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

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NASA Applied Sciences Program, Water Resources Meeting
National Drought Mitigation Center, Lincoln, NE

USDA ARS Agricultural Research Service

NASA

Water Resources – Project Summary

- Title: Enhancing the USDA Global Crop Production Decision Support System with NASA Soil Moisture Active Passive (SMAP) Satellite Observations
- PI: John Bolten (NASA Goddard Space Flight Center)
- Co-I: Wade Crow (USDA ARS HRSL), Curt Reynolds (USDA FAS)
- Science Lead: Iva Mladenova (NASA GSFC)
- Collaborator: Jerry Zhan (NOAA NESDIS)
- Call: 2014 A.45
- Motivation: 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.
- Domain: Global
- Products/Tools: SMOS soil moisture observations (since October 2011); SMAP soil moisture observations (late 2015), TRMM, GPM
- Goal: Improved root-zone soil moisture data products for USDA FAS.

Water Resources – Project Summary

- **Follow-on project to:**

- Project Title: *Enhancing the USDA Global Crop Production Decision Support System with the NASA Land Information System and Water Cycle Satellite Observations*
- PI: Wade Crow (USDA ARS HRSL)
- Co-I: Xiwu Zhan (NOAA NESDIS), Curt Reynolds (USDA-ARS)
- Call: NNH08ZDA001N-DECISIONS

- Final year (2014) ARL: 8
- Major Accomplishments: Soil moisture products have been operationally delivered to USDA FAS since late 2013 and fully incorporated into the USDA FAS Crop Explorer decision support system since April 2014.

Statement of Problem

• USDA International Production Assessment Division (IPAD)

•Provides monthly global production estimates for commodity Crops >> drought detection >> famine early warning

•Uses combination of satellite data sources, input databases, climate data, crop models, and data extraction routines to arrive at yield and area estimates "*Convergence of Evidence Analysis*"

Dependent on coverage, accuracy and consistency of data sources used…. e.g. soil moisture

Weaknesses of current approach: lacking soil moisture observations at desired spatial resolution and accuracy needed for optimal agricultural assessment

Project Partners

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

End-Users / Stakeholders

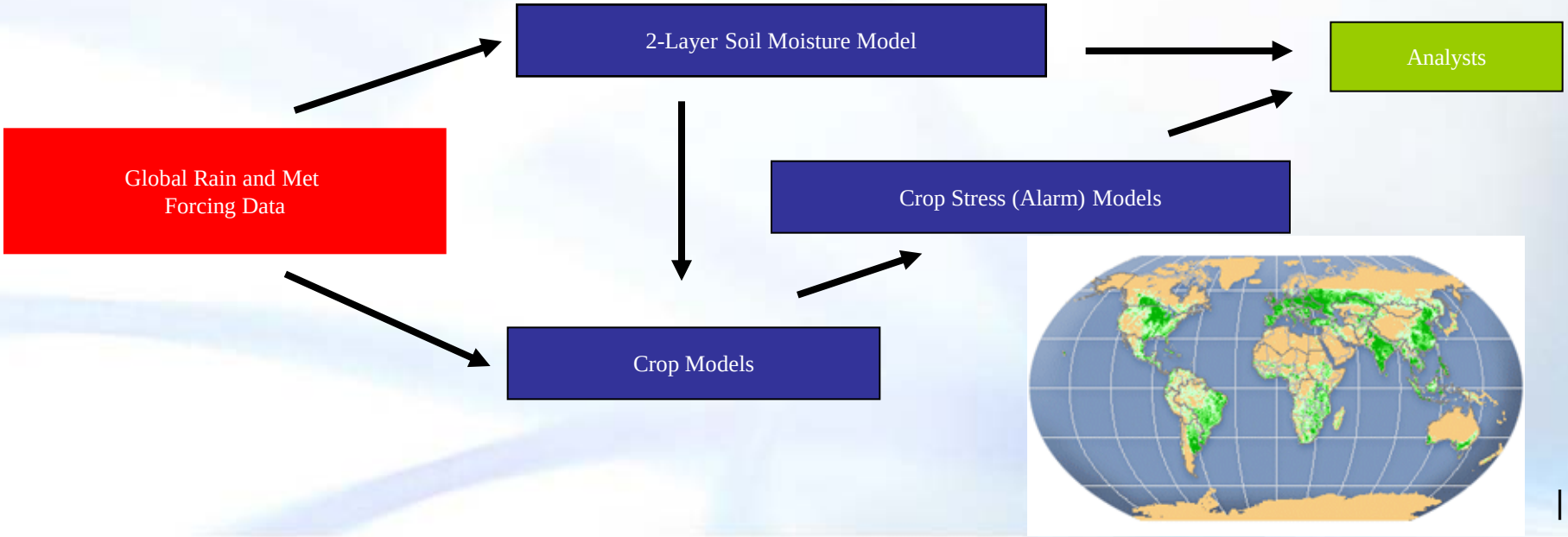
Role	Organization Name	Organization Type
Co-I/End-User	USDA Foreign Agricultural Service (Curt Reynolds, Dath Mita, Don Brown)	Federal Agency
End-User	USDA NASS	Federal Agency

Role	Organization Name	Organization Type
SMAP Early Adopter	USDA Foreign Agricultural Service (Curt Reynolds, Dath Mita, Don Brown)	Application Innovator

Approach

Goal: Use global soil moisture products (among many other things) to forecast variations in international agricultural productivity and yield.

Baseline Approach: Global application of a (simple) soil water balance model.



