Using Aircraft and Ground-Based Observations to Monitor Methane and Improve a Greenhouse Gas Inventory Network for the San Francisco Bay Area

Abstract

Methane (CH_4) is a potent greenhouse gas. According to the Environmental Protection Agency (EPA), one ton of methane emissions can absorb almost twenty-five times as much energy as one ton of carbon dioxide emissions over a one hundred year timescale. A majority of these emissions can be attributed to livestock farms, landfills, and wastewater treatment plans. The Bay Area Air Quality Management District (BAAQMD) regulates these and other stationary sources of air pollution in the nine counties surrounding San Francisco Bay, an area with a diverse array of landforms and emissions sources. BAAQMD traditionally estimates emissions using a bottom-up approach, combining emissions factor and activity data to estimate source emissions per sector. However, recent literature suggests that these bottom-up approaches are underestimating CH_4 emissions by nearly 50% in many regions of California. Therefore, there is interest in characterizing the ground-level distribution of methane within the urban region of the San Francisco Bay Area and compare the top-down measurements with the bottom-up spatial emissions inventories utilized by the Bay Area Air Quality Management District (BAAQMD). Though Earth-observing satellites can effectively monitor mid-to-upper tropospheric CH_4 on a global scale, current instrumentation is limited in its capacity to accurately measure near-surface CH_4 on a local scale. This project used sub-Planetary Boundary Layer aircraft measurements from the NASA Alpha Jet Atmospheric eXperiment (AJAX) to create a comprehensive spatially-resolved CH_4 map. Locations of "hotspots" (classified as significantly elevated CH_4 concentrations) were investigated using US Geological Survey (USGS) High-Resolution Orthoimagery (HRO) and trajectory analysis. Furthermore, NASA Landsat 8 imagery and HRO were used to classify the types of indicated emission sources and infer other points of concern not included in the current BAAQMD emissions inventory. These findings help pinpoint specific sites for further investigation by the upcoming BAAQMD Mobile GHG Measurement Network; furthermore, this project suggests future sites for coincident data collection by various top-down methods.

Objectives

- Develop comprehensive spatially-resolved CH_4 map for the San Francisco Bay Area using NASA AJAX data
- Locate and investigate CH_4 "hotspots" using anomalies detected by AJAX to pinpoint specific sites for further monitoring via upcoming BAAQMD Mobile GHG Measurement Network
- Classify high-emissions sources using NASA Landsat 8 and US Geological Survey (USGS) High-Resolution Orthoimagery (HRO)

