**Washoe County Urban Development**

*Utilizing NASA Earth Observations to Assess Urban Heat Island Reduction Strategies in Washoe County, Nevada*

**VPS Title:** **Washoe Away the Heat: Assessing the Urban Heat Island and Vulnerability in Washoe County, Nevada**

**Project Team**

***Project Team*:**

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***Advisors & Mentors*:**

Dr. David Hondula (Arizona State University)

**Project Overview**

***Project Synopsis*:**

The urban heat island (UHI) is a phenomenon in which urban centers experience higher temperatures than the surrounding rural areas. This causes greater energy expenditures for air conditioning, discourages active forms of transportation such as biking and walking, and puts vulnerable populations at greater risk for respiratory and heat-related illnesses. This project utilized NASA Earth observations to assess trends in the factors contributing to the elevated temperatures in the cities of Reno and Sparks, Nevada. The results from this project will support decision-makers of Washoe County, Nevada in their efforts to mitigate the UHI as the cities grow and the climate warms.

***Abstract*:**

Extreme heat events (EHEs) are one of the leading causes of natural hazard-related deaths in the world. With rising global temperatures, these events will continue to increase in frequency, duration, and magnitude. The urban heat island (UHI) effect exacerbates the consequences of EHEs, discourages active transportation, necessitates greater energy expenditures for air conditioning, and elevates the risk of heat-related and respiratory illness in urban populations. The NASA DEVELOP Washoe County Urban Development Team utilized NASA Earth observations including Landsat 5 Thematic Mapper (TM), Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS), and Terra Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) to identify the biophysical characteristics, such as impervious surfaces, vegetation, and tree canopy cover, that contribute to the UHI effect and which ones have the greatest influence on land surface temperature (LST). The team also created a heat vulnerability index (HVI) by combining socioeconomic and health data from the US Census and the Centers for Disease Control and Prevention (CDC), respectively. These processed datasets were integrated onto a web map platform for users to visualize areas of high heat and high vulnerability. Results showed that urbanized areas of the Truckee Meadows region were warmer on average than surrounding suburban areas. Areas that experienced highest temperatures occurred in the northeast portion of the Reno-Sparks districts. The confluence of these highly vulnerable areas and biophysical characteristics will assist the Washoe County Health District’s Air Quality Management Division (AQMD) with decision-making related to UHI mitigation strategies in the Truckee Meadows region.

**Keywords:**

Earth observation, urban heat island, heat vulnerability, Landsat, Google Earth Engine

***National Application Area Addressed:*** Urban Development

***Study Location:*** Washoe County, NV

***Study Period:*** 2010 – 2017

***Community Concern:***

* Extreme heat is leading to elevated numbers of heat related illness and mortality within the region for vulnerable populations.
* Increasing energy demand and consumption from building cooling load is contributing to ozone levels reaching near maximum acceptable levels set by the EPA (Environmental Protection Agency).
* Discouraged residents choose to use greenhouse gas emitting modes of transportation, exacerbating air quality concerns in the region.
* Increases in impervious surface has led to poorer air quality and higher overnight minimum temperatures.

***Project Objectives:***

* Measure the extent and magnitude of the UHI in the region
* Assess biophysical factors including tree canopy cover, vegetation prevalence, surface albedo, and impervious surface in the Truckee Meadows region
* Construct a HVI to identify vulnerable populations
* Create scripts that users to produce updated data layers (e.g. biophysical factors) for future datasets
* Produce a regression model that identifies the biophysical characteristics that contribute most to the UHI effect
* Create a web map that allows users to easily view and interact with processed data layers

**Partner Overview**

***Partner Organizations***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Washoe County Health District, Air Quality Management Division** | Daniel Inouye, Air Quality Management, Planning & Monitoring Chief | End User | No |
| **Stantec Consulting Service, Inc.** | Cynthia J. Albright, Principal Urban Planning & Design | Collaborator | No |

***Decision Making Practices & Policies***:

The Washoe County Health District’s Air Quality Management Division (AQMD) participates in the Environmental Protection Agency’s (EPA) Ozone Advance Program. This program works with states, tribes, and local municipalities to promote local initiatives for reducing fine particulate and ozone pollution. One key goal includes the reduction of the amount of heat-absorbing, impermeable features which amplify the UHI. Lowering urban temperatures will reduce energy demand for air conditioning, curtail the use of personal vehicles in favor of active transportation methods, and slow the chemical reactions which produce ground-level ozone and nitrogen oxide pollution. The AQMD currently lacks any tools for measuring UHI factors locally and has a need to estimate the biophysical factors (i.e. tree cover, vegetation, surface albedo, and percent impervious surface).

***Project Benefit to End User***:

End users received maps of the study area, highlighting surface temperature, the factors contributing to the UHI, and demographic information on the affected population. These maps will inform the end users on the impact of the biophysical factors of UHI and enable them to use that information in their decisions as they work to mitigate the intense heat and plan for long-term ease of living. They were also provided with the tools to continue analysis.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 5 TM** | Top-of-atmosphere reflectance/radiance | This dataset was used to calculate vegetation indices and land surface temperature. |
| **Landsat 8 OLI** | Top-of-atmosphere reflectance/radiance | This dataset was used to calculate vegetation indices. |
| **Landsat 8 TIRS** | Brightness temperature/radiance | This dataset was used to calculate daytime and nighttime land surface temperature. |
| **Terra ASTER** | Top-of-atmosphere reflectance/Brightness Temperature | This dataset was used to calculate nighttime land surface temperature. |

