Recent Improvements to the Community Radiative Transfer Model (CRTM) for GOES-R and JPSS/NPP Applications

Yong Han, Paul Van Delst, Fuzhong Weng, Quanhua Liu, Dave Groff and Yong Chen
US Joint Center for Satellite Data Assimilation, Camp Springs, MD

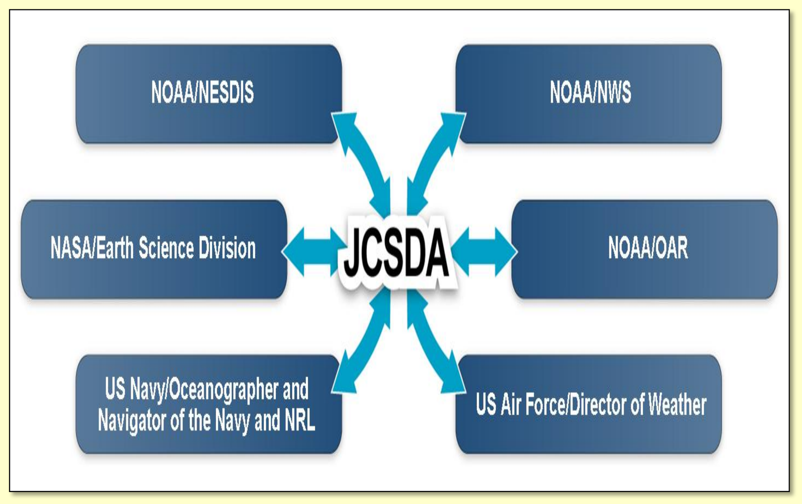
1. Introduction

The community radiative transfer model (CRTM) is developed by the US Joint Center for Satellite Data Assimilation (JCSDA) for rapid satellite radiance simulations and radiance derivative calculations under various sky and surface conditions. It is a key component of the Gridpoint Statistical Interpolation (GSI) data assimilation system at the NOAA National Center for the Environmental Prediction (NCEP) Environmental Modeling Center (EMC) and systems at other Numerical Weather Prediction (NWP) centers, as well as in many other satellite radiance data applications. The model has been recently upgraded from version 1.2 to version 2.0.2. In this presentation, we will summarize our progress in the development of the CRTM model with a focus on the improvements that have been or will soon be implemented in CRTM versions 2.x.x and are significant to the applications of the sensors on the future national operational environmental satellite systems, in particular the Joint Polar Satellite System (JPSS) and the Geostationary Operational Environmental Satellite R-Series (GOES-R).

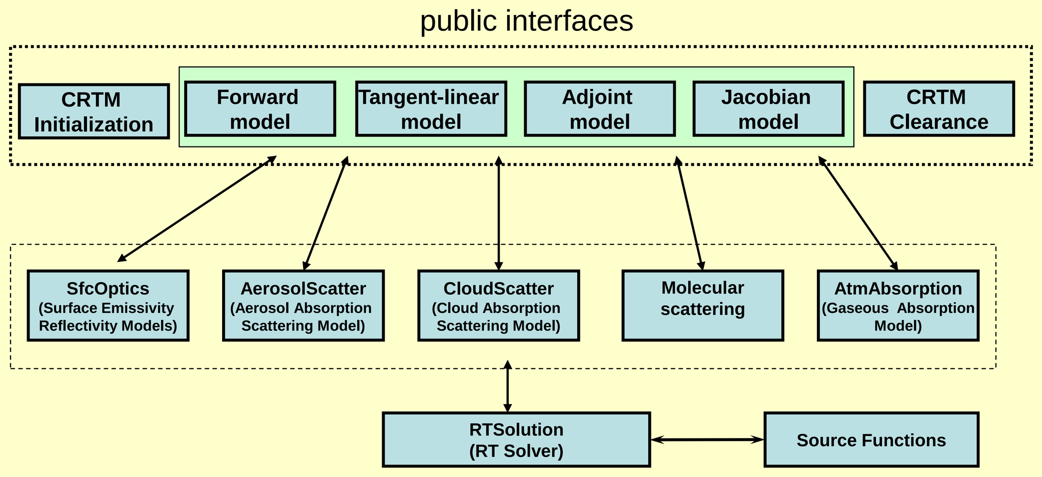
2. CRTM Applications

- CRTM was initially proposed to support primarily the JCSDA partners to assimilate satellite radiance data into global/regional forecast systems
- It is now also supporting the US satellite program developments through generating a high quality proxy data for algorithm tests, developments and integrations
- It has been used in the NOAA/NESDIS microwave sounding product system
- It can be used to generate the synthetic satellite radiances from NWP nature runs for observation system simulation experiments (OSSE)
- It is linked to other key projects such as climate reanalysis and satellite cal/val

