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:** October 1, 2014 **To:** October 31, 2014	**REPORT #**	4

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 another set of WRF simulations for April – October 2011. The simulations are initialized using the North American Regional Reanalysis (NARR) data. Soil moisture data from North American Land Data Assimilation Systems (NLDAS) were used to replace the soil moisture data in NARR. Land surface processes were simulated using the Noah land surface model. MODIS year specific LAIs were used instead of the default MODIS data in the WRF input dataset. Model performance for surface meteorology conditions and soil moisture were compared. This set of simulations shows greater improvement in predicted meteorology and soil moisture conditions.

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 October/November/December milestones were addressed as follows:

a. compare baseline to treatment measurements: Measurements commenced in the greenhouse during October. Figures 1 and 2 how the observed greenhouse temperatures and light levels. Figures 3 through 6 show preliminary baseline (Figs. 1&3) and drought treatment (Figs. 2&4) group photosynthesis rates and isoprene emissions results. The post oak in the control group showed relative stability in photosynthesis and isoprene emissions, while the drought treatment groups showed lower and slightly higher variability in isoprene emissions under reduced photosynthesis rates. Similarly, after an increase from early to late October, the water oak seedlings in the control group showed relatively stable photosynthesis rates and isoprene emissions, while the drought treatment group displayed lower rates and higher variability.

b. analyze observed drought responses of seedlings and field-grown mature trees: In Figures 7 and 8 we show two examples of the development of photosynthesis and isoprene emissions with the measured soil moisture over time during the drought treatment period in October

c. execute two regular field trips in October: this was not accomplished due to lack of time and scheduling conflicts

d. submit data files to UT: We will begin submitting Excel files with the data to the sponsor after approval of the format attached to this report as an example.

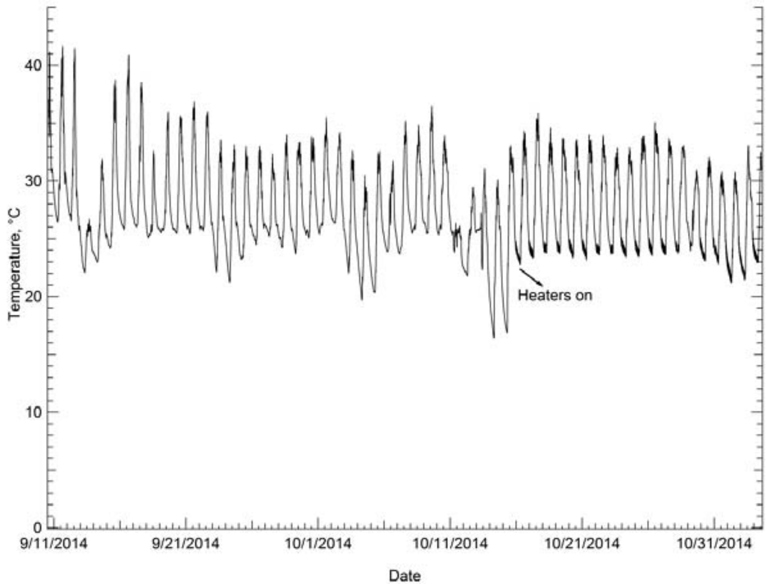

Figure 1: Greenhouse (air) temperatures mid-September through early November showing a relatively stable growth environment supplemented through heaters since mid-October.

