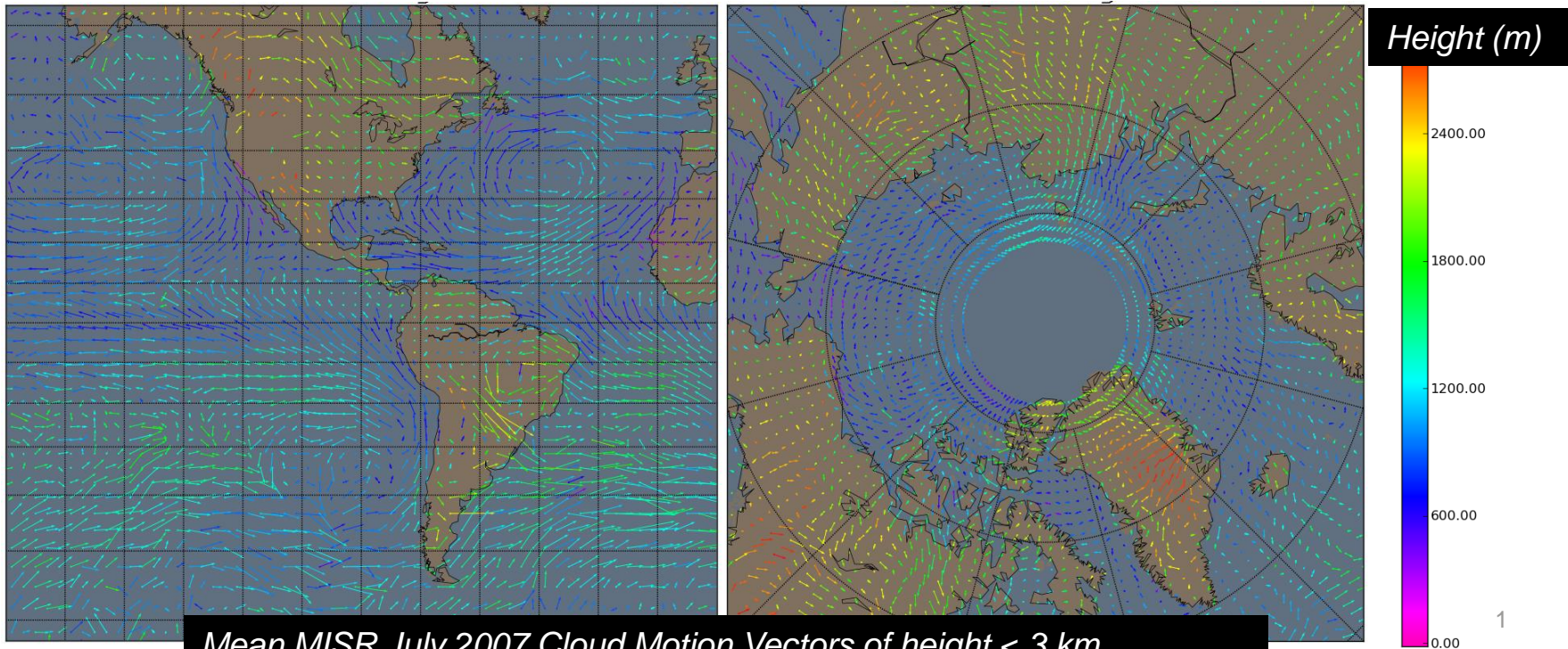


# MISR 17.6 km Gridded Cloud Motion Vectors: Overview and Assessment

**Kevin Mueller, Michael Garay, Catherine Moroney,  
Veljko Jovanovic**

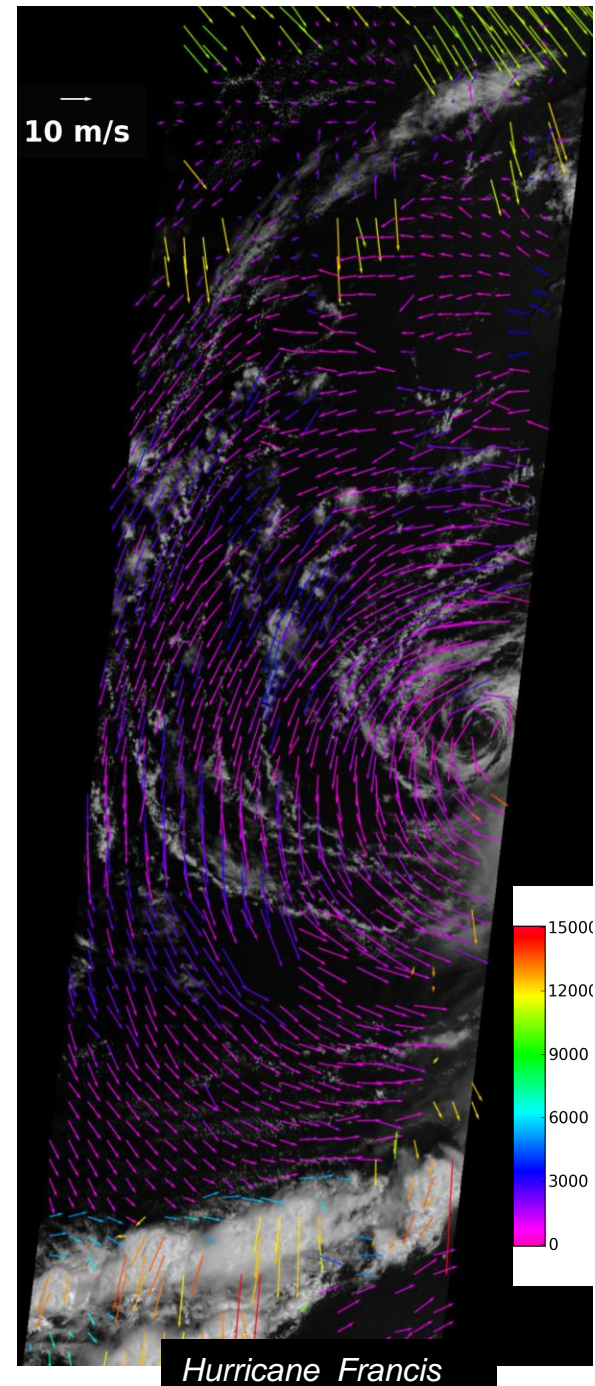
*Jet Propulsion Laboratory*

Feb. 22, 2012

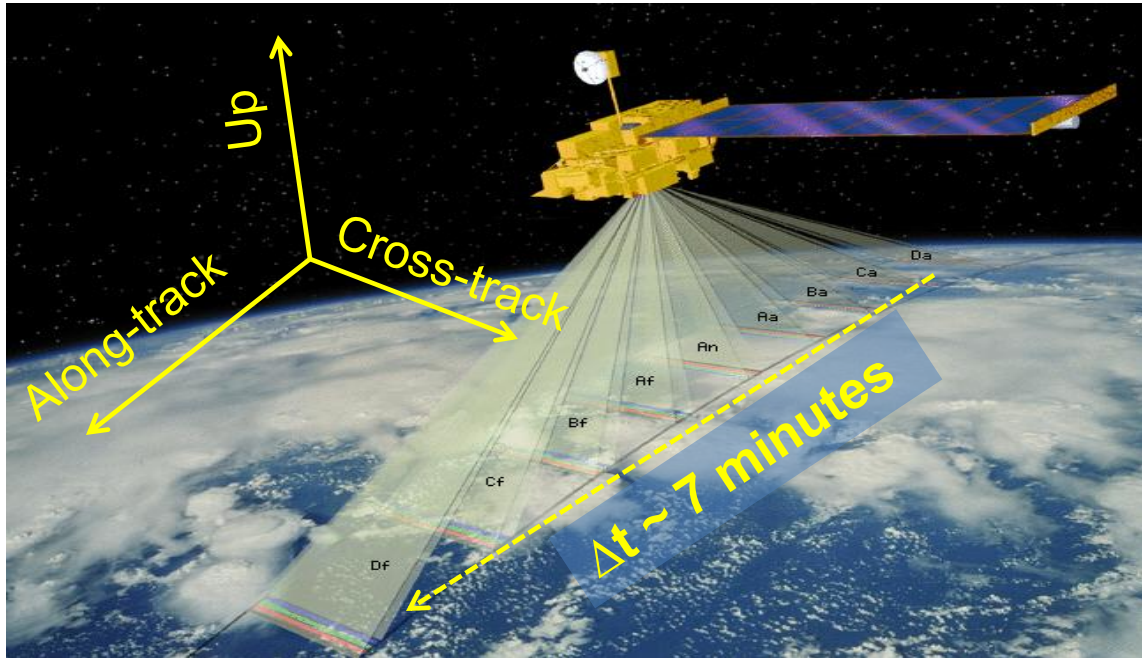


# Introduction and Overview

- Introduction and Overview
  - The MISR Instrument
  - MISR Cloud Motion Retrieval
  - New MISR Product Developments
- 2012 MISR Cloud Motion Vector Product (CMVP)
  - Overview of 2012 TC Cloud Product Algorithm
  - Comparison with previous CMVP
  - CMV Sampling Frequency and Coverage
- Atmospheric Motion Vector Intercomparison
  - MISR versus RAOB
  - MISR versus GOES
  - MISR versus MODIS
