Atmospheric Motion Vectors Derived via a New Nested Tracking Algorithm Developed for the GOES-R Advanced Baseline Imager (ABI)

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Topics

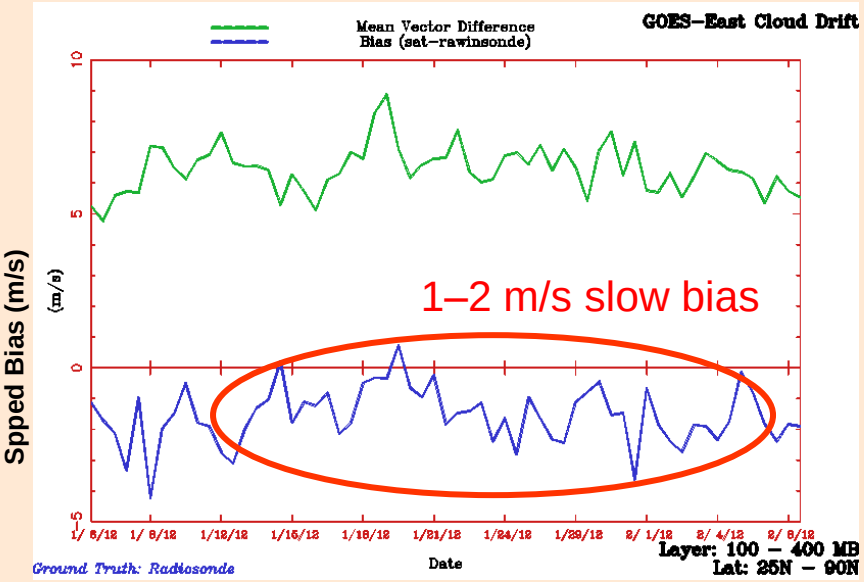
- Motivation for Developing a new Winds Algorithm for GOES-R
- Overview of the Nested Tracking Approach
- Product Examples and Validation Results
- Assessing the Impact of Winds Derived from New GOES-R Winds Algorithm in NWP
- Applying the GOES-R Winds Algorithm to GOES-N/O/P Imagers and NPP/VIIRS
- Summary

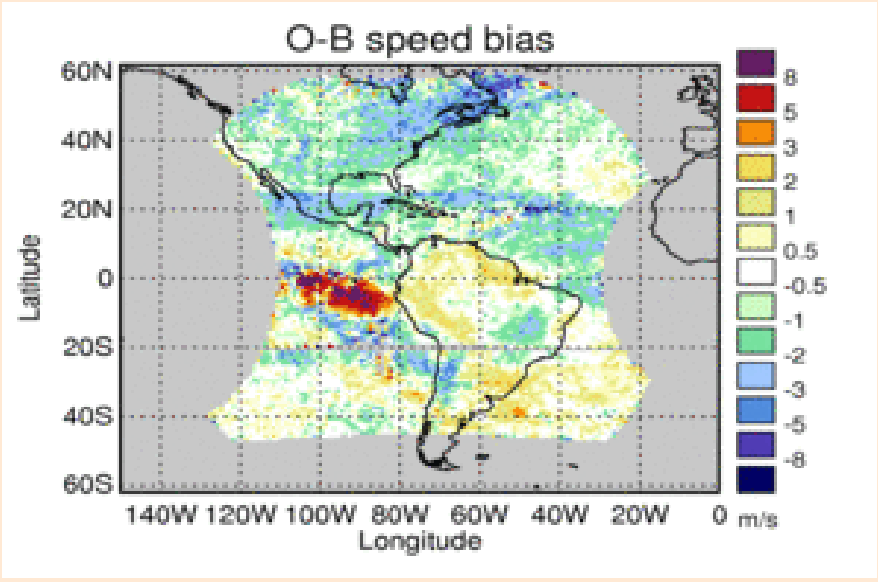
Motivation for Developing a New Winds Algorithm for GOES-R

- **Minimize the observed slow speed bias of satellite winds; *a significant concern of the NWP user community***

(Heritage NESDIS Winds Algorithm)

GOES-13 (100-400mb) January 2012





- **Two leading causes**
  - Poor heights assigned to AMVs (ie., too high)
  - Derived motion is an average of motion at multiple levels and/or different scales

Illustration of Feature Tracking

2nd Image: Time = t_0

- Targeting is performed on center image of image triplet
- A target is a NxN scene of pixels

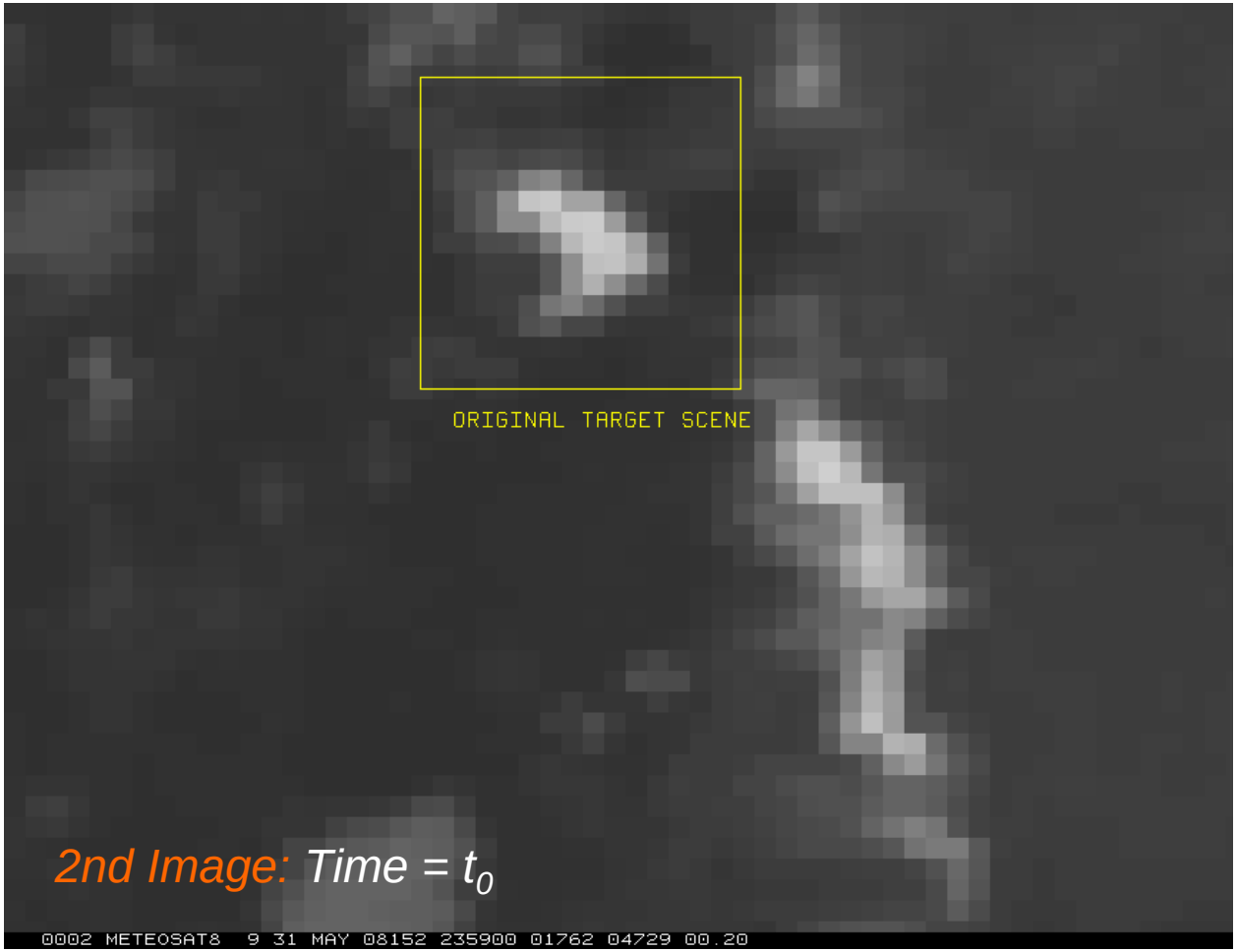


Illustration of Feature Tracking

1st Image: Time = t_0 - 10mins

- Feature is tracked backward in time

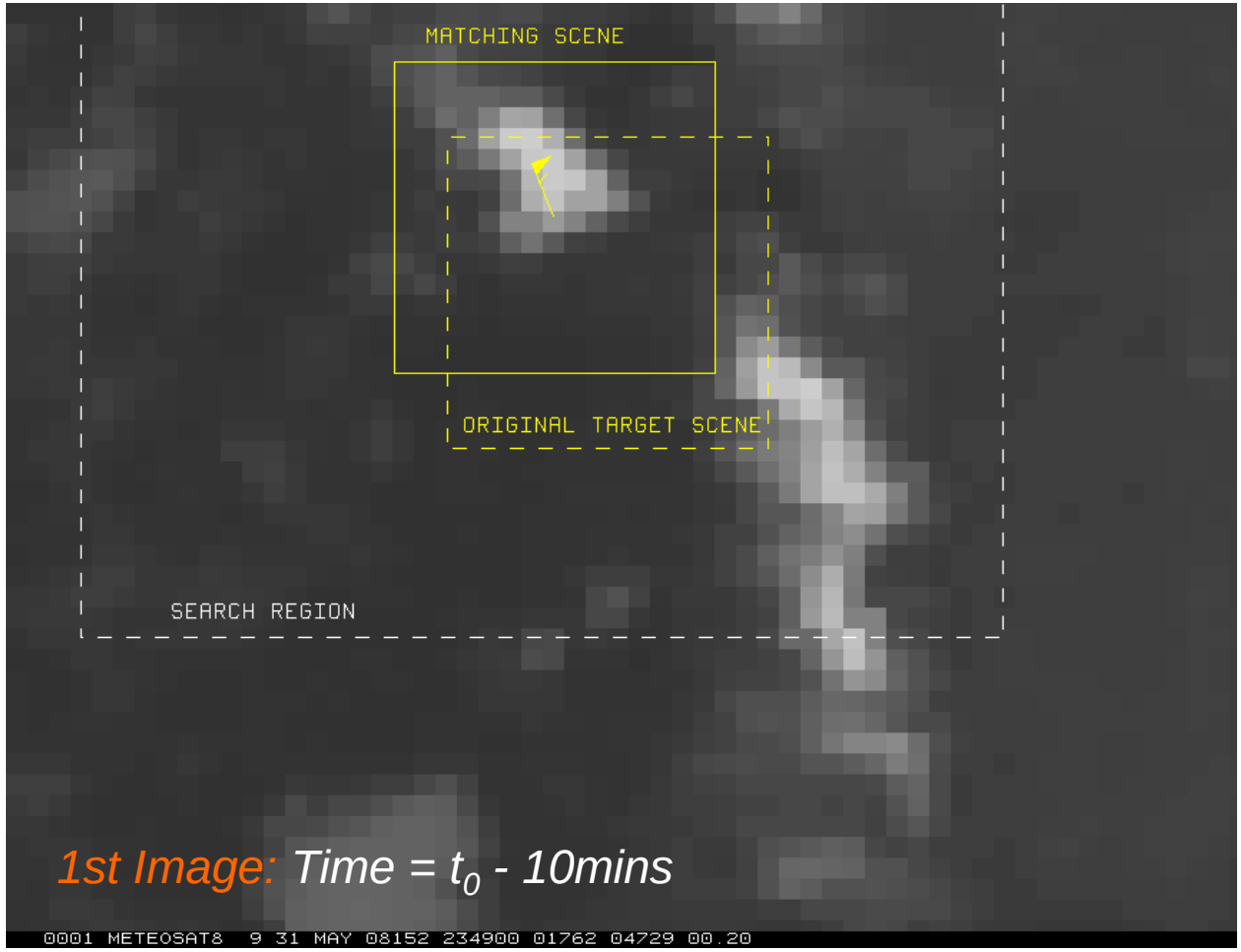
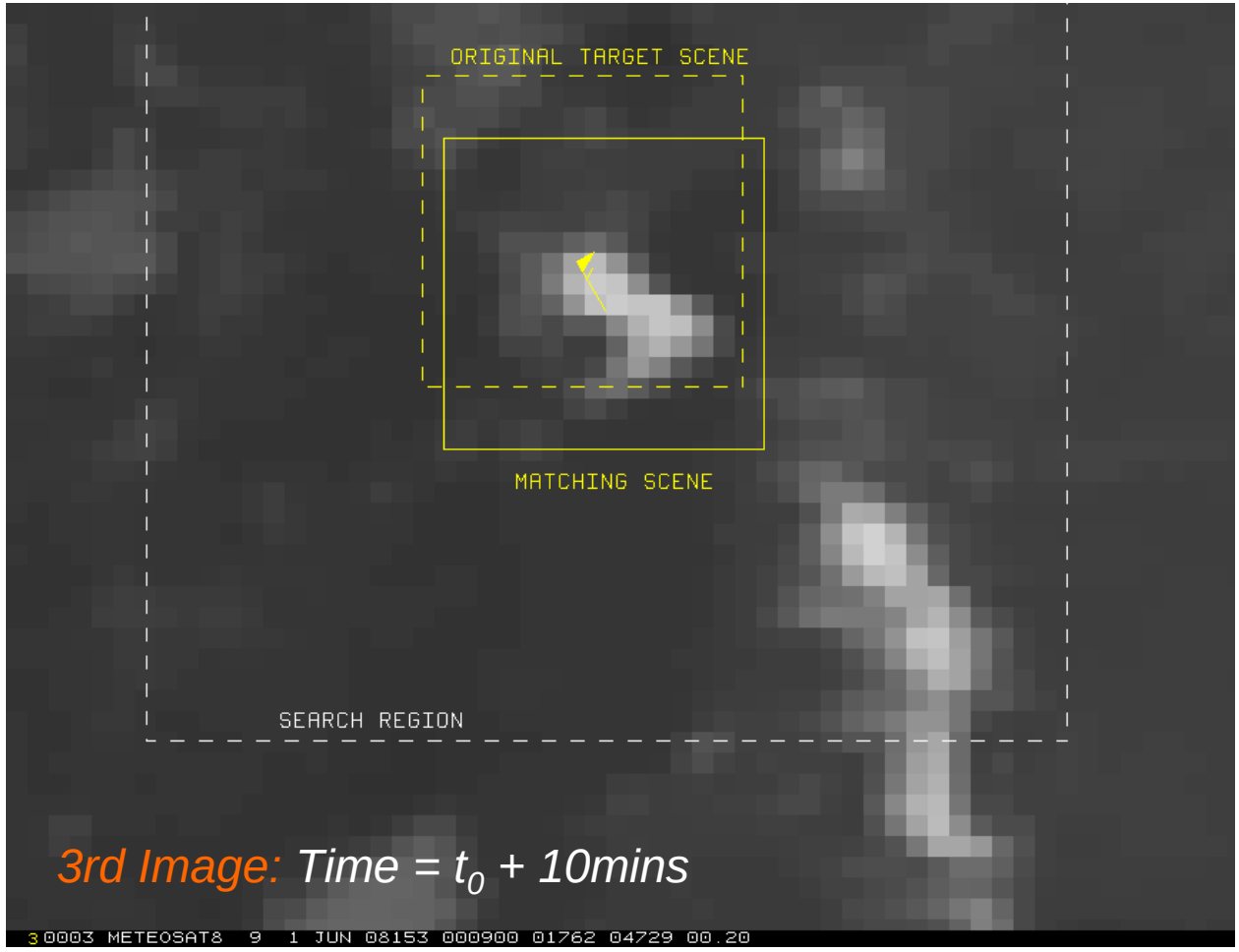


