March 11, 2019

SPECIFICATION SHEET: WILDFIRE AND PRESCRIBED BURN EMISSIONS

Description: Wildfire and prescribed burn source emissions (sector abbreviation is "ptfire") for simulating 2016 and future year U.S. air quality

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Contents

1. EXECUTIVE SUMMARY

The ptfire emissions inventory was developed using currently available fire emissions inventory tools along with year 2016 fire information databases from national, state, and tribal agencies. This document summarizes 1) the inventory tools, 2) the methodologies used to incorporate all fire information data available, 3) the supporting ancillary data and 4) provides emissions summaries. Base year inventories were processed with the Sparse Matrix Operator Kernel Emissions (SMOKE) modeling system version 4.6. 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

Wildfires and prescribed burns that occur during the inventory year are included in the year 2016 beta version as event and point sources. The agricultural fires (ptagfire) are described in a separate document. Estimated emissions from wildfires and prescribed burns are calculated from burned area data. Input data sets were collected from state/local/tribal (S/L/T) agencies and from national agencies and organizations. Raw burned area data compiled from S/L/T agencies and national data sources are organized and combined to produce a comprehensive burned area data set. Emissions are calculated using fire emission models that rely on burned area as well as fuel and weather information. The resulting emissions are then compiled by date and location.

For purposes of emission inventory preparation, wildland fire (WLF) is defined as "any non-structure fire that occurs in the wildland" (an area in which human activity and development are essentially non-existent, except for roads, railroads, power lines, and similar transportation facilities). Wildland fire activity is categorized by the conditions under which the fire occurs. These conditions influence important aspects of fire behavior, including smoke emissions. In the 2016 beta inventory, data processing is conducted differently depending on the fire type, as defined below:

- Wildfire (WF): "any fire started by an unplanned ignition caused by lightning; volcanoes; other acts of nature; unauthorized activity; or accidental, human-caused actions, or a prescribed fire that has developed into a wildfire."
- Prescribed (Rx) fire: "any fire intentionally ignited by management actions in accordance with applicable laws, policies, and regulations to meet specific land or resource management objectives." Prescribed fire is one type of fuels treatment. Fuels treatments are vegetation management activities intended to modify or reduce hazardous fuels. Fuels treatments include prescribed fires, wildland fire use, and mechanical treatment.

The SCC used and SCC descriptions for the ptfire sources are shown in Table 1 and include separate SCCs for the flaming and smoldering combustion phases for wildfire and prescribed burns. Also, note that prescribed grassland fires specifically for Flint Hills, Kansas have its own SCC in the 2016 beta inventory. The year 2016 fire season also included some major wild grassland fires. These wild grassland fires were assigned the standard Wildfire SCCs shown in Table 1.

Table 1. The SCCs included in the ptfire sector for the 2016 beta inventory

SCC	Description
2801500170	Grassland fires; prescribed
2810001001	Forest Wildfires; Smoldering; Residual smoldering only (includes grassland wildfires)
2810001002	Forest Wildfires; Flaming (includes grassland wildfires)
2811015001	Prescribed Forest Burning; Smoldering; Residual smoldering only
2811015002	Prescribed Forest Burning; Flaming

3. INVENTORY DEVELOPMENT METHODS

National Fire Information Data

Numerous fire information databases are available from U.S. national government agencies. Some of the databases are available via the internet while others must be obtained directly from agency staff. Table 2 provides the national fire information databases that were obtained and used in 2016beta inventory development.

Table 2. National fire information databases used in 2016beta ptfire inventory.

Dataset Name	Fire Types	Format	Agency	Coverage	Source
Hazard Mapping System (HMS)	WF/RX	CSV	NOAA	North America	https://www.ospo.noaa.gov/Products/land/hms.html
Geospatial Multi-Agency Coordination (GeoMAC)	WF	SHP	USGS	Entire US	https://rmgsc.cr.usgs.gov/outgoing/GeoMAC/
Incident Command System Form 209: Incident Status Summary (ICS-209)	WF/RX	CSV	Multi	Entire US	https://fam.nwcg.gov/ fam-web/
National Association of State Foresters (NASF)	WF	CSV	Multi	Participating US states	https://fam.nwcg.gov/ fam-web/
Monitoring Trends in Burn Severity (MTBS)	WF/RX	SHP	USGS, USFS	Entire US	https://www.mtbs.gov/direct-download

The Hazard Mapping System (HMS) was developed in 2001 by the National Oceanic and Atmospheric Administration's (NOAA) National Environmental Satellite and Data Information Service (NESDIS) as a tool to identify fires over North America in an operational environment. The system utilizes geostationary and polar orbiting environmental satellites. Automated fire detection algorithms are employed for each of the sensors. When possible, analysts apply

quality control procedures for the automated fire detections by eliminating those that are deemed to be false and adding hotspots that the algorithms have not detected via a thorough examination of the satellite imagery. The HMS product used in 2016 beta inventory development consisted of daily comma-delimited files containing fire detect information including latitude-longitude, satellite used, time detected, and other information. The Visible Infrared Imaging Radiometer Suite (VIIRS) satellite fire detects were introduced into the HMS in late 2016. Since it was only available for a small portion of the year, the VIIRS fire detects were removed for the entire year for consistency reasons. In the 2016alpha version, the grassland fire detects were put in the agricultural burn processing step. However, there were a few significant grassland wildfires in Kansas and Oklahoma in year 2016. Therefore, for the 2016beta version, all grassland fire detects were processed through SmartFire2 and BlueSky.

