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**	2/15/2015
REPORTING PERIOD	**From:** January 1, 2015 **To:** January 31, 2015	**REPORT #**	9

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 15^{th} of the month following the reporting period shown above.

Detailed Accomplishments by Task
Completed the stand-alone implementation of the UC-Berkeley and Dalhousie University Soil NOx parameterization (BDSNP) in MEGAN (short description is attached at the end of this report).

We performed control WRF simulations for 2013. We are in the process of performing cloud assimilation. We have noticed some problems with the quality of satellite data and we are in the process of addressing them. This has delayed the completion of this task.

Preliminary Analysis
Attached.

Data Collected
Satellite retrievals of surface insolation and cloud albedo for the period of August-September 2013 were collected.

Identify Problems or Issues Encountered and Proposed Solutions or Adjustments
Problem with the satellite insolation and cloud albedo was identified and we are in the process of resolving the issue. We are pursuing a temporary fix by making adjustment to our cloud assimilation algorithm, as well as a permanent fix by reprocessing satellite data.

Goals and Anticipated Issues for the Succeeding Reporting Period
Resolving data quality issue for cloud assimilation.

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

Arastoo Pour Biazar

Submitted to AQRP by:

Principal Investigator: Arastoo Pour Biazar

Developing offline BDSNP module for soil NOx emission estimates

This section updates our progress in developing an offline version of the Berkeley-Dalhousie Soil NOx Parameterization (BDSNP) (Hudman et al., 2012). Compared to the soil NO emission module used in most air quality models (Yienger and Levy 1995), the BDSNP scheme generates higher estimates of emissions and provides a more physically realistic representation of the dependence of emissions on soil temperature and moisture. BDSNP has previously been implemented into the GEOS-Chem global model, and into CMAQ by Ben Lash at Rice. However, the inline BDSNP module in CMAQ is computationally expensive and is not cross-platform applicable, so Rice is working to develop an offline version of the BDSNP module.

In the BDSNP scheme, soil NO emissions estimates at each location are determined based on a biome-specific base emission factor and an available soil nitrogen pool originating from fertilizer application and nitrogen deposition from the atmosphere. Emission rates are modulated based on response functions to soil temperature and soil moisture, a soil pulsing factor when precipitation follows a dry period, and a canopy reduction factor (see Figure 1).

NO Emissions =

– A(Biome, Soil Nitrogen) x
  f(T) x g(θ)
  Pulse(Dry Period) x
  Canopy Reduction

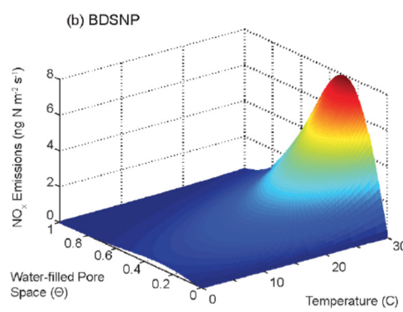

Fig 1. BDSNP soil NOx emission scheme given by Hunman et al. (2012)

From the software engineering point view, Figure 2 provides the flow chart of the BDSNP scheme implementation with the option to run inline or offline with the air quality model. Static input files such as arid/non-arid climate zone, soil biome type (must be consistent with the type of the soil emission factors given by Steinkamp and Lawrence (2011)) and global fertilizer pool from Potter et al. (2010) are needed to determine the soil base emission value at each modeling grid. Soil moisture and temperature as well as some meteorological variables such as radiation, wind and air pressure are needed (from weather models) to drive the BDSNP to representing the occurrence of pulsing and the process of canopy reduction. The major difference with the option of inline and offline BDSNP model is the approach to deal with the available nitrogen pool from the soil. For the inline BDSNP model (the dashed line), the dry or wet deposition process considered in the air quality model will continuously update the available nitrogen from the atmosphere to the ground; while for the offline BDSNP model (the sold line), only the generic daily nitrogen pool from deposition process are used. Since soil nitrogen pool needs a long time to build up to reach the quasi-steady state in the model, a new series of SOILINSTATE files are needed in the offline BDSNP model to provide the generic daily variation of N deposition. Here, we performed a full year CMAQ simulation over the 12km US continental modeling domain in 2005 and recorded their daily total soil N reservoir from deposition for further usage.