Illustration of Feature Tracking

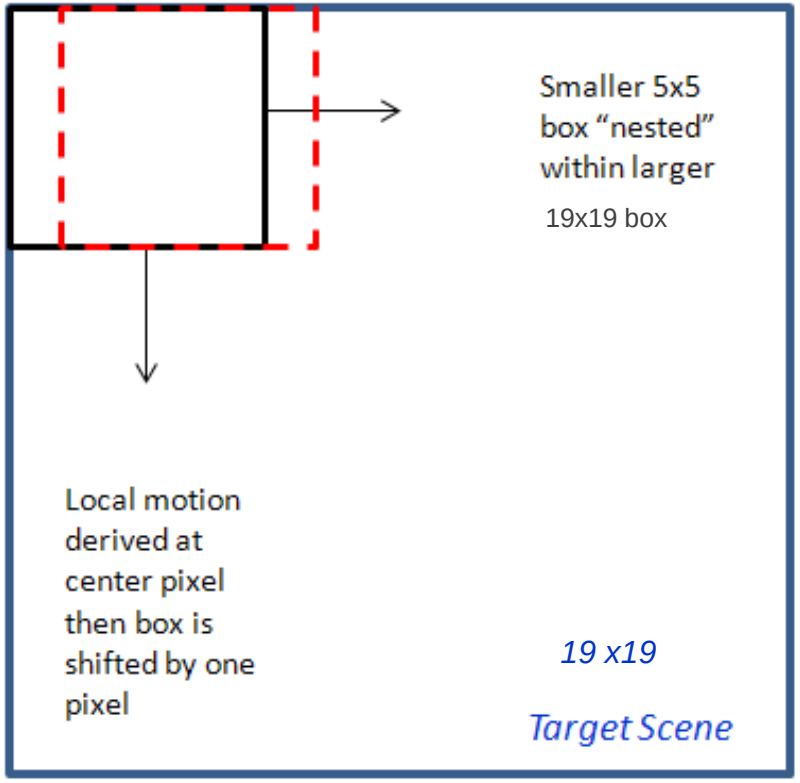
3rd Image: Time = t_0 + 10mins

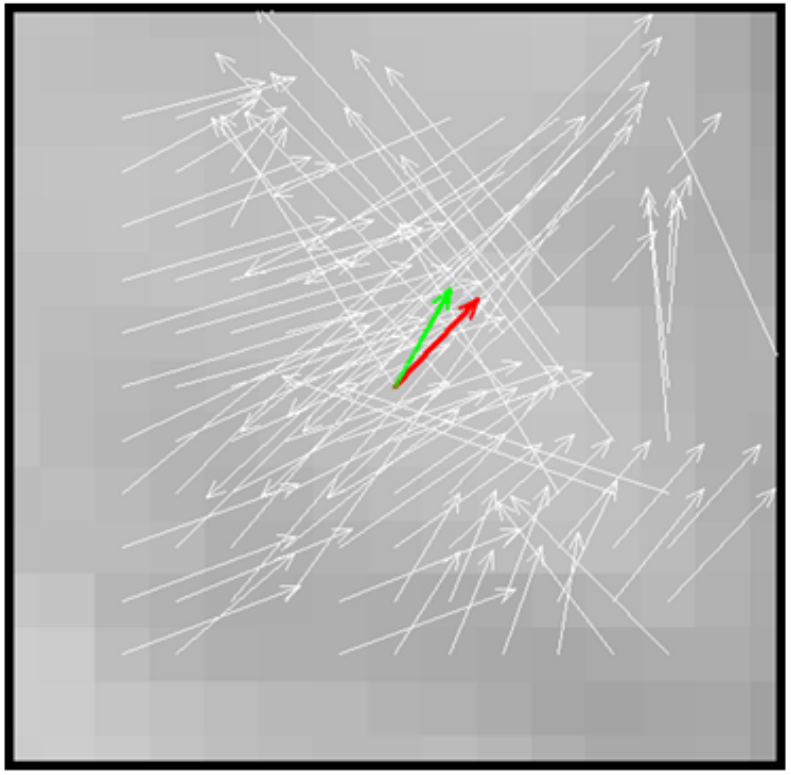
- Feature is tracked forward in time



Nested Tracking Approach

Small 5x5 sub-target scenes are *"nested"* within a larger target scene and are used to derive all possible local wind vectors





Agreement indicates that speed estimate from larger target box is an *average of local motion*

- From different levels and/or
- From different scales

White arrows show local motion derived using 5x5 box centered at pixel location

Green arrow shows average of all local (white) vectors

Red arrow shows vector if larger target scene is tracked

Nested Tracking Approach

- **How can we use local motion vector field?**
  - Need to be able to extract dominant motion from local motions
  - Want to link pixels driving the tracking solution with the height assignment

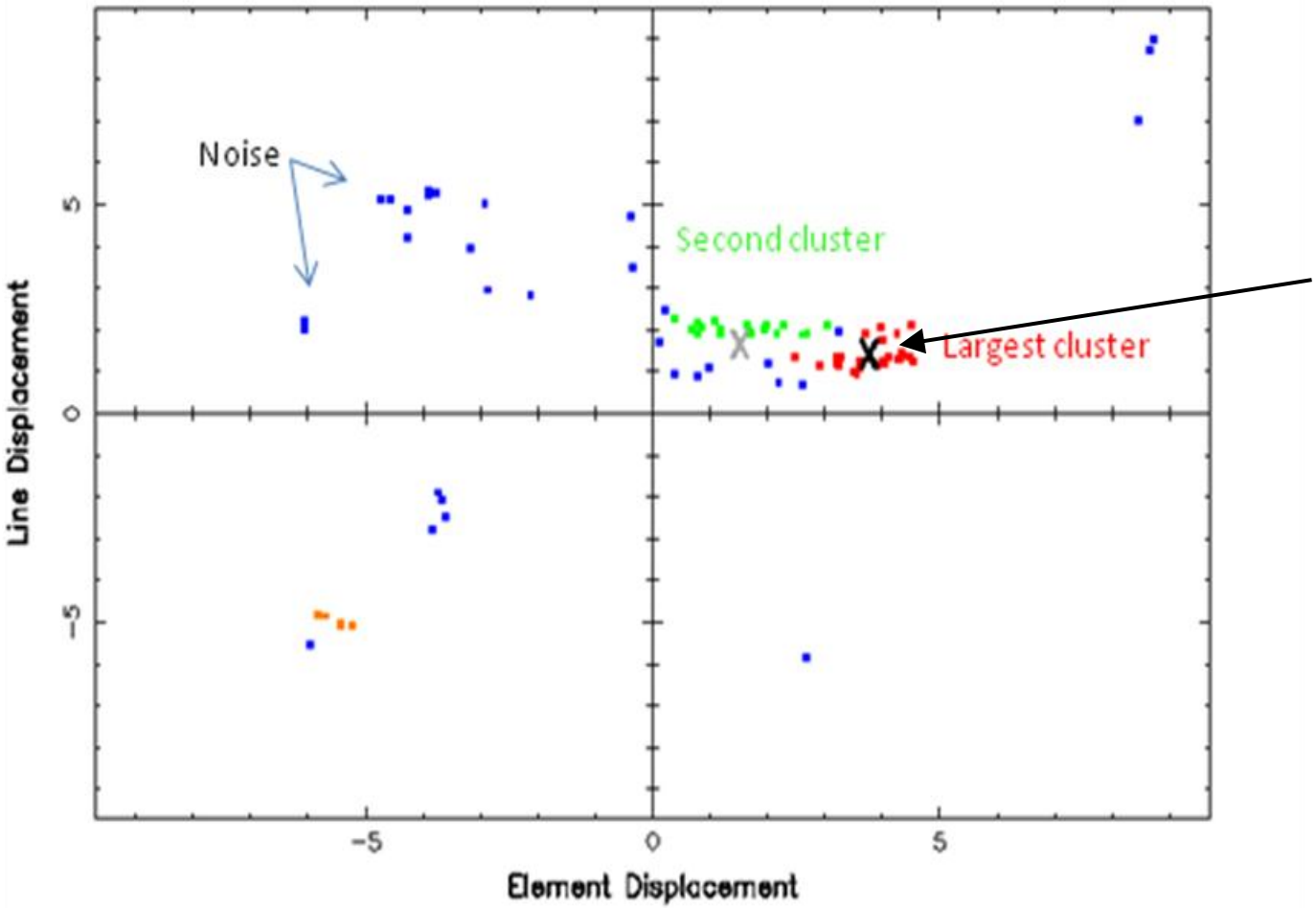
- **Perform cluster analysis of line and element displacements**
  - Use density-based cluster analysis scheme (DBSCAN**)

- ***Poster Today:*** Atmospheric Motion Vectors Derived via a New Nested Tracking Algorithm Developed for the GOES-R Advanced Baseline Imager (ABI) – Daniels, Bresky, Wanzong, Bailey, Velden

** Ester, M., H.-P. Kriegel, J. Sander and X. Xu (1996): A Density-Based Algorithm for Discovering Clusters in Large Spatial Databases with Noise. In Proceedings of 2nd International Conference on Knowledge Discovery and Data Mining (KDD-96), Portland, Oregon, USA, 226-231

Nested Tracking Approach

Clustering is done on displacements in line/element space:

