Technical Review of VISTAS Visibility Modeling for the Second Round of Regional Haze State Implementation Plans

By: D. Howard Gebhart, May 2021

Introduction and Background

This report provides a technical review of the VISTAS (Visibility Improvement - State and Tribal Association of the Southeast) visibility modeling effort, which has been conducted to assist in development of the second round of regional haze State Implementation Plans (SIPs) for ten states in the southeastern United States.

The visibility modeling effort relied mainly upon the Comprehensive Air Quality Model with Extensions (CAMx). The VISTAS CAMx modeling effort was jointly conducted by Eastern Research Group and Alpine Geophysics. CAMx modeling was conducted for a 2011 baseline period and also for a future year emission projection representing 2028.

Technical documents reviewed were those posted to the VISTAS website[1] along with associated guidance provided by VISTAS to member states (also found at the VISTAS website). Consistent with the terminology developed by the VISTAS group, the second round of visibility modeling is described using the name "VISTAS II".

Executive Summary

This section provides a brief overview of technical comments regarding the VISTAS II modeling studies. Additional detail on the topics identified in this section has been provided in the "Technical Discussion" sections later in this report.

1. The Model Performance Evaluation (MPE) conducted by VISTAS as part of the 2011 baseline CAMx modeling effort showed a large and significant underprediction for sulfate and organic carbon. In particular, the sulfate errors were outside of the modeling error boundaries established by VISTAS for its own CAMx modeling efforts[2]. The sulfate errors were also larger during the summer, when the sulfate extinction is known to be the greatest contributor to visibility impairment. The large sulfate underprediction clearly means that the VISTAS II CAMx results should not be used without properly accounting for the known bias in the sulfate predictions. The known sulfate underprediction in the VISTAS II CAMx modeling results also has repercussions in other areas of the modeling analysis.

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1 https://www.metro4-sesarm.org/content/vistas-regional-haze-program

2 VISTAS Model Performance Evaluation Report, Table 2-1 (Page 6)

2. VISTAS needs to reexamine whether the 2028 emission projection provides an accurate portrayal of the hourly/daily/seasonal Electric Generating Unit (EGU) emission profiles. The 2028 CAMx modeling inputs should be adjusted as necessary to capture the expected 2028 EGU utilization. The VISTAS II assumption that EGUs will operate in 2028 as they did in 2011 is simply not accurate.

3. In the VISTAS II modeling, the 20% most-impaired days were determined using the 2009-2013 IMPROVE measurements. This improper baseline was then erroneously carried forward to the 2028 modeling projection. As such, the VISTAS II 2028 modeling projection was not calculated using the 20% most-impaired days expected to be present in 2028, days that would be more impacted by nitrates based on changes in regional emissions since the baseline period. A better approach would have been to establish the 20% most-impaired days using more current IMPROVE measurements, e.g., 2014-2018 or later. Because the 20% most-impaired days were not accurately defined in the 2028 model projection, the VISTAS II modeling was biased in that it did not assess visibility impacts on days with elevated nitrate concentrations. In turn, the VISTAS II modeling failed to properly identify EGU and point sources with large NOx emissions as contributing to visibility impairment and also failed to address potential visibility benefit of NOx emission controls at these sources.

4. The Area of Influence (AOI) analysis was overly restrictive and failed to properly identify all sources contributing to adverse visibility conditions at VISTAS Class I areas. Most VISTAS states selected an AOI threshold in the range of 2-5% of the overall sulfate and/or nitrate impacts to identify emission sources contributing to visibility impairment. As a result, most states identified six or fewer contributing emission sources through the AOI analysis. Where a lower and more appropriate AOI threshold was selected, i.e., West Virginia, the number of emission sources captured by the AOI analysis was more reasonable.

5. The VISTAS II CAMx modeling also relied on a flawed PSAT modeling analysis that applied an outdated 2028 emissions inventory, provided incomplete information on source-specific contributions to visibility impairment, and carried forward known deficiencies in the modeled sulfate projections (see Item #1 above). VISTAS has coupled this flawed PSAT modeling analysis with a recommendation that only those sources which contribute 1% or greater to either the modeled sulfate or nitrate concentrations would be recommended for the "four-factor" emissions control analysis. As a result, VISTAS has concluded that only a relatively small group of emission sources would be considered for the "four-factor" analysis[3].

   One solution to this problem would have been to use an alternative method to screen emission sources for the "four-factor" analysis. For example, a simple emissions-to-distance (Q/D) ratio could have been applied or VISTAS could have placed a greater reliance on its initial "area of influence" (AOI) modeling (after addressing the AOI shortcomings discussed above). Relying on other modeling instead of the PSAT modeling would have generated a more realistic number of sources potentially subject to the "four-factor" analysis. The current approach that relied on the PSAT modeling (and also used an unacceptably high source contribution threshold) unduly limited the number of emissions sources subject to the "four-factor" analysis. The current

[3] VISTAS Regional Haze Project Update, May 20, 2020

VISTAS modeling approach was fundamentally flawed and contrary to the intent of the EPA Regional Haze regulations.

