Monthly Technical Report

(Due to AQRP Project Manager on the 8th day of the month following the last day of the reporting period.)

PROJECT TITLE	Soil Moisture Characterization for Biogenic Emissions Modeling in Texas	**PROJECT #**	14-008
PROJECT PARTICIPANTS **(Enter all institutions with Task Orders for this Project)**	The University of Texas at Austin	**DATE SUBMITTED**	9/8/14
REPORTING PERIOD	**From:** 8/1/2014 **To:** 8/31/2014	**REPORT #**	3

A Financial Status Report (FSR) and Invoice will be submitted separately from each of the Project Participants reflecting charges for this Reporting Period. I understand that the FSR and Invoice are due to the AQRP by the 15th of the month following the reporting period shown above.

Detailed Accomplishments by Task *(Include all Task actions conducted during the reporting month.)*

Work during August focused on a comparison between observed and North American Land Data Assimilation System Phase 2 (NLDAS-2) predicted soil moisture water contents at four eastern Texas monitoring locations previously discussed in the July monthly technical report. A summary of the preliminary and on-going analysis follows:

Description of NLDAS-2

The North American Land Data Assimilation System Phase 2 (NLDAS-2) provides high-resolution simulations of land surface variables, including soil moisture. Predictions are available from this on-going dataset beginning in January 1979. NLDAS-2 (Mitchell et al., 2004; Xia et al., 2012) integrates a large quantity of observation-based and model reanalysis data to drive land-surface models and executes at a horizontal grid spacing of 1/8th-degree latitude/longitude over central North America.

Three land-surface models are included in NLDAS-2: NASA's Mosaic, NOAA's Noah, and Princeton's Variable Infiltration Capacity (VIC). Mosaic was developed by Koster and Suarez (1994, 1996) to account for sub-grid vegetation variability. Each grid has three soil layers; the upper two are in the root zone. All grid cells in the Mosaic configuration have a predominant soil type and three soil layers with fixed thickness values of 10, 30, and 160 cm (providing a constant rooting depth of 40 cm and a constant total column depth of 200 cm, ref. Table 1).

The Noah model was developed as the land component of the NOAA National Centers for Environmental Prediction (NCEP) mesoscale Eta model (Betts et al. 1997; Chen et al. 1997; Ek et al. 2003). The model has four soil layers with spatially invariant thicknesses of 10, 30, 60, and 100 cm. The first three layers span the root zone in non-forested regions; the fourth layer is added in forested regions (ref. Table 1).

In this update, we analyze the Mosaic and Noah datasets. In VIC, the thicknesses of soil layers vary spatially making comparisons to in-situ measurements more difficult. The soil depths are different between the NLDAS-2 model configurations and the in-situ measurements (i.e., 5, 10, 20, 50, 100 cm); therefore, a linear interpolation is applied to estimate modeled values at these measurement depths.

Table 1. Vertical soil layers defined in the Mosaic and Noah NLDAS-2 models.

Model	Layer description
Mosaic	0-10 cm, 0-40 cm, 0-100cm, 0-200cm, 10-40 cm, 40-200 cm
Noah	0-10 cm, 0-100cm, 0-200cm, 10-40 cm, 40-100 cm, 100-200cm

Seasonally-averaged soil moisture

Figure 1 shows the comparison of seasonally-averaged soil moisture contents (m^3/m^3) at the Prairie View measurement location (denoted as OBS; ref. previous monthly report for map and description of the Prairie View location) to the NLDAS-2 Mosaic (denoted as MOS) and Noah (denoted as NOAH) predicted values during 2006-2013. Hourly soil moisture observations are first aggregated to a daily timescale (i.e., daily averages) and seasonally-averaged soil moisture values are then generated from the daily averages. In the measurement dataset, missing data gaps occurred periodically from season to season as well as by soil depth; a future report will summarize the missing data periods. A 70% completeness criterion is applied for both the daily and annual seasonal averages to minimize potential uncertainties caused by any large measurement gaps. The model outputs are continuous; for this preliminary analysis all outputs are used to compute corresponding seasonal average values. If significant, future analyses could exclude periods with missing data values in analyzing model outputs.

