**NASA DEVELOP National Program**

**2019 Spring Project Proposal**

**Idaho – Pocatello**

**Argentina Water Resources**

*Measuring Soil Moisture and Evapotranspiration in Semi-arid Climates with NASA Earth Observations to Understand Water Balance in the Patagonian Steppe of Argentina*

**Project Overview**

***Project Synopsis*:** This project will use Landsat 5 TM, Landsat 8 OLI, SMAP, Aqua MODIS, Terra MODIS, SRTM, Sentinel-2 MSI, Sentinel-1 C-SAR, and ECOSTRESS to derive evapotranspiration (ET) and soil moisture models in the semi-arid Patagonian Steppe of Argentina. Dr. Pablo G. Aceñolaza of the Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) de Argentina, translated as the National Scientific and Technical Research Council of Argentina, is interested in using methods developed for the Snake River Plane, a semi-arid sagebrush steppe environment of western Idaho, to better understand water availability and transport in Argentina. Specifically, Dr. Aceñolaza is interested in comparing the team’s proposed ET and soil moisture models with his existing regional models. The collaboration between the Idaho – Pocatello node and CONICET will provide a critical next step in the validation of both these products and will allow the determination of which models correlate best for use in areas that have limited *in situ* measurement availability.

***Community Concern:*** The National Scientific and Technical Research Council of Argentina is tasked with the promotion of science and technology within Argentina. Currently, models exist to measure ET and soil moisture for agricultural lands, but many are generally untested for use in natural environments. These models tend to significantly overestimate ET fluxes and soil moisture values, especially across heterogeneous natural systems. Providing researchers and land and resource managers with a calibrated methodology for effectively modeling ET rates and soil moisture utilizing NASA Earth observations will allow for the implementation of more targeted and effective water conservation strategies.

***Source of Project Idea:*** Dr. Pablo G. Aceñolaza, was introduced to the DEVELOP National Program through Keith Weber (Idaho State University GIS TReC) in the spring of 2018 during a project idea planning meeting. Recognizing that the geospatial capacity necessary to complete a portion of one Dr. Aceñolaza’s current projects was not currently available in his laboratory, Dr. Aceñolaza approached Idaho – Pocatello NASA DEVELOP staff to learn more about employing SEBAL and SSEBOP ET and soil moisture modeling approaches via NASA Earth observations and to discuss project feasibility.

***National Application Area Addressed:*** Water Resources

***Study Location:*** Patagonian Steppe, Argentina

***Study Period:*** January 2000 – January 2018

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

**Partner Overview**

***Partner Organization:***

|  |  |  |  |
| --- | --- | --- | --- |
| **Organization** | **POC (Name, Position/Title)** | **Partner Type** | **Boundary Org?** |
| National Scientific and Technical Research Council (Argentina) | Dr. Pablo G. Aceñolaza, Researcher; Gavilan Sebastian Anibal, Researcher | End User | Yes |

***End-User Overview***

***End User’s Current Decision-Making Process:***Currently, rural regions of the Patagonian Steppe often do not incorporate empirical measurements such as soil moisture, ET, erosion rates, and land use and change into management decisions. CONICET is actively working to promote the use of derived measurements and calculations via model outputs into these future decisions. From that, CONICET has developed regional ET and soil moisture models for Patagonian Steppe; however, these models need to be further evaluated and compared with similar Earth observation-derived spatial models to improve the reliability of the model outputs.

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

*National Scientific and Technical Research Council (Argentina)* – This national organization encompasses a broad array of academic researchers and policy makers tasked with searching for solutions to technical, land, and resource management problems that affect every day Argentinians. Our specific point of contact has limited experience using NASA Earth observations in their research. This project will further build the capacity for the partner, as well as the National Scientific and Technical Research Council organization as a whole, by showcasing the use and applications of NASA Earth observations.

***Boundary Organization Overview***

***Dissemination by Boundary Organizations*:**

*National Scientific and Technical Research Council (Argentina)* – The national organization’s (CONICET) principal mission is to advance the implementation of rigorous scientific and technical practices across all fields of knowledge within the country of Argentina. Dr. Pablo G. Aceñolaza will work directly with local partners and fellow agencies to disseminate the end products generated from the NASA DEVELOP project.

