NASA Science Mission Directorate
Earth Science Division
Applied Sciences Program

Enhancing the USDA Global Crop Production Decision Support System with NASA Soil Moisture Active Passive (SMAP) Satellite Observations

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NASA Water Resources PI Meeting
April 26-28, 2016

Statement of challenges / need / opportunity

Challenge: Improve USDA Foreign Agricultural Service commodity crop forecasts by integrating NASA soil moisture remote sensing products and land surface modeling/assimilation tools into the operational USDA FAS global water balance modeling system. Soil moisture provides an early indication of vegetation change.

Need: The USDA FAS currently applies a ‘convergence of evidence’ approach for estimating future global crop yields based on secondary estimates or modeled soil moisture, precipitation, vegetation.

Opportunity: The NASA SMAP mission launched in January, 2015 and could potentially reduce the uncertainty of the SMOS-based global soil moisture product operationally being applied by the USDA FAS

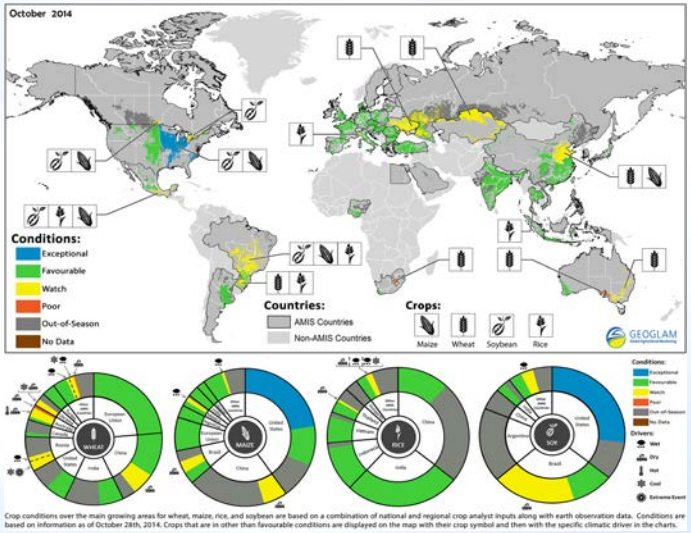
Current partners and user community

Role	Name(s)	Affiliation
Co-I	Wade Crow	USDA ARS HRSL
Co-I	Curt Reynolds	USDA FAS
Science Lead	Illiana Mladenova	NASA GSFC
Collaborator	Jerry Zhan	NOAA NESDIS

Role	Organization Name	Organization Type
Co-I/End-User	USDA Foreign Agricultural Service (Curt Reynolds, Dath Mita, Don Brown)	Federal Agency
End-User	USDA NASS	Federal Agency
End-User	GEOGLAM	Collaboration

Partner communities you / your project could engage in the future

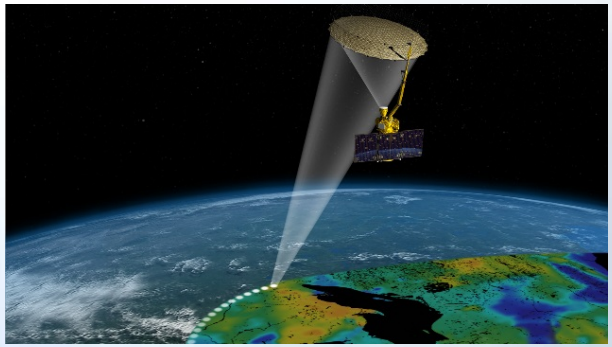
- Agricultural drought monitoring, forecasting (e.g., FEWSNET, NDM)
- Disaster monitoring and forecasting (e.g., landslide probability)
- Hydrologic model/ GCM initialization / AGMIP
- Global hydrology/ climate change adaptation studies



Key datasets, models, scientific, technical tools

Products/Tools: AMSR-E (2002-2011), SMOS soil moisture observations (since October 2011); SMAP soil moisture observations (late 2015), ASCAT soil moisture observations (2006-present), TRMM, GPM

Models – Palmer 2-layer soil moisture model, EnKF



Approach

Set up:

Palmer Model

- physically based model
- 2 layers, surface and subsurface
- 0.25° -> *improved resolution*

