March 6, 2019

SPECIFICATION SHEET: AFDUST 2016beta Platform

Description: Nonpoint area fugitive dust (afdust) emissions, for simulating 2016 and future year U.S. air quality

1. EXECUTIVE SUMMARY

The area fugitive dust (afdust) sector consists of fugitive dust particulate matter (PM) emissions from the 2014 National Emissions Inventory (NEI) version 2 nonpoint source category. Categories included in the afdust sector are paved roads, unpaved roads and airstrips, construction (residential, industrial/commercial/institutional, road and total), agriculture production, and mining and quarrying. For the 2016 beta platform, emissions from paved roads are projected from 2014 to 2016 based on county total VMT, but emissions from all other sources, including unpaved roads, are held constant. Base and future year inventories were processed with the Sparse Matrix Operating Kernel Environment (SMOKE) v4.6. SMOKE creates emissions in a format that can be input into air quality models. After SMOKE processing, afdust emissions are reduced using a gridded transport fraction file that takes into account the impact of the roughness of the landscape on the emissions. Emissions are further reduced at specific hours based on snow cover and precipitation. National and state-level emission summaries for key pollutants are provided.

2. INTRODUCTION

This document details the approach and data sources used for developing 2016 beta emissions for the nonpoint area fugitive dust (afdust) sector. The beta platform uses a partial 2016 projection of afdust emissions from the 2014NEIv2: paved road emissions are projected from the 2014NEIv2 to 2016 while emissions from all other afdust categories are held constant. This section includes background information on the sector in general. The projection method is described in Section 3.

The afdust sector contains PM_{10} and $PM_{2.5}$ emission estimates for nonpoint SCCs identified by EPA as dust sources. Categories included in the afdust sector are paved roads, unpaved roads and airstrips, construction (residential, industrial/commercial/institutional, road and total), agriculture production, and mining and quarrying. It does not include fugitive dust from grain elevators, coal handling at coal mines, or vehicular traffic on paved or unpaved roads at industrial facilities because these are treated as point sources so they are properly located.

Table 1 is a listing of the Source Classification Codes (SCCs) in the afdust sector.

Table 1. Afdust SCCs in the 2016 beta platform

SCC	Tier 1 description	Tier 2 description	Tier 3 description	Tier 4 description
2275085000	Mobile Sources	Aircraft	Unpaved Airstrips	Total
2294000000	Mobile Sources	Paved Roads	All Paved Roads	Total: Fugitives
2294000002	Mobile Sources	Paved Roads	All Paved Roads	Total: Sanding/Salting - Fugitives
2296000000	Mobile Sources	Unpaved Roads	All Unpaved Roads	Total: Fugitives
2311000000	Industrial Processes	Construction: SIC 15 - 17	All Processes	Total
2311010000	Industrial Processes	Construction: SIC 15 - 17	Residential	Total
2311010070	Industrial Processes	Construction: SIC 15 - 17	Residential	Vehicle Traffic
2311020000	Industrial Processes	Construction: SIC 15 - 17	Industrial/Commercial/ Institutional	Total
2311030000	Industrial Processes	Construction: SIC 15 - 17	Road Construction	Total
2325000000	Industrial Processes	Mining and Quarrying: SIC 14	All Processes	Total
2325060000	Industrial Processes	Mining and Quarrying: SIC 10	Lead Ore Mining and Milling	Total

SCC	Tier 1 description	Tier 2 description	Tier 3 description	Tier 4 description
2801000000	Miscellaneous Area Sources	Ag. Production - Crops	Agriculture - Crops	Total
2801000003	Miscellaneous Area Sources	Ag. Production - Crops	Agriculture - Crops	Tilling
2801000005	Miscellaneous Area Sources	Ag. Production - Crops	Agriculture - Crops	Harvesting
2801000007	Miscellaneous Area Sources	Ag. Production - Crops	Agriculture - Crops	Loading
2801000008	Miscellaneous Area Sources	Ag. Production - Crops	Agriculture - Crops	Transport
2805001000	Miscellaneous Area Sources	Ag. Production - Livestock	Beef cattle - finishing operations on feedlots (drylots)	Dust Kicked-up by Hooves (use 28-05-020, -001, -002, or -003 for Waste
2805001100	Miscellaneous Area Sources	Ag. Production - Livestock	Beef cattle - finishing operations on feedlots (drylots)	Confinement
2805001200	Miscellaneous Area Sources	Agriculture Production – Livestock	Beef cattle - finishing operations on feedlots (drylots)	Manure handling and storage
2805001300	Miscellaneous Area Sources	Agriculture Production – Livestock	Beef cattle - finishing operations on feedlots (drylots)	Land application of manure
2805002000	Miscellaneous Area Sources	Ag. Production - Livestock	Beef cattle production composite	Not Elsewhere Classified
2805003100	Miscellaneous Area Sources	Ag. Production - Livestock	Beef cattle - finishing operations on pasture/range	Confinement
2805007100	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - layers with dry manure management systems	Confinement
2805007300	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - layers with dry manure management systems	Land application of manure
2805008100	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - layers with wet manure management systems	Confinement
2805008200	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - layers with wet manure management systems	Manure handling and storage
2805008300	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - layers with wet manure management systems	Land application of manure