As shown in Figure 1, both the Mosaic and Noah models tend to over-estimate the soil moisture content in the top soil layers but under-estimate soil moisture in the deep layers with best agreement in middle layers (10 and 20 cm). Both models show a tendency to under-estimate the seasonal variations in moisture contents compared to observations at all soil depths. Between the NLDAS-2 datasets, Noah simulates greater soil water contents at shallow soil depths compared to Mosaic across all seasons; at 100 cm, the directionality is reversed with greater soil moisture for Mosaic compared to Noah.

Figure 2 compares the average seasonal soil moisture contents at the 5 cm soil depth for four eastern Texas monitoring locations (Prairie View, Port Aransas, Austin and Palestine; ref. previous monthly report for map of locations). The Noah seasonal predictions are consistently greater compared to Mosaic (typically by 10-50%) with greatest differences at Port Aransas that has relatively low soil moisture values. At the Austin location, the Mosaic model under-estimates the observed seasonal soil moisture contents while Noah tends to over-estimate. At other locations, the lower Mosaic (compared to Noah) soil moisture values are closer to observed values but are nonetheless often characterized by a substantial over-prediction of 25-100% (except for Palestine in winter that shows under-prediction).

Similar to Figure 2 showing results at 5 cm, Figure 3 compares the average seasonal soil moisture values but at a depth of 100 cm; note that observations at this depth are not collected at Austin. Across all locations except Port Aransas, the Noah values are typically 10-50% lower compared to Mosaic. At Port Aransas, the relatively low observed values are over-predicted by both the Mosaic and Noah models; otherwise, the relatively drier Mosaic values are closer to the observed values with a typical under-prediction of 10-30% (except at Palestine during summer that shows slight over-prediction).

