Simulated Geostationary CH_4, CO_2, CO and aerosol Measurements Testbed: California Laboratory for Atmospheric Remote Sensing

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Objectives for GEO-CAPE pre phase A work

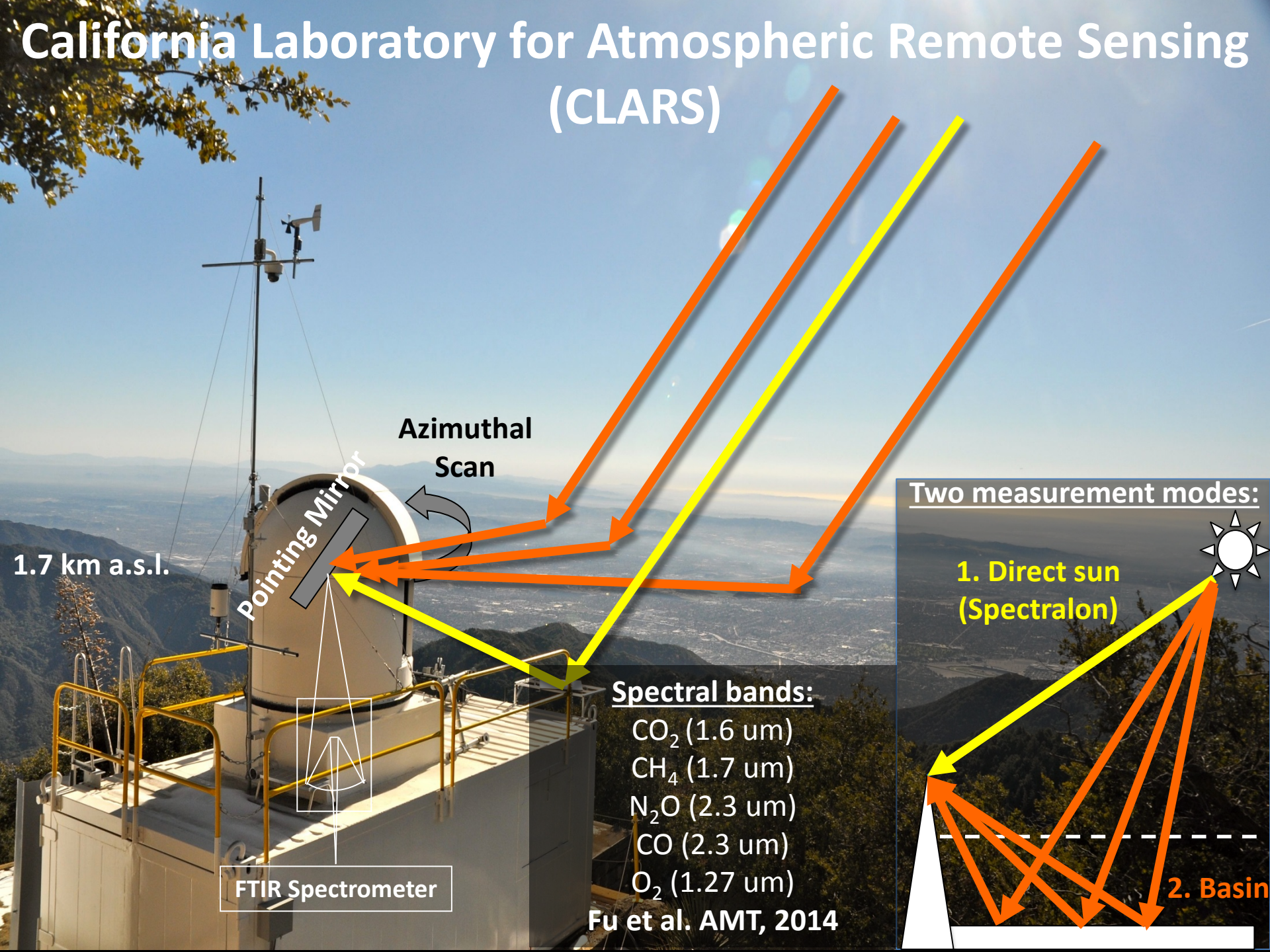
1. Using an observing system for trace gases that emulates a spectrometer in geostationary orbit, obtain spatially and temporally resolved fluxes of trace gases including CH_4, CO_2 and CO from column abundance measurements.

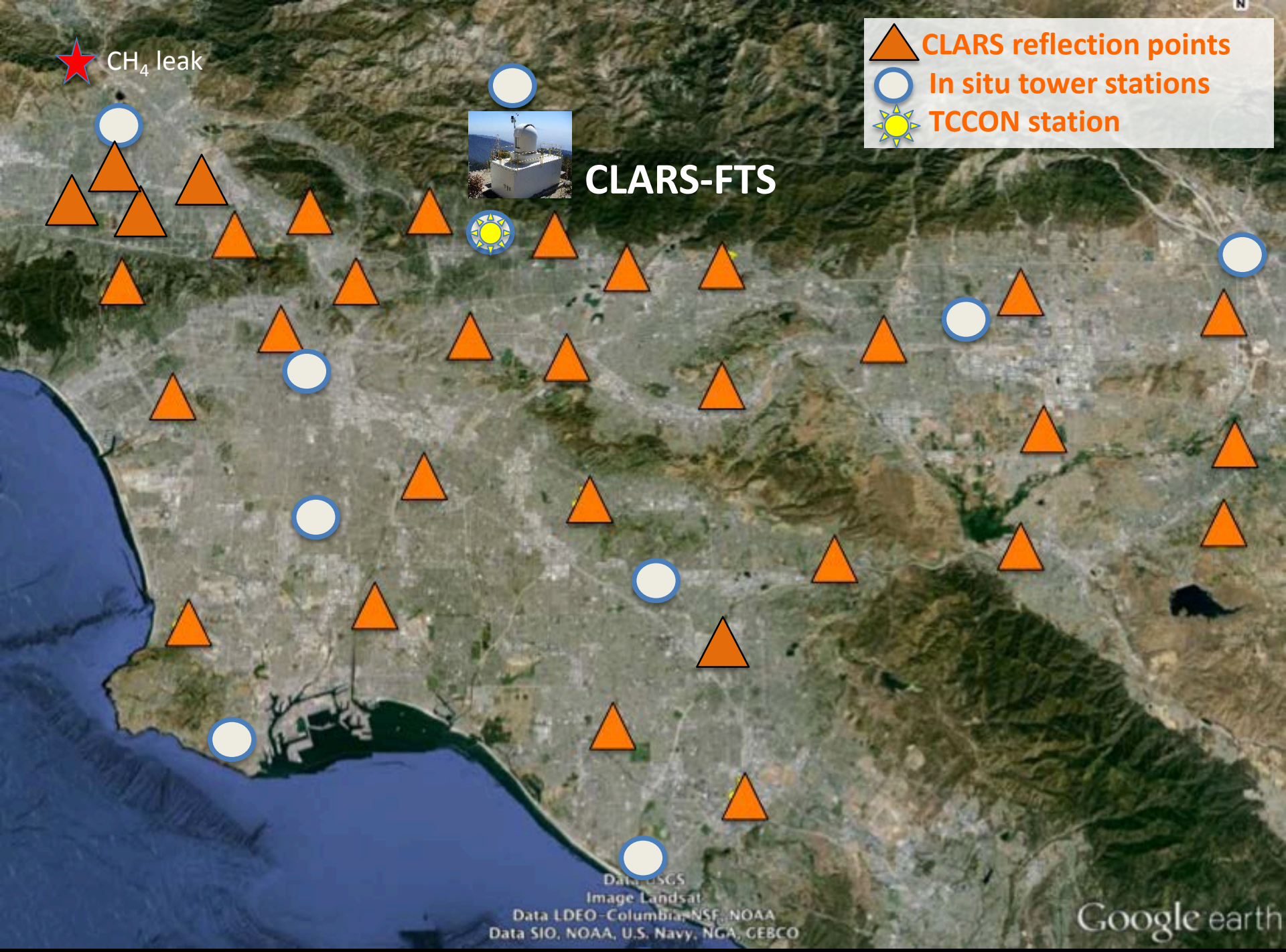
2. Assess the impact of confounding variables including high and low clouds and aerosols, topographic relief, and surface albedo variations

