Effect of Revisions to IMPROVE Equation and EPA's Defaults on Satisfying 2018 Reasonable Progress Goals using Latest VISTAS' Modeling Results

Presented to

VISTAS
Technical Analysis & Data Analysis
Workgroups

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By

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Outline

- Purpose
- Caveats
- Method
- Results
- Conclusions and Recommendations
- Suggested Next Steps for RPOs

Purpose

To illustrate why making refinements to the procedures for calculating the 2018 Reasonable Progress Goal (RPG) could be critical to determining whether or not a state's chosen regional haze strategy achieves that goal

Caveats

- Illustrative results are presented using the latest, but not final, information.
- Baseline includes data from 2000 to 2003 only.
- The illustrative results for the nearby Class I areas do not include adjustments for African/Asian dust, forest OC, or oceanic OC.
- There are other adjustments that can and should be made as changes are made to the IMPROVE equation (e.g., the increase over annual natural haze for the 20% worst days will change as a function of OCM/OC assumed). These need to be carefully considered as we move forward.

VISTAS and Nearby Class I Areas Assessed in this Study

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Method

- Calculate the level of 2018 visibility achieved by the VISTAS "On-the-Way (OTW)" strategy (i.e., average haze index for 20% worst days) for each Class I area, and
- Calculate the presumptive 2018 reasonable progress goal for visibility (i.e., average haze index for 20% worst days) from interpolation between baseline and natural visibility levels for each Class I area, using:
- Four alternate methods:
  - 1: IMPROVE equation and EPA's defaults,
  - 2: Revised IMPROVE equation and increased 20% worst natural haze,
  - 3: Added sea-salt haze and increased the natural OC & soil concentrations, and
  - 4: Added natural haze concentration contributions from man-made emissions outside U.S.

Alternate 1 – EPA default

- IMPROVE equation for light extinction
  - Constant dry extinction efficiencies of “3” for ammonium sulfate and nitrate and “4” for OCM
  - OCM/OC ratio of 1.4
- Site-specific monthly climatological RH
- Natural Haze
  - Average haze index for 20% worst days is annual haze plus 1.28 σ (σ is 3 deciviews in east)
  - EPA guidance uses regional values (east/west) as site-specific natural species concentrations

Alternate 2

- Revised IMPROVE equation for light extinction
  - Use of dry extinction efficiency equations in lieu of constant coefficients for SO_4, NO_3, and OCM[1]
  - OCM/OC ratio 1.8/2.1 for current/natural haze[2]
- Natural Haze change
  - Average haze index for 20% worst days is annual haze plus 1.42 σ (σ is 3.5 deciviews in east)[3]

1 Ryan, P., D. Lowenthal, and N. Kumar (2005). Light Scattering in Light Extinction Reconstruction. Journal of Air and Waste Management Association in press.

2 Tombach, I. and P. Brewer. Reasonable Progress Goals in the VISTAS Region. In Proceedings of the Air & Waste Management Association Conference on Regional and Global Perspectives on Haze: Causes, Consequences and Controversies Visibility Specialty Conference. October 2004.

3 Ryan, P.A. Review of the U.S. Environmental Protection Agency Default Implementation Guideline for the Regional Haze Rule. EPRI, Pal Alto, CA: 2004. 1011119.

Alternate 3

- Added sea salt (SS) effect (SS = 3.27 [Na] f(RH))[1] to revised IMPROVE equation for light extinction.
- Natural Haze changes
  - Alternate 2
  - For VISTAS sites, increased natural OC and Soil concentrations by[1]:
    - 0.2 and 0.1 ug/m^3 from forest and oceanic OC; site-specific
    - 0.35 ug/m^3 from African and Asian dust at southern VISTAS sites
  - For nearby Class I areas, no adjustment for African/Asian dust, forest OC, or oceanic OC was made

1 Tombach, I. and P. Brewer. Reasonable Progress Goals in the VISTAS Region. In Proceedings of the Air & Waste Management Association Conference on Regional and Global Perspectives on Haze: Causes, Consequences and Controversies Visibility Specialty Conference. October 2004.