SCC	Tier 1 description	Tier 2 description	Tier 3 description	Tier 4 description
2805009100	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - broilers	Confinement
2805009200	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - broilers	Manure handling and storage
2805009300	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - broilers	Land application of manure
2805010100	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - turkeys	Confinement
2805010200	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - turkeys	Manure handling and storage
2805010300	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry production - turkeys	Land application of manure
2805018000	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle composite	Not Elsewhere Classified
2805019100	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle - flush dairy	Confinement
2805019200	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle - flush dairy	Manure handling and storage
2805019300	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle - flush dairy	Land application of manure
2805020002	Miscellaneous Area Sources	Ag. Production - Livestock	Cattle and Calves Waste Emissions	Beef Cows
2805021100	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle - scrape dairy	Confinement
2805021200	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle - scrape dairy	Manure handling and storage
2805021300	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle - scrape dairy	Land application of manure
2805022100	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle - deep pit dairy	Confinement
2805022200	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle - deep pit dairy	Manure handling and storage
2805022300	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle - deep pit dairy	Land application of manure
2805023100	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle - drylot/pasture dairy	Confinement
2805023200	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle - drylot/pasture dairy	Manure handling and storage
2805023300	Miscellaneous Area Sources	Ag. Production - Livestock	Dairy cattle - drylot/pasture dairy	Land application of manure
2805025000	Miscellaneous Area Sources	Ag. Production - Livestock	Swine production composite	Not Elsewhere Classified (see also 28-05-039, -047, -053)

SCC	Tier 1 description	Tier 2 description	Tier 3 description	Tier 4 description
2805030000	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry Waste Emissions	Not Elsewhere Classified (see also 28-05-007, -008, -009)
2805030007	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry Waste Emissions	Ducks
2805030008	Miscellaneous Area Sources	Ag. Production - Livestock	Poultry Waste Emissions	Geese
2805035000	Miscellaneous Area Sources	Ag. Production - Livestock	Horses and Ponies Waste Emissions	Not Elsewhere Classified
2805039100	Miscellaneous Area Sources	Ag. Production - Livestock	Swine production - operations with lagoons (unspecified animal age)	Confinement
2805039200	Miscellaneous Area Sources	Ag. Production - Livestock	Swine production - operations with lagoons (unspecified animal age)	Manure handling and storage
2805039300	Miscellaneous Area Sources	Ag. Production - Livestock	Swine production - operations with lagoons (unspecified animal age)	Land application of manure
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
2805047100	Miscellaneous Area Sources	Ag. Production – Livestock	Swine production - deep-pit house operations (unspecified animal age)	Confinement
2805047300	Miscellaneous Area Sources	Ag. Production – Livestock	Swine production - deep-pit house operations (unspecified animal age)	Land application of manure
2805053100	Miscellaneous Area Sources	Ag. Production – Livestock	Swine production - outdoor operations (unspecified animal age)	Confinement

The afdust sector is separated from other nonpoint sectors to allow for the application of a "transport fraction," and meteorological/precipitation reductions. These adjustments are applied using a script that applies land use-based gridded transport fractions based on landscape roughness, followed by another script that zeroes out emissions for days on which at least 0.01 inches of precipitation occurs or there is snow cover on the ground. The land use data used to reduce the NEI emissions determines the amount of emissions that are subject to transport. This methodology is discussed in Pouliot, et al., 2010, and in "Fugitive Dust Modeling for the 2008 Emissions Modeling Platform" (Adelman, 2012). Both the transport fraction and meteorological adjustments are based on the gridded resolution of the platform (i.e., 12km grid cells); therefore, different emissions will result if the process were applied to different grid

resolutions. A limitation of the transport fraction approach is the lack of monthly variability that would be expected with seasonal changes in vegetative cover. While wind speed and direction are not accounted for in the emissions processing, the hourly variability due to soil moisture, snow cover and precipitation is accounted for in the subsequent meteorological adjustment.

For the data compiled into the 2014NEIv2, meteorological adjustments are applied to paved and unpaved road SCCs but not transport adjustments. For the 2014NEIv1, the meteorological adjustments were inadvertently not applied. This created a large difference between the 2014NEIv1 and 2014NEIv2 dust emissions which did not impact the modeling platform because the modeling platform applies meteorological adjustments and transport adjustments based on unadjusted NEI values (for both v1 and v2). Thus, for the 2014NEIv2, the meteorological adjustments that were applied (to paved and unpaved road SCCs) had to be backed out so that the entire sector could be processed consistently in SMOKE and the same grid-specific transport fractions and meteorological adjustments could be applied sector-wide. Because it was determined that some counties in 2014NEIv2 did not have the adjustment applied, their emissions were used as-is. Thus, the FF10 that is run through SMOKE consists of 100% unadjusted emissions, and after SMOKE all afdust sources have both transport and meteorological adjustments applied. The total impacts of the transport fraction and meteorological adjustments for 2016 beta are shown in Table 2. Note that while totals from AK, HI, PR, and VI are included at the bottom of Table 2, they exist in a separate domain.

Figure 1 illustrates the impact of each step of the adjustment, using the 2014v7.0 platform afdust sector as an example. The reductions due to the transport fraction adjustments alone are shown at the top of Figure 1. The reductions due to the precipitation adjustments alone are shown in the middle of Figure 1. The cumulative emission reductions after both transport fraction and meteorological adjustments are shown at the bottom of Figure 1. The top plot shows how the transport fraction has a larger reduction effect in the east, where forested areas are more effective at reducing PM transport than in many western areas. The middle plot shows how the meteorological impacts of precipitation, along with snow cover in the north, further reduce the dust emissions.

