RUN SPECIFICATION SHEET

NATURAL (NAT) AND NO INTERNATIONAL ANTHROPOGENIC EMISSIONS (ZROW) GEOS-CHEM AND CAMX SIMULATIONS

WRAP 2014 Modeling Study
February 5, 2020

Run Name:	**Task 1.7: No Anthropogenic (NAT) and No International Anthropogenic Emissions (ZROW) Zero-Out Sensitivity Simulations**
Models:	GEOS-Chem and CAM v7.0
Domains:	Global (GEOS-Chem) and 36US1 and 12WUS2 two-way nesting (CAMx)
Period:	2014v2 annual period
Emissions:	Representative Baseline
Boundary Conditions:	Paired GEOS-Chem and CAMx for Base, NAT and ZROW cases
Source Apportionment:	None
Purpose:	To obtain PM and resultant visibility and ozone estimates in the U.S. in the absence of any anthropogenic emissions (i.e., natural [NAT] conditions) and in the absence of International anthropogenic emissions (ZROW, Zero-Out Rest of World)..

DESCRIPTION

Paired GEOS-Chem and CAMx v7.0 simulations will be performed for two anthropogenic emissions zero-out simulations (NAT and ZROW) for the 2014 calendar year with appropriate spin-up (15 days for CAMx and 6 months for GEOS-Chem) and using Representative Baseline emissions. The ZROW (Zero-Out Rest of World) GEOS-Chem and CAMx simulations would eliminate all non-U.S. anthropogenic emissions. The NAT (Natural) simulations would eliminate all anthropogenic emissions world-wide.

SOURCE APPORTIONMENT SPECIFICATIONS

None.

EMISSIONS

The Representative Baseline (RepBase) emissions will be used for the CAMx NAT and ZROW simulations. This will allow for a comparison with the natural conditions and international anthropogenic emissions contributions from the Task 1.8 RepBase anthropogenic and natural emissions source apportionment simulation.

NAT – Natural Emissions Simulations

GEOS-Chem NAT Simulation: The NAT GEOS-Chem simulation eliminates all anthropogenic emissions so that just natural emissions and all fire emissions remain (GEOS-Chem does not distinguish among types of fires).

CAMx NAT Simulation: The CAMx 2014 NAT simulation will use Boundary Conditions (BCs) based on the GEOS-Chem NAT simulation (GCBC_NAT).

The NAT CAMx run will include natural emissions as follows:

- Biogenic VOC and adjusted biogenic NO_X
- Lightning NO_X (LNOx)
- Windblown dust (WBD)
- Sea Salt and dimethyl sulfide (DMS)
- U.S. Wildfires (WF) and all Mexico and Canada fires (WF, Rx and Ag fires not separated in Mex/Can).

The following emission categories will not be included in the CAMx NAT run:

- Biogenic soil NO_X due to fertilizer and anthropogenic nitrogen deposition
- U.S. Prescribed Burns (Rx)
- U.S. Agricultural Burning (Ag)
- U.S. Anthropogenic Emissions
- Mexico Anthropogenic Emissions
- Canada Anthropogenic Emissions
- Off-Shore Anthropogenic Emissions

The biogenic NO_X emissions for the CAMx NAT simulation will be based on a MEGAN v3.1 simulation in which all the contributions of biogenic NO_X emissions due to fertilizer application and anthropogenic nitrogen deposition to soils has been set to zero. More details on the treatment of biogenic emissions in the CAMx NAT simulation is discussed in the Additional Discussion section below.

ZROW – Zero-Out International Emissions Scenario

GEOS-Chem ZROW Simulation: For the ZROW scenario, GEOS-Chem was run without any anthropogenic emissions from any country but the U.S., which included continental U.S., Alaska and Hawaii. For the gridded anthropogenic emissions that are not associated with any country (e.g., marine vessels and in-flight aircraft), the gridded anthropogenic emissions were eliminated (zero-out) outside of boxes covering the continental U.S. and Alaska. Figure 1 displays the CONUS and Alaska boxes outside of which the gridded anthropogenic emissions were eliminated.

