28 OCTOBER 2024

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), Los Alamos National Laboratory (Christa Brelsford)

PAOLA PASSALACQUA
Professor, Dept. of Civil, Architectural & Environmental Engineering, The University of Texas at Austin

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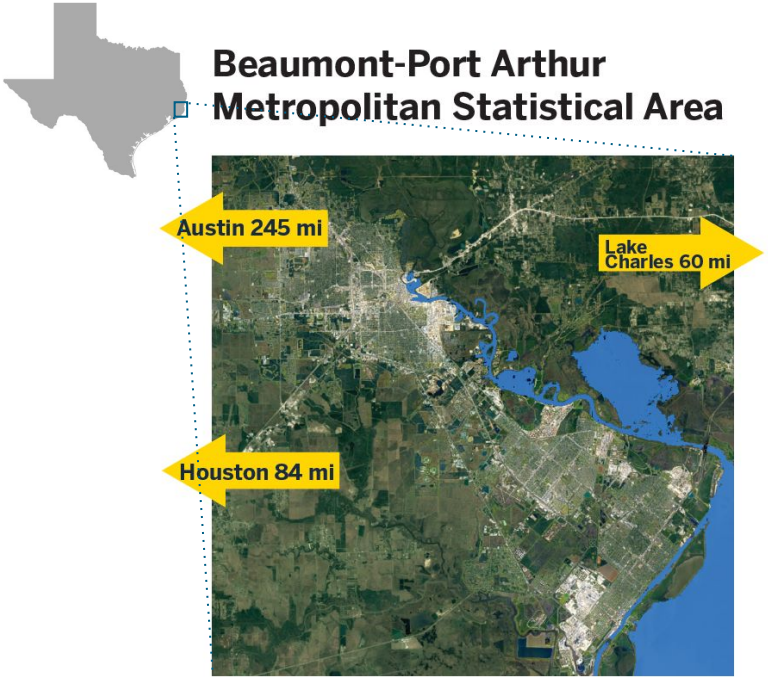
https://www.setx-uifl.org

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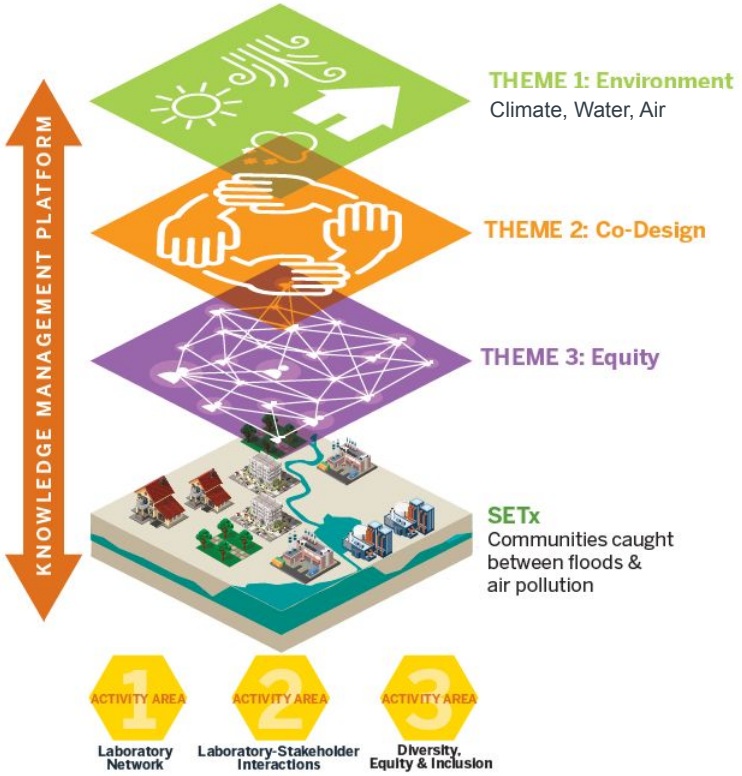
Providing better data, modeling, & planning to support climate adaptation in SETx and the Gulf Region

- 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

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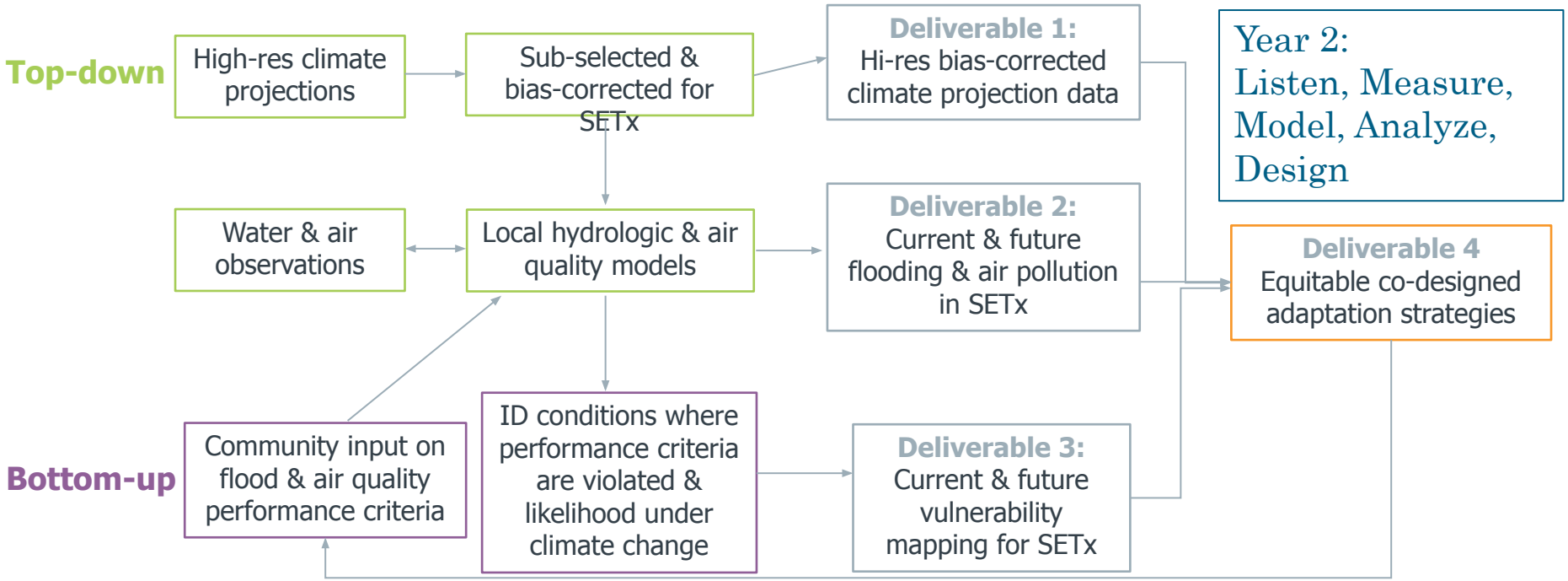
SETx-UIFL approach: top-down and bottom-up

Year 1:
Listen, Build, Train, Measure

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



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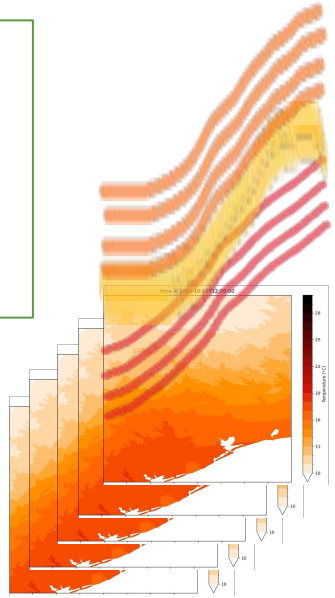
Environment | Equity | Co-design

Climate Y2: Hi-resolution and storm-scale climate datasets generated and evaluated

