WORKING TOGETHER;

A Landscape Analysis to Inform Practical, Innovative, and Beneficial Use of NASA Earth Science Data to Advance Equity and Environmental Justice in the Gulf South Region

DRAFT DO NOT DISTRIBUTE

June 2023

Submitted in partial fulfillment of Award ID:
80NSSC22K1470

Authors:
Dr. Beverly Wright, Dr. David Padgett, and
Dr. Nathan Morrow

TABLE OF CONTENTS

“There is a need for additional discussion about how to work together and collaborate more broadly around a movement toward climate and environmental equity and justice in the South. The South offers lessons about some of the worst environmental challenges and most severe disasters in the nation. These lessons learned can inform work on these issues across the nation.”

Catherine Coleman Flowers (NAS, 2021)

ACKNOWLEDGEMENT

We would like to acknowledge the high quality and generous contributions from so many to this Landscape Analysis. First, our sincere appreciation to the EJ Networks that participated in the convenings from the National Black Environmental Justice Network, Historically Black College and University-Community Based Organization (HBCU-CBO) Gulf Coast Equity Consortium, the Deep South Center for Environmental Justice (DSCEJ) Community Advisory Board, and the Environmental Justice Forum. A special thanks to Major Joe Womack and Pastor Calvin Avant for contributing the case studies, providing their incredible insight on community-engaged action research, and being available for in-depth discussion. Deepest gratitude goes to Mary Williams of the Deep South Center for Environmental Justice for her project management and guidance on the Communiversity model. A thank you also to Kim Boyd at DSCEJ for coordination and scheduling. We thank our two graduate assistants, Tyneisha Bradley and Pornpimol Kodsup, for supporting the context analysis and logistics for the convening. Thanks for the excellent document presentation to Margaret Hudson. We would like to thank Phillip Williams for the persistent effort to keep the project moving forward. The contributions of the NASA program officers that traveled to our AGEJL-4-Equity convening made the experience informative and memorable for all the participants, thank you: Owen Hooks, Cydi Hall, Nati Phan, and Lauren Childs Gleason. Lauren, thank you, in particular, for the timely and useful guidance throughout the project. We applaud NASA leadership for bringing the power of diversity and the potential of inclusiveness to the forefront in their initiatives to advance equity and environmental justice.

EXECUTIVE SUMMARY

Four Environmental Justice (EJ) networks convened to map priorities and discuss NASA Earth science data to advance underserved, primarily African American, EJ communities of the Gulf South: the National Black Environmental Justice Network, Historically Black College and University-Community Based Organization (HBCU-CBO) Gulf Coast Equity Consortium, the Deep South Center for Environmental Justice (DSCEJ) Community Advisory Board, and the Environmental Justice Forum. The "Communiversity" model for co-created participatory action research guided the community-led academic-supported process. Grounded firmly in Environmental Justice Movement principles, the Communiversity approach safeguards equitable participation in research and honors the wealth of diverse knowledge held by EJ communities.

This Landscape Analysis intends to inform longer-term NASA Earth Science Division equity and environmental justice (EEJ) efforts and Applied Sciences Program's EEJ-oriented application activities. A context analysis summarizes relevant background and trends in EJ activism and scholarship, EJ policy development, hazards of the Gulf South in relation to climate change, open community-engaged science, NASA data, and NASA EEJ initiatives. Impact case studies of EJ networks' Communiversity action research and results of participatory EJ network convenings are presented in synthetic findings of 1) EJ priorities and 2) strategic NASA Earth science engagement opportunities.

Environmental Justice priorities were complex and multidimensional, relating immediately to the experience of frontline communities. **Air quality**-related adverse health outcomes, unexplained odors, smoke, dust, or toxic emissions leaving corrosive residues in homes and across front-line communities intersected with unacceptable current air quality monitoring and calls for more localized community-engaged research. **Localized flooding** invoked discussion of larger water management priorities of clean water, groundwater contamination, sink holes, energy and climate justice, infrastructure investment decision processes and implementation that could be framed within associated personal economic and health burdens. Cultural **legacy and heritage** research using observational data in community asset mapping intersected with concerns of **gentrification** resulting from poorly informed EJ action. **Climate Crisis and cumulative effects** exemplified EJ community integrated impact-centric understanding of increased storms, localized flooding, and heat combined with the complexity of economic bias, health disparities, and multi-source toxic and environmental exposures. **Novel areas of research** came both from the EJ communities experience, such as marsh fires, and from consideration of NASA's current projects, such as heat mapping. Two foundational priorities were emphasized as foundational in every consultation:

- Integrity in engagement with honest, open, transparent, and committed partnership sharing values to advance EEJ.
- Fairness in data ownership as a foundation of equity in all aspects of partnering with EJ organizations and EJ communities.

Opportunities to improve measurement of EJ disparities should be primarily place-based on a local scale. TEMPO and the Multi-Angle Imager for Aerosols (MAIA) missions that increase spatial and temporal resolution more closely align to EJ priorities than sensors from global scale monitoring missions. Commercial data sets (CSDA) are promising for local-level infrastructure, gentrification, and localized flooding investigations. Landcover change timeseries, including Harmonized Landsat Sentinel-2 (HLS), may improve EJ research into drivers of disparity and distance-based exposure science. Historical patterns of harm central to EJ theory development require innovative approaches that could include radar data. Future PACE and GLIMR missions with hyperspectral and high temporal frequency capabilities promise a data transformation for coastal environmental, climate, and ocean justice research. Lacking sufficient integrated socio-environmental data, available measures and models continue to ignore not only disparities, but participation, recognition, and other essential EJ concepts.

Opportunity to improve participation of EJ communities in decisions that affect their lives is the most immediate opportunity for NASA to advance EJ with its current data and systems. NASA landcover mapping and information system products about land, water, climate, and air are perfectly suitable as base maps for community-led participatory mapping. Mapping assets, hazards, risks, and patterns of harm can all benefit from integration of NASA products in data collection, synoptic analysis, and presentation. Visualizations for both community-engaged investigations and EJ issue advocacy could be supported with open-source tools by academic partners or backbone functions of bridging organizations. Capacity development to improve the scale, scope, and scientific validity of community-engaged science could leverage existing NASA initiatives: TOPS, ARSET, DEVELOP, and FINNEST. A timely opportunity for impactful data use exists to expand focus on decision support to Justice40 for both covered programs, of Community Engagement and Climate Resilience, and beyond.

Opportunity to recognize the value of EJ community knowledge and honor the historical and cultural foundations of the EJM can be realized with EJ community-academic engagement models such as Dr. Beverly Wright's Communiversity model and mandating alignment with Environmental Justice Principles and Ways of Working. Open science capacity development and certification could promote novel and high-quality EJ community-led research, bring new insights, understanding, and advancing EJ science (theory, methods, measurement, findings, and evidence-based action).

Participants in the AGEJL-4-Equity convenings welcomed NASA EEJ program development and perceived the benefit of NASA data products to advance and strengthen EJ communities. Acting on these opportunities does not imply small or simple adjustments, but instead calls for sustained transformative commitment and investment that 1) focuses on wellbeing and prioritizes EJ community development, 2) develops capacity and strengthens community institutions, and 3) supports community-led engagement in all steps of scientifically valid research.

The authors make the following recommendations based on the conclusions of the analysis and their understanding of the EJ context, policy, and policy implementation landscape in the Gulf South:

Recommendation 1 Institutionalize **Dr. Beverly Wright's Communiversity model** at NASA with sustainable funding for EJ community-academic partnerships

Recommendation 2 Promote **Open Science for EJ community-engagement** as a basis for training initiatives and network development in the Gulf South through a regional hub partner

Recommendation 3 Recognize, support capacity development, and sustainably fund **"backbone" functions of bridging EJ organizations** to advance equity and environmental justice with NASA data products

Recommendation 4 Empower EJ and underserved communities with NASA data and open science capacity support focused on planning, monitoring, and evaluating **Justice40 infrastructure investments** to safeguard anticipated fair distribution and intended benefits to underserved and EJ communities

Recommendation 5 Extend and prioritize funding to integrated multidisciplinary community-driven research that contributes to **diversification and development of EJ theory** and related open access publishing

Recommendation 6 Adapt **ARSET and DEVELOP** approaches for needs of EJ communities

Recommendation 7 Initiate **youth engagement and workforce development for EJ Communities** in community-engaged open Earth science

Recommendation 8 Stand-up a Distributed Active Archive Center **(DAAC) for EJ** located in the Gulf South to address a great challenge for advancing EJ – lack of appropriate data

1. INTRODUCTION

Data is a primary challenge to advancing environmental justice (Bullard & Wright, 2020; Banzhaf, Ma, & Timmins, 2019; Mohai & Saha, 2006, Bowen & Wells, 2002). NASA Earth science produces a great deal of data intended not only to further scientific discovery, but for applied benefit to humanity. The purpose of this Landscape Analysis is to co-investigate data use and data gaps in the Gulf South with four environmental justice (EJ) networks engaging communities across the region: the National Black Environmental Justice Network, the Historically Black College and University-Community Based Organization (HBCU-CBO) Gulf Coast Equity Consortium, the Deep South Center for Environmental Justice (DSCEJ) Community Advisory Board, and the Environmental Justice Forum.

The Landscape Analysis is motivated by the following guiding questions:

1. What are priority issues for EJ communities in the Gulf South? How do these priorities map to current or near future NASA Earth science missions and data?
2. How should NASA engage with EJ communities and researchers in applied science activities? How should this align with EJ Principles and ways of working together that align with historical and policy context? Can Dr. Beverly Wright's Communiveristy model of community-engaged academic-supported action research serve as a model for NASA equity and EJ activities?
3. What practical next steps should NASA take to optimize data and programs to advance EJ in the Gulf South?

The Landscape Analysis is organized into the following sections. A context analysis of EJ background and trends summarizes relevant EJ activism and scholarship, drawing out the importance of activist scholars from the South. A short discussion of physical hazards and climate change is followed by discussion of a new multi-indicator screening tool for environmental and climate justice. NASA data assets and work on open science are complemented by list resources in the Annexes. The next section of the document describes the participatory research based on Dr. Beverly Wright's Communiversity model that was undertaken with the EJ networks. Several case studies of the EJ networks' application of the Communiversity model are presented. The results of the participatory EJ network co-analysis are then summarized with a synthesis of overall findings. The final section provides conclusions of the Landscape Analysis with eight recommendations intended to inform longer-term NASA Earth Science Division (ESD) Equity & Environmental Justice (EEJ) efforts, and to inform NASA Applied Sciences Program's EEJ-oriented application activities.

2. BACKGROUND & TRENDS

2.a. Historical Context of Environmental Justice Activism & Scholarship in the South

The Environmental Justice Movement (EJM) is rooted in Civil Rights activism in the South. The EPA's timeline of the EJM begins with Rev. Dr. Martin Luther King's engagement in the 1968 Memphis Sanitation Strike that was to become the first nationally televised African American mobilization against environmental injustice (https://www.epa.gov/environmentaljustice). The EJM grew in the United States and founded allied movements globally through organized civil action against racial inequality and the subsequent burden of environmental hazards disproportionately borne by marginalized communities. The physical landscape, particularly of the Gulf South, also informs the development of EJM with hazardous waste sites often situated in African American communities and the cumulative effects of extreme weather concentrated in certain locations. To advance EJ and understand how to work with EJ organizations and communities, this section of the landscape analysis presents an abbreviated historical summary of how southern environmental justice scholarship and activism informed the EJM and subsequent influence on national policy.

The lived experience of EJ communities and identifying the undesirable outcomes of discrimination, chronicled in place-based civil activism, are essential to the grassroots ethos that first advanced and still guides the EJM. In December 1979, a collective of activists in Houston, Texas formed the Northeast Community Action Group (NECAG) to stop the permitting of large landfills near public schools. Their class-action lawsuit, *Bean v. Southwestern Waste Management Corp*, was a precedent setting legal challenge to environmental discrimination. In September 1982, a coalition of EJ organizations lent support to the nonviolent sit-in protest against a proposed polychlorinated biphenyl (PCB) landfill in Warren County, North Carolina. This case of disposing of extremely toxic chemicals with significant potential for harm to predominantly African American residents highlighted racial discrimination in environmental injustice and became a model for grassroots action catalyzing the larger EJM support and action.

EJ research and scholarship often follow EJ activism (see Table 1). Following the national attention brought to the Warren County protest and the EJM, a 1983 General Accounting Office investigation found 75% of hazardous waste sites within Southern states were specifically located in predominantly African American communities (GAO, 1983). In April 1983, Dr. Robert Bullard published the first book on EJ, "Solid Waste Sites and the Black Houston Community." Dr. Robert Bullard's study of environmental racism serves as a model for place-based scholarship integrating data and analytical critiques across disciplines with a focus on a wholistic analysis of the role of systems and structures in observed, typically negative and discriminatory, outcomes. In June 1983, a study conducted by the General Accounting Office, titled "Siting of Hazardous Waste Landfills and Their Correlation with Racial and Economic Status of Surrounding

Communities," provided further empirical evidence to support claims of environmental injustice. The 1987 publication of the United Church of Christ's study, "Toxic Waste in the United States," marked the first comparative and nationwide examination of race, class, and their intersection with environmental injustice. Dr. Robert Bullard advanced EJ scholarship with a historical and regional analysis in "Dumping in Dixie," published in October 1990, with a systematic accounting and structural explanation of patterns of harm and environmental injustice. EJ activist scholars following or working with Dr. Robert Bullard often share a similar perspective and political consciousness with a systems-informed, multidisciplinary, multi-perspective and experiential sensibility to their choice of research questions, subjects, methods, and analytical interpretations (See Annex G for chronological list of Dr. Beverly Wrights' publications).

Table 1: Timeline

February 11, 1968	Memphis Sanitation Strike, a significant moment in the national mobilization of African Americans against environmental injustices.
December 1979	Formation of Northeast Community Action Group (NECAG) and filing of the class-action lawsuit *Bean v. Southwestern Waste Management Corp.*, a landmark in legal action against environmental discrimination
September 1982	Nonviolent sit-in protest against a PCB landfill in Warren County, North Carolina. This protest catalyzed the Environmental Justice Movement.
April 1983	Publication of Solid Waste Sites and the Black Houston Community by Dr. Robert Bullard, the first comprehensive account of environmental racism in the United States.
June 1983	The General Accounting Office conducts a study titled Siting of Hazardous Waste Landfills and Their Correlation with Racial and Economic Status of Surrounding Communities, providing empirical support for claims of environmental racism.
1987	Publication of the United Church of Christ's study Toxic Waste in the United States, the first national examination of race, class, and environment.
October 1990	Publication of Dumping in Dixie by Dr. Robert Bullard, the first book documenting environmental injustice in the United States.
October 24-27, 1991	First National People of Color Environmental Leadership Summit takes place, resulting in the 17 Principles of Environmental Justice and the Principles of Working Together.
1992	Founding of the Deep South Center for Environmental Justice at Xavier University of Louisiana, the nation's first Environmental Justice (EJ) center.
February 11, 1994	President Bill Clinton signs Executive Order 12898, Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations.
December 1999	Launch of the National Black Environmental Justice Network (NBEJN) in New Orleans.

October 2022	The second People of Color Environmental Leadership Summit takes place in Washington, D.C.
2007	Publication of Toxic Waste and Race at Twenty, reiterating the ongoing issue of environmental racism in the United States.
July 2012	Publication of The Wrong Complexion for Protection by Robert D. Bullard and Beverly Wright, highlighting the racial disparities in governmental disaster response.
June 2015	Release of the initial version of EJSCREEN, a nationally consistent approach for considering environmental justice by the EPA.
April 2021	Environmental Justice published Special Issue “Revisiting Katrina” (https://www.liebertpub.com/toc/env/14/2)

The EJ community in the South continued to advance EJ even as the EJM broadened and diversified nationally and internationally with impacts on policy change up to the federal level. The First National People of Color Environmental Leadership Summit held from October 24-27, 1991, led to the development of the 17 Principles of Environmental Justice and the Principles of Working Together (see Annexes D & E), which remain touchstones for the EJM and have enduring relevance that inspired the title of this Landscape Analysis. In 1992, the Deep South Center for Environmental Justice at Xavier University of Louisiana was established as the nation's first academic center dedicated to EJ.

