Polar Winds – A Tale of Two Algorithms

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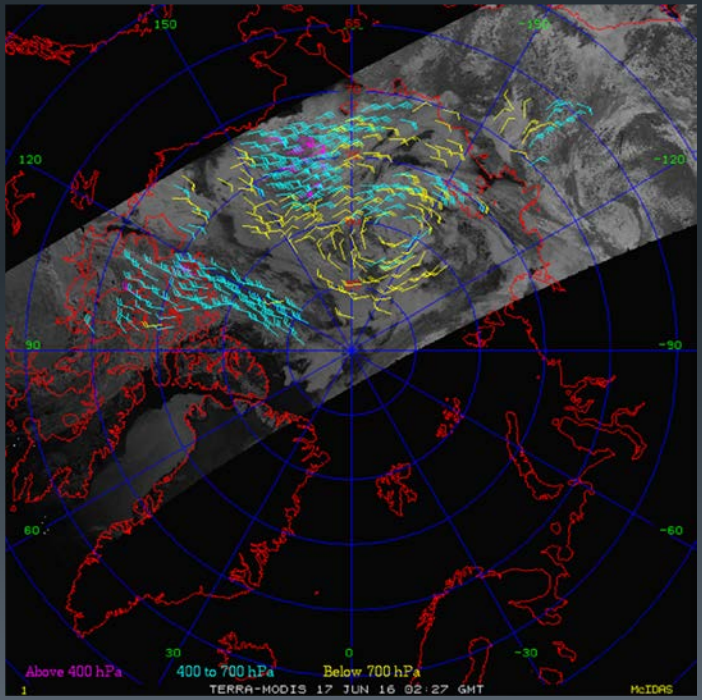


14th International Winds Workshop, Jeju City, South Korea, 23-27 April 2018

Nested Tracking versus WINDCO

- MODIS winds were used to evaluate the relative accuracies of the VIIRS winds algorithm (“nested tracking”) and the heritage algorithm (“windco”). MODIS winds were used because both algorithms are not implemented for VIIRS. This was the most robust comparison to date. Winds from both algorithms are compared to radiosonde winds.
- It was found that the VIIRS algorithm has a significantly lower vector root-mean-square-error (RMSE): 6.05 m/s for nested tracking vs 7.26 m/s for windco with Aqua data. The difference for Terra was somewhat smaller.
- The largest increase in accuracy for nested tracking is for high-level winds.
- Some differences in vertical distributions and speeds were noted.

Nested Tracking versus WINDCO: Statistics

Statistics for 2017-2018, Northern Hemisphere, IR winds

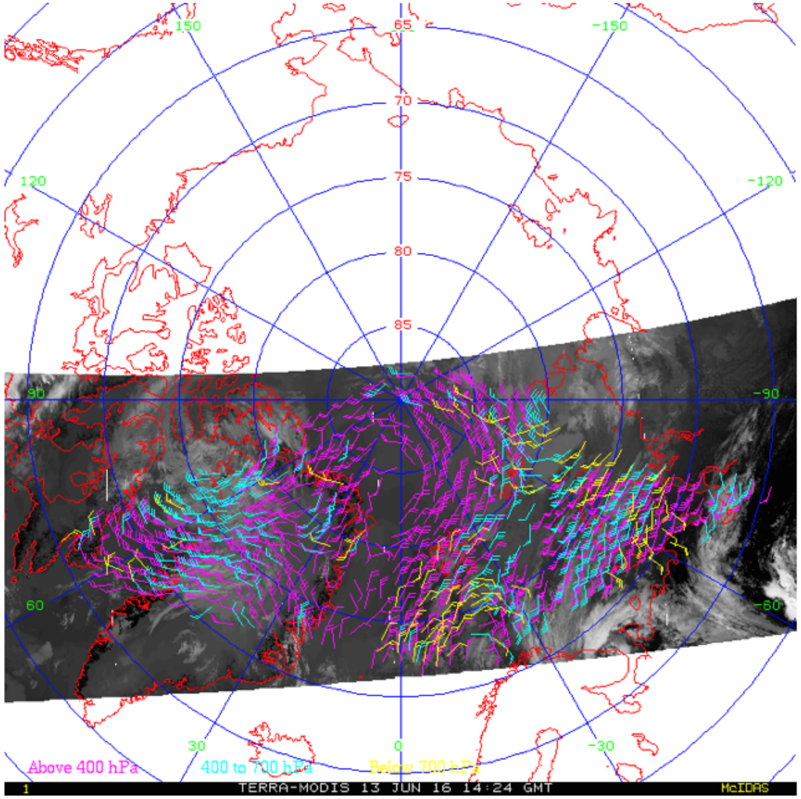
QI>60

Aqua	**Count**	**Accur.**	**Prec.**	**Speed Bias**	**Speed RMSE**
NT	1158	4.99	3.41	-0.21	4.32
Windco	1158	5.86	4.29	-0.02	4.85

