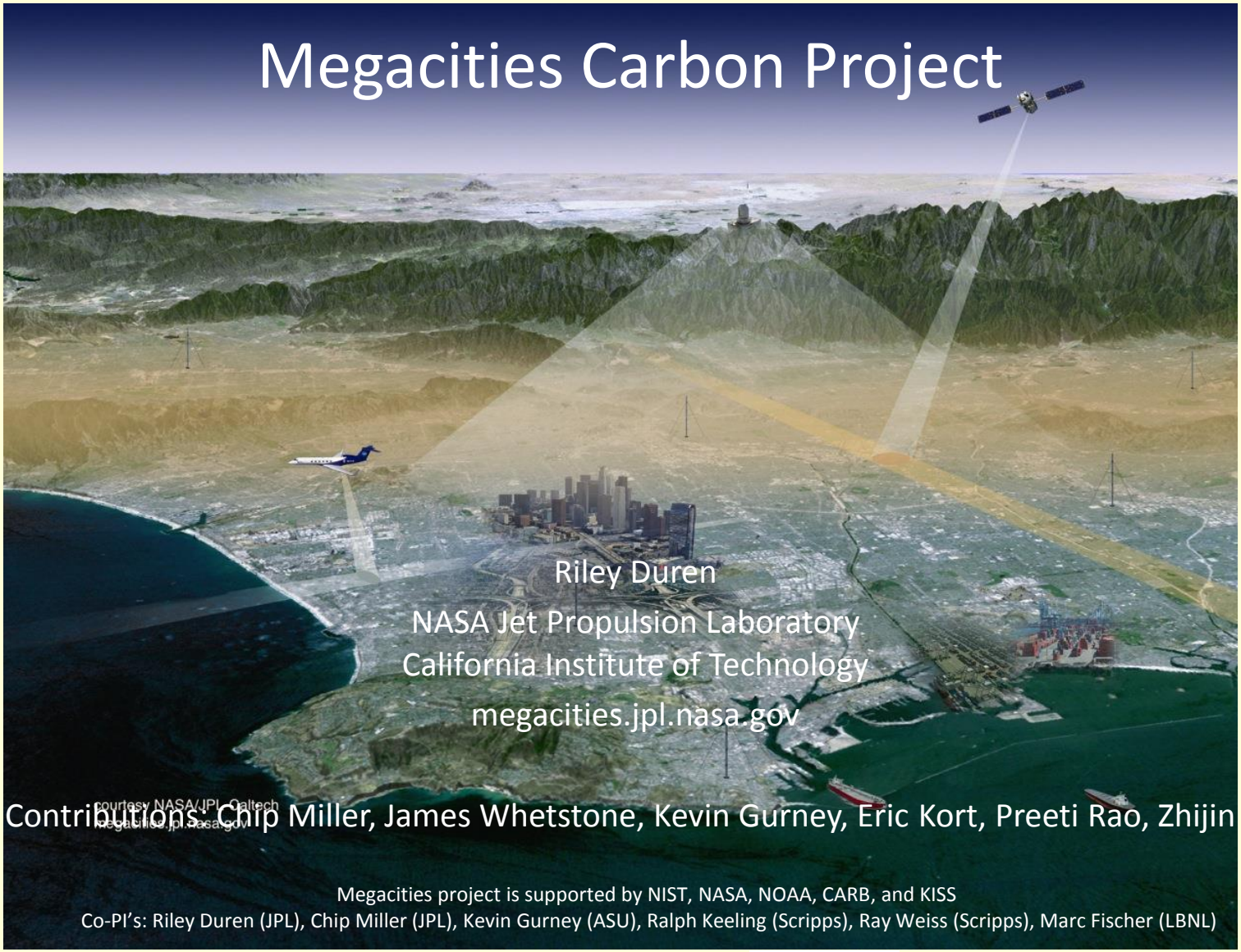
Megacities Carbon Project



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

courtesy NASA/JPL-Caltech
megacities.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)

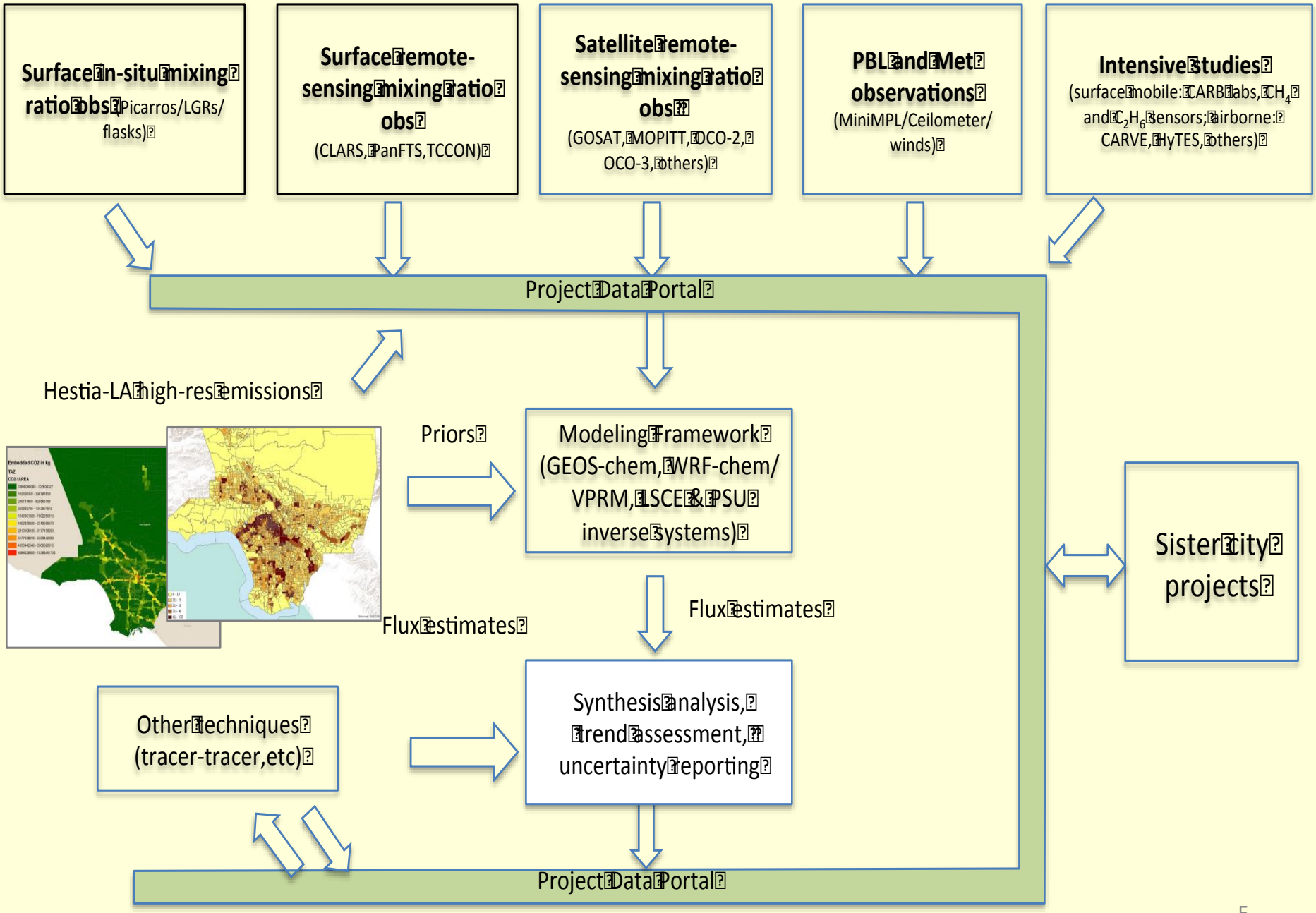
LA Project Objectives

#	Objective	Phase 1 (3-5 years)	Phase 2 (5-10 years)
O.1	(1a)Develop and (1b)demonstrate measurement systems capable of quantifying trends in the total (and anthropogenic) carbon emissions of the LA Megacity (target: 10% change in CO_2 emissions over 5 years; TBD CH_4)	✔	✔
O.2	Reduce uncertainty in CH4 (and N2O?) to levels comparable to CO and CO2	✔ (CH4)	✔ (N2O?)
O.3	Validate assertion (with truly independent methods) that "CO2 and CO inventories are good to within X%"		✔
O.4	Attribute observed emission signatures to key sectors & activity in the megacity (diagnose inventories)	✔	✔
O.5	Identify and quantify individual fugitive CH4 emission sources (e.g., ports, power plants, landfills, natural gas infrastructure, oil/gas production, etc)	✔ (detect)	✔ (quantify)
O.6	Advance measurement capabilities, models, and protocols to bridge the research to operations gap		✔
O.7	Extend methods and techniques to many cities and establish open and transparent, sustained data, analysis, and measurement methodology sharing [including capacity building]		✔