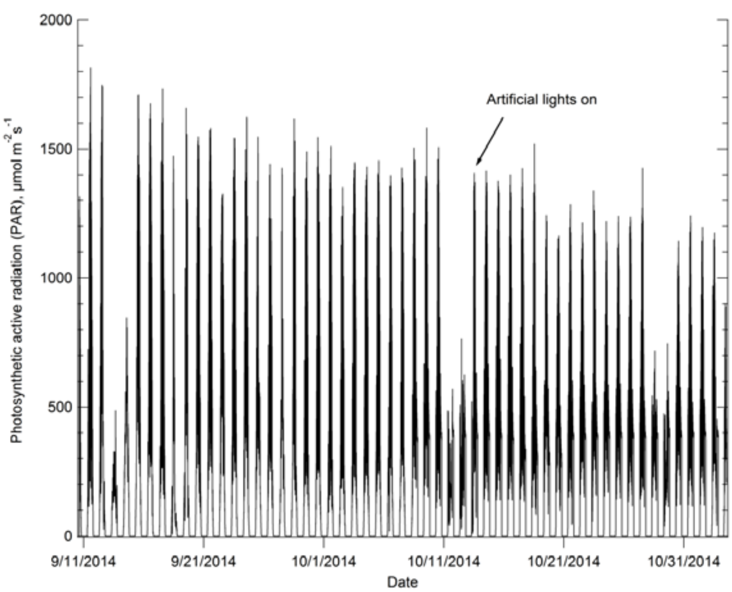

Figure 2: same as Fig. 1 but for PAR levels. Note beginning of supplemental light in mid-October to delay the onset of senescence.

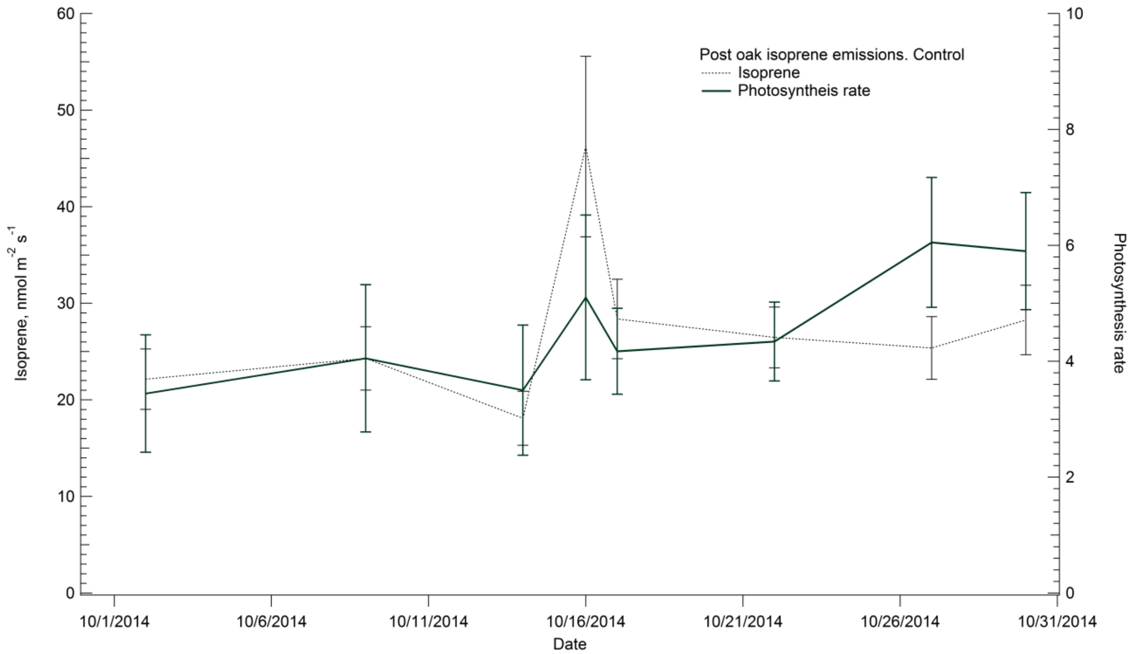

Figure 3: Preliminary photosynthesis (µmol m^{-2} s^{-1}) and isoprene emission rates from the post oak seedlings in the control group. Error-bars show variability (standard error, se).

