Modeling Sensitivity Runs for Fire Emissions

White Paper

***Status Report* - December 7, 2004**

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Introduction

During 2004, the WRAP Regional Modeling Center (RMC) has been planning and conducting modeling sensitivity runs for various fire emissions scenarios on behalf of both the Fire Emissions Joint Forum (FEJF) and the Attribution of Haze (AoH) Workgroup's Phase I project. The RMC has been performing this work as Task 11: Sensitivity Studies Designed to Evaluate Uncertainties in Fire Emissions, as part of our 2004 workplan. The purpose of the sensitivity studies is to use regional scale CMAQ dispersion modeling runs to assess the sensitivity of the regional air quality model to varying parameters in the fire emissions inventory. This white paper updates an RMC memo titled Progress on Fire Sensitivity Scenarios dated October 28, 2004, that summarizes the fire sensitivity cases as well as questions still needing resolution in order to complete the analysis of the fire sensitivity simulations.

The AoH Workgroup has identified the results of 3 modeling sensitivity runs to include as regional assessments of fire impacts at Class I areas for their Phase I report. These 3 modeling runs are described first in this status report. In addition to those runs, the concept and design of specific other FEJF sensitivity runs are described in a technical memo prepared by Air Sciences for the Emissions Task Team (ETT) of the FEJF[1]. The description of the modeling runs in the Air Sciences technical memo were developed during a series of ETT and Air Quality Modeling Forum conference calls, and were finalized in August 2004. Each of the FEJF fire sensitivity runs currently identified for RMC action are also described in this status report.

Regional Assessments of Fire Impacts for AoH Phase 1 Report

The RMC has completed 3 sensitivity runs for use as regional assessments of fire impacts for the AoH Phase 1 report. These runs use the FEJF Phase 1 2002 emissions inventory data developed by Air Sciences for prescribed and wildfire emissions, and the 2018 "base case" agricultural fire inventory developed for the **§**309 planning process. With all other emissions sources included in the regional CMAQ dispersion model, these 3 runs characterize the following fire impacts:

1) The difference between the CMAQ-modeled visibility impacts with and without all fire emissions;
2) The difference between the CMAQ-modeled visibility impacts with "natural" fire emissions, and without all fire emissions; and
3) The difference between the CMAQ-modeled visibility impacts with all fire emissions, and without "manmade" fire emissions.

First, the 3 sensitivity runs completed for AoH Phase 1 report are described in more detail.

1. All Fire Emissions versus No Fire Emissions

Purpose:

[1] Plan for Model Sensitivity Runs for Fire, prepared for: Pete Lahm & Darla Potter, FEJF Co-Chairs, by: Dave Randall, Air Sciences, Inc., August 23, 2004.

This model run is designed to isolate the effect of fire emissions on visibility from the effect of all other emissions sources in the model.

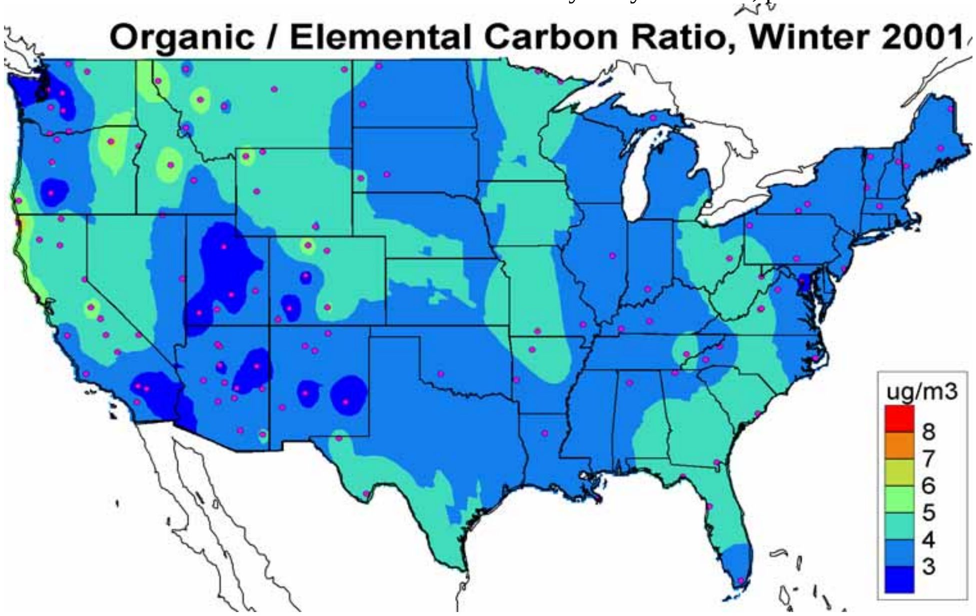
Progress & Results:

We have completed this fire sensitivity simulation and present the results as spatial difference plots, shown as monthly and annual average differences, as well as stacked bar plots for each Class I site. Specifically, the fire emissions compared are the preliminary 2002 case with all fires (Pre02f) compared to the preliminary 2002 case with no fire emissions (Pre02b). Because the model performance evaluation is computationally time consuming to run, we have chosen to initially show the monthly and annual average results. If requested, additional results addressing the 20% Worst and Best visibility days, monitored and/or modeled, might also be extracted for review. Also, results consisting of modeled versus monitored time series plots of mass concentration, extinction, and organic/elemental carbon ratios could be prepared. Example plots for IMPROVE OC/EC ratio data are shown next[2].

Difficulties Encountered/Resolutions/ Next Steps:

During November we completed the evaluation for spatial distribution plots of this fire sensitivity case. Based on FEJF review, we will complete additional evaluations displaying other data suggested above.

MAPS 1, 2: IMPROVE and EPA STN data have been used to look at the ratios of organic to elemental carbon. These data suggest that OC/EC rations differ between urban and rural settings as well as between the eastern and western United States. Maps 1 and 2 illustrate the ratio in winter and summer. Presumably this difference in ratios is due to a difference in source mixes. Data from IMPROVE analysis by W. Malm, personal communication.



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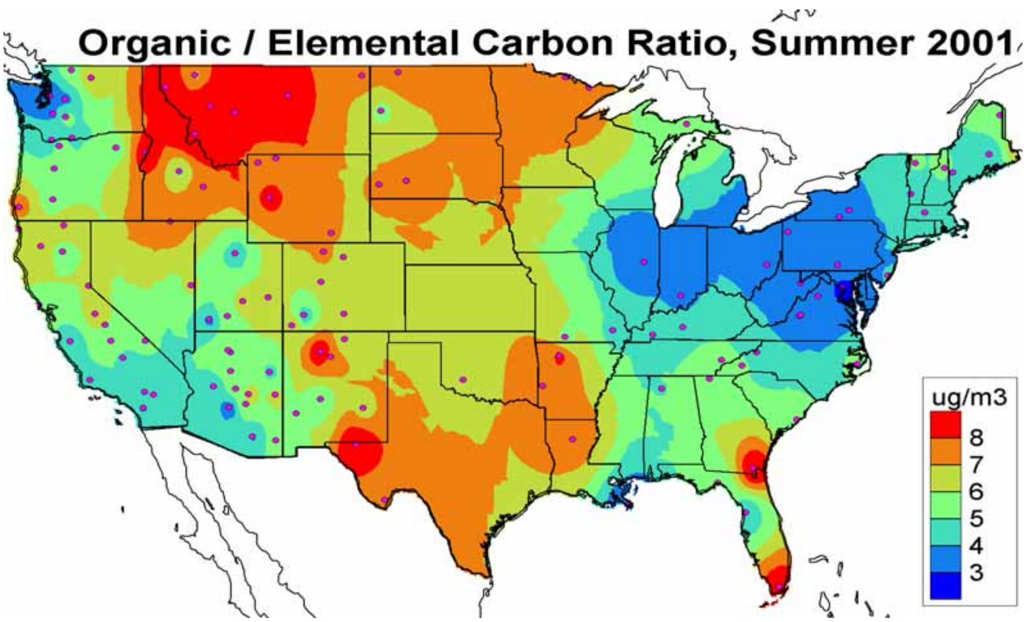
2 The Importance of Carbonaceous Aerosol in Air Quality Planning: Bridging the Gap between Research and Application; Richard, Tim and Moore, Tom; draft for Attribution of Haze Workgroup review; November 18, 2004.



