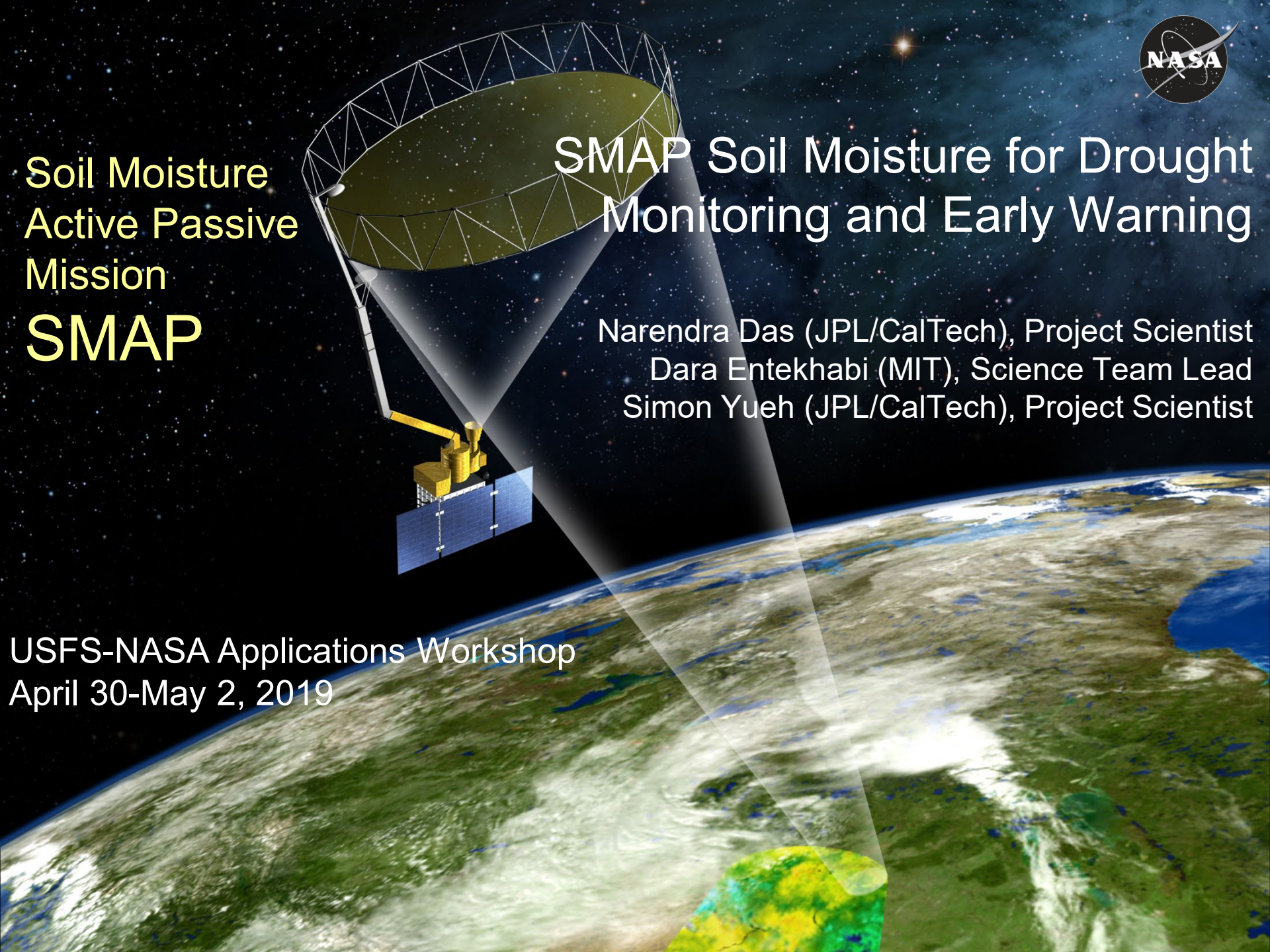


SMAP Soil Moisture for Drought Monitoring and Early Warning

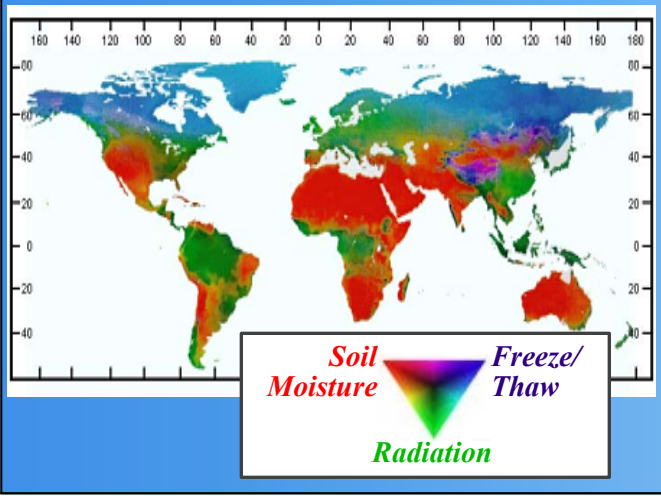
Narendra Das (JPL/CalTech), Project Scientist
Dara Entekhabi (MIT), Science Team Lead
Simon Yueh (JPL/CalTech), Project Scientist

USFS-NASA Applications Workshop
April 30-May 2, 2019

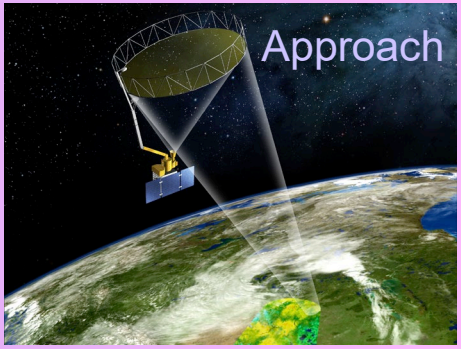
SMAP Program-Level Requirements (PLRA)

Science Returns

Understand Processes that ***Link*** the Terrestrial Water, Energy, and Carbon Cycles

