27 SEPTEMBER 2023

SETx-UIFL: Equitable solutions for communities caught between floods and air pollution

Collaborating institutions and PIs:

University of Texas at Austin (Paola Passalacqua), Lamar University (Liv Haselbach), Texas A&M University (Michelle Meyer), Prairie View A&M University (Noel Estwick), Oak Ridge National Laboratory (Ethan Coon)

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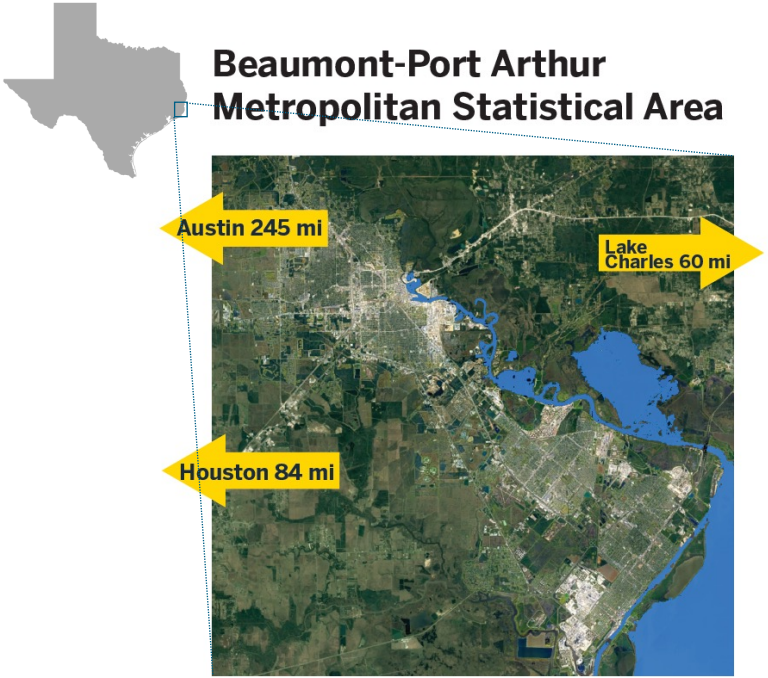
Southeast Texas: acute on chronic hazards on vulnerable communities



- Frequent acute (e.g. compound flooding) on chronic (e.g. toxic air pollution) hazards, expected to worsen with climate change, aging infrastructure, etc.
- Continuous urban expansion and increased impervious cover over past several decades
- Home to one of the largest petrochemical industrial complexes
- Ranks in the top 10% of most polluted US communities
- Represents urban conditions along the Gulf Coast – experiencing population and industrial transitions but in inequitable ways and with less resources available than larger cities
- A quarter of families and 40% of children in poverty
- SETx-UIFL builds on existing work, including major expansion of the flood sensing and air sensing networks

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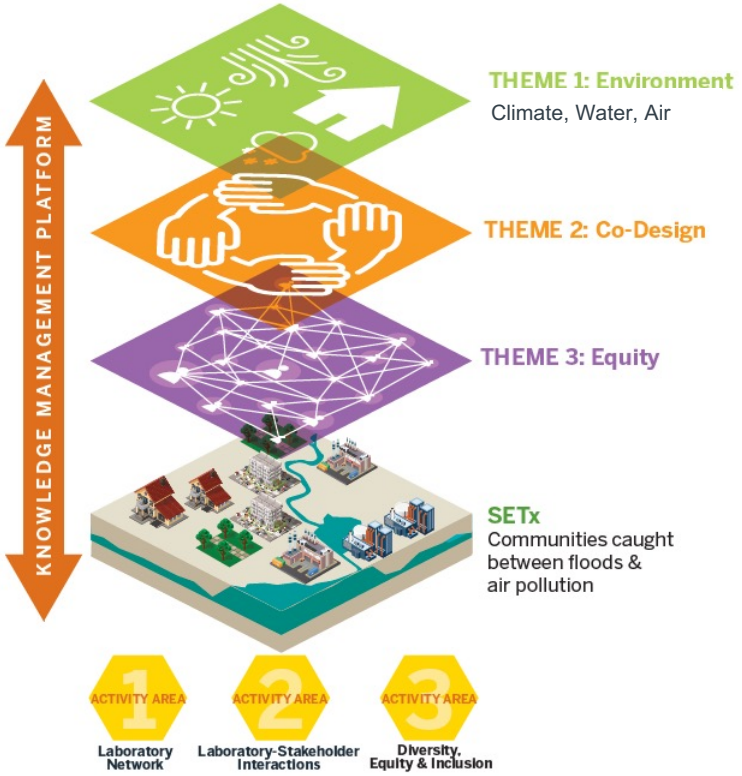
Providing better data, modeling, & planning to support climate adaptation in SETx and the Gulf Region

- Which processes and variables need to be captured in regional scale hydrological and atmospheric models so that they are representative of the conditions experienced by local communities and help inform adaptation strategies?
- How can we understand the linkages between and within natural, built, and social systems in urbanized regions to better support natural and human resilience?



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We collaborate with a group of more than 100 stakeholders

Goal: Co-develop data and decision making frameworks with stakeholders to aid community-led development of equitable climate change adaptation strategies

Approach to engagement: engage in two-way relationships between decision makers/residents and researchers to ensure stakeholder knowledge is incorporated into modeling and scenarios development and that data from SETx-UIFL research are useful for and incorporated into community-led climate adaptation decision making

- SETx-FCS (Flood Coordination Study): led by Liv Haselbach (Lamar University PI) includes SETx counties, cities, river authorities, drainage districts, industries, federal agencies
  URL: https://www.setxfloodcoordstudy.org/members.html
- Resident groups working with Texas Target Communities and community-level stakeholders and community leaders experienced in the challenges faced by marginalized populations
- Lamar University is in Beaumont; Prairie View A&M is a 1890s land grant (HBCU)

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RFA1: Land use & meteorological conditions contributions to hazards (W1, W2, A1)

- What characteristics of meteorological conditions contribute most to flooding, air toxicity & their compounding effects & must be represented in high-res climate projection data?

RFA2: Observations, pollutants, & effects of wetland restoration on the ecosystem (W3, W4, W5, A2, A3, A4)

- How can an enhanced flood & air pollution sensing network inform the public & decision-makers during acute events & provide data for future mitigation strategies?

- What is the source apportionment of gas-phase pollutants that vulnerable communities are exposed to indoors and outdoors?

