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Development and Improvement of a Temporal Allocation Factor File

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ABSTRACT

Emissions inventories have traditionally been developed to produce estimates of emissions for annual or daily time periods. In order to be used as input to photochemical and other atmospheric simulation models, hourly emissions estimates are usually required. Ideally, emissions for specific hourly time periods would be measured or calculated directly at the emissions source; however, this approach is normally impractical due to technical and resource restraints. As an alternative, hourly emissions estimates can be obtained using surrogate temporal allocation factors from "temporal profiles" assigned to specific emissions source categories. Estimates of hourly emissions may then be calculated by applying the appropriate temporal allocation factors to available annual, seasonal, or daily emissions values. This approach has been followed in previous air pollution studies, including the National Acid Precipitation Assessment Program (NAPAP) and the Northeast Corridor Regional Modeling Project (NECRMP). Since the performance of atmospheric simulation models is dependent upon the availability of accurate, temporally resolved emissions values, suitable methodologies and databases must be available to personnel responsible for developing the daily emissions estimates needed for model inputs.

The purposes of this project were to evaluate the quality and completeness of data and methods presently being used for temporal allocation of emissions data, to identify and prioritize needed improvements to the current methods for developing temporal allocation factors, and to collect and use data to improve an existing temporal allocation factor (TAF) file. The TAF file will be used as a source of national default allocation factors by the emissions model processing systems that calculate temporally resolved emissions estimates for model input.

INTRODUCTION

The purposes of this paper are:

- to summarize the information contained in the identified data sources and discuss the usefulness of the data for improving or developing the TAF file
- to discuss the methodology used to prioritize source categories (represented by EPA source classification codes [SCCs]), for incorporation into the TAF file
- to propose a plan of action for developing the TAF file

METHODOLOGY

Literature Search

Relevant current literature references were identified, acquired, and reviewed in order to evaluate the quality and completeness of data and methodologies presently being used for temporal allocation of emissions data. The most comprehensive set of temporal allocation factors to date has been developed for NAPAP, although other work has focused on some specific aspects of temporal allocation. In addition, significant work has been completed for the Urban Airshed Model (UAM) to develop a methodology for temporal allocation and a set of default factors.

Temporal allocation factors were developed for emissions of the following 10 pollutants from the point and area source categories in the 1980 NAPAP emissions inventory: sulfur dioxide (SO_2), primary sulfate, oxides of nitrogen (NO_x), total suspended particulates (TSPs), carbon monoxide (CO), ammonia, hydrogen chloride, hydrogen fluoride, volatile organic compounds (VOCs), and total hydrocarbons (THCs). Of these, NO_x, TSPs, and THCs were further resolved into component species or groups of species.

NAPAP temporal allocation factors were updated and applied to the 1980 and 1985 emissions data. Four seasonal, three seasonal-daily (*i.e.*, a typical weekday, Saturday, and Sunday) and 24 hourly allocation factors were developed for NAPAP point and area sources.

Factors were developed for the 102 source categories (including mobile sources) in the 1985 NAPAP area source data. Depending on the magnitude of emissions within the source category and availability of data, factors were frequently resolved to the regional, state, or local level. Point source factors were developed for electric utility processes.

A major limitation of the NAPAP allocation factors is that they were developed only for the NAPAP point and area sources. Documentation of the data and assumptions upon which the NAPAP factors were developed are incomplete. In addition, NAPAP factors focus primarily on criteria pollutants that play a role in the formation of acid rain; in the future, however, temporal allocation factors for hazardous air pollutants (HAPs) will be an important focus.