3. Use these results to refine the measurement and instrument requirements for instruments on future missions.

4. Continue to develop the technology for future imaging Fourier transform spectrometers such as PanFTS.

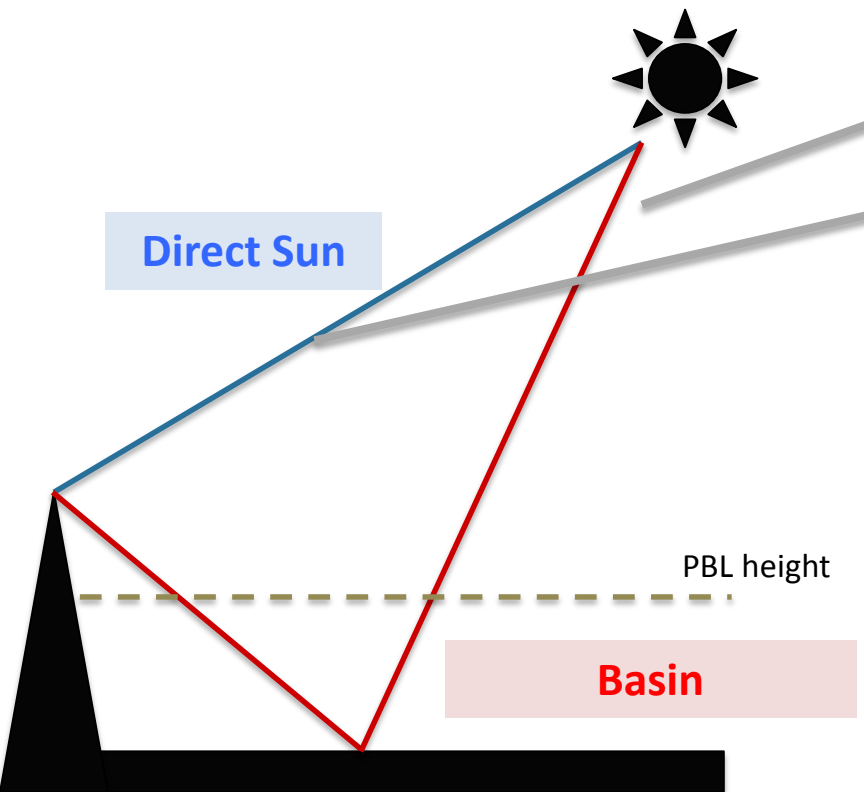
California Laboratory for Atmospheric Remote Sensing (CLARS)

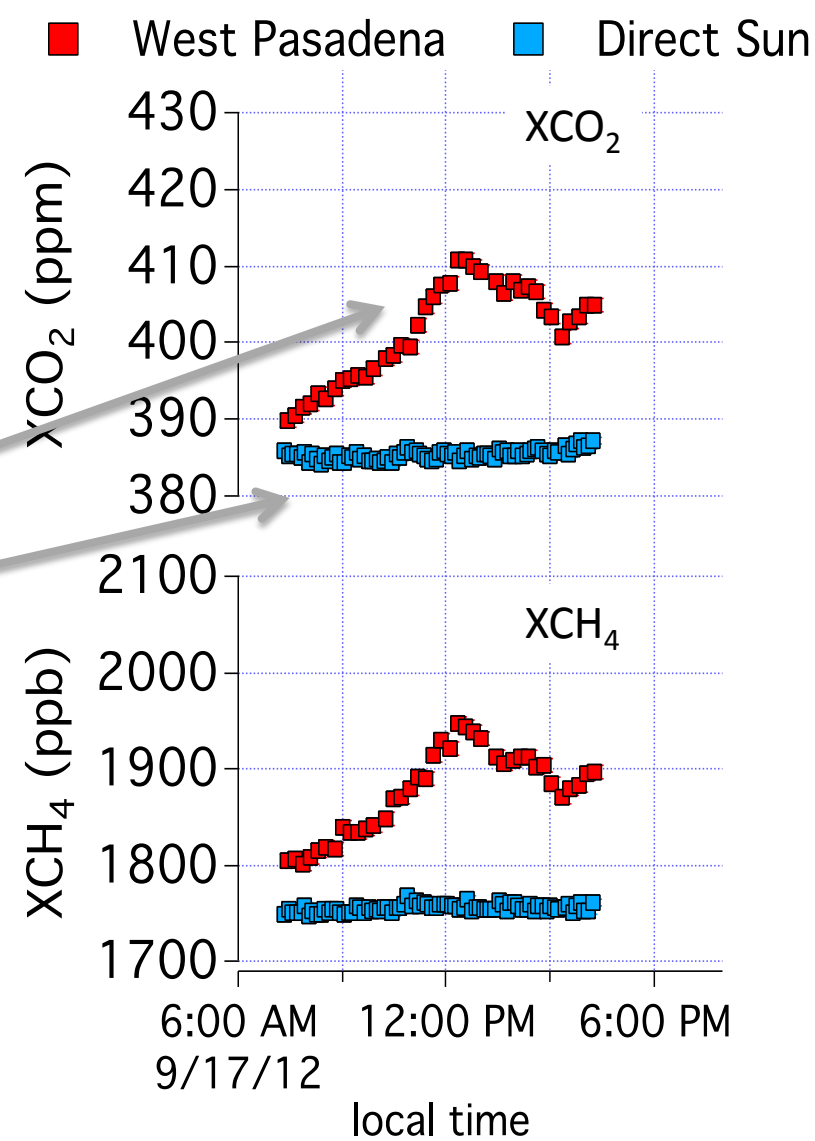



CH4 leak
CLARS-FTS
CLARS reflection points
In situ tower stations
TCCON station
Image Landsat
Data LDEO-Columbia, NSF, NOAA
Data SIO, NOAA, U.S. Navy, NGA, GEBCO
Google earth