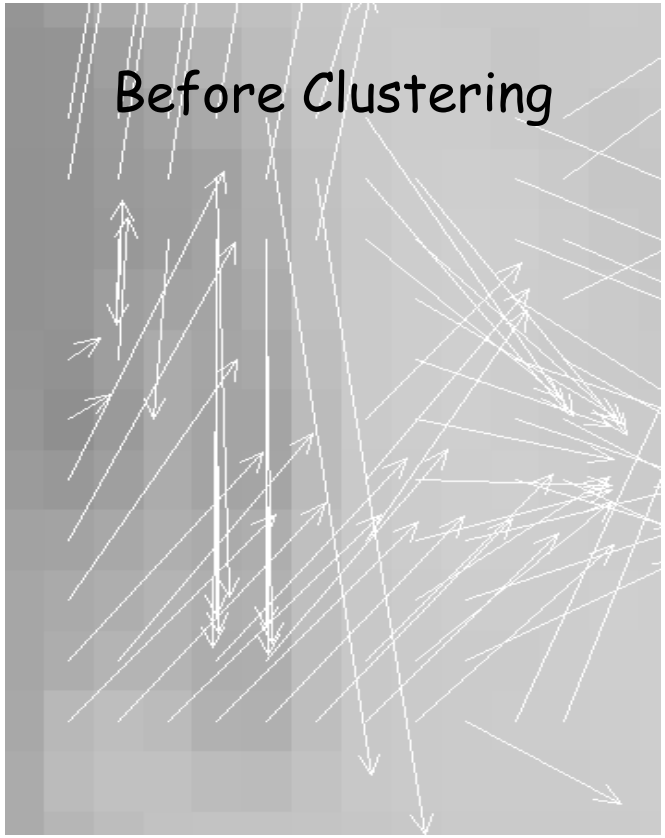


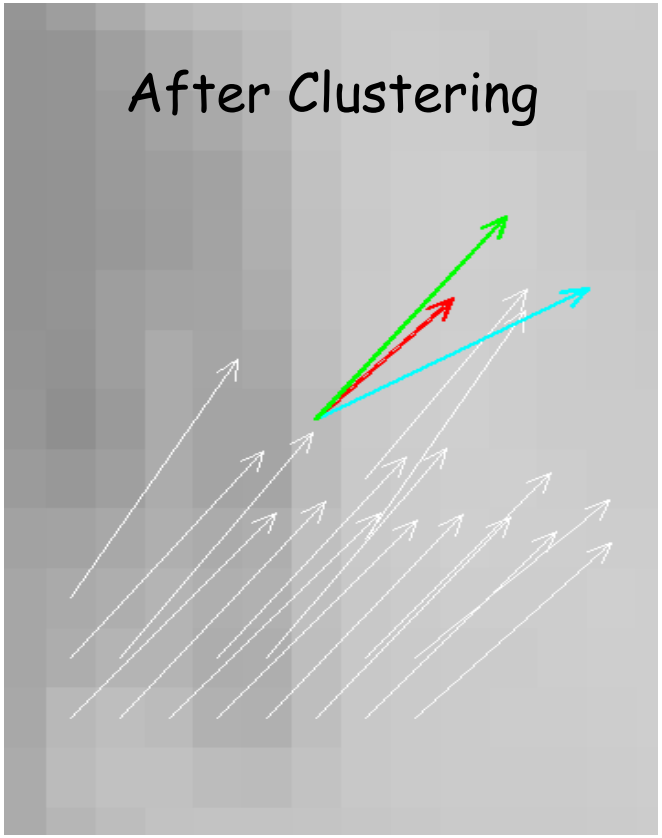
X – Average displacement of points in cluster

Algorithm capable of extracting motion at different heights and/or scales for a single target scene

Nested Tracking Approach

Resulting vector field:





Motion of entire 15x15 box

SPD: 25.0

Average of largest cluster

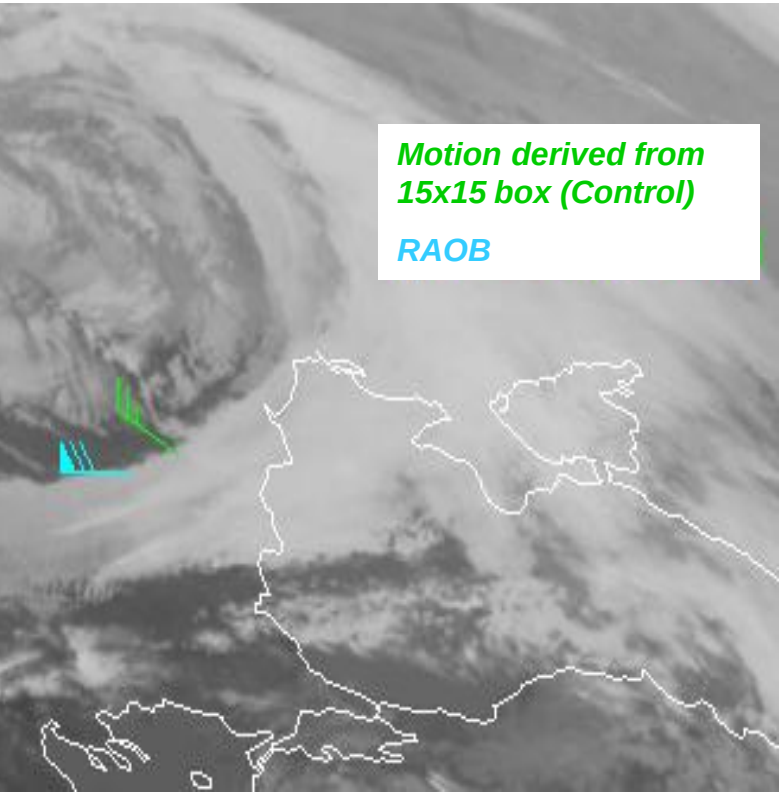
SPD: 39.8

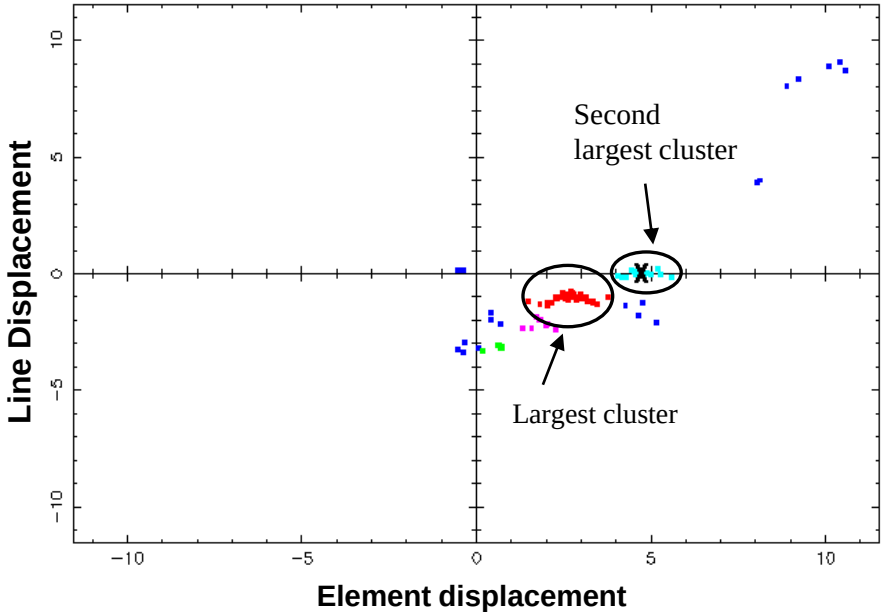
Forecast

SPD: 38.9

Multiple Motion Solutions

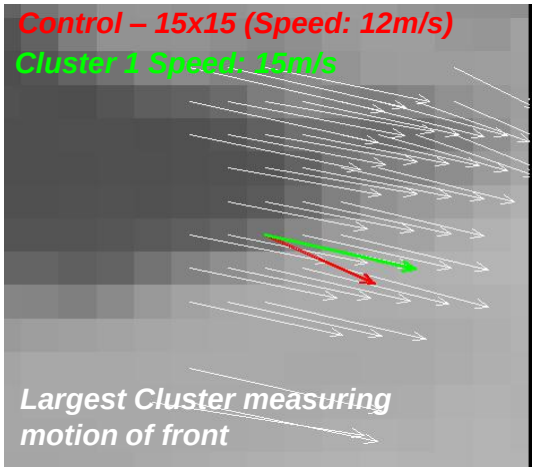
What motion is represented?...

