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**	June 23, 2015
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Work during this period included preparation for the presentation by Andrew White and Rui Zhang at the Texas AQRP meeting in Austin, and the modeling work described below.

MEGAN simulation with satellite PAR during September 2013

By using the UAH provided PAR satellite retrievals from GOES imager (case 'UAH/PAR') as well as two sets of WRF simulations (control case 'cntrl' with basic configurations and cloud assimilation case 'analytical' with cloud assimilation from GOES observations), three sets of MEGAN runs were carried out to quantify the impact of PAR inputs to biogenic emission estimates over the TCEQ SIP domains during September 2013. The details of the WRF-MEGAN model configurations, simulation case arrangement, and simulation time period selection as well as model performance evaluation are given in Table 1.

The raw UAH 4km CONUS PAR retrieval products were mapped to the three TCEQ SIP simulation domains (36km for CONUS, 12km for Texas and 4km for east Texas) using the revised utility codes based on the UNC Spatial Allocator. As shown in our last report, the revised codes ensure the consistency of spatial and temporal cloud locations between satellite imagers and the different domains. The regridded PAR products were directly replaced with the calculated PAR, which in MEGAN model is directly assumed as half of the solar radiation reaching surface value (RGRND) from WRF/MCIP insolation results. Figure 2 provides the snapshot of the spatial distribution of the three PAR inputs for MEGAN runs on 20:00:00 UTC, September 1, 2013 over Texas. It can be seen that the satellite PAR value is overall quite lower than the calculated PAR from two sets of WRF runs. The maximum value at that hour is 443 W/m^2 for satellite PAR while the corresponding value is 513 W/m^2 for case 'analytical' and 515 W/m^2 for case 'cntrl'. The spatial pattern of satellite PAR is also different with the calculated PAR due to the consideration of zenith angle and cloud optical depth correction instead of using uniformly scaling factor 0.5. The ratio between insolation and PAR can be varied from 0.42-0.70 depends on different locations (see the details in the PAR retrieval algorithms). Further evaluations were made to compare the UAH satellite insolation retrievals as well RGRND values from two WRF runs with the ground observations at 47 TCEQ broadband radiation monitoring network sites, and the statics are summarized in Table 2 (Notice that there is no site in Texas that directly observes PAR). The UAH satellite retrieval has better agreement than WRF simulations both in terms of correlation (R=0.96 for UAH versus R=0.91 for WRF_cntrl and R=0.91 for WRF_analytical) and error (NME=25.5% for UAH versus NME=27.7% for WRF_analytical and NMB=26.7% for WRF_cntrl). Similar to the evaluations carried out for August 2006, using satellite data can substantially reduce the over-prediction bias of the WRF control run, reducing NMB from 17.2% to 7.9% for the cloud-assimilated WRF run and 5.3% for UAH retrievals.

Figure 2 provides the spatial pattern comparison of the simulated average daily isoprene emission rates (moles/s) in MEGAN using the three different PAR inputs over Texas during September 2013. The average spatial patterns of the three cases were similar, with the predicted hotspots over the adjacent regions of northern Louisiana, southern Arkansas and western Mississippi. The hotspots of isoprene emissions are correlated with the locations of forests where the emission factor is high. Due the correction of clouds from satellite observations, the hotspots of isoprene emission for the control WRF case over northern Arkansas disappeared for the case of 'analytical' and 'UAH/PAR'. In terms of magnitude, the lower PAR values from the satellite retrieval yield lower isoprene emissions which is as expected. Figure 3 provides the domain-wise sum of daily isoprene and monoterpene emission strength over the Texas for the three cases. It can be seen that the PAR retrieval case predicted nearly one fourth lower ISOP emission compared with the WRF simulation runs (5463 moles/s for case 'cntrl', 5377 moles/s for case 'analytical' and 3698 moles/s for case 'PAR'). No significant change for TERP emission for the three cases were observed, since the monoterpene emission algorithm in MEGAN is not directly linked with PAR/insolation but more response with the surface temperature.