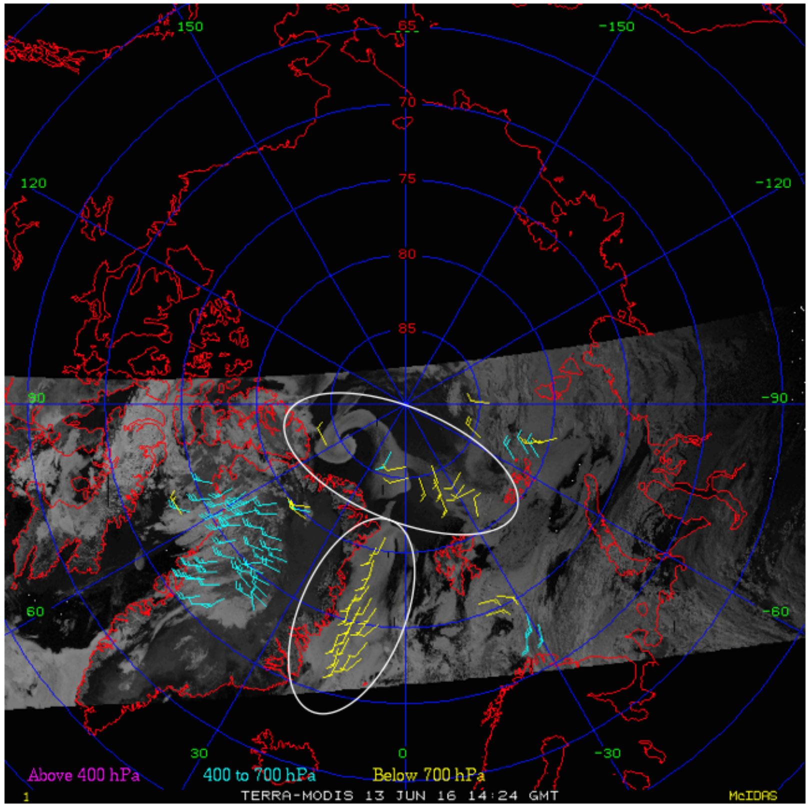
Terra	**Count**	**Accur.**	**Prec.**	**Speed Bias**	**Speed RMSE**
NT	2281	4.97	3.64	-0.18	3.96
Windco	2281	5.38	4.01	-0.56	3.99

