**NASA DEVELOP National Program**

**Fall 2015 Project Proposal**

**International Research Institute for Climate and Society**

**New Jersey Health and Air Quality**

Modeling of Near Surface Air Temperature Profile of Complex Urban Systems Based on Land Surface Properties

**Objective:**

To improve understanding of the effect of the Urban Heat Island (UHI) on the near surface air temperature where humans interact and how to mitigate these effects, develop a correlation identifying the role of surface features impact on near surface air temperature where humans in urban settings operate for new perspectives in urban design for developers and city management.

**Community Concern:**

There are a number of factors in urban environments that can put human health at risk, one of which is the increased heating of urban environments. With temperatures rising from global warming factors, the changing three-dimensional landscape and lack of vegetation can cause urban landscapes to trap larger amounts of heat. There is little understanding on the true effects of urban heat island on human health. Extra heat produced by urban ecosystems is captured by the urban heat island and could possibly contribute to global warming. This captured heat is then felt directly by those in large urban centers, effectively increasing the temperatures in their living environment. The increased temperatures, especially in summer months, can lead to an increase in heat related illnesses and death. There is a need for better understanding of the urban microclimate in order to improve quality of life for fast growing urban populations. Discovery of a correlation between heating microclimates within urban environments can lead to preventative strategies for heat related illnesses and deaths in places suffering from the urban heat island effect. This correlation can also reduce the energy demands of buildings because occupants will no longer feel an extreme heat stress due to the urban setting, and will therefore require less air conditioning to keep them at comfortable temperatures. This reduction on energy would help to control the amount of pollution a city produces.

In addition reducing the additional heat gathered within urban centers will reduce the stresses felt by surrounding wildlife. One such stress is one experienced by surrounding aquatic wildlife. The excess heat within the urban environments can cause storm runoff to also be at increased temperatures. These waters then enter the aquatic environment and cause changes in temperature that negatively impact the wildlife. As such, mitigating urban heat island not only improves quality of life for those living within a city but also for its surrounding areas.

**Partner Organizations:**

* Bureau of Environmental Surveillance and Policy, New York City Department of Health and Mental Hygiene (Partner, POC: Thomas Matte, Assistance Commissioner)
* We Act for Environmental Justice (Partner, POC: Aurash Khawarzad, Policy Coordinator)
* Columbia University, Mailman School of Public Health (Collaborator, POC: Patrick Kinney, Professor)
* Consortium for Climate Risk in the Urban Northeast (CCRUN), (Collaborator, POC: Brian Vant-Hull, Scientist)

The possible end users for this research are the increasing population in the cities, officials in the city management, urban developers as well as urban heat island modelers to factor in the vertical temperature fluctuations. The vertical temperature variation at micro scale has been the missing part of the puzzle which this study intends to bring that piece to the table. The result of this work can be used to aid in both the improvement and development of current and new urban environments. Business and communities can also benefit from the result of this study by understanding the effects of urban structures on the urban heat island, strategic implementation of methods of heat mitigation, which can be used in locations that are deemed to be at risk for high urban heat island effect in order to reduce the overall heating effect of cities.

**Decision Making Process:**

This project will be an extended work of the Surface-Atmospheric-Statistical (SAS) Model, used to study the impacts of land surface characteristics and climate change in the New York City UHI with its goal of anticipating climate adaptation and mitigation at the neighborhood scale and to prepare the health community for climate induced increases in heat wave frequency and intensity. The final product will help cities to strategize mitigation efforts in cooling the identified hot spots. The mitigation efforts include but not limited to planting trees and adding green areas such as community parks with water fountains. Department of Health (DOH) could use the product to issue targeted warning to the residents in the hotspots and help the neighborhood hospitals to allocate staff and resources before and during heat waves.

**Earth Observations:**

The following data sets will be used in this project.

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| --- | --- | --- |
| **Platform** | **Sensor** | **Geophysical Parameter** |
| Landsat 7 | ETM+  | Temperature |
| Landsat 8 | OLI/TIRS | Temperature |
| Terra & Aqua | MODIS | Temperature |
| Lidar |  | Temperature |

**NASA Earth Observations to be Highlighted:**

The project will focus on analyzing temperature derived from Landsat, Lidar with field measurements in New York. NASA datasets (Landsat and MODIS) and models (atmospheric correction models, land surface model) will form the mainframe of the project.