GeoMAC (Geospatial Multi-Agency Coordination) is an online wildfire mapping application designed for fire managers to access maps of current fire locations and perimeters in the United States. Historical 2016 wildfire perimeter shapefiles were downloaded from GeoMAC site (see Table 2). The wildfire perimeter data is based upon input from incident intelligence sources from multiple agencies, GPS data, and infrared (IR) imagery from fixed wing and satellite platforms.

The Incident Status Summary, also known as the "ICS-209" is used for reporting specific information on fire incidents of significance. The report is a critical interagency incident reporting tool giving daily 'snapshots' of the wildland fire management situation and individual incident information which include fire behavior, size, location, cost, and other information. The historical ICS-209 data is archived, and the year 2016 data was downloaded from site in Table 2. Data from two tables in the ICS-209 database were merged and used: the SIT209_HISTORY_INCIDENT_209_REPORTS table contained daily 209 data records for large fires, and the SIT209_HISTORY_INCIDENTS table contained summary data for additional smaller fires.

The National Association of State Foresters (NASF) is a non-profit organization composed of the directors of forestry agencies in the states, U.S. territories, and District of Columbia to manage and protect state and private forests, which encompass nearly two-thirds of the nation's forests. The NASF compiles fire incident reports from agencies in the organization and makes them publicly available. The year 2016 data was downloaded from the website shown in Table 2. The NASF fire information includes dates of fire activity, acres burned, and fire location information.

Monitoring Trends in Burn Severity (MTBS) is an interagency program whose goal is to consistently map the burn severity and extent of large fires across all lands of the United States from 1984 to present. This includes all fires 1000 acres or greater in the western United States and 500 acres or greater in the eastern Unites States. The extent of coverage includes the

continental U.S., Alaska, Hawaii and Puerto Rico. Fire occurrence and satellite data from various sources are compiled to create numerous MTBS fire products. The MTBS Burned Areas Boundaries Dataset shapefiles were downloaded. The shapefiles include year 2016 fires and the shapefiles are classified as either wildfires, prescribed burns or unknown fire types. The unknown fire type shapes were omitted in the 2016beta inventory development due to temporal and spatial problems found when trying to use these data.

State/Local/Tribal fire information

In June 2018, S/L/T agencies were invited by EPA and 2016 Fire Workgroup to submit all fire occurrence data for use in developing the 2016beta fire inventory. A template form containing the desired format for data submittals was provided. The list of S/L/Ts that submitted fire data is provided in Table 3. Overall, the 2016beta inventory development comprised of using data sets from 7 individual states and one Indian Nation.

Table 3. List of S/L/T agencies that submitted fire data for 2016beta with types and formats.

S/L/T name	Fire Types	Format
NCDENR	WF/RX	CSV
KSDAQ	RX/AG	CSV
CO Smoke Mgmt Program	RX	CSV
Idaho DEQ	AG	CSV
Nez Perce Tribe	AG	CSV
GA DNR	ALL	EIS
MN	RX/AG	CSV
WA ECY	AG	CSV

The data provided by S/L/Ts were evaluated by EPA and further feedback from agencies was requested at times. Table 4 provides a summary of the type of data submitted by each agency which includes spatial, temporal, acres burned and other information.

Table 4. Brief description of fire information submitted for 2016beta inventory use.

S/L/T name	Fire Types	Description
NCDENR	WF/RX	Fire type, period-specific, latitude-longitude and acres burned information. Technical direction was to totally replace all wildfire and prescribed fires in 2016alpha in NC with these submitted data for WF and Rx fires.
KSDAQ	RX/AG	Day-specific, county-centroid located, acres burned for Flint Hills prescribed burns for Feb 27-May 4 time period. Also reclassified fuels for some agricultural burns.
CO Smoke Mgmt Program	RX	Day-specific, latitude-longitude, and acres burned for prescribed burns

S/L/T name	Fire Types	Description
Idaho DEQ	AG	Day-specific, latitude-longitude, acres burned for agricultural burns. Total replacement of 2016 alpha fires for Idaho.
Nez Perce Tribe	AG	Day-specific, latitude-longitude, acres burned for agricultural burns. Total replacement of 2016 alpha fires for this tribal region.
GA DNR	ALL	Data submitted included all fires types via EIS. The wildfire and prescribed burn data were provided as daily, point emissions sources. The agricultural burns were provided as annual, non-point emissions sources.
MN	RX/AG	Corrected latitude-longitude, day-specific and acres burned for some prescribed and agricultural burns.
WA ECY	AG	Month-specific, latitude-longitude, acres burned, fuel loading and emissions for agricultural burns. Not day-specific so allocation to daily implemented by EPA. Also note WA state direction included to continue to use the 2014NEIv2 pile burns that were included in the non-point sector for 2016 beta.