Polar Winds from a SWIR Band: New Statistics

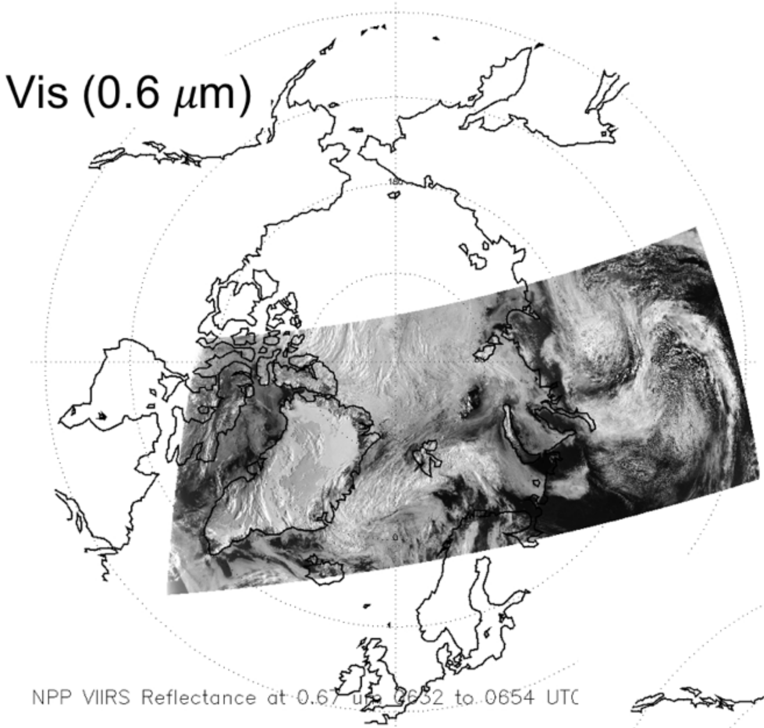
WV & IR

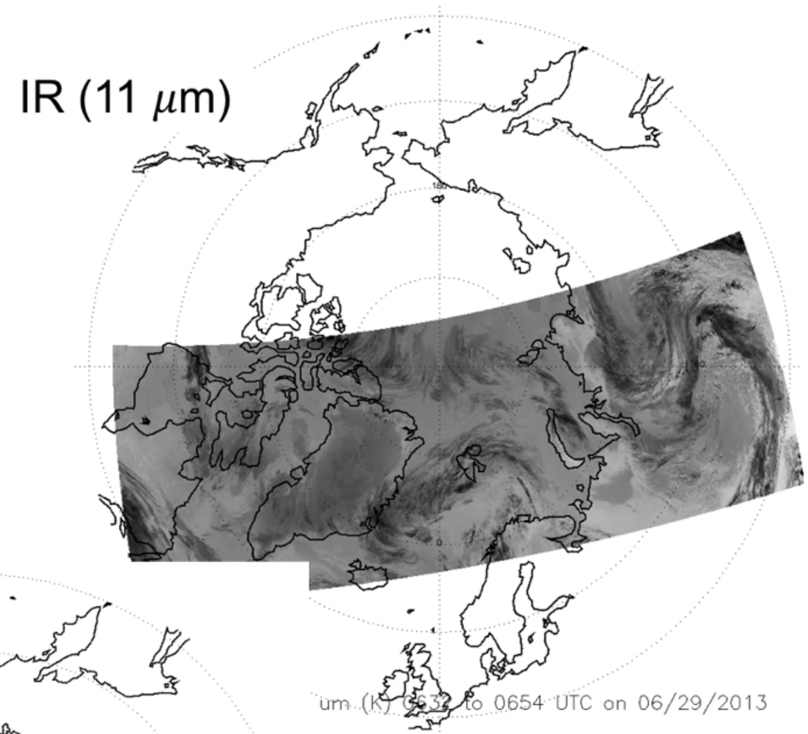


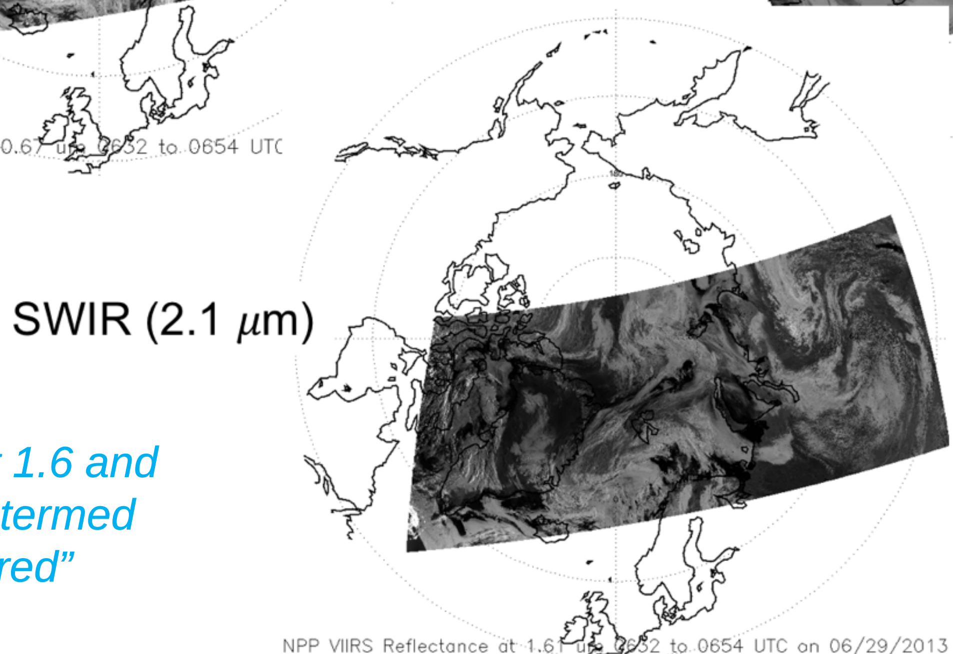
SWIR



MODIS Visible, SWIR, and IR: Arctic







Imager bands at 1.6 and 2.1 μm are best termed "shortwave infrared" (SWIR).

Comparison to Raobs

MODIS Aqua and Terra SWIR, Arctic only

Aqua	Count	Accur.	Prec.	Speed Bias	Speed RMSE
HIGH	759	5.62	3.13	-0.35	4.48
MID	4042	4.80	3.21	-0.85	3.80
LOW	647	4.62	3.26	-0.56	3.37
TOTAL	5488	4.90	3.22	-0.75	3.85

Terra	Count	Accur.	Prec.	Speed Bias	Speed RMSE
HIGH	833	5.67	3.63	-0.47	4.32
MID	2631	4.65	3.02	-0.78	3.73
LOW	670	4.17	2.40	-0.48	3.23
TOTAL	4134	4.77	3.10	-0.67	3.78

VIIRS IR, Sep 2013 - Jan 2014

All Levels (100-1000 hPa)	*VIIRS Polar Wind v… Winds (…* NHEM
Accuracy	5.67
Precision	3.41
Speed bias	0.38
Speed	17.61
Sample	9650
High Level (100-400 hPa)	**NHEM**
Accuracy	6.21
Precision	3.55
Speed bias	-0.06
Speed	23.62
Sample	3054
Mid Level (400-700 hPa)	**NHEM**
Accuracy	5.65
Precision	3.40
Speed bias	0.56
Speed	16.69
Sample	4468
Low Level (700-1000 hPa)	**NHEM**
Accuracy	4.95
Precision	3.08
Speed bias	0.64
Speed	10.91
Sample	2128

MODIS SWIR vs IR

MODIS Aqua and Terra SWIR, Arctic only, Apr-Sep 2017

Collocated vectors within 10 km

	Count	SWIR Vector RMSE	IR Vector RMSE	SWIR Mean Pressure	IR Mean Pressure
Aqua	645	6.02	6.26	535.91	526.71
Terra	838	5.87	6.08	532.52	519.09

Feature-tracked 3D winds from Hyperspectral IR Sounder

David Santek[1], Derek Posselt[2], Will McCarty[3]

[1]Space Science and Engineering Center/University of Wisconsin – Madison

[2]NASA JPL

[3]NASA Global Modeling and Assimilation Office

Why 3D Winds?

