

ATTACHMENT 1 - TECHNICAL PROPOSAL

Prescribed and Other Fire Emissions: Particulate Matter Deterministic & Empirical Tagging & Assessment of Impacts on Levels (PMDetail)

Western Governors' Association – Air Quality Program

CFDA No. 15.232

JFSP Request for Applications (RFA) 2012-1, Task 8

Principal Investigator and Project Team

Charles Thomas (Tom) Moore, Jr., Air Quality Program Manager of the Western Governors' Association (WGA) is the Principal Investigator for the PMDetail project. WGA is incorporated under Article 26 of Title 7 of the 1973 Colorado Revised Statutes as a non-profit association to advocate policies and programs before any branch or agency of state and/or federal government. The WGA air quality program collects and analyzes data, maintains databases, and conducts studies to understand current and evolving regional air quality issues for state and federal agencies in the context of the Clean Air Act (CAA) and its Amendments. Team members include: National Park Service and U.S. Forest Service national air quality programs' fire analysts, modeling, and program management staff (all FLM time is in-kind), Air Sciences, Inc. (experts in developing fire emission inventories); ENVIRON International Corporation (experts in chemical transport modeling), Carnegie-Mellon University (CMU – experts in atmospheric chemistry, biomass burning emissions, chemical transport modeling), and Colorado State University (CSU – experts in atmospheric chemistry, air sampling and laboratory analysis).

I. Overview

The 3-year PMDetail project will quantify the impact of prescribed and other fire sources on particulate matter (characterized as PM_{2.5} and PM₁₀, hereafter PM) levels across the continental U.S. It will also develop new fire emissions inventories and computational modules for chemical transport models to simulate the atmospheric transformations of these emissions. The resulting models (CAMx and PMCAMx) and inventories will be evaluated against field measurements for 2002, 2008, and 2010. CAMx is a publicly available chemical transport model (CTM) used for regulatory purposes, while PMCAMx is its research version developed by the CMU team. We will leverage and significantly extend emission inventory development and CAMx modeling from an ongoing JFSP study, [Deterministic and Empirical Assessment of Smoke's Contribution to Ozone](#) (DEASCO3).

To develop ranges of future fire impacts, we will analyze and assess the contribution of prescribed and other fire types to elevated PM episodes using the DEASCO3 and new inventories and the regulatory CAMx and research PMCAMx models from three historic years (2002, 2008, and 2010) and alternate future scenarios. PMDetail will deliver both regulatory assessments and investigate research-grade variations of the inventories and modeling tools and provide detailed comparisons of the two approaches in the predicted PM impacts. From the 3 historic years and 3 alternate future emission scenarios, we will identify up to 30 “episode areas” that capture a broad range of relationships of prescribed and other fire emissions on PM concentrations on an annual and/or 24-hour basis, with the intent of characterizing fire's contribution across a wide geographic area of the continental U.S. Based on these results, we intend to publish fire emissions inventories' data and results from CAMx and PMCAMx, in the form of technical products (e.g., maps, charts, tables, probability functions, etc) and as a “PM exceedance vulnerability matrix” or PM-EVM that rank orders the potential impact of prescribed fire emissions by location. This will enable FLMs to evaluate the effect of historic and future real-world decisions about prescribed burning and its effects on air quality in the context of both exceptional events and nonattainment SIPs for the PM standards, analogous to situations that FLMs will encounter in the future. This leveraging and coalescing of work from the JFSP-funded DEASCO3 and other JFSP projects and synergies with other regional emissions and modeling studies underway will provide comprehensive regulatory and research results for multiple historic years and alternate future scenarios of fire activity and associated emissions based on historic patterns.

1. Project Justification and Expected Benefits

Smoke from prescribed and other types of fires can be a significant contributor to ambient PM, urban and regional air pollution, and regional haze (visibility impairment). Such contributions are often clear near fire sources, but can also

be significant as smoke plumes are transported far downwind. Prior work on fires' contributions to PM has largely focused on the primary particle emissions (particles formed immediately after combustion) assuming that these particles are nonvolatile and inert. However, once in the atmosphere, fire emissions are photochemically processed over a period of days. This processing includes dilution and partial evaporation of the emitted particles, and secondary organic aerosol (SOA) formation from the reactions of the VOCs and SVOCs emitted by the fire. SOA also results from the oxidation of organics that evaporate from the primary particles. Recent field and laboratory results suggest that SOA formed from fire emissions can increase total fire contributions to PM organic carbon (OC) by a factor of two or more. For example, source apportionment analysis in Yosemite indicates fire-derived SOA during aged (2-3 days) fire plume impact periods is estimated to be $\sim 3\text{-}4 \mu\text{g}/\text{m}^3$, a factor of 3-4 larger than the primary smoke carbon estimate (Engling et al. 2006). A study in the Atlanta area by Lee et al. (2008) found that half of $\text{PM}_{2.5}$ OC in a smoke plume was potentially SOA, representing a 1.5- to 6-fold enhancement of the primary smoke contribution. Recent lab work at CMU has demonstrated that photo-chemical aging of dilute smoke from residential wood fires (Grieshop et al. 2009) and simulated wildfires (Hennigan et al. 2011) can both produce substantial SOA. The measured SOA production in the smog chamber could not be explained solely by oxidation of recognized biogenic SOA precursors, such as the monoterpenes. Instead, a substantial fraction of SOA appears to be due to photo-oxidation of a complex mixture of low-volatility organic vapors that are poorly represented in existing fire emission inventories. Finally, laboratory experiments at CMU and elsewhere suggest that photo-oxidation may also decrease concentrations of levoglucosan, an important primary marker of biomass burning (Hennigan et al. 2010). This may cause receptor models to systematically underestimate contribution of fires to ambient $\text{PM}_{2.5}$ (Holden et al. 2011). All these results underline the importance of physico-chemical transformations of the fire emissions on the actual impact that these emissions have on PM levels in various receptors and the need to include them in the corresponding modeling tools used for impact assessment.