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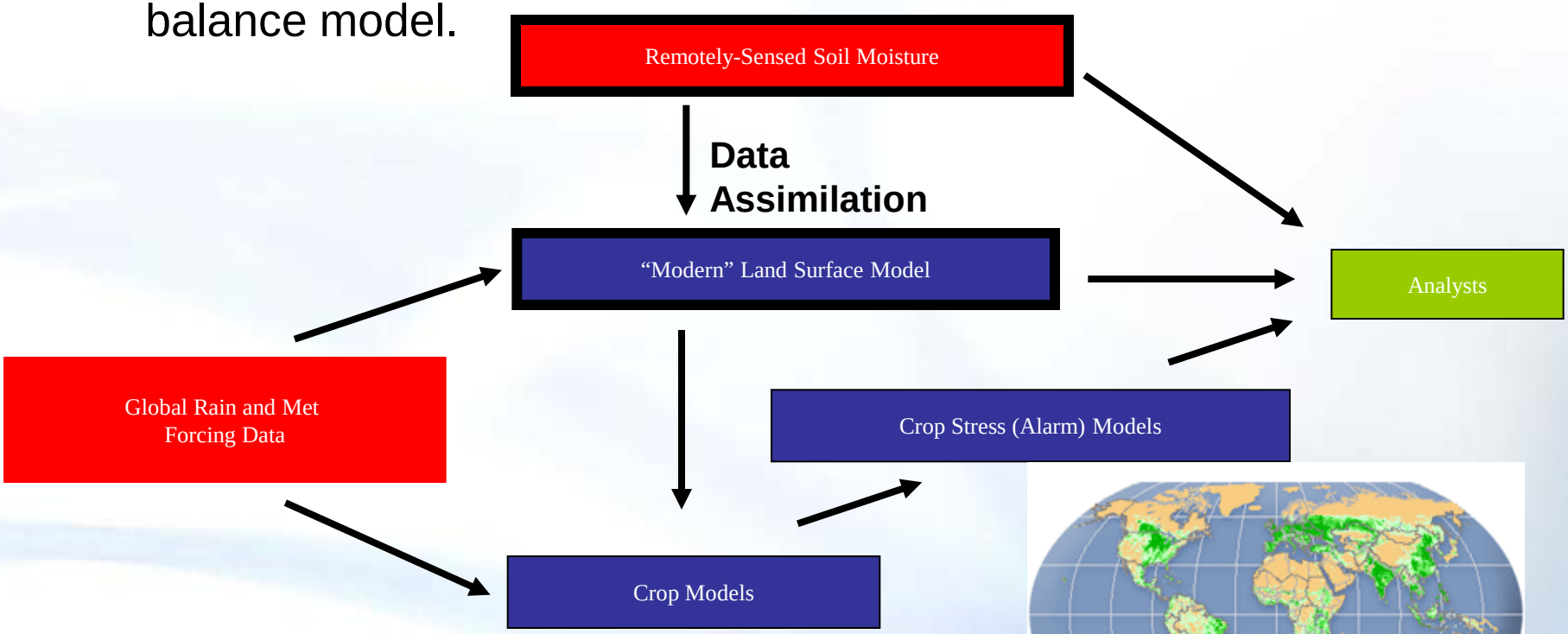
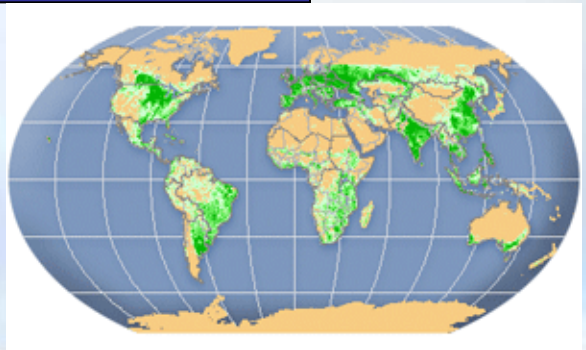
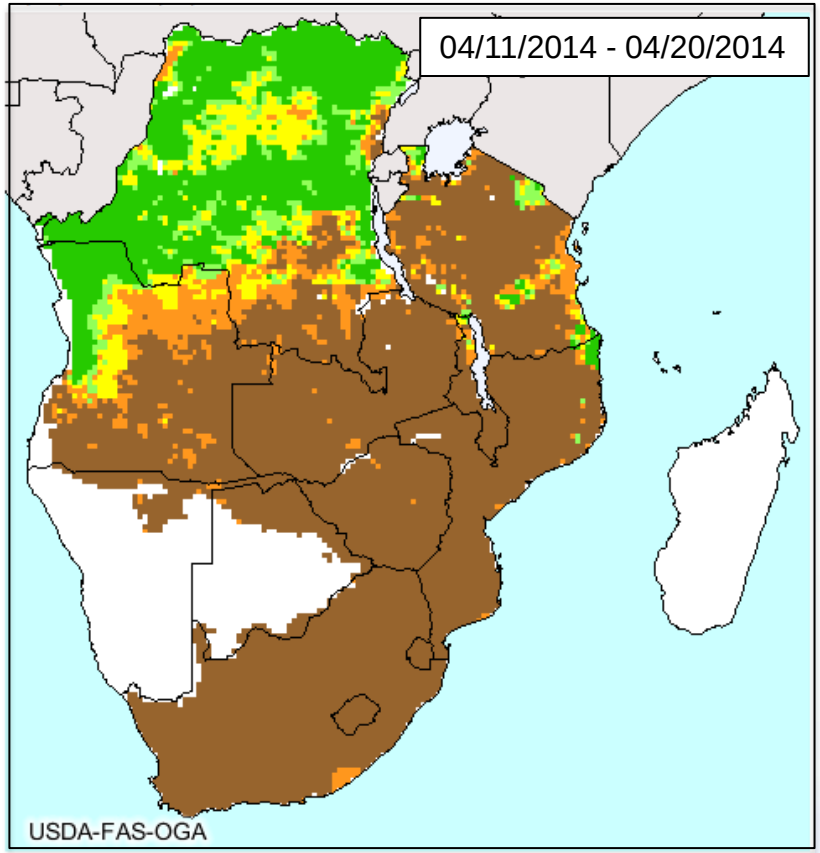


