Background

Currently, anthropogenic CO₂ emissions over urban regions can be calculated in several ways: 1) bottom-up approaches (or inventories) based on energy consumption within city limits and emission factors that depend on type of fuel and processes, 2) using ¹³C as tracer for fossil CO₂, and 3) subtracting the biosphere signal from observation (measured) CO₂ data. All of these approaches have their limitations. Given the immense amount of time and resources needed to develop inventories, generic emission factors and data assumptions are often used which result in a high degree of uncertainty. Additionally, temporal extrapolation and spatial redistribution lead to further uncertainties. Albeit ¹³C is an ideal tracer for fossil CO₂ because ¹³C is entirely lost to radioactive decay in fossil fuels, the high costs and technological requirements of radio isotope measurements make this method hardly reproducible in the long term and high frequency required to monitor urban emissions. Subtracting the biosphere signal is not always straightforward because there are many biosphere models and they all give different results.

Methods

Calculating COS surface fluxes based on NDVI

\[
\text{COS flux} = \text{GPP} \times \text{CO}_2 \times \text{NDVI}
\]

Using STEM to determine COS mixing ratios

Surface flux and drawdown (difference between 450 ppt and simulated COS surface concentrations) is shown below on left for a typical day reflecting mean flow conditions, northerly winds, significant drawdown over the continent and less drawdown over the ocean. The model also showed some synoptic events in which continental air is brought to the

Results

Observed COS mixing ratio at Sutro Tower

- NOAA Sutro tower measurements in San Francisco (Montzka et al JGR 2007) are on average upwind from study area of Livermore and provides background COS mixing ratio (average of 505 ppt for study period).
- Seasonal variations are about 10-15%, and are similar to previous studies.
- Synoptic variation during study period shown in zoomed-in box, is about 10%
- COS measurements are taken twice daily, not every day (15 measurements during study period).

Average mean wind speed

- NOAA Sutro tower measurements in San Francisco (Montzka et al JGR 2007) are on average upwind from study area of Livermore and provides background COS mixing ratio (average of 505 ppt for study period).
- Seasonal variations are about 10-15%, and are similar to previous studies.
- Synoptic variation during study period shown in zoomed-in box, is about 10%
- COS measurements are taken twice daily, not every day (15 measurements during study period).

Future work

1. Run STEM for anthropogenic and respiration CO₂ so that together with most appropriate plant uptake CO₂ (current work) and observed CO₂, we can determine a top-down modified observation anthropogenic CO₂ flux. 2) Use dynamic boundaries from global chemical transport models. 3) study other periods to establish diurnal patterns and validate model results with observed data.

Abstract

We suggest that COS can be used to determine which ecosystem model best represents the biosphere signal. Just like CO₂, COS is taken up by photosynthesis but is not given off in respiration and can thus be used as a trace gas to estimate GPP. We begin with COS surface fluxes provided by SIB and CASA, regressed to lower resolution using NDVI values, for a 9, 3, and 1 km-resolution domains over the Bay Area of San Francisco and part of the San Joaquin Valley. Simulations using the atmospheric model WRF provide the meteorological data, which along with the COS fluxes, are used to run the transport model STEM over a 20-day period in March 2015. Simulations of COS mixing ratio based on the various surface flux models are compared to observed data available from several locations (see abstract B42B-06 by Whelan, M. et al). The model that best represents COS uptake consequently also provides the most accurate simulation of CO₂ biosphere signal, and can be used to estimate fossil fuel CO₂ emissions.