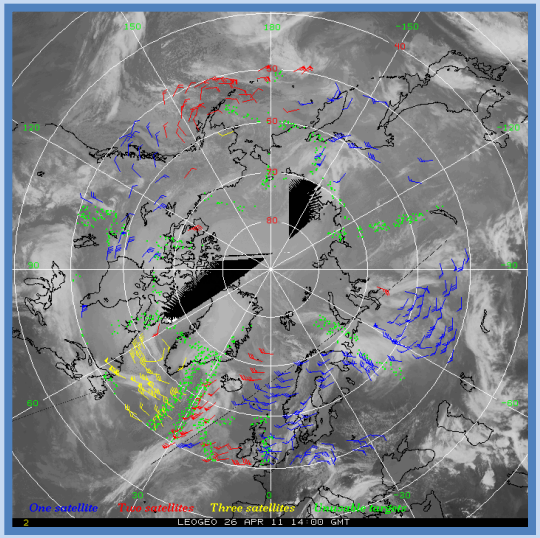
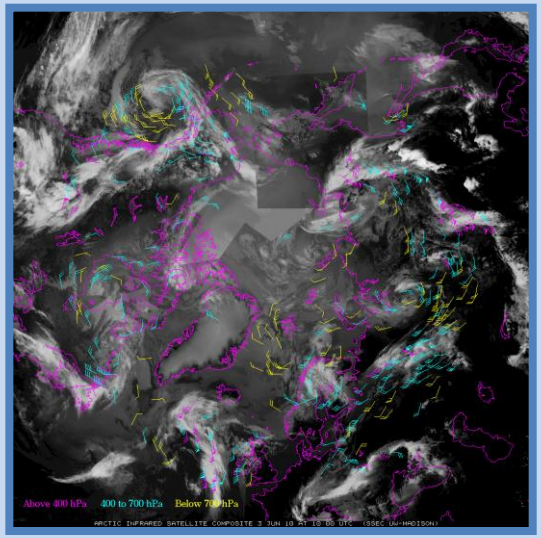
Combined Geo/Leo High Latitude Atmospheric Motion Vectors



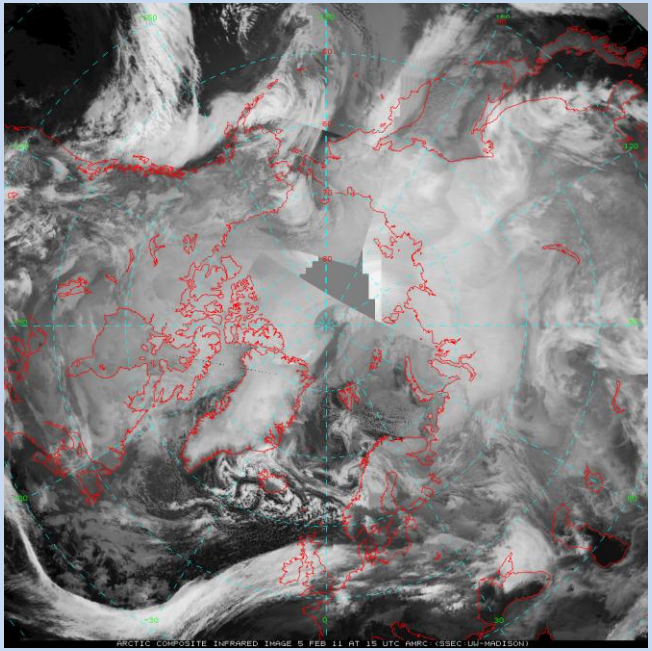


Matthew A. Lazzara[1], David A. Santek[2], Brett Hoover[2], Nick A. Bearson[2], Richard Dworak[2], Jeffrey R. Key[3], Jamie Daniels[3], and Chris S. Velden[2]

[1]Antarctic Meteorological Research Center
[2]Cooperative Institute Meteorological Satellite Studies
Space Science and Engineering Center
University of Wisconsin-Madison

[3]NOAA/NESDIS/STAR

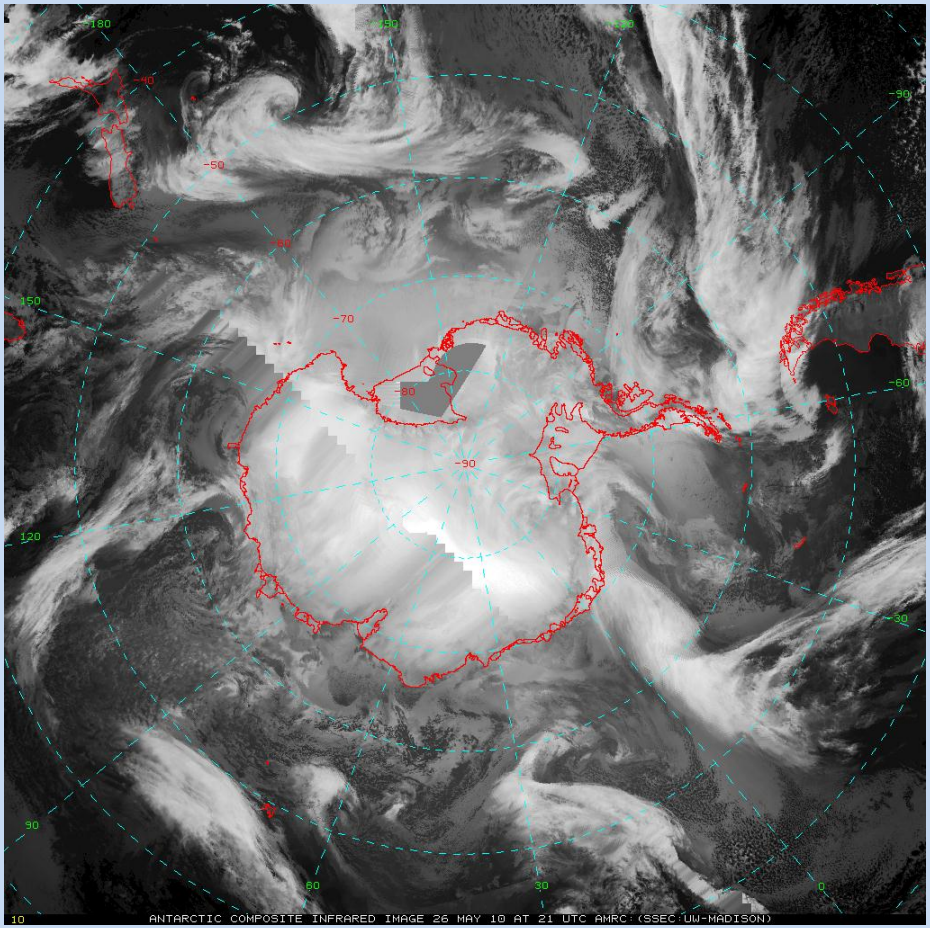
Outline: Combined Geo/Leo High Latitude Atmospheric Motion Vectors (AMV)