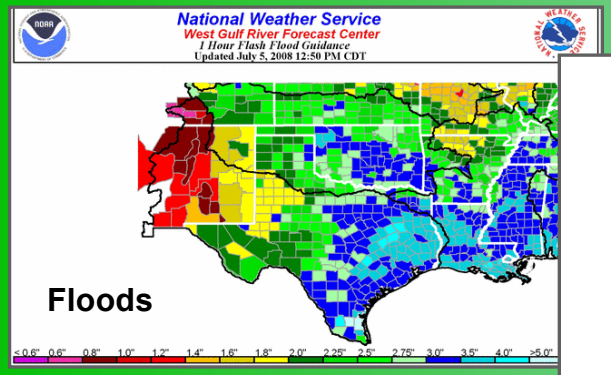


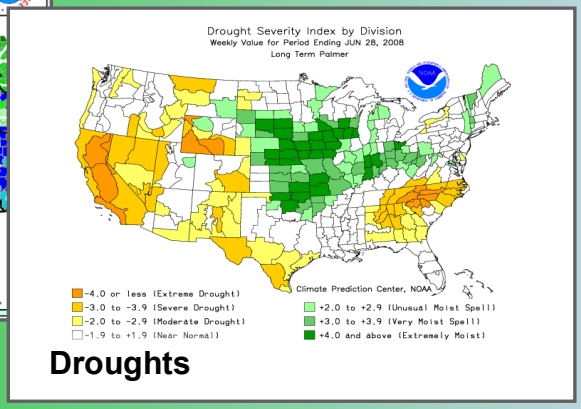
1. Estimate global surface water and energy fluxes
2. Quantify net carbon flux in boreal landscapes
3. Reduce uncertainty of climate model projections



L-band (~21 cm; All-Weather; Canopy Penetration; Sensing Depth)

Applications Returns



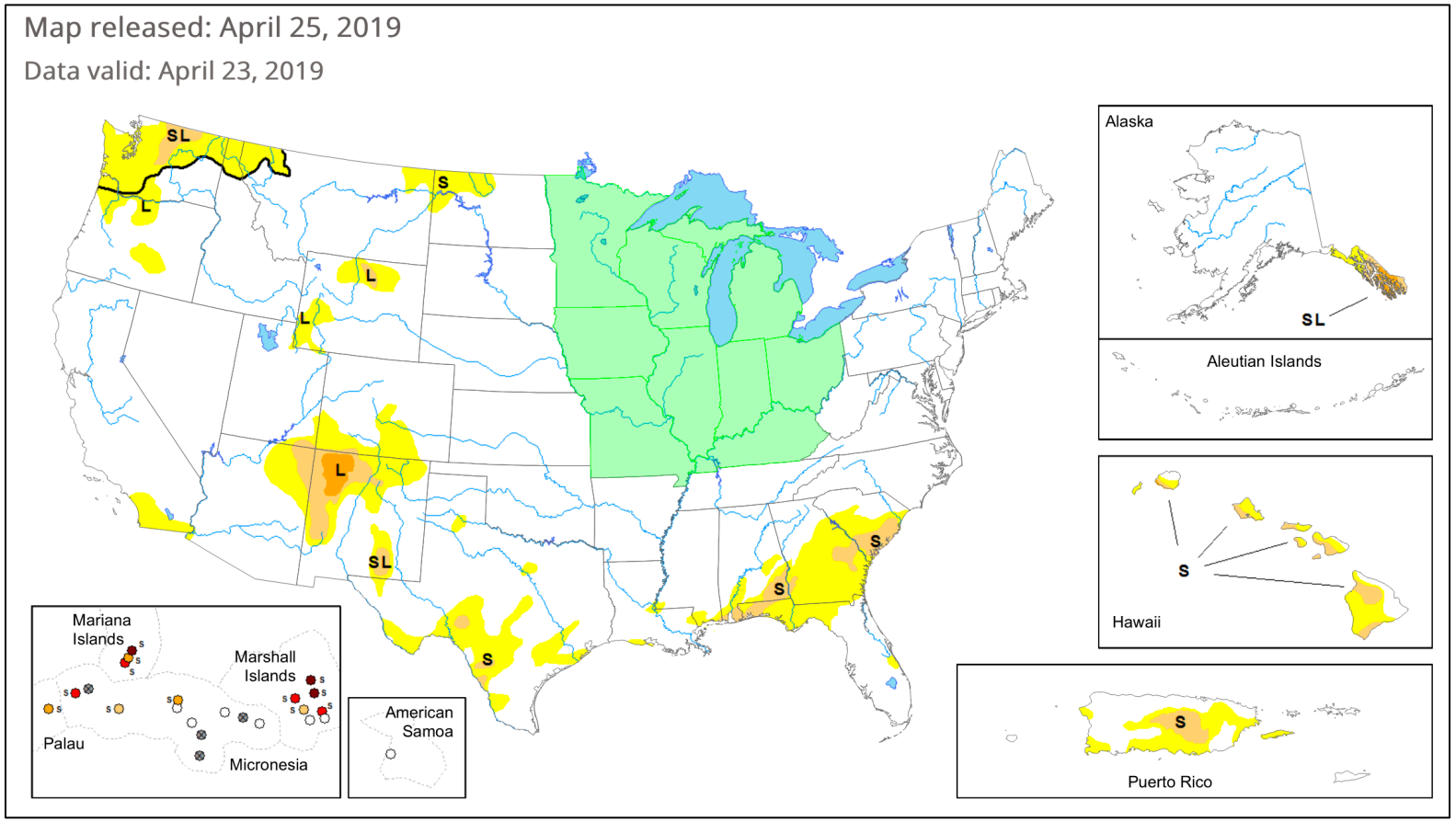


4. Enhance weather forecasts
5. Improve flood prediction and drought monitoring

6m conically scanning (14 rpm) antenna for 1000 km swath

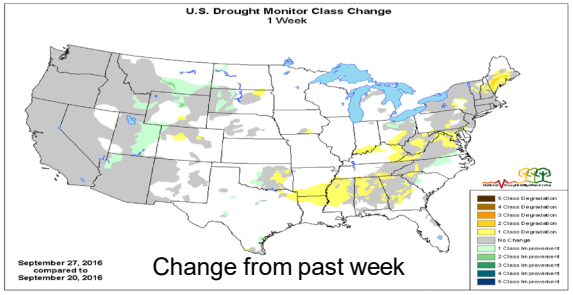
Global coverage every 2-3 days

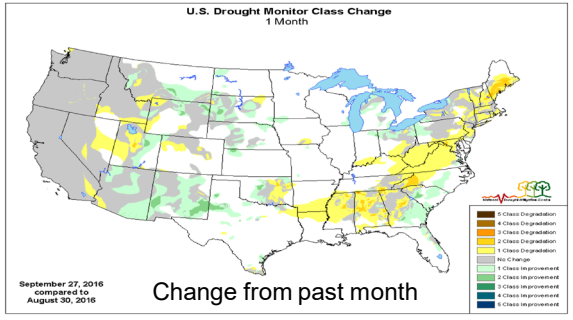
Drought Monitor (DM) from National Drought Mitigation Center (NDMC)

