DEPARTMENT OF HOMELAND SECURITY (DHS)

STATEMENT OF WORK (SOW)
FOR
EMPOWER - Exploiting Mesonets for Emergency Preparedness and Response to Weather Extremes

1 GENERAL

1.1 Background

The State University of New York at Albany (UAlbany) proposed the development and pilot of EMPOWER, a next-generation scalable decision-support tool suite for the emergency management enterprise. EMPOWER integrates advanced analytics, real-time localized high resolution mesonet-based weather data, critical infrastructure "lifelines", social vulnerability data, and novel visualization capabilities to provide rapid assessment of changing weather conditions and their potential impacts on communities and critical infrastructure. EMPOWER leverages state and federal computing investments, integrates with existing state-of-the-art weather observational infrastructure and data pipelines, aligns with crisis decision-making principles and protective action repertoires to protect lives and property, and provides modular capabilities for future integration of additional advanced sensor-based weather hazard monitoring networks. In short, EMPOWER equips the emergency management enterprise today with tools, data, and decision support analytics to manage the emergencies of tomorrow.

1.2 Overview

The objective of EMPOWER is the launch of a pioneering, regional pilot program to support federal, state and local emergency response to weather-related disasters for the development and deployment of real-time stakeholder-driven decision support solutions. This pilot program will make direct contributions to several Department of Homeland Security Science and Technology (DHS S&T) research priorities by improving first responder, emergency manager, and community stakeholder access to high-quality, relevant, and timely weather information, thus supporting the DHS S&T commitment to developing knowledge for improved incident management as well as first responder capabilities and critical infrastructure resilience. Furthermore, this initiative is consistent with the goal of "leading the whole community in climate resilience" in the FEMA Strategic Plan for 2022-2026, key preparedness challenges identified in the recently released 2022 FEMA National Preparedness Report, as well as President Biden's priorities outlined in the National Climate Task Force climate goals. The EMPOWER initiative will catalyze collaborative research and capability development with the responder community, national laboratories, industry, and DHS S&T international bilateral agreement partners such as Sweden and the Netherlands.

This high impact effort will leverage millions of dollars in state and federal funds as well as the unique UAlbany weather observational and computational infrastructure and data-enabled emergency management expertise including: New York State (NYS) Mesonet[i], a statewide network of weather stations that observe and report weather information in real time to support situational awareness (see Section 3 for more details). Key assets and comparative advantages supporting this project include:

- **The NYS Mesonet:** Designed, constructed, and fully operational since 2017 by UAlbany, the NYS Mesonet was enabled by a $30M hazard mitigation program grant provided by FEMA. The NYS Mesonet provides real-time, high-quality measurements of meteorological and environmental variables every 5 minutes every 17 miles across NYS. The proposed effort is timely and aims to integrate and translate the data and derived products into a usable form that can be more easily, systematically, and effectively exploited by emergency managers.
- **ETEC:** An $180 million, 246,000 square foot state-of-the-art building, the brand new ETEC building houses researchers and practitioners working in atmospheric science as well as emergency management and data analytics and visualization. ETEC is also home to the Albany National Weather Service (NWS) and is a short walk from the NYS Division of Homeland Security and Emergency Services (DHSES). The co-location of these groups facilitates research relationships and collaborations essential for EMPOWER. EMPOWER will also leverage existing stakeholder partnerships with public, private, and non-profit sectors, some of which are tenants in the ETEC incubation space. EMPOWER draws upon unique constellations of expertise at the first-in-the nation College of Emergency Preparedness Homeland Security and Cybersecurity (CEHC), home to the Departments of Emergency Management & Homeland Security and Information Sciences and Technology as well as a vibrant eco-system of focused centers and research labs that will support this project.
- **xCITE:** The ExTreme Collaboration, Innovation, and Technology, or xCITE, laboratory is a state-of-the-art facility with enhanced capabilities in artificial intelligence (AI), software development, and data/visual analytics innovation. xCITE is a core facility within the Atmospheric Sciences Research Center (ASRC). This infrastructure will support technical development within EMPOWER.
- **AI Supercomputing:** UAlbany has recently launched an AI Supercomputing Initiative supported by a $75 million investment from NYS. Such infrastructure with 27 new faculty hires will propel UAlbany to a leading national position in AI education, research, and development. AI solutions will be critical to realizing the longer term EMPOWER vision beyond the regional pilot and preliminary prototyping effort toward mature, scalable products capable of harnessing the potential of big data to improve emergency management outcomes.

1.2.1 Vulnerabilities to Extreme Weather in a Warming Climate

The frequency of severe weather is increasing in association with a warming global climate (IPCC, 2021[ii]). Over the last decade there have been more than 120 extreme weather events across the U.S. that each have resulted in more than $1 billion in damage , where the destruction from such storms now tops $148.4 billion per year on average in the past five years (NOAA 2021[iii]), not to mention thousands of lives lost. While national in impact, some states (e.g., NYS) are more susceptible to a wide variety of high-impact extreme weather events, including hurricanes, flooding, blizzards, ice storms, tornadoes, severe windstorms, severe cold and heat, and drought. These hazards can exact a considerable human and financial cost while threatening the national economy and homeland security.

Given their rapid and dynamic evolution, severe weather events require a broad array of detailed, real-time data to best equip emergency professionals for response. When that information is lacking, especially as microclimates vary within many jurisdictions, even routine events can become costly disasters. One approach to address this information gap is through the deployment of mesonets, or networked (typically

state-wide), high-fidelity weather monitoring stations. In NYS, three successive events – Hurricane Irene, Tropical Storm Lee, and Superstorm Sandy - spurred the generation of a statewide mesonet, supported by the FEMA Hazard Mitigation Grant Program (HMGP). Mountainous flooding from Irene costing $1 billion, river-sourced flooding from Lee, and $5 billion in storm surge flooding from Sandy could have been better mitigated with the continuously available and updated, detailed situational awareness data that a mesonet provides.

The NYS Mesonet (detailed in section 1.3.2.2) is a critical piece in the weather-emergency response nexus, providing the necessary infrastructure for real-time monitoring and the collection of billions of datapoints for weather-related research and practical exploitation. However, weather monitoring networks and data collection are only the first step in achieving the objective stated above. For example, Hurricane Ida (2021) revealed additional gaps and vulnerabilities across many states that climate-change-exacerbated severe weather events can generate. These included life-threatening deficiencies concerning the production, fusion, and communication of "weather intelligence" and "weather hazard vulnerabilities" through expert advice and effective warnings to decision-makers, critical infrastructure, and other "lifeline" operators and the public-at-large. Ida underscored *persistent difficulties in monitoring, tailoring and communicating weather information* to meet the specific and local needs of emergency managers, first responders, and other key public, private, and non-profit stakeholders.