On February 11, 1994, President Bill Clinton signed Executive Order 12898, titled “Federal Actions to Address Environmental Justice in Minority Populations and Low-Income Populations.” This order mandates that each federal agency must make achieving environmental justice a part of its mission. This involves identifying and addressing any disproportionately high and adverse human health or environmental effects of their actions on minority and low-income populations. The order also established the Interagency Working Group on Environmental Justice, chaired by the Environmental Protection Agency (EPA), to coordinate the implementation of the order across different federal departments and agencies.

> *“The events that unfolded in New Orleans and the Gulf Coast region before and after Hurricane Katrina provide the socio-historic backdrop to our examination of social vulnerability and government response… to weather related events such as hurricanes, floods and droughts, but also includes case studies on toxic contamination, industrial accidents, train derailments and explosions, medical experimentation, and bioterrorism threats.”*
>
> Bullard and Wright, 2012

The launch of the National Black Environmental Justice Network (NBEJN) in New Orleans in December 1999 provided a coalition model that included policy engaged activists, EJ community and organizations representatives, and activist scholars; a model that continues to inform the organization, approaches, and events of the EJM today. The second People of Color Environmental Leadership Summit held in Washington, D.C. in October 2002 re-emphasized the movement's principles and objectives while broadening alliances particularly around tribal, traditional, and indigenous EJ community representatives, youth, and multilingual diversity.

Recent activist scholarship has investigated the interrelated and cumulative effects of disparities in environmental, economic, social, racial, health equity, and disaster/climate justice. The 2007 publication of “Toxic Waste and Race at Twenty” reiterated the persistent lack of improvement in EJ and investigated the phenomenon of clustering of toxic polluters in minority communities. A critical examination of racial disparities in governmental disaster response and its relation to a range of social and environmental injustice across the South was explored in “The Wrong Complexion for Protection,” authored by Dr. Robert Bullard and Dr. Beverly Wright in July 2012. The book underscored the systemic biases present not only in disaster response mechanisms but also in protection for the socially vulnerable more broadly, further exacerbating existing wellbeing, economic, and environmental inequities. At the federal policy level, this multi-risk and integrated systems-informed understanding informed the multi-indicator EJScreen released by the EPA in June 2015. The tool was intended to give a nationally consistent measure to inform communities, researchers, and policymakers with an evidence-base for policy discussions and action for EJ.

> *“Hurricane Katrina exposed the systematic weakness in the nation’s emergency preparedness and response systems…[but] the response to Hurricane Katrina was no fluke. Unfortunately, eight decades of “Katrina responses” to public health emergencies, environmental hazards, industrial accidents, and natural and human-induced disasters have left blacks less safe and less secure than whites in their homes, schools, neighborhoods, and workplaces.”*
>
> Bullard and Wright, 2012

The April 2021, the journal Environmental Justice’s first Special Issue was titled “Revisiting Katrina” (https://www.liebertpub.com/toc/env/14/2) and it makes a considerable contribution by giving a good overview of EJ research in the post Hurricane Katrina disaster period. It focuses on cumulative impacts including links between EJ and multi-cause vulnerability. The patterns of harm and systemic injustice evident in environmental disasters can inform a diversity of EJ-focused investigations. This special issue spans disciplines including mental health, disaster communications, climate change, telecoupling of the global energy industry with environmental injustice,

historical loss and damage on health, and cumulative EJ impacts. The following articles are particularly relevant to the Landscape Analysis as they highlight EJ priorities and may benefit from improved data:

- Hendricks and Van Zandt (2021) argue that EJ literature has inadequately addressed key topics related to critical infrastructure like stormwater, green space, sewerage, energy, and roads. The authors posit that neighborhoods are not inherently vulnerable, but are systematically neglected and underserved, leading to disparities in infrastructural robustness and resilience.
- An article by Corbin (2021) evaluates the federal investigations and disaster policy in the wake of Hurricane Katrina, concluding that federal disaster policy lags behind state and local policies that incorporate EJ considerations.
- Minovi (2021) explores the public health implications of chemical releases triggered by extreme weather conditions, emphasizing the environmental injustice experienced by low-wealth, Black, and Hispanic communities located near high-risk chemical facilities.
- Weden et al. (2021) study the interrelationships between health, residential segregation, and disaster-related material losses.
- Flores et al. (2020) show minority and low socio-economic status populations had limited access to resources for disaster mitigation, were less prepared for disasters, and were disproportionately affected by the physical and health impacts.

Familiarity with the work of activist scholars, their foundational case studies, and methodological approaches is essential to engaging with the evidence-base and key stakeholders in the EJM. Many trained in Earth, environmental, or health sciences may be unfamiliar with this literature and place-based systems-informed or realist and critical approaches to research. The Tishman Environment and Design Center analyzed the philanthropic engagement landscape in the southern region and **found broad misalignment** between environmental “conservation” and more community relevant issues of economic justice, disaster resilience, and empowerment (Baptista & Perovich, 2020). Morrow et al. (2022) found similar patterns in international environmental projects promoting environmental protection in marginalized and oppressed communities.

The EPA, in an effort to mainstream EJ, instituted mandatory all staff training. Personnel of other federal agencies and the Earth, environment, and health researchers perhaps should also have access to EJ training so they can learn from, and subsequently contribute to, the measurement and understanding of causes, consequences and potential prevention and remedies to environmental injustice. Ornelas Van Horne and co-authors (2023), contribute to the emerging work on bringing an EJ framework to exposure science and other environmental health research (see Table 2).

Table 2: Subset of the 17 Principles of EJ from The First National People of Color Environmental Leadership Summit, 1991

Principle		Entry point for research engagement
1	Affirms the sacredness of Mother Earth, ecological unity and the interdependence of all species, and the right to be free from ecological destruction.	Research question: • Priority set by those affected
2	Demands that public policy be based on mutual respect and justice for all peoples, free from any form of discrimination or bias.	Action/policy: • Engage in policymaking
5	Affirms the fundamental right to political, economic, cultural, and environmental self-determination of all peoples.	Measuring contaminants: • Done in a culturally and ethically responsible way Participative justice: • Involve and considers all
7	Demands the right to participate as equal partners at every level of decision making, including needs assessment, planning, implementation, enforcement, and evaluation.	Participative justice: • Involve and considers all Communication/results dissemination • Sharing of information
9	Protects the right of victims of environmental injustice to receive full compensation and reparations for damages as well as quality health care.	Shared funding • Budget is shared
12	Affirms the need for urban and rural ecological policies to clean up and rebuild our cities and rural areas in balance with nature, honoring the cultural integrity of all our communities, and provided fair access for all to the full range of resources.	Leadership: • Represents the community researchers Data ownership • Collective
13	Calls for the strict enforcement of principles of informed consent, and a halt to the testing of experimental reproductive and medical procedures and vaccinations on people of color.	Data collection • Involves community
16	Calls for the education of present and future generations which emphasizes social and environmental issues, based on our experience and an appreciation of our diverse cultural perspectives.	Sustainability • Builds capacity

2.b. Trends: Recent Federal Policy with Implications for Advancing EJ with NASA Data

In this section, we highlight recent executive action from the White House with implications for NASA engagement with EJ and underserved communities in the Gulf South. We summarize key points from executive orders 13985, 14008, 14035, and the Executive Order on Revitalizing Our Nation's Commitment to Environmental Justice for

All (14096). We also discuss the release of the Climate and Economic Justice Screening Tool (CEJST).

January 2021	White House Executive Order 13985

"Executive Order on Advancing Racial Equity and Support for Underserved Communities Through the Federal Government"

On his first day in office, President Biden signed Executive Order 13985, *Advancing Racial Equity and Support for Underserved Communities Through the Federal Government*. This Order emphasized the enormous human costs of systemic racism and persistent poverty and provided a powerful and unprecedented mandate for all federal agencies to launch a whole-of-government approach to equity.

The order relates directly to a NASA Science Mission Directorate Bridge Program to foster partnerships between the agency and Historically Black Colleges and Universities (HBCUs), Minority-Serving Institutions (MSIs), Tribal Colleges and Universities (TCUs), community colleges, and very high research-intensive universities. The program focuses on providing students with paid research and engineering opportunities to support the transition of undergraduate students into graduate programs and/or employment with NASA and in the broader science and engineering fields; it supports capacity-building efforts at partner institutions that are historically under-resourced in the NASA research and engineering enterprise to intentionally promote diversity, inclusion, and accessibility.

January 2021	White House Executive Order 14008

"Executive Order on Tackling the Climate Crisis at Home and Abroad"

Executive Order 14008 includes a subsection ordering action specific to EJ with the title, "Securing Environmental Justice and Spurring Economic Opportunity." Notably, this order formalizes the White House Environmental Justice Interagency Council and a White House Environmental Justice Advisory Council (WHEJAC). Dr. Beverly Wright, the co-author of this Landscape Analysis, serves on WHEJAC. Guidance from the WHEJAC was used specifically in the approach to this Landscape Analysis where we have endeavored to provide user-friendly capacity development, technical assistance and consultation that fully engages and possibly is co-led by underserved and EJ communities (WHEJAC, 2021).

It also establishes the Justice40 Initiative and the Climate and Environmental Justice Screening Tool (CEJST). We were able to piggyback on to Justice40 focused convenings of our partner EJ networks to expand our originally planned engagement. The CEJST tool provided a broader geospatial mapping consistent across the region to complement the priority mapping and local participatory mapping of the EJ networks. Specifically, the order:

- **Formalizes President Biden's commitment to make EJ a part of the mission of every agency** by directing federal agencies to develop programs, policies, and activities to address the disproportionate health, environmental, economic, and climate impacts on disadvantaged communities.
- **Establishes a White House Environmental Justice Interagency Council and a WHEJAC to prioritize EJ and ensure a whole-of-government approach to addressing current and historical environmental injustices**, including strengthening EJ monitoring and enforcement through new or strengthened offices at the Environmental Protection Agency (EPA), Department of Justice (DOJ), and Department of Health and Human Services (DHHS). The new bodies are also tasked with advising on ways to update Executive Order 12898 of 1994.
- **Creates a government-wide Justice40 Initiative with the goal of delivering 40 percent of the overall benefits of relevant federal investments to disadvantaged communities** and tracks performance toward that goal through the establishment of an Environmental Justice Scorecard.
- **Initiates the development of a Climate and Environmental Justice Screening Tool**, building off the EPA's EJScreen, to identify disadvantaged communities, support the Justice40 Initiative, and inform equitable decision making across the federal government.

January 2021	White House Executive Order 14035
"Executive Order on Diversity, Equity, Inclusion, and Accessibility in the Federal Workforce"	

This order reinforces the focus of the Landscape Analysis to address the capacity requirements for research on EJ in an inclusive way that emphasizes diversity and equity. Specifically, this order calls on NASA and federal agencies to:

- **Better facilitate recruitment of diverse individuals from underserved communities into public service,** particularly through developing and strengthening partnerships with HBCUs, Hispanic Serving Institutions, TCUs, MSIs, and women's colleges.
- **Advance diversity, equity, inclusion, and accessibility (DEIA) through a comprehensive government-wide approach** that includes assessing the current state of DEIA across the whole-of-government, examining barriers, instituting a data-driven approach with reporting systems for agency progress, and reaffirming the centrality of equity-focused personnel policies and practices.

November 2022	Climate and Environmental Justice Screening Tool released

The Climate and Environmental Justice Screening Tool (CEJST) is a geospatial mapping tool that identifies areas across the nation where communities are faced with significant burdens. These burdens are organized into eight categories: 1) climate

change, 2) energy, 3) health, 4) housing, 5) legacy pollution, 6) transportation, 7) water and wastewater, and 8) workforce development. Census tracts that are overburdened and underserved are highlighted as being disadvantaged on the map. Federally Recognized Tribes, including Alaska Native Villages, are also considered disadvantaged communities.

April 2023	White House Executive Order 14096
"Executive Order on Revitalizing Our Nation's Commitment to Environmental Justice for All"	

This most recent order directly calls for specific EJ actions that are directly pertinent to this Landscape Analysis and NASA planning and programs. The first action on assessing data and research capacity needs for EJ is perhaps the most directly applicable to the recommendations of this Landscape Analysis. The EJ scorecard and emphasis on capacity development are also relevant to NASA and our analysis. It makes an explicit link to the Justice40 initiative which is also a primary focus of the EJ network partners. It challenges users to extend engagement to tribal communities in the Gulf South. Notably, the DSCEJ also will serve as one of the Environmental Justice Thriving Communities Technical Assistance Centers called for in this order. Specifically, the order calls to:

- **Support EJ research and analysis, including expanding the accessibility of environmental and health data to communities with EJ concerns and the public at large.** Agencies are directed to identify and develop strategies to address data and research gaps.
- **Establish the White House Office on Environmental Justice** to coordinate EJ policies and programs.
- **Introduce new Justice40 covered programs** in the Department of Commerce, the National Science Foundation, and NASA, expanding the number of programs covered across federal agencies to close to 470. For NASA, this included the Applied Sciences: Community Action and Applied Sciences: Climate Resilience programs.

Additional steps and complementary initiatives announced in partnership with the executive order include:

- **The publishing of Phase One of the Environmental Justice Scorecard**, which establishes for the first time a baseline for federal agencies to track their progress towards facilitating EJ.
- **The establishment of 17 new Environmental Justice Thriving Communities Technical Assistance Centers** to provide technical and capacity-building assistance to communities and partners seeking to access federal resources.
- **The formal recognition of the contributions and importance of Indigenous Knowledge.**

2.c. Changing Climate & Demographics Increase Risk to EJ Communities of the Gulf South Region

States bordering the Gulf of Mexico have the fastest growing U.S. coastal population (Cohen, 2019) and are subject to the worst health and socio-economic disparities nationally (Radley et al., 2021). Macro-trends in demographics and population growth reinforce patterns of increased risk exposure. Predicted Southern Gulf Coast extreme events exemplify the potential for exceeding Climate Justice and Environmental Justice tipping points into public health disasters. The United States Global Change Research Program's (USGCRP) report on health impacts of climate change warns that underlying health disparities in underserved, primarily African American and Hispanic, communities will become worse (Balbus et al., 2016). Greater inequality is both the result of and a contributor to structural socio-economic disadvantages that limit community capacities for adapting, managing, and responding.

Hurricanes and hurricane storm surge are predicted to increase under climate change with increased damage to property and risk to people (Camelo, Mayo, & Gutmann, 2020). Hurricane-induced storm surges are expected to increase with an average change of +36% significantly increasing inundation in Texas, Louisiana, Mississippi, and the west coast of Florida.

Tornado occurrence has decreased in parts of the central and southern Great Plains while increasing in parts of the Midwest and Southeast United States (Gensini & Brooks, 2018). The shift of tornado activity to "Dixie Alley" is particularly concerning because the region is largely unprepared for preventing harm from extreme storms. Infrastructure and housing are often less sturdy, with large populations in mobile homes. There is a lack of tornado warning sirens or appropriate radar in the region as well as a lack of experience and education dealing with these types of storms.

The extreme freezing events of April 2021 caused deaths in Texas. Extreme events are likely to become more common under climate change and regions like the Gulf South with previously milder climates will be most vulnerable. In 2023, nearly half of all Southerners reported being exposed to at least one extreme weather event. Approximately one in five Southern residents, 18%, say they were affected by a hurricane, more than any other type of extreme weather event in any other region. Ten (10) percent of Southerners say they experienced extreme cold, and seven percent experienced a snow or ice storm (Jones, 2023).

