Increasing Disaster Preparedness & Building Resilient Communities

SRP Climate Change and Health Webinar

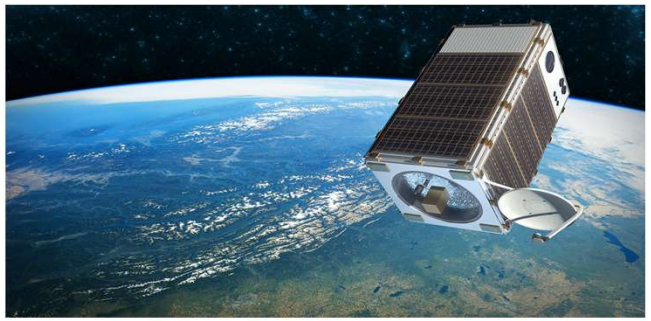
Nov 4, 2022

Elena Craft, Ph.D.
Associate Vice President
Climate & Health

EDF
ENVIRONMENTAL DEFENSE FUND®
Finding the ways that work

EDF
ENVIRONMENTAL DEFENSE FUND®
Finding the ways that work

- One of the largest **non-profit** environmental organizations in the world
- Track record of **corporate partnerships** with companies like FedEx, Walmart, and Starbucks
- Oil & Gas **engagement** through science studies, technology pilots
- Disaster response following **climate-related disasters**



Science »
Founded by scientists, we are evidence-based advocates.

Economics »
We find economic incentives to drive environmental progress.

Partnerships »
Our allies range from farmers to Fortune 500 companies.

Nonpartisan policy »
We build broad support for environmental progress.


A&M


Duke
UNIVERSITY
Srp
Superfund
Research Program


HOUSTON HEALTH
DEPARTMENT


UNIVERSITY OF
LOUISVILLE


NC


RICE


EDF
ENVIRONMENTAL
DEFENSE FUND
Finding the ways that work


Harris County
Pollution Control


UNIVERSITY OF
NOTRE DAME


entanglement
TECHNOLOGIES, INC.


Baylor
College of
Medicine
GIVING LIFE TO POSSIBLE


UNC
Chapel Hill
SUPERFUND
Research Program


UTHealth
The University of Texas
Health Science Center at Houston
School of Public Health

The New York Times

More Than 40 Sites Released Hazardous Pollutants Because of Hurricane Harvey

By TROY GRIGGS, ANDREW W. LEHREN, NADJA POPOVICH, ANJALI SINGHVI and HIROKO TABUCHI SEPT. 8, 2017

Houston's sprawling network of petrochemical plants and refineries released millions of pounds of pollutants in the days after Hurricane Harvey began barreling toward Texas.

Even under normal operations, the hundreds of industrial facilities in the area can emit harmful chemicals. But from Aug. 23 to Aug. 30, 46 facilities in 13 counties reported an estimated 4.6 million pounds of airborne emissions that exceeded state limits, an analysis by the Environmental Defense Fund, Air Alliance Houston and Public Citizen shows.

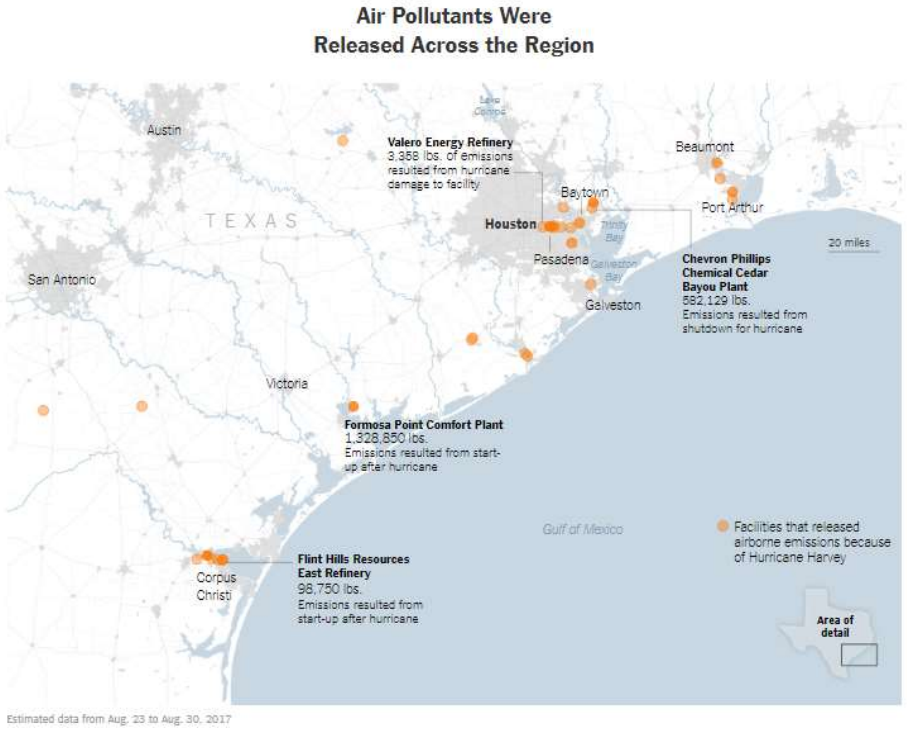



Photo: Scott Olson

FLOODING: 60 inches of rain fell from Hurricane Harvey in Texas, shattering the U.S. storm record. The 275 trillion tons of water on the Houston region was heavy enough to cause the earth's crust to drop by 2cm.

Independent Monitors Found Benzene Levels After Harvey Six Times Higher Than Guidelines

After an oil tank in Houston's Manchester neighborhood caved in, private monitors found levels that far exceeded California's health guidelines

By Lisa Song and Al Shaw, ProPublica, and Kiah Collier, The Texas Tribune, September 14, 2017

High Levels of Carcinogen Found in Houston Area After Harvey

An aerial view of the Valero Houston Refinery is seen in Houston, Texas, U.S. August 31, 2017. REUTERS/Adrees Latif Published Credit: adrees latif/Reuters PHOTO: ADREES LATIF/REUTERS

THE WALL STREET JOURNAL. Subscribe Now

Home World U.S. Politics Economy Business Tech Markets Opinion Life & Arts Real Estate WSJ. Magazine

STYLE

U.S.

After Oil Refinery Is Damaged by Harvey, Benzene Is Detected in Houston Area

City and EPA investigate potentially dangerous plume after Valero Energy Partners reported leak tied to hurricane

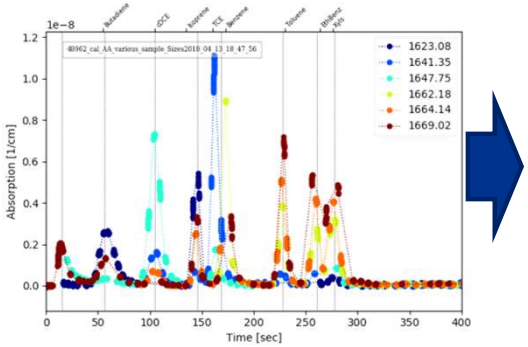
High levels of chemicals found in air around Houston refinery after EPA told residents not to worry

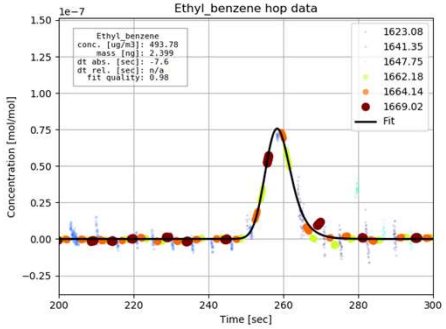
The revelations came after an environmental group conducted its own testing.

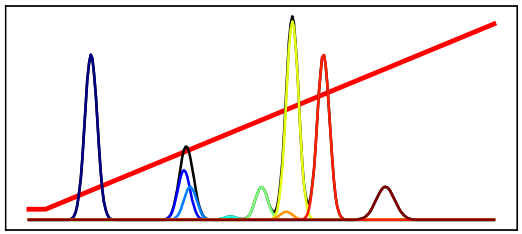
MARK HAND SEP 15, 2017, 11:29 AM

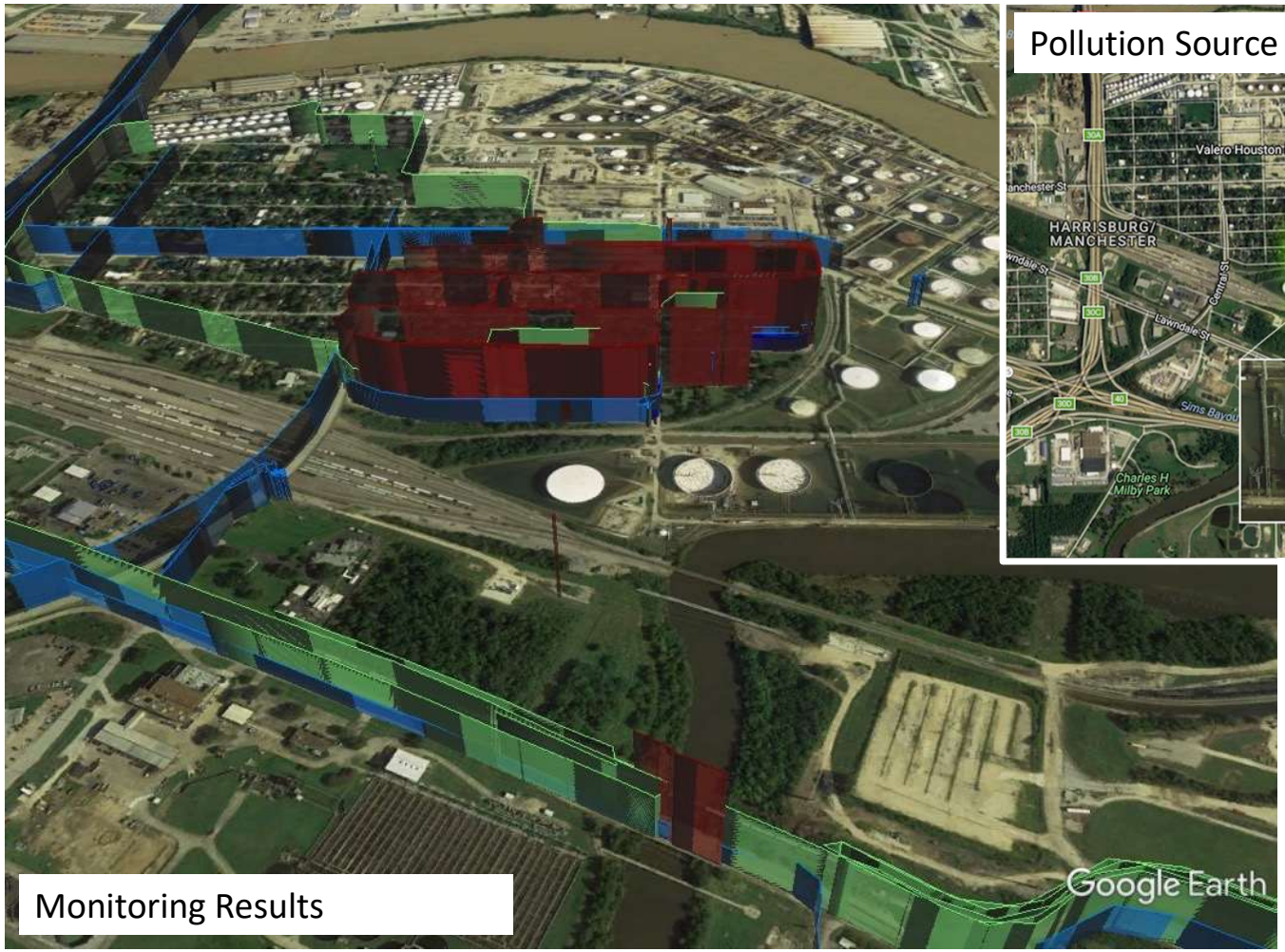
The AROMA Analyzer was deployed for ten days in the greater Houston area to fill in gaps in the monitoring network that was taken offline by the impact of the Hurricane.