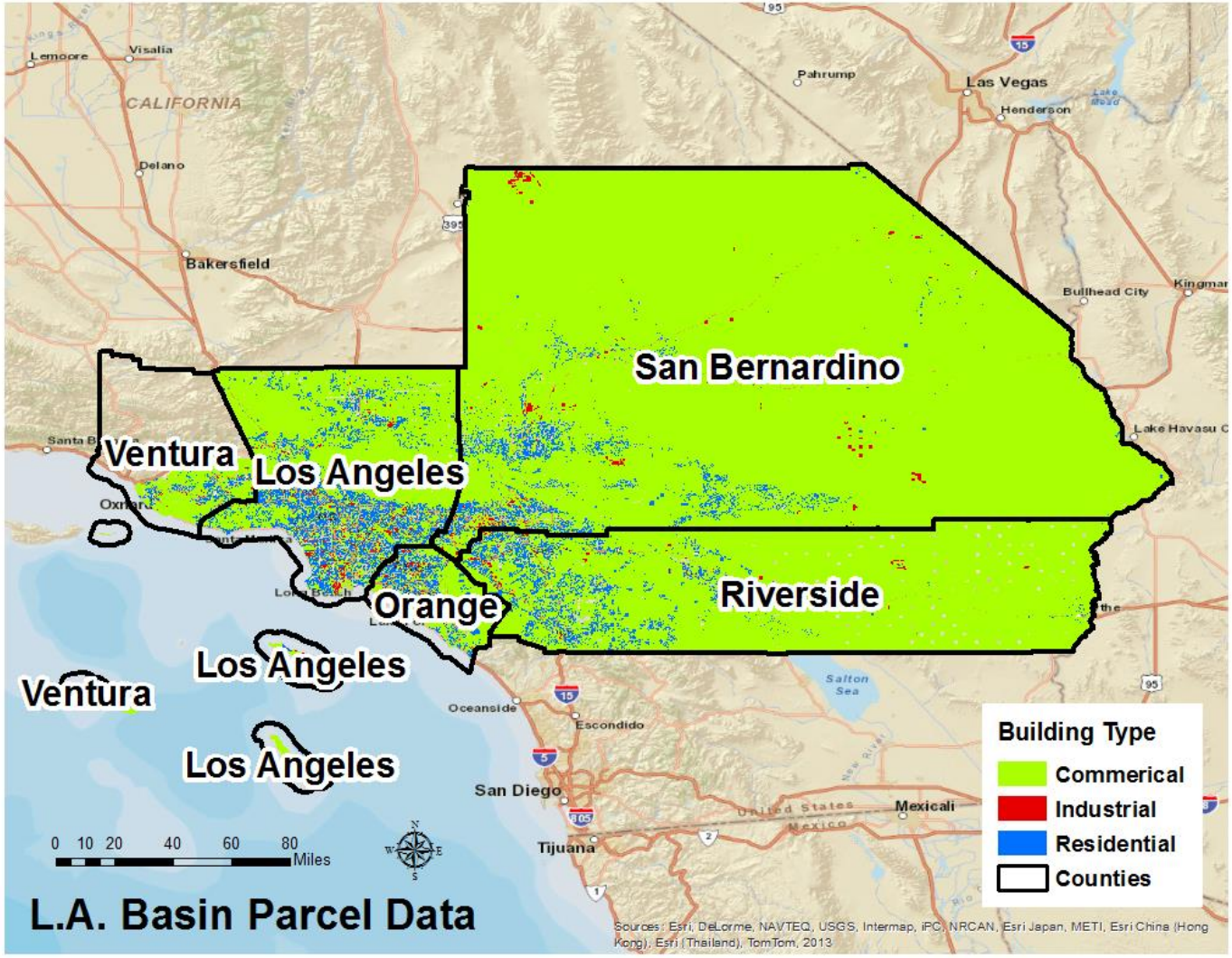
LA Megacity Project Components

1. GHG Inventory Information – Bottom up Methods
   - Hestia-LA: high resolution CO2 emissions data set (Gurney et al)

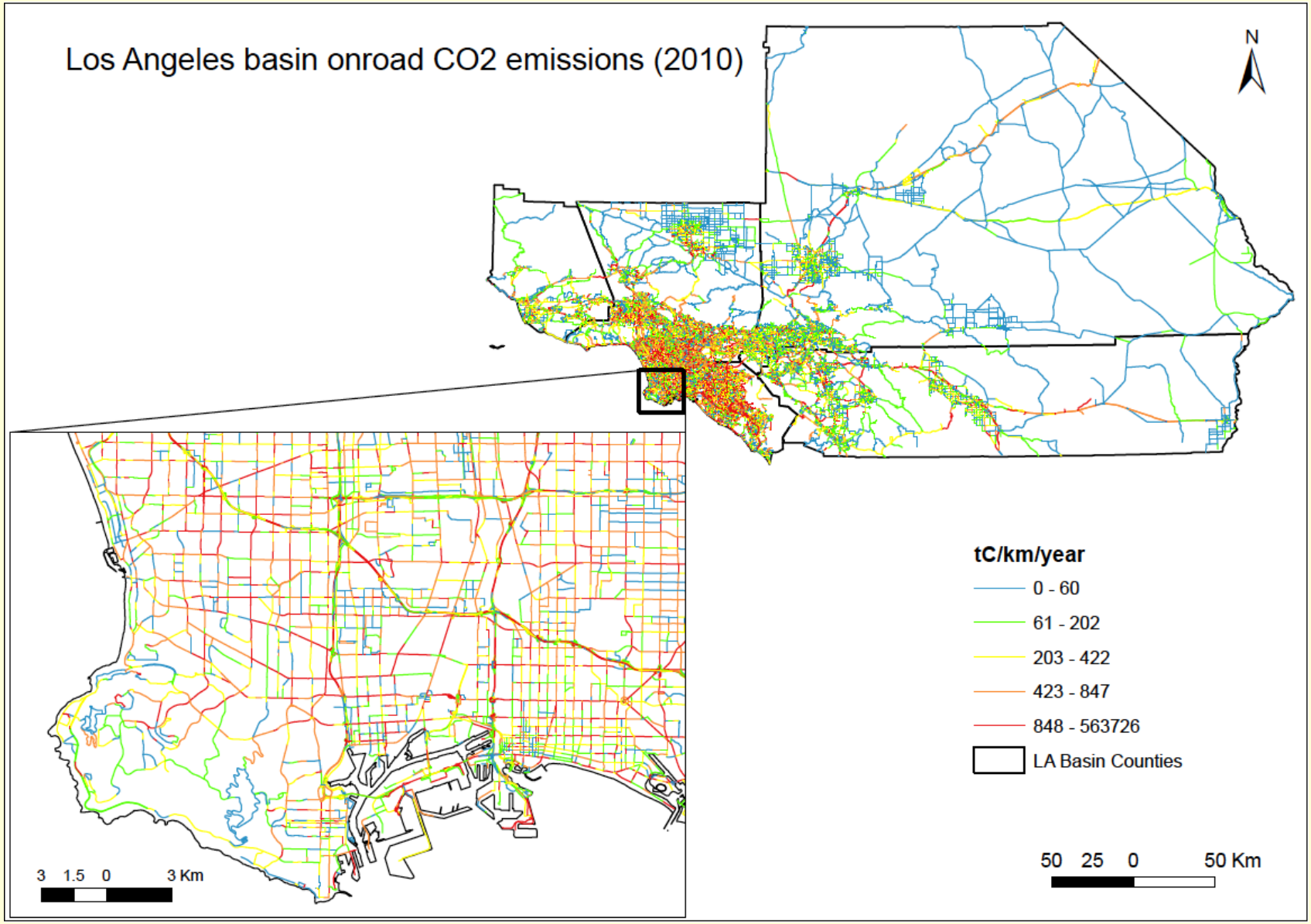
2. WRF/chem/VPRM/STILT: high res tracer-transport modeling (Lauvaux, Li et al)
3. Surface GHG measurements – in-situ and remote-sensing (Duren, Keeling, Weiss, Sander, Wennberg et al)
4. Satellite GHG measurements (Miller, Eldering, et al)
5. Integration and synthesis (group effort)
6. Data Portal – 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

(1) Hestia: High resolution CO_2 data set for LA
The Bottom-Up Inventory Information



Hestia-LA: K. Gurney & R. Patarasuk (ASU), P. Rao (JPL) http://hestia.project.asu.edu