CAMx ZROW Simulation: The CAMx 2014 36/12-km ZROW simulation used BCs from the GFEOS-Chem ZROW simulation and eliminated all anthropogenic emissions from Mexico and Canada in the 36/12-km domains (Figure 2) will be eliminated. Off-shore emissions are included in the Other Point Source (othpt) and CMV input files to CAMx and require special consideration as discussed below.

> CMV Emissions: The CMV emissions include smaller C1&C2 marine vessels and the larger C3 ocean going vessels (OGV). The C1&C2 emissions includes smaller vessels on rivers and in ports (e.g., tug boats) so will be assumed to be associated with the U.S. when in locations within or offshore of the U.S., so they will be retained in the CAMx ZROW simulation. C1&C2 vessel emissions off-shore Mexico and Canada or on-shore within Mexico and Canada will be eliminated in the CAMx ZROW simulation. For the emissions from the CMV C3 OGV, we will assume emissions within the Emissions Control Area (ECA)

shown in Figure 3 off the coast of the U.S. are U.S. anthropogenic emissions so will be retained in the ZROW simulation and C3 OGV emissions outside of the ECA region or within the ECA region and off the coast of Canada are international so will be eliminated in the CAMx ZROW simulation. The ECA corresponds to a region off-shore of the U.S. of approximately 200 nautical miles.

Other Point Sources: The off-shore anthropogenic emissions in the othpt source category are off-shore oil and gas (O&G) sources. The off-shore O&G emissions associated with the U.S. will be retained, and all other O&G emissions will be eliminated (zero-out). Off-shore O&G emissions within lease tracts administered by U.S. agencies (BOEM and EPA) shown in Figure 4 be retained in the CAMx ZROW simulation. Off-shore O&G emissions outside of the lease tracts in Figure 4 will be eliminated in the CAMx ZROW simulation..

Off-Shore U.S. Anthropogenic Emission Processing Approach

Off-shore CMV C3 OGV emissions within the ECA region off the coast of the U.S. will be assumed to be U.S. anthropogenic emissions. And off-shore O&G emissions within BOEM lease tracts will be assumed to be U.S. anthropogenic emissions. In practice, both of these off-shore areas correspond an area within 200 nautical miles of the U.S. coast so are essentially the same, as shown in Figure 5. Thus, we will use the shapefiles for the BOEM tract regions (Figure 5) to define the areas where emissions from CMV C3 OGVs and O&G are assumed to be U.S. anthropogenic sources in the CAMx ZROW modeling.