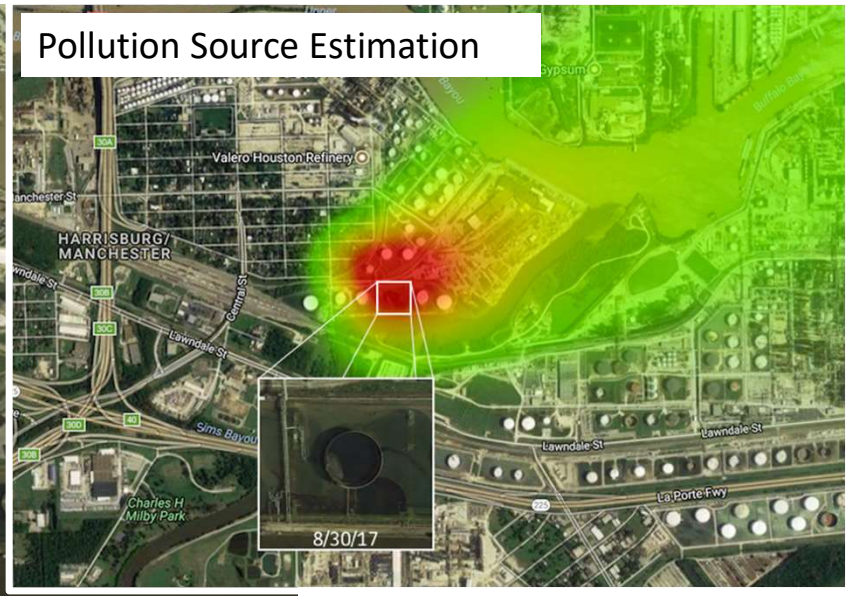
AROMA combines Cavity Ring-Down Spectroscopy with analyte dispersion to provide part-per-trillion level speciated analysis of BTEX compound in real-time. Developed through NSF and NIH SBIR funding.



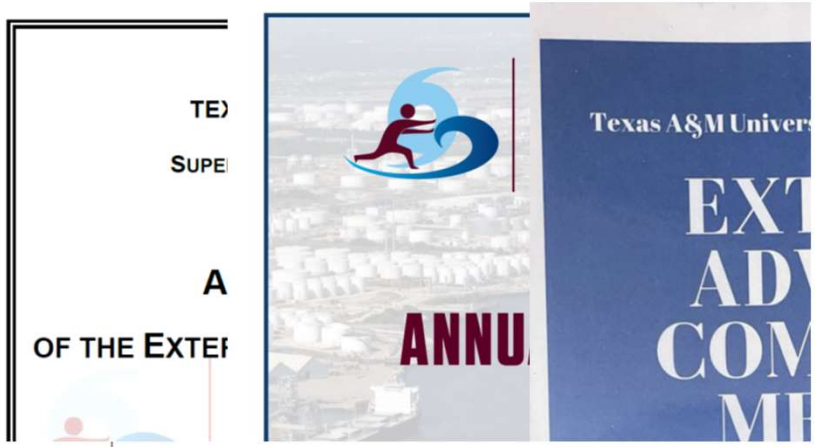








- Manchester Neighborhood saw highest concentrations (>300 ppb benzene)
- Repeated measurements allowed source localization, later confirmed by satellite imagery



FEMA

TEXAS A&M ENGINEERING EXTENSION SERVICE

National Emergency Response and Recovery Training Center

in cooperation with the

Department of Homeland Security

Federal Emergency Management Agency

Elena S. Craft

has successfully completed

WMD/Terrorism Awareness for Emergency Responders

4 Hours

December 5, 2018

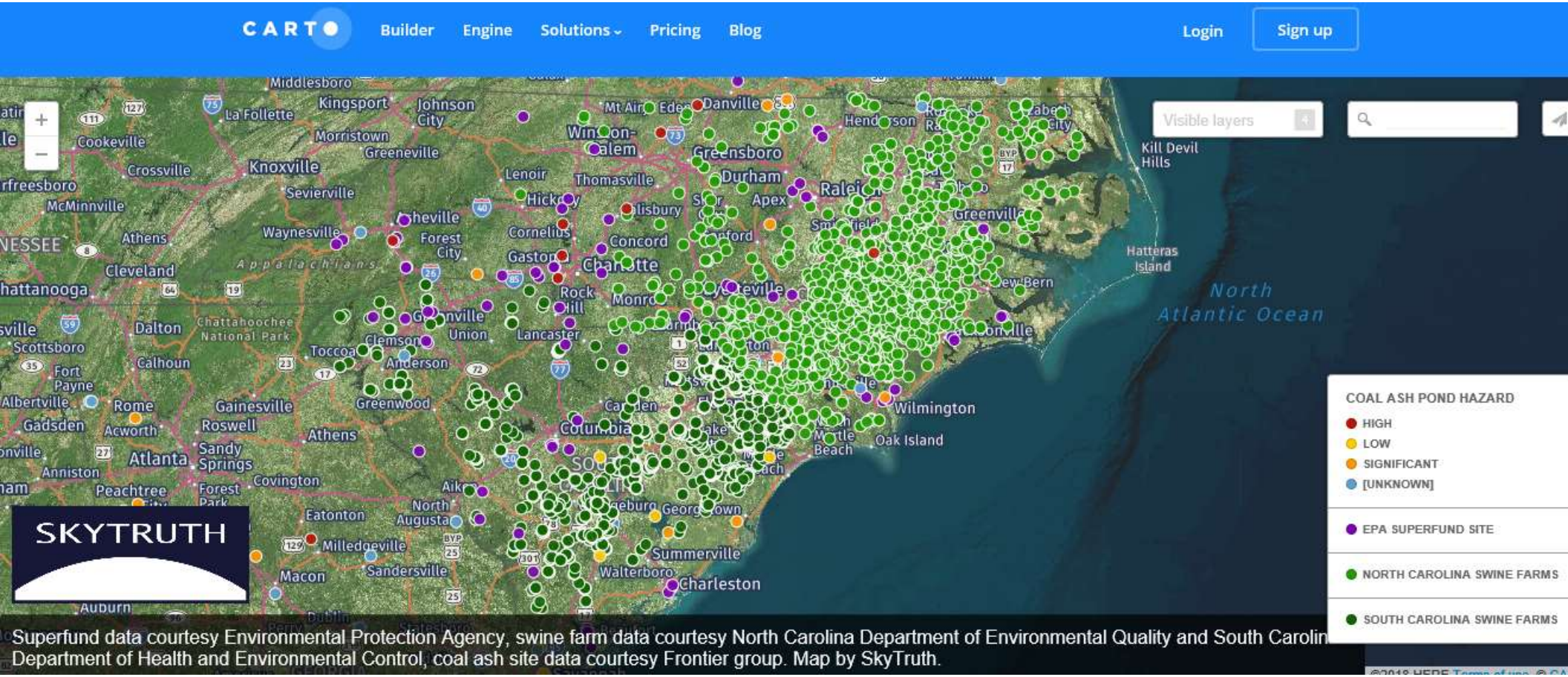
Continuing Education Units Earned .40

Gary T. Sera, Director
Texas A&M Engineering Extension Service

H. Dawson, Jr., Director
National Emergency Response and Recovery Training Center
Texas A&M Engineering Extension Service

FP AWR160 131 TEEX ID 1717764 State Board for Educator Certification #500132

Hurricane Florence Risk Sites



https://skytruth-org.carto.com/viz/ddfae580-b63a-4ade-9315-5bd1dfc24c00/public_map

Awarded 2018 **Best E-Newsletter** by the National Association of Government Communicators