Through intensive literature searches and telephone interviews with technical staff members of EPA, selected state/local regulatory agencies, universities, and other government or private research organizations, the following data sources were identified as providing sufficient information to support TAF file development:

- Business and Labor Statistics (BLS) data
- Department of Energy (DOE) data pertaining to production/consumption from various energy industries
- California Air Resources Board (CARB) AB-2588 "Hot Spots" pooled source test reports
- Texas Air Control Board (TACB) stationary source operating schedule data
- Southern Oxidant Study (SOS) data
- Lake Michigan Ozone Study (LMOS) data
- Continuous Emissions Monitoring (CEM) data
- Other Data Sources, including wastewater data from publicly owned treatment works (POTWs); operating schedule/parameter data from resource recovery facilities; acid-modes field study data; and UAM Emissions Preprocessor System (EPS) temporal profiles

Two distinct types of data were identified: first, national economic statistics were identified as potential surrogate indicators of production activity applicable at a major category level where process-specific data are absent or incomplete; and second, specific category or plant data were identified through a variety of sources, including state-of-the-art emissions inventories, CEM, and industrial and federal reports, surveys, and databases.

Business and Labor Statistics Data. Industrial activity and output are often monitored by trade associations, private organizations, and governmental agencies. The types of statistical information compiled by these groups include number of employees, labor hours worked, sales, production, capacity, energy consumption, peak demand, and other operating and economic indicators, such as production rate per employee. The statistics are published on varying temporal resolutions: seasonally, monthly, and weekly. The information is often specific to Standard Industrial Classification (SIC) codes.

Labor and economic statistics were used to develop a default seasonal TAF file for ozone atmospheric modeling purposes. The data were supplemented by industry survey or CEM data for further resolution to an hourly basis. Information sources and frequency of publication can be documented for easy retrieval during future TAF file updates.

The general methodology for incorporating these data into the TAF file is to calculate fractional proportions over the temporal basis of the data. For example, monthly proportions can be developed by dividing each monthly indicator by the yearly total. Seasonal fractions are then developed by summing each season's constituent months. Operating or economic statistics act as surrogate indicators of industrial processes releasing pollutants. For example, the number of hours worked by employees or the industry's production rate are assumed to be directly related to that industry's potential emissions during a given time frame. The *Commodity Year Book,* published by the Commodity Research Bureau, and *Employment and Earnings* and *Employment, Hours, and Earnings, United States*, published by the U.S. Department of Labor, Bureau of Labor Statistics, cover a broad range of industrial source categories. These data are compiled on a level suitable for SIC code or third-level SCC assignment. These data were used to develop seasonal and monthly temporal profiles.

California Air Resources Board Data. In accordance with the California Air Toxic "Hot Spot" Inventory and Assessment Act of 1987, many types of industrial sources were required to submit air toxic emissions data to local air pollution control agencies in the state. Collectively, the program is called the Assembly Bill (AB-)2588 program.

The data contained in the CARB reports include emissions of various pollutants determined from actual source test measurements taken at each facility during a certain time of the year while the facility was operating at normal capacity. For many of the reports, these emissions rates are given in pounds per hour. In addition to the measured emissions rates, many of the CARB reports also contain various process operating parameters which were used as direct or surrogate indicators when developing profiles. Operating information includes operating schedules (hours per day, days per week, weeks per year), product throughput (tons or pounds per year and tons or pounds per hour) and fuel throughput (pounds per hour), or stack gas flow rates (dry standard cubic feet per minute). Some reports give relative monthly activity percentages for the various processes tested.

Several CARB reports provide monthly activity percentages for processes tested at the facility. These numbers represent the amount of production activity during a particular month. From these reports, an estimate of the activity for other months of the year was provided. These data yield an indicator of hourly emissions since the hourly activity information given in the reports is more of an indicator of the actual production activity for that particular month of the year.

Texas Air Control Board Data. TACB collects extensive emissions data through its permitting, State Implementation Plan (SIP) inventory, and enforcement processes. Two databases were identified from the TACB. The first database lists facilities, addresses, points of contact, type of business, operating schedules, and seasonal operating percentages, but does not contain either SIC or SCC codes, although SCC-level process descriptions are available. The second database contains both SIC and SCC codes for each respective business. The plant-specific information includes the facility operating status, individual process descriptions and their respective operating schedules, and seasonal operating percentages. Throughput data, although collected by TACB, are considered confidential and therefore cannot be accessed. Data are maintained for 6,000 plant sites within the State of Texas. Site operating schedules are given for each process in hours per day, days per week, and weeks per year. Seasonal operating percentages are provided as a percentage for each of the four seasons of the year.

