Annex A

Final Technical Report: LEQSF-EPS(2022)-RAP-40
Assessing NASA's Open Science Outlook for Environmental Justice and Resilience of the Louisiana Gulf Coast (OSO-LoGiC)

In this annex, you will find **Proposals to NASA for Open Science and Environmental Justice projects:**

1. Assessment of the Gulf Coast Environmental Justice Landscape for Equity (AGEJL-4-Equity)
    a. Prop_1_AGEJL_4_Equity.pdf
    b. Status: Selected
2. High-resolution Extreme Event and Localized Temperature for Health Forecasting in Underserved Lowlands of the Gulf Coast (HEELTHFUL-GC)
    a. Prop_2_HEELTHFUL_GC.pdf
    b. Status: Submitted
3. Analysis of Locally Flooded Areas with Environmental Justice Communities (ALFA-EJC)
    a. Prop_3_ALFA_EJC.pdf
    b. Status: Submitted
4. Ancient Climate Change Resilient but Understudied Enset agri-food system Diversity Mapping for Food Security and Sustainability (ACCRUED-MFSS)
    a. Prop_4_ACCRUED_MFSS.pdf
    b. Status: Submitted
5. Environmental Justice Core on the Gulf Coast (EJ CORE GC)
    a. Prop_5_EJ_CORE_GC.pdf
    b. Status: Declined
6. Improving Our Understanding of Gulf Coast Wetland Dynamics With Spaceborne Lidar
    a. Prop_6_sub_LIDAR.pdf
    b. Status: Tulane as Sub-award Submitted
7. Application of Commercial Smallsat Data to Enhance Flood Resilience in Support of Underserved Communities in Puerto Rico
    a. Prop_7_sub_EJ_PR.pdf
    b. Status: Tulane as Sub-award Submitted
8. TWSC proposal "Open Source Science for Environmental Justice and Climate Change Resilience on the Gulf Coast"
    a. Prop_8_TWSC_TOPS_Tulane
    b. Status:TBD

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

Four environmental justice networks convene around the "Communiversity" model with expert university-based support to map underserved Gulf Coast community stakeholder priorities & co-create a landscape analysis to inform next steps for engagement with NASA open Earth science as an evidence base for both greater equity in mitigating cumulative impacts of environmental injustice and preventing increased inequality due to climate change-related severe weather

Section 1.0 Table of Contents

2.0 AGEJL-4-Equity Objectives, Technical Approach & Management

2.1 AGEJL-4-Equity Overview: Four Equity and Environmental Justice (EEJ) networks will convene to map Southern Gulf Coast, primarily African American, underserved EJ communities and their priorities: the National Black Environmental Justice Network, the 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. Tulane University School of Public Health and Tropical Medicine (Tulane) and DSCEJ will provide capacity development-centered support through an Earth science-focused adaptation of the tried-and-true Communiversity participatory assessment model. Author, EEJ organization leader, and member of the White House Environmental Justice Advisory Council (WHEJAC), Dr. Beverly Wright will co-lead support with Dr. Nathan Morrow who together have more than 50-years of combined experience with inclusive participatory assessment. Dr. Morrow also continues to apply geospatial analysis of NASA products to social and environmental challenges following-on from his early research contributing to the NASA MODIS, NPOESS, and Land-Use-Land-Cover-Change missions. Each EEJ network will be empowered with participatory mapping tools developed by Dr. David Padgett of Tennessee State University and supported with a common multi-disciplinary multi-perspective EEJ analytical frame. Simple but effective comparative analysis between participating networks will help pinpoint specific potential use cases for lowering barriers to access and promoting innovative applications. A reflection on the findings in comparison to other regions and national EEJ context will further deepen understanding of the distinct Southern underserved community distributional justice challenges related to wellbeing and risk exposure as well as opportunities to improve procedural justice by increasing participation, recognition, and agency with NASA open Earth science. By leveraging existing networks and deep wells of located and experiential expertise, the Assessment of the Gulf Coast Environmental Justice Landscape for Equity (AGEJL-4-Equity) project will have delivered not only a novel and comprehensive Landscape Analysis identifying gaps and opportunities for improved access and use of NASA open science products to advance EEJ in underserved communities along the Gulf Coast, but a validated engagement model that advances the capacities of EEJ networks and communities themselves.

2.2 Southern Gulf Coast Relevance for Advancing EEJ with NASA Open Science
Environmental damage and climate change related hazards are unequally distributed in communities on Earth in patterns that are often observable from space. Inequity and environmental injustice occurs when the uneven distribution of any of the broad range of environmental ills is coincident or collocated with marginalization of groups of people and increased vulnerability of underserved communities. Unfair exposure to hazards, harm to health and wellbeing, and systemic barriers to participation in life and livelihood-affecting decisions may be mitigated, remedied, or avoided -- at least in part -- through improved capabilities and recognition of affected people to use Earth science, including

NASA open science, as an evidence base to frame EEJ decision making and solutions in an inclusive and scientifically valid way.

Southern institutions and organizations were disconcertingly underrepresented in the first NASA Equity & Environmental Justice Listening Workshop (NASA ESD, 2021). EJ community context, stakeholders, issues and drivers differ by region. Comparative analysis helps to appreciate this important diversity of experience to highlight evidence gaps such as the intersection of hurricane vulnerability and point source pollution on the Gulf Coast. The first Federal investigation into environmental injustice as racial inequality found 3-of-4 hazardous waste sites in the southern States located in African American communities (GAO, 1983). Disproportionate burden of environmental ills sited in segregated and disempowered communities, according to Dr. Robert Bullard's foundational environmental justice treatise *Dixie Dumping: Race, Class, and Environmental Quality* (1990), "placed African American and poor communities on the frontlines of environmental assault". As Catherine Coleman Flowers, member of WHEJAC, noted:

> "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." -- (NAS, 2021)

The overall goal of the AGEJL-4-Equity project is to advance EEJ and those that work to advance EEJ on the Gulf Coast by engaging underserved community networks in geospatial technology-assisted participatory assessment process. While flexible enough to be adapted to reflect on the potential of NASA Open-source Science and data products, the "Communiversity" model safeguards against a potentially extractive or exploitative process by ensuring EJ communities are equal active participants in research (Bullard & Wright, 1993). This autochthonous equity-focused participatory process, advanced alongside the EEJ movement in the South, makes community voices heard through engagement, capacity development, and recognizing diverse knowledge contributions with the support of university-based experts to present environmental justice problems and policy solutions in a scientifically valid way.

2.3 Research for Advancement Objectives alignment and their significance

AGEJL-4-Equity seeks in all activities to align with recent executive orders that advance equity by focusing programmatically on underserved communities in White House Executive Order 13985 and intentionally promote diversity, inclusion and accessibility as described in White House Executive Order 14035. Dr. Beverly Wright, the AGEJL-4-Equity Co-Investigator, serves on the WHEJAC that was created in response to White House Executive Order 14008 that calls for a redoubling of efforts to understand domestic impacts of environmental and climate change. Inclusive processes to EEJ and principles of the Communiversity model are evident in recommendations that signature EJ initiatives, such as the Climate and Environmental Justice Screening Tool, have us-

er-friendly capacity development, technical assistance and consultation that fully engages and possibly is co-led by underserved and EJ communities (WHEJAC, 2021).

The ESD Applied Science Program promotes measurable social benefit from NASA research and information products with the aim to improve decision making and related policy solution implementation. Clearly defining 'who' and 'where', as proposed by AGEJL-4-Equity, is the first step to making improved decision making and social benefit measureable. As with action research for EEJ, a more inclusive science processes promotes greater consensus around the evidence base for policy formation that in turn advances collective action. Research into the links between Open Science, equity, and environmental justice may demonstrate practical pathways for realizing sustainable and more equitable program benefits for underserved communities. AGEJL recognizes significant synergies for EEJ projects and NASA's mission Transform to Open Science (TOPS); a decade long strategic commitment to lowering barriers to entry for historically excluded communities, better understanding how people use NASA data and code to take advantage of big data collections, and increasing opportunities for collaboration while promoting scientific innovation, transparency, and reproducibility.

AGEJL-4-Equity has identified three Research for Advancement Objectives (RAO) adapted for a southern regional landscape analysis from "key objectives" stated in A.49 Equity and Environmental Justice program element. Each RAO is SMART -- Specific, Measurable, Attainable, Relevant, and Time-Bound -- and calls for specific tasks:

RAO1. **Advance Information** -- Over three-months, engage and capacitate four EEJ networks to map underserved EEJ stakeholder communities, EEJ priorities, ways of working, and knowledge of Earth science-based evidence to advance EEJ decision-making and action, to present as a network-landscape analysis

RAO2. **Advance Organizations** -- Convene network representatives of underserved primarily African American Gulf Coast communities in New Orleans for a two-day participatory workshop of approximately twenty participants to:

   a. Compare and overlay EEJ network community mapping results in a dynamic visualization and synthesize evidence for joint landscape analyses
   b. Interrogate integrated geo-spatial, socio-economic and earth science data, highlighting NASA products and open source science resources, to map EEJ landscape characteristics such as access to data and EJ patterns
   c. Explore existing and innovative ideas to address gaps in evidence that may be addressed by current or planned NASA-related missions and those that will require further data integration and process innovation

RAO3. **Advance Integration** -- Synthesize learning in a comparative 20-page landscape analysis report within 6-months that leverages geolocation to map potential open Earth and social science integration to address evidence gaps and EJ community priorities; reporting on barriers, opportunities and community assets unique to the Gulf Coast context and next steps to advance EJ organizations

As a first significant contribution – AGEJL-4-Equity will have provided an operationally feasible, high quality and cost effective EJ community engagement model. Adapted from the Communiversity approach, NASA and potentially other agencies and organizations will then be able to advance EEJ with evidence-based process leveraging Open, Earth, and related geospatial, historical/political or socio-economic science by inclusive and equitable engagement with the larger EEJ stakeholder community.

As a second significant contribution – NASA will have sponsored the co-creation of a novel regional scale EJ community mapping and priority analysis at the intersection of environmental justice, climate justice and potential cumulative burden. The Tishman Environment and Design Center analysed the philanthropic engagement landscape in the southern region and **found broad misalignment** between environmental "conservation" with more community relevant issues of economic justice, disaster resilience, and empowerment (Baptista, & Perovich, 2020). Morrow et al. (2022) found similar misalignment between goals related to environmental security and human security in international projects that were mitigated when problem analysis begins, as with AGEJL-4-Equity, with the experience and observation of a diversity of stakeholders and front-line communities in a resilience and wellbeing-focused participatory process. Advancing EEJ at the intersection of climate change resilience from a multi-method, multi-scale, multi-disciplinary, and multi-sectoral perspective, the Landscape Analysis will be of professional conference presentation or peer-reviewed publication quality, but also speak a broad audience of decision makers and stakeholders with Southern lessons learned.

As third significant contribution -- AGEJL-4-Equity will have communicated specificities of Gulf Coast EJ community and network priorities with respect to the larger national EEJ policy priorities and discussions. At the same time, AGEJL-4-Equity's comprehensive comparative analytical frame for environmental, social and climate justice relevance of Earth and open science could be revised as a rubric for future assessment or community engagement appraisal.

2.4 Adapted Communiversity analytical frame for NASA EEJ Landscape Analysis
Beginning in the 1990's, DSCEJ pioneered the Communiversity model for participatory data collection and assessment processes that focusses 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. 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 environmental justice landscape in a scientifically valid way. The model has five action research activities to co-create or investigate:

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

Detailed discussions of data stream processing, sensor technology or satellite platforms are likely to be beyond the scope of the EEJ network and community engagement. None-the-less, Dr. Morrow and Dr. Padgett are previous contributors/investigators on NASA-funded projects and will be sensitive to organizing the final Landscape Analysis for easy alignment with current and future missions or program elements. Instead, EEJ networks will focus on discussing current NASA product EEJ use cases while demonstrating related low barrier NASA data access utilities on the web highlighting capacities of EOSDIS and Socioeconomic Data and Applications Center (SEDAC).

AGEJL-4-Equity analytical frame will explore 1) relevance of current NASA EEJ applications for air quality and climate-related hazards to the Gulf Coast, 2) infrastructure, LULU, water quality, and risk monitoring potential of newly available improvements in spatial, temporal, and spectral resolution data, 3) novel policy, historical and socio-economic data integration. Communiveristy model guidance materials including KI or group interview guides, analysis/mapping protocols, and webinar session plans will be adapted to the to the multi-disciplinary open Earth science-focus of the analytical frame.

Current EEJ applications of NASA data include air quality and climate-related hazards of extreme weather, sea level rise, changes in water availability, flooding 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 team work will be reviewed. SEDAC gridded data sets and application descriptions will be used as examples in EEJ network engagement. Furthermore, reflection on collaborative science that can engage previously marginalized and underserved communities to better access and use these breakthrough NASA data products will explore synergies with missions such as TOPS and initiatives such as the Multi-Mission Algorithm and Analysis Platform (MAAP).

For EEJ applications typically relevant at neighbourhood 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. Increased temporal monitoring for EEJ applications has great potential from platforms such as EOS (LANCE) with products such as the MODIS NRT Global Flood Product or **fire monitoring** products -- that may also apply to EEJ monitoring concerns around **industrial fires and accidents**. Landsat 9 and Sentinel 2 integration will provide an unprecedented possibility to track LULU or land degradation over time. Im-

proved monitoring of water quality and localized flooding beyond passive sensors is increasingly possible with active radar or laser sensors such as ICESat-2.

Historical discriminatory policy, particularly for African American communities, is often a predictor of current poor wellbeing outcomes and evidence of environmental injustice as seen in recent research associating current disparities in air quality to historical discrimination in mortgage lending revealed in maps of federal government “Redlining” (Lane et al., 2022). In another investigation using archaeological techniques that could potentially benefit from NASA products, aerial imagery helped identify cemeteries of enslaved people as a predictor of the worst contributors to toxic pollution in Louisiana’s epicentre of environmental injustice referred to as Cancer/Death Alley (Forensic Architecture, 2021). Spatial data sets of socio-economic inequality and historical discrimination such as Roberts et al.’s (2022) “Mapping Inequality” project will also be utilized in participatory mapping and discussions of drivers of environmental injustice.

DSCEJ has extensive experience with funding EEJ work to be done by the most concerned communities and networks. The first step of this process is to negotiate a documented commitment with time bound deliverables from each network partner. The basic set of commitments for each of the EEJ networks are as follows: self-assessment; address any identified capacity gaps; review EJ communities, organizations and priorities; hold a webinar or hybrid conduct a Communiversity Landscape Analysis workshop; prepare maps of EJ communities, organizations and priorities; prepare presentation based on geolocated participatory data collection; attend AGEGJ-4-Equity two-day workshop hosted by Tulane University and DSCEJ; report back to network on learning; and submit timely comments and endorsement of the final EEJ Landscape Analysis.

The participatory process supported by DSCEJ and Tulane is complemented by application of geospatial location mapping utilizing the Climate and Economic Justice Screening Tool spatial data layers (Council on Environmental Justice, 2022). For visualization and comparative analysis, participants will also consider the FEMA (2022) National Risk Index Map. Mapping support, capacity development and co-analysis will use open source mapping tools QGIS and QGIS cloud. A geospatial comparison and data synthesis will also serve as central session of the AGEGJ-4-Equity Landscape Analysis workshop. Resulting maps will be included in final reports and maintained by individual networks and institutions according their ability. Thematic, temporal and spatial comparison will serve as the central method for data synthesis in the final report.

Comparative analysis at national level structured using the EEJ analytical frame will serve as an additional step for the finalizing the AGEJL-4_equity Landscape Analysis. As detailed in the DMP in section 3.2, all information collected will be compliant with NASA SMPD-4 data policy and all documents from meetings or analysis will have unique DOI identifiers and uploaded research sharing site zenodo.org.

2.5 Implementation plan with milestones, risk mitigation & management structure

By working through well-established networks, AGEJL-4-Equity is cost effective and ready for immediate action on a 6-month implementation plan. Each of three phases will conclude with concrete milestone deliverables. Phases build on work delivered in previous phase.

Phase 1—participatory process -- (months 1-3) will include a participatory data collection and assessment processes led by each of the four EEJ networks. A kickoff meeting of EEJ network representatives, DSCEJ and Tulane will inform the Project and Costing plan to be submitted in 30-days. Within the month, each EEJ network will complete a self-assessment of capacities related to the adapted Communiversity participatory engagement process, EJ community mapping, and network-landscape analysis. Tulane and DSCEJ will make individualized support plans for each network. By the end of the third month, each EEJ network will have created a network-landscape presentation.

Phase 2 – specific community cross-sharing and comparative analysis -- (month 4) a Landscape Analysis workshop will be co-hosted by DSCEJ and Tulane in New Orleans. Three-to-five network representatives will be invited and attend a previously scheduled conference at the same venue – the 'Open-source Science Outlook for Environmental Justice". This offers an additional engagement opportunity for the participants to advance their capacity through interaction with open science communities, networks, and experts working on potentially relevant open source tools, approaches and products to forward bottom-up approaches to EEJ such as action research and citizen science. The workshop will first focus on presentation and information exchange. Then, the workshop participants will co-create of a common landscape analysis outline in sessions on comparative analysis of EEJ context and organizations, co-analysis of EEJ priorities, multi-network integration of participatory mapping of underserved and vulnerable communities, and finally a statement on next steps for engagement with NASA data streams and products considering. As a milestone deliverable, a report of the meeting will be posted to Zenodo open access data repository and DOI creation site.

Phase 3 – comparative and landscape analysis finalization -- (months 5 and 6). Dr. Padgett will lead comparative gap analysis, supported by Dr. Morrow and Dr. Wright, to underline potentially distinct EEJ priorities for the southern region compared to information available from other regions in terms of type of hazard, severity, magnitude and comparative impact. This will serve as the final analytical section of the AGEJL-4-Equity Landscape Analysis report that will include 1) introduction articulating the EEJ analysis and potential NASA open science and products relevant in the gulf Coast Context; 2) comparative analysis of priorities, challenges and paths to engagement for networks; 3) synthesis mapping of underserved communities, state of EEJ engagement for evidence, and comparison to other regions; 4) NASA open source science and product relevance; 5) recommended next steps. Pre-print for the open access manuscript will be uploaded.

Risk Mitigation -- Potential sources of uncertainty for AGEJL-4-Equity project plan are primarily related to Covid-19 restrictions. Changing infection trends and health regula-

tions may limit the ability to convene face-to-face gatherings. The PI has recently led a major international organization to pivot a global capacity development program to online. Lessons from this experience include leveraging collaborative online tools for better engagement, fully facilitating virtual sessions with dedicated technological backstopping, and adjusting the length/frequency/tempo of sessions to promote active interaction. Network engagement with coastal communities, local authorities and private sector stakeholders may require appropriate health safeguards and be adjusted to virtual or one-on-one meetings rather than in-person group interviews. The PI will support primary stakeholders to follow Tulane Covid policy when implementing their research and capacity development plans. If one key personnel became ill, the PI, CO-I and senior consultant all have the skills necessary to complete deliverables on time.

Management structure for AGEJL-4-Equity follows principles of the Communiversity model where those closest to the EJ communities and issues set the objectives of the research agenda. The university and network based expertise is focused on supporting.

Dr. Nathan Morrow as principle investigator is accountability for grant implementation, compliance, risk management and reporting -- supported by an experienced R1-level sponsored project team at Tulane University. Dr. Morrow is also responsible for maintaining the control environment, quality and timeliness of all deliverables, implementation of the data management and inclusion plan, and responsive communication and reporting to NASA and all stakeholders. He is responsible for NASA requests for "Communication, Outreah and Inreach" and will be lead author of Landscape Analysis.

Dr. Beverly Wright as Co-Investigator supported by DSCEJ is accountable for the fidelity of the proposed activities and deliverables to the principles of Communiversity. Dr. Wright, supported by experienced staff and volunteers, will direct workshop design and day-to-day engagement with networks and Tulane. DSCEJ is responsible engage directly with networks' appoint representatives to administer necessary travel and honorarium payments. Dr. Wright will be co-lead author of the final Landscape Analysis.

Dr. David Padgett is Senior Consultant to Tulane University for comparative analysis and participatory mapping. He will advise on participatory mapping component of data collection and data synthesis during the workshop. He will co-lead the workshop and is responsible for collecting all necessary information from the networks and workshop for comparative and landscape analysis finalization. He will contribute a technical review and as a contributing author on the Landscape Analysis.

Doctoral candidate Mom Kefeyin TatahMentan, MPH will manage support on background evidence scan and support networks with self-assessment and capacity building. She will liaise with Drs. Morrow, Wright and Padgett to provide additional capacity support to networks as needed in completing their network-landscape presentations. She will assist in managing the workshop, ensuring information is handled as per DMP, and fully collaborate on analysis and reporting activities.

Section 3.0, Bibliography, Data Management Plan, Schedule, and Inclusivity Plan

Section 3.1 AGEJL Proposal Bibliography

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3.2 Data management plan

Accountability for full implementation of the Data Management Plan (DMP) and ensuring full compliance to NASA DMP requirements lies with the Dr. Nathan Morrow as PI. He has extensive experience managing geographic and remotely sensed data for research and decision making. He has published peer reviewed articles on data for decision making (Mock, Morrow & Papendeick, 2012) has written and taught about data responsibility (Morrow, 2022), and recently was awarded a grant for increasing the use of Open-source Science for Environmental Justice.

This is an innovative project that includes gathering data from community-based networks as well as professional researchers. To address potential privacy, ethical and consent issues, the AGEJL-4 Equity team will conduct a Privacy Impact Assessment (PIA), following the NASA PIA Summary as a template, on each network's plan for gathering information for their network-landscape analyses. As a general privacy safeguard, data will only be collected, analyzed or presented at spatially aggregated at community or census track level. No data will be collected about individuals. Results of the PIA will be reviewed and all identified potential risks will be mitigated or eliminated by substituting lower impact data collection approaches. When key informants or group interviews are conducted, a standard informed consent statement will be distributed with personal contact information of the PI for any follow up questions about how the data will be used. All interview guides will follow templates that follow guidance criteria for an IRB exemption. Any participatory contributions from networks or community members will be able to be retracted through the telephone, email and snail-mail address details that will be provided to all participants.

The AGEJL-4-Equity team will pursue the development plan along the lines of the "Geosciences Paper of the Future" with the intention move towards improving the DMP "to make data, software, and methods openly accessible, citable, and well documented" (Gil et al., 2016) and the FAIR principles: Findable, Accessible, Interoperable, & Reusable (Wilkinson et al., 2016). As part of the advancement of EEJ data for decision making methods and with the specific expertise in the AGEJL-4-Equity science leadership in this research area, the team will seek ways to ensure data and information are shared in ways that maximize access, reuse and application to new problems, contexts, and research questions. Data will be made publically available with enough detail to allow for validation and metadata standards will conform to requirements of the designated repository and is expected to be coded in XML.

The AGEJL-4-Equity data management plan ensures public access to publications and digital datasets arising from NASA research. All AGEJL-4-Equity data posting and archiving tasks will be **completed by the fifth month** of the project. The preprint will be posted by the sixth month and open access article will be available as soon at final revisions are accepted, but expected to be within one year from project closure. Data and documents will be posted on data archive, preprint and journal sites that all plan to make the materials openly accessible indefinitely.

Data sets, meta data and other materials developed to support the proposed research will be archived at data.nasa.gov, as appropriate, and Zenodo (https://zenodo.org/) site associated with European Organization for Nuclear Research (CERN) and expected to maintain the open archive as long as CERN exists. AGEJL-4-Equity has created an Environmental Justice 'community' on Zenodo to encourage findability of the research and exchange with other EEJ researchers. A preprint of a peer reviewed journal article describing the landscape analysis approach and findings will be posted on Earth and Space Science Open Archive, associated with the American Geophysical Union, preprint server https://www.essoar.org/. The article will then be submitted to journals offering open access. Wiley and potentially other publishers have an agreement in place with the repository to later transmit the edited and formatted Version of Record (VoR) or it will be linked manually. A READ.ME text file will be posted along with any documents and geospatial files. The geographic data ".shp" format files will also have metadata filled out with projection parameters, data description, and links to original source files for base layers.

All data and documents produced by AGEJL-4-Equity encourage redistribution, reproduction and creation of derivatives with a Creative Commons Attribution 4.0 International license or equivalent, and uploaded to Zenodo including:

- 4 spatial data sets will be derived from the publically available Environmental Protection Agency (EPA) Economic Justice Screening (EJScreen) tool data set as attributes linked to existing vector layers for census tracks. These will be made available as comma separated values and .shp files. A single layer file and cvs files that combine the four data sets along with additional analysis from the joint sessions.
- 4 network landscape presentations and a video recording of the webinar session
- Final landscape analysis document will be presented in a webinar that will be recorded. The document and recording of the presentation will be uploaded.
- Guidance on the adapted Communiversity approach and participatory mapping will be used as references during capacity development support. These will be given a unique doi when uploaded.

No software development or more complicated scripting are currently included in the technical approach. Our research team does have the skills to produce scripts to automate some geospatial mapping or analysis tasks. If a request from a community or network does warrant some script development, our research team will inform NASA and post any scripts to a GitHub project page.

The PI will maintain communication as necessary with the data repository and the NASA program manager to ensure that: DMP is updated as needed at time of award; appropriate attribution is included; data meet minimum quality standards; and data are appropriately evaluated for and secured to prevent disclosure of personally identifiable information and to protect proprietary interests, confidentiality, and intellectual property rights.

Section 3.3 AGEJL Schedule

The AGEJL-4-Equity Milestone Schedule outlines the activities, expected deliverables and reporting for each of the six months in the expected life of project. Similar activities are grouped into three phases. In the first phase, EEJ networks are primarily responsible for leading co-creation of the deliverables with ample support from DSCEJ, Tulane and Dr. Padgett. To integrate across and compare EEJ network contexts, the co-creation leadership shifts to a DSCEJ-Tulane hosted workshop with facilitation by Dr. Padgett in phase 2 that takes place in the fourth month. Finally, Dr. Morrow takes ultimate responsibility as the accountable team member for final reporting and deliverables in phase 3 for activities taking place in months 5 & 6.

Milestone Schedule			
	Month	Activity(ies)	Milestone Deliverable
PHASE 1	#1	∗ Kickoff meeting of DSCEJ ∗ EEJ network will complete a self-assessment of capacities ∗ Tulane and DSCEJ will make individualized capacity development support plans **∗ Submit Project and Costing plan**	Each of 4 EEJ networks: • Capacity development (CD) support plans
	#2	∗ EEJ network implement CD plan ∗ EJ community mapping • Environmental justice initiatives, organizations and communities ∗ EEJ networks convene webinar ∗ Supplemental participatory data collection	Each of 4 EEJ networks: • EJ community map • EJ stakeholder priority mapping
	#3	∗ Complete participatory mapping & data collection ∗ Use analysis frame to conduct network-Landscape analysis **∗ Quarterly report**	Each of 4 EEJ networks: • created a network-landscape presentation & map
PHASE 2	#4	∗ Convene EEJ workshop at Tulane University	PI, CO-I, Dr. Padgett: • Report of workshop results • Preliminary statement of EEJ priorities • Integrated map and analysis
PHA	#5	∗ Prepare publication based on participatory mapping Finalize Landscape Analysis	Dr. Padgett, Dr. Morrow: • Online version of participatory map

SE 3			posted
	#6	∗ **Summary and Final Reporting** ∗ Final edit and sharing of Landscape Analysis ∗ Closing of all DMP activities ∗ Closing and reporting on all Inclusion Plan activities	PI-Dr. Morrow: • Final Technical Report • Final Financial Report • Landscape Analysis distribution to partners and NASA

There will be monthly meetings of the PI, CO-I, lead consultant and graduate student to monitor progress towards milestones and take any action to address emerging concerns. The following activities will result in measurable outputs each month:

- Month-1 activities include kickoff meeting and self-assessment with the EEJ networks. The AGEJL-4-Equity team works with each network to plan their participatory data collection and co-analysis that results in a customized capacity development and support plan.
- Month-2 sees EEJ networks implementing plan by mapping EEJ issues, organizations and communities with mixed approaches including key informant and group interviews.
- Month-3 will include hybrid or webinar meetings of EEJ network stakeholders. This will provide the analysis for development of the network-Landscape Analyses
- Month-4 is when Tulane and DSCEJ will co-host the EEJ Workshop. Three to four representatives per EEJ network will contribute to the workshop. A report of the workshop will be produced. Co-analysis and co-mapping will be in draft form.
- Month-5 Dr. Padgett to take lead on Landscape Analysis supported by Dr. Morrow. A draft for rapid comment will be completed at the end of the month.
- Finalization of the Landscape Analysis will be completed in the 6th month. Final reporting and deliver of the Landscape analysis will be submitted before the closing data of the grant. A draft pre-print of an article intended for peer-review will be posted. A common map of EJ communities and priorities will be made available on QGIS cloud and partner websites. All data and materials will be archived on data.nasa.gov and Zenodo.

Ongoing activities will include support requests for Communication, Outreach and Inreach to NASA. Also, frequent communications to EEJ network focal points for any needed support will be handled by Dr. Wright's staff and Ms.TatahMentan and identified for responsive support from Drs. Padgett and Morrow as necessary.

3.4 Inclusion Plan

Tulane University School of Public health and Tropical Medicine (Tulane) and the Deep South Center for Environmental Justice (DSCEJ) have core commitments to Equity, Diversity and Inclusion (EDI) that will support the specific AGEJL-4-Equity EDI goals, action plans and measurement approach.

Tulane's Dean LaVeist has set a goal to be the most diverse public health school in the country. EDI is the focus of a flagship presidential initiative for Tulane called 'Strategy for Tomorrow' that monitors progress towards concrete commitments to EDI. Our project team can rely on an array of support from our EDI office such as providing training on positive and inclusive workplaces.

DSCEJ is a fully independent nonprofit center for collaboration to confront the unique challenges of environmental justice and climate change facing communities of color and poor communities in the South. With roots in New Orleans' historically Black Dillard and Xavier Universities, DSCEJ continues to maintain and grow collaborative relationships with HBCUs in Louisiana and around the country. A major goal of DSCEJ is the development of leaders in communities of color along the Mississippi River Chemical Corridor and the broader Gulf Coast Region that are disproportionately harmed by pollution and vulnerable to climate change.

The first EDI-related goal for AGEJL-4_Equity is to maintain a positive and inclusive work environment. One effective entry point for inclusivity is intentionality in hiring, but the project team is relatively small and diverse. EEJ networks represent a diversity, although primarily African American, of underserved communities all along the Gulf Coast. EJ networks will be encouraged to select focal points and participants in the Landscape Analysis workshop from underrepresented groups in science including women, those from diverse racial or ethnic back ground, sexual orientations, and with different or reduced abilities.

AGEJL-4-Equity actions to create and maintain an inclusive and positive workplace will aspire to consistent modeling of respect, dignity, and civility by each member of the team. The first concrete action is to ensure fairness in access to resources and relative work burden. The AGEJL-4-Equity budget was created with this in design, and we will monitor work effort and resource availability throughout the project to see if there are needed adjustments. The PI, Co-I and lead consultant will complete institutionally available courses or access Tulane's courses (https://hr.tulane.edu/institutional-equity/education-training-programs) on: Creating a positive Workplace; Macroaggressions in the workplace; Unconscious bias; and Workplace diversity, inclusion and sensitivity. AGEJL-4-Equity PI, Co-I and lead consultant will also reiterate the commitment for everyone's voice to be heard, contributions are valued, and are safe to engage at meetings with EJ networks, the larger team or other stakeholders, A standing agenda item

will be included on monthly AGEJL-4-Equity team meetings to reflect on inclusivity and equity during project implementation.

AGEJL-4-Equities second goal focuses on contributing to a more inclusive and diverse scientific workforce. The actions and measures for this goal look to the positive project outcomes primarily for EJ network participants and younger members of the Tulane and DSCEJ support teams. The Communiveristy method, that inspired the design for AGEJL-4-Equity's Technical Approach, was developed to address inequity. Dr. Wright and other early environmental justice researchers realized that achieving environmental sustainability and equity required the coming together of, the traditionally unequal, communities and academic partners in a mutually respectful and beneficial relationship that encourages significant strides toward achieving solutions. This means ensuring community members have an equal voice with university researchers in developing, resourcing, and implementing projects, and are able to benefit from the partnership. This model emphasizes collaborative management of the partnership between a community and a university and encourages capacity development at every opportunity. In this way, communities are more capable of describing environmental issues and advocating for solutions in a scientifically valid way. This approach to engagement has for decades contributed to developing EEJ leaders and a more inclusive science workforce

Engagement with the networks and capacity development for network focal points to implement the Communiversity model will rest on open exchange between equally valued partners in a safe environment that ensures respect, dignity, and civility. Capacity development for the EJ networks will include lessons on inclusivity, micro aggression, unconscious bias and sensitivity to equity when facilitating participatory processes. Differences in ability such as color blindness will be discussed as part of preparation for participatory mapping.

For our stated objectives to be SMART, the following measures will be included in reporting:
Within the 6-months of the training, actions for a positive and inclusive work environment will include:

- 3 or more key personnel complete 3 or more relevant e-learning courses
- 75% of stakeholder meetings begin with a DIE commitment statement
- 6 of 6 monthly meetings include reflection on DIE commitments

6-months of the training, contributions to a diverse and inclusive science workforce:

- 12-20 EJ network focal points and workshop participants engage in capacity development for DIE sensitive facilitation
- 12-20 EJ network focal points and workshop participants develop capacity for equity focused participatory landscape analysis
- 12-20 EJ network focal points acquire knowledge, skills and motivations to lead participatory mapping of EJ communities and their proximities

Section 4.0 Biographical Sketches
PI: Nathan Morrow

1. Professional Preparation

Boston University, Geography, Bachelor of Arts with Honors 1997
Boston University, Geography, Master of Arts 1998
University of Maryland, Geography, Doctor of Philosophy(M. Hansen advisor) 2021

2. Professional Experience and Positions (Appointments)

Co-I, Sahel Collaboration & Communication, USAID-funded, 2020-present
Associate Research Professor, Tulane Law, 2014-2018, Adjunct 2007-2012
Associate Clinical Professor, Tulane School of Social Work, 2012-2014
Associate Clinical Professor, Tulane Public Health & Tropical Medicine, 2011-2014, Adjunct 2007-present

3. Selected Bibliography

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

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**

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

Muchoney, D., Borak, J., Chi, H., Friedl, M., Gopal, S., Hodges, J., **Morrow, N.**, & Strahler, A. (2000). Application of the MODIS global supervised classification model to vegetation and land cover mapping of Central America. *International Journal of Remote Sensing*, *21*(6–7), 1115–1138. https://doi.org/10.1080/014311600210100

Morrow, N., & Prince, S. (1999). Use of potential and actual primary production models to map drought and degradation in semi-arid Southern Africa. *EOS Transactions, 80*(46), F403.

Morrow, N., & Friedl, M. (1998). Modeling biophysical controls on land surface

temperature and reflectance in grasslands. *Agricultural and Forest Meteorology*, *92*(3), 147–161. https://doi.org/10.1016/S0168-1923(98)00098-7

4. Research Experience: Scientific, Technical, Management

Dr. Morrow has acquired a wide range of skills and expertise with 25 years of experience leading implementation, developing capacity and ensuring research-based evidence for multi-sectoral food security, humanitarian response, and child wellbeing policy implementation projects. He has served as Chief of Party for a multi-organizational consortium for multi-country developmental relief and humanitarian aid response valued at over 400 million USD responding to an El Niño drought food security crisis in southern Africa. The response developed systems and approaches that served as a precursor to now ubiquitous resilience policy-focused programming. As co-chair of the Emergency and Disaster Evaluation thematic group at the American Evaluation Association, Dr. Morrow has promoted inclusive engagement and more rigorous measurement models in resilience research and intervention planning. The most recent Global Environment Facility (GEF-7) replenishment strategy was informed, in part, by a geospatial analysis of armed conflict and environmental security led by Dr. Morrow.

Dr. Morrow has also recently worked on a user needs-based capacity development strategy, including Landscape Analysis, for the global resilience and emergency response work of the Food and Agriculture Organization of the United Nations. As Landscape Analysis is a core element of organizational strategy processes, Dr. Morrow has taught Landscape Analysis in his foundational Design and Implementation of Global Health Projects course that is now a school-wide requirement. He introduced Landscape Analysis as a systems assessment approach in other courses focused at system strengthening and addressing structural inequality. Strategic assessment and strategy processes to strengthen evidence-based decision support have been a feature of Dr. Morrow's research and consulting with a variety of organizations including work on USAID's resilience measurement operational research in the Horn of Africa, needs assessment capacity for the United Nation's World Food Programme, and the global redesign of World Vision International's system for reporting to the International Board and other stakeholders on impact for improved child wellbeing. Dr. Morrow was invited to conduct the first-ever technical review of an SDG target indicator; 2.1.2 -- Prevalence of severe or moderate food insecurity.

Dr. continues to actively use remote sensing and geospatial analysis in his applied research following on early contributions to the MODIS, NPOESS, and Land-Use and Land-Cover Change science mission. These technologies featured in Developmental Evaluations of the World Food Program's mVAM program for improved needs assessment and hazard monitoring. They also feature in his teaching that includes problem sets related to assessing flood damage or humanitarian logistics planning.

Co-I:Institutional PI: Dr. Beverly Wright

1. Professional Preparation

Grambling State University, Sociology, Bachelor of Arts 1969
State University of New York at Buffalo, Sociology, Master of Arts 1971
State University of New York at Buffalo, Sociology, Doctor of Philosophy 1977

1. Professional Experience and Positions (Appointments)

Executive Director, Deep South Center for Environmental Justice, 2005-present
Professor of Sociology , Dillard University, 2005-2017,
Professor of Sociology, Xavier University of Louisiana, 1992-2005
Associate Professor, Wake Forest University, 1989-1993

2. Selected Bibliography

Wright, B.H., (2015) Environmental Injustice and the State of Black New Orleans," pp. 100 - 113 in McConduit-Diggs, Erika, State of Black New Orleans: 10 Years Post-Katrina. New Orleans: The Urban League of Greater New Or-leans.

Wright, B.H.,, and Nance, E., (2012). "Toward Equity: Prioritizing Vulnerable Communities in Climate Change," Duke Forum for Law and Social Change, 4 (1), 1-21.

Wright, B.H., (2011). "Race, Place, and the Environment in the Aftermath of Katrina," Anthropology of Work Review, American Anthropological Associa-tion, 32 (1), 4-8.

Bullard, Robert D. & **Wright**, **B.H.,** "Disastrous Response to Natural and Man-Made Disasters: An Environmental Justice Analysis Twenty-Five Years after Warren County," UCLA Journal of Law and Environmental Policy 26: 2008.

Wright, B.H., (1998). "Endangered Communities: The Struggle for Environmental Justice in Louisiana's Chemical Corridor," Journal of Public Management and Social Policy, 4(2), 181-191.

Wright, B.H., Bullard, R.D., & Johnson, G.S., (1997). "Confronting Environmental Injustice," [Special Issue]. Journal of Race, Gender, and Class, 5, 65-79.

Bullard, R. D. & **Wright, B.H**., (1993). "Environmental Justice for All: Community Perspectives on Health and Research Needs," Toxicology and Industrial Health, 9(5), 821-841.

Wright, B.H., & Bullard, R.D., (1990). "Hazards in the Workplace and Black Health: A Review," Journal of Sociology, 4(1), 45-74.

3. **Research Experience: Scientific, Technical, Management**

In 1992, Dr. Wright founded the Deep South Center for Environmental Justice at Xavier University in New Orleans (later moved to Dillard University in 2005) modeled on Communiversity Model approach. As the founding director of the first university based environmental justice organizations, Dr. Wright has been at the forefront of the movement to empower and build resiliency in low-income and people of color who are threatened by natural and manmade disaster, hazards, and emergencies. Dr. Wright worked collaboratively with some of the nation's leading environmental justice and health equity scholars on communities disproportionately impacted by industrial pollution, environmental hazards, and natural and manmade disasters in the Louisiana Chemical Corridor, also known as "Cancer Alley." Dr. Wright have served as PI or coinvestigator on dozens of research projects that address emergency management, response, and resiliency of workers and residents impacted by nearby or "fence line" refineries and petrochemical plants, Superfund sites, hurricanes, floods, and industrial accidents and spills – managing grants of over 23,000,000 USD. DSCEJ addresses environmental and health inequities along the Mississippi River Chemical Corridor and is a community/university partnership providing education, training, and job placement. Since Hurricane Katrina, much of her work at the Center has focused on research, policy and community outreach as well as assistance and education of displaced African-American residents of New Orleans. After EPA identified more than 200 sites around the city with elevated lead and arsenic levels, I forged a unique partnership with the U.S. Steelworkers to launch "A Safe Way Back Home Project," a proactive pilot neighborhood cleanup project. Using our NIEHS-funded Minority Worker Training Program model, the neighborhood-centered pilot cleanup project trained more than 60 small businesses and contractors in hazardous waste removal, mold remediation and health and safety methods, and trained hundreds of volunteers from around the country to assist community residents in the cleanup and return safely to their devastated New Orleans homes and neighborhoods. Over these last thirty years working in the field of environmental justice, health disparities and community sustainability. Her research experience has shown that federal, state and local policies can have a long lasting and sometimes devastating impact on communities. Dr. Wright recognizes the importance of educating communities on the science related to issues of health and that engaging them with policymakers empowers communities to advocate on their own behalf to push government to make policy changes that better protect the public health. Dr. Wright is currently a member of the White House Environmental Justice Advisory Council (WHEJAC) and she serves on the Justice 40 committee.

Senior Consultant: David Padgett

1. **Professional Preparation**

Western Kentucky University, Geography/Geology, Bachelor of Science 1987
University of Florida, Geography/Environmental Engineering, Master of Science 1992
University of Florida, Geography/Geology, Doctor of Philosophy 2001

2. Professional Experience and Positions (Appointments)

Associate Professor of Geography, Tennessee State University, 2005-present
Visiting Assistant Professor, Vanderbilt University 2012-2013,
Assistant Professor of Geography, Tennessee State University 1999-2005
Visiting Assistant Professor of Environmental Studies, Oberlin College 1996-1999

3. Selected Bibliography

Padgett, D.A., Solis, P., Adams, J.K., Duram, L.A., Hume, S., Kuslikis, A., Lawson, V., Miyares, I.M., and Ramirez, A. "Diverse Experiences in Diversity at the Geography Department Scale," The Professional Geographer online edition, January (2013).

Padgett, D.A., Marsh, E., Harper, J., and Robinson, C. "Green Careers Curriculum Manual: Improving Access to Green Careers through Environmental Science and En-gineering at Historically Black Colleges and Universities," U.S. Environmental Protec-tion Agency (EPA 904-B-12-001), January (2012).

"Teaching Race, Class, and Cultural Issues in Earth Science to Enhance Multicultural Education Initiatives," Journal of Geoscience Education, vol. 49, no. 4, (2001), pp. 364-369.

4. **Research Experience: Scientific, Technical, Management**

Dr. David Padgett is a geoscientist by training with more than 30-years of experiences of in community engaged action research. He has worked in academia and as a consultant on projects including Community Air Quality Sensor Training and Community Air Quality Mapping, Community Asset Mapping, and WeGlobal Research Project on African Americans Living Abroad. Through his research and experience he has the appropriate expertise to co-develop participatory mapping tools. He has also mentored generations of graduate students at Tennessee State University throughout their academic journey. Given his expertise and skillset he is a highly-valued member of the team for ensuring quality deliverables from this project.

Graduate Student: Tatah Mentan Kefeyin Mom

1. **Professional Preparation**

University of Minnesota-TwinCities, Bachelor of Arts 2013
Dornsife School of Public Health, Drexel University, MPH 2016
Tulane University, School of Public Health and Tropical Medicine, Doctor of Philosophy expected (2023)

2. **Professional Experience and Positions (Appointments)**

ARMHR Research Fellow, Office of Global Health, Tulane University, 2021
Research Assistant, Environmental Health Sciences, Tulane University, 2019-Present
Research Assistant, Check It, Department of Epidemiology, Tulane, 2019-2021

3. **Selected Bibliography**

Craig-Kuhn, M.C., Schmidt, N., Scott Jr, G., Gomes, G., **TatahMentan, M**., Enaholo, O., Guzman, S., Tannis, A., Hall, J., Triggs, D.R. and Kissinger, P.J., 2021. Changes in sexual behavior related to the COVID-19 stay-at-home orders among young Black men who have sex with women in New Orleans, LA. Sexually Transmitted Diseases, 48(8), pp.589-594.

TatahMentan, M., Nyachoti, S., Scott, L., Phan, N., Okwori, F.O., Felemban, N. and Godebo, T.R., 2020. Toxic and Essential Elements in Rice and Other Grains from the United States and Other Countries. *International Journal of Environmental Research and Public Health*, *17*(21), p.8128.

Momplaisir, F.M., Aaron, E., Bossert, L., Anderson, E., **Tatahmentan, M.,** Okafor, V., Kemembin, A., Geller, P., Jemmott, J. and Brady, K.A., 2018. HIV care continuum outcomes of pregnant women living with HIV with and without depression. *AIDS care*, *30*(12), pp.1580-15854. Research Experience: Scientific, Technical, Management

4. **Research Experience: Scientific, Technical, Management**

As a qualitative researcher at the Children's Hospital of Philadelphia, Ms. TatahMentan coded and analyzed data focused on treatment for ADHD in low-income children. She has performed chart abstractions and assisted in manuscript writing on a project focused on HIV continuum of care for women experiencing perinatal depression. She coordinated the data collection including survey administration, focus group and key informant interviews for two separate WASH projects in Rwanda. In the Check It program a Chlamydia and Gonorrhea study, she recruited study participants, the creation and dissemination of health communication materials. She is a lab assistant for over two years processing samples, perform acid digestion and prepare samples to undergo inductively coupled plasma mass spectrometry analysis

Section 5. Summary of work effort

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Name	Title	NASA Level of Effort	OTHER LOE (or not known eg. consultant)	Planned Focus	Period of Work
Nathan Morrow	Principal Investigator	30%	70%	Lead research and accountable for project management and deliverables	Life of Project
Mom Tahta-Mentan	Graduate Student	30-50%	70-50%	Support research	Life of Project
Beverly Wright	Co- Investigator: Institutional PI	<10%	>90%	Co-lead research and manage support to EJ networks. Network support assitance by DSCEJ administrative staff.	Life of Project

Section 6. Current and Pending Support

NAME OF INVESTIGATOR: Nathan Morrow

Status of Support: _x__Current ___Pending ___Submission Planned in Near Future

Project/Proposal Title: Sahel Collaboration and Communication

Source of Support: USAID

Award Amount (or Annual Rate): $_1,450,000_____ Period Covered:_Sept 2020-Aug 2025_____

Location of Activity: Niger and Burkina Faso

Person-Months or % of Effort Committed to the Project: __50%_calendar____Cal Yr _____Acad _____Summ

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Status of Support: ___Current _X__Pending ___Submission Planned in Near Future

Project/Proposal Title: Assessing NASA Open Science Outlook for Environmental Justice and Resilience of the Louisiana Gulf Coast (OSO-LoGiC)

Source of Support: NASA EPS-CoR

Award Amount (or Annual Rate): $____65,000_____ Period Covered:__April 2022 – March 2023_____

Location of Activity:

Person-Months or % of Effort Committed to the Project: ___15%__Cal Yr _____Acad _____Summ

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Status of Support: ___Current ___Pending _X__Submission Planned in Near Future

Project/Proposal Title: Diagnosing The Health of Amazonian Wetlands with Multisensor Satellite Data

Source of Support: NASA Applied Science –A.35 SERVIR Applied Science Team

Award Amount (or Annual Rate): $_____200,000_____ Period Covered:____Jan 2023-Dec 2026_____

Location of Activity:

Person-Months or % of Effort Committed to the Project: ___15%__Cal Yr _____Acad _____Summ

Section 7. Statements of Commitment and Letters of Support

NBEJN
NATIONAL BLACK ENVIRONMENTAL JUSTICE NETWORK

9801 Lake Forest Blvd.
New Orleans, LA 70127
(504) 272-0956

Dr. Nathan Morrow
Tulane University School of Public Health and Tropical Medicine
1440 Canal St, Suite 2200
New Orleans, Louisiana, 70112

Dear Dr. Morrow,

It is with pleasure that I provide this letter of support for your proposal entitled “Assessment of the Gulf Coast Environmental Justice Landscape for Equity”. As the Network Coordinator of the National Black Environmental Justice Network, I have experience engaging communities on issues related to environmental justice. After review of your proposal, I believe this is an opportune time to conduct this landscape analysis. Specifically, because of the vast array of environmental health inequities that are affecting the gulf coast. The mission of National Black Environmental Justice is centered on addressing these inequities and advocating for environmental justice with data and anecdotal experiences denoted by communities we serve. I firmly believe that this landscape analysis will be a starting point to jumpstart the use and integration of community engaged methodologies and environmental health data to improve the quality of life of our constituents.

We acknowledge that we.are identified by name as Collaborators to the investigation, entitled "AGEJL-4-Equity", that is submitted by Dr. Nathan Morrow to the NASA funding announcement NNH21ZDA001N-EEJ -- A.49 Equity and Environmental Justice, and that we intend to carry out all responsibilities identified for me us in this proposal. We understand that the extent and justification of our participation, as stated in this proposal, will be considered during peer review in determining in part the merits of this proposal. We have read the entire proposal, including the management plan and budget, and we agree that the proposal correctly describes our)commitment to the proposed investigation. To conduct work for this investigation, my participating organization is the National Black Environmental Justice Network.

I am thrilled at the prospect of this work and am happy to endorse and give this my full support. If there is any additional information you need from me, please do not hesitate to ask and I’d be happy to assist as best as I can,

Cordially,

Asti Davis, JD
Network Coordinator
National Black Environmental Justice Network

March 14, 2022

Dr. Nathan Morrow
Tulane University School of Public Health and Tropical Medicine
1440 Canal St, Suite 2200
New Orleans, Louisiana, 70112

Dear Dr. Morrow,

We are pleased to provide this letter of support for your proposal entitled “Assessment of the Gulf Coast Environmental Justice Landscape for Equity”. As co-directors of the Historically Black College and University (HBCU)-Community Based Organization (CBO) Gulf Coast Equity Consortium, we have experience engaging communities on issues related to environmental and climate justice. The goal of the Consortium is to improve the health and lives of children and families in the Gulf Coast Region. We believe this is the perfect time to conduct a landscape analysis because of the various environmental health inequities existing in the region. The landscape analysis will be a starting point to use and integrate community engaged methodologies and environmental health data to improve the quality of life of Gulf Coast constituents.

"We acknowledge that we are identified by name as a Collaborator for the proposed project, entitled "AGEJL-4-Equity", that is submitted by Dr. Nathan Morrow to the NASA funding announcement NNH21ZDA001N-EEJ -- A.49 Equity and Environmental Justice, and that we intend to carry out all responsibilities identified for me in this proposal. We also understand that the extent and justification of my participation, as stated in this proposal, will be considered during peer review in determining in part the merits of this proposal. We have read the entire proposal, including the management plan and budget, and agree that the proposal correctly describes the commitment of the Consortium to the proposed investigation.” To conduct work for this investigation, our participating organization is the HBCU-CBO Gulf Coast Equity Consortium.

We are happy to endorse and give this work our full support. If there is any additional information you need from us, please do not hesitate to ask and we will be happy to assist.

Cordially,

Beverly Wright, Ph.D.
Co-Director

Robert Bullard, Ph.D.
Co-Director

DEEPSOUTH CENTER FOR ENVIRONMENTAL JUSTICE

9801 Lake Forest, Blvd
New Orleans, LA 70127
(504) 272-0956
www.dscej.org

March 15, 2022

Dr. Nathan Morrow
Tulane University School of Public Health and Tropical Medicine
1440 Canal St, Suite 2200
New Orleans, Louisiana, 70112

Dear Dr. Morrow,

It is with pleasure that I provide this letter of support for your proposal entitled “Assessment of the Gulf Coast Environmental Justice Landscape for Equity.” As the Executive Director of the Deep South Center for Environmental Justice (DSCEJ), I have experience engaging communities on issues related to environmental justice. After review of your proposal, I believe this is an opportune time to conduct this landscape analysis. Specifically, because of the vast array of environmental health inequities that are affecting the gulf coast. The mission of the DSCEJ is dedicated to improving the lives of children and families harmed by pollution and vulnerable to climate change in the Gulf Coast Region through research, education, community, and student engagement. I firmly believe that this landscape analysis will be a starting point to jumpstart the use and integration of community engaged methodologies and environmental health data to improve the quality of life of our constituents.

