AQRP Monthly Technical Report

PROJECT TITLE	Improving Modeled Biogenic Isoprene Emissions under Drought Conditions and Evaluating Their Impact on Ozone Formation	**PROJECT #**	14-030
PROJECT PARTICIPANTS	Qi Ying, Gunnar W. Schade, John Nielsen-Gammon, Huilin Gao	**DATE SUBMITTED**	10/8/2014
REPORTING PERIOD	**From:** September 1, 2014 **To:** September 30, 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

Task 1: Meteorology simulation with WRF.
Completed WRF simulations using the CLM4 model for April – October 2011. The simulations are initialized using the North American Regional Reanalysis (NARR) data. Land surface processes were simulated using the Noah land surface model. Model performance for surface meteorology conditions and soil moisture were compared. Soil moisture data from North American Land Data Assimilation Systems for both 2007 and 2011 were downloaded. An initial evaluation of the NLDAS data for the 2011 modeling period was conducted.

Task 2: Perform field and laboratory measurements on common Texas tree species
Note: Due to an additional project start delay from June to July and the unanticipated need to move all our seedlings to a different greenhouse in July, all monthly milestones described in the QAPP had to be moved by one month ahead

The original August (now September, 3rd reporting month) milestones were addressed as follows:

a. evaluate baseline measurements – Figures 1 through 3 show preliminary baseline isoprene emissions results for selected viable trees in this study. For post oak between-tree or (different leaves) among-tree emission differences were not statistically significant. For water oak, emissions similarly were not statistically different. Two lower emitting trees were also measured but those trees had significantly lower photosynthesis rates and one has since perished
b. select and mark trees for intermediate and drought treatments – we selected seedlings based on (i) biomass (growing plants are assumed to have adjusted to the greenhouse), (ii) lack of pest infection, and (iii) leaf maturity (wide/large enough for measurements); there will be two groups: the baseline group and the drought regime group, each containing 3-4 plants
c. begin treatment schedule – treatments will begin in October (see also "problems" section)

d. execute 2nd field trip to Freeman ranch for *Q. fusiformis* measurements, and two regular field trips – we executed the Freeman Ranch field trip on 7 Oct 2014; additional field measurements were performed in parallel to our NSF project.

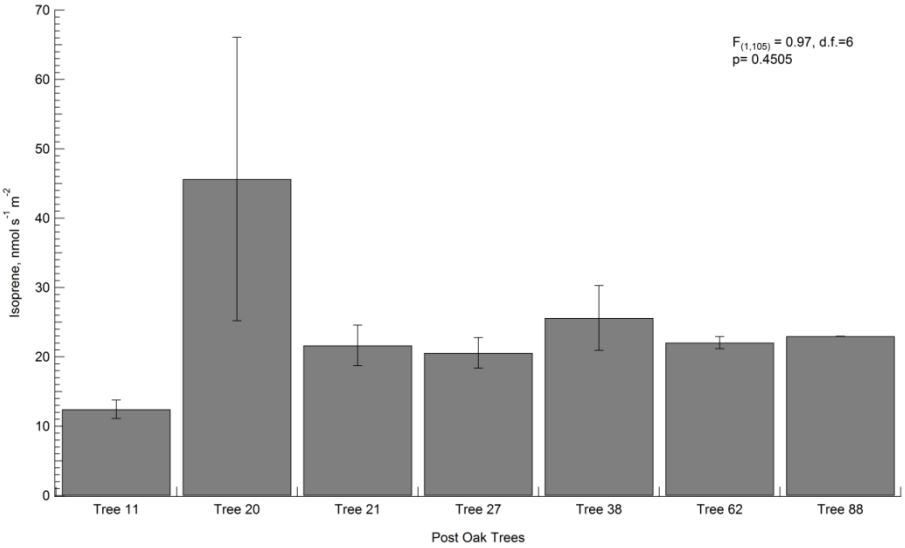

Figure 1: Preliminary isoprene emission rates from the post oak seedlings. Error-bars show variability (standard error, se, of the mean, sd/√n) among leaves belonging to the one seedling identified by number.