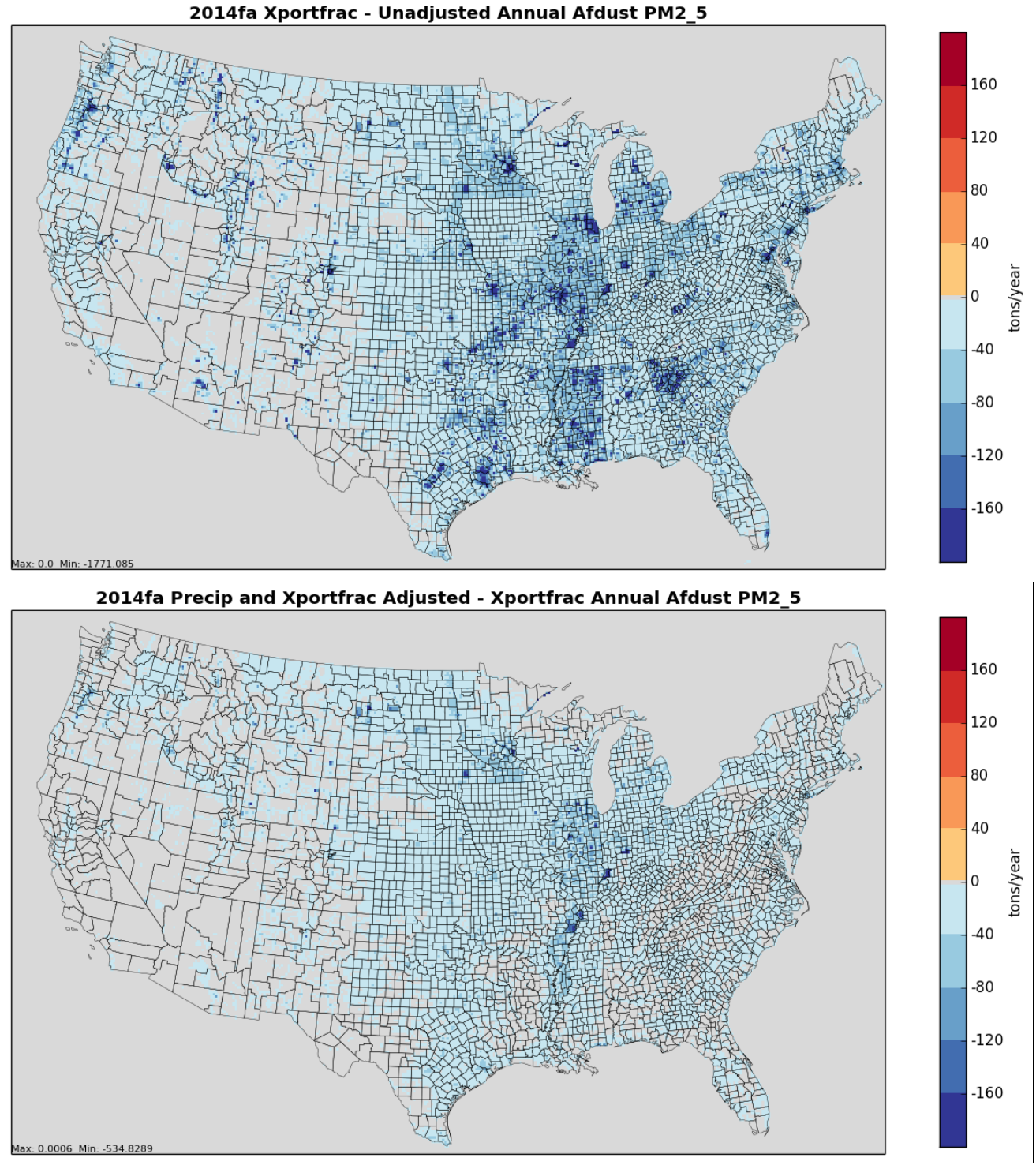
Table 2. Total impact of fugitive dust adjustments to unadjusted 2016 beta inventory

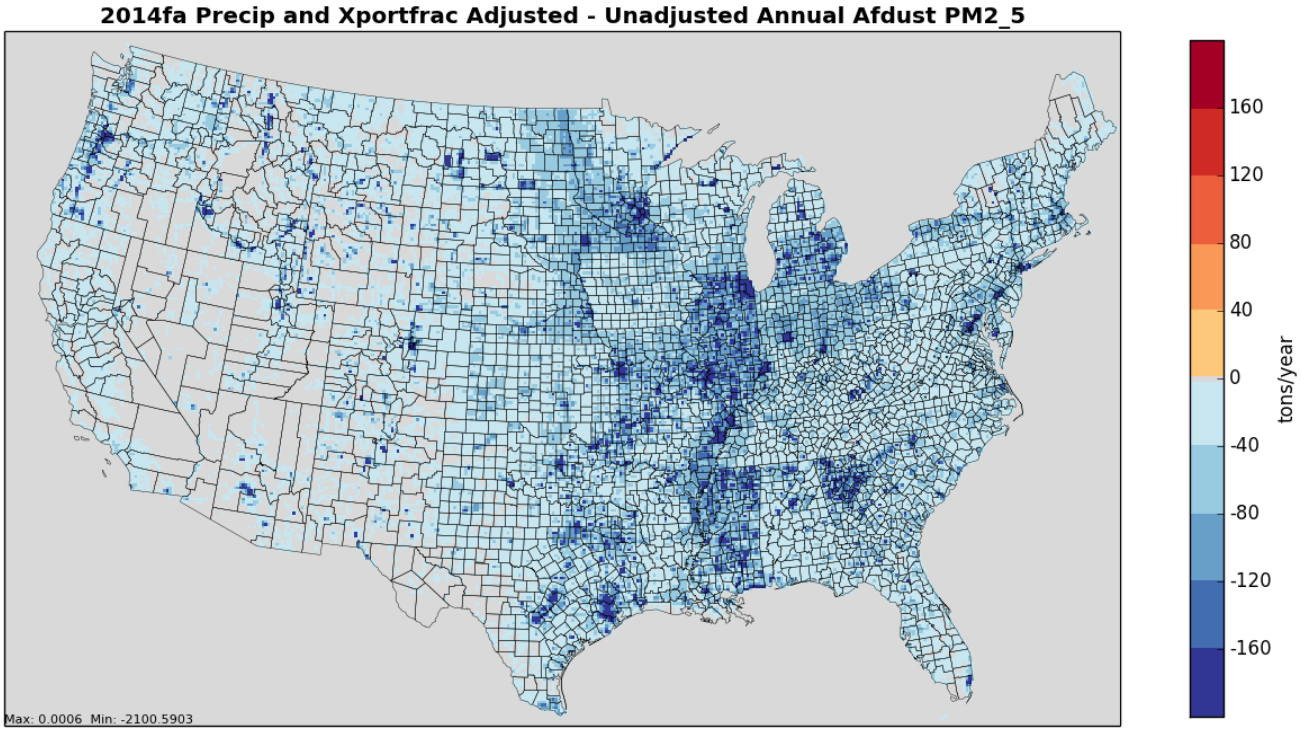
State	Unadjusted PM_{10}	Unadjusted $PM_{2.5}$	Change in PM_{10}	Change in $PM_{2.5}$	PM_{10} Reduction	$PM_{2.5}$ Reduction
Alabama	535,218	63,682	-372,853	-44,336	70%	70%
Arizona	264,628	32,808	-96,814	-11,809	37%	36%
Arkansas	321,488	49,397	-211,050	-31,802	66%	64%

