EXHIBIT A

SCOPE OF WORK

☒ Contract ☐ Grant

Does this project include Research (as defined in the UTC)? ☒ Yes ☐ No

PI Name: Michael Kleeman

Project Title: Using Integrated Observations and Modeling to Better Understand Current and Future Air Quality Impacts of Wildfires and Prescribed Burns

Contract Augmentation; Modifications to original proposal are reflected as **bold and underlined** text.

Project Summary/Abstract

Prescribed fire has been promoted as a tool for managing fire-resilient ecosystems and mitigating risk from catastrophic wildfires. However, prescribed fires also have potentially significant consequences for air quality and public health. Therefore, new scientific studies are needed to better understand the relative emissions, chemistry, and transport of smoke from wildfires versus prescribed burns. These scientific studies will support policies that are likely to influence the pace and scale of prescribed burns in the state of California, including those outlined in the Action Plan of the Wildfire and Forest Resilience Task Force. In support of this effort, the University of California, Davis (UCD or the Contractor) will quantify the relative magnitude and timing of pollutant emissions, the extent of chemical transformation, transport, and dispersion, and the resultant toxicity of smoke from wildfires and prescribed burns. The Contractor will employ a combined measurement-modeling approach, utilizing a mobile measurement system developed at UCD for rapid deployment during fires, and Chemical Transport Models (CTMs) developed at UCD and the National Center for Atmospheric Research (NCAR), which have been enhanced to predict dispersion and chemical transformation in smoke plumes. The models chosen for this project allow prediction of air pollutants, including particulate matter and hazardous air pollutants, at 1-24 kilometer (km) resolution. This is an appropriate spatial scale for tracking the impacts of wildfires and prescribed burns on urban population centers in California, allowing sufficient spatial and temporal resolution to understand trends in exposure, which is crucial given the inherent variability in fires and their effects on air quality. The UCD and NCAR models will be used for a retrospective analysis of wildfire smoke in the context of air quality, present-day measurement-model comparisons of the composition and health impacts of smoke from wildfires and prescribed burns, and a forecasting analysis of the differential air quality impacts of wildfires and **multiple** prescribed burn~~s~~ **scenarios to cover a range of treatments being considered by the agencies tasked with reducing forest fuel loads. One set of scenarios will focus on reducing fuel loads at the wildland-urban interface, prioritizing property protection and reduced risk of injury or death, but placing prescribed burn emissions closer to population centers. The second set of scenarios will focus on reducing fuel loads in the forest center, which mitigates potential smoke impacts from major fires that can increase particulate matter burdens over large geographical regions**. Emissions inventories and plume rise parameterizations will be updated

in ~~both~~ **the** models **used to represent wildfires and prescribed burns** to reflect the current state of the science. This approach builds on more than a decade of wildland fire research by each investigator/subcontractor, and represents a new collaboration to provide the broad expertise needed to address the interdisciplinary problems inherent in wildfires.

If Third-Party Confidential Information is to be provided by the State:

☐ Performance of the Scope of Work is anticipated to involve the use of third-party Confidential Information and is subject to the terms of this Agreement; ***OR***

☐ A separate CNDA between the University and the third-party is required by the third-party and is incorporated in this Agreement as Exhibit A7.

Task 1: Design a Research Plan / Field Deployment Plan for Characterizing Wildfire Smoke

Fire Selection and Sampling Strategies. The Contractor will make measurements in at least two (2) wildfires and two (2) prescribed burns over the first two (2) years of the project as recommended by an advisory board with membership from CARB, CALFIRE, UC Agriculture and Natural Resources (UC ANR), and US EPA, and as conditions permit. The random nature of wildfires precludes the definition of specific sampling events; however, locations will be prioritized based on the prevalence of recent catastrophic wildfires, the wildfire hazard index, and the proposed efficacy of prescribed burns. Northern California (North Coast, Klamath, Modoc, Sierra Nevada), with > 87% of the area burned in the largest wildfires over the past six (6) years[57]It is one (1) region of priority. However, opportunities to sample in Southern California (South Coast, Transverse) will also be pursued. Wildland-urban interface (WUI) wildfires will be prioritized over all other fires, given current knowledge gaps, limited opportunities, and inherent challenges in sampling these events.

It is unlikely that a wildfire would spontaneously start alongside a prescribed burn, given the required meteorological conditions for prescribed burns and the fact that prescribed burns are typically conducted during the off-season, but a prescribed burn may grow into a wildfire if conditions shift unexpectedly. If the prescribed burn does evolve into a wildfire, the Contractor will continue to monitor this rare event and separately analyze prescribed burn periods versus wildfire periods.

