Western Regional Modeling and Analysis Platform

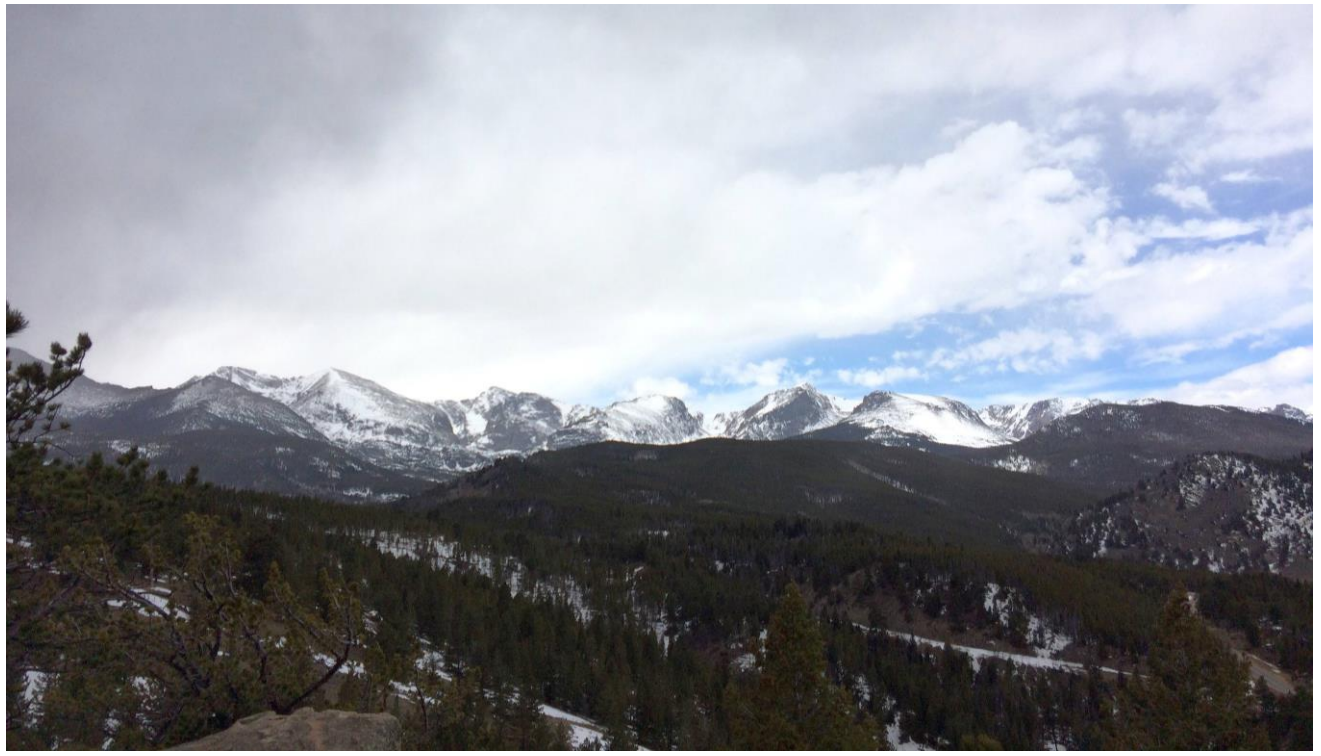
2014 Modeling Update for March 31, 2020

Ralph Morris, Pradeepa, Vennam, Marco Rodriguez, Jung Chien, Jeremiah Johnson, Tejas Shah and B.H. Baek (UNC)

WRAP RTOWG Webinar

March 31, 2020

RAMBOLL



2020 -- The Show So Far – WRAP Regional Modeling

- RTOWG Webinar Jan 22, 2020 on CAMx 2014v2 MPE
- RTOWG Webinar on Feb 26, 2020:
  - Representative Baseline Modeling Results
  - Initial WEP/AOI through Residence Time Analysis
  - Preliminary 2028 Emissions & 5 Run Spec Sheets
- RTOWG Webinar on Mar 12, 2020
  - Initial WEP analysis for CIAs -- Overlay gridded emissions on EWRT
  - White Paper on 2028 Visibility Projection approaches
- Today's RTOWG Webinar (Mar 31, 2020)
  - Preliminary 2028 Visibility Projections (2014v2/2028OTBb)
  - WEP/AOI to be Posted on TSS/IWDW
  - 2028 Source Apportionment Modeling Run Spec Sheet

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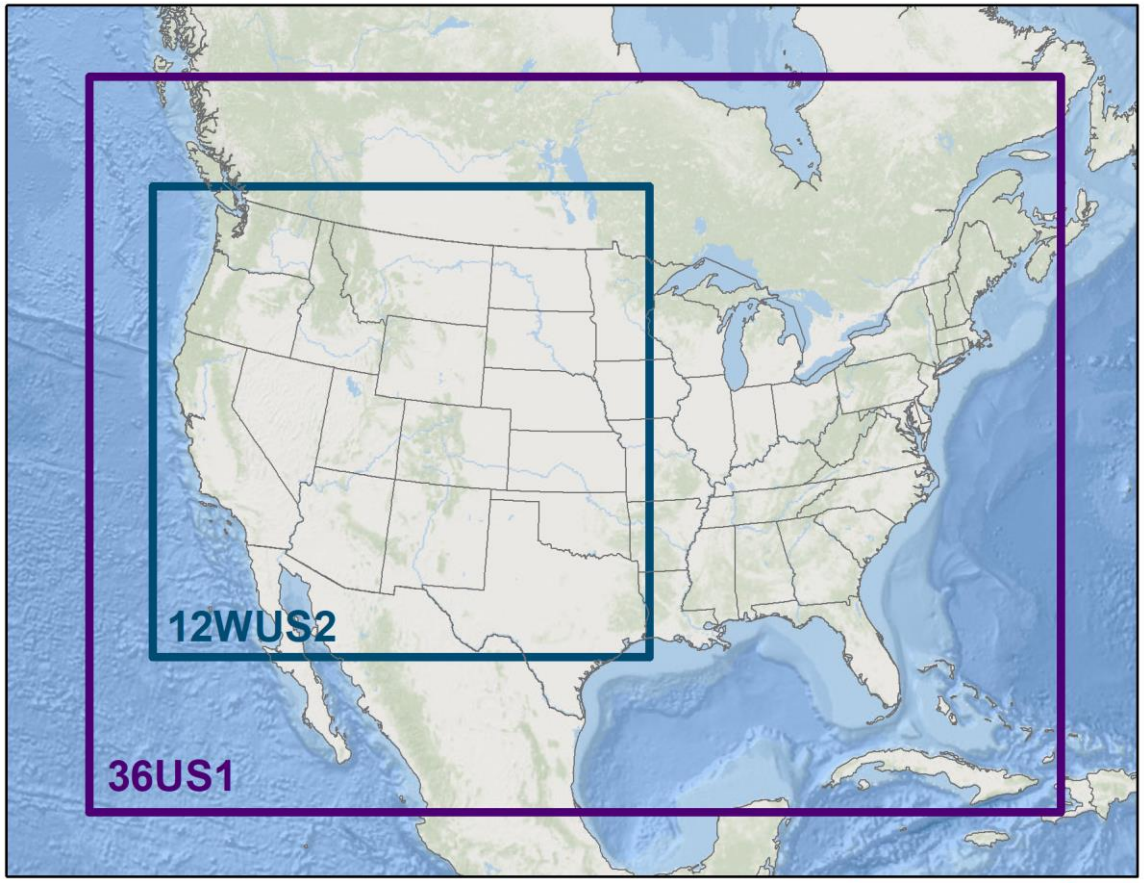
WRAP/WAQS 2014 Modeling Platform

- WAQS 2014 36/12-km WRF Meteorology
- BCs based on WRAP 2014 GEOS-Chem
- 2014v2 NEI w/ State Updates Emissions
  - Model Performance Evaluation
- RepBase (2014-2018) Emissions
  - NAT and ZROW Zero-Out
  - Source Apportionment
- 2028OTBa & 2028OTBb Emissions
  - (a) RepBase and (b) 2014 Actual Fires
  - 2028 Visibility Projections
  - Source Apportionment
- Dynamic Evaluation
  - 2002 Emissions



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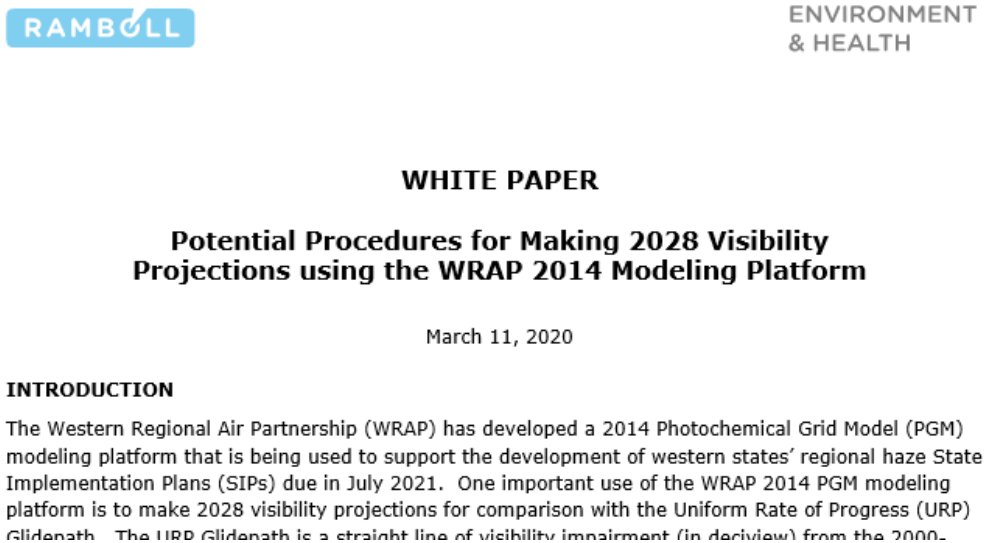
Preliminary 2028 Visibility Projections

2028 Visibility Projection White Paper

- Purpose:
  - Document potential approaches for projecting the observed 2014-2018 IMPROVE Most Impaired Days (MID) visibility to 2028 using the WRAP 2014 current and 2028 future year CAMx modeling results
  - WRAP also investigating other ways for using the modeling results to better understand the relationship between reductions in U.S. anthropogenic emissions and progress in reducing visibility impairment at Class I Areas that will be discussed in the future



