CRTM Working Group

05 Feb 2009 Meeting

Agenda

- 3:00pm Review of CWG#3 action items (10min)
- 3:10pm CRTM Software Status (5min)

Core Team Member Reports

- 3:15pm Visible RT (5min)
  Multiple transmittance algorithm (5min)
  Transmittance production (5min)
- 3:30pm NRL update; Ben Ruston (5min)
- 3:35pm StAR update; Fuzhong Weng (5min)
- 3:40pm NCAR/AFWA update; Zhiquan Liu (5min)

Collaborating Team Member Reports

- 3:45pm UWisc update; Ralf Bennartz (5min)
- 3:50pm AER update; Vivienne Payne (5min)
- 3:55pm Texas A&M update; Ping Yang (5min)
- 4:00pm Open Discussion

CWG#3 Action Items

1) Respond to AER on spectroscopy priorities (PvD and YHan).
   No record of our response. Save for discussion.
2) Address land MW desert emissivity bias (BYan and WZheng), produce new empirical emissivity (BYan).
   No record of action.
3) Investigate large CRTM Jacobians responsible for the large stratopause temperature increments at GMAO (YChen and ELiu).
   No record of action. Extra layering issue? Save for discussion.
4) Address large ocean surface MW emissivity error at high frequency and any other outstanding bias issue in GFS (QLiu and BYan).
   No record of action.
5) Complete generation of FengYun-3 coefficients (YChen and YHan).
   Completed. Available from CRTM ftp site.
6) Improve User Guide. (PvD).
   Draft User Guide available from CRTM ftp site.

CRTM Software Status

- REL-1.2 made available 2009-02-04.
- ftp://ftp.emc.ncep.noaa.gov/jcsda/CRTM/
- Major code changes:
  - Low-frequency (<20GHz) MW sea surface emissivity model
  - FASTEM-3 (>20GHz) MW sea surface emissivity model
  - SSMIS Snow and Ice surface emissivity model
  - New generic interpolation module to preserve derivatives across interpolation boundaries. Implemented for cloud and aerosol optical property interpolation.
  - Modified cloud and aerosol optical property interpolation to reduce TL and AD model computational burden.
  - Atmosphere (set layers) and GeometryInfo (source zenith) bug fixes.
- Major coeff changes.
  - Updated cloud and aerosol optical properties.
  - Added sensors: CrIS, MT-2 imgr, NOAA-19, SSMIS F17-F20

Status of CRTM Visible component development

Quanhua Liu, Yong Han, Paul van Delst and Fuzhong Weng

Joint Center for Satellite Data Assimilation

- A test version of the forward model for visible channels has been completed:
  - The atmospheric transmittance module has been extended into the visible region (OPTRAN algorithm)
  - The cloud and aerosol optical parameter LUTs have been extended into the visible region.
  - Rayleigh scattering of atmosphere has been added.
  - Fourier component for azimuth angles and the solar term have been added to the Advanced Doubling-Adding RT solver.
- CRTM is now available for GOES-R visible channels.

CWG meeting on Feb. 5, 2009

Multiple Transmittance Algorithm; Y.Han, Y.Chen, and T.Zhu

- New transmittance model ODPS (Optical Depth in Pressure Space)
  - Training software completed.
  - Application FWD, TL, and AD models completed. Testing continues.
  - Absorbers (sensor and resolution dependent):
    - Variable: H2O, CO2, O3, N2O, CO and CH4
    - Fixed: N2O(broadband), O2, CFCs, HNO3, NOx, SO2, N2 and OCS
- Remaining Work
  - Add altitude dependence to the zenith angle profiles to take the Earth curvature effect into account.
  - Further test, evaluate and refine the algorithm and implementation.
- Multiple algorithm framework
  - Different transmittance algorithms can be used with the same user interface.
  - Compact-OPTRAN (operational), ODPS, SSMIS-Zeeman and SARTA
  - Transmittance algorithm is dynamically selected by using the algorithm ID, which is stored in the sensor-dependent transmittance coefficient file.

Transmittance Production; D.Groff, P.vanDelst

- Verification of all infrared SRFs. Experienced issues with AVHRR and various GOES sounder and imager SRFs.
- Conversion of all current IR SRFs to the new format.
- Creation of MW SRF files from our current frequency-only definitions (assuming rectangular passband shape).
- Started use of MonoRTM for microwave transmittances (how to get optical depth profiles?)
- Will be recomputing transmittance database for all instruments (historical, current, and planned) using LBLRTM for IR and MonoRTM for MW.

