Status of AIRS RTA Development

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**RTA Flow**

- **Spectral Database**: eg HITRAN2012
- **US Standard Profile + T(z), H2O, Minor Gas offsets**
- **UMBC LBL code (Matlab/FORTRAN or LBLRTM)**
- **KCARTA Algorithm (FORTRAN or MATLAB)**
- **SVD Compression Of LBL OD's**
- **OD database, N gases x 100 layers x 25 cm⁻¹ chunks @0.0025 cm⁻¹ spacing**
- **49 – 25000 Regression/Test Profiles**
- **Create Fast RTA Coefficients**
- **Training/Testing Radiances AIRS, CrIS, IASI**
- **Test Radiances**
- **Co-located profiles; NWP, Gruan, etc**
- **SARTA + Database**

**New Developments**

- HITRAN 2012
- Version of kCARTA trained with LBLRTM
- Can support *large* sets of training/testing profiles
- New training code under development
- Will examine new parameterizations
In-depth analysis of co-incident high-quality sondes
Sondes indicated that HITRAN 2012 will improve some water lines by $\sim 0.2$-0.4K
LBLRTM vs UMBC LBL line-mixing uncertain. CrIS TVAC indicates UMBC LBL better for 720 cm$^{-1}$ Q-branch, LBLRTM maybe better for 667 cm$^{-1}$ Q-branch
LBLRTM Q-branch mixing is newer, so will use that first
New MT-CKD water continuum fixes problems at 2400+ cm$^{-1}$ that we dealt with by tuning in early versions of SARTA
Non-LTE might need a little tuning, will do once parameterization are finished
Given JPL desire for improved short-wave, will examine (a) solar model, (b) solar ray-tracing for low solar angle polar scenes, and (c) any existing BRDF databases that may be useful (after parameterizations are done).
Code Base Issues

Existing F77 Code

- Huge attempt to run old F77 code written by Scott Hannon, provides a baseline.
- Too time consuming to modify (∼100 F77 programs)
- Nearly done for CrIS FSR, but need to create new variable CO₂ approach (old approach not clearly documented).
- Way too time consuming, so I am writing a new, very simple MATLAB parameterization code: Pressure-layer done, working on OPTRAN layering for H₂O. Nearly 50X less code, very automated.
- New code base will allow for easy experimentation
- kCARTA + our cpu resources allow us to test SARTA on 25,000+ profiles. (Work already done.)
### Present Plan

- Produce nominal new parameterizations for AIRS + CrIS (FSR) using old F77 code base
- Develop new (MATLAB) parameterization code using (nearly) the same algorithm as a baseline
- With new code, increase number/type of fitting profiles and possibly produce scene (latitude?) dependent coefficient sets
- Focus on polar areas, where we presently have problems with low water amounts and low solar angles (which are very hard to do).
- Fundamental quantity is layer-to-space transmittance, a 0-1 function that should be weighted by it’s vertical derivative
- We think this approach is likely well suited for machine learning algorithms
Early AIRS Parameterization

![Graph showing observed vs calculated biases and stds in Kelvin over wavenumber (cm⁻¹) range.](image_url)
CrIS FSR vs ECMWF in Mid-Wave

![Graph showing bias in K for HITRAN 2008 SARTA and HITRAN 2012 SARTA across different wavenumbers (cm\(^{-1}\)). The graph displays fluctuations in bias values ranging from -0.8 to 0.8 K.](image-url)
CrIS FSR Fitting Errors
CrIS FSR Independent Test: 705 Profiles

![Graph showing B(T) in K vs Wavenumber (cm⁻¹)](chart1)

- **Bias/Std in K**
  - Bias
  - Std

![Graph showing Bias/Std in K vs Wavenumber (cm⁻¹)](chart2)
**HNO₃ Signals in kCARTA vs SARTA**

**SARTA response to 10% change in HNO₃**

- **kCARTA**
- **SARTA**

<table>
<thead>
<tr>
<th>Wavenumber (cm⁻¹)</th>
<th>Bias/Std in K</th>
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<tbody>
<tr>
<td>800</td>
<td>0</td>
</tr>
<tr>
<td>1000</td>
<td>0.02</td>
</tr>
<tr>
<td>1200</td>
<td>0.04</td>
</tr>
<tr>
<td>1400</td>
<td>0.06</td>
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<tr>
<td>1600</td>
<td>Mean</td>
</tr>
<tr>
<td>1800</td>
<td>Variance</td>
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</tbody>
</table>
Changes in New Approach (and Code)

Preliminary

- Empirical weighting of OD’s replaced with a physically based approach: Derivative of layer-to-space transmittance. Improves fitting accuracy.

- Automated selection of predictors out of a pool of possible ones. Lowers number of predictors a bit, but Scott did a very good job overall.

- Continuous testing with radiative transfer comparisons
Fit Diagnostics with New System
677 cm$^{-1}$ channel

Improvements with New Weighting

<table>
<thead>
<tr>
<th></th>
<th>Old Weighting</th>
<th>New Weighting</th>
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</thead>
<tbody>
<tr>
<td>Bias</td>
<td>0.0048K</td>
<td>0.0024K</td>
</tr>
<tr>
<td>RMS</td>
<td>0.0328K</td>
<td>0.0275K</td>
</tr>
</tbody>
</table>
Conclusions

- Able to run old SARTA regression codes except:
  - Missing complete CO$_2$ recipe, working on fixes now
  - Apparently some bias issues, maybe with water continuum
  - Other minor gases working OK, but need some improvements to CH$_4$

- Plan to build acceptable RTA’s using mostly existing code
- Re-build with new code base, improved weighting, etc.
- Explore better parameterizations with new code base (machine learning)
- If time, do regional testing and improvements, concentrating on polar scenes in the shortwave