2.d. Mapping Underserved Communities in the Gulf South with the Climate and Economic Justice Screening Tool (CEJST)

The Climate and Economic Justice Screening Tool (CEJST) is a geospatial mapping tool that identifies disadvantaged communities in the United States that are

underserved, overburdened by pollution, and marginalized (WHCEQ & UDS, 2022). Executive Order 14008 “Tackling the Climate Crisis at Home and Abroad” called for the tool to inform the Justice40 Initiative, aimed at providing 40% of the benefits of Federal investments to disadvantaged communities in areas such as climate change, clean energy, clean transit, sustainable housing, workforce development, pollution remediation, and critical clean water and wastewater infrastructure development.

The CEJST was released as a beta version on February 18, 2022, to gain public and tribal feedback. It uses environmental, climate, and socioeconomic indicators to identify disadvantaged communities at the U.S. census tract level, which generally includes around 4,000 people. Data sources for the tool include the U.S. Census Bureau, the EPA, the Centers for Disease Control and Prevention (CDC), the U.S. Department of Transportation (DOT), the U.S. Department of Energy (DOE), the Federal Emergency Management Agency (FEMA), and the U.S. Department of Housing and Urban Development (HUD). It gathers data in eight (8) categories: climate change, clean energy and energy efficiency, clean transit, affordable and sustainable housing, reduction and remediation of legacy pollution, critical clean water and wastewater infrastructure, health burdens, and training and workforce development.

An article by Emily Pontecorvo in GRIST (https://grist.org/equity/the-little-known-open-source-community-behind-the-governments-new-environmental-justice-tool/) describes the development of CEJST as a pioneering experiment in open governance, with its software development being entirely open source. Led by the U.S. Digital Service (USDS) and the Council on Environmental Quality, the open-source science approach allowed anyone to access the code on GitHub, contribute to its development, and understand its functionality. A public Google Group, monthly community chats, and regular office hours via Zoom supported the engagement of the development community. This project was designed to be open, transparent, inclusive, and aligned with EJ principles.

Figure 1: Disadvantaged Communities in the Gulf South

About half of census tracts in the lowland Gulf Coast communities and rural areas of Louisiana, Alabama, Mississippi, Florida, and Texas are considered underserved in the CEJST mapping. Figure 1 displays locations of disadvantaged communities in gray.

2.e. NASA Missions & Programs Contributing to the Equity and Environmental Justice Mission[1]

NASA's Applied Sciences Program serves as an essential avenue to address Earth's most pressing challenges by harnessing Earth observations. Designed to improve decision-making regarding the environment, food, water, health, and safety. The program supports user engagement throughout the Earth science satellite and instrument missions' lifecycle.

The Equity and Environmental Justice (EEJ) initiative at NASA endeavors to ensure that the significant investment made in NASA satellites and science is equitably distributed, enabling communities across the U.S to make informed decisions about the environmental challenges they face. NASA's EEJ efforts include the ROSES A.49 Equity and Environmental Justice, ARSET training, and some DEVELOP projects. There are also a small number of Future Investigators in NASA Earth and Space Science and Technology (FINESST), Advanced Information Systems Technology (AIST) projects, and a subset of the Indigenous Peoples Initiative activities with EEJ themes.

ROSES A.49 Equity and Environmental Justice: the ROSES A.49 EEJ Solicitation aimed to improve EJ domestically by deepening understanding of community needs and fostering increased use of Earth science, geospatial, and socioeconomic information. Thematic EEJ topics addressed include extreme heat and urban heat islands, ecological conservation practices such as urban forestry and green infrastructure, air quality issues like air pollution and wildfire smoke, and disaster management strategies for urban flooding and stormwater. Other topics of focus include fire risk and exposure, water pollution, and various aspects of agriculture, including crop health and food insecurity.

Table 3: A.49 Projects Overview

No. Projects	Project Type	Main Topics
22	Heat	Extreme Heat, Urban Heat Islands, Climate Hazards
14	Ecological Conservation	Urban Greenspace, Green Infrastructure, Urban Forestry, Tree Canopy Coverage
13	Air Quality	Air Pollution, Wildfire Smoke

[1] Based on presentation by Lauren Childs-Gleason, Lauren.M.Childs@nasa.gov, at AGEJL-4_Equity Convening March 17, 2023: “Earth Observations for Environmental Justice: An Introduction & Resource Guide”.

10	Disasters	Urban Flooding, Green Infrastructure Solutions, Stormwater Management
5	Wildfires	Fire Management, Fire Risk & Exposure
4	Water	Water Pollution, Stormwater Management, Precipitation Monitoring, Green Infrastructure Solutions
4	Agriculture	Crop Health, Food Insecurity, Urban Agriculture, Agriculture Burning

'Heat' projects are the most prevalent, accounting for 22 of the total A.49 projects selected for funding. These projects aim to tackle extreme heat, urban heat islands, and climate hazards, key factors that influence EJ. The second most common type of project falls under 'Ecological Conservation' (14 projects), addressing urban greenspace, green infrastructure, urban forestry, and tree canopy coverage. 'Air Quality' and 'Disasters' projects are also significant with 13 and 10 initiatives, respectively. These are focused on mitigating the harmful effects of air pollution, managing wildfire smoke, and improving urban flood and stormwater management. 'Wildfires', 'Water', and 'Agriculture' projects were fewer in number.

Applied Remote Sensing Training (ARSET) Program: ARSET contributes to capacity building through education in Earth observation applications. Key training areas include monitoring and modeling floods using Earth observations, understanding and measuring urban heat islands through satellite remote sensing, performing disaster risk assessment & resilience, detecting fire risks and conducting analysis, and monitoring air quality from space. ARSET also offers training on integrating population grids with remote sensing data for sustainable development and disaster management.

Table 4: ARSET Training Areas

Training Type	Description
Floods	Monitoring & Modeling Floods using Earth Observations
Urban Heat	Satellite Remote Sensing for Urban Heat Islands
Urban Heat	Satellite Remote Sensing for Measuring Urban Heat Islands and Constructing Heat Vulnerability Indices
Disaster Risk	Earth Observations for Disaster Risk Assessment & Resilience
Wildfires	Satellite Observations and Tools for Fire Risk, Detection, and Analysis
Air Quality	High Resolution NO2 Monitoring From Space with TROPOMI
Data Integration	Introduction to Population Grids and their Integration with Remote Sensing Data for Sustainable Development and Disaster Management

DEVELOP's EJ Projects: DEVELOP's EJ projects have demonstrated how Earth observations and socioeconomic data can be synergized to enhance our understanding of the inequalities and injustices some communities face. The projects cover themes such as extreme heat and urban heat island effects, urban tree canopy coverage, urban flooding, and landslide risk. They have been implemented in over 20 states, with partners like Groundwork USA, the City of Austin Office of Sustainability, the Philadelphia Department of Public Health, and the Louisiana Public Health Institute.

The presentation included three DEVELOP case studies:

Case 1: Cincinnati, OH & Northern Covington, KY

In this case, Earth observations were obtained from Landsat 8 OLI/TIRS and the Global Precipitation Measurement (GPM) Integrated Multi-satellitE Retrievals for GPM (IMERG) data. The project had multiple objectives. The first was to map stormwater runoff, runoff retention, and the potential cost of damage. The second was to map the susceptibility and exposure to landslides. The third objective was to create a standard operating procedure for future analysis.

Case 2: Wyandotte County, Kansas

In Wyandotte County, GPM IMERG was used to obtain Earth observations. The objectives of this project were to identify areas with low rates of stormwater retention. Next, the project sought to examine the inequitable distribution of ecosystem services affecting water quality. The third objective was to explore the implications of variations in land cover on socio-economically vulnerable populations. Finally, the project aimed to identify points of intervention for green infrastructure projects. Specific focus areas included impervious surfaces, green infrastructure, and land use change and flooding.

Case 3: Milwaukee

In Milwaukee, the project used data from Landsat 8's Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS), the International Space Station (ISS), and the ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station (ECOSTRESS). The focus here was on both nighttime and daytime evapotranspiration.

NASA Data Resource Centers:

- EOSDIS Distributed Active Archive Centers (DAACs) https://earthdata.nasa.gov/about/daacs
- Earth Data Search https://search.earthdata.nasa.gov/search
- Earthdata Forum https://forum.earthdata.nasa.gov/
- Ask questions about data types, access, issues, etc.
- LP DAAC AppEEARS https://lpdaac.usgs.gov/tools/appeears/
- Simple and efficient data access and transformation

The ROSES A.49 and DEVELOP products consistently use data from these sensors and products from these data systems:

- Landsat 7&8
- MODIS - Moderate Resolution Imaging Spectroradiometer
- VIIRS - Visible Infrared Imaging Radiometer Suite
- GOES-R - Geostationary Operational Environmental Satellite
- Composite products and information systems
- IMERG-GPM - Integrated Multi-satellitE Retrievals for GPM – Global Precipitation Monitoring
- CyGNSS - Cyclone Global Navigation Satellite System
- SMOS/SMAP - Soil Moisture
- NASA LIS - Land information System
- DEVELOP with one example using ECOSTRESS

Conclusions: Current EEJ applications of NASA data include air quality and climate-related hazards of extreme weather, sea level rise, changes in water availability, flooding, green space, and extreme heat (NASA, 2022). A variety of sensors and products are utilized such as Suomi NPP/VIIRS DNB nights at light imagery to monitor disaster recovery; sea level estimates from TOPEX/Poseidon, Jason-1-3/OSTM, OSTM/Jason-2, Jason-3, Sentinel-6 Michael Freilich; climate-related hazards imaging capabilities of TRMM, VIIRS and MODIS; and air quality indicators derived from MISR, SeaWIFS, SeaStar, and MOPPIT. NASA Health and Air Quality Applied Sciences with the TEMPO mission and the Multi-Angle Imager for Aerosols (MAIA) mission have higher resolutions for local scale analysis and may be expanded to southern cities. SEDAC gridded data sets are appropriate for some EEJ research applications that require socio-economic and demographic indicators. Currently, these gridded data sets are most appropriate for global modeling, and project specific data is often for international study sites. EEJ researchers tend to use data information systems and more processed data products from IMERG- GPM (Integrated Multi-satellitE Retrievals for GPM – Global Precipitation Monitoring), CyGNSS (Cyclone Global Navigation Satellite System), SMOS/SMAP (Soil Moisture), and NASA LIS (Land Information System). There may be potential for the Multi-Mission Algorithm and Analysis Platform (MAAP) to produce refined data sets ready to use in EEJ research.
Scale is very important to EEJ research and data is typically most relevant at neighborhood scale. Current and future NASA missions that will increase spatial, temporal, and spectral resolution such as ESDS Commercial Smallsat Data Acquisition (CSDA) Program offer a previously unimaginable potential for addressing EEJ research questions and integrating with socio-economic data.

The NASA Geostationary Littoral Imaging and Monitoring Radiometer (GLIMR) mission will be specifically important to the Gulf South region, coastal ecosystems, and EEJ research into cumulative effect. This hyperspectral and high temporal frequency data will be important for understanding temporal dimensions of air-water-land interactions,

coastal resilience, and potential for greater bio-geochemical interactions with cumulative effects on coastal populations.

2.f. Open & Community Engaged Science

A search of GitHub pull requests reveals a striking lack of participation in open-source projects across the Southern United States. At the same time, many parts of the region struggle against pervasive environmental injustice and inequity revealed in health, education, vulnerability, and socio-economic disparities. NASA data is rapidly developing proven capacity to provide an improved evidence base on urgent issues of air quality, flooding, climate change-related extreme events, and disaster resilience. Currently, there is a massive but unfortunate missed opportunity for greater engagement of underserved communities and minority serving institutions in the Open-Source Science for climate and EJ that is possible with NASA data streams and approaches.

NASA designated 2023 as the Year of Open-Source Science (YOOS). Open-Source Science approaches for interdisciplinary complex system problems such as climate change were pioneered by the Sciences and Exploration Directorate/Goddard Space Flight Center/Earth Science Division. Now, Open-Source Science is an institutional-level priority strategy to maximize data, software, and science investment value by broadening engagement with diverse communities for applied and citizen science, capacity development, and innovation. More inclusive science processes promote greater consensus around the evidence base for policy formation that in turn advances collective action in implementing the shared solutions, research into the links between Open Science, equity, and EJ may demonstrate practical pathways for realizing sustainable and more equitable program benefits.

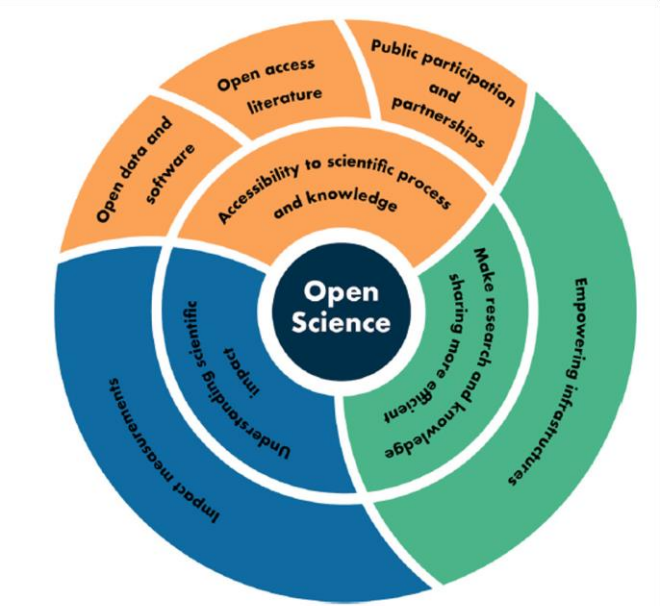
Despite a relatively long history of ESD efforts to make open data more accessible and promote open-source software, NASA Open-Source Science leadership recognizes the tantamount importance of new efforts to promote inclusive and diverse engagement throughout the scientific process with intentional empowering infrastructure that builds lasting sustainable relationships and capacity. Measuring the impact of NASA investments also now requires interdisciplinary engagement with social and applied scientists whose institutions have the experience promoting evidence-based policy and ensuring quality policy implementation. Health, wellbeing, equity, and inclusion are pillars of EJ. Making measurable impact on EJ will require bringing together the work of Earth scientists, data scientists, and engineers with institutions and organizations specializing in resilience, health, governance/policy formulation and implementation, and environmental disciplines.

Open-Source Science broadens participation in the scientific process with tangible benefits of increased value for money, faster innovation, and equitable policy response.

Perhaps most importantly for policy impact, Open-Source Science inclusion of the private sector, public entities, academia and citizens builds common trust in the evidence that informs decisions and policy dialogues. The synoptic observational power of NASA data products to address environmental/climate justice-related domestic challenges remains largely underutilized even as it has played a decades-long role in global monitoring of Earth system changes. Increased temporal and spatial resolution of NASA data streams make previous research on global issues like climate change now tractable for decision support at more local levels. The resilience of the Gulf Coast with a broad diversity of communities facing a wide-range of environmental challenges could potentially benefit the most as well as provide real world assessment of opportunities for value addition to NASA investments with greater inclusive and equitable engagement in Open-Source Science.

Three NASA researchers published a paper to articulate the defining elements of Open-Source Science that are illustrated in Figure 2 (see Ramachandran, Bugbee, & Murphy, 2021). The researchers identified three focus areas that explain their proposition to move from Open Data to Open Science. These include more access to the scientific process and knowledge that is commonly promoted by open access to literature, data, and software. The outer-most ring on Figure 2 represents the proposed specific program strategies to enable Open-Source Science. Public participation and partnerships have been the focus of previous NASA program elements in Citizen Science and Capacity Development activities often focused on support to STEM education. New initiatives and strategies at NASA are redoubling this effort in historically undeserved communities, institutions and jurisdictions. NASA has acknowledged that greater understanding of the communication channels and opportunities for scientific exchange require immediate systematic inquiry and new research. The framing in Figure 2 could be used as the general organizing framework for the proposed EJ ScienceCore learning module and interactive EJ Open-Source Science workflow development.

