**NASA DEVELOP National Program**

**2019 Fall Project Proposal**

**Idaho – Pocatello**

**Great Basin Ecological Forecasting:**

*Integrating NASA Earth Observations into Live Fuel Moisture Models to Improve Wildfire Timing and Severity Forecasting*

**Project Overview**

***Project Synopsis*:** This project will use Landsat and Sentinel satellite series, MODIS, VIIRS, SMAP, and ECOSTRESS as inputs to model Live Fuel Moisture (LFM) in order to increase spatial coverage for partner agencies to make informed decisions regarding wildfire resource planning. The NASA DEVELOP team will model LFM using satellite data, which will increase spatial coverage from only 155 *in situ* observation points to complete coverage across the 260,000 mi2 eastern Great Basin of Idaho and Utah. Improved LFM estimates and forecasts will streamline resource allocation during the fire season and improve emergency response. DEVELOP will include remotely sensed data, such as NDVI/MSAVI2, Tasseled Cap, soil moisture, evapotranspiration, and topographic variables, into a machine learning modeling techniques Classification Tree Analysis and Support Vector Model to create a predictive model of LFM. The model will be tested against historical data obtained from partners at the Bureau of Land Management (BLM) and Great Basin Coordination Center (GACC). Modeled data will provide complete coverage across the eastern Great Basin and be leveraged to improve short-term forecasts, which land managers routinely use throughout the fire season.

***Community Concern:*** Whether caused by lightning strikes or other ignition sources, wildfires have increased in both frequency and size across the western U.S. since the 1950’s (Davis and Weber 2018). As a result, wildfires cost billions of dollars in suppression and rehabilitation (Toombs et al., 2018). A key component to fire management is measuring LFM, which is a measure of the amount of moisture in biomass/fuel sources. LFM can be help determine how susceptible an area is to wildfire as wet vegetation requires more energy to combust. Partners are interested in incorporating NASA Earth observations into the predictive modeling of LFM. Better fuels management is integral to reduce wildfire hazards to human communities and mitigate ecological impacts of climate change.

***Source of Project Idea:*** The Idaho DEVELOP team has seasonal meetings with local partners to discuss their interests, and this idea has come up frequently over the past two years. Previous DEVELOP research into soil moisture and evapotranspiration of semiarid environments suggests a study on LFM is now feasible and a good way to bring several projects together.

***National Application Areas Addressed:*** Ecological Forecasting

***Study Location:*** Great Basin: UT, NV, ID, OR

***Study Period:*** 2001 – 2019 (May – October); Forecasting to 2020

***Advisor:*** Keith Weber (Idaho State University, GIS TReC)

**Partner Overview**

***Partner Organizations:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| **Idaho Department of Fish and Game, Southeast Regional Office** | Scott Bergen, Senior Wildlife Research Biologist | End User | No |
| **Bureau of Land Management, Upper Snake Field Office** | Ben Dyer, Fire Ecologist; Michelle Mavor, Fire Ecologist | End User | No |
| **NOAA, National Weather Service** | Mike Huston, Meteorologist, Science and Operations | End User | No |
| **Great Basin Coordination Center** | Nanette Hosenfeld, Meteorologist | Collaborator | Yes |

***End-User Overview***

***End User’s Current Decision-Making Process:***Land managers currently rely on 155 field collection sites to estimate LFM levels for the entire eastern Great Basin region, which occupies several states and nearly 160,000 km2. This equates to approximately one observation site for every 1,000 km2. Due to the sheer size of the area and its variability in topography, soil associations, and vegetation type, applying earth observing satellite imagery to improve estimates of LFM will result in better informed decisions and a more effective use of agency resources.

***End User’s Capacity to Use NASA Earth Observations:***

*Bureau of Land Management, Upper Snake Field Office* – The Upper Snake Field Office has worked in close collaboration with the GIS TReC at Idaho State University since 1999 on a variety of rangeland research projects that use NASA Earth observations, with many focusing on the effect of wildfire on rangeland health. Beginning with DEVELOP’s Idaho Disasters project in the fall term of 2014, the understanding and use of remotely sensed data for specific applications has continued to grow.

