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Project Summary

Status Report on the Development of the NAPAP Emission Inventory for the 1980 Base Year and Summary of Preliminary Data

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The report documents the compilation of a 1980 emissions inventory for use in the National Acid Precipitation Assessment Program (NAPAP). The current inventory (Version 3.0) contains point source data for over 50,000 plants (with over 201,000 emission points) and area source data for the 3,069 counties in the 48 contiguous states and the District of Columbia. Emissions of SO_2, NO_x, VOC, CO, and particulates are included in the inventory, but the report focuses on SO_2, NO_x, and VOC which are of primary interest for acid deposition research. NAPAP Version 3.0 emissions of SO_2, NO_x, and VOC are 27.1, 23.7, and 23.3 million tons per year, respectively. Summaries of emissions by source category, geographic region, state, fuel type, season, and stack height range are presented along with emission density maps and fuel use summaries. Emissions in the NAPAP data base are in reasonable agreement with Work Group 3B and EPA/OAQPS emissions trends estimates. NAPAP fuel use data show reasonable agreement with fuel values in DOE's State Energy Data Report. Version 3.0 of NAPAP represents a detailed inventory of emissions on a national scale; however, it should be noted that additional improvements are planned.

The full report is an initial version of the 1980 NAPAP emissions inventory. While it describes the methods used to compile the 1980 NAPAP emissions inventory and gives preliminary results from applying those methods, several improvements to the methods and data used are currently in process. Other changes can be anticipated as the need or opportunity for changes is identified. Thus, it is important to emphasize the less-than-final nature of this report and the many numbers it contains. The report is being circulated to facilitate the critique process, not because it is a completed document suitable for uncritical use. Any use outside of these bounds should be considered with the utmost caution.

This project was administered by the USEPA, with funding from NAPAP's Task Group B—Man-Made Sources. The report has been reviewed and approved for publication consistent with the above conditions by appropriate EPA and NAPAP personnel.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

A detailed 1980 base year emission inventory has been developed by Task

Group B of the Interagency Task Force on Acid Precipitation to support the needs of the National Acid Precipitation Assessment Program (NAPAP). This report summarizes the current version (3.0) of the NAPAP inventory.

Development History of Version 3.0

The NAPAP data were developed starting with information from EPA's National Emissions Data System (NEDS). These data have been improved by incorporating the latest available emission factors, substitution of data from the Northeast Corridor Regional Modeling Project and other more representative of 1980 NEDS data, cross-checking the electric utility data with DOE's data compiled by E. H. Pechan and Associates, cross-checking data with information from the U.S./Canada Work Group 3B report, and adding county centroid latitude and longitude for sources with missing or incorrect Universal Transverse Mercator (UTM) coordinates. The NAPAP data are stored in the Emission Inventory System (EIS) format on EPA's IBM computer at Research Triangle Park, NC. The data consist of point source data for 50,200 establishments (with over 201,000 emission points) and area source data for each of 3,069 counties included in the 48 contiguous states of the U.S. and the District of Columbia. Currently, NAPAP reports emissions of SO_2, NO_x, VOC, particulates, and CO. It is planned to add sulfates, ammonia, and other pollutants in the future. This report focuses on emissions of SO_2, NO_x, and VOC which are of primary interest for acid deposition research.

Emissions Summary and Comparison

Tables 1-7 summarize national emissions of SO_2, NO_x, and VOC from Version 3.0 of NAPAP. Regional totals of emissions and state totals of point and area source emissions are also shown. More detailed emissions summary information is given in report Chapter 2, including emissions by state, emissions by season and stack height ranges, and emission density maps.

