AQRP Monthly Technical Report

PROJECT TITLE	Incorporating Space-borne Observations to Improve Biogenic Emission Estimates in Texas	**PROJECT #**	14-017
PROJECT PARTICIPANTS	Arastoo Pour-Biazar; Richard McNider; Daniel Cohan, Rui Zhang	**DATE SUBMITTED**	7/15/2015
REPORTING PERIOD	**From:** June 1, 2015 **To:** June 30, 2015	**REPORT #**	14

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

Progress Summary: MEGAN simulations

The August and September 2013 MEGAN simulations using satellite derived PAR were completed. A detailed report is attached below.

Progress Summary: Stand-alone soil NO emissions with BDSNP scheme

The functionality of standalone soil NO emission module with BDSNP scheme and the development of new soil biome map using the 12km resolution CONUS 40-category 2006 NLCD-MODIS land use classification (NLCD40) and Köppen-Geiger climate classification map was demonstrated. With the high efficiency of the standalone version, more sensitivity tests can be carried out by switching the key input parameters for soil NO emission in BDSNP module (e.g. different soil biome, different base emission factors, and different fertilizer pools). Detailed document is attached below.

Progress Summary: Preparation for final report

Now that all the tasks in this project has concluded satisfactorily, we are in the process of preparing final report for this project.

Preliminary Analysis

Attached.

Data Collected

None for this period.

Identify Problems or Issues Encountered and Proposed Solutions or Adjustments

None.

Goals and Anticipated Issues for the Succeeding Reporting Period

Drafting final report..

Detailed Analysis of the Progress of the Task Order to Date
Attached.

Arastoo Pour Biazar

Submitted to AQRP by:

Principal Investigator: Arastoo Pour Biazar

MEGAN simulation with satellite PAR during Aug-Sep 2013

Rice team has finished the three sets of MEGAN runs over the TCEQ SIP modeling domains (D1 for CONUS 36km domain, D2 for Texas 12km domain and D3 for East Texas 4km domain) during August and September 2013 by using different PAR inputs, namely PAR from control WRF run (cntrl), PAR from WRF cloud assimilation run (analytical), and PAR from GOES satellite retrieval using the new algorithm developed by UAH (UAH). The VOC emissions from biogenic in MEGAN were lumped with CB05 chemical mechanism and were archived in the NetCDF format. The total disk storage of the two months MEGAN runs is 2.9 GB for D1, 5.4 GB for D2 and 16.8 GB for D3. It is ready to share with the CAMx Fortran binary input format using the CMAQ2CAMx interface program provided by Ramboll-Environ (http://www.camx.com/getmedia/a9e648b7-2b2d-487d-9243-2f363a6feea4/cmaq2camx-4sep13.tgz.aspx).

Here, the Texas domain (D2) MEGAN results are further analyzed to demonstrate the feasibility of our products. Figure 1 and Figure 2 show the comparison of the spatial patterns of the monthly mean isoprene (ISOP, Figure 1) and monoterpene (TERP, Figure2) emission rate using the three different PAR inputs during August and September 2013. For the ISOP simulations during August 2013, the general emission pattern for the three PAR inputs case is quite similar, with the hot spots over the Texas territory mainly concentrated over the Edwards Plateau and the eastern Texas boundary adjacent with the Louisiana and Arkansas, where the broadleaf evergreen tree or shrub is the dominate plant functional type. In terms of the magnitude, the 'UAH' case is the lowest with the maximum value 54 moles/s, following by the 'analytical' case and 'cntrl' case. For September case, the base ISOP emission is lower that in August 2013 due to the lower mean surface temperature and smaller leaf area index value input from MODIS. For the TERP simulation pattern during the two months in 2013, additional hot spot located near the south Texas boundary adjacent with Mexico is apparent. The overall magnitude of mean TERP emission rate is much smaller than for ISOP, with the range of former 0-6 moles/s and the range of latter 0-68 moles/s.

In order to characterize BVOC emission pattern from different MEGAN simulations over the heterogeneous plant functional type over Texas, the average monthly emission rates over the 10 climate divisions in Texas were calculated separately. The climate classification is based on historical climate analyses (1895-2013) for the monitored drought, temperature, precipitation and heating/cooling degree day values over the continental US (http://www.ncdc.noaa.gov/monitoring-references/maps/us-climate-divisions.php). The geographic locations of those 10 climate divisions in Texas are illustrated in Figure 3. An area mask file consistent with the TCEQ domain configurations were generated based on the climate division boundary polygon shapefiles provided by NCAR (http://www.ncl.ucar.edu/Applications/Data/cdf/climdiv_polygons.nc). The ISOP and TERP results are given as the histogram comparison plots in Figure 4 and detailed statistics in Table 1. For ISOP, the top 3 highest emission regions in Texas are East Texas (2754 tons/day for case 'UAH'), North Central Texas (2036 tons/day for case 'UAH'), and Edwards Plateau (1199 tons/day for case 'UAH') separately. For TERP, the top 3 highest emission regions are East Texas (1011 tons/day for case 'UAH'), Trans-Pecos (615 tons/day for case 'UAH'), and North Central Texas (562 tons/day for case 'UAH'). To quantify the impact of different PAR inputs on BVOC emission estimation, the case 'UAH' using GOES satellite retrievals on averagely predict 21% less ISOP than the base WRF case ('cntrl') during August 2013 and -19% during September 2013 (see Table 1). The cloud assimilation WRF case ('analytical') predicts slightly less ISOP than case 'cntrl' with the mean value around -2% during August 2013 and -3% during September 2013. It is expected that not so much impact of TERP emission due to the introduction of more realistic insolation data from satellite, the relative difference between case 'UAH' and case 'cntrl' is on average -5%. The TERP emission algorithm in MEGAN is more directly connected with the surface temperature instead of PAR. At least for the evaluated two months in 2013, the most sensitivity climate region for ISOP emission estimation in Texas due to different PAR inputs is Trans-Pecos, with the relative difference compared to base case -28.8% during August 2013 and -24.7% during September 2013.

