

ARSET

Applied Remote Sensing Training

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 @NASAARSET

Overview of Soil Moisture Active Passive (SMAP) Applications

Erika Podest and Amita Mehta

Learning Objectives

By the end of this presentation, you will be able to explain how SMAP can apply to different events:

- weather prediction
- floods
- drought
- crop yield
- human health

Outline

1. SMAP Early Adopter Program
2. Samples of SMAP Data Applications

SMAP Applications

The SMAP mission is in the first tier recommended by the 2007 National Research Council (NRC) Earth Science Decadal Survey

Incorporating applications into mission plans is **not optional**, but rather:

- 1) is mandated from Congress with the NASA authorization act
- 2) is recommended as a requirement from the National Research Council
- 3) is a critical component of the SMAP Applied Sciences activities, and
- 4) quickly became a measure for the mission's success

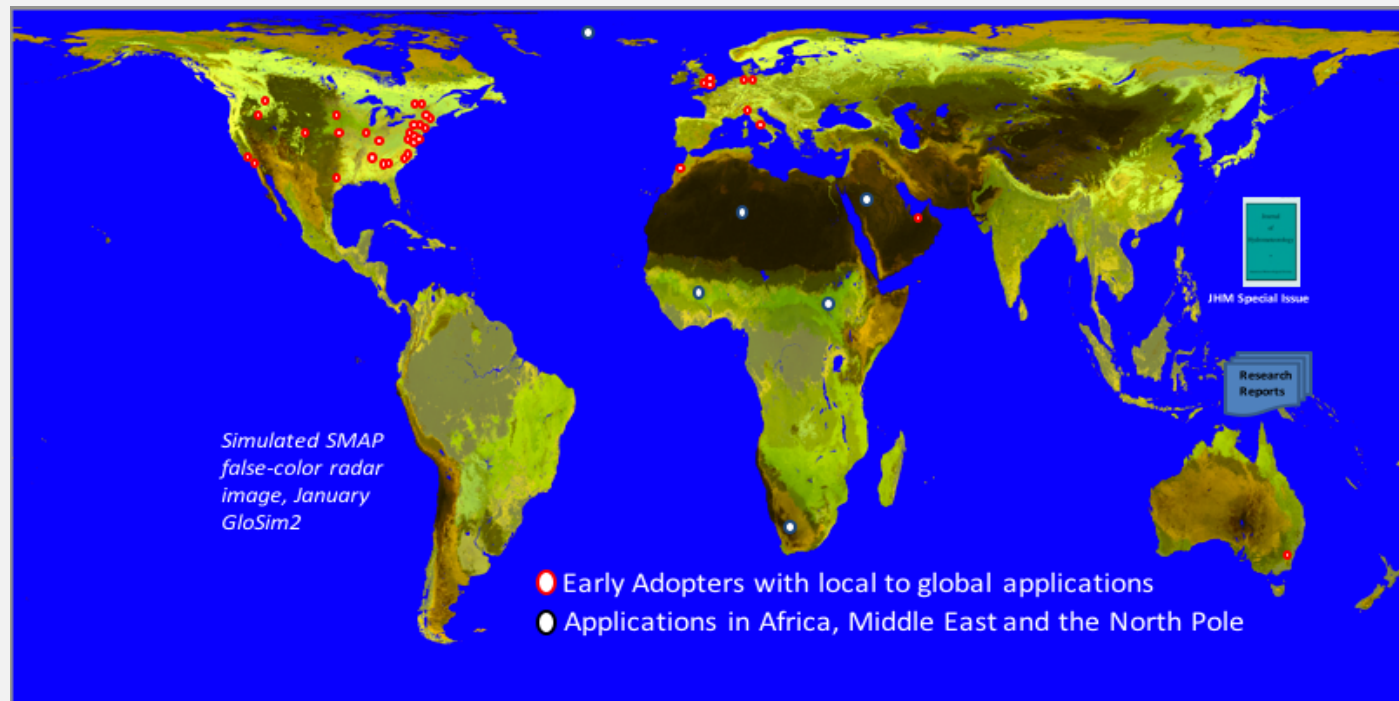
What is an application?

- **Application:** innovative use of mission data products in decision-making activities for societal benefit
- **Application Research:** provides fundamental knowledge of how mission data products can be scaled and integrated into users' activities to improve decision-making efforts
- The **user community** includes individuals or groups:
 - from the public or private sector
 - from national or international organizations
 - with decision-making on a local to global scale



SMAP Early Adopters

- The Early Adopters (EA) are a subset of the mission user community
- A volunteer effort that links the EA to the SMAP science team to trade ideas, guidance, and feedback in an effort to understand the applications of SMAP data



SMAP Applications Early Adopters

| SMAP Early Adopters†, SMAP project contacts, and applied research topics. Many Early Adopters cross multiple applications. | |
|---|--|
| Early Adopter PI and institution SMAP Contact | Applied Research Topic |
| Weather and Climate Forecasting | |
| * Stephane Bélair , Meteorological Research Division, Environment Canada (EC); SMAP Contact: Stephane Bélair | Assimilation and impact evaluation of observations from the SMAP mission in Environment Canada's Environmental Prediction Systems |
| * Lars Isaksen and Patricia de Rosnay , European Centre for Medium-Range Weather Forecasts (ECMWF); SMAP Contact: Eni Njoku | Monitoring SMAP soil moisture and brightness temperature at ECMWF |
| * Xiwu Zhan, Michael Ek, John Simko and Weizhong Zheng , NOAA National Centers for Environmental Prediction (NCEP), NOAA National Environmental Satellite Data and Information Service (NOAA-NESDIS); SMAP Contact: Randy Koster | Transition of NASA SMAP research products to NOAA operational numerical weather and seasonal climate predictions and research hydrological forecasts |
| * Michael Ek, Marouane Temimi, Xiwu Zhan and Weizhong Zheng , NOAA National Centers for Environmental Prediction (NCEP), NOAA National Environmental Satellite Data and Information Service (NOAA-NESDIS), City College of New York (CUNY); SMAP Contact: Chris Derksen | Integration of SMAP freeze/thaw product line into the NOAA NCEP weather forecast models |
| * John Galantowicz , Atmospheric and Environmental Research, Inc. (AER); SMAP Contact: John Kimball | Use of SMAP-derived inundation and soil moisture estimates in the quantification of biogenic greenhouse gas emissions |
| ◇ Jonathan Case, Clay Blankenship and Bradley Zavodsky , NASA Short-term Prediction Research and Transition (SPoRT) Center; SMAP Contact: Molly Brown | Data assimilation of SMAP observations, and impact on weather forecasts in a coupled simulation environment |
| Droughts and Wildfires | |
| * Jim Reardon and Gary Curcio , US Forest Service (USFS); SMAP Contact: Dara Entekhabi | The use of SMAP soil moisture data to assess the wildfire potential of organic soils on the North Carolina Coastal Plain |
| * Chris Funk, Amy McNally and James Verdin , USGS & UC Santa Barbara; SMAP Contact: Molly Brown | Incorporating soil moisture retrievals into the FEWS Land Data Assimilation System (FLDAS) |
| ◇ Brian Wardlow and Mark Svoboda , Center for Advanced Land Management Technologies (CALMIT), National Drought Mitigation Center (NDMC); SMAP Contact: Narendra Das | Evaluation of SMAP soil moisture products for operational drought monitoring: potential impact on the U.S. Drought Monitor (USDM) |
| ◇ Uma Shankar , The University of North Carolina at Chapel Hill – Institute for the Environment; SMAP Contact: Narendra Das | Enhancement of a Bottom-up Fire Emissions Inventory Using Earth Observations to Improve Air Quality, Land Management, and Public Health Decision Support |
| Floods and Landslides | |
| * Fiona Shaw , Willis, Global Analytics; SMAP Contact: Robert Gurney | A risk identification and analysis system for insurance; eQUIP suite of custom catastrophe models, risk rating tools and risk indices for insurance and reinsurance purposes |