Recent snowstorms in the Buffalo region have further highlighted the vulnerabilities of communities and infrastructure to extreme winter weather. While traditional forecasts of winter weather conditions remain critical for preparing ahead of a storm, it is vital to have real-time situational awareness of what is happening "on the ground." Forecasts are probabilistic, not always accurate, and can obscure local variation and extremes of interest to emergency responders. Such information, and the enhanced situational awareness it enables, is critical to informed, effective, and equitable protective action decision-making[iv]. During the November 2022 lake- effect event, NYS Mesonet data was critical for understanding the rate of snowfall in real time in and near Buffalo. The Brant station (southeast of Buffalo) recorded a maximum of more than 6 inches of snow within an hour. This information combined with information regarding highway snow-clearing capacity facilitated life-saving protective actions such as major highway closures. Climate change is also altering the frequency and impact of extreme heat, currently the deadliest form of natural weather-related disaster in the U.S. according to NOAA Hazardous Weather Statistics for 2021. While extreme heat is often effectively handled in typically hot parts of the country, traditionally cooler regions, such as the Pacific Northwest and the upper eastern seaboard, are suffering from this phenomenon without proper infrastructure to respond. Extreme heat events are particularly challenging in urban environments such as New York City, where socially vulnerable populations with substandard cooling and energy infrastructures (e.g., power grids) tend to be exposed to heightened heat hazard due to the so-called urban heat island effect in which features of the built environment amplify temperatures. Citywide average forecasts and sparse observations can obscure these risks. More granular observations such as those provided by mesonets—ideally supplemented by urban micronet coverage—can enable improved situational awareness and smarter, more precise, and efficient interventions to protect the most vulnerable. Mesonets exist in varying degrees of sophistication across many states and locations within the U.S. Within the last year, a variety of new statewide mesonets have been funded and are currently beginning or in the midst of construction. These are in a diverse set of states, including Hawaii[v], Maryland[vi], Wisconsin[vii], Louisiana[viii], and more. This rapidly growing influx of new weather data will present a challenge for federal stakeholders because the instruments and observed

variables are not standardized across mesonets. While EMPOWER proposes to use the NYS Mesonet as a proof-of-concept, the tools and strategies developed here will be designed to be conducive to future interfacing with existing and forthcoming mesonets.

1.2.2 Weather-Response Gaps

Response to recent weather disasters across the country indicate that major gaps remain between weather observations and emergency response systems. These gaps handicap government officials, critical infrastructure operators, and other key stakeholders who are forced to make urgent decisions to protect life and property without direct and actionable access to the necessary real- time weather observation data, such as that provided by mesonets. *Exploiting neglected and underused high-impact data from our nation's vast weather science and observation infrastructure is the primary objective of this proposal.* There exists a disconnect between the data available in current situational awareness systems, and the data associated with weather risk information (e.g., rainfall/flooding, wind, snow, heat, intensity, duration, impacts, and forecast/measurement uncertainty). Further, available data regarding vulnerabilities of the built and social environments, and the critical infrastructures that support them, are critical to next-generation severe weather decision-support tools and systems.

The recent weather events and hazards outlined above highlight three important gaps that will be addressed by this proposal to mitigate more effectively and equitably the negative impacts of severe weather:

- **Intra-Weather-Enterprise Gaps:** Progress has been made in establishing advanced weather observations through statewide mesonets (e.g., NYS Mesonet). However, advanced observational data is not yet fully integrated into NWS and commercial weather products and a gap remains between the forecast and the ground truth experienced by communities, first responders, and emergency managers. EMPOWER products will complement forecasting with real-time mesonet-based weather observations (nowcasting) to improve situational awareness and contribute to improved outcomes in severe weather emergencies.
- **Weather-Emergency Management Gaps:** Producers of weather information often lack insight into the needs of emergency management stakeholders and fail to provide *actionable* weather intelligence. Emergency managers, stakeholders, and citizens struggle to decode and act upon weather messages and data, at times leading to improper deployment of resources or unheeded warnings resulting in catastrophe. EMPOWER will embed stakeholders from both communities into the development schemas to ensure the proposed deliverables are tailored to the needs of the end user. Cross-professional workshops and simulation-based training and exercises will provide opportunities to bring these communities closer together.
- **Intra-Emergency-Management Gaps**: Disconnects and silos across mission areas/phases of disaster within emergency management and first responder organizations create potential vulnerabilities. For example, information collected for purposes of building preparedness capabilities (e.g., National Threat and Hazard Identification and Risk Assessment, or THIRA) and supplementary preparedness capability assessment activities such as NYS County Emergency Preparedness Assessment, or CEPA) and hazard risk mitigation may not be accessible or systematically integrated into real-time risk assessment and decision-making processes in "emergency response mode." Through leveraging existing collaborations among this proposal's personnel, EMPOWER will serve as a conduit for integration of the disparate knowledge and

capabilities within and across emergency management and response organizations.

The expertise and infrastructure outlined in section 1.2 (i.e., NYS Mesonet, xCITE, AI Supercomputing, ETEC, and leading national expertise in atmospheric science and emergency management) uniquely positions UAlbany and the proposers of this work to advance a regional pilot program aimed at exploiting mesoscale weather data to strengthen emergency preparedness and response.

1.2.3 Sensemaking and Decision Making

Severe weather events such as the examples presented above force decision-makers and emergency responders to make decisions under crisis conditions. From a behavioral perspective, **crisis** can be defined in terms of threat to core values (such as protecting lives and property and minimizing disruption to critical infrastructure), urgency (there are often fleeting windows of opportunity to remove vulnerable people from harmful situations or take action to protect vital infrastructure and assets), uncertainty regarding hazards (e.g., accuracy of weather forecasts and impact assessments), and/or the reactions to and consequences of potential public safety guidance and other interventions by government or private/non-profit sector actors[ix]. **Sensemaking** in crisis situations, such as impending severe weather events, refers to the challenging task of developing an adequate interpretation of what are often complex, dynamic, and ambiguous situations[x]. This entails developing not only a picture of what is happening (situational awareness) but also the implications for values such as public safety, public order, trust in government, etc. Crisis sensemaking is action-oriented and is geared towards identifying harmful impacts and opportunities for potential protective interventions.

Decision-making recognizes that crises are experienced by leaders (and those who follow them) as a series of "what do we do now?" problems triggered by the flow of events. These decision problems emerge simultaneously or in succession over the course of the event[xi,xii,xiii]. Decision- making processes may take many forms, are liable to stress-induced disruption, and can either incorporate or exclude relevant --or irrelevant-- data and expertise. Protecting communities in crises and emergencies requires an interdependent series of crucial decisions to be made in an informed, timely and effective fashion under extremely difficult conditions.

In the emergency management and disaster science literature, there is a growing interest in decisions regarding protective action. An integrative **Protective Action Decision-making Model**[iv] has been proposed, which has typically been deployed in efforts to explain protective action decisions by individuals and households. However, the approach can be adapted to focus on decision-making by public, private, and non-profit sector leaders and organizations as well. For present purposes, examples of protective action decisions in the face of extreme weather events are measures such as traditional ("horizontal") evacuations, vertical evacuations (seeking higher ground), various forms of sheltering in place (individual or actively supported "community shielding"), school closures, protective shutdowns of critical infrastructure, such as roads, bridges, tunnels, airports, power grids (c.f. PSEG in California re wildfire risk), etc.[xiv] In the face of escalating severe weather hazard risk, difficult and often politically complex decisions must be considered regarding whether, when, where, and how to make such protective interventions.

Recognizing the above-mentioned gaps, vulnerabilities, needs, and conditions, **EMPOWER will work**

with emergency management stakeholders at federal, state, and local levels to provide weather data analytics and tailored decision support tools designed to empower their sense- making and decision-making and to enable smart, effective, and equitable protective action.

