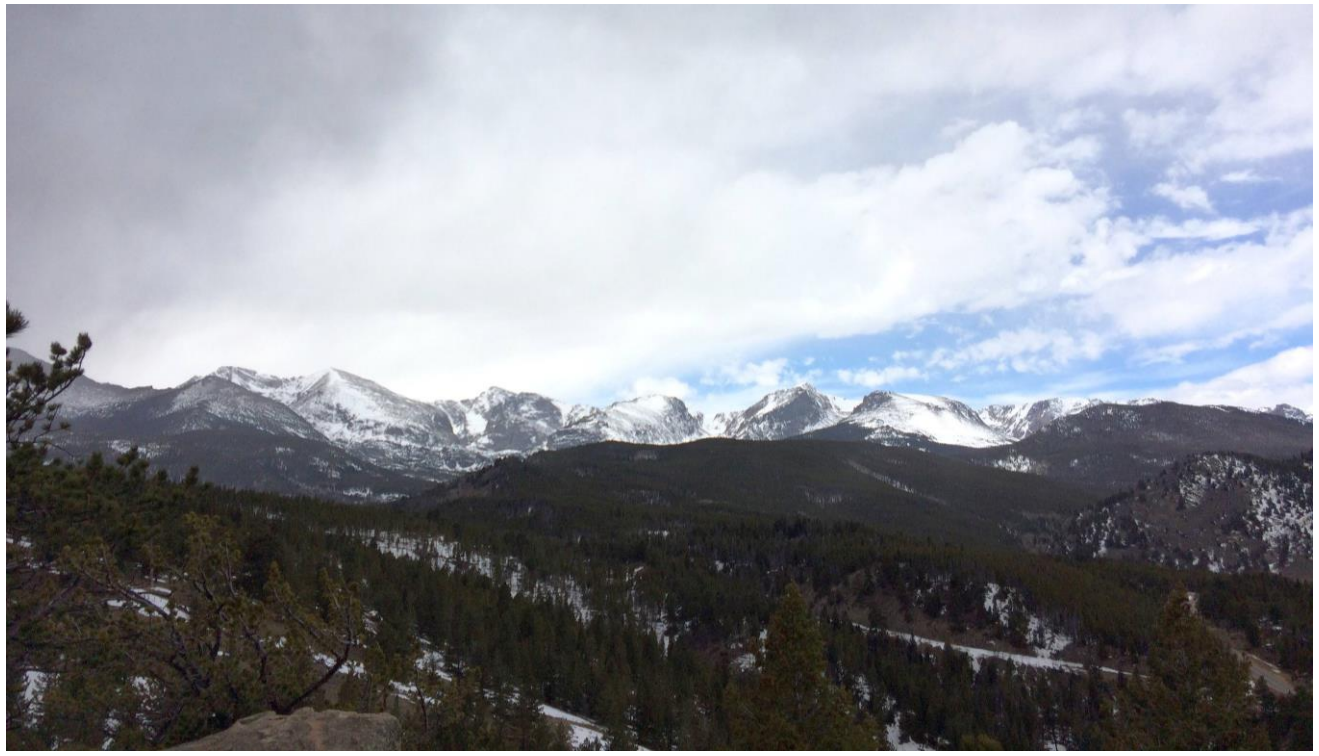
Western Regional Modeling and Analysis Platform

2014 Modeling Update



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

WRAP RTOWG Webinar

February 26, 2020

RAMBOLL

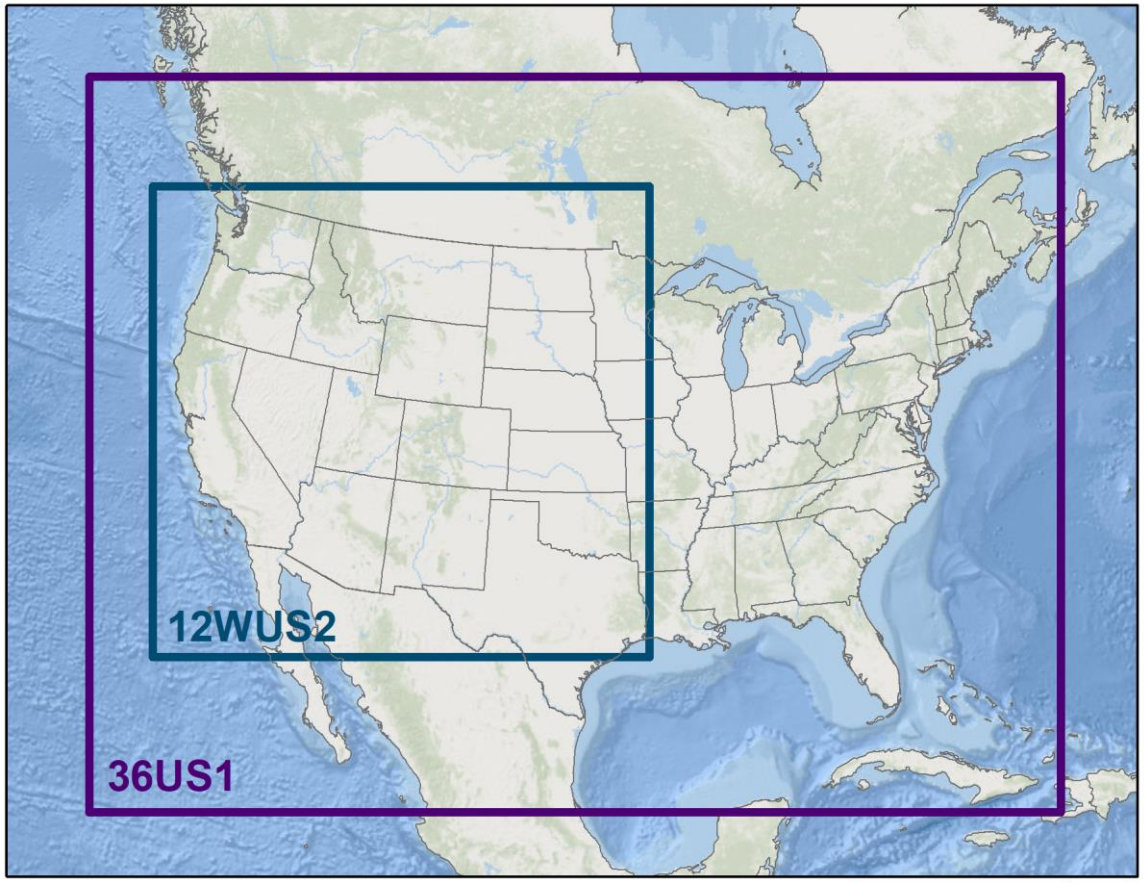
Today's Content – WRAP 2014 Modeling

- Last RTOWG webinar Jan 22, 2020 on CAMx 2014v2 MPE
- Today (Feb 26, 2020) RTOWG will discuss the following:
  - Compare CAMx 2014v2 and Representative Baseline Modeling Results
    - In particular for IMPROVE 2014 Most Impaired Days (MID)
  - Weighted Emissions Potential/Area of Influence (WEP/AOI)
    - Completed through Residence Time analysis, need 2028 EI for WEP
  - 2028 Emissions and Modeling Update
    - Preliminary 2028 Emissions
  - Run Specification Sheets
    - Natural (NAT) and No International (ZROW) GEOS-Chem/CAMx
    - RepBase Source Apportionment Modeling (NAT/ANT & U.S./Intl)
    - RepBase and 2028 On-the-Books (2028OTB) Modeling
    - Dynamic Evaluation CAMx 2002 Modeling
    - WEP/AOI Analysis

RAMBOLL

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
  - 2028 Visibility Projections
  - Source Apportionment
- Dynamic Evaluation
  - 2002 Emissions



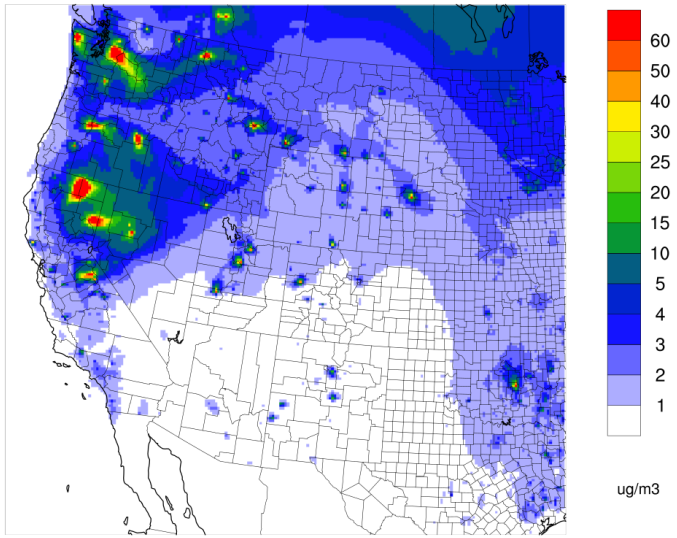
Representative Baseline vs. 2014v2 Comparison

- 2014v2 uses actual 2014 emissions
- Representative Baseline (RepBase) represents emissions from the 2014-2018 5-year planning period
  - Biggest difference are use of FSWG RepBase fires instead of 2014v2 actual fires
  - Details in RepBase & 2028OTB Run Specification Sheet
- Compare spatial maps of 2014v2 and RepBase concentrations and their differences
- Comparison across the 2014 IMPROVE Most Impaired Days (MID)
  - IMPROVE MID uses a statistical technique to identify the 20% days most impaired by anthropogenic emissions by screening out natural events due to fires and windblown dust
  - The 2014 IMPROVE MID are used to develop RRFs for projecting 2014-2018 IMPROVE MID to 2028 using the RepBase/2028OTBa and 2014v2/2028OTBb CAMx modeling results (EPA Guidance)
    - Any 2014v2 or RepBase modeled fire impacts on the 2014 MID will result in stiff RRFs and understate visibility improvements in 2028

RAMBOLL

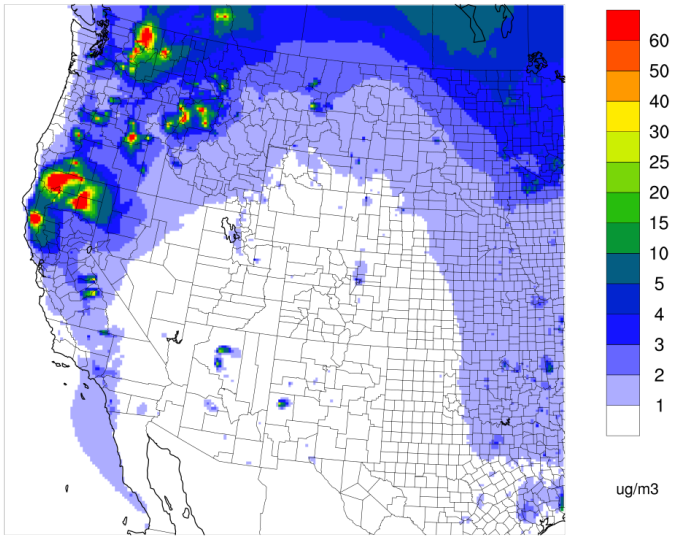
August Average Concentrations

Average Aug POA
WRAP_12km_RepBase



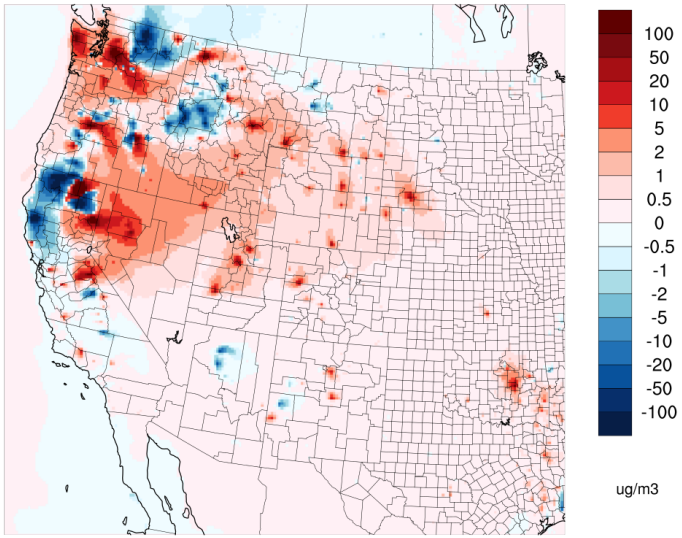
◇max(31,141) = 3750.1 ug/m3
○min(1,1) = 0.0 ug/m3

Average Aug POA
WRAP_12km_2014v2b



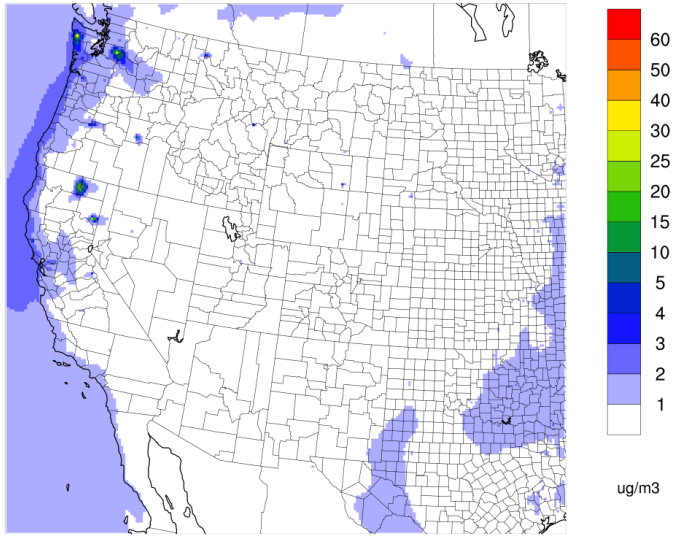
◇max(58,203) = 986.9 ug/m3
○min(1,1) = 0.0 ug/m3

Average Aug POA
WRAP_12km_RepBase_M_2014v2b



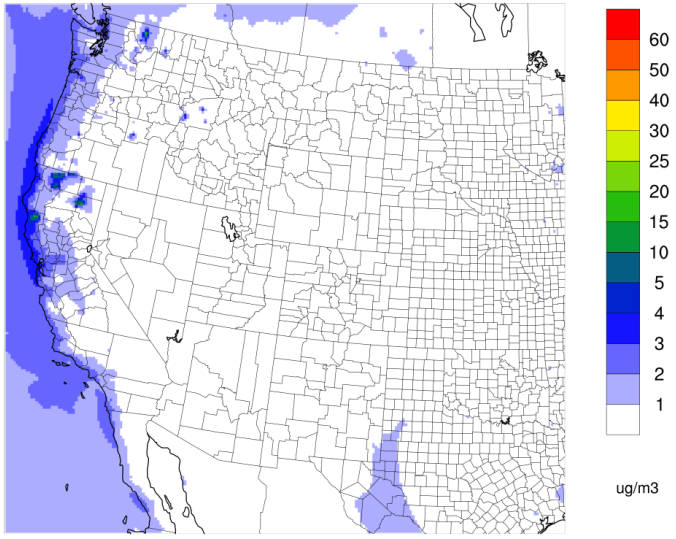
◇max(31,141) = 3739.4 ug/m3
○min(58,203) = -982.9 ug/m3

Average Aug PM25_PSO4
WRAP_12km_RepBase



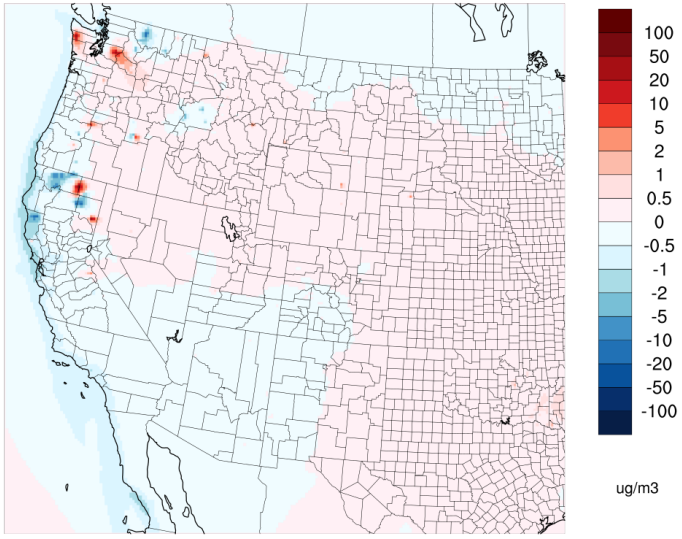
◇max(31,141) = 54.0 ug/m3
○min(1,1) = 0.0 ug/m3