For sources which operate on less than a 24-hour basis, exact operating times were estimated. For each SCC given, facility (*i.e.*, process-level) descriptions are also given. Actual hourly data were used to the extent possible. Below the smallest temporal level, continuous operation was assumed. For example, if no data were available below a seasonal level, the percentage of annual production corresponding to that season was distributed evenly among all hours in the season. The TACB data are comprehensive and contain direct or surrogate information for a wide variety of SCCs.

Southern Oxidant Study Data. The SOS emissions inventory, as completed by the Georgia Department of Natural Resources, Air Protection Branch, is a point source inventory for the 1992 Atlanta, Georgia, 6-week intensive ozone season, July 15 to August 31, which includes data on 57 local facilities. In addition to summary statistics used to update Aerometric Information Retrieval System (AIRS) Facility Subsystem (AFS) data, day-specific emissions and production data for the 6-week intensive ozone season were collected to update the 1990 data in the AIRS/AFS database.

Data collected include process code and description, normal operating schedule (including normal start and end time for processes), stack height, type of raw materials, specific gravity or density, percent by weight VOC, throughput, and emissions. For each process, the following data were recorded for each day in the 6-week intensive ozone season: actual operating schedule (hours per day, start time, and end time), input or production rate, and VOC emissions.

The SOS data set provides diurnal production cycles for the summer months; the data were used to describe daily operations at the type of facilities and processes found in the survey. Although the survey addresses only 6 weeks of the year, the daily production cycles were used to support estimates of other season's activities for SCCs lacking diurnal data.

The SOS also surveyed two area sources for scheduling and operational information, the printing industry and auto body repair work. Data for these two area sources were also included in the TAF file.

Lake Michigan Ozone Study Data. The LMOS data include emissions rates calculated from production data received by the Wisconsin Department of Natural Resources for approximately 200 of the largest facilities in the 21-county LMOS region of Wisconsin. Production data, including operating rates, fuel use, and solvent use, were collected from facilities on a process-by-process basis from June 10 through August 24, 1991. The emissions estimates were calculated on a process level basis, and SCC-level allocation factors were assigned. There are approximately 65,000 daily emissions estimates included in the LMOS database, representing 560 unique SCCs.

The LMOS data represent a reliable, documented source of information for the development of the TAF file. Algorithms were developed to construct temporal allocation factor distributions from the hourly emission estimates related to the various processes.

Continuous Emissions Monitoring Data. CEMs are installed at facilities to monitor pollutant emissions on a continuous basis for demonstrating compliance with permit conditions and/or state or federal regulations. Several pollutants may be monitored with CEMs; however, the most commonly monitored pollutants are SO_2, NO_X, and CO.

CEM data for approximately 30 SCCs from approximately 70 sources were compiled on an hourly basis at the facility level; therefore, temporal profiles were determined diurnally, by day of the week, or by season of the year. The CEM data were aggregated to develop temporal profiles for each hour of the day for a typical weekday, Saturday, and Sunday for each season.

Wastewater Data. Wastewater data were used as a nontraditional surrogate for actual industrial activity levels. Using wastewater data to allocate air emissions assumes that air emissions variations will correspond to industrial wastewater release fluctuations. Industrial wastewater discharge data are maintained under the National Pollution Discharge Elimination System (NPDES). The NPDES program is managed at the state level. Monthly average values of wastewater flow and pollutant concentrations are maintained at the national level in the Permit Compliance System. The temporal frequency of a facility's wastewater monitoring data depends on the facility's permit requirements. The permit requirements are based on the type of waste discharged, location of discharge (*i.e.*, to a receiving stream or POTW), and the uniformity or variability of discharge flow.

Wastewater flow and pollutant loading data were assigned to industry SIC codes. National wastewater discharge data were retrieved through the EPA Region 4 Office of Water Permits and Compliance in Atlanta, Georgia. Only major dischargers as defined in the Clean Water Act are tracked at the national level, representing approximately 10 percent of all discharges. Available wastewater parameters include flow, total suspended solids (TSS), pH, and biological oxygen demand (BOD) (though less common than the others). The data are compiled as monthly averages.

