**NASA DEVELOP National Program**

**North Carolina – NCEI**

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*Project Summary – Fall 2017*

**Northeast US Cross-Cutting**

*Developing Annual, Seasonal, and Monthly Temperature Indices over the Northeast United States to Represent Recent Temperature Trends using NASA and NOAA Datasets*

**VPS Title:** A Mountain of Data, Can We Climate? A Look into Temperature Trends in the Northeastern United States

**Project Team**

***Project Team*:**

Lilian Yang (Project Lead), Lilianlyang@Gmail.com

Laurel Mahoney

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***Advisors & Mentors*:**

Anthony Arguez (NOAA National Centers for Environmental Information)

Anand Inamdar (Cooperative Institute for Climate and Satellites – NC, NOAA National Centers for Environmental Information)

**Project Overview**

***Project Synopsis*:** The ten warmest years on record globally have all been recent with the oldest being

1998, making it difficult to differentiate the relative warmth of individual years from the overall trend. This project aims to devise a temperature score that places monthly, seasonal, or annual rankings of temperatures for the Northeast US Region defined by the National Climate Assessment in context, accounting for recent year-to-year fluctuations with respect to long term trends. The team will utilize NASA GISTemp, monthly nClimGrid, NASA’s Terra and Aqua Moderate Resolution Imaging Spectroradiometer (MODIS), and Climate Reference Network datasets to provide high-resolution temperature-based metrics to the energy and agriculture sectors.

***Abstract*:**

Since 1977, every year has been in the top ten warmest years on record when first ranked, reflecting the upward progression of annual global temperatures. However, some years within this time frame, such as 2012, are significantly cooler than surrounding years like 2010 or 2013. The variability of yearly rankings makes it difficult to differentiate the relative warmth or coolness of individual years from the secular trend. This project consists of two parts. For the first part, the team devised a simple algorithm to create monthly, seasonal, and annual temperature scores regionally, within the Northeast US, and globally for the time periods ranging from 1975 to 2016 and 1880 to 2016. The temperature score product allows users to differentiate the relative coolness or warmth of a particular year in regard to the warmth or coolness of surrounding years from the overall temperature rankings. The algorithm also provides context for the temperatures in the Northeast Region, accounting for recent year-to-year fluctuations with respect to longer term trends. The second part of this project utilizes daily Aqua and Terra MODIS LST (Land Surface Temperature) data to provide useful, high-resolution temperature-based metrics to the energy and agriculture industries. This consisted of producing heating, cooling and growing degree days (for energy and agriculture industries respectively) for the Northeast US using satellite derived data. The results from this study give climate services the ability to observe maps of monthly degree days at a higher spatial resolution than indices previously used, which are expected to be distributed to various clients by NOAA's Northeast Regional Climate Services Directorate and Climate Monitoring Branch.

**Keywords:** Climate monitoring, remote sensing, MODIS, temperature analysis, degree days, cross-cutting, land surface temperature

***National Application Area Addressed:*** Cross-Cutting

***Study Location:*** Northeastern United States: ME, VT, NH, MA, RI, DE, CT, DC, NY, PA, NJ, MD, WV

***Study Period:*** Temperature Scores: January 1975 – December 2016, Degree Days: August 2002 – September 2017

***Community Concern:***

* Climate monitoring agencies (e.g. NASA and NOAA) request better ways to differentiate the relative warmth or coolness of individual years, seasons, and months from the secular trend
* Climate monitoring agencies have a greater need for high quality climate data at a higher spatial resolution that is of ample period of record
* There is a need within industries and agencies to determine changes over time in climate data for analysis and assessment as well as practical usage (i.e., heating, cooling, and growing degree days) in determining how to respond to possible impacts of temperature trends and variability within these economic sectors:
  + Energy: This industry may benefit from using the heating and cooling degree day data to track energy demand trends at a higher resolution than current capabilities allow.
  + Agricultural: This industry may benefit from using the growing degree day data to help monitor the growing season at a higher resolution than current capabilities allow.

