**Alaska Disasters**

*Evaluating the Atmosphere-Land Exchange Inverse Evaporative Stress Index for the Alaskan Environment to Determine Wildfire Likelihood*

**VPS Title:** To Burn or Not to Burn: Determining the Likelihood of Alaskan Wildfires

**Project Team**

***Project Team:***

Christine Evans (Project Lead)

Ryan Marshman

Brianna Santallana

***Advisors & Mentors:***

Dr. Jeffrey Luvall (NASA Marshall Space Flight Center)

Dr. Robert Griffin (University of Alabama in Huntsville)

Helen Baldwin (University of Alabama in Huntsville)

Maggi Klug (University of Alabama in Huntsville)

Leigh Sinclair (University of Alabama in Huntsville, Information Technology and Systems Center)

**Project Overview**

***Project Synopsis:*** Recent changes in Alaska’s climate have led to longer wildfire seasons. This project evaluated the Atmosphere-Land Exchange Inverse (ALEXI) Evaporative Stress Index (ESI) product, a tool that provides valuable information about vegetation that may be experiencing water stress. Using imagery from Aqua and Terra Moderate Resolution Imaging Spectroradiometer (MODIS), Suomi National Polar-orbiting Partnership (NPP) Visible Infrared Imaging Radiometer Suite (VIIRS), and National Oceanic and Atmospheric Administration-20 (NOAA-20) VIIRS, the team assessed pre- and post-fire images and various vegetation monitoring indices and compared them with the ALEXI ESI product. This analysis determined the usefulness of the ALEXI ESI product in conjunction with the partner’s current decision-making processes.

***Abstract:***

Alaska’s wildfire season has progressively increased in duration and intensity over the last decade, leaving forested areas subject to devastating destruction. These increases in wildfire occurrence are due to gradual rises in land surface temperature, decreases in precipitation levels, and lack of soil moisture throughout the state. This causes concerns for air pollution as well as the destruction of homes and wildlife habitats within or around forests. The Alaska Disasters project team used remotely sensed data obtained from Aqua Moderate Resolution Imaging Spectroradiometer (MODIS), Terra MODIS, Suomi National Polar-orbiting Partnership (NPP) Visible Infrared Imaging Radiometer Suite (VIIRS), and National Oceanic and Atmospheric Administration-20 (NOAA-20) VIIRS from April through September of 2004, 2005, 2015, and 2018 to observe vegetation and moisture changes in affected areas before and after wildfires. Using the Atmosphere-Land Exchange Inverse (ALEXI) Evaporative Stress Index (ESI) generated by the NASA Short-term Prediction Research and Transition Center (SPoRT), the team determined if ALEXI ESI provided lead time on the evaluation of vegetation stress. Team members completed this analysis by using Pearson’s correlation coefficient to determine the correlation between the ALEXI ESI output and various vegetation monitoring indices. The team then compared the utility of the ALEXI ESI to the Canadian Fire Weather Index (FWI) to evaluate the benefit of using ALEXI ESI in conjunction with current decision-making processes in Alaska. With these results, the Alaska Interagency Coordination Center (AICC) and Alaska Fire Science Consortium (AFSC) are able to make better-informed decisions when determining fire management techniques and assessing the risk of future wildfire outbreaks.

**Keywords:**

Terra MODIS, Aqua MODIS, Suomi NPP VIIRS, NOAA-20 VIIRS, remote sensing, vegetation, wildfires, water stress

***National Application Area Addressed:*** Disasters

***Study Location:*** AK

***Study Period:*** April 2004 to September 2018

***Community Concerns:***

* It has warmed six degrees Fahrenheit during the winter months over the last 60 years. Environmental changes like this are increasing the quantity and intensity of wildfires experienced by the state of Alaska.
* Wildfires release harmful pollutants into the atmosphere and also destroy homes and wildlife habitats, averaging 1.2 million acres burned each year over the past 50 years.
* Areas experiencing vegetation stress are more susceptible to these wildfires and can act as fuel for the wildfires.

***Project Objectives:***

* Utilize NASA Earth observations to introduce improved methods of evaluating vegetation stress and determining wildfire likelihood
* Evaluate and calibrate the ALEXI ESI product when applied to the high latitudes of the Alaskan environment by determining appropriate parameters that consider the low solar azimuth angle
* Identify areas throughout Alaska that are prone to drought and wildfires
* Communicate project results using an ArcGIS Online Story Map to display the benefit of using NASA Earth observations for wildfire management to future partners and the public

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC** | **Partner Type** | **Boundary Org?** |
| **Alaska Interagency Coordination Center** | Heidi Strader, Predictive Services Fire Weather Program Manager | End User | Yes |
| **Alaska Fire Science Consortium** | Alison York, Research Scientist | Collaborator | Yes |
| **NASA Short-term Prediction Research and Transition Center (SPoRT)** | Chris Hain, Research Scientist; Chris Schultz, Research Scientist | Collaborator | No |

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

The AICC is the Geographic Area Coordination Center for Alaska. The AICC’s mission is to serve as the focal point of logistics support, tactical resource coordination, and predictive services for wildfire mitigation. The AICC works alongside the AFSC to strengthen the link between fire science research and field applications. The interagency fire management plan details the state’s wildfire policies and procedures. There are four wildland fire management options: Critical, Full, Modified, and Limited. These categorizations for management options prioritize populated areas for initial response to protect human life. In order to assist with the fire management decision process, the AICC uses Esri ArcGIS to create maps of Alaska that identify natural and anthropogenic fires, lightning activity, and historical wildfire trends. The AICC currently uses the Canadian Fire Weather Index (FWI) to provide numeric ratings of the potential for wildfires to occur. The AICC also uses VIIRS and MODIS products to identify where fires start and spread.