Environmental Factor

Your Online Source for NIEHS News

NOVEMBER 2018

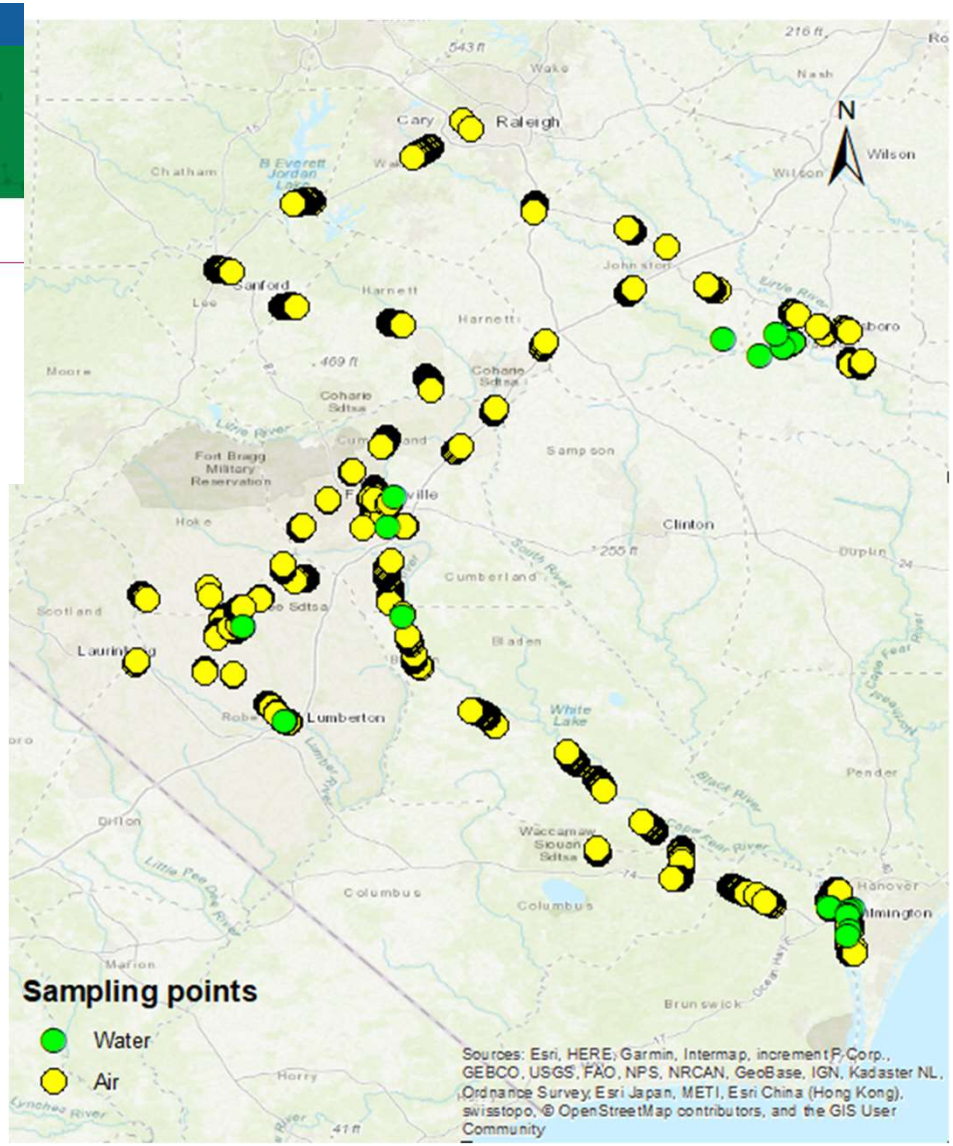
NIH National Institute of Environmental Health Sciences

Researchers respond quickly after Hurricane Florence

Previous Article | Next Article

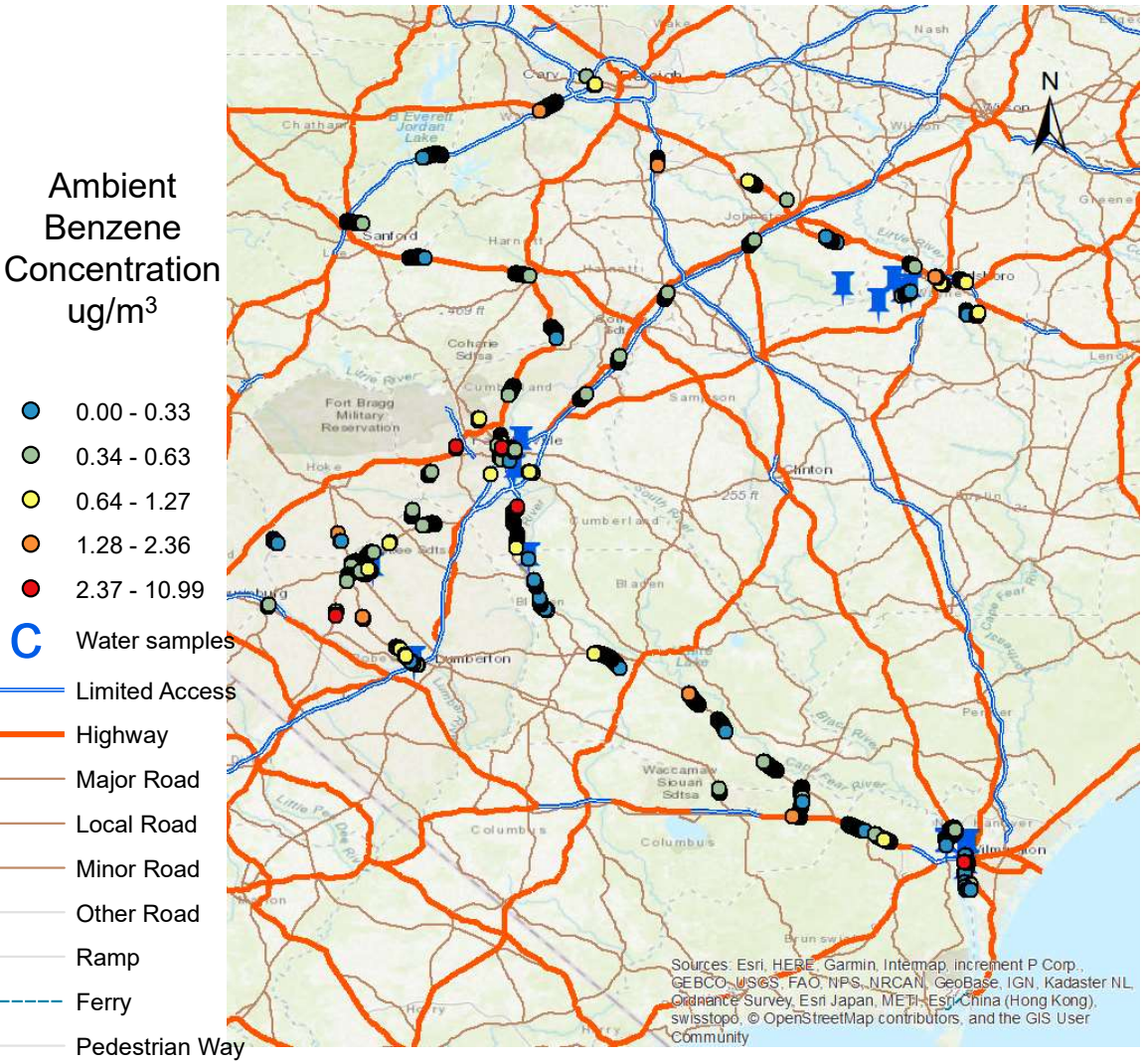
After Hurricane Florence devastated southeastern North Carolina, NIEHS grantees hit the ground running to test for contaminants.

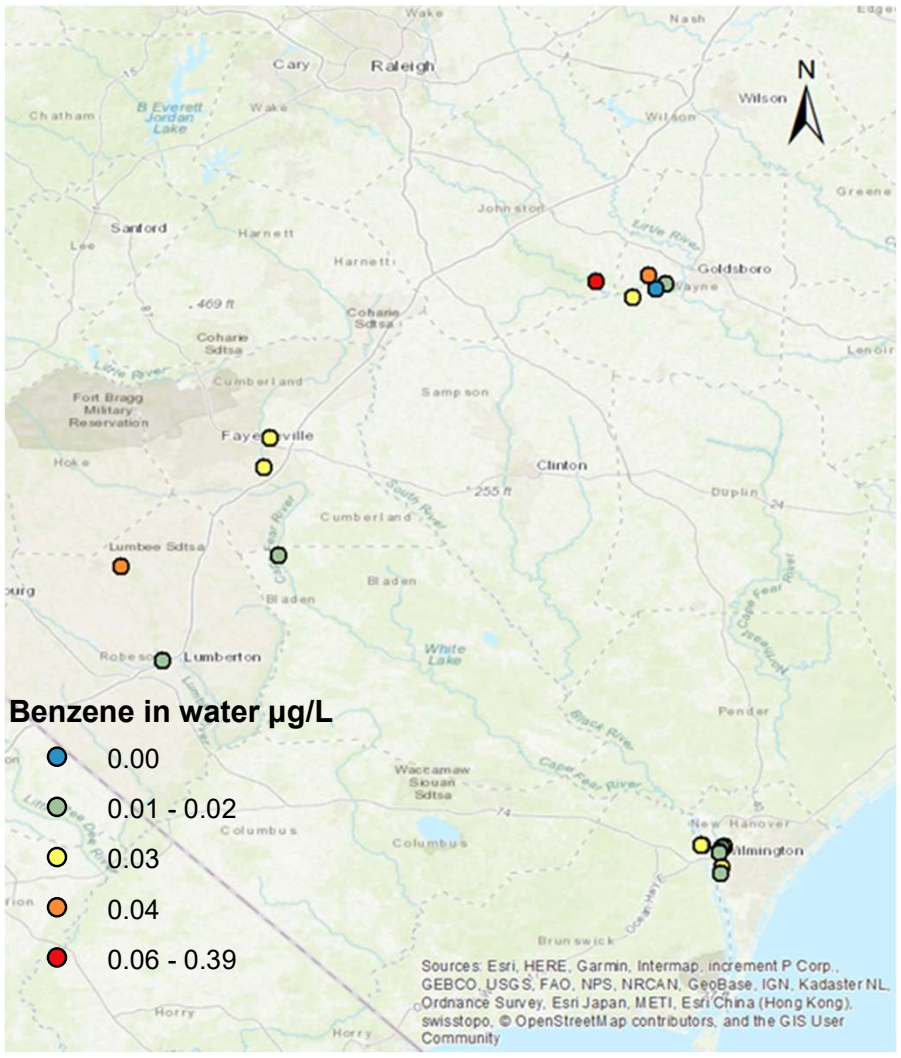
BY SARA AMOLEGBE



Air

Water


Ambient Benzene Concentration ug/m3
0.00 - 0.33
0.34 - 0.63
0.64 - 1.27
1.28 - 2.36
2.37 - 10.99
Water samples
Limited Access
Highway
Major Road
Local Road
Minor Road
Other Road
Ramp
Ferry
Pedestrian Way
N
Sanford
Fayetteville
Clinton
Lumberton
Fort Bragg Military Reservation
Wilmington
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community


Benzene in water µg/L
0.00
0.01 - 0.02
0.03
0.04
0.06 - 0.39
N
Raleigh
Cary
Wilson
Goldsboro
Sanford
Fayetteville
Clinton
Lumberton
Fort Bragg Military Reservation
Wilmington
Sources: Esri, HERE, Garmin, Intermap, increment P Corp., GEBCO, USGS, FAO, NPS, NRCAN, GeoBase, IGN, Kadaster NL, Ordnance Survey, Esri Japan, METI, Esri China (Hong Kong), swisstopo, © OpenStreetMap contributors, and the GIS User Community

NASA/USGS Photo

Hurricane Florence Presents Environmental Health Challenges for the Carolinas

Published September 20, 2018

Hurricane Florence caused widespread flooding and destruction throughout the Carolinas and parts of Virginia. Officials are still in the early stages of evaluating the full impact of the storm, but it's clear from reports of coal ash spills, flooded hog waste lagoons, and the inundation of hazardous waste sites that there are, and will continue to be, serious environmental health concerns in the storm's wake.