Figure 2: Three (3) key domains of Open-Source Science and their program elements



The NASA-engaged Earth Science community has less experience in program strategies to enable empowering infrastructure and strengthen impact measurement than other Open-Source Science program elements. Empowering infrastructure is envisioned as both the cyberinfrastructure and

associated collaborations. As the scientific process for complex problem research becomes more data centric, the analysis environment must by design become more focused on how scientists and others interact with data to answer meaningful questions. This calls for leveraging decentralized and sustainability-focused technology for new approaches informed by those using the data (Robinson et al, 2020). This focus on multisource multidisciplinary connections as well as data that first understands user needs is also the approach for linking science to decision making. Impact measurement has too often been limited to metrics of journal citations and significant user-focused research is required for more relevant metrics aligned to Open-Source Science and focusing on links to decision making and action.

Strong concurrency exists between the Open-Source Science focus on accessibility, empowerment, and impact with approaches to advance EEJ. The first NASA hosted EEJ workshop was held in October 2021, but lacked participation from Southern and Gulf Coast researchers or community representatives (NASA, 2021). Even as EEJ is a specific NASA Applied Science program element, it is also a division-wide priority crosscutting all the work of the Earth Science Division (ESD). Initial strategic direction coming out of the workshop was summarized into four division level goals:

ESD Goal 1: Conduct assessments of current environmental justice engagements, barriers and gaps, and opportunities;

ESD Goal 2: Engage with a range of organizations involved with environmental justice communities and harvest lessons and potential partnerships for the strategy;

ESD Goal 3: Host data accessibility and utility sessions;

ESD Goal 4: Enable transdisciplinary science and applications that integrate physical and social science using NASA datasets.

All these goals can be achieved more efficiently, be more broadly relevant, and have greater impact if pursued with Open-Source Science. An intentional program integrating open science into EEJ research would build on these principles to make concrete progress aligned with NASA priorities and consistent with the expressed requirements of underserved EJ communities and climate justice/environmental justice researchers.

3. ANALYTICAL APPROACH, METHODS, & DATA

3.a. Assessment of the Gulf Coast Environmental Justice Landscape for Equity (AGEJL-4-Equity)

Assessment of the Gulf Coast Environmental Justice Landscape for Equity (AGEJL-4-Equity) is one of ten (10) Landscape Analysis projects selected for funding under the NASA Applied Sciences A.49 EEJ program element. By leveraging existing networks and deep wells of located experiential expertise, AGEJL-4-Equity activities have been undertaken to contribute to this Landscape Analysis, which identifies gaps and opportunities for improved access and use of NASA open science products to advance EEJ in underserved communities along the Gulf Coast.

Following the Communiversity model developed by Dr. Beverly Wright, we convened four EEJ networks to map Southern Gulf Coast, primarily African American, underserved EJ community priorities: the National Black Environmental Justice Network, Historically Black College and University-Community Based Organization Gulf Coast Equity Consortium, the Deep South Center for Environmental Justice (DSCEJ) Community Advisory Board, and the Environmental Justice Forum. The Communiversity model, advanced alongside the EEJ movement in the South, safeguards against a potentially extractive or exploitative process. By ensuring EJ communities are equal active participants in research and recognizing diverse knowledge contributions, university-based experts support the presentation of EJ problems and policy solutions in a scientifically valid way. The technical and academic partners were Dr. Beverly Wright of the Deep South Center for Environmental Justice, Dr. David Padgett of Tennessee State University, and Dr. Nathan Morrow of Tulane University.

Assessment of the Gulf Coast Environmental Justice Landscape for Equity (AGEJL-4-Equity) identified three objectives adapted for Southern coastal landscape analysis:

1. **Advance Information:** engage and capacitate four EEJ networks to map underserved EEJ stakeholder communities priorities, ways of working, and knowledge of Earth science-based evidence;
2. **Advance Organizations:** Convene network representatives of underserved, primarily African American, Gulf Coast communities for a participatory workshop to compare EEJ network community priority mapping, highlight NASA products and Open-Source Science resources, and explore existing and innovative ideas to address gaps in evidence to be addressed by current or planned NASA-related missions;
3. **Advance Integration**: Synthesize learning in a comparative Landscape Analysis that explicates barriers and opportunities unique to the Gulf Coast context and next steps to advance EJ organizations.

3.b. Four Environmental Justice Networks

In this section, we provide a brief background for each of the four EJ networks that participated in AGEJL-4-Equity.

National Black Environmental Justice Leadership Forum (NBEJN)	The BEJN is a national coalition of environmental justice organizations and activists of African descent. Since its inception, NBEJN has pursued a proactive strategy for organizing a broad- based Black community to meet the environmental and health threats that disproportionately affect African Americans and other people of color.
Historically Black College and University-Community Based Organization (HBCU-CBO) Gulf Coast Equity Consortium	The goal of the Consortium is to improve the health and lives of children and families in the Gulf Coast Region. Members of the Consortium are dedicated leaders of community-based organizations and accomplished professors at HBCUs. Through the Consortium, voices within Gulf Coast Region communities are heard, community members are educated on the issues most important to them, and community members are trained in the use of effective strategies to put into action. The community's strategic action results in the transformation of their communities so that children and families enjoy improved health outcomes and a better quality of life.
Deep South Center for Environmental Justice (DSCEJ) Community Advisory Board	The purpose of the DSCEJ Community Advisory Board is to bring together diverse community stakeholders to develop solutions to environmental and climate inequities adversely impacting people of color communities along the Gulf Coast Region. The advisory board is comprised of environmental experts, community leaders, educators, faith-based leaders, and public health professionals from the Gulf Coast Region (Louisiana, Mississippi, Alabama, Florida, and Texas).
Environmental Justice Leadership Forum	The Environmental Justice Leadership Forum is a national coalition of 54 environmental justice organizations working together to advance climate justice and impact policy to ensure the protection and promotion of communities of color and low-income communities throughout the U.S.

3.c. Communiversity

Beginning in the 1990's, Dr. Beverly Wright and DSCEJ pioneered the Communiversity model for participatory data collection and assessment processes that focuses on

capacity development and empowering context specific community advancement of EEJ (DSCEJ, 2022). **“Community voices must be heard”** is a fundamental principle of the process that recognizes equitable value in lived knowledge of those facing environmental injustice alongside more theory-oriented knowledge contributed by the scientific method. The capacity of communities to respond to environmental threats and hazards is developed through workshops, supported by academic university-based experts, to systematically investigate equity and the EJ landscape in a scientifically valid way.

Many disciplinary traditions and current research in Earth science might not include human subjects at all. On the contrary, EJ research often involves the participation of some of the most vulnerable members of society. Subjecting EJ communities or their members to experimental or positivist approaches to research can reinforce power imbalances, contribute to further ‘othering’ of EJ communities as research subjects, and may risk ethical issues with Institutional Review Boards unless proper safeguards are put in place. Unequal relationships between researchers and EJ communities can lead to systematic bias, thus influencing results and skewing data. The genesis of this bias can stem from the initial stages of study design, including the selection of research questions, sites, and methodologies. These types of intrinsic bias can risk compromising the reliability and fairness of the outcomes. Consequently, safeguarding against such biases becomes central to the principles of EJ and its research methodology.

Developed within the EJ movement in the South, the Communiversity model safeguards against extractive or exploitative processes by ensuring EJ communities are equal, active participants in research (Bullard & Wright, 1993). It incorporates capacity development, diverse knowledge contributions, and university-based expertise to present EJ issues and policy solutions in a scientifically valid way. Importantly, the Communiversity model is versatile enough to align with NASA's Open-Source Science and data products, maintain the integrity of the research process and amplify the voices of EJ communities. The approach is flexible enough to be adapted to accommodate Open Science approaches and shares the focus on inclusivity in the scientific process. The diversity, inclusivity, and equity outcomes of Open Science is an emerging area or research that could be informed by piloting within the existing Communiversity model.

The Communiversity model is guided by the foundational EJ Principle: **“We speak for ourselves,”** embodying the essence of self-determination, and has five participatory action research activities to co-create investigations:

1. Environmental hazards proximity analysis and/or community-based monitoring;
2. Risk and harm assessment of toxic exposures, place- and group-based vulnerability, and disaster resilience;
3. Inventory of existing environmental data and identify gaps to be addressed;
4. Rights and the duties of communities and governmental agencies; and

5. Capacity requirements to advance evidence-based strategic advocacy.

The Principles of Communiversity to guide co-created participatory action research include:

Equal Voice Partnership: The model establishes an equal voice partnership between community members and academic researchers. This ensures that the knowledge generated, and policies advocated for, are rooted in the community's realities, bridging the gap between theoretical academia and lived experience.

Community-engaged Research, Citizen Science, and Research-to-Action: Incorporating citizen science and research-to-action methodologies, the model encourages community participation in the research process, fostering understanding, trust, and collaboration. This approach aids in the production of research findings that are relevant, actionable, and have direct impacts on the communities involved.

Integrity of Design: Maintaining the integrity of the Communiversity model is crucial. It safeguards the community-research partnerships, ensuring their long-term sustainability and effectiveness. This integrity is built on respect for the community's knowledge, experience, and the value of their input.

Strengthened Communities: The model advocates for HBCUs to work in close collaboration with communities. By engaging community members as true working partners, it empowers them and strengthens their ability to effect positive change.

Keeping the Ultimate Goal at Center: The ultimate objective of the Communiversity model is to enhance communities' capacities to influence change that improves the health and well-being of their children and families.

Operationalizing the Communiversity Model

Prioritize Community Issues: Start by conducting a needs assessment to identify priority issues and the community's vision for the future.

Map and Build Relationships: Identify existing and missing relationships within the community and potential local, state, and federal partners. Then, strengthen or establish the necessary relationships to support the advocacy process.

Make Your Case for Change: Gather information to develop a compelling case for change, utilizing powerful storytelling, research, and advocacy tactics.

In conclusion, the Communiversity model presents a robust, community-centered approach to integrating academic research with grassroots action. By respecting and valuing the lived experiences of community members, we can develop more effective, equitable, and evidence-based policies that truly address the needs of the community.

3.d. Case Analysis from Communiversity EJ Network Engagement

In this section, we present two (2) case studies of the Communiversity model engagement with EJ Networks.

Case Study 1: Mapping Environmental Justice - The Successful Use of Geographic Information Systems in the Wedgewood Community's Fight Against Pollution in Pensacola, Florida

Context and Communiversity Response

The shallow groundwater flow in southern Escambia County, Florida is threatened by pollutants from contaminated burrow pits and unlined landfills (see Figure 3). Pastor Calvin Avant is a leader in the Wedgewood Community located in this threatened watershed near Pensacola. He is the executive director of Unity in the Family Ministry and a member of the National Black Environmental Justice Leadership Network (NBEJLN). Following Dr. Wright's Communiversity model with the support of the Deep South Center for Environmental Justice, Pastor Avant and the BJLN partnered with the Earth Scientist Dr. David Padgett from Tennessee State University to analyze potential EJ threats in the area.

Together, they embarked on a comprehensive mapping strategy to visualize and combat the environmental challenges facing the community. The network leveraged Geographic Information Systems (GIS) technology to map the point source pollution and shallow groundwater flows. This was done using maps from the NW Florida Water Management District, elevation maps from Topographic-map.com, and aerial photography. They then overlayed these maps with proposed development plans, providing a powerful tool to combat harmful environmental changes. Additional construction could increase groundwater flow from these sites, spreading contamination further.

Key Advocacy Wins: Timeline

- **Fall 2019:** Wedgewood Community stakeholders successfully employed GIS maps at a County Commission meeting to block the construction of a four-lane highway, which would have worsened the groundwater pollution problem.
- **Fall 2021:** Utilizing local hydrology maps and aerial photos, the Wedgewood stakeholders successfully blocked a landfill permit application, further protecting their community.

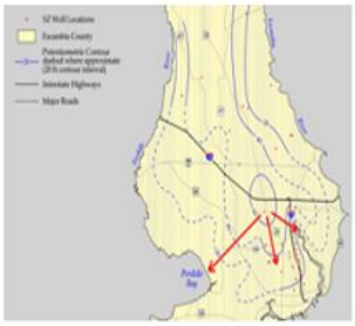
Conclusions & Potential for Integrating NASA Satellite Data

The case of Wedgewood Community, guided by Pastor Avant and the National Black Environmental Justice Leadership Network, demonstrates the transformative power of the Communiversity model. Community-led research supported by community-engaged academics informed community action and leveraged the site appropriate use of publicly available data and appropriate technology. Considering these achievements, incorporating data from NASA satellite missions and sensors has potential to strengthen evidence available to the Wedgewood EJ community including:

- Commercial satellite data to improve measurement (size), characterization, and identification of burrow pits, landfills, and other point source pollution sources. High resolution imagery from these sensors would also allow improved infrastructure mapping to assess current impact and model future risk under proposed development or environmental change.
- Timeseries from the Harmonized Landsat Sentinel-2 could better characterize land cover and lands use change. This is important for identifying and modeling changes subtle changes in water flow and pollutants. Also, longitudinal data helps characterize the potentially impacted communities and how they have changed through improved integration with socio-economic, race, and demographic data. These data also provide engaging mapping and visualization to better advocate for policy decisions favoring EJ and affected communities.

The GRACE mission for ground water may not be able to support studies at this very local scale, but SMOS/SMAP for soil moisture and IMERG-GPM for precipitation may be useful in mapping and monitoring groundwater flows and EJ communities.

Figure 3: Pastor Calvin Avant presenting ground water maps at City Council Meeting



DEEPSOUTH CENTER FOR ENVIRONMENTAL JUSTICE

Case Study 2: Community Asset Mapping Africatown, Alabama

Historical Overview

Africatown is a historically significant community near Mobile, Alabama. The West African founders were forcefully and illegally transported across the Atlantic on the ship Clotilda, arriving in 1860. The inhabitants of Africatown maintained their language and

customs into the 1950's. After a peak population of nearly 12,000 inhabitants coinciding with expansion of the papermill industry, the current Africatown population of 2,000 is predominantly English speaking. The recent discovery of the remains of the Clotilda has added to the wealth of cultural heritage sites in Africatown and was featured on the cover of National Geographic.

Major Joe Womack is a descendent of the Africatown community and co-founder of the community-based organization CHESS. Major Womack, who recently received an honorary doctorate from Oberlin College, brings experience in the military, a successful private sector career, and deep experience in community mobilization to his leadership of CHESS and popular Africatown-focused blog. CHESS is an acronym standing for Clean, Healthy, Educated, Safe, and Sustainable, summarizing the organization's core objectives:

- **Clean**: CHESS advocates for a well-maintained and attractive environment, working to secure funds for regular maintenance and equitable treatment of public spaces.
- **Healthy**: In a community surrounded by heavy industry, CHESS calls for routine environmental health monitoring and aims to combat the food desert status of Africatown.
- **Educated**: Understanding the crucial role of education, CHESS emphasizes the need for environmental awareness among adults and children.
- **Safe**: To enhance community enjoyment and wellbeing, CHESS is implementing the Africatown Plan that includes the creation of safe recreational trails.
- **Sustainable**: In all its initiatives, CHESS ensures sustainability, guiding their approach to the development of all facilities.

Major Womack is a member of the Environmental Justice Forum (EJF). Working with DSCEJ and Dr. David Padgett of Tennessee State University, aligned with the Communiversity Model, Major Womack along with members of CHESS and EJF embarked on a participatory mapping of community assets in service of the organizations' multi-dimensional environmental-social-racial-economic justice mission.

A Timeline of Mapping for Preservation, Equity, and Sustainability

- **2009**: Africatown was acknowledged for its historical significance and was included in Mobile's African American Heritage Trail, recognizing its unique cultural legacy.
- **2012**: Africatown received further recognition when it was listed on the National Register of Historic Places, underscoring the national importance of its heritage.
- **2019**: The discovery of the Clotilda attracted major attention to Africatown. This historical find made the cover of National Geographic in February 2020, amplifying the community's story to a global audience.