NRL Update; Ben Ruston

StAR Update; Fuzhong Weng

Land Emissivity Models and Data Sets

Fuzhong Weng
Center for Satellite Applications and Research

Team Members:

Banghua Yan – Microwave land and snow emissivity model, liaison with EMC land team
Ron Vogel – Infrared land emissivity data base and surface classification, liaison with EMC land team
Lihang Zhou – Hyperspectral infrared land emissivity retrievals
Sid Boukabara – MIRS land emissivity retrievals
Ninghai Sun – Emissivity data base for conical scanning instruments

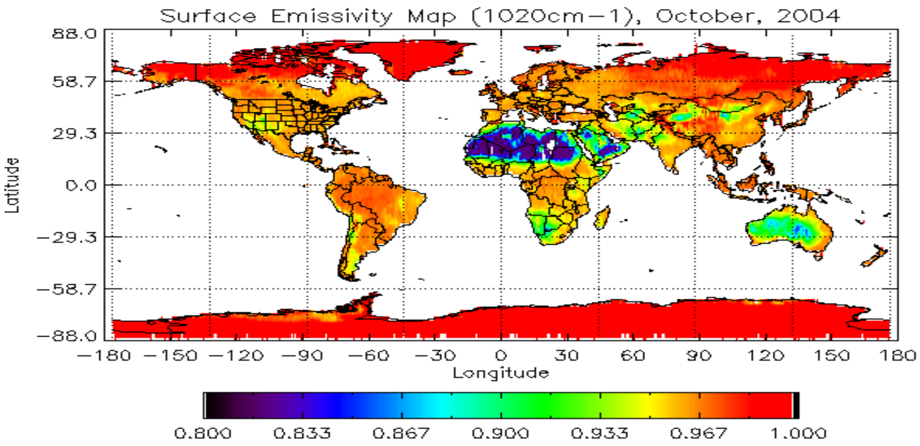
New Developments

- Snow emissivity modeling (Yan)
- 20 years of SSM/I emissivity data base (Sun)
- AIRS and IASI emissivity data base at 39 hinge points (Zhou)
- Multilayer land emissivity model (Weng)
- MIRS land surface emissivity from AMSU/MHS (Boukabara)

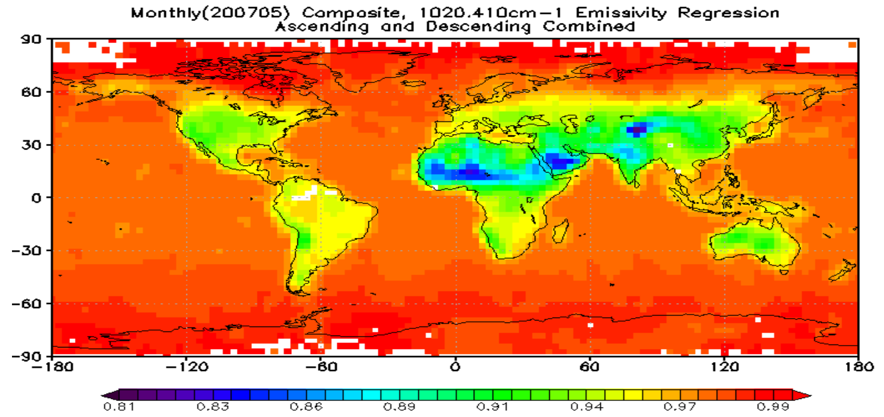
Hyperspectral Emissivity Data Base

- AIRS and IASI 39 hinge point emissivity data are retrieved in AIRS/IASI systems
- Two LSE data sets agree well within 1% for most areas
- Differences exist over coastal areas and desert region where the large variations of emissivity occur
- The IASI and AIRS systems will be enhanced to cover the entire 2-15 micron emissivity with dynamic updated information from pentad to monthly scale