The Duke University Superfund Research Center is actively engaged in efforts to assess and respond to these concerns, and we will work with communities in the southeastern part of North Carolina to understand and mitigate risks of exposure to contaminants that may have migrated from hazardous waste sites damaged by the storm and subsequent flooding.

Credit: Waterkeeper Alliance

A team of scientists coordinated by Elena Craft, a former Duke Superfund trainee and current Environmental Health Scientist at the Environmental Defense Fund, have been on the coast this week taking environmental samples of floodwaters, air, soil, and sediment in an attempt to characterize the contaminants that may be present, their concentrations, and their likely sources. Duke Superfund Investigator Lee Ferguson and DUSRC Analytical Chemistry Core Manager Abigail Joyce joined the team in the field, along with researchers from the Texas A&M University Superfund Research Center.

The Community Engagement and Research Translation Cores will be assisting researchers by connecting them with local groups in the Wilmington area, facilitating conversations about community needs, and sharing and translating research on environmental health impacts to a variety of stakeholders throughout the response

Duke Superfund Begins Floodwater Testing in Wake of Hurricane Florence

Published September 24, 2018

Lee Ferguson interviewed about floodwater sampling and potential environmental health concerns. Credit: *newsy*

On September 19th, Principal Investigator Lee Ferguson and Analytical Chemistry Core Manager Abigail Joyce, collected floodwater samples along the Neuse River and some of its tributaries. The Analytical Chemistry Core will conduct a 'non-target analysis' on the samples, allowing them to test for the presence of multiple chemicals and quantify them without the need to know what they're looking for ahead of time. Non-target analysis is a vital tool for assessing environmental health risks after flooding events that have many potential sources of contamination.

Dr. Ferguson and Dr. Joyce join a collaborative of scientists coordinated by Elena Craft, Environmental Health Scientist at the Environmental Defense Fund that have been on the coast this week taking environmental samples of floodwaters, air, soil, and sediment in an attempt to characterize the contaminants that may be present, their concentrations, and their likely sources. Researchers from the Texas A&M University Superfund Research Center are also on site, and were involved in similar work following Hurricane Harvey last year. The

RECENT POSTS

CEC release guides on collecting data on contaminants in fish and on communicating about fish consumption advisories
October 31, 2022

Duke Superfund Research Center awarded 5-year $11.7 million grant for continued environmental health and exposure research
October 21, 2022

New A Letter Home: Contemplating the State of Dead Worms
August 11, 2022

When Choosing Paint Colors, Keep this in Mind
August 11, 2022

ITC Fire 2019

https://www.abcactionnews.com/news/national/firefighters-battle-massive-fire-at-itc-petrochemical-plant-in-deer-park-texas

- Fire began near an 80,000 gallon above ground storage tank containing naphtha–a feedstock or blendstock used to produce gasoline
- Facility was not equipped with a fixed gas detection system to alert ITC employees of the release
- Naphtha was being released by the tank; both ITC and responders were unable to stop the release to control the fire due to the blaze
- At the time, there were 242 storage tanks on the ITC property ranging in size from 8,000 barrels to 160,000 barrels storage capacity

CSB
U.S. Chemical Safety and Hazard Investigation Board

Storage Tank Fire at Intercontinental Terminals Company, LLC (ITC) Terminal

Deer Park, Texas | *Incident Date: March 17, 2019* | No. 2019-01-I-TX

Factual Update

Published: October 30, 2019

Ambient Air Monitoring Following Natural Disasters and Industrial Accidents, 2017-2021

January 28, 2022

TEXAS COMMISSION ON ENVIRONMENTAL QUALITY

Figure 2. Max Benzene Concentrations Measured around Hurricane Harvey.

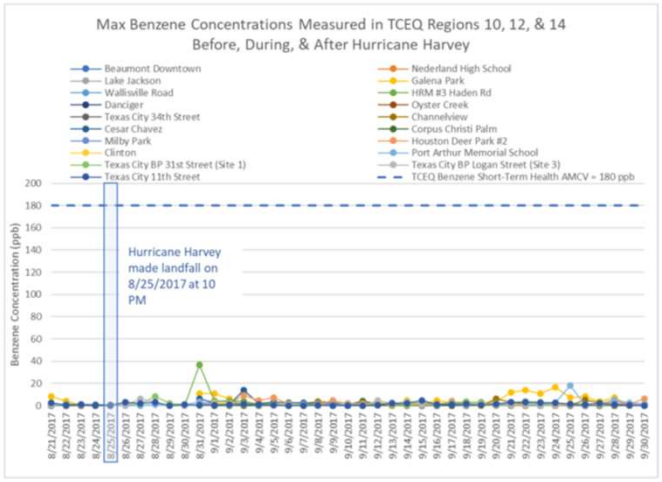
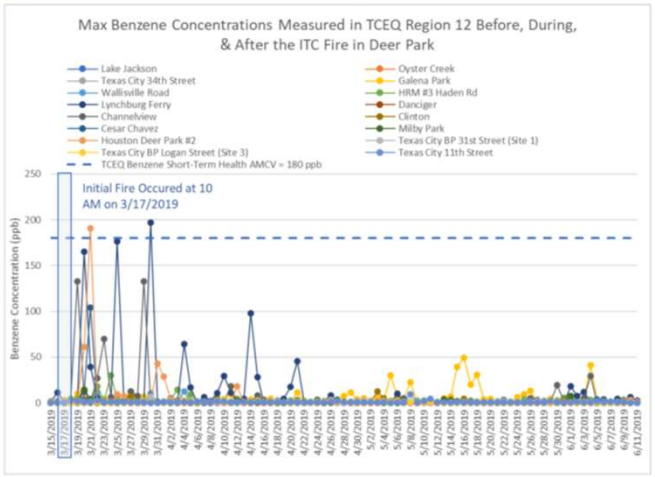


Figure 10. Max Benzene Concentrations Measured around the ITC Fire.



State report shows how Texas environmental agency misses industrial pollution spikes during and after storms

> A more than 200-page report by Texas' environmental agency found that the majority of pollution emitted by industrial facilities during storms occurs at a time when the state's air monitors are offline.

BY ERIN DOUGLAS JAN. 28, 2022 3 PM CENTRAL

COPY LINK REPUBLISH

The flooded plant of French chemical maker Arkema SA, which produces organic peroxides, is seen after fires were reported at the facility after Hurricane Harvey passed in Crosby in 2017. REUTERS/Adrees Latif

Responding to Disasters

HURRICANE HARVEY REGISTRY

Disaster Medicine and Public Health Preparedness

www.cambridge.org/dmp

Brief Report

Journal of Exposure Science & Environmental Epidemiology

www.nature.com/jes

ARTICLE OPEN

The Texas flood registry: a flexible tool for environmental and public health practitioners and researchers

Marie Lynn Miranda[1,2✉], Rashida Callender[3], Joally M. Canales[3], Elena Craft[4], Katherine B. Ensor[5], Max Grossman[1], Loren Hopkins[5,6], Jocelyn Johnston[1], Umair Shah[7,8] and Joshua Tootoo[1]

BACKGROUND: Making landfall in Rockport, Texas in August 2017, Hurricane Harvey resulted in unprecedented flooding, displacing tens of thousands of people, and creating environmental hazards and exposures for many more.
OBJECTIVE: We describe a collaborative project to establish the Texas Flood Registry to track the health and housing impacts of major flooding events.
METHODS: Those who enroll in the registry answer retrospective questions regarding the impact of storms on their health and housing status. We recruit both those who did and did not flood during storm events to enable key comparisons. We leverage partnerships with multiple local health departments, community groups, and media outlets to recruit broadly. We performed a preliminary analysis using multivariable logistic regression and a binomial Bayesian conditional autoregressive (CAR) spatial model.
RESULTS: We find that those whose homes flooded, or who came into direct skin contact with flood water, are more likely to experience a series of self-reported health effects. Median household income is inversely related to adverse health effects, and spatial analysis provides important insights within the modeling approach.
SIGNIFICANCE: Global climate change is likely to increase the number and intensity of rainfall events, resulting in additional health burdens. Population-level data on the health and housing impacts of major flooding events is imperative in preparing for our planet's future.

Keywords: Air pollution, Climate change, Geospatial Analyses

Journal of Exposure Science & Environmental Epidemiology (2021) 31:823–831; https://doi.org/10.1038/s41370-021-00347-z

INTRODUCTION

Hurricane Harvey made landfall on August 26, 2017 in Rockport, Texas, just southwest of Houston. Hurricane Harvey conjures vivid images of huge swaths of flooded areas, with dramatic boat and helicopter rescues of people of all ages and backgrounds. Dumping over 50 inches of rain on the Houston region, Harvey was the most significant tropical cyclone rainfall event in United States history, resulting in unprecedented flooding, including 300,000 confirmed flooded structures [1]. Over 40 counties in the region were declared disaster areas due to the storm [2]. At least 68 people died in Texas from the direct effects of Hurricane Harvey, representing the largest number of direct deaths from a tropical cyclone in the state since 1919 [1]. Less well understood, however, are the long term health and housing effects that will inevitably result from the storm.

Flooding in Houston brings additional environmental health concerns to its residents. The greater Houston area includes roughly 570 chemical plants, 43 Superfund sites (13 of which flooded), 9 refineries, 188 cement batch plants, 80 metal recycling facilities, as well as numerous underground storage tanks [3–6]. For the three most prevalent carcinogenic hazardous air pollutants—benzene, 1,3 butadiene, and formaldehyde – the area is subject to routine industrial emissions of over 472 tons/year [7]. Industry reported unexpected emissions events during the week of Harvey, releasing ~30 tons of benzene and 34 tons of 1,3 butadiene. Events at the Arkema plant in Crosby required evacuation of the residents in that area [8]. Elevated levels of benzene were observed in the Manchester neighborhood near the Houston Ship Channel with measurements of over 300 ppb, exceeding the 100 ppb level at which special breathing equipment is recommended [9, 10]. Measurements by EPA of dioxin in the San Jacinto riverbed were 70,000 nanograms per kilogram, compared to the recommended clean up level of 30 nanograms per kilogram for the site [11, 12].

