

RUN SPECIFICATION SHEET

REPRESENTATIVE BASELINE (RepBase2) AND 2028 ON-THE-BOOKS (2028OTBa2) CAMx SIMULATIONS

WRAP 2014 Modeling Study
Revised September 30, 2020

Run Names:	RepBase2 CAMx Simulation 2028OTBa2 CAMx Simulation
Model:	CAMx v7.0
Domains:	36US1 and 12WUS2 two-way nesting (see Figure 1)
Period:	2014 annual period
Emissions:	Representative Baseline 2 and 2028OTBa2
Boundary Conditions:	WRAP Revised 2014 GEOS-Chem Base Case
Source Apportionment:	None
Purpose:	<p>The primary use of the RepBase2 and 2028OTBa2 modeling scenarios is to make 2028 visibility projections for comparison against the Uniform Rate of Progress (URP) Glidepath. WRAP has prepared a separate document discussing the 2028 visibility projection approaches.¹</p> <p>The RepBase2 and 2028OTBa2 emission scenarios will also be used for particulate matter source apportionment modeling to obtain separate contributions of natural, fire, U.S. anthropogenic and international anthropogenic emissions. Details on the RepBase2 and 2028OTBa2 source apportionment modeling approach is provided in a separate Run Specification Sheets with the RepBase2 and 2028OTBa2 source apportionment use summarized as follows:</p> <ul style="list-style-type: none"> • To make alternative 2028 visibility projection approaches (i.e., EPAwof and ModMID). • Populate the WRAP Technical Support System (TSS) modeling express tools on source contributions to visibility at IMPROVE sites.² • Estimate international anthropogenic and prescribed (Rx) fire contributions for adjusting the URP Glidepath.³ • Used as part of the Dynamic Evaluation to determine whether the U.S. anthropogenic emissions are on a path toward no perceptible impairment in 2064.

DESCRIPTION

The CAMx second Representative Baseline (RepBase2) anthropogenic emission inputs will be developed for the 36/12-km domains and are designed to be the best data representative of the 2014-2018 period. Anthropogenic emission inputs will also be developed for the 2028 future year emissions scenario assuming On-the-Books (OTB) controls that is consistent with RepBase2 (i.e., 2028OTBa2

¹ http://www.wrapair2.org/pdf/2028_Vis_Proj_WhitePaper_2020-07-24draft.pdf

² <https://views.cira.colostate.edu/tssv2/Express/ModelingTools.aspx>

³ http://www.wrapair2.org/pdf/URP_Glidepath_Adjust_WRAP_2020-07-24draft.pdf



scenario). The meteorological conditions, natural emissions (i.e., biogenic, lightning NO_x, oceanic and windblown dust) and boundary conditions (BCs) will be held constant at 2014v2 actual levels.

SOURCE APPORTIONMENT SPECIFICATIONS

Currently, High-Level (e.g., anthropogenic vs. natural vs. international) Source Apportionment (H-L SA) modeling is planned for the RepBase2 and 2028OTBa2 scenarios. Low-Level (i.e., separate Source Sector contributions from 13 WRAP states) Source Apportionment is planned for the 2028OTBa2 scenario. See the Run Specification Sheet on the RepBase2 and 2028OTBa2 source apportionment modeling for details.

EMISSIONS

There are several sources of emissions information that will be used for the RepBase2 and 2028OTBa2 emission scenarios. It is important that emissions for the two scenarios be consistent as the relative changes in the CAMx RepBase2 and 2028OTBa2 PM concentration estimates are used to construct the Relative Response Factors (RRFs) that are used to scale (project) the measured IMPROVE Most Impaired Days (MID) from 2014-2018 PM concentrations to 2028.

There are several sources of consistent current and future year emission estimates that are available for use in the RepBase2 and 2028OTBa2 scenarios as follows:

WRAP-2014v2 – The WRAP 2014v2 emissions scenario represent actual 2014 base case emissions and will be used for the WRAP Non-EGU point in the RepBase2 and 2028OTBa2 emissions scenario as well as for the on-road mobile for the Repbase2. For both the RepBase2 and 2028OTBa2 emissions scenarios, the 2014v2 natural emissions [i.e., Biogenic, oceanic (SSA/DMS), lightning (LNO_x), and windblown dust (WBD)] will be used.

