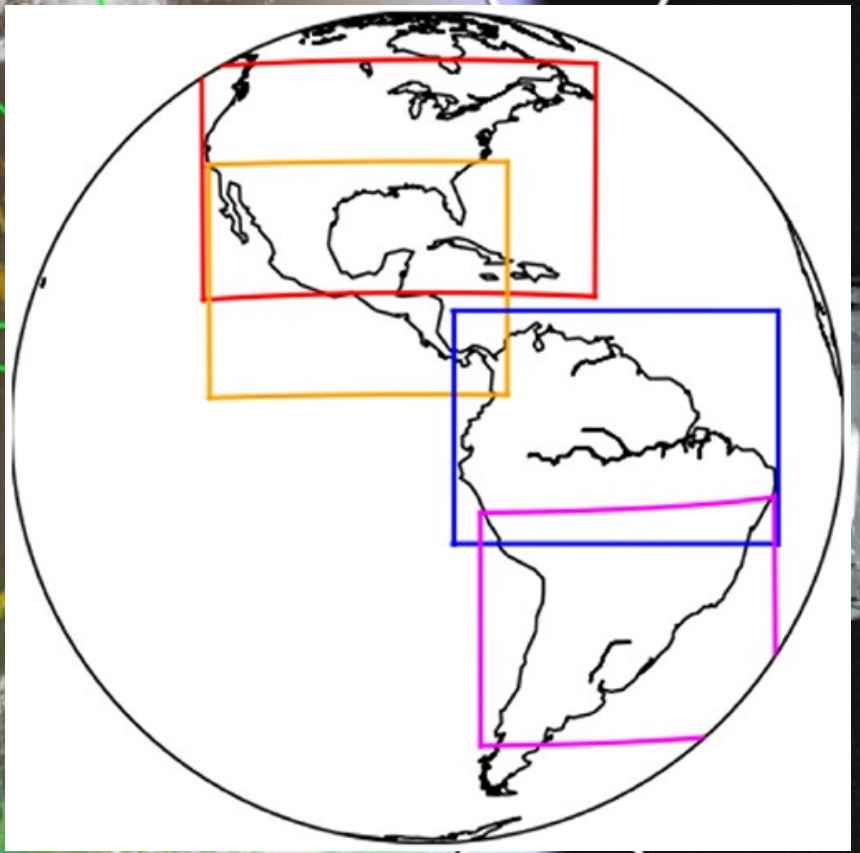
Instrumentation and Monitoring of Rural-Urban Gradients for Carbon Dioxide and Methane for Atmospheric Model Integration and Assimilation; Preliminary Results

Wesley T. Honeycutt*,
Elizabeth Spicer,
Lucas J. Livingstone,
Lee Fithian,
Sean M. R. Crowell

CHRISTOPHER C. GIBBS
COLLEGE OF ARCHITECTURE
The UNIVERSITY of OKLAHOMA

Geostationary Carbon Cycle Observatory

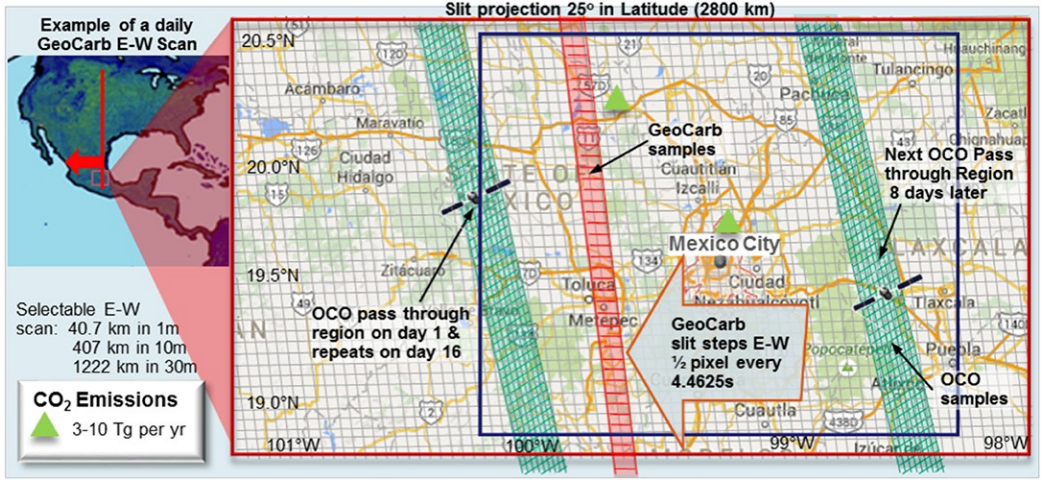


Launch: 2024

2 Scans/day

Spatial

- Altitude: 35,786 km
- Sweeping slit across each region
- Angular resolution: 123 µrad
- Resolution: 2.7km x 5.4km pixels
  - Sequential samples overlap
- Collects ~1000 soundings every 9s
  - ~4,000,000 soundings per day



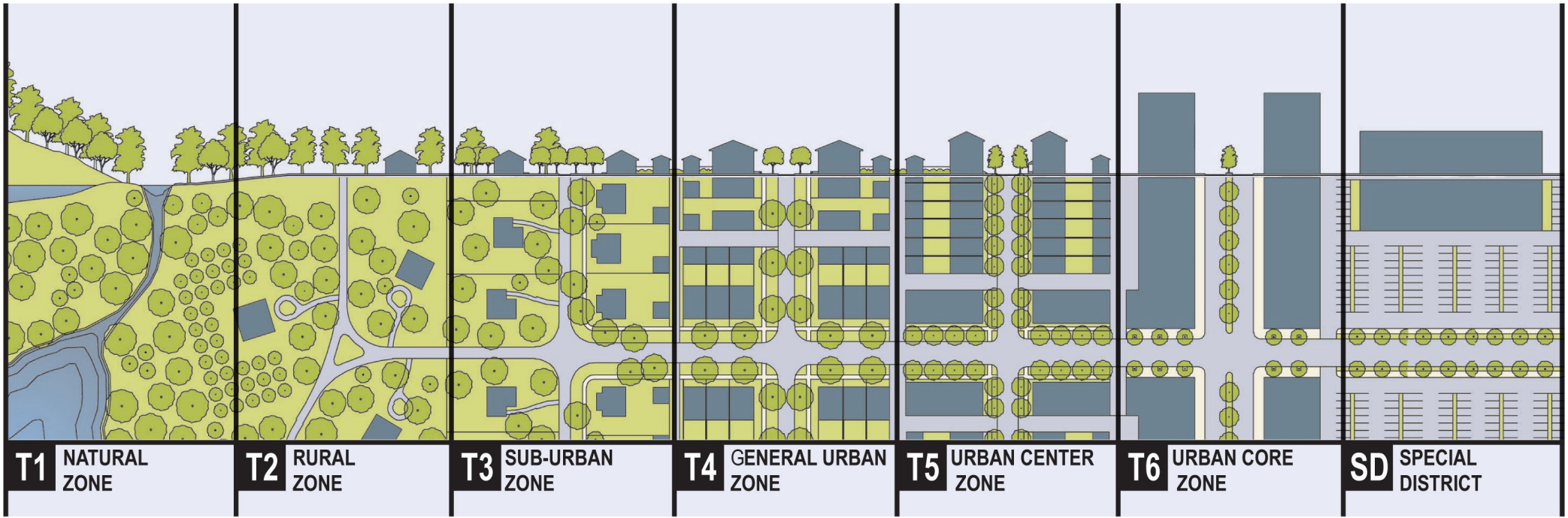
Spectral

Target	Band (µm)	Min λ (µm)	Max λ (µm)	Resolution (nm)
O_2 A-band/SIF	0.765	0.7569	0.7710	0.0474
Weak CO_2	1.606	1.5915	1.6212	0.101
Strong CO_2	2.065	2.0450	2.0850	0.136
CH_4/CO	2.323	2.3006	2.3456	0.153