“I acknowledge that I am identified by name as Collaborator to the investigation, entitled "AGEJL-4-Equity", that is submitted by Dr. Nathan Morrow to the NASA funding announcement NNH21ZDA001N-EEJ -- A.49 Equity and Environmental Justice, and that I intend to carry out all responsibilities identified for me in this proposal. I understand that the extent and justification of my participation, as stated in this proposal, will be considered during peer review in determining in part the merits of this proposal. I have read the entire proposal, including the management plan and budget, and I agree that the proposal correctly describes my commitment to the proposed investigation.” To conduct work for this investigation, my participating organization is the DSCEJ Community Advisory Board.

I am thrilled at the prospect of this work and am happy to endorse and give this my full support. If there is any additional information you need from me, please do not hesitate to ask and I’d be happy to assist as best as I can.

Sincerely,

Beverly Wright, Ph.D.
Executive Director

March 15, 2022

Dr. Nathan Morrow
Tulane University School of Public Health and Tropical Medicine
1440 Canal St, Suite 2200
New Orleans, LA 70112

Dear Dr. Morrow:

I am writing with a letter of support for your proposal entitled *Assessment of the Gulf Coast Environmental Justice Landscape for Equity*.

The Environmental Justice Forum – a network of more than 55 environmental justice groups representing 22 states including several based in the Gulf Coast region. I serve as Senior Director of Strategy and Federal Policy and serve as lead for the EJ Forum and, after review of your proposal, believe this is the opportune time to conduct this landscape analysis that examines the vast array of environmental health inequities that are affecting the gulf coast. I firmly believe that this landscape analysis will be a starting point to jumpstart the use and integration of community engaged methodologies and environmental health data to improve the quality of life of constituents.

I acknowledge that I am identified by name as Collaborator to the investigation, entitled "AGEJL-4-Equity", that is submitted by Dr. Nathan Morrow to the NASA funding announcement NNH21ZDA001N-EEJ -- A.49 Equity and Environmental Justice. I understand that the extent and justification of my participation, as stated in the proposal, will be considered during peer review in determining in part the merits of this proposal. I agree that the proposal correctly describes my commitment to the proposed investigation." To conduct work for this investigation, my participating network is the Environmental Justice Leadership Forum.

I am happy to endorse and give this my full support. If there is any additional information you need from me, please do not hesitate to ask and I'd be happy to assist as best as I can.

Sincerely,

Dana Johnson

Dana Johnson

Section 8. Budget Justification:

Key Personnel:

Tulane personnel will be leading the project from start to finish over the proposed period of 6 months.

Nathan Morrow, The Principal Investigator will contribute a level of effort 30%, is accountable for achievement of science objectives and quality of research. This will be achieved through exemplary project management. As PI, Nathan is accountable for maintenance of resource control environment, meeting all award milestones and reporting requirements, grant administration, and regular communication with stakeholders and deliverables. He is NASA's primary contact point. He will ensure clear communication between all project partners and stakeholders. He will provide overall supervision as well as strategic and technical direction of activities. He will dedicate a minimum of 2-full month equivalent of time over life of project and will be paid 30% of his effort for the life of the project. He is responsible for implementing the overall data management plan and monitoring the inclusion plan.

Additional Personnel:

Mom Kefeyin TatahMentan, Graduate Student, level of effort 30-50%. will manage support on background evidence scan and support networks with self-assessment and capacity building. She will liaise with Drs. Morrow, Wright and Padgett to provide additional capacity support to networks as needed in completing their network-landscape presentations. She will assist in managing the workshop, ensuring information is handled as per DMP, and fully collaborate on analysis and reporting activities

Staff, Program Manager, will contribute a level of effort 5 % , is responsible to facilitate project logistics, supporting project activities, and contributing to project reporting. (fully cost shared)

Fringe Benefits:

Fringe Benefits are charged as direct costs and are set by Tulane at the current negotiated rates for budgeting purposes. FY22 rates: Faculty: XX%, Students: XX%, Staff: XX%.

Consultants:

Dr. David Padgett, will contribute a level of effort 20-days: Dr. Padgett is a professor at Tennessee State University and established NASA investigator will be hired as a consultant for 20 days to provide expert participatory and dynamic mapping and facilitate community engagement. The consultant rate was determined by the field competi-

tion and an average rate was derived. The total cost for consultancy is provided in the NSPIRES cover page and does not include any other costs than Dr. Padgett's time.

Equipment:

Total Requested for Equipment Support: $0

Travel: $1,500. Dr. Padgett will travel to facilitate workshop meetings in New Orleans in October 2022.

Airfare	$400
Lodging	$750
Meals & Incidentals	$250
Taxis to/from airport	$100
Total Costs	**$1,500**

Facilities and Equipment:

Training and Workshops: Tulane will provide space and facilities for project workshops at no cost to the project.

Total Requested for Equipment Support: $0

Sub-Contract:

Deep South Center for Environmental Justice was selected as a Subcontract candidate due to the expert work in integrating participatory methods in environmental justice work. They were also selected for their reputation for agile high quality community collaboration. DSCEJ will facilitate direct support for four community networks and will dedicate experienced personnel to the project's Communiversity-modeled activities. Dr. Beverly Wright, CO-I and Institutional PI supported by DSCEJ staff, is accountable for the fidelity of the proposed activities and deliverables to the principles of Communiversity and will contribute directly to workshop design and engagement with networks. Dr. Wright will be co-lead author of the final Landscape Analysis.

The sub-award will be spent on travel for 3-5 participants from each network travel to the Landscape Analysis workshop. A small honorarium may also be paid to networks for hosting webinars and undertaking AGEJL-4-Equity activities to prepare presentations for the workshop. Based on the principles of equity, each network will receive an equal amount for travel and honorarium. If travel savings are realized, networks will fund more than the minimum of 3 participants to attend the workshop. Agile collaboration is necessary for frontline community organizations to make the most of limited resources.

DSCEJ has extensive experience with funding EEJ work to be done by the most concerned communities and networks. The first step of this process is to negotiate for most

effective and efficient approach to meeting objectives and then co-create a documented set of commitments with time bound deliverables from each network partner. In fact, working together on resource management is part of the capacity development Communiversity model. Network participants are invited to attend the 2-day Landscape Analysis workshop and also to attend the 2-day Open Science for Environmental Justice conference directly preceding. Overnight accommodation in New Orleans using Tulane University negotiated rate is $150 per night. If each network invites 3 participants for 4 nights, the total is $1800. Meal allowance of $50 per day for 3 participants is $600. A travel allowance for airfare, train or car travel estimated at $350 for 4 participants is $1400. Each network will have a travel budget of $3800. Honorariums for the networks of $1200 for each network to engage in webinars, AGEJL-4-Equity activities and for any costs to prepare network landscape analysis presentations. The total budget passed on to networks is $5000.

Dr. Wright and DSCEJ are fully committed to making as much of the funding as possible directly available to the EEJ networks. This means for them to be as agile and lean in their project management as possible by leveraging volunteer time and shifting tasks among the Center's staff to bolster Dr. Wright and the leadership team's efforts. In that way, Dr. Wright's LOE remains low while she is flexible and available to make contributions at the most critical times. It is a matter of efficiency and value for money. DSCEJ will receive $2000 in other funds to reimburse any costs of supporting networks and distributing travel and honorarium fees.

$2400 will be spent from sub-contract on open access publishing fees.

As necessary for the Costing Plan task in the first month of the award, more detailed costs disaggregated by network or individual will be articulated. Specific hotel and travel reservations, that represent the bulk of the network resource requirements, could potentially be made at that time to provide highly detailed cost estimates to be communicated as necessary to the program officer. Working with NASA on models to engage EJ community organizations is encouraged in the NOFO, and AGEJL-4-Equity looks forward to exploring the best possible approaches to include budgeting and costing in these engagement models.

Total Requested for Sub-Contracts: $26,400

Section 9. Detailed Budget

*As per ROSES guidance, all cost for people including salary, benefits, overhead or totals have been removed.

AGEJL - Detailed budget

	NASA Funds requested			Institutional Contribution		
Tulane	Amount	Unit	Total	Amount	Unit	Total
Direct Labor:						
PI reseracher (30% LOE)	XX	6 Months	XX	XX	6 Months	XX
Graduate assistants	XX	6 Months	XX			
Staff (5% LOE)				XX	6 Months	XX
Fringe rates:						
Faculty - XX%			XX			XX
Student - XX%			XX			
Staff - XX%						XX
Salary and Fringe subtotal			XX			XX
Equipment:						
Supplies:						
Travel:			1,500.00			
Tuition:						
Other:						
Dr. Padgett (consultant)		20 days	XX			
Subtotal - Direct			XX			XX
Subawards: **DSCEJ**						
4 awards, passed on to networks			24,000.00			
journal article processing fee			2,400.00			
Subtotal- Subaward			XX			
Indirect Costs:						
Direct cost (52%)			XX			XX
Subaward (Applied to first 25k)			XX			
Cost Sharing:						20,085.89
Total Costs:			XX			

DSCEJ sub-award budget - Detailed

	NASA Funds requested		
DSCEJ	Amount	Unit	Total
Direct Labor:			
Co-I: Institutional PI	XX	6 Months	XX
Support Staff	XX	6 Months	XX
Fringe rates:			
Salary and Fringe subtotal			XX
Equipment:			
Supplies:			
Travel:	5,000.00	4	20,000.00
Tuition:			
Other:			
journal article processing fee	2,400.00	1	2,400.00
distributing funds & travel to networks	2,000.00	1	2,000.00
Subtotal - Direct			XX
Indirect Costs:			
			XX
			XX
Total Costs:			XX

Section 10. Facilities and Equipment:

Tulane will provide facilities for workshops and meetings at no direct cost to the project. Facilities include the state-of-the-art research, education and outreach amenities of the River and Coastal Center offered by the ByWater Institute at Tulane. The TRCC opened in 2016 and features laboratories, offices, and a public meeting space with views of the Mississippi River. The building is managed by the ByWater Institute, but scholars can use the meeting space for programming relevant to the TRCC mission. The Tulane River and Coastal Center is available for exhibitions, classes, demonstrations, shows, receptions, meetings, and/or conferences that relate to the mission of the ByWater Institute. The Forum is 1400 square feet with flexible seating and views of the Mississippi River. The Selley Foundation Room is 200 square feet with fixed conference seating and views of the river

High-resolution Extreme Event and Localized Temperature for Health Forecasting in Underserved Lowlands of the Gulf Coast (HEELTHFUL-GC)

Improving anticipatory estimation of climate change-related extreme event impact on Gulf Coast Climate Justice (CJ) and Environmental Justice (EJ) communities by addressing structural disparity and local context bias that has limited the effectiveness of previous health forecasting initiatives – with an interdisciplinary team including – the Deep South Center for Environmental Justice (DSCEJ) and four experienced NASA investigators from social, Earth, health, data, and decision support science

Section 1.0: Table of Contents

Section 2.0: Scientific Objectives, Technical Approach and Management

2.1 Response to Program Element A.28 Sub-element 4

Climate change related hazards and environmental damage are unequally distributed in communities on Earth in patterns that are often observable from space. Environmental injustice results in the uneven distribution of any of the broad range of environmental ills coincident or collocated with marginalization of groups of people. Climate injustice results in vulnerability disparities for underserved communities. Unfair exposure to hazards, harm to health and wellbeing, and systemic barriers to participation in life and livelihood-affecting decisions may be mitigated, remedied, or avoided – at least in part – through improved recognition and capabilities of EJ&CJ communities. HEELTHFUL-GC responds to Program Element A.28 Interdisciplinary Research in Earth Science, Sub-element 4 "Environmental and Climate Justice Using Earth Observations" with an integrated use of open source socioeconomic, health and Earth science, including NASA data streams and approaches, as an evidence base to inform CJ&EJ decision making and advance healthy solutions in an inclusive and scientifically valid way.

2.1.1 Objectives for Climate and Environmental Justice Impact

Climate change threatens public health globally. Leading research institutions of the Lancet Countdown on Climate Change and Health consortium reported now pervasive negative impacts on **all** health and socio-economic outcomes they monitor (Romanello et al., 2022). Cumulative negative health impacts already concentrate in the most vulnerable places as increasing extreme temperature and precipitation events continue to shock interconnected natural and socio-economic systems.

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

Health forecasting (HF) merges meteorological, environmental, and socio-economic factors to support community health system decision makers identify risks and better manage changing demand (Soyiri & Reidpath, 2013). Numerous studies have linked data from the United Kingdom's meteorological service and health service to predict climate change-related impacts (Arnell, 2022). Weather affects behavior (Katz & Murphy, 2005), injuries and disease(Patz, et al., 2000), and access to healthcare (Codjoe et al., 2020). Two major problems arise for appropriate and effective health forecasting:

1. **Discriminatory access** to health services, and structural inequalities observed in available health system data, enhance the risk of training forecasting models to propagate those same injustices and bias (Sarri, 2022).
2. **Local level context** decidedly affects accuracy of model predictions as well as the

operationalization of policy and program solutions (Soyiri & Reidpath, 2013).

NASA supported Environmental Justice and Equity-focused research has not only linked local meteorological and environmental factors to health outcomes but revealed underlying causes of the observed disparities. A study by Hammock et al. (2022) identified local level urban heat islands and connected them to the historical discriminatory housing policy. Lack of investment in public green spaces and private trees could be observed by satellite remote sensing and readily inform local decision making. The NASA-funded Socioeconomic Data and Applications Center (SEDAC) distributes a social vulnerability index data set for coastal West Africa (Yuan et al., 2020), but no such data set is available for the Southern Gulf Coast of the United States. Despite a diversity of promising cases, use of satellite-derived surface temperature or precipitation measurements of extreme events to improve predictions in wider decision-making contexts, such as local and regional health systems as well as cumulative impacts of multiple risks and stressors on community health, remain under-investigated in health forecasting.

HEETHFUL-GC's technical approach will harness the synoptic power of **NASA Earth observation satellites** to measure and **model temperature and precipitation extreme events** at decision-relevant local scales. NASA's sensors collect data at applicable scales to be integrated with health data, but have not previously been reprocessed and made available to social scientists studying health dipartites and climate justice in a format that facilitates forecasts. Furthermore, high-resolution measurement of land temperature or precipitation rate will reveal highly localized extremes that may be lost in data interpolated from ground-based weather stations previously used in health forecasting thereby addressing a significant shortcoming of previous models.

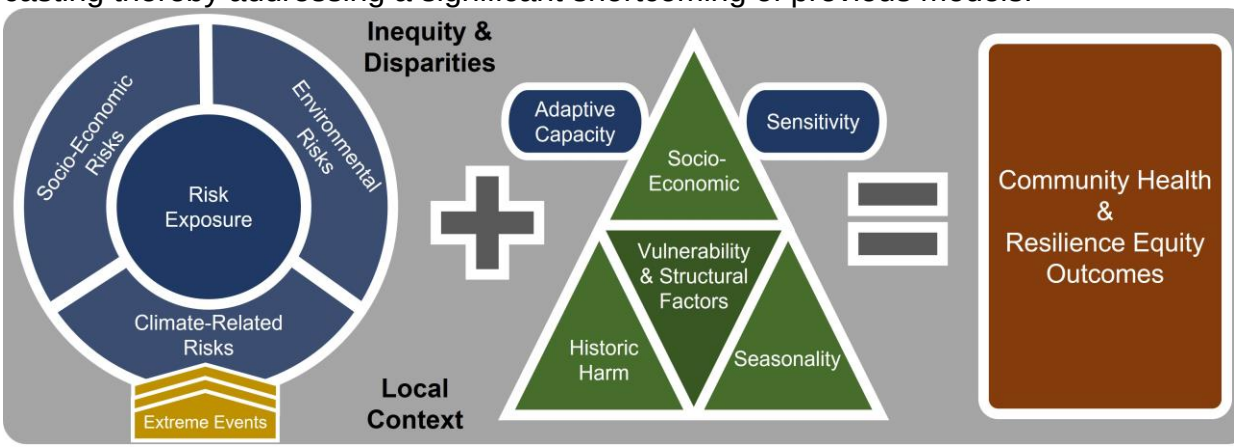

Figure 1: HEELTHFUL-GC model

Causality is the foundation for developing appropriate and actionable solution-oriented policies and effective programs. USGCRP(Crimmins et al,2016) and Interagency Panel on Climate Change(IPCC, 2014)propose a high level model for predicting negative impacts of climate change: 'risk exposure + sensitivity + adaptive capacity = climate change vulnerability'. In Figure 1, HEELFUL-GC unpacks the USGCRP/IPCC formulation to indicate the proposed data streams to parameterize a forecasting model. Data on risk exposure is contextualized from a multidisciplinary perspective and makes explicit the connection to extreme events. Underlying patterns of structural disparities inform the model description of sensitive and adaptive capacity from a rich *in situ*

evidence base of socio-economic and health demographic data. Finally, model outcomes focus on negative expected impacts of climate change vulnerability on resilience and health. In this way, **HEELTHFUL-GC equity outcome forecasts constitute a fundamental advance** at the interface of earth processes and human factors driving climate change resilience from a multi-method, multi-scale, multi-disciplinary, and multi-sectoral perspective. This facilitates vital, and novel, research questions: a) CJ&EJ communities' differential exposure to climate related extreme events; b) discriminate seasonal and structural moderation of local extreme events' impact on community health; c) extreme events coincidence with other disproportionate risk exposure; d) cumulative impacts on health; e) policy leverage to improve CJ&EJ outcomes and resilience; and f) entry points to strengthen CJ&EJ community capacity to use NASA Open Source Science.

The urgent need for more justice-aligned and locally informed community health and resilience equity outcome forecasts requires interdisciplinary research objectives. Three HEELTHFUL-GC Interdisciplinary Science Objectives (IDSOs) are SMART – Specific, Measurable, Attainable, Relevant, and Time-Bound – and call for specific tasks:

IDSO 1: **Back-cast** impact of extreme events on CJ&EJ community health outcomes using a 10-year satellite remotely sensed data timeseries and existing socio-economic, demographic and health data for Gulf Coast lowland census tracts.

IDSO 2: **Now-cast** - Provide an easily accessible web-based tool for monthly now-casting and scenario planning in policy-relevant 5-year time steps for potential and cumulative effects of extreme events on EJ community health outcomes.

IDSO 3: **Broadcast** - Provide high impact project result engagement with diverse research, STEM, policy, and preparedness audiences – based on CJ&EJ networks' ground validated model results and identified links between health outcomes and extreme event resilience in 10 locations over life of project.

2.1.2 Relevance of Open Science to advancing CJ and addressing underlying disparities driving vulnerability of underserved Gulf Coast EJ communities

Recent executive orders direct federal agencies to recognize and adapt their programs to combat the twin challenge of inequity and negative impacts of climate change. White House Executive Order(WHEO) 13985 seeks to advance equity by focusing programmatically on underserved communities and intentionally promote diversity, inclusion and accessibility as further described in WHEO 14035. The White House Environmental Justice Advisory Committee (WHEJAC, 2021) was created in response to WHEO 14008 that calls for a redoubling of efforts to understand domestic impacts of environmental and climate change. To address a critical lack of contextually relevant equity-focused open science data sets to support these efforts, WHEJAC empowered the open source science community to create the Climate and Economic Justice Screening Tool (CEJST) in order to provide user-friendly capacity development, technical assistance and consultation engaging or co-led by CJ&EJ communities (WHCEQ & UDS, 2022).

Satellite data products provide crucial capability to extend the CEJST from a static map comparing census track level areas against statistical thresholds into a dynamic public health decision support tool. The CEJST provides (or can integrate) many

socioeconomic indicators of poor access to health services and health outcomes as predicted under climate change for underserved communities by the USGCRP. The currently limited observational data on environmental factors and capacity for dynamic modeling will be addressed with integration of NASA data streams. Co-creation with CJ&EJ communities will improve models to reflect the underlying causal relations present in their context and determinates of health and wellbeing aligned with their lived experience. All along the Gulf Coast, the current lack of local scale forecasting impedes urgent, necessary, and immediate policy focus on the existing vulnerabilities and the potential for resilience of CJ&EJ communities on the frontlines of climate change. HEELTHFUL-GC activities(tasks, approaches, & engagements) are guided by three unifying principles:

1. **Open Source Science:** Research efforts linking Open Science, equity, and environmental justice demonstrate practical pathways for realizing sustainable and more equitable program benefits for underserved communities. HEELTHFUL-GC recognizes significant synergies for CJ&EJ projects and NASA's mission Transform to Open Science; a decade-long strategic commitment to lowering barriers to entry for historically excluded communities, better understanding how people use NASA data and code to take advantage of big data collections, and increasing opportunities for collaboration while promoting scientific innovation, transparency, and reproducibility.

2. **Mobilizing social science expertise in an interdisciplinary team to engage with CJ&EJ communities on complex challenges:** The ESD Applied Sciences Program promotes measurable social benefit from NASA research and information products with the aim to improve decision making and related policy solution implementation. Clearly defining human factors and socio-economic structural drivers of health inequity, as proposed by HEELTHFUL-GC, is the first step to making improved decision making and social benefit measureable. As with action research for CJ&EJ, a more inclusive science process promotes greater consensus around the evidence base for policy formation that in turn advances collective action.

3. **Modeling and integrating social and earth science data:** Health forecasting may be one of the most promising and practical uses of NASA satellite data to advance fundamental understanding of the role of extreme events in and human consequences of climate vulnerability and disaster resilience. USGCRP identified increasing challenges in access to health care as a primary negative impact pathway of climate change on EJ communities (Gamble et al., 2016). Integrated socio-ecological systems' questions are now the vanguard of Earth-system science research.

For science to have meaningful impact and engage the public to address climate change, Limaye(2021)argues the importance of results at a human scale, cumulative impact focus, and socio-economic framing. HEELTHFUL-GC expected results are:

As a <u>first significant contribution</u>: HEELTHFUL-GC will have contributed novel located and interdisciplinary insights on climate-related risk exposure interaction with structural factors in determining community health vulnerability and resilience with a policy relevant focus on economic and health disparities. The modeling approach is a novel triangulation of satellite remote sensing, *in situ* health/socio-economic data, expert/CJ&EJ observations of cumulative effects, extreme events and tipping points.

As a second significant contribution: HEELTHFUL-GC will have supported CJ&EJ communities' expanding awareness, accessibility, and use of Earth data through an open source science approach. This provides an operationally feasible, high quality and cost effective CJ&EJ community engagement model for evidence-based study.

As a third significant contribution: HEELTHFUL-GC will have engaged social and health science researchers in an interdisciplinary team for systems-informed development of retrospective and prognostic models including parameters related to underlying causes. Forecast scenarios are necessary for policy and program formulation to address complex and challenging problems facing CJ&EJ communities.

As a fourth significant contribution: HEELTHFUL-GC will have sustainably transferred research products, tools, capacity and a nowcasting model to a well-supported community-based end user. The DSCEJ will incorporate all deliverables into the Bezos Earth Fund-supported data center with potential for co-creation of new related applications: STEM-education materials; productive engagement opportunities with CJ/EJ/equity communities, young researchers, and a broad range of stakeholders; compliment high priority CJ&EJ topics of urban heat islands, flooding, coastal community hazards, air pollution, infrastructure and precipitation/landcover change.

2.2 Technical Approach to Community-engaged Interdisciplinary Modeling

2.2.1 Geographic focus of HEELTHFUL-GC & the Open Source Science CEJST

Southern institutions and organizations were underrepresented in the first NASA Equity & Environmental Justice Listening Workshop (NASA ESD, 2021). As Catherine Coleman Flowers, member of WHEJAC, noted:

> "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." (NAS, 2021).

HEELTHFUL-GC's study site includes the lowland Gulf Coast communities and rural areas of Louisiana, Alabama, Mississippi, Florida, and Texas. The unit of analysis will be the census tract as relevant socio-economic and health data are collected at local level for both local decision making and federal government climate fund resourcing decisions using the CEJST. The CEJST using the agreed thresholds "… identifies communities that are marginalized, underserved, and overburdened by pollution".(WHCEQ & UDS, 2022). Figure 2 displays locations of disadvantaged communities in gray.

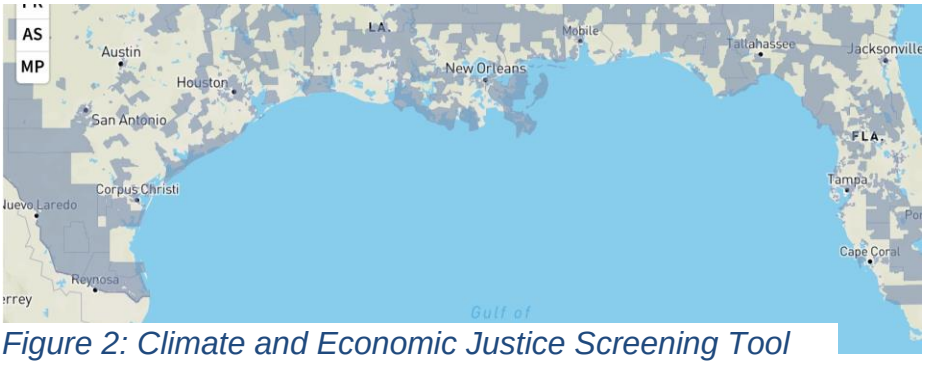

Figure 2: Climate and Economic Justice Screening Tool

Gulf Coast adjacent lowlands are identified using Environmental Protection Agency's bioregions designated "coastal" or "river plains" (Omernik & Griffith, 2014). All Gulf Coast

lowlands census tract will be included in HEELTHFUL-GC modeling and results. This will provide an opportunity for policy-relevant comparative analysis of the impacts on community health for populations both inside and outside of CEJST identified 'disadvantaged' census tracks.

2.2.2 Remote Sensing Products for Characterizing Extreme Events

Co-I Dr. Borak, an experienced NASA investigator at the University of Maryland's Earth System Science Interdisciplinary Center, conducted an in-depth assessment of appropriate remote sensing data products for inclusion in health forecasting models. He identified primary precipitation land surface temperature (LST) data sets with optimal characteristics for identifying extreme events and aggregating to the census tract level. The Integrated Multi-satellitE Retrievals for Global Precipitation Monitoring (IMERG) Final Precipitation (Huffman et al., 2022) data set will be appropriate for both retrospective and prognostic modeling. The Moderate Resolution Imaging Spectroradiometer (MODIS) Aqua Daytime and Nighttime LST (Hulley, 2021a; 2021b) will be used only for back-casting as the Aqua platform is currently being decommissioned. The Visible Infrared Imaging Radiometer Suite (VIIRS) Daytime and Nighttime LST and Emissivity (Hulley & Hook, 2018a; 2018b) will be used in nowcast and scenario forecasting models. The signal from extreme events in the study area environment will be much larger than calibration-related differences in absolute temperature between the sensors/data products. Analysis by Islam et al. (2016) indicates that intersensor (VIIRS vs. MODIS) LST retrieval differences are less than 0.5 K over a wide range of surface types, thus presenting no significant barriers to answering research questions.

A number of other sensors and data products such as impervious surfaces or air quality could be incorporated into future health forecast modeling efforts, but would expand the current scope of research beyond available resources. Review of the health forecasting literature indicated that primary focus should remain on temperature and precipitation as main drivers of community health outcomes and shock response to extreme events, but these effects are consistently moderated by greenspace. Therefore, we will also include and aggregate the MODIS Aqua Enhanced Vegetation Index (Didan, 2021).

Using requested NASA High End Computing (HEC) resources, Dr. Borak will lead acquisition and processing of the datasets into formats and variables that can be ingested into the models. Table 1 lists remote sensing data inputs for the back-casting model. A time series of at least 10 years will be aggregated to census tract level by deriving appropriate spatial measures of central tendency (e.g., mean & median), variability (coefficient of variation) and dispersion (e.g., min & max values). The time series will be leveraged to compute temporal metrics for identification of extremes.

Table 1: Satellite data products employed in support of back-casting activities.

Remotely Sensed Parameter	Data Source(s) and Period of Record	Reference(s)	Spatial	Temporal
Land Surface Temperature	MODIS Aqua Daytime and Nighttime LST and Emissivity (2002-2022)	Hulley (2021a; 2021b)	1-km	Twice Daily
Precipitation	GPM IMERG Final Precipitation (2000-)	Huffman et al. (2022)	10-km	30-minute

Vegetation Index	MODIS Aqua Enhanced Vegetation Index (2002-2022)	Didan (2021)	500-m	16-day

For temperature and vegetation measures, mean, minimum, and maximum are useful for describing a tract's environmental condition over time (Borak et al., 2000). High-frequency availability of precipitation observations (half-hourly) enables identification of heavy precipitation and very-heavy precipitation events (Zhang et al., 2011). The forthcoming reprocessed version of VIIRS products (Collection 2) provides continuity of a long-term data stream needed for nowcasting and dynamic scenarios (see Table 2).

Table 2: Satellite data products to be employed in now-casting and scenarios

Remotely Sensed Parameter	**Data Source(s) and Period of Record**	**Reference(s)**	**Spatial**	**Temporal**
Land Surface Temperature	VIIRS Daytime and Nighttime LST and Emissivity (2012-)	Hulley & Hook (2018a; 2018b)	1-km	Twice Daily
Precipitation	GPM IMERG Final Precipitation (2000-)	Huffman et al. (2022)	10-km	30-minute
Vegetation Index	VIIRS Enhanced Vegetation Index (2012-)	Didan & Barreto (2018)	500-m	8-day (2x VIIRS)

Years 2 & 3 of HEELTHFUL-GC bring an intensified focus on engaging CJ&EJ communities and other stakeholders directly in an open science process with enhanced access to model results and opportunities to interface with data, *e.g.,* event timelines or community historic profiles. Additional data processing for "deep dives" at specific locations within the study area (e.g., "hot-spots") or contribution to the open source science site that will be transferred to the DSCEJ's Data Center will require additional processing. Open source science sites (GitHub, Tulane, DSCEJ) will document and accessibly archive all procedures and codes used and all datasets generated, an overall summary of satellite data characteristics over the study area, and a set of specific lessons learned.

2.2.3 Integrated Earth, Socio-economic and Health Data Modeling

The CEJST reviewed 150 data sets to select indicators that were relevant to the goals of Executive Order 14008, publicly available, consistent high quality measures, and available at census track level (WHCEQ & UDS, 2022). Existing screening tools from the Environmental Protection Agency (EPA), California, and Maryland were used as models for setting the thresholds for 'disadvantaged' communities. HEELTHFUL-GC's research aim is to improve understanding of the underlying relation of climate change-related extreme events and structural socioeconomic factors driving poor health outcomes observed in these 'disadvantaged' communities. This will require a timeseries rather than threshold analysis, but most CEJST data sets can be reused in the HEELFUL-GC modeling approach as useful and appropriate parameters (See Table 3).

Table 3: Indicators of Risk exposure, Socio-economic factors and Health outcomes shared by CEJST and HEELTHFUL-GC models

	Indicators	**Data Source(s)**	**Refs**
Health outcomes	13 health outcomes (asthma, diabetes, heart disease..), 3 health status, 4 chronic disease-related health risk behaviors & 9 use of preventive services.	PLACES 2021: Local Data for Better Health (CDC, 2016-2019)	Greenland et al., 2022
	Low life expectancy	U.S. Small-area Life Expectancy(CDC,2010-15	Arias et al 2018

Socio-economic factors	poverty, employment, housing, lead paint, education & linguistic isolation	American Community Survey (U.S. Census, 2007-2021)	National Research Council, 2007
	Housing burden	HUD	CEJST, 2022
Risk factors	Environmental risk measures: Air Quality, proximity to toxic & hazardous sites, traffic, waste water	EJScreen (EPA, varies, 2014-2021)	Corrales, 2016
	Average of 14 natural disaster risk for population loss, building loss, & agricultural loss	FEMA https://github.com/usds/justice40-tool.	CEJST, 2022

The CEJST-aligned indicators are available at annual level and some sources have an incomplete record or missing data . For modeling purposes, some values will be imputed, based on trends, to cover the same analysis periods as the temperature, precipitation, and vegetation data series. Valuable community health outcome signals from more punctual extreme events will be observable at annual time scales. HEELTHFUL-GC will further seek to model intra-annual health forecasts that can discriminate seasonality from effects related to extreme events. A subset of risk indicators and health outcomes are archived at weekly and monthly intervals. Multiple cause, infant, and maternal mortality at county level are available weekly as a consistent quality checked data set a beginning in 2001 from the National Vital Statistics System. Data series with relatively higher temporal frequency (air quality, risk, health access…) will be used in modeling to define seasonality effects on key indicators and statistical relationships between indicators including local data sets available in one part of the study site. Literature review will also reveal applicable seasonal adjustments appropriate to the study site and context. To account for the area unit differences of weekly and monthly data available only at county and census track levels, hierarchal mixture models will be employed to capture interannual seasonal effects on observed outcomes. Assumptions and indicators will be validated with CJ&EJ communities. The team is confident that the community engagement for ground truthing results described in Section 2.2.4 (“Communiversity”) will not only provide for realistic causal descriptions of observed relationships, but a means to improve and adapt methods at each analytical step.

Back-casting to estimate marginal effects of extreme events on community health of underserved communities on the Gulf Coast will begin with checking the magnitude and pattern of missing data and as necessary conducting multiple imputation or Heckman selection modeling. If our missing values are missingness is confined to the outcome variable (MCAR), we will use complete case analysis. Numerous outcome variables are identified (diabetes, mortality, heart conditions…) potentially resulting in type 1 error inflation due to multiplicity. Type I error inflation is controlled by Hochberg and Hommel methods for mildly correlated outcomes and the step-down minP method or Bonferroni adjustment for highly correlated outcomes. The Shapiro Wilks tests the normality assumption while the Levene test for homogeneity of variances in comparison sets. An independent t-test discriminate significant differences between groups of communities or with transformations or nonparametric methods like the Mann Whiteney test.

Cumulative risk models will then be developed using weighted quantile sum (WQS) regression models to create an index of all meteorological and non-meteorological exposures. The WQS index will be estimated from ranking exposure concentrations in

quartiles adjusted for covariates like age and sex. The weights will be calculated based on the equation $g(\mu) = \beta_0 + \beta_1(\sum_{i=1}^{c} w_i q_i) + z'\varphi$. Here w_i denotes the weights which will be constrained to a value between 0 and 1. All confounders are represented by z' φ. A Gaussian distribution will test for relationships between a continuous outcome and the cumulative index adjusted for various covariates to unpack combined risk from extreme events, aggregate exposures, and multiple stressors that multiply harm(EPA, 2003).

Now-casting and scenario development will be driven by near-realtime meteorological data and predicted extreme event trends (temperature, rain, flooding) using autoregressive integrated moving average (ARIMA) modelling. ARIMA models make use of previous observations to make predictions of future values using lag parameter values. A seasonal ARIMA model (ARIMA(p,d,q)(P,D,Q)m,) will be specified where parameters p, d, and q are non-negative integers, p is the order (number of time lags) of the autoregressive model, d is the degree of differencing), and q is the order of the moving-average model, and m refers to the number of periods in each season, and the uppercase P,D,Q refer to the autoregressive, differencing, and moving average terms for the seasonal part of the ARIMA model. The data will be divided into two sets: training data and validation data. The Box-Jenkins approach will fit the models. A (partial) autocorrelation function will be plotted to examine stationarity and lags and to assist in identification of model. All analyses will be performed using R version 4 at the 5% level of significance

Bayesian decision network (BDN) will be used to create probabilistic graphical models representing both manifest and latent variables. Both factor and scaled variables will be specified. Conditional dependencies and conditionally independent variables will be identified. Maximum likelihood approach will be used to estimate unknown parameters. Once the structure is determined, probability distributions will be assigned to each node. The BDNs will be used for both predictive and diagnostic inference. All three causal classes: Causal chain, common effect, and common cause will be explored. Model specification will enable anomaly detection and trend analysis to inform the development of census track level scenarios. Scenarios from the IPCC and other climate forecasts will be used to estimate future sets of model parameters at 5, 10, 15, 20, and 25 years into the future. Seasonal model elements and frequency and severity of shocks from extreme events will be estimated. Scenarios based on engagement with the underserved EJ communities will be developed in years 2 & 3 such as increased green space or flood mitigation potentially improving community health outcomes.

2.2.4 Communiversity – Ground truthing with EJ community science partners

CJ networks and their underserved EJ community representatives will fully participate as community science partners in an approach adapted from the tried and true DSCEJ Communiversity model. While flexible enough to reflect on the potential of NASA Open-source Science and data products, the “Communiversity” model safeguards against a potentially extractive or exploitative process by ensuring EJ communities are equal active participants in research (Bullard & Wright, 1993). CJ community partner scientists will contribute beginning with the earliest project tasks of ground truthing of model assumptions and key indicator selection. Causal pathways of extreme event impact on community health outcomes found in the literature will be the subject of a process of

community-led ground truthing. Frontline communities' lived experiences will have the team's full appreciation in discussions and analysis as congruent sources of knowledge.

Beginning in the 1990's, DSCEJ pioneered the Communiversity model for participatory data collection and assessment processes that focuses on capacity development and empowering context specific community advancement of CJ&EJ (DSCEJ, 2022). The model has five action research activities to co-create or investigate: 1) Environmental hazards proximity analysis and/or community-based mapping; 2) Risk and harm assessment of toxic exposures, place and group based vulnerability, and disaster resilience; 3) Inventory of existing environmental knowledge and identify gaps to be addressed; 4) Rights and duties of communities and governmental agencies; and 5) Capacity requirements to advance evidence-based strategic advocacy.

Formal qualitative tools will be used alongside participatory techniques such as resilience storytelling to develop localized extreme event and community health timelines that match the back-cast modeling period of 2011-2021. As model community health outcomes are identified in the, CJ community partner scientists will follow a ground truth protocol to validate, refine or reject potential causal explanations. The Communiversity model will then inform the activities and potential use of nowcasting results by CJ networks and EJ communities and the scenario development co-creation.

2.2.5 Open Source Software and Hardware

HEELTHFUL-GC is committed to every aspect of Open Source Science and will only use open source software. The open source code/data for the CEJST is available from their GitHub site. HEELTHFUL-GC will also have a GitHub site and use the Zenodo folder 'Environmental Justice' for archiving and sharing research outputs. Modeling will primarily be conducted in R, Python and other open source languages will be used as necessary to manipulate data. All scripts will be posted. Jupyter notebooks will be piloted for CJ&EJ community engagement. Computing hardware requirements are minimized as most data processing will be conducted through requested NASA HEC resources. University Data Hub and available departmental IT support and equipment are sufficient for other modeling, scenario development and broadcast communication tasks. The DSCEJ's Bezos Earth Fund Data Center has sufficient resources to sustainably host research outputs and open source materials for the foreseeable future. A an open source tool capable UNIX/GNU workstation will be purchased for the postdoc.

2.3 Resilience and robustness of HEELTHFUL-GC in the face of uncertainty

Potential pitfalls for HEELTHFUL-GC related to uncertainty and error are largely counterbalanced by a very experienced team of researchers. Furthermore, special capabilities related to long-term relationships with CJ&EJ networks and complementary on-going CJ&EJ evidence base data initiatives ensure project resilience. For example, if the HEC request is not approved, the team has necessary skills for data processing with Google Earth Engine. The team has >120-years of combined data analysis and statistical modeling experience with a diverse set of analytical tools to handle most challenges. Methods illustrate procedural expertise with myriad tests to identify Type-1 error inflation, deal with multicollinearity, and ensure validity and accuracy of explained variability.

Covid and potentially other health-related restrictions to engage face-to-face with community may limit some ground truth and research broadcast activities. The PI has recently led a major international organization to pivot a global capacity development program to online. Lessons from this experience include leveraging collaborative online tools for better engagement, fully facilitating virtual sessions with dedicated technological backstopping, and adjusting the length/frequency/tempo of sessions to promote active interaction. Engaging coastal communities may require health safeguards and adjustment to virtual or 1-to-1 meetings rather than in-person group interviews.

Land surface temperature and vegetation data products derive from algorithms grounded in well-established theory. Sources of error and uncertainty should mainly be limited to a) information loss due to insufficient spatial and/or temporal resolution; b) instrument calibration and c) uncorrected atmospheric effects. IMERG rainfall product (Maggioni et al., 2022) expected sources of error and uncertainty consist of: 1) sensor characteristics; and 2) retrieval schemes, but is reduced by blending sensor types with different orbital characteristics. Resolution should not be a major source of error since the selected datasets are at much finer spatial resolutions than a census tract. Multiple observations reduce temporal uncertainty of extreme events identification

Special capabilities DSCEJ and Tulane University are currently leading an adapted-for-NASA Communiversity activity with four EJ networks: the National Black Environmental Justice Network, the 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. Their work mapping Southern Gulf Coast, primarily African American, underserved EJ communities and their priorities will facilitate mobilization of CJ&EJ community partner scientists for this project. The LA Board of Regents and NASA EPS-CoR have supported Tulane University to conduct convene Open Source Science and Environmental/Climate Justice networks, organizations, change makers, and CJ&EJ communities along the Gulf Coast for greater collaboration. The University has made generous availably of facilities and funds to support data driven initiatives including work on CJ&EJ including use of the excellent facilities and outstanding conference support of our Tulane Bywater Institute Coastal and River Center. Tulane University Presidential Initiatives on data literary and equity, inclusion and diversity have come together in a new Data Hub that will connect not only students but diverse stakeholders to open science approaches. DSCEJ will provide a sustainable home for building upon HEELTHFUL-GC's results with its well-funded Besos Earth Fund Data Center initiative that will be the premiere CJ&EJ knowledge hub in the South if not the entire United States.

HEELTHFUL-GC's robustness will be derived from investing the lion's share of the budget in creating an inclusive and diverse interdisciplinary team. Dedicated team members are budgeted to work in an essential roles 1)remote sensing/modeling data & 2)external facing CJ&EJ Communiveristy lead. Essential high level/higher cost interdisciplinary expertise is more modestly budgeted and focused on periods of greatest need to maintain a flexible, diverse, and robust technical backbone. Three IDSOs build upon

one another with major outcome level deliverables completed each project year (PY). PY1/IDSO1 retrospective modeling informs the development of PY2/IDSO2 nowcast models and scenarios. Engagement with CJ&EJ community scientists with ground truth from the start of the project ensures a coherent logic to causal description of model of both retrospective and prognostic model results, with PY3/IDSO3 primarily EJ&CJ community facing, built around an open science platform with open science output milestones to ensure alignment and coherence across project activities.

2.4 Plan for achieving objectives & interdisciplinary open science

2.4.1 Management structure

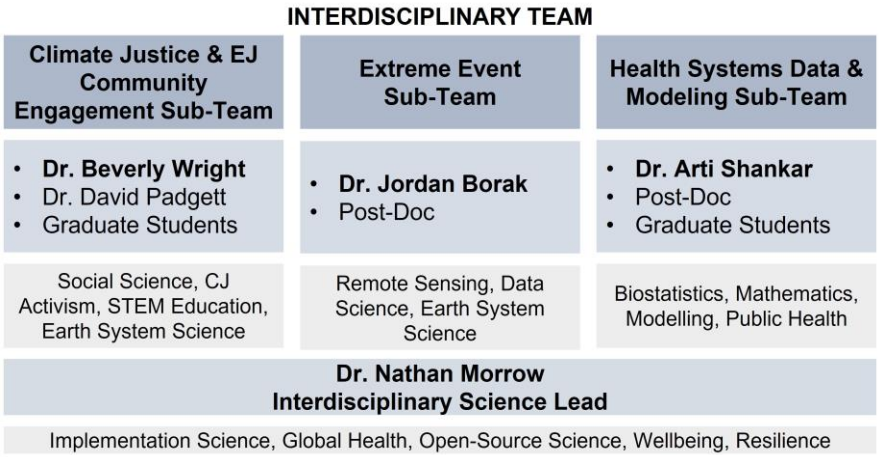

Figure 3: Sub-team Interdisciplinary Management Structure

The HEELTHFUL-GC management structure aims to encourage collaboration enabled by technology (Ramachandran, Bugbee & Murphy, 2021) with clear shared objectives, empowered leadership of sub-teams, and easy exchange through advanced digital tools for inclusive communication. Implementing an interdisciplinary project requires active and engaged project leadership with regular team communication and directed reflection. HEELTHFUL-GC brings together investigators that work at different time and spatial scales as well as with different disciplinary tools and methods. To balance interdisciplinary interaction with research efficiency, tasks and sub-tasks will be assigned to sub-teams led by a Co-Investigator with the PI participating in all of the three teams' work planning and task result monitoring. Furthermore, the PI is responsible for promoting necessary cross-team interaction, monitoring dependencies, open science, and further interdisciplinary co-creation tasks and results. Quarterly virtual all team meetings, annual workplanning, and PI/Co-I business meeting focused on reporting project progress during the AGU meeting provide necessary collaborative discourse. Dependencies, emerging challenges, co-created cross-learning and solutions from virtual/face-2-face team interaction will be used to monitor workplan and share with NASA.

2.4.2 Task by task description of contribution by identified personnel

Dr. Jordan Borak's research responsibilities will focus on acquiring data and generating satellite-based (i.e., extreme event) indicators supported by the postdoc. For IDSO/PY-1, Co-Investigator Borak will contribute to building by assembling appropriate satellite datasets that provide temperature and precipitation information pertinent to quantifying extreme events, and quantify evolution of green spaces for back-cast modeling. Using requested HEC processing capacity, he will aggregate the data to census-tract level by deriving appropriate spatial measures of central tendency and temporal metrics intended to facilitate identification of extremes. In IDSO/PY-2, he will provide his remote

sensing expertise to develop the web-based tool for now-casting and scenario planning from appropriate satellite data products. For IDSO/PY-3, he will conduct all additional data processing as necessary to support the scenario development and CJ&EJ communities' exchange. In addition to detailed documentation of all procedures and codes used and all datasets generated, overall summary of satellite data characteristics over the study area and a set of specific lessons learned will be posted following the DMP.

Dr. Arti Shankar's research will focus on application of multiple regression analysis, time series analysis, and multivariate analysis including temporal and spatial interpolation methods to merge diverse socio-environmental datasets. The first half of IDSO/PY-1, data validation and interpolation for modeling will be directed by Dr. Shankar and supported by the postdoc. Cumulative impact model Backcasting is planned the following 6-months. IDSO/PY2 starts with design and testing of ARIMA nowcasting models. Bayesian modeling for further nowcasting and scenario development will begin in the later part of IDSO/PY2. Adjustment of models and co-creation of new scenarios will be redoubled in the beginning of !DSO/PY3 with the last 6-months dedicated to transfer of models.

Dr. Beverly Wright as Co-Investigator supported by a DSCEJ associate is accountable for the fidelity of the proposed activities and deliverables to the principles of Communiversity for engagement with CJ&EJ communities. As Director of DSCEJ, 'end-user', she will advise on planning and tasking with the goal of applying all HEELTHFUL-GC to advance health outcomes for CJ&EJ communities. Dr. Wright/DSCEJ staff associate will lead sub-team tasks directly related to CJ&EJ community engagement. IDSO/PY-1, mobilizes community science partners in the Communiverity model, any necessary training, and grountruthing of backcasting results. IDSO/PY-2 nowcasting model and scenario co-creation improvement through CJ&EJ community input and interactive validation of causal dynamics and interim results. IDSO-PY3 utilization of results and deliverables for advancing health outcomes, influencing decisions, developing capacity and ultimately advancing CJ&EJ in the 10 primary communities and wider Gulf Coast region. Finally, standing-up an open source science HF site hosted on the DSCEJ data center.

Dr. Michelle Lacey will be a collaborator on nowcasting and scenario development tasks aligned to her statistical expertise: integration/analysis of multi-dimensional data streams(Luo, 2014) predictive models at the community level(Wells, 2014).

Dr. Nathan Morrow as PI is accountable for grant implementation, compliance, risk management and reporting, Supported by an experienced R1-level sponsored project team, Dr. Morrow is responsible for maintaining the control environment, quality and timeliness of all deliverables, implementation of the DMP and inclusion plan, responsive communication, and reporting to NASA and all stakeholders. Dr. Morrow will supervise graduate assistants and a postdoc with responsibilities for collaboration enabling technology including management of the GitHub sites, virtual team data management workspaces, and modeling environment. The postdoc will implement day-to-day health forecasting tasks under technical guidance from CO-Is, while graduate assistants will engage primarily in Communiversity research activities. Dr. Morrow's primary task is continuous whole team communication to align all tasks with fundamental research

questions and follow-up on schedule of implementation tasks. In this role, he is responsible for leading annual work planning, actively monitoring dependencies, engaging with all Co-I led sub-teams, on-going direct support tasks as required, and encouraging cross learning for adaptive solution development as challenges arise. Dr. Morrow will take the technical lead on all spatial analysis and mapping sub-tasks. Accountable for all milestones, he ensures inclusive and equitable contributions to collaborative deliverables including publications, open science and reports in following Milestone Schedule. Specifically for IDSO-PY1, he will convene 2-virtual and 2 in person team meetings, assure all (sub)are finalized in a timely fashion, lead authorship of a literature review, monitor subteam kickoff tasks, and facilitate data/information exchanges while monitoring for dependencies. He will ensure GitHub, Zenodo and NASA open source sites/repositories are stood up and inclusion/DMP indicators are monitored. He will contribute to data management and analytical tasks as required and lead documentation and article co-production. He will engage with community partner scientists in capacity development and model result ground truth engagements. IDSO-PY2 sees continuation of many activities with a new focus on the design and validation of the Cumulative effects model, also, ensuring coherence of information collection from community science partners for use in scenario development. Monitoring and any training on research standards or data collection including potentially necessary, but not expected, Institutional Review oversight of data collection will be assured. Dr. Morrow in IDSO-PY3 will lead shift of project focus to the end user and CJ&EJ community engagement events and promotion of new applications for project results and deliverables (eg. liaison with Data Hub STEM work).

Consultants: Dr. David Padgett is Senior Consultant to DSCEJ for 'ground truth' activity community engagement with in the Communiversity model. He will advise on participatory approaches to mapping CJ&EJ community/network causal pathways/priorities, co-lead up to 10 CJ&EJ community/network engagements/workshops, and advise on transfer of STEM related outputs to the Data Hub and the Data Center.

2.5.3 Milestone Schedule

Project Year 1: Back-cast			
Q	**Milestone deliverable**	**Open science output**	**Reporting**
Q1	• Data audit for NASA and community health timeseries data sets • Literature review focus on modeling & forecasting EE, CJ and Health • IDS science team or project team planning	• Open Access Annotated Bibliography • GitHub site	• Submit Work and Costing plan • Submit PY1 Q1 report
Q2	• CJ&EJ Community initial engagement • Selection and retrieval of parameters from NASA and *in situ* sources	• Register open science plan for reproducibility	• PY1 Q2 report with some discussion of data quality
Q3	• Run back-cast model for precipitation EE • CJ&EJ partner review of causal links	• Open science badges PI/CO-I	• PY1 Q3 Report w/initial model overview
Q4	• Run back-cast model for temperature EE • First ground truth CJ&EJ engagement	• GitHub updated • Annual inclusion/DMP tasks	• Draft peer review manuscript • PY1 Annual Report
Project Year 2: Now-cast			
Q	**Milestone deliverable**	**Open science output**	**Reporting**
Q1	• Annual IDS planning meeting • CJ network meeting ground truth back-cast	• CJ community Open Science badge contest	• Share PY2 workplan • Submit PY2 Q1 report

Q2	• Run now-cast model for precipitation EE • Train cohort of CJ community scientists to ground truth now-cast results	• Community GitHub event • Posting of CJ engagement materials	• PY2 Q2 report w/ nowcast model overview
Q3	• Run now-cast model for temperature EE • CJ network causal elements of CJ scenarios	• Open Science presentation at AGU	• PY2 Q3 Report w/ discussion of open science engagement
Q4	• Ground truth now-cast with CJ networks • Develop future cast and scenario model based on back-/now-cast model learning	• GitHub updated • Annual inclusion/DMP tasks	• Draft peer review manuscript • PY2 Annual Report
Project Year 3: Broadcast			
Q	**Milestone deliverable**	**Open science output**	**Reporting**
Q1	• Annual IDS planning meeting • Scenario results ground truth	• Plan for full open source science transfer	• Share PY3 workplan • Submit PY3 Q1 report
Q2	• Ground truth future cast scenarios • Co-create general audience guide to EE, CJ and health forecasting	• Data Hub and Data Center transfer	• PY3 Q2 report w/ focus on transfer plan
Q3	• Broadcast - CJ community-led event • Research products and tools for DSCEJ & Tulane data hubs	• GitHub update • All documents to Zenodo	• PY3 Q3 Report w/ focus on transfer status
Q4	• Finalize & broadcast general aguide to EE health forecasting on the GC	• Closing and reporting on all Inclusion and DMP Plan activities	• Final Tech/Financial Report • Draft peer review manuscript

Important note: The proposal team humbly acknowledges that local CJ&EJ communities have the absolute right to engage, or not engage, in this research and may have input to timelines and proposed activities. Any changes to the proposed project milestones will be communicated with in the first 30-days of project kick-off to be included in the initial project reconciliation.