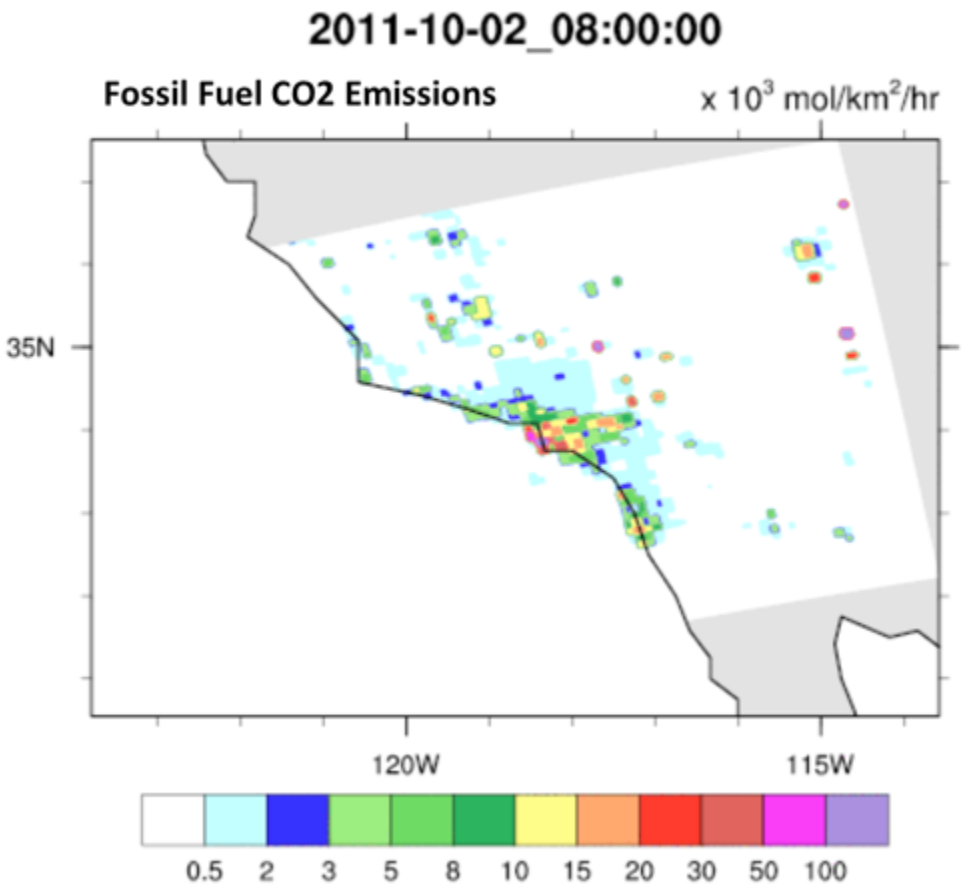


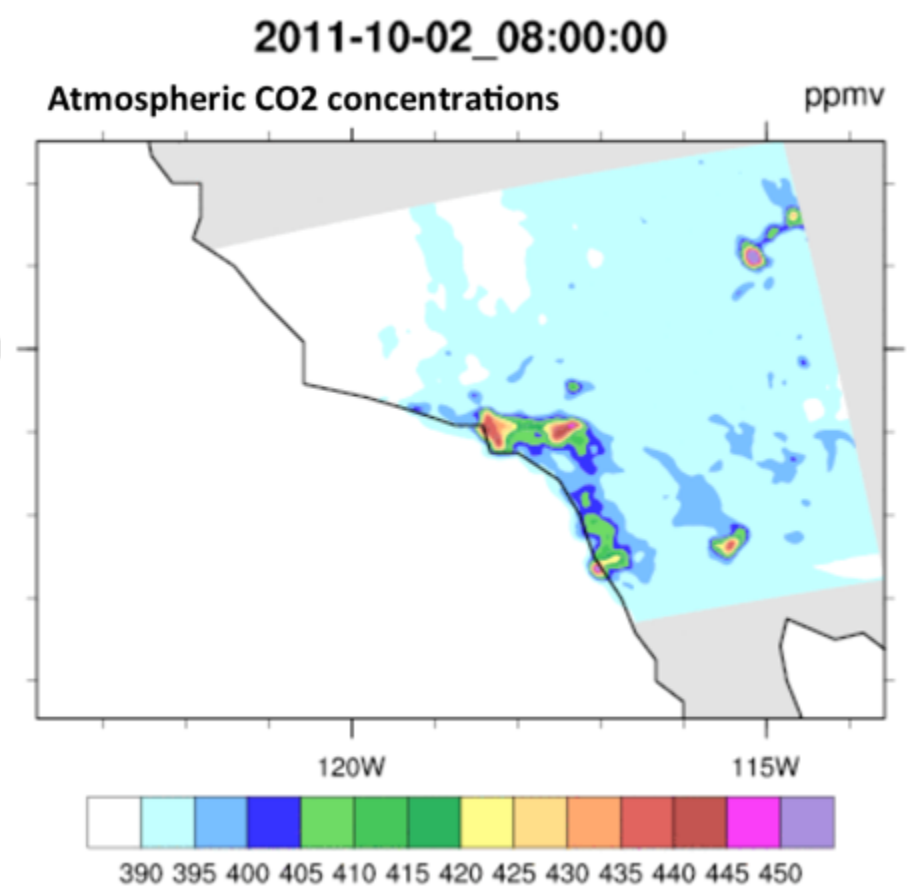
Hestia-LA: K. Gurney & R. Patarasuk (ASU), P. Rao (JPL)