- Conclusion
  - 17.6 km CMV resolution (as opposed to 70.4 km)
  - 3x coverage
  - Better agreement with RAOB, GOES, and MODIS
    - Low Cloud CMV MISR vs. GOES RMSVD  $\sim 3.3$  m/s
    - Low Cloud CMV MISR vs. GOES bias removed
    - MISR along-track bias reduced by 50-80% generally
    - MISR RMSVD reduced by 10-60% generally



# The Multi-Angle Imaging SpectroRadiometer (MISR)



## MISR highlights

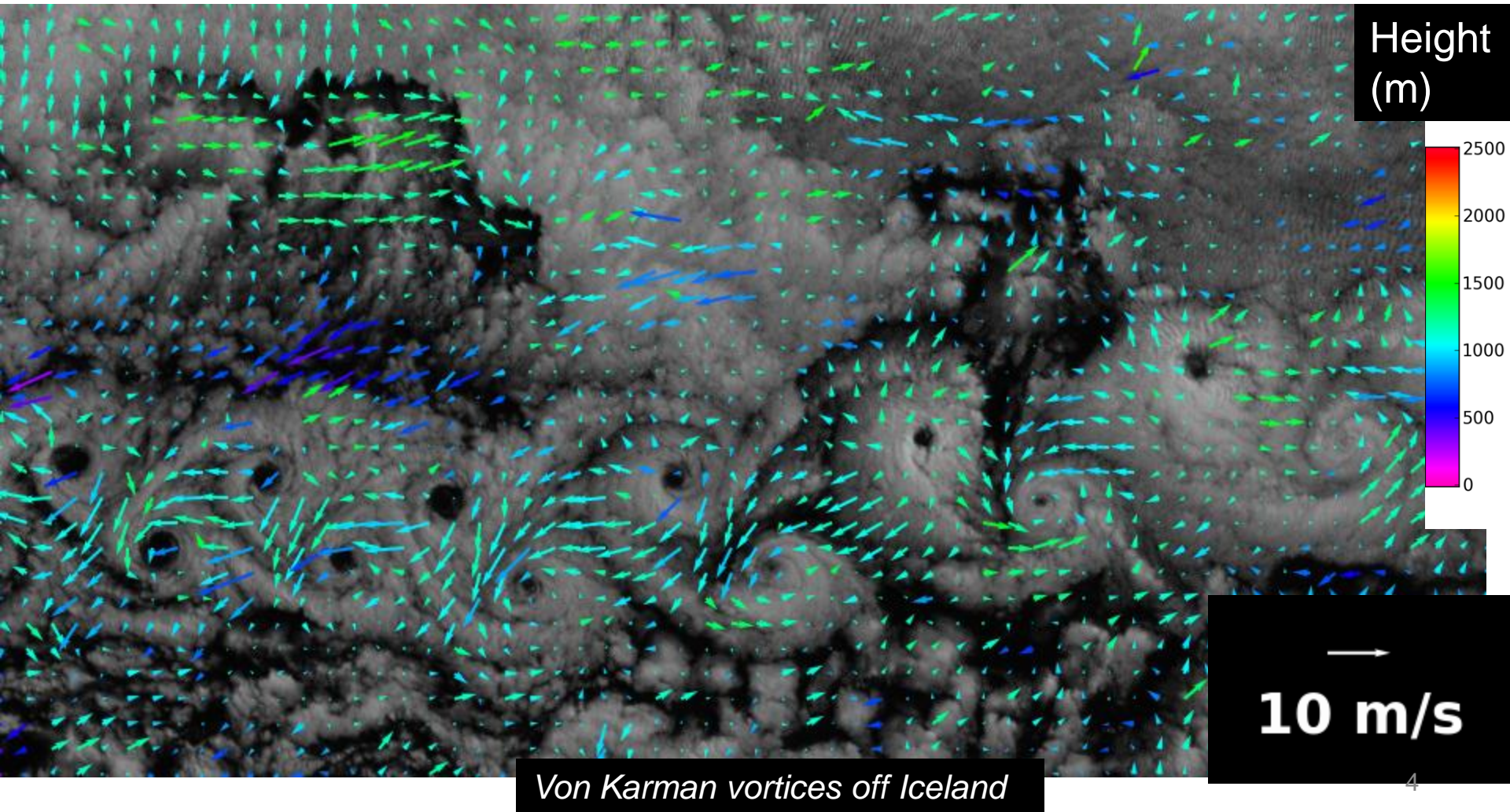
- ◉ Mission Lifetime
  - ◉ **2001 -> 2017**
- ◉ Swath Width ~ 360 km
- ◉ 9 Camera View Angles
  - ◉ 0° (Nadir)
  - ◉ ±26.1°, ± 45.6°
  - ◉ ±60.0°, ± 70.5°
  - ◉ 7 minute sequence
- ◉ R, G, B, & NIR Bands
- ◉ Resolution
  - ◉ **275 m for Nadir and Red Band**
  - ◉ 1100 m all else

