AQRP Monthly Technical Report

PROJECT TITLE	Incorporating Space-borne Observations to Improve Biogenic Emission Estimates in Texas	**PROJECT #**	14-017
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REPORTING PERIOD	**From:** February 1, 2015 **To:** February 28, 2015	**REPORT #**	10

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 for WRF 2013 Simulations

The motivation for this task is to test the impact of satellite cloud assimilation on improving biogenic emission estimates. While replacing model-derived PAR with satellite PAR can improve biogenic emission estimates, correcting cloud fields in the model not only improves model-derived PAR, but also it will improve air quality simulations. Thus, in this project the impact of satellite cloud assimilation for summers of 2006 and 2013 is being examined.

The August and September 2013 WRF simulations consist of three different runs over three domains. A domain with 36-km grid spacing that covers the continental U.S., a 12-km resolution nested domain that covers east/southeast U.S., and a 4-km domain that mainly covers the state of Texas. For each domain, the first run is the control (CNTRL) simulation, which does not include any assimilation. The second is the max insolation (INSO) simulation, which has the microphysics and cumulus parameterization disable. This simulation is needed so that the maximum amount of solar insolation received at the surface for every model grid point can be determined. Using the INSO and CNTRL insolation fields then allows us to determine the model cloud albedo. The model cloud albedo, is then compared to GOES satellite observations for use in the cloud assimilation algorithm. Once this is finished, the final satellite assimilation (ASSIM) simulation can be completed.

Originally, the CNTRL and INSO simulations for domains one through three were completed using a 42 layer vertical structure. However, the decision was made to go with a 43 layer vertical structure that was consistent with the other groups working on this project. Therefore, the 2013 WRF simulations needed to be redone. With the new vertical layer structure in place, the CNTRL simulations for all three domains and the INSO simulation for domain 1 have been completed. With the INSO and CNTRL simulations completed for domain 1, the ASSIM simulation can be started for domain 1. The INSO simulation for domain 2 is currently being run, which will then allow the domain 2 ASSIM simulation to be completed. Once all three simulations are complete for domain 2 it will then allow further progress to be made on the third domain.

Progress Summary for 2006 PAR evaluations

WRF simulations with and without satellite cloud assimilation for August 2006 were performed. Results from these simulations were compared with UAH and University of Maryland insolation products and were all evaluated against SURFRAD observations. The details are provided in the attached document (at the end of this report).

Preliminary Analysis

Attached.

Data Collected

Satellite retrievals of surface insolation and cloud albedo for the period of August 2006 were collected.

Identify Problems or Issues Encountered and Proposed Solutions or Adjustments

In order to be consistent with other ongoing projects, WRF simulations for 2013 were repeated. The new simulations have 43 vertical layers with higher resolution around tropopause.

Goals and Anticipated Issues for the Succeeding Reporting Period

Detailed Analysis of the Progress of the Task Order to Date

Attached.

Arastoo Pour Biazar

Submitted to AQRP by:

Principal Investigator: Arastoo Pour Biazar

Evaluating satellite insolation retrievals during August 2006

In order to evaluate the satellite insolation retrievals product from UAH and compare with the similar photosynthetically active radiation (PAR) retrievals from Pinker's group at University of Maryland (UMD) (http://www.atmos.umd.edu/~srb/gcip/cgi-bin/historic.cgi?auth=no parameter=par), UAH provided the hourly 4km × 4km resolution CONUS satellite insolation and PAR retrievals during August 2006 by using the updated retrieval algorithm (given in the last quarterly report section 2.2) for the GOES satellite imagery. Figure 1 shows the snapshot of satellite-derived insolation (top) and PAR (bottom) at 15:45 GMT, Aug 16, 2006. In total 1500 (columns) × 800 (rows) grids were generated over the continental US domain. For later comparison, those instantaneous retrieval values at each 45 minutes of the hour were linearly interpolated to the ending of the hour. The UMD PAR satellite retrievals used here for comparison were hourly average flux, which is an estimate of the flux averaged for an hour ending at the hour in local standard time. MEGAN has a utility to directly read those UMD PAR archive files and generate hourly outputs. The UMD PAR products were archived at a much coarser resolution (0.5 degree X 0.5 degree), resulting in 121 (columns) × 61 (rows) over the continental US. Figure 2 shows the UMD satellite-derived PAR at 16:00 GMT, Aug 16, 2006.