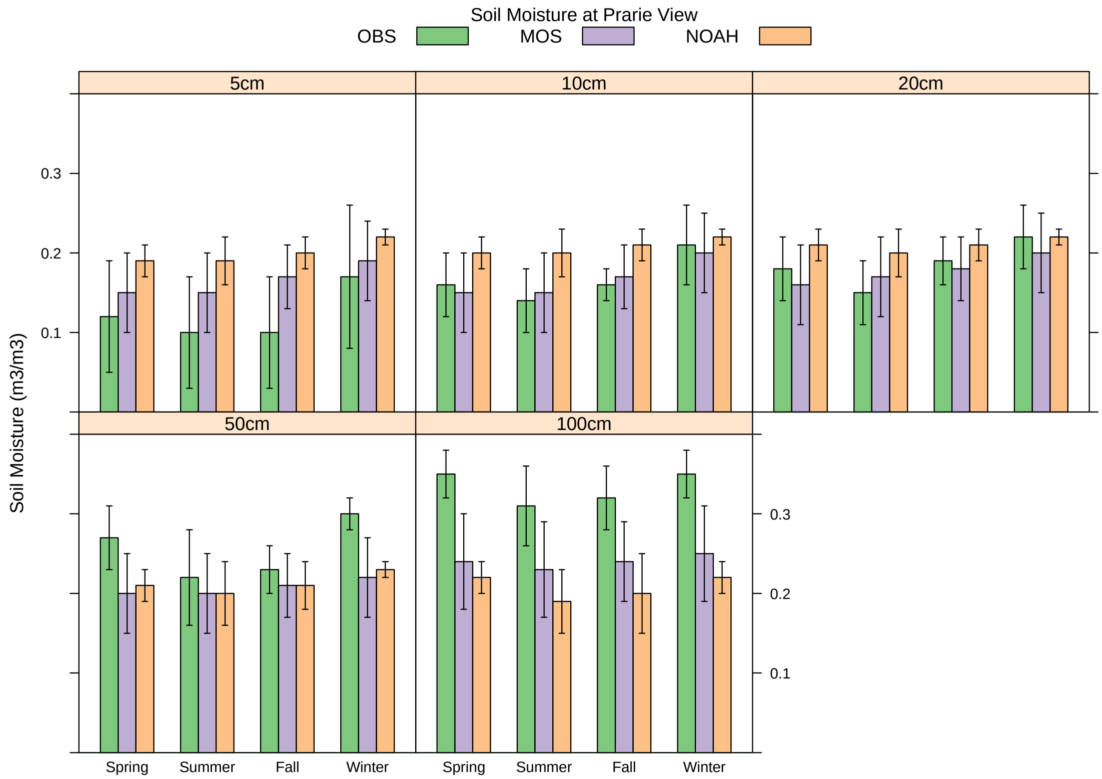


Figure 1. Comparison of NLDAS-2 Mosaic (denoted as MOS) and Noah (denoted as NOAH) model predictions of seasonal soil moisture contents at different soil depths against the SCAN (denoted as OBS) network dataset at Prairie View. Data are averaged for the 2006-2013 period. The error bars represent ± 1 standard deviations across all years.

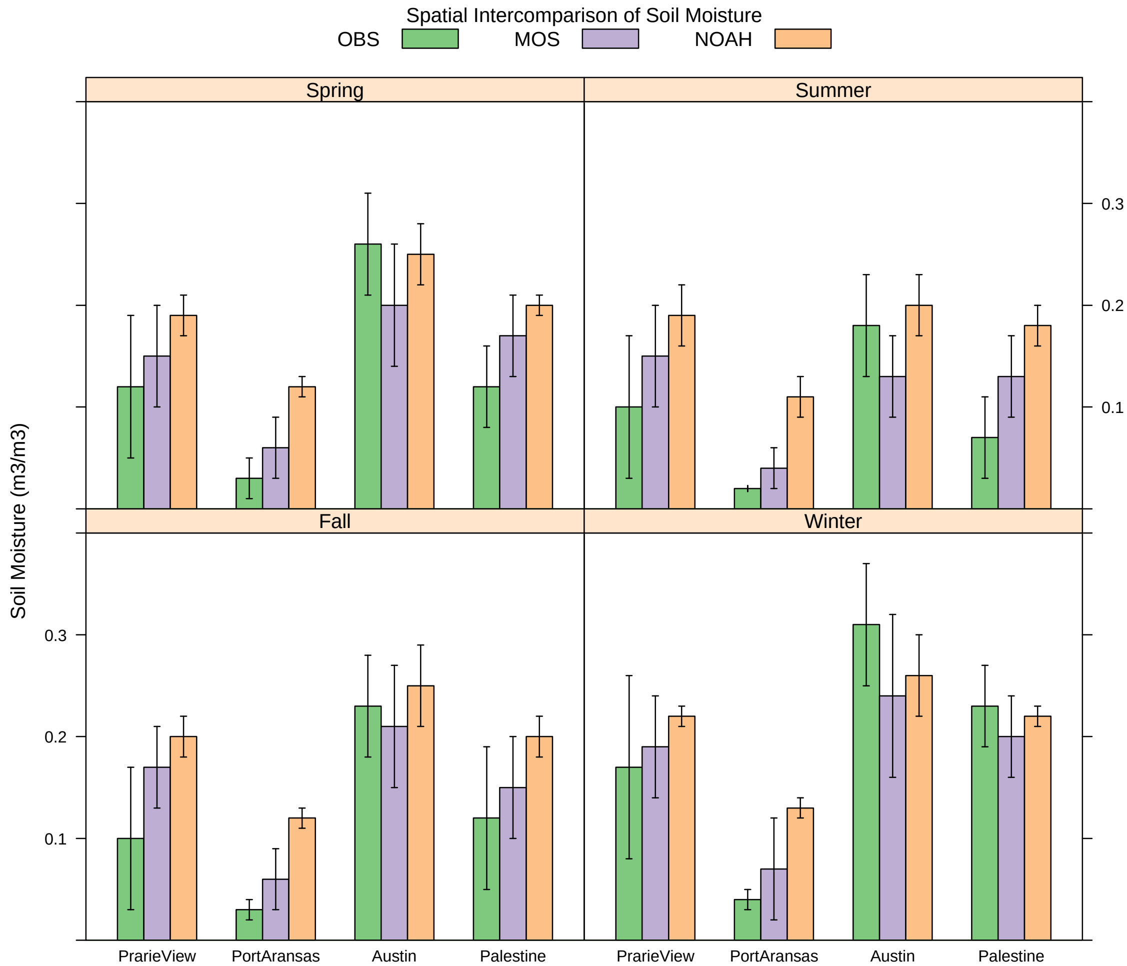


Figure 2. Comparison of NLDAS-2 Mosaic (MOS) and Noah (NOAH) model predictions of seasonal soil moisture content at the 5 cm depth to the USCRN (OBS) network dataset at four eastern Texas monitoring locations. Data are averaged for 2006-2012 at Prairie View and during 2009-2013 at Port Aransas, Austin, and Palestine.