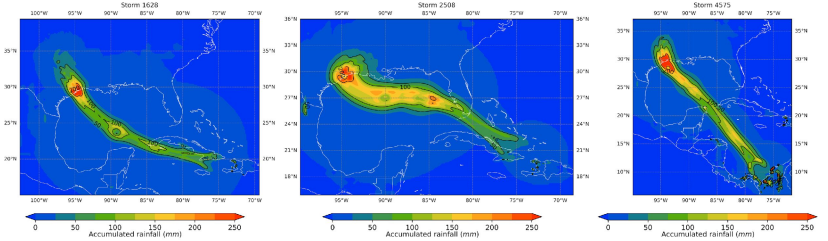
Daily, 1 km resolution

- average, high, and low temperature
- relative humidity
- specific humidity
- wind speed
- surface solar radiation

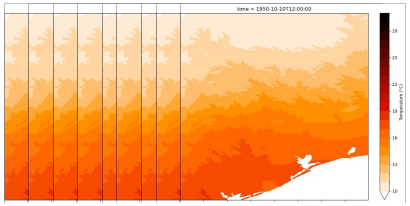


Daily evolution of meteorological conditions in SETx through 2100 with comprehensive coverage of future climate change uncertainty

Event-scale future projections of tropical cyclone tracks and rainfall



Daily evolution over historical period



Time

Daily evolution through 2100 for 4 scenarios of climate change ("SSPs")

as realized by 10 "best" climate models for SETx

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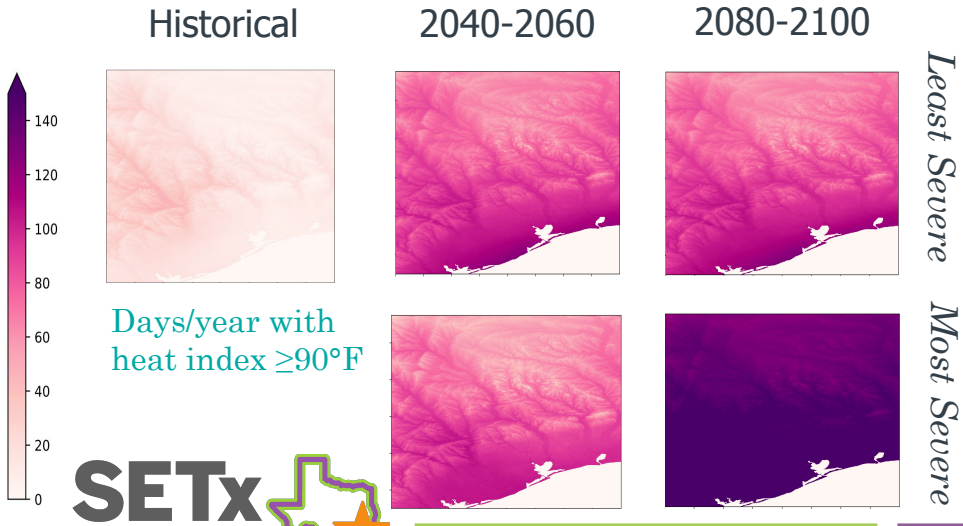
Lead: Geeta Persad (UT)

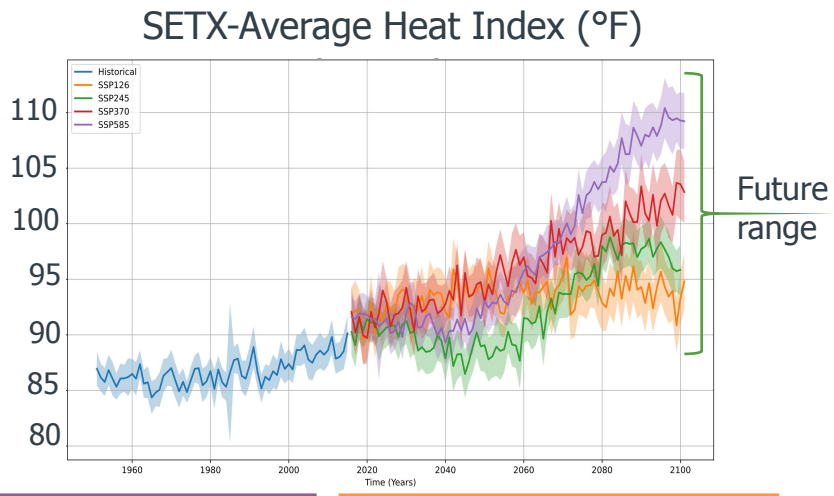
Climate Y2: Iteration with stakeholders and project team to maximize climate data utility

Heat stress projections presented to Technical and Community Task Forces for feedback on data analysis, visualization, and uncertainty characterization strategies to maximize usability by SETx stakeholders

City by city heat stress projections

	Average number of days/year with heat index above 90°F		
	Historical (1980 - 2014)	End of Century (2080-2100) *Least Severe Scenario*	End of Century (2080-2100) *Most Severe Scenario*
Port Arthur	8	115	159
Beaumont	8	106	157
Houston	13	103	162
Galveston	9	123	162
Orange	9	109	158
Kountze	9	97	155
Silsbee	9	97	155
Lumberton	8	99	156
Bridge City	8	111	158
Port Neches	8	111	158





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Y2: Improved flood frequency analysis through integrated hydrologic models

Scientific Challenge

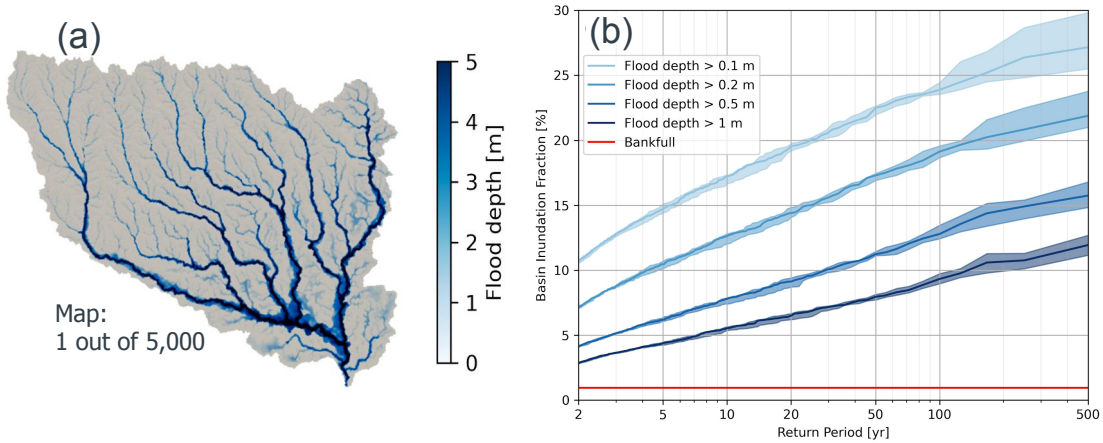
- There is a critical need to translate changing rainfall patterns into actionable flood hazard maps through models.
- Hazard maps are usually created for specific reaches rather than the entire basin, complicating regional flood mitigation planning.

Approach and Findings

- We developed a novel framework predicting flood return periods (the 100 year flood) by combining the hydrological model ATS and Stochastic Storm Transposition.
- We demonstrate the method by simulating 5,000 annual flood events in Village Creek, a ~2,000 km^2 watershed in Southeast Texas.
- Flood analysis is enhanced by providing peak flows, flood extent, and population exposure for up to the 500-year return period.

Significance and Impact

- By using spatially explicit models, we move beyond typical peak flow analysis to include flood hazard and population flood exposure analyses at the basin scale.
- These improved flood maps, which can be generated for both current and future conditions, facilitate decision-making for flood mitigation and emergency planning.