AIRS



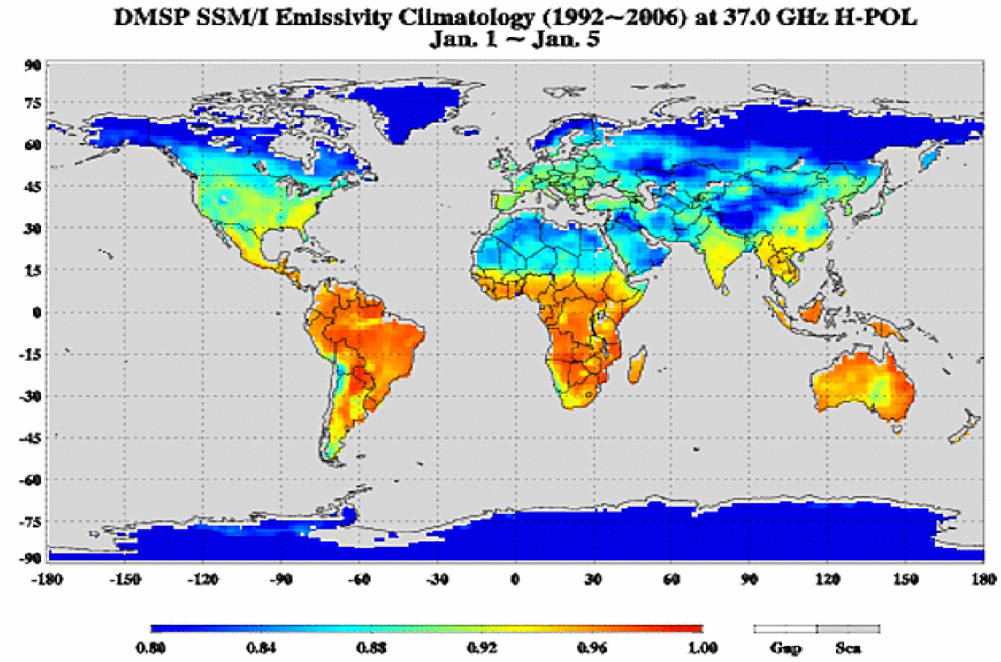
IASI



Infrared emissivity data sets will result in improved uses of surface sensitive sounding channels from hyperspectral instruments

Global Land Emissivity Characterization SSM/I Fifteen Year Time Series

- Large season change at higher frequencies
- Large polarization difference for several surfaces (e.g. desert, snow, flooding)
- Deserts appear as a scattering medium



SSM/I surface emissivity climatological data set is developed at various time scales (e.g. pentad, weekly and monthly, anomaly). SSM/I sensors from F10 to 15 satellites are intercalibrated to a reference satellite (F13)

Next Step

- Refine snow emissivity models for all MW sensors
- Extend SSM/I emissivity data base including 150 GHz from SSMIS
- Extend AIRS and IASI hinge point emissivity to hyperspetral
- Refine multilayer snow emissivity model for SMOS and SMAP

NCAR/AFWA Update; Zhiquan Liu

See accompanying CWG_Z.Liu.2009-02-05 PDF

UWisc Update; R. Bennartz

SOI-CRTM update

Bennartz/Greenwald 2/5/2009

- Completely revamping SOI -integration: Solves all open issues from last year's study by Yoshihiko Tahara.
- Reduces overhead: Use internal CRTM routines for standard tasks (e.g. δ-scaling, phase function expansion etc…).
- FWD-model revamp ready end of February 2009.
- Next tasks: Speed and accuracy comparison with ADA. Should be coordinated with JCSDA staff.
- TL and ADJ will be ready May 2009. Testing as above.
- Some integration/interfacing issues we would like to discuss in detail with JCSDA staff. Visit?

AER Update; V. Payne

Updates to spectroscopy in AER's line-by-line RT models

LBLRTM

CO_2 line parameters
Tashkun et al. (1999)

CO_2 line coupling
Application of Niro et al. (2005) code to Tashkun line parameters

CO_2 continuum
Using ARM ground-based interferometer meas.

