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**	12/9/2014
REPORTING PERIOD	**From:** November 1, 2014 **To:** November 30, 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

Task 1: Meteorology simulation with WRF.
Completed production WRF run for both 2007 and 2011. The production WRF run utilized the following configurations: 1) 3-h resolution North American Regional Reanalysis (NARR) dataset, 2) daily satellite-based sea surface temperature, 3) gridded soil moisture from North America Land Data Assimilation System (NLDAS), 4) Noah land surface scheme and 5) MODIS-based, year specific Leaf Area Index (LAI) and land use/land cover classification. Model performance analysis for 2011 was completed and still on going for 2007.

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: Some measurements commenced in the greenhouse during November. Figures 1 and 2 show the observed greenhouse temperatures and light levels, supplemented with growth lights and heaters in an attempt to delay leaf senescence. However, as demonstrated via Figure 3, we observed much lower isoprene emissions in November, as expected from a gradual shutdown of isoprene synthase production in senescing leaves.
b. analyze observed drought responses of seedlings and field-grown mature trees: In Figures 4 and 5 we show post oak and water oak individualized results, including the soil moisture sensor data for those specimen. There was no clear relationship between soil moisture, photosynthesis (Pn), and isoprene emissions. However, as can be observed with plant 89, a water oak with new leaf growth, the expected behavior was observed during the two drought tests (decreasing Pn and isoprene emissions), but the very rapid response was unexpected. Then, the seasonal decrease in isoprene ended the experiment for this year. Similar results

from post oak plant 21, Figure 5, suggest that the drought response can be observed, but daily monitoring will be necessary alongside longer periods of re-watering.

c. submit data files to UT: we need approval of the data format submitted with the previous monthly report before submitting more results to the sponsor.

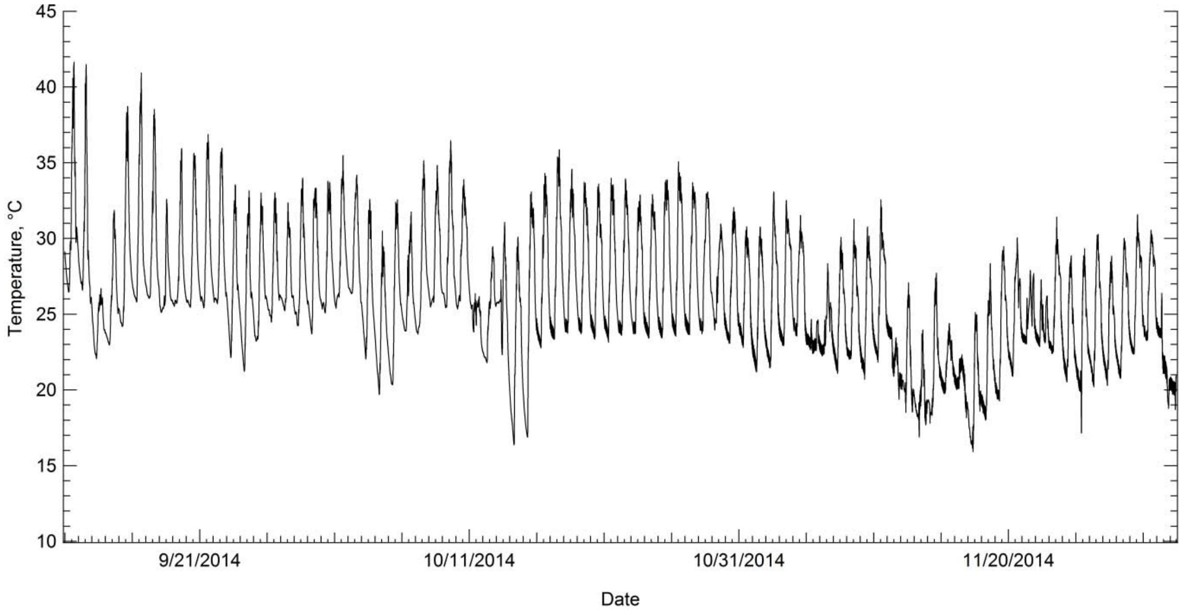

Figure 1: Greenhouse (air) temperatures mid-September through early December showing a much cooler growth environment, supplemented through heaters, in November.