Moore III, B., Crowell, S.M.R., Rayner, P.J., Kumer, J., O'Dell, C.W., O'Brien, D., Utembe, S., Polonsky, I., Schimel, D., Lemen, J., 2018. The Potential of the Geostationary Carbon Cycle Observatory (GeoCarb) to Provide Multi-scale Constraints on the Carbon Cycle in the Americas. Frontiers in Environmental Science 6.

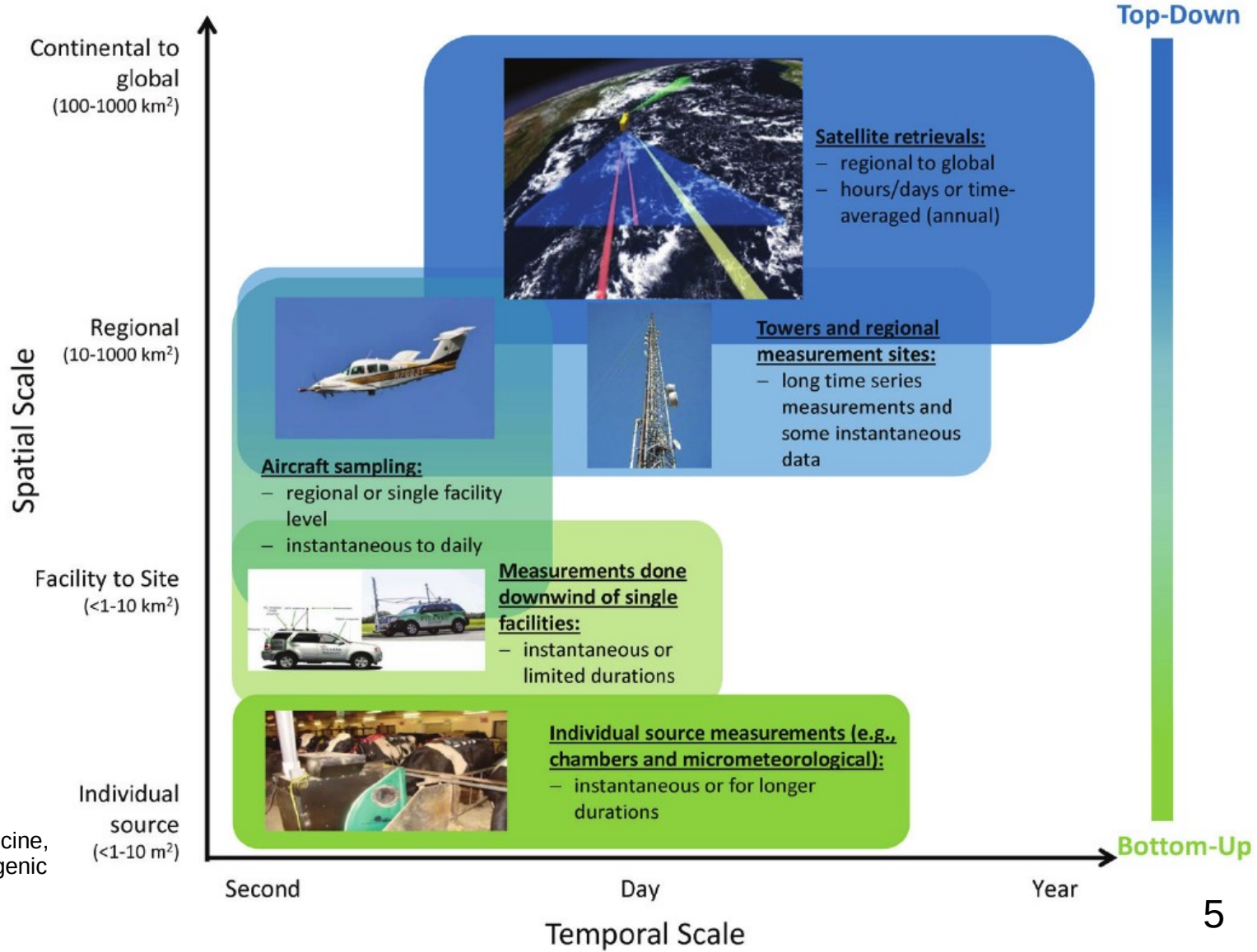
Somkuti, P., O'Dell, C.W., Crowell, S., Köhler, P., McGarragh, G.R., Cronk, H.Q., Burgh, E.B., 2021. Solar-induced chlorophyll fluorescence from the Geostationary Carbon Cycle Observatory (GeoCarb): An extensive simulation study. Remote Sensing of Environment 263, 112565. https://doi.org/10.1016/j.rse.2021.112565