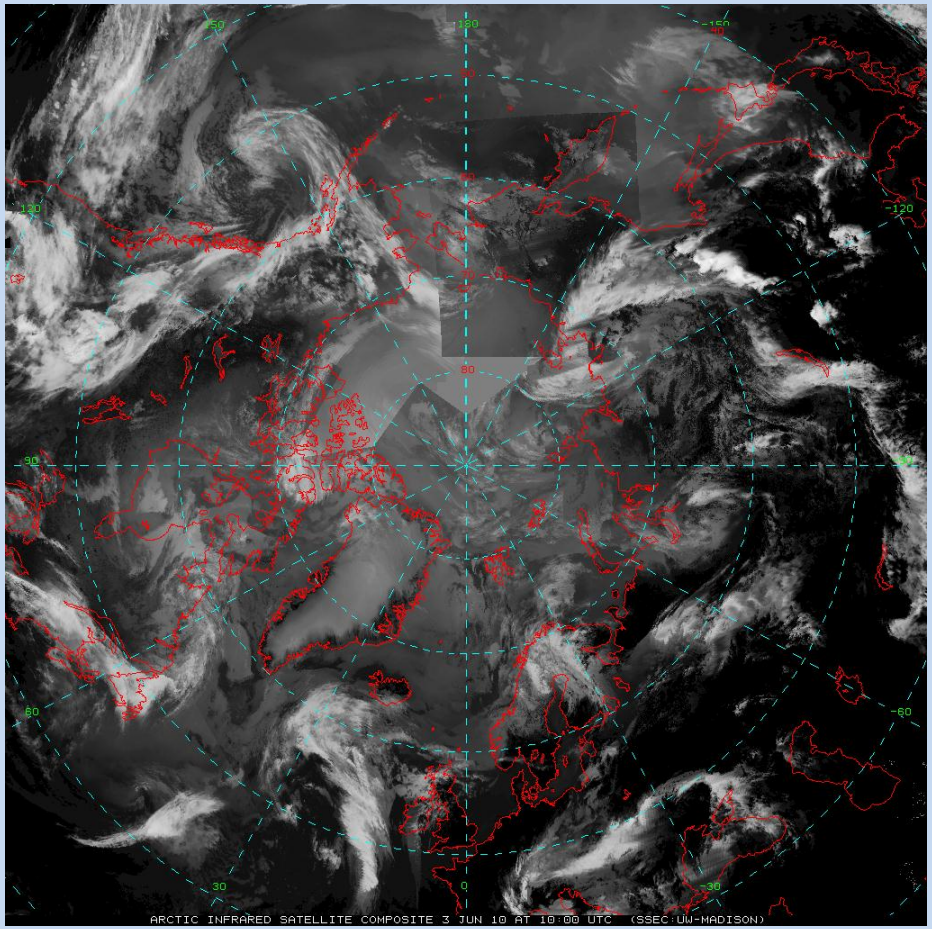
- Phase 0: Exploration
- Phase I: Year 1 - Testing
- Phase II: Year 2 - Refining
- Future
  - AMVs and Composites
- Thanks:
  - Rick Kohrs, Jerry Robaidek, Steve Wanzong, Scott Lindstrom, & Utkan Kolat
  - NOAA GOES-R Risk Reduction Program

Original Polar Satellite Composites

Antarctic



Arctic



Combined via selecting the coldest pixel
- *Reduces limb darkening
- *Smooth transition between satellites
- *Intended for visualization

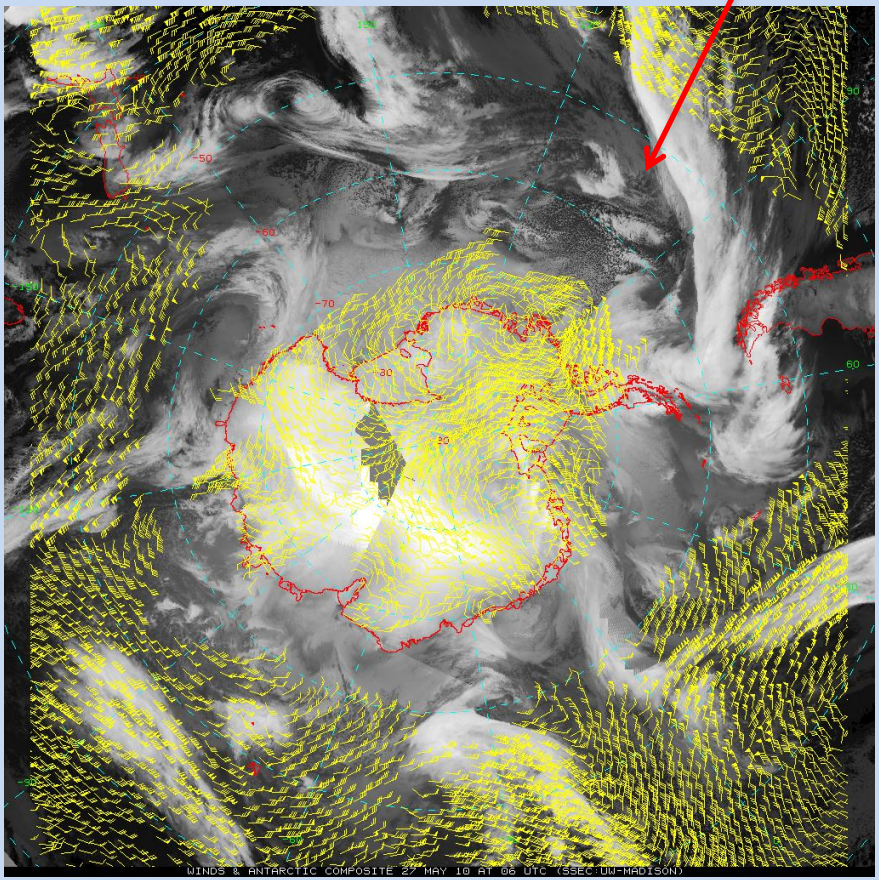
Geostationary:
- *GOES, Meteosat, FY-2, MTSAT