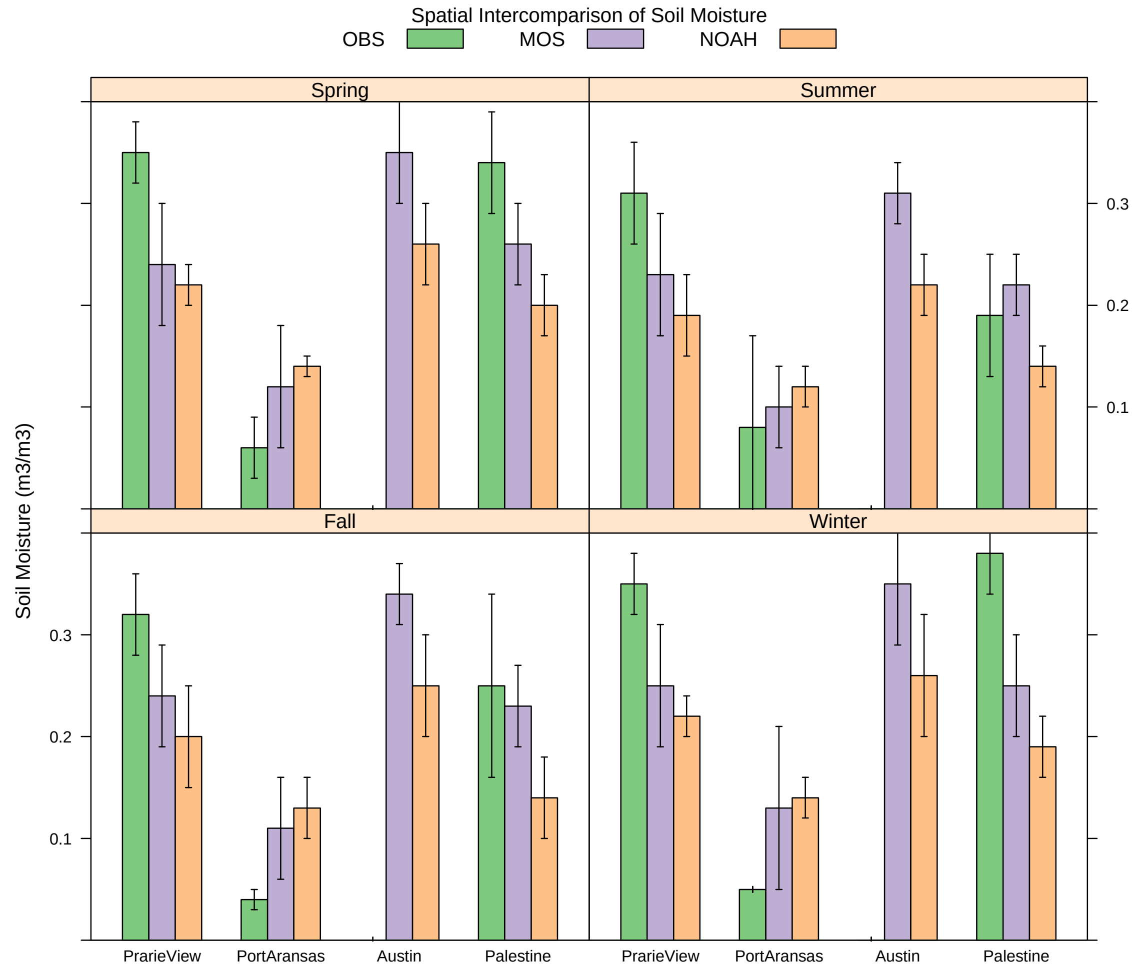