Forcing

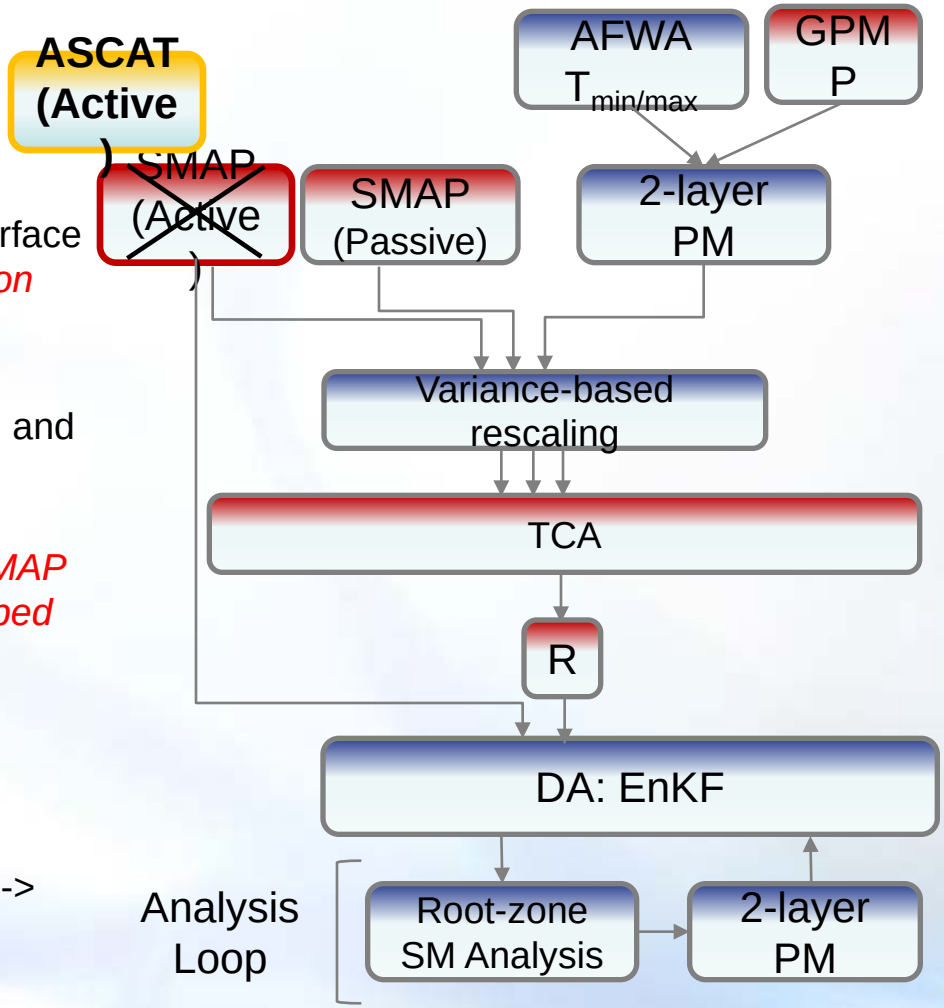
- former AFWA -> *GPM*
- Variables: Precipitation; Min and Max Temp.

Satellite observations

- SMOS ESA (SMOPS) -> *SMAP (Passive and Active); Prototype developed (SMOS and ASCAT)*

Data Assimilation

- EnKF
- 30 ensemble members
- Rescaling: Variance-based
- R: DNVI-based climatology -> Triple Collocation Analysis



