Comparison of LAND SURFACE EMISSIVITY from MODIS, AIRS, and SEVIRI

Objective
An accurate infrared land surface emissivity product is critical for deriving accurate land surface temperatures, needed in many studies including surface energy and water balance research. An emissivity product is also useful for mapping geologic and land-cover features. These emissivity products have been developed from MODIS, AIRS, and SEVIRI satellites, each with their own methodologies and associated strengths and weaknesses. Calculations of brightness temperatures using the different emissivity products will be compared to observed SEVIRI channels.

Methodology
The observed top of atmosphere radiation is the sum of atmospheric, surface, and reflected contributions. Using an RTM to make calculations for each part we can easily evaluate the TOA radiation assuming any given surface emissivity. Then we can compare these calculated radiances to observed SEVIRI radiances - for an objective evaluation of the different emissivity products.

The atmospheric state is described by ECMWF model runs for August 18, 2006 at 00UTC. The radiation transfer model (LBLRTM by AER5 Inc.) was used to calculate the TOA radiation given by the atmosphere, the surface, and reflected terms in a 1x1 degree grid over North Africa. The calculations were then interpolated onto the finer SEVIRI grid, and convolved to the SEVIRI spectral resolution. We assumed the surface temperatures used by LSA SAF, and the surface emissivities given by LSA SAF, MODIS BF, and NASA L2 AIRS. The LSA SAF emissivities are daily averages for August 18, 2006. The MODIS BF emissivities are monthly averages, and the AIRS Level 2 emissivities are for August 16, 00UTC values (August 18th was not available).

Observations
SEVIRI
The Spinning Enhanced Visible and Infrared Imager (SEVIRI) onboard the European MSG satellite became operational February 2004. Its coverage includes the whole of Europe and Africa and parts of South America every 15 minutes. It has a 3km resolution, and 12 spectral channels (8 channels in the IR ranging from 3.9 µm to 15.9µm). The greater volume and quality of data offers among other things, improved measurement of the Earth surface and cloud top temperatures; features we will exploit to evaluate different emissivity products.

Emissivity is estimated from the SEVIRI observations using the equation:

$$R_{obs} = R_{atm} + B(T_s) * Tran * e$$

where $R_{obs}$ is the observed radiance TOA, $R_{atm}$ is the radiance from the atmosphere, $B(T_s)$ is the Planck radiance for the surface temperature $T_s$, $Tran$ is the transmission through the atmosphere TOA, and $e$ is the surface emissivity. Solving for $e$. The reflected contribution is ignored.

Database Descriptions
UW MODIS BF

The University of Washington’s MODIS Baseline Fit (UW MODIS BF) global infrared land surface emissivity database is derived from a combination of high spectral resolution laboratory observation of selected materials, and MODIS MYD01 observed land surface emissivities at 3.7, 3.9, 4.0, 5.8, 11.0, and 12.0 µm. The UW MODIS BF emissivity database is derived at moderate spectral resolution (10 values in the 3.7-14.3 micron range), with wavelengths chosen as the inflection points that best characterize the shape of each relevant laboratory emissivity spectra. The BF method described in detail in Seemann et al. is applied by adjusting the magnitude of the emissivity of each of the inflection point wavelengths based on the observed MODIS MYD01 emissivity values. A spectrum of emissivity at the ten inflection points is given for each month at each MYD11 latitude and longitude point (0.05 degree resolution) over land. Seemann, S.W., et al., 2007: Development of a Global Infrared Land Surface Emissivity Database for Application to Clear Sky Sounding Retrievals from Multi-spectral Satellite Radiance Measurements. J. Appl Meteorol & Clim, accepted April 2007. http://nws.usgs.wr.usgs.gov/erh/eim/database/LSA.Database.

LSA SAF
The land surface emissivity are derived for use in land surface temperature retrievals from Meteosat Second Generation / Spinning Enhanced Visible and Infrared Imager (MSG/SEVIRI). The Satellite Application Facility on Land Surface Analysis (LSA SAF) (http://landsci.meteo.pt) generates maps for MSG/SEVIRI channels at 10.8 µm and IR 12.0 µm. The algorithm is based on the so-called vegetation cover method (VCM), and uses also LSA SAF product - the Fraction of Vegetation Cover (FVC). This methodology has been developed for the currently retrieved LSE maps (R10.8 µm and R 12.0 µm), as well as for the remaining IR channels (R3.9 and R8.7), and for a broadband LSE (3-14 µm), necessary for the estimation of longwave surface fluxes. The SEVIRI data will be reprocessed by EUMETSAT in January, 2008 to include several calibration corrections.

AIRS L2
The operational Atmospheric Infrared Sounder (AIRS) emissivity retrieval uses a NOAA regression emissivity product (Golding et al., 2003) as a first guess over land. The NOAA approach is based on clear radiances simulated from the European Centre for Medium-Range Weather Forecasts (ECMWF) forecast and a surface emissivity training dataset. The training dataset used for the AIRS v4 algorithm has a limited number of soil, ice, and snow types and very little emissivity variability in the training ensemble. (ATMOS AIRS Team Retrieval for Core Products and Geophysical Parameters Level 2, JPL-D-17006, M.T. Chahine et al.)

Conclusions
The calculated brightness temperatures using the three different emissivity products is in good agreement with SEVIRI observations at 12.0 µm, about ±0.1K, ±0.1K and ±0.1 K, respectively for UW Modis BF, LSA SAF, and AIRS Level 2. At 10.8 µm the agreement is good also – approximately ±0.4 +0.6, and ±0.02 K, respectively. However all the emissivity models lead to a disagreement with SEVIRI observations of about <3K at 8.7 µm, and between 0.5 and 4.3 K at 3.8-5.8 µm.

The use of 12.0 and 10.8 µm for the determination of land surface temperature appears to be valid. UW Modis BF and AIRS L2 emissivities are in generally good agreement with each other while the LSA SAF emissivity is limited by its lack of spatial detail.

Acknowledgements
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Spectral Response Function for Meteosat 8, Transmissioin TOA

Table of Statistics for Brightness Temperature Differences

<table>
<thead>
<tr>
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