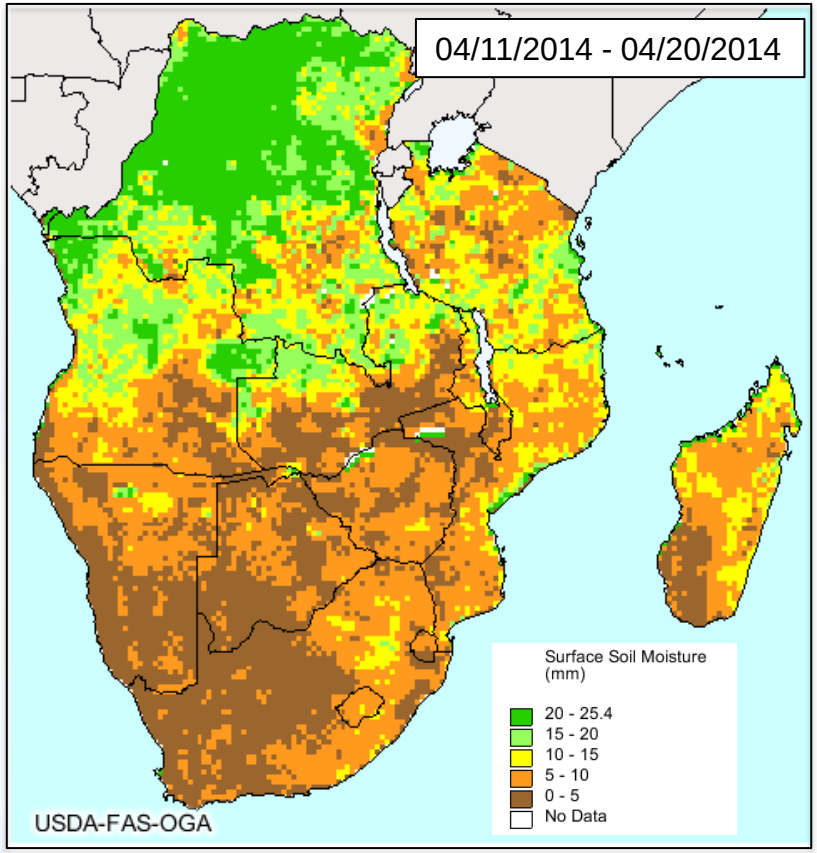


Water Resources – Project Summary

Model



Model + satellite observations



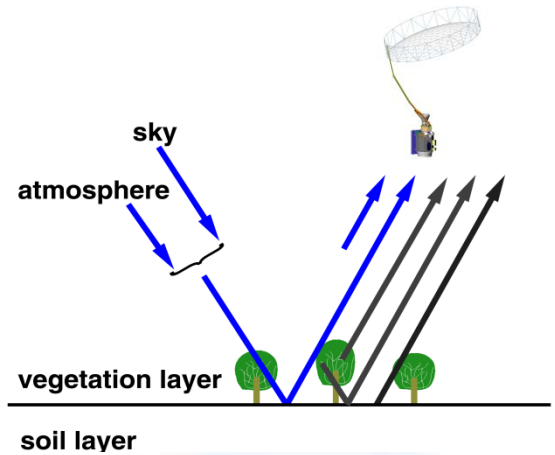
http://www.pecad.fas.usda.gov/cropexplorer/

Satellite-based soil moisture observations are improving USDA's ability to globally monitor agricultural drought and predict its short-term impact on vegetation health and agricultural yield.

John D. Bolten
NASA/GSFC

System Definition

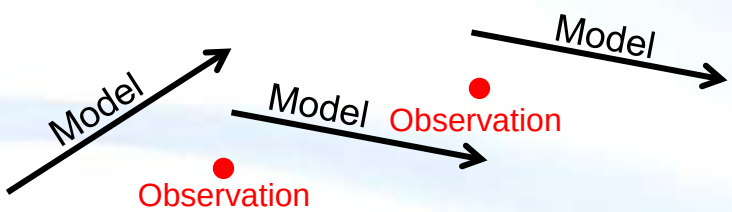
Soil Moisture Remote Sensing:



- LPRM AMSR-E soil moisture product
- Passive micro., C-band, 40-km resolution
- Descending orbits only, once every 2-3 days
- July 2002 to December 2010
- 0-5 cm surface soil moisture

- LPRM SMOS soil moisture product
- Passive micro., L-band, 30-km resolution
- Global coverage once every 2-3 days
- Launched November 2009,
- Integrated in Spring 2012 - present
- 0-5 cm surface soil moisture

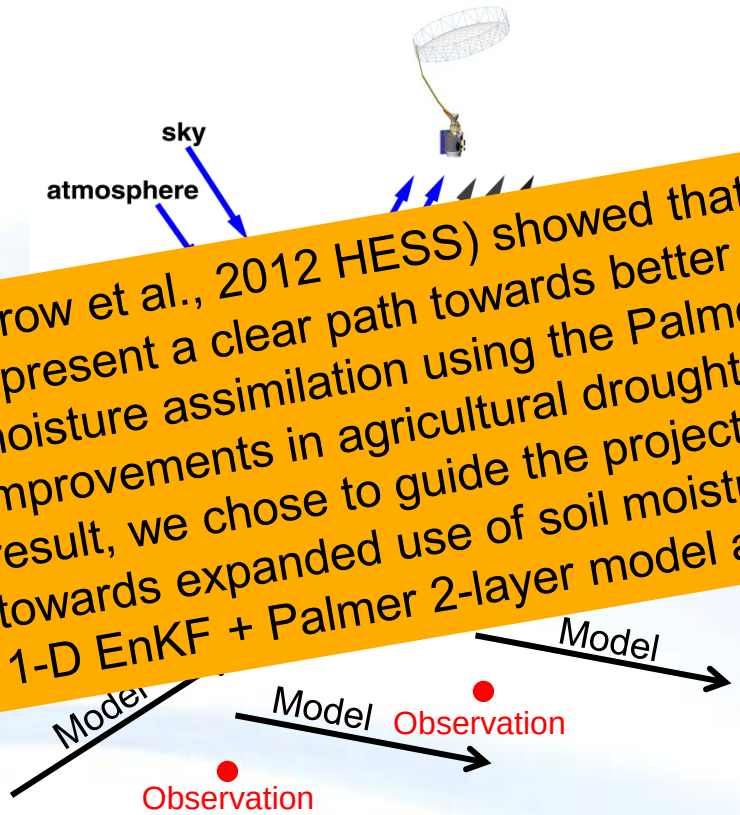
Soil Moisture Data Assimilation:



- 30-member Ensemble Kalman filter (EnKF)
- 2-layer Palmer Model
- Use EnKF to update root-zone
- Obs. error defined by climatological NDVI
- 0.25° analysis grid

System Definition

Soil Moisture Remote Sensing:



- LPRM AMSR

(Crow et al., 2012 HESS) showed that the more complex models in LIS do not represent a clear path towards better agricultural drought monitoring. In contrast, soil moisture assimilation using the Palmer 2-layer model lead to significant improvements in agricultural drought monitoring (Bolten et al., 2012 GRL). As a result, we chose to guide the project away from the more complex models in LIS and towards expanded use of soil moisture data assimilation system demonstrated by the 1-D EnKF + Palmer 2-layer model approach.

- 30-member Ensemble Kalman filter (EnKF)
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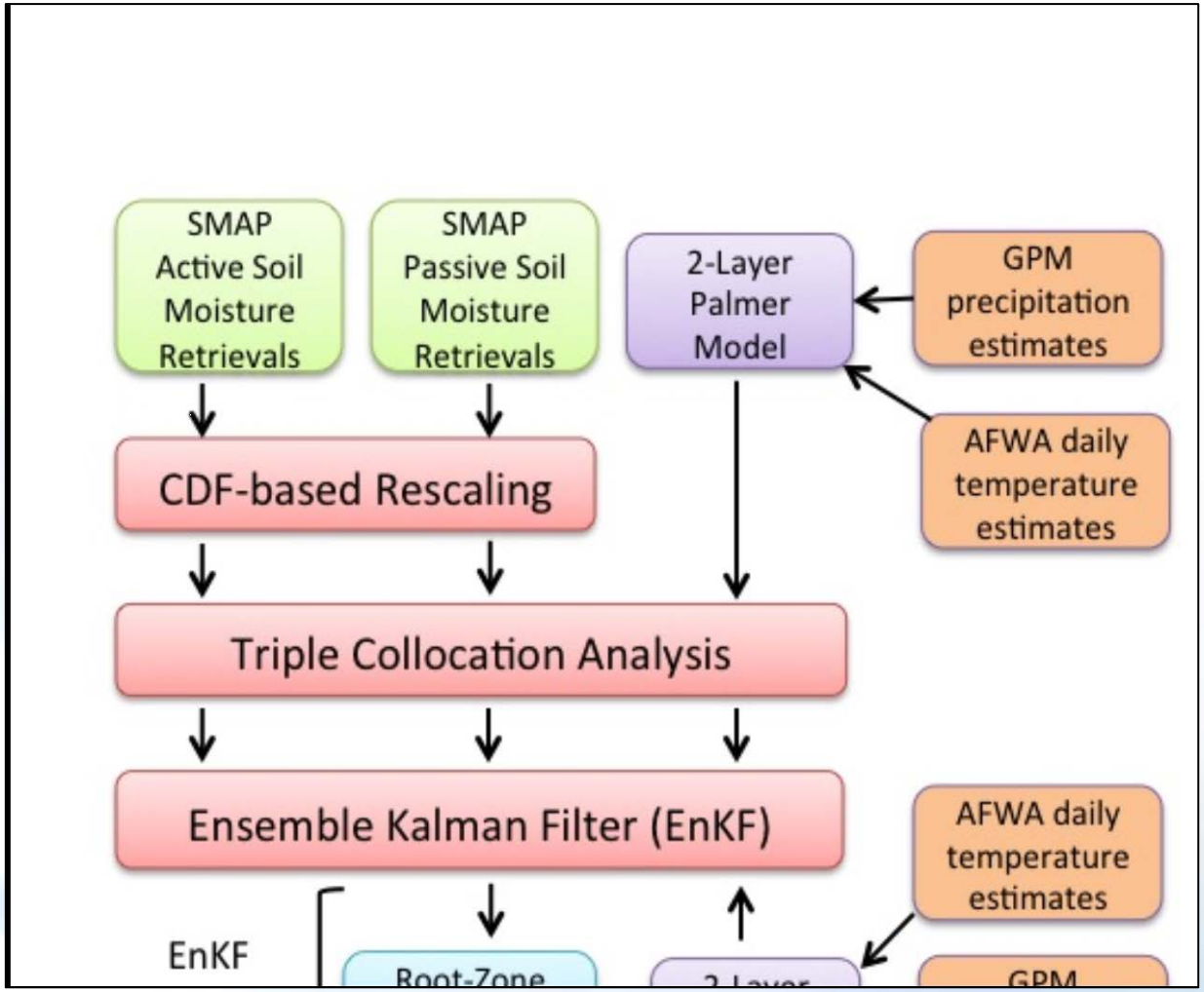
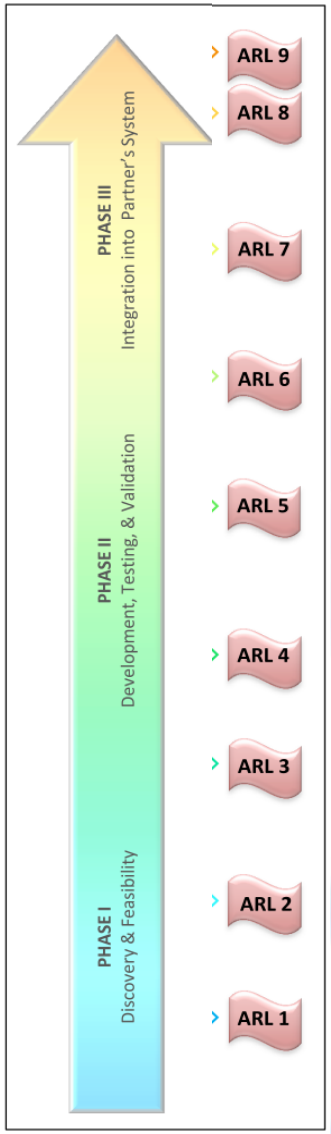
Project Schematic