- **2020**: In a Communiversity collaboration, Africatown community stakeholders partnered with Tennessee State University for community-based participatory mapping using GIS. This project helped the community retain control of their local history, culture, and community assets.
- **2020**: Africatown community stakeholders, Tennessee State University's Urban Geography students, and the National Park Service worked together to create a story map of the 14 points of interest on the proposed Africatown Connections Blueway.
- **Summer 2021**: Further collaborative efforts saw Tennessee State University, the US Park Service, and citizen scientists from Mobile create a high-resolution drone imagery story map in support of the proposed Africatown Connections Blueway project.

Conclusions & Potential for Integrating NASA Satellite Data

The Communiveristy, with a focus on capacity development, can extend spatial analysis skills to a diversity of participants with methods such as participatory mapping. Community engagement in research and evidence base for policy strengthens advocacy and can foster consensus when a plurality of the communities has a stake in the science.

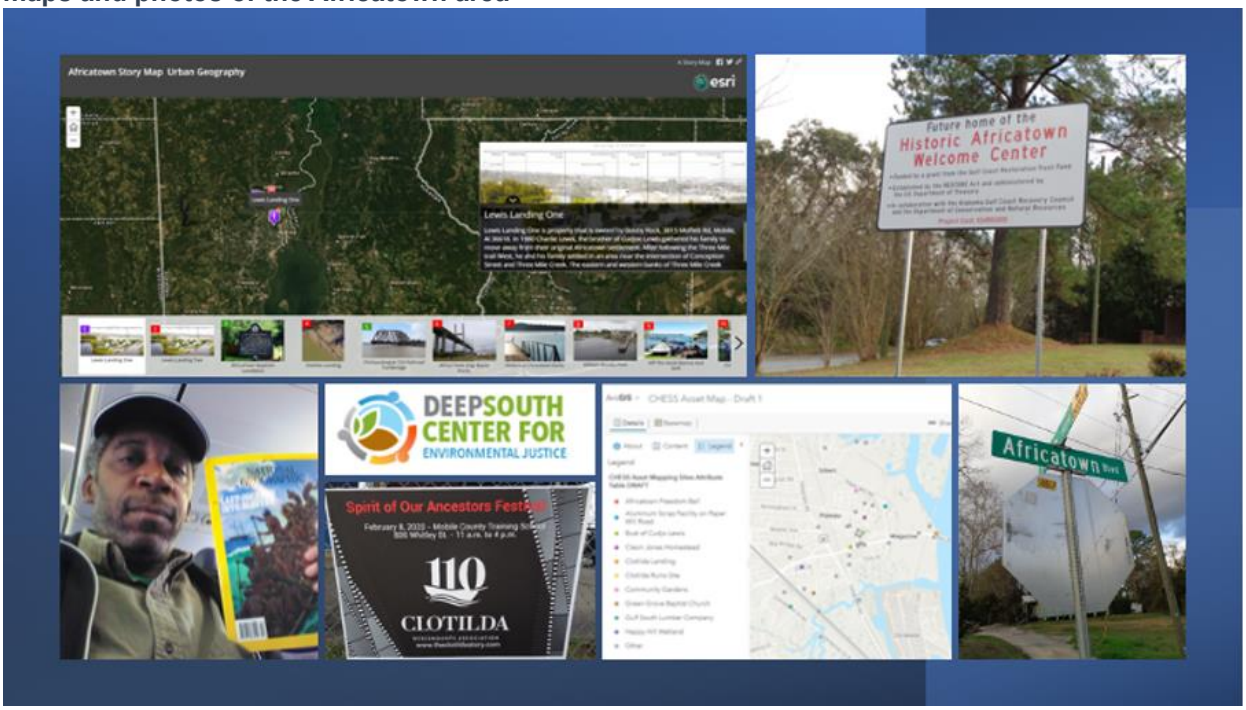
NASA, through open science initiatives and providing ready to use satellite derived basemaps for participatory mapping, could promote this type of community engagement. This not only empowers organizations like CHESS and community members alike, but it can also be critical to understanding and explaining the community's priorities and multi-dimensionality of the context. Both high resolution Commercial Satellite and the Harmonized Landsat Sentinel-2 could be used to improve basemaps for participatory community asset mapping.

Enhanced environmental monitoring is essential for the health of the community and the attractiveness of community assets like the African American Heritage Trail and the new Blueway highlighting historically and environmentally significant places. NASA's satellite data is capable of providing extensive environmental information on water quality, water resources, and air quality. This can be combined with GIS with the results of the participatory community asset maps for monitoring, planning and for taking necessary actions to improve or respond to negative changes. NASA products for water quality and air quality that may be appropriate include:

- NASA open science initiatives, NASA data assets, and methods like participatory mapping have potential for engaging youth in research, civil society, and making a lasting impact on education. Major Womack has long advocated for environmental education as a tool for community resilience. Additionally, NASA's educational resources can be used to enhance environmental science teaching, adding a real-world context to learning.

- Action for community health could build on the Blueway to promote expansion of safe recreational spaces. To advocate for and assist planners in expanding parks and other safe outdoor space, work on green areas and heat islands could benefit from NASA assets and EJ research approaches for sensors such as previously used in air quality monitoring with MISR, SeaWIFS, SeaStar, and MOPPIT or TEMPO and the Multi-Angle Imager for Aerosols (MAIA), mission that may be expanded to southern cities. Integrating current land use with socio-economic data, existing recreational spaces, community usage, and safety records could promote planners making more informed decisions on funding and locating safe and accessible recreational spaces with data sets such as the harmonized Landsat Sentinel-6 Michael Freilich land cover change timeseries.
- Data-driven approaches, including NASA open science and data assets, could become a regular part of community engagement to long-term community resilience and sustainability. Data products on climate and environmental change could be used for mitigation and protection of culturally significant sites and the Africatown community. Africatown faces a variety of risks from unchecked industrial development to regular hurricane risk. NASA sensors and products that could be used include Suomi NPP/VIIRS DNB nights at light imagery to monitor disaster recovery; sea level estimates from TOPEX/Poseidon, Jason-1-3/OSTM, OSTM/Jason-2, Jason-3; and climate-related hazards imaging capabilities of TRMM, VIIRS and MODIS. Furthermore, with the Blueway development, the PACE mission and GLIMR will be useful in monitoring water quality improvement investments.

Figure 4: Dr. David Padgett with National Geographic article about excavations at Africatown with maps and photos of the Africatown area



3.e. AGEJL convening and piggyback sessions on Justice40 convening

To honor the time of the EJ network representatives and to make most efficient use of project funds, we adapted our planned single large in-person meeting into three (3) separate engagements following an initial “kick off” meeting to introduce the project to EJ network representative is October 2022. We held the flagship AGEJL-4-Equity Convening on March 17, 2023, at the Tulane University Coastal and River Center in New Orleans, Louisiana. Ten (10) EJ Network members living in or able to travel to New Orleans attended. Owen Hooks, Lauren Childs Gleason, and Nati Phan represented NASA at the convening. The convening was co-facilitated by Mary Williams of the DSCEJ, Dr. David Padgett of Tennessee State University, and Dr. Nathan Morrow of Tulane University.

AGEJL Convening Agenda, March 17, 2023:

9:00 am - 10:00 am	Welcome and coffee
10:00 am - 10:45 am	Mary William and EJ representatives Opening Remarks, Communiversity potential for equitable EJ community engagement, and Essential EJ networks and events -- timeline
10:45 am - 11:15 am	Dr. David Padgett NASA Communiversities Gulf Coast Communities (EJ network priority mapping presentations)
11:15 am - 11:45 am	EJ communities’ discussions
11:45 am - 11:55 am	Nati Phan Maps using NASA satellite data for EJ use
11:55 am - 12:30 pm	Lauren Childs Gleason NASA EJ Resources
12:30 pm - 2:30 pm	Lunch break in Slidell
2:30 pm - 4:00 pm	Tour of NASA Infinity Science Center

AGEJL Workshop Participant list (March 17, 2023)

1. Rayliene Johnson
2. Kristen St. Cyr
3. Freddie Leslie
4. Mary Williams (Deep South)
5. Owen Richard (NASA)
6. Dr. David Padgett (NASA)
7. Nati Phan (NASA)
8. Lauren Childs-gleason (NASA)
9. Dr. Nathan Morrow (Tulane University)
10. Pornpimol Kodsup-Taylor (Tulane University)
11. Tyneisha Bradley (Tulane University)
12. Arthur Busby
13. Dawn Hebert
14. Marcia McWilliams
15. Lourdes Landrum
16. Sabrina Mays
17. Claudia Celestin
18. Johnnette Jackson

There was a Justice40 convening that included participants from the same EJ networks as AGEJL-4-Equity in New Orleans on February 22, 2023. Participants included Major Joe Womack and Pastor Calvin Avant profiled in the Case Study section of this Landscape Analysis. Justice40 convenings led by the DSCEJ follow much of the same approach as AGEJL-4-Equity with the Communiversity method employed to build the capacity of participants to map and articulate EJ priorities for decision making and advocacy. This focused on infrastructure, investments, and localized flooding. In the data for decision making session co-led by Dr. David Padgett and Dr. Nathan Morrow, a range of disaster vulnerability and preparedness topics were discussed. There was a good deal of concern about recent and previously unthinkable tornado and freeze events across the south. Participants were interested in how NASA data could help monitor EJ community concerns and how EJ network members could learn more about the potential of NASA data. Participants also were eager to collect their own data with instruments such as Purple Air Sensors.

A Justice40 meeting was held in Houston March 20-22, 2023. The session focused on understanding and use of multiple screening tools including the highly anticipated HBCU Climate and Environmental Justice Screening Tool (HCEJST). The HCEJST was developed to supplement the Council on Environmental Quality's (CEQ) CEJST that excluded race as an indicator—despite race being the most potent predictor of environmental and climate vulnerability and despite feedback from Drs. Bullard, Wright

and other members of the WHEJAC. Community leaders will use several tools to properly understand environmental and climate justice data in their communities and assess the efficacy of screening tools to accurately identify “disadvantaged” community designation for Justice40 funding.

The AGEJL-4-Equity convening coincided with an Open Science workshop supported by the Louisiana Board of Regents and Louisiana NASA EPSCor that took place March 16, 2023. This focused specifically on Louisiana-based researchers and EJ organizations. NASA program officers including Cynthia Hall, the NASA Community Coordinator for their flagship open science project, presented and led lively round table discussions based on EJ community prioritization of issues, including:

- Open engagement and partnering,
- Fair data access, and
- Open evidence-based communication and publishing.

4. RESULTS

4.a. EJ Priority Mapping

EJ network priorities were mapped together during AGEJL-4-Equity and associated convenings and workshops. We were able to analyze patterns of EJ network priorities and identify potential EJ use cases for NASA data in the Gulf South. The EJ priorities mapped into the following groupings:

Air Quality, both indoor and outdoor, remains a top concern for stakeholders. The public health threats from the presence of harmful particulates and odors in the air were a top priority. Asthma for children was the greatest concern as well as cancer, respiratory illness, and cardiovascular diseases. Stakeholders highlighted the need for robust monitoring and regulation to improve air quality, specifically targeting industrial sites and heavily trafficked areas.

The adverse health outcomes related to air quality and pollution were clear to participants, but there was dissatisfaction with the current air quality monitoring and calls for more localized and community engaged research. Stakeholders called for studies on the health impacts of localized and fluctuating toxic exposure. They emphasized the importance of assisting overburdened communities with relevant environmental and health data for permitting and monitoring adherence to regulations.

Flooding and Water Management was a top concern. The issues with localized flooding also intersected with discussion of infrastructure investment, personal economic cost, and general health concerns. Many EJ network members had personal stories about flooding exacerbated by poor planning of new infrastructure, neglected infrastructure causing flooding, or economic and health hardship from flood mitigation that did not take residents' knowledge and perspectives into consideration. For older and more vulnerable EJ residents, flooding is a major concern as a frequent disruption and threat to their wellbeing.

Clean Water and Groundwater Contamination remains a significant issue in many communities, often tied to groundwater contamination. Surface water quality and odor was also an identified priority.

Energy Justice & Solar Energy investments under Justice40 in the transition towards renewable and clean energy sources was a somewhat unexpected EJ network priority. The influence and impact of the petro-chemical industry along the coast likely contributes to the attention to links of local impact with telecoupled and global energy concerns. This local level infrastructure improvement also needs data and research according to participants so that the energy transition can be inclusive, provide opportunities for marginalized communities, promote participation, and benefit EJ communities.

Heat Mapping to identify urban hotspots where lack of vegetation and high concentration of buildings contribute to elevated temperatures. This was discussed as part of the larger health, air quality, and asthma discussions.

Legacy and Heritage – the importance of preservation and research into cultural legacy and heritage within the context of environmental justice with community asset mapping was also emphasized. Research and policy discussions should incorporate and be appropriate to historical and cultural contexts, ensuring that research, policy changes, investments are in harmony with and protect cultural practices and heritage.

Gentrification was a concern that social inequality would be exacerbated, and EJ communities displaced, with large infrastructure investment in EJ communities. Gentrification is also a concern following remediation of toxic spaces and hazards. Environmental improvements must not inadvertently displace current residents but enhance the living conditions of existing communities while preserving cultural diversity.

Climate Crisis – EJ networks emphasized the importance of further research into the climate crisis, specifically focusing not only on land loss, sea level rise, and coastal erosion, but the impacts on their communities of increased storms, localized flooding, and heat. They highlighted the need for studies on climate adaptation strategies and the societal impacts of displacement due to these environmental changes.

Novel areas of research – EJ network representatives also suggested potential topics for investigation based on their own experience. Marsh fires and smoke were an unexpected issue in the wetlands of the coasts. Fires and flares from multiple sources including intentional burning of crops and industrial accidents could also be investigated with thermal sensing products. Potholes and poor maintenance of roads may be correlated with other lacking services in underserved neighborhoods. There was a good deal of concern about lead and other toxic metals in the soil and water, but there was not a clear connection to how NASA data might help with those issues. Food justice and agriculture were also raised as areas of interest to EJ communities. Odor and noise sources, proximity to heavily trafficked roads, lack of protective infrastructure, and lack of services along with community assets could be investigated and mapped with higher resolution sensors or integrated data sets.

Cumulative effects – stakeholders suggested focusing on the complexity of economic and environmental exposures, which often lead to new and cumulative vulnerabilities for communities. One interaction that was mentioned is the increase in toxic and petro-chemical odors with increasing heat as more gas escapes from leaking storage facilities or other sources. The group recommended linking regional and international economic data to the inequitable impacts on local communities, emphasizing the need for a systems-aware analysis in EJ research.

Overall, the felt experience of the EJ community residents with personal stories of harm and unresolved health issues or unexplained odors were a main source of discussion and identifying priorities. Time and again, discussion would reiterate the connection between environmental and social justice. The EJ communities did want to participate in better understanding the EJ issues and putting forward solid advocacy for solutions based in improved understanding of causes for environmental injustice seen and experienced. Participants fully supported efforts to prioritize diversity, equity, and inclusion, and recommended increased community-based participation in research. The discussion points to a need for data literacy in the context of EJ, particularly with youth. Stakeholders stressed the importance of understanding and utilizing data to make informed EJ decisions, emphasizing the necessity for accessible and understandable data for all community members. Two themes in particular were raised in each meeting, beginning with the AGEJL-4-Equity "Kick-off" meeting in October of 2022 and continuing to the last consultations:

- Integrity in engaging with EJ organizations and communities is of primary importance. Honest, open, and transparent communication is required alongside commitment to the partnership and shared values in advancing EJ.
- Fairness in data ownership and sharing also was a primary concern because of a pattern over a long period of researchers exploiting communities. Fairness in data is a foundation of equity in all aspects of partnering with EJ organizations and EJ communities.