SMAP Early Adopters Post-Launch

SMAP Mission Applications Themes

| | |
|---------------------------------|------------------------------------|
| Weather and Forecasting (5 EAs) | Agricultural Productivity (11 EAs) |
| Droughts (9 EAs) | Human Health (5 EAs) |
| Floods (7 EAs) | National Security/Mobility (3 EAs) |
| Carbon (1 EA) | |

SMAP Mission Applications Themes

| | |
|-----------------------------------|--|
| National Security-Sea Ice (5 EAs) | Decision Support/Communication Tools (6 EAs) |
|-----------------------------------|--|

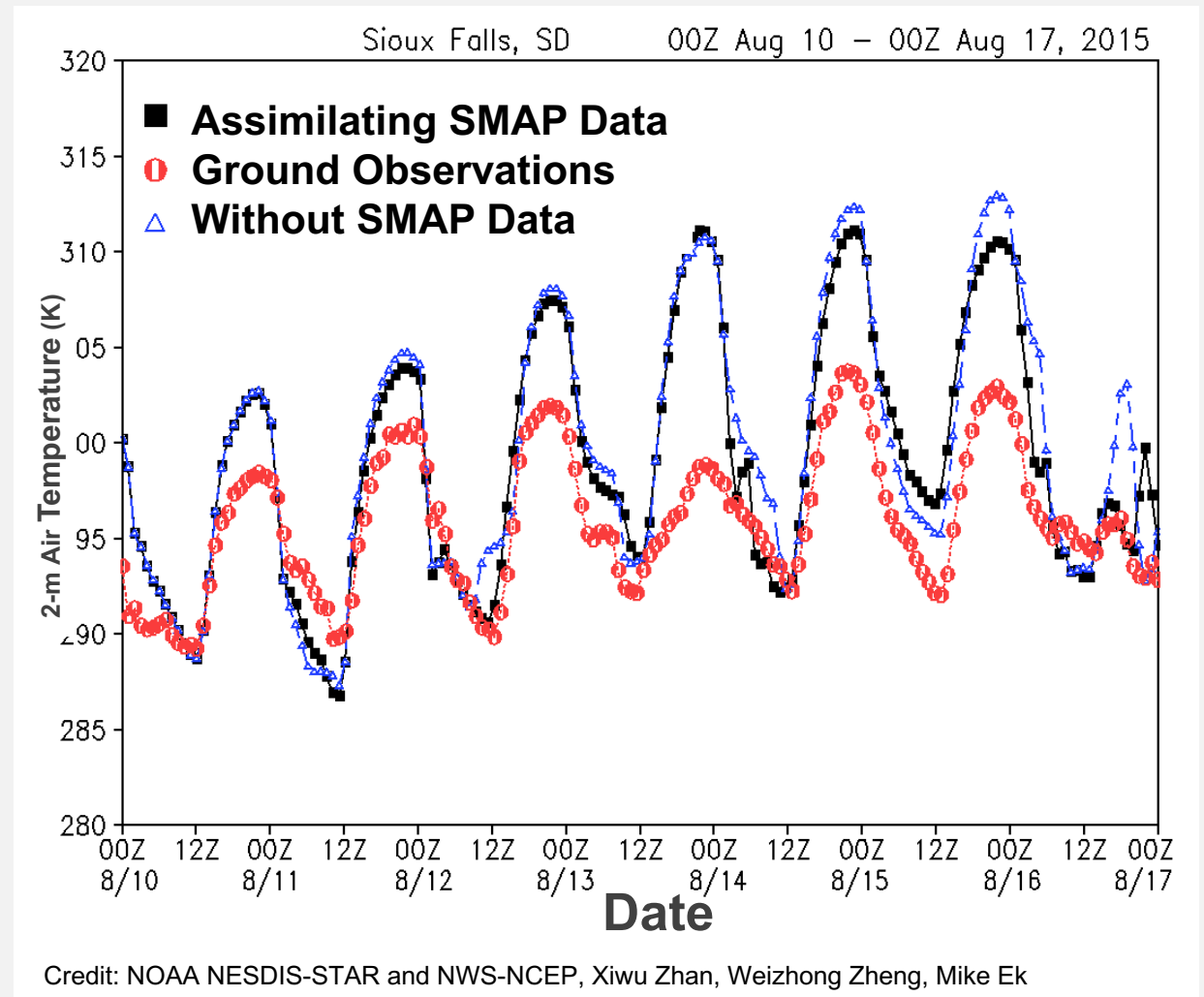
- Each EA will provide clear metrics and an analysis of the value of soil moisture or freeze/thaw data for their application
 - EA case study per EA category
- EAs given the opportunity to apply for access to pre-beta-release products for their research

A topographic map showing a river system. The map uses a color gradient from green (low elevation) to brown (high elevation). A large, semi-transparent white rectangular box is overlaid on the map, containing the text "Weather Prediction" and a horizontal line below it. The river flows from the top right towards the bottom left, with several meanders and tributaries.