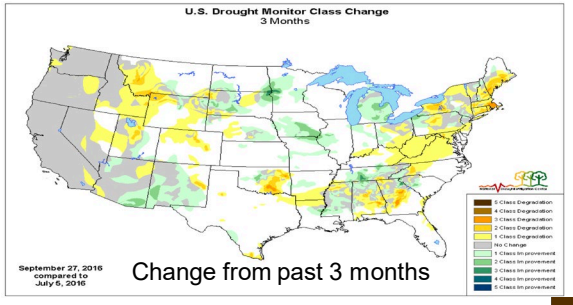


SMAP Data Used For Operational Drought Extent and Recovery Assessment

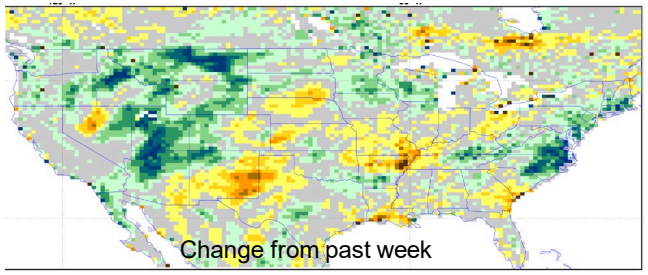
US Drought Monitor Change Maps

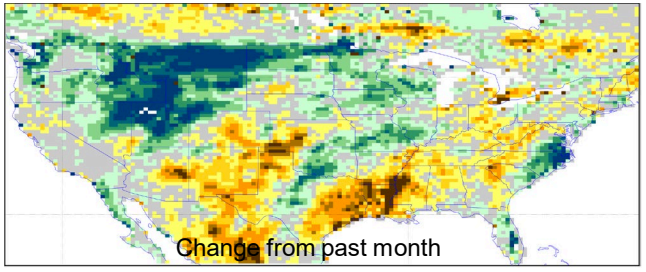


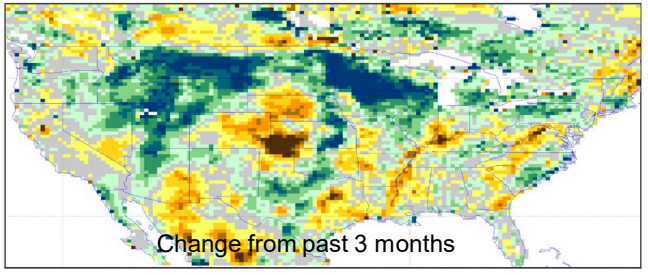


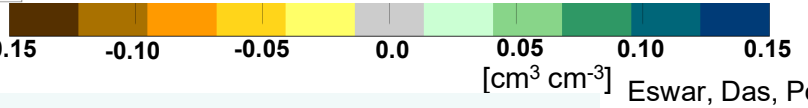


Soil Moisture Change From SMAP









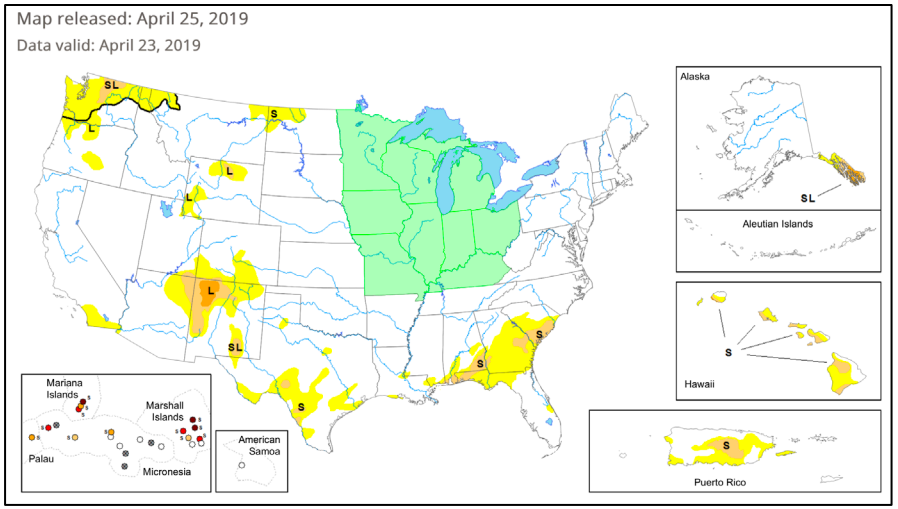
Problem: National Drought Mitigation Center (NDMC) provides information to State Climatologists who issues maps of drought severity and its recovery status using model soil moisture.

