2nd CRTM Working Group Meeting
28 April, 2008

Joint Center for Satellite Data Assimilation

Agenda

2:30pm: Review of CWG#1 action items (10min)

2:30pm: CRTM Software Status (5min)

2:45pm: Dr. Z.Liu Presentation (15min)

3:00pm: Core Member Reports

- JCSDA Report; Q. Liu, Y.Han, P.van Delst (15min)
- GMAO; Emily Liu (5min)
- NRL; Ben Ruston (5min)
- NPOESS; Ye Hong (5min)
- OAR; Dan Birkenheuer (5min)

3:35pm: Collaborating Member Reports

- Texas A&M; Ping Yang (5min)
- UW-Madison; Ralf Bennartz (5min)
- AER; Jean-Luc Moncet (5min)
- CSU; Andy Jones (5min)

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4:30pm: Adjourn

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CWG#1 Action Items

- **Code Review and Acceptance Guidelines**: CWG members to provide feedback.
  - None Received.
- **ftp upload**: Done. CWG members notified.
  - No notification of test uploads received.
- **CRTM Web Page**: Framework created by JCSDA webmaster. Content needs to be added.
- **CRTM Repository**: EMC has began process to set up accessible Subversion repository.
  - Hardware is being purchased.
  - Primary and secondary servers will be in NCEP “DMZ”. Access via user ID.
  - Incremental backups every night (online for 7 days). Full backups weekly (online for 28 days).
  - Trac SCM software to be used. ViewVC also available.
  - Current server will become read-only mirror, with additional web services such as web page, forums, wiki, etc.

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CRTM Software Status

- CRTM v1.1 released 29 February, 2008.
- Available from **`ftp://ftp.emc.ncep.noaa.gov/jcsda/crtm`**
- Main changes in this release:
  - implementation of extra-layering methodology to supplement atmospheres with climatology if the inputs are lower than the CRTM model top (0.005hPa).
  - implementation of the NESDIS MHS Snow and Sea Ice emissivity models.
  - Several updates to coefficients
    - new directory structure
    - Microwave TauCoeff: no longer include the Liebe Zeeman effect adjustment factor. For comparison with previous coeffs, the Liebe files should be used.
    - Infrared TauCoeff: We now have “ordinary” (ORD) coefficients, those based on Planck-weighted (PW) transmittances, and those using a mixture (ORD-PW). Only a few instruments – with exceptionally broad channels – have Planck-weighted transmittance based coefficients.
    - Microwave SpcCoeff: Files for no antenna correction (No_AC), the AAPP antenna correction (AAPP_AC) and the NESDIS antenna correction (NESDIS_AC). AAPP_AC for AMSU-A/B and MHS; NESDIS_AC for AMSUA-A.

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Improving Computational Efficiency (1)

Quanhua Liu

- The CRTM is used operationally in the GSI for clear radiance assimilation. Cloudy radiance assimilation is the next effort for the CRTM team. This is challenging due to:
  - Unlike temperature, water vapor and trace gases, clouds are discontinuous media in the horizontal, vertical, and time domain. Generating the multi-dimensional error covariance is difficult.
  - Large uncertainties in cloud microphysics; such as particle size and shape. How to obtain this information from cloud water content, temperature and water vapor.
  - Computational needs are expensive because of multiple scattering in the cloud and between clouds as well as between surface and clouds.

Improving Computational Efficiency (2)

Quanhua Liu

- In concert with NCEP scientists and IBM CCS support, it was found that the IBM intrinsic matrix multiplication was extremely slow. We also found that the computational efficiency is memory-usage sensitive. We are testing the following changes in the CRTM code:
  - Add fast(er) matrix manipulation functions.
  - Move the RTV structure (holds the RTSolution forward results for adjoint calculation) from the **`CRTM_RTSolution.f90`** and make pointer for its large arrays to **`CRTM_RTSolution_Define.f90`**

- The changes save about 30% CPU time, but still does not satisfy the requirement for cloudy radiance assimilation.

Improving Computational Efficiency (3)

Quanhua Liu

- Further improvement have been made to develop fast two and four streams + observation angle. The four-stream + observation angle is generally accurate for microwave and infrared radiance simulation. Requires a better treatment of cloud and aerosol phase functions.
- The new two and four stream + observation algorithm uses the same adding code as ADA, but a fast calculation for each layer in a new module **`CRTM_RTSolution_AMOM.f90`**. Preliminary results are shown in Table 1.