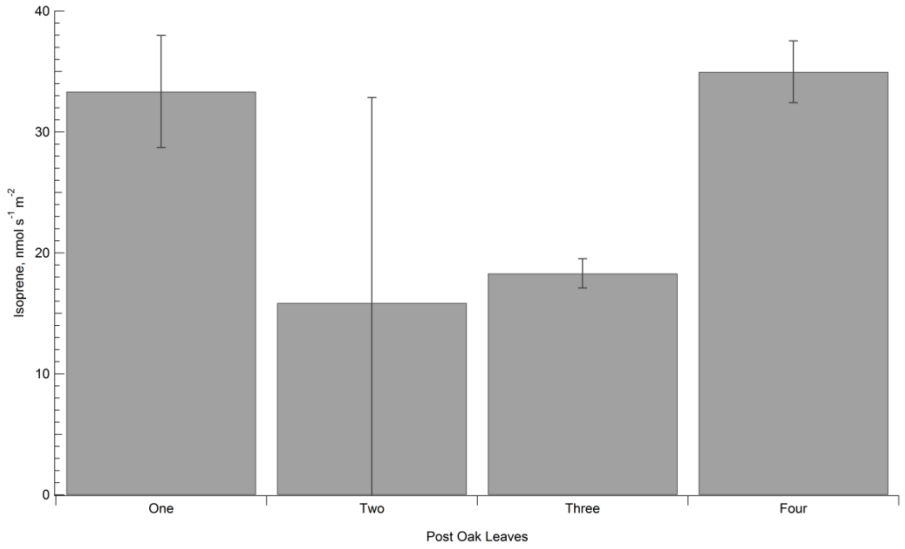

Figure 2: Preliminary isoprene emission rates from leaves 1-4 of one post oak seedling. Error-bars show variability (se) as determined from replicate sample taking.

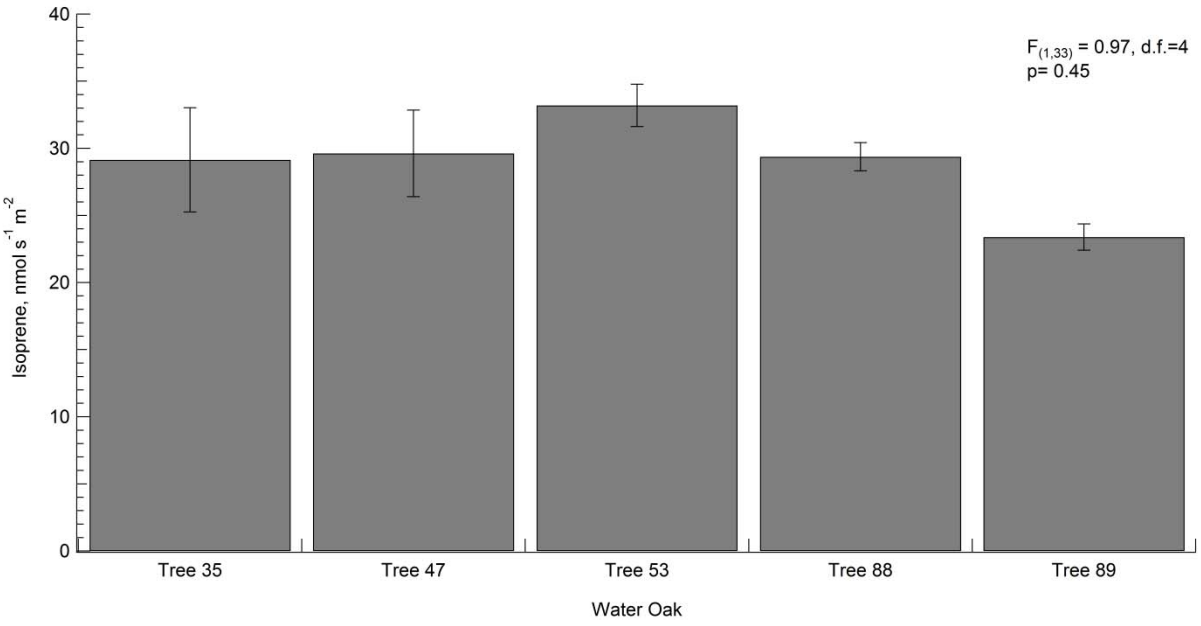

Figure 3: Preliminary isoprene emission rates from the water oak seedlings. Error-bars show variability (se) among leaves belonging to the one seedling identified by number.

