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

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 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.

The proposal listed several tasks to be completed or begun within the first six months. Below is a listing of those tasks and a brief discussion of their progress status:

Literature Review: This is somewhat of an ongoing process, but relevant prior work has been identified and will continue to be applied where possible. One critical component of this literature review was identifying a method of estimating black globe temperature, which is needed to calculate wet bulb globe temperature. No observations collected for this study possess such data (that sensor is not deployed at the stations we’re using), but the literature provides multiple ways of estimating this.

IRB Approval: This was accomplished before our project officially began by Dr. Jeannette Sutton.

Retrospective Case Analysis: Dr. Eric Stern has worked closely with NWS and NYCOEM to identify prior cases and has begun working with a team of undergraduates to analyze these more closely.

Develop Observational Data Streams: Dr Nick Bassill has secured data streams for the NYS Mesonet and ConEd micronet data. Hourly ASOS data is available, but we are examining the potential for getting more high-resolution 5-minute data to match the aforementioned other two data streams. Finally, the CUNY network has been down during COVID, but in conversations with their PI they believe they will be restarting soon.

Gather Forecast Data: Dr. Nick Bassill has largely completed this and has developed a real-time forecast gathering and storage system for real-time GEFS, NAM Nest, and HRRR forecasts. However, additional forecast types or products may need to be incorporated as this work progresses.

Usability Study/Needs Assessment: Drs. Jeannette Sutton and Carol Anne Germain have done extensive work on this topic (see below detailed answer in 25).

25. What was accomplished under these goals?\*

As the project is just beginning, concrete results are mostly still in our future. However, significant progress toward these goals has been met. The project team has met with our NWS collaborators numerous times to further assess their own interests and goals for this project, as well as to establish an understanding of how products are issued and disseminated throughout core NYC partners such as OEM.

As mentioned above, two broad components of this project are a core meteorological component, and a social science component that will inform the meteorological component. Necessarily, the social science component provide the most benefit when conducted first, so we have included a detailed explanation of what has been done on that topic so far below.

Dr. Sutton has held multiple meetings with partner organizations including with NYCOEM (Sutton has met with Rebecca Baudendistal and with Josh Rapp independent of the larger team) and with NWS OKC (SOO Dave Radell, Nelson Vaz, Joe Polina, and others) to discuss the coordination and information exchanged between the two organizations pre-heat event and during an excessive heat event. Conversations with Rapp helped to clarify the decision support tools that NYC EM would benefit from having for future excessive heat events. This also helped to clarify the content needs for a public-facing webpage on excessive heat.

Sutton also conducted a review of the websites for all the NWS WFOs that posted an excessive heat product in 2021. Using the Iowa Mesonet platform, we reviewed historical data and found that 50 WFOs had excessive heat events resulting in the issuance of a watch or warning product. She then reviewed the website for each of the 50 WFOs to assess the location and content of heat related information on their WFO webpage. She found that only 5 of the 50 had a local webpage dedicated to local information; several in the western part of the U.S. linked to the HeatRisk experimental product for their local area; the remainder linked to the NOAA WRN page on excessive heat. She also evaluated the content of each of the 5 local webpages, finding that they prioritized historical information about the region or scientific information to calculate local heat stress. It was not apparent for whom these websites had been designed.

Sutton also developed card sorting interviews in the lab. Pilot testing was conducted with the project co-investigators (two atmospheric scientists and one who represents the area of crisis research), state emergency managers, and faculty from UAlbany public health. Face to face interviews have been completed with 25 graduate student participants from the University at Albany and preliminary analyses have been conducted. Due to the difficulty in getting students to participate face to face, we have moved data collection online using zoom and card sorting software. Additional participants have been recruited via Facebook emergency management groups. Interviews are currently underway with professional emergency managers. We have not yet begun conducting observations of real-time decision making during extreme events.

On the meteorological side of this project, Dr. Bassill has primarily focused on developing observational data streams from the networks of opportunity identified in the proposal. Thus far the NYS Mesonet and ConEd micronet streams have been secured and used to develop real-time analyses of temperature and other products across NYC updating every five minutes. Additionally, Dr. Bassill has begun archiving surface data for hourly HRRR, NAM Nest, and GEFS forecast data stretching back over a period of several years. Although no significant quantitative analysis has been done comparing forecast data with observational data, a simple website has been constructed (see questions 30 and 32) which allows a qualitative analysis of recent HRRR forecast variables compared with observations.

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

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.

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

The social science research on usability was presented at the American Meteorological Society Annual meeting by Dr. Suttong 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.

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

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.

PRODUCTS         Guidance

29. Publications, conference papers, and presentations\*

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.

30. Technologies or techniques\*

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/>

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

Nothing to Report

32. Other products\*

Nothing to Report

PARTICIPANTS & OTHER COLLABORATING ORGANIZATIONS         Guidance

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

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.

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?\*

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.

Nothing to Report

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

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.

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

Nothing to Report

IMPACT         Guidance

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

Nothing to Report

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

Nothing to Report

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

Nothing to Report

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

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.

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

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.

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

Nothing to Report

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

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.

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

Enter percent

%

Enter explanation:

45. Changes in approach and reasons for change\*

Nothing to Report

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

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.

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

Nothing to Report

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.

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

Nothing to Report

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

Nothing to Report

PROJECT OUTCOMES Guidance

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

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.