Western Regional Air Partnership

Monitoring Data & Glide Path Summary Document

2018 Work Summary Document

WRAP Monitoring Data & Glide Path Subcommittee
February 27, 2019

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Purpose

The overall purpose of the Monitoring Data and Glide Path Subcommittee (MDGPS) is to develop tools and protocols for the western states to use in Regional Haze State Implementation Plans (SIPs) creation, through in-kind work or contract services, that:

1. Determine the method for identifying Most Impaired Days (MID) in the West, with emphasis on methods to identify contributions to impairment from routine natural emissions and extreme episodic events (e3), such as wildfires, dust storms, volcanoes, and other uncontrollable and unpredictable natural events;
2. Using the MID metric, evaluate the EPA default approach and alternative methods to recommend a protocol for recalculating the Baseline Period (2000-2004) MID average impairment (in deciviews) as the new start point for the Glide Path to achieving Natural Conditions by 2064;
3. Using the most impaired days metric, evaluate the EPA default approach and alternative methods to recommend a protocol for calculating an updated Natural Conditions (2064 endpoint) in deciviews to redraw the Glide Path from the baseline (2000-2004) to the new 2064 endpoint; and
4. Determine a methodology for adjusting the uniform rate of progress to account for the impacts of prescribed fires[1] and international emissions.

This will enable states to calculate the Uniform Rate of Progress (the slope of the Glide Path) at each of their IMPROVE monitors for SIP documentation purposes under Section 51.308(d)(1)(i)(B) of the January 10, 2017 revised Regional Haze Rule. This document provides general information related to the monitoring data tracking metric as well as work performed by the MDGPS during 2018 and recommendations to western States for processing IMPROVE monitoring datasets. The information presented in this document attempts to address the first three items from the list above. However, additional work in 2019 is needed to: 1) finalize IMPROVE monitoring data substitution procedures, 2) provide recommendations on the uniform rate of progress adjustment to account for the impacts of prescribed fires and international emissions, and 3) determine what improvements to EPA's natural conditions estimates can be made to increase accuracy for future planning periods.

This document contains five broad topics. These topics present a general overview of the monitoring data network and tracking metric, describe EPA's approach for isolating anthropogenic visibility impairment, discuss the MDGPS approach to testing EPA's tracking metric approach, provide alternative approaches to the preferred tracking metric approach, and outline previously completed and remaining Subcommittee coordination needs to complete the remaining Subcommittee tasks. These topics are listed below and further description is provided in subsequent chapters of this document. The five topics include:

- **Background**
- **Natural Haze vs Anthropogenic Impairment vs Uncontrollable Sources**
- **Most Impaired Days Metric Analysis**
- **Alternatives to EPA's Most Impaired Days Metric**
- **Subcommittee Coordination**

[1] EPA's e3 threshold does not distinguish between carbon from wildfires vs carbon from prescribed fire. The intent, however, is that the e3 threshold should eliminate the carbon from wildfires. Since prescribed fire emissions are typically much lower than wildfire emissions and are of shorter duration and acreage consumed, it is assumed that the e3 threshold will likely not remove the carbon from prescribed fires in most states. States will need to confirm this, based on the spatial and temporal analysis of prescribed fires in their respective state. EPA allows prescribed fire impairment to be used to adjust the 2064 endpoint. The questions regarding how to handle prescribed fires relate to quantification and will need to be answered in conjunction with work of the Fire and Smoke Work Group and the Modeling/Emissions Inventory Subcommittee.

Please note that the Subcommittee will continue to pursue additional resolutions to some of the topics listed above. As these resolutions are finalized, the Subcommittee will finalize the findings in subsequent white papers.

For the description of tasks assigned to this work group, please see Appendix B, pp. 52-53 – from the WRAP 2018-2019 Work Plan.

Background

Background and Methods for the Revised Visibility Tracking Metric

Regional haze is caused by air pollutants that absorb or scatter light, thereby reducing visual range and causing a loss of color, contrast, and detail in visual landscapes[2]. In the 1977 Clean Air Act Amendments, Congress set a national goal of remedying existing and preventing future visibility impairment from manmade pollution at Class I Federal areas (national parks greater than 6000 acres and wilderness areas greater than 5000 acres in existence in August 1977) across the United States. The 1999 Regional Haze Rule (RHR)[3] instructs states to develop plans every 10 years that demonstrate reasonable progress in improving visibility in 156 Class I national parks and wilderness areas (tribes have the option to undertake regional haze plans, but it is not required as it is for states). One hundred and eighteen Class I areas are located in the 15 western states. In each 10 year plan, states are to set a reasonable progress goal (RPG) for visibility improvement and compare the RPG to a uniform rate of progress (URP) calculated as the straight line glidepath between visibility for the 2000-2004 baseline period and estimated natural visibility conditions for the target year 2064, as illustrated in Figure 1.

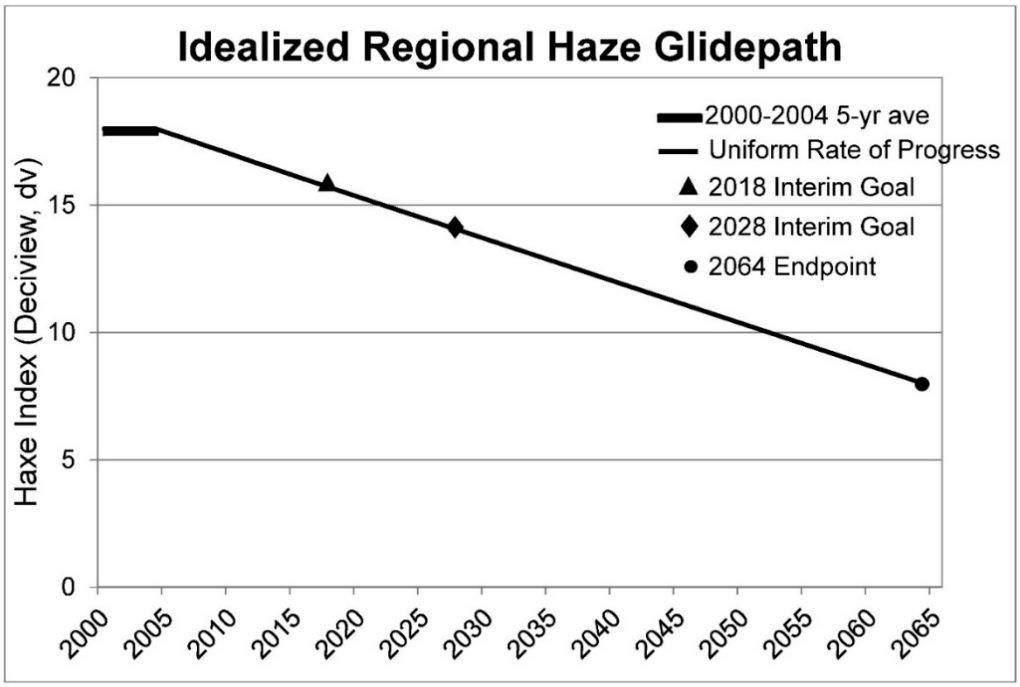

Figure 1: Idealized Regional Haze Rule Glidepath.

[2] Grand Canyon Visibility Transport Commission, (1996). Recommendations for Improving Western Vistas. https://www.wrapair.org/WRAP/reports/GCVTCFinal.PDF. Accessed March 9, 2018.

[3] U.S. EPA. (1999). Regional Haze Regulations. 40 CFR Part 51, [FRL-6353-4], RIN 2060-AF32, [Docket No A-95-38], Federal Register / Vol 64, No. 126 / Thursday, July 1, 1999 / Rules and Regulations. https://www.gpo.gov/fdsys/pkg/FR-1999-07-01/pdf/99-13941.pdf

IMPROVE monitoring network and data analysis

Particulate matter (PM) data collected by the Interagency Monitoring of Protected Visual Environments (IMPROVE) monitoring network are used to calculate light extinction from PM species at Class I areas[4] and to track visibility progress over time. The IMPROVE monitoring network[5] collects 24-hour aerosol samples every third day. The network includes 110 monitors (Figure 2) representing 155 Class I areas (Figure 3) to support implementation of the regional haze rule. Aerosol composition and mass are measured for each daily sample.

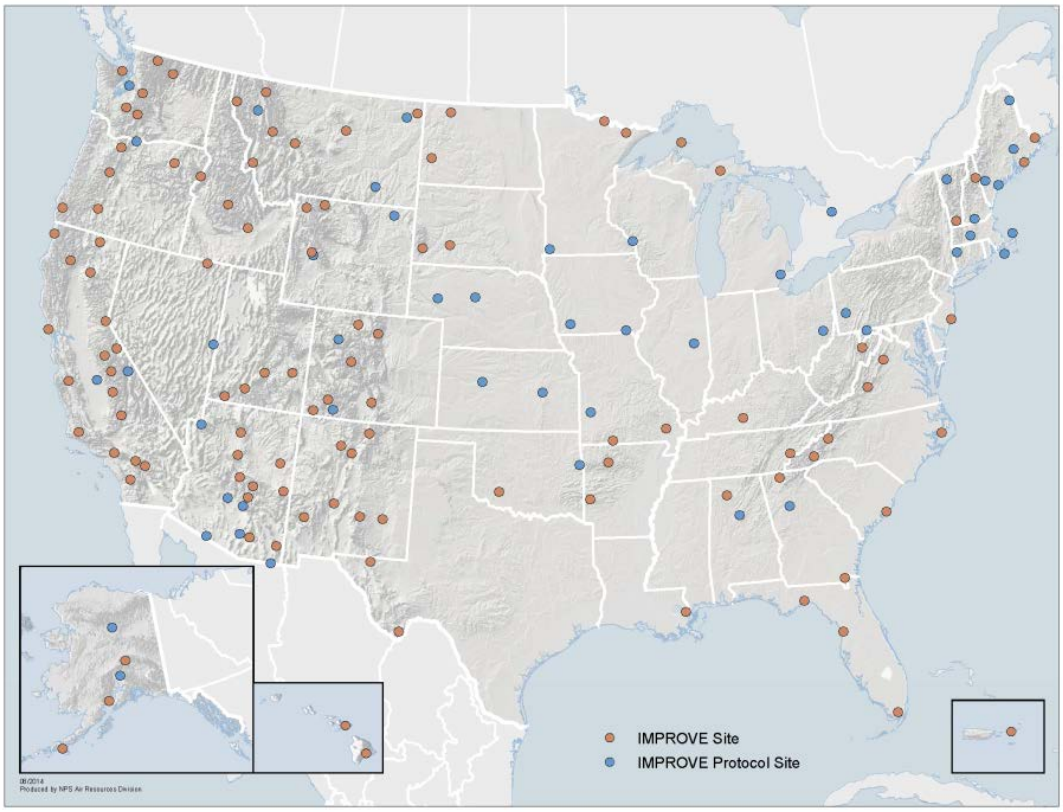

Figure 2: Nationwide IMPROVE monitoring network (obtained from the Federal Land Managers website)

[4] U.S. EPA. (2003). Guidance for Tracking Progress Under the Regional Haze Rule. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, EPA-454/B-03-004. https://www3.epa.gov/ttnamti1/files/ambient/visible/tracking.pdf
Interagency Monitoring of the Protected Visual Environments (IMPROVE). http://vista.cira.colostate.edu/Improve/wp-content/uploads/2016/04/Chapter3.pdf

[5] Hand, J. L., Copeland, S. A., Day, D. E., Dillner, A.M., Indresand, H., Malm, W.C., McDade, C.E., Moore, C.T., Pitchford, M.L., Schichtel, B.A.,Watson, JG. (2011). IMPROVE (Interagency Monitoring of Protected Visual Environments): Spatial and seasonal patterns and temporal variability of haze and its constituents in the United States: Report V, 2011, CIRA Report ISSN: 0737-5352-87; http://vista.cira.colostate.edu/improve/Publications/Reports/2011/2011.htm. (accessed August 2017.)

Figure 3: Mandatory Class I Areas (obtained from the Federal Land Managers website)

Light extinction in the atmosphere is defined as light attenuated by the scattering and absorption by particles and gases through which it travels. Light extinction is calculated for each IMPROVE sample day based on measured aerosol composition and mass using parameters for aerosol extinction efficiency that vary as a function of relative humidity, and clear air Rayleigh scattering in the atmosphere[6] Extinction is expressed in inverse megameters (Mm^{-1}.) The RHR visibility tracking metric is a haze index expressed in terms of deciview (dv) and is calculated as the logarithm of cumulative light extinction due to all aerosol and gas species[7] as:

$$dv = 10 \ln(bext/10\ Mm^{-1})$$

where the denominator in the log term is a default constant value for clear air scattering.

Visibility tracking metric

In the first regional haze planning period, the Regional Haze Rule instructed states to use the 20% haziest days in each year to track visibility progress. Western Regional Air Partnership (WRAP) used regional photochemical grid models to project visibility improvement between the 2002 base year and the 2018 future year and to set RPGs for the RHR state implementation plans. Western states projected large emission reductions from fossil fuel-fired electrical generating units and onroad and offroad mobile sources between 2000 and 2018 and widespread applications of prescribed and agricultural smoke management programs. Yet the 2018 visibility RPGs for many western Class I areas were projected to achieve less progress than the URP. Several western states cited the influences of wildfires and dust storms on the haziest days as important reasons that visibility RPGs adopted in individual regional haze state implementation plans projected less progress than the URP. Episodes of elevated carbonaceous aerosols or crustal material, attributable to

[6] Pitchford, M.; Malm, W.; Schichtel, B.; Kumar, N.; Lowenthal, D.; Hand, J. (2007). Revised algorithm for estimating light extinction from IMPROVE particle speciation data. J. Air & Waste Manage. Assoc. 2007, 57, 1326-1336; DOI: 3155/1047-3289.57.11.1326.
[7] Pitchford, M.L. and Malm, W.C. (1994). Development and Applications of a Standard Visual Index. Atmospheric Environment 28:1049-1054. https://doi.org/10.1016/1352-2310(94)90264-X

wildfires or dust storms, respectively[8,9], can dominate aerosol concentrations on haziest days and make it more difficult to demonstrate the visibility improvement attributable to reductions in anthropogenic emissions.

In January 2017, the Environmental Protection Agency (EPA) revised the Regional Haze Rule[10], including the metric used to track progress toward natural visibility conditions. EPA clarified that instead of tracking the days with highest total haze, states should track visibility progress on days with the highest anthropogenic impairment. The EPA recommended method uses operationally defined estimates of natural and anthropogenic pollutant contributions to IMPROVE measured aerosol light extinction on each sample day. Most impaired days are the 20% of days with the highest anthropogenic fraction of total haze. EPA's recommended methods are detailed in the 2016 proposed guidance for the second implementation period[11], 2018-2028, and the accompanying Technical Support Document[12]. Tracking visibility progress on those days with highest impairment is intended to limit the influence of episodic wildfires and dust storms on the visibility trends.

The EPA method begins by defining site-specific thresholds for episodic extreme natural contributions to light extinction from carbonaceous species (organic carbon mass, OCM, plus elemental carbon, EC) and crustal material (fine soil plus coarse mass), as indicators of wildfires and dust storms, respectively. The threshold proposed is the minimum annual 95th percentile daily value for the 15-year period 2000-2014. Daily species extinction values greater than the 95th percentile threshold are assigned as episodic natural in origin. Smaller, routine natural contributions from biogenic or geogenic emissions are assumed to be a constant fraction of the measured IMPROVE species concentrations on each day, with the fraction calculated as the ratio of a previously estimated annual average natural concentration[13] divided by the annual average measured IMPROVE concentration for each species. For example, the Natural Conditions II annual average estimate of nitrate for Glacier is 0.95Mm^{-1}, and the annual average measured nitrate at Glacier NP is 1.47 Mm^{-1}, thus, the daily routine natural nitrate at Glacier NP is assumed to be 65% of the daily measured IMPROVE nitrate. All sea salt is assigned as natural. The remainder of total haze not assigned to natural contributions is assumed to be anthropogenic in origin. Daily impairment is calculated as:

$$Dv_{anthropogenic} = 10 \ln(bext_{total}/bext_{natural})$$

Daily impairment values are ranked from highest to lowest impairment to select the 20% most impaired days in each year.

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[8] Hand, J.L., Schichtel, B.S., Malm, W.C., Frank, N.H., (2013). Spatial and temporal trends in PM2.5 organic and elemental carbon across the United States. Advanced. Meteor.2013. Article ID 367674.