Weather Prediction

Impact of SMAP on Weather Prediction

Assimilating SMAP soil moisture from August 1-10, 2015, **reduced the warm biases** of the Global Forecast System 7-day forecasts of 2-meter air temperature

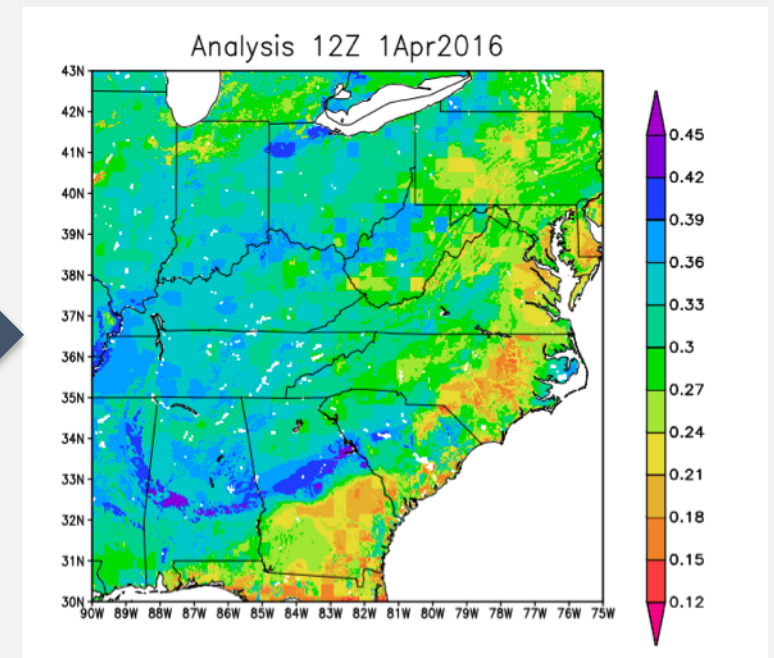
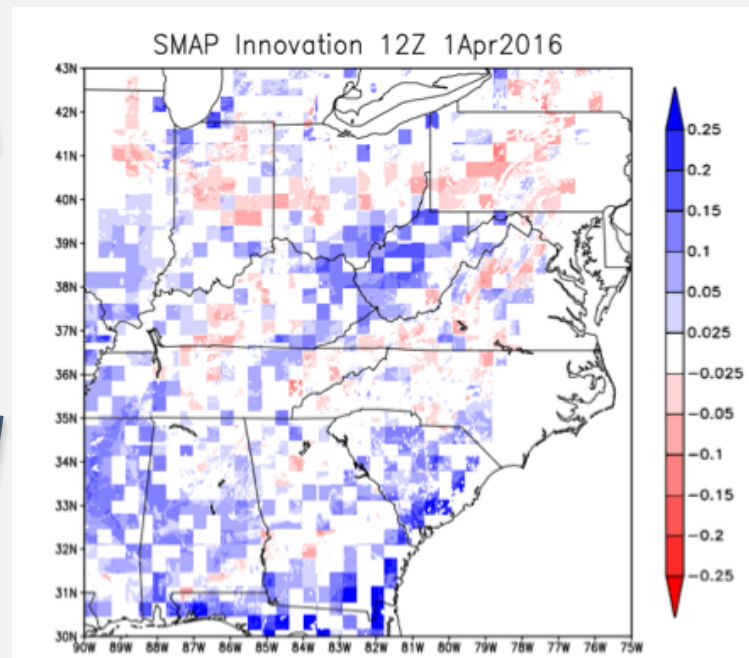
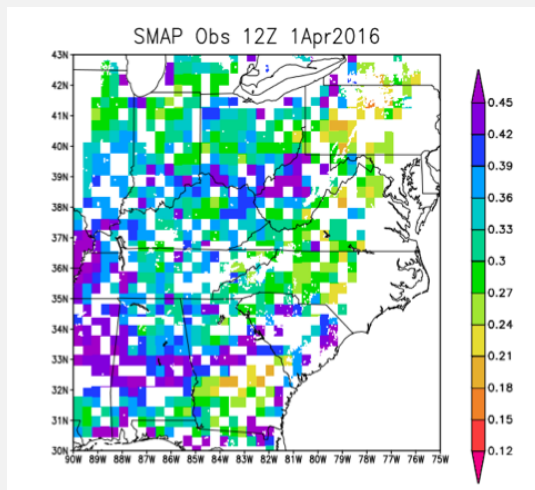
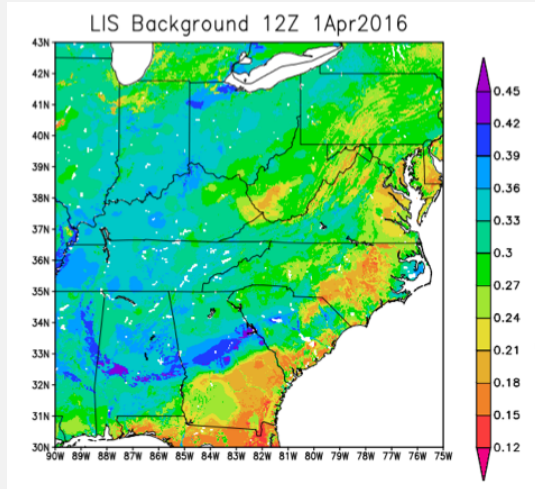