6. Despite visibility improvements at Class I areas in the VISTAS states, current IMPROVE data continue to show that the remaining visibility impairment is largely dominated by sulfate and nitrate. As such, further sulfur dioxide (SO_2) and nitrogen oxides (NOx) emissions reductions at EGUs and other point sources will be required to reach the national visibility goal. As per EPA's 2017 Regional Haze regulations, the state is required to look beyond the uniform rate of progress (URP) "glide path" in the current SIP planning period to judge success of the regional haze program. Compliance with the applicable EPA Regional Haze regulations stipulates that any emissions reduction measures meeting the "four-factor" emissions control criteria stated in the regulations should be implemented in the current SIP planning period, whether or not a given Class I area has met the URP visibility goals.

Technical Discussion

The Technical Discussion covers several individual items, as summarized below:

- CAMx Model Performance Evaluation
- Hourly/Daily/Seasonal Emissions Profile assumed in CAMx Modeling Input
- 20% Most-Impaired Days assumed for 2028 CAMx Modeling Projections
- Source Attribution and Selection of Sources for the Four-Factor Analysis
- CAMx Model Results vs. Visibility Glide Path

CAMx Model Performance Evaluation

All CAMx modeling studies are generally accompanied by a Model Performance Evaluation (MPE) under which statistics are developed that describe the accuracy of the model projections. In this instance, the VISTAS II MPE was developed using the CAMx 2011 base case modeling platform. The 2011 CAMx baseline scenario results were compared against IMPROVE (Interagency Monitoring of Protected Visual Environments) measurements from the same time period along with other available air quality monitoring data. In this report, the focus is on the CAMx MPE vs. IMPROVE measurements as the IMPROVE data are the primary measurement tool for assessing visibility trends.

The MPE compared the CAMx modeling results from the 2011 VISTAS platform against actual IMPROVE measurements. The statistical comparisons reported in the MPE used CAMx modeling projections paired in time and space with the IMPROVE measurements.

This discussion focusses on modeled sulfate impacts which are generally traceable to SO_2 emissions from point sources such as EGUs. Other emitting sources are also of interest because an important objective of the second-round regional haze SIPs is to identify sources which emit to visibility impairing pollutants affecting Class I areas and as such might be subject to a "four-factor" analysis which would review the feasibility of additional emissions controls.

Based on the VISTAS II MPE, the CAMx model results for the 20% most impaired days showed that the model results were biased low for two important visibility components: sulfate and organic carbon. The reported sulfate Normalized Mean Bias (NMB) for the VISTAS II CAMx MPE are listed below for the 20% most impaired days vs. measured IMPROVE data[4].

- Sulfate NMB (All Seasons) -19.13%
- Sulfate NMB (Summer) -32.81%
- Sulfate NMB (VISTAS II Goal) +/- 10%
- Sulfate NMB (VISTAS II Criteria) +/- 30%

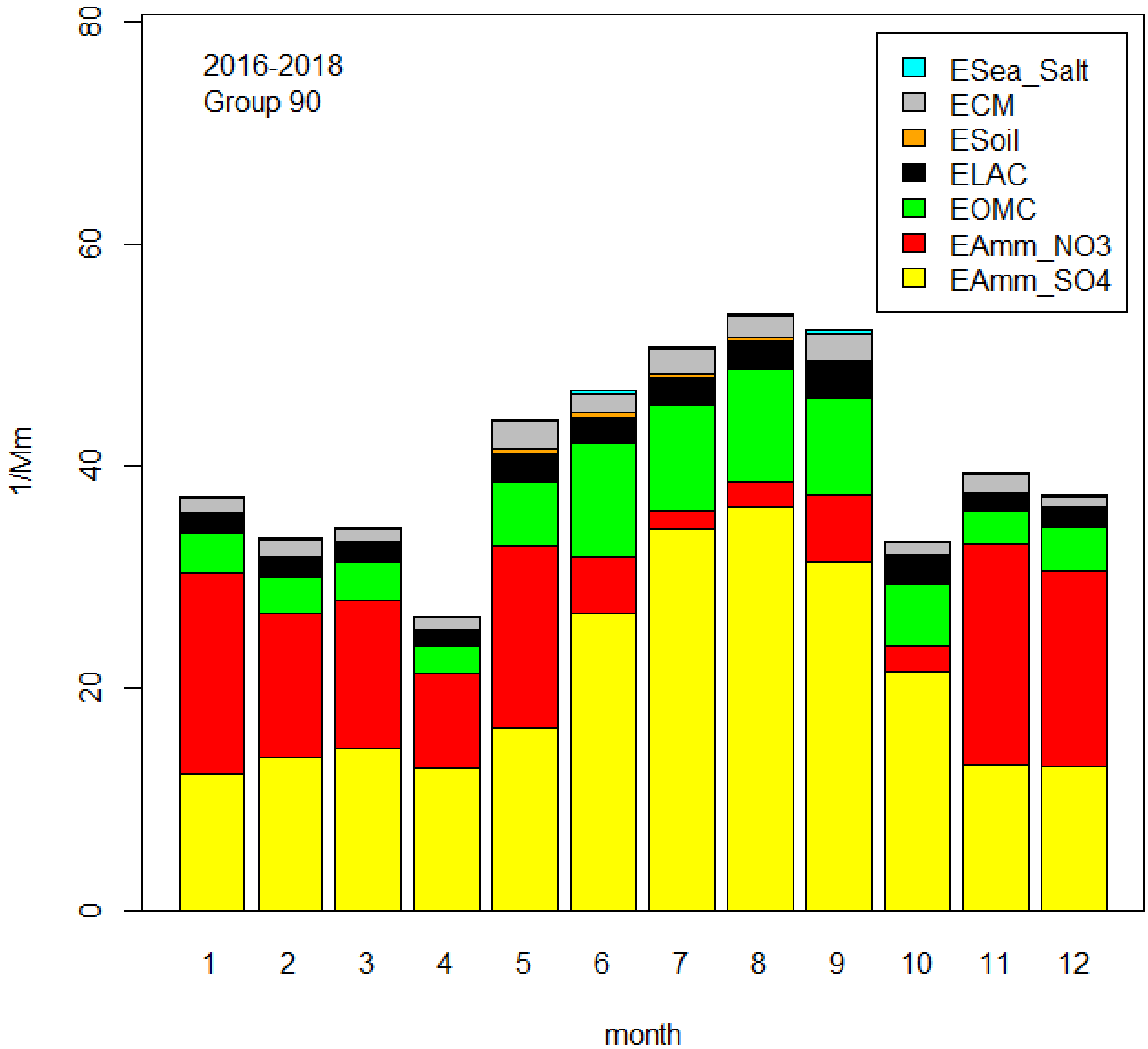
As reported above, the VISTAS II CAMx modeling using the 2011 emissions platform reported a significant underprediction for sulfate vs. the IMPROVE measurements on the 20% most impaired days for the same time period. The degree of the underprediction was also alarming as the sulfate error was outside of the CAMx model performance criterion selected by VISTAS (also listed above).