[9] Hand, J.L, W.H. White, K.A. Gebhart, N.P. Hyslop, T.E. Gill and B.A. Schichtel. (2016). Earlier onset of the spring dust season in the southwestern United States. Geophys. Res. Lett., 43, 4001-4009, doi:10.1002/2016GL068519. http://vista.cira.colostate.edu/Improve/wp-content/uploads/2016/07/Hand_et_al-2016-GRL.pdf

[10] U.S. EPA. (2017). Protection of Visibility: Amendments to Requirements for State Plans. 40 CFR Parts 51 and 52, [EPA-HQ-OAR-2015=-0531; FRL-9957-05-OAR], RIN 2060-AS55, Federal Register / Vol 82, No. 6 / Tuesday, January 10, 2017 / Rules and Regulations. https://www.gpo.gov/fdsys/pkg/FR-2017-01-10/pdf/2017-00268.pdf

[11] U.S. EPA. (2016). Draft Guidance on Progress Tracking Metrics, Ling-Term Strategies, Reasonable Progress Goals and Other Requirements for Regional Haze Implementation Plans for the Second Implementation Period. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. EPA-457/P-16-001. July. https://www.epa.gov/sites/production/files/2016-07/documents/draft_regional_haze_guidance_july_2016.pdf

[12] U.S. EPA. (2016). Technical Support Document I (TSD) Revised Recommendations for Visibility Progress Tracking Metrics for the Regional Haze Program. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. July. https://www.epa.gov/sites/production/files/2016-07/documents/technical_support_document_for_draft_guidance_on_regional_haze.pdf

[13] IMPROVE. 2007. Natural Haze Levels II: Application of the New IMPROVE Algorithm to Natural Species Concentrations Estimates. Interagency Monitoring of Protected Visual Environments. http://vista.cira.colostate.edu/Improve/gray-literature/ (accessed August 2017)

The URP glidepath for the most impaired days uses the five-year average deciview for the 2000-2004 baseline period as the starting point for the straight line slope to the natural conditions endpoint in 2064[14]. The average of the annual estimated natural contributions on the 20% most impaired days in each year for the period 2000-2014 is to be used to define the 2064 endpoint of the URP for most impaired days. In this way, the 2064 is assumed to be equal to impairment in the absence of anthropogenic impacts. For western Class I areas, the deciview values of the most impaired days are lower than the values for the haziest days, and the URP for 2000-2004 baseline and 2064 endpoints are also lower for the most impaired days than for the haziest days (Figure 4).

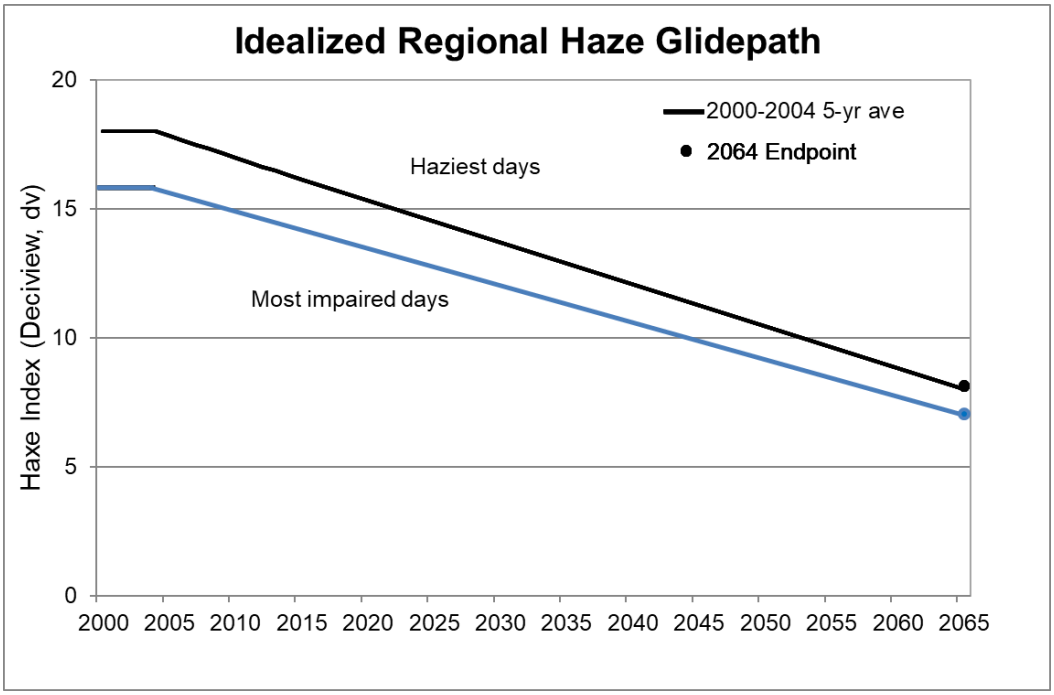

Figure 4: Idealized Regional Haze Rule Glidepath using haziest days compared to most impaired days.

The western states will use photochemical grid models to predict future visibility improvements in response to anthropogenic emission reductions and to compare a modeled visibility progress (RPG) to EPA's estimated URP. If the modeled estimates of natural and anthropogenic pollutant contributions differ from EPA's estimates used in the operational analysis of the IMPROVE data, the two approaches could project difference rates of visibility progress by 2028.

The revised RHR allows states to propose methods to adjust the URP glidepath to account for contributions from international anthropogenic emissions and/or wildland prescribed fires. A photochemical grid model is one approach to apportion contributions from U.S. anthropogenic, U.S. natural, and international emissions to the IMPROVE observations and natural conditions used in the URP.

[14] U.S. EPA. (2016). Draft Guidance on Progress Tracking Metrics, Ling-Term Strategies, Reasonable Progress Goals and Other Requirements for Regional Haze Implementation Plans for the Second Implementation Period. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. EPA-457/P-16-001. July. https://www.epa.gov/sites/production/files/2016-07/documents/draft_regional_haze_guidance_july_2016.pdf

Natural Haze vs Controllable Impairment vs Uncontrollable Sources

It is important to recognize the difference between sources that are natural, controllable anthropogenic, and uncontrollable anthropogenic. Table 1 provides characterization of emissions into natural vs. anthropogenic categories, as well as defines controllability. EPA's 2016 proposed guidance[15] approach makes attempts to isolate those sources which are controllable anthropogenic sources. The initial planning period's 20% haziest days metric included influences from controllable and uncontrollable sources alike. Given that States are only able to control those sources that are anthropogenic, within State boundaries, and not otherwise preempted from State control by federal law, it was important to track those emissions which are attributable to sources under the State's control when determining the progress of a State towards meeting the goals of visibility improvement.

Within EPA's 2016 guidance document, the agency outlined a methodology which attempts to isolate anthropogenic, controllable emissions through the following steps:

1. A method for the isolation and removal of dust and carbon (i.e. wildfire) extreme episodic events (E3) (EPA Guidance Section 5.5)
2. A method for the isolation and removal of routine natural visibility impacts (EPA Guidance Section 5.5)
3. Support of Uniform Rate of Progress (URP) adjustment for international emission impacts (EPA Guidance Section 5.19)
4. Support of Uniform Rate of Progress (URP) adjustment for prescribed fire impacts (EPA Guidance Section 5.20)

These methods allow for the potential isolation and removal of uncontrollable international emissions, anthropogenic prescribed fire emission impacts since this is a control methodology utilized to reduce the incidence of wildfire occurrence, large uncontrollable dust storms, and large uncontrollable wildfires. Ideally, with the isolation and removal of these emission impacts, a State should better be able to track the progress of visibility improvement attributable from reductions of emissions from controllable sources.

For additional information on natural haze vs. controllable impairment vs. uncontrollable source emissions, the MDGPS recommends States review the documentation authored by Mary Uhl and Tom Moore, entitled "Visibility, Haze, and Background Air Pollution in the West"[16] which further described these distinctions and how natural impairment changes over time, dependent on environmental factors. A few mitigating strategies exist to reduce the impact of natural emissions on visibility at specific Class I Areas, but the focus in this planning period is on reducing emissions from anthropogenic sources.

Table 1: Characterization of emission impacts by origin and controllability[17]

EPA definitions of contributions to IMPROVE monitoring data	Source Category and Air Emissions	Controllability
Anthropogenic	U.S. anthropogenic (SO_2, NO_x, NH_3, PM, VOC)	Most emissions are controllable

[15] U.S. EPA. (2016). Draft Guidance on Progress Tracking Metrics, Ling-Term Strategies, Reasonable Progress Goals and Other Requirements for Regional Haze Implementation Plans for the Second Implementation Period. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. EPA-457/P-16-001. July. https://www.epa.gov/sites/production/files/2016-07/documents/draft_regional_haze_guidance_july_2016.pdf

[16] Uhl, M and Moore, T (2017). Visibility, Haze, and Background Air Pollution in the West: An overview of visibility issues in the Western United States. The Magazine for Environmental Managers. January. https://www.wrapair2.org/pdf/uhl.pdf

[17] U.S. EPA. (2016). Draft Guidance on Progress Tracking Metrics, Long-Term Strategies, Reasonable Progress Goals and Other Requirements for Regional Haze Implementation Plans for the Second Implementation Period. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. EPA-457/P-16-001. July. https://www.epa.gov/sites/production/files/2016-07/documents/draft_regional_haze_guidance_july_2016.pdf

EPA definitions of contributions to IMPROVE monitoring data	Source Category and Air Emissions	Controllability
	Agricultural fire, biomass fuel (predominantly OC +EC); Road/construction dust (PM)	Most emissions are controllable
	International anthropogenic (SO_2, NO_x, NH_3, PM, VOC)	Not controllable by U.S. state or federal regulations
Natural	International and U.S. and International Wildfire and Prescribed fire (predominantly OC, EC, some SO_2, NO_x)	Mostly un-controllable
	International and U.S. Volcanic SO_2 Wind-blown Dust (PM) Other Natural (sea salt, Cl^-; lightning and soils N; vegetative, VOC)	Mostly un-controllable

Keep in mind that technology also changes. Currently there are some remaining uncontrolled anthropogenic sources for which there are no technologies to reduce further or completely remove emissions. Even with cost-effective controls, there will be a residual veneer of anthropogenic emissions from in-State and International sources, now and in the future. Over time, it is expected that new technological controls will be developed or operational measures (e.g. fuel switching) will become feasible and cost-effective. This means that in-State anthropogenic emissions will continue to be reduced in future planning periods, if it is not reasonable to reduce emissions further during the current planning period. This situation is depicted graphically below in Figure 5. Emissions from Natural Sources are increasing while emissions from Anthropogenic Sources should be decreasing. Overall, visibility should be improving as light extinction and deciview levels decrease.

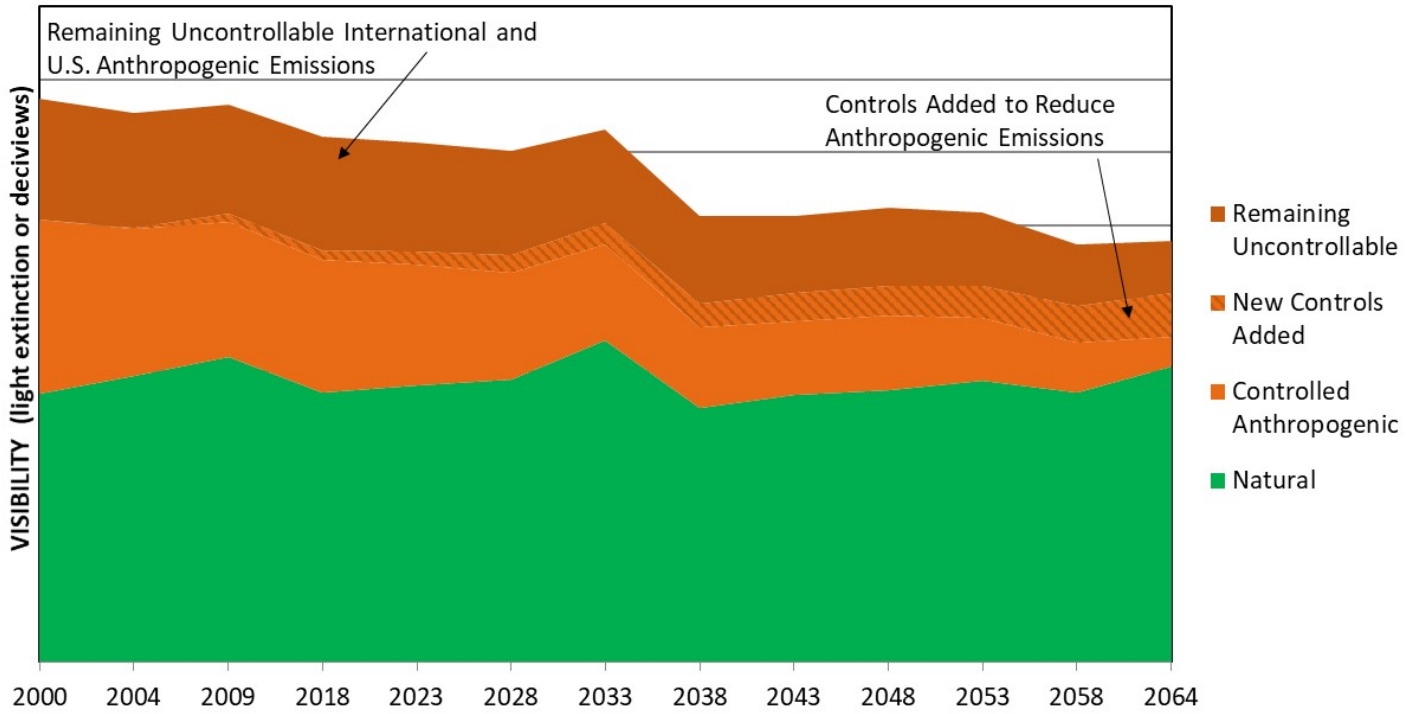

Figure 5: Conceptual progress in reducing Visibility Impairment

Most Impaired Days Metric Analysis

Background

Within each year of monitoring data, the 20% haziest days represent the upper quintile of the haze index, represented in deciviews. In the first regional haze planning period, the worst days were the same as the haziest days. The 20% best days are the same as the 20% clearest days and represent the lower quintile of the haze index. Both use rankings of raw monitoring data before impairment calculations. The haziest days metric remains as a vestige of the previous Regional Haze Rule and can be used by States to complete their Progress Reports for the 2018 RPG, modeled as Worst Days in the first planning period. States can also compare their Worst (haziest) Days against the Most Impaired Days (MIDs) for improving the understanding of the causes of haze throughout the year. However, EPA now defines the worst days as the MID and in the revised Rule, requires states to track progress on the MID. The Worst (haziest) Days metric was replaced by the MID. The latter gives a more accurate measurement of progress reducing anthropogenic impairment, rather than progress reducing haze caused by natural and anthropogenic sources combined.

The MDGPS developed tools and results to help states analyze many different calculation options for the MID. The Subcommittee also spent time considering natural conditions, how it is calculated and what impact it has on the 2064 endpoint. This section describes the work that was done, the conclusions reached, and recommendations for future analysis.

Representative Sites

The EPA Regional Haze webpage (https://www.epa.gov/visibility/draft-guidance-second-implementation-period-regional-haze-rule) and the FED website (http://views.cira.colostate.edu/fed/) provide the IMPROVE data processed using the proposed impairment metric, using a 95%-ile) Organic Carbon +Elemental Carbon and Fine Soil + Coarse Mass. To determine the most appropriate protocol, the Subcommittee's technical team chose 27 representative sites spanning 14 western states and applied various methodologies to calculate impairment.

Individual states or contractors may use the recommended protocols to calculate baseline impairment, current impairment and all intervening years' impairment. If states deviate from the recommended protocols, their State Implementation Plan documentation should include a reasonable explanation, based on site-specific analysis. It is also highly recommended that the State which is pursuing alternative protocols work with their EPA regional office to ensure the methods will result in an approvable SIP submittal. Further, any states which deviate should share their approach with surrounding states to ensure consistency within regional analyses and to meet coordination requirements. The method for calculating MID affects how the Reasonable Progress Goals (RPGs) are set through modeling and how progress is measured.

The purpose of these 27 test sites was to allow states to look for conditions where the EPA recommended 95%-ile metric may not be the most appropriate way of removing episodic events. The 27 test sites are listed in Table 2.

