# 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)

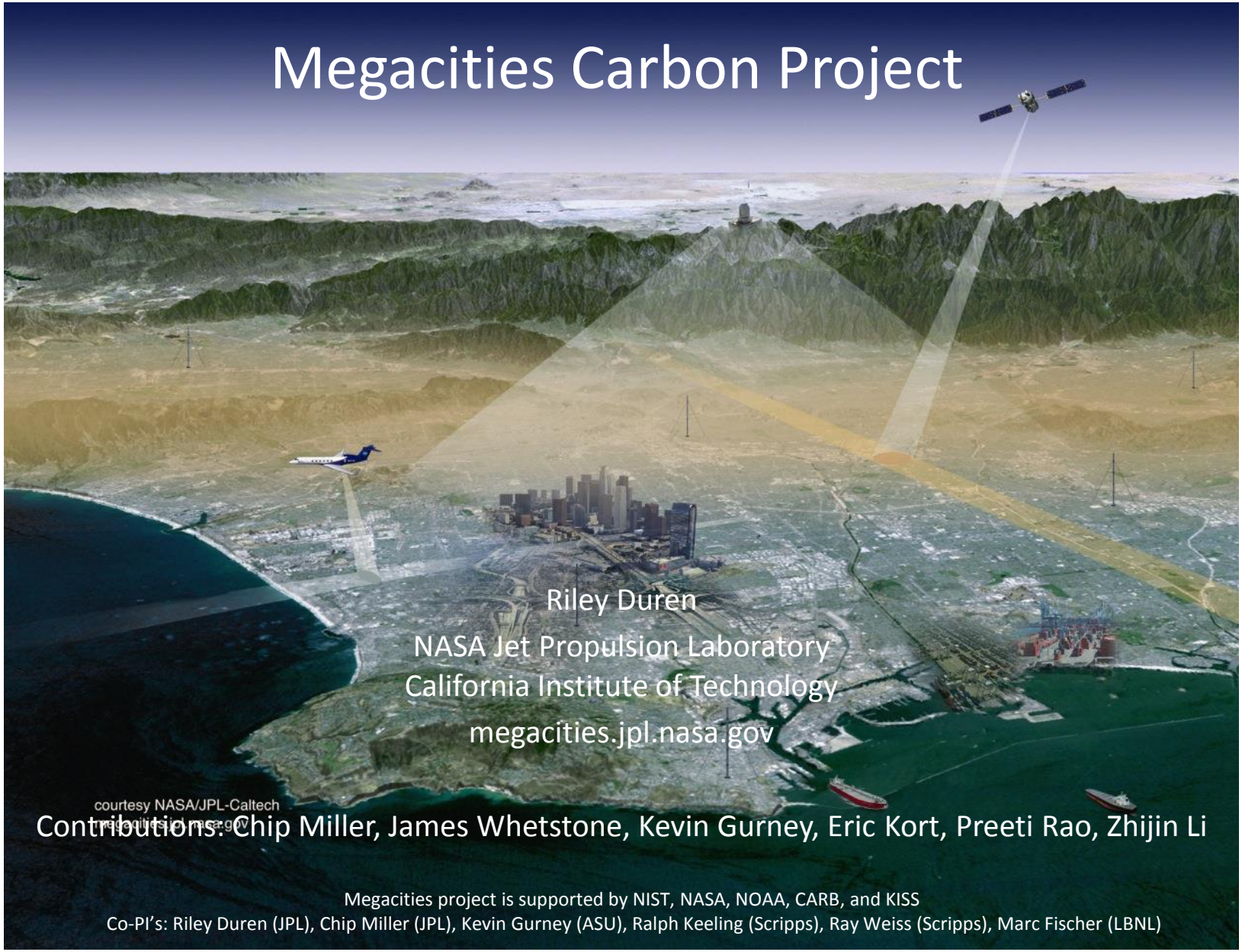
- São Paulo Group
- USP, IPEN, INPE

# 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.jpl.nasa.gov

# Megacities Carbon Project



Riley Duren
NASA Jet Propulsion Laboratory
California Institute of Technology
megacities.jpl.nasa.gov

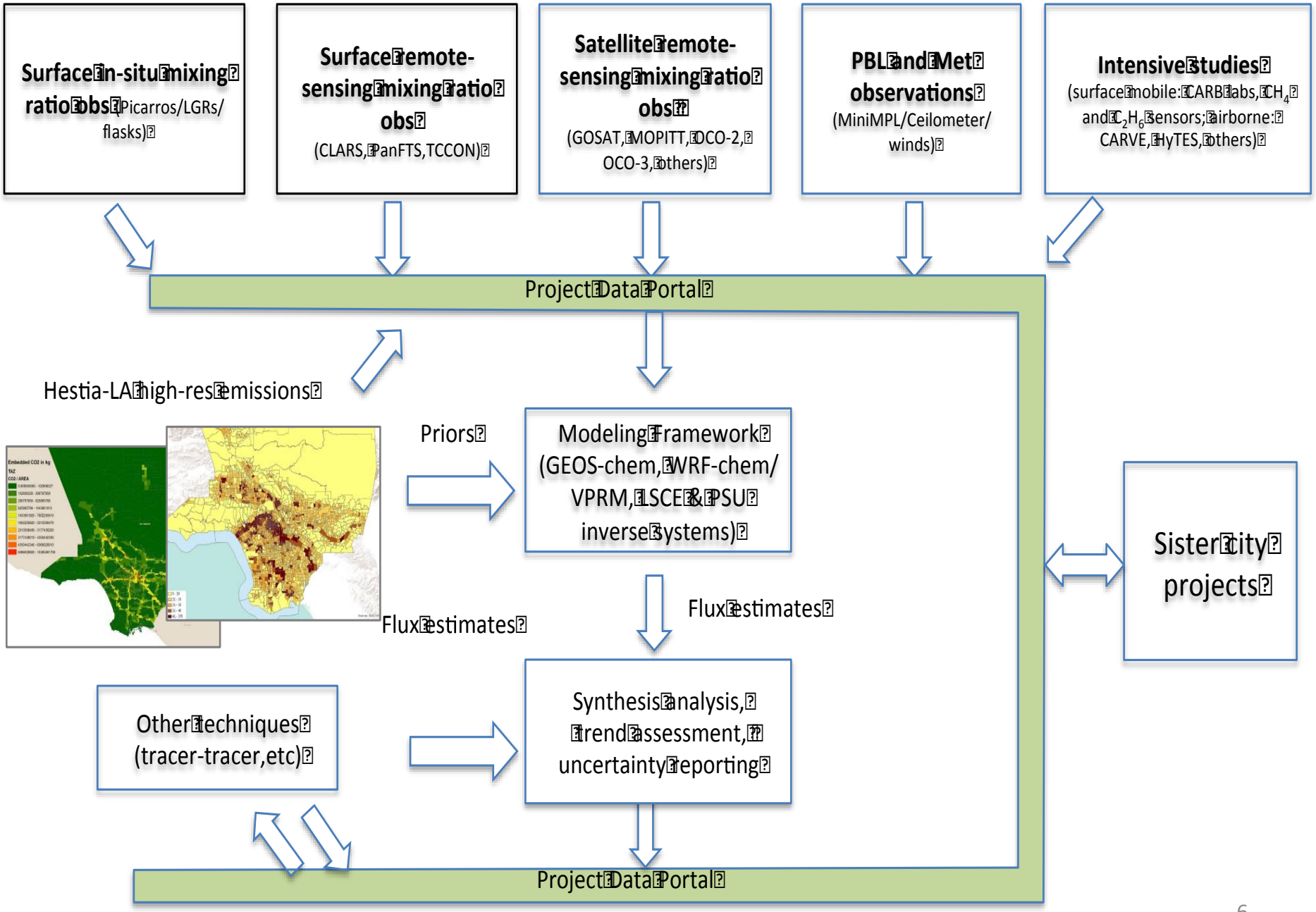
courtesy NASA/JPL-Caltech
http://photojournal.jpl.nasa.gov/