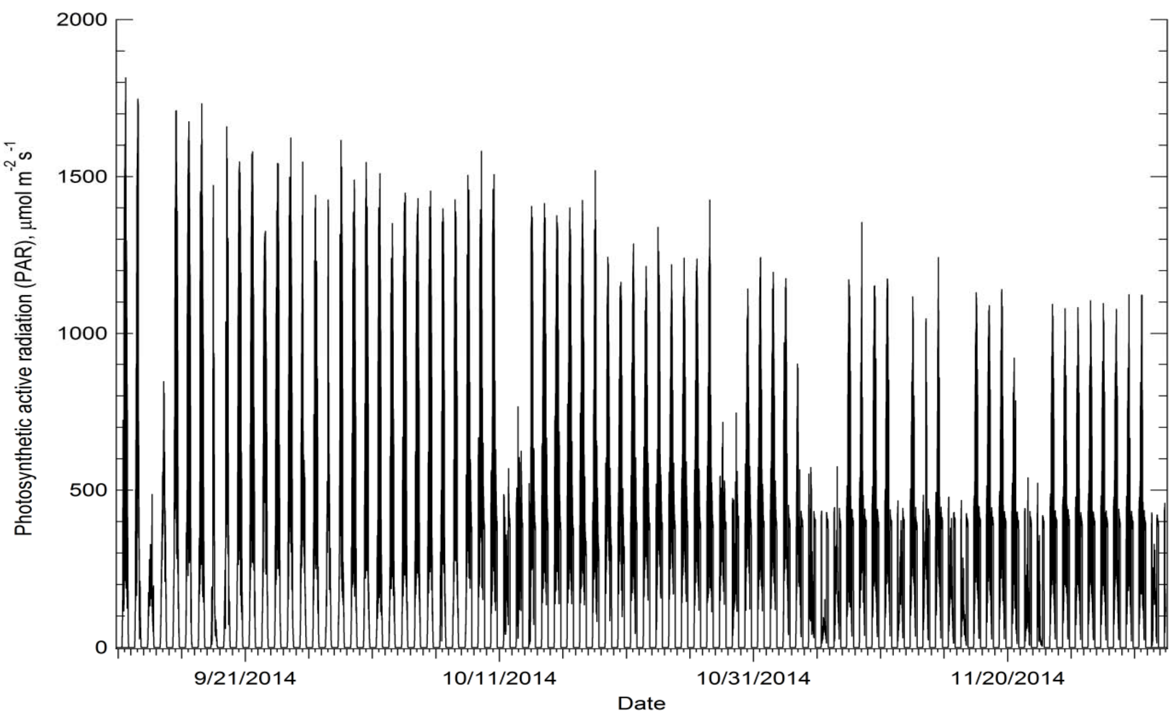

Figure 2: same as Fig. 1 but for PAR levels. Note decreasing light levels but maintenance of levels in November up to 1000 PAR units due to light supplementation.