Alternate 4

- Alternate 3, plus
  - Natural Haze changes
    - Natural conditions include concentrations in the U.S. resulting from trans-boundary (e.g., from Asia, Canada, & Mexico) man-made emissions
    - Trans-boundary man-made contributions estimated from the latest GEOS-CHEM simulation (1 x 1º resolution over N. America)[1]. Concentration contributions are for ammonium sulfate, ammonium nitrate, elemental carbon, and organic carbon

1 Park, Rokjin and Jacob, Daniel, Personal Communications (manuscript in preparation)

VISTAS OTW Strategy

- VISTAS performed air quality modeling of 2002 typical emissions and (2018) OTW emissions.
- Model Results used to Project Baseline Reductions
  - Average Relative Reduction Factor (RRF) calculated

$$RRF_j(C) = \frac{\frac{1}{N}\sum_{i=1}^{N} C_{ij}(2018)}{\frac{1}{N}\sum_{i=1}^{N} C_{ij}(2002)}$$

  - RRFs multiplied by baseline 20% worst haze average aerosol concentrations. These OTW average aerosol concentrations for 20% worst haze days input to the four alternate light extinction methods defined the VISTAS OTW Strategy visibility.

Revised IMPROVE Equation

- Revised IMPROVE equation shown for OCM/OC = 1.8 (for current conditions)[1]

$$b_{ext}\ (Mm^{-1}) = 1.61\ ([(NH_4)_2SO_4 + NH_4NO_3)^{1.28}\ f(RH) + 1.99\ (\mathbf{1.8}\ [OMC])^{1.42} + 10\ [EC] + [Soil] + 0.6\ [CM] + 10$$