Figure 5 plots the time series comparison of the daily mean ISOP and TERP emission rate at the highest BVOC emission climate division (East Texas) in Texas during the two months simulation period. It can be seen that both ISOP and TERP emission experienced the decreasing trend with the highest emission rate appearing at the first week of August (~ 5500 tons/day for ISOP and ~ 1300 tons/day for TERP in case 'UAH') and the lowest emission rate appearing at the third week of September (~ 200 tons/day for ISOP and ~600 tons/day for TERP in case 'UAH'). The two lowest emission days during the simulation period, namely August 15 and September 20, correlate well with the regional weather pattern of low surface temperature, cloudy sky and major rain events (see Figure 6 for the corresponding variations of meteorological parameters). One of the exceptions is the date August 8, 2013, when for both 'cntrl' and 'analytical' case, the predicted ISOP emission rate is around 7000 tons/day while the corresponding 'UAH' value is only less than half of it. The large contrast is mainly due to suddenly drop of the PAR retrieval value from 140 W/m^2 to 80 W/m^2 (see Figure 6). In order to evaluate the correctness of the extreme low PAR value from case 'UAH' on September 20, 2013 (daily mean PAR for that day is only 13 W/m^2 comparing with typical 120 W/m^2 for the rest of days), the surface weather map archive from NOAA (http://www.wpc.ncep.noaa.gov/dailywxmap/) as well as the daily mean PAR retrieval from UAH over continental US are given in Figure 7. It can be seen that the extremely low satellite PAR retrieval values in grey areas (less than 18 W/m^2) over Arkansas and East and north central Texas match well with the low-pressure trough and large rain belt (in green area) from ground observations. Ongoing work includes demonstrating the quantitative ozone impact from different MEGAN BVOC emission estimations by running CMAQ over the TCEQ SIP modeling domains during August and September 2013. The anthropogenic emissions are provided by TCEQ with the base year 2011. Since the boundary condition files from GEOS-Chem are not available during the simulation period, the MOZART outputs with global CO data assimilation will be used as alternative.

Stand-alone soil NO emission simulation with BDSNP scheme

Functionality of standalone soil NO emission module with BDSNP scheme and the development of new soil biome map using the 12km resolution CONUS 40-category 2006 NLCD-MODIS land use classification (NLCD40) and Köppen-Geiger climate classification map. With the high efficiency of the standalone version, more sensitivity tests can be carried out by switching the key input parameters for soil NO emission in BDSNP module (e.g. different soil biome, different base emission factors, and different fertilizer pools). Figure 8 provides the spatial pattern difference of soil NO base emission simulated by this standalone model using global GEOS-Chem soil biome (control), updated regional soil biome based on NCLD40 (new Biome), and North American specified emission factors (NA EF) over continental US. Comparing to the 'control' case, the soil NO base emission pattern from case 'new Biome' has much detail texture due to the usage of higher resolution biome map and better representation of geographic locations for cropland over Midwest and evergreen board leaf forest along the South Eastern coastal areas. The original implementation of soil NO BDSNP module used the global average biome type specific emission factors, which is 2-3 times higher than the local US measured values for the category such as cold savannah. Using the local emission factor intend to have more realistic results for this project.

The soil NO emission rate is from the default MEGAN model using the Yienger and Levy 1995 (YL95) scheme. We are using the standalone BDSNP module to replace the soil NO emission simulation during August and September 2013 over TCEQ SIP simulation domains. All the BDSNP input files including biome type map, fertilizer pool map, arid/non arid map, nitrogen deposition from dry and wet process are re- gridded to the consistent TCEQ modeling domains. Since no complete CMAQ run for August and September 2013 is available, the daily magnitudes of nitrogen deposition pool are assumed from the 2005 CMAQ simulation results. Figure 9 demonstrates the spatial pattern difference for daily mean NO emission rate using YL95 or BDSNP on Augest 1, 2013 over the TCEQ Texas domain (D2). Notice the different color scale, the magnitude of soil NO emission predicted from BDSNP at that day is generally 2-3 times higher than that from YL95, with the maximum value 14.6 gm/s versus 8.4 gm/s. The spatial pattern for the two cases is also quite different due to the combined contributions from different soil biome type, fertilizer implementations and the different response curve for soil temperature and moisture in the two soil NO schemes. The two-month soil NO emission simulated with BDSNP scheme by using the two set of WRF runs (case 'cntrl' and case 'analytical') will be archived separately along with MEGAN results and hand over to TCEQ for further test. The documentation of the user manual for the standalone soil NO BDSNP module is also under way and will be ready to share for the community at the end of this project.

Table 1. Comparison of daily average isoprene (ISOP) and monoterpene (TERP) emission rate (tons/day) over 10 different climate zone at Texas from MEGAN using different PAR inputs