Once on-site in an active fire zone, the Contractor will coordinate all sampling efforts through incident command and will originate at base camp. Any subsequent movement within the fire zone will be at the discretion and direction of onsite personnel. Existing and new relationships with CALFIRE, the California Occupational Safety and Health Act (Cal/OSHA), the UCD, and Santa Rosa Fire Departments, as well as UC ANR, will be leveraged to facilitate sampling of both wildfires and prescribed burns, following incident-specific safety protocols. An advisory committee will be formed with individuals from these stakeholder agencies, as well as the California Air Resources Board (CARB), local District Staff, and an Air Resource Advisor, to consult on the selection, location, and duration of sampling events. For wildfires, the Contractor anticipates a minimum of two (2) days per sampling event, but will be equipped for a maximum of ten consecutive sampling days. The intent is to remain at the sampling site until the emissions subside sufficiently for background measurements to be made. A secondary objective is to measure the full spectrum of combustion phase (flaming to smoldering) for specific fires as opportunity allows, which may require additional time or relocation. In this case, additional supplies and samples can be ferried to and from UCD as needed. Prescribed burns will be sampled for the duration of the event. Ambient background conditions will be measured immediately prior to ignition for prescribed burns and upwind of wildfires using the same sampling and analysis techniques. When comparing wildfire and prescribed burn measurements, data will be normalized by total, background-corrected carbon measured (CO_2 + CO + CH_4 + NMHCs + particulate C), which serves as a proxy for carbon consumed by the fire.

Task 2: Design Multiple Scenario-Based Modeling Frameworks for Prescribed Burning Activities

Model Wildfires in Northern California and Southern California, Past 10 Years. Principal Investigator (PI) Kleeman has support under National Institutes of Health (NIH)/ National Institute of Environmental Health Sciences (NIEHS) R01ES031701, United States Department of Agriculture (USDA) 2021-51181-35862, and US EPA RD84048401 to simulate smoke exposure during all major wildfires in California over the past 10 years using a combination of advanced emissions models, CTMs (source-oriented UCD/CIT model for this project), and machine learning models.

For these retrospective simulations, the Contractor will derive wildfire area burned from historically mapped perimeters from the CALFIRE and Resource Assessment Programs GIS database. The Contractor will then use satellite-based active fire products (MODIS, VIIRS, GOES-ABI) to apportion the area burned within specific days. Emissions will be generated as described under emissions algorithms above.

Hourly meteorology inputs to drive the regional chemical transport model at one (1) km resolution will be simulated using the WRFv3.4 model (www.wrf-model.org). The model will have 31 vertical layers, ranging from ground level to a top pressure of 100 hPa. Initial and boundary conditions for meteorological simulations will be obtained from the North American Regional Reanalysis (NARR), which has a spatial resolution of 32 km and a temporal resolution of 3 hours. The Yonsei University (YSU) boundary layer vertical diffusion scheme[58] and the Pleim-Xiu land surface scheme[59] will be adopted in this study. Four-dimensional data assimilation will be applied to anchor the model predictions to observed meteorological patterns.

The base 2020 emission inventory produced by CARB will act as the starting point for CTM anthropogenic emissions. CARB provided the 2020 emissions inventory based on a CEPAM 2019v1.03 Planning Inventory. The yearly changes to these emissions inventories can be estimated using emissions trends available on the CEPAM website (https://ww2.arb.ca.gov/applications/cepam2019v103-standard-emission-tool). This inventory will represent all mobile, point, and non-point (area) sources with four (4) km spatial resolution across California. This inventory will first be downscaled to one (1) km spatial resolution over selected subdomains of California using more detailed location information for sources or their spatial surrogates. This method should be accurate when averaging over sufficiently large areas, but may be inaccurate over smaller domains. Many aspects of the emissions inventory are based on "average day" time patterns that do not account for accidents, unusual weather patterns, or other events. Once again, these emissions are considered accurate when averaged over sufficiently long time periods, but they may be inaccurate over shorter periods.

The Contractor will use Random Forest Regression (RFR) to combine CTM predictions with measurements from satellites and ground-based monitors to improve the accuracy of the predicted exposure fields. RFR is a statistical machine learning (ML) approach that has been demonstrated to be a powerful tool for air quality modeling, surpassing traditional statistical methods such as bias correction (BC) and multiple linear regression (MLR)[60–63]. Four (4) major support elements will be used in the RFR approach: surface monitoring data from US EPA and Purple Air, Moderate Resolution Imaging Spectroradiometer optical depth (AOD) retrievals, meteorology data from WRF, and CTM results from the UCD/CIT model.