Calibration/Validation at the Continental Scale



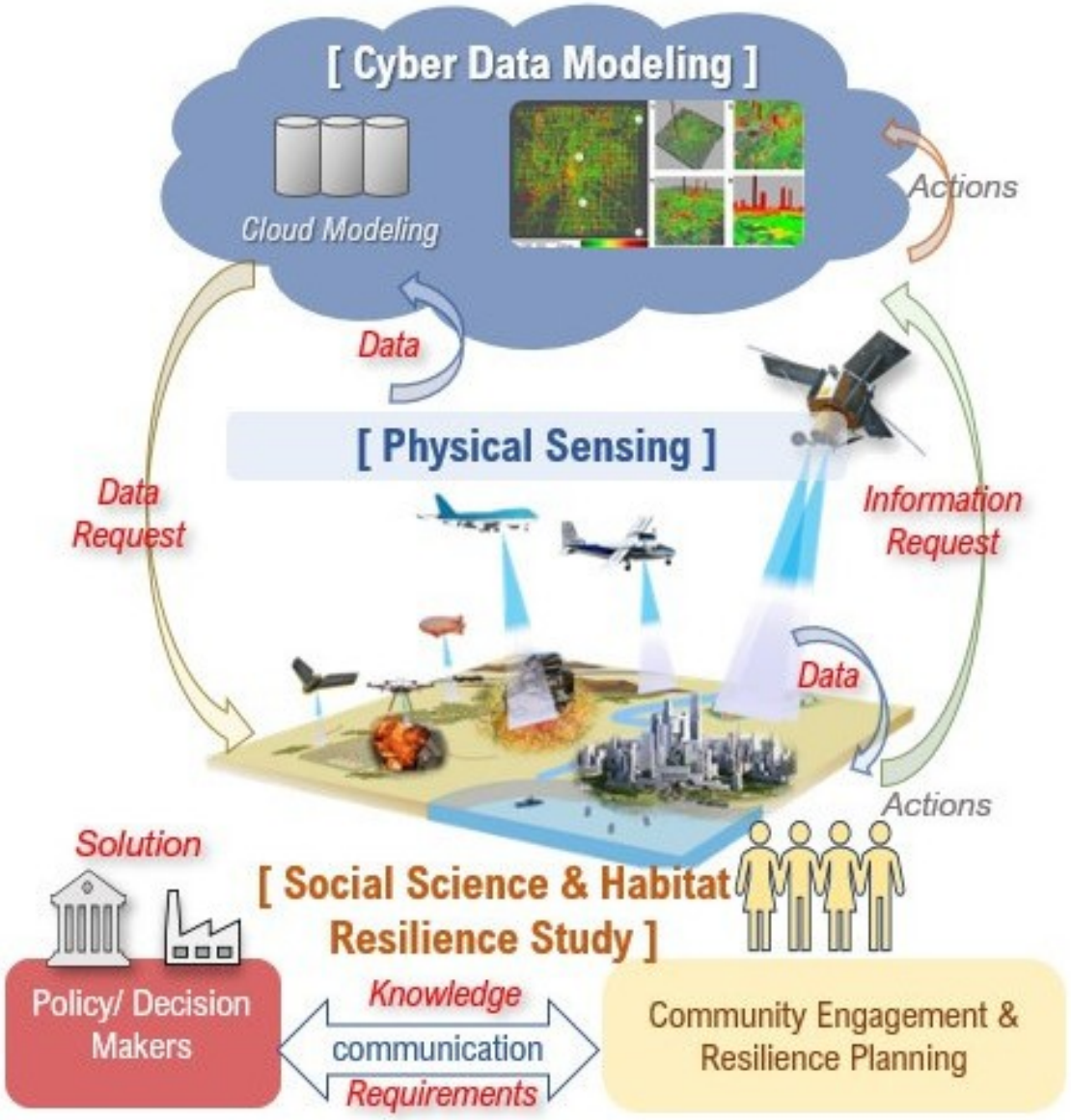
Duany, A., Sorlien, S., Wright, W., 2009. SmartCode Version 9.2. Ithaca: New Urban News Publications Inc.

Rethink Paradigms

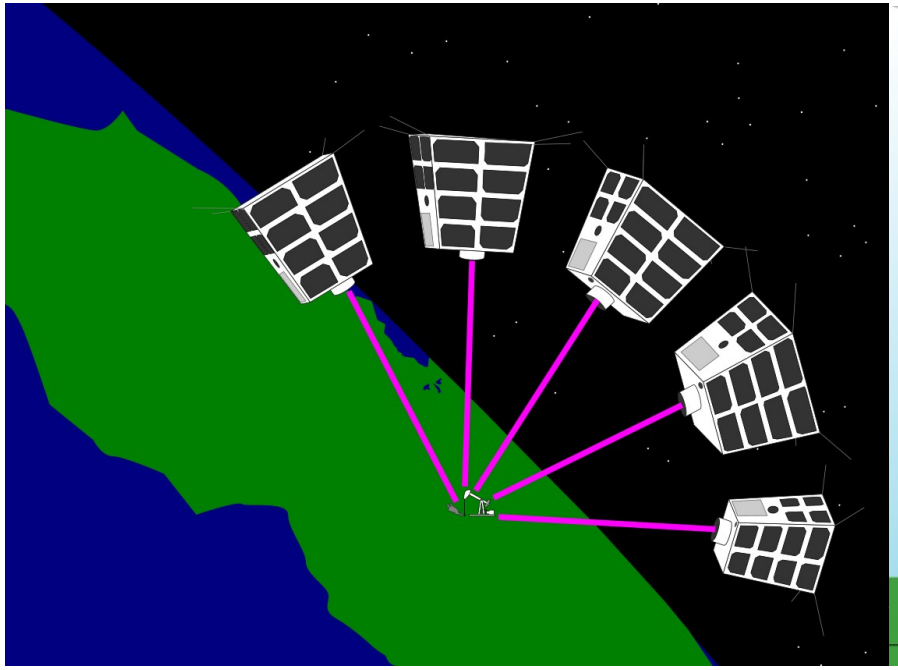


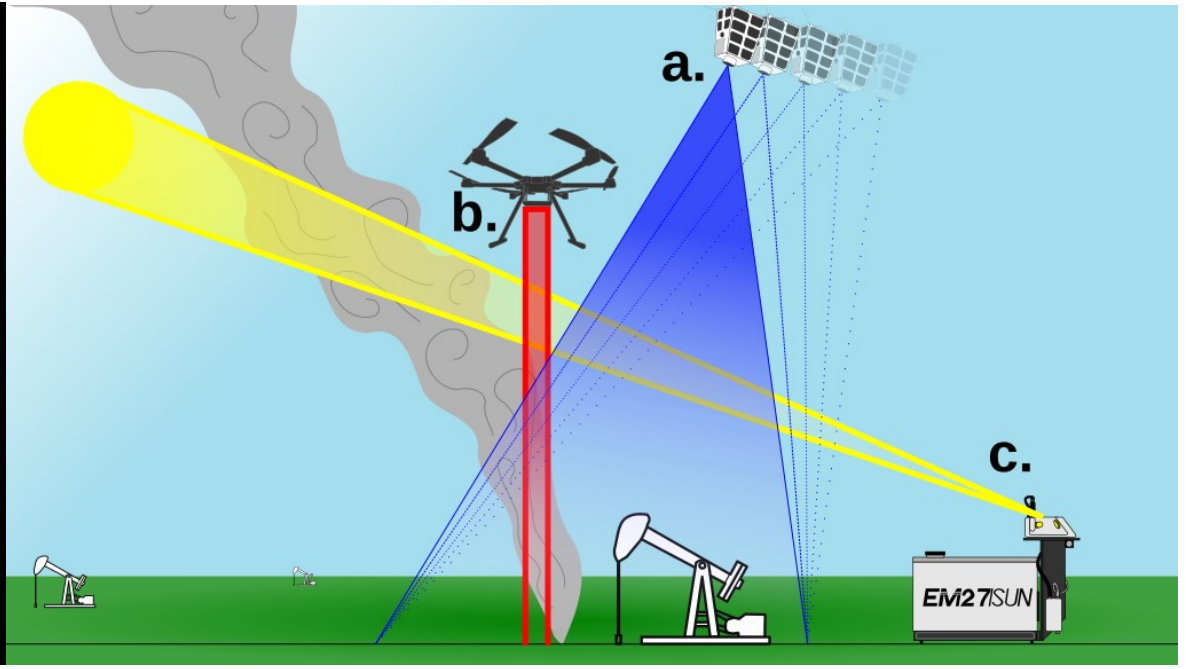
National Academies of Sciences, E., and Medicine, 2018. Improving Characterization of Anthropogenic Methane Emissions in the United States The National Academies Press, Washington, DC. https://doi.org/10.17226/24987