- What is the chemical composition of air & water in zones most vulnerable to hazards & how does it change under current and future meteorological conditions?

RFA3: Co-design & planning processes to support equitable interventions (W6, W7, A5, C1, C2, C3, C4, C5, C6, E1, E2, E3)

- What are the planning processes & tools to support the implementation of equitable interventions?
- How can a co-designed process & outputs help communities anticipate & prevent unintended consequences of acute & chronic events?
- How can place-based social vulnerability & climate equity measurements contribute to resilience planning processes such as co-design?

- What co-designed portfolios of traditional infrastructure strategies & nature-based strategies will reduce flooding & mitigate air pollution?

- How can climate adaptation portfolios be co-designed so that marginalized communities experience equitable benefits?
- Do individual problems shift to shared understanding through co-design?
- How are predicted impacts of climate change & proposed strategies distributed across groups?

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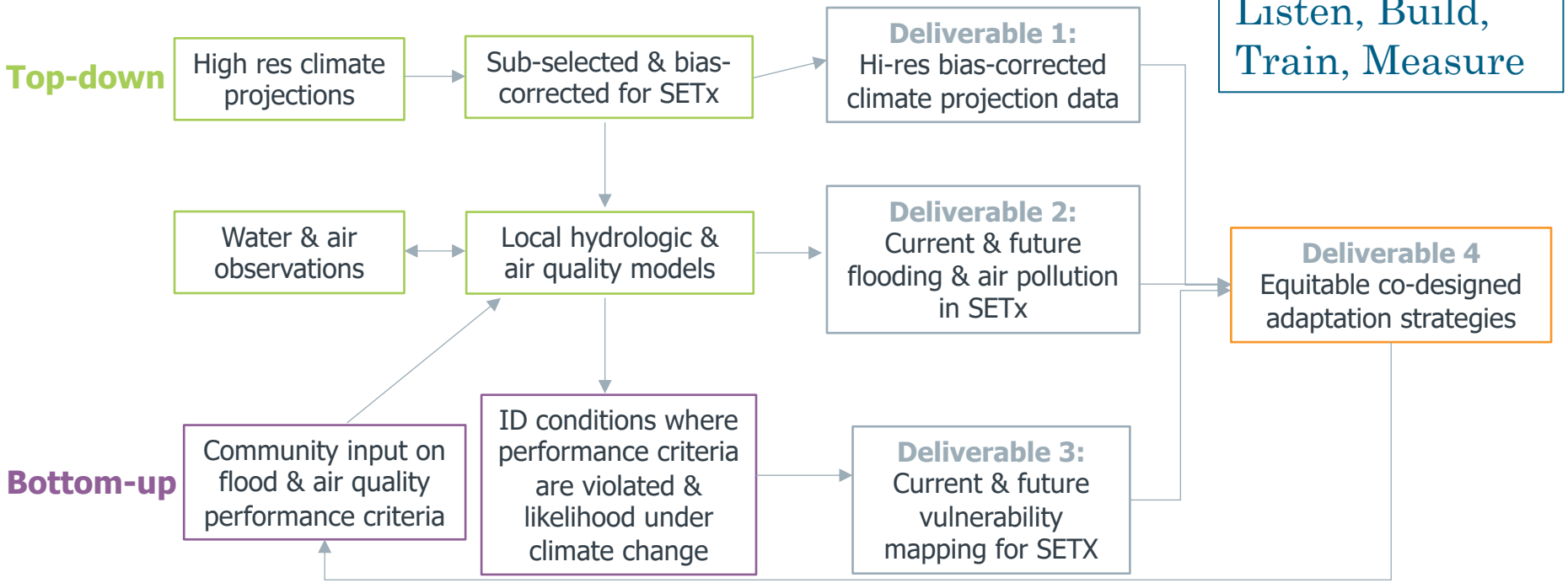
Environment | Equity | Co-design

Vulnerability and adaptation in SETx

Year 1:
Listen, Build, Train, Measure



SETx URBAN IFL

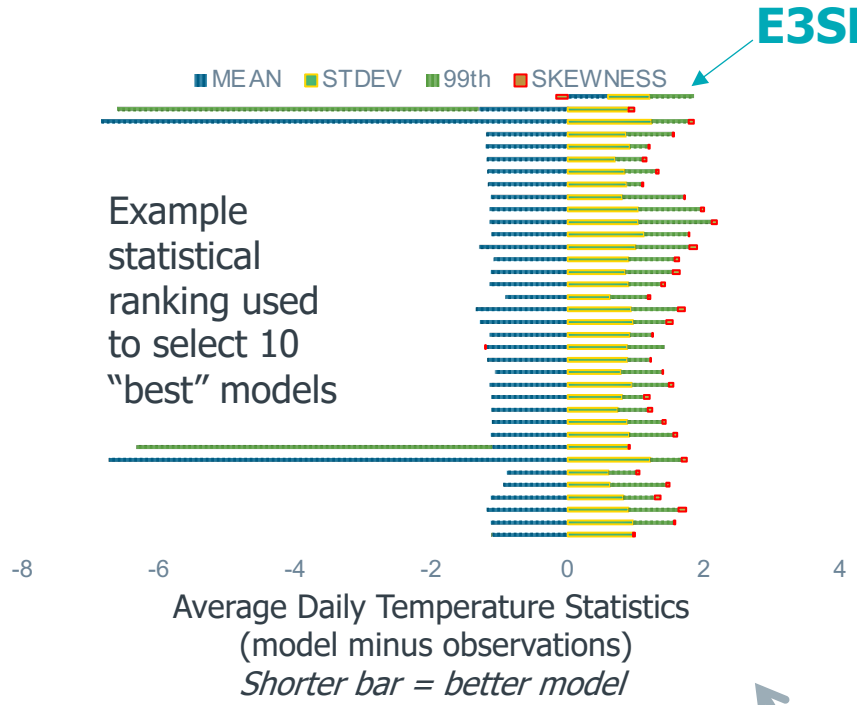
Environment | Equity | Co-design

Y1: Establishing a locally-tailored climate dataset for downscaling to high res

First filter (35→30 GCMS): Regional Climate Basic Statistics over Southern US
*Is the model reasonable with the **big picture**?*

Second filter (30→20 GCMS): Regional Climate Pattern over Southern US
*Does the model capture the dominant weather patterns that are **important for air quality** over SETx?*