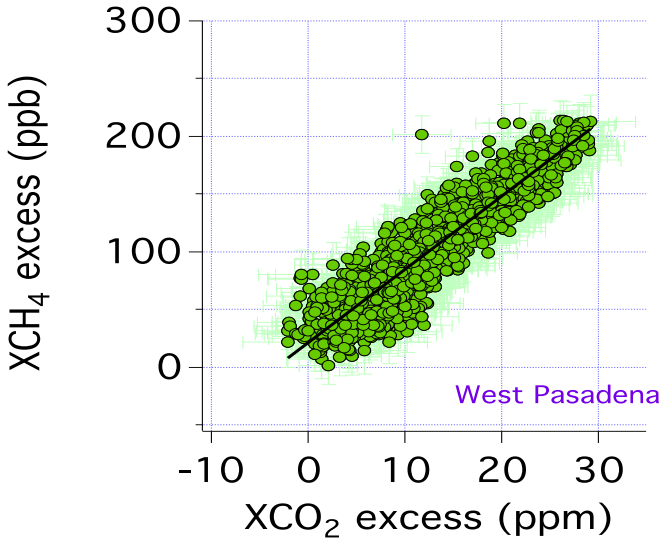
Diurnal variations of Direct Sun & Basin XGAS

- Direct sun XGAS has no diurnal variations.
- Basin XGAS shows strong diurnal variation due to basin emissions.