1.2.4 New York State: An ideal location for a regional test bed

The spectra of regional and seasonal severe weather make NYS an ideal testbed for EMPOWER. NYS has experienced and will continue to experience severe weather and climate events, such as droughts, floods, hurricanes, blizzards, and snow and ice storms[xv,xvi,xvii,xviii]. Furthermore, UAlbany is unique in its constellation of expertise in both applied atmospheric science and emergency management/public safety: UAlbany has one of the largest and most distinguished weather, climate and emergency preparedness research groups in the U.S. led by leading researchers from the acclaimed Atmospheric Sciences Research Center (ASRC), the Department of Atmospheric and Environmental Science (DAES), and the Center of Excellence (COE) in Climate and Data Analytics. UAlbany is also home to the first-of-its-kind College of Emergency Preparedness, Homeland Security, and Cybersecurity (CEHC) with its nationally leading expertise in crisis and emergency management, community and infrastructure resilience/vulnerability, hazard risk communication, and applied information and communications technology.

The two principal leaders of this proposed effort, Drs. Christopher Thorncroft and Eric Stern, represent UAlbany's strength in atmospheric sciences and emergency management, respectively. Dr. Thorncroft is the Director of ASRC as well as the NYS Mesonet and COE and is an expert in weather and climate variability including in the northeast U.S. region. Dr. Stern is Faculty Chair at CEHC, a 2022 FEMA Vanguard Leadership Fellow, and an internationally recognized expert in crisis decision-making and Emergency Management with a long history of collaboration with government agencies (including DHS S&T, FEMA, USCG, and NY DHSES), international organizations, and non-governmental organizations (NGOs) on a variety of applied research, development, and training/exercise projects. Drs. Thorncroft and Stern will be supported by a uniquely qualified ETEC-based multi-disciplinary research and development team introduced in section 11 below.

1.3 Scope

1.3.1 Operational Concept

The impact of weather-related disasters on communities can be reduced significantly through improved access to higher quality and more relevant hazard and vulnerability data for enhanced situational awareness. More precise and contextually relevant weather information will allow emergency managers to be more strategic regarding how, when, and where to take protective action and deploy resources both prior to and during extreme weather events and disasters. Specifically, EMPOWER will leverage the NYS Mesonet and NYS Mesonet-derived dynamic statistical models to develop and deploy real-time solutions resulting from ongoing, needs- driven, stakeholder dialogue with emergency managers, first responders, critical infrastructure operators, as well as private and non-profit sector partners. The regional pilot will pursue two primary objectives:

- To leverage the NYS Mesonet and other advanced weather observations to develop and deploy real-time, mesoscale weather products and tools to enable stakeholder-driven solutions to protect life

and property at federal, state, and local levels.

- To develop additional stakeholder-driven advanced decision support tools by fusing NYS Mesonet data with other weather and non-weather observations, such as and data regarding socio-technical and environmental vulnerabilities, to provide timely, tailored, localized hazard warnings, and facilitate protective action for vulnerable communities, businesses, and infrastructure.

These objectives will be accomplished through the development of a dynamic interface within which weather and weather-relevant data will be readily available. A key component to the usability of this interface is that the data be understandable, useful, and actionable, such as translation of raw weather data to risk maps with predefined thresholds. To accomplish this, EMPOWER effort will build upon and reinforce existing SUNY Albany partnerships with FEMA, NYS DHSES, New York City Emergency Management (NYCEM), American Red Cross, among other emergency-relevant state agencies and critical infrastructure operators. These partnerships provide opportunities for dialogue and elicitation of requirements that will enable this project to best tailor the data communicated on this platform to meet urgent real world needs.

1.3.2 Technical Concept

1.3.2.1 Overview

The general approach taken with this project will be to ensure that the weather information provided to the various stakeholders is actionable and useful. To achieve this, end-to-end interaction with stakeholders is required. The targeted stakeholders will include representation from the emergency management community at federal, state, and local levels, as well as the weather community. Efforts will be made to understand how and when decisions are made and by whom to tailor the weather information appropriately to a diverse range of organizations participating in whole community emergency management.

1.3.2.2 Technical Description of the New York State Mesonet

Central to EMPOWER will be exploitation of the NYS Mesonet weather data. Figure 1 shows the location of all the weather stations that comprise the NYS Mesonet.

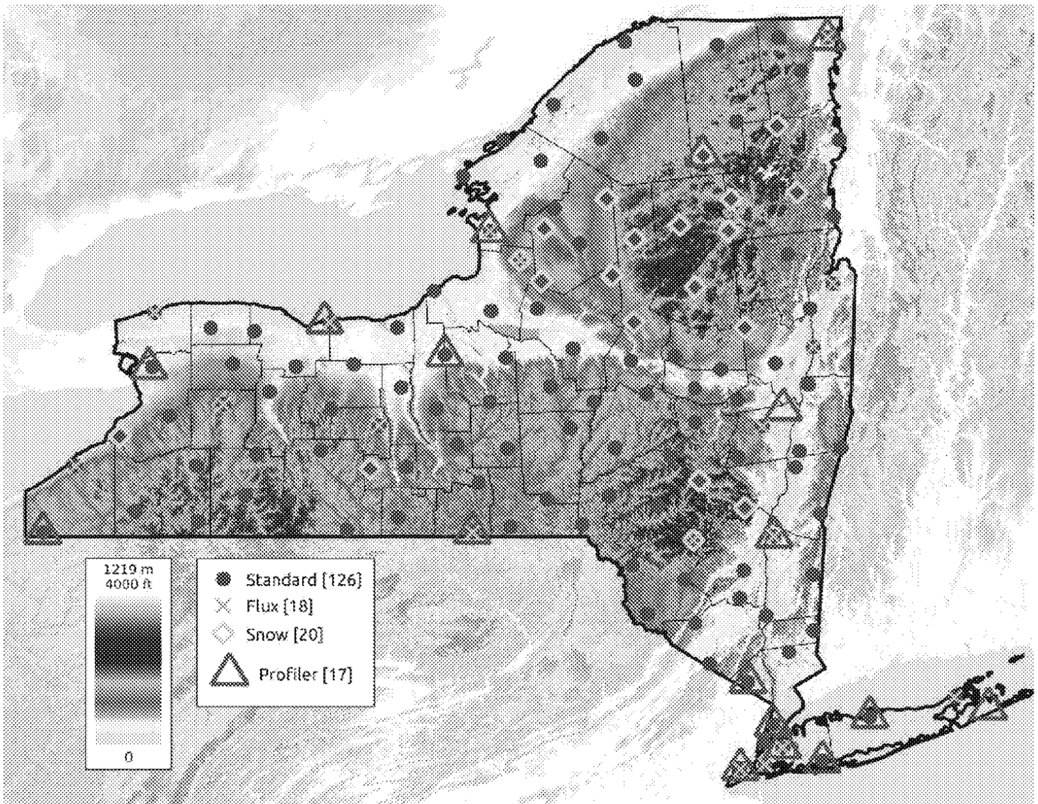


Figure 1: Map of NYS Mesonet stations overlaying topography (shading).

The centerpiece of the NYS Mesonet is a network of 126 standard weather stations across the state, with at least one site in every county and borough. Each of the 126 stations measures temperature, humidity, wind speed and direction, pressure, solar radiation, snow depth, and soil information. In addition, several sub-networks of specialty sensors have been deployed: A profiler network of 17 sites provides additional atmospheric data in the vertical (up to 6 miles above ground); a flux network of 17 stations monitors the surface energy budget; and a snow network of 20 sites measures snow water content. Operated by UAlbany, the NYS Mesonet collects, archives, and processes data in real-time every 5 minutes, with over a billion datapoint collected to date. Data is quality controlled and assured and communicated via a cellular network with NOAA satellite communications backup (hourly).