Table 2: List of sites chosen to represent the west

Representative Site	Category
AGTI (CA)	Border Site – Mexico
CANY (UT)	Overall site
CHIR (AZ)	Border Site – Mexico
GLAC (MT)	Border Site -Canada
GRBA1 (NV)	Overall site
GRCA2 (AZ)	Historical Significance
GUMO (NM)	Desert
HAVO1 (HI)	Volcano
JOSH (CA)	Overall site
KALM1 (OR)	Coastal Site
MELA (MT)	Oil and Gas & Border Site -Canada
MEVE1 (CO)	Oil and Gas
NOCA (WA)	Forest
REDW (CA)	Coastal Site
ROMO (CO)	Urban Area
SACR (NM)	High Impact Dust
SAGO (CA)	Urban Area
SAWE (AZ)	High Impact Dust & Desert
SAWT1 (ID)	Other
SIME (AK)	Tundra & Border Site – Other
STAR1 (OR)	Forest
THRO (ND)	Overall site
TUXE (AK)	Tundra & Border Site – Other
WHPE (NM)	High Elevation Site
WHRI (CO)	High Elevation Site
YELL (WY)	High Impact Fire
YOSE (CA)	High Impact Fire

Tools

The Subcommittee created a variety of tools for states to use to analyze the conditions at the representative sites.

Excel Workbooks

- Excel workbooks are available for all test sites and have graphics showing trends in haziest, most impaired, and clearest days.
- The Data tab displays data as downloaded from EPA, including the Worst Days under the old metric;
- The Episodic Treatment tab allows you to adjust the percentages of carbon or dust extinctions;
- The Natural Conditions tab lists the NCII species contributions;
- The Daily Constituents tab shows graphical daily contributions for the most recent 5 years; and
- The Trends Tab provides tabular data and plots showing 5-year average, Annual, and URP trend lines and a list of MIDs that change automatically with changes in e3 thresholds are made in the Episodic Treatment Tab.

The Excel workbook provides a very useful means to analyze factors that may contribute to MIDs in multiple Class I areas, however, what works well for one area may not be optimal for other areas. For more detailed information on the Excel workbook tool, please refer to "2018-10-24 IMPROVE Monitoring Data Excel Workbook Users Guide.docx".

R Code

- The R-code allows users to vary the statistics, seasons, and percentile of the MID
- The R-code can be downloaded to make unique graphics for your specific site or
- Premade graphics were created for 26 test sites and made available to the group
- The premade graphics included the following:
    - Annual averages using the haziest days, 95%-ile metric, and 70%-ile metric
    - Monthly and seasonal differences in light extinction
    - Yearly plots showing daily constituents with markers for haziest and most impaired days. These plots are sorted by calendar day and then worst to best and are available for the 95%-ile metric and the 70%-ile metric
    - Plots showing only the MID for each metric, allowing users to clearly see how the distribution of days within a year shifted using different metrics.

These tools were made available to the Subcommittee throughout the process and are available upon request.

Most-Impaired Metric

In the updated Regional Haze Rule, EPA recommends using the minimum annual 95%-ile episodic contribution as the threshold for wildfire and dust events. This threshold is then used to reclassify light extinction into three categories: natural-routine, episodic, and anthropogenic. The 20% MID are selected as the days with the highest anthropogenic impairment. EPA notes that other percentiles, averaging periods (annual vs. seasonal), and statistics (mean, median, minimum) could be used to calculate this threshold. The Subcommittee looked at the following options for calculating the MID:

- 95%ile of the minimum yearly (EPA recommended option). This was used as a baseline to compare the other metrics to.
- Other percentiles varying from 50% - 99%. For example, 70% selected the 70%-ile of the episodic contribution rather than the 95%-ile, which would increase the episodic contribution and lower the anthropogenic contribution on days when the threshold is exceeded.
- Other statistics (mean, median, minimum). For example, the EPA recommended option is for the minimum 95%-ile, meaning the lowest of the annual 95%-ile values from 2000-2014. Changing this metric allows the user to select the mean or median year instead.
- Seasonal vs. Annual. The EPA recommended option looks at annual variability in the episodic contribution. This option allows the user to use different thresholds for each season, such as summer wildfire season.

After running analyses on all possible options of these variables, premade graphics were created for the 26 representative sites and made available to the Subcommittee. The premade graphics looked at the comparison of haziest days, 95%-ile metric, and 70%-ile metric for MID. Users wishing to see graphics for other options need to run the R code. Members of the Subcommittee reviewed the sites to see how the 95%-ile metric compared to other options for calculating the MID.

EPA 95%-ile Method

Overall, the 95%-ile metric does remove a significant amount of wildfire impacts from the calculated MID. For example, at Yellowstone National Park, the annual contribution of carbon on the most impaired days drops significantly, as shown in Figure 6.

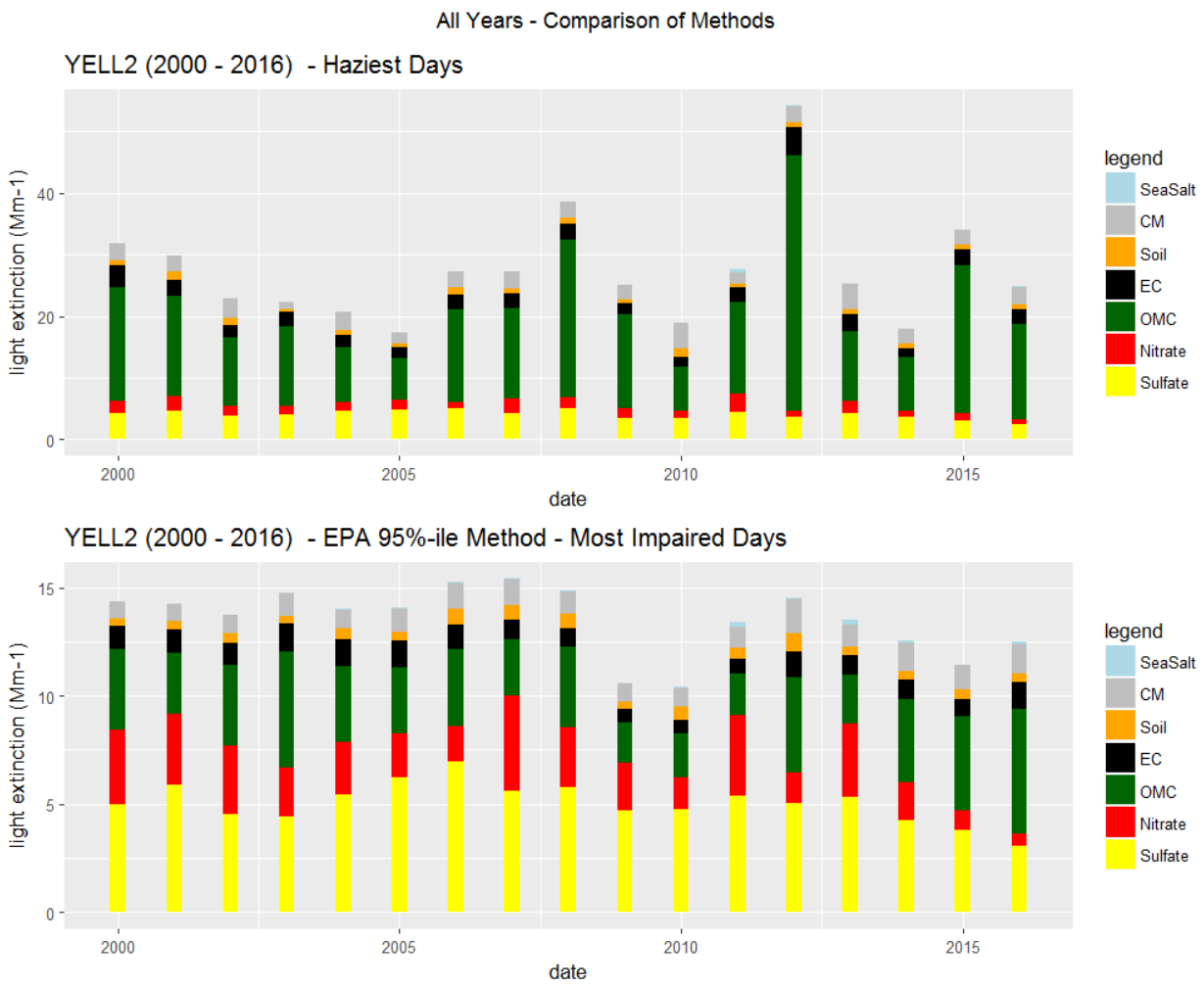

Figure 6: Comparison of the Haziest and Most Impaired Day light extinction at Yellowstone

By contrast, at a high impact dust site, the impact of removing episodic dust is less noticeable. This is likely due to extreme dust events being less frequent and less severe than wildfire impacts (Figure 7).

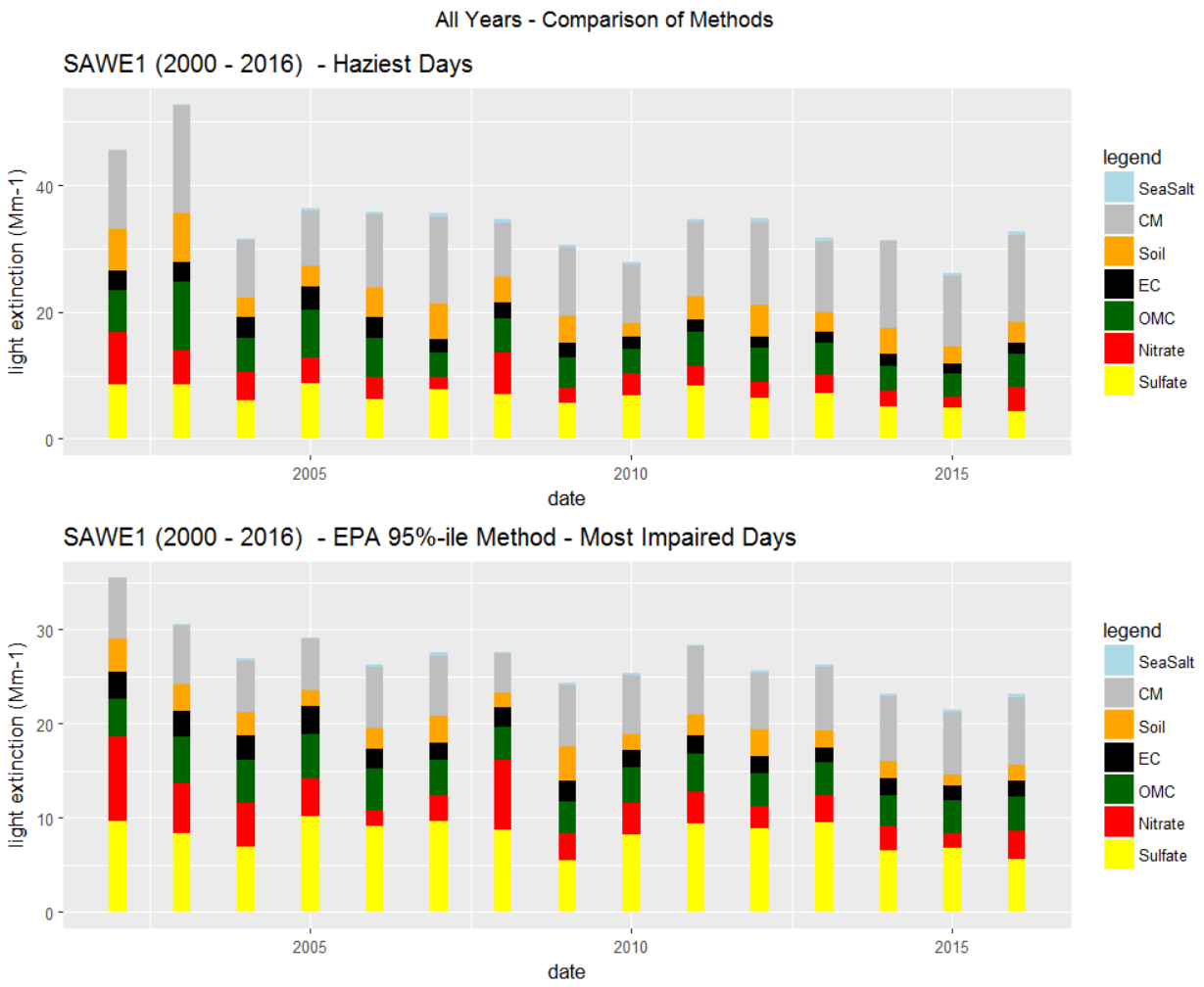

Figure 7: Comparison of the Haziest and Most Impaired Day light extinction at Saguaro West

When looking at individual days, the impact of the 95%-ile metric becomes even clearer. In Yellowstone in 2012, the 20% worst days occur almost exclusively in the summer and are dominated by carbon due to wildfire impacts. When looking at the 95%-ile metric for selection of the MID, the days shift primarily to the spring time, encompassing more sulfate and nitrate contributions (Figure 8).

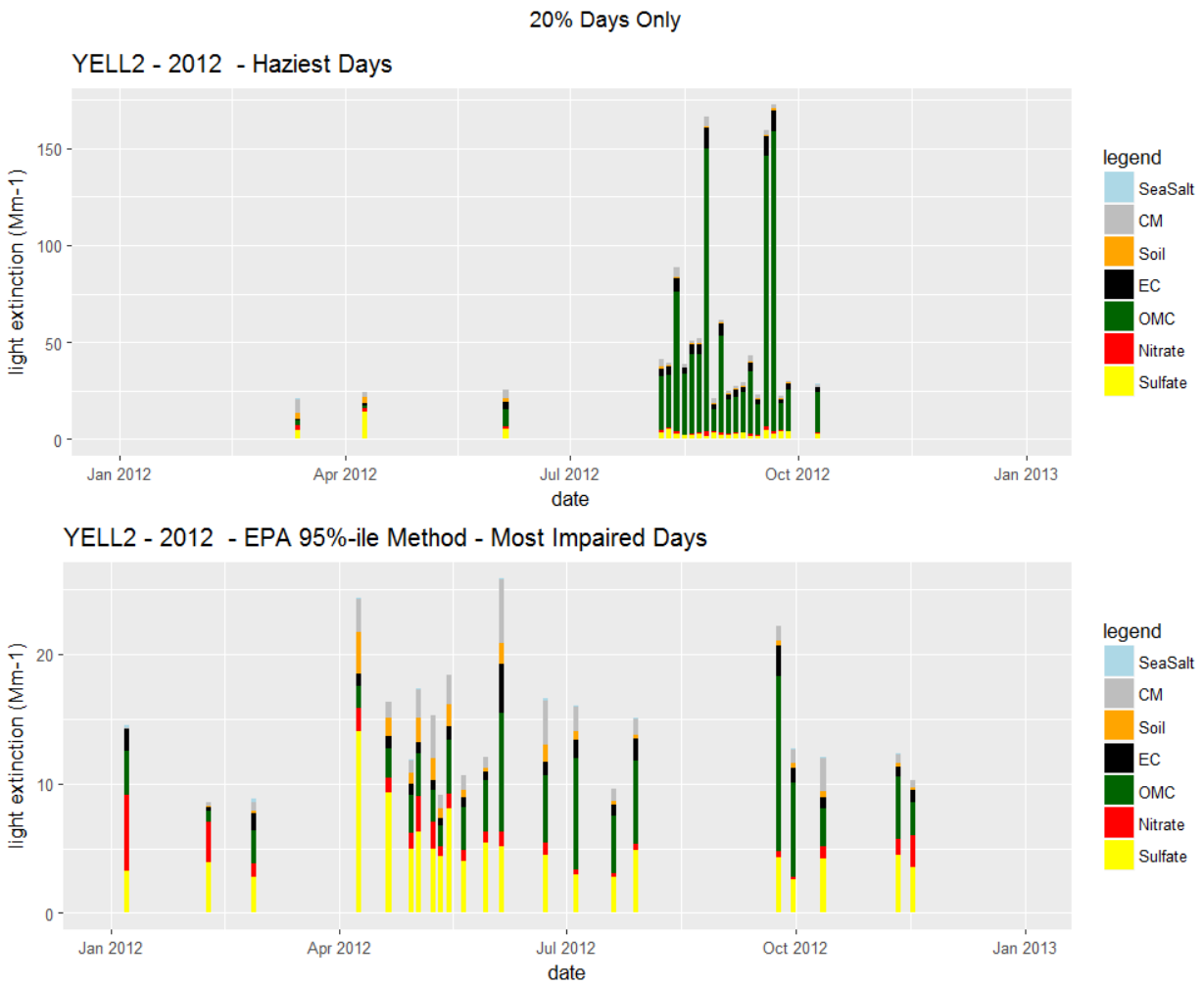

Figure 8: Comparison of the Haziest and Most Impaired Day light extinction at Yellowstone in 2012

At the high dust site, shown below in 2013, the MID under the 95%-ile metric shift away from the dry period of spring/early summer to later in the year when dust storms are less likely (Figure 9).