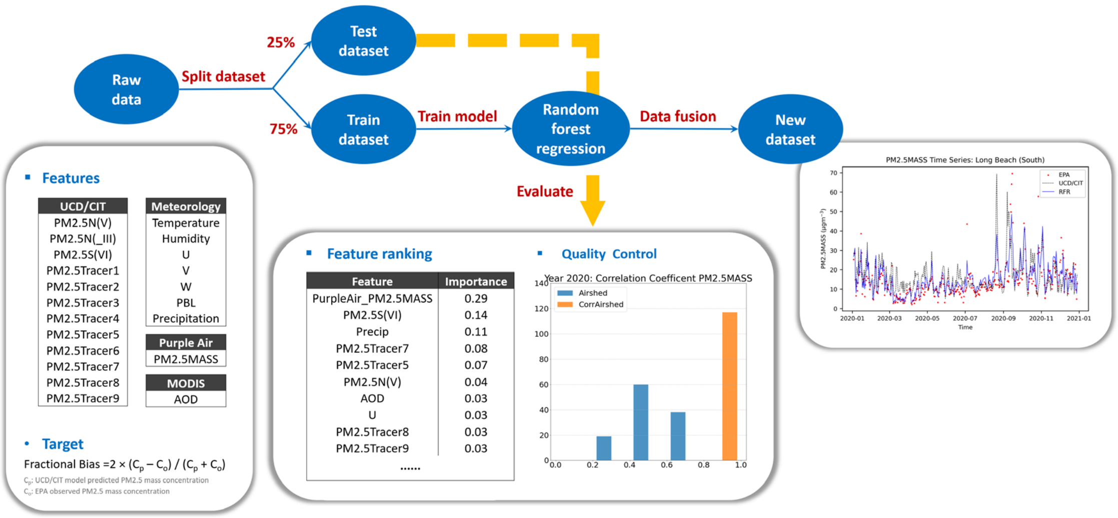

Figure 6. Flow chart of the random forest algorithm.

The fractional bias (FB) values between UCD/CIT PM2.5 variables and US EPA daily average observations will be calculated as training targets in the RFR approach. Fractional bias is defined as

$$FB = 2\left(\frac{M - O}{M + O}\right)$$

Where *M* is the model prediction and *O* is the measured value. The equation cannot take on values outside the range of -2 to +2. Figure 6 illustrates the basic steps of how the RFR technique will be employed in this study, using $PM_{2.5}$ mass as an example. The FB between predicted and measured $PM_{2.5}$ mass concentrations will be calculated first. The dataset will then be randomly split into a training set (75%) using the training features listed in Figure 6 and a test set (25%). During training, the RFR algorithm constructs a large number of decision trees and then combines the predictions from all the trees to arrive at a final prediction for the output data. To evaluate model accuracy, the RFR model derived from the training dataset is applied to the test dataset. Once trained, the RFR model is used to predict the FB for $PM_{2.5}$ mass in every model grid cell. The RFR predictions are independent of the original FB equation, and so any extreme FB values must be limited to the range between +2 and -2. The correction factor (CF) will then be applied to the UCD/CIT PM2.5 mass prediction:

$$CF_{PM2.5MASS} = (2 + FB_{PM2.5MASS}) / (2 - FB_{PM2.5MASS}).$$

The training process summarized above for $PM_{2.5}$ mass will be applied to five (5) additional predicted concentrations, including PM2.5 OC, PM2.5 EC, PM2.5 ammonium ion, PM2.5 nitrate, and $PM_{2.5}$ sulfate. Some of these species also appear as training support variables. In these cases, the RFR training procedure is modified to remove the target variable from the list of training support variables. The final step of the RFR method involves calculating the mean CF based on the weighted fraction average of the CF values derived from the six (6) sets of RFR training. This approach optimizes improvements across all PM variables. Figure 7 summarizes the performance of the RFR approach during simulations for the year 2020 at the Bakersfield, California, monitoring site. Peak concentrations in the fall months are associated with wildfire events.

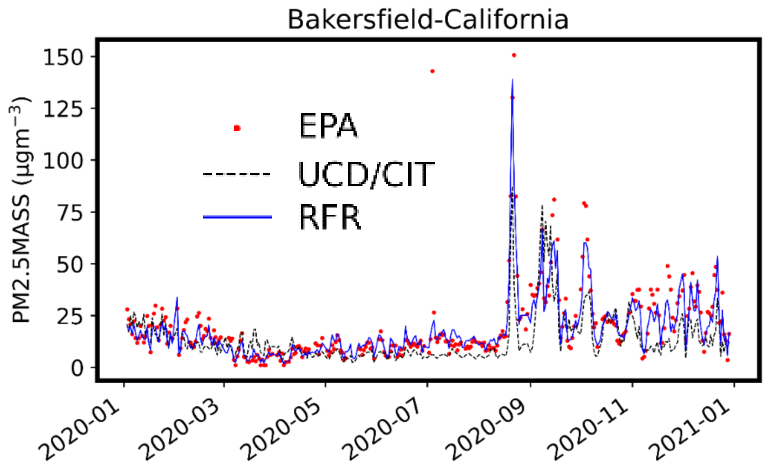

Figure 7. Predicted $PM_{2.5}$ mass concentrations with and without RFR correction at Bakersfield, CA, during the year 2020. Peak concentrations in fall months are associated with wildfire events.

The Contractor will track wildfire smoke separately from routine sources of airborne PM, such as mobile sources, industrial sources, etc., using source tagging features inherent in the UCD/CIT CTM. Smoke generated from natural vegetation will be tracked separately from smoke generated from the urban interface, where buildings, vehicles, and other infrastructure may be burned. The products from this externally funded research will act as a comparison point for scenarios that use prescribed burns to mitigate wildfire risk.

