AIRS L1B and ECMWF model matchups for 2009/03/01

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1. Introduction

We have put together a data set of 7377 thermodynamic and cloud profiles, together with viewing geometry and surface emissivity information, for use in an inter-comparison exercise of clear and scattering radiative transfer codes. We hope the participants in this exercise can upload their clear-sky and all-sky radiances to a ftp site we will be setting up, so that we can inter-compare the results.

The data set uses Atmospheric Infrared Sounder (AIRS) L1b observed BT 1231 cm^{-1}(AIRS channel 1291) observations for 2009/03/01 and the European Center for Medium-Range Weather Forecast (ECMWF) surface temperatures as guidance to select a wide and representative set of atmospheric states. We then matched these AIRS locations and times to ECMWF (via a 2d interpolation in space at each σ level)to get a thermodynamic and cloud state of the atmosphere.

The data set include the observed AIRS L1b radiances together with clear sky radiance estimates using the SARTA fast forward model. These clear sky estimates can be used to establish a baseline comparison of the Radiative Transfer Algorithms used in this comparison study.

In addition we present a representative set of all-sky radiance calculations for AIRS Channel 1291 using the TwoSlab cloud representation model and the ECMWF cloud model fields. Though we have already compared these radiances to AIRS observations, we may refine our scattering algorithm and/or cloud representation model in the future and in particular the single channel all-sky radiance calculations should only be considered as an example.

The provided data are described in the appendix. Though the data/codes used are for the AIRS instrument, in the future we could also provide similar data for other hyperspectral sounders such as the Infrared Atmospheric Sounding Interferometer (IASI) and Cross-track Infrared Sounder (CrIS).

2. NWP model

The ECMWF model data was obtained by finding the nearest-in-time 3 hour forecast to the AIRS data, and then doing an interpolation to the AIRS L1B geo-locations. 91 level profile data for the temperature, humidity and ozone fields, surface temperatures, and cloud amount and cloud cover were obtained from the model.

We also have a set of default profiles for CO2,CH4,CO and N2O spanning the SARTA 101 pressure levels (provided to us by Xianglei Huang and Xiuhong Chen from University of Michigan), for which the top-of-atmosphere is 0.005 mb. This meant we extended the ECMWF profiles by adding on one point at 0.005 mb, from the US Standard Atmosphere.

3. Levels to layers

At UMBC we use our standard klayers package to turn the levels profiles into layer averaged profiles (over the AIRS 101 standard levels). In addition we have our own Matlab wrapper to map the NWP cloud profiles and cloud fractions into TwoCloud slabs.

4. Radiative Transfer and Cloud Representation

The clear and scattering fast radiative transfer codes used for the provided synthetic radiances are UMBC's SARTA [*Strow et al.*, 2003] (developed by Larrabee Strow and Scott Hannon). SARTA includes daytime 4.3 μmNLTE effects.

The atmospheric optical depths for SARTA are based on KCARTA [*De Souza-Machado et al.*], generated using HITRAN 2008 and include the UMBC CO2 linemixing effects.

The scattering model for the all-sky radiances is the Parametrization of Clouds for Longwave Scattering in Atmospheric Models (PCLSAM) [*Chou et al.*, 1999]. The cloud representation models used were a TwoSlab cloud model [*De Souza-Machado et al.*, 2016] for SARTA (developed by Sergio Machado and Larrabee Strow and Scott Hannon). Ice scattering parameters come from the general habit models described in *Baum et al.* [2011] while the water clouds came from Mie scattering calculations. More details can be obtained from S. Machado.

We use land surface emissivity from the *Zhou et al.* [2011] land emissivity database, and ocean emissivity from *Masuda et al.* [1988].

5. AIRS SRFs

The SARTA v108 clear and cloudy sky code both used the "m140" version of the SRF tables. The clear sky SARTA is available at http://asl.umbc.edu/pub/packages/sarta.html while the SRF files are available on http://asl.umbc.edu/pub/airs/srf/ (click on the srftables_m140_postNov2003.hdf link).