- For natural conditions, OCM/OC = 2.1

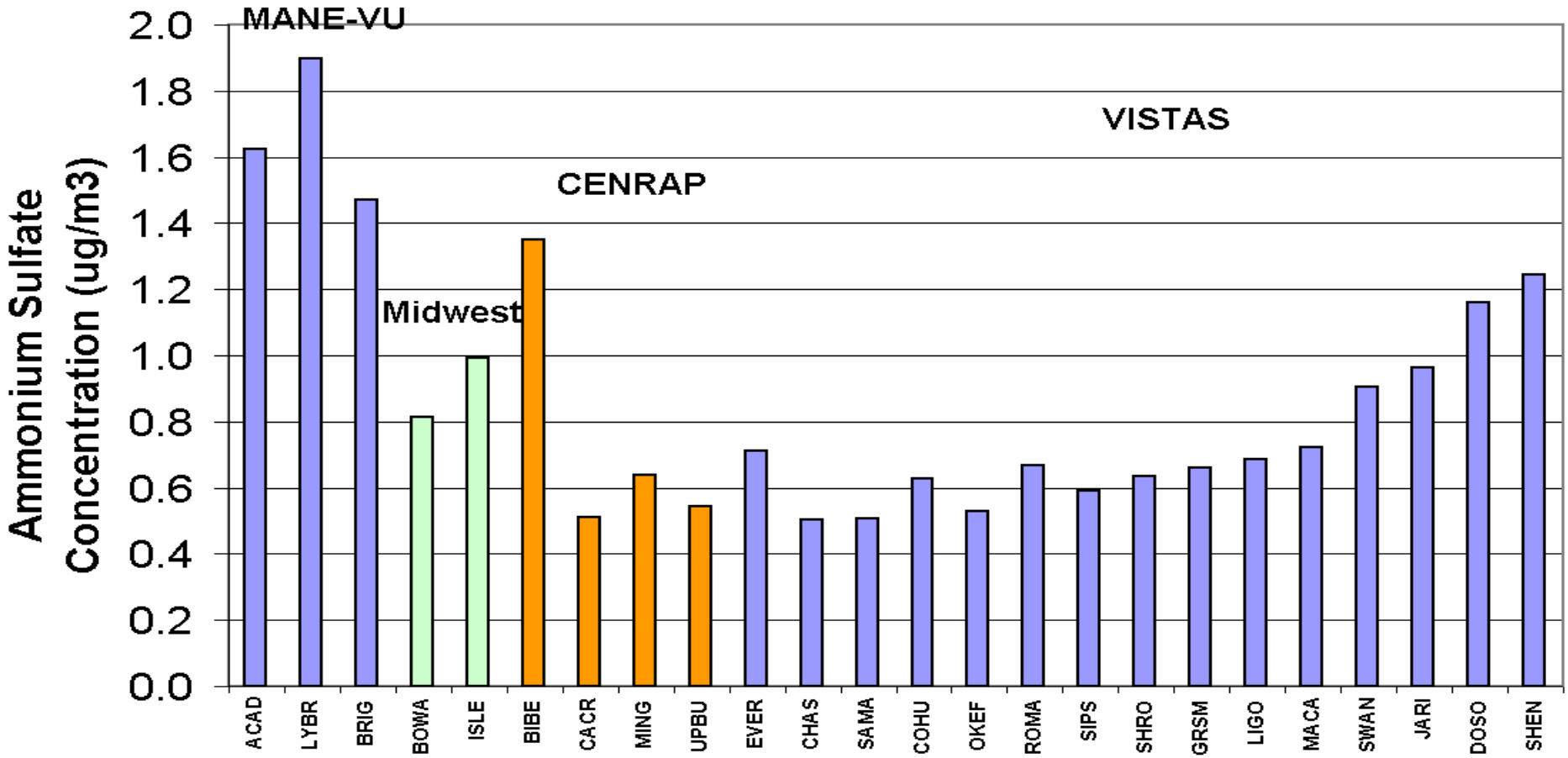
1 Ryan, P., D. Lowenthal, and N. Kumar (2005). Light Scattering in Light Extinction Reconstruction. Journal of Air and Waste Management Association in press.

Natural Concentration (ug/m^3) increases above EPA's defaults in Alternates 3 and 4

CLASS I AREAS	SEA SALT	AFRICAN + ASIAN DUST	FOREST OC	OCEANIC OC
Sipsey Wilderness Area, AL	0.46		0.2	-
Chassahowitzka Wilderness Area, FL	0.59		-	0.1
Everglades National Park, FL	0.69		-	0.1
St. Marks Wilderness Area, FL	0.56		-	0.1
Cohutta Wilderness Area, GA	0.39		0.2	-
Okefenokee Wilderness Area, GA	0.59	0.35	0.2	0.1
Mammoth Cave National Park, KY	0.33		0.2	-
Great Smoky Mountains National Park, TN	0.39		0.2	-
Linville Gorge Wilderness Area, NC	0.29		0.2	-
Swanquater Wilderness Area, NC	0.62		-	0.1
Cape Romain Wilderness Area, SC	0.62		-	0.1
James River Face Wilderness Area, VA	0.36		0.2	-
Shenandoah National Park, VA	0.36		-	-
Dolly Sods Wilderness Area, WV	0.29		-	-
Caney Creek Wilderness Area, AR	0.36		-	-
Upper Buffalo Wilderness Area, AR	0.36		-	-
Mingo Wilderness Area, MO	0.23		-	-
Brigantine Wilderness Area, NJ	0.69	0.00	-	-

-Sea salt, African and Asian dust, and Forested and Ocean organic carbon concentrations (µg/m^3)
- -Sea salt contributes to baseline and natural haze
- -African and Asian dust adds to natural haze
- -Forest and Oceanic OC adds to natural haze

