Enhancing the USDA Crop Assessment Decision Support System Using NASA SMAP Soil Moisture Observations

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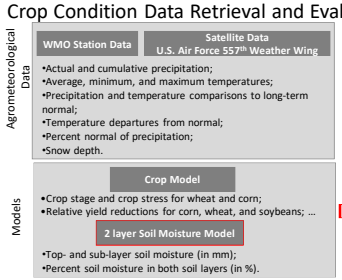
I. ABSTRACT

One of the U. S. Department of Agriculture-Foreign Agricultural Services (USDA-FAS) mission objectives is to provide current information on global crop supply and demand estimates. Crop growth and development is especially susceptible to the amount of water present in the root-zone portion of the soil profile. Therefore, accurate knowledge of the root-zone soil moisture (RZSM) is an essential for USDA-FAS global crop assessments. This paper focusses on the possibility of enhancing the USDA-FAS's RZSM estimates through the integration of passive-based soil moisture observations derived from the Soil Moisture Active Passive (SMAP) mission into the USDA-FAS Palmer model. Lag-correlation analysis, which explores the agreement between changes in RZSM and crop status indicated that the satellite-based observations can enhance the model-only estimates

II. BACKGROUND

Crop Condition Data Retrieval and Evaluation (**CADRE**) Database Management System (**DBMS**)



Improving the USDA-FAS *soil moisture information* developed using the **Palmer Model** by integrating **SMAP** soil moisture observations.

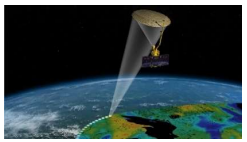


Image courtesy: https://smap.jpl.nasa.gov/data/\

Soil Moisture Active Passive (**SMAP**)

- ❑ 6 a.m.
- ❑ Product: L3, Passive Only Soil Moisture
- ❑ SCA-V Soil Moisture Retrievals

Figure 1: Schematic representation of the CADRE DBMS.

III. SYSTEM SET UP

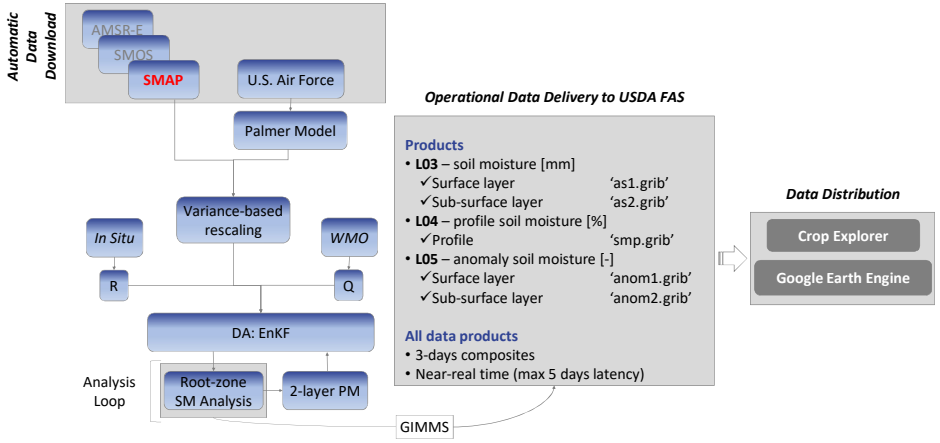


Figure 2: Schematic representation of the USDA-FAS Palmer Enhanced soil moisture forecasting system and its operational implementation.

The current baseline root-zone soil moisture estimates unitized by USDA-FAS are developed using the modified two-layer Palmer model. The Palmer model is a water-balance-based hydrologic model that is driven by daily estimates of minimum and maximum temperature, and daily precipitation observations. These meteorological data are based on ground meteorological station measurements from the World Meteorological Organization (WMO), and gridded weather data from the former U.S. Air Force Weather Agency 557th Weather Wing. Generally, the model accuracy is determined by the quality of the precipitation forcing data. The assimilation of SMAP has been specifically designed to improve the model estimates and aid USDA-FAS crop forecasting activities in data poor regions and areas with poor precipitation data quality.

IV. RESULTS

NASA Soil Moisture Data Advances Global Crop Forecasts

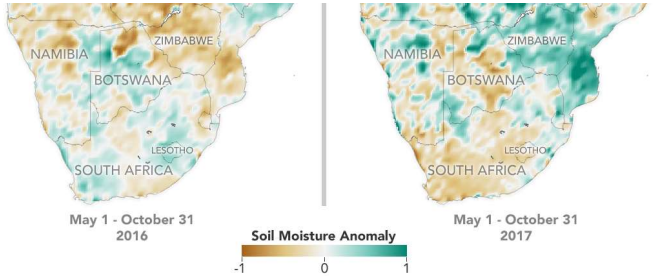


Image courtesy: https://www.nasa.gov/feature/2018/goddard/new-nasa-soil-moisture-data-spots-droughts-floods

Figure 3: Drought monitoring using soil moisture anomalies over the Wester Cape, South Africa. The maps show the average soil moisture conditions for the 2017 growing season. Data represent standardized anomalies, where negative values indicate that the soil moisture conditions are below average and positive values indicate surplus of water.

According to the USDA FAS Crop Intelligence Report reported sever drought in the Western Cape province of South Africa during The 2017 growing season. The Western Cape is the counties largest wheat producing area, where wheat is typically planted in May and harvested in October. Rainfall this period is essential for crop production. The decline in soil moisture availability as shown in Figure 3 during the 2017 have resulted in poor crop growth and decline in potential end of season yield.

Global Lag Soil Moisture-NDVI Correlation Analysis

Model alone
PM

Satellite Enhanced Model
PM + SMAP

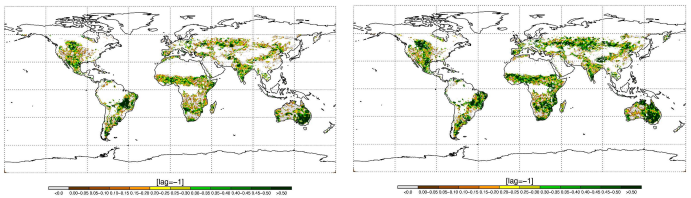


Figure 4: Global lag rank correlation analysis between soil moisture and NDVI at lag of 1 month

Change in soil moisture conditions is typically preceded by the change in vegetation health as crops have several coping mechanisms to deal with the environmental stresses associated with drought. Maps show the lag correlation agreement between the sub-surface soil moisture values estimated using the SMAP-enhanced Palmer model and NDVI, used here as an indicator of vegetation status. Overall SMAP improves the model.

Google Earth Engine

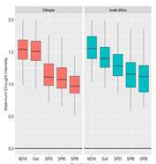


Figure 5: Drought intensity. :

All data products generated using the SMAP-enhanced Palmer model are made available through Google Earth Engine. In addition, several exploration tools allow to easily process and manipulate the data, extract various drought characteristics, and inter-compare it against other data sets available in GEE. Figure 5 shows drought intensity estimates over Ethiopia and South Africa computed using sub-surface soil moisture anomalies, NDVI anomalies, SPI3, SPI6 and SPI9.

V. SUMMARY

- ❑ USDA-FAS PM+SMAP soil moisture observation system:
  - System is fully set up and operational
  - Positive feedback
  - Data publicly available through Crop Explorer and Google Earth Engine
  - Several papers in progress

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