http://hestia.project.asu.edu

(2) High-resolution atmospheric CO_2 modeling

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



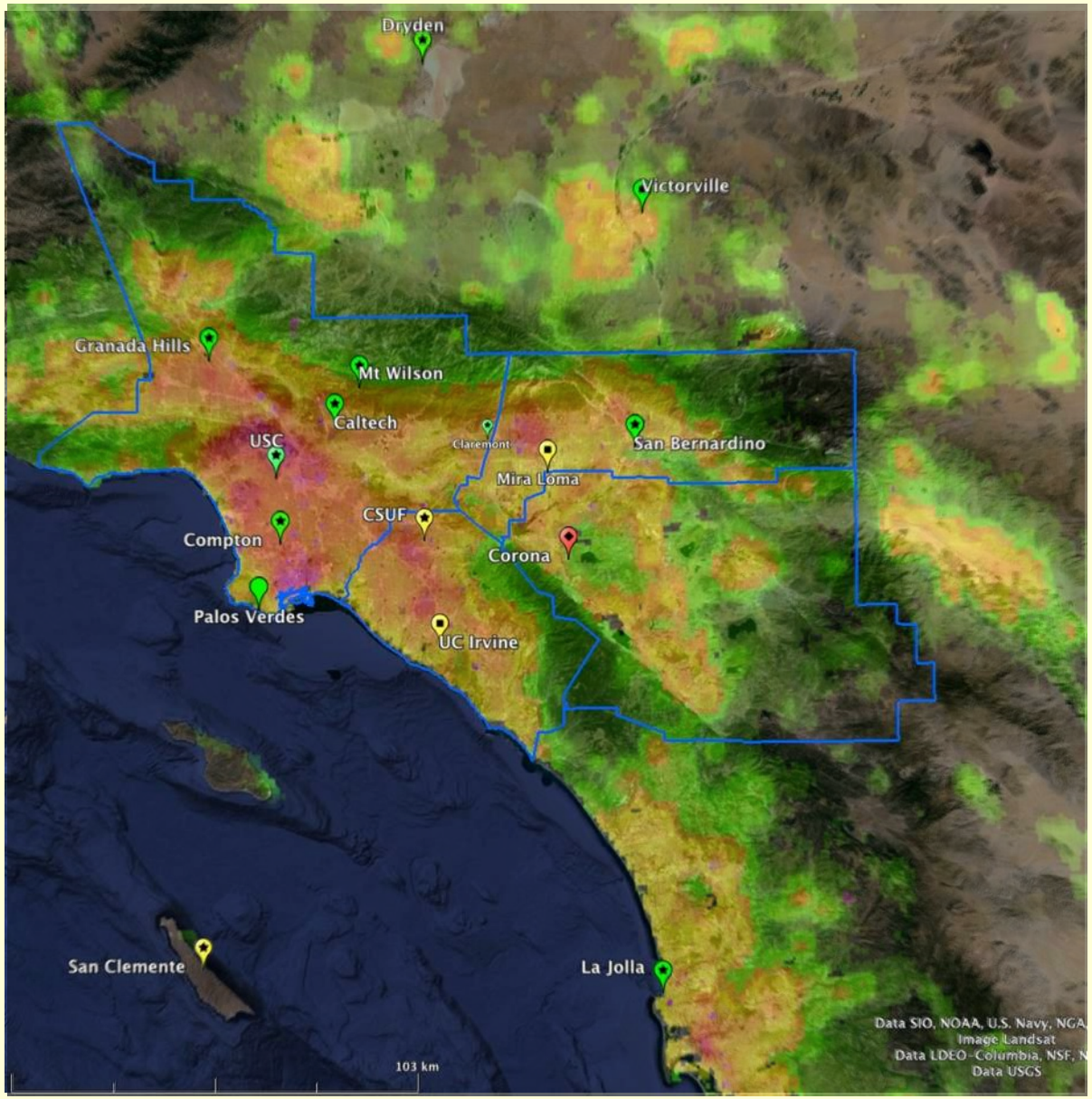


Solve for this

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

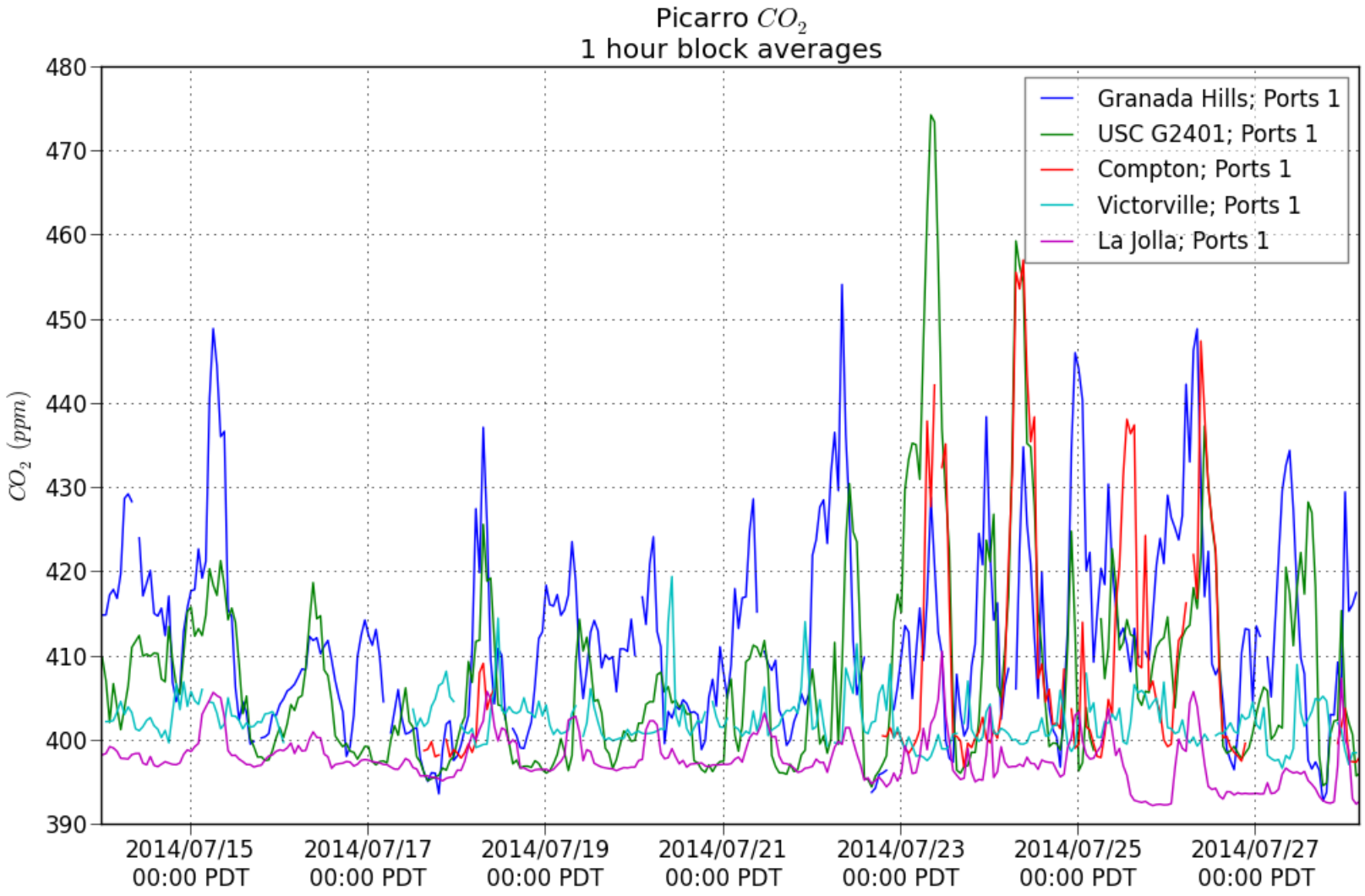
Fossil fuel CO2 overlay courtesy T. Oda, CSU/NOAA, ODIAC v3, 2010, 1km, log scale (green: 100, purple >10,000 gC/m2/yr)

