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**	11/7/14
REPORTING PERIOD	**From:** 10/1/2014 **To:** 10/31/2014	**REPORT #**	5

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.)*

Isoprene emissions were predicted for three Texas soil moisture monitoring locations: Palestine, Prairie View, and Port Aransas. These locations were chosen for a by-site analysis because in-situ observational data were available for 2011 (record drought and heat in Texas) and the sampling depths (100cm) were sufficient to represent deep soil moisture. Input soil moisture datasets for the MEGAN simulations included in-situ observations and estimates provided by the NLDAS-2 Mosaic and Noah datasets. The results have been summarized in the attached poster presentation to be presented at the 2014 American Geophysical Union (AGU) annual meeting in San Francisco during December 15-19, 2014.

During October, our focus was also on developing a comparison of observed and Mosaic/Noah soil moisture values using all available SCAN and CRN observational data within the 12km grid domain during 2006-2013. Maps showing the locations and annual data completeness are provided as Figures 1 (SCAN) and 2 (CRN).

In addition, the 12km grid domain shown in Figures 1 and 2 has been divided into four sub-regions (West, Central West, Central East, and East) in order to quantify the seasonal and interannual variability of the NLDAS-2 Mosaic and Noah datasets (regionally-averaged soil moisture by depth) during 2006-2013.

Analyses for the two efforts above are on-going; preliminary results will be provided in the December 8 monthly technical report.