## MISR cloud motion capabilities:

- Two Camera Cloud Retrieval
  - Cross-track cloud motion,  **$\Delta t = 50$  seconds**
  - Cloud Top Height (along-track error 90 m/ms-1)
- Three Camera Cloud Retrieval:
  - Full cloud motion vector,  **$\Delta t = 200$  seconds**
  - Cloud Top Height (no along-track error)

# What is MISR capable of?

- Case study illustrates possibilities
- Example shows  $u'$  and  $v'$  calculated on 4 km grid

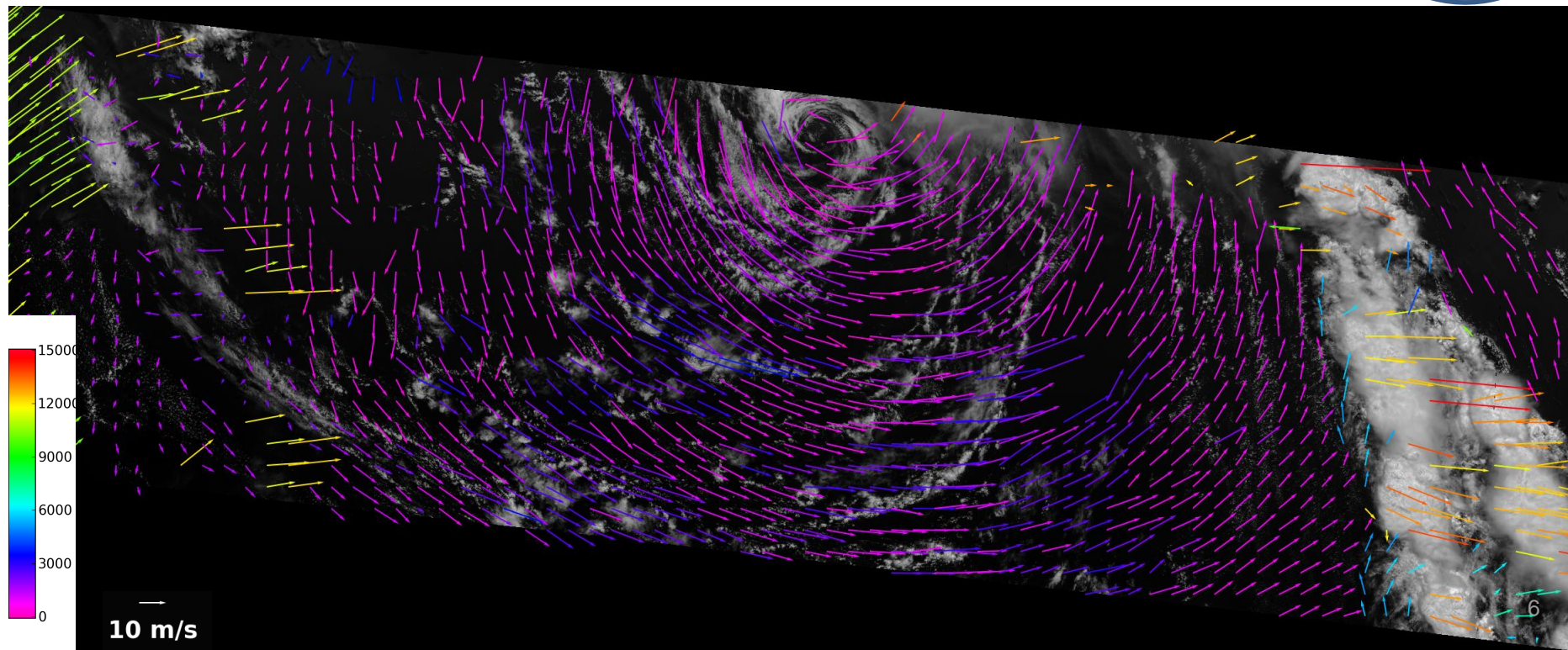
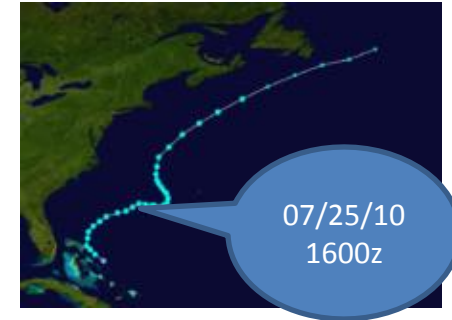


# Recent MISR Developments

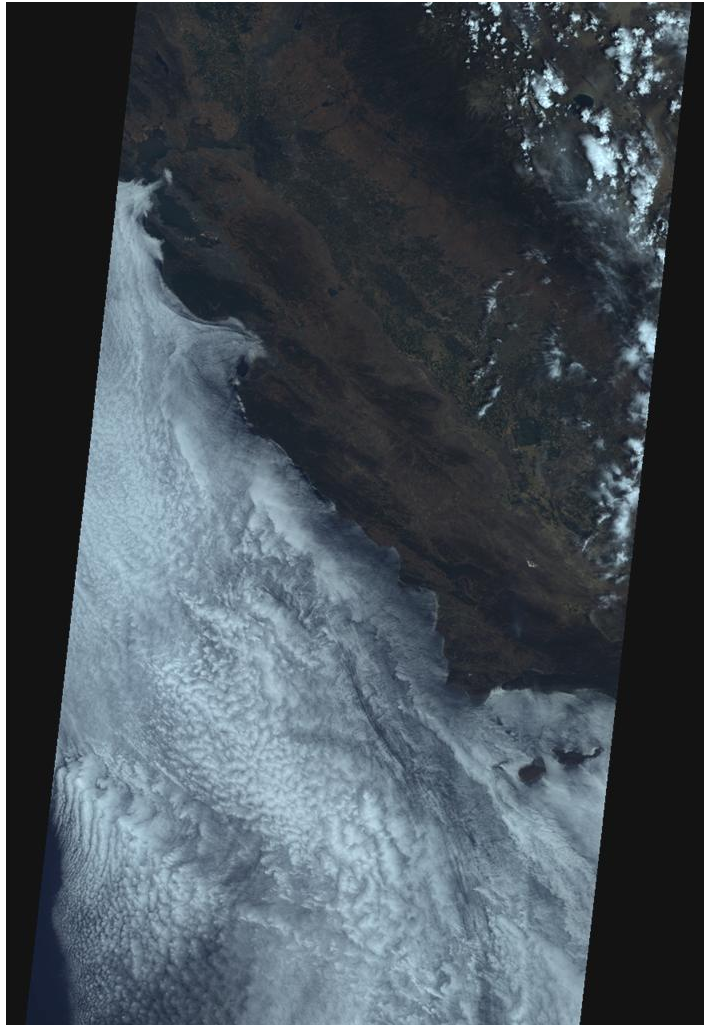
- **New (March 2012) MISR TC Cloud Product**
  - Based on and intended to replace existing MISR TC Stereo Product
  - Highlights:
    - 17.6 km CMV resolution (as opposed to 70.4 km)
    - 3x areal coverage
    - Bias versus RAOB, MODIS, and GOES greatly reduced
    - RMSVD versus RAOB, MODIS, and GOES greatly reduced
    - Quality Indicator (QI) follows EUMETSAT methodology
- **5 Hour Latency Possible (From Sensing to Data Availability)**
  - Current latency between sensing and data availability is 12 hours
  - Initial investigation shows negligible difference in product quality
- **New (April 2012) MISR Cloud Motion Vector Product**
  - Cloud Motion Vector Product (CMVP) packages MISR CMV data into smaller simpler NetCDF files
  - CMVP as introduced in August 2011 repackages TC Stereo Product data