Joint Center for Satellite Data Assimilation (JCSDA) Partner Organizations



3. CRTM Modules and Supported Sensors



CRTM main modules

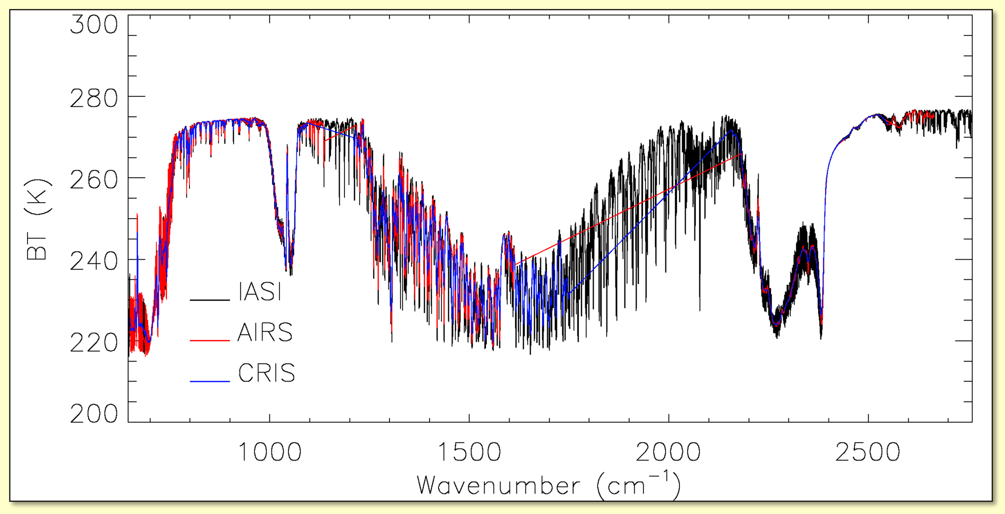
Support more than 100 Sensors

GOES-R ABI
TIROS-N to NOAA-19 AVHRR
TIROS-N to NOAA-19 HIRS
GOES-8 to 14 Imager
GOES-8 to 14 sounder
Terra/Aqua MODIS
METEOSAT-SG1 SEVIRI
Aqua AIRS, AMSR-E, AMSU-A, HSB
NOAA-15 to 19 AMSU-A
NOAA-15 to 17 AMSU-B
NOAA-18, 19 MHS
TIROS-N to NOAA-14 MSU
DMSP F13 to 15 SSM/I
DMSP F13,15 SSM/T1
DMSP F14,15 SSM/T2
DMSP F16-20 SSMIS
Coriolis Windsat
TiROS to NOAA-14 SSU
METOP-A IASI AMSUA, MHS, HIRS, AVHRR
FY-3 IRAS, MWTS, MWHS, MWRI
NPP/JPSS CrIS/ATMS/VIIRS

4. Recent Improvements applicable to GOES-R and JPSS/NPP Sensors

4.1 New Transmittance Model

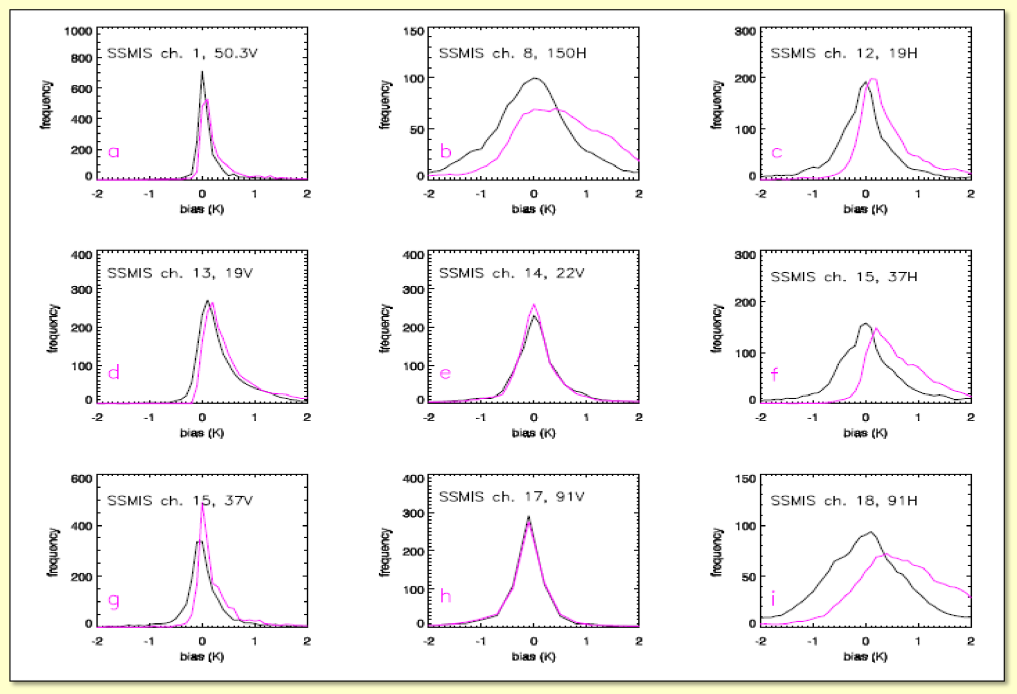
- The transmittance model is to compute atmospheric transmittance from absorbing gases
- A new transmittance model ODPS (Optical Depth in Pressure Space) has been implemented in version 2; the OPTRAN (Optical Path TRANsmittance) model from version 1 is available in version 2
- Variable absorbing gases: H_2O, CO_2, O_3, CO, N_2O and CH_4
- The new model takes the Zeeman-splitting effect into account for affected microwave channels