The SO_2 emissions are dominated by electric utilities, primarily from coal-fired generating stations in the eastern U.S. Other significant source sectors include industrial combustion (again, mostly from coal), non-ferrous smelters (primarily copper smelters in the southwestern U.S.), and other industrial processes (largely petroleum refining, chemicals, cement plants, and pulp mills). For NO_x, the largest sources are transportation (mostly highway vehicles), electric utilities, and industrial combustion. Electric utility emissions result primarily from coal combustion, but a significant portion also results from natural gas combustion. For industrial sources, the largest portion of NO_x emissions comes from natural gas combustion. For VOC, emissions result largely from transportation (again, primarily highway vehicles), other industrial processes, and miscellaneous sources. Principal industrial process sectors include chemicals, petroleum refining, petroleum transportation and storage, and a wide variety of activities involving organic solvent consumption. Miscellaneous sources include additional organic solvent use not accounted for by point sources in NAPAP, retail gasoline service stations, and forest wildfires.

The geographic breakdown of SO_2 emissions shows that EPA Regions 4 and 5 are the largest contributors, accounting for about 53% of the national total. Region 3 also has significant emissions, with a 14% contribution. The eastern 31 states account for over 82% of nationwide emissions. For NO_x, Regions 4, 5, and 6 are the highest emitters, with 60% of the national total. Region 3 is again next, with 10% of total emissions. Although not as great a contribution as for SO_2, the eastern 31 states still account for about 64% of national emissions. Regions 4, 5, and 6 are also responsible for the greatest amount of VOC emissions, with 54% of the national total. The eastern 31 states account for 66% of the nation's emissions, which is about the same as for NO_x. Thus, emissions of all three pollutants are concentrated in the east, especially those of SO_2. Substantial variability in SO_2 emissions exists between regions, with less difference for NO_x and even less for VOC.

The relative importance of point versus area source emissions varies for each of the three pollutants. Point sources contribute about 92% of national SO_2 emissions. For NO_x, emissions are nearly evenly distributed, with area sources contributing 51%. Area sources, on the other hand, emit about 79% of total VOC emissions. Ohio, Pennsylvania, and Indiana have the greatest SO_2 emissions. Texas, California, and Ohio are the greatest NO_x emitters, while Texas and California have the greatest VOC emissions. The relative contribution of point versus area sources varies from state to state.

Seasonal variations were derived from operating data in the point source inventory and seasonal factors added to the area source file. Power plant operating data were updated based on monthly fuel use data reported on FPC Form 4. Seasonal variations are less than expected. For SO_2, the maximum variation is 3% (24 to 27%). Emissions are greatest in winter, lowest in spring, and differ by 11.9%. The maximum variation for NO_x is only 2% (24 to 26%). Emissions are again greatest in winter and lowest in spring, with only a 6.3% difference. The maximum variation for VOC is the same as for NO_x (24 to 26%), with an 8.0% difference between the highest season (summer) and the lowest (winter).

Although effective plume height is of greatest interest to modelers, only stack height data are included in NAPAP. Thus, only emissions by stack height range

Table 1. *NAPAP Emissions by Source Category[a] (Preliminary Data)*

	SO_2	NO_x	VOC
Electric Utilities	17.3	8 1	0.1
Industrial Combustion	3.7	4.5	1.0
Residential/Commerical Combustion	0.9	0.7	0.1
Non-ferrous Smelters	1.2	Neg	Neg
Other Industrial Processes	3.0	1.0	4 5
Transportation	0.9	9.1	8.0
Miscellaneous	0.1	0.3	9.6
Total	27.1	23.7	23 3

[a] 10^6 tons/year.

Table 2. *NAPAP Emissions by Region[a,b] (Preliminary Data)*

	SO_2	NO_x	VOC
EPA Region 1	0.7	0.6	1 2
EPA Region 2	1 2	1.2	1.8
EPA Region 3	3.8	2.3	2 1
EPA Region 4	6 5	4 1	4.0
EPA Region 5	7.9	4 8	4 5
EPA Region 6	2 3	5.3	4.0
EPA Region 7	2.0	1.8	1 4
EPA Region 8	0 8	1 2	0.9
EPA Region 9	1.5	1.7	2.4
EPA Region 10	0.4	0.7	1.0
31 Eastern States[c]	22 3	15 1	15.3
Nation	27.1	23.7	23.3

[a] Includes Continental U.S. only.
[b] 10^6 tons/year.
[c] Includes tier of states from Minnesota south to Louisiana and all states east.