Rethink Paradigms



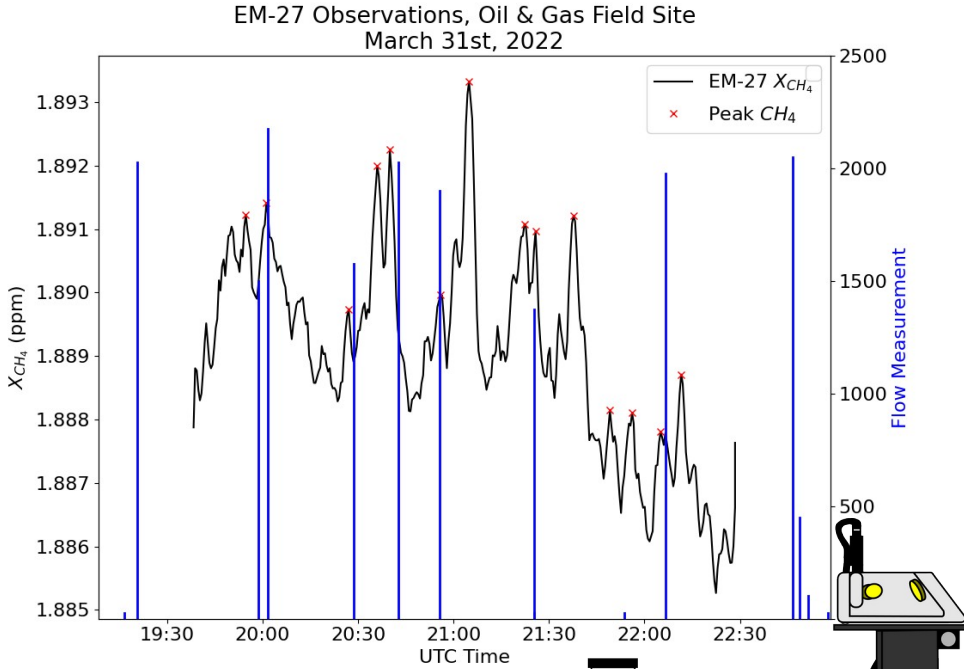
Rural: Oilfield CH_4 Cycles

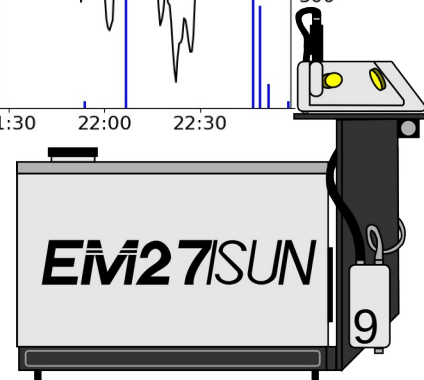




Rural: Oilfield CH_4 Cycles

Rural: Oilfield CH_4 Cycles





Rural-Urban: TRACER

U.S. DEPARTMENT OF ENERGY | Office of Science

ARM

The **Atmospheric Radiation Measurement (ARM)** user facility is a U.S. Department of Energy Office of Science user facility that provides a global infrastructure for obtaining real observations of the natural atmosphere—clouds, aerosols, precipitation, and energy. Heavily instrumented field observatories are located in Alaska and Oklahoma in the United States and on Graciosa Island in the Azores in the North Atlantic Ocean.

Continuous measurements from the fixed-location observatories are supplemented with measurements obtained by mobile and aerial platforms during shorter time frames at other locations. This coverage enables scientists to study regional and global atmospheric processes and improve the computer models that simulate them.

ARM Instrument Locations for TRACER Campaign

- **Main ARM instrument site** — *La Porte*
- **Precipitation radar** — *Pearland*
- **Secondary ARM instrument site** — *Guy*
- **Main tethered balloon site** — *Smith Point*

TRACKING AEROSOL CONVECTION INTERACTIONS EXPERIMENT (TRACER) FIELD CAMPAIGN

Studying Storm Clouds in the Greater Houston Area

Deep convective clouds, which often pack lightning and pour rain, are key features of the atmosphere. Despite their importance, convective clouds are difficult to represent in earth system models. Researchers need more information about the life cycle of these clouds, including the influence of aerosols (small particles in the air) and the environment.

A new field campaign—the **TRacking Aerosol Convection interactions ExpeRiment (TRACER)**—will take place in the Houston, Texas, area from October 2021 through September 2022. The Houston area is unique because it commonly experiences isolated convective systems and a spectrum of aerosol conditions.

During the entire TRACER campaign, ARM will collect atmospheric data with one of its mobile observatories in La Porte and a scanning precipitation radar in Pearland.

From June through September 2022, ARM will also operate a small instrumented site in Guy, which is less affected by urban emissions than the mobile facility site. Over this four-month period, ARM will host many guest experiments and interagency collaborations at the sites in La Porte, Pearland, and Guy. In addition, ARM is planning tethered balloon system flights at Guy and at Smith Point, and will be collecting other measurements throughout the greater Houston region from piloted aircraft, small remotely piloted aircraft, and mobile trucks and trailers during this period.

TRACER will provide convective cloud observations with high space and time resolution over a broad range of environmental and aerosol conditions. These observations will advance fundamental understanding of convective motions and microphysics and improve their representation in multiscale models. Atmospheric data obtained during TRACER will be made freely available to all scientists.

Key Collaborators: University of Houston, Texas Commission on Environmental Quality, National Science Foundation, NASA, NOAA National Weather Service's Houston/Galveston office, Baylor University, Texas A&M University, Texas Tech University, the U.S. Department of Energy's Atmospheric System Research program

ARM Mobile Facility at La Porte

Purpose. Scientists use the ARM Mobile Facility (AMF) to obtain atmospheric measurements from under-sampled but climatically important regions. The AMF provides a flexible instrument platform for conducting field experiments typically lasting from 6 to 12 months anywhere in the world. It comes with a baseline suite of about 50 instruments for measuring atmospheric components such as clouds, water vapor, aerosols, energy, and precipitation.

Operations. Several customized shipping containers provide space for trained staff, instruments, and computers. An experienced installation team prepares the site infrastructure and sets up the AMF shelters and instruments. Because deployments may be associated with experiments from other agencies, the AMF was designed to host guest instruments in addition to the baseline collection.

Three full-time technicians maintain the instruments, which operate 24 hours a day, seven days a week. In addition, local personnel trained by AMF staff launch weather balloons daily.

Data. Large amounts of data from AMF instruments are collected by computers, checked for quality, and then sent to a main storage archive. These data are freely available to scientists around the world to use in testing and improving regional and global earth system models.

