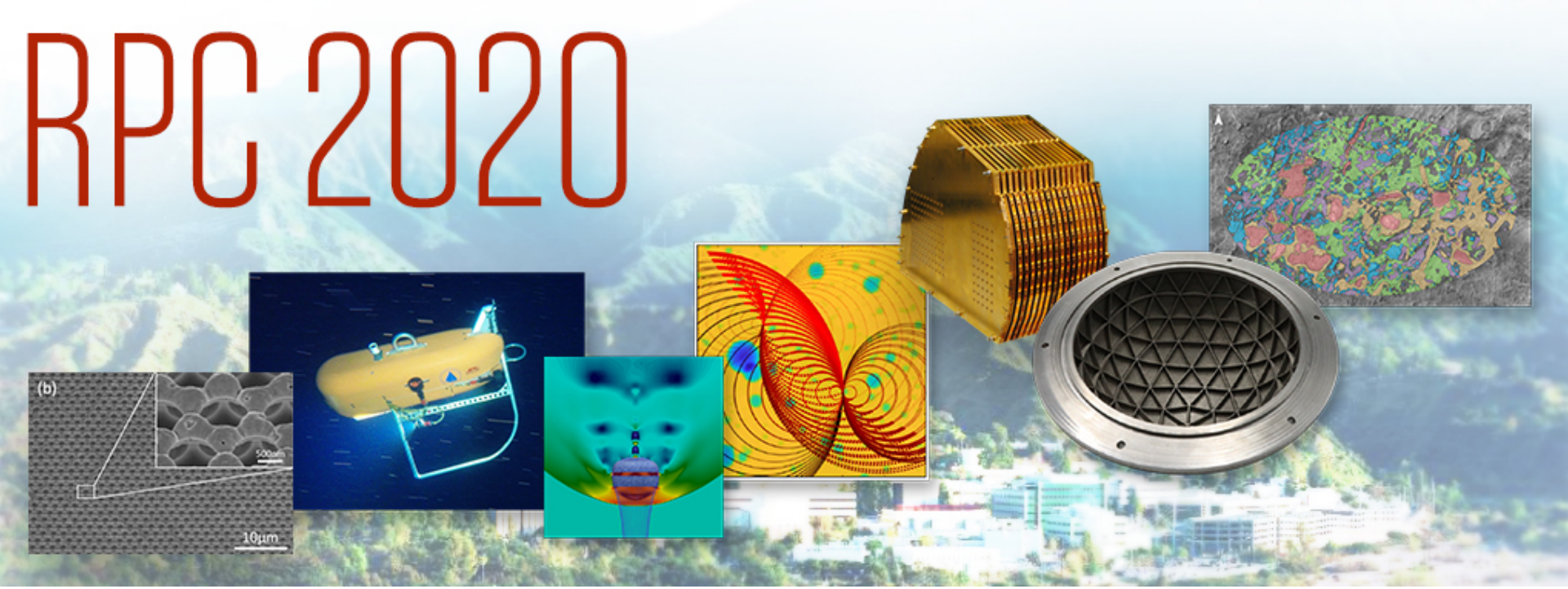
RPC 2020



Virtual Research Presentation Conference

Strategic Advances in Air Quality Research and Technology Development

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Program: Strategic Initiative

Assigned Presentation # RPC-039 / R18033

Jet Propulsion Laboratory
California Institute of Technology

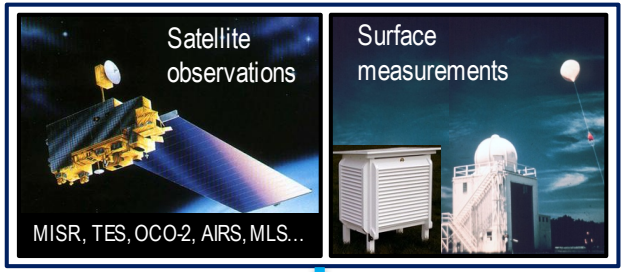
Tutorial Introduction

Abstract: This project is to develop a capability to provide surface aerosol and trace gas concentrations at spatial scales (100 m to 2 km) needed to support human and ecosystem health studies identified as a Most Important objective by the Decadal Survey (DS).