UAH also provided two sets of WRF simulations for August 2006 to compare with the satellite products either from UAH or UMD and evaluate their influence on biogenic emission estimates using MEGAN. Table 1 and Figure 3 provide the detailed domain configurations for UAH WRF simulations. The three nested domains zoom down from the continental US (D1: 36km × 36 km) to the southern US (D2: 12km × 12km) to eastern Texas (D3: 4km × 4km). The first WRF simulation (labeled 'cntrl' for control case) assimilated data only from traditional observations, while the second simulation (labeled 'analytical') also assimilated the cloud information from GOES satellite observations. The month was separated into 7 patches each lasting 5 days, with the first 12 hours used as spin-up. Figure 4 provides daily mean difference of simulated 2-m temperature on Aug 16, 2006 between the 'analytical' and 'cntrl' simulations. It can be seen that with the inclusion of observed clouds, the radiation balance calculations in WRF were redistributed and on average result in less downward shortwave radiation reaching the ground and lower ground temperatures. The change of available downward shortwave radiation will directly impact the PAR available for biogenic emission calculation, since MEGAN calculates PAR as half of the insolation if PAR is not directly specified. The magnitude of daily mean difference of 2-m temperature can be as high as 3.9K due to the existence of cloud.

PAR from the two satellite retrievals (UAH and UMD) and the two WRF simulations (cntrl and analytical) were compared with the direct PAR measurements at the seven Surface Radiation Budget Network (SURFRAD) sites that report continuous PAR measurements. Data were taken from the grid cell closest to each site, using the 4-km resolution UAH data, the half-degree resolution UMD data, and the 36-km resolution D1 domain for the WRF simulations.

Figure 5 provides time series plots comparing each set of PAR estimates with observations at the PSU SURFRAD site. The base case WRF simulation overestimates the daily peak PAR values by 25%~37% for nearly the whole month (Figure 5a). The cloud assimilation WRF simulation also overestimates daily peak PAR values but by smaller amounts (12%~23%) (Figure 5b). The differences between the WRF simulations are most apparent on Aug 8, Aug 20 and Aug 30. Both satellite retrievals (Figure 5c-d) achieve better agreement with measured values of PAR at the PSU site than the WRF simulations achieved. The UAH retrieval tends to slightly overestimate daily peak PAR at PSU, while the UMD retrieval PAR tends to slightly underestimate PAR.

Figure 6 and Table 2 extend our analysis to all seven SURFRAD sites. The UAH and UMD retrievals both achieve similar performance for statistics such as correlation coefficient (R), root mean square error (RMSE), mean aggregate gross error (MAGE), and normalized mean error (NME), and outperform the WRF simulations on these measures (Table 2). However, the UMD retrieval tends to underestimate PAR (normalized mean bias (NMB) of -12.4%) while the UAH retrieval tends to overestimate PAR (NMB of 10.2%).

Ongoing PAR/insolation performance evaluations from difference sources (either WRF outputs or satellite retrievals from UMD or UAH) during August 2006 are:

(1) Compare the PAR/insolation results against other ground observations such as the Soil Climate Analysis Network (SCAN) and Texas local broadband pyranometer observations.
(2) Conduct MEGAN simulations over the East Texas domain (D3) to quantify the influence of different PAR inputs on the biogenic emission estimates.

