MISR CMVs

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Acknowledgements: MISR Science and Data Processing Team
(especially Catherine Moroney and Mike Garay)
MISR and the multi-angle remote sensing of clouds: 
*before the launch of Terra, over 10-years ago…*

- albedos from multi-angle measurements would be nice …
  - *but these measurements must be co-registered to the same dynamic reference height*
- dynamic cloud-top heights would be nice …
  - *but it takes 7 minutes to measure all angles, and clouds move*
- cloud-tracked winds would be nice …
At the 9th IWW

- showed improvements due to sub-pixel matching
- preliminary comparisons between MISR and NCEP
  - also with ECMF (Claire Delsol, Niels Bormann, and Lueder von Bremen)
overview

• comparison of the MISR standard product with 10-years of NCEP reanalysis
  – more to follow on this from Dong Wu

• known problems with/improvements to the MISR standard product
  – more to follow on this from KatrinLonitz

• 10-years of global CMV wind fluctuations
MISRCMV’s from Stereo Processing

• conventional stereo techniques ⇒ far too slow
  – new techniques of pattern matching had to be developed
  – initially quite noisy (averaged over 70.4 km domain), but unbiased

• 0°, 45°, and 70° triplet of views needed for along-track wind
  – works because the Earth is not flat

• many improvements since then
  – image navigation (< 275 m)
  – sub-pixel enhancement
  – fore and aft redundancy provides quality control

• faster computers have helped
  – less noisy techniques
  – complete reprocessing of stereo data record is practical
MISR-NCEP Comparison

• Analyzed entire data set of MISR winds at version 17
• Compared against NCEP/NCAR reanalysis
  • matched in time, space (area weighted) and height
  • over $22 \times 10^6$ matches in10 years
MISR average winds below 3 km
Average reanalysis–MISR scalar wind difference, z<3 km
Reanalysis—MISR scalar bias: land
Reanalysis—MISR scalar bias: ocean
rms scalar wind difference: ocean
Summary of standard product-reanalysis

<table>
<thead>
<tr>
<th>Height Range(m)</th>
<th>Over Land</th>
<th>Over Ocean</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean Vector Difference ($ms^{-1}$)</td>
<td></td>
</tr>
<tr>
<td>1000-3000</td>
<td>5.8</td>
<td>6.1</td>
</tr>
<tr>
<td>3000-7000</td>
<td>8.0</td>
<td>10.9</td>
</tr>
<tr>
<td>7000-20000</td>
<td>15.8</td>
<td>15.6</td>
</tr>
<tr>
<td></td>
<td>Standard Deviation ($ms^{-1}$)</td>
<td></td>
</tr>
<tr>
<td>1000-3000</td>
<td>3.3</td>
<td>3.3</td>
</tr>
<tr>
<td>3000-7000</td>
<td>6.0</td>
<td>9.0</td>
</tr>
<tr>
<td>7000-20000</td>
<td>15.8</td>
<td>16.2</td>
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<tr>
<td></td>
<td>RMSE ($ms^{-1}$)</td>
<td></td>
</tr>
<tr>
<td>1000-3000</td>
<td>6.7</td>
<td>6.9</td>
</tr>
<tr>
<td>3000-7000</td>
<td>10.0</td>
<td>14.1</td>
</tr>
<tr>
<td>7000-20000</td>
<td>25.2</td>
<td>22.5</td>
</tr>
</tbody>
</table>

Table 6.4: **MISR\ NCEP** Comparison
directional bias by latitude

MISR is biased towards the south

Figure 6.6: Directional bias by latitude - Plot of angular bias over land and ocean against latitude for winds sub 3km
<table>
<thead>
<tr>
<th>Latitude Range</th>
<th>1 - 3km</th>
<th>3 - 7km</th>
<th>7km +</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Over Land</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25°N – 60°N</td>
<td>−11.16°</td>
<td>−5.86°</td>
<td>−0.26°</td>
</tr>
<tr>
<td>25°S – 25°N</td>
<td>6.99°</td>
<td>5.96°</td>
<td>9.18°</td>
</tr>
<tr>
<td>60°S – 25°S</td>
<td>−10.10°</td>
<td>−23.60°</td>
<td>−15.09°</td>
</tr>
<tr>
<td><strong>Over Ocean</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30°N – 60°N</td>
<td>−5.35°</td>
<td>−0.46°</td>
<td>−2.02°</td>
</tr>
<tr>
<td>30°S – 30°N</td>
<td>9.50°</td>
<td>9.86°</td>
<td>2.70°</td>
</tr>
<tr>
<td>60°S – 30°S</td>
<td>−4.06°</td>
<td>−18.92°</td>
<td>−24.26°</td>
</tr>
</tbody>
</table>

Table 6.3: Directional Bias measured as reanalysis-MISR
Improvements

• more exhaustive matcher
  – greater coverage ≈70% more winds than original method
  – increased coverage at high latitudes
  – double the number of high altitude winds
  – eliminates drop-outs at East-West cardinal points
  – Improves ascending-descending differences
new versus old coverage
Standard Product
Old and new versions
New version, with land mask 100 orbits, global

![Graph showing scaled sampling fraction vs wind direction](image)
Polar surface wind speeds: standard product
Polar surface wind speeds: new product

since have found a systematic bias in the along-track wind, ranging from 0 at centre of swath to 3 m/s at swath edge (see Lonitz and Horváth)
Terra/MISR: 10-year Climate Data Records

- cloud-top heights (from March/2000)
  - cloud fraction by height
  - at 1.1 km
- height-resolved cloud motion vectors (from March/2000)
  - at 70.4 km
- top-of-atmosphere albedos (from May/2000)
  - spectral, equivalent broadband, local, restrictive or expansive too
  - at 35 km
- summarized into 140x300 km blocks, \( \approx 140 \text{ blocks/orbit}, \approx 420 \text{ orbits/month} \)
New Zealand Average Winds Over Ten Years
Summary

• MISR and reanalysis winds differ
  – physical reasons
    • land effects (-3 m/s MISR below 3 km)
    • tropical wind divergence, thunderstorms (-5 m/s reanalysis)
    • resolution (-1.4 m/s reanalysis)
  – model/algorithm deficiencies
    • MISR still has a weak meridional bias depending on swath position (0-3 m/s), turns wind to the South by 5-10° in descending branch of orbit
    • the reanalysis winds appear 2-3 m/s too fast in the Southern Ocean
• Low level (<3 km) winds agree well
  – overall scalar wind speed bias <0.4 m/s
  – vector rms ≈6 m/s
Summary

• MISR algorithms will likely be changed and reprocessed to correct the swath bias
  – then perhaps repeat this study using high resolution ECMWF reanalysis

• the global fluctuation analysis seems to be useful as is, and of interest to climate change studies
  – a lower background wind speed (-1 m/s/decade) is a reasonable consequence of polar warming
  – with less surface wind over ocean, expect higher Bowen ratios
  – the decrease is greater (up to -4 m/s/decade in North Pacific)
  – an increase 2-3 m/s/decade in Southern Oceans
  – MISR and reanalysis generally agree on this, with MISR showing more regional detail