A21G-0233 Trends in Monthly Methane Emissions in Los Angeles Inferred by Mountaintop Remote Sensing Measurements

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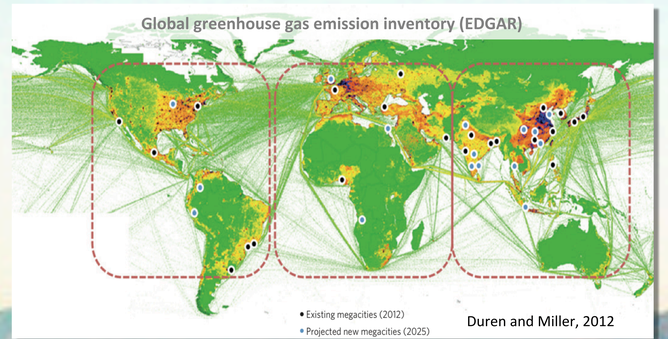
1. Introduction

- Megacities (e.g., Los Angeles) are significant sources of anthropogenic greenhouse gases (GHGs). As a result of urbanization, the number of megacities is projected to increase from 22 in 2012 to 38 in 2025.
- Tracking urban emission trends is necessary to verify the effectiveness of control policies.
- To track GHG emissions in megacities, which are spatially and temporally inhomogeneous, it is necessary to develop a robust measurement technique which resolves the domain with high spatio-temporal resolution. This can be performed by satellites at geostationary orbits.

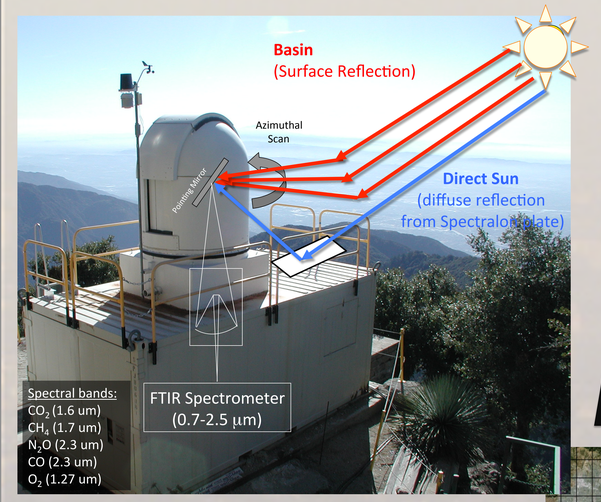


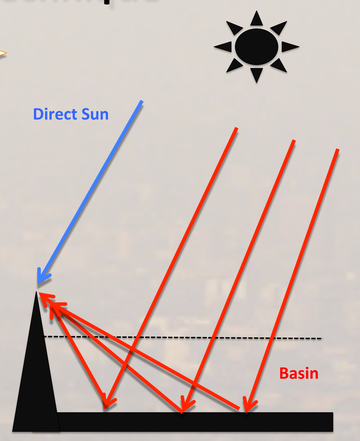
The objective of this work is to demonstrate that remote sensing from Mount Wilson (a testing platform for geostationary satellite observations) can effectively track methane (CH_4) emissions in Los Angeles.

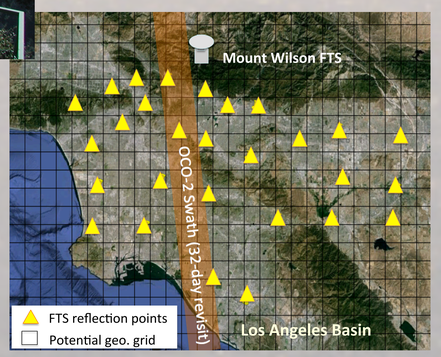
Here are the scientific questions we aim to answer:

1. What are the monthly and interannual trends from 2011 to 2015?
2. What does our instrument see during nearby massive natural gas leak event?

2. Measurement technique







- Since 2010, a JPL-built Fourier Transform Spectrometer (FTS) has been operating on Mount Wilson.
- It measures the clean background GHG columns (Direct Sun mode) and the basin GHG columns (Basin mode) using reflected near-infrared sunlight.
- There are about 5-8 measurement cycles per day. In each measurement cycle (90 min), the FTS points at the 28 reflection points and makes four direct sun measurements.
- The Mount Wilson FTS serves as a testbed for future geostationary satellite missions and provides context for OCO-2 measurements in the Los Angeles basin.

3. Tracking monthly changes in methane emissions (2011-2015)

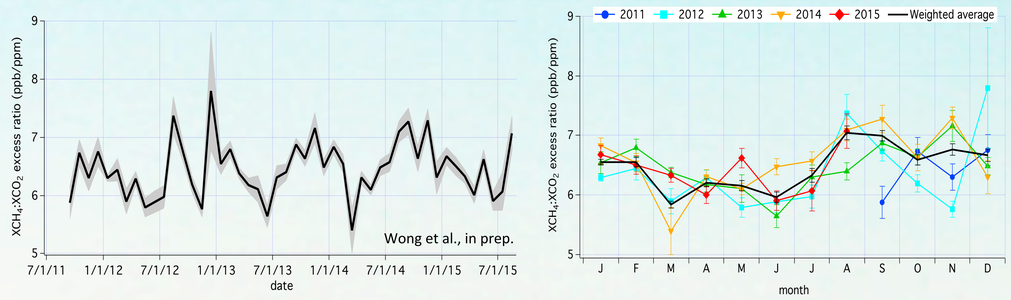
- Basin averaged XCH_4:XCO_2 excess ratio showed monthly variability, ranging from 5.5 to 7.8 ppb/ppm.
- Derived CH_4 flux (using Equation 1) had -18% to +35% monthly variability from annual mean. CH_4 flux ranged from 27 to 45 Gg per year, with peaks in late summer, early fall and winter.
- Further analysis is necessary to attribute sources to the observed seasonal fluctuations in Los Angeles.

