Monitoring of Global Microwave Land Surface Emissivities From Combined AMSR-E, MODIS and AIRS Observations

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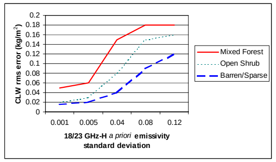
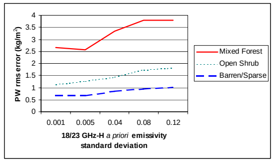
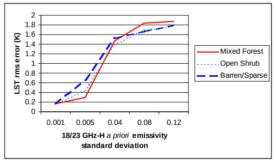
1. Motivation

Microwave land retrieval performance as a function of a priori knowledge of surface emissivity (cloudy conditions)







2. Goal

- Derive high temporal resolution global AMSR emissivity database with sufficiently high accuracy for enabling useful retrieval of LST, cloud liquid water and water vapor over land from AMSR measurements
- Builds on previous work from C. Prigent on SSM/I and AMSU

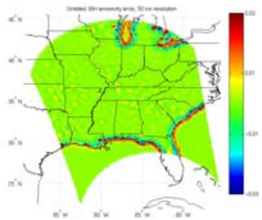
Potential Applications of Emissivity Database

Science Area	Parameters	Comment
Global surface property characterization		
Microwave land retrieval support/ assimilation in meteorological models	Precipitation, LST, CLW, PW, Snow Fraction	For all these applications, good *a priori* spectral surface emissivity information is critical; database is universal and can serve many other conically-scanning microwave sensors, thereby providing high local refresh
Sudden event and retrieval quality control	Floods, Snow, RFI, Precipitation	The UR and emissivity database will provide a natural means of detection through large Chi-squared residuals, lack of convergence, and sudden changes in retrieved emissivity

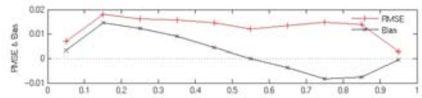
3. Approach

- Use matched measurements from combined AMSR, AMSU/AIRS and MODIS to help specify atmospheric and surface state (LST, surface type) in AMSR field-of-view
- Take advantage of the high information content of MODIS imager and AIRS sounders as well as unique temporal/spatial co-location between those measurements to improve quality of emissivity product

5. Quality Control: Regridding Errors

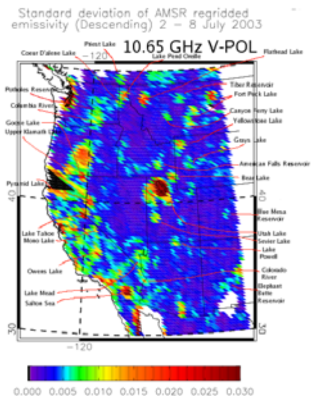


Simulated regridding errors in retrieved emissivity for a 50-km FOV. Errors are largest where emissivity is changing rapidly over short distances, such as coastlines, lakes and rivers. This is confirmed in the analysis with real AMSR-E data below.



Simulated RMSE and Bias of regridded emissivity as a function of land fraction.

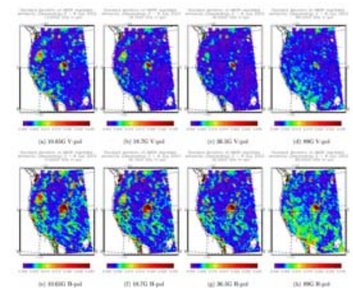
Actual Standard Deviation of Regridded Emissivity from AMSR-E (2-8 July 2003)



Most of the areas of elevated variance in the weekly emissivity are associated with water bodies.

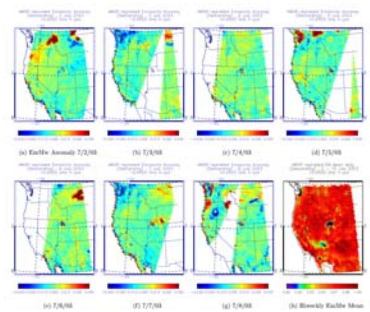
7. Case Study: Continental US, 2-8 July 2003 (continued)

Weekly Standard Deviation vs. Frequency



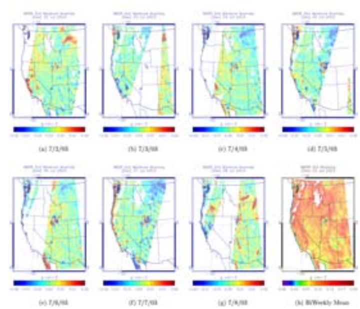
Variance of gridded emissivity has strong dependence on frequency and polarization.

