**NASA DEVELOP National Program**

NASA Langley Research Center

**Summer 2015**

**Short Title: Arizona Health & Air Quality**

**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: Surface Temperature in the Valley of the Sun

**Project Team & Partners**

**Project Team:**

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**Partner Organizations**

Arizona Department of Health Services (ADHS), End-User and Boundary Organization, POC: Matthew Roach

Environmental Remote Sensing and Informatics lab (ERSL) at Arizona State University (ASU), End-User, POC: Billie L. Turner II

Center for Policy Informatics (CPI) at ASU, End-User, POC: Erik W. Johnston

**Project Details**

**Applied Sciences National Applications Addressed:**

Health & Air Quality

**Study Area:** Maricopa County, AZ

**Study Period:** May – September months from 2005 – 2014

**Earth Observations & Parameters**

Landsat 7 & 8, ETM+, OLI, TIRS - Land Surface Temperature

Terra, MODIS- Land Surface Temperature, Digital Elevation Model

Aqua, MODIS - Land Surface Temperature

**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 (MCDPH) 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 - Map creation of Landsat 7 ETM+, Landsat 8 OLI/TIRS, spatial statistics, Terra MODIS, Aqua MODIS

Qualtrics- Survey and interview development and response recording

RStudio - Statistical analysis and clustering of surface temperature averages from MODIS raster files and census tract shapefiles

ENVI – MODIS and Landsat 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 helped produce visual aids outlining potential heat islands, communities at higher risk, and zones of greatest incidence. This will provide information regarding appropriate locations for cooling centers and assist officials in delivering proper aid.

**Abstract**

Extreme heat causes more human fatalities in the United States than any other natural disaster, elevating the concern of heat-related mortality. 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 an urban environment raises nighttime temperatures and induces a positive feedback loop by further raising daytime temperatures, creating an urban heat island (UHI) effect. Individuals at higher risk are unequally distributed, leaving the poor, homeless, non-native English speakers, elderly, and the socially isolated vulnerable to heat events. 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 NASA Earth observation technology from Landsat 8 and MODIS satellites, the daily variability within the UHI was quantified over the summer seasons of 2005 – 2014 in terms of spatial distribution and average surface temperature shifts. A series of one-way ANOVAs revealed significant differences between daily surface temperature averages of the top 30% of census tracts by month within a single season. These results provide detailed information regarding nuances within the UHI effect and allow pertinent recommendations regarding the health department’s adaptive capacity. They also hold 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. Civilians most affected include those without air conditioning or proper insulation, those with low income, newcomers, homeless, minorities, and socially isolated.
* Expanding urban landscapes with impervious surfaces slow down cooling rates at nighttime, resulting in elevated nighttime and daily average temperatures. Area types most affected are dependent on housing type, location and distance from the nearby urban heat island(s), land cover type, and crime rate. Knowing this information can show where the optimal position of new cooling centers would be located.

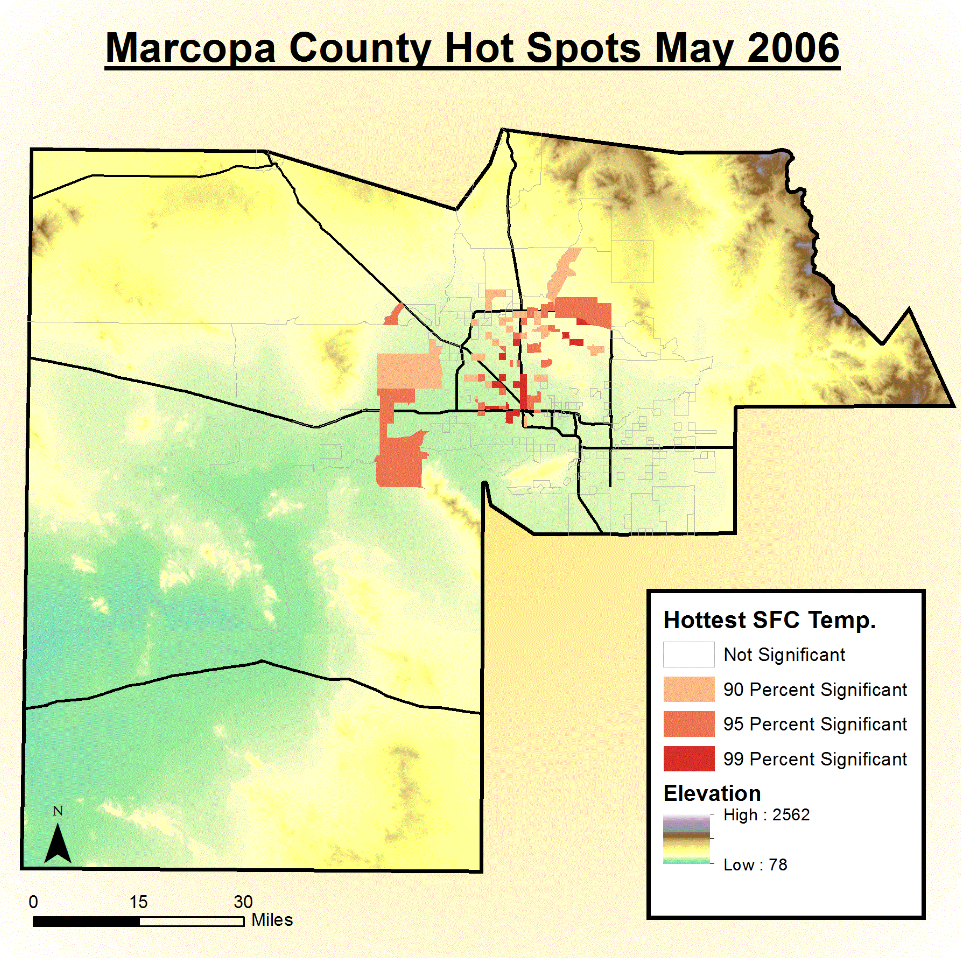
**Current Management Practices & Policies**

There are currently no state laws with regard to heat surveillance or heat monitoring policies in Arizona. Consequently, 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 Health Insurance Portability and Accountability Act (HIPAA), 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**

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| **End-Product** | **Earth Observations Used** | **Benefit & Impact** |
| Remotely Sensed Climatology of Maricopa County Surface Temperatures on Extreme Heat Days and Nights | Aqua MODIS | Suitable candidate communities for heat warning messages and cooling station locations |
| Maps of correlations with teleconnection indices | Landsat 7 EMT+, Landsat 8 OLI/TIRS, Aqua MODIS | 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 | Understanding how/when UHI varies and how various urban landscapes affect seasonal variations in surface temperature |
| Revised heat vulnerability maps | Landsat 7 EMT+, Landsat 8 OLI/TIRS, Aqua MODIS | Updated knowledge of socio-economic reasons for vulnerability locations and densities |

**Project Imagery**



**Caption:** Clusters of census tracts containing higher surface temperatures were created by comparing z-scores with neighboring tracts. Highlighted in red are significant clusters along freeways in Phoenix. Image Credit: Arizona Health & Air Quality Team.

**Image:** May2006\_HotSpots.PNG