# New MISR Example: Hurricane Franklin

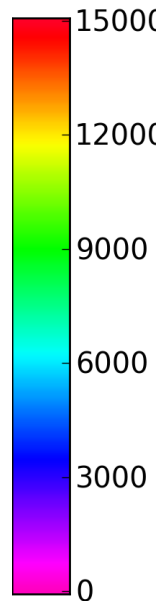
- Operational TC Cloud Product handles cyclones / multi-layer cloud quite well
- Finer resolution case studies perform better



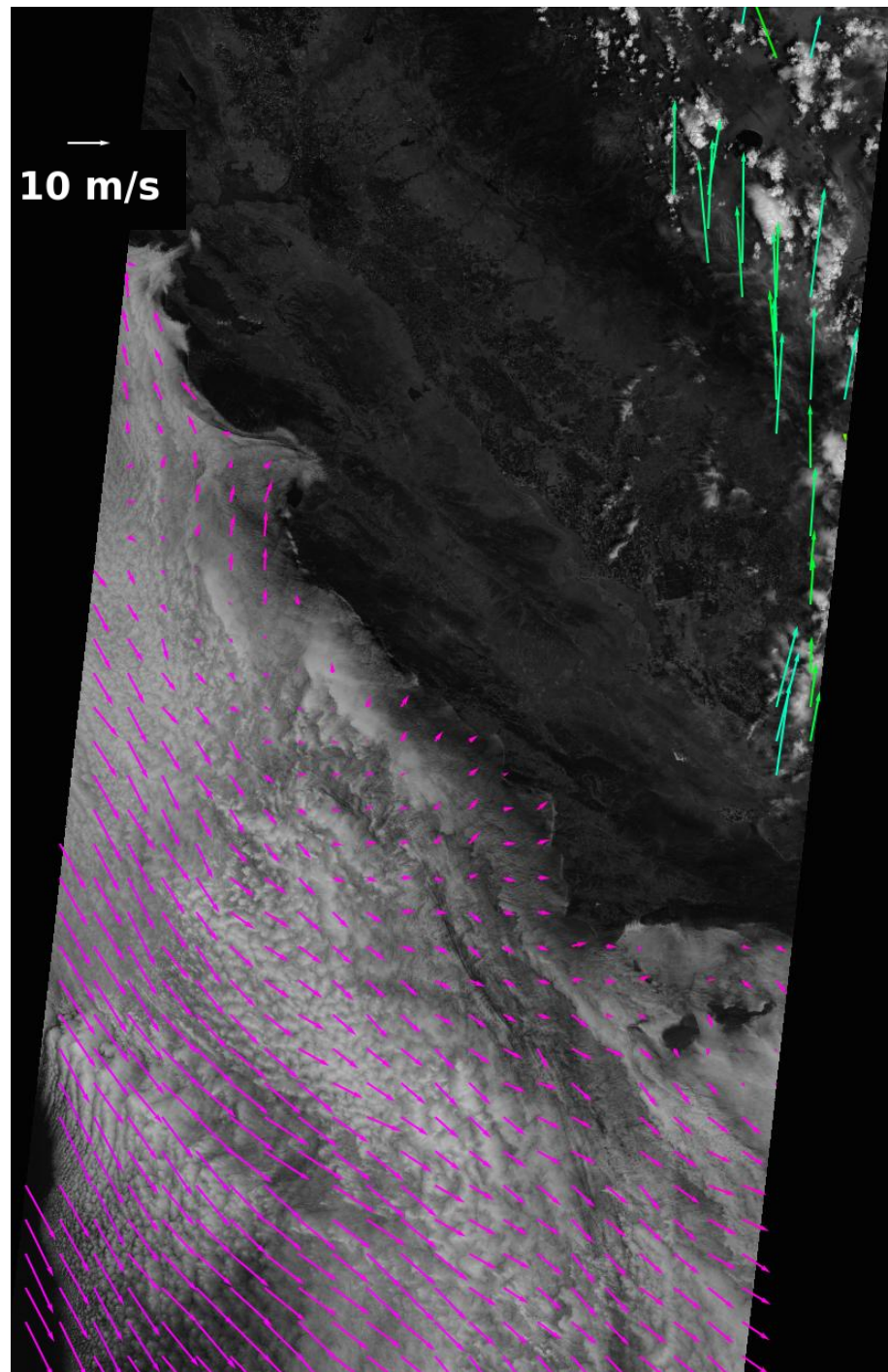
# New MISR Example: LA Coastal Circulation



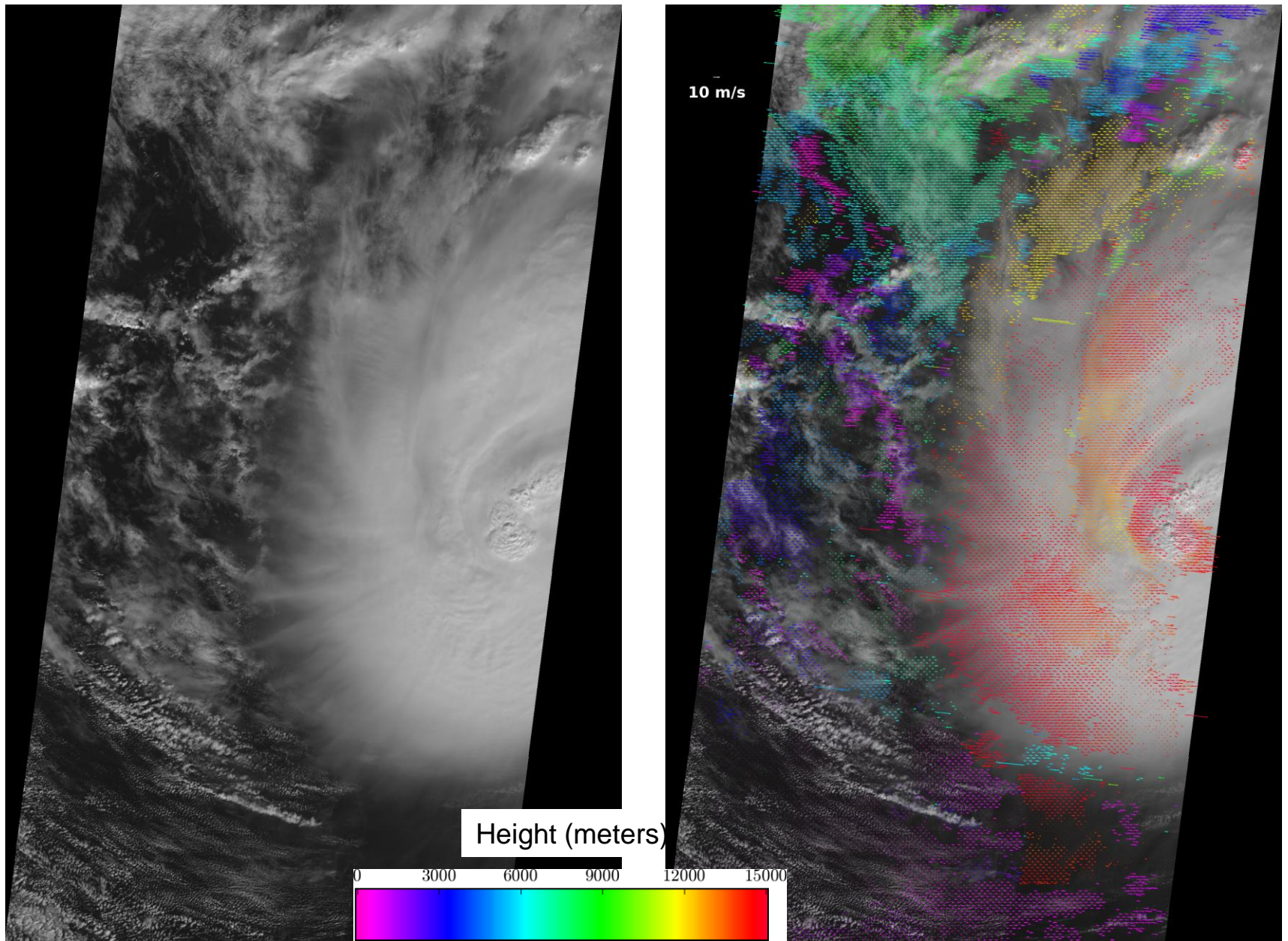
height  
(m)



