Development of Radiative Transfer Models based on the Optimum Spectral Sampling (OSS) Method

PI: Jean-Luc Moncet

NWP Center Collaborators:
Fuzhong Weng

Accomplishments

Pressure interpolation* supports RT on user-specified pressure grid

Node sharing among multiple sensors*

Generalized training* increases speed

Demonstrated high accuracy over low-emissivity surfaces

Scattering accelerated – less computation

*** Reduces memory requirements**

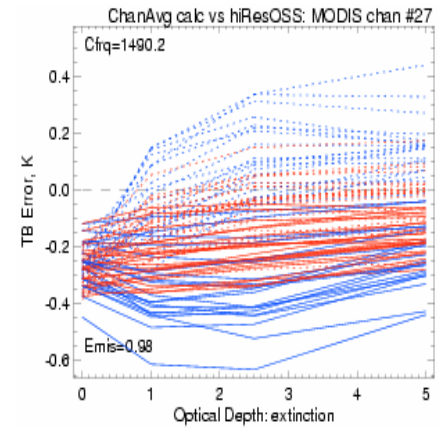
Future Plan

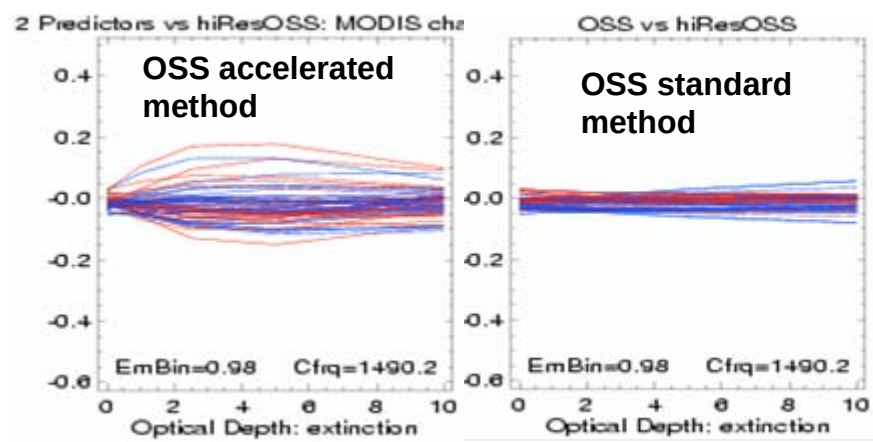
Improve and test scattering, emissivity

Add variable minor gases, solar, 4.3 NLTE

Scattering TB error
MODIS channel 27 (6.7 μm)

Channel transmittance method





Improved Spectroscopy for Microwave and Infrared Satellite Data Assimilation

J.-L. Moncet, S. A. Clough and V. Payne, AER, Inc.

Summary of Accomplishments

- **Microwave**
  - Updates to O_2 line widths and line coupling in MonoRTM
  - Updates to water vapor line parameters in MonoRTM
  - Validation of updates using ground-based measurements
- **Infrared**
  - Implementation of P&R line coupling in CO_2 ν_2 and ν_3 regions
  - Updates to CO_2 continuum
  - Improvements in consistency between ν_2 and ν_3 regions

Future Work

- **Microwave**
  - Implementation of Zeeman line splitting
  - Continued validation at ARM sites
  - Infrared/Microwave consistency
- **Infrared**:
  - Further improvements to CO_2 continuum
  - P&R branch line coupling for CH_4 and N_2O
  - Work with Larrabee Strow on LBLRTM/SARTA comparisons