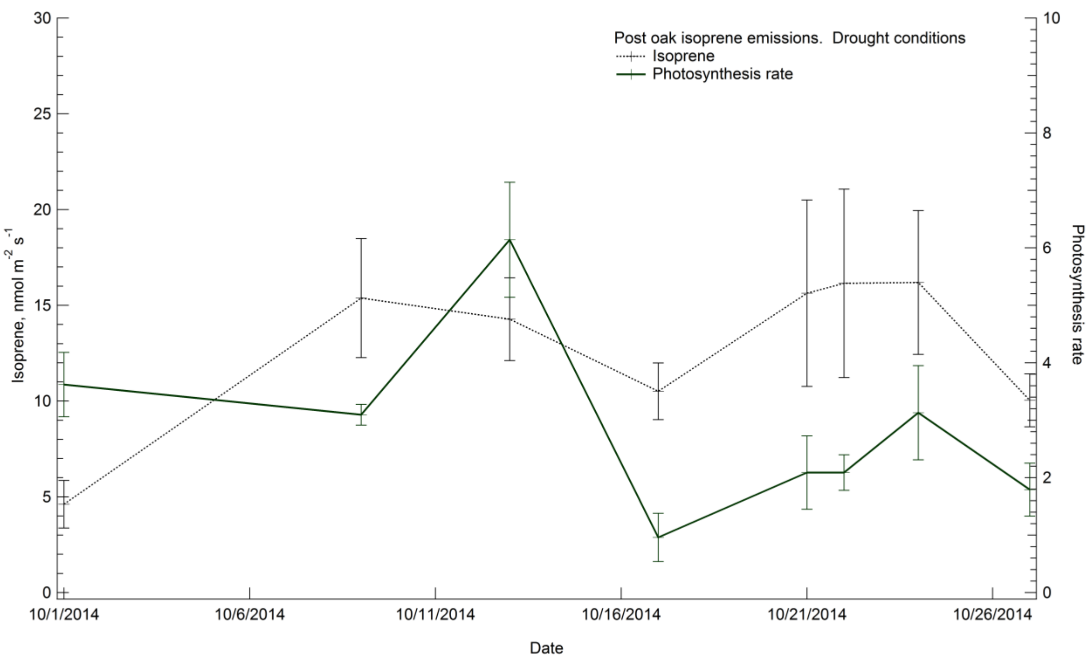

Figure 4: Preliminary photosynthesis and isoprene emission rates from the post oak seedlings in the drought treatment group. Error-bars show variability (standard error, se).

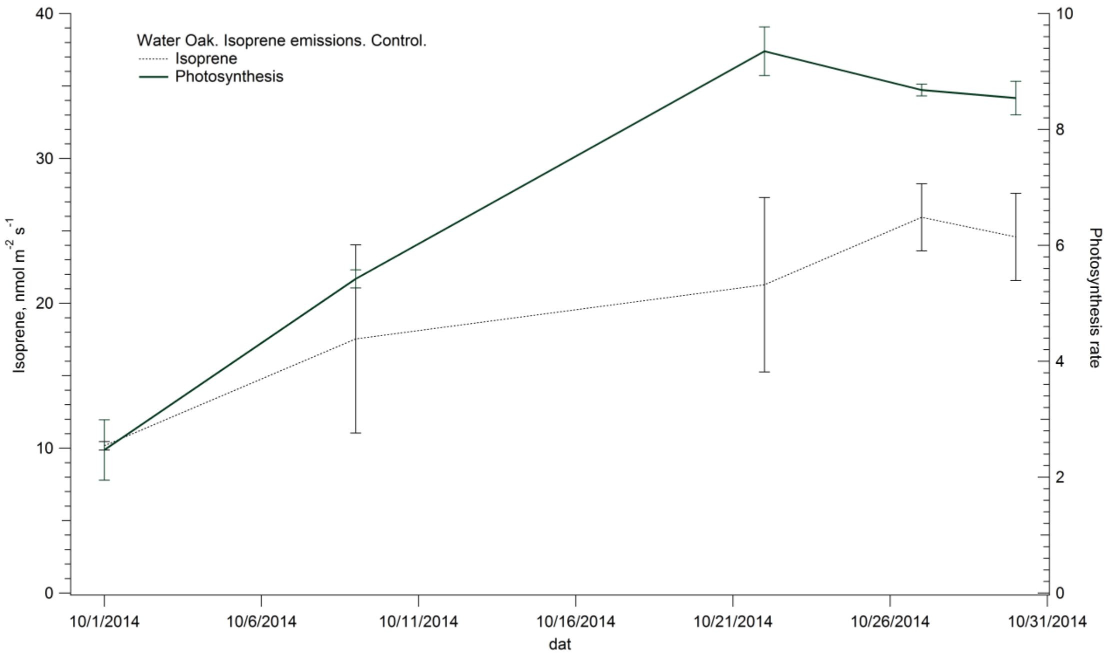

Figure 5: Preliminary photosynthesis and isoprene emission rates from the water oak seedlings in the control group. Error-bars show variability (se).