Final filter (20→10 GCMS): Regional Climate and Flooding Control Indices over SETx
*Does the model capture basic climate statistics over SETX that are most important for driving **high frequency and extreme flood events**?*



Metrics defined with input from across SETx-UIFL allow **locally-specific ranking and sub-selection of climate data**

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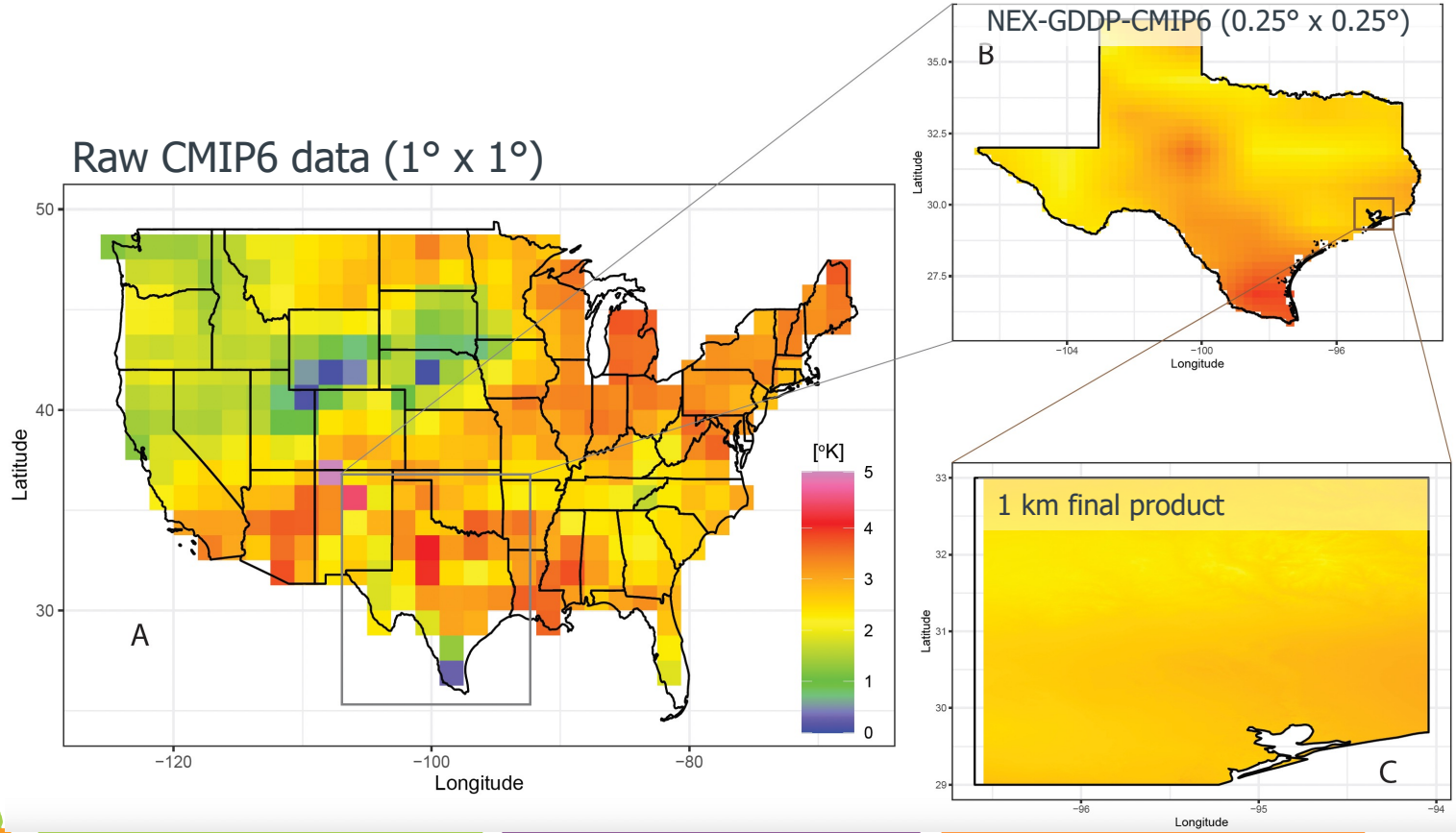
Y1: Developing & testing algorithms for statistical downscaling of selected climate projection data

First Look:
Summertime average temperatures in 2050 (SSP 8-5.8) compared to 2020 as produced by our statistical downscaling algorithm



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Y1: Improving Real-time Flood Monitoring by expanding sensor network

- Extending an existing Flood Coordination Study network: 73 (current) + 20 (future) systems
- Low-cost sensors track water depth and are often collocated with other sensors (rain gages, water temperature/quality)
- Augments existing USGS standard gage network with longer-term observations at a few sites
- Transfer data to project collaborators, local, state, federal agencies and integrate data into regional flood model databases

5 of 9 new sensors installed so far:

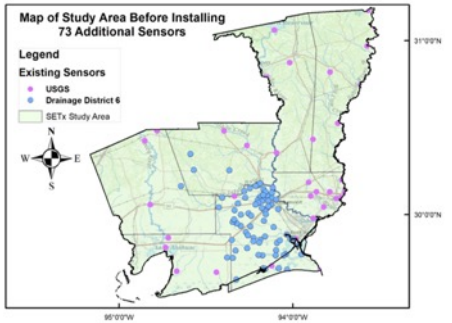
Collected input from:

- Local stakeholders (Drainage Districts, NOAA, municipalities, industry)
- Social vulnerability indices (input from equity team)
- Project needs (more data for storm surge events)

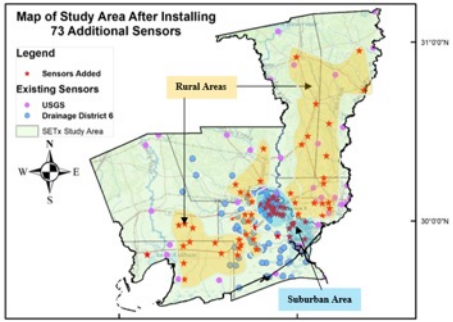
Selected sites (broad area) for 9 sensors this year

Challenges due to dangerously high heat in Texas, but on target to install all 9 sensors this season.

