**24. What were the major goals and objectives of this project?\***

Report 1 Text (note I will remove report 1-specific text to remain under the character limit):

As originally stated in our letter of intent and subsequent proposal, the primary questions (and product) we proposed are:
Q1) Does a combination of multiple networks of opportunity improve the analysis of spatial and

temporal variability during extreme temperature events in relation to the ASOS network?

Q2) Are available numerical weather prediction models and forecasts capable of simulating the observed spatial and temporal variability of extreme temperature at lead-times of hours to days?

Q3) How accurately do extreme temperature metrics (such as heat index, wind chill, wet bulb

globe temperature) map onto observed impacts and/or contribute to effective decision support?

Q4) How can the conclusions from (1), (2), and (3) best improve the communication of extreme temperature events to key stakeholders such as emergency management?

P5) We further propose to create a real-time high-resolution analysis and forecast product for NYC [New York City] built using these observations and forecasts for all stakeholders to use.

Addressing these four questions and creating an analysis and forecast product for New York City remains our goals and objectives. To accomplish this, a combination of “traditional” meteorological analysis is necessary in addition to a social science component. The intention of the latter is to inform the needs of the former, with an eye toward achieving our readiness goals. Specifically, we will utilize several networks of opportunity in the New York City metro area to develop a temperature and heat product analysis and testing system, and to ultimately understand how to better predict heat impacts on a more granular level across New York City. Usability studies testing excessive heat product displays and an examination of real-time decision making during extreme events serve as the backbone of the social science component. For both the meteorological analysis and the social science components, close cooperation with the local National Weather Service (NWS) OKX office as well as the New York City Office of Emergency Management (NYCOEM) was considered instrumental in achieving our stated goals.

Report 2 Update:

~~The proposal listed a number of tasks to be completed or begun within the first twelve months and coinciding with this reporting period. In the interest of space, this discussion will lump similar tasks together and broadly discuss their status, with a focus on tasks either behind schedule and/or that have involved significant work conducted. Section 25 below will add further detail.~~

Literature review: Literature review is a perpetual project. To the extent one can be on track to “complete” literature review, this is on track. This is the responsibility of all project members.

Develop observational and forecast data streams: This was largely completed within the report 1 time period by PI Bassill for observational data streams and high-resolution NWP data such as the HRRR and NAM Nest models. However, we are still seeking a reliable way to obtain more temporally dense ASOS observations, to correspond with the temporal resolution of our other observational networks. One outstanding forecasting component NWS would like us to include is the NBM) which we have yet to operationalize as part of this project.

Develop real-time analyses and evaluate them: This was scheduled to be completed in the report 3 time period, though real-time analyses have already been largely created and operationalized in a prototype website. Further evaluation is needed.

Calculate forecast biases: this is being done in real-time, though a systematic evaluation has not been concluded.

~~(Note that the above, and other proposed tasks such as evaluating spatial and temporal variability were largely assigned to the proposed post-doctoral hire. This position will not be filled until report 3, which is why some tasks have lagged their expected completion date.)~~

Retrospective Case Analysis: co-PI Eric Stern has worked closely with NWS and NYCOEM to identify prior cases and has incorporated this analysis into class projects over this past semester. As the interplay between NWS and NYCOEM is somewhat of a moving target, this will likely be an ongoing evaluation.

Usability Studies/Field Research: This has been mostly completed by co-PI Sutton, though final interpretation is still ongoing. COVID has transformed planned in-person visits to NWS/NYCOEM into virtual engagements.

**25. What was accomplished under these goals?\***

(In the interest of space I have removed all report 1 text. Please see report 1 for a breakdown of the prior 6 months.)

Report 2 Update:

A primary focus of this period was creating a wet-bulb globe temperature (WBGT) variable. This was more complex than PI-Bassill expected! This variable relies on a globe temperature instrument, which is not readily available, but which is able to be replicated via knowledge of other data such as irradiance, temperature, wind speed, humidity, and zenith angle, along with a variety of other estimates for constants such as albedo, emissivity, surface roughness, and more. The “official” NWS WBGT code was also obtained from the NWS OKX office. Although this code was analyzed, it was ultimately not used in part because it estimates irradiance from expected insolation and cloud cover, whereas the NYS Mesonet and Con Edison sites directly measure irradiance, which is a superior option. At the conclusion of this reporting period, we were able to create WBGT values for historical periods and were ready to create real-time WBGT values and maps operationally shortly after the beginning of reporting period 3. One benefit to our approach is that we are able to supplement NYC-area ASOS sites with NYS Mesonet and Con Edison irradiance data, which allows for the calculation of WBGT for these sites using an identical approach.

