**NASA DEVELOP National Program**

**Spring 2016 Project Proposal**

**NASA Langley Research Center**

**Arizona Health & Air Quality II**

Enhancing Extreme Heat Intervention and Preparedness Activities in Maricopa County, Arizona with NASA Earth Observations

**Project Overview**

***Objective:*** To learn how information regarding spatial variability in heat exposure in Maricopa County, Arizona, can improve extreme heat adaptation strategies. This project will create an extreme heat remote sensing climatology of Maricopa County that will subsequently be integrated into a participatory research process with end-users, collaborators, and boundary organizations to determine if and how spatial variability in temperature is relevant to customization of heat-health interventions. These efforts will support the creation of an operational decision-support tool for users that leverages the remote sensing climatology and real-time sensing capabilities of NASA Earth observations that is co-designed by regional stakeholders with diverse needs related to heat preparedness and interventions.

***Community Concern:*** Extreme heat is a chronic health hazard in the hot desert climate of central Arizona and one that is projected to become more dangerous because of climate fluctuations and an aging population. The urban environment is a potentially exacerbating contributor to heat-related health risks as infrastructure and human activities elevate nighttime and daily average temperatures compared to rural surroundings. This variability in environmental conditions interacts with demographic patterns to create a complex urban “riskscape” for heat-related health hazards. A variety of adaptation strategies are in place in Maricopa County, including a public heat warning system and a network of publicly-available cooling centers, but providing such services (e.g., warning message content, location of cooling centers) generally does not account for location-based variability in risk. A shared goal of public health practitioners and researchers in the region is to tailor service provision to the places and populations of greatest need to reduce preventable heat-related illnesses and deaths.

***National Application Areas Addressed:*** Health & Air Quality, Disasters, Climate

***Study Location:*** Maricopa County, Arizona

***Study Period:*** Summer months (April – October) 2006-2015

***Advisors:*** Kate Goodin (Maricopa County Department of Public Health), Dave Hondula (Arizona State University), Dr. Kenton Ross (NASA DEVELOP National Program), Lance Watkins (Arizona State University)

***Source of Project Idea:*** The project builds on a number of related initiatives at the Maricopa County Department of Public Health and Arizona State University assessing spatial variability in sensitivity to heat, evaluating utilization and accessibility patterns in the Phoenix Heat Relief Network, and enhancing heat warning products for suitability with the regional climate. This project idea emerged from conversations between the proposed advisors regarding opportunities for improving these efforts and public health practices related to extreme heat.

**Partner Overview**

***Partner Organizations:***

Arizona Department of Health Services (ADHS) (End-user/Boundary Organization, POC: Matthew Roach, Climate and Health Program Manager)

Phoenix Heat Relief Network (End-user, POC: Celina Brun, Continuum of Care Intern, Maricopa Association of Governments)

National Weather Service Phoenix Forecast Office (End-user, POC: Paul Iniguez, Science and Operations Officer)

Environmental Remote Sensing and Informatics Lab (ERSL) at Arizona State University (Collaborator, POC: Billie L. Turner II, Professor)

Center for Policy Informatics (CPI) at Arizona State University (Collaborator, POC: Erik W. Johnston, Associate Professor)

***End-User Current Decision Making Process:***

The National Weather Service issues heat warning products to the service region based on meteorological observations at Phoenix Sky Harbor airport and forecaster opinion on the conditions that are dangerous for human health. One message is broadcast to the service region. No remote sensing information data is currently used to customize the warnings based on spatial variability. The warning zone typically spans multiple counties across Arizona; temperatures—especially at night—can be highly variable within this large zone because of the urban heat island effect and topography. Currently the Phoenix Forecast Office is piloting a new decision support product for heat that will take advantage of high-resolution information about forecast heat events contextualized against climatology, but little is known about how this information will be used by decision-makers, including the public at large.

The Phoenix Heat Relief Network serves the homeless population, thus, many facilities in the network are already involved in providing other services to the homeless (e.g., food banks, Salvation Army). Thus the network is based on the location of existing resources and willing participants without explicit consideration of spatial risk patterns. No remote sensing products are used to evaluate network coverage or identify places most in need of new network members at present.