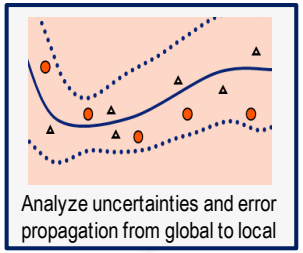
Science Questions: How do local and remote anthropogenic and natural emissions affect regional air quality, and therefore affect public health, ecosystem health and the economy?

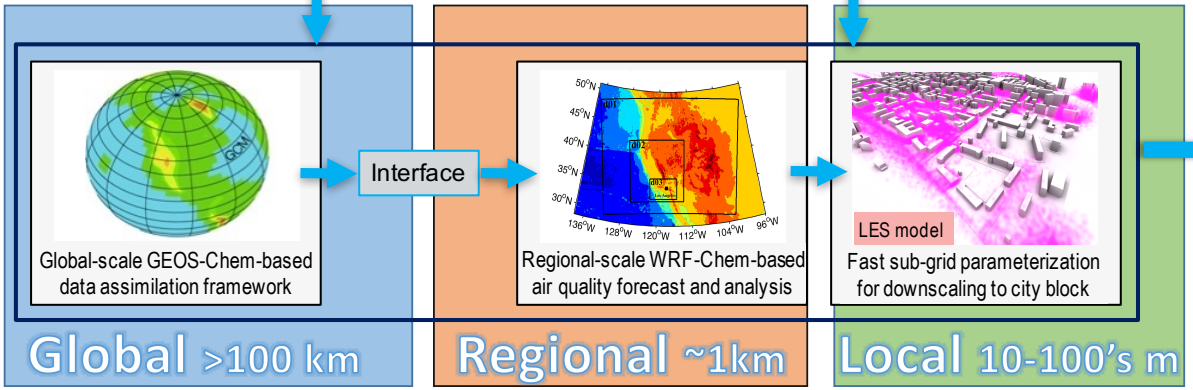
Link to Earth Science Grand Challenges & DS: Air Quality Hazard, Carbon, and improve our capabilities for hazard response and preparedness.

Application Aspiration: Integrate and advance observing and modeling capabilities at JPL and provide comprehensive technical capabilities to assess air quality from global to neighborhood scales in order to enhance the scientific return from current and identified future missions.



Data fusion & assimilation





System Deliverable:

- A unified modeling and data assimilation system that shall provide JPL with strategic technical capability for use in application and formulating missions for advancing air quality monitoring, forecast-ting, and decision support.

Problem Description

- This project is directly relevant to two of the strategic areas identified by JPL's Earth Science and Technology Directorate: "Linkages in the Earth System" and "Natural Hazards". This initiative addresses a fundamental "linkage" in the Earth atmosphere: Composition–Weather–Ecosystem Interactions. The characterization, monitoring and prediction of pollution is key to understanding the impact of "hazards" of both anthropogenic and biogenic emissions on air quality and the impacts of air quality on human and ecosystem health. Mapping of near-surface concentrations of particulate matter (PM), ozone, and other relevant trace gases is critical for assessing these impacts.
- JPL's remote sensing assets in this area include instruments (e.g. MISR, TES, MLS, AIRS, and OCO-2), necessary for assessing particulate matter and trace gas pollution impacts on human, ecosystem, and economic health and well-being. Research and mission opportunities in the next decade are expected to focus on near-surface and high-resolution air quality measures and observing and modeling co-varying properties of composition/air quality with other Earth System components (e.g. radiation/clouds, ecosystems, agriculture).
- There is a clear need for assimilation of both in situ and remotely-sensed measurements into state-of-the-art models at relevant spatial scales in order to provide observationally-constrained, spatially comprehensive estimates of near-surface pollution and associated uncertainties that can be utilized in public health and ecosystem studies.
- JPL is uniquely positioned to leverage our observational expertise, recent advances in modeling and technological capabilities to provide the community and NASA with leadership in the Atmospheric Composition–Weather–Ecosystem Interactions focus area, namely by contributing new missions and advancing the state of the science and applications associated with air quality research.
- The 2017 Decadal Survey (DS) identified a "Most Important" science and application question: "What processes determine the spatial-temporal structure of important air pollutants and their concomitant adverse impact on human health, agriculture and ecosystems? This project provides a means to address this question using the program of record and helps establish observing system requirements for relevant DS targeted observables.