Because of direct participation by NASA program officers and Dr. David Padgett's long-term experience with NASA, presentations and discussion led to the EJ network convening and workshop participants becoming enthusiastic about the possibilities of better use of NASA data for EJ. For the diversity of potential projects discussed such as stormwater management, inequity in infrastructure, air quality and asthma, urban green space disparity, or climate change, expectations have been raised that a good deal of investment would be put in place for EJ community–academic engagements to leverage NASA data for improved decisions and policy that will address injustice and advance EJ communities.

4.b. EJ community preferred engagement approaches

Participants in the AGEJL-4-Equity convenings and workshops welcomed NASA EEJ program development and could see the benefit of NASA data products to the identified EJ priorities. The groups had a refined formulation of "program" development from decades of experience partnering with different agencies and institutions. The program would need to advance and strengthen the EJ communities and their members with a multi-layered approaches and longer-term commitments that would 1) focus on the wellbeing and priorities of the EJ community, 2) develop capacity and strengthen community institutions, 3) engage the community fully in any research.

EJ community engagement approach 1: EJ community development

The shared common goal of any program should be to strengthen the EJ communities and improve the environment for and health of all community members. Participants noted that most community-based EJ organizations and their constituents are not organized around a single EJ issue but simultaneously support enfranchisement, social and economic advancement, and a healthy environment. This unity of purpose should be integrated into any engagement, capacity development, or research activity. Engagement, in turn, comes from an integrated understanding of the social, economic, and environmental resilience of EJ communities. Tangible results of engagement and advocacy should build on community assets and be intentional, practical, and observable. This includes creating paid employment opportunities, supporting local organizations/institutions/businesses, increasing safe and green spaces, and visible improvements in infrastructure and services. Health and wellbeing should remain at the center of communications with EJ community members, and projects should clearly result in healthier environments and households.

EJ community engagement approach 2: EJ network and organizational capacity development

EJ network or organizational capacity development remains a central concern to advancing EJ. EJ organizations are over-stretched with both the magnitude of EJ issues and the increasing demands to engage with a range of agencies and institutions now wishing to do EJ research and action. Sufficient resources, over sufficient periods of time, should be committed to allow EJ organizations to recruit and retain necessary capacity for evidence-based decision support and action research. There are equipment and infrastructure needs, particularly for backbone knowledge management and training services of medium-sized bridging institutions. Capacity development of EJ community members should not be limited to data collection. The participants were specifically interested in manipulating the data for their own investigation and advocacy purposes particularly with online GIS or other visualization tools. There was an interest in understanding the full spectrum of NASA data and how it was disseminated. Communiversity specifically, and open science more generally, frame EJ network and community capacity development to serve through the entire scientific process beginning with defining research questions to dissemination and use of results.

EJ community engagement approach 3: Embrace EJ principle #1 “We speak for ourselves”

Taking community-engaged science to “EJ community-owned” science should be the longer-term goal of the NASA EEJ program. The participants emphasized the importance of involving the youth in community-engaged EJ research. Institutions within the community such as schools should be involved along with nearby colleges and universities. DSCEJ and EJ network members were asking for, often clamoring for, academic support for their research, but there was a recognition that a distinct lack of academic focus to EJ and community-engaged science in the institutions of the Gulf

South. The high level of interest in Purple Air Quality sensors[2] and having the necessary equipment and connectivity to collect data managed by the community was appealing. This led to discussion of other potential sensors for heat or noise. Linking to the first pilar of community development, there were stories and encouragement for EJ community leaders and organizations to be available and prepared with appropriate data to advocate for community members as EJ-related problems emerged. There was also interest in facilitating exchanges of information, mutual support, and perhaps collective action that could be facilitated by programs promoting exchange visits between EJ communities and youth networks.

4.c. Synthesis of Findings: Environmental Justice Disparities, Procedural, Recognition opportunities

To advance equity and EJ, NASA must not only provide data and technical solutions to better measure disparities but also support EJ communities leading research and advocacy to inform the decisions, policy, and policy implementation that impacts their lives. Furthermore, EJ demands recognition of the value of EJ communities' knowledge and to honor the history, culture, and perspectives of EJ communities and the EJ movement. This may require changes to processes, different approaches to planning and managing programs, and capacity development for NASA personnel that are beyond the scope of this Landscape Analysis. In this section we will briefly summarize main findings of the analysis considering the potential opportunities for NASA to address gaps from EJ disparities, procedural, and recognition perspectives.

Opportunities to improve measurement of EJ disparities

EJ research is primarily place-based on a local scale. Current data products from synoptic satellite measurements over large areas generally have only a secondary, but important in the longer-term, role integrating Earth system processes with systems and patterns of environmental injustice. For immediate use, a specifically curated set of NASA data and newly tailored information system products are likely required (e.g., information products mapping and visualizing localized impacts of climate change for specific EJ communities). Mapping of thermal hotspots and green spaces with existing NASA data has demonstrated promising results but is not a top priority, particularly without integration of health data, for the EJ networks contributing to this analysis from the more rural Gulf South.

There is greater potential to respond to EJ community priorities with missions such as TEMPO and the Multi-Angle Imager for Aerosols (MAIA), which was specifically built to

[2] For more information on Purple Air sensors, see https://www2.purpleair.com/.

better understand air quality in localized areas at scales relevant to decision making. Higher resolution data from commercial data sets may be appropriate for more local level investigations related to infrastructure, gentrification, and localized flooding. Landcover change timeseries may improve EJ research into drivers of disparity and distance-based exposure science. Historical investigations may also benefit from improved land cover mapping over time and archaeological approaches using radar. Future PACE and GLIMR missions with hyperspectral and high temporal frequency capabilities may prove very relevant to coastal environmental, climate, and ocean justice issues. In nearly all cases, significant processing or application of integrated socio-environmental models is likely to be required.

Opportunity to improve participation of EJ communities in decisions that affect their lives

Engagement and capacity development of EJ community organizations and members is the most immediate opportunity for NASA to advance EJ with its current data and systems. NASA landcover mapping and information system products about land, water, climate, and air are perfectly suitable as base maps for community-led participatory mapping. Mapping assets, hazards, risks, and patterns of harm can all benefit from integration of NASA products in data collection, synoptic analysis, and presentation. Visualizations for both community-engaged investigations and EJ issue advocacy could be supported with open-source tools by academic partners or backbone functions of bridging organizations. Capacity development to improve the scale, scope, and scientific validity of community-engaged science could leverage existing NASA initiatives such as TOPS, ARSET, DEVELOP, FINNEST and other programs. Justice40 and the NASA covered programs of Community Engagement and Climate Resilience are good starting points for empowering EJ community to actively engage in the implementation of Justice40 supported by a robust evidence base.

Opportunity to recognize the value of EJ community knowledge and honor the historical and cultural foundations of the EJM

Recent academic attention to indigenous and marginalized community knowledge, particularly for climate change and nature-based solution research, provides some models and approaches for NASA engagement in research with EJ communities. Using existing EJ community-academic engagement models and seeking to incorporate the EJ Principles and Ways of Working into research design are immediate and appropriate to steps for NASA to take for advancing environmental justice and EJ communities. With certification in and application of open science, novel and high-quality research into EJ issues identified by the community is likely to bring new insights, understanding, and development to the science of EJ. Frontline communities observe effects and know the patterns of occurrence for flooding, smoke or air quality, and cumulative effects that may be unfamiliar to narrowly disciplinary-focused scientists. By recognizing the value of this knowledge and supporting the capacity for EJ community-led science, novel and useful applied EJ research can be advanced.

Acting on these opportunities does not imply small or simple adjustments, but instead calls for sustained transformative commitment and investment. Expectations of EJ communities and researchers are high, but they also have decades of progress and experience to build from to advance EJ with NASA data and resources. Entry points for NASA engagement include:

- Building upon the EJ community engagement models developed by the activist scholars, such as Communiversity built on existing knowledge of necessary safeguards for research with vulnerable population in EJ contexts and deeply informed by the historical and policy context of EJM.
- Leveraging the complementarity and coherence of open science approaches with community-engaged science.
- Leveraging the organizations already working in the community with established relationships to lower access barriers in the most appropriate and helpful ways.
- Rededicating to the mission objectives of applying the Earth sciences to benefit humanity by supporting the development of an EJ evidence base aligned to EJ policy framework and local context for making desired change.
- Building upon the knowledge of experienced and energized frontline EJ communities.
- Engaging with academic and EJ organization partners experienced in contemporary approaches to capacity development. These approaches are self-directed, promote immediate application, and use tools that are accessible, directly applicable to context, foster peer-to-peer and expert engagement in an experiential learning context.
- Partnering with professional societies like AGU and NASA programs to support diversity and inclusion in the Earth science research workforce.
- Ensuring future missions expand data sources that have spatial, temporal, and spectral resolutions necessary for EJ research and integration with socio-economic and health data as well as socio-environmental models of EJ-related risk, exposure, and impact.

In summary, the EJ communities involved in this Landscape Analysis applaud NASA's initiative for EEJ. New ways of working together to co-produce research that makes the best use of NASA data and information systems will require a new and perhaps different engagement approach. Capacity development for open science and EJ-aware program implementation will be required for EJ community-engaged researchers, academics who support them, and NASA personnel involved in the EJ initiative. As NASA Earth science missions further improve resolutions and adjust processing of data to meet the needs of EJ communities, there is significant potential for major transformational improvement in the access and use of NASA data to support equitable, just, and fair decision making with real beneficial impact on vulnerable and underserved communities.

5. RECOMMENDATIONS

The intention of this Landscape Analysis is to inform longer-term NASA ESD EEJ efforts and Applied Sciences Program's EEJ-oriented application activities. The authors make the following recommendations based on the conclusions of the analysis and their understanding of the EJ context, policy, and policy implementation landscape in the Gulf South.

Recommendation 1	**Institutionalize Dr. Beverly Wright's Communiversity model at NASA with sustainable funding for EJ community-academic partnerships**

The Communiveristy model requires equity and integrity in community-academic partnerships that ensure community voices are heard. The community benefit model should include integrated support for direct payments for work, community micro-grants, whole-of-community development, and innovative resourcing approaches, as the situation requires. Capacity development is a central element of community-academic partnerships with a participatory geo-spatial analysis, data visualization, and mapping focus. Empowerment for evidence-based action is advanced with promotion of participation through rights-based knowledge of decision, regulation, and policy processes. Institutionalization of Dr. Beverly Wright's Communiversity model builds on decades of work of the EJ movement by crediting her foundational and ongoing contributions.

Recommendation 2	**Promote Open Science for EJ community-engagement training initiative and network development in the Gulf South through a regional hub partner**

Open science approaches have great potential to advance EJ community-engaged science, but more attention must be given to the networking and capacity development aspects of open-source science empowering infrastructure. Specifically, actions to develop open science initiatives in underserved regions such as the Gulf South with a focus on diversity and inclusion should be top priorities. Certification of EJ network and EJ community members in open science will improve quality, scientific validity, and recognition of community-engaged science. Promotion of academic certification through dedicated programs at community college, undergraduate, and graduate levels will address the near complete unavailability of open science trained academic partners in the Gulf South. To make a transformational change to open science in this region, an open science regional hub and open science research champions should be sustainably funded.

Recommendation 3	Recognize, support capacity development, and sustainably fund **"backbone" functions of bridging EJ organizations** to advance equity and environmental justice with NASA data products

Bridging access and use barriers to NASA Earth science data for frontline community-based EJ organizations and EJ community members requires dedicated support. Connectivity, facilities, capacity, and regular engagement with NASA focal points or sources of information dissemination to make best use of available data are unrealistic and overly burdensome requirements for small thinly staffed frontline EJ activists and community-based researchers. These action-oriented small organizations or local institutions may require the experience, systems, and personnel of bridging organizations to respond to opportunities or handle management of federal agency funded programs. Dedicated support for data-oriented backbone functions to support access to and the use of NASA data and development of capacity for data-oriented advancement of EJ communities and researchers is necessary and should be sustainably financed. These medium sized EJ organizations are also the appropriate venues to develop facilities to host dedicated in-person and virtual capacity development sessions for diverse groups. Engagement with youth through schools, youth activity-focused organizations, and dedicated youth programs may require appropriate experience and skills to be sustained as a backbone function. These medium sized experienced regional partners can bridge engagement of local government and non-governmental institutions with other federal agency initiatives and EJ hubs in order to facilitate synergies and avoid wasteful duplication of effort.

Recommendation 4	Empower EJ and underserved communities with NASA data and open science capacity support focused on planning, monitoring, and evaluating **Justice40 infrastructure investments** to safeguard anticipated fair distribution and intended benefits to underserved and EJ communities

Transformational improvement in the wellbeing and environment of underserved communities is possible with Justice40 commitments to climate change and infrastructure investment. Yet, EJ communities continue to face risk of inappropriate, irrelevant, or harmful infrastructure interventions and have well-founded concerns about gentrification and other forms of marginalization. Safeguarding benefits of Justice40 investments could be advanced by leveraging NASA data to inform, monitor, and evaluate policy implementation and impact. Higher frequency and higher resolution NASA data streams could refine the scale of geospatial information and build on the CEJST's integrated data set. An improved evidence base, informed by NASA data and NASA supported community-engaged open science, could advance these investments for environmental, climate, and ocean justice to forefront of resilience building in Gulf South underserved communities.

Recommendation 5	Extend and prioritize funding to integrated multidisciplinary community-driven research that contributes to **diversification and development of EJ theory** and related open access publishing

Advancement of EJ is held back by lack of availability and access to appropriate data. The scales, sites, and methods of data collection are not always fit for purpose to answer EJ research questions that may originate in EJ communities' experience or reflect distributional, procedural, recognition, and other theoretical EJ perspectives, traditions, and frameworks. NASA should promote multidisciplinary approaches to improved modeling risk and exposure with geospatial observational data paying special attention to scale effects. Causal research designs that emphasize observational counterfactuals, impact evaluation, modeling, systems thinking, or critical realist explanatory investigations of cumulative, integrated, and structural explanations of environmental injustice should be prioritized. NASA should access the significant potential to contribute to historical and cultural investigations leveraging timeseries data and data from active sensor systems. NASA opportunities should honor and uplift tribal, indigenous, and local community knowledge in EJ research. Specific topics suggested for research include:

- Novel measures focusing on extreme events, hyper spectral measurements, rich data streams, socio-economic high frequency near-real time data such as social media activity or expenditure during extreme events on heating/cooling.
- Novel sensors made and operated by communities including drones, digital capture of community experience, expanding on purple air, and heat sensors.
- Novel threats with EJ disparity potential health and climate change, disaster EJ, freezing, and tornados.

Recommendation 6	Adapt **ARSET and DEVELOP** approaches for needs of EJ communities

The contributions and capacity of EJ networks and community members cannot be realized if barriers to participation persist. NASA should ensure ARSET, DEVELOP, and other community-engagement opportunities meet the needs for EJ community member involvement. Accommodations should be made to promote participation for full time working people with 40-hour M-F jobs that may lack flexibility and for older or younger people with specific transportation, connectivity, capacity, and other differences. Existing ARSET content or DEVELOP planning tools could be adapted to reflect EJ action research formulations that emphasize inquiry on fairness, equity, disparities, procedural participation, and representation. Sessions and tools should be reviewed and updated to include approaches that uplift community voices and promote empowerment with community engaged science and critical making approaches. The updates could build upon principles of Communiversity or adopt the Communiversity approach as possible.

Recommendation 7	Initiate **youth engagement and workforce training for EJ Communities** in community-engaged Open Earth Science

Capacity requirements to sustainably advance EJ require long-term multigenerational engagement. NASA should engage youth to advance EJ in existing programs such as GLOBE and through support to backbone functions in medium sized EJ organizations for engagement in schools and with dedicated youth-engaged EJ programs. An academic qualification such as an associate degree program from minority serving community colleges for Open Earth Science concentrating on EJ could promote development of the workforce necessary to advance EJ research and action. Partnering with minority serving colleges and universities to offer educational opportunities, certificates, or other qualifications for engagement in EJ should be investigated. FINNEST, Early Career Researcher and other NASA higher education engagement should focus on EJ research and advancing EJ community members.

