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Evaluation of IR Land Surface Emissivity Model Impacts on GFS

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Abstract

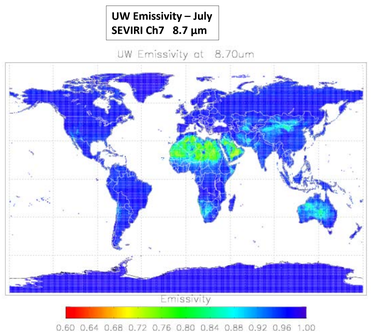
An accurate IR land surface emissivity (LSE) model is essential for IR window channels simulation. In this work, we investigated the potential impacts of two IR land surface emissivity models on GFS forecast. The two emissivity models are recently connected with CRTM model. The first one is the NASA/LARC IR land emissivity model retrieved from IASI observation and the second one is UW-RTTOV IR emissivity module. The major difference and variance of the two emissivity models are over desert regions, where UW emissivity is smaller than IASI emissivity for about 0.01 – 0.02 in both summer and winter times for most spectral bands from 4 to 13 µm. The CRTM simulations at SEVIRI four surface sensitive channels are improved by using the two new emissivity models. There is little change for the simulation over water vapor and CO2 bands.

Three one-month GFS forecast experiments are performed by using the two new IR emissivity models in GSI data assimilation system, and compared with current CRTM look-up-table IR emissivity. Small positive impacts were found by using the two new IR land surface emissivity models. There is small positive impact on GFS forecast from 4 to 7 days when using IASI and UW-RTTOV IR emissivity models. The total assimilated observation numbers for IR sensors are increased, and there is very little change of the assimilation numbers for microwave sensors. In general for IR sensors, like IASI and AIRS, the observation simulation numbers show bigger increase over IR window bands, but smaller decrease over WV and CO2 bands.

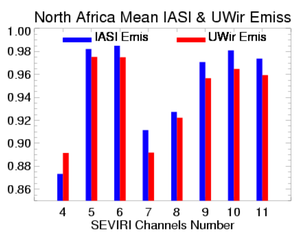
IASI and UWIR Monthly Land Surface Emissivity

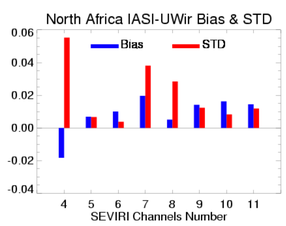
The IASI monthly land surface emissivity model was developed by Dr. Dan Zhou at NASA/LARC:
- •8461 IASI channels
- •645 – 2760 (cm^{-1})
- •0.5^0 x 0.5^0 lat/lon
- •Monthly 07/2007 – 06/2008
- •Daytime, Nighttime, Combined

The UWIR-RTTOV module was developed by Eva Borbas et al. at CIMSS/SSEC University of Wisconsin :
- •10 hinge points of UW/CIMSS BF global IR land
- •Eigenfunction represents for the laboratory measurements
- •From 3.6 to 14.3 µm
- •0.1^0 x 0.1^0 lat/lon .



IASI and UWIR Monthly Emissivity
Averaged over North Africa



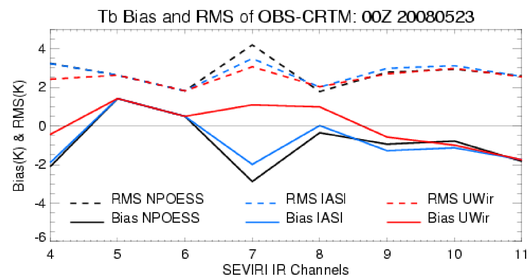


The major difference and variance of the two emissivity models are over desert regions. Over North Africa UW emissivity is smaller than IASI emissivity for about 0.01 – 0.02 in both summer and winter times for most spectral bands from 4 to 13 µm.

New Emissivity impacts on CRTM Simulation

- •Compare CRTM simulations with observations over land in SEVIRI full disk domain by using IASI, UW-RTTOV emissivity and current CRTM emissivity LUT,
- •Simulations are improved at 5 surface sensitive channels by using the two new emissivity models,
- •RTTOV-UW emissivity gives better results at channel 4, 7, and 9, while IASI emissivity shows smaller bias at channel 8 for this one time case study,
- •Accuracy is not changed at two water vapor channels and CO_2 channel.

