Title: LAND SURFACE EMISSION MODELING TO SUPPORT PHYSICAL PRECIPITATION RETREIVALS

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Land surface modeling and data assimilation can provide dynamic land surface state variables necessary to support physical precipitation retrieval algorithms over land. It is well-known that surface emission, particularly over the range of frequencies to be included in the Global Precipitation Measurement Mission (GPM), is sensitive to land surface states, including soil properties, vegetation type and greenness, soil moisture, surface temperature, and snow cover, density, and grain size. In order to investigate the robustness of both the land surface model states and the microwave emissivity and forward radiative transfer models, we have undertaken a multi-site investigation as part of the NASA Precipitation Measurement Missions (PMM) Land Surface Characterization Working Group. Specifically, we will demonstrate the performance of the Land Information System (LIS; http://lis.gsfc.nasa.gov; Peters-Lidard et al., 2007; Kumar et al., 2006) coupled to the Joint Center for Satellite Data Assimilation (JCSDA's) Community Radiative Transfer Model (CRTM; Weng, 2007; van Delst, 2009).

LIS is a high-resolution land modeling and data assimilation software framework that integrates the use of advanced land surface models, high resolution satellite and observational data, data assimilation techniques, and high performance computing tools. The LIS infrastructure unifies and extends the capabilities of the ¼ degree Global LDAS (GLDAS; Rodell et al., 2004) and the 1/8 degree North American LDAS (NLDAS; Mitchell et al., 2004) in a common software framework capable of ensemble land surface modeling (e.g., Noah, GMAO Catchment, CLM, HYSSiB, Mosaic) on points, regions or the globe at spatial resolutions from 2x2.5 degrees down to 1km or finer. The sub-1km capability of LIS allows it to take advantage of the latest EOS-era observations, such as MODIS land cover type, leaf area index, snow covered area, and surface temperature, at their full resolution. Although LIS has been configured for the PMM LSWG as an uncoupled land surface modeling and data assimilation system, LIS can also be configured to execute fully two-way coupled to the WRF-ARW core, enabling a coupled system to study land-atmosphere interactions. (Kumar et al. 2007; Case et al., 2008; Santanello et al., 2009).

As described above, LIS has evolved from two earlier efforts – North American Land Data Assimilation System (NLDAS; Mitchell et al. 2004) and Global Land Data Assimilation System (GLDAS; Rodell et al. 2004) that focused primarily on improving numerical weather prediction skill by improving the characterization of the land surface conditions. Both of these systems now use specific configurations of the LIS software in their current implementations. LIS not only consolidates the capabilities of these two systems, but also enables a much larger variety of configurations with respect to horizontal spatial resolution, input datasets and choice of land surface model through "plugins". In addition to these capabilities, LIS has also been demonstrated for parameter estimation (Peters-Lidard et al., 2008; Santanello et al., 2007) and data assimilation (Kumar et al., 2008; 2009).

The land surface is characterized by complex physical/chemical constituents and creates temporally and spatially heterogeneous surfaceproperties in response to microwave radiation scattering. The uncertainties in surface microwave emission (both surface radiative temperature and emissivity) and very low polarization ratio arelinked to difficulties in rainfall detection using low-frequency passive microwave sensors (e.g.,Kummerow et al. 2001). Therefore, addressing these issues is of utmost importance for the GPM mission. There are many approaches to parameterizing land surface emission and radiative transfer, some of which have been customized for snow (e.g., the Helsinki University of Technology or HUT radiative transfer model;) and soil moisture (e.g., the Land Surface Microvave Emission Model or LSMEM).

The CRTM was designed to support satellite data assimilation (Weng, 2007; van Delst, 2009). The components of CRTM are given in Figure 1. The CRTM "Forward" model estimates radiance given a characterization of the land surface and atmosphere (the CRTM "Forward" model). Additional models (CRTM "Tangent-linear", "Adjoint" and "Jacobian" models) support data assimilation of satellite observed radiance (clear and cloudy infrared (IR) and microwave (MW)) into atmospheric models. CRTM can take input derived from atmospheric profile data sources and surface information to calculate radiance quantities such as surface emissivity and brightness temperature.