Section 3.0: Bibliography, Data Management Plan, Schedule, and Inclusivity Plan

Section 3.1 HEELTHFUL-GC Proposal Bibliography

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3.2 Data management plan

Accountability for full implementation of the Data Management Plan (DMP) and ensuring full compliance to NASA DMP requirements lies with the Dr. Nathan Morrow as PI. He has extensive experience managing geographic and remotely sensed data for research and decision making. He has published peer reviewed articles on data for decision making (Mock, Morrow & Papendeick, 2012) has written and taught about data responsibility (Morrow, 2022), and recently was awarded a grant for increasing the use of Open Source Science for Environmental Justice.

HEELTHFUL-GC is committed to Open Source Science and identified personnel will complete NASA TOPS core curriculum to earn a minimum of 5 open science badges.

This is an innovative project that includes gathering data from community-based networks as well as health-related data and modeled results. To address potential privacy, ethical and consent issues, HEELTHFUL-GC will conduct a Privacy Impact Assessment (PIA), following the NASA PIA Summary as a template, during annual planning for Communiveristy engagement. As a general privacy safeguard, data will only be collected, analyzed or presented at spatially aggregated at community or census track level. No data will be collected about individuals. Results of the PIA will be reviewed and all identified potential risks will be mitigated or eliminated by substituting lower impact data collection approaches. When key informants or group interviews are conducted, a standard informed consent statement will be distributed with personal contact information of the PI for any follow up questions about how the data will be used. All interview guides will follow templates that follow guidance criteria for an IRB exemption. Any participatory contributions from networks or community members will be able to be retracted through the telephone, email and snail-mail address details that will be provided to all participants.

The HEELTHFUL-GC team will pursue the development plan along the lines of the “Geosciences Paper of the Future” with the intention move towards improving the DMP “to make data, software, and methods openly accessible, citable, and well documented” (Gil et al., 2016) and the FAIR principles: Findable, Accessible, Interoperable, & Reusable (Wilkinson et al., 2016). As part of the advancement of CJ&EJ data for decision making methods and with the specific expertise in the HEELTHFUL-GC science leadership in this research area, the team will leverage the DSCEJ Data Center and Tulane University’s Data Hub along side GitHub, data.nasa.gov, and Zenodo to ensure data and information are shared in ways that maximize access, reuse and application to new problems, contexts, and research questions. Data will be made publically available with enough detail to allow for validation and metadata standards will conform to open science standards of the repository such as coding in XML.

The HEELTHFUL-GC data management plan ensures public access to publications and digital datasets arising from NASA research. All HEELTHFUL-GC data posting and archiving tasks will be **confirmed quarterly**. Open Science milestones are identified on the schedule and assigned responsibility to the postdoc and accountability to the PI. The preprints will be posted on Earth and Space Science Open Archive, associated with

the American Geophysical Union, pre-print server https://www.essoar.org/. Open access articles will be available as soon at final revisions are accepted, but expected to be within one year from project closure.

Data sets, meta data and other materials developed to support the proposed research will be archived at data.nasa.gov, as appropriate, and Zenodo (https://zenodo.org/) site associated with European Organization for Nuclear Research (CERN) and expected to maintain the open archive as long as CERN exists. HEELTHFUL-GC has created an Environmental Justice 'community' on Zenodo to encourage findability of the research and exchange with other CJ&EJ researchers.

All data and documents produced by HEELTHFUL-GC encourage redistribution, reproduction and creation of derivatives with a Creative Commons Attribution 4.0 International license, and uploaded to Zenodo/DSCEJ Data Hub/Github including:

- 3 spatial data sets will be linked to the publicly available Climate and Economic Justice Screening Tool:1) back-cast, 2) now-cast, 3) scenarios. These will be made available as comma separated values and .shp.
- Scripts and source code for extracting data and aggregating into census tracks
- Model source code, guidance notes and results
- Guidance on the Communiversity approach and aggregated ground truth results. These will be given a unique doi when uploaded.
- STEM modules for e-learning and in person workshops

Development of the project in year one will take place primarily on a dedicated GitHub site. During initial extraction of remote sensing measurements for aggregation at census track level, data sets will temporarily be stored in the NASA HEC environment. Once parameters for modeling are recorded at census track level, open source archive capacities will be sufficient for archiving. As data sets are finalized and model source code documented in a distributable version, these information assets will be open source licensed and uploaded to data.nasa.gov and Zenodo. In the third year of broad stakeholder and community engagement, dedicated open source portals focusing on STEM and CJ&EJ community engagement will be developed at the DSCEJ Data Center and the Tulane Data hub with links to the permanent archives.

The PI will maintain communication as necessary with the data repository and the NASA program manager to ensure that: DMP is updated as needed at time of award; appropriate attribution is included; data meet minimum quality standards; and data are appropriately evaluated for and secured to prevent disclosure of personally identifiable information and to protect proprietary interests, confidentiality, and intellectual property rights.

3.3 Inclusivity Plan

Tulane University School of Public health and Tropical Medicine (Tulane), the Deep South Center for Environmental Justice (DSCEJ), and UMD have core commitments to Equity, Diversity and Inclusion (EDI) that will support the specific HEELTHFUL-GC EDI goals, action plans and measurement approach.

Tulane's Dean LaVeist has set a goal to be the most diverse public health school in the country. EDI is the focus of a flagship presidential initiative for Tulane called 'Strategy for Tomorrow' that monitors progress towards concrete commitments to EDI. Our project team can rely on an array of support from our EDI office such as providing training on positive and inclusive workplaces. DSCEJ is a fully independent nonprofit center for collaboration to confront the unique challenges of environmental justice and climate change facing communities of color and poor communities in the South. With roots in New Orleans' historically Black Dillard and Xavier Universities, DSCEJ continues to maintain and grow collaborative relationships with HBCUs in Louisiana and around the country. A major goal of DSCEJ is the development of leaders in communities of color along the Mississippi River Chemical Corridor and the broader Gulf Coast Region that are disproportionately harmed by pollution and vulnerable to climate change.

The first EDI-related goal for HEELTHFUL-GC is to maintain a positive and inclusive work environment. One effective entry point for inclusivity is intentionality in hiring, and the project team is relatively small and very diverse. EEJ networks represent a diversity, although primarily African American, of underserved communities all along the Gulf Coast. EJ networks will be encouraged to select focal points and participants in the Landscape Analysis workshop from underrepresented groups in science including women, those from diverse racial or ethnic background, sexual orientations, and with different or reduced abilities.

HEELTHFUL-GC actions to create and maintain an inclusive and positive workplace will aspire to consistent modeling of respect, dignity, and civility by each member of the team. The first concrete action is to ensure fairness in access to resources and relative work burden. The HEELTHFUL-GC budget was created with this in design, and we will monitor work effort and resource availability throughout the project to see if there are needed adjustments. The PI, Co-I and lead consultant will complete institutionally available courses or access Tulane's courses (https://hr.tulane.edu/institutional-equity/education-training-programs) on: Creating a positive Workplace; Macroaggressions in the workplace; Unconscious bias; and Workplace diversity, inclusion and sensitivity. HEELTHFUL-GC PI, Co-PIs and lead consultant will also reiterate the commitment for everyone's voice to be heard, contributions are valued, and are safe to engage at meetings with EJ networks, the larger team or other stakeholders, A standing agenda item will be included on monthly HEELTHFUL-GC team meetings to reflect on inclusivity and equity during project implementation. HEELTHFUL-GC's second goal focuses on contributing to a more inclusive and diverse scientific workforce. Capacity development and learning integrated at all levels of the project is the primary pathway for addressing structural barriers to equity and inclusion. In each project engagement, an environment supporting a learning perspective and focusing on learning from each other will be

maintained. Academics will learn from community leaders and organizations, all activities and project deliverables will enhance the capacity of EJ Network organizations and the participating individuals to ensure “Community voices must be heard” and that greater capacity to use evidence in support of the proposed solutions is developed. The actions and measures for this goal look to the positive project outcomes primarily for EJ network participants and younger members of the Tulane and DSCEJ support teams. The Communiveristy method, at the core of the design for AGEJL-4-Equity’s Technical Approach, was specifically **developed to address inequity**. Dr. Wright and other early environmental justice researchers realized that achieving environmental sustainability and equity required the coming together of, the traditionally unequal, communities and academic partners in a **mutually respectful and beneficial relationship** that encourages significant strides toward achieving solutions. This means **ensuring community members have an equal voice** with university researchers in developing, resourcing, and implementing projects, and are able to benefit from the partnership. This model **emphasizes collaborative management of the partnership between a community and a university and encourages capacity development at every opportunity**. EJ community-led participatory processes outlined in the Technical Approach, go beyond collaborative management to EJ community empowerment as they lead the adaption of the process and prioritization of research engagement approaches and objectives in the specific EJ context. In this way, communities are more capable of describing environmental issues and advocating for solutions in a scientifically valid way. This approach to engagement has for decades contributed to developing EEJ leaders and a more inclusive science workforce

Engagement with the networks and capacity development for network focal points to implement the Communiversity model will rest on open exchange **between equally valued partners in a safe environment that ensures respect, dignity, and civility**. Capacity development for the EJ networks will include lessons on inclusivity, micro aggression, unconscious bias and sensitivity to equity when facilitating participatory processes. Differences in ability such as color blindness will be discussed as part of preparation for participatory mapping. For our stated objectives to be SMART, the following measures will be included in reporting. **Actions for a positive and inclusive work environment will include:** 3 or more key personnel complete 3 or more relevant e-learning courses and this will include graduate student within the first 6-months of the project;100% of project & stakeholder meetings begin with a EDI commitment statement; Annual planning meetings include reflection on EDI commitments. **Contributions to a diverse and inclusive science workforce:** 12-20 EJ community members and Communiversity participants engage in capacity development for DIE sensitive facilitation; 12-20 EJ community members and Communiversity participants develop capacity for equity focused participatory CJ&EJ analysis; STEM with equity focused content e-learning piloted with more than 50 students and community members.

Section 4.0 Biographical Sketches

PI: Nathan Morrow

1. Professional Preparation

Boston University, Geography, Bachelor of Arts with Honors 1997
Boston University, Geography, Master of Arts 1998
University of Maryland, Geography, Doctor of Philosophy (M. Hansen advisor) 2021

2. Professional Experience and Positions

Current Sponsored Research:

- PI, Assessment of the Gulf Coast Environmental Justice Landscape for Equity (AGEJL-4-Equity), NASA-funded, 10/22-4/23
- PI, Open Science Outlook for Environmental Justice and Resilience of the Louisiana Gulf Coast (OSO-LoGiC), NASA-EPSCoR-funded, 5/22-4/23
- Co-PI, Sahel Collaboration & Communication, USAID-funded, 10/20-9/25

Appointments:

- Associate Research Professor, Tulane Public Health & Tropical Medicine, 2022-.
- Associate Research Professor, Tulane Law, 2014-2018, Adjunct 2007-2012
- Associate Clinical Professor, Tulane School of Social Work, 2012-2014
- Associate Clinical Professor, Tulane Public Health & Tropical Medicine, 2011-2014, Adjunct 2007-2022

3. Selected Bibliography

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

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**

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

Muchoney, D., Borak, J., Chi, H., Friedl, M., Gopal, S., Hodges, J., **Morrow, N.**, & Strahler, A. (2000). Application of the MODIS global supervised classification model to vegetation and land cover mapping of Central America. *International Journal of Remote Sensing*, *21*(6–7), 1115–1138. https://doi.org/10.1080/014311600210100

Morrow, N., & Prince, S. (1999). Use of potential and actual primary production models to map drought and degradation in semi-arid Southern Africa. *EOS Transactions, 80*(46), F403.

Morrow, N., & Friedl, M. (1998). Modeling biophysical controls on land surface temperature and reflectance in grasslands. *Agricultural and Forest Meteorology*, *92*(3), 147–161. https://doi.org/10.1016/S0168-1923(98)00098-7

4. Research Experience: Scientific, Technical, Management

Dr. Morrow has acquired a wide range of skills and expertise with 25 years of experience not only as a professor but also leading implementation, developing capacity and ensuring research-based evidence for interdisciplinary/multi-sectoral food security, humanitarian response, and child wellbeing policy implementation projects. He has served as Chief of Party for a multi-organizational consortium for multi-country developmental relief and humanitarian aid response valued at over 400 million USD responding to an El Niño drought food security crisis in southern Africa -- a precursor to now ubiquitous resilience policy-focused programming. As co-chair of the Emergency and Disaster Evaluation thematic group at the American Evaluation Association, Dr. Morrow has promoted inclusive engagement and more rigorous measurement models in resilience research and intervention planning. The Global Environment Facility (GEF-7) replenishment strategy was informed, in part, by a geospatial analysis of environmental security led by Dr. Morrow.

Dr. Morrow is PI for two projects that intend to strengthen capacity for open source science to address challenges in CJ & EJ research in collaboration with Gulf Coast EJ community networks and organizations. Strategic assessment and strategy processes to strengthen evidence-based decision support have been a feature of Dr. Morrow's research and consulting with a variety of organizations including work on USAID's resilience measurement operational research in the Horn of Africa, needs assessment capacity for the United Nation's World Food Programme, and the global redesign of World Vision International's system for reporting to the International Board and other stakeholders on impact for improved child wellbeing. Dr. Morrow was invited to conduct the first-ever technical review of an SDG target indicator; 2.1.2 -- Prevalence of severe or moderate food insecurity. He recently completed a global capacity development effort for evidence based policy and policy implementation for the UN Food and Agriculture Organization for >50 countries.

Dr. Morrow continues to actively use remote sensing and geospatial analysis in his applied research following on early contributions to the MODIS, NPOESS, and Land-Use and Land-Cover Change science mission. These technologies featured in Developmental Evaluations of the World Food Program's mVAM program for improved needs assessment and hazard monitoring. They also feature in his teaching that includes problem sets related to assessing flood damage or humanitarian logistics planning.

Co-I: Institutional PI: Dr. Beverly Wright

1. Professional Preparation

Grambling State University, Sociology, Bachelor of Arts 1969
State University of New York at Buffalo, Sociology, Master of Arts 1971
State University of New York at Buffalo, Sociology, Doctor of Philosophy 1977

2. Professional Experience and Positions

Executive Director, Deep South Center for Environmental Justice, 2005-present
Professor of Sociology, Dillard University, 2005-2017,
Professor of Sociology, Xavier University of Louisiana, 1992-2005
Associate Professor, Wake Forest University, 1989-1993

3. Selected Bibliography

Wright, B.H., (2015) Environmental Injustice and the State of Black New Orle-ans," pp. 100 - 113 in McConduit-Diggs, Erika, State of Black New Orleans: 10 Years Post-Katrina. New Orleans: The Urban League of Greater New Or-leans.

Wright, B.H.,, and Nance, E., (2012). "Toward Equity: Prioritizing Vulnerable Communities in Climate Change," Duke Forum for Law and Social Change, 4 (1), 1-21.

Wright, B.H., (2011). "Race, Place, and the Environment in the Aftermath of Katrina," Anthropology of Work Review, American Anthropological Associa-tion, 32 (1), 4-8.

Bullard, Robert D. & **Wright**, **B.H.,** "Disastrous Response to Natural and Man-Made Disasters: An Environmental Justice Analysis Twenty-Five Years after Warren County," UCLA Journal of Law and Environmental Policy 26: 2008.

Wright, B.H., (1998). "Endangered Communities: The Struggle for Environmental Justice in Louisiana's Chemical Corridor," Journal of Public Management and Social Policy, 4(2), 181-191.

Wright, B.H., Bullard, R.D., & Johnson, G.S., (1997). "Confronting Environmental Injustice," [Special Issue]. Journal of Race, Gender, and Class, 5, 65-79.

Bullard, R. D. & **Wright, B.H**., (1993). "Environmental Justice for All: Community Perspectives on Health and Research Needs," Toxicology and Industrial Health, 9(5), 821-841.

Wright, B.H., & Bullard, R.D., (1990). "Hazards in the Workplace and Black Health: A Review," Journal of Sociology, 4(1), 45-74.

4. Research Experience: Scientific, Technical, Management

In 1992, Dr. Wright founded the Deep South Center for Environmental Justice at Xavier University in New Orleans (later moved to Dillard University in 2005) modeled on

Communiversity Model approach. As the founding director of the first university based environmental justice organizations, Dr. Wright has been at the forefront of the movement to empower and build resiliency in low-income and people of color who are threatened by natural and manmade disaster, hazards, and emergencies. Dr. Wright worked collaboratively with some of the nation's leading environmental justice and health equity scholars on communities disproportionately impacted by industrial pollution, environmental hazards, and natural and manmade disasters in the Louisiana Chemical Corridor, also known as "Cancer Alley." Dr. Wright have served as PI or coinvestigator on dozens of research projects that address emergency management, response, and resiliency of workers and residents impacted by nearby or "fence line" refineries and petrochemical plants, Superfund sites, hurricanes, floods, and industrial accidents and spills – managing grants of over 23,000,000 USD. DSCEJ addresses environmental and health inequities along the Mississippi River Chemical Corridor and is a community/university partnership providing education, training, and job placement. Since Hurricane Katrina, much of her work at the Center has focused on research, policy and community outreach as well as assistance and education of displaced African-American residents of New Orleans. After EPA identified more than 200 sites around the city with elevated lead and arsenic levels, I forged a unique partnership with the U.S. Steelworkers to launch "A Safe Way Back Home Project," a proactive pilot neighborhood cleanup project. Using our NIEHS-funded Minority Worker Training Program model, the neighborhood-centered pilot cleanup project trained more than 60 small businesses and contractors in hazardous waste removal, mold remediation and health and safety methods, and trained hundreds of volunteers from around the country to assist community residents in the cleanup and return safely to their devastated New Orleans homes and neighborhoods. Over these last thirty years working in the field of environmental justice, health disparities and community sustainability. Her research experience has shown that federal, state and local policies can have a long lasting and sometimes devastating impact on communities. Dr. Wright recognizes the importance of educating communities on the science related to issues of health and that engaging them with policymakers empowers communities to advocate on their own behalf to push government to make policy changes that better protect the public health. Dr. Wright is currently a member of the White House Environmental Justice Advisory Council (WHEJAC) and she serves on the Justice 40 committee.

Co-I: Institutional PI: Dr. Jordan Borak

1. Professional Preparation

Graduate Certificate, Data Science: University of Maryland, College Park, 2019.
Ph.D. in Geography: Boston University, 2000.
Master of Arts in Geography: Boston University, 1996.
Bachelor of Science in Geography (Math minor): University of Illinois, Urbana-Champaign, 1992.

2. Professional Experience and Positions

Current Sponsored Research:

- PI, Enhanced Roughness Length Estimates from ICESat-2 Vegetation Products
- Co-I,National Climate Assessment Land Data Assimilation System
- Co-I, Shallow Water Bathymetry Products and Analysis for Near-shore

Appointments:

- Associate Research Scientist, Earth System Science Interdisciplinary Center, University of Maryland and Hydrological Sciences Laboratory, NASA/Goddard Space Flight Center (June 2011 – present).
- Senior Support Scientist, Science Systems and Applications, Inc., then Wyle Information Systems, LLC, and Hydrological Sciences Branch, NASA/GSFC (July 2002 – June 2011).
- Support Scientist, Science Systems and Applications, Inc., MODIS Land Data Operational Product Evaluation Facility, NASA/GSFC (November 2000 – June 2002).
- Research Associate, Department of Geography and Laboratory for Global Remote Sensing Studies, University of Maryland (July 1999 – November 2000).
- Research Fellow, Department of Geography and Center for Remote Sensing, Boston University (September 1993 – June 1999).

3. Selected Bibliography

Borak, J.S., M.F. Jasinski, and N. Tangdamrongsub, 2021: Fusing ICESat-2 and MODIS Vegetation Data Products to Enhance Momentum Aerodynamic Roughness Fields with Spatially-Explicit Scaling for Improved Land Surface Modeling [Poster presentation G15B-0350]. AGU 2021 Fall Meeting, 13-17 Dec.

Tangdamrongsub, N., C. Hwang, **J.S. Borak**, S. Prabnakorn, and J. Han, 2021: Optimizing GRACE/GRACE-FO data and *a priori* hydrological knowledge for improved global Terrestrial Water Storage component estimates. *J. Hydrol.*, **598**, 126463.

Borak, J.S., M.F. Jasinski, and N. Tangdamrongsub, 2020: Enhanced vegetation aerodynamic roughness for momentum with ICESat-2 data products: early results [Poster presentation H194-0005]. AGU 2020 Fall Meeting, 1-17 Dec.

Jasinski, M.F., **J.S. Borak**, S.V. Kumar, D.M. Mocko, C.D. Peters-Lidard, M. Rodell, H. Rui, H.K. Beaudoing, B.E. Vollmer, K.R. Aresenault, B. Li, J.D. Bolten, and N. Tangdamrongsub, 2019: NCA-LDAS: Overview and Analysis of Hydrologic Trends for the National Climate Assessment. *J. Hydrometeorol.*, **20**, 1595-1617.

Kumar, S.V., M. Jasinski, D. Mocko, M. Rodell, **J. Borak**, B. Li, H. Kato Beaudoing, and C. D. Peters-Lidard, 2019a: NCA-LDAS land analysis: Development and performance of a multisensor, multivariate land data assimilation system for the National Climate Assessment. *J. Hydrometeorol.*, **20**, 1571-1593.

Kumar, S.V., D.M. Mocko, S. Wang, C.D. Peters-Lidard, and **J. Borak**, 2019b: Assimilation of remotely sensed Leaf Area Index into the Noah-MP land surface model: Impacts on water and carbon fluxes and states over the Continental U.S. *J. Hydrometeorol.*, **20**, 1359-1377.

de Gonçalves, L.G.G., **J.S. Borak**, M.H. Costa, S.R. … 2013: Overview of the Large-Scale Biosphere-Atmosphere Experiment in Amazonia Data Model Intercomparison Project (LBA-DMIP). *Agr.Forest Meteorol.,***182-183**,111-127.

Borak, J.S., and M.F. Jasinski, 2009: Effective interpolation of incomplete satellite-derived leaf-area index time series for the continental United States. *Agr. Forest Meteorol.,* **149**, 320-332.

Borak, J.S., M.F. Jasinski, and R.D. Crago, 2005: Time series vegetation aerodynamic roughness fields estimated from MODIS observations. *Agr. Forest Meteorol.,* **135**, 252-268.

4. Research Experience: Scientific, Technical, Management

Dr. Borak's research interests include Earth science data processing and analysis: particular focus on long-term time series data at regional and continental scales; inter-annual and seasonal variability of vegetation and water cycle components; land-cover characterization from satellite observations; quality assessment of remotely sensed data. He has 25+ years experience with C programming and shell scripting in Unix-type environments; 4+ years with Python and Java. He also is an expert in machine learning software: scikit-learn and Keras; statistics and visualization packages: R, Tableau, and SAS.

Co-I: Arti Shankar

1. Professional Preparation

Gorakhpur University, Psychology, Bachelor of Arts with Honors 1985
Gorakhpur University, Psychology, Master of Arts 1987
Indian Institute of Technology, Organizational Behavior, Doctor of Philosophy

2. Professional Experience and Positions

Sponsored Research:

- Climate, Culture, Movement: Navigation Decision-Making in a Shifting Landscape for a Resilient United Houma Nation, USAID, 585K

Appointments:

- Clinical Professor, Tulane Public Health & Tropical Medicine, 2017 – present
- Clinical Associate Professor. Tulane Public Health & Tropical Medicine, 2009/17
- Clinical Assistant Professor, Tulane Public Health & Tropical Medicine, 2001/09
- Adjunct Professor, Tulane Public Health & Tropical Medicine, 2000 – 2001,Hampton University, 1994-1996, College of William and Mary,1993

3. Selected Bibliography

Zilversmit Pao L, Harville EW, Wickliffe JK, Shankar A, Buekens P. The Cumulative Risk of Chemical and Nonchemical Exposures on Birth Outcomes in Healthy Women: The Fetal Growth Study. Int J Environ Res Public Health. 2019 Oct 1;16(19)

Gokoel AR, Shankar A, Abdoel Wahid F, Hindori-Mohangoo AD, Covert HH, Wickliffe JK, Harville EW, Zijlmans WCWR, Lichtveld MY. The Cumulative Risk of Prenatal Exposures to Chemical and Non-Chemical Stressors on Birth Outcomes in Suriname. Int J Environ Res Public Health. 2021 Jul 20;18(14):7683. doi: 10.3390/ijerph18147683. PMID: 34300134; PMCID: PMC8305475.

4. Research Experience: Scientific, Technical, Management

Dr. Shankar's research focuses on the application of experimental design, multiple regression analysis, time series analysis, and categorical data analysis, multivariate and longitudinal data analysis in the areas of epidemiological, occupational, and environmental health. Successfully using univariate, multivariate as well as spatial methods to describe, quantify, and explain the role of demographic, environmental and geographical variations in health using latent growth models and structural equation models. Working actively in community health research, we developed new scales using exploratory and confirmatory factor analysis and measuring the psychometric properties of the scales and a new statistical method using hierarchical linkage cluster analysis to provide validation of a Bayley scale. Developing path models to resilience following manmade and natural disasters and lead biostatistician of the Caribbean Consortium for Research in Environmental and Occupational Health, Dr. Shankar promotes GIS technology to develop spatial methods to link ambient air quality, environmental factor and health data.

Senior Consultant: David Padgett

1. Professional Preparation

Western Kentucky University, Geography/Geology, Bachelor of Science 1987
University of Florida, Geography/Environmental Engineering, Master of Science 1992
University of Florida, Geography/Geology, Doctor of Philosophy 2001

2. Professional Experience and Positions (Appointments)

Associate Professor of Geography, Tennessee State University, 2005-present
Visiting Assistant Professor, Vanderbilt University 2012-2013,
Assistant Professor of Geography, Tennessee State University 1999-2005
Visiting Assistant Professor of Environmental Studies, Oberlin College 1996-1999

3. Selected Bibliography

Padgett, D.A., Solis, P., Adams, J.K., Duram, L.A., Hume, S., Kuslikis, A., Lawson, V., Miyares, I.M., and Ramirez, A. "Diverse Experiences in Diversity at the Geography Department Scale," The Professional Geographer online edition, January (2013).

Padgett, D.A., Marsh, E., Harper, J., and Robinson, C. "Green Careers Curriculum Manual: Improving Access to Green Careers through Environmental Science and Engineering at Historically Black Colleges and Universities," U.S. Environmental Protection Agency (EPA 904-B-12-001), January (2012).

"Teaching Race, Class, and Cultural Issues in Earth Science to Enhance Multicultural Education Initiatives," Journal of Geoscience Education, vol. 49, no. 4, (2001), pp. 364-369.

4. Research Experience: Scientific, Technical, Management

Dr. David Padgett is a geoscientist by training with more than 30-years of experiences of in community engaged action research. He has worked in academia and as a consultant on projects including Community Air Quality Sensor Training and Community Air Quality Mapping, Community Asset Mapping, and WeGlobal Research Project on African Americans Living Abroad. Through his research and experience he has the appropriate expertise to co-develop participatory mapping tools. He has also mentored generations of graduate students at Tennessee State University throughout their academic journey. Given his expertise and skillset he is a highly-valued member of the team for ensuring quality deliverables from this project.

Section 5.0: Current and Pending Support

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.	
Investigator: **Dr. Nathan Morrow**	Other agencies (including NASA) to which this proposal has been/will be submitted.
Support: ☒ Current ☐ Pending Project/Proposal Title: Assessment of the Gulf Coast Environmental Justice Landscape for Equity (AGEJL-4-Equity), (lauren.m.childs@nasa.gov) Role: PI Source of Support: NASA A.49 Earth Science Applications: Equity and Environmental Total Award Period Covered: 10/22-03/23, Award amount: $99.6K Person-Months Per Year Committed to the Project: 2.0	
Support: ☒ Current ☐ Pending Project/Proposal Title: Open Science Outlook for Environmental Justice and Resilience (Gregory Guzik, tgguzik@lsu.edu) Role: PI Source of Support: NASA EPSCoR Louisianna BoR RID Project Total Award Period Covered: 3/22-03/23, Award amount: $66K Person-Months Per Year Committed to the Project: 2.0	
Support: ☒ Current ☐ Pending Project/Proposal Title: Sahel Collaboration and Communication Role: Co-PI Source of Support: USAID, (nmock@tulane.edu) Total Award Period Covered: FY20-FY25, Award amount: $1,499,000 Person-Months Per Year Committed to the Project: 4.0	
Support: ☐ Current ☒ Pending Project/Proposal Title: EJ Core GC; Engaging diverse researchers and EJ communi- Role: PI Source of Support: NASA Science Mission Directorate –F.14- Transform to Open Sci- Total Award Period Covered: 07/23-06/25 Person-Months Per Year Committed to the Project: 3.0	

Investigator:	Other agencies (including NASA) to which this proposal has been/will be submitted.
Dr. Jordan S. Borak	
Support: ☒ Current ☐ Pending Project/Proposal Title: Enhanced Roughness Length Estimates from ICESat-2 Vegetation Products (T. Markus; Thorsten.Markus@nasa.gov) Role: PI Source of Support: NASA Cryospheric Program/Studies with ICESat-2 Total Award Period Covered: 05/20-04/23, Award amount: $292K Person-Months Per Year Committed to the Project: 3.0	

Support: ☒ Current ☐ Pending
Project/Proposal Title: National Climate Assessment Land Data Assimilation System, (J. Kaye; Jack.Kaye@nasa.gov)
Role: Co-I
Source of Support: NASA National Climate Assessment Program
Total Award Period Covered: FY16-FY23, Award Amount: $380K/yr
Person-Months Per Year Committed to the Project: 3.6

Support: ☒ Current ☐ Pending
Project/Proposal Title: Shallow Water Bathymetry Products and Analysis for Near-
Role: Co-I
Source of Support: NASA The Science of Terra, Aqua, and Suomi-NPP
Total Award Period Covered: FY22-FY24
Person-Months Per Year Committed to the Project: 3.0

Support: ☐ Current ☒ Pending
Project/Proposal Title: Improving Our Understanding of Gulf Coast Wetland Dynamics (M. Falkowski; Michael.Falkowski@nasa.gov)
Role: PI
Source of Support: NASA Cryospheric Program/Studies with ICESat-2
Total Award Period Covered: 05/23-04/26, Award amount: $571K
Person-Months Per Year Committed to the Project: 3.0

Support: ☐ Current ☒ Pending
Project/Proposal Title: Improving Our Understanding of Gulf Coast Wetland Dynamics
Role: PI
Source of Support: NASA Cryospheric Program/Studies with ICESat-2 (T. Markus; Award amount: $584K
Total Award Period Covered: 05/23-04/26
Person-Months Per Year Committed to the Project: 3.0

Investigator:	Other agencies (including NASA) to which this proposal has been/will be submitted.
Dr. Arti Shankar	

Support: ☒ Current ☐ Pending
Project/Proposal Title**:** Climate, Culture, Movement: Navigation Decision-Making in a Shifting Landscape for a Resilient United Houma Nation (Maureen Lichtveld, +1 412-624-6818 mlichtve@pitt.edu)
Source of Support:
Total Award Period Covered: 05/20-04/23, Award amount: $585K
Person-Months Per Year Committed to the Project: 3.0

Section 6.0: Statements of Commitment and Letters of Support

DEEPSOUTH CENTER FOR ENVIRONMENTAL JUSTICE

9801 Lake Forest, Blvd
New Orleans, LA 70127
(504) 272-0956
www.dscej.org

November 12, 2022

Dr. Nathan Morrow
Tulane University School of Public Health and Tropical Medicine
1440 Canal St, Suite 2200
New Orleans, Louisiana, 70112

Dear Dr. Morrow,

It is with pleasure that I provide this letter of support for your proposal entitled “High-resolution Extreme Event and Localized Temperature for Health Forecasting in Underserved Lowlands in the Gulf Coast ((HEELTHFUL-GC)” As the executive director of the Deep South Center for Environmental Justice, I have experience engaging communities on issues related to environmental justice and policy. After review of your proposal, I believe this is an opportune time to leverage NASA open Earth science to address the adverse impacts of climate change on vulnerable communities.

Specifically, because of the vast array of environmental health inequities that are affecting the gulf coast. The mission of the Deep South Center for Environmental Justice is to improve the lives of children and families harmed by pollution and vulnerable to climate change in the Gulf Coast Region through research, education, community, and student engagement for policy change. I firmly believe that this landscape analysis will be a starting point to jumpstart the use and integration of community engaged methodologies and environmental health data to improve the quality of life of our constituents.

I acknowledge that I am identified by name as Collaborator to the investigation, entitled ""“High-resolution Extreme Event and Localized Temperature for Health Forecasting in Underserved Lowlands in the Gulf Coast ((HEELTHFUL-GC)", that is submitted by Dr. Nathan Morrow to the NASA funding announcement**,** NNH22ZDA001N-IDS Interdisciplinary Research in Earth Science**,** and that I intend to carry out all responsibilities identified for me in this proposal. I understand that the extent and justification of my participation, as stated in this proposal, will be considered during peer review in determining in part the merits of this proposal. I have read the entire proposal, including the management plan and budget, and I agree that the proposal correctly describes my commitment to the proposed investigation.” To conduct work for this investigation, my participating organization is the Deep South Center for Environmental Justice.

I am thrilled at the prospect of this work and am happy to endorse and give this my full support. If there is any additional information you need from me, please do not hesitate to ask and I’d be happy to assist as best as I can.

Sincerely,

Beverly Wright

Beverly Wright, Ph.D.
Executive Director

TENNESSEE STATE UNIVERSITY
College of Liberal Arts
3500 John A. Merritt Blvd.
Nashville, Tennessee 37209-1561
Department of History, Political Science, Geography & Africana Studies
(615) 963-5497 (FAX)
(615) 963-5471

To: Whom it may concern

From: Dr. David A. Padgett, Associate Professor

Re: Letter of Commitment

I acknowledge that I am identified as a Consultant on the project entitled Assessment of the "High-resolution Extreme Event and Localized Temperature for Health Forecasting in Underserved Lowlands of the Gulf Coast (HEELTHFUL-GC)" submitted by Dr. Nathan Morrow. It is my intent to collaborate and/or commit resources and tasks for three years as detailed in the proposal.

I further acknowledge that the activities described in the proposal contribute to the goals of our project.

I am budgeted $11,000.00 USD for my time spent on the project, or 160 hours at 68.75 USD per hour (approximately $550.00 USD per day).

I have read the entire proposal and I agree that the proposal correctly describes my commitment and project goals to the proposed investigation.

Sincerely,

David Padgett 11/9/2022

David A. Padgett
dpadgett@tnstate.edu
615.258.3657

Section 7a. Budget Narrative:

Key Personnel:

Tulane personnel will be leading the project from start to finish over the proposed period of 36 months.

Nathan Morrow, The Principal Investigator will contribute a level of effort (LOE) 45%, is accountable for achievement of science objectives and quality of research. This will be achieved through exemplary project management. As PI, Nathan is accountable for maintenance of resource control environment, meeting all award milestones and reporting requirements, grant administration, and regular communication with stakeholders and deliverables. He is NASA's primary contact point. He will ensure clear communication between all project partners and stakeholders by convening meetings and direct communication. He will provide overall supervision as well as strategic and technical direction of activities. He will dedicate a minimum of 16.2 month equivalent of time over life of project and will be paid 45% of his effort for the life of the project. With HEELTHFUL-GC as his largest and primary research activity, he will be available and expected to work on this project any working day of the year, with additional time dedicated for achieving the identified deliverables. He is responsible for implementing the overall data management plan and monitoring the inclusion plan.

Additional Personnel:

Arti Shankar, The Co-Investigator will contribute a level of effort (LOE) 15%, is responsible for leading the integrated retrospective and prognostic modeling design and quality control of the results. There are three distinct modeling activities that will be backcasting with a Cumulative-effects model in PY1, followed by ARIMA nowcasting and Bayesian scenario development in PY2 and into PY3. She will be directly supported by the Postdoctoral Associate and Dr. Morrow with additional support of graduate students and the Tulane administrative team as needed. She will share regular updates in team meetings and contribute to reporting and peer reviewed manuscripts. In PY 3, she will assist in transferring all coding scripts and relevant documentation to open source archives. She will dedicate a minimum of 5.4 month equivalent of time over life of project and will be paid 15% of her effort for the life of the project.

Post doctoral associate, to be identified, level of effort 100% responsibilities will include day-to-day project tasks that will provide coherence and continuity across the research activities. A primary responsibility is for ensuring collaboration enabling technology including management of the GitHub sites, virtual team data management workspaces, and modeling environment. The postdoc will implement day-to-day health forecasting tasks under technical guidance from CO-Is, and support Communiversity research activities and applying model results. The postdoc will support Dr. Shankar with data validation and interpolation for cumulative impact model Backcasting, design and testing of ARIMA nowcasting models, Bayesian modeling for further nowcasting

and scenario development. The postdoc will also support integration of Dr. Borak's work acquiring data and generating satellite-based (i.e., extreme event) indicators, assembling appropriate satellite datasets that provide temperature and precipitation information pertinent to quantifying extreme events, and quantify evolution of green spaces for back-cast modeling, develop the web-based tool for now-casting and scenario planning from appropriate satellite data products. The post doc will assist Dr. Morrow in the full implementation of the DMP and Inclusion plan with full transfer of all materials to open-source archives and the end user. All the HEELTHFUL-GC team are communicating with their professional and academic networks to ensure application by a diverse and highly capable set of candidates. The postdoc salary rate was determined by the field competition and an average rate was derived. The postdoc will dedicate a minimum of 34 months equivalent of time over life of project and will be paid 100% of her/his effort for the beginning in the 3rd month of the project and continuing for the remaining life of the project.

Tyneisha Bradley & Pornpimol Kaudsup, Graduate Students, level of effort 20-30%. will manage support documentation for open source sites, literature review and contribute to all three research streams: NASA data, integrated socio-economic and health modeling, and engagement with CJ community science partners. They will liaise with Drs. Morrow, Wright and Padgett to provide additional capacity support to CJ community science partners as needed in completing their ground truthing and results application activities. They will assist in managing meetings, ensuring information is handled as per DMP, and fully collaborate on analysis and reporting activities. The grad students will contribute between 10-15 hours per week during the academic year and additional effort during the summer recess for a total of 600 hours per year over the life of the project.

Fringe Benefits:

Fringe Benefits are charged as direct costs and are set by Tulane at the current negotiated rates for budgeting purposes. FY22 rates: Faculty: XX%, Students: XX%, Staff: XX%.

Supplies and Materials (small equipment):

Post doc laptop: In the first year of the project, a UNIX/GNU open-source capable laptop will be purchased for the postdoctoral associate. This is necessary because they will be totally dedicated to their time to project activities and will need to travel to CJ community engagement events and to the local offices of Deep South Center for Environmental Justice DSCEJ.

Total Requested for Equipment Support: $2000

Travel: $12,000. Dr. Morrow and Postdoc will travel to HEELTHFUL-GC business meeting and to present results at the annual professional conference of the American Geophysical Union, typically in December, in 2023, 2024, & 2025. Additionally, Dr.

Morrow and the Postdoc will travel to CJ community events at least twice to each of 10 communities.

Airfare(6 round trip domestic)	$2400
Lodging(24-nights at 200$)	$4800
Meals & Incidentals (24- days at 100$)	$2400
Ground transportation to study site communities for i-day events (twice for 10 Communities at 120$)	$2400
Total Costs	**$12,000**

Sub-Contracts:

1. **Deep South Center for Environmental Justice** was selected as a Subcontract candidate due to the expert work in integrating participatory methods in environmental justice work and expertise of developing EJ Community capacity to engage with Earth and social science. They were also selected for their reputation for agile high quality community collaboration. DSCEJ will facilitate direct support for community science partners and community science organizations that from their extensive CJ&EJ networks across the region. DSCEJ will dedicate experienced personnel to the project's Communiversity-modeled activities. Dr. Beverly Wright, CO-I and Institutional PI supported by DSCEJ staff, is accountable for the fidelity of the proposed activities and deliverables to the principles of Communiversity and will contribute directly to workshop design and engagement with networks. Dr. Wright will be co-lead author of all peer-reviewed manuscripts and other major communications.

   The majority of the sub-award will be spent on engagement of 3-5 community science partners from each of 10 CJ network/CJ&EJ community to engage their communities, travel, and participate in ground truthing and validation workshops. A small honorarium will also be paid to CJ networks or CJ&EJ community organizations for hosting in person or virtual workshops and undertaking HEELTHFUL-GC activities to prepare Broadcasting of results, presentations, or STEM/EJ community engagement workshops. Based on the principles of equity, each network will receive an equal amount for travel and honorarium. If travel savings are realized, networks will fund more than the minimum of 3 community science partners per community science partner organization. Agile collaboration is necessary for frontline community organizations to make the most of limited resources.

DSCEJ has extensive experience with funding CJ&EJ work to be done by the most concerned communities and networks. The first step of this process is to negotiate for most effective and efficient approach to meeting objectives and then co-create a documented set of commitments with time bound deliverables from each network partner. In fact, working together on resource management is part of the capacity development Communiversity model. Network participants are invited to attend the 1-day Communiversity kickoff training, and then additional 1-day capacity development workshops in PY2 and PY3. Daily stipends will depend on distance traveled but would typically range form 50-150$ per participant for total of 3000$. Honorariums for the community science partners of $1200 per year for each of the 10 communities with three community science partners for a total of 36,000$. HEELTHFUL-GC activities and any costs to prepare CJ community engagement presentations or meetings will be 1000$ per year per CJ community for a total of 10,000$. Better practice from decades of Environmental Justice work suggests maximizing equity by directly funding EJ community activities and the total budget to be passed on to CJ community level will be 49,000$ for a total of 147,000$ over the Life of Project.

Dr. Wright and DSCEJ are fully committed to making as much of the funding as possible directly available to the CJ&EJ community science partners/organizations. This means for them to be as agile and lean in their project management as possible by leveraging volunteer time and shifting tasks among the Center's staff to bolster Dr. Wright and the leadership team's efforts. A dedicated DSCEJ staff associate will support Dr. Wright on day-to-day engagement on HEELTHFUL-GC activities at an estimated LOE of 30%. In that way, Dr. Wright's LOE remains low while she is flexible and available to make contributions at the most critical times. It is a matter of efficiency and value for money. DSCEJ will receive $2000 in other/communication funds to reimburse any costs of supporting communications of HEELTHFUL-GC deliverables among CJ&EJ networks, distributing travel and honorarium fees to community science partners, and facilitating transfer of HEELTHFUL-GC deliverables to the Data Center.

$4000 will be spent from sub-contract on open access publishing fees.

As necessary for the Costing Plan task in the first month of the award, more detailed costs disaggregated by network or individual will be articulated. Specific costs based on geographical location of the 10 CJ communities that represent the bulk of the resource requirements, could potentially be made at that time to provide highly detailed cost estimates to be communicated as necessary to the program officer. Working with NASA on models to engage EJ community organizations is encouraged in the NOFO, and HEELTHFUL-GC looks forward to exploring the best possible approaches to include budgeting and costing in these engagement models.

DSCEJ Consultant: <u>Dr. David Padgett,</u> will contribute a level of effort 78-days: Dr. Padgett is a professor at Tennessee State University and established

NASA investigator will be hired as a consultant for 78 days to provide expert participatory and dynamic facilitation of community engagement. The consultant rate was determined by the field competition, past consulting fee history on a similar NASA funded grant and an average rate was derived. The total cost for consultancy is provided in the NSPIRES cover page and does not include any other costs than Dr. Padgett's time.

DSCEJ Travel: $14,400. Dr. Wright will travel to HEELTHFUL-GC business meeting and to present results at the annual professional conference of the American Geophysical Union, typically in December, in 2023, 2024, & 2025. Additionally, in 2023 the DSCEJ community engagement associate will also attend the AGU to participate in a in person initial HEELTHFUL-GC business meeting to ensure coherence of tasking and reporting. Dr. Padgett and the DSCEJ community engagement associate will travel to CJ community events at least twice to each of 10 communities. Dr. Padgett will travel out of state and therefore need a minimum of one airfare each year.

Airfare(8 round trip domestic – 4 for AGU, 4 for Dr. Padgett CJ community events at 400$)	$3200
Lodging(28-nights at 200$)	$5600
Meals & Incidentals (20- days at 100$)	$2000
Ground transportation to study site communities for i-day events (three visits for 10 Communities at 120$)	$3600
Total Costs	**$14,400**

Fringe Benefits:

Fringe Benefits are charged as direct costs and are set by DSCEJ at the current negotiated rates for budgeting purposes. FY22 rates: Staff: XX%.

Total Requested for DSCEJ Sub-Contract: $XXXX.XX

2. **The Earth Systems Science Interdisciplinary Center of the University of Maryland (ESSIC-UMD) and Dr. Borak** were selected as a Subcontract candidate because they are known as leader in data driven Earth science using satellite remote sensing to address interdisciplinary science questions. Dr. Borak will

use requested HEC resources for the majority of heavy computational tasks and therefore does not require any additional equipment. He will lead NASA data processing activities and provide modeling inputs in each of the PYs 1-3. This includes acquiring data and generating satellite-based (i.e., extreme event) indicators, assembling appropriate satellite datasets that provide temperature and precipitation information pertinent to quantifying extreme events, and quantify evolution of green spaces for back-cast modeling, develop the web-based tool for now-casting and scenario planning from appropriate satellite data products. In PY3, he will conduct all additional data processing as necessary to support the scenario development and CJ&EJ communities' exchange. In addition to detailed documentation of all procedures and codes used and all datasets generated, overall summary of satellite data characteristics over the study area and a set of specific lessons learned will be posted following the DMP. Dr. Borak will dedicate a minimum of 7.2 months equivalent of time over life of project and will be paid 15-30% of LOE as PY1 will see significantly greater requirements for data processing that will taper down towards the end of the project.

Travel: $12,000. Dr. Morrow and Postdoc will travel to HEELTHFUL-GC business meeting and to present results at the annual professional conference of the American Geophysical Union, typically in December, in 2023, 2024, & 2025. Additionally, Dr. Morrow and the Postdoc will travel to CJ community events at least twice to each of 10 communities.

Airfare(3 round trip domestic)	$1200
Lodging(12-nights at 200$)	$2400
Ground Transportation, Meals & Incidentals (15- days at 150$, and 3 transfers at 50$)	$2400
Total Costs	**$6,000**

Fringe Benefits:

Fringe Benefits are charged as direct costs and are set by University of Maryland at the current negotiated rates for budgeting purposes. FY22 rates: Faculty Scientists: XX%.

Total Requested for ESSIC-UMD Sub-Contract: $XXXX.XX

Section 7b. Budget details

*As per ROSES guidance, all cost for people including salary, benefits, overhead or totals have been removed.

Tulane		**Year 1**	**Year 2**	**Year 3**	**Total**
	Personnel				
	Faculty - Morrow - .45 LOE	X	X	X	X
	Faculty - Shankar - .15 LOE	X	X	X	X
	Graduate Students	X	X	X	X
	Postdoc (10 mo. Yr1)	X	X	X	X
	Fringe Benefits				
	Faculty (17.1%)	X	X	X	X
	Students (7.9%)	X	X	X	X
	Postdocs (18.5%)	X	X	X	X
	Subtotal Personnel	X	X	X	X
	Travel - AGU Meeting/community partners				
	Airfare	800.00	800.00	800.00	2,400.00
	Hotel	1,600.00	1,600.00	1,600.00	4,800.00
	Ground and meals	1,600.00	1,600.00	1,600.00	4,800.00
	Supplies & Materials	2,000.00	-	-	2,000.00
Total Direct Costs - Tulane		X	X	X	X
F&A (indirect) Tulane (53%)		X	X	X	X
Subawards					
DSCEJ					
	Personnel				
	Staff Associate .3 LOE	X	X	X	X
	Fringe Benefits (X%)	X	X	X	X
	Subtotal Personnel	X	X	X	X
	Community partner engagement	49,000.00	49,000.00	49,000.00	147,000.00
	Consultants (Dr. Padgett)	X	X	X	X
	Open access publication costs	-	1,000.00	3,000.00	4,000.00
	Communication	2,000.00	2,000.00	2,000.00	6,000.00
	Travel - (AGU & regional meetings)				
	Airfare	1,600.00	800.00	800.00	3,200.00
	Hotel	2,400.00	1,600.00	1,600.00	5,600.00
	Ground and meals	2,400.00	1,600.00	1,600.00	5,600.00
	Total Direct	X	X	X	X
	F&A (Indirect) DSCEJ (X%)	X	X	X	X
	Subtotal	X	X	X	X
	F&A (Indirect) Tulane 53% (<=25k)	X	X	X	X
	Subaward Total	X	X	X	X
UMD					
	Personnel				
	Faculty - Borak (.3, .25, .15)	X	X	X	X
	Fringe Benefits (X%)	X	X	X	X
	Subtotal Personnel	X	X	X	X
	Travel - Annual Meeting (N.O.)				
	Airfare	400.00	400.00	400.00	1,200.00
	Hotel	800.00	800.00	800.00	2,400.00
	Ground and meals	800.00	800.00	800.00	2,400.00
	Total Direct	X	X	X	X
	F&A (Indirect) UMD (X%)	X	X	X	X
	Subtotal	X	X	X	X
	F&A (Indirect) Tulane (X%)	X	X	X	X
	Subaward Total	X	X	X	X
Total Project					
	Total Direct Cost	X	X	X	X
	Total Indirect Cost	X	X	X	X
	Total Project Cost	X	X	X	X

Section 8. Table of Work Effort

Name	**Role**	**Commitment (months per year)**											
		Year 1			***Year 2***			***Year 3***			***Sum***		
		This Project		*Other Funded Projects*	*This Project*		*Other Funded Projects*	*This Project*		*Other Funded Projects*	*This Project*		*Other Funded Projects*
		NASA Support	*Total*		*NASA Support*	*Total*		*NASA Support*	*Total*		*NASA Support*	*Total*	
Dr. Nathan Morrow	PI	5.4	5.4	5.6	5.4	5.4	5.6	5.4	5.4	0	16.2	16.2	11.2
Dr. Arti Shankar	Co-I	1.8	1.8		1.8	1.8		1.8	1.8		5.4	5.4	
Dr. Jordan Borak	Co-I/ Institutional PI	3.6	3.6	6.6	2.4	2.4	3.0	1.8	1.8	0	7.8	7.8	9.6
Dr. Beverly Wright	Co-I/ Institutional PI	>1	>1		>1	>1		>1	>1		>3	>3	
Project officer for Dr. Wright/DSCEJ	Project officer for Dr. Wright/DSCEJ	12	12		12	12		12	12		36		
Postdoctoral associate	Postdoctoral associate	10	10	0	12	12	0	12	12	0	34	34	0
Graduate Student(s)	Graduate Student(s)	8	8		8	8		8	8		24	24	
Sum of work effort:		**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Comments: Dr. Beverly Wright the director of the Deep South Center for Environmental Justice and she supports the project in that capacity rather than direct costs that will be dedicated to specific project engagement activities.													

