CO_2-Urban Synthesis and Analysis (CO_2-USA) Project & Report from Initial Workshop

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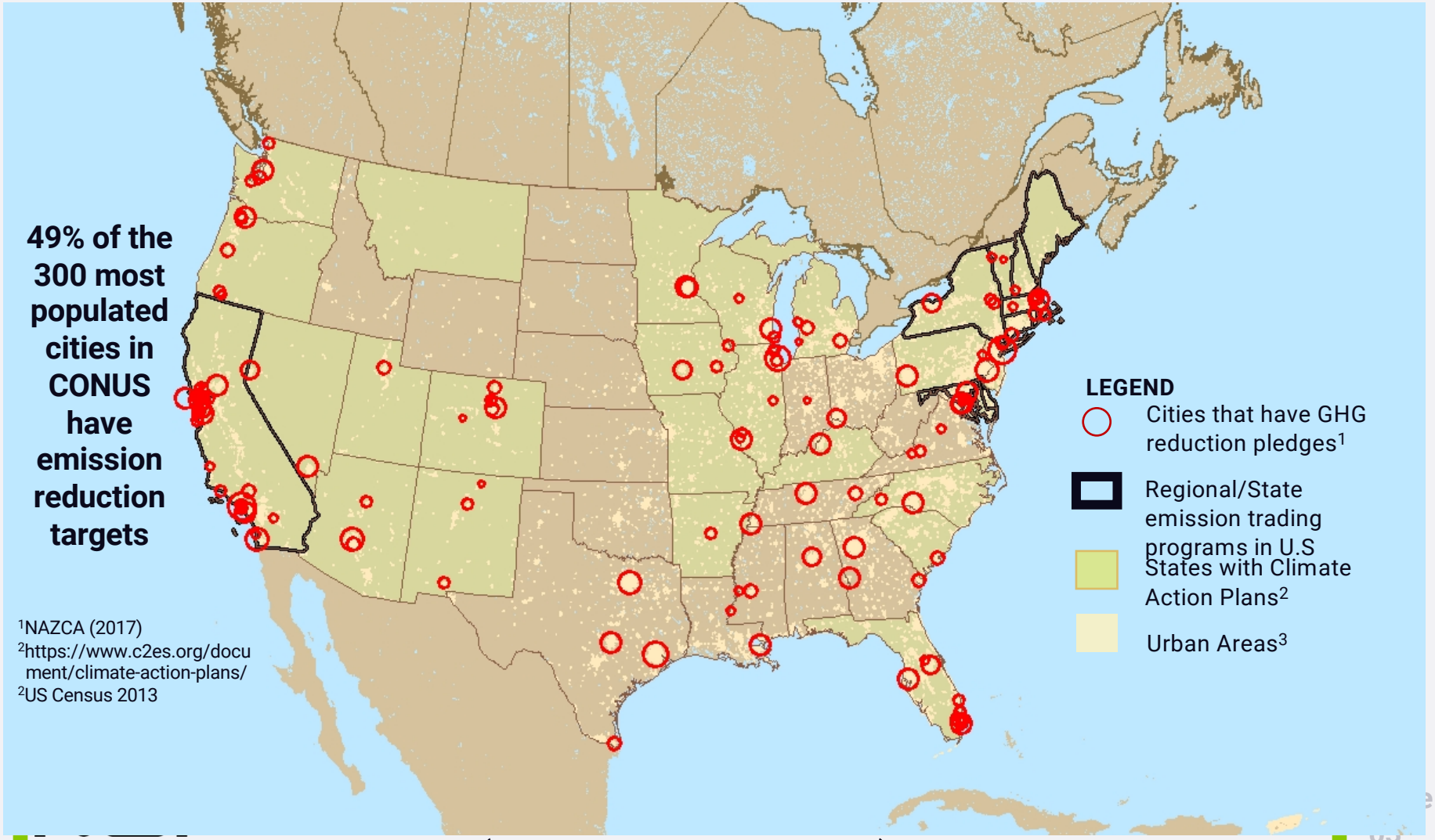
NIST, November 6th~7th, 2017

Motivation

- **Urban areas are responsible for significant quantities of carbon emissions**
- **Increased population residing in cities**
- **Understanding *how much, where,* and *why* a particular city emits carbon remain scientific goals**
- **Cities have emerged as leading players in reducing greenhouse gas emissions**

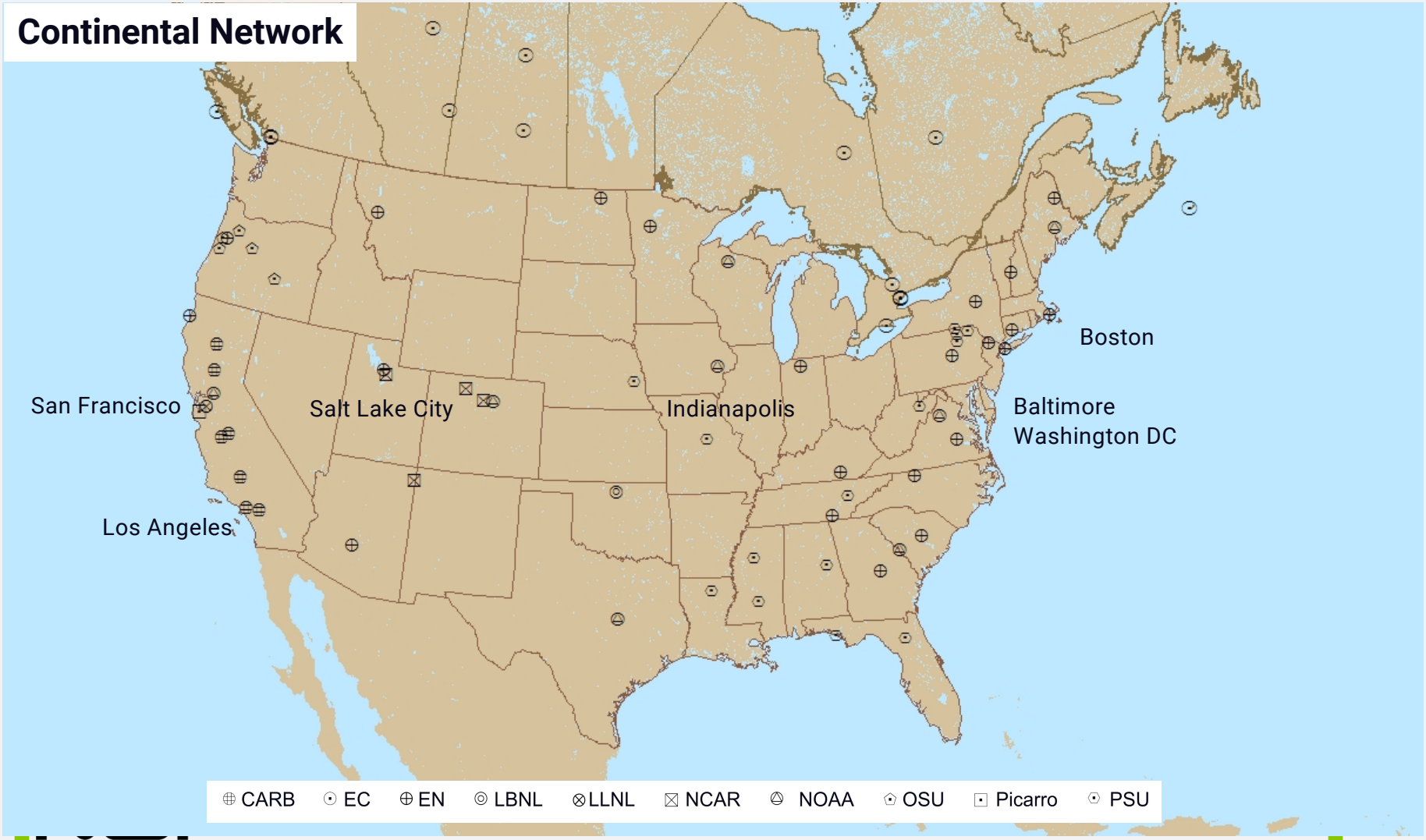
“Demand” for Localized GHG Emission Information ex. GHG mitigation policies/pledges



(from Kim Mueller)