Receding flood waters resulted in widespread mold and bacterial contamination in residential and commercial structures [13]. There is also uncertainty related to the complex mixtures of contaminants, as well as the impact of psychological stress. The potential for health risk is clear.

Public health registries play a key role in our understanding of health outcomes resulting from exposure to an event, disaster or

[1]Children's Environmental Health Initiative, University of Notre Dame, South Bend, IN, USA. [2]Department of Applied and Computational Mathematics and Statistics, University of Notre Dame, South Bend, IN, USA. [3]Children's Environmental Health Initiative, Rice University, Houston, TX, USA. [4]Environmental Defense Fund, Austin, TX, USA. [5]Department of Statistics, Rice University, Houston, TX, USA. [6]Houston Health Department, Houston, TX, USA. [7]Harris County Public Health, Houston, TX, USA. [8]Washington State Department of Health, Olympia, WA, USA. ✉email: mlm@nd.edu

Received: 22 October 2020 Revised: 24 May 2021 Accepted: 25 May 2021
Published online: 26 June 2021

Responding to Natural and Industrial Disasters: Partnerships and Lessons Learned

Elaine Symanski PhD[1,2], Heyreoun An Han PhD[2], Inkyu Han PhD[3], Michelle McDaniel BS[3], Kristina W. Whitworth PhD[1,2], Sheryl McCurdy PhD[3,4], William Brett Perkison MD, MPH[3], Amal Rammah PhD[1,2], P. Grace Tee Lewis PhD[5], George L. Delclos MD, MPH, PhD[3], Elena Craft PhD[5], Melissa Bondy PhD[6], Cheryl Lyn Walker PhD[2,7], Loren Hopkins PhD[8,9], José Guillermo Cedeño Laurent ScD[10] and Daisy James MS[8]

[1]Center for Precision Environmental Health, Department of Medicine, Baylor College of Medicine, Houston, Texas, USA; [2]Gulf Coast Center for Precision Environmental Health, Baylor College of Medicine, Houston, Texas, USA; [3]Southwest Center for Occupational and Environmental Health (SWCOEH), The University of Texas Health Science Center at Houston (UTHealth) School of Public Health, Houston, Texas, USA; [4]Center for Health Promotion and Prevention Research, UTHealth School of Public Health, Houston, Texas, USA; [5]Environmental Defense Fund, Austin, Texas, USA; [6]Department of Epidemiology and Population Health, Stanford University, Stanford, California, USA; [7]Center for Precision Environmental Health, Departments of Molecular & Cell Biology and Medicine, Baylor College of Medicine, Houston, Texas, USA; [8]Houston Health Department, Houston, Texas, USA; [9]Department of Statistics, Rice University, Houston, Texas, USA and [10]Department of Environmental Health, Harvard T.H. Chan School of Public Health, Boston, Massachusetts, USA

Abstract

Objectives: The aim of this study was to provide insights learned from disaster research response (DR2) efforts following Hurricane Harvey in 2017 to launch DR2 activities following the Intercontinental Terminals Company (ITC) fire in Deer Park, Texas, in 2019.
Methods: A multidisciplinary group of academic, community, and government partners launched a myriad of DR2 activities.
Results: The DR2 response to Hurricane Harvey focused on enhancing environmental health literacy around clean-up efforts, measuring environmental contaminants in soil and water in impacted neighborhoods, and launching studies to evaluate the health impact of the disaster. The lessons learned after Harvey enabled rapid DR2 activities following the ITC fire, including air monitoring and administering surveys and in-depth interviews with affected residents.
Conclusions: Embedding DR2 activities at academic institutions can enable rapid deployment of lessons learned from one disaster to enhance the response to subsequent disasters, even when those disasters are different. Our experience demonstrates the importance of academic institutions working with governmental and community partners to support timely disaster response efforts. Efforts enabled by such experience include providing health and safety training and consistent and reliable messaging, collecting time-sensitive and critical data in the wake of the event, and launching research to understand health impacts and improve resiliency.

Medical News & Perspectives

Determining Health Effects of Hazardous Materials Released During Hurricane Harvey

M.J. Friedrich

When Hurricane Harvey parked over the gulf coast of Texas, dumping as much as 50 inches of rain on Houston and its surrounding areas, including the Galveston Bay and Houston Ship Channel, concerns grew about the threat of toxic exposures from the more than 500 industrial sites peppering the area.

Sorting out which hazardous chemicals were released from numerous hot spots in the region is an enormous task. Researchers still can't say for sure which chemical exposures are of greatest concern as a result of the hurricane, or the adverse health outcomes these exposures might portend.

But even before the floodwaters had receded, researchers began to determine the health consequences of chemical exposures to the more than 6.5 million residents of the Houston area by sampling the air, water, and sediment; tracking hazardous exposures; and working to strengthen safeguards to protect communities from future disasters.

Assessing the Damage

Chemical plants, oil refineries, and hazardous waste sites—including dozens of abandoned Superfund sites contaminated with highly toxic chemicals that the Environmental Protection Agency (EPA) has slated for clean-up—have contributed a wide range of waste products and toxic pollutants to the floodwaters from Hurricane Harvey. Toxicants, such as dioxins, polyaromatic hydrocarbons (PAHs), polychlorinated biphenyls (PCBs), pesticides, phthalates, and metals that accumulated in sediments of the ship channel and bay, were likely churned up and spread by floodwaters during the hurricane, mixing with chemicals from local industrial wastelands, residences, and businesses.

Elena Craft, PhD, a toxicologist with the Environmental Defense Fund (EDF), a nonprofit environmental advocacy group, has been working in the Houston area for about a decade, primarily monitoring air quality. "With the density of industry here, there is ongoing concern about air toxins like benzene and 1,3-butadiene, as well as ozone," she said.

After Hurricane Harvey dissipated, Craft and her group detected high concentrations of the carcinogen benzene in the Manchester community in southeastern Houston next to the Valero Energy refinery along the ship channel. "The fact that we were able to find high concentrations of benzene that weren't registered by the existing monitoring networks is concerning," she said. Acute exposure can cause eye and skin irritation as well as headache, dizziness, tremors, and confusion.

While there are a lot of air monitors, they are sparsely located and don't provide a full picture of air quality at a microscale level. "We need better information at higher resolution," Craft said, "because if you live in that community, you care about microscale."

Underscoring an Existing Problem

The threat of toxic chemical exposure is not new for the city of Houston.

"The folks who live in communities such as Manchester have been concerned for many years about the health impacts of living near the ship channel and the industries concentrated there," said Jennifer Horney, PhD, associate professor in the department of epidemiology and biostatistics at Texas A&M University (TAMU) in College Station.

Horney is a disaster preparedness expert who leads an interdisciplinary research group at the university called the Institute for Sustainable Communities. For the last several years, she has been working to identify and measure water, soil, and air contaminants along the Ship Channel and Sims Bayou Watershed. In a recent sampling study carried out before the hurricane, for example, Horney and her group found high levels of PAHs—a known carcinogen emitted from petroleum-based processing—in homes of Manchester residents.

Communities such as Manchester that are most at risk are made up disproportionately of low-income people and people of color, said Robert Bullard, PhD, professor of urban planning, environmental policy, and administration of justice at Texas Southern University in Houston.

Previous studies have identified potential linkages between chronic exposure to toxicants and poor health outcomes among the mostly poor and minority residents of these marginalized communities, including a 2016 study by the Union of Concerned Scientists.

In reality, the disaster that we're talking about with Harvey actually occurred before

An official website of the United States government Here's how you know

COVID-19

- Get the latest public health information from CDC
- Get the latest research information from NIH | Español

Environmental Factor
Your Online Source for NIEHS News
NOVEMBER 2018

NIH National Institute of Environmental Health Scienc

All Issues Subscribe RSS +A -A

Home | Science Highlights | Community Impact | Papers Published | Awards & Recognition | Beyond the Bench

Researchers respond quickly after Hurricane Florence

Previous Article | Next Article

After Hurricane Florence devastated southeastern North Carolina, NIEHS grantees hit the ground running to test for contaminants.

BY SARA AMOLEGBE

After Hurricane Florence devastated parts of North and South Carolina in September, current and former NIEHS Superfund Research Program (SRP) grantees hit the ground running to test for pollution. As soon as they could reach areas affected by severe flooding, SRP researchers teamed up to take air, soil, and water samples in an effort to characterize contaminants that might be present, including concentrations and likely sources.

The team saw the flooding firsthand, including in Lumberton, North Carolina, where the Lumber River flooded the Lumberton Science and Technology Center. (Photo courtesy of Tony Miller)

"With tens of thousands of homes damaged, it is likely that the storm also damaged industrial facilities and waste sites, increasing the potential risk for exposure to harmful pollution," said Elena Craft, Ph.D., a senior director at the Environmental Defense Fund (EDF).

Craft is a former Duke University SRP Center trainee and winner of the 2002 SRP Wetterhahn Award. She coordinates the sampling team, which consists of researchers from SRP centers at Duke and Texas A&M University, as well as SRP small business grantee Entanglement Technologies.

Connecting with the community

Duke SRP Center staff are coordinating with research staff and working with communities in southeastern North Carolina to discuss potential risks and ways to reduce exposures from contaminants that may have migrated from hazardous waste sites damaged by the storm and flooding.

Bryan Luukinen, coordinator of the Duke SRP Center Research Translation and Community Engagement Core, is leading efforts to connect researchers with local community partners in the Wilmington area.

The group works with community members to understand their needs, and shares research needs and findings throughout the response and recovery process.

Check out these web resources that Luukinen shared.

- Addressing Environmental Health Concerns After a Hurricane.
- Flooding and Potential Environmental Contamination

On-site testing

After the first few days of testing, the team was happy to report that they did not det dangerous levels of benzene, trichloroethylene (TCE), mercury, perfluorooctanoic aci and other specific contaminants. They sampled air, soil, and water at locations in Nor Carolina, including around Fayetteville, Wilmington, Lumberton, and Maxton. As they continue their work, the researchers are looking for additional contaminants around the Neuse River basin.

"Because of the hog farming and the other types of agriculture, especially in the Neu River watershed, we're going to be looking for signatures of agriculture," said Lee Ferguson, Ph.D., an associate professor of environmental chemistry at Duke and member of the Duke SRP Center. "For example, pesticides, herbicides, antibiotics, an other kinds of contaminants might be associated with hog farming or other intensive agriculture."