Average Aug PM25_PSO4
WRAP_12km_2014v2b



◇max(58,203) = 18.8 ug/m3
○min(1,1) = 0.0 ug/m3

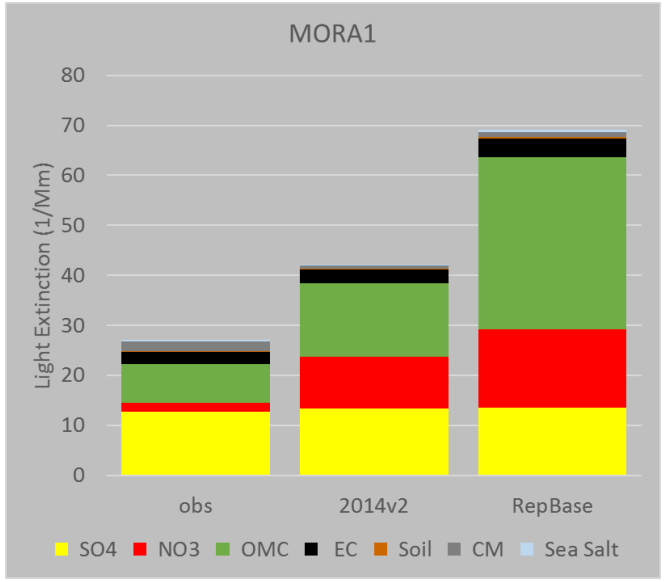
Average Aug PM25_PSO4
WRAP_12km_RepBase_M_2014v2b



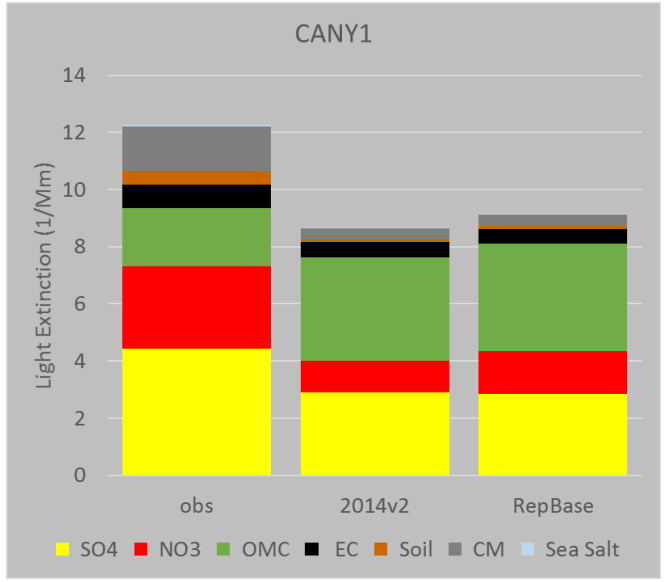
◇max(31,141) = 53.1 ug/m3
○min(58,203) = -18.1 ug/m3