Data Expansion

ex. in-situ obs. for top-down models



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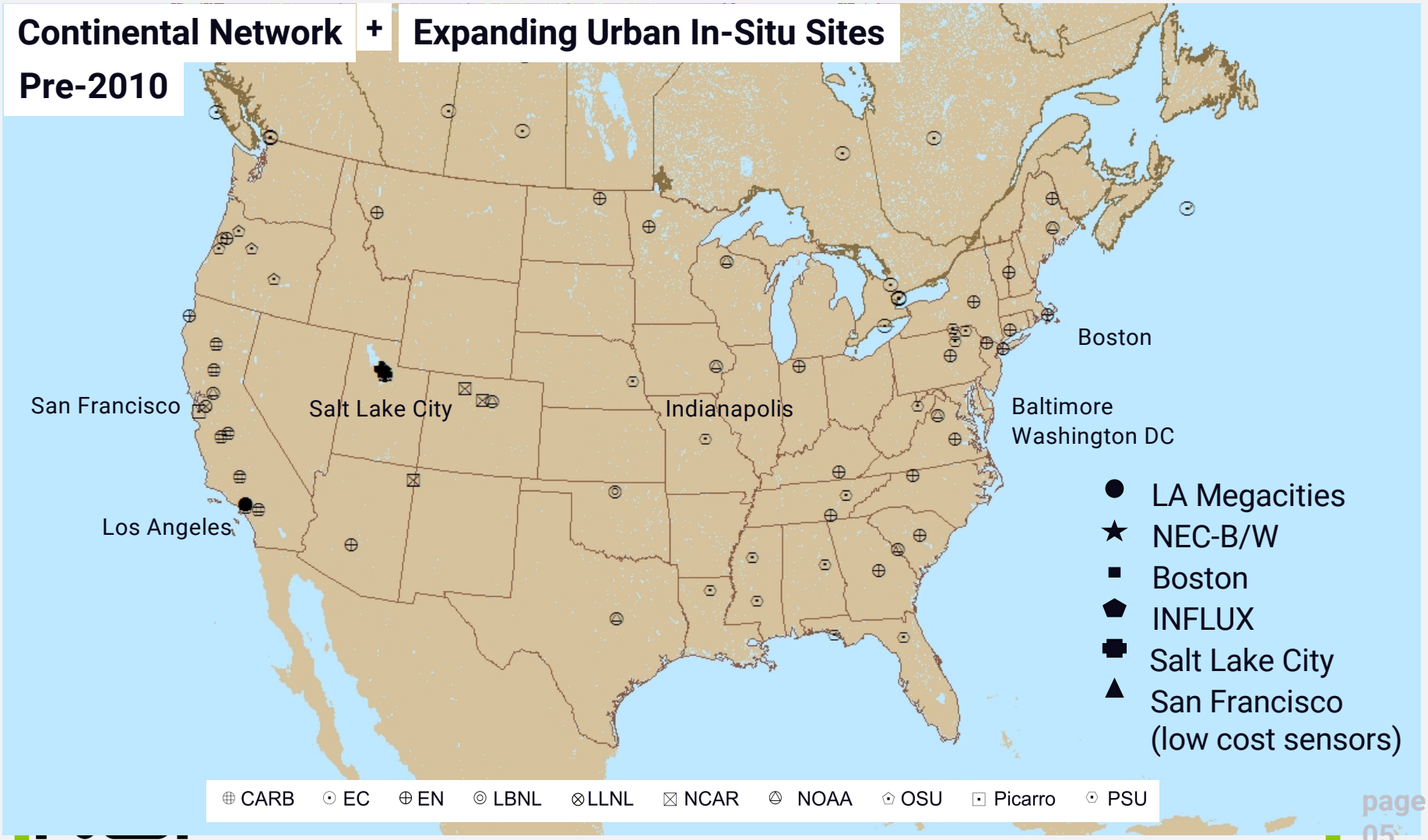

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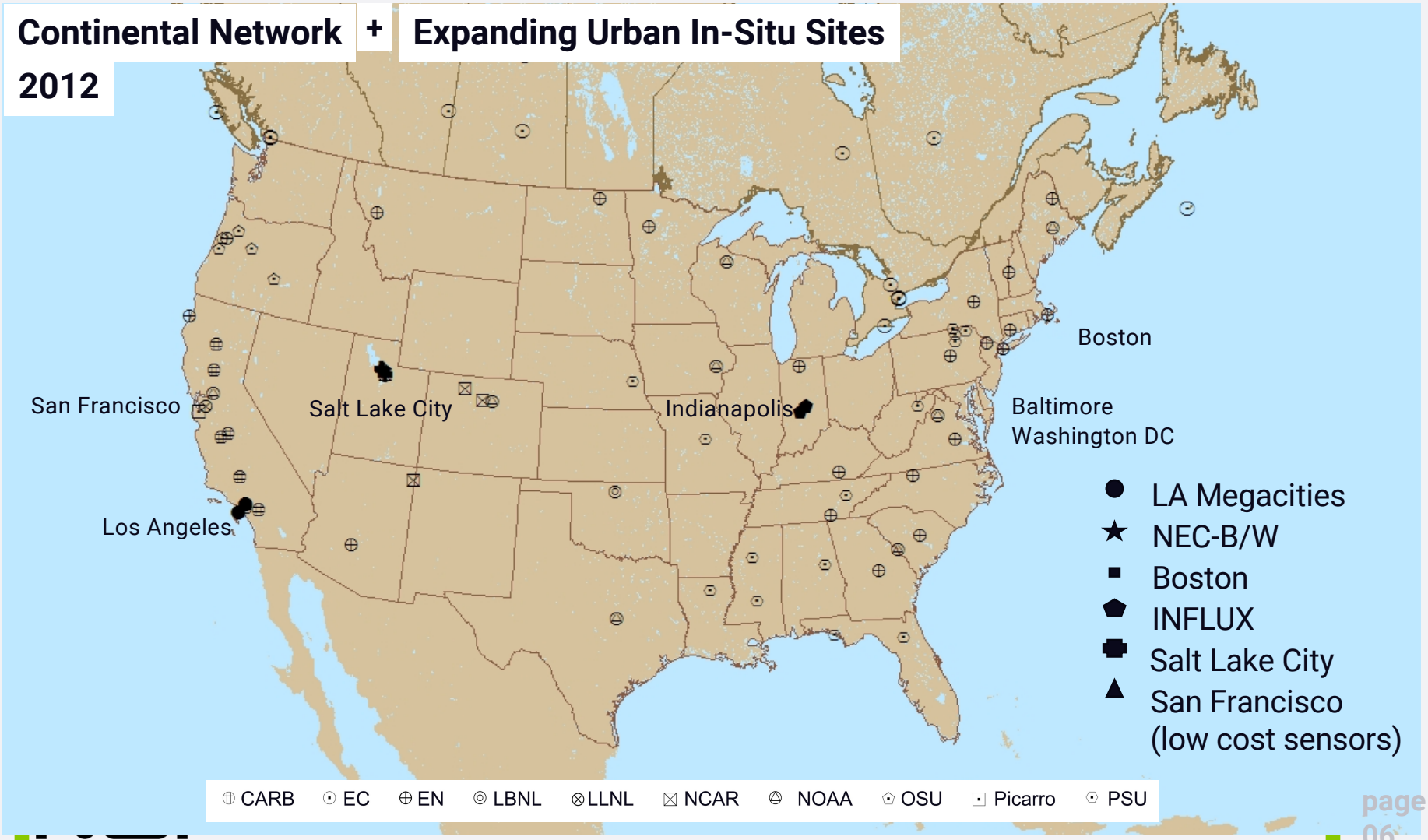

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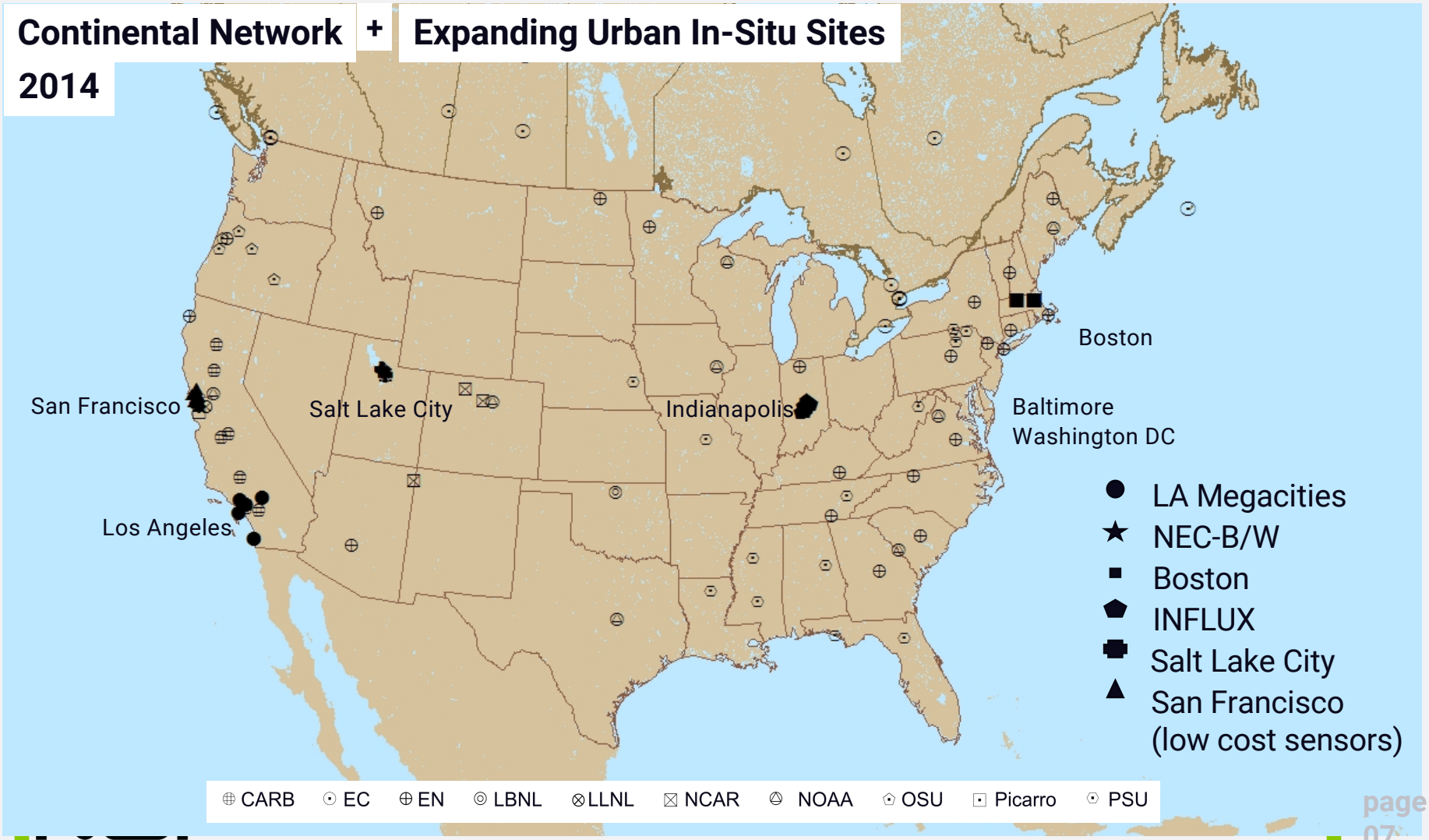