6. Data format

We have saved the data in two formats (a) as a Matlab structure in a .mat file and (b) used the save -v7.3 option in Matlab to save the data in an hdf5 file. We have used linux tools to query and subset the hdf5 file, and verified that the output from the command line tools is the same as what is in the mat file (see appendix).

The data files are available at

- UMBC at http://asl.umbc.edu/pub/sergio/forITOVS
- JPL at http:/jpl.nasa.gov/blahblah

Note : For now we use temporary UMBC website till we settle on the final dataset to be provided, as a JPL website location

Below is a summary of the data in the .mat and .hdf5 files. More information about the data fields can also be found in http://asl.umbc.edu/pub/packages/rtpspec201.html

A. Model

91+1 level ECMWF MODEL fields

```
lat                                plat: [1x7377 single]
lon                                plon: [1x7377 single]
surf alt                          salti: [1x7377 single]
surf pres                         spres: [1x7377 single]
landfrac 0/1                   landfrac: [1x7377 single]
surf windspeed                  wspeed: [1x7377 single]

surf temp                         stemp: [1x7377 single]
num levels                        nlevs: [1x7377 int32]
press levs                        plevs: [92x7377 double]
T(z)                              ptemp: [92x7377 double]
WV(z)                              gas_1: [92x7377 double] g/g
O3(z)                              gas_3: [92x7377 double] g/g
cloud cover                          cc: [92x7377 double]
cloud ice water content            ciwc: [92x7377 double]
cloud liquid water content         clwc: [92x7377 double]
total cloud cover                   tcc: [1x7377 single]


CO2(z)                             gas_2: [92x7377 double] ppmv
N2O(z)                             gas_4: [92x7377 double] ppmv
CO(z)                              gas_5: [92x7377 double] ppmv
CH4(z)                             gas_6: [92x7377 double] ppmv
```

B. Emissivity

EMIS/REFL

```
 nemis: [1x7377 int32]      number of emissivity points (varies betwween 19 and 100)
 efreq: [100x7377 single]   emissivity wavenumber  hingepoints
  emis: [100x7377 single]   emissivity
   rho: [100x7377 single]   number of relectivity points (same as nemis)
  nrho: [1x7377 single]     reflectivity = (1-emis)/pi
```

C. AIRS geolocation

AIRS L1B information

```
   pobs: [1x7377 single]     observation pressure (TOA)
   zobs: [1x7377 single]     observation height (705 km)
scanang: [1x7377 single]     scan angle at satellite, between -49 to +49 degrees
 satzen: [1x7377 single]     local satellite zenith at ground
 satazi: [1x7377 single]
 solzen: [1x7377 single]     local solar zenith at ground
 solazi: [1x7377 single]
   rlat: [1x7377 single]     observation point latitude
   rlon: [1x7377 single]     observation point longtitude
  rtime: [1x7377 double]     observation time (TAI)
 findex: [1x7377 int32]      AIRS granule number
 atrack: [1x7377 int32]      along track index
 xtrack: [1x7377 int32]      cross track index
```

D. Sample SARTA Radiances

```
             sarta_clear: [2378x7377 single]   clear sky SARTA radiances, 2378 channels
    sarta_cloud_calcCh1291: [1x7377 single]      all sky SARTA radiances for Ch 1291
```

E. HDF verification

We verified the hdf5 file as follows. For example, for the temperature profiles which are in a 92x7377 "ptemp" double matrix, at the linux prompt we typed

```
h5dump -d /p0/ptemp     -b LE -o ptemp.bin  forITOVS_ECM.hdf5'];
```

(note in this case I used "forITOVS_ECM.hdf5" as my test file)
This was followed by reading the subset-ted binary file in as follows in Matlab

```
fileID = fopen('ptemp.bin');
[A,count] = fread(fileID, [92,7377], 'double');
fclose(fileID);
```

There were no differences when compared to the original "ptemp" field. Other fields were also spot checked.

References

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