Figures

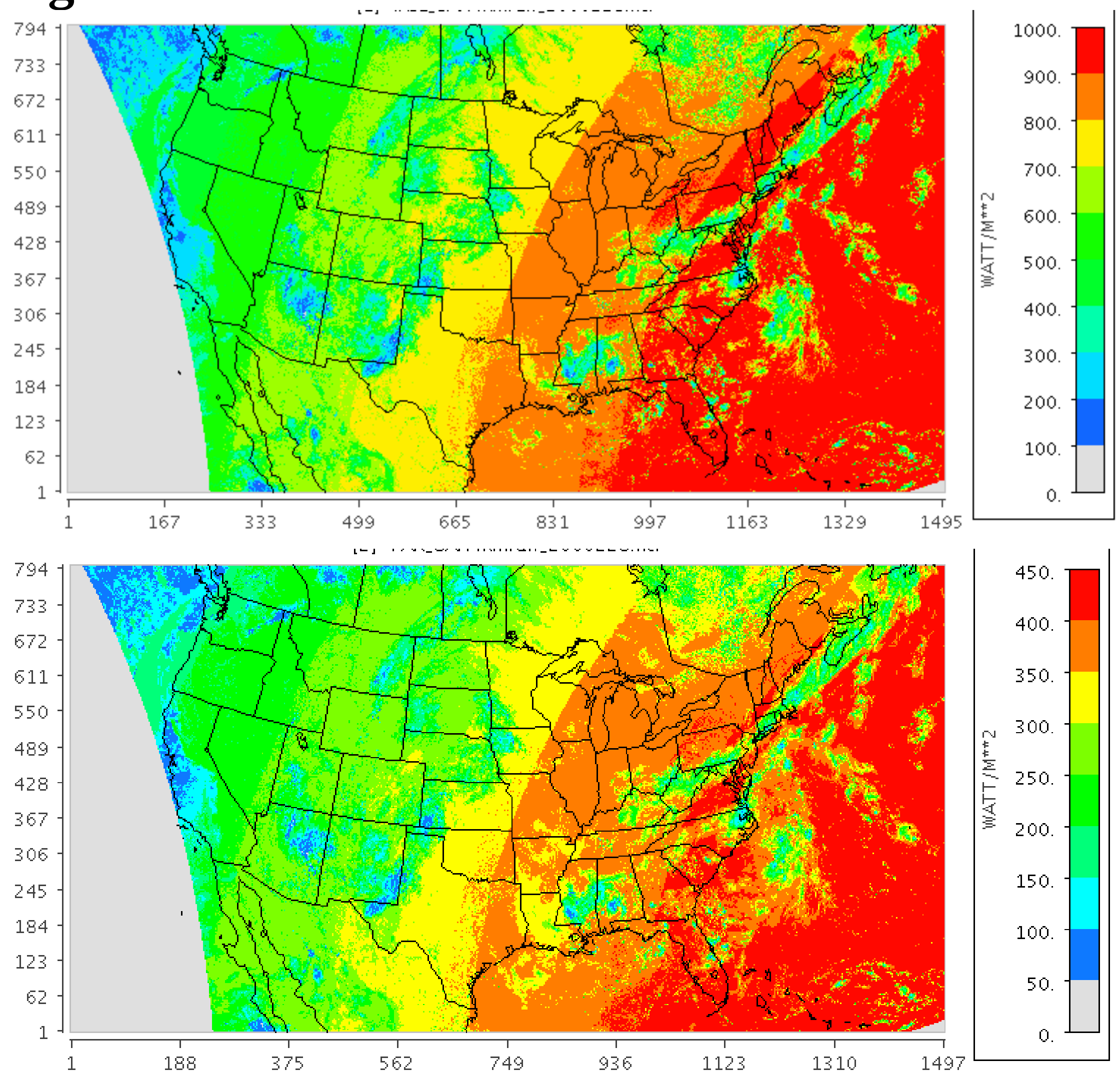

Figure 1. Snapshot of satellite-derived insolation (top) and PAR (bottom) at 15:45 GMT, Aug 16, 2006 from the UAH retrieval.