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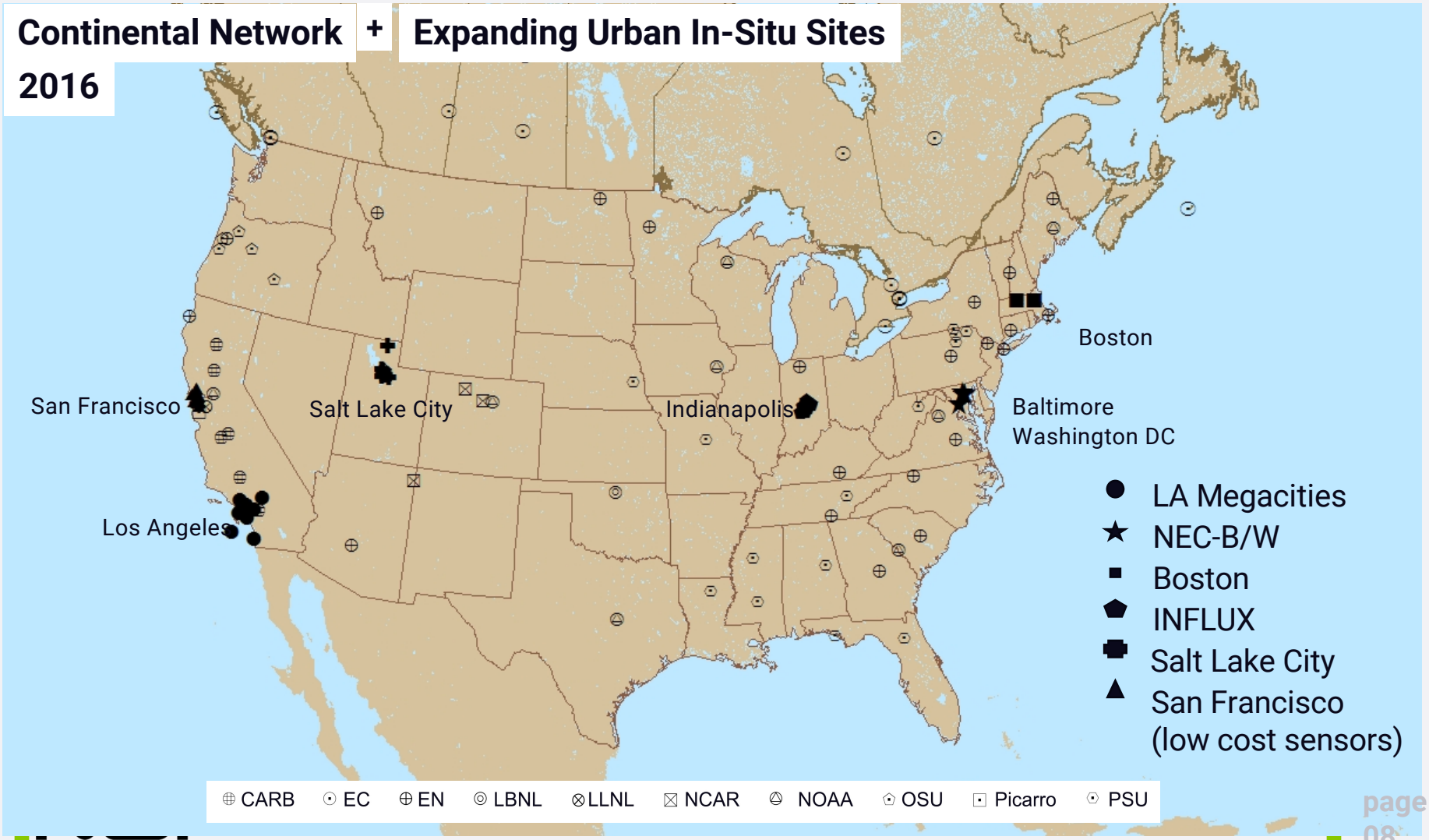

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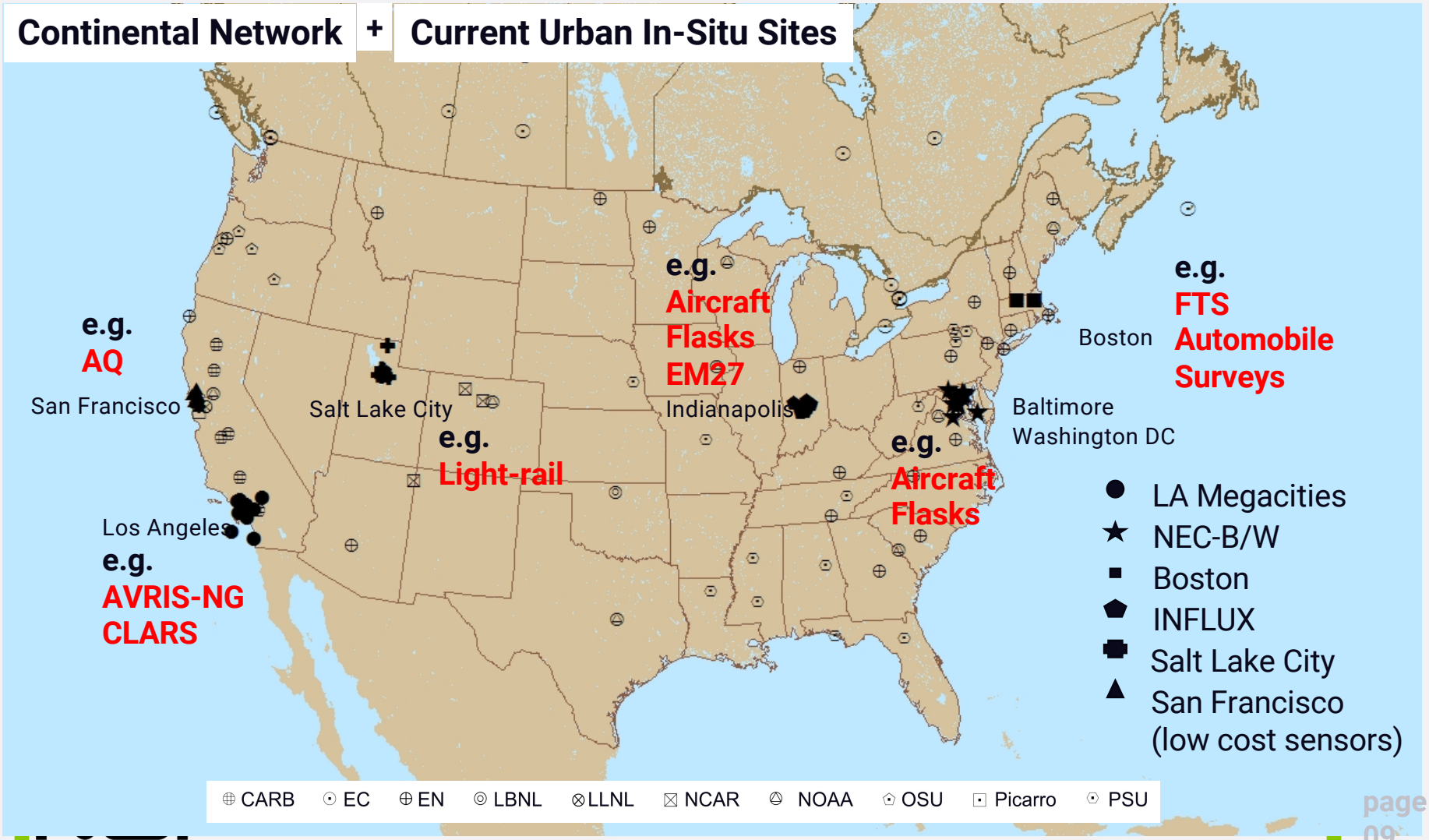
Data Expansion
ex. in-situ obs. for top-down models

Many other measurements!



(from Kim Mueller)

Assets in Different Cities

		Boston	Indianapolis	Los Angeles	Salt Lake City	San Francisco	Washington DC/Baltimore
GHG Observations	**In-situ mixing ratio**	~10 sites (CO_2, CH_4, CO) since 2012*	12 sites (CO_2, CH_4, CO) since 2012	14 sites (CO_2, CH_4, CO, N_2O) first one in 2012; 2 planned	9 sites (first one established in 2001)	50 low cost sensor sites (CO_2, CO, NO, NO_2, O_3, PM10)	9 sites (CO_2, CH_4) first one in 2015; 7 planned; aircraft campaigns
	Flasks	episodic	5 sites ($^{14}CO_2$ & trace gases) since 2010	3 sites ($^{14}CO_2$ & trace gases) 2014-2017; MWO since 2010 ($^{14}CO_2$ & trace gases) with 2012-2014 gaps	$\delta^{13}CO_2$ stable isotope flasks at 1 site since 2002	-	3 planned at tower sites ($^{14}CO_2$ & trace gases)
	Column Carbon Observations	FTS	TCCON, 2012; EM27 May, 2016	TCCON since 2012	-	-	-
	Radiocarbon	-	-	-	Radiocarbon in tree rings, leaves	-	-
	Other	automobile surveys of CO_2 and CH_4	Automobile surveys, 500km of road data, 2012-2014; CO_2 Lidar (JPL, Goddard, and Langley)	CLARS since 2010; AVRIS-ng, AVRIS-C & HyTES (CO_2,CH_4,NO_2, NH_3 - retrievals not robust yet) since 2012	Continuous light rail transects since Dec 2014; mobile lab surveys	PANDORA since 2017 (column O_3 and NO_2)	Planned network of low-cost sensors
Meteorological Observations	**Surface stations**		Met. observations from 2–4 sites since 2013	ASOS stations; 5 radar wind profilers	25 research-grade meteorological sites	BAAQMD maintains stations in vicinity including 6 Picarro CO_2	Met observations at most in-situ sites; METAR and ASOS
	Radiosondes		-	-	Regular NWS launches at KSLC airport (00 and 12 UTC)	-	Regular NWS launches at Sterling, VA (00 and 12 UTC)
	Profilers	MiniMPL	HRDL/HALO Doppler LIDAR since 2013	MiniMPL & Ceilometer (CalTech) since 2012; AQMD wind LIDAR since 2016	Ceilometer, sodar, radiometer, lidar (deployed during IOPs)	Ceilometer	Ceilometer at Sterling and UMBC; MiniMPL at UMBC, GSFC and Sigma Space Corp
Land cover and biospheric observations		Lidar, extensive field plots, hi res land cover	-	-	Lidar survey	-	Plot level SIF measurements on NIST campus since 2017

