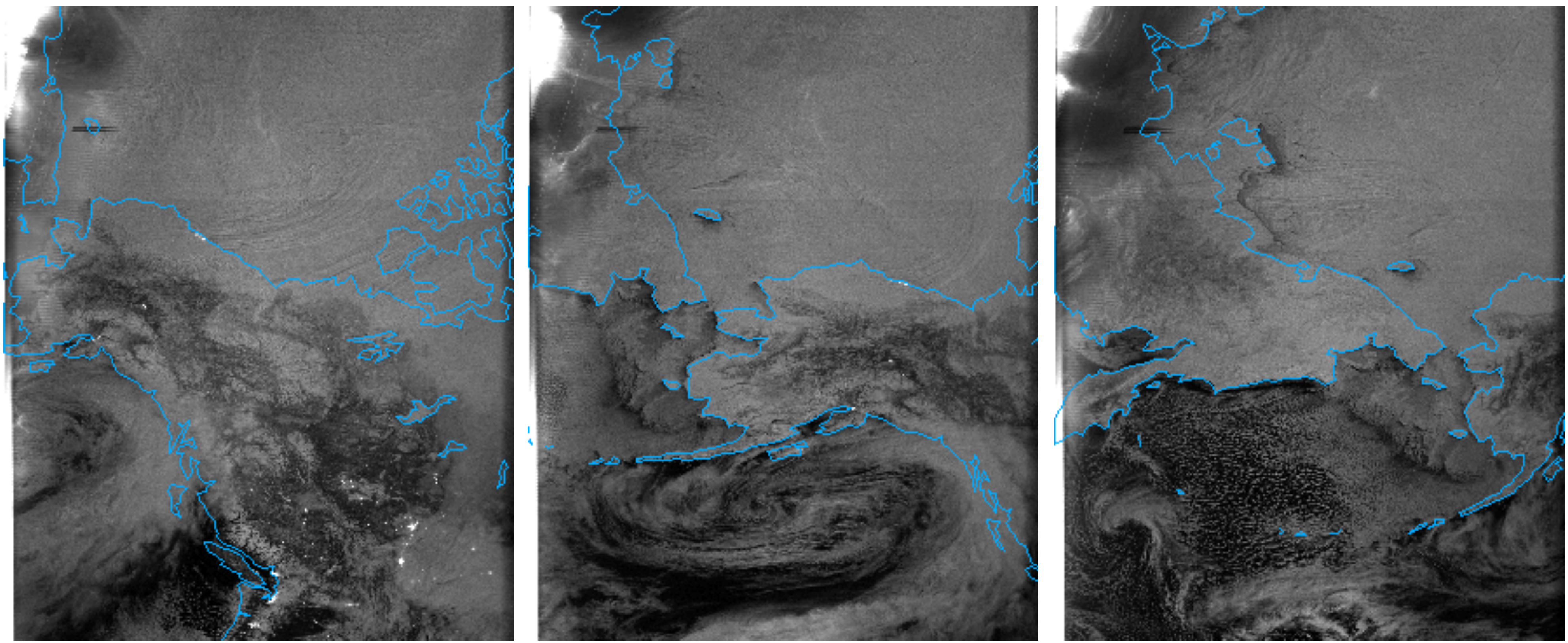
5-Year (2011-2015) Statistics
(Example)