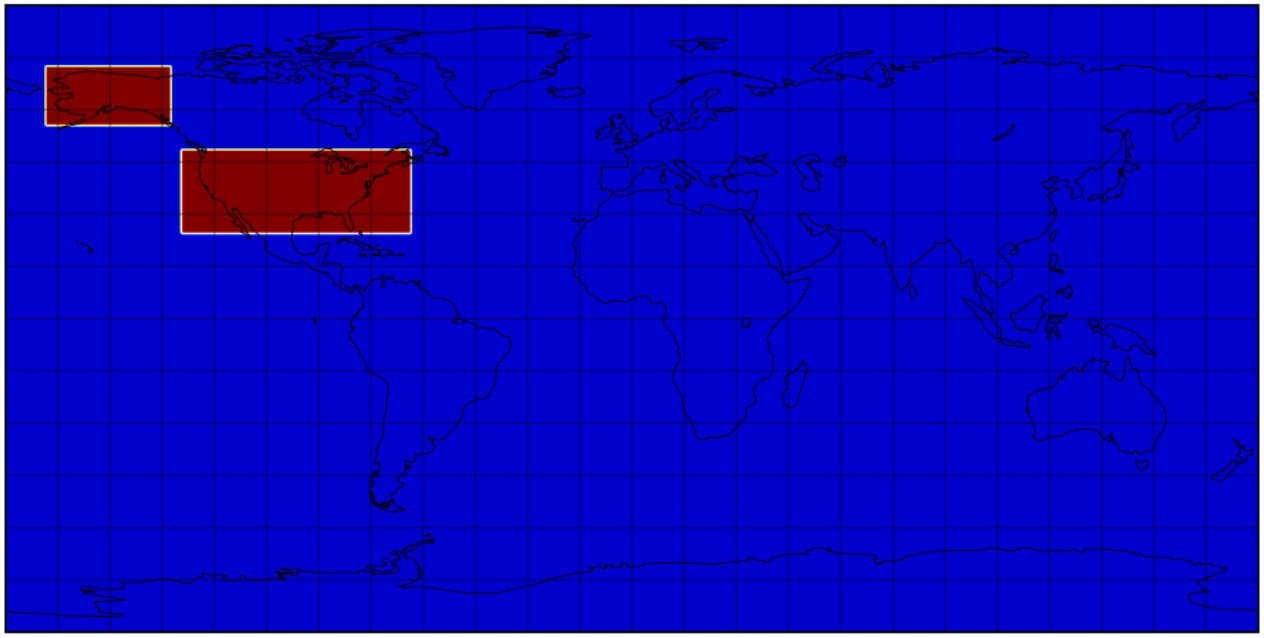

Figure 1. CONUS and Alaska boxes (masks) where shipping and aircraft emissions were retained in the WRAP GEOS-Chem 2014 ZROW simulation.

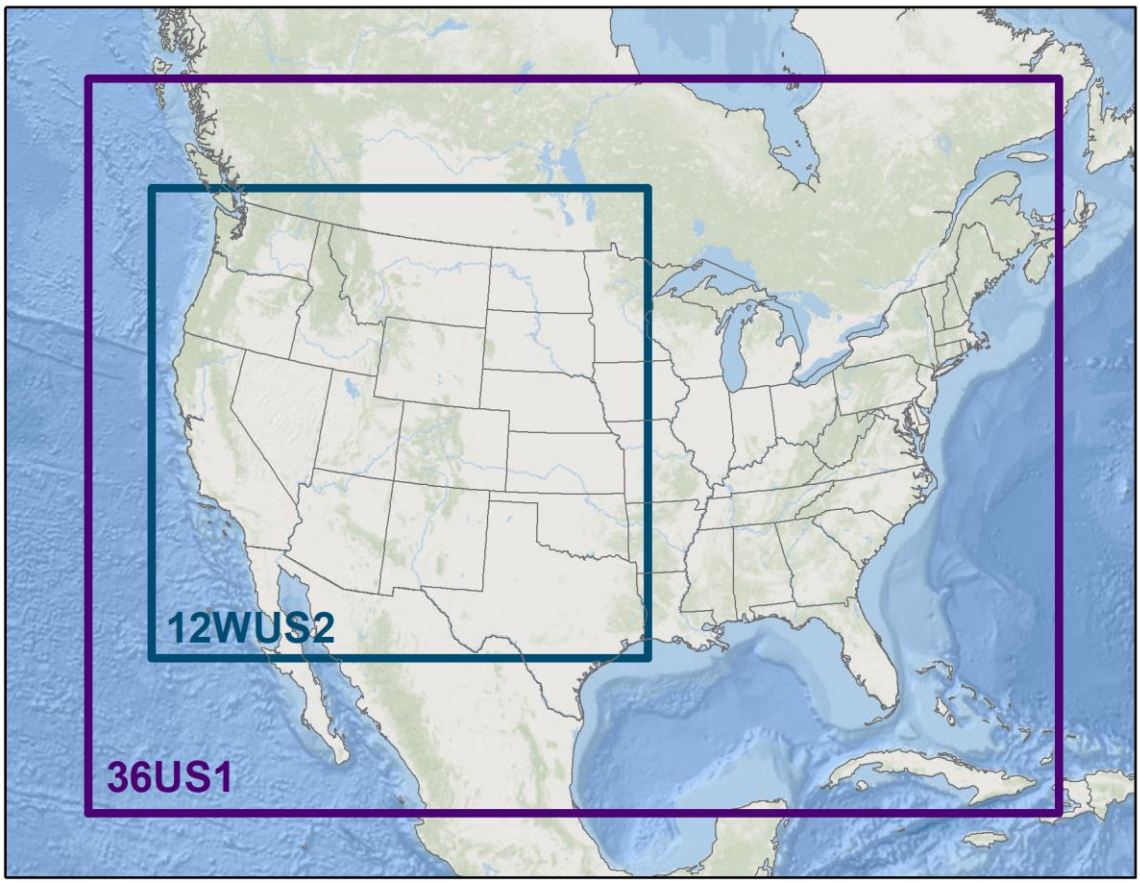

Figure 2. WRAP/WAQS 36/12-km 36US/12WUS2 modeling domains used in the WRAP 2014v2 and RepBase CAMx simulations.