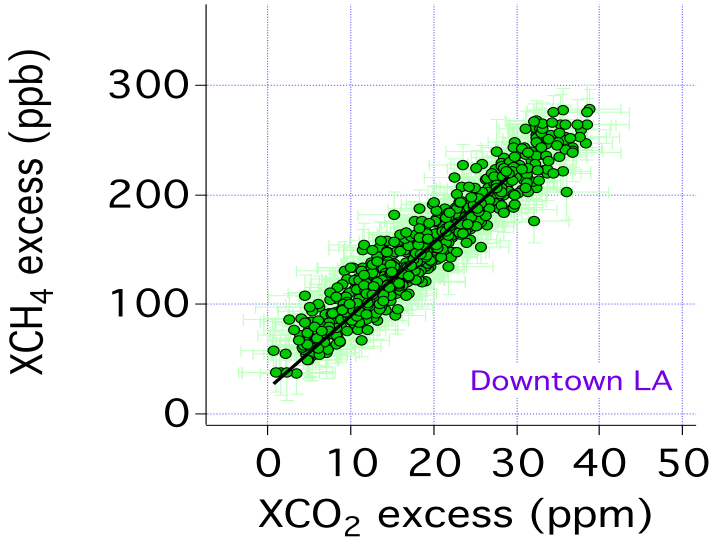




Correlation Between XCH_4 and XCO_2 Excess

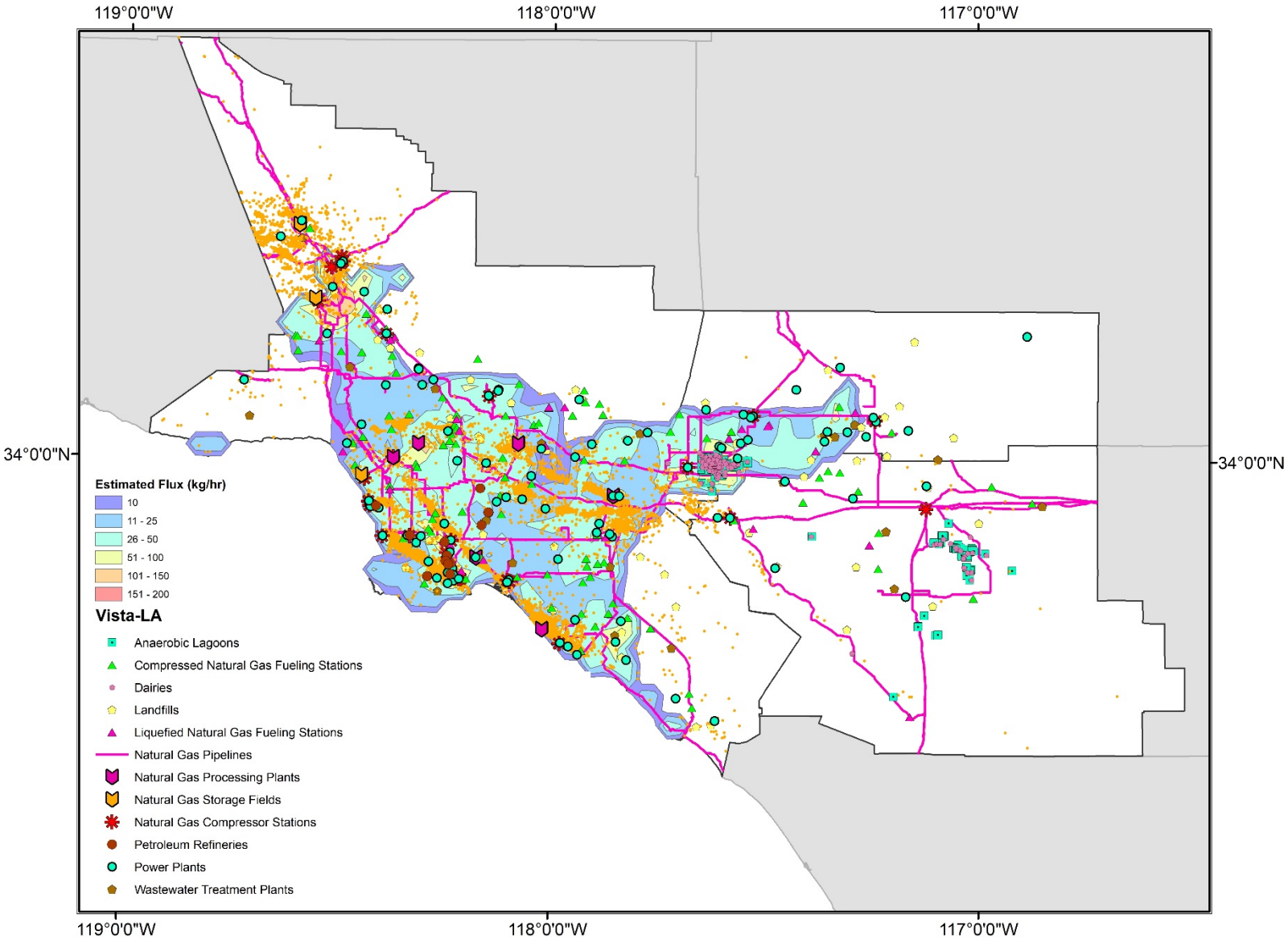


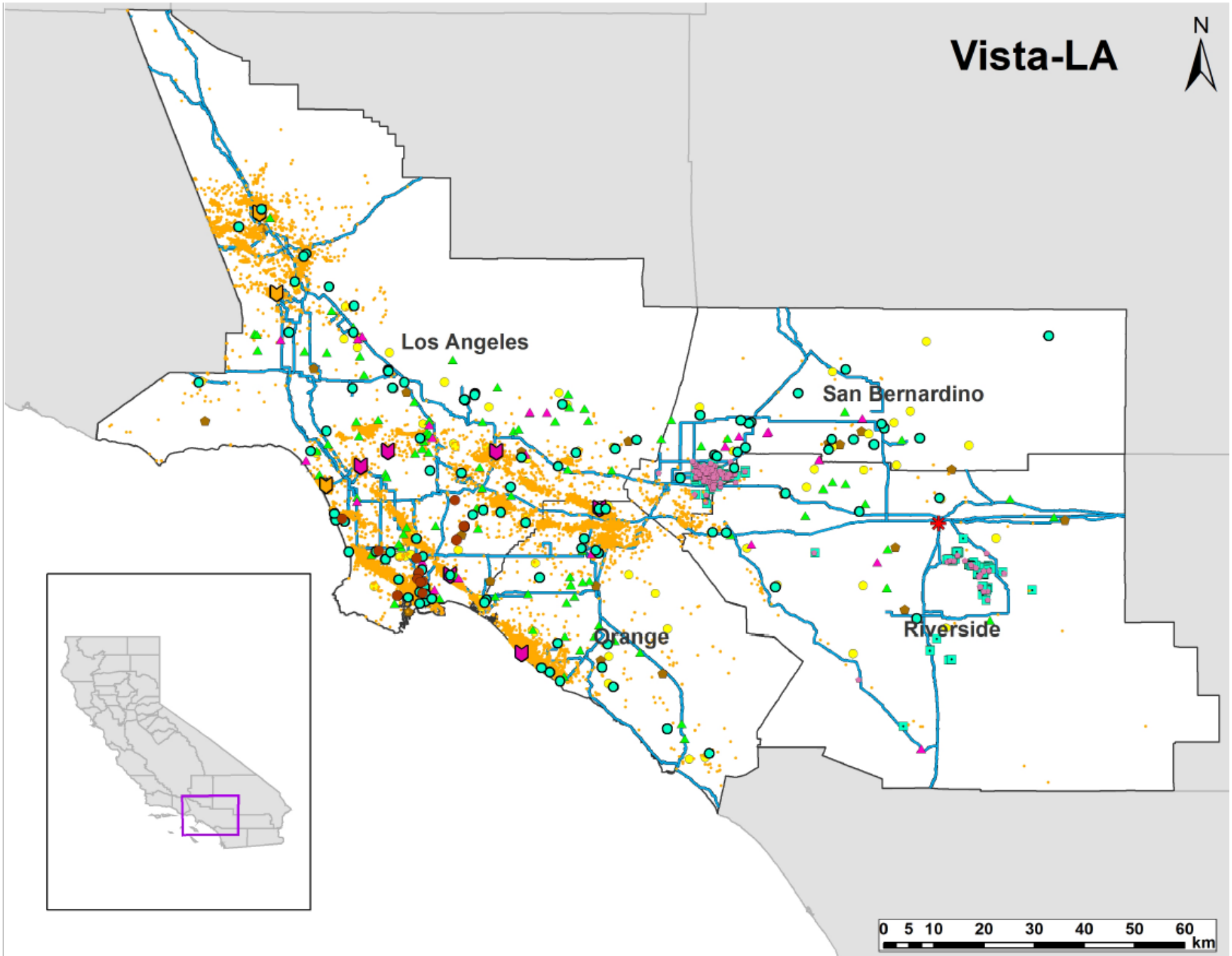
Period: September 2011 – October 2013



- Tight correlations between XCO_2 and XCH_4 excess are observed at every reflection point even though they are emitted by different sources – why?

- Both species are chemically inert, so the variability of both CO_2 and CH_4 is controlled by atmospheric mixing and dynamics of the boundary layer.


119°0'0"W
118°0'0"W
117°0'0"W
34°0'0"N
Estimated Flux (kg/hr)
10
11 - 25
26 - 50
51 - 100
101 - 150
151 - 200
Vista-LA
Anaerobic Lagoons
Compressed Natural Gas Fueling Stations
Dairies
Landfills
Liquefied Natural Gas Fueling Stations
Natural Gas Pipelines
Natural Gas Processing Plants
Natural Gas Storage Fields
Natural Gas Compressor Stations
Petroleum Refineries
Power Plants
Wastewater Treatment Plants


Vista-LA
N
Los Angeles
San Bernardino
Orange
Riverside
0 5 10 20 30 40 50 60
km

Energy
(IPCC Level 1 – Category 1)

Energy Industries (IPCC - 1A1)

- Petroleum refineries
- Power plants

Oil and Natural Gas (IPCC - 1B2)

- Liquefied natural gas fueling stations
- Compressed natural gas fueling stations
- Natural gas compressor stations
- Natural gas pipelines
- Natural gas processing plants
- Natural gas storage fields
- Oil and gas wells

Agriculture, Forestry, and Other Land Use
(IPCC Level 1 – Category 3)

Enteric Fermentation (IPCC - 3A1)

- Dairies

Manure Management (IPCC - 3A2)

- Anaerobic lagoons

Waste
(IPCC Level 1 – Category 4)

Managed Waste Disposal (IPCC - 4A1)

- Landfills

Domestic & Industrial Wastewater Treatment & Discharge (IPCC - 4D1 & 4D2)