In the PMDETAIL study, we will provide these benefits and results:

- Quantify the impact of prescribed burns and other fires on 2002, 2008, and 2010 24-hour and annual average PM levels for monitored and unmonitored locations across the entire continental U.S. and use the national results to then select up to 30 "episode areas" as case study locations for more detailed analysis;
- Develop a 2010 fire emission inventory and chemical transport modeling database and model 2008 and 2010 fire impacts on PM concentrations using the regulatory version of CAMx;
- Develop research versions of 2008 and 2010 fire emission inventories for CAMx and PMCAMx ("CMU inventories") that include semi-volatile organic compounds (SVOCs) and levoglucosan in addition to traditional VOC and PM mass emissions;
- Develop a new module for the simulation of fire emissions in PMCAMx using the volatility basis set to account for gas particle partition and photo-oxidation and processing based on the recent FLAME-III laboratory experiments;
- Evaluate the performance of CAMx for 2008 and 2010 and revised PMCAMx for 2008 against both routine (e.g. IMPROVE and STN) and research-grade (levoglucosan and C^{14}) ambient data and inter-compare the predictions of the two CTMs for 2008;
- Develop and apply empirical data analysis approaches relating fire emissions to observed PM concentrations using the deterministic PM source apportionment modeling results;
- Investigate response of predicted PM with both CAMx and PMCAMx to changes in emissions found in alternate future scenarios of Wildfire-Rx Fire-Agricultural Fire activity and associated emissions mixes; and
- Develop a "PM exceedance vulnerability matrix" or PM-EVM that rank orders the potential impact of prescribed fire emissions by location in the continental U.S.

2. Project Objectives and Hypotheses

PMDETAIL proposal tasks and research objectives are directly aligned with the JFSP's RFA Task 8 objectives:

Quantify the contributions from prescribed fires to ambient levels of fine particulates using tools and procedures similar to those currently used by federal, state and local air agencies in developing State Implementation Plans (SIPs).

- Use a regulatory CTM (CAMx) to quantify contributions of prescribed burns and other fires to U.S. PM levels.

- Develop state-of-the-art fire emission inventories that include emissions of semi-volatile organic compounds and levoglucosan.

Modeling and analysis results must demonstrate their accuracy in comparison with fine particulate measurements from regulatory data (EPA and states) and other appropriate data sets.

- Compare and evaluate predictions of a regulatory and state-of-the-science CTM against a comprehensive set of routine (e.g. IMPROVE, CASTNet and STN/CSN) and research-grade (levoglucosan and C¹⁴) data.
- Perform source-resolved CTM simulations to evaluate the relative importance of primary and secondary organic aerosol from fires to ambient PM levels.
- Investigate the effects of levoglucosan oxidation on receptor model estimates of fire contributions to PM

Use results from the above analyses, ambient data, and any other available information to produce a ranked order of locations where prescribed fire emissions will have the greatest potential to challenge attainment and maintenance of anticipated new fine particulate standards.

- Develop a new module for the simulation of partitioning and chemical processing of fire emissions in CTMs.
- Utilize ambient data, deterministic modeling, and tested empirical analyses to develop quantitative data pertaining to prescribed and other fire emissions' potential to influence PM concentrations.
- Provide FLMs with technically accurate, policy-relevant, and timely materials to enable them to participate more fully in future PM SIP development.
- Leverage past engagement with FLMs in the West, and obtain new input from FLMs in the Southeast, to inform 3 future scenarios of projected prescribed and other fire activity.

We will test the following hypotheses to address critical technical and policy issues identified in RFA Topic 8:

Technical Hypotheses

- Accounting for gas-particle partitioning of primary organic aerosol will reduce the contribution of primary PM emissions from fires and will reduce the predicted near fire (within 25 km) PM levels.
- The major contribution of fires to ambient PM will be secondary organic aerosol.
- Oxidation of levoglucosan creates biases greater than a factor of 2 in existing chemical receptor model estimates of the contribution of fires to ambient PM levels.
- The updated regulatory and research CTMs (CAMx and PMCAMx) treating the fire PM emissions as semivolatile and reactive can simulate accurately the fire impacts on regional PM levels.

Policy Hypotheses

- Improved quantitative information about fire emissions' contribution to PM levels will allow fire managers to demonstrate the change in air quality resulting from smoke management programs (e.g., individual fire management methods, cumulative fires, emissions reduction techniques), and more effectively participate in air quality planning efforts to address PM nonattainment areas.
- Improved quantitative information will increase FLMs' understanding of spatial and temporal variation in fire emissions' contribution to elevated PM and accommodate more effective and timely involvement of FLMs in air quality planning processes.