Contacts

Rolanda Jundt,
ARM Public Information Officer
Pacific Northwest National Laboratory
rolanda.jundt@pnnl.gov

Heath Powers,
AMF Facility Manager
Los Alamos National Laboratory
hpowers@lanl.gov

Michael Jensen,
TRACER Principal Investigator
Brookhaven National Laboratory
mjensen@bnl.gov

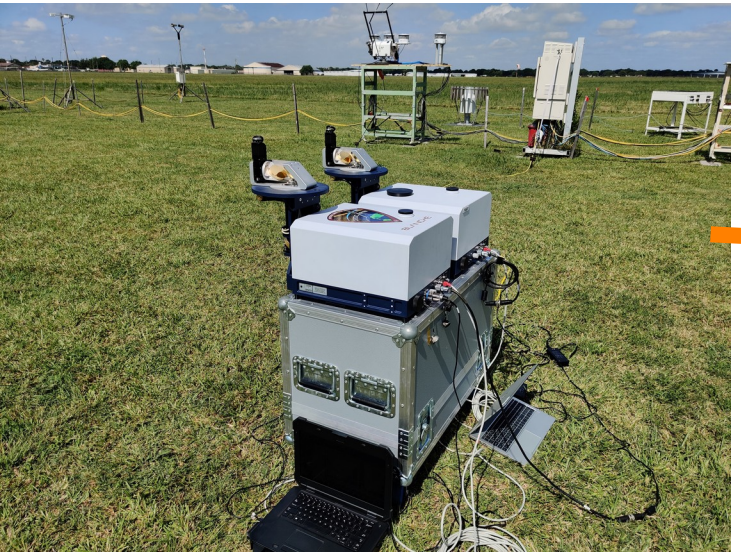
CONNECT WITH ARM

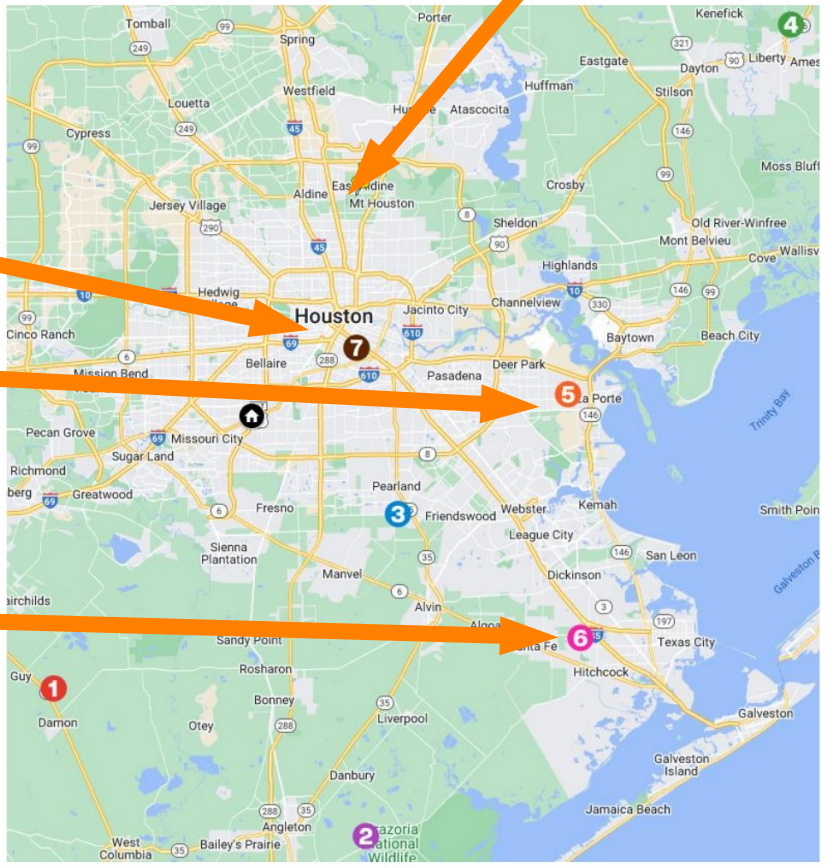
www.arm.gov

ARM TRACER Web Page

https://www.arm.gov/research/campaigns/amf2021tracer

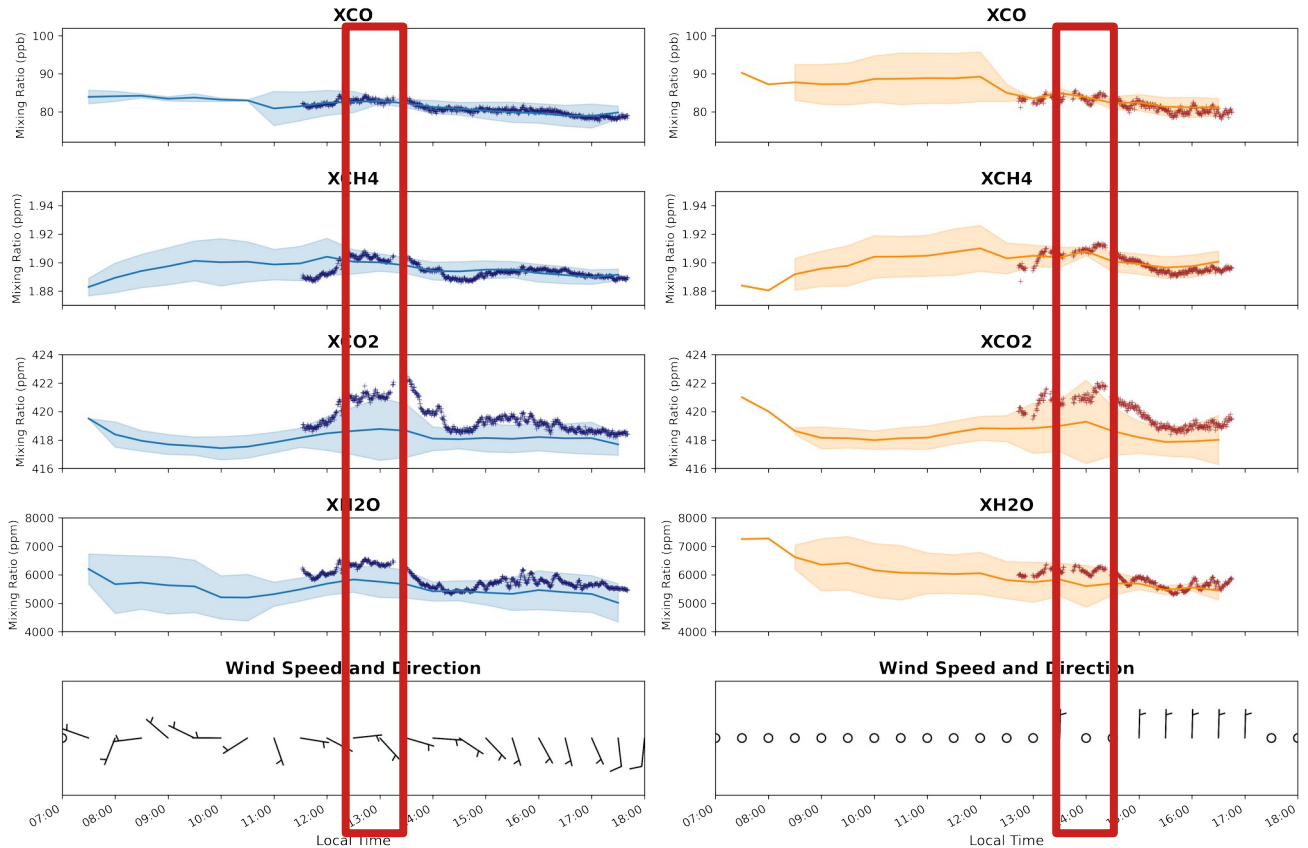
Rural-Urban: TRACER





Rural-Urban: TRACER

June 19 Observations and Daily Average Mixing Ratios at Urban (Orange) and Background (Blue) Sites in Houston, TX During June 16-25, 2022