(a) Example of one out of 5,000 flood inundation maps generated from the spatially-resolved hydrological model ATS and the Stochastic Storm Transposition model RainyDay. (b) Estimation of basin inundation fractions for different annual recurrence intervals obtained from the 5,000 flood inundation maps.

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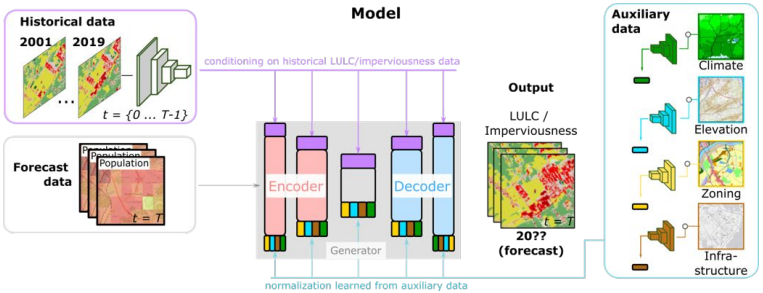
Perez, G., Coon, E.T., Rathore, S.S., & Le, P.V. (2024). Advancing process-based flood frequency analysis for assessing flood hazard and population flood exposure. Journal of Hydrology, 639, 131620.

Lead: Ethan Coon (ORNL)

Y2: Land Use Land Cover forecasting using generative AI

Can we extend GenAI to generate realistic land-use forecasts, conditioning on relevant auxiliary data?

- Idea: LULC forecasting as **a data synthesis problem conditioned on historical & auxiliary data sources**



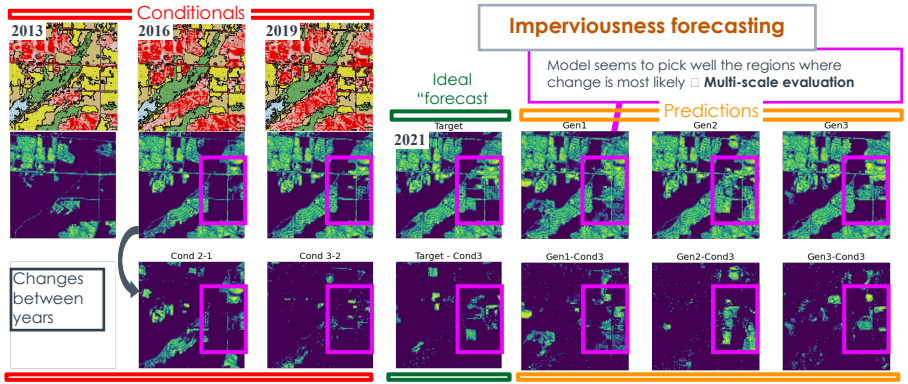
Why Generative AI?

- Data-driven: leverage **datasets** at **large spatial scales,** learn non-linear interactions between drivers
- Ability to synthesize multiple plausible futures
- Successful in many image/video generation tasks, capturing complex spatiotemporal patterns

- P. Dias, B. Pandey, E. Coon, D. Lunga "Generative artificial intelligence models for land use and land cover forecasting" To be presented at the Global Land Programme's (GLP) 5th Open Science Meeting (OSM) 2025
- P. Dias, B. Pandey, E. Coon "Contemplating Generative AI for land use and land cover forecasting" To be presented at the AGU 2024
- P. Dias & C. Brelsford "Conditional diffusion models for land-use and imperviousness forecasting" CV4EO Workshop at IEEE Winter Applications of Computer Vision 2024

Current status: Imperviousness forecasting

- National Land Cover Database (NLCD): 30m/px, historical LULC & imperviousness maps
- Test Case: learn from [2013,2016,2019], predict 2021



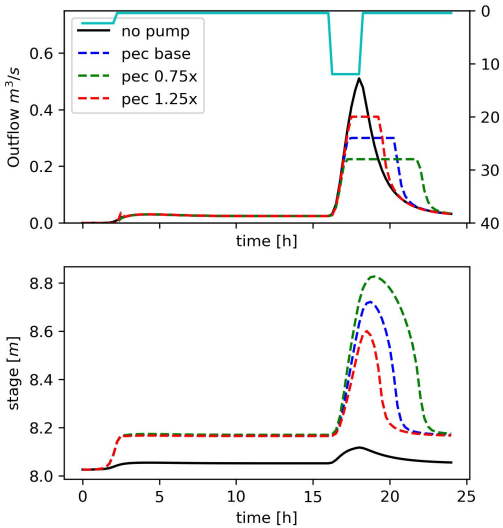
Multi-scale R^2 analysis for 10 held-out metropolitan areas across US:

- ~5% of change variance explained at 0.25x0.25 km^2 resolution
- ~30% at ~3x3 km^2

Next steps: 10+ years LULC forecasting, leveraging auxiliary data (e.g., elevation, infrastructure, population). Theory-informed evaluation/modeling, assessing known patterns (e.g., inequality - Moran's I), biases (spatial), and uncertainty.

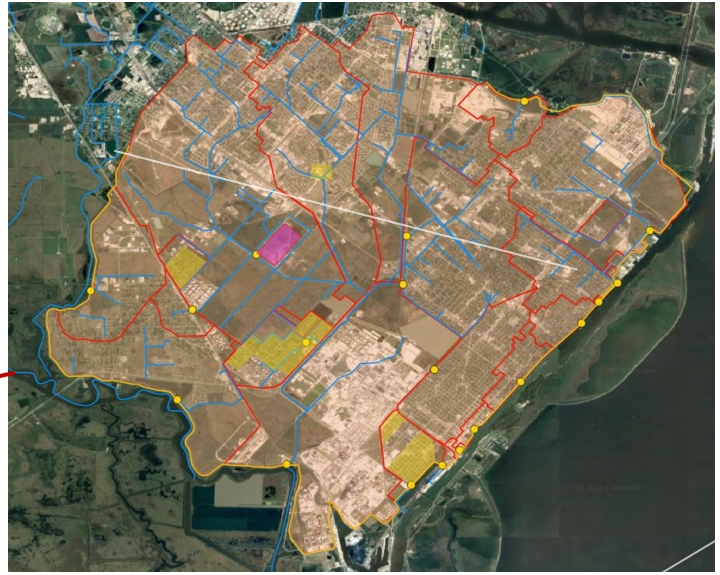
Y2: Infrastructure modeling at river basin scales

Comparison of pump implementation across different pump efficiency curves. Pumps, gates, impervious surface, and other drainage management infrastructure are implemented in ATS.



ATS simulation of the Neches River Basin

Hydrologic model representing pumps (yellow glyphs), drainage canals (blue) and the Halbouty Detention Pond (pink) is being used to investigate implications of co-designed infrastructure scenarios. This high-res simulation is embedded within broader Neches River Basin simulations to study compound flooding events.