EMPOWER will also leverage the recently installed NY City Micronet that consists of enhancements to the surface station network in NY Metropolitan area (Figure 2). The NYC Micronet is a dense network of 22 weather stations, 17 owned by Consolidated Edison Company of New York, Inc., and 5 owned by the NYS Mesonet. Collectively, the Micronet provides critical real-time weather data during high-impact weather and long-term data for monitoring climate change. A majority of Micronet stations measure air temperature, relative humidity, precipitation, and pressure. A mix of stations also measure wind speed and direction, solar radiation, snow depth, soil temperature and moisture, surface (skin) temperature, and water temperature. Micronet data are collected every 5 minutes, quality controlled, archived, and made available

to users in real-time.

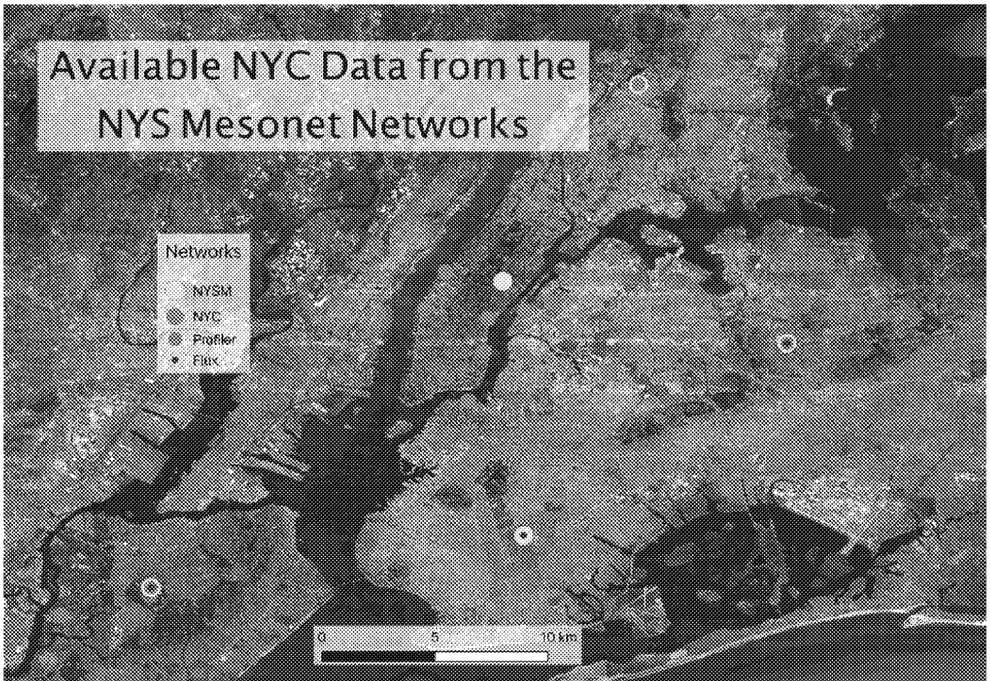


Figure 2: Locations of NYS Mesonet stations in the New York Metropolitan Area.

1.3.2.3 Beyond Social Vulnerability Indices

Emerging research and practice regarding incorporating social vulnerability to inform emergency management often rely upon Social Vulnerability Indices (SVIs). SVIs typically are formed from the distribution of individuals based on specific categories, such as socioeconomic status, household composition, disability status, race/ethnicity and languages, housing, and transportation[xix,xx]. Most have been used to focus on disasters from natural hazards [xix], although these concepts are complex with definitional changes under various contexts, and the indices themselves are "quantitative assessments of qualitative phenomena." While there has been a broad push to quantify social vulnerability, the definitional inconsistencies and challenges in consensus regarding the methods used for SVIs have increased concern about their use[xxi]. SVIs can lack internal and theoretical consistency, where researchers noted, for example, that "social vulnerability scores decreased when the percentage of unemployed persons increased[xxii]." Similarly, they also found "simply by changing the geographic extent of the inputs, we are able to make variables shift from being among the most important ingredient to the least important [xxii]." In another study, one popular SVI evaluated was characterized as "imbued with a high magnitude of uncertainty, statistically biased, and less precise in areas of high vulnerability [xxi]." In a sensitivity analysis on SVIs, researchers noted that without expertise and knowledge about specific locations, the validity, interpretation, and reasonableness of the SVI may be called into question[xxiii].

The EMPOWER approach too will depart from geographically delineated SVIs (which are currently used on ad hoc basis by state emergency management in New York), but will also explore ways of further

contextualizing, localizing, and validating rough aggregate social vulnerability estimates stemming from SVIs. Following emerging federal best practice, additional mission- relevant and community-based open-source data and/or accessible government data will be incorporated. A good example of how this can be done was the combination of tornado storm track and home insurance coverage data by the FEMA Geospatial Response Office (GRO) to enable prioritized community outreach to areas most likely to experience uninsured losses during the Multi-State Tornado event of December 2021 (information provided by Chris Vaughn of FEMA GRO). Furthermore, dashboards will be designed to enable manual flagging of social vulnerability "hot spots" identified via local stakeholder dialogue (c.f. NY DHSES CEPA methodology).

1.3.2.4 Built Environment and Critical Infrastructure Vulnerability

EMPOWER will seek to systematically incorporate data and known/discoverable points of vulnerability in the built environment and critical infrastructure "lifelines" into the weather hazard vulnerability dashboards. This promises to help overcome siloing in emergency management, e.g., between those who work on hazard risk identification /mitigation and those actively participating in real-time emergency warning and response efforts. For example, the NYS Hazard Mitigation Plan (GIS) database developed by UAlbany in collaboration with NY DHSES provides a good point of departure for anticipating weather hazard impacts on the built environment as do open- source databases such as USA Structures. UAlbany (ASRC) currently supports a number of state agencies and utilities with regard to weather hazard risk assessment and currently has access to partner data, such as power distribution system and road transportation vulnerability. Similarly, a weather hazard specific variant of the above-mentioned local stakeholder dialogue-based NYS CEPA methodology can be deployed to identify locally recognized nodes of vulnerability in critical infrastructure lifelines.

1.3.2.5 Overview of Selected EMPOWER Prototypes

Two general dashboard prototypes will be developed, delivered and evaluated: (1) a dashboard that provides key weather information for NYS designed for federal emergency management (2) and a dashboard targeting state and local emergency managers and responders that maps the weather information onto known vulnerabilities of the social and built environment. An ergonomic approach will be deployed, enabling dynamic and adaptable products and interfaces. Products and interfaces will be designed to be easily usable in high stress, information- and noise-rich environments (such as emergency operation centers) and to automatically direct user attention to potentially dangerous developments and other high priority information such as locations of particularly vulnerable populations.

Decision support dashboards will include the capacity for users to define key weather-related thresholds with respect to hazard manifestation parameters, such as observed or projected (forecast) rainfall or snow density (inches per hour) in relation to specific community or critical infrastructure resilience capacity measures, such as urban sewer system water drainage capacity or snow clearing capacity of major roadway operators. Similarly, as mentioned above, dashboards will have the capacity to flag vulnerability hotspots generated via local stakeholder dialogue and partner (e.g., utility operator) data sharing. A technical strategy for delivering the weather information and dashboards to the key stakeholders will be implemented. This could take the form of a live data feed (API) or a web-based dashboard depending on the need and existing capacity of the users.

Finally, training will be developed and provided to the stakeholders combining general hazard risk and vulnerability education, real-life case studies, and technology-enhanced simulation exercises featuring scenario data delivered via EMPOWER dashboards. In developing scenarios, emphasis will be given to known high-impact weather situations in NYS for both cold season weather (e.g., snow, ice, blizzards, snowmelt, etc.) as well as warm season weather (e.g., heat, hurricanes, extreme rainfall/wind events, etc.). Training materials will be iterated based on participant feedback, and materials for multi-scenario exercises will be provided at project end for transition to sustainability.