2014 MID AVERAGE Extinction

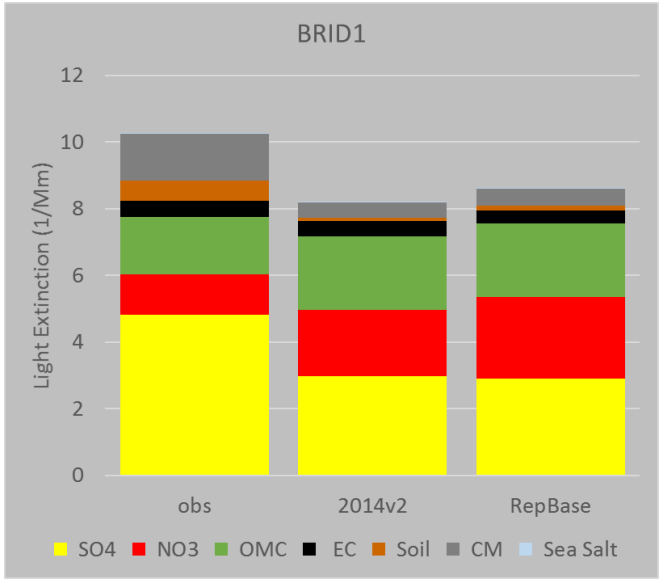
North West



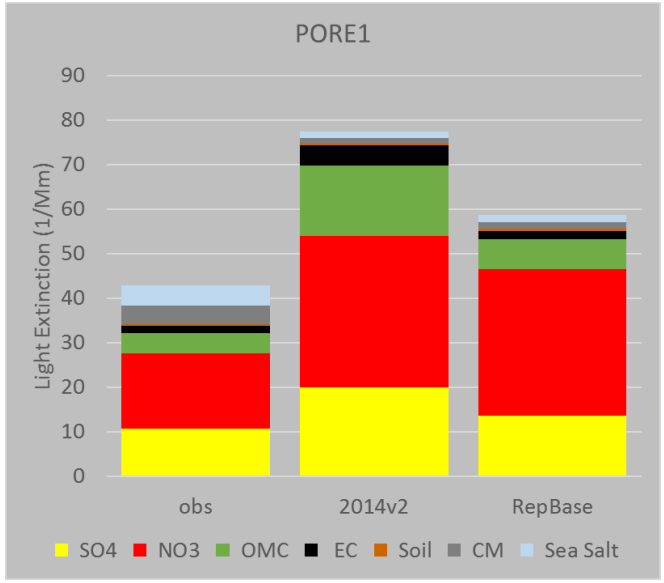
South West

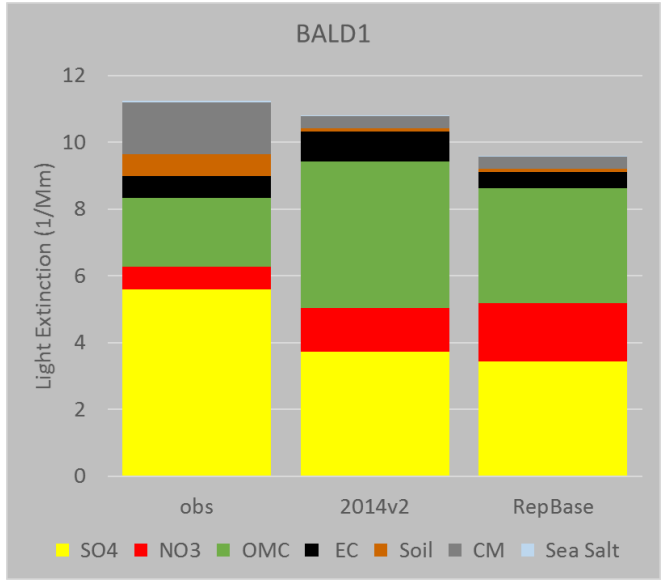


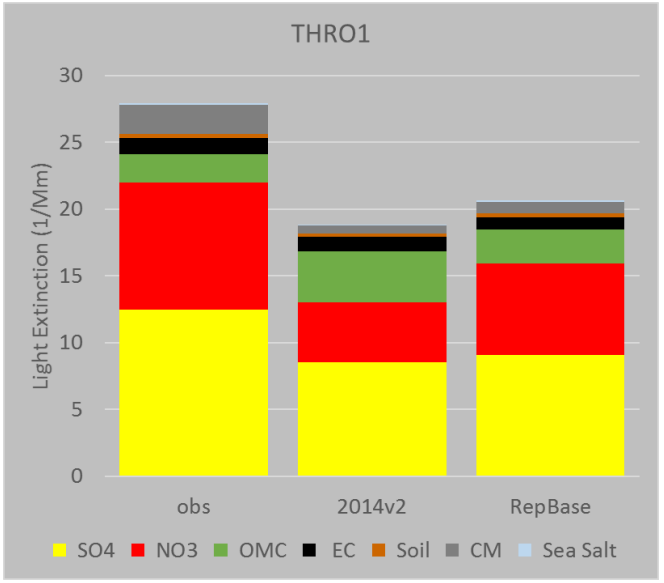
N Rockies Plains



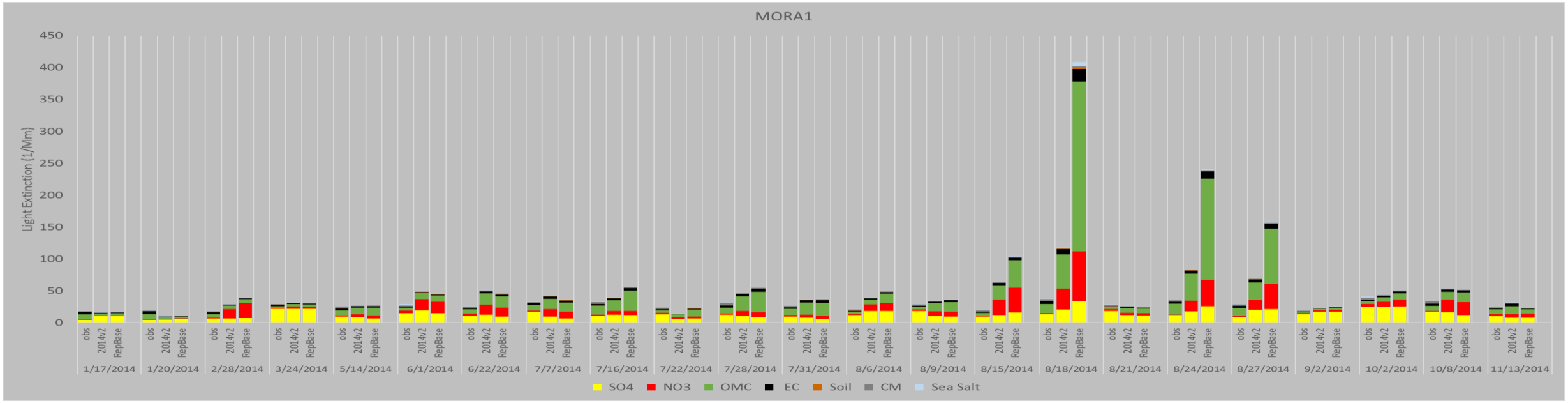
West

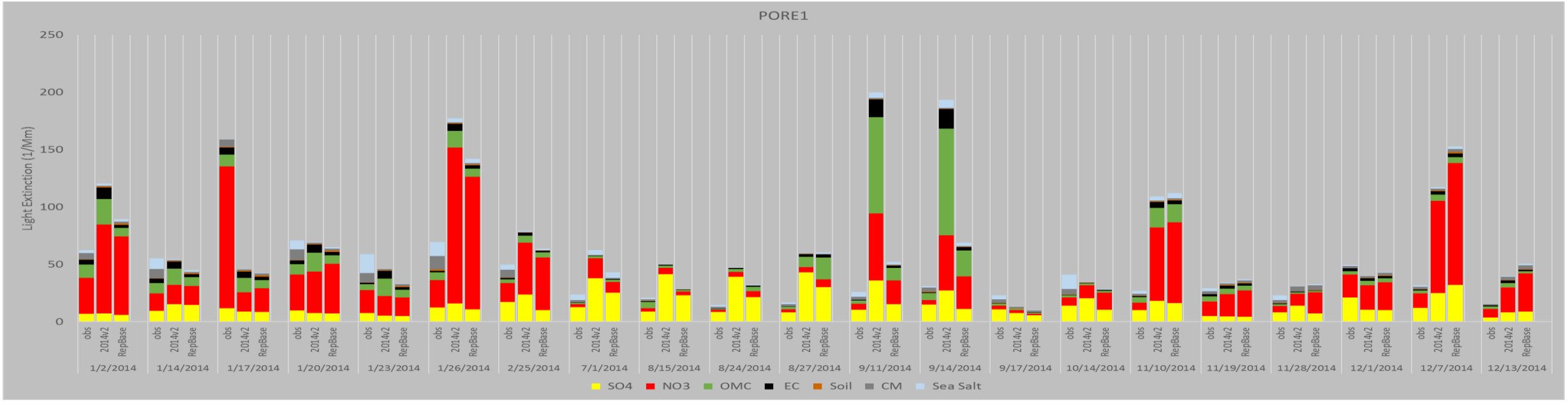




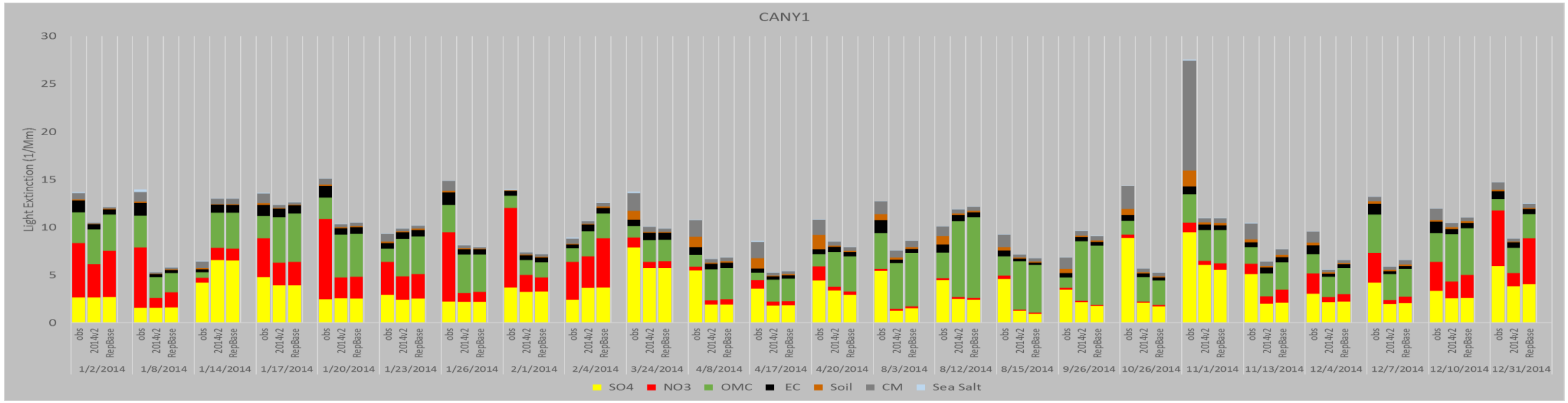


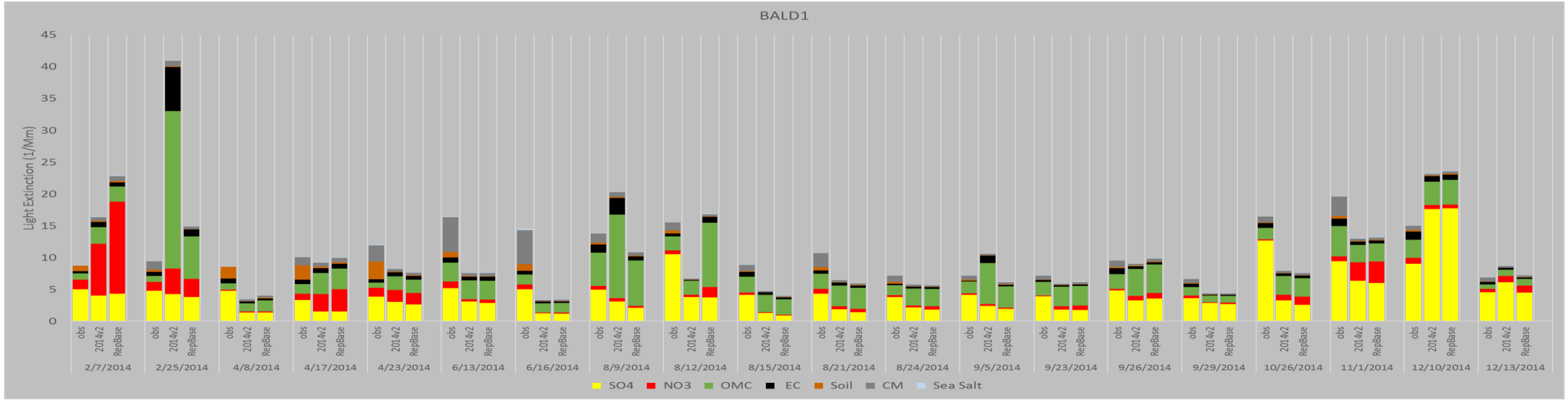
2014 MID DAILY Extinction: West COASTAL



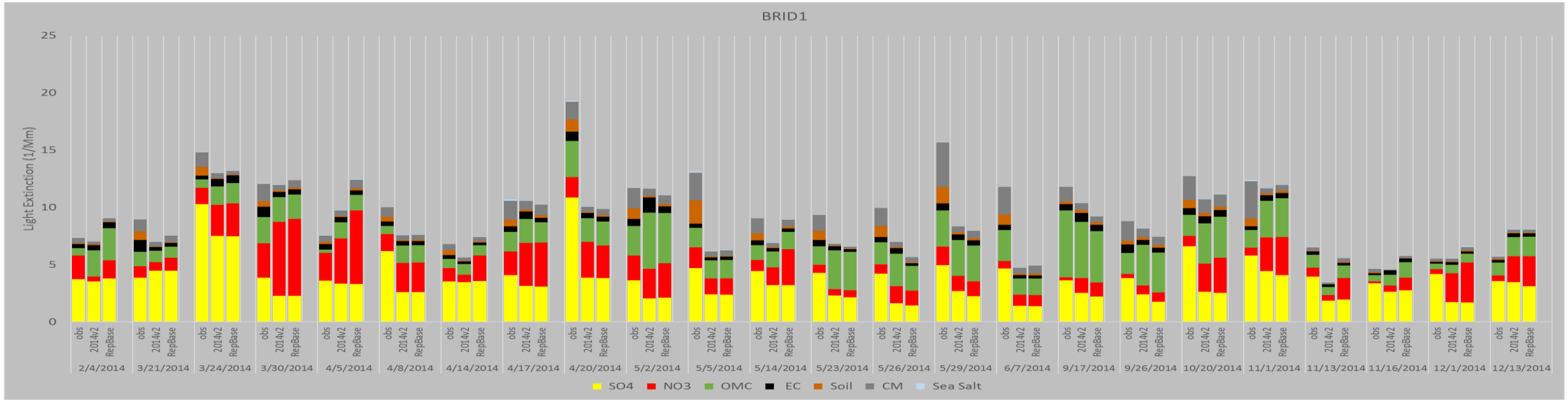


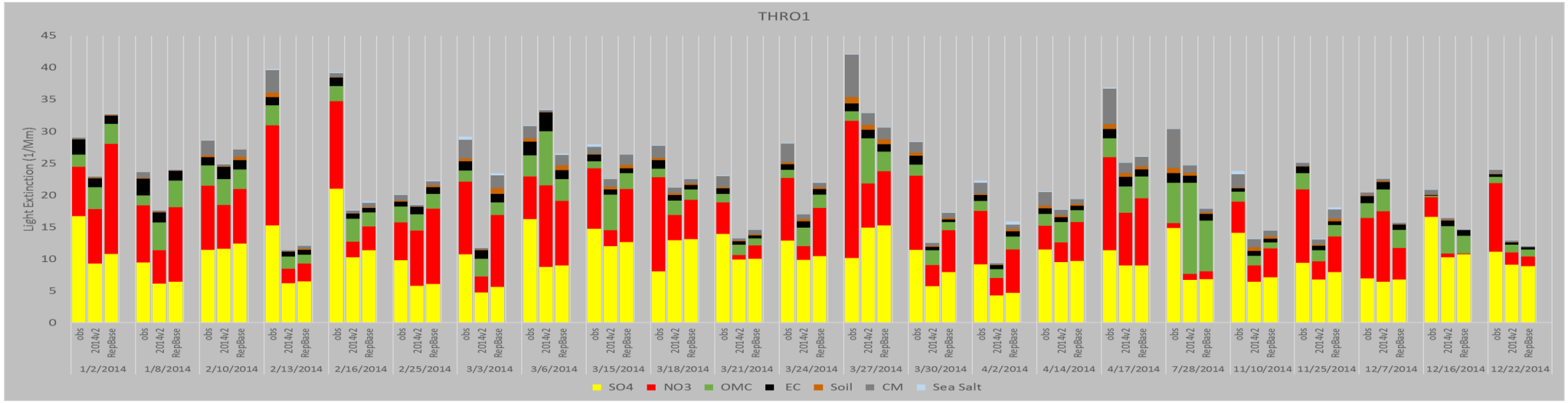
2014 MID DAILY Extinction: south West



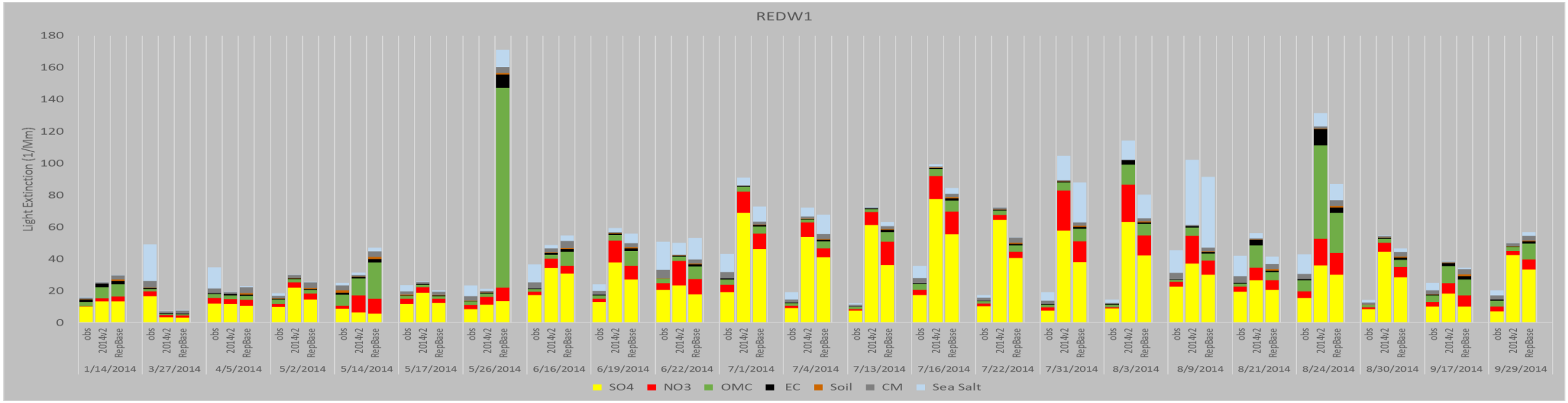


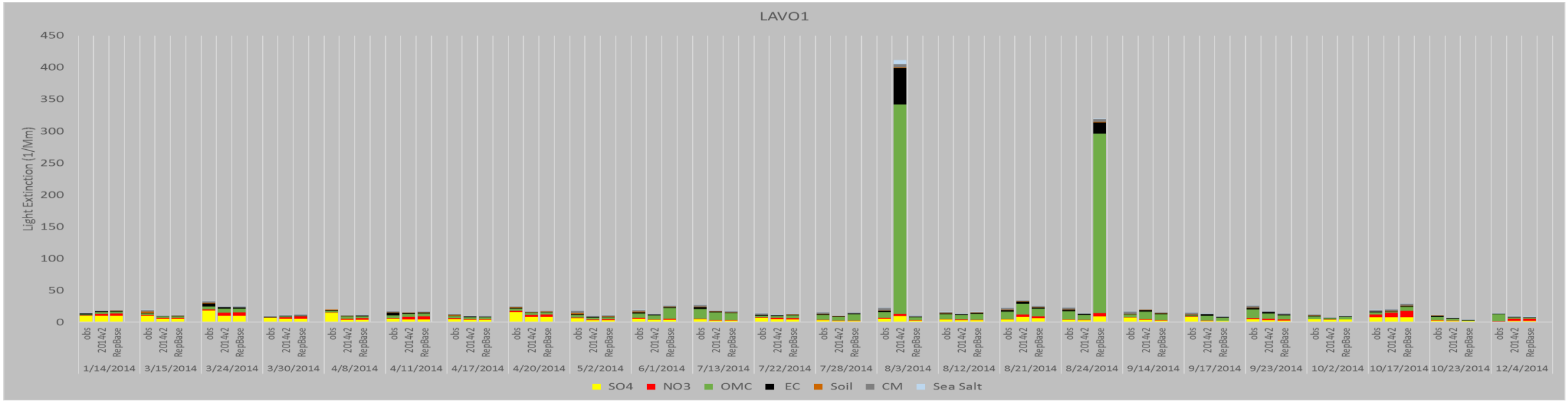
2014 MID DAILY Extinction: North Rockies Planes





2014 MID DAILY Extinction: west fire influence





Conclusions of RepBase vs. 2014v2 Comparison

- As expected, biggest difference between RepBase and 2014v2 is due to the differences in the RepBase and 2014v2 actual fire emissions
  - Most of the time, there are no fire impacts so differences are small
  - But when there are fire impacts, differences can be very large (OA & EC)
- Concerns have been raised about RepBase fire impacts on IMPROVE 2014 MID used in the RRFs to make 2028 visibility projections
  - Turns out there are days in IMPROVE 2014 MID that the 2014v2 CAMx simulation has fire impacts
- Propose to make 2028 visibility projections using RepBase & 2014v2 baes and 2028 modeling results using three types of RRFs:
  - Based on IMPROVE 2014 MID (EPA, 2018 guidance)
  - Using IMPROVE 2014 MID removing days with modeled fire impacts
  - Using RepBase modeling days with highest U.S. anthropogenic visibility contributions (i.e. modeled MID) [needs RepBase source apportionment simulation]

RAMBOLL

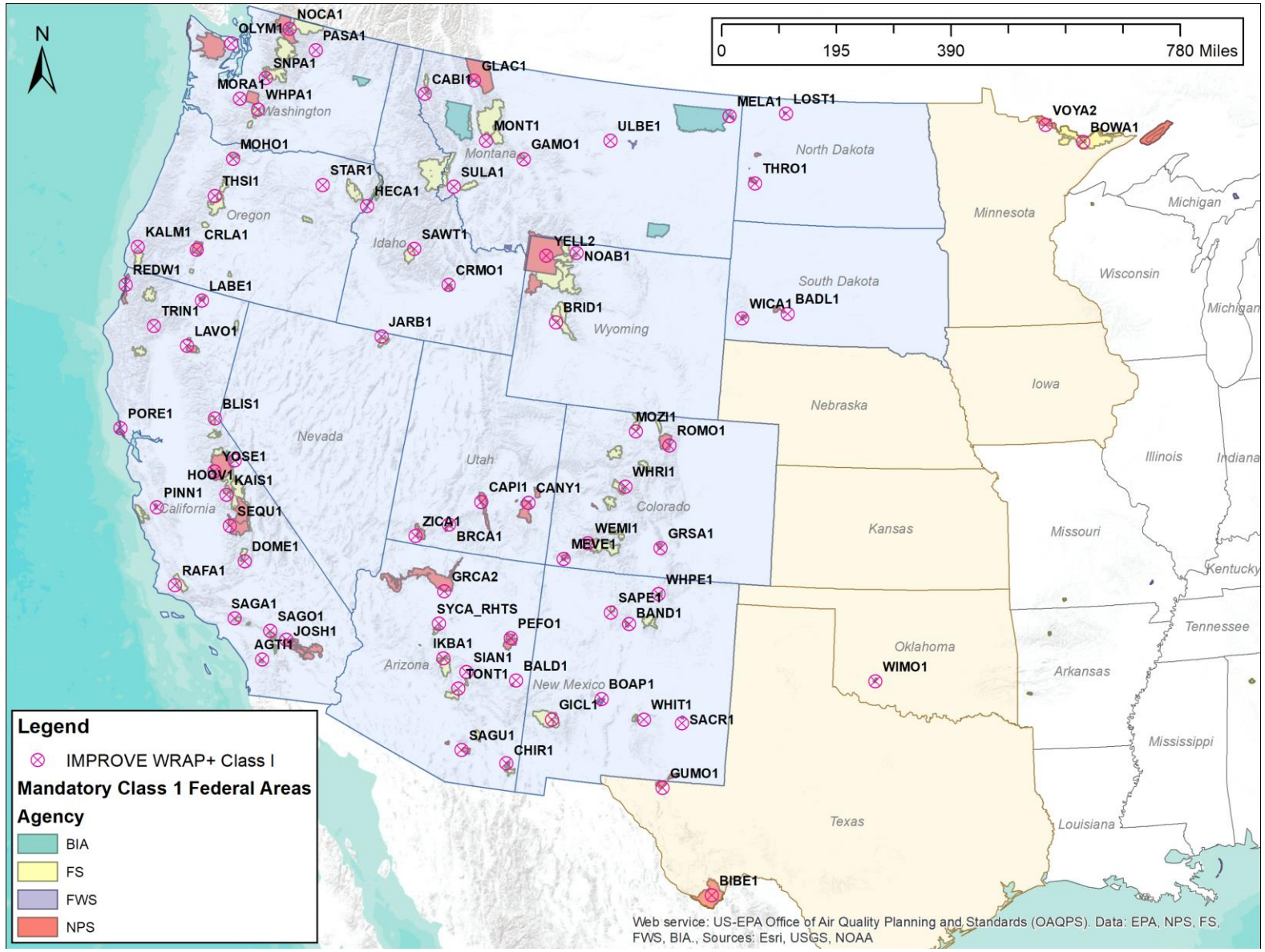
WEP/AOI Analysis -- Outline of Approach

1. Used latest (Dec 2019) IMPROVE 20% most impaired days (MIDs) for 2014-2018 at regional haze rule IMPROVE monitoring sites (~ 24 days per year)
2. Model back trajectories for each MID using HYSPLIT
3. Calculate residence times based on HYSPLIT back trajectories and estimate Area of Influence (AOI)
4. Overlay AOI with emissions sources to obtain Weighted Emissions Potential of source regions and point sources

Class I Areas

77 IMPROVE Sites representing:

- 111 Class I areas in WRAP states (blue)
- 6 Class I areas in neighboring states (orange)



RAMBOLL

Comparison of AOI/WEP Approach Compared to Q/d analysis and PGM modeling (from Dec 12, 2018 single-source visibility modeling webinar)

- Advantages:
  - Accounts for geography and transport paths to CIA on MIDs
  - Can use extinction weighting
  - Significantly less costly than PGM modeling

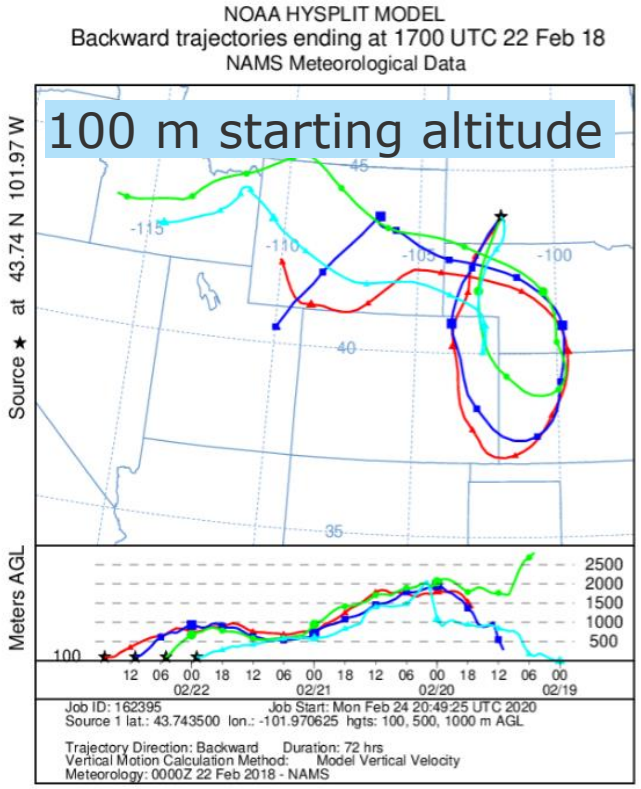
- Disadvantages:
  - Uncertainties in HYSPLIT back trajectories
  - Does not account for chemical transformation
  - Difficult to compare rankings across different CIAs
  - Not quantitative
  - No estimate of how visibility impairment would change based on emissions reductions
  - More costly than Q/d

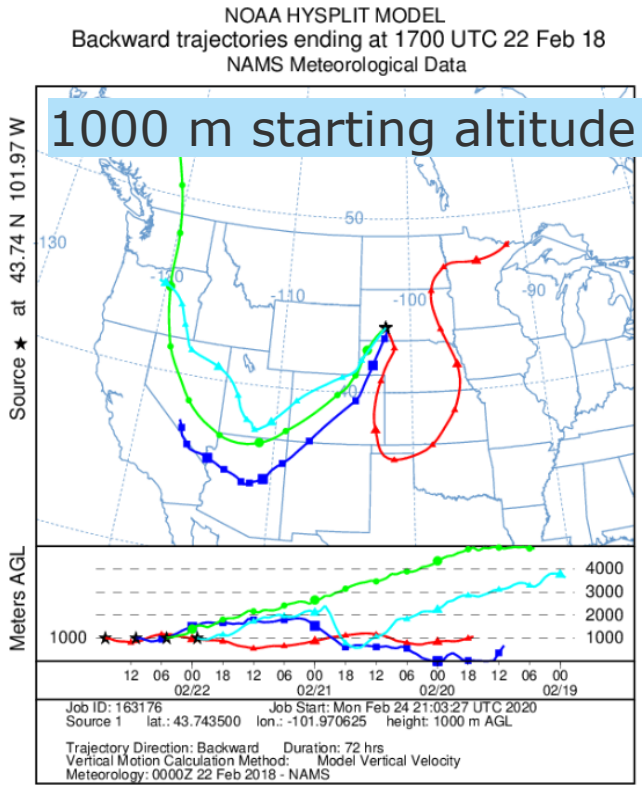
RAMBOLL

Back trajectories on 20% Most Impaired Days

HYSPLITv4 used to simulate back trajectories from IMPROVE monitors on 20% MIDs

- Four ending times: 6:00, 12:00, 18:00, 24:00 LST
- Four ending elevations: 100, 200, 500, 1,000 m
- Endpoints output every 10 minutes
- ~150,000 total 72-hour back trajectories
- ~600,000 endpoints per IMPROVE monitor