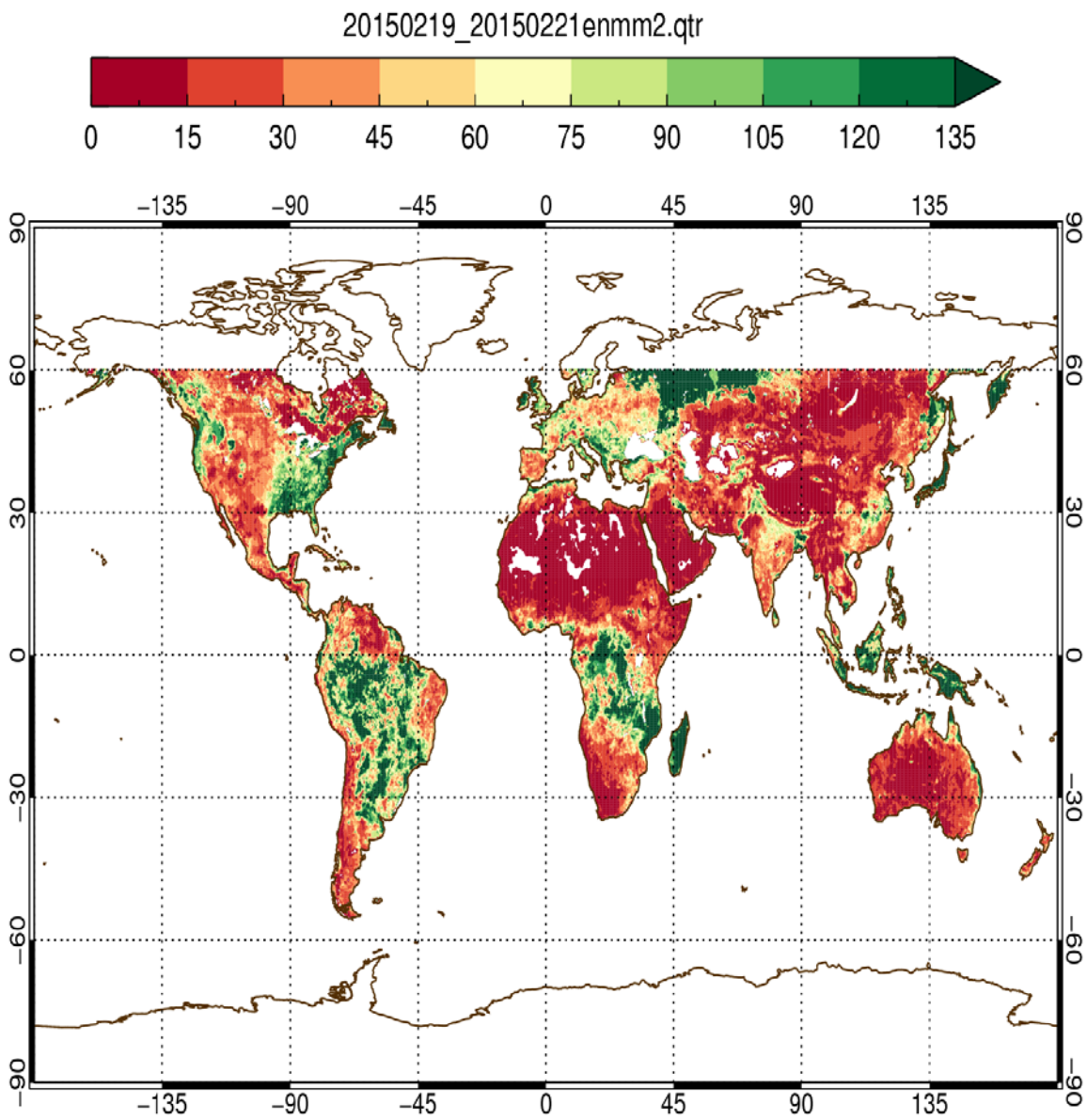
Performance/ARL and Transition Strategy

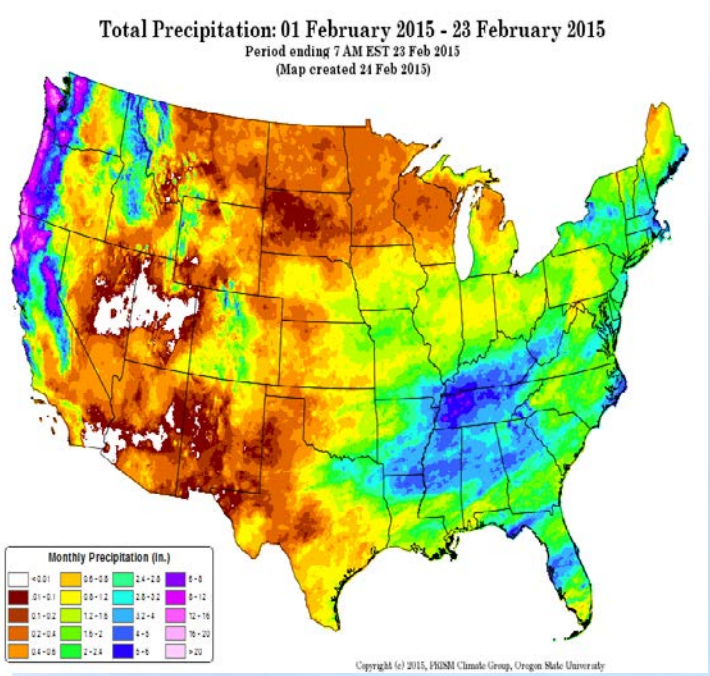


- Start of project ARL = 3 *(01/01/15)*
- Current ARL = 3
  - Project was selected in late CY 2014
- Expected Ending ARL = 8 *(12/31/2018)*

<u>Goals for end of year 1 (September, 30, 2015)</u>
Complete pre-processing of GPM data to USDA Palmer soil moisture model modeling grid and climatology (Task 1)
Commence modification of ASCAT/SMOS data assimilation system to ingest GPM observations (Task 2)