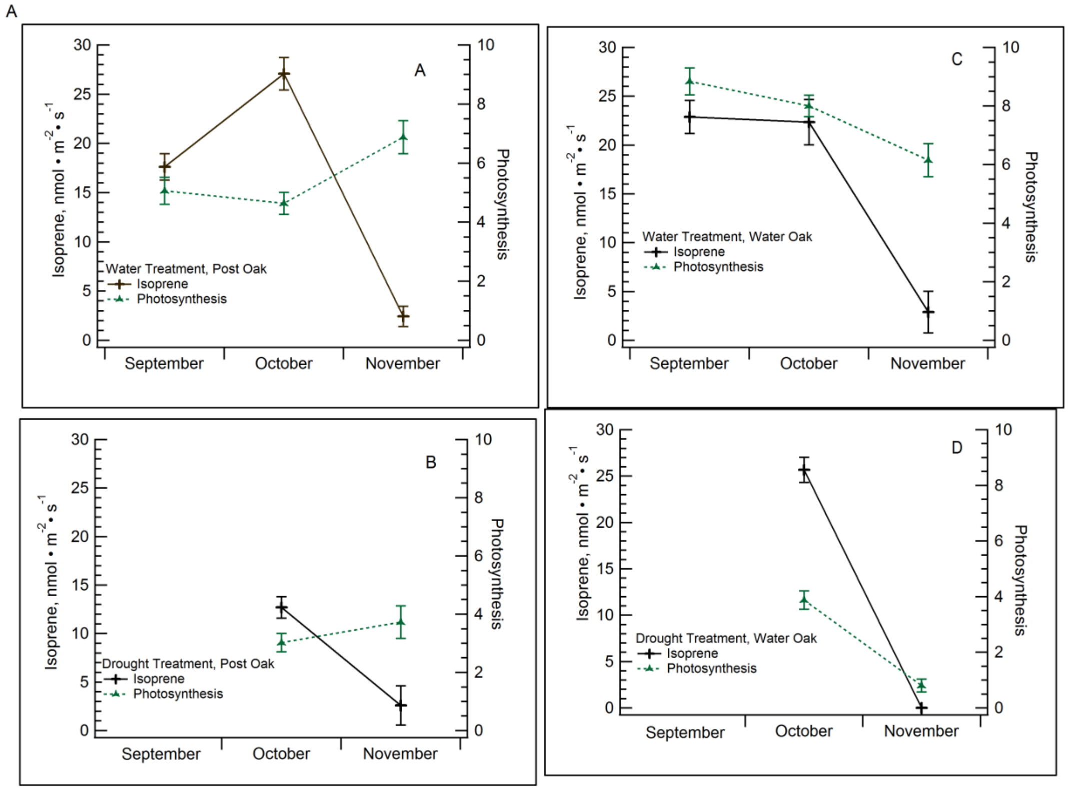

Figure 3: Preliminary photosynthesis (μmol m^{-2} s^{-1}) and isoprene emission rates from the greenhouse-based oak seedlings over time. Error-bars show variability (standard error, se).

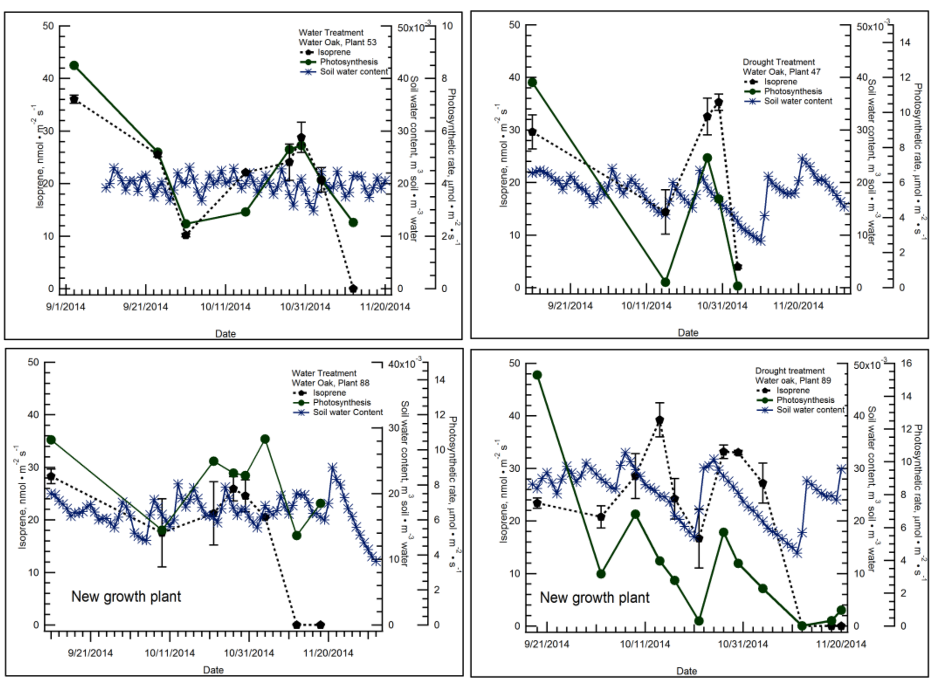

Figure 4: Preliminary photosynthesis and isoprene emission rates from four water oak seedlings investigated, two each per treatment group. Error-bars show variability (standard error, se).