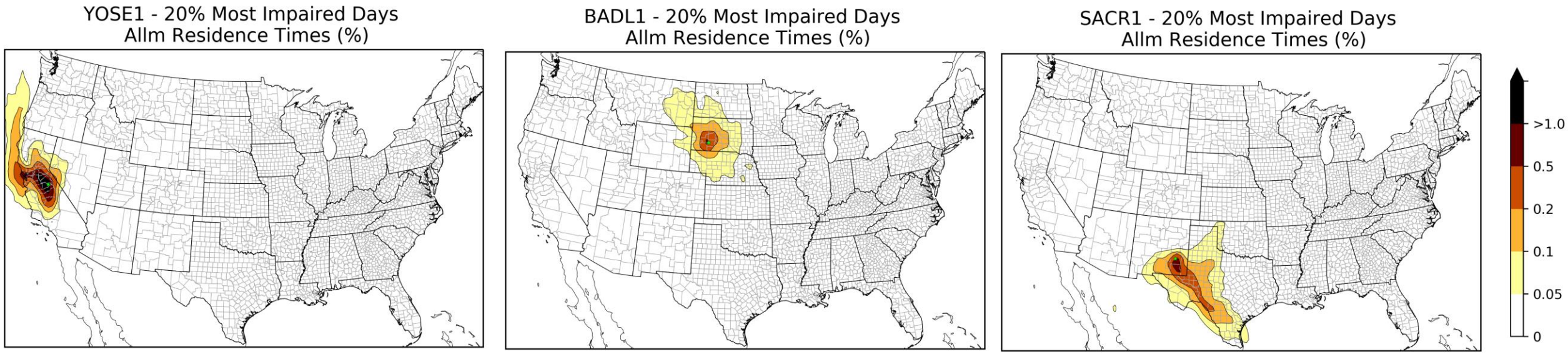


Badlands

RAMBOLL

Residence Time Analysis

- Residence Time Analysis (τ_{ij}): $$\tau_{ij} = \frac{1}{NT}\sum_{k=1}^{N}\tau_{ijk}$$ where τ_{ijk} is the residence time of the kth trajectory at the grid cell (i, j)
  - Calculated using grid cells of the 36US modeling domain at 36 km resolution
  - Provided for both separately for each ending elevation and also aggregated across all
  - Plotted as percentage of total across all grid cells



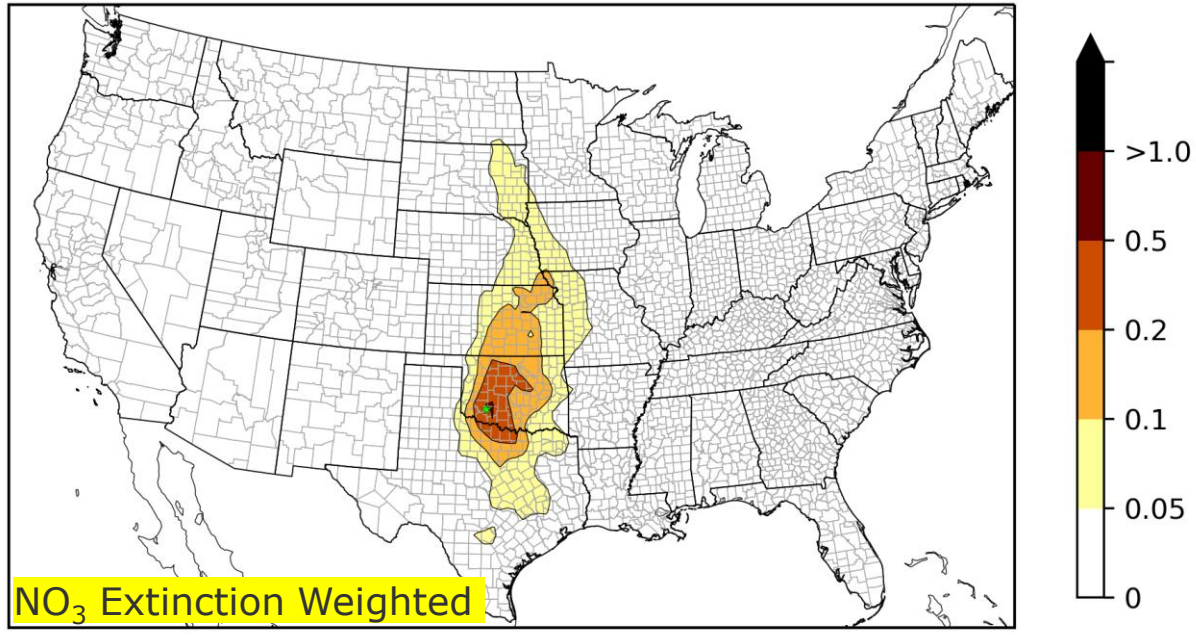
RAMBOLL

Extinction Weighted Residence Time (EWRT)

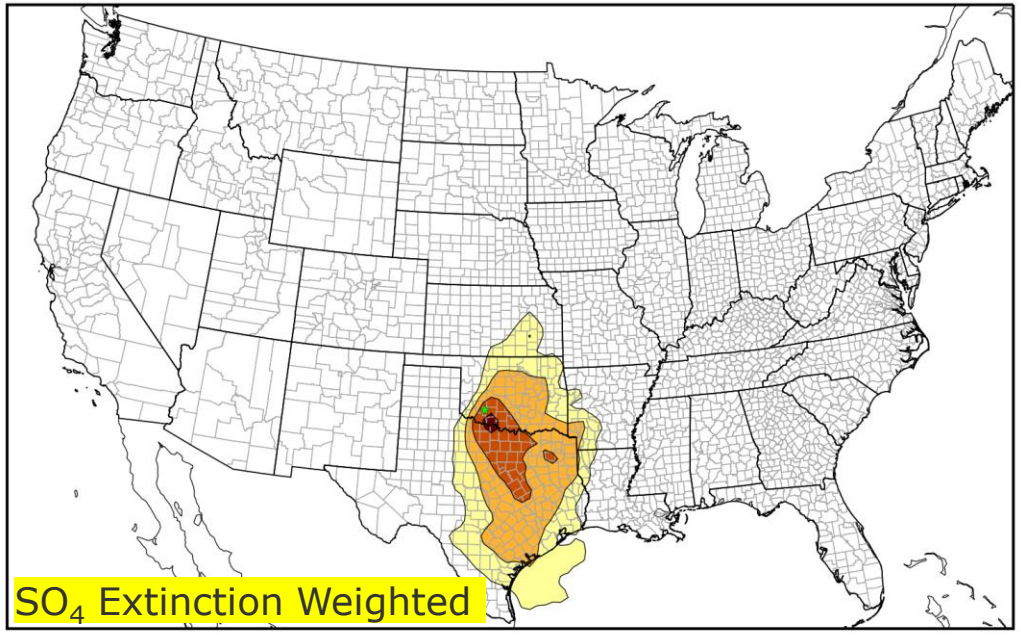
$$EWRT_{ij} = \sum_{k=1}^{N} b_{ext_k} \tau_{ijk} \P$$

- Weight the Residence Time by the Sulfate, Nitrate, Elemental Carbon, Organic Carbon Extinctions (b_{ext}) for each MID
- Trajectories corresponding to greatest visibility impairment have the most influence on the AOI
- May indicate different AOIs for different visibility impairing pollutants

WIMO1 - 20% Most Impaired Days
Allm NO3 Extinction Weighted Residence Times (%)



WIMO1 - 20% Most Impaired Days
Allm SO4 Extinction Weighted Residence Times (%)

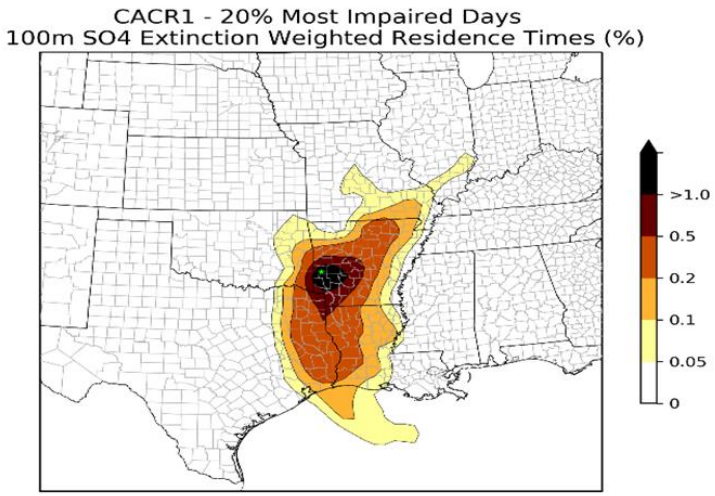


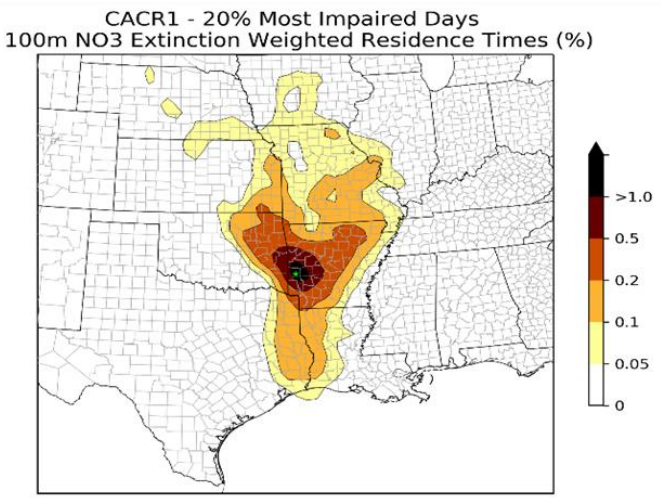
WEP/AOI Next Steps

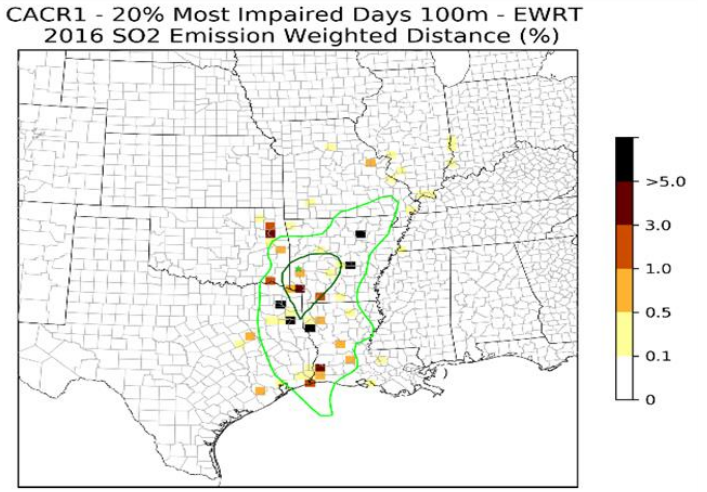
- **Weighted Emissions Potential** (WEP): $\frac{Q_{ij}}{d_{ij}} EWRT_{ij}$

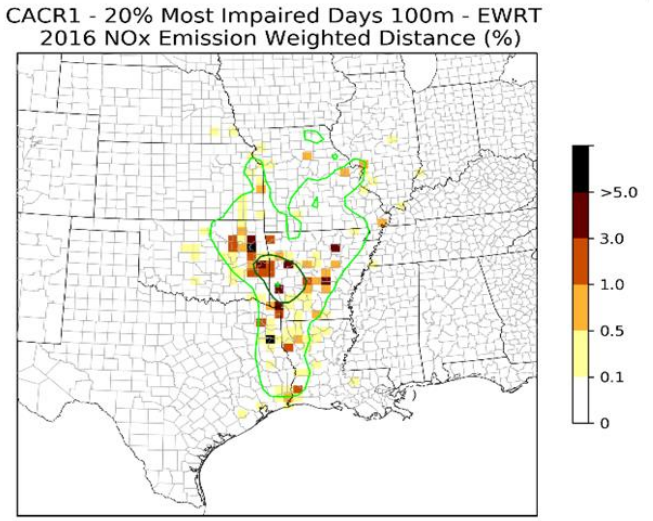
  where Q_{ij} is the Emissions in cell (i,j)

- For each SO_2 (NOx, EC, OC) source, weigh the SO_4 (NO3, EC, OC) $EWRT_{ij}$ by SO_2 (NOx, EC, OC) emissions divided by distance
- Need 2028 OTB Emissions
- Example plots from CenSARA since 2028 WRAP emissions are still in development









RAMBOLL

WEP/AOI Next Steps

- Calculate Weighted Emissions Potential to rank source regions and when the 2028 emissions are ready
- Rank 2028 point emissions sources for each IMPROVE site
- Generate various combinations of plots of RT, EWRT, WEP, etc. for each IMPROVE site to CSU for incorporating in WRAP TSS for regional haze planners

2028 Future Emissions Data Sources

Table 1. Source of emissions for the 12-km 12WUS2 domain and the WRAP current Representative Baseline (RepBase) and 2028OTBa emission scenarios.

Source Sector	RepBase	2028 OTB	2028 SMOKE Required
California All Sectors 12WUS2	CARB-2014v2	CARB-2028	Yes-UNC (T4.1)
WRAP Fossil EGU w/ CEM	WRAP-RB-EGU	WRAP-2028-EGU[1]	Yes-Ramboll (T4.2)
WRAP Fossil EGU w/o CEM	WRAP-RB-EGU	WRAP-2028-EGU	Yes-Ramboll (T4.2)
WRAP Non-Fossil EGU	EPA-2016v1	EPA-2028v1	Yes-Ramboll (T4.2)
Non-WRAP EGU	EPA-2016v1	EPA-2028v1	No (EPA Platform)
O&G WRAP O&G States	WRAP-RB-O&G	WRAP-2028-O&G	Yes-UNC (T4.3)
O&G WRAP Other States	EPA-2016v1	EPA-2028v1	Yes-UNC (T4.3)
O&G non-WRAP States	EPA-2016v1	EPA-2028v1	Yes-UNC (T4.3)
WRAP Non-EGU Point[2]	WRAP-2014v2	EPA-2028v1	Yes-Ramboll
Non-WRAP non-EGU Point	EPA-2016v1	EPA-2028v1	Yes-Ramboll
On-Road Mobile 12WUS2	WRAP-2014v2	WRAP-2028-Mobile	No (WRAP MS study)
On-Road Mobile 36US	EPA-2016v1[4]	EPA-2028v1[4]	No (EPA Platform)
Non-Road 12WUS2	EPA-2016v1	WRAP-2028-Mobile	No (WRAP MS study)
Non-Road non-WRAP 36US	EPA-2016v1	EPA-2028v1	No
Other (Non-Point) 12WUS2	EPA-2016v1	EPA-2028v1	Yes-UNC (T4.5)
Can/Mex/Offshore 12WUS2	EPA-2016v1	EPA-2028v1	Yes-UNC (T4.6)
Fires (WF, Rx, Ag)[3]	WRAP-RB-Fires	WRAP-RB-Fires[3]	No (already processed)
Natural (Bio, etc.)	WRAP-2014v2	WRAP-2014v2	No (2014v2)
Boundary Conditions (BCs)	WRAP-2014-GEOS[5]	WRAP-2014-GEOS[5]	Hold BCs Constant?

