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**	4/12/2015
REPORTING PERIOD	**From:** March 1, 2015 **To:** April 10, 2015	**REPORT #**	11

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 August and September 2013 WRF simulations have been completed for domain 1, a 36 km grid covering the Continental United States (CONUS) region, and for domain 2, a nested 12 km grid covering part of the Southern United States (SouthUS). The simulations for domain 3, a nested 4 km grid covering Texas, are still in the process of being completed. A summary of the simulations along with the preliminary results will accompany this report.

Preliminary Analysis
Attached.

Data Collected
None for this period.

Identify Problems or Issues Encountered and Proposed Solutions or Adjustments
The new KF cumulus parameterization with Ma-Tan trigger function, caused instability over complex terrain in the western U.S. causing WRF to crash. Reduction of advection time step avoided the model crash, but unreasonable winds over a small region is still a problem.

Goals and Anticipated Issues for the Succeeding Reporting Period
Finish the analysis of WRF simulations and continue emission estimate efforts.

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

Arastoo Pour Biazar

Submitted to AQRP by:

Principal Investigator: Arastoo Pour Biazar

Progress Summary for WRF 2013 Simulations

The motivation for this study 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.

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Table 1: WRF configuration

	Domain 1	Domain 2
Running Period	August – September 2013	
Horizontal Resolution	36 km	12 km
Time Step	90 s	30 s
Number of Vertical Levels	43	
Top Pressure of the Model	50 hPa	
Shortwave Radiation	RRTMG	
Longwave Radiation	RRTMG	
Surface Layer	Monin-Obukhov	
Land Surface Layer	Unified Noah (4-soil layer)	
PBL	YSU	
Microphysics	Thompson	
Cumulus Physics	Kain-Fritsch (with Ma and Tan 2009 trigger function)	
Meteorological Input Data	NAM Analysis	
Analysis Nudging	Yes	
U, V Nudging Coefficient	3×10^{-4}	
T Nudging Coefficient	3×10^{-4}	
Q Nudging Coefficient	1×10^{-5}	
Nudging within PBL	Yes for U and V, No for q and T	

The results of two different WRF simulations will be presented: the control (CNTRL) simulation and the GOES satellite assimilation (ASSIM) simulation. The CNTRL simulation only nudges in the NAM analysis temperature, wind, and mixing ratio data throughout the forecast time period, while the ASSIM simulation uses an analytical technique for assimilating in GOES satellite observations through the nudging field. The results that will be presented in this report are the cloud agreement between satellite observations and the WRF simulations.

Agreement Index

The cloud agreement index (AI) calculates how well the model does at producing clouds in the correct place and at the correct time when compared to GOES satellite observations. Thus, it will be used as the metric to rate the model cloud performance. The AI was calculated for each hour in the range 15:00-22:00 GMT in the August-September 2013 time frame. The time range was chosen to ensure maximum daylight coverage across the domain so that GOES imager observations are available. The hourly AIs were then averaged to produce the daily AI.

a) Agreement Index 36 km Domain

The daily AI in Figure 1 shows that the ASSIM simulation has a greater AI than the CNTRL simulation for all days in the simulation time period. The average daily percentage increase in the AI from the CNTRL to the ASSIM simulation was found to be 12.71%. The individual hourly results similarly showed that the AI was greater for the ASSIM simulation than it was for the CNTRL simulation. The maximum hourly percentage increase was found to be 22.54%, while the minimum increase was 0.92%. These results show that this GOES assimilation technique, overall, does improve cloud placement in space and time relative to GOES satellite observations.