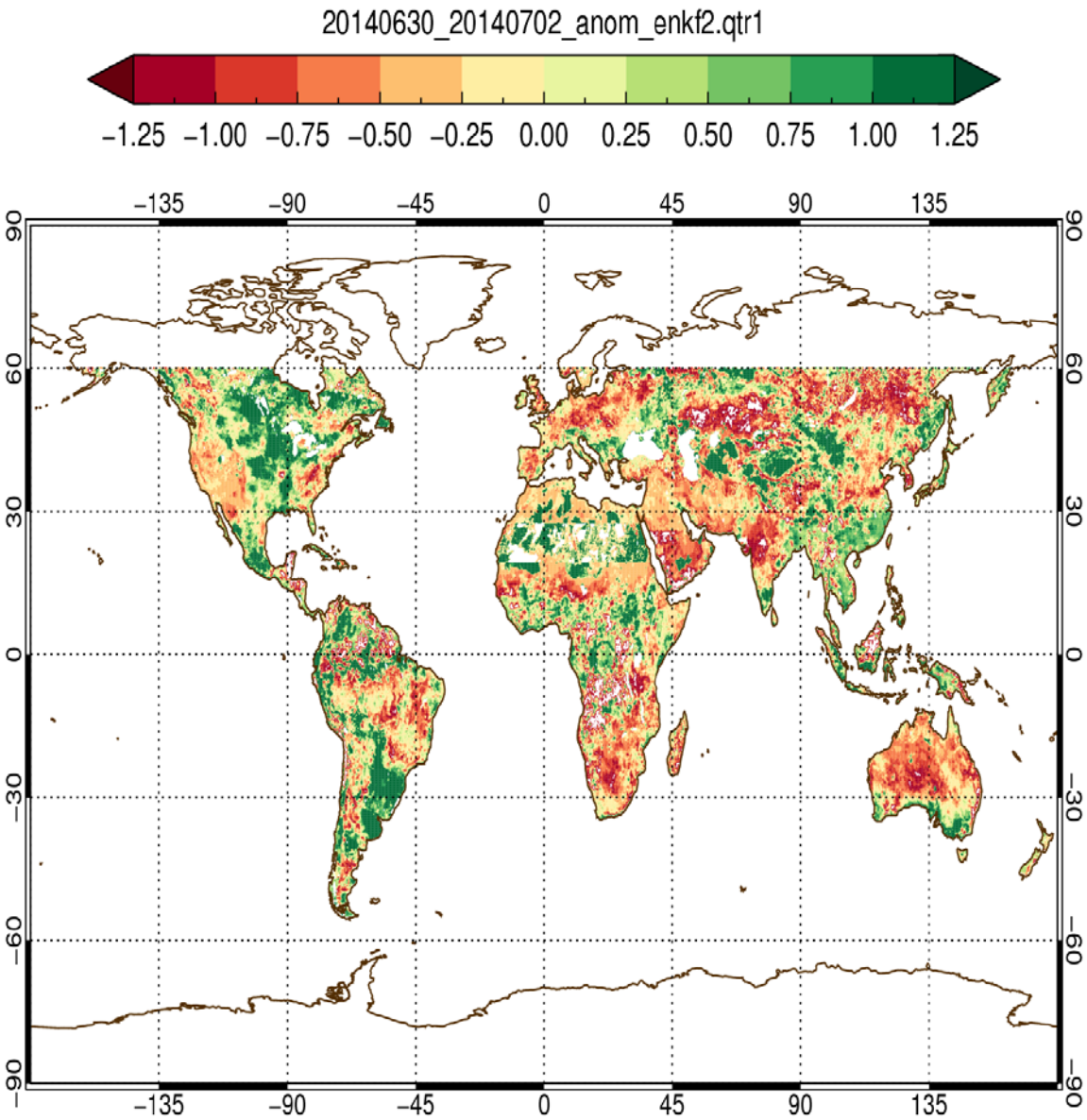
Root-Zone Soil moisture [mm]





http://www.prism.oregonstate.edu/mtd/

Anomaly Product



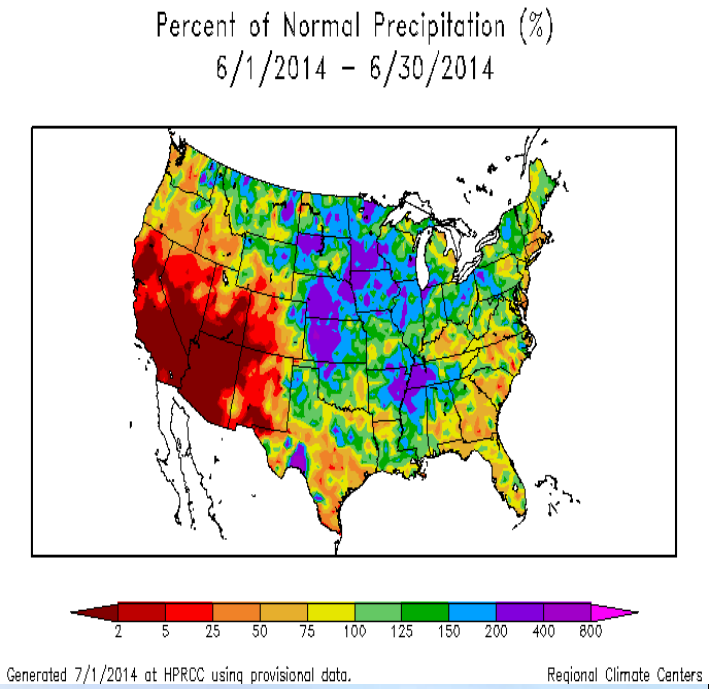
Product description:

Surface and root-zone (*example shown here*) soil moisture anomalies

3-days composite

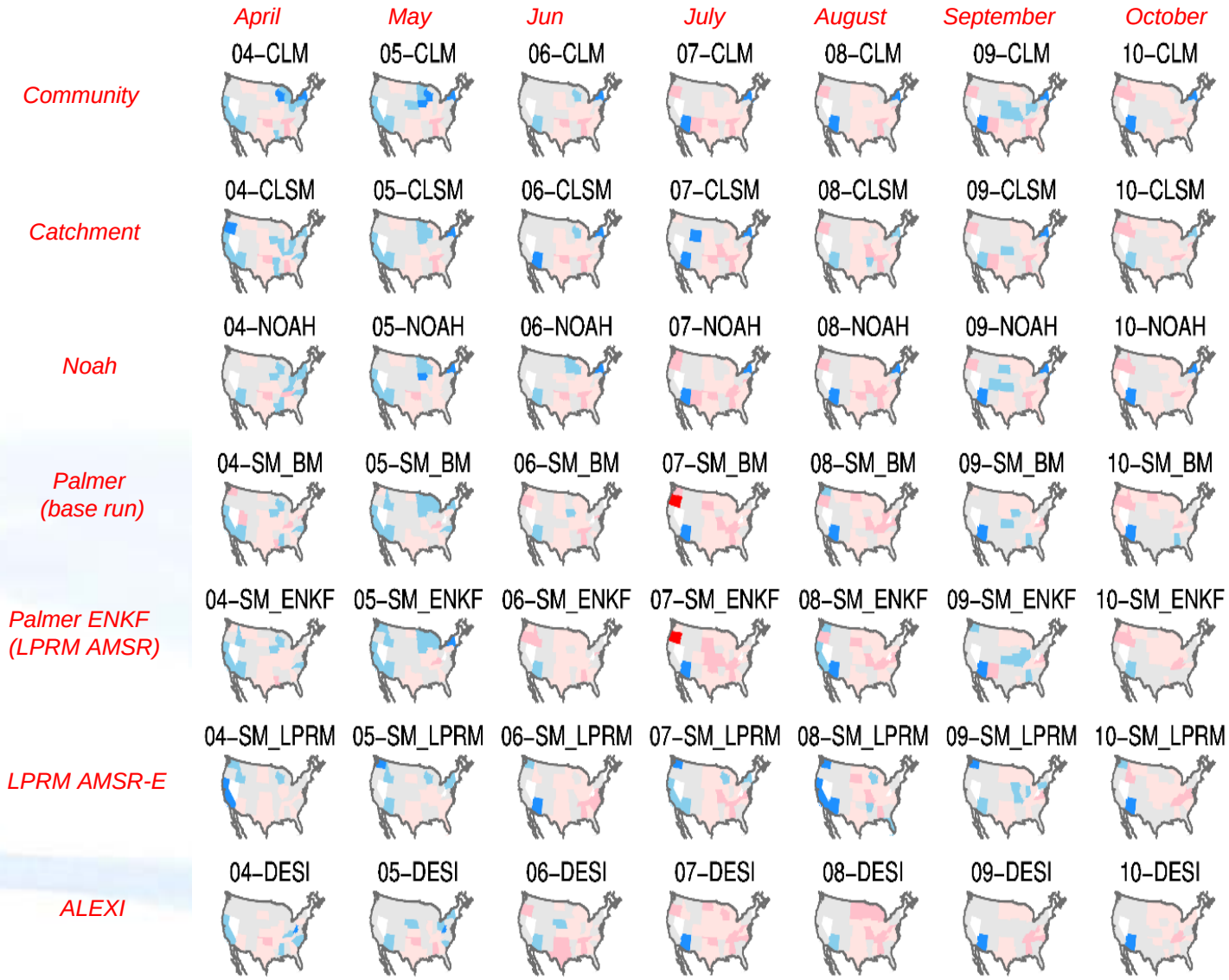
Standardized anomalies

Computed using 30 days moving window



courtesy: http://www.ncdc.noaa.gov/sotc/synoptic/2014/6

Yield Monitoring and Prediction over the US

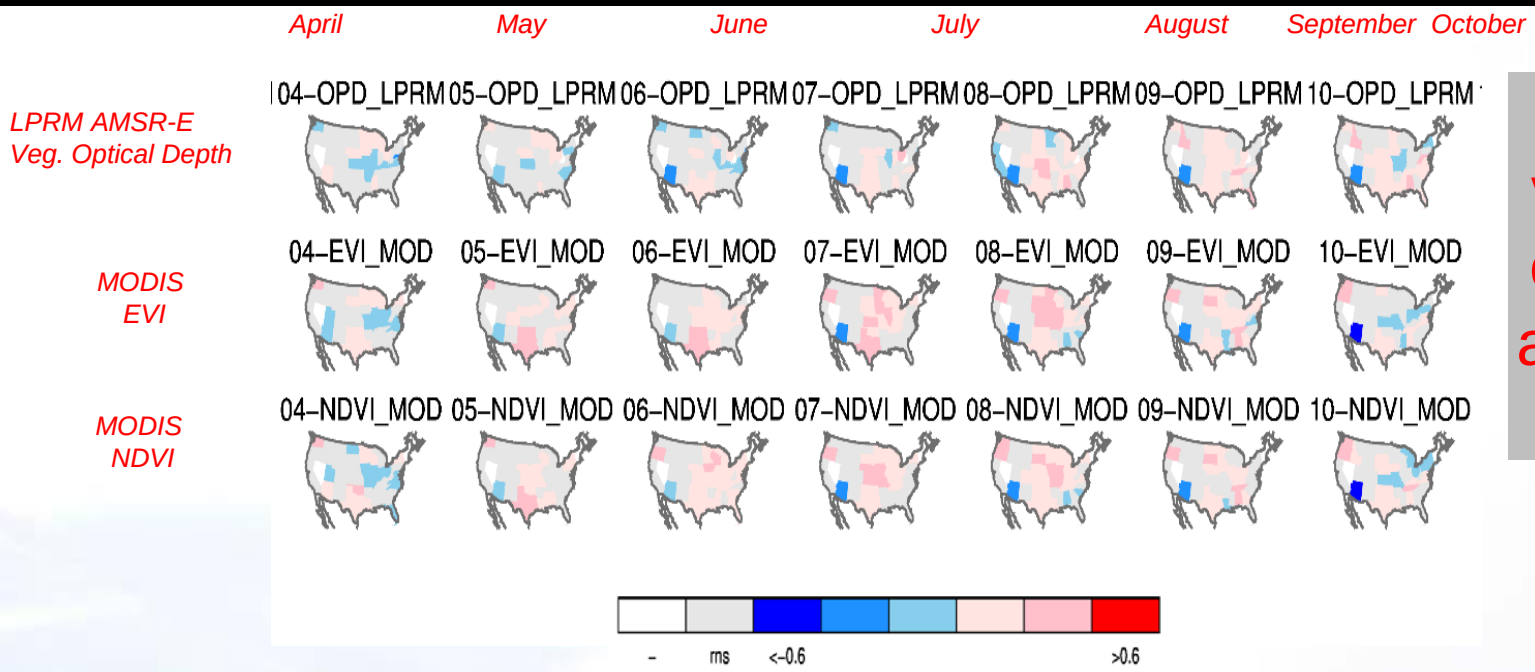


Yield–soil moisture correlation analysis for corn

Mladenova, Bolten, Anderson, Crow 2015 – In prep

Soil Moisture Products

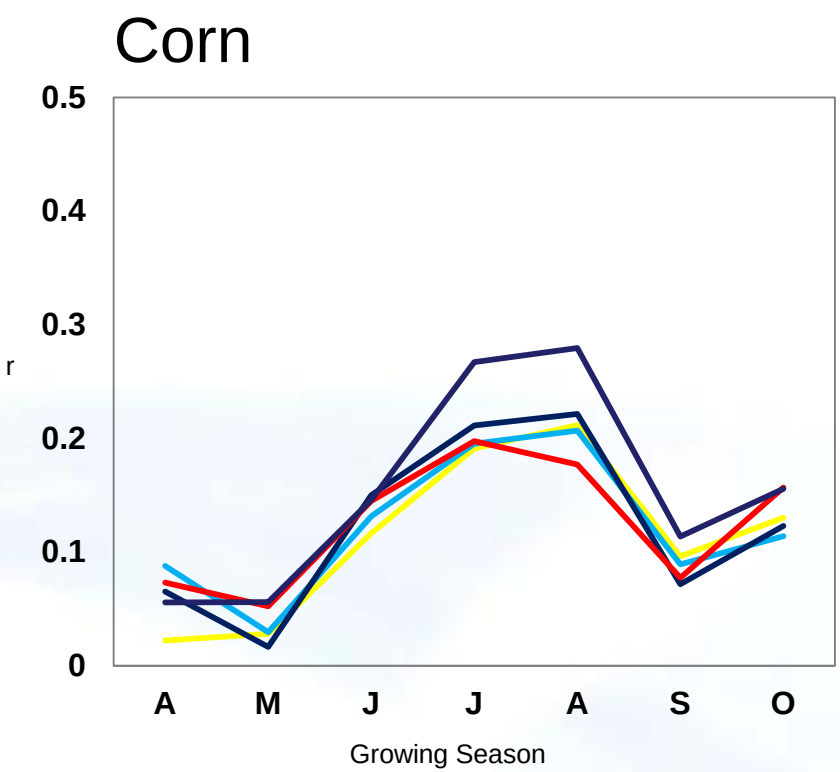
Yield Monitoring and Prediction over the US

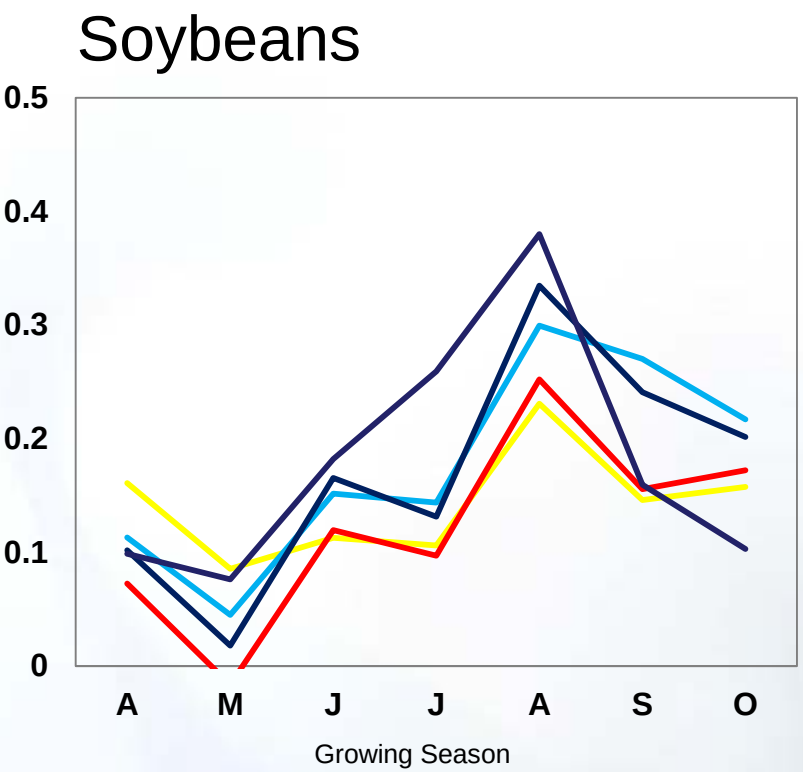


Yield–vegetation correlation analysis for corn

Vegetation Products

Yield Monitoring and Prediction over the US





NOAH
Palmer (base run)
Palmer (ENKF; AMSR-E, LPRM)
AMSR-E (LPRM)
ALEXI (DESI)

Lessons Learned From Crow et al. Project

- Importance of strategy for continued availability of soil moisture product and establish contingency plan for back-up soil moisture delivery and integration
- Need for continued and frequent engagement of end user
- Quantitative analysis and feedback from end user on product performance has proven difficult due to USDA FAS crop forecast confidentiality
  - By working closely with the stakeholders, we have been able to effectively guide the product format development and delivery

Thank you…..questions?

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