SMAP Data Assimilation for Weather Prediction

Eastern United States, April 1, 2016

SMAP Observation –
Modeled Soil Moisture

Blending Modeled &
SMAP Observations to
Improve Analysis

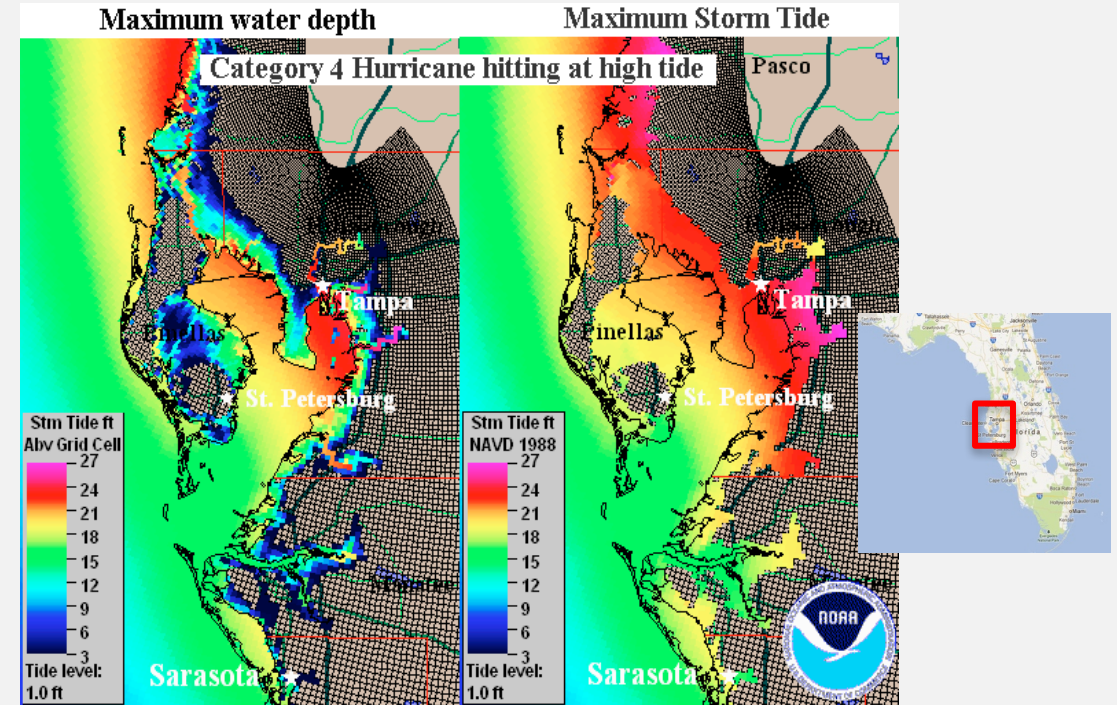
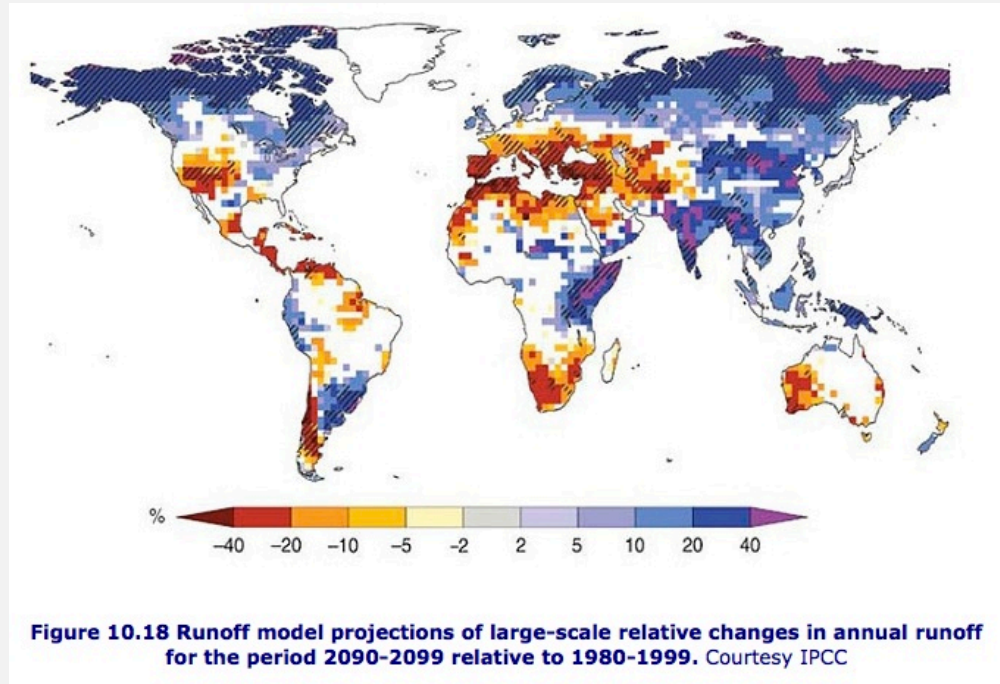


NASA Short-term Prediction Research and Transition Center, Jonathan Case, Clay Blankenship, and Brad Zavodsky

A topographic map showing a river system. A semi-transparent light blue rectangular area is overlaid on the map, representing a flood. The word "Floods" is written in black text within this area, with a horizontal black line underneath it. The map uses a color gradient from green (low elevation) to brown (high elevation) to show terrain. The river is shown as a dark blue line winding through the landscape.