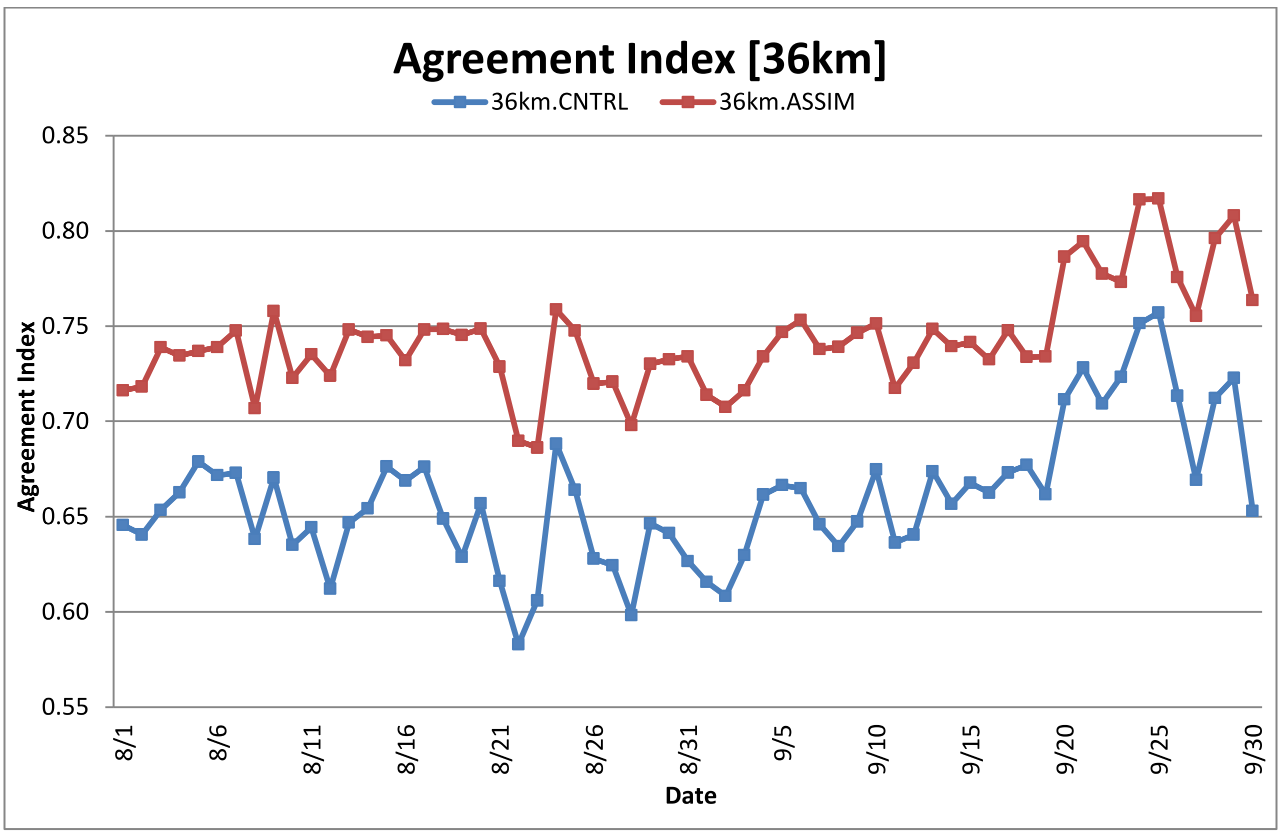

Figure 1: Daily agreement index for CNTRL and ASSIM 36 km WRF simulations over August-September 2013 using a 10% cloud albedo threshold.

Figure 2 shows a spatial plot of the agreement index for August 21, 2013 at 17 UTC. From Figure 2a, we see that the CNTRL simulation has trouble creating clouds in locations that GOES observes them as indicated by the large coverage of orange shading. Also, the CNTRL simulation tends to produce more clouds over the ocean than what is observed by GOES, as indicated by the red shading in Figure 2a. By assimilating GOES observations into WRF, the result is less overprediction and underprediction of clouds with respect to observations, as can be seen with the reduction of orange and red shading in Figure 2b when compared to Figure 2a.