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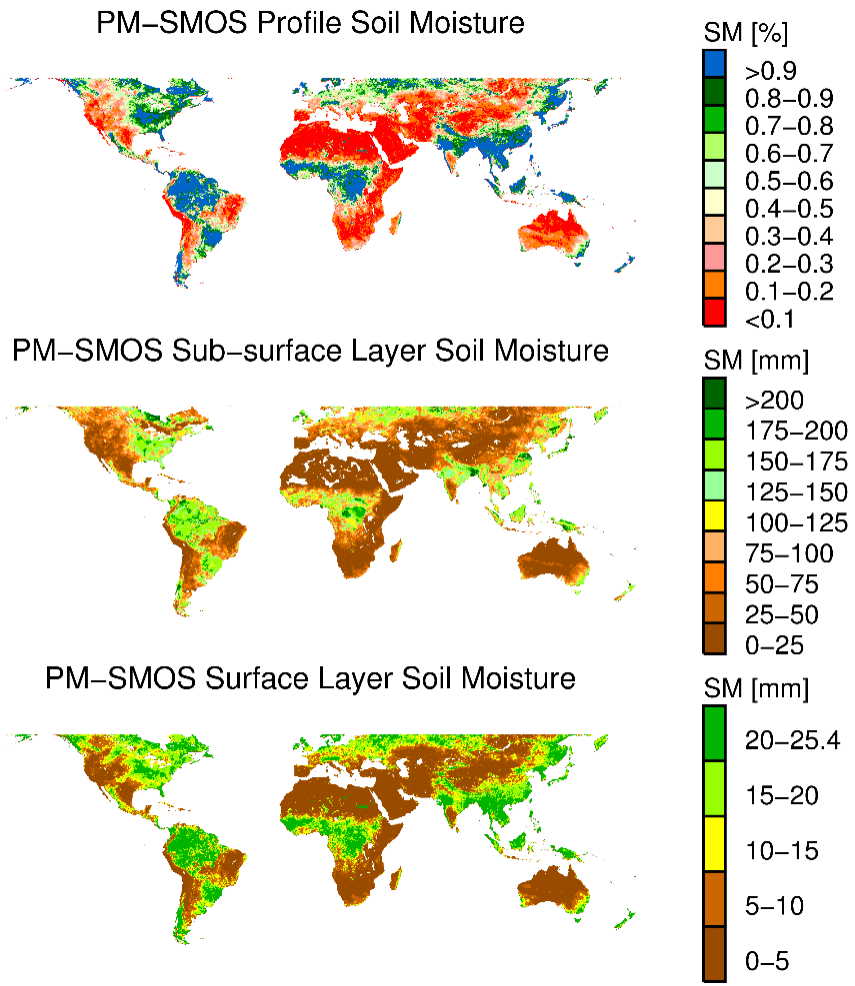
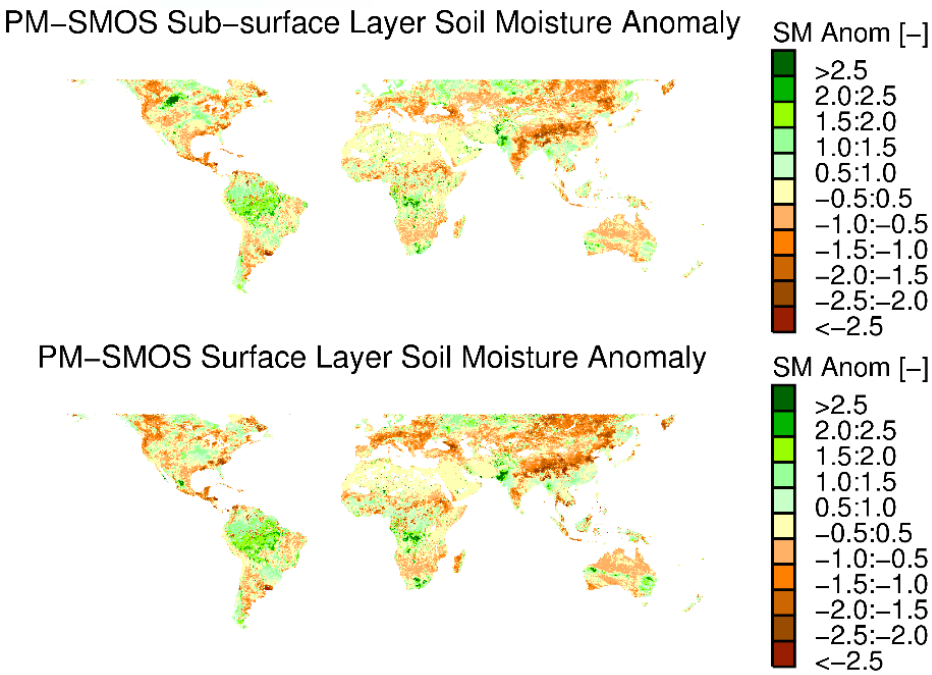
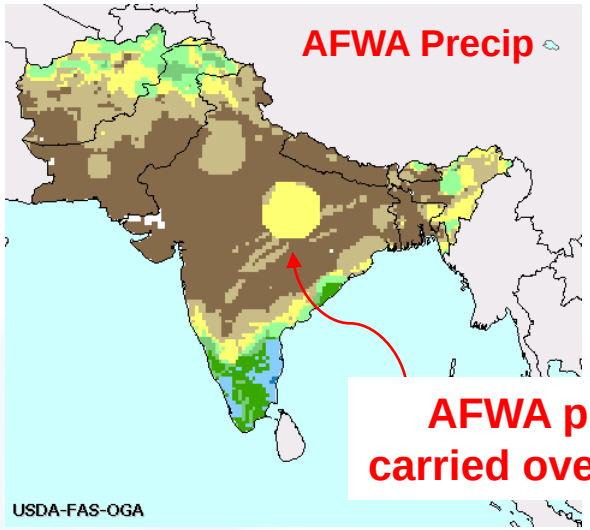
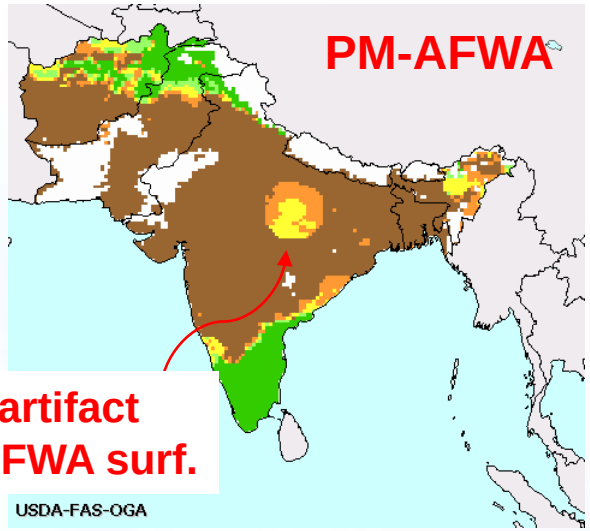