OC/EC ratio values on order of 3-5 suggest fossil fuel combustion contributions, while values greater than 7 suggest fire emissions. High OC/EC rations suggest a source mix resulting from either inefficient combustion (vegetation fires) or secondary organic formation.

2. All Fire Emissions versus No "Anthropogenic" Fire Emissions

Purpose:

This model run is designed to isolate the effect of "anthropogenic" fire emissions on visibility from the effect of all other emissions sources in the model, including "natural" fire.

Progress & Results:

We have completed this fire sensitivity simulation and present the results as spatial difference plots, shown as monthly and annual average differences, as well as stacked bar plots for each Class I site. Specifically, the fire emissions compared are the preliminary 2002 case with all fires (Pre02f) compared to the preliminary 2002 case with only natural fire emissions (Pre02e). The classification of natural and manmade fire emissions in the FEJF Phase I inventory was done by Air Sciences and documented in a technical memo[3]. Because the model performance evaluation is computationally time consuming to run, we have chosen to initially show the monthly and annual average results. If requested, additional results addressing the 20% Worst and Best visibility days, monitored and/or modeled, might also be extracted for review. Also, results consisting of modeled versus monitored time series plots of mass concentration, extinction, and organic/elemental carbon ratios could be prepared.

[3] Approach for Categorizing Natural and Anthropogenic for WRAP Phase I Fire Emission Inventory, prepared for: Pete Lahm, FEJF Co-Chair, by: Dave Randall, Air Sciences, Inc., Project Number: 178-6-3, September 3, 2004

Difficulties Encountered/Resolutions/ Next Steps:

During November we completed the evaluation for spatial distribution plots of this fire sensitivity case. Based on FEJF review, we will complete additional evaluations displaying other data suggested above.

3. "Natural" Fire Emissions versus No Fire Emissions

Purpose:

This model run is designed to isolate the effect of "natural" fire emissions on visibility from the effect of all other emissions sources in the model, including "anthropogenic" fire.

Progress & Results:

We have completed this fire sensitivity simulation and present the results as spatial difference plots, shown as monthly and annual average differences, as well as stacked bar plots for each Class I site. Specifically, the fire emissions compared are the preliminary 2002 case with "natural" fires (Pre02e) compared to the preliminary 2002 case no fire emissions (Pre02b). The classification of natural and manmade fire emissions in the FEJF Phase I inventory was done by Air Sciences and documented in a technical memo. Because the model performance evaluation is computationally time consuming to run, we have chosen to initially show the monthly and annual average results. If requested, additional results addressing the 20% Worst and Best visibility days, monitored and/or modeled, might also be extracted for review. Also, results consisting of modeled versus monitored time series plots of mass concentration, extinction, and organic/elemental carbon ratios could be prepared.

Difficulties Encountered/Resolutions/ Next Steps:

During November we completed the evaluation for spatial distribution plots of this fire sensitivity case. Based on FEJF review, we will complete additional evaluations displaying other data suggested above.

Objectives for the FEJF Sensitivity Runs

Following are the objectives for the FEJF Sensitivity Study, from the Air Sciences August 23rd technical memo:

Prioritize Data Collection Efforts - The Regional Haze Rule (RHR) requires many forms of data collection pertaining to fire emissions. Examples include: emission inventories for modeling (as part of regional haze State Implementation Plans); emission tracking systems; and tracking/quantifying "credit" for emission reduction techniques. The sensitivity studies should serve to prioritize data collection efforts.

Prioritize Long-Term Research Needs - The FEJF has acknowledged the uncertainty and imprecision of the information and tools available to estimate emissions from fire. The sensitivity studies should serve to prioritize research needs.