We are now using CMAQ instead of CAMx as the host air quality model to run the simulations to quantify the impact of different BVOC emission estimates to ozone predictions over Texas. The anthropogenic emissions are provided by TCEQ with the 2010 as the base year. The series of CMAQ outputs will be evaluated against Discover-AQ data to investigate the sources of uncertainty reported in the literature with respect to BVOCs.

Table 1. WRF-MEGAN model configurations over TCEQ domains during September 2013

WRF			
Version:	ARW V3.6.1	**Shortwave radiation:**	RRTMG scheme
Horizontal resolution:	D1 (CONUS, 36km); D2 (Teaxs, 12km)	**Surface layer physic:**	Pleim-Xiu surface model
	D3 (E Teaxs, 4km)	**PBL scheme:**	ACM2
Vertical resolution:	42 layer (first layer height ~ 37 m)	**Microphysics:**	Morrison double-moment scheme
Boundary Condition:	NARR 32km	**Cumulus Parameterization:**	Kain-Fritsch scheme
Initial condition:	NCEP-ADP	**Assimilation:**	Analysis nudging @ D1
Longwave radiation:	RRTMG scheme		Option run w/ cloud assimilation from GOES
MEGAN			
Version:	V2.10	**Emission factor:**	Global emission factor (ver. 2011)
Horizontal resolution:	Same as WRF	**Leaf area index:**	30 sec, MODIS 8 day average
Plant function type:	16 CLM PFT types, 30 sec	**Gas-phase mechanism:**	CB-05
Simultaion Case Arrangement			
1. PAR_cntrl:	Base WRF simulation to provide insloation for MEGAN		
2. PAR_analytical:	Base WRF + cloud assimilaition from GOES to provide insolation for MEGAN		
4. PAR_UAH:	Direct use PAR reterivals from UAH, other met inputs same as case 'PAR_analytical'		
Simulation Time Period			
	Sep 1-30, 2013		
Model Performance Evaluation			
TCEQ broadband radiation moitoring Network	(http://www.tceq.state.tx.us/agency/data/air_met_data.html)		

Table 2. Summary of statistics of insolation simulation/retrievals for different cases at 47 TCEQ network sites during September 2013

	OBS_AVE (W/m2)	SIM_AVE (W/m2)	IA[1]	R[2]	RMSE[3] (W/m2)	MB[4] (W/m2)	NMB[5] (%)	NME[6] (%)
cntrl	259.6	303.8	0.95	0.91	132.3	45.9	17.2	26.7
analytical	259.6	276.8	0.95	0.91	133.9	17.3	7.9	27.7
UAH	259.6	269.6	0.96	0.96	117.2	10.1	5.3	25.5

Note: 1. IA-index of agreement; 2. R-correlation coefficient; 3. RMSE-root mean square error; 4. MB-mean bias; 5. NMB-normalized mean bias; and 6. NME-normalized mean error