Section 9. Facilities and Equipment:

Tulane will provide facilities for workshops and meetings at no direct cost to the project. Facilities include the state-of-the-art research, education and outreach amenities of the River and Coastal Center offered by the ByWater Institute at Tulane. The TRCC opened in 2016 and features laboratories, offices, and a public meeting space with views of the Mississippi River. The building is managed by the ByWater Institute, but scholars can use the meeting space for programming relevant to the TRCC mission. The Tulane River and Coastal Center is available for exhibitions, classes, demonstrations, shows, receptions, meetings, and/or conferences that relate to the mission of the ByWater Institute. The Forum is 1400 square feet with flexible seating and views of the Mississippi River. The Selley Foundation Room is 200 square feet with fixed conference seating and views of the river

Analysis of Locally Flooded Areas with Environmental Justice Communities (ALFA-EJC)

Gulf Coast Climate Justice (CJ) and Environmental Justice (EJ) communities engage in Open Science analysis and mapping that leverages high resolution remote sensing assets to better measure and monitor localized flooding

Section 1.0: Table of Contents

Section 2.0: Scientific Objectives, Technical Approach and Management

2.1 Relevance to A.44 Program Element and Proposed New Capabilities Building on Equity & Environmental Justice (EEJ) Program's "Assessment of the Gulf Coast Environmental Justice Landscape for Equity"

Analysis of Locally Flooded Areas with Environmental Justice Communities (ALFA-EJC) is a standalone project to leverage high resolution remote sensing assets of CSDA that will immediately build upon the currently funded A.49 project, Assessment of the Gulf Coast Environmental Justice Landscape for Equity(AGEJL-4-Equity). AGEJL-4-Equity is led by Tulane University International Health and Sustainable Development faculty and the Deep South Center for Environmental Justice. Localized flooding in underserved communities is the EJ & CJ community priority identified in AGEJL-4-Equity's engagement with four EEJ networks that convened to map Southern Gulf Coast, primarily African American, underserved EJ communities and their priorities: the National Black Environmental Justice Network, the 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. Although an on-going threat to vulnerable households and underserved communities, localized flooding is too often unacknowledged, poorly documented, and not analyzed with scientifically valid evidence. ALFA-EJC will multiply the impact of research objectives through further engagement and communications with a growing network of Open Science for Environmental Justice researchers, data scientists, and frontline communities that came together during a Louisiana Board of Regents and NASA supported EPSCoR project: Assessing NASA's Open Science Outlook for Environmental Justice and Resilience of the Louisiana Gulf Coast. Tulane University continues to invest in research and special capabilities to advance equitable environmental health outcomes and resilience under climate change, engaged capacity development for Open Source Science, and necessary data education infrastructure to ensure maximum impact from learning about application of CSDA data to pressing Environmental Justice priorities.

The ESD Applied Science Program promotes measurable social benefit from NASA research and information products with the aim to improve decision making and related policy solution implementation. Akin to the A.49 Earth Science Applications: Equity and Environmental Justice program element, ALFA-EJC seeks to align with recent executive orders that advance equity by focusing programmatically on underserved communities in White House Executive Orders 13985, 14035, and 14008. Accordingly, ALFA-GC will not only produce top quality research products as an evidence base for decision making but will have user-friendly capacity development, technical assistance and consultation that fully engages and possibly is co-led by underserved and EJ communities (WHEJAC, 2021). The proposed work will have contributed to NASA applied science program focuses including effects of extreme weather, inequality in access to water security and protection from water-related hazards.

2.2 ALFA-EJC Research for Advancement Objectives

CSDA assets present an unprecedented opportunity for scientifically valid analysis at a scale -- local community and neighborhood -- that matters most to creating credible evidence about issues faced by CJ & EJ communities. Environmental damage and climate change related hazards are unequally distributed in communities on Earth in patterns that are often observable from space. Inequity and environmental injustice occurs when the uneven distribution of any of the broad range of environmental ills is coincident or collocated with marginalization of groups of people and increased vulnerability of underserved communities. Unfair exposure to hazards, harm to health and wellbeing, and systemic barriers to participation in life and livelihood-affecting decisions may be mitigated, remedied, or avoided -- at least in part -- through improved capabilities and recognition of affected people to use Earth science, including NASA open science, as an evidence base to frame EEJ decision making and solutions in an inclusive and scientifically valid way.

The overall goal of the ALFA-EJC project is to leverage CSDA data assets to advance EEJ and those that work to advance EEJ on the Gulf Coast by engaging underserved community networks in geospatial technology-assisted participatory mapping and analysis of localized flooding. We will employ the tried and true “Communiversity” model that safeguards against a potentially extractive or exploitative process by ensuring EJ communities are equal active participants in research (Bullard & Wright, 1993). This autochthonous equity-focused participatory process, that interconnects with NASA Open Source Science through the previous AGEJL-4-Equity NASA EEJ project, makes community voices heard through engagement, capacity development, and recognizing diverse knowledge contributions with the support of university-based experts to present environmental justice problems and policy solutions in a scientifically valid way. ALFA-EJC has identified three Research for Advancement Objectives (RAOs).

RAO1: **Advance actionable information on localized flooding in EJ communities** – In the first year, engage and capacitate EEJ community members in four study sites to map and analyze localized flooding. In the second year, analysis and mapping will focus on extreme and other events to better measure near real-time approach to community engaged monitoring of localized flooding.

RAO2: **Advance capacity for Open Source Science for EJ organizations to leverage CSDA data for analysis and mapping**—Convene EJ/CJ community members, through existing EJ networks, in a minimum of four open science mapping and analysis of localized flooding events that explore and document opportunities to increase community resilience. Multiply opportunities to present policy-relevant community-led analysis in a scientifically valid way with at least four novel community-led investigations using CSDA data.

RAO3: Advance integration of research and learning through Open Source Science – Creatively advance the use of CSDA derived products with at least two engaged open science events at community level each program year. Synthesize

learning on analysis and mapping of flooding hazards at fine scale and next steps to advance EJ organizations in an open science format useful for EEJ network communications each program year and in one open access peer-reviewed publication.

2.3 Technical Approach to Community-engaged Mapping of Localized Flooding

2.3.1 Geographic focus of ALFA-EJC & the Open Source Science CEJST

Southern institutions and organizations were underrepresented in the first NASA Equity & Environmental Justice Listening Workshop (NASA ESD, 2021). As Catherine Coleman Flowers, member of WHEJAC, noted:

> "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." (NAS, 2021).

ALFA-EJC's study site includes the lowland Gulf Coast communities and rural areas of Louisiana, Alabama, Mississippi, Florida, and Texas. The unit of analysis will be the sub- census tract as relevant socio-economic and health data are collected at local level for both local decision making and federal government climate fund resourcing decisions using the CEJST. The CEJST using the agreed thresholds "… identifies communities that are marginalized, underserved, and overburdened by pollution" (WHCEQ & UDS, 2022). Figure 2 displays locations of disadvantaged communities in gray.

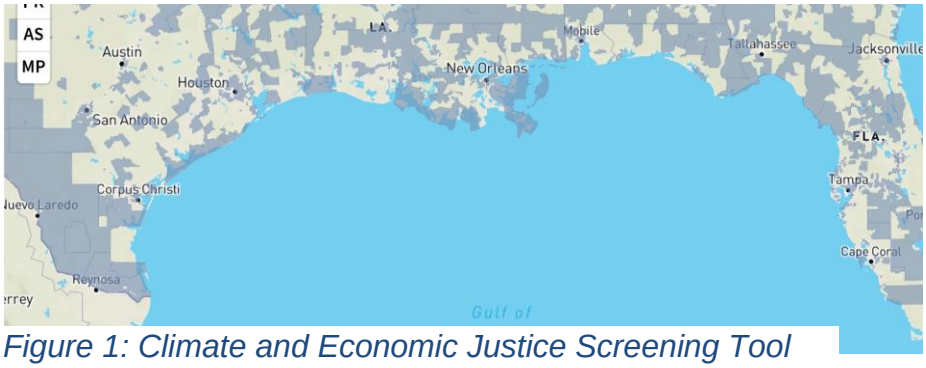

Figure 1: Climate and Economic Justice Screening Tool

Gulf Coast adjacent lowlands are identified using Environmental Protection Agency's bioregions designated "coastal" or "river plains" (Omernik & Griffith, 2014). All Gulf Coast lowlands census tract will be included in ALFA-EJC mapping and results. This will provide an opportunity for policy-relevant comparative analysis of the impacts on community health for populations both inside and outside of CEJST identified 'disadvantaged' census tracks.

Final selection of the four primary study sites will be undertaken in consultation with the EJ networks. Likely sites where community engagement and local hazard mapping have taken place include EJ communities near Pensacola Florida, Houston Texas, Saint James or Lower 9th Ward Louisiana and Africatown outside Mobile Alabama.

2.3.2 Communiversity – Ground truthing with EJ community science partners

CJ networks and their underserved EJ community representatives will fully participate as community science partners in an approach adapted from the tried and true DSCEJ Communiversity model. While flexible enough to reflect on the potential of NASA Open-source Science and data products, the "Communiversity" model safeguards against a potentially extractive or exploitative process by ensuring EJ communities are equal active participants in research (Bullard & Wright, 1993). CJ community partner scientists will contribute beginning with the earliest project tasks of ground truthing of methodological assumptions and key indicator selection. Causal pathways of of occurrence and changes in localized flooding will be the subject of a process of community-led ground truthing. Frontline communities' lived experiences will have the team's full appreciation in discussions and analysis as congruent sources of knowledge.

Beginning in the 1990's, DSCEJ pioneered the Communiversity model for participatory data collection and assessment processes that focuses on capacity development and empowering context specific community advancement of CJ&EJ (DSCEJ, 2022). The model has five action research activities to co-create or investigate:
1) Environmental hazards proximity analysis and/or community-based mapping;
2) Risk and harm assessment of toxic exposures, place and group based vulnerability, and disaster resilience;
3) Inventory of existing environmental knowledge and identify gaps to be addressed;
4) Rights and duties of communities and governmental agencies; and
5) Capacity requirements to advance evidence-based strategic advocacy.

Formal qualitative tools will be used alongside participatory techniques such as resilience storytelling to develop localized flooding timelines that match the historical flooding assessment period of 2017-2022. As flooded areas are identified in the, CJ community partner scientists will follow a ground truth protocol to validate, refine or reject potential causal explanations. The Communiversity model will then inform the activities and potential use of results by CJ networks and EJ communities to be used in capacity development and advocacy activities.

2.3.3 CSDA Earth observations for analysis and mapping

ALFA-EJC's technical approach will leverage **CSDA Earth observations** to analyze and map localized flooding events at decision-relevant local scales. Furthermore, high-resolution measurement of flooding extent and duration will reveal highly localized patterns that may be lost in data interpolated from existing flood maps that may or may not take into account infrastructure and maintenance in underserved communities. EJ community members during AGEJL-4-Equity discussions pointed out that flood maps do not take into account the flooding effects of on-going and extensive grey infrastructure improvements. Also, it was noted that cumulative effect of increasing impervious surfaces contributes to more frequent and deeper flooding. Previously approaches, that had lower spatial and temporal resolution or had been interpolated to try to improve coverage do not necessarily capture this local context. CSDA data at applicable scales

to be integrated with local knowledge to deepen understanding of EJ/CJ community flooding, but have not previously been reprocessed and made available to community engaged scientists from the Gulf Coast in a format that facilitates open science for EJ.

Passive multispectral remote sensing for extent and duration of flooding is well established and has the additional advantage of visual inspection of results to engage a wide audience. Particularly for monitoring, we will seek index related approaches that give best results beginning with the Normalized Water Index (NDWI) (Gao, 1996) and then compare to the various subsequent modified indexes. Classification methods that in iteration can include additional community sourced information will be pursued following Sadiq et al.(2022). Using requested NASA High End Computing (HEC) resources, university based researchers will lead acquisition and processing of the datasets into formats that can be used in participatory analysis and mapping. Table 1 lists CSDA remote sensing data inputs to be used. A time series of at least 5-years will be used to identify patterns of flooding and then to relate them to extreme or other events and clear sky flooding.

Using requested NASA High End Computing (HEC) resources, University of Maryland (UMD) based researchers will lead acquisition and processing of the datasets into formats that can be used with high resolution field measurements. Table 1 lists CSDA remote sensing data inputs to be used. A time series of at least 5-years of cloud free images at community identified and informed moments of localized flooding will be used to identify temporal and spatial flooding patterns.

Table 1: Satellite data products employed in support of back-casting activities.

Source	Relevant spectral bands	Expected Distribution	Spatial	Temporal
Planet -- PlanetScope	**Primary for water detection:** Near infrared, red, far red, coastal blue **Secondary depending on CJ/EJ community requirement:** panchromatic, green	16-bit Geo Tiff	3 meter	1-day
Maxar – Worldview (1-4)	**Primary for water detection:** Near infrared1, Near infrared2, red, red edge, coastal blue **Secondary depending on CJ/EJ community**	11-bit	0.31m panchromatic 1.24m spectral	varies

Flood monitoring is more than creating a simple mask for standing water commonly used in landcover mapping. Researchers found that most indexes such as the Water Index (WI), Normalized Difference Water Index (NDWI), Red and Short Wave Infra-Red (RSWIR), and Green and Short Wave Infra-Red (GSWIR) over or underestimated flooded area (Memon et al., 2015). Turbulence and sediment in the water can lead to underestimation as can flooding in high vegetation or treed areas. Reflective surfaces may be misclassified as flooded areas leading to over estimation.

Mateo-Garcia et al. (2021) have successfully mapped flooding using a machine learning classifier with small sat data to overcome index based approaches. They used a large data set of over 100 human identified ground truth flood observations to train the flood segmentation algorithm. Thresholds are set on water indexes based on the machine learning (neural network) classifier.

ALFA-EJC proposes to follow on the work of these and other researchers in a two-step approach to **Supervised classification** of CSDA images. This approach to image processing is possible due to the in-depth engagement of EJ communities to create local flooding timelines and maps. This is a unique opportunity to train a classifier on such site specific first hand knowledge of small scale and localized flooding. ***Our methodology makes highly efficient use of resources by leveraging the engagement of EJ communities through the Communiversity model to carry out field work for collecting ground truth data for training and validation.***

Analysis Step 1: create a training data set developed with the EJ community members in the four study sites. This will require:

1. Identification of cloud free Maxar Worldview at times when flooding has occurred in the past. A major question remains: will be four sites will have a sufficient number of cloud free views. This may lead to reselection of study sites that have more clear views when flooding has occurred.
2. In study sites, EJ communities will delineate the boundaries of their community and this may be divided based on overlay of the census track boundaries
3. Flooded area detection segmentation for EJ communities with Worldview cloud free views will proceed with automated detection via index and followed by on screen digitization of plots as necessary
4. Beginning with a set of cloud free PlanetScope views, we will compare the different water indexes to see what works best in each site and across study sites
5. We will then calculate changes in PlanetScope NDWI (or alternative water index that performs better) for each identified localized flood hazard area. This will serve as training data.
6. This training data will be cross-validated between study sites
7. Assessment of training set type 1 and type 2 errors will inform next steps for improving training data precision and accuracy

Analysis Step 2: supervised classification of entire scenes covering surrounding CEJST census tracks will proceed based on the training data set**.** We propose to use supervised classification packages available in the open source software R. Our research team also has experience in custom coding in C and Python to handle any data management, data preparation or adjustments to classifier algorithms. We begin with tried and true Decision Tree classifiers following Friedl and Brodley (1997). PI Morrow co-authored a paper with Friedl in 1998 using a different modeling approach (see biosketches in section 4). Steps for supervised classification include:

- Select a set of training sites representative across image to be classified

- Extract pixels representing desired classes of flooding (eg recurrent flooding, clear sky flooding, standing water, …)
- Train classifier based on samples
- Classify the image
- Evaluate the classification. Possible sources of error may be introduced from numerous sources but special attention will be given to discrepancy between training and classified images due to angle viewing effects in PlanetScope data

This expanded classification will allow the research team to measure differences in frequency and area of localized flooding between EJ communities as well as between better severed and underserved census tracts identified by the CEJST tool. Measurement of these differences may inform assessment of distributional justice of localized flooding as well as some relationships to other indicators of root causes of potentially observed inequality.

Flood monitoring in project year 2 will be undertaken with community members based on the Communiversity model. It is likely that this will include flood journals, but the community will lead the discussion on how best to record flood events through at least 6-months of PY2 to test the ability to of the trained classifier to identify flooding that is most important from a community point of view.

2.4 Expected contributions to EJ Community localized flood knowledge from synoptic analysis of integrated ground truth and high resolution remotely sensed observations

Very localized flooding effecting parts of a community, a single street or a few homes has received little research attention. There are practical limitations such as difficulty in observing smaller areas with aerial imagery for recurrent or clear sky flooding. Flood maps based on digital elevation models may not capture recent changes in topography from local earth work or new grey infrastructure. Cumulative impacts of impervoious surfaces are complicated to estimate by simple models and may be underreported. Therefore, estimation of recurrent small scale flooding or increasingly reported clear sky flood of underserved communities requires alternative observational approaches such as those offered by CSDA assets..

The contributions of this research may progress basic questions about localized flooding. ALFA-EJC will:

- As a first contribution, have produced observation based estimates of the extent of recurrent, periodic and clear sky localized flooding.

- As a second contribution, have improved understanding of the prevalence of different types of flooding in EJ communities.

- As a third contribution, have explored the capability of different water indexes to identify different types of localized flooding.

- As a fourth contribution, have improved understanding of localized flooding in increasing or undergoing other types of change.

- As a fifth contribution, have assessed the ability to detect localized flooding in areas and times of the year that have high levels of cloud cover.

Although these contributions will be initially limited to the four study sites and the surrounding census tracks, there is potential for expansion into more regular localized flood monitoring of the most at risk CJ and EJ communities.

2.5 Open Source Software and Hardware

ALFA-EJC is committed to every aspect of Open Source Science and will only use open source software. The open source code/data for water indexes/flooding threshold tools will be available from our GitHub site. ALFA-EJC will also have dedicated repositories for all project outputs on a GitHub site and use the Zenodo folder 'Environmental Justice' for archiving and sharing research outputs. Modeling will primarily be conducted in R, Python and other open source languages will be used as necessary to manipulate data. All scripts will be posted. Jupyter notebooks will be piloted for CJ&EJ community engagement. Computing hardware requirements are minimized as most data processing will be conducted through requested NASA HEC resources. University Data Hub and available departmental IT support and equipment are sufficient for other modeling, scenario development and broadcast communication tasks. The DSCEJ's Bezos Earth Fund Data Center has sufficient resources to sustainably host research outputs and open source materials for the foreseeable future.

2.6 Resilience and robustness of ALFA-EJC in the face of uncertainty

Potential pitfalls for ALFA-EJC related to uncertainty and error are largely counterbalanced by a very experienced team of researchers. Furthermore, special capabilities related to long-term relationships with CJ&EJ networks and complementary on-going CJ&EJ evidence base data initiatives ensure project resilience. For example, if if one study site has too much cloud cover during flood events, the EJ networks will likely be able to find several alternative study sites along the Gulf Coast. The team has >100-years of combined data analysis and participatory experience with a diverse set of analytical tools to handle most challenges. Methods illustrate procedural expertise with tests to identify Type-1 and Type-2 errors in classification, deal with view angle issues, and ensure validity and accuracy of research products. Dr. Borak did his PhD on dealing with view angle issues and regularly works in areas that have cloud cover challenges.

Covid and potentially other health-related restrictions to engage face-to-face with community may limit some ground truth activities. The PI has recently led a major international organization to pivot a global capacity development program to online. Lessons from this experience include leveraging collaborative online tools for better

engagement, fully facilitating virtual sessions with dedicated technological backstopping, and adjusting the length/frequency/tempo of sessions to promote active interaction. Engaging coastal communities may require health safeguards and adjustment to virtual or 1-to-1 meetings rather than in-person group interviews.

Special capabilities DSCEJ and Tulane University are currently leading an adapted-for-NASA Communiversity activity with four EJ networks: the National Black Environmental Justice Network, the 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. Their work mapping Southern Gulf Coast, primarily African American, underserved EJ communities and their priorities will facilitate mobilization of CJ&EJ community partner scientists for this project. The LA Board of Regents and NASA EPS-CoR have supported Tulane University to conduct convene Open Source Science and Environmental/Climate Justice networks, organizations, change makers, and CJ&EJ communities along the Gulf Coast for greater collaboration. The University has made generous availably of facilities and funds to support data driven initiatives including work on CJ&EJ including use of the excellent facilities and outstanding conference support of our Tulane Bywater Institute Coastal and River Center. Tulane University Presidential Initiatives on data literary and equity, inclusion and diversity have come together in a new Data Hub that will connect not only students but diverse stakeholders to open science approaches. DSCEJ will provide a sustainable home for building upon ALFA-EJC's results with its well-funded Besos Earth Fund Data Center initiative that will be the premiere CJ&EJ knowledge hub in the South if not the entire United States.

ALFA-EJC's robustness will be derived from investing the lion's share of the budget in creating an inclusive and diverse interdisciplinary team. Dedicated team members are budgeted to work in an essential roles 1)remote sensing/modeling data & 2)external facing CJ&EJ Communiveristy lead. Essential high level/higher cost interdisciplinary expertise is more modestly budgeted and focused on periods of greatest need to maintain a flexible, diverse, and robust technical backbone. Three SOs build upon one another with major outcome level deliverables completed each project year (PY). PY1/IDSO1 retrospective modeling informs the development of PY2/IDSO2 nowcast models and scenarios. Engagement with CJ&EJ community scientists with ground truth from the start of the project ensures a coherent logic to causal description of model of both retrospective and near real time flood mapping results. ALFA-EJC is built around an open science platform with open science output milestones to ensure alignment and coherence across project activities.

2.7 Management structure

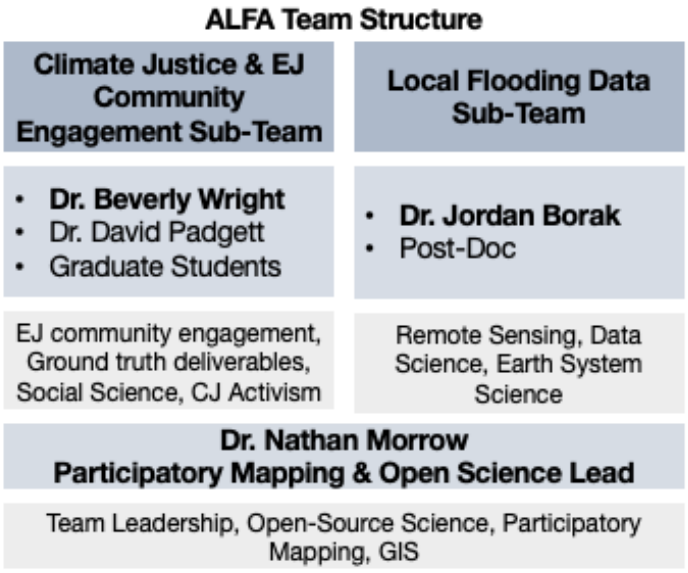

Figure 1: Sub-team Management Structure

The ALFA-EJC management structure aims to encourage collaboration enabled by technology (Ramachandran, Bugbee & Murphy, 2021) with clear shared objectives, empowered leadership of sub-teams, and easy exchange through advanced digital tools for inclusive communication. Implementing an interdisciplinary project requires active and engaged project leadership with regular team communication and directed reflection. ALFA-EJC brings together investigators that work at different time and spatial scales as well as with different disciplinary tools and methods. To balance interdisciplinary interaction with research efficiency, tasks and sub-tasks will be assigned to sub-teams led by a Co-Investigator with the PI participating in all of the teams' work planning and task result monitoring. Furthermore, the PI is responsible for promoting necessary cross-team interaction, monitoring dependencies, open science, and further interdisciplinary co-creation tasks and results. Quarterly virtual all team meetings, annual workplanning, and PI/Co-I business meeting focused on reporting project progress during the AGU meeting provide necessary collaborative discourse. Dependencies, emerging challenges, co-created cross-learning and solutions from virtual/face-2-face team interaction will be used to monitor workplan and share with NASA.

2.8 Outcomes and primary tasks of task identified personnel

ALFA-EJC outcomes will produce Open Science deliverables (see Tentative Schedule 2.4.1 below). These will include a more technical publication based on findings related to localized flooding in the study sites and another on the use of CSDA for engaged Open EJ research to be presented to scientific and applied audience at the AGU. Open science plan, assessment and mapping training materials, community research presentations, will be posted on a GitHub and other sites.

Dr. Nathan Morrow as PI is accountable for grant implementation, compliance, risk management and reporting, quality and timeliness of all deliverables, implementation of the DMP, responsive communication, and reporting to NASA and all stakeholders. Dr. Morrow will manage collaboration, GitHub sites. Dr. Morrow will take the technical lead on all spatial analysis and mapping sub-tasks. Accountable for all milestones, he ensures inclusive and equitable contributions to collaborative deliverables including publications, open science and reports in following Milestone Schedule.

Dr. Beverly Wright as Co-Investigator supported by a DSCEJ associate is accountable for the fidelity of the proposed activities and deliverables to the principles of Communiversity for engagement with CJ&EJ communities. As Director of DSCEJ, 'end-user', she will advise on planning and tasking with the goal of applying all ALFA-EJC deliverables to advance wellbeing outcomes for CJ&EJ communities. Dr. Wright/DSCEJ staff associate will lead sub-team tasks directly related to CJ&EJ community engagement. SO/PY-1, mobilizes community science partners in the Communiverity model, any necessary training, and grountruthing of classifier. SO/PY-2 co-creation and improvement of ALFA products through CJ&EJ community input and interactive validation of causal dynamics and interim results. DSCEJ will promote the utilization of results and deliverables for advancing justice outcomes, influencing decisions, developing capacity and ultimately advancing CJ&EJ in the 4 primary communities and wider Gulf Coast region. Finally, standing-up an open source science ALFA-EJC site hosted on the DSCEJ data center.

Dr. Jordan Borak's research responsibilities will focus on acquiring data and generating satellite-based (i.e., localized) maps and flood measurements. In addition to detailed documentation of all procedures and codes used and all datasets generated, overall summary of satellite data characteristics over the study area and a set of specific lessons learned will be posted following the DMP. Dr. Borak will also visit the study sites with the Senior Consultant who leads community engagement with in the Communiversity model. They will work together on integration of participatory approaches to mapping and analysis with the image processing approach.

Consultants: Dr. David Padgett is Senior Consultant to DSCEJ for 'ground truth' activity community engagement with in the Communiversity model. He will advise on participatory approaches to mapping CJ&EJ community/network causal pathways/priorities, co-lead up to 8 CJ&EJ community/network engagements/workshops, and advise on transfer of all materials that could be used as STEM related outputs to the Data Hub and the Data Center.

2.9 Tentative Schedule of Research and Deliverables

Project Year 1: Establish patterns of clear sky and precipitation event flooding at EJ study sites			
Q	**Milestone deliverable**	**Open science output**	**Reporting**
Q1	• Review of NASA and EJ community timeseries data sets on localized flooding • Literature review focus on measuring, modeling & forecasting localized flooding in EJ communities	• Open Access Annotated Bibliography for Localized Flooding and EJ Open Science • GitHub site	• Submit Work and Costing plan • Submit PY1 Q1 report
Q2	• CJ&EJ Community initial engagement • Selection and retrieval of flood area parameters from CSDA and *in situ* sources • Team meeting with Dr. Borak for joint work at field sites	• Register open science plan for reproducibility	• PY1 Q2 report with some discussion of data quality
Q3	• Run classification model for clear sky and precipitation localized flooding in study sites • CJ&EJ partner review of causal links for flooding	• Open science badges PI/CO-I	• PY1 Q3 Report w/initial classification overview
Q4	• First ground truth CJ&EJ engagement	• GitHub updated • Annual inclusion/DMP tasks	• Draft peer review manuscript • PY1 Annual Report
Project Year 2: Near real time analysis of flooding with CJ & EJ communities			
Q	**Milestone deliverable**	**Open science output**	**Reporting**
Q1	• Annual planning meeting with Dr. Borak for joint work at study sites • CJ/EJ community meeting on flooding monitoring	• CJ & EJ community Open Science badge contest	• Share PY2 workplan • Submit PY2 Q1 report
Q2	• Train cohort of CJ community scientists on Localized Flooding Analysis	• Community GitHub event • Posting of CJ/EJ • Engagement materials	• PY2 Q2 report w/ monitoring overview
Q3	• Produce Localized Flooding Analysis in each study site • CJ network causal elements of CJ scenarios	• Open Science for localized flooding presentation at AGU • GitHub update • All documents to Zenodo	• PY2 Q3 Report w/ discussion of open science engagement
Q4	• Finalize & broadcast general guide to Analysis of Localized Flooding	• GitHub updated • Annual inclusion/DMP tasks • Closing and reporting on all Inclusion and DMP Plan activities	• Final Tech/Financial Report • Draft peer review manuscript

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4.0 Data management plan

Accountability for full implementation of the Data Management Plan (DMP) and ensuring full compliance to NASA DMP requirements lies with the Dr. Nathan Morrow as PI. He has extensive experience managing geographic and remotely sensed data for research and decision making. He has published peer reviewed articles on data for decision making (Mock, Morrow & Papendeick, 2012) has written and taught about data responsibility (Morrow, 2022), and recently was awarded a grant for increasing the use of Open Source Science for Environmental Justice.

End User License Agreements for PlanetScope and Maxar Worldview describe how commercial data can be used by NASA researchers for Scientific Use research purposes as outlined in the research award agreement. Public Release or Commercial Use of the CSDA data is prohibited. Any raw imagery must be securely handled. Only derivative products with clearly defined research purposes are to be shared with the general public, used in publications or shared with our community based stakeholders.

Every effort will be made to limit the access to original or raw PlanetScope and Maxar Worldview data. Dr. Borak works in a secure NASA affiliated research center with a nasa.gov email. The raw data will almost exclusively be processed in the HEC computing environment by Dr. Borak following the strict security protocols of his center. On occasions when Dr. Morrow is required to use imagery, it will be processed in HEC environment or on a secured workstation. No raw data will be present on laptops during travel. Tulane's Export Control officer also will advise on our compliance with EULAs for commercial data when working with the public, stakeholders, and EJ communities.

ALFA-EJC is committed to Open Source Science and identified personnel will complete NASA TOPS core curriculum to earn a minimum of 5 open science badges.

The ALFA-EJC's team will pursue the development plan along the lines of the "Geosciences Paper of the Future" with the intention move towards improving the DMP "to make data, software, and methods openly accessible, citable, and well documented" (Gil et al., 2016) and the FAIR principles: Findable, Accessible, Interoperable, & Reusable (Wilkinson et al., 2016). As part of the advancement of CJ&EJ data for decision making methods and with the specific expertise in the ALFA-EJC science leadership in this research area, the team will leverage the DSCEJ Data Center and Tulane University's Data Hub along side GitHub, data.nasa.gov, and Zenodo to ensure data and information are shared in ways that maximize access, reuse and application to new problems, contexts, and research questions. Data will be made publically available with enough detail to allow for validation and metadata standards will conform to open science standards of the repository such as coding in XML.

All spatial derived and map products will have ISO 19115 compliant meta data.

The ALFA-EJC data management plan ensures public access to publications and digital datasets arising from NASA research. All ALFA-EJC data posting and archiving tasks will be **confirmed quarterly**. Open Science milestones are identified on the schedule and assigned responsibility to the postdoc and accountability to the PI. The preprints will be posted on Earth and Space Science Open Archive, associated with the American Geophysical Union, pre-print server https://www.essoar.org/. Open access articles will be available as soon at final revisions are accepted, but expected to be within one year from project closure.

Data sets, meta data and other materials developed to support the proposed research will be archived at data.nasa.gov, as appropriate, and Zenodo (https://zenodo.org/) site associated with European Organization for Nuclear Research (CERN) and expected to maintain the open archive as long as CERN exists. ALFA-EJC has created an Environmental Justice 'community' on Zenodo to encourage findability of the research and exchange with other EJ/CJ researchers.

All derived products and documents produced by ALFA-EJC encourage redistribution, reproduction and creation of derivatives with a Creative Commons Attribution 4.0 International license, and uploaded to Zenodo/DSCEJ Data Hub/Github including:

- 4 or more localized flooding maps made available in geotiff and pdf formats
- Scripts and source code for training classifier and classifying flooded areas from imagery including source code, guidance notes and results/validation
- Manuscripts and documentation of change and stress detection. These will be given a unique doi when uploaded and include source code, guidance notes and results/validation on GitHub site

Development of the project in year one will take place primarily on a dedicated GitHub site. During initial extraction of remote sensing measurements as discreet data sets will temporarily be stored in the NASA HEC environment. As derived products are finalized and model source code documented in a distributable version, these information assets will be open source licensed and uploaded to data.nasa.gov and Zenodo. Full documentation will be completed by project close out and will be transferred to the Tulane Data hub with links to the permanent archives.

The PI will maintain communication as necessary with the data repository and the NASA program manager to ensure that: DMP is updated as needed at time of award; appropriate attribution is included; data meet minimum quality standards; and data are appropriately evaluated for and secured to prevent disclosure of personally identifiable information and to protect proprietary interests, confidentiality, and intellectual property rights.

Section 5.0 Biographical Sketches

PI: Nathan Morrow

1. Professional Preparation

Boston University, Geography, Bachelor of Arts with Honors 1997
Boston University, Geography, Master of Arts 1998
University of Maryland, Geography, Doctor of Philosophy (M. Hansen advisor) 2021

2. Professional Experience and Positions

Current Sponsored Research:

- PI, Assessment of the Gulf Coast Environmental Justice Landscape for Equity (AGEJL-4-Equity), NASA-funded, 10/22-4/23
- PI, Open Science Outlook for Environmental Justice and Resilience of the Louisiana Gulf Coast (OSO-LoGiC), NASA-EPSCoR-funded, 5/22-4/23
- Co-PI, Sahel Collaboration & Communication, USAID-funded, 10/20-9/25

Appointments:

- Associate Research Professor, Tulane Public Health & Tropical Medicine, 2022-.
- Associate Research Professor, Tulane Law, 2014-2018, Adjunct 2007-2012
- Associate Clinical Professor, Tulane School of Social Work, 2012-2014
- Associate Clinical Professor, Tulane Public Health & Tropical Medicine, 2011-2014, Adjunct 2007-2022

3. Selected Bibliography

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

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**

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

Muchoney, D., Borak, J., Chi, H., Friedl, M., Gopal, S., Hodges, J., **Morrow, N.**, & Strahler, A. (2000). Application of the MODIS global supervised classification model to vegetation and land cover mapping of Central America. *International Journal of Remote Sensing*, *21*(6–7), 1115–1138. https://doi.org/10.1080/014311600210100

Morrow, N., & Prince, S. (1999). Use of potential and actual primary production models to map drought and degradation in semi-arid Southern Africa. *EOS Transactions, 80*(46), F403.

Morrow, N., & Friedl, M. (1998). Modeling biophysical controls on land surface temperature and reflectance in grasslands. *Agricultural and Forest Meteorology*, *92*(3), 147–161. https://doi.org/10.1016/S0168-1923(98)00098-7

4. Research Experience: Scientific, Technical, Management

Dr. Morrow has acquired a wide range of skills and expertise with 25 years of experience not only as a professor but also leading implementation, developing capacity and ensuring research-based evidence for interdisciplinary/multi-sectoral food security, humanitarian response, and child wellbeing policy implementation projects. He has served as Chief of Party for a multi-organizational consortium for multi-country developmental relief and humanitarian aid response valued at over 400 million USD responding to an El Niño drought food security crisis in southern Africa -- a precursor to now ubiquitous resilience policy-focused programming. As co-chair of the Emergency and Disaster Evaluation thematic group at the American Evaluation Association, Dr. Morrow has promoted inclusive engagement and more rigorous measurement models in resilience research and intervention planning. The Global Environment Facility (GEF-7) replenishment strategy was informed, in part, by a geospatial analysis of environmental security led by Dr. Morrow.

Dr. Morrow is PI for two projects that intend to strengthen capacity for open source science to address challenges in CJ & EJ research in collaboration with Gulf Coast EJ community networks and organizations. Strategic assessment and strategy processes to strengthen evidence-based decision support have been a feature of Dr. Morrow's research and consulting with a variety of organizations including work on USAID's resilience measurement operational research in the Horn of Africa, needs assessment capacity for the United Nation's World Food Programme, and the global redesign of World Vision International's system for reporting to the International Board and other stakeholders on impact for improved child wellbeing. Dr. Morrow was invited to conduct the first-ever technical review of an SDG target indicator; 2.1.2 -- Prevalence of severe or moderate food insecurity. He recently completed a global capacity development effort for evidence based policy and policy implementation for the UN Food and Agriculture Organization for >50 countries.

Dr. Morrow continues to actively use remote sensing and geospatial analysis in his applied research following on early contributions to the MODIS, NPOESS, and Land-Use and Land-Cover Change science mission. These technologies featured in Developmental Evaluations of the World Food Program's mVAM program for improved needs assessment and hazard monitoring. They also feature in his teaching that includes problem sets related to assessing flood damage or humanitarian logistics planning.

Co-I: Institutional PI: Dr. Beverly Wright

1. Professional Preparation

Grambling State University, Sociology, Bachelor of Arts 1969
State University of New York at Buffalo, Sociology, Master of Arts 1971
State University of New York at Buffalo, Sociology, Doctor of Philosophy 1977

2. Professional Experience and Positions

Executive Director, Deep South Center for Environmental Justice, 2005-present
Professor of Sociology, Dillard University, 2005-2017,
Professor of Sociology, Xavier University of Louisiana, 1992-2005
Associate Professor, Wake Forest University, 1989-1993

3. Selected Bibliography

Wright, B.H., (2015) Environmental Injustice and the State of Black New Orle-ans," pp. 100 - 113 in McConduit-Diggs, Erika, State of Black New Orleans: 10 Years Post-Katrina. New Orleans: The Urban League of Greater New Or-leans.

Wright, B.H.,, and Nance, E., (2012). "Toward Equity: Prioritizing Vulnerable Communities in Climate Change," Duke Forum for Law and Social Change, 4 (1), 1-21.

Wright, B.H., (2011). "Race, Place, and the Environment in the Aftermath of Katrina," Anthropology of Work Review, American Anthropological Associa-tion, 32 (1), 4-8.

Bullard, Robert D. & **Wright**, **B.H.,** "Disastrous Response to Natural and Man-Made Disasters: An Environmental Justice Analysis Twenty-Five Years after Warren County," UCLA Journal of Law and Environmental Policy 26: 2008.

Wright, B.H., (1998). "Endangered Communities: The Struggle for Environmental Justice in Louisiana's Chemical Corridor," Journal of Public Management and Social Policy, 4(2), 181-191.

Wright, B.H., Bullard, R.D., & Johnson, G.S., (1997). "Confronting Environmental Injustice," [Special Issue]. Journal of Race, Gender, and Class, 5, 65-79.

Bullard, R. D. & **Wright, B.H**., (1993). "Environmental Justice for All: Community Perspectives on Health and Research Needs," Toxicology and Industrial Health, 9(5), 821-841.

Wright, B.H., & Bullard, R.D., (1990). "Hazards in the Workplace and Black Health: A Review," Journal of Sociology, 4(1), 45-74.

4. Research Experience: Scientific, Technical, Management

In 1992, Dr. Wright founded the Deep South Center for Environmental Justice at Xavier University in New Orleans (later moved to Dillard University in 2005) modeled on Communiversity Model approach. As the founding director of the first university based environmental justice organizations, Dr. Wright has been at the forefront of the movement to empower and build resiliency in low-income and people of color who are threatened by natural and manmade disaster, hazards, and emergencies. Dr. Wright worked collaboratively with some of the nation's leading environmental justice and health equity scholars on communities disproportionately impacted by industrial pollution, environmental hazards, and natural and manmade disasters in the Louisiana Chemical Corridor, also known as "Cancer Alley." Dr. Wright have served as PI or coinvestigator on dozens of research projects that address emergency management, response, and resiliency of workers and residents impacted by nearby or "fence line" refineries and petrochemical plants, Superfund sites, hurricanes, floods, and industrial accidents and spills – managing grants of over 23,000,000 USD. DSCEJ addresses environmental and health inequities along the Mississippi River Chemical Corridor and is a community/university partnership providing education, training, and job placement. Since Hurricane Katrina, much of her work at the Center has focused on research, policy and community outreach as well as assistance and education of displaced African-American residents of New Orleans. After EPA identified more than 200 sites around the city with elevated lead and arsenic levels, I forged a unique partnership with the U.S. Steelworkers to launch "A Safe Way Back Home Project," a proactive pilot neighborhood cleanup project. Using our NIEHS-funded Minority Worker Training Program model, the neighborhood-centered pilot cleanup project trained more than 60 small businesses and contractors in hazardous waste removal, mold remediation and health and safety methods, and trained hundreds of volunteers from around the country to assist community residents in the cleanup and return safely to their devastated New Orleans homes and neighborhoods. Over these last thirty years working in the field of environmental justice, health disparities and community sustainability. Her research experience has shown that federal, state and local policies can have a long lasting and sometimes devastating impact on communities. Dr. Wright recognizes the importance of educating communities on the science related to issues of health and that engaging them with policymakers empowers communities to advocate on their own behalf to push government to make policy changes that better protect the public health. Dr. Wright is currently a member of the White House Environmental Justice Advisory Council (WHEJAC) and she serves on the Justice 40 committee.

Co-I: Institutional PI: Dr. Jordan Borak

1. Professional Preparation

Graduate Certificate, Data Science: University of Maryland, College Park, 2019.
Ph.D. in Geography: Boston University, 2000.
Master of Arts in Geography: Boston University, 1996.
Bachelor of Science in Geography (Math minor): University of Illinois, Urbana-Champaign, 1992.

2. Professional Experience and Positions

Current Sponsored Research:

- PI, Enhanced Roughness Length Estimates from ICESat-2 Vegetation Products
- Co-I,National Climate Assessment Land Data Assimilation System
- Co-I, Shallow Water Bathymetry Products and Analysis for Near-shore

Appointments:

- Associate Research Scientist, Earth System Science Interdisciplinary Center, University of Maryland and Hydrological Sciences Laboratory, NASA/Goddard Space Flight Center (June 2011 – present).
- Senior Support Scientist, Science Systems and Applications, Inc., then Wyle Information Systems, LLC, and Hydrological Sciences Branch, NASA/GSFC (July 2002 – June 2011).
- Support Scientist, Science Systems and Applications, Inc., MODIS Land Data Operational Product Evaluation Facility, NASA/GSFC (November 2000 – June 2002).
- Research Associate, Department of Geography and Laboratory for Global Remote Sensing Studies, University of Maryland (July 1999 – November 2000).
- Research Fellow, Department of Geography and Center for Remote Sensing, Boston University (September 1993 – June 1999).

3. Selected Bibliography

Borak, J.S., M.F. Jasinski, and N. Tangdamrongsub, 2021: Fusing ICESat-2 and MODIS Vegetation Data Products to Enhance Momentum Aerodynamic Roughness Fields with Spatially-Explicit Scaling for Improved Land Surface Modeling [Poster presentation G15B-0350]. AGU 2021 Fall Meeting, 13-17 Dec.

Tangdamrongsub, N., C. Hwang, **J.S. Borak**, S. Prabnakorn, and J. Han, 2021: Optimizing GRACE/GRACE-FO data and *a priori* hydrological knowledge for improved global Terrestrial Water Storage component estimates. *J. Hydrol.*, **598**, 126463.

Borak, J.S., M.F. Jasinski, and N. Tangdamrongsub, 2020: Enhanced vegetation aerodynamic roughness for momentum with ICESat-2 data products: early results [Poster presentation H194-0005]. AGU 2020 Fall Meeting, 1-17 Dec.

Jasinski, M.F., **J.S. Borak**, S.V. Kumar, D.M. Mocko, C.D. Peters-Lidard, M. Rodell, H. Rui, H.K. Beaudoing, B.E. Vollmer, K.R. Aresenault, B. Li, J.D. Bolten, and N. Tangdamrongsub, 2019: NCA-LDAS: Overview and Analysis of Hydrologic Trends for the National Climate Assessment. *J. Hydrometeorol.*, **20**, 1595-1617.

Kumar, S.V., M. Jasinski, D. Mocko, M. Rodell, **J. Borak**, B. Li, H. Kato Beaudoing, and C. D. Peters-Lidard, 2019a: NCA-LDAS land analysis: Development and performance of a multisensor, multivariate land data assimilation system for the National Climate Assessment. *J. Hydrometeorol.*, **20**, 1571-1593.

Kumar, S.V., D.M. Mocko, S. Wang, C.D. Peters-Lidard, and **J. Borak**, 2019b: Assimilation of remotely sensed Leaf Area Index into the Noah-MP land surface model: Impacts on water and carbon fluxes and states over the Continental U.S. *J. Hydrometeorol.*, **20**, 1359-1377.

de Gonçalves, L.G.G., **J.S. Borak**, M.H. Costa, S.R. … 2013: Overview of the Large-Scale Biosphere-Atmosphere Experiment in Amazonia Data Model Intercomparison Project (LBA-DMIP). *Agr.Forest Meteorol.,***182-183**,111-127.

Borak, J.S., and M.F. Jasinski, 2009: Effective interpolation of incomplete satellite-derived leaf-area index time series for the continental United States. *Agr. Forest Meteorol.,* **149**, 320-332.

Borak, J.S., M.F. Jasinski, and R.D. Crago, 2005: Time series vegetation aerodynamic roughness fields estimated from MODIS observations. *Agr. Forest Meteorol.,* **135**, 252-268.

4. Research Experience: Scientific, Technical, Management

Dr. Borak's research interests include Earth science data processing and analysis: particular focus on long-term time series data at regional and continental scales; inter-annual and seasonal variability of vegetation and water cycle components; land-cover characterization from satellite observations; quality assessment of remotely sensed data. He has 25+ years experience with C programming and shell scripting in Unix-type environments; 4+ years with Python and Java. He also is an expert in machine learning software: scikit-learn and Keras; statistics and visualization packages: R, Tableau, and SAS.

Senior Consultant: David Padgett

1. Professional Preparation

Western Kentucky University, Geography/Geology, Bachelor of Science 1987
University of Florida, Geography/Environmental Engineering, Master of Science 1992
University of Florida, Geography/Geology, Doctor of Philosophy 2001

2. Professional Experience and Positions (Appointments)

Associate Professor of Geography, Tennessee State University, 2005-present
Visiting Assistant Professor, Vanderbilt University 2012-2013,
Assistant Professor of Geography, Tennessee State University 1999-2005
Visiting Assistant Professor of Environmental Studies, Oberlin College 1996-1999

3. Selected Bibliography

Padgett, D.A., Solis, P., Adams, J.K., Duram, L.A., Hume, S., Kuslikis, A., Lawson, V., Miyares, I.M., and Ramirez, A. "Diverse Experiences in Diversity at the Geography Department Scale," The Professional Geographer online edition, January (2013).

Padgett, D.A., Marsh, E., Harper, J., and Robinson, C. "Green Careers Curriculum Manual: Improving Access to Green Careers through Environmental Science and Engineering at Historically Black Colleges and Universities," U.S. Environmental Protection Agency (EPA 904-B-12-001), January (2012).

"Teaching Race, Class, and Cultural Issues in Earth Science to Enhance Multicultural Education Initiatives," Journal of Geoscience Education, vol. 49, no. 4, (2001), pp. 364-369.

4. Research Experience: Scientific, Technical, Management

Dr. David Padgett is a geoscientist by training with more than 30-years of experiences of in community engaged action research. He has worked in academia and as a consultant on projects including Community Air Quality Sensor Training and Community Air Quality Mapping, Community Asset Mapping, and WeGlobal Research Project on African Americans Living Abroad. Through his research and experience he has the appropriate expertise to co-develop participatory mapping tools. He has also mentored generations of graduate students at Tennessee State University throughout their academic journey. Given his expertise and skillset he is a highly-valued member of the team for ensuring quality deliverables from this project.

Section 6.0: Current and Pending Support

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.	
Investigator: Dr. Nathan	Other agencies (including NASA) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending

Project/Proposal Title**:** Assessment of the Gulf Coast Environmental Justice Landscape for Equity (AGEJL-4-Equity)

Source of Support: NASA A.49 Earth Science Applications: Equity and
Total Award Period Covered: 10/22-06/23

Person-Months Per Year Committed to the Project: 2.0

Support: ☒ Current ☐ Pending

Project/Proposal Title: Open Science Outlook for Environmental Justice and
Role: PI

Source of Support: NASA EPSCoR Louisianna BoR RID Project
Total Award Period Covered: 3/22-05/23

Person-Months Per Year Committed to the Project: 2.0

Support: ☐ Current ☒ Pending

Project/Proposal Title: High-resolution Extreme Event and Localized Temperature

Role: PI

Source of Support: NASA A.28 Interdisciplinary Science
Total Award Period Covered: FY24-FY26

Person-Months Per Year Committed to the Project: 5.4

Support: ☐ Current ☒ Pending

Project/Proposal Title: EJ Core GC; Engaging diverse researchers and EJ
Role: PI

Source of Support: NASA Science Mission Directorate –F.14- Transform to Open
Total Award Period Covered: 07/23-06/25

Person-Months Per Year Committed to the Project: 3.6

Support: ☐ Current ☒ Pending

Project/Proposal Title: Analysis of Locally Flooded Areas with Environmental Justice
Role: PI

Source of Support: NASA Science Mission Directorate –A.44- COMMERCIAL
Total Award Period Covered: 09/23-08/25

Person-Months Per Year Committed to the Project: 1.8

Support: ☐ Current ☒ Pending

Project/Proposal Title: Application of Commercial Smallsat Data to Enhance Flood Resilience
Role: Co-PI

Source of Support: NASA Science Mission Directorate –A.44- COMMERCIAL
Total Award Period Covered: 09/23-08/25

Person-Months Per Year Committed to the Project: 1.8

Current and Pending Support

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Dr. Jordan S. Borak	Other agencies (including NASA) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending
Project/Proposal Title: Enhanced Roughness Length Estimates from ICESat-2 Vegetation Products
Role: PI
Source of Support: NASA Cryospheric Program/Studies with ICESat-2
Total Award Period Covered: 05/20-04/23
Person-Months Per Year Committed to the Project: 3.0

Support: ☒ Current ☐ Pending
Project/Proposal Title: National Climate Assessment Land Data Assimilation System, NCA-LDAS
Role: Co-I
Source of Support: NASA National Climate Assessment Program
Total Award Period Covered: FY16-FY23
Person-Months Per Year Committed to the Project: 3.6

Support: ☒ Current ☐ Pending
Project/Proposal Title: Shallow Water Bathymetry Products and Analysis for Near-Shore Coastal and Inland Waters
Role: Co-I
Source of Support: NASA The Science of Terra, Aqua, and Suomi-NPP
Total Award Period Covered:
Person-Months Per Year Committed to the Project:3.0

Support: ☒ Current ☐ Pending
Project/Proposal Title: Remote Sensing of Vegetation in Puerto Rico for NIST's Hurricane Maria Infrastructure Project
Role: PREP Research Associate
Source of Support: NIST Community Resilience Program
Total Award Period Covered: 07/22-06/23
Person-Months Per Year Committed to the Project: 3.0

Support: ☐ Current ☒ Pending
Project/Proposal Title: Improving Our Understanding of Gulf Coast Wetland Dynamics with Spaceborne Lidar
Role: Co-I
Source of Support: NASA Cryospheric Program/Studies with ICESat-2
Total Award Period Covered: 05/23-04/26
Person-Months Per Year Committed to the Project: 3.0

Support: ☐ Current ☒ Pending
Project/Proposal Title: Spatio-Temporal Connections of Integrated Energy, Water and Biogeochemical Processes Across Alaska's Land and Ocean Ecosystems
Role: Co-I
Source of Support: NASA Interdisciplinary Research in Earth Science
Total Award Period Covered: 6/23-05/26
Person-Months Per Year Committed to the Project: 1.2

Support: ☐ Current ☒ Pending Project/Proposal Title: High-resolution Extreme Event and Localized Temperature for Health Forecasting in Under-served Lowlands of the Gulf Coast (HEELTHFUL-GC) Source of Support: NASA Interdisciplinary Research in Earth Science Total Award Period Covered: 07/23-06/26 Person-Months Per Year Committed to the Project: 3.6/2.4/1.8
Support: ☐ Current ☒ Pending Project/Proposal Title: Ancient Climate Change Resilient but Understudied Enset agrifood system Diversity Mapping for Food Security and Sustainability (ACCRUED-MFSS) Role: Co-I Source of Support: NASA Commercial Smallsat Data Scientific Analysis Total Award Period Covered: 09/23-08/25 Person-Months Per Year Committed to the Project: 3.6
Support: ☐ Current ☒ Pending Project/Proposal Title: Application of Commercial Smallsat Data to Enhance Flood Resilience in Support of Under-served Communities in Puerto Rico Role: PI Source of Support: NASA Commercial Smallsat Data Scientific Analysis Total Award Period Covered: 10/23-09/25 Person-Months Per Year Committed to the Project: 2.4

Section 7.0: Statements of Commitment and Letters of Support

DEEPSOUTH CENTER FOR ENVIRONMENTAL JUSTICE

9801 Lake Forest, Blvd
New Orleans, LA 70127
(504) 272-0956
www.dscej.org

March 21, 2023

Dr. Nathan Morrow
Tulane University School of Public Health and Tropical Medicine
1440 Canal St, Suite 2200
New Orleans, Louisiana, 70112

Dear Dr. Morrow,

It is with pleasure that I provide this letter of support for your proposal entitled "Analysis of Locally Flooded Areas with Environmental Justice Communities (**ALFA-EJC**)." Funding opportunity A.44 COMMERCIAL SMALLSAT DATA SCIENTIFIC ANALYSIS -- NNH22ZDA001N-CSDSA)." As the executive director of the Deep South Center for Environmental Justice, I have experience engaging communities on issues related to environmental justice and policy. After review of your proposal, I believe this is an opportune time to leverage NASA open Earth science to address the adverse impacts of climate change on vulnerable communities.

