Atmospheric and
Environmental Research, Inc.

Annual Progress Report 1
for the period 11 May 2009 – 10 May 2010

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AER Project P1462

Toward Assimilation of Satellite Data in Modeling Water Vapor Fluxes over Land

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1 Scope

This Annual Progress Report describes progress for the project “Toward Assimilation of Satellite Data in Modeling Water Vapor Fluxes over Land” funded by NASA grant NNX09AK04C under the NEWS Program. The current reporting period is 11 May 2009 – 10 May 2010. The period of activity discussed here runs from the time the grant was received, 16 July 2009, to the date of report submittal, 12 March 2010.

2 Project Overview

This project applies microwave and infrared satellite data to improve model estimations of evaporation over land. These satellite data contain information about near-surface soil and vegetative moisture. Data assimilation systems have the potential to optimally account for the information content and the error characteristics of all the data sources, while introducing physical constraints with a numerical model. Successful assimilation requires that the model parameterizations and variables are compatible with the satellite measurement sensitivities. When they are incompatible, the satellite information is effectively rejected or misguides the analysis. This project is intended to provide direction toward improving surface models and their assimilation of data for water vapor flux modeling. The specific objectives are:

1. Identify environments where the surface evaporation from current land surface models is inconsistent with satellite measurements of parameters related to these fluxes, particularly with respect to temporal and spatial structures.
2. For selected environments, characterize the discrepancies between modeled surface fluxes and related satellite-derived parameters and complementary in-situ measurements, in terms of the surface transfer processes for moisture and energy and remote sensing phenomenology, to provide direction toward improving surface models and their assimilation of data for water vapor flux modeling.
3. Produce estimates of evaporation from a combination of satellite measurements and satellite-derived indices, based on analysis of the statistical relationship between the satellite observations and the fluxes derived from land surface models, and implemented with a neural network.

3 Review of Reporting Period

3.1 Goals and Objectives for the Reporting Period

The primary objective for this period was to perform initial data processing, as preparation for the addressing the overall project objectives. Specifically, our plan called for preparing satellite-derived datasets and obtaining LSM-produced data. The plan also included extending the time period covered by the current prototype surface meteorology/satellite product database at CUNY, and to add to the collection of precipitation and radiative flux products.

3.2 Summary of Progress

3.2.1 *Joint analysis of the satellite observations and model fluxes*

We have been preparing data for training of the neural network that relates the remote sensing products to the surface fluxes computed by the land surface model. The applicable remote sensing products consist of microwave emissivity, land surface temperature (LST), reflectance, and net radiation. The initial training of the neural network will be made with monthly data for 2003. This training, to be conducted in the next period, will be used to identify regions and times of discrepancies between the satellite indicators and the model fluxes. Higher temporal resolution will be employed when we are at the stage of detailed analysis of the regions selected for further study.

The initial focus was on reprocessing of LST data from the microwave AMSR-E and assessment of its suitability for evaluating model products. By reprocessing, we take advantage of updates to the microwave land surface emissivity database developed under a different project. The elaborate quality control procedures employed in the development of that database are responsible for maximizing the quality of the emissivity data, which has a direct impact on the quality of the microwave LST retrievals. An example of the assessment of the LST data is in Figure 1, where the microwave LST is compared with what is available from the infrared. For evaluating model products, the primary contribution of LST information is related to the diurnal amplitude. The amplitude according to AMSR data is compared with what is available from MODIS in Figure 2. An obvious benefit of the microwave AMSR product is the far greater spatial coverage, into areas that were so persistently cloudy that the infrared MODIS product was unavailable either for the day or night measurements. The "clear-sky bias" of the infrared LST is apparent in areas where clouds are common in July, such as eastern Europe and the northeast United States.

The purpose of our use of reflectances is to account for variations in the vegetation. The reflectances used are from the two bands, visible and near-infrared, from which the normalized difference vegetation index (NDVI) can be derived. The neural network uses these data to resolve some of the ambiguity in the microwave emissivities, which are strongly sensitive to both vegetation and soil moisture. In prior applications of this neural network approach, AVHRR data have been used for the visible reflectances. For this project we are using data from MODIS. We have reviewed the qualities of several relevant MODIS data products and their trade-offs with respect to our current application and have selected the "Vegetation Indices Monthly L3 Global 1km" (MYD13A3, MOD13A3), and are currently preparing to perform the necessary spatial averaging to the neural network processing grid. The reflectances in this dataset have atmospheric and BRDF (non-Lambertian) corrections and quality control that are consistent with the NDVI and other vegetation indices produced by MODIS.

We currently have the net radiation products from the International Satellite Cloud Climatology Project (ISCCP) mapped to the grid for the neural network. We have obtained the land surface model data from the GLDAS NOAH model runs for the 2003 period and have in place the tools to regrid these data for the neural network. Among the GLDAS model suite, the NOAH is most directly applicable to this project because its grid resolution is similar to the grid of the neural network.