Drainage Outfalls



Bridge Crossings



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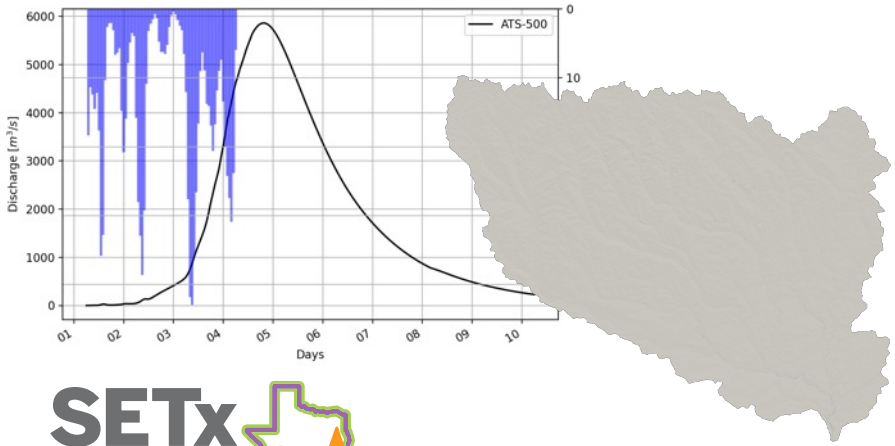
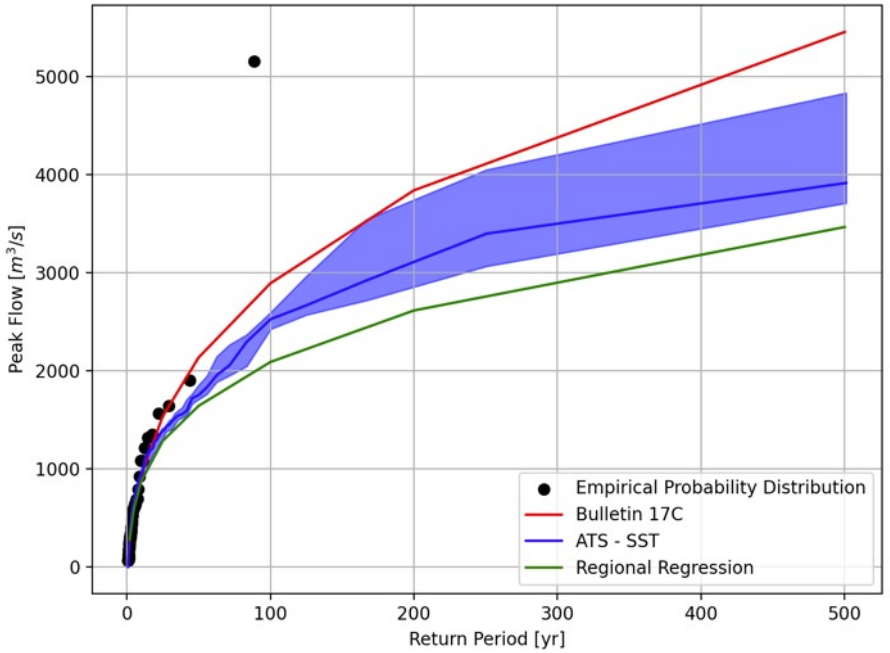
Y1: Producing robust flood predictions under future climate for SETx

Developed a new strategy for physically modeled flood frequency analysis

- Probabilistic methodology (e.g. ”100 year storm”)
- Traditionally done by performing flood frequency analysis from the historical record at gaging stations
- New method uses a non-calibrated model, enabling scenario-driven predictions based on climate change, land use change, and infrastructure





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Y1: Collecting air quality observations for capturing chemical exposure risks

Example source markers detected by the Vocus sniffer
Benzene, Styrene, Acetonitrile, Dimethyl Sulfide

Paper Mill

Evadale

Elastomer Plant

←Houston

Beaumont

I-10

Port Neches

Port Arthur

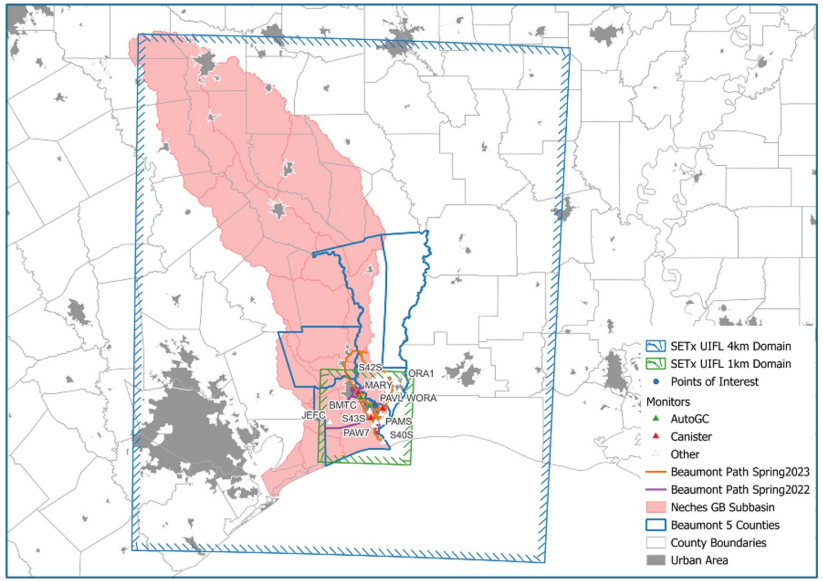
Tire Plant

Refineries

Y1: Modeling air toxics and criteria pollutant modeling with the Comprehensive Air quality Model with extensions (CAMx)

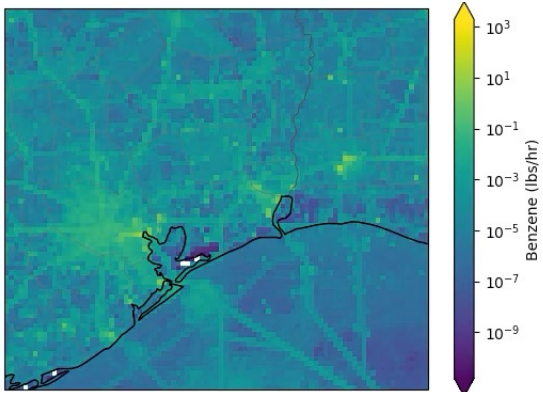
Objectives:

- Characterize spatial and temporal patterns of air toxics and criteria pollutants and precursors
- Evaluate emission source contributions
- Compare predictions with stationary and mobile measurements
- Support assessments of community exposure outdoors and indoors and cross-theme data integration and decisions