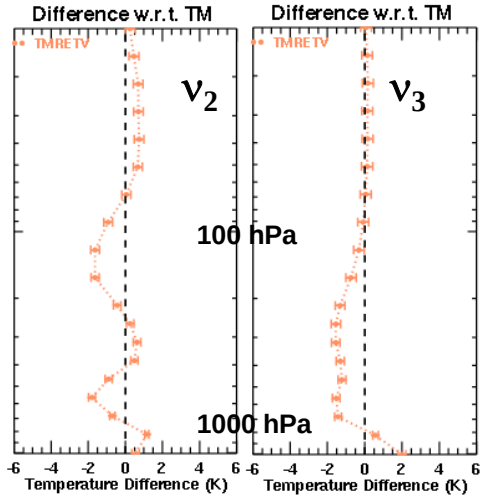


Figure 1: Temperature retrievals using LBLRTM v9.4

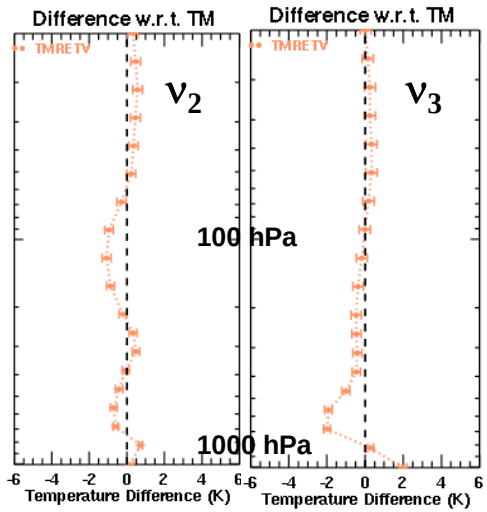


Figure 2: Temperature retrievals using LBLRTM v10.3

Fully Polarimetric Surface Model and Microwave Radiative Transfer

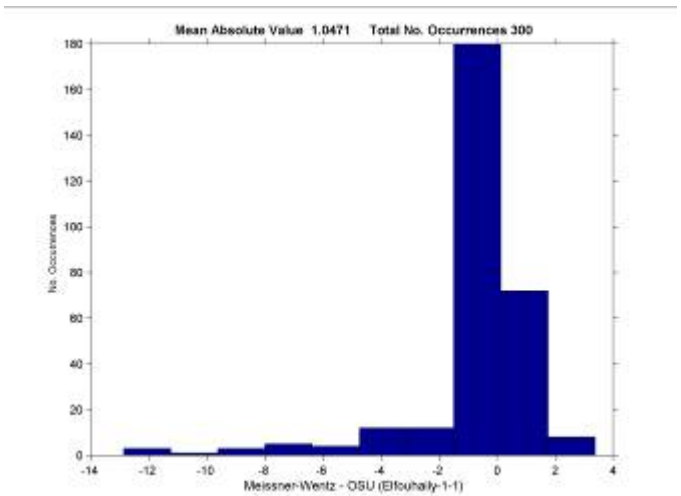
- Albin J. Gasiewski, University of Colorado

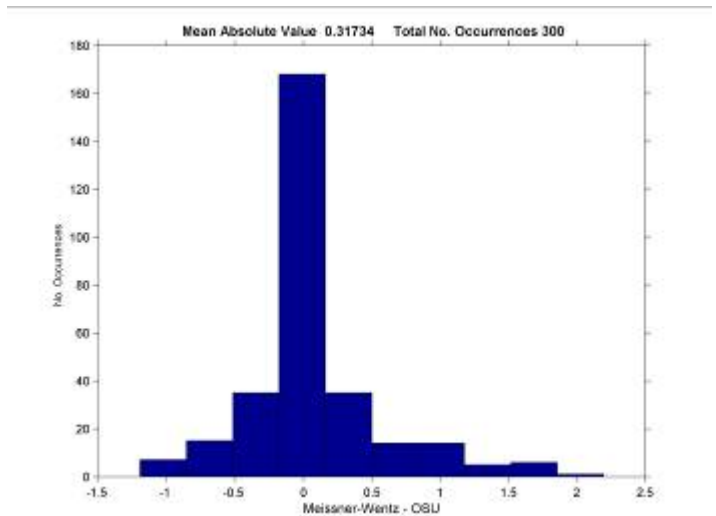
- The refined OSU model is presently being cross-validated against the Aqua AMSU-A and HSB data sets from May 2002 to February 2003 (when the HSB ceased to function) using the AMSR-E retrievals for wind speeds, and column water vapor and liquid water values to model the downwelling and upwelling atmospheric brightnesses. This validation may lead to some small further model adjustments pursuant to the goal of a standardized fast full-Stokes ocean surface emissivity model applicable at arbitrary microwave frequencies and incidence angles.

- Since AMSU-A and HSB are cross track scanners, they will provide data for the full range of incidence angles as well as a large range of frequencies.

- Radiative Transfer Modeling in support of JCSDA All-Weather Radiance Assimilation

DOTLRT (discrete ordinate tangent linear radiative transfer) model was delivered to JCSDA.





