P2.3 USE OF SCAN OBSERVATIONS FOR VALIDATION OF SOIL MOISTURE SPATIAL DISTRIBUTION SIMULATED BY THE LAND-SURFACE MODEL OVER THE LOWER MISSISSIPPI DELTA REGION

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1. INTRODUCTION

Surface soil moisture levels control the heat partition between latent and sensible heat fluxes. Due to this control soil moisture spatial variability represents an important factor affecting surface and planetary boundary layer thermodynamic properties. It has a direct impact on development of weather systems, especially at the local scale. Therefore, a retrieval of accurate and reliable estimates of soil moisture content at local, regional, and planetary scales represents an important practical task (Smirnova et al., 2000) for Numerical Weather Prediction (NWP). These estimates are also considered as a valuable input for various environment models including water management, agriculture, and forestry applications.

Generally, the network of soil moisture measurements (e.g. SCAN, 2006) is not dense (typically only few observation points are available within each state) enough to meet the 1 km or 5 km spatial resolution requirements in the NWP mesoscale models. Therefore, several approaches were developed and successfully used to specify/update soil moisture fields with resolution of 1 km or 5 km. One group of these methods is based on a variational approach for updating NWP model simulated soil moisture from other screen-level model variables (Hess, 2001). The second group uses Land Surface Model (LSM) offline simulations with a prescribed atmospheric forcing (e.g. Chen et al., 1996) to produce high-resolution surface fields. An accurate description of the atmospheric forcing is essential for producing unbiased soil moisture fields from LSM simulations.

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This study reports preliminary results of comparison between soil moisture fields produced by long-term (9 years) LSM simulations and point soil moisture measurements. The comparison was performed to evaluate basic merits and drawbacks of this approach used to generate soil moisture maps at a regional scale.

2. MODEL DESCRIPTION AND DATA USED

The NOAH LSM (Ek et al., 2003) available within the state-of-the-art Land Information System (LIS) developed at NASA Goddard Space Flight Center (Peters-Lidard et al., 2004, Kumar et al., 2006) was configured at a 0.01°x0.01° latitude-longitude resolution (approximately 1x1 km^2) over a domain covering the lower part of the Mississippi Delta, located mainly in the state of Mississippi (see Fig. 1). The NOAH LSM used for moisture simulations had 4 standard layers in the soil. Soil texture properties were represented by CONUS-SOIL (Miller and White, 2006) data based on USDA STATSGO database having 19 soil types. The geographical distribution of STATSGO soil types within the NOAH/LIS integration domain is shown in Fig. 1. The soil type number 2 shown in Fig. 1 corresponds to the sand and number 14 to the water. The vegetation/land use description was based on 13 land cover classification types developed at the University of Maryland.

For retrospective simulations the LIS framework supports various data sets such as GLDAS, GOES, NLDAS, ECMWF, and others with different levels of spatial and temporal resolution. The atmospheric input (forcing) into the LIS involves the following surface variables: air temperature and water vapor content, pressure, components of the wind, downward fluxes of solar and longwave radiation, and rain- snowfall rates.

In the present study North American Land Data Assimilation System (NLDAS) data were used to force the NOAH LSM model. The NLDAS forcing project was described in detail by Cosgrove et al. (2003). NLDAS fields cover the CONUS region and some adjacent regions of Canada and Mexico. They are available online from the end of 1996 until present with 1/8th latitude-longitude resolution (approximately 15 km grid spacing).

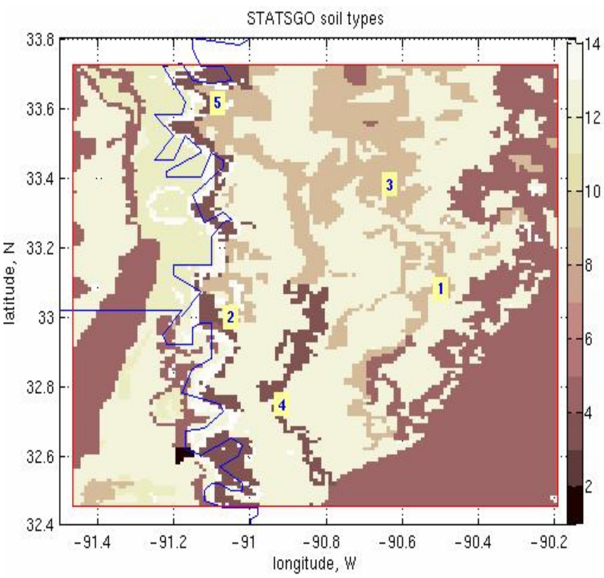

Figure 1. NOAH/LIS integration domain with 1-km resolution in the Lower Mississippi Delta and geographical distribution of STATSGO soil types. Numbers stand for SCAN sites with soil moisture observations.