10 m/s

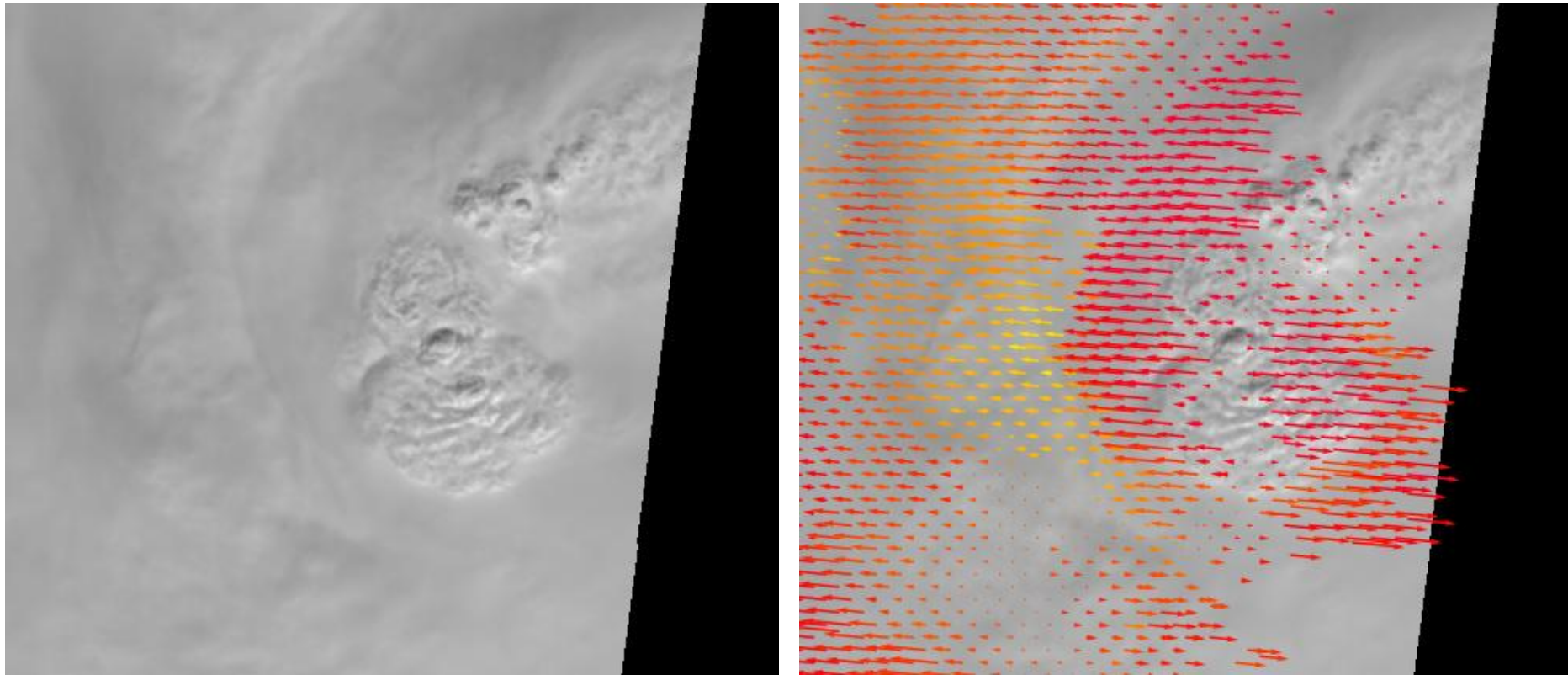


# 1.1 km Cross-track motion: Ida

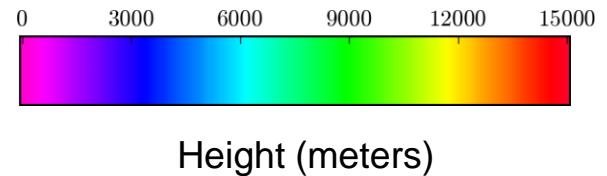




# 1.1 km Cross-Track Motion: Hurricane Ida



**Wind  
Speed 10 m/s** →



# TC Cloud Algorithm Overview

## Hierarchical SAD Correspondence

- Applies (Normalized) Sum-of-Absolute-Differences (SAD) using 5x5 km area for image pairs sampled at resolution 1100 m, then 550 m, and finally 275 m.

## Density Based Clustering

- Extracts dominant signal extracted from 256 1100 x 1100 m disparities within 17600 x 17600 m grid cell

## Registration Correction

- Corrects for focal plane distortion unaccounted for in L1B2 processing

## Height and Motion Reconstruction

- Solves overconstrained system of equations for cloud feature position and motion given observed disparities