1.3.2.6 Operational Utility Assessment Plan

The EMPOWER project will be designed and implemented in ways that facilitate rigorous assessment such that products address project goals and contribute to narrowing the gaps outlined in section 1.3 above and currently unmet emergency preparedness needs. The creation of weather dashboards is a major deliverable for EMPOWER. The utility of these dashboards will be assessed through iterative observations, such as discussions with user-focus groups, questionnaires, and interactive event analytics (e.g., button clicks and page views, such as that provided by Google Firebase to analyze how the users interact with the system. In deployment of the training task (discussed below), end-user input on dashboard utilization within response situations will be incorporated prior to exercise development. Finally, it is important that users can connect to the weather data and dashboards in real time. Robust data connectivity will be diagnosed and assessed and confirmed through routine testing and interactions between EMPOWER staff and end users. Training is an essential component of this project, needed to ensure that users can extract and decode the weather hazard and vulnerability information needed to empower their decision- making. Using a multi-scenario exercise design integrating decision-makers and the dashboard, operational utility will be assessed directly during a simulated event. Dashboard utilization and integration into the decision-making process will be formatively evaluated during and after the exercise, and feedback from participants will be used to revise the training materials before subsequent delivery. Finally, dissemination of knowledge and recommendations gained from EMPOWER is an important deliverable. The interest and value in the dissemination approach will be assessed via downloads metrics (via website and social media), citations of published articles, and written feedback from conference participants. Similarly, international cooperation will be monitored and milestone fulfillment and international collaborative network building will be assessed in terms of metrics such as collaborative research proposals to DHS S&T as well as other funders in the U.S. and partner countries, co-authorship, cross national diffusion of good practices.

2 SPECIFIC REQUIREMENTS / TASKS

The objective of EMPOWER is the delivery of a pioneering, regional pilot program to support federal, state, and local emergency response to weather-related disasters, through the development and deployment of real-time stakeholder-driven decision-support solutions that leverage the nationally leading New York State (NYS) Mesonet.

2.1 TASK ONE. Connect Federal Emergency Response with NYS Mesonet Data

Task 1 will carry out the work needed to connect Federal emergency management with tailored weather products based on NYS Mesonet observations and NOAA weather forecast information. The main deliverable will be a weather dashboard that will incorporate stakeholder needs. Also included here are practical tasks to support the whole project (stakeholder group, hiring, etc.)

2.1.1 Establishment of a Regional Pilot Stakeholder Group

A priority for this project is to ensure that products created and shared with federal, state, and local emergency management are useful. It is therefore essential to ensure end-to-end engagement with key stakeholders throughout this project. This will start with the establishment of a stakeholder group including representatives of federal, state, and local interests. Federal user interests will be represented by FEMA HQ (e.g., FEMA GRO), FEMA Region 2, NDRCC, and DHS S&T. State and local user interests will be represented by NY DHSES along with county and municipal officials, utilities, NGOs (e.g., American Red Cross), etc. UAlbany is currently collaborating with and can draw on existing partnerships with most of these stakeholders.

2.1.2 Hiring

In order to carry out the work in this and other tasks, it will be necessary to hire 3 post-doctoral research assistants (PDRAs).

- **Two data/visualization PDRAs** will be dedicated to data analytics and weather data visualization including the creation of the weather dashboards. They should have a solid background in programming and data visualization as well as working with weather data. They will be focused on the work in Tasks 1 and 3.
- **A third social science PDRA** will be hired and focus on the work with stakeholders in Task 2, be instrumental in the training development and execution in Task 4, and serve as a primary conduit between dashboard development and stakeholder input. This PDRA should have a strong background in social science and be familiar with mixed-method data gathering.

2.1.3 Creation and delivery of Federal Weather Dashboard

2.1.3.1 Identification of federal emergency management weather challenges, priorities, datasets, and emerging good practices of interest to state and local emergency management

An assessment will be performed to determine federal emergency management weather needs and institutional information systems. End-user requirements will be established through a site visit, interviews, and focus groups with FEMA GRO Watch Center, and NRCC. These collaborations will guide supplemental weather dataset gathering considered useful to stakeholders and suggest basic statistical

tools (e.g., error trend analyses between NWS forecast data and NYS Mesonet ground truth). The creation of the federal weather dashboard will be an iterative process between technical development and stakeholder input/feedback

2.1.3.2 Creation of prototype weather dashboard

Considering the conclusions from 2.1.3.1, a prototype dashboard (v1) will be created and shared for preliminary evaluation. Additional prototypes will be created after feedback and assessment of usage.

2.1.3.3 Establish Technical Connectivity to Federal Emergency Management

This will be achieved via interactions with the FEMA Geospatial Response Office, which will provide a conduit to the FEMA Watch Center and NRCC. Work will be carried out to ensure that trusted, operationally relevant data integrated within the weather dashboard is communicated to FEMA in real time.

2.1.3.4 Delivery of Prototype dashboard following task iteration

Taking into consideration the knowledge gained in Tasks 2 and 3 (outlined below) and after receiving feedback on the prototype dashboard, a final developed prototype (v2) weather dashboard will be developed and delivered

2.1.4 Roadmap for including multi-mesonet coverage for the nation

Taking advantage of the knowledge gained from 2.1.3, a roadmap will be developed that provides recommendations on how to incorporate weather information from other statewide mesonets. This will take the form of a report that outlines recommendations and steps needed to expand EMPOWER nationally. Thorough documentation will be maintained throughout the project to ensure seamless methodology for research and technology transfer to other mesonets.

2.2 TASK TWO. Map current decision-making practices, processes, and systems across jurisdictions and conduct stakeholder dialogue

Task 2 will systematically take stock of how and by whom protective action decisions regarding extreme weather events are currently made in NYS with regard to protecting communities, businesses, and critical infrastructure lifelines. The focus will be on state, tribal, and local stakeholders including elected officials, government professionals, first responders, critical infrastructure operators, NGOs such as the American Red Cross and other voluntary organizations active in disasters (VOADs), etc.

Key questions to guide this task include: Who are making the key decisions? What are the key decisions? To what extent and how are decisions informed by advanced weather observational and hazard

vulnerability data and expertise? What types of decision support tools and data fusion would be most helpful in improving outcomes? What specific design considerations and capability enhancements should be considered in the development of next generation decision-support tools for severe weather events?

2.2.1 Conduct cognitive task analysis

Current state, and local emergency preparedness and response practices will be examined regarding acute weather hazards.

- Select specific weather hazard-vulnerability use cases and jurisdictions for analysis (e.g. winter storm in the Buffalo area, urban heat and deluge flooding in New York City etc.).
- Specify use case-relevant protective action options(based on emergency plans, playbooks, practitioner experience as well as the literature), map associated decision making processes and identify authoritative (de jure and de-facto) decision-makers for the use cases.

2.2.2 Decision Process Analysis

Identify good practices and obstacles to data-informed and data-enabled protective action affecting decision-making and resource allocation during severe weather events.

- Conduct content analysis of relevant literature, After Action Reviews, and other relevant documentation.
- Develop a set of recent event case study profiles. Case profile memos will be developed outlining protective action decision-making in recent severe events based on open-sources, agency/organizational documents (if available), witness panels, and/or individual oral history interviews.
- Observe Real Time Severe Weather Hazard Decision-Support at state and/or local level.