II. Methods

1. Study Sites

PMDetail's technical deliverables and the online tool will be based on the analysis of case studies using ambient data and the results from simulations using two chemical transport models: CAMx, a photochemical modeling system widely used in State Implementation Plan (SIP) analyses for PM and ozone, and PMCAMx, a research grade version of CAMx. These case studies will be comprised of periods with elevated PM concentrations caused by prescribed and other fire emissions. The modeling will encompass 2002, 2008, and 2010 annual simulations of daily PM air quality across the entire continental U.S., with higher spatial resolution in western and southeastern U.S. The case studies will be selected from these 3 historic base years. For each of the 2008 case studies, modeling sensitivity studies of 3 alternate future scenarios, developed with extensive FLM input in the regional haze planning process, will be conducted and the results assessed to quantify the impacts of prescribed burns and other fires on the range of EPA PM standards.

2. Sampling Design

2.1 Fire Emission Inventories

Air Sciences will lead the fire inventory development with substantial input from other project participants. We will build upon DEASCO3 2002 and 2008 inventories in this study and leverage their development methodology to create a 2010 fire emission inventory. These inventories will be applied in annual photochemical modeling using the CAMx version routinely used for SIP and NEPA air quality studies —the goals and methodology of applying these base year and alternate future scenarios in the regulatory CAMx version are discussed in Section 2.2. The DEASCO3 methodology uses NOAA’s Hazard Mapping System (HMS), Monitoring Trends in Burn Severity data (MTBS) from the USFS’s Remote Sensing Applications Center, and WRAP’s Fire Emissions Tracking System (FETS) to create a database of daily, classified fire activity for 2008. We will extend this methodology to develop activity for 2010, and then calculate emissions for each of those years using an enhanced DEASCO3 method: a more robust plume rise algorithm will be selected and employed, and Python-CONSUME, developed by Michigan Tech Research Institute, will be used to calculate emissions. Python-CONSUME allows for use of customized emission factor profiles that are separable by region and/or vegetation classes (e.g. coniferous forest versus grassland). Unique emission factor profiles will be developed and used to calculate emission inventories. In particular, we will update emission profiles for important vegetation classes, incorporating recent data for PM and traditional SOA precursors e.g. (Akagi et al. 2011; Warneke et al. 2011). These standard fire inventories will be used in annual photochemical modeling using the CAMx version routinely used for SIP and NEPA air quality studies - the goals and methodology of applying these base year and alternate future scenarios in the regulatory CAMx version are discussed in Section 2.2.

We will also extend the 2008 inventory above to explicitly account for emissions of a) semivolatile organic emissions, and b) levoglucosan, an important marker for primary biomass PM emissions. The new emissions data will be derived by CMU based on analysis of smog chamber and emissions data from an ongoing JFSP project (09-1-03-1), other projects and published data. The SVOC emissions will be represented using the Volatility Basis Set (VBS) approach used by PMCAMx. These enhanced inventories are needed to simulate the gas-particle partitioning and photochemical aging of semi-volatile organics emitted by fires and other combustion sources. The goals and methodology of applying VBS using PMCAMx are discussed in Section 2.2. The basic approach will involve developing emissions data for different biomass classes, which will be fed into the Python-CONSUME emission inventory work by Air Sciences. For example, the levoglucosan inventory will be based on the work of Munchak et al. (2011) which combined emissions data measured at the Fire Science Laboratory for different types of biomass with a fuel bed model to create spatially variable maps of smoke markers 1 x 1 km emission ratio maps for the conterminous United States. The emission ratios from Munchak et al. (2011) will be combined with PM emission estimates from Air Sciences to create a levoglucosan emission inventory for fires. We will also extend the analysis of Munchak et al. (2011) to include residential wood combustion. A similar approach will be taken to incorporate VBS emissions into the model. Using data collected during FLAME-III (2011) and other projects we are developing volatility distributions and emission factors for SVOC for different types of biomass types. (Akagi et al. 2011; Warneke et al. 2011) Other inputs for the CTM work (meteorological modeling and emissions from non-fire source categories) will leverage 2002 modeling for Regional Haze for the southeast (VISTAS¹) and western (WRAP²) U.S., the 2008 WestJumpAQMS project³, and will be based on new 2010 modeling work. We will use a 36 km continental U.S. domain and 12 km domains in the western and southeast U.S.

To develop alternate future emissions scenarios, we will apply future scenarios of Wildfire, Prescribed Fire, and Agricultural Fire activity to the 2008 inventory using the methodology in [Development of 2000-04 Baseline Period and 2018 Projection Year Emission Inventories](#) . We will create the future scenarios by averaging fire activity for the period 2001 through 2010 by state and fire type to generate the scalars and then apply those averages to the 2008 DEASCO3 fire inventory. The result will be 3 base fire inventories (2002, 2008, and 2010) and 3 alternate future fire inventory scenarios based on 2008 fire locations and dates. The previous work by WGA to develop 3

¹ <http://www.vistas-sesarm.org/>

² <http://www.wrapair2.org/>

³ http://www.wrapair2.org/pdf/WestJumpAQMS_Modeling_Plan_Sep30_2011v2.pdf

future year scenarios relied on significant input from FLMs. We will leverage this prior work as well as engage FLMs in the southeastern United States to refine the previously defined 3 scenarios. Additional improvements may also be made to agricultural projections based on known changes in regulations (e.g., Oregon).