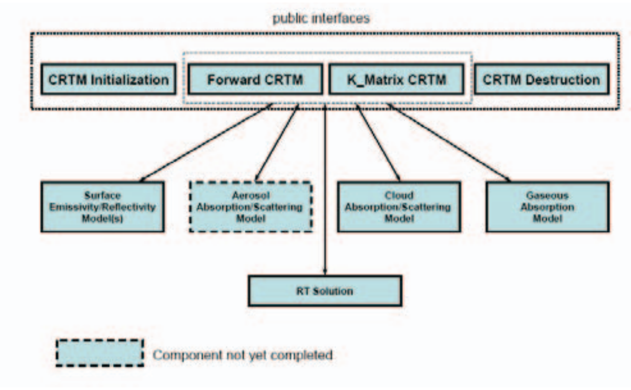

Figure 1. Major components of CRTM

The CRTM Land Emissivity Model is a physically based emissivity model that must be tightly coupled with off/on-line land-surface model (LSM) output to obtain the necessary surface parameters (vegetation characteristics, soil moisture, snow, and roughness, among others) needed to predict surface emissivity. The surface emissivity from CRTM, combined with dynamic temperatures from the LSM, allow one to diagnose the total emission at various frequencies. One advantage of this model is its ability to estimate surface emissivity on short time scales in response to rapid (daily or hourly) changes in soil moisture or surface snow accumulation under any weather condition. However, its application to operational rainfall retrieval could be limited by the lack of i) accurate LSM-simulated geophysical parameters (soil moisture, skin temperature and snow accumulation) and ii) fundamental understanding of single-scattering properties in response to land-surface constituents.

Under funding from the Air Force Weather Agency (AFWA) and the Joint Center for Satellite Data Assimilation (JCSDA), we have analyzed and addressed some of the issues related to coupling the CRTM land emissivity model with typical land surface models in LIS, such as the Noah LSM. One of the major issues is mapping the LIS land states into those states expected by CRTM. Similarly, the land cover classification scheme in CRTM's Land Emission model is different from the typical USGS 24-category land cover classification system used in LIS (and in most LSMs).

The PMM LCWG has selected 12 Targets/9 types of surfaces, as shown in Figure 2, to intercompare surface microwave emission estimates from a variety of techniques at the frequencies relevant to GPM.

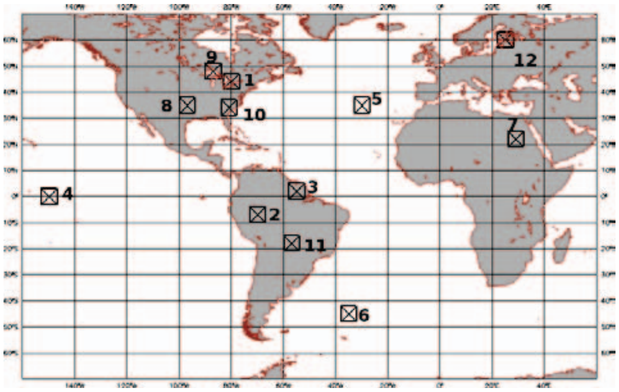

Figure 2. Targets for PMM LWSG surface emission intercomparisons.

The study period has been defines as a single year: 1 July 06 – 30 June 07. Several satellite datasets have been assembled, including AMSR-E, SSMI, SSMIS, TMI, AMSU, and WindSat, as well as ancillary satellite data including ISCCP, PR/VIRS, CloudSat, and model fields including GDAS, the GLDAS and NLDAS land surface modeling systems, and JCSDA emissivities.

The LIS-CRTM system was configured for the study period at the C3VP and ARM sites, using the Noah and Catchment land surface models at all of the AMSU-A and AMSU-B frequencies. Figures 3a and 3b illustrate the ability of LIS-CRTM to accurately predict brightness temperatures. Figure 4 illustrates the time series of brightness temperatures and emissivities for the period. These figures demonstrate the strong sensitivity of surface emission to land surface states such as snow, temperature and soil moisture during the study period.