EPA-2016fh and EPA-2028fh – EPA has released the 2016v1 36/12-km modeling platform through the IWDW that includes the 2016fh, 2023fh and 2028fh model-ready emission inputs for the 36-km 36US3 and 12-km 12US2 modeling domains. The EPA 2016v1 36US3 and 12US2 domains are larger than the WRAP 2014 36US1 and 12WUS2 domains so can be used to window-out emissions for the WRAP 2014 modeling platform. The EPA 2016fh was developed as part of the joint MJO/EPA Inventory Collaborative⁴ effort so has input from some states. The 2028fh projections were made by EPA without state input and were used for some source sectors in the initial WRAP 2028OTB scenarios. However, some issues were found with EPA's 2028fh projections so 2028OTBa2 is using current year emission estimates for those categories in 2028OTBa2 (e.g., WRAP non-EGU Point).

CARB-2014 and CARB-2028 -- The California Air Resources Board (ARB) has provided 2014 and 2028 anthropogenic emissions organized into the same anthropogenic emission source categories for California as used for all other WRAP states. These data will be used for the RepBase2 and 2028OTBa2 scenarios, respectively.

WRAP-2028-EGU & WRAP-RB-EGU -- The WRAP EGU Emissions Analysis Project⁵ has developed RepBase and 2028 SO₂ and NO_x emissions for WRAP state large Electrical Generating Units (EGU) with Continuous Emissions Monitoring (CEM) devices. The EGU study also compiled a list of 2018 and 2028 non-CEM (non-CAMD) fossil-fueled EGUs with NO_x and SO₂ emissions. These data are used for WRAP EGU sources in RepBase2 and 2028OTBa2, unless a state

⁴ <https://views.cira.colostate.edu/wiki/wiki/9169#Overview>

⁵ <http://wrapair2.org/EGU.aspx>

provided alternative emissions assumptions in July-August 2020 to be used in RepBase2 and/or 2028OTBa2.

WRAP-2028-O&G and WRAP-RB-O&G -- The WRAP Oil and Gas Work Group (O&GWG⁶) has developed a RepBase and 2023 future year⁷ O&G emissions for 7 of the 8 WRAP states that have significant O&G emissions that are used in the RepBase2 and 2028OTBa2 scenarios. Some O&G sources were double counted in RepBase and 2028OTBa; these emissions have been reviewed and corrected for RepBase2 and 2028OTBa2. CARB is providing 2014 and 2028 O&G emissions for California that is the 8th WRAP state with significant O&G emissions. For WRAP non-O&G states and non-WRAP states the EPA-2016v1 O&G emissions are used for both the RepBase2 and 2028OTBa2 scenarios.

WRAP-2028-Mobile-- Another WRAP study has generated 2028 CAMx-ready emissions for on-road and non-road mobile sources as well as off-shore shipping, rail and airports for the 12-km 12WUS2 modeling domain that is used in 2028OTBa2⁸. Outside of the 12-km domain, the EPA 2028fh on-road mobile source emissions are being used. The 2014v2 mobile source emissions are being used for the RepBase2 scenario.

WRAP-RB-Fires -- The WRAP Fire & Smoke Work Group (F&SWG) has developed Representative Baseline fire emissions⁹ that is used in the RepBase2 and 2028OTBa2 scenarios. They are also preparing a future year fire sensitivity scenario that will be used in a 2028 fire sensitivity scenario that will be discussed at a later date.

The sources for the PGM-ready emissions for the WRAP current year RepBase2 and future year 2028OTBa2 emission scenarios are shown in Table 1. As the 2028OTBa2 and RepBase2 PGM modeling results are used in a relative fashion to project the observed 2014-2018 visibility to 2028, the RepBase2 and 2028OTBa2 emissions must be consistent. EPA's model-ready EPA-2016fh¹⁰ and EPA-2028fh emissions from the EPA 2016v1 modeling platform will be used in the RepBase2 and 2028OTBa2 emission scenarios for some of the anthropogenic emission source categories in the 12-km 12WUS2 western U.S. domain and for some source categories the EPA 2016fh emissions are used for both RepBase2 and 2028OTBa2.