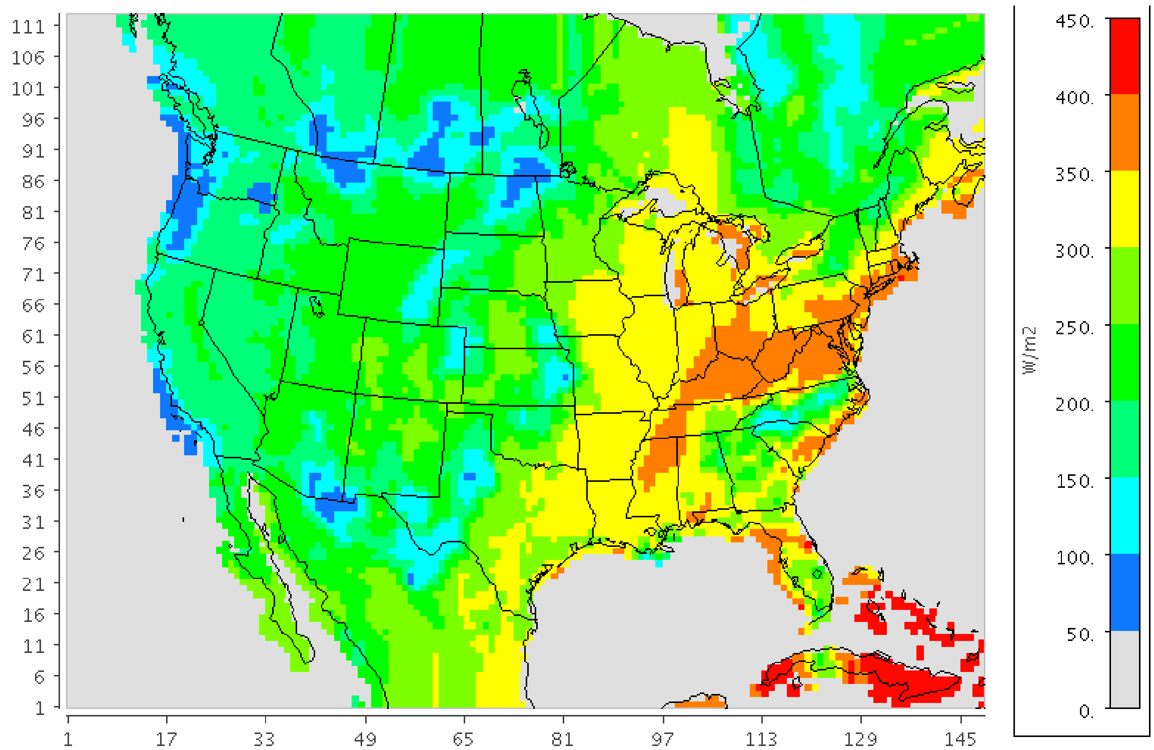

Figure 2. Satellite-derived PAR for the hour ending at 16:00 GMT, Aug 16, 2006 from the UMD retrieval.

