National Aeronautics and Space Administration

Strategic Advances in Air Quality Research and Technology Development

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Program: FY21 R&TD Strategic Initiative **Strategic Focus Area: Linkages in the Earth System**

Objectives

The objective of this SRTD has been to develop the capability to provide surface aerosol and trace gas concentration estimates at spatial scales (from 100m to 2km) needed to support human and ecosystem health studies. Quantifying these trace gases for this purpose has been identified as a Most Important (MI) objective by the NASA Decadal Survey (DS). We have shown that data sets from the Program of Record (POR) can be used to quantify surface gases by assimilating these data into state-of-the art models. This capability can then be used for both addressing NASA science objectives and supporting Observation System Simulation Experiments (OSSE's) needed to evaluate new mission requirements for air-quality and health studies.

Background

We have shown that data sets from the Program of Record (POR) can be used to quantify surface gases by assimilating these data into state-of-the art models. This capability can then be used for both addressing NASA science objectives and supporting Observation System Simulation Experiments (OSSE's) needed to evaluate new mission requirements for air-quality and health studies. In pursuing our objectives, we have leveraged existing connections with the NASA Health and Air Quality Applied Science Team (H-AQAST), the South Coast Air Quality Management District (SCAQMD) and the California Air Resources Board (CARB) to ensure that our efforts are addressing the needs of air quality management stakeholders. In the near future, we will target the above efforts capabilities toward optimally positioning JPL for capturing missions in these areas, including Earth Ventures, DS mission opportunities.

Approach and Results

We have accomplished this objective as the following: (1) Developed and documented a global-scale Goddard Earth Observing System with Chemistry (GEOS-Chem) based Data Assimilation framework (GC-DA) for joint assimilation of observed concentrations of trace gases and selected aerosol species, including O3, CO, CO2 and AOD and apply the system to the current satellite observations from MLS, TES, AIRS+OMI, MISR, MODIS, and OCO2. This global low-resolution (100 km) speciated gas and AOD from GEOS-Chem have been used to provide lateral boundary conditions required for running the regional WRF-Chem. (2) Developed a streamlined interface between the GEOS-Chem and the Weather Research and Forecasting model coupled with Chemistry (WRF-Chem) for generating a comprehensive set of the gas species and aerosol species, for WRF- Chem with respect to spatial coverage and resolution, temporal coverage and resolution, and the file format. (3) Integrated the WRF-Chem model particulate matter and trace gases (O3 and CO) estimates with surface monitor and satellite data to generate spatially and temporally gap-filled constituent maps at 2 km scales with quantified uncertainties. (4) Integrated JPL's Large-Eddy Simulation (LES) model with the WRF-Chem fields, capitalized on the small-scale dynamics within the LES with downscaling techniques, and parameterized surface - level pollution and associated uncertainty estimate on scales of 10s to 100s m, and thus provided detailed exposure maps for health impact studies.

Significance/Benefits to JPL and NASA

The capability developed by this project coalesced in-house capabilities in aerosol, atmospheric chemistry, and air quality research, and global and regional modeling. The unified modeling and data assimilation system will contribute critical information needed for assimilation of future space-borne air quality and chemical composition measurements and accelerate JPL's readiness in formulating future missions identified as high priority in 2017 DS. More importantly, this SRTD data assimilation system we developed can serve as a prototype for a national multiscale forecasting and attribution model identified as a critical need by the JPL Climate Change Tiger Team for providing input to the next DS. The project will support the JPL Earth science community in the areas of: 1) improved temporal and spatial resolution global and regional map with a joint assimilation of the satellite observations with the model simulation, and 2) initial and boundary condition service for WRF-Chem and other regional models.