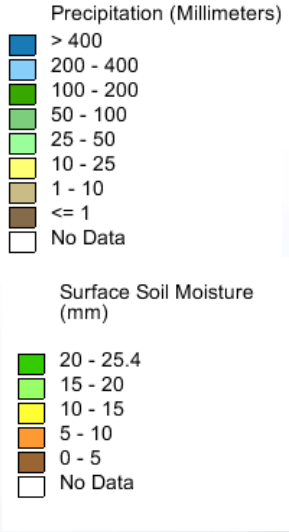


2015/07/28-2015/07/30

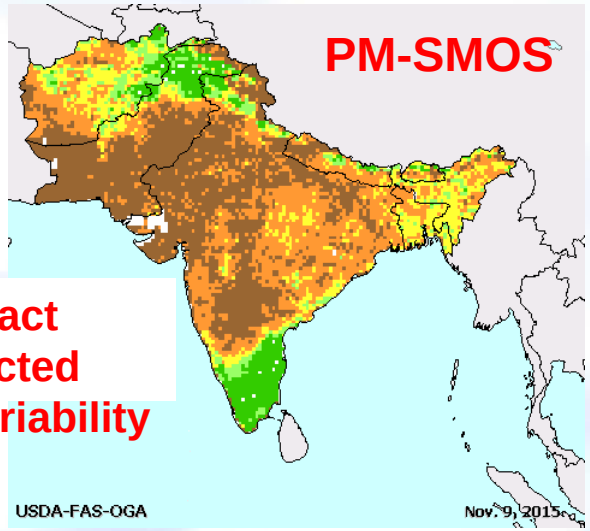
Impacts







AFWA precip artifact carried over to AFWA surf. SM



Artifact corrected
Better variability

Surface Soil Moisture
November 1-10, 2015

Image courtesy: C. Reynolds, Crop Explor

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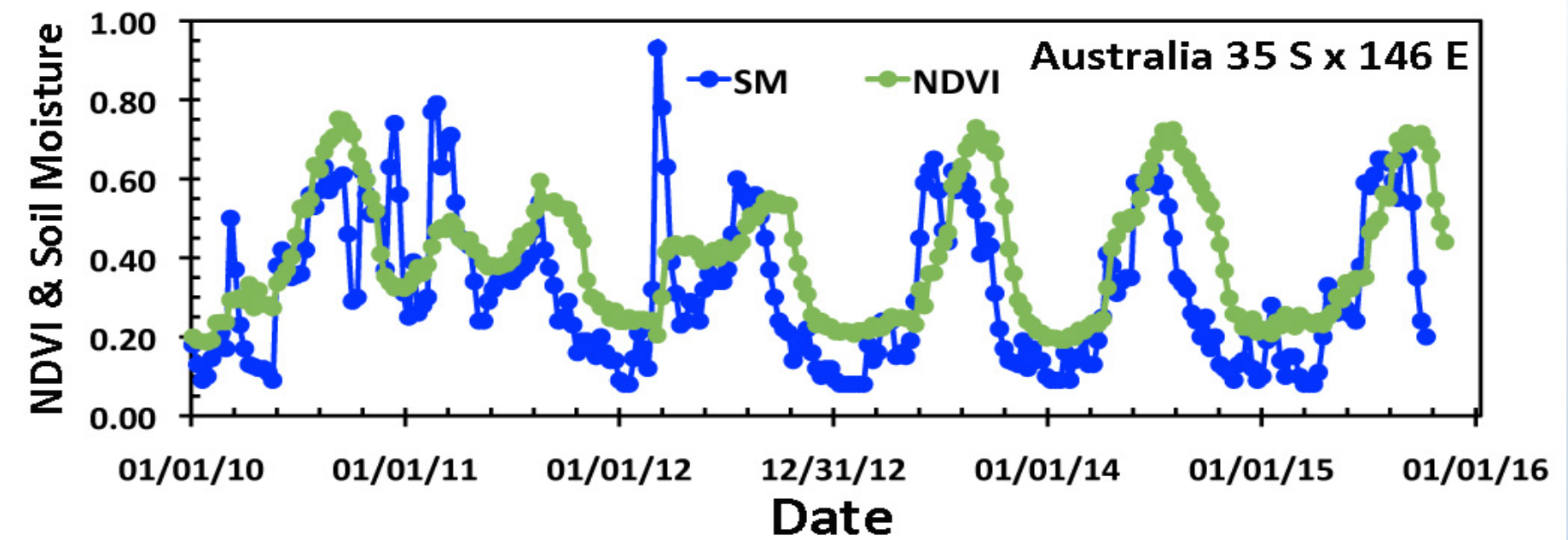
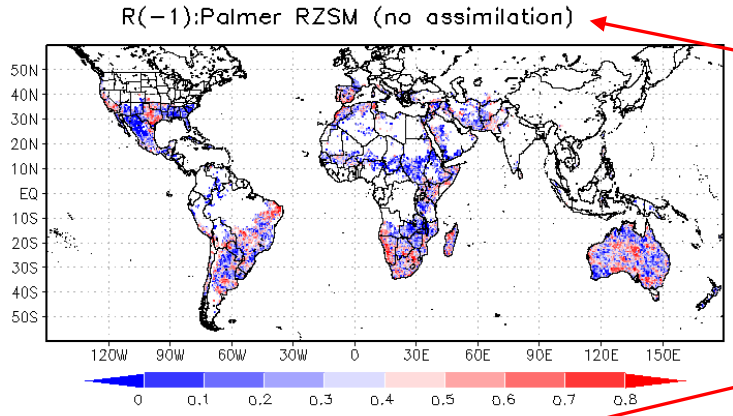
Impacts