2.2.3 Design Workshop(s) with End Users and Stakeholders

A workshop-- including scenario-based facilitation – will be held with end users to ensure usability and value in dashboard design.

- The workshop will elicit preferences with regard to decision support tool affordances and functionality symbology etc.
- Specify ergonomic (interactivity) considerations for dashboard design tailored to crisis response conditions drawing on workshop results and the literature.

2.3 TASK THREE. Fusing Weather Hazard and Social, Built-Environment, and Critical Infrastructure Vulnerability Information

The objective of this proposal is to combine disparate data and expertise in such a way that the scientific data presented to stakeholders are understandable and actionable. As such, Task 3 will draw on and extend the accomplishments of Tasks 1 and 2. This task will fuse the weather information identified in Task 1 with the stakeholder needs analysis performed in Task 2. This means, identifying the needs of decision makers and emergency responders, and remapping the weather datasets according to contextual information regarding vulnerabilities stemming from the social environment, built environment (including critical infrastructure lifelines), and other data deemed critical to decision making. This work proposes to address a major deficiency: information gaps between weather experts and decision makers. Thus, Task 3 will be an iterative process, enabling consistent communication and feedback. This collaboration is critical to ensure that the most informative and actionable data are included, and in a manner conducive to proactive weather-emergency response. This may include the identification of hazard thresholds, whether fixed or user-defined, to focus the response of decision makers. Finally, a major component of this task is to ensure systematic, effective, and seamless delivery of information so that decision-makers can focus on response without technical complications and distractions. Specific, contextualized use cases will be explored in greater depth building upon the NYS CEPA methodology for local stakeholder dialogue and ongoing UAlbany collaboration with NYS Agencies and Utilities. These products will be designed in modular fashion to complement official weather hazard event-based risk assessment practices.

2.3.1 Vulnerabilities Data Integration

Building on the mesonet-based dashboard design from Task 1, identify and secure access to vulnerabilities databases for incorporation into the severe weather hazard-vulnerability fusion dashboards (described in 2.3.4).

- Write scripts to access public archives via API or other open-source available methods
- Develop real-time tools to archive data from source, if data changes in real-time and is not available via public archive.

2.3.2 Develop a generic hazard threshold model

A generic, operationalizable severe hazard threshold conceptual model and analytical framework will be developed, drawing on the general literature and existing severe weather hazard applications such as the NWS database of alerts.

2.3.3 Hazard Threshold Selection

Identify stakeholder-generated, use-case-specific hazard thresholds to create an automated acute risk flagging feature in the dashboard prototypes. These will depart from and draw on national and regional

open-source data (e.g., USA Structures), innovative NYS hazard identification and preparedness assessment methodology (c.f. CEPA) and hazard mitigation map data (NY SHMP GIS database), contingency-specific data bases such as the New York State and New York City heat vulnerability index maps, existing UAlbany operational and analytical partnerships in NYS as well as EMPOWER specific workshops and interviews. Final selections will be made in consultation with end users and with an eye to end-user priorities, data sufficiency, and availability.

2.3.4 Vulnerabilities Data Integration

Design, development, evaluation, and revision of a user-needs driven, ergonomically informed, weather hazard-vulnerability fusion dashboard building on the weather-specific effort in Task 1, end user requirements generated in Task 2, and hazard manifestation thresholds.

- Design emergency use suitable (ergonomic) user interface, symbology, and data visualizations. Application technology (e.g., Firebase) will be enabled to monitor interactive usage (e.g., button clicks, page views) to determine usability, ergonomics, and application preferences.
- Specification and implementation of data fusion, affordances for threshold monitoring and flagging of acute hazard manifestation and vulnerability "hot spots," culminating in revised version of the prototype dashboard (v3).
- Conduct iterative elicitation and processing of end-user feedback, using interviews, tutorials, and surveys, regarding functionality and the end-user interface (including via Task 4 simulations), resulting in a revised prototype dashboard (v4).

2.4 TASK FOUR. Develop Technology-Enhanced, Cross-Professional Simulations for Training and Exercise

Improving the capacity of decision-makers to assess severe weather hazards risks and make proactive decisions regarding protective action requires creating a realistic practice environment in which decision-makers can practice emergency sense- and decision-making in a simulated setting. This task will focus on designing and developing simulations incorporating and providing opportunities to use EMPOWER decision support tools-- embedded in broader, multi-dimensional scenarios-- for both training and exercise purposes.

2.4.1 Priority Identification

Identification of priorities and needs with the Regional National Pilot Stakeholder Group (from WP1) and regional stakeholders. This will depart from and draw on activities and findings stemming from Tasks 1, 2, and 3.

2.4.2 Design Inputs Memo

Develop an integrative ***design inputs memo*** for the Cross Professional Simulation based on EMPOWER end user and stakeholder dialog.

2.4.3 Training Development

Assessment of existing training and simulation models at FEMA, NOAA/NWS, and other public and private sector organizations.

- Conduct ***focused literature review*** and content analysis of agency doctrine and education/training modules (e.g., DHSE HSEEP, FEMA EMI courses etc.)
- Conduct ***interviews/focus group*** sessions to document the state of the art.

Design, develop and pre-test a next generation cross-professional exercise prototype incorporating realistic forecasts and observational data including technology-enhanced, visualization features.

- Select instructional design and develop ***alignment architecture*** with standard decision-making requirements within weather-related response events.
- Development of *exercise scenario*(s) and related cross-media ***artifacts.***
- ***Alpha test*** of exercise prototype with internal project team.

2.4.4 Training Pilot

Host a pilot regional training with state and local emergency managers and meteorologists to evaluate and assess the cross-professional simulation models.

- Development of an evaluation and ***assessment protocol and instrument.***
- Implementation of ***the Simulation Exercise***
- ***Assessment and evaluation*** of the simulation exercise and implications for EMPOWER operational decision support tools.

2.4.5 Revisions and Transition

Revise and refine the model for statewide simulation-based training for emergency decisionmakers, forecasters, and related stakeholders along the weather-emergency management continuum.

2.5 TASK FIVE. International Cooperation and Dissemination of Research Findings and Practical Recommendations

The EMPOWER project is a regional pilot of interest to jurisdictions around the nation and abroad as mesonet coverage and other forms of advanced sensor-based weather hazard observation spread across

the nation and peer countries. DHS S & T bilateral partners such as Sweden and the Netherlands are well positioned to contribute to and benefit from the EMPOWER initiative. As a result, the EMPOWER effort can help to catalyze and demonstrate positive impacts of international cooperation with regard to severe weather preparedness. The work is intended to bridge gaps between research and practice as well as atmospheric science and emergency management. Therefore, it is imperative that the work and results are documented and effectively disseminated in professionally appropriate forms for a variety of target audiences.

2.5.1 International Collaboration

Organize a series of virtual and in-person bilateral workshop sessions with international partners with representatives from both research and practice. Document the proceedings of the international workshops summarizing key takeaways for research and practice.

2.5.2 Host an International Conference

UAlbany will host a conference focused on advanced weather data solutions for emergency preparedness. Conference participants would include federal, state, tribal, and local emergency managers, NGOs, the National Weather Service, and operators from statewide mesonets nationwide.

2.5.3 Dissemination of Findings and Recommendations

- Development of a publicly accessible web-based platform to host materials and findings from the Regional Pilot Program.
- Report back to DHS Science and Technology the findings of the Regional Pilot Program to exploit Mesonets for emergency preparedness and response during severe weather threats.
- Produce policy relevant/popular science publications to disseminate findings to homeland security enterprise and whole community target groups.