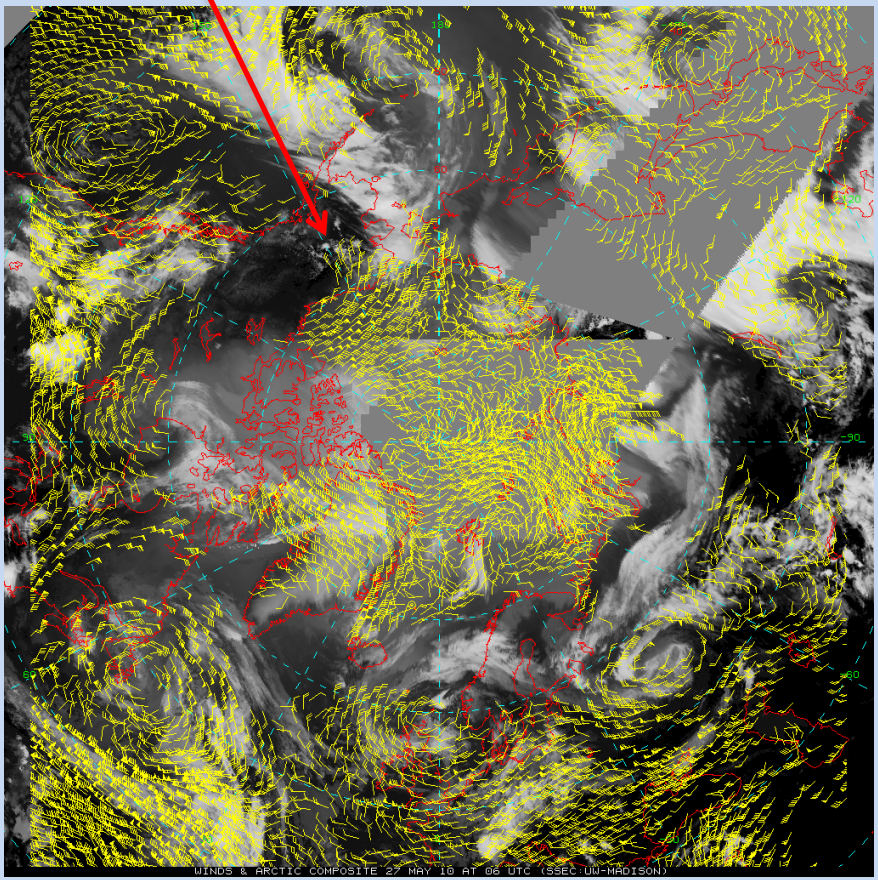
Polar-orbiting:
- *NOAA, MODIS, Metop

Geostationary and Polar-orbiting Atmospheric Motion Vectors

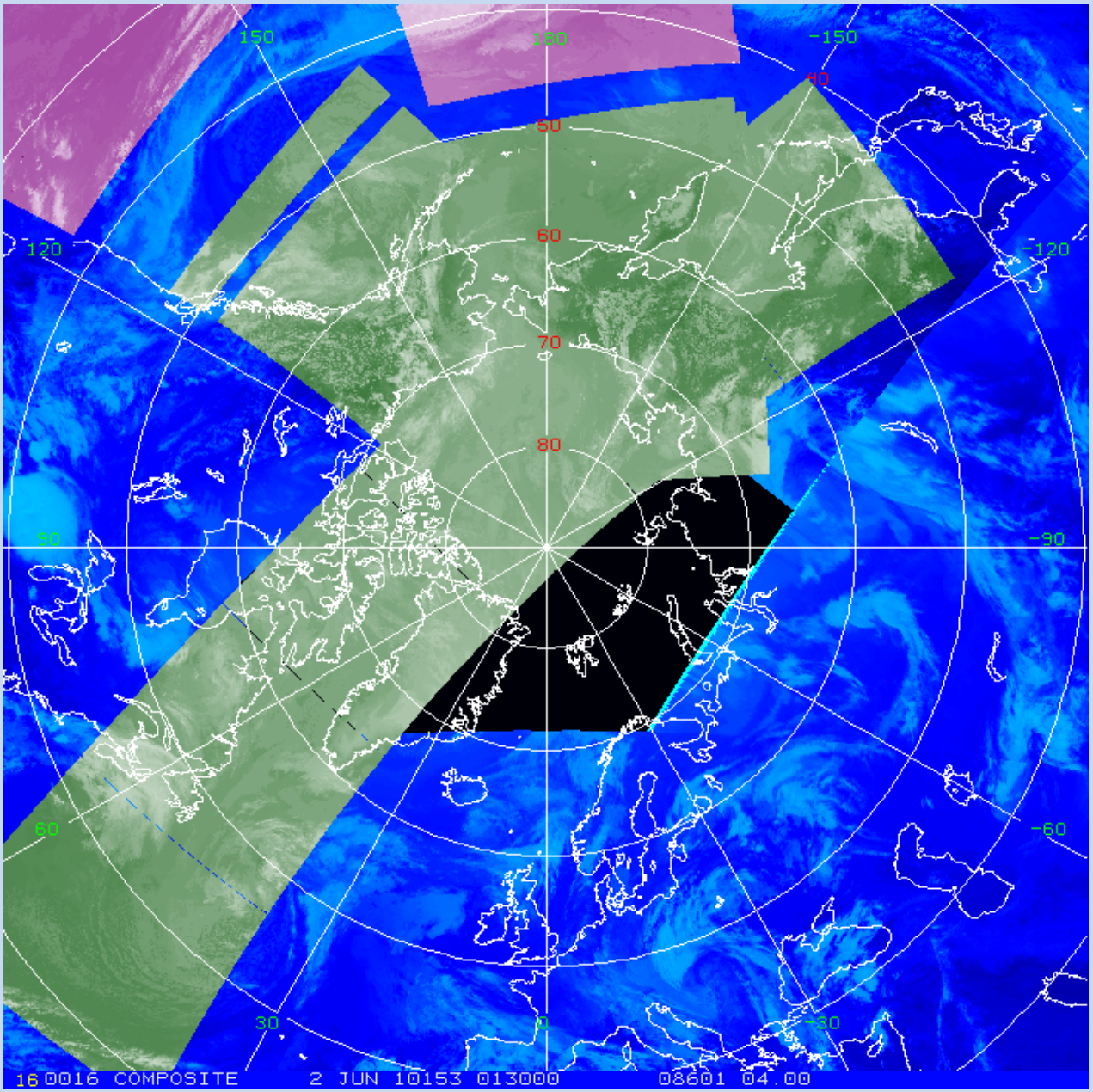
Missing winds – gap in coverage

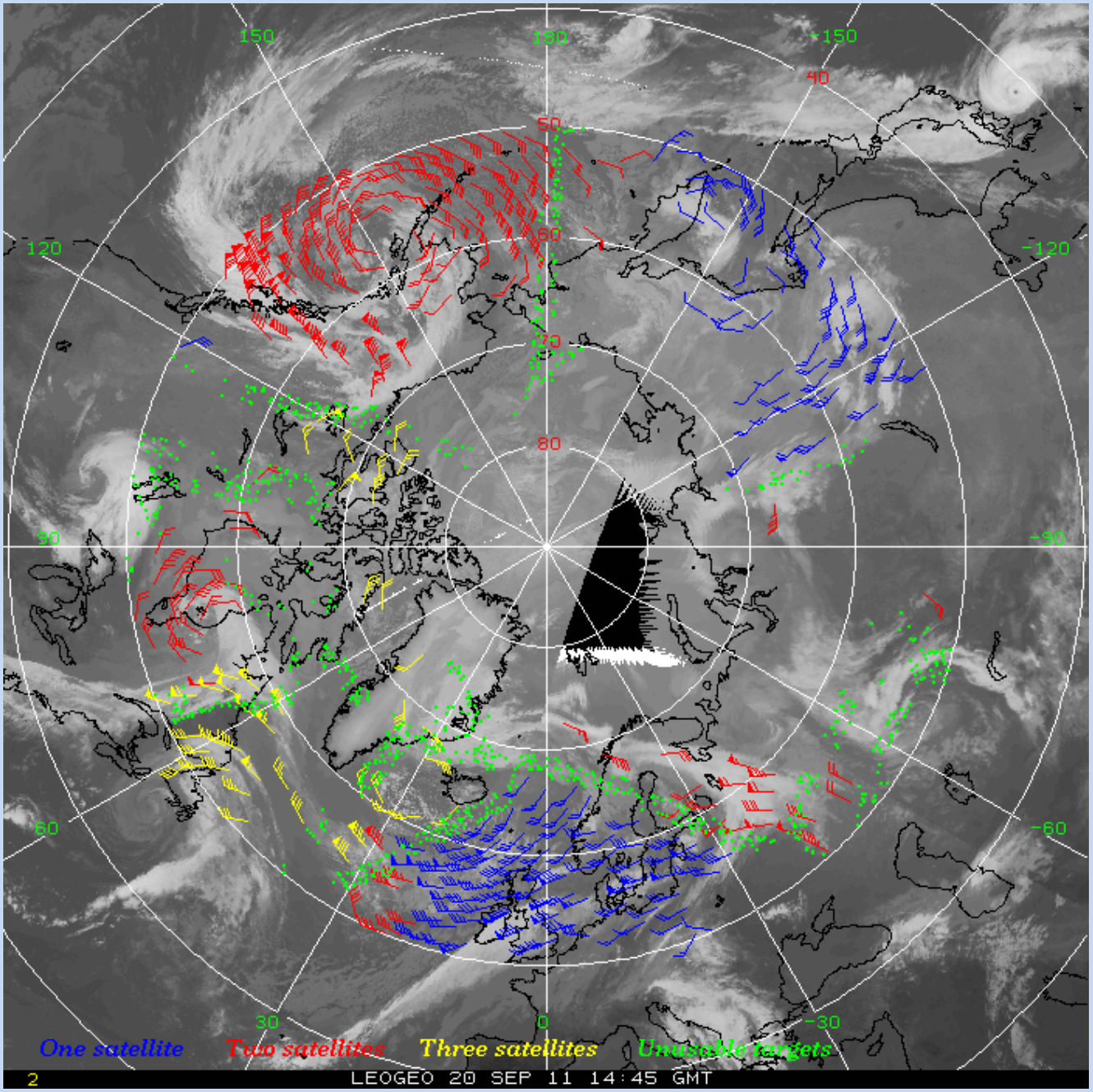
- NWP centers: the polar jet stream can be located in this gap; improper model initialization can lead to errors in the forecasts.
- CIMSS research: the addition of the wind information is important in this region.





Example Mix of Satellites

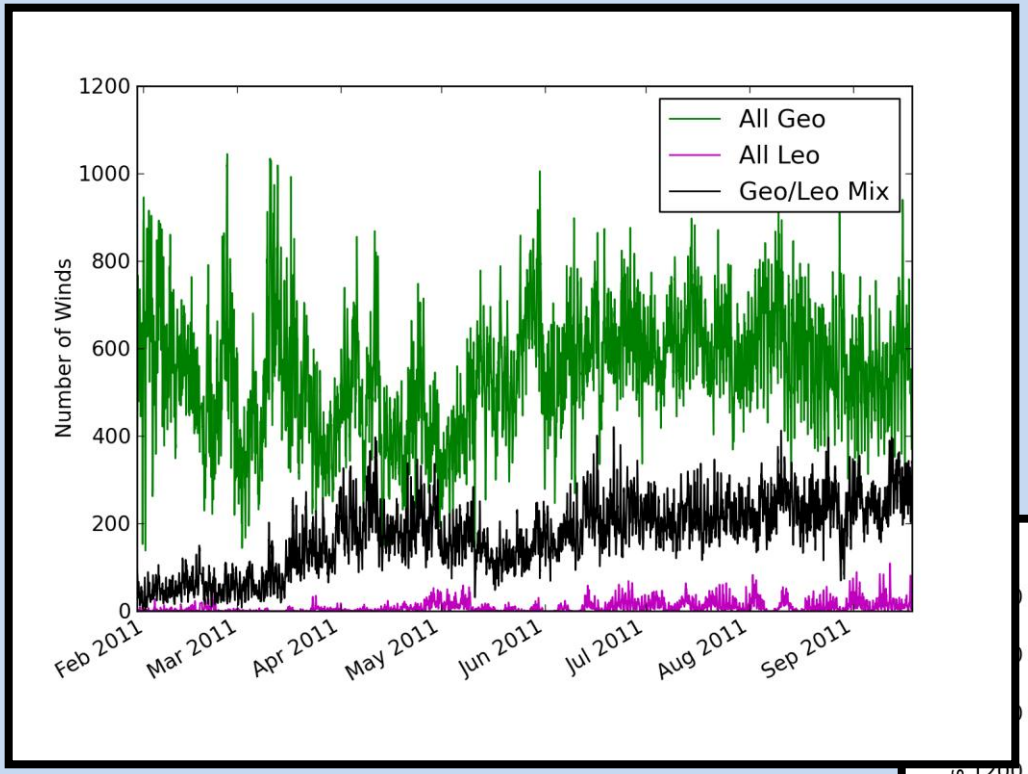



150
180
-150
40
50
60
70
80
120
-120
90
-90
60
-60
30
0
-30
One satellite
Two satellites
Three satellites
Unusable targets
2
LEOGEO 20 SEP 11 14:45 GMT