Main Objectives of CO_2-USA

- Leverage existing scientific infrastructure and investments in GHG work over the past few years
- Quantify & understand similarities/differences in CO_2 and CH_4 fluxes across cities
- Foster a community of urban carbon cycle researchers and generate collaborative studies
- Engage stakeholders to link them with data, syntheses, and insights into urban emissions

NOAA National Oceanic and Atmospheric Administration U.S. Department of Commerce

NIST National Institute of Standards and Technology U.S. Department of Commerce

Thanks To:

NOAA Climate Program Office's Atmospheric Chemistry, Carbon Cycle, and Climate program for funding this project

NIST for hosting this workshop and for providing travel and logistical support

NIST
National Institute of Standards and Technology
U.S. Department of Commerce

Workshop Website

CO2 Urban Synthesis and Ana

Secure | https://www.nist.gov/news-events/events/2017/11/co2-urban-synthesis-and-analysis-usa-network-workshop

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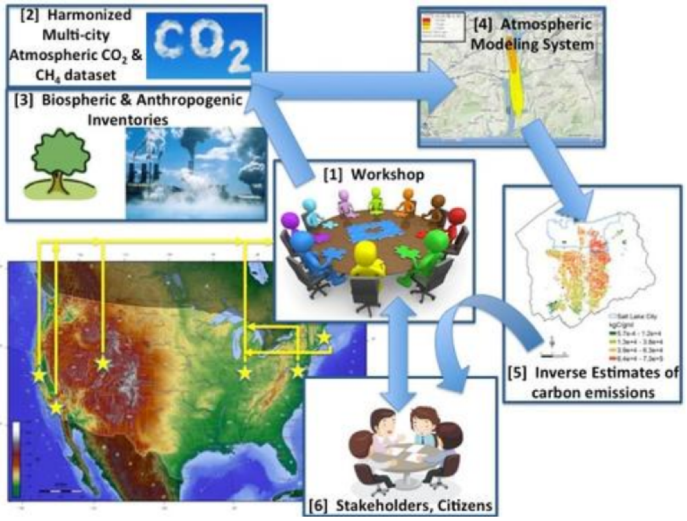
EVENTS

CO2 Urban Synthesis and Analysis (USA) Network Workshop

Purpose: Launch a collaborative network of researcher and stakeholders facilitating collaboration and information exchange concerning best practices and approaches to urban greenhouse gas measurements, data, and estimation results.

Planning Team: John Lin, Lucy Hutyra, James Whetstone, & Tamae Wong



Participants:

1. Scientists leading urban-scale CO2 & CH4 flux measurements using bottom-up and topdown methods;
2. Regulators and policymakers interested in integrating scientific observations into their greenhouse gas reporting systems;

WORKSHOP

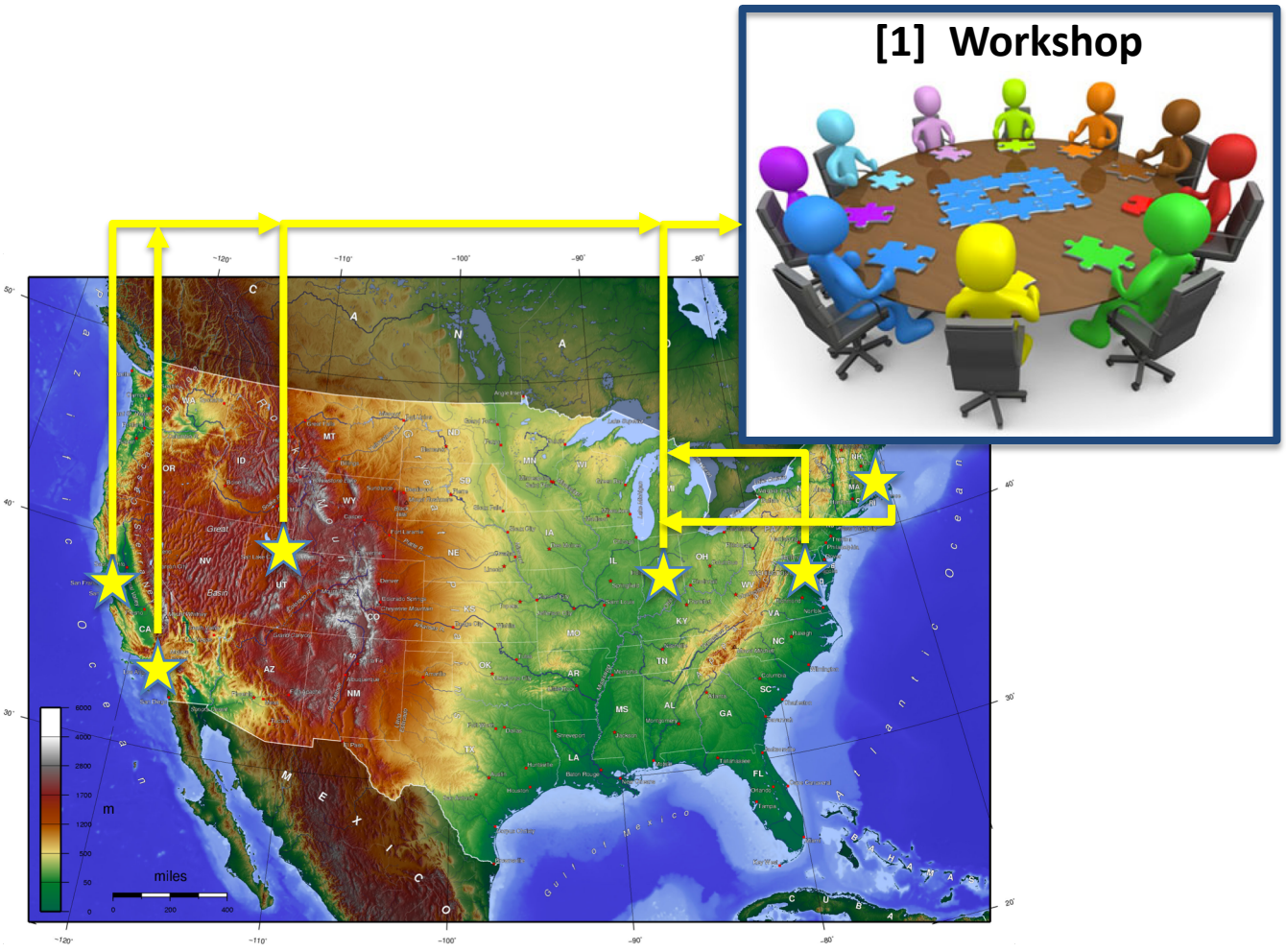
November 06, 2017 to November 07, 2017

NIST, 100 Bureau Drive, Gaithersburg, Maryland 20899 (Portrait Room)

Registration has closed. We are offering a webinar Option. The Webinar/BlueJeans information is available upon request from Tamae Wong. Please contact her no later than Friday November 3rd by 12:00pm EDT.

All attendees must be pre-registered to gain entry to the NIST campus. Photo identification must be presented at the main gate to be admitted to the conference. International

https://www.nist.gov/news-events/events/2017/11/co2-urban-synthesis-and-analysis-usa-network-workshop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[2] Harmonized Multi-city Atmospheric CO_2 & CH_4 dataset

[3] Biospheric & Anthropogenic Inventories

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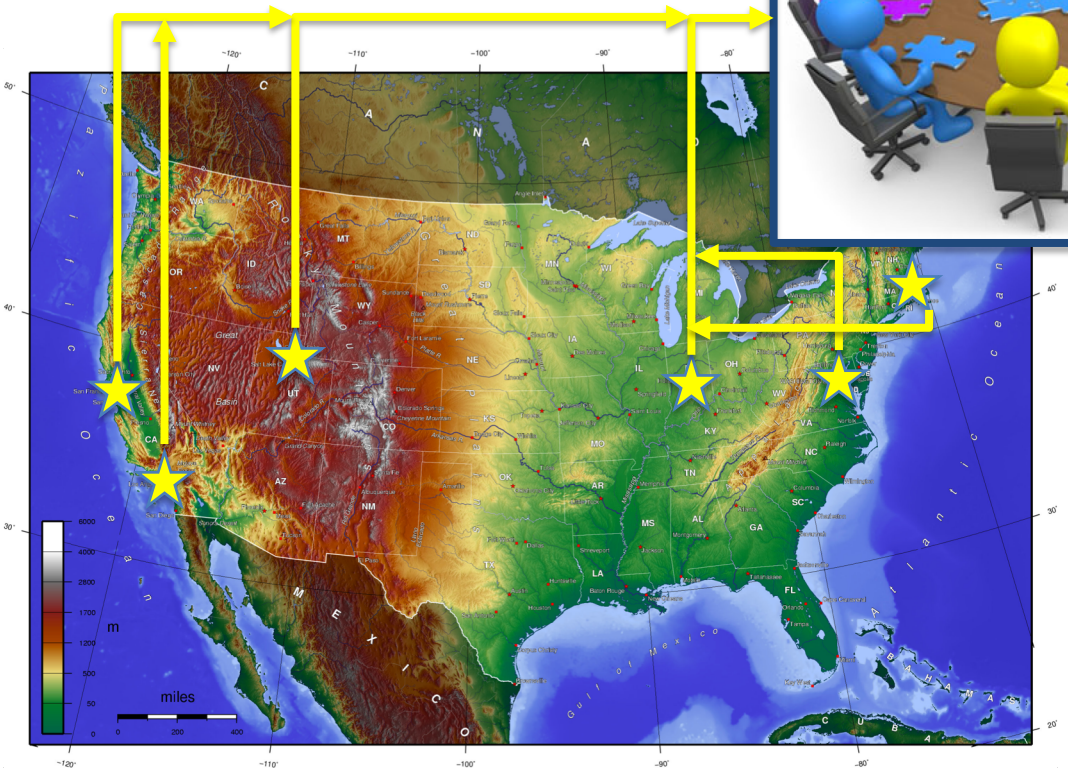