Table 1. CPU time usage for operational algorithm (op), operational algorithm with the fast matrix manipulation (rev-op), new four-stream and new two-stream methods.

	op	rev-op	Four-stream + observation angle	Two-stream + observation angle
Single CPU	100	69	26	17
32 CPUs for GSI	100	66	29	18

Transmittance Algorithm Improvement (1)

Motivation, plan and progress

Yong Han and Yong Chen

- Current CRTM transmittance algorithm: Compact OPTRAN

The effective absorption coefficient k^* at layer A_i is estimated with predictors x_j :

$$Ln(k^*(A_i)) = c_0(A_i) + \sum_{j=1}^{6} c_j(A_i) x_j(A_i)$$

A_i – integrated absorber amount at layer i

$C_j(A_i)$ is an n^{th} (<= 10) order polynomial of variable A_i, obtained through regression

H_2O and O_3 are variable gases

- Advantages:
  - Smooth Jacobian profiles, due to the constraint of the polynomial function
  - Good memory efficiency
- Disadvantages:
  - At some channels, poor accuracy
  - At some channels, the algorithm is trained (the regression) with some artificial k^* values because they are required to be positive. It is known that the effective absorption coefficients can be negative.
  - Relatively poor computational efficiency because of the need to evaluate the polynomial

Transmittance Algorithm Improvement (2)

Work based on available algorithms

Yong Han and Yong Chen

- Two classes of transmittance algorithms
  - Band-based: channel transmittances (SRF-averaged) are estimated directly. CRTM-OPTRAN, RTTOV and UMBC SARTA belong to this class.
  - Node-based: monochromatic transmittances and radiances are first estimated at a set of selected frequencies (nodes), the radiances are then weighted to form the channel radiance. OSS and PC algorithms belong to this class.
- The band-based algorithms are referenced for this work, since they match to the current CRTM structure.
- Differences among OPTRAN, RTTOV and SARTA
  - OPTRAN: optical paths are estimated at fixed levels of the integrated absorber amount
  - RTTOV: optical paths are estimated at fixed pressure levels
  - SARTA: a mix of OPTRAN and RTTOV.
- H2O, O3, CO2, CO, CH4 and CO (possible others) will be treated as variable gases

Transmittance Algorithm Improvement (3)

Progress and remaining work

Yong Han and Yong Chen

- The development includes two parts: training package and CRTM transmittance module
- Training package
  - Transmittance algorithm (50% completed)
  - Training software for generating transmittance coefficients (50% completed)
- CRTM transmittance module (0% completion)
  - It will be built to accommodate multiple transmittance algorithms. Compact-OPTRAN will be kept as an option.
  - SSU and Zeeman transmittance algorithms will be included.
- Test and evaluation (0% completed)
  - Test against LBL model
  - Comparison with Compact-OPTRAN
  - Comparison with observations
  - Evaluation in data assimilation experiments

Interpolation Module Update (1)

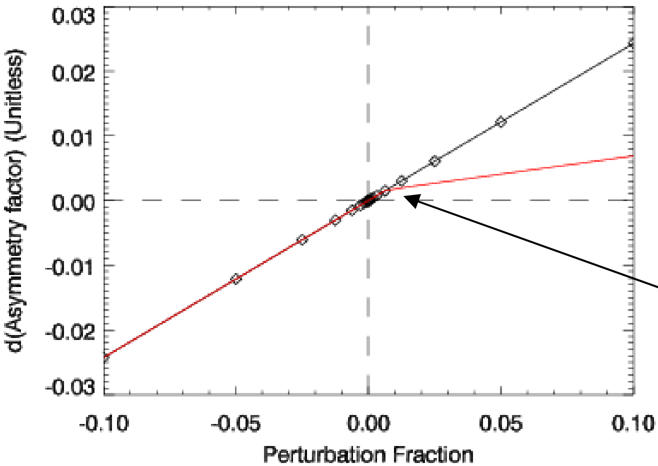
Paul van Delst

- Interpolation code update to accommodate scattering (cloud and aerosol) calculations.
- Bulk optical properties in LUT interpolated to input data values (e.g. frequency, effective radius, temperature.
- Updated tests with regular polynomial and spline interpolation revealed a number of (known) problems. Need to get it right since:
  - More people working on assimilation of cloudy radiances.
  - Want to use same interpolation code in emissivity models.
- Problems.
  - Derivatives of interpolates not continuous across LUT hingepoints.
  - CloudCoeff and AerosolCoeff LUT data have data density and quality issues.
- Implemented Averaged Quadratic interpolation