Table 3. *National Summary of NAPAP Emissions by State[a] (Preliminary Data)*

State	SO_2 Point	SO_2 Area	SO_2 Total	NO_x Point	NO_x Area	NO_x Total	VOC Point	VOC Area	VOC Total
AL	774	76	850	273	252	525	73	351	424
AZ	824	20	844	141	153	294	13	228	241
AR	59	30	89	65	167	232	14	230	244
CA	416	118	534	455	868	1,323	417	1,691	2,108
CO	114	20	134	137	155	292	21	300	321
CT	51	18	69	41	103	144	44	259	303
DE	105	22	127	36	33	69	26	48	74
DC	11	6	17	5	22	27	1	43	44
FL	1,124	78	1,202	246	383	629	23	725	748
GA	847	30	877	279	308	587	28	495	523
ID	36	20	56	9	82	91	6	205	211
IL	1,360	99	1,459	655	462	1,117	208	768	976
IN	1,746	134	1,880	536	324	860	117	472	589
IA	366	24	390	167	182	349	31	241	272
KS	198	33	231	302	290	592	81	241	322
KY	1,113	45	1,158	373	231	604	125	280	405
LA	343	158	501	568	253	821	322	299	621
ME	122	12	134	21	43	64	20	73	93
MD	273	23	296	114	164	278	76	270	346
MA	317	45	362	88	184	272	108	444	552
MI	844	34	878	378	368	746	238	730	968
MN	242	21	263	229	227	456	63	360	423
MS	256	50	306	99	196	295	52	234	286
MO	1,236	61	1,297	349	258	607	177	429	606
MT	146	22	168	28	102	130	12	203	215
NE	65	12	77	92	118	210	46	119	165
NV	140	7	147	76	47	123	4	73	77
NH	102	5	107	30	30	60	20	69	89
NJ	234	69	303	160	274	434	155	562	717
NM	247	11	258	224	83	307	52	109	161
NY	787	77	864	321	427	748	143	988	1,131
NC	621	32	653	302	268	570	108	465	573
ND	95	19	114	103	65	168	2	46	48
OH	2,655	50	2,705	665	554	1,219	165	914	1,079
OK	86	16	102	177	285	462	72	297	369
OR	31	25	56	53	175	228	40	279	319
PA	1,770	82	1,852	595	487	1,082	240	802	1,042
RI	10	4	14	6	30	36	13	84	97
SC	324	18	342	154	148	302	228	259	487
SD	34	7	41	22	55	77	3	88	91
TN	1,103	31	1,134	336	237	573	157	353	510
TX	1,081	260	1,341	1,543	1,943	3,486	940	1,710	2,650
UT	89	27	116	80	95	175	11	134	145
VT	3	7	10	1	43	44	4	36	40
VA	338	48	386	160	251	411	105	358	463
WA	280	46	326	131	219	350	48	373	421
WV	1,091	13	1,104	352	121	473	14	124	138
WI	668	20	688	205	221	426	76	372	448
WY	224	25	249	184	115	299	20	74	94
Totals	25,001	2,110	27,111	11,566	12,101	23,667	4,962	18,307	23,269

[a] 10^3 tons/year.

Table 4. *NAPAP Emissions by Season[a] (Preliminary Data)*

	SO_2	NO_x	VOC
Winter	27	26	24
Spring	24	24	25
Summer	25	25	26
Fall	24	25	25
Total (10^6 tons/year)	27.1	23.7	23.3

[a]Percent of total.

Table 5. *NAPAP Emissions by Stack Height Range[a] (Preliminary Data)*

Range (ft)	SO_2	NO_x	VOC
0-120	20	34	94
121-240	15	17	5
241-480	22	20	1
>480	43	29	0
Total (10^6 tons/year)	25.0	11.6	5.0

[a]Percent of total.