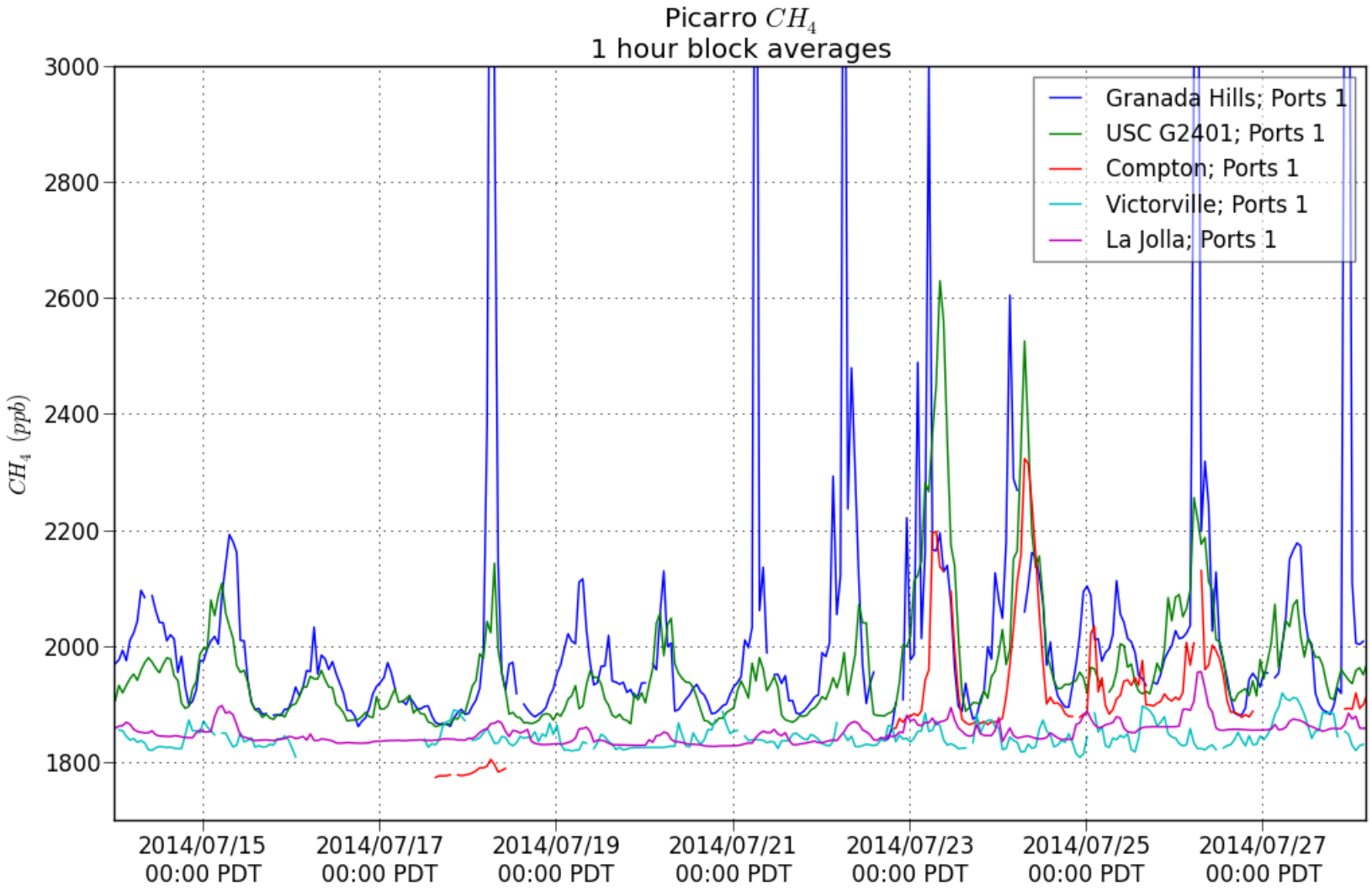
LA Network status August 2014

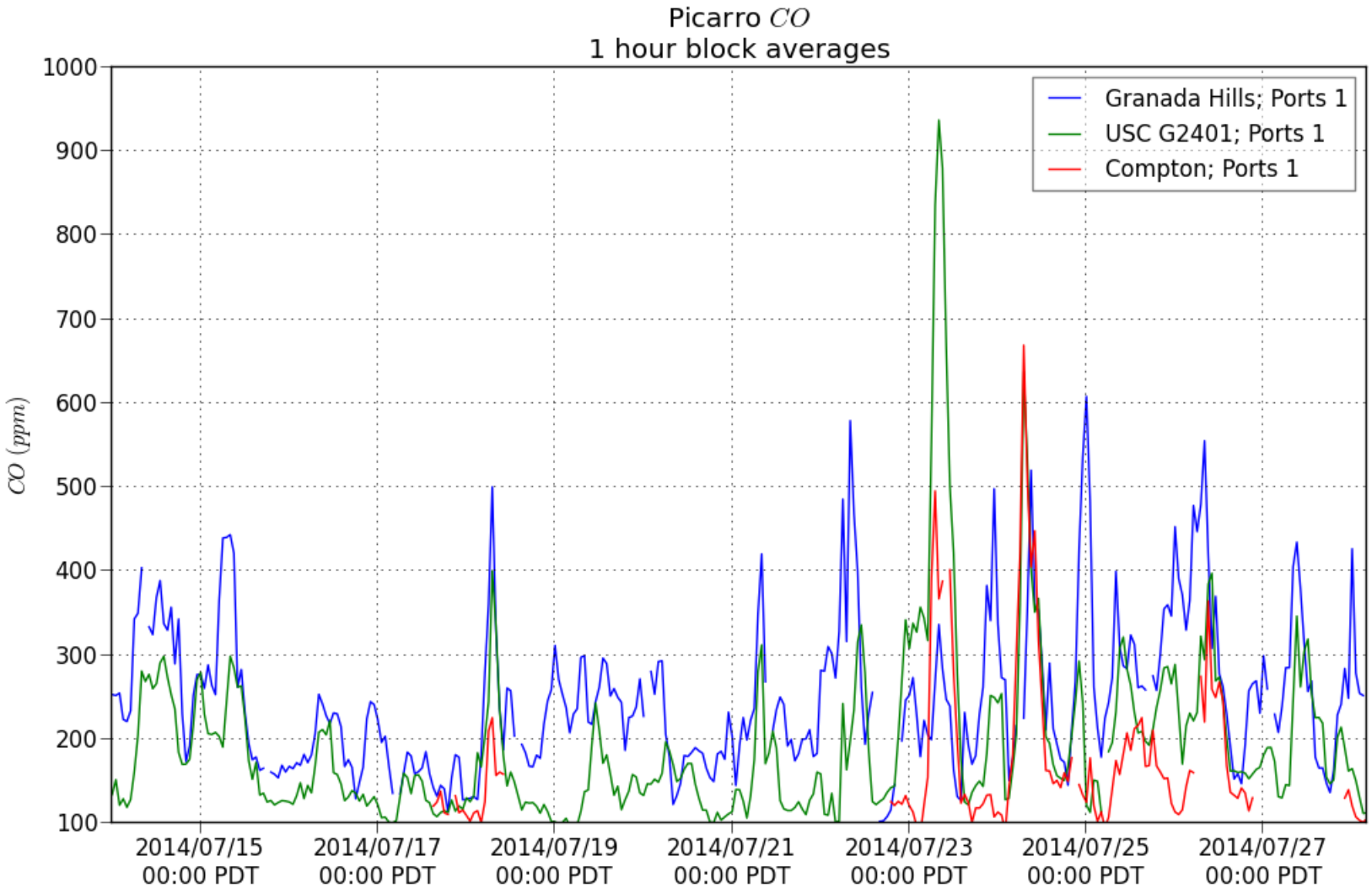
#	Site	Status	CO2	CO	CH4	Site notes
1	Mt Wilson	operating	I/C	I/C	I/C	Mountain/surface: Non-standard config
2	Caltech	operating	I/C	I/C	I/C	10 m roof,Non-standard; upgrade to G2401 on 40m roof & standard roof config circaAug '14*
3	Granada Hills	operating	I	I	I	50m tower, Standard tower config
4	USC	operating	I	I	I	50m roof, Standard roof config*
5	Compton	operating	I	I	I	45 m tower, Standard tower config
6	Palos Verdes	operating	I			Surface, non-standard config
7	San Clemente	Planned	I	I	I	10 m, Standard tower config
8	La Jolla	operating	I	I	I	10m, Scripps config
9	CSU Fullerton	Planned	I	I	I	40m roof, Standard roof config*
10	Claremont	operating	I	I	I	10m roof, non-standard config
11	San Bernardino	operating	I	I	I	60m tower, non-standard config
12	Victorville	operating	I		I	70 m tower on mountain; Standard config
13	Dryden	operating	C	C	C	TCCON only; no in-situ sampling
14	UC Irvine	Planned	I		I	20m roof, Standard roof config*
15	Riverside	Under Study	I		I	30+m tower, Standard tower config
16	LA Live	Under study	I		I	200m roof, TBD config**

*EN roof-top config consists of 4 corner inlets (each on 3m long masts) – symmetric sampling to account for different wind conditions
**LA Live skyscraper (near shorter USC site) intended to evaluate potential bias in LA network (most of which consist of low elevation inlets)

I: in-situ measurements (continuous),
C: column measurements (daytime).
Secondary GHG sites and meteorological observations not shown.


Picarro CO_2
1 hour block averages
Granada Hills; Ports 1
USC G2401; Ports 1
Compton; Ports 1
Victorville; Ports 1
La Jolla; Ports 1
CO_2 (ppm)
480
470
460
450
440
430
420
410
400
390
2014/07/15 00:00 PDT
2014/07/17 00:00 PDT
2014/07/19 00:00 PDT
2014/07/21 00:00 PDT
2014/07/23 00:00 PDT
2014/07/25 00:00 PDT
2014/07/27 00:00 PDT


Picarro CH_4
1 hour block averages
Granada Hills; Ports 1
USC G2401; Ports 1
Compton; Ports 1
Victorville; Ports 1
La Jolla; Ports 1
CH_4 (ppb)
3000
2800
2600
2400
2200
2000
1800
2014/07/15 00:00 PDT
2014/07/17 00:00 PDT
2014/07/19 00:00 PDT
2014/07/21 00:00 PDT
2014/07/23 00:00 PDT
2014/07/25 00:00 PDT
2014/07/27 00:00 PDT