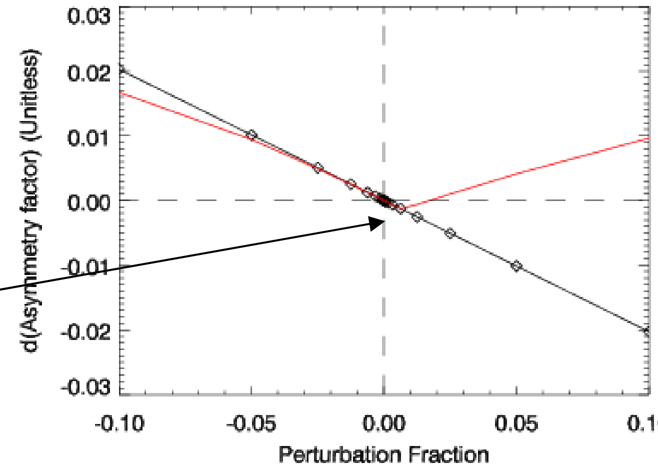
Interpolation Module Update (2)

Paul van Delst

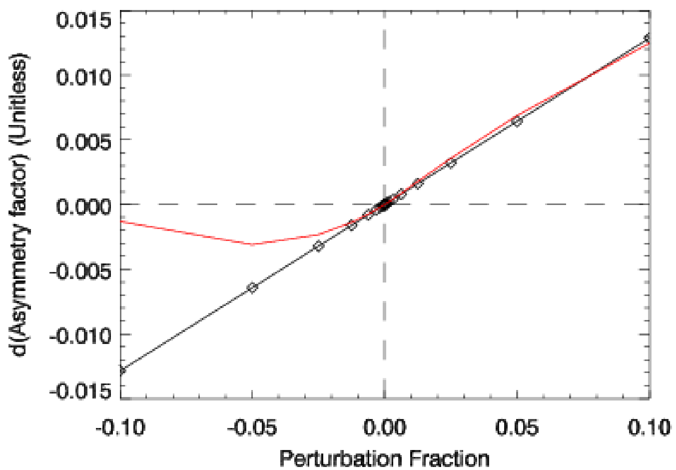
Linear



Cubic



Slope changes with interp method, and non-linear derivatives are discontinuous across LUT hingepoint.