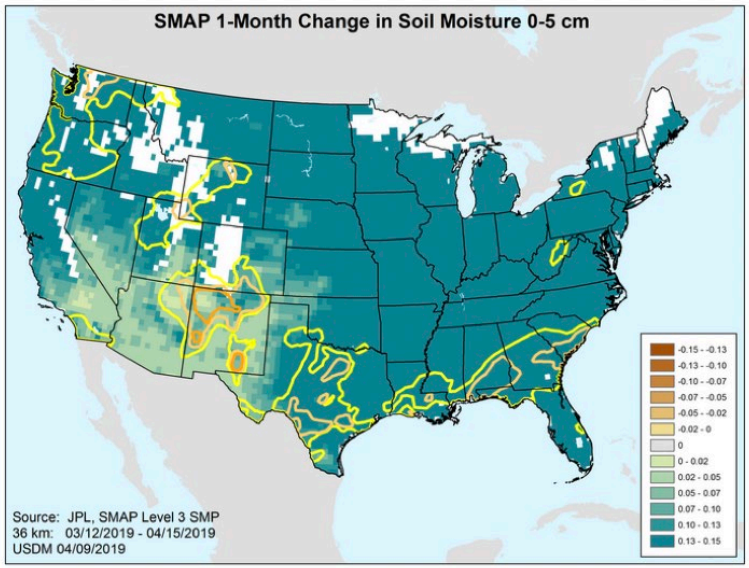
Finding: The SMAP Soil Moisture Change Maps provide NDMC broader coverage and complement the its operational *US Drought Monitor* product.

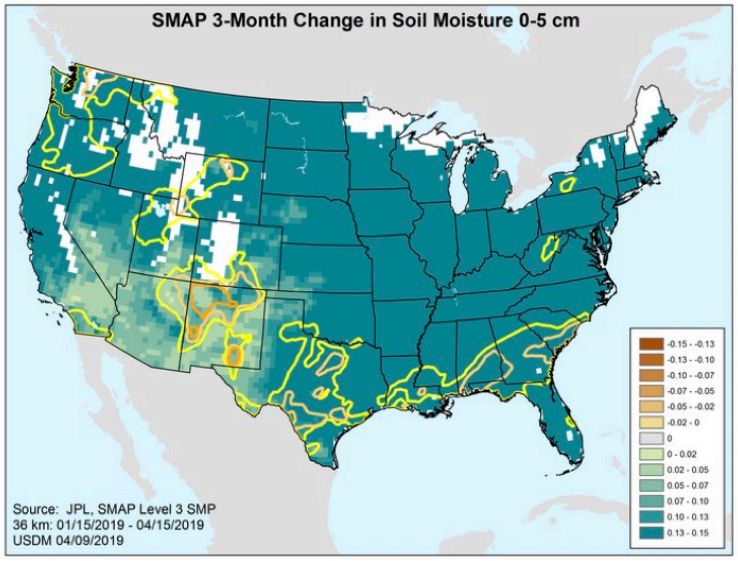
Impact: SMAP provide direct mapping of soil moisture changes governing drough extent and recovery

Eswar, Das, Poulsen, Behrangi, Swigart, Svoboda, Entekhabi, Yueh, Doorn, Entin, 2018: SMAP soil moisture change as an indicator of drought conditions. *Remote Sensing.*

US Drought Monitor and SMAP Soil Moisture Change (Current 1 month and 3 months)

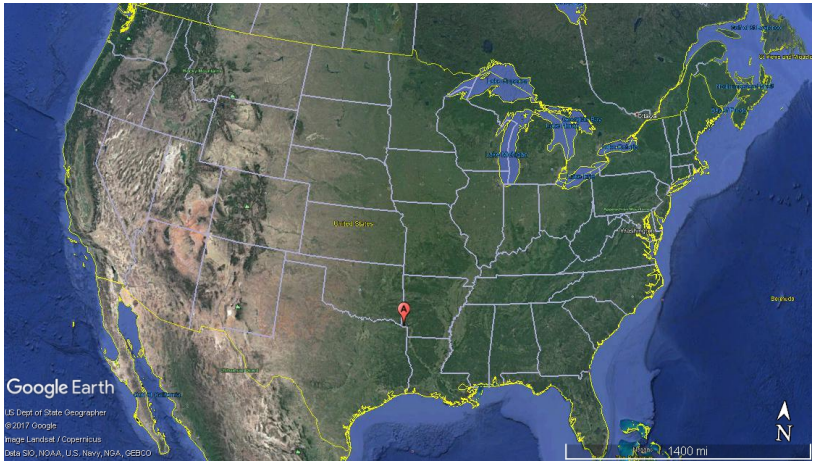




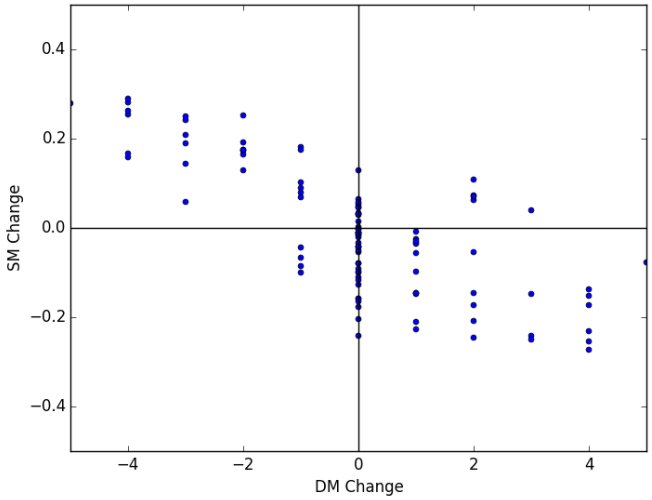


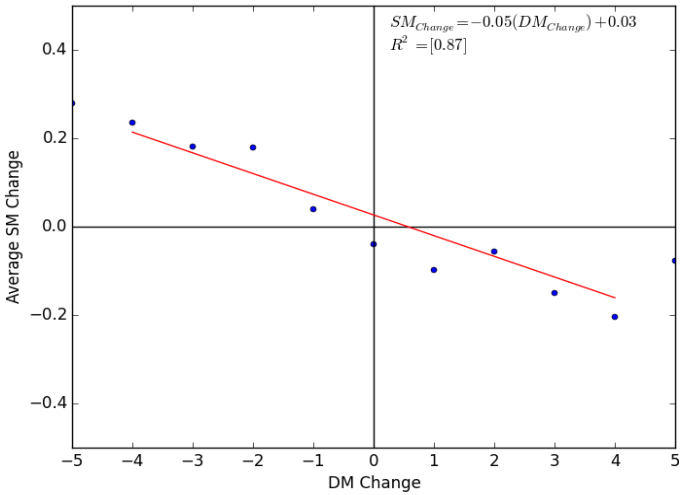
An Example Site Comparison

SMAP soil moisture changes and
DM categorical changes (D1 to D4)

