RAMBOLL

26 January 2018

Via Email

Regional Technical Operations Work Group Members
c/o Tom Moore
Western States Air Resources Council-Western Regional Air Partnership
3 Caliente Rd #8
Santa Fe, NM 87508

Re: Western Regional Air Partnership Regional Technical Operations Workgroup Regional Modeling Representativeness Study

Dear Regional Technical Operations Work Group Member:

Thank you for soliciting our response to the Western Regional Air Partnership (WRAP) Regional Technical Operations Workgroup (RTOWG) Scope of Work (SOW) for evaluating year(s) for the next round of regional photochemical modeling to address ozone, particulate matter (PM), regional haze and deposition modeling for the western states. The work would determine inter-annual variability of meteorology, emissions, and air quality observations in the western and central U.S. to assess representativeness for regional modeling and air quality planning.

About Ramboll

The Environment and Health Division of Ramboll (Previously Ramboll Environ and ENVIRON) is an environmental and health consulting firm with more than 2,000 professionals working from a network of offices throughout the U.S. and overseas. We have gained a national reputation as a leader in the areas of emissions and air quality modelling, control technology assessments, broad based air quality control strategy analyses, emissions standards assessment, environmental data analysis, environmental strategic analysis, regulatory compliance assurance, environmental and public health risk assessment, and risk management. At the end of 2014, ENVIRON joined forces with Ramboll, Northern Europe's leading engineering, design and management consultancy. Headquartered in Copenhagen and privately owned, Ramboll has more than 12,000 employees across 300 offices in 35 countries. Ramboll's consultancy skills complement ENVIRON's existing portfolio, especially in the energy, oil & gas, water resources, sustainable development and climate change sectors.

Ramboll has a long history of supporting WRAP with regional air quality emissions, ambient data, and modeling analyses focused on addressing current air quality management issues in the western U.S. This includes development of bottom-up emission inventories for upstream oil and gas sources, photochemical modeling, and data analysis for trends, monitoring network assessment, and model evaluations. We would be happy to provide relevant project summaries, resumes for key personnel, and work samples upon request.

Scope of Work

We understand that the RTOWG is seeking to develop information to inform the selection of a specific year (or years) for the updated annual western regional photochemical modeling platform. As significant resources are required to develop and exercise an annual air quality modeling platform for analysis of the issues of concern (ground-level ozone, regional haze, nitrogen deposition, etc.), it is important to establish the "degree of representativeness" of the year chosen for the annual simulation. Within this context, "representativeness" can be taken to mean the degree to which simulations of the selected year using future emissions projections are likely to be least affected by any "unusual" or "atypical" conditions and thus be most useful to decision makers. In other words, the information developed in this analysis will allow air quality modelers and planners to understand "how representative" the selected modeling base year will be for projecting the future. Thus, the objective of this study is to compare and contrast the key characteristics of each year analyzed, both with respect to each other and with respect to long-term averages.[1]

Given the goal of selecting a recent year for modeling and the availability of emissions data, we understand that the next annual western regional modeling platform to be employed for the contiguous US domain by the WRAP RTOWG will most likely be based on either CY2014 or CY2016 although it is still possible a different year may be selected. To understand the "representativeness" of these candidate years, it will be necessary to compare them with each other and with other recent years including, at a minimum, all years from 2012 to 2016 (inclusive). We will also include data from 2017 in the analysis to the extent to which it is available. The RTOWG has requested proposals to examine meteorological conditions, emissions, and air quality observations for these years within the context of longer-term averages and trends. There may also be some interest in including 2017 in the comparison to the extent that data become available in time for this study. We therefore propose to provide both inter-annual comparisons for this period as well as comparisons to climatological normals and longer-term trends to the extent the normals and trends have been previously compiled. In our examination of 2012 – 2016, our overarching goal will be to develop and use tools and methods that can be extended to data from a longer period, e.g., 2000 – 2016 in a cost-effective manner if additional funding for such an extended analysis becomes available.

Coincident with the objectives of the planned photochemical modeling study, our representativeness analysis would focus on the western and central U.S., including the WRAP states and selected adjacent CENRAP states within the contiguous U.S. using data on meteorology, emissions, and air quality. Available data from Alaska and Hawaii would also be

[1] We recognize that selection of a specific year for modeling involves many considerations, including data availability and relevance to current conditions. However this study will focus on the representativeness of meteorological and air quality conditions during each candidate year.

analyzed. While there are a vast amount of data and data analyses that could inform the representativeness study, we propose to focus on key features that are directly related to goal of selecting a year which will be most suitable for serving as the base case for useful predictions of future air quality under potential alternative future emissions scenarios. In particular, achieving this goal requires that the base case simulation faithfully reproduces existing conditions and simulates the correct source-receptor relationships. Any unusual or difficult to simulate conditions in the selected base case year that might lead to model performance issues or skew source-receptor relationships in an anomalous manner would be detrimental to this goal.