State	Unadjusted PM_{10}	Unadjusted $PM_{2.5}$	Change in PM_{10}	Change in $PM_{2.5}$	PM_{10} Reduction	$PM_{2.5}$ Reduction
California	314,917	41,395	-134,347	-17,059	43%	41%
Colorado	242,327	36,848	-121,263	-17,718	50%	48%
Connecticut	23,509	3,343	-17,376	-2,478	74%	74%
Delaware	14,752	2,560	-8,961	-1,569	61%	61%
District of Columbia	2,577	374	-1,601	-233	62%	62%
Florida	721,379	82,397	-412,621	-46,899	57%	57%
Georgia	557,354	66,609	-389,482	-46,272	70%	69%
Idaho	454,301	55,978	-241,373	-28,363	53%	51%
Illinois	997,748	143,992	-619,594	-88,735	62%	62%
Indiana	718,027	84,663	-498,442	-58,430	69%	69%
Iowa	387,029	60,253	-222,941	-34,557	58%	57%
Kansas	613,183	99,486	-277,007	-44,234	45%	44%
Kentucky	312,872	42,952	-233,163	-31,762	75%	74%
Louisiana	266,812	35,788	-172,875	-22,923	65%	64%
Maine	38,295	5,953	-31,852	-4,970	83%	83%
Maryland	104,580	16,541	-67,414	-10,741	64%	65%
Massachusetts	151,623	19,156	-115,434	-14,478	76%	76%
Michigan	390,994	48,838	-286,999	-35,560	73%	73%
Minnesota	405,052	61,723	-250,646	-37,609	62%	61%
Mississippi	434,575	53,546	-299,888	-36,494	69%	68%
Missouri	1,604,501	185,103	-1,084,830	-124,078	68%	67%
Montana	432,844	62,062	-236,341	-32,695	55%	53%
Nebraska	349,373	55,303	-165,083	-25,739	47%	47%
Nevada	161,820	23,360	-54,899	-7,953	34%	34%
New Hampshire	22,406	4,631	-18,498	-3,823	83%	83%
New Jersey	41,133	9,320	-27,293	-6,165	66%	66%
New Mexico	490,617	54,236	-200,695	-22,038	41%	41%
New York	262,998	43,976	-195,453	-32,674	74%	74%
North Carolina	204,383	29,759	-140,145	-20,439	69%	69%
North Dakota	473,241	82,478	-249,646	-43,138	53%	52%
Ohio	931,847	116,560	-638,128	-79,098	68%	68%
Oklahoma	450,904	67,915	-232,046	-33,983	51%	50%
Oregon	659,099	73,832	-456,949	-49,830	69%	67%
Pennsylvania	240,300	37,407	-178,061	-27,752	74%	74%
Rhode Island	4,847	776	-3,439	-550	71%	71%

State	Unadjusted PM_{10}	Unadjusted $PM_{2.5}$	Change in PM_{10}	Change in $PM_{2.5}$	PM_{10} Reduction	$PM_{2.5}$ Reduction
South Carolina	164,477	22,016	-110,278	-14,795	67%	67%
South Dakota	339,195	63,248	-169,300	-31,302	50%	49%
Tennessee	295,092	43,414	-204,746	-29,995	69%	69%
Texas	1,264,131	180,314	-636,591	-87,931	50%	49%
Utah	209,800	26,453	-111,587	-13,771	53%	52%
Vermont	22,295	3,244	-18,531	-2,674	83%	82%
Virginia	284,968	36,806	-210,973	-27,201	74%	74%
Washington	242,907	41,851	-135,713	-23,281	56%	56%
West Virginia	122,601	15,067	-104,762	-12,861	85%	85%
Wisconsin	690,830	89,899	-486,508	-62,683	70%	70%
Wyoming	240,156	29,140	-123,388	-14,561	51%	50%
Domain Total (CONUS)	**18,480,005**	**2,506,452**	**-11,277,878**	**-1,500,040**	**61%**	**60%**
Alaska	112,025	11,562	-101,822	-10,508	91%	91%
Hawaii	109,120	11,438	-73,612	-7,673	67%	67%
Puerto Rico	5,889	1,313	-4,355	-984	74%	75%
Virgin Islands	3,493	467	-1,477	-195	42%	42%

Figure 1. Impact of adjustments to fugitive dust emissions due to transport fraction, precipitation, and cumulative





3. Inventory Development Methods

The starting point for the afdust emissions is the 2014 National Emissions Inventory version 2. The methodologies to estimate emissions for each SCC in Table 1 are described in the 2014 NEI version 2 Technical Support Document[1].

For paved roads (SCC 2294000000), the 2014NEIv2 paved road emissions in afdust were projected to year 2016 based on differences in county total VMT between 2014 and 2016:

*2016 afdust paved roads = 2014 afdust paved roads * (2016 county total VMT) / (2014 county total VMT)*

The development of the 2016 VMT is described in the onroad documentation.

All emissions other than those for paved roads are held constant in the 2016 inventory, including unpaved roads.