RAMBOLL ENVIRONMENT & HEALTH

WHITE PAPER

Potential Procedures for Making 2028 Visibility Projections using the WRAP 2014 Modeling Platform

March 11, 2020

INTRODUCTION

The Western Regional Air Partnership (WRAP) has developed a 2014 Photochemical Grid Model (PGM) modeling platform that is being used to support the development of western states' regional haze State Implementation Plans (SIPs) due in July 2021. One important use of the WRAP 2014 PGM modeling platform is to make 2028 visibility projections for comparison with the Uniform Rate of Progress (URP) Glidepath. The URP Glidepath is a straight line of visibility impairment (in deciview) from the 2000-

Basic 2028 Visibility Projection Approach

- IMPROVE Most Impaired Days (MID) uses a statistical approach that infers routine and episodic natural conditions with the remainder assumed to be anthropogenic impairment with the 20% most "anthropogenically" most impaired days defining the MID
  - High OA concentrations used to filter out days with wildfire impacts
  - High Soil concentrations used to filter out days with high dust impacts
- Species-specific Relative Response Factors (RRFs) are used to scale the observed concentrations from the 2014-2018 IMPROVE MID to 2028:
  - $PM_{2028} = RRF \times PM_{2014\text{-}2018}$
- RRFs are defined as the ratio of the future year to current year modeling results and are Class I Area (IMPROVE site) and species-specific (i.e., SO4, NO3, EC, OA, Soil and CM)
  - For example: $RRF(SO4) = (1/N) \times \sum Model(SO4)_{2028} / \sum Model(SO4)_{2014}$
- The subject of how to pick the N days used to defined the RRFs is discussed in the White Paper

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WRAP 2014 Modeling Platform Results

- CAMx photochemical modeling for the 2014 annual period and several emission scenarios:
  - 2014v2: 2014 actual emissions, including actual fires (used for MPE)
  - Representative Baseline (RepBase): Anthropogenic emissions representative of the 2014-2018 period, RepBase fires from WRAP FSWG.
  - 2028OTB: U.S. anthropogenic emissions projected to 2028 assuming On-the-Book (OTB) controls, natural emissions kept constant at 2014 levels, two types of fires used:
    - 2028OTBa use RepBase fires
    - 2028OTBb use 2014v2 actual fires
- Results in two sets of CAMx current and 2028 future year emission scenarios that can be used to make 2028 visibility projections:
  - RepBase/2028OTBa using RepBase fires
  - 2014v2/2028OTBb using 2014v2 actual fires

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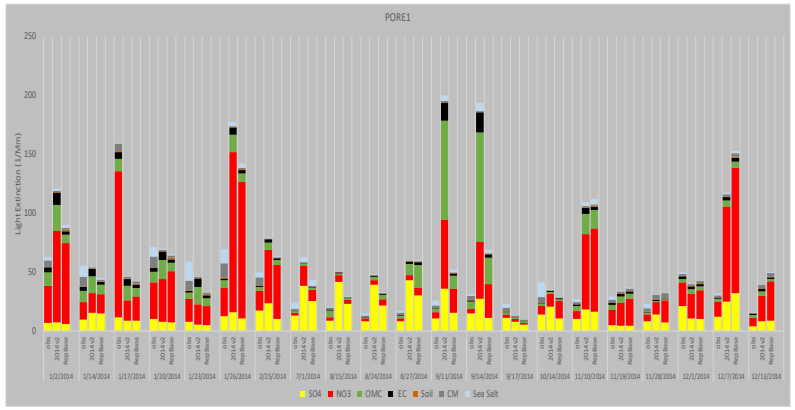
2028 Visibility Projection Approaches

- EPA Method: Follows EPA 2018 Guidance for Regional Haze Modeling (O3 & PM2.5)
  - Develop RRFs for each aerosol species (SO4, NO3, EC, OA, Soil and CM) using average concentrations across the 2014 MID
    - Could be potential issues if modeled fire impacts occur during 2014 MID.
- EPAwoF Method: EPA Method only w/o days with fire impacts
  - Use RRFs based on 2014 MID only don't use days in 2014 MID that have obvious fire impact (e.g., PORE→)
- ModMID Method: Modeled Most Impaired Days
  - Use RepBase Source Apportionment modeling to identify the 20% days with the highest U.S. anthropogenic emissions visibility impairment and no fire impacts
- MPE Adjustment: Adjust Methods above by not using days in the RRFs that do not achieve some level of Model Performance Evaluation (MPE)
  - Apply MPE criteria for SO4 and NO3 RRFs where days are only use on that day if the predicted and observed SO4 and NO3 are "close" to each other (e.g., < 20%).



Preliminary 2028 Visibility Projections

- Currently just have results for 2028 projections using CAMx 2014v2/2028OTBb modeling results (2014 actual fire emissions) using the EPA Method
  - EPA's Software for the Modeled Attainment Test (SMAT) tool codifies EPA's recommended Projection Method in their modeling guidance (EPA, 2018)
  - SMAT comes pre-loaded with observed IMPROVE data with MID days flagged (group90)
    - Currently has older IMPROVE data through 2017
    - New (December 2019) filled IMPROVE data through 2018 is being evaluated by EPA and ported into SMAT
- Compare preliminary 2028 visibility projections at CIAs with Uniform Rate of Progress (URP) Glidepath
  - Glidepath (i.e., 2000-2014 Baseline and 2064 Natural Conditions) based on new (Dec 2019) IMPROVE data
  - Linear URP Glidepath based on deciview (dv)
    - Also display converted to extinction (Mm^{-1})

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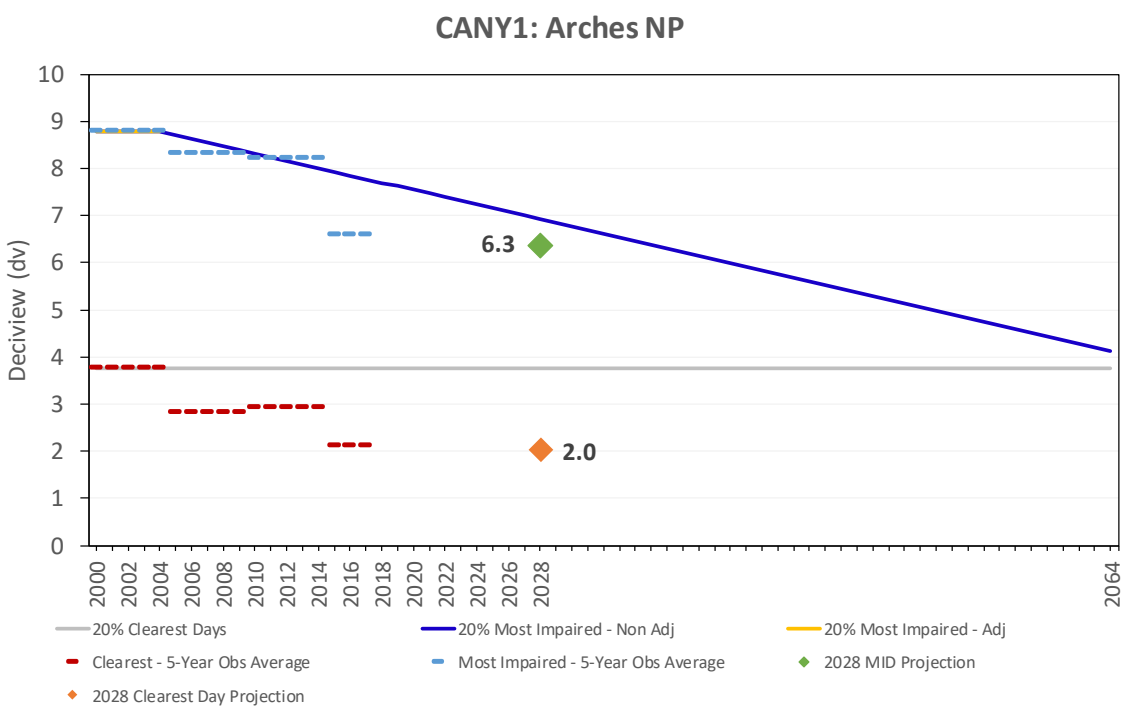
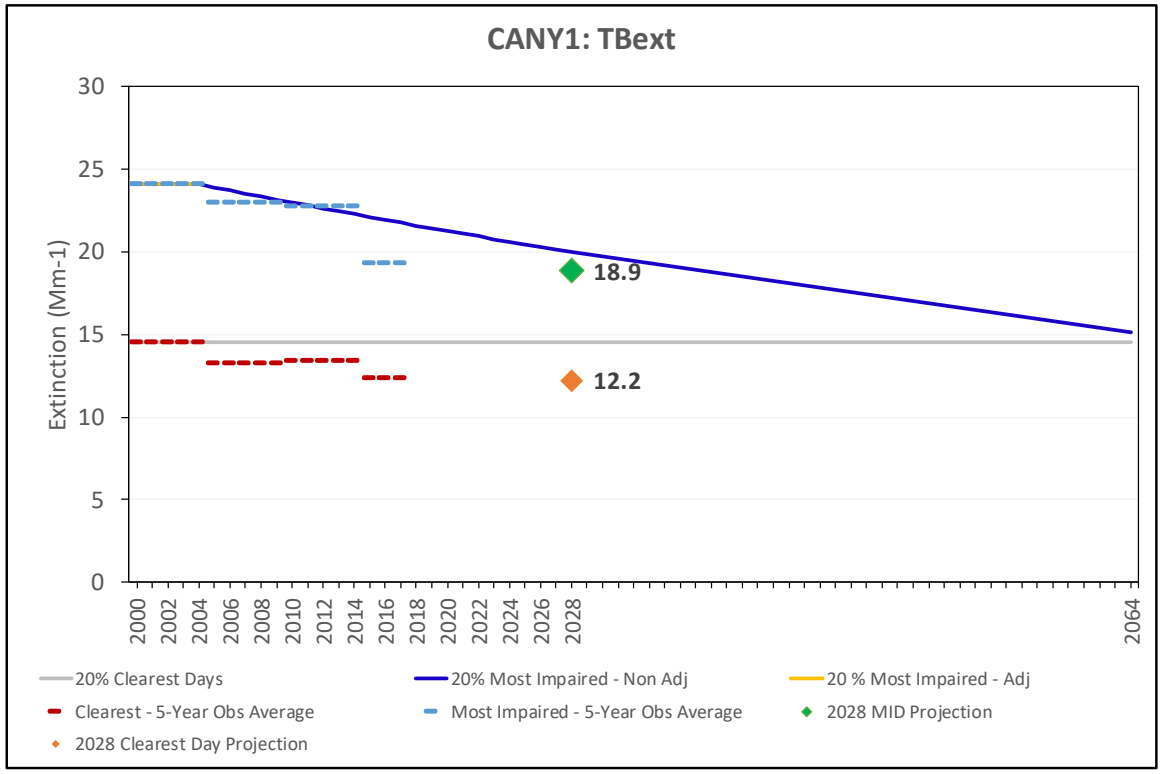
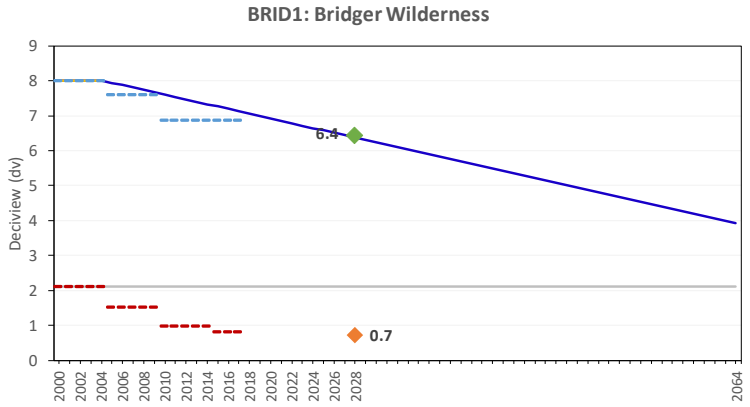
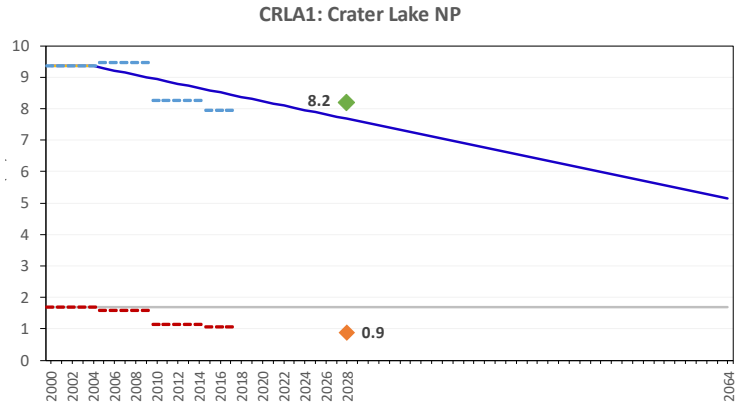
Canyonlands UT – EPA Method using 2014v2/2028OTBb