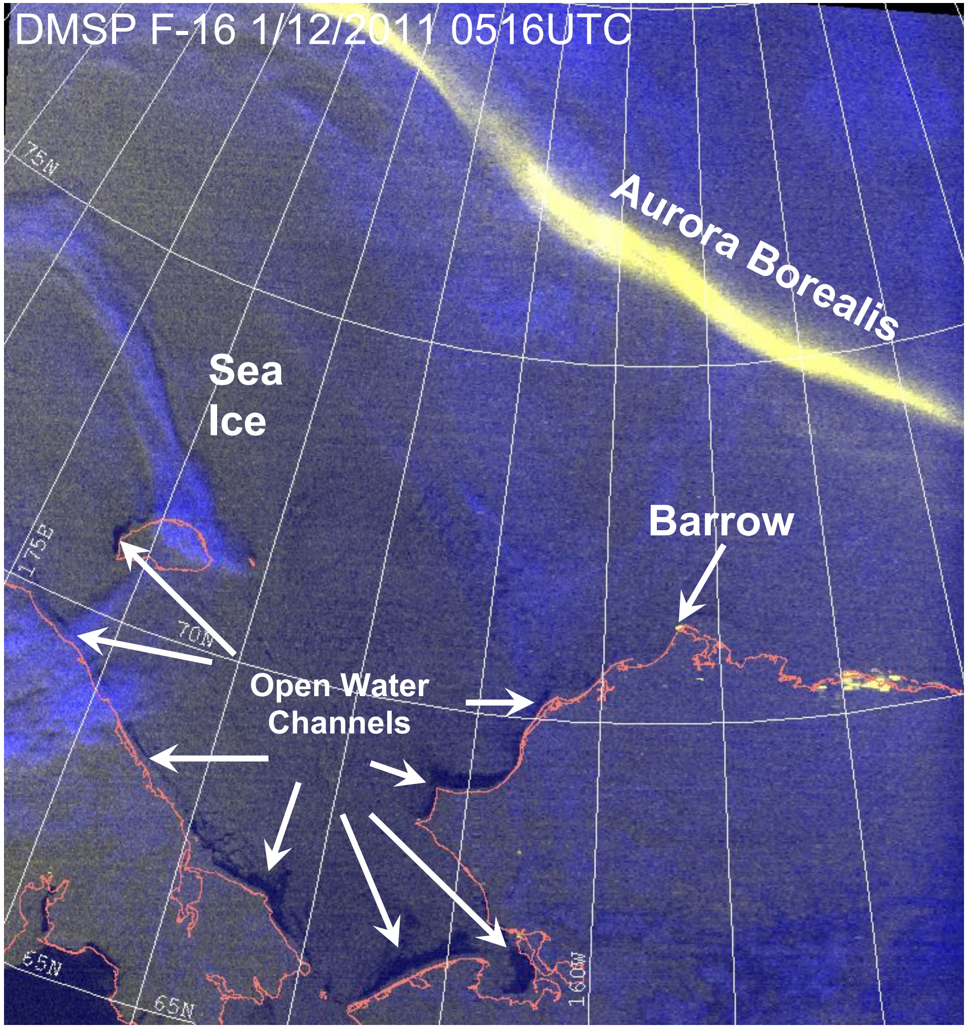
(Courtesy of Steve Miller, CIRA)

OLS (F-16) Nighttime Visible Images (not co-registered)