The negative sulfate bias occurred across all seasons but was larger during the summer months. This bias was also present across the entirety of the VISTAS modeling domain. For those Class I areas in the VISTAS domain, the occurrence of the 20% most impaired days was more frequent during the summertime and sulfate was also a major contributor to visibility impairment in the summer months. As an example, Figure 1 presents a monthly distribution for IMPROVE visibility data collected at Shenandoah National Park (SHEN) for the 20% most impaired visibility days (2016-18). Figure 1 shows that reconstructed extinction (a measure of impaired visibility) is largest at SHEN in the summer and that sulfate is the largest contributor to the measured summertime visibility impairment.

While no air quality model is perfect, the large and significant sulfate underprediction calls into question how one should best apply the VISTAS II CAMx model results. As Figure 1 demonstrates, the modeling errors are largest for the same period when the sulfate concentrations make the largest contribution to visibility impairment. The large sulfate underprediction means that the VISTAS II CAMx results should not be used directly without properly accounting for the known sulfate bias. The known sulfate underprediction in the VISTAS II CAMx modeling results also has repercussions in other areas. These issues are addressed in other sections of my report.

[4] VISTAS Model Performance Evaluation Report, Table 2-1 and Table 3-1.

**Figure 1: IMPROVE Visibility Reconstructed Extinction by Month (2016-18)
Shenandoah National Park VA (SHEN): 20% Most Impaired Days
From Gebhart 2020**



Hourly/Daily/Seasonal Emissions Profile

For EGUs, the VISTAS II CAMX modeling includes an hourly/daily/seasonal emissions profile derived mainly from continuous emissions monitoring (CEMS) data which EGUs are required to collect under various regulations. This information was created using the Sparse Matrix Operator Kernel Emissions (SMOKE) processing system within CAMx. The hourly emissions data from 2011 CEMS measurements were used to create hourly profiles at EGUs for SO_2 and NOx emissions. For other pollutants (which typically lack CEMS measurements), the hourly EGU emissions profiles were based on load data.

For non-EGU point sources, an hourly emissions profile was not created, and the annual emissions were assumed to occur at a uniform emission rate over the year.

In the VISTAS II CAMx modeling, the same hourly/daily/seasonal emissions profiles used in the 2011 modeling were also used for the 2028 emissions projections, e.g., at any given hour of the year being modeled, the 2028 emissions were at the same relative emissions in the 2011 data, adjusting for changes in the annual emissions total where necessary. Under the above approach, the implicit assumption was that the 2028 hourly/daily/seasonal EGU emissions profile would be unchanged from the 2011 data.

It is highly questionable whether the hourly/daily/seasonal EGU emissions profile for the 2028 projection would remain unchanged from the 2011 baseline, as assumed by the VISTAS II modeling. Since 2011, the electric utility industry has undergone dramatic shifts, influenced by numerous factors designed to increase reliance on alternative energy sources such as renewables and/or natural gas. For example, renewable energy mandates or goals have been established in VISTAS states such as North Carolina, South Carolina, and Virginia.[5] Also, a major utility operating in the VISTAS region (Southern Company) has publicly announced a company-wide goal of reducing greenhouse gas (GHG) emissions by 50 percent before 2030.[6]

In response to the above and other initiatives, a number of electric utilities in the VISTAS region are in the process of moving away from coal-fired EGUs as their primary baseline generation assets. Moving forward, an increasing number of coal-fired units may be used to balance peak seasonal loads as opposed to meeting the normal baseline electric load on the grid. The 2028 VISTAS II modeling failed to account for the dramatic shift in how coal-fired EGU are expected to be utilized. By 2028, many EGUs are expected to have a dramatically different hourly/daily/seasonal emissions profile.