Design Prescribed Burn scenarios to Mitigate Wildfire Risk. The Contractor will model prescribed burn scenarios using MUSICAv0 and the UCD/CIT model based on emissions from FINNv2.5 and BlueSky. Building on existing collaborations and recent research projects (Barsanti as co-PI on UC Lab Fees-Banerjee and CARB 19RD008), prescribed burn scenarios will be developed in coordination with UC ANR, CAL FIRE, and CARB to hypothetically reduce fuel load in locations where wildfires occurred or are likely to occur. Each prescribed burn scenario will stipulate the exact days on which prescribed burns would have been or future days when burns could be carried out, the ignition points, and the target burn area. Prescribed burn days in each scenario will be selected based on actual meteorological predictions for each day of the calendar year in current/historical simulations. As an example, ideal conditions for prescribed burns in coniferous forests include clear sunny days (< 30 °C) with low winds (< 5 m/s) and moderate humidity (0.25-0.45) during a time of the year when soil moisture is relatively high (0.15-0.03 m^3/m^3)[64]. Each of these parameters is available from existing WRF simulations for California archived by PI Kleeman's research group with hourly time resolution and four (4) km spatial resolution over California between the years 2000-2023.

Note that the frequency and duration of present-day prescribed burns are not sufficient to suppress wildfire at the desired level in the current analysis. The future modeling scenarios will explore much greater amounts of prescribed burning. The Contractor will model the monitored prescribed burns and quantify the change in air quality induced by that fire, but the future scenarios will go far beyond this level.

From the retrospective modeling led by UCD, the Contractor will have statistical representations of historical wildfires, including location, size (daily acres), emissions, duration, and air quality impacts. The Contractor will use these representations to design and conduct a set of model simulations representing the observed range of historical fires over a five-year time period. The Contractor will then rerun these simulations, gradually increasing prescribed burns and gradually decreasing wildfires over the same time period. The Contractor will consult with Rob York of UC Berkeley/UC ANR to develop realistic prescribed burn scenarios, including location, duration, and timing of the burns, as well as the extent to which they are likely to reduce the frequency and severity of wildfires over that time period. This analysis will attempt to represent the stochastic nature of both wildfires and prescribed burns within the project's resource constraints.

The air quality impacts of prescribed burns relative to wildfires are strongly linked to the types and amounts of fuel consumed, the spatial overlap of the burns (and thus the efficacy in reducing fuel loads and fire intensity, for example), and seasonal meteorology. By removing fuels in a controlled manner, prescribed burns can dramatically reduce the likelihood of larger, more destructive wildfires. Compared to uncontrolled wildfires, prescribed burns can result in a net decrease in total smoke and pollutant emissions.

To account for important differences in air quality drivers, the Contractor will consider two prescribed burn scenarios with different management objectives:

- **(i)** **priority areas defined by the state of California that are primarily concentrated in or near the WUI, thus designed to reduce fuels in areas that protect human life and property, and**
- **(ii)** **forested areas defined by the state of California that are located further from the WUI, thus designed to reduce fuels in areas with heavy fuel loads.**

A range of simulations (as described in the previous paragraph) will be considered under each of the scenarios.

Measures of success for prescribed burns targeting WUI areas include:

- **Fire intensity reduction: a decrease in fire intensity and flame length within and around the WUI due to strategic fuel breaks.**
- **Reduced fire spread: a reduced likelihood of fire spotting and ember ignition in residential areas.**
- **Minimized loss: a reduction in the number of homes and other critical assets at risk during wildfire events.**

Measures of success for prescribed burns targeting heavily forested areas include:

- **Fire intensity reduction: a decrease in fire intensity and flame length, resulting in less canopy consumption.**
- **Reduced fuel loading: a decrease in fuels available for consumption, thereby reducing smoke emissions.**
- **Ecosystem function: simulation demonstrating that these managed fires can reduce fuel loads in inaccessible areas with minimal environmental cost or risk, while restoring the ecosystem's natural fire cycle.**

The modeling scenarios will not evaluate the effectiveness of the Rx burns, but can enable a more comprehensive comparison of the air quality impacts of Rx burns relative to wildfires, considering both of these important management objectives.

Determining the burned area in both scenarios will involve the use of a spatial optimization program that identifies and prioritizes the fuel treatment locations based on the identified management objective(s). The spatial locations of fires in each scenario (e.g., WUI vs. forest) are informed by the CalFire priority landscapes descriptions. The spatial distributions of burns are dependent on burned acreage per year and databases of standard burn sizes as a function of landscape type. Detailed fuel maps (including fuel types, loading, and moisture) are then used in calculations of emissions, reflecting the

differences between wildfires and the prescribed burn scenarios. The spatial optimization model relies on a suite of geographic and environmental data to define burn locations and sizes, which, coupled with fuel data, are then used in emissions calculations.

The burn scenarios will build on existing literature and be developed in consultation with experts at UC Berkeley (John Battles) and CalFire (Joe Restaino). Under the first scenario, prescribed fire in and around the WUI can help prevent wildfires from burning into urban areas, but the smoke from the prescribed burns will also be much closer to those same urban populations. Alternatively, prescribed burns in the forest center can reduce the intensity of major wildfires that can affect air quality hundreds of kilometers away, but may do little to protect cities from the direct effects of fire. In addition to location, prescribed fire emissions will also depend heavily on the fuels burned. Both scenarios are plausible, and the results from this project will help agencies understand the population impacts of prescribed burning smoke as a function of proximity to city centers.