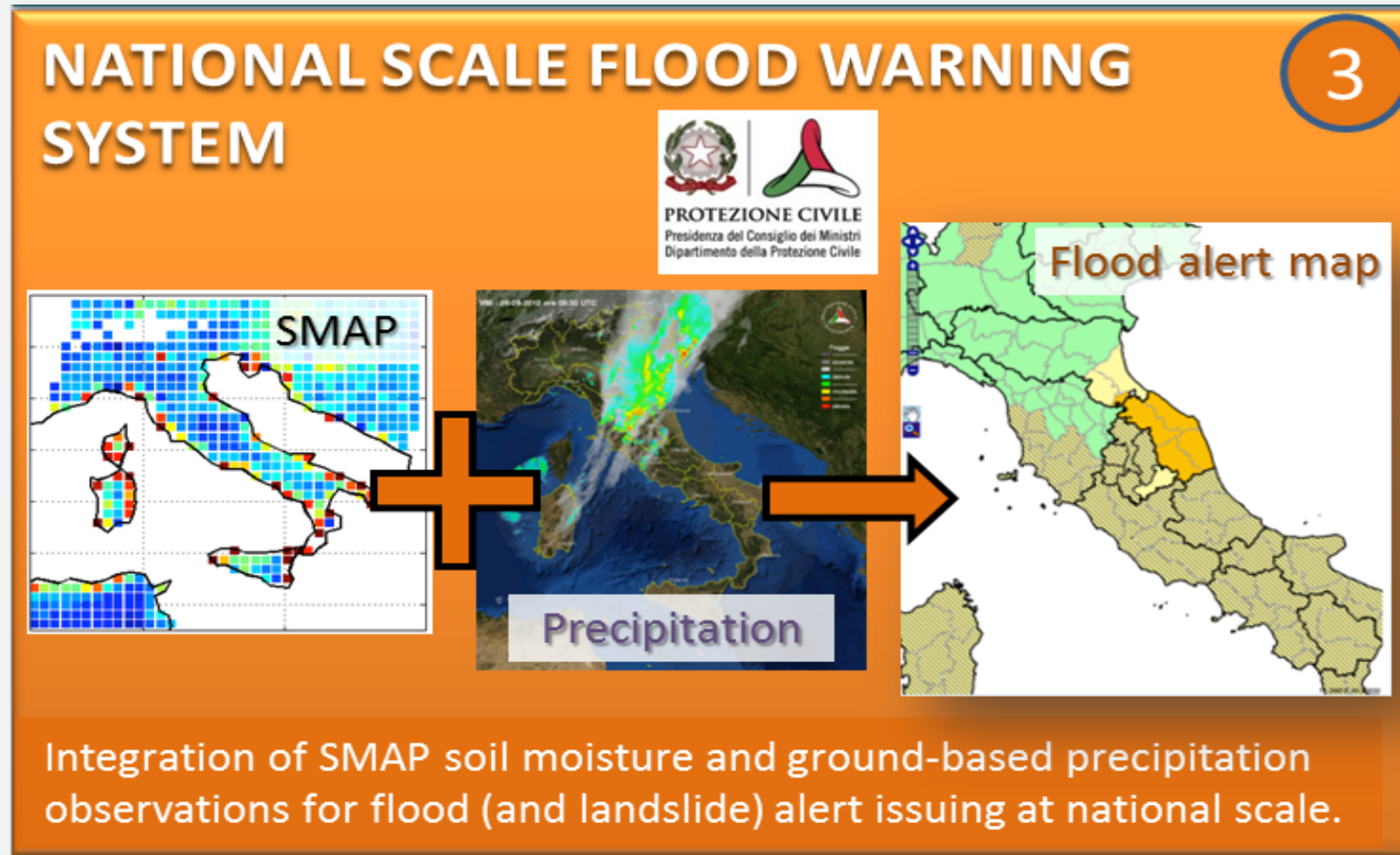
Floods

Global Applications of Soil Moisture for Flooding



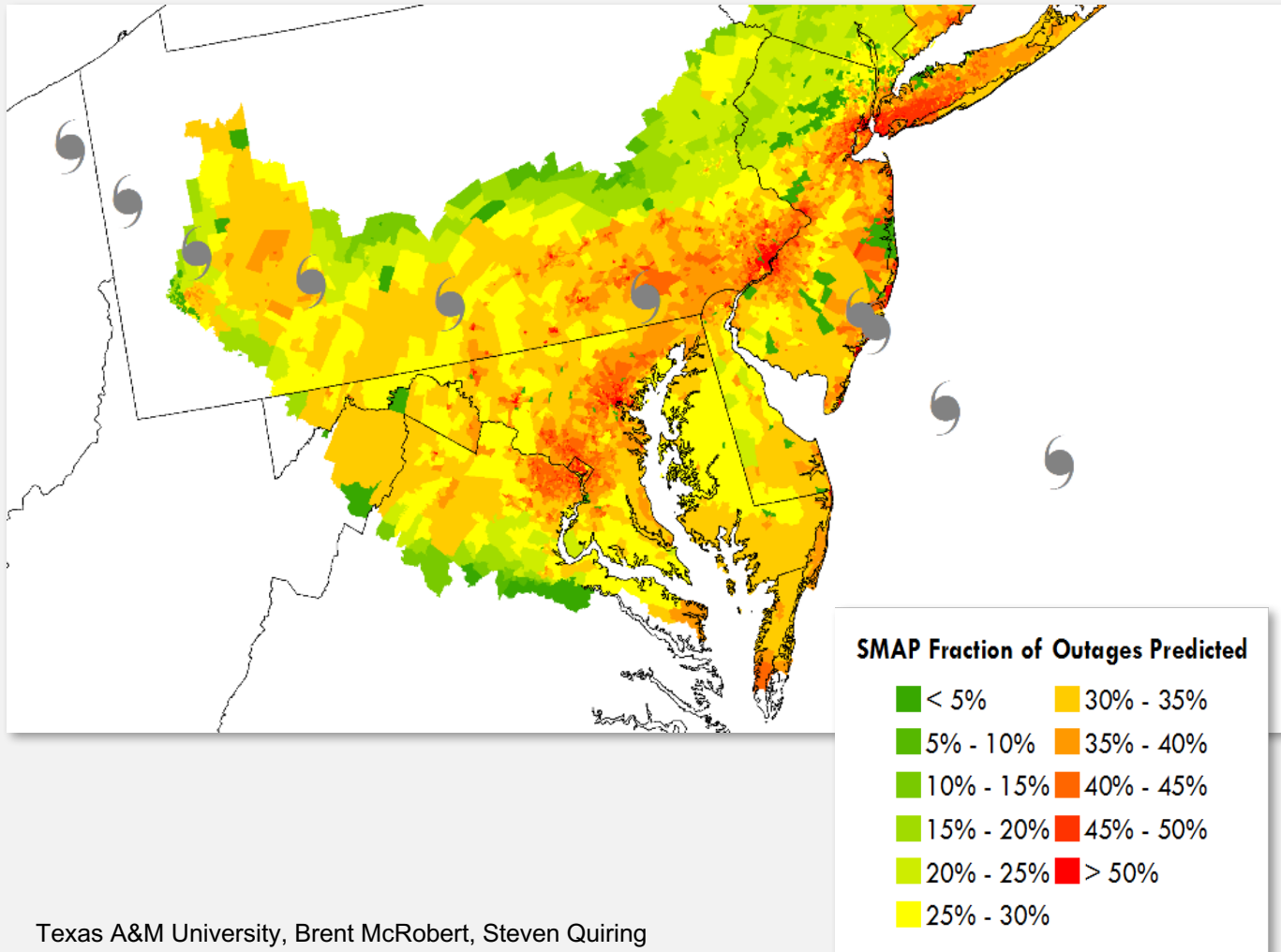
- Evaluate global scale run off models with climate models
- Evaluate scenarios at the global scale using soil moisture data
- Evaluate the scale of data needed for decision making