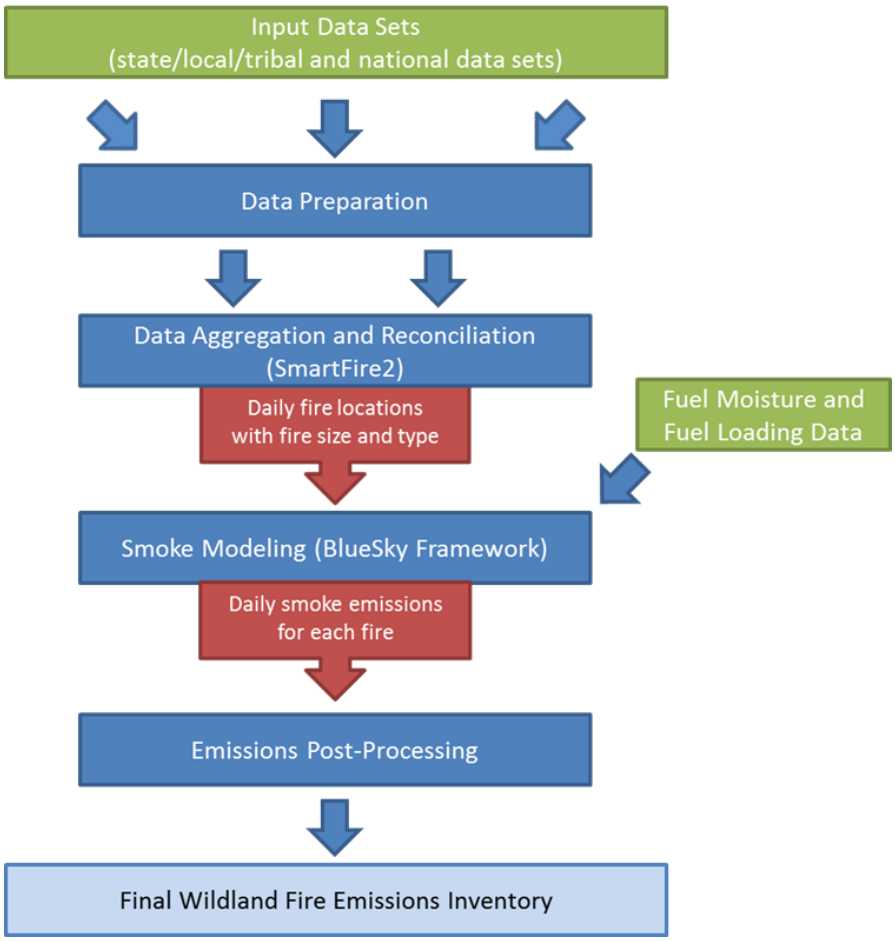
Emissions Estimation Methodology

Preparation of the 2016beta wildfire and prescribed burn emissions begins with the national and S/L/T data mentioned earlier and ends with daily estimates of emissions from flaming combustion and smoldering combustion phases. Flaming combustion is combustion that occurs with a flame. Flaming combustion is more complete combustion and is more prevalent with fuels that have a high surface-to-volume ratio, a low bulk density, and low moisture content. Smoldering combustion is combustion that occurs without a flame. Smoldering combustion is less complete and produces some pollutants, such as PM2.5, VOCs, and CO at higher rates than flaming combustion. Smoldering combustion is more prevalent with fuels that have low surface–to-volume ratios, high bulk density, and high moisture content. Models sometimes differentiate between smoldering emissions that are lofted with a smoke plume and those that remain near the ground (residual emissions), but for the purposes of the 2016 beta inventory the residual smoldering emissions were allocated to the smoldering SCCs mentioned in Table 1. The lofted smoldering emissions were allocated along with the flaming emissions to the flaming emissions SCCs in Table 1.

Figure 1 shows the processing stream for the 2016beta inventory for wildfire and prescribe burn sources. The emissions estimate methodology consists of two tools or systems. The first system is called Satellite Mapping Automated Reanalysis Tool for Fire Incident Reconciliation version 2 (SMARTFIRE2). SMARTFIRE2 is an algorithm and database system that operate within a geographic information system (GIS) framework. SMARTFIRE combines multiple sources of fire information and reconciles them into a unified GIS database. It reconciles fire data from space-borne sensors and ground-based reports, thus drawing on the strengths of both data

types while avoiding double-counting. At its core, SMARTFIRE2 is an association engine that links reports covering the same fire in any number of multiple databases. In this process, all input information is preserved, and no attempt is made to reconcile conflicting or potentially contradictory information (for example, the existence of a fire in one database but not another). In the 2016beta inventory case, the national and S/L/T fire information is input into SMARTFIRE2 and then all information is merged and associated together based on user-defined weights for each fire information dataset. The output from SMARTFIRE2 is daily acres burned and latitude-longitude coordinates for each fire.

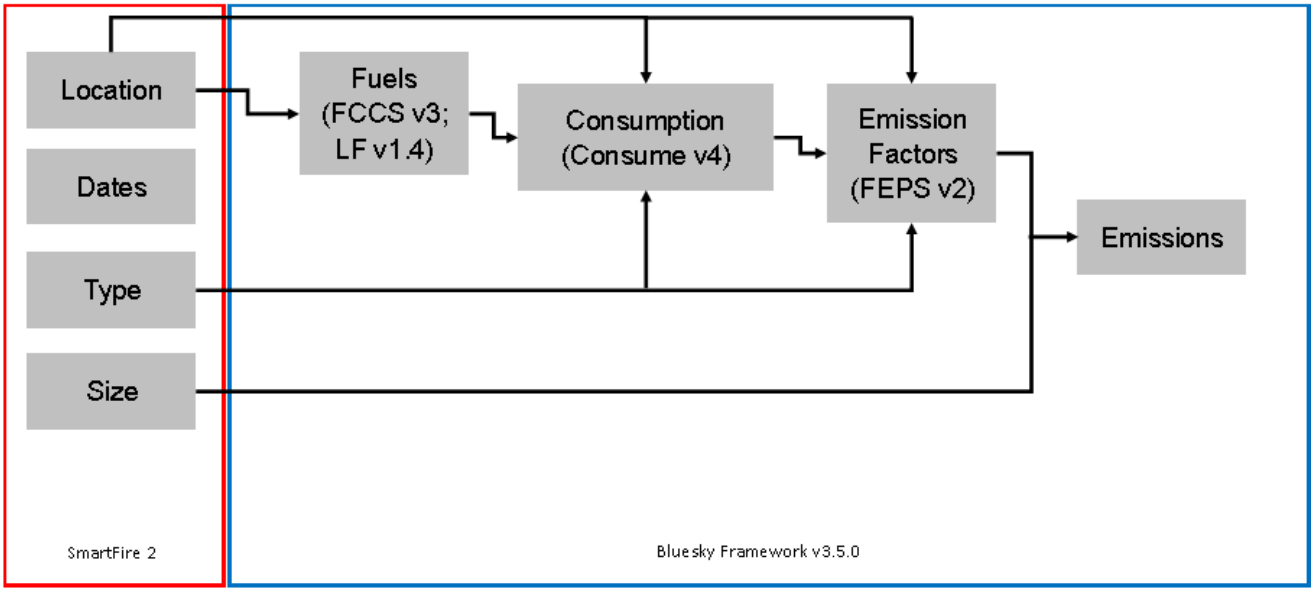
Figure 1. Processing flow for fire emission estimates in the 2016beta inventory