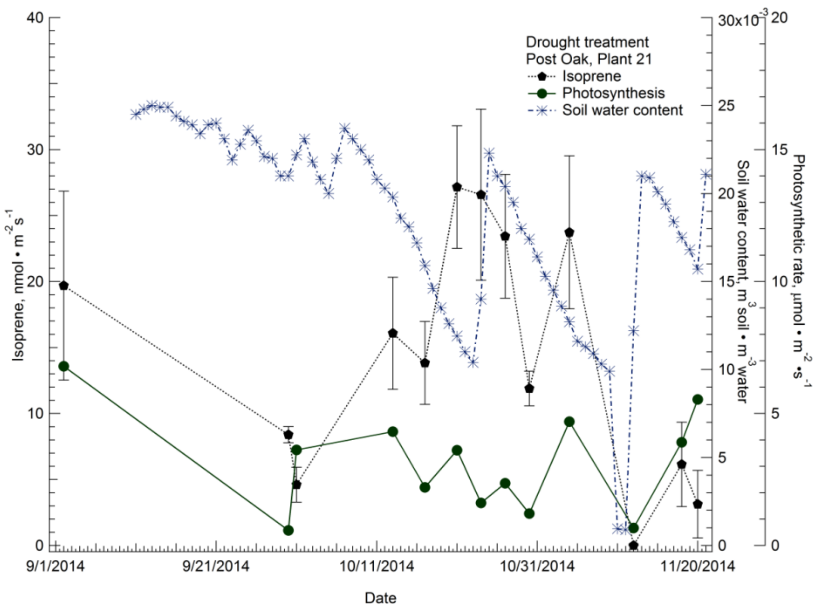

Figure 5: Preliminary photosynthesis and isoprene emission rates from post oak seedling 21 exposed to two drought periods. During the first in early October, isoprene emissions still appeared to be recovering from the previous stress periods. During the second, an emissions drop occurred early and the plant's emissions were not followed closely enough thereafter. Error-bars show variability (se).

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

We modified the LAIv input data for urban grid cells. LAI in the urban grid cells is now based on the TCEQ approach: Leaf area index (LAI) for non-urban grid cells was based on the eight-day averaged 1-km resolution LAI in the Moderate Resolution Imaging Spectroradiometer (MODIS) MCD15A2 product. LAI for the urban grid cells were estimated based on four urban classes from National Land Cover Database (NLCD) with predesignated maximum LAI and a season variation profile. Year specific NLCD data were used (NLCD 2006 was used for 2007 emissions). The four urban categories and the maximum LAI values are: developed open area (maximum LAI=3.3), developed low density (maximum LAI=2.3), developed medium density (maximum LAI=1.3) and developed high density (maximum LAI=0.3). The LAI values are then normalized by the factional vegetation cover in a grid cell to calculate LAIv. Production MEGAN emission processing has been completed for both years.

Task 5: Perform regional air quality simulations

No progress to report on this month. CMAQ simulation for 2011 will start in December.

Preliminary Analysis

Task 1:
We analyzed WRF model performance on soil moisture from the production run (configuration of the WRF model and data is discussed in the Accomplishment section) and compared that with the original simulation based on NARR data only. Figure 6 shows that at the surface layer, the MB values of the production run are lower than the original simulation for all months in 2011 at both layers.

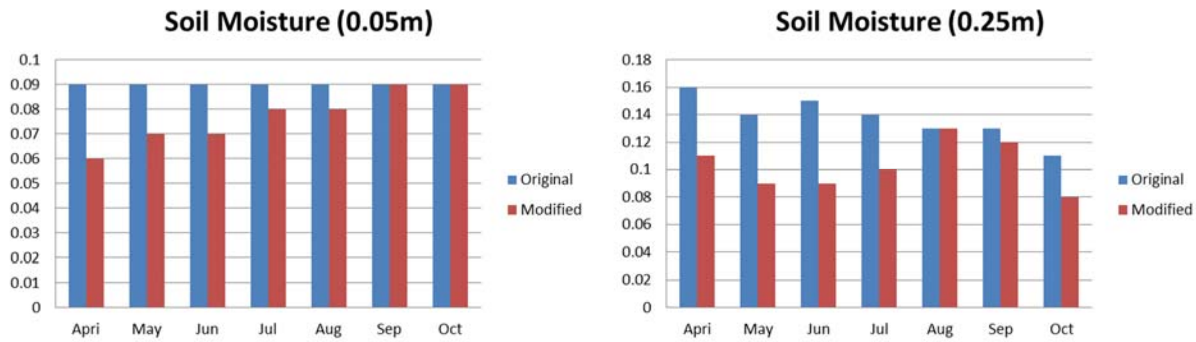

Figure 6: Mean bias (MB) of predicted soil moisture content at the surface layer (0.05 m) and at 0.25 m based on the NARR (original) and NLDAS (modified) initial soil moisture. (there are also other changes in the production run).

Figure 10 shows the Root mean square error (RMSE) of surface temperature (TEMP), precipitation (RAINS), wind speed (WSPD) and relative humidity (RH) for the original and the production runs. Model performance of temperature, precipitation and relative humidity is improved. Model performance for wind speed deteriorated slightly from August to October.