1. WRAP-EB-EGU and WRAP-2028-EGU has updates from WRAP states.
2. WRAP-2014v2 Non-EGU Point has updates from WRAP states
3. A second 2018OTBb run will be made using 2014v2 actual fires

RAMBOLL

Emission Source Sectors

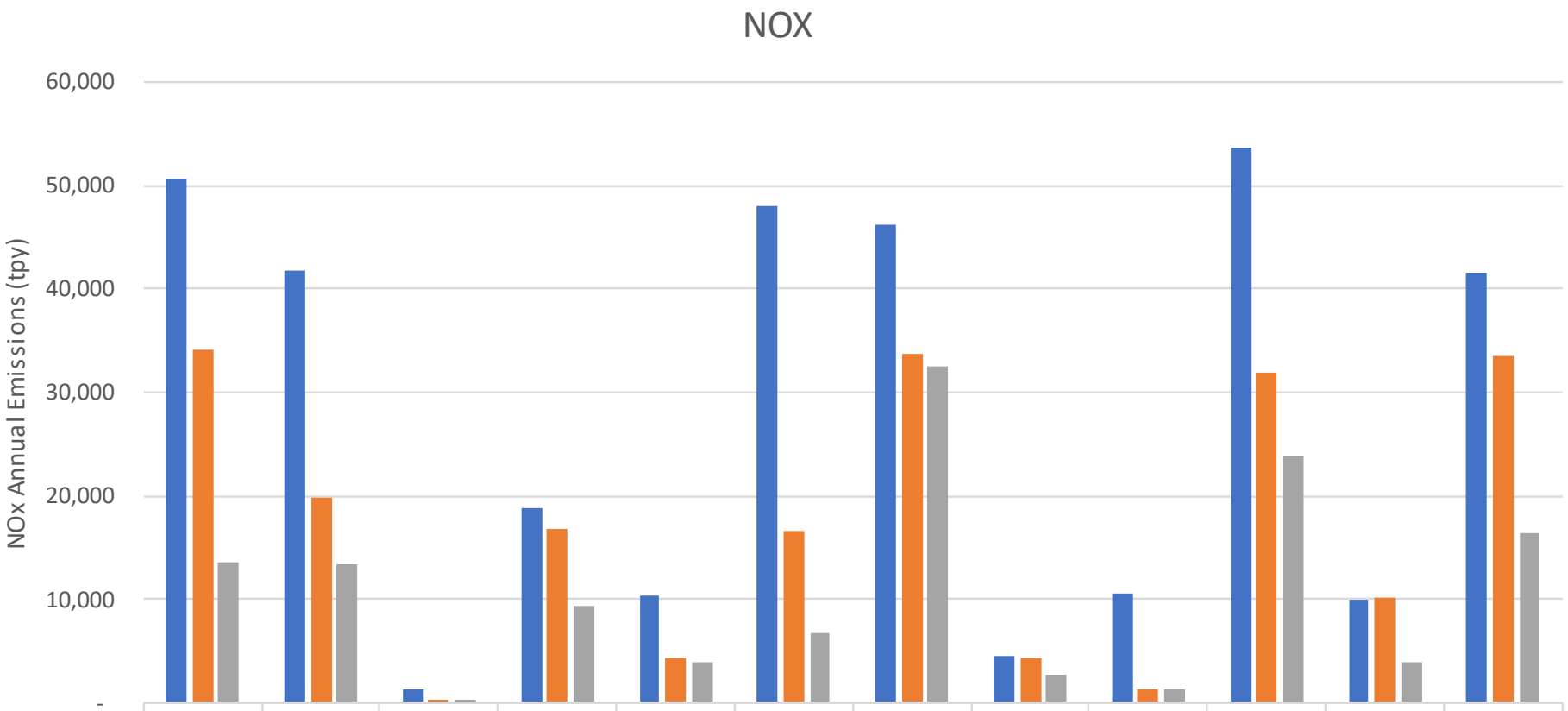
- Anthropogenic source sectors are different between 2014v2, RepBase and 2028OTB scenarios
  - 2014v2: 35 sectors
  - RepBase & 2028: 40 sectors
  - CA stand alone and mostly remain the same except new fixes in Road Dust emissions for RepBase and 2028OTB.
- Natural sources:
  - Fires: WRAP Fires; Different between 2014 actual fires vs. RepBase fires
  - Others (including MEGAN, LNOx, SeaSalt, and WBD): same between 2014v2, RepBase and 2028OTB

WRAP2014v2	WRAP RepBase	2028OTB	Combined Sector
afdust_wrapv2_adj	afdust_adj	afdust_adj	**afdust_adj**
ag_wrapv2	ag	ag	**ag**
cmv_c1c2_wrapv2	cmv_c1c2 (point only)	cmv_c1c2 (point only)	**CMV_c1c2c3**
cmv_c3 (point only)	cmv_c3 (point only)	cmv_c3 (point only)	
nonpt_wrapv2	nonpt	nonpt	**nonpt**
nonroad_wrapv2	nonroad	nonroad	**nonroad**
np_oilgas_wrapv2_only	np_oilgas	np_oilgas_wrap_only	**np_oilgas**
np_oilgas_wrapv2	np_oilgas_Nowrap	np_oilgas	
onroad	onroad	onroad	**onroad**
onroad_can	onroad_can	onroad_can	**Non-US**
onroad_mex	onroad_mex	onroad_mex	
othafdust_adj	othafdust_adj	othafdust_adj	
othar	othar	othar	
othpt (point only)	othpt (point only)	othpt (point only)	
	othptdust_adj	othptdust_adj	
ptegu_wrapv2	ptegu_nonwrap (point only)	ptegu_nonwrap (point only)	**ptegu**
	ptegu_wrap (point only)	ptegu_wrap	
	airport	airport	**ptnonipm**
ptnonipm_wrapv2	ptnonipm_nonwrap (area+point)	ptnonipm_nonwrap (area+point)	
	ptnonipm_wrap (area+point)	ptnonipm_wrap (area+point)	
pt_oilgas_wrapv2_only	pt_oilgas (area+point)	pt_oilgas_wrapv4_only	**pt_oilgas**
pt_oilgas_wrapv2	pt_oilgas_NOwrap (area+point)	pt_oilgas_wrapv4	
rail_wrapv2	rail	rail_wrapv4	**Rail**
rwc_wrapv2	rwc	rwc_wrapv4	**Rwc**
aircraft (area+point)	aircraft (same as base)	aircraft 2028 (area+point)	**CARB-aircraft**
Area	Area	Area 2028	**CARB-area**
FertNH3_gentpro	FertNH3_gentpro	FertNH3_gentpro 2028	**CARB-Ag**
LivestockNH3_gentpro	LivestockNH3-gentpro	LivestockNH3-gentpro 2028	
OGV_Area	OGV_Area (same as base)	OGV_Area 2028	**CARB-OGV**
OgvPorts (point only)	OgvPorts (same as base)	OgvPorts 2028 (point only)	
onroad	onroad	onroad 2028	**CARB-onroad**
Point (point)	Point (same as base)	Point 2028 (point)	**CARB-Point**
RoadDust_Paved	RoadDust_Paved	Roaddust_Paved 2028	**CARB-Roaddust**
RoadDust_Unpaved	RoadDust_Unpaved		
RWC	RWC	RWC 2028	**CARB-RWC**

RAMBOLL

2028 EGU Emissions

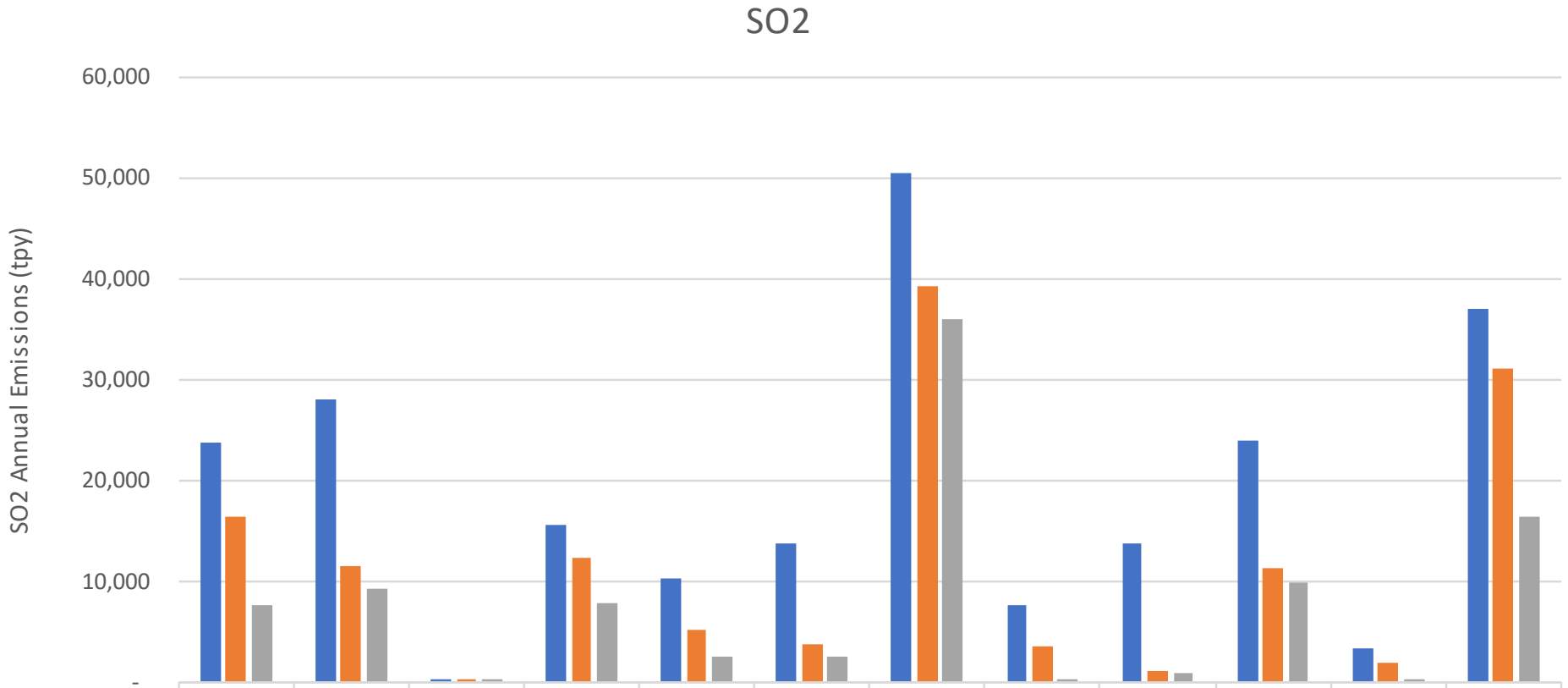
EGU State Level Emissions Comparison



	AZ	CO	ID	MT	NV	NM	ND	OR	SD	UT	WA	WY
2014v2	50,651	41,749	1,237	18,795	10,457	48,064	46,123	4,570	10,601	53,687	10,016	41,551
RepBase	34,109	19,851	265	16,703	4,331	16,635	33,705	4,399	1,219	31,875	10,081	33,540
2028OTB	13,533	13,354	265	9,433	3,891	6,670	32,509	2,634	1,348	23,843	3,886	16,352

RAMBOLL

EGU State Level Emissions Comparison



	AZ	CO	ID	MT	NV	NM	ND	OR	SD	UT	WA	WY
2014v2	23,675	28,025	51	15,664	10,254	13,785	50,556	7,546	13,855	23,989	3,338	36,926
RepBase	16,483	11,414	33	12,264	5,089	3,664	39,286	3,536	1,010	11,346	1,879	31,079
2028OTB	7,680	9,301	33	7,891	2,538	2,561	35,928	254	968	9,857	356	16,450

RAMBOLL

EGU UNIT-LEVEL EMISSIONS CHANGES BETWEEN 2014V2, REPBASE AND 2028OTB

Emissions in TPY

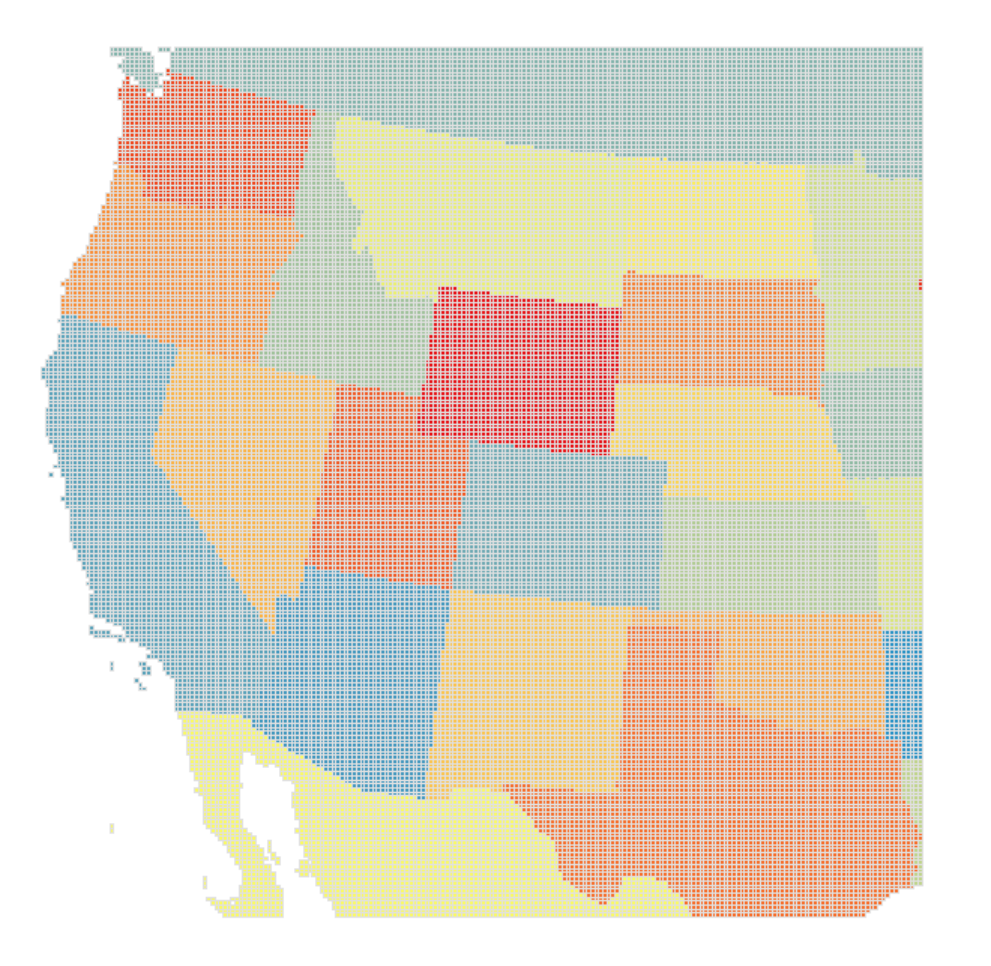
AZ, CO and NM

				2014v2		RepBase		2028OTB	
State	Facility Name	oris_id	Unit ID	SO2 (tor	NOx (to	SO2 (tor	NOx (t	SO2 (tor	NOx (t
AZ	Apache Station	160	3	2,774	3,228	143	872	-	-
AZ	Cholla	113	1	604	980	296	587	3	37
AZ	Cholla	113	3	657	2,094	557	1,406	8	103
AZ	Cholla	113	4	1,410	3,089	956	2,037	13	176
AZ	Coronado Generating Station	6177	U1B	475	4,949	68	2,804	132	687
AZ	Coronado Generating Station	6177	U2B	433	1,503	69	669	168	728
AZ	Navajo Generating Station	4941	1	1,760	5,547	1,545	4,524	-	-
AZ	Navajo Generating Station	4941	2	1,883	6,402	2,205	4,570	-	-
AZ	Navajo Generating Station	4941	3	2,023	5,942	1,714	4,716	-	-
AZ	Springerville Generating Statio	8223	1	2,811	2,407	3,407	2,185	2,417	1,792
AZ	Springerville Generating Statio	8223	2	1,564	1,967	3,432	2,405	2,686	2,192
AZ	Springerville Generating Statio	8223	4	1,022	978	931	956	926	911
AZ	Springerville Generating Statio	8223	TS3	1,060	1,108	1,044	1,086	963	963
CO	Comanche (470)	470	1	726	1,236	985	1,524	-	-
CO	Comanche (470)	470	2	972	2,089	1,091	2,021	-	-
CO	Comanche (470)	470	3	1,459	1,333	2,110	1,654	2,140	1,688
CO	Craig	6021	C1	799	3,768	501	3,679	-	-
CO	Craig	6021	C2	963	4,603	497	964	497	964
CO	Craig	6021	C3	2,001	5,368	1,183	2,034	1,183	2,034
CO	Hayden	525	H1	1,001	3,406	799	298	922	330
CO	Hayden	525	H2	1,226	2,656	915	350	944	383
CO	Martin Drake	492	6	1,272	608	65	471	80	565
CO	Martin Drake	492	7	1,902	924	86	823	107	997
CO	Nucla	527	1	931	764	121	130	-	-
CO	Pawnee	6248	1	5,508	1,690	1,868	1,113	1,949	1,130
CO	Rawhide Energy Station	6761	101	909	1,412	711	1,100	877	1,326
CO	Ray D Nixon	8219	1	3,315	1,734	408	915	530	1,180
NM	Escalante	87	1	732	2,579	880	2,442	-	-
NM	Four Corners Steam Elec Statio	2442	4	4,024	14,570	833	2,667	1,254	2,007
NM	Four Corners Steam Elec Statio	2442	5	4,012	11,903	679	2,098	1,283	2,053
NM	San Juan	2451	1	656	2,837	274	1,881	-	-
NM	San Juan	2451	4	1,616	5,215	972	4,522	-	-