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

This project provided the AICC with resources and methodologies that will enable them to enhance their early warning system for vegetation stress and wildfire activity. The ALEXI ESI Comparative Analysis end product can help aid decision makers in the selection of specified burn areas and allocation of wildfire mitigation resources in Alaska. The AICC will be able to evaluate the benefits of using the ALEXI ESI in comparison to the FWI. The ArcGIS Online Story Map highlights the benefits of using the ALEXI ESI product.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Terra MODIS** | Land surface temperature (LST), Normalized Difference Vegetation Index (NDVI), surface reflectance | The team used pre- and post-fire imagery to identify wildfire extent for calibrating the ALEXI ESI product for the high latitudes of Alaska. This imagery was also compared to MODIS NDVI products to determine a spatial correlation between brown vegetation and vegetation water stress. |
| **Aqua MODIS** | LST, NDVI | The team used pre- and post-fire imagery to identify wildfire extent for calibrating the ALEXI ESI product for the high latitudes of Alaska. This imagery was also compared to MODIS NDVI products to determine a spatial correlation between brown vegetation and vegetation water stress. |
| **Suomi NPP VIIRS** | LST | The team used pre- and post-fire imagery to identify wildfire extent for calibrating the ALEXI ESI product for the high latitudes of Alaska. |
| **NOAA-20 VIIRS** | LST | The team used pre- and post-fire imagery to identify wildfire extent for calibrating the ALEXI ESI product for the high latitudes of Alaska. |

***Ancillary Datasets:***

* NASA Arctic-Boreal Vulnerability Experiment (ABoVE) Wildfire Date of Burning within Fire Scars across Alaska and Canada, 2001 to 2015 – Identify wildfires through 2015
* United States Department of Agriculture US Drought Monitor – Identify areas that are currently in drought
* Canadian Fire Weather Indices (FWI) – Determine wildfire intensity
* United States Department of the Interior, LANDFIRE, Landscape Fire and Resource Management Planning Tool – Identify vegetation and fuel data
* NASA SPoRT Atmosphere-Land Exchange Inverse (ALEXI) Evaporative Stress Index (ESI) – Determine areas experiencing vegetation water stress

***Software & Scripting:***

* Esri ArcMap – Raster manipulation and analysis, imagery processing, and map production

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **ALEXI ESI Comparative Analysis** | Aqua MODIS  Terra MODIS  Suomi NPP VIIRS  NOAA-20 VIIRS | Land cover, vegetation, and surface meteorological measurements can assist decision-makers when assessing the likelihood of fire occurrence, as the current parameters may need to be adjusted for the high latitudes of Alaska. | N/A |
| **Canadian Fire Weather Indices Comparative Analysis** | Aqua MODIS  Terra MODIS  Suomi NPP VIIRS  NOAA-20 VIIRS | The team evaluated the benefit of using ALEXI ESI over the current methods of predicting the probability of wildfires to allow the partners to assess which indices will add value to their decision-making processes pertaining to prescribed burns. | N/A |
| **ArcGIS Online Story**  **Map** | Aqua MODIS  Terra MODIS  Suomi NPP VIIRS  NOAA-20 VIIRS | The interactive map provides the partners with an outreach tool to highlight the ALEXI ESI product and its applications. | N/A |

**Project Handoff Package**

*Transition Plan:* The team provided all end products and deliverables to the project partners via Google Drive during the final week of the term. A handoff presentation was conducted via Google Hangouts. During this meeting, the team presented the project results to the partners and answered questions.

**Team POC:** Christine Evans, cae0004@uah.edu

**Partner POC:** Heidi Strader, hstrader@blm.gov

Alison York, ayork@alaska.edu

Chris Hain, christopher.hain@nasa.gov

Chris Schultz, christopher.j.schultz@nasa.gov

**Handoff Package:**

* Project Summary
* Technical Paper
* Poster
* Presentation
* Project one-pager
* ALEXI ESI Comparative Analysis
* Canadian Fire Weather Indices Comparative Analysis
* ArcGIS Online Story Map

**References:**

AK Division of Forestry Information Office.(2015, July). *Alaska wildland fire guide*. Retrieved from http://forestry.alaska.gov/Assets/pdfs/fire/assignments/2016%20Alaska%20Wildland%20Fire%20Guide.pdf

Anderson, M. C., Norman, J. M., Mecikalski, J. R., Otkin, J. A., & Kustas, W. P. (2007). A climatological study of evapotranspiration and moisture stress across the continental United States based on thermal remote sensing: 1. Model formulation. *Journal of Geophysical Research, 112*, D10117. doi:10.1029/2006jd007506

Calef, M. P., Varvak, A., & Mcguire, A. D. (2017). Differences in human versus lightning fires between urban and rural areas of the boreal forest in interior Alaska. *Forests, 8*(11), 422. doi:10.3390/f8110422

Hain, C. R., & Anderson, M. C. (2017). Estimating morning change in land surface temperature from MODIS day/night observations: Applications for surface energy balance modeling. *Geophysical Research Letters, 44*(19), 9723-9733. doi:10.1002/2017gl074952

Otkin, J. A., Anderson, M. C., Hain, C., Mladenova, I. E., Basara, J. B., & Svoboda, M. (2013). Examining rapid onset drought development using the thermal infrared–based evaporative stress index. *Journal of Hydrometeorology, 14*(4), 1057-1074. doi:10.1175/jhm-d-12-0144.1

United States Environmental Protection Agency. (2016, August). *What climate change means for Alaska*. Retrieved from https://19january2017snapshot.epa.gov/sites/production/files/2016-09/documents/climate-change-ak.pdf