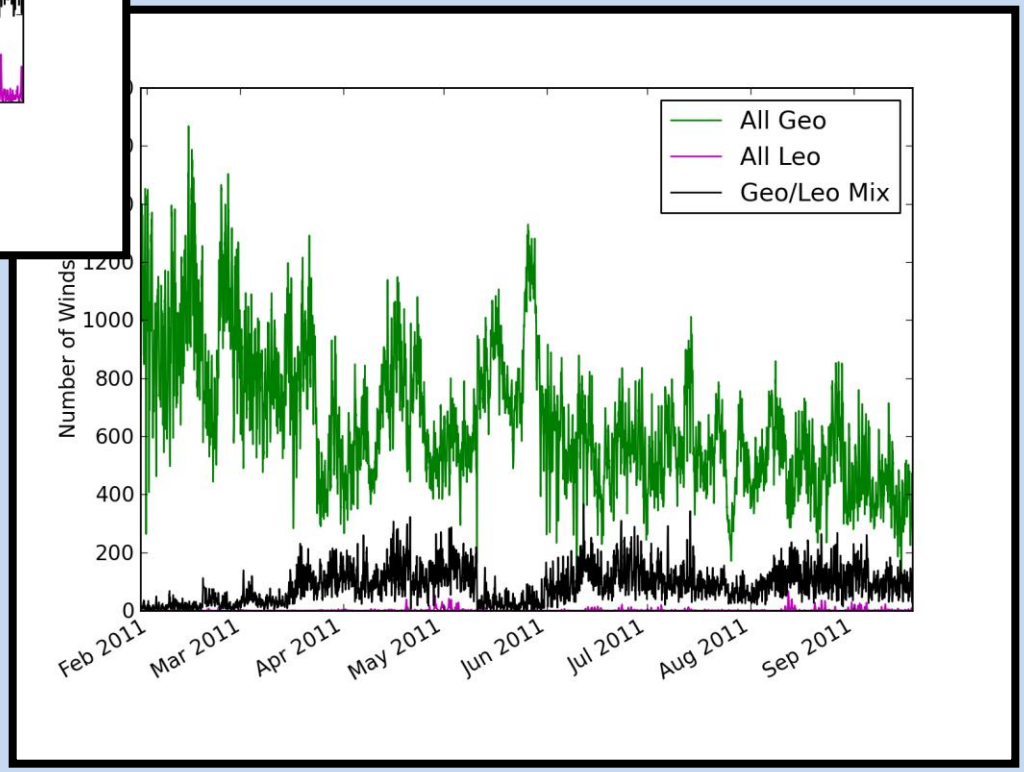
Phase/Year II: Project Goals…

- Continue the routine production of the composites and associated atmospheric motion vector (AMV) wind product at CIMSS.
  - Archive the generated AMV winds at CIMSS.
  - Make available the composite AMV to interested NWP Centers (e.g. FNMOC, JMA, etc.)
  - Provide the composite AMV to the GOES-R proving ground.
  - Continue validation in real-time using NESDIS methods with radiosondes and continue to explore verification with aircraft observations.
- Report on assimilation statistics of the composite AMV wind product as compared to those from the geostationary and polar wind products.
  - Investigate model forecast impact of Composite AMVs
- Continue to compose paper on the project and submit to a peer-reviewed journal.

Tracking Multiple Satellite Usage…



…Northern Hemisphere

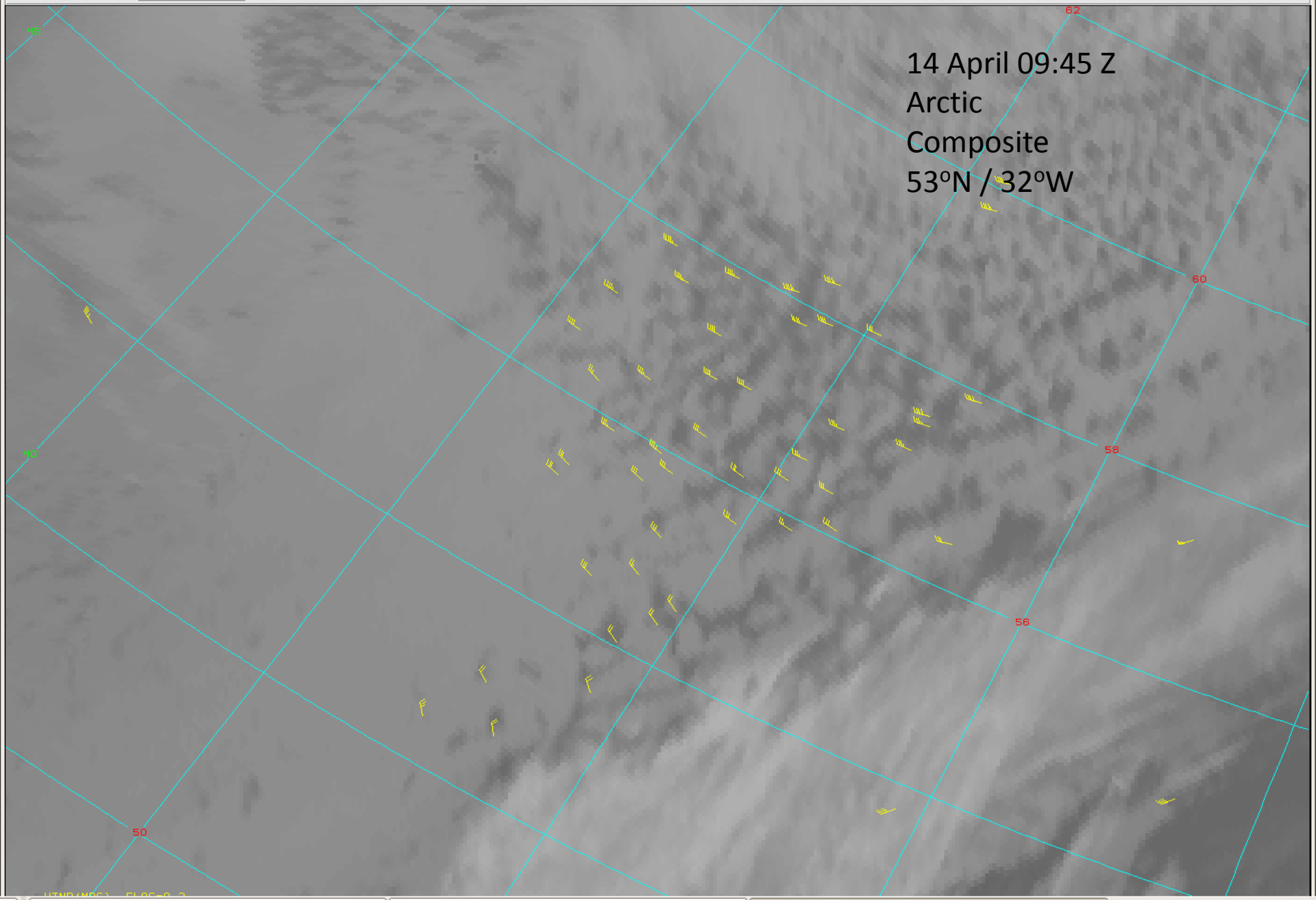


Southern Hemisphere…

McIDAS-X 2010.1: ukolat@geneva.ssec.wisc.edu

File Display Copy List Colors Configure View Sidecars Help

1 Show Frame Loop Speed: Pause on Latest



[WiscMail - Mozilla Firefox] T:ukolat@geneva.ssec.wisc.edu I:ukolat@geneva.ssec.wisc.edu