Figure 1. Locations and annual data completeness at SCAN monitoring stations.
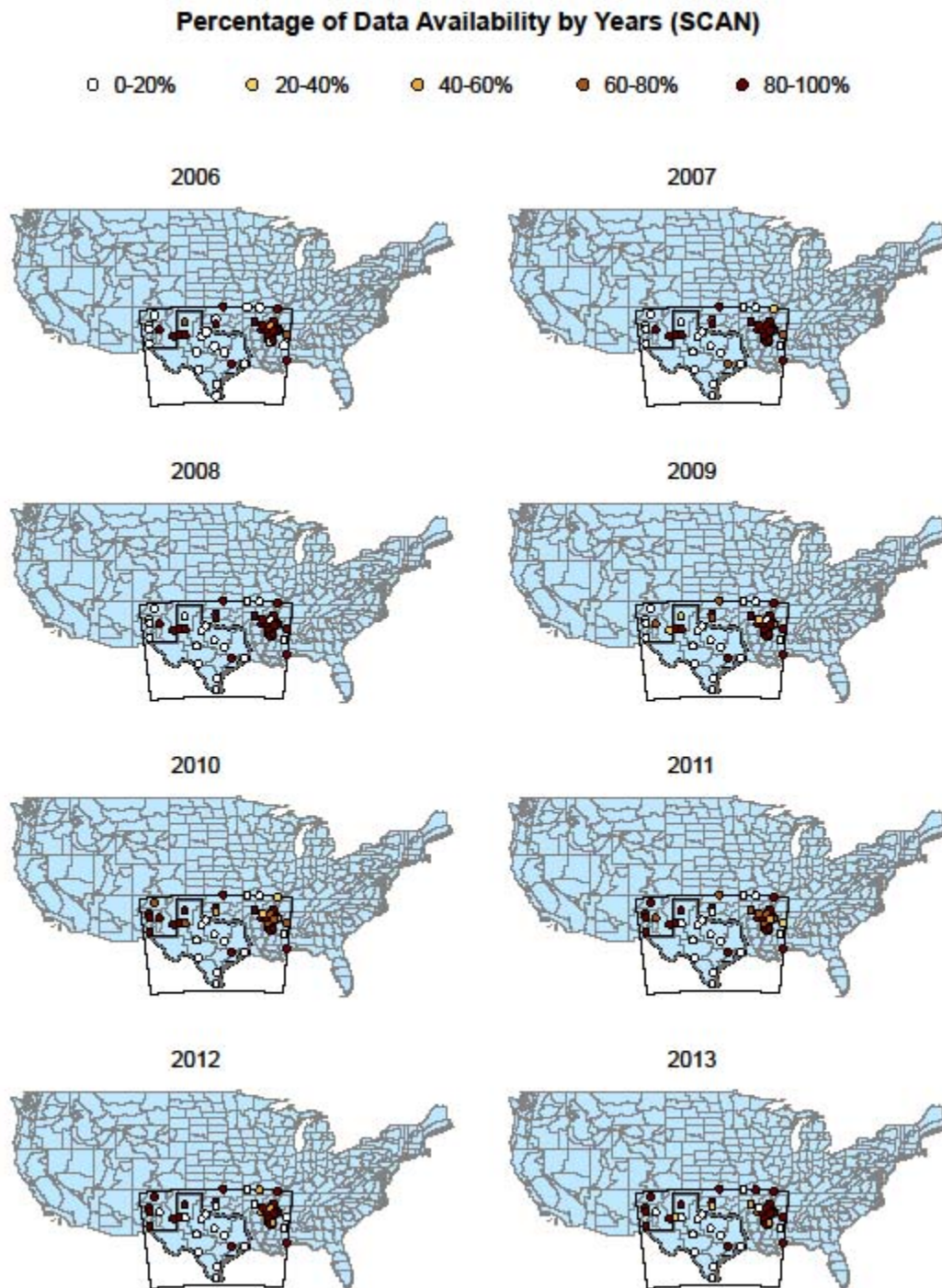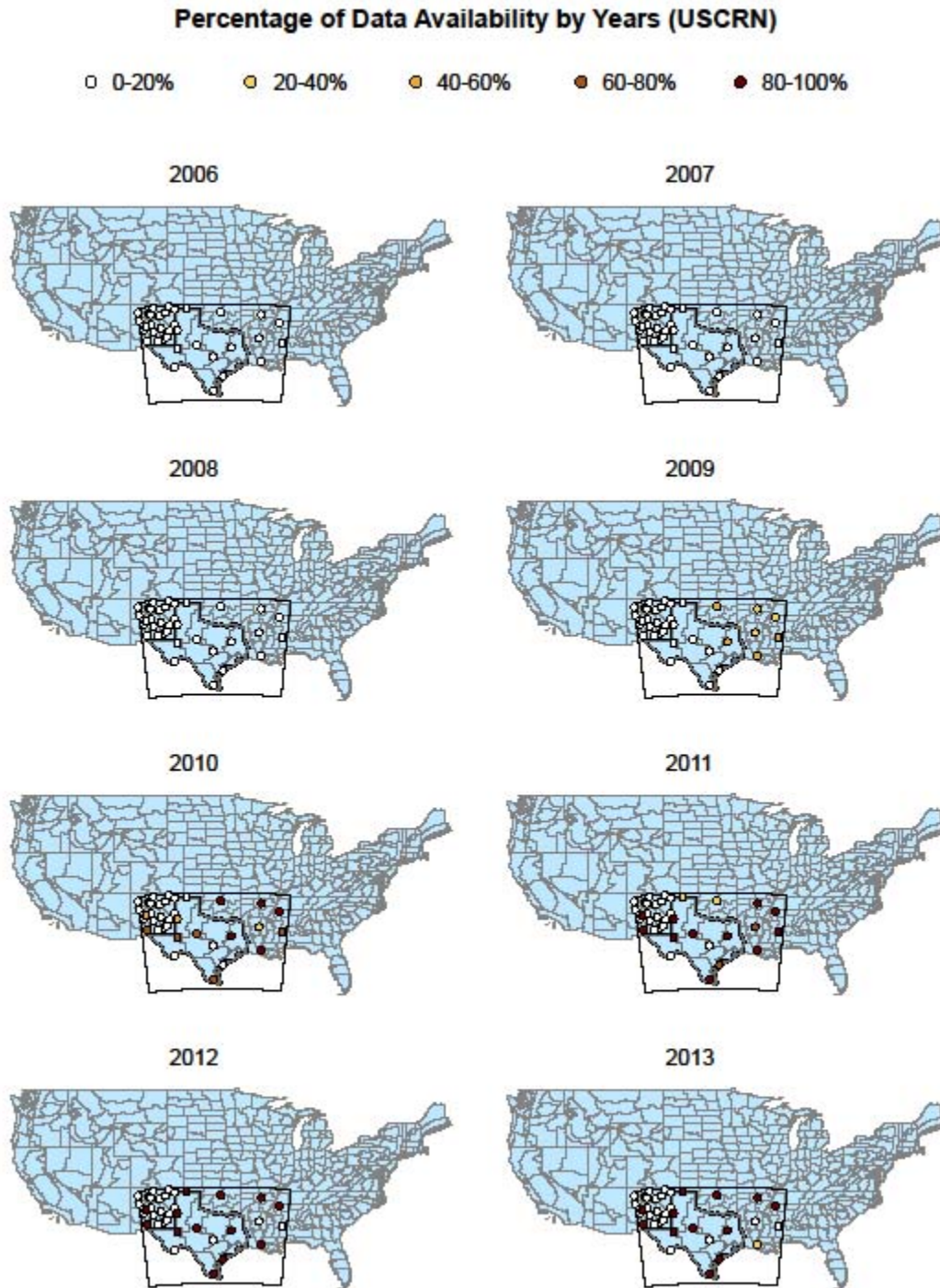

Percentage of Data Availability by Years (SCAN)

○ 0-20%   ○ 20-40%   ○ 40-60%   ● 60-80%   ● 80-100%

Figure 2. Locations and annual data completeness at CRN monitoring stations.