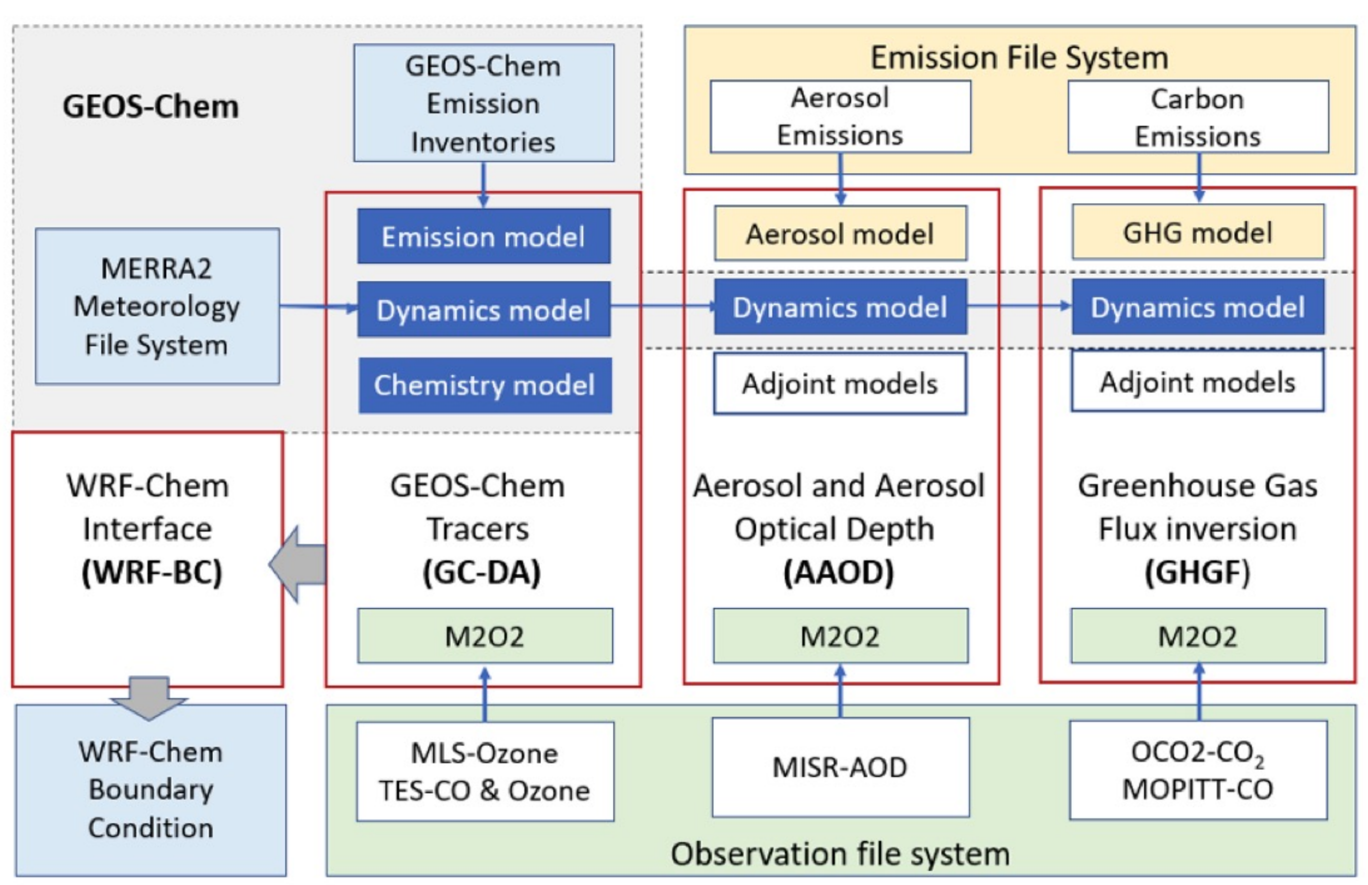

Figure 1. Figure 1: Global data assimilation framework and usage of the GEOS-Chem models.

