LASE measurements of water vapor, aerosol, and cloud distributions during GRIP

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Data from dropsondes, radiosondes, and MMS were used in the analysis.

Thank: Dr. Ramesh Kakar, NASA HQ for funding.
Outline

• Archival of LASE Data

• Advanced/Research Products

• Comparison with satellite retrievals

• Observations over Hurricane Earl
  - Development of the ‘eye’ on Aug. 30, 2010
  - Water vapor and temperature distributions within the eye and surrounding regions

• Additional analysis
LASE System and Data Products

- **System Features:**
  - DIAL system operating in the 817nm band of H₂O
  - Uses a Ti:sapphire laser (100 mJ at 5 Hz double pulsed)
  - 3 line pairs are used to capture the full dynamic range of water vapor in the troposphere

- **Data Products (Archived):**
  - Water vapor mixing ratio profiles
    - surface to upper troposphere
    - 0.01 to 25 g/kg
    - accuracy: 6% or 0.01 g/kg
    - resolution (variable)
      - vertical: 330 m nadir, 990 m zenith
      - horizontal: 42 to 70 km (3 - 5 min)
  - Aerosol/cloud profiles
    - daytime and nighttime
    - 0.03 to 25 km
    - resolution (nominal)
      - vertical: 30 m
      - horizontal: 2.1 km
<table>
<thead>
<tr>
<th>Flight # / Date</th>
<th>Objective</th>
<th>LASE Observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 8/13/10</td>
<td>Transit</td>
<td>TD-S cirrus outflow; increased moisture and aerosols over the Gulf</td>
</tr>
<tr>
<td>6 8/17/10</td>
<td>System Tests</td>
<td>AQUA underpass 18:41 UT</td>
</tr>
<tr>
<td>7 8/24/10</td>
<td>Frontal Survey</td>
<td>AIRS underpass 19:00 UT; TRIMM overpass</td>
</tr>
<tr>
<td>8 8/28/10</td>
<td>Transit to STX</td>
<td>After 15:46 LASE has zenith only</td>
</tr>
<tr>
<td>9 8/29/10</td>
<td>Hurricane Earl</td>
<td>SAL below at 16:43; eye not well defined; 22:22 descent into SAL</td>
</tr>
<tr>
<td>10 8/30/10</td>
<td>Hurricane Earl</td>
<td>Evolution of eye during rapid intensification; 6 eye crossings; LASE measurements extend down close to surface in the eye</td>
</tr>
<tr>
<td>11 8/30/10</td>
<td>Transit to FLL</td>
<td>LASE did not operate</td>
</tr>
<tr>
<td>12 9/01/10</td>
<td>Hurricane Earl</td>
<td>Dry air to NW, W, and SW of storm; very moist in and near eye, and SE; Descent into SAL at end (~ 18:30)</td>
</tr>
<tr>
<td>13 9/02/10</td>
<td>Hurricane Earl</td>
<td>LASE measures water vapor and aerosols in the eye, water clouds in eye wall, cirrus outflow above the storm; global hawk above</td>
</tr>
<tr>
<td>14 9/05/10</td>
<td>Transit to STX</td>
<td>20:00 in situ sampling of SAL</td>
</tr>
<tr>
<td>15 9/06/10</td>
<td>Gaston</td>
<td>TS Remnants – intensification questionable</td>
</tr>
<tr>
<td>16 9/07/10</td>
<td>Gaston, to FLL</td>
<td>TS Remnants (LASE seeding problems)</td>
</tr>
<tr>
<td>17 9/12/10</td>
<td>PGI-44 (Karl)</td>
<td>Not a TD or TS in clouds</td>
</tr>
<tr>
<td>18 9/13/10</td>
<td>PGI-44 (Karl)</td>
<td>In clouds, Dry air mass observed near end of flight</td>
</tr>
<tr>
<td>19 9/14/10</td>
<td>PGI-44 (Karl)</td>
<td>In clouds</td>
</tr>
<tr>
<td>20 9/16/10</td>
<td>PGI-44 (Karl)</td>
<td>In clouds</td>
</tr>
<tr>
<td>21 9/17/10</td>
<td>PGI-44 (Karl)</td>
<td>Eye makes landfall over</td>
</tr>
<tr>
<td>22 9/20/10</td>
<td>Transit to STX</td>
<td>1st hour is low leg for in situ aerosol</td>
</tr>
<tr>
<td>23 9/21/10</td>
<td>PGI-46/CALIPSO/Cloudsat</td>
<td>LARGE see Dust on runway before takeoff; Initial low leg for LARGE in Dust; LASE and CALIPSO qualitative agreement of aerosol features; Descent into SAL</td>
</tr>
<tr>
<td>24 9/22/10</td>
<td>PGI-46/CALIPSO/Cloudsat</td>
<td>Overpass at 18:14:20, 18:14:35 UT; 17:40:40 GV coincidence; dust and dry S of Haiti</td>
</tr>
<tr>
<td>25 9/25/10</td>
<td>Transit to Palmdale</td>
<td>A zenith test segment with all energy up</td>
</tr>
</tbody>
</table>
Advanced* data products

• RH derived from LASE mixing ratio and dropsonde/radiosondes

• Total Precipitable Water (TPW)

• Aerosol extinction and scattering coefficient profiles, and aerosol optical depth.

*Retrieved on a case by case basis on request
Retrievals of RH, Aerosol Extinction Profiles and Optical Depth
Hurricane Earl Flt #4, Sept. 2, 2010
Comparison of LASE and AIRS water vapor and RH retrievals
September 21, 2010

Ferrare et al, poster this afternoon
Evolution of the eye of Hurricane Earl on Aug 30, 2011
Water vapor, aerosol, and cloud distributions in the ‘eye’
Dropsonde Temperature and water vapor Distributions Inside and Outside the ‘Eye’
September 30, 2010
# 1 North → South

From the East

From the West
LASE measured water vapor, aerosol, and cloud distributions during flights over Hurricane Earl.

LASE and dropsonde measurements of water vapor just outside eyewall show good agreement.

Water Vapor Mixing Ratio

Flight Segment across Earl between 18 – 19 UT

Water Vapor Mixing Ratio

Eye

LASE - Dropsonde Comparison Flight 13 / 2-Sep-2010

- LASE (18:55)
- Dropsonde (18:52)

Water Vapor Mixing Ratio (g/kg)

cirrus clouds (outflow)

Relative Aerosol And Cloud Scattering

water clouds (eyewall)