GEOS-CHEM Predictions of Transboundary Man-Made Impacts



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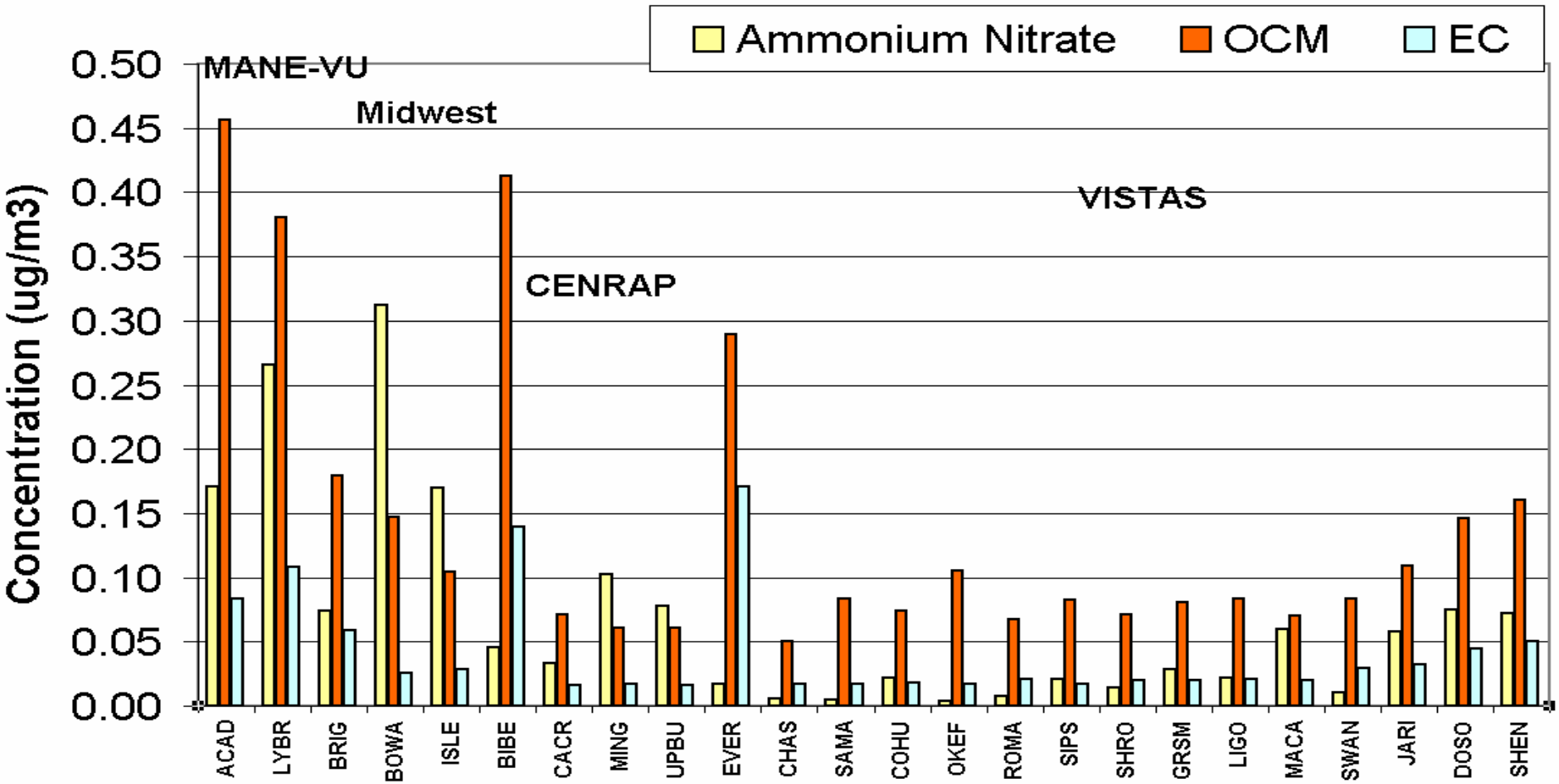
GEOS-CHEM Predictions of Transboundary Man-Made Impacts