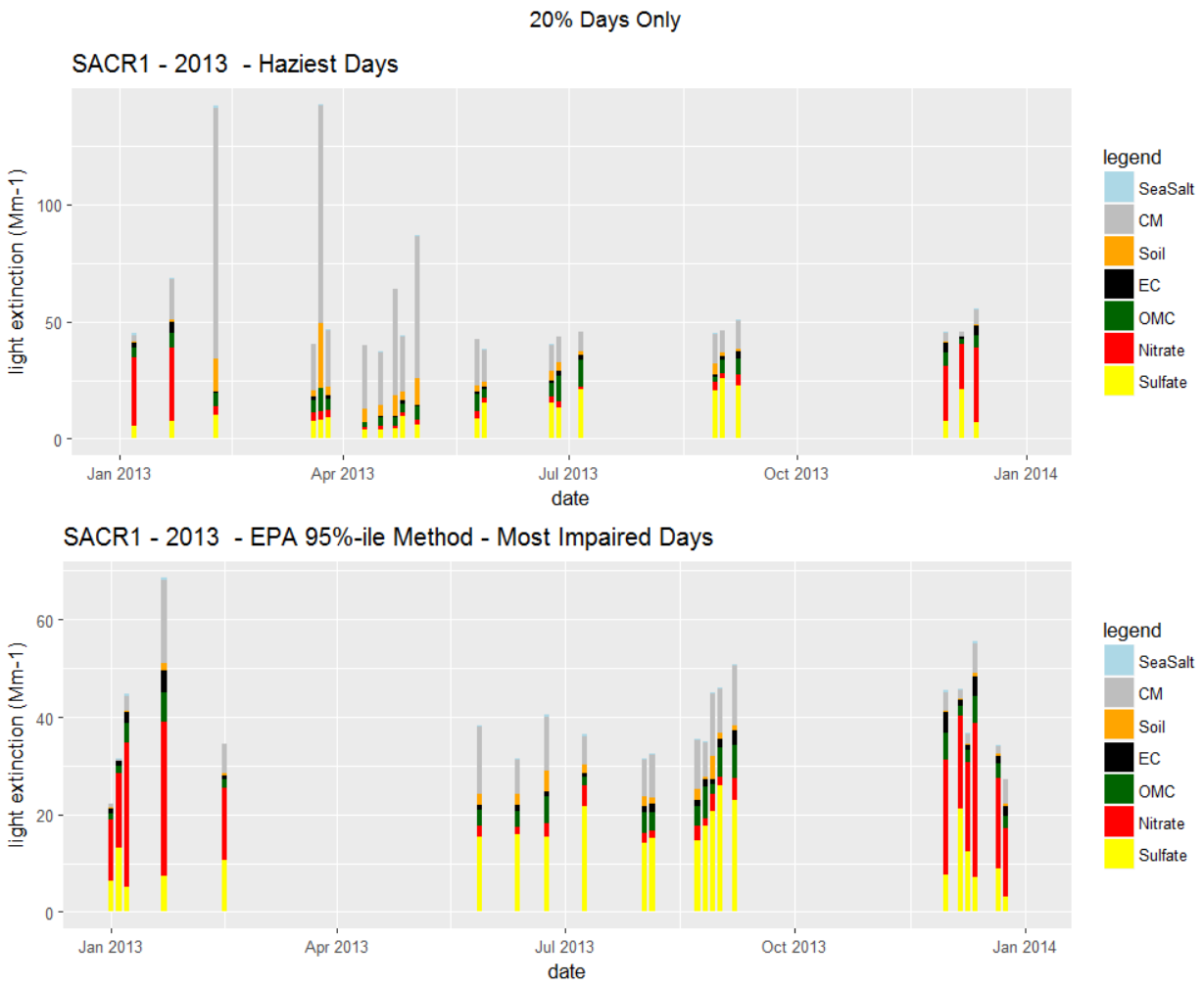

Figure 9: Comparison of the Haziest and Most Impaired Day light extinction at Salt Creek in 2013

Comparing Other Methods

The tools developed by the Monitoring Subcommittee allow for 36 different ways to calculate the MID. Reviewing results for every possibility and every station was not feasible for the Subcommittee. To address these concerns, the Subcommittee compared each metric to the 95%-ile metric and looked at the cumulative number of MIDs that changed (Figure 10). Sites with high variation across metrics indicated areas where the 95%-ile metric may not be capturing all episodic events. Alternatively, sites with a low variation indicate that the 95%-ile metric is likely capturing most episodic days[18]. The Monitoring Subcommittee recommends states with sites of medium and high variability take a closer look at how changing the metric impacts the site.

[18] Some sites with exceptionally low variation may also indicate the proposed metric is inadequate. HAVO1 is one example, where the metric is inadequate for isolation of natural emissions that originate from volcanic activities. Site considerations, such as this, should be taken into account when States further examine each site.

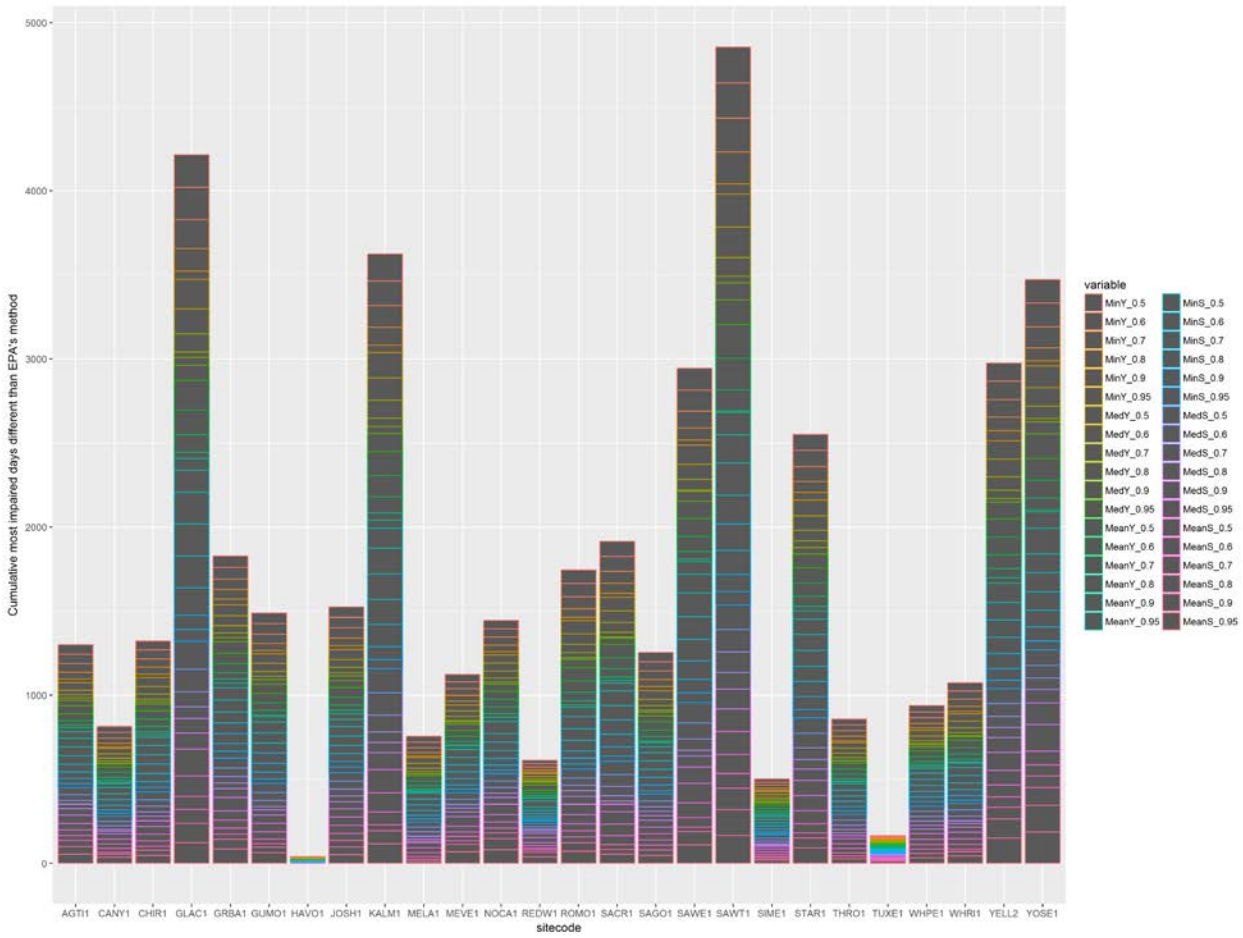

Figure 10: Cumulative MID days that changed for each site for all 36 metrics tested as referenced to EPA's proposed metric

The graphic above indicates that Sawtooth Wilderness has high variability among the changing metrics. A closer look at this site shows that the 95%-ile method still has a significant amount of carbon among the MID. When dropping the percentile threshold to 70%, that contribution drops as more wildfire days are removed (Figure 11 and Figure 12).

When looking at only the selected MIDs, the 95%-ile metric still includes many summer wildfire days with a high carbon contribution (Figure 12). These days are fully removed at the lower percentile. This finding indicates there may be some wildfire impacts not removed using the 95%-ile metric.

Alternatively, a low variability site, such as Medicine Lake shows the MID does not change much between the 95%-ile and the 70%-ile metrics, indicating that wildfire impacts are sufficiently removed at this site.

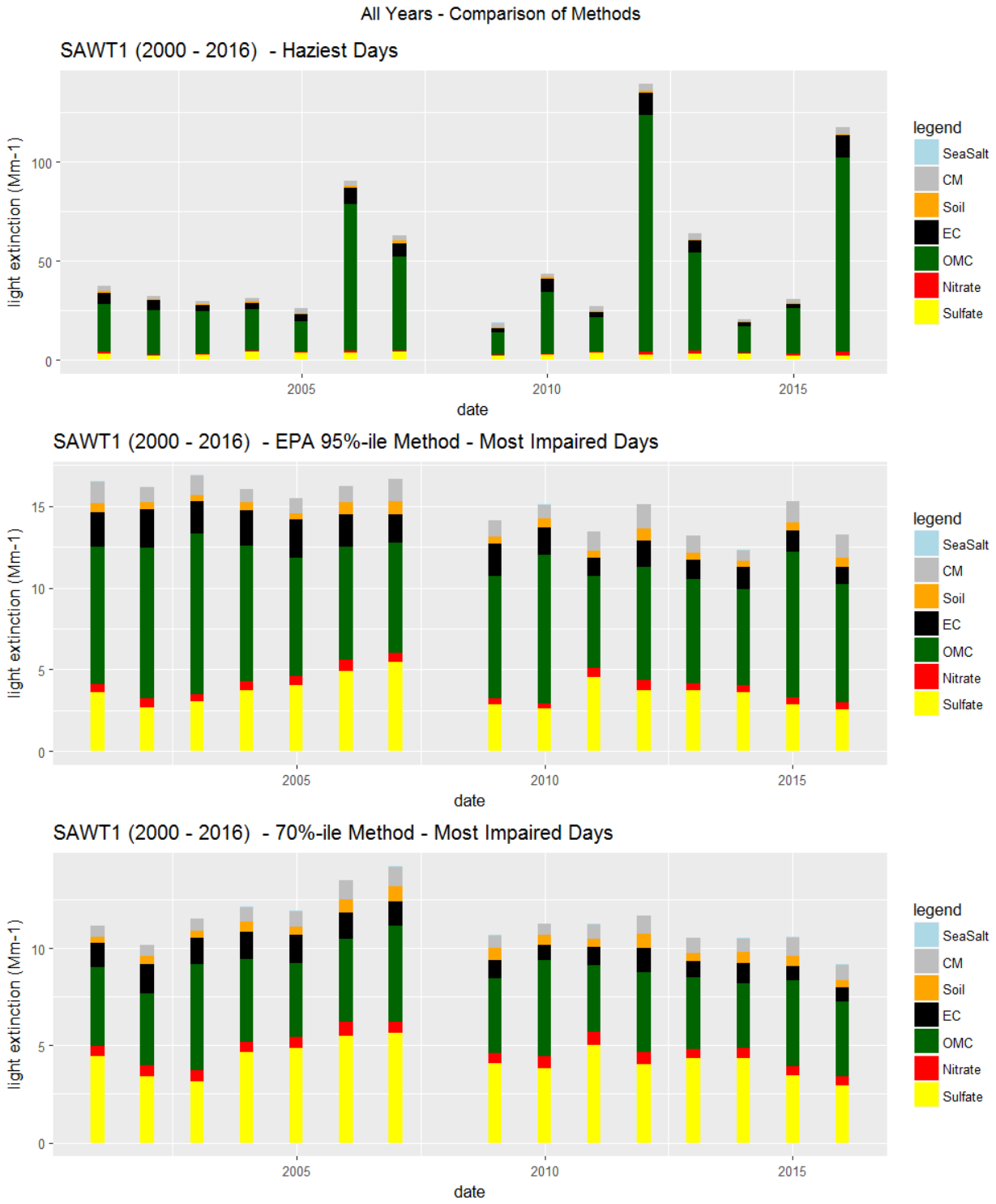

Figure 11: Comparison between the average (2000-2016) haziest days, most impaired days, and most impaired days with a 70% E3 threshold for Sawtooth

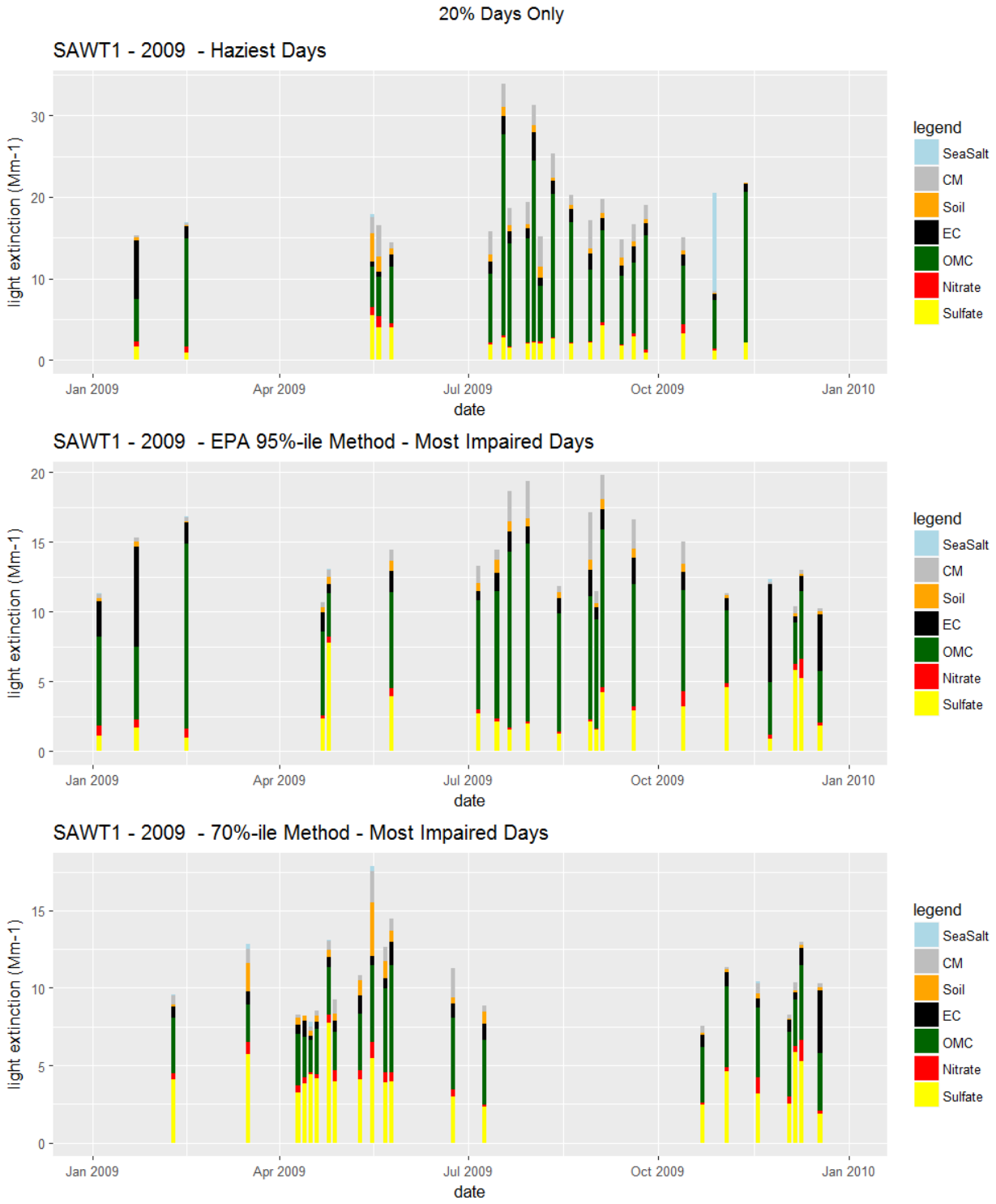

Figure 12: Comparison between the 2009 haziest days, most impaired days, and most impaired days with a 70% E3 threshold for Sawtooth