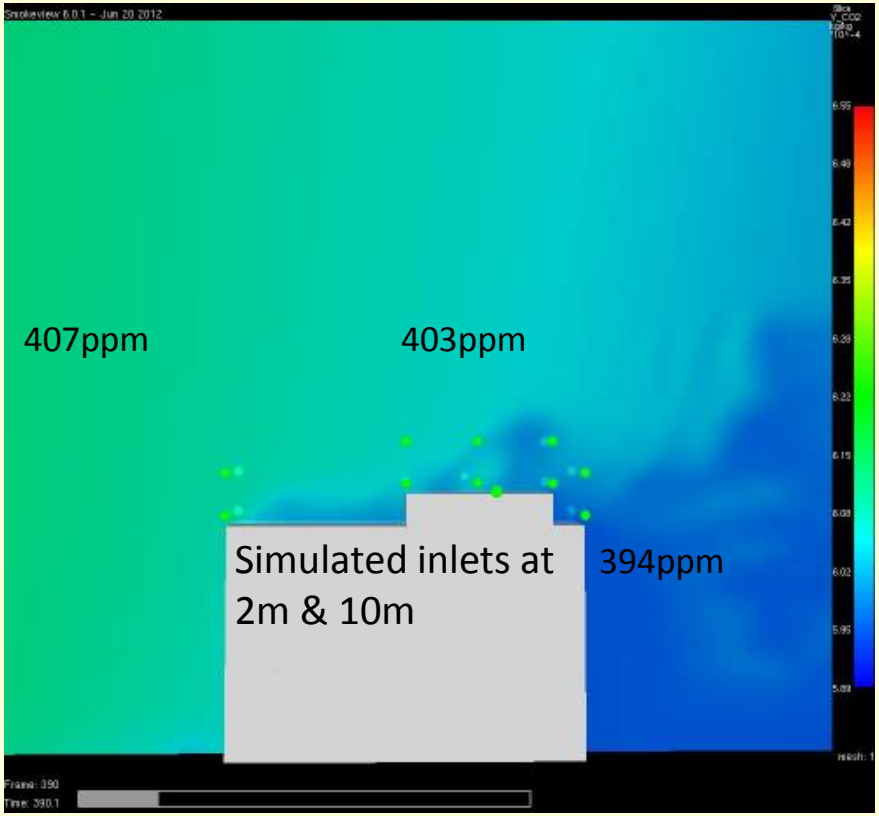
CO is currently un-calibrated

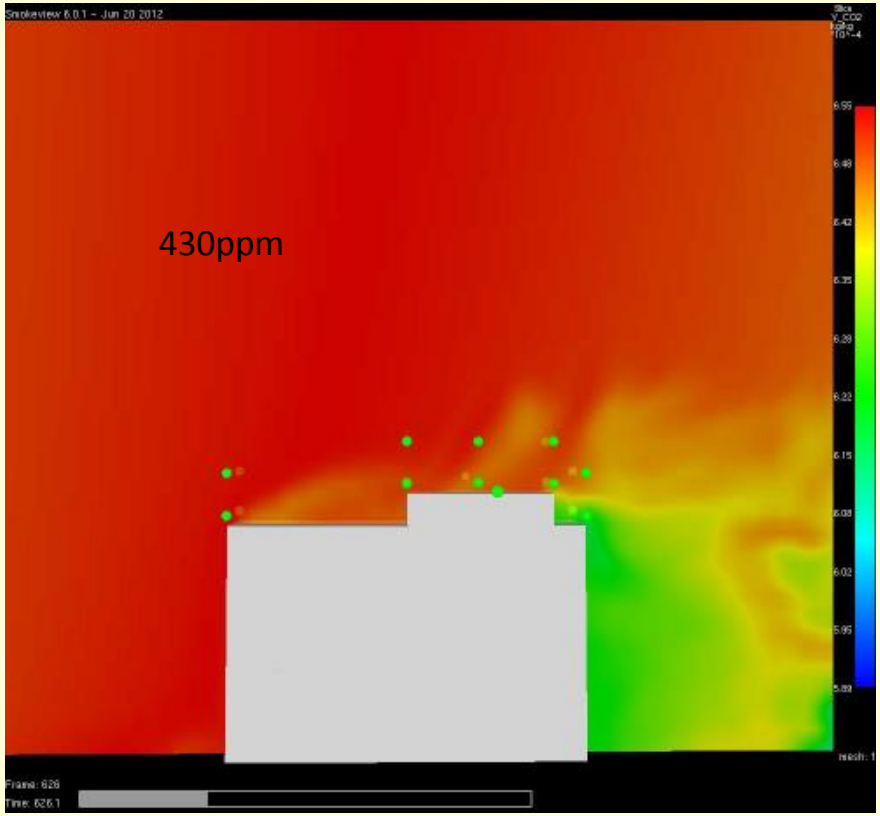
Examples of in-situ sites

Tower (Granada Hills)
inlets at 52 and 31 meters

Rooftop (USC)
4 inlets at 50 meters

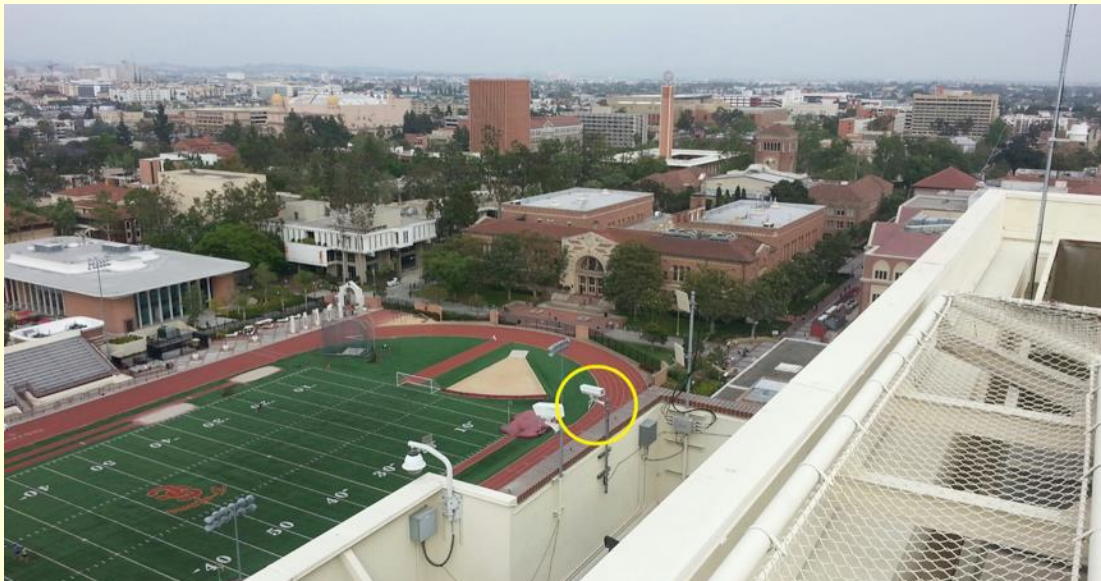
Rooftop Sampling Considerations
(NIST, Prasad et al, April 2013)





Conclusion: even tall (>10m masts) do not resolve recirculation issue except when placed near the upwind edge; inlets at the 4 corners of roof-top (ideally each at least 3m out/above roof line) are preferred

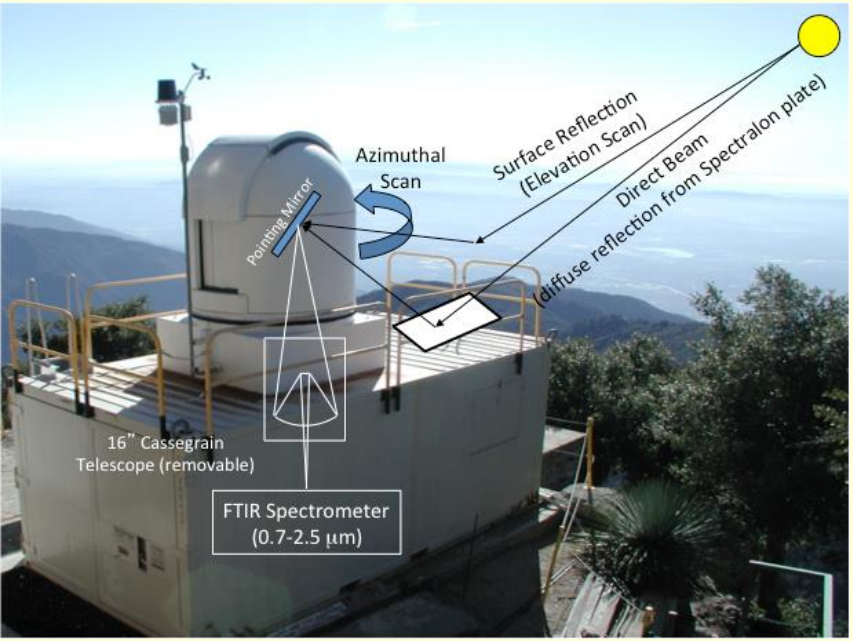
Placement meteorological observations at each corner of the building.



Examples Of Remote-Sensing Sites

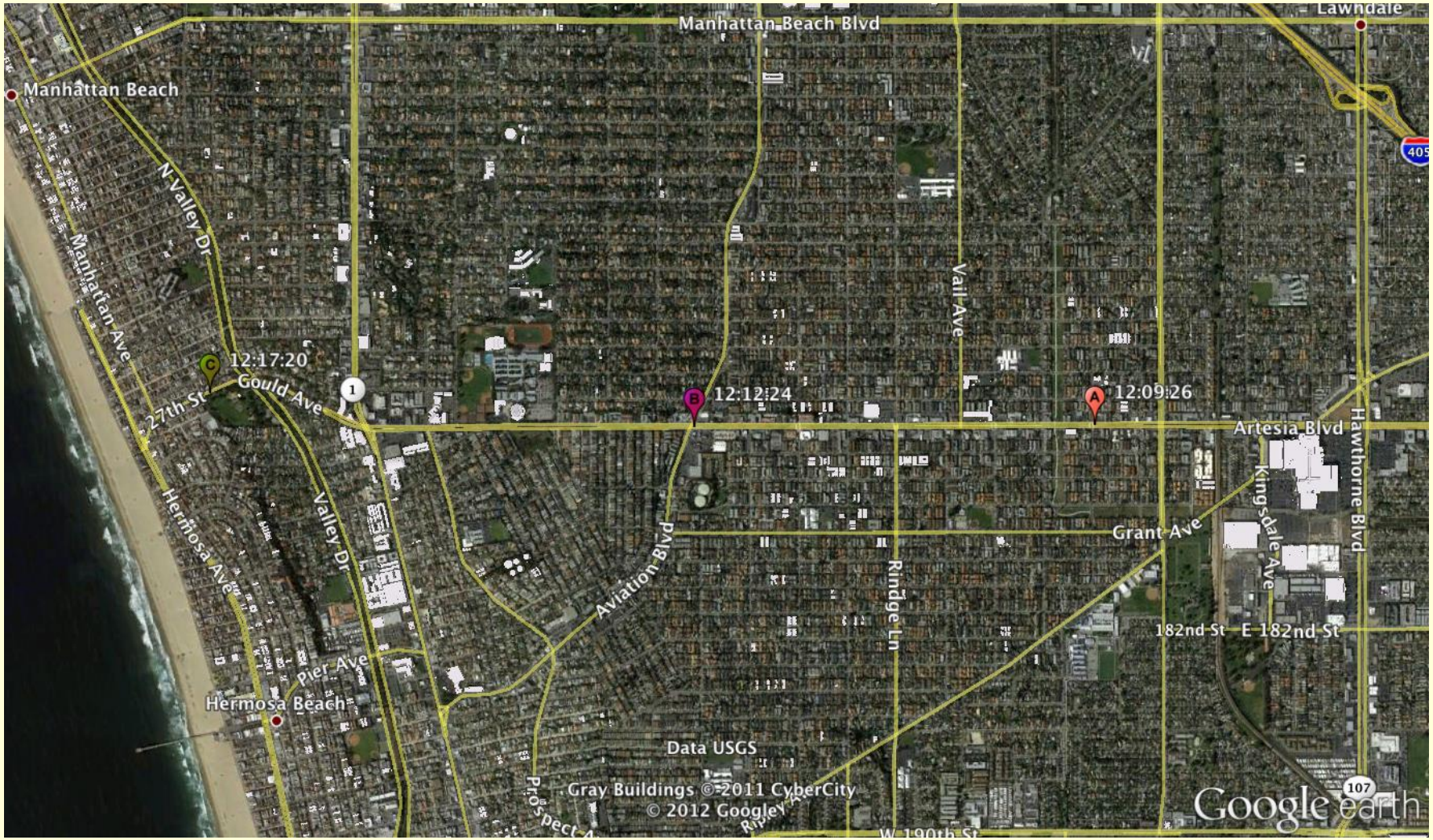
Near IR Spectrometers Observing Atm. Absorption – Solar Illumination