3 OTHER APPLICABLE CONDITIONS

3.1 SECURITY

Contractor access to unclassified, but Security Sensitive Information may be required under this SOW. Contractor employees shall safeguard this information against unauthorized disclosure or dissemination. All work performed under this SOW is unclassified. If provided DHS "sensitive" information (e.g., items marked with FOUO or other appropriate marking), the contractor agrees it shall safeguard such information in accordance with the parameters outing in the resulting award. The contractor shall adhere to all applicable government laws, regulations, orders, guides, and directives pertaining to classified, Sensitive but Unclassified (SBU), FOUO, or personally identifiable information. The contractor shall safeguard SBU, FOUO information specifically in accordance with DHS Management Directive 11042.1.

3.2 PERIOD OF PERFORMANCE

The period of performance for this contract shall not exceed thirty-six (36) months, including a base period of performance as defined below:

a. Base Period of Performance. The base period of performance will be thirty-six (36) months from the date of award.

3.3 PLACE OF PERFORMANCE

The primary place of performance will be the Contractor's facilities. Contractor shall specify any other place(s) of performance. All work must be performed in the United States.

3.4 POST AWARD CONFERENCE

The Contractor shall attend a Post Award Conference with the Contracting Officer and the COR no later than 15 business days after the date of award. The purpose of the Post Award Conference is to discuss technical and contracting objectives of this contract and review the Contractor's draft Project Management Plan (PMP). The Post Award Conference will be held at the Government's facility, located at 1120 Vermont Ave., NW Washington, DC 20005, or virtually (e.g., MS Teams, or teleconference).

3.5 PROJECT MANAGEMENT PLAN AND SCHEDULE

The Contractor shall provide a Project Management Plan (PMP) and Schedule for all tasks to include: task approach, deliverables, timelines, assumptions and requirements for the successful execution of the task objective for Government review and comment. Project plans will contain metrics that are relevant to the particular task(s) covering financial, schedule, scope, risk, and performance assessment information.

The Contractor shall provide a draft Project Plan at the Post Award Conference for Government review and comment. The Contractor shall provide a final Project Plan to the COR not later than fifteen (15) days after the Post Award Conference.

3.6 MONTHLY FINANCIAL AND TECHNICAL STATUS REPORTS

The Contractor shall provide a *monthly* progress report (financial, and technical status) to the Contracting Officer, COR, and Project Manager via electronic mail. The monthly report shall include a summary of all Contractor work performed during the previous month. The report shall contain a discussion of progress and timeline of ongoing projects against the overall project plan and schedule, an assessment of technical progress, discussion of any technical or programmatic difficulties encountered, discussion of any risks

identified with proposed mitigation measures, the Contractor's plan for the next month including expected deliverables milestones, a roster of all Contractor personnel holding proximity passes/DHS IDs, identification and tracking of Government property, and an accounting of any travel and ODCs during the period. The COR and the contractor will further determine the content and format of reports at award.

Contractor shall provide all written reports in electronic format with read / write capability using applications that are compatible with DHS workstations (Windows and Microsoft Office Applications).

3.7 PROGRESS MEETINGS

The Contractor shall meet with the Government Project Manager(s) on a *biweekly* basis to discuss progress, exchange information and resolve emergent technical problems and issues. These meetings shall take place *via teleconference.* The Government shall provide a Quad Chart for use in the progress meetings.

3.8 GENERAL REPORT REQUIREMENTS

The contractor shall provide all deliverables, in Portable Document Format (PDF) to the DHS Contracting Officer Representative, DHS S&T Program Manager and the DHS Contracting Officer (CO) and to [redacted]

4 GOVERNMENT FURNISHED RESOURCES

a. Government-Furnished Equipment: No Government Equipment shall be used.

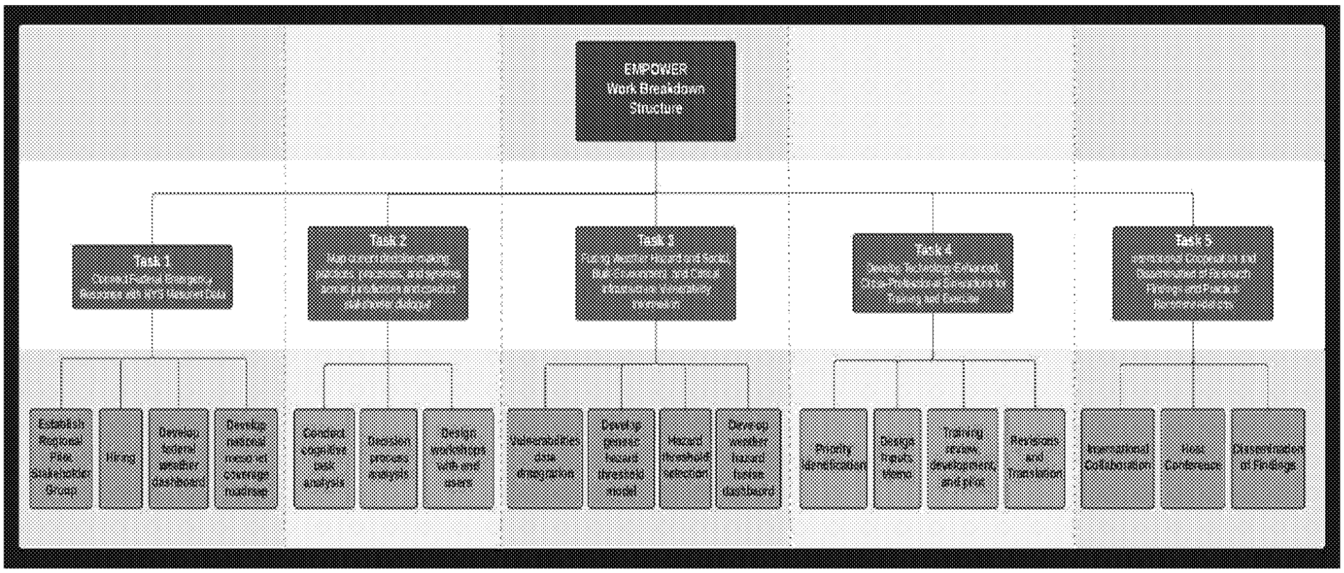
b. Government Furnished Information: The DHS COR will provide any material that DHS deems appropriate. The Government will provide all necessary information, data and documents to the Contractor for work required under this Contract. The Contractor shall use Government furnished information, data and documents only for the performance of work under this Contract, and shall be responsible for returning all Government furnished information, data and documents to the Government at the end of the performance period. The Contractor shall not release Government furnished information, data and documents to outside parties without the prior and explicit consent of the CO. The COR identified in Section G will be the Point of Contact (POC) for identification of any required information to be supplied by DHS. The Contractor shall prepare all documentation according to the guidelines provided by the COR.

c. Government-Furnished Property: The Government does not anticipate providing any Government Property for this Contract. The Contractor's proposal may identify property that it may purchase or supply in the performance of this Contract. In that case, before purchasing any individual item or equipment, not already included in the Contractor's proposal, exceeding $5,000.00 that is required to support technical tasks performed pursuant to the requirements of the proposal in this Contract, the Contractor shall obtain

the DHS CO's prior written consent. The DHS CO may lower the above $5,000.00 threshold at his/her discretion via written modification to the Contract. If the DHS Contracting Officer, in consultation with the COR, consents to such purchase, such items shall become the property of DHS. The Contractor must maintain any such items according to the Government Property Clause of this Contract. The DHS CO will determine the final disposition of any such items.