For example, if the EGU load were to shift such that the unit utilization increased during the winter, the SO_2 and NOx emissions (as a percentage of total annual emissions) will be skewed toward the winter months. This change in utilization would not be reflected in the 2011 CEMS data. IMPROVE data at VISTAS Class I areas also show that nitrate extinction (as the resulting visibility degradation) is much greater during the winter period. Under such a scenario, the VISTAS II CAMx modeling could be underestimating the winter-time visibility impacts associated with EGUs.

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[5] Source: National Conference of State Legislatures website, www.ncsl.com

[6] Source: Southern Companies website, www.southerncompany.com

VISTAS needs to reexamine whether the future EGU emission projections based on 2011 CEMS data provided for an accurate portrayal of the expected 2028 hourly/daily/seasonal emissions profiles. The 2028 CAMx modeling inputs should be adjusted as necessary to capture the expected 2028 EGU utilization. The assumption that EGUs will operate in 2028 as they did in 2011 is simply not accurate.

Selection of 20% Most-Impaired Days

The VISTAS II modeling used 2009-2013 as the baseline period. In addition, IMPROVE monitoring data from that same period were used to select the 20% most impaired days for analyzing future visibility impacts for the 2028 projection. This approach was flawed as the 20% most impaired days have shifted since the 2009-13 baseline period due to the imposition of emission controls and other actions that occurred as a result of the first-round of Regional Haze SIPs and other factors. Instead, as required under the federal Regional Haze regulations, the selection of the 20% most-impaired days for the 2028 projection should have been based on more current IMPROVE measurements. The current IMPROVE data (2014-18) are the most accurate projection available at this time for the future 2028 visibility conditions.

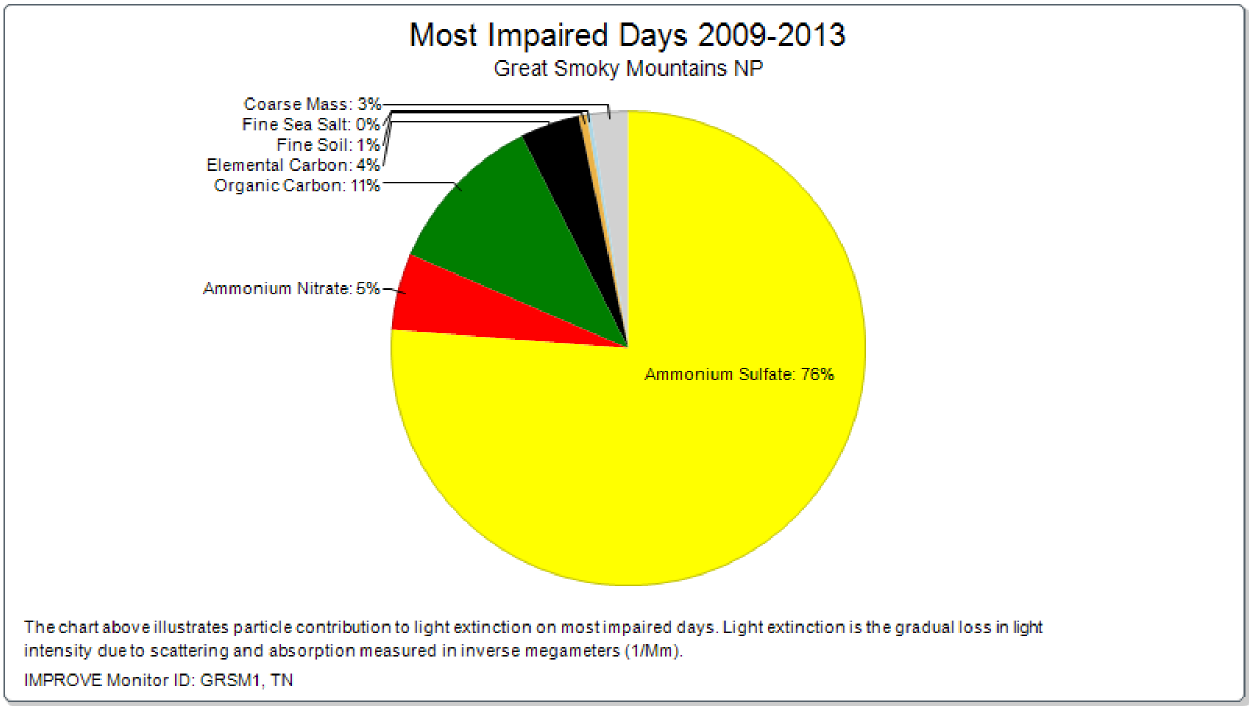
As an example which illustrates the changes described above, Figure 2 presents the reconstructed extinction for the 20% most-impaired days at Great Smoky Mountains National Park (GRSM). The data in Figure 2 compare the reconstructed extinction for the 20% most-impaired days covering the 2009-13 baseline period against the 2014-18 period. The 2014-18 time period would have been the most recent IMPROVE data available at the of the VISTAS II modeling effort.