e. suggest preliminary drought response parameterization based on field data in Sep. 2014 – since no drought was experienced anywhere in East Texas, and also not at the Freeman Ranch, this task could not be addressed; however, we plan to develop this task over the next few months from (i) older data, (ii) the greenhouse measurements, and (iii) an additional field trip to the Freeman Ranch should drought develop in October

Task 3: Evaluate drought parameterization for isoprene emissions – Not started yet.

Task 4: Perform regional BVOC modeling using MEGAN

MODIS LAI data for the entire years of 2007 and 2011 have been downloaded and processed to match the domain and resolution in Alex Guenther's data. Alex's data (as provided on his old website in NCAR) are not complete for 2007 and 2011.

Task 5: Perform regional air quality simulations

Problems in 2011 NEIv1 were resolved and emissions for the entire year have been processed (except biogenic sources).

Preliminary Analysis

Task 1:
Soil moisture predicted using the Noah land surface scheme and initialized with the North American Regional Reanalysis (NARR) under predicted soil moisture at all levels (above 1.0 m). Figure 4 shows observed soil moisture averaged using data from all available soil moisture measurements in the 4-km Texas domain within the TAMU North American Soil Moisture

Database, as well as the corresponding averaged predictions (avg_NARR) for May 2011. The Noah predictions were interpolated to the points where the measurements were made. As the soil moisture levels in the lower layers do not change significantly, it is suspected that the soil moisture data in the NARR data might not be accurate for lower layers. Figure 1 also shows the averaged soil moisture based on the North American Land Data Assimilation System (NLDAS). The NLADS data captures the soil moisture in the lower layers better than the NARR data, which warrants an additional WRF simulation using the NLADS soil moisture.

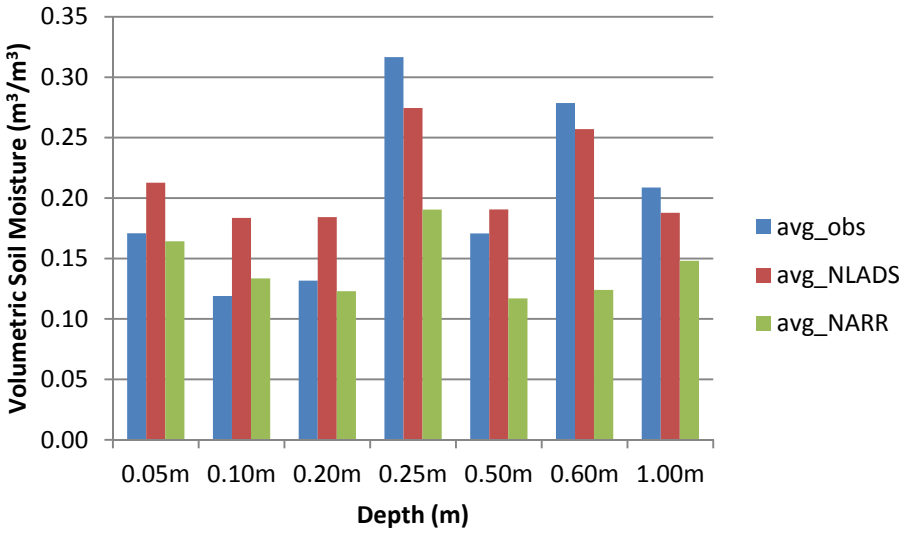

Figure 4:. Observed and WRF-predicted (NARR) soil moisture, and soil moisture from NLADS. Note: The NLADS soil moisture has not been applied in WRF simulations yet.

Predicted soil moisture based on the Noah land surface scheme were compared with the CLM4 scheme, both using the NARR reanalysis data. No significant differences were observed in soil moisture based on several statistical measures of model performance. For example, Figure 5 shows the mean bias (MB) for all predictions in 2011.

