CHARACTERIZATION OF THE IMPACTS OF CONDITIONS ALOFT ON SURFACE AIR QUALITY TO IMPROVE OZONE SIP MODELING IN THE SAN JOAQUIN VALLEY

I. OBJECTIVE

This research project will collect measurements to characterize atmospheric conditions aloft to improve ARB's modeling of ozone (O_3) concentrations in the San Joaquin Valley (SJV). The extent to which ozone and its precursors aloft (above what the traditional surface monitoring network samples) mix down after sunrise and kick-start ozone formation on days with high ozone concentrations is currently unclear. This research project is designed to improve the accuracy of the modeled vertical structure, mixing, and composition of the atmosphere by making air quality and meteorological measurements aloft on days anticipated to have high ozone concentrations at ground-level sites in the southern SJV. Specifically, these measurements will be used to validate the model's ability to capture the chemical and physical processes leading to elevated ozone concentrations aloft, and to determine to what extent the ozone aloft contributes to photochemistry and high ozone concentrations on subsequent days. If the model is not able to accurately capture these processes, then the measurements will be used as a foundation for improving ARB's ozone modeling and will provide a detailed dataset for validating future updates to the modeling.

II. BACKGROUND

The SJV is classified as an extreme ozone nonattainment area for the 8-hour ozone NAAQS. To attain the NAAQS, it is important to understand better how the various sources of ozone contribute to the high ozone concentrations. The vertical structure and mixing of the lower atmosphere is a very important factor affecting ground-level air quality. During summer in the SJV, relatively shallow nocturnal temperature inversions can cut off the air aloft from the surface layer of air. During the night, differences in emissions and atmospheric processes can cause significantly different pollutant concentrations in the two layers, with higher ozone concentrations aloft due to lack of titration and deposition. The next morning the ozone and other pollutants aloft can mix down and accelerate the formation of ozone, leading to high ozone concentrations.

Recognizing the importance of conditions aloft on air quality at the surface, a number of special field measurement campaigns (e.g., SSJVOS, 1984; SJVAQS, 1990; CCOS, 1999-2001; CalNex, 2010) conducted over several decades have sampled conditions aloft in the SJV. The most recent study (CalNex) occurred early in the summer when ozone concentrations were not representative of the design value upon which the control plan is developed. In addition, measurements from the earlier studies may be out-of-date due to increasing background concentrations of ozone in the free troposphere.

The ability to accurately replicate current and predict future atmospheric processes above the SJV with air quality models is key to the development of effective control plans. Current air quality models often have difficulty replicating the summertime conditions in the SJV associated with temperature inversions and the mixing processes that break them. Air quality (e.g., ozone and its precursors) and meteorological (e.g., temperature, relative humidity) measurements are needed to characterize conditions immediately aloft during episodes with

high ozone concentrations at the surface. The analysis of the measurements will be used to improve the chemistry and advection/diffusion modules in air quality models and to evaluate the number of layers near the earth's surface that are needed for models to accurately represent the atmospheric processes in the southern SJV where the highest O_3 concentrations occur. Because this project will make measurements that are critical to characterizing environmental conditions aloft and improving ARB's modeling of ozone concentrations in the San Joaquin Valley, the results will help ARB to cost-effectively meet the mandate to attain the ambient air quality standard for ozone by 2032.

III. Scope of Work

Air quality and meteorological measurements of conditions aloft are desired on days likely to be associated with high 8-hr mean O_3 concentrations (>75ppb) in the San Joaquin Valley. The measurements should include Fresno, Bakersfield, and the area between the two urban areas. This project would entail sampling the vertical distribution of pollutants (e.g., an aircraft sampling during spirals) at multiple sites in the southern SJV before dawn, in the late morning (when downmixing occurs), and in the afternoon/early evening. The monitoring platform(s) shall at a minimum measure O_3 and meteorological parameters. If practical, trace level measurements of NO_X, CO, particle number, or other indicator of anthropogenic origins are also desired. Ideally, but not critical for this investigative effort, night-time measurements of pertinent NO_X species (e.g., $ClNO_2$, HONO, N_2O_5, and RNO_2) as well as continuous measurements related to surface heat and moisture fluxes would also be useful to the modeling community. Sampling efforts need to focus on collecting data in at least the lowest 1000 feet (agl) of the atmosphere during multiple peak O_3 periods occurring in 2015. Measurements may be needed occasionally at higher altitudes to confirm that local concentrations are not being driven by global or continental processes. The proposal must articulate a monitoring plan that collects the required data (O_3, T, RH, WS/WD measurements at approximately 0400, 1000, 1400, 1800 local time) and as much ancillary information as possible. The plan shall include the rationale for the measurements and locations proposed.

The primary focus of this project will be to better document the vertical concentration profiles of ozone (and ideally other pollutants) that contribute to "kick-starting" the photochemistry on days with high O_3 concentrations in the southern San Joaquin Valley. Because air quality models can "over-mix" the air depending on vertical layer structure (i.e., over-dilute the pollutant concentrations), fine vertical structure characterization is desired to help document the chemical and meteorological processes near the ground layer and into the free troposphere (0-5000 feet agl). The analysis of the measurements will be used to investigate, and where possible improve, the chemical and physical processes in the model related to ozone aloft, including an evaluation of the number of layers near the earth's surface that are needed for models to accurately reproduce ambient conditions and to improve performance relative to the measurements. Ideally, measurements will be continuous to provide the spatial and temporal resolution necessary for evaluating (validating) the performance of the air quality model.

It is not the intent of this Scope of Work to prescribe the best research approach or tools. However, there are a variety of potential resources and tools that could be considered: mobile in-situ measurements (e.g., drones, aircraft), ozonesondes, remote sensing instruments (e.g.,

DIAL, DOAS), and fixed in-situ measurements at various heights (e.g., towers, tall buildings, tethersondes).

Data quality is critical to ensure that measurements are appropriately made and sound conclusions result from the analysis of the observations and comparison with modeling outputs. Thus, the research proposal must also include a section describing the planned quality assurance and quality control (QA/QC) activities which will be performed by the research team. Minimally, the QA/QC plan should provide the efforts listed below.

- Instrument audits (e.g., aircraft instrument responses tested with a through-the-probe audit of multiple known concentrations from a certified source)
- Instrument comparisons (e.g., compare measurements associated with an aircraft spiral or an ozone lidar conducted in conjunction with an ozonesonde release)
- Instrument calibrations against certified standards
- Documentation of data validation protocols and criteria

The research proposal must include draft plans for monitoring/sampling, QA/QC, and basic data analysis.

IV. DELIVERABLES

- Quarterly Progress Reports
- Draft and Final Reports
- Peer-reviewed journal article(s), as appropriate
- All data and analyses generated through the course of this project (the final data from this project will be publicly available for use by modelers and the air quality community)

V. TIMELINE

It is anticipated that this project will be completed 30 months from the start date. This allows 24 months for completion of all work through delivery of a draft final report. The last 6 months are for review of the draft final report by ARB staff and the Research Screening Committee (RSC), modification of the report by the contractor in response to ARB staff and RSC comments, and delivery of a revised final report and data files to the ARB. This timeline assumes the contractor will able to conduct the flights in the summer of 2015. Any lengthy delays in approval or execution of the contract that leads to insufficient time to plan activities for the summer of 2015 would add 12 months to the contract period.

VI. BUDGET: $300,000