RAMBOLL

Comparison of Anthropogenic Emissions

2014v2 & RepBASE vs. 2028OTB

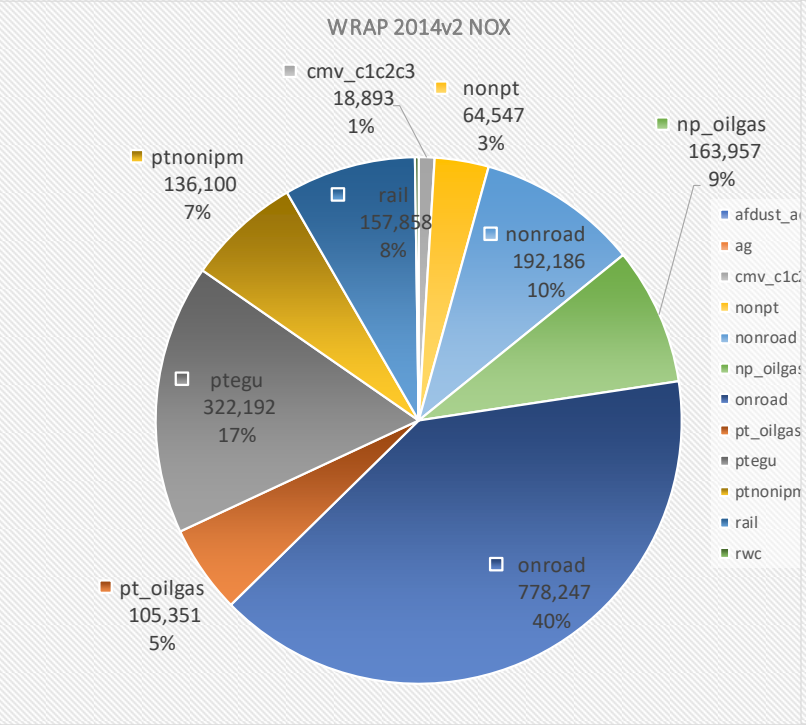


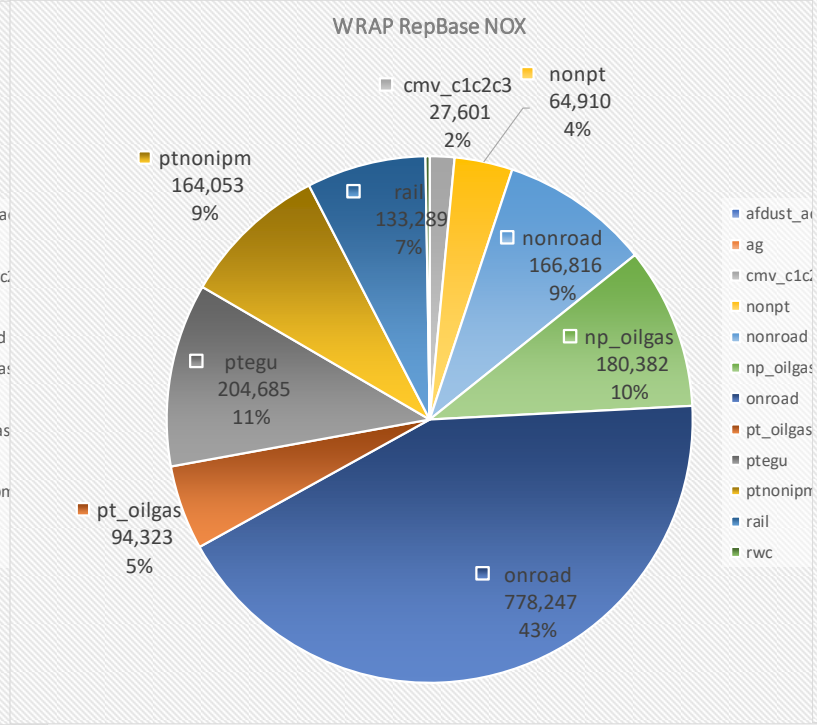
RAMBOLL

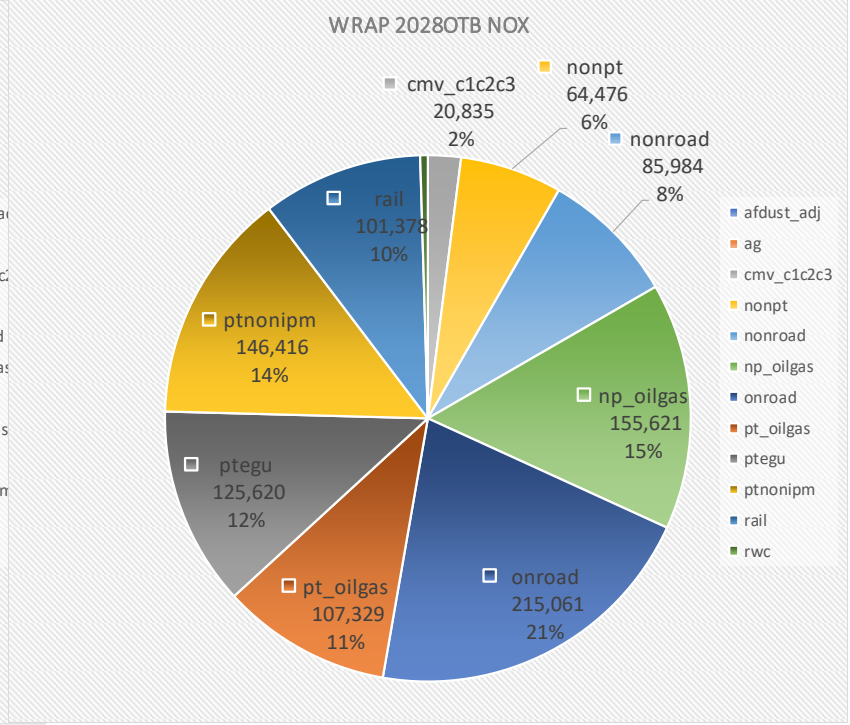
COMPARISON OF 2028 EMISSIONS WITH 2014V2/REPBASE

- Pie chart showing emissions comparison
- Display stacked bar chart by Pollutant, State and Source Sector

2028OTB vs. Repbase/2014v2 (anthro only)

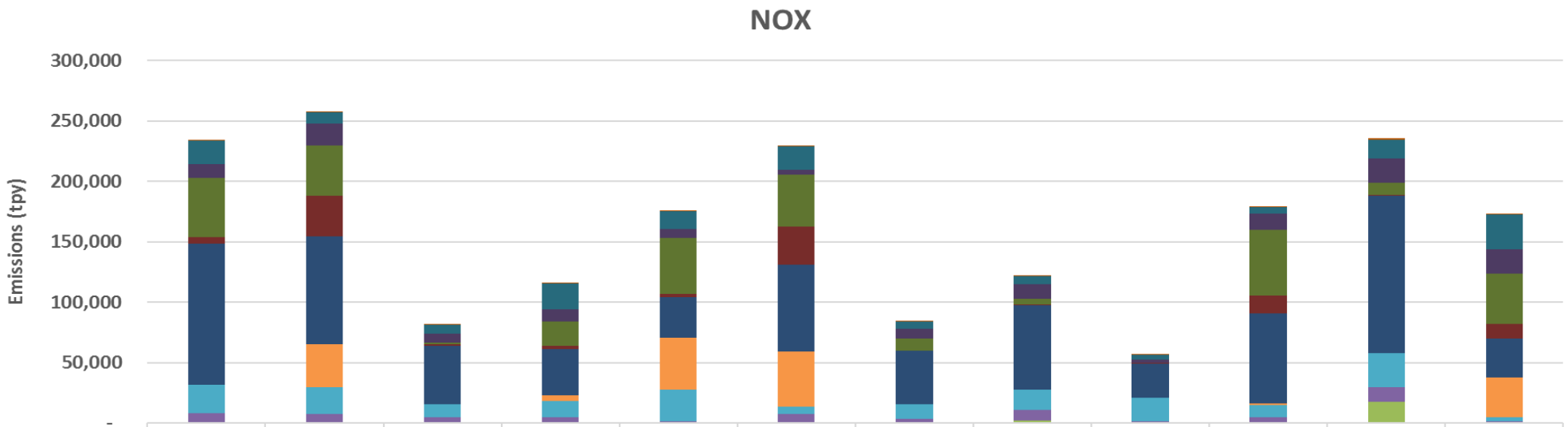




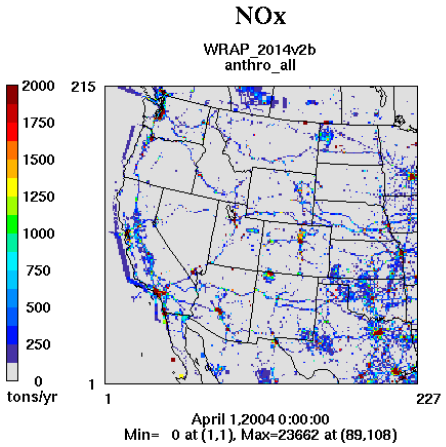


RAMBOLL

2014v2 Emissions by State AND sector

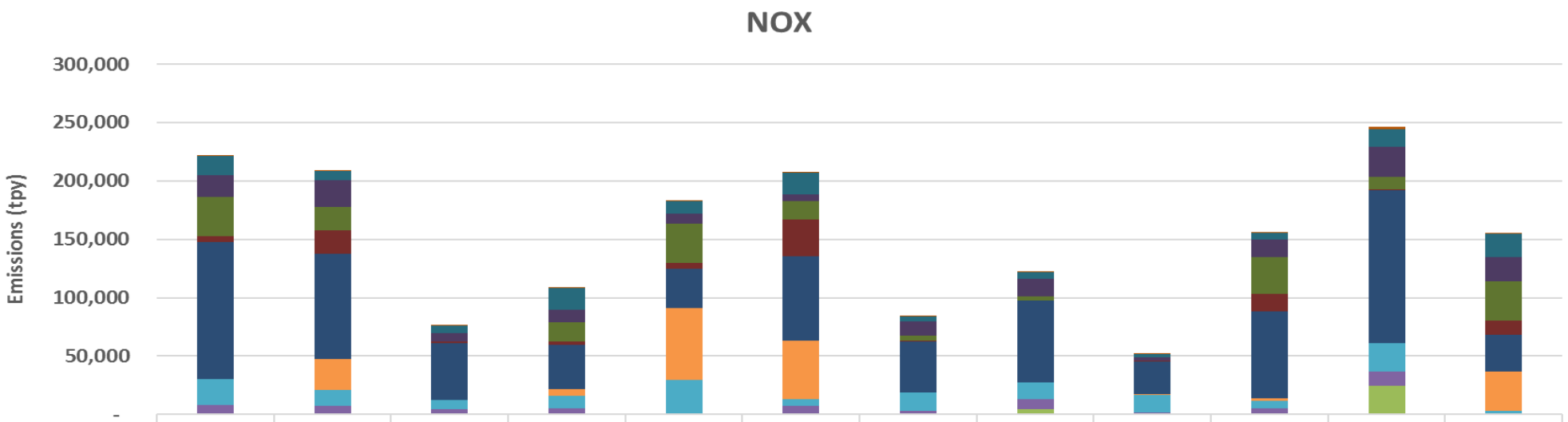


	AZ	CO	ID	MT	ND	NM	NV	OR	SD	UT	WA	WY
rwc	427	446	201	177	126	197	181	676	154	189	1,530	82
rail	19,285	9,833	7,429	21,312	14,758	19,766	5,742	6,485	3,794	5,646	15,202	28,606
ptnonipm	11,763	17,613	7,368	10,628	7,734	3,720	8,067	12,621	2,824	13,086	20,242	20,433
ptegu	48,757	41,596	1,360	19,885	46,410	43,071	10,123	4,697	87	54,497	10,023	41,686
pt_oilgas	5,221	33,694	1,198	2,820	2,702	31,437	269	421	435	14,636	445	12,073
onroad	117,227	89,776	48,314	38,220	33,305	72,203	44,052	69,994	27,996	74,643	130,504	32,017
np_oilgas	15	35,373	5	4,616	43,237	45,355	11	33	398	1,811		33,102
nonroad	23,521	22,355	10,885	13,174	26,182	6,078	12,295	16,759	19,294	9,669	28,412	3,576
nonpt	7,921	7,209	4,595	5,041	1,194	7,649	3,287	8,456	1,275	4,846	12,051	1,023
cmv_c1c2c3				0				2,125		1	17,288	
ag	-	-	-	-	-	-	-	-	-	-	-	-
afdust	-	-	-	-	-	-	-	-	-	-	-	-

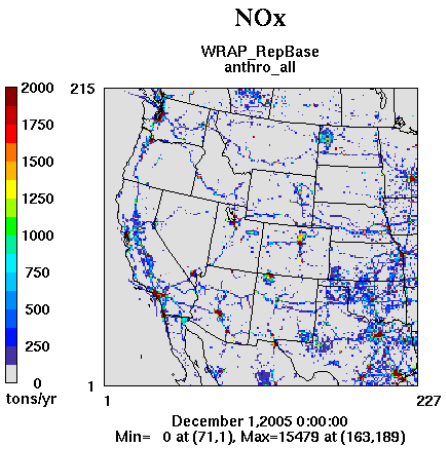


RAMBOLL

Repbase Emissions by State AND sector

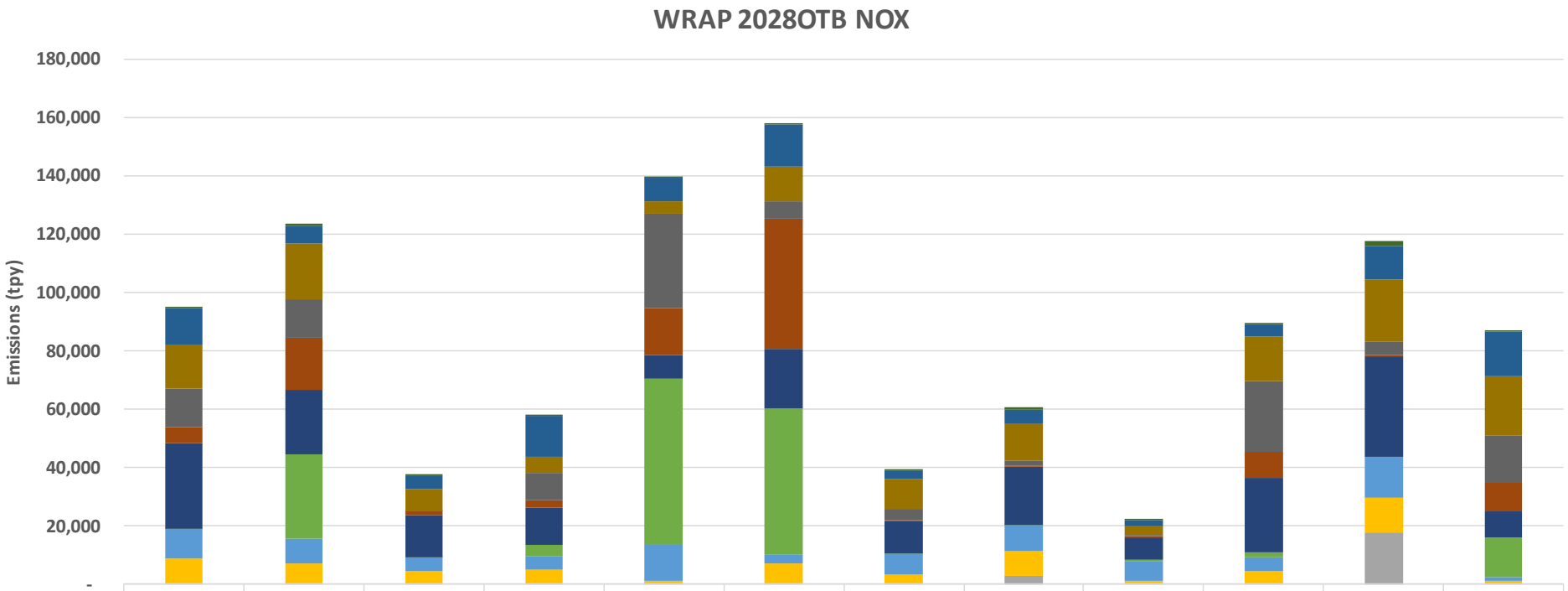


	AZ	CO	ID	MT	ND	NM	NV	OR	SD	UT	WA	WY
rwc	401	467	204	180	139	218	188	600	165	196	1,697	84
rail	16,963	7,924	6,334	18,448	10,720	19,252	4,351	5,897	2,780	5,263	15,002	20,356
ptnonipm	18,110	22,770	7,366	10,338	8,293	5,078	12,117	14,773	3,159	15,135	26,158	20,757
ptegu	33,817	20,155	269	16,592	33,472	16,218	4,280	3,612	165	31,879	10,926	33,320
pt_oilgas	5,263	20,152	1,405	2,820	5,187	31,199	215	424	435	14,611	754	11,857
onroad	117,226	89,776	48,314	38,220	33,305	72,203	44,052	69,994	27,996	74,643	130,504	32,017
np_oilgas	9	26,987	12	5,660	62,190	50,064	3	15	468	1,806		33,168
nonroad	21,986	13,463	7,805	10,868	28,060	5,717	15,451	14,142	15,506	7,029	24,523	2,281
nonpt	8,261	7,215	4,596	5,040	1,195	7,647	3,295	8,459	1,276	4,848	12,055	1,024
cmv_c1c2c3								4,761			24,707	
ag	-	-	-	-	-	-	-	-	-	-	-	-
afdust_adj	-	-	-	-	-	-	-	-	-	-	-	-