The second system used to estimate emissions is the BlueSky Modeling Framework version 3.5 (revision #38169). The framework supports the calculation of fuel loading and consumption, and emissions using various models depending on the available inputs as well as the desired results. The contiguous United States and Alaska, where Fuel Characteristic Classification System (FCCS) fuel loading data are available, were processed using the modeling chain described in Figure 2. The Fire Emissions Production Simulator (FEPS) in the Bluesky Framework

generates all the CAP emission factors for wildland fires used in the 2016beta inventory (need note about HAPS factors).

Figure 2. Blue Sky Modeling Framework



For the 2016beta inventory, the FCCSv2 was upgraded to the LANDFIRE v1.4 fuel bed information (See: https://www.landfire.gov/fccs.php). The FCCSv3 module was implemented along with the LANDFIREv1.4 (at 200 meter resolution) to provide better fuel bed information for the BlueSky Framework. The LANDFIREv1.4 was aggregated from the native resolution and projection to 200 meter using a nearest-neighbor methodology. Aggregation and reprojection was required for the proper function on BSF.

4. Ancillary Data

Temporal Allocation

The output from the BlueSky Framework are daily emissions totals for various pollutants. The standard air quality models used by the community for air quality research and regulatory use require emissions at an hourly time scale. SMOKE version 4.6 was used to import the daily inventory files. The Temporal program within SMOKE was used to apply available diurnal profiles to generate the required hourly emissions. Figures 3 and 4 display the state-specific diurnal profiles for wildfires and prescribed burns that were used for 2016beta processing.

Figure 3. State-specific diurnal profiles for wildfires

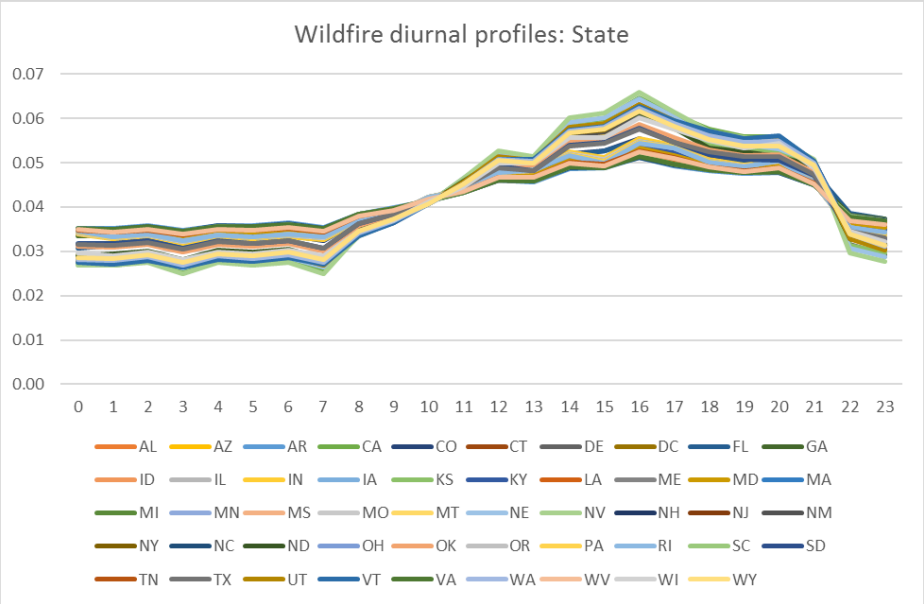
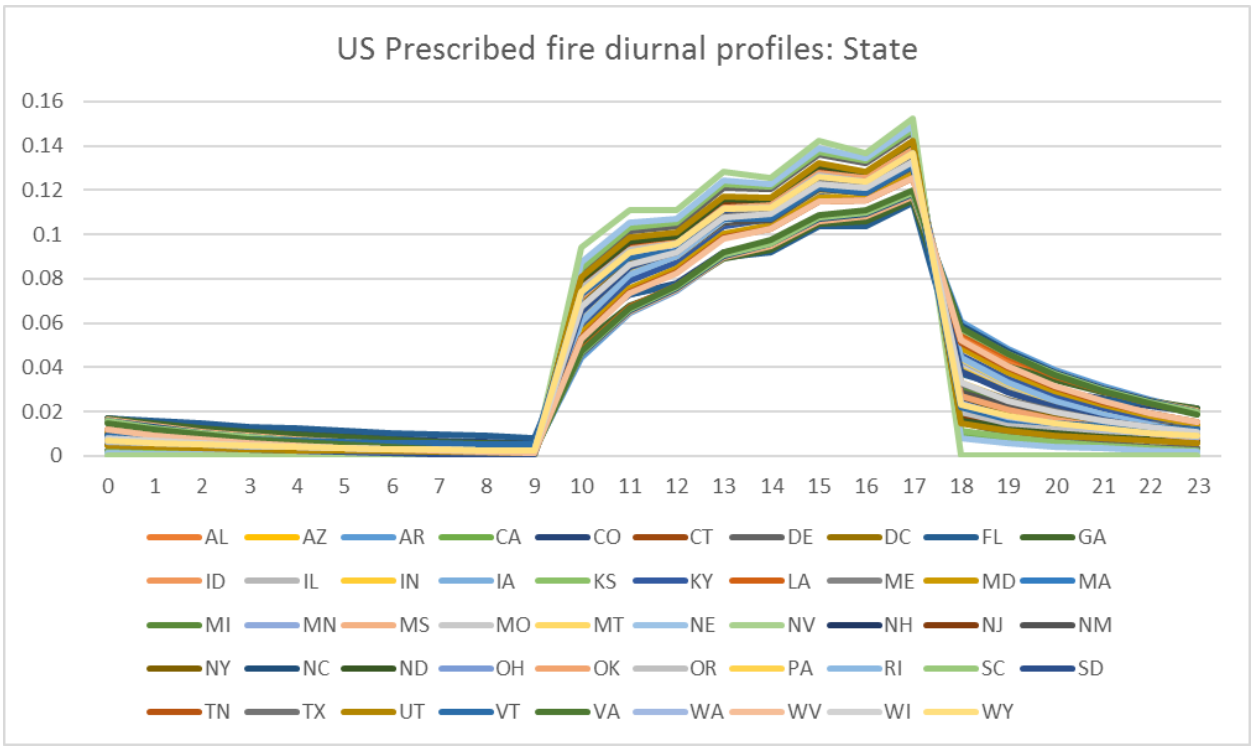