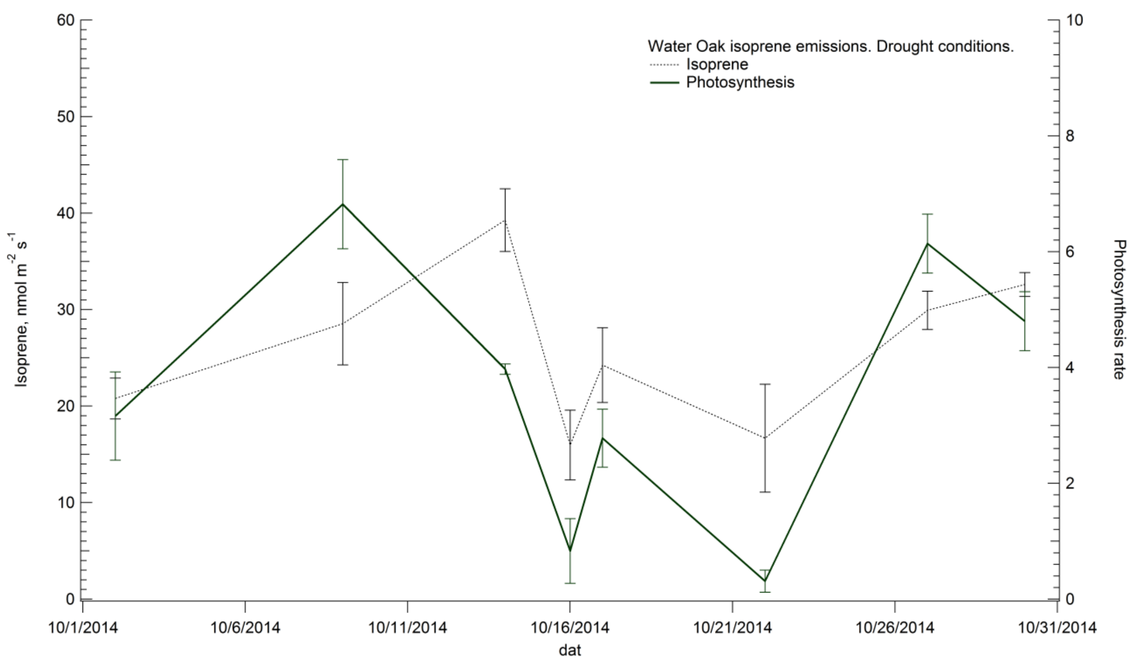

Figure 6: Preliminary photosynthesis and isoprene emission rates from the water oak seedlings in the drought treatment group. Error-bars show variability (se).