Flood Mitigation in Central Italy



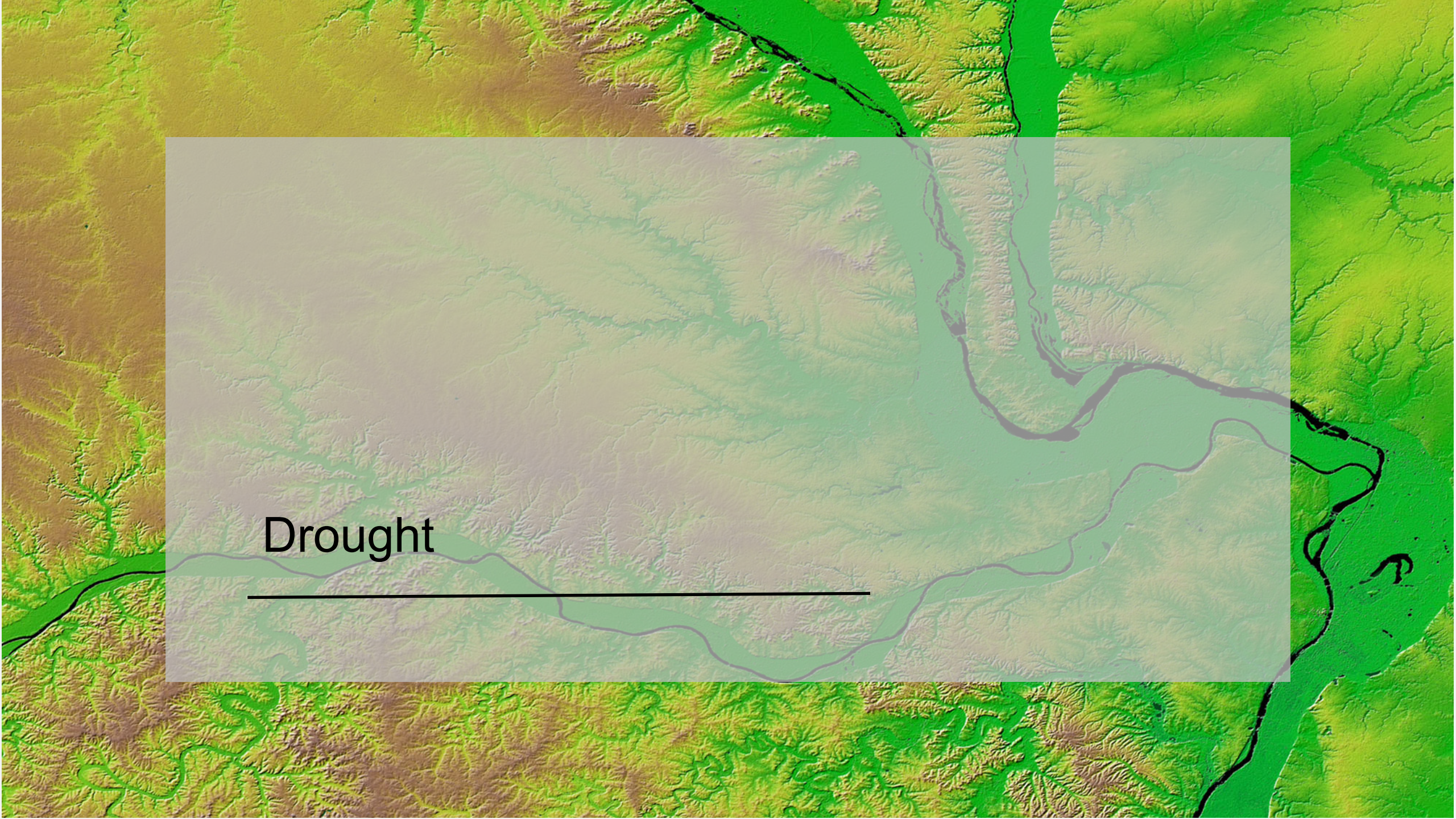
Research Institute for Geo-Hydrological Protection, Luca Brocca

Hurricane Power Outage Prediction



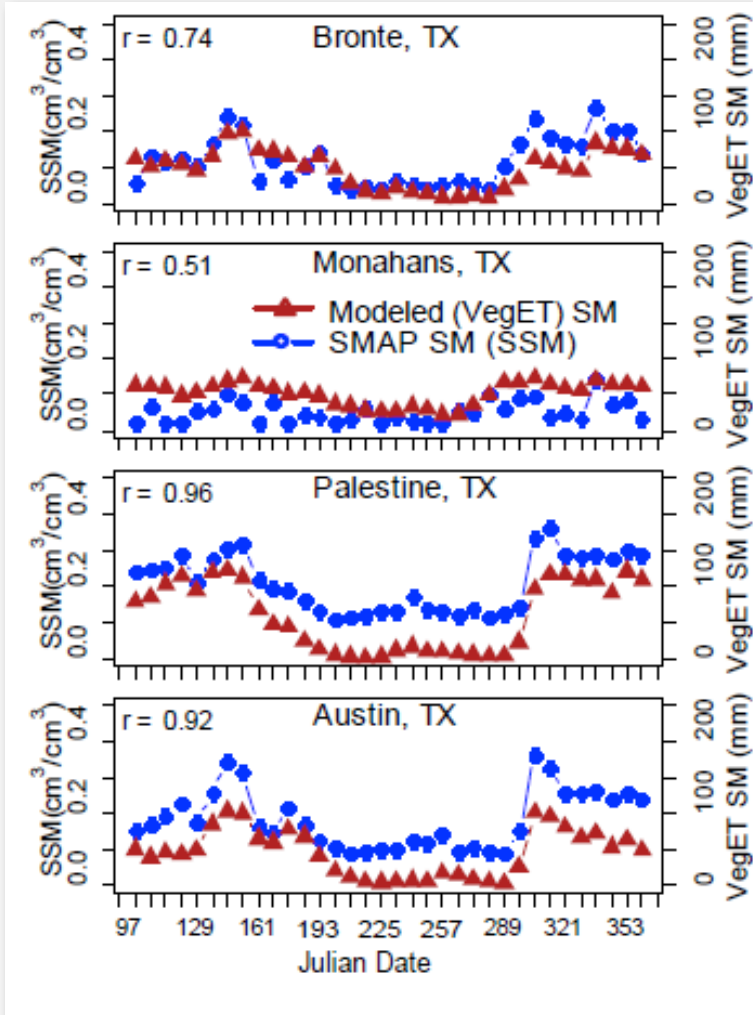
Texas A&M University, Brent McRobert, Steven Quiring

- Prediction of Power Outages for Sandy Wind Field
 - With modeled soil moisture: 15,989,091 people affected
 - With SMAP soil moisture: 16,327,051 people affected
- Outage predictions are sensitive to soil moisture
- Using SMAP data has a significant impact on predictions of people affected by outages

A topographic map showing a river system. A semi-transparent rectangular box is overlaid on the map, covering a large portion of the river's course. The word "Drought" is written in black text inside the box, positioned above a horizontal black line. The map uses a color gradient from green to brown to represent elevation, with the river channel highlighted in a darker green.