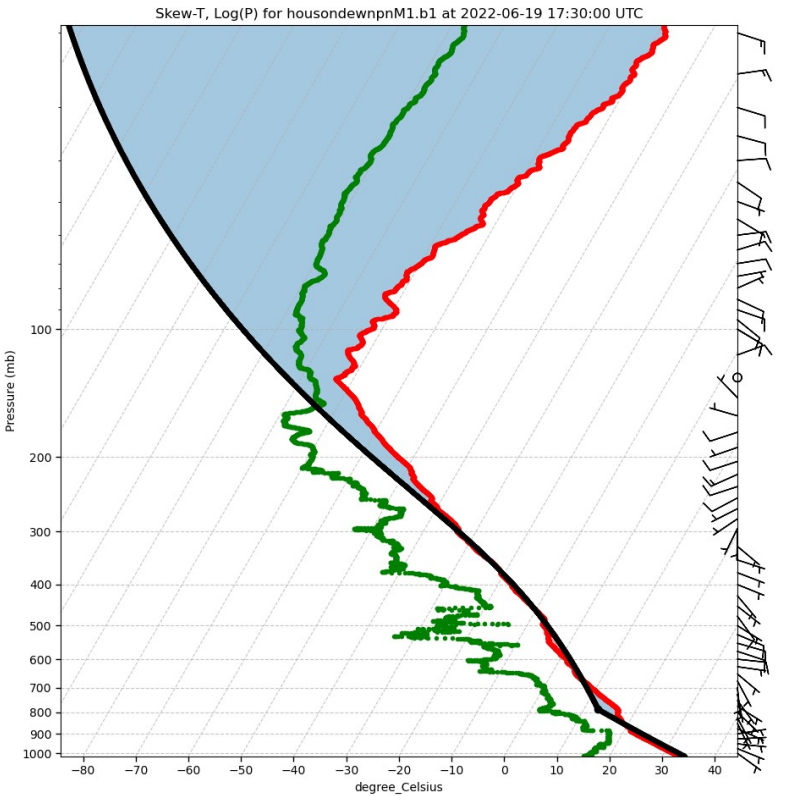
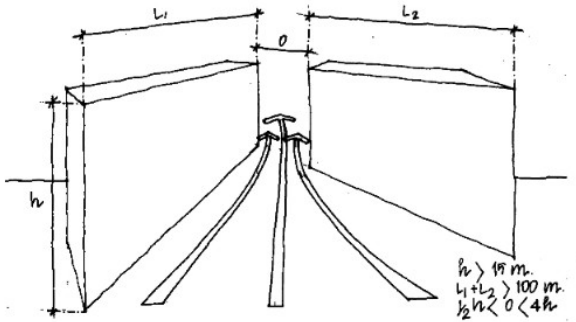
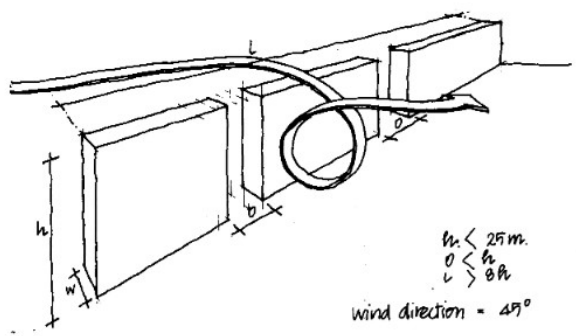


Image provided by ARM Data Quality Office 2022-06-20 07:47:31

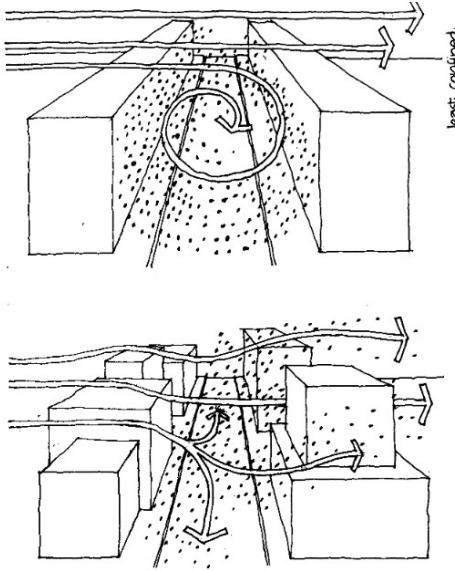
Urban: Gas in Urban Canyons



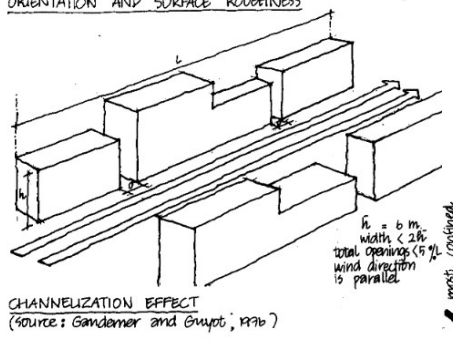
VENTURI EFFECT
(Source: Gandemer and Guyot, 1976)



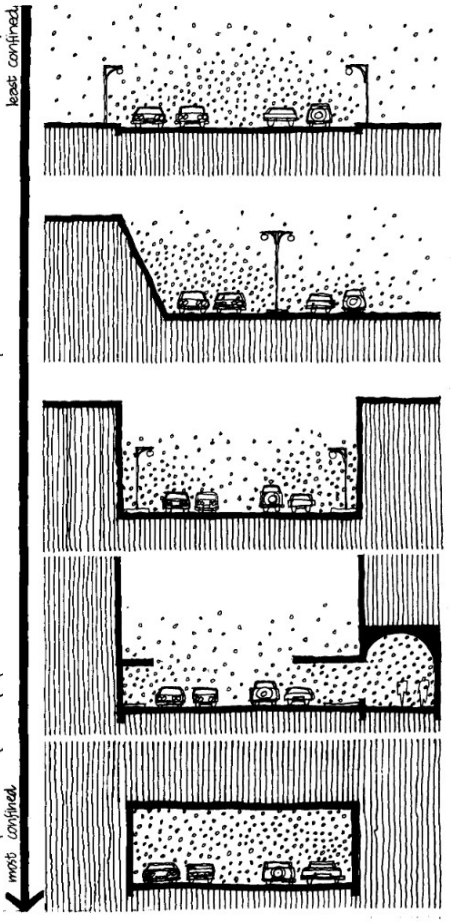
BAR EFFECT
(Source: Gandemer and Guyot, 1976)



VARIABLES INFLUENCING AIR CIRCULATION:
ORIENTATION AND SURFACE ROUGHNESS



CHANNELIZATION EFFECT
(Source: Gandemer and Guyot, 1976)

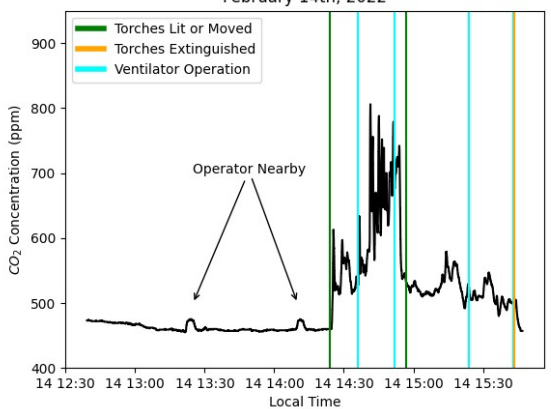


Spirn, A.W., 1986. Air Quality at Street-Level: Strategies for Urban Design. Boston Redevelopment Authority, Boston, MA.