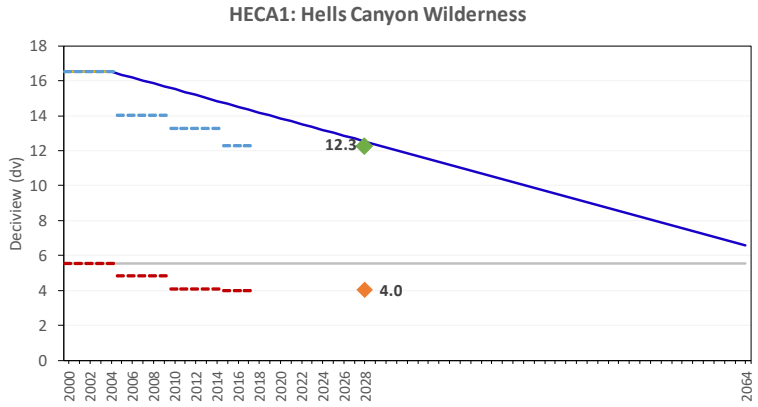


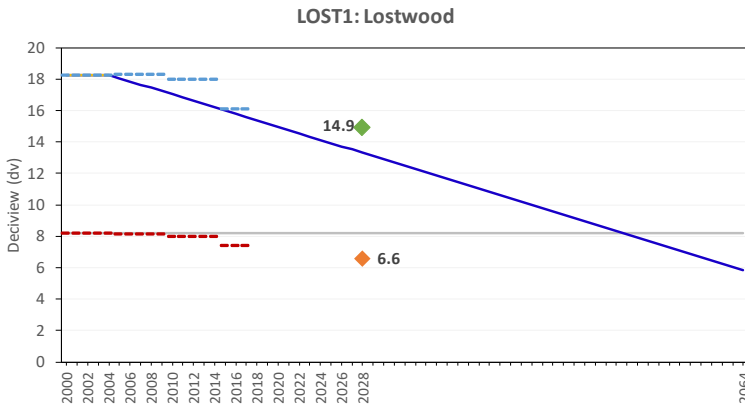


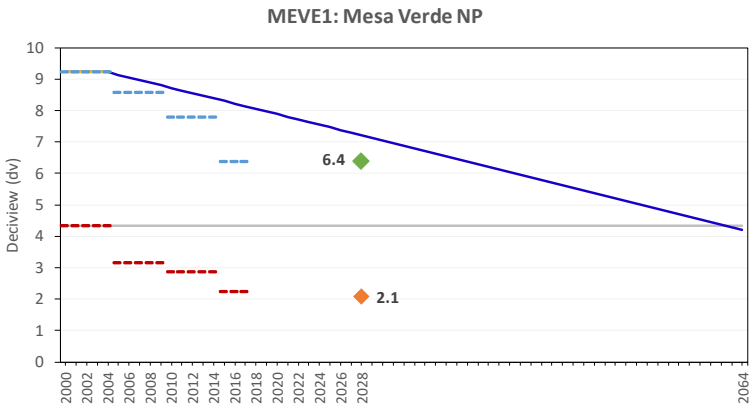
BRID, CRLA, HECA, LOST, MEVE, MORA, MOZI, PEFO, SACR