Sampling team members hit the road out of EDF's Raleigh headquarters. From left, Casillas, Duke SRP Center student Anna Lewis, Miller, Craft, and Gunnar Skulason, from Entanglement Technologies. (Photo courtesy of Tony Miller)

Combining SRP expertise

Gaston Casillas, a trainee from Texas A&M University SRP Center, worked on the response team. Texas A&M researchers plan to compare samples taken after Hurricane Harvey in Houston — an area widely known to be affected by chemical manufacturing and other industrial facilities — with those taken in rural North Caroli

"In participating in responses to these events, we can truly put our basic research an development of our sampling methods, analysis methods, and communication methods to the test," Casillas said.

Casillas collected soil samples after Hurricane Florence in Eastern North Carolina. (Photo courtesy of Gaston Casillas)

International Journal of Environmental Research and Public Health

MDPI

Article

Spatial and Temporal Analysis of Impacts of Hurricane Florence on Criteria Air Pollutants and Air Toxics in Eastern North Carolina

Sharmila Bhandari [1,2], Gaston Casillas [1], Noor A. Aly [1,2], Rui Zhu [3], Galen Newman [3], Fred A. Wright [4], Anthony Miller [5], Gabriela Adler [6], Ivan Rusyn [1,2] and Weihsueh A. Chiu [1,2,*]

1 Department of Veterinary Integrative Biosciences, Texas A&M University, College Station, TX 77843, USA; sharmilatbhandari@gmail.com (S.B.); casillas.gaston@gmail.com (G.C.); naly@cvm.tamu.edu (N.A.A.); irusyn@cvm.tamu.edu (I.R.)
2 Interdisciplinary Faculty of Toxicology, Texas A&M University, College Station, TX 77843, USA
3 Department of Landscape Architecture and Urban Planning, Texas A&M University, College Station, TX 77844, USA; zr1991@tamu.edu (R.Z.); gnewman@arch.tamu.edu (G.N.)
4 Bioinformatics Research Center, Departments of Statistics and Biological Sciences, North Carolina State University, Raleigh, CA 27695, USA; fred_wright@ncsu.edu
5 Entanglement Technologies, San Bruno, CA 94066, USA; amiller@entanglementtech.com
6 Breezometer, Haifa 3303124, Israel; gabrielaa@breezometer.com
* Correspondence: wchiu@cvm.tamu.edu; Tel.: +1-979-845-4106

Abstract: Natural and anthropogenic disasters are associated with air quality concerns due to the potential redistribution of pollutants in the environment. Our objective was to conduct a spatiotemporal analysis of air concentrations of benzene, toluene, ethylbenzne, and xylene (BTEX) and criteria air pollutants in North Carolina during and after Hurricane Florence. Three sampling campaigns were carried out immediately after the storm (September 2018) and at four-month intervals. BTEX were measured along major roads. Concurrent criteria air pollutant concentrations were predicted from modeling. Correlation between air pollutants and possible point sources was conducted using spatial regression. Exceedances of ambient air criteria were observed for benzene (in all sampling periods) and PM2.5 (mostly immediately after Florence). For both, there was an association between higher concentrations and fueling stations, particularly immediately after Florence. For other pollutants, concentrations were generally below levels of regulatory concern. Through characterization of air quality under both disaster and "normal" conditions, this study demonstrates spatial and temporal variation in air pollutants. We found that only benzene and PM2.5 were present at levels of potential concern, and there were localized increases immediately after the hurricane. These substances warrant particular attention in future disaster response research (DR2) investigations.

Keywords: air pollution; geospatial analyses; criteria pollutants; volatile organic compounds

check for updates

Citation: Bhandari, S.; Casillas, G.; Aly, N.A.; Zhu, R.; Newman, G.; Wright, F.A.; Miller, A.; Adler, G.; Rusyn, I.; Chiu, W.A. Spatial and Temporal Analysis of Impacts of Hurricane Florence on Criteria Air Pollutants and Air Toxics in Eastern North Carolina. *Int. J. Environ. Res. Public Health* **2022**, *19*, 1757. https://doi.org/10.3390/ijerph19031757

Academic Editors: Danielle J. Carlin and Cynthia V. Rider

Received: 9 December 2021
Accepted: 31 January 2022
Published: 3 February 2022

1. Introduction

The increase in the frequency and intensity of hurricanes and typhoons is one of the most notable signs of climate change [1]. While the monetary losses due to destruction of property are among the most notable concerns regarding natural disasters [2], the potential for immediate and delayed human health effects from environmental mobilization of contaminants is also widely acknowledged [1,3]. Increasing attention is being devoted to the potential for natural disasters to affect the release, fate, and transport of air pollutants in the environment [4]. Air pollution includes both criteria air pollutants regulated by national ambient air quality standards (e.g., ozone, particulate matter, lead, nitrogen dioxide, carbon monoxide, and sulfur dioxide) and air toxics, such as volatile organic compounds (VOCs).

The adverse health effects of criteria air pollutants are well established and the scientific evidence for ambient air quality standards are periodically updated by various regulatory bodies [5]. The associations between climate change, criteria air pollutants and human

EPA United States Environmental Protection Agency

Search EPA.gov

Environmental Topics | Laws & Regulations | Report a Violation | About EPA

News Releases: Headquarters | Office of the Administrator (AO)

CONTACT US

EPA Administrator Regan Announces Bold Actions to Protect Communities Following the Journey to Justice Tour

Initial set of steps includes multiple actions to protect public health and community specific deliverables

January 26, 2022

Contact Information
EPA Press Office (press@epa.gov)

WASHINGTON (Jan. 26, 2022) – Following through on his commitment to
Protection Agency Administrator Michael S. Regan announced today the fi
communities historically and disproportionately impacted by pollution. TI
driven efforts, reflect Administrator Regan's commitment to deliver enviro
and are part of the Biden-Harris Administration's whole-of-government ap
marginalized, underserved, and overburdened by pollution.

"In every community I visited during the Journey to Justice tour, the mess
state, and federal agencies have to do better," **said EPA Administrator Mic**
these communities for decades. Our actions will begin to help not only the
country who have suffered from environmental injustices."

In response to concerns from residents in overburdened neighborhoods, E
visited on the tour. In addition, EPA is outlining a series of broad policy act

- Committing EPA to aggressively use its authority to conduct unannoun
needed to protect public health. When facilities are found to be non-cc
accountable.
- Deploying a new program to expand air monitoring capacity, utilizing a
monitoring vehicle, and additional air pollution inspectors to enhance
- Mobilizing agency resources to invest in community air monitoring to b
- Pressing state and local elected officials to take urgent action to better
- Holding companies more accountable for their actions in overburdene
polluting facilities.
- Applying best available science to agency policymaking to safeguard p

HOUSTON CHRONICLE

STAY INFORM
26 WEEKS FO

SALE! GET AN ENTIRE 26 WEEKS FOR 99¢ | DIGITAL ACCESS ACT NOW

LOCAL // ENVIRONMENT

EPA promises help with contaminated Fifth Ward rail yard, targeting 'unjust conditions'

Emily Foxhall, Staff writer
Jan. 26, 2022 | Updated: Jan. 27, 2022 2:47 p.m.

1 of 11

EPA Administrator Michael S. Regan listens during a Houston Environmental Justice Roundtable at Fifth Ward Missionary Baptist Church in Houston on Nov. 19, 2021. Administrator Regan's stop was part of a week-long trip through Mississippi, Louisiana and Texas to highlight environmental justice concerns, hear from impacted communities and discuss solutions for communities most in need.

Elizabeth Conley, Houston Chronicle / Staff photographer

HOUSTON, Tex
Wednesday to h
due to railroad c

ENVIRONMENTAL PROTECTION AGENCY

Kashmere Gardens in Fifth Ward set to be cleaned up by EPA after decades of contaminated soil

By Pooja Lodhia
Wednesday, January 26, 2022 9:02PM

EMBED <>

Those who live i
in their area.

EPA chief promises action after Houston residents blame cancer deaths on toxic rail yard

CBS EVENING NEWS

BY JANET SHAMLIAN
UPDATED ON: NOVEMBER 20, 2021 / 3:43 PM / CBS NEWS

News 88.7

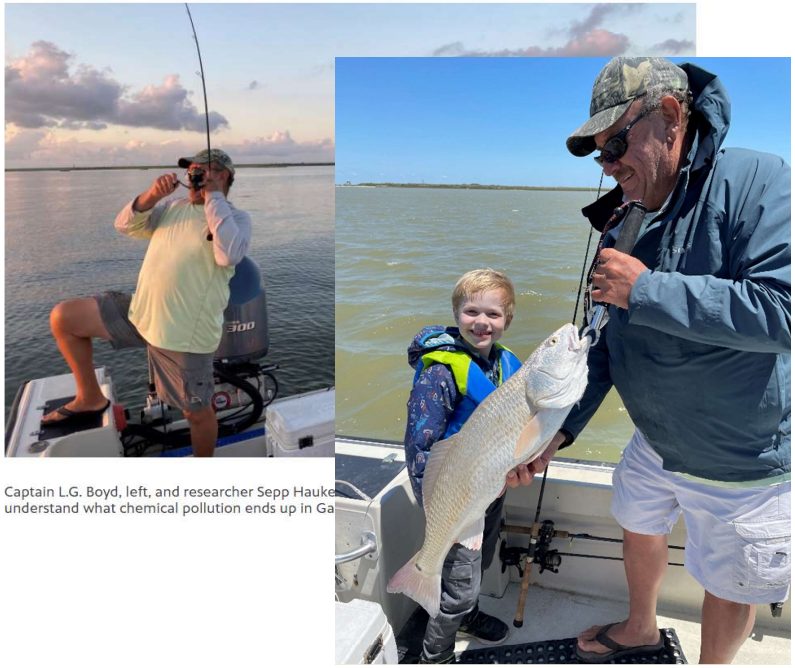
inDepth ENERGY & ENVIRONMENT

Galveston Bay researchers are fishing for data about chemical runoff — literally

Industrial facilities along Houston's Ship Channel are increasingly at risk of flooding as climate change accelerates rising sea levels and strengthens storms. Now, local researchers are examining how pollution runoff during these flood events is impacting the bay's ecosystem — and how to mitigate it.