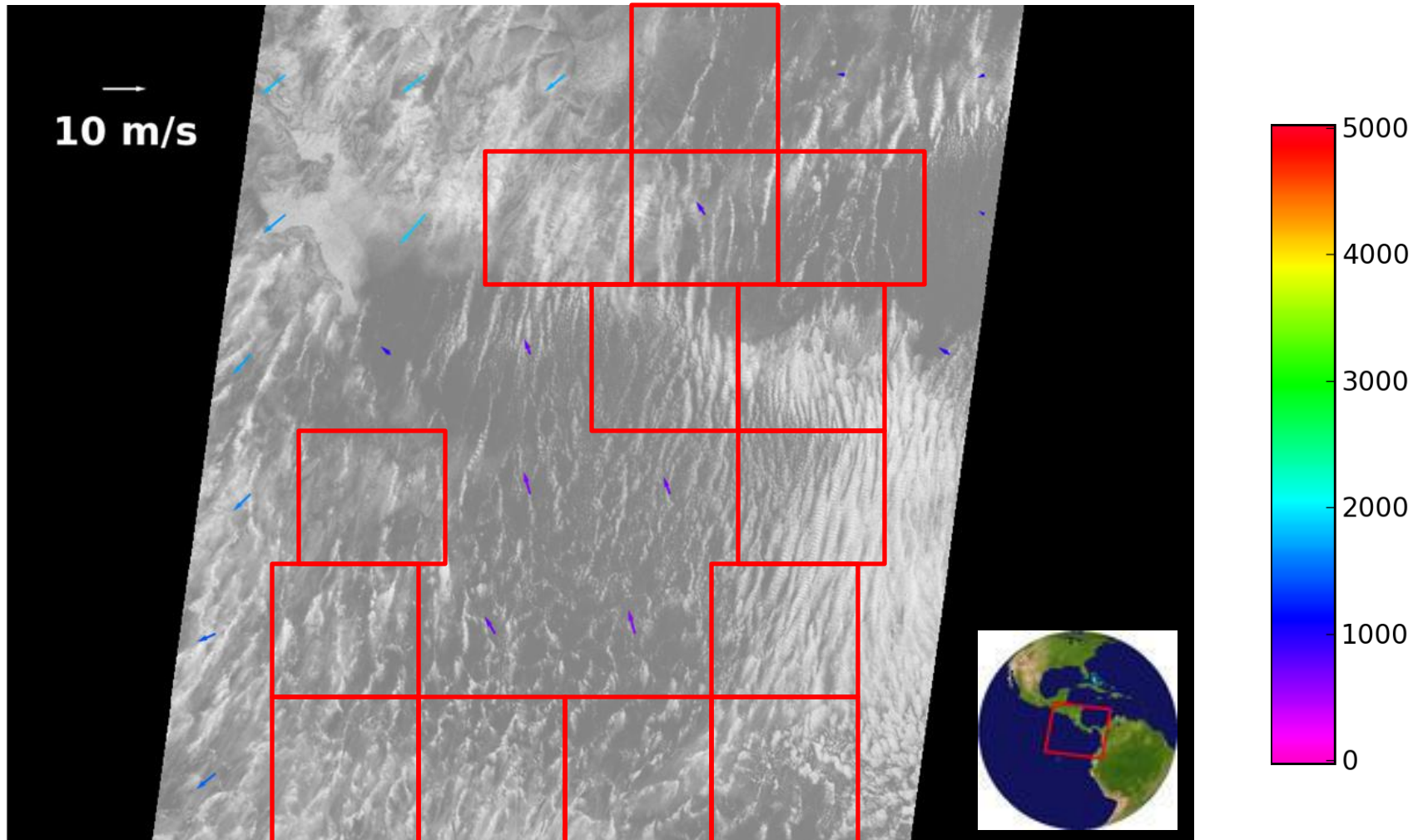
## Cloud Masking

- Removes near-surface low-speed retrievals

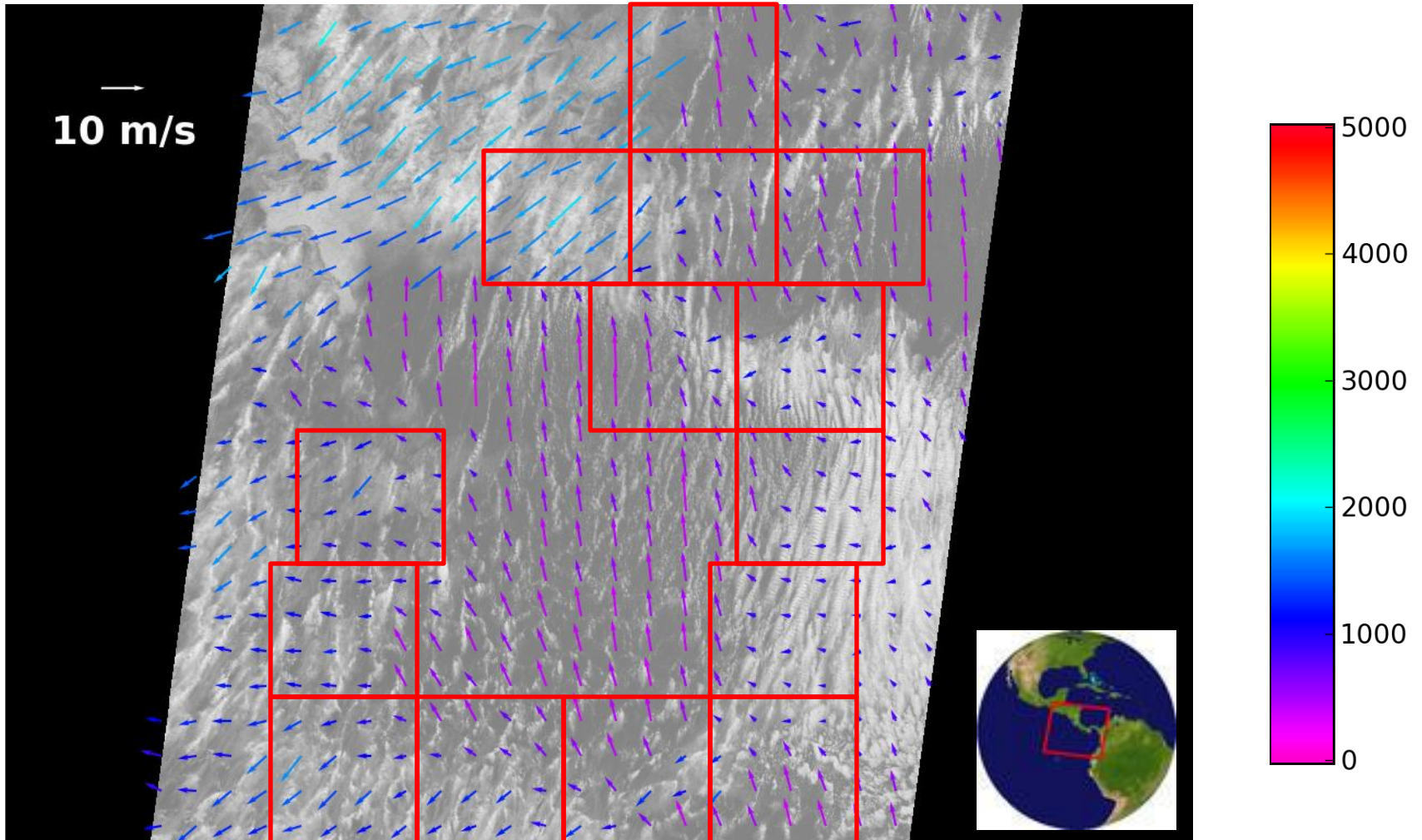
## Quality Filtering

- Assigns quality indicator and screens low quality retrievals following EUMETSAT methodology