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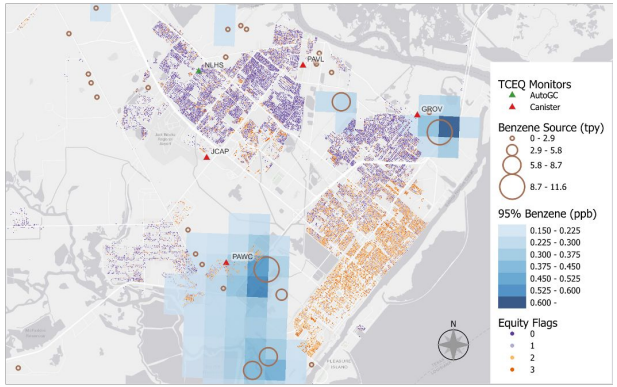
Y2: Assessing emission source contributions and simulated spatiotemporal patterns of air toxics with the Comprehensive Air Quality Model with Extensions (CAMx)

Objectives:

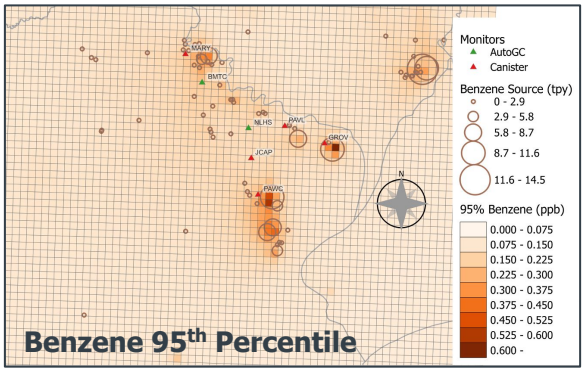
CAMx platform developed for SETx to examine:

- Relative hot spots of key air toxics (abundance/toxicity)
- Emission source contributions across the region
- Comparisons with outdoor/indoor air quality measurements
- Potential impacts of future changes in emissions

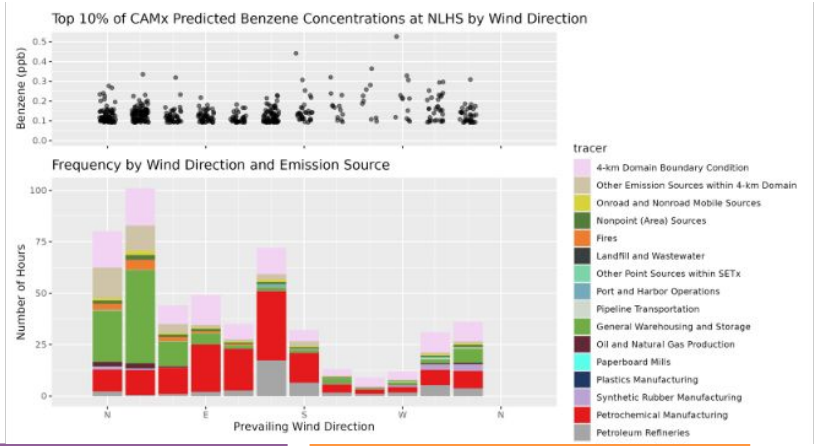


Cross-theme efforts between air and equity are evaluating CAMx results with community metrics such as household allocation, equity flags, and social vulnerability

CAMx simulations examine benzene, 1,3-butadiene, ethylene oxide, styrene, acetonitrile concentrations



Emission source contributions to air toxics concentrations under different wind patterns are tracked at locations throughout SETx



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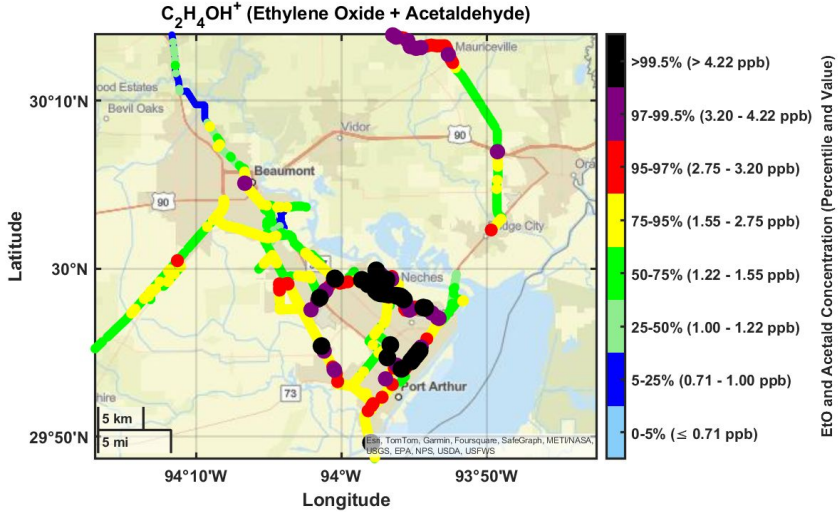
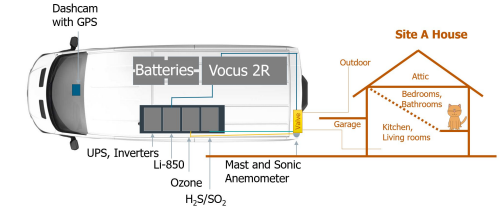
Leads: Clayton Jeffreys (Lamar) & Kerry Kinney (UT)

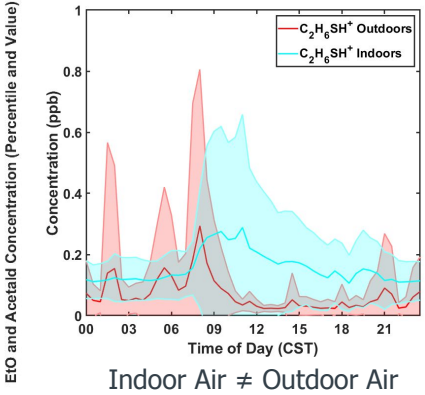
Y2: Evaluation of source contributions to observed chemical compositions outdoors and indoors

Objectives:

- Fingerprint and apportion sources indoors and outdoors
- Assess acute outdoor plume penetration indoors
- Examine spatiotemporal source distribution
- Integrate with odor assessment and CAMx modeling

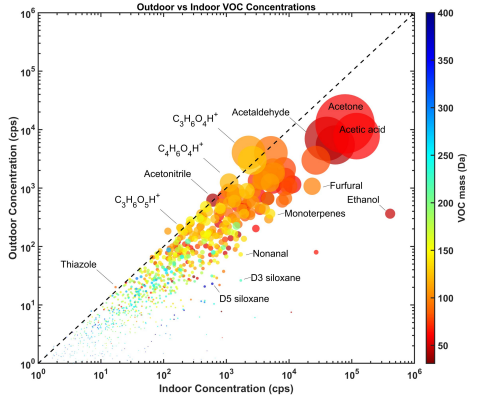




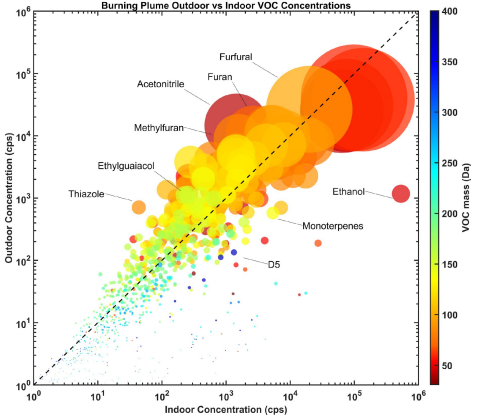


Indoor Air ≠ Outdoor Air

Clean non-plume "Indoors=Outdoors Plus"



Acute Plume Slow penetration



Regulated and emerging air toxics have been identified from a range of outdoor sources (chemical, paper mill, elastomer, petrochemical) and indoor sources (cooking, cleaning, chemical volatile products)

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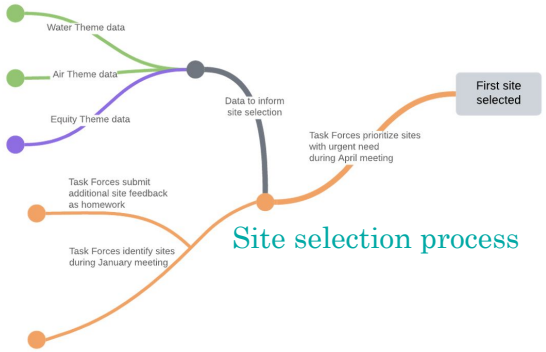
Y2: Translate Task Force members' values, visions, & problem definitions into potential climate adaptation strategies

Task Force Co-Design of Strategies (2024):