Industrial wastewater discharge data were used for the development of the TAF file under the assumption that wastewater flow and pollutant loads are good indicators of a facility's emissions over time. Times of increased wastewater flow or higher concentration of pollutants in the wastewater may be assumed to indicate simultaneously increased air pollutant emissions.

Waste-to-Energy Source Data. Waste-to-energy data were used to characterize emissions from solid waste disposal facilities that generate energy (included in SICs 4900 through 4999, and SCCs 5-01-001-01 through 5-03-900-10).

The *Resource Recovery Yearbook* provides statistical data on the number and types of waste recovery facilities located throughout the United States. Information is provided for conceptually planned facilities, advance planned/existing facilities, and facilities which have been shut down on either a temporary or permanent basis. The directory includes facility-specific information that was useful as surrogate indicators for developing the TAF file (*e.g.*, operating schedules and average operating throughput).

Generally, the operating schedule data were broken down into various periods of the day since the number of shifts of operation for a given day was known. Although the scheduling data did not delineate information by season, it was assumed that these operating schedules are the same throughout the entire year. By multiplying the hours per shift by shifts per day, the total number of hours per day was determined.

Acid-Modes Field Study. EPA's Air and Energy Engineering Research Laboratory (AEERL) conducted a study to estimate hourly emissions of SO_2 and NO_x from coal-burning electric power utilities in the Eastern United States. The data were to be used in conjunction with the 1985 NAPAP as the emissions input for the verification runs of two acidic deposition computer simulation models.

These data, in Statistical Analysis System (SAS) format data files, were used, where applicable, to replace or augment the current allocation profile for electric utility emission sources. The database includes actual hourly electric generation profiles. The Acid-Modes Field Study database contains data from a large number of sources in a wide variety of areas. The hourly megawatt load data were used to develop a profile of a typical operating day for specific utility SCCs.

Urban Airshed Model Emissions Preprocessor System Temporal Profiles. The UAM has been designated as the preferred model for "photochemical pollutant modeling applications involving entire urban areas" by EPA's Office of Air Quality Planning and Standards (OAQPS). UAM simulates the hour-by-hour photochemistry occurring for each grid cell in the modeling domain; consequently the input emissions data must contain the same level of resolution. To accommodate this level of resolution in the input data, a system of computer programs, the UAM-EPS, Version 2.0, has been designed to perform the intensive data manipulations necessary to adapt a county-level annual or seasonal emissions inventory for photochemical modeling use. In the EPS, the TAF file is cross-referenced to point, area, and mobile source processes by profile codes. The TAF file exists for an array of different temporal scenarios consisting of typical monthly distributions, day to week distributions, and hourly distributions for typical weekday and weekend scenarios. The TAF file was compiled from operating parameters found in the NAPAP emissions inventory files, as well as data resulting from field studies conducted by the CARB approximately 10 years ago.

The data were incorporated, where applicable, into the TAF file through a method which prioritized the EPS TAF file along with other data sources. Due to the dated nature of the EPS TAF file, however, its priority in relationship to other sources of information used was comparably low.

Source Category Prioritization

Emissions source categories were prioritized to ensure proper attention to the source categories that are major national contributors to air pollution. The prioritized source categories reflect only data available from AIRS/AFS. Area and mobile source categories were excluded because those data were not publicly available from the AIRS Area and Mobile Source Subsystem (AMS) at the time of this study. The source category prioritization focused on ozone precursors (VOCs, NO_X, and CO) because these pollutants will be targeted in pending ozone/CO SIP modeling efforts. Because AFS data were the sole source of emissions estimates in this study, the source categories themselves are generally referred to by AFS SCCs.

Source categories were not prioritized by HAPs emissions due to insufficient HAPs emissions data in AIRS/AFS. The prioritized list of SCCs emitting HAPs includes 9 industry groups and 19 major source categories. The major source categories include:

- Electric utility, industrial, and commercial/institutional external combustion boilers
- Industrial internal combustion engines
- Chemical manufacturing
- Primary and secondary metal production
- Mineral products
- Surface coating operations

To check for consistency with previous EPA efforts, the source categories assigned high priority under this methodology were compared to high-priority source categories defined in the *Federal Register Notice* dated September 24, 1992. The *Federal Register Notice* lists 17 industry groups and 171 source categories that are targeted for Maximum Achievable Control Technology (MACT) standard development. All categories identified in this prioritization effort were included in the *Federal Register* list. This comparison demonstrates consistency with earlier prioritization efforts.