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Comparing Alternates

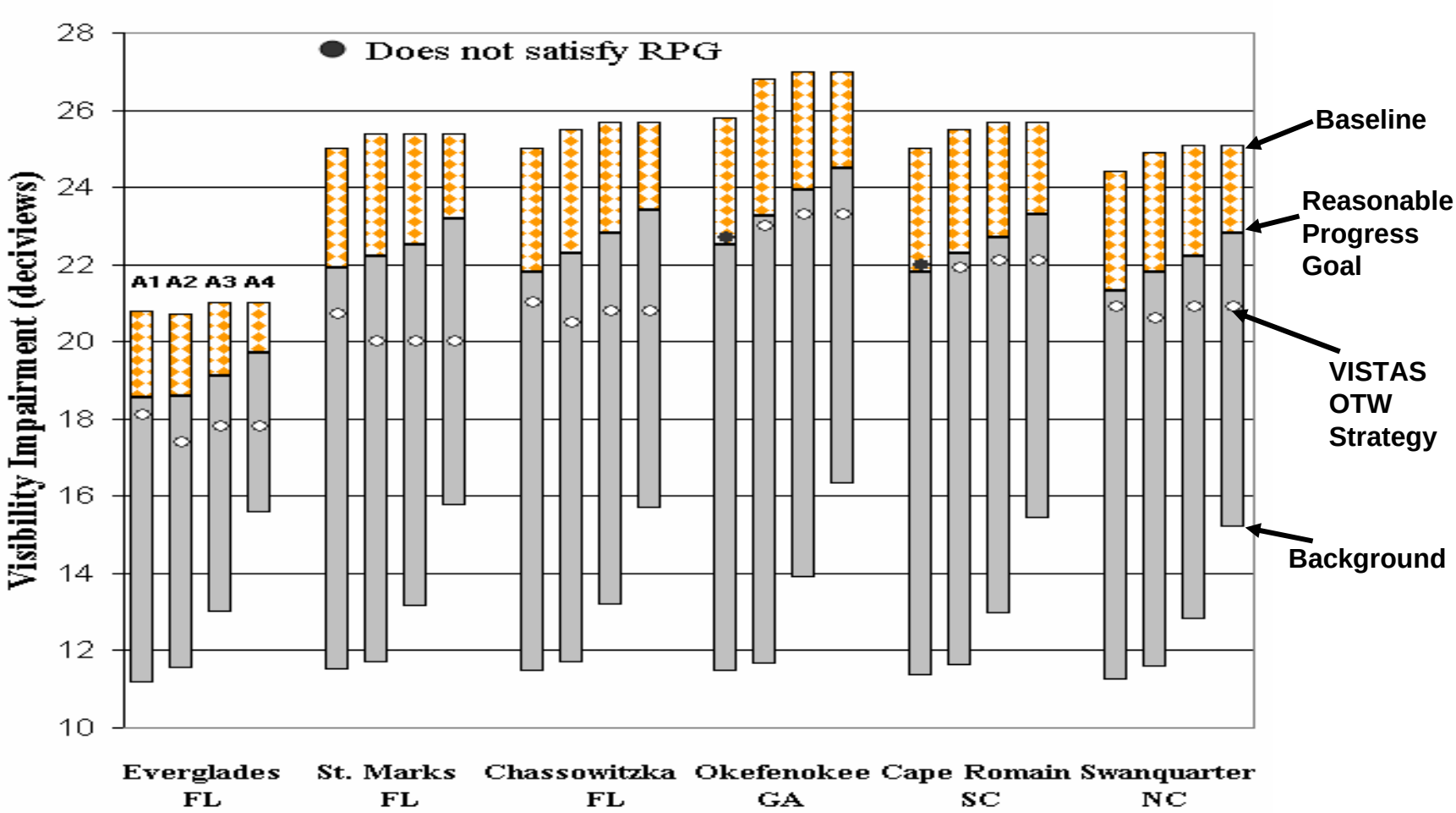
Assumption	Alternate 1	Alternate 2	Alternate 3	Alternate 4
Light Extinction Equation				
Dry Extinction Efficiencies	Constants for SO_4, NO_3, & OCM	Equations for SO_4, NO_3, & OCM		
OCM/OC Ratio	1.4	1.8 and 2.1 for current and natural haze		
Sea Salt Mass	-	-	3.27 C_{Na}(ug/m3)	
Sea Salt Light Extinction	-	-	3.27 C_{Na}(ug/m3) f(RH)	
Natural Haze				
20% Worst Natural Visibility	Annual + 3.84 dV (East)	Annual + 4.97 dV (East)		
Forest Organics	-	-	0.2 ug/m3 for forested VISTAS sites	
Oceanic Organics	-	-	0.1 ug/m3 for oceanic VISTAS sites	
Asian & African Dust	-	-	0.35 ug/m3 for southern VISTAS sites	
Transboundary Emissions	-	-	-	GEOS-CHEM

