The Validation of AIRS Retrievals

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Outline:

August Data Release & New Results

• Public Data Release in August: Oceans between 40°S and 40°N
  – Further restricted so retrieved sea surface temperatures (SST) agree with NCEP forecast within ±3 K
    • a simple, temporary substitute for self-consistent indicators
    • recent analyses show this is not a perfect quality indicator
    • internal quality indicators are under development
  – Validated Quantities:
    • SST
      – ECMWF model, buoys, shipborne spectrometer
    • Temperature profiles (T)
      – ECMWF, sondes
    • Water vapor profiles (q)
      – ECMWF, sondes

• Exploratory Analyses: Some preliminary results
The AIRS / AMSU / HSB Retrieval System

- Utilizes a combination of *infrared* and *microwave* observations
  - AIRS: 2378 IR channels, 15 km horizontal resolution
  - HSB: 4 MW channels, 15 km horizontal resolution
  - AMSU: 15 MW channels, 50 km horizontal resolution
  - Vis/NIR: 4 channels, 2 km resolution (daytime-only diagnostics)

- Each retrieval uses 9 AIRS spectra, 9 HSB spectra, 1 AMSU spectrum

- Invert these radiances to geophysical quantities of cloud cleared radiance, T and q profiles, cloud properties, surface T and emissivity, trace gases.
The AIRS / AMSU / HSB Viewing Geometry

1. AMSU footprint, 45 km across at nadir, contains 9 AIRS spectra
   – THIS IS THE RETRIEVAL GRANULARITY.

2. Viewing swath 30 AMSU footprints or ~1650 km wide.

3. The result: 324,000 retrievals per day
Effect of Constraining SST to ±3K from Forecast

6 September 2003, Nighttime

BLUE: Full IR retrievals
GRAY: Other retrieval types
RED: Full IR where |SST - Forecast SST| > 3 K
Magnitude of Cloud Clearing
6 Sept 2002, Retrieved Cloud Fraction: 40-50%

Top: Average observed spectrum & average cloud cleared spectrum

Bottom: Statistics of cloud correction.
Validating Cloud-Cleared Radiance

6 September 2002, night, cloud fractions of 40-50%

**Top:** AIRS CC Rad & Calculated w/ECMWF

**Bottom:** Difference stats

**Summary:**
- Errors ~1K for <50% cover
- Increase to ~3K at 70%
AIRS SST Compared with Shipborne Radiometer
M-AERI on *Explorer of the Seas*, Caribbean, Fall 2002

These Are Our Best SST Comparison Data
(Not preselected by SST difference with NCEP forecast)

Bias = -0.85 degC
Std = 1.22
Temperature Profile Differences with ECMWF
6 September 2002, day and night, 40S-40N, oceans

Red: RMS Error, full IR retrievals
Green: Microwave only
Blue: Regression
Dashed line = 1 K / km.

NOTE: We can also achieve this without ‘peeking’ at forecast SST.
Total Water Vapor

General agreement with 3 ‘truth’ data sets
Except… Dry bias in very wet areas

<table>
<thead>
<tr>
<th>Data source</th>
<th>Relative Bias, percent</th>
<th>Relative RMS, percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>ECMWF analyses</td>
<td>0.01</td>
<td>16.2</td>
</tr>
<tr>
<td>Operational sondes</td>
<td>1.9</td>
<td>13.7</td>
</tr>
<tr>
<td>Dedicated Sondes, Chesapeake Platform</td>
<td>-0.1</td>
<td>10.6</td>
</tr>
<tr>
<td>Dedicated Sondes, Nauru* (ARM TWP)</td>
<td>-10.0</td>
<td>11.4</td>
</tr>
</tbody>
</table>

*Nauru is THE global water vapor maximum (Piexoto & Oort, 1993)
Total Water from Sondes at Chesapeake Light Platform

September-October 2002; Dynamic range is a mix of meteorology and burst balloons!
Water Vapor Profile

ECMWF, sondes in agreement to 500 mb

<table>
<thead>
<tr>
<th>Layer</th>
<th>ECMWF (%)</th>
<th>Operational Sondes (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1100 to 700 mb</td>
<td>-1.8 ± 9.6</td>
<td>3.6 ± 11.0</td>
</tr>
<tr>
<td>700 to 500 mb</td>
<td>-1.1 ± 31.2</td>
<td>0.0 ± 26.5</td>
</tr>
<tr>
<td>500 to 350 mb*</td>
<td>-12.5 ± 30.0</td>
<td>-3.7 ± 50.5</td>
</tr>
</tbody>
</table>

*Are these errors from AIRS or the correlative data?

Upper tropospheric humidity is currently a major validation activity
AIRS and ECMWF at Nauru (ARM TWP)

Tropical Western Pacific
Conclusions:
Cloud-Cleared Rad., SST, Temperature, Water Vapor

- Cloud cleared radiance based only on ECMWF
  - $\sim0.5$ to $3$ K, strongly dependent on cloud fraction

- General agreement for other quantities from multiple data sources
  - SST: $\sim0.9 \pm 1$ K from buoys, ECMWF, radiometer
  - Temperature profile: $\sim0.2 \pm 0.6-1.2$ K from sondes and ECMWF
    - lower trop most difficult
  - Total water vapor: $\sim1 \pm 10-15\%$ from sondes and ECMWF
  - Water vapor profile: $\sim1 \pm 10-30\%$ from sondes, ECMWF
    - best results in lower troposphere
Some Preliminary Results:
Retrieving Small-Scale Structure near the Surface

• Today’s Example: Temperature inversions off west coast of Mexico and US.
Near-Surface Temperature Inversions

Granule 210, 3 January 2003

Left: ‘Good’ (SST) inversions in red

Right: Vis/NIR image
Good Agreement with ECMWF in Temperature

Black = T, Blue = $T_{dew}$  
Smooth: AIRS, Dashed: ECMWF

Blue Asterisk = AIRS SST, Red Asterisk = ECMWF SST

NOTE: T agrees well, humidity does not!
Conclusions:

Exploratory Analyses

- Small vertical scale structure is seen in the AIRS retrievals.
  - Particularly apparent in temperature, supported by ECMWF
  - Cloud fields are consistent with Vis/NIR (not shown).
  - Currently examining humidity