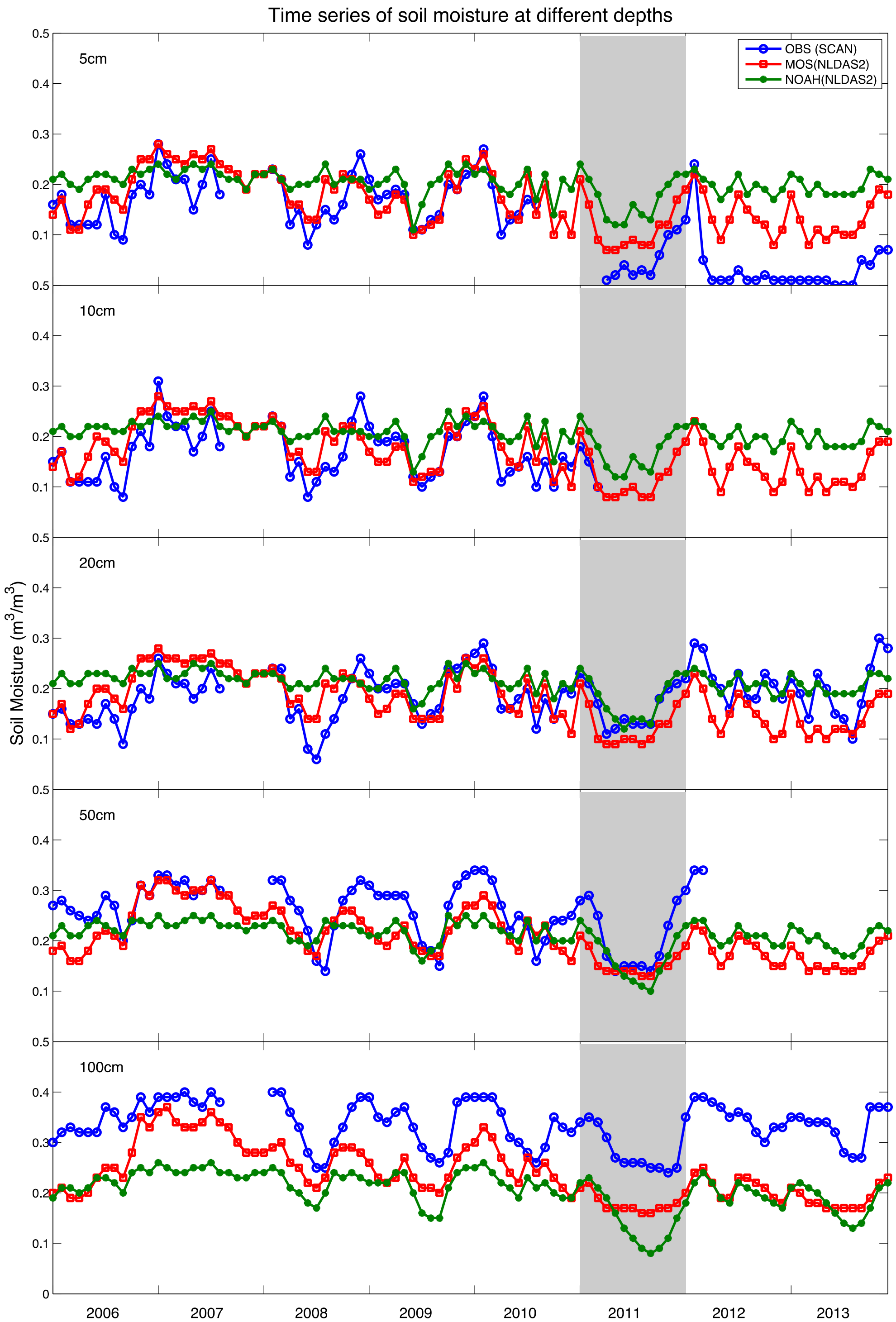