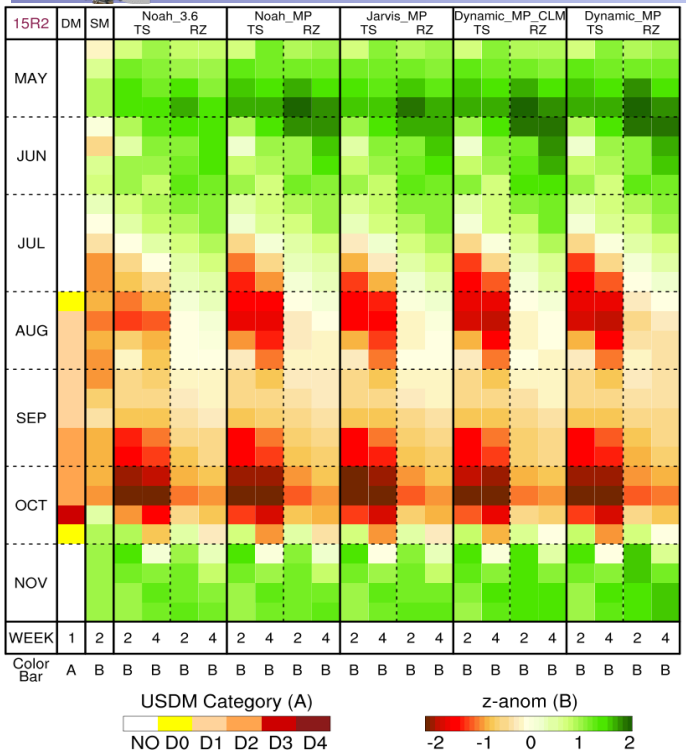


Change with 13 weeks interval for the
M36 grid 33. 62924 N and 94.294609 W





Detection of Flash Recovery-Flash Drought in 2015 over the South-Central U.S.



Drought evolution across the south-central U.S. in 2015. The USDM analysis is shown in column 1 followed by anomalies of SMAP in column 2. Anomalies (based on 1979-2017) of top soil (TS) and root zone (RZ) soil moisture from the Noah 3.6, Noah-MP, Jarvis-MP, Dynamic-MP-CLM, and Dynamic MP simulations are shown in subsequent columns.

Problem: The 2015 growing season across the south-central U.S. was characterized by an unusual sequence of events where parts of the region saw a drought end with a pluvial in the spring, followed by a period of rapid drought intensification (*flash drought)* during late summer that was terminated by heavy rainfall at the end of October, which eliminated drought conditions over a two-week period (*flash recovery*)

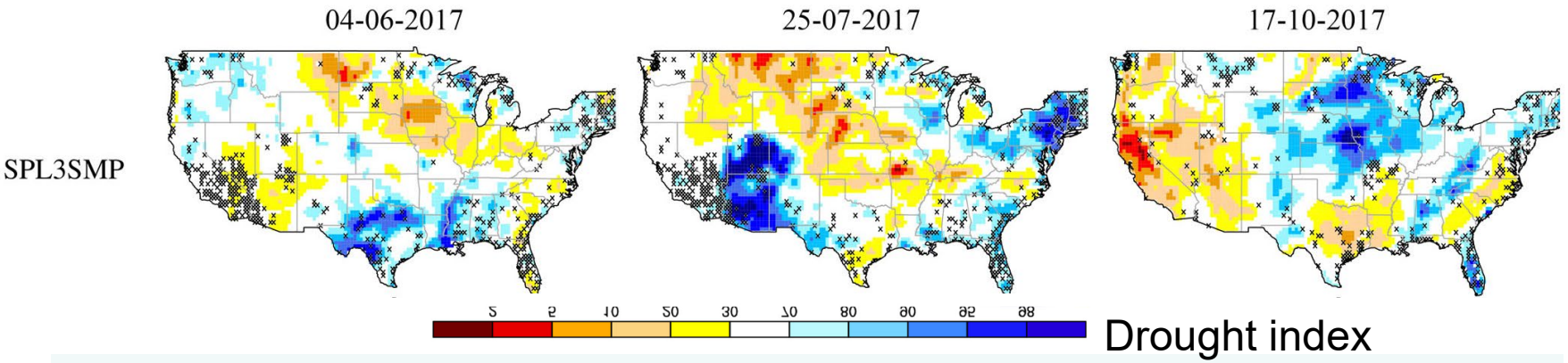
Finding: Using NLDAS forcing for five different land surface model simulations in the Land Information Systems (LIS) framework and 36-km L3 Soil Moisture Active Passive (SMAP) data, we determined that SMAP anomalies correctly characterized the rapid changes in the region and the LIS simulations provided an overall accurate characterization, while also providing enough variability in output to determine more optimal configurations for future analysis of flash drought and flash recovery.

Impact: The accurate characterization of the sequence of flash drought to flash recovery increases confidence that SMAP can be used to assess rapid changes in soil moisture conditions in data-sparse regions.

Otkin, Zhong, Hunt, Basara, Svoboda, Anderson, Hain, 2019: Assessing the evolution of soil moisture and vegetation conditions during a flash drought-flash recovery sequence over the south-central Unites States. *Journal of Hydrometeorology.*

Developing a Drought-Monitoring Index for the Contiguous US Using SMAP

Problem: There has been no high-quality systematic soil moisture observations to enable monitoring of drought conditions globally.



Finding: This figure shows drought during the period from 4 June through 17 October 2017, for the near surface. In this period, there was one agricultural drought event in Montana and North and South Dakota, with losses exceeding USD 1 billion across the United States. The plains of eastern Montana experienced exceptional drought from July to October 2017, and in late October, drought started to end.