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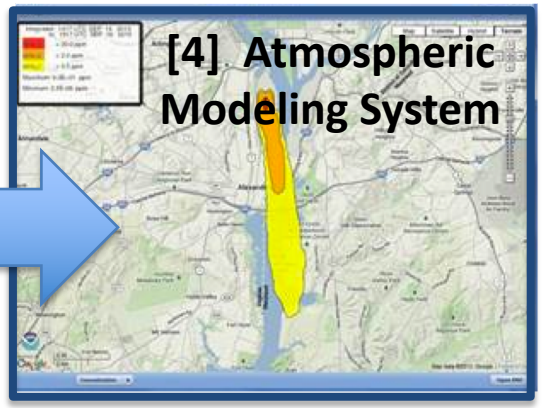

[4] Atmospheric Modeling System

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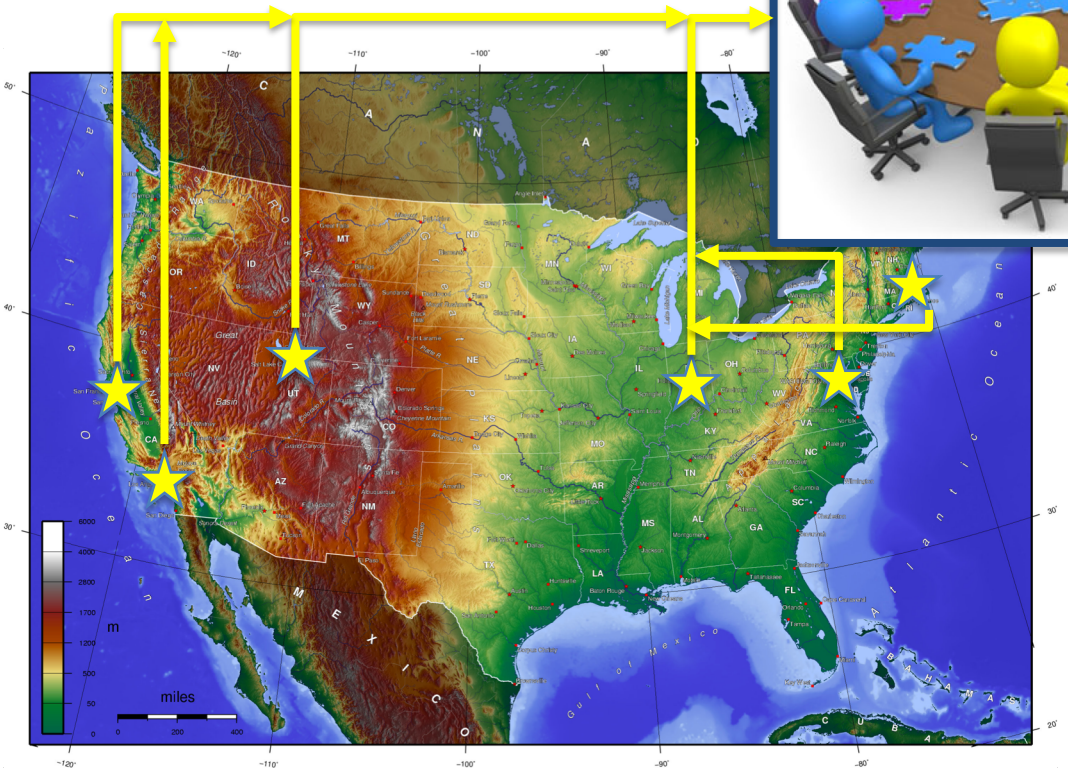

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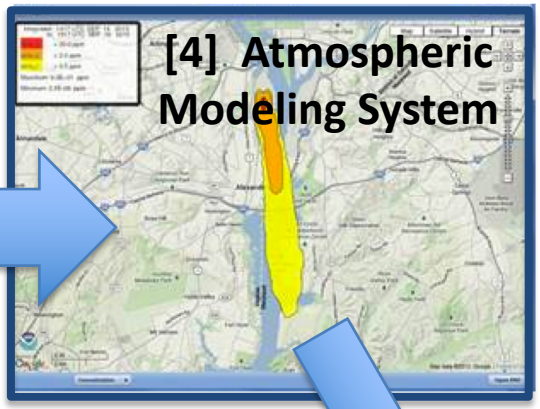

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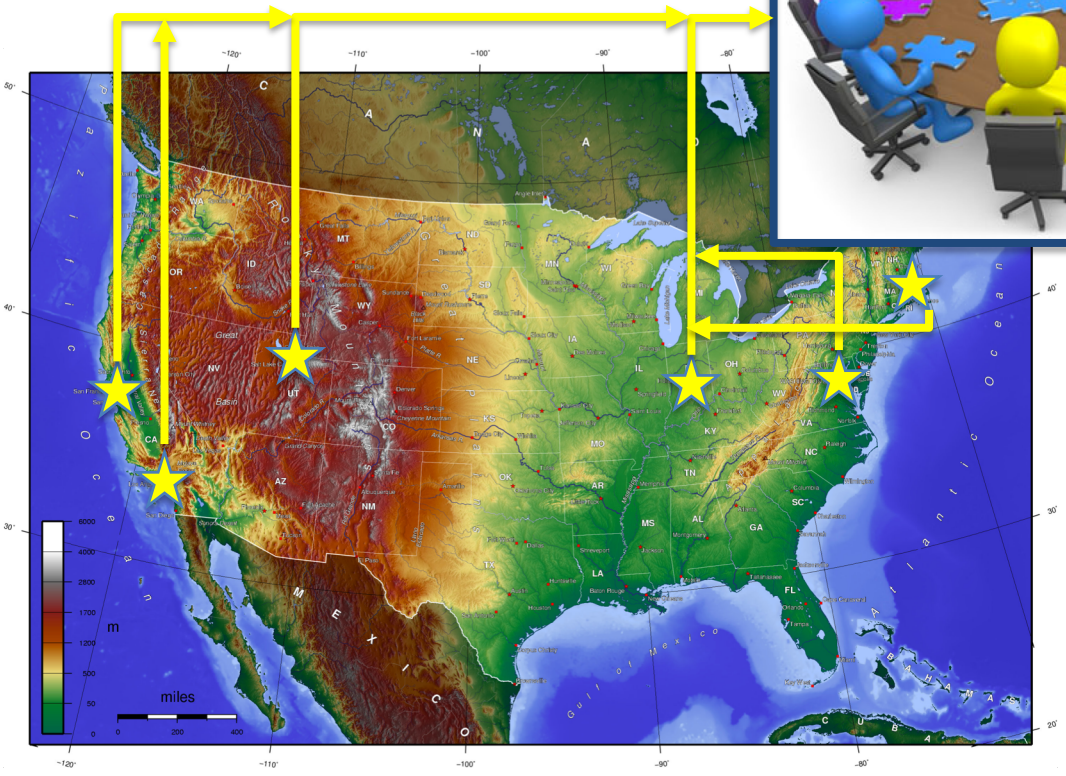

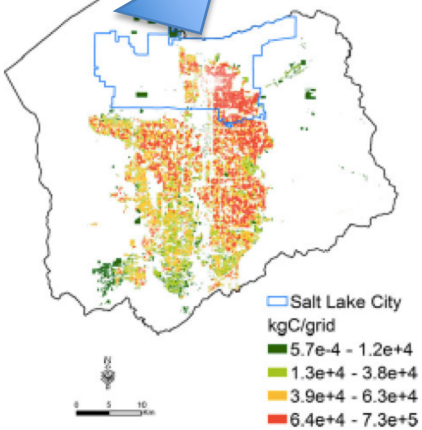

[5] Inverse Estimates of carbon emissions

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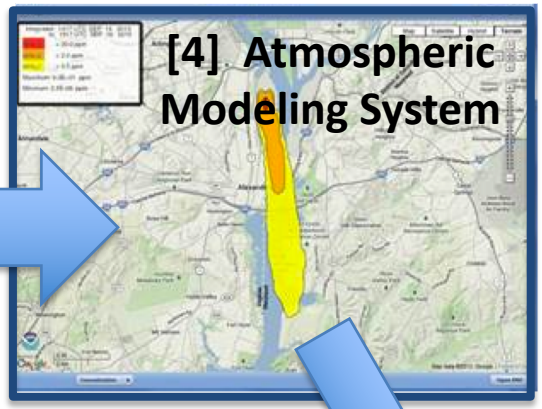