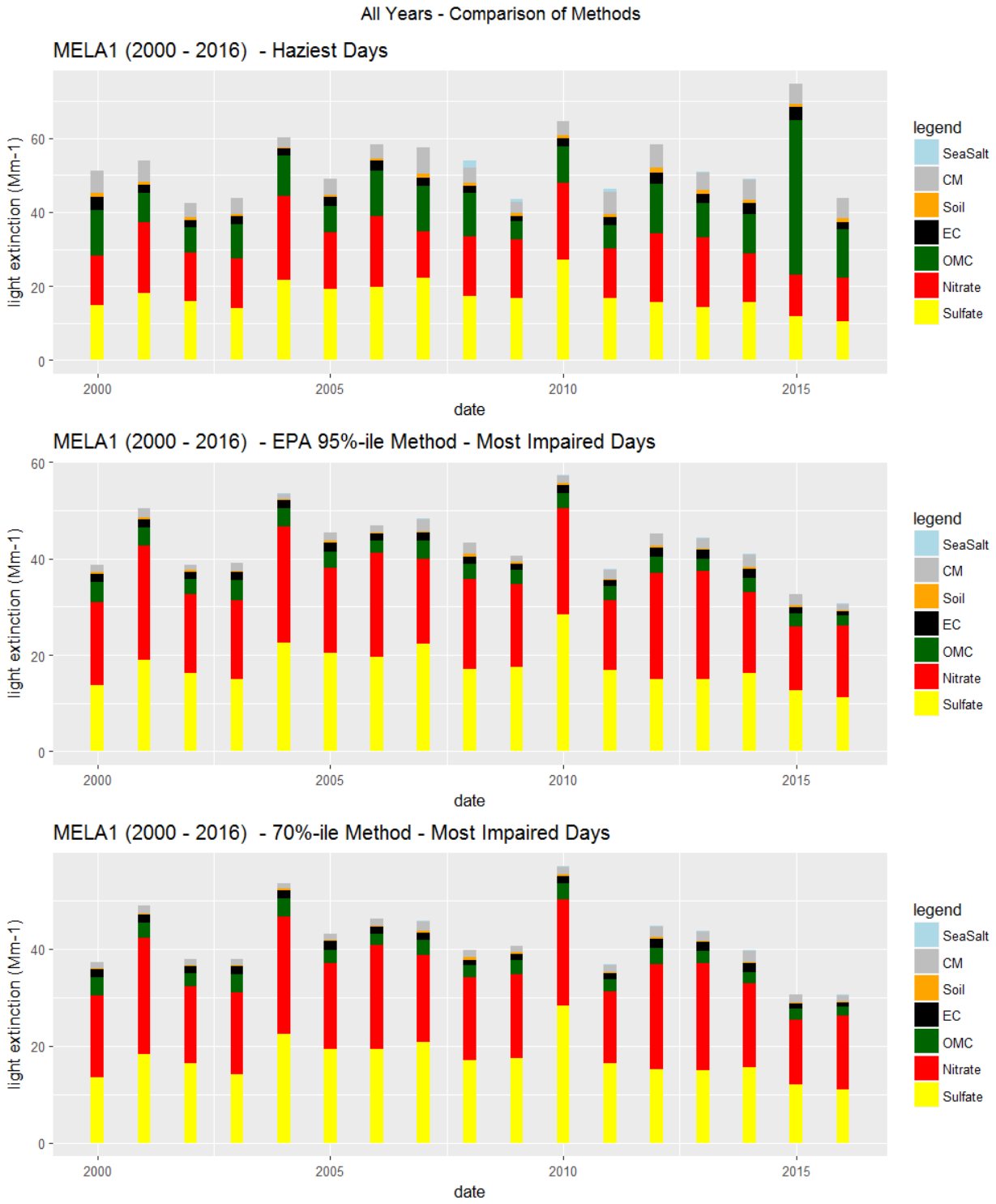

Figure 13: Comparison between the average (2000-2016) haziest days, most impaired days, and most impaired days with a 70% E3 threshold for Medicine Lake

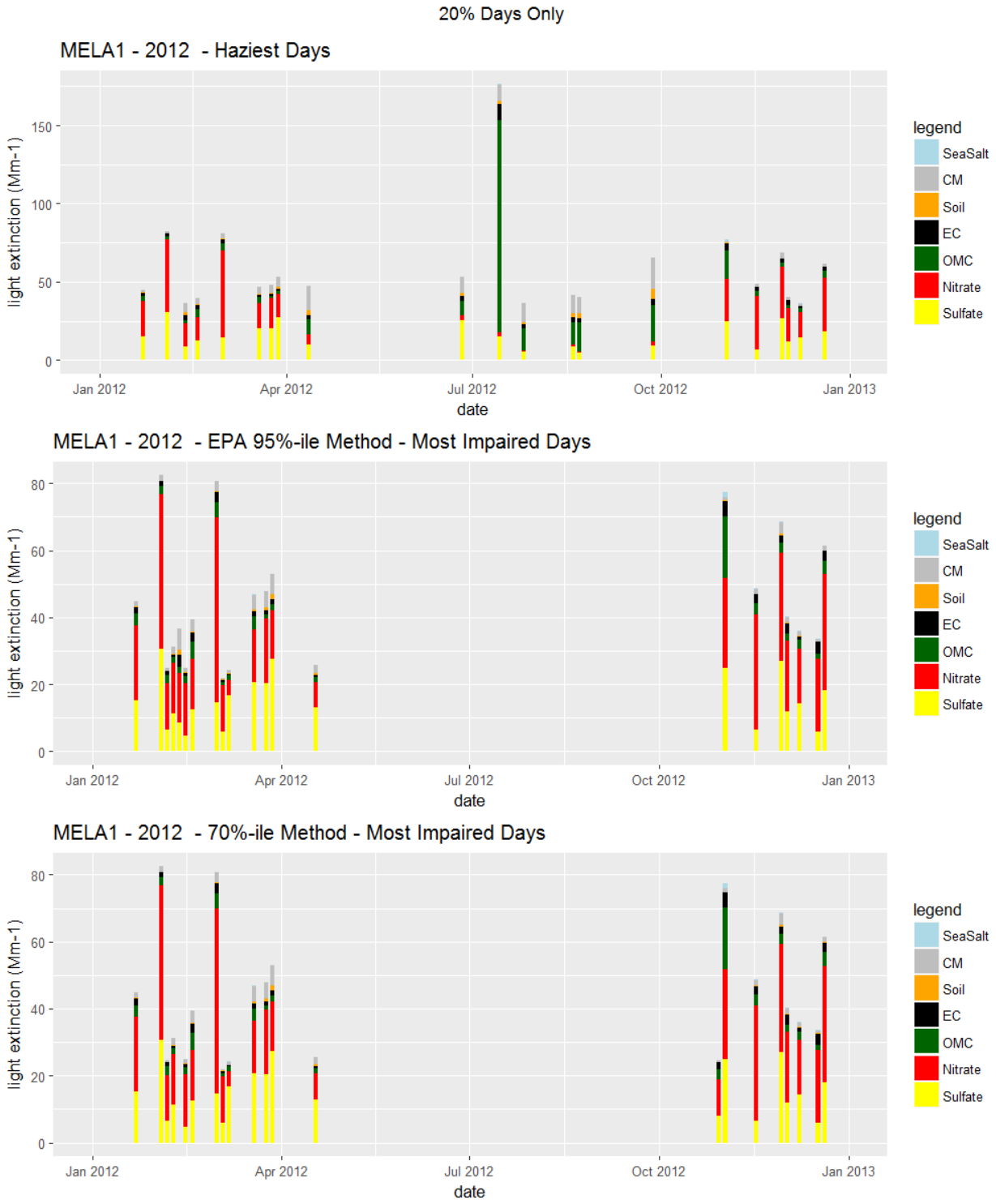

Figure 14: Comparison between the 2009 haziest days, most impaired days, and most impaired days with a 70% E3 threshold for Medicine Lake

Low Level Wildfire Impacts

The Subcommittee concluded that the 95%-ile metric does a reasonable job of removing extreme episodic wildfire events. However, sites with persistent, low level wildfire impacts throughout the summer present a unique situation. In this case, the high number of days impacted by wildfire are not fully removed with the 95%-ile metric. The intention of

the 95%-ile metric is to remove 'extreme' episodic events, and these situations may or may not qualify as extreme, since they are the normal summer experience at these sites. Below is an example from Sula, MT (Figure 15 and Figure 16). This site is remote with very few, if any, industrial sources nearby. The site is located near the Selway-Bitterroot Wilderness Area, which experiences long duration wildfires almost every summer. The graphics below show that the 95%-ile metric includes many days that were also included in the original haziest days metric. Many of these days occur during the wildfire season. By lowering the threshold, more light extinction is pulled into the episodic category and the days are ultimately removed from the MID.

The Subcommittee believes sites that experience low level long duration wildfire impacts, such as in SULA, may want to consider a different approach. One approach would be to lower the threshold to classify more wildfire impacts into the episodic category. Another option would be to adjust the 2064 goal to account for the normal, but elevated, wildfire smoke as natural. Additional coordination with EPA should be sought when pursuing an alternative metric approach.

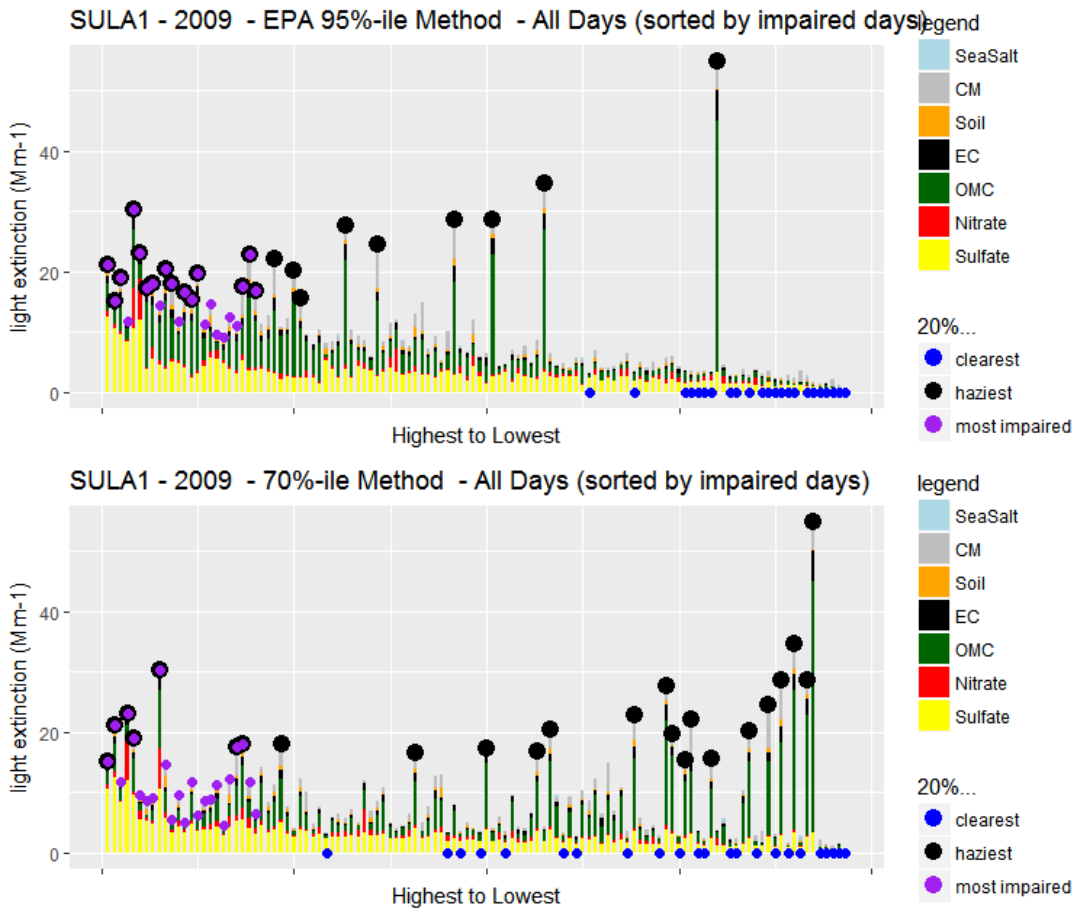

Figure 15: Clearest, haziest, and most impaired days for Sula in 2009 comparing an E3 threshold of 70% to 95%

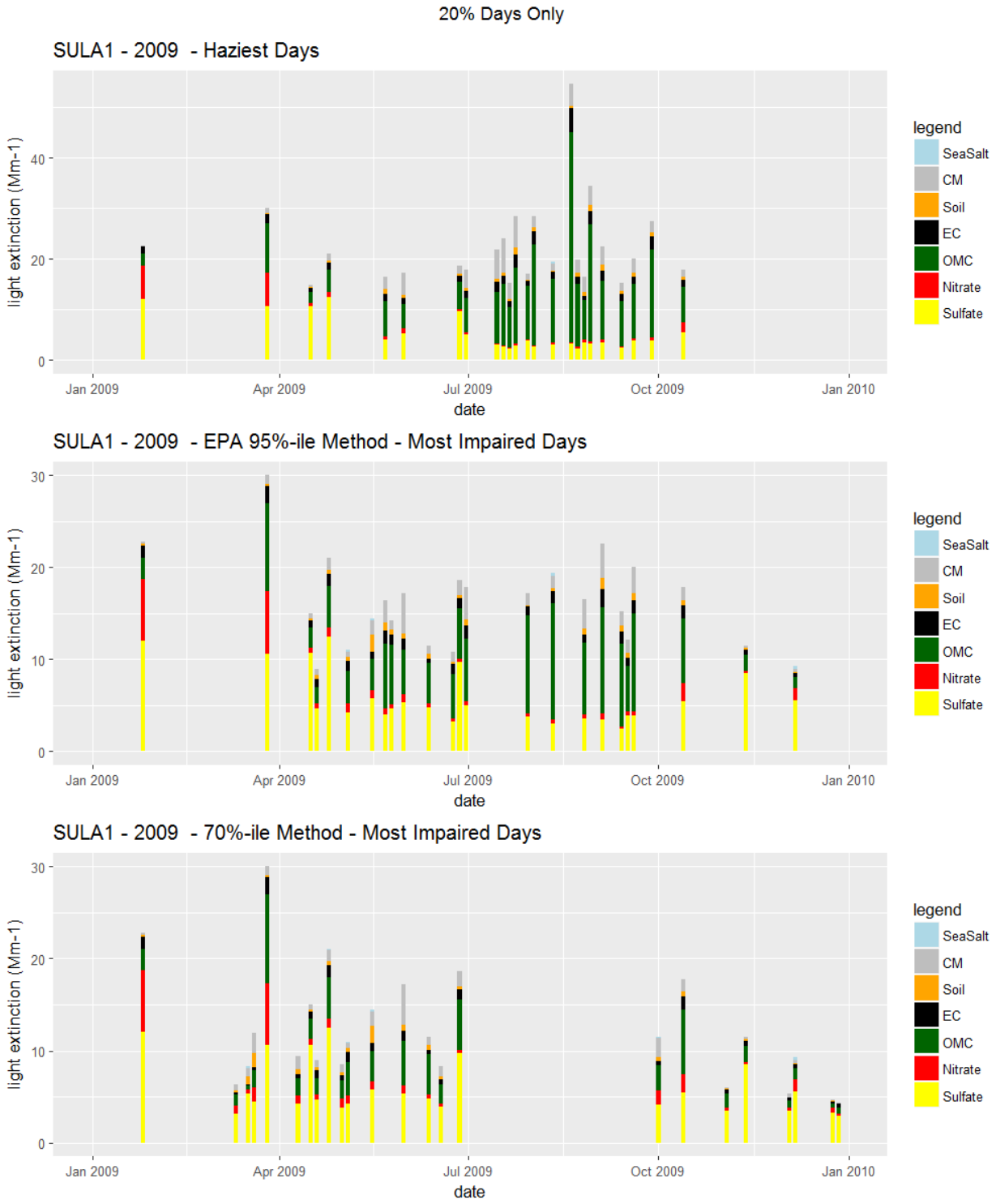

Figure 16: Comparison between the 2009 haziest days, most impaired days, and most impaired days with a 70% E3 threshold for Sula

Most Impaired Days Conclusion and Next Steps

The 95%-ile metric is effective at most sites for removing wildfire and dust days from the MID, although the effectiveness is variable. The committee has identified low level wildfire smoke impacts and volcanic impacts at western sites that are not removed using the 95%-ile metric. The Subcommittee recommends states take a closer look at sites

where this scenario occurs to see if a better metric would be appropriate. States are also encouraged to use the tools made available by the Subcommittee to identify other sites where the 95%-ile metric does not perform well.