Specifically, because of the vast array of environmental health inequities that are affecting the gulf coast. The mission of the Deep South Center for Environmental Justice is to improve the lives of children and families harmed by pollution and vulnerable to climate change in the Gulf Coast Region through research, education, community, and student engagement for policy change. I firmly believe that this landscape analysis will be a starting point to jumpstart the use and integration of community engaged methodologies and environmental health data to improve the quality of life of our constituents.

I acknowledge that I am identified by name as Collaborator to the investigation, entitled "Analysis of Locally Flooded Areas with Environmental Justice Communities (**ALFA-EJC**)," that is submitted by Dr. Nathan Morrow to the NASA funding announcement**,** NNH22ZDA001N-IDS Interdisciplinary Research in Earth Science**,** and that I intend to carry out all responsibilities identified for me in this proposal. I understand that the extent and justification of my participation, as stated in this proposal, will be considered during peer review in determining in part the merits of this proposal. I have read the entire proposal, including the management plan and budget, and I agree that the proposal correctly describes my commitment to the proposed investigation." To conduct work for this investigation, my participating organization is the Deep South Center for Environmental Justice.

I am thrilled at the prospect of this work and am happy to endorse and give this my full support. If there is any additional information you need from me, please do not hesitate to ask and I'd be happy to assist as best as I can.

Sincerely,

Beverly Wright

Beverly Wright, Ph.D.
Executive Director

UNIVERSITY OF
MARYLAND
EARTH SYSTEM SCIENCE INTERDISCIPLINARY CENTER
Office of the Director

5825 University Research Court, Suite 4001
M Square Building
University of Maryland
College Park, Maryland 20740
TEL (301) 405-0050 FAX (301) 405-8468

Letter of commitment

Date: March 14, 2023

To: Dr. Nathan Morrow, Tulane University
From: University of Maryland, ESSIC
Subject: Statement of Commitment from Department

Dear Dr. Morrow

I acknowledge that Dr. Jordan Borak is identified by name as a Collaborator to the research proposal entitled: "Analysis of Locally Flooded Areas with Environmental Justice Communities (ALFA-EJC)" that is submitted by Tulane University to NASA in response to the NASA Roses Commercial Smallsat Data Scientific Analysis NNH22ZDA001N-CSDSA. Dr. Borak intends to carry out all responsibilities identified by Tulane University in this proposal.

Sincerely,

Ellen D. Williams

Dr. Ellen Williams,
Director, Earth System Science Interdisciplinary Center (ESSIC)

TENNESSEE STATE UNIVERSITY
College of Liberal Arts
3500 John A. Merritt Blvd.
Nashville, Tennessee 37209-1561
Department of History, Political Science, Geography & Africana Studies
(615) 963-5497 (FAX)
(615) 963-5471

March 23, 2023

Dr. Nathan Morrow
Tulane University School of Public Health and Tropical Medicine
1440 Canal St, Suite 2200
New Orleans, Louisiana, 70112

Dear Dr. Morrow,

I am writing this letter in support for your project entitled "Analysis of Locally Flooded Areas with Environmental Justice Communities (ALFA-EJC)." Funding opportunity A.44 COMMERCIAL SMALLSAT DATA SCIENTIFIC ANALYSIS -- NNH22ZDA001N-CSDSA)."

For at least the past five years, I have provided technical assistance through the Deep South Center for Environmental Justice (DSCEJ) for environmental justice and community-based organization (CBO) stakeholders on issues related to your project, including:

- Stakeholder training in geoscience and cartography in support of strategies to mitigate the negative impacts of landfills upon the hydrologic ecosystems in the Wedgewood Community in Pensacola, Florida.
- Community-based participatory asset mapping and hydrological data analysis in support of community legal actions versus a proposed inland port facility that threatens the quality of life in the historic Turkey Creek community in Gulfport, Mississippi.
- Geographic information systems (GIS) training in support of a community-based flood mitigation program in New Orleans' Lower Ninth Ward.
- Leading community-based organizations in the DSCEJ "Gulf Waters Justice Training Institute" (GWJTI), a six-week series of workshops designed to enhance tropical storm and flooding preparedness and mitigation

I acknowledge that I am identified by name as Consultant to the investigation, entitled "Analysis of Locally Flooded Areas with Environmental Justice Communities (ALFA-EJC)," that is submitted by Dr. Nathan Morrow to the NASA funding announcement, NNH22ZDA001N-IDS Interdisciplinary Research in Earth Science, and that I intend to carry out all responsibilities identified for me in this proposal.

I accept the daily consulting fee of 550 USD for 23.6 days of work for a total fee of 13,000 USD.

I understand that the extent and justification of my participation, as stated in this proposal, will be considered during peer review in determining in part the merits of this proposal.

I have read the entire proposal, including the management plan and budget, and I agree that the proposal correctly describes my commitment to the proposed investigation."

If you need any further information from me, please contact me at dpadgett@tnstate.edu or 615.258.3657

Cordially,

David Padgett

David A. Padgett

Section 8.0: Budget

Section 8a. Budget Narrative:

Senior Personnel
Dr. Nathan Morrow as PI will provide 0.15 FTE. He is accountable for grant implementation, compliance, risk management and reporting, quality and timeliness of all deliverables, implementation of the DMP, responsive communication, and reporting to NASA and all stakeholders. Dr. Morrow will manage collaboration, GitHub sites. Dr. Morrow will take the technical lead on all spatial analysis and mapping sub-tasks. Accountable for all milestones, he ensures inclusive and equitable contributions to collaborative deliverables including publications, open science and reports in following Milestone Schedule. The base salaries applied to this budget reflect the actual salaries and include a 3% anticipated increase per year.

Fringe Benefits
Tulane's fringe rates include health insurance, FICA, unemployment, workers' compensation, retirement, terminal leave payout and employee assistance. Amounts for the sponsor's contribution to employee fringe benefits are calculated using Tulane's U.S. Department of Health and Human Services (DHHS) approved Fringe Benefit Rates effective August 30, 2022. The approved rates are as follows: XX% for Faculty and XX% for students.

Consultant: Dr. Padgett is a professor at Tennessee State University and established NASA investigator will be hired as a consultant to provide expert participatory and dynamic facilitation of community engagement. The consultant rate was determined by the field competition, past consulting fee history on a similar NASA funded grant and an average rate was derived. The total cost for consultancy is provided in the NSPIRES cover page and does not include any other costs than Dr. Padgett's time. $XX in year 1 and $XX in year 2.

Travel
Site visits in project Year 1 to four sites allow Dr. Morrow to work with the communities Establish patterns of clear sky and precipitation event flooding at EJ study sites. Site visits in the second project year will allow Dr. Morrow to support the annual planning meetings and community meetings on flooding monitoring. Total: $8,000.

Total Direct Costs
Direct costs are $XX in Year 1, and $XX in Y2. Total direct costs: $XX.

Subawards

Deep South Center for Environmental Justice:

> Deep South Center for Environmental Justice was selected as a Subcontract candidate due to the expert work in integrating participatory methods in environmental justice work and expertise of developing EJ Community capacity to engage with Earth and social science. They were also selected for their reputation for agile high quality community collaboration. DSCEJ will facilitate direct support for community partners and community organizations that from their extensive CJ&EJ networks across the region. DSCEJ will dedicate experienced personnel to the project's Communiversity-modeled activities. Dr. Beverly Wright, CO-I and Institutional PI supported by DSCEJ staff, is accountable for

the fidelity of the proposed activities and deliverables to the principles of Communiversity and will contribute directly to engagement with communities. Dr. Wright will be co-lead author of all peer-reviewed manuscripts and other major communications.

The sub-award will be spent on engagement of community partners to engage their communities: $28,000 in year 1 and $28,000 in year 2.

$0 will be spent from sub-contract on open access publishing fees.

Indirect Costs. Deep South Center for Environmental Justice had an indirect rate of XX%. $XX in year 1, $XX in year 2.

Total Subaward: $XX.

University Of Maryland:

Personnel salaries and benefits are requested for the UMD personnel who will be performing this research as described in the proposal narrative. The Senior/Key Personnel are as follows: Dr. Jordan Borak, Associate Research Scientist (FTE of .20 person-months per year).The base salaries applied to this budget reflect the actual salaries set forth by our institution and include a 3% anticipated escalation per year.

Fringe benefits include health insurance, FICA, unemployment, workers' compensation, retirement, terminal leave payout and employee assistance. Amounts for the sponsor's contribution to employee fringe benefits are calculated using UMD's U.S. Department of Health and Human Services (DHHS) approved Fringe Benefit Rates effective July 1, 2022. The approved rates are as follows: X% for Faculty, XX% for Staff, XX% for Graduate Assistant and XX% for Contractual Faculty/Staff, hourly students, and most Faculty/Staff additional pays. Tuition Remission is a UMD fringe benefit but is not included in the fringe calculation and is budgeted separately as applicable. Additional information about fringe benefits can be found at: https://ora.umd.edu/resources/benefits-stipends. The Fringe Benefit Rate Agreement can be found at: https://ora.umd.edu/resources/fa. Fringe rates may be renegotiated and adjusted in future years.

Travel funds are requested in the amount of $5,000 ($2,500 per year) for the PI to attend one Annual Team Meeting, in each year of this project for the purpose of collaborating with colleagues and co-creation of research findings. Dr. Borak will also participate in joint field work with communities in study sites. The standard travel cost estimates below are based on the average expenses reported by department faculty for similar activities in previous fiscal year. All travel costs are budgeted in accordance with UMD, state, and federal policies and are estimated based on historical averages, UMD per diem rates (domestic travel, only) and current gsa.gov rates. Please note that this travel is contingent upon COVID-19 regulations imposed at the state and federal level.

Yr 1: Team Meeting and Joint Field Work, New Orleans & Gulf Coast, LA: $2,500
Yr 2: Team Meeting and Joint Field Work, New Orleans & Gulf Coast, LA: $2,500

Indirect Costs
The University of Maryland's established indirect cost rate for research conducted off-campus is 27.5% of Modified Total Direct Costs (MTDC). The MTDC base excludes

tuition remission, equipment over $5,000, rental costs of off-campus facilities, and the portion of individual subcontracts over $25,000. This rate has been approved by the cognizant government agency, Department of Health, and Human Services. This rate was approved on June 23, 2022 and is effective until amended. Any questions should be referred to the Office of Research Administration (301) 405-6269 or oraa@umd.edu.

Total Subaward: $XX

Indirect Costs

The Negotiated Indirect Cost Rate Agreement for Tulane University is XX%. Indirect costs are $XX in Y1, and $XX in Y2. Total indirect costs: $XX.

Total Direct and Indirect Costs

The total budget for 2 years is $XX.

Section 8b. Budget details

*As per ROSES guidance, all cost for people including salary, benefits, overhead or totals have been removed.

Tulane		**Year 1**	**Year 2**	**Total**
	Personnel			
	Faculty - Morrow - .15 LOE	X	X	X
	Graduate Students	X	X	X
	Fringe Benefits			
	Faculty (XX%)	X	X	X
	Students (XX%)	X	X	X
	Subtotal Personnel	X	X	X
	Consultants (Dr. Padgett)	X	X	X
	Travel - 4 sites 1/yr			
	Ground transport	1,600.00	1,600.00	3,200.00
	Hotel	1,600.00	1,600.00	3,200.00
	Meals & incidentals	800.00	800.00	1,600.00
Total Direct Costs - Tulane		X	X	X
F&A (indirect) Tulane (XX%)		X	X	X
Subawards				
DSCEJ				
	Community partner engagement			
	Open access publication costs	-	-	-
	Total Direct	28,000.00	28,000.00	56,000.00
	F&A (Indirect) DSCEJ XX%	X	X	X
	Subtotal	X	X	X
	F&A (Indirect) Tulane XX% (<=25k)	X	X	X
	Subaward Total	X	X	X
UMD				
	Personnel			
	Faculty - Borak (.2 yr1, .15 yr 2)	X	X	X
	Fringe Benefits (XX%)	X	X	X
	Subtotal Personnel	X	X	X
	Travel - Annual Meeting (N.O.)			
	Airfare	500.00	500.00	1,000.00
	Hotel	1,000.00	1,000.00	2,000.00
	Ground and meals	1,000.00	1,000.00	2,000.00
	Total Direct	X	X	X
	F&A (Indirect) UMD XX%	X	X	X
	Subtotal	X	X	X
	F&A (Indirect) Tulane XX% (<=25k)	X	X	X
	Subaward Total	X	X	X
	Total Direct	X	X	X
	Total Indirect	X	X	X
Total Project Cost		X	X	X

Section 9. Table of Work Effort

Work Effort

Name	Role	Commitment (months per year)								
		Year 1			***Year 2***			***Sum***		
		This Project		*Other Funded Projects*	*This Project*		*Other Funded Projects*	*This Project*		*Other Funded Projects*
		NASA Support	*Total*		*NASA Support*	*Total*		*NASA Support*	*Total*	
Nathan Morrow	PI	1.8	1.8	0	1.8	1.8	0	3.6	3.6	0
Jordan Borak	Co-I	2.4	2.4	3.0	1.8	1.8	3.0	7.2	7.2	0
Sum of work effort:		**4.2**	**4.2**	**3.0**	**3.6**	**3.6**	**3.0**	**7.8**	**7.8**	**6.0**
Comments: Dr. Beverly Wright is the director of the Deep South Center for Environmental Justice and she supports the project in that capacity rather than direct costs that will be dedicated to specific project engagement activities.										

Section 10. Facilities and Equipment:

Tulane will provide facilities for workshops and meetings at no direct cost to the project. Facilities include the state-of-the-art research, education and outreach amenities of the River and Coastal Center offered by the ByWater Institute at Tulane. The TRCC opened in 2016 and features laboratories, offices, and a public meeting space with views of the Mississippi River. The building is managed by the ByWater Institute, but scholars can use the meeting space for programming relevant to the TRCC mission. The Tulane River and Coastal Center is available for exhibitions, classes, demonstrations, shows, receptions, meetings, and/or conferences that relate to the mission of the ByWater Institute. The Forum is 1400 square feet with flexible seating and views of the Mississippi River. The Selley Foundation Room is 200 square feet with fixed conference seating and views of the river

Ancient Climate Change Resilient but Understudied Enset agri-food system Diversity Mapping for Food Security and Sustainability (ACCRUED-MFSS)

Section 1.0: Table of Contents

Section 2.0: ACCRUED-MFSS Scientific Objectives, Technical Approach and Management

Section 2.0: Scientific Objectives, Technical Approach and Management

2.1 Specific Relevance to Program Element A.44 CSDA, ESD Agriculture & Climate Resilience programs

Ancient Climate Change Resilient but Understudied Enset agri-food system Diversity Mapping for Food Security and Sustainability (ACCRUED-MFSS) is a standalone project to leverage remote sensing assets of CSDA but will immediately contribute to the Earth Science Division (ESD) Applied Science Program (ASP) on Agriculture and the specific program priorities of Food Security and Protecting Livelihoods. The ESD ASP promotes measurable social benefit from NASA research and information products with the aim to improve decision making and related policy solution implementation. Understanding the role of agricultural diversity in addressing climate change resilience of the global agri-food system is a high priority research area. The greatest opportunity for major advances are in research areas relevant to food security and resilient livelihoods are often least studied. Neglected or 'orphan' crops still play a major role in food security for millions and may hold the genetic and cropping diversity that will underpin agri-food system resilience under climate change. Increasing, studies identify these types of traditional crops as 'future smart foods' that are nutritious and resilient to climate change (Adhikari et al., 2019). Our project team includes researchers from Kew Royal Botanical Gardens and the University of Addis Ababa that have collected meticulous farm level data that will provide more than >2500 ground truth sites to calibrate remote sensing of this unique staple crop.

Ethiopia has historically been the world's largest recipient of targeted food aid, yet little food-insecurity has been reported for the enset-growing southern Ethiopian highlands even during the devastating famines of the 1980s (Dessalegn, 1996). Today, the agricultural systems of the southern Ethiopian highlands successfully support one of the highest rural population densities in Africa and enset is the main staple for more than 20-million people (Borrel et al. 2020). Here, we propose to investigate the landscape scale dynamics, interactions and resilience of these agri-food systems leveraging CSDA data to map crop extent, management practices, and diversity. We will analyze how this may have changed due to threats from climate change-related drought, disease, and land use change whilst continuing to provide food security for a growing Ethiopian population – predicted to reach 172 million by 2050.

2.2 ACCRUED-MFSS Research Objectives

CSDA assets provide an unprecedented opportunity for research on crops that are understudied because they have complicated cropping patterns or grown in gardens that are difficult to distinguish with lower resolution remote sensing. A fundamental question in the evolution of domesticated plants is the extent to which genetic diversity and diversification is driven primarily by environment or culture over time. Vegetatively propagated crops in indigenous agri-food systems lend themselves to such evolutionary assessment as clonally propagated lineages are tightly coupled with cultural traditions and likely to acquire new diversity gradually (e.g. through somatic mutations and structural variation). Using enset, a clonal propagated Ethiopian crop, we will explore

questions of diversity and adaptation to local environmental factors and cultural preferences that are the foundations of food security and agri-food system resilience.

Figure 1:Co-Investigator Dr. Borrell pictured with stand of giant false banana enset plants

Three ACCRUED-MFSS Science Objectives (SOs) are SMART – Specific, Measurable, Attainable, Relevant, and Time-Bound – and call for specific tasks:

SO 1: Map where enset grows within identified study sites at farm relevant scales to inform species distribution models and improve reporting of national production that do not currently use extensive observational data. Using CSDA high resolution data together with ground truth data that we already have (>2500 points), demonstrate observation-based mapping at scale of enset to be tractable for the first time.

SO 2: Identify change and relation to diversity – Map how small and non-standard Enset fields have changed over the 5-year study period. These will be compared to *in situ* measures to investigate diversity, food security and livelihoods.

SO 3: Detect yellowing and other forms of stress – Indicators of enset drought-resistance are not currently based on remotely sensed observations and this research will seek to identify yellowing and other signs of drought stress by combining remote and in situ observations.

2.3 Expected contributions to enset agri-food system knowledge from synoptic analysis of integrated ground truth and high resolution remotely sensed observations

Enset agri-food systems have received little research attention. There are practical limitations such as difficulty in access to enset areas or the physical difficulty of destructive sampling of such large plants to measure biomass. Although there is great diversity in phenotypes and planting systems, observations are typically limited to those farms closest to exiting hard top roads. Therefore, production of enset is extrapolated from limited sampling and is a gross estimation for such a large and diverse crop.

The contributions of this research may progress basic questions of this ancient, important and potentially climate change resilient crop. ACCRUED-MFSS will:

- As a first contribution, have produced observation based estimates of the extent of enset and the extent of enset on farms.

- As a second contribution, have improved understanding of the prevalence of enset monoculture, mixed cropping, and diversity.

- As a third contribution, have explored the possibility of texture and timeseries data to detect enset age and transplanting rotation system.

- As a fourth contribution, have improved understanding of where enset farming or enset farming practices are undergoing change.

- As a fifth contribution, have assessed the ability to detect stress from drought or disease in enset stands using remote observation. If stress can be detected, then extent and range of enset stands under stress might inform urgent action and prioritize locations for further research or intervention.

There greater import of this work may be more generally in supporting research into orphan and traditional crops with the new capabilities of high resolution CSDA data. Diversity is the key to resilience, and CSDA research may provide new insights into these understudied but largely sustainable and notably resilient agri-food systems.

2.4 Enset farm data to ground truth and calibrate remotely sensed measurements

Kew Royal Botanical Gardens' team led by Co-Investigator Dr. Borrel and Ethiopian researchers led by Dr. Wendawek at Addis Ababa University have recorded enset characteristics at >2500 independent farms. Area and distribution of enset has been measured at >1200 of these farms. They have used the data for create a geobiome niche model of Enset distribution. This is possible because of the large amount of geolocated data of Enset plots associated with farms from across virtually the entire distribution of enset. A significant field campaign recorded Enset along elevational transects. Each of the eight replicated transects are between 20-40km long. These

transects encompasses a great deal of the climate and edaphic variation that will be advantageous to calibrating measurements retrieved by remote sensing.

Where enset is grown as a monoculture, altitude can be useful in discerning and separating out classification of banana stands. The mix of other crops with enset increases further out from the center of enset cultivation in Gurage and towards the south. Secondary data from agricultural surveys such as the Ethiopian Socio-economic survey can be used to support analysis of place specific mixed cropping patterns.

The enset knowledge and expertise working in enset regions accessible through the Co-Is and their institutions is unmatched. They have sequenced over 700 Enset landraces and have decades of experience working with enset farmers. Working with farmers, the have catalogued the signs of stress and shock to enset: yellowing for drought; brown for frost damage; and further yellowing for bacterial wilt. This knowledge can be put to work for the first time on a synoptic data set at the resolution necessary to begin quantifying these stresses and shocks across the enset growing region while at the same time assessing the capability for remote observation of these resilience threatening changes.

2.5 CSDA Earth observations for analysis and mapping

ACCRUED-MFSS' technical approach will leverage **CSDA Earth observations** to analyze and map enset extent, diversity and signs of stress. Furthermore, high-resolution measurement of diversity and change will reveal highly localized patterns that may be lost in current remote sensing. Previously approaches, that had lower spatial resolution cannot observe change in the relatively small enset plots. CSDA data at applicable scales to be integrated with *in situ* farm level measurements have not previously been processed and made available to botanists and agricultural scientists working on this understudied crop.

Drones are tightly regulated in Ethiopia. Receiving import permission of imaging drones has proven unsuccessful for several years. The licensing and permission to fly drones is still under policy discussion thus leaving researchers with a great deal of uncertainty and possibility of unintentional violation of local drone use norms. An alternative to drones is necessary to address the current lack of observational data on this significant staple crop.

Small and irregular agriculture plots are the norm in many traditional agri-food systems. These fields are not visible in sensors that may have daily return views but spatial resolutions of greater than 250 meters. Recognizing boundaries of irregular fields pose problems even for 30-meter resolution NDVI data from Landsat and Sentinel-2 data.

Figure 2: Drone image of enset farm in Gurage Ethiopia

By exploiting the high spatial resolution of Maxar Worldview and the higher temporal return views of Planetscope, researchers successfully delineated boundaries of traditional farming plots that were less than one hectare in size (Cheng et al., 2020). After the period of peak senescence, potential plots were identified using a spatial segmentation approach on Worldview data. Planetscope-derived NDVI was then used in a temporal series to delineate plots growing different plants or under different agricultural rotations.

NDVI is expected to allow not only spatial delineation of the field boundaries, but to provide additional information about plant status and vegetation vigor. We have a high confidence that NDVI from PlanetScope data will be readily interpretable. Houborg and McCabe (2016) found that NDVI calculated from PlanetScope data was correlated at R^2 of 0.97 with simultaneous overpass of Landsat 8. Particularly for monitoring, we will seek index related approaches that give best results beginning with the Normalized Difference Vegetation Index (NDVI) to characterize vegetation dynamics and drought effects (Anyamba, Tucker & Eastman, 2001).

Using requested NASA High End Computing (HEC) resources, United States university-based researchers will lead acquisition and processing of the datasets into formats that can be used with high resolution field measurements. Table 1 lists CSDA remote sensing data inputs to be used. A time series of at least 5-years of cloud free images at key moments in the agricultural calendar will be used to identify patterns of change and diversity.

Table 1: Satellite data products employed in support of back-casting activities.

Source	Relevant spectral bands	Expected Distribution	Spatial	Temporal
Planet -- PlanetScope	**Primary for enset detection:** Near infrared, green panchromatic, yellow	16-bit Geo Tiff	3 meter	1-day
Maxar – Worldview (1-4)	**Primary for plot detection:** Near infrared1, Near infrared2, green, panchromatic	11-bit	0.31m panchromatic 1.24m spectral	Varies

Supervised classification approach to CSDA image processing is possible due to the abundance of ground truth data available in our enset farm survey. This is a unique opportunity to train a classifier on such a large set of irregular, complex, and small farm plots. ***Our methodology makes highly efficient use of resources because expensive filed work for collecting ground truth data is already available through collaborators.***

Analysis Step 1: create a training data set from >1200 geolocated farm sites with area estimates for enset**.** We propose to build on the approach to identification and segmentation of enset farm plots following on the methods of Cheng et al. (2020) to create a highly accurate enset map that can be used to train a subsequent supervised classification. This will require:

1. Identification of cloud free Maxar Worldview at the beginning and end of the growing season when field measurements were recorded. With >1200 measurements, we expect that we will have a sufficient number of sites to increase chances of cloud free views.
2. Edge detection segmentation for surveyed farms in cloud free views will proceed with automated detection and followed by on screen digitization of plots as necessary
3. Beginning with a set of monthly cloud free PlanetScope views, we will calculate changes in NDVI for each identified plot on the surveyed farms with identified field boundaries
4. Using the ground truth survey data, we will automate matching as possible but manually assign field characteristics for enset and mixed crops as necessary. We will then visualize and inspect matching of the phenological pattern evident in the time series of PlanetScope NDVI at plot level
5. This training data will be validated against the sub set of the >1200 farm surveys that were not sufficiently cloud free in Maxar but have PlanetScope views
6. Assessment of training set type 1 and type 2 errors will inform next steps for improving training data precision and accuracy

A process of on-screen digitization and supervised classification has been completed for selected enset growing communities using imagery taken by drones (see Figure 3). We seek to expand the scale to answer fundamental questions about enset distribution with the use of Maxar WorldView and PlanetScope data.

Figure 3: Multiple fields with plants of different ages on single farms demonstrate complex transplanting pattern of enset cultivation

Analysis Step 2: supervised classification of the >2500 farms geolocated and surveyed based on phenological signatures of the training data set**.**We propose to use supervised classification packages available in the open source software R. Our research team also has experience in custom coding in C and Python to handle any data management, data preparation or adjustments to classifier algorithms. We begin with tried and true Decision Tree classifiers following Friedl and Brodley (1997). PI Morrow co-authored a paper with Friedl in 1998 using a different modeling approach (see biosketches in section 4). Steps for supervised classification include:

- Select a set of training sites representative across image to be classified
- Extract pixels representing desired classes (eg pure mature enset, enset nursery, mixed cropping, …)
- Train classifier based on samples
- Classify the image
- Evaluate the classification. Possible sources of error may be introduced from numerous sources but special attention will be given to discrepancy between training and classified images due to angle viewing effects in PlanetScope data

Derived products including the classified images will now be shared with collaborators at Key Royal Botanical Gardens and University of Addis Ababa. They would proceed with calculating diversity measures and indexes. They will also interpreted the classifications with respect to their farm survey data sets and extrapolate estimations of enset diversity and quantity. Tulane University Export control officer will advise.

Analysis Step 3: assessment of change over time. Supervised classification will be completed for a sub-set of farms with cloud free images that allow for detection of change at two time periods 3-5 years apart. Detecting change for small and irregular plots is more complicated that identifying large scale change in broad landcover

classes. Therefore, the objectives of this analytical step are more modest and will cover a limited area of the study site. We will:

- Assess the ability to detect change in small and irregular plots from two classified images for ~50 farms.
- If change detection is unexpectedly successful with classified images, the team will proceed to map change throughout the study site
- If classified image change detection produces poor results, we will proceed with identifying plots in the training data using Worldview and PlanetScope data. Comparison between classified image change detection and chance detection following the training data set plot identification method will be analyzed and documented for reporting or publication

Analysis Step 4: stress and shock assessment to identify patterns of yellowing in enset stands. We will compare vegetation indexes to identify which index may be best at identifying stress from drought or disease in enset stands. We will compare results of indexes with available ground truth data for:

- Enhanced NDVI (ENDVI)
- Normalized Difference Red Edge
- Vegetation Condition Index
- Other index combinations using PlanetScope's eight bands including Yellow (610nm) and Red Edge (705nm)

Analysis Step 5: pilot test algorithms to identify individual enset 'trees'.We are inspired by the work, published recently in the journal Nature, by Tucker, Brandt and their team to estimate the number and carbon content of individual trees in semi-arid areas of Africa (Tucker et al., 2023). Time and resources permitting, we will pilot algorithms to identify individual enset 'trees'.

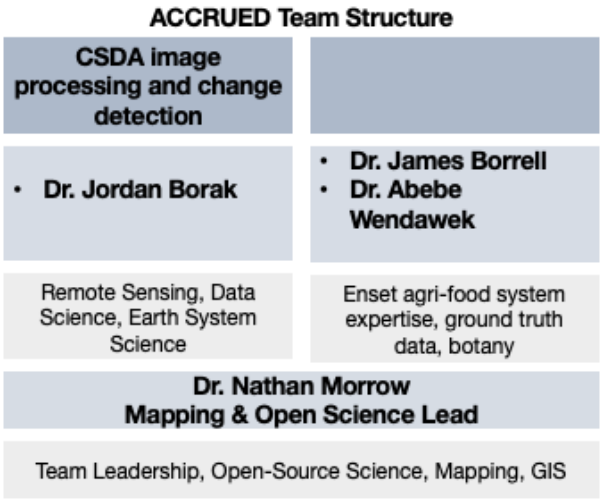
2.6 Open Source Software and Hardware

ACCRUED-MFSS is committed to every aspect of Open Source Science and will only use open source software. The open source code/data for image classification, change detection, and available from their GitHub site. ACCRUED-MFSS will also have a GitHub site and use the Zenodo folder 'Enset Research' for archiving and sharing research outputs. Modeling will primarily be conducted in R, Python and other open source languages will be used as necessary to manipulate data. All scripts will be posted. Jupyter notebooks will be piloted for potential future frontline researcher or community engagement. Computing hardware requirements are minimized as most data processing will be conducted through requested NASA HEC resources. University computing resources and available departmental IT support and equipment are sufficient for all other tasks.

2.7 Resilience and robustness of ACCRUED-MFSS

Potential pitfalls for ACCRUED-MFSS related to uncertainty and error are largely counterbalanced by a very experienced team of researchers supported by leading institutions. CSDA data has not been used in enset agri-farm systems and the unique shape and structure of enset stands may pose challenges due to viewing angle and bidirectional reflectance. Dr. Borak did his PhD. on these issues. The team as a whole has a broad and diverse toolkit for managing research challenges. For example, if the HEC request is not approved, the team has necessary skills for data processing with Google Earth Engine. The team has >100-years of combined data analysis and applied research experience. Travel restrictions due to health or security concerns may require meetings and research convenings to be held virtually and the PI recent experience in leading online teams. ***Special capabilities and facilities*** include the extensive botanical research into enset at Kew, agri-food systems applied research community led by Addis Ababa University, UMD's leading expertise in terrestrial remote sensing as well as Tulane's Export Control Officer and R-1 administrative support will ensure compliance that may be complicated for working with CSDA assets.

2.8 Management structure



The ACCRUED-MFSS management structure aims to encourage collaboration enabled by technology (Ramachandran, Bugbee & Murphy, 2021) with clear shared objectives, empowered leadership of sub-teams, and easy exchange through advanced digital tools for inclusive communication. Implementing an interdisciplinary project requires active and engaged project leadership with regular team communication and directed reflection. ACCRUED-MFSS brings together investigators that work at different time and spatial scales as well as with different disciplinary tools and methods. To balance interdisciplinary interaction with research efficiency, tasks and sub-tasks will be assigned to sub-teams led by a Co-Investigator with the PI participating in all of the teams' work planning and task result monitoring. Furthermore, the PI is responsible for promoting necessary cross-team interaction, monitoring dependencies, open science, and further interdisciplinary co-creation tasks and results. Quarterly virtual all team meetings, annual workplanning, and PI/Co-I business meeting focused on reporting project progress will provide necessary collaborative discourse. Dependencies, emerging challenges, co-created cross-learning and solutions from virtual/face-2-face team interaction will be used to monitor workplan and share with NASA.

In the third quarter of project year one, Dr. Morrow and Dr. Borak will travel for a research team meeting at Kew Royal Botanical Gardens outside London UK. The purpose of this meeting is to review the classified image derived products against Kew Researchers' ground truth data in an intensive workshop. This should result in a fully

validated product by Kew's team of enset experts. We will also prepare annual reports on research progress to date and conduct workplaning for project year 2. Travel to Kew Royal Botanical Gardens outside London UK in project year 2 will proceed with a Kew enset expert validation of the change and stress products. The team will also prepare for final reporting and publication and DMP plan completion. In the fourth quarter of project year 1, Dr. Morrow will travel to Addis Ababa to validate products with collaborator Dr. Wendawek and Ethiopian enset researchers. In these meetings, we will engage with enset researchers at institutions through out the country and seek meaningful opportunities for collaborating on publications, planning future research to build on derived ACCRUED-MFSS products, and engaging in policy processes. The travel in project year two has similar purposes with validation and encouraging use and impact of the change and stress products. Both engagements in Ethiopia will contribute to required reporting and promote use of the research products – leading to the greater contribution to applied science benefits for those living in enset growing areas.

2.9 Foreign participation and compliance with U.S. export laws and regulations

The majority of CSDA Planet and Maxar data will be processed within the NASA High End Computing (HEC) environment. As required, Dr. Borak or Dr. Morrow may produce a RGB, monochromatic or false color image from Maxar or Planet data to spot check classification results or resolve classification conflicts using a Geographic Information System overlay. This use of data would be only undertaken within the secure university computing environment or on their own secure personal computers. Only derived products would be shared with Co-Investigators Dr. Borrell or Dr. Wendewek. Only derived products would be presented during annual meetings of the research team in London and Addis Ababa. The Tulane University Export Control officer will be regularly consulted and included on communications to ensure compliance with regulations. Specifically, the roles and location for handling CSDA data will be:

- Dr. Borak – within HEC and UMD computing environments. He will ensure only derived products and no raw data is transported on any personal devices when he travels to team meetings in London.
- Dr. Morrow – may also engage with raw data within the HEC environment. He will occasionally create overlay images from raw CSDA data for use in improving supervised classifications within the Tulane University computing environment and a secure personal workstation. He will only share or present derived products with foreign collaborators. No raw data will be present on his personal computing devices during annual meetings in London or Addis Ababa.
- Dr. Borrel will only work with supervised classification results and related derived products. His collaboration does not require use of any raw data.
- Dr. Wendawek will only work with supervised classification results and related derived products. His collaboration does not require use of any raw data.

Dr. Morrow is responsible for full compliance with the EULA for Planet and Maxar data. He has already corresponded with the NASA CSDA team that assured him

> "Data access is restricted to US Government funded researchers (https://www.earthdata.nasa.gov/esds/csda/csda-faq). Derived products may be shared without restrictions however the raw data would not be accessible to them".

With regard to **Export Controls**, it is understood that this proposed research is subject to United States laws and regulations controlling the export of technical data, computer

software, laboratory prototypes and other commodities, articles, and information, including the Arms Export Control Act as amended in the Export Administration Act of 1979, and that the parties' obligations are contingent upon compliance with applicable United States export laws and regulations, including the International Traffic in Arms Regulations (ITAR; 22 CFR Parts 120-130) and the Export Administration Regulations (EAR; 15 CFR Parts 730-774). The transfer of certain technical data and commodities could require a license authorization from an agency of the United States Government and/or written assurances by Licensee that Licensee shall not export data or commodities to certain foreign individuals/countries without prior approval of such agency. Tulane represents neither that a license is not required nor that, if required, it can obtain approval.

2.10 Outcomes and primary tasks of task identified personnel

ACCRUED-MSFF will produce a series of novel data and mapping for the understudied enset with coordinated research activites over two project years (see Milestone Schedule in section 2.11). The primary output is novel classification product using CSDA data to demonstrate an approach to mapping enset extent, shape and size of fields. Data integration with a >2500 point *in situ* data set of enset botanical, farm system and farming household food security and resilience will inform both the classification and the interpretation of results. In the second year, these data will be interrogated to better understand the ability to detect diversity and change in enset stands. Analysis of the relation of diversity and change related to food security and resilience indicators will then be undertaken. Finally, likely drought stress indicators will be identified based on multispectral data and ins situ measurements.

Dr. Morrow as PI is accountable for grant implementation, compliance, risk management and reporting, quality and timeliness of all deliverables, implementation of the DMP, responsive communication, and reporting to NASA and all stakeholders. Dr. Morrow will manage collaboration, GitHub sites. Dr. Morrow will take the technical lead on all spatial analysis and mapping sub-tasks. Accountable for all milestones, he ensures inclusive and equitable contributions to collaborative deliverables including publications, open science and reports in following Milestone Schedule.

Dr. Borak's research responsibilities will focus on processing CSDA data and generating satellite-derived classifications and data products in the HEC environment. He will oversee and implement the training of the classifier, classify images, and conduct stress and change analysis. In addition to detailed documentation of all procedures and codes used and all datasets generated, overall summary of satellite data characteristics over the study area and a set of specific lessons learned will be posted following the DMP.

Dr. Borrel will contribute to data integration with 2500+ field observation of enset gardens and related livelihood, food security and agri-food system indicators. He will lead analysis and documentation of results related to enset botanical traits, environmental and cultural determinants of diversity. Together with the team, he will assess the quality and significance of deliverables for answering enset-related science questions about agri-food system resilience and sustainability.

Dr. Wendawek will convene and communicate with enset researchers in Ethiopia and around the world to multiply the impact of the research. He will contribute to validation and ground truthing of derived products. He will advise on publishing strategy and further articulation of research questions to ensure the highest levels of relevance.

2.11 Tentative Schedule of Research and Deliverables

Project Year 1: Enset extent mapping and integration of in situ data			
Q	**Milestone deliverable**	**Open science output**	**Reporting**
Q1	• Literature review focus on measuring, and analyzing enset diversity and climate change resilience	• Open Access Annotated Bibliography GitHub site	• Submit Work and Costing plan • Submit PY1 Q1 report
Q2	• *in situ* ground truth data set created for study sites • *Enset study site CSDA data parameters extracted and organized for extent mapping*	• Register open science plan for reproducibility	• PY1 Q2 report with some discussion of data quality
Q3	• Run multiple classification models based on training data set • Team meeting in London	• Open science badges PI/CO-I	• PY1 Q3 Report
Q4	• Quality control and selection of optimal enset extent mapping classifier • Data integration of in situ data and CSDA classification • Research meeting in Addis Ababa	• GitHub updated • Annual inclusion/DMP tasks	• Draft peer review manuscript • PY1 Annual Report
Project Year 2: Change, diversity and stress analysis			
Q	**Milestone deliverable**	**Open science output**	**Reporting**
Q1	• Change analysis based on extent map	• CJ & EJ community Open Science badge contest	• Share PY2 workplan • Submit PY2 Q1 report
Q2	• Diversity analysis on integrated data	• Community GitHub event	• PY2 Q2 report w/ monitoring overview
Q3	• Seek indicators for drought/disease stress based on *in situ* and CSDA measures. • London team meeting	• presentation at AGU • GitHub update • All documents to Zenodo	• PY2 Q3 Report
Q4	• Final lessons learned workshop in Addis Ababa	• GitHub updated • Annual inclusion/DMP tasks • Closing and reporting on all Inclusion and DMP Plan activities	• Final Tech/Financial Report • Draft peer review manuscript

3.0 References

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- Anyamba, A., Tucker, C. J., & Eastman, J. R. (2001). NDVI anomaly patterns over Africa during the 1997/98 ENSO warm event. International Journal of Remote Sensing, 22(10), 1847-1860.
- Borrell, J. S., Goodwin, M., Blomme, G., Jacobsen, K., Wendawek, A. M., Gashu, D., Lulekal, E., Asfaw, Z., Demissew, S., & Wilkin, P. (2020). Enset-based agricultural systems in Ethiopia: A systematic review of production trends, agronomy, processing and the wider food security applications of a neglected banana relative. *Plants, People, Planet*. *2*(3), 212–228. https://doi.org/10.1002/ppp3.10084
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- Friedl, M. A., & Brodley, C. E. (1997). Decision tree classification of land cover from remotely sensed data. *Remote sensing of environment*, *61*(3), 399-409.
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- 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
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- Wilkinson, M. D., Dumontier, M., Aalbersberg, I. J., Appleton, G., Axton, M., Baak, A., ... & Mons, B. (2016). The FAIR Guiding Principles for scientific data management and stewardship. *Scientific data*, *3*(1), 1-9.

4.0 Data management plan

Accountability for full implementation of the Data Management Plan (DMP) and ensuring full compliance to NASA DMP requirements lies with the Dr. Nathan Morrow as PI. He has extensive experience managing geographic and remotely sensed data for research and decision making. He has published peer reviewed articles on data for decision making (Mock, Morrow & Papendeick, 2012) has written and taught about data responsibility (Morrow, 2022), and recently was awarded a grant for increasing the use of Open Source Science for Environmental Justice.

End User License agreements for PlanetScope and Maxar Worldview describe how commercial data can be used by NASA researchers for Scientific Use research purposes as outlined in the research award agreement. Public Release or Commercial Use of the CSDA data is prohibited. Any raw imagery must be securely handled. Only derivative products with clearly defined research purposes are to be shared with the general public, used in publications or shared with our non-US based collaborators.

Every effort will be made to limit the access to original or raw PlanetScope and Maxar Worldview data. Dr. Borak works in a secure NASA affiliated research center with a nasa.gov email. The raw data will almost exclusively be processed in the HEC computing environment by Dr. Borak following the strict security protocols of his center. On occasions when Dr. Morrow is required to use imagery, it will be processed in HEC environment or on a secured workstation. No raw data will be present on laptops during travel. Tulane's Export Control officer is fully aware of this work and will set up standard protocols and secure approaches to communication and exchange of information and derivative products with our foreign collaborators.

ACCRUED-MFSS is committed to Open Source Science and identified personnel will complete NASA TOPS core curriculum to earn a minimum of 5 open science badges.

The ACCRUED-MFSSteam will pursue the development plan along the lines of the "Geosciences Paper of the Future" with the intention move towards improving the DMP "to make data, software, and methods openly accessible, citable, and well documented" (Gil et al., 2016) and the FAIR principles: Findable, Accessible, Interoperable, & Reusable (Wilkinson et al., 2016). As part of the advancement of CJ&EJ data for decision making methods and with the specific expertise in the ACCRUED-MFSSscience leadership in this research area, the team will leverage the DSCEJ Data Center and Tulane University's Data Hub along side GitHub, data.nasa.gov, and Zenodo to ensure data and information are shared in ways that maximize access, reuse and application to new problems, contexts, and research questions. Data will be made publically available with enough detail to allow for validation and metadata standards will conform to open science standards of the repository such as coding in XML.

The ACCRUED-MFSS data management plan ensures public access to publications and digital datasets arising from NASA research. All ACCRUED-MFSS data posting and archiving tasks will be **confirmed quarterly**. Open Science milestones are identified on the schedule and assigned responsibility to the postdoc and accountability to the PI. The preprints will be posted on Earth and Space Science Open Archive, associated with

the American Geophysical Union, pre-print server https://www.essoar.org/. Open access articles will be available as soon at final revisions are accepted, but expected to be within one year from project closure.

Data sets, meta data and other materials developed to support the proposed research will be archived at data.nasa.gov, as appropriate, and Zenodo (https://zenodo.org/) site associated with European Organization for Nuclear Research (CERN) and expected to maintain the open archive as long as CERN exists. ACCRUED-MFSS has created an Enset 'community' on Zenodo to encourage findability of the research and exchange with other enset researchers.

All derived products and documents produced by ACCRUED-MFSS encourage redistribution, reproduction and creation of derivatives with a Creative Commons Attribution 4.0 International license, and uploaded to Zenodo/DSCEJ Data Hub/Github including:

- 1 or more enset plot classification maps made available in geotiff and pdf formats
- Scripts and source code for training classifier and calssifying images including source code, guidance notes and results/validation
- Manuscripts and documentation of change and stress detection. These will be given a unique doi when uploaded and include source code, guidance notes and results/validation on GitHub site

Development of the project in year one will take place primarily on a dedicated GitHub site. During initial extraction of remote sensing measurements as discreet data sets will temporarily be stored in the NASA HEC environment. As derived products are finalized and model source code documented in a distributable version, these information assets will be open source licensed and uploaded to data.nasa.gov and Zenodo. Full documentation will be completed by project close out and will be transferred to the Tulane Data hub with links to the permanent archives.

The PI will maintain communication as necessary with the data repository and the NASA program manager to ensure that: DMP is updated as needed at time of award; appropriate attribution is included; data meet minimum quality standards; and data are appropriately evaluated for and secured to prevent disclosure of personally identifiable information and to protect proprietary interests, confidentiality, and intellectual property rights.

5.0 Biographical Sketches

PI: Dr. Nathan Morrow

1. Professional Preparation

Boston University, Geography, Bachelor of Arts with Honors 1997
Boston University, Geography, Master of Arts 1998
University of Maryland, Geography, Doctor of Philosophy (M. Hansen advisor) 2021

2. Professional Experience and Positions

Current Sponsored Research:

- PI, Assessment of the Gulf Coast Environmental Justice Landscape for Equity (AGEJL-4-Equity), NASA-funded, 10/22-4/23
- PI, Open Science Outlook for Environmental Justice and Resilience of the Louisiana Gulf Coast (OSO-LoGiC), NASA-EPSCoR-funded, 5/22-4/23

Appointments:

- Associate Research Professor, Tulane Public Health & Tropical Medicine, 2022-.
- Associate Research Professor, Tulane Law, 2014-2018, Adjunct 2007-2012
- Associate Clinical Professor, Tulane School of Social Work, 2012-2014
- Associate Clinical Professor, Tulane Public Health & Tropical Medicine, 2011-2014, Adjunct 2007-2022

3. Selected Bibliography

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

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

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

Muchoney, D., Borak, J., Chi, H., Friedl, M., Gopal, S., Hodges, J., **Morrow, N.**, & Strahler, A. (2000). Application of the MODIS global supervised classification model to vegetation and land cover mapping of Central America. *International Journal of Remote Sensing*, *21*(6–7), 1115–1138. https://doi.org/10.1080/014311600210100

Morrow, N., & Prince, S. (1999). Use of potential and actual primary production models to map drought and degradation in semi-arid Southern Africa. *EOS Transactions, 80*(46), F403.

Morrow, N., & Friedl, M. (1998). Modeling biophysical controls on land surface temperature and reflectance in grasslands. *Agricultural and Forest Meteorology*, *92*(3), 147–161. https://doi.org/10.1016/S0168-1923(98)00098-7

4. Research Experience: Scientific, Technical, Management

Dr. Morrow has a paper co-authored with Dr. Borrell on enset under minor revisions at the journal Food Policy. His research and publications are informed by 25 years of experience not only as a professor but also leading implementation, developing capacity and ensuring research-based evidence for interdisciplinary/multi-sectoral food security, humanitarian response, and child wellbeing policy implementation projects. He has served as Chief of Party for a multi-organizational consortium for multi-country developmental relief and humanitarian aid response valued at over 400 million USD responding to an El Niño drought food security crisis in southern Africa -- a precursor to now ubiquitous resilience policy-focused programming. As co-chair of the Emergency and Disaster Evaluation thematic group at the American Evaluation Association, Dr. Morrow has promoted inclusive engagement and more rigorous measurement models in resilience research and intervention planning. The Global Environment Facility (GEF-7) replenishment strategy was informed, in part, by a geospatial analysis of environmental security led by Dr. Morrow.

Dr. Morrow is PI for two projects that intend to strengthen capacity for open source science to address challenges in CJ & EJ research in collaboration with Gulf Coast EJ community networks and organizations. Strategic assessment and strategy processes to strengthen evidence-based decision support have been a feature of Dr. Morrow's research and consulting with a variety of organizations including work on USAID's resilience measurement operational research in the Horn of Africa, needs assessment capacity for the United Nation's World Food Programme, and the global redesign of World Vision International's system for reporting to the International Board and other stakeholders on impact for improved child wellbeing. Dr. Morrow was invited to conduct the first-ever technical review of an SDG target indicator; 2.1.2 -- Prevalence of severe or moderate food insecurity. He recently completed a global capacity development effort for evidence based policy and policy implementation for the UN Food and Agriculture Organization for >50 countries.

Dr. Morrow continues to actively use remote sensing and geospatial analysis in his applied research following on early contributions to the MODIS, NPOESS, and Land-Use and Land-Cover Change science mission. These technologies featured in Developmental Evaluations of the World Food Program's mVAM program for improved needs assessment and hazard monitoring. They also feature in his teaching that includes problem sets related to assessing flood damage or humanitarian logistics planning.

Co-I: Institutional PI: Dr. Jordan Borak

1. Professional Preparation

Graduate Certificate, Data Science: University of Maryland, College Park, 2019.
Ph.D. in Geography: Boston University, 2000.
Master of Arts in Geography: Boston University, 1996.
Bachelor of Science in Geography (Math minor): University of Illinois, Urbana-Champaign, 1992.

2. Professional Experience and Positions

Current Sponsored Research:

- PI, Enhanced Roughness Length Estimates from ICESat-2 Vegetation Products
- Co-I,National Climate Assessment Land Data Assimilation System
- Co-I, Shallow Water Bathymetry Products and Analysis for Near-shore

Appointments:

- Associate Research Scientist, Earth System Science Interdisciplinary Center, University of Maryland and Hydrological Sciences Laboratory, NASA/Goddard Space Flight Center (June 2011 – present).
- Senior Support Scientist, Science Systems and Applications, Inc., then Wyle Information Systems, LLC, and Hydrological Sciences Branch, NASA/GSFC (July 2002 – June 2011).
- Support Scientist, Science Systems and Applications, Inc., MODIS Land Data Operational Product Evaluation Facility, NASA/GSFC (November 2000 – June 2002).
- Research Associate, Department of Geography and Laboratory for Global Remote Sensing Studies, University of Maryland (July 1999 – November 2000).
- Research Fellow, Department of Geography and Center for Remote Sensing, Boston University (September 1993 – June 1999).

3. Selected Bibliography

Borak, J.S., M.F. Jasinski, and N. Tangdamrongsub, 2021: Fusing ICESat-2 and MODIS Vegetation Data Products to Enhance Momentum Aerodynamic Roughness Fields with Spatially-Explicit Scaling for Improved Land Surface Modeling [Poster presentation G15B-0350]. AGU 2021 Fall Meeting, 13-17 Dec.

Tangdamrongsub, N., C. Hwang, **J.S. Borak**, S. Prabnakorn, and J. Han, 2021: Optimizing GRACE/GRACE-FO data and *a priori* hydrological knowledge for improved global Terrestrial Water Storage component estimates. *J. Hydrol.*, **598**, 126463.