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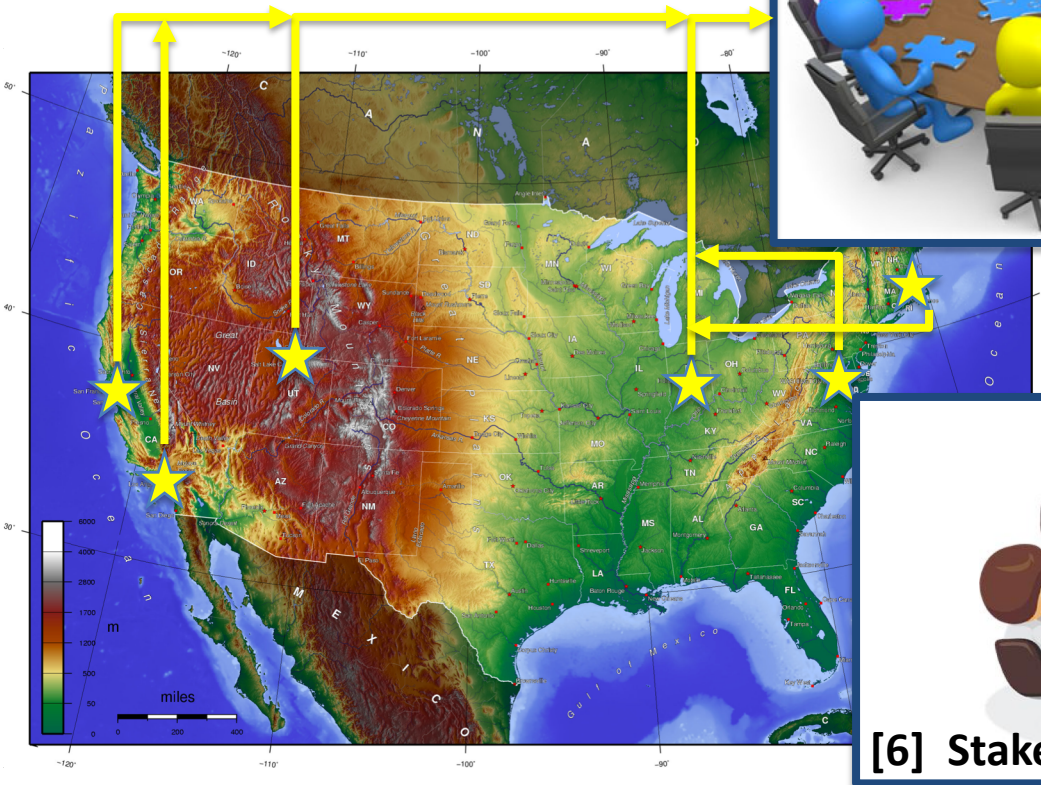
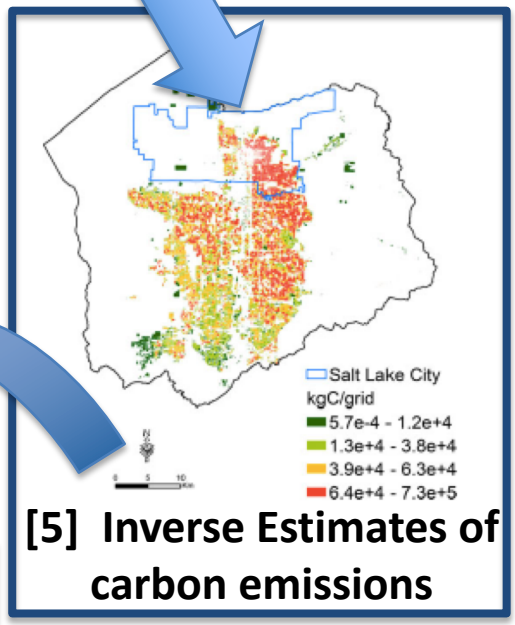


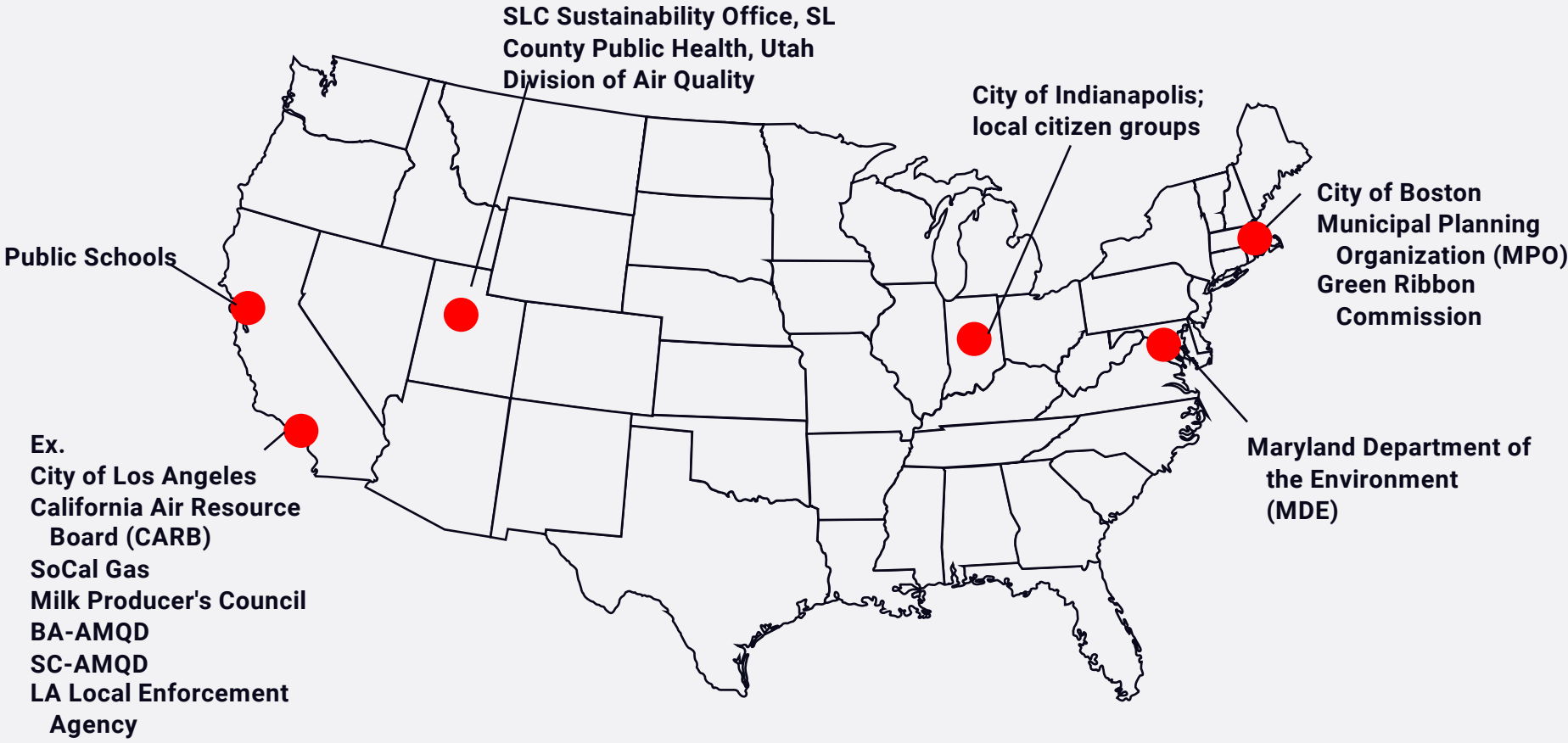


[5] Inverse Estimates of carbon emissions

[6] Stakeholders, Citizens

Stakeholder Engagement

"Demand" for Localized GHG Emission Information ex. stakeholders



(from Kim Mueller)

Importance of Co-benefits of GHG Reductions for Stakeholders

- Improved air quality
- Healthier living (e.g., more walking/biking from reduced driving)

Value to Cities from Community's Scientific Research

- Retrospective: Assessment of economic/social values of reduction efforts.
- Diagnostic & Prognostic: Mitigation guidance-estimated impacts, prioritization and cost/benefit
- Trend Detection
- Policy Relevant timescales
- Evaluation of scope 1 inventory
- Hot spots/attribution - bias & knowledge gaps
- Value of carbon sinks

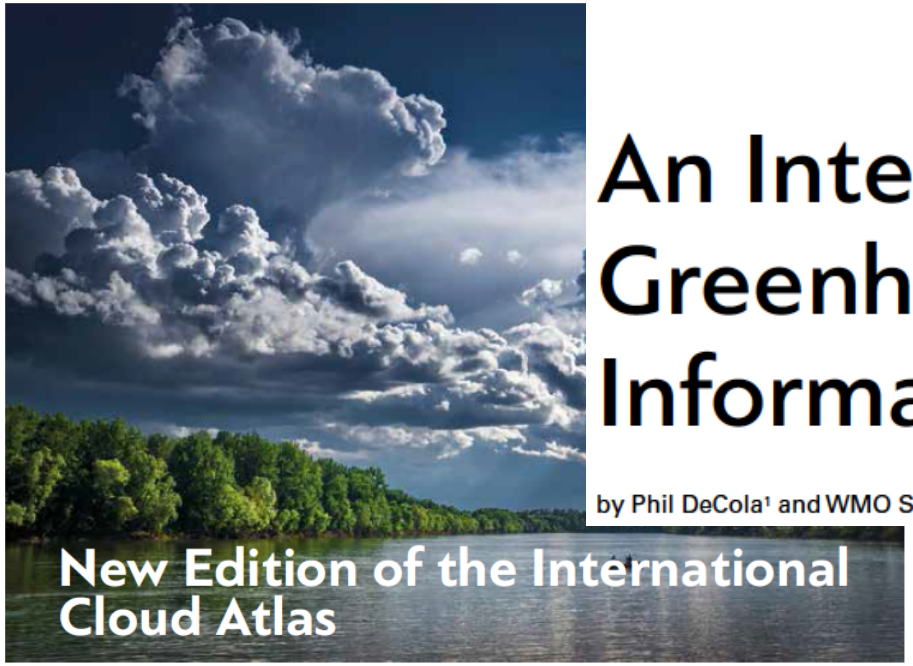
Issue of Uncertainties for Stakeholders

Do stakeholders care about uncertainties?