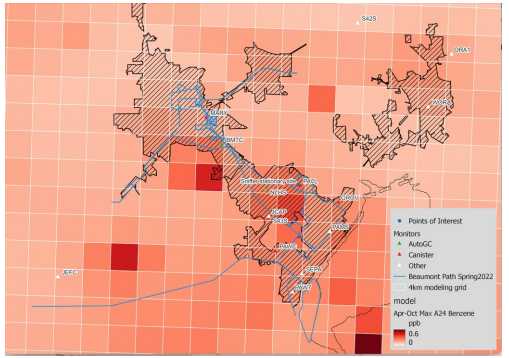


CAMx is a 3-D photochemical model that simulates the emissions, transport, chemistry, and physical removal of atmospheric pollutants

Benzene Emissions (Emission Inventory)



Predicted Benzene Concentrations



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Y1: Developing connections with participants and document understanding of values that relate to climate adaptation and strategy portfolio development

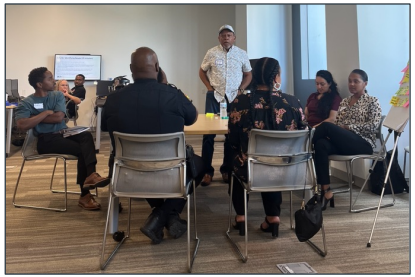
Formed Task Forces (Technical Task Force & Community Organization Task Force):

- Revised community engagement strategy that is sensitive to community context
- Developed recruitment materials; recruited members
- 3.21.23: initial meeting with members of Technical Task Force (TTF) in Beaumont; panel about sustainable stormwater solutions at Flood Coordination Study meeting
- 6.5.23: initial meeting of Community Organization Task Force (COTF) (virtual)
- 9.6.23 Joint Task Force (both TTF & COTF) meeting @ Lamar University

Task Force members interactions, interviews & survey:

- Developed and implemented Part 1 of the community-engaged research training module
- Interview/qualitative methods training module for graduate research assistants (April)
- Developed interview questions: incorporated feedback from broader team; conducted pilot interviews (finalized in July)
- IRB approved (Aug.)
- Distributed survey virtually & in-person at September Task Force meeting; focused on values, problem definition, and strategy identification (Sept.)
- Task Force meeting: workshop sessions (Sept.)

List of initial Task Force members & organizations;
Photos from 9.6.23 Joint Task Force meeting



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Y1: Provide input from task force on scenarios/performance criteria & develop observations of gray/green stormwater infrastructure impacts under local conditions

Products:

- Existing plan/policy inventory Green-Grey strategy catalog
- Green infrastructure & benefits /values article (in development)
- Co-design literature review article (in development)
- "Scenario Generation for Disaster-Resilient Infrastructure in the Built Environment: a Scan-to-BIM-to-Digital Twin (S-BIM-DT) Workflow" article (submitted)
- Model Integration Workshop via Halbouty Pump Station & Vicinity Case (in development)

Clockwise from upper left: Halbouty aerial and elevation map; map of GIS demos; sensor installation; pervious concrete installation; aerial of Montrose Park site

- In conjunction with EPA grant 02D19522: installed two new GSI test beds at Montrose Park and Lamar University (LU)
- Performed pre-installation soil infiltration tests & pervious concrete surface infiltration tests at two sites
- Installed rain gauge w/ water level sensor inside underground aggregate bed at one site, providing real-time data on rain and water level

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Y1: Creating integrated environmental, health & social vulnerability data for equity metrics

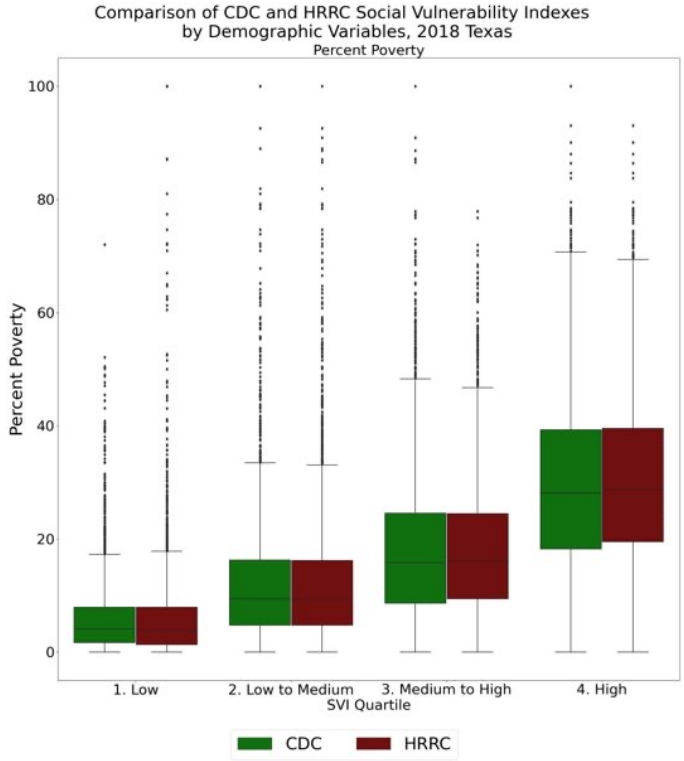
Social Vulnerability (SV): "the characteristics of a person or group and their [social] situation that influence their capacity to anticipate, cope with, resist and recover from the impact of a natural hazard" (Wisner et al., 2004).

Common characteristics measured: Economic, Demographics, Household composition, Housing characteristics, Transportation access

Challenges:

- Many indices exist at different spatial and temporal scales
- Indices use different formulas for setting composite score
- Sensitivity analysis and uncertainty quantification needed to map areas within community where community engagement will help improve model development.

We have undertaken uncertainty and sensitivity analysis for three indices: CDC, HRRC at TAMU, and Bixler at UT.