3.2.2 *Combining satellite measurements with in-situ data*

The prototype surface meteorology/satellite product database has been extended to include infrared and microwave products for surface skin temperature through June 2008. These data have not yet been merged together with the surface meteorology data. Comparison of cloudy and clear contrasts of microwave surface skin temperatures have begun; also comparison of IR surface skin with MODIS products has started.

During the coming year, the IR surface skin temperature product comparisons will be completed and a revised version of the microwave product produced. Also, during this time, the production software for merging the satellite and surface weather observations, including filling in missing data and interpolating over the diurnal cycle, will be completed. Processing with this refined software and the revised inputs will lead to an extended prototype product that can be evaluated by comparison to newer satellite products and NASA MERRA. This prototype product will be released to the NEWS team (ahead of schedule, even though it will be revised after some further investigations). Analysis during the coming year will be focused on the diurnal and seasonal variations of the surface skin and air temperature differences.

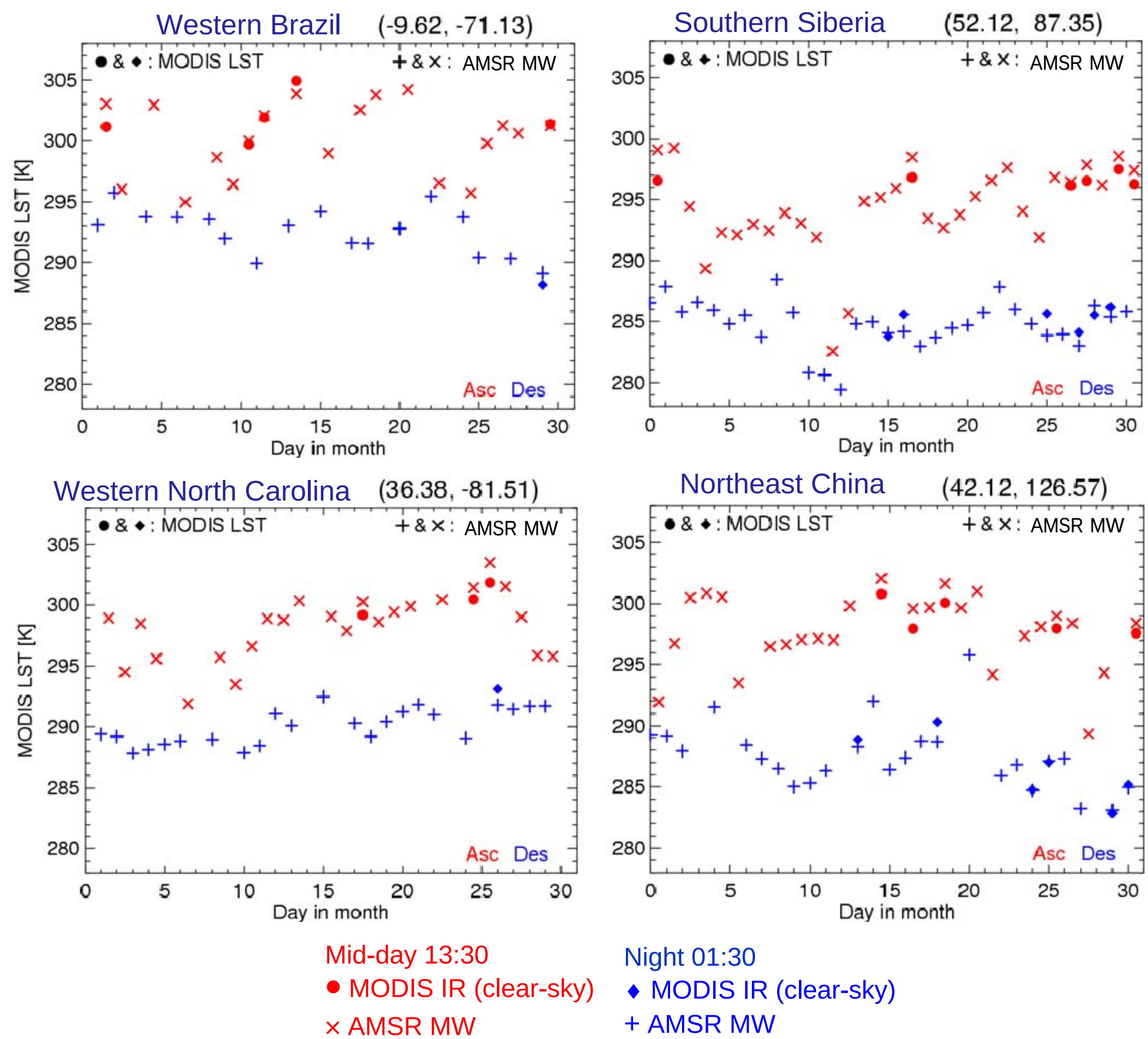

Figure 1. LST at four sites, plotted as a function of day of the month. The source of data and the time of observation are indicated in the legends. The infrared products from MODIS are only available in clear-sky conditions, while the microwave products from ASMR-E are available almost every day. On clear days, there is high agreement of AMSR microwave with MODIS IR measurements. On cloudy days, the retrieved AMSR LSTs capture the synoptic trends that MODIS misses. Note that, for the mid-day measurements, the clear-sky cases sampled by MODIS are among the warmest days, which is associated with the "clear-sky bias" in LST statistics from infrared data alone.

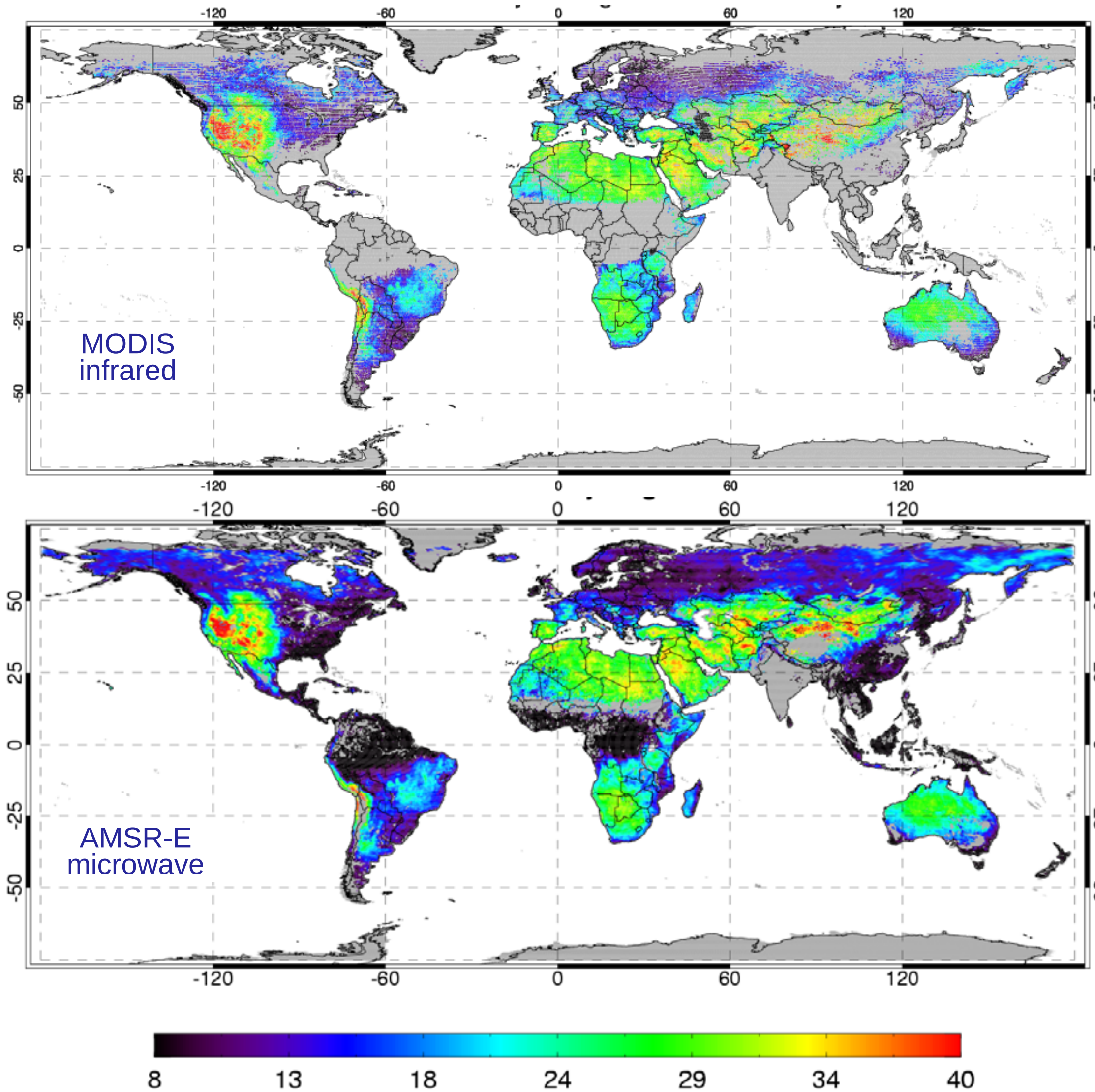

Figure 2. Land surface temperature diurnal amplitude (13:30 minus 01:30 LT) from MODIS and AMSR-E.