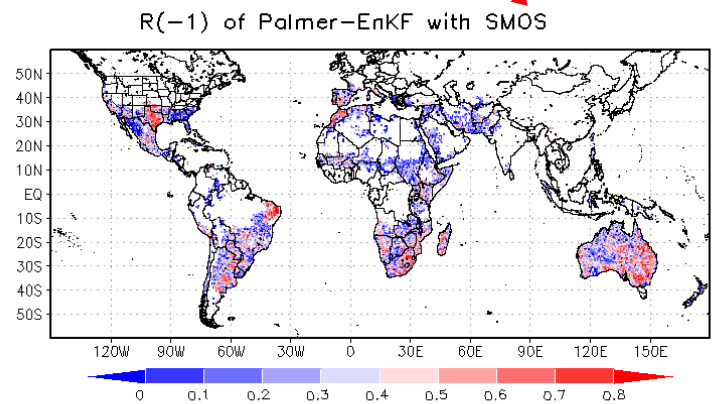


Evaluation



Model only – no data assimilation

Model + assimilating Passive only observations



Model + assimilating Passive and Active observations simultaneously

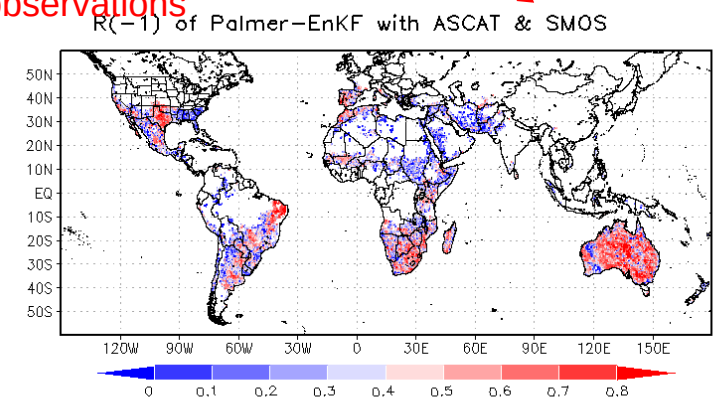
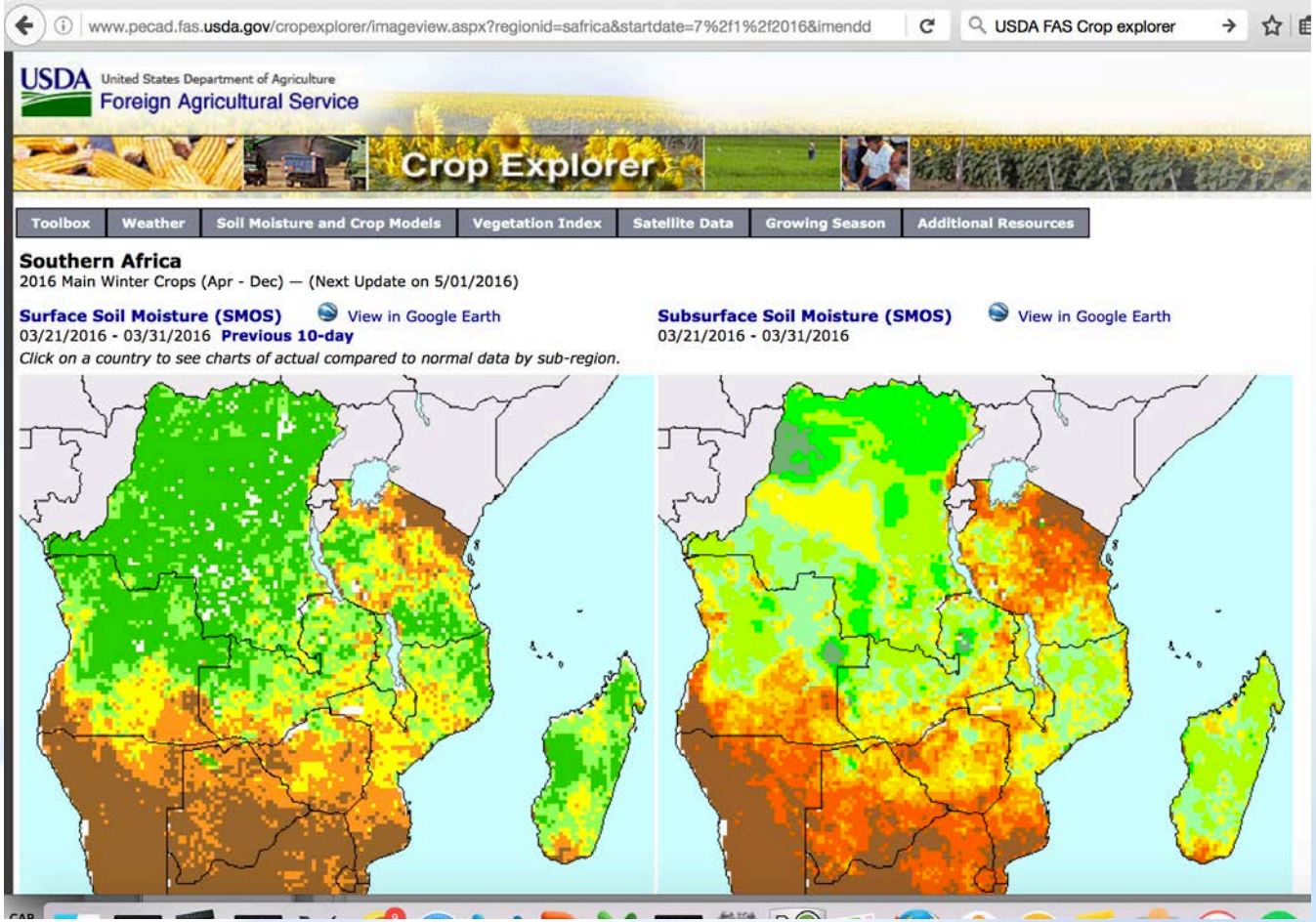