Importance of global 3D winds in weather predictability

•Fill in data void regions, most notably over oceanic, tropical, and polar regions.

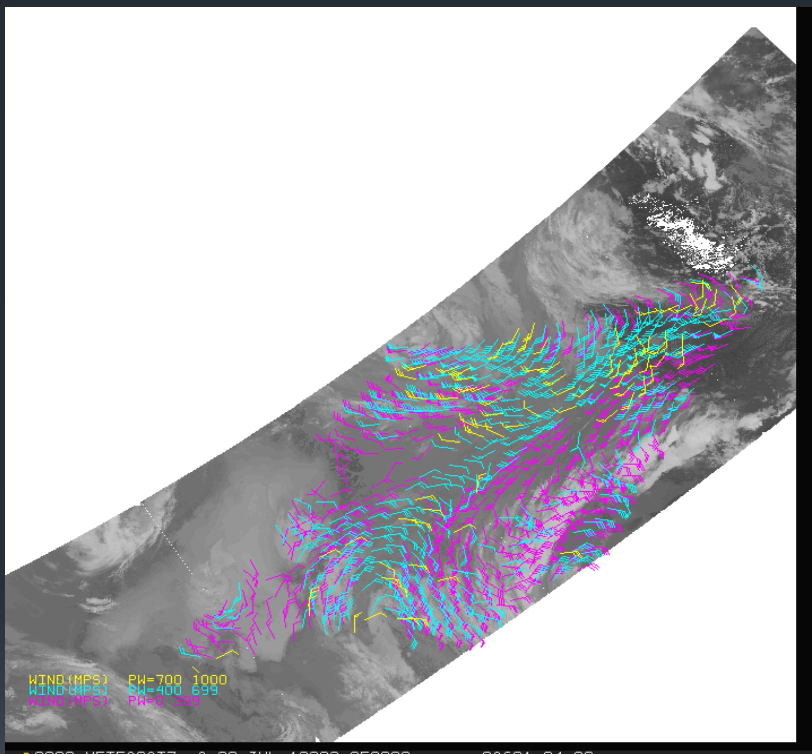
•This lack of data, especially wind information, is "the number-one unmet measurement objective for improving weather forecasts." (NRC 2007).

•Decadal Survey recommended a 3D tropospheric wind mission, using a space-based LIDAR instrument and/or the use of hyperspectral infrared measurements.

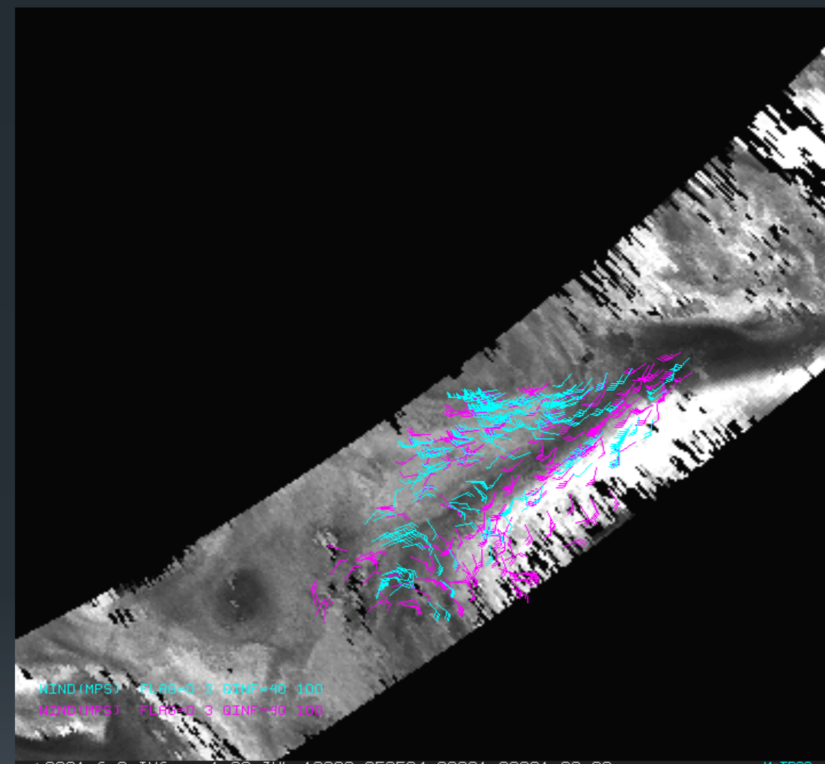
What are 3D Winds?