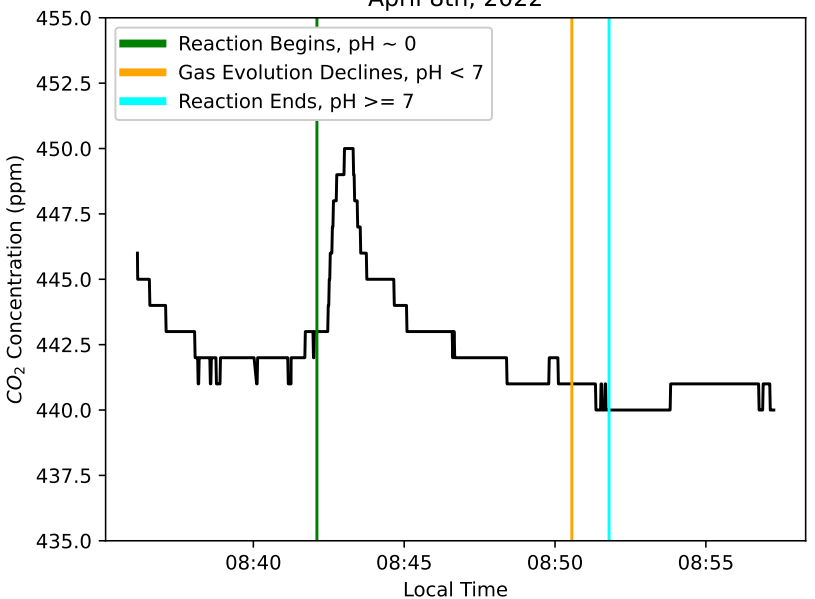
Urban: Gas in Urban Canyons

Urban: Gas in Urban Canyons

CONEX Tiki Torches, inside canyon
February 14th, 2022



CONEX Chemical CO_2 Generator, south of canyon
April 8th, 2022



Urban: Gas in Urban Canyons

Experiment 0 & 1 Reaction

$C_{10}H_{18}O + 14O_2 \rightarrow 10CO_2 + 9H_20$

1.103 moles burned

10 * 1.103 - 11.03 moles
= < 485.32g of CO_2
*assuming ideal combustion, over 10 mins

Experiment 2 Reaction

$NaHCO_3 + HCl \rightarrow NaCl + CO_2 + H_2O$

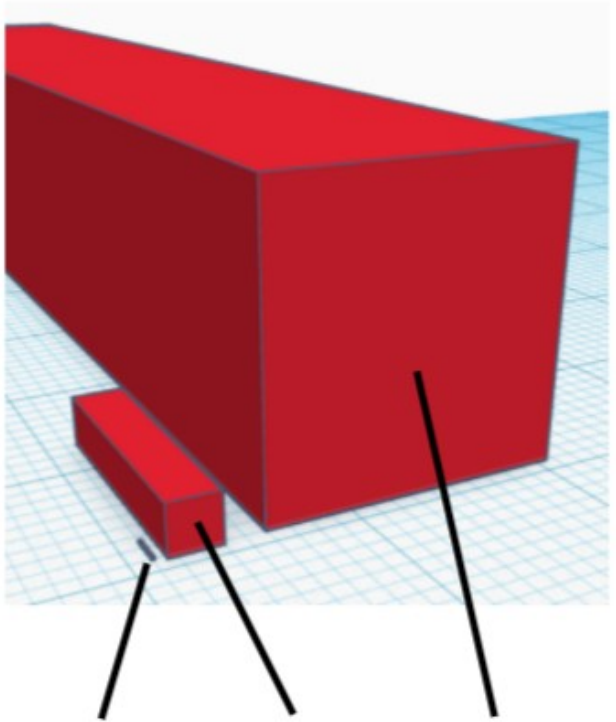
37.8 moles of reactant
31.8 moles of reagent (limiting)

31.8 moles
= 1399.518g of CO_2
*over 10 mins

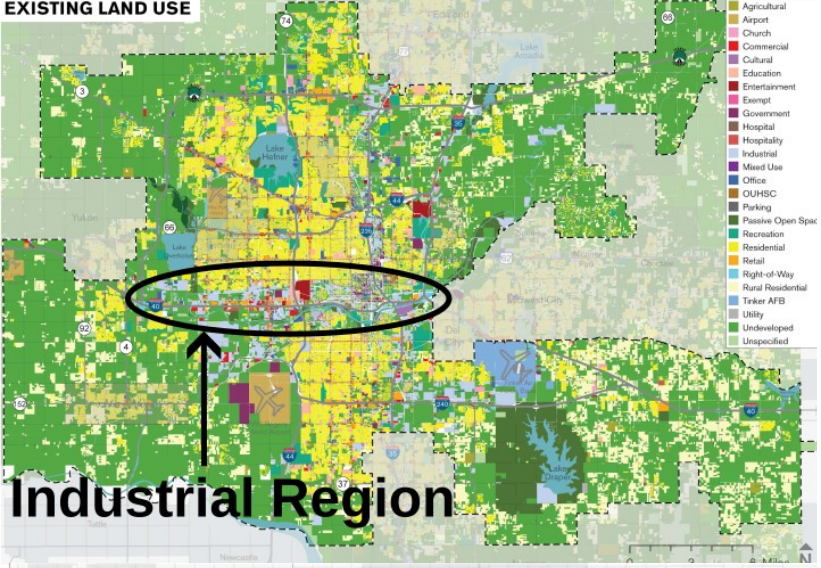
Reaction Scaling

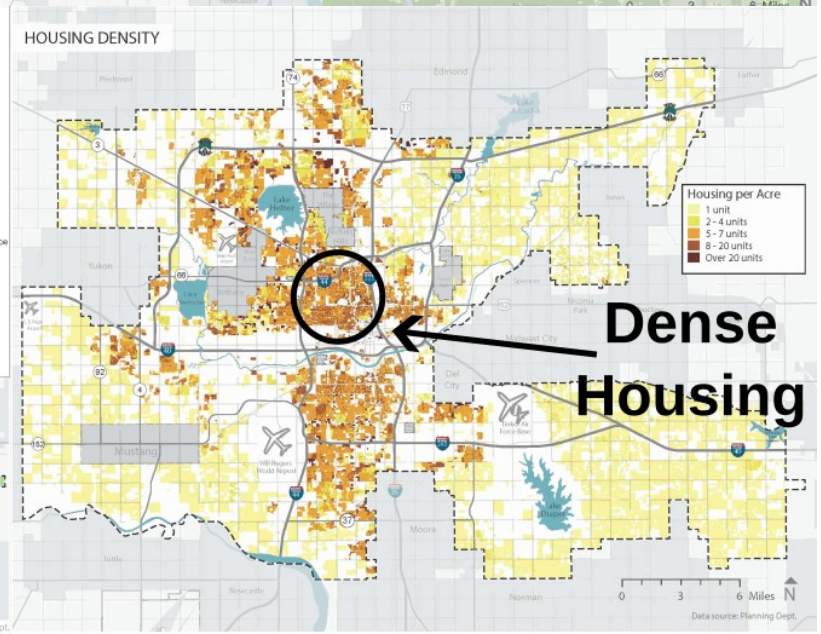
Wind Tunnel Canyon Volume (C) (1.5*0.057*0.06)
= 0.00513m^3 (**0.102g** of CO_2)
CONEX Canyon Volume (12.2*2.4*2.4)
= 70.272 m^3 (**1399.518g** of CO_2)
Approx. Urban Canyon Volume (C) (80.4*14.6*14.6)
= 17139.6m^3 (**341342.44g** of CO_2)