Contributions: Chip Miller, James Whetstone, Kevin Gurney, Eric Kort, Preeti Rao, Zhijin Li

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)

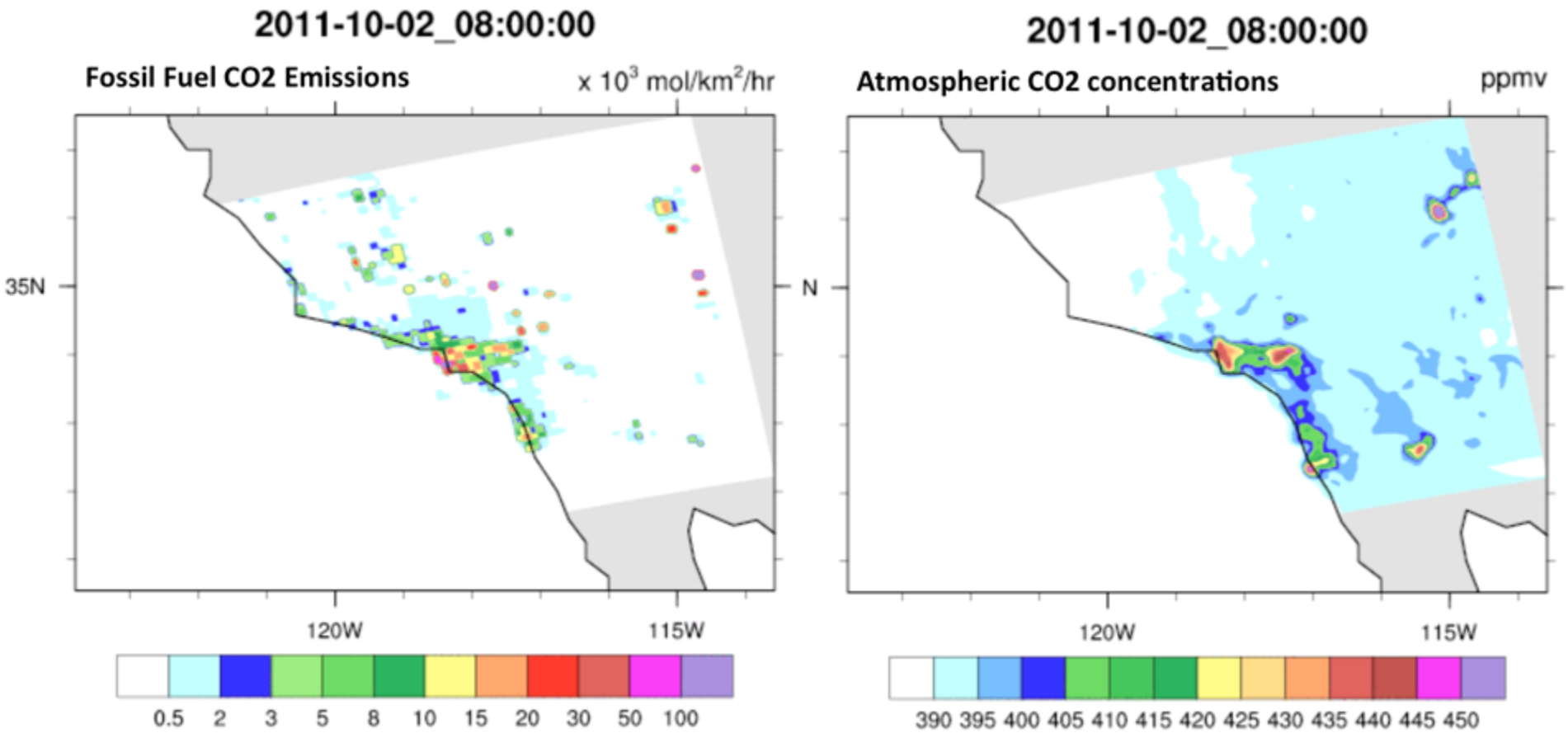
# LA Project components

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)
3. Surface GHG measurements – in-situ and remote-sensing (Duren, Keeling, Weiss, Sander, Wennberg 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)


Surface in-situ mixing ratio obs (Picarros/LGRs/ flasks)
Surface remote-sensing mixing ratio obs (CLARS, PanFTS, TCCON)
Satellite remote-sensing mixing ratio obs (GOSAT, MOPITT, OCO-2, OCO-3, others)
PBL and Met observations (MiniMPL/Ceilometer/ winds)
Intensive studies (surface mobile: CARB labs, $CH_4$ and $C_2H_6$ sensors; airborne: CARVE, HyTES, others)
Project Data Portal
Hestia-LA high-res emissions
Priors
Modeling Framework (GEOS-chem, WRF-chem/ VPRM, LSCE & PSU inverse systems)
Flux estimates
Flux estimates
Sister city projects
Other techniques (tracer-tracer, etc)
Synthesis analysis, trend assessment, uncertainty reporting
Project Data Portal