Model outcomes and benefits: The model-based scenario provides several key insights and benefits that have not yet been addressed with a state-of-the-science air quality modeling:

- **Shifting fire location: Simulations show how the landscape-scale networks of prescribed burn treatments influence the magnitude of emissions, smoke dispersion, and population exposure estimates at different treatment locations while considering different management objectives and realistic meteorological conditions.**
- **Fire severity and ecosystem resilience: The model builds on published relationships showing how fire-based fuel treatments (designed to restore forest resilience by promoting fire-resistant tree species and breaking up large, contiguous areas of hazardous fuels) influence fire severity, subsequent emissions, and associated health outcomes.**
- **Strategic planning: The results provide land managers with science-based estimates of the air quality impacts, including potential exposure levels and associated health costs, across multiple scenarios: recent historical wildfires, wildfires influenced by prescribed burns (reflecting reduced fuel loads and fire severity), and prescribed burns conducted under varying management objectives and diverse fuel conditions. These insights can inform decisions on where and how to invest resources to achieve the most significant ecological and fire mitigation benefits across both WUI and remote landscapes.**

The Contractor will characterize the effects of wildfires on air quality through modeling analysis of historical burns and measurement and modeling of current fires, demonstrating the impact of wildfires with little to no influence from prescribed burns. This will serve as a lower-end estimate of the “business as usual” scenario. Further analysis (e.g., as a function of shifting vegetation and population dynamics, different emissions, and climate scenarios) is beyond the scope of this contract.

The Contractor will evaluate changes in air quality between the wildfire and prescribed burn scenarios, particularly $PM_{2.5}$, and the associated health impacts. These changes will be assessed at different temporal (e.g., 1-hr, 24-hr, annual) and spatial scales (e.g., 4- 100s km) accessible using MUSICAv0 and the UCD/CIT model that are appropriate to understand trends in exposure, which is important given the inherent variability in both wildfires and prescribed burns and their resultant impacts on air quality. Statistical analyses will be performed to determine the extent to which wildfires and prescribed burns result in differential health impacts within the variability of the predictions generated by the two (2) modeling systems. The mean and standard deviation of population exposure to smoke will be calculated during multiple wildfires and prescribed burns. Hypothesis tests and confidence intervals will be used to determine if population exposure to smoke is reduced during scenarios that adopt prescribed burns.

Compare Population Exposure in Wildfire and Prescribed Burn Scenarios. One approach for estimating the health impacts of smoke is to calculate daily short-term excess mortality from fires, which accounts for the relative risk of exposure to daily PM2.5 concentrations with and without fires, taking into account both the change in concentration and the potential increase in toxicity associated with $PM_{2.5}$ from smoke.[66,67] This approach for estimating relative risk and short-term mortality is at the foundation of the US EPA BenMap[65] model, and has been used previously for fires in the US and other countries[67]. BenMap encodes concentration-response functions from high-quality epidemiological studies, providing a convenient tool for estimating health effects resulting from changes in the burdens of $PM_{2.5}$ and ozone. Unfortunately, BenMap does not directly predict public health impacts from toxic compounds; therefore, these effects will be described through changes in population exposure.

A key consideration in evaluating prescribed burning scenarios will be the requirement that changes in air pollution exposure do not disproportionately increase the health burden on any group, especially those from historically disadvantaged communities. The Contractor will calculate population-weighted concentrations of wildfire smoke for each racial and ethnic group using demographic information obtained from the American Community Survey (ACS). The relative toxicity of each unit of fire smoke exposure will be considered based on the composition measurements made during prescribed burn and wildfire events (Task 1). The potential changes in health burdens carried by each racial and ethnic group will be carefully considered in the final evaluation of public health impacts.

Task 3: Data Analysis of Ambient Observations and Corroboration with Scenario-Based Modeling

Compare Predicted and Measured Concentrations in Plumes Downwind of Wildfires and Prescribed Burns. The Contractor will conduct simulations of the wildfires and prescribed burns measured during Task 1 of the current study using both the UCD/CIT and MUSICAv0 models, and then evaluate model predictive accuracy for those events. The Contractor will characterize each burn by total smoke emissions (kg/hr) to help put the results in context relative to the spectrum of current wildfires. The evaluation will focus on $PM_{2.5}$ mass, PM chemical composition, and HAPs. The Contractor will develop specific metrics to evaluate model accuracy that are relevant for exposure and health outcomes and take advantage of the extensive measurement capabilities of the 2RMRU platform. The Contractor will also evaluate model results using PurpleAir, US EPA AQS (Air Quality System), and satellite retrievals of aerosol optical depth. Both the UCD and NCAR teams have experience with such measurement-model evaluations for fires.