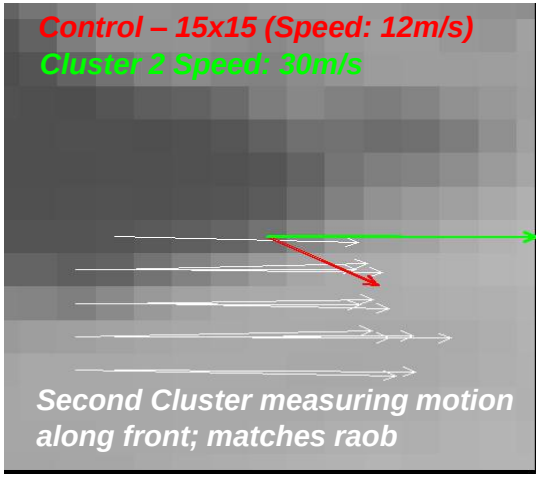




Red – motion of synoptic front

Light Blue – motion along front

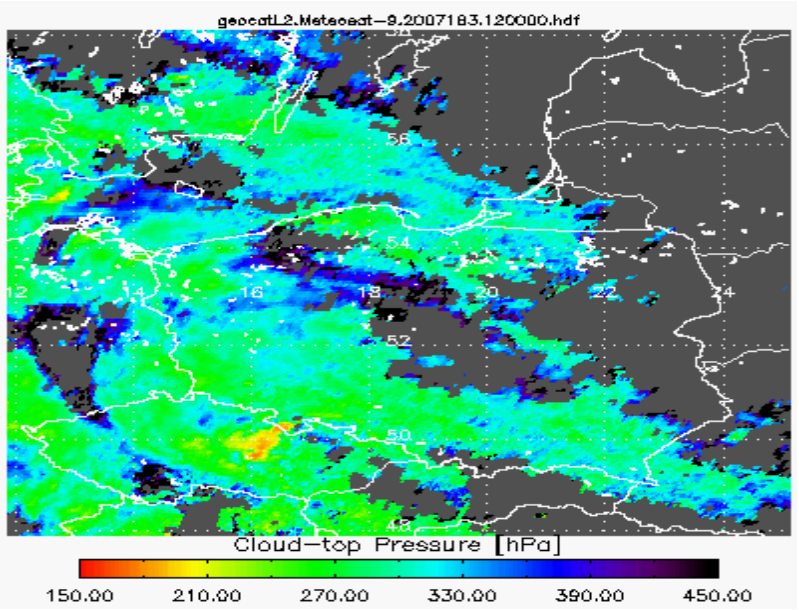


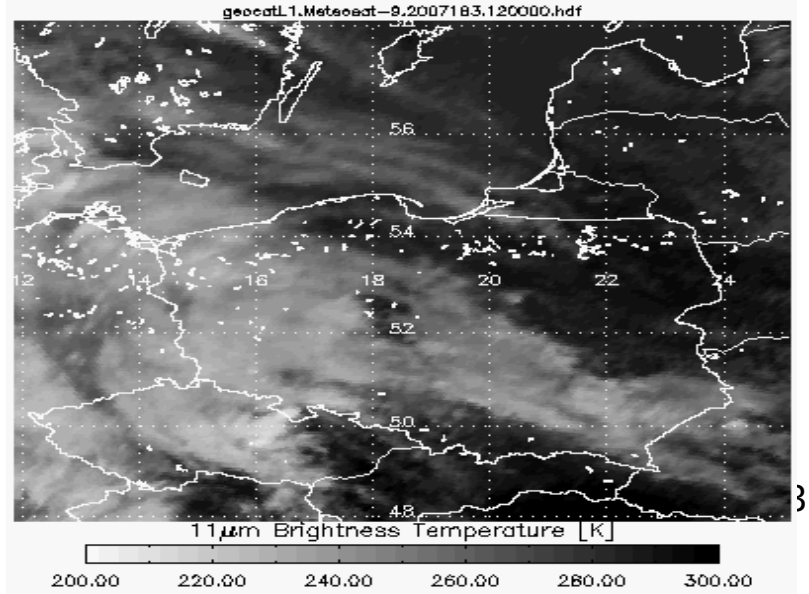


Nested Tracking Approach

Linking Tracking to Height Assignment…

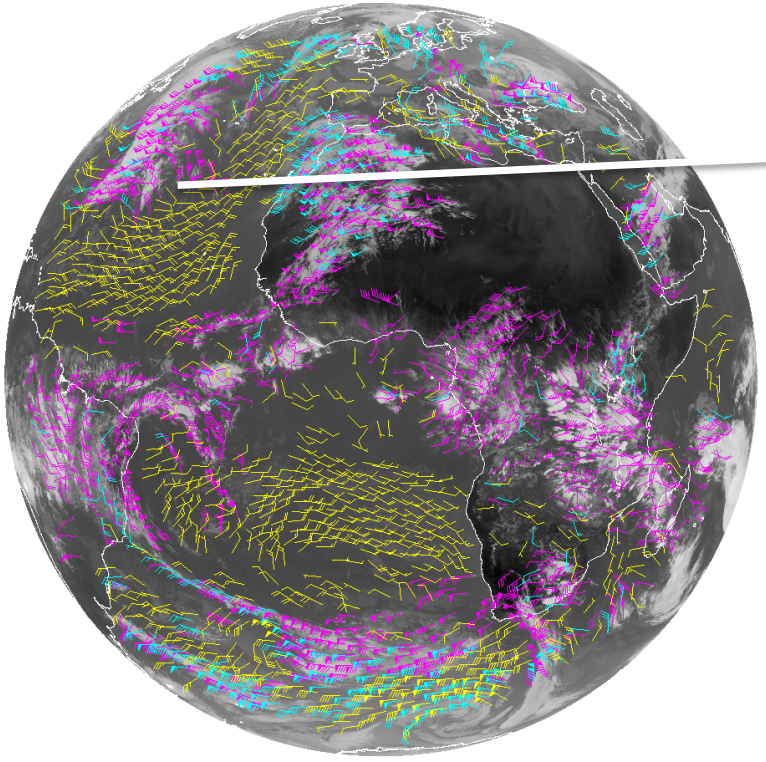
- Level-2 Cloud products *(computed upstream)* are used to assign heights to the derived motion winds
- Nested tracking determines dominant motion in target scene
- Pixels belonging to the largest cluster are used to assign a representative height to the derived motion wind ***(Linking cloud heights to the retrieved motion…)***

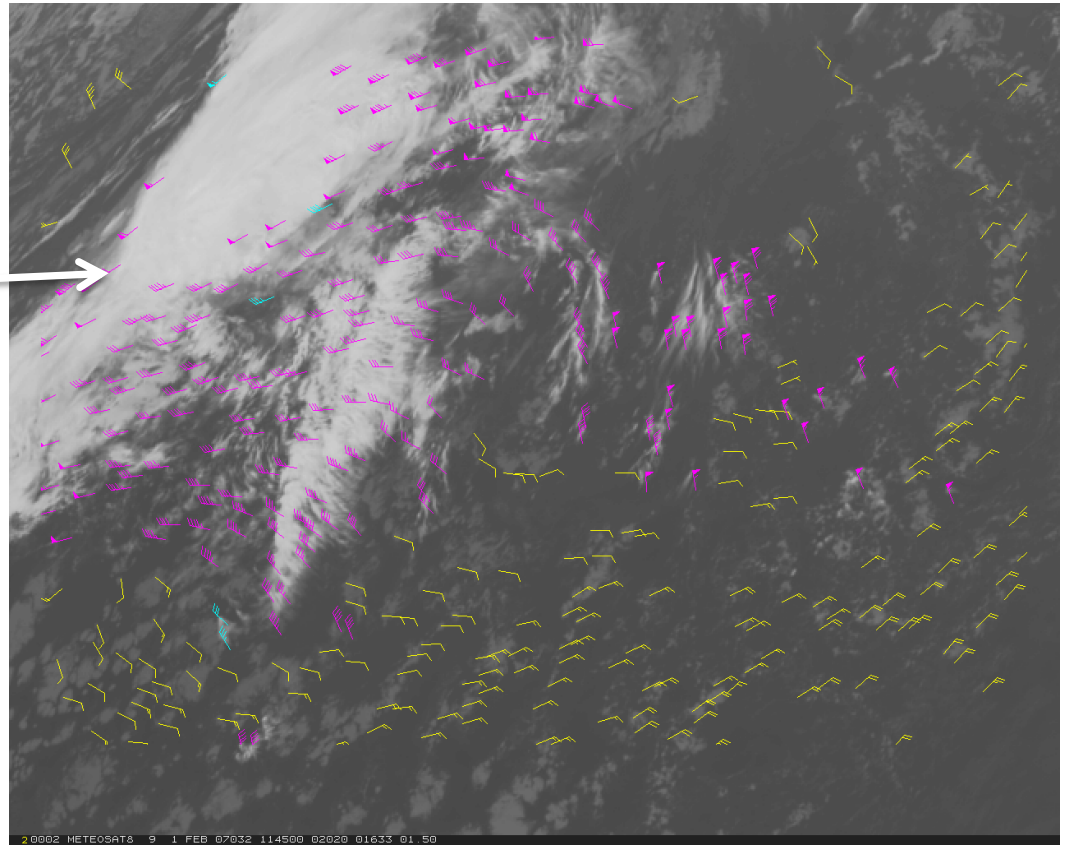




Using SEVIRI as a Proxy for the Future GOES-R ABI

Cloud-drift Winds derived from a Full Disk Meteosat-8 SEVERI **10.8 µm** image triplet centered at 1200 UTC 01 February 2007

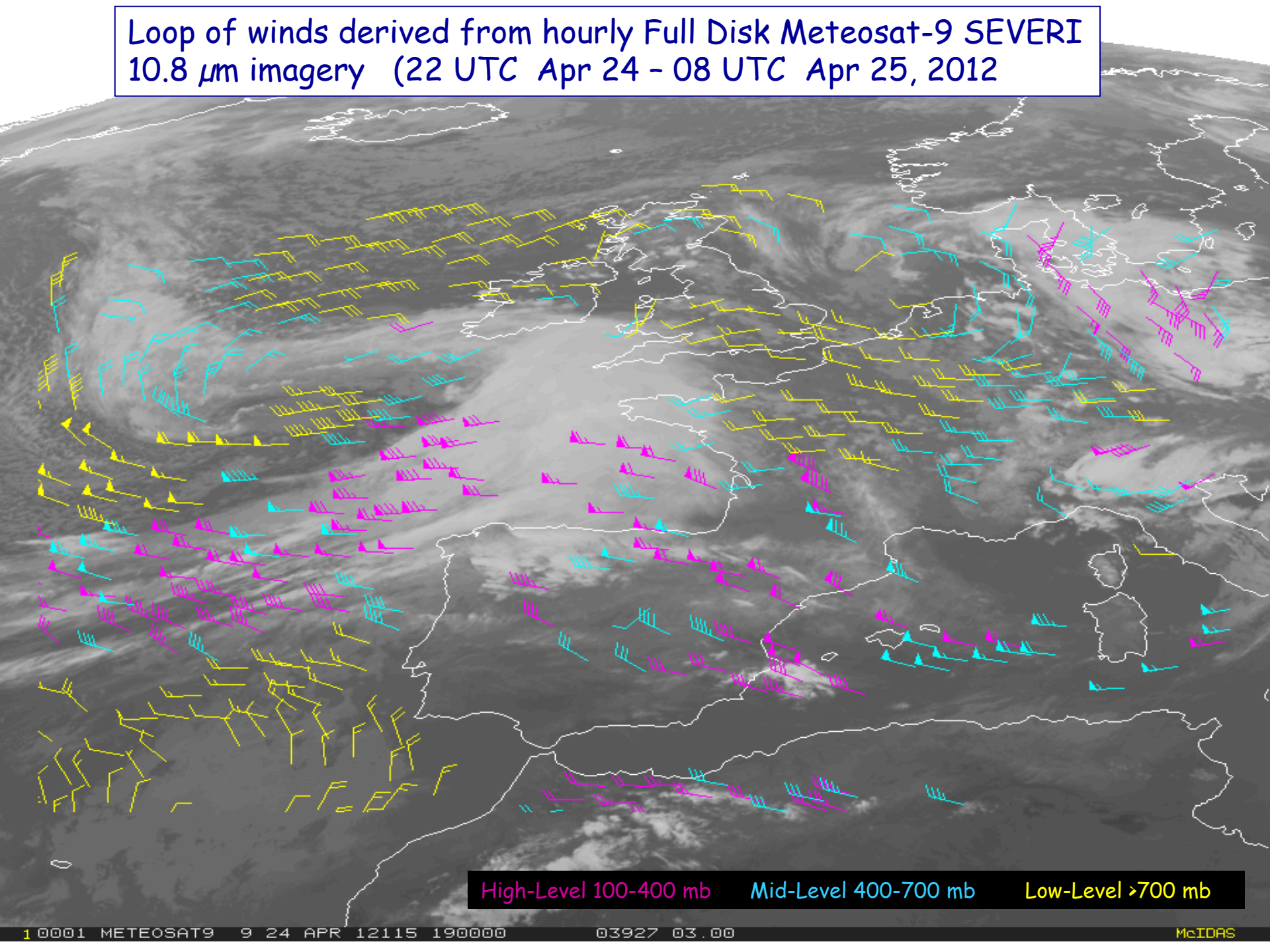




High-Level 100-400 mb Mid-Level 400-700 mb Low-Level >700 mb

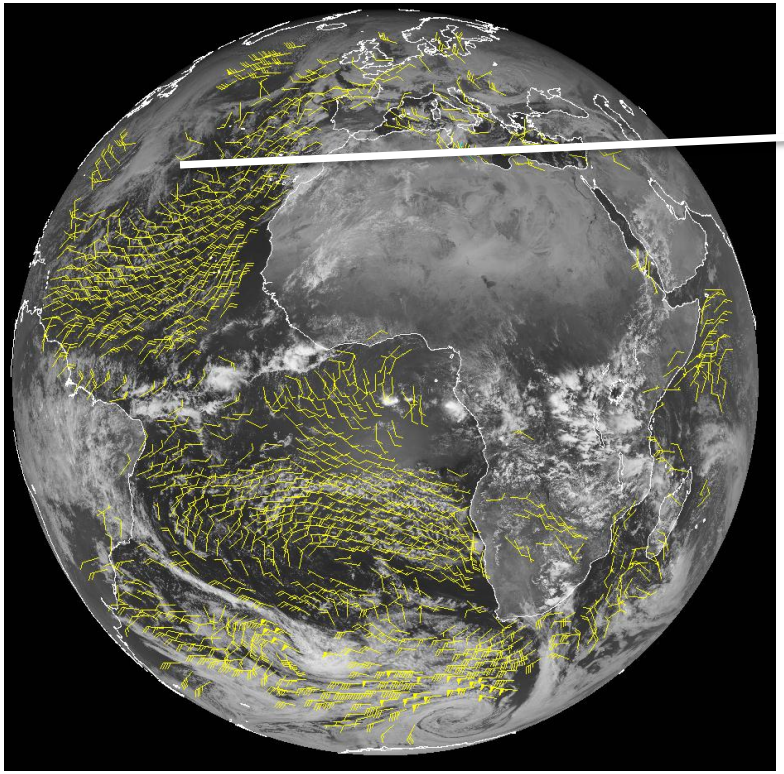
Since February 2011, NESDIS/STAR has been routinely generating experimental winds from Meteosat-9/SEVIRI using the GOES-R winds algorithm (ie., nested tracking)