***NASA Earth Observations Capacity:***

Arizona Department of Health Services (ADHS) – The Climate and Health Program Manager at ADHS regularly participates in working groups and reads reports that involve the use of (or refer to) NASA Earth observations in support of public health practice. Use of NASA Earth observations does not currently directly support ADHS activities related to extreme heat.

Phoenix Heat Relief Network (PHRN) – Phoenix HRN staff are generally unfamiliar with NASA Earth observations and NASA products have not been used to support HRN operations to date.

National Weather Service (NWS) – The professional meteorologists at the National Weather Service are generally familiar with NASA Earth observations, although these products are not directly incorporated in current NWS activities related to extreme heat forecasting or messaging. Earth observations provide a higher-resolution perspective on urban environmental variability than is currently available from operational weather forecast tools.

***Collaborator & Boundary Organization Support:***

Environmental Remote Sensing and Informatics Lab at Arizona State University will be providing the project team with tools, and data relevant to their analysis.

The Center for Policy Informatics at Arizona State University will be providing the project team with tools and data relevant to their analysis.

Arizona Department of Health Services – ADHS coordinates the Arizona State Heat Safety task force, which convenes quarterly under the auspices of CDC’s Building Resilience Against Climate Effects (BRACE) program. ASU, NWS, and HRN all participate in this ADHS working group, which serves as a mechanism for translating project findings statewide and to other states and cities participating in the BRACE program.

***Communication Plan & Transition Approach:***

The design of this project will include having 2 participants sit at the Maricopa County Department of Public Health and Arizona State University (both located in Maricopa County, Arizona) and 2 participants sitting at Langley Research Center. This will allow for frequent and consistent communication throughout the term. The hand off approach will involve an in-person and virtual hand off of the materials to include the entire team in the transition processes. Project output will be delivered to these partners in the second half of the spring term to support decision-making efforts in the summer months as well as allow for evaluation of the effectiveness of the tools for decision support during the heat season. Understanding how end-users interpret and utilize information about spatial variability in heat-risks is a longer-term goal of this project.

***End-User Benefit:***

Project methodology and results will be communicated with decision-making entities for heat-health interventions in Phoenix including the National Weather Service Phoenix Forecast Office and the Phoenix Heat Relief Network. These organizations are responsible for coordination of the heat warning system and network of cooling centers, respectively. This project will enable end-users to determine where new cooling centers would be most effective. It would also enable more targeted heat warning messages, potentially reducing heat related illness and mortality across the region. Results will also be more broadly shared with agencies who participate in MCDPH and ADHS efforts related to heat preparedness and response whose decision-making strategies for tailoring services are currently being inventoried in separate projects by ASU and ADHS.

**Letters of Support:** Submitted with the summer 2015 proposal

**Earth Observations Overview**

***Earth Observations:***

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| **Platform** | **Sensor** | **Geophysical Parameter** |
| **Aqua/Terra** | MODIS, ASTER | Land surface temperature, DEM |
| **Landsat 7 and 8** | ETM+, TIRS | Land surface temperature |
| **Suomi NPP** | VIIRS | Day/Night band reflectance |

***NASA Earth Observations Use:***

Aqua/Terra – MODIS will be used to determine land surface temperatures and a climatology for the region. This climatology will allow the team to identify areas of extreme heat and urban heat islands.

Terra – ASTER DEM data will be added to visualize the spatial variation in heat with elevation.

Landsat 7 and 8 will be used as a higher spatial resolution alternative to land surface temperature

Suomi NPP VIIRS will be used as a proxy for population through the use of the Day/Night Band reflectance.

***Ancillary Datasets:***

Ground-based meteorological observations from the Arizona Meteorlogical Network (AZMet) and Weather Underground; locations of Heat Relief Network cooling centers from Maricopa County Health Department; geospatial boundary files and demographic indicators from ASU-GIS spatial data repository and U.S. Census/TIGER; Maricopa County heat vulnerability maps from ASU Urban Vulnerability to Climate Change project; maps of spatial variability in heat-health outcomes from Maricopa County Department of Health and Dr. Hondula’s dissertation research; responses from summer 2014 cooling center evaluation conducted by MCDPH, ASU, and ADHS, including facility manager interviews, visitor surveys, and facility observations; community public health evaluation (CASPER) survey responses collected by MCDPH in spring 2015; teleconnection Indices from NOAA National Centers for Environmental Information (NCEI)(Formerly National Climatic Data Centers); National Land Cover Dataset 2011 impervious surface estimates