*Idaho Department of Fish and Game, Southeast Regional Office* – The Idaho Department of Fish and Gamehas research and management groups that currently use satellite-derived imagery (e.g. MODIS, Landsat) for natural resource management throughout the state of Idaho. Satellite data are used to meet some specific informational needs, such as annual vegetation production, invasive species detection, and fire recovery estimation.

*NOAA, National Weather Service –* The National Weather Service (NWS) is interested in outputs from this project and believe they may be able to be of use for integrating weather and climate data into the project. They routinely use LFM as input in their forecasting and a factor when issuing fire weather warnings due to predicted, incoming thunderstorm events. Our contact at the NWS has some familiarity with GIS but has not used remote sensing for wildfire applications.

***Collaborator & Boundary Organization Overview***

***Boundary Support:***

*Great Basin Coordination Center* – The Great Basin Coordination Center maintains partnerships with agencies that oversee the Great Basin eco-region. Our partner currently manages a database of all LFM measurements and makes use of Earth observation data for other decision-making such as pre-emptively staging fire suppression resources if LFM and fire weather reports indicate the potential for numerous fire starts in the near term. This agency will enable coordination and collaboration between various other local and federal partners, both for distribution of data and decision-making.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The team will communicate with partners and collaborators biweekly

via teleconference meetings. The Center Lead and Project Lead will be the primary points of contact with the partner organizations.

***Transition Plan*:** At the end of the term, the team will host a web-based seminar to disseminate project results. A handoff package will be sent to the end users via email. Within the handoff package, the end-user will receive a Live Fuel Moisture Model and relevant project deliverables, including the project’s Technical Report, and Video Tutorial. There is no software release required for this project.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameter(s)** | **Use** |
| **Terra MODIS** | Land Surface Temperature (LST), Evapotranspiration(ET), NDVI, Tasseled Cap (brightness, greenness, and wetness) | MOD16 evapotranspiration (ET) products will be used to approximate land surface ET and assist in estimates of water/energy fluxes in the study area. Terra MODIS NDVI data will be used for correlation analysis. |
| **Aqua MODIS** | LST | LST from Aqua MODIS will be used as an input in the Climate Engine SSEBop ET model. |
| **Terra ASTER** | LST, Surface Reflectance, Elevation | Terra ASTER products will be used to approximate LST and surface reflectance in the study area. These data will be used in the METRIC algorithm. |
| **NOAA-20 VIIRS** | LST, NDVI, Tasseled Cap(brightness, greenness, and wetness) | VIIRS derived GIS products will be fed into the machine learning model to determine best-fit parameters for the model. |
| **ECOSTRESS** | Evapotranspiration, Plant Temperature | ECOSTRESS ET products will be a factor in determining LFM based on ET role in the water cycle. |
| **SMAP/Sentinel-1 enhanced** | Soil Moisture | SMAP/Sentinel-1 enhanced L2 products will be used to determine soil moisture content at 1 km. |
| **Landsat 8 OLI** | Surface Albedo, NDVI | Landsat 8 OLI data will be used to monitor vegetation health as well as provide energy parameters that will be used in applied models. |
| **Landsat 8 TIRS** | LST | Landsat 8 TIRS data will be used to provide energy parameters that will be used in applied models. |

***Ancillary Datasets:***

* Great Basin Coordination Center LFM *in situ* Database – historical LFM data to validate model outputs from our LFM prediction
* National Land Cover Database 2016 – used for calibrating vegetation land cover and as well as identifying and masking out impervious surfaces
* Landfire Land Cover datasets 2018- used to define existing vegetation type (EVT) and existing vegetation cover (EVC) to potentially improve LFM modeling by clustering vegetation types and modeling within each type.
* Modern-Era Retrospective Analysis for Research and Application (MERRA) – daily average precipitation, temperature, atmospheric water vapor, and atmospheric radiation. These data may be needed to help validate the LFM or component soil moisture?ET models.