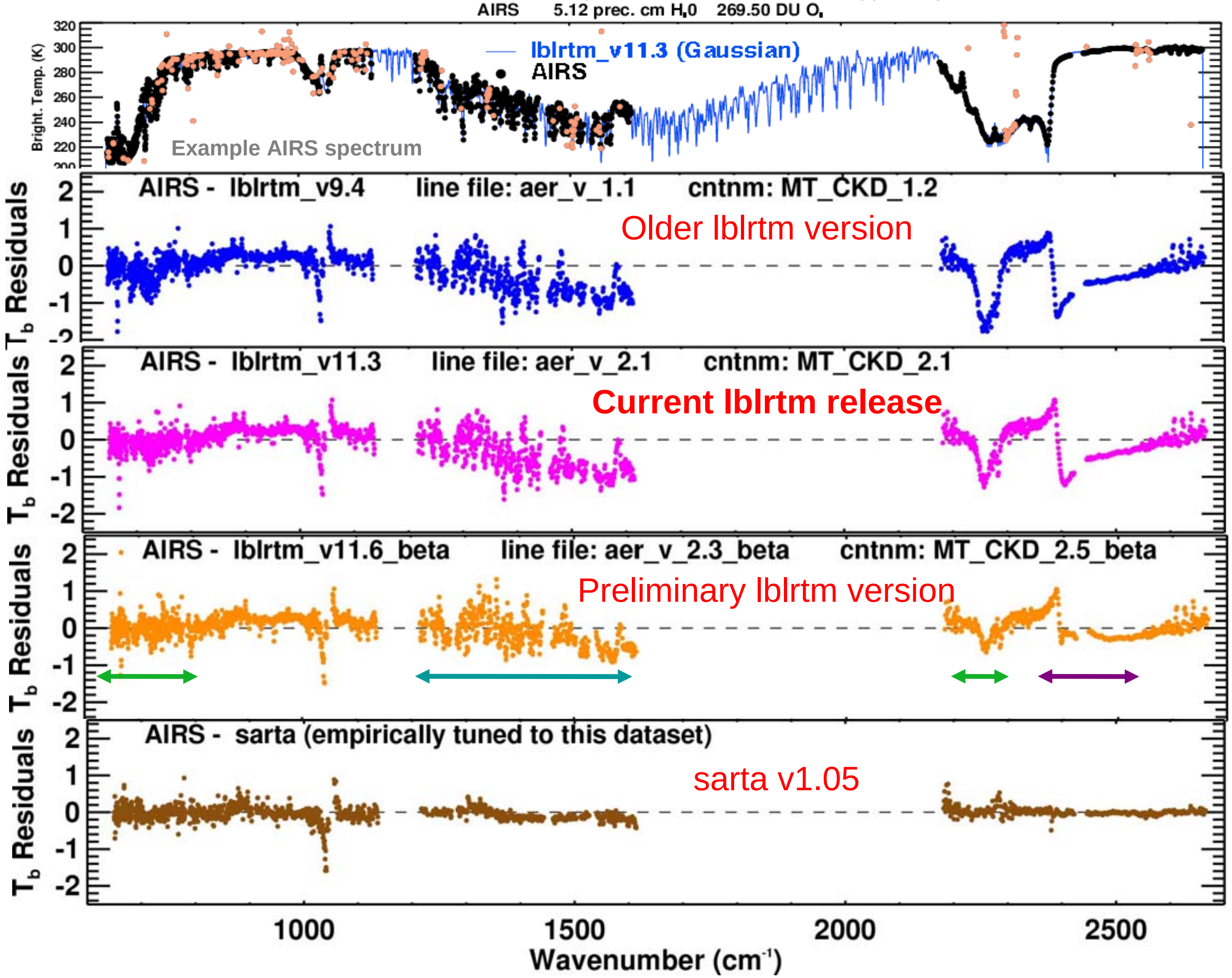
H_2O line parameters
Coudert et al. (2008)

Updates to LBLRTM are all independent of the AIRS dataset used here to demonstrate them.

MonoRTM

H_2O continuum
Using ARM ground-based radiometer meas. (Payne et al., 2009, in preparation)

Mean residuals from 36 ARM TWP cases: Profile inputs and "SARTA" results supplied by L. Strow and S. Hannon.



Significant improvements to consistency between spectral regions!

Texas A&M Update; P. Yang

Scattering properties of dust aerosols, water and ice clouds: applications to CRTM

Ping Yang and Shuoguo Ding
Department of Atmospheric Sciences
Texas A&M University

