Update on Satellite GW Products and Forward Model for DEEPWAVE Science

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OUTLINE:

Analysis of AIRS and CrIS GW Products Continues

Meaningful Model/Data Comparisons Requires a Forward Model to Connect Model Fields to Data

Forward Models for DEEPWAVE Science

• Representative vertical weighting functions
• Full 3D forward model capability
Acknowledgements

NRL’s DEEPWAVE research and support is/was supported by:

• The Chief of Naval Research (CNR) through the NRL base 6.1 and 6.2 research program

• The Office of Naval Research (ONR) Departmental Research Initiative (DRI)“Predictability of Seasonal and Intraseasonal Oscillations.”

• The National Science Foundation

• The Oceanographer of the Navy through PMW-120/SPAWAR 6.4 transition contracts

• NASA through the Heliophysics Division SR&T and GI programs.
The Model/Data Comparison Issue

Channel Brightness Temperature $T_B(x_S, y_S)$

Divergence $D(x, y, p, t)$ $p=5$ hPa $t=0600Z$
Community Radiative Transfer Model v2.1.3 (CRTM)

- State-of-the-art operational radiative transfer (RT) model supported by Joint Center for Satellite Data Assimilation and used for radiance assimilation by US operational centers (e.g. NAVGEM)
- Updates AIRS and CrIS transmittance coefficients for all IR channel bands
- V2.1 includes non-LTE IR physics for upper altitudes (Chen et al. JOAT 2013)
- Includes Zeeman splitting of high-altitude microwave radiances.
- Allows user-specified channel subsets
Mean Profiles for Austral Winter

### AIRS Channel Averaging

- **50 raw channels → 12 net channels**

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Gong Wu & Eckermann (Atmos. Chem. Phys., 12, 1701-1720, 2012)

<table>
<thead>
<tr>
<th>Pressure (hPa)</th>
<th>Channel numbers</th>
<th>Noise ($K^2$)</th>
<th>NEdT ($K^2$)</th>
<th>Zonal mean</th>
<th>Map</th>
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<tr>
<td>2</td>
<td>74</td>
<td>0.149</td>
<td>0.165</td>
<td>3.78</td>
<td>26.64</td>
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<td>0.166</td>
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<td>0.161</td>
<td>3.63</td>
<td>25.55</td>
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<tr>
<td>4</td>
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<td>0.145</td>
<td>0.160</td>
<td>3.66</td>
<td>25.80</td>
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<td>0.162</td>
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<td>27.34</td>
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<td>0.182</td>
<td>0.172</td>
<td>4.62</td>
<td>32.53</td>
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<tr>
<td>20</td>
<td>81, 82</td>
<td>0.084</td>
<td>0.078</td>
<td>2.14</td>
<td>15.05</td>
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<tr>
<td>30</td>
<td><strong>102, 108, 114, 120, 125, 126</strong></td>
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<td>0.029</td>
<td>0.98</td>
<td>6.88</td>
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<tr>
<td>40</td>
<td>64, 88, 90, <strong>94, 100, 106, 118</strong></td>
<td>0.033</td>
<td>0.028</td>
<td>0.83</td>
<td>5.86</td>
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<tr>
<td>60</td>
<td>66, 68, 70, 86, 87, 91, 93, 97, 130</td>
<td>0.026</td>
<td>0.018</td>
<td>0.66</td>
<td>4.68</td>
</tr>
<tr>
<td>80</td>
<td>92, 98, 104, 105, 110, 111, <strong>116, 117, 122, 123, 128, 129, 134, 140</strong></td>
<td>0.020</td>
<td>0.011</td>
<td>0.50</td>
<td>3.54</td>
</tr>
<tr>
<td>100</td>
<td>132, 133, 138, 139, 149, 152</td>
<td>0.026</td>
<td>0.014</td>
<td>0.67</td>
<td>4.73</td>
</tr>
</tbody>
</table>
AIRS Vertical Weighting Functions
AIRS WF Variation with Scan Angle
Two Options for DEEPWAVE Model/AIRS GW Comparisons

Comparing model GWs to AIRS GWs requires a forward model to convert 3D model $T'(x,y,z)$ fields into a $T'_B(x,y)$ fields along measurement swaths

**Option 1** (Simple): $W(z,\alpha)$ can now be sent to modelers

$$T_B(x_S,y_S) = \int_0^{z_S} W(z, \alpha)T(x,y,z,t)dz$$

$$T'_B(x_S,y_S) = T_B(x_S,y_S) - \overline{T_B(x_S,y_S)}$$

or

$$T'(x,y,z) = T(x,y,z) - \overline{T(x,y,z)}$$

$$T'_B(x_S,y_S) = \int_0^{z_S} W(z, \alpha)T'(x,y,z,t)dz$$

**Option 2** (Brute Force): Working at NRLDC, not readily distributable as yet

$T(x,y,z,t)$ $T'(x,y,z,t)$ $(x_S,y_S,\alpha,t)$ CTRM $T_B(x_S,y_S), \ T'_B(x_S,y_S)$
Questions....
AIRS Premission Climatology