Recommendation 8	Stand-up a Distributed Active Archive Center DAAC for EJ located in the Gulf South to address a great challenge for advancing EJ – lack of appropriate data

Data, systems, and capacity requirements of the NASA EJ initiative are distinctive from approaches used in previous missions or programs. Informed by experience and content of other DAAC's such as Socio-economic Data and Applications Center (SEDAC)'s global gridded demographic data and landcover information from the Land Processes DAAC, NASA should stand up a dedicated DAAC to advance EJ in the Gulf South region to provide integrated data products and information systems customized to the specific needs of EJ, climate justice, ocean justice, and equity-focused research audiences. EJ data and analysis have unique spatial, temporal, spectral, and disaggregation requirements for appropriate and scientifically valid EJ analysis. EJ data users also have specific resource requirements to lower barriers to access and use of Earth science data.

A DAAC for EJ would be designed with integrated support for open and community-engaged science that originates from frontline EJ communities. Unique data visualization and interactive and real-time analysis for participatory, critical, and cumulative effect analysis and monitoring would be a design priority. Furthermore, the system design would incorporate unique data archiving and integration requirements of community-based science in approaches, including machine learning, that would synthesize learning and inform more wholistic analysis of systems and structures supporting EJ. The DAAC network needs a dedicated center to focus on fairness and disparities with dedicated EJ research capacity on demand for EJ communities and EJ organizations. Placement in the Gulf South would advance EJ in a region with significant gaps in EJ research capacity and data. The Gulf South region is at intersection of some of the greatest issues of environmental, climate, and ocean justice making the possibility of a DAAC located at the convergence of an emerging nexus

around ‘coastal justice’ concerns. Future missions of PACE and GLIMR would benefit greatly from a dedicated center focused on open, equitable, and engaged science located on the Gulf Coast.

Annex A: Bibliography

Baptista, A.I. & Perovich, A. (2020). Environmental Justice and Philanthropy: Challenges and Opportunities for Alignment Gulf South and Midwest Case Studies. Tishman Environment and Design Center. https://static1.squarespace.com/static/5d14dab43967cc000179f3d2/t/5e5e7781cccebf576948d365/1583249295033/EJ+and+Philanthropy+Alignment+MW+and+

Balbus, J., A. Crimmins, J.L. Gamble, D.R. Easterling, K.E. Kunkel, S. Saha, and M.C. Sarofim, 2016: Ch. 1: Introduction: Climate Change and Human Health. *The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment*. U.S. Global Change Research Program, Washington, DC, 25–42. http://dx.doi.org/10.7930/J0VX0DFW

Banzhaf, H.S., Ma, L., & Timmins, C. (2019). Environmental Justice: Establishing Causal Relationships. *Annual Review of Resource Economics*, *11*(1), 377–398. https://doi.org/10.1146/annurev-resource-100518-094131

Bowen, W.M., & Wells, M.V. (2002). The politics and reality of environmental justice: A history and considerations for public administrators and policy makers. *Public Administration Review*, *62*(6), 688-698.

Bullard, R.D., & Wright, B. (2020). *The Wrong Complexion for Protection: How the Government Response to Disaster Endangers African American Communities*. New York University Press. https://doi.org/10.18574/nyu/9780814799932.001.0001

Bullard, R. (2019). Addressing Environmental Racism. *Journal of International Affairs*, *73*(1), 237–242. https://www.jstor.org/stable/pdf/26872794.pdf?casa_token=7pkV6J3dEDIAAAAA:yUwHUB_x6EY9bcrvbZ1LVxeS12bkJdvq4HIkZFLmOchAjiLUW0LzwnziwFDP1_qEUjQCUJEzHe64TiAFw6128XxVoKIe7aoIx3BihbkBRPZGY4uMZQ

Bullard, R.D., & Wright, B.H. (1993). Environmental Justice for all: Community Perspectives on Health and Research. *Toxicology and Industrial Health*, *9*(5), 821–841. https://doi.org/10.1177/074823379300900508

Camelo, J., Mayo, T.L., & Gutmann, E.D. (2020). Projected Climate Change Impacts on Hurricane Storm Surge Inundation in the Coastal United States. Frontiers in Built Environment, 6, 588049. https://doi.org/10.3389/fbuil.2020.588049

Cohen, D.T. (2019). About 60.2 m live in areas most vulnerable to hurricanes. *US Census Bur*. Accessed 11-11-2022: https://www.census.gov/library/stories/2019/07/millions-of-americans-live-coastline-regions.html

Corbin, T.B. (2021). Disasters and Environmental Justice Policy 15 Years After Hurricane Katrina: What Has Changed?. Environmental Justice, 14(2), 98-104.

Council on Environmental Quality. (2022). *Climate and Economic Justice Screening Tool*. https://screeningtool.geoplatform.gov/en/cejst#3/33.47/-97.5

DSCEJ, Deep South Center for Environmental Justice. (n.d.). Our Work; Community Engagement. Retrieved March 1, 2022, from https://www.dscej.org/our-work/community-engagement

EPA. (2022). *Downloading EJ Screen Data*. https://www.epa.gov/ejscreen/download-ejscreen-data

Flores, A.B., Collins, T.W., Grineski, S.E., Griego, A.L., Mullen, C., Nadybal, S.M., ... & Trego, S.A. (2021). Environmental injustice in the disaster cycle: Hurricane Harvey and the Texas Gulf Coast. *Environmental Justice*, *14*(2), 146-158.

Gil, Y., David, C.H., Demir, I., Essawy, B.T., Fulweiler, R.W., Goodall, J.L., Karlstrom, L., Lee, H., Mills, H.J., Oh, J., Pierce, S.A., Pope, A., Tzeng, M.W., Villamizar, S.R., & Yu, X. (2016). Toward the Geoscience Paper of the Future: Best practices for documenting and sharing research from data to software to provenance. Earth and Space Science, 3(10), 388–415. https://doi.org/10.1002/2015EA000136

Gensini, V.A., & Brooks, H.E. (2018). Spatial trends in United States tornado frequency. *Npj Climate and Atmospheric Science*, *1*(1), 38. https://doi.org/10.1038/s41612-018-0048-2

Government Accounting Office. (1983). Siting of hazardous waste landfills and their correlation with racial and economic status of surrounding communities. https://www.osti.gov/biblio/5606995

Hendricks, M.D., & Van Zandt, S. (2021). Unequal protection revisited: Planning for environmental justice, hazard vulnerability, and critical infrastructure in communities of color. *Environmental justice*, *14*(2), 87-97.

Jones, J.M. (2023). Nearly Half in South Recently Affected by Extreme Weather. https://news.gallup.com/poll/473237/nearly-half-south-recently-affected-extreme-weather.aspx

Lane, H.M., Morello-Frosch, R., Marshall, J.D., & Apte, J.S. (2022). Historical Redlining Is Associated with Present-Day Air Pollution Disparities in U.S. Cities. Environmental Science & Technology Letters, acs.estlett.1c01012. https://doi.org/10.1021/acs.estlett.1c01012

Minovi, D. (2021). Toxic Floodwaters on the Gulf Coast and Beyond: Commentary on the Public Health Implications of Chemical Releases Triggered by Extreme Weather. Environmental Justice, 14(2), 105-109.

Mohai, P., & Saha, R. (2006). Reassessing racial and socioeconomic disparities in environmental justice research. *Demography*, *43*(2), 383-399.

Mock, N., Morrow, N., & Papendieck, A. (2012). From complexity to food security decision-support: Novel methods of assessment and their role in enhancing the timeliness and relevance of food and nutrition security information. *Global Food Security*, *2*(1), 41–49. https://doi.org/10.1016/j.gfs.2012.11.007

Morrow, N. (2022). *People-centered design in Open Sourced Science for enhanced use of Earth observation in equitable engagement, empowerment for collective action, and meaningful measurable impact.* Open Sourced Science (OSS) for Earth System Observatory (ESO) Mission Science Data Processing Study. https://doi.org/10.5281/zenodo.5932699

Morrow, N. (2022). *Open Sourced Science Geospatial Data Responsibility by Design.* Open Sourced Science (OSS) for Earth System Observatory (ESO) Mission Science Data Processing Study. https://doi.org/10.5281/zenodo.5932699

Morrow, N., Mock, N.B., Gatto, A., LeMense, J., & Hudson, M. (2022). Protective Pathways: Connecting Environmental and Human Security at Local and Landscape Level with NLP and Geospatial Analysis of a Novel Database of 1500 Project Evaluations. Land, 11(1), 123. https://doi.org/10.3390/land11010123

NAS -- National Academies of Sciences, Engineering, and Medicine - Gulf Health and Resilience Board, Gulf Research Program (2021). Perspectives on Climate and Environmental Justice on the U.S. Gulf Coast: Proceedings of a Webinar-in Brief (J. Saunders, Ed.; p. 26348). National Academies Press. https://doi.org/10.17226/26348

NASA. (2014). *NASA Plan for Increasing Access to the Results of Scientific Research*. https://www.nasa.gov/sites/default/files/atoms/files/206985_2015_nasa_plan-for-web.pdf

NASA. (2021). NASA Earth Science Division Equity & Environmental Justice Workshop Report. Accessed January 6th, 2022, https://science.nasa.gov/science-red/s3fspublic/atoms/files/NASA_EEJ_Workshop_Report_Oct_2021_final.pdf

NASA. (2022). Environmental Justice at NASA. https://earthdata.nasa.gov/learn/backgrounders/environmental-justice

Radley, D.C., Baumgartner, J. C., Collins, S.R., Zephyrin, L., & Schneider, E.C. (2021). Achieving Racial and Ethnic Equity in US Health Care.

Ramachandran, R., Bugbee, K., & Murphy, K. (2021). From open data to open science. *Earth and Space Science*, *8*(5), e2020EA001562.

Robinson, N.H., Hamman, J., & Abernathey, R. (2020). Seven principles for effective scientific bigdata systems. ArXiv. http://arxiv.org/abs/1908.03356

Van Horne, Y.O., Alcala, C.S., Peltier, R.E., Quintana, P.J.E., Seto, E., Gonzales, M., Johnston, J.E., Montoya, L.D., Quirós-Alcalá, L., & Beamer, P.I. (2023). An applied environmental justice framework for exposure science. *Journal of Exposure Science & Environmental Epidemiology*, *33*(1), 1–11. https://doi.org/10.1038/s41370-022-00422-z

Weden, M.M., Parks, V., Parker, A.M., Drakeford, L., & Ramchand, R. (2021). Health disparities in the US Gulf Coast: The interplay of environmental disaster, material loss, and residential segregation. *Environmental Justice*, *14*(2), 110-123.

White House Council on Environmental Quality & U.S. Digital Service (WHECEQ&UDS), (2022), Climate and Economic Justice Screening Tool Technical Support Document Public Beta, Version 0.1, Accessed 11-11-2022: https://static-data-screeningtool.geoplatform.gov/data-pipeline/data/score/downloadable/cejst_technical_support_document.pdf

Wilkinson, M.D. et al. The FAIR Guiding Principles for scientific data management and stewardship. Sci. Data 3:160018 doi: 10.1038/sdata.2016.18 (2016)

Annex B: Listing the current NASA Earth Science missions

Mission Name	Launch Year	Main Purpose
EMIT	2022	Improve understanding of the effects of mineral dust on atmosphere and human health, provides new mineral maps of dust-producing regions
Landsat 9	2021	Improve understanding of Earth's surface changes, including crop health, deforestation, glacial retreat, urban expansion
Sentinel-6 Michael Freilich	2020	Improve understanding of sea level changes, provides data on temperature and humidity in the troposphere and stratosphere
ICESat-2	2018	Improve understanding of height of Earth's land and sea ice, forests and vegetation, and urban areas
GRACE-FO	2018	Improve tracking Earth's water movement, provides insights into ice sheets and glaciers, underground water storage, and sea level changes
CYGNSS	2016	Measures wind speeds over the ocean in tropical storms, provides insights on hurricane data, locust infestations, and microplastics tracking
NISTAR, EPIC	2015	Improve understanding of sulfur dioxide from volcanic eruptions, ozone, UV aerosols, cloud and vegetation properties
SMAP	2015	Measures the amount of water in surface soil, helps in improving weather forecasts, monitors drought, and predicts flooding
OCO-2	2014	To study carbon sources and sinks, as well as variations over seasonal cycles
GPM	2014	Provides global observations of rain and snow, helps understand Earth's water and energy cycles, and improves forecasting of natural hazards
Landsat 8	2013	Provides essential observations of our changing planet, informs decision making in applications like human health, agriculture, climate, energy, and natural disasters
Suomi-NPP	2011	Provides valuable weather and environmental data, informs science like climate change, ozone layer health, natural disasters, and vegetation
CALIPSO	2006	Improve understanding of the role of aerosols and clouds in regulating Earth's weather, climate, and air quality

CloudSat	2006	Improve understanding of the inner structure of clouds and related climate changes
Aura	2004	Monitors Earth's atmosphere chemistry, provides data on the ozone layer, air quality, and greenhouse gases
Aqua	2002	Collects data about the Earth's water cycle, measures aerosols, natural hazards, vegetation cover, temperatures
Terra	1999	Provides data on atmospheric composition, carbon cycle and ecosystems, climate variability and change, the water and energy cycle, and weather
Landsat 7	1999	Provides multispectral imaging of the Earth’s surface, informs studies of land cover change and surface conditions

Launched:

TEMPO	2023	Monitor air pollutants hourly across the North American continent during daytime. Collect high-resolution measurements of ozone, nitrogen dioxide and other pollutants.

Annex C: NASA (Upcoming) Missions that will provide data in coming years

(https://science.nasa.gov/earth-science/earth-missions-future)

Mission Name	Launch Year	Main Purpose and Contribution to Understanding
TROPICS	2022	Collect temperature, water vapor, precipitation, and cloud ice measurements to study storms and meteorological events and improve forecasting capabilities.
NISAR	2023	Use two different radar frequencies to measure changes in Earth's surface, ecosystems, dynamic surfaces, and ice masses. Provide data on biomass, natural hazards, sea level rise, and groundwater.
SWOT	2023	Make the first global survey of Earth's surface water, observe ocean's surface topography, and measure how water bodies change over time.
MAIA	2023	Combine observations of atmospheric aerosols with pollution monitors and computer models to create daily maps of particulate amounts. Study effects on human health.
PREFIRE	2023	Make the first spectral measurements of Far InfraRed (FIR) radiation throughout the day and over seasons. Expand knowledge of the Arctic energy budget and the role of FIR radiation in Arctic warming, sea ice loss, ice sheet melt, and sea level rise.
TSIS-2	2024-2025	Collect detailed measurements of how much radiation the Sun emits to Earth on an hour-by-hour basis.
GeoCarb	2024	Collect daily observations of the concentrations of carbon dioxide, methane, carbon monoxide and solar-induced fluorescence. Extend measurement of greenhouse gasses and vegetation health.
PACE	2024	Study phytoplankton, clouds, and aerosols. Provide insights into oceanographic and atmospheric responses to Earth’s changing climate. Investigate the diversity of organisms fueling marine food webs.
Sentinel-6B	2025	Measure the height of the ocean. Continue sea-level observations, which are critical to understanding climate change. Measure temperature and humidity in the troposphere and the stratosphere.
GLIMR	2026-2027	Provide unique observations of ocean biology, chemistry, and ecology. Help protect ecosystem sustainability, improve resource management, and enhance economic activity.
Libera	2027	Continue recording the balance between solar radiation entering Earth’s atmosphere and the amount absorbed, reflected, and emitted. Essential to understand climate warming and cooling.