Table 1 lists the key processes affecting emissions, transport and fate of pollutants in the atmosphere. For each process, we identify the related key driving parameters that have spatial and temporal distributions which typically exhibit large inter-annual variations. For example, vertical mixing is largely controlled by the Planetary Boundary Layer (PBL) depth and presence of convective activity that are related to the surface wind speed, vertical heat flux, and vertical stability profile. Prevailing PBL depths during, say, winter in a given part of the study region may be significantly lower in some years than in others and convective activity may also be more prevalent during some years as compared to others. However, direct measurements of some of these parameters such as PBL depth and convection are limited in space and time or difficult to process, thus reducing their usefulness for direct use in this analysis. We therefore include in the right-hand column of Table 1 additional parameters (lightning, precipitation, cloud cover) which are potentially useful indicators of the degree of vertical mixing. In contrast, other parameters related to vertical mixing such as surface roughness are not expected to change much from one year to the next and are therefore not of interest here.

We note that in many cases it will be advantageous to use analyzed data rather than raw data values for our interannual comparisons. For example, maps of monthly or seasonal mean departures from normal in many surface and upper air parameters are readily available via NOAA on-line resources, thus eliminating the need to access and process the large underlying data sets.

Table 1. Processes, associated key driving parameters, and related potential indictors.

Process	Key Driving Parameters with Inter-Annual Variations[a]	Potential Indicators[a]
Vertical Mixing	Sfc WS, Heat flux, Vertical stability, PBL depth, Convective activity	Lightning, precipitation, sfc T, cloud cover
Horizontal Advection and Dispersion	Trajectory patterns, Synoptic Types, sfc WS	SLP patterns, geopotential height fields Precipitation
Photochemical Production Potential	UV actinic flux, Snow cover, Cloud cover, sfc T	Snow cover, cloud cover, Total column O_3, O_3 concentration
Boundary conditions	Volcanic emissions, Large fire events, Global anthropogenic emissions, Global transport patterns	Global model (e.g., GEOS-Chem) output, Sfc AQ measurements at inflow boundaries
Biogenic/Geogenic Emissions	Sfc T, WS, PAR, Soil moisture, Lightning	Precipitation, Drought Index, Sfc AQ measurements
Fires	Fuel moisture, Sfc WS, Sfc T, Lightning, Human activities	Fire emissions (e.g., FINN Fire), fire size (acres burned), Rx fire activity, Drought Index, Sfc AQ measurements
Anthropogenic Emissions	Human activities	Sfc AQ measurements, Regulatory implementation schedule, Economic disruptions, Employment, VMT, Energy consumption, Natural disasters
Deposition	Sfc WS, Sfc heat flux, Precipitation	Deposition measurements, Drought Index

[a]Sfc = surface, AQ = air quality, T = Temperature, WS = wind speed, SLP = sea level pressure, Rx = prescribed

Task 1: Data Gathering

We will work with the RTOWG to compile a list of target parameters and recommended displays of analyzed data based on the information in Table 1 along with a suitable priority ranking. Upon review and approval of the target parameters by the RTOWG, we will gather the selected data sets from publically available sources. We recommend ranking the selected parameters and data displays into two general groups: an initial group to be completed within the Phase I budget (see Schedule and Budget below) and a second group to be included if additional funding for a Phase II becomes available. Phase I would focus on data from 2012 – 2016 with particular emphasis on the 2014 – 2016 candidate modeling years. However, the analysis of trends in visibility-reducing species at IMPROVE sites would cover 2000 – 2016, given the importance of these trends to regional haze planning. Other years including 2017 could be included in Phase I to the extent data are available and the marginal cost of including it are minimal. Otherwise, the additional data, associated analysis and additional years of data could be added under Phase II. This would facilitate an examination of longer-term trends and evaluation of the extent to which the effects of "outlier" meteorological years are reflected in the air quality data. Our initial suggestion for these groupings is provided in Table 2.

Table 2. Suggested parameters and analyses.