Figure 4. State-specific diurnal profiles for prescribed burns



Chemical Speciation

Chemical speciation is another emissions modeling step taken to support the desired chemical mechanism for an air quality model simulation. SMOKE was used to support Carbon Bond version 6 (CB6) speciation for the 2016beta inventory. Figures 5 and 6 display the speciation profiles applied for wildfires and prescribed burns for Total Organic Gases (TOG) emissions. Figure 7 displays the speciation profiles for wildfire and prescribed burns for PM2.5 emissions.

Figure 5. Total Organic Gases (TOG) speciation profiles for wildfires and map where profile applied for 2016beta

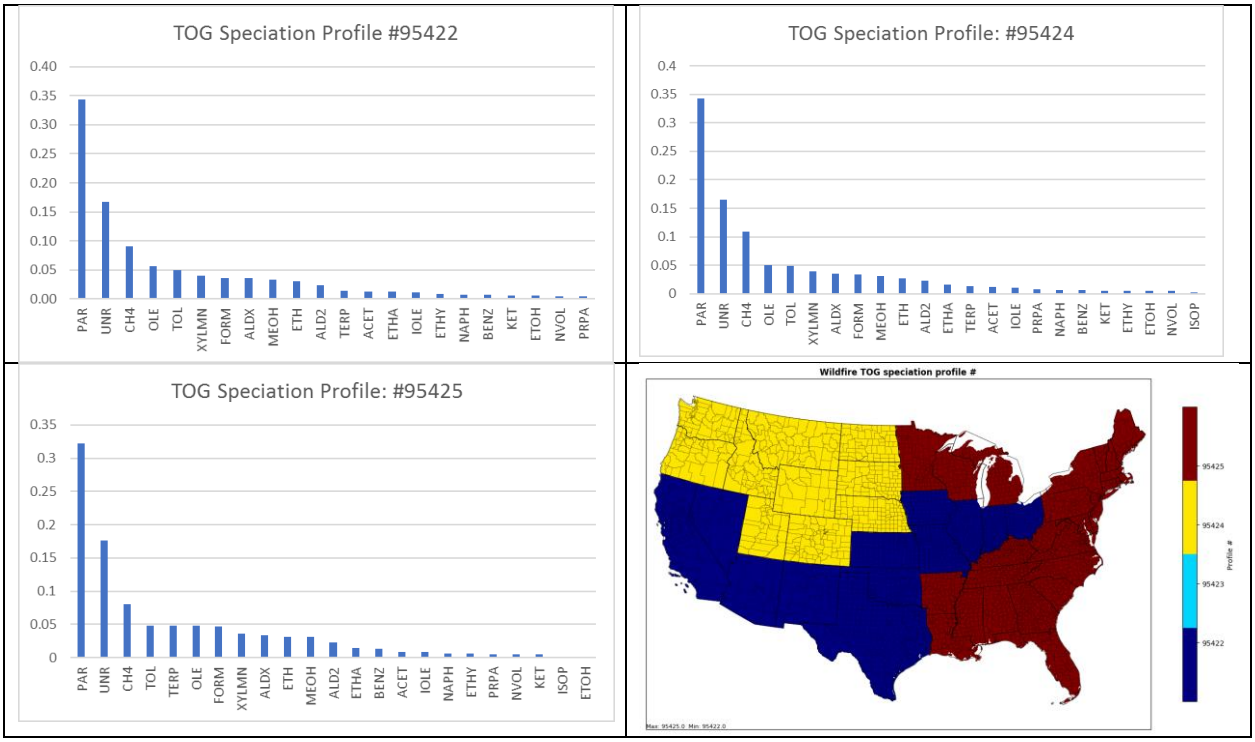


Figure 6. Total Organic Gases (TOG) speciation profiles for prescribed burns and map where profile applied for 2016beta