4. Ancillary Data

Spatial Allocation

Spatial allocation of afdust emissions to the national 12km domain used for air quality modeling is accomplished using spatial surrogates, and afdust emissions for the national 36km domain are aggregated from the gridded 12km emissions. Spatial surrogates map county polygons to

[1] https://www.epa.gov/air-emissions-inventories/2014-national-emissions-inventory-nei-technical-support-document-tsd

the uniformly spaced grid cells of a modeling domain. The afdust sector uses the total road miles surrogate to allocate emissions from paved roads, and surrogates based on National Land Cover Data (NLCD) land use to allocate other sources. A report summarizing total emissions by spatial surrogate at the national level is provided in Table 3. Reports summarizing total emissions by spatial surrogate at the state and county level are included in the emissions modeling workgroup reports package.

Table 3. 2016ff afdust emissions by spatial surrogate, Continental US (no transport or meteorological adjustments applied)

Srg	Description	PM10	PM2.5
240	Total Road Miles	1,278,337	295,442
304	NLCD Open + Low	10,592,072	1,053,145
306	NLCD Med + High	345,358	43,636
308	NLCD Low + Med + High	1,188,214	122,943
310	NLCD Total Agriculture	5,010,982	987,447

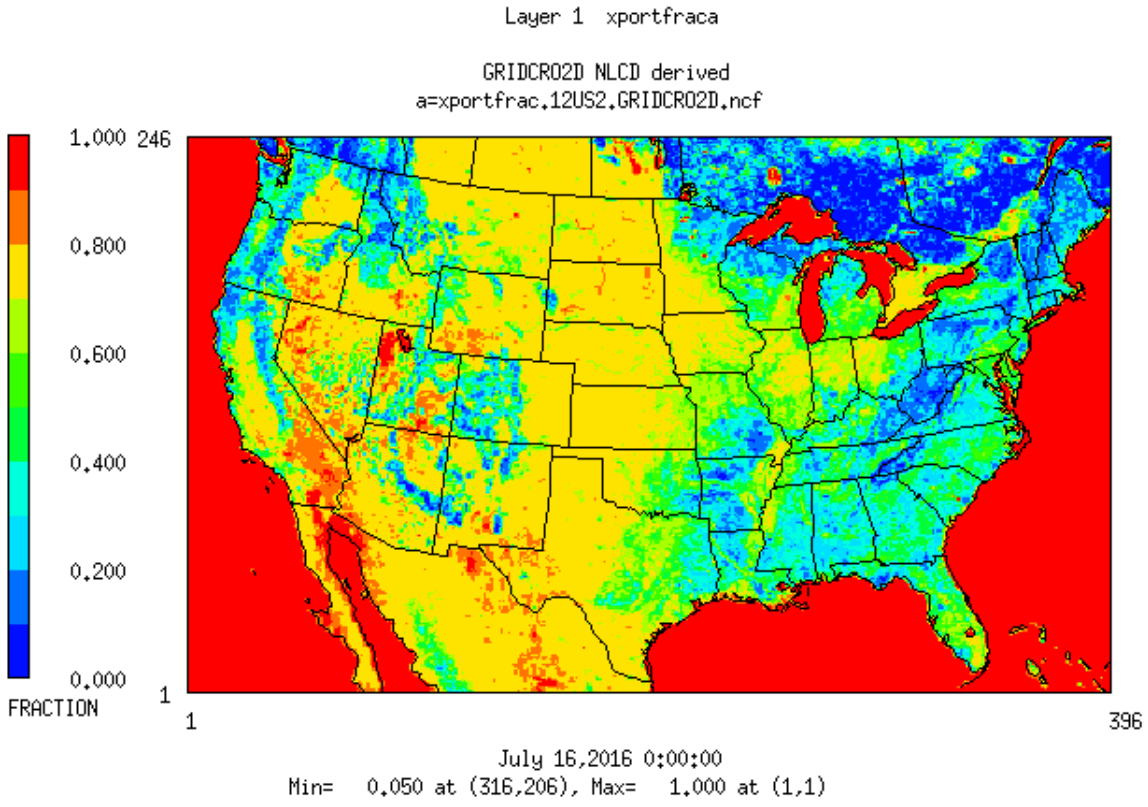
The meteorological adjustments applied to afdust emissions are particularly sensitive to changes in grid resolution and meteorology. So that afdust emissions can be consistent between resolutions, afdust emissions for the national 36km domain are aggregated from the gridded 12km emissions, rather than processed separately using 36km meteorology. The exception is for Southeast Alaska, which is partially inside the 36US3 modeling domain but is outside the 12km domains. For Southeast Alaska only, we process afdust emissions using 36km surrogates and meteorology as a separate sector called “afdust_ak”, which is a supplement to afdust 36km emissions for the Continental US which were aggregated from 12km resolution.

Application of a transport fraction to reduce afdust emissions is applied with a gridded file called the XPORTFRAC file. Formerly, XPORTFRAC files were developed based on BELD3 land use. For the beta platform, XPORTFRAC files are now developed using land use data from the MCIP GRIDCRO2D file. GRIDCRO2D files contain several LUFRAC variables, which represent different types of land use. Each land use type is grouped into a general category, each of which has a distinct transportable fraction, as shown in Table 4. For example, in areas that are 100% forest, afdust emissions are multiplied by 0.05 (95% reduction). In areas that are 50% urban and 50% shrubland, emissions are multiplied by 0.60 (average of 0.40 and 0.80; 40% reduction). Figure 2 displays the resulting gridded transport fractions for the 12US2 modeling domain that were applied in the spatial allocation steps of the emissions modeling.

Table 4. Transportable fractions for different land use categories

Category	Transport fraction
Agricultural	0.75
DevLowIntensity	0.70
DevMedIntensity	0.40
DevHiIntensity	0.10
Grasses	0.75
Water	1.00
Forest	0.05
Urban	0.40
Shrubland	0.80

Figure 2. Gridded transport fractions for the 12US2 modeling domain using GRIDCRO2D land use



Temporal Allocation

Reports summarizing total emissions according to the monthly, day-of-week, and hour-of-day temporal profile assignments were developed at the state and county level. A national-level summary is provided in Table 5.