	Phase I (2014 – 2016)	Phase II (additional analyses and years)
Meteorology	Sfc and upper air T, P[a], WS, WD: Seasonal mean departures from normal PRISM seasonal total precipitation maps	Cloud cover Snow cover maps Lightning Drought Index (TBD)
Fires	Monthly total emissions from FINN and other sources as available (e.g., EPA) total acres burned by state from National Interagency Coordination Center	Evaluate data on prescribed fires for interannual variability and compare with FINN
Air Quality	O_3, $PM_{2.5}$, PM_{10} seasonal means and percentiles by geographic sub-region (keeping urban and rural sites separate) IMPROVE haze composition by year and location for 2000 - 2016 Seasonal total deposition by geographic sub-region from CASTNET/NTN	HNO3 and SO2 seasonal means and percentiles by geographic sub-region (keeping urban and rural sites separate) Additional/Custom IMPROVE PM composition analysis by sub-region and season
Anthropogenic Emissions	High-level NEI totals by state for 2002 – 2016	
Other	Location, time period, and observed parameters for special (short-term, intensive) field studies during ~2014 – 2017; e.g., FRAPPE, CABOTS, LVOS/FAST-LVOS	Case studies examining influence of interannual variations in rural AQ on AQ in urban areas and cross-correlations between species

[a]Sea level pressure (SLP) at surface and 700 and 500 hPa geopotential heights.

Most if not all of the meteorological parameters identified in Table 2 are readily available from various NOAA sources. In addition, some parameters may be available from other sources such as the Western Regional Climate Center (https://wrcc.dri.edu).

Most if not all of the air quality observations are readily accessible via the Intermountain West Data Warehouse, IWDW (http://views.cira.colostate.edu/tsdw/). Certain data analyses, including trends and light extinction composition are also accessible via the IWDW. Additional data, including design values and trends are available from EPA.

Fire emissions are readily available via the FINN (https://www2.acom.ucar.edu/modeling/finn-fire-inventory-ncar). Using FINN has the particular advantage of being available for all years in a consistent fashion so year-to-year deviations in fires will not be due to changes in methodology. FINN has global coverage so fires in southern Canada relevant to air quality in the contiguous US are included. While FINN may not capture smaller fire events, including prescribed fires, it may be possible to compare with data from other sources such as records of prescribed fires kept by some states (WA, OR, ID, MT) and data on total acres burned compiled by the National Interagency Fire Center (https://www.nifc.gov/). Summaries of historical fires are also available from USGS via GEOMAC (https://www.geomac.gov/viewer/viewer.shtml).

Emission inventory data by Source Classification Code (SCC) are available in both raw and summary form from EPA and can also be generated from emissions files compiled by Ramboll and the IWDW for previous studies. Ramboll will work with the RTOWG to identify SCC groupings for summarizing emissions that are most relevant to the states based on the SCCs used by EPA to generate state-level annual summaries (see https://www.epa.gov/air-emissions-inventories/air-pollutant-emissions-trends-data).

In addition to the data identified in Tables 1 and 2, other information sources may be of interest, for example, annual summaries of notable weather events and climate anomalies compiled by NOAA (https://www.ncdc.noaa.gov/climate-information/extreme-events) and documented in the literature (https://www.ametsoc.org/ams/index.cfm/publications/bulletin-of-the-american-meteorological-society-bams/state-of-the-climate/).

Working with the Intermountain West Data Warehouse (IWDW), we will make all collected data available for archive in the IWDW for further analysis in the future.

Task 2: Data Analysis and Display

Data from Task 1 will be summarized by comparing annual and seasonal means and distributions between years by geographic sub-regions. The distributional comparisons will focus on medians and higher and lower percentiles as appropriate including extremes. We suggest the NOAA Climate Regions map (Figure 1) may be most useful for this purpose as it keeps the number of potential sub-regions to a manageable level and conveniently uses state boundaries, thus eliminating the need for a GIS analysis. For Alaska and Hawaii, we suggest that appropriate geographic divisions be discussed with the RTOWG. For air quality data, we suggest keeping results from rural (i.e., IMPROVE, CASTNET) networks separate from the more urban AQS sites. Including the urban sites will be useful for identifying conditions associated with exceedances of the NAAQS that may occur in some years but not others.

Many of the analyses will take advantage of on-line mapping and display functions available via the NOAA and IWDW websites. Where downloaded data files need to be analyzed (e.g., for the routine air quality data), we will use R and Python tools so as to facilitate application to a longer data period in Phase II or later studies and allow others to easily reproduce our results.

Generally speaking, target parameters identified in Tables 1 and 2 can be expected to have reasonably complete data records for the period of interest. However, we will review data availability and apply data completeness criteria appropriate for each analysis to avoid introducing spurious biases in the interannual comparisons.