Or more about BIASES or hotspots?

If biases, then CONSISTENT bias for trend detection instead of continually improving methods, such that introduce “jumps” in estimates?

Linkage to International Efforts



An Integrated Global Greenhouse Gas Information System (IG^3IS)

by Phil DeCola[1] and WMO Secretariat[2]

Objective 1 – support of national GHG emission inventories

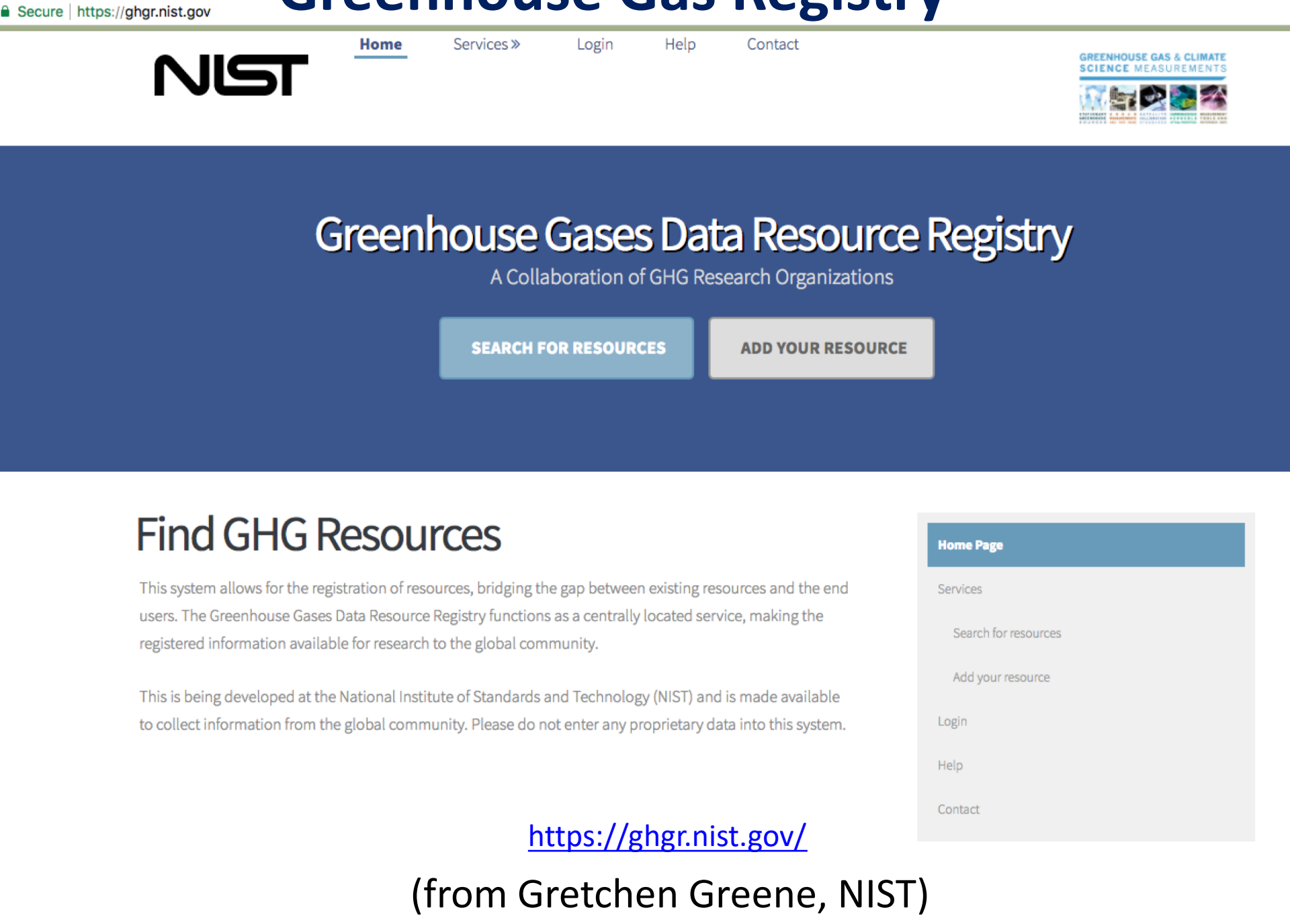
Objective 2 - Detection and quantification of fugitive methane emissions

Objective 3 - Estimation and attribution of megacities emissions

Linkage to International Efforts

https://citiesipcc.org/en/conference-programme/preliminary-programme

Greenhouse Gas Registry



https://ghgr.nist.gov/

(from Gretchen Greene, NIST)

Greenhouse Gas Registry

https://ghgr.nist.gov/

(from Gretchen Greene, NIST)

Working Groups

1. Data Synthesis Working Group

Goal: shared dataset of observed CO2 plus CH4 (where available) and associated tracers in multiple U.S. cities (and potentially beyond)

Working group defining:

- Data format
- Reporting of standards and calibrations
- QA/QC
- Data archive location (likely Oak Ridge DAAC)
- Fair use policy
- Ancillary datasets
  - Aircraft and ground-based surveys
  - Meteorology
  - Satellite
  - Inventories

Working Groups

2. Atmospheric Transport Working Group

Goal: evaluate atmospheric simulations alongside meteorological observations

Potentially leveraging NOAA-ARL's HYSPLIT-based modeling system (see later slides), that allows
1) Multiple meteorological fields
2) Tracer release datasets to evaluate dispersion

3. Atmospheric Inversion Working Group

Goal: compare different atmospheric inversions techniques and results in different cities

CO_2-USA ARL Modeling System Updates

Chris Loughner – University of Maryland / NOAA ARL

Ariel Stein – NOAA ARL

John Lin – University of Utah

Introduction

- **Goal:**
  - Apply model to estimate carbon emissions and trends in different U.S. cities
- **1st Step:**
  - Construct an atmospheric modeling system that is scalable and transferable between cities
    - Enhance HYSPLIT with STILT routines
    - Compile urban/suburban scale datasets for testing updated HYSPLIT model
    - Host benchmark scenarios for future testing of model updates and model inter-comparisons
- **Benefits of HYSPLIT modeling system updates:**
  - Enhance HYSPLIT's capabilities
  - Host and maintain STILT routines with HYSPLIT code that will continue to be updated with the state of the science
  - Provide testing platform to evaluate and examine model similarities and differences to other Lagrangian models / model options. Testing platform can also be used to test inversion techniques to estimate source strength and location.

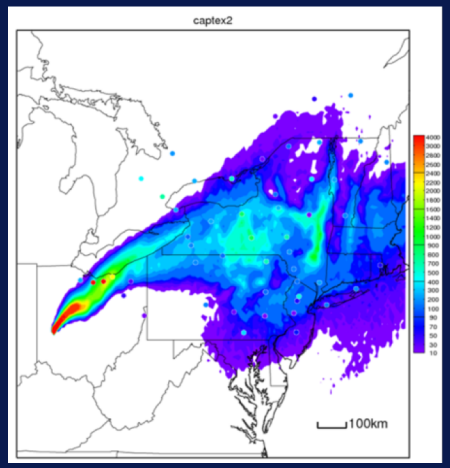
meteorological input files

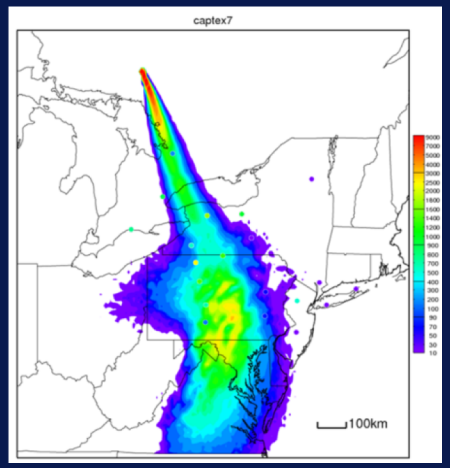
- Pre-processors for many different meteorological models and gridded analysis/reanalysis datasets (WRF, RAMS, MM5, ECMWF, GALWEM, MERRA, ERA interim, ERA5) to convert data to the ARL format, in addition to the archives of existing NOAA models and analysis/reanalysis (NAM, HRRR, GFS, SREF, NARR, GDAS, NCEP/NCAR reanalysis).
- ARL new WRF simulation
  - Resolution: 27 km (216 E->W, 174 S->N, 33 vertical from surface to 100mb)
  - Timeframe: 1980-2016 with plans to continue through 2017 and beyond
  - Domain covers all of CONUS
  - Model configured to obtain optimal transport results; not temperature
  - Some STILT specific optional inputs are available (mass conserving winds available, but no convection variables)
  - Converted to ARL formatted files and is publically available
- Future ARL WRF simulation
  - Resolution: 9 km, nested down from the 27 km domain described above
  - All STILT optional inputs will be available
  - Will be converted to ARL formatted files and made publically available

Model Evaluation System

Data Archive of Tracer Experiments and Meteorology (DATEM)

- **Approach**
  - Meteorology
    - North American Regional Reanalysis (NARR)
    - WRF runs
  - Common statistical evaluation protocols
- **Accomplishments**
  - Web access to run HYSPLIT for each experiment
  - Standardized model change testing in conjunction with version control