KATIE WATKINS | OCTOBER 12, 2021, 7:29 AM

Share



Captain L.G. Boyd, left, and researcher Sepp Hauke understand what chemical pollution ends up in Ga

The National Academies of | SCIENCES ENGINEERING MEDICINE

SEARCH

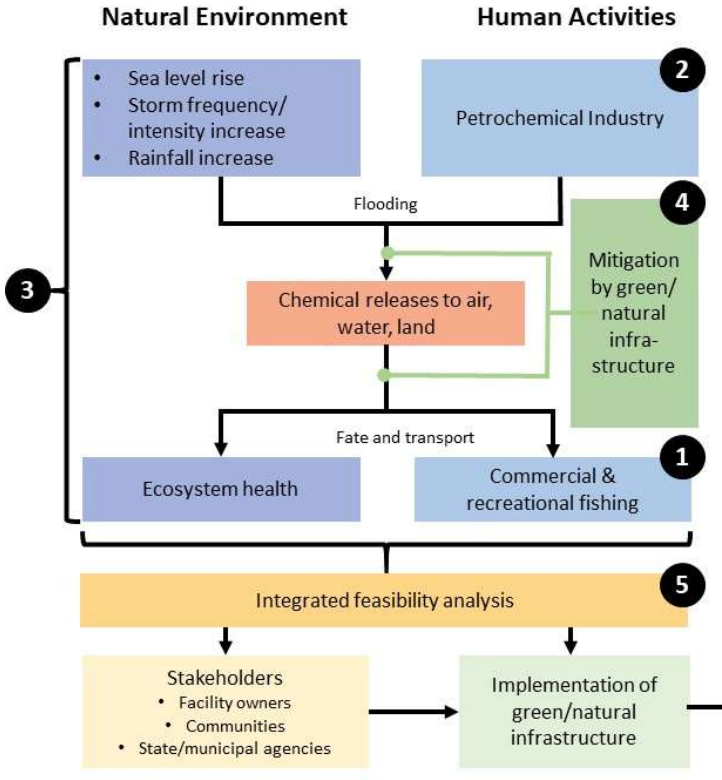
About Us | Events | Our Work | Publications | Topics | Engagement | Opportunities

SHARE

National Academies' Gulf Research Program Awards $5.27 Million to Enhance Understanding of Gulf Ecosystems and Their Interactions with Natural Processes and Human Activities

News Release | **November 10, 2020**

WASHINGTON — The Gulf Research Program (GRP) of the National Academies of Sciences, Engineering, and Medicine today announced grant awards totaling $5.27 million for six new projects. These projects, planned to span two to three years, aim to improve understanding of how natural processes and human activities interact to affect coastal ecosystems in the U.S. Gulf Coast region.



Project Aims

1. Baseline sampling of existing chemical contamination in commercial fish
2. Prioritization and characterization of petrochemical facilities using baseline data and risk metrics of chemical hazards
3. Computational modeling of flooding, chemical releases, fate and transport
4. Development of green/natural infrastructure-based mitigation strategies for high priority facilities
5. Integrated feasibility analysis outlining planning and design criteria for green/natural infrastructure-based mitigation of impacts from chemical releases

