October 15, 2019

SPECIFICATION SHEET: AG

Description: Nonpoint agricultural (ag) emissions, for simulating 2016 and future year U.S. air quality

1. EXECUTIVE SUMMARY

This document details the approach and data sources to be used for developing 2016 gridded nonpoint agriculture (ag) sector emissions for use in an air quality model. The ag sector includes NH3 and VOC emissions from livestock and fertilizer sources. 2016 livestock emissions consist of county-level back-projections of livestock emissions from the 2017NEI based on U.S. Department of Agriculture (USDA) animal population projections. For livestock in which a data back-projection factor did not exist, emissions are held constant at the 2017 emission estimate. Fertilizer emissions for 2016 come from the FEST-C and EPIC model. The SMOKE program GenTPRO estimates the hourly temporalization of ag livestock and fertilizer emissions using hourly gridded meteorology data. Base year inventories were processed with the Sparse Matrix

Operating Kernel Emissions (SMOKE) modeling system version 4.7. SMOKE creates emissions in a format that can be input into air quality models. National and state-level emission summaries for key pollutants are provided.

2. Introduction

The ag sector includes NH_3 emissions from fertilizer and emissions of all pollutants other than $PM_{2.5}$ from livestock in the nonpoint (county-level) data category of the 2017NEI. $PM_{2.5}$ from livestock are in the Area Fugitive Dust (afdust) sector. Combustion emissions from agricultural equipment, such as tractors, are in the Nonroad sector. The sector now includes VOC and HAP VOC in additional to NH_3. The 2016 version 1 (v1) platform uses a 2016-specific fertilizer inventory from the EPIC model combined with a 2016 USDA-based county-level back-projection of 2017NEI livestock emissions. The SCCs included in the ag sector are shown in Table 1.

Table 1. 2016v1 platform SCCs for ag sector

SCC	Tier 1 description	Tier 2 description	Tier 3 description	Tier 4 description
2801700099	Miscellaneous Area Sources	Ag. Production - Crops	Fertilizer Application	Miscellaneous Fertilizers
2805002000	Miscellaneous Area Sources	Ag. Production - Livestock	Beef cattle production composite	Not Elsewhere Classified
2805007100	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - layers with dry manure management systems	Confinement
2805009100	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - broilers	Confinement
2805010100	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - turkeys	Confinement
2805018000	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle composite	Not Elsewhere Classified
2805025000	Miscellaneous Area Sources	Ag. Production - Livestock	Swine production composite	Not Elsewhere Classified (see also 28-05-039, -047, -053)
2805035000	Miscellaneous Area Sources	Ag. Production - Livestock	Horses and Ponies Waste Emissions	Not Elsewhere Classified
2805040000	Miscellaneous Area Sources	Ag. Production - Livestock	Sheep and Lambs Waste Emissions	Total
2805045000	Miscellaneous Area Sources	Ag. Production - Livestock	Goats Waste Emissions	Not Elsewhere Classified

For livestock, meteorologically-based temporal allocation (described in Section 4, Temporal Allocation) is used for month-to-day and day-to-hour temporal allocation. Monthly profiles are based on the daily data underlying the EPA estimates. Fertilizer uses different state-specific year-to-month profiles than livestock but uses the same meteorological-based month-to-hour profiles as livestock. These temporal profile methodologies have not changed from recent platforms.

3. INVENTORY DEVELOPMENT METHODS

Livestock

The version 1 platform livestock emissions consist of a back-projection of 2017NEI livestock emissions to the year 2016 and include NH3 and VOC. The livestock waste emissions from 2017NEI contain emissions for beef cattle, dairy cattle, goats, horses, poultry, sheep, and swine. The data come from both state-submitted emissions and EPA-calculated emission estimates. Further information about the 2017NEI emissions can be found in the 2017 National Emissions Inventory Technical Support Document (https://www.epa.gov/sites/production/files/2019-09/documents/nei2017_tsd_29aug2019.pdf). Back-projection factors for 2016 emission estimates are based on animal population data from the USDA National Agriculture Statistics Service Quick Stats (https://www.nass.usda.gov/Quick_Stats/). These estimates are developed by data collected from annual agriculture surveys and the Census of Agriculture that is completed every five years. These data include estimates for beef, layers, broilers, turkeys, dairy, swine, and sheep. Each SCC in the 2017NEI livestock inventory, except for 2805035000 (horses and ponies) and 2805045000 (goats), was mapped to one of these USDA categories. Then, back-projection factors were calculated based on USDA animal populations for 2016 and 2017. Emissions for animal categories for which population data were not available (e.g. horses, goats) were held constant in the projection.

Back-projection factors were calculated at the county level, but only where county-level data was available for a specific animal category. County-level factors were limited to a range of 0.8 to 1.2. Data were not available for every animal category in every county. State-wide back-projection factors based on state total animal populations were calculated and applied to counties where county-specific data was not available for a given animal category. However, data were often not available for every animal category in every state. For categories other than beef and dairy, data are not available for a majority of states. In cases of missing state-level data, a national back-projection factor was applied. Back-projection factors were not pollutant-specific and were applied to all pollutants. The national back-projection factors, which were only used when county or state data were not available, are shown in Table 2. The national factors were created using a ratio between animal inventory counts for 2017 and 2016 from the USDA National livestock inventory projections published in February 2018 (https://www.ers.usda.gov/webdocs/publications/87459/oce-2018-1.pdf?v=0).

