EXPLORING THE BEHAVIOR OF ATMOSPHERIC MOTION VECTOR (AMV) ERRORS THROUGH SIMULATION STUDIES

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Study Content

- Motivation
- Simulated GOES-R ABI Data Methodology
- Simulated ABI AMVs
- Analysis Strategy (Imposed Noise Effects)
- Comparison to WRF Model Wind Fields
- Summary

Study Motivation

GOES-R Advanced Baseline Imager (ABI) -- Expected Launch in ~2017

What effect would imposed noise at spec, and over-spec, have on the derived AMV product?

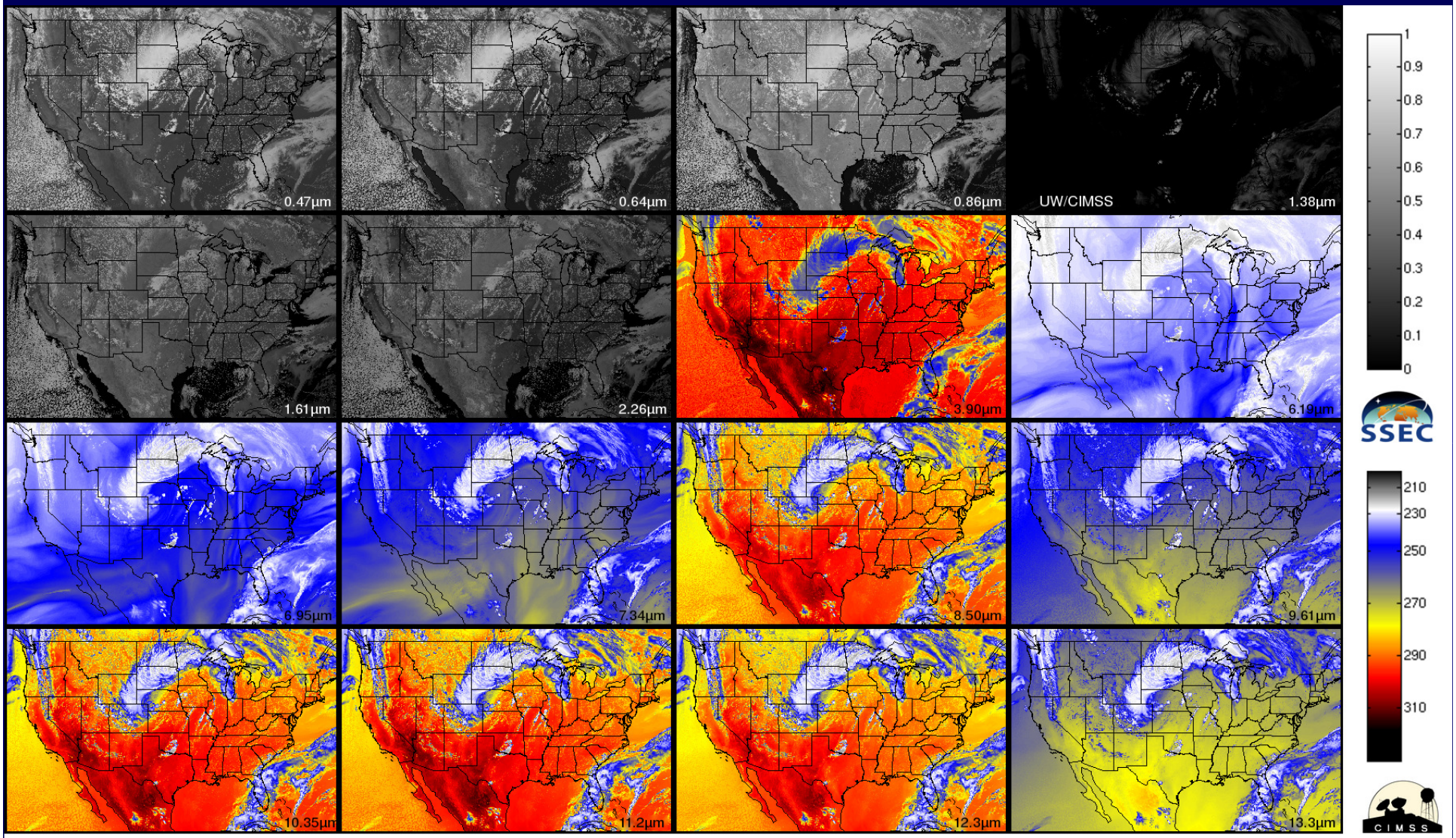
	ABI	Current GOES Imager
Spectral coverage		
	16 bands	5 bands
Spatial resolution		
0.64 μm Visible	0.5 km	Approx. 1 km
Other Visible/near-IR	1.0 km	n/a
Bands (>2 μm)	2 km	Approx. 4 km
Spatial coverage		
Full disk	4 per hour	Scheduled (3 hrly)
CONUS	12 per hour	~4 per hour
Mesoscale	Every 30 sec	n/a
Visible (reflective bands)		
On-orbit calibration	Yes	No

CIMSS

ABI Simulations - Methodology

- Employ the high resolution Weather Research and Forecasting (WRF) mesoscale model to generate simulated atmospheres.
- Calculate Top of Atmosphere (TOA) infrared radiances from the WRF model simulations using CRTM and SOI for ABI bands 7-16 (LW Infrared).
- Calculate TOA reflectances from the WRF model simulations using CRTM and SOI for ABI bands 1-6 (Visible/near-Infrared bands).
- Use automated feature-tracking software to derive AMVs from the simulated fields.

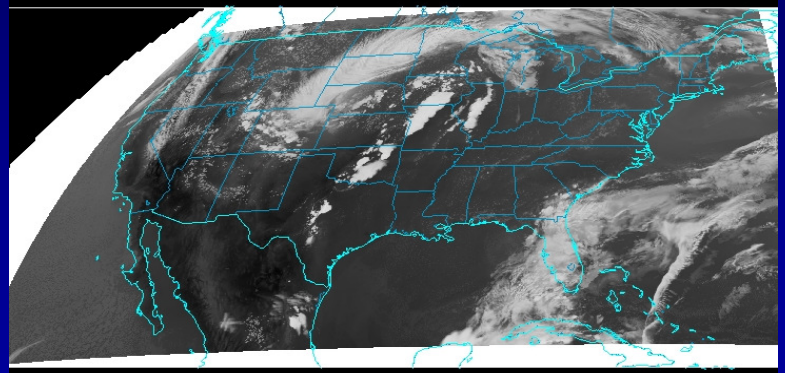
ABI bands via WRF simulation



ABI band data for 2005 June 04 22:00 UTC

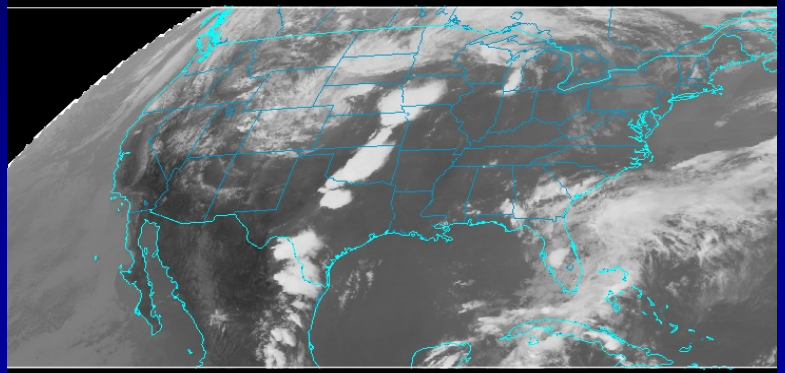
GOES-R ABI – CONUS Coverage

Simulated GOES-R ABI



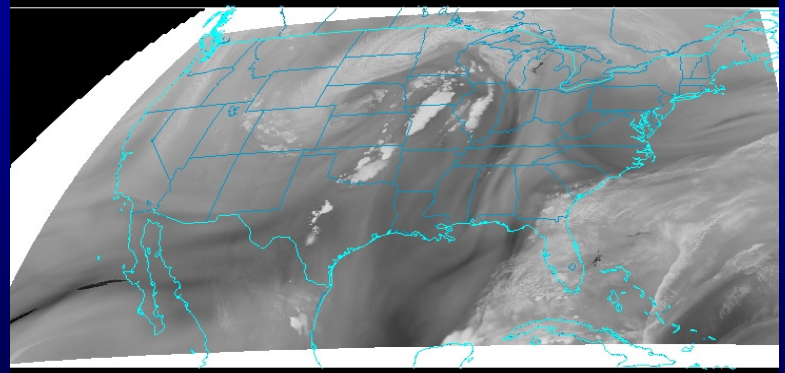
Band 14: 11.2 µm

GOES-12 Imager



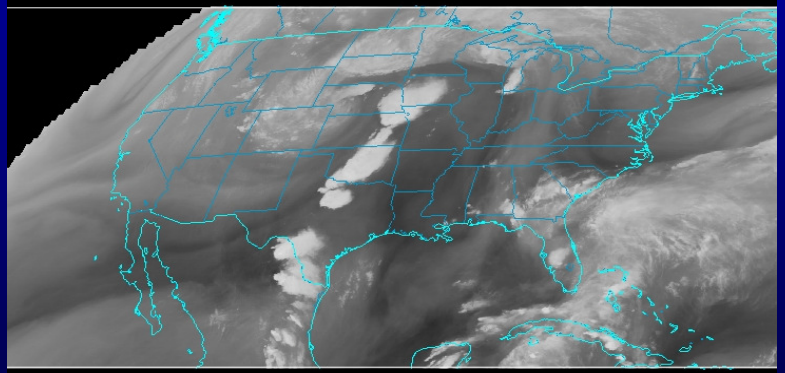
Band 04: 10.7 µm

Simulated GOES-R ABI



Band 08: 6.19 µm

GOES-12 Imager



Band 03: 6.5 µm

Simulated AMVs: Retrieval and Analysis Strategy

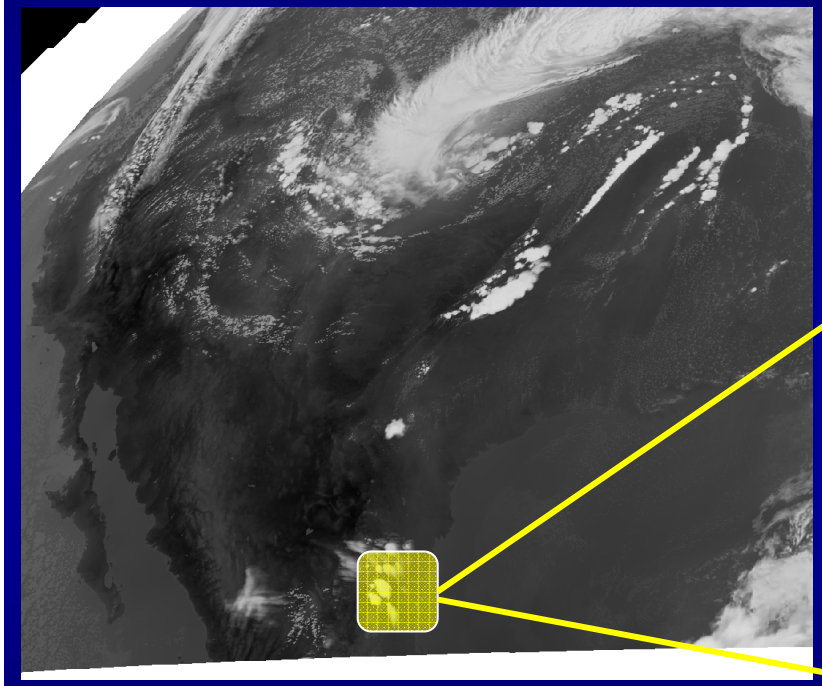
1. Obtain a set of 3 precisely calibrated, navigated and co-registered simulated images from the WRF model output for selected spectral channels ("pure" dataset = baseline "truth")
2. Employ the CIMSS/NESDIS automated AMV derivation algorithm to target, height assign, track, and QC AMV fields from these simulated images
3. Redo 1) above, except with introduced noise effects that represent proposed GOES-R satellite specs, and 3X specs. The noise includes striping, calibration and navigation offsets
4. Redo 2) above for each imposed noise AMV sample
5. Perform a quantitative error analysis on the resultant AMV fields using an objective toolkit called GRAFIIR, to deduce the effects of the imposed instrument noise on the derived AMV products.