2.2 Chemical Transport Modeling

ENVIRON will perform CAMx modeling with the version routinely applied in SIP and NEPA air quality studies for the 2002, 2008, and 2010 historic year inventories and the three (3) alternate future inventory scenarios based on 2008 meteorology and non-fire emissions to assist in selection of case studies as requested in the RFA. This will provide an assessment using existing regulatory type tools. The standard regulatory version of CAMx uses a SOA module that treats SOA formation from VOCs using several condensable gases (CG) and SOA pairs (CG/SOA) with different volatility properties. Based on thermodynamic and other factors, the CG/SOA pairs are in equilibrium, and can transfer between gaseous and particle phases. We will apply CAMx version with the PM Source Apportionment Technology (PSAT) to separately track the contributions of PM concentrations due to three types of fires: prescribed burns, wildfires and agricultural burning. Based on these annual runs, approximately 30 case study episodes when fires (most notably prescribed burns) contribute to elevated PM concentrations will be identified. These case studies will be used in developing the empirical fire PM assessment tool described in Section 2.3.

In addition to the regulatory type modeling performed with CAMx, CMU will perform research-grade modeling using PMCAMx to better simulate the atmospheric evolution of the fire emissions and their ultimate contribution to ambient PM. The motivation for this additional research grade modeling are field and laboratory studies that indicate that traditional SOA models of the type used in the regulatory version of CAMx appeared to severely underpredict the SOA production from fire emissions (Lee et al. 2008; Grieshop et al. 2009; Hennigan et al. 2011). Much of the unexplained SOA appears due to the photo-oxidation of SVOCs not accounted for in traditional models and inventories (Grieshop et al. 2009). PMCAMx uses the volatility basis set to simulate organic aerosol concentrations (both primary and secondary). The goals of the VBS are to include emissions of all low-volatility organics in the model, to simulate the dynamic gas-particle partitioning of the primary and secondary organic aerosol, and to allow for efficient treatment of multi-generational SOA chemistry. The VBS is a semi-empirical framework based on absorptive partitioning theory. The VBS lumps low-volatility organics into a set of “volatility bins” according to their vapor pressures. It also uses a volatility-based chemical mechanism to simulate multiple generations of SOA chemistry. To implement the VBS one needs emission factors and volatility distributions for SVOC emissions; these are derived from the gas-particle partitioning data and sorbent samples (Grieshop et al. 2009). One also needs the chemical mechanism, which are derived from smog chamber data (Grieshop et al. 2009). As part of an ongoing JFSP project ([09-1-03-1](#)), CMU has collected volatility-resolved emissions data and conducted smog chamber studies for simulated open burns with a variety of North American wildland fuels (Hennigan et al. 2011). As part of that project, we are also conducting similar experiments with agricultural residues. Finally, CMU has previously conducted similar experiments with residential wood smoke (Grieshop et al. 2009). Therefore, a reasonable database is available to develop inputs (emissions and chemistry) required for the VBS mechanism to simulate the atmospheric evolution of fire emissions. We have developed VBS parameterization (emissions and chemistry data) for the residential wood smoke data and have begun developing them as part of [09-1-03-1](#) for the wild land fire experiments for box and plume-model applications. In this project, we will refine these parameterizations for use in PMCAMx and other CTMs. Levoglucosan will also be tracked separately in the model following the approach of Roy et al. (2010) using published laboratory kinetic data (Hennigan et al. 2010, 2011). These parameterizations will create new version of PMCAMx to:

- Perform simulations for 2008 separately tracking emissions from different fire sources (prescribed burns, wildfires, residential combustion, agricultural).
- Predict ambient levoglucosan concentrations with and without oxidation for selected periods (summer, winter, spring/autumn) during 2008.
- Evaluate PMCAMx predictions with standard network (IMPROVE and STN) and research (levoglucosan, C¹⁴, AMS and WSOC) data.
- Investigate response of PM_{2.5} to changes in emissions found in alternate future scenarios of Wildfire-Rx Fire-Agricultural Fire activity and associated emissions mixes as described in Section 2.1, for 2008.

A detailed intercomparison of the predictions of CAMx and PMCAMx will be performed for 2008 to quantify the effects of semi-volatile emissions and aging (represented with the VBS) on model performance but also on the impacts of fire emissions on ambient PM levels. In addition, we will also apply the CAMx option that uses a VBS SOA module (the PMCAMx VBS is more advanced) for selected 2008 periods using the enhanced CMU fire emission inventory. This CAMx option has several basis sets of varying volatility CG/SOA pairs and as the VBS species react they cascade from the more to less volatile until they are in the particle phase. Comparison of the three different models (regulatory CAMx, PMCAMx, VBS CAMx) will provide for the 2008 periods will provide a clear signal of the changes in PM and SOA due to the enhanced scientific treatment of fires.