Aug 2013										
			ISOP					TERP		
climate zone	cntrl (tons/day)	analytical (tons/day)	PAR (tons/day)	relative diff. (analytical-cntrl) %	relative diff. (PAR-cntrl) %	cntrl (tons/day)	analytical (tons/day)	PAR (tons/day)	relative diff. (analytical-cntrl) %	relative diff. (PAR-cntrl) %
Edwards Plateau	1794.6	1736.4	1374.0	-3.2	-24.2	645.8	640.2	600.9	-0.9	-7.0
East Texas	3876.0	3837.2	3062.0	-1.0	-21.2	1207.4	1196.2	1128.8	-0.9	-6.5
High Plains	600.8	596.9	451.6	-0.6	-25.0	239.2	238.7	222.4	-0.2	-7.0
Low Rolling Plains	1217.1	1199.6	926.4	-1.4	-24.2	423.4	420.6	393.1	-0.7	-7.2
Lower Valley	173.3	171.3	137.8	-1.1	-20.7	80.9	80.3	76.4	-0.7	-5.6
North Central Texas	2887.6	2829.5	2248.1	-2.0	-22.6	673.9	662.7	629.0	-1.7	-6.7
South Central Texas	1203.5	1176.4	955.4	-2.3	-21.1	355.5	351.6	335.3	-1.1	-5.7
South Texas	257.8	248.1	197.7	-3.8	-24.2	110.1	107.3	102.2	-2.6	-7.1
Trans-Pecos	1655.1	1614.4	1189.9	-2.5	-28.8	769.4	758.2	707.6	-1.5	-8.0
Upper Coast	1135.7	1118.2	922.5	-1.5	-19.1	343.7	340.3	326.9	-1.0	-4.9
Sep 2013										
			ISOP					TERP		
climate zone	cntrl (tons/day)	analytical (tons/day)	PAR (tons/day)	relative diff. (analytical-cntrl) %	relative diff. (PAR-cntrl) %	cntrl (tons/day)	analytical (tons/day)	PAR (tons/day)	relative diff. (analytical-cntrl) %	relative diff. (PAR-cntrl) %
East Texas	3060.0	3084.5	2445.6	0.8	-19.9	943.5	943.5	892.9	0.0	-5.4
High Plains	411.3	396.6	325.6	-3.6	-21.6	169.6	166.2	161.2	-2.0	-5.0
Low Rolling Plains	905.8	869.0	702.6	-4.1	-23.4	320.1	313.4	302.1	-2.1	-5.6
Lower Valley	137.6	139.0	111.9	1.1	-18.5	68.0	68.5	65.1	0.8	-4.1
North Central Texas	2247.3	2257.1	1823.8	0.4	-18.8	521.2	519.5	495.3	-0.3	-5.0
South Central Texas	908.2	896.0	744.2	-1.3	-18.3	271.3	268.4	259.5	-1.0	-4.3
South Texas	192.4	183.4	149.8	-4.7	-23.2	86.5	84.8	82.0	-1.9	-5.2
Trans-Pecos	1162.8	1089.4	893.5	-6.3	-24.7	553.2	536.9	522.8	-2.9	-5.5
Upper Coast	918.0	942.5	773.6	2.7	-15.3	272.9	274.6	263.4	0.6	-3.5

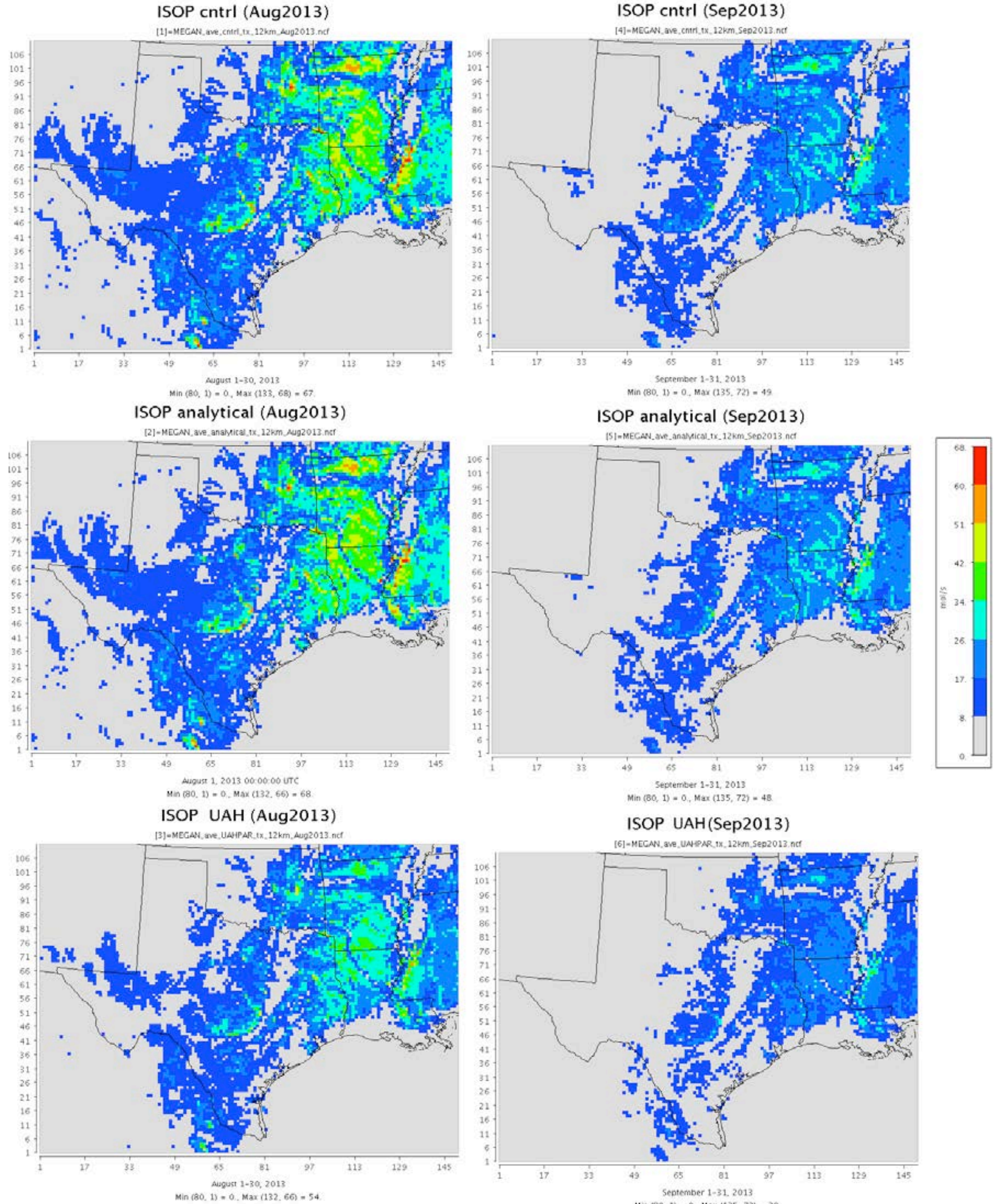


Figure 1. Comparison of the spatial patterns of the monthly mean isoprene (ISOP) emission rate using different PAR inputs for WRF control case (cntrl), WRF cloud assimilation case (analytical) and PAR satellite retrievals (PAR) in MEGAN over Texas domain during August (left) and September (right) 2013.