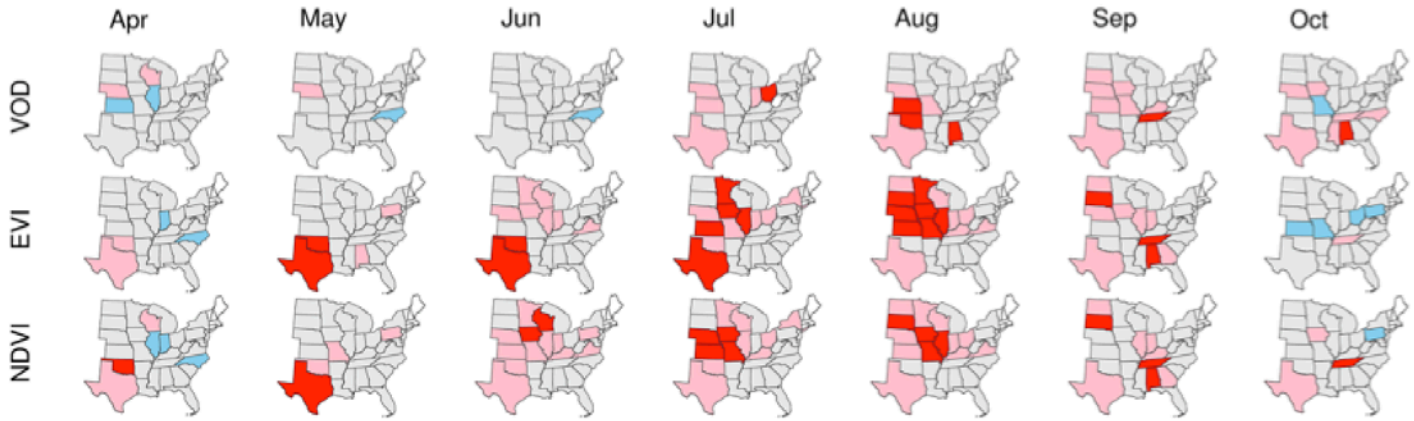
Image courtesy: E. Han and W. Crow

Transition Strategy

Full transition of operational system to FAS (ARL8-9) is planned by end of project, in coordination with combined NDVI (GLAM) – SM Crop Explorer System hosted at NASA GSFC



Yield Analysis



VI-yield rank correlation analysis for corn over central and eastern U.S.