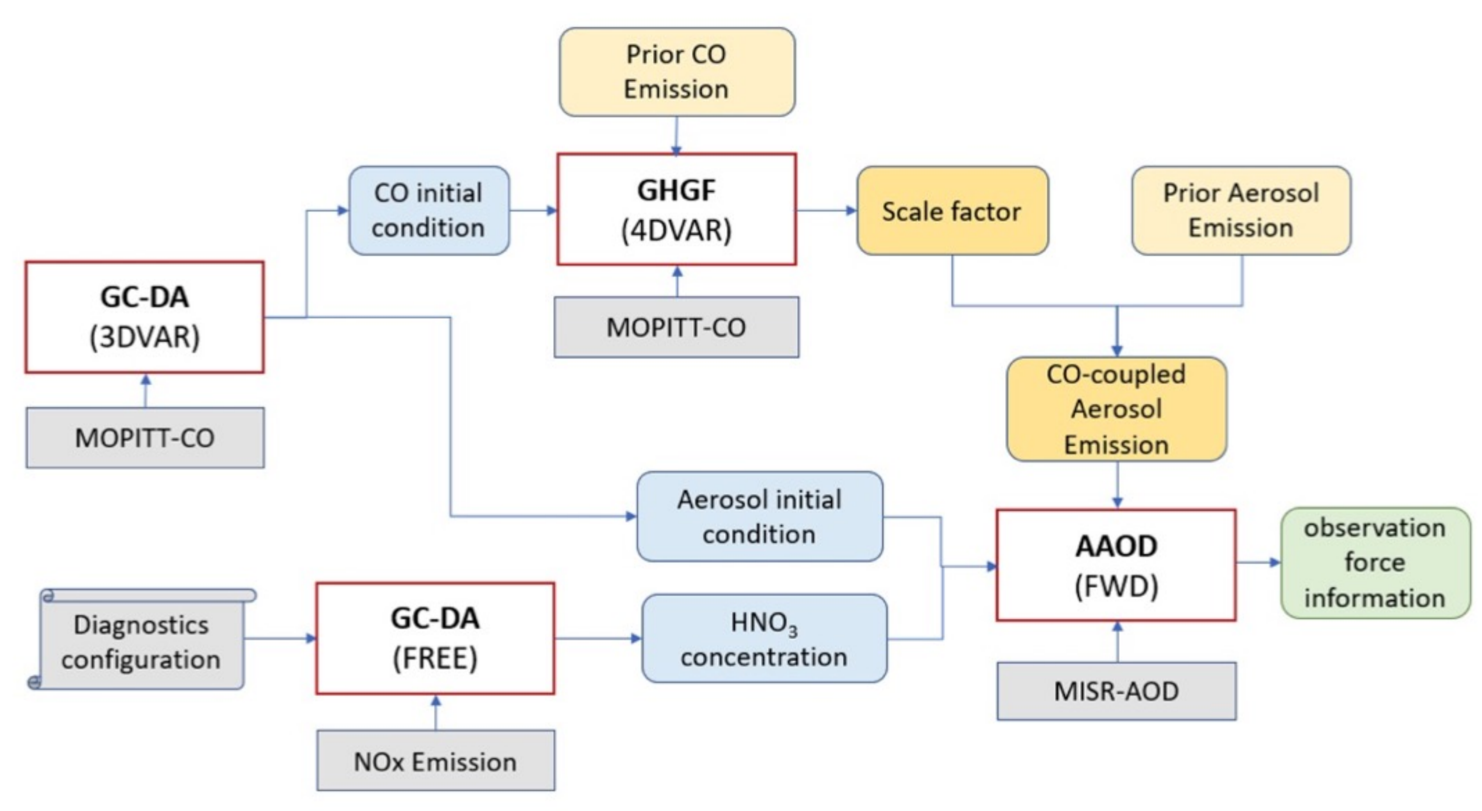

Figure 2. Figure 2: Collaborative relationship between the thee assimilation systems in analyzing the inter-annual trend of MOPITT-CO constrained CO emission, model AOD with CO-coupled aerosol emissions, and MISR-AOD observation.