36-km 36US Domain: The EPA-2016fh and EPA-2028fh anthropogenic emissions will be used for the RepBase and 2028OTB emissions scenarios in the portions of the 36US domain outside of the 12WUS2 domain (see Figure 1). The WRAP anthropogenic emissions for the 12-km 12WUS2 will be aggregated to 36-km resolution and replace the anthropogenic emissions in the 36US domain where they overlap. Thus, the EPA-2016fh and EPA-2028fh 36-km domain model-ready emissions are only used for the Mexico, Canada, off-shore and the eastern U.S. portions of the 36US domain not covered by the 12WUS2 domain.

EGUs: For Electrical Generating Units (EGUs), there are three categories: (1) fossil-fueled EGUs with CEMs from the CAMD database; (2) fossil-fueled EGUs without CEMs; and (3) non-fossil fueled EGUs (e.g., biomass fired EGUs). The fossil-fueled CEM and non-CEM EGUs in the WRAP states and the RepBase and 2028OTB scenarios will be based on the WRAP EGU Emissions Analysis Study¹¹ (WRAP-RB-EGU and WRAP-2028-EGU) conducted by the Center for the New Energy Economy (CNEE). In some cases a WRAP state has provided new information on the 2028 EGU emissions that was used in 2028OTBa2. All other EGU emissions for the RepBase and 2028OTBa2 scenario, including all EGUs in

⁶ <http://wrapair2.org/OGWG.aspx>

⁷ Due to the uncertainties in O&G emission projections, they are projected out to 2023 and are used for the 2028 future year modeling.

⁸ http://views.cira.colostate.edu/wiki/Attachments/2014v2_Review/WRAP_MSEI_24Jan2020a.pdf

⁹ <http://wrapair2.org/RBFESWG.aspx>

¹⁰ Un-merged model-ready emission inputs for EPA's 2016v1 emissions (i.e., 2016fh and 2028fh) are available on the IWDW. The same kind of files for the WRAP 2014-based Regional Haze modeling platform scenarios will also be available on the IWDW, later in 2020.

¹¹ <https://www.wrapair2.org/EGU.aspx>

non-WRAP states and all non-fossil EGUs, will be based on EPA's 2016fh and 2028fh scenarios, respectively.

O&G: There are three sources for U.S. oil and gas (O&G) in the RepBase and 2028OTB emission scenarios: (1) California ARB for O&G sources in California (CA); (2) WRAP O&G Work Group WRAP-RB-O&G and WRAP-2028-O&G¹² for 7 WRAP states (CO, MT, ND, NM, SD, UT, WY); and (3) EPA-2016fh other WRAP states and non-WRAP states that are used for both the RepBase2 and 2028OTBa2 scenarios.

Non-EGU Points: For the WRAP states, the WRAP-2014v2 emissions for the non-EGU Point source sector that has updates provided by the WRAP states will be used for both the RepBase2 and 2028OTBa2 scenarios. For the non-WRAP states non-EGU point sources, the EPA-2016fh emissions will be used for both the RepBase2 and 2028OTBa2 scenarios..

Mobile: 2028 model-ready emissions for on-road mobile, non-road, rail, airports and CMV sources will be generated for the 12WUS2 domain (WRAP-2028-Mobile) for use in the 2028OTBa2 scenario. The WRAP-2014v2 on-road mobile sources emissions will be used for the RepBase scenario. For the 36US domain outside of the 12WUS2 domain including the eastern U.S., the EPA-2016fh and EPA-2028fh on-road and non-road mobile source emissions will be used for the, respectively, RepBase2 and 2028OTBa2 scenarios.

Other Non-Point: Non-point emissions include area sources (e.g., consumer products, residential wood combustion, ammonia, etc.) and fugitive dust sources. The EPA-2014v2 with WRAP state corrections will be used in the 12WUS2 domain and the 2016fh emissions will be used outside of the 12WUS2 domain for other non-Point emissions in both the RepBase and 2028OTB emission scenarios.

Canada/Mexico: The EPA-2016fh emissions will be used for Canada and Mexico in both the RepBase2 and 2028OTBa2 scenarios.

Fires: The WRAP Fire and Smoke Work Group (FSWG) has developed representative baseline fire emissions (WRAP-RB-Fires) that will be used in both the RepBase2 and 2028OTBa2 emission scenarios.