McIDAS-X 2010.1: ukolat@geneva.ssec.wisc.edu

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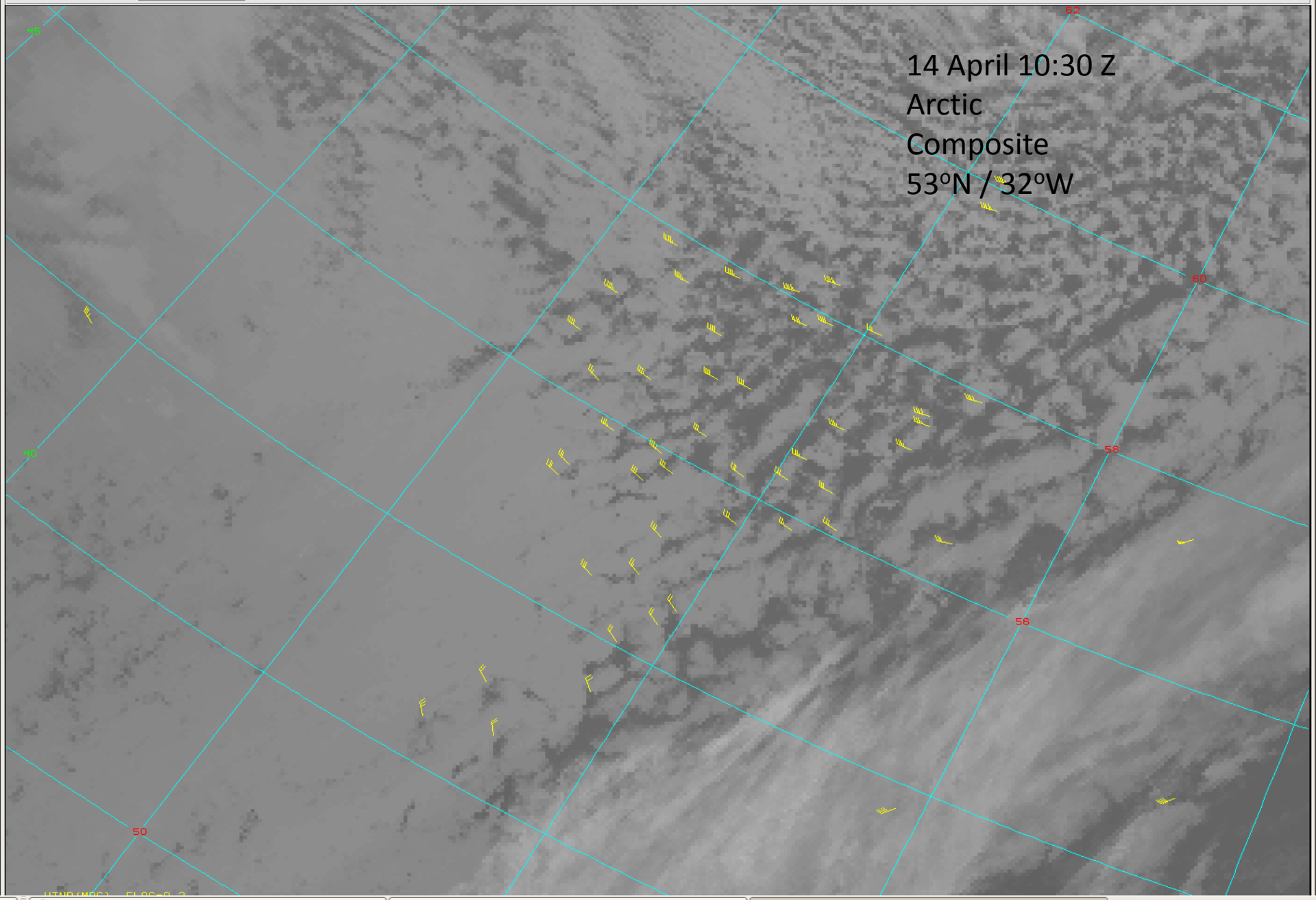
2 Show Frame Loop Speed: Pause on Latest



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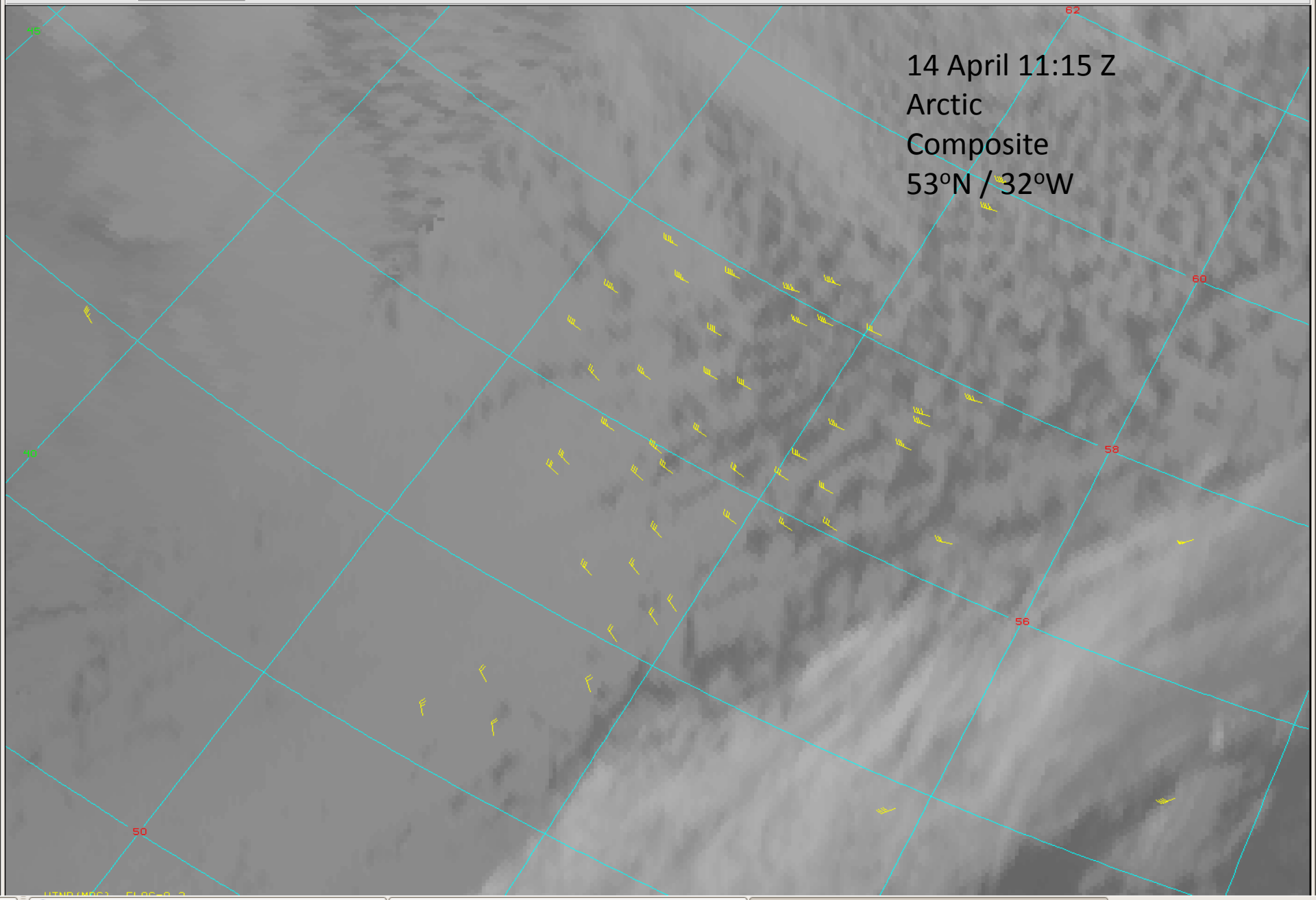
3 Show Frame Loop Speed: Pause on Latest



[WiscMail - Mozilla Firefox] T:ukolat@geneva.ssec.wisc.edu I:ukolat@geneva.ssec.wisc.edu