Improve Smoke Management Decisions - Ultimately, States and Tribes will need to make real-time decisions with regard to issuing permits and requiring emission reduction and/or smoke management techniques. The sensitivity studies should serve to improve the ability of air quality agencies to make prudent decisions pertaining to fire emissions.

FEJF-Suggested Sensitivity Runs

The following list presents the status of FEJF sensitivity runs. The runs discussed were sorted on July 28, 2004 into high priority runs that RMC should "carry out" now and runs the FEJF "defers". These are numbered A through H.

A. S1 – Quantify / characterize the contribution to extinction due to (a) all fire sources contributing in combination, and (b) each type of fire source contributing individually (agricultural burning (2018 Base), prescribed burning (2002), and wildfire (2002)).

Purpose:

This model run is designed to evaluate the total effects of all fire emissions on haze and individually the effects of each of the fire emissions source categories: wild fires, prescribed burning and agricultural burning. Emissions files were provided separately by Air Sciences to the RMC for each of these 3 categories and then merged into a single emissions file by the RMC for the base case CMAQ simulation. For the sensitivity studies the RMC created 3 emissions files in which each of the three fire categories were merged individually with the remaining emissions source (i.e., mobile, point, area, biogenic).

Progress & Results:

We have completed this fire sensitivity simulation and present the results as spatial difference plots, shown as monthly and annual average differences, as well as stacked bar plots for each Class I site. Specifically, the fire emissions compared are the following:

- All fire emissions (pre02c) minus the base case with no fires (pre02b)
- Wild Fire minus the base case with no fires (pre02b)
- Agricultural burning minus the base case with no fires (pre02b)
- Prescribed burning minus the base case with no fires (pre02b)

Because the model performance evaluation is computationally time consuming to run, we have chosen to initially show the monthly and annual average results. If requested, additional results addressing the 20% Worst and Best visibility days, monitored and/or modeled, might also be extracted for review. Also, results consisting of modeled versus monitored time series plots of mass concentration, extinction, and organic/elemental carbon ratios could be prepared.

Difficulties Encountered/Resolutions/ Next Steps:

During November we completed the evaluation for spatial distribution plots of this fire sensitivity case. Based on FEJF review, we will complete additional evaluations displaying other data suggested above.

B. S2 – Quantify / characterize the effect of Optimal Smoke Management (OSM) on extinction levels. Suggest comparing results of 2018 OSM to 2018 Base model runs. Attempt to use model results to characterize predicted benefits to regional haze with less aggressive OSM reductions. FEJF is interested in quantifying the effect of: (a) OSM applied to prescribed fire and agricultural burning, (b) OSM applied to prescribed fire (see Deferred Section), and (c) OSM applied to agricultural burning (see Deferred Section).Quantify / characterize the contribution to extinction due to (a) all fire sources contributing in combination, and (b) each type of fire source contributing individually (agricultural burning (2018 Base), prescribed burning (2002), and wildfire (2002)).

Purpose:

This model run is designed to compare the effects on haze of the optimal smoke management (OSM) strategy to the base smoke management strategy.

Progress & Results:

We completed these fire sensitivity simulations for calendar year 2018 as part of the Section 309 modeling. We presented the results as spatial difference plots, shown as monthly and annual average differences.. . If requested, additional results addressing the 20% Worst and Best visibility days, monitored and/or modeled, might also be extracted for review. Also, results consisting of modeled versus monitored time series plots of mass concentration, extinction, and organic/elemental carbon ratios could be prepared.

C. S5 – Quantify / characterize the contribution to extinction due to smaller fire events (between 10 acres and 100 acres). Subsets (representing only fires larger than specified size cut points) of the 2002 emission inventory (wildfire and prescribed burning) will be provided by the FEJF to the RMC.

Purpose:

This model run is designed to evaluate the effects of smaller fire events on haze.

Progress & Results:

This activity has been delayed pending availability of funding for Air Sciences to process fire emissions for events between 10-100 acres.