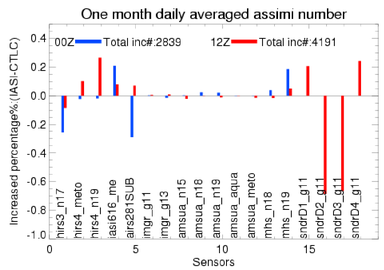
Bias and RMS of Tb(OBS) – Tb(Simulation)



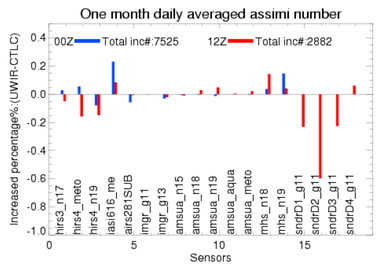
New Emissivity Impacts on GSI Analysis

GSI Assimilation Number Increase or Decrease Percentage

Using IASI Emissivity



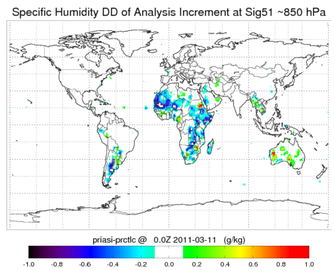
Using UWIR Emissivity

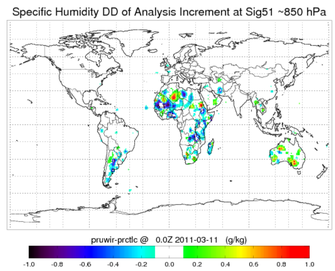


Percentage of increased assimilation number for each sensor:
Increase precentage (sensor)=100 x [num_exp(sensor) - num_ctl(sensor)] / num_ctl(sensor)

- •The total assimilated observation numbers for IR sensors are increased, and there is very little change for the assimilation number of microwave sensors.
- •The most contributions to the assimilation number increase is from the assimilation of IASI and AIRS data.

Comparison of GSI Analysis Increment





- •Above two figures show the difference (exp-ctl) of analysis increments at GSI first cycle for specific humidity over sigma level-51 (near 850 hPa).
- •Comparing with current CRTM emissivity LUT, the lower level temperature increases in the most of African and the south of South American regions, and the moisture decreases over these regions, when using of two new emissivity models .
- •In the west part of Australia, the temperature decreases and the moisture increases over lower atmosphere.

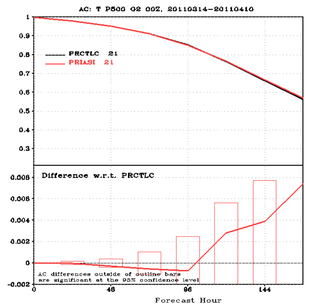
New Emissivity Impacts on GFS Forecast

Experiments Configuration

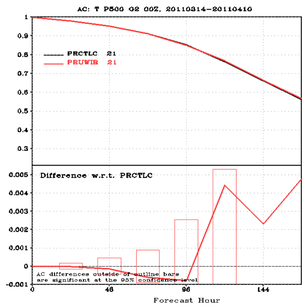
- •GSI June 2011 truck version was used, with T382 resolution,
- •All conventional data and current satellite sensors data in Q1FY11 are assimilated,

1. CTL: March 10 – April 12, 2011, with current CRTM emissivity
2. Exp1: March 10 – April 17, 2011, with IASI emissivity
3. Exp2: March 10 – April 17, 2011, with UWir-RTTOV emissivity

Comparison of CTL and Exp1 experiments



Comparison of CTL and Exp2 experiments



Above two figures show 21 days averaged anomaly correlations (AC) of globe temperature forecasts over 500 hPa.

1. By using IASI land surface emissivity in GDAS, there is neutral to small positive impact on GFS forecast from 4 to 7 days, but which does not pass the significant test.
2. By using UW-RTTOV IR land surface emissivity, there is neutral to small positive impact on GFS forecast, and also does not pass the significant test.

Summary and Future Plan

- •The major difference and variance of the two emissivity models are over desert regions. Over North Africa UW emissivity is smaller than IASI for about 0.01 – 0.02 for both summer and winter times for most spectral bands from 4 to 13 µm,
- •CRTM simulations at SEVIRI 4 surface sensitive channels are improved by using the two new emissivity models. There is no change for water vapor and CO2 bands.
- •By using IASI and UW-RTTOV IR land surface emissivity models in GDAS, there is small positive impact on GFS forecast from 4 to 7 days.
- •The total assimilated observation numbers for IR sensors are increased, and there is very little change for the assimilation number of microwave sensors,
- •In general for IR sensors, IASI and AIRS, the observation assimilation number is increased over atmospheric window bands, but decreased over WV and CO2 bands,
- •Perform more detail diagnostic study of the experiment results,
- •Evaluate the impacts in another season,
- •Study the improvement of CRTM IR band simulations by using GOES-R AWG LST scheme.

Acknowledgements

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