February 5, 2009

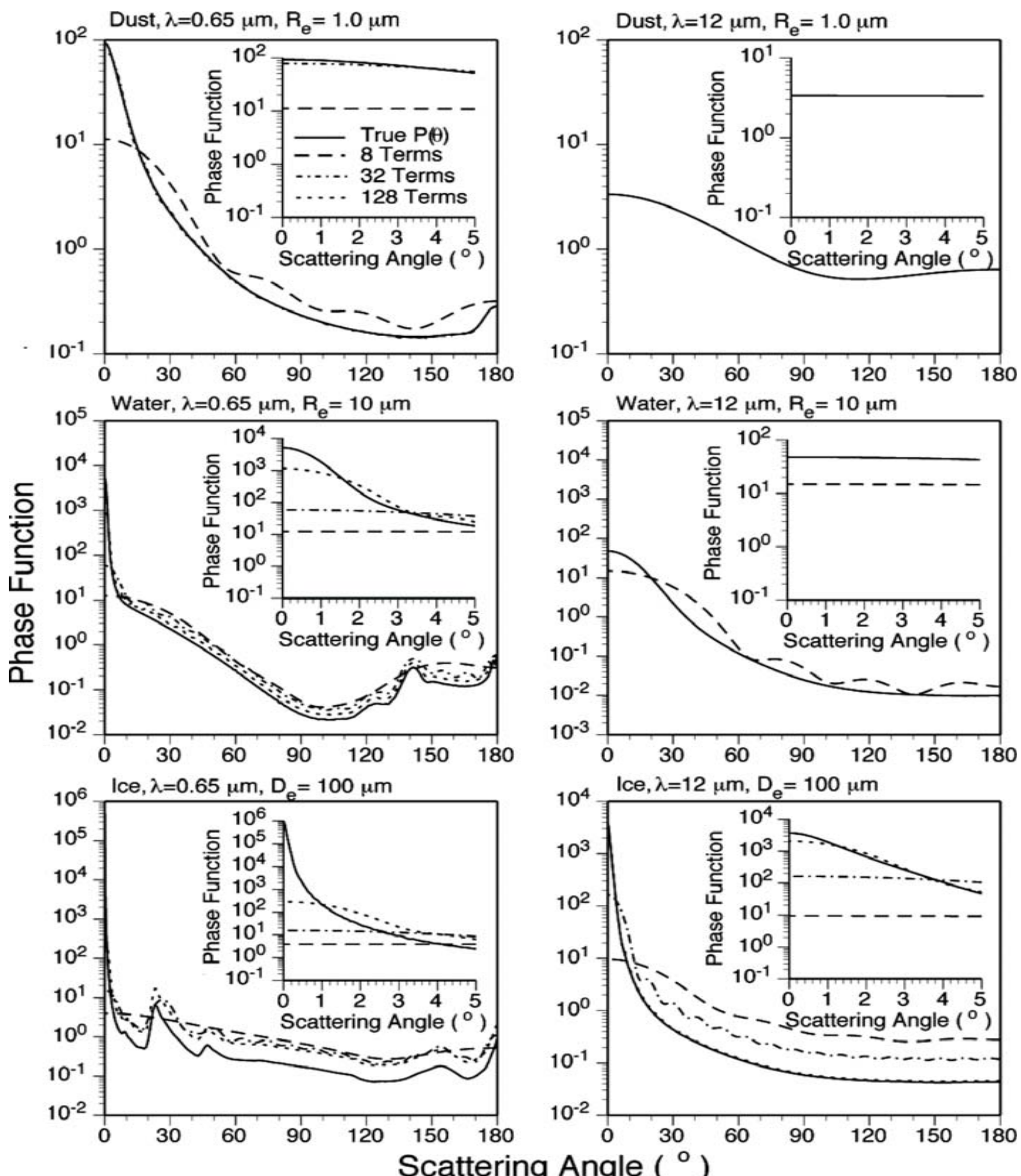
Overview

- Dust aerosols
  - Simulation of the bulk scattering properties.
  - Interpolation of the bulk scattering properties to 3001 wavelengths between 0.225 and 20.0 μm
  - Truncation of the scattering phase functions
- Ice clouds
  - Same as dust aerosols
- Water clouds
  - Same as dust aerosols

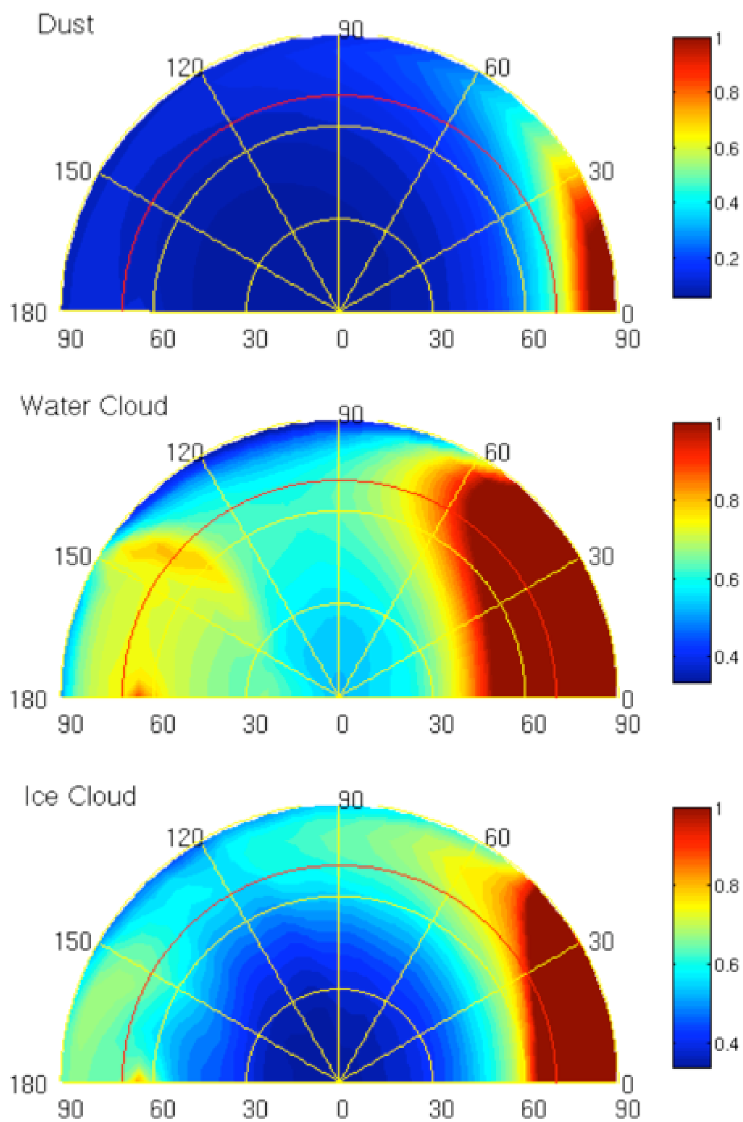
Three bulk-scattering property data sets