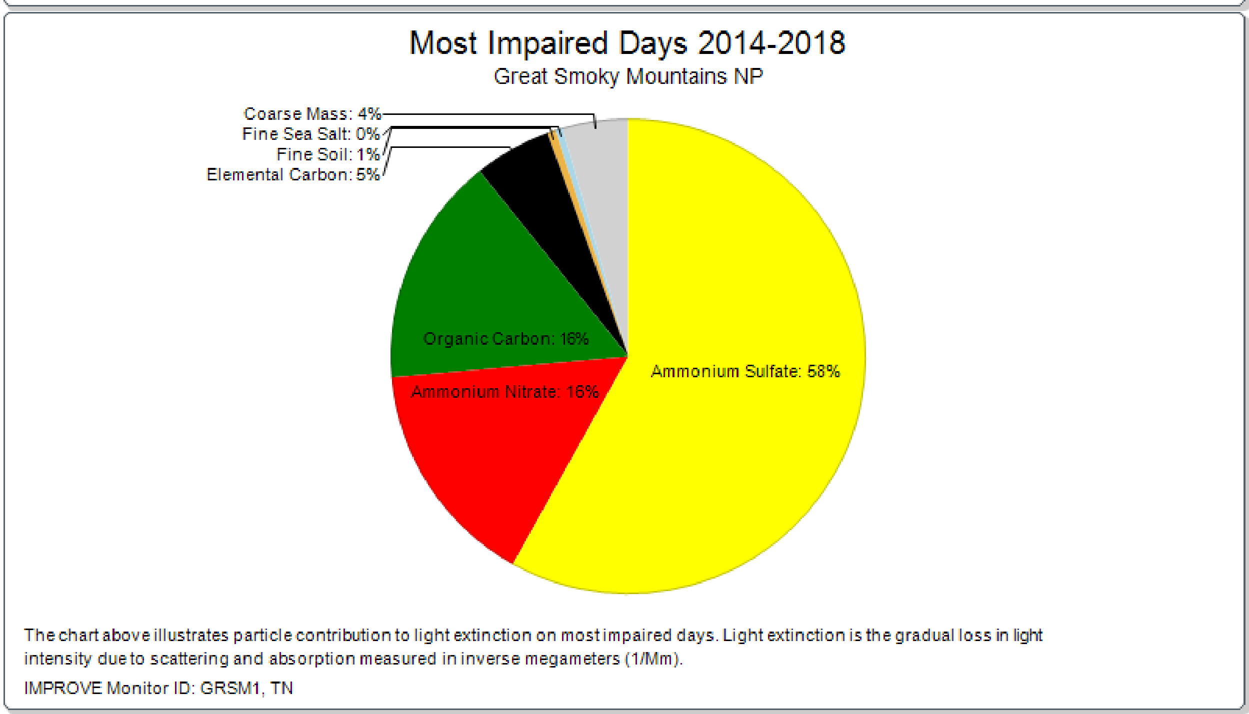
The reconstructed extinction on the 20% most-impaired days in Figure 2 shows a dramatic trend toward less sulfate extinction and greater nitrate extinction. The decrease in sulfate likely represents the effect of SO_2 emission controls and other regulatory actions including those that were imposed in the first round of regional haze SIPs. In turn, nitrate has become an increasingly important contributor to current visibility impairment. For example, at GRSM, the nitrate extinction budget has roughly tripled since the 2009-13 baseline period, increasing from 5 percent to 16 percent. The temporal trends showing increased nitrate extinction for the 20% most-impaired days are also repeated at other Class I areas in the VISTAS domain.

Nitrate is also a seasonal pollutant with a tendency for significantly higher concentrations during the wintertime period (See Figure 1 above). Consistent with the observed increases in the nitrate extinction budget, occurrences of the 20% most-impaired days would have also shifted since the 2009-13 baseline period with more of these days also occurring during the winter months. Nitrate levels are typucally higher during the winter due to the colder average temperatures.

In the VISTAS II visibility modeling, the 20% most-impaired days were determined using the 2009-2013 IMPROVE measurements and the same data were erroneously carried forward to the 2028 modeling projection. As such, the VISTAS II 2028 modeling projection was not calculated using the 20% most-impaired days that would be expected to be present in 2028. A better approach would have been to establish the 2028 20% most-impaired days using more current IMPROVE measurements, e.g., 2014-2018 as these data more accurately reflect the shift/increase in nitrate extinction levels.

Figure 2
Temporal Trends in Reconstructed Extinction
Great Smoky Mountains National Park[7]





7 Data source: [Improve – Interagency Monitoring of Protected Visual Environments (colostate.edu)]

In summary, the 20% most-impaired days were not properly captured for the 2028 VISTAS II model projection. The 20% most impaired days selected by VISTAS for 2028 were in error as these days did not properly reflect the substantial increases in nitrate extinction contributions that were evident using more recent IMPROVE monitoring data. As a result, large NOx emission sources contributing to adverse visibility impairment were not properly identified by VISTAS and the potential visibility benefits of emission controls at large NOx emission sources were not properly analyzed.

Source Attribution

The VISTAS II modeling effort included information on source attribution to the visibility impairment. In this report, my focus is on the visibility source attribution analysis for individual point sources as it is the individual point sources (both EGUs and non-EGUs) which would be potentially subject to the so called "four-factor" emissions control analysis. The "four-factor" analysis evaluates whether additional controls to reduce visibility impairment might be required under the second-round regional haze SIPs in each state.

