FirstLight Forward Model Observations/Validation

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Overview

- Overall results are fantastic! Congratulations to the many people who designed, built, and tested AIRS!

- Obs-Calcs with both ECMWF and NCEP below 0.5K in mid-, lower-trop temperature (CO$_2$) channels, except for a few regions where spectroscopy needs some adjustments.

- Concentrated on ECMWF since NCEP water Obs-Calcs much larger.

- ECMWF Obs-Calcs in water region range from 1-2K. Origin of obs-calcs uncertain at this time.

- Redundancy of channels is already helping validation.

- kCARTA runs use Cont-V5.1 and sometimes CO$_2$ modification. We are working on re-fitting laboratory data.

- Non-LTE may be a major issue during daylight.

- Clear detection is mostly uniformitivity test, and split-window agreement. Also force ±3K agreement with SST for outliers, uniform clouds.
Clear Selection: 1st find uniform golfballs

Our FOV selection was based on three semi-independent tests: (1) the uniformity of the FOV radiances compared to all adjacent FOVs, (2) window channels at different wavelengths must have the same B(T), after correction for water, and (3) remove outliers by forcing agreement between observed and computed SST to $\pm 3K$.

Uniform B(T) test:

- test channels $= [759, 903, 2328, 2333] = [900, 961, 2611, 2616 \text{ cm}^{-1}]$
- calculate $BT_{\text{mean}}$ of test channels for every FOV
- calculate $|\Delta BT|$ for all 8 adjacent FOVs
- FOV is uniform only if max $|\Delta BT| < \Delta BT_{\text{max}}$
- $\Delta BT_{\text{max}} = 0.25 \text{ Kelvin}$
Clear Selection: Spectrum flatness, SST comparison

- use individual test channels = [759, 903, 2333]
- or binned test channels (average of nearby channels in micro windows)
- max land fraction = 0.001
- use nearest ECMWF profile and sea surface emissivity
- calculate effective sea surface temperature for test channels
  \[ \text{Planck}(T_{eff}) = \text{Planck}(T_{sea}) + \frac{(R_{obs} - R_{cal})}{\text{emissivity}} \]
- skip if \( T_{eff} < 273 \) K since it is ice not open sea
- find model vs calc \( \Delta T < 5 \) Kelvin (or 3 K for binned)
- find all channel \( \Delta T < 0.5 \) Kelvin (or 0.3 K for binned). This says you must have almost the same \( T_{eff} \) for each channel.
Absolute Radiometry; Comparisons with SST’s, Night/Ocean

Find clear by demanding uniform B(T) in 3x3 cell of FOVS (0.25K)
Discard uniform low clouds with |B_SST - B_obs| < 5K. Not robust but apparently OK for data studied so far.

<table>
<thead>
<tr>
<th>granule</th>
<th># uniform</th>
<th>#clear</th>
<th>2616 cm(^{-1})</th>
<th>960 cm(^{-1})</th>
</tr>
</thead>
<tbody>
<tr>
<td>5</td>
<td>686</td>
<td>582</td>
<td>-0.52</td>
<td>-0.43</td>
</tr>
<tr>
<td>21</td>
<td>122</td>
<td>101</td>
<td>-1.02</td>
<td>-1.03</td>
</tr>
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<td>89</td>
<td>164</td>
<td>106</td>
<td>-0.75</td>
<td>-0.65</td>
</tr>
<tr>
<td>90</td>
<td>60</td>
<td>51</td>
<td>-0.31</td>
<td>-0.17</td>
</tr>
<tr>
<td>236</td>
<td>369</td>
<td>307</td>
<td>-0.15</td>
<td>-0.24</td>
</tr>
</tbody>
</table>

Mean ~ -0.55K +- 0.35K
AIRS Bias with ECMWF for Various Geographic Locations

- **B(T) in K**
  - G005
  - G021

- **Δ B(T) in K**
  - G089

- **Wavenumber (cm^{-1})**
  - G236

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Forward Model Sensitivity to SRF Parameters

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AIRS Bias with ECMWF and NCEP, Original H\textsubscript{2}O and CO\textsubscript{2}
CLAMS S-HIS vs ECMWF/NCEP Calcs

ECMWF/NCEP – NAST Bias/Std

Wavenumber (cm$^{-1}$)

Obs-Calc in K

Ecmwf bias
Ecmwf std
Ncep bias
AIRS Bias with ECMWF and NCEP, Original H$_2$O and CO$_2$
AIRS Bias with ECMWF and NCEP, Original H$_2$O and CO$_2$
15 Micron Laboratory Data of CO$_2$

![Graph showing wavenumber vs. absolute coefficient observed versus calculated with lines for Cousin, Q-Mixing only, Q-,P/R-Mixing, Lorentz mixing.](image)

- Wavenumber (cm$^{-1}$)
- Abs. Coeff. Obs.-Calc. (%)

Legend:
- Red: Cousin
- Green: Q-Mixing only
- Blue: Q-,P/R-Mixing
- Black: Lorentz

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AIRS: kCARTA versus GENLN2 AIRS Bias with ECMWF

- Scatter plots showing the comparison between kCARTA and GENLN2 for various wavenumbers.
- Data points for B(T) in K and O-C in K are plotted against wavenumber (cm\(^{-1}\)).
- The graph includes a legend distinguishing between GENLN2 (red) and kCARTA (blue).
WINTEX: O-C With and Without P/R Mixing

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ECMWF vs S-HIS during CLAMS

B(T) in K

Obs − Calc in K

Wavenumber (cm$^{-1}$)

PR−Mixing

Cousin

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AIRS Bias with ECMWF and NCEP, Original H₂O and CO₂

![Graph showing AIRS bias comparison between ECMWF and NCEP for H₂O and CO₂ concentrations.](image)
AIRS Bias with ECMWF and NCEP, Original H₂O and CO₂
4.3 Micron Laboratory Data of CO$_2$

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AIRS:kCARTA versus GENLN2 AIRS Bias with ECMWF

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Sonde vs NAST-I during WINTEX

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AIRS Bias with ECMWF, CO$_2$ Corrected Using Laboratory Data

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AIRS Bias with ECMWF, CO₂ Corrected Using Laboratory Data

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CAMEX-1, WINTEX H$_2$O Obs-Calcs using Sondes

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ECMWF SHIS in the 1600 cm$^{-1}$ region
ECMWF SHIS in the 1400 $cm^{-1}$ region
Water Continuum Using Super-Lorentz Near-Wing Lineshape
Super-Lorentz Water Lineshape ($\chi$-function)
Non-LTE

- Non-LTE emission is larger than expected
- Emission is very high in atmosphere, 40 - 90 km
- Cores of 4.3 micron lines peak above the top AIRS layer below about 2380 cm\(^{-1}\)
- Non-LTE significantly affects some sounding channels during the day!
- GENLN3 has the best non-LTE emission model. We are starting to work with David Edwards (NCAR), on modeling the non-LTE to verify what is going on and to look for any solutions.
June 14, Granule 212

B(T) in K

O-C in K

Wavenumber (cm\(^{-1}\))

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June 14, Granule 115

B(T) in K

O−C in K

Wavenumber (cm\(^{-1}\))

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June 14, Granule 116 (only 2 clear FOVs)
Day vs Night Obs-Calcs at 4.3 microns

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Day vs Night Obs-Calcs at 4.3 microns

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