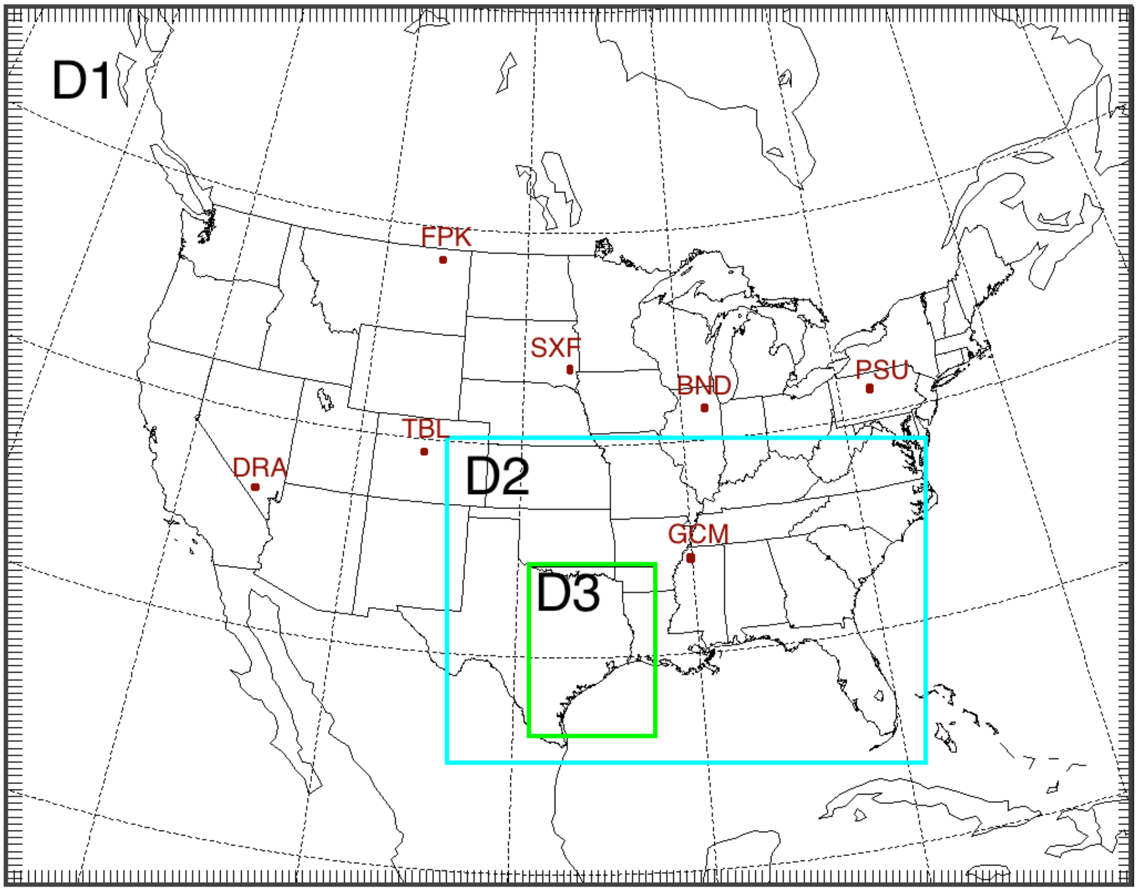

Figure 3. Domain coverage for the UAH WRF simulations during August 2006 and the location of SURFRAD sites for PAR measurements

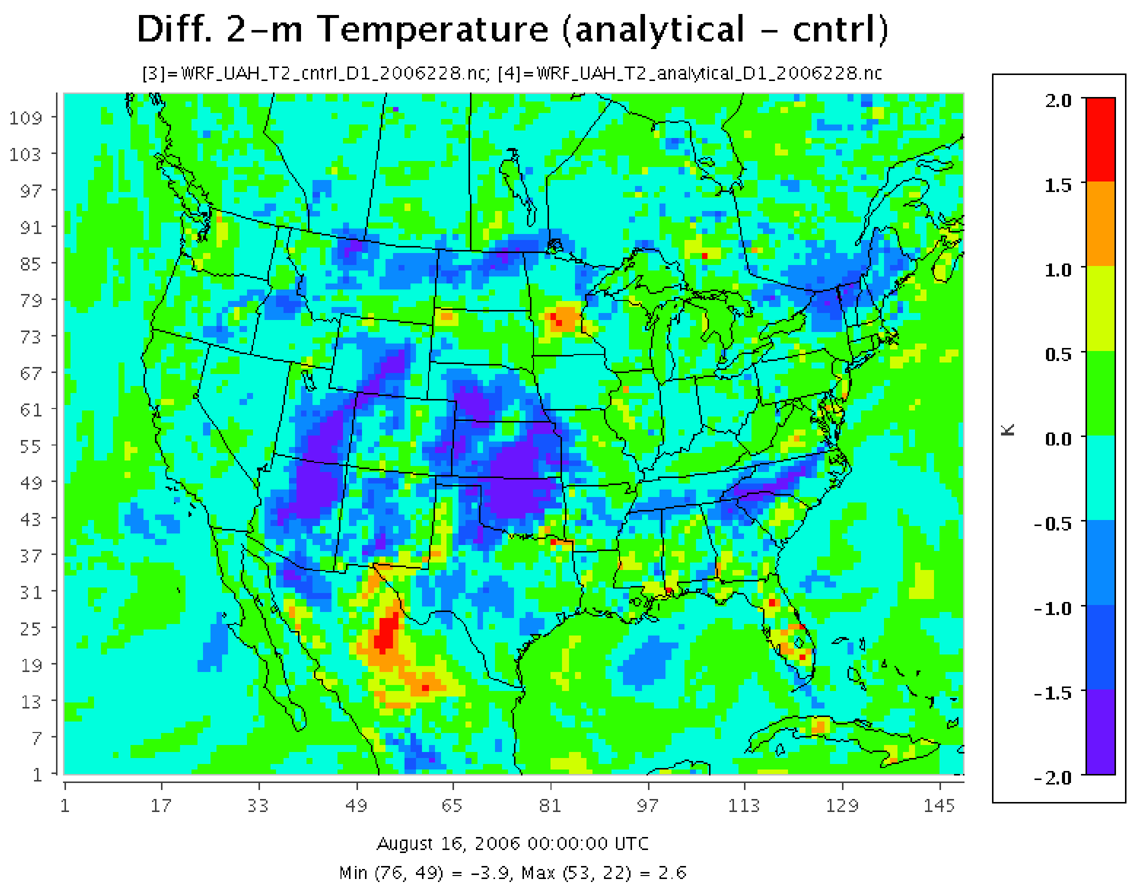

Figure 4. Daily mean difference of 2-m ground temperature between ‘cntrl’ and ‘analytical’ WRF simulations on August 16, 2006.