- 1.5.24: meeting @Lamar U. to develop selection criteria & identify potential sites
- 4.22.24: meeting @Lamar U. to analyze UIFL data & select two initial sites for co-design
- 8.20.24: new member on-boarding meeting (virtual)
- 9.10.24 meeting @ Lamar U. for bottom-up feedback on climate projections
- Fall 2024: site data prep & problem definition for Jan. 2025 strategy co-design workshop; additions to strategy inventory

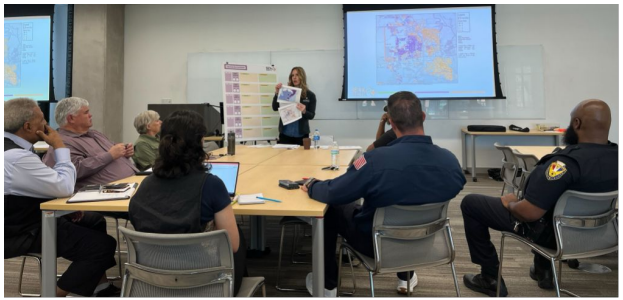


Site selection process

Data gathering with Task Force members: data integration, site visits, pilot process (2024):

- Spring 2024: integrated SETx-UIFL flooding, air quality, and equity data for 20 sites selected by Task Force
- Summer 2024: site visits
- Ongoing, 2024: develop co-design pilot process with Treasure Island Golf Course (Port Arthur, TX) redesign
- Fall 2024: Task Force survey: site problem definition & strategy input

Task Force site selection activity and two sites identified by Task Force members for strategy co-design.



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Y2: Provide input from task force on scenarios/performance criteria & develop observations of gray/green stormwater infrastructure impacts under local conditions

- Haselbach, L. et al. "Green buffers near industrial plants, examples in Jefferson County TX" (*Spatial Information Research*)
- Haselbach, L. et al. "Realtime Rainfall and Infiltration Rates in a Pervious Concrete Test Bed" (*ASCE International Conference on Transportation and Development Proceedings*)
- Murphy, S. et al. "Leveraging Emerging Flood Modeling Methods and Infrastructure Designs for Land-Use Analysis: a Case Study in the Southeast Texas Region" (accepted)
- Luo, L. et al. "Scenario Generation for Built Environment Decision Support Under Uncertainty: Case Studies on Airflow Modeling and Climate-resilient Infrastructure System Design (in review)
- Haselbach, L. et al. "Efficacy of Underground Aggregate Infiltration Beds Under a Permeable Pavement System" (in review)

Counter-clockwise from top: Pleasure Island Gulf Course Project Map; images of flood sensor nodes & rain gauges for two GSI test beds @ Lamar

Repurposing an area abandoned after Hurricane Rita to multi-use community green space

In conjunction with EPA grant 02D19522: two green stormwater infrastructure (GSI) test beds provide: 1) physical, implemented examples of the types of strategies that the Task Force may develop; and 2) observational data about how implemented strategies perform in the unique environmental and social context of the Gulf Coast.

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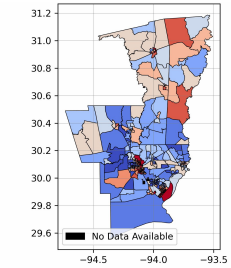
Equity Y2: Develop Social Vulnerability Indicators

Open Source Tool for Calculating SVIs

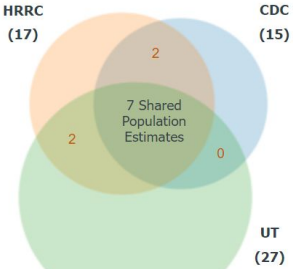
- Preisser et al., (2024), *Under Review*
- Open-source tool using Factor Analysis and Ranking methods.
- Tailor made Census based SVIs for any study area in US.
- Automate comparisons between years and calculation methods



2013-2022 Factor Analysis Method Block Group SVIs for SETx

Explicitly Document SVI Assumptions

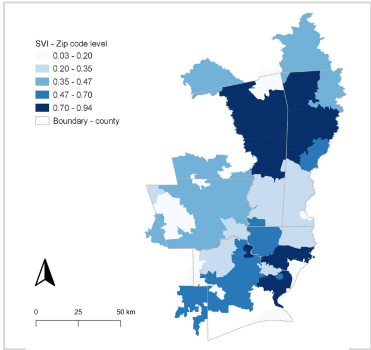
- What are the basic assumptions that SVI modelers must consider before generating or using an SVI?
- Defined assumptions for demographic data, spatial data, and index construction.
- SVI options Centers for Disease Control and Prevention (CDC), Hazard Reduction and Recovery Center (HRRC), Preisser et al. 2024 (UT)



Three SVI options only share 7 variables

ZIP code level SVI for Health Equity

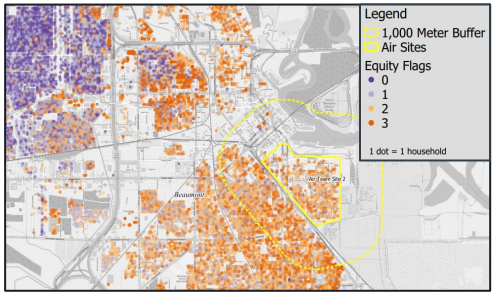
- Followed CDC SVI, gathered 16 indicators and calculated 4 themes
- Each data extracted by ZIP Code Tabulation Areas (ZCTA) Level in Texas.
- ZIP Code boundaries required to match Texas Health Data



2020 ZIP code level SVI

Housing Unit Allocation with Equity Flags

- Presented test maps during community engagement task force meeting.
- Maps used to inform decision for selection of flood and air team study sites.



Community with pollution concerns and significant number of low-income minority renters

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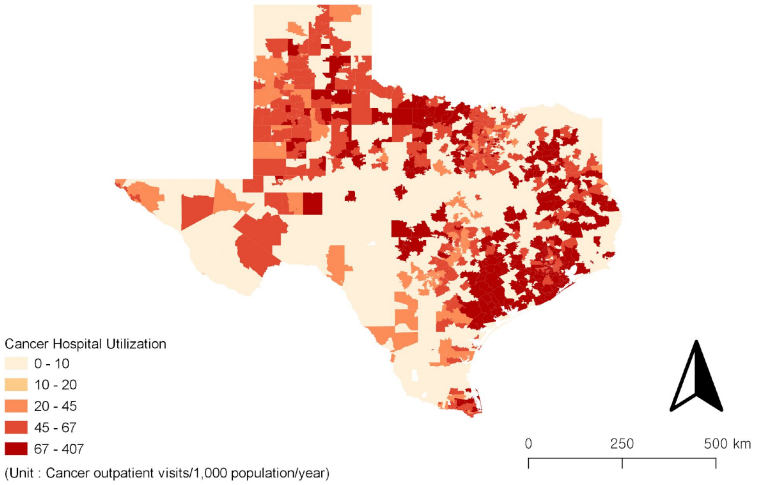
Leads: Nathanael Rosenheim & Michelle Meyer (TAMU)

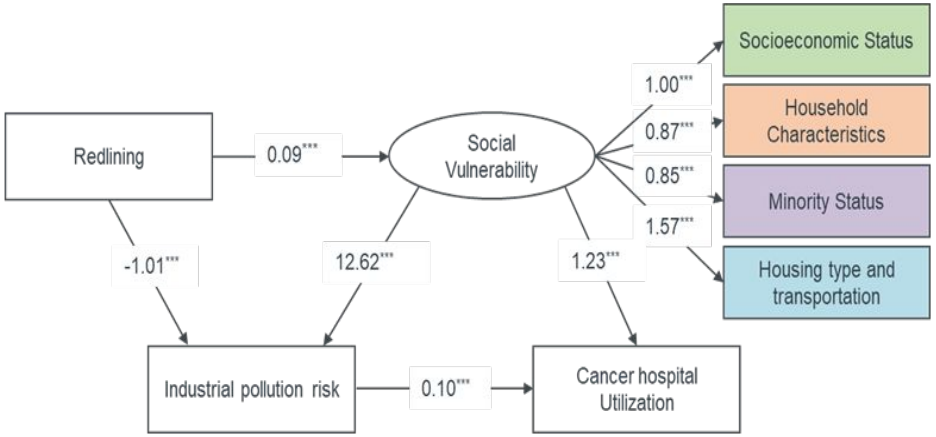
Equity Y2: Incorporating health data

Cancer Hospital Utilization

- Source: Texas Department of State Health Services
- Data/spatial coverage:500+ hospitals across Texas State (Public, private, specialized, including general care and urgent care)



Cancer hospital utilization in Texas



$^{*}p < 0.05, ^{**}p < 0.01, ^{***}p < 0.001$

Structural Equation Model (SEM)

- Epidemiological study: Analyzed the relationships among variables—Redlining, SVI themes, industrial pollution risk, and cancer hospital utilization
- Social vulnerability has a positive and significant relationship with industrial pollution risk and cancer hospital utilization
- Redlining has association with cancer hospital utilization.