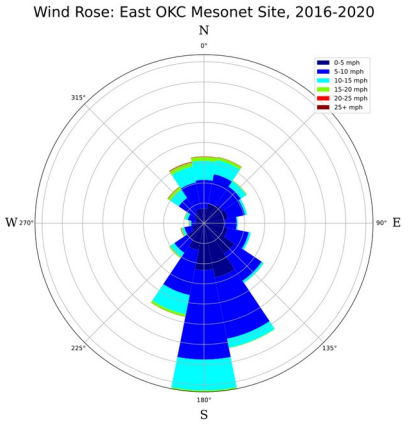
Experiment Scaling Visualization



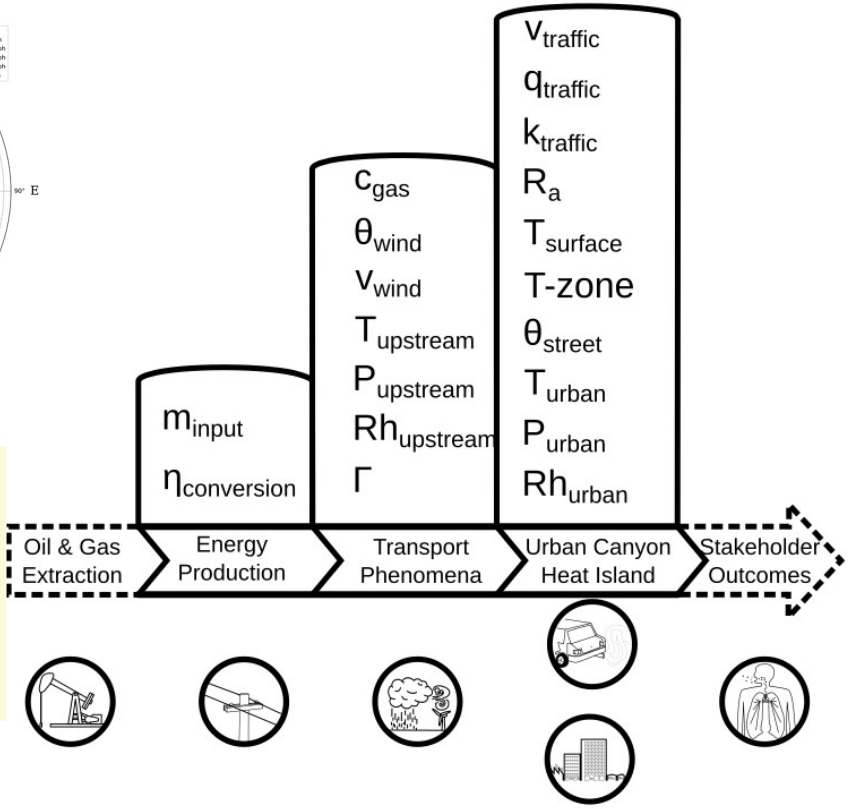
Wind Tunnel, CONEX, Urban Canyon







Environmental Justice: How is a social problem of local weather uncertainty a mapped as a pollution system?

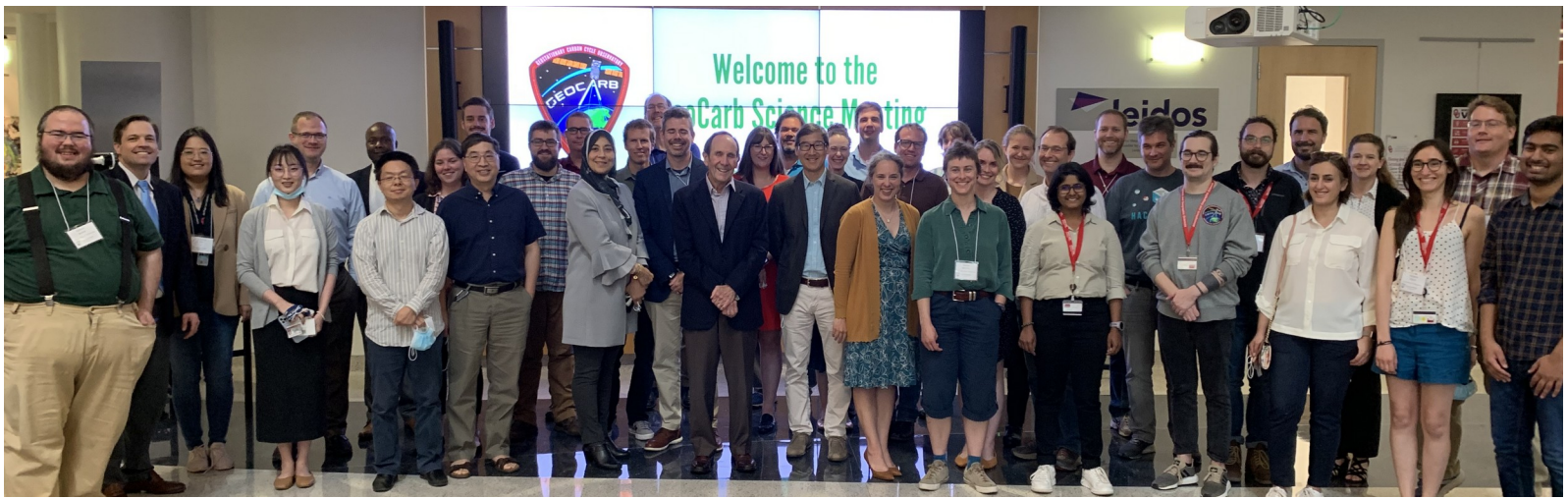


Basara, J.B., Hall Jr., P.K., Schroeder, A.J., Illston, B.G., Nemunaitis, K.L., 2008. Diurnal cycle of the Oklahoma City urban heat island. Journal of Geophysical Research: Atmospheres 113. https://doi.org/10.1029/2008JD010311

The City of Oklahoma City, 2019. Resolution of Intent of the Mayor and Council of the City of Oklahoma City Setting Forth a New MAPS Program to be Known as "MAPS"

Tierney, S., Petty, C., 2015. Gentrification in the American heartland? Evidence from Oklahoma City. Urban Geography 36, 439-456. https://doi.org/10.1080/02723638.2014.977038

honeycutt@ou.edu



CHRISTOPHER C. GIBBS COLLEGE OF ARCHITECTURE
The UNIVERSITY of OKLAHOMA

X-GEM Community Sustainability Emission Monitoring

The UNIVERSITY of OKLAHOMA
The SYSTEMS REALIZATION LABORATORY @ OU