In the VISTAS II modeling, the source attribution analysis used a two-step process:

1. An "Area of Influence" (AOI) analysis was conducted to identify potential sources of visibility impairment impacting Class I areas within the VISTAS domain.
2. For individual point sources identified using the AOI approach, the emissions were "tagged" and the source contributions to visibility impairment were calculated within CAMx using the Particulate Matter Source Apportionment Technology (PSAT) option within CAMx.

The VISTAS source attribution analysis has two significant issues. First, the AOI analysis itself was overly restrictive in that the thresholds used to identify qualifying sources was too high, resulting in too few sources being identified. Second, the PSAT "tagging" approach introduced additional errors into the analysis. Also, the PSAT modeling itself was unnecessary given that AOI analysis already had the goal of identifying sources with the potential to contribute to adverse visibility conditions in VISTAS Class I areas.

The initial AOI evaluation utilized the HYSPLIT model. HYSPLIT allows calculation of "back-trajectories" that define the path taken by an air parcel before arriving at any given point. The various steps in the AOI analysis conducted by VISTAS II can be summarized as follows:

- The 20% most impaired days for a given Class I area/IMPROVE site were identified.
- HYPLIT trajectories were calculated for each of the 20% most impaired days at all Class I areas in the VISTAS domain.
- Based on the HYPLIT trajectories, the residence time in each grid cell was calculated. The residence time was also weighted by the extinction, creating the "extinction-weighted residence time" (EWRT).
- The EWRT was overlayed with emissions information from individual point source emissions, using the Q/D (emissions over distance) ratio between the point source of interest and the Class I area.

Table 1 below summarizes the findings from the AOI analysis as reported by VISTAS in a May 20, 2020 briefing to stakeholders. Table 1 shows the criteria adopted by each state in applying the AOI analysis as well as the number of qualifying sources based on these criteria.

Table 1

Summary of VISTAS AOI Analyses[8]

State	Threshold	Notes	# of Qualifying Sources
AL	2%	Sulfate only	9
FL	5%	Sulfate or nitrate + 4 additional sources	13 (AOI) + 4 = 17
GA	2% for GA facilities, 4% for non-GA facilities	Sulfate or nitrate,	5
KY	2%	Sulfate or nitrate	4
MS	2%	Sulfate or nitrate	2
NC	3%	Sulfate + nitrate	5
SC	2% for sulfate 5% for nitrate	+ 3 additional sources	3 (AOI) + 3 = 6
TN	3%	Sulfate + nitrate + 1 additional source	5 (AOI) + 1 = 6
VA	2%	Sulfate + nitrate	3
WV	0.2%	Sulfate or nitrate	13

Except for West Virginia, VISTAS states adopted AOI impact thresholds generally in the range of 2-5% to identify sources that are believed to contribute to existing visibility impairment in Class I areas. The lower threshold used by West Virginia (0.2%) resulted in the identification of the greatest number of emission sources (13). Otherwise, the AOI analysis for the most part generated only a handful of emission sources for further consideration as contributing to Class I visibility impairment. In seven of the ten VISTAS states, the unrealistically high AOI thresholds generated only six or fewer qualifying sources[9].

[8] Data Source: VISTAS Regional Haze Project Update, Powerpoint Presentation dated May 20, 2020

[9] Florida had 13 sources identified through the AOI analysis despite having one of the higher thresholds. The VISTAS AOI report does not discuss this anomaly, but one possible explanation is that Class I areas are scattered across all areas of Florida (north, central, and south). As such the distance from a given source in Florida to the nearest Class I area may less than the distance to the nearest Class I areas in other states.

Despite the problems in selecting a specific threshold, the use of a percentage impact to screen sources in the AOI analysis is itself flawed. By using a percentage, the calculated threshold in absolute terms was actually higher for Class I areas where the visibility impacts were more severe. This approach generated the opposite of what is necessary to achieve real-world improvements in visibility conditions. Where the current visibility impacts are known to be more severe, the need for emission reductions is greater and the criteria for selecting contributing emission sources should reflect that need. The current VISTAS AOI approach based on meeting a minimum percentage of the total impact failed in that regard.

Also, in some cases (e.g., NC, TN, and VA), states considered the combined impacts of sulfate and nitrate, while the other states evaluated sulfate and nitrate impacts separately. The approach used by NC, TN, and VA that considered the combined sulfate and nitrate impact would be preferred as real-world visibility impacts result from the combined effects of all visibility precursor pollutants.

The reader is encouraged to review the appropriate VISTAS technical report for additional details about the AOI analysis. As mentioned previously, the VISTAS II modeling addressed source attribution for more than just individual point sources such as emissions on a state-wide or industry-wide level. However, my comments address only the source attribution analysis for individual point sources.

Based on the documentation in the VISTAS technical reports, those point sources identified through the AOI analysis or otherwise selected by a particular state were subject to additional modeling using the CAMx PSAT source "tagging" procedure. The VISTAS II PSAT "tagging" was applied only to the 2028 emission projections and not the 2011 baseline emissions inventory. The PSAT "tagging" was also limited to sulfate and nitrate.

Although the VISTAS II documentation notes that the initial 2028 emission inventory projections were updated for the final CAMx modeling, the associated AOI and PSAT modeling did not use the final 2028 inventory. In the case of the PSAT modeling, model projections using the outdated inventory were adjusted based on source-specific changes in the SO_2 and NOx emissions.