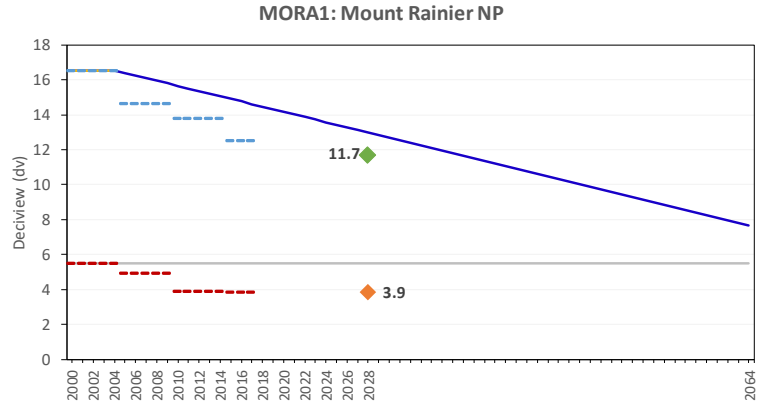


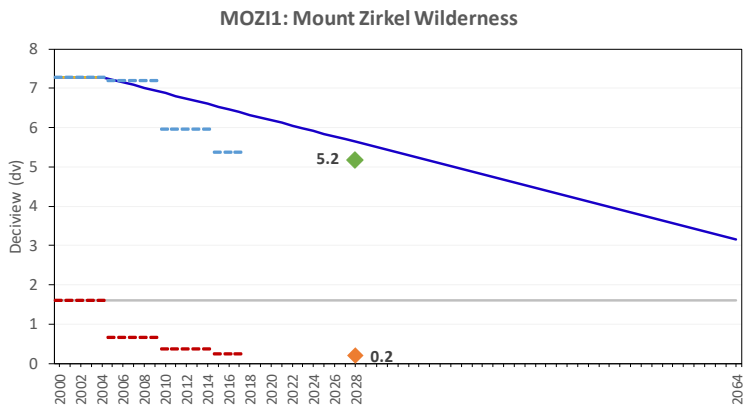


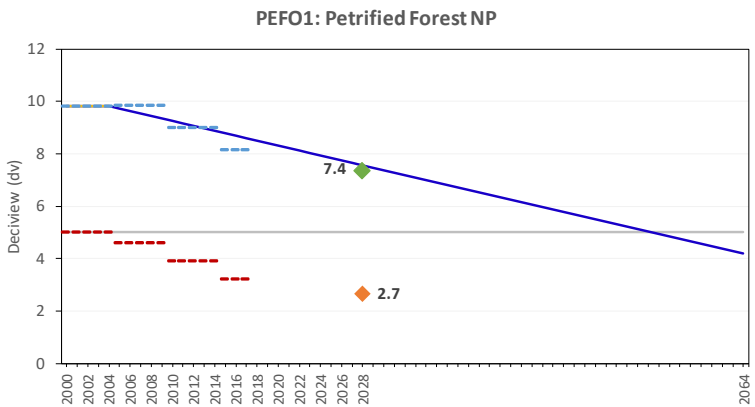


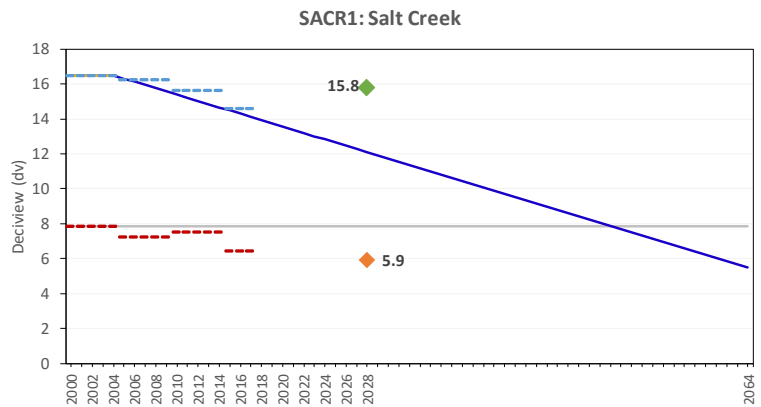






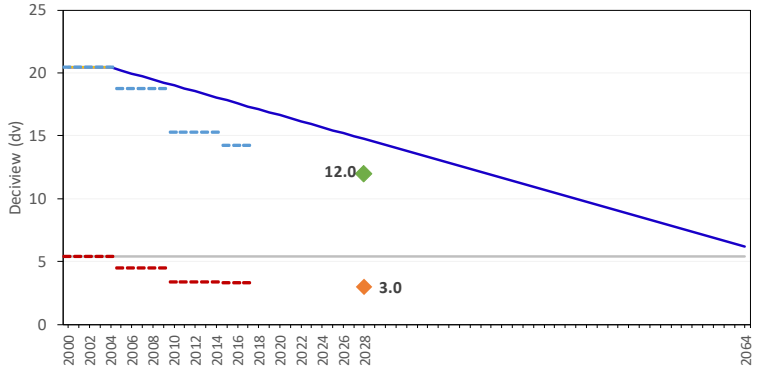




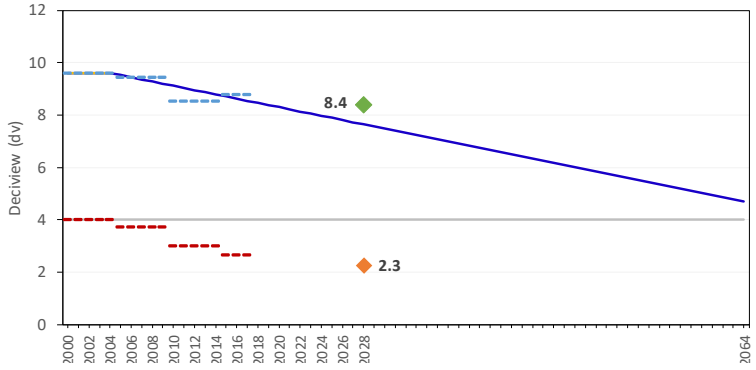


SAGO, SAWT, SEQU, THRO, ULBE, WHIT, WIMO, YELL, YOSE

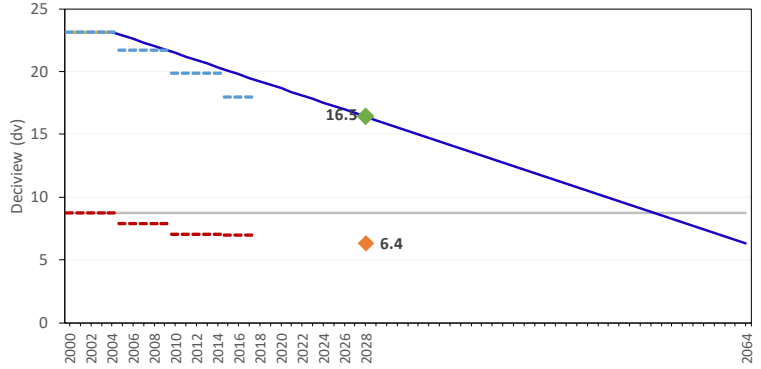
SAGO1: San Gorgonio Wilderness



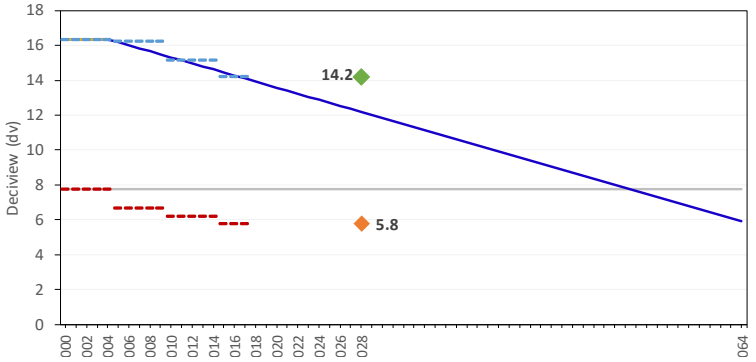
SAWT1: Sawtooth Wilderness



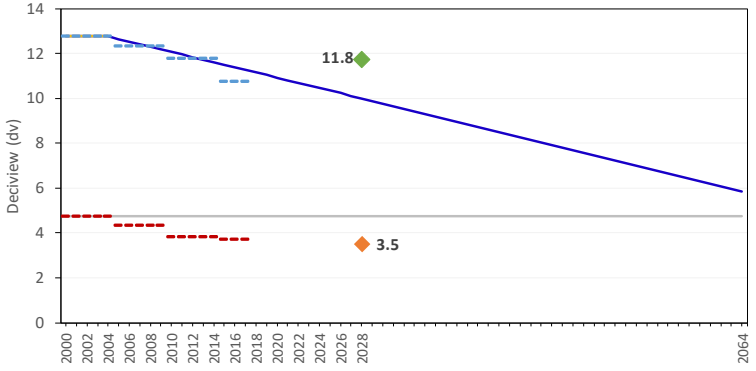
SEQU1: Kings Canyon NP



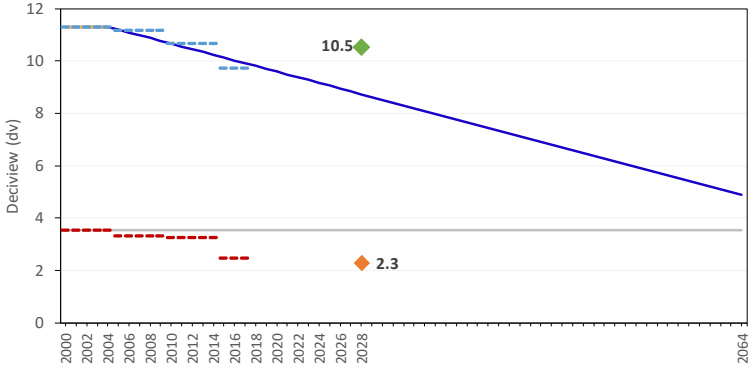
THRO1: Theodore Roosevelt NP



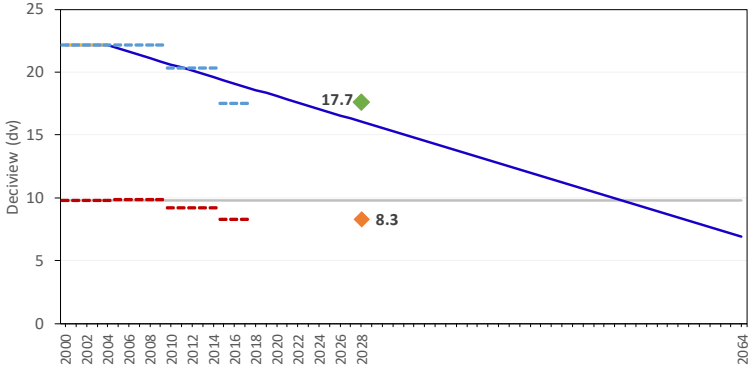
ULBE1: UL Bend



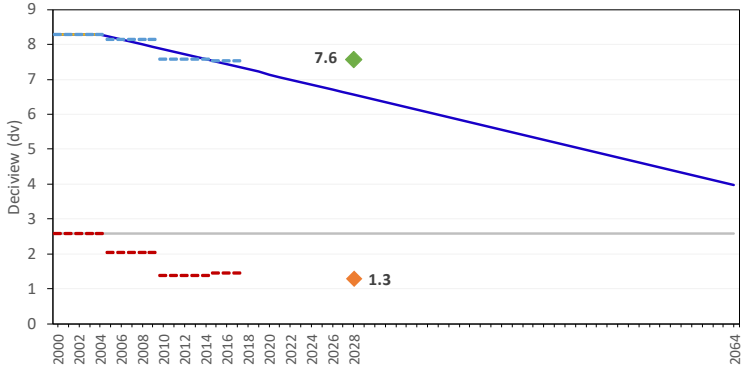
WHIT1: White Mountain Wilderness



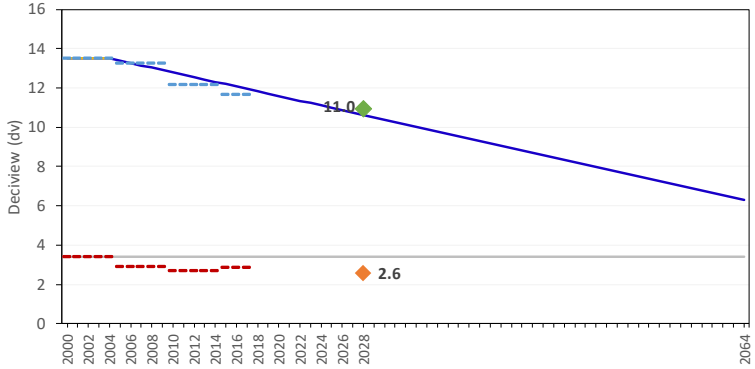
WIMO1: Wichita Mountains



YELL2: Grand Teton NP



YOSE1: Emigrant Wilderness



2028 Visibility Projections – Next Steps

- Need SMAT with new (Dec 2019) IMPROVE Data through 2018 [from EPA]
- Identify 2014 IMPROVE days with obvious 2014v2 and RepBase fire impacts
  - Needed for EPAwoF Method 2028 visibility projections
- Complete RepBase Source Apportionment Simulation
  - Used to define modeled MOD for ModMID Method
  - Also use standard model output for RepBase/2028OTBa visibility projections
- Define MPE adjustment in 2028 visibility projections
  - Implement in EPA, EPAwoF and ModMID Methods
- International anthropogenic emissions Adjusted Glidepath
  - Will have results from RepBase ZROW and RepBase and 2028 SA modeling
- Transfer of results to CSU and implement on TSS