(a) RMS AIRS Brightness Temperature: June-July 2003-2011 2.5 hPa
AIRS GWs: 2-4 hPa June 2003-2011
AIRS GWs: 2-4 hPa June 2014

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AIRS GWs: 2-4 hPa July 2003-2011

Asc+Des 2 hPa | July 2003-2011 | Asc+Des 2.5 hPa

Asc+Des 3 hPa | Asc+Des 4 hPa
AIRS GWs: 2-4 hPa July 2014

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Reproduction of WFs for Every AIRS & CrIS Channel Using CRTM
AIRS DEEPWAVE Gravity-Wave Product

- GWs isolated as small horizontal scale perturbations in Level-1b swath-scanned thermal nadir radiances
- Channel averaging to reduce noise floors and increase S/N thresholds for GW detection
- For DEEPWAVE, provided “nowcast” AIRS GW product based on near-realtime (NRT) radiances
- Post DEEPWAVE, reprocessed 2014 data from 1 April to present using research-quality radiances

Eckermann and Wu, GRL, 2012
Gong, Wu and Eckermann, ACP, 2012
BACKUP SLIDES
AIRS 40 hPa Radiance Channels

(a) 40 hPa Kernel Functions

(b) 40 hPa GW Smearing

\[
\frac{\hat{T}_B}{\bar{T}_B} = \epsilon(\lambda_z) \frac{\hat{T}}{\bar{T}}
\]

AIRS channels 64, 88, 90, 94, 100, 106 & 118 (665.015–678.839 cm\(^{-1}\))

**Individual Channel Radiances 64,…,118**

**Mean Channel Radiance 64,…,118**

AIRS channel 71 (666.773 cm\(^{-1}\)).

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see Hoffmann and Alexander (JGR, 2009)

Eckermann et al. (GRL 2009)
South Island

Mean (2003-2011)
+/- 1 st. dev.
Max/Min
2014 DEEPWAVE
South Island

- Mean (2003-2011)
- +/- 1 st. dev.
- Max/Min
- 2014 DEEPWAVE
18-28 May
18-28 May
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2014.06.14 Descending 2 hPa
Max = 2.20 K
Min = -2.77 K

2014.06.14 Ascending 2 hPa
Max = 1.94 K
Min = -1.43 K

2014.06.15 Descending 2 hPa
Max = 1.84 K
Min = -2.06 K

2014.06.15 Ascending 2 hPa
Max = 2.41 K
Min = -2.57 K

2014.06.14 Descending 7 hPa
Max = 1.85 K
Min = -1.32 K

2014.06.14 Ascending 7 hPa
Max = 1.71 K
Min = -1.93 K

2014.06.15 Descending 7 hPa
Max = 1.96 K
Min = -1.40 K

2014.06.15 Ascending 7 hPa
Max = 1.58 K
Min = -1.60 K

2014.06.14 Descending 20 hPa
Max = 0.98 K
Min = -1.17 K

2014.06.14 Ascending 20 hPa
Max = 1.28 K
Min = -1.14 K

2014.06.15 Descending 20 hPa
Max = 1.46 K
Min = -0.99 K

2014.06.15 Ascending 20 hPa
Max = 1.07 K
Min = -1.09 K

2014.06.14 Descending 80 hPa
Max = 0.43 K
Min = -0.50 K

2014.06.14 Ascending 80 hPa
Max = 0.62 K
Min = -0.45 K

2014.06.15 Descending 80 hPa
Max = 0.44 K
Min = -0.46 K

2014.06.15 Ascending 80 hPa
Max = 0.64 K
Min = -0.53 K

June 15-16
19-24 June
2014.06.20 Descending 2 hPa  Max = 3.19 K  Min = -4.33 K
2014.06.20 Ascending 2 hPa  Max = 8.42 K  Min = -3.84 K
2014.06.21 Descending 2 hPa  Max = 2.81 K  Min = -0.02 K
2014.06.21 Ascending 2 hPa  Max = 8.46 K  Min = -4.42 K

2014.06.20 Descending 7 hPa  Max = 2.14 K  Min = -2.07 K
2014.06.20 Ascending 7 hPa  Max = 1.63 K  Min = -2.63 K
2014.06.21 Descending 7 hPa  Max = 1.46 K  Min = -2.09 K
2014.06.21 Ascending 7 hPa  Max = 1.92 K  Min = -1.91 K

2014.06.20 Descending 20 hPa  Max = 1.16 K  Min = -1.13 K
2014.06.20 Ascending 20 hPa  Max = 1.24 K  Min = -1.19 K
2014.06.21 Descending 20 hPa  Max = 1.29 K  Min = -1.40 K
2014.06.21 Ascending 20 hPa  Max = 1.06 K  Min = -1.19 K

2014.06.20 Descending 80 hPa  Max = 0.48 K  Min = -0.75 K
2014.06.20 Ascending 80 hPa  Max = 0.38 K  Min = -0.55 K
2014.06.21 Descending 80 hPa  Max = 0.57 K  Min = -0.53 K
2014.06.21 Ascending 80 hPa  Max = 0.58 K  Min = -0.47 K
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19-24 June
S. Ocean W55S

- Mean (2003-2011)
- +/- 1 st. dev.
- Max/Min
- 2014 DEEPWAVE