**Project Summary**

**UHEAT Urban Development**

*Increasing Capabilities and Updating the Urban Heat Exposure Assessment for Tempe (UHEAT) Tool*

**Project Team:**

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**Past or Other Contributors:**

Sydney Boogaard

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Blake Steiner

**Project Objectives:**

* Generalize the UHEAT 1.0 tool for application to other communities within the United States
* Create an open-source user interface for greater accessibility and adoption of the UHEAT tool by future DEVELOP participants and partners
* Extend vulnerability indices to account for additional biophysical and socioeconomic factors and integrate higher resolution NASA Earth observations

**Abstract:**

Extreme heat is a leading weather-related cause of death in the United States. Given that vulnerability to extreme heat is strongly related to heat exposure and socioeconomic status, policy-makers can use heat-priority maps to visualize how these variables interact. This kind of geographic information is key to informing targeted heat risk mitigation efforts. In response to this need, the Fall 2020 Tempe Urban Development II team developed the Urban Heat Exposure Assessment for Tempe (UHEAT) Tool to provide insight on heat exposure, heat vulnerability, and heat priority within Tempe, Arizona. However, UHEAT is limited in its application to other cities and does not provide a user interface to ensure the tool is accessible to all users. To better provide critical heat-related information to local policymakers, this project developed UHEAT 2.0, which is applicable to any US city. The tool is equipped with a user-friendly interface through Google Earth Engine, utilizes the Python API and utilizes up-to-date Earth observation data. The tool incorporates Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) along with Aqua Moderate Resolution Imaging Spectroradiometer (MODIS) data. UHEAT 2.0 offers rapid, easy, accessible, and efficient heat-related information to users.

**Earth Observations & End Products Overview**

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| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Aqua MODIS** | Nighttime Land Surface Temperature (LST) | Land surface temperatures were used to generate the Nighttime LST variable included in the Principal Component Analysis. |
| **Landsat 8 OLI/TIRS** | Albedo; Daytime Land Surface Temperature (LST); Normalized Difference Built-up Index (NDBI); Normalized Difference Vegetation Index (NDVI) | Surface reflectance data were used to generate the Daytime LST, NDBI, and NDVI variables included in the PCA. Future teams have the option of using Landsat 9 data once it is made available on Google Earth Engine. |

**Ancillary Datasets:**

* US Census Bureau, Five-Year American Community Survey by Census Tract 2014-2020 – These data were used to generate socioeconomic variables included in the PCA
* US Geological Survey National Land Cover Database (NLCD) – This database provided percent tree cover, used as variables in the PCA
* The Global Impervious Surface Area (GISA) Dataset – This dataset supplied impervious surface data used to generate the imperviousness variable, used in the PCA

**Software & Scripting:**

* Google Earth Engine API – Generating Landsat 8 OLI driven environmental variables (Albedo, NDVI, NDWI, and NDBI) and Landsat 8 TIRS Daytime LST data and Aqua MODIS Nighttime LST data for urban heat contribution variables
* Python 3.8.8 – Scripting for data acquisition from American Community Survey, PCA implementation and building a user interface

**End Products:**

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used**  | **Benefit & Use** | **Software Release Category** |
| **Urban Heat Exposure Assessment Tool (****UHEAT)**  | Aqua MODISLandsat 8 OLI/TIRS | End-users will be able to use this tool to assess heat exposure and vulnerability within their cities on a census tract scale. This information can then be used to inform the development of targeted heat risk mitigation strategies. | V |
| **UHEAT 2.0 User Guide** | N/A | This guide will provide comprehensive instructions on how to download and use UHEAT.  | N/A |
| **UHEAT 2.0 How-To Video** | N/A | This video will provide a step-by-step demonstration of how to operate UHEAT. | N/A |

**Project Reflections** (to be completed at the end of the term)

**Does the team consider this project to be successful?**

We consider this project to be successful, as we reached every goal we had set for ourselves at the start of the term. We converted the R portion of UHEAT 1.0 to Python, integrated the GEE Python API, and built a user interface. Of course, there were a few sub-goals we did not achieve. This included using an alternative to PCA, building the tool to allow users to upload their own data, and changing how scores are calculated to account for differences between climate zones. We also did not test the tool on as many cities as we had hoped to. There simply wasn’t enough time in the term for us to pursue every idea that came up, but there was *just* enough time to address our main goals.

**If you had the opportunity to do this project again, what would you do differently?**

If we had the opportunity to do the project again, we would have pursued an alternative to the Principal Component Analysis – perhaps hotspot analysis, as Blake Steiner suggested. We would have further generalized UHEAT by investigating variable relationship differences between climate zones. It might have also been worth looking into different measures for heat vulnerability and heat exposure, as there are multiple methods used in this field. Finally, we would collect more datasets to test UHEAT on. We had planned to test the tool on a number of cities, but did not get to do this in the end.

**Do you have any recommendations for future teams pursuing a similar project to consider?**

We highly recommended using aspects of the "Agile" software development system, including breaking the term into sprints and assigning well-defined roles and tasks to team members. We also recommend compiling test data sets early in the term to better integrate consistent testing into development. Finally, we recommend investigating alternative heat score calculations early on (i.e., regional variation, variable selection, PCA alternatives), to at least determine if pursuing them is feasible.

**NASA Earth Observation Data**

Aqua MODIS (<https://doi.org/10.5067/MODIS/MOD11A1.006>

* **Source**: downloaded from the Earth Engine public data archive
* **General Overview**: We did not encounter issues while working with this data. It must be noted, though, that we used Version 6, which is set to be replaced by Version 6.1. This updated version was not available in the GEE public data archive while we developed UHEAT 2.0, but future teams should consider updating the data themselves.
* **Acquisition**: Loading MOD11A1 V6 from the GEE public data archive into our GEE scripts was straightforward and we did not encounter any issues.
* **Processing/Analysis**: We did not encounter any issues while processing and analyzing the data.

Landsat 8 OLI/TIRS (<https://doi.org/10.5066/P975CC9B>)

* **Source**: downloaded from the Earth Engine public data archive
* **General Overview**: We did not encounter issues while working with this data.
* **Acquisition**: Loading Landsat 8 Collection 2 from the GEE public data archive into our GEE scripts was straightforward and we did not encounter any issues.
* **Processing/Analysis**: We did not encounter any issues while processing and analyzing the data.

**Culminating Research Questions Generated**

**Team-Identified Future Work:**

* Customize methodology by region, based on climate zones
* Include alternatives for PCA for better generalization
* Create guidelines for better PCA interpretation
* Provide options to include a variety of user-provided layers. This might include allowing the users to upload their own, customized set of variables, specific to their location.
* Improve GEE processing times