Natural: Natural emissions of biogenic VOC and NO_x, lightning NO_x (LNO_x), oceanic sea salt (SSA) and dimethyl sulfide (DMS) and windblown dust (WBD) emissions will be held constant at 2014v2 levels for both the RepBase2 and 2028OTBa2 scenarios.

Boundary Conditions: Boundary Conditions (BCs) for the 36US domain will be held constant at 2014v2 levels (i.e., based on the revised WRAP 2014 GEOS-Chem simulation) for both the RepBase2 and 2028OTBa2 scenarios.

¹² The WRAP-2028-O&G emissions for the 7 WRAP states are actually projections out to 2023.

Table 1. Source of emissions sector data for the 12-km 12WUS2 and 36-km US domains for the new WRAP current Representative Baseline (RepBase2) and new 2028OTBa2 modeling scenarios. (August 23, 2020)

Source Sector	new RepBase2	new 2028OTBa2
California All Sectors 12WUS2	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 ¹	WRAP-2028-EGU ¹
WRAP Non-Fossil EGU	EPA-2016v1	EPA-2028v1
Non-WRAP EGU	EPA-2016v1	EPA-2028v1
O&G WRAP O&G States	WRAP-RB-O&G ²	WRAP-2028-O&G ²
O&G WRAP Other States	EPA-2016v1	EPA-2016v1 ³
O&G non-WRAP States	EPA-2016v1	EPA-2016v1
WRAP Non-EGU Point ⁴	WRAP-2014v2 ⁴	WRAP-2014v2 ⁴
Non-WRAP non-EGU Point	EPA-2016v1	EPA-2016v1
On-Road Mobile 12WUS2	WRAP-2014v2	WRAP-2028-Mobile
On-Road Mobile 36US	EPA-2016v1	EPA-2028v1
Non-Road 12WUS2	EPA-2016v1	WRAP-2028-Mobile
Non-Road non-WRAP 36US	EPA-2016v1	EPA-2028v1
Other (Non-Point) 12WUS2	EPA-2014v2 ⁵	EPA-2014v2 ⁵
Other (Non-Point) 36US	EPA-2016v1	EPA-2016v1
Can/Mex/Offshore 12WUS2	EPA-2016v1	EPA-2016v1
Fires (WF, Rx, Ag)	WRAP-RB-Fires	WRAP-RB-Fires
Natural (Bio, etc.)	WRAP-2014v2	WRAP-2014v2
Boundary Conditions (BCs)	WRAP-2014-GEOS	WRAP-2014-GEOS
<p>All EPA-2016v1 and EPA-2028v1 files for sources in the WESTAR-WRAP region will include any unit-level updates from individual states applied as provided by a state.</p> <ol style="list-style-type: none"> WRAP-RepBase-EGU and WRAP-2028-EGU both have changes/corrections/updates from WESTAR-WRAP states, all state-provided updates will be used in new scenarios. WRAP-RepBase-O&G and WRAP-2028-O&G both include corrections for duplicates, lowered point source projections, and other corrections from WESTAR-WRAP states. EPA-2016v1 applied for 2028OTBa2 includes unit-level changes provided by WESTAR-WRAP states. WRAP-2014v2 Non-EGU Point will be used in RepBase2 with updates from WESTAR-WRAP states, as well as additional WESTAR-WRAP-state provided updates will be further applied for 2028OTBa2, in both cases, for specific sources identified by individual states. 12WUS2 domain Non-Point emissions will be held constant in new RepBase2 and 2028OTBa2 scenarios, allowing state-provided corrections from 2019 EIMP Subcommittee meetings to review of 2014v2 data to be included in regional modeling. This holds the sector constant, i.e., no assumptions will be made about controls or future emissions changes for western Non-Point sources. 		