Table 2. National back-projection factors for livestock: 2017 to 2016

beef	-1.8%
swine	-3.6%
broilers	-2.0%
turkeys	-0.3%
layers	-2.3%
dairy	-0.4%
sheep	+0.4%

Fertilizer

Fertilizer emissions for 2016 are based on the FEST-C model (https://www.cmascenter.org/fest-c/). The bidirectional version of CMAQ (v5.3) and the Fertilizer Emissions Scenario Tool for CMAQ FEST-C (v1.3) were used to estimate ammonia (NH_3) emissions from agricultural soils. The approach to estimate year-specific fertilizer emissions consists of these steps:

- Run FEST-C to produce nitrate (NO_3), Ammonium (NH4+, including Urea), and organic (manure) nitrogen (N) fertilizer usage estimates
- Use USDA Economic Research Services crop specific fertilizer use data and state submitted data to adjust the FEST-C fertilizer totals to match the USDA and State submitted.
- Run the CMAQ model with bidirectional ("bidi") NH_3 exchange to generate gaseous ammonia NH3 emission estimates.
- Calculate county-level emission factors as the ratio of bidirectional CMAQ NH_3 fertilizer emissions to FEST-C total N fertilizer application.
- Assign the NH3 emissions to one SCC: "…Miscellaneous Fertilizers" (2801700099).

FEST-C is the software program that processes land use and agricultural activity data to develop inputs for the CMAQ model when run with bidirectional exchange. FEST-C reads land use data from the Biogenic Emissions Landuse Dataset (BELD), meteorological variables from the Weather Research and Forecasting model, and nitrogen deposition data from a previous or historical average CMAQ simulation. FEST-C, then uses the USDA's Environmental Policy Integrated Climate (EPIC) modeling system (https://epicapex.tamu.edu/epic/) to simulate the agricultural practices and soil biogeochemistry and provides information regarding fertilizer timing, composition, application method and amount.

An iterative calculation was applied to estimate fertilizer emissions for the 2016 platform. We first estimate fertilizer application by crop type using FEST-C modeled data. After receipt and addressing of comments to the extent possible, we then adjusted the fertilizer application estimates using state submitted data, currently only Iowa, and USDA Economic Research Service state and crop specific survey data. The USDA and state submitted annual fertilizer data was used to estimate the ratio of UDSA/state fertilizer use to FEST-C annual total fertilizer estimates for each state and crop with USDA or state data. This ratio is then applied to the FEST-C fertilizer application rates for each state and crop with data. A maximum annual fertilization rate was estimated from the FEST-C simulation and annual adjusted totals were limited to this rate to prevent unrealistically higher fertilization rates. The we ran the CMAQ v5.3 model with the Surface Tiled Aerosol and Gaseous Exchange (STAGE) deposition option with bidirectional exchange to estimate fertilizer and biogenic NH_3 emissions. We use this approach for three reasons: (1) FEST-C estimates fertilizer applications based on crop nutrient needs which is typically lower than real world fertilization rates; (2) FEST-C fertilizer timing and application methods are assumed to be correct; and (3) We desired a method to incorporate state submitted and USDA reported data into the final fertilization emission estimates.

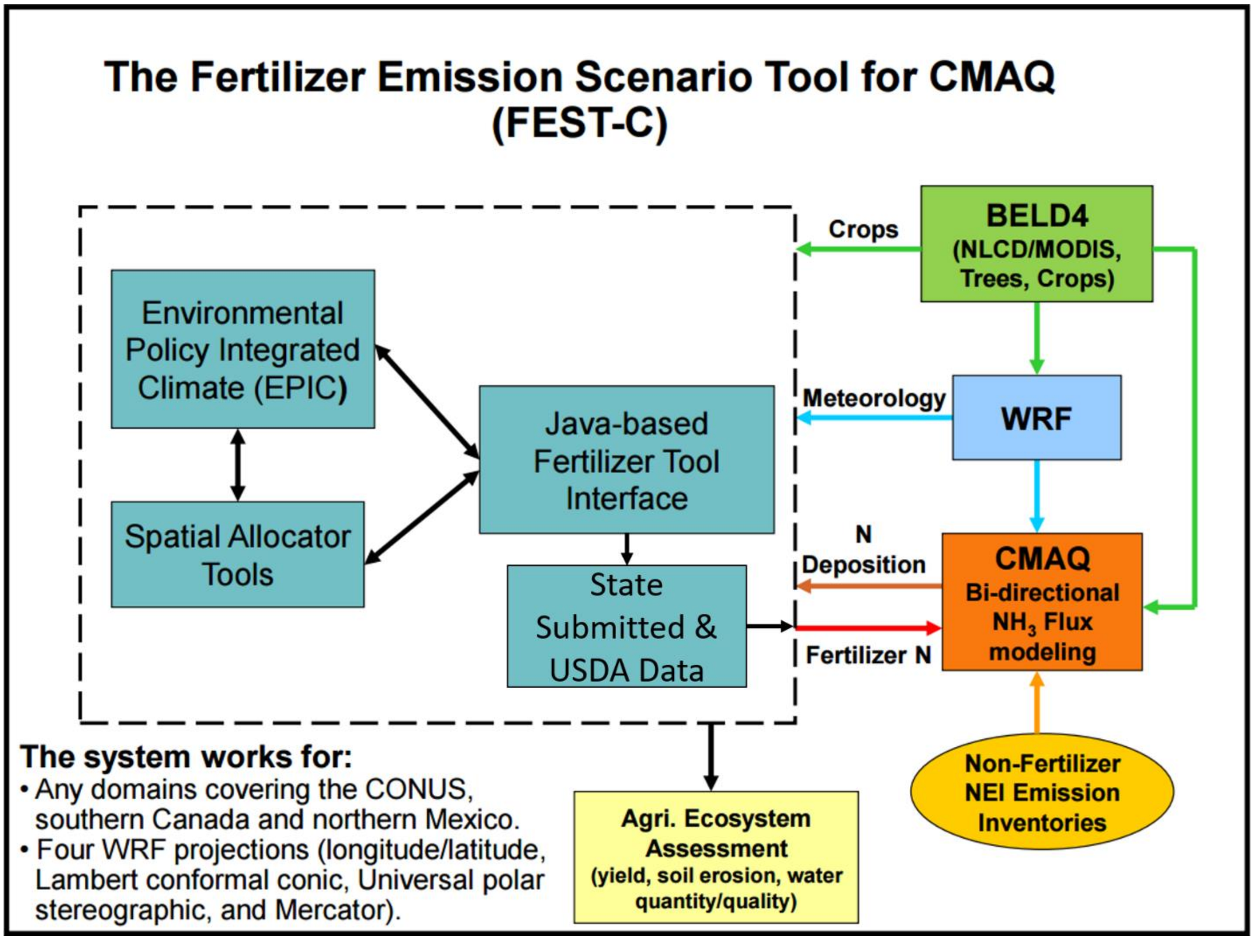
Example Calculation:

Adjustment of FEST-C fertilizer rates using state or USDA data:

$$Fert_{ajusted,crop} = max\left(\frac{Fert_{submitted,crop}}{\frac{1}{n_{crop}}\sum Fert_{FEST-C,crop}} Fert_{FEST-C,crop}, Fert_{max,crop}\right)$$

Where $Fert_{adjusted,crop}$ is the FEST-C 12km grid cell adjusted fertilization rate, $Fert_{Submitted,i}$ is the USDA or State submitted state mean annual application data for the specified crop, in kg ha^{-1}, $FERT_{FEST-C,I}$ is the initial FEST-C 12km grid cell fertilization rate for the state being considered, n_{crop} is the number of grid cells with fertilization use for the specified crop in the state, and $Fert_{max,crop}$ is the maximum fertilization rate estimated from EPIC for the crop.

Figure 1. "Bidi" modeling system used to compute 2016 Fertilizer Application emissions



Activity Data

The following activity parameters were input into the EPIC model:

- Grid cell meteorological variables from WRF (see Table 3)
- Initial soil profiles/soil selection
- Presence of 21 major crops: irrigated and rain fed hay, alfalfa, grass, barley, beans, grain corn, silage corn, cotton, oats, peanuts, potatoes, rice, rye, grain sorghum, silage sorghum, soybeans, spring wheat, winter wheat, canola, and other crops (e.g. lettuce, tomatoes, etc.)
- Fertilizer sales to establish the type/composition of nutrients applied
- Management scenarios for the 10 USDA production regions. These include irrigation, tile drainage, intervals between forage harvest, fertilizer application method (injected versus surface applied), and equipment commonly used in these production regions.

The WRF meteorological model was used to provide grid cell meteorological parameters for year 2016 using a national 12-km rectangular grid covering the continental U.S. The meteorological parameters in Table 3 were used as EPIC model inputs.

Table 3. Environment variables needed for an EPIC simulation

EPIC input variable	**Variable Source**
Daily Total Radiation (MJ m^2)	WRF
Daily Maximum 2-m Temperature (C)	WRF
Daily minimum 2-m temperature (C)	WRF
Daily Total Precipitation (mm)	WRF
Daily Average Relative Humidity (unitless)	WRF
Daily Average 10-m Wind Speed (m s^{-1})	WRF
Daily Total Wet Deposition Oxidized N (g/ha)	CMAQ
Daily Total Wet Deposition Reduced N (g/ha)	CMAQ
Daily Total Dry Deposition Oxidized N (g/ha)	CMAQ
Daily Total Dry Deposition Reduced N (g/ha)	CMAQ
Daily Total Wet Deposition Organic N (g/ha)	CMAQ

Initial soil nutrient and pH conditions in EPIC were based on the 1992 USDA Soil Conservation Service (CSC) Soils-5 survey. The EPIC model then was run for 25 years using current fertilization and agricultural cropping techniques to estimate soil nutrient content and pH for the 2016 EPIC/WRF/CMAQ simulation.

The presence of crops in each model grid cell was determined through the use of USDA Census of Agriculture data (2012) and USGS National Land Cover data (2011). These two data sources were used to compute the fraction of agricultural land in a model grid cell and the mix of crops grown on that land.

Fertilizer sales data and the 6-month period in which they were sold were extracted from the 2014 Association of American Plant Food Control Officials (AAPFCO, http://www.aapfco.org/publications.html). AAPFCO data were used to identify the composition (e.g. urea, nitrate, organic) of the fertilizer used, and the amount applied is estimated using the modeled crop demand. These data were useful in making a reasonable assignment of what kind of fertilizer is being applied to which crops.

Management activity data refers to data used to estimate representative crop management schemes. The USDA Agricultural Resource Management Survey (ARMS, https://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Ag_Resource_Management/) was used to provide management activity data. These data cover 10 USDA production regions and provide management schemes for irrigated and rain fed hay, alfalfa, grass, barley, beans, grain corn, silage corn, cotton, oats, peanuts, potatoes, rice, rye, grain sorghum, silage sorghum, soybeans, spring wheat, winter wheat, canola, and other crops (e.g. lettuce, tomatoes, etc.).