Study Area

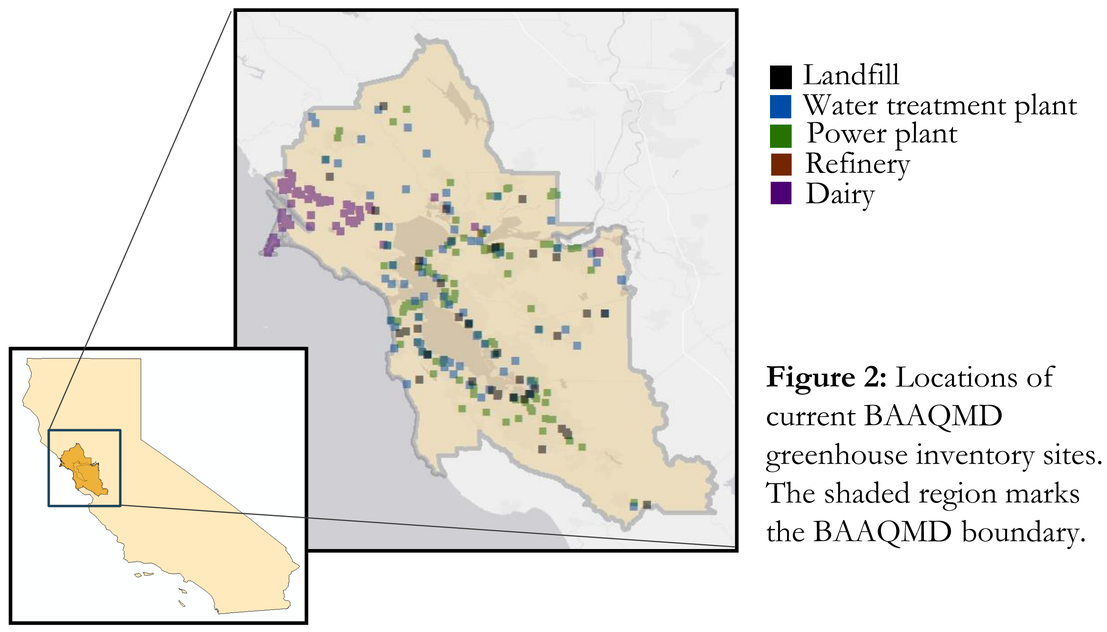

Figure 2: Locations of current BAAQMD greenhouse inventory sites. The shaded region marks the BAAQMD boundary.

Methodology

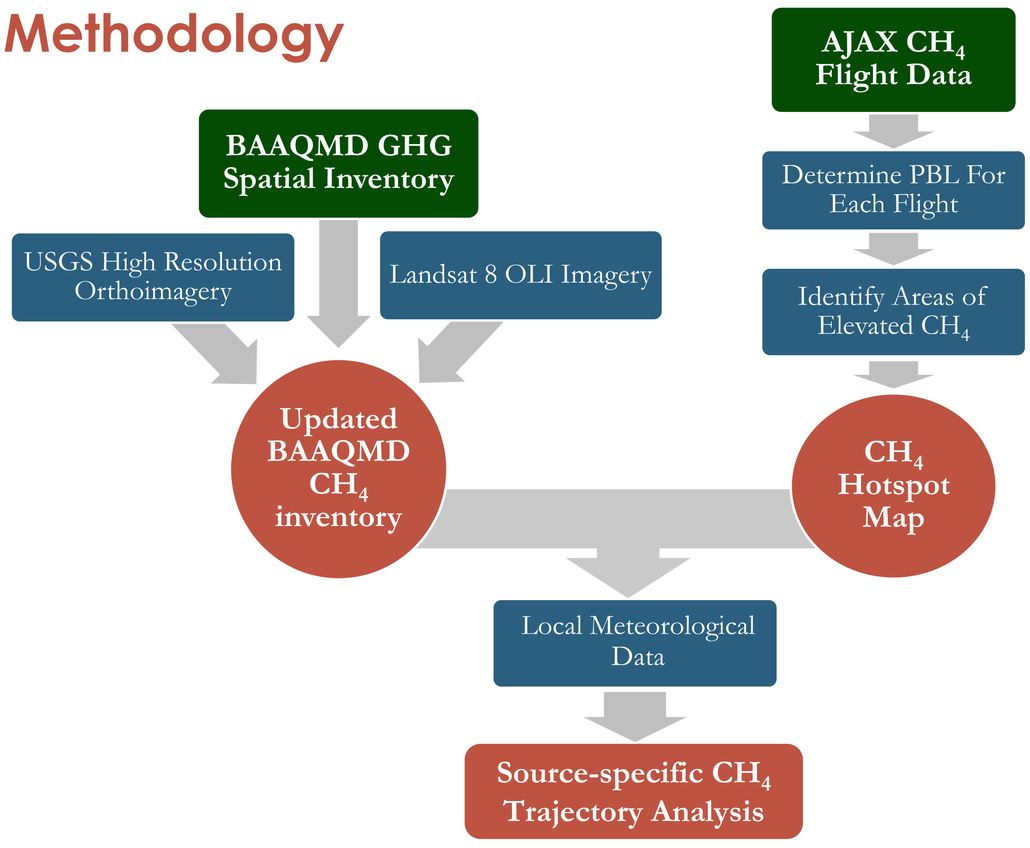

Figure 1: Flowchart describing data acquisition (green) and processing (blue). Final products in red.