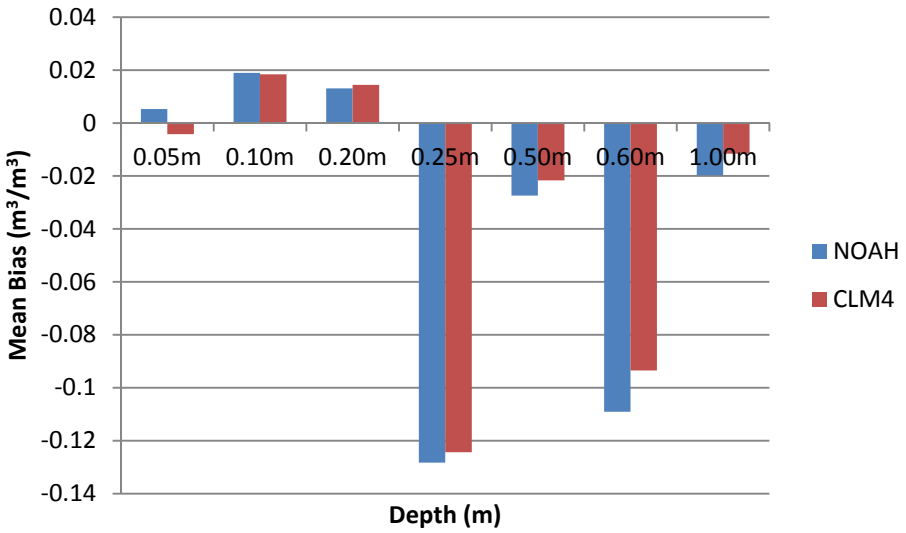

Figure 5: Mean bias (MB, Observation – Prediction) of soil moisture for April – October 2011. Predictions were based on the Noah (NOAH) and the CLM4 land surface schemes.

Task 2: During the month of September several factors had affected the timeline proposed, as well as the outcome of the experiments. The modifications done to the greenhouse, such as the asbestos abatement and the delay of the addition of lights to the greenhouse affected plants' growth and health. During the remodeling period the greenhouse doors were kept open, allowing additional pests to enter the greenhouse. Tree damage was evident, and this forced a pesticide treatment in early October.

The delay on the addition of lights in the greenhouse is another factor that will likely modify the time frame that we proposed for out project. We hope to delay the onset of senescence by providing additional light sources and promote a longer growing period in the seedlings by simulating summer daylight patterns throughout the fall.. Unfortunately, the lamps were not operational until early October, and senescence may have begun for some specimen. While isoprene emission variability (Figs. 1-3) is limited and may allow a clear distinction between drought-stressed and control plants, the overall stress in these plants as we approach senescence may create a higher than normal variability and potentially either invalidate the measured response's representativeness or render the development of a more precise drought-function for the emission model impossible, meaning no improvement over the current function. It is thus a distinct possibility that we cannot address the drought regime task appropriately through our greenhouse measurements this year.

Task 4: We examined the LAI data for 2007 and 2011. The drought effect on soil moisture is obvious. LAI in 2011 in most part of Texas (especially western Texas) were much lower compared to the values in 2007, as shown in Figure 6 for a one-week period in August. This suggests that the importance of using correct LAI data for biogenic emission modeling, especially under drought conditions.