- Create images of horizontal fields of humidity and ozone, derived from retrievals using AIRS, CrIS, IASI
- Track humidity and ozone features over time
- Advantages:
  a) 3D wind distribution
  b) Implicit AMV height
  c) Clear sky and above cloud
- Current disadvantages:
  - Low spatial resolution (13.5 km)
  - Narrower swath

Aqua MODIS AMVs
AIRS Retrieval AMVs at All Levels



MODIS 20 July 2012 0551 UTC
Infrared and Water Vapor
(including clear sky)



AIRS 20 July 2012 0505 UTC
Ozone: 103 to 201 hPa
Moisture: 359 to 616 hPa

New NASA Project

- NASA ROSES 2017 A.37: The Science of Terra, Aqua, and Suomi NPP
- Proposal selected: Assimilation of 3D Atmospheric Motion Vectors to Improve Subseasonal Numerical Weather Forecasts
  - PI: D. Santek   Co-I: D. Posselt (JPL), W. McCarty (NASA/GMAO)
  - Previous work only used AIRS; this extends to CrIS and IASI and improvements to algorithm (SSEC)
  - Better quantify winds uncertainty (JPL)
  - Evaluate impact in longer range forecasts, on the order of 2 weeks (GMAO)

ICWG Cloud Height Topical Group Activity

Phil Watts (EUMETSAT), Andy Heidinger (NOAA)

- Standardization of uncertainty reporting.
- Overlap cloud detection methods. Comparison of external and internal methods and use switch between them. EUMETSAT issues resolved.
- Planetary Boundary Layer Height Assignment, especially related to AMVs.
- Vertical Homogeneity: methods and impact on height retrievals
- Optimal cloud microphysical assumptions and their impact
- Cloud base estimation.   NOAA implemented a cloud base retrieval and other methods exist to infer geometrical extent. Is this of use for AMVs?
- EUMETSAT close to Himawari-8/GOES-16 support.

EUMETSAT

ICWG Cloud Height Intercomparison Plans

Phil Watts (EUMETSAT), Andy Heidinger (NOAA)

- Intercomparison Data
  - July 20 - 21, 2016 JMA HIMAWARI 8 (primary and aligns with IWWG)
  - August 19, 2015 JMA HIMAWARI 8 (ICWG-1)
  - June 13, 2008 EUMETSAT MSG (CREW)
  - NOAA SNPP VIIRS (optional and date to be determined)
  - NOAA GOES-16 (optional and date to be determined)
- Intercomparison Plans
  - Standard “CREW” analysis will be applied to cloud heights, temperatures and pressures. This includes provider to provider scatterplots, Taylor Plots relative to CALIPSO and individual CALIPSO cross-sections (with AVACS). Providers expected to be CMA, EUMETSAT, JMA, KMA, NOAA, NASA and others
  - Cloud Height Topical Group will add some IWWG specific analysis
    - Level of Best Fit from NWP Background and RAOB co-locations
    - Uncertainty Comparisons (for those that provide this)