Making Composite AMV available for the community…

- Informal archive of Composite AMVs at CIMSS
- Composite AMVs for Numerical Weather Prediction:
  - Nancy Baker & Randy Pauley – NRL (NOGAPS)
    - JCSDA Partner
  - Jordan Powers/Jim Bresch – NCAR (Polar WRF – AMPS)
- Effort underway for winds to go into the GOES-R Proving Ground
  - NWS Alaska, others…
- Available via the Web/FTP:
  - http://stratus.ssec.wisc.edu/cgi-bin/polarwinds?leogeo
  - ftp://stratus.ssec.wisc.edu/pub/winds/leogeo/
  - ftp://ftp.ssec.wisc.edu/pub/ssec/leogeo
  - http://amrc.ssec.wisc.edu - coming soon…
  - http://arctic.ssec.wisc.edu - coming soon…

Northern Hemisphere Validation Statistics

Phase 0 January-August 2011

- # Observations: 23,567
- All Vector RMSE: 7.49
- All Vector Difference: 6.01
- Speed Bias: -0.59

- # Observations: 5,172
- 60-70° Vector RMSE: 7.78
- 60-70° Vector Difference: 6.25
- Speed Bias: -0.70

Phase II March-August 2011 (Mix satellite only)

- # Observations: 30,980
- All Vector RMSE: 6.25
- All Vector Difference: 4.97
- Speed Bias: -0.51

- # Observations: 7022
- 60-70° Vector RMSE: 6.20
- 60-70° Vector Difference: 5.14
- Speed Bias: -0.92

Southern Hemisphere Validation Statistics

Phase 0 January-August 2011

- # Observations: 416
- All Vector RMSE: 12.37
- All Vector Difference: 8.39
- Speed Bias: -0.78

- # Observations: 278
- 60-70° Vector RMSE: 13.27
- 60-70° Vector Difference: 8.31
- Speed Bias: -1.09

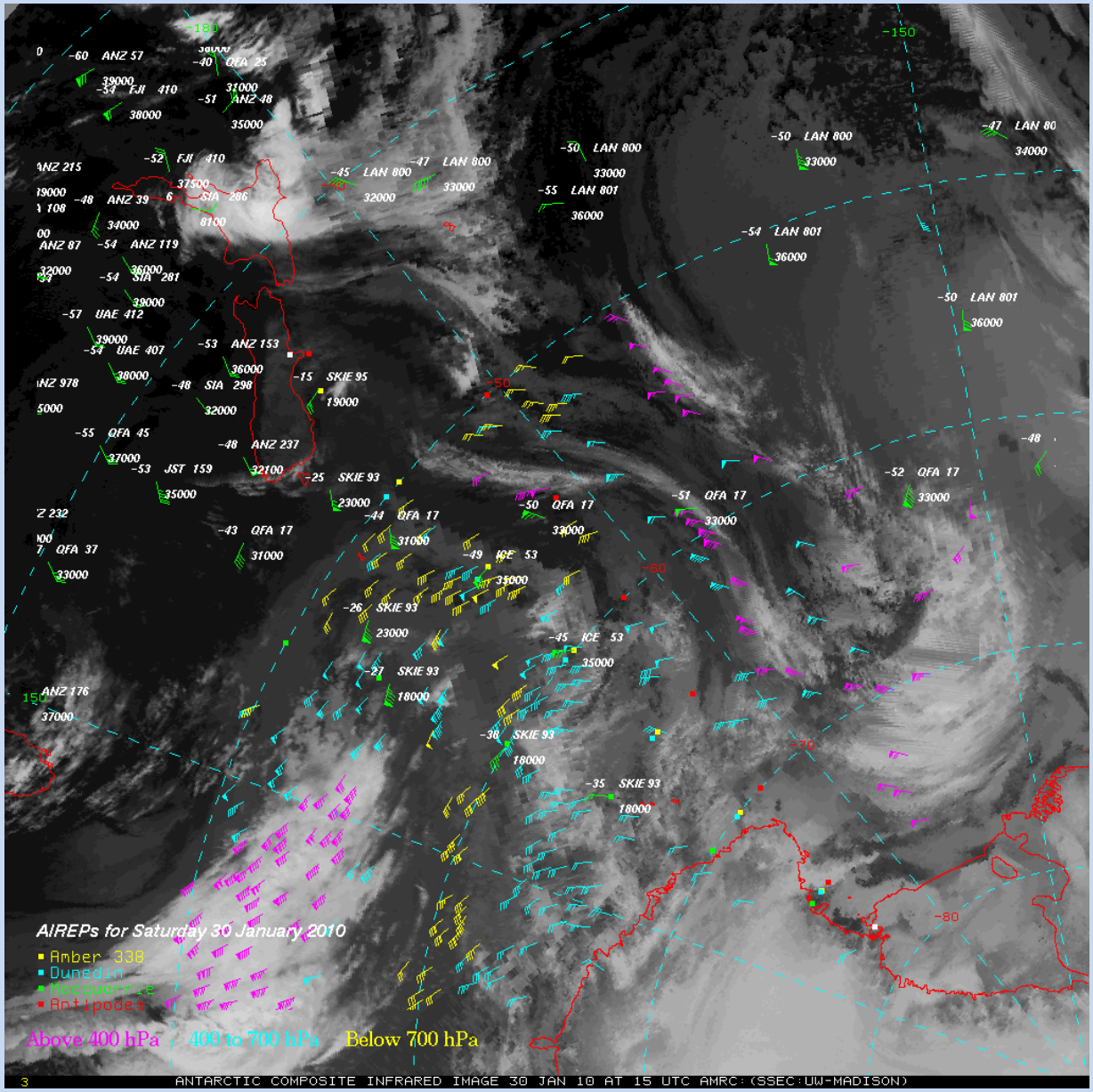
Phase II March-August 2011 (Mix satellite only)

- # Observations: 92
- All Vector RMSE: 7.91
- All Vector Difference: 6.50
- Speed Bias: 0.60

- # Observations: 46
- 60-70° Vector RMSE: 7.51
- 60-70° Vector Difference: 6.25
- Speed Bias: 1.43

Trial Using Aircraft for Validation…

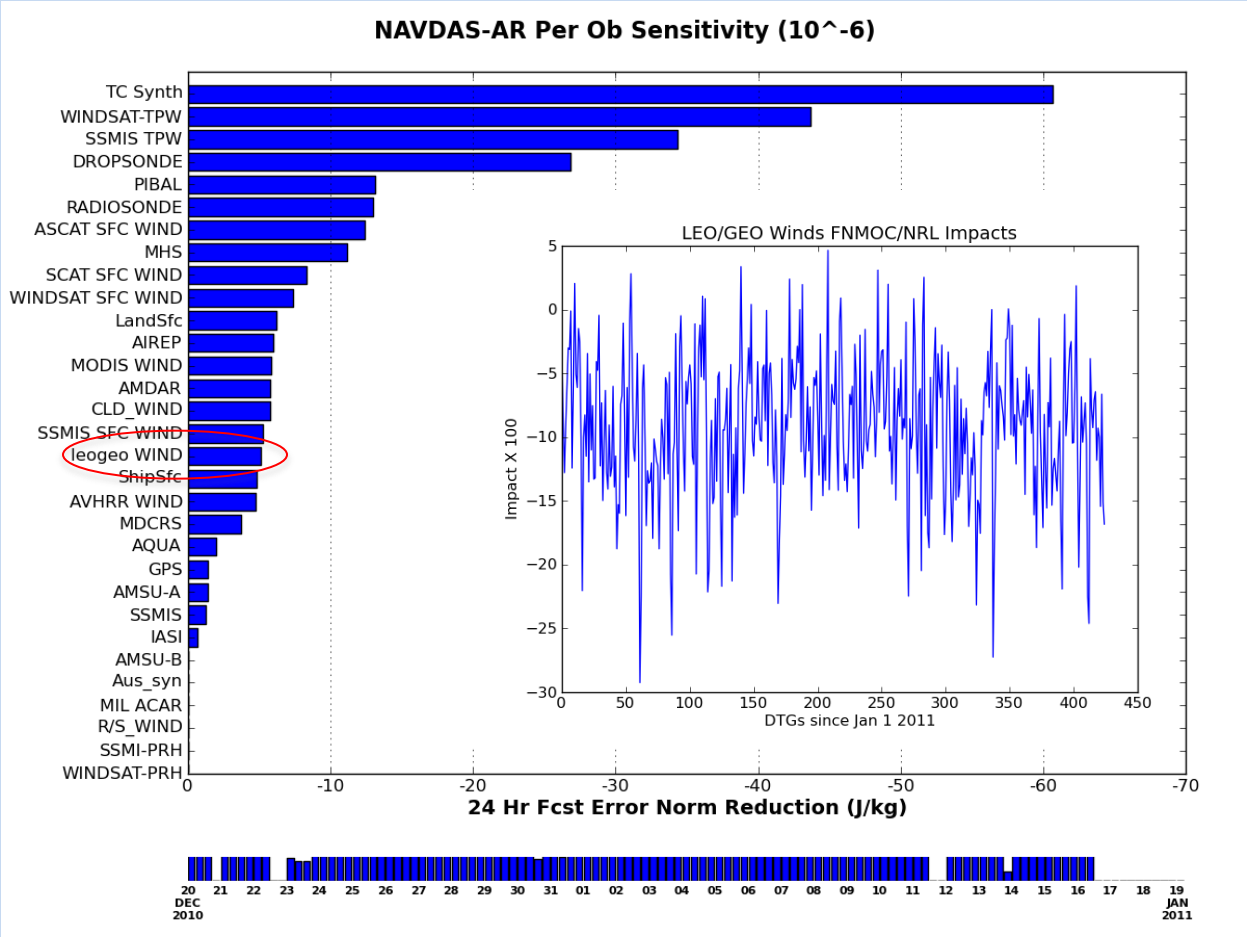
- Validation and trial testing of the compositing and AMV generation process in real-time
  - Using NESDIS methods with radiosondes and…
  - Exploring verification with aircraft observations (Experimental)
- Using in situ aircraft observations –
  - Different than prior efforts (Hasler et al., 1977)