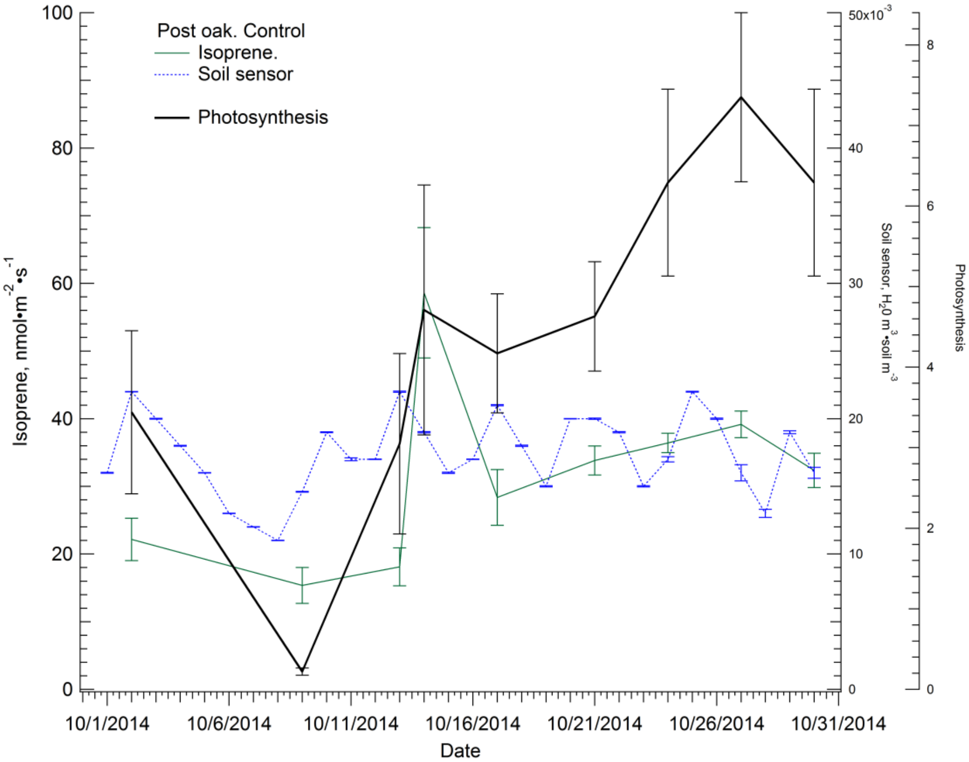

Figure 7: Time series of soil moisture (blue), photosynthesis (black), and isoprene emissions (green) for a post oak in the control treatment group

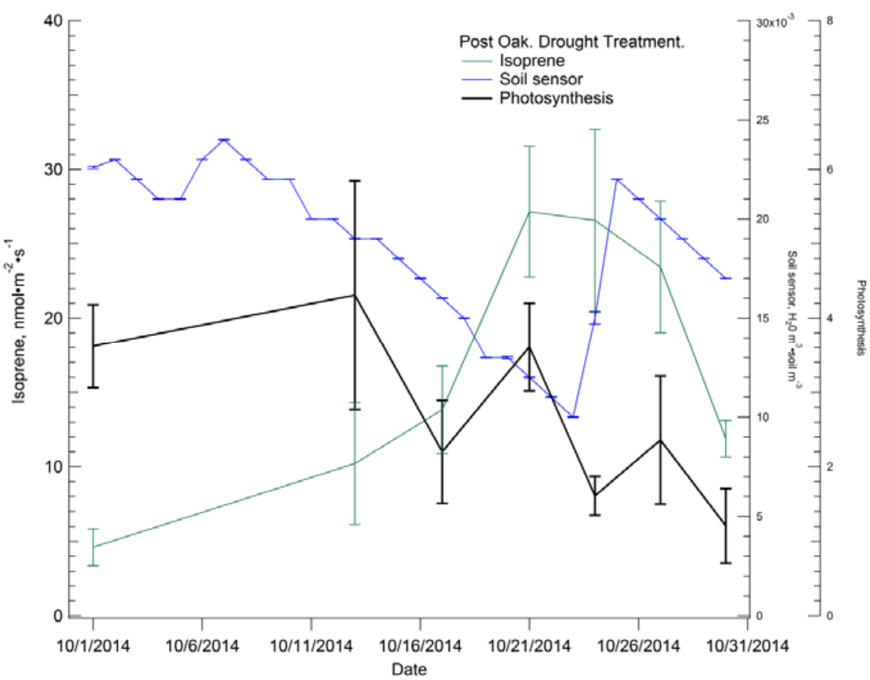

Figure 8: Time series of soil moisture (blue), photosynthesis (black), and isoprene emissions (green) for a post oak in the drought treatment group

Task 3: Evaluate drought parameterization for isoprene emissions – waiting for alternative parameterization from Alex Guenther. Expected to start in December.