D. S7 – Quantify / characterize the effect on extinction levels of physical plume characteristics provided for each fire event. Use 2002 wildfire emission inventory. FEJF to provide modified plume profile data to RMC. As agreed to by the ETT in New Orleans on May 6, 2004, FEJF to provide RMC with 2018 Ag base emission inventory with emissions fumigated to the first vertical layer (LAY1F) adjusted by 38/80 to account for the RMS vs. FEJF discrepancy in the assumed height of the first vertical layer. Alternatively, if a new plume rise algorithm is proposed, it would be better to run SMOKE again with the new algorithm.

Purpose:

This model run is designed to evaluate the sensitivity of the modeled haze to the vertical distribution of emissions from agricultural burning.

Progress & Results:

We reprocessed the agricultural burning emissions to reduce the mass emissions in the surface layers by about 50% and to redistribute these mass emissions equally among the mixed layers. We have completed this fire sensitivity simulation and present the results as spatial difference plots, shown as monthly and annual average differences, as well as stacked bar plots for each Class I site. CMAQ results were compared for the vertical distribution case to the base case. There were only very small effects on the CMAQ results. We concluded that for agricultural burning the model was relatively insensitive to the vertical distribution of fire emissions because the emissions were primarily during the daytime and were confined to the boundary layer, and that during the daytime the boundary layer is well mixed. Therefore, the model was insensitive to changes in the layer at which emissions were injected. We do not expect this conclusion to apply to wildfire emissions for which fires might be large and for which the emissions might be injected above the boundary layer.

E. S2 – Quantify / characterize the effect of Optimal Smoke Management (OSM) on extinction levels. Suggest comparing results of 2018 OSM to 2018 Base model runs. Attempt to use model results to characterize predicted benefits to regional haze with less aggressive OSM reductions. FEJF is interested in quantifying the effect of: (b) OSM applied to prescribed fire, and (c) OSM applied to agricultural burning. Analyze using PAVE on a grid scale to quantify the effect on net change in emissions and net change in extinction. As of July 28, 2004, analysis S2(a) is to be carried out and S2(b) and S2(c) are deferred.

Purpose:

This model run is designed to evaluate individually the effects of OSM applied to prescribed fire and OSM applied to agricultural burning. This run was dropped as being a low priority.

F. S3 – Quantify / characterize the effect on extinction due to the changes in spatial distribution between the revised 2018 OSM Agricultural Burning inventory and the original 2018 OSM Agricultural Burning. Evaluate the effect of changes in temporal and spatial distribution with no significant change in emissions. Analyze first using PAVE on a grid scale to quantify the effect on net change in emissions. If the change indicated by this analysis is significant then run CMAQ model and analyze using PAVE at grid scale to analyze effect on net change in extinction. S3 is deferred as it is a lower priority, would require model runs, and would be better suited with specifically engineered emission inventory inputs.

This run was dropped as being a low priority.

G. S4 – Quantify / characterize the effects of the current (revised) 2018 OSM and the original 2018 OSM (with extra 450 tons PM2.5) for prescribed fire. Evaluate the effect of increased emissions with no changes to the temporal and spatial distribution of the fire events. Analyze first using PAVE on a grid scale to quantify the effect on net change in emissions. If the change indicated by this analysis is significant then run CMAQ model and analyze using PAVE at grid scale to analyze effect on net change in extinction. S4 is deferred as it is a lower priority, would require model runs, and would be better suited with specifically engineered emission inventory inputs.

This run was dropped as being a low priority.

H. S6 – Quantify / characterize the effect on extinction levels of the diurnal fire emission profiles provided to the RMC by the FEJF and used to distribute daily emissions to each hour of the day. Use 2002 wildfire emission inventory. FEJF to provide modified diurnal profiles to RMC. (To be prepared by ETT at 06/14/04 meeting in Portland, OR. P. Lahm may provide alternative diurnal profile as Strawman.) This can be accomplished by modifying the SMOKE fire output file to change the diurnal profile. Changes in emissions in night, early morning or late evening would be expected to have the largest effect.

This run was dropped as being a low priority.