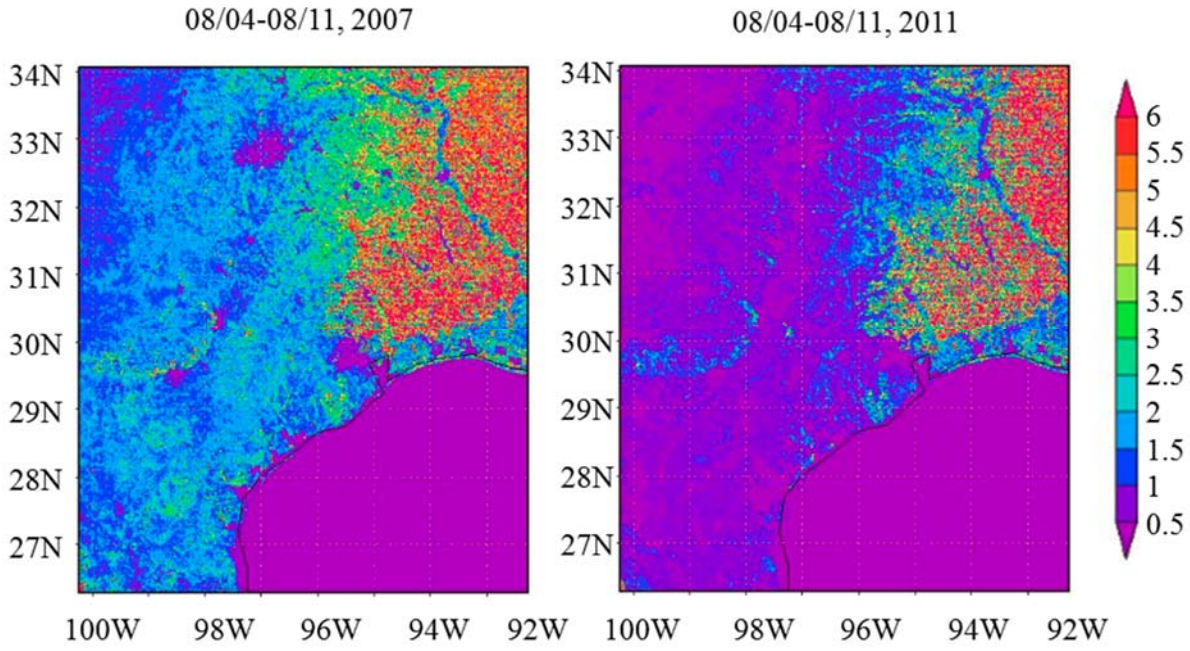

Figure 6: MODIS Leaf Area Index (LAI) for August 4-11, 2007 and 2011 for the 4-km domain.

Data Collected

1. Leaf-level photosynthesis and isoprene emissions data for *Quercus fusiformis*, obtained at the Freeman Ranch near San Marcos in early October 2014
2. Leaf-level photosynthesis data for water oak and post oak seedlings in the greenhouse during several multi-day periods in September 2014, the latter including isoprene emissions using both carbon-based and Tenax adsorbent cartridges (see above)

Identify Problems or Issues Encountered and Proposed Solutions or Adjustments

1. Since it is available, we shall deploy a LI840 CO_2/H_2O analyzer for ambient CO_2 measurements to the greenhouse in October; currently awaiting calibration
2. Since we cannot guarantee that – due to the past and current issues – all seedlings will remain viable for the drought study throughout October, including the absence of senescence and pests due to the time of year, we recommend allowing us to plan an additional set of experiments for spring 2015. Since spring leaf-out occurs early in Texas, we are confident that a set of viable seedlings with new leaves will be available in May 2015. Redoing the experiment in spring will allow for stronger, less stressed, and potentially more seedlings for a statistically more representative study. Some of the seedlings have started re-growing leaves in September, so we know that not all trees previously classified as "dead" are actually so, and may thus become viable again this fall or next spring. While this is going to cause delays in the other tasks, we will make every effort to provide an improved drought-response for the modeling part in the upcoming months.

Goals and Anticipated Issues for the Succeeding Reporting Period

<u>Goals</u>

Task 1: Perform WRF modeling for 2007 and 2011 using soil moisture from North American Land Data Assimilation System (NLDAS).

Task 2: 1) Execute field work; 2) continue leaf-level measurements in the greenhouse, and execute drought treatments; 3) execute a 3rd field trip to Freeman Ranch, if drought is actually developing in October/November

Task 4: Finish MEGAN modeling for 2007 and 2011 with default parameterization.

Task 5: Finish generating all anthropogenic emissions; start a preliminary CMAQ simulation.

Detailed Analysis of the Progress of the Task Order to Date

Task 1: Due to delayed start of the project, we are behind schedule slightly. We expect Task 1 to be completed by end of October instead of September, as stated in the work plan. However, we

will start Task 4 in October 2014 as planned, generating biogenic emissions with completed WRF runs at that time. We don't expect a delay in Task 4 at this point.

Task 2: Due to delayed start of the project, we are one month behind schedule.

Task 5: On schedule.

Submitted to AQRP by: Qi Ying

Principal Investigator: Qi Ying