Task 4: Perform regional BVOC modeling using MEGAN

The MEGAN model (FORTRAN version 2.10) was updated to include the drought parameterization as documented in Guenther et al. (2006). The public version of the original MEGAN model does not include the drought parameterization (Alex Guenther, personal communication). Modifications were also made to the Meteorology Chemistry Interface Processor (MCIP) program, the CMAQ utility program to process WRF meteorology outputs and generate meteorology input files for CMAQ. The modified MCIP program now saves soil moisture at all four Noah levels instead of the first layer. The MEGAN processors were modified to read and process the additional soil moisture data. The modified MEGAN is backward compatible with the original MEGAN and can be run without additional soil moisture data. The drought parameterization can also be turned off during MEGAN execution by an environmental variable defined in the run script. We prepared a 1x1 km resolution wilting point data using gridded soil texture from the Penn State CONUS-SOIL database. Wilting point in other regions was based on the Global Gridded Surfaces of Selected Soil Characteristics (IGBP-DIS) data set from ORNL (http://webmap.ornl.gov/wcsdown/dataset.jsp?ds_id=569), which as a resolution of 5'. Preliminary tests were conducted to ensure that the code is work properly.

Reference:
Guenther, A., Karl, T., Harley, P., Wiedinmyer, C., Palmer, P.I., Geron, C., 2006. Estimates of global terrestrial isoprene emissions using MEGAN (Model of Emissions of Gases and Aerosols from Nature). Atmospheric Chemistry and Physics 6, 3181-3210.

Task 5: Perform regional air quality simulations

The CMAQ model (v5.0.2) was modified to allow online windblown dust emission simulation using the MODIS land use information. Previously, online dust emission calculation depends on the vegetation cover information from the Biogenic Emission Inventory System (BEIS). Alternative windblown emission parameterization schemes were added to the CMAQ code.

Preliminary Analysis

Task 1:
Soil moisture predicted using the Noah land surface scheme and initialized with the North American Regional Reanalysis (NARR) were lower than observation at all levels (above 1.0 m). We explored the possibility of using initial soil moisture from NLDAS and tested if it could improve moisture simulations. Figure 9 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 for April 2011 using NARR and NLDAS soil moisture field as initialization. The predictions were interpolated to the points where the measurements were made. Using NLDAS appears to improve soil moisture at 0.25-1 m range.

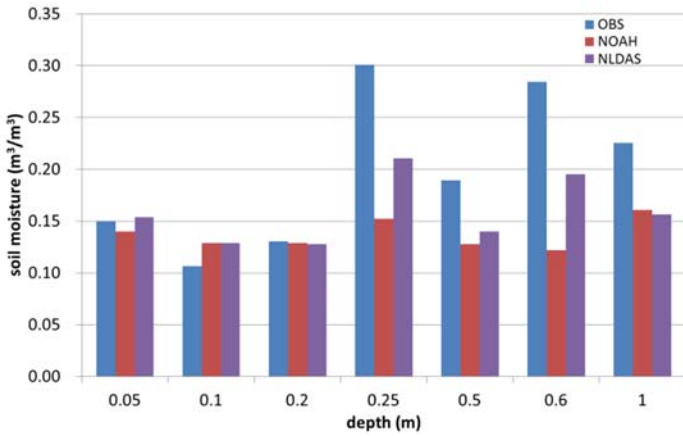

Figure 9: Observed (OBS) and WRF-predicted soil moisture in April 2011 using NARR (NOAH) and NLDAS (NLDAS) averaged over all available soil moisture monitors.

Figure 10 shows the Mean Bias (MB) of surface temperature (TEMP), precipitation (RAINS), wind speed (WSPD) and relative humidity (RH) using NARR and NLDAS. The surface meteorology predictions were improved using the NLDAS soil moisture input.

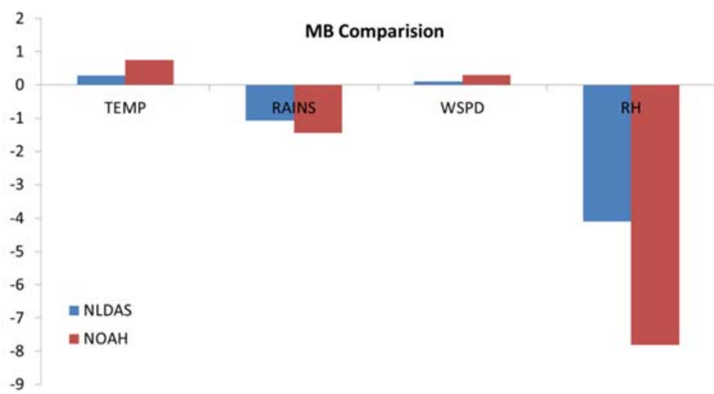

Figure 10: Mean bias (MB, Observation – Prediction) of surface meteorology parameters for April 2011. Predictions were based on the NARR (NOAH) and NLDAS soil moisture data. Units for temperature, rain, wind speed and relative humidity are K, mm hr^{-1}, m s^{-1}, and %, respectively.