- Randomly oriented spheroidal dust particles
- Perfect spherical water droplets
- A mixture of various ice crystal habits

The original and re-constructed scattering phase functions of dust, water clouds, and ice clouds at two wavelengths: 0.65 μm (left column) and 12.0 μm (right column).



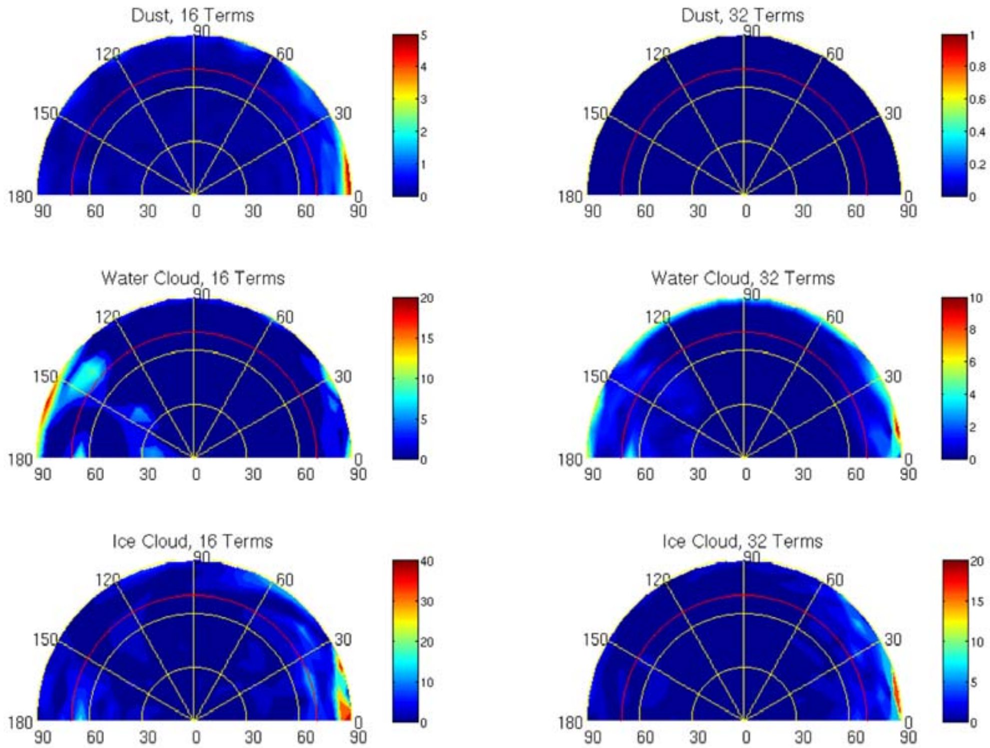
The bidirectional reflectances over clouds and dust aerosols



✧The bidirectional reflectances simulated by using 128 terms of Legendre polynomials at a wavelength of 0.65 μm for a dust layer, a water cloud and an ice cloud.
✧The solar zenith angle is 60°. An optical depth of τ=1 and an effective particle size of R_e=1 μm are assumed for dust; τ=20 and R_e=10 μm for the water cloud; and τ=5 and D_e=100.0 μm for the ice cloud.
✧The red arcs represent the contour of a viewing zenith angle of 70°
✧Here we assume that the results with 128 terms to be the 'truth'. The relative error, δ, of the bidirectional reflectance is defined in the form