The NOAH/LIS simulations of soil moisture at the 1-km grid were compared with point measurements. Five Soil Climate Analysis Network (SCAN, 2006) points supported by the USDA Natural Resources Conservation Service were available over the given NOAH/LIS domain shown in Fig. 1. Locations of these points with available measurements of the volumetric soil moisture at different levels are indicated by numbers in Fig. 1. Additionally, eight other SCAN points located to the North of the NOAH/LIS domain were used for verification of soil moisture simulations performed at the 5-km grid (Mostovoy and Anantharaj, 2007). A total of 13 SCAN sites were used in this study.

Because of the close association between surface soil moisture content and skin/surface temperature, the Aqua MODIS Land Surface Temperature (LST) product (MODIS, 2005) was used for validation of NOAH/LIS simulations. Finally, North American Regional Reanalysis (NARR) soil moisture data (available every 3 hr) with an approximate 32-km resolution (Mesinger et al., 2003) was also used as reference fields.

3. RESULTS

NOAH/LIS runs were performed using NLDAS forcing spanning the period from October 1996 to the end of the year 2005. Figure 2 shows typical examples of the soil moisture geographical distribution (valid for 2005/05/30 3PM of local time) simulated by the NOAH/LIS at different depths. Close association of simulated soil moisture spatial patterns with those of soil types shown in Fig. 1 is apparent. Specifically, areas of relatively low soil moisture content coincide with regions of "sandy" soil types (soil type number from 1 to 4 in Fig. 1). Conversely, areas of relatively high moisture correspond to clay soil types (soil type number from 7 to 11 in Fig. 1).

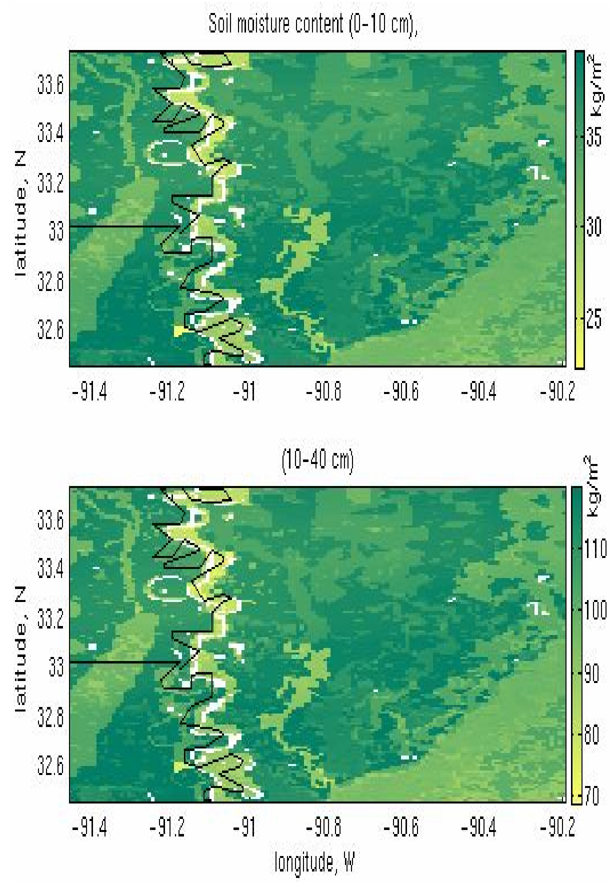

Figure 2. Examples of soil moisture content distribution simulated with NOAH/LIS. Average values in 0-10 cm (upper frame) and 10-40 cm (lower frame) layers are shown. Values are valid at 2005/05/30 3PM LT. Note close association between soil moisture patterns and those of soil types shown in Fig. 1.

Before performing a comparison of simulated soil moisture with SCAN measurements it would be instructive to consider seasonal and spatial features of moisture fields revealed by these measurements. Figure 3 shows distinct seasonal variations of spatial dependence (measured as correlation coefficient for bi-monthly periods) between soil moisture content at the 5-cm level observed at 13 SCAN points. High degree of spatial association between soil moisture is observed during the relatively dry period of September-October in this region. Correlation coefficients remain extremely high exceeding 0.9 and do not change significantly with a distance between measurements points.