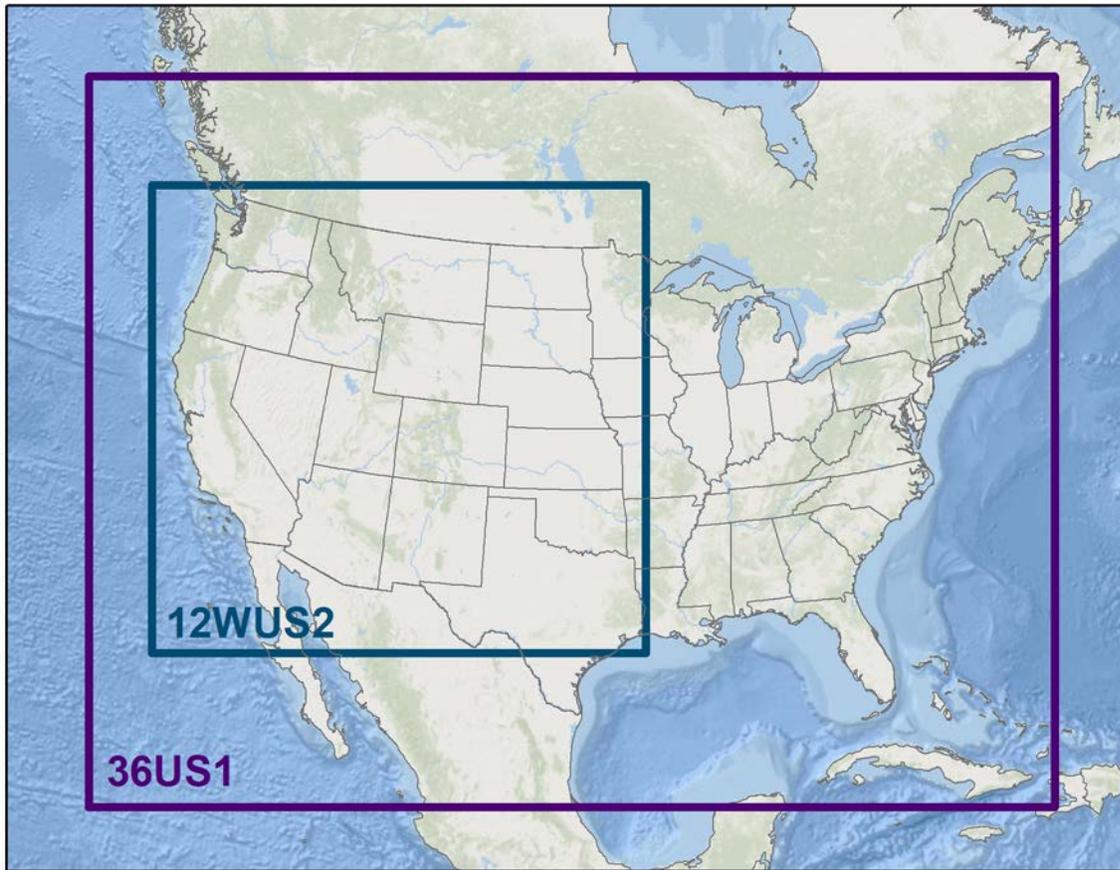


Figure 1. WRAP/WAQS 36-km 36US1 and 12-km 12WUS2 modeling domains used in the WRAP 2014v2, RepBase and 2028OTB CAMx simulations.

The RepBase2 and 2028OTBa2 anthropogenic emissions are processed in several separate streams of emissions processing using the Spare Matrix Operator Kernel Emissions (SMOKE¹³) processing tool. Each separately processed stream of emissions by SMOKE generates a “pre-merged” gridded low level or point source emissions input file for photochemical grid model modeling. Table 2 shows the different anthropogenic emission source categories and how they were combined in the SMOKE emissions processing streams to generate the pre-merged model-ready emission files. Note that California ARB provided separate emissions with combined source sectors for 2014 and 2028 that were processed separately from the other WRAP states in the, respectively, RepBase and 2028 emission scenarios. For RepBase2 and 2028OTBa2, California ARB provided emissions organized in the same source sectors and they were processed the same as the other WRAP states. This allows for consistency across the WRAP states when displaying the state/county emissions by source sectors.

¹³ <https://www.emascenter.org/smoke/>

Table 2. Anthropogenic source sectors for the WRAP RepBase and 2028OTB emission scenarios and how they are processed through SMOKE to generate the pre-merged PGM emissions input files (Combined Sector).

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)	
	airport	airport	ptnonipm
ptnonipm_wrapv2	ptnonipm_nonwrap (area+point)	ptnonipm_nonwrap (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