# (2) High-resolution atmospheric $CO_2$ modeling

## (currently 4km for SoCal – moving to 1km)

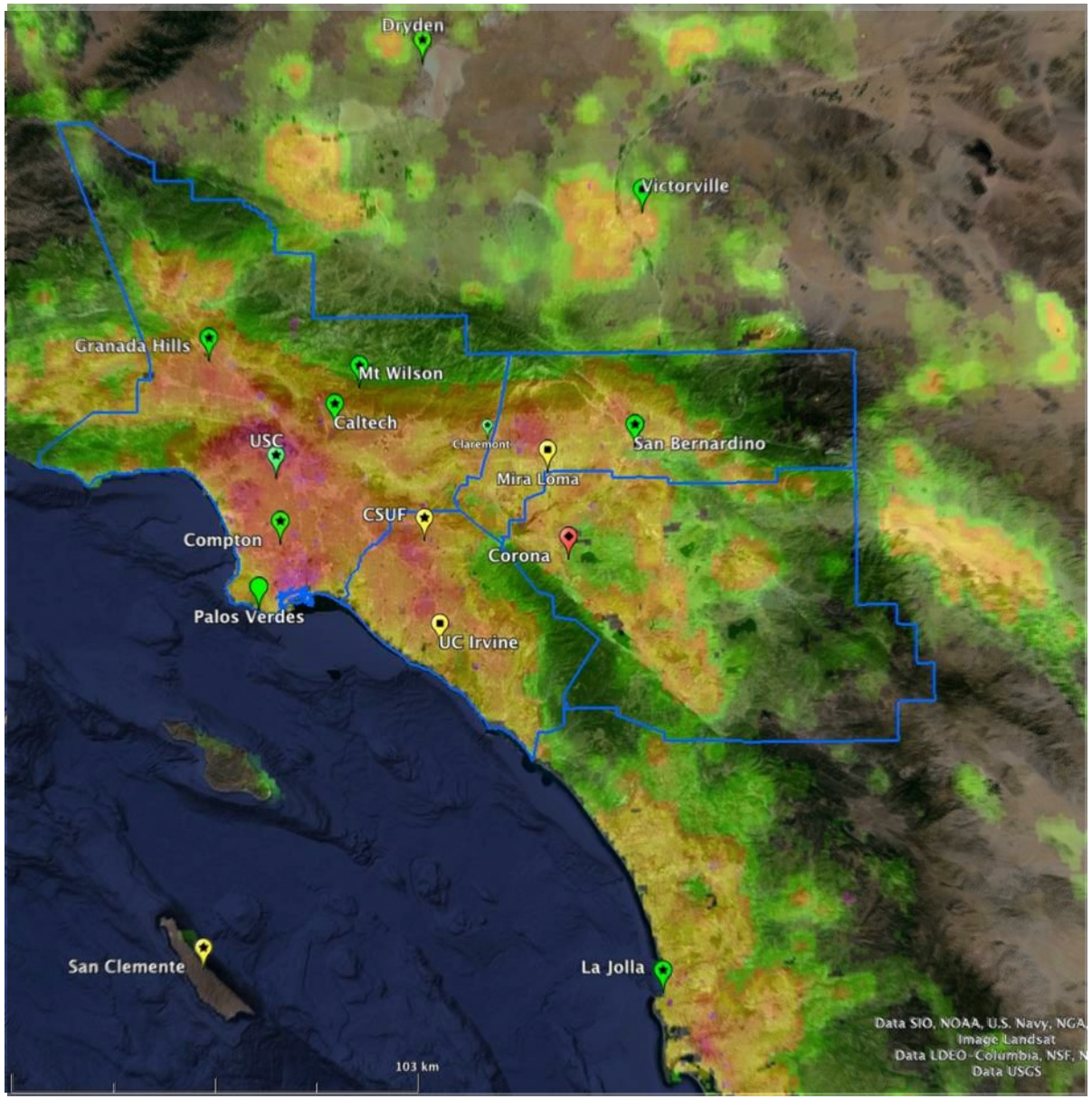



**Solve for this**

**Measure this**

*J. Li & S. Feng (JPL)*

# (3) Surface measurement network

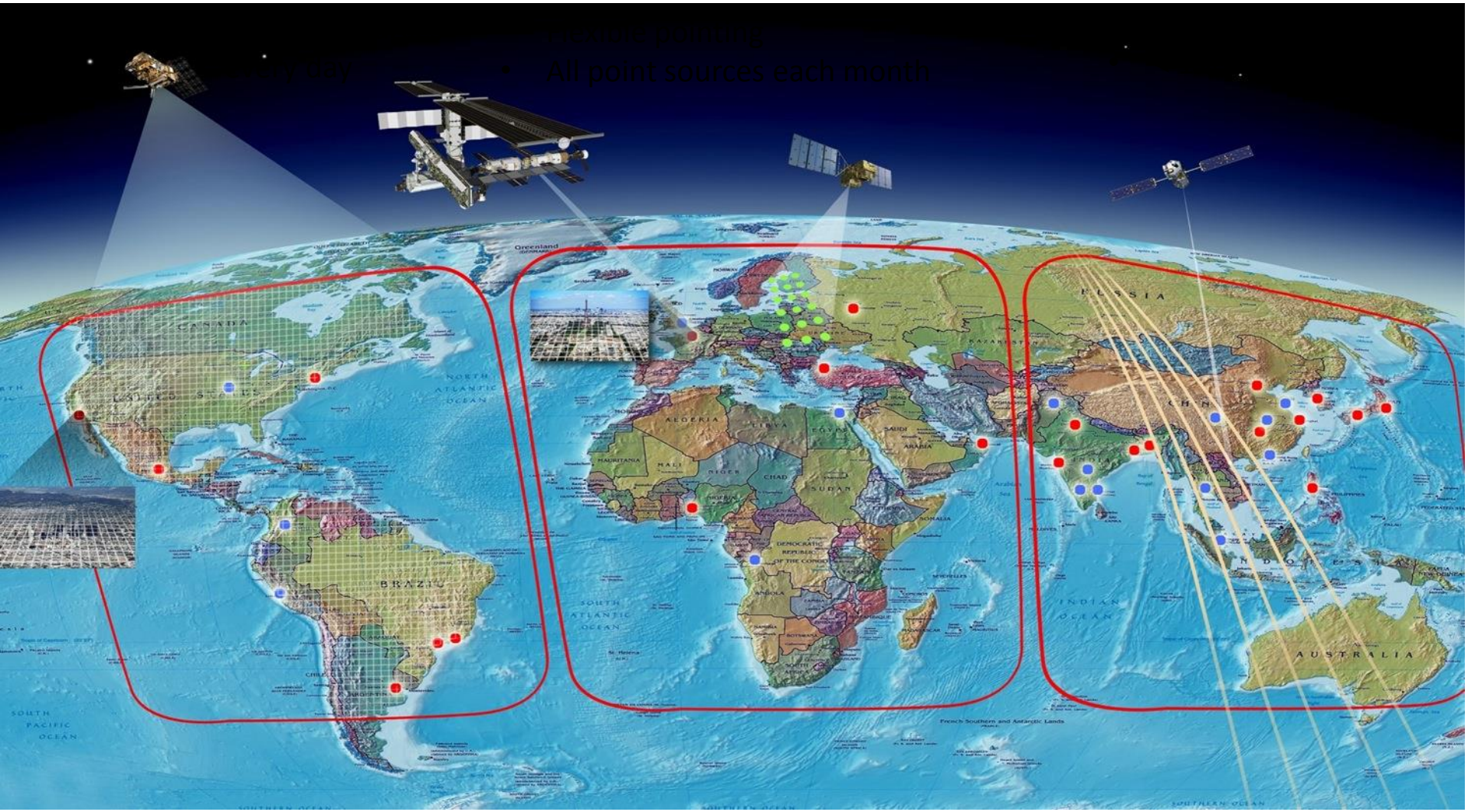



Mira Loma and Corona sites will likely be Replaced by sites at Riverside and TBD downtown LA location

Fossil fuel CO2 overlay courtesy T. Oda, CSU/NOAA, ODIAC v3, 2010, 1km, log scale (green: 100, purple >10,000 gC/m2/yr)