Borak, J.S., M.F. Jasinski, and N. Tangdamrongsub, 2020: Enhanced vegetation aerodynamic roughness for momentum with ICESat-2 data products: early results [Poster presentation H194-0005]. AGU 2020 Fall Meeting, 1-17 Dec.

Jasinski, M.F., **J.S. Borak**, S.V. Kumar, D.M. Mocko, C.D. Peters-Lidard, M. Rodell, H. Rui, H.K. Beaudoing, B.E. Vollmer, K.R. Aresenault, B. Li, J.D. Bolten, and N. Tangdamrongsub, 2019: NCA-LDAS: Overview and Analysis of Hydrologic Trends for the National Climate Assessment. *J. Hydrometeorol.*, **20**, 1595-1617.

Kumar, S.V., M. Jasinski, D. Mocko, M. Rodell, **J. Borak**, B. Li, H. Kato Beaudoing, and C. D. Peters-Lidard, 2019a: NCA-LDAS land analysis: Development and performance of a multisensor, multivariate land data assimilation system for the National Climate Assessment. *J. Hydrometeorol.*, **20**, 1571-1593.

Kumar, S.V., D.M. Mocko, S. Wang, C.D. Peters-Lidard, and **J. Borak**, 2019b: Assimilation of remotely sensed Leaf Area Index into the Noah-MP land surface model: Impacts on water and carbon fluxes and states over the Continental U.S. *J. Hydrometeorol.*, **20**, 1359-1377.

de Gonçalves, L.G.G., **J.S. Borak**, M.H. Costa, S.R. … 2013: Overview of the Large-Scale Biosphere-Atmosphere Experiment in Amazonia Data Model Intercomparison Project (LBA-DMIP). *Agr.Forest Meteorol.,***182-183**,111-127.

Borak, J.S., and M.F. Jasinski, 2009: Effective interpolation of incomplete satellite-derived leaf-area index time series for the continental United States. *Agr. Forest Meteorol.,* **149**, 320-332.

Borak, J.S., M.F. Jasinski, and R.D. Crago, 2005: Time series vegetation aerodynamic roughness fields estimated from MODIS observations. *Agr. Forest Meteorol.,* **135**, 252-268.

4. Research Experience: Scientific, Technical, Management

Dr. Borak's research interests include Earth science data processing and analysis: particular focus on long-term time series data at regional and continental scales; inter-annual and seasonal variability of vegetation and water cycle components; land-cover characterization from satellite observations; quality assessment of remotely sensed data. He has 25+ years experience with C programming and shell scripting in Unix-type environments; 4+ years with Python and Java. He also is an expert in machine learning software: scikit-learn and Keras; statistics and visualization packages: R, Tableau, and SAS.

Collaborator: Dr. James Borrell

1. Professional Preparation

University of Exeter, Biology, Bachelor of Science 2011
Queen Mary University of London, Botany, Doctor of Philosophy 2017

2. Professional Experience and Positions

Current Sponsored Research:

- Evolutionary dynamics of vegetative agriculture in the Ethiopian Highlands:
- Evaluating genetic bottlenecks in planted and naturally colonised young woodlands: Implications for resilience to pests, diseases and environmental
- Realising the potential of plant bioresources as nature-based solutions in African biodiversity hotspots
- Building an incentive mechanism for agrobiodiversity conservation

Appointments:

Future Leader Research Fellow, RBGKew. Developing an independent research programme in plant health and adaptation, food security and ecological modelling. Responsible for decision making, budgets, leading and managing teams and accountable for outputs.(2021-present)

3. Selected Bibliography

- Borrell, J.S., Gebremariam, Z. & Abebe, W.M. *Nature Biotechnology* 39, 1064–1065 (2021).
- Koch, O., Mengesha, W. A., Pironon, S., Pagella, T., Ondo, I., Rosa, I., ... & Borrell, J. S. (2021) Modelling potential range expansion of an underutilised food security crop in Sub-Saharan Africa. *Environmental Research Letters* , *17*(1), p.014022.
- Borrell, J. S., Zohren, J., Nichols, R. A., & Buggs, R. J. A. (2020). Genomic assessment of local adaptation in dwarf birch to inform assisted gene flow. *Evolutionary Applications*, 13, 161–175.
- Borrell, J. S., Goodwin, M., Blomme, G., Jacobsen, K., Wendawek, A. M., Gashu, D., … Wilkin, P. (2020). Enset based agri-systems in Ethiopia: A systematic review of production trends, agronomy, processing and the wider food security applications of a neglected banana relative. *Plants, People, Planet*. *00, 1-17.*

4. Research Experience: Scientific, Technical, Management

James Borrell is a Future Leader Research Fellow, combining a background in associating genome-wide markers with broad-scale environmental models, together with extensive field experience in sub-Saharan Africa. For the past 4 years JB has studied the diversity and distribution of enset and its agri-systems in Ethiopia, funded through three large GCRF grants (with Co-I Wilkin, totaling ~£1.8m). Borrell was lead author of the two largest and most recent reviewson enset diversity5 and agronomy6,7, and has established relationships with key regional stakeholders. JB also provides expertise in biogeography, genomics of adaptation, and demographic reconstruction.

Collaborator: Dr Wendawek Abebe Mengesha

1. Professional Preparation

Addis Ababa University, Biology, Bachelor of Science 2011
Addis Ababa University, Botany, Doctor of Philosophy 1994

2. Professional Experience and Positions

Selected Sponsored Research:

1. Yams of West and South West Ethiopia: conserving yam agrobiodiversity and associated indigenous knowledge for Ethiopia's future. Establishment of cultivated yam germplasm collections and capture and dissemination of associated biocultural information. Funded by the Ellis Goodman Family Foundation and The Christensen Fund
2. Modeling and genomics resources to enhance exploitation of the sustainable and diverse Ethiopian starch crop Enset and support livelihoods. Funded by the Biology and Biotechnology Research Council (BBSRC, BB/P02307X/1) under the GCRF Foundation Awards for Global Agricultural and Food Systems Research call.

Appointments:

2015 - Associate professor, Department of Biology Hawassa University.
2008-2015 Assistant Professor, Department of Biology Dilla University,

3. Selected Bibliography

- Wendawek Abebe, Sebsebe Demissew, Fay M.F., Smith R.J, Nordal, I. & Wilkin. P. 2012. Genetic Diversity and Population structure of Guinea yams and their wild relatives in South and South West Ethiopia as revealed by Microsatellite markers. Genetic Resources & Crop Evolution 60:529–541 (Online first 18/7/12). DOI 10.1007/s10722-012-9856-0
- Wendawek Abebe, Sebsebe Demissew, Fay M.F., Smith, R.J, Nordal. I. & Wilkin. P. 2012. Genetic diversity and species delimitation in the Cultivated and Wild Guinea Yams from Southwest Ethiopia as determined by AFLP (Amplified Fragment Length Polymorphism) Markers. Genetic Resources & Crop Evolution 60: 1365-1375 (Online first 10/12/12). DOI 10.1007/s10722-012-9925-4
- Wendawek Abebe ; Sebsebe Demissew ; Fay, M. F. ; Smith, R. J. ; Nordal, I. ; Wilkin, P. (2008). Morphological and molecular characterization of Guinea yam from south and south west Ethiopia. (A poster presented at the 4th International Conference on Comparative Biology of Monocots, 2008, Denmark, Copenhagen).

4. Research Experience: Scientific, Technical, Management

Beginning with a MSc thesis on tissue culture and genetics of *Brassica nigra*, Dr. Wendawek has been working research on diversity, conservation and genetics of plants. Now focusing on taxonomy and genetics of yams, one of the food security crops in south and south West Ethiopia. He is heavily involved in teaching and advising MSc students of Botanical Science and Genetics streams and supports a growing group of researchers.

6.0: Current and Pending Support

Current and Pending Support

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.	
Investigator: Dr. Nathan Morrow	Other agencies (including NASA) to which this
Support: ☒ Current ☐ Pending Project/Proposal Title**:** Assessment of the Gulf Coast Environmental Justice Landscape for Equity (AGEJL-4-Equity) Source of Support: NASA A.49 Earth Science Applications: Equity and Environmental Justice Total Award Period Covered: 10/22-06/23 Person-Months Per Year Committed to the Project: 2.0	
Support: ☒ Current ☐ Pending Project/Proposal Title: Open Science Outlook for Environmental Justice and Resilience of the Louisiana Role: PI Source of Support: NASA EPSCoR Louisianna BoR RID Project Total Award Period Covered: 3/22-05/23 Person-Months Per Year Committed to the Project: 2.0	
Support: ☐ Current ☒ Pending Project/Proposal Title: High-resolution Extreme Event and Localized Temperature for Health Forecasting Role: PI Source of Support: NASA A.28 Interdisciplinary Science Total Award Period Covered: FY24-FY26 Person-Months Per Year Committed to the Project: 5.4	
Support: ☐ Current ☒ Pending Project/Proposal Title: EJ Core GC; Engaging diverse researchers and EJ communities in inclusive Role: PI Source of Support: NASA Science Mission Directorate –F.14- Transform to Open Science Training Total Award Period Covered: 07/23-06/25 Person-Months Per Year Committed to the Project: 3.6	
Support: ☐ Current ☒ Pending Project/Proposal Title: Analysis of Locally Flooded Areas with Environmental Justice Role: PI Source of Support: NASA Science Mission Directorate –A.44- COMMERCIAL SMALLSAT Total Award Period Covered: 09/23-08/25 Person-Months Per Year Committed to the Project: 1.8	
Support: ☐ Current ☒ Pending Project/Proposal Title: Application of Commercial Smallsat Data to Enhance Flood Resilience in Role: Co-PI Source of Support: NASA Science Mission Directorate –A.44- COMMERCIAL SMALLSAT Total Award Period Covered: 09/23-08/25 Person-Months Per Year Committed to the Project: 1.8	

Current and Pending Support

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Dr. Jordan S. Borak	Other agencies (including NASA) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending
Project/Proposal Title: Enhanced Roughness Length Estimates from ICESat-2 Vegetation Products
Role: PI
Source of Support: NASA Cryospheric Program/Studies with ICESat-2
Total Award Period Covered: 05/20-04/23
Person-Months Per Year Committed to the Project: 3.0

Support: ☒ Current ☐ Pending
Project/Proposal Title: National Climate Assessment Land Data Assimilation System, NCA-LDAS
Role: Co-I
Source of Support: NASA National Climate Assessment Program
Total Award Period Covered: FY16-FY23
Person-Months Per Year Committed to the Project: 3.6

Support: ☒ Current ☐ Pending
Project/Proposal Title: Shallow Water Bathymetry Products and Analysis for Near-Shore Coastal and Inland Waters
Role: Co-I
Source of Support: NASA The Science of Terra, Aqua, and Suomi-NPP
Total Award Period Covered:
Person-Months Per Year Committed to the Project:3.0

Support: ☒ Current ☐ Pending
Project/Proposal Title: Remote Sensing of Vegetation in Puerto Rico for NIST's Hurricane Maria Infrastructure Project
Role: PREP Research Associate
Source of Support: NIST Community Resilience Program
Total Award Period Covered: 07/22-06/23
Person-Months Per Year Committed to the Project: 3.0

Support: ☐ Current ☒ Pending
Project/Proposal Title: Improving Our Understanding of Gulf Coast Wetland Dynamics with Spaceborne Lidar
Role: Co-I
Source of Support: NASA Cryospheric Program/Studies with ICESat-2
Total Award Period Covered: 05/23-04/26
Person-Months Per Year Committed to the Project: 3.0

Support: ☐ Current ☒ Pending
Project/Proposal Title: Spatio-Temporal Connections of Integrated Energy, Water and Biogeochemical Processes Across Alaska's Land and Ocean Ecosystems
Role: Co-I
Source of Support: NASA Interdisciplinary Research in Earth Science
Total Award Period Covered: 6/23-05/26
Person-Months Per Year Committed to the Project: 1.2

Support: ☐ Current ☒ Pending Project/Proposal Title: High-resolution Extreme Event and Localized Temperature for Health Forecasting in Under-served Lowlands of the Gulf Coast (HEELTHFUL-GC) Source of Support: NASA Interdisciplinary Research in Earth Science Total Award Period Covered: 07/23-06/26 Person-Months Per Year Committed to the Project: 3.6/2.4/1.8
Support: ☐ Current ☒ Pending Project/Proposal Title: Ancient Climate Change Resilient but Understudied Enset agrifood system Diversity Mapping for Food Security and Sustainability (ACCRUED-MFSS) Role: Co-I Source of Support: NASA Commercial Smallsat Data Scientific Analysis Total Award Period Covered: 09/23-08/25 Person-Months Per Year Committed to the Project: 3.6
Support: ☐ Current ☒ Pending Project/Proposal Title: Application of Commercial Smallsat Data to Enhance Flood Resilience in Support of Under-served Communities in Puerto Rico Role: PI Source of Support: NASA Commercial Smallsat Data Scientific Analysis Total Award Period Covered: 10/23-09/25 Person-Months Per Year Committed to the Project: 2.4

7.0: Statements of Commitment and Letters of Support

UNIVERSITY OF MARYLAND
EARTH SYSTEM SCIENCE INTERDISCIPLINARY CENTER
Office of the Director

5825 University Research Court, Suite 4001
M Square Building
University of Maryland
College Park, Maryland 20740
TEL (301) 405-0050 FAX (301) 405-8468

Letter of commitment

Date: March 14, 2023

To: Dr. Nathan Morrow, Tulane University
From: University of Maryland, ESSIC
Subject: Statement of Commitment from Department

Dear Dr. Morrow

I acknowledge that Dr. Jordan Borak is identified by name as a Collaborator to the research proposal entitled: "Ancient Climate Change Resilient but Understudied Enset agrifood system Diversity Mapping for Food Security and Sustainability (ACCRUED-MFSS)" that is submitted by Tulane University to NASA in response to the NASA Roses Commercial Smallsat Data Scientific Analysis NNH22ZDA001N-CSDSA. Dr. Borak intends to carry out all responsibilities identified by Tulane University in this proposal.

Sincerely,

Dr. Ellen Williams,
Director, Earth System Science Interdisciplinary Center (ESSIC)

Royal Botanic Gardens, Kew, Richmond TW9 3AE
020 8332 5000 | kew.org | info@kew.org

Dr. Nathan Morrow
Tulane University
1440 Canal Street, New Orleans, USA

Date March 22nd, 2023

Dear Dr. Morrow,

I wish to write in support of this proposal, which I believe will significantly advance research in this field, as well as making an important contribution to food security and sustainable development in Ethiopia.

I acknowledge that I am identified by name as Collaborator to the investigation, entitled Ancient Climate Change Resilient but Understudied Enset agri-food system Diversity Mapping for Food Security and Sustainability (ACCRUED-MFSS), that is submitted by Dr. Morrow to the NASA funding announcement NNH22ZDA001N-CSDSA, and that I intend to carry out all responsibilities identified for me in this proposal. I understand that the extent and justification of my participation, as stated in this proposal, will be considered during peer review in determining in part the merits of this proposal. I have read the entire proposal, including the management plan and budget, and I agree that the proposal correctly describes my commitment to the proposed investigation." To conduct work for this investigation, my participating organization is Royal Botanic Gardens Kew, based in the UK.

In support of this application, I highlight that I will make available extensive previously acquired datasets. This includes >3000 ground truthed enset observations, species compositions of over 1200 farms and contemporary species distribution modelling wild and domesticated enset. The opportunity to use this data in a high resolution remote sensing context is significant, and will lead to high impact research.

Thank you for your consideration,
Kind regards,

James Borrell, PhD
Research Leader, Kew RBG

Patron: His Majesty King Charles III
The Royal Botanic Gardens, Kew is an exempt charity.

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ADDIS ABABA UNIVERSITY
DEPARTMENT OF MICROBIAL CELLULAR AND MOLECULAR BIOLOGY

Date: March 23, 2023
Ref. No: SF/MCMBl.35:5')15/2023

Dear assessment committee.

I wish to write in support of this proposal, which I believe will support our progress towards the sustainable development goals and food security in Ethiopia, as well as fostering productive international collaborations.

I acknowledge that I am identified by name as Collaborator to the investigation,entitled Ancient Climate Change Resilient but Understudied Ensel agri-food system Diversity Mapping for Food Security and Sustainability (ACCRUED-MFSS), that is submitted by Dr. Morrow to the NASA funding announcement NN1-122ZDA001N-CSDSA, and that I intend to carry out all responsibilities identified for me (us) in this proposal. I understand that the extent and justification of my participation, as stated in this proposal, will be considered during peer review in determining in part the merits of this proposal. I have read the entire proposal, including the management plan and budget, and I agree that the proposal correctly describes my commitment to the proposed investigation." To conduct work for this investigation, my participating organization is Addis Ababa University, based in Ethiopia.

In support of this application, I highlight that I will make all relevant ground observation data available and support collection of additional contextual information as required. I have extensive experience of researching these agri-systems throughout my career, and so feel I am ideally placed to provide support for this important work.

Thank you for your consideration,

Kind regards,

Addis Ababa University
Department Of Microbial Cellular Molecular Biology
College Of Natural Sciences

Associate Professor Wendawek Abebe
Department of Microbial, Cellular and Molecular Biology
Addis Ababa University
Ethiopia

P.O.Box 1176
Addis Ababa
Tele: 251-8-95 92 16
mmc_biol_cns@;aau.edu.et

8.0 Budget
8a. Budget Narrative:

Key Personnel:

Tulane personnel will be leading the project from start to finish over the proposed period of 24 months.

Nathan Morrow, The Principal Investigator will contribute a level of effort (LOE)

Dr. Nathan Morrow as PI will provide 0.25 FTE. Dr. Morrow as PI is accountable for grant implementation, compliance, risk management and reporting, quality and timeliness of all deliverables, implementation of the DMP, responsive communication, and reporting to NASA and all stakeholders. Dr. Morrow will manage collaboration, GitHub sites. Dr. Morrow will take the technical lead on all spatial analysis and mapping sub-tasks. Accountable for all milestones, he ensures inclusive and equitable contributions to collaborative deliverables including publications, open science and reports in following Milestone Schedule.

Fringe Benefits
Tulane's fringe rates include health insurance, FICA, unemployment, workers' compensation, retirement, terminal leave payout and employee assistance. Amounts for the sponsor's contribution to employee fringe benefits are calculated using Tulane's U.S. Department of Health and Human Services (DHHS) approved Fringe Benefit Rates effective August 30, 2022. The approved rates are as follows: XX % for Faculty.

Travel
In the third quarter of project year one, Dr. Morrow and Dr. Borak will travel for a research team meeting at Kew Royal Botanical Gardens outside London UK. The purpose of this meeting is to review the classified image derived products against Kew Researchers' ground truth data in an intensive workshop. This should result in a fully validated product by Kew's team of enset experts. We will also prepare annual reports on research progress to date and conduct workplaning for project year 2. Travel to Kew Royal Botanical Gardens outside London UK in project year 2 will proceed with a Kew enset expert validation of the change and stress products. The team will also prepare for final reporting and publication and DMP plan completion.

In the fourth quarter of project year 1, Dr. Morrow will travel to Addis Ababa to validate products with collaborator Dr. Wendawek and Ethiopian enset researchers. In these meetings, we will engage with enset researchers at institutions throughout the country and seek meaningful opportunities for collaborating on publications, planning future research to build on derived ACCRUED-MFSS products, and engaging in policy processes. The travel in project year two has similar purposes with validation and encouraging use and impact of the change and stress products. Both engagements in Ethiopia will contribute to required reporting and promote use of the research products – leading to the greater contribution to applied science benefits for those living in enset growing areas.

Total travel: $17,260.

Total Direct Costs
Direct costs are XX in Year 1, and XX in Y2. Total direct costs: XX.

Subawards

University Of Maryland:

Personnel Dr. Borak's research responsibilities will focus on acquiring data and generating satellite-derived classifications and data products. He will manage data processing in the HEC environment. Oversee and implement the training of the classifier, classify images, and conduct stress and change analysis. In addition to detailed documentation of all procedures and codes used and all datasets generated, overall summary of satellite data characteristics over the study area and a set of specific lessons learned will be posted following the DMP. salaries and benefits are requested for the UMD personnel who will be performing this research as described in the proposal narrative. The Senior/Key Personnel are as follows: Dr. Jordan Borak, Associate Research Scientist (FTE of .20 person-months per year).The base salaries applied to this budget reflect the actual salaries set forth by our institution and include a 3% anticipated escalation per year.

Fringe benefits include health insurance, FICA, unemployment, workers' compensation, retirement, terminal leave payout and employee assistance. Amounts for the sponsor's contribution to employee fringe benefits are calculated using UMD's U.S. Department of Health and Human Services (DHHS) approved Fringe Benefit Rates effective July 1, 2022. The approved rates are as follows: XX % for Faculty, XX % for Staff, XX % for Graduate Assistant and XX % for Contractual Faculty/Staff, hourly students, and most Faculty/Staff additional pays. Tuition Remission is a UMD fringe benefit but is not included in the fringe calculation and is budgeted separately as applicable. Additional information about fringe benefits can be found at: https://ora.umd.edu/resources/benefits-stipends. The Fringe Benefit Rate Agreement can be found at: https://ora.umd.edu/resources/fa. Fringe rates may be renegotiated and adjusted in future years.

Travel
In the third quarter of project year one Dr. Borak will travel for a research team meeting at Kew Royal Botanical Gardens outside London UK. The purpose of this meeting is to review the classified image derived products against Kew Researchers' ground truth data in an intensive workshop. This should result in a fully validated product by Kew's team of enset experts. We will also prepare annual reports on research progress to date and conduct workplaning for project year 2. Travel to Kew Royal Botanical Gardens outside London UK in project year 2 will proceed with a Kew enset expert validation of the change and stress products. The team will also prepare for final reporting and publication and DMP plan completion.

Total travel: $10,000

Indirect Costs
The University of Maryland's established indirect cost rate for research conducted off-campus is 27.5% of Modified Total Direct Costs (MTDC). The MTDC base excludes tuition remission, equipment over $5,000, rental costs of off-campus facilities, and the portion of individual subcontracts over $25,000. This rate has been approved by the cognizant government agency, Department of Health, and Human Services. This rate was approved on June 23, 2022 and is effective until amended. Any questions should be referred to the Office of Research Administration (301) 405-6269 or oraa@umd.edu.

Total Subaward: $ XX

Indirect Costs

The Negotiated Indirect Cost Rate Agreement for Tulane University is 53%. Indirect costs are $XX in Y1, and $XX in Y2. Total indirect costs: $XX.

Total Direct and Indirect Costs

The total budget for 2 years is $XX.

8b. Budget details

*As per ROSES guidance, all cost for people including salary, benefits, overhead or totals have been removed.

ACCRUED-MFSS - Budget
Ancient Climate Change Resilient but Understudied Enset agrifood system Diversity Mapping for Food Security and Sustainability

Tulane		**Year 1**	**Year 2**	**Total**
	Personnel			
	Faculty - Morrow - (.25)	X	X	X
	Fringe Benefits			
	Faculty (17.1)	X	X	X
	Subtotal Personnel	X	X	X
	Travel - London UK (2 days); Addis Ababa (8 days)			
	Airfare	4,500.00	4,500.00	9,000.00
	Hotel	2,700.00	2,700.00	5,400.00
	Ground and meals	1,430.00	1,430.00	2,860.00
Total Direct Costs - Tulane		X	X	X
F&A (indirect) Tulane (53%)		X	X	X
Subawards				
UMD				
	Personnel			
	Faculty - Borak (.3)	X	X	X
	Fringe Benefits (29.9%)	X	X	X
	Subtotal Personnel	X	X	X
	Travel - London UK 4 days			
	Airfare	2,500.00	2,500.00	5,000.00
	Hotel	1,200.00	1,200.00	2,400.00
	Ground and meals	1,300.00	1,300.00	2,600.00
	Total Direct	X	X	X
	F&A (Indirect) UMD (27.5)	X	X	X
	Subtotal	X	X	X
	F&A (Indirect) Tulane 53% (<=25k)	X	X	X
	Subaward Total	X	X	X
	Total Direct	X	X	X
	Total Indirect	X	X	X
Total Project Cost		X	X	X

Section 9. Table of Work Effort

Name	Role	Commitment (months per year)								
		Year 1			***Year 2***			***Sum***		
		This Project		*Other Funded Projects*	*This Project*		*Other Funded Projects*	*This Project*		*Other Funded Projects*
		NASA Support	*Total*		*NASA Support*	*Total*		*NASA Support*	*Total*	
Nathan Morrow	PI	1.8	1.8	0	1.8	1.8	0	3.6	3.6	0
Jordan Borak	Co-I	3.6	3.6	3.0	3.6	3.6	3.0	7.2	7.2	0
Sum of work effort:		**5.4**	**5.4**	**3.0**	**5.4**	**5.4**	**3.0**	**10.8**	**10.8**	**6.0**
Comments: Collaborators Dr. Borrell and Dr. Wendewek have contributed many months of work collecting the farm level data we will use in this research. During the project their actual time commitment will vary based on their interest but is not necessary to complete research objectives.										

Section 10. Facilities and Equipment:

Tulane University will provide facilities for workshops and meetings at no direct cost to the project. Facilities include the state-of-the-art research, education and outreach amenities of the River and Coastal Center offered by the ByWater Institute at Tulane. The TRCC opened in 2016 and features laboratories, offices, and a public meeting space with views of the Mississippi River. The building is managed by the ByWater Institute, but scholars can use the meeting space for programming relevant to the TRCC mission. The Tulane River and Coastal Center is available for exhibitions, classes, demonstrations, shows, receptions, meetings, and/or conferences that relate to the mission of the ByWater Institute. The Forum is 1400 square feet with flexible seating and views of the Mississippi River. The Selley Foundation Room is 200 square feet with fixed conference seating and views of the river

The Royal Botanic Gardens, Kew offers world-class research expertise in plant taxonomy allied to specialist knowledge and research being undertaken on some of the world's most important crop wild relatives. This research is underpinned by collections including an extensive living collection, 7 million herbarium specimens, 1.8 million fungarium specimens and 2 billion seeds. Kew currently has ~15 research projects in biodiverse LMIC/LDC countries in Africa including three Darwin grants and one Belmont grant addressing food security. The Jodrell Laboratory provides world-class plant genomic facilities and infrastructure, together with accompanying staff expertise and extensive experience in biodiversity informatics and spatial analyses. Kew has collaborated with Addis Ababa University for three decades, currently through projects on enset, coffee, yams, lupin and *Aloe*.

Environmental Justice Core on the Gulf Coast (EJ CORE GC)
Engaging diverse researchers and underserved communities in inclusive environmental justice and climate change-related Open-Source Science for an equitable and sustainable Gulf Coast region

1.0 Proposal Summary

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 [1]. 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 environmental justice that is possible with NASA data streams and approaches.

EJ CORE GC responds as a ScienceCore proposal for NASA Earth Science Division priority (b.) environmental justice with relevance to associated priorities of health & air quality, disasters, climate, and water resources. EJ CORE GC will bring together a coalition of environmental justice leaders with experienced NASA investigators, multidisciplinary scientists (health, Earth, and social scientists) and local open source advocates to co-create a SCIENCE CORE module focused on the most pressing climate justice and environmental harms prevalent in the Southern Gulf Coast States (Louisiana, Alabama, Mississippi, Florida and Texas). The goals of EJ CORE GC are:

- **OSS-EJO 1.** Increase understanding and adoption of Open-Source Science principles and techniques for climate justice (CJ) and environmental justice (EJ) applications
- **OSS-EJO 2.** Train a diversity of professional, academic and community-based EJ scientists to leverage Open-Source Science for inclusive collaboration to accelerate major scientific discoveries urgently needed to address climate change-related increasing disparities and vulnerability
- **OSS-EJO 3.** Broaden participation in SMD-funded research into EJ and climate change by historically under-represented communities in the Southern Gulf Coast States

EJ CORE GC will not create only static content. A dynamic and engaging multi-lingual multimedia platform is envisioned that will promote the creation, management, and sharing of reproducible Open-Source Science workflows related to climate and environmental justice. This will build on all five of the Open Core modules, principles and approaches to build capacity for EJ/CJ analysis and visualization particularly based on the Earthdata Pathfinders including Health and Air Quality, Sea Level Change, Disasters, Water Quality, and GIS. We intend to use both TOPS Open edX platform for a 3-hour MOOC and interactive Jupyter Books hosted on the TOPS GitHub. EJ CORE GC investigators will be available for teaching at in-person or virtual professional meetings and science team meetings. The impact of these modules will be magnified by the regionally relevant user groups based at longstanding environmental justice advocacy organizations and university centers focused on mobilizing for improved student and researcher data literacy. The EJ CORE GC module and approach will have provided both content and tools that could be adapted to any number of regional climate and environmental justice contexts around the nation and potentially around the world.

Section 2.0: Table of Contents

Section 3.0: Scientific Objectives, Technical Approach and Management
3.1 Response to ScienceCore ESD priority on environmental justice

3.1.1 Open-Source Science Objectives for Environmental Justice CORE - GC

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[1]. 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 environmental justice that is possible with NASA data streams and approaches.

EJ CORE GC responds as a ScienceCore proposal for NASA Earth Science Division priority (b.) on environmental justice with relevance to associated priorities of health & air quality, disasters, climate, and water resources. EJ CORE GC will bring together a community of environmental justice leaders with experienced NASA investigators, multidisciplinary scientists (health, Earth, and social scientists) and local open source advocates to co-create a SCIENCE CORE module focused on the most pressing climate justice and environmental harms prevalent in the Southern Gulf Coast States (Louisiana, Alabama, Mississippi, Florida and Texas). The Open-Source Science objectives of EJ CORE GC (OSS-EJOs) are:

> **OSS-EJO 1.** Increase understanding and adoption of Open-Source Science principles and techniques for climate justice (CJ) and environmental justice (EJ) applications
>
> **OSS-EJO 2.** Train a diversity of professional, academic and community-based EJ scientists to leverage Open-Source Science for inclusive collaboration to accelerate major scientific discoveries urgently needed to address climate change-related increasing disparities and vulnerability
>
> **OSS-EJO 3.** Broaden participation in SMD-funded research into EJ and climate change by historically under-represented communities in the Southern Gulf Coast States

EJ CORE GC objectives are aligned with the NASA mission Transform to Open-Source Science (TOPS) that is a decade long strategic commitment beginning in 2022 to engage the scientific community in Open-Source Science practices through events and activities aimed at:

- Lowering barriers to entry for historically excluded communities
- Better understanding how people use NASA data and code to take advantage of big data collections
- Increasing opportunities for collaboration while promoting scientific innovation, transparency, and reproducibility.

3.1.2 Relevance of ESD Open-Source Science to advancing EJ and addressing underlying disparities driving vulnerability of underserved Gulf Coast EJ communities

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.

Equity and Environmental Justice is one of the newest program element of the Earth Sciences Division (ESD) of the NASA Science Mission Directorate (SMD). In describing this new initiative, NASA cites recent executive orders that advance equity by focusing programmatically on underserved communities, redoubling efforts to understand domestic impacts of environmental and climate change, and intentionally promote diversity, inclusion and accessibility. The ESD Applied Science Program promotes measurable social benefit from NASA research and information products with the aim to improve decision making and resulting actions. As 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 environmental justice 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 environmental justice. Making measurable impact on environmental justice will require bringing together the work of Earth scientist, 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 1 [2]. The researchers identify three focus areas that explain their proposition to move from Open Data to Open Science.

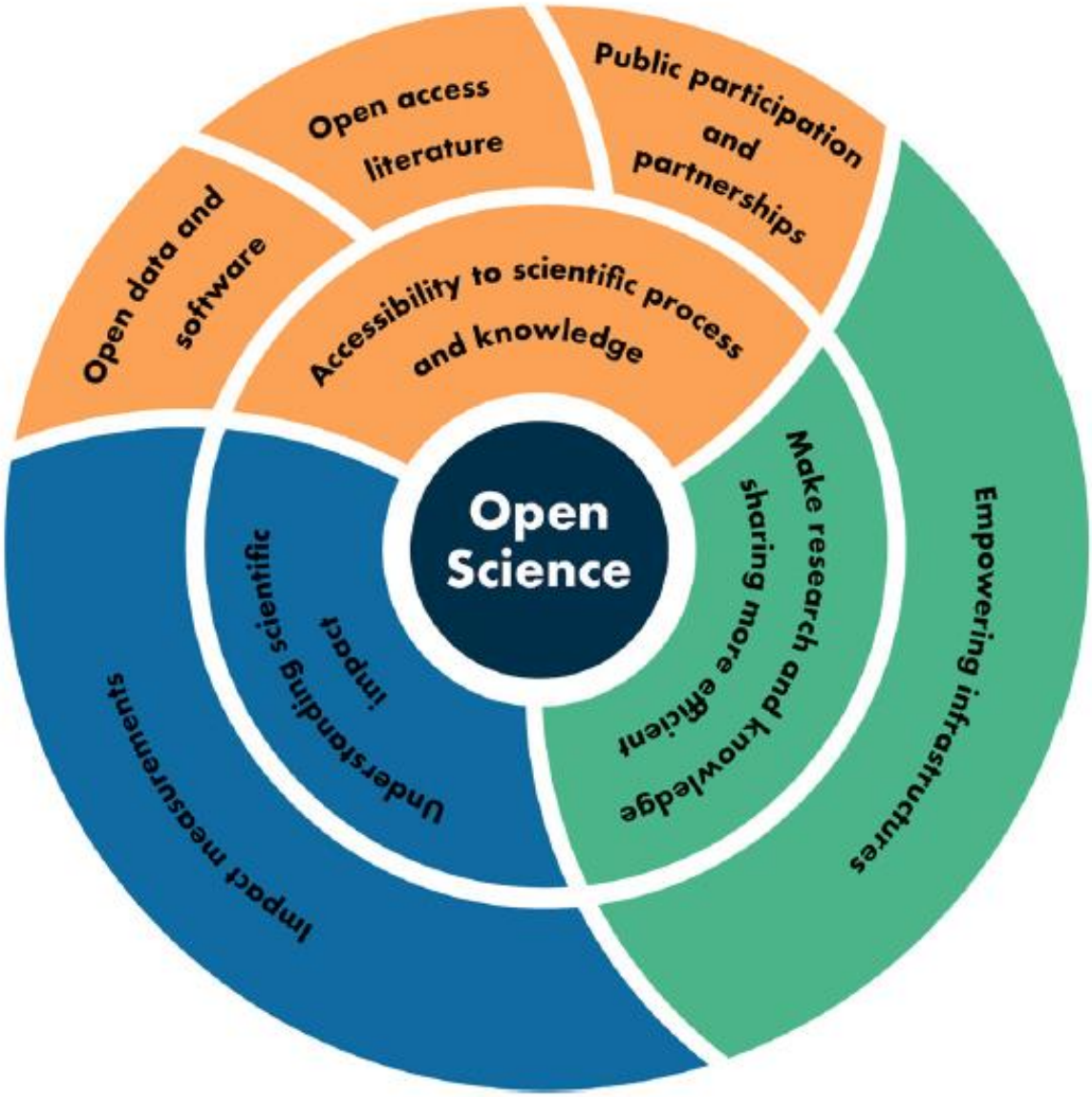

Figure 1: Three key domains of Open-Source Science and their program elements[2].

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 1 represent 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 initiates and strategy 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 1 and program description of [2] is the general organizing framework for the proposed EJ ScienceCore learning module and interactive EJ Open-Source Science workflow development.

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 must 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 [3]. 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. EJ CORE GC proposes instead to be user focused and engage with a broad and diverse mix of Open-Source Science experts and EJ/CJ community-based researchers to priorities content and highlight the most effective approaches from a community level results perspective.

Strong concurrency exists between the Open-Source Science focus on accessibility, empowerment, and impact with approaches to advance Equity and Environmental Justice. The first NASA hosted Equity and Environmental Justice workshop was held in October 2021, but lacked participation from Gulf Coast researchers or community representatives [4]. Even as Equity and Environmental Justice is a specific NASA Applied Science program element, it is also a division-wide priority crosscutting all the work of the Earth Science Division. 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. EJ CORE GC builds on these principles to make concrete progress aligned with NASA priorities and consistent with the expressed requirements of underserved EJ communities and CJ/EJ researchers.

3.2 Technical Approach

EJ CORE GC will not create only static content. A dynamic and engaging multi-lingual multimedia platform is envisioned that will promote the creation, management, and sharing of reproducible Open-Source Science workflows related to climate and environmental justice. This will build on all five of the Open Core modules, principles and approaches to build capacity for EJ/CJ analysis and visualization particularly based on the Earthdata Pathfinders including Health and Air Quality, Sea Level Change, Disasters, Water Quality, and GIS. We intend to use both TOPS Open edX platform for a 3-hour MOOC and interactive Jupyter Books hosted on the TOPS GitHub. EJ CORE GC investigators will be available for teaching at in-person or virtual professional meetings and science team meetings. The impact of these modules will be magnified by the regionally relevant user groups based at longstanding environmental justice advocacy organizations and university centers focused on mobilizing for improved student and researcher data literacy. The EJ CORE GC module and

approach will have provided both content and tools that could be adapted to any number of regional climate and environmental justice contexts around the nation and potentially around the world.

The first research activity of EJ CORE GC is to map and assess the diversity, experience and capacity of EJ stakeholders on the Gulf Coast for engaging in Open-Source Science. In depth investigation will focus on barriers to entry for different communities in finding, accessing and using NASA data, code and research to further social, environmental and wellbeing aspirations. This understanding of differences and disparities will inform all next steps in creating the EJ ScienceCore modules, their validation and communication.

The second research activity is to understand how NASA data, code and research products have been used in the past for decision support around issues of resilience, equity and environmental/climate justice in general and specifically on the Gulf Coast. This research will inform an inclusive structured process that engages both open source science practitioner experts, EJ/CJ leaders and researchers, and specific EJ/CJ thematic experts in formative and validation workshops. In the final stage, these engaged researchers and experts will inform communication aimed at diverse communities, private sector and local authorities on potential pathways for increased relevance and utilization of NASA Open Source Science resources to inform more equitable policy, policy implementation and collective action.

The third research activity is to convene EJ Open-Source Science coalition of climate and environmental justice stakeholders, and EJ thematic experts in collaborative for collective problem solving to first provide use cases and other content to guide the creation of the EJ ScienceCore modules. They will also advise on promoting inclusion and innovation in the use of NASA data, code and research products to address gulf coast environmental justice disparities is intended to maximize the potential for more informed decision making, policy, and policy implementation.

The fourth research activity is to articulate the nexus of Open-Sourse Science, Equity, Environmental Justice and NASA resources for the benefit of communities and decision makers on the Gulf Coast into a 3-hour MOOC that builds on all five of the Open Core modules to be created by the AGU. With real world examples from the Gulf Coast region, the principles and approaches to build capacity for EJ/CJ analysis and visualization particularly based on the Earthdata Pathfinders including Health and Air Quality, Sea Level Change, Disasters, Water Quality, and GIS. This is to be implemented on the TOPS Open edX platform.

The fifth research activity will be to turn the EJ MOOC content into interactive Jupyter Books hosted on the TOPS GitHub that can be used by an expanding number of EJ/CJ researchers in the Gulf Coast region and potentially around the country. This activity includes community level validation with EJ/CJ expert practitioners in all five Gulf Coast States.

A final sixth research activity will use of multiple communication channels aligned with NASA priorities for intentional engagement of historically disadvantaged communities, women and youth. Community facing information strategy will include social media while policy-oriented research communications will include professional society conference presentations, at the American Geophysical Union (AGU), and peer-reviewed journal articles. High quality research on the nexus of Open-Source Science and environmental/climate justice will find a broad audience of researchers, policy makers and program managers.

AGU whose mission is "to advance earth and space science" is the primary forum for NASA related scientific exchange. The proposed EJ CORE GC panel and presentations at the annual meeting of the AGU will be an opportunity to present the Gulf Coast as an emerging and innovative Open-Source Science center for EJ/CJ research. Highlighting the potential of organizations, communities and institutions to engage on the frontlines of environmental justice and costal resilience will be of broad interest to the NASA and other potential stakeholders interested in applying better evidence that leverages observational technologies to decision-making.

3.3 Robustness and Resilience of the EJ CORE GC approach

Born from seminal environmental justice action with significant origins in the Southern USA, measurement, assessment, community mobilization, demand creation, system strengthening, policy-relevant interdisciplinary complex system analysis, and evidence for decision making are traditional strengths of the actively engaged coalitions of EJ communities and institutions of higher education in this region. Longstanding relationships and deep wells of community knowledge will inform EJ CORE GC content and tools prioritization and design. Regular interactions and opportunities for validation in EJ communities will ensure relevance and effectiveness of the deliverables -- that would otherwise risk irrelevance if developed in isolation by disengaged technical experts alone.

Covid and potentially other health-related restrictions to engage face-to-face with community may limit some ground truth and research broadcast activities. The PI has recently led a major international organization to pivot a global capacity development program to online. Lessons from this experience include leveraging collaborative online tools for better engagement, fully facilitating virtual sessions with dedicated technological backstopping, and adjusting the length/frequency/tempo of sessions to promote active interaction. Engaging with stakeholders across the Gulf Coast may require health safeguards and adjustment to virtual or 1-to-1 meetings rather than in-person group interviews.

A diverse EJ CORE GC team and coalition will enhance robustness of the project with attention to multiple perspectives. Recruitment plan for graduate student will follow standard procedure that emphasizes Equity, Diversity and Inclusion. A similar approach will be followed in selecting coalition partners.

Finally if a suitable independent Open Source standards consultant is not available within the projects scope or resources, there are numerous capacities available at the participating institutions that are available for limited consulting services. In this way, we assure there is sufficient budgeted resources for very high level quality control and documentation of the final deliverables.

3.4 Plan to meet EJ CORE GC objectives and management structure

3.4.1 Management structure

The EJ CORE GC management structure aims to encourage collaboration enabled by technology [1] with clear shared objectives, empowered thematic sub-teams, and easy exchange through advanced digital tools for inclusive communication. The small team of Principal Investigator (PI) and a graduate student will engage a wider group of Open-Source Science expert practitioners and

CJ/EJ researchers in the process of identifying and prioritizing content for the EJ ScienceCore modules. This voluntary group will have a shared workspace hosted on GitHub and quarterly all group meetings. A thematic lead will be identified for each of air quality & health, water resources/localized flooding/sea level, heat & energy poverty, disasters. There will be two engagement meetings. The year one meeting will focus on the identification and validation of the module content and examples. The year two meeting will focus on validation of the content and communication/broadening engagement strategy. A consultant, managed by the PI, will be retained to ensure quality of the final Open Source Science deliverables (MOOC, Jupyter Books) and their full documentation on GitHub.

3.4.2 Task by task description of contribution by identified personnel

The PI is accountable for grant implementation, compliance, risk management and quarterly/annual/final reporting. Supported by an experienced sponsored project team, they are responsible for maintaining the control environment, quality and timeliness of all deliverables, implementation of the Open-Source Science Development Plan, responsive communication, and reporting to NASA and all stakeholders. They will supervise the graduate assistant and consultant with responsibilities for collaboration enabling technology including management of the GitHub site(s), virtual team data management workspaces, and deliverables. The PI's primary task is continuous progress on deliverables and whole team communication and follow-up on schedule of implementation tasks. In this role, they are responsible for leading annual work planning, actively monitoring dependencies, and engaging with stakeholders. They will convene two 'in person' team workshops, lead authorship of two peer-reviewed publications, monitor kickoff tasks, and facilitate data/information ex-changes while monitoring for dependencies. They will ensure GitHub, Zenodo and NASA open source sites/repositories are stood up and Open-Source Science Development Plan indicators are monitored. They will contribute to data management and analytical tasks as required and lead documentation and article production. He will engage with community partner scientists in the second year to validate content and build capacity for use of Jupyter Book tools. In the final quarters, they will shift of project focus to the end user and CJ&EJ community engagement events and promotion of new applications for project results and deliverables – and ensure timely final reporting.

Consultants: One consultant will be engaged as an independent quality assurance expert for ensuring absolute compliance of deliverables with industry leading standards in Open source platform project/MOOC/Jupyter Book deployments and their documentation.

3.4.3 Implementation Strategy and Milestone Schedule

In the first quarter of Ej CORE GC activity, the PI will be accountable for submitting a revised Work and Costing Plan, setting up Open-Source Science platforms/sites (see Figure 2 Deliverable,, Open Science and Reporting Milestones). In this quarter, all relevant existing literature and secondary data will be scanned for review with regards to Open-Source Science, CJ and EJ in the region – to produce an Open-Source Science scan for the region.

The first AGU meeting will mark a second major milestone where revised project plans will be presented and discussed with colleagues. Before the meeting identified personnel will ensure they have the CORE Open-Source Science Badges and will actively encourage others to follow the course as well. An Open-Source Science plan for the project will also be registered at this point – in the second quarter of the project.

A coalition with at least one EJ/CJ community or network representative and an Open-Source Science researcher from each of the five Gulf Coast States will be identified. They will be invited to contribute to EJ CORE GC content prioritization and Open-Source Science strategy discussion at the first EJ CORE GC coalition meeting. Open-Source Science scan results will inform the discussion.

By the end of the first year, a draft MOOC will be produced with interactive, video and multi-lingual delivery capacities. A manuscript for peer review on the project approach will be produced. A workflow of the Jupyter Books interactive EJ ScienceCore delivery will be produced. This is intended to 'teach' the EJ CORE GC to community members in situ – where they can follow the course to investigate EJ/CJ issues with NASA data streams that are of interest to them and their community. Also – annual reporting will be complete in a timely fashion.

The second year will begin with a validation and revision of the MOOC. There will be a second meeting of the EJ CORE GC coalition to validate and make final adjustments to the MOOC. Also, validation of the Jupyter Book with community-based testing and validation in at least one underserved EJ community in each state will be conducted.

At this point the PI, graduate assistant and potentially a EJ CORE GC coalition member from each state will be available to present/teach the MOOC in person or virtually. They may also be able to simply encourage and coach or open and close science team meetings and other stakeholder events that may make use of the EJ CORE GC MOOC or Jupyter Book workflow. Presentations and a potential professional development workshop may be presented at the AGU.

The second half of the second year of project activities will focus on quality assurance and documentation and communication. All materials will be archived with high quality documentation to EJ ScienceCore upload sites on TOPS Open edX platform and TOPS GitHub. All OSSDP plan activities will be completed. Exemplary final reporting and project closure will be completed in a timely manner.

Table 1 Open-Source Science, Reporting and EJ CORE GC deliverable milestones

Project Year 1			
Q	**Milestone deliverable**	**Open science output**	**Reporting**
Q1	Literature review and stocktaking: • Open-Source Science for Equity & Environmental Justice in Gulf Coast • Remote sensing of Gulf Coast Environmental Justice with NASA products Open-Source Science scan & CJ/EJ stakeholder map • Open-Source Science initiatives on the Gulf Coast • Environmental justice initiatives, organizations and communities across the Gulf Coast	• Open Access Annotated Bibliography • GitHub site • Annual 4-day TOPS coordination meeting in Washington DC participation/learning/ presentation	• Submit Work and Costing plan • Submit PY1 Q1 report • Check against Research activity 1 – "barriers to entry"
Q2	• AGU – Chicago	• Register open science plan for reproducibility	• PY1 Q2 report with some discussion of state of GC open science

	-Convene a panel session on Earth Observation, Open Science, Equity & Environmental Justice -Identify and invite participants to EJ CORE GC coalition meeting		• Open-Source Science scan • CJ/EJ stakeholder map • Check against Research activity 2 – "engage EJ/CJ community"
Q3	• 1st EJ CORE GC coalition meeting in New Orleans • Prepare publication based on AGU panel	• Open science badges PI/graduate assistant • Open-Source Science Scan results • Report on EJ CORE GC coalition meeting with content priorities	• PY1 Q3 Report w/initial module overview • Check against Research activity 3 – "convene Open-Source Science & EJ/CJ community"
Q4	• Draft MOOC for comment • Jupyter Books Open-Source Science workflow map	• GitHub updated • Annual inclusion/DMP tasks	• Submit Manuscript 1 for publication • PY1 Annual Report
Project Year 2			
Q	**Milestone deliverable**	**Open science output**	**Reporting**
Q1	• Revised MOOC • MOOC testing with coalition partners • 2nd EJ CORE GC coalition meeting in New Orleans	• CJ community Open Science badge contest • Annual 4-day TOPS coordination meeting in Washington DC • Validated MOOC piloted	• Share PY2 workplan • Submit PY2 Q1 report • Check against Research activity 4 – "3-hour MOOC"
Q2	• Jupyter Books testing in EJ communities with coalition partners • AGU – Chicago -Present draft EJ ScienceCore products	• Community GitHub event • Posting of CJ/EJ CORE engagement materials	• PY2 Q2 report w/Jupyter Books overview • Check against Research activity 5 – "Jupyter Books"
Q3	• Quality Control & final documentation: -MOOC -Jupyter Book Prepare publication based on AGU presentation	• EJ ScienceCore upload to: -TOPS Open edX platform -TOPS GitHub	• PY2 Q3 Report w/ discussion of open source science engagement • Check against Research activity 5 – "Check-in w/CJ/EJ communities"
Q4	• Project Closure and Reporting	• GitHub final update • OSSDP tasks checked and completed	• Final Technical Report • Final Financial Report

Section 4.0: Bibliography & Open-Source Science Plan

Section 4.1 EJ CORE GC Proposal Bibliography

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

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

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

[4] 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

[5]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

[6] 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)

4.2 Open-Source Science Development Plan
Accountability for full implementation of the Open-Source Science Development Plan (OSSDP) and ensuring full compliance to NASA ESD requirements lies with the PI. EJ CORE GC is committed to Open-Source Science and identified personnel will complete NASA TOPS core curriculum to earn a minimum of 5 open science badges.

This is an innovative project that includes gathering data from community-based networks as well as academics and subject matter experts. To address potential privacy, ethical and consent issues, EJ CORE -GC will conduct a Privacy Impact Assessment (PIA), following the NASA PIA Summary as a template, during annual planning for engagement. As a general privacy safeguard, data will only be collected, analyzed or presented at spatially aggregated level. No data will be collected about individuals. Results of the PIA will be reviewed and all identified potential risks will be mitigated or eliminated by substituting lower impact data collection approaches.

The EJ CORE GC team will pursue the development plan along the lines of the "Geosciences Paper of the Future" with the intention move towards improving the OSSDP "to make data, software, and methods openly accessible, citable, and well documented" [5] and the FAIR principles: Findable, Accessible, Interoperable, & Reusable [6]. As part of the specific expertise of the EJ CORE GC science leadership in this research area, the team will leverage GitHub, data.nasa.gov, and Zenodo to ensure data and information are shared in ways that maximize access, reuse and application to new problems, contexts, and research questions. Data will be made publicly available with enough detail to allow for validation and metadata standards will conform to open science standards of the repository such as coding in XML.

The EJ CORE GC data management plan ensures public access to publications and digital datasets arising from NASA research. All EJ CORE -GC data posting and archiving tasks will be **confirmed quarterly**. Open Science milestones are identified on the schedule and assigned responsibility to the postdoc and accountability to the PI. The preprints will be posted on Earth and Space Science Open Archive, associated with the American Geophysical Union, pre-print server https://www.essoar.org/. Open access articles will be available as soon at final revisions are accepted, but expected to be within one year from project closure.

Data sets, meta data and other materials developed to support the proposed research will be archived at data.nasa.gov, as appropriate, and Zenodo (https://zenodo.org/) site associated with European Organization for Nuclear Research (CERN) and expected to maintain the open archive as long as CERN exists. EJ CORE -GC has created an Environmental Justice 'community' on Zenodo to encourage findability of the research and exchange with other CJ&EJ researchers.

Final deliverables of a 3-hour MOOC TOPS will be transferred to the Open edX platform and interactive Jupyter Books will be hosted on the TOPS GitHub. All documentation will be checked for high standards and quality assurance. EJ CORE GC investigators will be available for teach the in person at professional meetings and science team meetings using these openly accessible materials.