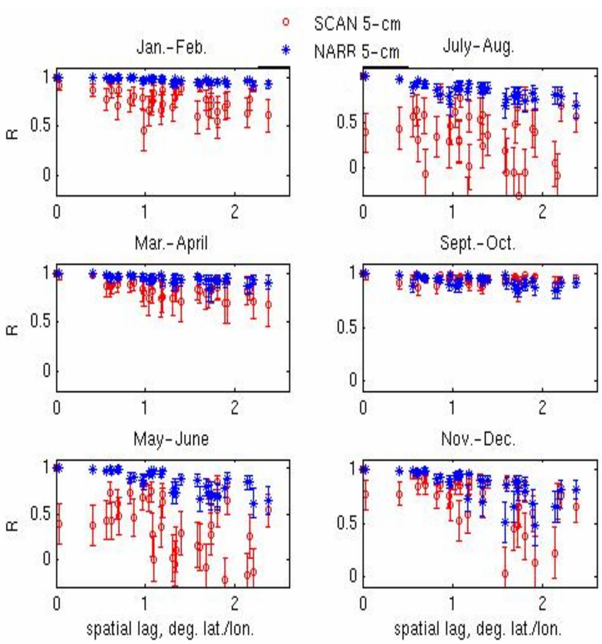

Figure 3. Seasonal variations of spatial dependence of correlation coefficients (R) between soil moisture content (5-cm level) measured at 13 SCAN sites for the year 2005. Similar estimates of R but from NARR data are also shown. Vertical bars stand for 95% confidence interval of R values.

3.1 *Comparison with SCAN observations*

Figure 4 illustrates a comparison plot between simulated and observed time series of the volumetric soil moisture content at the N. Issaquena SCAN site for the year 2005. This site is indicated by number 2 in Fig. 1. Some bias between simulated and observed values is apparent. Partly this bias can be attributed to deviation of local meteorological conditions (observed at the SCAN site) from those of NLDAS atmospheric forcing used for the NOAH/LIS simulations. Indeed, a certain deviation exists between 2-m air temperatures, as is shown in Fig. 5. The standard deviation of the difference between these temperatures is equal to 1.41 °C and to 1.34 °C for N. Issaquena and Silver City (shown by number 1 in Fig.1) SCAN sites respectively. More drastic difference/scattering is observed between local and NLDAS precipitation values as shown in Fig. 5 (right frame).

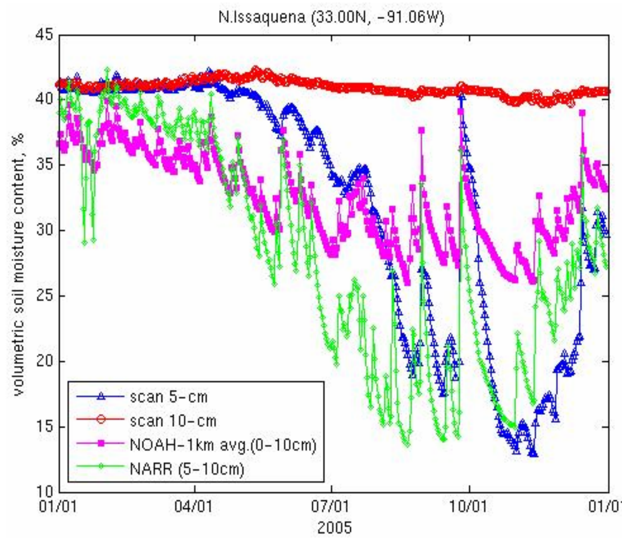

Figure 4. Time series of soil moisture content (daily averaged values) observed at N. Issaquena (SCAN site # 2 in Fig. 1) and simulated by the LIS/NOAH model for the year 2005. NARR soil moisture time series from the closest grid point are shown for comparison.

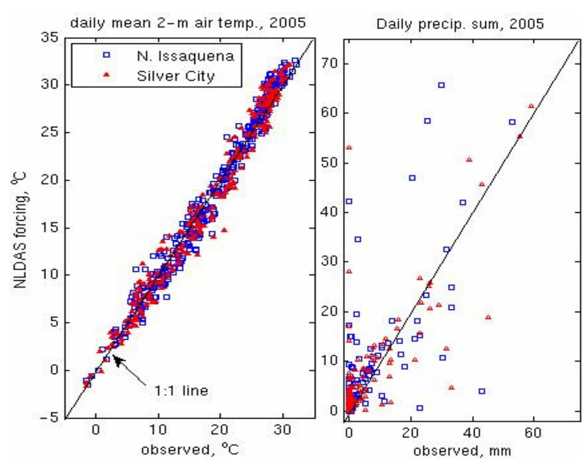

Figure 5. Scatterplots between NLDAS forcing data and SCAN site observations for 2-m air temperature (left frame) and precipitation (right frame).