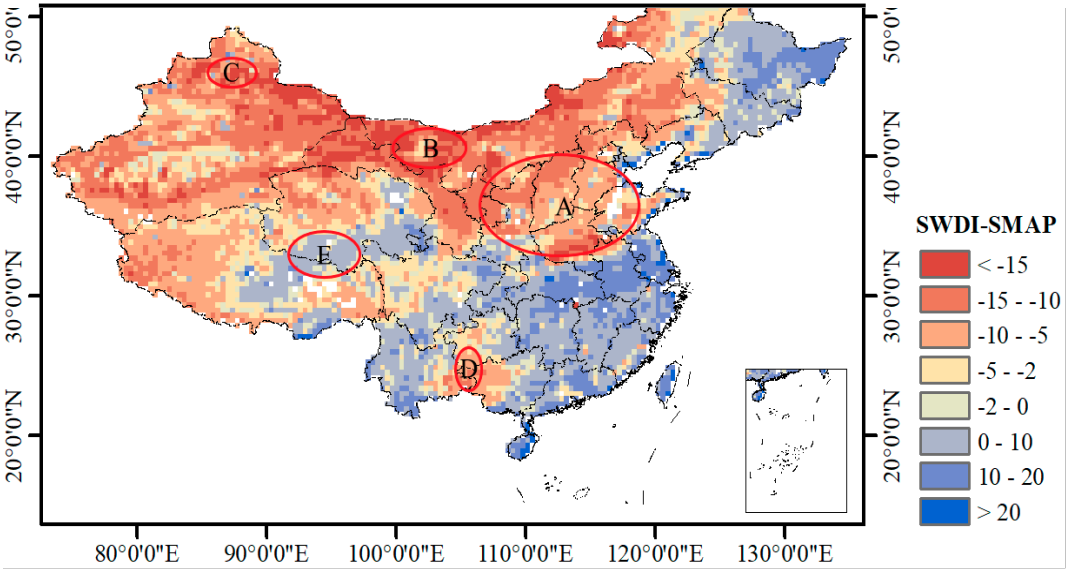
Impact: The results here provide significant support for a global SMAP drought and pluvial conditions monitoring system. It is important that the future developments focus on drought assessment using SMAP in underrepresented parts of the world.

Sadri, Wood, Pan, 2018: Developing a drought-monitoring index for the contiguous US using SMAP, *Hydrology and Earth System Sciences.*

SMAP-Derived Soil Water Deficit Index tracks Agricultural Drought in China

Problem: Agriculture drought has a severe impact on global food production; there is a need of accurate satellite data for global monitoring.

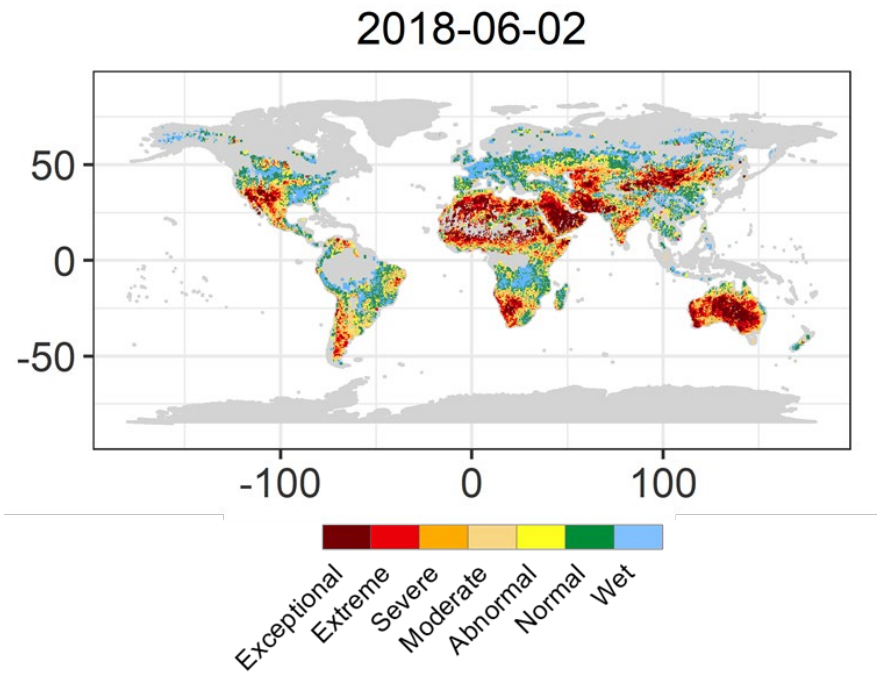
Finding: The SMAP-Derived Soil Water Deficit Index (SWDI-SMAP) is compared with the atmospheric water deficit (AWD) and vegetation health index (VHI). Spatial distribution of the SWDI-SMAP across China for the month of June 2016 (regions A–E denote representative areas with drought differences between the SWDI-SMAP and VHI. There are severe and extreme drought in region A-C and moderate drought in region D on the SWDI-SMAP; however, the drought conditions are much lighter, or there is no drought, on the VHI.



Impact: The SWDI-SMAP has a good overall performance on drought monitoring.

Bai, Cui, Chen, Yu, Mao, Meng, Cai, 2018: Assessment of the SMAP-derived soil water deficit index as an agricultural drought index in China. *Remote Sensing.*

Global Agricultural Drought Monitoring in Near-Real-Time using SMAP



Global agricultural drought severity measured in terms of soil moisture stress for 2nd June 2018.