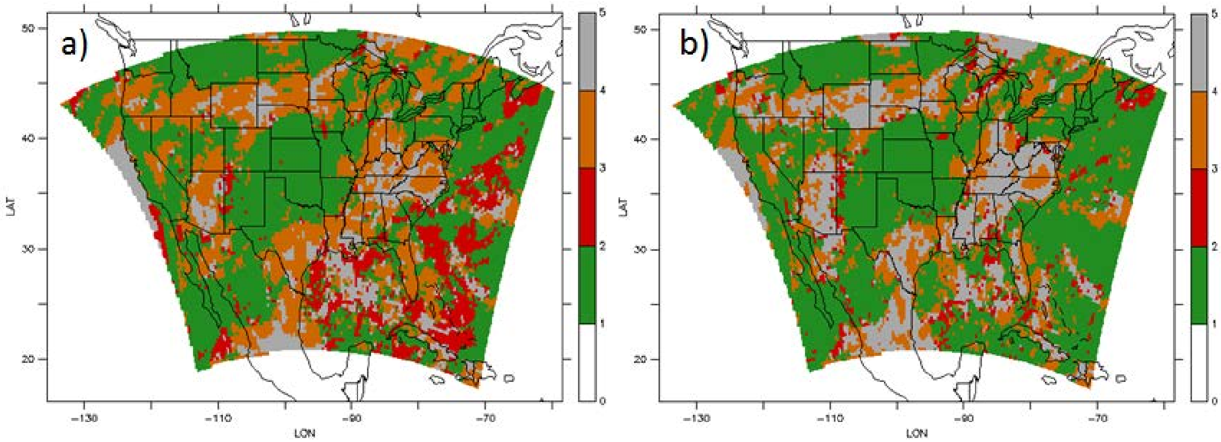

Figure 2: Agreement Index for August 21, 2013 at 17 UTC from a) CNTRL (AI=59.9%) b) ASSIM (AI=73.4%). Green indicates the model and GOES was clear, Red indicates locations where the model overpredicts clouds, Orange indicates locations where the model underpredicts clouds, and Grey indicates locations where the model and GOES are cloudy.

b) Agreement Index 12 km Domain

For the 12 km domain, we once again compared the CNTRL and ASSIM WRF simulations. The daily AI results are shown in Figure 3. Similar to the results for the 36 km domain, we see that the daily AI for the ASSIM simulation was greater than the CNTRL simulation. However, the daily percentage increase was determined to be less at 9.65%. There was also found to be greater variability in the hourly AI percentage change between the CNTRL and ASSIM simulations. The maximum hourly percentage increase was found to be 24.75%, while the minimum hourly percentage increase was found to be -4.70%. The negative indicates that at the particular hour, the CNTRL simulation actually had better agreement with the satellite than the ASSIM simulation did. However, this decrease in the AI occurred during times where the CNTRL AI was already high (AI>80%), in which corrections to disagreement areas tend to have a higher probability of disrupting areas previously in agreement with the GOES observations. Figure 4 shows a spatial plot of the AI for August 27, 2013 at 22 UTC. For this particular hour, the AI for the CNTRL, Figure 4a, was low with a large amount of underprediction (orange) by the model centered over Texas and overprediction (red) by the model over the Gulf of Mexico up into Mississippi. The ASSIM simulation, Figure 4b, was able to efficiently clear the overprediction areas and increase the cloud coverage over the state of Texas where there was underprediction. This resulted in better overall agreement between the model and GOES observations. Thus, while there are particular hours when the assimilation technique reduces the AI at the 12 km domain, there is still an overall improvement in cloud placement.