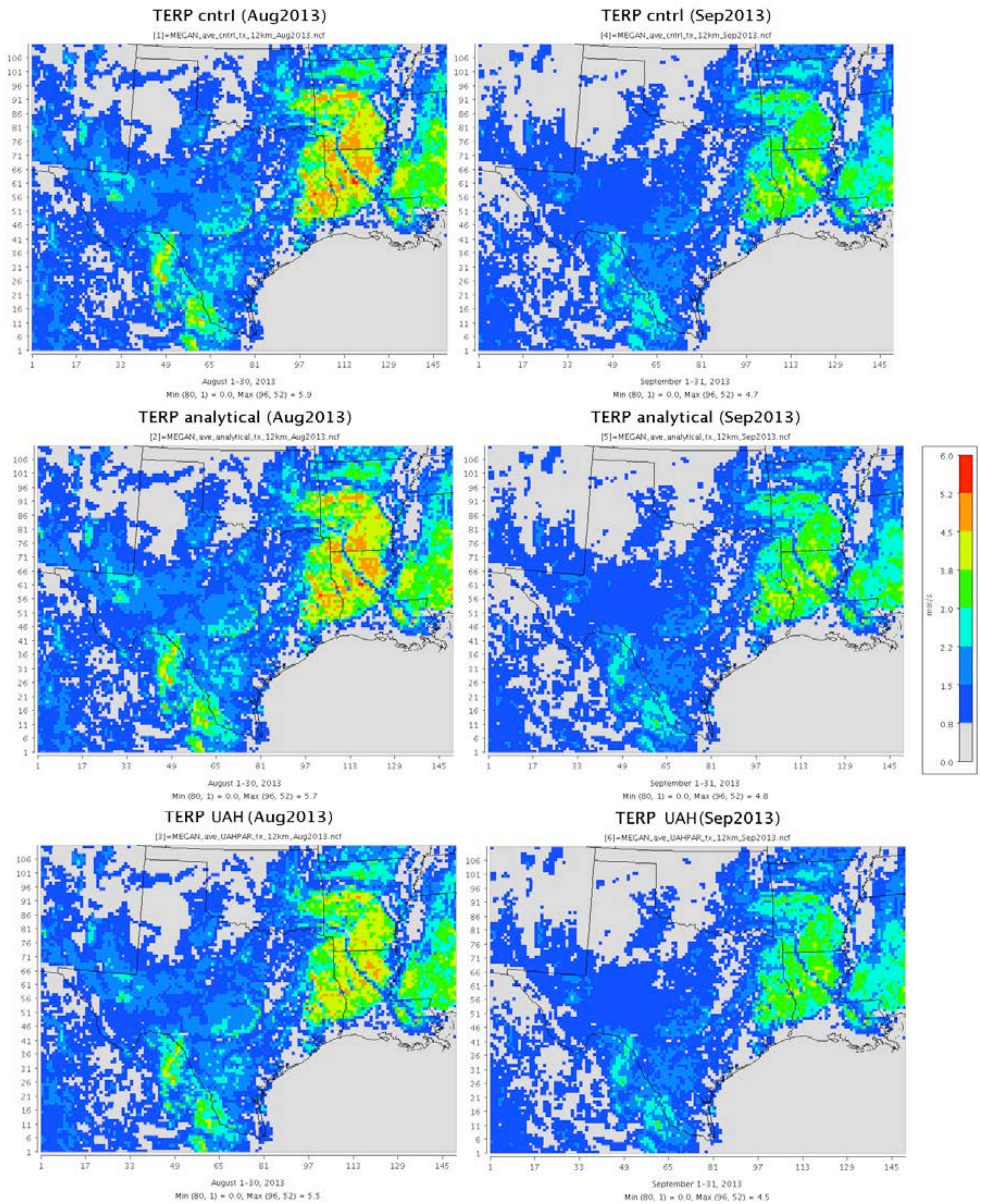


Figure 2. Comparison of the spatial patterns of the monthly mean monoterpene (TERP) emission rate using different PAR inputs for WRF control case (cntrl), WRF cloud assimilation case (analytical) and PAR satellite retrievals (PAR) in MEGAN over Texas domain during August (left) and September (right) 2013.