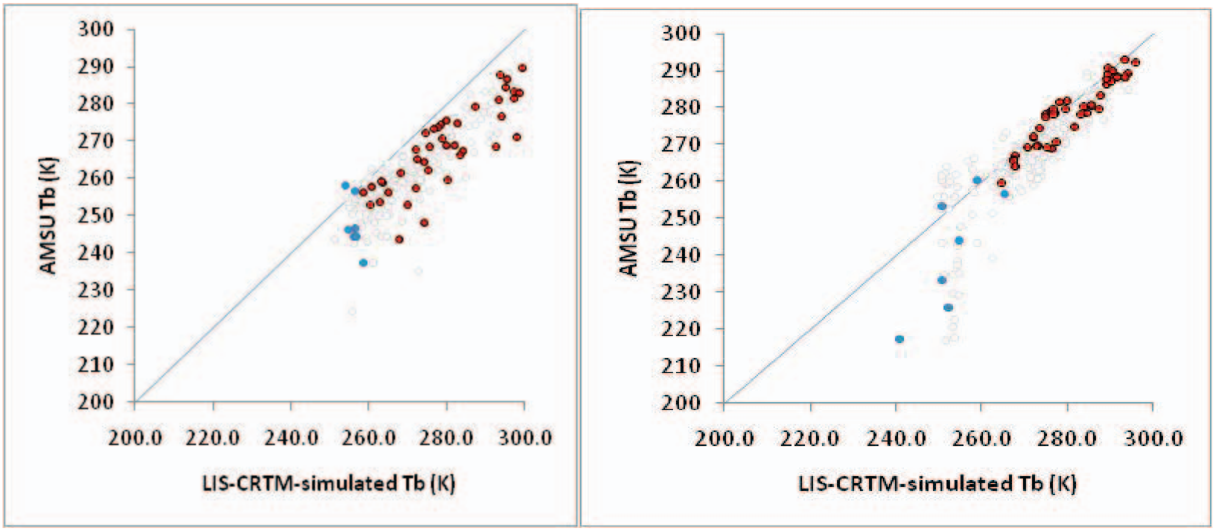

Figure 3. Observed vs. simulated Tb for AMSU-A 31.4 GHz (left) and AMSU-B 89 GHz (right).

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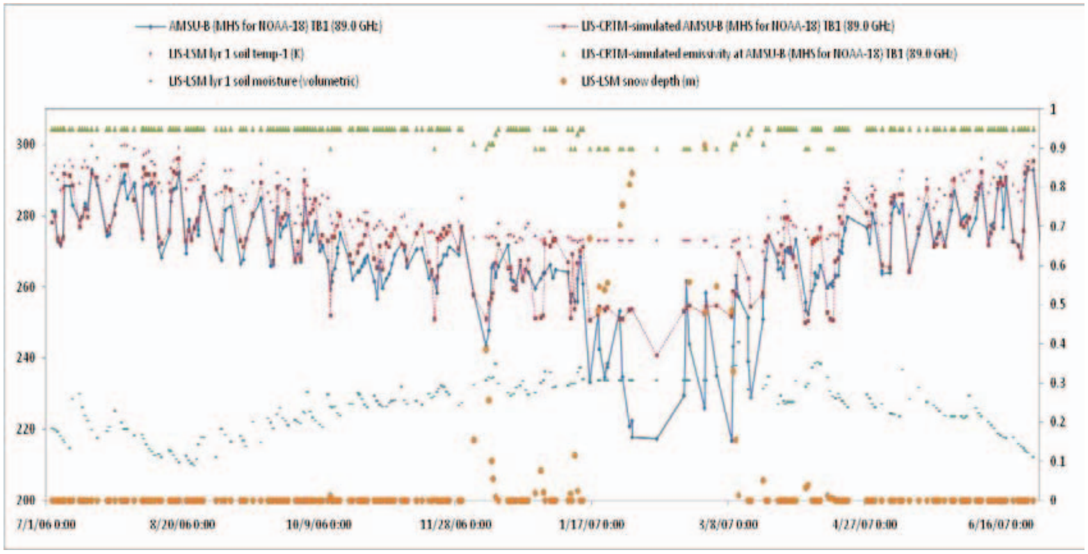

Figure 4. Time series of brightness temperatures (left axis) and emissivities, snow depth and soil moisture (right axis) simulated with LIS-Noah-CRTM. Observed AMSU-B 89 GHz temperatures are shown as the blue line.

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