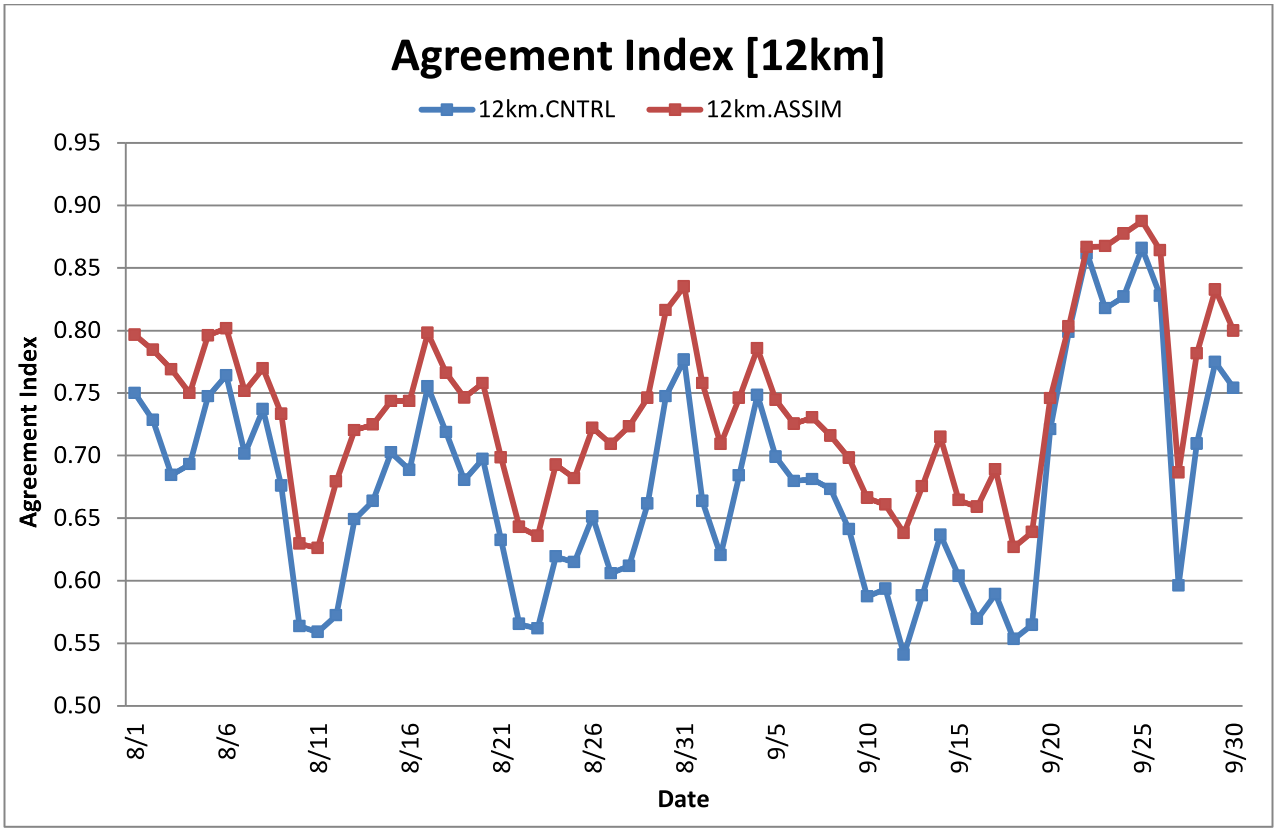

Figure 3: Daily agreement index for CNTRL and ASSIM 12 km WRF simulations over August-September 2013 using a 10% cloud albedo threshold.

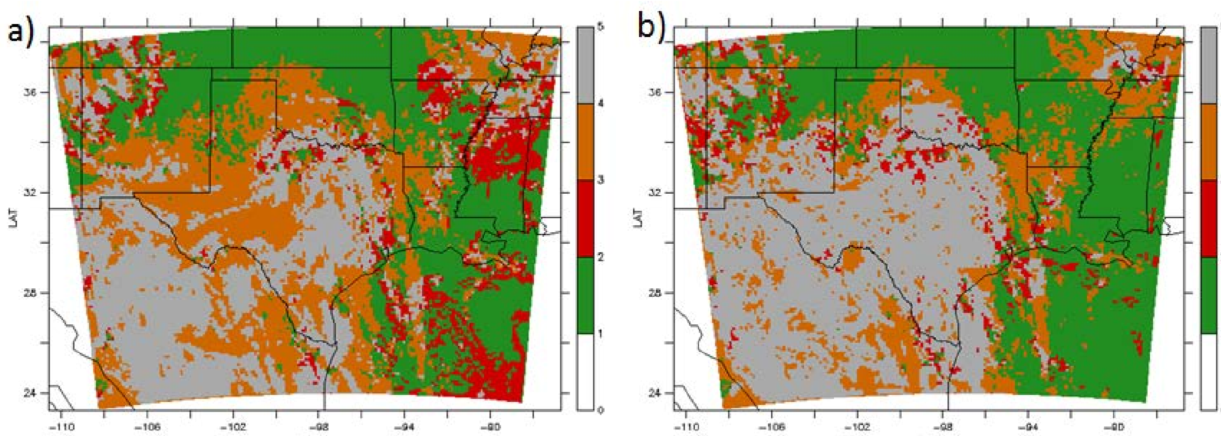

Figure 4: Agreement Index for August 27, 2013 at 22 UTC from a) CNTRL (AI=59.0%) b) ASSIM (AI=73.6%). Green indicates the model and GOES was clear, Red indicates locations where the model overpredicts clouds, Orange indicates locations where the model underpredicts clouds, and Grey indicates locations where the model and GOES are cloudy.