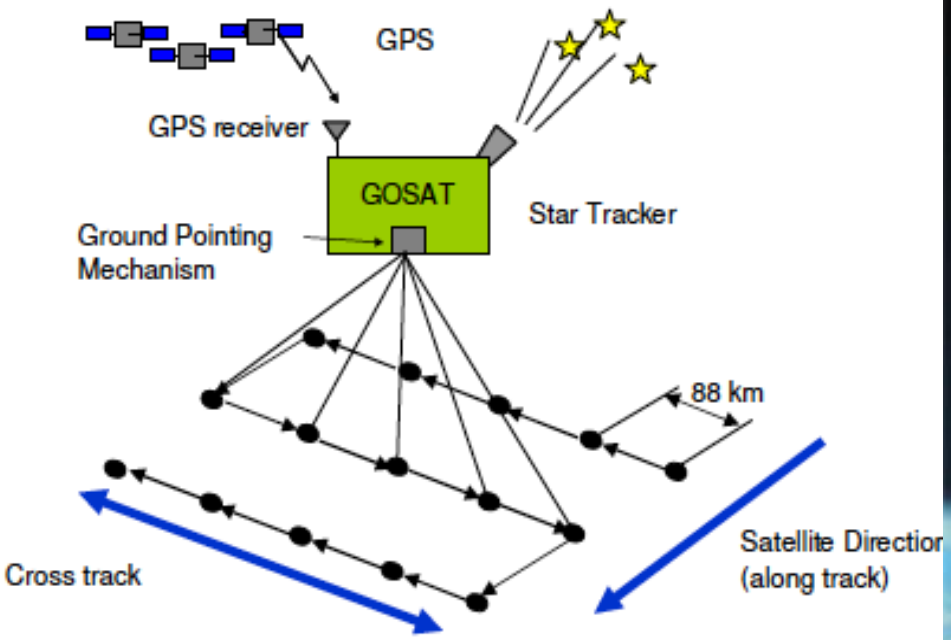
# (4) Emerging satellite capabilities

Geostationary (20xx?) OCO-3 on ISS (2017?) GOSAT (2009-?) OCO-2 (2014-2016)




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

# Greenhouse Gas Observing Satellite (GOSAT) Observations of NIR Reflected Sunlight

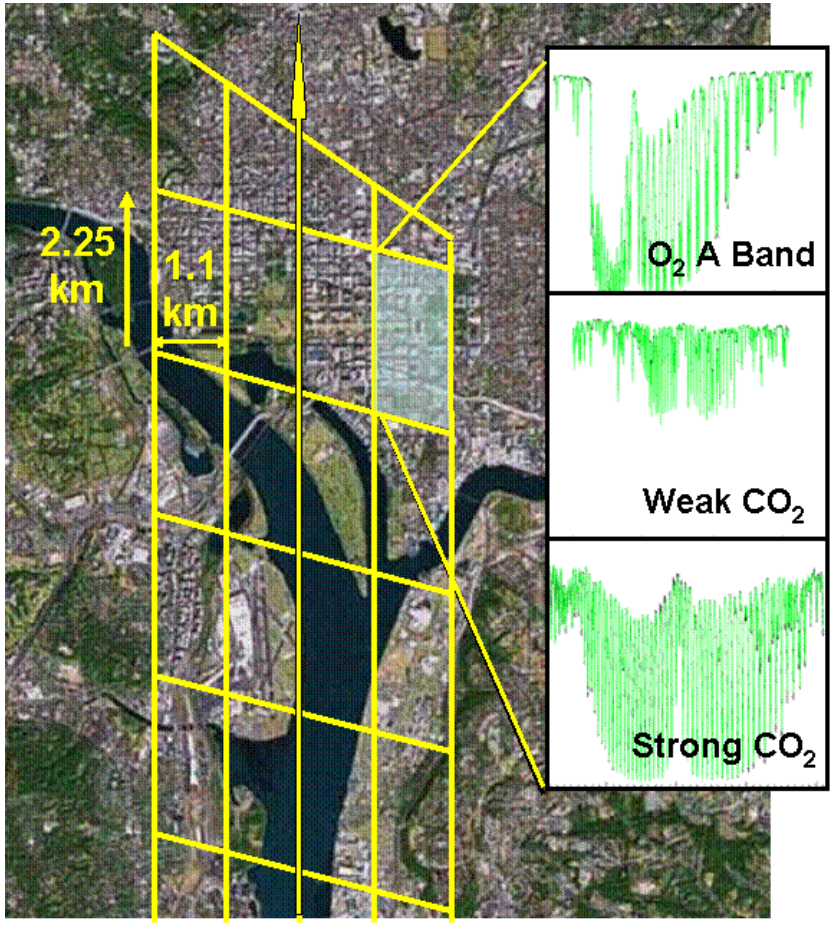


GOSAT TANSO-FTS samples on a ~150 km grid
Can also TARGET individual surface locations

Launch: January 2009

Charles.E.Miller@jpl.nasa.gov

# 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

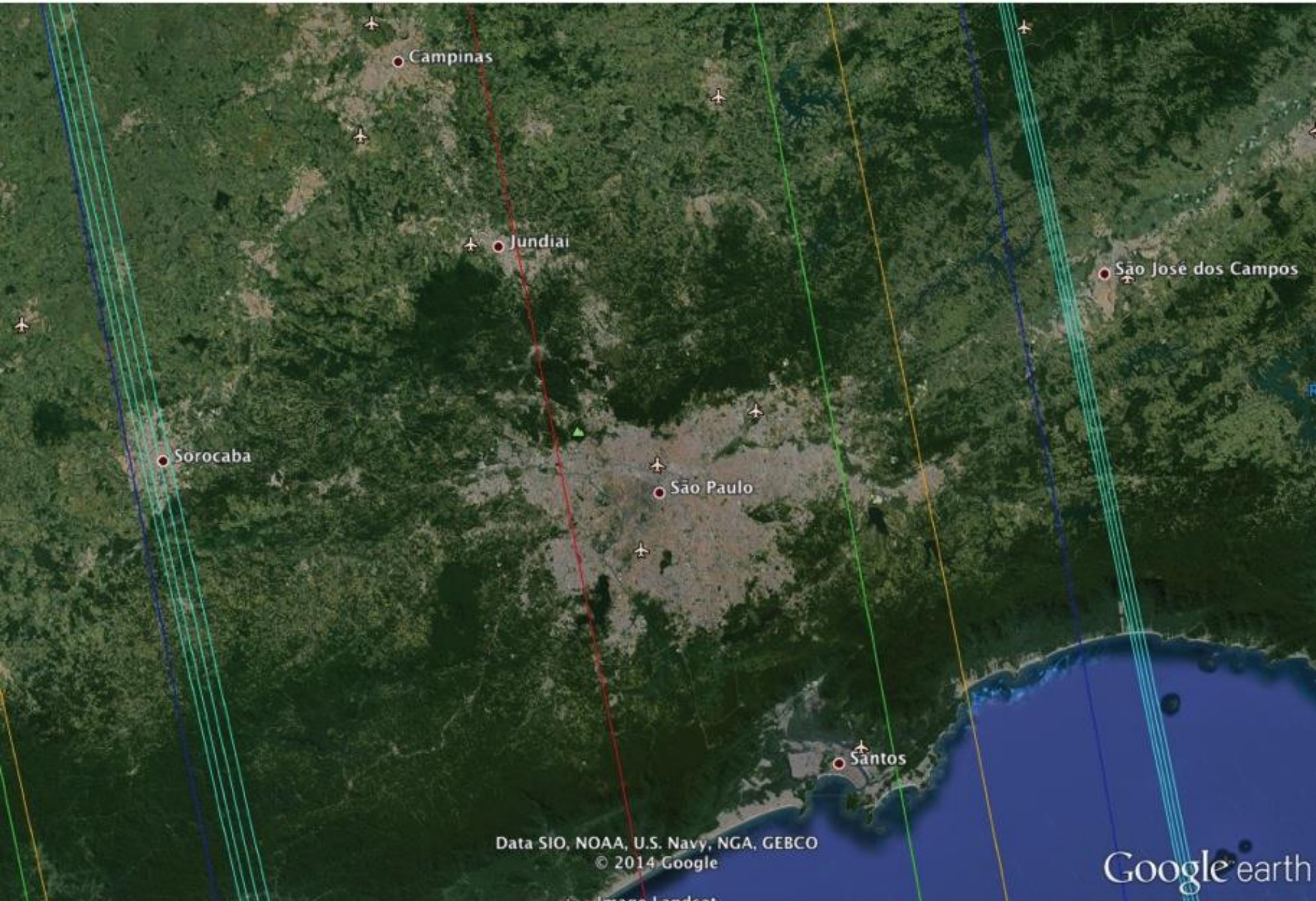
- 24 samples/second along track
- **~1 million samples per day**
- **10-20%** of the soundings expected to yield useful $X_{CO2}$ estimates

