Analyzing carbon dioxide and methane emissions in California using airborne measurements and model simulations

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Greenhouse gas (GHG) concentrations have increased over the past decades and are linked to global temperature increases and climate change. These changes in climate have been suggested to have varying effects, and uncertain consequences, on agriculture, water supply, weather, sea-level rise, the economy, and energy. To counteract the trend of increasing atmospheric concentrations of GHGs, the state of California has passed the California Global Warming Act of 2006 (AB-32). This requires that by the year 2020, GHG (e.g., carbon dioxide (CO_2) and methane (CH_4)) emissions will be reduced to 1990 levels.

To quantify GHG fluxes, emission inventories are routinely compiled for the State of California (e.g., CH_4 emissions from the California Greenhouse Gas Emissions Measurement (CALGEM) Project). The major sources of CO_2 and CH_4 in the state of California are: transportation, electricity production, oil and gas extraction, cement plants, agriculture, landfills/waste, livestock, and wetlands. However, uncertainties remain in these emission inventories because many factors contributing to these processes are poorly quantified. To alleviate these uncertainties, a synergistic approach of applying air-borne measurements and chemical transport modeling (CTM) efforts to provide a method of quantifying local and regional GHG emissions will be performed during this study. Additionally, in order to further understand the temporal and spatial distributions of GHG fluxes in California and the impact these species have on regional climate, CTM simulations of daily variations and seasonality of total column CO_2 and CH_4 will be analyzed.

To assess the magnitude and spatial variation of GHG emissions and to identify local "hot spots", airborne measurements of CH_4 and CO_2 were made by the Alpha Jet Atmospheric eXperiment (AJAX) over the San Francisco Bay Area (SFBA) and San Joaquin Valley (SJV) in January and February 2013 during the Discover-AQ-CA study. High mixing ratios of GHGs were observed in-flight with a high degree of spatial variability. To provide an additional method to quantify GHG emissions, and analyze AJAX measurement data, the GEOS-Chem CTM is used to simulate SFBA/SJV GHG measurements. A nested-grid version of GEOS-Chem will be applied and utilizes varying emission inventories and model parameterizations to simulate GHG fluxes/emissions. The model considers CO_2 fluxes from fossil fuel use, biomass/biofuel burning, terrestrial and oceanic biosphere exchanges, shipping and aviation, and production from the oxidation of carbon monoxide, CH_4, and non-methane volatile organic carbons. The major sources of CH_4 simulated in GEOS-Chem are domesticated animals, rice fields, natural gas leakage, natural gas venting/flaring (oil production), coal mining, wetlands, and biomass burning. Preliminary results from the comparison between available observations (e.g., AJAX and CALGEM CH_4 emission maps) and GEOS-Chem results will be presented, along with a discussion of CO_2 and CH_4 source apportionment and the use of the GEOS-Chem-adjoint to perform inverse GHG modeling.