MISR 17.6 km Gridded Cloud Motion Vectors: Overview and Assessment

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Mean MISR July 2007 Cloud Motion Vectors of height < 3 km
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 ~ 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 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)

MISR highlights
- Mission Lifetime
  - 2001 -&gt; 2017
- Swath Width ~ 360 km
- 9 Camera View Angles
  - $0^\circ$ (Nadir)
  - $\pm 26.1^\circ$, $\pm 45.6^\circ$
  - $\pm 60.0^\circ$, $\pm 70.5^\circ$
  - 7 minute sequence
- R, G, B, & NIR Bands
- Resolution
  - 275 m for Nadir and Red Band
  - 1100 m all else
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

07/25/10 1600z
New MISR Example:
LA Coastal Circulation
1.1 km Cross-track motion: Ida
1.1 km Cross-Track Motion: Hurricane Ida
# TC Cloud Algorithm Overview

<table>
<thead>
<tr>
<th>Process</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Hierarchical SAD Correspondence</strong></td>
<td>• 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.</td>
</tr>
<tr>
<td><strong>Density Based Clustering</strong></td>
<td>• Extracts dominant signal extracted from 256 1100 x 1100 m disparities within 17600 x 17600 m grid cell</td>
</tr>
<tr>
<td><strong>Registration Correction</strong></td>
<td>• Corrects for focal plane distortion unaccounted for in L1B2 processing</td>
</tr>
<tr>
<td><strong>Height and Motion Reconstruction</strong></td>
<td>• Solves overconstrained system of equations for cloud feature position and motion given observed disparities</td>
</tr>
<tr>
<td><strong>Cloud Masking</strong></td>
<td>• Removes near-surface low-speed retrievals</td>
</tr>
<tr>
<td><strong>Quality Filtering</strong></td>
<td>• Assigns quality indicator and screens low quality retrievals following EUMETSAT methodology</td>
</tr>
</tbody>
</table>
70.4 -> 17.6 km resolution, >3x coverage
70.4 -> 17.6 km resolution, >3x coverage
### Jan / July Test Data

<table>
<thead>
<tr>
<th>Height Range</th>
<th>Previous TC Stereo (QI &gt; 50)</th>
<th>New TC Cloud (QI &gt; 50)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Produced at 70.4 km resolution</td>
<td>Averaged to 70.4 km resolution</td>
</tr>
<tr>
<td>0-3 km</td>
<td>444</td>
<td>1126</td>
</tr>
<tr>
<td>3-7 km</td>
<td>66</td>
<td>376</td>
</tr>
<tr>
<td>7+ km</td>
<td>31</td>
<td>225</td>
</tr>
</tbody>
</table>

Number of CMV x1000

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<th>Height Range</th>
<th>Previous TC Stereo (QI &gt; 50)</th>
<th>New TC Cloud (QI &gt; 50)</th>
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<tr>
<td></td>
<td>% of 1.1 km stereo heights with matching CMV</td>
<td></td>
</tr>
<tr>
<td></td>
<td>52%</td>
<td>87%</td>
</tr>
<tr>
<td></td>
<td>27%</td>
<td>77%</td>
</tr>
<tr>
<td></td>
<td>26%</td>
<td>77%</td>
</tr>
</tbody>
</table>

Retrieval Efficiency

### Diagrams

Previous vs. New

- **Previous**: MISR CMV Cloud Top Altitude distribution
- **New**: MISR CMV Cloud Top Altitude distribution
One day of MISR CMV Sampling

January 3, 2007

July 1, 2007

CTH (m)
### Improved Agreement With GOES

<table>
<thead>
<tr>
<th>Vs. GOES January/July 2007</th>
<th>Previous TC Stereo (QI &gt; 50) Produced at 70.4 km resolution</th>
<th>New TC Cloud (QI &gt; 50) Averaged to 70.4 km resolution</th>
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</thead>
<tbody>
<tr>
<td>Number</td>
<td>0-3 km</td>
<td>3-7 km</td>
</tr>
<tr>
<td>Component bias (along, cross-track)</td>
<td>1.2, -0.3</td>
<td>2.9, -0.2</td>
</tr>
<tr>
<td>Component RMS (along, cross-track)</td>
<td>3.1, 1.6</td>
<td>6.0, 3.0</td>
</tr>
<tr>
<td>Vector RMSD</td>
<td>3.7</td>
<td>7.3</td>
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Note: TC Cloud at native 17.6 resolution

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<th>0-3 km</th>
<th>3-7 km</th>
<th>7+ km</th>
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<tr>
<td>Number</td>
<td>52600</td>
<td>3700</td>
<td>8500</td>
</tr>
<tr>
<td>Component bias</td>
<td>0.1, -0.3</td>
<td>1.2, 0.0</td>
<td>1.3, -0.1</td>
</tr>
<tr>
<td>Component RMS</td>
<td>2.7, 1.8</td>
<td>5.1, 3.5</td>
<td>5.7, 3.5</td>
</tr>
<tr>
<td>Vector RMS</td>
<td>3.3</td>
<td>6.3</td>
<td>6.8</td>
</tr>
<tr>
<td>Vs. GOES January/July 2007</td>
<td>New TC Cloud (QI &gt; 50) Averaged to 35.2 km resolution</td>
<td>New TC Cloud (QI &gt; 75) Averaged to 35.2 km resolution</td>
<td></td>
</tr>
<tr>
<td>---------------------------</td>
<td>-------------------------------------------------------</td>
<td>-----------------------------------------------------</td>
<td></td>
</tr>
<tr>
<td></td>
<td>0-3 km</td>
<td>3-7 km</td>
<td>7+ km</td>
</tr>
<tr>
<td>Coincidences</td>
<td>69000</td>
<td>6600</td>
<td>18100</td>
</tr>
<tr>
<td>Component bias (along, cross-track)</td>
<td>0.1, -0.3</td>
<td><strong>1.3, -0.0</strong></td>
<td><strong>1.5, -0.5</strong></td>
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<td>Component RMS (along, cross-track)</td>
<td>3.1, 1.6</td>
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<tr>
<td>Vector RMSD</td>
<td>3.2</td>
<td>6.3</td>
<td>7.1</td>
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# Improved Agreement With Arctic RAOB

<table>
<thead>
<tr>
<th>Vs. Arctic RAOB 2002-2008</th>
<th>Previous TC Stereo (QI &gt; 50) Produced at 70.4 km resolution</th>
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<tr>
<td></td>
<td>0-3 km</td>
<td>3-7 km</td>
</tr>
<tr>
<td>Number</td>
<td>323</td>
<td>121</td>
</tr>
<tr>
<td>Component bias</td>
<td>1.8, 0.7</td>
<td>3.8, 0.1</td>
</tr>
<tr>
<td>(along, cross-track)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Component RMS</td>
<td>4.5, 3.2</td>
<td>9.0, 3.5</td>
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<td></td>
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<tr>
<td>Number</td>
<td>206</td>
<td>67</td>
<td>19</td>
</tr>
<tr>
<td>Component bias</td>
<td>0.6, 0.0</td>
<td>1.3, 0.0</td>
<td>0.3, 0.5</td>
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<tr>
<td>(along, cross-track)</td>
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## Improved Agreement With MODIS

### Vs. Terra MODIS January/July 2007

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<tr>
<td></td>
<td>3320</td>
<td>3795</td>
</tr>
<tr>
<td>Component bias</td>
<td>1.6, -0.1</td>
<td>2.4, -0.4</td>
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Conclusion

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