**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.

Charles.E.Miller@jpl.nasa.gov

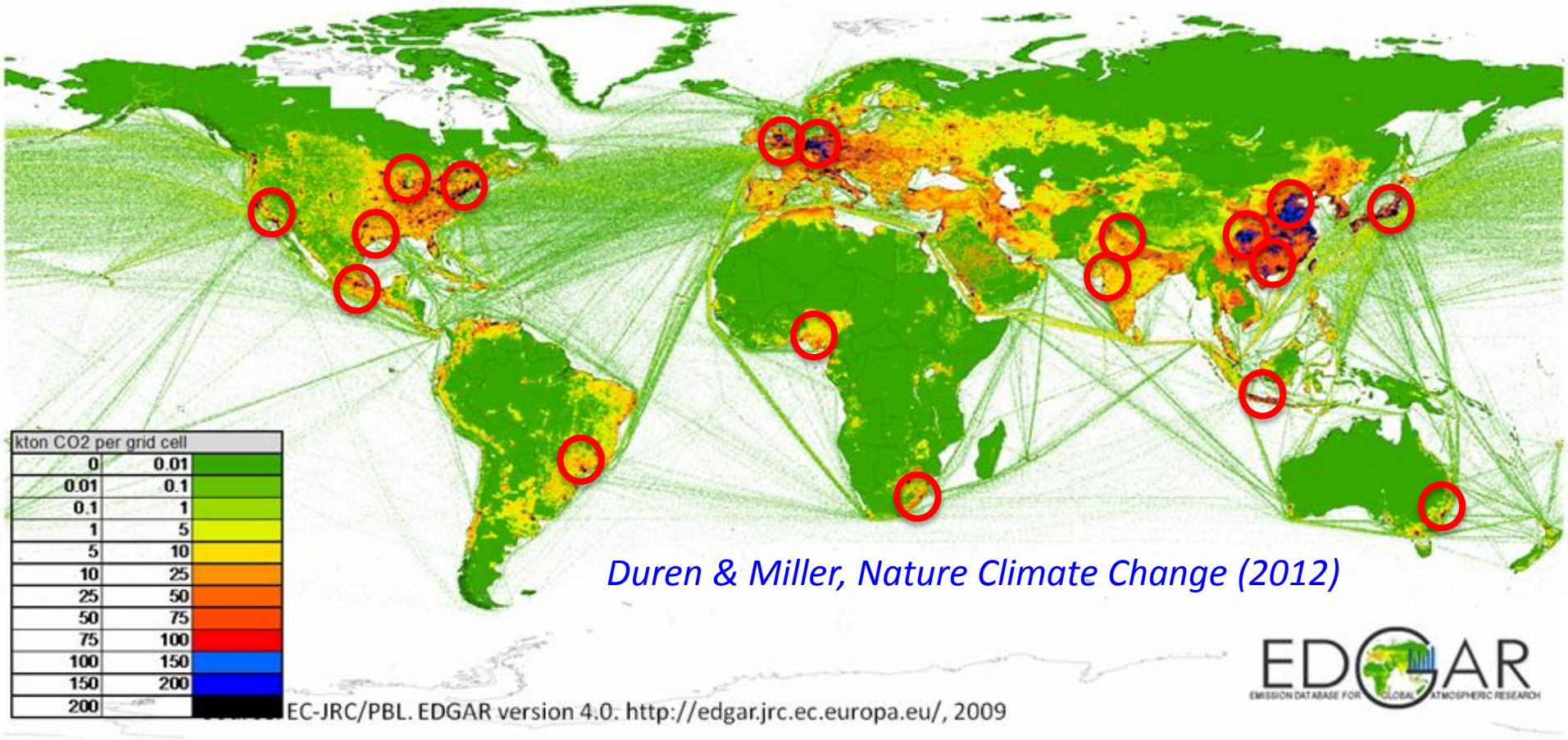
# OCO-2 Nadir & Glint Sampling of Sao Paulo