Imposed ABI Navigation Error - Methodology

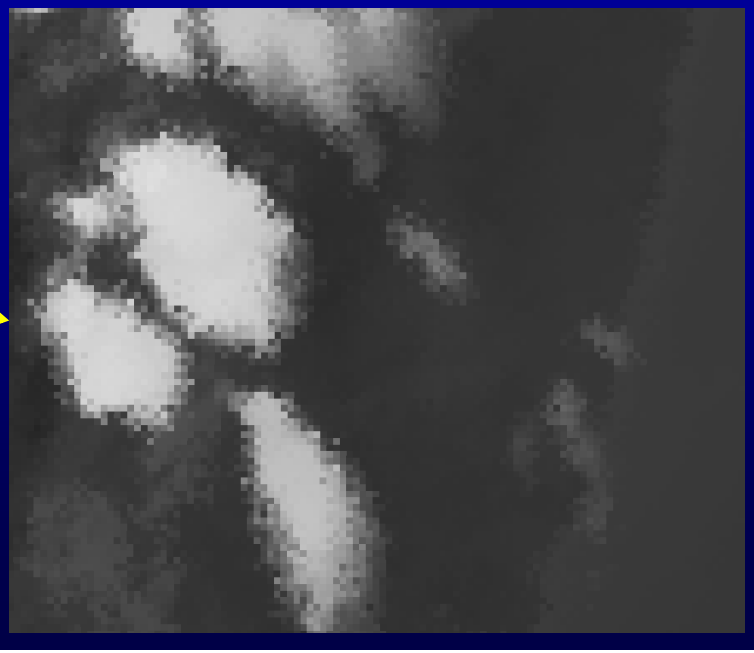
- The GOES-R PORD specification for navigation error is +/- 21 microradians (0.75 km).
- Each pixel is given a random compass direction and a random normally distributed (about 0) shift the equivalent of 21 microradians.
- New pixel positions are generated using the random shift and random direction.
- The radiances are then linearly interpolated to these new positions from the original pixel locations.
- Second experiment: 3X Spec

GOES-R ABI – NavError (3Xspec)

Baseline



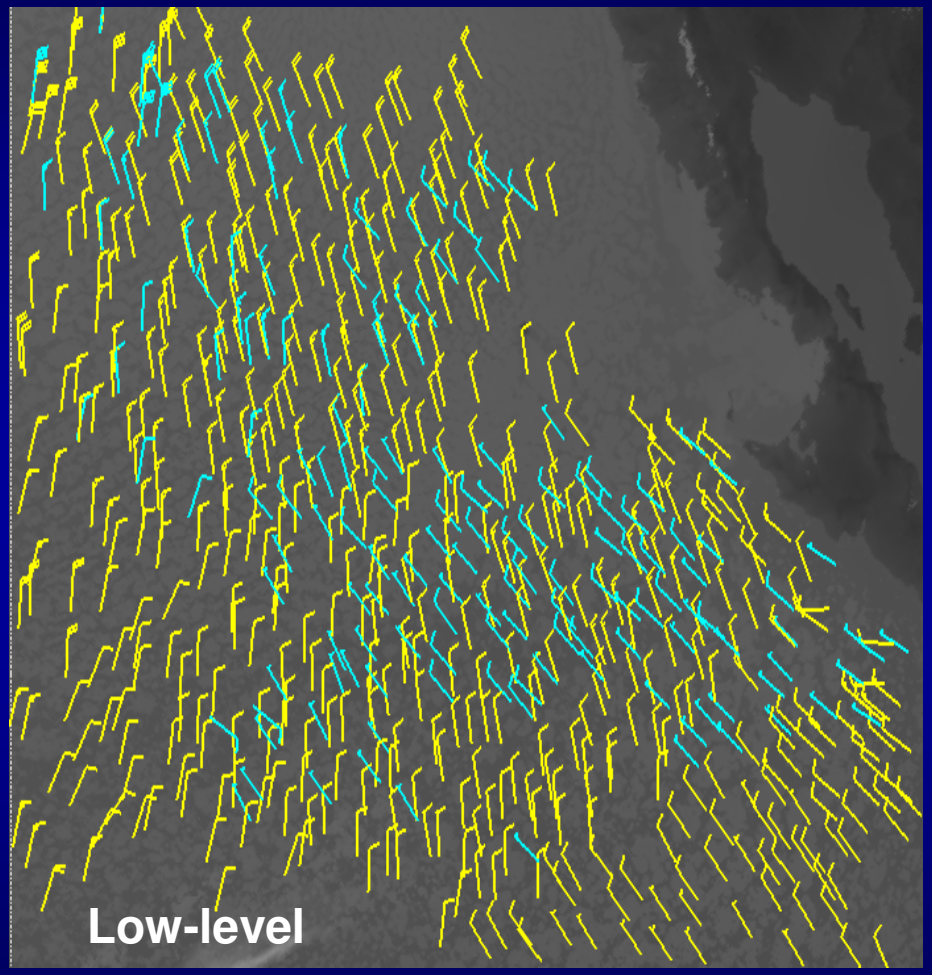
Band 14 (11.2 μm)

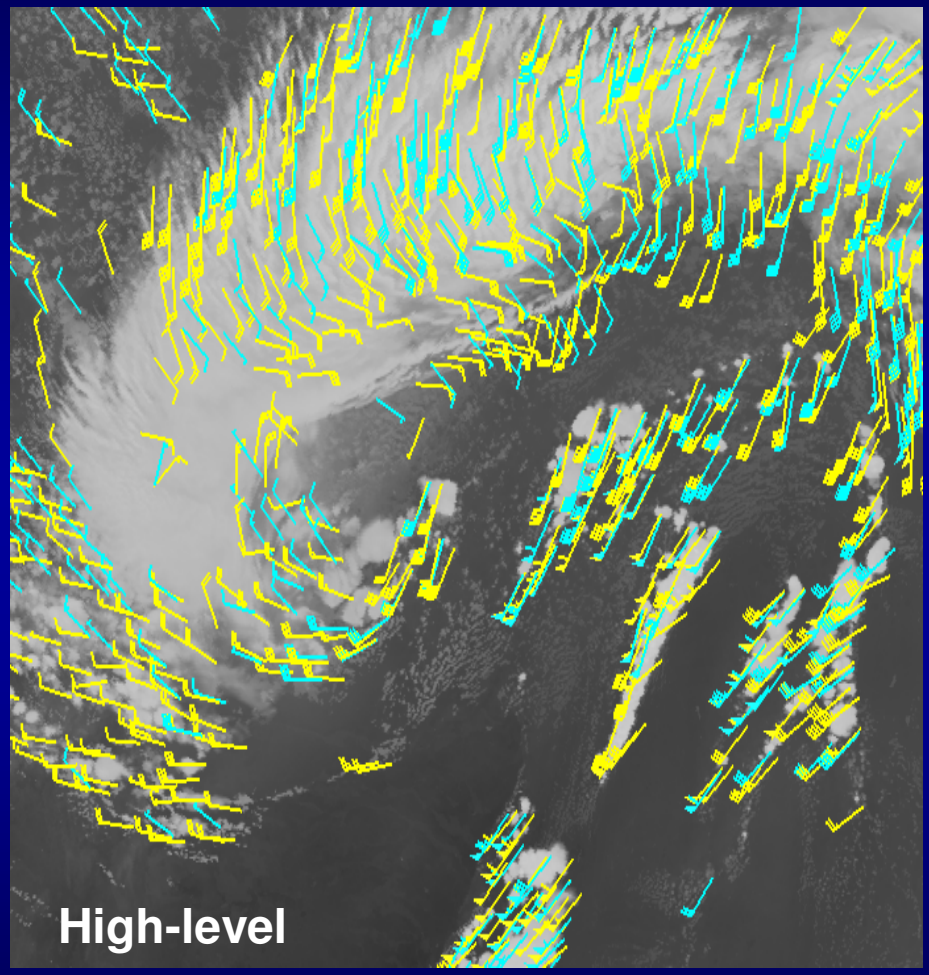


NavError3x

GOES-R ABI – NavError (3Xspec)