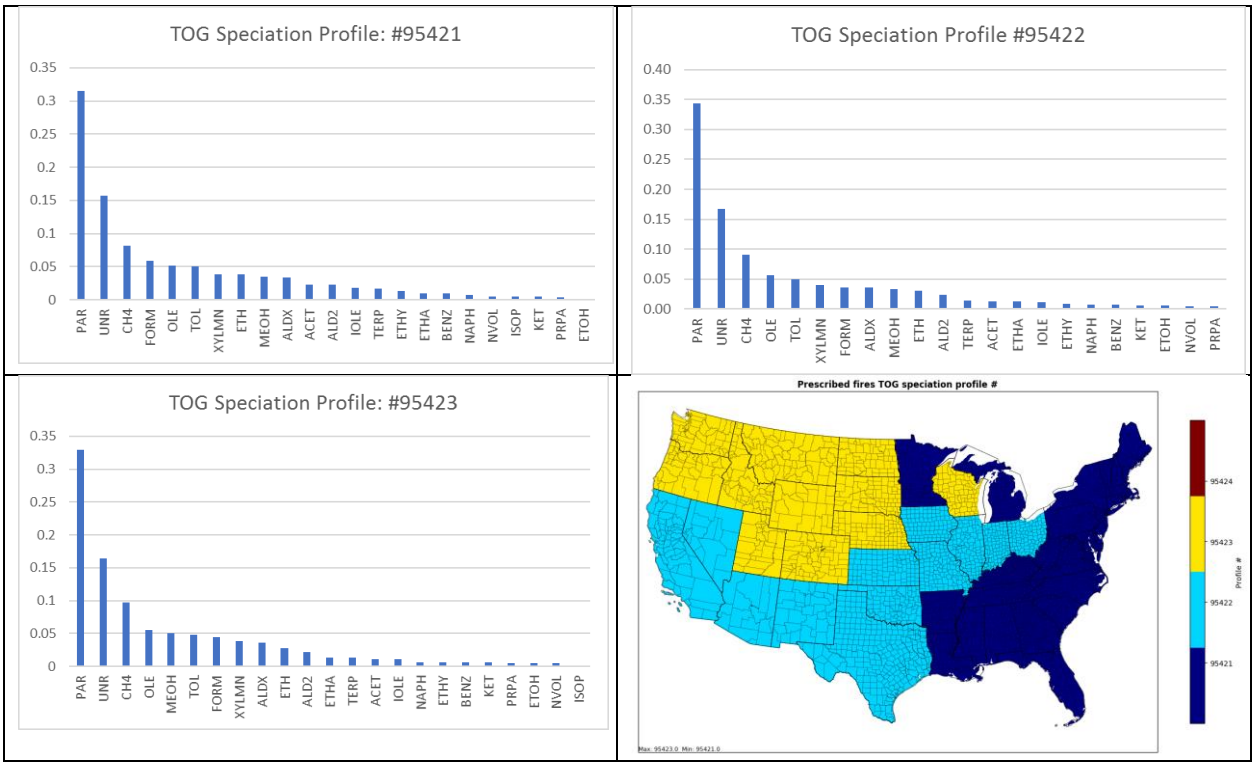
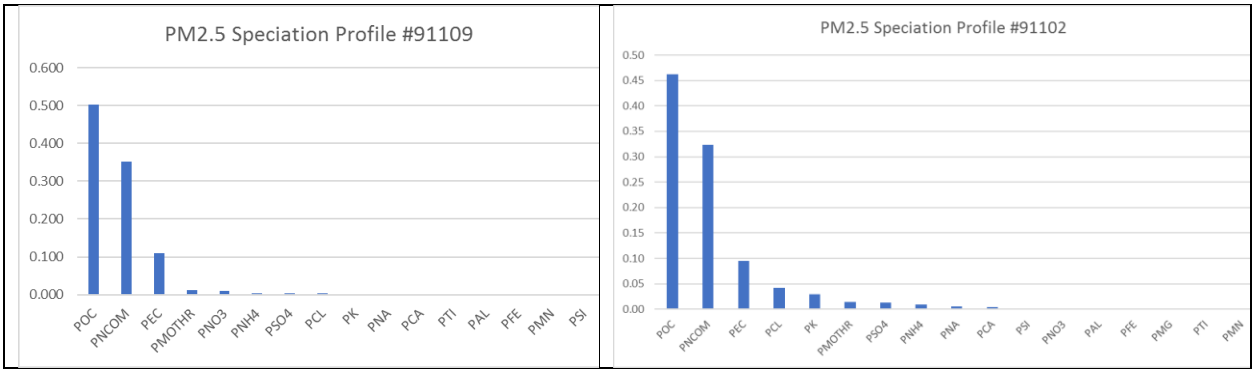


Figure 7. PM2.5 speciation profiles for prescribed burns (left) and wildfires (right) applied 2016beta



5. Emissions Projection Methods

There are no future-year projections for fires in 2016 beta modeling platform.