Percentage of Data Availability by Years (USCRN)

Soil Moisture Characterization for Biogenic Emissions Modeling in Texas

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Introduction

- Isoprene is among the most significant biogenic volatile organic compounds (BVOCs) emitted globally each year.[1]

- Annual biogenic emissions in Texas ranked first within the continental U.S. in the 2011 National Emissions Inventory.

- Soil moisture conditions may have substantial impacts on biogenic emissions during periods of drought.[1]

- Drought is a recurring phenomena in Texas; similar to most of the western U.S., the frequency and intensity of Texas droughts are expected to increase over the coming decades.[2]
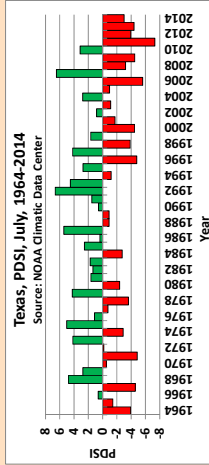
Texas, PDSI, July, 1964-2014
Source: NOAA Climatic Data Center

Fig. 1 July PDSI values for Texas during 1964-2014; **2011 had all-time record drought and heat throughout the state.**
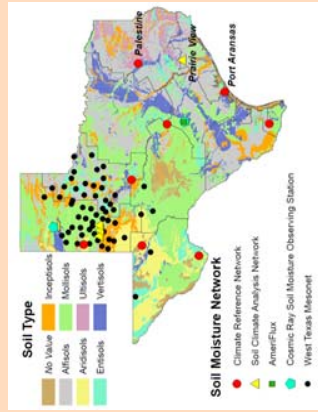
Soil Monitoring Locations

Fig. 2 Locations of soil moisture observation stations in Texas overlain on a soils type map. Measurement data collected at the labeled sites in eastern Texas during 2006-2013 are currently being investigated.

NLDAS-2

The density of soil monitoring stations over the eastern half of Texas, which is heavily vegetated and contains the major metropolitan areas, is sparse. Continuously updated soil moisture data is available from the North American Land Data Assimilation System-Phase II (NLDAS-2). NLDAS-2 model output has 1/8 degree resolution and is available from 1979 to present. NLDAS-2 is an offline modeling system running four land models (Mosaic, Noah, SAC, and VIC); Noah and Mosaic were developed within the surface-vegetation-atmosphere transfer scheme community.[3]

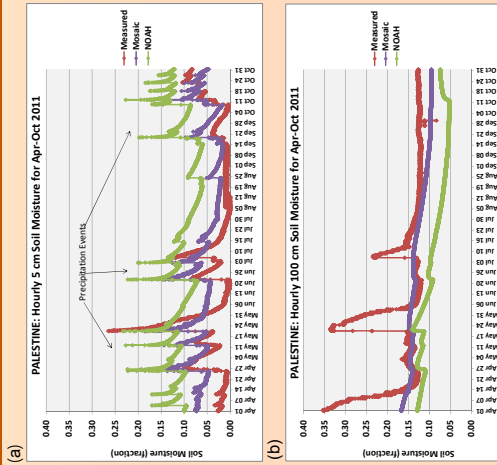## Hourly Observed and NLDAS-2 Soil Moisture

Fig. 3 Hourly observed and Mosaic/Noah predictions of volumetric soil moisture content (fraction) at the Palestine monitoring location during Apr-Oct 2011 at soil depths of (a) 5 cm and (b) 100 cm.

Comparison of observed and Mosaic/Noah predictions of soil moisture across the three eastern Texas locations shows that NLDAS-2 often captures the abrupt increases in soil moisture associated with precipitation events; however, the relative changes with respect to depth are often different. The NLDAS-2 predictions generally replicate the seasonal (i.e., long-term) changes in observed soil moisture; however, a baseline offset is evident.

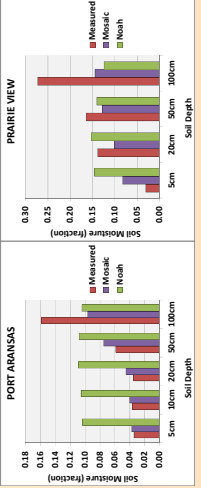## Average Apr-Oct 2011 Soil Moisture

Fig. 4 Average Apr-Oct 2011 observed and predicted (Mosaic and Noah) volumetric soil moisture contents at (left) Port Aransas and (right) Prairie View.