IR-W AMVs - 5 minute time step

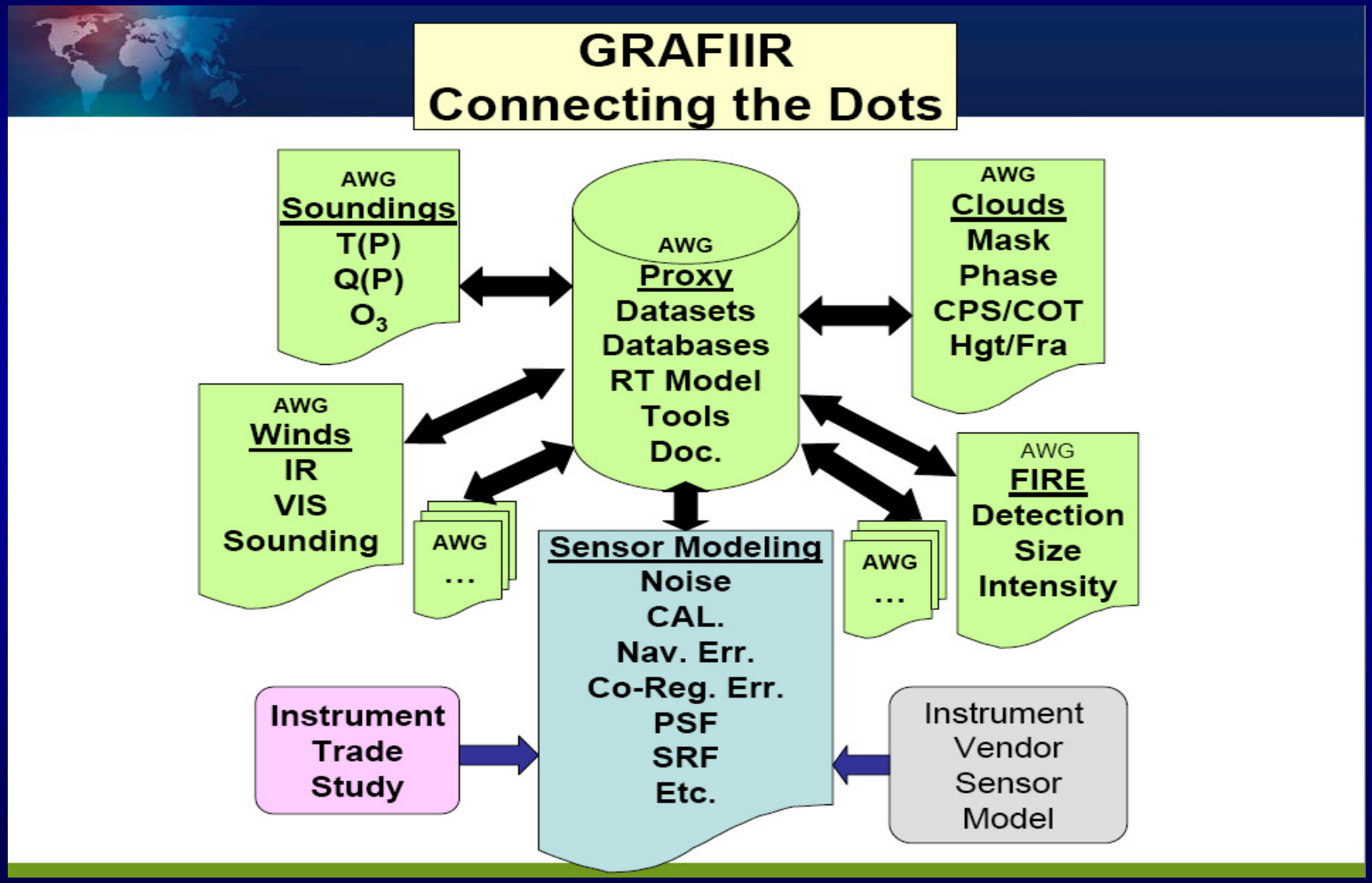




Yellow AMVs – “truth”
Blue AMVs -- NavError3x

Simulated AMV Analysis Tool

GOES-R Analysis Facility for Instrument Impacts on Requirements



GOES-R ABI Simulated AMV Comparison Metrics

All AMVs are QI>80, and compared against WRF model winds

$$MVD = \frac{1}{N}\sum_{i=1}^{N}(VD_i)$$

$$SD = \sqrt{\frac{1}{N}\sum_{i=1}^{N}((VD_i) - (MVD))^2}$$

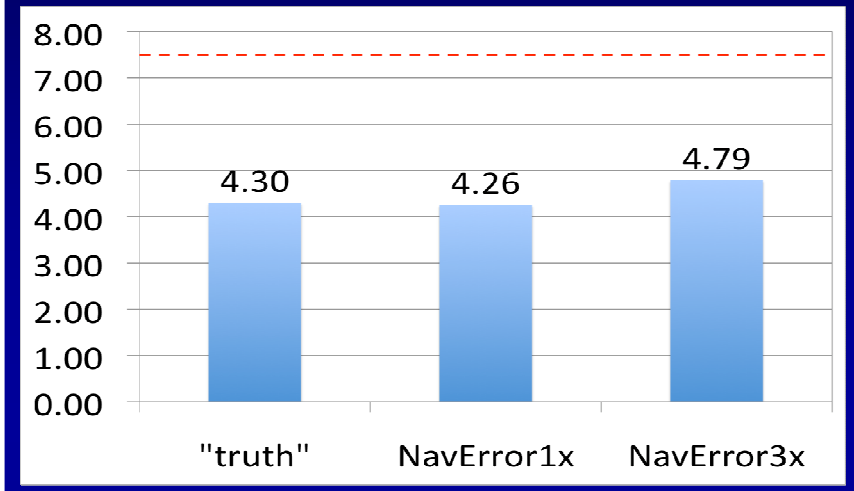
Where:

$$(VD)_i = \sqrt{(U_i - U_r)^2 + (V_i - V_r)^2}$$

U_i and V_i -> AMV
U_r and V_r -> "Truth"

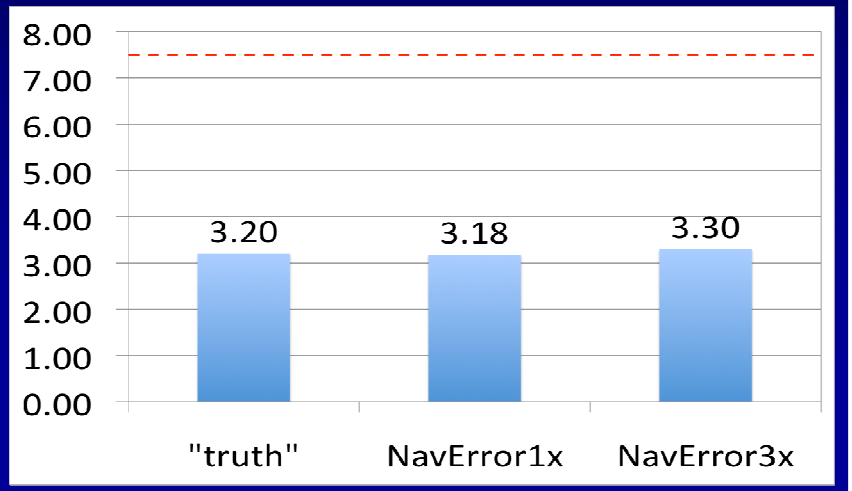
GOES-R ABI - Comparison Statistics

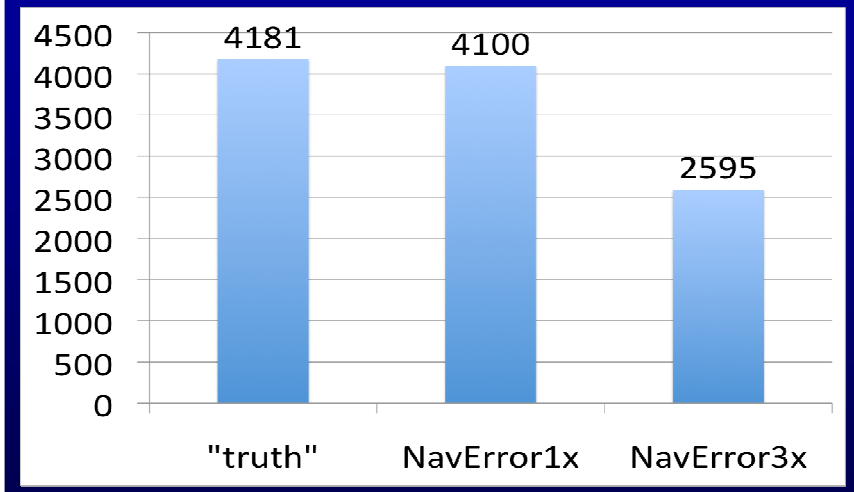
AMVs Derived from ABI Simulated Imagery vs. WRF Model Winds



7.5 m/s

MVD





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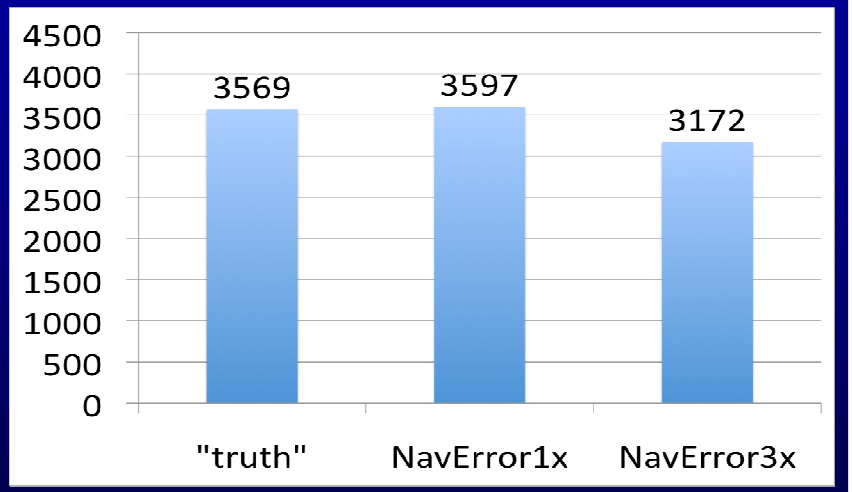
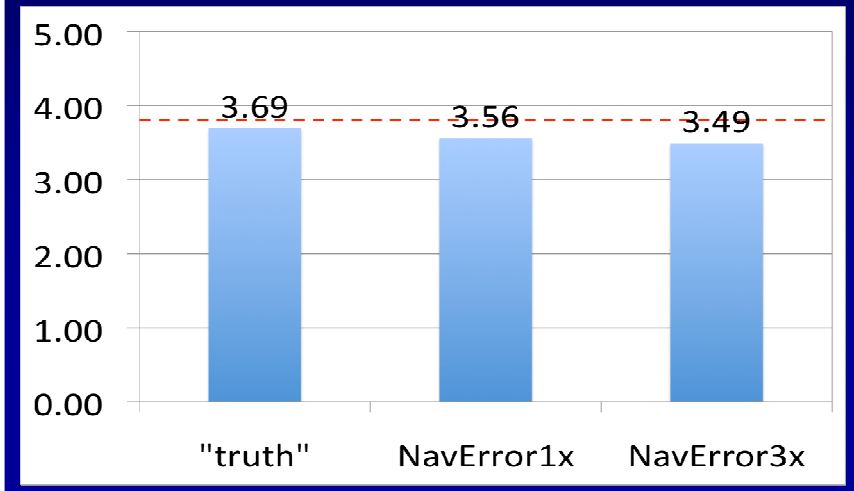


05 min – IR (11.2 µm)

15 min – IR (11.2 µm)