All data and documents produced by EJ CORE GC encourage redistribution, reproduction and creation of derivatives with a Creative Commons Attribution 4.0 International license, and uploaded to Zenodo/Open edX platform/Github including:

- 3-hour MOOC with interactive elements, video, graphics and text
- Jupyter Books that follow the 5-modules of the AGU-NASA Open Source Science Core that will allow a diversity of users to pursue their own EJ projects
- Model source code, guidance notes and results
- Guidance documents on the CORE and EJ ScienceCore approach and tools. These will be given a unique doi when uploaded.
- The MOOC modules will be tailored for both e-learning and in person workshops

Development of the project will take place primarily on a dedicated TOPS or a project specific stagging GitHub site. During initial extraction of remote sensing products,, for use in interactive modules, will be stored on local machines for testing. As appropriate, links or use of an API will enable dynamic connection to relevant NASA data products. As data sets are finalized and model source code documented in a distributable version, these information assets will be open source licensed and uploaded to data.nasa.gov and Zenodo. In the final year, broad stakeholder and community engagement will be dedicated to the open source Open edX platform/Github portals.

The PI will maintain communication as necessary with the data repository and the NASA program manager to ensure that: OSSDP is updated as needed at time of award; appropriate attribution is included; data meet minimum quality standards; and data are appropriately evaluated for and secured to prevent disclosure of personally identifiable information and to protect proprietary interests, confidentiality, and intellectual property rights.

Section 5a. Budget Narrative:
*Note budget is for two years. Cover page budget has 3 time periods. Last time period(year) intentionally left blank.

Key Personnel:

Personnel will be leading the project from start to finish over the proposed period of 24 months.

The Principal Investigator will contribute a level of effort (LOE) 30%, is accountable for achievement of science objectives and quality of research. This will be achieved through exemplary project management. The PI is accountable for maintenance of resource control environment, meeting all award milestones and reporting requirements, grant administration, and regular communication with stakeholders and deliverables. They are NASA's primary contact point. They will ensure clear communication between all project partners and stakeholders by convening meetings and direct communication. They will provide overall supervision as well as strategic and technical direction of activities. They will dedicate a minimum of 8 month equivalent of time over life of project and will be paid 30% of his effort for the life of the project.

Graduate Student, level of effort 20-30%. will manage support documentation for open source sites, literature review and contribute to ongoing Open-Source Science activities. They will assist in managing meetings, ensuring information is handled as per OSSDP, and fully collaborate on analysis and reporting activities. The grad students will contribute between 10-15 hours per week during the academic year and additional effort during the summer recess for a total of 600 hours over the life of the project.

Fringe Benefits:

Fringe Benefits are charged as direct costs and are set at the current negotiated rates for budgeting purposes. FY23 rates: Faculty: XX%, Students: XX%, Staff: XX%.

Supplies and Materials (small equipment):

Laptop: In the first year of the project, a UNIX/GNU open source capable laptop will be purchased for the project requirements. This is necessary because they will be totally dedicated to their time to project activities and will need to travel to EJ/CJ community engagement events. Estimated cost is $2000 per unint.

Tablets: Are used for the development and piloting of the Jupyter Books application where communities and experts can work through the EJ Science Core Modules will examples from their own communities or research sites. Completion of the EJ ScienceCore Modules will then allow the user to continue their Open-Source Science project for eventual communication, sharing or publication – or contributing to a larger Open Science effort of the EJ CORE GC coalition. Tablets will also allow access to in-person/hybrid MOOC teaching session *in situ* EJ and underserved communities. Estimated cost is $450 per unit.

Total Requested for Supplies and Materials: $7400

Travel: $11,500. The PI will travel to TOPS meetings in Washington DC each year. They will also travel to the American Geophysical Union (AGU) conference each year to present results and potentially lead EJ ScienceCore sessions at science team or other meetings. They will travel to EJ/CJ community validation and teaching in at least one community in each Gulf Coast State.

Airfare (6 round trip domestic)	$2400
Lodging (22-nights at 200$)	$4400
Meals & Incidentals (22-days at 100$)	$2200
Ground transportation to study site communities for 1-day events (twice for 10 Communities at 125$)	$2500
Total Costs	**$11,500**

Other Expenses:

EJ CORE GC coalition meetings: In year one of the proposal, at least one EJ/CJ community representative and one Open-Source Science expert from each of the five Gulf Coast states will be invited for input into EJ CORE GC content and tool development priorities. Each participant will be expected to present compelling EJ/CJ cases from their state that might be appropriate for investigation with Open-Source Science. Attendance at a two day meeting in a Gulf Coast location will be paid for including travel, transfers, meals and accommodation. Four experts in the NASA priority thematic areas will also be invited to the first meeting (eg. air quality & health, localized flooding, disasters, an water quality). If savings are realized from the budgeted 1500 USD per participant, then additional participants will be invited from EJ/CJ networks, organizations and communities. We will invite 14 participants in Year 1.

In the second year, a smaller group that will still include representation from EJ an Open-Source Science to validate MOOC content, flow, look and feel. The EJ CORE Coalition will also make significant contributions at the meeting to Jupyter Book work flow and potential validation site selection. We will invite 10 participants in Year 2.

Cost: $36000

Consultant: will contribute a level of effort xx-days. Will be engaged as an independent quality assurance expert for ensuring absolute compliance of deliverables with industry leading standards in Open source platform project/MOOC/Jupyter Book deployments and their documentation.

Cost: XXXX

Section 5b. Budget details

EJ CORE Budget - Redacted

		Year 1	Year 2
A. Direct Labor			
	Faculty (.3 LOE)	XX	XX
	Graduate Students	XX	XX
	Fringe Benefits	XX	XX
	Subtotal A.	**XX**	**XX**
B. Supportive Expenses			
	Travel		
	AGU Trip	2,500.00	2,500.00
	DC trip	2,000.00	2,000.00
	Coastal visits	-	2,500.00
	Supplies & Materials	7,400.00	-
	Communications	-	-
	Equipment	-	-
	Other Expenses		
	Stakeholder Meetings	21,000.00	15,000.00
	Consultant	XX	XX
	Subtotal B.	XX	XX
	Total Direct Cost	XX	XX
	F&A (Indirect) 53%	XX	XX
C. Total Project Cost			
		XX	**XX**

*As per ROSES guidance, all cost for people including salary, benefits, overhead or totals have been removed.

Section 6. Table of Work Effort

Name	**Role**	**Commitment (months per year)**								
		Year 1			***Year 2***			***Sum***		
		This Project		*Other Funded Projects*	*This Project*		*Other Funded Projects*	*This Project*		*Other Funded Projects*
		NASA Support	*Total*		*NASA Support*	*Total*		*NASA Support*	*Total*	
	PI	4	4	7	4	4	7	8	8	14

Improving Our Understanding of Gulf Coast Wetland Dynamics with Spaceborne Lidar

In Response To: NNH22ZDA001N-ICESAT2:A.32 Studies with ICESat-2

1. Proposal Summary

This team proposes using ICESat-2 data products to generate new spatiotemporal datasets appropriate for monitoring Gulf Coast Region wetlands from space. The products will incorporate image data from radar and optical sources in order to provide complementary time-series information on surface conditions, and to provide a matrix for generation of two-dimensional data fields from the spatially discontinuous information that is native to the ICESat-2 observatory's along-track products. The gridded datasets will consist of monthly maps of 1) above ground biomass density (AGBD); 2) vegetation canopy height; 3) vegetation canopy base height; 4) fractional vegetation cover; 5) land surface type; and 6) hydrologic status.

The need to improve wetlands monitoring is general, and wetlands in the Gulf Coast Region, covering hundreds of thousands of square kilometers in the immediate coastal zone alone, merit specific attention. These ecosystems provide crucial ecosystem services at the interface between terrestrial and aquatic systems – amounting to unique combinations of the two that vary over space and time. Consequently, their well-being is key to the efficiency with which they provide these services to residents and industries in the Gulf Coast Region.

There is an under-represented, yet valuable spatiotemporal scale of wetlands research: frequent, regional monitoring. This presents an ideal situation to bridge a gap with innovative datasets derived from the unique capabilities of ICESat-2. In the Gulf Coast Region specifically, wetlands cover such a large extent that it would be difficult to assemble appropriate datasets without leveraging spaceborne remotely sensing observations. These efforts will complement existing data and modeling initiatives in novel ways.

2. Scientific/Technical/Management Plan

2.1 Background

Of the seventeen Sustainable Development Goals (SDGs) the United Nations recognizes in its 2030 Agenda [1], there are at least seven that intersect substantively with concerns over wetland status: 1) Life Below Water; 2) Life on Land; 3) Climate Action; 4) Zero Hunger; 5) Clean Water and Sanitation; 6) Sustainable Cites and Communities; and 7) Responsible Consumption and Production. However, it is SDG target 6.6.1 – "Change in the extent of water-related ecosystems over time" – that is considered most relevant to wetland dynamics research [2].

Wetlands provide three major categories of ecosystem services: provisioning, regulating, and cultural. The health of wetlands is clearly key to the efficiency with which they provide these services. Dynamics of physical wetland health link most directly to variability in both land cover and climate. Land cover change affects provisioning (food/water), regulating (water flows), cultural (tourism/recreation and spiritual development) – as well as habitation of both flora and fauna. Yet, consistent information on wetland extent, condition, and their specific ecosystem services is frequently difficult to access or unavailable [3].

Thus, the need to improve wetlands monitoring is general, and wetlands in the Gulf Coast Region (GCR) – covering hundreds of thousands of square kilometers in the immediate coastal zone alone – merit specific attention. These ecosystems provide crucial ecosystem services at the interface between terrestrial (usually forest, agriculture, or urban) and aquatic systems – amounting to unique combinations of the two that vary over space and time. Consequently, their well-being is key to the efficiency with which they provide these services to residents and industries in the GCR.

This proposal team considers wetland ecosystems in the context of both physical and socioecological function – that is, whether the system functions as it should – relative to its natural physical state – and whether it is capable of sustainably providing the services that society derives from the system.

In the Gulf Coast Region, the need to improve monitoring of wetland ecosystem services is clear. Key areas where gaps in needs could be filled by improved monitoring tools include [4]:

1. Detailed wetland mapping
2. Land use planning
3. Trends at the watershed scale

The U.S. Department of the Interior (DOI) conducts and coordinates mapping of wetlands at the national level through its Fish and Wildlife Service's National Wetlands Inventory (NWI) [5]. The NWI is tasked with providing data on extent, status, and change of wetland ecosystems throughout the United States. Although its mapping mission is relatively narrow in scope, dataset updates tend to be infrequent given such a large spatial domain.

Conversely, the U.S. Geological Survey's Wetland and Aquatic Research Center (WARC) takes a more interdisciplinary "applied ecology" approach [6]. With less emphasis on mapping, and a tighter geographic focus – mainly the Southeastern region of the United States – WARC's

interdisciplinary research portfolio tends to concern study domains of limited spatial and/or temporal extent.

There is an under-represented area of research between these two approaches: frequent, regional monitoring of wetlands. This is frequently the spatiotemporal scale used in land surface models [7] and fire risk mapping [8,9], and thus presents an ideal situation to bridge a gap with innovative datasets derived from the unique capabilities of ICESat-2. In the GCR specifically, wetlands cover such a large extent that it would be difficult to provide appropriate datasets without leveraging spaceborne remotely sensing observations. Such datasets would complement existing data initiatives such as LANDFIRE and various land surface/data assimilation modeling efforts [10].

This team proposes using ICESat-2 data products to generate new spatiotemporal datasets appropriate for monitoring GCR wetlands from space. The products will incorporate image data from radar and optical sources in order to provide complementary time-series information on surface conditions, and to provide a matrix for generation of two-dimensional data fields from the spatially discontinuous information that is native to the ICESat-2 observatory's along-track products. The gridded datasets will consist of monthly maps of 1) above ground biomass density (AGBD); 2) vegetation canopy height; 3) vegetation canopy base height; 4) fractional vegetation cover; 5) land surface type – i.e. what type(s) of vegetation are present (woody/herbaceous/both/neither); and 6) hydrologic status.

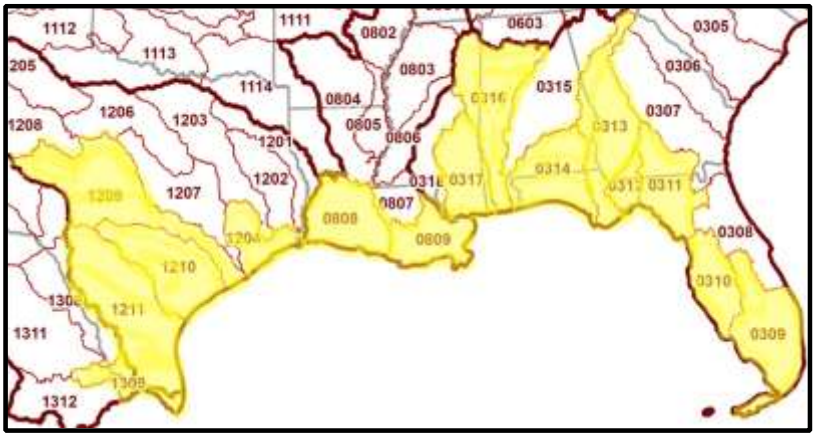

Figure 1: Proposed domain for Gulf Coast Region study; areas of analysis highlighted.

All six datasets will be produced over the entire GCR domain. Here, the proposal team defines the Gulf Coast Region as the set of USGS Hydrologic Unit Code (HUC) 4-digit subregions that empties directly into the Gulf of Mexico (Figure 1). The datasets will be mapped to a common 500-meter grid – a resolution that serves as a practical compromise between spatial and temporal resolutions. Monthly resolution will be realized as a rolling 3-month database that concludes with the month of interest. These tradeoffs in spatiotemporal resolution allow for sufficient ICESat-2 observations to accumulate over the domain to produce the gridded output data. Although the goal of this investigation is to create GCR-specific datasets, the methodology is readily adapted to monitoring wetlands in other regions. Table 1 lists the watersheds of interest identified in Figure 1, and includes their spatial extents.

Table 1: Summary details of the proposed domain, defined as the set of HUC subregions that empty into the Gulf of Mexico. Approximate total area of the domain: 58 million ha.

HUC Region	Subregion(s)	Area (1000s ha)	U.S. State(s)
Rio Grande (13)	Lower Rio Grande (1309)	326	Texas
Texas-Gulf (12)	Nueces-S.W. Texas Coastal (1211) Central Texas Coastal (1210) Lower CO-San Bernard Coastal (1209) Galveston Bay-San Jacinto (1204)	7511 4713 7356 2067	Texas; Louisiana
Lower Mississippi (08)	Louisiana Coastal (0808) Lower Mississippi (0809)	3626 2450	Louisiana
South Atlantic-Gulf (03)	Pascagoula (0317) Mobile - Tombigbee (0316) Choctawhatchee - Escambia (0314) Apalachicola (0313) Ochlockonee (0312) Suwannee (0311) Peace-Tampa Bay (0310) Southern Florida (0309)	3134 5672 3885 5309 945 3574 2590 4843	Mississippi; Alabama; Georgia; Florida

For purposes of this study, a wetland mask will be generated by a spatial union of the most-recent releases of the National Wetlands Inventory and Global Surface Water Extent [11]. Wetland ecosystems within the GCR will receive additional attention, and the team will report statistics and trends for all six datasets on a monthly basis for all wetlands.

These datasets comprise physical properties that can be quantified with models and measurements, and that indicate whether the ecosystem is in a physical state that is conducive to functioning as it would in a purely natural state. The wetland aspects being monitored here – vegetation and hydrology – are by no means exhaustive. A comprehensive wetland monitoring system would also incorporate water quality, soil, and buffer characteristics [12], but those are outside the scope of this study.

Ecosystem services depend not just on the objective ecosystem physical properties; they are defined by the extent to which humans are able to derive value from the ecosystem. Thus it is very possible for an ecosystem to be physically healthy, but if its societal value is perceived to be low, its ecosystem service value will be correspondingly low. Homeowners commonly encounter this situation when they apply for a permit to build on a property they already own, only to learn that this parcel of land includes protected wetland that they cannot build on, and so the property becomes "worthless" to them. The ecosystem may be pristine, and have great value for regulating (by controlling for flooding of the rest of the property or filtering out chemical pollutants before they enter the water supply), but that is not how the property owner sees it.

Of particular significance is the Harmonized Landsat Sentinel (HLS) dataset, which provides spectrally and spatially consistent 30-m atmospherically-corrected imagery from Landsat and Sentinel-2 going back to 2013.

2.2 Goals and Expected Significance

When the Global Ecosystem Dynamics Investigation (GEDI) instrument is de-installed from the International Space Station (scheduled for early 2023), ICESat-2 will be the only lidar mission on orbit. This team's main goal is to use ICESat-2 data products to create new datasets that will leverage the unique characteristics of the ATLAS instrument aboard ICESat-2 in order to improve wetland monitoring.

It is expected that the information about vegetation structure dynamics will be useful to wetland ecologists as they study impacts due to natural stressors (e.g., hurricanes), climate change (e.g., sea-level rise and warming), and anthropogenic influences such as conversion. Policymakers may be interested as well, particularly in the context of development.

Fire researchers will also want to work with the vegetation data. Biomass and canopy height information are both used as fuel parameters in fire likelihood and propagation models. Seasonally-inundated wetlands in particular are sensitive to short-term meteorological stresses such as droughts and excessive heat, and can burn out of control – especially those with peaty soils.

It is also anticipated that trends in hydrologic status will be of high interest to ecologists. Wetlands that are changing quickly in size or moisture character, or if exhibiting anomalously high interannual variability would merit additional research and possibly action on the part of stakeholders.

Ultimately, people in the Gulf Coast Region whose livelihoods depend on healthy wetlands for ecosystem services such as fishing and farming may be the group that is most concerned about dynamics of GCR wetlands. Few of them will make use of the datasets, but they will certainly benefit from their existence.

2.3 Technical Approach and Methodology

The proposal team will use a multisensor approach to characterize and monitor the wetland ecosystems. In addition to ICESat-2 products, the team will acquire visible and radar data, which will complement the information value of the lidar-based products. The optical remote sensing analysis will be based on the Harmonized Landsat and Sentinel-2 (HLS) surface spectral reflectance dataset with nominal 30-meter spatial resolution. Although the HLS data acquisition plan promises frequent overpasses of the Sentinel-2 and Landsat sensors, the area of interest experiences frequent cloud cover, and so having a second imagery option is likely to be a necessity. Hence, the inclusion of Sentinel-1 C-Band SAR imagery.

The general strategy is to use the optical and radar image data along with in-situ (or airborne) data to extrapolate the ICESat-2 along-track information across the entire domain. This is generally achieved in two stages:

1. Use ground observations of the intended outputs – e.g., AGBD, canopy height, etc. – to build mathematical models that relate the ICESat-2 observations (canopy height metrics or water heights) to the ground data and predict the outcome for new instances [13]:

$$\textit{ICESat-2 data} = \text{f(ground data)} \quad (1)$$

Initial candidate models would be ordinary least-squares regression or Random Forest if relationships were non-linear. More-complicated models would only be employed if neither of these approaches produced acceptable results.

2. After selecting a usable model, the radar and optical image data can be used to extrapolate the sparsely-distributed estimates based on ICESat-2 across the terrestrial portion of the domain [14, 15]:

$$\textit{distributed estimate} = \text{f(image data)} \quad (2)$$

As above, initial candidate models would use regression or Random Forest at first.

For ground data, the team will acquire field observations collected by the National Ecological Observatory Network (NEON) project [16], which includes several field sites within the GCR domain, both terrestrial and aquatic.

Tables 2-3 contain lists of satellite-based indicators for characterizing the vegetation and hydrology GCR wetland ecosystems. The team will generate temporal indicators and analyze their trends [10, 25]. Also for each indicator, the team will construct a baseline reference from multiyear timeseries leading up to Project Year 1. The cadence and period of record will vary for different sensors, but the conservative goal is for each to include at least 5 years of previous observations. Once the team has a representative satellite-based history of the wetland sites, it can begin looking at new data – from the start of the project onward.

For vegetation (Table 2), the team plans to assess the vertical structure of the forest canopy using ICESat-2 Land and Vegetation Height (ATL08), as well as monitor the seasonality of the wetland ecosystems. The team also includes indices designed specifically to monitor both aquatic and terrestrial vegetation formations. It is probably unrealistic to commit to identifying different species of aquatic vegetation, but it may be possible to discriminate broadleaved floating vegetation like hyacinth from herbaceous types.

Table 2: Remote sensing inputs to be used for characterizing wetland vegetation status. The ICESat-2 canopy metrics will be distributed over the GCR domain using the HLS and Sentinel-1 image data.

Vegetation Indicator Type	Source(s) (index names)	Reference(s)	Spatial Resolution	Temporal Resolution
Vertical structure	ICESat-2 Land & Veg. Height (ATL08)	[17]	20-m 100-m	Variable
Aquatic Vegetation Indices	HLS[1] (NDAVI[2]; WAVI[3]; EAVI[4])	[18, 19, 20]	30-m	2-3 Days
Terrestrial Vegetation Indices	HLS (NDVI[5]; EVI[6])	[21]	30-m	2-3 Days
Canopy Backscatter	Sentinel-1 Interferometry	[22]	~5x20-m	Variable

[1]HLS = Harmonized Landsat Sentinel; [2]NDAVI = Normalized Difference Aquatic Vegetation Index; [3]WAVI = Water Adjusted Vegetation Index; [4]EAVI = Enhanced Aquatic Vegetation Index; [5]NDVI = Normalized Difference Vegetation Index; [6]EVI = Enhanced Vegetation Index

Table 3 presents the proposed hydrology indicators; these are mostly designed to capture variability in water cycle components, but they also track flooding and other changes in surface water volume. These indicators also reflect the broad, multisensor nature of this team's approach. As with the vegetation data, the ICESat-2 Inland Surface Water Data product will be modeled and distributed over the aquatic parts of the domain.

Table 3: Remote sensing inputs for monitoring wetland hydrology. Vertical surface water information from ICESat-2 will be distributed over the GCR domain using the HLS and Sentinel-1 image data.

Hydrology Indicator Type	Source(s)	Reference(s)	Spatial Resolution	Temporal Resolution
Surface Water Storage	ICESat-2 Inland Surface Water Data (ATL13)	[23]	Variable	Variable
Global Surface Water Extent	Landsat	[11]	30-m	Static
Inundation	HLS (MNDWI[1])	[24]	30-m	2-3 Days
Surface Moisture Content	Sentinel-1 Interferometry	[22]	~5x20-m	Variable

[1]MNDVI = Modified Normalized Difference Water Index

Finally, the proposal team plans to incorporate into this project new remote sensing sources as they become available. These include satellite sensors like NISAR [26] and its L-Band SAR scheduled to launch in 2023, and the hyperspectral OCI (Ocean Color Instrument) – scheduled for launch in the same year aboard the PACE (Plankton, Aerosol, Cloud, ocean Ecosystem)

platform [27]. The OCI will provide hyperspectral information at moderate spatial resolution on a near-daily basis, which affords our team opportunities to develop and apply novel spectral indices with frequent looks.

2.3.1 Sources of error and uncertainty

Potential quantifiable sources of error consist mainly of satellite and other GIS data products, which are never perfect, and satellite data collected over the Gulf Coast Region often exhibit persistent atmospheric effects. This is a primary reason for including radar data.

Another source of error is insufficient resolution – spatial or temporal – for resolving a phenomenon of interest. As mentioned above, it is not realistic to claim that this study will capable of describing wetland vegetation in terms of species composition; however the proposal team does expect to be able to discriminate between broadly distinct physiognomies (e.g., broadleaf versus graminoid).

One other source of uncertainty is the in-situ data collected at the NEON sites. For a given data type, the error on field data collection is almost certain to be smaller than satellite-based estimates.

2.3.2 Resilience of the approach and methodology

As mentioned previously, the proposal team has identified multiple options for image data sources so that success never depends on degree of cloud cover or is prevented by a single point of failure with one of the satellite sensors. Thus, several of the entries in Tables 2-3 list multiple data sources. Additionally, the proposal team considers risk factors due to mission length and life cycle to be low at this time, as several new sensors have, or will come online during the course of the proposed project. For example, Landsat 9 launched in September 2021, and is now providing science data for the HLS product, and Sentinel-1C is scheduled for a 2023 launch.

2.4 Impact of the Proposed Work on the State of Knowledge in the Field

The most direct impact of the proposed work is for land surface and fire modelers who use time series canopy structure data to drive their models. Improvement in those datasets will lead to more realistic LSM outputs and greater understanding of fire risk and likelihood. Given their very large areal extent and crucial role as an ecosystem, it is particularly important in the Gulf Coast Region to model wetland processes well.

Indirectly, the residents of the GCR stand to benefit from improved understanding of the dynamics of wetlands in the region. Citizens who depend on provisioning services of these wetlands have the most critical stakes in their preservation. Food and water security are particular concerns for low-income residents; especially women, and underrepresented groups such as indigenous people – who often have severe health outcomes due to remoteness of location and lack of adequate health services.

Also of great concern are the regulating services; air quality, local climate regulation, and hurricane/flood protection. Perhaps of less importance to locals, but of great interest to policymakers is preserving these assets in support of aesthetic and touristic ventures.

2.5 Relevance to the Program Element and to NASA Programs and Interests

This proposed investigation is clearly relevant to the program element. As indicated in the text of the call, it is clearly of an exploratory nature. Although the technical aspects build on previously published research, the crux of the project is quite novel to the best of the team's knowledge. Literature searches turned up no peer-reviewed articles that tested the applicability of ICESat-2 to map fire likelihood or fuel parameters. Similarly, there seems to be little work being done with ICESat-2 that focuses specifically on wetland ecosystems – even in some of the existing boreal land work, where wetlands are ubiquitous. Finally, there seem to be no active efforts to conduct research specific to the Gulf Coast Region. This is somewhat surprising given the region's high vulnerability to natural hazards.

Regarding NASA's interests [28], the proposed research is relevant to Strategic Goal 1, to "Expand Human Knowledge through New Scientific Discoveries" and Strategic Objective 1.1, which is to "Understand the Earth system and its climate." Novel data on vegetation and hydrology in will help scientists and modelers better understand the dynamics of a vast ecosystem that (when functioning correctly) promotes resilience in an area that is both ecologically and economically fragile.

Furthermore, the work comports with Strategic Objective 1.3, which is to "Ensure NASA's science data are accessible to all and produce practical benefits to society." Regarding accessibility, the Data Management Plan clearly explains how the datasets produced by this project are to be made available and accessible through NASA's own Open Data Portal. In terms of yielding societal benefit, it is difficult to name an area of the U.S. that is in greater ecological peril than the Gulf Coast, and so providing datasets designed to improve environmental models of that region shows obvious benefit.

Finally, the PI understands that they will serve as a member of the ICESat-2 Science Team, with responsibilities to:

- represent ICESat-2 at meetings and conferences, and provide the liaison with the broader discipline science and applications communities
- report to NASA Headquarters on the impacts to ICESat-2 science resulting from any changes with mission operations
- and provide guidance to the ICESat-2 Project Office for mission planning, as requested.

2.6 Implementation Plan

2.6.1 Project Schedule

Project Year 1:

1. The project PI hires and onboards a Postdoctoral Associate to support data processing efforts
2. The PI works with the Postdoctoral Associate to establish data acquisition and processing pipelines for:
    a. ICESat-2 products
    b. Optical remote sensing datasets
    c. SAR data
    d. NEON site data

3. The PI and the Postdoc begin to build models that relate ICESat-2 Vegetation products to NEON site data.
4. The PI and the Co-I begin to build models that relate ICESat-2 Inland Water product data to NEON site data.
5. The team writes up the results from PY1; publishes data on Open Data Portal.
6. PI provides annual report to HQ.

Project Year 2:

1. The project team continues to acquire new data as they become available; look into incorporating NISAR data upon their release.
2. The team works on distributing the along-track model datasets (derived from ICESat-2) over the full GCR domain using the image data.
3. As in PY1, the team will write up modeling results and post data to Open Data Portal.
4. PI provides annual report to HQ.

Project Year 3:

1. Project team updates input dataset with latest versions of all inputs.
2. The team generates final models and final outputs.
3. The team also generates temporal trends over the domain
4. Project team writes up trend results and posts final datasets to Open Data Portal.
5. PI provides final annual report to HQ.

2.6.2 Work Flow

The Principal Investigator will manage the project, direct the members of the project team, and be responsible for fulfilling all reporting requirements. The PI's research responsibilities will focus on acquiring data and working with the Postdoctoral Associate to create workflows to process input data. The PI will travel to all Science Team meetings and will also attend one conference each year to discuss/exchange results with colleagues.

The Co-I will work with the PI to ensure the assembly of an optimal wetland hydrology dataset as defined above, and will be the point person on the utilization of lidar hydrology data products.

An unfunded collaborator will join the proposal team as its advisor on socioeconomic concerns, including social justice, and ensuring proper consideration for all underrepresented groups. They will also provide advice on potential partnerships between the team and social scientists interested in working in the Gulf Coast Region.

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4. Data Management Plan

In general, this project will follow an open data and science policy, where the databases, algorithms, and code used for the development of the project will be made freely and openly available, as well as sample Jupyter notebooks that contain basic code for programmatic access to the outputs. The team will post product versions to NASA's Open Data Portal and provide metadata as required. The team will post project output data there, and evaluate the feasibility to have that hosted at a DAAC if data volume becomes too large for the Portal.

Data types, volume, formats, and (where relevant) standards:
There are two main groups of data the team will need to distribute: 1) Vegetation parameter data fields; and 2) hydrology data fields, which will likely be distributed as netCDF files at an anticipated data volume of roughly 15TB per project year (as also indicated in HEC request).

Note that because the input datasets used by this project are all freely available via open data sites on the Internet, there is no requirement for the team to manage those data.

Intended repositories for archived data, including mechanisms for public access & distribution:
As described above, in deference to open data and science policies, the output data will be transferred from NASA/GSFC to the NASA Open Data Portal.

How the plan enables long-term preservation of data:
If the Open Data Portal is capable of maintaining the outputs long term, that would comply with open data protocols. Otherwise, the team's preference would be to use Zenodo owing to its commitment to FAIR compliance.

Roles and responsibilities of team members in accomplishing the DMP:
The project PI will have responsibility for managing any code or output data products.

5. Table of Personnel and Work Effort

Name	Role	Commitment (months per year)											
		Year 1			***Year 2***			***Year 3***			***Sum***		
		This Project		*Other Funded Projects*	*This Project*		*Other Funded Projects*	*This Project*		*Other Funded Projects*	*This Project*		*Other Funded Projects*
		NASA Support	*Total*		*NASA Support*	*Total*		*NASA Support*	*Total*		*NASA Support*	*Total*	
PI	PI	3.0	3.0	6.6	3.0	3.0	3.0	3.0	3.0	0.0	9.0	9.0	9.6
Co-I	Co-I	1.2	1.2	13.0	1.2	1.2	7.6	1.2	1.2	3.6	3.6	3.6	24.2
TBD	Postdoctoral Associate	8.2	8.2	0.0	7.8	7.8	0.0	7.2	7.2	0.0	23.2	23.2	0.0
Collaborator	Collaborator (unfunded)	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Sum of work effort:		**12.4**	**12.4**	**19.6**	**12.0**	**12.0**	**10.6**	**11.4**	**11.4**	**3.6**	**35.8**	**35.8**	**33.8**

REDACTED BUDGET
Sponsor: NASA
Proposal Title: Improving Our Understanding of Gulf Coast Wetland Dynamics with Spaceborne Lidar
Due Date: 10/12/2022
Period of Performance: May 1, 2023 - April 30, 2026

		YEAR 1	YEAR 2	YEAR 3	TOTAL
I. PERSONNEL	***FTE Months***				
	Principal Investigator *(3.0 / 3.0 / 3.0 Months)*	$ -	$ -	$ -	$ -
	Post Doc *(8.2 / 7.8 / 7.2 Months)*	$ -	$ -	$ -	$ -
	TOTAL SALARY AND WAGES	$ -	$ -	$ -	**$ -**
II. FRINGE BENEFITS	***Fringe Rate***				
	Principal Investigator *[REDACTED]*	$ -	$ -	$ -	$ -
	Post Doc	$ -	$ -	$ -	$ -
	TOTAL FRINGE BENEFITS	$ -	$ -	$ -	**$ -**
III. TRAVEL					
	DOMESTIC	$ 6,000	$ 6,000	$ 6,000	$ 18,000
	FOREIGN	$ -	$ -	$ -	$ -
	TOTAL TRAVEL	$ 6,000	$ 6,000	$ 6,000	$ 18,000
IV. EQUIPMENT		$ -	$ -	$ -	$ -
	TOTAL EQUIPMENT	$ -	$ -	$ -	$ -
V. SUBCONTRACTS					
	TOTAL SUBCONTRACTS	$ -	$ -	$ -	$ -
VI. OTHER DIRECT COSTS					
	PUBLICATIONS	$ 2,900	$ 2,900	$ 2,900	$ 8,700
	TOTAL OTHER DIRECT COSTS	$ 2,900	$ 2,900	$ 2,900	$ 8,700
TOTAL DIRECT COSTS		$ 8,900	$ 8,900	$ 8,900	**$ 26,700**
VII. INDIRECT COSTS *[REDACTED]*					
		$ -	$ -	$ -	**$ -**

CO-I INSTITUTION REQUESTED SUPPORT	$ 19,872	$ 16,312	$ 18,804	$ 54,988
TOTAL REQUESTED SUPPORT	$ 28,772	$ 25,212	$ 27,704	$ 81,688

Redacted Budget Justification

Proposal Title: Improving Our Understanding of Gulf Coast Wetland Dynamics with Spaceborne Lidar

Period of Performance: May 01, 2023 – April 30, 2026

Section I. PERSONNEL
Principal Investigator FTE:
Year 1 – 3.0 person months
Year 2 – 3.0 person months
Year 3 – 3.0 person months

Post Doc FTE:
Year 1 – 8.2 person months
Year 2 – 7.8 person months
Year 3 – 7.2 person months

Section II. FRINGE BENEFITS
[REDACTED AND ANONYMIZED]

Section III. TRAVEL
Funds are requested in the amount of $18,000 ($6,000 per year) for the PI to attend one domestic conference, the American Geophysical Union (AGU) Annual Meeting, and two trips to attend the ICESat-2 Team Meetings in each year of this project for the purpose of collaborating with colleagues and disseminating research findings. The standard travel cost estimates below are based on the average expenses reported by department faculty for attending AGU in the previous fiscal year. Please note that this travel is contingent upon COVID-19 regulations imposed at the state and federal level.

Year 1: AGU Annual Meeting, Destination TBD ($3000/person x 1 trip): $3,000
ICESat-2 Science Team Meeting ($1,500/person x 2 trips): $3,000
Year 2: AGU Annual Meeting, Destination TBD ($3000/person x 1 trip): $3,000
ICESat-2 Science Team Meeting ($1,500/person x 2 trips): $3,000
Year 3: AGU Annual Meeting, Destination TBD ($3000/person x 1 trip): $3,000
ICESat-2 Science Team Meeting ($1,500/person x 2 trips): $3,000

AGU- TBD ***(Projected Cost per trip $3,000)***				
Expense	**Cost**	**Day(s)**	**# of Trips**	**Total**
Airfare	$615	1.00	1.00	$615
Hotel	$185	5.00	1.00	$925
Per-diem	$120	6.00	1.00	$720
Ground transportation	$20	6.00	1.00	$120
Conference registration	$500	1.00	1.00	$500
Abstract fee	$70	1.00	1.00	$70
Other/Baggage Fee	$25	2.00	1.00	$50
Total				**$3,000**

Science Team Meeting - Destination TBD				
Expense	**Cost**	**Day(s)**	**# of Trips**	**Total**
Airfare	$615	1.00	2.00	$1,230
Hotel	$185	2.00	2.00	$740
Per-diem	$120	3.00	2.00	$720
Ground transportation	$35	3.00	2.00	$210
Conference Registration fee	$0	1.00	2.00	$0
Abstract fee	$0	1.00	2.00	$0
Other/Baggage Fee	$25	2.00	2.00	$100
Total				**$3,000**

Section IV. EQUIPMENT
N/A

Section V. SUBCONTRACTS
N/A

Section VI. OTHER DIRECT COSTS

Publications: Funds are requested in the amount of $8,700 ($2,900 per year) to support the publication of one peer-reviewed journal article of approximately 20 pages in length in each year of this project. This standard estimate is based on current rates for publishing in the Journal of Geophysical Research (JGR), American Geophysical Union (AGU).

Co-I Institution Support: Funds are requested in the amount of $54,988 to support the Co-I Institution expenses for this project:

Year 1: $19.872
Year 2: $16,312
Year 3: $18,804

Section VII. INDIRECT COSTS
[REDACTED AND ANONYMIZED]

Below is the total budget for the items described in the Budget Narrative. Also below are any supporting budgets.

Per ROSES solicitation instructions, all labor dollars are redacted from budgets in Proposal Documents.

COMPETITION SENSITIVE - FOR PROPOSAL SUBMISSION & PANEL REVIEW ONLY
Budget by Program Year

Solicitation: NNH22ZDA001N-ICESAT2, Studies with ICESat-2, A.32

Proposal Title: Improving Our Understanding of Gulf Coast Wetland Dynamics with Spaceborne Lidar

Total Excluding Labor Dollars and Indirect Costs: $54,988
Proposal Start Date: 05/01/2023
Proposal End Date: 04/30/2026

Description	PY 1 FTE	PY 1 Cost	PY 2 FTE	PY 2 Cost	PY 3 FTE	PY 3 Cost	Total FTE	Total Cost
A. Personnel	0.10		0.10		0.10		0.30	
B. Personnel								
Subtotal Labor-Redacted Cost	0.10		0.10		0.10		0.30	
Travel Total		3,353						3,353
Other Costs								
Publications						2,200		2,200
ADP/Computer Services		396		408		420		1,224
Other Direct Costs		16,123		15,904		16,184		48,211
Other Assessment		0		0		0		0
Reserves/Contingency		0		0		0		0
Subtotal Other Cost		16,519		16,312		18,804		51,635
Total Labor-Redacted Proposal Costs	0.10	19,872	0.10	16,312	0.10	18,804	0.30	54,988

Title: Improving Our Understanding of Gulf Coast Wetland Dynamics with Spaceborne Lidar
Submitted in response to NNH22ZDA001N-ICESAT2, Studies with ICESat-2, A.32

Summary of Personnel and Work Effort

The following table reflects the level of support required of all personnel necessary to perform the proposed investigation, regardless of whether these individuals require funding from this proposal.

Role	PY 1 FTEs	PY 2 FTEs	PY 3 FTEs	Total
Co-I - 1	0.10	0.10	0.10	0.30
Total:	0.10	0.10	0.10	0.30

Role	Commitment (months per year)											
	Year 1			Year 2			Year 3			Sum		
	This Project		Other Funded Projects	This Project		Other Funded Projects	This Project		Other Funded Projects	This Project		Other Funded Projects
	NASA Support	Total		NASA Support	Total		NASA Support	Total		NASA Support	Total	
Co-I	1.20	1.20	10.2	1.20	1.20	7.8	1.20	1.20	7.8	3.60	3.60	25.8
Sum of work effort:	1.20	1.20	10.2	1.20	1.20	7.8	1.20	1.20	7.8	3.60	3.60	25.8

The proposed work level is appropriate for the Co-I to perform the investigation.

Budget Justification: Narrative and Details

Notice of Restriction on Use and Disclosure of Proposal Information
The information (data) contained in this section of the proposal constitutes information that is financial and confidential or privileged. It is furnished to the Government in confidence with the understanding that it will not, without permission of the offeror, be used or disclosed other than for evaluation purposes; provided, however, that in the event a contract (or other agreement) is awarded on the basis of this proposal, the Government shall have the right to use and disclose this information (data) to the extent provided in the contract (or other agreement).

Budget Justification: Narrative

Labor Redacted Costs Only

Per ROSES solicitation instructions, all labor dollars are redacted from budgets in Proposal Documents.

Funding By Program Year

	PY 1 Cost	**PY 2 Cost**	**PY 3 Cost**	**Total Cost**
Total:	19,872	16,312	18,804	54,988

Roles and Cost Basis:

The Co-I will advise the PI and provide supporting input on ICESat-2 ATL13 surface water products that include mixed vegetation and open water signals including inland and coastal wetlands. The Co-I will assist in the interpretation of ICESat-2 photon clouds in the presence of vegetation and surface water.

Other Direct Costs

Travel

The budget includes travel as shown below based on the following cost assumptions:

- Estimated airfare and auto rental costs were obtained from either customary source or from other airfare estimating search engines (ie, Travelocity, etc.)
- Inflation of 3% per year is applied for annual occurrences.

Cost Details
Trip 1

	Lodging	MI&E or Per Diem	Airfare	Ground Trans	Auto Rental	Conf Fee	Fuel	Parking	Tolls	Other	Total	
Rate	232	79	2,100	50	75	0	45	0	0	0		
Nbr of People	1	1	1	1								
Nbr of Days	3	3			3							
Total	696	237	2,100	50	225	0	45	0	0	0	3,353	PY 1
											0	PY 2
											0	PY 3
											3,353	Total

Purpose of Trip: Science Team Meeting
Depart from: Origin
Arrive To: San Francisco

Summary of Travel Budget Requirements

Domestic/Foreign; Purpose	PY 1	PY 2	PY 3	Total
Domestic; Science Team Meeting	3,353	0	0	3,353
Total:	3,353	0	0	3,353

Other

Computer Support - Computer Support is required for the Co-I's laptop and two servers that will be used for this project.

Item	PY 1	PY 2	PY 3	Total
IT support	396	408	420	1,224
Total:	396	408	420	1,224

Publications - Cost estimates are based on recent similar publication costs.

Item	PY 1	PY 2	PY 3	Total
Journal publication	0	0	2,200	2,200
Total:	0	0	2,200	2,200

Other Direct Costs - These costs cover system administration for the complex information technology services required to support the proposed research activities, administrative and resource analysis support, and supplies to support the research effort.

Cost Sharing/Leveraging/Contributions
The project will leverage off the ICESat-2 data products currently produced at the Snow and Ice Data Center (NSIDC). The specific products will include the ATL13, ATL22 and ATL03 Georeferenced Photon Products

Budget Justification: Details

Title: Improving Our Understanding of Gulf Coast Wetland Dynamics with Spaceborne Lidar
Submitted in response to NNH22ZDA001N-ICESAT2, Studies with ICESat-2, A.32

Summary of Personnel and Work Effort

The following table reflects the level of support required of all personnel necessary to perform the proposed investigation, regardless of whether these individuals require funding from this proposal.

Role	PY 1 FTEs	PY 2 FTEs	PY 3 FTEs	Total
Co-I - 1	0.10	0.10	0.10	0.30
Total:	0.10	0.10	0.10	0.30

Role	Commitment (months per year)											
	Year 1			Year 2			Year 3			Sum		
	This Project		Other Funded Projects	This Project		Other Funded Projects	This Project		Other Funded Projects	This Project		Other Funded Projects
	NASA Support	Total		NASA Support	Total		NASA Support	Total		NASA Support	Total	
Co-I	1.20	1.20	10.2	1.20	1.20	7.8	1.20	1.20	7.8	3.60	3.60	25.8
Sum of work effort:	1.20	1.20	10.2	1.20	1.20	7.8	1.20	1.20	7.8	3.60	3.60	25.8

The proposed work level is appropriate for the Co-I to perform the investigation.

Budget Justification: Narrative and Details

Notice of Restriction on Use and Disclosure of Proposal Information
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Budget Justification: Narrative

Labor Redacted Costs Only

Per ROSES solicitation instructions, all labor dollars are redacted from budgets in Proposal Documents.

Funding By Program Year

	PY 1 Cost	**PY 2 Cost**	**PY 3 Cost**	**Total Cost**
Total:	19,872	16,312	18,804	54,988

Roles and Cost Basis:

The Co-I will advise the PI and provide supporting input on ICESat-2 ATL13 surface water products that include mixed vegetation and open water signals including inland and coastal wetlands. The Co-I will assist in the interpretation of ICESat-2 photon clouds in the presence of vegetation and surface water.

Other Direct Costs

Travel

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- Estimated airfare and auto rental costs were obtained from either customary source or from other airfare estimating search engines (ie, Travelocity, etc.)
- Inflation of 3% per year is applied for annual occurrences.

Cost Details
Trip 1

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Nbr of People	1	1	1	1								
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Total	696	237	2,100	50	225	0	45	0	0	0	3,353	PY 1
											0	PY 2
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Purpose of Trip: Science Team Meeting
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Other Direct Costs - These costs cover system administration for the complex information technology services required to support the proposed research activities, administrative and resource analysis support, and supplies to support the research effort.

Cost Sharing/Leveraging/Contributions
The project will leverage off the ICESat-2 data products currently produced at the Snow and Ice Data Center (NSIDC). The specific products will include the ATL13, ATL22 and ATL03 Georeferenced Photon Products

Budget Justification: Details

Below is the total budget for the items described in the Budget Narrative. Also below are any supporting budgets.

Per ROSES solicitation instructions, all labor dollars are redacted from budgets in Proposal Documents.

COMPETITION SENSITIVE - FOR PROPOSAL SUBMISSION & PANEL REVIEW ONLY
Budget by Program Year

Solicitation: NNH22ZDA001N-ICESAT2, Studies with ICESat-2, A.32

Proposal Title: Improving Our Understanding of Gulf Coast Wetland Dynamics with Spaceborne Lidar

Total Excluding Labor Dollars and Indirect Costs: $54,988
Proposal Start Date: 05/01/2023
Proposal End Date: 04/30/2026

Description	PY 1 FTE	PY 1 Cost	PY 2 FTE	PY 2 Cost	PY 3 FTE	PY 3 Cost	Total FTE	Total Cost
A. Personnel	0.10		0.10		0.10		0.30	
B. Personnel								
Subtotal Labor-Redacted Cost	0.10		0.10		0.10		0.30	
Travel Total		3,353						3,353
Other Costs								
Publications						2,200		2,200
ADP/Computer Services		396		408		420		1,224
Other Direct Costs		16,123		15,904		16,184		48,211
Other Assessment		0		0		0		0
Reserves/Contingency		0		0		0		0
Subtotal Other Cost		16,519		16,312		18,804		51,635
Total Labor-Redacted Proposal Costs	0.10	19,872	0.10	16,312	0.10	18,804	0.30	54,988

Application of Commercial Smallsat Data to Enhance Flood Resilience in Support of Underserved Communities in Puerto Rico

Dr. Jordan S. Borak, Principal Investigator
Dr. Nathan Morrow, Co-Investigator
Dr. Stephen E. Flynn, Collaborator
Mr. Fernando E. Pabón Rico, Collaborator

In Response To NNH22ZDA001N-CSDSA: Commercial Smallsat Data Scientific Analysis

1. Scientific/Technical/Management Plan

1.1 Executive Summary

Tropical Depression Seven of the 2022 Hurricane Season became Hurricane Fiona on September 18, 2022 (NWS, 2022). In Puerto Rico, spatial distribution of Fiona's rainfall was very uneven; with precipitation amount much lower in the north than the south – where storm totals generally ranged from 12-20 inches, and as high as 35 inches. Infrastructure damage was considerable and widespread. Hundreds of thousands were without municipal water, and the power grid (still recovering from Hurricane Maria's impact five years earlier) was again slow to recover.

Most residents of Puerto Rico are considered members of underserved communities, and it is therefore impossible to consider the impacts of a storm like Hurricane Fiona without examining them in the context of environmental justice. The Council on Environmental Quality's Climate and Economic Justice Screening Tool (CEJST) indicates widespread disadvantage and overburden on the island due to climate change, energy, health, housing, legacy pollution, transportation, water and wastewater, and workforce development. Furthermore, a key characteristic of land use in Puerto Rico is the limited spatial extent of many of the properties. For example, the average farm size is about 23 ha, and are mostly family or individual farms.

Compared to most freely-available data, many commercial datasets offer superior spatial resolution, and so it's possible to 1) identify land use type (e.g., agriculture vs. natural vegetation); 2) discriminate vegetation morphology, and 3) even count individual plants (Brandt et al., 2020). These fine-scale observations allow decision-makers access to information that answers questions that cannot be adequately addressed with coarser resolution maps (e.g., 250- or 500-meters with MODIS) because the decisions often concern social and physical dynamics occurring at finer spatial scales. For example, are there differences in resilience status between small-scale farms with tree-free agriculture vs those including forested patches? What amounts and types of vegetation make the difference between flood-resilient and flood-hazardous?

This proposal addresses questions of resilience within a proper context of environmental justice. It is accurate to characterize nearly the entire Commonwealth population as underserved, and no environmental study of Puerto Rico should neglect it. Our plan can be summarized as follows:

1. Research the physical damage from Hurricane Fiona across Puerto Rico, and use the CEJST to identify affected communities that are underserved and those that are not.
2. Work with staff from Puerto Rico Science, Technology & Research Trust (PRSTRT) to engage with decision-makers in a community impacted by flooding due to Hurricane Fiona.
3. Assess what socioeconomic and resilience-relevant metric information exists.
4. Collect available and relevant satellite data provided by Planet as well as public data.
5. Use machine learning techniques to provide annual maps of flooding extent and vegetation characteristics, and model relationships between environmental (satellite-based) metrics and flood resilience.
6. Provide recommendations on land use practices that enhance community resilience to future extreme events as indicated by modeling results.

1.2 Background and Previous Work

In its latest report, the United Nations' Intergovernmental Panel on Climate Change notes that those who contribute least to climate change are generally most vulnerable to its negative impacts. For small island states like the Commonwealth of Puerto Rico, these impacts are disproportionate to their population size, particularly in the contexts of human physical and mental health (IPCC, 2023). Large shares of its population, infrastructure, and economy are vulnerable to sea level rise, more frequent intense rainfall – and with that, coastal flooding, and saltwater intrusion. These risks are compounded by relatively low levels of adaptive capacity as compared to coastal areas within the continental United States. This means extreme climate-related events such as hurricanes can devastate large portions of local economies and cause widespread damage to crops, water supplies, infrastructure, and other critical resources and services (USGCRP, 2018).

In late September of 2022, Puerto Rico sustained a devastating shock from Hurricane Fiona. Although categorized as "just" a Category 1 hurricane, Fiona brought torrential rains and flooding. Coincidentally, this disaster occurred exactly five years after Hurricane Maria made landfall on the main island as a Category 5 storm – leaving many lives lost, and key infrastructure badly damaged, particularly the power grid. Slow recoveries from both events highlighted the underserved status of much of the territory's population.

Absent steps taken to increase its climate resilience, there is little reason to expect improved outcomes for Puerto Rico when the next major hurricane strikes. According to the U.S. General Accountability Office (GAO, 2022), federal recovery programs "lack key information—data and analysis—that would allow them to determine if access barriers and disparate recovery outcomes exist." Furthermore, GAO found several key areas of improvement need to provide meaningful assistance to disaster survivors and local governments, including:

- Better flood mapping: the Federal Emergency Management Agency's (FEMA) flood mapping investments were lower for communities with higher levels of underserved populations than communities with lower levels, other factors being equal.
- Improved support for assistance programs: disaster survivors, including low-income individuals, faced numerous challenges obtaining aid and understanding assistance programs.

This proposal intends to improve flood mapping in Puerto Rico using commercial satellite data, while providing support to community members seeking access to assistance via a community engagement component. Fulfillment of these recommendations would increase climate resilience and speed the progress of recovery from extreme events in Puerto Rico.

This proposal team's relevant published papers and products in this area of remote sensing include land cover classification using machine learning (Borak and Strahler, 1999), vegetation dynamics from temporal metrics (Borak et al., 2000), and gridding global canopy heights from ICESat-2 data (Borak et al., 2020). Team members also have expertise in analysis of hydrologic trends (Jasinski et al., 2019) and the role of vegetation in the water cycle (Kumar et al., 2019).

Project team collaborator Flynn recently led a FEMA-funded effort to directly assist pandemic recovery efforts in the six New England States by working in support of the Region 1 Federal Disaster Recovery Coordinator. This effort involved completing individual Resilience Rapid Needs Assessments for each of the states, involving data collection and interviews with nearly 500 stakeholders in 18 communities, many of them disadvantaged, across New England.