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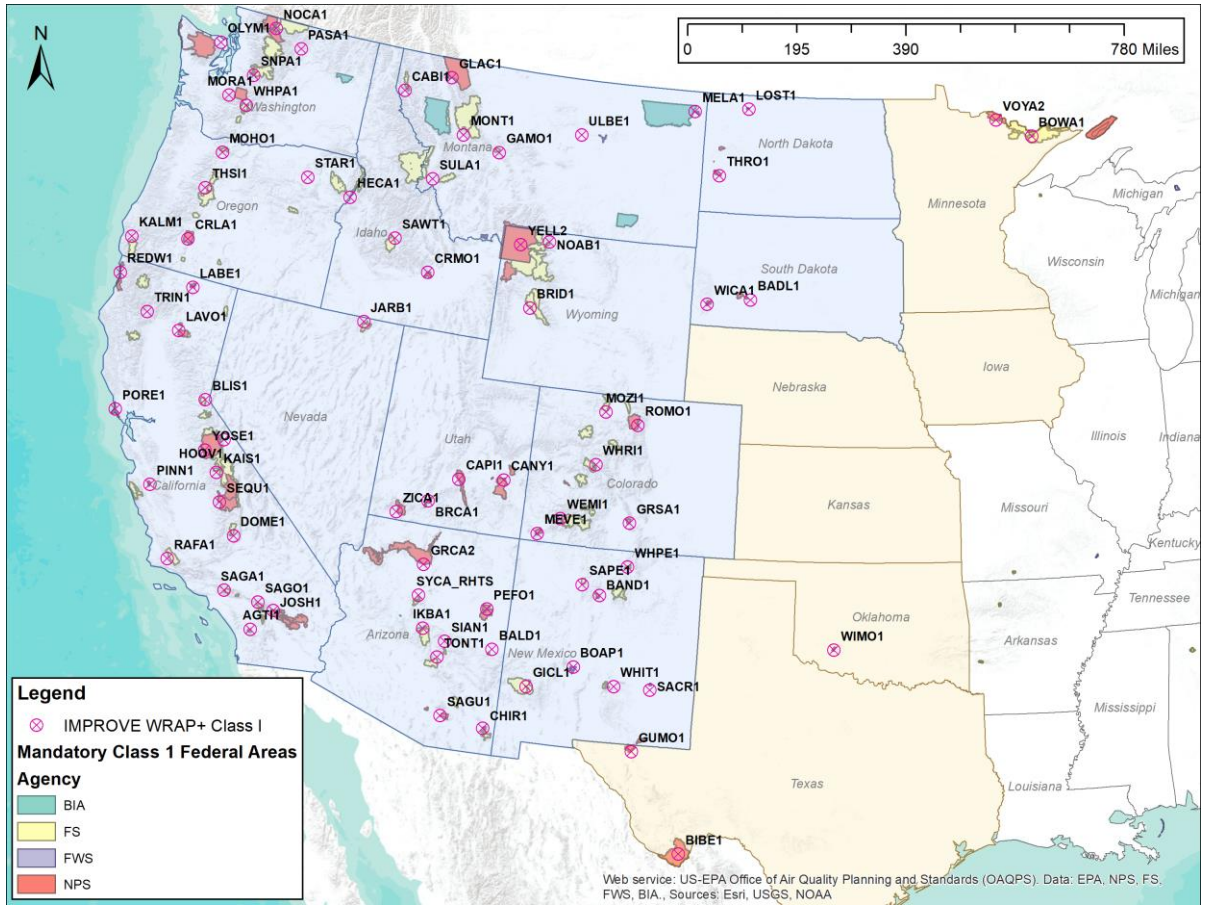
Interim Weighted Emissions Potential (WEP) Results on TSS/IWDW

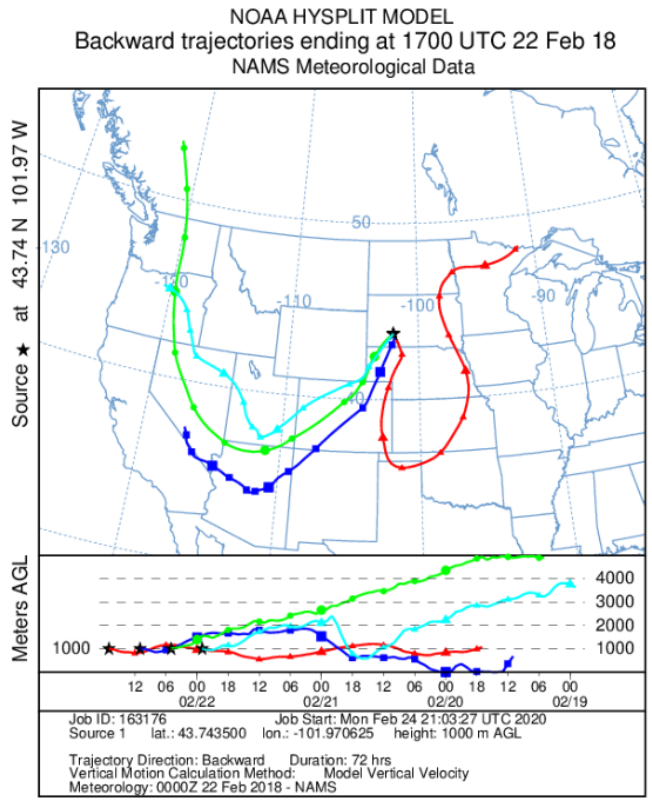
Weighted Emissions Potential (WEP) Analysis

1. HYSPLIT Back Trajectories from Class I Areas (CIAs) on IMPROVE MID in 2014-2018
   - 4 times a day at 4 heights
   - 100, 200, 500 and 1,000 m AGL
2. Residence Time (RT) analysis of frequency of occurrence trajectories pass over locations and arrive at CIA on MID
3. Extinction Weighted Residence Time (EWRT)
   - SO4, NO3, OA and EC
4. Overlay 2028 emissions on EWRT to get WEP
   - SO2, NOx, EC and POA emissions
     - 77 IMPROVE sites representing 117 CIAs in WRAP and neighboring states = ~150,000 HYSPLIT back trajectories conducted

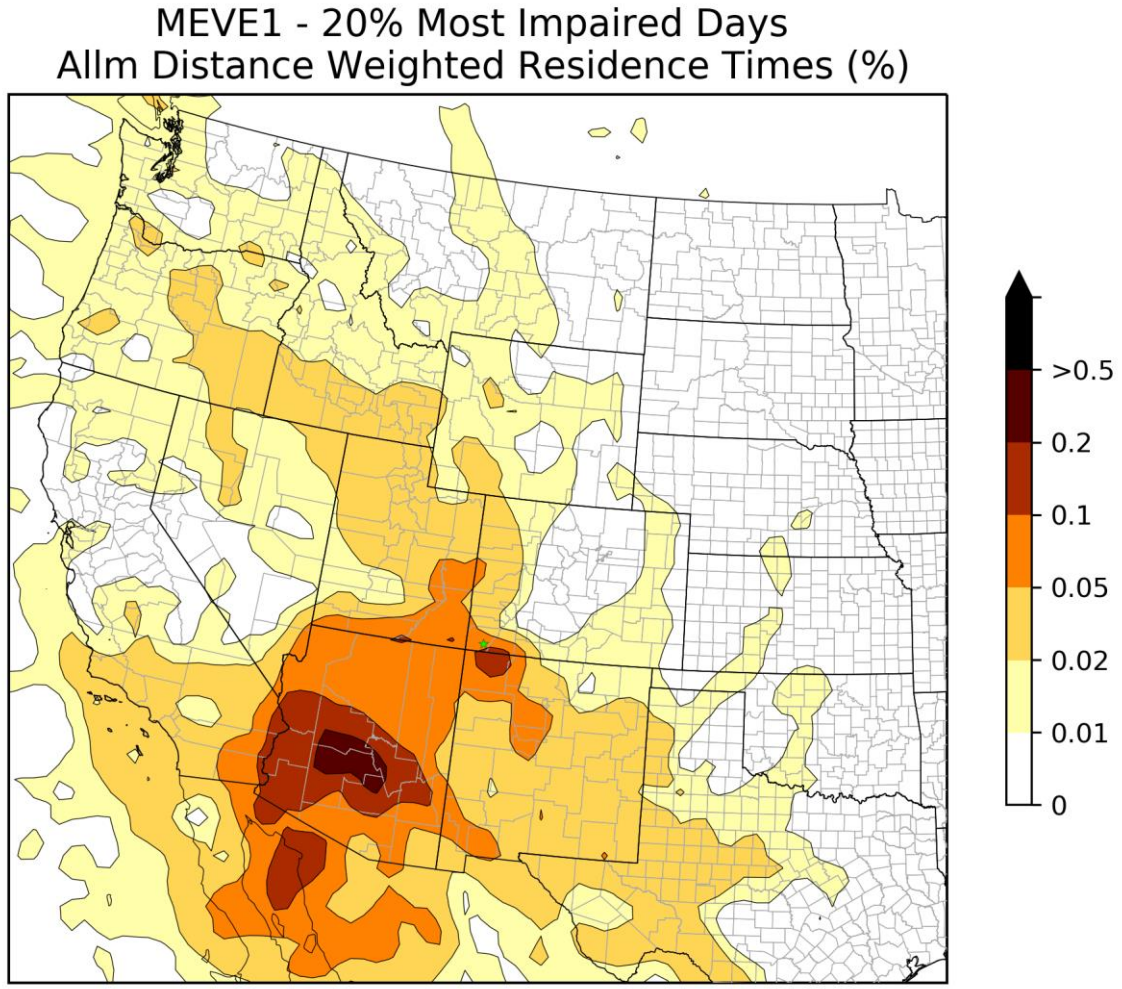


Back Trajectories Processed to Obtain Residence Time

- For each CIA ~2,000 HYSPLT back trajectories on the 2014-2018 MID

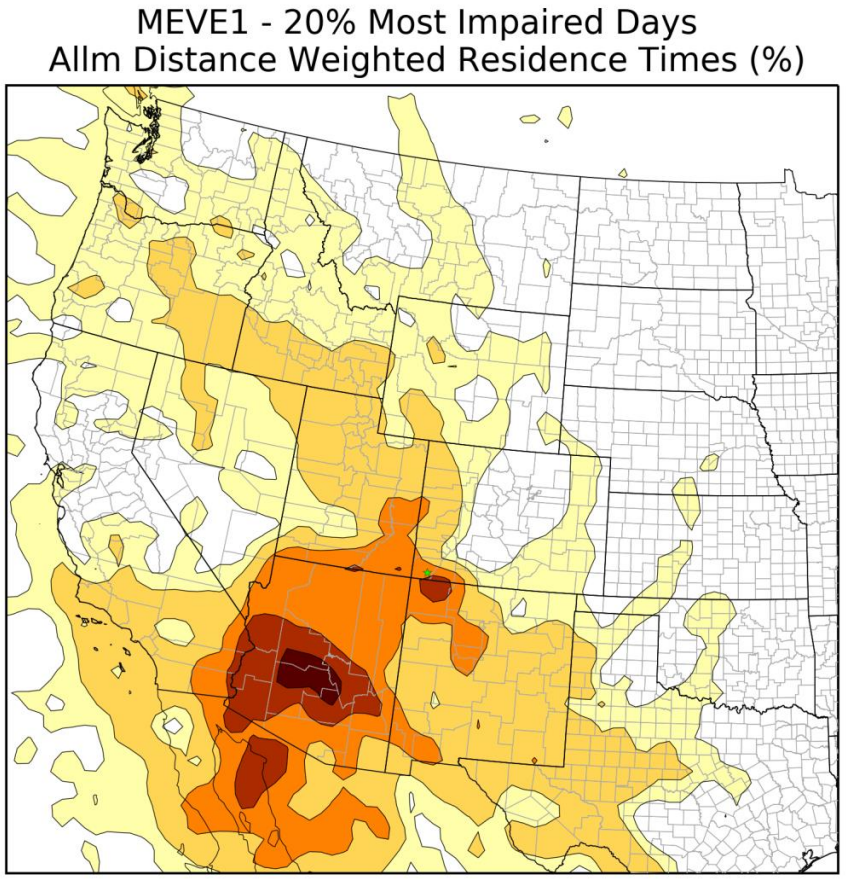


- Residence Time (RT) AOI analysis for 2014-2018 MID at Mesa Verde (MEVE)