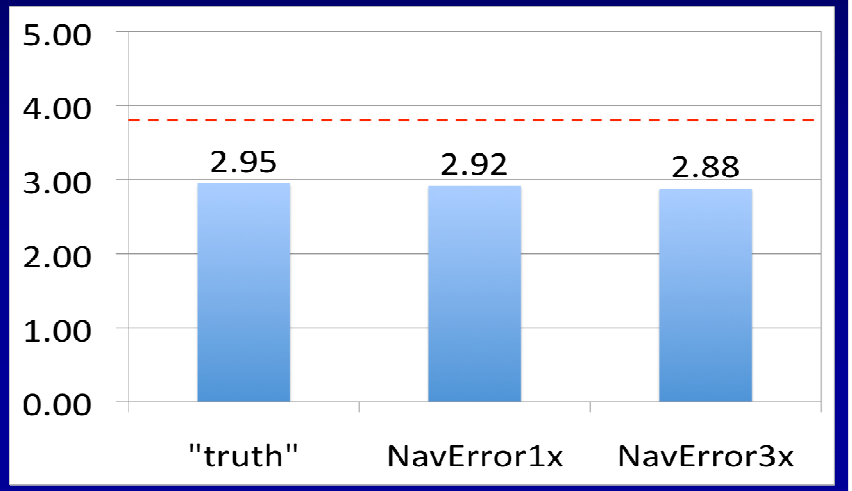
GOES-R ABI - Comparison Statistics

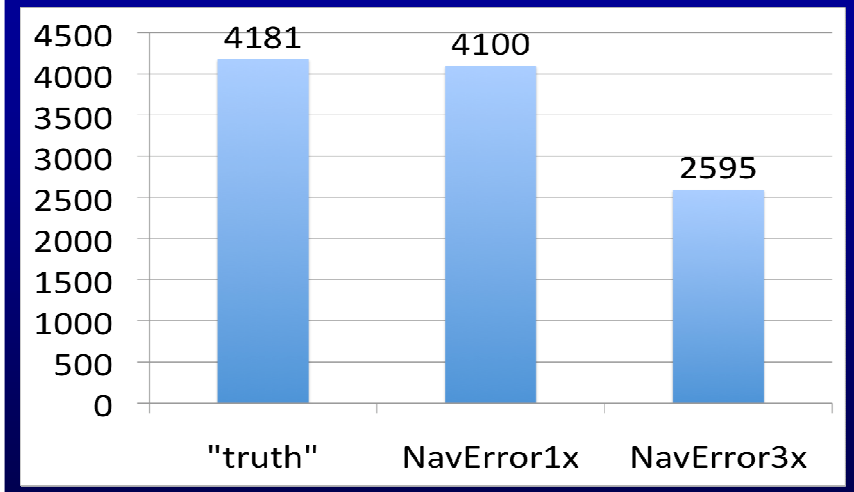
AMVs derived from ABI Simulated Imagery vs. WRF Model Winds



3.8 m/s

Std Dev





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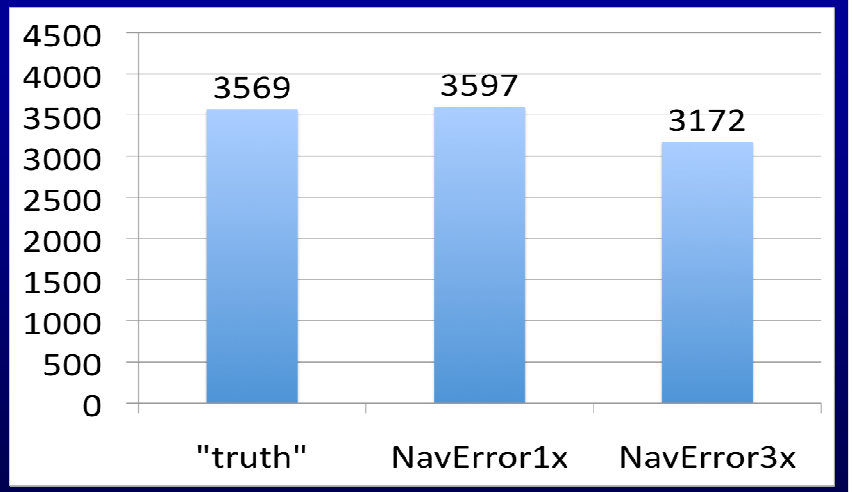


05 min – IR (11.2 µm)

15 min – IR (11.2 µm)

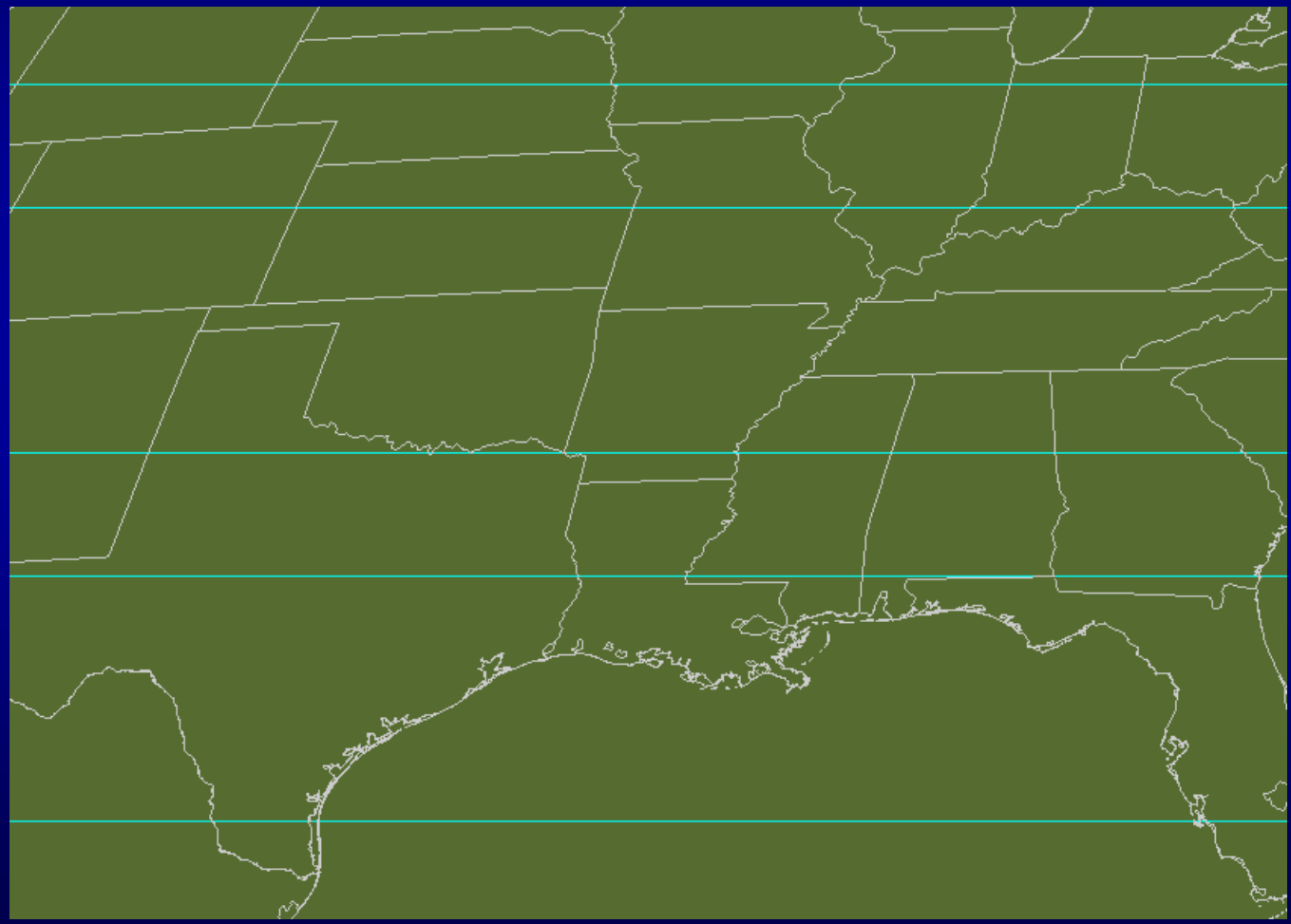
Imposed ABI Striping Error - Methodology

- The GOES-R PORD spec for striping error is that it should be less than the spec instrument noise.
- Assume a detector array (100 high) has 1 line simulated to be “bad”.
- Every 100th line has striping error applied by adding a radiance offset equal to the spec noise.
- Second experiment with 3X spec.

GOES-R ABI – Striping3x

Temperature difference between “truth” and 3x Striping

Green is zero difference. Blue stripes are only observed difference.