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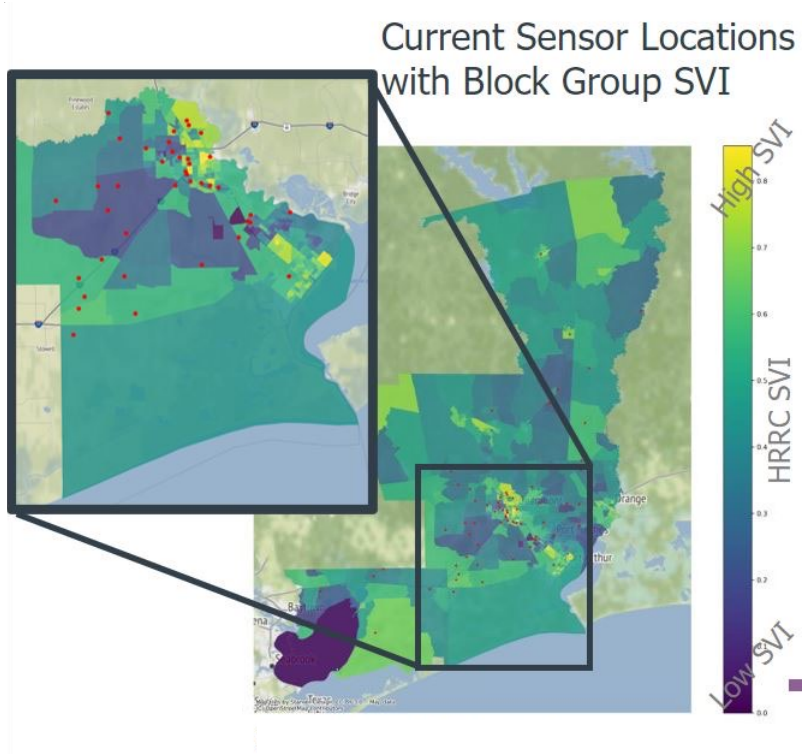
Y1: Water Sensor Placement and Social Vulnerability in Collaboration with Water



- Higher SVI means more marginalized populations
- 75% of sensors, but only 60% of population, are in tracts with an SVI less than the 55th percentile (i.e., areas of less social vulnerability)
- Lower SV locations are slightly overrepresented in sensor location. This is especially true for socio-economic status and minority/language indicators

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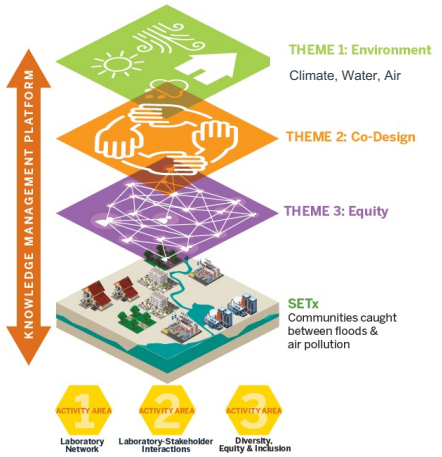
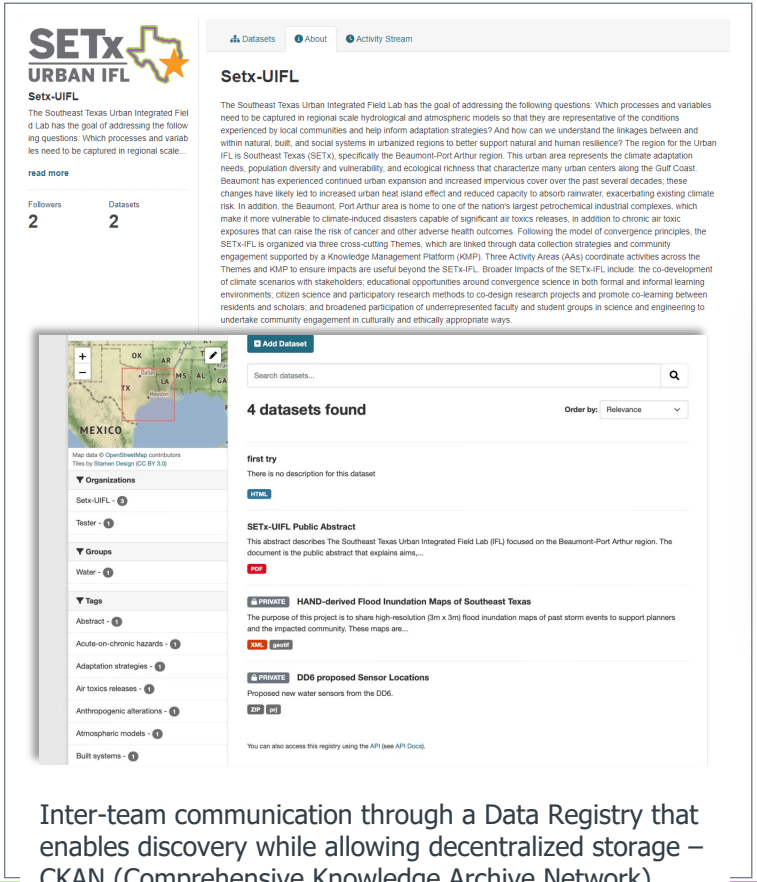
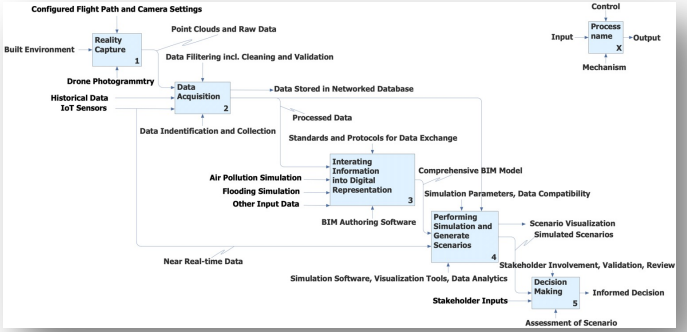
Y1: KMP - Supporting Data Collection, Integration, and Inter-team Collaboration







Inter-team communication through a Data Registry that enables discovery while allowing decentralized storage – CKAN (Comprehensive Knowledge Archive Network)

KMP provides a workflow that streamlines the integration of Water and Air data and facilitates visualization through web-based applications. Co-Design will leverage this integration and visualization to support community-led development of adaptation strategies.