Impact of LEO/GEO AMVs

NOGAPS FNMOC/NRL

- ✓ 24-hr error reduction in the FNMOC model for various observation types.
- ✓ The reduction in error resulting from the incorporation of the LEO-GEO wind product is circled.
- ✓ This wind product is incorporated into FNMOC's operational system.



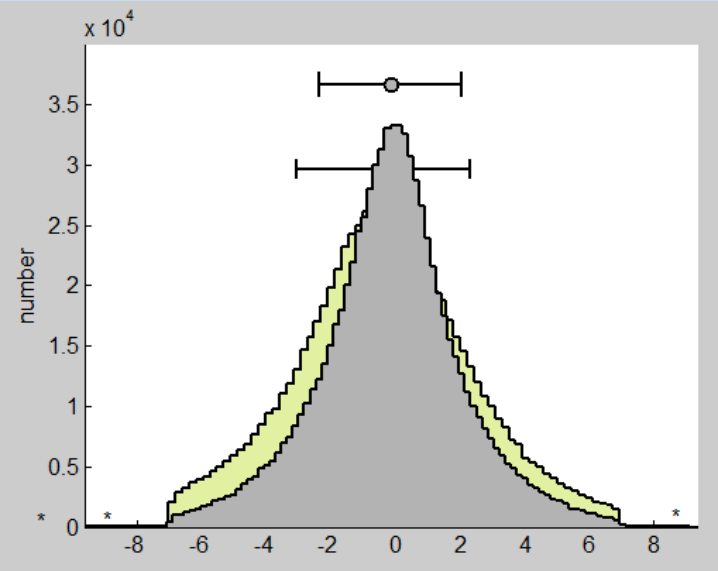
GDAS/GFS Model Impact

- Running GDAS/GFS (early 2010 operational version) on NCEP development system
- Leo/Geo winds from May 2011
- QC using MODIS polar winds criteria
  - Additionally, QI > 0.90
- Following statistics based on 10 days for all winds
  - both Arctic and Antarctic
  - 2 – 11 May 2011
  - approximately 800,000 winds

Assimilation Impact

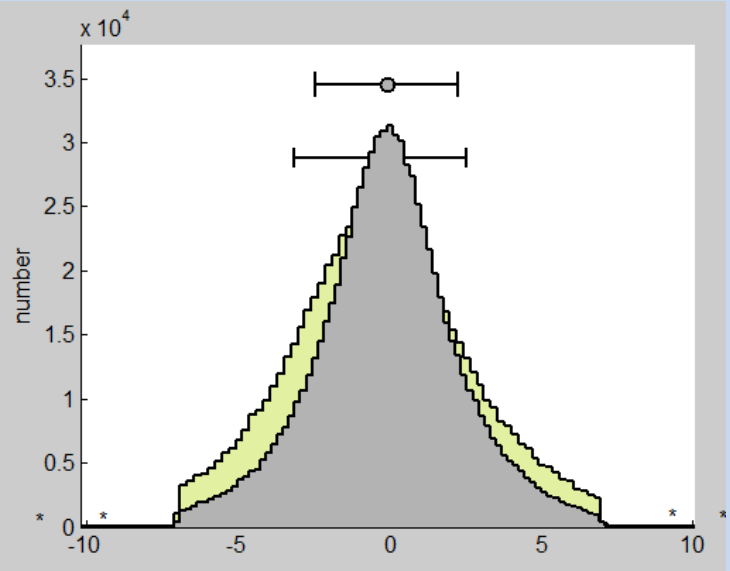
NCEP GSI

Observation minus background and analysis



U-component (ms^{-1})

O-B: mean = -0.4 stddev = 2.7
O-A: mean = -0.2 stddev = 2.2



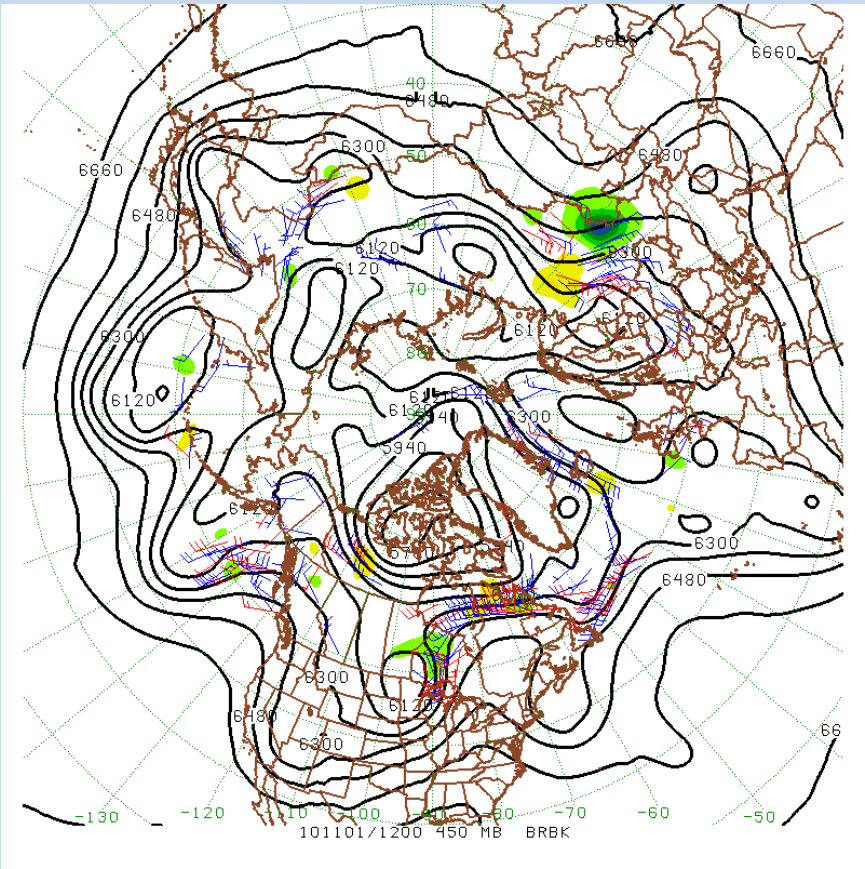
V-component (ms^{-1})