$$\delta = \frac{\left|R_{128} - R_N\right|}{R_{128}} \times 100$$

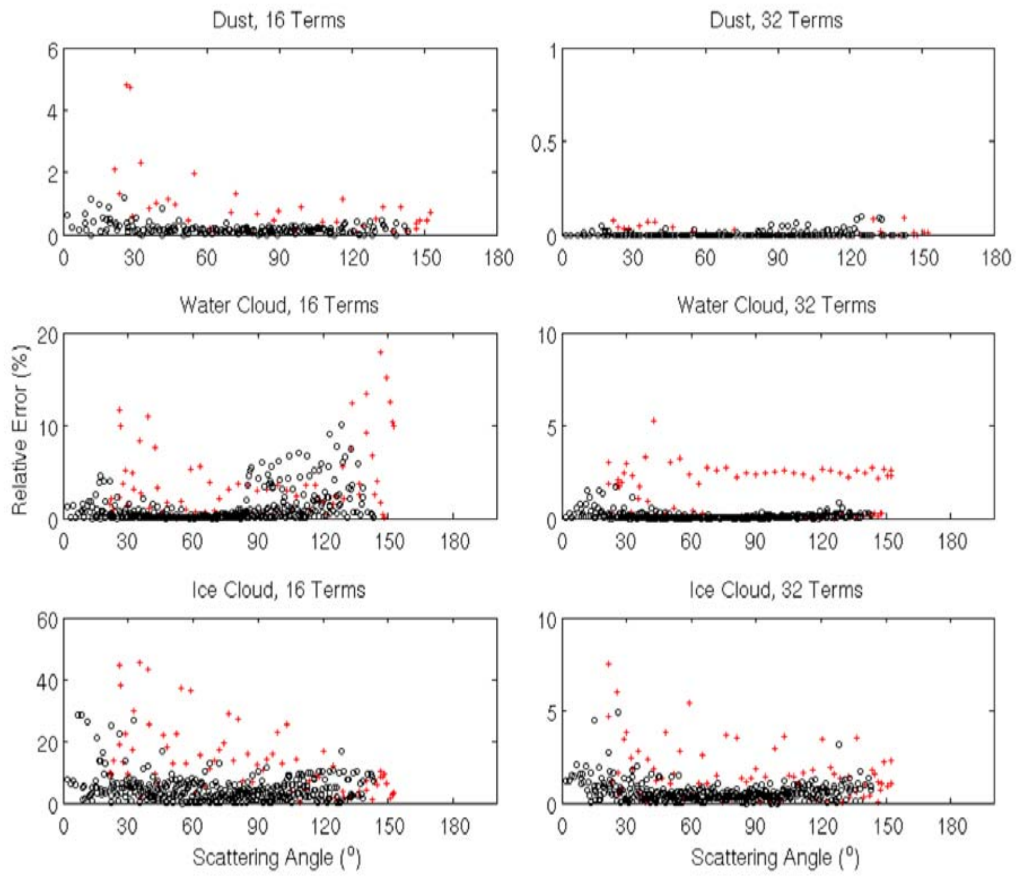
The distribution of relative errors with viewing zenith angles and relative azimuth angles



- For dust, 16 terms seems to be sufficient.
- For water clouds, there are some angular regions in both forward- and back-scattering regions with relative errors higher than 10%.
- For ice clouds, the bidirectional reflectances are more sensitive to solar-satellite relative azimuth and satellite viewing zenith angles.