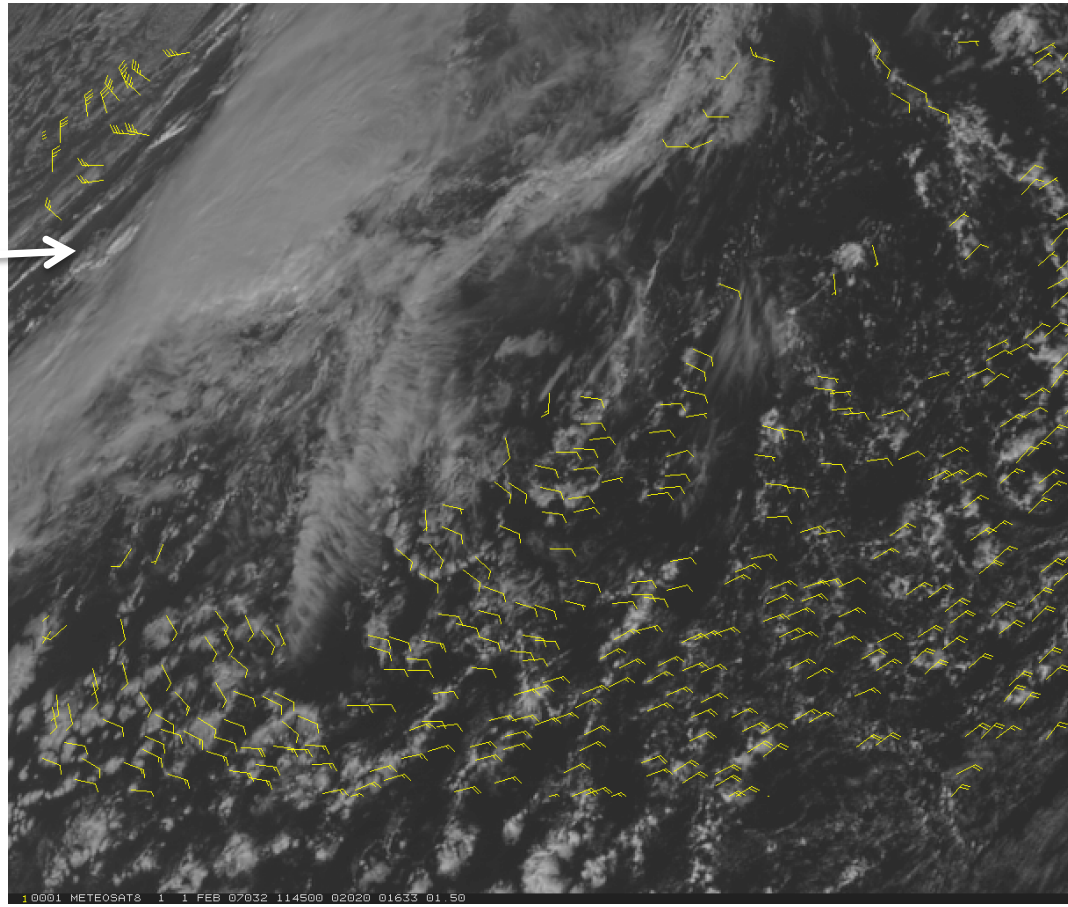
Loop of winds derived from hourly Full Disk Meteosat-9 SEVERI 10.8 μm imagery (22 UTC Apr 24 – 08 UTC Apr 25, 2012



Using SEVIRI as a Proxy For the Future GOES-R ABI

Cloud-drift Winds derived from a Full Disk Meteosat-8 SEVERI **0.60 um** image triplet centered at 1200 UTC 01 February 2007

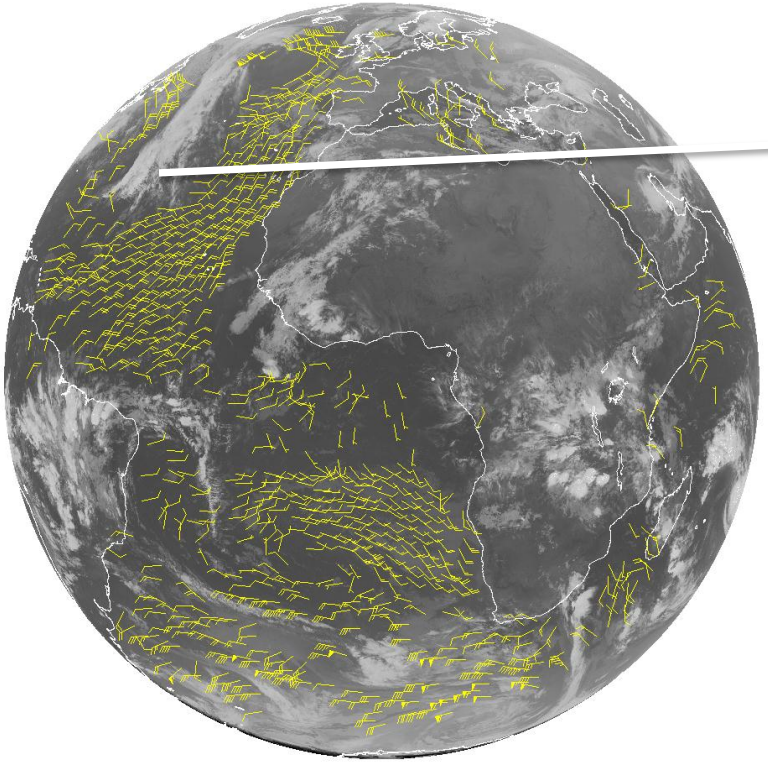


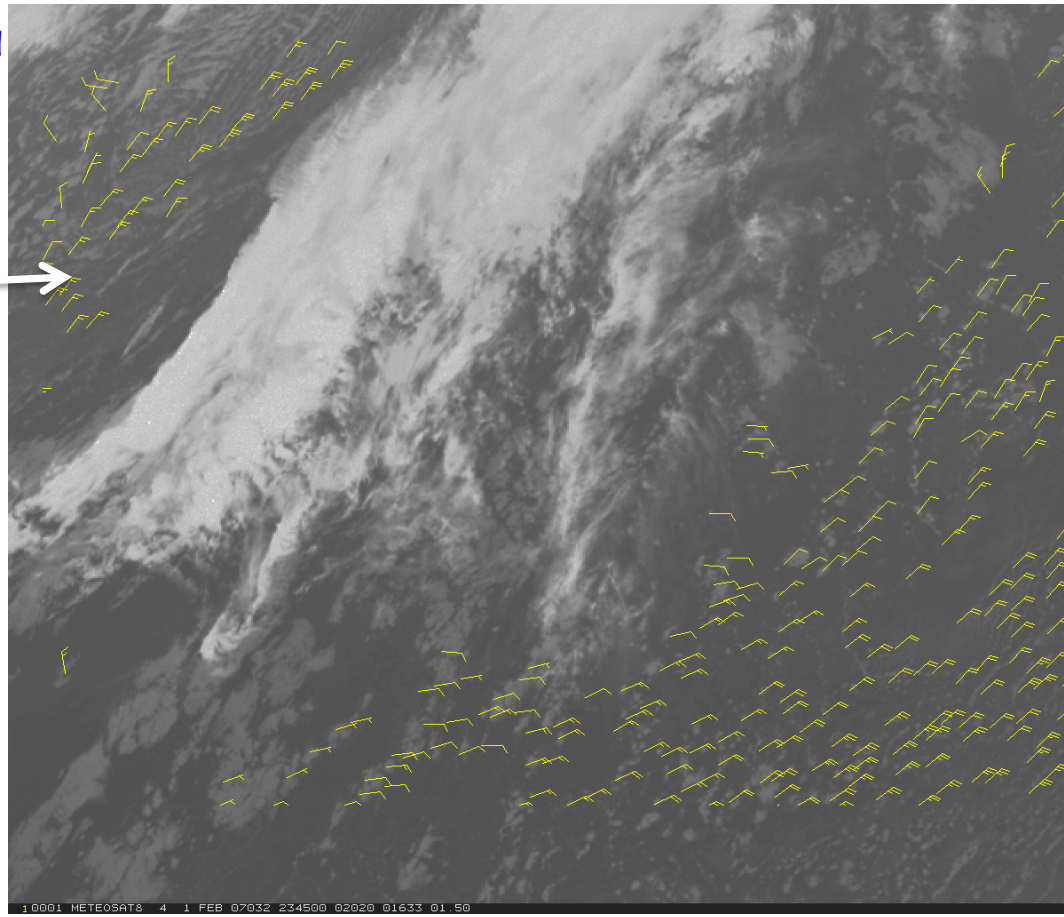


Low-Level >700 mb

Using SEVIRI as a Proxy For the Future GOES-R ABI

Cloud-drift Winds derived from a Full Disk Meteosat-8 SEVERI **3.9μm** image triplet centered at 0000 UTC 02 February 2007

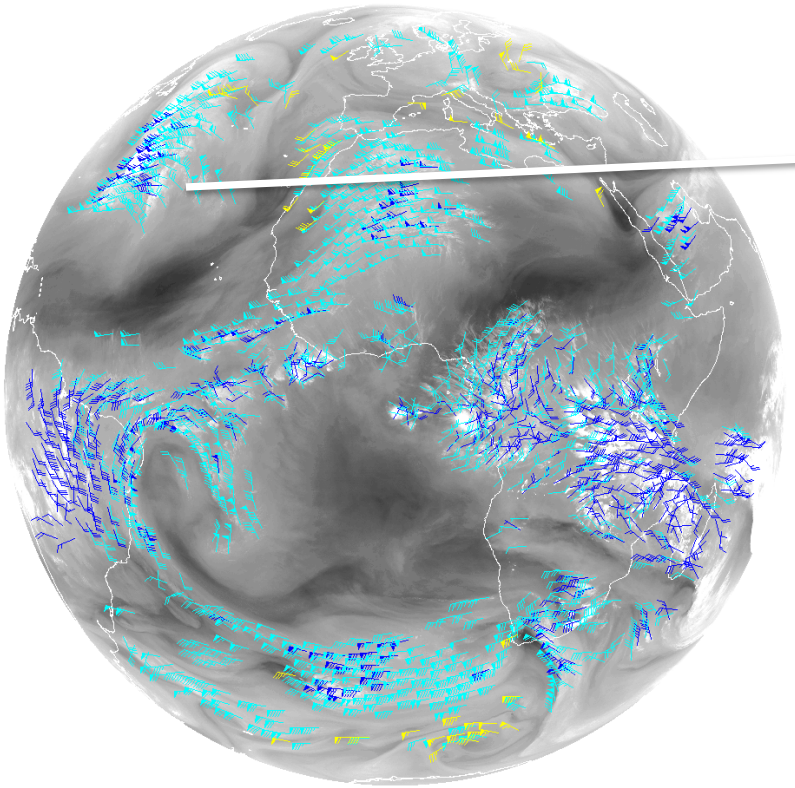


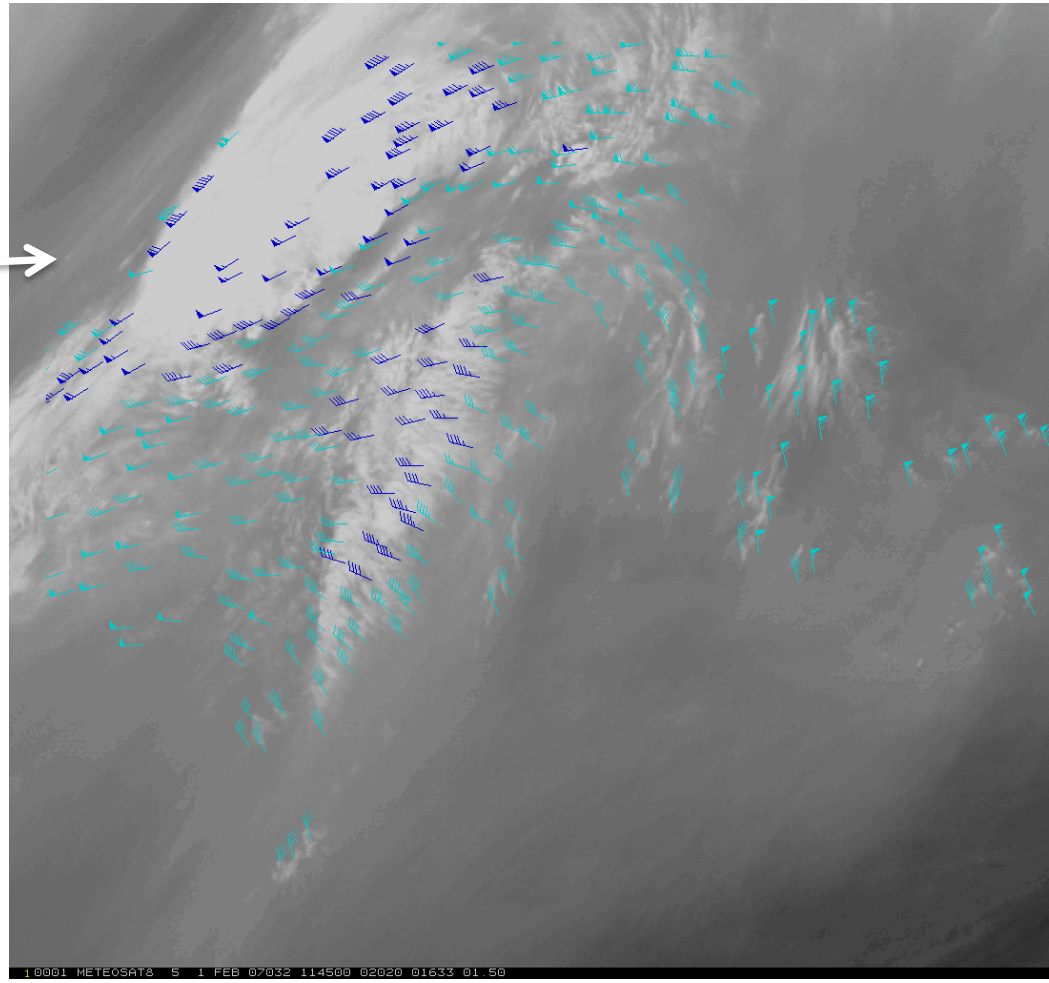


Low-Level >700 mb

Using SEVIRI as a Proxy For the Future GOES-R ABI

Cloud-top Water Vapor Winds derived from Full Disk Meteosat-8 SEVERI **6.2um** image triplet centered at 1200 UTC 01 February 2007