2.3 Empirical Assessment Approach

The empirical assessment is intended to derive case studies as identified in the RFA. To first address the regulatory analysis identified in the RFA, we will independently evaluate temporal and spatial patterns and PM densities predicted by CAMx modeling and fire occurrence data. We will evaluate the fire source contribution estimated by CAMx its PM Source Apportionment Tool (PSAT) for each historic year. We will use 2002, 2008, and 2010 observed every 3rd day IMPROVE and STN PM_{2.5} concentrations and available sources of fire incident and emissions data (e.g., MODIS, FETS, others) along with available meteorological data to identify instances and locations when emissions from fires have likely contributed to elevated PM concentrations. Other, experiential understandings of Team members will also be used to identify areas of interest for the empirical studies. Examples may include: 1) focus on fire “hot spots” like the southeastern U.S. for Rx and western U.S. for Rx, agricultural, and WF; 2) focus on sylvan areas upwind of (urban or small population center) PM hot spots with high incidence of WF, agricultural, and/or Rx fire; 3) include areas presumed to be high PM areas but with no current PM monitoring data; and 4) review available sources of other pollutants (e.g., ozone precursors) that indicate the presence of emissions due to fire (e.g., NO₂, CO, etc.). We will also analyze and compare CAMx and PMCAMx results for 2008 case study periods to quantify the effects of semivolatile emissions and aging (represented with VBS) on model performance, as well as quantifying the contribution of prescribed burns and other fires to PM levels in the U.S. with PMCAMx results. Therefore, these assessments will evaluate monitored and unmonitored areas in the continental U.S. Using these analyses, we will select approximately 10 case studies (episode areas) west of the 100th meridian and in the southeast for each historic year, for a total of up to 30. Selection of case studies will address seasonal variation and account for locations with annual PM levels strongly affected by episodic fire activity. We will evaluate the 2008 alternate future scenarios’ CAMx PSAT results in combination with the simulated emissions patterns in these scenarios to develop bounding estimates of the effects at the 2008 episode areas. Using all these assessments, we will construct and deliver the PM exceedance vulnerability matrix (PM-EVM) based on case studies and variation in PM impacts from the 3 historic years and 2008 alternate future scenarios. This matrix will be implemented as web display tool with graphical outputs and “data selected” tables.

3. Field Measurements – No new field measurements will be made for this project. We do require large datasets for model evaluation (e.g. IMPROVE and STN data). In particular we need levoglucosan data to evaluate the primary biomass smoke inventories. Although there are a number of large levoglucosan datasets available e.g. (Zhang et al. 2010), none of them are available for any of the study years (2002, 2008, and 2010). Therefore, we propose to analyze two months of archived one-in-three samples from 40 sites to build up a database for levoglucosan. As part of this work, CSU will perform the retrospective levoglucosan analyses of archived EPA FRM filter samples using previously developed approaches (Sullivan et al. 2011). In addition, with in-kind support the NPS will further evaluate measuring levoglucosan from IMPROVE samples, and if successful, will analyze 100-300 samples which would be included in the model evaluation. The project will also involve significant integration of results from the series of FLAME experiments to update emission inventory and photochemical modeling portions of this study.

4. Data Analysis

As in the DEASCO3 project, a distinctive strength of the PMDETAIL Team is the combined expertise of consulting firms, FLM collaborators, academics. During the execution of every major technical task we will execute two important steps to promote excellent deliverables: 1) technical results will be deliberately organized and data will be carefully designed to promote effective review and interpretation, and 2) Task Teams (e.g., Emissions, Modeling, Empirical Assessment, Data Analysis) formed from PMDETAIL Team members (and,

likely, other interested experts/stakeholders) will convene to review and interpret data and develop findings. The PMDETAIL Team’s model for executing the technical work of each major task will be: Data Gathering ⇔ Execute Technical Work ⇔ QA/QC ⇔ Organize/Present Data ⇔ Review/Interpret ⇔ Develop Findings/Lessons-Learned ⇔ Build Final Deliverables ⇔ Document.

For the 30 “episode area” case studies selected from the empirical assessment to characterize fire’s contribution across a wide geographic area of the continental U.S., we will review the commonalities, differences, and representativeness of the cases. For this suite of case studies, we intend to publish fire emissions inventories’ data and results from regulatory and PMCAMx modeling platforms, in the form of technical products (e.g., maps, charts, tables, probability functions, et cetera) and will construct and deliver a “PM exceedance vulnerability matrix” (PM-EVM) that will be deployed as a PMDETAIL on-line tool, to enable FLMs to evaluate future real-world decisions about prescribed burning and effects on air quality, analogous to situations that FLMs will encounter in the future.

5. Materials

The table below presents data sources and software to be used in the PMDETAIL project. Data sources and software for use are either publicly-available or already belong to Team members. PMDETAIL deliverables will not be encumbered by software licensing fees or use-limiting intellectual property agreements.