**Decision Support Tool & End-Product Overview**

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| --- | --- | --- |
| **Proposed End Products** | **Decision to be Impacted** | **Current Partner Tool/Method** |
| Climatology of Maricopa County Surface Temperatures | Location of candidate communities for tailored heat warning messaging/ triggers, selecting site locations of Phoenix heat relief network cooling centers | Warning system – uniform application of strategy across service region  Cooling centers – Network comprised of volunteering facilities |
| Teleconnection Indices Correlation Maps | Seasonal heat preparedness, research concerning drivers of local temperature change | Little evidence of seasonal outlooks being incorporated into awareness campaigns at present |
| Maps of Heat Duration and Recurrence | County and state health department vulnerability mapping | Vegetation cover and urban NLCD fraction are primarily used as proxy variables for temperature |
| Revised Heat Vulnerability Maps | County and state health department research identifying vulnerable communities (serving as basis for subsequent interventions) | Other variables commonly used as proxy variables for temperature in vulnerability index calculation, use of remote sensing products highly limited (e.g., 1 image) |
| Extreme Heat Vulnerability Tool | County and state health department research identifying vulnerable communities (serving as basis for subsequent interventions) | Other variables commonly used as proxy variables for temperature in vulnerability index calculation, use of remote sensing products highly limited (e.g., 1 image) |

*Climatology of Maricopa County Surface Temperatures* – The team will assemble a set of remotely sensed images of surface temperature patterns on hot days and nights. Where possible, comparisons will be made with ground-based observations to validate representativeness of surface temperature as a proxy variable for spatial variability in heat stress using spatial regression techniques. Separate maps will be created for daytime and nighttime conditions and daily mean, as well as a complementing set of maps assessing inter-image variability in temperature patterns.

*Teleconnection indices Correlation Maps* – The teams will create maps that show the correlation values between MODIS LST climatology and teleconnection indices. This will provide a spatial perspective of how the variability in temperatures across this large county can vary with larger-scale atmospheric patterns.

*Maps of Heat Duration and Recurrence* – This will be two separate maps showing how long (durations) heat stress occurs, and the recurrence interval of extreme heat days throughout the large study region. Both maps will be based on MODIS LST climatology and in situ measurements.

*Revised Heat Vulnerability Map* – This map will show the climatological risk across the Maricopa county area using an index calculated from humidity, temperature, duration of high heat, population, and distance from cooling stations.

*Extreme Heat Vulnerability Tool* – This tool will create the heat vulnerability maps in near real-time, incorporating the MODIS LST climatology with subsequent MODIS data acquisitions in order to update risk patterns.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 2 terms: 2015 Summer and 2016 Spring

***Multi-Term Objectives:***

* **Term 1** – Created a library of extreme heat days by remote sensing imagery of Maricopa County, AZ from 2006–present from Terra and Aqua MODIS data; generated maps of representative surface temperature patterns and variability for day and night conditions; compiled ancillary data sets.
* **Term 2 (Proposed Term)** – The second term will automate the processes developed during the Summer 2015 term into a python tool to create near real-time product. This proof of concept will be shared with the advisors at ASU who will help distribute the tool to end users after the software release process has been completed.

***Previous Related DEVELOP Work:***

Summer 2015 (Langley Research Center) – Arizona Health and Air Quality: Enhancing Extreme Heat Intervention and Preparedness Activities in Maricopa County, Arizona with NASA Earth Observations

**Project Needs/Requests**

***Participants Requested:*** 4

***Software & Scripting:***

ArcGIS - Raster Manipulation/Analysis, Image Enhancement & Map Creation of Landsat 7 ETM+, Landsat 8 OLI/TIRS, Spatial Statistics, Terra MODIS/ASTER, Aqua MODIS

Qualtrics – Survey and interview development and response recording

R – Statistical analysis of teleconnection indices and heat wave magnitudes and duration

Python 2.7 – Programming language the tool will be built with

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