Natural Conditions

The Subcommittee spent time researching how natural conditions are calculated, what assumptions are made and what the impact on those assumptions are to the most impaired days and the 2064 endpoint. The key input in calculating natural conditions is the Trijonis number[19,20], which is an estimate of 'natural' (non-anthropogenic) for each haze-contributing species. These values assumed that all 'natural' haze were constant in the western U.S. The NCII values are essentially the Trijonis values converted to light extinction units for each site, taking into account sites' individual species distributions and humidity characteristics, limiting the variability in NCII values between sites. The natural routine contribution is then normalized to the NCII values, again limiting variation between sites based on the Trijonis value. The natural routine values (along with the episodic values) are then used to calculate the 2064 endpoint, causing the Trijonis value to impact the glidepath at all sites.

The Subcommittee looked at how the Trijonis values compared to the IMPROVE site specific distribution of each species for the years 2000-2016. For some species, the Trijonis value seems reasonable. The Trijonis sulfate value, however, are significantly below the distribution of sulfate light extinction across the 26 representative sites. Figure 17 shows box plots for each site of all sulfate concentrations (in $\mu g/m^3$) between 2000-2016, with the Trijonis value shown by the black line and the red dot showing the 2064 endpoint. It appears the Trijonis value could be unrealistically low for sulfate, although more research is needed.

The Subcommittee also looked at two alternatives to the Trijonis input to help illustrate the effects of how the 2064 endpoints depended on them. In one scenario, the Trijonis numbers were doubled across all species, and in the other scenario the Trijonis values were replaced with site/species specific values that were the 20%-ile of each site/species mass concentrations for 2000-2016. The former was used to show sensitivity and the latter was an attempt to estimate "natural" concentrations as the lowest quintile of the mass distributions. The endpoints in deciviews are displayed in Figure 18, showing how the endpoints increased in all cases for doubling the Trijonis. At most sites (17 out of 26) the deciview endpoints increased for the 20%-ile ("q20") approach (Figure 18).

A closer look at the sulfate distributions (in light extinction) illustrate the previous point that the original Trijonis input for the west is too low (Figure 19). However, when looking at the coarse mass distributions below, one can argue that the Trijonis input for the west may be too high (Figure 20).

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[19] Trijonis, J.C. (1990) Characterization of Natural Background Aerosol Concentrations, Appendix A in Acidic Deposition: State of the Science and Technology, Report 24, Visibility Existing and Historical Condition – Causes and Effects, National Acid Precipitation Assessment Program.

[20] Copeland, S.A.; Pitchford, M.; Ames, R. Regional Haze Rule Natural Level Estimates Using the Revised IMPROVE Aerosol Reconstructed Light Extinction Algorithm, available at http://vista.cira.colostate.edu/improve/Publications/GrayLit/032_NaturalCondIIpaper/Copeland_etal_NaturalConditionsII_Description.pdf

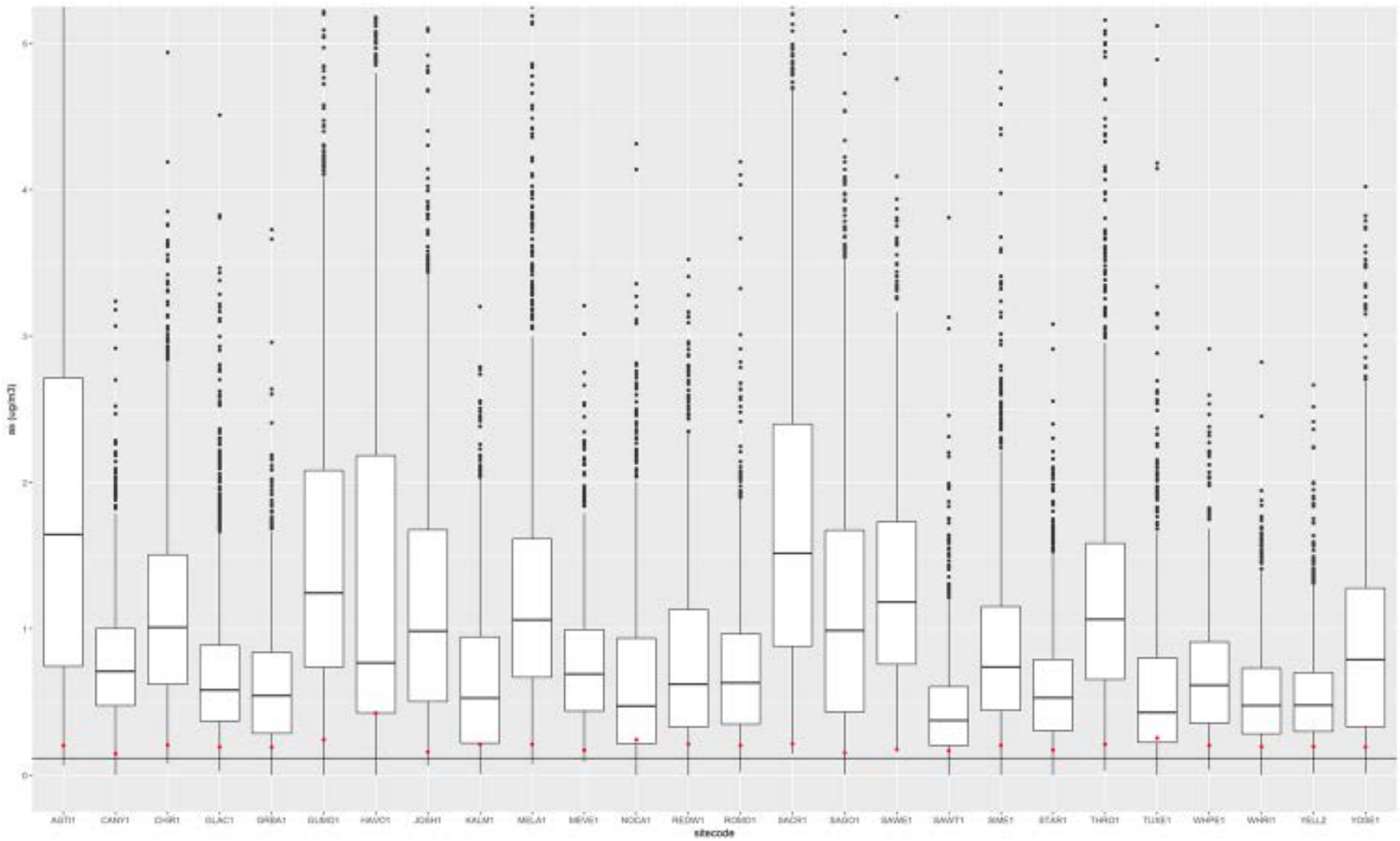

Figure 17: Comparison of the Trijonis sulfate mass values to the NCII mass values to the 2000-2016 distribution of mass values for each representative site

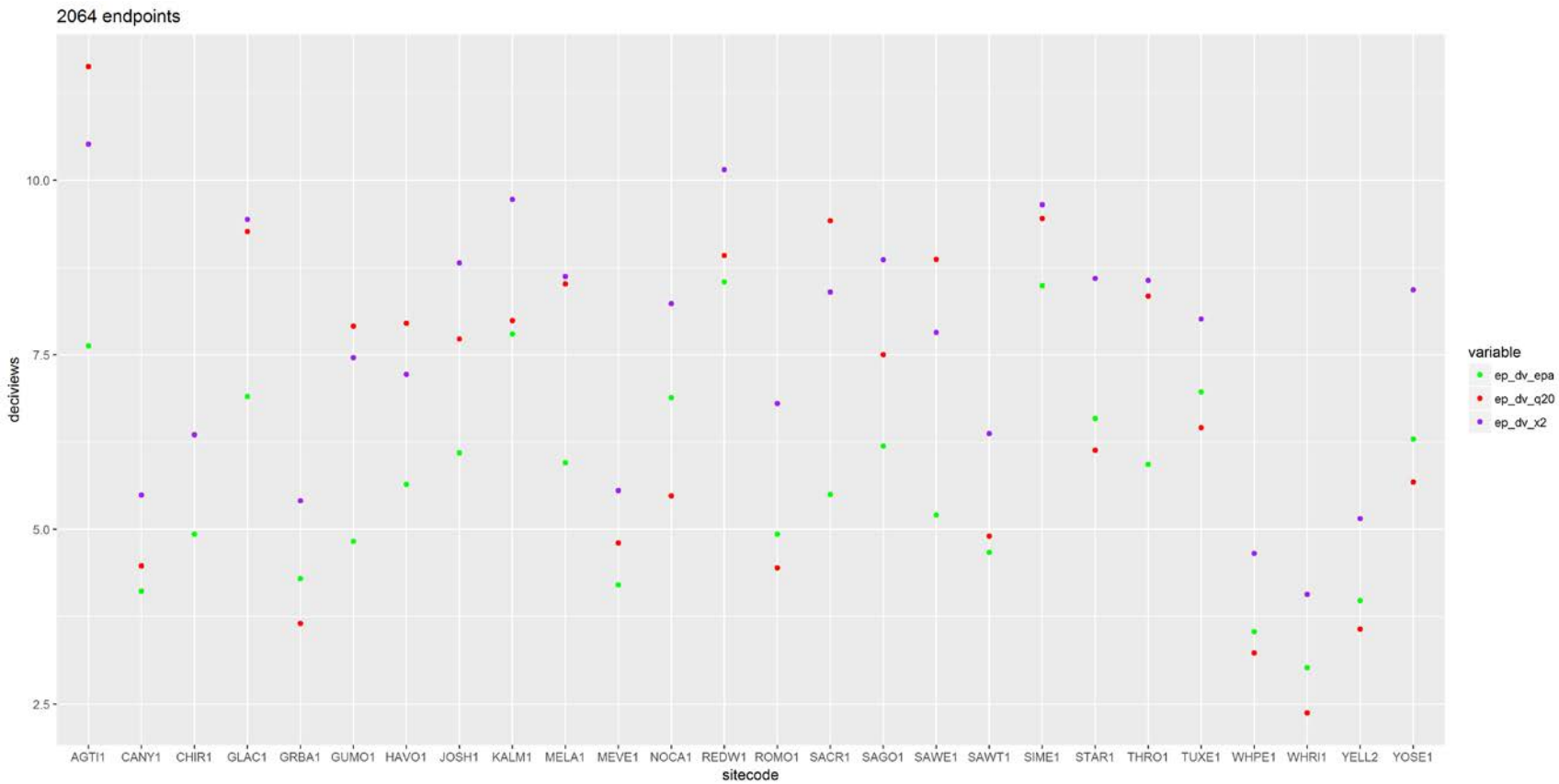

Figure 18: A Comparison of the 2064 deciview endpoints for 3 scenarios: EPA's natural conditions (ep_dv_epa), 20th % average from 2000-2016 (ep_dv_q20), and doubling the Trijonis value(ep_dv_x2)

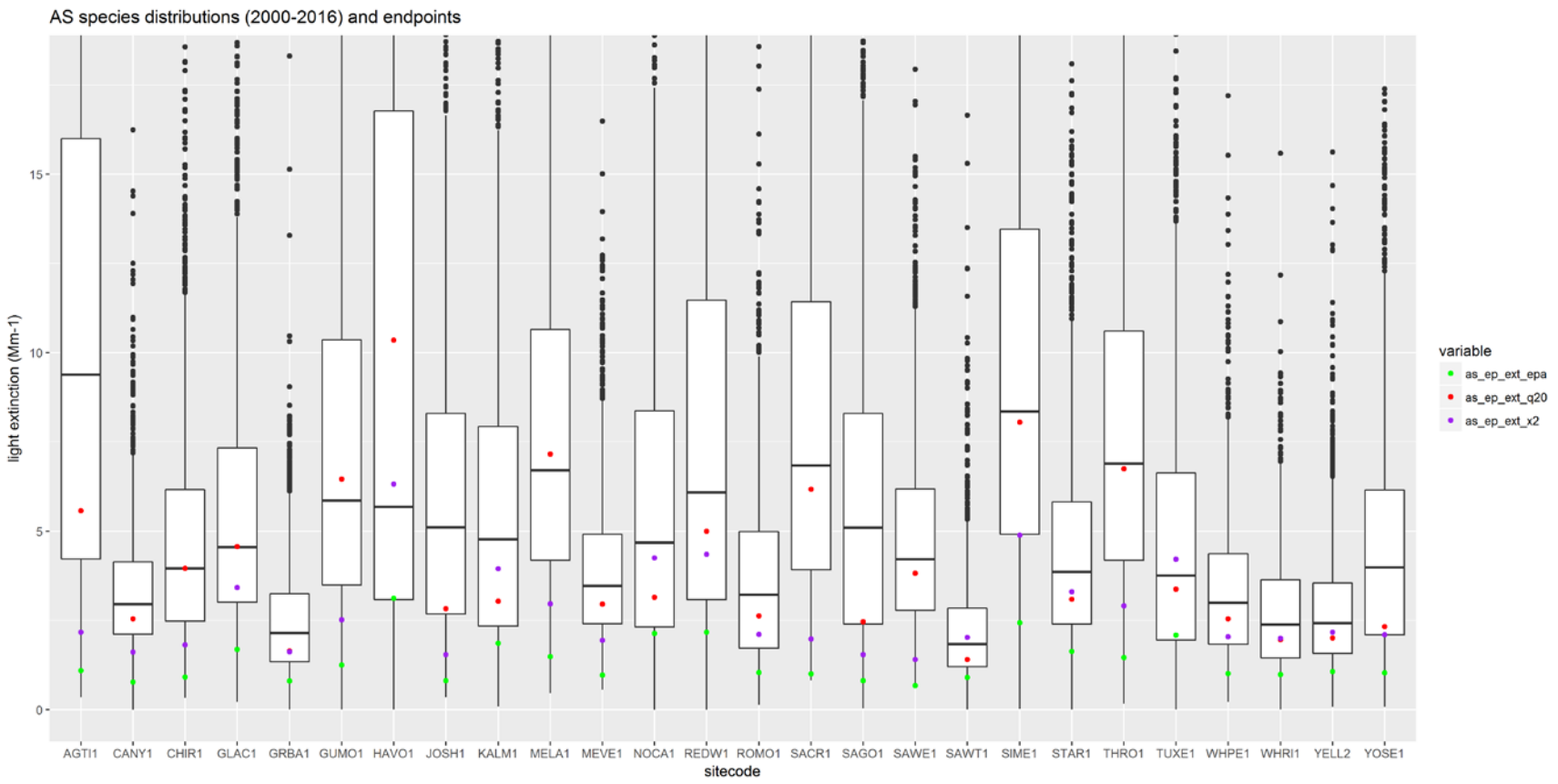

Figure 19: Comparison of the Trijonis sulfate mass values to the 3 different endpoint scenarios [EPA's natural conditions (ep_dv_epa), 20th % average from 2000-2016 (ep_dv_q20), and doubling the Trijonis value(ep_dv_x2)] for 26 representative sites