Task 2: Data density is relatively low and encountered variability higher than expected. We attribute part of that to work in the greenhouse (asbestos abatement, lamps and heaters installations) designed to upgrade the facility. Unfortunately, two colder nights in October (Fig. 1) may have triggered senescence in numerous specimen. The greenhouse work limited our activities and introduced pests into the greenhouse. Figures 7 and 8 demonstrate that the effects of the drought treatment are measurable but unless we can minimize external impacts that also have the ability to affect emissions, we are left with a hard to interpret response. In this example, the well-watered post oak had significantly higher photosynthesis rates and isoprene emissions; however, earlier that month, likely due to pest impacts, photosynthesis was lower. Its increase during the month was not mirrored by isoprene emissions but, overall, isoprene emissions were higher in the second half of October, after completion of all greenhouse upgrades. The drought-treatment, a two-week period from about 8-23 October, had obvious impacts on photosynthesis; however, this specimen had started out with lower photosynthesis rates and isoprene emissions and appeared to recover slightly during the drought treatment, showing improved, instead of diminished, isoprene emission rates while the soil was drying. It is thus too early to say whether we will be able to provide a new and improved soil moisture response for isoprene modeling since the currently available data is in part counter-intuitive.

In this case, we also encountered at times large differences between the soil moisture measurements between the different seedling pots despite a consistent watering regime. That means that scaling isoprene emissions and photosynthesis against soil moisture is likely going to have to rely on relative, not absolute data for the moment until we have evaluated the causes for the pot-to-pot differences. Since we also have weights of the seedling pots taken on measurement days, we will address the soil moisture sensor issue first that way.

Task 4: We tested the drought effect on MEGAN predicted isoprene using the updated MEGAN model. Figure 11 shows the predicted overall emission activity factor (γ) at 1200-1300 CST July 1, 2011 were significantly reduced due to drought impact. Correspondingly, the emission rates of isoprene were also reduced.