Results

- Plotted are the:
  - 2018 OTW visibility (average haze index of 20% worst days)
  - RHR baseline, background and 2018 reasonable progress goal (RPG)
- For four alternate approaches at:
  - VISTAS coastal sites
  - VISTAS inland sites
  - Other nearby Class I areas

VISTAS Coastal Sites from FL to NC

- OTW visibility at 4 of 6 Class I areas satisfies Alternate 1 2018 progress goals
- OTW visibility at 6 of 6 Class I areas satisfies Alternate 2-4 2018 progress goals



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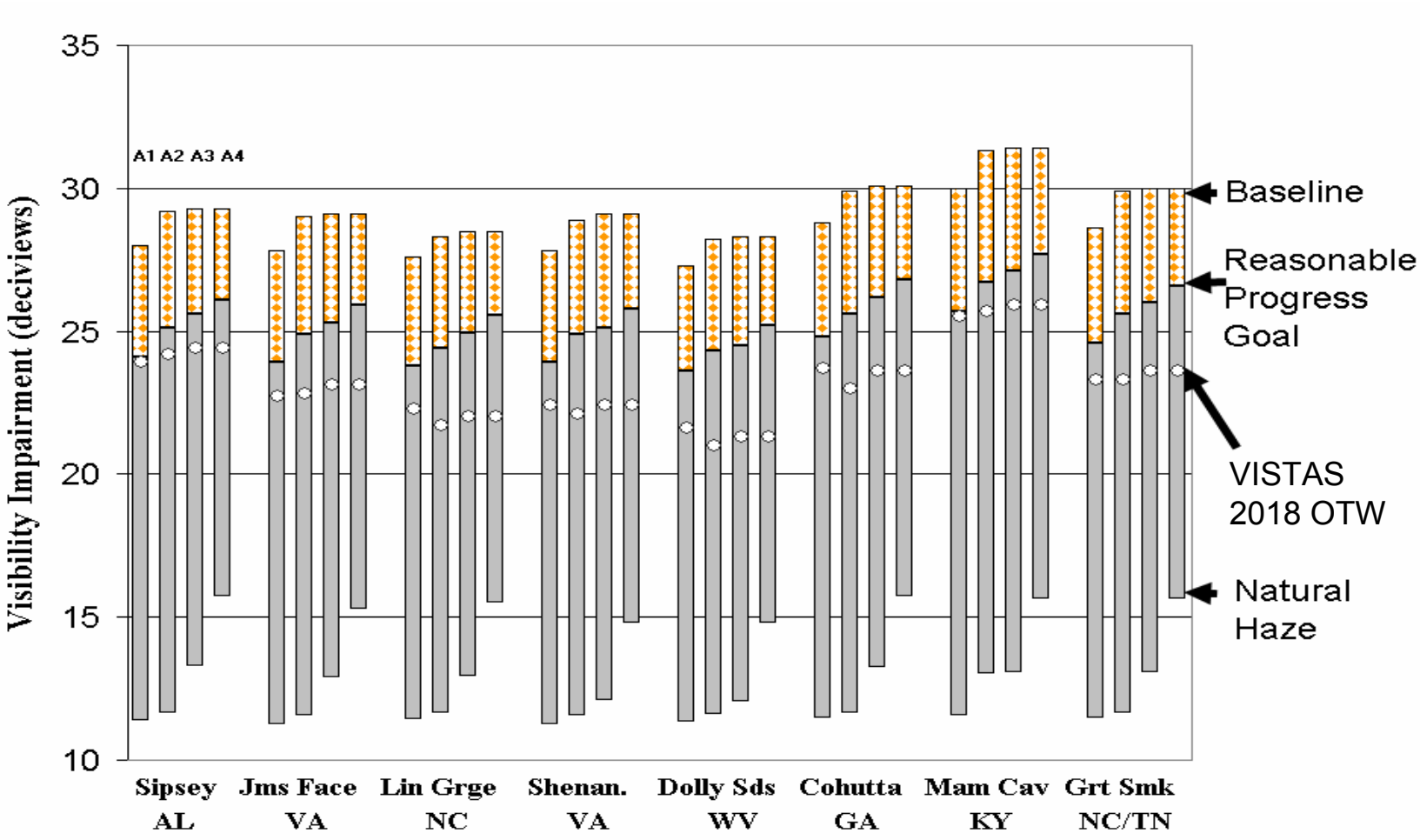
VISTAS Inland Sites