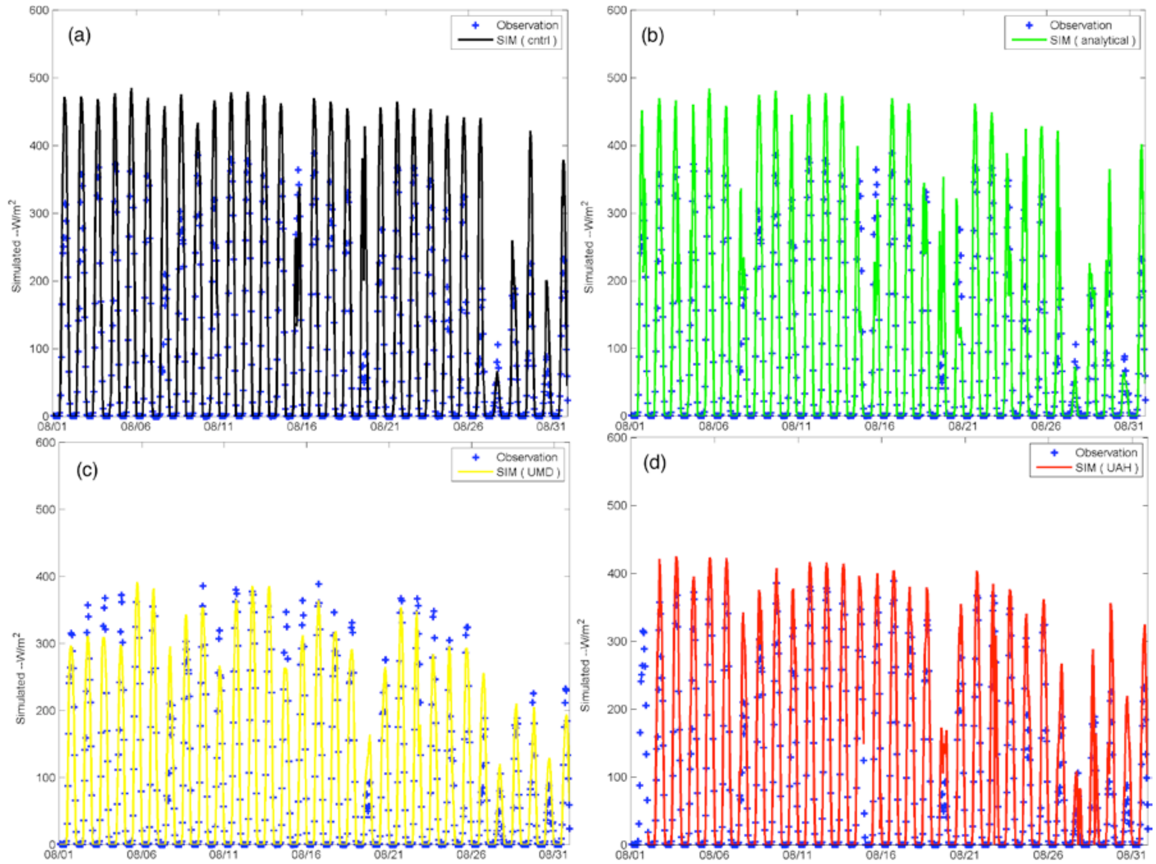

Figure 5. Time series of PAR from (a) WRF cntrl simulation, (b) WRF analytical simulation, (c) UMD retrieval, and (d) UAH retrieval compared with PAR measured at the PSU SURFRAD site during August 2006.