Emission Factors

The emission factors were derived from the 2016 CMAQ FEST-C outputs adjusted using USDA ERS state and crop specific reported annual fertilizer rates. Total fertilizer emission factors for each month and county were computed by taking the ratio of total fertilizer NH_3 emissions (short tons) to total nitrogen fertilizer application (short tons).

12 km by 12 km gridded NH_3 emissions were mapped to a county shape file polygon. The cell was assigned to a county if the grid centroid fell within the county boundary.

4. Ancillary Data

Spatial Allocation

Spatial allocation of ag emissions to the national 36km and 12km domains used for air quality modeling is accomplished using spatial surrogates. Spatial surrogates map county polygons to the uniformly spaced grid cells of a modeling domain. The ag sector uses the NLCD Total Agriculture surrogate (310) for the entire sector.

Temporal Allocation

Both the livestock and fertilizer emissions inventories include monthly values. Livestock monthly values are based on SMOKE temporal profiles, pre-applied to the inventory. These livestock profiles, which are by state and separate for beef, layers, broilers, dairy, and swine, are based on daily ag emissions from 2014NEIv1 developed by CMU[1]. Fertilizer monthly emissions values come from the EPIC model.

Hour-of-month temporalization for all ag sources – both livestock and fertilizer, all pollutants – is based on meteorology, using the Bash algorithm applied by the SMOKE program GenTPRO (https://www.cmascenter.org/smoke/documentation/4.6/html/ch05s03s05.html). GenTPRO uses an equation derived by Jesse Bash of the EPA's ORD based on the Zhu, Henze, et al. (2013)

[1] McQuilling, A. M. & Adams, P. J. Semi-empirical process-based models for ammonia emissions from beef, swine, and poultry operations in the United States. Atmos. Environ. 120, 127–136 (2015).

empirical equation. This equation is based on observations from the TES satellite instrument with the GEOS-Chem model and its adjoint to estimate diurnal NH_3 emission variations from livestock as a function of ambient temperature, aerodynamic resistance, and wind speed. The equations are:

$$E_{i,h} = [161500/T_{i,h} \times e^{(-1380/T_{i,h})}] \times AR_{i,h}$$

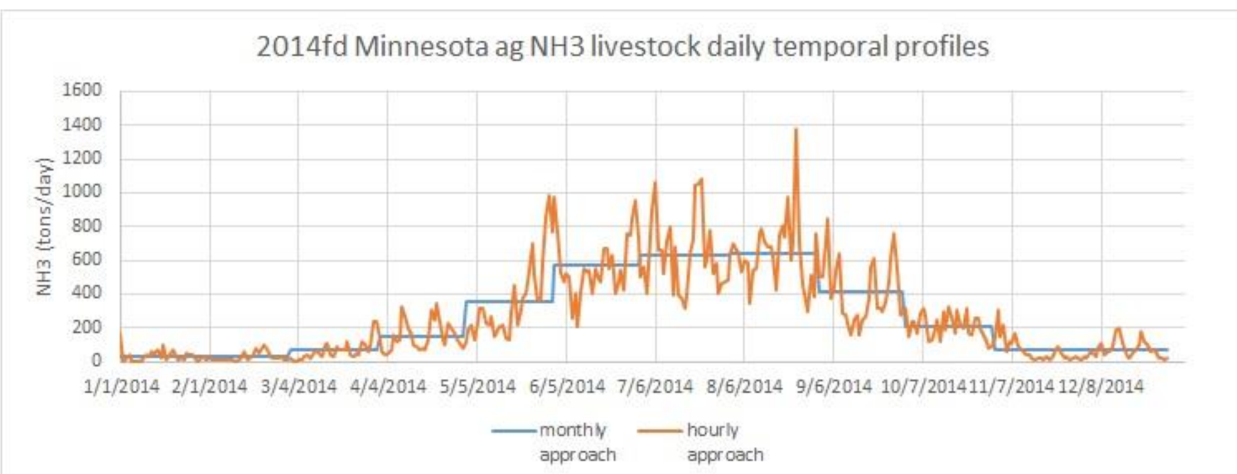
$$PE_{i,h} = E_{i,h} / Sum(E_{i,h})$$

where

- $PE_{i,h}$ = Percentage of emissions in county *i* on hour *h*
- $E_{i,h}$ = Emission rate in county *i* on hour *h*
- $T_{i,h}$ = Ambient temperature (Kelvin) in county *i* on hour *h*
- $V_{i,h}$ = Wind speed (meter/sec) in county *i* (minimum wind speed is 0.1 meter/sec)
- $AR_{i,h}$ = Aerodynamic resistance in county *i*

These hourly GenTPRO profiles were calculated at the county level based on hourly 12km meteorology and are applied on an hour-of-month basis, in combination with the monthly values in the emissions inventory. GenTPRO profiles based on 12km meteorology are used for all modeling domains and resolutions to ensure consistency between runs. An example plot showing daily emissions derived from applying this approach to Minnesota for calendar year 2014 is shown in Figure 2.

Figure 2. Example temporal profile of NH3 livestock emissions for Minnesota



Chemical Speciation

The ag sector includes speciation of NH3 and VOC emissions. For NH3, in support of optional bidirectional NH3 application within CMAQ, an extra species called NH3_FERT is generated.

NH3_FERT = NH3 for fertilizer sources, and NH3_FERT = 0 for all other sources. The NH3_FERT species is created in addition to the normal NH3 species, which includes both fertilizer and livestock as always. Reports summarizing total VOC emissions according to VOC speciation profile were developed at the state and county level. VOC speciation employs the use of partial HAP integration.