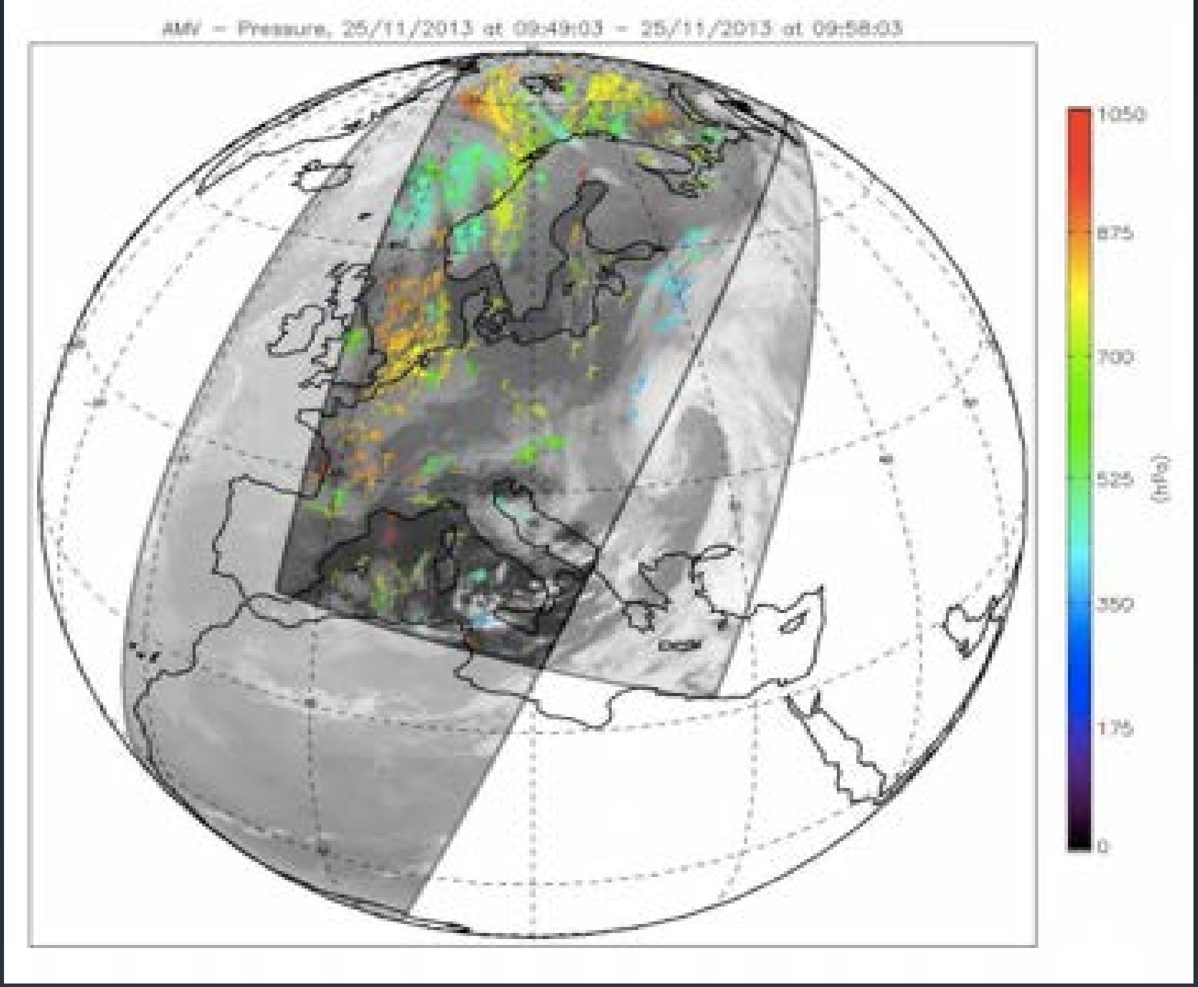
EUMETSAT

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
NOAA
U.S. DEPARTMENT OF COMMERCE

Funded JPSS Risk Reduction

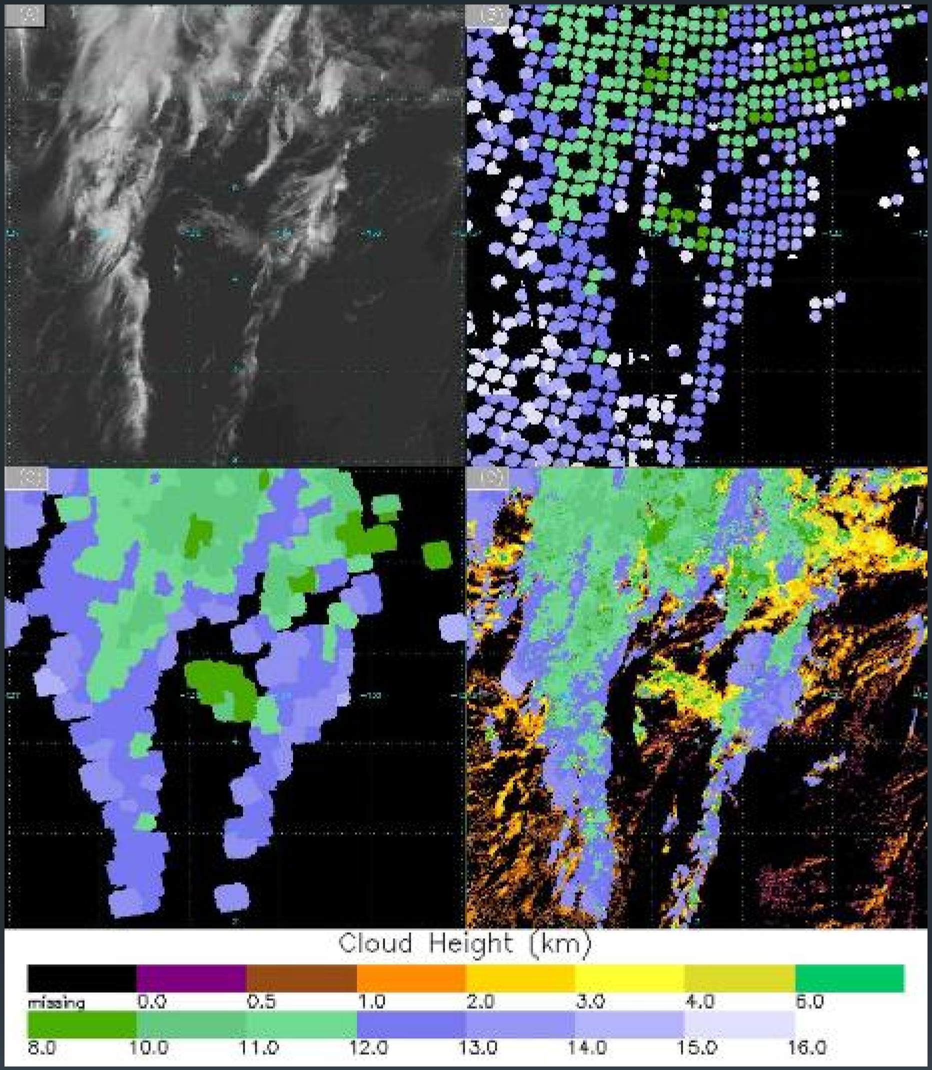
- Tandem S-NPP/NOAA-20 AMVs
  - Key, Santek, Daniels, Collard, Borde, Nebuda, Zhang, Dworak
- Merging NUCAPS and VIIRS
  - Heidinger, Wanzong, Nebuda, Quinn, Bearson, Key, Smith
  - Daniels, Bresky, Bailey
- Extending VIIRS spectral coverage
  - Weisz, Borbas, Menzel, Baum, Moeller, Frey, Wanzong, Goldberg, Santek
  - Daniels, Bresky, Bailey