***Modeling:***

* Classification Tree Analysis (POC: Keith Weber, GIS TReC)
* Support Vector Machines (POC: Keith Weber, GIS TReC)

***Software & Scripting:***

* Esri ArcGIS Pro – raster manipulation and analysis, map creation
* TerrSet – Raster processing and spectral classification and land cover change modeling
* Google Earth Engine Application Programming Interface – time series data sampling and automation
* Python – ArcPy scripting, raster analysis
* R – statistical analysis, regression, variable selection
* Inkscape – graphic creation, map manipulation

**Decision Support Tool & End Product Overview**

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **Live Fuel Moisture and Forecasting Model** | LFM models will allow partners to make better informed decisions regarding impending fire events and streamline resource allocation in advance of wildfires. | This model will integrate elevation, aspect, soil moisture, evapotranspiration, vegetation type, and vegetation indices along with in situ LFM measurements to model LFM across the eastern Great Basin.  Forecasting future LFM can be accomplished by foreward projecting near term (1-2 weeks) using past trends. This will be the focus of term 2 | I |
| **Developing Reliable Live Fuel Moisture Datasets: A Tutorial** | The tutorial will enable end users to replicate this study in the future. | This tutorial will describe the steps to generate the model described above. | I |

***End-User Benefit*:**

LFM is used by land management agencies for resource allocation in advance of wildfire events. LFM estimates can be used to predict how much energy is required to combust, how hot (intense) an area will burn, and how long it will burn. Creating a model that allows partners to use remotely sensed data will provide better estimate of LFM across the entire extent of the eastern Great Basin, streamline the decision-making process, and if demonstrated to be successful, find application across the remaining eight Geographic Area Coordination Centers (GACC) across the nation. While *in situ* measurements will never be eliminated, these modeling efforts can effectively utilize field measurements to produce a more spatially explicitly model of LFM and find use for many years to come.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 2 Terms: Fall 2019 to Spring 2020

***Multi-Term Objectives:***

* **Term 1 (Proposed Term):** 2019 Fall – Great Basin Ecological Forecasting I
  + This will be the feasibility study, meant to determine if live fuel moisture can be determined from existing spatial datasets. The team will gather data and determine what data inputs best match *in situ* datasets. The research done for this study area in the Eastern section of the Great Basin focuses initially on areas within this section of the Great Basin, but can eventually be applied to the entire Great Basin and potentially other GACC’s across the nation. End products from this term will be useful on their own and validated using the LFM observations database using boot strap/Monte Carlo simulation.
* **Term 2:** 2020 Spring – Great Basin Ecological Forecasting II
  + The second term of this project will be focused on building upon previous work and focusing upon projections and forecasting Outputs from these LFM models will be ready for use by land managers during the fire 2020 season. Final handoff will occur in person at closeout, with methods outlined in tutorials, and export approved technical report turned over to the partner. Since this will be a culmination, a project video will be required which will outline the needs of the partner and tell the story of the project.

***Related DEVELOP Work:***

2019 Spring (ID) – Argentina Water Resources: Evaluating Evapotranspiration in Humid Subtropical and Semi-Arid Climates with NASA Earth Observations to Understand Water Balance in Paraná and the Patagonian Steppe of Argentina

2018 Fall (ID) – Idaho Water Resources II: Evaluating Evapotranspiration and Water Budget Components in Semi-Arid Sagebrush Steppe

2018 Summer (ID) – Idaho Water Resources: Estimating Soil Moisture in Semiarid Sagebrush Steppe utilizing NASA Satellite Imagery

**Notes & References:**

***Notes*:** These projects should come across as: first term feasibility/initial validation and second term forecasting and final validation. The lessons learned about the water cycle from Idaho Water Resources I and II projects for rangelands within Idaho’s sagebrush steppe, and modeling lessons learned from the Argentina Water Resources project, will be incorporated into this project to maximize a successful outcome.

***References:***

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