Figure 3. Location of Emissions Control Area (ECA) off the coast of the U.S. and in Europe.

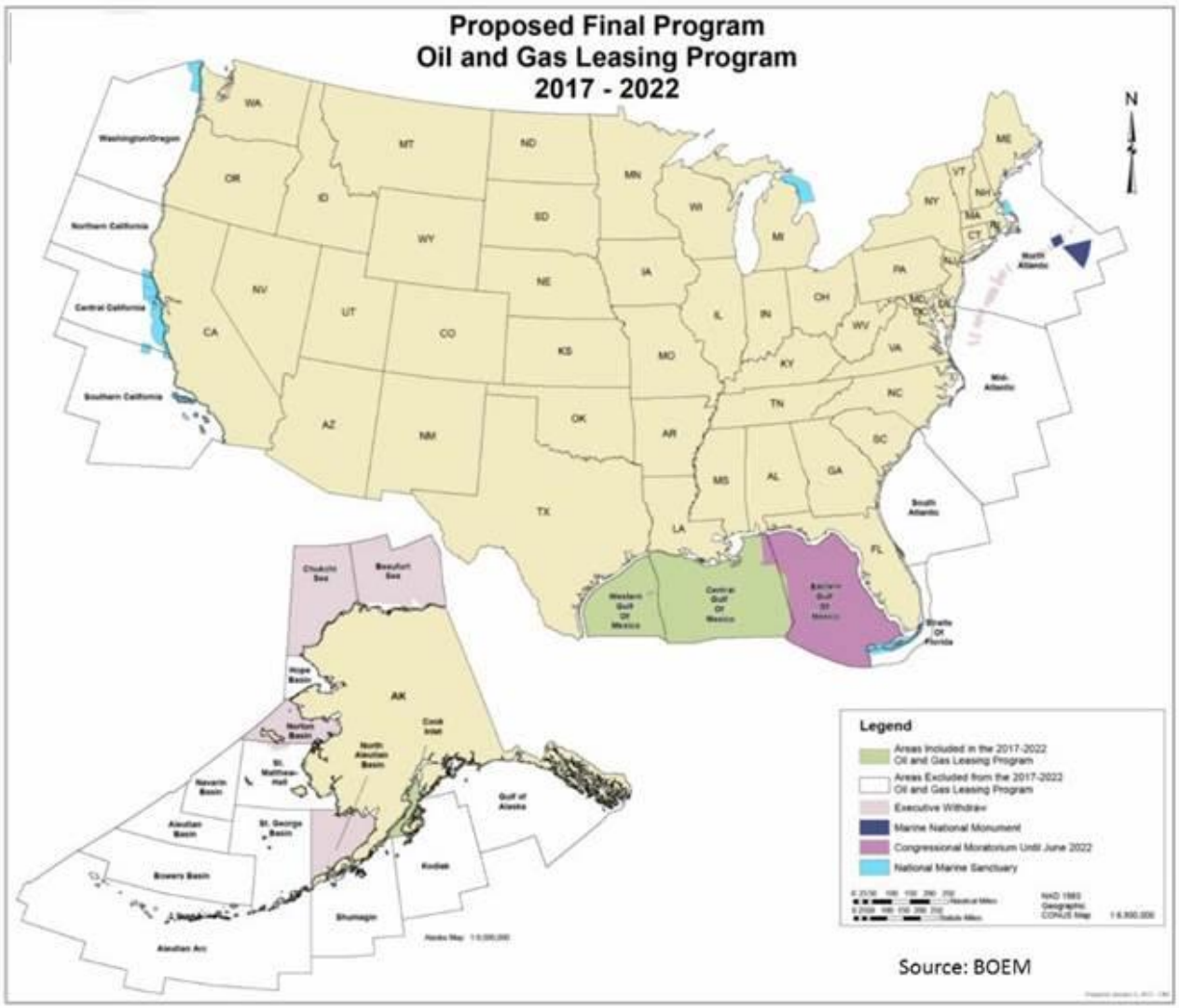

Figure 4. Off-shore U.S. O&G lease tracts, including Western, Central and Eastern planning areas for O&G development in the GOMR.

