Mineral dust and AIRS

From Hong et al., 2006, GRL

From Preridieu et al., 2010, ACP
Global Yield of AIRS L2 Mid-Trop CO₂

AIRS Daily CO₂ Yield
1°x1° Spatial Resolution

AIRS Monthly CO₂ Yield
1°x1° Spatial Resolution

AIRS Level 2 Mid-Trop CO₂ retrieval yield is controlled by requirement for highest quality temperature and water vapor AIRS Level 2 products in 2x2 array of adjacent FOVs.

Day/Night, Pole-to-Pole, Land/Ocean/Ice, Cloudy/Clear

From Ed Olsen (JPL)
Monsoon circulation and chemistry

Figure 1. Horizontal structures of 2-month (July and August 2003) average (a) National Centers for Environmental Prediction (NCEP) geopotential height (km) and horizontal winds (m s\(^{-1}\)) at 150 hPa, (b) modified potential vorticity (MPV) (PVU, 10\(^{-6}\) km\(^2\) kg\(^{-1}\) s\(^{-1}\)), (c) Atmospheric Infrared Sounder (AIRS) water vapor (ppmv), and (d) ozone (ppbv) centered in Asian monsoon region at 360 K. White contours in Figures 1a and 1b show the OLR less than or equal to 205 (W m\(^{-2}\)). Thick dotted lines in Figures 1a, 1c, and 1d mark the 14,320 m geopotential height contour.

Figure 3. Hovmöller diagram of outgoing longwave radiation (OLR) (W m\(^{-2}\)) averaged over 15\(^\circ\)–30\(^\circ\)N from May to September 2003.

From Randel et al., 2006, JGR
Mesoscale turbulence scaling for T and q

Kahn and Teixeira (2009), J. Climate

Restrict to ice clouds: \textit{RHI} sampling dependent on cloud type

Kahn et al. (2009), \textit{J. Geophys. Res.}

Average for Sept. 2006 – Aug. 2007
A (Very) Brief Introduction to MODIS

Brian Kahn (JPL)
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UCLA Remote Sensing
Tuesday May 11th, 2010
Rough Outline – Lecture 3

• A brief introduction to the instrument(s) and products
  • Moderate Resolution Imaging Spectroradiometer (MODIS)
  • Located on both EOS Terra and Aqua

• Overview of some selected products
  • Atmospheres (clouds and aerosols)
  • Land, ocean, ice

• A few research highlights in the published literature
Overview of MODIS Channels
The MODIS Channels

MODIS TECHNICAL SPECIFICATIONS

Orbit: 705 km, 10:30 a.m. descending node or 1:30 p.m. ascending node, sun-synchronous, near-polar, circular scan track
Swath Dimensions: 2320 km (across track) by 10 km (along track at nadir)
Telescope: 17.78 cm diam. off-axis, afocal (collimated), with intermediate field stop
Size: 1.0 x 1.6 x 1.0 m
Weight: 250 kg
Power: 225 W (orbital average)
Data Rate: 11 Mbps (peak daytime)
Quantization: 12 bits
Spatial Resolution: 250 m (bands 1-2)
(at nadir): 500 m (bands 3-7), 1000 m (bands 8-36)
Design Life: 5 years

<table>
<thead>
<tr>
<th>Primary Use</th>
<th>Band</th>
<th>Bandwidth</th>
<th>Spectral Radiance</th>
<th>Required SNR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land/Cloud</td>
<td>1</td>
<td>620-670</td>
<td>21.8</td>
<td>128</td>
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<tr>
<td>Boundaries</td>
<td>2</td>
<td>841-876</td>
<td>24.7</td>
<td>201</td>
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<tr>
<td>Land/Cloud</td>
<td>3</td>
<td>459-479</td>
<td>35.3</td>
<td>243</td>
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<tr>
<td>Properties</td>
<td>4</td>
<td>548-566</td>
<td>29.0</td>
<td>228</td>
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<tr>
<td></td>
<td>5</td>
<td>1230-1250</td>
<td>5.4</td>
<td>74</td>
</tr>
<tr>
<td></td>
<td>6</td>
<td>1629-1652</td>
<td>7.3</td>
<td>275</td>
</tr>
<tr>
<td></td>
<td>7</td>
<td>2105-2155</td>
<td>1.0</td>
<td>110</td>
</tr>
<tr>
<td>Ocean color/</td>
<td>8</td>
<td>405-420</td>
<td>44.9</td>
<td>880</td>
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<tr>
<td>Phytoplankton/</td>
<td>9</td>
<td>438-448</td>
<td>41.9</td>
<td>838</td>
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<tr>
<td>Biogeochemistry</td>
<td>10</td>
<td>483-493</td>
<td>32.1</td>
<td>802</td>
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<tr>
<td></td>
<td>11</td>
<td>526-536</td>
<td>27.9</td>
<td>754</td>
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<tr>
<td></td>
<td>12</td>
<td>546-556</td>
<td>21.0</td>
<td>750</td>
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<td>13</td>
<td>662-672</td>
<td>9.5</td>
<td>910</td>
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<td></td>
<td>14</td>
<td>673-683</td>
<td>8.7</td>
<td>1087</td>
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<td>15</td>
<td>743-753</td>
<td>10.2</td>
<td>586</td>
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<tr>
<td></td>
<td>16</td>
<td>862-877</td>
<td>6.2</td>
<td>516</td>
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<tr>
<td>Atmospheric</td>
<td>17</td>
<td>690-920</td>
<td>10.0</td>
<td>167</td>
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<tr>
<td>Water Vapor</td>
<td>18</td>
<td>931-941</td>
<td>3.6</td>
<td>57</td>
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<tr>
<td></td>
<td>19</td>
<td>915-965</td>
<td>15.0</td>
<td>250</td>
</tr>
</tbody>
</table>