RAMBOLL

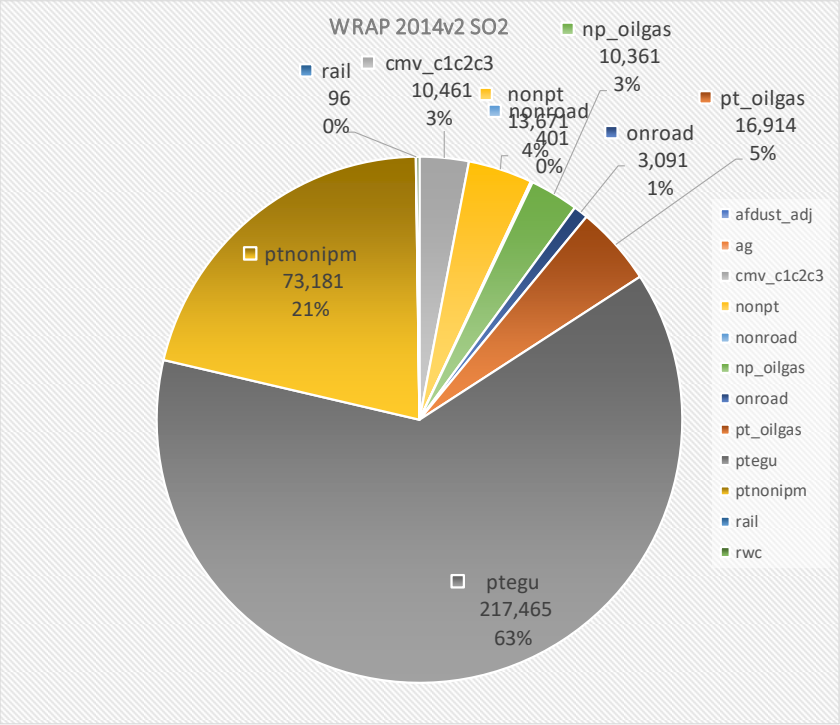
2028OTB Emissions by State AND sector

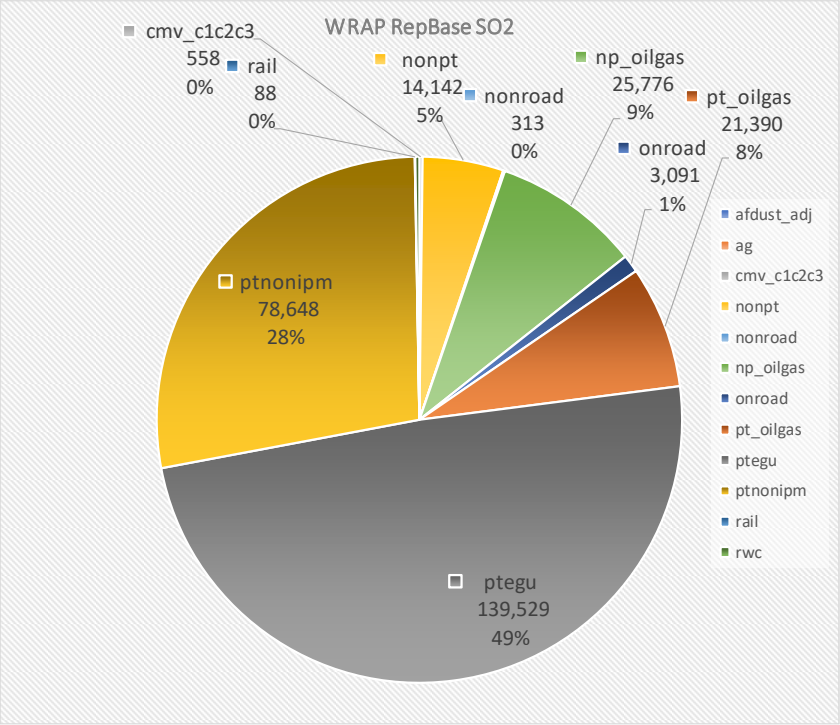


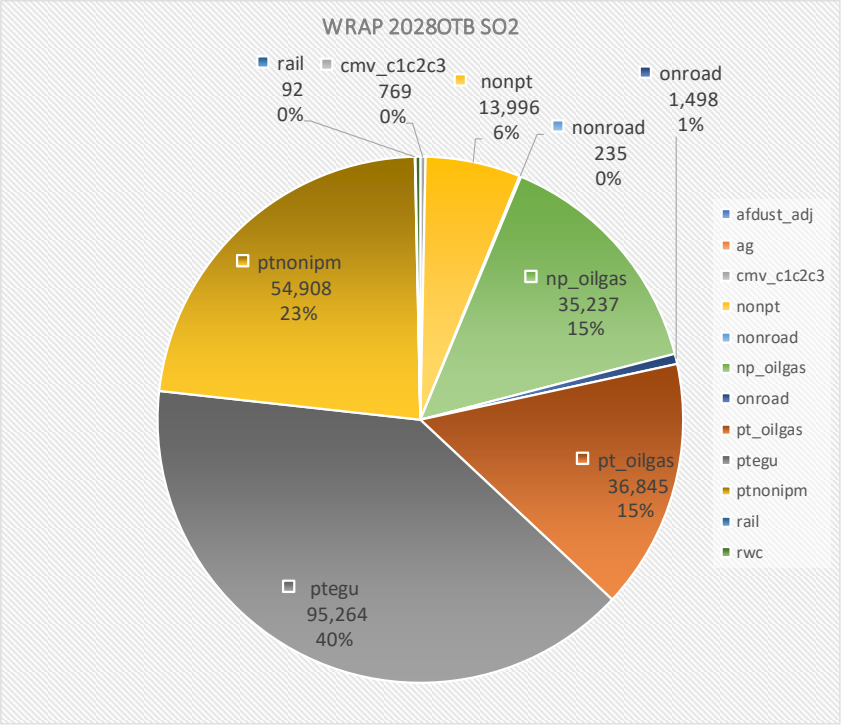
	AZ	CO	ID	MT	ND	NM	NV	OR	SD	UT	WA	WY
rwc	391	496	220	194	136	217	209	677	166	208	1,807	90
rail	12,704	6,103	4,814	13,988	8,244	14,458	3,297	4,680	2,237	4,164	11,631	15,057
ptnonipm	14,702	19,183	7,526	5,859	4,144	11,909	10,146	12,753	3,090	15,692	21,005	20,405
ptegu	13,188	13,356	265	9,435	32,516	5,997	3,892	1,821	246	23,848	4,701	16,355
pt_oilgas	5,514	17,494	1,244	2,439	15,858	44,292	186	381	435	9,163	631	9,691
onroad	29,389	22,097	14,401	12,767	8,051	20,601	11,255	20,080	7,592	25,539	34,366	8,923
np_oilgas	7	29,023	10	3,783	57,258	50,103	4	11	319	1,427	-	13,677
nonroad	10,341	8,462	4,449	4,639	12,200	3,037	7,082	8,898	6,881	4,741	13,886	1,366
nonpt	8,724	7,230	4,706	4,960	1,196	7,105	3,323	8,341	1,276	4,706	11,883	1,025
cmv_c1c2c3	-	-	-	-	-	-	-	2,958	-	-	17,877	-
ag	-	-	-	-	-	-	-	-	-	-	-	-
afdust_adj	-	-	-	-	-	-	-	-	-	-	-	-

RAMBOLL

2028OTB vs. Repbase/2014v2 (anthro only)

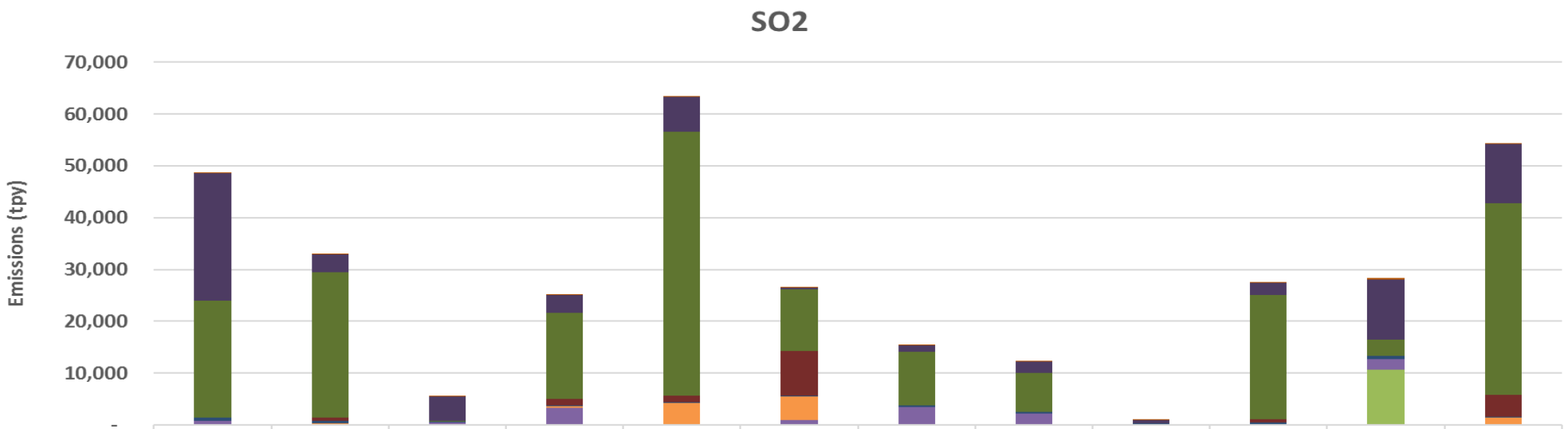




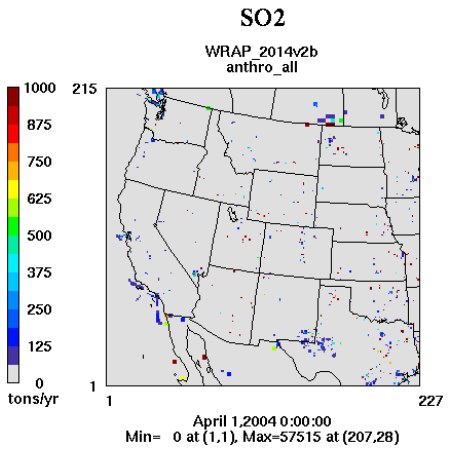


RAMBOLL

2014v2 Emissions by State AND sector

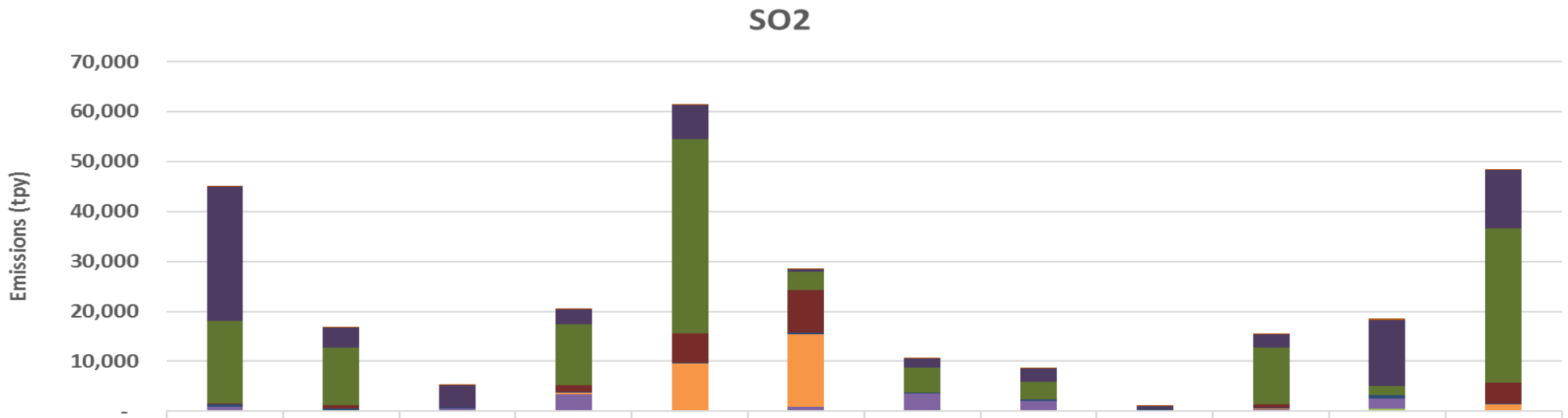


	AZ	CO	ID	MT	ND	NM	NV	OR	SD	UT	WA	WY
rwc	59	48	36	26	31	32	22	109	37	24	229	12
rail	11	6	4	13	9	12	4	4	2	3	10	18
ptnonipm	24,647	3,335	4,721	3,437	6,716	303	1,314	2,185	653	2,400	11,577	11,564
ptegu	22,525	28,158	80	16,566	50,900	11,911	10,361	7,554	5	24,011	3,229	36,975
pt_oilgas	38	583	3	1,370	1,314	8,642	17	13	1	664	14	4,255
onroad	537	458	156	117	91	229	195	303	84	275	552	94
np_oilgas	1	182	1	232	4,043	4,481	3	0	45	41		1,333
nonroad	51	53	25	24	44	15	30	41	33	25	52	9
nonpt	772	81	476	3,340	171	946	3,472	1,942	127	61	2,042	67
cmv_c1c2c3				-				230		-	10,634	
ag	-	-	-	-	-	-	-	-	-	-	-	-
afdust	-	-	-	-	-	-	-	-	-	-	-	-

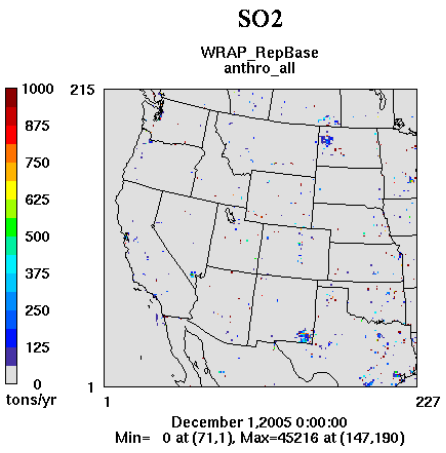


RAMBOLL

Repbase Emissions by State AND sector

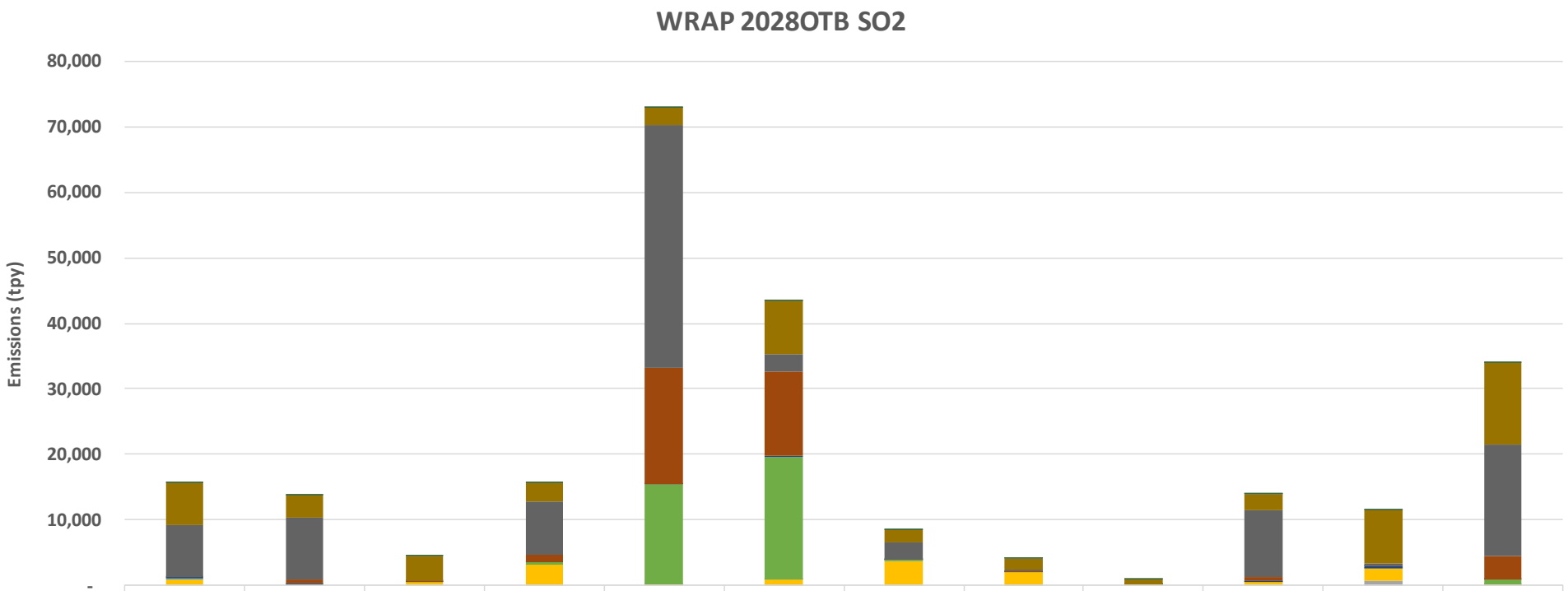


	AZ	CO	ID	MT	ND	NM	NV	OR	SD	UT	WA	WY
rwc	62	50	36	26	33	34	22	97	39	25	255	12
rail	12	5	4	12	7	13	3	4	2	3	10	14
ptnonipm	26,927	4,056	4,531	2,991	6,743	449	1,869	2,596	700	2,691	13,161	11,604
ptegu	16,577	11,597	33	12,190	39,039	3,699	4,937	3,570	7	11,313	1,934	30,893
pt_oilgas	16	570	7	1,370	5,814	8,643	16	13	1	664	20	4,255
onroad	537	458	156	117	91	229	195	303	84	275	552	94
np_oilgas	0	22	1	440	9,391	14,484	3	2	59	41		1,333
nonroad	36	34	17	16	40	12	30	33	23	16	50	5
nonpt	874	82	476	3,338	171	945	3,471	1,942	127	434	2,042	67
cmv_c1c2c3								82			537	
ag	-	-	-	-	-	-	-	-	-	-	-	-
afdust_adj	-	-	-	-	-	-	-	-	-	-	-	-