- **Cross Appalachian Tracer Experiment (CAPTEX)** Dayton, OH, and Sudbury, ONT, Sep., Oct., 1983
- **Atlantic Coast Unique Regional Atmospheric Tracer Experiment (ACURATE),** Savannah River Plant, SC, Spring 1982 – Summer 1983
- **Across North America Tracer Experiment (ANATEX)**, Glasgow, MT, and St. Cloud, MN, January through March 1987
- **Oklahoma Tracer Experiment**, Norman, OK, July, 08 1980
- **Metropolitan Tracer Experiment (METREX)** , Washington, DC, January – December 1984
- **European Tracer Experiment (ETEX)**, Rennes, France, October 23, 1994
- **Savannah River Plant Experiment** , Aiken, SC, Aug. 1975 through Sep. 1977
- **Atmospheric Studies in Complex Terrain (ASCOT)** , California, September 12-25, 1980
- **Colorado Springs Tracer Experiment (COSTEX)**, October 18, 21, 23, 2010
- **Sagebrush, Idaho, 2013**
- **Aliso Canyon well blowout, 2015**
- **Tracers of opportunity (e.g. SO2 flight data)**

STILT

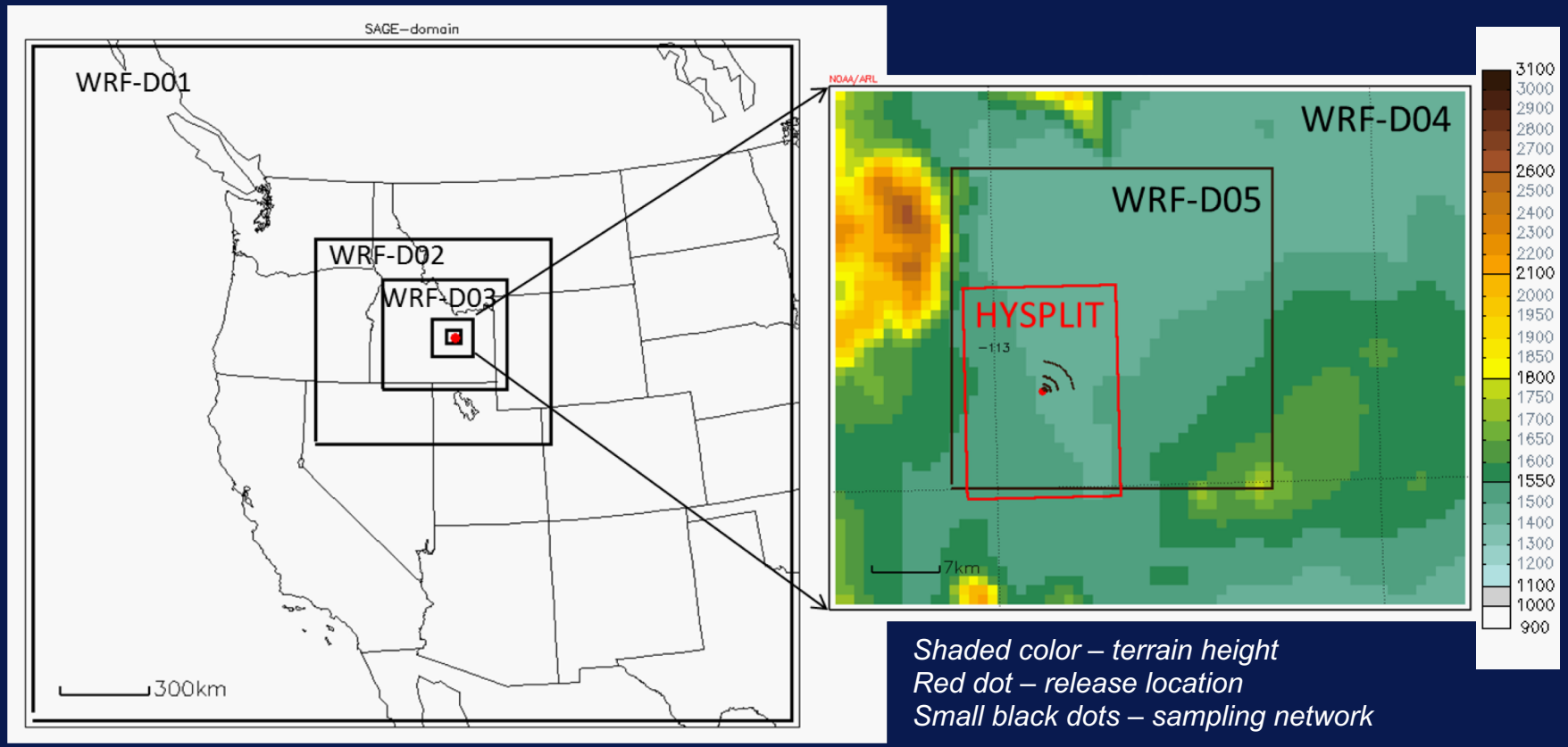
- Built from the HYSPLIT code
- Major STILT features not currently in HYSPLIT:
  - Mass conservation
  - Hanna Lagrangian timescale
  - Convection scheme that utilizes WRF convective fluxes
  - A more complex turbulence module that includes a reflection/transmission scheme for Gaussian turbulence. This preserves well-mixed distributions of particles moving across interfaces between step changes in turbulence parameters.
  - Account for transport errors by incorporating uncertainties in winds into the motion of air parcels

STILT features being incorporated into HYSPLIT

- Mass Conservation
- Convection scheme
- Hanna Lagrangian timescale
- Complex turbulence module
- Account for transport errors

- Allow for updated features to be modular

HYSPLIT simulation of Sagebrush experiment

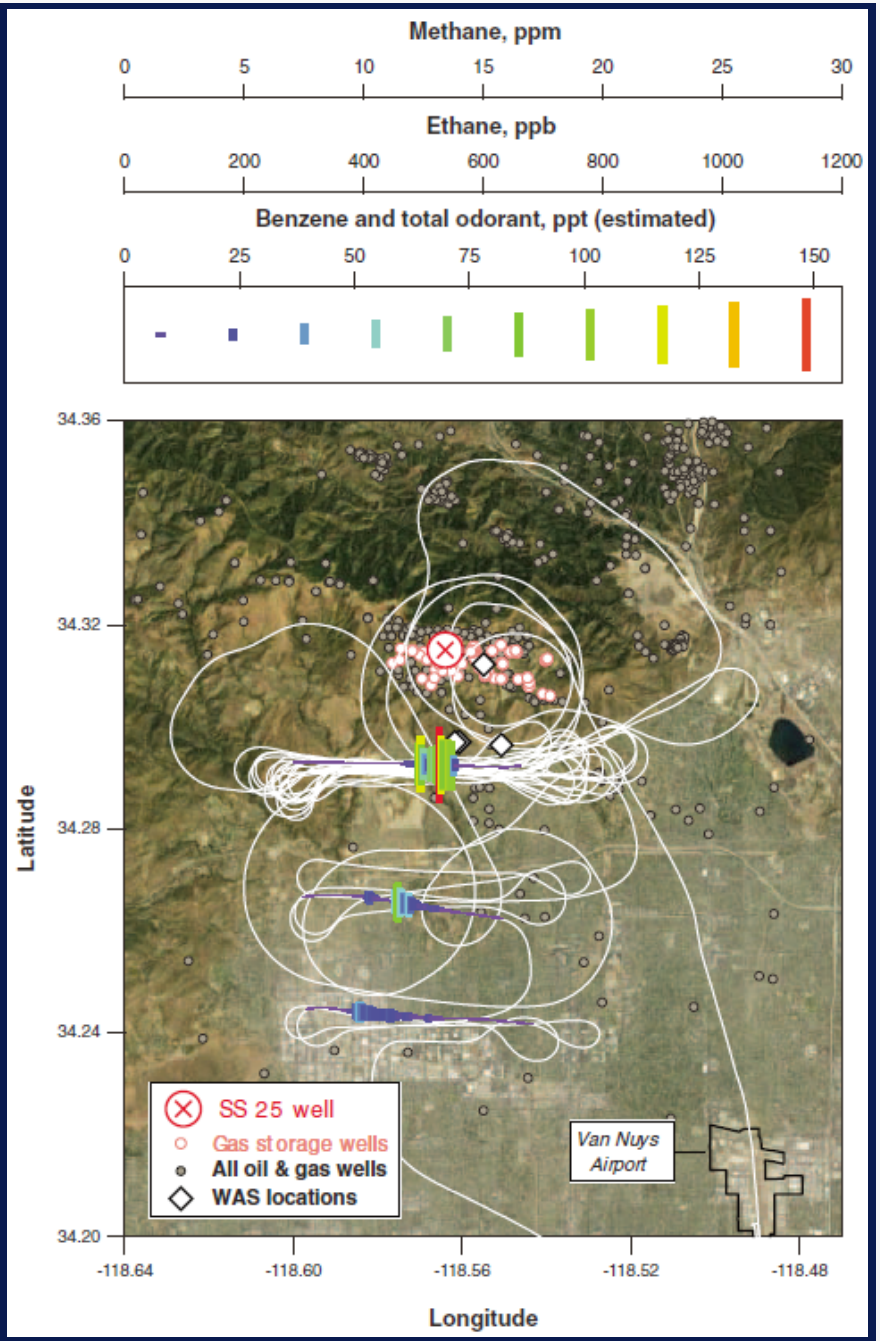


Shaded color – terrain height
Red dot – release location
Small black dots – sampling network

- Horizontal grid: 27km, 9km, 3km, 1km and 333m
- Vertical coordinate: 33 layers with the 1st mid-layer at around 8m and 20 layers included below 850 hPa.
- Simulation period: 2013/10/07 00UTC – 10/08 00UTC

2015 Aliso Canyon blowout

- Large natural gas emissions released from a well blowout of connected to an underground storage facility
- 13 research aircraft flights sampled the plume
- Atmospheric leak rates up to 60 metric tons of methane and 4.5 metric tons of ethane per hour (Conley et al., 2016)



Tracers of Opportunity

- Observations downwind of an isolated source with known emissions rates
- Continuous Emissions Monitoring Systems (CEMS) measures actual emissions from stationary sources.

TEXAQS II