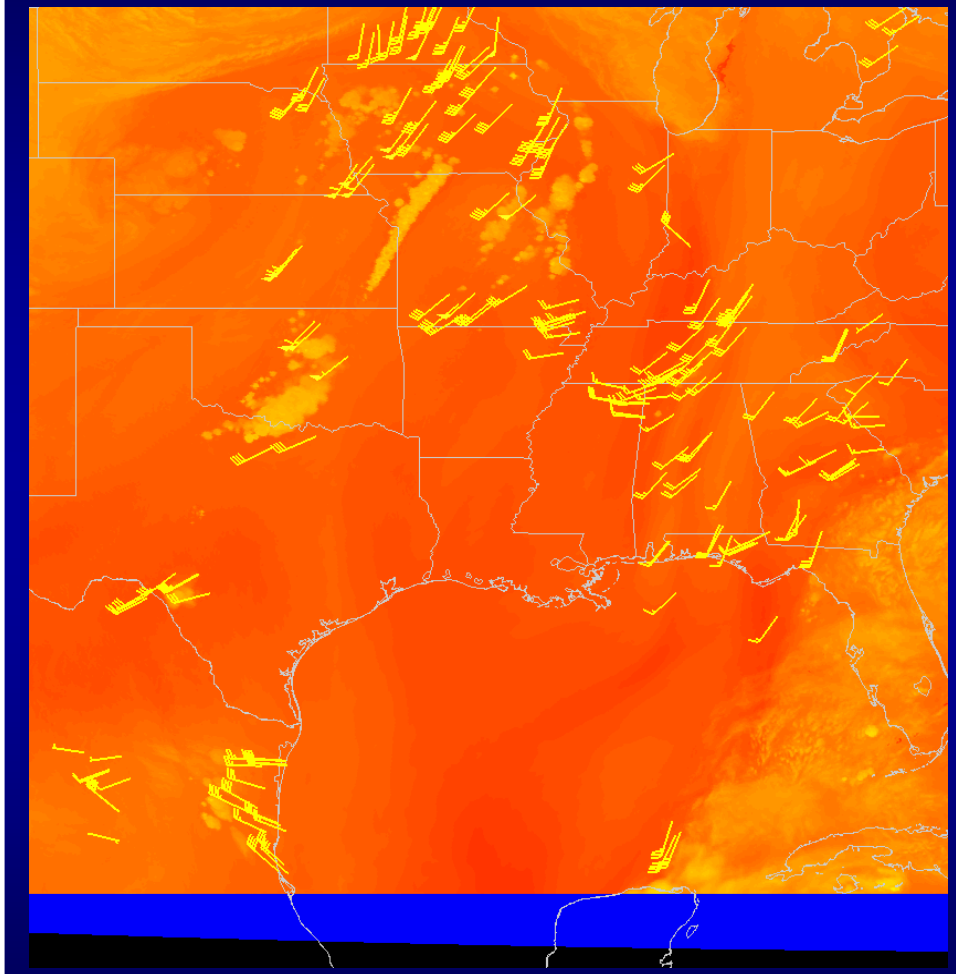


Band 08 - 6.19 μm

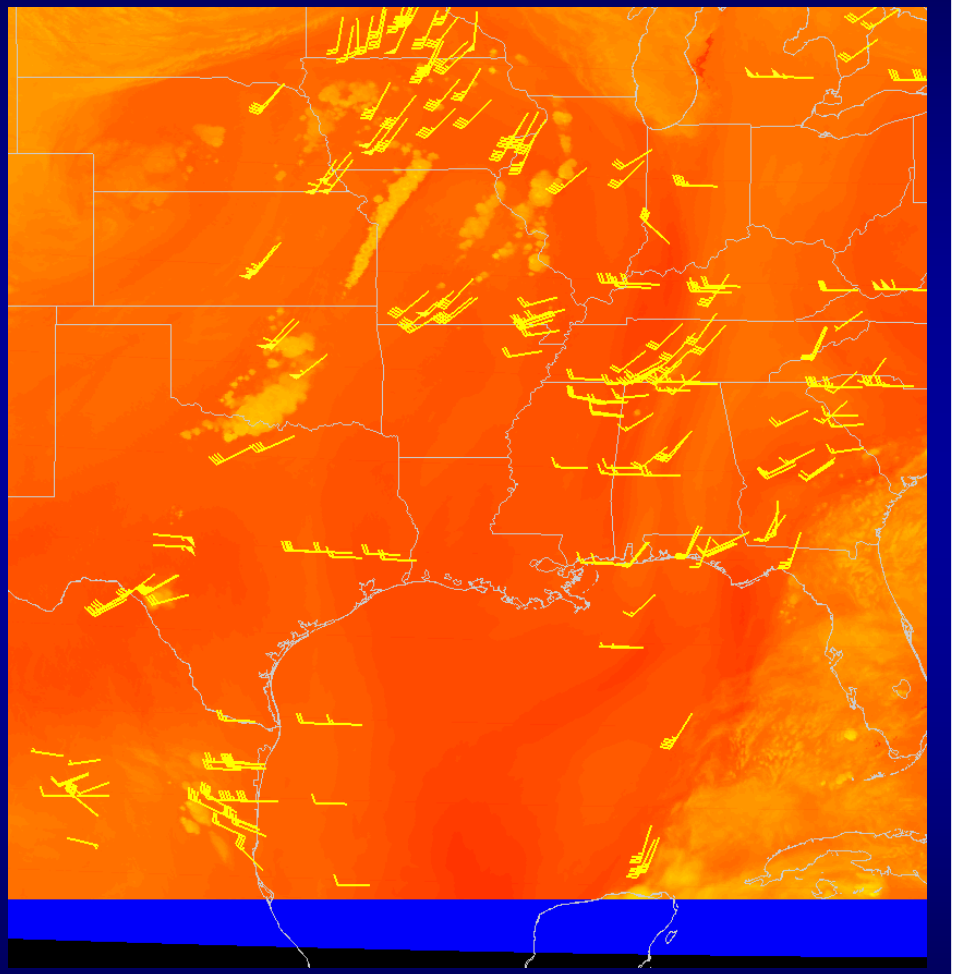
GOES-R ABI – Striping3x

15 minute time step

Clear sky water vapor tracking



Baseline (no striping) AMVs
Band 08 (6.19 μm)

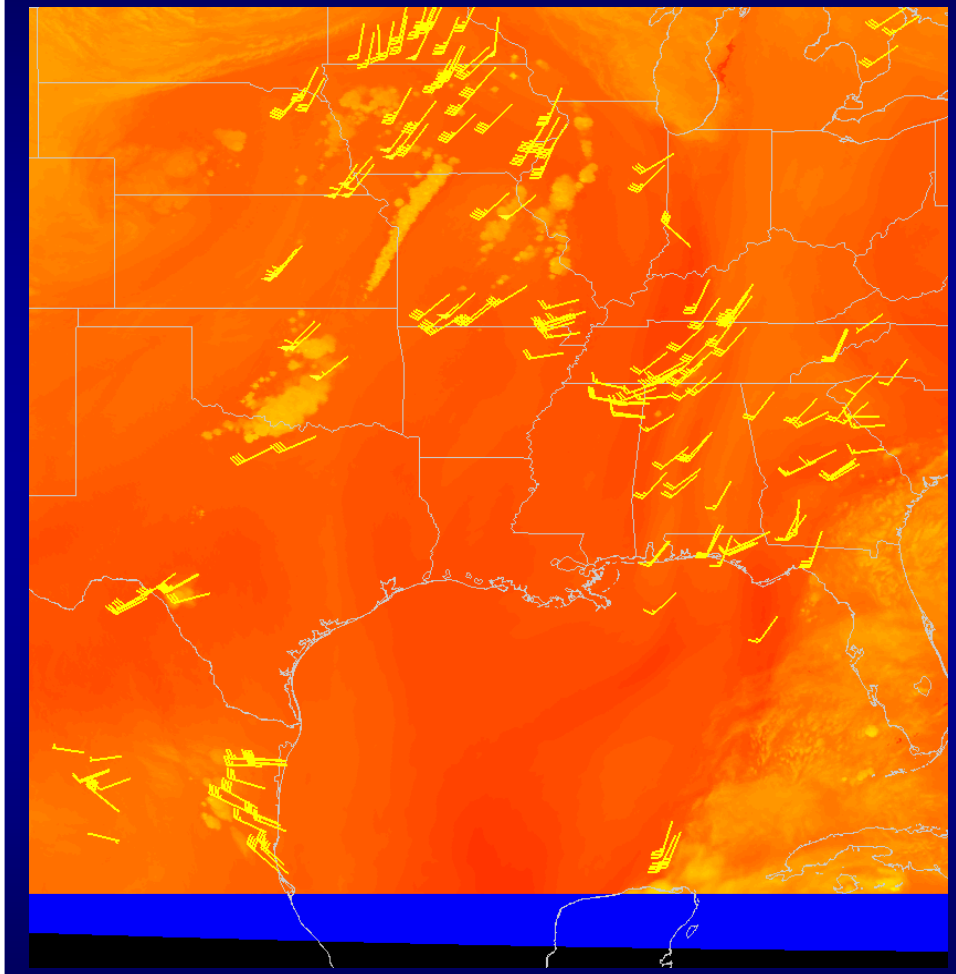


Striping3x Band 08 AMVs

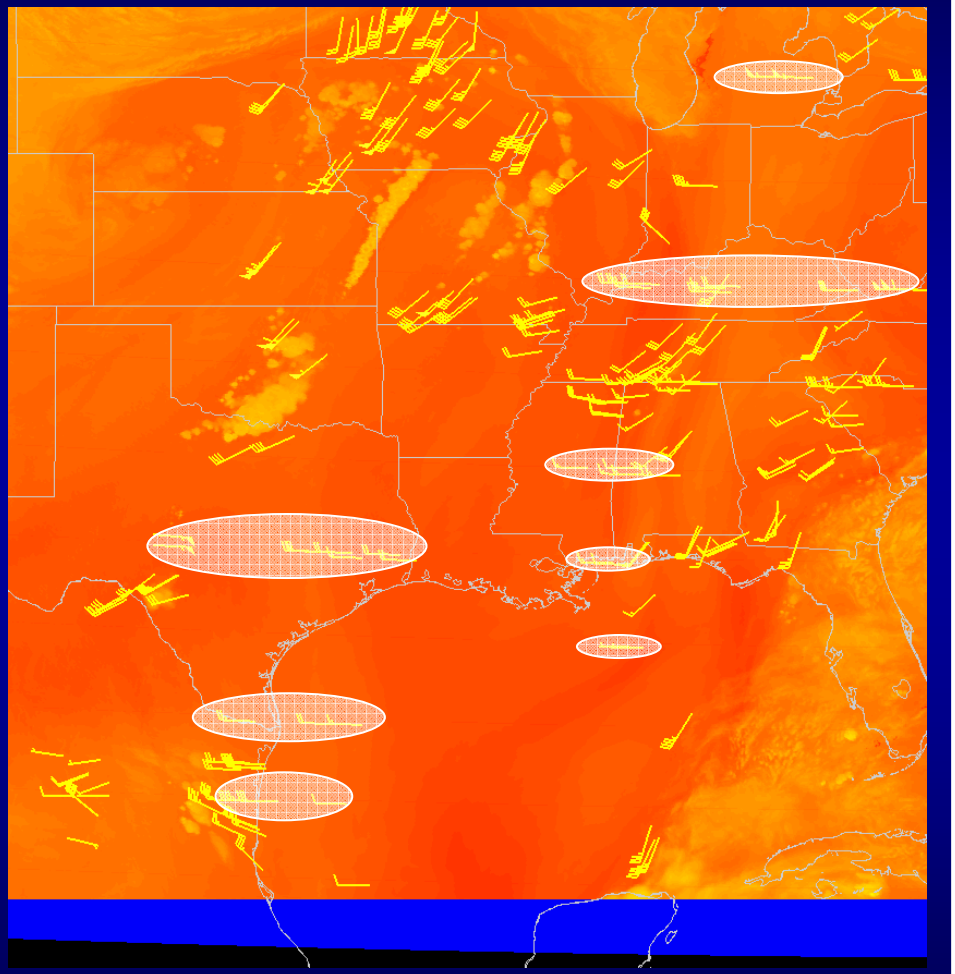
GOES-R ABI – Striping3x

15 minute time step

Clear sky water vapor tracking



Baseline (no striping) AMVs
Band 08 (6.19 μm)