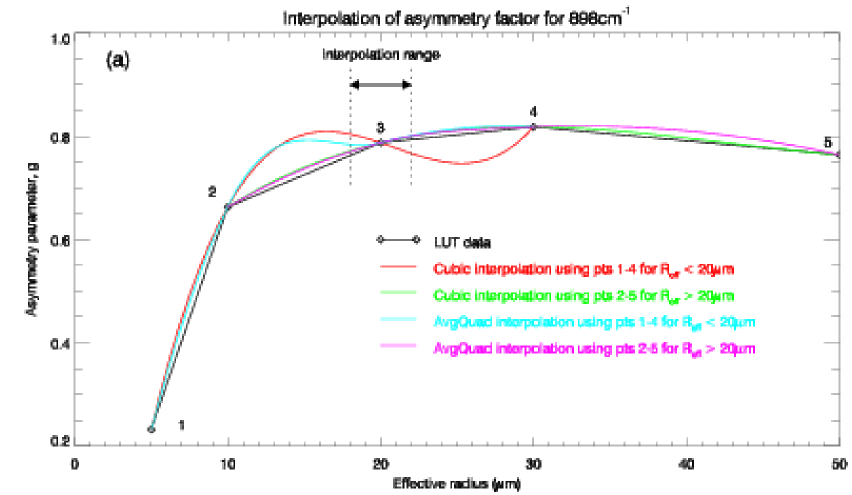


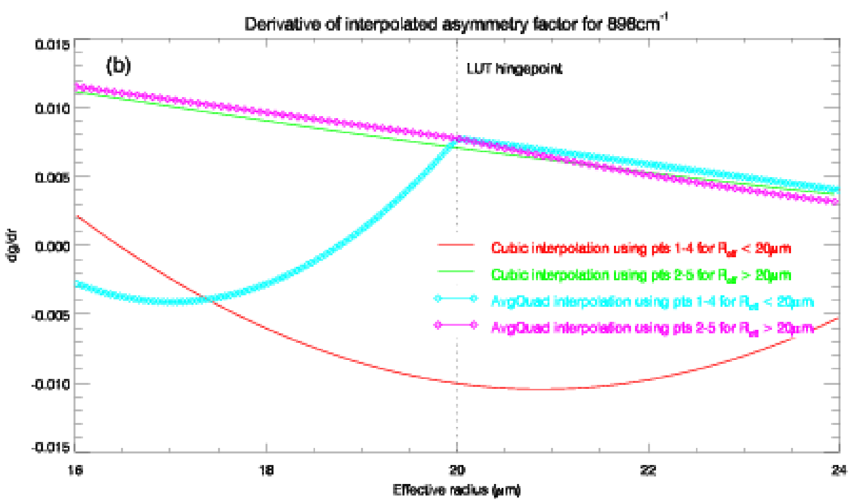
Averaged Quadratic interpolation
Non-linear derivative is continuous across hingepoint.

Interpolation Module Update (3)

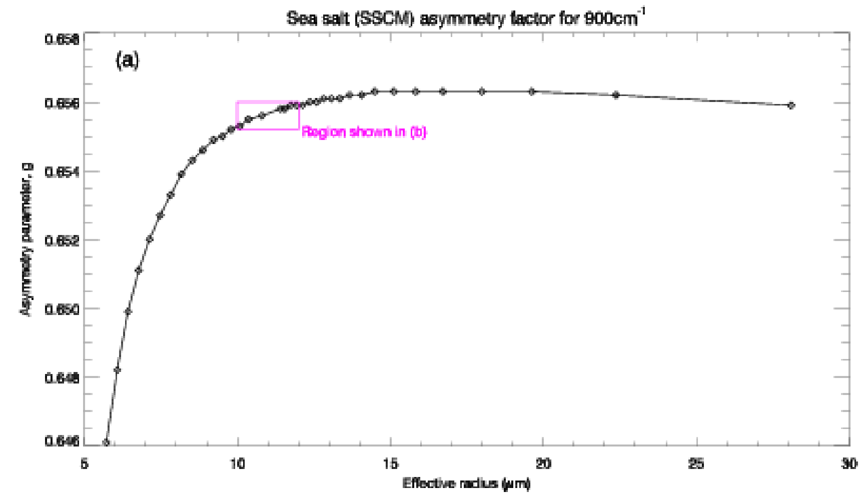
Paul van Delst

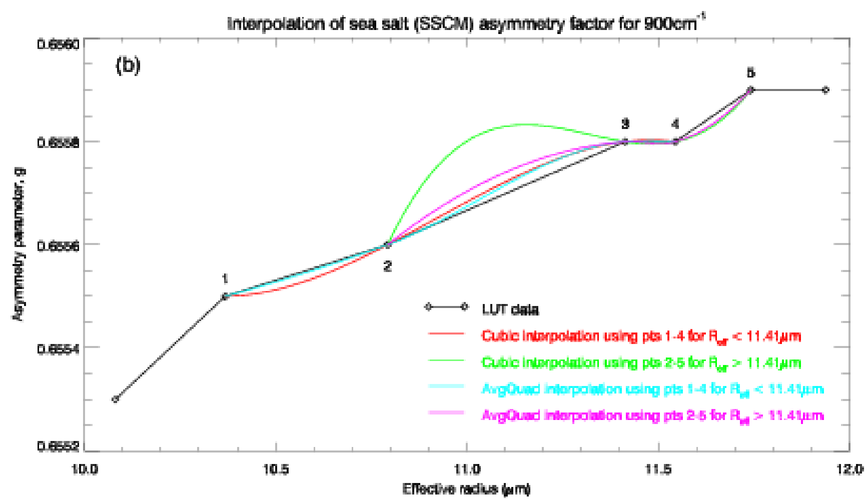
Cloud asymmetry factor





Aerosol (SSCM) asymmetry factor





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CSU; Andy Jones

- CSU MWLSM source code delivered to JCSDA.
- Forward and adjoint model of code delivered.
- Code is currently under review at JCSDA.

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