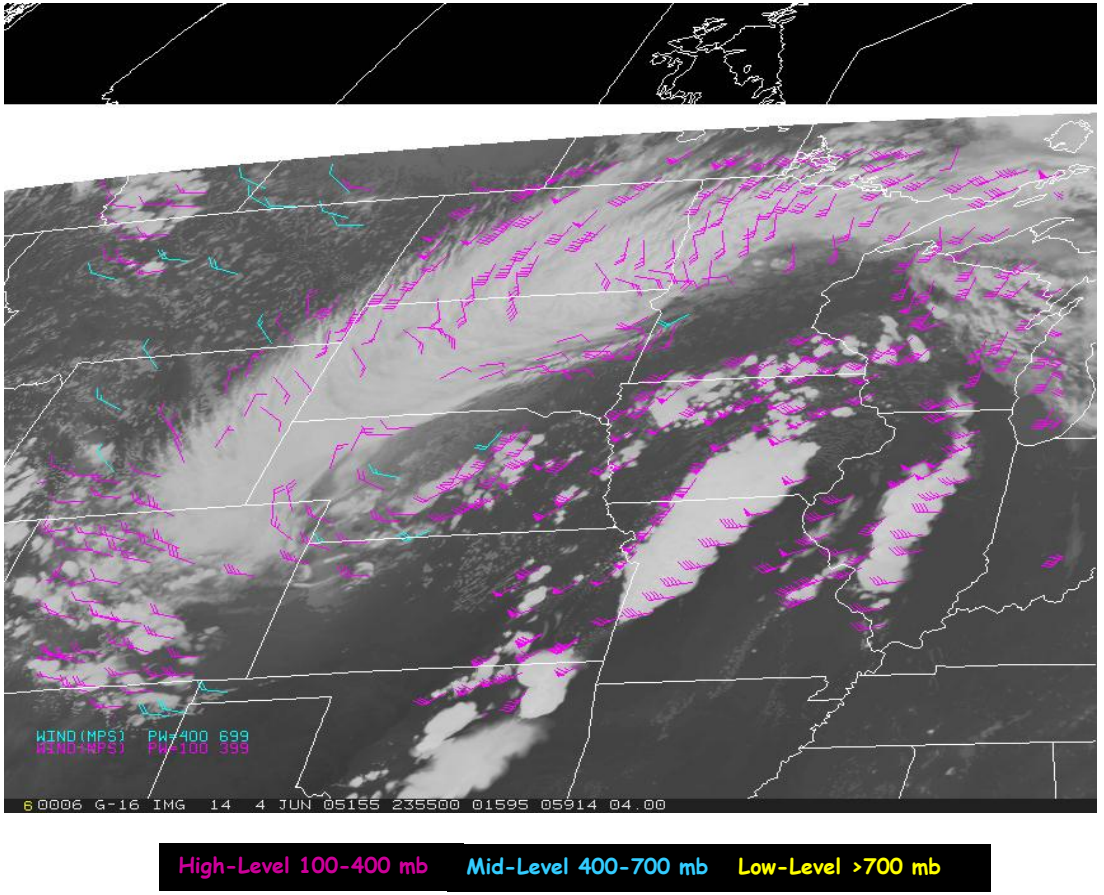


100-400 mb | 250-350 mb | 350-550 mb

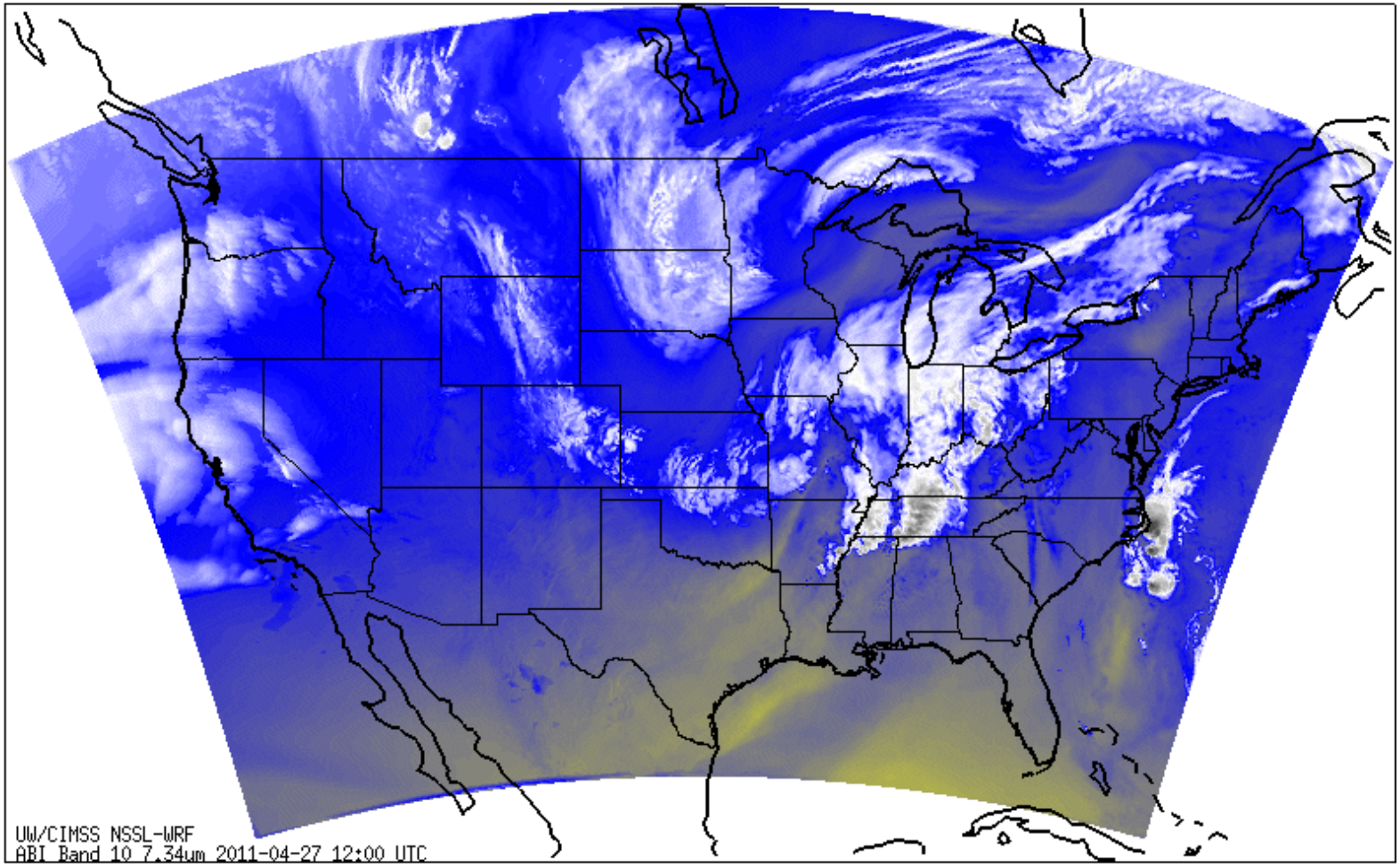
Application to Simulated ABI Imagery

- GOES-R AWG Data Proxy Team has generated a large number of simulated ABI datasets
  - All ABI bands
  - Various spatial and temporal resolutions
- Simulated datasets have been used by some of the algorithm teams to generate Level-2 products
- Simulated datasets will support a number of tests for elements of the GOES-R ground system segment

Cloud-drift AMVs derived from a Simulated GOES-R ABI image (Band 14; 11um) triplet centered at 0000Z on 05 June 2005



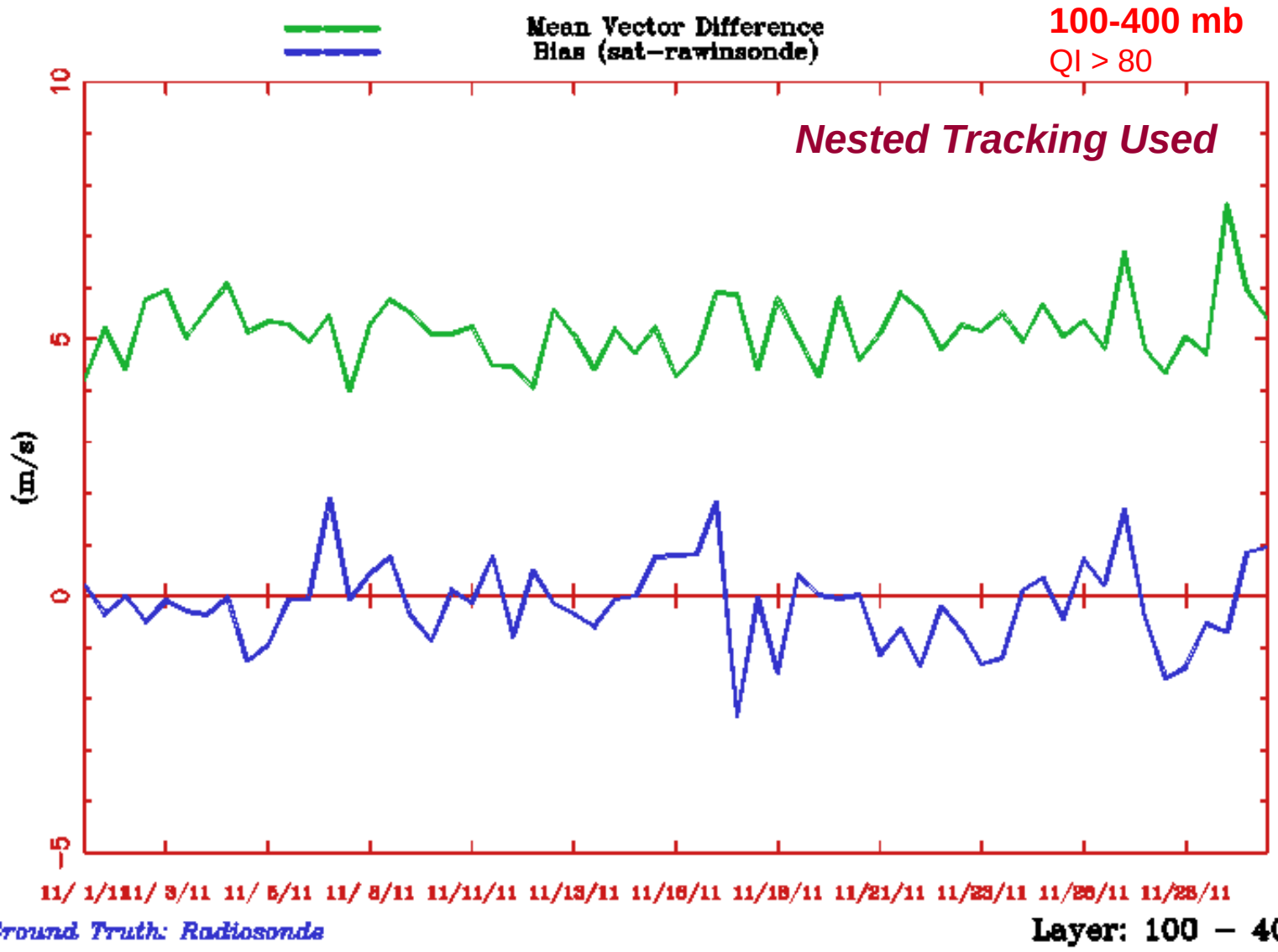
Simulated ABI band – NSSL WRF



- GOES-R AWG Proxy Team at CIMSS generates these in near real-time each day.
- Future plans call for all ABI bands to be simulated, currently only 8 or 9 are being generated and use these for end-to-end demonstrations, simulation studies, etc