Methodology

This project included four major tasks to develop a capability that includes:

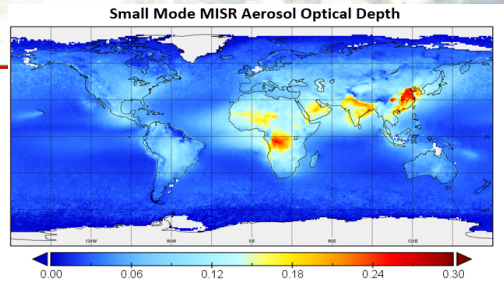
1. A global-scale GEOS-Chem-based data assimilation framework (GC-DA) for global assimilation of satellite measurements for MLS O_3 and CO; TES O_3 and CO; MISR AOD at 100 km scale;
2. An interface between the regional WRF-Chem model and the global GEOS-Chem model (GC-DA-IF)
3. A regional-scale WRF-Chem-based data assimilation (WC-DA) with comprehensive chemical schemes at 1-10km scale;
4. An urban-scale (10-100 meters) Large Eddie Simulation (LES) pollution model running based on combined surface sources and WRF-Chem output.

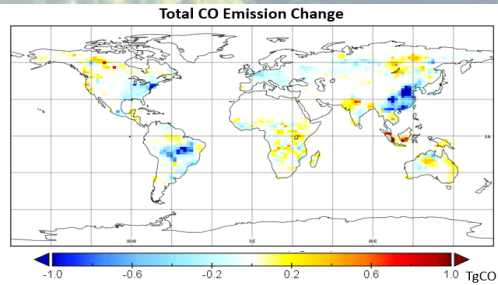
The work also included validation and uncertainty estimation tasks by sensitivity experiments and surface station data analysis.

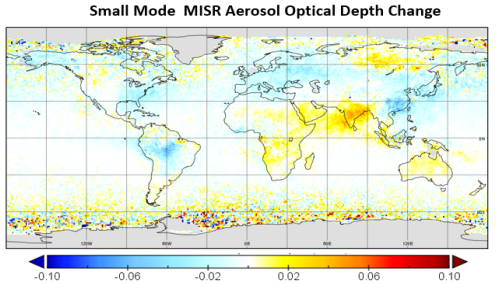
Results I:

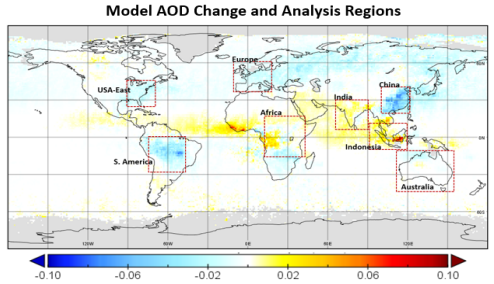
Global-scale GEOS-Chem based data assimilation system

(GC-DA)