Mt Wilson



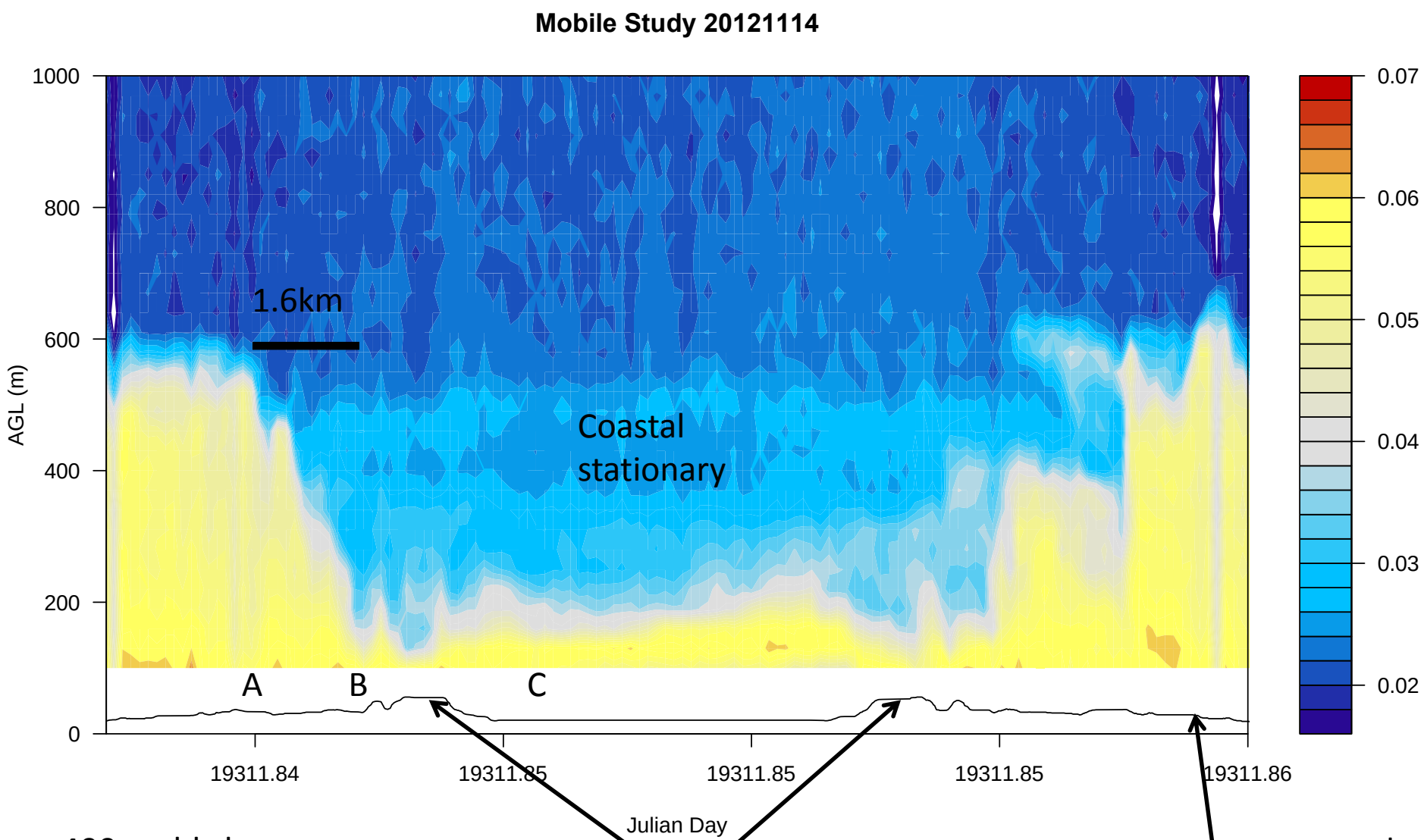
Caltech

Coastal Study – PBL Height



1.63km from point A to point B

Kort, Duren, DeCola 2012



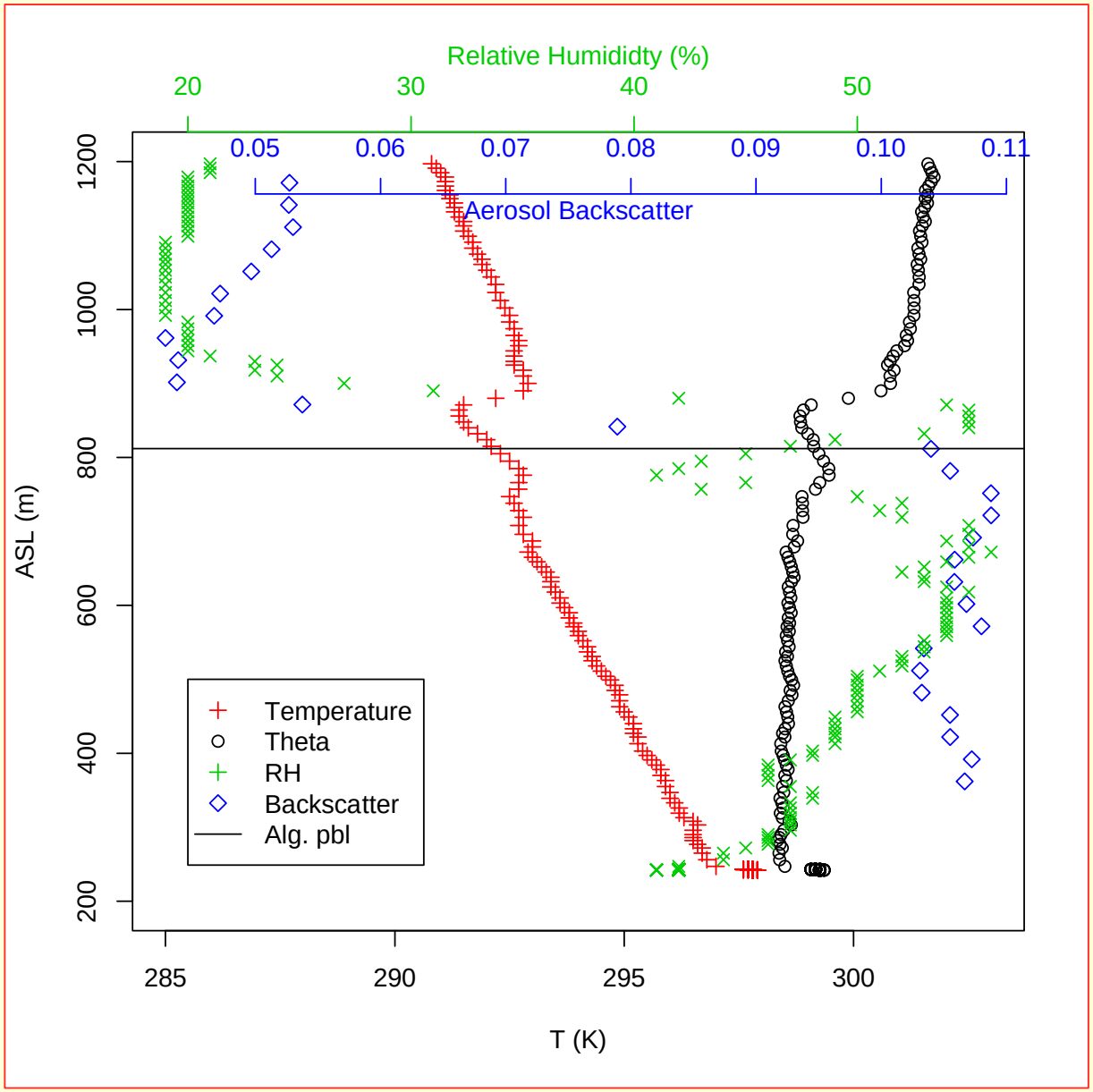
400m pbl change over 1.6km

Small Hill- Pacific Coast Highway

topography

Kort, Duren, DeCola 2012

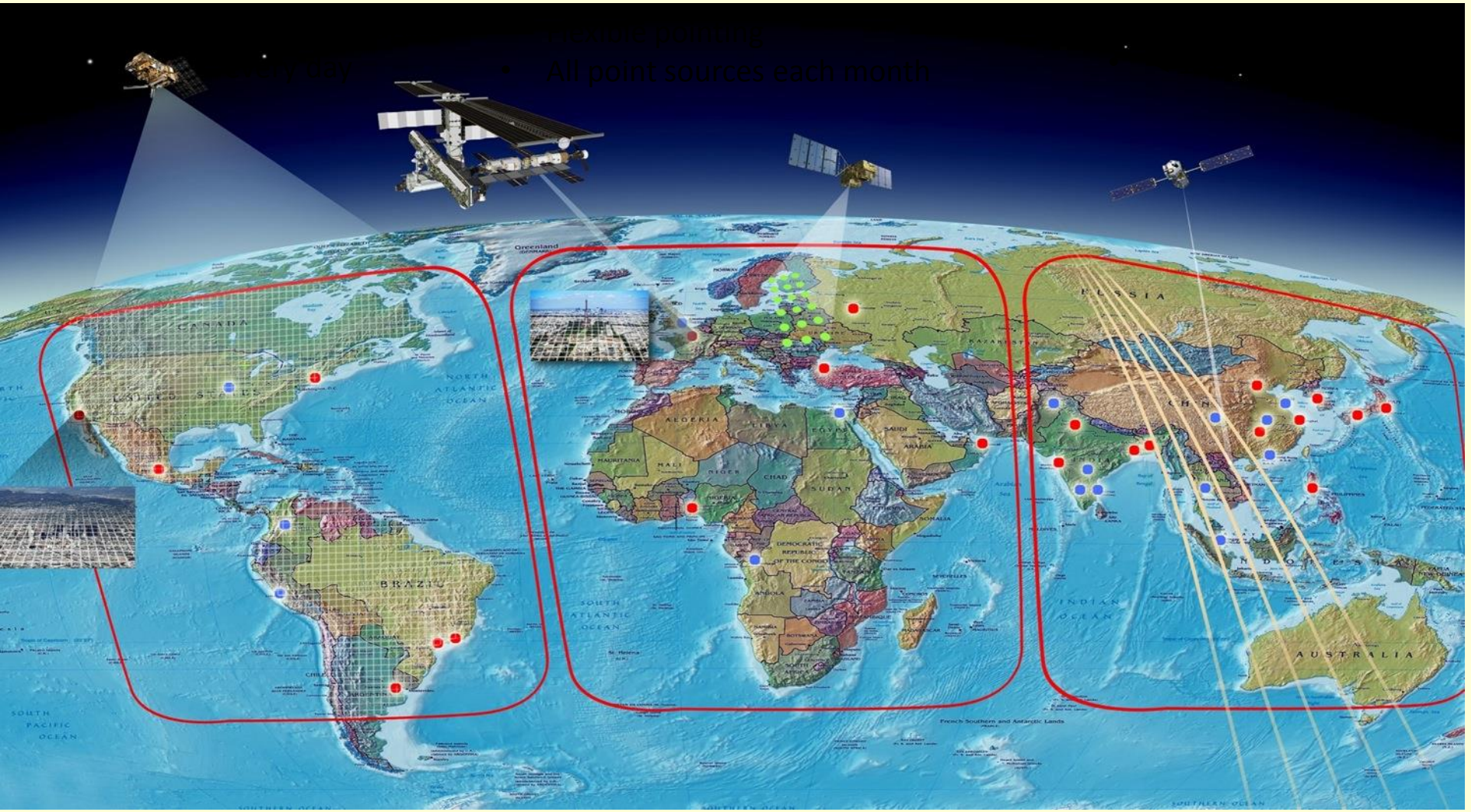
Validation of miniMPL



Kort, Duren, DeCola 2012

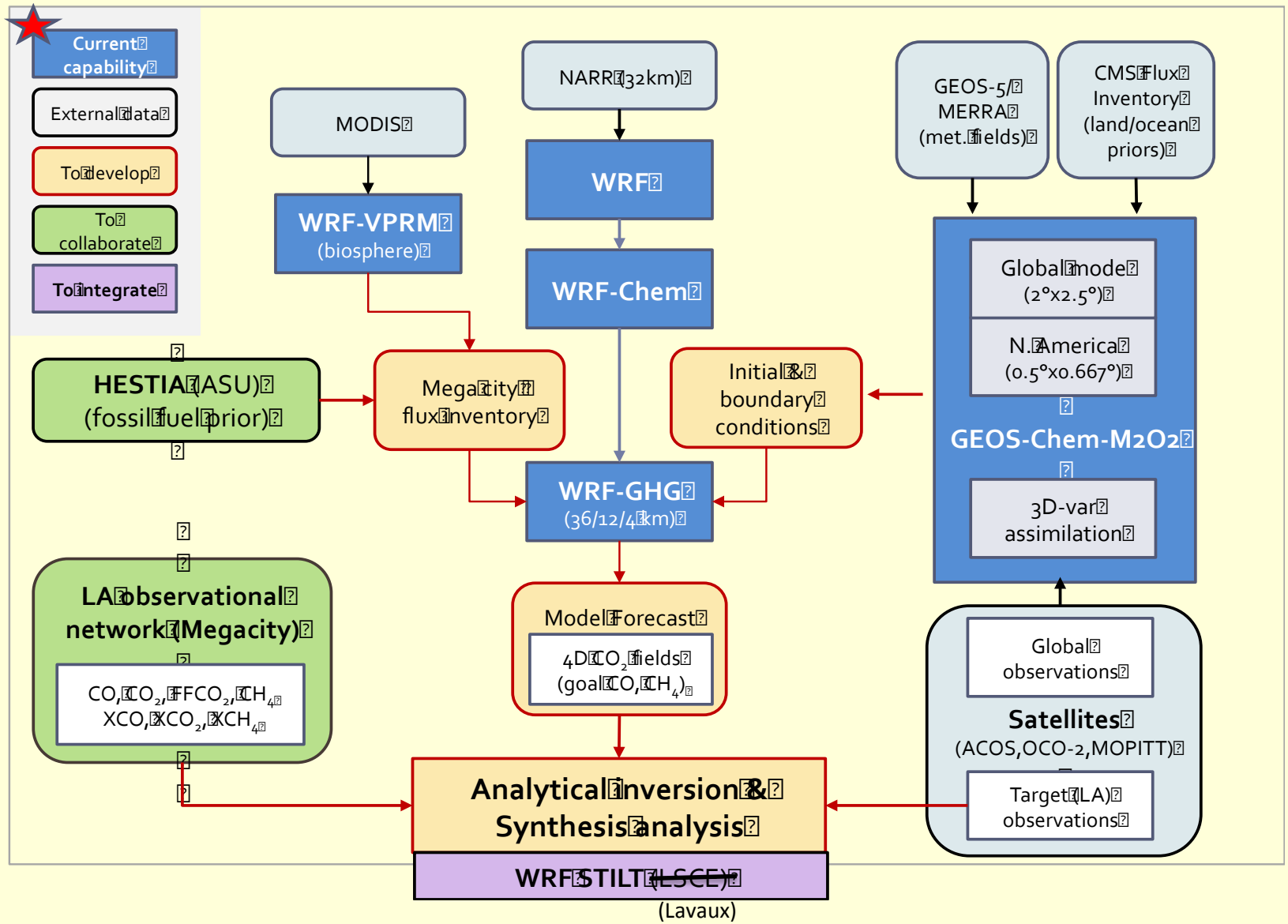
(4) Emerging satellite capabilities

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

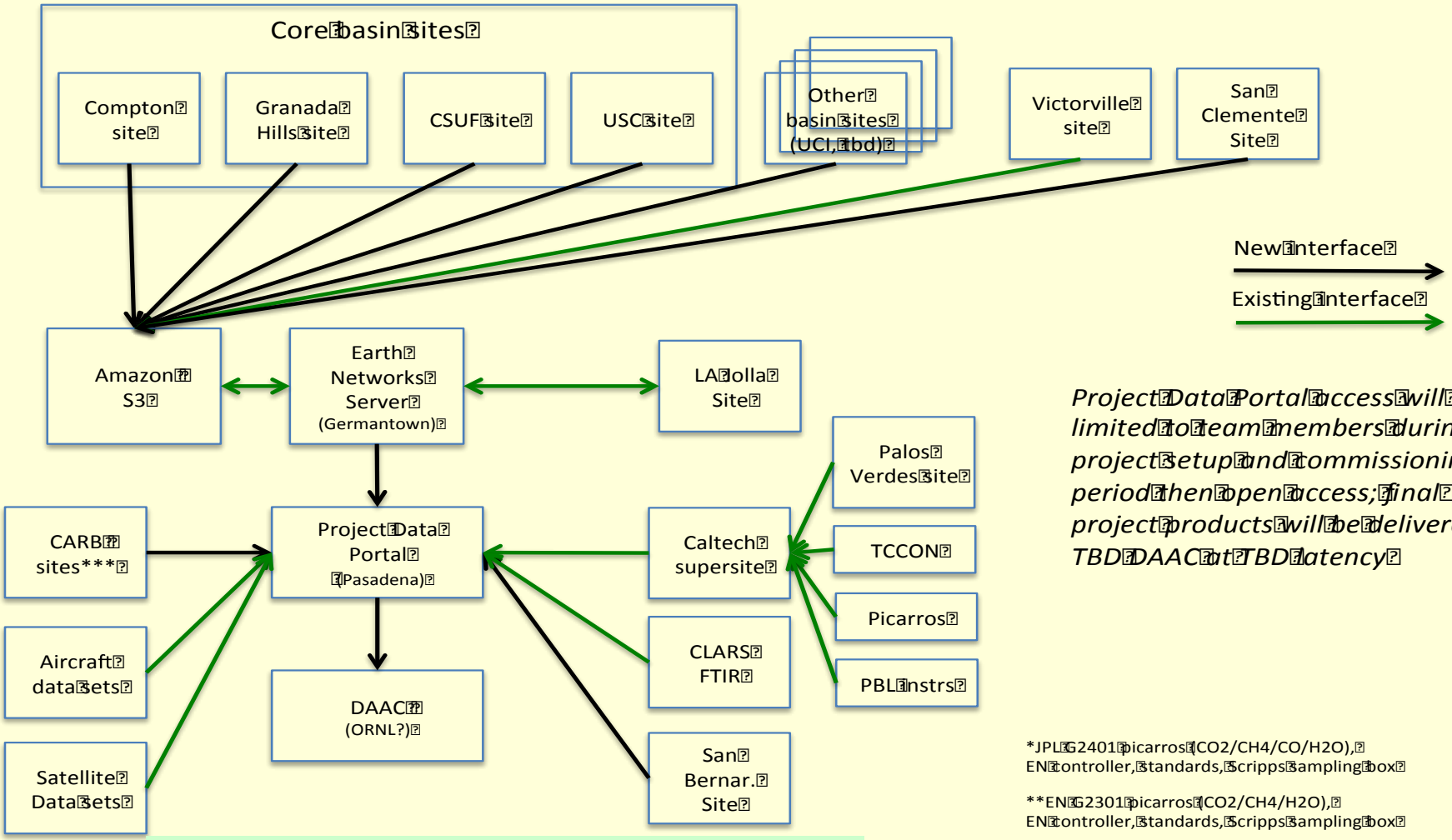


Example of different sampling strategies relative to existing megacities (red dots) and projected new megacities by 2025 (blue dots)

(5) Synthesis framework



Data Flow & Portal



Project Data Portal access will be limited to team members during project setup and commissioning period then open access; final project products will be delivered to TBD DAAC at TBD latency

Potentially >10 "configurations" in terms of how data are collected, QC'd, calibrated, etc

*JPL G2401 picarros (CO2/CH4/CO/H2O), EN controller, standards, Scripps sampling box

**ENG2301 picarros (CO2/CH4/H2O), EN controller, standards, Scripps sampling box

***CARB Picarros and LGRs at Mt Wilson and Claremont

Thank you

Riley.M.Duren@jpl.nasa.gov
megacities.jpl.nasa.gov