~~One realization during this work was that WBGT is extremely sensitive to a variety of empirically derived constants – which do not have an agreed-upon value – and treatment of other factors such as the wind speed adjustment to 2 m, a minimum wind threshold, the distribution of direct vs. diffuse sunlight, and more. These may present interpretation and communication challenges that are in addition to those being studied by the social science component of this project.~~

~~The existing prototype dashboard was further refined to increase readability based on feedback from NWS OKX, and was made more robust such that down periods were effectively non-existent by the end of the reporting period. Additional variables were added such as min/max 24 hour heat index.~~

The research component led by co-PI Sutton collected 250 tweets posted by 6 WFO Twitter accounts during the first major heatwave in their jurisdictions in 2021. We conducted content analysis by coding each tweet (the content in the tweet text and in the tweet graphic) for the presence of words and phrases necessary for the effective communication of a warning message (the name of the hazard, a description of the threat, the area or population that is vulnerable to the threat, the protective actions that vulnerable populations should take, the message source and the time to take actions). We also coded for the presence of scientific "jargon," that is, the use of technical words that are meaningful to scientists but may not relay the same meaning to a lay person. We found that 40% of tweets include jargon, with heat advisory being used most frequently and heat index was commonly communicated (38% of the time). Both terms infrequently included a definition or explanation. Heat impacts/consequences were included in 31% of tweets; guidance was included in ~58% of tweets, and 36% of tweets including content about vulnerable populations.

The research team also completed the analysis of card sorting interviews conducted with 45 participants to learn about how different heat content user populations process, understand, and organize information about excessive heat. We find that while emergency managers and atmospheric scientists generally group terms in a similar manner, the process of grouping them and choosing which terms are more important differs. While atmospheric scientists put effort into organizing scientific terms, emergency managers described a stronger interest in the concepts about heat impacts, vulnerable populations, and safety precautions.

Co-PI Stern conducted an upper level-undergraduate "capstone" policy analysis class at the UAlbany College of Emergency Preparedness, Homeland Security and Cybersecurity (CEHC) which explored interaction between the NWS/weather information enterprise and emergency managers with regard to urban heat hazard exacerbated by the "heat island effect" and in the context of COVID-19.

Co-PI Thorncroft also organized meetings with potential ancillary partners such as the NYS DEC, NY DHSES, IBM, BNL, and others where this project and its goals were discussed.

~~While not explicitly stated as a goal in the prior report nor proposal, this period also involved the writing and near-completion of our transition plan, which was conducted in cooperation with our POC Jeff Waldstreicher and OKX SOO Dave Radell.~~

PI Bassill also hired a research scientist and helped organized and mentor a NERTO student, who conducted work on behalf of this project. The research scientist will begin in reporting period 3.

**26. What opportunities for training and professional development has the project provided?\***

Report 1 Text:

Training and professional development was not a stated component of this project. However, ancillary training and professional development may be accomplished through the incorporate of this project into Dr. Stern's class, graduate involvement, and future internship opportunities.

One research assistant has been trained on card sorting interview techniques and conducted the card sorting interviews. He completed his Master's degree in December and has accepted a job that will begin in mid-summer. A new RA will be hired to begin with the fall semester.

In case you need his name - Nick Waugh.

Report 2 Update:

PI Bassill has collaborated with OKX SOO Dave Radell and NOAA physical scientist Jordan Gerth to mentor a NOAA Experiential Research and Training Opportunities (NERTO) student, tasking with contributing to this project. Dimitri Ambroise, our NERTO student, is currently a student at the CUNY City College of New York pursuing an MS degree in Sustainability in the Urban Environment. He will continue working on this project into August.

**27. How were the results disseminated to communities of interest?\***

Report 1 Text:

The social science research on usability was presented at the American Meteorological Society Annual meeting by Dr. Sutton during a session hosted by Weather Ready Nation. Approximately 50 persons attended the session. Dr. Bassill has also discussed this project with potential ancillary stakeholders such as Con Edison, the NYC utility.