Development and Impact of Global Winds from Tandem S-NPP and NOAA 20 VIIRS

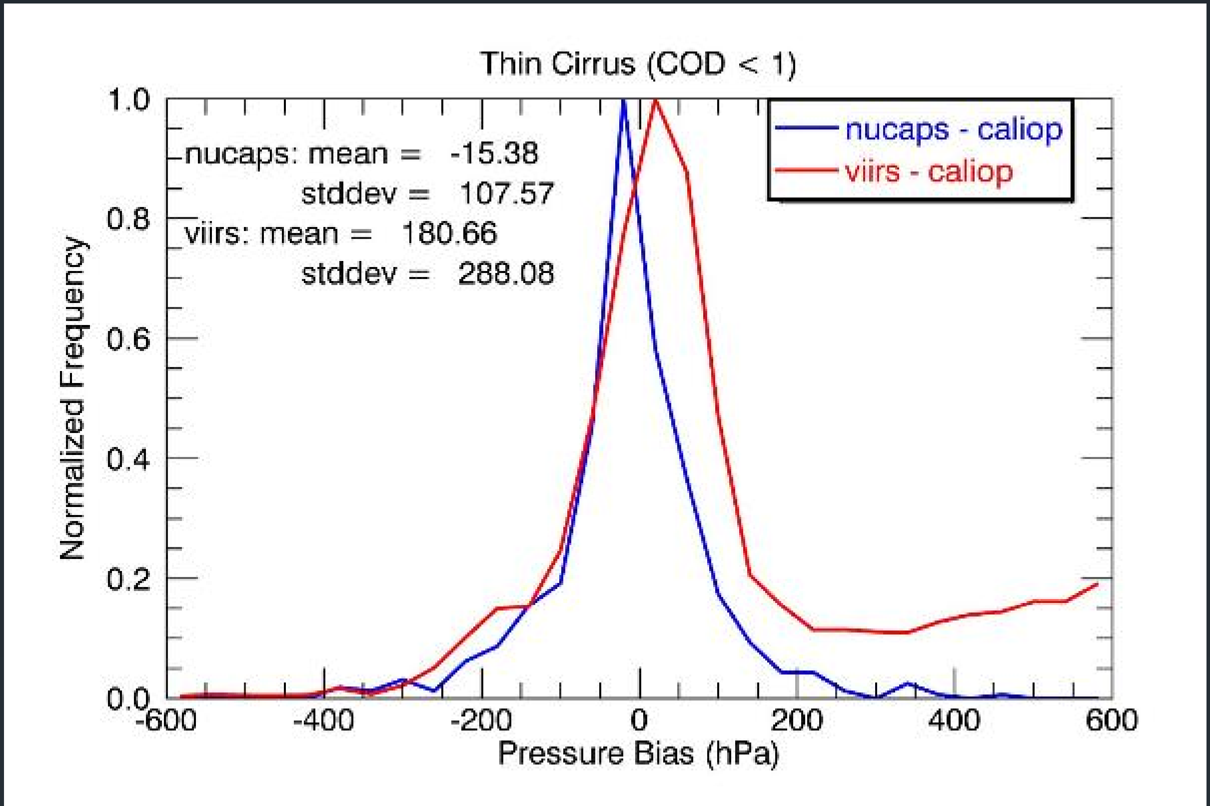


- Tandem wind example from Metop-A/B AVHRR.
- S-NPP and NOAA-20 (formerly JPSS-1) are ½ orbit apart. There is opportunity to track global winds using tandem VIIRS 50 minutes apart.

Merging NUCAPS with the VIIRS Enterprise Cloud Algorithms for Improved Polar Cloud Detection, Cloud Heights and Polar Winds.



