**Mato Grosso Agriculture**

*Enhancing Crop Classification Mapping Using Optical and Radar Satellite Sensors to Enhance Agricultural Management and Policymaking in Mato Grosso, Brazil*

***Project Team:***

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**Project Overview**

***Project Synopsis:***

Mato Grosso, Brazil, is one of the world’s largest agricultural producers, meriting the need for large-scale crop monitoring and classification. Due to Mato Grosso’s tropical climate, optical imagery used for crop classification is often limited by dense cloud cover. To enhance partners’ classification capabilities, the team utilized both radar and optical imagery to create enhanced classification maps using a random forest model. These maps provide increased crop classification accuracy and coverage to inform policy decision making and commodity estimates.

***Abstract:***

Ranked as the fourth largest food producer in the world, Brazil is an agricultural powerhouse. Agricultural production at this scale warrants accurate crop monitoring and classification, however, this tropical area is frequently concealed by dense cloud cover in standard optical imagery. To improve the accuracy and spatial coverage of current crop monitoring operations, the team incorporated radar data capable of penetrating cloud coverage to classify second season corn and cotton fields. Utilizing optical imagery from Landsat 8 Operational Land Imager (OLI), as well as radar imagery from Sentinel-1 C-band Synthetic-Aperture Radar (C-SAR), the NASA DEVELOP team worked with the United States Department of Agriculture (USDA) Foreign Agricultural Service (FAS) and World Agricultural Outlook Board to generate a crop classification procedure using a random forest model for accurate mapping and crop area estimates. Additionally, accuracy assessments were performed to ensure confidence in classification accuracy and to allow for comparison with previous classification maps of the area. Classification maps and area estimates produced will be used by the USDA FAS to generate accurate estimates of available commodities as well as assist in policy decision making. The DEVELOP team’s classification procedures were shared with partners, to increase crop classification capacity.

***Key Terms:***

remote sensing, radar imagery, accuracy assessment, sensitivity analysis, SAR, random forest, cloud cover

***National Application Area Addressed:*** Agriculture

***Study Location:*** Mato Grosso, Brazil

***Study Period:*** 2014

***Community Concerns:***

* *In situ* monitoring of crops in remote agricultural regions is time-consuming and expensive. Cloud cover can negatively impact optical-only crop classification accuracy
* US foreign policy and trade is dependent on crop yield and commodity estimates derived from crop classification maps. Incomplete or inaccurate crop classification maps provide a poor foundation for such important policies and trade decisions.
* Brazil is a leading agricultural power in the world, with most of its corn, cotton, and soy grown in the Mato Grosso state. The agricultural significance of this location merits accurate crop classification in order to advance agricultural opportunities and management.

***Project Objectives:***

* Produce crop classification maps for corn, cotton, and soybean to enhance map inventories limited by cloud cover Perform accuracy assessments to increase partner confidence in the optical and radar data fusion approach to crop classification
* Generate F-1 Analyses to assess precision and recall of our classes of interest

**Partner Overview**

***Partner Organization:***

|  |  |  |
| --- | --- | --- |
| **Organization** | **Contact (Name, Position/Title)** | **Partner Type** |
| USDA Foreign Agriculture  Service | Dr. Sunita Yadav-Pauletti, Crop Analyst for Brazil | End User |
| USDA Office of the Chief  Economist | Mark Brusberg, Chief Meteorologist | Collaborator |

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

The USDA Foreign Agriculture Service (FAS) supports the US in decisions regarding agricultural exports and foreign policy by collecting intelligence on current agricultural conditions globally. The USDA FAS for Brazil collects intelligence on market conditions, production forecasts, export opportunities, and agricultural policy. The USDA FAS is responsible for making commodity and yield estimates in Brazil. Currently, the USDA FAS for Brazil relies on spatially comprehensive crop classification maps created using optical satellite imagery, however, the dense cloud cover brought on by the tropical climate of Brazil presents an obstacle to collecting clear and consistent data.

**Earth Observations & End Products Overview**

***Earth Observations:***

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| --- | --- | --- |
| **Platform & Sensor** | **Parameters** | **Use** |
| **Landsat 8 OLI** | Surface reflectance, Normalized Difference Vegetation Index (NDVI), Enhanced Vegetation Index (EVI) | Spectral signatures and indices were used to classify crops at a 30 m resolution. Variation in spectral signatures indicated change in crop types. |
| **Sentinel-1 C-SAR** | Backscatter values,  vertical polarization (VV), horizontal polarization (VH) | Radar data were used to identify crop areas and to help classify crop types. |
| **SRTM** | Elevation, Slope, Aspect | Elevation, slope, and aspect were incorporated to improve land cover identification at 30 m resolution. |

***Ancillary Datasets:***

* Kastens, et al. S3 Dataset Land Cover Map - Used to create training and validation data delineating corn, cotton, and soybean for the random forest model
* University of Maryland Global Land Analysis & Discovery Laboratory (GLAD) Global Cropland Expansion in the 21st Century – Cropland classifications used to create crop masks

***Modeling:***

* Random Forest (Contact): Dr. Garrett Graham, NOAA National Centers for Environmental Information, North Carolina Institute for Climate Studies) – Machine learning algorithm used for crop classification generation

***Software & Scripting:***

* Esri ArcGIS Pro – Crop classification map creation
* Google Earth Engine API – Data acquisition
* Google Colab – Random Forest Model and Python API

***End Products:***

|  |  |  |  |
| --- | --- | --- | --- |
| **End Product** | **Earth Observations Used** | **Partner Benefit & Use** | **Software Release Category** |
| **Crop Classification Maps** | Landsat 8 OLI  Sentinel-1 C-SAR  SRTM | These maps will aid partners in updating map inventories limited by cloud cover and facilitate more informed decision-making. | I |
| **Accuracy Assessment** | Landsat 8 OLI  Sentinel-1 C-SAR  SRTM | This assessment will inform the partners confidence in the optical and radar data fusion approach for classifying crop types. | I |

***Product Benefit to End User:***

This project will provide the partners with crop classification maps that delineate the spatial extent of corn, soybean, and cotton fields within the state of Matto Grosso, Brazil in 2014. Along with these maps and accuracy assessments will provide quantitative results that justify the maps’ results. Crop classification maps using both optical and radar satellite sensors have been shown to increase accuracy and spatial coverage. By using radar satellite sensor datasets, partners will be able to update map inventories limited by cloud cover. End products will supplement USDA FAS’ current crop classification methodology~~,~~ and aid their decision-making processes surrounding agricultural market conditions, production forecasts, export opportunities assessments, and changes in policies affecting U.S. agricultural exports and imports. Furthermore, the partners will be able to use these products as models for creating their own crop classification maps.

**References**

Kastens, J. H., Brown, J. C., Coutinho, A. C., Bishop, C. R., Esquerdo, J. C. D. M. (2017). Soy moratorium impacts on soybean and deforestation dynamics in Mato Grosso, Brazil. *PLOS ONE 12*(4), e0176168. https://doi.org/10.1371/journal.pone.0176168