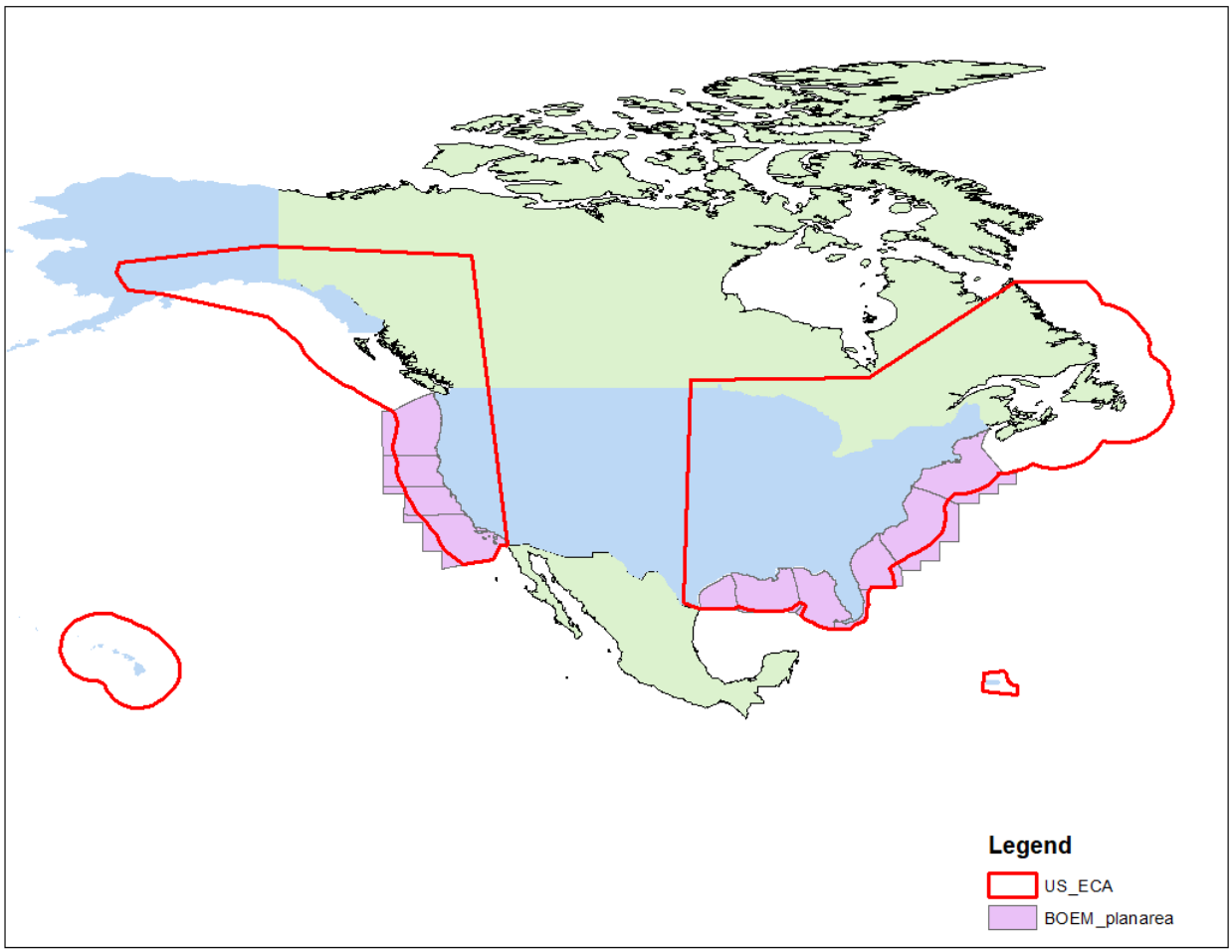

Figure 5. Comparison of ECA region shape files (red) and BOEM off-shore lease tracts (purple) that justifies the use of BOEM lease tracts to define areas off-shore of the U.S. in the CAMx 36/12-km domains (Figure 2) out to 200 nautical miles where emissions from off-shore CMV C3 OGVs and O&G sources are assumed to be U.S. anthropogenic emissions.