70.4 -> 17.6 km resolution,  
>3x coverage

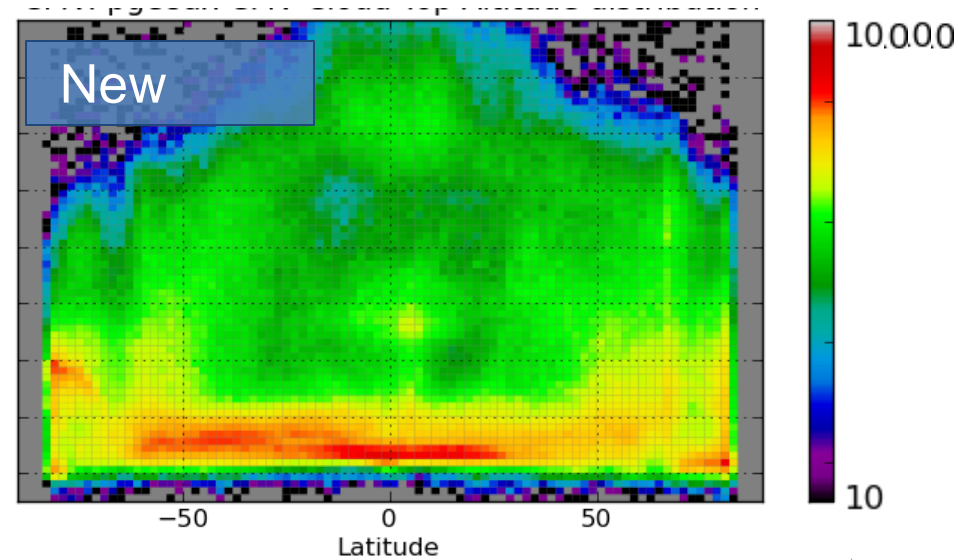
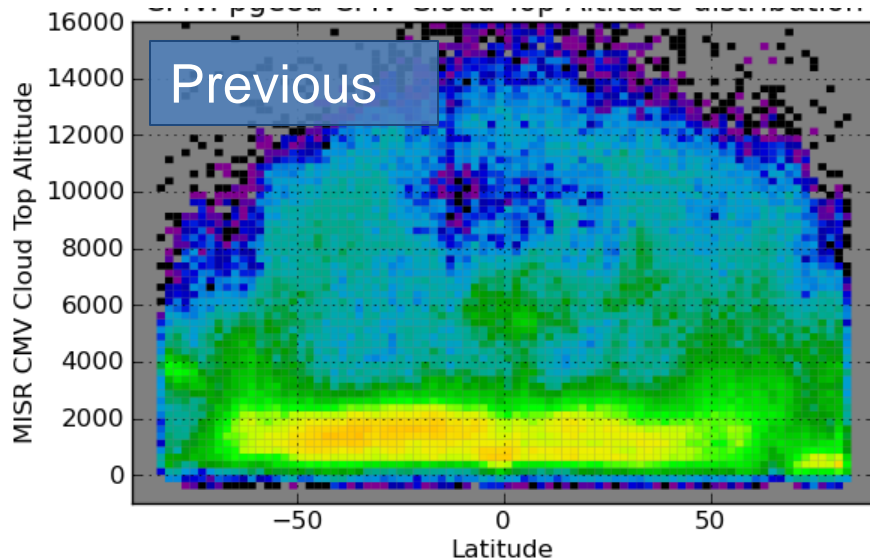


70.4 -> 17.6 km resolution,  
>3x coverage



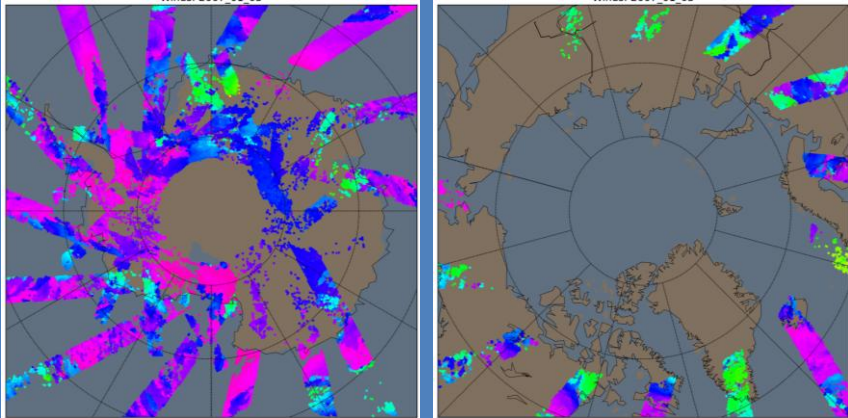
# >3x Coverage

Jan / July Test Data	Previous TC Stereo (QI > 50) Produced at 70.4 km resolution			New TC Cloud (QI > 50) Averaged to 70.4 km resolution		
	0-3 km	3-7 km	7+ km	0-3 km	3-7 km	7+ km
Height Range						
Number of CMV x1000	444	66	31	1126	376	225
Retrieval Efficiency <i>% of 1.1 km stereo heights with matching CMV</i>	<b>52%</b>	<b>27%</b>	<b>26%</b>	<b>87%</b>	<b>77%</b>	<b>77%</b>

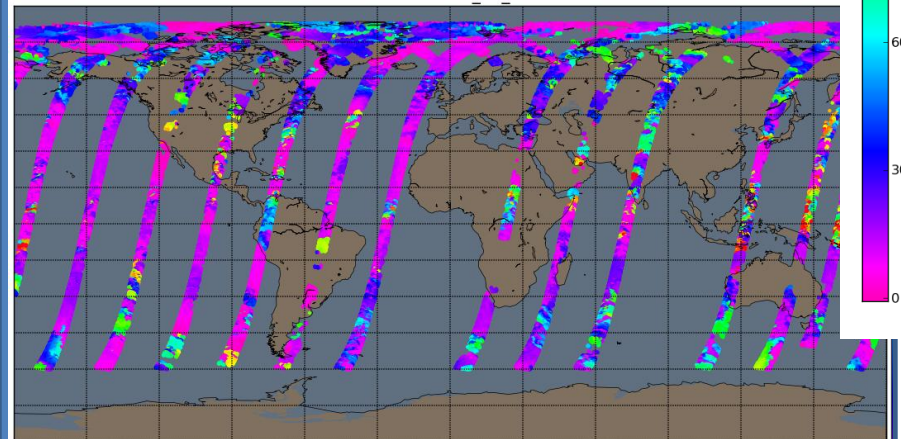
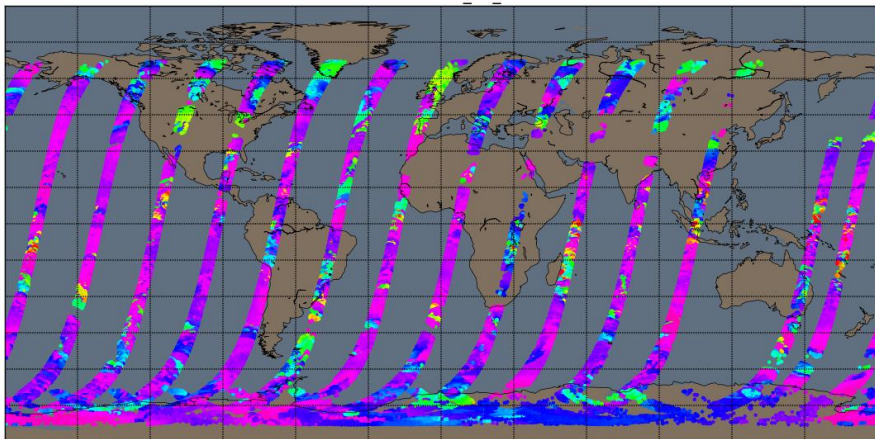
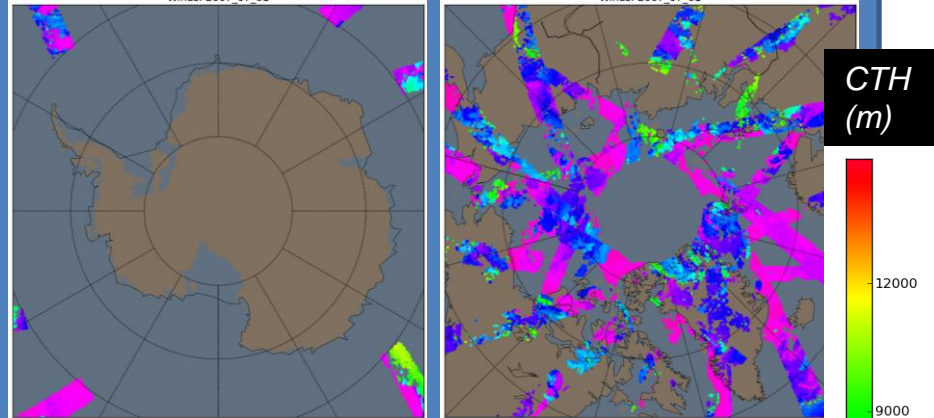


