Radiative Transfer Algorithm Updates

AIRS Virtual Science Team Meeting

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October 2020

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Summary

- What is the Stand-alone radiative transfer algorithm (SARTA)
- Who uses SARTA.
- Current SARTA build status.
- Plans.

The SARTA

- The Stand-alone radiative transfer algorithm (SARTA) is constructed using kCARTA
- Therefore SARTA has the same spectroscopy as kCARTA.
- SARTA was developed 18 years ago for the AIRS.
- It uses sets of coefficients that parameterize atmospheric transmittances derived using a set of training profiles.
- Is written in Fortran
- Permits very fast computation of radiances for predefined spectral response functions.
- Has a version for clear sky radiance calculations and for cloudy radiances.

Who uses SARTA

- SARTA is used to compute clear and all-sky radiances for any and all FoVs from AIRS, CrIS and IASI missions.
- Is fast enough to make whole-mission modelling easily manageable. Faster than kCARTA *way* faster than LBL.
- Currently used in ASL for the RTP production for analysis of sensor performance and global studies and geophysical retireval.
- Is used in the AIRS geophysical product retrieval.
- Is used in NUCAPS.

Current Spectroscopy

- HITRAN 2016
- CO_2, CH_4 line mixing from LBLRTM12.8
- MT CKD3.2
- CO_2 CIA from WV and N_2 by Hartmann (4.3 um)
- Single parameter surface emissivity.

Future Improvements

- HITRAN 2020.
- Line Mixing package from the HITRAN folks (Iouli Gordon).
- Currently use kCARTA at 0.0025 cm-1, can update to 0.0005 cm-1 in 15 um region
- poss. linear-in-tau RT.
- poss. Nalli surface emissivity parameterization.
- poss. look into running off NLTE from Manuel esp. the extreme solar angles.
- Tuning for 'real world' application.

Current SARTAs at ASL

- The following SARTAs are in use at ASL:
  - AIRS vL1B (2008) as supplied to JPL is tuned.
  - AIRS vL1C (2016) as supplied untuned.
  - CrIS NSR v2008, & v2016.
  - CrIS FSR v2016 (untuned).
  - IASI v2008 and v2016 (untuned).
  - CHIRP v2016 (under development).

Validating by bias and residual

- After completing the fast coefficient regression, top-of-atmosphere (TOA) radiances predicted by SARTA are compared to those from kCARTA from the training set or extended profile set.

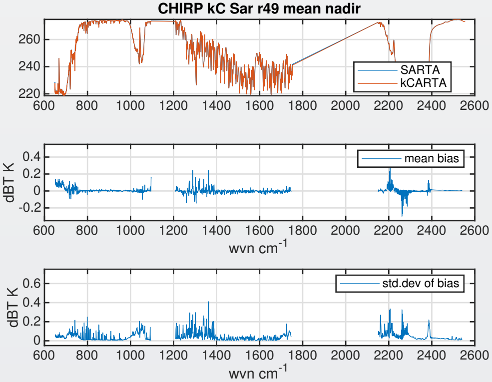

Figure 1: CHIRP channels. AIRS bias relative to SNPP from global

Improved bias & std.dev relative to kCARTA

- kCARTA monochromatic layer-so-space optical depths are convolved to the sensor grid.
- For AIRS (and any spectrometer) convolution with the spectral response functions (SRF) is well behaved. Transmittance approaches zero for opaque channels.
- For interferometers (IASI, CrIS, CHIRP) convolution with the instrument line shape (ILS) produces tau that goes -ve and +ve into the opaque region.
- Regression of the fast coefficients is controlled down to a minimum transmittance which is set by inspection of these 'wings'.
- Sarta builds for IASI, CrIS version 2019 and CHIRP 2020 included some fits in strong (CO_2) bands that were not optimal. (See next slides).

Example of optimization: CHIRP 640 cm-1

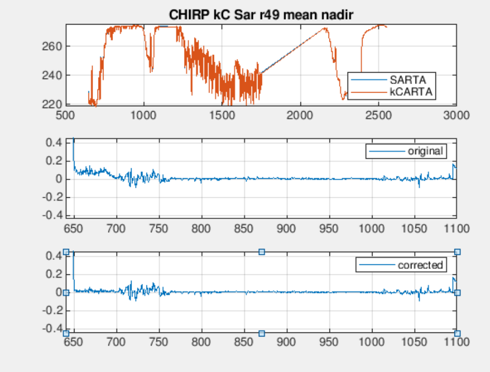

Figure 2: CHIRP SARTA bias compared to kCARTA, with and without improved regression.

Example of optimization: IASI 4.3 um

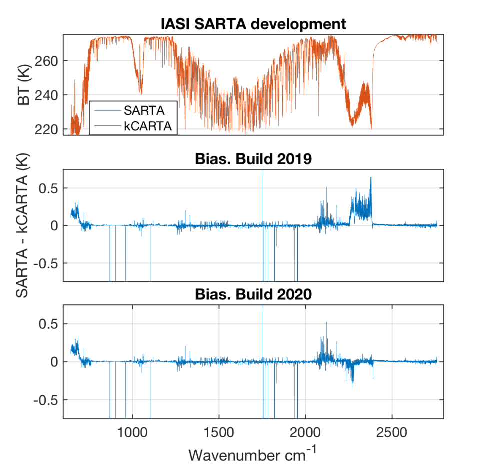

Figure 3: IASI SARTA bias compared to kCARTA, with and without improved regression at 4.3 um.

Tuning: 1

In the real world differences in measured top-of-atmosphere radiances compared to calculated have several potential sources:

- AIRS radiometric calibration.
- AIRS spectral calibration and instrument line shape.
- AIRS fast model parameterization.
- cloud contamination in fields of view selected as clear.
- validation data, including time/space mismatches and uncertainties in minor gas abundances.
- spectroscopy used in the AIRS RTA.

Tuning: 2

The objective of tuning is to reduce bias in the real world sufficiently to increase the yield in single footprint geophysical retrievals.

- Large data sets are compared covering all global atmospheric and scene types.
- Bias and std.dev characterisctics between coincident TOA measurements with forward model predictions are determined.
- RTA transmittances are adjusted for specific channels where needed.
- SARTA uses a supporting data file of tuning parameters.
- Tuning of transmittances in the RTA are preferred over tuning BT of TOA predicts.

Tuning: Case study

- Selection of June 25 talk

Conclusions

- TBD