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Equity Y2: Prepared for and started interviews

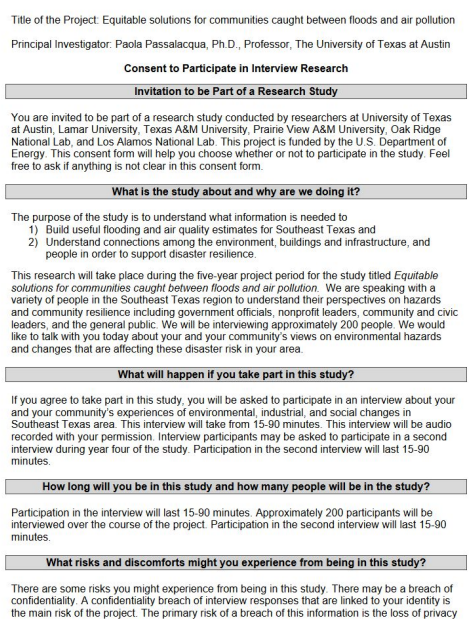
Milestones:

- Obtained IRB approval for interviews
  - CITI training completed by entire team
- Trained interviewers
- Developed, beta tested, and revised interview guide
- Began participant recruitment
  - Scheduled first 10 interviews. Interviews started 10/21/24.

Products:

- Consent form
- Interview guide

Consent form



Title of the Project: Equitable solutions for communities caught between floods and air pollution

Principal Investigator: Paola Passalacqua, Ph.D., Professor, The University of Texas at Austin

Consent to Participate in Interview Research

Invitation to be Part of a Research Study

You are invited to be part of a research study conducted by researchers at University of Texas at Austin, Lamar University, Texas A&M University, Prairie View A&M University, Oak Ridge National Lab, and Los Alamos National Lab. This project is funded by the U.S. Department of Energy. This consent form will help you choose whether or not to participate in the study. Feel free to ask if anything is not clear in this consent form.

What is the study about and why are we doing it?

The purpose of the study is to understand what information is needed to

1) Build useful flooding and air quality estimates for Southeast Texas and
2) Understand connections among the environment, buildings and infrastructure, and people in order to support disaster resilience.

This research will take place during the five-year project period for the study titled *Equitable solutions for communities caught between floods and air pollution.* We are speaking with a variety of people in the Southeast Texas region to understand their perspectives on hazards and community resilience including government officials, nonprofit leaders, community and civic leaders, and the general public. We will be interviewing approximately 200 people. We would like to talk with you today about your and your community's views on environmental hazards and changes that are affecting these disaster risk in your area.

What will happen if you take part in this study?

If you agree to take part in this study, you will be asked to participate in an interview about your and your community's experiences of environmental, industrial, and social changes in Southeast Texas area. This interview will take from 15-90 minutes. This interview will be audio recorded with your permission. Interview participants may be asked to participate in a second interview during year four of the study. Participation in the second interview will last 15-90 minutes.

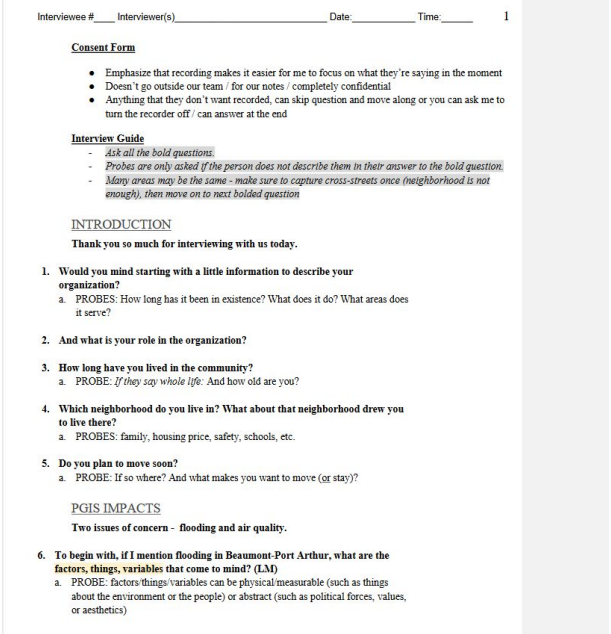
How long will you be in this study and how many people will be in the study?

Participation in the interview will last 15-90 minutes. Approximately 200 participants will be interviewed over the course of the project. Participation in the second interview will last 15-90 minutes.

What risks and discomforts might you experience from being in this study?

There are some risks you might experience from being in this study. There may be a breach of confidentiality. A confidentiality breach of interview responses that are linked to your identity is the main risk of the project. The primary risk of a breach of this information is the loss of privacy

Interview guide



Interviewee #____ Interviewer(s)_____ Date:_____ Time:_____ 1

Consent Form

- Emphasize that recording makes it easier for me to focus on what they're saying in the moment
- Doesn't go outside our team / for our notes / completely confidential
- Anything that they don't want recorded, can skip question and move along or you can ask me to turn the recorder off / can answer at the end

Interview Guide

- *Ask all the bold questions.*
- *Probes are only asked if the person does not describe them in their answer to the bold question.*
- *Many areas may be the same - make sure to capture cross-streets once (neighborhood is not enough), then move on to next bolded question*

INTRODUCTION

Thank you so much for interviewing with us today.

1. **Would you mind starting with a little information to describe your organization?**
   a. PROBES: How long has it been in existence? What does it do? What areas does it serve?
2. **And what is your role in the organization?**
3. **How long have you lived in the community?**
   a. PROBE: *If they say whole life:* And how old are you?
4. **Which neighborhood do you live in? What about that neighborhood drew you to live there?**
   a. PROBES: family, housing price, safety, schools, etc.
5. **Do you plan to move soon?**
   a. PROBE: If so where? And what makes you want to move (or stay)?

PGIS IMPACTS

Two issues of concern - flooding and air quality.