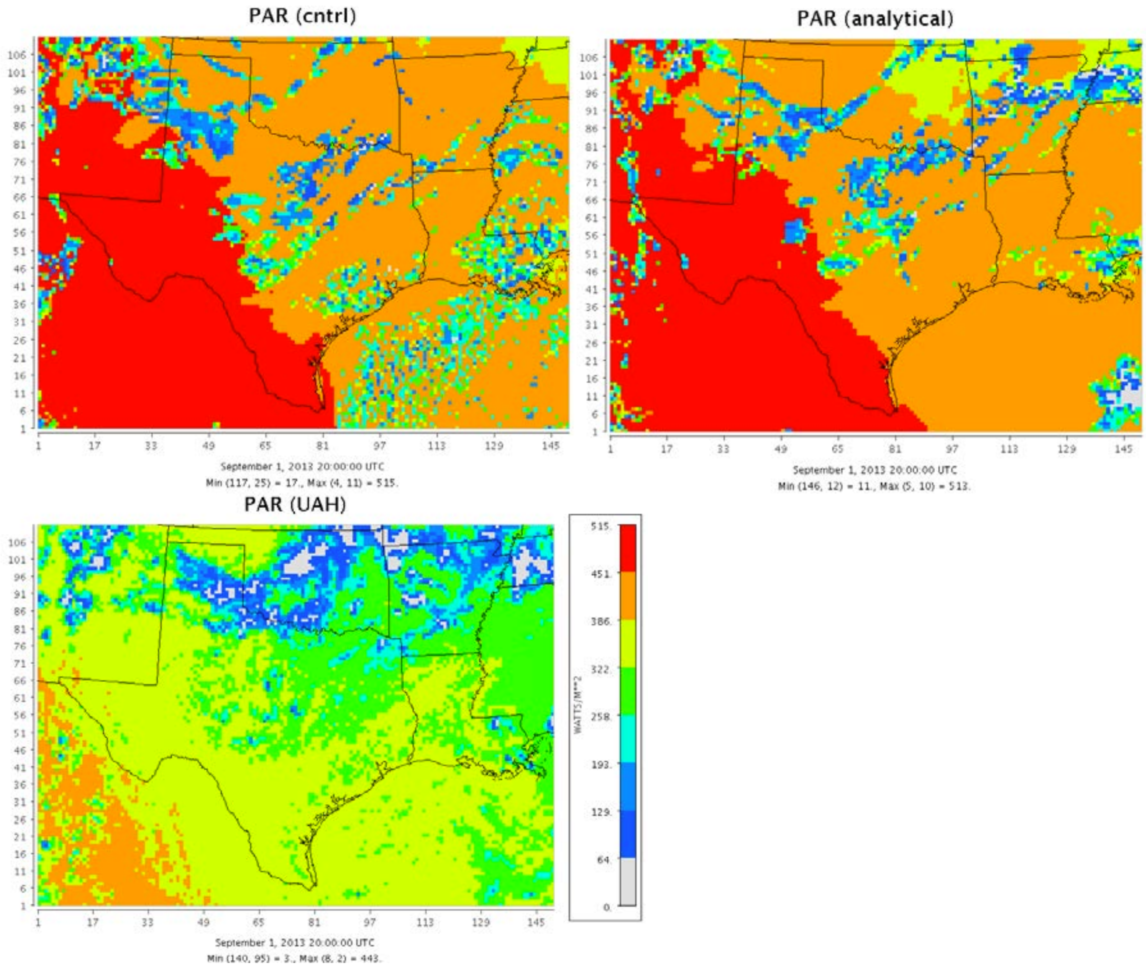

Figure 1. Comparison of the spatial pattern of different PAR inputs for WRF control case (cntrl), WRF cloud assimilation case (analytical) and PAR satellite retrievals (UAH) in MEGAN over Texas domain on 20:00:00 UTC, September 1, 2013