Table 5. 2016ff afdust emissions grouped by temporal profile assignment (no transport or meteorological adjustments applied)

Monthly profile	Weekly profile	Diurnal profile	PM10	PM2.5
22	**18**	**26**	1,555,728	168,967
22	**18**	**27**	3,921,630	781,685
262	**7**	**26**	171	29
262	**20021**	**2013**[1]	12,083,970	1,371,263
1560	**7**	**26**	228	89
1560	**7**	**27**	1,636	338
1570	**7**	**26**	1	0
Ag[2]	**7**	**26**	22,875	3,925
Ag[2]	**7**	**27**	1,077,013	203,887

[1] Separate diurnal profiles for weekdays (2013wd) and weekends (2013we).

[2] Includes multiple monthly profiles, which vary by state and by ag emissions category.

Chemical Speciation

The afdust sector only includes PM10 and PM2.5 emissions. Seven different PM2.5 profiles are used for the afdust sector due to the varied nature of the emissions that comprise the sector. Reports summarizing total PM2.5 emissions according to PM2.5 speciation profile were developed at the state and county level.

5. Emissions Projection Methods

For paved roads (SCC 2294000000), the 2016 afdust emissions were projected to future years 2023 and 2028 based on differences in county total VMT:

*Future year afdust paved roads = 2016 afdust paved roads * (Future year county total VMT) / (2016 county total VMT)*

The VMT projections are described in the onroad document.

All emissions other than paved roads are held constant in future year projections.

6. Emissions Processing Requirements

Afdust emissions are processed for air quality modeling using the Sparse Matrix Operator Kernel Emissions (SMOKE[2]) modeling system version 4.6 modeling system. Gridded emissions output from SMOKE do not have any transport fraction or meteorological adjustments applied, and so SMOKE outputs are considered "unadjusted" emissions. For this sector, extra steps are needed outside of SMOKE to apply those adjustments.

[2] http://www.smoke-model.org/index.cfm

First, the transport fraction, represented as a gridded file called the XPORTFRAC (see Section 4, Spatial Allocation), is applied to the emissions using a Fortran program called "mult" that multiplies an emissions file by a gridded set of fractions. Output files from this step are placed in the same premerged/afdust directory, but with "xportfrac" in the file name.

Second, meteorological adjustments are applied to the xportfrac-adjusted emissions, in which emissions are zeroed out whenever there is snow cover or falling precipitation. Output files from this step are assigned a new sector name: "afdust_adj". Only the afdust_adj emissions, and not the unadjusted afdust emissions, should be included in the final sector merge or any downstream modeling.

Afdust emissions are processed through SMOKE using representative days: one file for each day of the week per month, plus holidays. Transport fractions are not time-dependent, and are also applied on a representative day basis. Meteorological adjustments are time-dependent, and so emissions with meteorological adjustments are generated separately for every day of the year.

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

7. EMISSIONS SUMMARIES

National and state unadjusted afdust totals by pollutant for the beta platform cases are provided here in Table 6 – Table 8, along with some example plots. Additional plots and maps are available online through the LADCO website[3] and the Intermountain West Data Warehouse[4].

Descriptions of the emissions platform cases shown in the tables and plots below are as follows:

2011en, 2023en, 2028el = Final 2011, 2023, and 2028 cases from the 2011v6.3 platform

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

Table 6. Comparison of national total annual CAPS unadjusted afdust emissions (tons/yr)

Pollutant	2011en	2014fd	2016fe	2016ff	2023en	2023ff	2028el	2028ff
PM10	18,725,249	18,609,657	18,609,657	18,663,254	20,859,668	18,753,210	21,666,297	18,791,296
PM2.5	2,510,307	2,517,877	2,517,877	2,530,184	2,753,900	2,550,512	2,845,757	2,558,876

[3] https://www.ladco.org/technical/modeling-results/2016-inventory-collaborative/

[4] http://views.cira.colostate.edu/iwdw/eibrowser2016

Table 7. Comparison of state total annual Primary PM10 unadjusted afdust emissions (tons/yr)