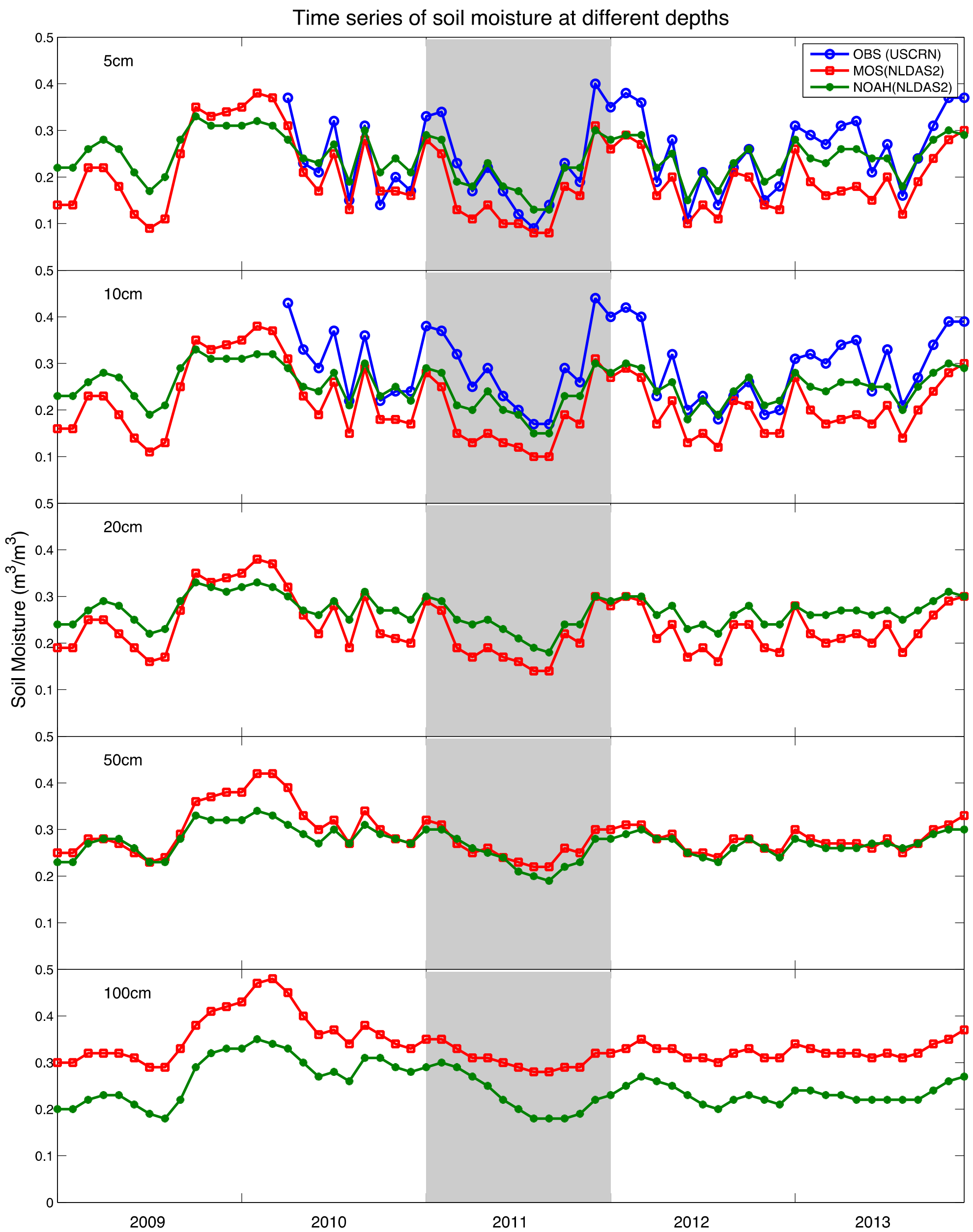
Figure 3. Similar to Figure 2, but at depth of 100 cm.