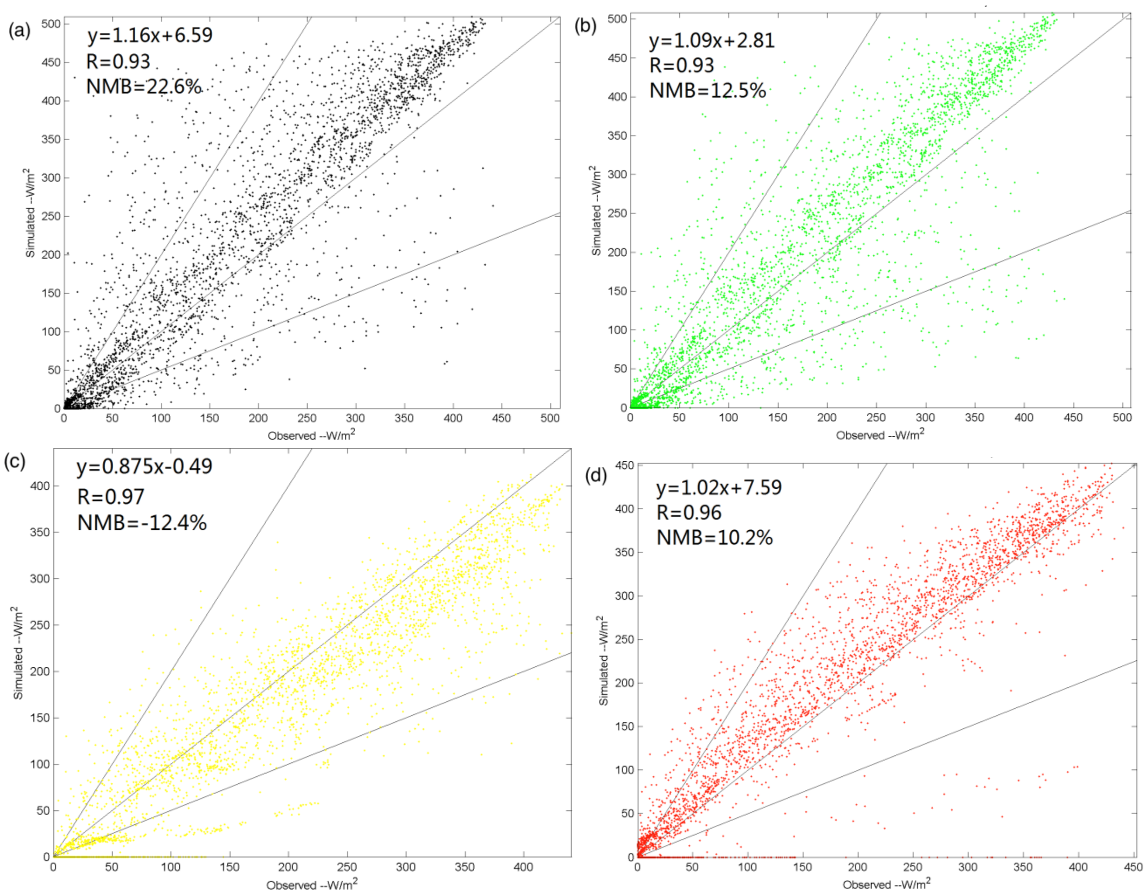

Figure 6. PAR estimated by(a) WRF cntrl simulation (b) WRF analytical simulation (c) UMD retrieval (d) UAH retrieval, plotted against PAR measurements during August 2006 at the seven SURFRAD sites.

Tables

Table 1. Domain configuration for the UAH WRF simulation during August 2006

Domain	Range [km]		Number of Grid Points		Cell Size [km]		Starting Grid Cell Relative to domain 1	
	Easting	Northing	Easting	Northing	Easting	Northing	Easting	Northing
D1 (CONUS)	(-2952,2952)	(-2304,2304)	165	129	36	36	1	1
D2 (South US)	(-648,1872)	(-1656,36)	211	142	12	12	65	19
D3 (E Texas)	(-216,444)	(-1512,-636)	166	220	4	4	77	23

Table 2. Statistics of different PAR products evaluated against observation from the seven SURFRAD network sites

PAR Source	OBS_AVE (W/m2)	SIM_AVE (W/m2)	IA	R	RMSE (W/m2)	MB (W/m2)	MAGE (W/m2)	NMB (%)	NME (%)
WRF_cntrl	107.7	131.2	0.95	0.93	65.3	23.4	37.1	22.6	35.5
WRF_analytical	107.7	121.0	0.95	0.93	59.6	13.3	34.3	12.5	32.8
UMD_retrieval	107.7	93.4	0.97	0.97	38.5	-14.2	22.5	-12.4	20.7
UAH_retrieval	107.7	117.8	0.97	0.96	43.0	9.7	22.0	10.2	21.0

*IA-index agreement, R-correlation coefficient, RMSE-root mean square error, MB-mean bias, MAGE-mean aggregate gross error, NMB-normalized mean bias, NME-normalized mean error