Drought

Drought Monitoring



- USGS conducts drought monitoring in areas dominated by grasslands and shrublands
- SMAP showed a reliable and expected response by capturing seasonal soil moisture dynamics in relation to:
 - precipitation
 - land surface temperature
 - evapotranspiration

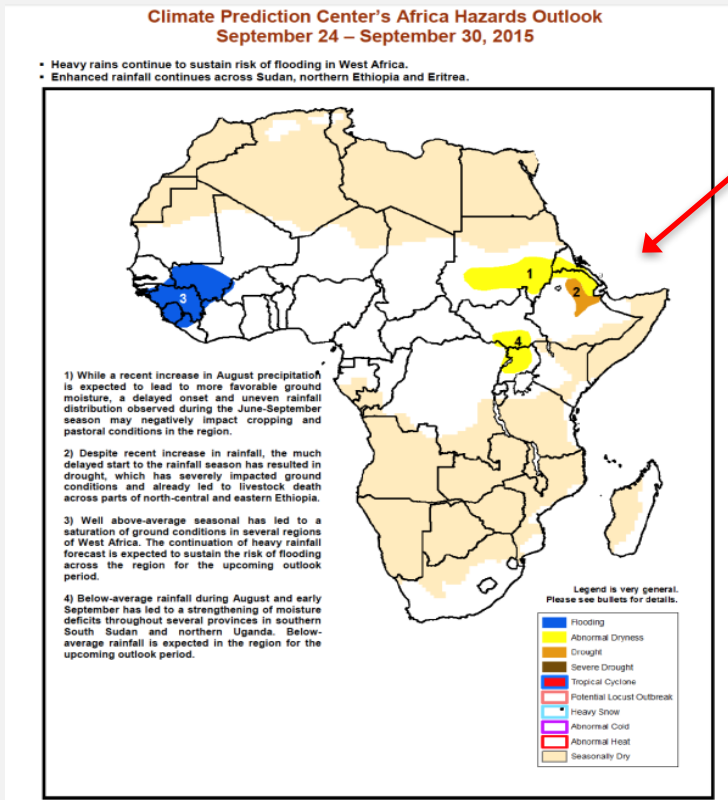
U.S. Geological Survey, Manohar Velpuri, Jeff Morisette

Famine Early Warning System (FEWS) in Africa

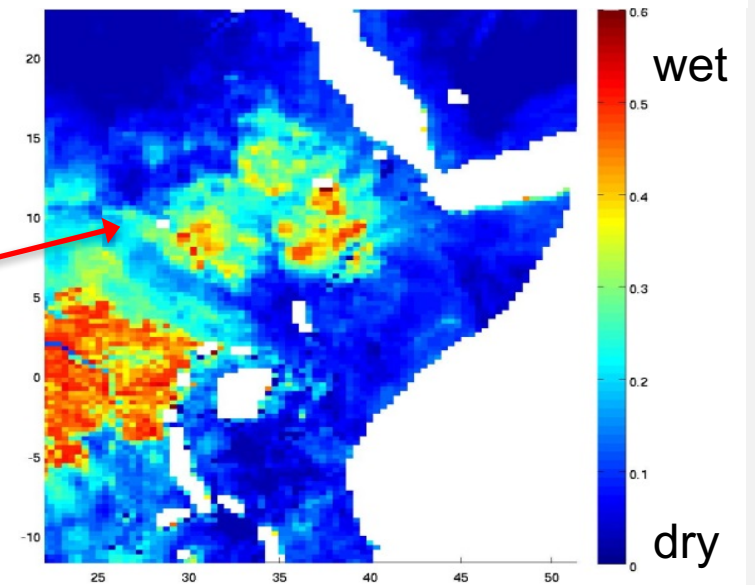
SMAP images will be introduced to FEWS analysts for better famine prediction

FEWS reports drought in Ethiopia but higher than average Sep rain

SMAP sees moderately-to-very wet soil.