# 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



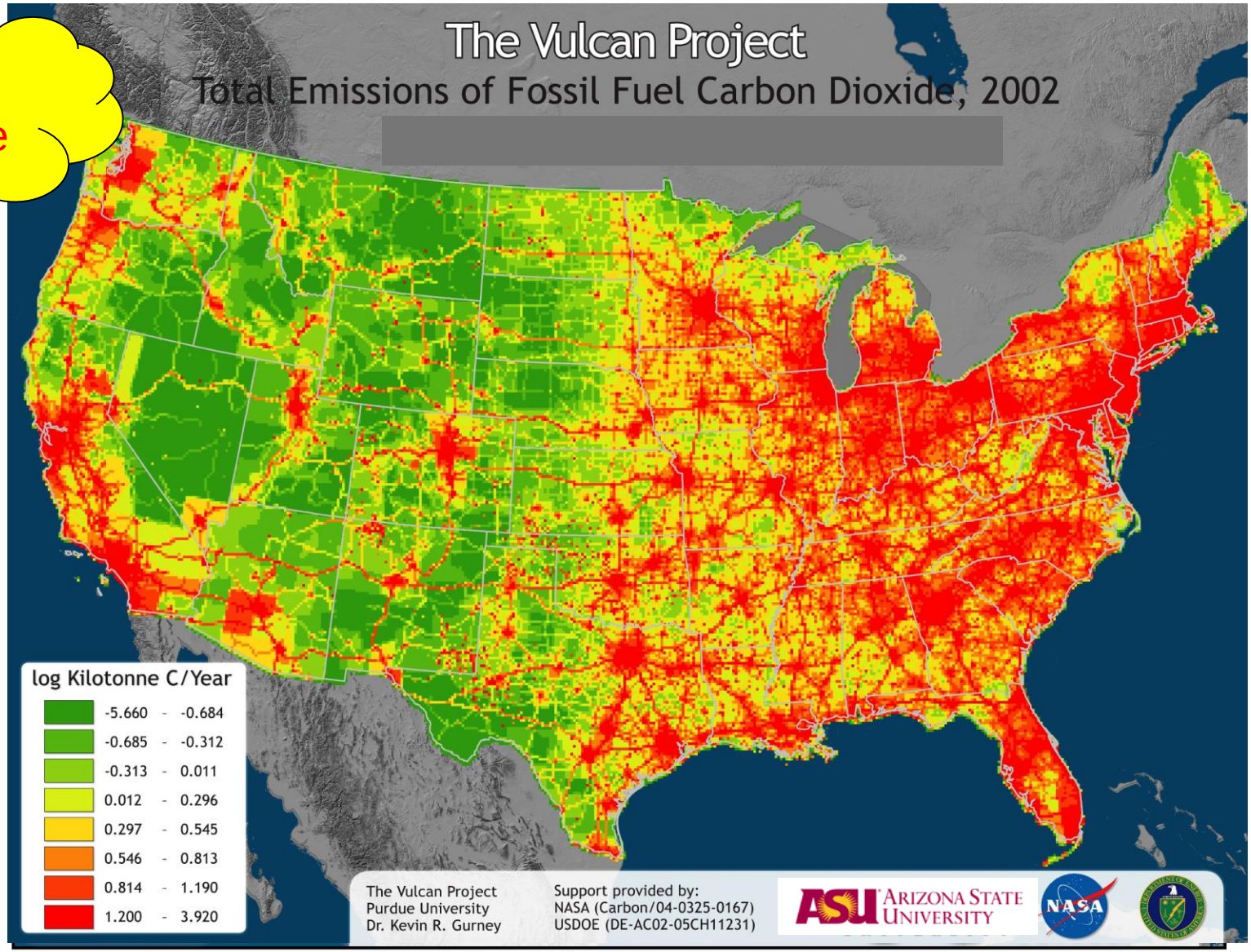

*Duren & Miller, Nature Climate Change (2012)*

# 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

# Vulcan

Roman
God of Fire




www.vulcan.project.asu.edu

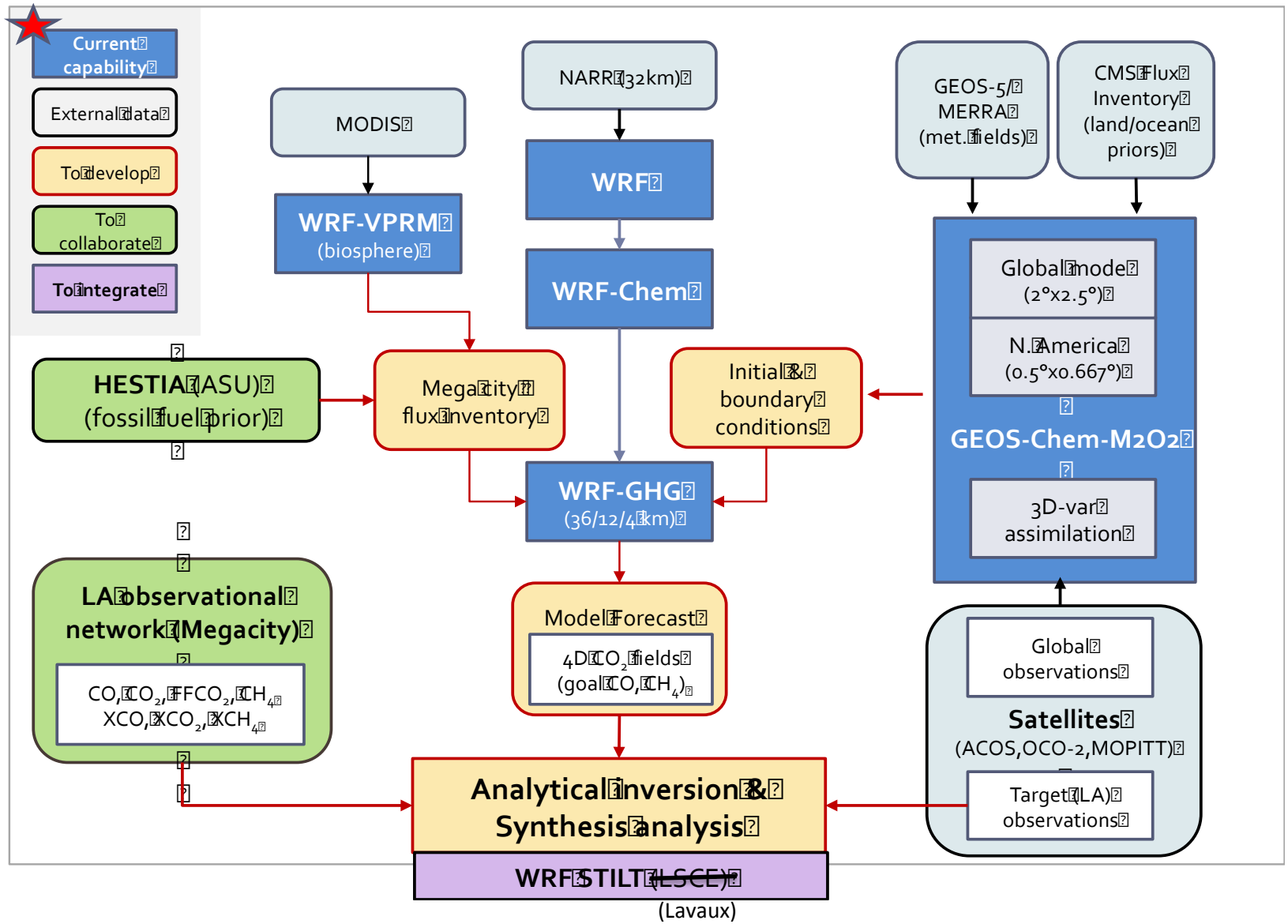
Gurney et al., *Env. Sci & Tech*, 2009

# Hestia

Greek goddess of the hearth fire

www.hestia.project.asu.edu

# Synthesis framework



# NARROWING THE UNCERTAINTIES ON AEROSOL AND CLIMATE CHANGES IN SAO PAULO STATE

# NUANCE-SPS

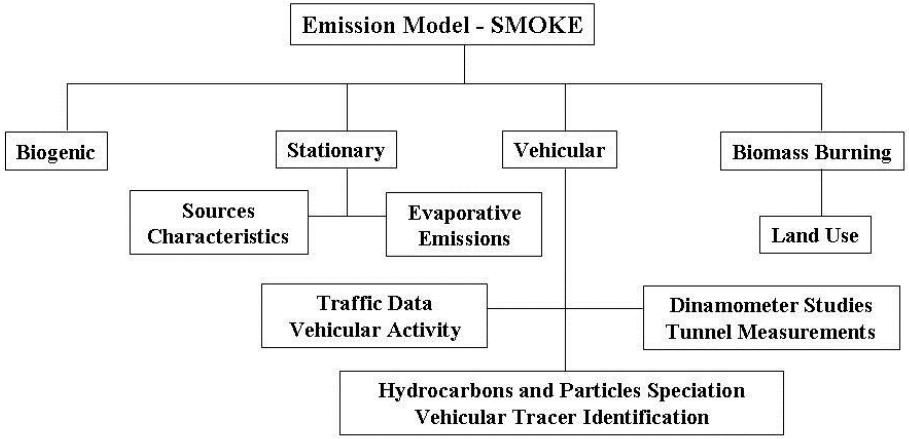
LAPAT
Departamento de Ciências Atmosféricas
Instituto de Astronomia, Geofísica e Ciências Atmosféricas-USP