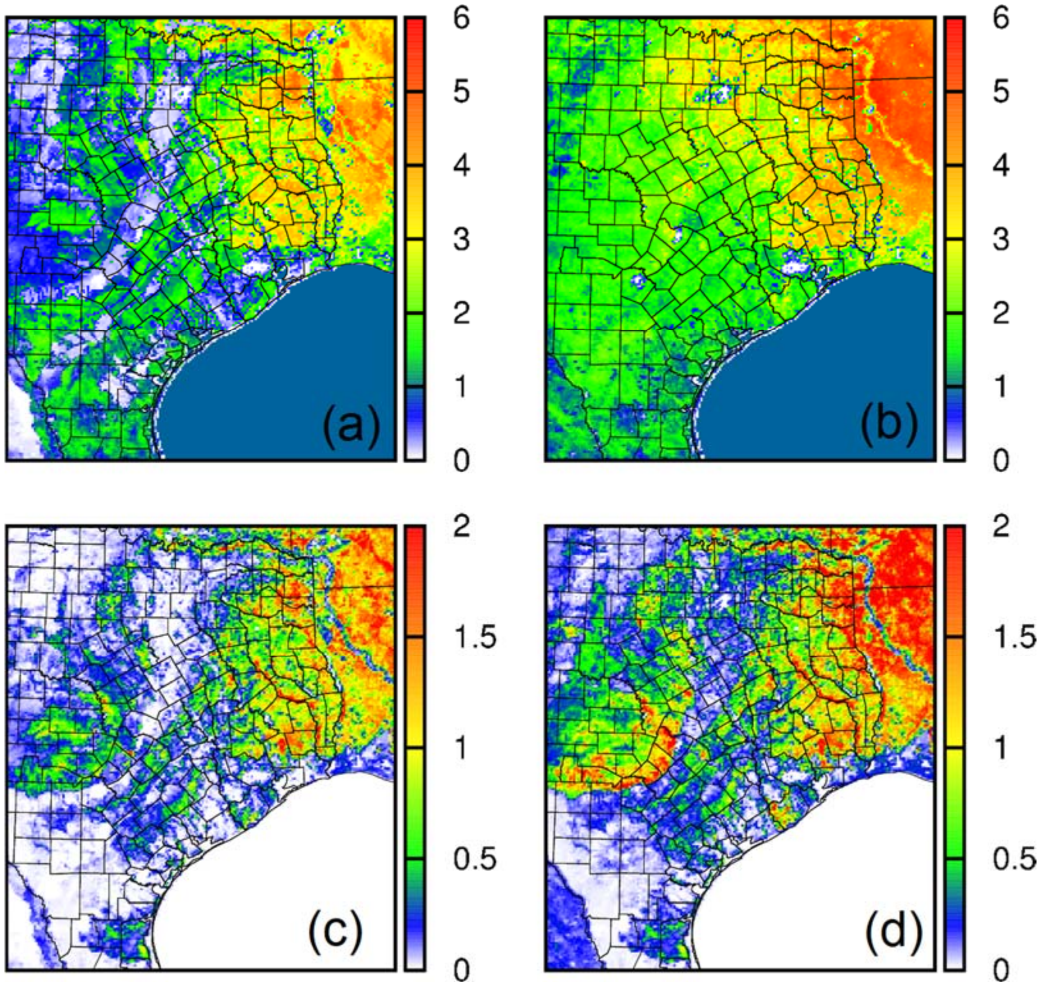

Figure 11: Environmental activity factor (γ, panels a,b) and isoprene emission (mol s^{-1} $grid^{-1}$) (panels c-d) with (a,c) and without (b,d) drought parameterization. Data are for July 1, 2011 at 1200-1300 CST.

Data Collected

Leaf-level photosynthesis data for water oak and post oak seedlings in the greenhouse during several periods in October 2014, the latter using mostly our carbon-based and adsorbent cartridges

Identify Problems or Issues Encountered and Proposed Solutions or Adjustments

1. Pest influences during early October, as well as beginning senescence in some of the specimen seemed to have affected the measurements. Effects were visually detected and at times clear in the photosynthesis measurements. When the pests became prevalent, plants were treated with a mild pesticide, but we do not know how much the pests or the pesticide affected isoprene emissions.
2. We ended up not deploying our LI840 CO2/H2O analyzer for ambient CO2 measurements to the greenhouse in October because both our calibration and zero gases did not arrive in time; we found a discrepancy between the manufacturer's calibration and our own calibration gases we are currently trying to resolve; we may deploy the instrument over winter for testing
3. We are planning to repeat some of the measurements in November, as possible, with seedlings that have not yet begun senescing. In this case, this means water oak only since all post oak seedlings except one seem to have gone dormant. As outlined in the last monthly report, we hope to be able to do an additional set of experiments in spring 2015. The current set of experiments has shown the limitations of using potted soil moisture sensors, showing pot-to pot differences while appearing internally (within-pot) consistent. We need to analyze these limitations to be able to derive not only relative but absolute soil moisture differences in a repeatable fashion. We have also learned that greenhouse measurements are only reproducible when external effects can be minimized. The delay of the project alongside numerous changes out of our control (had to change greenhouses, updates during the measurements, pests) appear to have strongly affected our results, and therefore we may need to rely on an additional set of measurements to complete this project task successfully.

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 NLDAS and year specific land use/land cover data based on MODIS. Evaluate model performance. This will be the final meteorology product for this project.

Task 2: 1) continue leaf-level measurements in the greenhouse, and execute one more set of drought treatments on water oak; 2) execute the 1st set of cartridge tests in November (storage test); 3) continue to analyze data

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 November.

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

Task 4: On schedule

Task 5: On schedule.

Submitted to AQRP by: Qi Ying

Principal Investigator: Qi Ying