1.3 Goals and Expected Significance

Proposed Deliverables:

- Annual 30-m maps of land cover characteristics (percent cover; tree/no-tree; flooded/not flooded) for the main island of Puerto Rico (2013-2022)
- Map of climate resilience for Comunidad La Margarita (Municipio Salinas)
- Findings on relationship between vegetation characteristics and community resilience to flooding

Objective 1: Research the physical damage from Hurricane Fiona across the main island of Puerto Rico, and use the CEJST to identify affected communities that are underserved, and those that are not. The CEJST operates at the census tract level and illustrates the presence and prevalence of underserved populations in Puerto Rico (Figure 1).

Figure 1: Map of Puerto Rico's advantaged (light grey) disadvantaged communities (dark grey) as labeled by the Climate and Economic Justice Screening Tool (CEJST).

Objective 2: Work with staff from Puerto Rico Science, Technology & Research Trust (PRSTRT) to engage with decision-makers and stakeholders in a community impacted by flooding due to Hurricane Fiona. The primary community of focus here is Comunidad La Margarita in Municipio Salinas, located on the southern coast of the main island of Puerto Rico.

Objective 3: Assess what socioeconomic and resilience-relevant metric information exists. Several candidate metrics and tools exist; we intend to investigate the Flood Resilience Measurement for Communities (FRMC, Keating et al., 2017) and the scalable Flood Resilience Index presented by Leandro et al. (2020), but will work cooperatively with PRSTRT and the community engagement consultant to identify what is the best metric to use based on available

information and participation from the community. Ultimately, we will evaluate their appropriateness based primarily on availability of necessary physical and socioeconomic input data at the local level; however it is crucial that the contextual definition of "resilience" to include community perspectives on needs.

Objective 4: Collect available and relevant commercial satellite data provided by Planet and Maxar, as well as public data (see Table 1). Our primary commercial data source will consist of PlanetScope acquisitions, as the frequency of overpasses increases the likelihood of obtaining cloud-free looks over the location of interest. A limited number of high-quality Maxar scenes will serve to evaluate results produced from spatially coarser input datasets.

Objective 5: Use machine learning techniques to provide annual maps of flooding extent and vegetation characteristics, and to model relationships between environmental (satellite-based) metrics and flood resilience. The primary interests here are discrimination of water and vegetation from other surface elements, and splitting vegetated surfaces into tree vs. non-tree categories. These categories all translate into explainable land use categories and practices.

We will leverage the Maxar acquisitions for building machine learning models – i.e., for provision of training, tuning, and validation data. A random forest model – whether using the traditional (Breiman, 2001) algorithm or a boosted approach (e.g, Hastie et al., 2009) is appropriate for classification of the vegetation characteristics of interest (USFS, 2020), and generally provides classification rules and results that are more easily interpretable than deep learning. Random forest is also appropriate for flood mapping in this context, as it is intended to be retrospective rather than real-time (Leach et al., 2022). Ideally, a single random forest model would map both vegetation and flooding; however if this is unsuitable – e.g., the vegetation classification works, but discrimination between water/not-water is unclear – we will apply a separate random forest model to map surface water from PlanetScope data and train/tune/test with data from the Maxar scenes.

Objective 6: Provide recommendations on land use practices that enhance community resilience to future extreme events as indicated by modeling results. Our intent is to co-produce these recommendations along with community members in Salinas. This will involve the joint efforts of the entire team, but it is a key element of the environmental justice component of this investigation and is the primary motivation for including a community engagement consultant on our team. This cooperative approach is far more likely to yield results that will of actionable value to community members than a simplistic, top-down methodology.

1.4 Technical Approach and Methodology

Objectives 1-3 consist primarily of working with PRSTRT and the consultant to acquire data and reports on Fiona's local impacts. This will not provide an unbiased or exhaustive inventory of affected areas, but it will provide direction about where to look and whom to contact. Flooding damage from Fiona was widespread, especially in southern coastal areas of the main island, and one example of a profoundly affected location in that region is Communidad La Margarita (Figure 2); collaborators on this proposal team are currently funded by NASA's Equity and

Environmental Justice program to investigate how NASA Earth observations can assist members of this community (PI: Dr. Flynn).

Our team will identify other communities in Puerto Rico – underserved or not – impacted to varying degrees by Fiona. Likely candidates include populations located in the Jacaguas, Coamo, and Bucaná river floodplains. As with La Margarita, we will investigate relationships between satellite data products and resilience, although active engagement with community members in these other locations is likely beyond the scope of this project.

(a) **(b)**

Figure 2: True-color composites of La Margarita and beach, acquired by Maxar's Worldview-3 in January 2022, before Hurricane Fiona (a) and in September 2022, immediately afterward (b). Note collapsed bridge over storm-breached inlet in upper left of scene, and missing piers along shoreline.

We will employ a multisensor approach to characterize the vegetation of the study area, and how it relates to flood resilience. PlanetScope provides the frequent looks required in Puerto Rico's tropical location, but is inadequate on its own for supplying the combination of extensive spatial and temporal coverage of a source such as Landsat. Therefore, much of our analysis will be based on Planet's multispectral datasets at 3-4 meter resolution to characterize sub-pixel variability of Harmonized Landsat and Sentinel-2 (HLS) imagery, which has a 30-meter nominal spatial resolution (Claverie et al., 2018). For example, 3-meter PlanetScope data, when geolocated with the coarser HLS observations, can provide accurate estimates of percent vegetation cover at the HLS (30-m) scale. In addition, the team will utilize data products from other sensors to provide collateral information such as vegetation seasonality and height (see Table 1 for summary list).

The static datasets listed in Table 1 will be acquired first, followed by the time-varying datasets. Of the latter, the HLS dataset is limited in terms of period of record; it begins in 2013. Thus, for each time-varying indicator, we will acquire all publicly-available input data products (i.e., excluding commercial) for 2013 onward for the main island of Puerto Rico. Since the vast majority of census tracts in Puerto Rico are considered "underserved" we will effectively use the Climate and Economic Justice Tool to identify areas that are *not* underserved; these will be identified as candidates for experimental controls. We select Comunidad La Margarita in Salinas – the same community of interest in Dr. Flynn's EEJ project – as the main experimental test

case. Areas around Salinas experienced substantial flooding impacts due to Hurricane Fiona's heavy rainfall.

Next, we will acquire all PlanetScope data available for the La Margarita area, and perform simple data classifications that discern: 1) vegetated/unvegetated; 2) tree/no-tree; and 3) flooded/dry. These labels, confirmed with higher-resolution Maxar acquisitions, will be used to map the underlying areal proportions from PlanetScope (~3-m) to the HLS (30-m) scale. We will

Table 1: Remote sensing products to be used by this project for monitoring vegetation.

Vegetation Indicator Type	**Source(s) (index names)**	**Reference(s)**	**Spatial Resolution**	**Temporal Resolution**
Phenology	MODIS/VIIRS	Zhang *et al.* (2018)	500-m	Annual
Land Use	MODIS/VIIRS	Friedl *et al.* (2010)	500-m	Annual
Aquatic Indices	Maxar, PlanetScope, HLS[1] (NDWI[2])	McFeeters (1996); Xu et al. (2006)	sub-meter, 3-m, 30-m	1, 2-3 Days
Vegetation Indices	Maxar, PlanetScope, HLS (NDVI[3]; EVI[4])	Huete *et al.* (2002)	sub-meter, 3-m, 30-m	1, 2-3 Days
Vertical structure	GEDI Gridded Canopy Height & Ground Elevation	Dubayah *et al.* (2021)	1000-m	Static
Biomass Density	GEDI Gridded Biomass	Dubayah *et al.* (2022)	1000-m	Static

[1]HLS = Harmonized Landsat Sentinel; [2]NDWI = Normalized Difference Water Index; [3]NDVI = Normalized Difference Vegetation Index; [4]EVI = Enhanced Vegetation Index

do the same for 2-3 "control" (advantaged) locations that experienced extensive flooding, 2-3 control locations that did not experience extensive flooding, and 2-3 underserved locations that did not experience extensive flooding. The intent is to create an exhaustive comparison of flood/no-flood and underserved/advantaged cases (although the Salinas area will receive the most attention as it will be our most data-rich).

Figure 3 illustrates the overall flow of the proposed research. Once we bring the earth observation datasets together – commercial and public – we will use machine learning to map percent tree cover and flooded/dry for the entire main island from the HLS data on an annual basis. We will then analyze how differences in flood resilience correlate with physical vegetation characteristics at the 30-m level. Next, we will incorporate socioeconomic data and knowledge from Salinas to understand how vegetation characteristics and resilience relate with socioeconomic condition and cultural practices. The intent is to work with Salinas-area decision-makers on actionable suggestions for improving flood resilience through vegetation management practices, and to uncover patterns in the data that point to wider-scope actions that would benefit other underserved communities in Puerto Rico with enhanced flood resilience.

1.4.1 Sources of error and uncertainty

Chief source of error and uncertainty in the satellite data include inadequate screening of low-quality data, poor radiometric characterization, incorrect co-location of datasets, and

misclassifications. Our use of compositing promotes, but does not ensure, moderation of atmospheric contamination.

1.4.2 Resilience of the approach and methodology

By selecting PlanetScope as a primary input, versus Maxar, we trade away better spatial resolution in favor of increased frequency of quality looks. This is a key consideration in a tropical environment such as Puerto Rico, where frequent cloud cover is a perennial issue.

1.5 Impact of the Proposed Work on the State of Knowledge in the Field

A science-backed approach to vegetation characteristics serves as the evidence-based foundation for user engagement – leading to more informed decision-making for flood resilience. An open science approach and co-creation of monitoring tools – facilitated by efforts of the Puerto Rico Science, Technology & Research Trust – will advance understanding of both the threats to, and positive drivers of, flood resilience to a range of audiences from small-scale farmers to senior decision-makers. An assessment of users and user needs is underway as part of Dr. Flynn's EEJ project in Salinas, which is anticipated to provide NASA with specific environmental justice concerns with which its data can be applied, identify barriers to the use of that data, and list ways in which NASA could equitably aid communities in overcoming these barriers. It will also have articulated a pathway for community engagement that ensures federal resources will be appropriately suited and leveraged by communities facing environmental injustices.

Although it is a U.S. territory, the Commonwealth of Puerto Rico is typically understudied in U.S.-based Earth science. Many datasets and programs exclude Puerto Rico from their domains because of political reasons (it's not a state) or practical considerations (it's inconvenient to include it and CONUS in the same data fields). By producing annual 30-meter vegetation maps of Puerto Rico, we are filling data gaps that have existed for years. For example, the Multi-Resolution Land Cover program (MRLC) releases 30-m tree cover data for the conterminous U.S. every five years, but to date they've only produced maps for Puerto Rico in 2011 and 2016 (MRLC, 2019), which completely miss effects of Hurricanes Maria.

1.6 Relevance to the Program Element and to NASA Programs and Interests

This research is relevant according to the National Academy's latest Decadal Survey (NASEM, 2018), as it seeks to address Question H-4: "How does the water cycle interact with other Earth system processes to change the predictability and impacts of hazardous events and hazard-chains (e.g., floods, wildfires, landslides, coastal loss, subsidence, droughts, human health, and ecosystem health), and how do we improve preparedness and mitigation of water-related extreme events?" It comports with Earth Science/Applications Objective H-4d – to "[u]nderstand linkages between anthropogenic modifications of the land, including…land use…on response to hazards.'

The proposed research is also relevant to several of NASA's Strategic Goals and Objectives (NASA, 2022). It responds directly to Strategic Objective 1.1, "Understand the Earth system and its climate" by mapping floods and vegetation in Puerto Rico. It also responds to Strategic Objective 1.3, "Ensure NASA's science data are accessible to all and produce practical benefits to society." This project's results are intended to provide actionable recommendations regarding

land use in Puerto Rico, and all science and derived data products are explicitly proposed as "open."

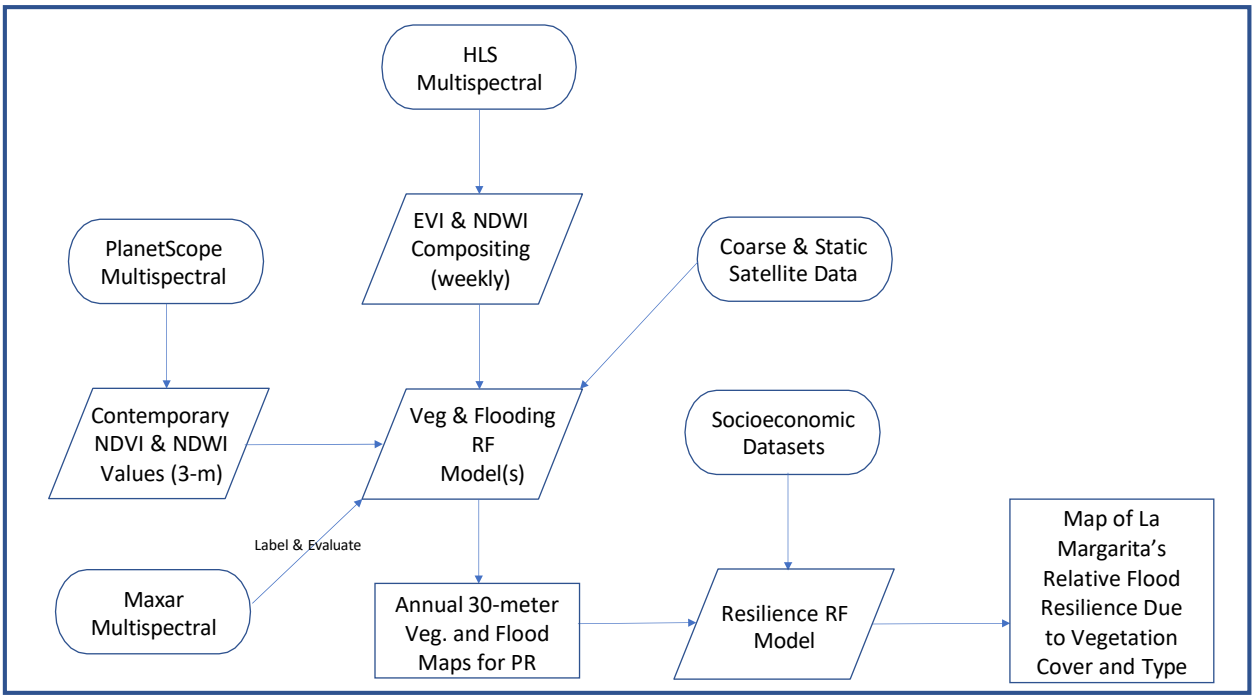

Figure 3: Synopsis of project flow and methodology. Inputs are represented by ovals, with outputs represented by rectangular boxes.

1.7 Implementation Plan

1.7.1 Project Schedule

PY1: Acquire all earth observation datasets and process as described; discuss community requirements and status with representatives of Puerto Rico Science, Technology & Research Trust; acquire socioeconomic data and information as appropriate and available.

PY2: Build statistical and machine learning models; run and interpret results with feedback from Puerto Rico Science, Technology & Research Trust; deliver maps to OpenData site as described in Data Management Plan; provide vegetation management recommendations to Puerto Rico Science, Technology & Research Trust and to community.

1.7.2 Management Structure

Key Personnel

Dr. Jordan Borak of the University of Maryland and NASA's Goddard Space Flight Center will serve as Principal Investigator (PI) for this uniquely qualified proposal team. Dr. Borak possesses considerable expertise as a remote sensing and data scientist, including two-plus decades of participation in NASA-funded research projects as both a Co-I and PI, and is currently a member of the ICESat-2 Science Team. His background includes the design, assessment, and analysis of a wide variety of both passive and active remote sensing data

products, with particular focus on land use/cover, land surface hydrology, and their variability. His current activities of relevance to this proposed investigation include: 1) Co-I on NASA's "National Climate Assessment Land Data Assimilation System" (NCA-LDAS); 2) PI on "Enhanced Vegetation Roughness Length Estimates from ICESat-2 Vegetation Products"; and 3) research associate on "Remote Sensing of Vegetation in Puerto Rico for NIST's Hurricane Maria Infrastructure Project," funded under a cooperative agreement between UMD and the National Institute of Standards and Technology.

Dr. Nathan Morrow of Tulane University will serve as Co-Investigator. Dr. Morrow has led efforts for resilience decision support in more than 20-countries. He has designed, implemented, and evaluated decision support systems for many international organizations and completed a technical review of SDG target indicator 2.1.2 for Zero Hunger. He has supported the Food and Agriculture Organization's global resilience capacity development efforts and supported action research and citizen science on Gulf Coast disasters. With World Food Program's Resilience Analysis and Mapping function, he worked on digital strategies for more inclusive engagement with communities through mobile surveys and big data/social media.

Collaborators

Dr. Stephen E. Flynn of Northeastern University will serve as a collaborator on the project. Dr. Flynn is the founding director of the Global Resilience Institute, and is a Principal Investigator on a NASA-funded investigation entitled, "Leveraging Earth Observation Data to Support Environmental Justice: A Puerto Rico Coastal Community Case Study." From that project, he brings community-based data and engagement in partnership with the Puerto Rico Science, Technology & Research Trust to the current project. Flynn is a Professor of Political Science and Professor of Civil and Environmental Engineering and as director of GRI, leads a major university-wide research initiative to inform and advance societal resilience in the face of growing human-made and naturally-occurring turbulence. He serves as a Guest Scientist at Los Alamos National Laboratory and has led teams in conducting post-disaster community and infrastructure resilience assessments, initially with support from the Alfred P. Sloan Foundation, the U.S. Department of Homeland Security S&T Directorate, and FEMA. With support from the U.S. Economic Development Administration, he has been leading projects that inform how economic development can be undertaken to advance community resilience, sustainability, and equity.

Fernando E. Pabón Rico, director of the Caribbean Center for Rising Seas (CCRS) at the Puerto Rico Science, Technology & Research Trust (PRSTRT) will serve as the project's second collaborator. Representing PRSTRT, Mr. Pabón's role is to discuss with other project team members the possible avenues of collaboration to ensure the successful completion of the project. In particular, the CCRS team will be available as an ad hoc sounding board and liaison with stakeholders, and will provide input on identifying an appropriate consultant for the project's community engagement consultant.

Consultant

The consultant will work to facilitate engagement of project personnel with community members (e.g., leaders, stakeholders, and other residents) in order to a) identify and evaluate for use/quality the available secondary data – including damage and loss information within the

scope of project objectives and deliverables; and b) arrive in a participatory way at recommendations on land use practices that enhance community resilience to future extreme events.

1.7.3 Work Flow

PI Borak will manage the project and direct the members of the project team. He will also be responsible for the open data and open science requirements. Dr. Borak's research responsibilities will focus on acquiring data and generating satellite-based data using requested NASA/GSFC computing resources. He will also work as needed with Collaborator Flynn and Collaborator Pabón on community outreach and understanding how to tailor satellite-derived products for optimal use by decision-makers and stakeholders. Dr. Borak's annual trips to Puerto Rico are meant to strengthen these connections.

Co-I Morrow will be the project team's lead on socioeconomic concerns, including social justice, and ensuring proper consideration for all underrepresented groups. He will be responsible guiding socio-economic data integration and community engagement aspects of the proposed research. At island scale, Dr. Morrow will support Dr. Borak with Geographic Information System-based spatial and visual analysis including overlay analysis of CJEST indicators as necessary. Dr. Morrow will review socio-economic assessments and data beyond CJEST indicators are available/useful. At local level, Dr. Morrow will advise the PRSTST-affiliated consultant to identify and evaluate for use/quality the available secondary data including damage and loss information. Dr. Morrow will evaluate existing data for construction of a resilience index that can be further parameterized by CSDSA and other remotely sensed data in collaboration with Dr. Borak. Dr. Morrow will help to frame and document overall local government and community engagement efforts of PRSTST and affiliated consultant within the scope of project objectives and deliverables through supporting work planning and regular update reporting. Participatory evaluation with multiple stakeholders of the proposed resilience metrics will be supported by Dr. Morrow. He will also attend all team meetings and contribute to data management, publishing and reporting requirements.

Collaborator Flynn and the PI will work together to understand how best to use these Earth observation datasets to improve La Margarita's resilience to flooding, and they will exchange insights from their respective projects. Collaborator Pabón will also work with the PI on how best to use the Earth observations in La Margarita, and will also assist the PI in identifying an appropriate community engagement consultant.

2. References

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White House Council on Environmental Quality (WHCEQ), 2022: *Climate and Economic Justice Screening Tool, Ver. 1*. Accessed 2023-03-22 from https://screeningtool.geoplatform.gov.

Xu, H., 2006: Modification of Normalised Difference Water Index (NDWI) to Enhance Open Water Features in Remotely Sensed Imagery. *Int. J. Remote Sens.*, 27, 3025- 3033.

3. Data Management Plan

In general, this project will follow an open data and science policy, where the databases, algorithms, and code used for the development of the project will be made freely and openly available, as well as sample Jupyter notebooks that contain basic code for programmatic access to the outputs. The team will post product versions to NASA's Open Data Portal and provide metadata as required. The team will post project output data there, and evaluate the feasibility to have that hosted at a DAAC if data volume becomes too large for the Portal.

Data types, volume, formats, and (where relevant) standards:
There are two main groups of data the team will need to distribute: 1) Vegetation parameter data fields; and 2) flooding fields, which will likely be distributed as netCDF files at an anticipated data volume of roughly 1TB per project year (as also indicated in HEC request).

Note that because the input datasets used by this project are all freely available via open data sites on the Internet, there is no requirement for the team to manage those data.

Intended repositories for archived data, including mechanisms for public access & distribution:
As described above, in deference to open data and science policies, the output data will be transferred from NASA/GSFC to the NASA Open Data Portal.

How the plan enables long-term preservation of data:
If the Open Data Portal is capable of maintaining the outputs long term, that would comply with open data protocols. Otherwise, the team's preference would be to use Zenodo owing to its commitment to FAIR compliance.

Roles and responsibilities of team members in accomplishing the DMP:
The project PI will have responsibility for managing any code or output data products.

Licensing Considerations:
End User License agreements for PlanetScope and Maxar Worldview describe how commercial data can be used by NASA researchers for Scientific Use research purposes as outlined in the research award agreement. Public Release or Commercial Use of the CSDA data is prohibited. Any raw imagery must be securely handled. Only derivative products with clearly defined research purposes are to be shared with the general public, used in publications or shared with our community-based stakeholders.

Every effort will be made to limit the access to original or raw PlanetScope and Maxar Worldview data. The PI works in a secure NASA affiliated research center with a nasa.gov email. The raw data will almost exclusively be processed in the HEC computing environment by Dr. Borak following the strict security protocols of his center. On occasions when Co-I Morrow is required to use imagery, it will be processed in HEC environment or on a secured workstation. No raw data will be present on laptops during travel.

4. Biographical Sketches

Jordan S. Borak

Associate Research Scientist
University of Maryland/ESSIC · NASA/GSFC · Code 617 · Greenbelt, MD 20771
(410) 929-5394 · Jordan.Borak@nasa.gov

Education

- Graduate Certificate, Data Science: University of Maryland, College Park, 2019.
- Ph.D. in Geography: Boston University, 2000.
- Master of Arts in Geography: Boston University, 1996.
- Bachelor of Science in Geography (Math minor): University of Illinois, Urbana-Champaign, 1992.

Areas of Research Specialization

- Inter-annual and seasonal variability of vegetation and water cycle components.
- Earth science data processing and analysis: particular focus on long-term time series data at regional and continental scales.
- Land-cover characterization from satellite observations.
- Quality assessment of remotely sensed data.

Current Research Projects

- Principal Investigator/ICESat-2 Science Team Member: "Enhanced Roughness Length Estimates from ICESat-2 Vegetation Products" (NASA Cryospheric Sciences Program).
- Co-Investigator: "National Climate Assessment Land Data Assimilation System, NCA-LDAS" (NASA National Climate Assessment Program).
- Co-Investigator: "Shallow Water Bathymetry Products and Analysis for Near-Shore Coastal and Inland Waters" (NASA Earth Science Research and Analysis Program).
- PREP Research Associate: "Remote Sensing of Vegetation in Puerto Rico for NIST's Hurricane Maria Infrastructure Project" (NIST Community Resilience Program).
- PACE Early Adopter: "Mapping Wetland Vegetation Parameters with PACE's OCI."

Computing Skills

- Programming and scripting: 25+ years of C programming and shell scripting in Unix-type environments; 4+ years with Python and Java.
- Machine learning software: scikit-learn and Keras.
- Statistics and visualization packages: R, Tableau, and SAS.
- GIS and image processing packages: extensive work with ENVI, ID, and ArcGIS.

Employment

- Associate Research Scientist, Earth System Science Interdisciplinary Center, University of Maryland and Hydrological Sciences Laboratory, NASA/Goddard Space Flight Center (June 2011 – present).
- Senior Support Scientist, Science Systems and Applications, Inc., then Wyle Information Systems, LLC, and Hydrological Sciences Branch, NASA/GSFC (July 2002 – June 2011).
- Support Scientist, Science Systems and Applications, Inc., MODIS Land Data Operational Product Evaluation Facility, NASA/GSFC (November 2000 – June 2002).
- Research Associate, Department of Geography and Laboratory for Global Remote Sensing Studies, University of Maryland (July 1999 – November 2000).
- Research Fellow, Department of Geography and Center for Remote Sensing, Boston University (September 1993 – June 1999).

Publications (selected)

Borak, J.S., M.F. Jasinski, and N. Tangdamrongsub, 2022: Effects of ICESat-2 Vegetation Product Spatial Sampling Rate on Satellite-Derived Momentum Aerodynamic Roughness Fields [Poster presentation C35D-0915]. AGU 2022 Fall Meeting, 12-16 Dec.

Borak, J.S., M.F. Jasinski, and N. Tangdamrongsub, 2021: Fusing ICESat-2 and MODIS Vegetation Data Products to Enhance Momentum Aerodynamic Roughness Fields with Spatially-Explicit Scaling for Improved Land Surface Modeling [Poster presentation G15B-0350]. AGU 2021 Fall Meeting, 13-17 Dec.

Tangdamrongsub, N., C. Hwang, **J.S. Borak**, S. Prabnakorn, and J. Han, 2021: Optimizing GRACE/GRACE-FO data and *a priori* hydrological knowledge for improved global Terrestrial Water Storage component estimates. *J. Hydrol.*, **598**, 126463.

Borak, J.S., M.F. Jasinski, and N. Tangdamrongsub, 2020: Enhanced vegetation aerodynamic roughness for momentum with ICESat-2 data products: early results [Poster presentation H194-0005]. AGU 2020 Fall Meeting, 1-17 Dec.

Jasinski, M.F., **J.S. Borak**, S.V. Kumar, D.M. Mocko, C.D. Peters-Lidard, M. Rodell, H. Rui, H.K. Beaudoing, B.E. Vollmer, K.R. Aresenault, B. Li, J.D. Bolten, and N. Tangdamrongsub, 2019: NCA-LDAS: Overview and Analysis of Hydrologic Trends for the National Climate Assessment. *J. Hydrometeorol.*, **20**, 1595-1617.

Kumar, S.V., M. Jasinski, D. Mocko, M. Rodell, **J. Borak**, B. Li, H. Kato Beaudoing, and C. D. Peters-Lidard, 2019a: NCA-LDAS land analysis: Development and performance of a multisensor, multivariate land data assimilation system for the National Climate Assessment. *J. Hydrometeorol.*, **20**, 1571-1593.

Kumar, S.V., D.M. Mocko, S. Wang, C.D. Peters-Lidard, and **J. Borak**, 2019b: Assimilation of remotely sensed Leaf Area Index into the Noah-MP land surface model: Impacts on water and carbon fluxes and states over the Continental U.S. *J. Hydrometeorol*., **20**, 1359-1377.

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Roy, D.P., **J.S. Borak**, M. Zheng, and J. Descloitres, 2002: The MODIS Land product quality assessment approach. *Remote Sens. Environ.,* **83**, 62-76.

Borak, J.S., E.F. Lambin, and A.H. Strahler, 2000: The use of temporal metrics for land-cover change detection at coarse spatial scales. *Int. J. Remote Sens.,* **21**, 1415-1432.

Borak, J.S., and A.H. Strahler, 1999: Feature selection and land cover classification of a MODIS-like data set for a semiarid environment. *Int. J. Remote Sens.,* **20**, 919-938.

Co-I/Institutional PI: Nathan Morrow, PhD.

1. Professional Preparation

Boston University, Geography, Bachelor of Arts with Honors 1997
Boston University, Geography, Master of Arts 1998
University of Maryland, Geography, Doctor of Philosophy (M. Hansen advisor) 2021

2. Professional Experience and Positions

Current Sponsored Research:

- PI, Assessment of the Gulf Coast Environmental Justice Landscape for Equity (AGEJL-4-Equity), NASA-funded, 10/22-4/23
- PI, Open Science Outlook for Environmental Justice and Resilience of the Louisiana Gulf Coast (O8O-LoGiC), NASA-EPSCoR-funded, 5/22-4/23

Appointments at Tulane University:

- Ass. Research Prof, Public Health & Tropical Medicine, 2022-/Ass. Research Prof, Law School, 2014-2018, Adjunct 2007-2012/Ass. Clinical Prof, School of Social Work, 2012-2014/Ass. Clinical Prof, Public Health & Tropical Medicine, 2011-2014, Adjunct 2007-2022

3. Selected Bibliography

***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

***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 (ESQ) Mission Science Data Processing Study. **https://doi.org/10.5281/zenodo.5932699**

***Morrow, N.,** & Friedl, M. (1998). Modeling biophysical controls on land surface temperature and reflectance in grasslands. *Agricultural and Forest Meteorology,* 92(3), 147-161. https://doi.org/10.1016/80168-1923(98)00098-7

4. Research Experience: Scientific, Technical, Management

Dr. Morrow has acquired a wide range of skills and expertise with 25 years of experience not only as a professor but also leading implementation, developing capacity and ensuring research-based evidence for interdisciplinary/multi-sectoral food security, humanitarian response, and child wellbeing policy implementation projects. He has served as Chief of Party for a multi-organizational consortium for multi-country developmental relief and humanitarian aid response valued at over 400 million USO responding to an El Nino drought food security crisis in southern Africa As co-chair of the Emergency and Disaster Evaluation thematic group at the American Evaluation Association, Dr. Morrow has promoted inclusive engagement and more rigorous measurement models in resilience research and intervention planning. The Global Environment Facility (GEF-7) replenishment strategy was informed, in part, by a geospatial analysis of environmental security led by Dr. Morrow. Dr. Morrow is PI for two projects that intend to strengthen capacity for open source science to address challenges in CJ & EJ research in collaboration with Gulf Coast EJ community networks and organizations. Dr. Morrow continues to actively use remote sensing and geospatial analysis in his applied research following on early contributions to the MODIS, NPOESS, and Land-Use and Land-Cover Change science mission.

5. Table of Personnel and Work Effort

Name	Role	Commitment (months per year)								
		Year 1			***Year 2***			***Sum***		
		This Project		*Other Funded Projects*	*This Project*		*Other Funded Projects*	*This Project*		*Other Funded Projects*
		NASA Support	*Total*		*NASA Support*	*Total*		*NASA Support*	*Total*	
Jordan Borak	PI	2.4	2.4	3.0	2.4	2.4	0	4.8	4.8	3.0
Nathan Morrow	Co-I/ Institutional PI	2.4	2.4	0	2.4	2.4	0	4.8	4.8	0.0
Stephen Flynn	Collaborator (unfunded)	de minimis	de minimis	de minimis	de minimis	de minimis	de minimis	de minimis	de minimis	de minimis
Fernando Pabón	Collaborator (unfunded)	de minimis	de minimis	de minimis	de minimis	de minimis	de minimis	de minimis	de minimis	de minimis
Sum of work effort:		**4.8**	**4.8**	**3.0**	**4.8**	**4.8**	**0**	**9.6**	**9.6**	**3.0**

Comments:
Additional effort to be provided on hourly basis by TBD community engagement consultant (see Budget)

6. Current and Pending Support

Current and Pending: Dr. Jordan Borak

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Dr. Jordan S. Borak	Other agencies (including NASA) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending
Project/Proposal Title: Enhanced Roughness Length Estimates from ICESat-2 Vegetation Products
Role: PI
Source of Support: NASA Cryospheric Program/Studies with ICESat-2
Total Award Period Covered: 05/20-04/23
Person-Months Per Year Committed to the Project: 3.0

Support: ☒ Current ☐ Pending
Project/Proposal Title: National Climate Assessment Land Data Assimilation System, NCA-LDAS
Role: Co-I
Source of Support: NASA National Climate Assessment Program
Total Award Period Covered: FY16-FY23
Person-Months Per Year Committed to the Project: 3.6

Support: ☒ Current ☐ Pending
Project/Proposal Title: Shallow Water Bathymetry Products and Analysis for Near-Shore Coastal and Inland Waters
Role: Co-I
Source of Support: NASA The Science of Terra, Aqua, and Suomi-NPP
Total Award Period Covered: FY22-FY24
Person-Months Per Year Committed to the Project:3.0

Support: ☒ Current ☐ Pending
Project/Proposal Title: Remote Sensing of Vegetation in Puerto Rico for NIST's Hurricane Maria Infrastructure Project
Role: PREP Research Associate
Source of Support: NIST Community Resilience Program
Total Award Period Covered: 07/22-06/23
Person-Months Per Year Committed to the Project: 3.0

Support: ☐ Current ☒ Pending
Project/Proposal Title: Improving Our Understanding of Gulf Coast Wetland Dynamics with Spaceborne Lidar
Role: Co-I
Source of Support: NASA Cryospheric Program/Studies with ICESat-2
Total Award Period Covered: 05/23-04/26
Person-Months Per Year Committed to the Project: 3.0

Support: ☐ Current ☒ Pending
Project/Proposal Title: Spatio-Temporal Connections of Integrated Energy, Water and Biogeochemical Processes Across Alaska's Land and Ocean Ecosystems
Role: Co-I
Source of Support: NASA Interdisciplinary Research in Earth Science
Total Award Period Covered: 6/23-05/26

Person-Months Per Year Committed to the Project: 1.2

Support: ☐ Current ☒ Pending
Project/Proposal Title: High-resolution Extreme Event and Localized Temperature for Health Forecasting in Underserved Lowlands of the Gulf Coast (HEELTHFUL-GC)
Source of Support: NASA Interdisciplinary Research in Earth Science
Total Award Period Covered: 07/23-06/26
Person-Months Per Year Committed to the Project: 3.6/2.4/1.8

Support: ☐ Current ☒ Pending
Project/Proposal Title: Ancient Climate Change Resilient but Understudied Enset agrifood system Diversity Mapping for Food Security and Sustainability (ACCRUED-MFSS)
Role: Co-I
Source of Support: NASA Commercial Smallsat Data Scientific Analysis
Total Award Period Covered: 09/23-08/25
Person-Months Per Year Committed to the Project: 3.6

Support: ☐ Current ☒ Pending
Project/Proposal Title: Analysis of Locally Flooded Areas with Environmental Justice Communities (ALFA-EJC)
Role: Co-I
Source of Support: NASA Commercial Smallsat Data Scientific Analysis
Total Award Period Covered: 09/23-08/25
Person-Months Per Year Committed to the Project: 2.4

Current and Pending: Dr. Nathan Morrow

The following information should be provided for each investigator and other senior personnel. Failure to provide this information may delay consideration of this proposal.

Investigator: Dr. Nathan Morrow	Other agencies (including NASA) to which this proposal has been/will be submitted.

Support: ☒ Current ☐ Pending
Project/Proposal Title**:** Assessment of the Gulf Coast Environmental Justice Landscape for Equity (AGEJL-4-Equity)
Source of Support: NASA A.49 Earth Science Applications: Equity and Environmental Justice
Total Award Period Covered: 10/22-06/23
Person-Months Per Year Committed to the Project: 2.0

Support: ☒ Current ☐ Pending
Project/Proposal Title: Open Science Outlook for Environmental Justice and Resilience of the Louisiana Gulf
Role: PI
Source of Support: NASA EPSCoR Louisiana BoR RID Project
Total Award Period Covered: 3/22-05/23
Person-Months Per Year Committed to the Project: 2.0

Support: ☐ Current ☒ Pending
Project/Proposal Title: High-resolution Extreme Event and Localized Temperature for Health Forecasting
Role: PI
Source of Support: NASA A.28 Interdisciplinary Science
Total Award Period Covered: FY24-FY26
Person-Months Per Year Committed to the Project: 5.4

Support: ☐ Current ☒ Pending
Project/Proposal Title: EJ Core GC; Engaging diverse researchers and EJ communities in inclusive
Role: PI
Source of Support: NASA Science Mission Directorate –F.14- Transform to Open Science Training
Total Award Period Covered: 07/23-06/25
Person-Months Per Year Committed to the Project: 3.6

7. Letters of Support

To the ROSES Proposal Review Panel

Re: Letter in support of Dr. Jordan Borak's Initiative towards building community resilience against the impacts of flooding disasters in Puerto Rico

Dear Members of the Review Panel,

I am pleased to write this letter of support for Dr. Borak's proposed investigation regarding the role of vegetation in building community resilience to flooding impacts in Puerto Rico. At the time of writing this letter it stands as "*Application of Commercial Smallsat Data to Enhance Flood Resilience in Support of Underserved Communities in Puerto Rico*." Understanding the relationship of land use to flood resilience has never been more important here, with increasing frequency and severity of tropical cyclone activity. Hurricane Fiona unleashed torrential rains and flooding on Puerto Rico in September 2022, almost five years to the day that Hurricane Maria made landfall and brought devastation to the island. In both cases we saw the disproportionate impact of climate change on underserved and vulnerable communities.

The Puerto Rico Science, Technology & Research Trust (PRSTRT) is a 501(c)(3) non-profit organization based in Puerto Rico and created in 2004 to encourage and promote innovation, transfer and commercialization of technology, and creation of jobs in the technology sector. The PRSTRT's mission is to invest, facilitate and build capacity to continually advance Puerto Rico's economy and its citizens' well-being through innovation-driven enterprises, science and technology, and its industrial base. The vision is that Puerto Rico is a globally recognized innovation hub. The PRSTRT contributes to the creation and implementation of the Puerto Rico Government's public policy for the advancement of science, technology, research and development, and public health.

Dr. Borak's project will integrate high-resolution commercial satellite observations with publicly available remote sensing products in a novel way to produce maps of vegetation type and density. It will also identify flood-affected areas. These maps will then be associated with socio- economic and infrastructure information to improve our understanding of 1) how vegetation distribution correlates with flooding impacts on underserved communities; 2) how residents and other stakeholders in the community can use this information to increase resilience; and 3) how this policy-relevant information can be conveyed to decisionmakers such that federal resources will be appropriately allocated to, and applied by, communities experiencing environmental injustices.

This project is very relevant especially to the Caribbean Center for Rising Seas' (CCRS), one of the PRSTRT's newest programs. CCRS's mission is to prepare Puerto Rico and the Caribbean to adapt and thrive in the new era of increasing flood risk from storms, tides, and sea level rise. The CCRS is tasked with further establishing Puerto Rico's leadership and stature as a center of excellence and innovation. Flooding is worsening in communities all over the world since 100-year storms and extreme rain events are happening more frequently, often every couple of years. Sea level rise continues to accelerate, with estimates ranging from a foot higher by midcentury, to 7 feet higher by the end of the century. During hurricanes and severe storms, a few inches of higher sea level may result in flood waters entering buildings and causing major damage to infrastructure. Coastal communities are in jeopardy while facing billions of dollars of assets going underwater. The CCRS' focus on resiliency and adaptation – promoting guidelines and best practices for the built environment to better prepare communities for increased flooding would benefit greatly from the results of this study. Specifically, it will inform one of the primary areas of focus: promoting 100-year flood safe communities.

In keeping with the mission of facilitating the researchers' primary tasks, the PRSTRT stands ready to discuss any possible avenues of collaboration to ensure the successful completion of the project. While the CCRS team remains available as an ad hoc sounding board and liaison with stakeholders, other components of the PRSTRT are available to provide local technical and/or administrative support for a fee be it in Information Technology subfields such as data management and web-page development or Strategic Outreach and Communications to make available and publicize research progress and findings.

The PRSTRT commends Dr. Borak for his initiative. It will provide useful knowledge to develop initiatives that will reduce or eliminate risk and damage from future natural hazards, increase resiliency, and promote a culture of preparedness. We hope the proposal is considered favorably and we look forward to its implementation and the initiatives that will arise from it.

If you have any questions, please feel free to contact Mr. Fernando Pabón at fpabon@prsciencetrust.org.

Sincerely,

Luz A. Crespo Valentin

Luz A. Crespo Valentín

Chief Executive Officer

8. Budget

		YEAR 1	YEAR 2	TOTAL
TRAVEL				
	FOREIGN	$ 4,000	$ 4,000	$ 8,000
	TOTAL TRAVEL	$ 4,000	$ 4,000	$ 8,000
EQUIPMENT				
	TOTAL EQUIPMENT	$ -	$ -	$ -
SUBCONTRACTS				
Tulane University		$ 2,610	$ 2,610	$ 5,220
	TOTAL SUBCONTRACTS	$ 2,610	$ 2,610	$ 5,220
OTHER DIRECT COSTS				
	Community Engagement Consultant (TBD)	$ 20,000	$ 20,000	$ 40,000
	Publications	$ 2,900	$ 2,900	$ 5,800
	TOTAL OTHER DIRECT COSTS	$ 22,900	$ 22,900	$ 45,800
TOTAL DIRECT COSTS		$ 29,510	$ 29,510	**$ 59,020**
NASA GSFC 20% Assessment		$ 5,902	$ 5,902	**$ 11,804**
TOTAL REQUESTED SUPPORT		$ 35,412	$ 35,412	**$ 70,824**

University of Maryland, College Park (UMD) – Budget Justification

TRAVEL

International Travel: Funds are requested in the amount of $8,000 ($4,000 per year) for the PI to attend a Team / Community Engagement meeting in Puerto Rico, in each year of this project for the purpose of collaborating with colleagues and disseminating research findings. The standard travel cost estimates below are based on the average expenses reported by department faculty for attending meetings and conferences in the previous fiscal year. All travel costs are budgeted in accordance with UMD, state, and federal policies and are estimated based on historical averages, UMD per diem rates (domestic travel, only) and current gsa.gov rates. Please note that this travel is contingent upon COVID-19 regulations imposed at the state and federal level.

Year 1: NASA Team / Community Engagement Meeting, Puerto Rico: $4,000
Year 2: NASA Team / Community Engagement Meeting, Puerto Rico: $4,000

Team / Community Engagement Meeting, Peurto Rico				
Expense	**Cost**	**Day(s)**	**# of Trips**	**Total**
Airfare	$1,300	1.00	2.00	$2,600
Hotel	$280	5.00	2.00	$2,800
Per-diem	$150	6.00	2.00	$1,800
Ground transportation	$50	6.00	2.00	$600
Other/Baggage Fee	$50	2.00	2.00	$200
Total				**$8,000**

EQUIPMENT

N/A

SUBCONTRACTS

Funds are requested in the amount of $5,220 to support one (1) subcontract with the Tulane University.

Year 1: $2,610
Year 2: $2,610

OTHER DIRECT COSTS

Community Engagement Consultant (TBD): Funds are requested in the amount of $40,000 ($20,000 in each year of this project). The consultant will facilitate the engagement of the project personnel with community members (e.g., leaders, stakeholders, and other residents). The purpose: a) identifying and evaluating for use/quality the available secondary data – including damage and loss information within the scope of project objectives and deliverables; and b) arriving in a participatory way at recommendations on land use practices that enhance community resilience to future extreme events.

Publications: Funds are requested in the amount of $5,800 ($2,900 per year) to support the publication of one peer-reviewed journal article of approximately 20 pages in length in each year of this project. This standard estimate is based on current rates for publishing in the Journal of Geophysical Research (JGR), American Geophysical Union (AGU).

NASA GSFC Assessment Fee: Funds are requested in the amount of $11,804 to support the NASA Goddard Space Flight Center expenses for this project. These costs, as discussed in NASA financial regulations, are for services to support the research effort that go beyond the standard costs considered under Center Management and Operations (Center Overhead), and are not incurred elsewhere within GSFC. Within the Sciences and Exploration Directorate these costs cover system administration for the complex information technology services required to support the proposed research activities, administrative and resource analysis support, and supplies to support the research effort. The assessment rate is 20% of the total direct costs of the project:

Year1:$5902
Year2:$5902

REDACTED BUDGET

NASA - Puerto Rico

Prime: Univ. Maryland

Tulane		**Year 1**	**Year 2**	**Total**
	Personnel			
	Faculty - Morrow - .15 LOE	-	-	-
		-	-	-
		-	-	-
	Travel - Puerto Rico (6 days)			
	Airfare	750.00	750.00	1,500.00
	Hotel (DoD rate)	1,170.00	1,170.00	2,340.00
	Ground and meals (DoD rate)	690.00	690.00	1,380.00
Total Direct Costs - Tulane		2,610.00	2,610.00	5,220.00
		-	-	-
Total Project Cost		**2,610.00**	**2,610.00**	**5,220.00**

Redacted Budget Narrative : Dr. Nathan Morrow, Tulane Univeristy

Application of Commercial Smallsat Data to Enhance Flood Resilience in Support of Underserved Communities in Puerto Rico
(expected September 2023-August 2025)
University of Maryland, prime

Nathan Morrow as Co-I Institutional PI will provide 0.15 FTE to Application of Commercial Smallsat Data to Enhance Flood Resilience in Support of Underserved Communities in Puerto Rico project activities

A site visit in project years will allow Dr. Morrow to work with the PRSTST-affiliated consultant to ground truth the use/quality the available secondary data including damage and loss information. A site visit in the second project year will allow Dr. Morrow to support the participatory evaluation with multiple stakeholders of the proposed resilience metrics.

Travel - Puerto Rico (6 days)			
Airfare	750.00	750.00	1,500.00
Hotel (DoD rate)	1,170.00	1,170.00	2,340.00
Ground and meals (DoD rate)	690.00	690.00	1,380.00
sts - Tulane	2,610.00	2,610.00	5,220.00

9. Facilities and Equipment

The technical management and infrastructure to facilitate and support grant-based research computing is available to Earth System Science Interdisciplinary Center (ESSIC) scientists at the University of Maryland (UMD) Discovery District location.

The Center provides a modern data center with 10-Gigabit network capability, including dedicated HVAC, electrical, and fire-suppression systems, as well as raised flooring, cipher-controlled access, and both public and private-facing networks.

ESSIC technical staff manage an array of physical and virtual compute servers associated with existing research grants, including high-performance computing clusters with total storage resources of nearly three Petabytes. Server operating systems include both Windows Server and Red Hat Linux.

ESSIC scientists rely on the main UMD campus for additional technical resources that include software licensing, network support, email, authentication, specialized vendor contracts, and both no-cost (google) and fee-based storage. Deep Thought, the UMD high-performance computing facility with over 1000 compute nodes and several Petabytes of storage, is available to ESSIC scientists for approved projects.

The Center staffs a local helpdesk office offering researchers an array of services including desktop and personal computing deployment and support, technical procurement consultation and order assistance, IT security, connectivity, backups, asset management, and system diagnostics and troubleshooting.

The Center also offers network-accessible color printers, scanners/copiers, as well as meeting and conference spaces equipped with integrated projectors, conference phones, and room PCs. A rooftop platform, which currently hosts a NOAAPORT satellite-receiving dish and other sensors, is also available for instrumentation hosting.

Additionally, the UMD PI will work on-site at the NASA's Goddard Space Flight Center (GSFC), through a co-operative agreement between GSFC and UMD. GSFC facilities offer high-speed internet access, printing services (including a plotter for poster printing), office space, and conference rooms. The UMD PI will have access to High Efficiency Computing resources at the NASA Center for Climate Simulation to perform the proposed data analysis and to process the observations data sets.

SCHOOL OF PUBLIC HEALTH AND TROPICAL MEDICINE

Department of International Health and Sustainable Development

April 25th, 2022

RE: TWSC proposal "**Open Source Science for Environmental Justice and Climate Change Resilience on the Gulf Coast"**

Dr. Yaítza Luna-Cruz
PoC: Transform to OPen Science Training
NASA Science Mission Directorate
300 E St SW, Washington, DC 20546, United States

Dear Yaítza,

I am writing to confirm the relevancy of a Topical Workshops, Symposia, and Conference (TWSC) proposal tentatively titled "**Open Source Science for Environmental Justice and Climate Change Resilience on the Gulf Coast".** In preparation for the Year of Open Science (YOOS), Tulane University and partners would like to propose a series of capacity development workshops under Allowable Focus E. **"**Coordinate, communicate, and engage with … organizations that advance racial equity and support underserved communities". We seek to empower EJ and climate change vulnerable communities in the underserved southern Gulf Coast with capacities for accessing and using NASA open earth science in the decisions that affect their communities and environment.

The Gulf Coast has significant economic importance and is the fastest growing coast. At the same time, the region is home to increasing disparities that will be worse under climate change. Disparities in environmental and climate justice follow similar patterns of disparities in socio-economic wellbeing and barriers to enfranchisement of marginalized communities that lack adequate inclusion in the decisions that impact their environment and health. Open source science that promotes aggregating individual voices and observations in a scientifically valid way promises to promote research that is broadly inclusive and therefore has the potential to benefit even the most underserved communities. Unfortunately, the same social and geographically-located barriers concentrated in southern Gulf Coast region that make communities vulnerable also can pose barriers to necessary capacity development to engage in high quality open science.

The recent open source support to the Climate and Economic Justice Screening Tool provides a timely and powerful proof of concept for bringing Open Science and Climate/Environmental Justice communities together to co-create decision support tools. Also for NASA, we hope that capacity development activities can provide sustainability and synergy of the significant NASA investments made in projects such as the Gulf of Mexico Research Initiative and Delta-X in anticipation of the exciting possibilities for the region offered by missions such as GLIMR and SWOT.

The LA Board of Regents and NASA EPS-CoR have supported Tulane University School of Public Health and Tropical Medicine to conduct a stakeholder mapping of Open Source Science and

Environmental/Climate Justice networks, organizations, change makers, and communities along the Gulf Coast in the coming months. This coincides with Tulane University Presidential Initiatives on data literary and equity, inclusion and diversity. Our Dean has set a goal of being the most diverse Public Health School in the United States. Together, the University has made generous availably of facilities and funds to support initiatives such as this proposed set of TWSC capacity development workshops. This includes use of the excellent facilities and outstanding conference support of our Tulane Bywater Institute Coastal and River Center (https://bywater.tulane.edu/content/tulane-river-and-coastal-center).

We would propose 4-6 multi-day workshops beginning in late 2022 and continue through the kick off of YOOS in 2023. These events would concentrate on introducing key approaches to open science to EJ and underserved communities as a much needed introduction for this region to the YOOS. We would dedicate time to specific uses of NASA open earth science through case studies and hands on facilitated problem based learning. The final sessions of the workshop would bring together the identified communities with open source science organizations and experts to co-create open science activities and applications in support of equity and climate/environmental justice. Tulane would seek to partner with our existing and developing network of MSI including longstanding relationships with institutions including University of Texas and organizations that work with underserved communities such as New Orleans' Deep South Center for Environmental Justice or Louisiana Bucket Brigade. Each workshop would invite the communities that would likely most benefit, and will have been identified as part of the stakeholder mapping, such as:

- Frontline, primarily African American and Hispanic, EJ communities and organizations
- Fishing-related small enterprises and communities that often face linguistic barriers to engagement such as the large Vietnamese community on the Gulf Coast
- Tribal communities
- Linguistic and other underserved minority communities at risk of managed or unmanaged retreat from coastal areas
- Citizen scientists, sportsperson organizations, conservation and other groups interested in non-human as well as human environmental injustice
- Others to be identified

Perhaps we could also schedule a shared experience session for cross learning between the workshops at the Fall AGU in 2023.

Our experienced administrative team is eager to contribute to this important initiative. With confirmation of the relevance and basic guidance on budget and timing, we have at the stand by all the necessary elements for a compelling proposal that will ensure that the southern Gulf Coast is not left behind in YOOS – particularly considering the potential value of the NASA open Earth science to the region.

We look forward to your kind response, before submitting our proposal on or before May 13th.

Kind regards,

Nathan Morrow, PhD
Associate Research Professor
Department of International Health and Sustainable Development
Tulane Scholl of public Health and Tropical Medicine