$$\mathbf{E_{CH_4}} = \mathbf{E_{CO_2}} \times \mathbf{R} \times \frac{\mathbf{MW_{CH_4}}}{\mathbf{MW_{CO_2}}} \quad \textbf{(Eq. 1)}$$

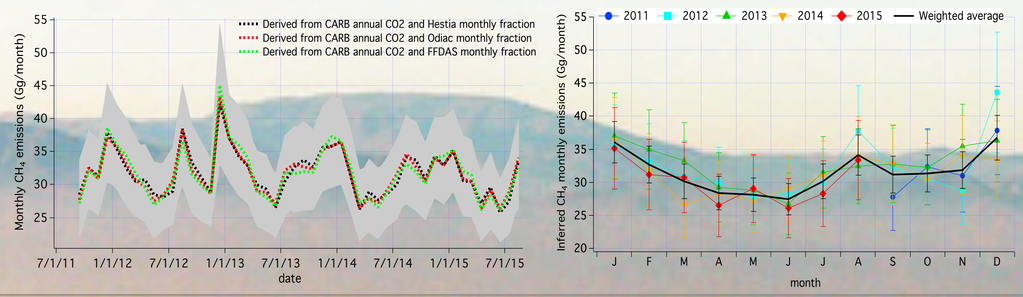
where,

- E_{CO_2} stands for CO_2 monthly emissions derived from the California Air Resources Board (CARB) annual emission and seasonal variability in Hestia, ODIAC and FFDAS.
- R is the observed basin average XCH_4:XCO_2 excess ratio.
- $\frac{MW_{CH_4}}{MW_{CO_2}}$ is the ratio of molecular weights.

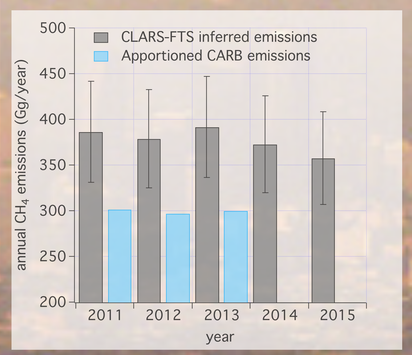
Observed basin average XCH_4:XCO_2 excess ratio



Derived CH_4 flux

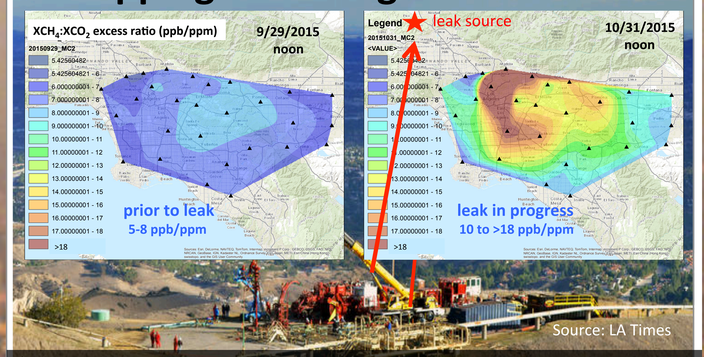


4. Tracking year-to-year variability in methane flux from 2011 to 2015



- We derived a decreasing trend of -17 ± 16 Gg CH_4 per year (with a 25% confidence level due to the large uncertainty in CO_2 emissions).
- Improved understanding of the uncertainty of CO_2 emission in the basin will allow us to reduce the uncertainty of CH_4 emission.
- The scaled CARB bottom-up CH_4 emission from 2011 to 2013 was 10-49% lower than our estimates.

5. Mapping massive gas leak event



- Southern California Gas Company reported a huge natural gas leak in Aliso Canyon underground storage field on 10/23/2015.
- CLARS-FTS mapped significantly enhancements in CH_4:CO_2 on 10/31/2015.
- Further analysis is necessary to derive a flux from the gas leak.

6. Conclusions and future work

- This study demonstrates the value of persistent observations of megacity GHG emissions from a mountaintop platform with high temporal (daily) and spatial (few km) resolution over a large spatial domain (~100 km x 50 km).
  - ✓ The derived methane emissions showed two peaks – in late summer/early fall and winter, repeating annually. Annual average methane emissions showed a slight decreasing trend in Los Angeles.
  - ✓ CLARS-FTS mapped the plume from a large natural gas leak in the basin, demonstrating the ability to track large pollution events.

Ongoing/future work includes methane source attribution in the Los Angeles basin and modeling of our CLARS-FTS observations using WRF-GHG to improve GHG emission estimates for the Los Angeles basin.

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