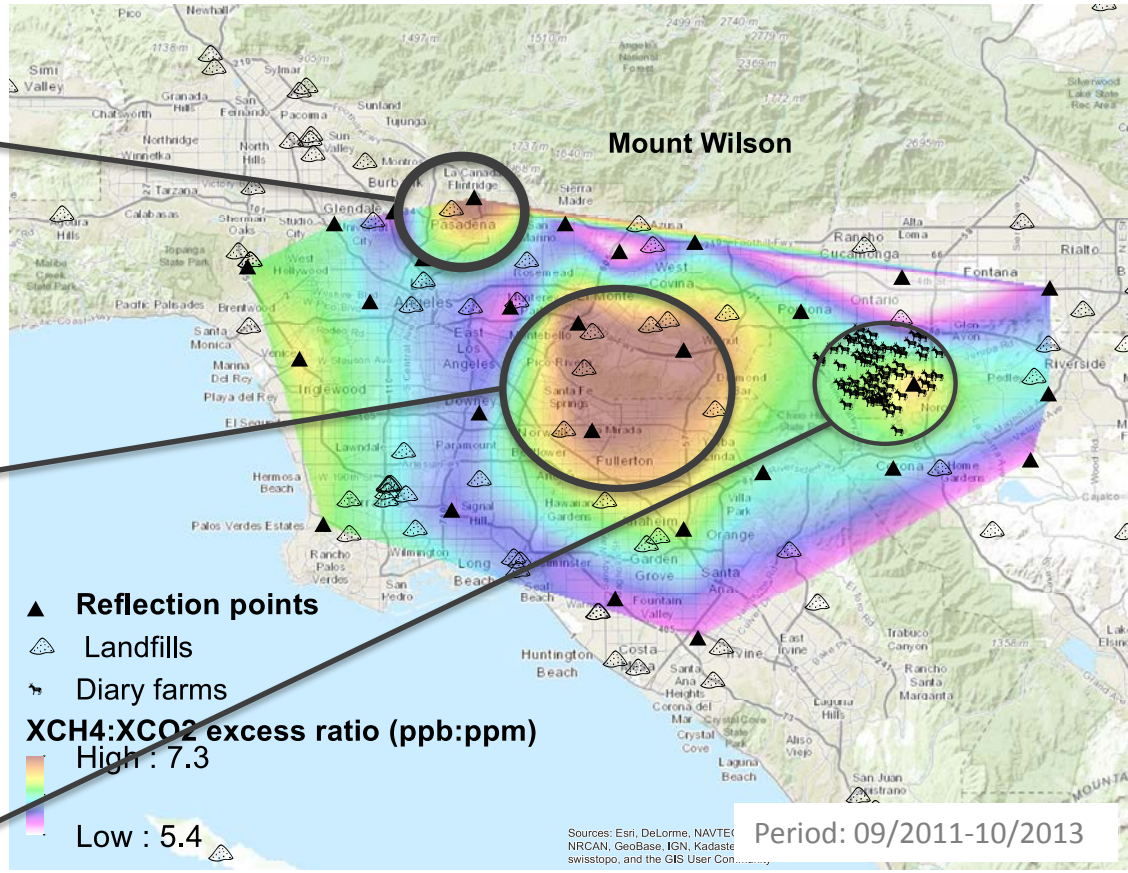
- Wastewater treatment plants

Map of XCH_4:XCO_2 Excess Ratio

- Scholl Canyon landfill
- NG pipeline

- Puente Hills landfill
- Fracking sites

Dairy farms



*Attribution of CH_4 hot spots to specific sources is not feasible. Other methods are required, e.g. in situ measurements, isotopic fractionation

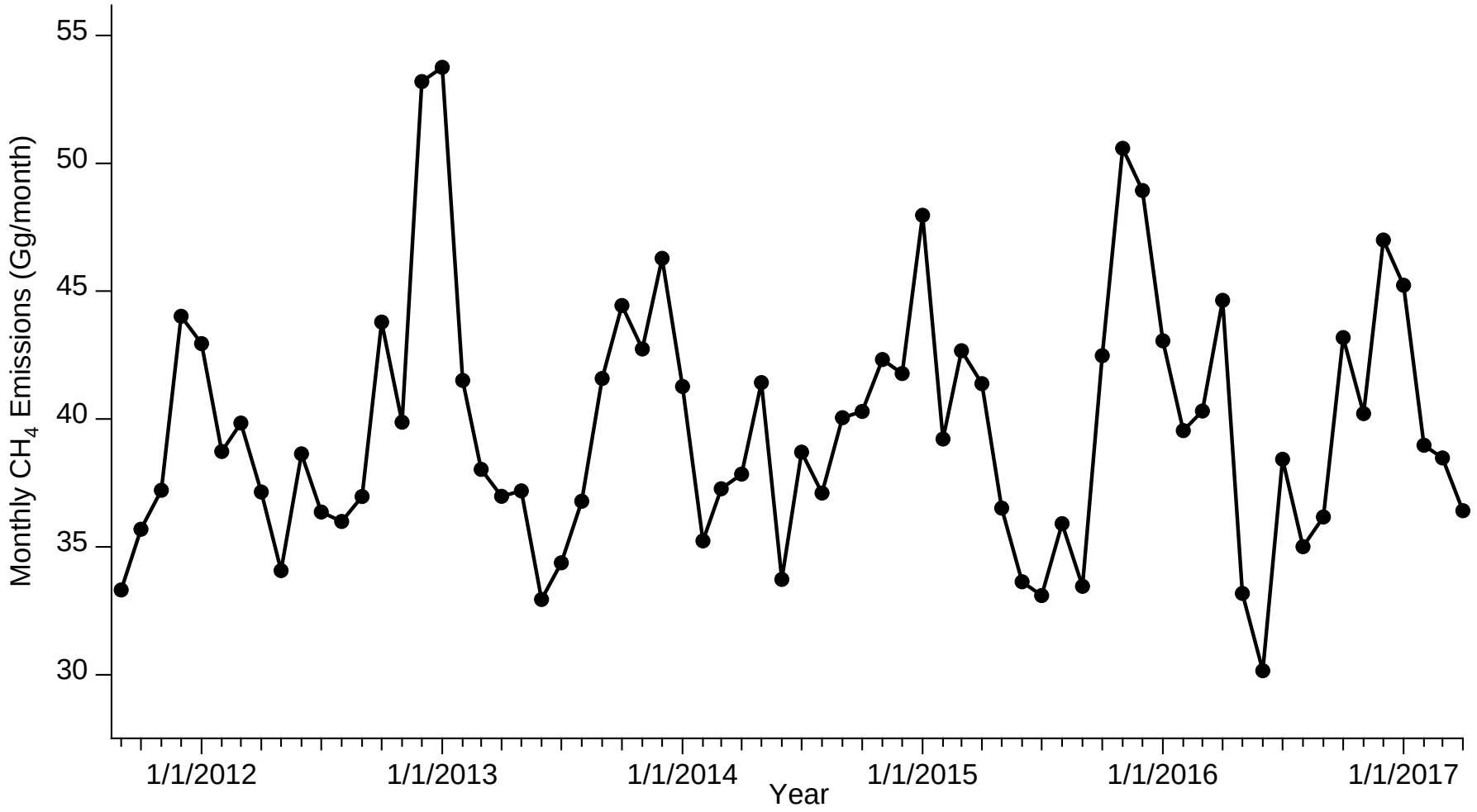
Basin-wide CH_4 emissions inventory

Using CLARS FTS XCH_4:XCO_2 excess ratio measurements, basin-wide CH_4 emissions are given by:

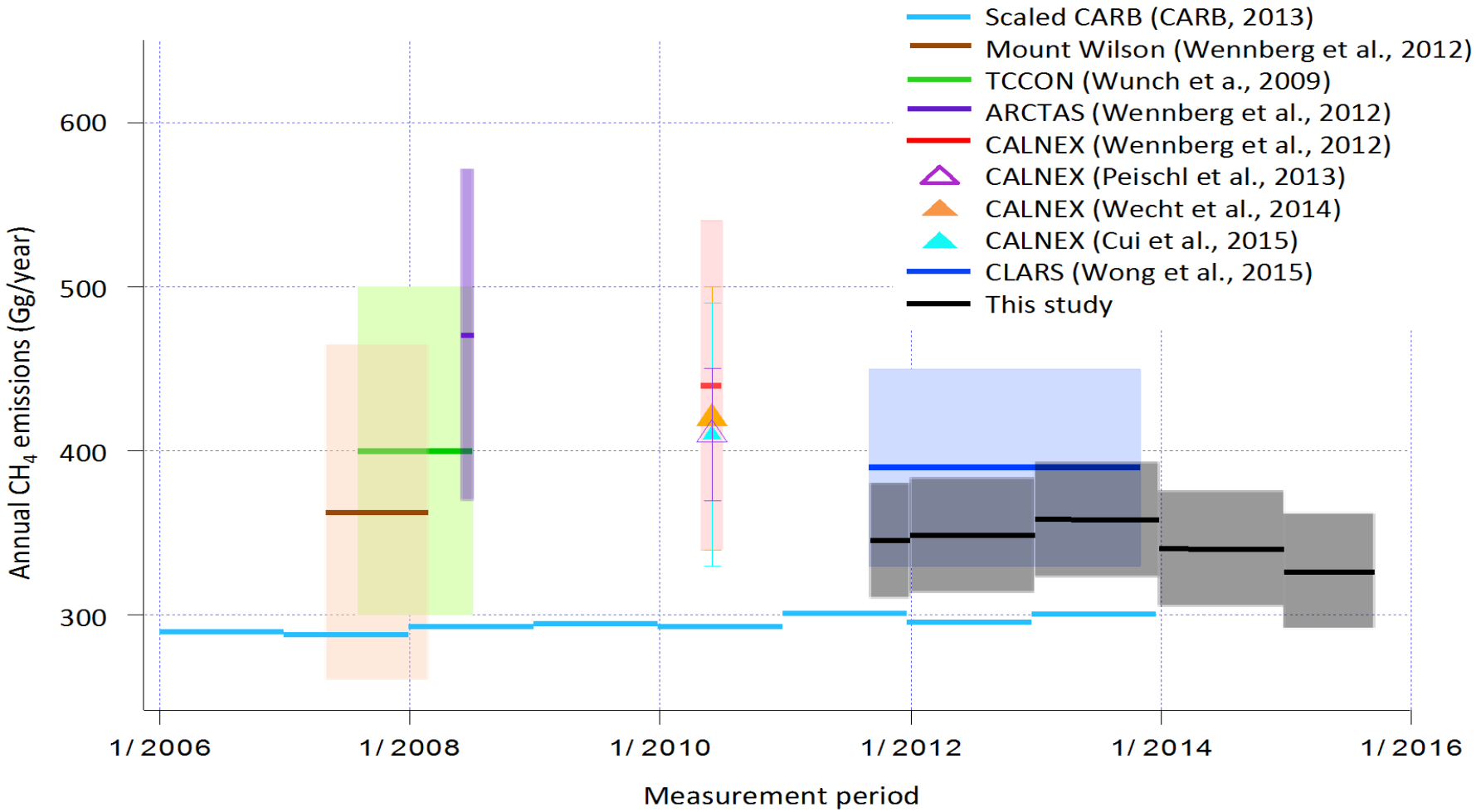
$$E_{CH_4}|_{top-down} = E_{CO_2}|_{bottom-up} \times \frac{XCH_4}{XCO_2}|_{slope} \times \frac{MW_{CH_4}}{MW_{CO_2}}$$

Estimated from the 2011 CA statewide emission

- scaled by population. South Coast LA basin has 43% of CA population.


55
50
45
40
35
30
Monthly CH_4 Emissions (Gg/month)
1/1/2012
1/1/2013
1/1/2014
1/1/2015
1/1/2016
1/1/2017
Year