Earth Observations

Results

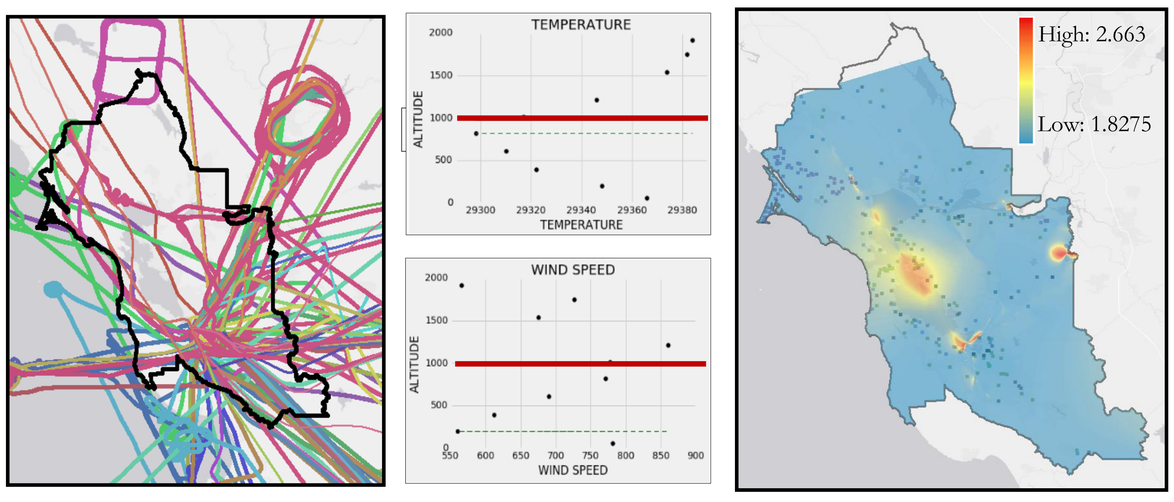

Figure 3: A) AJAX flight paths over the San Francisco Bay Area; BAAQMD jurisdiction outlined in black. B) Temperature and wind speed profiles for AJAX Flight 98 (September 10th, 2013); PBL (as defined by algorithm) marked in red. C) Comprehensive CH_4 map for BAAQMD jurisdiction.

Conclusions

- Though Earth-observing satellites can effectively monitor mid-to-upper tropospheric CH_4 on a global scale, current instrumentation is limited in its capacity to accurately measure near-surface CH_4 on a local scale.
- Airborne in-situ greenhouse gas concentration data from below the planetary boundary layer (PBL) can be utilized in understanding near-surface CH_4 concentrations.
- The San Francisco Bay Area has many CH_4 "hotspots" downwind of dairies, landfills, and areas of oil and gas production. A number of these sources are missing from the current BAAQMD bottom-up emissions inventory. Possible emissions sources can be classified using high-resolution Earth imagery.

Acknowledgements

Bay Area Air Quality Management District

Dr. Abhinav Guha, Senior Air Quality Engineer
Dr. Phil Martien, Air Quality Engineering Manager
Ms. Abby Young, Climate Protection Manager

NASA Alpha Jet Atmospheric eXperiment

Dr. Laura Iraci, Dr. Josette Marrero,
Dr. Emma Yates, & Dr. Warren Gore

NASA Ames Research Center

Ms. Chippie Kislik, DEVELOP Center Lead
Ms. Vickie Ly, DEVELOP Assistant Center Lead

Any opinions, findings, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of the National Aeronautics and Space Administration. This material is based upon work supported by NASA through contract NNL11AA00B and cooperative agreement NNX14AB60A.

Team Members


Maya Midzik
Team Lead


Joseph Abbate


Garima Raheja

Quality Health & Air San Francisco Bay Area