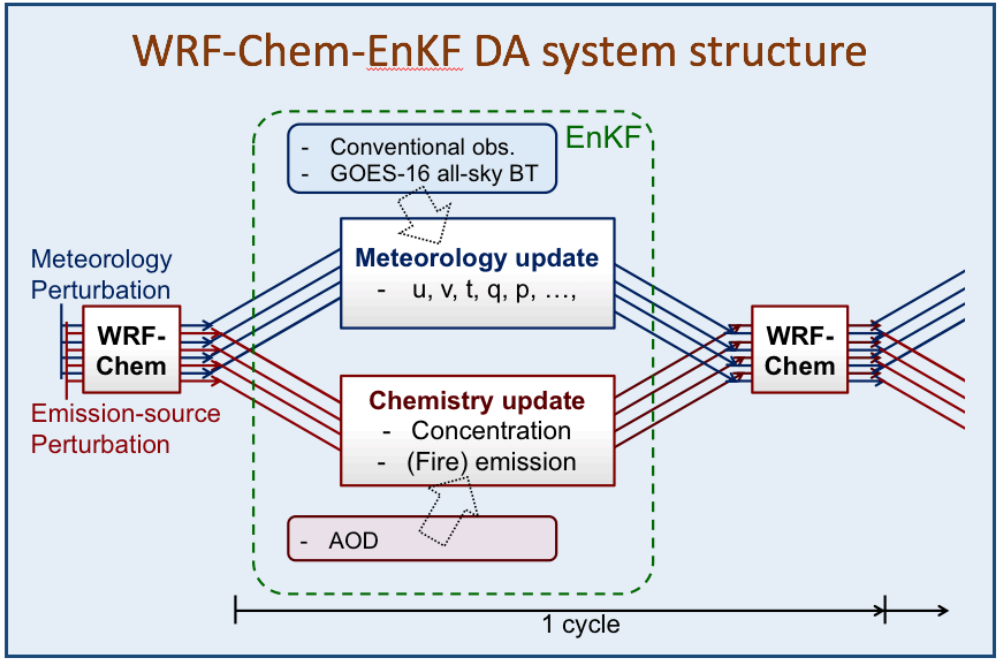




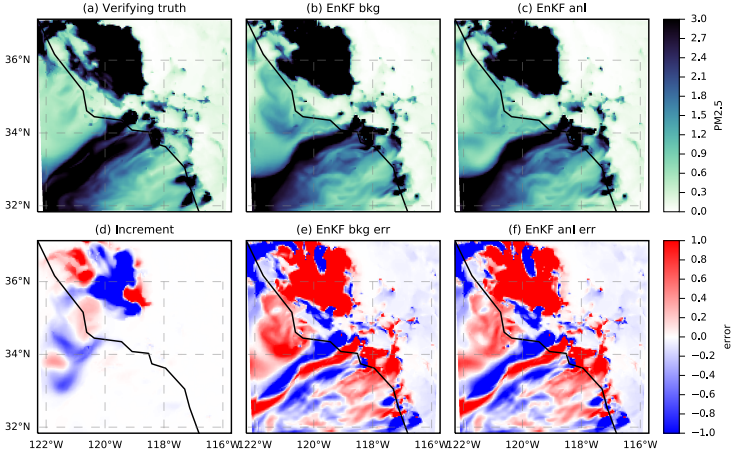


Results II:

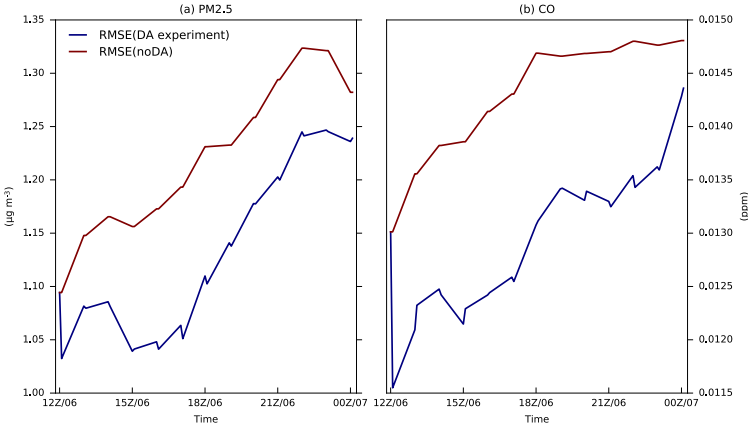
Regional-scale WRF-Chem based data assimilation system (WF-DA)



EnKF performances (snapshot of PM2.5)