Report 2 Update:

Research on this project has continued to be presented at scientific conferences, and discussions continue with ancillary stakeholders such as Con Edison. Additionally, our NERTO student lives in NYC, attends CUNY, and is working to apply observational data to socioeconomic as well as geographical aspects of NYC as part of his project.

**28. What do you plan to do during the next reporting period to accomplish the goals and objectives?\***

Report 1 Text:

One critical need is to finalize our post-doc hire, which we expect to complete by the next reporting period. This will enable us to further our meteorological goals of further developing and improving analysis products for NYC, with a goal of slowly building a more granular analysis system. Additionally, we will begin quantitatively evaluating model (or human) forecasts against collected observations, with a goal of identifying patterns where models may have unusual low or high predictability. This will also allow us to understand common model biases. We would also like to begin calculating wet bulb globe temperature (WBGT). NWS has identified WBGT as a key variable to compare and evaluate against more traditional heat metrics such as heat index or simple variables like temperature.

The social science team will complete the card sorting interviews and analyze the quantitative and qualitative data. We also intend to meet with the social science lead on excessive heat products for NOAA in order to determine if there are any specific public-facing products that are in development that might be incorporated into the excessive heat website.

Report 2 Update:

Our new post-doc (technically a visiting research scientist) will begin work analyzing heat impacts in NYC (using observational and other ancillary weather data) on a more granular level. We’ve recognized that there are likely biases in some of the observing sites we’re using to create analyses, so we would like to understand what biases are due to the specific siting location (on blacktop, next to a brick building, etc.) vs. what “biases” are actually real reflections of neighborhood effects such as tree cover, nearby water bodies, or other urban effects. Additionally, we’d like to transform certain key variables (such as WBGT or heat index) by placing them in percentile-space according to historical observations for that site. In this way, any local biases may be removed, and sites more easily compared.

Concurrently, we will “operationalize” the WBGT variable for NYC and add it to the simplistic website that has already been constructed. This variable will be calculated for all available observing sites in the NYC area, including NYS Mesonet, Con Edison, and ASOS (where data is present).

Usability studies and “field” research will continue to be collated and presented, and a publication is in preparation.

PRODUCTS         Guidance

**29. Publications, conference papers, and presentations\***

Report 1 Text:

Dr. Sutton presented on work related to this project at the 2022 AMS Annual Meeting.

Sutton, J., Waugh, N., & Germain, C.A. (2022, January) Communicating Wetbulb Globe Temperature: Results from a Usability Study. Presented at the 102nd Annual Meeting of the American Meteorological Society, 10th Symposium on Building a Weather-Ready Nation, Session 13 Innovation Leading the Way toward a Weather-Ready Nation. Houston, TX.

Report 2 Update:

Sutton, J., Olson, M, and Waugh, N. 2022 *Communicating Extreme Heat to At Risk Publics: A Content Analytic Study of Tweets from 2021*. American Meteorological Society, 6th Conference on Weather Warnings and Communication. June 14-17, 2022. Milwaukee, WI.

**30. Technologies or techniques\***

Report 1 Text:

As a means to accomplish our long-term research and product goals, Dr. Bassill has developed a simplistic webpage to display real-time extreme temperature products for New York City (as well as other variables), which updates current conditions every five minutes with the latest observations. Additionally, a forecasting component has been added which highlights time-lagged ensembles of both the HRRR and NAM Nest at this moment. Where possible, current observations are overlaid on the equivalent forecast variable. Currently, this is used primarily for qualitative rather than quantitative analysis. It is also intended to be used as a point of reference as we eventually refine a superior interactive web product. This website has been shared with our NWS collaborators. It can be viewed here: <https://operations.nysmesonet.org/~nbassill/NOAA/>

Report 2 Update:

The above text remains relevant. However, during this reporting period a variety of improvements (such as the addition of new variables and stability improvements to reduce/eliminate downtime) have been incorporated into this website. ASOS observations have also been added to most real-time maps.