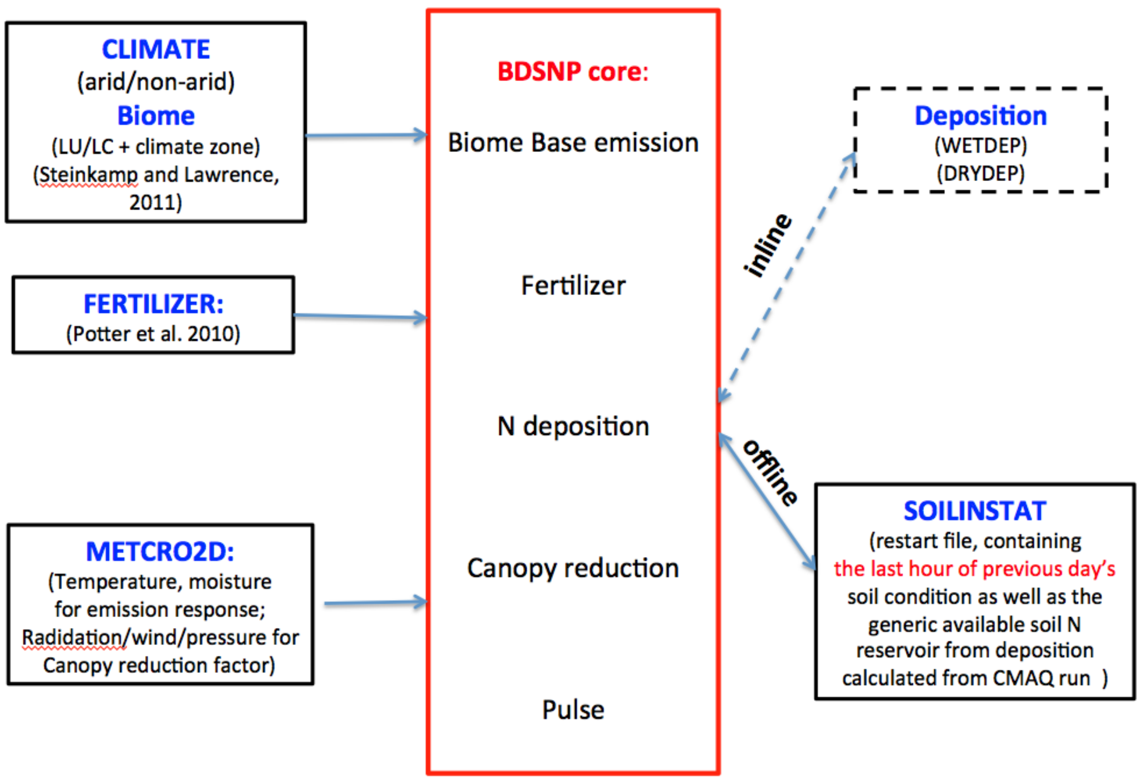

Fig 2. Flow chart of the inline/off line BDSNP soil NOx emission model

As the test case, we performed a one week simulation (Jun 26-Jul 3, 2011) for soil NO emission estimates with the option of inline and offline BDSNP module. Figure 3 demonstrates the available soil N reservoir from deposition at Jun 28 2011, which is needed as one of the input files for the off-line BDSNP model. The "generic" available soil N reservoir from deposition process in this test case is actually the directly usage of the CMAQ deposition simulation results with the exact same time period. It can be shown that the N deposition at Jun 28 is concentrated in the central United States and California.