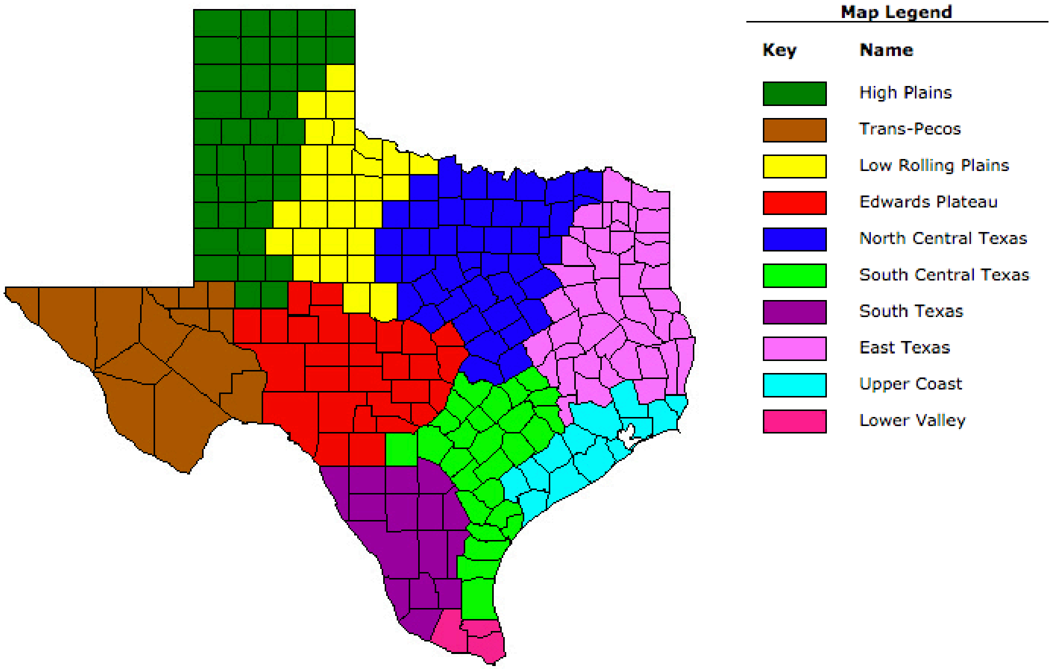
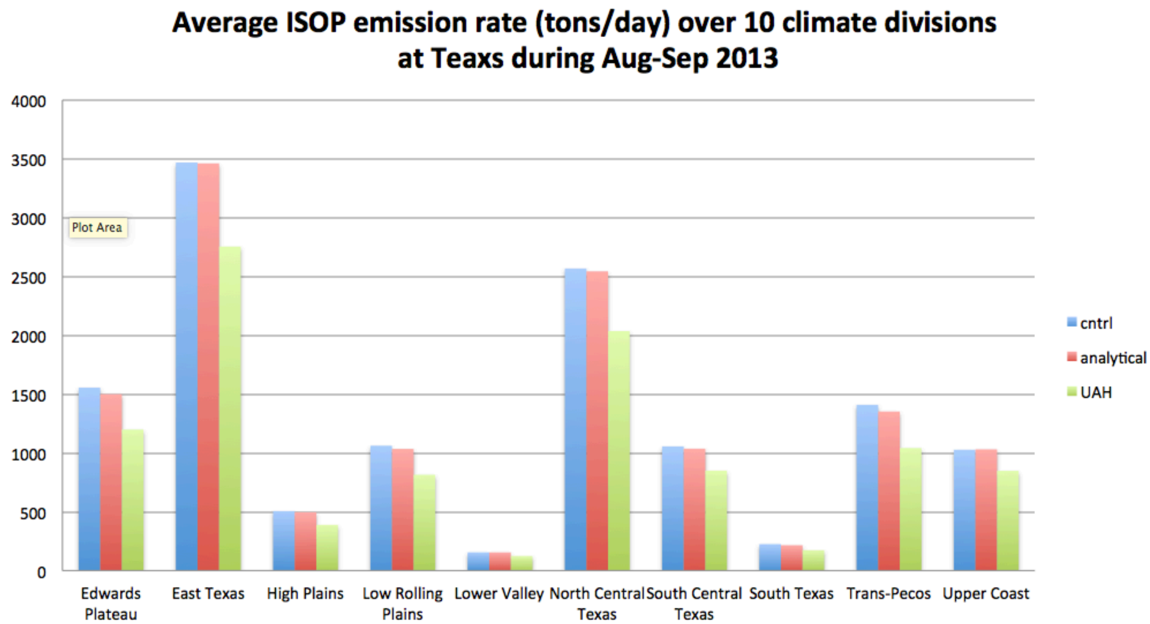


Figure 3. Geographic distribution of the 10 climate divisions in Texas by the National Weather Service (The figure is borrowed from http://www.nass.usda.gov/Statistics_by_State/Texas/Charts_&_Maps/cwmap.htm)



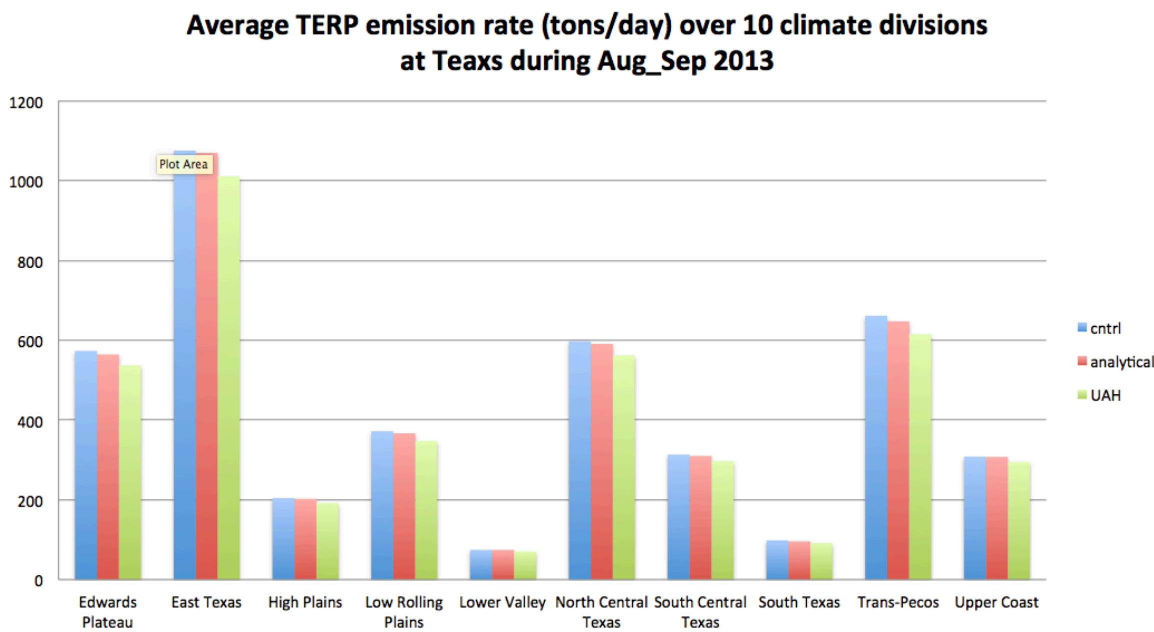


Figure 4. Comparsion of average isoprene (ISOP, top) and monoterpene (TERP, bottom) emission rate (tons/day) over the 10 climate divisions at Texas during August and Septmber 2013 by MEGAN using different PAR inputs.