***Project Objectives:***

* Provide an easily digestible perspective of how temperature trends have changed over the last few decades to better prepare and plan for future temperatures
* Utilize information from a variety of global temperature and satellite datasets
* Develop a temperature index specific to the Northeastern United States with a higher spatial resolution than other indices currently being utilized
* Compute heating, cooling, and growing degree days using daily LST data and *in situ* temperature data
* Create a product for NOAA’s Regional Climate Services Director (Eastern Region) and NOAA’s National Centers for Environmental Information, Climate Monitoring Branch that has the potential to expand to a diverse set of end-users to utilize the data

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| NOAA, Regional Climate Services, Eastern Region | Ellen Mecray, Director | End User | Yes |
| NOAA, National Centers for Environmental Information, Climate Monitoring Branch | Karin Gleason, Meteorologist | End User | Yes |

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

NOAA’s Regional Climate Services Director (Eastern Region) Ellen Mecray currently uses *in situ* data from NOAA and the National Weather Service to analyze temperature anomalies to create a Quarterly Climate Outlook and Impacts report for the Eastern United States. This report is utilized by regional industries, municipalities, and planners. Similar to the previous partner, NOAA NCEI’s Climate Monitoring Branch calculates their own annual and monthly temperature rankings for reports utilized by national industries, municipalities, and planners based on *in situ* and modeled data with relatively long periods of record that vary based on available data across the nation. Our partners aim to improve and expand the current data extraction process by utilizing remote sensing data and NOAA & NASA satellites.

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

The trend-adjusted indices would provide end users with a differentiated perspective of recent temperature fluctuations. This is accomplished through identifying relative cold and warm months, seasons, and years amidst the secular trend, which could be used to help industries better prepare future operations. Both end users will be able to operationalize the indices in future Quarterly Impact and State of the Climate reports to better utilize data and have a greater ability to analyze temperature anomalies for every month, season, and year throughout the northeastern United States. The Climate Monitoring Branch will be able to take the project’s trend-adjusted temperature index methodology and potentially expand it to other regions of the United States.

The degree days provide the energy and agriculture sectors with higher spatial resolution temperature information to better discern spatial variability throughout the Northeast. The public utilities commissions in the energy sector would benefit from the heating and cooling degree day data because they will be able to better track energy demand across the region, which they can use the data to set customer rates. The farmers in the agriculture sector would also benefit from growing degree days to determine the expected seasonal growths patterns of particular crops and plan for the future seasons. The end users have the possibility of turning this process into a valuable tool, either through a secondary project or independent research.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Terra MODIS** | Land Surface Temperature | Satellite derived LST will be combined to develop a regional temperature index that is annual, seasonal and monthly, for years after 2002 with high spatial resolution. |
| **Aqua MODIS** | Land Surface Temperature | Satellite derived LST will be combined to develop a regional temperature index, both seasonal and monthly, for years after 2002 with high spatial resolution. |

***Ancillary Datasets:***

NASA GISS Surface Temperature Analysis (GISTEMP) - global temperature record

NOAA Gridded GHCN - Monthly Temperature Dataset (nClimGrid) - Northeast monthly dataset

Climate Reference Network (CRN) - Northeast monthly dataset to calibrate daily satellite-derived LST data

***Software & Scripting:***

IDL – data acquisition, processing, validation, and statistical analysis

Esri ArcGIS – geospatial analysis, map creation

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| Trend-Adjusted Temperature Index, Global & Northeast US Region  (1975 - 2016) | These temperature indices (for the Northeast US Region, states, climate divisions, grid cells, and pixels) will be used to provide a communication perspective of how recent years, seasons, and months compare to recent temperatures while taking the overall temperature trend into account. | NASA GISTemp and monthly nClimGrid datasets were used to create the indices using statistical analysis written in IDL | N/A |
| Maps of Degree Days, Northeast US Region  (2002 - 2017) | The degree day maps will be used by the energy and agriculture industries to better interpret the data involving the tracking of energy demand trends and monitoring growing seasons. | NASA Terra and Aqua MODIS satellite imagery will be used to derive daily LST max and min. Heating, cooling, and growing degree days were analyzed with an algorithm derived from Inamdar et al., (2008) and processed with the Climate Reference Network database to calibrate the data, adjusting LST temperatures to measure as if recorded 2 meters above the surface for a better representation of air temperatures. | N/A |

**Project Handoff Package**

**Transition Plan:**

The team’s science advisor, Anthony Arguez, will maintain and distribute the results and methodology of the project after further additional research, building upon the project. This includes temperature score graphs, processing algorithms and degree day visuals.

**Team POC:** Lilian Yang, Lilianlyang@Gmail.com

**Partner POC:** Karin Gleason, Karin.l.gleason@Noaa.gov

**Handoff Package:**

* Temperature Scores graphs
* Visuals of growing, heating, and cooling degree days
* Technical Report outlining methodology and results