CRTM simulated IASI, AIRS and CrIS spectrum

4.2 Improved Microwave Ocean Emissivity Model (FASTEM-4)

- A new permittivity model, better fitting measurements over wide variability of temperature, salinity and frequency, is used.
- The improvement extends to low frequencies for studying salinity measurements (e.g. SMOS).
- Full polarimetric model including the Stokes 3rd and 4th components. The model can be used for the WINDSAT data.

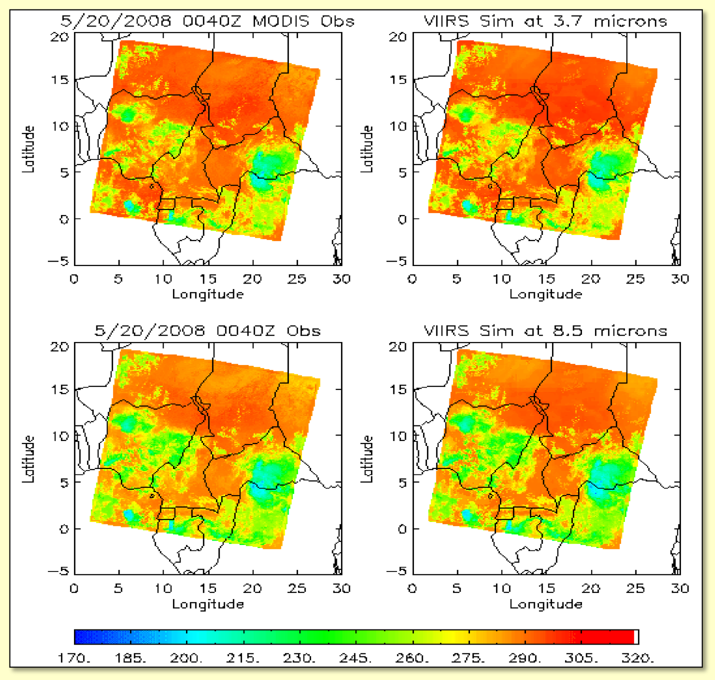


Histograms of the differences between simulated and observed brightness temperatures for six SSMIS channels. Red curve – CRTM with FASTEM-3; black curve – CRTM with FASTEM-4

4.3 Coefficients for GOES-R and JPSS/NPP Sensors

Coefficients have been generated to support the following GOES-R and JPSS/NPP sensors :

- Advanced Baseline Imager (ABI)
- Advanced Technology Microwave Sounder (ATMS)
- Visible/Infrared Imager Radiometer Suite (VIIRS)
- Cross-track Infrared Sounder (CrIS)