5. EMISSIONS PROJECTION METHODS

Livestock

The 2017NEI livestock emissions were projected to year 2023 and 2028 using projection factors created from USDA National livestock inventory projections published in March 2019 (https://www.ers.usda.gov/webdocs/publications/92600/oce-2019-1.pdf?v=3630.9). For emission projections to 2023, a ratio was created between animal inventory counts for 2023 and 2017 to create a projection factor. This process was completed for the animal categories of beef, dairy, broilers, layers, turkeys, and swine. The projection factor was then applied to the 2017NEI base emissions for the specific animal type to estimate 2023 NH_3 and VOC emissions. For emission projections to 2028, the same projection method was used. New Jersey (NJ) provided NJ-specific projection factors that were used to grow livestock waste emissions from 2017 to 2023 and 2028. North Carolina (NC) provided NC-specific projection factors that used a 2016-based projection, therefore, NC's livestock waste emissions are projected from the 2016 back-casted base year emissions to 2023 and 2028.

Table 2. National projection factors for livestock: 2016 to 2023 and 2028

Animal	2023	2028
beef	-0.02%	-2.87%
swine	+7.47%	+10.36%
broilers	+8.60%	+12.50%
turkeys	-0.03%	+1.57%
layers	+9.28%	+15.93%
dairy	+0.92%	+1.24%

Fertilizer

Fertilizer emissions for years 2023 and 2028 were held constant at year 2016v1 emission levels.

Figure 3. NH3 (tons) Ag Sector Emission Differences between 2028v1 and 2016v1

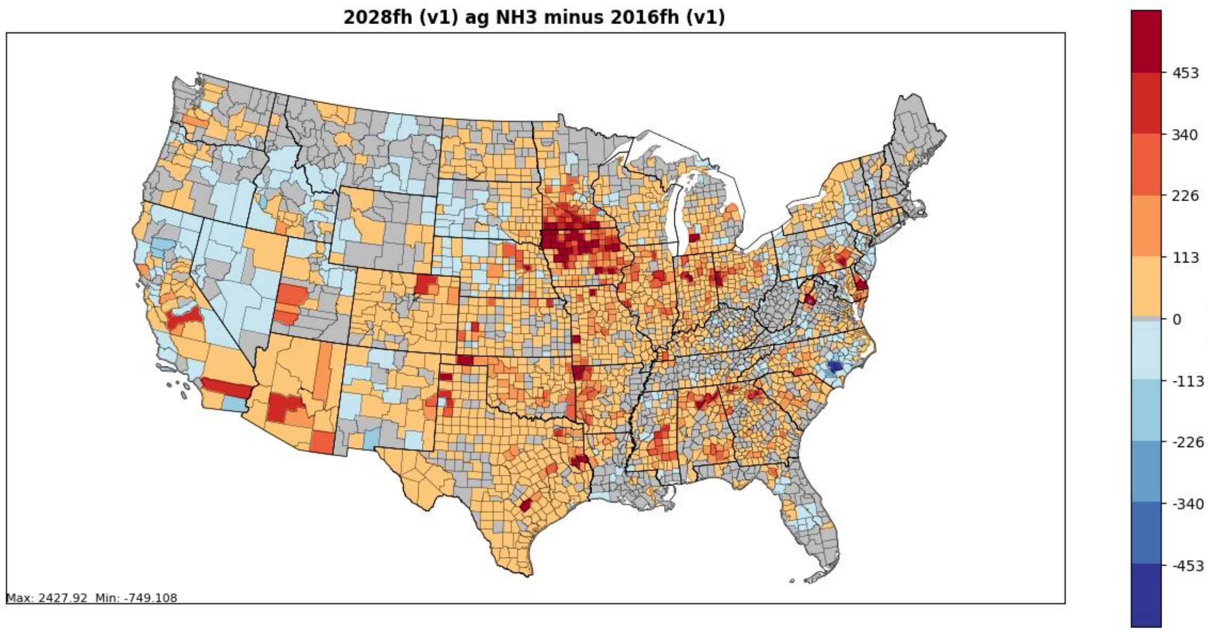


Figure 4. NH3 (tons) Ag Sector Emission Percent Differences between 2028v1 and 2016v1