RAMBOLL

2028OTB Emissions by State AND sector

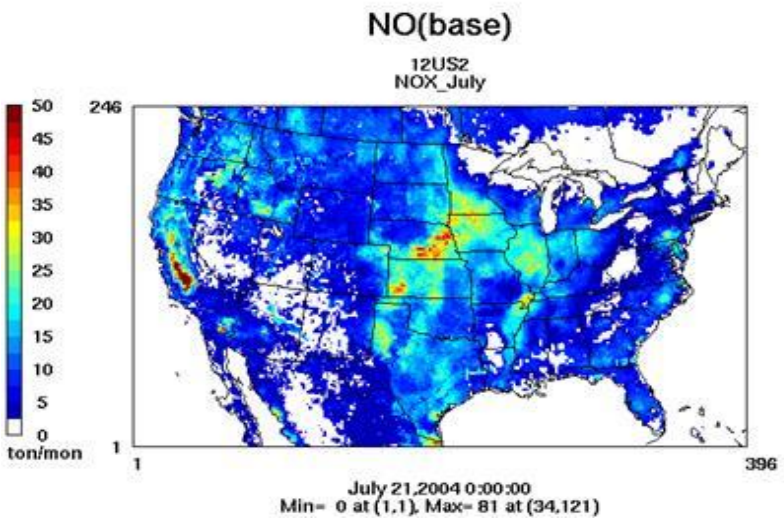


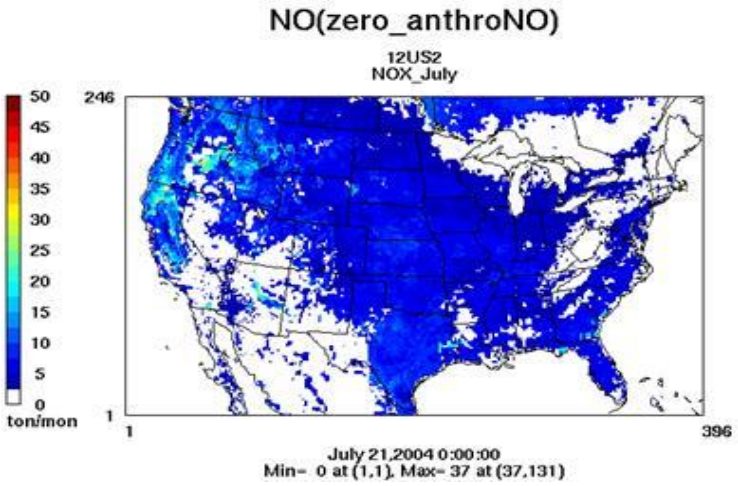
	AZ	CO	ID	MT	ND	NM	NV	OR	SD	UT	WA	WY
rwc	52	52	36	25	30	32	23	109	36	25	272	11
rail	12	5	4	13	7	14	3	4	2	3	10	14
ptnonipm	6,473	3,382	3,748	2,898	2,672	8,155	1,828	1,827	649	2,553	8,138	12,584
ptegu	7,870	9,531	33	8,046	36,990	2,624	2,597	216	7	10,088	394	16,868
pt_oilgas	40	533	8	1,136	17,802	12,877	17	13	1	688	20	3,711
onroad	231	180	83	62	53	129	99	136	48	185	241	51
np_oilgas	0	24	1	445	15,202	18,763	4	1	29	31	-	737
nonroad	32	24	11	11	32	9	24	25	17	13	34	3
nonpt	971	82	512	3,090	174	900	3,799	1,843	129	436	1,993	67
cmv_c1c2c3	-	-	-	-	-	-	-	116	-	-	653	-
ag	-	-	-	-	-	-	-	-	-	-	-	-
afdust_adj	-	-	-	-	-	-	-	-	-	-	-	-

RAMBOLL

Natural (NAT) and No International (ZROW) [Run-Spec-Sheet]

- Paired GEOS-Chem global and CAMx regional simulations using 2014 meteorology and RepBase emissions
- NAT = No Anthropogenic Emissions World-Wide
  - Compared model Natural with monitor based Natural (NCII)
  - MEGAN "biogenic" soil NOx emissions without contributions from fertilizer and anthro N deposition
- ZROW = Zero-out Rest of World (No International Anthropogenic Emissions)
  - Adjusted Glidepaths by adding International Emissions contribution to 2064 Natural Conditions





RAMBOLL

RepBase and 2028OTB Simulations

- Representative Baseline (2014-2018)
- 2014v2 Actual Baes Case
- 2028 On-the-Books (OTB)
  - 2028OTBa w/ RepBase Fires
  - 2028OTBb w/ 2014 Actual Fires
- 2028 Visibility Projections
  - RepBase/2028OTBa
  - 2014v2/2028OTBb
- Relative Response Factors (RRFs)
  - 2014 IMPROVE MID
  - 2014 IMPROVE MID w/ Fire Removed
  - Modeled RepBase U.S. Anthropogenic MID

Source Sector	RepBase	2028 OTB
California All Sectors	CARB-2014v2	CARB-2028
WRAP Fossil EGU w/ CEM	WRAP-RB-EGU[1]	WRAP-2028-EGU[1]
WRAP Fossil EGU w/o CEM	WRAP-RB-EGU	WRAP-2028-EGU
WRAP Non-Fossil EGU	EPA-2016eh	EPA-2028eh
Non-WRAP EGU	EPA-2016eh	EPA-2028eh
O&G WRAP O&G States	WRAP-RB-O&G	WRAP-2028-O&G
O&G WRAP Other States	EPA-2016eh	EPA-2028eh
O&G non-WRAP States	EPA-2016eh	EPA-2028eh
WRAP Non-EGU Point	WRAP-2014v2[2]	EPA-2028eh[2]
Non-WRAP non-EGU Point	EPA-2016eh	EPA-2028eh
On-Road Mobile 12WUS2	WRAP-2014v2	WRAP-2028-Mobile
On-Road Mobile 36US	EPA-2016eh	EPA-2028eh[4]
Non-Road 12WUS2	EPA-2016eh	WRAP-2028-Mobile
Non-Road non-WRAP 36US	EPA-2016eh	EPA-2028eh
Other (Non-Point) 12WUS2	EPA-2016eh	EPA-2028eh
Can/Mex/Offshore 12WUS2	EPA-2016eh	EPA-2028eh
Fires (WF, Rx, Ag)	WRAP-RB-Fires	WRAP-RB-Fires[3]
Natural (Bio, etc.)	WRAP-2014v2	WRAP-2014v2
Boundary Conditions (BCs)	WRAP-2014-GEOS[5]	WRAP-2014-GEOS

RAMBOLL

RepBase Source Apportionment Simulation

- CAMx v7.0 PM and Ozone Source Apportionment Simulation
- Obtain International and U.S. anthropogenic Emissions, Fire Emissions and Natural Emissions contributions to PM and ozone concentrations
- Emission Source Groups:
  - Natural Emissions (Biogenic, Sea Salt/DMS, LNOx, WBD)
  - U.S. Wildfires (WF)
  - U.S. Prescribed Burns (Rx)
  - U.S. Agricultural Burning (Ag)
  - Canada/Mexico Fires
  - U.S. Anthropogenic Emissions (USAnthro)
    - USAnthro includes U.S. off-shore O&G and small CMV C1&C2 vessels
  - Mexico Anthropogenic Emissions
  - Canada Anthropogenic Emissions
  - Off-Shore CMV C3 within 200 nautical miles)
  - Remainder off-shore anthropogenic emissions
- Boundary Condition Stratification:
  - International Anthropogenic
  - U.S. Anthropogenic
  - Natural

RAMBOLL

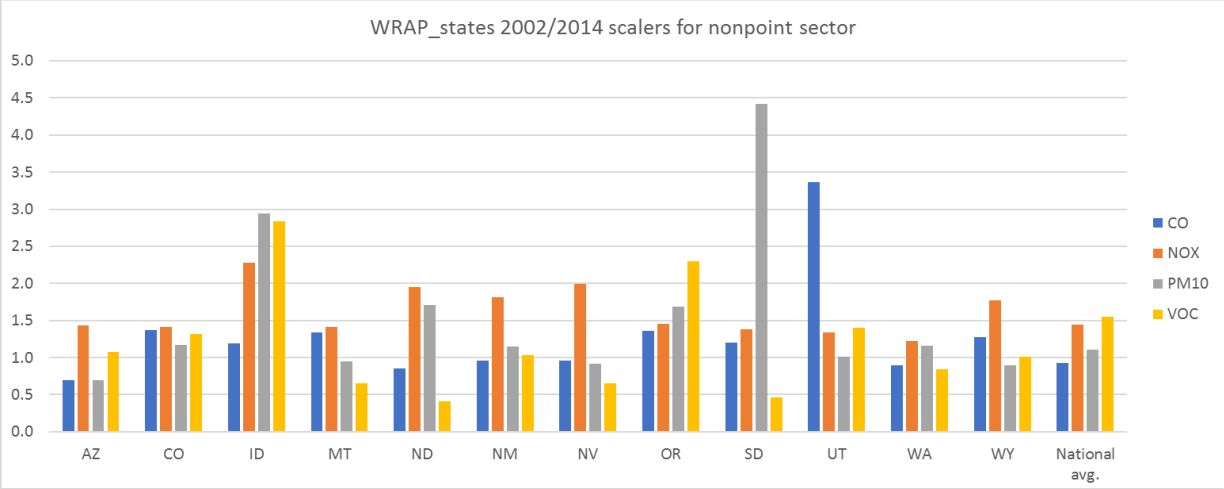
Dynamic Evaluation – 2002 CAMx Simulation

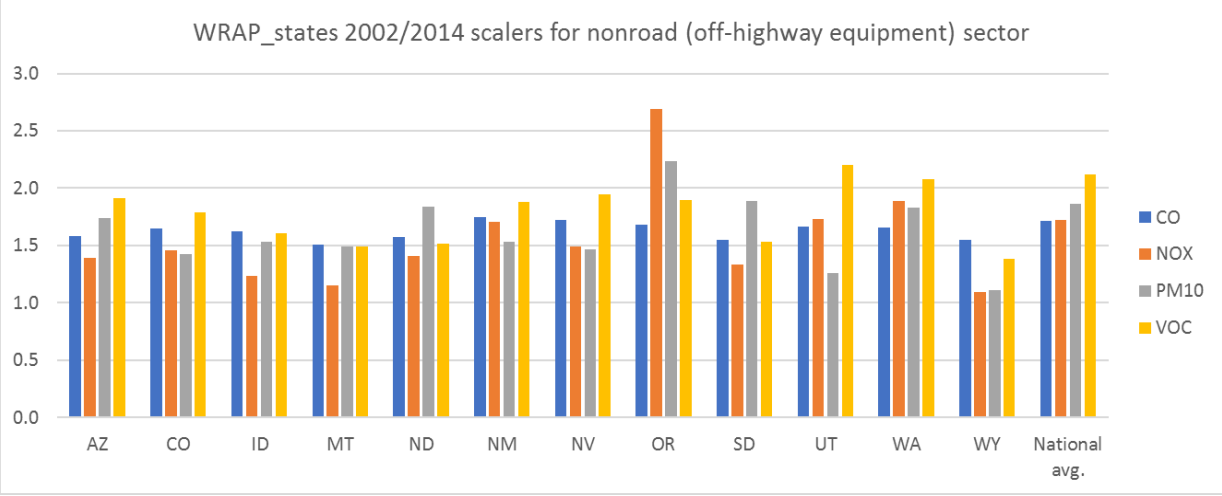
- Purpose:
  - Conduct Dynamic Evaluation of visibility projection techniques by comparing predicted and observed changes in visibility in response to changes in emissions between 2000-2004 Baseline and 2014-2018 5-year planning period
  - To estimate changes in U.S. anthropogenic emissions contribution to visibility impairment from past 2000-2004 period, to current 2014-2018 period, to future 2028 period.
- Approach:
  - Backcast 2014v2 model-ready gridded ("pre-merged") U.S. anthropogenic emissions to 2002 using state-specific and species-specific backcast scaling factors for each Source Sector
  - For most Source Sectors will use backcast scaling factors based on latest EPA Trends data
  - Exceptions to using EPA Trends data for backcasting 2014v2 emissions:
    - California Emissions (use ARB CEPAM trends data)
    - EGU and Non-EGU Point in WRAP states
    - Oil and Gas for WRAP states
  - Held constant at RepBase levels:
    - Natural (biogenic, oceanic, LNOx and WBD); RepBase fires; Mex/Can Anthro
    - 2014 GEOS-Chem BCs

RAMBOLL

Dynamic Evaluation – 2002 CAMx Simulation

- Example NEI Trends WRAP state-specific 2002/2014 backcast scaling factors for Non-Point and Off-Highway Equipment Non-Road Source Sectors





Dynamic Evaluation – 2002 CAMx Simulation

- Use WRAP Reg Haze Round 1 2002 Pivot Tables as is (bottom up) for 2002 EGU Point and Non-EGU Point in WRAP states

	% difference [(Plan02d - NEI)/NEI]						
Model-ready categories	**CO**	**NH_3**	**NO_X**	**PM_{10}**	**PM_{25}**	**SO_2**	**VOC**
Pt-EGU Total	28%	46%	4%	-36%	-59%	0%	45%
Pt-nonipm (non-EGU) Total	16%	-33%	34%	-21%	-57%	5%	48%
TOTAL	18%	-16%	11%	-26%	-58%	1%	47%

- For WRAP state O&G use scaling factors based on WRAP 2014v2 O&G and WRAP Reg Haze 2 Round 1 2002 O&G as 2002 NEI O&G emissions look wrong

	2002 WRAP EI (2007 Study)	**NEI Trends (2002)**	**x difference [WRAP = xNEI]**	**WRAP-based 2002/2014 Scaler**
State	NOx (tpy)	NOx (tpy)		NOx
CO	23,518	597	39.4	0.67
MT	7,557	488	15.5	1.62
NM	55,640	738	75.4	1.23
ND	4,631	10	477.6	0.11
UT	3,335	469	7.1	1.81
WY	14,725	2,954	5.0	0.44

RAMBOLL

Current Status (Feb 26, 2020)

- CAMx NAT Zero-Out Done; ZROW about to start
- CAMx RepBase Source Apportionment, working on off-shore U.S. Anthro classification
  - Also some emission updates/corrections to be consistent with 2028
- 2028 emissions received from UNC last Friday
  - Working with processing and transfer of new files
  - Ready next week
- WEP/AOI has completed Residence Time analysis, waiting for 2028 EI for WEP
- Dynamic Evaluation, have 2002/2014 backcast scaling factors, ready to generate 2002 emissions and start CAMx
- Data transfer proceeding with files and 2014v2 verification

RAMBOLL