# One day of MISR CMV Sampling

January 3, 2007



July 1, 2007



# Improved Agreement With GOES

Vs. GOES Janurary/July 2007	Previous TC Stereo (QI > 50) Produced at 70.4 km resolution			New TC Cloud (QI > 50) Averaged to 70.4 km resolution		
	0-3 km	3-7 km	7+ km	0-3 km	3-7 km	7+ km
Number	40500	2200	5400	78500	10000	33600
Component bias (along, cross-track)	<b>1.2</b> , -0.3	<b>2.9</b> , -0.2	<b>3.8</b> , -0.5	<b>0.1</b> , -0.3	<b>1.4</b> , 0.0	<b>1.8</b> , -0.2
Component RMS (along, cross-track)	3.1, 1.6	6.0, 3.0	7.7, 3.8	2.5, 1.8	5.5, 3.6	6.3, 3.6
Vector RMSD	<b>3.7</b>	<b>7.3</b>	<b>9.4</b>	<b>3.5</b>	<b>6.5</b>	<b>8.2</b>

Note: TC Cloud  
at native 17.6  
resolution

	0-3 km	3-7 km	7+ km
Number	52600	3700	8500
Component bias	<b>0.1</b> , -0.3	<b>1.2</b> , 0.0	<b>1.3</b> , -0.1
Component RMS	2.7, 1.8	5.1, 3.5	5.7, 3.5
Vector RMS	<b>3.3</b>	<b>6.3</b>	<b>6.8</b>

# QI Versus Sampling and GOES Agreement

Vs. GOES January/July 2007	New TC Cloud (QI > 50) Averaged to 35.2 km resolution			New TC Cloud (QI > 75) Averaged to 35.2 km resolution		
	0-3 km	3-7 km	7+ km	0-3 km	3-7 km	7+ km
Coincidences	69000	6600	18100	52400	3700	6900
Component bias (along, cross-track)	0.1, -0.3	<b>1.3, -0.0</b>	<b>1.5, -0.5</b>	0.1, -0.3	<b>0.7, -0.1</b>	<b>0.8, -0.0</b>
Component RMS (along, cross-track)	3.1, 1.6	6.0, 3.0	7.7, 3.8	2.5, 1.8	5.5, 3.6	6.3, 3.6
Vector RMSD	3.2	6.3	7.1	3.1	5.8	6.4



# Improved Agreement With Arctic RAOB

Vs. Arctic RAOB 2002-2008	Previous TC Stereo (QI > 50) Produced at 70.4 km resolution			New TC Cloud (QI > 50) Averaged to 70.4 km resolution		
	0-3 km	3-7 km	7+ km	0-3 km	3-7 km	7+ km
Number	323	121	42	388	185	60
Component bias (along, cross-track)	<b>1.8</b> , 0.7	<b>3.8</b> , 0.1	<b>8.7</b> , 1.0	<b>0.9</b> , 0.0	<b>1.2</b> , -0.1	<b>1.8</b> , 1.3
Component RMS (along, cross-track)	4.5, 3.2	9.0, 3.5	20.4, 5.5	3.6, 4.1	5.1, 3.4	7.7, 3.6
Vector RMSD	5.9	<b>10.3</b>	<b>22.9</b>	5.6	<b>6.3</b>	<b>8.8</b>

Note: TC Cloud  
at native 17.6  
resolution

	0-3 km	3-7 km	7+ km
Number	206	67	19
Component bias	<b>0.6</b> , 0.0	<b>1.3</b> , 0.0	<b>0.3</b> , 0.5
Component RMS	4.7, 3.5	4.1, 3.2	3.8, 1.9
Vector RMS	5.9	<b>5.3</b>	<b>4.3</b>

# Improved Agreement With MODIS

Vs. Terra MODIS January/July 2007	Previous TC Stereo (QI > 50) Produced at 70.4 km resolution			New TC Cloud (QI > 50) Averaged to 70.4 km resolution		
	0-3 km	3-7 km	7+ km	0-3 km	3-7 km	7+ km
Number	3320	3795	276	15085	28227	3741
Component bias (along, cross-track)	1.6, -0.1	<b>2.4, -0.4</b>	<b>5.2, 0.3</b>	1.7, -0.4	<b>1.7, -0.1</b>	<b>4.1, 1.3</b>
Component RMS (along, cross-track)	4.5, 3.6	4.8, 3.0	8.0, 4.9	4.4, 3.8	4.6, 3.3	6.9, 4.6
Vector RMSD	6.0	<b>6.2</b>	<b>10.8</b>	6.0	<b>5.9</b>	<b>9.3</b>

Note: TC Cloud  
at native 17.6  
resolution

	0-3 km	3-7 km	7+ km
Number	8740	13487	1025
Component bias	1.5, -0.4	<b>1.3, -0.1</b>	<b>3.5, 0.2</b>
Component RMS	4.3, 3.7	4.1, 3.2	6.7, 4.7
Vector RMS	5.9	<b>5.4</b>	<b>8.9</b>

# Conclusion

- **New (March 2012) MISR TC Cloud Product**
  - Based on and intended to replace existing MISR TC Stereo Product
  - Highlights:
    - 17.6 km CMV resolution (as opposed to 70.4 km)
    - 3x coverage
    - Better agreement with RAOB, GOES, and MODIS
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