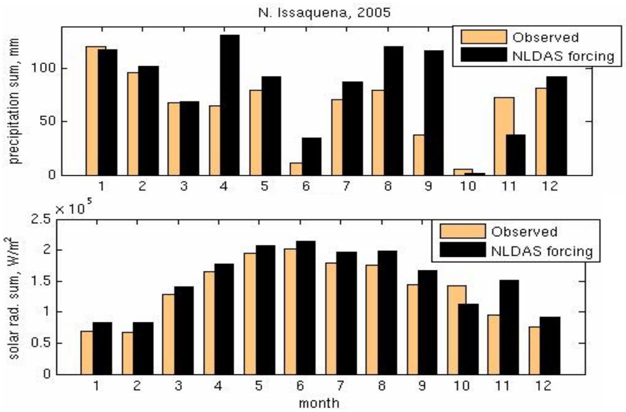

Figure 6. Comparison of monthly sum between NLDAS forcing data and SCAN measurements for precipitation (upper frame) and downward solar radiation flux (lower frame). Note substantial overestimation of NLDAS precipitation during April, August and September.

3.2 *Comparison with MODIS LST*

Spatial differences in skin temperature around midday hours are mainly modulated by variations in the vegetation fraction (e.g. Goetz, 1997). This well-known fact is clearly illustrated by Figs. 6 (see right frame with MODIS LST) and 7. Figure 6 indicates that MODIS LST is lower at about 8 °C over vegetated areas/pixels as compared with the NOAH skin temperature. Conversely, most non-vegetated pixels from the NOAH simulation have a higher skin temperature (in the range of 4-6 °C) than LST of corresponding MODIS pixels.

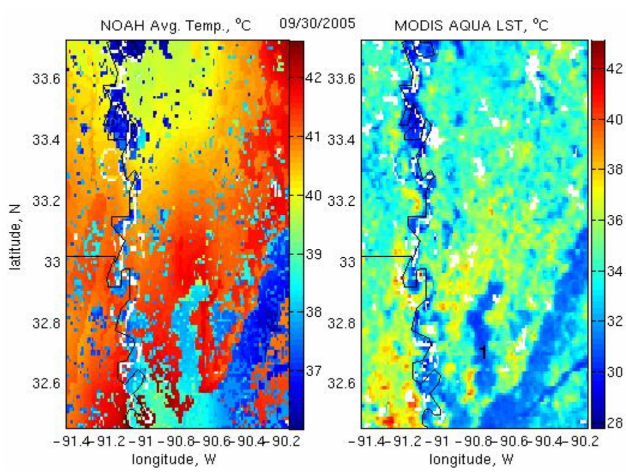

Figure 6. Example of land surface/skin temperature distribution at 09/30/2005 1:30 PM of local time. LIS/NOAH output (left frame) and MODIS AQUA estimate (right frame). Both data have 1-km resolution. Number 1 on the right frame indicate Delta National Forest.

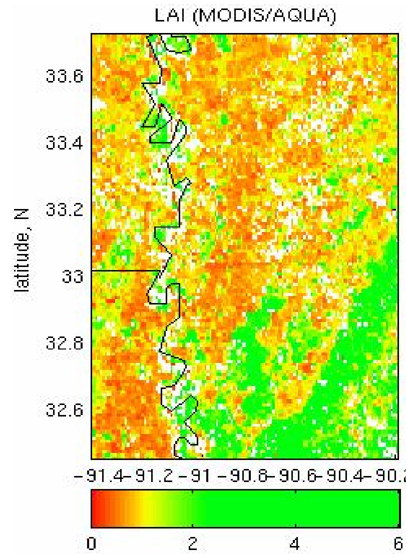

Figure 7. Geographical distribution of Leaf Area Index (LAI): composite for a period from 09/22/2005 to 10/16/2005.

This preliminary study suggests that there is still enough room for quality improvement of soil moisture maps simulated by NOAH/LIS retrospective runs. Better agreement of simulated data with point soil moisture measurements can be achieved with more fine-scale and accurate precipitation forcing.

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