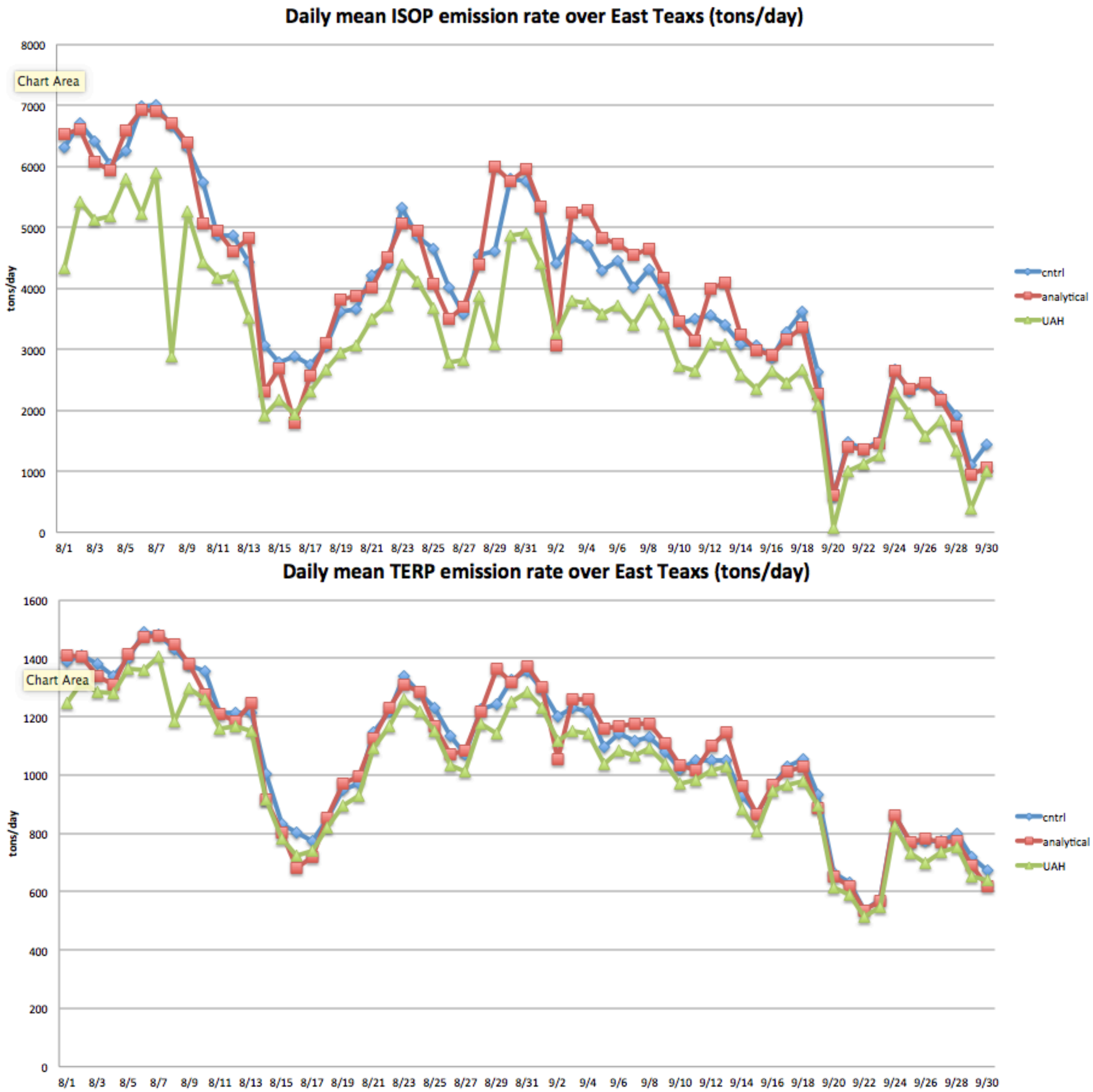


Figure 5. Comparison of the daily variation of isoprene (ISOP, top) and monoterpene (TERP, bottom) emission rate (tons/day) over East Texas during August and September 2013 by MEGAN using different PAR inputs.