EDF ENVIRONMENTAL DEFENSE FUND

Elena Craft, PhD
Project Lead

Cloelle Danforth, PhD
Project Manager,
Aims 1 & 2

Sepp Haukebo
Aim 1

Shannon Cunniff
Aim 4 & 5

Lauren Padilla, PhD
Aim 3

Devyani Kar, PhD
Aim 4 & 5

TEXAS A&M UNIVERSITY

Weihsueh Chiu, PhD
Aim 2

James Kaihatu, PhD
Aim 3

Galen Newman, PhD
Aim 4

Garett Sansom, PhD
Aim 4

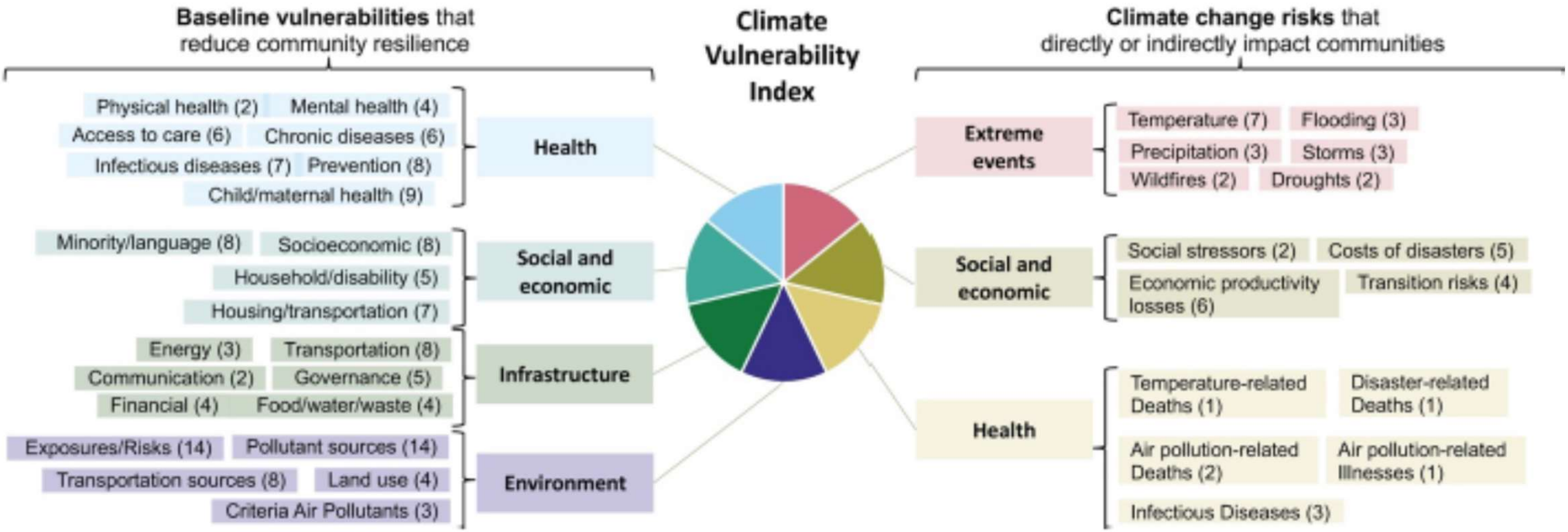
Thomas McDonald, PhD
Aim 1

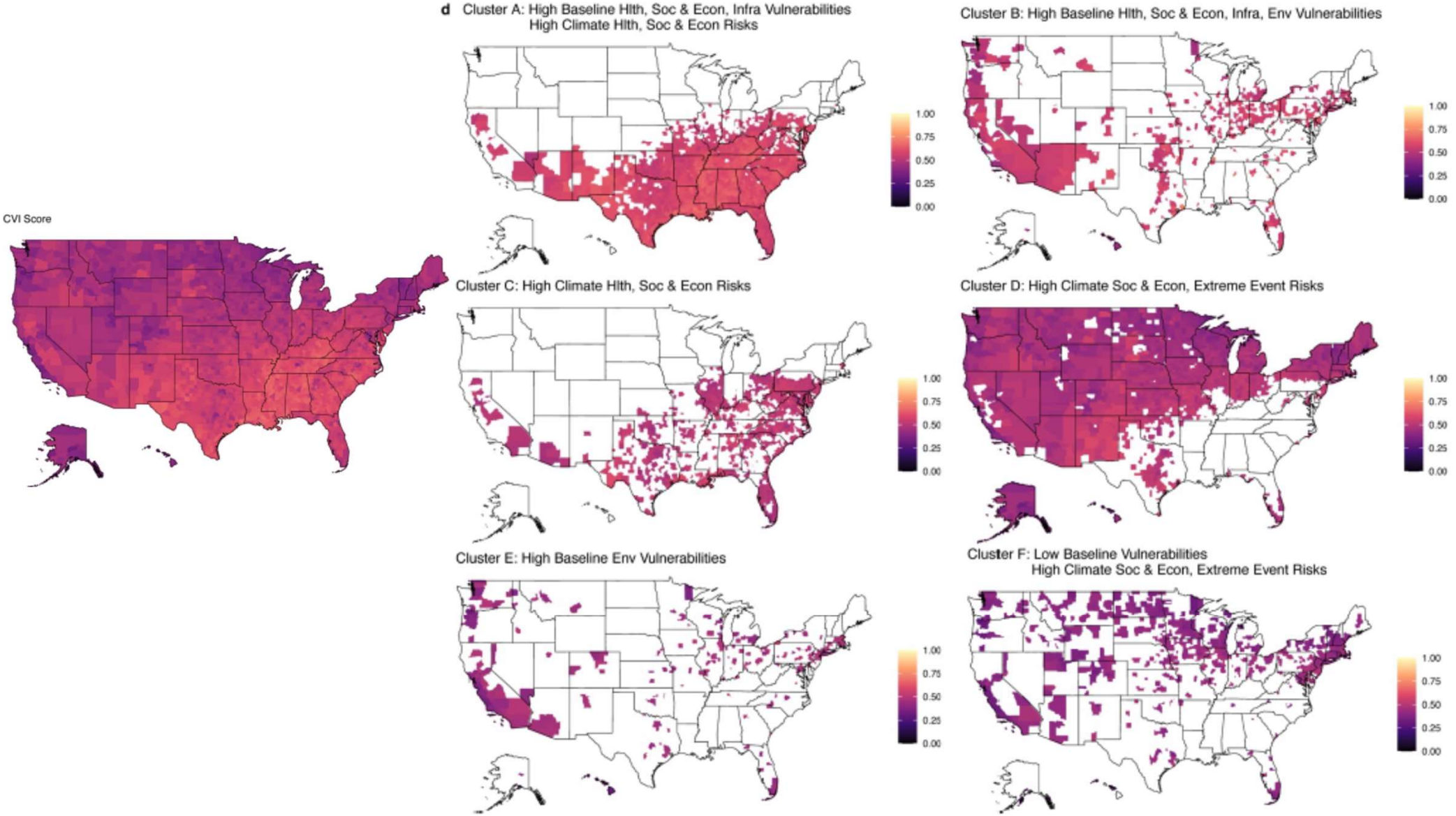
GALVESTON BAY FOUNDATION

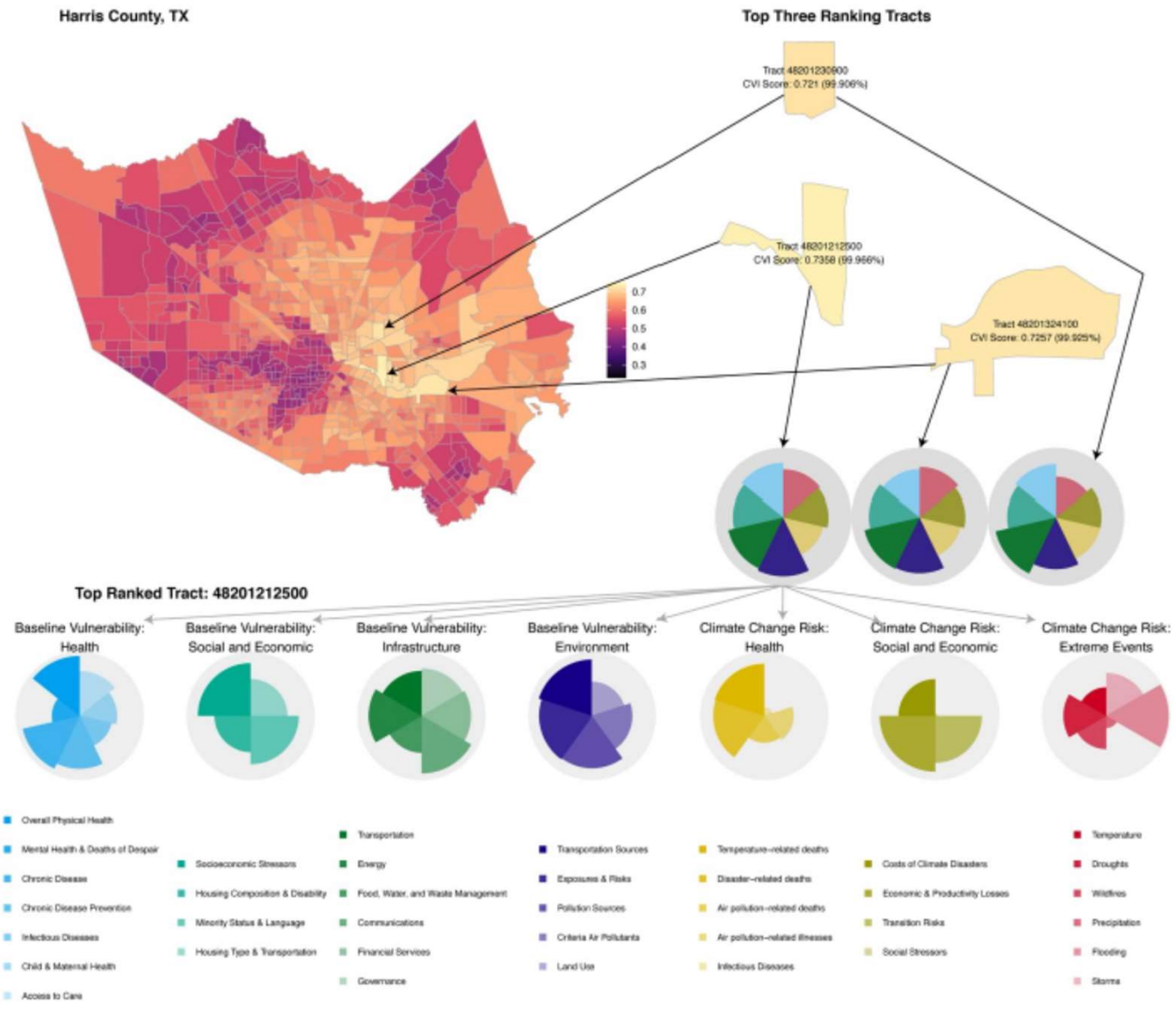
Charlotte Cisneros
Aim 1 & 5

Scott Jones
Aim 1 & 5

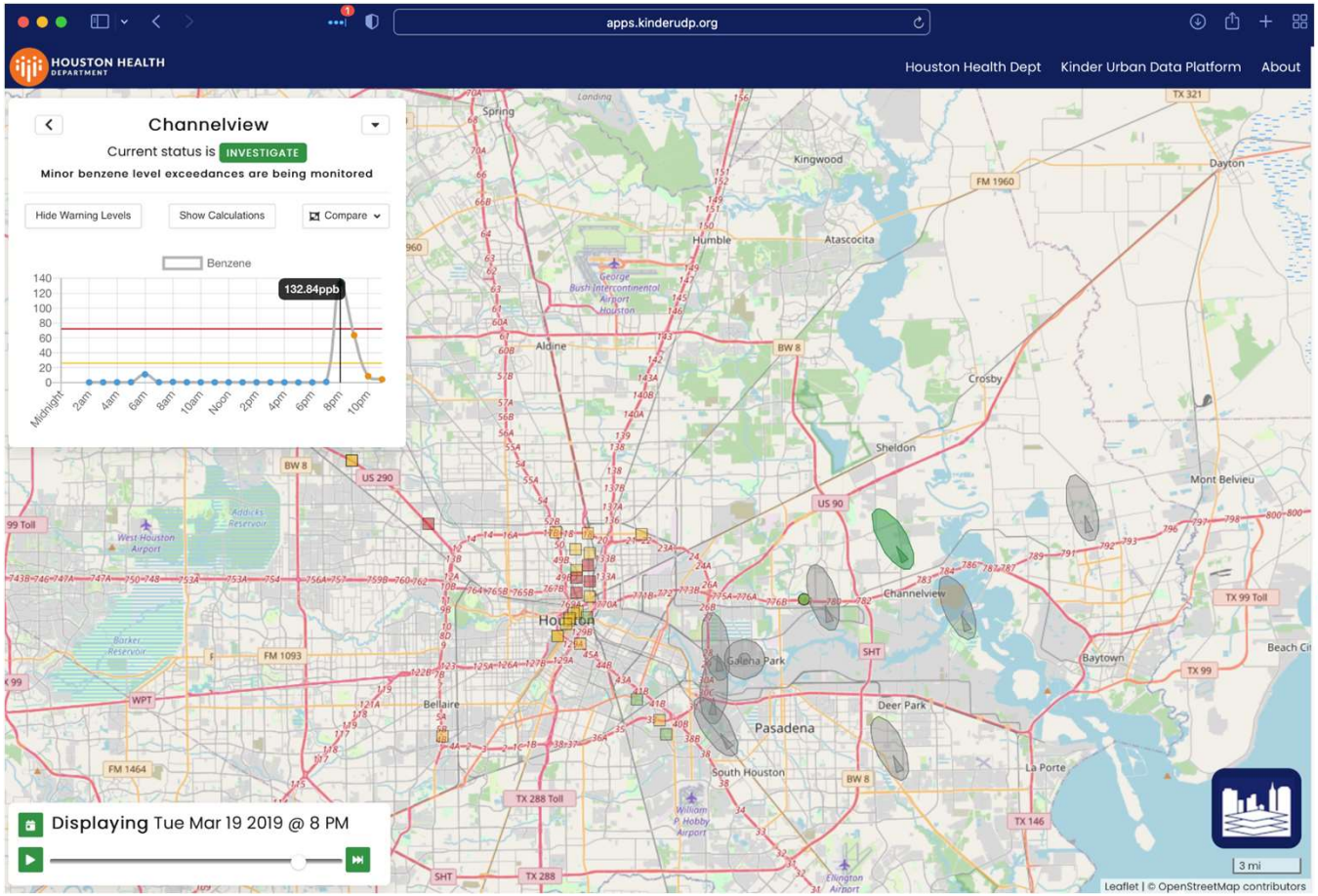
New Efforts to Understand Disparities Related to Climate & Health




CVI Score
d
Cluster A: High Baseline Hlth, Soc & Econ, Infra Vulnerabilities
High Climate Hlth, Soc & Econ Risks
Cluster B: High Baseline Hlth, Soc & Econ, Infra, Env Vulnerabilities
Cluster C: High Climate Hlth, Soc & Econ Risks
Cluster D: High Climate Soc & Econ, Extreme Event Risks
Cluster E: High Baseline Env Vulnerabilities
Cluster F: Low Baseline Vulnerabilities
High Climate Soc & Econ, Extreme Event Risks
1.00
0.75
0.50
0.25
0.00


Harris County, TX
Top Three Ranking Tracts
Tract 48201230900
CVI Score: 0.721 (99.906%)
Tract 48201212500
CVI Score: 0.7358 (99.966%)
Tract 48201324100
CVI Score: 0.7257 (99.925%)
0.7
0.6
0.5
0.4
0.3
Top Ranked Tract: 48201212500
Baseline Vulnerability: Health
Baseline Vulnerability: Social and Economic
Baseline Vulnerability: Infrastructure
Baseline Vulnerability: Environment
Climate Change Risk: Health
Climate Change Risk: Social and Economic
Climate Change Risk: Extreme Events
Overall Physical Health
Mental Health & Deaths of Despair
Chronic Disease
Chronic Disease Prevention
Infectious Diseases
Child & Maternal Health
Access to Care
Socioeconomic Stressors
Housing Composition & Disability
Minority Status & Language
Housing Type & Transportation
Transportation
Energy
Food, Water, and Waste Management
Communications
Financial Services
Governance
Transportation Sources
Exposures & Risks
Pollution Sources
Criteria Air Pollutants
Land Use
Temperature-related deaths
Disaster-related deaths
Air pollution-related deaths
Air pollution-related illnesses
Infectious Diseases
Costs of Climate Disasters
Economic & Productivity Losses
Transition Risks
Social Stressors
Temperature
Droughts
Wildfires
Precipitation
Flooding
Storms

Real time exposure condition visualization algorithm for mapping benzene



Map Color	Exposure Condition for Mapping	Lowering color/visualization
Extreme Event	99% LCB[1] for 24MA[2] is greater than or equal to 3 ppb	99% LCB for 24MA is **less** than 3 ppb
Warn	95% LCB for 24MA is greater than or equal to 3 ppb **OR** Two out of three consecutive hourly measurements are greater than or equal to 27 ppb	95% LCB for 24MA is less than 3 ppb **AND** No hourly measurements are greater than 27 ppb within 24 hours
Watch	24MA is greater than or equal to 3 ppb for 6 consecutive hours **OR** Two hourly measurements are greater than 27 ppb within 48 hours	24MA is less than 3 ppb for 3 consecutive hours **AND** No hourly measurements are greater than 27 ppb within 24 hours
Investigate	24MA is greater than or equal to 3 ppb **OR** Hourly measurements are	Criteria is not met

Action	Guidelines for expert decision-making
Evacuate	The event will not be resolved within 24 hours
Shelter-in-place	Benzene levels are expected to be below 3 ppb within 24 hours (to be confirmed by two consecutive hourly measurements)
Communicate	Benzene levels have been confirmed, and location of the event is known. Continue monitoring and communicate to public. Issue AQ alert
Investigate	Deploy monitors, contact/investigate likely source. Continue to monitor

HOUSTON HEALTH DEPARTMENT

RICE

EDF ENVIRONMENTAL DEFENSE FUND
Finding the ways that work

ecraft@edf.org