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

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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 <u>reveal highly localized extremes that may be lost</u> in data interpolated from ground-based weather stations previously used in health forecasting thereby addressing a significant shortcoming of previous models.

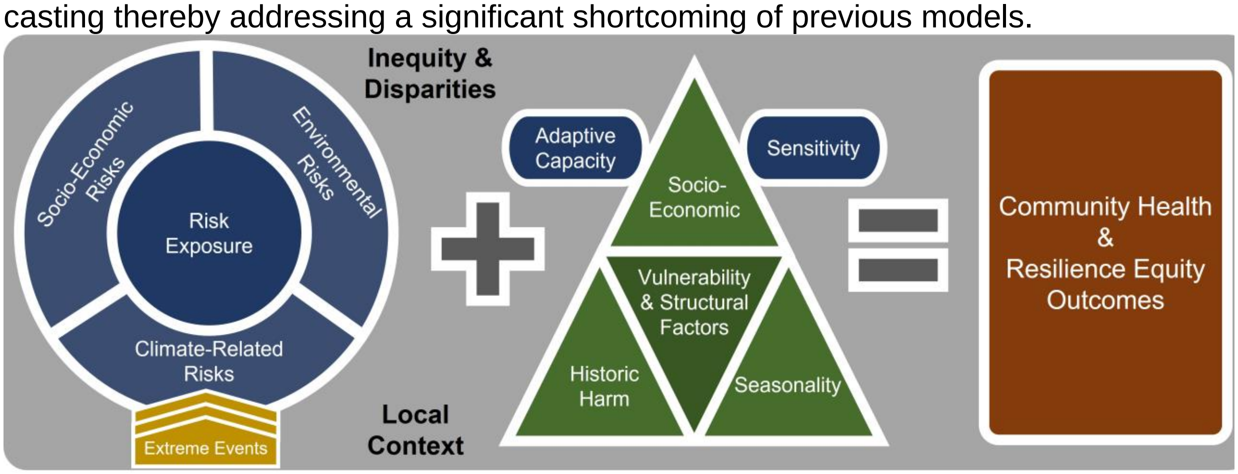

Figure 1: HEELTHFUL-GC model

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 <u>second significant contribution</u>: 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 <u>CJ&EJ community engagement model</u> for evidence-based study.

As a <u>third significant contribution</u>: 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 <u>fourth significant contribution</u>: 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.

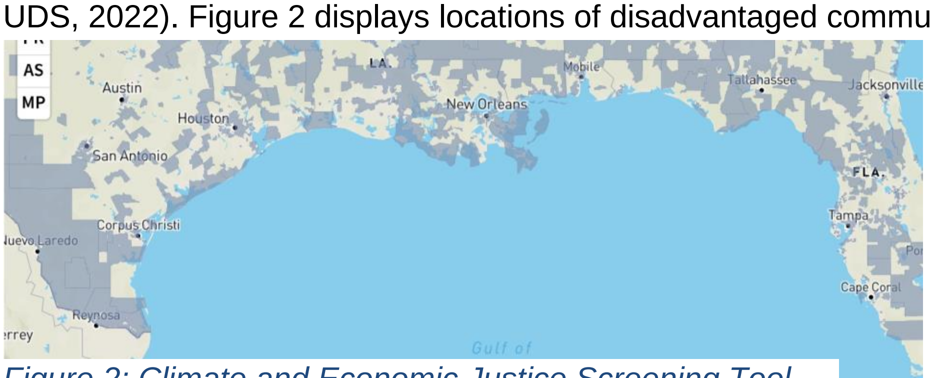

Figure 2: Climate and Economic Justice Screening Tool

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

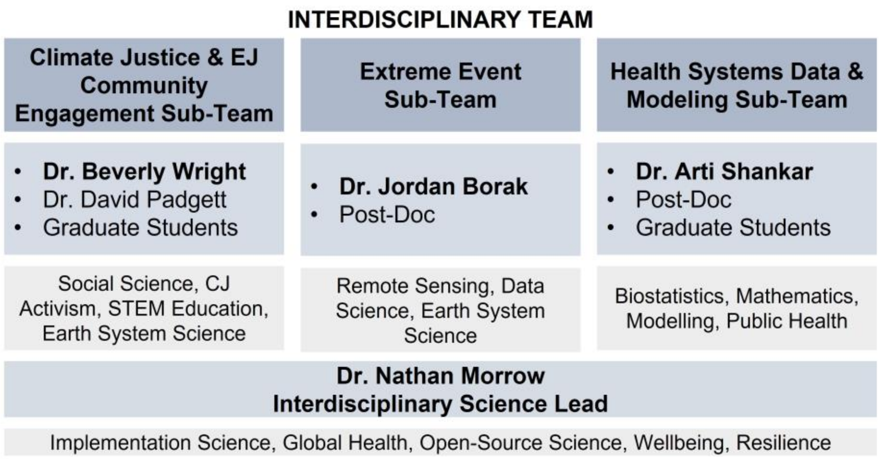

Figure 3: Sub-team Interdisciplinary Management Structure

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)](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 Communi-ties 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 Dis-asters: 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 Jus-tice 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 Injus-tice," [Special Issue]. Journal of Race, Gender, and Class, 5, 65-79.

Bullard, R. D. & **Wright, B.H**., (1993). "Environmental Justice for All: Community Per-spectives 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. Tang-damrongsub, 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

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: Dr. David Padgett, 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