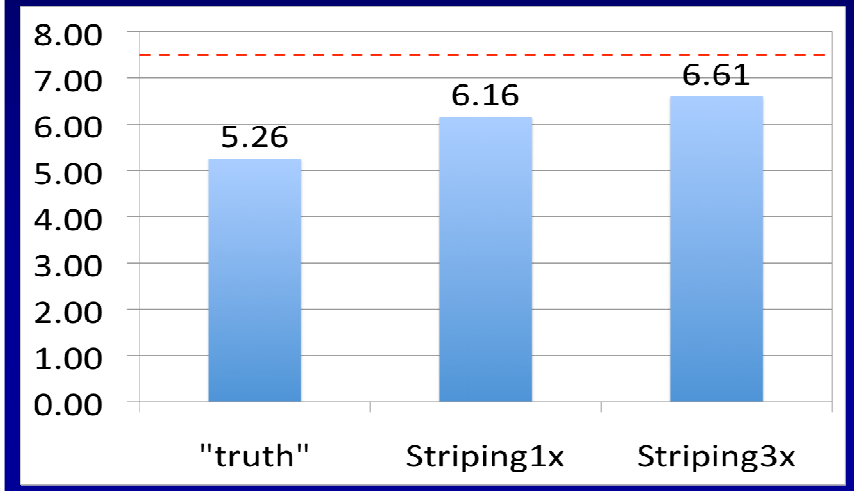


Striping3x Band 08 AMVs

White areas -- tracking striping

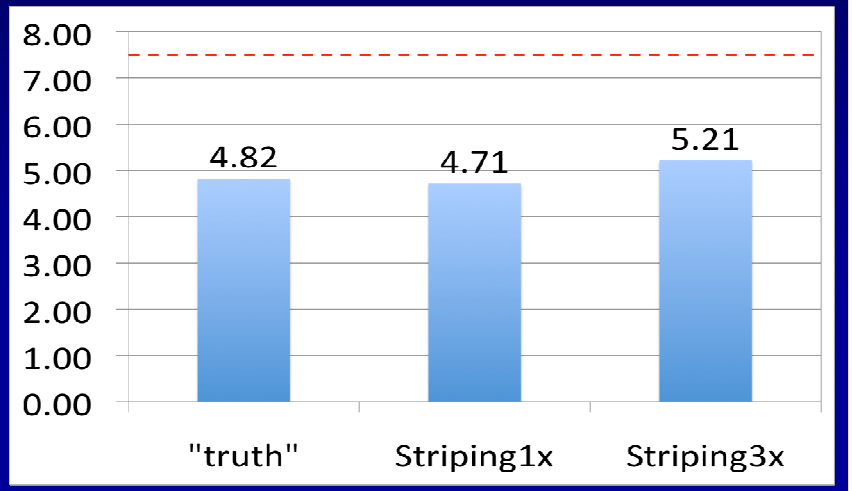
GOES-R ABI - Comparison Statistics

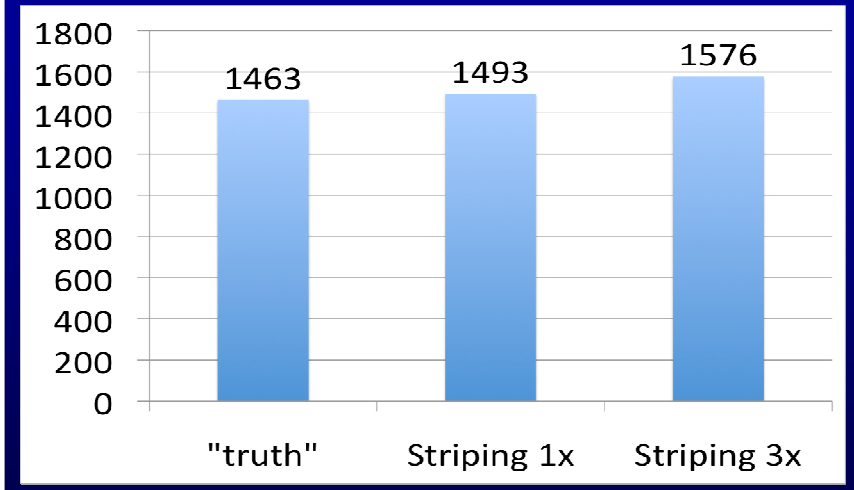
AMVs derived from ABI Simulated Imagery vs. WRF Model Winds



7.5 m/s

MVD





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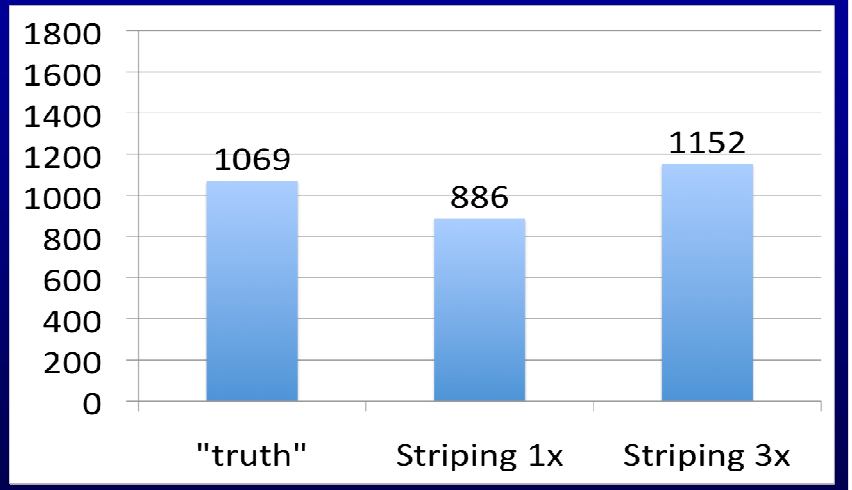
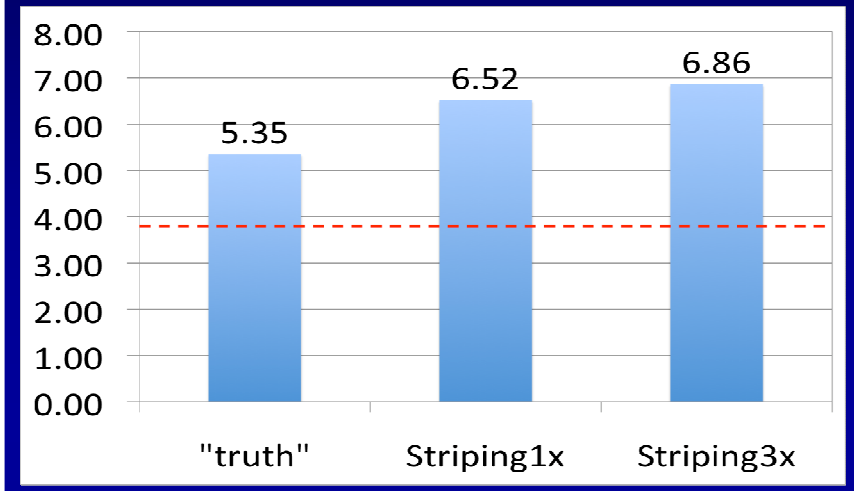


15 min – WV (6.19 µm)

30 min – WV (6.19 µm)

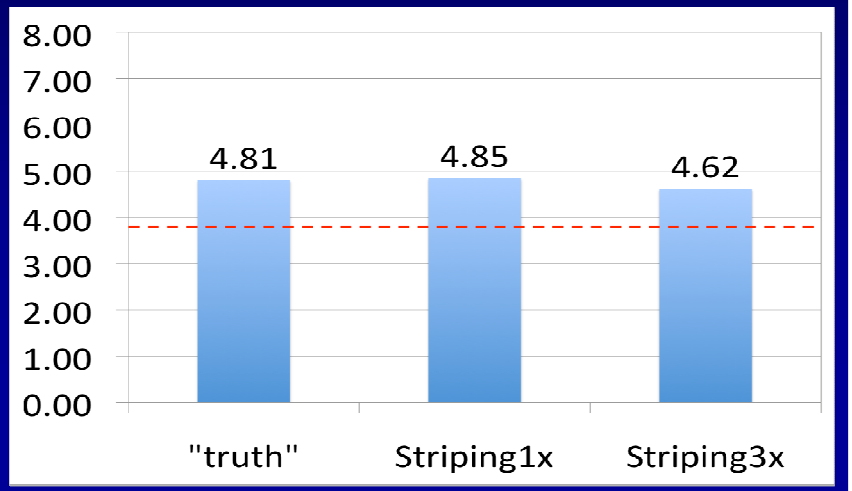
GOES-R ABI - Comparison Statistics

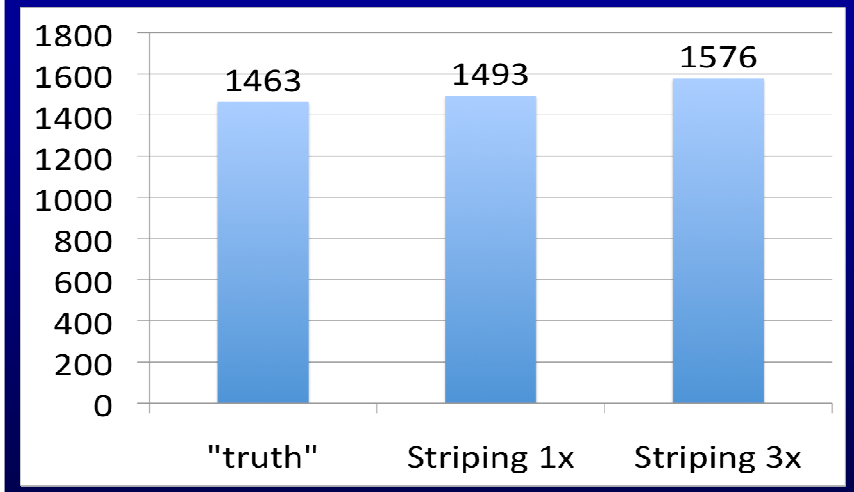
AMVs derived from ABI Simulated Imagery vs. WRF Model Winds