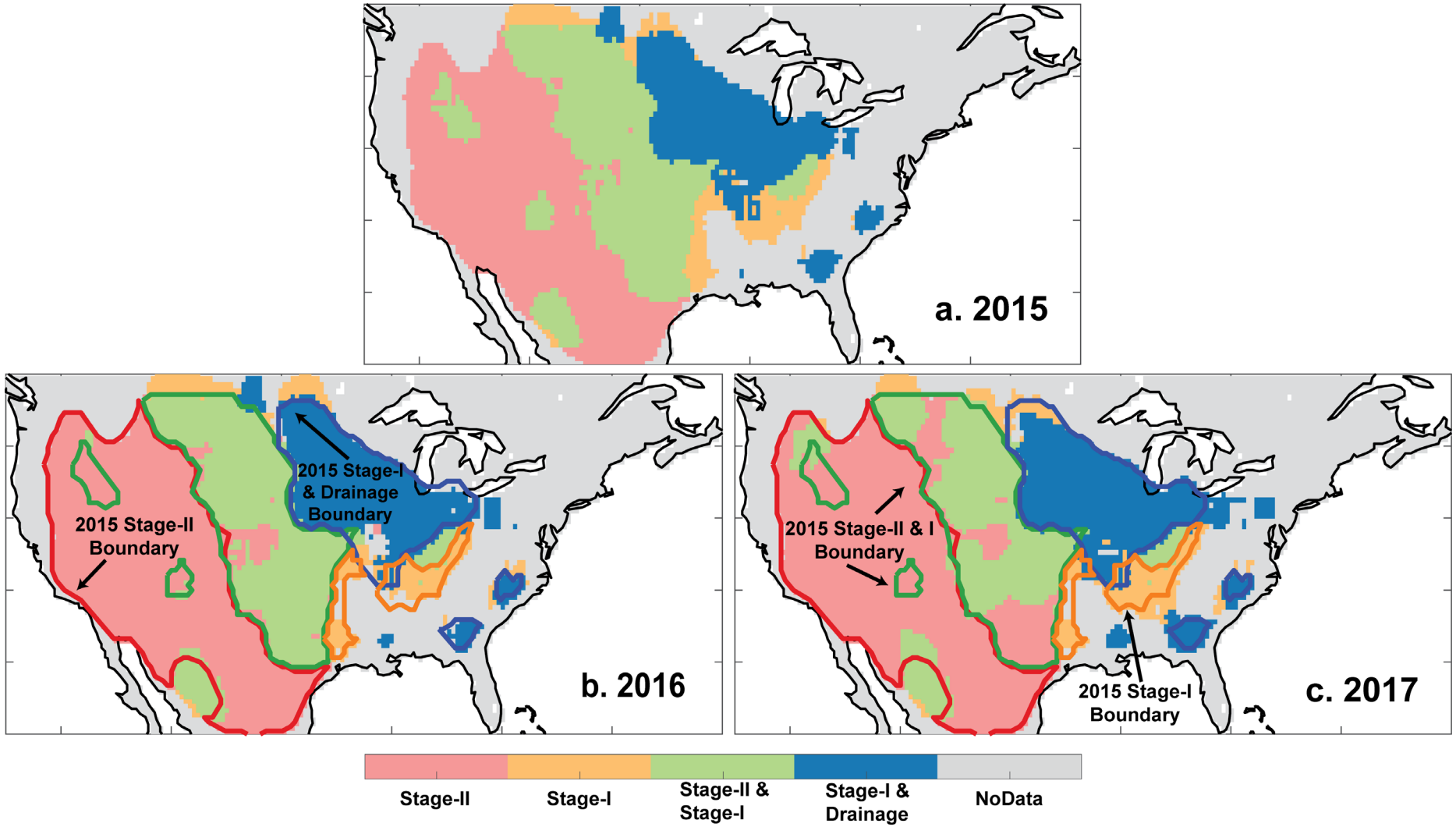
Problem:
Agricultural drought monitoring is limited by lack of long term observations and understanding of effective soil drydown processes from farmers' field, county, region, continent, to global scales.

Finding: Using multi-year SMAP data, characteristics soil moisture drydown at SMAP footprint scale can be parameterized using canonical forms. SMAP-derived drydown provide effective soil water retention and hydraulic parameters, which can be used to calculate plant stress due to emergent drought conditions in near-real time globally.

Impact: Improved understanding of effective soil drydown processes at remote sensing footprint scales under biophysical heterogeneity and seasonality. Near-real-time global monitoring of emergent drought conditions, leading to mitigation strategies.

Mohanty, Cosh, Lakshmi, Montzka, 2017: Soil moisture remote sensing – State-of-the-science, *Vadose Zone Journal*.
Sehgal, Gaur and Mohanty, 2018: Global drought monitoring using SMAP soil moisture and effective soil water hydraulic parameters. *AGU Fall Meeting*.

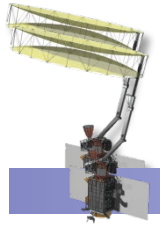
Dominant Hydrological Regimes
Year-to-Year Change (2015 to 2017)



Using only SMAP soil moisture!

Akbar, Gianotti, McColl, Haghighi, Salvucci, Entekhabi: 2018, *JHM.*

Anatomy of a “Flash Drought”