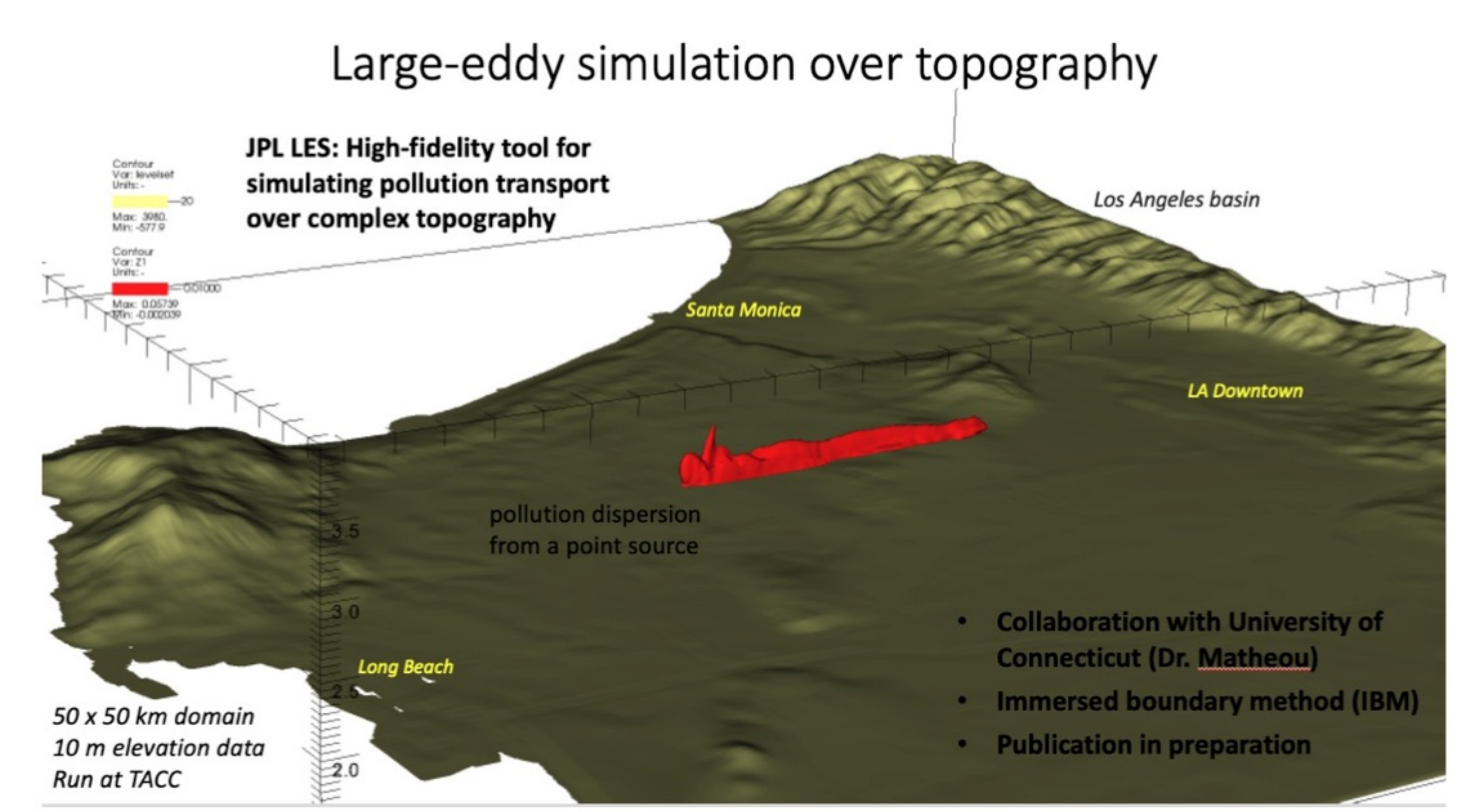

Figure 3. Figure3: Surface pollution transport simulation over topography.

Publications

Shi, H., Jiang, Z., Zhao, B., Li, Z., Chen, Y., Gu, Y., Jiang, J. H., Lee, M., Liou, K.-N., Neu, J. L., Payne, V. H., Su, H., Wang, Y., Witek, M., and Worden, J.: Modeling Study of the Air Quality Impact of Record-Breaking Southern California Wildfires in December 2017, J. Geophys. Res.-Atmos., 124, https://doi.org/10.1029/2019jd030472, 2019.

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.

Lee, M., J.R. Worden, S. Chakraborty, Y. Wang, M. Witek, H. Su, J.H. Jiang, Combustion Emissions Drove the 21st Century Changes in Global Small-Size Aerosols, submitted to JGR-Atmospheres., 2021.

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