Item	Description	Location	Method to Acquire
Emissions Inventories			
All RPO Wildfire Emissions Inventory		Public Doman	Team already has
WRAP 2002 All Fire EI	Episodic fire emissions: WF, RX, Ag.	Public Doman	Team already has
CENRAP 2002 Fire EI	Episodic fire emissions: WF, RX, Ag.	Public Doman	Team already has
MRPO, VISTAS, MANEVU 2002 Fire EIs	Episodic 2002 fire emissions	Public Doman	Team already has
Reported 2008 and 2010 Fire Incidents	Daily 2008 and 2010 <i>reported</i> fire occurrence from Smoke Mgmt. Programs, Federal Agencies, and Tribes	FETS; SLTs	Team has WRAP & Federal data & potential sources list for state data outside the West (e.g., FL).
HMS-based 2008 and 2010 Daily Fire Incident detections		Public Domain	Team already has
MODIS top-town Fire EI	Daily 2008 and 2010 fire missions global coverage at 1 km ²	NCAR	Team already has
GIS data to support 2008 and 2010 bottom-up EI	land use, ownership, MTBS perimeters & mosaics, MODIS Veg. Health, Daily Natl. Rainfall, LANDFIRE FCCS	Public Domain	Team already has
2002 Meteorological Data	2002 36 km MM5 CONUS WRAP 2002 12 km West US WRAP 2002 12 km East US VISTAS	Public Domain	Team already has
2008 and 2010 WRF Meteorological Data	2008 4km and 12 km CONUS EPA	WestJumpAQMS and BLM	Team already has/will provide
Modeling Software / Extensions			
CAMx/APCA	www.camx.com	Public Domain	Team already has
PMCAMx		Public Domain	Team already has
Online tool development software	Database server, web application development environment, needed data	N/A	Will all be open-source. Will obtain based on chosen hosting
Hosting Services	Third-party IT service to host database and web servers for the online tool.	N/A	Use Fire Emissions Tracking System (FETS) service.

III. Project Duration and Timeline

This project will last 3 years, assuming a start date of August 1, 2012, with completion in July 2015.

Project Milestone	Delivery Dates (end of)
2002 emission inventory ready for CTM	September 2012
2002 CTM complete	November 2012
2002 Empirical Analysis complete	January 2013
2008 DEASCO3 and CMU emission inventories and alternate future scenarios ready for CTM	April 2013

2008 CTM complete	July 2013
2008 Empirical Analysis complete	October 2013
2010 DEASCO3 and CMU emission inventories ready for CTM	December 2013
2010 CTM complete	February 2014
2010 Empirical Analysis complete	May 2014
Cross-cutting analysis/assessment of 3 years and selection of Case Studies	August 2014
Compile and release regulatory results for 3 years and 2008 alternate scenarios via Online Tool	October 2014
2008 PMCAMx CTM	Spring through Summer 2014
Analyses of 2008 Case Studies - Receptor Modeling, PMCAMx, and filter laboratory results	Fall 2014
Compile and release research results for 2008 case studies via Online Tool	Spring 2015
Project Report (draft and final) and manuscript(s) submitted to refereed publication(s)	Summer 2015

IV. Project Compliance - NEPA and other clearances – Not Applicable.

V. Research Linkage

The PMDETAIL Team recognizes and appreciates the JFSP’s continued significant investment in the advancement of wildland fire science. The PMDETAIL project will leverage and coalesce the projects listed below to address the issues in Topic 8, using both already-completed studies and other studies currently underway. For the modeling, both CAMx and PMCAMx will be fully integrated with the DEASCO3 and the WestJumpAQMS projects. The WestJumpAQMS project will assess regional air pollution transport and source contributions for Ozone and related air quality indicators in support of air quality planning by western states, using emissions, meteorological, and air quality modeling tools, source apportionment methods, and data analysis techniques. The project is currently underway, sponsored by western state air agencies, EPA, federal land managers, and private industry, to be completed Summer 2012. Also, as an input to modeling work in PMDETAIL, DEASCO3, and WestJumpAQMS, WGA is completing a Biogenic Emission Inventory Improvement study for WESTAR Council. The Southeastern States Air Resource Managers has a similar regional Ozone, PM_{2.5}, and regional haze air quality analysis and planning support ([SEMAP](#)) project underway. Results from PMDETAIL will be shared with the SEMAP project to advance air quality analysis and planning in the southeastern U.S. and with U.S. EPA Office of Air Quality Planning and Standards’ (OAQPS) Modeling Group.

Grant Program	Project or Proposal Description/Identification	Funding Amount	Project Completion Date
JFSP Project 11-1-6-6	DEASCO3 - Deterministic and Empirical Assessment of Smoke’s Contribution to Ozone.	\$370,000	April 2013
JFSP Project 09-1-03-1	Experimental Determination of Secondary Organic Aerosol Production from Biomass Combustion.	\$621,750	July 2012
Federal and State Agencies, Private Industry	WestJumpAQMS - Modeling and Analysis of Regional Ozone and Related Air Quality Indicators.	\$725,000+	Summer 2012
WESTAR Council	Biogenic Emissions Inventory Improvement.	\$130,000	Winter 2011-12
JFSP Project 05-3-1-06	Characterizing PM Emissions by Wildland Fires Relevant to Visibility Impairment & PM Nonattainment.	\$749,608	November 2009
JFSP Project 05-3-1-04	Hybrid Source Apportionment Model: An Operational Tool to Distinguish Wildfires Emissions from Prescribed Fire Emissions to Measurements of PM _{2.5} for Use in Visibility and PM Regulatory Programs.	\$439,737	August 2009

