# Comparison of Infrared Land Surface Emissivity from AIRS & MODIS for Improving Satellite Data Assimilation over Desert Regions

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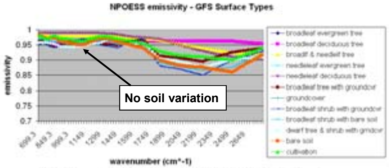
## Abstract

Surface emissivity is an important variable for estimating top-of-atmosphere satellite radiance with radiative transfer models (RTM). To assimilate satellite radiances for numerical weather prediction, accurate emissivity is needed for accurate RTM simulations, particularly for surface-sensing channels. In this study, two infrared emissivity datasets are compared for potential use in CRTM: satellite-derived AIRS and MODIS emissivity datasets. The AIRS emissivity is the NASA AIRS version 5 standard emissivity product. The MODIS emissivity is University of Wisconsin's global infrared emissivity database (UWIREMIS) derived from MODIS retrievals using Univ. Wisconsin's baseline-fit approach and high-spectral conversion. Also compared is the CRTM's default internal NPOESS emissivity look-up table. Results indicate that the UWIREMIS database provides the best bias between CRTM simulations and satellite observations for soil surfaces, in this case, the Sahara Desert for nighttime conditions. NWP forecast impact shows improved forecast with UWIREMIS compared to NPOESS

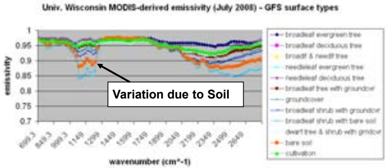
## Background

The CRTM's current operational infrared surface emissivity database (NPOESS) does not take soil emissivity variation into account. Because soil emissivity is especially variable, this creates potential inaccuracy in top-of-atmosphere radiance simulation for desert and bare ground regions, thus restricting the number of satellite data observations that could be assimilated over these regions.

CRTM's current operational emissivity does not vary for soils (shown is the implementation of CRTM's emissivity LUT for GFS surface types, as is done in GSI)




Satellite-derived emissivity shows soil variability (MODIS Aqua – UWIREMIS database for July 2008)




## Emissivity Datasets for Soil Surfaces

Emissivity from three different sources was tested in CRTM for desert regions:

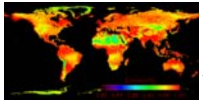
1) NPOESS emissivity LUT, default CRTM emissivity: does not contain soil information

2) NASA AIRS version 5 standard emissivity product

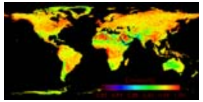
Monthly composite for May 2008, 45 hingepoint frequencies

Composite averaged spatially for FAO/STATSGO soil types (soil type x wavelength)

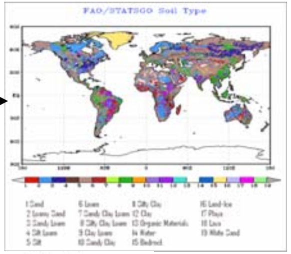
10.6 µm, Descending (night)

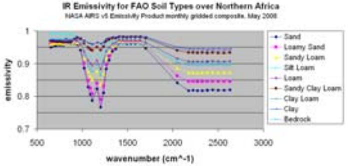


10.6 µm, Ascending (day)



Average emis for each soil type




FAO soil type emissivity at 45 hingepoint frequencies. Select emis by soil type and frequency.

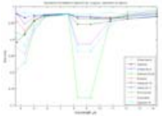
3) University of Wisconsin MODIS-derived infrared emissivity database (UWIREMIS)

Monthly composite (2003-2009). Three implementations tested:

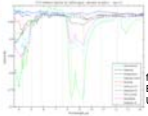
a) spatially averaged for FAO/STATSGO soil types (as above, i.e. soil type x frequency)

b) Baseline Fit: 10 hinge point frequencies for each lat/lon in 720x360 grid (lat x lon x 10 freq)

c) High Spectral Resolution: 10 freq converted to 416 using PC regression (lat x lon x 416 freq)

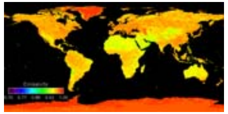


Baseline Fit



High Spectral Resolution

from E.Borbas, U.Wisc



Example: baseline-fit at 10.8 µm, Nov 2006

## CRTM-to-Satellite Comparison

CRTM (forward model) was run with current (NPOESS) and 4 emissivity data sets and compared to MODIS Aqua IR window channels. CRTM inputs: GDAS atmospheric profiles and surface parameters, interpolated to pixel using GSI interpolation.

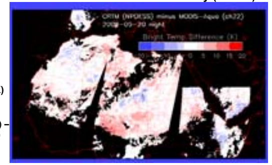
CRTM Tb minus MODIS-Aqua observed Tb (K), Channel 22 (3.96µm)

North Africa May 20, 2008 Nighttime

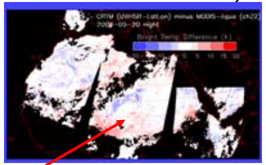
Tb Difference (K)

color bar: -20 (MODIS higher) – +20 (CRTM higher)

CRTM run with NPOESS Emissivity (no soil)



CRTM run with UWIREMIS-HSR Emissivity



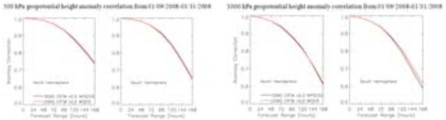
U.Wisconsin-HSR emissivity shows improvement over NPOESS emissivity

Tb Bias / RMSE, CRTM minus MODIS: best bias in RED / best RMSE in RED

| | Soil Emissivity Tests run in CRTM | | | | | |
|---|---|---|---|---|---|---|
| MODIS Channel (µm) | NPOESS (no soil) | NASA AIRS FAO soil types | UWisc-HSR FAO soil types | UWisc-HSR LatLon database | UWisc-BF LatLon database | Constant = 0.9 |
| 3.75 (Ch 20) | 2.226 / 3.821 | 1.865 / 3.560 | 2.953 / 4.262 | 1.280 / 3.183 | 1.304 / 3.298 | 2.087 / 3.737 |
| 3.96 (Ch 22) | 1.295 / 3.374 | 1.293 / 3.272 | 2.347 / 3.843 | 0.042 / 2.986 | 0.593 / 3.110 | 1.548 / 3.465 |
| 4.05 (Ch 23) | 1.014 / 2.909 | 1.099 / 2.894 | 1.826 / 3.246 | 0.282 / 2.689 | 0.518 / 2.761 | 1.284 / 2.993 |
| 11.03 (Ch 31) | 0.931 / 3.051 | 1.532 / 3.300 | 1.521 / 3.281 | 0.691 / 3.019 | 0.597 / 2.981 | -1.668 / 3.449 |
| 12.01 (Ch 32) | 0.243 / 2.874 | 0.700 / 2.965 | 0.753 / 2.977 | 0.315 / 2.928 | 0.583 / 2.936 | -2.307 / 3.847 |

## Forecast Impact

NPOESS emis (black) vs. U.Wisc.-HSR (red) in GSI global forecast impact test: U.Wisc-HSR shows improvement in Southern Hemisphere



## Conclusion

1) U. Wisconsin HSR emissivity lat-lon database provides best emissivity for Sahara region (nighttime), of the 4 soil emissivity data sets tested. Forecasts improved for S. Hemisphere.

2) FAO soil types not better than CRTM's NPOESS types that contain no soil information.