- OTW visibility at all 8 Class I areas satisfies Alternate 1-4 2018 progress goals
- OTW visibility more easily satisfies RPG with Alternate 2-4 than Alternate 1



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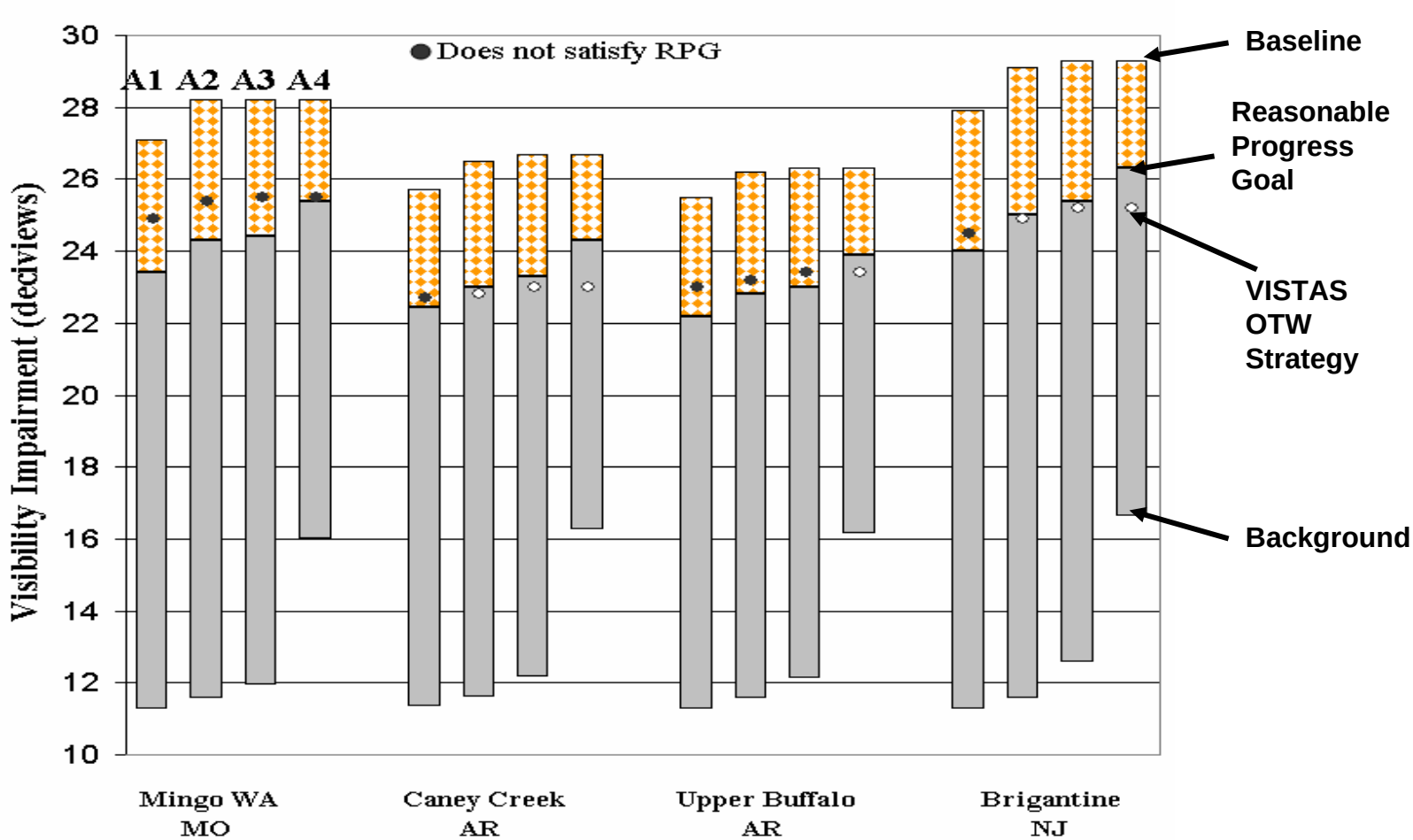
Nearby Class I Sites

- OTW visibility at no Class I area satisfies Alternate 1 progress goals
- OTW visibility at 2,2 & 3 of 4 Class I areas satisfy Alternate 2,3 & 4 progress goals



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Conclusions and Recommendations

- Using the IMPROVE equation and EPA's defaults, the VISTAS OTW strategy satisfied the 2018 RPG at 12 of the 18 Class I areas assessed.
- Refining the IMPROVE equation and EPA's defaults, the VISTAS OTW strategy satisfied the RPG at 16 (alts. 2-3) & 17 (alt. 4) of the 18 Class I areas.
- There is time for VISTAS and the other RPOs to consider, refine, and recommend to the states these alternates.

Suggested Next Steps for RPOs

- Revise the IMPROVE equation
- Apply revised IMPROVE equation to all days in the baseline period (including adding sea-salt) in order to get the final list of the 20% best and worst days.
- Decide on an approach for calculating the RRFs
- Decide on the site-specific natural conditions concentrations
- Decide on how to deal with trans-boundary (non-US) man-made emissions
- Consider development of tools to allow multiple alternatives to be assessed when final modeling results (and baseline data) are available

A Final Note About RRFs

- The VISTAS RRFs are preliminary because:
  - The final 2002 Typical and OTW strategy simulations have not been completed, and
  - The RRF methodology is under review and may change. For example:
    - weighting factors and more of the modeled days may be used to better represent the baseline days, and
    - The baseline days to be represented will change depending on which alternate is used but perhaps not significantly.
- For this study, the modeled days selected for calculating the relative reduction factors (RRFs) were developed by VISTAS and based on applying Alternate 1 to the baseline period.
  - Strictly speaking, the RRFs should be re-calculated with each alternate used.
  - However, alternate RRFs were not available for this study.
  - Therefore, even though the baseline visibility was re-calculated with each alternate, the same RRF was used.