1 Bands 1 to 19, nm; Bands 20-36, μm
2 (W/m²·μm·sr)
3 SNR=Signal-to-noise ratio
4 NEΔT=Noise-equivalent temperature difference

Performance goal is 30%-40% better than required.
Overview of MODIS Clouds


From Meyer et al. (2007), Rem. Sens. Env.
Monthly Mean Cloud Fraction
(S. A. Ackerman, R. A. Frey et al. – Univ. Wisconsin)

Aqua/MODIS
- Cloud fraction similar during day and night
  - High cloud amount
    ✓ Roaring 40s
    ✓ ITCZ
    ✓ North Atlantic
    ✓ Indonesia and western tropical Pacific
  - Low cloud amount
    ✓ Subtropical gyres over the ocean
    ✓ Deserts
    ✓ Antarctica
    ✓ Greenland

July 2006
Aqua Cloud Fraction – Terra Cloud Fraction
(M. D. King, S. Platnick et al. – NASA GSFC)

- **Terra**
  - Higher over oceans than land
    - Marine stratocumulus

- **Aqua**
  - Higher over land than ocean
    - Interior continents
    - Desert southwestern US
    - Australia
  - Higher over ocean than land
    - Northern Indian Ocean
Monthly Mean Cloud Fraction by Phase
(M. D. King, S. Platnick et al. – NASA GSFC)

July 2006
Terra
➢ Liquid water clouds
  - Marine stratocumulus regions
    ✓ Angola/Namibia
    ✓ Peru/Ecuador
    ✓ California/Mexico
➢ Ice clouds
  - Tropics
    ✓ Indonesia & western tropical Pacific
    ✓ ITCZ
  - Roaring 40s
Monthly Mean Cloud Effective Radius
(M. D. King, S. Platnick et al. – NASA GSFC)

July 2006 Terra (QA Mean)

- Liquid water clouds
  - Larger drops in SH than NH
  - Larger drops over ocean than land
  ✓ Due to cloud condensation nuclei (aerosols)

- Ice clouds
  - Larger in tropics than high latitudes
  ✓ Anvils
  - Small ice crystals at top of deep convection
# The MODIS “Atmospheres” Products

<table>
<thead>
<tr>
<th>Dataset</th>
<th>Responsible Investigators</th>
<th>Processing Level</th>
<th>Product ID(^a)</th>
<th>Spatial Resolution (km)</th>
<th>File Frequency</th>
<th>File Size</th>
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<tbody>
<tr>
<td><strong>Pixel-level products</strong></td>
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<tr>
<td>Cloud mask</td>
<td>Ackerman, Menzel</td>
<td>2</td>
<td>MOD35</td>
<td>0.25, 1</td>
<td>288/day</td>
<td>47.4 MB</td>
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<td>Aerosol product</td>
<td>Kaufman, Tanré, Remer</td>
<td>2</td>
<td>MOD04</td>
<td>10</td>
<td>139/day</td>
<td>12.0 MB</td>
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<tr>
<td>Total precipitable water</td>
<td>Gao, Kaufman, Tanré, Menzel</td>
<td>2</td>
<td>MOD05</td>
<td>1 (NIR), 5 (TIR)</td>
<td>288/day</td>
<td>20.2 MB (day) 3.6 MB (night)</td>
</tr>
<tr>
<td>Cloud product</td>
<td>King, Platnick, Menzel, Gao</td>
<td>2</td>
<td>MOD06</td>
<td>1, 5(^b)</td>
<td>288/day</td>
<td>69.6 MB (day) 14.1 MB (night)</td>
</tr>
<tr>
<td>Atmospheric profiles</td>
<td>Menzel</td>
<td>2</td>
<td>MOD07</td>
<td>5</td>
<td>288/day</td>
<td>32.2 MB</td>
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<tr>
<td><strong>Gridded time-averaged products</strong></td>
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<tr>
<td>Level-3 atmosphere products</td>
<td>King, Hubanks, Pincus</td>
<td>3</td>
<td>MOD08</td>
<td>1° x 1°</td>
<td>1/day</td>
<td>440.9 MB</td>
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<td></td>
<td></td>
<td>1/8-day</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1/month</td>
<td>810.6 MB</td>
</tr>
</tbody>
</table>

\(^a\)MOD\(x\) Products Apply to Terra, and MYD\(x\) Products Apply to Aqua. \(^b\)Daytime retrievals of cloud optical and microphysical properties are performed at 1-km resolution, while daytime and nighttime cloud-top altitude and cloud-top pressure are processed at 5 km [21]

From King et al. (2003), *IEEE TGARS*
Cloud Optical & Microphysical Retrievals

Retrieval space examples

Based on Nakajima and King (1990) algorithm
Figure 5. Correlation of the theoretical bidirectional reflectance (a,c) for 0.65 and 1.6 μm and (b,d) for 0.65 and 2.2 μm using cloud optical depths ranging from 0.1 to 8. Figures 5a and 5b are for tropical size distributions, and 5c and 5d are for midlatitude size distributions. The three sets of curves correspond habit assumptions. Superimposed data points are from MAS measurements. Note that for presentation purposes the results for only four out of the six size distributions are shown for both the midlatitude and tropical cases.
Figure 11. Correlation of the bidirectional reflectance (a and c) for 0.65 and 1.6 μm and for (b and d) 0.65 and 2.2 μm for the six midlatitude size distributions. Calculations are presented for the surface reflectance values obtained from analysis of the clear pixel histograms, ±1 standard deviation. Figures 11a and 11b correspond to the land surface case (track 7, April 16, 1996). Figures 11c and 11d correspond to the ocean surface case (track 13, May 12, 1996).

From Rolland et al. (2000), J. Geophys. Res.