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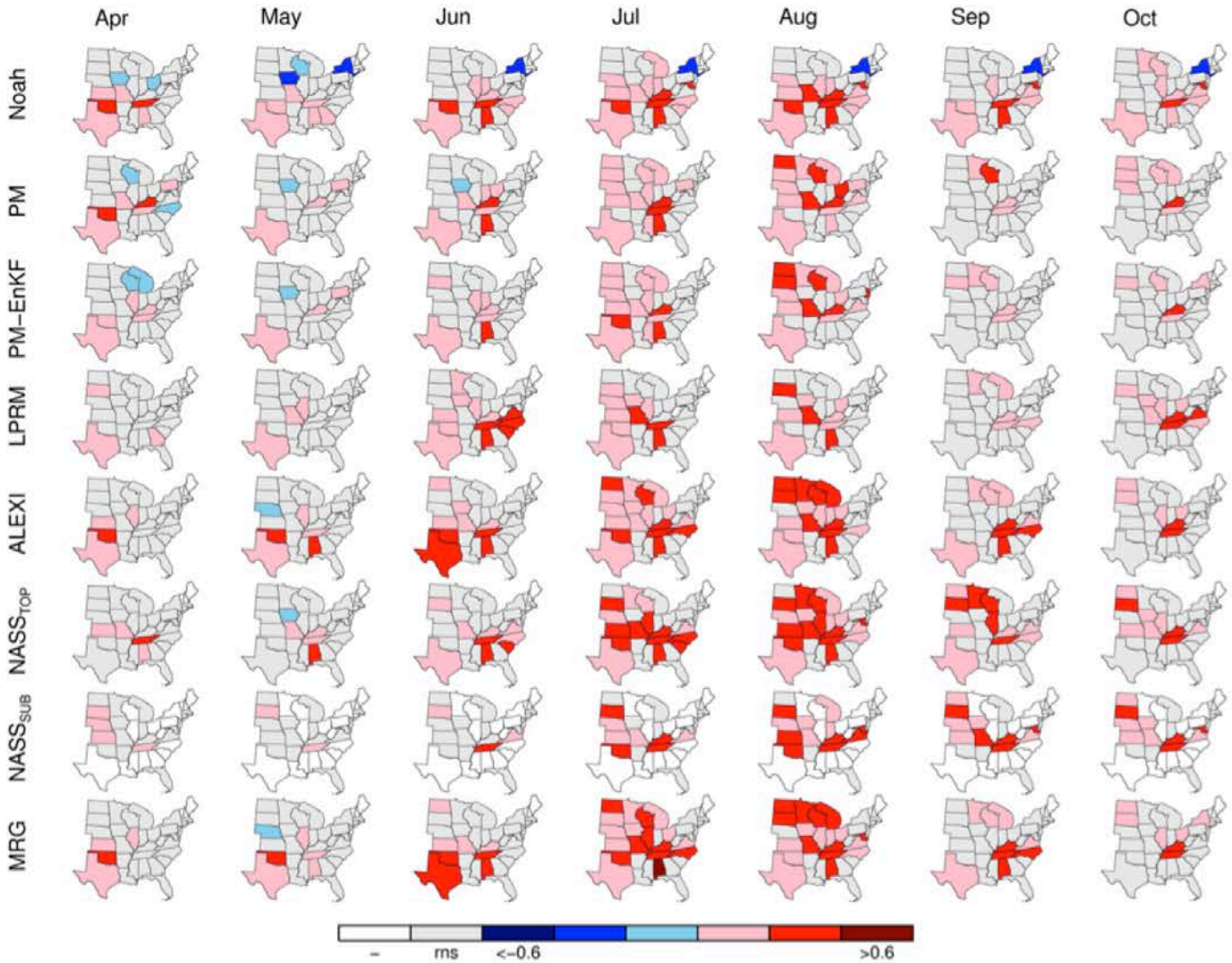
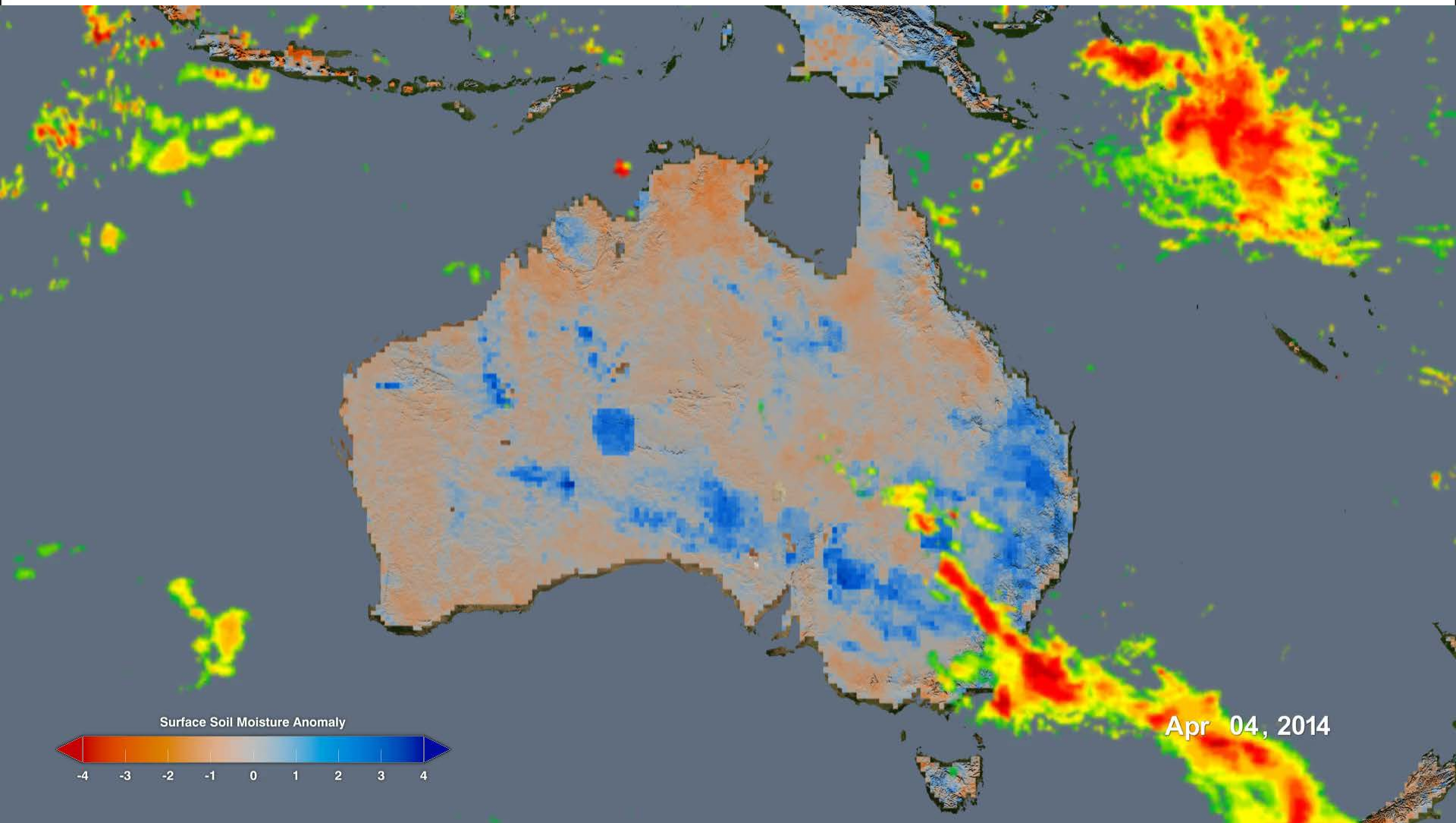
Yield Analysis



SM-yield rank correlation analysis for corn over central and eastern U.S.