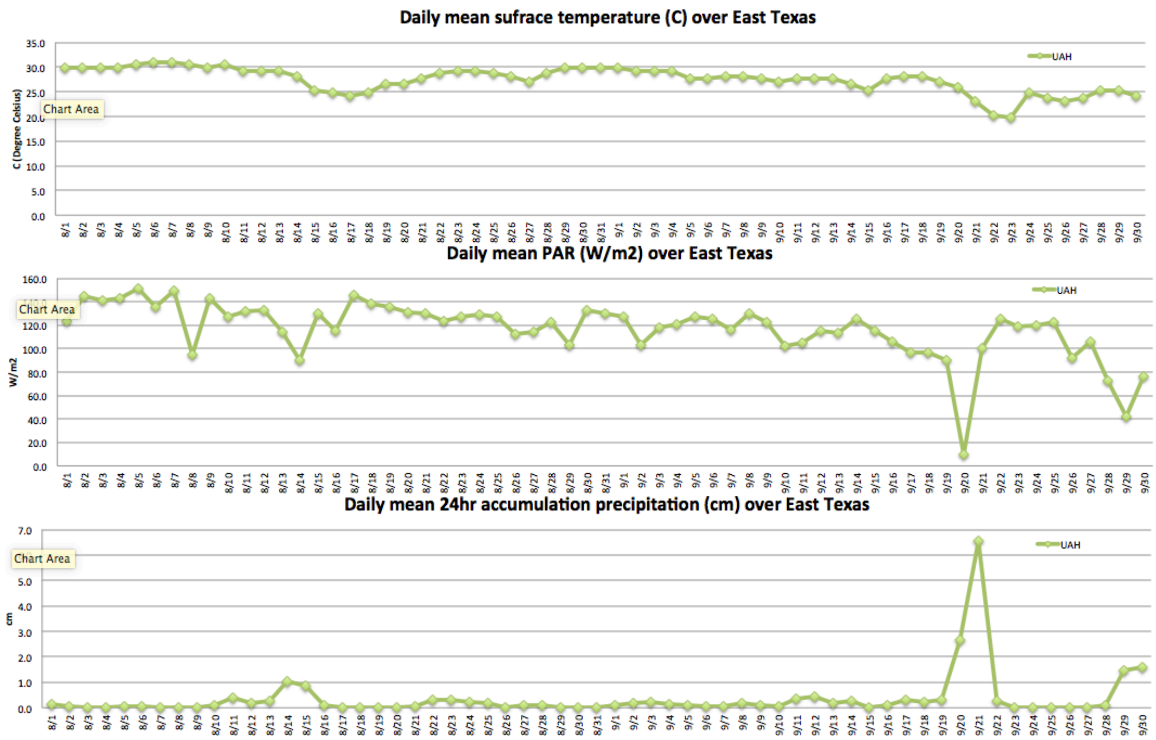


Figure 6. Time series of average daily mean surface temperature (degrees Celsius, top), PAR (W/m^2, middle) and 24hr accumulated precipitation (cm, bottom) over East Texas during August and September 2013 by MEGAN using PAR satellite retrievals from UAH.

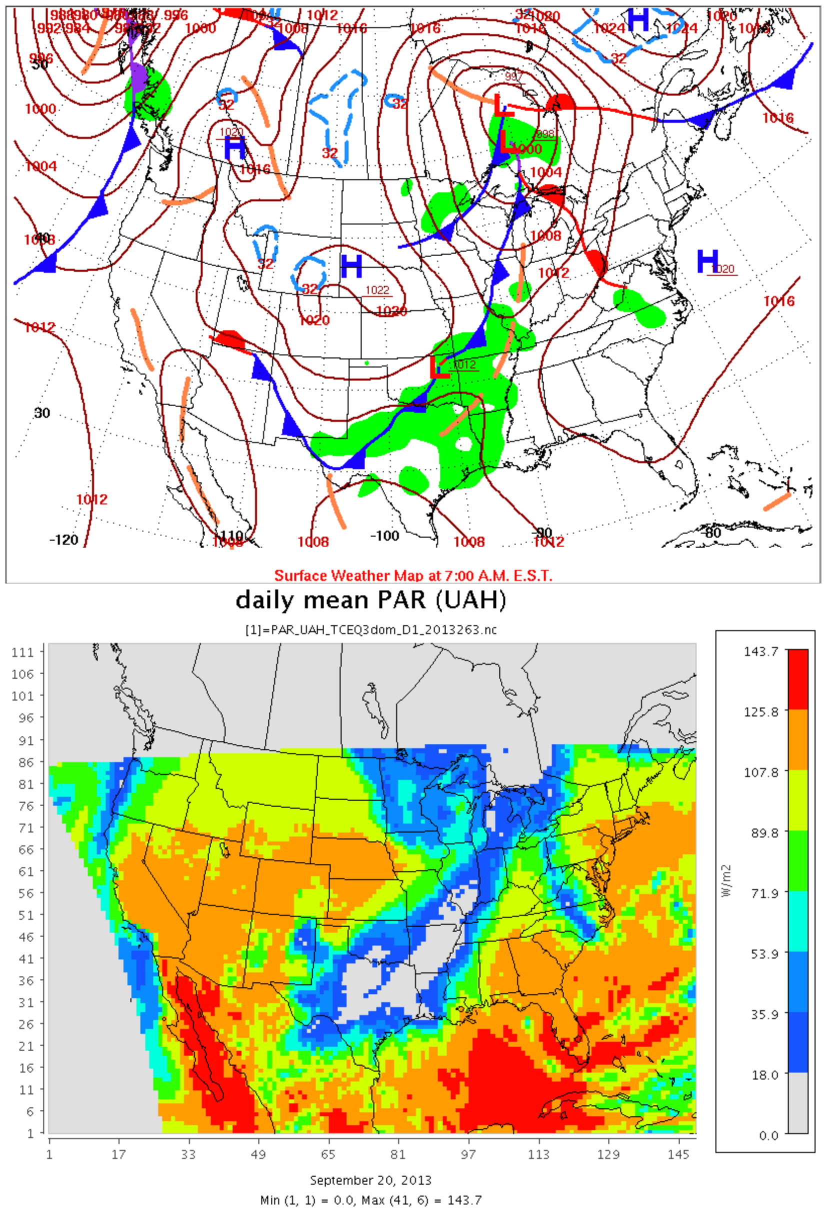


Figure 7. US surface weather map at 7 a.m. E.S.T on September 20, 2013 from NOAA (top); and the daily mean PAR retrieval from UAH on September 20, 2013 (bottom).