ADDITIONAL DISCUSSION

Biogenic NO_X Emissions

Biogenic NO_X emissions occur due to microbial processing of nitrogen compounds in soil that release gaseous NO emissions. The source of the nitrogen in soil can be either natural or anthropogenic in origin. Anthropogenic sources of nitrogen in soil include deposition of atmospheric NO_X concentrations and fertilizer application. For the WRAP 2014v2 and RepBase 12-km 12WUS2 emissions scenarios, biogenic VOC and NO_X emissions are based on the Biogenic Emissions Information System (BEIS[1]). Documentation of BEIS has the following text to describe the BEIS biogenic NO_X emissions algorithm (Pouliot and Pierce, 2009[2]):

> *"The soil NO algorithm distinguishes between agricultural and non-agricultural land use types. Adjustments due to temperature, precipitation, fertilizer application, and crop canopy coverage are limited to the growing season (assumed to be April 1-October 31) and are restricted to areas of agriculture as defined by the Biogenic Emissions Landuse Database (BELD). Outside of the growing season and for non-agricultural areas throughout the year, soil NO emissions are assumed to depend only on temperature and the base emission factor is limited to that for grasslands."*

Thus, ideally to develop a NAT biogenic emissions scenario with no anthropogenic emissions we would re-run the BEIS biogenic emissions model replacing the BELD agricultural landcover categories with a natural landcover category (e.g., grassland or forest) that existed before the land was converted to agricultural use and remove the contributions from anthropogenic atmosphere nitrogen deposition. However, since we did not perform the BEIS run and it is unclear how to remove anthropogenic nitrogen deposition in BEIS, such an approach using BEIS is not possible.

We also ran and evaluated the use of MEGAN[3] biogenic emissions model as part of the development of the WRAP/WAQS 2014v1 and 2014v2 modeling platforms. We ultimately selected BEIS over MEGAN due to better $PM_{2.5}$ Organic Aerosol (OA) model performance using BEIS. The MEGAN and BEIS biogenic soil NO_X emissions were remarkably similar, which is probably due to more limited soil NO_X emission factors available that are used by both biogenic emissions models. The MEGAN biogenic emissions model is better documented and is open source. MEGAN also has a component that provides an estimate of the anthropogenic NO_X deposition that is used in estimating the amount of nitrogen in soils.

For the CAMx NAT simulation MEGAN v3.1 will be run for the 36/12-km domains using 2014 meteorology with zero anthropogenic NO_X deposition and also zeroing out the fertilizer component of the soil NO_X emissions. The MEGAN v3.1 NAT biogenic NO_X will replace the biogenic NO_X in the RepBase modeling database for the CAMx NAT simulation, the biogenic VOC will remain unchanged at the BEIS levels.

Figure 6 displays the spatial distribution of the MEGAN v3.1 soil NO_X emissions in the 12WUS2 domain for the month of July and the base case and the case where the contributions due to fertilizer and

[1] https://www.epa.gov/air-emissions-modeling/biogenic-emission-inventory-system-beis

[2] https://www.epa.gov/sites/production/files/2015-10/documents/pouliot.pdf

[3] https://bai.ess.uci.edu/megan

atmospheric deposition of anthropogenic NO_X have been eliminated. The "biogenic" soil NO_X emission hotspots in the Midwest and California Central Valley agricultural areas in the base case have been eliminated in the zero anthropogenic deposition and fertilizer scenario. The MEGAN v3.1 domain-wide total NO_X emissions in the base case (631,840 tons/month) are a little over half (53%) in the no anthropogenic contribution scenario (337,864 tons/month).