Inter-annual soil moisture variability

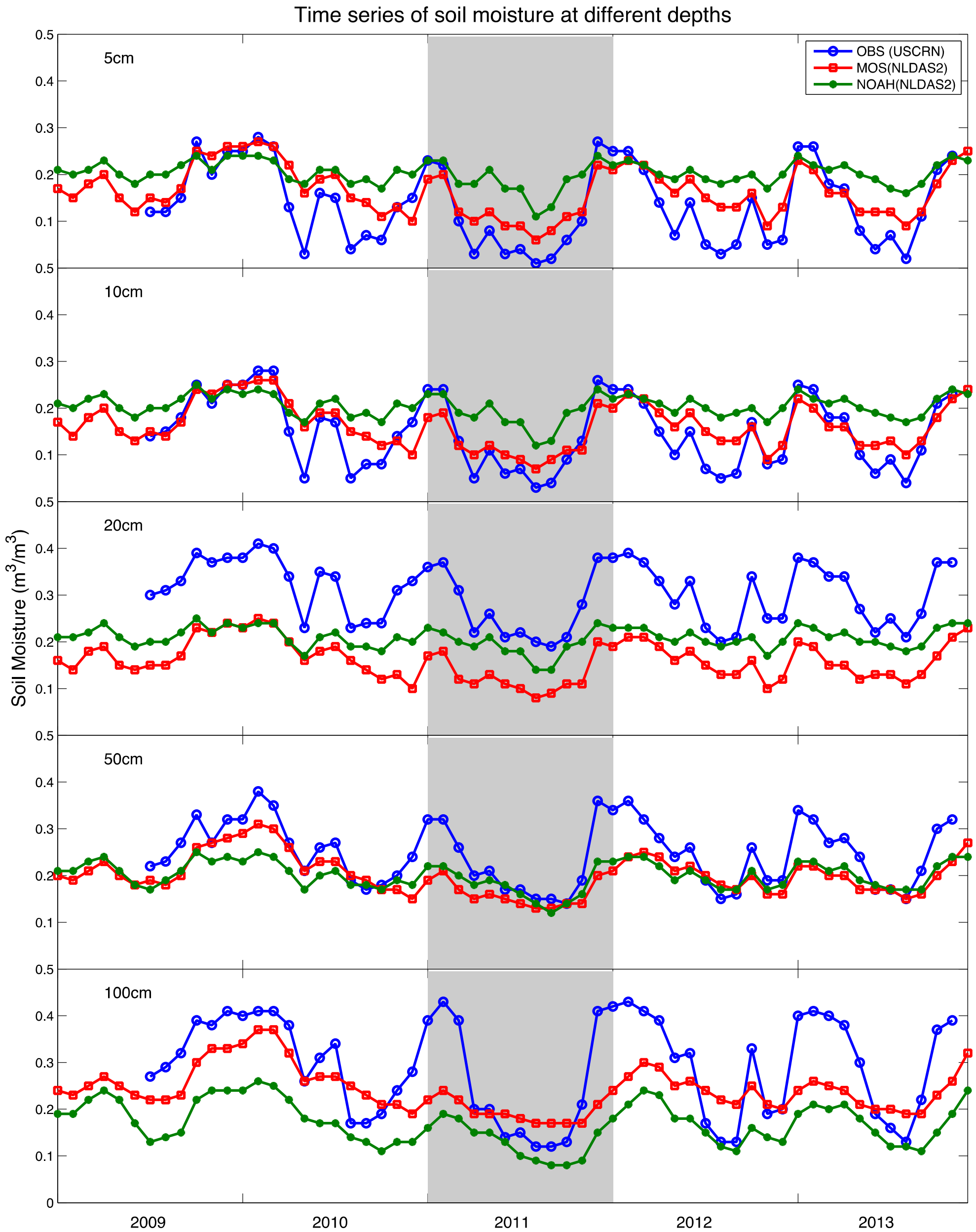
Figure 4 shows the temporal dynamics of soil moisture content (i.e. the drying and re-wetting variations) for the five soil depths at Prairie View. Because of the many oscillations in daily-averaged data, monthly soil moisture values are shown. The Mosaic and Noah models show best agreement with observations for the top soil layers and often capture the directional patterns of wetting-drying-rewetting (especially Mosaic); however, the very low 5 cm soil moisture observations during drought conditions (e.g., year 2011) are not captured by the modeled values. In the deeper soil layers (e.g., > 50 cm), both the Mosaic and Noah performance across all years is relatively poor providing soil moisture values that are generally far drier than observed.