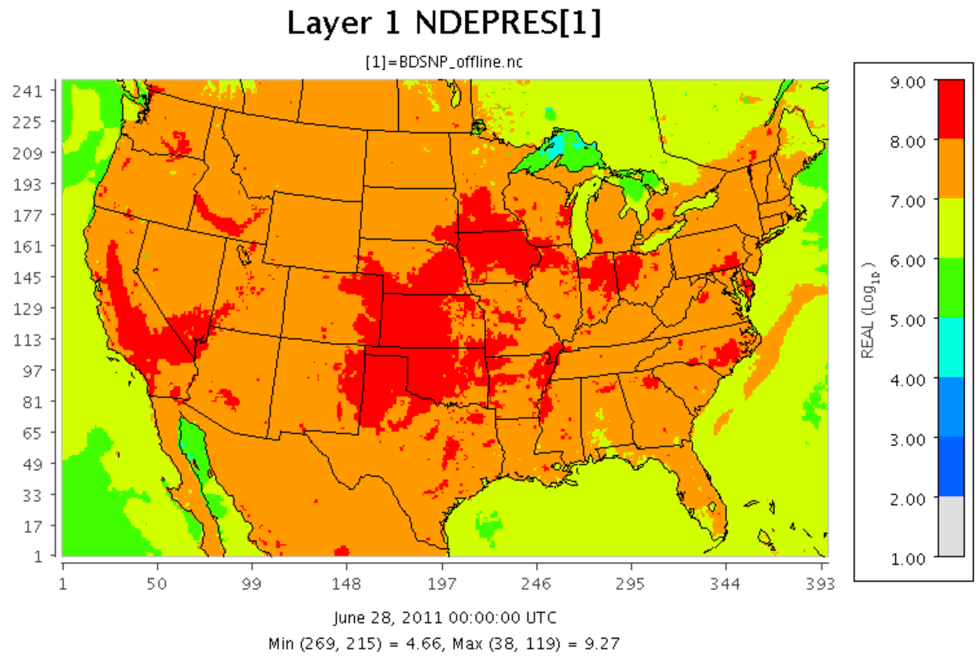

Fig 3. Soil N reservoir from deposition (NDEPRES) used in off-line BDSNP model which is calculated from 2005 CMAQ simulation results

Figure 4 provides the breakdown of each process in the off-line BDSNP model to impact the final soil NO emission estimates at the evaluation date Jun 28, 2011, namely the biome base emission (A_DIAG, Figure 4a), fertilizer application amount (AFERT_DIAFG, Figure 4b), soil nitrogen pool from deposition (NDEPRES, Figure 4c), pulse factor (PFACTOR, Figure 4d) and the canopy reduction factor (CRFAVG, Figure 5c). For each modeling grid, a higher biome base emission factor plus higher fertilizer application and higher available N from deposition will result in higher potential to produce soil NO. Pulsing occurs following a precipitation event, with the strength of the pulsing dependent on the length of the antecedent dry period. The scaling factor CRFAVG represents the loss of NO to the plant canopy.