In the end, the VISTAS II PSAT modeling concluded that 33 emission sources remained with a modeled sulfate and/or nitrate contribution at or above 1% at any VISTAS Class I area[10]. As such, these 33 emissions sources were recommended for consideration by VISTAS states for the "four-factor" emissions control analysis; however, individual states had the option to further reduce the number of "four-factor" sources by establishing a required contribution threshold above 1%. Table 2 summarizes the state-by-state distribution of the 33 sources identified using the VISTAS II PSAT modeling.

[10] VISTAS Regional Haze Project Update, Powerpoint Presentation dated May 20, 2020, Slide 122

Table 2

Summary of VISTAS PSAT Modeling Analyses

State	# of Qualifying Sources
AL	1
FL	10
GA	3
KY	2
MS	0
NC	3
SC	5
TN	2
VA	2
WV	5

In addition, the PSAT modeling returned 13 facilities located in non-VISTAS states that had modeled sulfate or nitrate impacts above the 1% threshold at Class I areas within VISTAS[11].

The 1% threshold criteria used by VISTAS for selecting emission sources for possible application of emission controls is by itself questionable. As noted above, by establishing the contribution threshold strictly on a percentage basis, the source-selection approach used by VISTAS for a more highly polluted Class I areas in essence would require that an individual point source have a larger absolute contribution to sulfate and/or nitrate concentrations before triggering the 1% threshold. Limiting the number of facilities subject to the "four-factor" emissions control analysis in this manner is contrary to the Regional Haze regulatory program objectives. Also, where the Class I area is more highly polluted, the future need for emissions controls will be greater. The source-selection procedure employed by VISTAS has resulted in fewer emission controls at sources impacting those Class I areas in the VISTAS domain which are more highly polluted.

[11] VISTAS Regional Haze Project Update, Powerpoint Presentation dated May 20, 2020, Slide 123

In addition, the 1% threshold selected by VISTAS was based on the modeled PSAT contribution to sulfate and nitrate concentrations individually. However, in the atmosphere, sulfate and nitrate act in combination to contribute to the reconstructed extinction and visibility impairment. The combined sulfate and nitrate impact on visibility from any individual point source was not calculated or evaluated by VISTAS. The VISTAS modeling should have instead considered all precursor emissions that contribute to visibility impairment and not just sulfate or nitrate. As a result, the overall contribution to visibility impairment from any individual point source was consistently underestimated in the VISTAS modeling approach.

Furthermore, the VISTAS II PSAT analysis itself contains significant uncertainties in describing the source attribution of individual sources to existing visibility impairment, as summarized below:

- The PSAT modeling was limited to "tagging" of sulfate and nitrate and did not address the source attribution from other visibility precursor pollutants. Any source-specific visibility attribution based solely on the sulfate or nitrate modeling projections would underestimate the overall visibility impact of an individual source. An accurate assessment of the source-specific visibility impact must be based on the source attribution considering all visibility impairing pollutants.

- As noted above, the PSAT projections applied in the VISTAS II modeling analysis were not calculated using the most recent 2028 emissions inventory update. Instead, PSAT data from an outdated 2028 emissions inventory were used. VISTAS II attempted to compensate for this shortcoming and adjusted the outdated PSAT projections by scaling the predicted sulfate and nitrate by the corresponding change in SO_2 and NOx emissions. However, this approach carried an implicit assumption that the resulting sulfate and nitrate would be proportional to any change in emissions. It is known that sulfate and nitrate formation in the atmosphere has many complex elements which would be non-linear vs. emissions. As such, the PSAT modeling using an outdated 2028 emissions inventory introduced unknown errors into the modeling.

- As reported previously, the CAMx MPE revealed a significant underprediction for sulfate across the VISTAS modeling domain. Any errors described by the MPE for sulfate would also be carried over into the PSAT modeling results. The PSAT results for sulfate and the resulting source attribution were likely underestimated by the same ratios as described in the MPE.

Instead of relying on a flawed PSAT modeling analysis that applied an outdated 2028 emissions inventory, provided incomplete information on source-specific contributions to visibility impairment, and carried forward known deficiencies in the modeled sulfate projections, the VISTAS states should have instead relied on other approaches to screen emission sources for applicability of potential emission controls in the second-round Regional Haze SIPs. For example, a simple emissions-to-distance (Q/D) ratio has been used in other states to provide an initial screen for sources subject to the "four-factor" emissions control analysis. Using the AOI and PSAT modeling results to limit the field to only 33 emission sources for possible application of the "four-factor" analysis generated an approach that was overly restrictive.

As required under the 2017 Regional Haze regulations, the “four-factor” emissions control analysis should have been broadly applied to emission sources contributing to visibility impairment. Furthermore, the VISTAS II AOI and PSAT projections also underestimated the source-specific attribution to visibility impairment and as such should not have been relied upon in selecting the appropriate list of emission sources for the “four-factor” emissions control analysis.

Visibility Glide Path

Based on the VISTAS II modeling results, it was reported that the 2028 visibility projections for all VISTAS Class I areas except Everglades National Park (EVER) would be below the so-called “glide path”, which is also known as the Uniform Rate of Progress (URP). Also, after the visibility projections were adjusted for non-US emissions, the 2028 EVER visibility projection was also below the URP “glide path”. The URP “glide path” represents a linear reduction in visibility between the original baseline visibility conditions and the 2064 goal of “natural background” visibility.