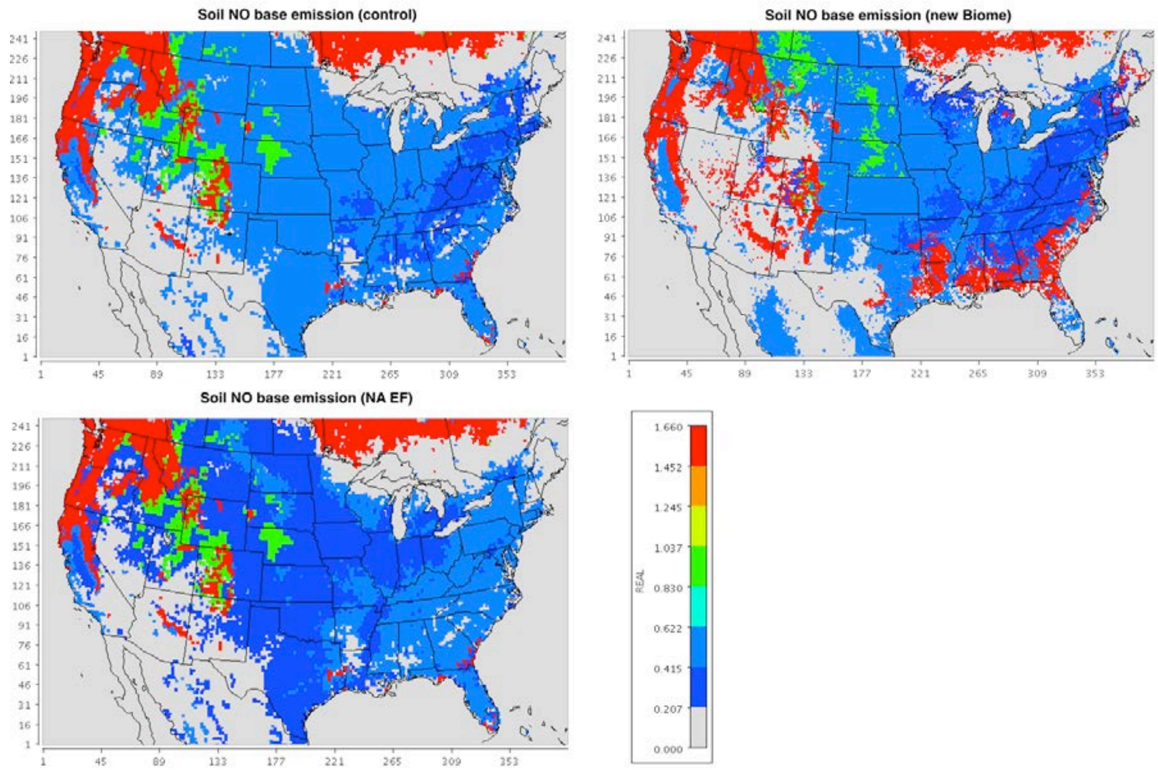


Figure 8. Spatial pattern difference of soil NO base emission simulated from BDSNP module using the global GEOS-Chem soil biome (control), updated regional soil biome based on NCLD40 (new Biome), and North American specified emission factors (NA EF) over the continental US.

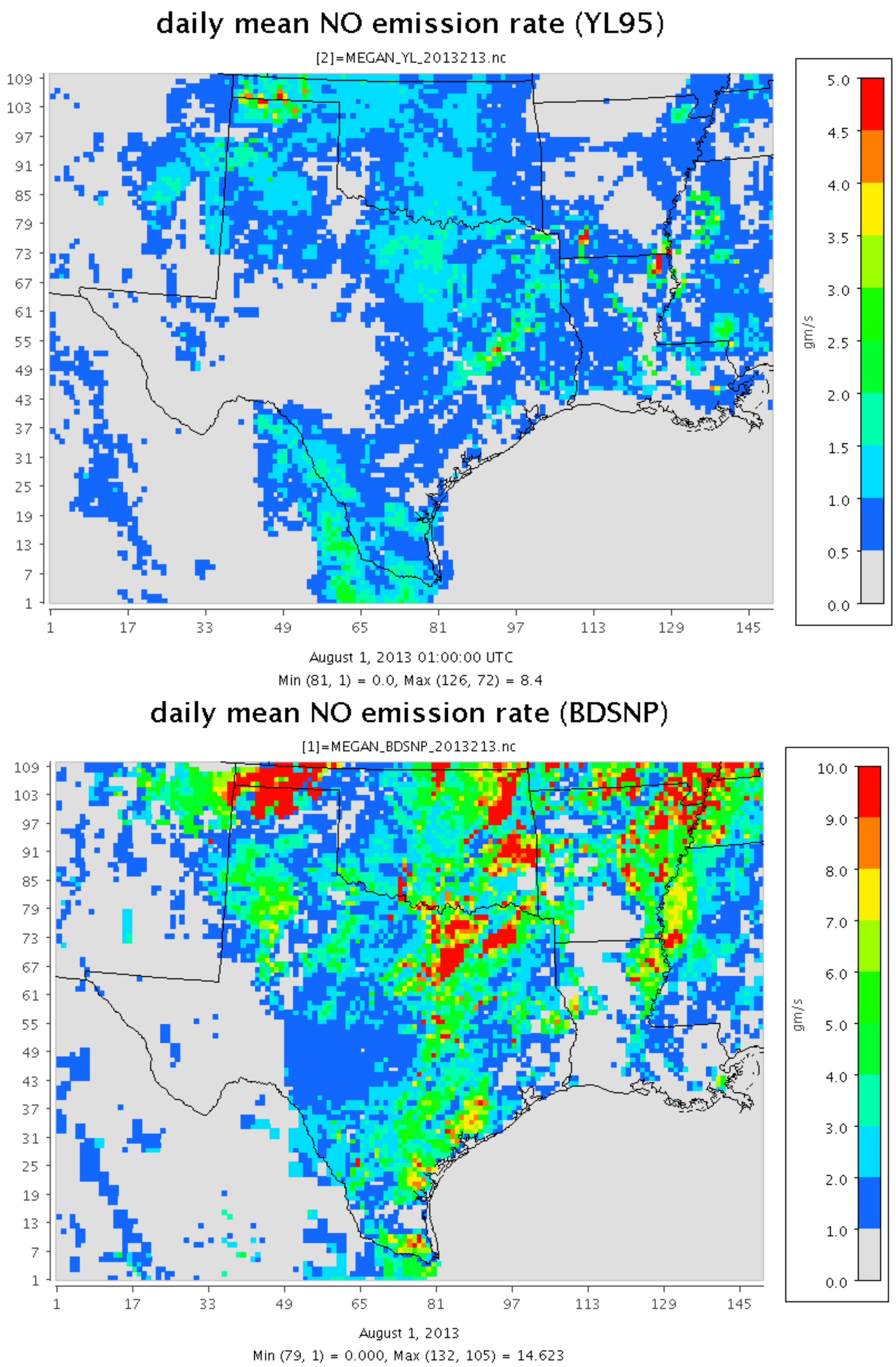


Figure 9. Spatial pattern difference of daily mean soil NO emission rate (g/s) from MEGAN default YL95 scheme (top) and BDSNP scheme (bottom) on August 1, 2013 over the Texas domain.