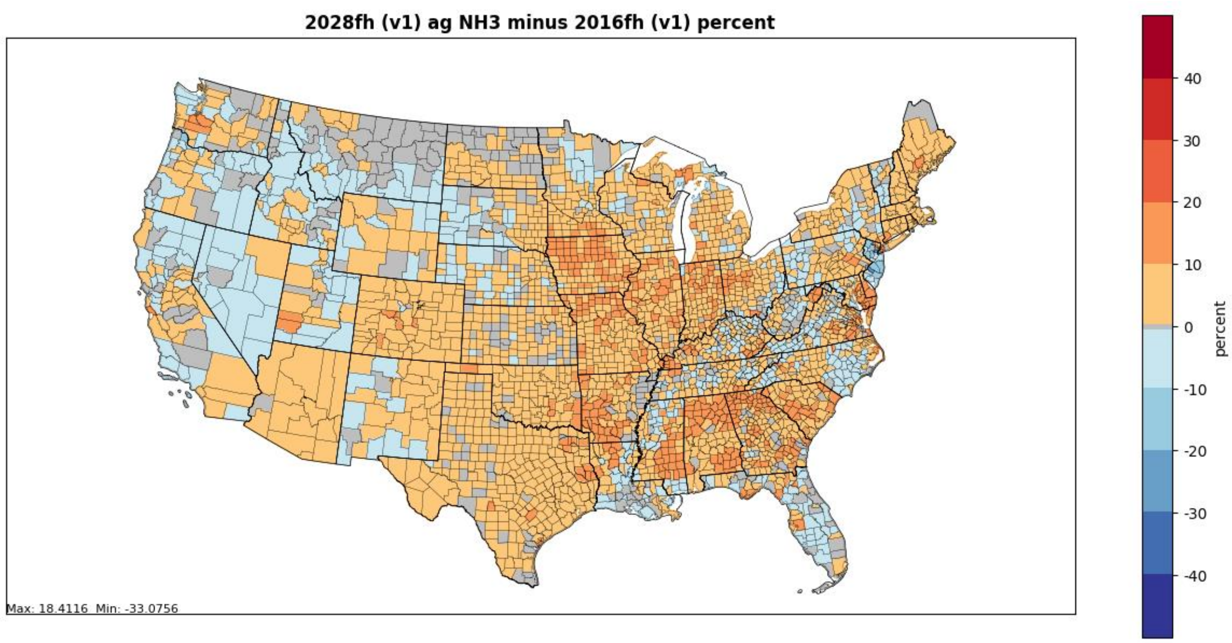


Figure 5. VOC (tons) Ag Sector Emission Differences between 2028v1 and 2016v1

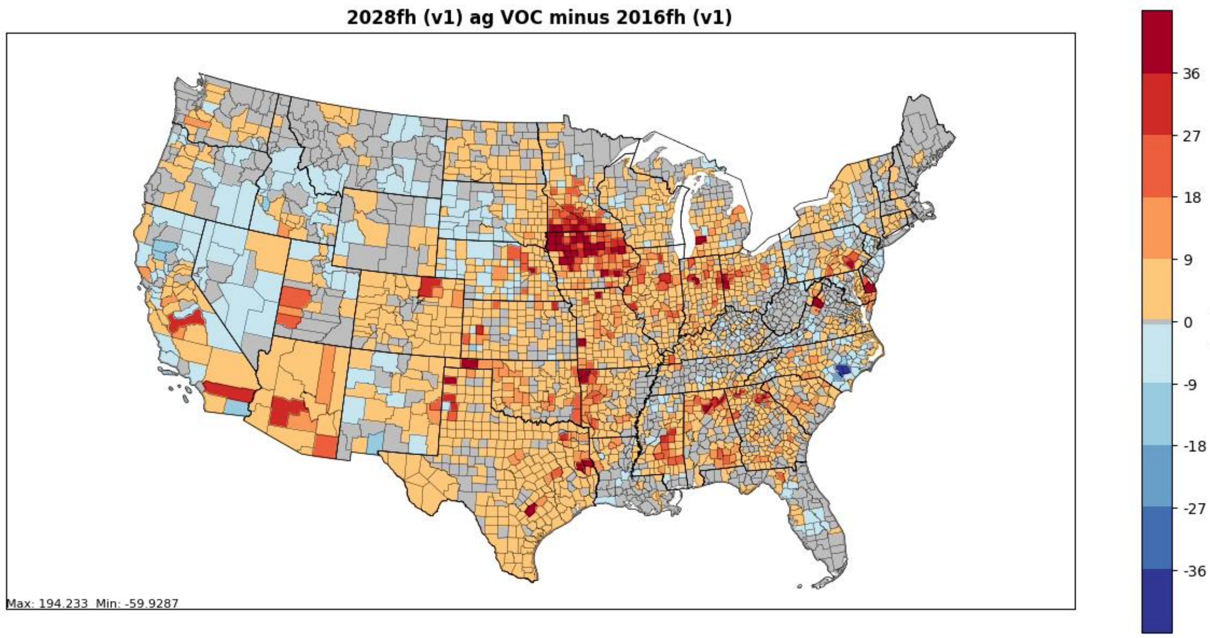
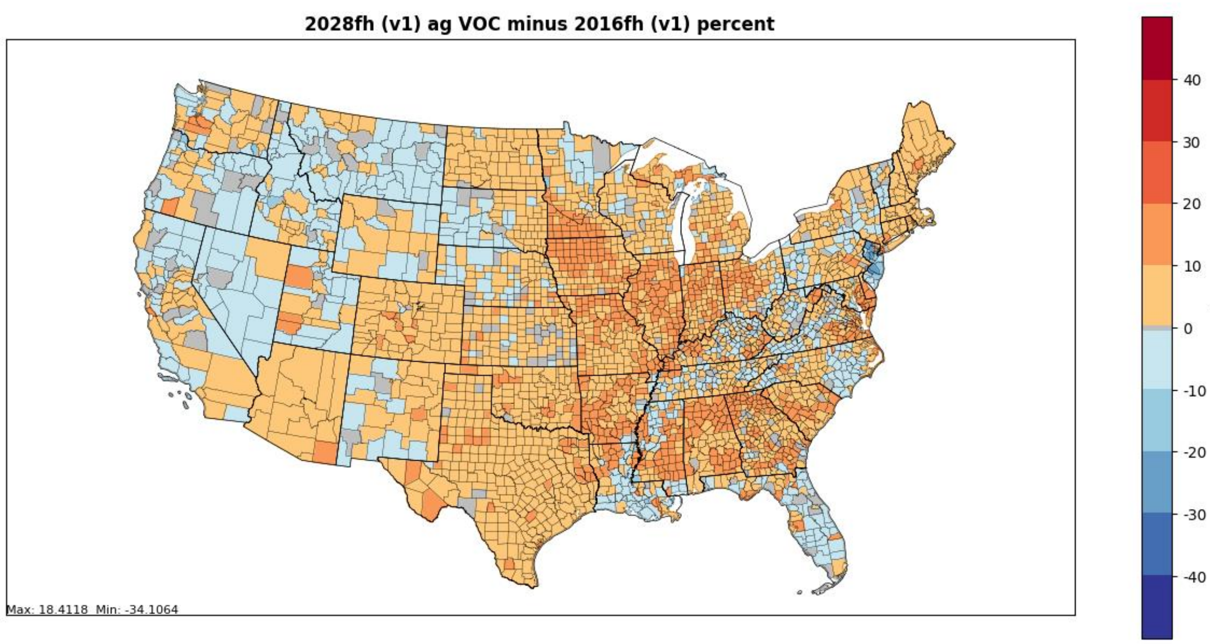