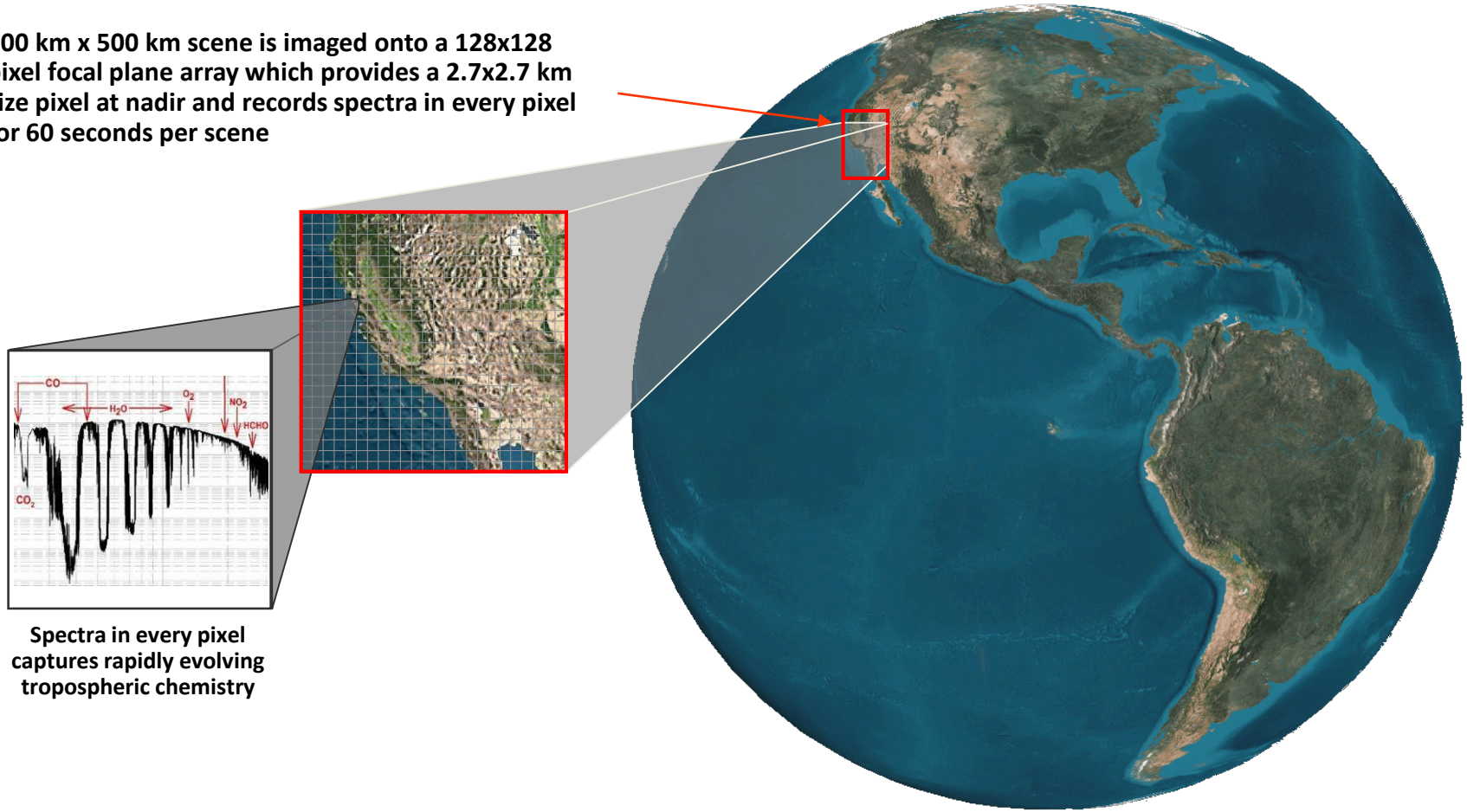
Annual CH_4 Emissions Estimates in the past 10 years in Los Angeles



- CLARS observations are consistent with previous estimates.
- Scaled CARB CH_4 emissions from 2011 to 2013 were 2-31% lower than our estimates.

Geostationary Imaging Fourier Transform Spectrometer: Hourly Sampling of XCO_2, XCH_4, XCO

500 km x 500 km scene is imaged onto a 128x128 pixel focal plane array which provides a 2.7x2.7 km size pixel at nadir and records spectra in every pixel for 60 seconds per scene

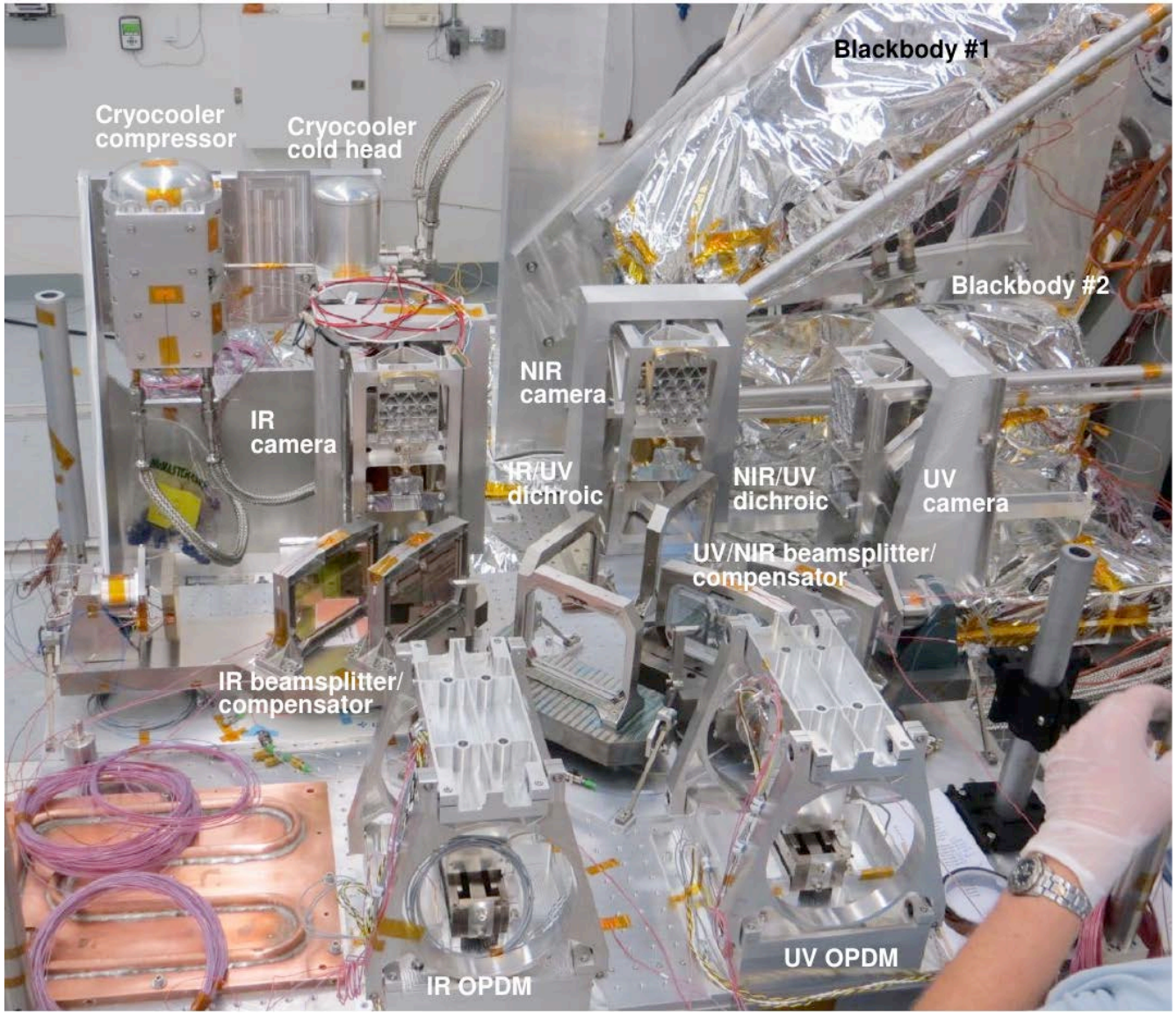


Spectra in every pixel captures rapidly evolving tropospheric chemistry

From geostationary orbit GeoFTS can map all of North and South America hourly with high resolution measurements (temporal, spatial, and spectral) that capture rapidly evolving tropospheric concentrations with planetary boundary layer sensitivity