Table 6. *NAPAP County Emission Density Summary (Preliminary Data)*

	SO_2		NO_x		VOC	
Density Range (tons/mi²)	Counties in Range (%)	Emissions in Range (%)	Counties in Range (%)	Emissions in Range (%)	Counties in Range (%)	Emissions in Range (%)
0-10	84	10	78	24	78	27
10-30	6	11	12	19	14	20
30-100	6	25	7	30	6	24
100-1000	4	51	3	27	2	27
>1000	0	3	0	0	0	2

Table 7. *Comparison of NAPAP, Trends, and Work Group 3B Emissions of SO_2 and NO_x[a] (Preliminary Data)*

	SO_2			NO_x		
	WG3B	Trends	NAPAP	WG3B	Trends	NAPAP
Electric Utilities	17.3	17.1	17.3	6.2	7.1	8.1
Non-Utility Combustion	3.5	3.6	4.6	4.6	4.1	5.2
Non-Ferrous Smelters	1.3	1.3	1.2	0.0	0.0	0.0
Transportation	0.9	1.0	0.9	9.3	10.5	9.1
Other Sources	3.3	2.7	3.1	1.1	1.1	1.3
Total	26.3	25.7	27.1	21.2	22.8	23.7

[a]10^6 tons/year.

could be summarized for this report. The stack height ranges were not selected based on any specific criteria; nevertheless, they show how emissions vary with height. Emissions of SO_2 in the three lowest ranges are similar, but emissions from stacks >480 feet in height are about twice as much as from any other one range, demonstrating the dominance of power plants and smelters with respect to SO_2 emissions. NO_x emissions are a little more evenly distributed: the lowest height range, <120 feet, has the greatest emissions, followed closely by the highest range. Thus, relatively small boilers and internal combustion engines probably emit slightly more NO_x as a group than do power plants. Nearly all VOC emissions come from the lowest stack height range, indicating the predominance of evaporative point source categories. These data show that nearly all VOC emissions (both point and area) are emitted below 120 feet. Of total NO_x emissions, 80% or more also are released below 120 feet. On the other hand, nearly 40% of all SO_2 is emitted at heights above 480 feet.

The county emission density summary was derived from data used to generate the density maps included in Chapter 2 of the report. The highest range shown on the maps, >100 tons/square mile, is divided into two ranges in the table for illustrative purposes. For SO_2, the counties in the two highest ranges shown in the table result from power plants in the east, primarily in the Ohio Valley and Great Lakes areas. These counties represent only 4% of those in the nation, but have 54% of the total emissions. The two counties with densities over 1,000 tons/square mile are Gallia, Ohio, and Marshall, West Virginia. Both have two power plants that are in the top 25 emitters in the nation. Counties in the lowest density range represent 84% of all counties, but only 10% of the total emissions. For NO_x, the counties in the two highest ranges shown in the table result from either power plants or highway vehicles. These counties represent only 3% of those in the nation, but contribute 27% of the total emissions. The only county with a density over 1,000 tons/square mile is New York City-Manhattan. Counties in the lowest density range represent 78% of all counties, but only 24% of the total emissions. Due to the greater area source influence, NO_x emissions are more evenly distributed among the ranges than are those for SO_2. For VOC, the counties in the two highest ranges shown in the table result from solvent use and highway vehicles These counties represent only 2% of all counties in the nation, but contribute 29% of the total emissions. The six counties with densities over 1,000 tons/square mile—Manhattan, Kings (New York), Baltimore, St. Louis, Denver, and San Francisco—are heavily urbanized, with relatively small geographic areas. Counties in the lowest density range represent 78% of all counties, but only 27% of the total emissions. Since area sources have a greater influence on VOC than on NO_x, emissions of VOC are even more evenly distributed among the density ranges than are those for NO_x.