Figure 6. NH3 (tons) Ag Sector Emission Percent Differences between 2028v1 and 2016v1



6. Emissions Processing Requirements

Ag emissions were processed for air quality modeling using the Sparse Matrix Operator Kernel Emissions (SMOKE[2]) modeling system. Because the fertilizer and livestock inventories are monthly, the sector is processed through SMOKE as a monthly sector; i.e. Smkinven was run once per month with the appropriate SMKINVEN_MONTH setting (this is handled automatically by the platform scripts when using smk_ar_monthly_emf.csh). Spcmat, Grdmat, and Temporal are then also run once per month, followed by Smkmerge. The Temporal program uses the hourly temporal profile NetCDF file created by GenTPRO (ATPRO_HOURLY_NCF) to apply hourly temporalization. GenTPRO does not need to be run in addition to the standard SMOKE programs unless a new ATPRO_HOURLY_NCF file is desired. Because the hourly temporalization is different for every day of the year, separate emissions files are generated for every day, not just for representative days.

This is a 2-D sector in which all emissions were output to a single layer gridded emissions file.

7. Emissions Summaries

National and state totals by pollutant for the v1 platform cases are provided here along with some example plots. Additional plots and maps are available online through the LADCO website[3] and the Intermountain West Data Warehouse[4]. The case descriptions are as follows:

2014fd = 2014NEIv2 and 2014 NATA

2016fe = 2016 alpha platform (grown from 2014NEIv2)

2016ff, 2023ff, and 2028ff = 2016, 2023, and 2028 cases from the 2016 beta platform

2016fh, 2023fh, and 2028fh = 2016, 2023, and 2028 cases from the 2016 v1 platform

Table 4. Comparison of national total annual CAPS ag emissions (tons/yr)

Pollutant	2014fd	2016fe	2016ff	2016fh	2023ff	2023fh	2028ff	2028fh
NH3	2,828,369	2,776,552	2,856,742	3,411,363	2,946,515	3,544,817	2,984,303	3,565,718
VOC	179,970	179,970	186,274	194,907	194,254	205,583	197,460	207,255

Table 5. Comparison of state total annual NH3 ag emissions (tons/yr)

State	2014fd	2016fe	2016ff	2016fh	2023ff	2023fh	2028ff	2028fh
Alabama	44,478	45,199	46,900	48,222	50,263	52,701	51,859	54,195

[2] http://www.smoke-model.org/index.cfm
[3] https://www.ladco.org/technical/modeling-results/2016-inventory-collaborative/
[4] http://views.cira.colostate.edu/iwdw/eibrowser2016