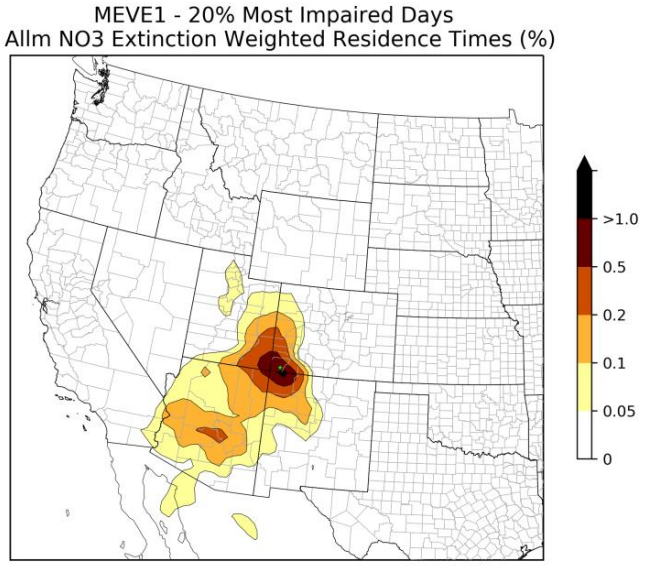
Extinction Weighted Resident Time

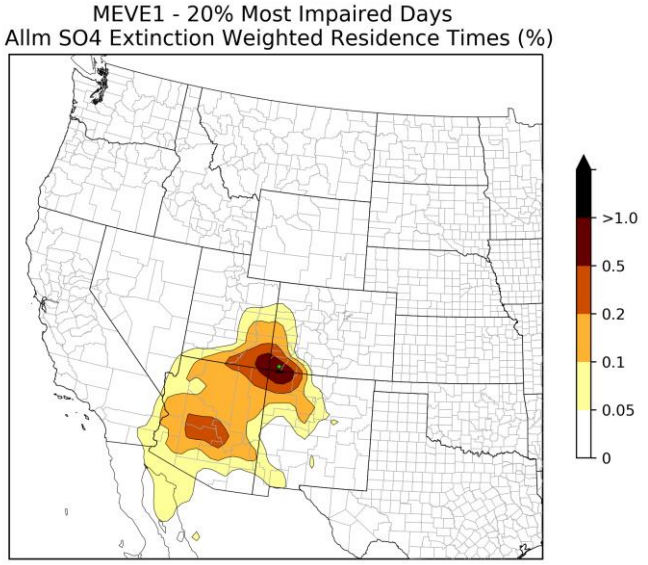
- **MEVE Residence Time**



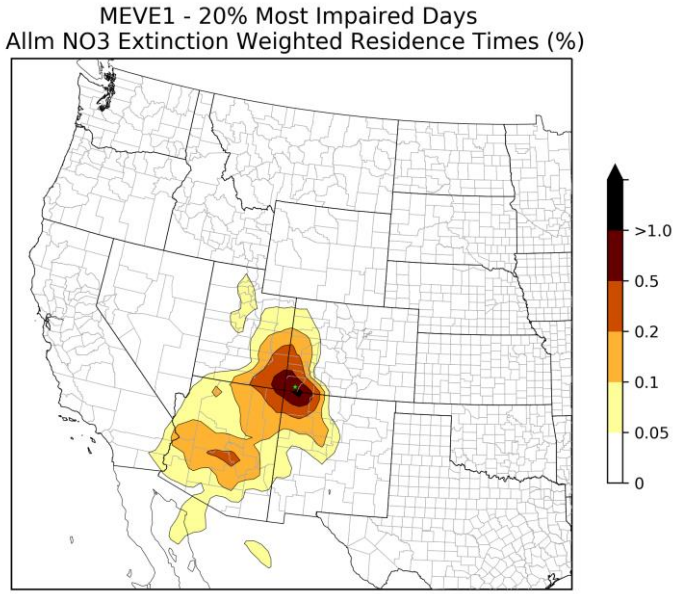
B_{AmmNO3}

B_{AmmSO4}





Weighted Emissions Potential (WEP)



B_{AmmNO3} EWRT

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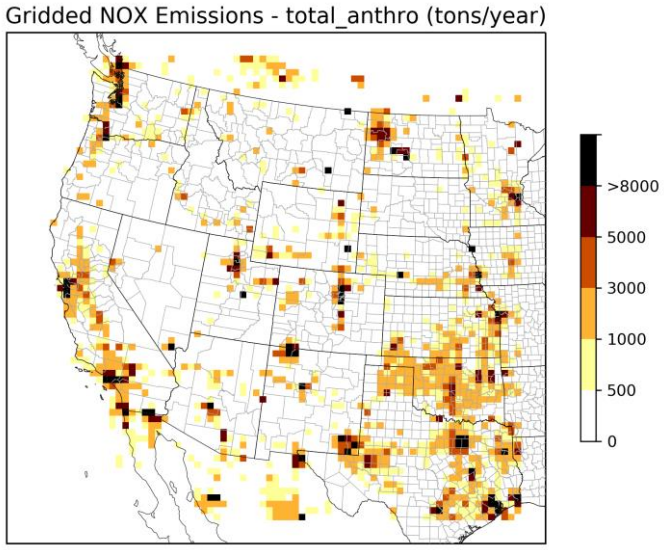
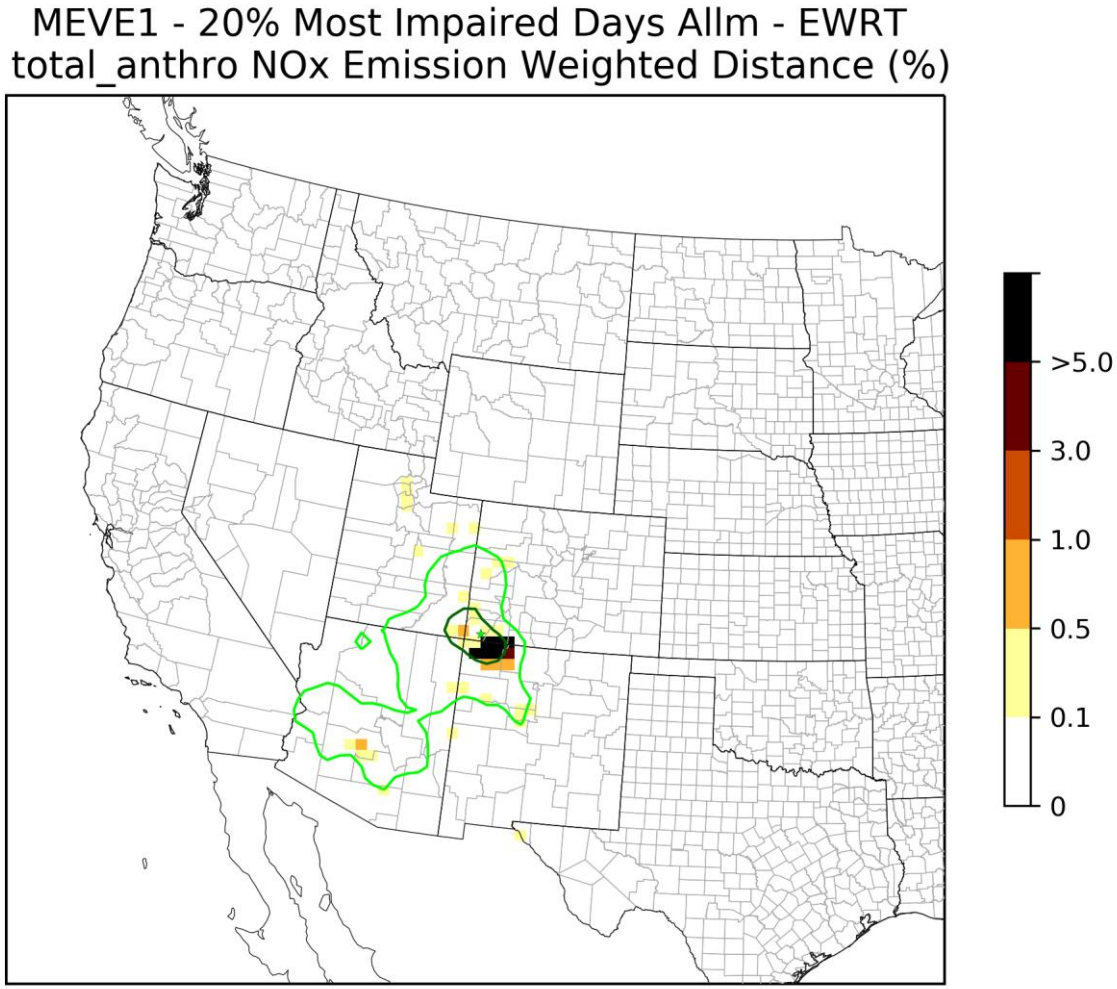