Pairing Precipitation and Soil Moisture to Illustrate 'Precipitation Memory'



Lessons Learned

- Frequent updates and meetings with FAS analysts has been a critical part of this project for promoting ongoing dialogue
- We are exploring expanding our user base (e.g., USDA, GEOGLAM, AgMIP, NRT flood/landslide applications)
- Synergistically combine NDVI, Soil Moisture, and other Earth observations in NASA GSFC GLAM system (In Progress!!)
- Work towards holistic crop monitoring and crop systems modeling:
  - Yield estimates
  - Analytical tools

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- Iliana E. Mladenova, John D. Bolten, Wade Crow, Martha Anderson, 'Inter-comparison of Soil Moisture, Water Use and Vegetation Indices for Estimating Corn and Soybean Yields Over the U.S.' , JSTARS (In Review)
- Iliana E. Mladenova, John D. Bolten, Wade Crow, Richard de Jeu, Evaluating the application of microwave-based vegetation observations in an operational soil moisture data assimilation system, conference proceedings of the IEEE International Geoscience and Remote Sensing Symposium (IGARSS), July 2015.
- Iliana E. Mladenova, Grey Nearing, John D. Bolten, Venkat Lakshmi, Remote Sensing Techniques and Data Assimilation for Hydrologic Modeling in Handbook of Applied Hydrology, McGraw-Hill, 2nd Edition, Expected publication date: May 2016.
- Bolten, J., Iliana Mladenova, Wade Crow,, '*Enhancing the USDA Global Crop Production Decision Support System with NASA Soil Moisture Active Passive (SMAP) Satellite Observations', NASA Applied Sciences Program, PI Meeting, Hyattesville, MD., March, 2015.*
- Bolten, J. -'The potential of Earth Observation data products to improve water quality monitoring and management'. World Water Forum, Daegu, South Korea, May, 2015.
- Bolten, J. 'Improving Water Resources Management through NASA Modeling and Satellite Observations', World Water Forum, Daegu, South Korea, May, 2015.
- Bolten, J., 'Earth Observations for Global Water Knowledge', World Water Forum, Daegu, South Korea, May, 2015.
- Bolten, J., 'Water Resources, Agriculture and Food Security, Global Precipitation Measurement' Applications Workshop, Hyattesville, MD, June, 2015.
- Bolten, J., Global Flood Monitoring with NASA Earth Observations', Eleventh Annual GEO IGWCO COP Meeting, College Park, Md, June, 2015
- Bolten, J., Iliana Mladenova, Wade Crow, Richard de Jeu, 'Evaluating the Applications of Microwave-Based Vegetation Observations in an Operational Soil Moisture Data Assimilation System',International Geospatial Remote Sensing Symposium, Presentation and Publication, July 2015, Milan, Italy,
- Bolten, J., 'NASA Water Resources Applications – Overview for K-Water', NASA GSFC K-Water Meeting, May 12, 2015.
- Bolten, J., Mladenova, I., Crow, W., 'Satellite-Enhanced Soil Moisture Products', USDA-FAS – NASA Project Meeting. USDA HQ, Washington, DC, September, 15, 2015.
- Iliana E. Mladenova, John D. Bolten, Wade Crow, Richard de Jeu, Evaluating the application of microwave-based vegetation observations in an operational soil moisture data assimilation system, conference proceedings of the IEEE International Geoscience and Remote Sensing Symposium (IGARSS), Presentation and Publication, July 2015.

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- Mladenova, I., Bolten, J., ‘On The Problem of Re-scaling Short-term Satellite Data Records, European Geophysical Union meeting, Vienna, Austria, April 2015.
- Mladenova, I., Bolten, J., ‘Enhancing USDA Global Crop Modeling Using SMAP Soil Moisture Products’, SMAP Applications Benchmark Meeting, College Park, MD, May 2015.
- Mladenova, I., Bolten, J., Efforts Towards Enhancing The USDA Crop Monitoring And Forecasting System Using NASA Resources, presented at the Young Scientist Forum at NASA Goddard, July 2015.
- Satellite-based Soil Moisture Estimates Obtained From The Soil Moisture Active Passive Mission, presented at the fall American Geophysical Union meeting, San Francisco, CA, December 2015.
- Evaluating the application of microwave-based vegetation observations in an operational soil moisture data assimilation system, presented at the IEEE International Geoscience and Remote Sensing Symposium (IGARSS), Milan, Italy, July 2015.
- Evaluation of Assimilated SMOS Soil Moisture Data for Cropland Soil Surface Moisture Monitoring, presented at the Agro-Geoinoformatics conference, held Istanbul, Turkey, July 2015.
- Enhancing the NASA/Goddard-Foreign Agricultural Service’s Global Agricultural Monitoring System with Coincident Soil Moisture Data, presented at the Food Energy Water Nexus. Workshop held at the World Bank, Washington DC, October 2005.