State	2011en	2014fd	2016fe	2016ff	2023en	2023ff	2028el	2028ff
Alabama	378,874	528,781	528,781	530,994	405,026	533,335	429,063	533,698
Alaska	155,471	111,865	111,865	112,052	155,471	112,312	155,471	112,469
Arizona	237,361	263,614	263,614	264,215	264,230	265,871	275,063	266,665
Arkansas	421,958	320,563	320,563	321,503	481,744	322,737	505,424	323,079
California	255,889	312,537	312,537	313,897	289,185	319,392	302,498	322,177
Colorado	244,630	241,417	241,417	242,584	264,206	244,162	272,316	245,094
Connecticut	29,067	23,465	23,465	23,432	30,793	23,710	31,110	23,914
Delaware	11,548	14,370	14,370	14,754	13,205	15,148	13,492	15,212
D.C.	2,115	2,568	2,568	2,588	2,230	2,610	2,248	2,601
Florida	292,797	711,690	711,690	715,197	354,400	719,072	379,159	720,397
Georgia	733,478	549,708	549,708	552,994	838,636	556,489	879,310	559,254
Hawaii	33,302	108,186	108,186	108,303	33,302	108,497	33,302	108,585
Idaho	432,116	449,496	449,496	452,564	498,752	458,164	521,857	461,597
Illinois	763,665	998,531	998,531	998,531	810,154	999,213	826,916	999,243
Indiana	603,152	711,183	711,183	713,044	667,885	715,073	693,150	715,366
Iowa	590,528	386,614	386,614	387,616	628,608	388,508	642,979	388,679
Kansas	747,242	613,261	613,261	614,019	802,043	615,349	823,387	615,790
Kentucky	199,744	310,944	310,944	311,552	219,500	312,847	227,278	313,114
Louisiana	236,787	265,725	265,725	265,899	266,350	267,273	278,087	267,784
Maine	50,547	37,803	37,803	38,122	52,565	38,593	53,357	38,654
Maryland	65,701	104,047	104,047	105,110	69,569	106,887	70,530	107,489
Massachusetts	205,561	146,920	146,920	150,390	208,303	150,994	208,480	151,413
Michigan	462,324	387,396	387,396	388,501	482,871	389,566	499,526	389,499
Minnesota	336,791	404,487	404,487	404,992	344,381	406,363	347,258	406,703
Mississippi	956,702	431,598	431,598	432,177	1,116,484	433,268	1,178,949	433,451
Missouri	1,063,992	1,590,321	1,590,321	1,592,353	1,198,473	1,595,288	1,239,126	1,596,115
Montana	385,541	431,833	431,833	432,151	443,972	433,179	468,320	433,838
Nebraska	591,457	348,666	348,666	349,245	648,433	350,023	670,326	350,355
Nevada	160,699	160,293	160,293	162,333	175,141	164,564	180,433	166,197
New Hampshire	25,540	21,673	21,673	22,239	27,118	23,746	27,715	24,912
New Jersey	24,273	39,690	39,690	40,771	24,890	41,693	25,411	42,372
New Mexico	924,497	484,805	484,805	486,558	1,144,824	488,402	1,233,693	489,375
New York	274,114	266,456	266,456	262,033	282,908	265,012	286,121	264,195
North Carolina	186,650	201,958	201,958	203,960	215,661	206,227	215,661	207,813
North Dakota	354,107	476,225	476,225	475,565	374,499	476,270	382,147	476,655
Ohio	414,902	924,347	924,347	926,792	446,467	930,603	456,267	932,347
Oklahoma	733,750	449,725	449,725	450,375	859,935	452,009	909,663	452,715
Oregon	348,093	653,001	653,001	653,875	409,037	655,359	432,836	656,282
Pennsylvania	208,246	240,126	240,126	240,224	219,512	241,963	221,735	241,743
Rhode Island	4,765	4,793	4,793	4,849	5,566	4,924	5,682	4,918
South Carolina	259,350	161,472	161,472	163,488	305,286	164,926	322,088	165,262
South Dakota	262,935	341,201	341,201	341,386	278,188	341,882	284,142	342,128
Tennessee	139,731	292,579	292,579	294,599	151,352	296,873	155,937	297,539
Texas	2,573,687	1,255,165	1,255,165	1,261,816	2,831,238	1,270,256	2,919,412	1,274,353

State	2011en	2014fd	2016fe	2016ff	2023en	2023ff	2028el	2028ff
Utah	196,551	207,301	207,301	208,700	230,528	210,140	238,768	210,996
Vermont	67,690	22,105	22,105	22,199	68,324	22,394	68,434	22,441
Virginia	131,798	283,229	283,229	283,555	143,233	285,119	146,718	285,556
Washington	174,969	240,697	240,697	242,998	188,482	247,491	193,984	250,089
West Virginia	85,956	121,931	121,931	121,952	85,983	122,328	85,994	122,368
Wisconsin	239,851	686,669	686,669	687,663	254,505	689,605	259,870	690,795
Wyoming	434,090	238,688	238,688	238,605	535,557	239,306	574,938	239,788
Puerto Rico		5,860	5,860	5,860		6,093		6,119
Virgin Islands		3,464	3,464	3,464		3,490		3,490
Tribal Data	10,662	18,613	18,613	18,613	10,662	18,613	10,662	18,613

Table 8. Comparison of state total annual Primary PM2.5 unadjusted afdust emissions (tons/yr)

State	2011en	2014fd	2016fe	2016ff	2023en	2023ff	2028el	2028ff
Alabama	47,158	62,688	62,688	63,229	50,435	63,800	53,308	63,887
Alaska	15,868	11,518	11,518	11,564	15,868	11,629	15,868	11,668
Arizona	30,015	32,630	32,630	32,775	33,477	33,166	34,869	33,354
Arkansas	58,648	49,285	49,285	49,509	65,243	49,805	67,852	49,888
California	38,664	41,064	41,064	41,268	42,638	42,093	44,224	42,511
Colorado	40,421	36,656	36,656	36,934	43,709	37,314	45,071	37,538
Connecticut	4,393	3,337	3,337	3,329	4,687	3,398	4,767	3,448
Delaware	1,968	2,456	2,456	2,551	2,225	2,649	2,297	2,665
D.C.	337	368	368	373	351	379	356	377
Florida	39,637	80,865	80,865	81,722	48,093	82,669	51,476	82,991
Georgia	90,041	65,362	65,362	66,147	101,596	66,989	106,086	67,655
Hawaii	3,036	11,324	11,324	11,353	3,036	11,402	3,036	11,424
Idaho	49,294	55,752	55,752	55,927	55,617	56,246	57,811	56,442
Illinois	123,680	144,503	144,503	144,503	129,434	144,671	131,512	144,679
Indiana	85,151	83,739	83,739	84,194	92,484	84,689	95,343	84,759
Iowa	96,070	60,224	60,224	60,464	100,370	60,677	101,992	60,717
Kansas	118,726	99,656	99,656	99,843	124,706	100,170	127,035	100,278
Kentucky	29,496	42,709	42,709	42,855	32,204	43,163	33,266	43,225
Louisiana	35,730	35,685	35,685	35,729	39,474	36,061	40,958	36,184
Maine	7,016	5,853	5,853	5,931	7,469	6,046	7,666	6,061
Maryland	10,215	16,323	16,323	16,584	10,895	17,020	11,131	17,167
Massachusetts	22,444	18,147	18,147	18,998	22,742	19,146	22,786	19,249
Michigan	61,969	48,344	48,344	48,612	64,337	48,872	66,259	48,856
Minnesota	64,253	61,739	61,739	61,864	65,642	62,201	66,168	62,285
Mississippi	107,965	53,207	53,207	53,348	124,551	53,615	131,034	53,660
Missouri	130,995	183,479	183,479	183,981	145,279	184,705	149,611	184,909
Montana	50,583	62,061	62,061	62,137	56,764	62,386	59,339	62,545
Nebraska	85,206	55,257	55,257	55,396	91,248	55,582	93,570	55,662
Nevada	20,477	22,915	22,915	23,423	22,514	23,978	23,206	24,385
New Hampshire	3,766	4,454	4,454	4,593	4,109	4,963	4,255	5,249
New Jersey	5,412	8,963	8,963	9,233	5,565	9,464	5,695	9,633