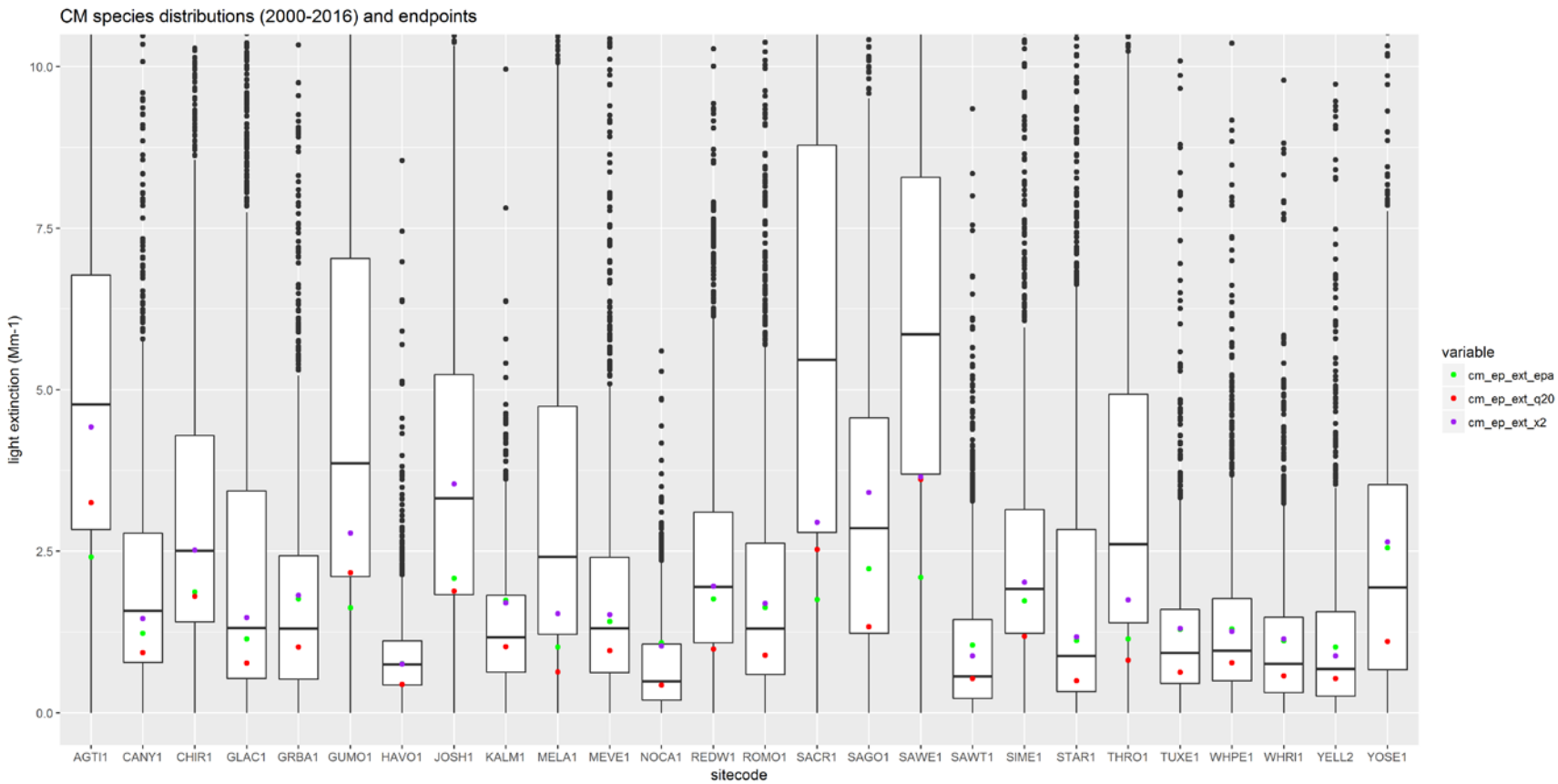

Figure 20: Comparison of the Trijonis coarse mass values to the 3 different endpoint scenarios [EPA's natural conditions (ep_dv_epa), 20th % average from 2000-2016 (ep_dv_q20), and doubling the Trijonis value(ep_dv_x2)] for 26 representative sites

The results of this research have not lead to any solid conclusions but has opened the door for further research. Specifically, the Subcommittee is considering if regional or site specific Trijonis values may be more appropriate rather than a single value for the west. This includes a more refined analysis of what is considered natural within the mass distributions, and possibly seasonal NCII values that capture the temporal patterns of natural conditions. However, since there is no way to measure true non-anthropogenic contribution to haze, there is no way to validate the values.

Next Steps

The Subcommittee has identified many areas for further analysis, including:

1) The impact of the 95%ile metric on dust events could use further analysis to determine if there are situations where a better metric would be appropriate.
2) How states can adjust the 2064 natural conditions end-point to account for prescribed fire, international impairment and other uncontrollable anthropogenic emissions?[21]
3) Are there other ways to measure visibility improvement, or reduction of anthropogenic impairment, that would make the progress clearer to the public?
    - States could include in their SIPs data analyses that serve as a weight of evidence that progress in reducing anthropogenic impairment is occurring. This might include downward changes in haze species light extinction largely resulting from anthropogenic sources emissions, such as NOx and SOx reductions resulting in lower nitrate and sulfate light extinction.
    - States could convert light extinction to visual range and trace progress in visual range on an annual average on Best days, Haziest Days, MIDs or middle quintile days, to illustrate some of the informative ways to explain visibility changes.

Work Products

Table 3, below, describes the work products that were delivered to various entities for specific planning needs.

Table 3: Outline of work products delivered by the Monitoring & Glide Path Subcommittee

Product	In-Kind or Contract Services	Product User(s)	Season/Year Completed	Notes
Protocol for identifying most impaired days		States check, then submit to Database Manager and Regional Modelers	Q4 2018	MDGPS recommends EPA's recommended approach, please refer to Section 5.5 of EPA's draft guidance document[22]. Our review of the metric is provided in the Calculation Options section of this document.

[21] Information to help answer these questions will come from the Modeling / Emissions Inventory Subcommittee and the Smoke & Fire Work Group.

[22] U.S. EPA. (2016). Draft Guidance on Progress Tracking Metrics, Ling-Term Strategies, Reasonable Progress Goals and Other Requirements for Regional Haze Implementation Plans for the Second Implementation Period. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards. EPA-457/P-16-001. July. https://www.epa.gov/sites/production/files/2016-07/documents/draft_regional_haze_guidance_july_2016.pdf

Product	In-Kind or Contract Services	Product User(s)	Season/Year Completed	Notes
Protocol for determining routine natural emissions		Regional Contractor, with State input	Q4 2019 (with ongoing work which may result in recommendations for future planning periods)	MDGPS recommends EPA's recommended approach, please refer to Section 5.5 of EPA's draft guidance document[23]. Our review of the metric is provided in the Calculation Options section of this document.
Substituted IMPROVE Dataset for all monitors	Air Resource Specialists		Q1 2019	Establish, State approved, patching and substitution procedures for all western Class I Areas missing data.
New "Natural Conditions" for 2064		States submit to Database Manager	Q4 2019	Determine whether states use protocol above or differentiate between "routine natural" (for calculating MID) and Natural Conditions 2064 (which may include allowances for prescribed fire, international emissions and other "uncontrollable" sources of haze)
Protocol for determining international emissions adjustments (2064)		Regional Contractor (results to Database Manager) and States for SIP preparation	Q4 2019	Developed with Modeling Subcommittee; results may depend on apportionment modeling; consensus agreement on rationale for holding value steady or assuming growth.
Prescribed fire adjustments (2064)		States	Q4 2019	WRAP Fire and Smoke Working Group to develop Protocol with FLM
New Glide Path		Database Manager and States for SIP preparation	Q4 2019	Discuss with Control Measures Subcommittee regarding control scenarios for RPGs in relation to 2028 benchmark on Glide Path

[23] ibid

Alternatives to EPA's Most Impaired Days Metric

Introduction

The WRAP MDGPS recommends that States utilize EPA's proposed tracking metric for the purposes of tracking visibility progress at Class I areas within their State or in downwind States. However, the MDGPS has also noted that EPA's proposed tracking metric may not be appropriate for every Class I area. Instances where EPA's proposed tracking metric may not be appropriate include, but are not limited to, sites that experience consistent low level fire or natural windblown dust impacts and Class I areas near volcanic activity. In these instances the State may perform data analyses that supports the use of an alternative approach to EPA's proposed tracking metric. When this occurs, the MDGPS encourages the States to document all information supporting the use of an alternative metric approach and coordinate with the WRAP, surrounding States, and the EPA on the proposed alternative metric approach to ensure regional consistency and approvability.

While the MDGPS has not defined a specific method by which monitoring data should be evaluated to determine the appropriateness of an alternative approach to EPA's tracking metric, the MDGPS has provided western States with a number of evaluation tools to aid in this determination, including:

- Extreme Episodic Event (E3) evaluation workbooks
    - Workbook tool - https://azdeq.sharefile.com/d-s2b1d86597ab41619
    - Workbook User's Guide - https://azdeq.sharefile.com/d-s8d6ba6d59d74a3b9
    - Select Site Evaluations - https://azdeq.sharefile.com/d-sbec6783ef784d63a
- E3 evaluation R code
    - R Code - https://azdeq.sharefile.com/d-s52acfe17fd24922b
    - Select Site Evaluations - https://azdeq.sharefile.com/d-sb0ad8007ae34c519
- Natural Conditions/Trijonis evaluation results – https://azdeq.sharefile.com/d-saf3ea3b450b4180a

In addition to these tools and work products, the MDGPS is further supplying States with alternative approaches to evaluate EPA's proposed approach or to adopt in place of utilizing EPA's proposed metric approach. These approaches are listed below. Some of these approaches have been assessed in the work provided by the MDGPS while other approaches have been proposed or examined by other external groups. When determining which approach is appropriate for a specific Class I area, the State should review available documentation on the approach and evaluate the alternative approach's results against EPA's proposed metric. Determination of the most appropriate metric approach should depend on that approach which provides the most accurate results for determining the anthropogenically most impaired days for the site of interest. In general, the MDGPS suggests that a State should only deviate from EPA's recommended tracking metric approach when an alternative approach has been reasonably shown to predict the most anthropogenically impaired days with at least 10% or more accuracy than EPA's proposed approach and/or provides for a similar increment increase in accuracy when determining anthropogenic impairment (dv) for the site's 5-year average impairment during the base period and most recent period. While metric accuracy is highly important, regional consistency in a metric approach also provides the benefit of reproducibility across sites, allowing for more direct comparisons between sites when performing control analyses and modeling. This should be taken into consideration and is the primary reason the MDGPS does not recommend deviation to an alternative approach unless there is generally a 10% or greater performance improvement of the alternative metric.

Alternative Metric Approaches

The following list contains alterations of and alternatives to EPA's proposed metric. The recommendations provided also include pros and cons of utilizing the proposed alternative as well as any notes that may be relevant for consideration.

1. **Altering the E3 threshold from 95% to another percentile**
    a. *Pros:* Allows for site-specific limits for carbon and dust E3s
    b. *Cons:* 1) It may be necessary to develop separate percent thresholds for each site and determining the appropriate thresholds depends on additional investigation, 2) Initial investigations indicate that altering the percent E3 threshold does not significantly change the glide path for some sites.
    c. *Notes:* Current tools for investigation are available for testing this approach (i.e. the MDGPS R code and excel workbook).
2. **Utilizing the median, mean, etc. annual threshold value as opposed to minimum and/or to utilize a seasonal value as opposed to annual**
    a. *Pros:* May better identify E3 events in some class I areas
    b. *Cons:* Initial investigations indicate that altering the % E3 threshold does not significantly change the glide path for some sites.
    c. *Notes:* Current tools for investigation are available for testing this approach (i.e. the MDGPS R code).
3. **Altering the threshold from percentile approach to some other statistical approach (e.g. outlier identification and removal)**
    a. *Pros:* 1) May provide more site appropriate isolation of E3 events. 2) Could provide a more accurate isolation of E3 events if extinction values are skewed during these events
    b. *Cons:* 1) Would depend on site specific analyses, 2) Initial investigations indicates that many sites extinction data are more uniform than skewed, which makes determining an appropriate statistical method difficult
    c. *Notes:* No current tools available for this estimation technique.
4. **Consider a fixed allocation (Mm-1) for carbon as a threshold for fire influence**
    a. *Pros:* Useful for culling data
    b. *Cons:* Is likely not appropriate for the accuracy needed for modeling of RPGs
5. **Only focus on sulfate and nitrate worst days**
    a. *Pros:* Focuses primarily on anthropogenic sources of emissions
    b. *Cons:* 1) May not capture all sources that require control (e.g. animal agricultural, unpaved roads, etc.), 2) Does not help States with large natural sulfate sources (e.g. Hawaii) 3) May not meet EPA guidance for addressing the top 80% of non-mobile anthropogenic emitters.
6. **Utilize the average 2nd quintile**
    a. *Pros:* Likely to completely remove the impacts of E3 events
    b. *Cons:* Consultation with EPA will be required to understand if this approach meets the requirements for the 20% Most Impaired Days (MID) (specifically, if it is adequate for isolating the 20% of days with the highest anthropogenic impairment).
    c. *Notes:* This introduces an entirely different concept for the metric; needs to be vetted by EPA and compared with source apportionment. The percentile may need to be

evaluated every planning period as increased anthropogenic impact is reduced and potentially more natural haze is introduced.

7. **Particulate Matter Source Apportionment Technology (PSAT) modeling**[24][25]
    a. *Pros:* Provides a form of source apportionment which more accurately identifies fire related emissions
    b. *Cons:* 1) Processed data only available for 2011, 2) Dust application has not been researched, 3) May not be able to accurately identify sources at all monitors, 4) May not be able to isolate wildfire from other fire emissions at all monitors, 5) Time/resource intensive
8. **Positive Matrix Factorization (PMF) modeling**[26]
    a. *Pros:* Identifies source types by chemical component
    b. *Cons:* 1) Time Consuming; 2) Will not pinpoint a facility or point of origin, just the type of source, 3) May not be able to isolate wildfire from other fire emissions at all monitors, 4) Dust application has not been researched, 5) May not be able to accurately identify sources at all monitors

Evaluation of Alternative Metric Approaches

The following list provides approaches for evaluating the performance of an alternative to EPA's proposed visibility tracking metric. The MDGPS strongly recommends that each State attempt to evaluate the performance of an alternative metric when choosing a method that is different than the MDGPS's recommended approach (i.e. EPA's proposed tracking metric).

1. **HYSPLIT/Fire location or WEP/Fire location spatiotemporal comparison**
    a. *Pros:* 1) Provides hourly resolution back-trajectories for determining fire contribution to a monitor on a given day
    b. *Cons:* 1) Time Consuming; 2) temporal resolution of monitoring data and fire data (daily) does not match HYSPLIT data (hourly)
    c. *Notes:* May be a good resource for spot-checking threshold viability or for specific fire-centric analyses for certain monitors.
2. **Satellite detection of fire/dust storms**
    a. *Pros:* 1) Provides accurate identification of event locations and potential plume movement
    b. *Cons:* Satellite products are not always available due to sampling periods or cloud coverage
3. **Determine smoke impaired days by utilizing the Hazard Mapping System (HMS) data**

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[24] Brewer, P.; Tonnesen, G.; Morris, R.; Moore, T.; Nopmongcol, U.; Miller, D. (2018). Air pollutant source characterization using the revised regional Haze tracking metric and a photochemical grid model and implications for regional Haze planning. Journal of the Air & Waste Management Association. 10.1080/10962247.2018.1537985.

[25] https://www.wrapair2.org/pdf/Brewer-Moore%20Visibility%20Tracking%20Metrics%20for%20Regional%20HazePlanning_%20WRAP%20Regional%20Haze%20Planning%20Work%20Group_062917.pptx

[26] Kotchenruther, R. (2018). Using Source Apportionment from Positive Matrix Factorization Receptor Modeling to Apportion the Carbon component of Natural and Anthropogenic Light Extinction at Class One Areas.

a. *Pros:* Quicker visual processing of information than utilizing a manual HYSPLIT/Fire or WEP/Fire spatiotemporal comparison
b. *Cons:* May not provide the same resolution as manually processing HYSPLIT/Fire or WEP/Fire data manually
c. *Notes:* May be a good resource for spot-checking threshold viability or for specific fire-centric analyses for certain monitors.

