Megacities Carbon Project

• Summary of Initial Meeting in São Paulo

• 28-29 of August

• Objective of the meeting: join São Paulo in the initiative

• Dr. James Whetstone

• Dr. Kevin Gurney

• Dr. Charles Miller

• Dr. Riley Duren (by Skype)

• São Paulo Group

• USP, IPEN, INPE
Megacities Project Objectives in LA
coordination of Riley Duren NASA JET Propulsion Lab
California Institute of Technology

• Objectives
  • Develop and demonstrate measurements systems capable of quantifying trends in the total (and anthropogenic) carbon emissions of the LA megacity
  • Reduce uncertainty in CH4 (and N2O) to levels comparable to CO and CO2
  • Validate assertion that CO2 and CO inventories are good to within X%
  • Attribute observed emission signatures to key sectors & activity in the megacity (diagnose inventories)
  • Identify and quantify individual fugitive CH4 emission sources (e.g. ports, power plants, landfills, natural gas infrastructure, oil/gas production, etc)
  • Advance measurements capabilities, models, and protocols to bridge the research to operations gap
  • Extend methods and techniques to many cities and establish open and transparent sustained data, analysis, and measurements methodology sharing (including capacity building).
Megacities Carbon Project

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Megacities project is supported by NIST, NASA, NOAA, CARB, and KISS
Co-PI’s: Riley Duren (JPL), Chip Miller (JPL), Kevin Gurney (ASU), Ralph Keeling (Scripps), Ray Weiss (Scripps), Marc Fischer (LBNL)
LA Project components

1. Hestia-LA: high resolution CO2 emissions data set (Gurney et al)
2. WRF/chem/VPRM/STILT: high res tracer-transport modeling (Lauvaux, Li et al)
4. Satellite GHG measurements (Miller, Eldering, et al)
5. Integration and synthesis (group effort)
6. Data Portal – transparent data sharing (Duren, Crichton et al)
(2) High-resolution atmospheric CO$_2$ modeling (currently 4km for SoCal – moving to 1km)

J. Li & S. Feng (JPL)
(3) Surface measurement network

Mira Loma and Corona sites will likely be replaced by sites at Riverside and TBD downtown LA location.
(4) Emerging satellite capabilities


Example of different sampling strategies relative to existing megacities (red dots) and projected new megacities by 2025 (blue dots)

- Example of different sampling strategies relative to existing megacities (red dots) and projected new megacities by 2025 (blue dots)
- Focus on land sinks
- < 1% of point sources
- Flexible pointing
- All point sources each month
- All point sources every day
Greenhouse Gas Observing Satellite (GOSAT) 
Observations of NIR Reflected Sunlight

Launch: January 2009

GOSAT TANSO-FTS samples on a ~150 km grid 
Can also TARGET individual surface locations

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Orbiting Carbon Observatory (OCO-2)
Observations of Reflected NIR Sunlight

OCO-2 strategy optimized to deliver accurate, global XCO2

Launch: 2 July 2014

Charles.E.Miller@jpl.nasa.gov
OCO-2 Spatial Sampling Approach

The OCO-2 Orbit:
- 705 km altitude, 98.2° inclination
  - 16-day ground track repeat cycle
- 98.8 minute period: 14.57 Orbits/day
  - ~25° longitude offset between consecutive orbits
- 1.5° longitude offset between orbit tracks after 16-days

Latitude Coverage
- Nadir: ±85° Solar zenith angle
- Glint: ±81° Solar zenith angle

Sampling Rate
- 24 samples/second along track
- ~1 million samples per day
- 10-20% of the soundings expected to yield useful $X_{CO2}$ estimates

OCO-2 is a SAMPLING system, not a MAPPING system.

OCO-2 collects samples continuously along a narrow track with much coarser sampling from track-to-track.

