Regulatory Needs for Smoke Management

Background

Management of emissions from fire activities (hereto referred as smoke) has both operational and regulatory needs. Short timeframe operational needs include determining suitable times for prescribed burning and the impact of the resulting smoke on neighboring communities and often require near-real-time information. Longer timeframe air quality regulatory needs involve determining the impact of smoke on regulated pollutants and air quality related values (AQRV). Regulatory assessment of smoke involves retrospective analyses to assess the actual impact of smoke on AQRV and prospective analyses to assess the potential impact of smoke under various emission control scenarios. The operational needs of smoke managers have received extensive attention and led to development and implementation of tools. However, the regulatory needs have received little attention. The following discusses smoke management needs from a long timeframe regulatory perspective.

U.S. air quality regulations include the National Ambient Air Quality Standards (NAAQS), which are set by the Environmental Protection Agency for pollutants considered harmful to public health and the environment. The primary NAAQS set limits to protect public health, while the secondary NAAQS set limits to protect the public welfare, including visibility and ecosystems. Fire can contribute significantly to fine particulate matter (PM) and ozone, causing nonattainment violations of both primary and secondary NAAQS levels in communities and regions throughout the United States. These regulations set limits on the concentrations allowed for hourly, daily, and annual average values. Smoke also contributes to haze in our national parks and wilderness areas, collectively known as Class I areas (CIA). Haze in CIAs is regulated via the Regional Haze Rule (RHR), which requires each state to set “reasonable progress” goals to return visibility to natural conditions on the 20% haziest days by 2064 while preventing further degradation of visibility on the 20% best haze days. The progress towards the RHR goals is tracked using 5-year average values. Fire-related emissions also contain substantial amounts of reactive nitrogen, and it is anticipated that at some time in the future there will be a secondary total reactive nitrogen deposition NAAQS standard.

The PM and ozone NAAQS are violated at a number of communities, and virtually all CIAs have haze above the natural background levels. Therefore, state and federal organizations need to develop and implement plans and programs to reduce and manage the emissions that cause the unhealthy air quality throughout the United States and haze in the CIAs. Central to any meaningful implementation plan is an understanding of which sources contribute to these pollutants. It is known that smoke can significantly contribute to the carbonaceous fraction of fine PM, haze, and ozone, particularly in the western and southeastern United States. The NAAQS and RHR regulations depend on daily and annual air quality metrics; thus it is necessary to understand the contribution of smoke and other sources’ pollutants on individual days throughout the year. However, current monitoring and modeling technologies are not capable of routinely apportioning or separating out smoke from other emissions, much less apportioning effects between smoke types such as wild versus prescribed fire.

Problem

One of the primary difficulties in apportioning smoke to various observed effects is that often more than 50% of the smoke particulate mass is secondary organic aerosol (SOA), i.e., particulates formed in the atmosphere from emitted organic gases. These SOAs are identical in composition to SOA formed from gases emitted by plant respiration. Vegetative SOA is especially prevalent in the southeastern and northwestern United States where fire activity is also high. Furthermore, the role of organic gases is an important contributor to fine PM and ozone NAAQS in areas where these standards are violated. The emissions of SOA precursors and formation processes in the atmosphere are still poorly understood, and modeling techniques have unacceptably large errors. Apportioning carbon aerosols related to urban activity is further complicated by the fact that there are potentially large contributions of carbonaceous PM from a wide variety of sources, including mobile sources, cooking, shipping, road dust, and industry.

The RHR requires that a clear distinction between natural and anthropogenic sources of haze be made as well as identification of the amount and type of haze caused by natural and international sources that cannot be controlled. Haze from smoke arises from natural fires (wildfire and wildland natural fires (WFU)) and human-caused fires including prescribed, agricultural, and residential wood burning both inside and outside the United States. Understanding the relative contribution of natural and anthropogenically-caused fires on a temporal and spatial scale is essential for states to track progress in their individual haze implementation plans for improving visibility in CIAs, which is required under the RHR.

Currently, wildfire, on the average, accounts for the majority of smoke emissions in the western United States; anthropogenic fires tend to occur in different seasons and geographic locations from wildfires and can significantly contribute to haze on both best and worst haze days. Wildfires occur most often across the warmest months across the United States, while in the West, prescribed and agricultural fires occur most often in the cooler spring, fall, and winter months, when and where wildfire activity is less. Haze from non-fire related sources is often lower during the winter months and the winter prescribed fires can diminish visibility on what would otherwise be some of the clearest days of the year.

Significant smoke concentrations from residential wood burning also tend to occur in population centers during cold months and these emissions can be transported to nearby CIAs. In the southeastern United States prescribed fires are set throughout the region typically from October – April, with wildfires in the Southeast occurring less frequently. Therefore, in the southeast smoke from prescribed fire emissions are generally larger than from wildfire. Last, smoke management plans anticipate that in the future prescribed fire will significantly increase to the degree that resources are not being consumed suppressing wildfire, increasing the possibility of reducing the occurrence of and emissions from wildfires and WFU management practices, providing further opportunities to manage fire-related activities, reducing the impact of smoke on human health, visibility, and ecosystems.

Without the measurement and analysis tools to properly separate carbonaceous material associated with smoke emissions from carbonaceous aerosol associated with vegetative SOA and other sources, emissions from fire management practices will be misidentified as the cause of haze and nonattainment violations of the PM and ozone standards. This can cause states to implement smoke mitigation strategies that do not appreciably assist or affect the federally required attainment of PM and ozone standards and progress toward improving haze conditions in parks and wilderness areas. Similarly, not properly separating the natural, anthropogenic, and trans-boundary sources of fire emissions could cause inappropriate implementation of smoke management policies that do not have the desired effect and at the same time adversely affect smoke management practices.

RFP Need

As required by the RHR and NAAQS, assessment of actual contributions of various fire management practices to PM, ozone, visibility, and reactive nitrogen (deposition) retrospectively can only be done by developing receptor/hybrid models for an integrated assessment of smoke contributions. This is because the required knowledge of emitted gas and particle species and aerosol chemistry formation processes to successfully exercise deterministic models for the apportionment of organic aerosols or other chemical species is not currently available and will not be in the foreseeable future (10-year timeframe). Development of a receptor/hybrid model will require a number of field programs to measure the appropriate tracer species and chemical and physical characteristics of both primary and secondary aerosols and gases as a function of fire and fuel type. The technology to cost-effectively and quantitatively measure many of these species has already been developed. The receptor/hybrid modeling approach must be further developed to combine these measurements with conservative and/or chemical dispersion model predictions to 1) separate fire-related carbonaceous material and gases from all other sources; 2) apportion the fire-related aerosols retrospectively to various fire types such as wildland, prescribed, agricultural, and residential fire emissions; and 3) estimate ranges of air quality impacts of various source types at 5- and 10-year future time scales.