4. **PSAT modeling**
    a. *Pros:* 1) Source apportionment allows organic carbon to be split into fire components, assuming no other interfering sources 2) Can provide a type of source apportionment for checking the effectiveness of a MID estimation approach.
    b. *Cons:* 1) Currently only evaluated for the year 2011, 2) Dust application has not been researched, 3) May not accurately identify fire sources at all monitors, 4) May not be able to isolate wildfire from other fire emissions at all monitors, 5) Time/resource intensive
5. **PMF modeling**
    a. *Pros:* 1) Identifies source types by chemical component; 2) Can provide a type of source apportionment for checking the effectiveness of a MID estimation approach.
    b. *Cons:* 1) Time Consuming; 2) Will not pinpoint a facility or point of origin, just the type of source, 3) May not be able to isolate wildfire from other fire emissions at all monitors, 4) Dust application has not been researched, 5) May not be able to accurately identify sources at all monitors

Alternative Metric Evaluation and Consultation

In order to ensure the alternative metric chosen is State Implementation Plan (SIP) approvable and regulatory and planning organizations are aware of deviations from the MDGPS recommended visibility tracking metric approach, the MDGPS recommends that States deviating from the proposed approach follow these steps:

- ☐ Evaluate the accuracy of the alternative approach as compared to the accuracy of the proposed metric utilizing a method listed in this document or another scientifically justified approach
- ☐ Document the results of this analysis and any additional justification/resources that support the use of the alternative metric
- ☐ Share the justification document for the alternative metric with the State's EPA Regional Office to ensure the regional office finds the approach reasonable for SIP planning for the monitoring site of interest
- ☐ While awaiting EPA feedback, provide the justification document to States, Tribes, locals, Federal Land Managers (FLMs) and the WRAP for review
- ☐ Once EPA approval is received, provide notice to surrounding States, Tribes, locals, FLMs and the WRAP of intention to utilize the EPA approved alternative approach
- ☐ Document all consultation and coordination which occurred during this process

Example of alternative metric evaluation and consultation

The MDGPS provides the following example to help State's understand the recommended approach for evaluating an alternative metric and the consultation steps which should occur in order to ensure EPA, surrounding States, Tribes, locals, FLMs and the WRAP are actively participating in the process.

In this example a nonspecific Class I area, designated Site X for this example purpose, is analyzed to determine if an alternative metric is appropriate. **This is only an example and does not represent a full analysis or actual work that was previously performed by the State of Arizona.** Please note that this example contains example information that is not accurate but is used to broadly illustrate the recommended approach for evaluating an alternative metric.

In addition, a more robust technical analysis than what is performed below should be undertaken when evaluating the datasets to ensure the process evaluation and metric alternative are well justified. Again, the example below is simply a method to illustrate the process a State should undertake as opposed to representing an exhaustive analysis of the dataset, which would likely be required to justify an alternative metric approach.

Again, please note that the information provided in this subsection is only provided to describe the process of evaluating an alternative metric and does not represent work that was performed for any particular monitor previously.

Evaluate the performance of recommended metric

The MDGPS has provided multiple tools to help in the assessment of an IMPROVE monitor dataset. These tools can be utilized to assist in determining the appropriateness of utilizing the recommended metric. Some of the data provided in this example originates from these tools.

In this example, Site X monitor data indicates that there are some large variations in the most impaired days (MID) chosen when altering the dataset to evaluate additional metrics, indicating that slight alterations in methodology can lead to drastic changes in the MID chosen (Figure 21).

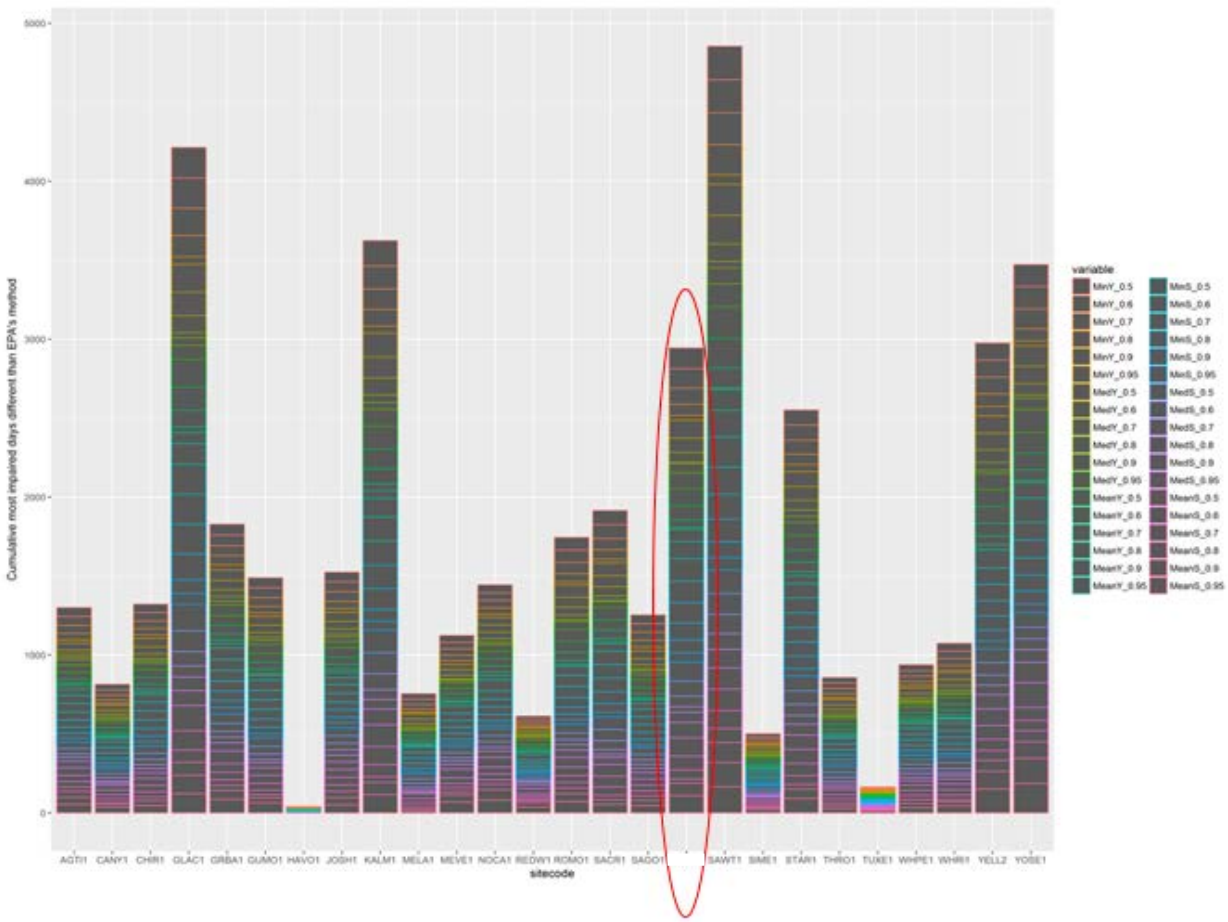

Figure 21: Cumulative MID days that changed for each site for all 36 metrics tested as referenced to EPA's proposed metric

In addition, further examination of the Site X IMPROVE data between 2002 and 2017 (2000 and 2001 were incomplete data years) indicates that there were 1815 days with complete data sampled over the period and of those, 1089 exceeded the E3 dust threshold of 11.98 mM^{-1}, which was estimated utilizing the proposed tracking metric. Therefore, 60% of sampled days exceeded the E3 dust threshold, which may indicate an oversampling of days that experience E3.

Finally, analysis of wind speeds at the site indicate that only 12% of days at the monitor experienced wind speeds that exceeded 12mph (the windspeed threshold shown to produce windblown dust in the Maricopa and Pinal PM_{10} nonattainment areas[27][28]).

Given the above information, the State felt it prudent to analyze alternative metric approaches for Site X.

[27] Maricopa Association of Governments. (2012). MAG 2012 Five Percent Plan for PM10 for the Maricopa County Nonattainment Area

[28] Arizona Department of Environmental Quality. (2015). 2015 West Pinal Moderate PM10 Nonattainment Area SIP.

Evaluate the alternative metric approach

After reviewing the MDGPS alternative metric approaches, the State determined that the most appropriate method for determining the most impaired days was using the following approach:

1. Performing Positive Matrix Factorization modeling for the baseline period (2000-2004) and the most recent progress period (2012-2017) to obtain factor mass allocations and factor chemical profiles.
2. Utilizing a step-by-step procedure similar to that of Kotchenruther (2018)[29] to determine those days that should be classified as MID; however, the procedure was altered for dust species as opposed to focusing on carbon species (more information on this updated is provided in supplemental documentation).
3. Performed wind tunnel field testing around the Site X monitor to determine the wind threshold that would be required to produce a visible windblown dust plume.
4. Reviewed local meteorological data to determine the days which contained 15-min average wind speeds exceeding the Site X specific wind threshold.
5. Compared the MID days chosen by the MDGPS recommended approach against those chosen through PMF modeling.
6. The method that had the lower fraction of MID included in wind speed threshold exceedance days was assumed to contain less bias towards natural E3 inclusion and was therefore assumed to be more accurate.

The methodology and results of the PMF modeling and metric comparative analysis are provided in supplemental documentation. Ultimately, the PMF approach chose 36% less days that exceeded the wind speed threshold than the MDGPS recommended approach. Therefore, the State determined that it was more appropriate to utilize PMF for MID determination.

Consultation with EPA, States, Tribes, locals, FLMs and the WRAP

Following completion of the State's analysis, technical documentation was provided to EPA Region 9 to request approval of the State's alternative approach for the Site X tracking metric. The State provided all documentation requested by the Region and met multiple times to discuss the approach. Ultimately, the EPA provided written approval to the State on the date 11/25/2018.

While EPA was reviewing the justification for the State's approach, the State also coordinated with surrounding States, Tribes, locals, FLMs and the WRAP to provide coordination with these entities and answer and questions and/or concerns these organizations provided. While not required, the State also asked these organizations to provide written approval/disapproval of the proposed methodology so that the State could document the feedback in the State's State Implementation Plan (SIP).

Finally, once the State received written approval of the use of the alternative approach from EPA, the approval was forwarded to surrounding States, Tribes, locals, FLMs and the WRAP so that they were aware of the State's intention to move forward with the use of the alternative metric approach.

Documentation of organizations, contacts, dates of contact, and notes on the information shared and/or received is provided in Table 4.

[29] Kotchenruther, R. (2018). Using Source Apportionment from Positive Matrix Factorization Receptor Modeling to Apportion the Carbon component of Natural and Anthropogenic Light Extinction at Class One Areas.

Table 4: Consultation documentation for the use of an alternative tracking metric

Organization	Contacts	Date of Contact	Information Shared/Received
State of California	Person A	11/21/2018	Support Document for Alternative Metric Approach
EPA	Person B	11/22/2018	PMF modeling files
National Park Service	Person C	11/23/2018	Memo supporting the use of the alternative metric
Etc.	Etc.	Etc.	Etc.

Again, please note that the information provided in this subsection is only provided to describe the process of evaluating an alternative metric and does not represent work that was performed for any particular monitor previously.

Subcommittee Coordination

Prior Consultation

The MDGPS has consulted with a number of WRAP Work Groups and Subcommittees to date to ensure work products are created that meet the general timelines and content needs of these other groups. To date, the MDGPS has met with several Subcommittees to discuss these topics; however, coordination with other Subcommittees and Work Groups is still necessary to ensure MDGPS continues to ensure the work products are completed on-time and with high quality. The coordination and consultation completed to date is listed in Table 5. Future consultation requirements are listed in Table 6.

Table 5: Schedule of prior coordination between the MDGPS and other entities.

Date	Method	Entities involved	Topic / Problem	Outcome	Notes / Links
6/14/2018	Webinar	USFS	IMPROVE data patching and substitution	Explanation of methods utilized for IMPROVE data patching and substitution and who is responsible for these tasks	
8/1/18	Webinar	Technical Steering Committee	Discussion of E3 threshold work	Relayed work performed to data and data products available	https://www.wrapair2.org/TSC.aspx
8/7/18	Webinar	RH Planning Workgroup	Discussion of E3 threshold work	Relayed work performed to data and data products available	https://www.wrapair2.org/RHPWG.aspx

Date	Method	Entities involved	Topic / Problem	Outcome	Notes / Links
8/24/18	Call	Shared Database Subcommittee Lead	IMPROVE dataset finalization	Determined steps moving forward for Subcommittee coordination and IMPROVE data finalization	
9/4/18	Call	Control Measures Subcommittee Lead, NPS, WRAP	Timeline for control measure IMPROVE data finalization	Outlined Control Measure data needs and timeline for completion. Determined critical steps for completion.	
9/11/18	Call	ARS, WRAP, NPS	Contractor tasks for IMPROVE data substitution	Outlined ARS tasks and timeline for completion, expectations for Subcommittee involvement, and ARS updates to Subcommittee	
9/27/18 – 10/1/18	Call / Email	WRAP, EPA	EPA involvement in MDGPS work and calls	Secured EPA technical assistance and participation in Subcommittee work	
12/13/18	Webinar	RTOWG, Electric Power Research Institute (EPRI)	International Emission Impact modeling	EPRI outlined the tasks they will complete related to the project and the tentative remaining timeline	https://azdeq.sharefile.com/d-sa1d95192e23431a8

Future Consultation

In general, the MDGPS needs to consult and coordinate with the Modeling / Emissions Inventory Subcommittee to help determine how much impairment is due to uncontrollable emissions, such as international transport. In addition, anthropogenic fire emissions (prescribed, agricultural, etc.) present opportunities and challenges for analyzing natural routine carbon and for adjusting the endpoint (2064) of the glide path. For this, the Subcommittee will need to coordinate with the Fire & Smoke Work Group. Prior modeling exercises indicating international emissions in the baseline period current source apportionment modeling for the year 2014 and 2028, and 2011 WestJumpAQMS modeling will be used in conjunction with the calculations of current conditions and future forecasts for international emissions made by EPRI to inform the decision on adjusting the 2064 endpoint of the Glide Path with International emissions. Consensus for the western states will be reached through discussions with the Emissions and Modeling Subcommittee and the Regional Technical Operations Work Group, working with the regional modeling contractor.

Future coordination needs with entities outside of the Monitoring & Glide Path Subcommittee are outlined in Table 6, below.

Table 6: Schedule of future coordination between the MDGPS and other entities.

Date	Method	Entities involved	Topic / Problem	Outcome	Notes / Links
		Fire and Smoke Workgroup	Prescribed Fire treatment for the Uniform Rate of Progress		
		Emissions Inventory and Modeling Subcommittee, Regional Technical Operations Workgroup	International Emissions treatment for the Uniform Rate of Progress		
		Shared Database Subcommittee	IMPROVE data finalization		

MDGPS Members

In addition to the consultation and coordination efforts listed in Table 5 and Table 6, MDGPS members are also heavily involved in other Subcommittees. Currently, members of the MDGPS also work on each of the other WRAP Subcommittees and Work Groups as contributing members. A list of active, current MDGPS members and their agency and WRAP Subcommittee affiliation is listed in Table 7.

Table 7: MDGPS Members with Agency and WRAP Subcommittee Affiliations

Member	State	Consultation & Coordination	Shared Database	EI & Modeling	Control Measures
Ryan Templeton	Arizona	☐	☑	☑	☐
Tina Suarez-Murias	California	☐	☑	☐	☑
Tim Allen	Fish & Wildlife Service	☑	☑	☑	☑
Pascale Warren	Idaho	☐	☐	☐	☐
Brandon McGuire	Montana	☐	☐	☐	☐
Kristen Martin	Montana	☐	☑	☐	☐
Rebecca Harbage	Montana	☑	☐	☐	☑
Pat Brewer	National Park Service (DOI)	☑	☑	☑	☑
Frank Forsgren	Nevada	☑	☑	☑	☑
Cindy Hollenberg	New Mexico	☐	☑	☑	☐
Phil Allen	Oregon	☐	☐	☐	☐
Amber Potts	Wyoming	☐	☐	☐	☐
Tom Moore	WRAP	☑	☑	☑	☑
Bob Lebens	WESTAR	☐	☐	☐	☐
Brett Gantt	EPA	☐	☐	☐	☐
Joe Adlhoch	Air Resource Specialists	☐	☐	☐	☐
Emily Vanden Hoek	Air Resource Specialists	☐	☐	☐	☐