Tuned

Modeling Aerosol Radiance using CRTM

Quanhua Liu, Fuzhong Weng, Yong Han, and Paul van Delst, JCSDA 5th Meeting, May 2, 2007

Accomplishments

Extension of CRTM for UV+VIS

Gaseous transmittance model

Lookup tables for clouds and aerosols

Radiative transfer solver including solar irradiance

Effect of aerosol on satellite measurements

Sensitivity to the aerosol altitude

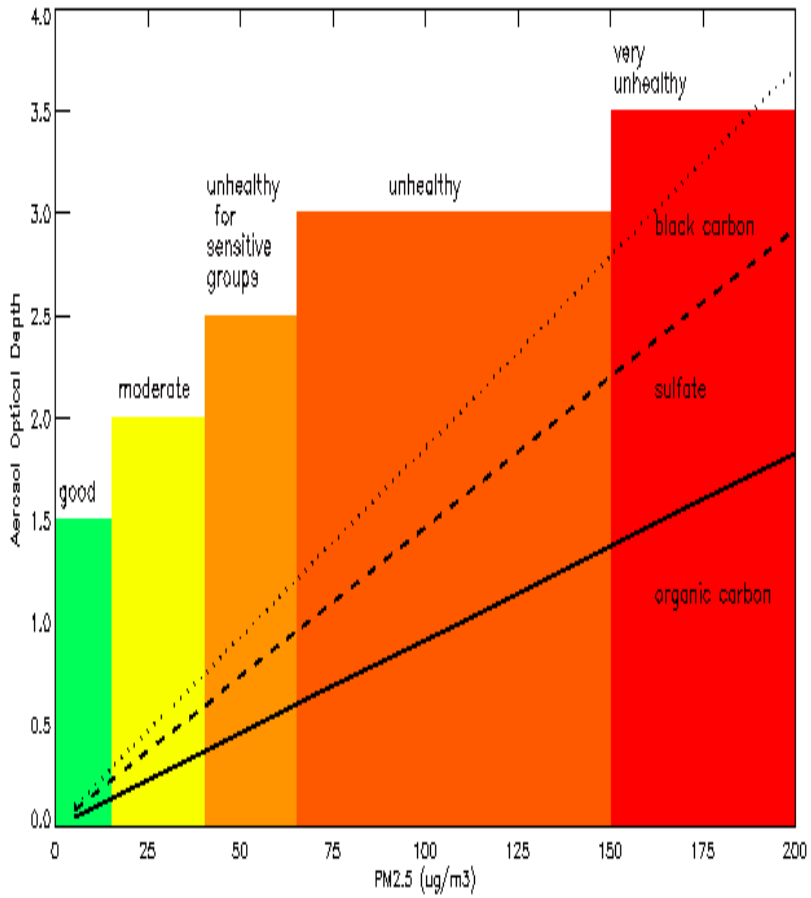
Dependency on aerosol types

Impact study

Error analysis on IR sensors by neglecting aerosols

Future Plan

Improving CRTM for UV+VIS parts, extending aerosol optical lookup tables for global, regional aerosol radiance simulations, and the sensitivity study to the aerosol radiance



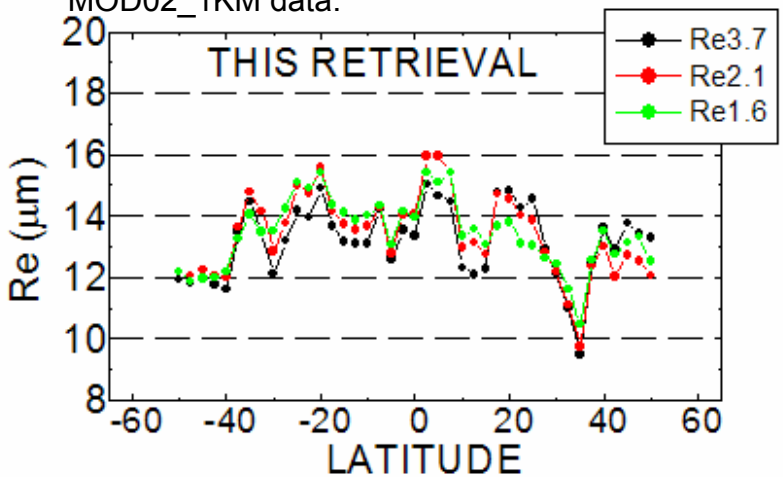
Air quality defined by aerosol optical depth