Std Dev

3.8 m/s





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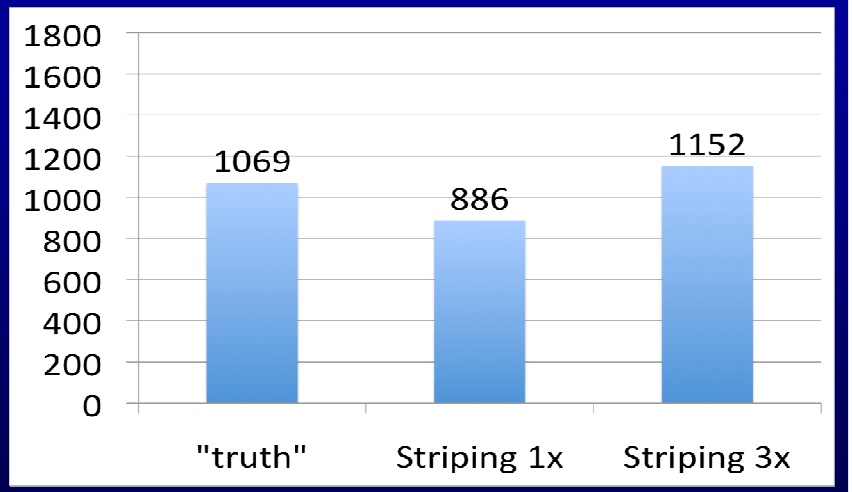
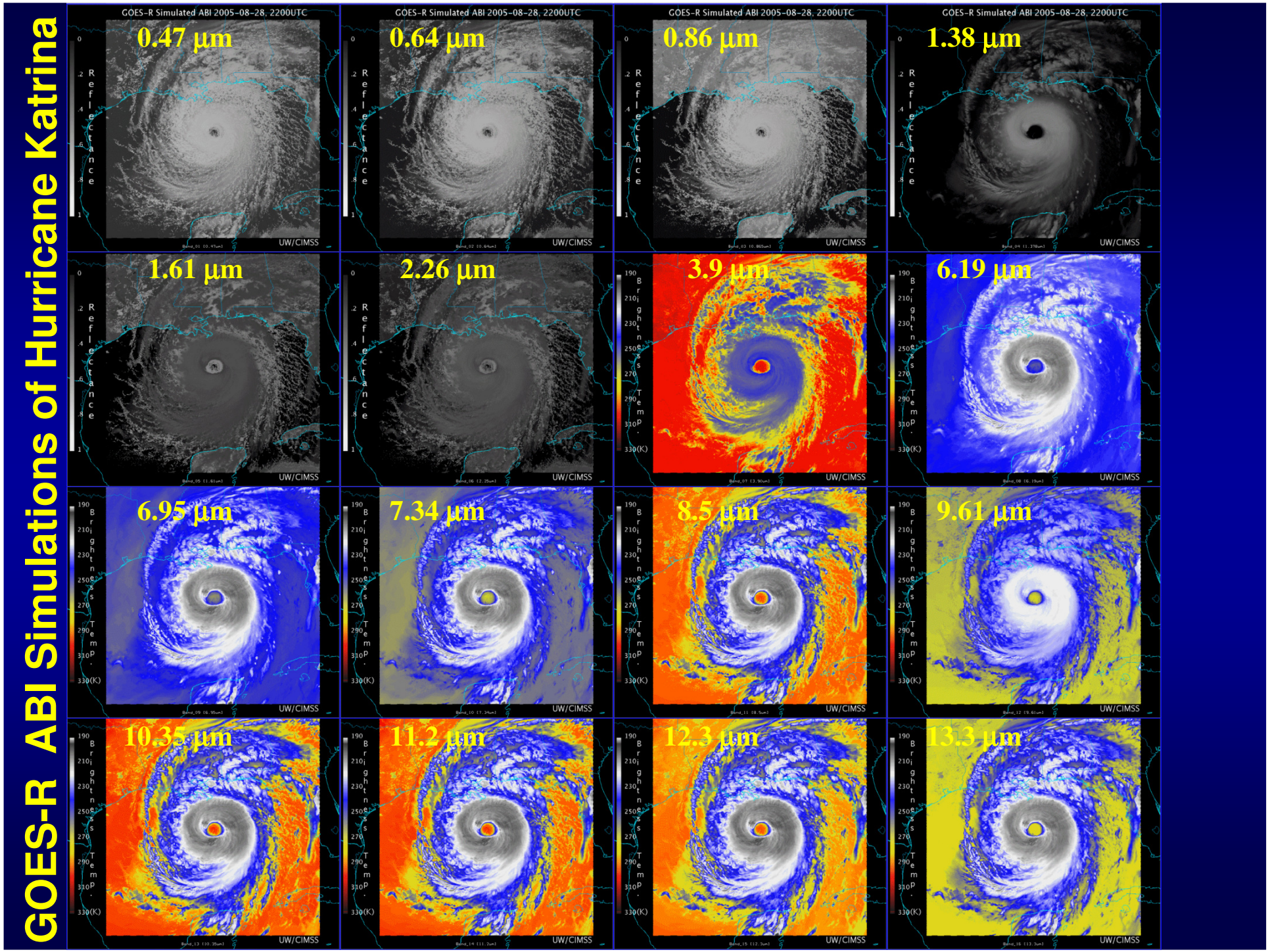
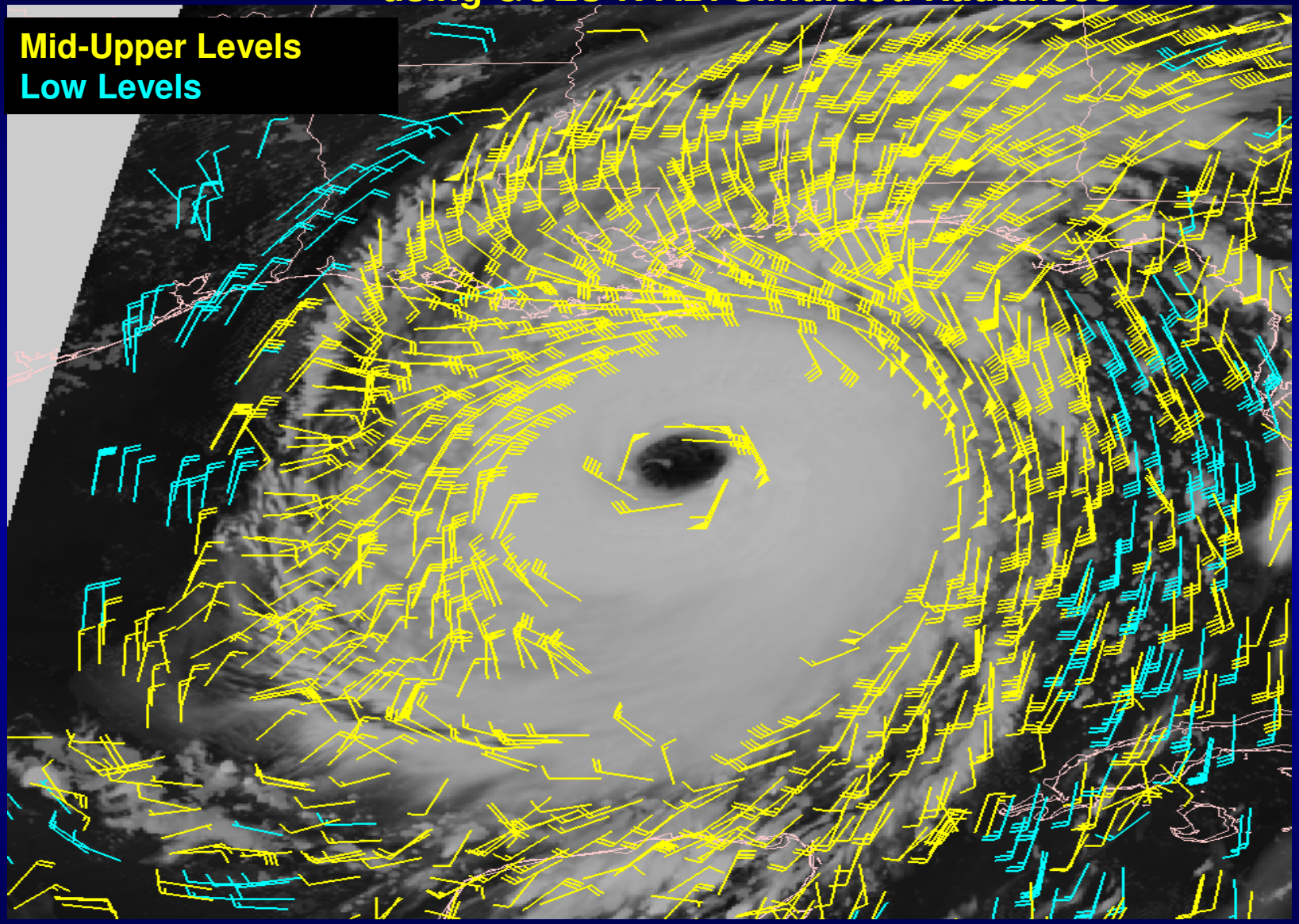


15 min – WV (6.19 µm)

30 min – WV (6.19 µm)

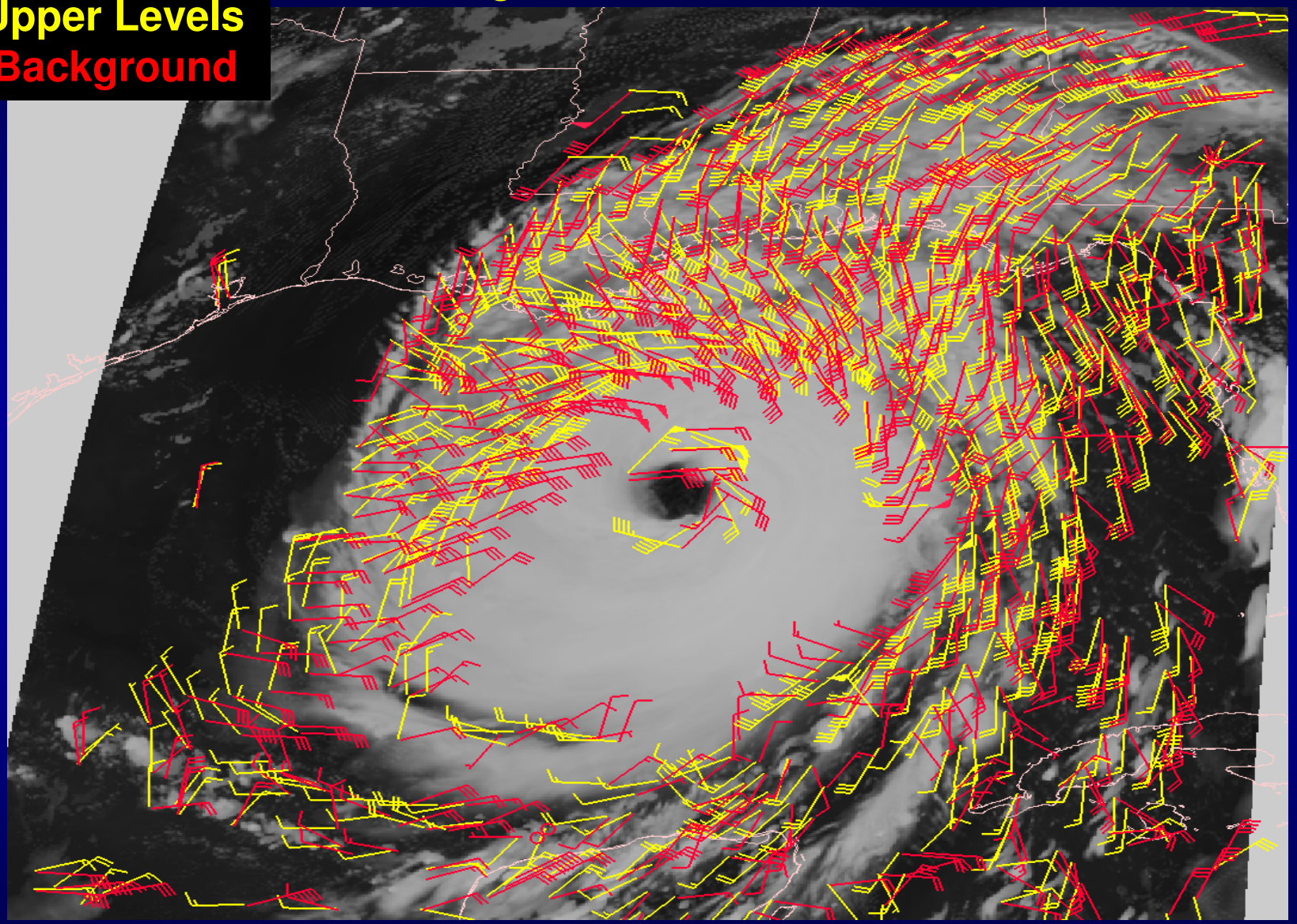

GOES-R ABI Simulations of Hurricane Katrina
GOES-R Simulated ABI 2005-08-28, 2200UTC
0.47 µm
0.64 µm
0.86 µm
1.38 µm
1.61 µm
2.26 µm
3.9 µm
6.19 µm
6.95 µm
7.34 µm
8.5 µm
9.61 µm
10.35 µm
11.2 µm
12.3 µm
13.3 µm
Reflectance
Brightness Temp. (K)
UW/CIMSS