5 PROJECT SCHEDULE

5.1 WORK BREAKDOWN STRUCTURE (WBS)



5.2 PROJECT MILESTONES

Task 1: Connect Federal Emergency Response with NYS Mesonet Data			Month Start	Month End
1.1	**(M) Establish Regional Pilot Stakeholder Group**		**1**	**3**
1.1.1	Delivery of Stakeholder Group Names	D1	3	3
1.2	**(M) Hire Three PDRAs**		**1**	**3**
1.2.1	Delivery of Names/Bios of PDRAs	D2	3	3
1.3	**(M) Creation and delivery of Federal Weather Dashboard**		**4**	**12**
1.3.1	Challenges, Priorities, Dataset Identification	D3	4	6
1.3.2	Prototype Development v1	D4	7	12
1.3.3	Federal Technical Connectivity Alignment		10	12
1.3.4	Prototype Development v2 & Delivery	D5	13	24
1.4	**(M) Multi-Mesonet Roadmap**	D6	**25**	**36**

Task 2: Map current decision-making practices, processes, systems, across jurisdictions and conduct stakeholder dialogue.			Month Start	Month End
2.1	**(M) Conduct cognitive task analysis**		**6**	**16**
2.1.1	Hazard-Vulnerability Use Case	D7	6	12
2.1.2	Protective Action Identification and Mapping	D8	13	16
2.2	**(M) Decision Process Analysis**		**17**	**24**
2.2.1	Content Analysis		17	20
2.2.2	Event Case Study Profiles	D9	21	24
2.2.3	Severe Weather Decision-Support Observations		23	24
2.3	**(M) Design Workshop with Stakeholders**	**D10**	**25**	**26**

Task 3: Fusing Weather Hazard and Social, Built-Environment, and Critical Infrastructure Vulnerability Information.			Month Start	Month End
3.1	**(M) Vulnerabilities Data Integration**		7	24
3.1.1	Script and API development		7	18
3.1.2	Data Archive and Management Protocols	D11	19	24
3.2	**(M) Hazard Threshold Model Development**		**10**	**24**
3.2.1	Hazard Threshold Selection	D12	19	24
3.2.2	Enhanced Weather-Hazard Dashboard	D13	18	36
3.2.3	Ergonomic Testing & Memo	D14	18	24
3.3	**(M)** Hotspot Integration and Prototype Revision (v3)	**D15**	25	30
3.4	**(M)** End-User Testing and Prototype Revision (v4)	**D16**	31	36

Task 4: Develop Technology-Enhanced, Cross-Professional Simulations for Training and Exercise			Month Start	Month End
4.1	**Priority Identification for Simulations**	D17	**13**	**15**
4.2	**(M) Design Inputs Memo**	D18	**16**	**18**
4.3	**(M) Training Development**		**13**	**32**
4.3.1	Education and Training Literature Review	D19	13	18
4.3.2	Training End-User Interviews & Summary	D20	19	21
4.3.3	Training Alignment Architecture		22	24
4.3.4	Exercise and Artifact Development		25	27
4.3.5	Internal Alpha Test		28	28
4.4	**(M) Training Pilot**		**29**	**32**
4.4.1	Assessment Protocol and Instrument	D21	29	29
4.4.2	Exercise Implementation		30	31
4.4.3	Exercise Assessment and Evaluation	D22	32	32

4.5	**(M) Revisions and Transition**	**D23**	**33**	**36**

Task 5: International Cooperation and Dissemination of Research Findings and Practical Recommendations			Month Start	Month End
5.1	**(M) Virtual / In-Person Workshops (x5)**		**6**	**36**
5.1.1	Workshop summary (1-5)	D24-D28	6	36
5.2	**Advanced Weather Data International Conference**	**D29**	**24**	**30**
5.3	**Dissemination of Findings and Recommendations**		**12**	**36**
5.3.1	Regional Pilot Website	D30	1	12
5.3.2	EMPOWER Final Report	D31	30	36
5.3.3	Academic and Stakeholder Publications		6	36

6 DELIVERABLES

The Contractor shall provide deliverables, subject to FAR 52.227-17, as identified below:

ITEM	SOW REFERENCE	DELIVERABLE / EVENT	DUE BY	DISTRIBUTION
D1	1.1.1	Delivery of Stakeholder Group Names	3 Months after date of award	COR, Contracting Officer, PM
D2	1.2.1	Delivery of Names/Bios of PDRAs	3 Months after date of award	COR, Contracting Officer, PM
D3	1.3.1	Challenges, Priorities, Dataset Identification	6 Months after date of award	COR, Contracting Officer, PM
D4	1.3.2	Prototype Development V1	12 months after date of award	COR, Contracting Officer, PM
D5	1.3.4	Prototype Development V2 and Delivery	24 months after date of award	COR, Contracting Officer, PM
D6	1.4	Multi-Mesonet Roadmap	36 months after date of award	COR, Contracting Officer, PM

ITEM	SOW REFERENCE	DELIVERABLE / EVENT	DUE BY	DISTRIBUTION
D7	2.1.1	Hazard Vulnerability Use Case	16 months after date of award	COR, Contracting Officer, PM
D8	2.1.2	Protective Action Identification Report	16 months after date of award	COR, Contracting Officer, PM
D9	2.2.2	Case Profiles Report with Cross Case Analysis	24 months after date of award	COR, Contracting Officer, PM, SandT-Cyber-Reports
D10	2.3	Virtual Workshop Design Document	26 months after date of award	COR, Contracting Officer, PM
D11	3.1.2	Data Archive and Management Protocols	24 Months after date of award	COR, Contracting Officer, PM
D12	3.2.1	Hazard threshold Selection	24 months after date of award	COR, Contracting Officer, PM
D13	3.2.2	Enhanced Weather-Hazard Dashboard	36 months after date of award	COR, Contracting Officer, PM
D14	3.2.3	EMPOWER Decision Support Tools CRISIS Ergonomics Memo	24 months after date of award	COR, Contracting Officer, PM
D15	3.3	Hotspot Integration and Prototype Revision (v3)	30 months after date of award	COR, Contracting Officer, PM
D16	3.4	End-User Testing and Prototype Revision (v4)	36 months after date of award	COR, Contracting Officer, PM
D17	4.1	Priorities for Simulation Framework	15 Months after date of award	COR, Contracting Officer, PM
D18	4.2	Design Inputs Memo	18 months after date of award	COR, Contracting Officer, PM

ITEM	SOW REFERENCE	DELIVERABLE / EVENT	DUE BY	DISTRIBUTION
D19	4.3.1	Education and Training Literature Review	18 months after date of award	COR, Contracting Officer, PM
D20	4.3.2	Training End-User Interviews & Summary	21 months after date of award	COR, Contracting Officer, PM
D21	4.4.1	Assessment Protocol and Instrument	29 months after date of award	COR, Contracting Officer, PM
D22	4.4.3	Exercise Assessment and Evaluation	32 months after date of award	COR, Contracting Officer, PM
D23	4.5	Revisions to Design and Transition	36 months after date of award	COR, Contracting Officer, PM
D24-D28	5.1.1	Workshop Summary	9, 15, 21, 26, 30 months after date of award	COR, Contracting Officer, PM
D29	5.2	International Conference Summary	39 months after date of award	COR, Contracting Officer, PM
D30	5.3.1	Regional Pilot Website	12 months after date of award	COR, Contracting Officer, PM
D31	5.3.2	EMPOWER Final Report	36 months after date of award	COR, Contracting Officer, PM