Across the three eastern Texas monitoring locations, Mosaic predictions showed the best agreement with observations and was directionally consistent with the relative changes in soil moisture values between layers. Unlike observations, Noah had little variability with respect to soil depth. Both Mosaic and especially Noah tended to be too wet in the near-surface layer and too dry at deeper depths compared to observations.

MEGAN Configuration

Isoprene emissions were calculated as[4]:

$$\varepsilon^i = \gamma^i \sum_j \chi_j \varepsilon_j$$

where ε is the basal emission factor for vegetation type j with fractional coverage χ_j within a model grid; γ is the overall emissions activity factor that multiplicatively accounts for the effects of environmental variations on leaf age, canopy environment, and soil moisture ($\gamma^i = \gamma^i_{age} \cdot \gamma^i_{sm}$) such that:

$$\gamma_{sm} = \sum_{i}^{n} \frac{f_{i,root}}{\Delta z} max(0, min(1, (\theta^i - \theta_{wilt})/0.04))$$

where θ^i is the soil moisture content and θ_{wilt} is the wilting point (content below which water is unavailable to plants), 0.04 is an empirical coefficient, and $f_{i,root}$ is the fraction of root mass within each soil layer. γ_{sm} decreases linearly from a value of one at 0.04 above the wilting point to zero at and below the wilting point. Based on availability of observations, 4 or 5 soil layers to a depth of 2 meters were specified (e.g., 0-8,8-15,15-35,35-75,75-200 cm); a single wilting point value was applied across all layers. The MEGAN configuration follows the approach of Huang et al.[5]

Table 1 Wilting point values (fraction).

Site Name	SSURGO	Mosaic	Noah
Palestine	0.107	0.018	0.023
Port Aransas	0.040	0.018	0.023
Prairie View	0.162	0.091	0.047

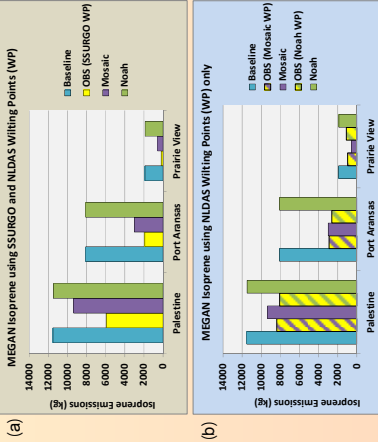## Predicted Isoprene Emissions (Apr-Oct 2011)

Fig. 5 Total isoprene emissions predicted for Apr-Oct 2011 at three Texas locations using obs/Mosaic/Noah soil moisture datasets. The simulations that used observations were repeated to utilize (a) SSURGO and (b) NLDAS-2 wilting points. Mosaic/ Noah employed NLDAS-2 values only. For comparison, a baseline run assumed no soil moisture deficit (i.e., γ_{sm}=1).

Similar to the comparison results for soil moisture, isoprene predictions that used observations had better agreement with Mosaic compared to Noah.

Differences in the magnitude of emissions between locations reflect MEGAN vegetation types; Prairie View is dominated by grasses, Port Aransas by broadleaf deciduous trees, Palestine has significant contributions from needleleaf evergreen trees.

Predicted emissions had substantial sensitivity to the input soil moisture dataset; for example, Noah predictions were same as baseline while Mosaic emissions at Port Aransas were lower by >60%.

In addition to soil moisture inputs, emissions are highly sensitive to the wilting point values employed.

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References

1. Sindelarova et al., 2014, *Atmos. Chem. Phys. Discuss.*, **45**, 10725-10788.
2. National Climate Assessment, 2014, http://nca2014.globalchange.gov/
3. Xia et al., 2012, *J. Geophys. Res.*, **117**, Issue D3.
4. Guenther et al., 2012, *Geosci. Model Dev.*, **5**, 1471-1492
5. Huang et al., 2014, *Atmos. Environ.*, **92**, 240-249.

Preliminary Analysis (*Include graphs and tables as necessary.*)
Analysis of predicted isoprene emissions at three Texas monitoring stations using observed and predicted soil moisture datasets as provided in the attached AGU presentation.

Data Collected (*Include raw and refine data.*)
NLDAS-2 Mosaic and Noah soil moisture data within the 12km grid domain have been retrieved and processed for years 2006-2013. In addition, once-per-day observational data have been gathered and processed for the monitoring locations shown in Figures 1 and 2.

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

Goals and Anticipated Issues for the Succeeding Reporting Period
Analysis of the NLDAS-2 datasets for the 12km grid domain will continue to quantify the seasonal and interannual variation of soil moisture by depth between the Mosaic and Noah datasets. Analysis will also continue on a comparison of measured and NLDAS-2 predicted soil moisture values for grid cells that contain monitoring stations during all or a portion of 2006-2013 within the 12km grid domain.

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)