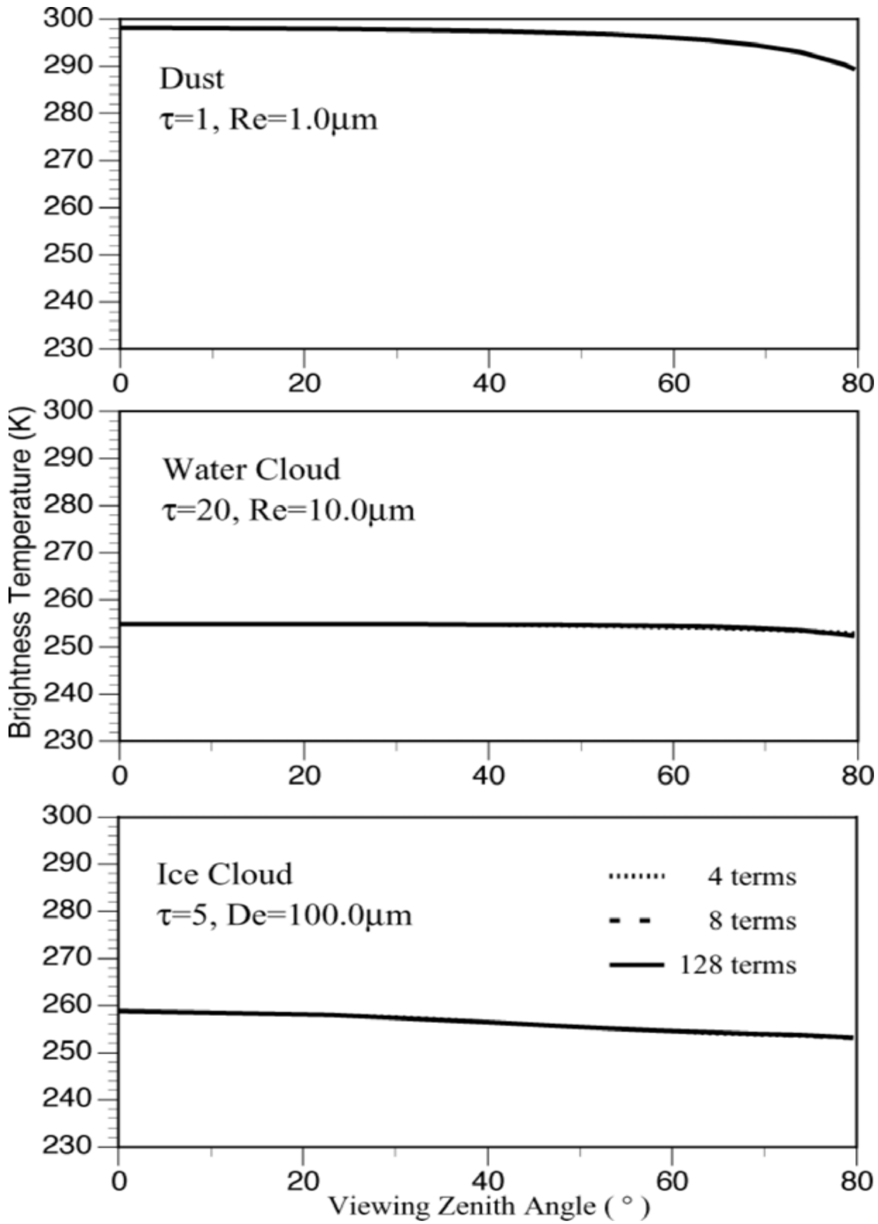
The relative errors of bidirectional reflectances obtained for the scattering phase functions re-constructed in terms of 16, and 32 Legendre Polynomials at a wavelength of 0.65 μm for a dust layer, a water cloud and an ice cloud.

The distribution of the relative errors of the bidirectional reflectances with scattering angle



The relative errors of bidirectional reflectances obtained for the scattering phase functions reconstructed with 16, and 32 Legendre polynomials at a wavelength of 0.65 μm for dust, water cloud and ice cloud. The black circles denote the relative errors for viewing angles smaller than 70° and the red crosses represent relative errors at viewing angles larger than 70°

Simulated brightness temperatures over a dust layer (upper panel), a water cloud (middle panel) and an ice cloud (lower panel) at λ=12.0 μm.



- The surface and cloud (dust layer) temperatures are assumed to be T_s=300K and $T_{\text{cloud or dust}}$=255K, respectively (Ding et al. 2008, submitted).

Summary

- Three bulk-scattering property datasets for the randomly oriented spheroidal dust aerosols, perfect spherical water droplets and ice crystals with a mixture of various habits were developed at the wavelengths between 0.225 to 20.0 μm.
- The δ-fit method is employed to truncate the forward-scattering peaks of the phase functions and to compute Legendre expansion coefficients.
- The error analyses indicate that 16 and 32 terms of Legendre polynomials should be used for dust aerosols and clouds (both ice and water) at visible spectrum, respectively.
- Brightness temperatures at the top of the atmosphere are computed by using the scattering properties of dust aerosols, water clouds and ice clouds. The result shows that 4 terms of Legendre polynomials should be sufficient in the radiative transfer computation at infrared wavelengths.

Plan

- Re-compute the single-scattering properties database by using the latest ice refractive index data.
- Consider the roughness of ice particles
- Add the shape (aspect ratio) distribution of spheriodal dust aerosols

Open Discussion

- Spectroscopic priorities for AER?
- Large upper level Jacobians at GMAO? Extra layering?
- How to improve our collaboration?
  - Progress has been hampered by communication inefficiencies.
  - How can we (not the royal we, but everyone) improve our communication without it becoming too onerous? (e.g. I’m sure people don’t want additional biweekly or monthly meetings)
- Science issues?
  - What do we want?
  - What can we do?