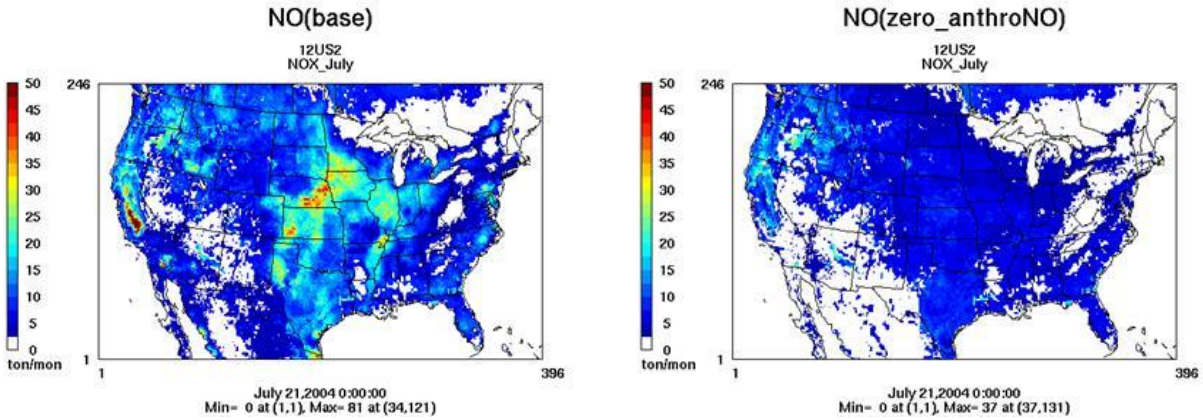

Figure 6. MEGAN v3.1 biogenic NO_X emissions in July 2014 for the base case (left) and the case with all NO_X emissions from atmospheric anthropogenic NOX deposition and fertilizer application eliminated (right).

Off-Shore Commercial Marine Vessel (CMV)

For CMV C3 OGV emissions, the assumption of what are U.S. and what are international anthropogenic emissions is unclear. States have jurisdiction over waters out to the State Seaward Boundary that extends 3 nautical miles (5.6-km) from the coast (9 miles, or 16.7-km, for Texas and Florida Gulf Coast). Under international law, every coastal nation has sovereignty over the air space, water column, seabed, and subsoil of its territorial sea that extends 12 nautical miles from the coast, subject to certain rights of passage for foreign vessels and, in more limited circumstances, foreign aircraft. Country's exclusive economic zones can extend as far as 200 nautical miles (370-km) out to sea. How far out to sea off the coast of the U.S. that emissions from CMV C3 vessels should be retained as U.S. anthropogenic emissions in a ZROW simulation is unclear. One argument is that all CMV C3 emissions within the CAMx 36/12-km domain should be retained as U.S. anthropogenic emissions as they would not be present without the presence of the U.S. EPA's 2016v1 platform separately processed emissions from CMV C3 OGVs for sources within and outside the Emissions Control Area (ECA; approximately 200 nautical miles from the coast, see Figure 3) and assumed CMV C3 emissions within the ECA were U.S. anthropogenic emissions and outside the ECA were International anthropogenic emissions. EPA's CAMx 2028 source apportionment simulation separately tagged CMV C3 emissions within (U.S.) the ECA and outside the ECA (International). EPA's recent (January 2020) draft guidance on Section 179B demonstrations[4] also define off-shore international emissions as those that are over 200 nautical miles from the U.S. coast line.

Thus, we propose to do a similar distinction of U.S. vs. International CMV C3 emissions and develop a grid cell mask so that CMV C3 emissions in all grid cells that are off the coast of the3 U.S. and within the ECA are assumed to by U.S. anthropogenic emissions so will be retained in the CAMx ZOW simulation, with the rest of the CMV C3 emissions eliminated. As noted previously, the BOEM O&G lease tracts approximate this area very well so will be used to define the ECA area off the cost of the U.S. (see Figure 5).

[4] https://www.epa.gov/sites/production/files/2020-01/documents/draft_179b_guidance-final_draft_for_posting.pdf