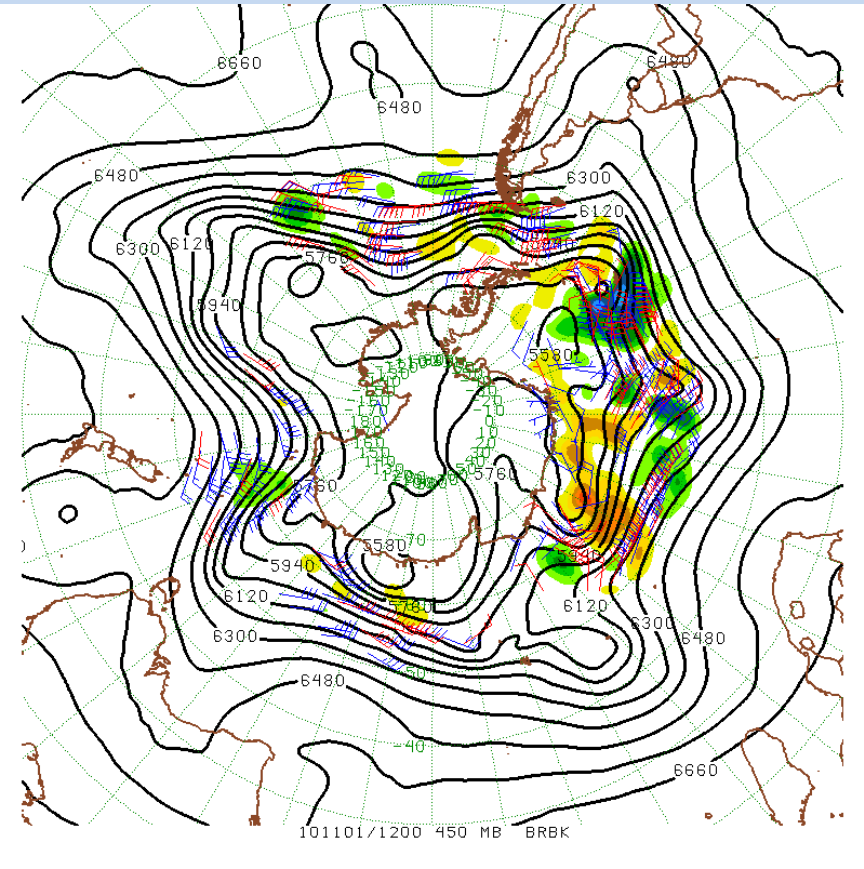
O-B: mean = -0.3 stddev = 2.9
O-A: mean = -0.1 stddev = 2.4

Yellow: Obs – Background Gray: Obs - Analysis

Assimilation Impact

01 May 2011 06 UTC Analysis





450 hPa heights and Leo/Geo winds between 400-500 hPa (blue accepted; red rejected). Fill-pattern is the difference between the analyses with and without the Leo/Geo winds.

Papers and Conference Presentations

- *Lazzara, M.A., D.A. Santek, R. Dworak, B. Hoover, J.R. Key, C.S. Velden, and J. Daniels, in preparation: Composite atmospheric motion vectors from combined geostationary and polar-orbiting satellites. In preparation.*

- Lazzara, M.A., R. Dworak, N.A. Bearson, D.A. Santek, C.S. Velden and J.R. Key, 2011a: Polar satellite composite atmospheric motion vectors. 6th Antarctic Meteorological Observation, Modeling, and Forecasting Workshop, Hobart, Tasmania, Australia, June 22-24, 2011.

- Lazzara, M.A., D.A. Santek, N.A. Bearson, R. Dworak, J.R. Key, J. Daniels, and C.S. Velden, 2011b: Combined GEO/LEO high latitude atmospheric motion vectors, 11th Conference on Polar Meteorology and Oceanography. American Meteorological Society. Boston, MA, May 2-5, 2011.

- Lazzara, M.A., D.A. Santek, R.A. Kohrs, N.A. Bearson, J. Robaidek, and S.L. Knuth, 2010a: Satellite composites: techniques in combining geostationary and polar orbiting observations. 17th Conference on Satellite Meteorology and Oceanography. American Meteorological Society, Annapolis, MD, Sept 27-30, 2010.

- Lazzara, M.A., D.A. Santek, R. Dworak, J.R. Key, C.S. Velden, and S. Wanzong, 2010b: High latitude atmospheric motion vectors from combined geostationary and polar orbiting observations. 17th Conference on Satellite Meteorology and Oceanography. American Meteorological Society. Annapolis, MD, Sept 27-30, 2010.

- Lazzara, M.A., R. Dworak; D.A. Santek, N. Bearson, C.S. Velden, and J.R. Key, 2010c Composite satellite atmospheric motion vectors. 5th Antarctic Meteorological Observation, Modeling, and Forecasting Workshop, Bryd Polar Research Center, Columbus, OH, July 12-14, 2010.

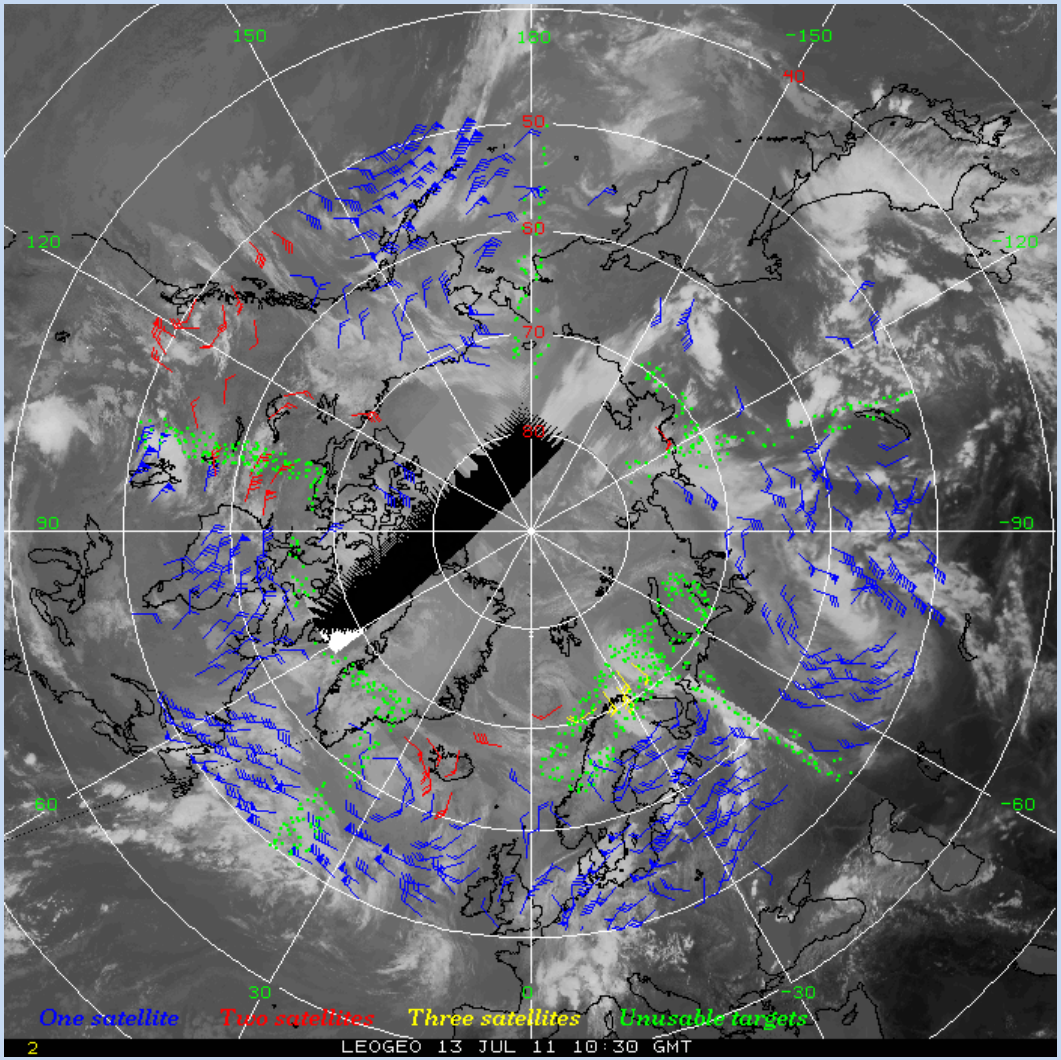
- Lazzara, M.A, R. Dworak, D.A. Santek, C.S. Velden, and J.R. Key, 2010d: High latitude atmospheric motion vectors: Applications for Antarctic and Arctic composite satellite imagery. 10th International Winds Workshop, Tokyo, Japan, February, 22-28 2010.

Conclusion & Future: What's Next?

GOES-R should be able to make good AMV winds to 70° latitude!

- Complete on-going activities –
  - Data to GOES-R Proving Ground & appropriate test beds…
- Finish model forecast impact investigations
- Complete peer-reviewed paper…
- Consider having these become operational…
- Sister project: Formal request for Arctic Composite imagery to become operational with NOAA/NESDIS
  - Users: Ocean Prediction Center, Hydrometeorological Prediction Center, National Weather Service (NWS) Alaska & National Ice Center
  - Not the exact same composite in this study…

Thank you! … Questions?



Acknowledgments
Thanks to NOAA GOES-R Risk Reduction Program: NA06NES4400002