**31. Inventions, patent applications, and/or licenses\***

**32. Other products\***

Report 1 Text:

As mentioned above in question 30:

As a means to accomplish our long-term research and product goals, Dr. Bassill has developed a simplistic webpage to display real-time extreme temperature products for New York City (as well as other variables), which updates current conditions every five minutes with the latest observations. Additionally, a forecasting component has been added which highlights time-lagged ensembles of both the HRRR and NAM Nest at this moment. Where possible, current observations are overlaid on the equivalent forecast variable. Currently, this is used primarily for qualitative rather than quantitative analysis. It is also intended to be used as a point of reference as we eventually refine a superior interactive web product. This website has been shared with our NWS collaborators. It can be viewed here: <https://operations.nysmesonet.org/~nbassill/NOAA/>

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS         Guidance

**33. What individuals have worked on this project?\***

Report 1 Text:

Proposed PI Dr. Bassill, and proposed co-PIs Dr. Jeannette Sutton, Dr. Eric Stern, and Dr. Christopher Thorncroft have all worked on this project. Additionally, Dr. Carol Anne Germain has assisted Dr. Sutton in the role as co-Investigator. Graduate student Nick Waugh has also worked on this project. Dr. Bassill has developed the meteorological tools addressed above and coordinated the project in total. Dr. Sutton, with assistance from Dr. Germain and Nick Waugh, has led the social science components of this project. Dr. Stern has coordinated discussion with NWS and NYCOEM to evaluate retrospective cases, while Dr. Thorncroft has assisted with a literature review and procuring a post-doc. All of these people work at the University at Albany in New York.

Report 2 Update:

Dimitri Ambroise participated in project work during June and July as part of the NERTO program.

Sav Olivas graduated with a BS from the University of Miami and joined the team in July. She is contributing to all facets of the social science portion of this project including data collection and analysis, writing up results, and presenting to academic and professional audiences.

**34. Has there been a change in the active other support of the PD/PI(s) or senior/key personnel since the last reporting period?\***

Report 1 Text:

There has been no significant change, though Dr. Carol Anne Germain has contributed to some of the original work conducted primarily by Dr. Jeannette Sutton.

Report 2 Update:

There has been no significant change. Dr. Carol Anne Germain’s contribution to the project has completed.

**35. What other organizations have been involved as partners?\***

Report 1 Text:

The New York City Office of Emergency Management has supplied supplementary information on how NWS forecasts are disseminated and used to activate various levels of service. Thus far, all work has been conducted remotely.

Report 2 Update:

No additional organizations have been involved, though I should note our NERTO student did participate (though this is through NOAA as well).

**36. Have other collaborators or contacts been involved?\***

IMPACT         Guidance

**37. What was the impact on the development of the principal discipline(s) of the project?\***

(No report 1 text)

Report 2 Update: we do not feel prepared to answer this question at such an early stage, though we eagerly look forward to future reports where this will become more relevant.

**38. What was the impact on other disciplines?\***

**39. What was the impact on the development of human resources?\***

**40. What was the impact on teaching and educational experiences?\***

Report 1 Text:

Currently, there is little to report. However, co-PI Dr. Stern is using aspects of this project in a class, which will expose the students to retrospective heat wave analysis. More is expected to be reported at the next reporting period.

Report 2 Update:

Dr. Eric Stern conducted an upper level-undergraduate "capstone" policy analysis class at the UAlbany College of Emergency Preparedness, Homeland Security and Cybersecurity (CEHC) consisting of roughly 30 students in work supporting the project from January to May, 2022. The class explored interaction between the NWS/weather information enterprise and emergency managers with regard to urban heat hazard exacerbated by the "heat island effect" and in the context of COVID-19. Student teams examined general issues of fusing hazard and social/environmental vulnerability data, surveyed good practices across jurisdictions with regard to responding to heat emergencies and mitigating urban heat risk, and conducted several open source case studies of "whole community" emergency management in New York City during recent heat events. The faculty supervised student research results will be incorporated into - and help to guide - ongoing project research.

**41. What was the impact on physical, institutional, and information resources that form infrastructure?\***

Report 1 Text:

Report 1 Text: This does not exist yet, but a core mission of this project is to create an extreme temperature dashboard for New York City that will enable NWS and key stakeholders improved granularity when analyzing extreme temperature events. Additionally, we plan to overlay key ancillary features such as locations of cooling centers, parks, water bodies, etc to help improve response.

Report 2 Update: Nothing to add at this time.

**42. What was the impact on technology transfer?\***

Report 1:

No technology has yet been transferred, though we will be meeting with our NOAA POC very soon to begin planning. We remain at the same readiness level we began at (5).

Report 2 Update:

We have met with our NWS POC and other NWS personnel to craft our transition plan, which should be finalized in the next reporting window. Over the course of reporting period 2 we have discussed and addressed the questions to the best of our ability, and are awaiting feedback which we anticipate to occur in reporting period 3. PI-Bassill has also discussed this project with NYS Mesonet program manager Dr. Jerry Brotzge (who has since departed) in regard to potentially integrating tools created here into the “official” NYS Mesonet website.