***Project Communication & Transition Overview***

***In-Term Communication Plan*:** The team will communicate with partners at the National Scientific and Technical Research Council on a biweekly basis via video conference and phone conversations. The Center Lead and Project Lead of this project will be the primary points of contact with the partner organization.

***Transition Plan*:** At the end of the term, the team will host a video seminar to disseminate project results and hand off decision support tools via NASA LFT. A short training workshop on the use of the data and a tutorial will follow the seminar.

**Earth Observations Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 5 TM** | Surface reflectance, Normalized Difference Vegetation Index, Normalized Difference Moisture Index, tasseled cap brightness, greenness, and wetness | This dataset will provide the temporal (16 days) and spatial (30 m2) resolution needed for environmental variables employed to calculate ET using the SEBAL and/or SSEBOP models. |
| **Landsat 8 OLI** | Surface reflectance, Normalized Difference Vegetation Index, Normalized Difference Moisture Index, tasseled cap brightness, greenness, and wetness | This dataset will provide the temporal (16 days) and spatial (30 m2) resolution needed for environmental variables employed to calculate ET using the SEBAL and/or SSEBOP models. |
| **Sentinel-1 C-SAR** | Synthetic aperture radar  backscatter values, surface roughness | This dataset will provide the temporal (6 days) resolution needed for environmental variables employed to calculate ET using the SEBAL and/or SSEBOP models. |
| **Sentinel-2 MSI** | Surface reflectance, Normalized Difference Vegetation Index, normalized difference Moisture Index | This dataset will provide the spatial (10-60 m2) resolution needed for environmental variables employed to calculate ET using the SEBAL and/or SSEBOP models. |
| **SMAP** | Soil moisture (Radar, Radiometer, Surface and Root Zone), Carbon net ecosystem exchange (NEE) | SMAP (3-9 km) data will be used as an input to create a high-quality soil moisture dataset. |
| **GPM GMI** | Precipitation | GPM GMI products will be used to approximate  near-real-time precipitation intensity. |
| **SMAP/Sentinel-1 enhanced** | Soil moisture | SMAP/Sentinel-1 enhanced L2 products will be used to determine soil moisture content at 1km. |
| **Aqua MODIS** | Evapotranspiration (ET), Normalized Difference Vegetation Index (NDVI) | MOD16 ET products will be used to approximate land surface ET and assist in estimates of water/energy fluxes in the study area. MODIS NDVI will be used for correlation analysis. |
| **Terra MODIS** | Evapotranspiration (ET), Normalized Difference Vegetation Index (NDVI) | MOD16 ET products will be used to approximate land surface ET and assist in estimates of water/energy fluxes in the study area. MODIS NDVI will be used for correlation analysis. |
| **ISS ECOSTRESS** | Evapotranspiration (ET), land surface temperature, Evaporative Stress Index | ECOSTRESS products will be used to compare as an ET product, with applications of other products potentially being investigated. |
| **SRTM** | Elevation, slope, aspect, Compound Topographic Index | This dataset will be used to derive topographic indices. |

***Ancillary Datasets:***

CONICET *in situ* dataset – Carbon dioxide, water vapor, and energy measurements utilized in soil moisture and ET modeling efforts

FLUXNET– Carbon dioxide, water vapor, and energy measurements utilized in soil moisture and ET modeling efforts

Joint Research Centre Global Surface Water Mapping Layers, v1.0 – Surface water datasets utilized for model validation

Modern-Era Retrospective Analysis for Research and Applications Reanalysis Model (MERRA-2) – Historical

climate data utilized in soil moisture and ET modeling efforts

NCEP-DOE Atmospheric Model Intercomparison Project (AMIP-II) – Carbon dioxide, water vapor, and

energy measurements utilized in soil moisture and ET modeling efforts

North American Land Data Assimilation System (NLDAS-2) Mosaic Precipitation, Soils, Surface Water –