6. **To begin with, if I mention flooding in Beaumont-Port Arthur, what are the factors, things, variables that come to mind? (LM)**
   a. PROBE: factors/things/variables can be physical/measurable (such as things about the environment or the people) or abstract (such as political forces, values, or aesthetics)

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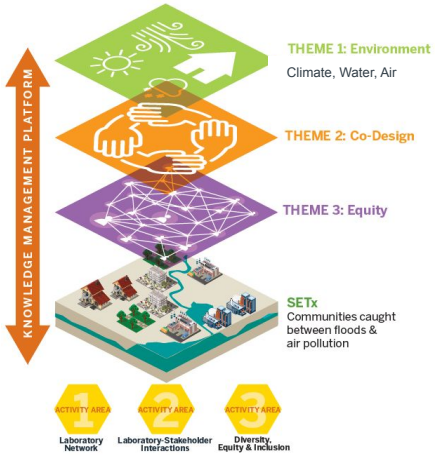
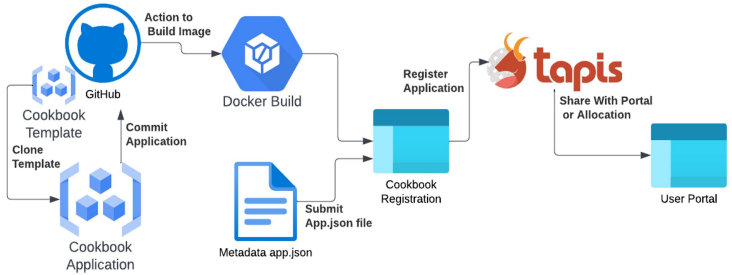
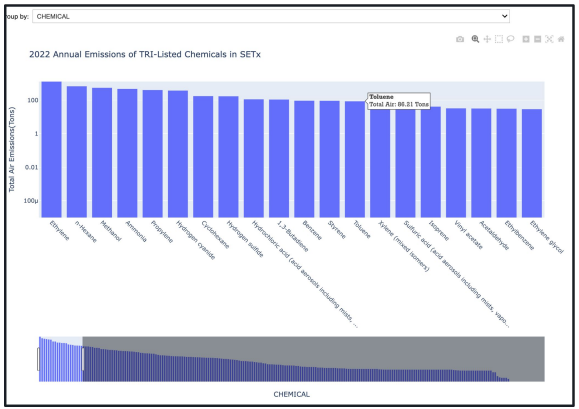
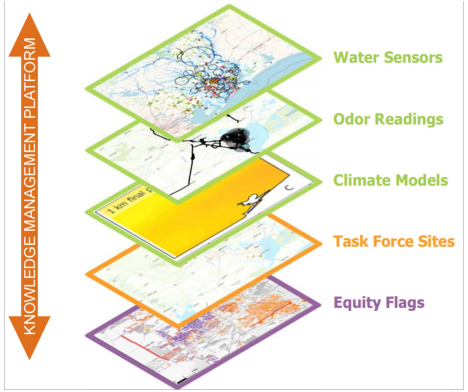
Y2: KMP - Supporting data collection, integration, and inter-team collaboration

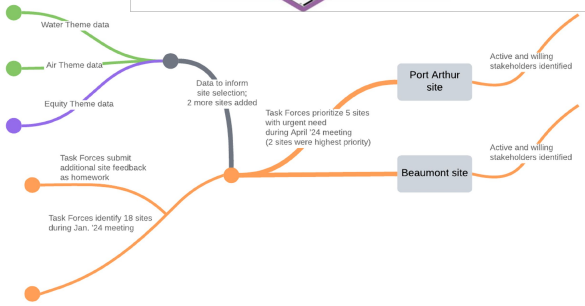






Developing workflows that improve collaboration and analyses through cookbooks on TACC.





Support of the co-design site selection process.

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Leads: Suzanne Pierce & Will Mobley (UT)

Y2: AA SETx-UIFL 2023 Annual Meeting, cross institutional course

Photos from 2023 Annual Meeting

2024 SETx-UIFL Summer Institute

Photos TAMU Land Design Field Trip

Additional activities:

- Support team field campaigns
- Support community projects
- Task force meetings
- SETx Flood Coordination Study

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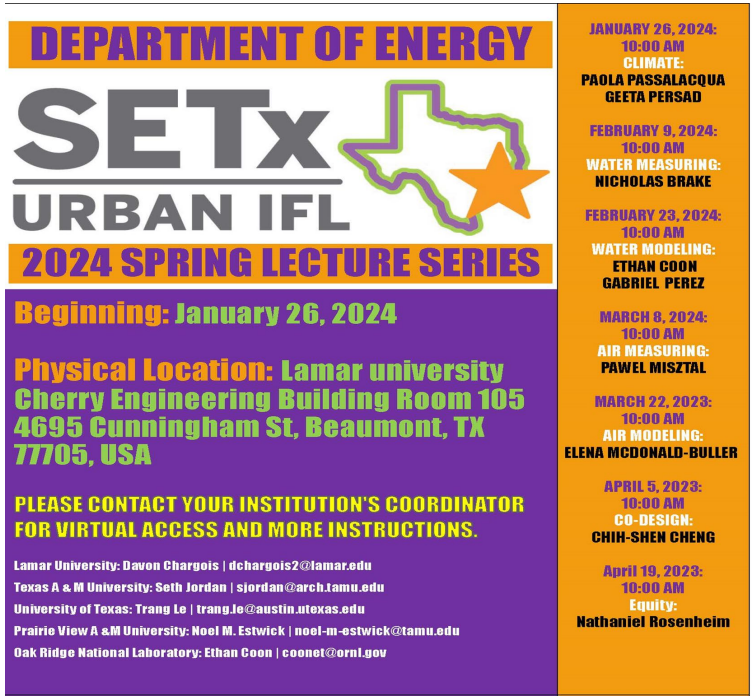
Lead: Liv Haselbach (Lamar)

Y2: Cross institutional course (planned for 2025 too)



Material also included in regular courses:

- Lamar University
  Course: Civil Engr Systems Design Project, CVEN 4212
- Texas A&M University
  Course: Landscape Design III, Land 311
  Course: Communication In Planning, Plan 611
- University of Texas at Austin
  Course: Air Pollution Engineering, CE 369L

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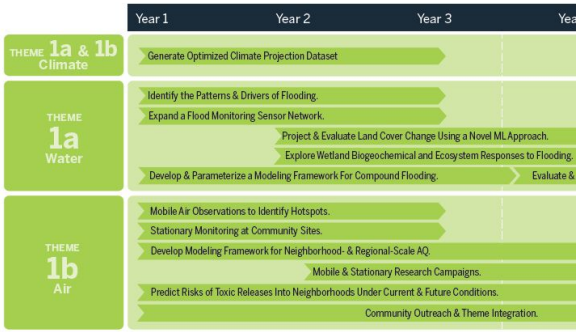
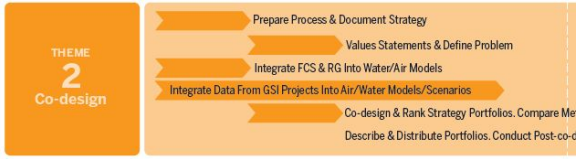
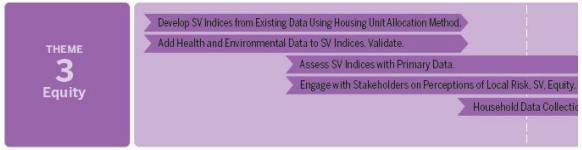
SETx-UIFL Y3 Plans



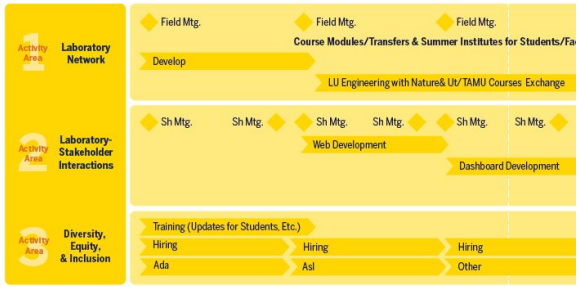
- **Hi-res climate projection dataset** complete; Community dissemination and integration with flood and air quality models underway
- **Add** 9 more new **sensors** + **scaling up modeling**
- **Integrating** ELM wetland modeling, flood inundation mapping, and hydrologic models
- **Develop infrastructure 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
- **Develop strategy portfolios** for community audience



- **Integrate SVI indicators** at household level to collaborations with Air and Water Themes.
- **Incorporate health data** in SVIs
- **Code and analyze interviews** to assess validity of SVIs in collaboration with Co-design Theme