Improving Clouds and Precipitation for NWP Assimilation Using Satellite Measurements

- Nai-Yu Wang, University of Maryland, ESSIC

- In the last 6 months (first year), work has begun to
  - Gather and analyze AMSR-E, CloudSat and MODIS clear/cloudy sky data
  - AMSR-E simulations for Clear/cloudy sky ocean using a radiative transfer model
  - Cloud information assessment from CloudSat and MODIS, for microwave radiative transfer model simulations

Comparing Water-Cloud Droplet Effective Radius Retrievals. Results from application of an independent retrieval technique to the coincident MOD02_1KM data.



Ongoing and future work

•Generating MODIS/AMSR-E/CloudSat matchups

•Will add MODIS cloud mask/type/integrated path information for microwave clear/cloudy sky simulations

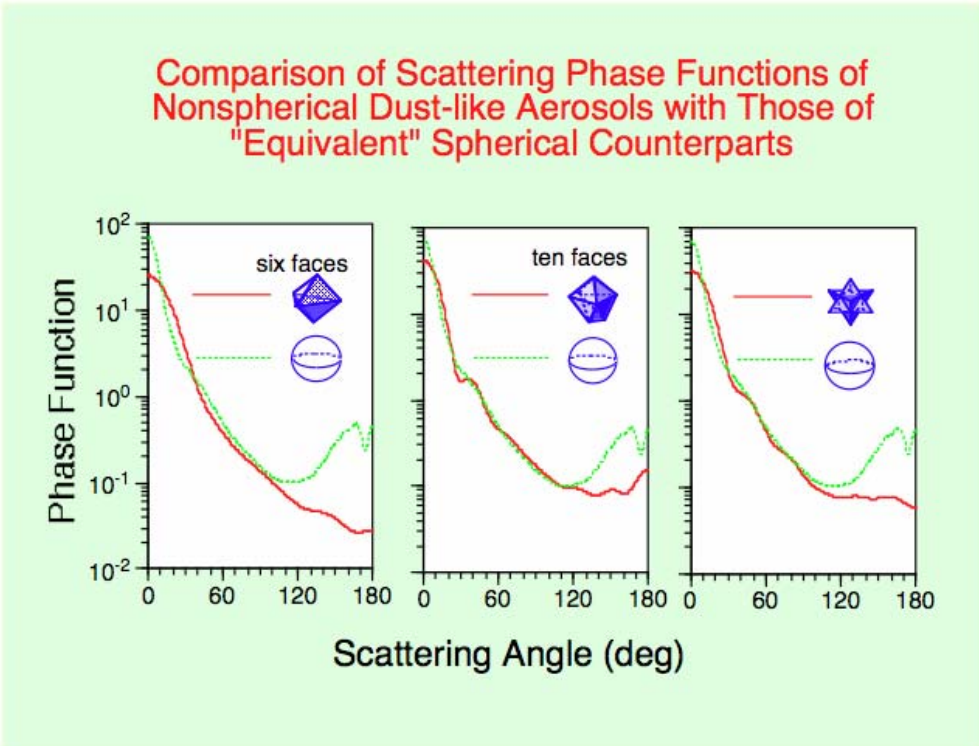
•Will Incorporate CRTM hydrometeor scattering modules for simulate microwave cloudy and precipitating conditions

Assessments of CRTM performance using Cloud and Aerosol Lookup Tables

Demonstration of current modeling capabilities in light scattering and radiative transfer simulations