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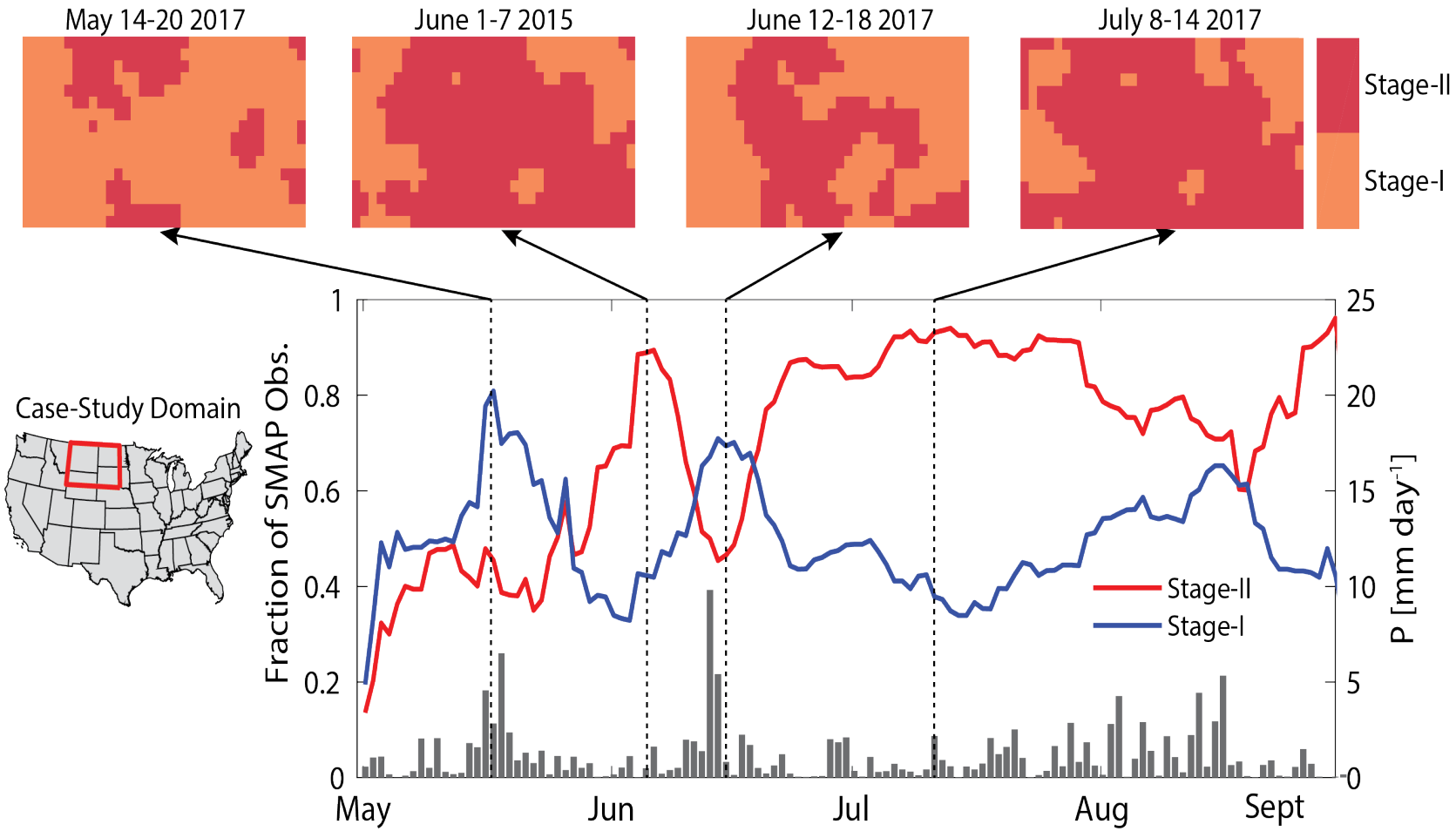
News & Features

‘Flash Drought’ Spreads Across Montana in Less Than 3 Months

More than a third of the entire state is now in severe, extreme or exceptional drought

BY ASSOCIATED PRESS // AUG 3, 2017

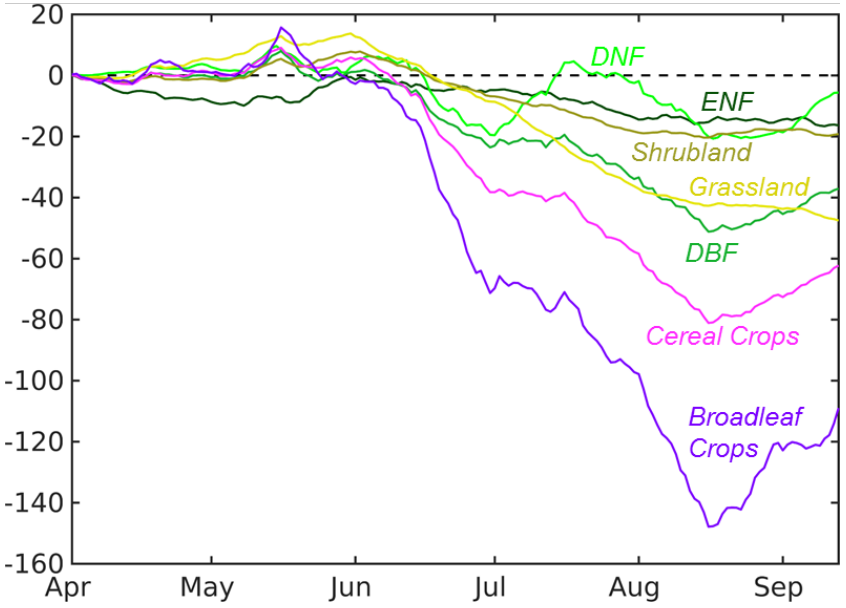


Akbar, Gianotti, McColl, Haghighi, Salvucci, Entekhabi: 2018, *JHM.*

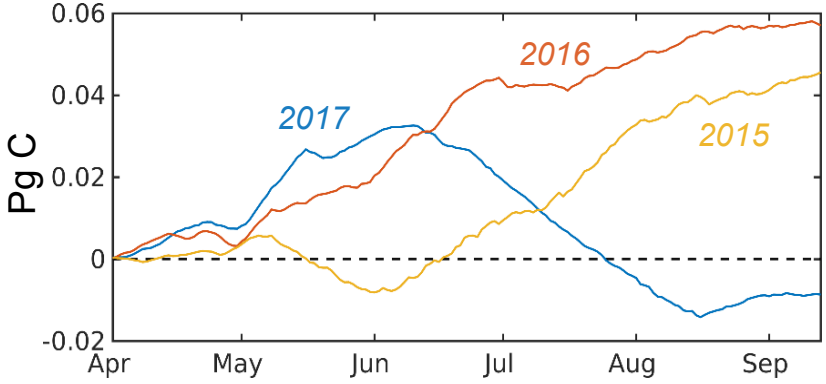
2017 Northern Plains Summer Drought Impact on L4C GPP

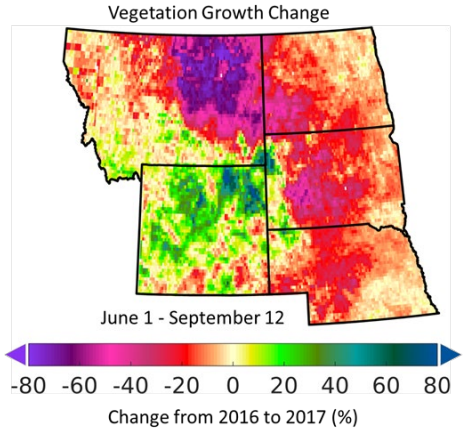
- Large GPP interannual variability (2015-17).
- Early growing season onset and spring GPP increase in 2017, followed by widespread productivity collapse due to hot, dry summer
- Regional productivity decline largely from croplands

NP Cumulative GPP Difference by PFT Class
(2017 – 2016, g C m^{-2})



NP GPP Cumulative Anomaly





J.S. Kimball, NTSG