The CTMs used in the current study employ a first-order closure method for turbulent transport in which the pollutant turbulent flux is assumed to be proportional to the mean gradient of the pollutant concentration (K-theory). It is important to recognize that this form of closure model only matches measurements over sufficiently large averaging operations in space and/or time. First-order closure models cannot predict the instantaneous behavior of the random turbulent processes in the atmosphere. For example, Figure 8a illustrates a hypothetical snapshot of a narrow smoke plume viewed from above, while Figure 8b illustrates the time-averaged concentration field downwind of the wildfire. The concentrated instantaneous narrow plume follows a random path dictated by individual turbulent eddies (a random process that cannot be precisely predicted). At the same time, the long-term average concentration assumes the standard Gaussian profile (follows predictable behavior). CTMs are based on the timescales inherent in Figure 8b; therefore, model-measurement comparisons must be carried out within that regime.

The Contractor will collect measurements during prescribed burns and wildfires over times that range from minutes to hours, depending on the sampling media and target analytical method. Measurements from multiple samples will be averaged in time and/or location to create a comparison point for model evaluation. CTM predictions with and without RFR corrections will be combined at corresponding times and places for comparison to measurements. Model performance statistics will include fractional bias, fractional error, Pearson Correlation Coefficient, and root mean square error. The accuracy of model predictions during historical fires will be used as an estimate of the accuracy of model predictions under prescribed burn scenarios.

(a) instantaneous concentration of a narrow plume originating from the left	(b) time-averaged Gaussian concentration profile originating from the left

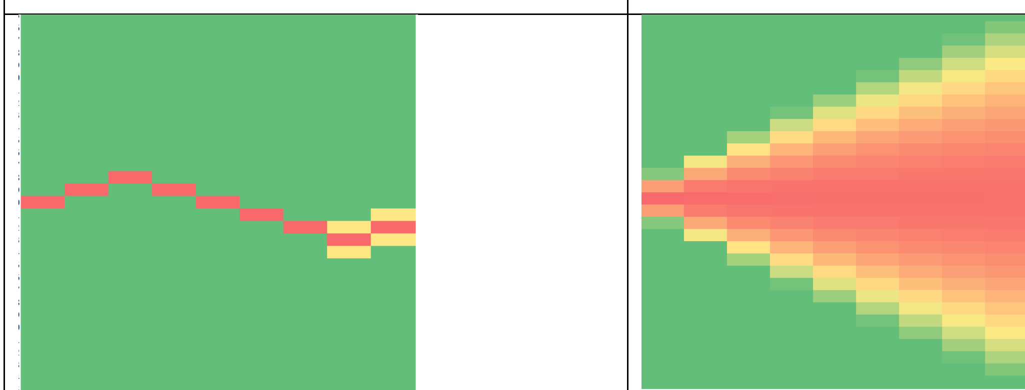

Figure 8. (a) Instantaneous vs. (b) time-averaged smoke concentration downwind of a wildfire.

Evaluate the Model's Ability to Predict Chemical Aging of Smoke. The CTMs chosen for this project represent gas-phase chemistry and secondary organic aerosol (SOA) formation with sufficient complexity to investigate differences in chemical aging of smoke between wildfires and prescribed burns. The Contractor will modify models as needed to incorporate recent updates in emissions, chemical mechanisms, and SOA parameterizations that may impact predictions of plume chemistry and chemical aging of smoke. Models will also be modified as needed to better represent the differences between prescribed burns and wildfires that aren't routinely captured by the existing CTMs. The Contractor will develop specific metrics to evaluate if the models accurately predict changes in smoke concentration and composition that are relevant for exposure and health outcomes. This will enable the Contractor to systematically assess the public health impact of wildfires and prescribed burns in the modeling scenarios.

Task 4 Communication and Coordination with CALFIRE/CARB to Improve Comparative Analysis

The Contractor will regularly communicate with CALFIRE and CARB staff members as relevant to optimize prescribed burns and wildfires targeted for measurements and model analysis. The project team will also regularly communicate with CALFIRE and CARB staff as relevant when designing prescribed burn scenarios to ensure that the location, frequency, and size of the prescribed burn scenarios capture the range of options being considered in California. Early and frequent communication throughout the project will ensure that the results provide helpful information for future policy decisions.

Task 5 Final Report and Sharing of Results

Project results will be compiled as a final report and as peer-reviewed articles in scientific journals. Plain-language summaries will be published on a website every six (6) months and at the conclusion of the project to inform interested members of the general public about project results. The Contractor will submit a draft final report to CARB and CAL FIRE six (6) months prior to the agreement end date. The final report will be amended based on comments received from CARB and CAL FIRE and will be submitted to CARB and CAL FIRE two (2) weeks before the agreement end date. A final seminar will be held in coordination with CARB to provide an interactive forum where the project's scientific findings and policy implications can be thoroughly discussed and explored.