State	2011en	2014fd	2016fe	2016ff	2023en	2023ff	2028el	2028ff
New Mexico	95,871	53,401	53,401	53,821	118,255	54,265	127,284	54,499
New York	37,493	44,879	44,879	43,794	39,366	44,526	40,159	44,327
North Carolina	33,409	29,221	29,221	29,716	38,719	30,275	38,719	30,666
North Dakota	59,113	83,206	83,206	83,045	61,355	83,218	62,196	83,313
Ohio	64,609	115,548	115,548	116,153	68,843	117,093	70,152	117,523
Oklahoma	87,864	67,833	67,833	67,989	101,036	68,380	106,224	68,549
Oregon	40,596	73,129	73,129	73,343	47,302	73,707	49,920	73,932
Pennsylvania	30,344	37,377	37,377	37,397	32,157	37,819	32,698	37,764
Rhode Island	731	760	760	773	848	792	877	790
South Carolina	31,494	21,416	21,416	21,907	36,780	22,258	38,713	22,340
South Dakota	44,587	63,674	63,674	63,718	46,327	63,837	47,006	63,895
Tennessee	25,357	42,944	42,944	43,403	27,690	43,923	28,604	44,076
Texas	304,551	178,633	178,633	180,237	332,235	182,268	341,714	183,249
Utah	21,589	26,003	26,003	26,353	25,243	26,713	26,129	26,927
Vermont	7,563	3,211	3,211	3,234	7,680	3,280	7,707	3,292
Virginia	19,374	36,615	36,615	36,673	21,558	37,042	22,409	37,144
Washington	27,999	41,318	41,318	41,894	29,978	43,017	30,780	43,666
West Virginia	10,652	15,005	15,005	15,006	10,657	15,095	10,659	15,104
Wisconsin	41,669	89,454	89,454	89,694	43,969	90,167	44,811	90,457
Wyoming	45,350	29,029	29,029	29,010	55,682	29,173	59,691	29,285
Puerto Rico		1,305	1,305	1,305		1,363		1,370
Virgin Islands		464	464	464		470		470
Tribal Data	1,460	2,885	2,885	2,885	1,460	2,885	1,460	2,885

Figure 3. Gridded Annual PM2.5 for adjusted afdust

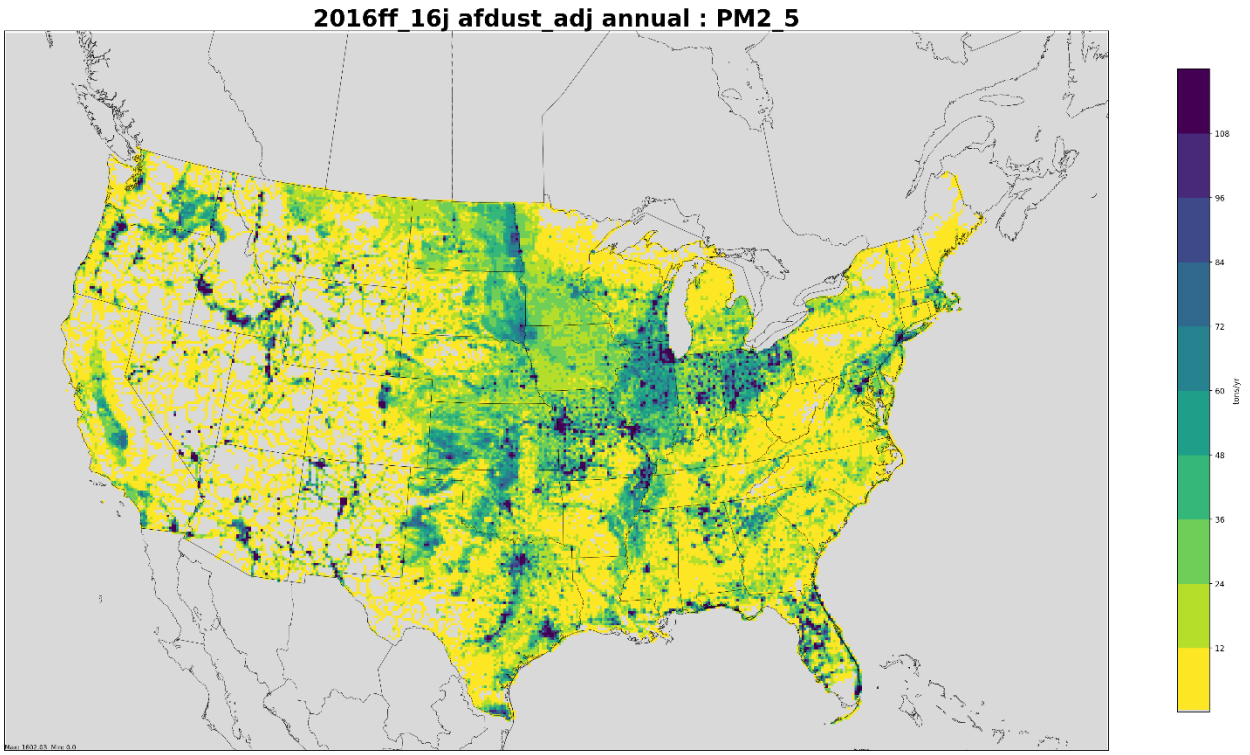


Figure 4. 2016 and 2023 PM10 Density for unadjusted afdust