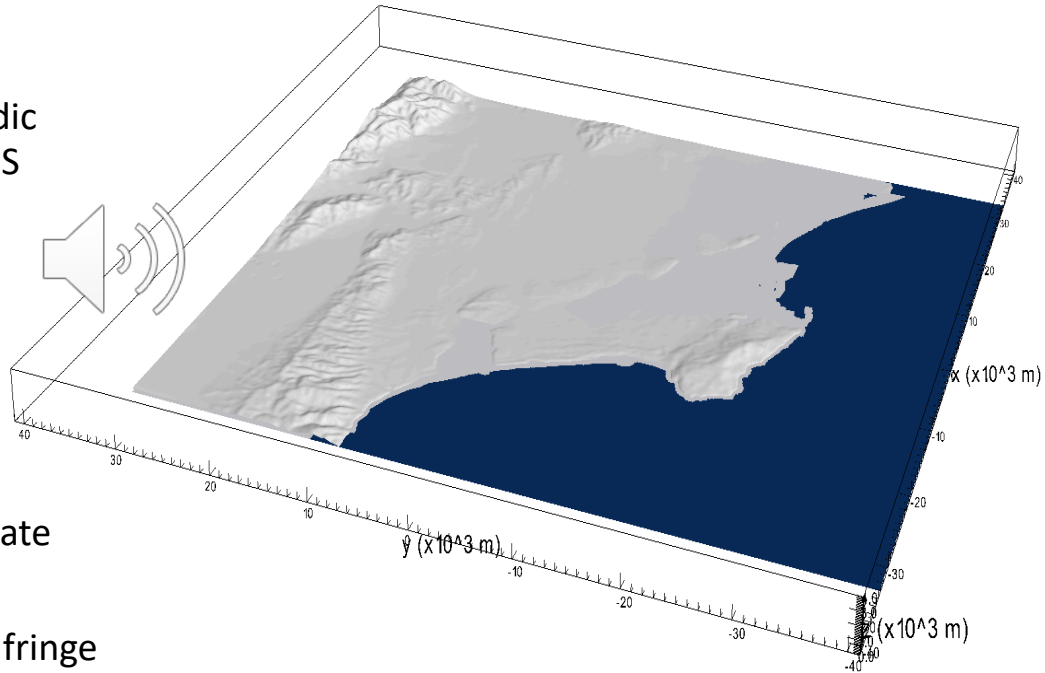
EnKF performances (temporal evolution of RMSE)



Results III:

Local-scale LES (part 1)