Annex D: Principles of Environmental Justice

Principles of Environmental Justice (https://www.nbejn.com/projects)

1. Environmental justice affirms the sacredness of Mother Earth, ecological unity and the interdependence of all species, and the right to be free from ecological destruction.
2. Environmental justice demands that public policy be based on mutual respect and justice for all peoples, free from any form of discrimination or bias.
3. Environmental justice mandates the right to ethical, balanced and responsible uses of land and renewable resources in the interest of a sustainable planet for humans and other living things.
4. Environmental justice calls for universal protection from nuclear testing, extraction, production and disposal of toxic/hazardous wastes and poisons and nuclear testing that threaten the fundamental right to clean air, land, water, and food.
5. Environmental justice affirms the fundamental right to political, economic, cultural and environmental self-determination of all peoples.
6. Environmental justice demands the cessation of the production of all toxins, hazardous wastes, and radioactive materials, and that all past and current producers be held strictly accountable to the people for detoxification and the containment at the point of production.
7. Environmental justice demands the right to participate as equal partners at every level of decision-making including needs assessment, planning, implementation, enforcement and evaluation.
8. Environmental justice affirms the right of all workers to a safe and healthy work environment, without being forced to choose between an unsafe livelihood and unemployment. It also affirms the right of those who work at home to be free from environmental hazards.
9. Environmental justice protects the right of victims of environmental injustice to receive full compensation and reparations for damages as well as quality health care.
10. Environmental justice considers governmental acts of environmental injustice a violation of international law, the Universal Declaration On Human Rights, and the United Nations Convention on Genocide.
11. Environmental justice must recognize a special legal and natural relationship of Native Peoples to the U.S. government through treaties, agreements, compacts, and covenants affirming sovereignty and self-determination.

12. Environmental justice affirms the need for urban and rural ecological policies to clean up and rebuild our cities and rural areas in balance with nature, honoring the cultural integrity of all our communities, and providing fair access for all to the full range of resources.
13. Environmental justice calls for the strict enforcement of principles of informed consent, and a halt to the testing of experimental reproductive and medical procedures and vaccinations on people of color.
14. Environmental justice opposes the destructive operations of multi-national corporations.
15. Environmental justice opposes military occupation, repression and exploitation of lands, peoples and cultures, and other life forms.
16. Environmental justice calls for the education of present and future generations which emphasizes social and environmental issues, based on our experience and an appreciation of our diverse cultural perspectives.
17. Environmental justice requires that we, as individuals, make personal and consumer choices to consume as little of Mother Earth's resources and to produce as little waste as possible; and make the conscious decision to challenge and reprioritize our lifestyles to insure the health of the natural world for present and future generations.

Adopted today, October 27, 1991 in Washington, D.C.

People of Color Environmental Justice

"Principles of Working Together"

PREAMBLE

"WE, THE PEOPLE OF COLOR, gathered together at this multinational [, multiethnic] People of Color Environmental Leadership Summit, to begin to build a national and international movement of all peoples of color to fight the destruction and taking of our lands and communities, do hereby re-establish our spiritual interdependence to the sacredness of our Mother Earth; to respect and celebrate each of our cultures, languages and beliefs about the natural world and our roles in healing ourselves; to ensure environmental justice; to promote economic alternatives [and to support traditional cultural economics] which would contribute to the development of environmentally safe livelihoods; and, to secure our political, economic and cultural liberation that has been denied for over 500 years of colonization and oppression, resulting in the poisoning of our communities and [, water, air,] land and the genocide of our peoples, to affirm and adopt these *Principles of Environmental Justice*."

Principles of Environmental Justice
October 27, 1991
First People of Color Leadership Summit
Washington D.C.

PRINCIPLE ONE: PURPOSE

1. A The Principles of Working Together uphold the Principles of Environmental Justice and to eradicate environmental racism in our communities.

1. B The Principles of Working Together require local and regional empowered partnerships, inclusive of all.

1. C The Principles of Working Together call for continued influence on public policy to protect and sustain Mother Earth and our communities and also honor past promises and make amends for past injustices.

PRINCIPLE TWO: CORE VALUES

2. A The Principles of Working Together commit us to working from the ground up, beginning with all grassroots workers, organizers and activists. We do not want to forget the struggle of the grassroots workers. This begins with all grassroots workers, organizers and activists.

2. B The Principles of Working Together recognize traditional knowledge and uphold the intellectual property rights of all peoples of color and Indigenous peoples.

2. C The Principles of Working Together reaffirm that as people of color we speak for ourselves. We have not chosen our struggle, we work together to overcome our common barriers, and resist our common foes.

2. D The Principles of Working Together bridge the gap among various levels of the movement through effective communication and strategic networking.

2. E The Principles of Working Together affirm the youth as full members in the environmental justice movement. As such, we commit resources to train and educate young people to sustain the groups and the movement into the future.

PRINCIPLE THREE: BUILDING RELATIONSHIPS

3. A The Principles of Working Together recognize that we need each other and we are stronger with each other. This Principle requires participation at every level without barriers and that the power of the movement is shared at every level.

3. B The Principles of Working Together require members to cooperate with harmony, respect and trust—it must be genuine and sustained relationship building. This demands cultural and language sensitivity.

3. C The Principles of Working Together demand grassroots workers, organizers and activists set their own priorities when working with other professionals and institutions.

3. D The Principles of Working Together recognize that community organizations have expertise and knowledge. Community organizations should seek out opportunities to work in partnerships with academic institutions, other grassroots organizations and environmental justice lawyers to build capacity through the resources of these entities.

PRINCIPLE FOUR: ADDRESSING DIFFERENCES

4. A The Principles of Working Together require affirmation of the value in diversity and the rejection of any form of racism, discrimination and oppression. To support each other completely, we must learn about our different cultural and political histories so that we can completely support each other in our movement inclusive of ages, classes, immigrants, indigenous peoples, undocumented workers, farm workers, genders, sexual orientations and education differences.

4. B The Principles of Working Together require respect, cultural sensitivity, patience, time and a willingness to understand each other and a mutual sharing of knowledge.

4. C The Principles of Working Together affirm the value in our diversity. If English is not the primary language, there must be effective translation for all participants.

PRINCIPLE FIVE: LEADERSHIP

5. A The Principles of Working Together demand shared power, community service, cooperation, and open and honest communication.

5. B The Principles of Working Together demand that people from the outside should not come in and think that there is no leadership in the grassroots community. The people in the community should lead their own community and create legacy by teaching young people to be leaders.

5. C The Principles of Working Together demand that people from grassroots organizations should lead the environmental justice movement.

5. D The Principles of Working Together demand accountability to the people, responsibility to complete required work, maintain healthy partnerships with all groups.

PRINCIPLE SIX: PARTICIPATION

6. A The Principles of Working Together demand cultural sensitivity. This requires patience and time for each group to express their concerns and their concerns should be heard.

6. B The Principles of Working Together require a culturally appropriate process.

6. C The Principles of Working Together have a commitment to changing the process when the process is not meeting the needs of the people. The changes should be informed by the people's timely feedback and evaluation.

PRINCIPLE SEVEN: RESOLVING CONFLICTS

7. A The Principles of Working Together encourage respectful discussion of our differences, willingness to understand, and the exploration of best possible solutions.

7. B The Principles of Working Together require that we learn and strengthen our cross-cultural communication skills so that we can develop effective and creative problem-solving skills. This Principle promotes respectful listening and dialogue.

7. C The Principles of Working Together affirm the value in learning strengthening mediation skills in diverse socio-economic and multicultural settings.

PRINCIPLE EIGHT: FUNDRAISING

8. A The Principles of Working Together recognize the need for expanding sustainable community based avenues for raising funds, such as building a donor base, membership dues, etc.

8. B The Principles of Working Together oppose funding from any organization impacting people of color and indigenous communities. In addition, the Principles oppose funding from any organization that is the current target of active boycotts, or other campaign activity generated by our allies.

8. C The Principles of Working Together encourage larger environmental justice organizations to help smaller, emerging environmental justice organizations gain access to funding resources. We encourage the sharing of funding resources and information with other organizations in need.

PRINCIPLE NINE: ACCOUNTABILITY

9. A The Principles of Working Together encourage all partners to abide by the shared agreements, including, but not limited to, oral and written agreements. Any changes or developments to agreements/actions need to be communicated to all who are affected and agreed upon.

9. B The Principles of Working Together encourage periodic evaluation and review of process to ensure accountability among all partners. Any violation of these agreements or any unprincipled actions that violate the EJ principles, either:
1. Must attempt to be resolved among the partners
2. Will end the partnership if not resolved
AND
3. Will be raised to the larger EJ community

Respectfully submitted by the Principles of Working Together Working Group
October 26, 2002
"Principles of Working Together"
Adopted at the
Second People of Color Environmental Leadership Summit Washington, D.C.
October 26, 2002
This and other environmental justice documents can be downloaded from: www.ejnet.org/ej

Annex F: OSO-LoGiC gathering of Louisiana-based researchers comparison of EJ and Open Science priorities

Louisiana Open Science Priorities	Louisiana Environmental Justice Priorities
Data to analyze: • Economic activity • Migration • Disaster resilience • Poverty alleviation • Exposures	Climate Crisis: • Climate and land loss and sea level rise • Climate adaptation • Displacement • Climate change • SLR • Climate crisis • Coastal erosion • Land loss
	Health effects of industrial pollution: • Air quality • Air quality and pollution related health outcomes • Assisting overburdened communities with environmental, health and permitting data • Health impacts of toxic exposure
Advance diversity, equity, and inclusion in open science: • Open science for diversity, equity, and inclusion • Greater collaboration, participation, integration of ways of knowing	Advance diversity, equity and inclusion in EJ research: • Equity and environmental justice • Community based participation – research – EJ CBOs • Environmental justice is social justice
Reducing boundaries to data and information: • Preserving data to improve access • Data more available and digestible for use in research (atmospheric data) • Open geospatial data sets at community scale	Data and EJ literacy to support EJ decisions
Data literacy and advocacy: • Public literacy and investment • Data quality and knowledge of secondary data uses and limits	
Data for Action: • Data sets for population based analysis • Data for environmental permitting decisions	
Complexity and systems-aware analysis: Transdisciplinary research • Open science linking scales	Complexity and systems-aware analysis: • Economic and environmental exposures = new vulnerabilities • Linking regional and international economic data to inequitable impacts on local communities

Annex G: Dr. Beverly Wright's publications in chronological order

Author(s)	Title	Source	Publication Year
Wright, B., Nance, E., King, D., & Semien, J.	A Question of Human Rights: Transnational Targeting of Environmental Justice Communities	Humanity & Society	2022
Bullard, R., & Wright, B.	Call for Special Issue Papers: Hurricanes, Man-Made Disasters, and Environmental Injustice in the Gulf Coast: Deadline for Manuscript Submission: August 31, 2020	Environmental Justice	2020
Wright, B. H.	The effects of occupational injury, illness, and disease on the health status of Black Americans: A review	Race and the Incidence of Environmental Hazards	2019
Wright, B. L., & Harden, M.	HBCU-CBO gulf coast equity consortium: An environmental justice model for improving the lives of children and families harmed by pollution and vulnerable to climate change	APHA's 2019 Annual Meeting and Expo (Nov. 2-Nov. 6)	2019
Wright, B., Bullard, R. D., & Turner, E. C.	Making the best of a worst case scenario: Creating job opportunities for workers in underserved communities through health and safety training in the Deep South	International Oil Spill Conference Proceedings	2017
Wright, B., & Turner, E.	Nontraditional Environmental Worker: Training Communities and Workers to Respond to Gulf Coast Disasters	APHA 2017 Annual Meeting & Expo (Nov. 4-Nov. 8)	2017
Nance, E., King, D., Wright, B., & Bullard, R. D.	Ambient air concentrations exceeded health-based standards for fine particulate matter and benzene during the Deepwater Horizon oil spill	Journal of the Air & Waste Management Association	2016
Waterhouse, C.	Environmental Justice: A Deadly Symptom of Larger Problems A Response to the Plenary of Dr. Beverly Wright	Journal of Healthcare, Science and the Humanities	2013
Wright, B.	2. Growing Up in a City That Care Forgot, New Orleans	The Wrong Complexion for Protection	2012
Wright, B., & Nance, E.	Toward equity: Prioritizing vulnerable communities in climate change	Duke FL & Soc. Change	2012
Wright, B.	The Post-Disaster Struggle for Equity and Justice in Communities of Color Along the Gulf Coast	Florida A & M University Law Review	2011b

Wright, B.	Race, place, and the environment in the aftermath of Katrina	Anthropology of Work Review	2011a
Wright, B.	The Post-Disaster Struggle for Equity and Justice in Communities of Color Along the Gulf Coast	Fla. A & M UL Rev.	2010
Bullard, R., & Wright, B.	The color of toxic debris: The racial injustice in the flow of poison that followed the flood	American Prospect	2009
Bullard, R. D., Mohai, P., Saha, R., & Wright, B.	Toxic wastes and race at twenty: A report prepared for the United Church of Christ Justice & Witness Ministries	United Church of Christ	2007
Wright, B.	Excellence & Heritage DILLARD UNIVERSITY	-	2007
Wright, B., & Bullard, R. D.	Washed away by hurricane Katrina: Rebuilding a “new” New Orleans	Growing Smarter: Achieving Livable Communities Environmental Justice and Regional Equity	2007
Pastor, M., Bullard, R., Boyce, J. K., Fothergill, A., Morello-Frosch, R., & Wright, B.	Environment, disaster, and race after Katrina	Race, Poverty & the Environment	2006
Wright, B.	Living and dying in Louisiana’s Cancer Alley	The Quest for Environmental Justice: Human Rights and the Politics of Pollution	2005b
Wright, B.	Katrina reveals environmental racism’s deadly force	New American Media	2005a
Wright, B.	Race, politics and pollution: Environmental Justice in the Mississippi River chemical corridor	Just Sustainabilities: Development in an Unequal World	2003
Wright, B.	Endangered communities: The struggle for environmental justice in the Louisiana chemical corridor	Journal of Public Management and Social Policy	1998

Wright, B.	New Orleans neighborhoods under siege	Just Transportation: Dismantling Race and Class Barriers to Mobility	1997
Wright, B.	Environmental equity justice centers: A response to inequity	Environmental Justice: Issues, Policies and Solutions	1995
Wright, B., Bryant, P., & Bullard, R. D.	Coping with poisons in Cancer Alley	Unequal Protection: Environmental Justice and Communities of Color	1994
Wright, B. H., & Bullard, R. D.	Hazardous in the Workplace and Black Health	National Journal of Sociology	1990
Wright, B.	Black New Orleans: The City that Care Forgot	In Search of the New South: The Black Urban Experience in the 1970s and 1980s	1989
Wright, B. H.	New Orleans: A city that care forgot	In Search of the New South: The Black Urban Experience in the 1970s and 1980s	1989
Bullard, R. D., & Wright, B. H.	Blacks and the Environment	Humboldt Journal of Social Relations	1987
Bullard, R., & Wright, B. H.	Environmentalism and the politics of equity: Emergent trends in the black community	Mid-American Review of Sociology	1987
Bullard, R. D., & Wright, B. H.	The politics of pollution: Implications for the black community	Phylon (1960-)	1986
Wright, B. H.	The effects of racial self-esteem on the personal self-esteem of Black youth	International Journal of	1985

		Intercultural Relations	
Wright, B. H.	SOCIAL CLASS AND ACHIEVEMENT MOTIVATION: THE EDUCATIONAL OPPORTUNITY PROGRAM AT SUNY AT BUFFALO; A CASE STUDY	Afro-Americans in New York Life and History (1977-1989)	1984
Wright, B. H.	Ideological change and black identity during civil rights movements	The Western Journal of Black Studies	1981
Wright, B., & Bullard, R.	Black New Orleans: Before and After Katrina	The Black Metropolis in the Twenty-First Century: Race, Power, and Politics of Place	n.d.