VI. Deliverables and Science Delivery

We will deliver innovative and useful technical products in the form of a quantitative assessment of prescribed and other fire types’ effect on likely PM standards, both 24-hour and annual average for each of 3 historic years and 2008 alternate future scenarios. This assessment will rank fire contributions by locations. The planned PM exceedance vulnerability matrix will enable FLMs to evaluate future real-world decisions about prescribed burning and effects on air quality. These deliverables will bring well-organized and presented wildland fire occurrence, emissions,

modeling results, and source attribution information together for FLMs to query, review, and produce reports. Always-on, web-based, secure access will be an effective and efficient way to transfer data, analytical tools, and findings of the project to field managers and other end users. Other PMDETAIL deliverables include: 1) essential documentation explaining data sources, technical methods, QA/QC, results, data interpretation, and assessments of uncertainty (or other potential limitations to the technical work and findings); 2) updated fire emissions and photochemistry modules for use in chemical transport modeling systems; 3) multiple manuscripts for publication in a refereed journals and presentations at technical conferences; 4) online tools and a webinar session to orient and train FLMs and other potential users/reviewers of reports generated by the tools; and 5) an annual progress report delivered one year after the start month; and 6) a 10-20 page final report that presents the major methodologies of the project, describes significant findings, presents analysis and assessment findings of fire’s impact on historic and future scenarios and describes the potential to exceed the levels of the likely PM standards, and identifies ways that the results and online tools could be effectively used in air quality planning processes.

Deliverable, Description, and Delivery Dates

Deliverable Type	Description	Delivery Dates
Updated FETS Website	Empirical analysis results for 2002, 2008, and 2010	Jan./Oct. 2013, May 2014
Online tools	Regulatory analysis/assessment results with case studies	October 2014
Training session	Webinar-style training to FLMs on use of online PMDETAIL tools	December 2014
Data and Results	Add research analysis/assessment results	Spring 2015
Report	Essential documentation & project summary report to JFSP	Summer 2015
Refereed publication(s)	Summary of methodology & findings of PMDETAIL submitted	

VII. Roles of Investigators and Associated Personnel

The PMDETAIL project includes the members of the experienced and well-qualified members of the DEASCO3 project team, while adding academic researchers with significant research and publication records with the JFSP. As in DEASCO3, Tom Moore will serve as Principal Investigator to coordinate and manage the project. In support of air quality planning to comply with CAA requirements, he has significant experience with large-scale air quality data analysis/assessment projects and detailed knowledge of fire emissions and applications of PGM results, and he has led projects to develop and deliver well-regarded web database tools for state air agency and FLMs’ use, through the Regional Haze planning process. We have experienced and well-regarded key technical contractor personnel assigned to technical analysis and work product delivery activities for fire emissions and empirical analyses and tools (David Randall) as well as PM and ozone photochemical grid modeling and source apportionment (Ralph Morris). Both technical contractors have performed comprehensive SIP-quality analyses under Mr. Moore’s direction in support of state air quality implementation plans, within specified time frames and limited resources. Further, Mr. Moore has project coordination experience with researchers at universities and academic institutes in the regional air quality analysis and planning process for regional haze. In this study, Professors Allen Robinson and Spyros Pandis from Carnegie-Mellon University and Professor Jeff Collett and research scientist Amy Sullivan from Colorado State University have been added to the project team. Dr. Robinson expertise is in atmospheric transformation of emissions from fires and other combustion processes; Dr. Pandis is internationally recognized expert in secondary organic aerosol and chemical transport modeling. Dr. Collett and Dr. Sullivan have worked together on a number of projects, sponsored by the Joint Fire Science Program, LADCO, Environmental Protection Agency, and National Park Service, that examine the impacts of biomass burning on ambient air quality.

The PMDETAIL project team also includes the strong team of FLM collaborators from the DEASCO3 project with extensive experience in and current responsibility for air quality resource protection to span the entire project scope, engage in analysis and review activities, assure analysis work is solid, and see that results are delivered in FLM-ready format and level of detail. Mark Fitch has extensive experience with fire activity and emissions through his career with a state air agency smoke management program, with a USFS regional office in a similar capacity, and now with the NPS at NIFC. Significant experience with CTM applications for air quality issues affecting national parks from fire and other sources is contributed by Michael Barna of NPS as well as by Bret Anderson, now of USFS through his previous career with U.S. EPA. With respect to interpreting technical results for FLM use in SIP air quality planning processes and evaluation of exceptional events, Michael George and John Vimont of NPS, and Ann Acheson of USFS bring strong technical and management backgrounds to this project from their tenures as state air agency and EPA

regional office regulators, and NPS and USFS smoke management and air resource protection programs, respectively, with their current responsibilities for air resource protection, planning, and policy analysis.