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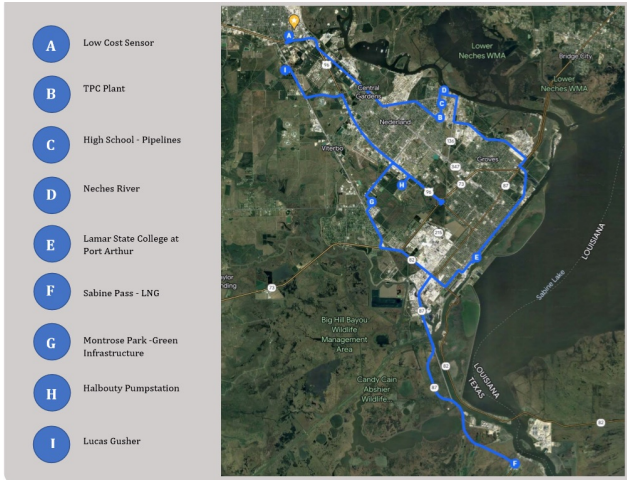
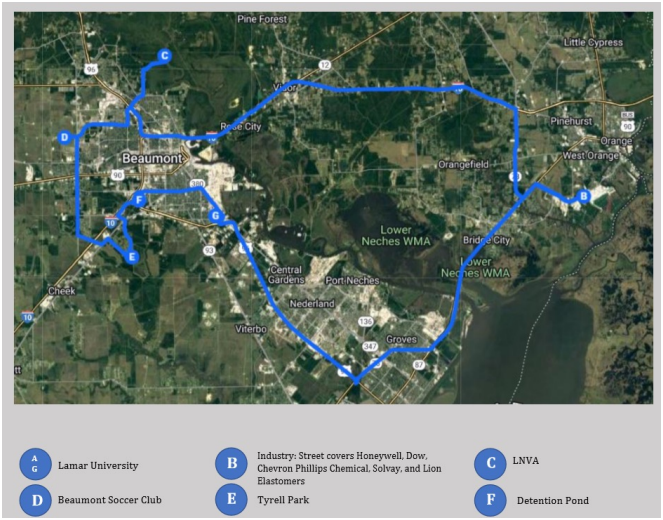
Y1: AA December 2022 Kickoff Bus & Boat Rides, field work and site visits organization

Photos from Team field visit December 2022



LNVA Saltwater Barrier



Additional activities:

- Supported team's field campaigns
- EPA Visit
- Task force meetings
- SETx Flood Coordination Study Monthly Meetings

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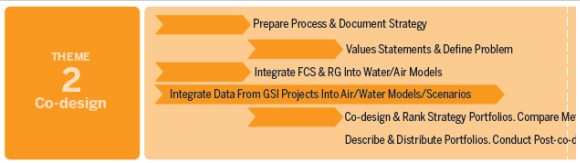
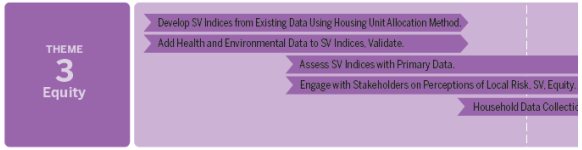
SETx-UIFL Y2 Plans

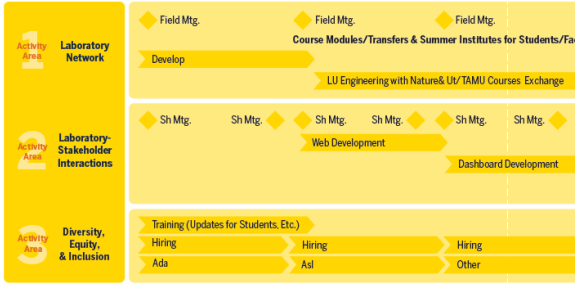
- **Hi-res climate projection dataset** complete and shared with community
- **Add** 9 more new **sensors** + **scaling up modeling**
- **Integrating** ELM wetland modeling, flood inundation mapping, and hydrologic models
- **Develop infrastructure models and scenarios** informed by community priorities and observations
- **Air quality campaigns** planned for October, November and January – survey tracks around major sources and focused tracks in studied receptor areas + data analysis + **indoor** air quality campaigns
- **Develop compilation** of CAMx predictions for **selected air toxics** across SETx + **Characterize emissions source** contributions at receptor sites and compare to data



- **Document shared understanding** of participants' values
- **Provide input from Task Forces** to other teams
- **Translate values/visions/problem** definition data **into potential strategies** while continuing co-design work with two Task Forces
- **Continue observations** about impacts of **gray/green stormwater infrastructure under local urban conditions** from four Lamar University-led green stormwater infrastructure (GSI) demonstration projects
- **Quarterly meetings** with Task Forces
- **Materials for community audience**



- **Develop Social Vulnerability Indicators** using household allocation method
- **Incorporate health data** in SVIs
- **Conduct interviews** to assess validity of Social Vulnerability Indicators in collaboration with Co-design Theme



- **Second 3-day annual meeting** in Beaumont
- **Unique course set-up** for Spring 2024 with flexibility for different departmental-faculty-research requirements of each participating institution
- **Summer institute** in 2024 for the students
- **Continue** to facilitate **site and community visits** for all themes

Year 2:
Listen, Measure, Model, Analyze, Identify

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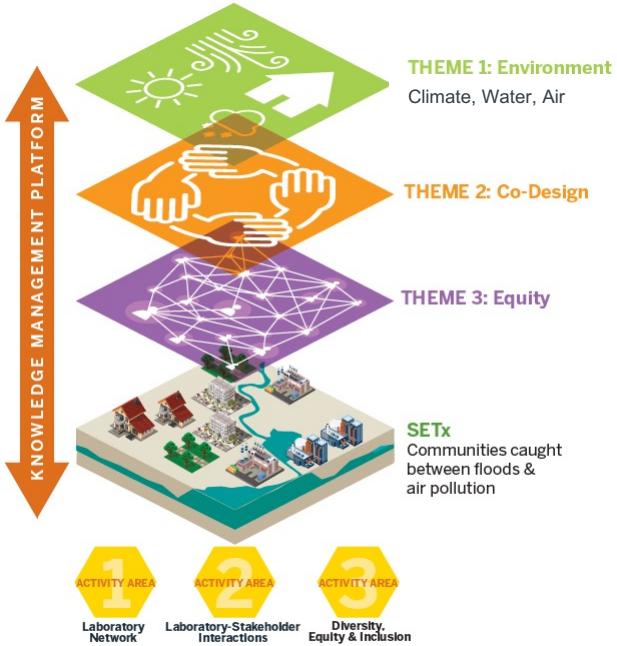
Thoughts, ideas, & questions for collaboration across UIFLs



- What downscaled climate projection datasets are other UIFLs using?
- What information-sharing can we be doing on best practices and pitfalls in applying these data in an urban setting, particularly with respect to changing extremes?
- How universal are the performance criteria we identify across urban stakeholders?
- Can our findings be generalized alongside similar efforts at other UIFLs to provide comprehensive recommendations on how climate projection data can be made more useful for urban applications?
- How are others approaching physical modeling from regional to local scale?
- What type of cyberinfrastructure are other labs creating?
- What strategies are UIFLs employing for co-design?
- Hold quarterly (or biannual) check-in between similar teams (e.g., flooding, air pollution, social science) to exchange lessons learned, troubleshoot, build connections perhaps through the MultiSector Dynamics Community of Practice (Urban Systems)?
- Develop a plan for joint academic articles on integrating social science and equity/justice work into climate and biophysical modeling and observation collection?

