**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*

**VPS Title:** From the Ground to the Sky: Evaluating Evapotranspiration Models

**Project Team**

***Project Team:***

Carl Jurkowski (Project Lead)

Ahmed Baqai

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A. R. Williams

***Advisors & Mentors:***

Keith T. Weber (Idaho State University, GIS TReC)

***Past or Other Contributors:***

Ian Lauer

Carolyn Macek

Francis Zurek

**Project Overview**

***Project Synopsis:*** We evaluated Evapotranspiration (ET) models for the humid subtropical Paraná, Argentina and the semi-arid Patagonian Steppe, Argentina. ET models validated by the Idaho Water Resources II team and a new ET model validated in Reynolds Creek Experimental Watershed, Idaho were applied to our study areas. We collaborated with the Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), translated as the National Scientific and Technical Research Council of Argentina, to improve the use and applicability of empirically derived ET datasets in land management decisions. ET model outputs were statistically analyzed in both study areas to understand the applicability of ET models in various climates.

***Abstract:***

Evapotranspiration (ET) is a key indicator of hydrological balance across different ecosystems. Water availability is a vital ecosystem service for biota and communities. The transpiration and evaporation of water from vegetation and soil can be estimated through *in situ* ET measurements. However, *in situ* ET data sampling represents an expensive and challenging task, especially in geographically remote areas. Models used in this study utilized data from sensors aboard multiple NASA satellites including, Landsat 8, Aqua, and Terra. Two models, Operational Simplified Surface Energy Balance (SSEBop) and Moderate Resolution Imaging Spectroradiometer (MODIS) Global ET Project (MOD16) were validated by the Fall 2018 NASA DEVELOP Idaho Water Resources II team. The Global Land Data Assimilation Noah evapotranspiration (GLDAS-2-Noah) was validated in Reynolds Creek Experimental Watershed (RCEW) by our Argentina Water Resources team. SSEBop, MOD16, and GLDAS-2-Noah were applied in two study areas: Paraná, province Entre Ríos, Argentina, a humid subtropical (Pampean) bioregion, and the Patagonian Steppe in Argentina, a semi-arid region, climatically similar to the validation site at RCEW. Validation and implementation of the models applied in this study will allow our partners at Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET) and land managers in Argentina to use the model that best suits their needs while also making empirically based decisions regarding water resources.

**Keywords:**

evapotranspiration, remote sensing, Landsat, climate, vegetation, energy balance model, water balance

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

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

***Study Period:*** January 2015 to December 2017

***Community Concerns:***

* Fifteen percent of Argentina is designated as semi-arid; however, ET models are untested for these environments.
* Modeling ET is important as it can aid in decision making when dealing with issues like water scarcity, drought, and crop production.
* Land managers need an available calibrated methodology for effectively modeling ET rates. Utilizing NASA Earth observations allows for more targeted and effective water conservation strategies.

***Project Objectives:***

* Evaluate the effectiveness of the following models in estimating ET in different bioregions and climate regions: Moderate Resolution Imaging Spectroradiometer (MODIS) Global ET Project (MOD16), Operational Simplified Surface Energy Balance (SSEBop), Global Land Data Assimilation Noah evapotranspiration (GLDAS-2-Noah)
* Validate GLDAS-2-Noah in Reynolds Creek Experimental Watershed (RCEW)
* Compare model outputs to each other in both study areas to determine the applicability of the models in different climate zones

***Previous Term:*** 2018 Fall (ID) – Idaho Water Resources II

**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;Sebastián Anibal Gavilán, Researcher | End User | Yes |

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

CONICETis actively working to promote the use of empirically derived measurements via energy balance models in future management decisions. This is being done through a broad array of academic researchers and policy makers tasked with solving technical, land, and resource management problems that affect Argentinians. However, most ET models have been created for use in agricultural regions, not in semi-arid heterogeneous environments. CONICET is interested in learning about the applicability of models in areas of different land cover and climate zones.