***Ancillary Datasets:***

US Census American Community Survey (ACS) – up-to-date information about the socioeconomic community needs; these data will aid in assessing heat vulnerability

CDC 500 Cities Project – census-tract level estimates of chronic disease risk factors, health outcomes, and

clinical preventive service use; these will be incorporated into the heat vulnerability analysis

USGS National Land Cover Dataset (NLCD) – national estimates of land cover, percent tree cover and percent impervious surface

USDA National Agriculture Imagery Program (NAIP) – high-resolution imagery for more accurate estimates of tree canopy coverage and percent impervious surface

***Software & Scripting:***

eCognition – object based land cover classification

Esri ArcGIS – map generation, vector data management

Google Earth Engine API – raster data processing and analysis, tool development

GWR4 – local and global regression analysis

R – vector and raster data management

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Urban Tree Cover**  **Canopy Maps** | Landsat 5 TM, Landsat 8 OLI | The assessment of urban tree canopy cover percentage allows partners to track the progress and impact of tree planting initiatives. | I |
| **Vegetation Prevalence Maps** | Landsat 5 TM, Landsat 8 OLI | The assessment of vegetation prevalence allows partners to track and assess the impact of all vegetated surfaces (grass, trees, etc.) on UHI. | I |
| **Surface and Roof Top Albedo Maps** | Landsat 5 TM, Landsat 8 OLI | Partners can use this to examine the how changes to surface and roof top albedo influences UHI. This can be useful to assess the influence of white roofing policy. | I |
| **Urban Heat Island Index Map Collection** | Landsat 5 TM, Landsat 8 TIRS, Terra ASTER | The end users will be able to display these data with the previous end products to better identify exposure of vulnerability communities and the effectiveness of urban infrastructure changes. | I |
| **Percent Impervious Surface Maps** | Landsat 5 TM, Landsat 8 OLI | The high spatial resolution impervious layer will be used to identify area with higher concentrations of impervious surface that could be replaced with green space. The higher spatial resolution imagery will resolve classes that cannot be resolved with moderate resolution data like sidewalks and roads. | I |
| **Heat Vulnerability Index and Maps** | N/A | This allows our partners to identify where populations vulnerable to extreme heat may be more likely to reside. This can help target interventions when combined with the biophysical parameters. | I |
| **Google Earth Engine UHI Indicator Tool and ArcGIS Online Web Map** | N/A | Each of the previous tools were created through Google Earth Engine scripts. These scripts will allow partners to produce and export updated data layers using Landsat 5 TM, Landsat 8 OLI, Landsat 8 TIRS, and Terra ASTER data. The results of the biophysical and vulnerability analyses will be displayed through an ArcGIS Online web map. The interactive map will allow partners to quickly display and explore the processed data layers. | IV |
| **UHI Biophysical Regression** | Landsat 5 TM, Landsat 8 OLI, Landsat 8 TIRS, Terra ASTER | Through this analysis partners will be able to identify which of the biophysical factors have the greatest impact to reduce the UHI. | I |

**Project Handoff Package**

**Transition Plan:**

The Washoe Urban Development team presented their project via videoconference with the project partners in August 2018. The handoff package was transferred over email with all items listed in the Handoff Package.

*Software Release Plan*: Upon completion of the project, the code, scripts, and tools will undergo a software release process, resulting in a deferral of delivery. The Geoinformatics and IT teams at NASA DEVELOP will review the software and its accompanying components for approval. The software will be supported through the process by the software release POC.

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**Software Release POC**: Julia Heslin, heslin.julia@gmail.com

**Partner POC**: Daniel Inouye, dinouye@washoecounty.us

**Handoff Package:**

* Biophysical Maps
* Heat Vulnerability Index Visualizations
* UHI Biophysical Regression Graphs and Tables
* Project Summary
* Technical Paper
* Project Video
* Poster
* Presentation
* Shapefiles
* Code Tutorial
* Code Support Documentation

**References:**

Buyantuev, A., & Wu, J. (2010). Urban heat islands and landscape heterogeneity: Linking spatiotemporal

variations in surface temperatures to land-cover and socioeconomic patterns. *Landscape Ecology, 25*(1),

17-33. https://doi.org/10.1007/s10980-009-9402-4

Environmental Protection Agency (2018). Measuring Heat Islands. Retrieved from

https://www.epa.gov/heat-islands/measuring-heat-islands

Georgescu, M. (2013). Challenges associated with adaptation to future urban expansion. *Journal of*

*Climate, 28*(7), 2544-63. <http://doi.org/10.1175/JCLI-D-14-00290.1>

Harlan, S. L., Brazel, A. J., Prashad, L., Stefanov, W. L., & Larsen, L. (2006). Neighborhood microclimates

and vulnerability to heat stress. *Social science & Medicine, 63*(11), 2847-2863.

<https://doi.org/10.1016/j.socscimed.2006.07.030>

Li, X., Li, W., Middel, A., Harlan, S. L., Brazel, A. J., & Turner, B. L. (2016). Remote sensing of the surface

urban heat island and land architecture in Phoenix, Arizona: Combined effects of land composition

and configuration and cadastral–demographic–economic factors. *Remote Sensing of Environment, 174*,

233-243. https://doi.org10.1016/j.rse.2015.12.022

Sarrat, C., Lemonsu, A., Masson, V., & Guedalia, D. (2006). Impact of urban heat island on regional

atmospheric pollution. *Atmospheric Environment, 40*(10), 1743-1758.

<https://doi.org/10.1016/j.atmosenv.2005.11.037>

Washoe County Health District. Air Quality Management Division (2017). Ozone Advance Path Forward.

Reno, Nevada.