1/9/2009 0258 UTC | 1/9/2009 0440 UTC | 1/9/2009 0622 UTC

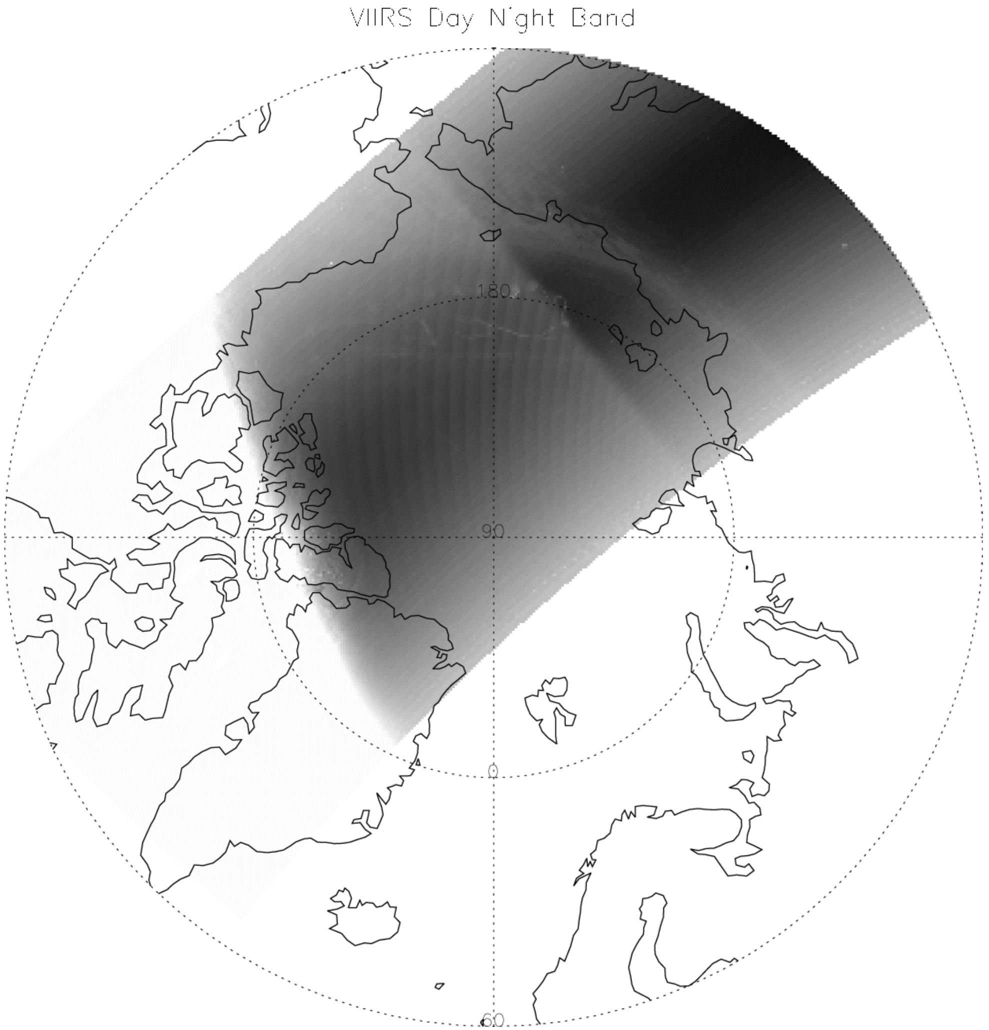


Nighttime Images, cont.



(Courtesy of Steve Miller, CIRA)