6. EMISSIONS PROCESSING REQUIREMENTS

The emissions are processed using SMOKE v4.6[1]. Vertical allocation of the fire emissions is usually performed by a plume rise algorithm either in the air quality model (e.g. CMAQ) or outside the air quality model (e.g. using SMOKE). SMOKE has a specific plume-rise calculation for fires.[2] Whichever option is used for plume-rise/vertical allocation, it is recommended that the smoldering emissions from wildfires and prescribed burns be put into the first layer in the in the air quality model (typically 20 or 40 meters high depending on layer profile).

7. EMISSIONS SUMMARIES

National and state totals by pollutant for the beta platform cases are provided here. Plots and maps are available online through the LADCO website[3] and the Intermountain West Data Warehouse[4].

The case descriptions 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

2016ff = 2016 beta platform

Table 5. Comparison of national total annual CAPS ptfire emissions (tons/yr)

Pollutant	2011en, 2023en, 2028el	2014fd	2016fe	2016ff
CO	22,802,146	19,144,792	37,929,946	20,635,054
NH3	365,813	308,886	621,059	352,471
NOX	352,996	271,366	441,873	287,252
PM10	2,389,921	1,963,429	3,790,993	2,072,874
PM2.5	2,028,892	1,665,175	3,212,706	1,749,920
SO2	179,118	143,091	261,903	152,735
VOC	5,213,612	4,440,901	8,927,717	4,731,912

Table 6. Comparison of state total annual NOx ptfire emissions (tons/yr)

Pollutant	2011en, 2023en, 2028el	2014fd	2016fe	2016ff
Alabama	14,551	16,472	16,397	7,751
Alaska	19,093	17,930	108,762	54,958
Arizona	21,311	4,842	5,287	5,218

[1] see https://www.cmascenter.org/smoke/documentation/4.6/html/

[2] https://www.cmascenter.org/smoke/documentation/4.6/html/ch06s06.html

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

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

Pollutant	2011en, 2023en, 2028el	2014fd	2016fe	2016ff
Arkansas	10,967	8,072	17,018	11,865
California	12,127	37,036	35,009	21,441
Colorado	4,701	975	1,888	5,898
Connecticut	12	17	21	43
Delaware	22	38	37	20
Florida	21,279	23,665	15,750	6,861
Georgia	38,888	15,668	21,066	15,245
Hawaii	487	6,153		
Idaho	8,046	7,870	15,689	12,318
Illinois	1,004	1,997	3,513	1,229
Indiana	430	925	1,512	562
Iowa	1,349	2,745	4,793	1,493
Kansas	23,338	6,030	8,575	21,443
Kentucky	3,018	5,044	8,943	6,516
Louisiana	12,050	9,732	15,269	5,769
Maine	46	63	171	92
Maryland	293	298	213	85
Massachusetts	59	57	131	124
Michigan	442	487	794	597
Minnesota	9,850	4,015	10,200	2,341
Mississippi	6,791	6,156	6,901	4,501
Missouri	7,457	9,393	19,038	11,686
Montana	9,775	3,426	5,699	4,091
Nebraska	2,529	1,648	972	1,355
Nevada	1,671	1,552	1,427	1,873
New Hampshire	9	12	65	58
New Jersey	143	765	488	209
New Mexico	14,567	1,447	3,226	2,541
New York	117	207	546	576
North Carolina	3,466	2,212	12,711	5,940
North Dakota	2,344	1,859	2,387	1,704
Ohio	165	621	1,051	469
Oklahoma	20,193	8,454	17,035	17,477
Oregon	14,222	18,828	14,233	8,384
Pennsylvania	295	538	1,766	902
Rhode Island	15	4	14	3
South Carolina	4,011	4,856	4,992	2,782
South Dakota	3,777	2,199	3,542	3,784
Tennessee	2,429	3,570	9,655	6,445
Texas	38,843	8,737	15,187	10,312
Utah	1,007	1,175	2,714	1,467
Vermont	8	20	60	38
Virginia	2,890	2,988	4,838	2,973
Washington	3,037	16,461	7,600	5,833
West Virginia	1,268	1,965	3,272	2,020

Pollutant	2011en, 2023en, 2028el	2014fd	2016fe	2016ff
Wisconsin	566	857	1,366	698
Wyoming	8,019	872	10,052	7,262
Puerto Rico	18	414		

Table 7. Comparison of state total annual Primary PM2.5 ptfire emissions (tons/yr)