State	2014fd	2016fe	2016ff	2016fh	2023ff	2023fh	2028ff	2028fh
Alaska				109		121		120
Arizona	28,031	26,929	27,100	70,926	27,340	72,389	27,360	72,364
Arkansas	58,981	58,436	60,223	68,215	63,344	72,638	64,824	74,282
California	364,703	273,648	270,635	308,926	273,272	310,380	272,853	310,394
Colorado	48,845	46,917	49,009	83,791	49,839	86,677	49,951	85,985
Connecticut	1,557	1,649	1,685	2,414	1,698	2,520	1,695	2,562
Delaware	5,827	5,563	5,831	6,825	6,298	7,524	6,519	7,795
D.C.	-	-	-	0	-	0	-	0
Florida	30,450	32,926	33,338	37,557	34,086	38,160	34,406	38,310
Georgia	61,890	62,822	65,515	64,504	70,259	70,167	72,571	72,292
Hawaii	3,804	-		1,493		1,539		1,533
Idaho	67,272	63,009	65,463	68,922	65,793	69,201	65,776	68,967
Illinois	107,521	70,723	72,957	89,635	75,314	96,436	76,446	97,954
Indiana	64,178	62,211	64,706	79,044	67,846	84,831	69,457	86,674
Iowa	273,253	280,014	294,160	296,512	309,866	322,860	317,583	329,308
Kansas	161,925	170,989	176,776	157,927	179,062	163,440	179,534	162,303
Kentucky	31,176	34,129	34,734	36,654	35,896	38,107	36,389	38,457
Louisiana	29,984	35,685	35,874	28,290	36,417	29,028	36,652	29,200
Maine	2,022	2,129	2,154	2,621	2,213	2,732	2,247	2,787
Maryland	12,190	12,412	12,798	12,018	13,534	12,599	13,889	12,879
Massachusetts	973	1,002	1,013	1,159	1,022	1,174	1,026	1,177
Michigan	31,779	33,748	34,918	42,837	35,845	44,868	36,291	45,319
Minnesota	129,605	138,954	144,526	195,046	150,346	204,693	153,160	207,288
Mississippi	52,170	53,177	55,026	47,010	58,170	50,658	59,676	51,935
Missouri	83,527	82,953	86,732	103,660	90,511	111,361	92,250	112,900
Montana	21,724	19,790	20,056	80,345	20,192	80,481	20,186	80,315
Nebraska	143,432	133,327	137,337	145,969	140,484	150,319	141,400	149,356
Nevada	16,928	17,474	16,659	21,570	16,799	21,903	16,696	21,466
New Hampshire	602	684	690	705	698	719	701	724
New Jersey	1,816	1,772	1,789	1,781	1,830	1,697	1,853	1,660
New Mexico	17,608	16,389	16,400	30,320	16,468	31,043	16,457	30,967
New York	21,242	21,311	21,492	33,884	21,708	34,236	21,807	34,382
North Carolina	161,525	163,374	171,518	188,093	183,125	187,775	188,979	187,608
North Dakota	36,340	48,191	48,156	79,875	48,259	80,248	48,263	80,138
Ohio	57,238	55,390	57,085	73,879	59,711	78,774	61,043	80,260
Oklahoma	95,232	101,727	105,010	110,679	108,247	116,322	109,572	116,846
Oregon	16,559	15,402	15,632	20,219	15,814	20,352	15,839	20,273
Pennsylvania	37,906	38,737	39,552	53,722	40,976	55,791	41,680	56,596
Rhode Island	148	177	179	164	182	170	184	171
South Carolina	19,392	19,875	20,621	23,892	21,929	25,424	22,570	26,026
South Dakota	59,001	74,665	76,315	88,279	77,284	89,906	77,584	89,832
Tennessee	23,328	26,755	27,302	24,805	27,972	25,471	28,240	25,602
Texas	279,564	293,335	303,714	399,634	308,796	414,701	309,905	412,811
Utah	14,089	14,284	14,825	24,427	15,407	24,983	15,682	25,170
Vermont	3,412	3,420	3,406	5,562	3,422	5,539	3,428	5,553

State	2014fd	2016fe	2016ff	2016fh	2023ff	2023fh	2028ff	2028fh
Virginia	21,661	24,841	25,230	33,138	26,109	34,353	26,489	34,772
Washington	27,445	24,017	24,616	34,827	25,068	35,321	25,284	35,510
West Virginia	4,697	5,679	5,814	7,021	6,028	7,265	6,121	7,351
Wisconsin	41,290	51,544	51,938	56,377	52,359	57,171	52,525	57,424
Wyoming	8,878	8,869	9,025	17,881	9,105	18,051	9,094	17,927
Tribal Data	1,170	297	306		309		307	

Figure 7. 2016fh ag NH3 emissions by county (tons)

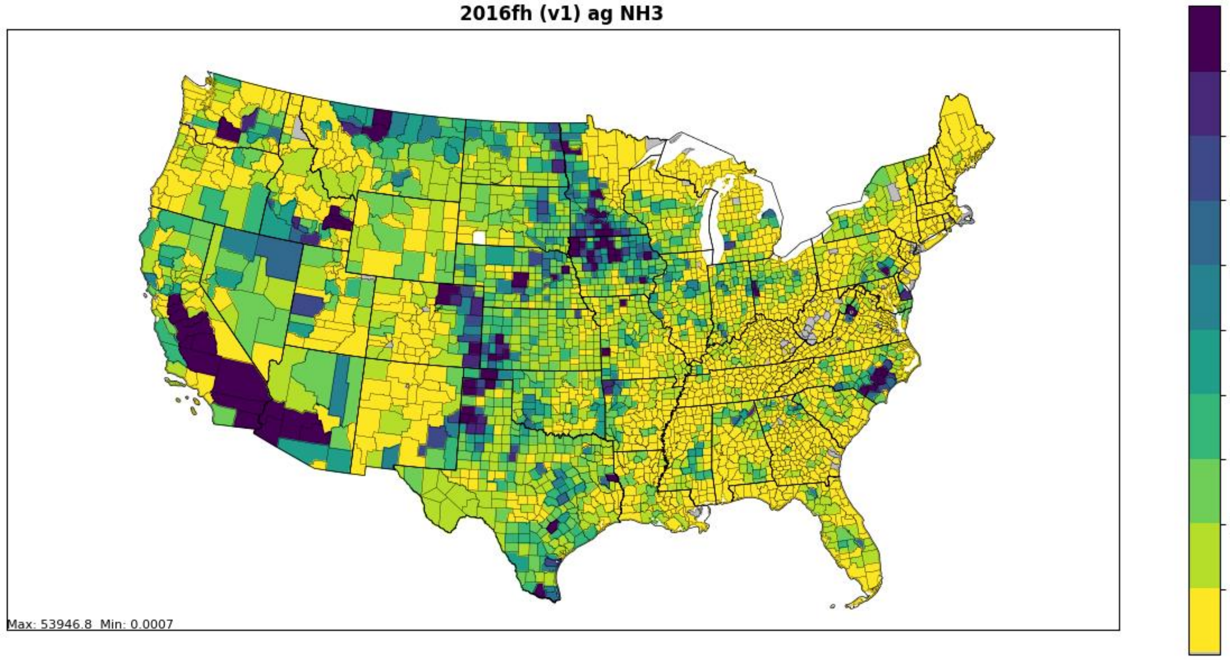


Figure 8. 2016fh ag VOC emissions by county (tons)