-- *Hurricane Katrina* -- Atmospheric Motion Vectors from WRF Model using GOES-R ABI Simulated Radiances

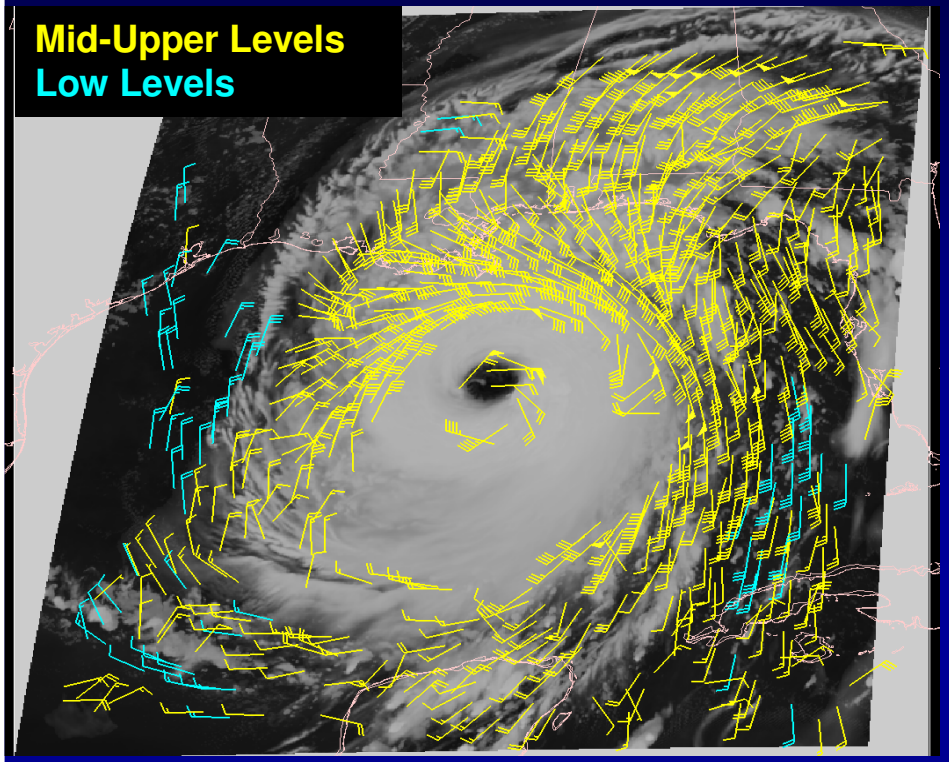


-- *Hurricane Katrina* -- Atmospheric Motion Vectors from WRF Model using GOES-R ABI Simulated Radiances

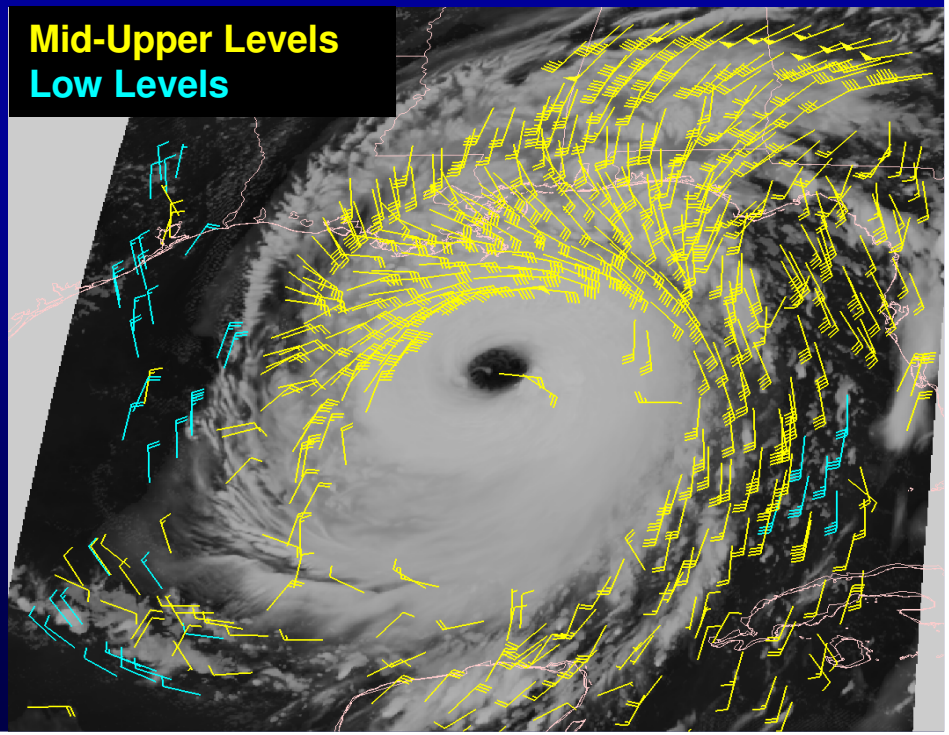
Mid-Upper Levels
GFS Background



Simulated Katrina

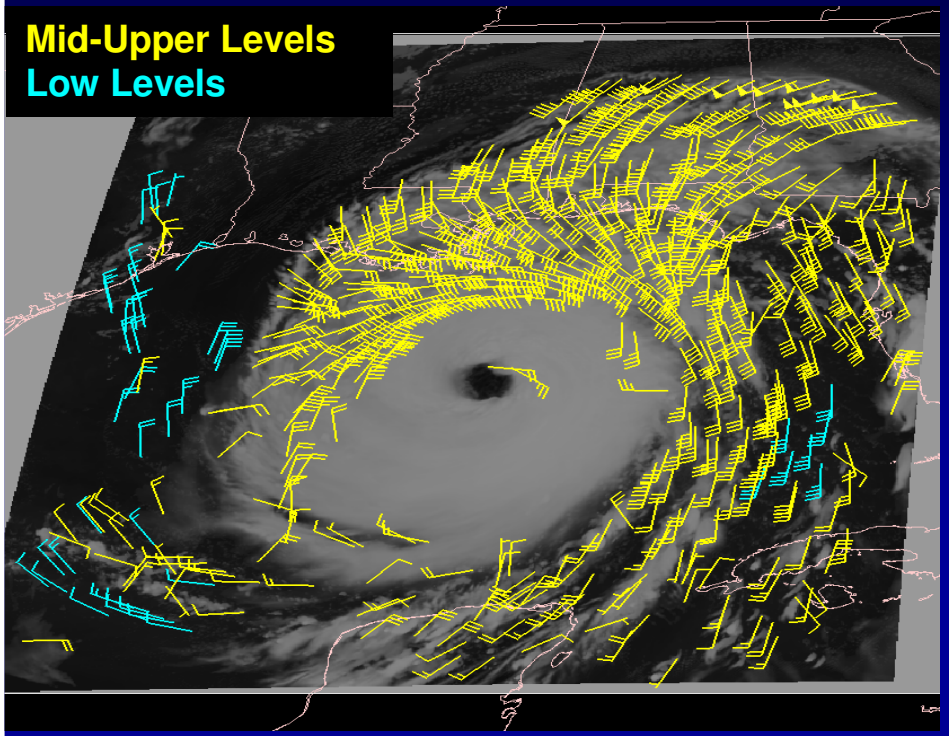


5-Minute Time Step
15x15 Target Box Size
2 km Resolution

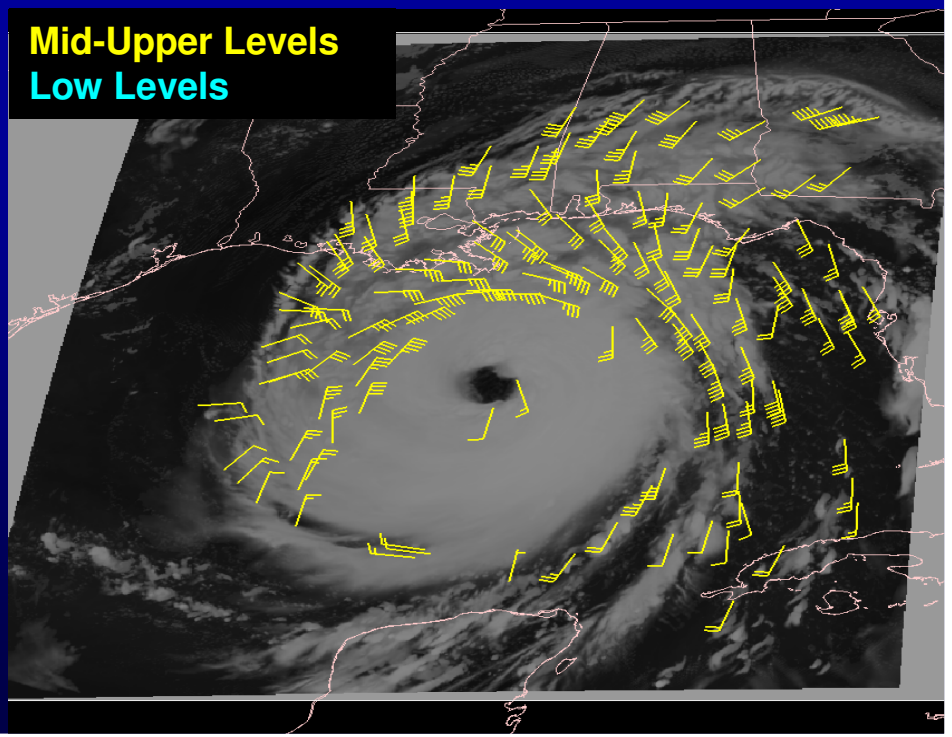


15-Minute Time Step
15x15 Target Box Size
2 km Resolution

Simulated Katrina



15-Minute Time Step
15x15 Target Box Size
2 km Resolution



15-Minute Time Step
15x15 Target Box Size
4 km Resolution

Summary

- Simulated ABI data produced from WRF model TOA radiances is an effective way to study the potential effects of various ‘noise’ sources and processing choices on AMVs.
- Unaltered radiance fields were used as the baseline (“truth”) AMV product.
- Imposed navigation/registration errors have the greatest negative impact on IR and Visible AMVs compared to baseline.
- Striping effects are troublesome for clear sky water vapor AMVs.
- The above findings are effectively quantified using the GRAFIIR data analysis tool.

Thank You

Questions?

Backups