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Overview of SETx-UIFL posters presented at this meeting

Climate: A Targeted, End-Use Informed Approach to Statistical Downscaling of Climate Projections for the Southeast Texas Region

Protocol developed to produce high-resolution, locally relevant climate projections needed for urban climate planning over SETx and results.

Climate: A Multi-Source Approach to Flood-Relevant Precipitation Projections over Southeast Texas

Three different approaches to assessing flood-relevant climate changes in precipitation statistics – a multi-source strategy needed to capture the coastal, fluvial, and pluvial sources of flood risk over Southeast Texas.

Water: Observations: Building Community Resilience through Rainfall, Water Depth and Water Quality Monitoring

Comprehensive water observing plan including flooding sensor networks, water quality, marsh health, and impervious pavement experiments.

Water: Hydrology: Informing Flood Mitigation with an Integrated Modeling Approach

Model-driven strategy for predicting flooding under future climate, urbanization, and scenarios around infrastructure for flooding mitigation.

Air: Comprehensive spatiotemporal measurements of volatile organic compounds and trace gases the Southeast Texas Gulf Coast Region

Comprehensive air quality monitoring plan including mobile and stationary monitoring, chemical & odor fingerprinting, and integration with models.

Air: Atmospheric modeling of air toxics and criteria pollutants

Approaches for air quality modeling including point source emissions, spatial patterns of air toxics, and accidental chemical releases

Co-Design: Multipronged Approach to Co-Design of Equitable and Effective Climate Adaptation Strategies in Southeast Texas

Fourfold approach to developing a process to move from data and modeling to co-design of adaptation strategies and implementation of these strategies.

Equity: Understanding social vulnerability as a method for integrating equity into water, air, and climate research and improve co-design processes

Comparison of existing social vulnerability indicators for SETx and use of SV for water sensor placement.

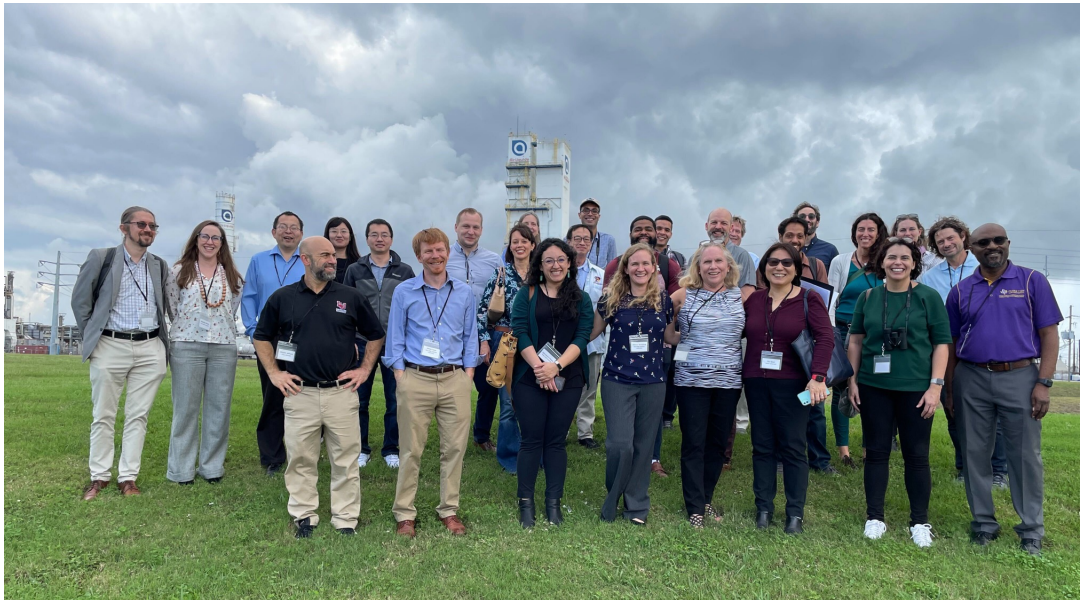
KMP: Software and infrastructure for sensor data storage and inter-team data sharing

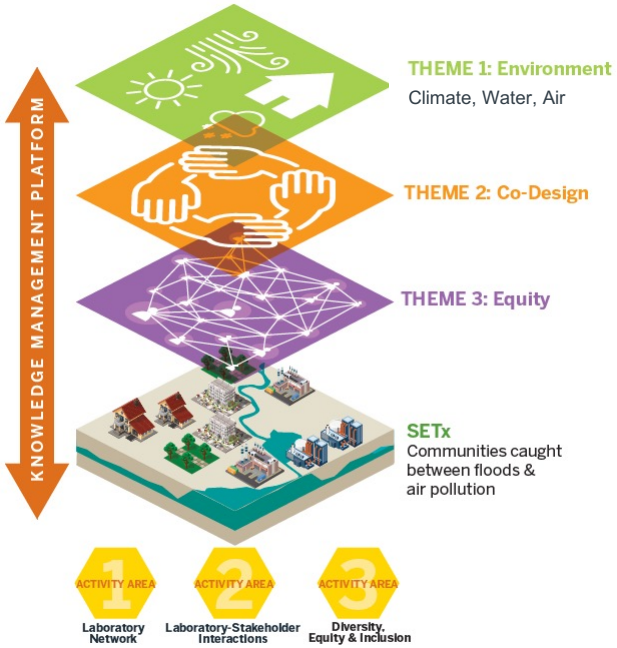
Examples of data visualization and integration in CKAN of water and air data.

AA: Southeast Texas Urban IFL: Education: Building Community Resilience through Innovative Learning Environments and Engaged Research

Description of Year 1 activities and plans for Year 2.

Thanks!





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