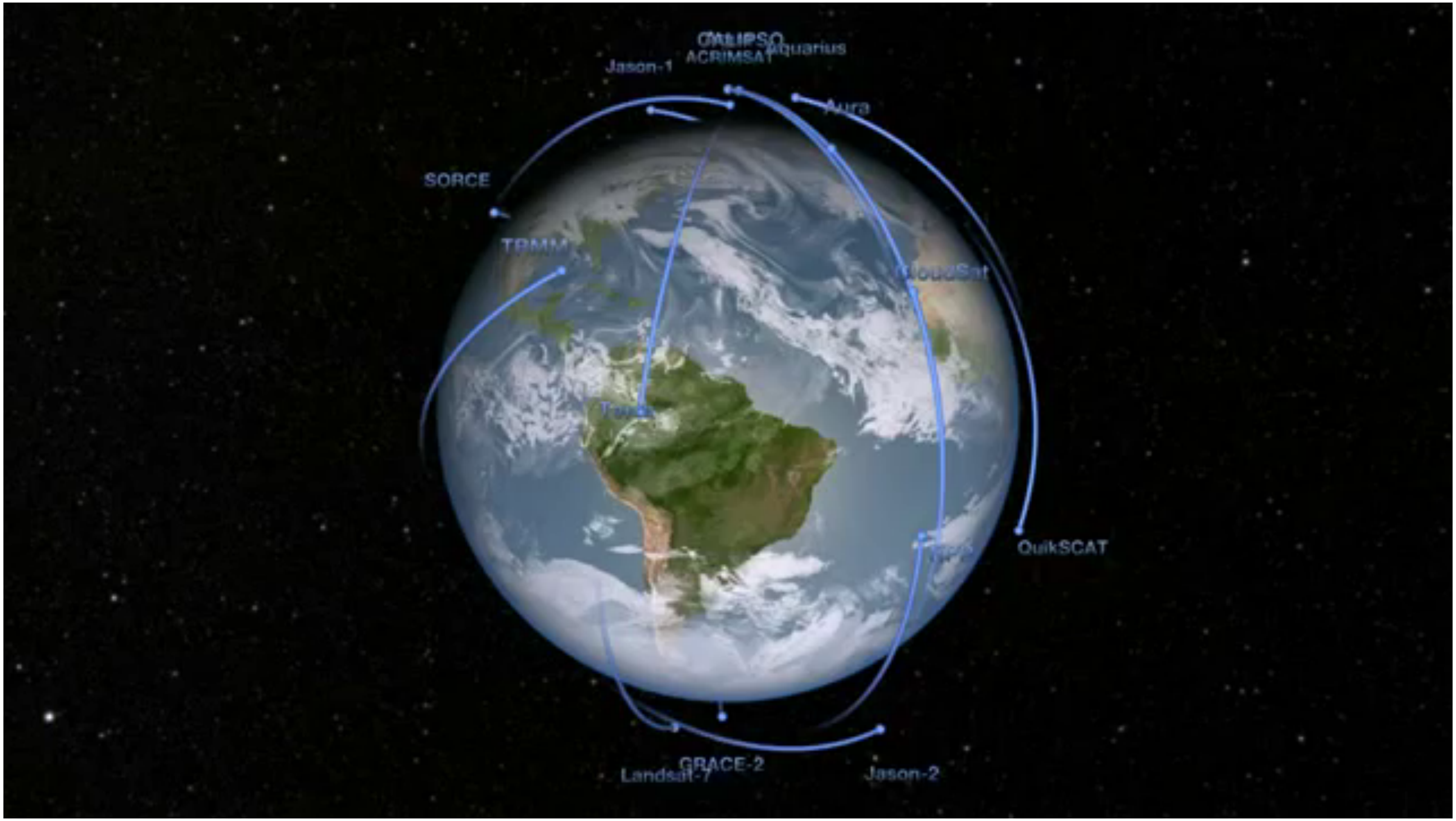
VIIRS DNB, 24 Jan 2012



(Animation courtesy of Yinghui Liu, CIMSS)

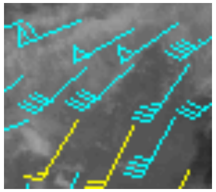
Stereo Winds

Can VIIRS and MODIS be combined for a MISR-like wind retrieval?



Unfortunately, NPP and Aqua fly in tandem for only a few orbits every three days. Can this be done with Metop-A and Metop-B, which will be in the same orbit but separated by 50 minutes?

(*Animation courtesy of NASA/Goddard Space Flight Center Scientific Visualization Studio*)



Summary

- Several unique characteristics of VIIRS are expected to influence the quality of the polar winds product:
  - **Wider swath** – Greater coverage and therefore more winds for each orbit.
  - **Higher spatial resolution at nadir and across the swath** – Tracking features will be better defined, resulting in more good winds toward the edges of the swath.
  - **Day-night band (DNB)** – Intriguing possibilities for the long polar night.
  - Unfortunately, VIIRS, like AVHRR, does not have a thermal water vapor band so no clear-sky winds.
- The VIIRS polar winds processing is being built on **the GOES-R AMV algorithm**, utilizing a nested-tracking approach and externally-generated cloud properties.
- The product will be operational in October 2012.
- Future work:
  - Mixed Metop-A and Metop-B winds *(Ken Holmlund's talk this session)*
  - PCW winds *(Louis Garand's talk this session)*