Temporal Allocation Factor File Development

Once data were collected for source categories identified as "high priority," standard methodologies were developed for creating data-source-specific intermediate files, and subsequently for combining data from these source-specific intermediate files into one final TAF file.

The identified data sources primarily target point source emissions. The traffic patterns that drive mobile source emissions are highly characteristic of each specific municipality and are not easily generalized as required for this project. However, NAPAP allocation factors were used for most stationary area and off-highway mobile sources.

A three-tiered approach was used to develop the final TAF file. Tier 1 provided a baseline TAF file, covering all source categories, but includes data only at a monthly level. Tier 1 data are useful for constructing seasonal allocation profiles. The low cost of and easy access to these data allow immediate improvement of the TAF file by providing documented, routinely updated seasonal data by which all point source emissions can be allocated. Within the season, however, a flat distribution (7 days per week, 24 hours per day) was assumed. Tier 1 data provide an acceptable temporal profile for many sources, but will not contain the detail desired for large emissions sources.

Tier 2 data provide increased temporal resolution for a large number of categories. Data contained in large databases were used to provide temporal profiles for many sources, improving the temporal resolution from that provided by Tier 1 data.

Tier 3 data were developed from CARB reports, CEM data, wastewater studies, and other data sources to improve existing profiles.

The Tier 1, 2, and 3 files were used as intermediary work files, from which a single, final TAF file was developed. All TAF records include data source indicator fields to provide traceability and documentation of the final product. The TAF file design allows future users to identify in-use data sources and to readily update the file as more current data become available.

Tier 1-Monthly operating profiles for all source categories were constructed, predominantly using monthly labor and energy consumption data. These profiles provide a baseline TAF file and allow quarterly allocations for all sources based on routinely updated, inexpensive, publicly available data. Tier 1 data cover a broad range of data sources, but provide only seasonal allocation factors (based on monthly data). Tier 1 data were used only for those sources not included in Tier 2 or 3.

Tier 2-The Tier 2 TAF file was created based on the information retrieved from data sources such as TACB, SOS, and LMOS. Methodologies for combining the data for source categories common to two or more of the data sources were developed. Tier 2 files were used to provide hourly profiles for a fairly large number of source categories. Tier 2 data were used for emissions sources not included in Tier 3.

Tier 3-For high priority source categories, operating profiles were developed based on CARB data, CEM reports, wastewater data, and other data sources. The data in Tier 3 files represent focused efforts toward improving the default operating profiles for a small number of important emission sources. As with Tier 2 data, methodologies were developed for combining the data for source categories common to two or more Tier 3 data sources. Tier 3 data are the most detailed and desirable data available to the final TAF file.

The TAF file developed under this project was completed in September 1993; no final EPA report has yet been released. Details regarding distribution of the final TAF file have not been completed at this time. The TAF file is in a computer-neutral format (flat ASCII) accessible by photochemical models such as: the UAM-EPS, the Geocoded Emissions Modeling and Projection (GEMAP) system, and the Regional Oxidant Model (ROM). Temporal profiles may supersede the temporal profiles found in the models or their preprocessors, although some revisions to the model's temporal processors may be required. Key fields to retrieve an allocation profile in the TAF file database include:

- AIRS SCC
- season (winter, spring, summer, fall)
- weekday or weekend

The TAF file includes hourly allocation factors for hours 00 through 24 that may be multiplied by the annual emissions estimates to yield hourly emissions estimates.

CONCLUSIONS

The work described in this paper was intended to create comprehensive, well-documented, representative national default allocation profiles that may be used to generate hourly emissions estimates from annual estimates. The objectives of the project were realized. The quality of the TAF file could be improved by further analysis of the collected data.

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