Conclusion

Advancing the representation of smoke from wildfires and prescribed burns in state-of-the-science air quality models, evaluating model predictions using state-of-the-science measurements, and developing prescribed burn scenarios representative of California are critical for assessing the public health impacts of prescribed burns relative to wildfires. **The modeling studies provide currently lacking information on the air quality impact estimates of prescribed burn scenarios in different landscapes with different management objectives. By simulating emissions, chemistry, and transport, these models can quantify the probability of smoke exposure in populated areas and optimize the allocation of resources to simultaneously protect human life and property, while also contributing to overall forest health in areas farther away from communities. By reducing fuel loads, prescribed burns also create fire-resilient landscapes where future fires burn with less intensity and are more easily managed. This protects ecosystems and helps prevent the release of large amounts of carbon that have been stored for decades.**

Addressing current knowledge gaps and informational needs in these areas, as highlighted in the SOW, requires a project team with interdisciplinary experience. To that end, the Contractor has assembled a new collaborative team and outlined an approach that combines measurements and models to specifically address the most critical knowledge gaps in the areas of emissions, chemical transformation, and exposure to smoke generated from prescribed burns and wildfires. The Contractor will share information with other project teams across the US working on similar problems in different geographic regions to maximize the benefits of the gained knowledge. The project's results will provide a scientific foundation for prescribed burn policies that enhance air quality and improve public health outcomes in California.

Meetings

A. Initial meeting. Before work on the contract begins, the Principal Investigator and key personnel will meet with the CARB Contract Project Manager and other staff to discuss the overall plan, details of performing the tasks, the project schedule, items related to personnel or changes in personnel, and any issues that may need to be resolved before work can begin.

B. Progress review meetings. The Principal Investigator and appropriate members of their staff will meet with CARB's Contract Project Manager at quarterly intervals to discuss the project's progress. This meeting may be conducted by phone.

C. Technical Seminar. The Contractor will present the project results to CARB staff and, if applicable, a webcast at a seminar held at CARB facilities in Sacramento or El Monte.

Deliverables

The deliverables produced in the proposed research include a database of measured concentrations downwind of prescribed burns and wildfires, estimated emissions for historical fires, predicted exposure fields downwind of prescribed burns and wildfires, and a final report synthesizing the results into overall conclusions.

Measured concentrations will be archived in comma-separated value (CSV) format with date, time, location, and value for each record. Method detection limits (MDL) will be reported for each analyte. Standard Operating Procedures (SOPs) will be provided for each measurement and analysis method.

Predicted exposure fields downwind of prescribed burns and wildfires will be archived in either CSV format or NetCDF format. Each exposure field will contain meta-data summarizing the model version, the map projection, date, time, and pollutant concentrations. **Separate files will be produced for each prescribed burn scenario (priority WUI focus vs. priority deep forest focus).**

The final report will utilize the measurement data and model predictions to test the hypotheses described above, thereby enhancing our understanding of the potential impact of prescribed burns on air quality in California.

Project Schedule

Task 1: Design a Research Plan / Field Deployment Plan for Characterizing Wildfire Smoke
Task 2: Design Multiple Scenario-Based Modeling Frameworks for Prescribed Burning Activities
Task 3: Data Analysis of Ambient Observations and Corroboration with Scenario-Based Modeling
Task 4: Communication and Coordination with CALFIRE/CARB to Improve Comparative Analysis
Task 5: Final Reporting and Sharing of Results

Task	Year 1				Year 2				Year 3			
1												
2												
3												
4												
5												
	m,p	p	m,p	p	m,p	p	m,p	p	m,p	m,p	m,p	m,p

Task	Year 4			
1				
2				
3				
4				
5				
	m,p	dfr	fr	

m=meeting p=progress report dfr=draft final report fr=final report

EXHIBIT A6

CURRENT & PENDING SUPPORT

PI: M. Kleeman					
Status	**Award #**	**Source**	**Project Title**	**Start Date**	**End Date**
ACTIVE	23RD006-1	CARB	Using Integrated Observations and Modeling to Better Understand Current and Future Air Quality Impacts of Wildfires and Prescribed Burns	4/1/2024	~~3/31/2027~~ **3/31/2028**
ACTIVE	R01-ES031701	NIH/NIEHS	The CHARGE Study Phase II	5/1/2020	1/31/2025
ACTIVE	4979-RFA20-1B/21	HEI	Ambient Air Pollution and COVID-19 in California	4/1/2021	12/31/2023
ACTIVE	R01-ES033413-01	NIH/NIEHS	Extreme weather, air pollution, and stroke among an aging female population	1/1/2021	12/31/2023
ACTIVE	R01-AG074347-01	NIH/NIEHS	Extreme weather-related events and environmental exposures in a risk for Alzheimer's disease and related dementias		
ACTIVE	NOA 1RF1NS130659-01	NIH/NIEHS	Do atmospheric ultrafine particles lodge in the brain and cause cognitive decline, leading to Alzheimer's disease-related dementias?	12/1/2022	11/30/2027
ACTIVE	2021-51181-35862	USDA	Smoke taint risk from vineyards exposed to wildfire smoke: Assignment and management strategies.	1/1/2022	12/31/2025
ACTIVE	RD84048401	EPA	Early Life Vulnerability to Climate-driven Wildfire Events on Pregnancy and Child Development Health Outcomes in Underserved Populations		
ACTIVE		Climateworks	Alternative Jet Fuel in California – Modeling LCFS Policy Scenarios and Air Quality Impact Considerations in the 2030 Timeframe	8/1/2021	12/31/2023