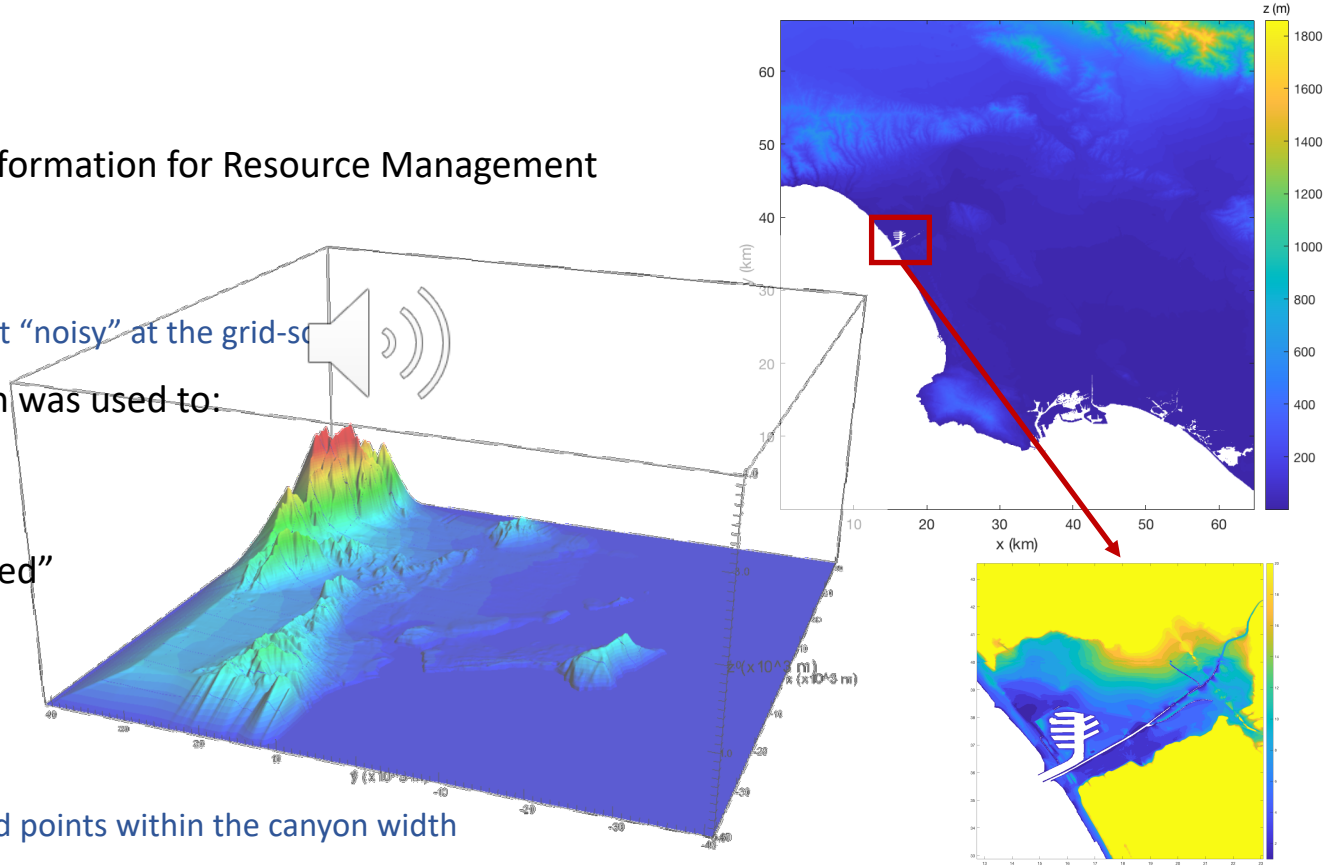
- In the past, most LES modeling included homogeneous surfaces (and often periodic lateral boundary conditions). Here, an LES model is extended to simulations over topography (e.g., Los Angeles basin) including passive scalar dispersion.
- Immersed boundary method (IBM) was implemented in the LES. IBM handles the interaction of a fluid represented on an Eulerian grid with a solid structure on a Lagrangian coordinate system.
- Domain: 82 × 82 × 4 km including lateral fringe to apply boundary conditions; 40 m uniform grid, ~400 million points.



Results III:

Local-scale LES (part 2)

