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 radiances 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 a University of Wisconsin’s global infrared emissivity database (UWIREMIS) derived from MODIS retrievals using Unix Wisconsin’s baseline fit approach and high-spectral conversion. Also compared is the CRTM’s default internal NASA 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 radiances for desert and bare ground regions, thus restricting the number of satellite data observations that could be assimilated over these regions.

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 hinge point frequencies
Composite averaged spatially for FAO/STATSGO soil types (soil type x wavelength)
3) University of Wisconsin MODIS-derived infrared emissivity database (UWIREMIS)
Monthly composite (2003-2009). 3 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)

Forecast Impact
1) University of 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.