Total Anthro NOx Emissions

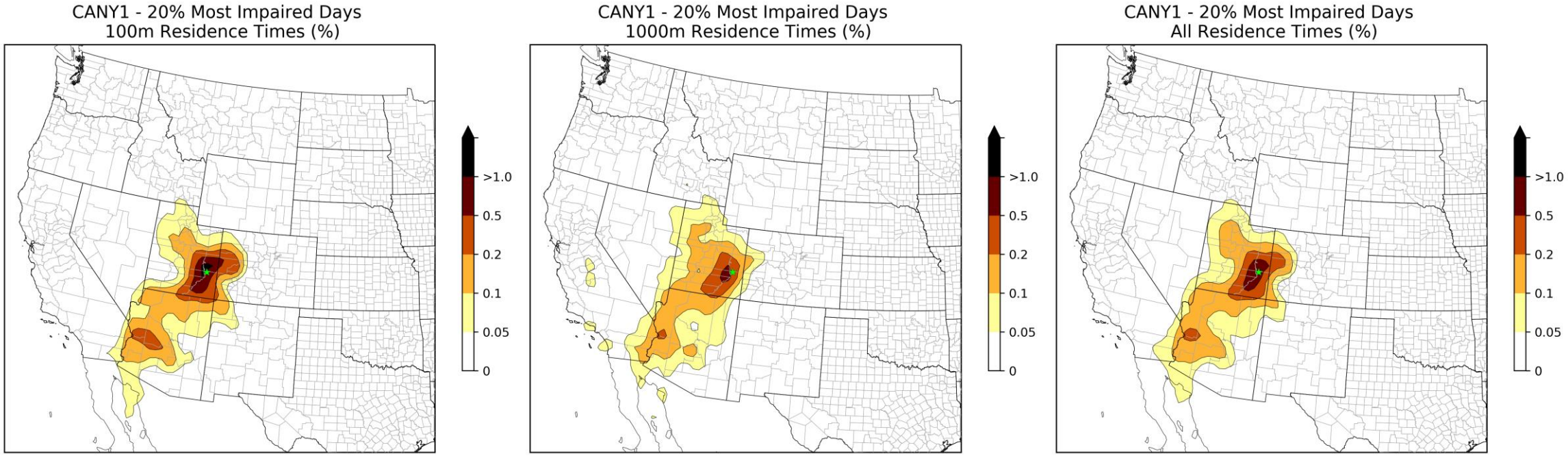
MEVE NOx WEP All Anthro



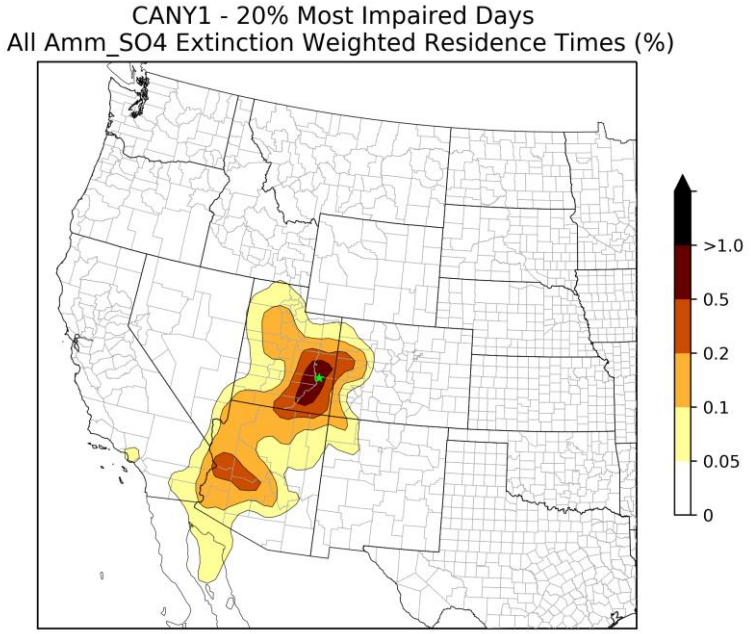
Interim WEP/AOI Displays to be on TSS/IWDW

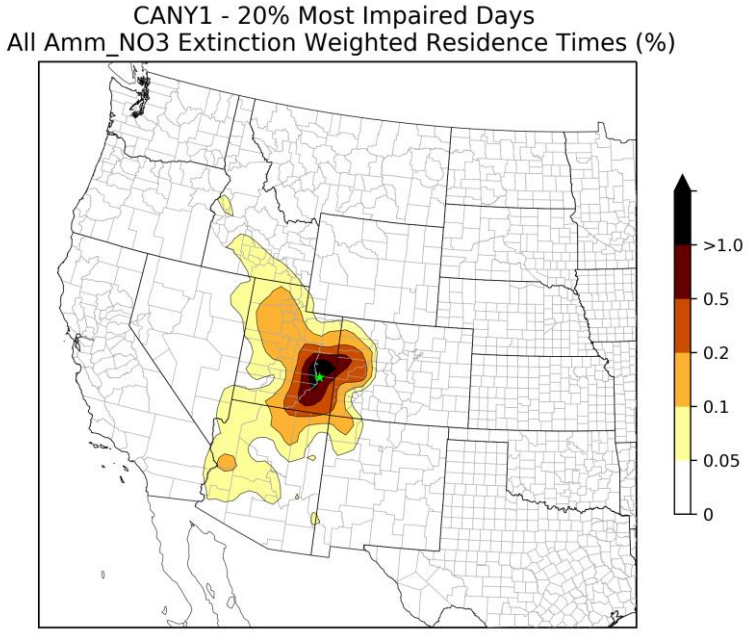
- For each Class I Area/IMPROVE Monitoring Site there will be four (4) folders:
  - \RT – Residence Time plots at 3 heights: 100m, 1,000m and Allm
  - \EWRT – Emissions Weighted RT for 3 heights and 4 species: SO4, NO3, OA and EC
  - \WEP – Weighted Emissions Potential for 3 heights, 4 species and 6 Source Sectors:
    - Total Anthropogenic
    - Total Point Source
    - Total EGU Point (No CA)
    - On-road Mobile
    - Area Source
    - CMV
  - \Rank_Point
    - Excel file with Facility level point source WEP analysis for SO2 and NOx emissions

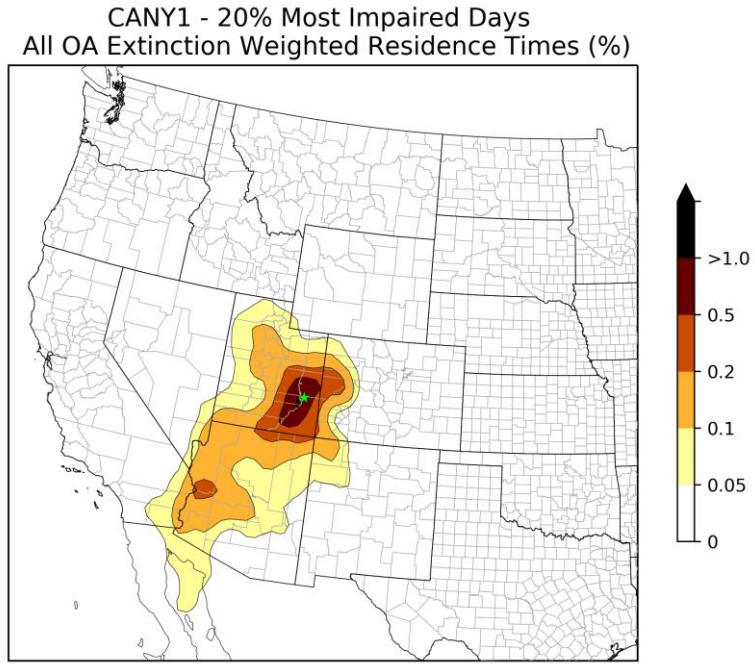
CANY1 – Residence Time Folder (\RT)



CANY1 – \EWRT at Allm Height and for SO4, NO3 and OA

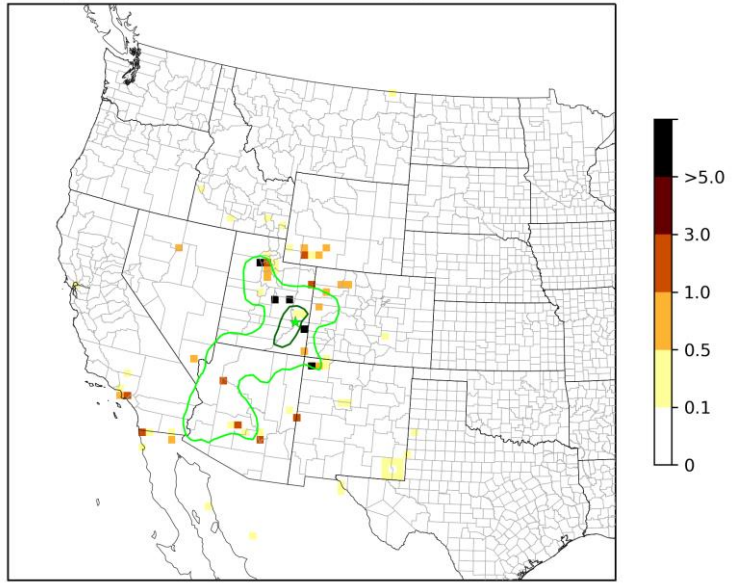




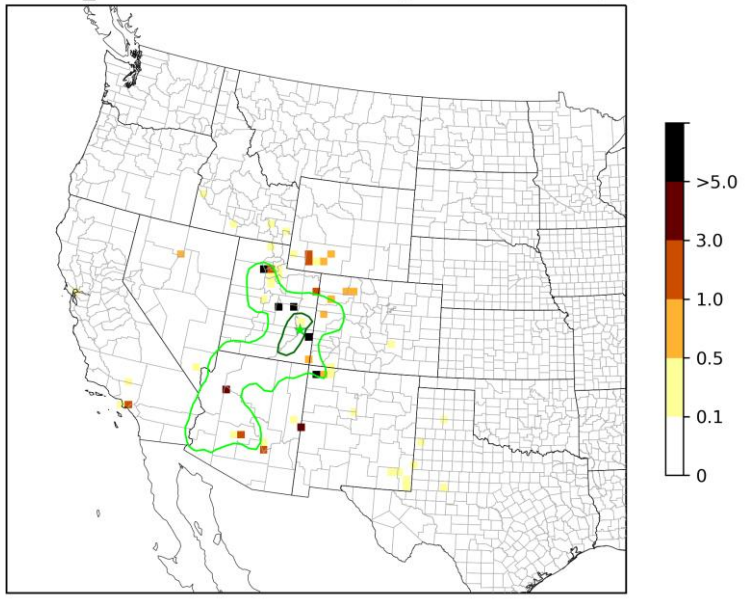


CANY1 -- \WEP at Allm Height, SO4/SO2 & Total Anthro, Total Point and EGU Point

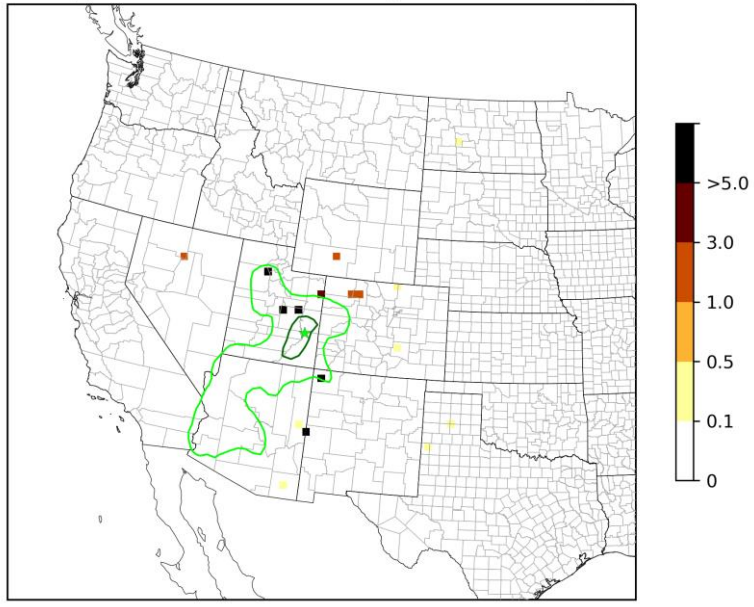
CANY1 - 20% Most Impaired Days All - EWRT
TOTAL_ANTRHO SOx Emission Weighted Distance (%)