Daily Emissivity Anomalies (10.65 GHz V-pol)



Positive anomalies are associated with cloudy regions and regions of active precipitation. The negative anomaly over Oregon on 8 July is due to increased soil moisture from a storm system that passed over the region prior to the Aqua overpass at 1030 UTC. (See radar-derived rainfall below)

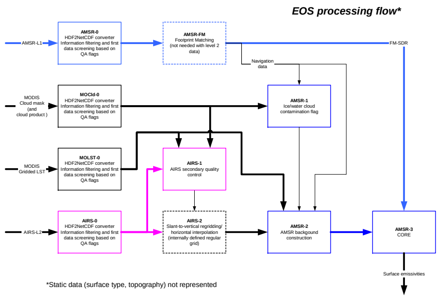
Retrieved Soil Moisture Product (AMSR)



The soil moisture anomaly maps show a strong positive anomaly on 8 July over Oregon.

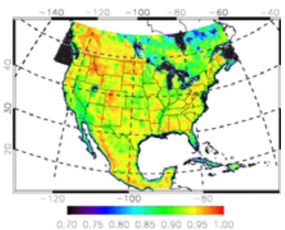
3. Approach (continued)

Overall Data Processing

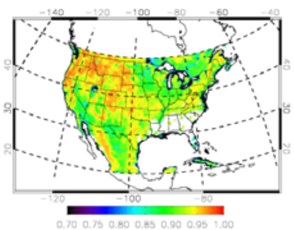


4. Example: SSM / I vs. AMSR-E Retrieved Emissivities

SSM/I Mean 19H (July 1992)

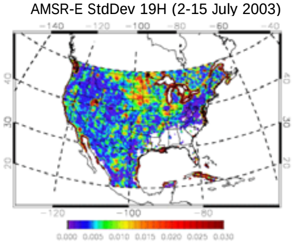


AMSR-E Mean 19H (2-15 July 2003)



General patterns of emissivity are quite similar. Differences in southeastern US and upper Midwest are in part due to the presence of clouds and precipitation. These are associated with areas of higher variance.

AMSR-E StdDev 19H (2-15 July 2003)



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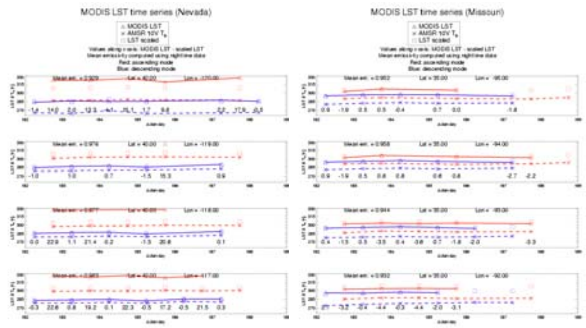
6. Quality Control: LST Errors



We performed physical retrievals of AMSR emissivity using AMSR brightness temperatures and MODIS LSTs, assuming that the LSTs are perfect (i.e. the physical retrieval was constrained to adjust only the emissivity, not LST, in order to best match the observed brightness temperatures). From the daily nighttime emissivity retrievals, we calculated a weekly mean emissivity. Then assuming no change in emissivity from day to night, we calculate a "scaled LST" by using the mean nighttime emissivity and the AMSR brightness temperatures, and assuming no atmospheric attenuation. At 10 GHz, where atmospheric effects are small, this should provide a reasonable estimate of LST. If the nighttime emissivity retrievals are accurate, then the nighttime scaled LST (blue squares) and the MODIS retrieved nighttime LST (blue triangles) should be in good agreement. Over Nevada the scaled LSTs are in good agreement with the MODIS nighttime LSTs, but significantly lower than the MODIS daytime LSTs (approaching 20 degrees K), indicating that the MODIS daytime LSTs are likely to be too high. Over Missouri, the agreement is quite good (within several degrees K) for both day and night, indicating better consistency between daytime and nighttime emissivities, and the corresponding AMSR and MODIS data.

7. Case Study: Continental US, 2-8 July 2003

- We process Aqua data for a 7-day period.
- For each AMSR-E footprint, we match MODIS LST retrievals obtained from the gridded 5-km day/night product (MYD11B1), and temperature and moisture profiles from the NCEP global GFS model.
- Quality control is performed by using MODIS cloud product and percent available LST data within each AMSR footprint.
- A physical/maximum liklihood retrieval of emissivity is performed at each location.
- Retrieved emissivities are then regridded to a 27-km global sinusoidal grid.
- All results are for descending (nighttime) data only.

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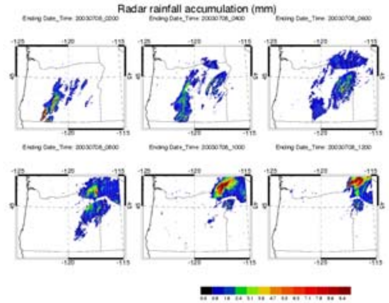
Sequence of Radar-Derived Rainfall over Oregon



Rainfall over Oregon on 8 July 2003 corresponds to the area of retrieved emissivity negative anomaly and elevated soil moisture (see above).

8. Summary and Future Plans:

- Quality control: effect of regridding, LST errors, clouds and precipitation.
- Currently processing other regions of interest: Amazon Basin and Sahara Desert.
- Eventually process one year of global Aqua data.
- Once initial emissivity database is established, process cloudy scenes using database statistics as constraint. Validate retrieved cloud amounts.

Acknowledgement

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