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

Collaboration between the NASA DEVELOP Argentina Water Resources team and CONICET will allow for the replication of modeling processes and evaluation of ET model performance between Paraná, Argentina, the Patagonian Steppe, and the RCEW for a variety of models used in this study. This will lead to an understanding of the most applicable model in varying climates and land cover types. The project will allow for future analysis across larger scales that would not have been possible without utilizing NASA Earth observations. The end products will potentially be integrated by the partner in their decision-making and conservation practices.

**Earth Observations & End Products Overview**

***Earth Observations:***

|  |  |  |
| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Aqua MODIS** | Land Surface Temperature (LST) | LST from Aqua MODIS was used as an input in the Climate Engine SSEBop ET model. |
| **Terra MODIS** | ET, Normalized Difference Vegetation Index (NDVI) | MOD16 ET products were used to approximate land surface ET and assist in the estimates of water/energy fluxes in the study area. NDVI data were used for correlation analysis. |
| **Landsat 8 OLI** | Surface reflectance | This dataset Landsat 8 Operational Land Imager (OLI) provided the temporal (16 days) and spatial (30 m2) resolution needed for environmental variables employed to calculate ET using the SEBAL and SSEBop models.  |
| **Landsat 8 TIRS** | Land Surface Temperature (LST) | This dataset Landsat 8 Thermal Infrared Sensor (TIRS) provided temporal (16 days) and spatial (30 m2) resolution needed for environmental variables employed to calculate ET from various models. |

***Ancillary Datasets:***

* RCEW meteorological station data – Validate ET models
* FLUXNET– Carbon dioxide, water vapor, and energy measurements utilized in ET modeling efforts
* Joint Research Centre Global Surface Water Mapping Layers, v1.0 – Surface water datasets utilized for model validation
* Global Land Data Assimilation System (GLDAS-2) Mosaic – Precipitation, soils, and surface water environmental predictor variables utilized in ET modeling efforts
* National Oceanic and Atmospheric Administration (NOAA) Earth System Research Laboratory/Physical Sciences Division CPC Merged Analysis of Precipitation (CMAP) – Standard monthly mean precipitation

***Modeling:***

* MOD16 (POC: Michael King, University of Colorado, Boulder) – ET values for model comparison
* GLDAS-2-Noah (POC: Dr. Matthew Rodell, NASA Goddard Space Flight Center) – ET values for model comparison
* SSEBop (POC: Dr. Justin Huntington, Desert Research Institute) – ET values for model comparison

***Software & Scripting:***

* Esri ArcGIS Pro – Image processing and end product generation
* Esri ArcMap – Image processing and end product generation
* R – Statistical analyses and raster processing
* Google Earth Engine API – Large scale image analysis
* Adobe Premiere Pro CC – Video creation for VPS and ET Modeling Tutorial
* JMP – Statistical analysis and visualization

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Products** | **Earth Observations Used**  | **Partner Benefit & Use** | **Software Release Category** |
| **ET Model Map and Model Output Comparison between Paraná, Argentina; Patagonia Steppe, Argentina; and RCEW, Idaho** | Aqua MODISTerra MODIS Landsat 8 OLILandsat 8 TIRS | These map and model comparisons between ET models developed in the Paraná, Argentina, and RCEW provided the partner with a more robust understanding of model performance across geographic space.  | II |
| **ET Modeling Tutorial** | Aqua MODISTerra MODIS Landsat 8 OLILandsat 8 TIRS | The tutorial enables end users to replicate the methodology used to implement ET models used in this study. | N/A |

**Project Handoff Package**

*Transition Plan:* At the end of the term, the team hosted a video seminar using Zoom with partners and members of the community to disseminate project results. Decision support tools were shared via Google Drive. A short training tutorial, that will enable our partners to replicate this study, was included in the handoff meeting.

**Team POC:** Carl Jurkowski, jurkcarl@isu.edu

**Partner POC:** Dr. Pablo G. Aceñolaza, acenolaza@gmail.com

**Handoff Package:**

* Technical Paper
* Poster
* Presentation
* Project Video
* ET Model Map and Model Output Comparison between Paraná, Argentina; Patagonia Steppe, Argentina
* ET Modeling Tutorial

**References:**

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