ACTIVE	19-RD012	CARB	Direct Measurements of Ozone Sensitivity to Oxides of Nitrogen and Volatile Organic Compounds in the South Coast Air Basin	8/1/2019	8/31/2023
ACTIVE	21-TTD004	CARB	Updated welding toxic emissions estimates in California	7/1/2022	6/30/2024
ACTIVE	22-ISD010	CARB	Evaluation of Air Toxics, Metals, and VOCs Found in Biogas, Biomethane, and their Combustion Products	6/1/2023	5/30/2026
ACTIVE		LADPH	Aliso Canyon Community Exposure and Health Study	11/1/2022	10/31/2025
ACTIVE	22AQP001	CARB	Updating California Temporal Profiles	7/1/2022	6/30/2024

Name: K. Barsanti					
Status	**Award #**	**Source**	**Project Title**	**Start Date**	**End Date**
ACTIVE	23RD006**-1**	CARB	Using Integrated Observations and Modeling to Better Understand Current and Future Air Quality Impacts of Wildfires and Prescribed Burns	4/1/2024	3/31/2027
ACTIVE		UC Lab Fees	Transforming Prescribed Fire Practices for California	3/1/2020	2/28/2024
ACTIVE		CARB	Understanding and Mitigating Wildfire Risk in California	1/1/2020	12/31/2023
ACTIVE		NSF	Mechanistic Studies of Secondary Organic Aerosol Production from Biomass Burning Derived Precursors	1/1/2018	8/31/2023

Name: K. Bein					
Status	**Award #**	**Source**	**Project Title**	**Start Date**	**End Date**
ACTIVE	23RD006**-1**	CARB	Using Integrated Observations and Modeling to Better Understand Current and Future Air Quality Impacts of Wildfires and Prescribed Burns	4/1/2024	3/31/2027

ACTIVE	R01ES026670	NIH/NIEHS	Air pollution, atherosclerosis, and the role of the aryl hydrocarbon receptor	3/1/2019	2/28/2024
ACTIVE	P30ES023513	UCD NIEHS Environmental Health Sciences Center	Wildfire toxicology: fingerprinting toxicological triggers in wildfire emissions	4/1/2021	9/30/2023
ACTIVE	RF1AG074709	NIH/NIEHS	Traffic-related air pollution exacerbates AD-relevant phenotypes in a genetically susceptible rat model via neuroinflammatory mechanisms.	5/1/2021	4/30/2026
ACTIVE	R21ES033460	NIH/NIEHS	Epigenetic crossroads of environmental exposures and early-life adversity	10/1/2021	9/30/2023
ACTIVE	P30CA093373	UCD P30 Comprehensive Cancer Center	Assessment of wildfire smoke exposures and the risk of lymphoma development: possible role of the Ah-receptor as a central mediator	9/1/2022	8/31/2024
ACTIVE	U54OH-007550-21	National Institute of Occupational Safety & Health	Assessing the impact of co-exposure to agricultural and wildfire emissions on California farmworker health	9/30/2022	9/29/2027
ACTIVE	R01NS130659-01	National Institute of Neurological Disorders and Stroke	Do atmospheric ultrafine particles lodge in the brain and cause cognitive decline, leading to Alzheimer's disease-related dementias?	12/1/2022	11/30/2027
ACTIVE	R01ES033472	National Institute of Environmental Health Sciences	Synergistic effects of stress and traffic-related air pollution on cardiovascular health	2/1/2023	1/31/2026

Name: S. Raffuse					
Status	**Award #**	**Source**	**Project Title**	**Start Date**	**End Date**
ACTIVE	23RD006**-1**	CARB	Using Integrated Observations and Modeling to Better Understand Current and Future Air Quality Impacts of Wildfires and Prescribed Burns	4/1/2024	3/31/2027
ACTIVE	RD84048401	EPA	Early Life Vulnerability to Climate-driven Wildfire Events on Pregnancy and Child Development		

			Health Outcomes in Underserved Populations		
ACTIVE	68HERH23D 0004	EPA	Support for the Chemical Speciation of PM Filter Samples	3/1/2023	3/1/2027
ACTIVE	140P212D00 04	NPS	IMPROVE Operations and Filter Analysis	1/1/2021	1/31/2026
ACTIVE	P21AC11294	NPS	Research and Development to Support the Interagency Monitoring of Protected Visual Environments Program	8/1/2021	7/1/2024
ACTIVE	19-JV-11261987-108	USDA Forest Service	Improving Fire and Smoke Emissions Modeling	10/1/2022	09/30/2024
ACTIVE	2131914	NSF	Mid-scale RI-1 (M1:IP): ASCENT: Atmospheric Science and Chemistry mEasurement NeTwork	10/1/2021	9/30/2024