The VISTAS II 2028 modeling projection showing that visibility conditions would be below the URP “glide path” are not disputed. In fact, modeling results showing that visibility improvements were below the URP “glide path” were not unexpected given that the regional haze program has resulted in significant emission reductions that were front-loaded to the early planning periods.

Nevertheless, whether the 2028 visibility projections were above or below the URP glide path should not have influenced the adoption of second-round regional haze SIP strategies that applied additional emission controls on visibility precursor pollutants. Although visibility improvements have occurred with “on-the-books” emission controls, current IMPROVE measurements also continue to show that the remaining visibility impairment on the 20% most impaired days is largely dominated by sulfate and nitrate extinction (See Figure 1 above showing the 2016-18 reconstructed extinction budget at SHEN). Sulfate and nitrate extinction is an indicator that SO_2 and NOx emissions from EGUs and other point sources still contribute to present-day visibility impairment. So, sulfate and nitrate are expected to remain a substantial contributor to post-2028 visibility impairment on the 20% most impaired days and further improvements in visibility would require additional SO_2 and NOx emission controls at EGUs and other point sources that go beyond current “on-the-books” controls. Consistent with current EPA policy, such emission controls would presumably yield visibility conditions that are even further below the URP “glide path” and would place the VISTAS Class I areas even closer to the national visibility goal.

The United States Environmental Protection Agency (EPA) concurs with the above position that the URP glide path does not present a "safe harbor" from the need to address EGUs and other point sources through the required four-factor emissions control analysis. In the Preamble to the USEPA 2017 Regional Haze Rule[12], EPA includes the following instructions:

> *"The EPA is clarifying the relationship between long-term strategies and RPGs in state plans and the long-term strategy obligations of all states. We are reiterating that the CAA requires states to consider the four statutory factors (costs of compliance, time necessary for compliance, energy and non-air quality environmental impacts and remaining useful life) in each implementation period to determine the rate of progress towards natural visibility conditions that is reasonable for each Class I area. The rate of progress in some Class I areas may be meeting or exceeding the uniform rate of progress (URP) that would lead to natural visibility conditions by 2064, but this does not excuse states from conducting the required analysis and determining whether additional progress would be reasonable based on the four factors."*

SO_2 and NOx emissions reductions at EGUs and other point sources in the VISTAS domain will be necessary to reach the national visibility goal of no anthropogenic visibility impairment. There is no environmental benefit in waiting until future SIP planning periods to implement additional emission controls at EGUs and other point sources, especially where the "four-factor" analysis concludes that such controls would already be reasonable and cost-effective.

Most importantly, the current EPA Regional Haze regulations require imposition of emissions controls where such controls may be deemed appropriate using the "four-factor" criteria set forth in the applicable regulations. The EPA Regional Haze regulations also require that current SIP planning period look beyond the URP "glide path" as the sole indicator of success. The SIP planning process and associated VISTAS II CAMx modeling should not be an attempt to limit the number of EGUs and other point sources subject to the required "four-factor" emissions control analysis.

References

Gebhart, K.A., 2020. Shenandoah Residence Time Analyses. Internal National Park Service PowerPoint Presentation, updated September 22, 2020.

[12] Federal Register, January 10, 2017

D HOWARD GEBHART

Environmental Compliance Section Manager

EDUCATION

M.S. Meteorology, University of Utah 1979

B.S. Professional Meteorology, Saint Louis University 1976

MEMBERSHIPS

Air & Waste Management Association

National Weather Association

Colorado Mining Association

Nebraska Industrial Council on Environment

EXPERIENCE SUMMARY

Mr. Gebhart has over 39 years' experience in air quality permitting and compliance specializing in issues technical and regulatory affecting regulated industries. Howard manages the environmental compliance section at ARS, where he provides technical studies and evaluations; and prepares models, client permit applications, air emission calculations, and performs multi-discipline environmental audits. He is very experienced in working with the federal Clean Water Act, Clean Air Act, Resource Conservation and Recovery Act (RCRA), and similar programs enacted in states throughout the U.S.

Howard also acts as an Expert Witness in legal proceedings involving the Clean Air Act and is a recognized technical expert in air dispersion modeling.

PROJECT EXPERIENCE

- Manages the Environmental Compliance Section team.
- Produces and manages quality assurance documents including quality management plans and quality assurance project plans.
- Provides technical studies and evaluations, including air dispersion modeling, permit application preparation, emissions inventories, regulatory analysis and interpretation, and environmental audits.
- Prepares applications for new source permits under federal Prevention of Significant Deterioration (PSD) and state construction and operating permit programs.
- Provides technical studies supporting Environmental Impact Statements (EISs) and Environmental Assessments (EAs) under the National Environmental Policy Act (NEPA).
- Performs air pathway evaluations for releases of hazardous air pollutants from Superfund sites, hazardous waste sites, and incinerators. Models the potential consequences of accidental releases of hazardous materials.
- Performs multi-discipline environmental audits at regulated industrial facilities.
- Manages air quality and environmental permitting studies for biofuel (ethanol and biodiesel), oil & gas exploration and production, mining and minerals, general manufacturing, and a variety of other industries with experience representing both government and private-sector clients.