The comparison of NAPAP, Trends, and Work Group 3B emissions of SO_2 and NO_x shows reasonable agreement. NAPAP total SO_2 emissions are greater than Work Group 3B by 3%, and than Trends by 5.5%. NAPAP and Work Group 3B/Trends emissions compare well for all categories except non-utility combustion. The difference in this category is caused by differences in fuel use, sulfur content, and control efficiency. NAPAP total NO_x emissions are greater than Work Group 3B by 11.8%, and than Trends by 4%. The greatest difference between NAPAP and Work Group 3B occurs for electric utilities. Although some of this variation is caused by fuel differences, most is believed to be a result of different emission factors and control efficiencies. The differences between NAPAP and Trends occur for electric utilities, non-utility combustion, and transportation. NAPAP emissions are higher for the first two categories and lower for the last. As was the case for the Work Group 3B comparison, some of the variation is a result of fuel differences, but most is likely to be caused by different emission factors and control efficiencies. The non-utility combustion variation occurs for the same reasons as the variation in utilities, except that non-utilities may be more affected by fuel differences. The transportation variation occurs because more detailed traffic data are used in developing the Trends estimate. Although these detailed traffic data are available on a national basis, very few areas in the nation maintain data with this detail. Thus, insufficient detailed data exist for use in NAPAP.

Data Evaluation

Version 3.0 of NAPAP represents a detailed inventory of emissions on a national scale; however, it should be noted that additional improvements are planned. Over 80% of the NAPAP emissions truly represent 1980. Over 90% are in the range from 1978 to 1981. Future efforts to improve NAPAP will focus on major point sources that currently do not have a 1980 year of record. Emissions of SO_2 and NO_x tend to be dominated by relatively few very large sources. The 1,000 largest emitting plants account for about 84% of total SO_2 emissions. The 1,000 largest emitting plants account for about 42% of total NO_x emissions (about 68% of the emissions from all stationary sources). Many of these large emitting facilities are electric utility plants and non-ferrous smelters for which extensive quality assurance efforts have already been performed. A review of the data for other large emitting plants would be desirable. To a limited extent, this activity can be completed using NAPAP resources. In addition, EPA is currently working with selected state agencies to review the top 50 or so largest emitting plants in each state. Results of this effort may also benefit NAPAP.

A principal use of the NAPAP inventory will be to support atmospheric long range transport and acid deposition modeling. In addition to emissions estimates, these models need location coordinates and stack parameters for major point sources. Currently, about 80% of point source SO_2 and NO_x emissions occur at sources with complete stack data and valid UTM coordinates. About 2-5% of the sources account for most of the 20% of emissions associated with sources that are lacking some stack parameters or valid coordinates. An effort will be made to collect the missing data for these sources. Note that sources with invalid coordinates have at present a default value corresponding to the county centroid.

Future Activities

Most Task Group B emission inventory resources remaining in FY 84 and FY 85 will be used to try to improve NAPAP to meet the needs of Eulerian modeling activities. The Eulerian models under development require additional pollutants not now in NAPAP, speciation of VOC and NO_x emissions, hourly temporal resolution of emissions, and spatial resolution of data into small grid zones covering the entire U.S. (48 states and the District of Columbia). At projected resource levels and the requested time frame (September 1984 for a preliminary data set and September 1985 for the final inventory), the Eulerian modeling requirements for an emissions inventory will have to be met using existing computer software to the extent possible, and perhaps, a number of simplifying assumptions to achieve adequate temporal, spatial, and species resolution of the data. The quality of emissions estimates for additional pollutants to be included may be limited.

Additional activities are planned for NAPAP that would support Eulerian modeling, but would be of interest for other purposes as well. These include incorporation of emissions data for Canada into NAPAP, coordination with Task Group A to include natural emissions sources into NAPAP, and a statistical evaluation of the uncertainty of NAPAP emissions estimates. Successful completion of these activities depends on the availability of adequate future funding.

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The complete report, entitled "Status Report on the Development of the NAPAP Emission Inventory for the 1980 Base Year and Summary of Preliminary Data," (Order No. PB 85-167 930/AS; Cost: $11.50, subject to change) will be available only from:
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