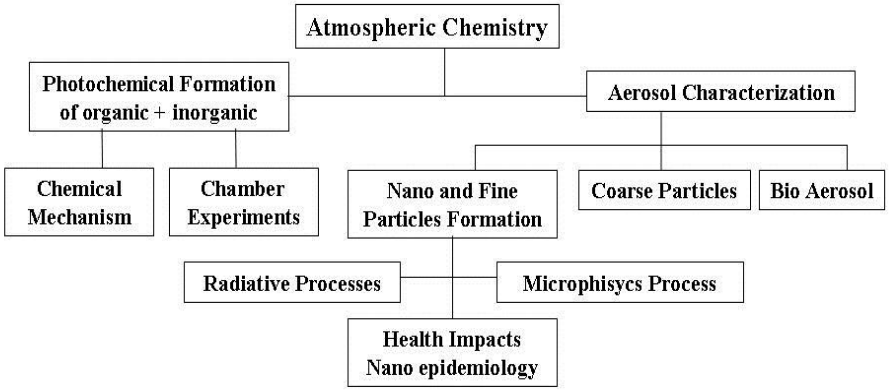
# The project – approach

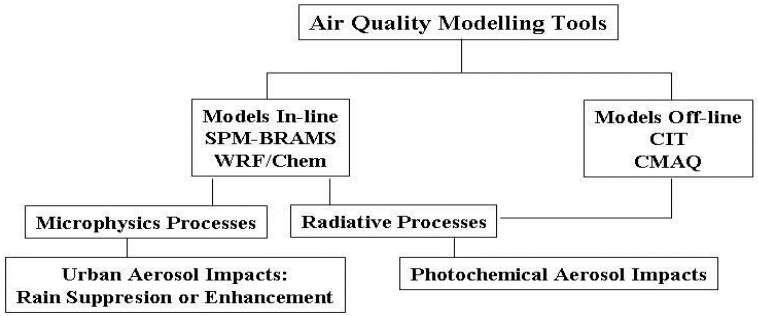
- ***The megacity of São Paulo will be an example of integrated approach regarding evaluating of the impact of the climate change on its air quality.***