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OCO-2 Nadir & Glint Sampling of Sao Paulo
Megacity Fossil Fuel (FFCO$_2$) Emissions as a Proxy for Anthropogenic CO$_2$ Emissions

Urbanization has concentrated >50% of the world’s population and 70% of fossil-fuel CO$_2$ emissions into <3% of the land surface. Monitoring FFCO$_2$ from ~30 Megacities worldwide provides a tractable measurement solution to trend total anthropogenic CO$_2$ emissions.

Duren & Miller, Nature Climate Change (2012)
High resolution, process-based greenhouse gas emissions data products or “bottom-up inventories”

Kevin Gurney
Associate Professor
School of Life Sciences
Senior Sustainability Scientist
Global Institute for Sustainability
Hestia

Greek goddess of the hearth fire

www.hestia.project.asu.edu
Synthesis framework

Current capability
- External data
- To develop
- To collaborate
- To integrate

HESTIA (ASU) (fossil fuel prior)

LA observational network (Megacity)
- CO, CO₂, FFCO₂, CH₄
- XCO₂, XCH₄

MODIS

WRF-VPRM (biosphere)

Mega city flux inventory

NARR (32km)

WRF

Initial & boundary conditions

WRF-GHG (36/12/4 km)

Model Forecast
- 4D CO₂ fields (goal CO₂, CH₄)

Analytical inversion & Synthesis analysis

WRF STILT (LSCE) (Lavaux)

GEOS-5/ MERRA (met. fields)

Global mode
- (2°x2.5°)
- N. America
  - (0.5°x0.667°)

Satellites
- (ACOS, OCO-2, MOPITT)

Target (LA) observations

CMS Flux Inventory (land/ocean priors)

3D-var assimilation

To develop

To collaborate

To integrate
NARROWING THE UNCERTAINTIES ON AEROSOL AND CLIMATE CHANGES IN SAO PAULO STATE
NUANCE-SPS

LAPAT
Departamento de Ciências Atmosféricas
Instituto de Astronomia, Geofísica e Ciências Atmosféricas-USP
The megacity of São Paulo will be an example of integrated approach regarding evaluating of the impact of the climate change on its air quality.

The Metropolitan Area of Sao Paulo will be an observatory of the climate, with special attention to the variation of the meteorological characteristics due to the climate change.
NARROWING THE UNCERTAINTIES ON AEROSOL AND CLIMATE CHANGES IN SÃO PAULO STATE – NUANCE-SPS

- **Emission Model - SMOKE**
  - Biogenic
  - Stationary
  - Vehicular
  - Biomass Burning
  - Sources Characteristics
  - Evaporative Emissions
  - Dinamometer Studies
  - Tunnel Measurements
  - Traffic Data
  - Vehicular Activity
  - Hydrocarbons and Particles Speciation
  - Vehicular Tracer Identification

- **Air Quality Modelling Tools**
  - Models In-line SPM-BRAMS
  - Models Off-line CIT
  - WRF/Chem
  - Radiative Processes
  - Photochemical Aerosol Impacts
  - Urban Aerosol Impacts: Rain Suppression or Enhancement

- **Atmospheric Chemistry**
  - Photochemical Formation of organic + inorganic
    - Chemical Mechanism
    - Chamber Experiments
    - Nano and Fine Particles Formation
    - Radiative Processes
    - Microphysics Process

- **Health Impacts**
  - Nano epidemiology

- **Integrating the modules**
  - Evaluation of different scenarios: Feedback process

- **Emission Model**
  - Atmospheric Modeling + Dose response system
  - Chemical Mechanism
  - Gas – aerosol description
Mortality and morbidity risk associated to ozone and particles concentration

Martins, 2013
Application – Climate Change Impacts

Two nested grids → 9 and 3 km grid spacing, respectively, having the grid center collocated in the center of the MASP

Meteorological fields for the initial conditions were provided by the Global Forecast System (GFS), with horizontal grid spacing of 1 by 1 degree every 6 hours

Boundary Conditions CCSM3
• Community Climate System Model
• NCAR

Mazzoli C., 2013