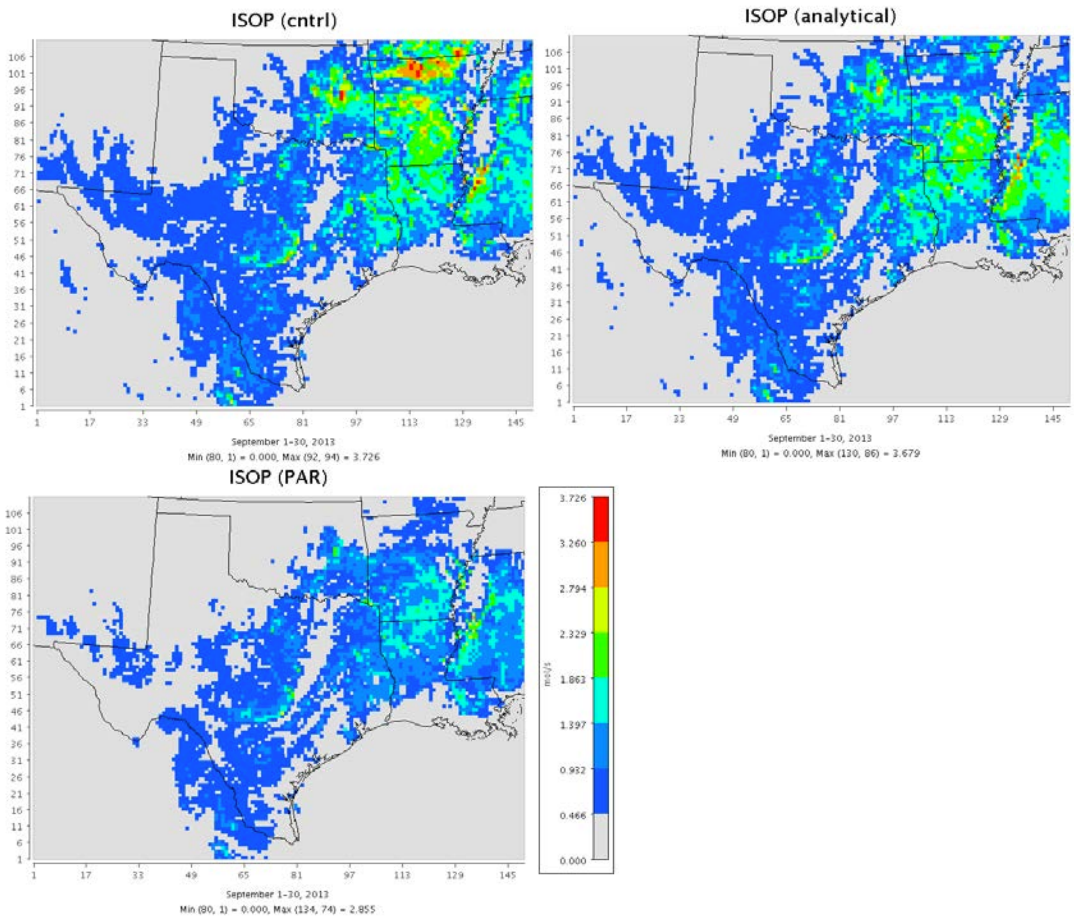

Figure 2. Comparison of the spatial pattern of estimated average isoprene emission rate in MEGAN using different PAR inputs over Texas domain during September 2013

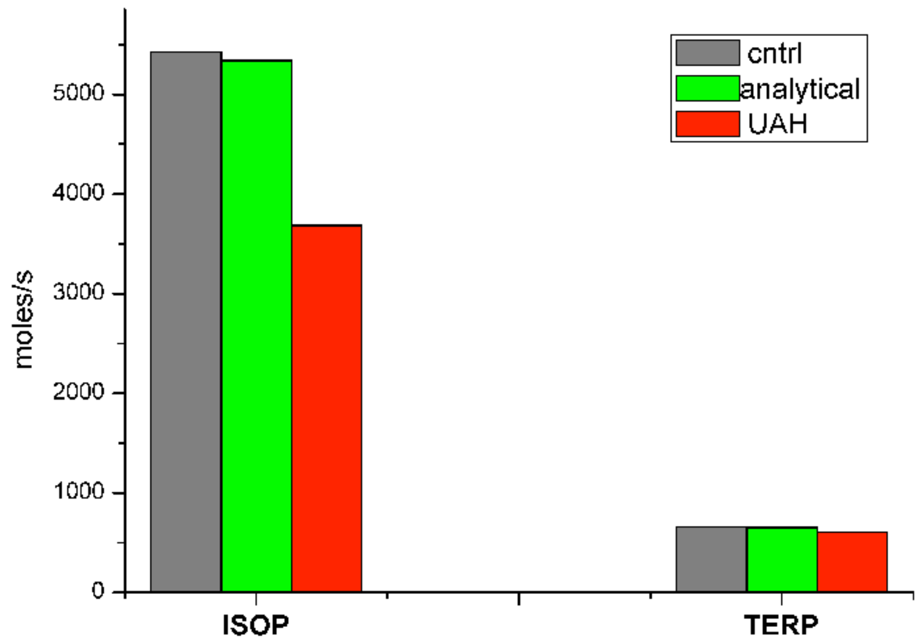

Figure 3. Domain-wise sum of estimated isoprene (ISOP) and monoterpene (TERP) emission strength over Texas area using different PAR inputs in MEGAN during September 2013