- **Third 3-day annual meeting** in Beaumont
- **Unique course set-up** for Spring 2025 with flexibility for different departmental-faculty-research requirements of each participating institution
- **Summer institute** in 2025 for students
- **Continue** to facilitate **site and community visits** for all themes
- **Integration** of projects and science **into regular university** level **courses**

Year 3:
Listen, Measure, Model, Analyze, Identify, Integrate, Catalyze, Communicate, Nurture

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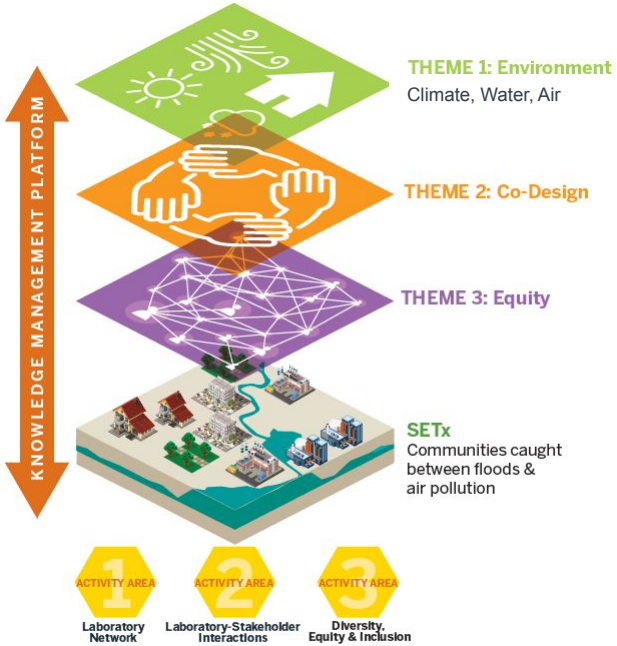
Thoughts, ideas, & questions for collaboration across UIFLs



- What information-sharing can we be doing on best practices and pitfalls in applying climate data in an urban setting, particularly with respect to changing extremes, uncertainty, and community engagement?
- 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?
- What adaptation strategies able to address compounding hazards are other UIFLs considering? And what are their impacts (e.g., GSI on heat island)?
- Develop a plan for joint academic articles on integrating social science and equity/justice work into climate and biophysical modeling and observation collection?
- 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?

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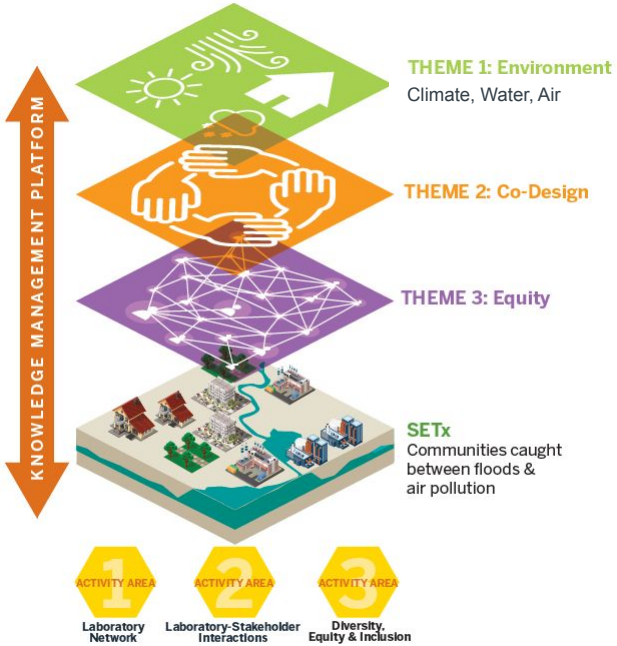
Collaboration across UIFLs via monthly coordination, seminar series, and supplementary projects



- Monthly PIs meetings
- Quarterly seminar series with 2 UIFLs presenting (coordinated by BSEC)
- 7 supplementary project funded (SETx-UIFL leads 5 and participates in 2):

1. MSD Urban Working Group Cross-IFL Community Building (Lead: Christa Brelsford, LANL)
2. Unified Multilayer Interface for Cataloguing Spatiotemporal Observation across IFLs (Lead: Will Mobley, UT)
3. Green infrastructure representations in hydrologic models (Lead: Ethan Coon, ORNL)
4. Coordinating urban land surface modeling across UIFLs (Lead: Ben Sulman, ORNL)
5. Coordinated inter-IFL measurements of gas-phase and particle-phase pollutants in joint intensive observation periods (Lead: Misztal, UT)
6. Collaborative Evaluation of the Urban Integrated Field Laboratories (UIFLs) Transdisciplinary Team Science (SETx-UIFL representative: Lieberknecht, UT)
7. Greenhouse gas, criteria air pollutant, and anthropogenic heat flux inventories for the UIFL domains at the asset scale (SETx-UIFL representative: Misztal, UT)

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Overview of SETx-UIFL posters presented at this meeting

- Climate: High-Resolution Climate Projections for the Southeast Texas Region
- Water + Climate: Changes in tropical cyclone rainfall in Southeast Texas under global warming
- Water: Integrated Modeling Framework for Actionable Insights on Future Flood Risk
- Water: Building Community Resilience through Monitoring and Modeling of Hydrology, Water Quality, and Wetland Function
- Air: Measured Source Apportionment of Volatile Organic Compounds and Trace Gases Indoors and Outdoors in the Southeast Texas Gulf Coast Region
- Air: Assessing Emission Source Contributions and Simulated Spatiotemporal Patterns of Air Toxics to Support Collaborative Community Decision Processes in Southeast Texas
- Air: Monitoring and Modelling Chronic and Acute Pollution Release
- Co-Design: SETx-UIFL Task Force Co-Design Site Selection Process
- Co-Design: Cyclical Approach to Co-Design of Equitable and Actionable Climate Adaptation Strategies in Southeast Texas
- Equity: Association of historical redlining and Social Vulnerability Index (SVI) with cancer-related hospital utilization in Texas
- Equity: Community-Driven Nature-Based Solutions Utilizing Urban Vacant Lands to Enhance Flood Resilience in Port Arthur, TX
- Equity: Social Vulnerability Indices (SVI): Exploring Assumptions and Limitations
- KMP: Expanding access to HPC enabled analyses through reproducible cookbooks
- KMP: Integrated Approaches for Flood Mitigation and Land Use Planning in Southeast Texas
- AA: Education: Building Community Resilience through Innovative Learning Environments and Engaged Research

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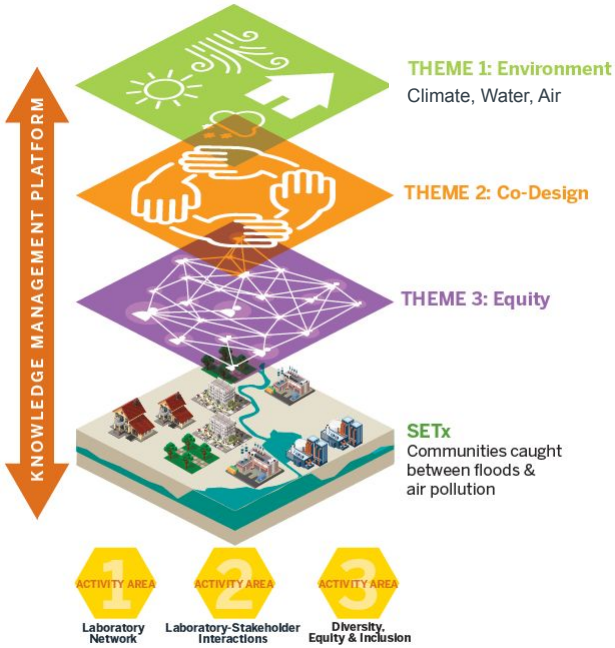
SETx-UIFL: Equitable solutions for communities caught between floods and air pollution



https://www.setx-uifl.org

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