**43. What was the impact on society beyond science and technology?\***

Report 1 Text:

Currently, there is nothing to report. However, while we consider NWS to be a core partner, we are expecting that improved prediction of extreme temperature events - particularly heat events - will allow for more optimized responses to these events by city emergency management. For instance, if a forecast event is considered marginal, or only meeting advisory criteria for certain portions of New York City but not others, cooling centers and wellness checks could be focused on those areas expected to exceed the criteria. Currently, New York City is generally treated as a single unit.

Report 2 Update: In addition to the above, we have had preliminary discussions with NYC’s primary electric utility (Con Edison) about using output of this project in their internal energy demand forecasts for NYC.

**44. What percentage of the award’s budget was spent in foreign country(ies)?\***

Enter percent

0%

Enter explanation:

**45. Changes in approach and reasons for change\***

Report 2:

As discussed below (Q46), the primary change at this point regards eliminating travel to NYC to embed with NWS (or NYC EM) during heat events. This change was made due to COVID, and virtual interactions have replaced any planned in-person interactions.

**46. Actual or anticipated problems or delays and actions or plans to resolve them\***

Report 1 Text:

One primary issue has been the ongoing COVID-19 pandemic, which necessarily limits in person contact, and thus provides and impediment to easy coordination. Thus far we have relied exclusively on virtual meetings to meet with our NWS collaborators. A secondary issue was that hiring a post-doc to conduct a portion of this work has not been as easy as anticipated. We are currently working on hiring an excellent candidate based currently in India, though paperwork and work permitting has taken a lengthy time to work through. We are confident he will be able to start this summer.

One potential risk is that our hired post-doc does not possess the web building skills needed to produce the type of easily used and highly functional website we have proposed. Should this be the case, we may look elsewhere within the university for assistance on designing and implementing this website. Finally, there is a risk that one of our networks of opportunity (CUNY) may continue to remain inaccessible through the duration of this project. Should this occur, we believe the remaining three networks of opportunity still constitute a consider improvement in observational coverage of New York City.

Report 2 Update:

We have been able to hire a post-doc (technically, he is a visiting research scientist because it has been longer than 3 years since his PhD) from India with significant experience on the topic of Urban Heat Island analysis. However, due to various immigration bottlenecks – enhanced due to COVID – he was not able to secure a VISA for several months. Thankfully, he has secured a VISA and arrived in Albany, NY a few days before the end of this reporting period and will be starting immediately thereafter.

COVID remains a hindrance due to its effect on in-person meetings and events. A portion of the proposed work involved “on-site” education and integration (where feasible) by/at the NWS OKX field office during a heat event. This has not been possible due to COVID restrictions, but our NWS office has been willing to educate us virtually where possible.

**47. Changes that had a significant impact on expenditures\***

Report 1 Text:

The only thing to report here is that hiring a post-doc took longer than expected, so they will begin ~6-9 months later than expected. This will understandably cause expenditures to lag slightly, and thus they will be lower than what may have been initially predicted at this time.

Report 2 Update:

The post-doc (technically visiting scientist) has been successfully hired, and will begin immediately after this reporting period ends. Certainly this has reduced expenditures by a significant amount. We will very likely seek a no-cost extension, which would allow the visiting scientist to work on this project for the 2 years that was planned.

**48. Significant changes in use or care of human subjects, vertebrate animals, biohazards, and/or select agents\***

None.

**49. Change of primary performance site location from that originally proposed\***

PROJECT OUTCOMES Guidance

**50. What were the outcomes of the award?\***

Report 1 text:

This project is not yet complete, and thus we are unable to give concrete or finalized answers. However, preliminary work does suggest that incorporating multiple networks of opportunity does significantly increased the granularity with which we can observe subtle temperature differences across New York City. The social science component of this work has uncovered a surprising variety of ways that heat products are communicated to the public, as well as a variety of ways the public interprets or views language concerning excessive heat forecasting.

Report 2 update:

The text above remains accurate, but we are now tentatively able to add the ability to create and display wet-bulb globe temperature for NY-based observations from the NYS Mesonet, NYC Con Edison micronet, and ASOS. This will allow verification of forecasts that NWS currently makes but has little ability to verify in NY.