The recent update of the UW/CIMSS high spectral resolution global IR land surface emissivity database: the satellite viewing angle dependence

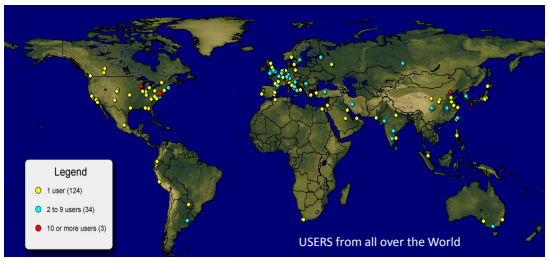
Eva E. Borbas and Robert O. Knuteson
Space Science and Engineering Center, University of Wisconsin – Madison, WI, USA

Abstract: The monthly, UW/CIMSS Baseline Fit (BF) global infrared land surface emissivity database has been available for distribution since 2006 at the http://cimss.ssec.wisc.edu/iremis/ website and includes data from October 2002 at ten wavelengths (3.6, 4.3, 5.0, 5.8, 7.6, 8.3, 9.3, 10.8, 12.1, and 14.3 microns) with 0.05 degree spatial resolution. To derive high spectral resolution emissivity spectra, the UW High Spectral Resolution (HSR) IR Emissivity Algorithm was also developed. This algorithm uses a principal component analysis (PCA) regression from a combination of high spectral resolution laboratory measurements of selected materials, and the above-mentioned UW/CIMSS Baseline Fit (BF) Global Infrared Land Surface Emissivity Database to provide a 5 wavenumber resolution emissivity database at 416 wavenumbers. Applying the UW HSR Emissivity Algorithm to the UW BF emissivity data makes it possible to create a monthly instrument specific emissivity spectrum for any application involving forward model calculations such as retrieval methods and NWP assimilation or for use in studies of surface energy and water balance.
This poster introduces new updates and results focusing on the satellite viewing angle dependence of the IR emissivity over land.

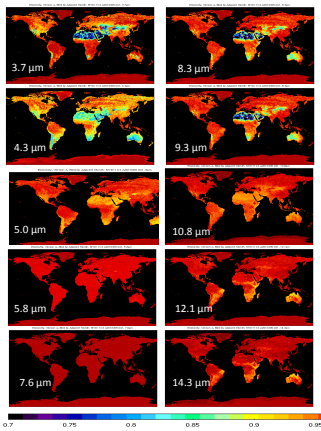
The UW BF global IR land Surface Emissivity Database

The UW BF emissivity database is available at: http://cimss.ssec.wisc.edu/iremis/

- Time coverage: Monthly: Oct 2002 - Dec 2006 based on MYD11 V4.0 emissivity products
- Jan 2007 – Dec 2011 - based on MYD11 V4.1 emissivity products
- **Data no longer available based on MYD11 V5.0 !!!!**



The BF emissivity at November 2011



Interests for applications/users :

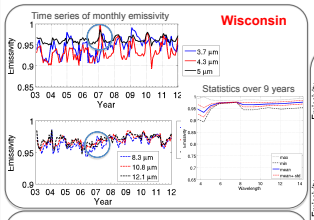
- MODIS MOD07 Atmospheric Retrieval Algorithm MOD07 (UW, NASA DAAC)
- IMAPP/AIRS and MODIS retrievals (UW)
- RTTOV (EUMETSAT/UKMO)
- Climate Monitoring SAF (EUMETSAT)
- AIRS Retrieval of Dust Optical Depths (UMBC/ ASL)
- Official AIRS atmospheric retrievals V6 (NASA/JPL)
- IASI-Metop Cal/Val (CNES, France)
- IASI retrievals (EUMETSAT, UW)
- Retrieval of hot spot data from AATSR (ESA)
- Energy balance from ASTER over glacier (Univ of Milan)
- AIRS trace gas retrieval (Stellenbosch University, South-Africa, JCET-UMBC)
- Education (Seoul National Univ.; NTA, Konstantin)
- SEVIRI water vapor retrievals (UW, EOS)
- SEVIRI aerosol retrieval (Univ Oxford)
- SEVIRI cloud and ozone retrieval (EUMETSAT)
- SEVIRI cloud phase, other cloud top parameter retrievals (KNMI)
- LST retrievals from GOES-R (NOAA NESDIS)
- OSS calculations (AER)
- CRTM (JCSDA)
- AIRS NWP model assimilation (UKMO)

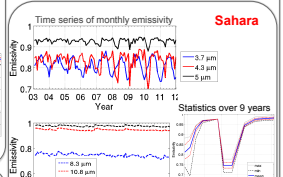
9 year time series of the UW BF Emissivity Database

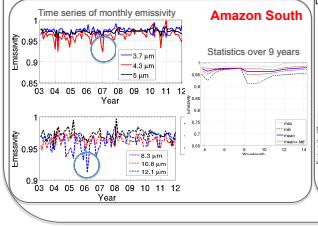
Nine year time series (between Jan 2003 and Dec 2011) and statistics are shown below for some selected locations plotted on the map (right).

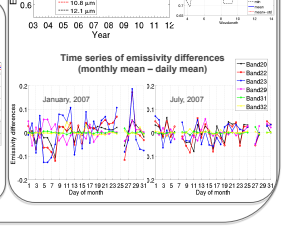
The blue circles indicate some interesting features: the 2007 January cloud mask update (from Col4 to Col5), seasonal variation, emissivity decreasing or increasing, trend, extremes, etc.