- ***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

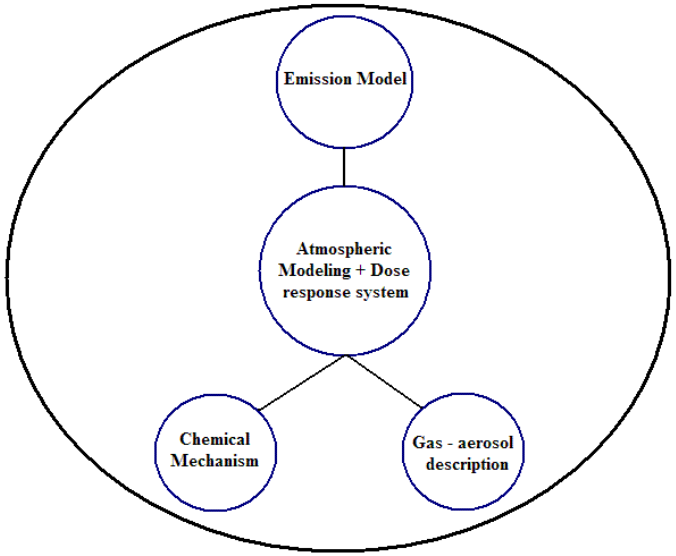


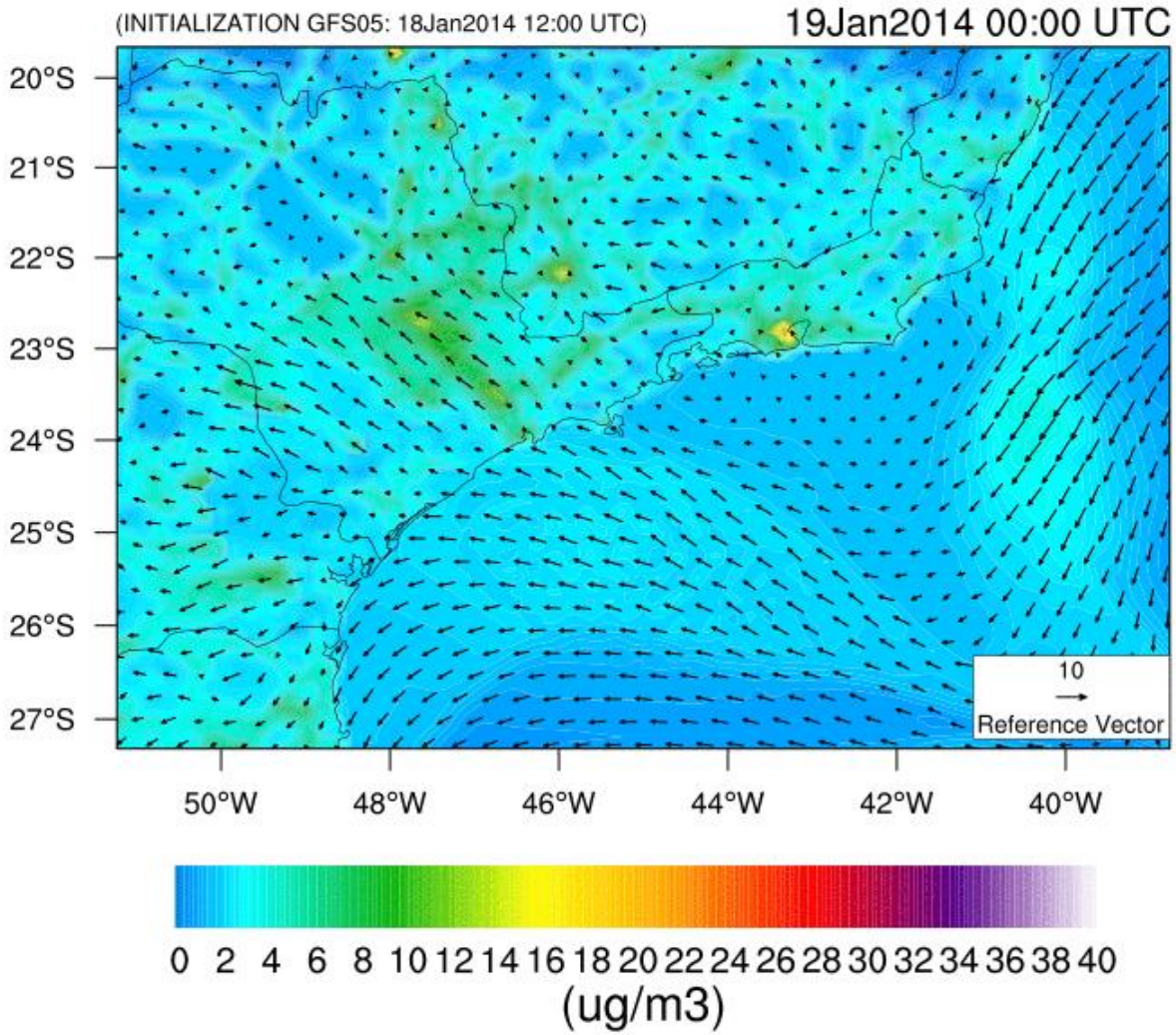




**Integrating the modules**

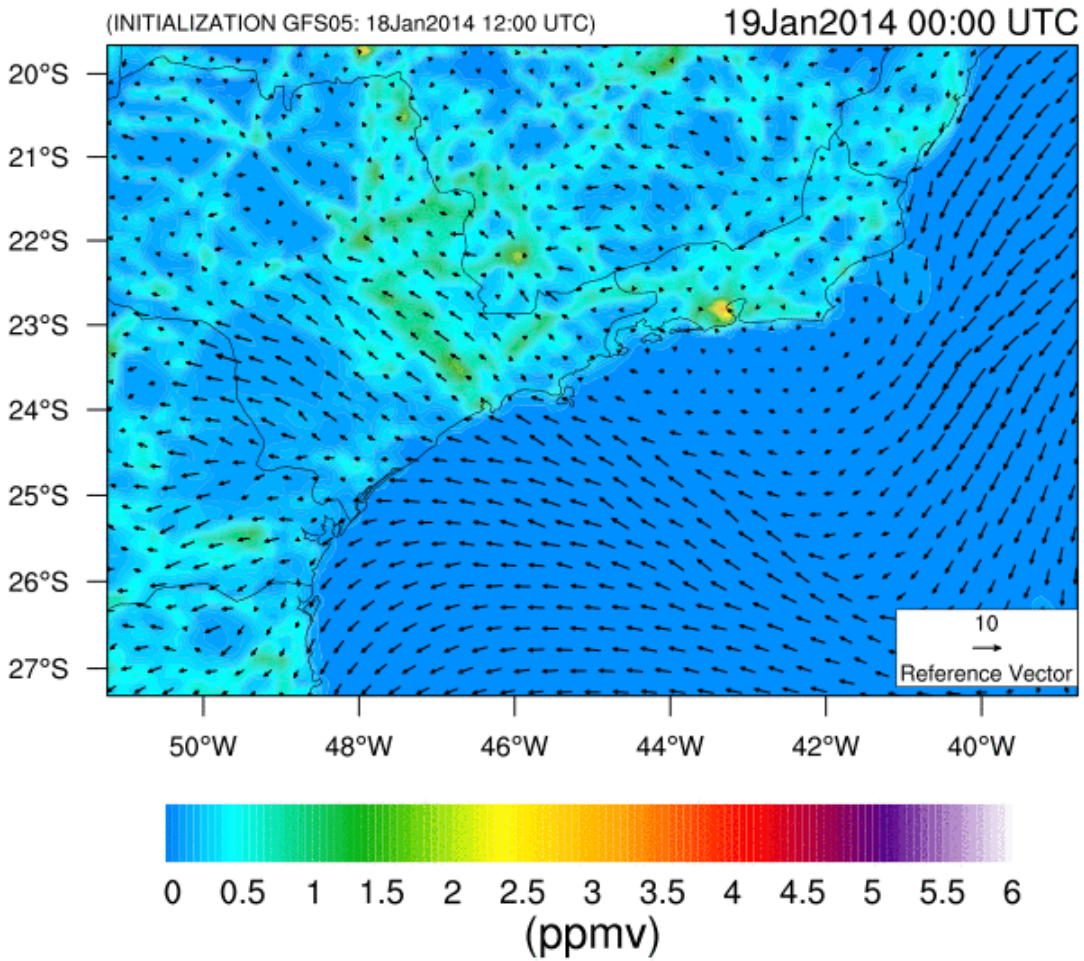
**Evaluation of different scenarios: Feedback process**

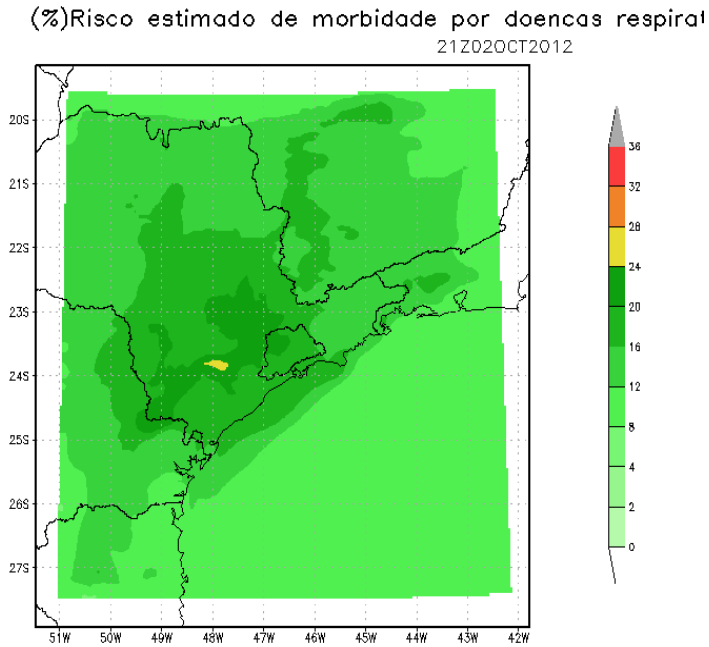


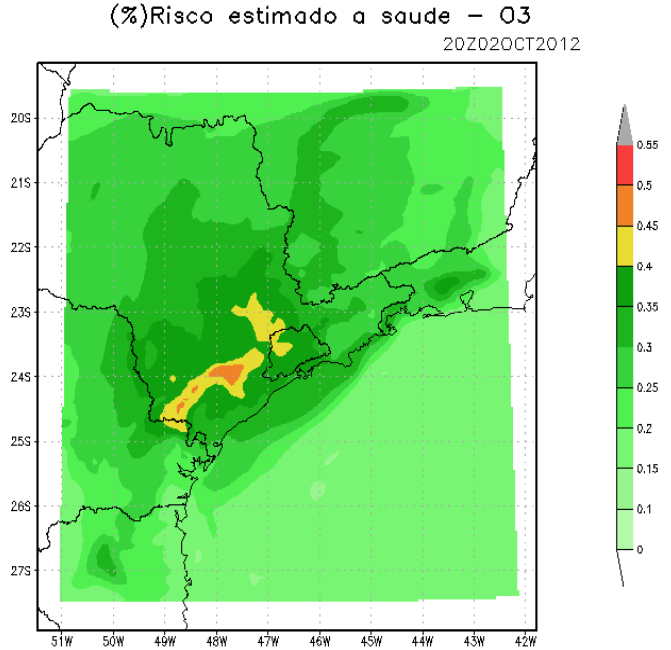
# PM 2.5 CONCENTRATION (ug/m3) and SURFACE WIND



# BLACK CARBON CONC. (ug/kg-dryair) and SURFACE WIND






***Mortality and morbidity risk associated to ozone and particles concentration***

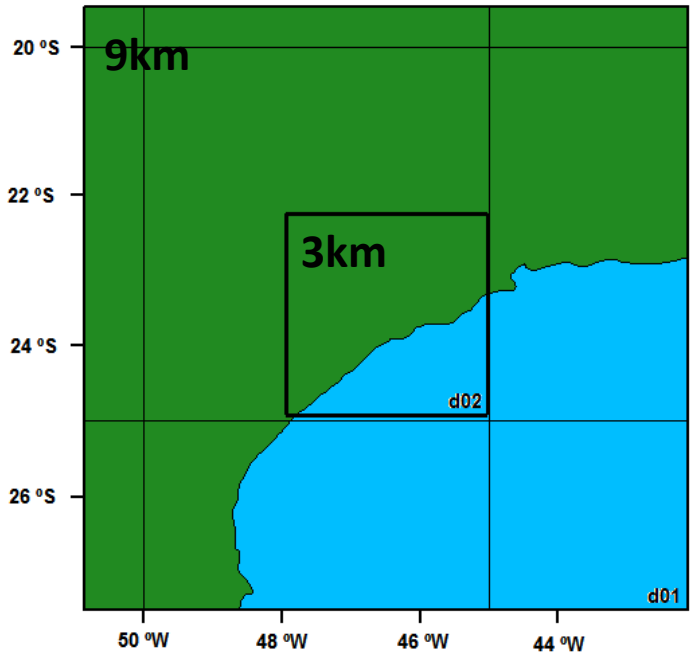
www.lapat.iag.usp.br

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




**<u>Boundary Conditions CCSM3</u>**

- *Comunity Climate System Model*
- NCAR

Mazzoli C., 2013