At the Austin location, measurements are only available at 5 cm and 10 cm. The pattern is similar to that at Prairie View (Figure 5); both the Mosaic and Noah models can capture the wetting-drying-rewetting variations at 5 and 10 cm. Conditions in Austin during the drought year 2011 are better simulated compared to Prairie View. At the Palestine site (Figure 6), the magnitude of predicted variations over time is greater for Mosaic compared to Noah but both models fail to properly capture the variations in observed soil moisture. The predictions tend to be too wet at the upper depths and too dry at depths >20 cm where the performance is relatively poor especially during the observed wetter periods.





Time series of soil moisture at different depths
OBS (USCRN)
MOS(NLDAS2)
NOAH(NLDAS2)
5cm
10cm
20cm
50cm
100cm
Soil Moisture (m3/m3)
0
0.1
0.2
0.3
0.4
0.5
2009
2010
2011
2012
2013


Time series of soil moisture at different depths
5cm
10cm
20cm
50cm
100cm
OBS (USCRN)
MOS(NLDAS2)
NOAH(NLDAS2)
Soil Moisture (m3/m3)
2009
2010
2011
2012
2013

Preliminary Analysis (*Include graphs and tables as necessary.)*
Initial analysis of observed and predicted soil moisture datasets for Texas as described above.

Data Collected *(Include raw and refine data.)*
On-going collection of modeled soil moisture datasets as described above.

Identify Problems or Issues Encountered and Proposed Solutions or Adjustments
None this period.

Goals and Anticipated Issues for the Succeeding Reporting Period
The team will continue to focus on fully investigating and summarizing all available soil moisture databases (observations and predictions) for eastern Texas during 2006-2013. In addition, work will begin on building inputs to the biogenics estimation model MEGAN in order to predict isoprene emissions at the grid cells that contain the four previously discussed Texas soil moisture monitoring locations.

Detailed Analysis of the Progress of the Task Order to Date *(Discuss the Task Order schedule, progress being made toward goals of the Work Plan, explanation for any delays in completing tasks and/or project goals. Provide justification for any milestones completed more than one (1) month later than projected.)*
Ongoing.

Submitted to AQRP by:

Principal Investigator: Elena McDonald-Buller

(Printed or Typed)

References

Betts, A., F. Chen, K. Mitchell, and Z. Janjic (1997), Assessment of the land surface and boundary layer models in two operational versions of the NCEP Eta model using FIFE data, *Mon. Weather Rev.*, 125, 2896-2916.

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Ek, M. B., K. E. Mitchell, Y. Lin, E. Rodgers, P. Grunman, V. Koren, G. Gayno, and J. D. Tarpley (2003), Implementation of Noah land surface model advances in the National Centers for Environmental Prediction operational mesoscale Eta model, *J. Geophys. Res.*, 108(D22), 8851.

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Koster, R., and M. Suarez, 1996: Energy and water balance calculations in the Mosaic LSM. *NASA Tech. Memo.*, 104606, **9**, 60 pp.

Mitchell, K.E., D. Lohmann, P.R. Houser, E.F. Wood, J.C. Schaake, A. Robock, B.A. Cosgrove, J. Sheffield, Q. Duan, L. Luo, R.W. Higgins, R.T. Pinker, J.D. Tarpley, D.P. Lettenmaier, C.H. Marshall, J.K. Entin, M. Pan, W. Shi, V. Koren, J. Meng, B.H. Ramsay, and A.A. Bailey, 2004: The multi-institution North American Land Data Assimilation System (NLDAS): Utilizing multiple GCIP products and partners in a continental distributed hydrological modeling system, *J. Geophys. Res.*, **109**, D07S90.

Xia, Y., K. Mitchell, M. Ek, J. Sheffield, B. Cosgrove, E. Wood, L. Luo, C. Alonge, H. Wei, J. Meng, B. Livneh, D. Lettenmaier, V. Koren, Q. Duan, K. Mo, Y. Fan, and D. Mocko, (2012), Continental-scale water and energy flux analysis and validation for the North American Land Data Assimilation System project phase 2 (NLDAS-2): 1. Intercomparison and application of model products, *J. Geophys. Res.*, 117, D03109.