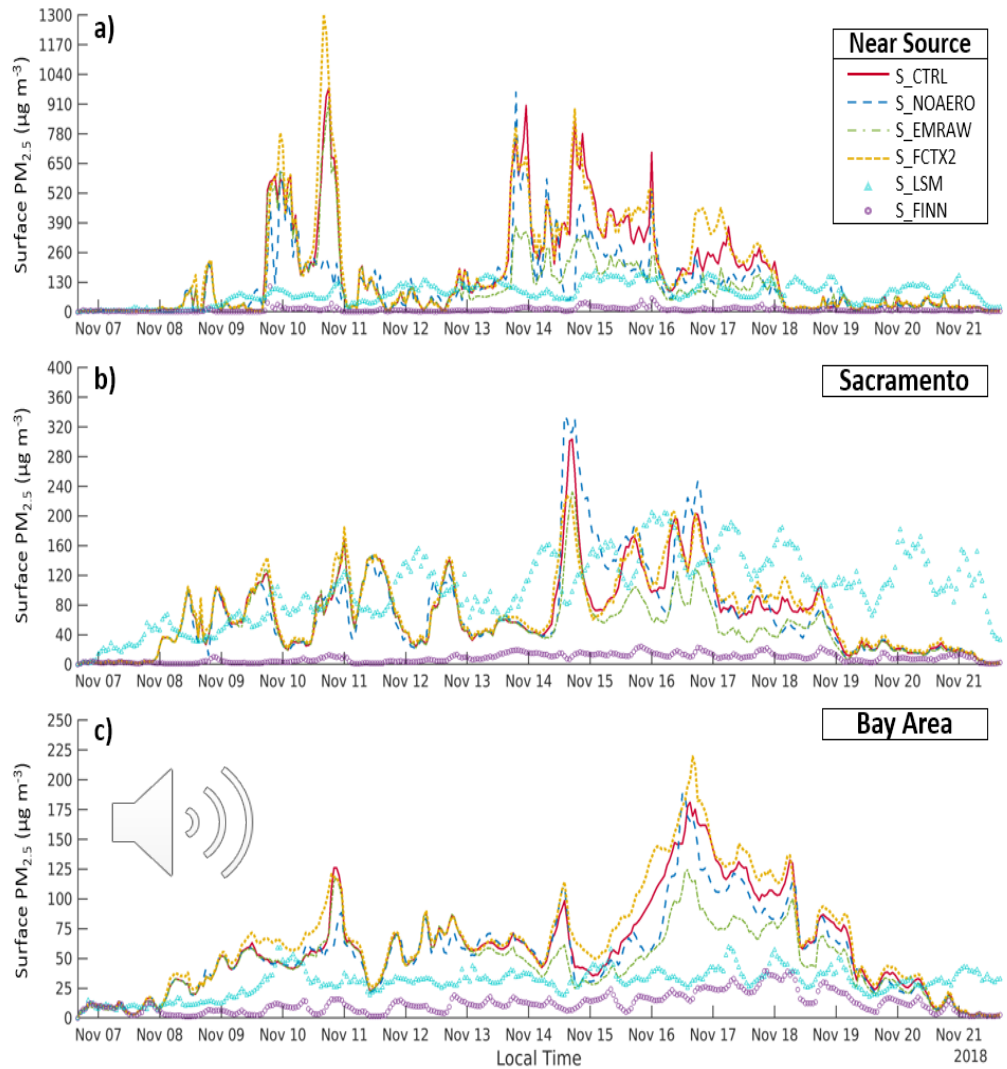
- Elevation data from Fire Information for Resource Management System (FIRMS)
- 10 m-resolution dataset
  - Very fine, but somewhat “noisy” at the grid-sc
- Box filter with 500 m width was used to:
  - Coarsen to 40 m
  - Smooth
- Elevation data were “padded” to match model’s lateral boundary conditions
- Narrow canyons pose modeling challenge
  - Must have at least 5 grid points within the canyon width



Results IV

Uncertainty Quantification via Parameter Perturbation Experiment

Name	Fire Data	Smoldering Emissions	Flaming Factor	Entrainment Constant	Land Surface Model	Aerosol Radiative Feedback
S_CTRL[1]	VIIRS	x3 Nov. 13, x2 Nov. 14-16	Native	0.05	Noah/MYJ	Yes
S_EMRAW	VIIRS	Native	Native	0.05	Noah/MYJ	Yes
S_NOAERO	VIIRS	x3 Nov. 13, x2 Nov. 14-16	Native	0.05	Noah/MYJ	No
S_FCTX2	VIIRS	x3 Nov. 13, x2 Nov. 14-16	x2	0.05	Noah/MYJ	Yes
S_ENTR	VIIRS	x3 Nov. 13, x2 Nov. 14-16	Native	0.02	Noah/MYJ	Yes
S_LSM	VIIRS	x3 Nov. 13, x2 Nov. 14-16	Native	0.05	P-X/ACM2	Yes
S_FINN	FINN	-	-	0.05	Noah/MYJ	Yes



Publications and References

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Rooney, B. Y. Wang, J.H. Jiang, et al., Air Quality Impact of the Northern California Camp Fire of November 2018, *Atmo. Chem. Phys. Diss*. https://doi.org/10.5194/acp-2020-541, 2020.