Location of the 3 selected places



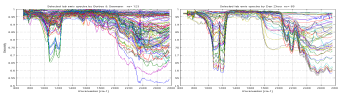




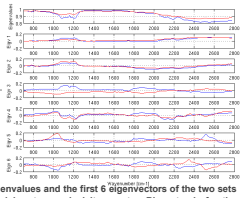


Comparison between the UW MODIS–based HSR emissivity and the IASI–based (Dan Zhou, LaRC/NASA) global monthly datasets

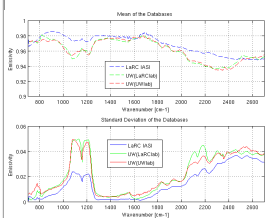
- The global statistics for one selected month (mean of 2007 and 2008 July) showed that the two databases agree well generally (less than 1% mean difference on most of the spectra).
- The differences of the stdev are larger than 2 % at the 1100-1250 [cm-1] water vapor band and at the short wave range (> 2300 [cm-1]), where the emissivity spectra generally have the largest variation.
- But we have found local differences by visual investigation of the maps on some certain wavenumbers. The causes can be: the nature of the algorithms, the temporal and spatial resolution of the two databases etc.
- The effect of the laboratory spectra selection on the emissivity differences was also investigated.
- The UW HSR database has been recreated by using the laboratory emissivity dataset selected by Dan Zhou (LaRC/NASA) and used to create the global monthly IASI database. The two UW HSR databases (one with the original lab data selection and one with the LaRC/ NASA selection) were compared to the IASI dataset for July (2007-200e8).
- The differences of the eigenvalues and eigenvectors of the two lab datasets show very small differences.
- The small mean and std differences between the two UW sets indicate that the differences between the IASI and MODIS-based databases *are not sensitive for/ based on the laboratory data selection.*



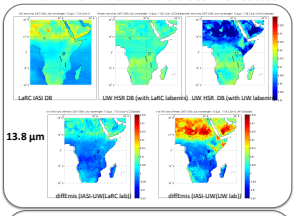
Selected laboratory emissivity spectra (left, 65) by Dan Zhou, LaRC/ NASA and (right, 123) by Seemann and Borbas (SSEC/UW).

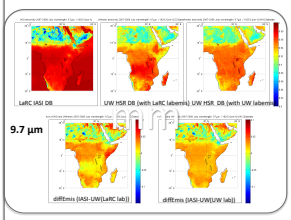


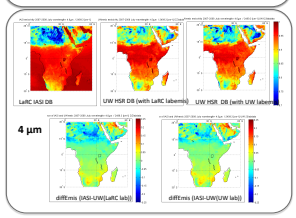
Eigenvalues and the first 6 eigenvectors of the two sets of laboratory emissivity spectra. Blue stands for the LaRC/NASA and red stands for the SSEC/UW selection.



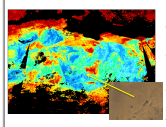
Mean and Stdev diff. between the LaRC IASI and UW emissivity database for July mean (from 2007 and 2008). The green indicates the case when the UW emissivity DB was created by using the LaRC/NASA lab spectra and red indicates the case when the original UW lab spectra was used.





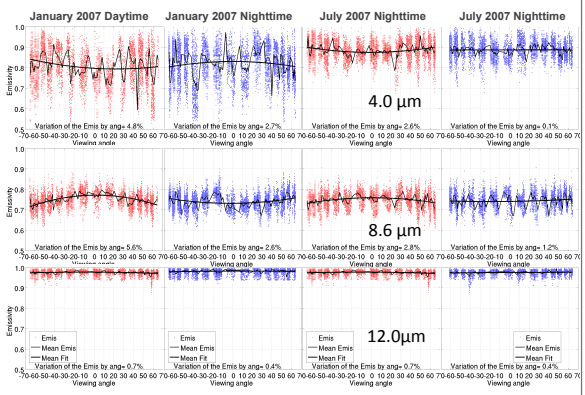


Is there any angular dependence of the MODIS emissivity products ?



Laboratory measurements show that there is angular variation of thermal infrared emissivity at SW and the 8-9 µm restrahlen band for clay, sand, slime, gravel (~ 1-3% from 0 to 65 degree), but for example homogeneous grass does not show angular dependence. The emissivity decreases with increasing viewing angle. (Label and Stoll, 1991, Sobrino and Cuenca, 1999).

The daily mean MODIS MYD11C1 emissivity products over a homogeneous sandy area of the Sahara Dessert have been selected at January and July 2007 for this study.



Conclusions:

- In our study over the sandy subarea of the Sahara Desert, the SW and 8.3 µm bands of the MOD11CX emissivity products do show angular variation.
- The maximum variation occurred for the 8.3 µm band at winter daytime (5.8 %).
- In this study the emissivity behaves opposite for day and night and the SW and 8.3 µm bands.
- Over this area there is a strong daily and seasonal variation for the SW and the restrahen band: the daily mean time series showed a 5 -10 % (winter-summer) variation of emissivity during a single month and the 9 year time series also showed a 10 % seasonal variation.
- **In the future** we will extend our study for other surface types like vegetated area, shrubs, snow etc…

Acknowledgements: We would like to thank Daniel Zhou (LaRC) for providing the monthly IASI-based emissivity database. This research was supported by the NOAA grant NA10NES4400013.