The primary Earth observation data set will be LandSat imagery, from which will be derived surface skin temperature (after split window atmospheric correction), vegetation (from atmospherically corrected NDVI), and albedo (via narrow to broadband conversion). The atmospheric correction in solar bands will be supplemented by MODIS aerosol retrievals, with aerosol transmission function lookup tables generated by the Santa Barbara DISTORT Atmospheric Radiative Transfer Model (SBDART) assuming an urban aerosol model.

Cloud clearing will be done by day, by an algorithm based on the MODIS aerosol algorithm cloud mask, derived from the observation that clouds are brighter and exhibit more variability than the surface. At night the same type of mask can be applied to thermal images, assuming that clouds are colder and vary more than the surface. A one pixel buffer zone is applied around any detected clouds.

Conversion of LandSat skin temperatures to air temperatures (described below) will also require building characteristics from the New York City MapPluto dataset, which provides basic building and plot dimensions. Ground truth and weather data local to the test area will be derived from SAS model described in the next section. The final product of this project will help the cities deal with heat waves and heat related mortalities during hot summer days.

**Models:**

Surface-Atmospheric-Statistical (SAS) Model (POC: Dr. Brian Vant-Hull, The NOAA Crest Institute of the City University of New York)

The SAS model was developed for neighborhood based temperature predictions using large-scale measurements with down-scaling techniques for both near-term and future climate projections. The SAS model was developed for New York City’s thermal variations based on the collected data from field campaigns by correlation of the surface parameters to the measured temperature anomalies and incorporation of meteorological parameters such as cloud cover, humidity, wind speed and direction, and climate data. The SAS model will be further expanded during this project by modeling the near surface air temperature profile of New York City based on its land surface properties and by finding a vertical correlation between surface and air temperature in the range of 0’-10’ in relation to different surface properties and structures.

**Decision Support Tools & Analyses:**

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| --- | --- | --- |
| **Proposed End Products** | **Decision to be Impacted** | **Current Partner Tool/Method** |
| Refined Methodology for Modeling UHI | Locations for strategic implementation of methods of heat mitigation | Brian Vant-Hull |
| Collecting measurements at different urban classes |  |
| Understanding the impact of different land surface types and meteorology on urban microclimate |  |

*Refined Methodology for Modeling UHI* - Businesses and communities will benefit from the results of this study by understanding the effects of urban structures on the urban heat island. Strategic implementation of methods of heat mitigation can be used in locations that are deemed to be at risk for high urban heat island effect in order to reduce the overall heating effect of cities.

The temperature profilers will be installed on various land surface types representing urban classes. The temperature profilers will be installed in the study locations for the period of one year to collect a comprehensive set of data cover diurnal and seasonal changes to study the temperature changes at different levels of vertical profile based on different land surface types. The collected data of each temperature profiler will be analyzed and used to correlate against its land surface type.

The temperature profile data will be used to correlate against the noted surface parameters to develop the Surface Temperature Profiler (STP) model. Also in addition to complete the STP model, detail building height and density can be obtained from LIDAR and remote sensing data to study the impact of the built environment on overall temperature. Then meteorological parameters will be added to the STP model to further understand the impact of different land surface types on urban microclimate and to build a Surface Atmospheric-Temperature Profile (SATP) model. Lastly, the remote sensing (Landsat) data will be added to the SATP model for land surface classification. The thermal bands of Landsat data will be used to calculate the land surface temperature and normalized vegetation index to measure the impact of vegetation on air temperature.

**Project Details:**

**National Application Area Addressed:** Health and Air Quality

**Source of Project Idea:** The idea for the project originated from work on understanding heat Island effect in New York.

**Study Location:** Glassboro, New Jersey

**Period being studied:** 2014-2015

**Advisor:** Dr. Pietro Ceccato (Research Scientist, Lead Environmental Monitoring Program)

**Participants Requested:** 1

**Project Timeline:** 1 Term: 2015 Fall

**Software & Scripting Requested:**

Excel and Stata – Statistical analysis tool for all of the products

ArcGIS – Map creation and vector manipulation

IRI Data Library – Data retrieval

ENVI – Image processing