**NASA DEVELOP National Program**

NASA Langley Research Center, Hampton, VA

**Summer 2015**

**Short Title: Heat-Health & Spatial Variation in Maricopa County, Arizona**

**Subtitle:** Enhancing Extreme Heat Intervention and Preparedness Activities Using Remote Sensing and Spatial Analysis of Heat-Related Health Risks and Mortality

**VPS Title:** Beat the Heat: Remote Sensing of Surface Temperature in the Valley of the Sun

**Project Team & Partners**

**Project Team:**

Amy Stuyvesant (Project Lead), [astuyvesant@bren.ucsb.edu](mailto:astuyvesant@bren.ucsb.edu)

Geordi Alm

Rocky Garcia

Emma Baghel

April Rascon

Bernardo Gracia

**Advisors & Mentors:**

David Hondula (Arizona State University)

Dr. Kenton Ross (NASA DEVELOP)

**Partner Organizations**

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

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

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

**Project Details**

**Applied Sciences National Applications Addressed:**

Health & Air Quality and Climate

**Study Area:** Maricopa County, Arizona

**Study Period:** May – September months from 2006 – 2014

**Earth Observations & Parameters**

*Landsat 7 & 8, Enhanced Thematic Mapper Plus, Operational Land Manager, Thermal Infrared Sensor* - Land Surface Temperature

*Terra, MODIS, ASTER* - Land Surface Temperature, Digital Elevation Model

*Aqua, MODIS* - Land Surface Temperature

*Suomi NPP, VIIRS* - Day/Night Band Reflectance

**Ancillary Datasets Utilized**

* AZMet and Weather Underground - Ground-based meteorological observations
* Maricopa County Health Department - Locations of Heat Relief Network cooling centers
* ASU-GIS spatial data repository and U.S. Census/TIGER - Geospatial boundary files and demographic indicators
* ASU Urban Vulnerability to Climate Change Project - Maricopa County heat vulnerability maps
* Maricopa County Department of Health and David Hondula’s dissertation research - Maps of spatial variability in heat-health outcomes
* MCDPH, ASU, and ADHS interviews, surveys, and observations - Responses from summer 2014 cooling center evaluation
* NOAA National Centers for Environmental Information (NCEI) (Formerly National Climatic Data Centers) - Teleconnection Indices
* National Land Cover Dataset - 2011 impervious surface estimates
* Mesowest Automated Weather Observation Network

**Software Utilized**

*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

*ENVI/ENVI for ArcGIS* - Imagery analysis and processing

**Project Overview**

**80-100 Word Objectives Overview**

Human exposure to excessive heat, especially in cities, accounts for more fatalities in the United States than any other weather hazard. An unbalanced vulnerability of the poor, homeless, elderly, and ethnic minorities highlights the necessity for understanding these spatial discrepancies in order to enact effective and meaningful change. Remote sensing will help produce visual aids outlining potential heat islands, communities at higher risk, and zones of greatest incidence. This in turn will provide more appropriate locations for cooling centers and assist officials in delivering proper aid.

**Abstract**

Extreme heat causes more human fatalities in the United States compared to other natural disasters, elevating the concern of heat-related mortality in the public health arena. Hotter climates and urban sprawl create conditions where localized regions in the southwest portion of the country take the hardest blow from this phenomenon. Maricopa County, Arizona is specifically known for its high heat index and is the leading megapolitan area in the U.S. for population growth and urbanization. As Phoenix expands, the increase in a built environment raises the nighttime temperatures and induces a positive feedback loop by further raising the daytime temperatures, creating an urban heat island effect. Most vulnerable to this hazard are unequally distributed between the poor, homeless, non-native speakers, elderly, and those who have no social communication within their community. While this is a devastating incidence, it can be prevented. The Arizona Department of Health Services and the Phoenix Heat Relief Network, among others, are working to create more effectively placed cooling centers and heat warning systems to aid those with the highest exposure. Using Earth observation technology from thermal wavelength bands of Landsat 7 and 8, ASTER, and MODIS imagery, a spatial perspective can be created and analyzed. Not only will spatial analyses containing information on revised heat vulnerability, heat duration, and heat incident recurrences prove beneficial for those suffering from heat-caused and heat-related injuries, but they will also provide essential components for future policy decision-making regarding appropriate locations for cooling centers and efficient warning systems.

**Community Concerns**

* Extreme heat is a chronic health hazard and is expected to become more dangerous with time and individuals’ vulnerability.
* Expanding urban landscapes with impervious surfaces slow down cooling rates at nighttime, resulting in elevated nighttime and daily average temperatures.
* Civilians most affected include those without air conditioning, proper insulation, low-income, newcomers, homeless, minorities, and socially isolated.
* Area types most affected were dependent on housing type, location and distance from the nearby urban heat island(s), land use/cover, and crime rate.

**Current Management Practices & Policies**

There are currently no state laws with regard to heat surveillance or heat monitoring policies in Arizona. Subsequently, there are no guidelines for governing entities to follow in such situations. While laws do not explicitly cover heat surveillance or heat monitoring, the Federal HIPAA Health Insurance Portability and Accountability Act, where Public Health is an exempt entity, does allow for data collection regarding relevant fatalities. This allows the Maricopa County Department of Public Health (MCDPH) to obtain information on a patient without violating the patient’s confidentiality. MCDPH primarily collects data through preliminary reports of death from the office of the medical examiner and by obtaining death certificates from the MCDPH office of Vital Registration. This data is then classified into heat-caused and heat-related deaths, and is evaluated to obtain the demographics of heat related deaths and the risk factors for mortality in order to inform relief efforts. Presently, policy formation does not employ information gathered from NASA Earth Observations.

**Decision Support Tools & Benefits**

|  |  |  |
| --- | --- | --- |
| **End-Product** | **Earth Observations Used** | **Benefit & Impact** |
| Remote Sensing Climatology of Maricopa County Surface Temperatures on Extreme Heat Days and Nights | Landsat 7 EMT+, Landsat 8 OLI/TIRS, Aqua MODIS, Terra MODIS/ASTER, Suomi NPP VIIRS | Suitable candidate communities found for heat warning messages and cooling station locations. |
| Maps of correlations with teleconnection indices | Landsat 7 EMT+, Landsat 8 OLI/TIRS, Aqua MODIS, Terra MODIS/ASTER | Seasonal heat preparedness and awareness campaigns. |
| Maps of heat duration and recurrence (including definitions based on temp and temp-humidity metrics) | Landsat 7 EMT+, Landsat 8 OLI/TIRS, Aqua MODIS, Terra MODIS/ASTER | Understanding how various vegetation cover vs. urban landscapes affect temperature and its implementation for future construction projects. |
| Revised heat vulnerability maps | Landsat 7 EMT+, Landsat 8 OLI/TIRS, Aqua MODIS, Terra MODIS/ASTER | Updated knowledge of social-economic reasons for vulnerability locations and densities. |

**Project Imagery**

**[Insert image here]**

**Caption:** [Insert Caption Here. Max of 25 words.] Image Credit: [Insert project short title] Team.

**Image:** File Name (Please submit your image as a separate .jpeg as well as inserting it in this document)