- Ping Yang, Texas A&M University

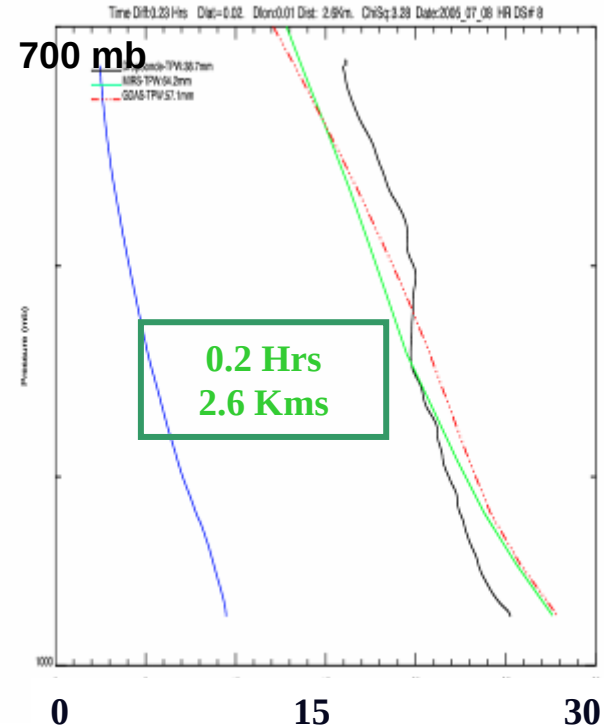
- We have developed modeling capabilities to compute the single-scattering properties of cloud particles and aerosol particles.
- We have developed fast IR and shortwave radiative transfer models to simulate the radiances at the top of a cloudy or dusty atmosphere.
- These modeling capabilities can be integrated into the CRTM in a straightforward way.



Cloudy 1DVAR - S-A. Boukabara, *NOAA/NESDIS/STAR*

- 1DVAR Algorithm coupled with CRTM integrates imaging and sounding capabilities in all-weather conditions
- Challenging task to undertake validation in active areas: Case-by-case comparison preferred to statistical assessment. GPS-Dropsondes helpful.
- Hybrid Approach (1DVAR+4DVAR) leads to better analyses of hurricane vortex structures and allows a smooth start for forecast runs.

Temperature retrieval in Hurricane →



Profile of DS Distance Departure

1DVAR Algorithm Description:

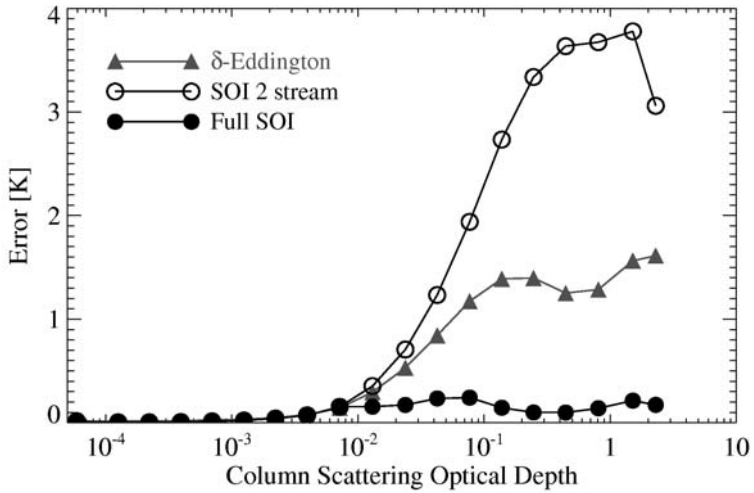
- 1DVAR Algorithm used: MIRS
- Currently applied to POES, METOP and DMSP microwave systems
- Uses CRTM as the forward operator
- Performs both Sounding and/or Imaging
- Integrates the cloud and precip parameters as part of the retrieved state vector
- EOF decomposition used for the vectors (emiss, atmospheric profiles)
- Regression-based algorithms serve as first guess to the 1DVAR

Clouds & Precipitation: Observation error characterization

- Ralf Bennartz, University of Wisconsin

- Radiative transfer solver errors (SOI 2-stream errors): MW – up to 4 K; IR – up to 1 K
- Cloud/precipitation overlap models: New approach derives two/three optimal columns based on subscale distribution of precipitation columns with similar optical properties. Optimal approach reduces errors due to cloud overlap from maximum values of 5-10 K to values < 1K
- 3D errors: slant path errors

RT solver errors under scattering conditions in MW



Future plans:

- Further test and integrate SOI with other models in CRTM
- Develop formulation for observation error including all modeling errors, RT solver, ice scattering, cloud overlap, 3 D effects etc.
- Bias statistics for various sensors under cloud precipitating conditions for different cloud microphysics schemes.

Discussion

- Radiative Transfer Code
  - Integration of new code
    - Subversion access
    - Testing
    - FTP site access to older versions
  - Access to alternate routines
  - Error covariances & systematic errors
- Geo – Microwave OSSEs