http://cimss.ssec.wisc.edu/goes_r/proving-ground/nssl_abi/nssl_wrf_goes.html

Met-9/SEVIRI Winds (10.8um) vs Radiosondes

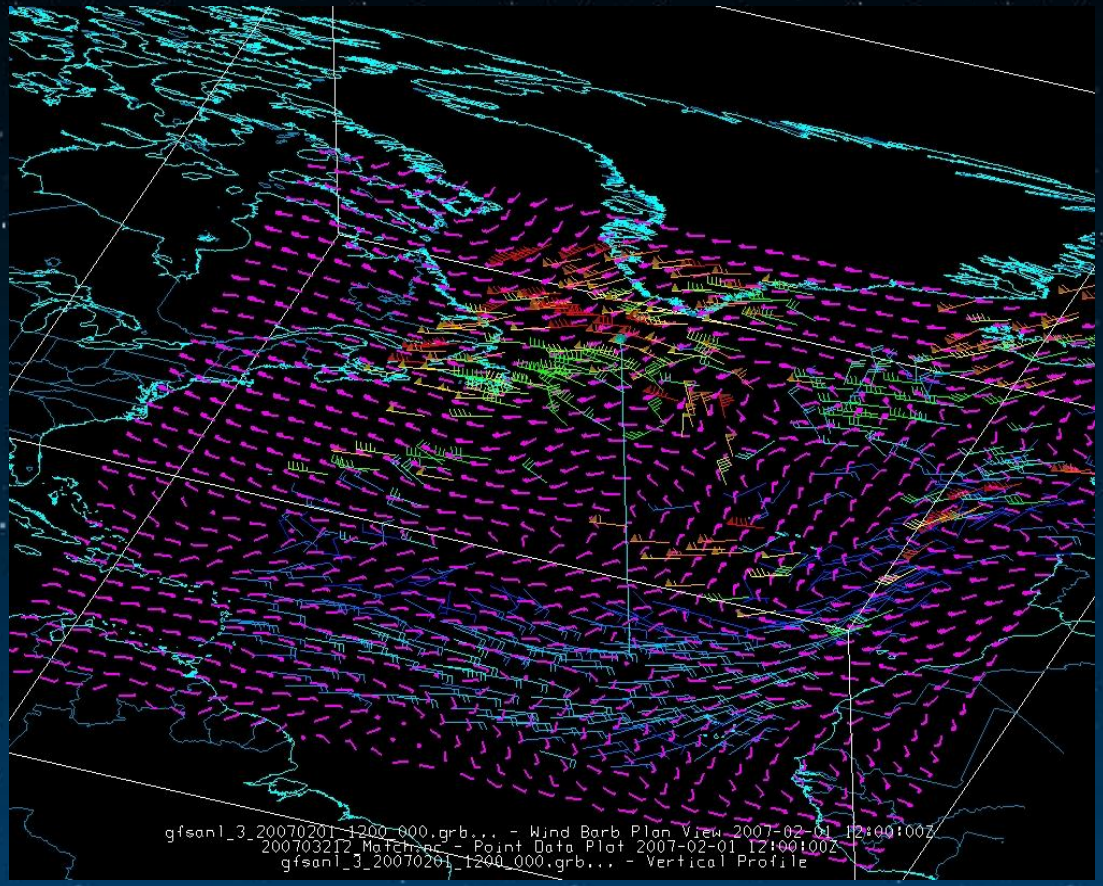


Nov 2011 Stats:

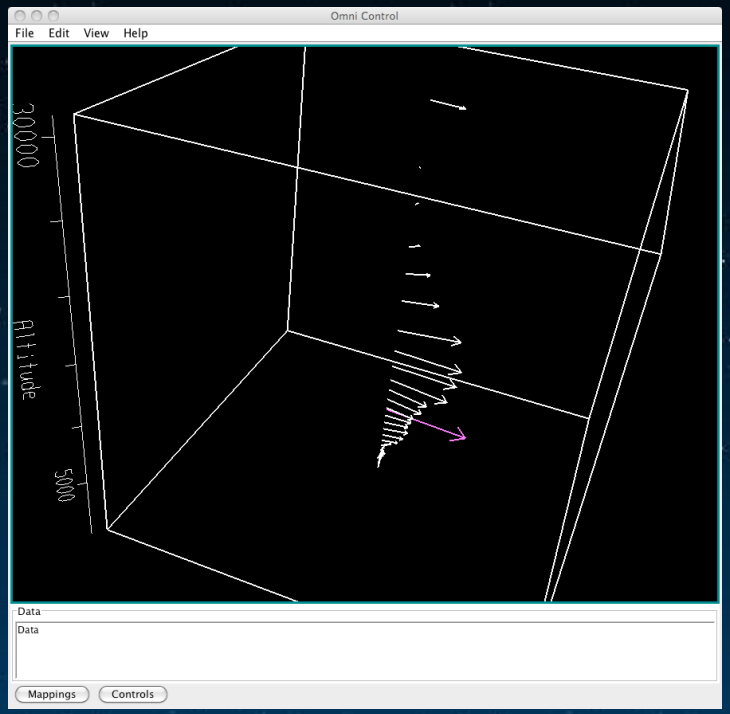
MVD = 5.05 m/s
NRMS = 0.31
Speed Bias = -0.31
N = 7295

Deep Dive Validation Tool – McIDAS-V Utilities Under Development

Interrogation of vertical structure of surrounding reference winds from model analysis and/or in-situ obs near location of selected AMV allows for easier visualization in error diagnosis.



Plot of low-level AMVs color scaled by wind speed, with nearest-level GFS gridded wind field in magenta.



Profile of GFS winds (white) at selected AMV (magenta) location

Slide courtesy of Tom Rink, UW-Madison/SSEC/CIMSS

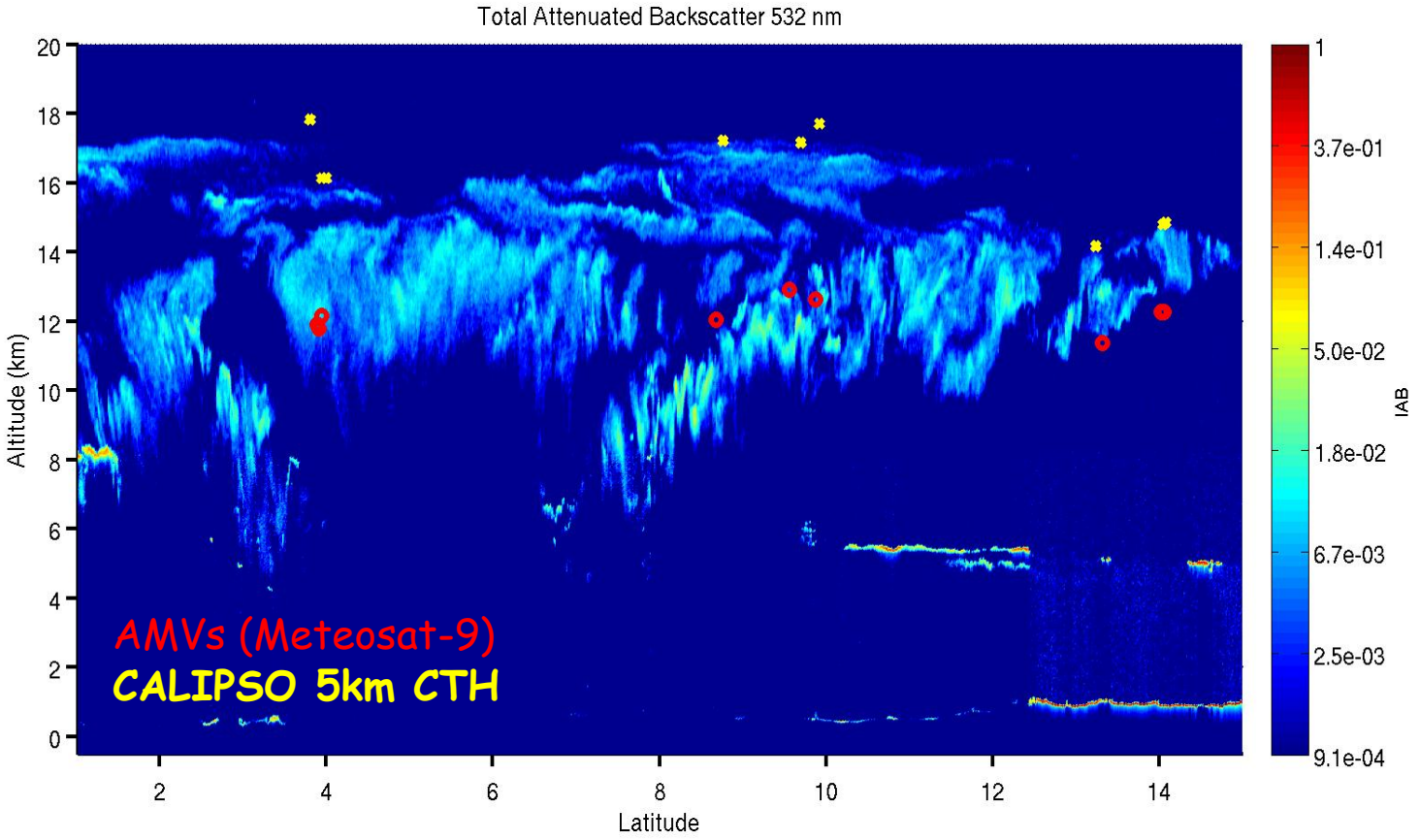
CIMSS
Cooperative Institute for Meteorological Satellite Studies
University of Wisconsin - Madison

McIDAS V

GOES R
GEOSTATIONARY OPERATIONAL ENVIRONMENTAL SATELLITE R-SERIES
NOAA ~ NASA

Comparing AMV Heights and CALIPSO Cloud-top Heights

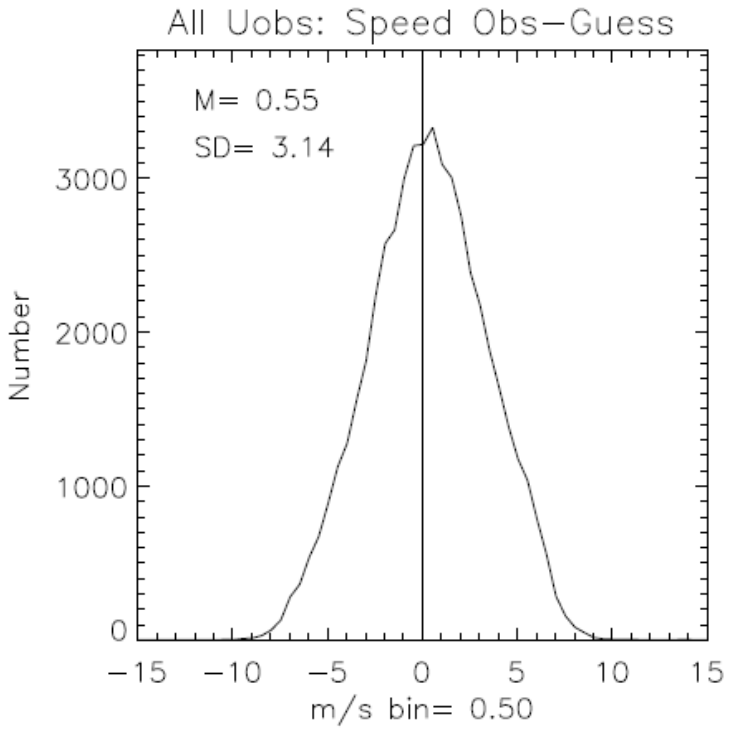
More transparent upper level clouds



Instruments "see" different things, but comparisons are still useful

Assessing Impact of Nested Tracking Winds in NCEP's Global Forecast System (GFS)

- Meteosat-9/SEVIRI winds (10.8um) using GOES-R AMV algorithm
- Initial set of data assimilation stats (O-B) have been generated for two 10 day periods (July&Dec 2011)
  - Encouraged by what we see, especially with respect to the bias
  - Gaussian; centered at zero



Talk on Thursday: Developing Assimilation Techniques for Atmospheric Motion Vectors Derived via a New Nested Tracking Algorithm Derived for the GOES-R Advanced Baseline Imager (ABI); Daniels, Jung, Nebuda, Santek, Bresky