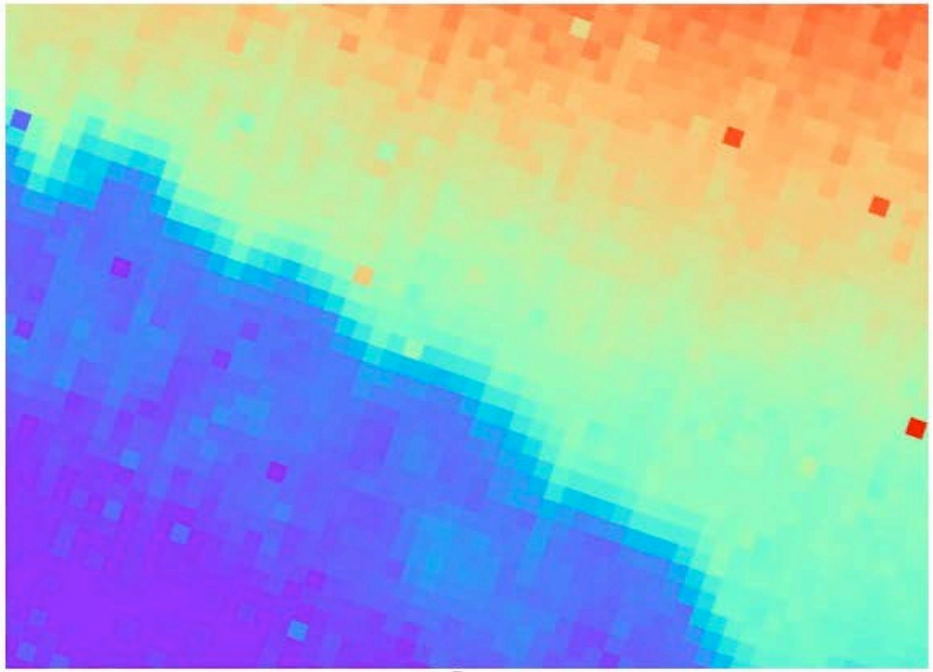
Panchromatic Fourier Transform Spectrometer (PanFTS): Engineering Model for Geostationary Chemical Imaging

- Spectral Coverage: 0.3-10 μm
- 2 Dynamically Aligned Plane Mirror Michelson Interferometers MOPD = 10 cm
- 3 Cameras: 128x128 focal plane arrays with in-pixel digitization
- 2.7 km nadir ground sampling/pixel from GEO orbit

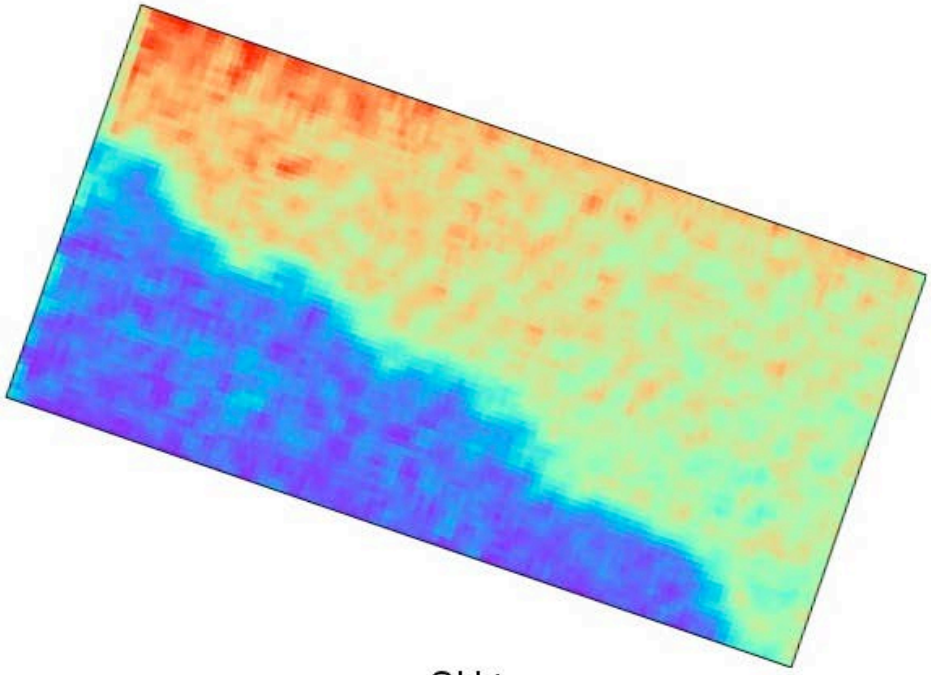


GEO-PanFTS Engineering Model Demonstrated in LA

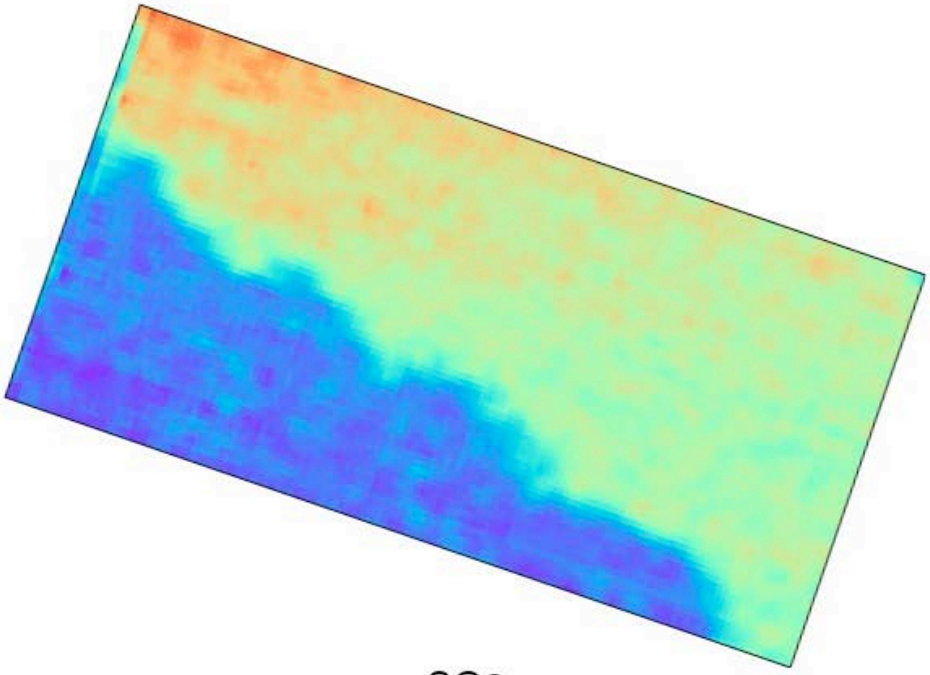
Visible



O2



CH4



CO2

Other results:
CO, aerosols