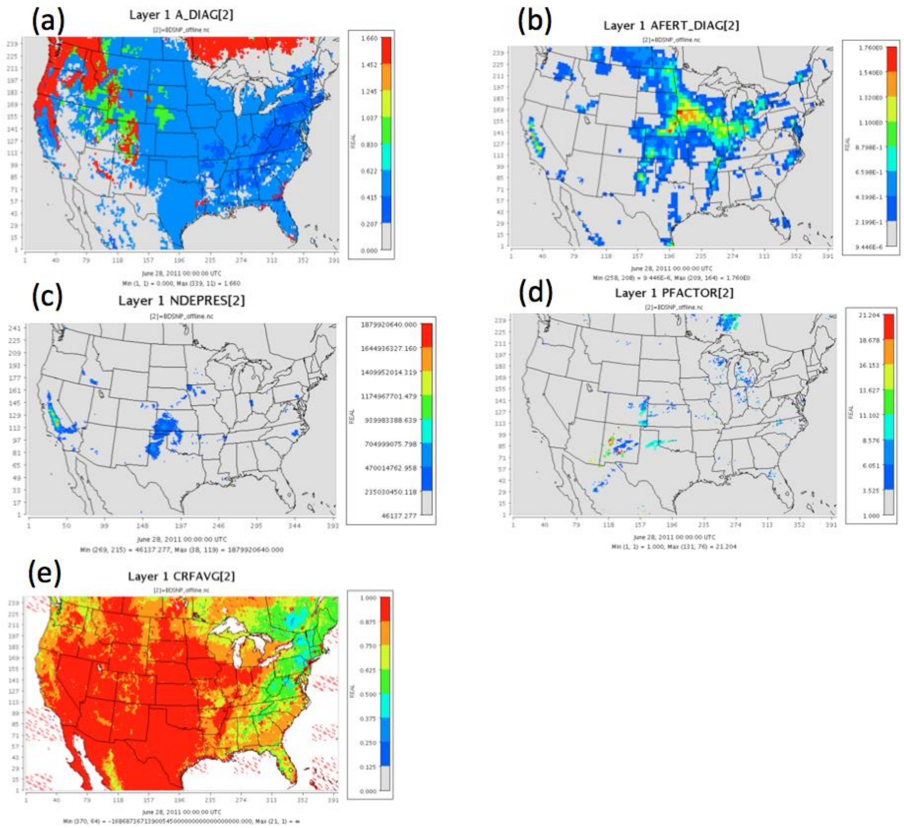

Fig 4. Impact of different BDSNP module process to the Soil NOx emission estimates

Figure 5 provides the comparison of the soil NOx emission estimates with the inline and offline option. It is obvious that with the nearly identical inputs files, the two options yield a quite similar result in terms of general spatial pattern and peak values. However, for other time period simulation, since we do not have the pre-existed CMAQ N deposition fields as the test case shown here, we need to use the full year 2005 CMAQ deposition results as a surrogate. The assumption by using this in offline BDSNP module is that the corresponding date N deposition pattern in 2005 is comparable with the situation for the date need to simulate.

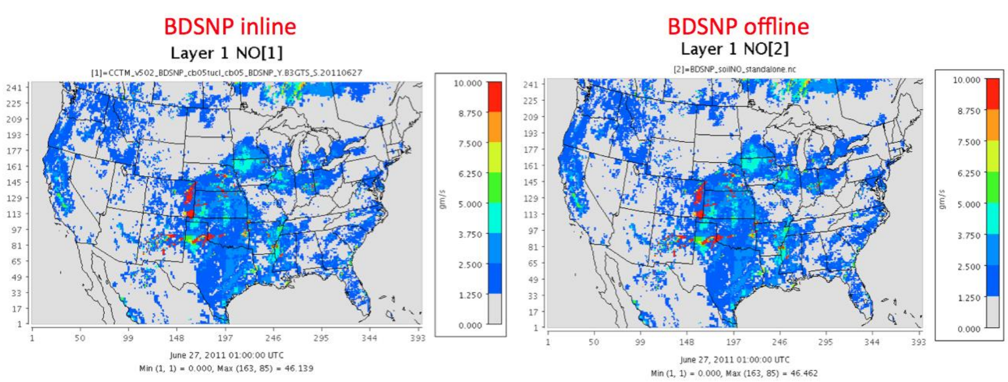

Fig 5. Comparison of soil NOx emission estimates using the inline (left) and offline (right) BDSNP scheme on Jun 28, 2011

In terms of computation time, the offline BDSNP module involves a far smaller burden than the inline option, which requires running the full CMAQ. Table 1 gives the CPU time estimation for the one-week test case run. The CPU time decrease from 282 min with multiple processor parallel run for inline BDSNP module to single processor 3 min for offline BDSNP module.

Table 1. Comparison of CPU time usage for inline and offline BDSNP

	Grid resolution	Total grid	CPU used	CPU speed	Memory	CPU time
inline BDSNP module	12kmX12km CONUS	396X246	144	2.83GHz	48G	283 min
offline BDSNP module	12kmX12km CONUS	396X246	1	2.83GHz	8G	3 min

The ongoing work about the offline BDSNP module development is:

1. Generating a new soil biome spatial map (Figure 4a) based on the finer resolution land use/ land cover definition used in current CMAQ simulation (NLCD40)
2. Checking the possibility of reading soil temperature and moisture data from different meteorological model outputs (current version of off-line BDSNP requires that the meteorological model outputs be processed through MCIP)
3. Preparing documentation so that TCEQ and others can use the off-line BDSNP release to generate soil NO emissions fields.