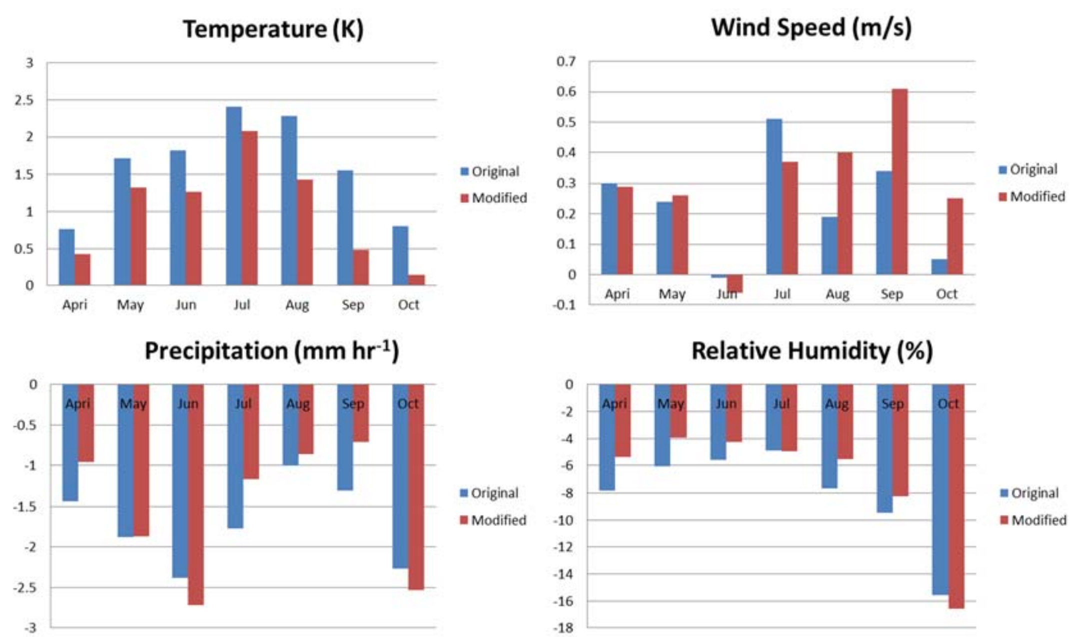

Figure 10: Root mean square error (RMSE) of hourly surface meteorology parameters for 2011. Units for temperature, rain, wind speed and relative humidity are K, mm hr^{-1}, m s^{-1}, and %, respectively.

Task 2: Results from November did not alter our main findings from previous months: Data density was relatively low and encountered variability higher than expected. Based on our findings of, at times a rapid decrease of both photosynthesis and isoprene emissions (Figure 4, plants 47 and 89), we conclude that future measurements need to focus on the healthiest specimen and be done daily at various times throughout the day since soil moisture can drop rapidly. In the specimen the drought-treatment produced a reasonable response, e.g. plant 89, the four days of measurements in late October, early November showed the expected response; namely a drop in photosynthesis rate in parallel to soil moisture, but a delayed drop in isoprene emissions. This type of response has typically been encountered before (e.g. Centritto et al., Tree Physiology, 31, 275f, 2011) and is understood to be related to the continued availability of the isoprene precursor and isoprene synthase activity under drought conditions, until photosynthate limits precursor levels under severe drought.

Data Collected

1. Leaf-level photosynthesis data for water oak and post oak seedlings in the greenhouse during several periods in November 2014, the latter using mostly our carbon-based and adsorbent cartridges
2. Numerous comparisons of the Tenax and carbon-adsorbent cartridges via duplicate sample taking
3. First set of cartridge tests completed.

Identify Problems or Issues Encountered and Proposed Solutions or Adjustments

1. Though some seedlings are “confused” and developed new growth, it appears that nearly all seedlings have ceased to emit isoprene, meaning greenhouse measurements are completed for this season. We will monitor soil moisture, keep watering, and occasionally measuring life leaves for emissions in the upcoming months. Past experience suggests that future drought test need to be followed closely to maintain high enough data density.
2. An additional set of experiments in spring 2015 is needed, unavoidable to address the main objectives.

Goals and Anticipated Issues for the Succeeding Reporting Period

Goals

Task 1: Complete model performance analysis for the final production run.

Task 2: 1) potentially execute a field day to the Freeman ranch to observe winter photosynthesis and isoprene emissions in local life oak; 2) execute the 2^{nd} set of cartridge tests in December; 3) continue to analyze data

Task 4: Completed.

Task 5: Generate preliminary CMAQ results.

Detailed Analysis of the Progress of the Task Order to Date

Task 1: Almost completed (just need to finish performance analysis for 2007)

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

Task 4: Completed.

Task 5: Delayed but will be able to catch up by firing more runs at the same time.

Submitted to AQRP by: Qi Ying

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