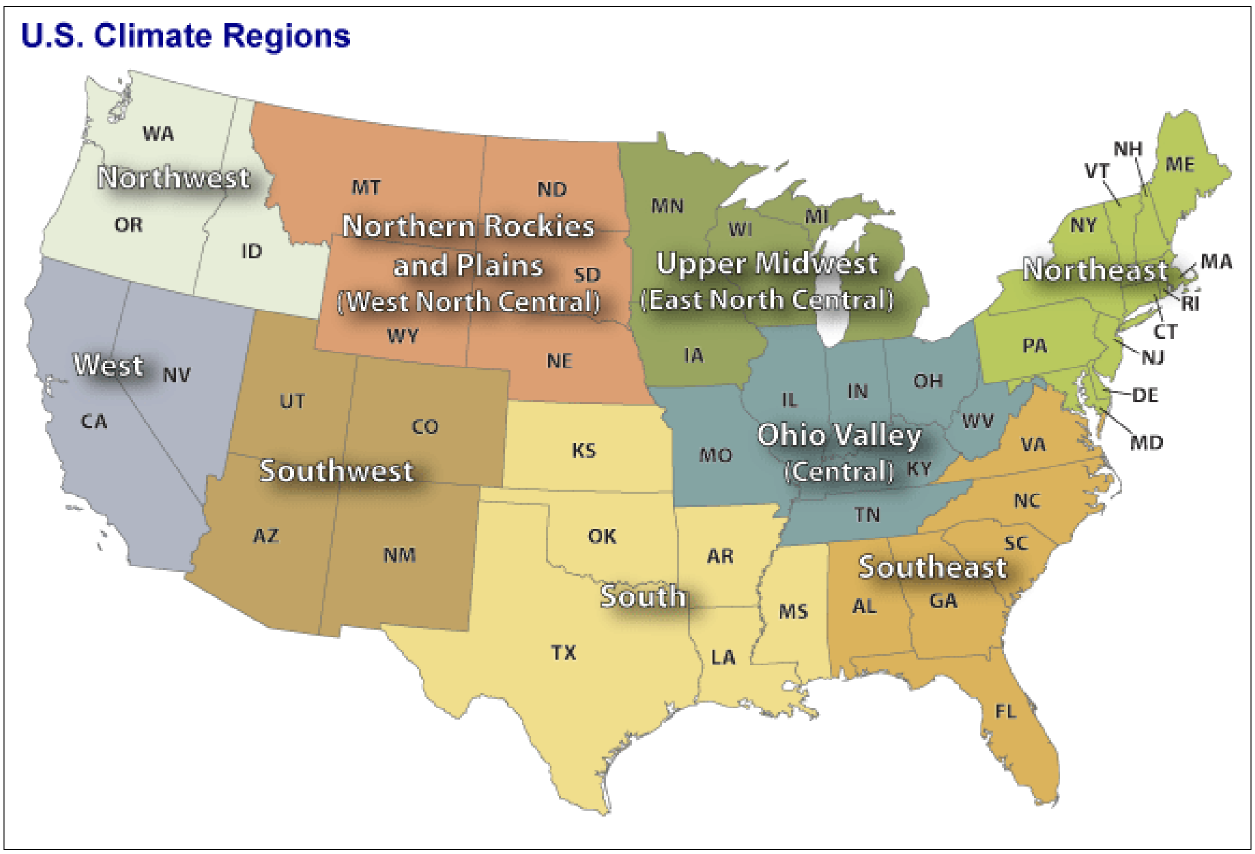

Figure 1. US Climate Regions (source: https://www.ncdc.noaa.gov/monitoring-references/maps/us-climate-regions.php)

<u>Task 3: Reporting</u>

Results from Tasks 1 and 2 will be presented to and discussed with RTOWG representatives via a series regularly scheduled webinars during the course of the project. A final compilation and discussion of results together with documentation of data sources and analysis procedures will be presented in a final technical memorandum. Results for Alaska and Hawaii will be included as appendices to, or sidebars within, the memo to make them easier to locate and understand. The final memorandum will also include recommendations for analyses to pursue under Phase II of the study for the RTOWG's consideration. All data gathered for this project will be made available for archiving in the IWDW.

Cost/Deliverables/Schedule

The following table presents the cost and deliverables for completion of this work.

Phase/Task		Deliverables	Schedule[a]	Cost
Phase I	Task 1: Data Gathering	Data Files	4 weeks	$6,000
	Task 2: Data Analysis and Display	Bi-weekly Webinar Presentations	8 weeks	$10,000
	Task 3: Reporting	Technical Memorandum	12 weeks	$9,000
			Phase I Subtotal:	**$25,000**
Phase II	Additional data gathering and analysis	Bi-weekly Webinar Presentations	15 weeks	$10,000
	Revise/update memo	Technical Memorandum	21 weeks	$5,000
			Phase II Subtotal:	**$15,000**

[a]From authorization to proceed.

Sincerely,

Till Stoeckenius
Sr. Managing Consultant

Ralph Morris
Principal