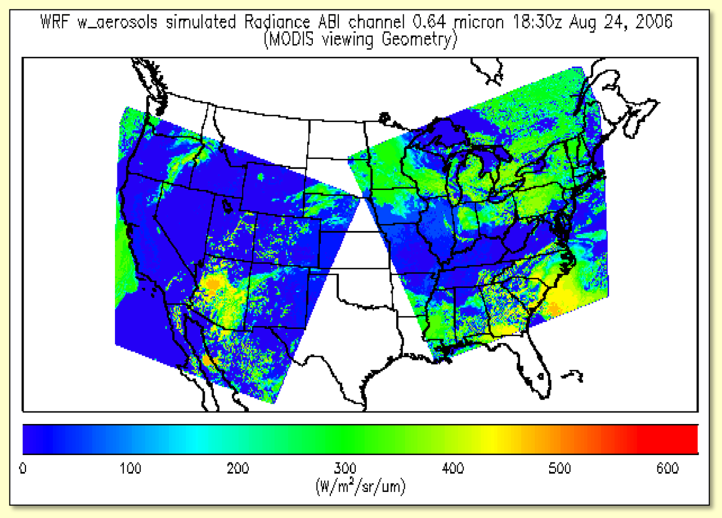


Simulated VIIRS images and observed MODIS images

4.4 Vis/UV Components

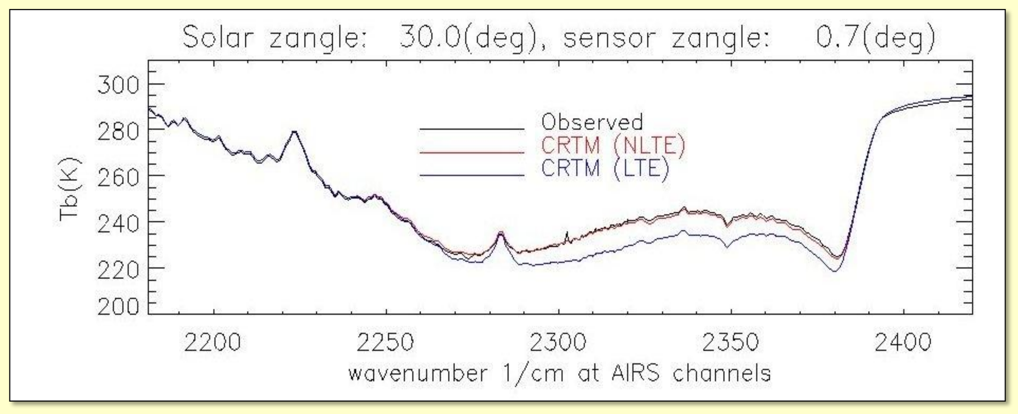
Components to support Visible/Ultraviolet channels have been developed and implemented in CRTM version 2:

- A loop over Fourier components for azimuth angles included in the RTSolution's Advanced Doubling-Adding method
- A new module for molecular scattering
- Cloud and aerosol modules extended in to Vis/UV regions



CRTM simulated Visible GOES-R ABI image in the 0.64 µm channel (from Bradley Pierce et al.)

4.5 NLTE Model

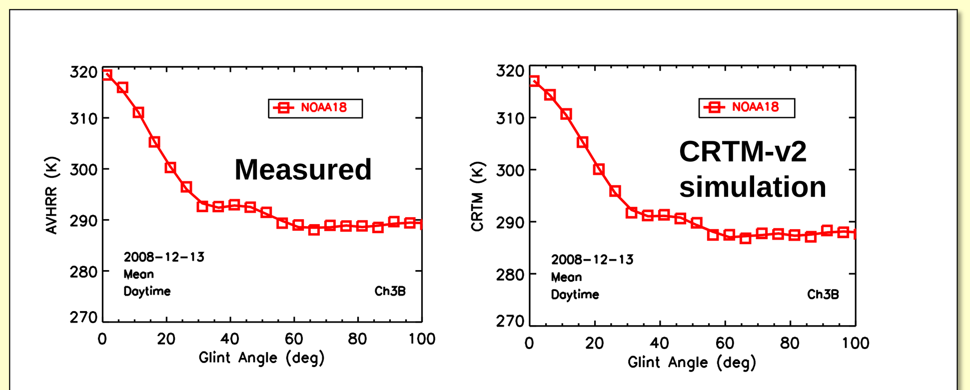


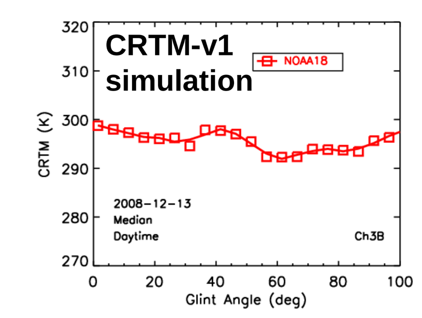
AIRS shortwave radiance spectral simulated with (red) and without (blue) the NLTE model compared with the observation (black).

A fast model to correct IR radiance affected by the Non-Local Thermodynamic Equilibrium (NLTE) phenomenon has recently been developed and implemented in CRTM version 2.1. Coefficients have been generated for AIRS, IASI and CrIS.

4.6 IR Ocean BRDF Model

The bi-directional reflection distribution function (BRDF) (Breon, 1993) has been implemented in CRTM version 2 for solar refection over a sea surface with a wave slope distribution given by Cox and Munk (1954)





- AVHRR channel 3 brightness temperature as a function of sun glint angle
- Data plotted are averages over a day in global scale

5. CRTM Next Release and Download Site

- CRTM version 2.1 is planned to be released in March of 2011, with features including FASTEM-4 and the NLTE model
- CRTM source codes, coefficient files, example codes and user guide can be downloaded from the website:

ftp://ftp.emc.ncep.noaa.gov/jcsda/CRTM/

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