VIII. Literature Cited

- Air Sciences. July 2005. 2002 Phase II Fire Emission Inventory for WRAP Region. Air Sciences Golden, CO.
- Air Sciences/EC/R. May 2005. Inter-RPO 2002 National Wildfire Emission Inventory. Air Sciences, Golden, CO.
- Air Sciences/EC/R. May 2007. Development of 2000-04 Baseline Period and 2018 Projection Year Emission Inventories. Air Sciences. Golden, CO.
- Akagi, S. K., R. J. Yokelson, C. Wiedinmyer, M. J. Alvarado, J. S. Reid, T. Karl, J. D. Crouse and P. O. Wennberg (2011). "Emission factors for open and domestic biomass burning for use in atmospheric models." Atmospheric Chemistry and Physics **11**(9): 4039-4072.
- Engling, G., P. Herckes, S. M. Kreidenweis, W. C. Malm and J. L. Collett Jr (2006). "Composition of the fine organic aerosol in Yosemite National Park during the 2002 Yosemite Aerosol Characterization Study." Atmospheric Environment **40**(16): 2959-2972.
- ENVIRON. 2010. Users Guide to the Comprehensive Air-quality Model with extensions (CAMx) – Version 5.3. ENVIRON International Corporation, Novato, CA.
- EPA. 2007. Guidance on Use of Models and Other Analyses for Demonstrating Attainment of Air Quality Goals for Ozone, PM_{2.5} and Regional Haze. U.S. EPA, Research Triangle Park, NC. EPA-454/B-07-002. April.
- Grieshop, A. P., J. M. Logue, N. M. Donahue and A. L. Robinson (2009). "Laboratory investigation of photochemical oxidation of organic aerosol from wood fires 1: Measurement and simulation of organic aerosol evolution." Atmospheric Chemistry and Physics **9**: 1263-1277.
- Grieshop, A. P., M. A. Miracolo, N. M. Donahue and A. L. Robinson (2009). "Constraining the Volatility Distribution and Gas-Particle Partitioning of Combustion Aerosols Using Isothermal Dilution and Thermogravimetric Measurements." Environmental Science & Technology **43**(13): 4750-4756.
- Hennigan, C. J., M. A. Miracolo, G. J. Engelhart, A. A. May, A. A. Presto, T. Lee, A. P. Sullivan, G. R. McMeeking, H. Coe, C. E. Wold, W. M. Hao, J. B. Gilman, W. C. Kuster, J. de Gouw, B. A. Schichtel, J. J. L. Collett, S. M. Kreidenweis and A. L. Robinson (2011). "Chemical and physical transformations of organic aerosol from the photo-oxidation of open biomass burning emissions in an environmental chamber." Atmospheric Chemistry and Physics **11**(15): 7669-7686.
- Hennigan, C. J., A. P. Sullivan, J. L. Collett, Jr. and A. L. Robinson (2010). "Levoglucosan stability in biomass burning particles exposed to hydroxyl radicals." Geophysical Research Letters **37**(9): L09806.
- Holden, A. S., A. P. Sullivan, L. A. Munchak, S. M. Kreidenweis, B. A. Schichtel, W. C. Malm and J. L. Collett Jr (2011). "Determining contributions of biomass burning and other sources to fine particle contemporary carbon in the western United States." Atmospheric Environment **45**(11): 1986-1993.
- Lee, S., H. K. Kim, B. Yan, C. E. Cobb, C. Hennigan, S. Nichols, M. Chamber, E. S. Edgerton, J. J. Jansen, Y. T. Hu, M. Zheng, R. J. Weber and A. G. Russell (2008). "Diagnosis of aged prescribed burning plumes impacting an urban area." Environmental Science & Technology **42**(5): 1438-1444.
- Moore, T. and Brewer, P. 2007. Regional Haze Planning in the Western and Southeastern United States. *Environmental Manager*, Air & Waste Management Association; September.
- Munchak, L. A., B. A. Schichtel, A. P. Sullivan, A. S. Holden, S. M. Kreidenweis, W. C. Malm and J. L. Collett Jr (2011). "Development of wildland fire particulate smoke marker to organic carbon emission ratios for the conterminous United States." Atmospheric Environment **45**(2): 395-403.
- Sullivan, A. P., N. Frank, G. Onstad, C. D. Simpson and J. L. Collett, Jr. (2011). "Application of high-performance anion-exchange chromatography-pulsed amperometric detection for measuring carbohydrates in routine daily filter samples collected by a national network: 1. Determination of the impact of biomass burning in the upper Midwest." Journal of Geophysical Research **116**(D8): D08302.
- UNC. 2009. Peer Review of Source Apportionment Tools in CAMx and CMAQ. University of North Carolina, Institute for the Environment, Chapel Hill, North Carolina. August 31.
- Warneke, C., J. M. Roberts, P. Veres, J. Gilman, W. C. Kuster, I. Burling, R. Yokelson and J. A. de Gouw (2011). "VOC identification and inter-comparison from laboratory biomass burning using PTR-MS and PIT-MS." International Journal of Mass Spectrometry **303**(1): 6-14.
- Wiedinmyer, C. 2006. Estimating emissions from fires in North America for air quality modeling. *Atmos. Env.*, 40
- Zhang, X., A. Hecobian, M. Zheng, N. H. Frank and R. J. Weber (2010). "Biomass burning impact on PM 2.5 over the southeastern US during 2007: integrating chemically speciated FRM filter measurements, MODIS fire counts and PMF analysis." Atmospheric Chemistry and Physics **10**(14): 6839-6853.