Pollutant	2011en, 2023en, 2028el	2014fd	2016fe	2016ff
Alabama	61,573	69,117	68,796	35,443
Alaska	183,808	171,533	1,166,514	499,002
Arizona	128,329	26,939	31,071	33,601
Arkansas	64,964	48,493	89,777	62,800
California	79,353	295,438	252,595	133,588
Colorado	32,261	6,312	13,544	40,866
Connecticut	50	68	91	244
Delaware	105	160	157	125
Florida	88,968	97,306	70,126	33,950
Georgia	132,861	56,283	89,526	
Hawaii	801	11,150		
Idaho	61,683	54,357	107,288	88,352
Illinois	5,561	9,901	16,002	7,074
Indiana	2,275	5,306	7,255	3,302
Iowa	6,833	12,396	20,730	8,984
Kansas	84,235	24,405	33,440	100,330
Kentucky	15,976	30,106	54,026	32,176
Louisiana	105,165	86,691	163,097	40,240
Maine	367	477	1,465	664
Maryland	2,604	2,836	1,368	500
Massachusetts	413	284	740	731
Michigan	2,694	2,710	5,294	4,265
Minnesota	68,168	22,630	111,109	20,267
Mississippi	29,805	26,913	31,663	21,168
Missouri	53,610	63,143	99,238	61,471
Montana	84,736	27,392	40,803	28,762
Nebraska	10,771	7,530	4,622	7,036
Nevada	7,124	9,466	7,247	10,072
New Hampshire	47	56	480	363
New Jersey	1,416	7,327	4,974	1,473
New Mexico	84,896	9,005	15,663	14,666
New York	664	1,207	2,911	3,768
North Carolina	11,744	13,881	86,614	35,156
North Dakota	14,241	9,870	10,637	10,340
Ohio	876	3,511	5,390	2,594
Oklahoma	93,067	41,022	79,147	82,032
Oregon	121,632	135,074	121,253	68,312
Pennsylvania	1,867	3,338	11,068	5,639

Pollutant	2011en, 2023en, 2028el	2014fd	2016fe	2016ff
Rhode Island	64	16	53	20
South Carolina	18,263	22,180	25,104	14,527
South Dakota	32,403	15,265	30,067	25,069
Tennessee	11,280	16,576	46,767	30,217
Texas	194,224	50,670	86,943	48,471
Utah	6,758	6,486	16,916	9,066
Vermont	55	112	407	251
Virginia	14,698	16,682	27,002	15,262
Washington	22,503	119,131	53,858	41,750
West Virginia	7,495	12,676	19,588	10,524
Wisconsin	3,179	4,314	7,129	4,237
Wyoming	72,405	6,863	73,151	51,167
Puerto Rico	19	576		

Table 8. Comparison of state total annual VOC ptfire emissions (tons/yr)

Pollutant	2011en, 2023en, 2028el	2014fd	2016fe	2016ff
Alabama	158,720	177,887	177,057	92,637
Alaska	523,379	488,198	3,346,808	1,414,503
Arizona	349,159	72,545	84,280	92,157
Arkansas	176,392	131,900	239,971	167,944
California	218,043	828,310	701,387	364,981
Colorado	89,113	17,325	37,587	112,997
Connecticut	128	172	235	659
Delaware	183	413	404	344
Florida	228,822	249,469	182,442	89,883
Georgia	74,976	31,010	230,961	29,964
Hawaii	2,062	29,665		
Idaho	172,302	150,248	296,242	245,181
Illinois	14,966	26,219	41,798	19,136
Indiana	6,082	14,346	19,116	8,957
Iowa	18,156	32,332	53,655	24,440
Kansas	210,152	62,376	84,830	166,148
Kentucky	42,725	81,822	147,052	85,156
Louisiana	297,155	245,363	467,811	111,344
Maine	1,029	1,330	4,135	1,845
Maryland	7,370	8,069	3,751	1,356
Massachusetts	1,145	754	1,997	1,986
Michigan	7,342	7,297	14,578	11,831
Minnesota	188,466	61,048	319,104	57,230
Mississippi	77,346	69,792	82,802	55,589
Missouri	148,807	174,023	264,801	164,243

Pollutant	2011en, 2023en, 2028el	2014fd	2016fe	2016ff
Montana	239,299	76,815	113,208	79,651
Nebraska	27,798	19,676	12,160	18,764
Nevada	18,389	25,796	19,264	26,995
New Hampshire	125	148	1,336	992
New Jersey	4,040	20,854	14,222	4,079
New Mexico	230,032	24,600	41,344	39,687
New York	1,792	3,269	7,795	10,353
North Carolina	6,671	37,957	239,063	95,446
North Dakota	38,791	26,408	27,678	28,161
Ohio	2,343	9,475	14,346	6,981
Oklahoma	243,573	108,272	207,421	215,346
Oregon	343,104	374,844	341,923	191,890
Pennsylvania	5,109	9,114	30,261	15,414
Rhode Island	164	42	134	55
South Carolina	47,699	57,959	66,628	38,772
South Dakota	91,426	42,217	84,761	68,980
Tennessee	29,559	43,436	123,401	79,310
Texas	515,030	137,205	235,031	127,274
Utah	18,622	17,449	46,219	24,747
Vermont	151	303	1,124	691
Virginia	39,077	44,946	72,746	40,630
Washington	62,651	330,883	149,273	115,833
West Virginia	20,346	34,773	53,255	28,081
Wisconsin	8,571	11,452	19,025	11,540
Wyoming	205,153	19,216	203,297	141,729
Puerto Rico	76	1,878		

Table 9. National acres burned and emissions (tons) by fire type for 2016alpha and 2016beta

	RX	RX	WF	WF	WF+RX	WF+RX
Variable	**2016alpha**	**2016beta**	**2016alpha**	**2016beta**	**2016alpha**	**2016beta**
ACRESBURNED	15,458,815	11,383,754	5,584,866	5,614,599	21,043,681	16,998,353
CO	15,148,093	6,972,293	22,781,853	13,662,574	37,929,946	20,634,867
NH3	248,964	128,768	372,095	223,700	621,059	352,468
NOX	224,424	121,770	217,449	165,478	441,873	287,248
PM2_5	1,319,351	641,780	1,893,355	1,162,546	3,212,706	1,804,326
SO2	119,260	56,540	142,643	96,194	261,903	152,733
VOC	3,578,854	1516,921	5,348,863	3,214,946	8,927,717	4,731,867