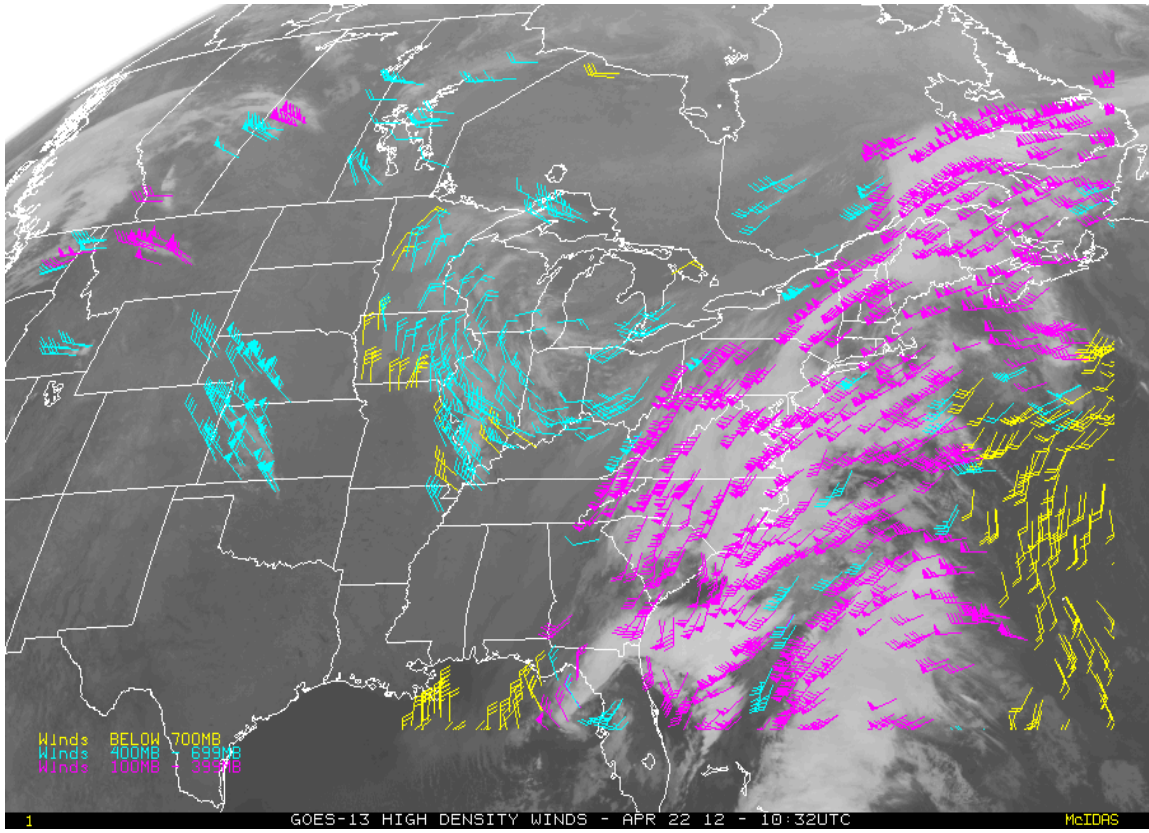
Poster Today: Evaluation and Quality Control of Nested Tracking Approach for Atmospheric Motion Vectors (AMVS); Nebuda, , Jung, Santek, Daniels, Bresky

Application of GOES-R Winds Algorithm to GOES-N/O/P

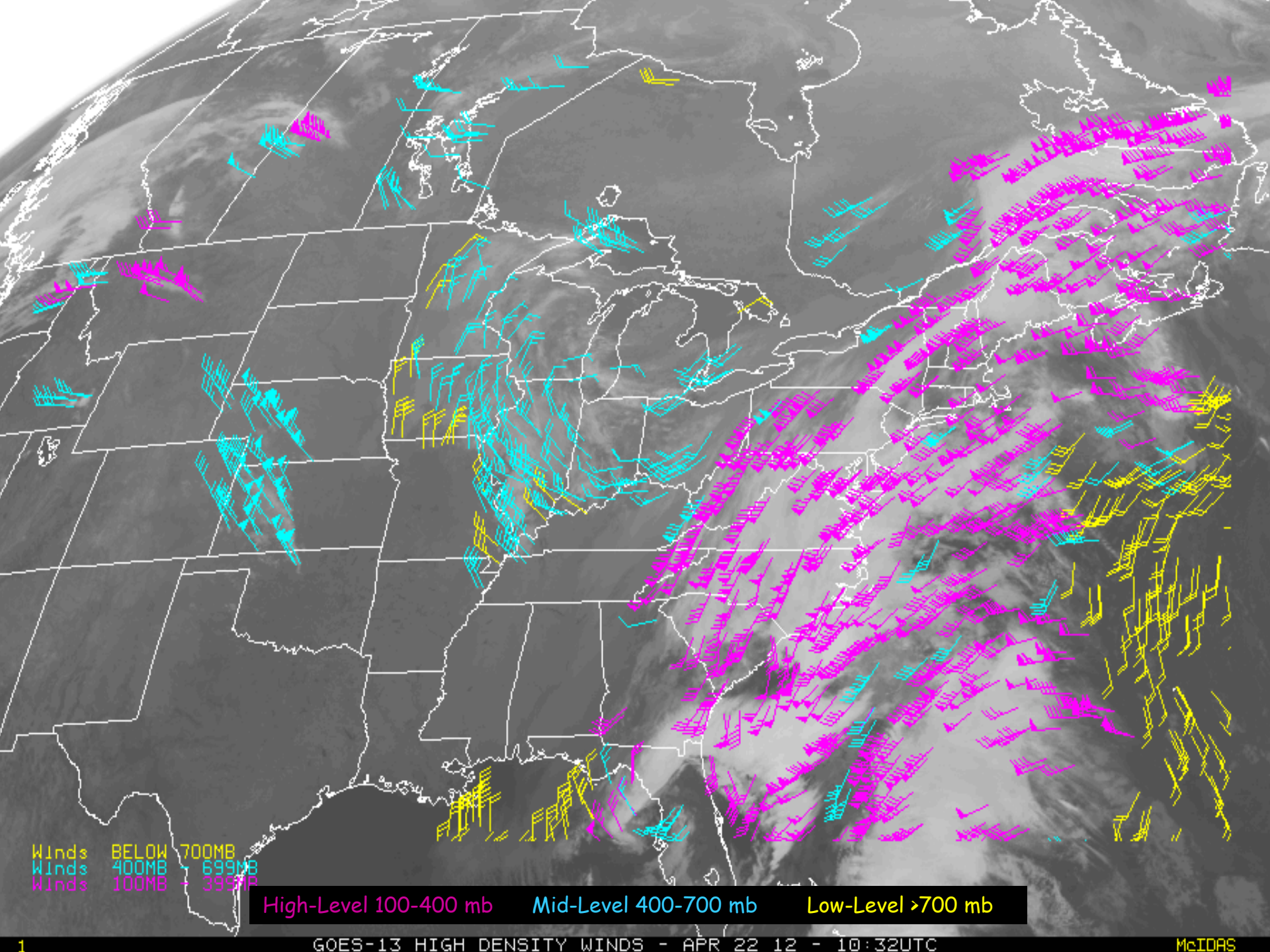
- Since September 2011, we have been routinely generating experimental winds from GOES-13 using the GOES-R winds algorithm (ie., nested tracking)
- Setting up processing of experimental winds for GOES-15 (Apr 2012)
- Supporting GOES-R PG Activity at SAB/OPC/HPC
- Funded PSDI projects in place to replace heritage AMV algorithm running in NESDIS operations with GOES-R Winds algorithm
  - GOES (funded effort) – March 2013
  - VIIRS (funded effort) – Dec 2012

Recent Nor'Easter

Cloud-drift winds derived from 15-minute GOES-13 11um imagery 1000 UTC 22 April 2012 – 0800 UTC 23 April 2012

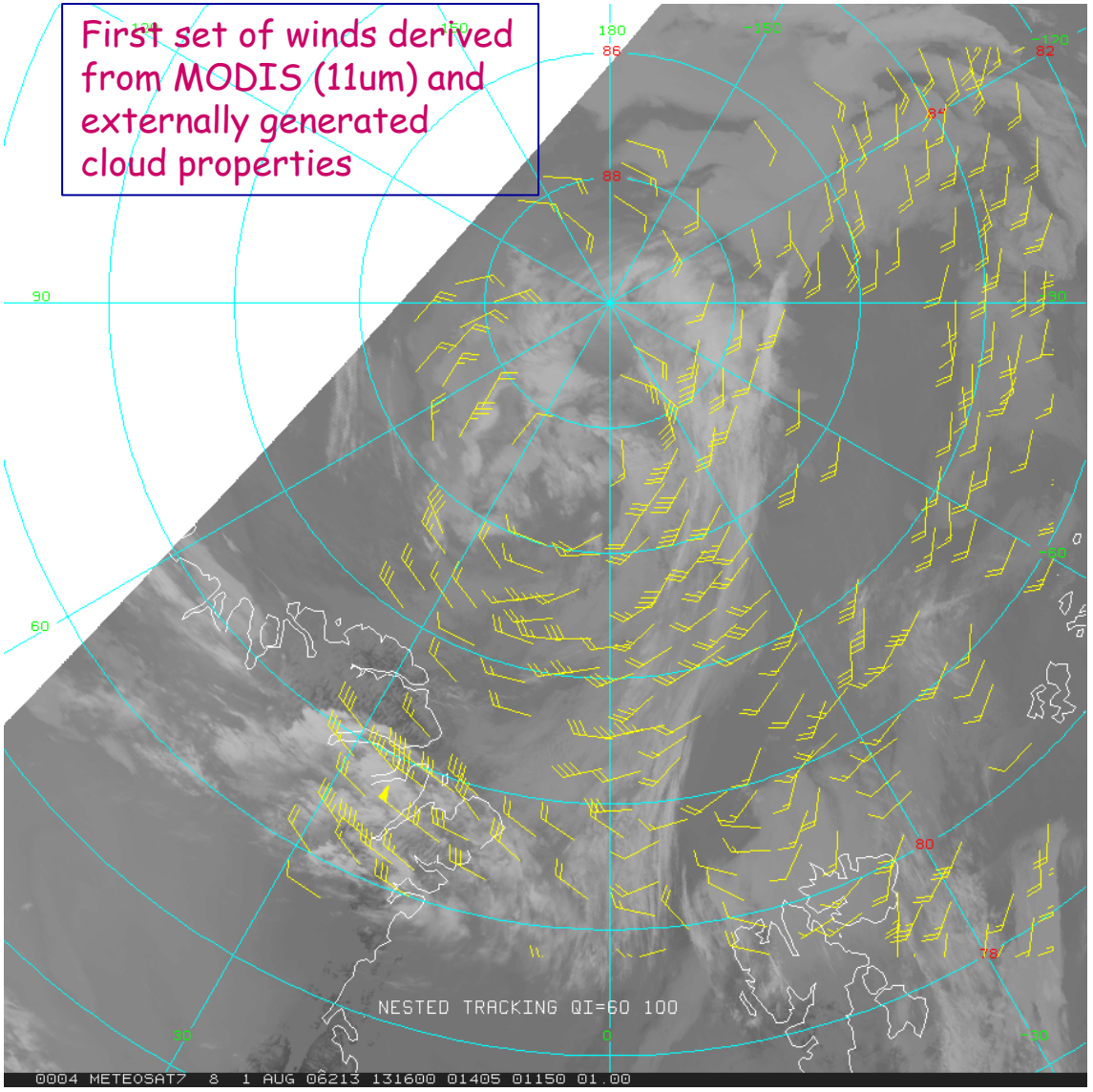


High-Level 100-400 mb Mid-Level 400-700 mb Low-Level >700 mb


Winds BELOW 700MB
Winds 400MB - 699MB
Winds 100MB - 399MB
High-Level 100-400 mb
Mid-Level 400-700 mb
Low-Level >700 mb
1
GOES-13 HIGH DENSITY WINDS - APR 22 12 - 10:32UTC
McIDAS

Application of GOES-R Winds Algorithm to NPP/VIIRS

- 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 VIIRS polar winds product is scheduled to be operational in NESDIS this coming October '2012.
- Many changes to the processing have been made to the system to:
  - Handle conversion of imagery to a polar stereographic projection
  - Handle and preprocess granules
- Next steps: Use VIIRS imagery



Summary

- **GOES-R Winds Algorithm (Nested Tracking)**
  - Minimizes slow speed bias without increasing noise (RMSE)
  - Expected to benefit NWP
  - Enables extraction of motion at different heights and/or scales for a single target scenes
  - Brings new exploitation opportunities (NWP)

- **Began assessing the impact of Nested Tracking Winds in NCEP's Global Forecast System (via GOES-R3)**

- **Projects in place for early transition of nested tracking approach into NESDIS operations (GOES, NPP/VIIRS)**

Wind Posters (Today)

- (#2) Atmospheric Motion Vectors Derived via a New Nested Tracking Algorithm Developed for the GOES-R Advanced Baseline Imager (ABI) – *Daniels, Bresky, Wanzong, Bailey, Velden*

- (#3) Evaluation and Quality Control of Nested Tracking Approach for Atmospheric Motion Vectors (AMVs) – *Nebuda, jung, Santek, Daniels, Bresky*