CANY1 - 20% Most Impaired Days All - EWRT
TOTAL_POINT SOx Emission Weighted Distance (%)



CANY1 - 20% Most Impaired Days All - EWRT
EGU_noCA SOx Emission Weighted Distance (%)



CANY1 -- \Rank_Point at Allm Height & SO4/SO2

FacilityID	FacilityName	State	NAICS	NAICSDesc	SO2_tpy	EWRTxQoverD_SO4
5050511	PacifiCorp- Hunter Power Plant	UT	221112	Fossil Fuel Electric Power	3498	78103
5050611	PacifiCorp- Huntington Power Plant	UT	221112	Fossil Fuel Electric Power	2449	48076
6432411	CCI Paradox Midstream, LLC: Lisbon Natural Gas Processir	UT	211111	Crude Petroleum and Nat	535	39468
7197711	Four Corners Power Plant	0	221112	Fossil Fuel Electric Power	2538	32557
5066411	Sunnyside Cogeneration Associates- Sunnyside Cogenera	UT	221112	Fossil Fuel Electric Power	461	25633
7569011	Kennecott Utah Copper LLC- Power Plant Lab Tailings Im	UT	212319	Other Crushed and Broke	2152	21268
7735111	TUCSON ELECTRIC POWER CO - SPRINGERVILLE	AZ	221112	Fossil Fuel Electric Power	6992	13953
1090211	CHEMICAL LIME NELSON PLANT	AZ	32741	Lime Manufacturing	2041	13409
6281811	Bonanza	0	221112	Fossil Fuel Electric Power	1281	11908
1074511	ASARCO LLC - HAYDEN SMELTER	AZ	33141	Nonferrous Metal (excep	3062	10729
6478511	Green River Works	WY	212391	Potash, Soda, and Borate	5671	8738
8237411	Kennecott Utah Copper LLC- Smelter & Refinery	UT	33141	Nonferrous Metal (excep	735	7169
7558611	Tesoro Refining & Marketing Company LLC - Salt Lake City	UT	32411	Petroleum Refineries	519	5852
8840011	Resolute Natural Resources Company - Aneth Unit	0	211111	Crude Petroleum and Nat	118	4072
3962711	Jim Bridger Plant	WY	221112	Fossil Fuel Electric Power	4731	3961
8041211	Westvaco Facility	WY	212391	Potash, Soda, and Borate	2766	3568
4956711	Rock Springs Fertilizer Complex	WY	325312	Phosphatic Fertilizer Man	1506	3435
4458511	PUBLIC SERVICE CO - HAYDEN PLT	CO	221112	Fossil Fuel Electric Power	1865	3237
7302011	NORTH VALMY GENERATING STATION	NV	221112	Fossil Fuel Electric Power	2277	2846
1839711	TRI STATE GENERATION CRAIG	CO	221112	Fossil Fuel Electric Power	1680	2593
8091911	San Juan River Gas Plant	NM	21112	0	143	2370
3660511	OLDCASTLE SW GROUP DBA UNITED CO OF MESA	CO	327320	Ready-Mix Concrete Man	29	2056
291	ENTERPRISE GAS PROC - MEEKER GAS PLANT	CO	211130	Natural Gas Extraction	210	1928
6282011	Brigham Young University- Main Campus	UT	61131	Colleges, Universities, an	93	1292
4208111	Rock Springs Coal Calcining Plant	WY	324199	All Other Petroleum and	629	1232
929311	THE AMALGAMATED SUGAR COMPANY LLC - TWIN FALLS	ID	311313	Beet Sugar Manufacturing	706	1128
4367811	PUBLIC SERVICE CO - COMANCHE PLT	CO	221112	Fossil Fuel Electric Power	2140	1100
559811	J R SIMPLOT COMPANY-DON SIDING POCATELLO	ID	325312	Phosphatic Fertilizer Man	735	991
4930011	TOLK STATION	TX	22111	Electric Power Generatio	19225	968
8178611	Holcim (US) Inc.- Devil s Slide Plant	UT	32731	Cement Manufacturing	189	906
931611	THE AMALGAMATED SUGAR COMPANY LLC - NAMPA	ID	311313	Beet Sugar Manufacturing	1025	896

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WEP/AOI Next Steps (March 31, 2020)

- Transfer Interim WEP/AOI results to TSS/IWDW for two webpages
  - WRAP Technical Support System (TSS) where states and stakeholders can download data
  - WEP/AOI Webpage on IWDW describing the technical details of the WEP/AOI analysis time periods:
- Obtain 2028 disaggregated low-level source sector emissions for California from ARB
  - Process by SMOKE and merged with corresponding source sector with other WRAP states
- Re-run WEP/AOI scripts with all source sectors and transfer results to TSS/IWDW

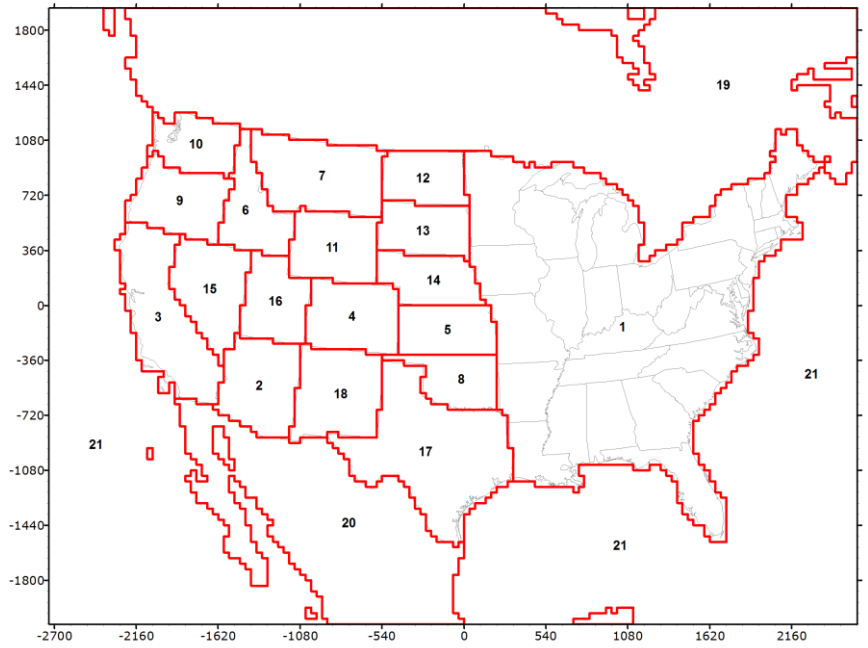
2028 Source Apportionment Run Specification Sheet

2028 Source Apportionment Run Specification Sheet (1 of 2)

- Want to obtain consistent source contributions as the RepBase Source Apportionment Run so can compare Current (2014-2018) to Future (2028) year source contributions
  - U.S. vs. International Anthropogenic emissions contributions
  - Three types of Fires (WF, Rx, Ag)
  - Natural Sources (Biogenic, LNOC, SSA, DMS, WBD, Mexico and Canada Fires)
- Also obtain WRAP state anthropogenic emissions contribution by source sector
- Purpose:
  - Estimate contributions of international and U.S. anthropogenic emissions to visibility impairment and ozone under 2028OTBa conditions.
  - Estimate contribution of contiguous WRAP region states' anthropogenic emissions to visibility impairment at Class I Areas (CIAs).
  - Estimate contribution of contiguous WRAP region states' anthropogenic emissions to ozone at rural and CIAs' monitoring sites
  - Estimate WRAP state-specific source sector contributions to visibility impairment at CIAs for key source sectors that may be considered for reasonable progress controls.

2028 Source Apportionment Modeling (2 of 2)

- PM (PSAT) and Ozone (APCA) source apportionment tools ion CAMx
  - Obtain SO4, NO3/NH4 and primary PM PSAT source apportionment results
  - PSAT not used for SOA, use standard model output to obtain anthro vs. bio SOA
- Boundary Conditions (BCs) stratified by International Anthropogenic, U.S. Anthropogenic and Natural
- Separate source apportionment for domain-wide Natural and 3 types of U.S. fires (WF, Rx, Ag)
- 13 WRAP states contributions:
  - EGU Point
  - Non-EGU Point
  - Oil and Gas
  - On-Road plus Non-Road Mobile
    - Includes locomotive, airports and CMV
  - Remainder Anthropogenic
    - Non-Point, RWC, fugitive dust, ammonia



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Next Steps in WRAP Regional Modeling (Mar 31, 2020)

- Upload Interim WEP/AOI products to TSS/IWDW
- Start CAMx RepBase Source Apportionment simulation
- Start CAMx 2028OTBa (w/ RepBase fires)
- Finishing 2002 emissions development for Dynamic Evaluation
  - Then start CAMx 2002 36/12-km simulation
- Comments on 2028 Visibility Projection White Paper
- Webpages documentation on IWDW
  - 2014v2 Model Performance Evaluation
  - WEP/AOI Analysis technical description
- Comments on 2028 Source Apportionment Run Specification Sheet
- Process California 2028 disaggregated emissions prepared by ARB
  - Then set-up 2028OTBa source apportionment run

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