Environmental predictor variables data

FLUXNET – Carbon dioxide, water vapor, and energy measurements utilized in soil moisture and ET modeling efforts

***Modeling:***

Penman-Monteith MOD16 (PM-MOD16) algorithm (POC: Dr. Kenton Ross, NASA Langley Research Center)

***Software & Scripting:***

Esri ArcGIS – Image processing and end product generation

ENVI/IDL – Image calibration and LandTrendr coding

R – Statistical analysis and raster processing

Google Earth Engine API – Large-scale image analysis

**Decision Support Tool & End Product Overview**

***End Products:***

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| --- | --- | --- | --- |
| **End Product** | **Partner Use** | **Datasets & Analyses** | **Software Release Category** |
| **ET and Soil Moisture Modeling ArcGIS Toolbox** | Partners can use this ArcGIS tool to translate raw satellite imagery into useful soil moisture and ET model calculations. | An ArcGIS Toolbox utilizing derived indices from Landsat 5 TM, Landsat 8 OLI, SMAP, Aqua MODIS, Terra MODIS, SRTM, Sentinel-2 MSI, Sentinel-1 C-SAR, GPM GMI and ECOSTRESS sensors as well as FLUXNET, MERRA-2, and NCEP datasets will be employed to calculate soil moisture and ET via the SEBAL and/or SSEBOP methods. | I |
| **ET Model Map and Model Output Comparison: Patagonian Steppe of Argentina and Snake River Plane** | This is a map and model comparison between ET models developed in the Patagonian Steppe of Argentina and Snake River Plane that provides the partner with a more robust understanding of the model performance across geographic space. | Indices derived from Landsat 5 TM, Landsat 8 OLI, SMAP, Aqua MODIS, Terra MODIS, SRTM, Sentinel-2 MSI, Sentinel-1 C-SAR, GPM GMI and ECOSTRESS sensors as well as FLUXNET, MERRA-2, and NCEP datasets will be employed to calculate and compare soil moisture and ET via the SEBAL and/or SSEBOP methods | I |
| **ET and Soil Moisture Modeling and Calibration Tutorial** | The tutorial will enable end users to replicate this study while also providing a statistical methodology for calibrating the tool for multiple environments. | The tutorial will cover data collection and processing, fitting statistical models to the data, and interpretation of model output. | N/A |

***End-User Benefit*:** This project will rapidly allow the National Scientific and Technical Research Council to repeat the modeling processes and evaluate the soil moisture and ET model performance between both the Patagonian Steppe of Argentina and the Snake River Plane, resulting in a potentially more fine-tuned ET model. The project also enables future analysis across larger scales that would not be possible without utilizing NASA Earth observations. End products will be potentially integrated into the National Scientific and Technical Research Council decision-making and conservation processes.

**Project Timeline & Previous Related Work**

***Project Timeline:*** 1 Term: 2019 Spring

***Related DEVELOP Work:***

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

2018 Fall (ID) – Idaho Water Resources II: Approximating Evapotranspiration in Semi-Arid Sagebrush Steppe to Improve Water Balance Calculations in Southeast Idaho

2016 Summer (JPL) – Costa Rica Agriculture: Applying ECOSTRESS Diurnal Cycle Land Surface Temperature and Evapotranspiration to Agricultural Soil and Water Management

2017 Spring (JPL) – Arizona Agriculture: Demonstrating the Potential Applications of ECOSTRESS Evapotranspiration Products in Plant Phenotyping and Predicting Patterns in Global Species Richness

**Notes & References:**

***Notes*:** Both Terra MODIS and Aqua MODIS will be employed to calculate ET in the Patagonia sensor if the SEBAL and/or SSEBOP methods, using the Landsat series, are not effective. ECOSTRESS will be investigated during the course of the project, but will most likely not be utilized for final calculations. The Sentinel series is included as a final avenue to investigate as an option to potentially improve the spatial resolution; however, this will also most likely not be utilized for final calculations due to the 10-week timeframe.

***References:***

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