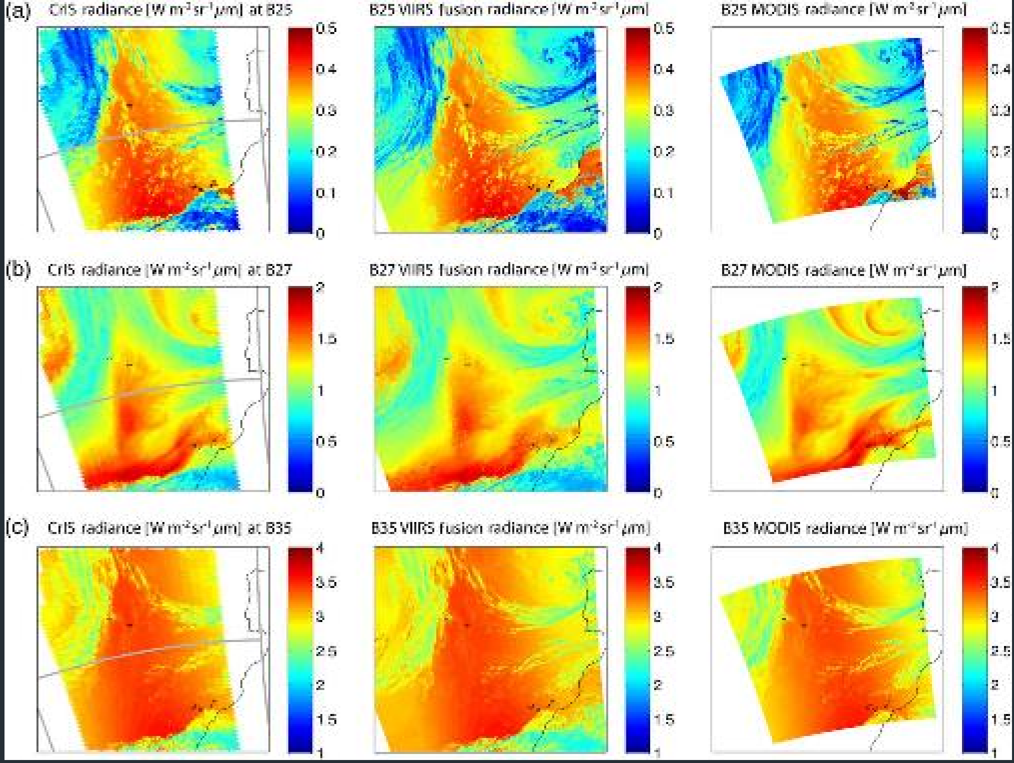
An example region within a granule observed between 2213 and 2221 UTC on 20 Aug 2015 shows (a) 11 μ m brightness temperature (b) sounder height at original resolution (c) smoothed sounder height background (d) final retrieved cloud height for both water and ice phases. Smoothing is applied to sounder field of views with cloud pressure less than 440 hPa only in (c). Water cloud retrievals in (d) are not impacted by sounder. The color bar at the bottom applies to all of the cloud height images.



Bias of thin cirrus cloud top pressure from NUCAPS and VIIRS relative to CALIPSO/CALIOP, based on one day of SNPP/CALIPSO matchups on 20 June 2017. CALIPSO/CALIOP cloud phase and optical depth data are applied for used to select thin cirrus.

Heidinger, A. K, Y. Li, , S. Wanzong and R. Holz, 2018: Using Sounder Data to Improve Cirrus Cloud Height Estimation from Satellite Imagers. under review at JTECH .

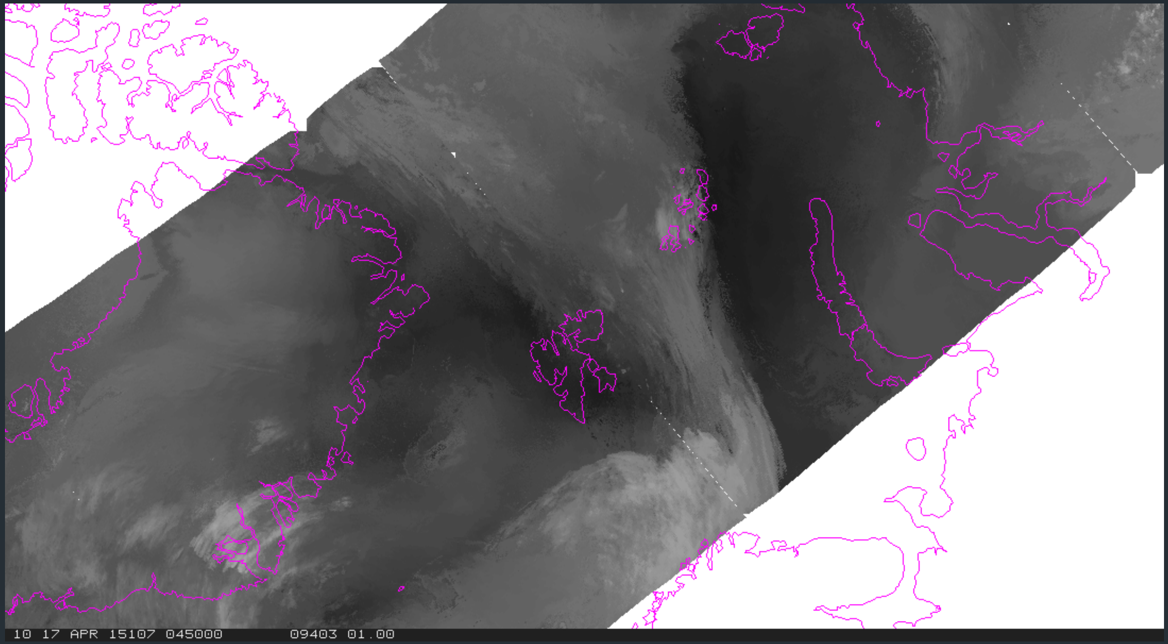
Concept Study to Extend VIIRS Spectral Coverage Using CrIS Radiance Measurements and to Explore Potential Applications



Convolved CrIS radiances (left), newly constructed VIIRS fusion radiances (middle), and the observed MODIS radiances (right) for the same geographical region for MODIS bands 25, 27, and 35 in (a–c), respectively. VIIRS granule outlines are shown in gray in the left column.

Weisz, E., B. Baum and W. P. Menzel (2017): Fusion of satellite-based imager and sounder data to construct supplementary high spatial resolution narrowband IR radiances, J. of Applied Remote Sensing, Volume 11, Issue 3, 2017.

Fusion



Original MODIS