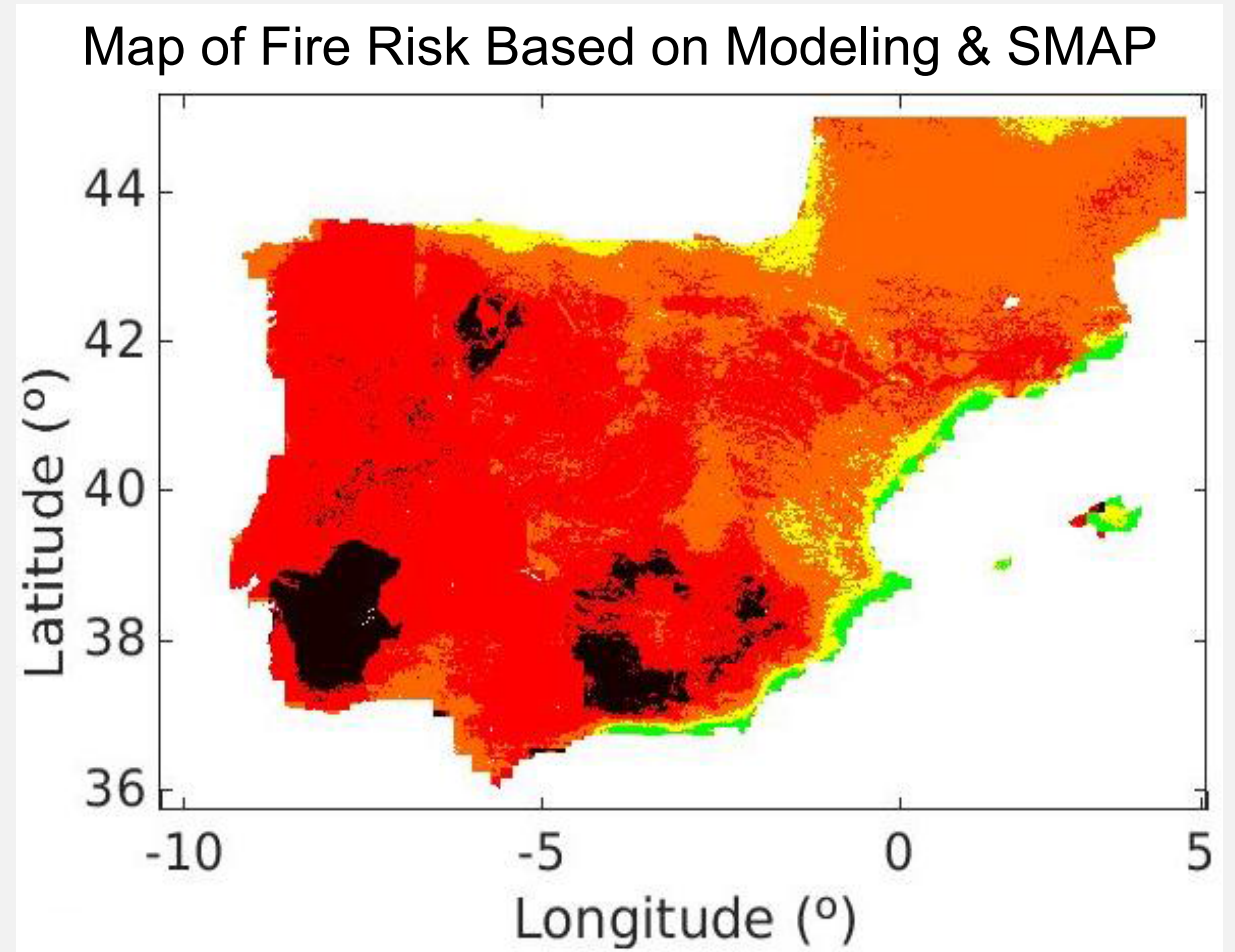
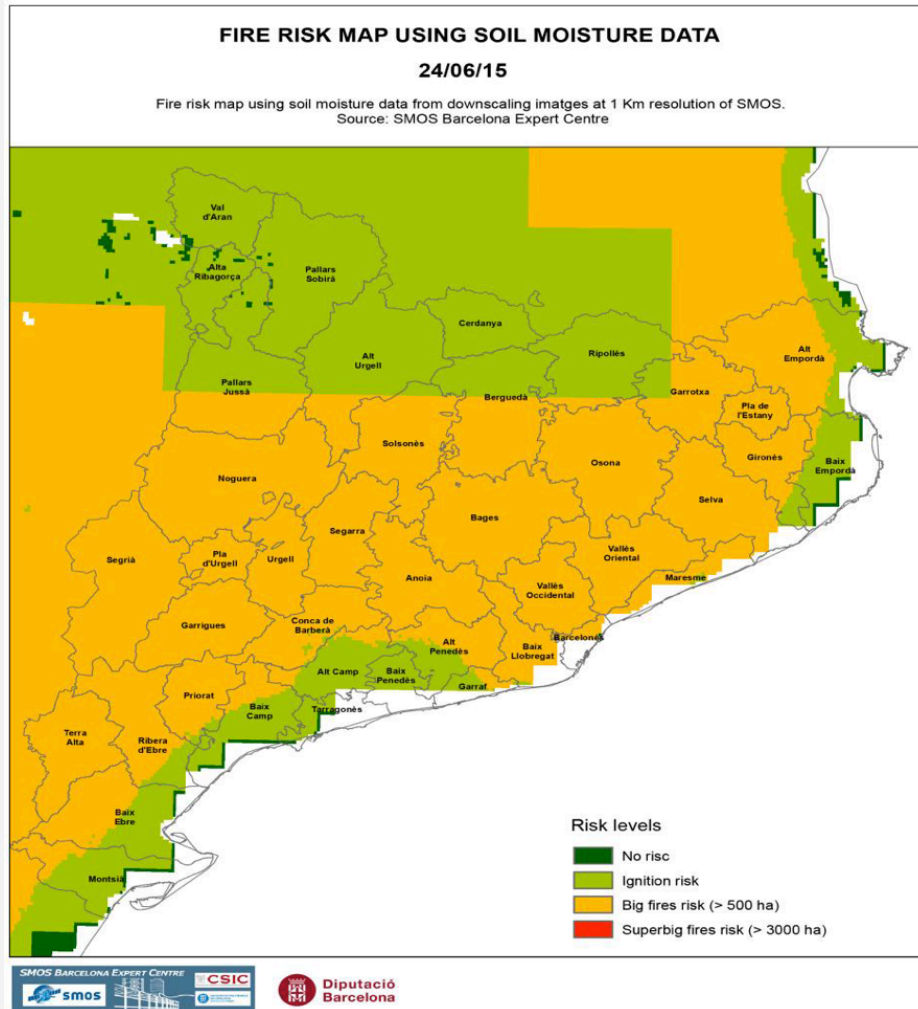


Sep Flooding in East Africa
SMAP L-3 Regional Images
(Sep 10-18, 2016)



USGS & UC Santa Barbara, Chris Funk, Amy McNally, and James Verdin

Improving Forest Fire Risk Maps



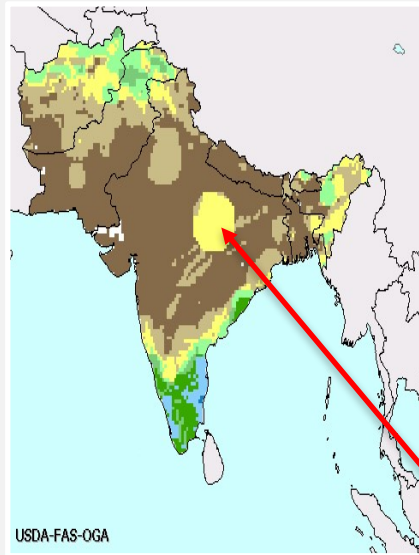
Barcelona Expert Center, ICM/CSIC, UPC, Maria Piles

A topographic map showing terrain elevation with a color gradient from brown (high elevation) to green (low elevation). A semi-transparent light green rectangular overlay covers the central portion of the map. A black horizontal line is drawn across the lower part of this overlay. The text 'Crop Yield' is positioned above this line.

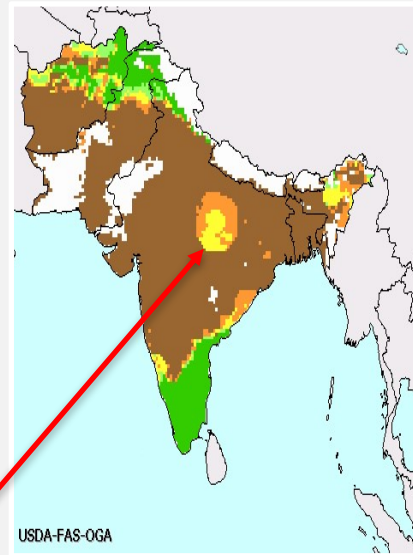
Crop Yield

USDA Global Crop Assessment Decision Support

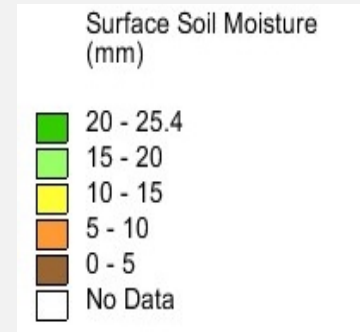
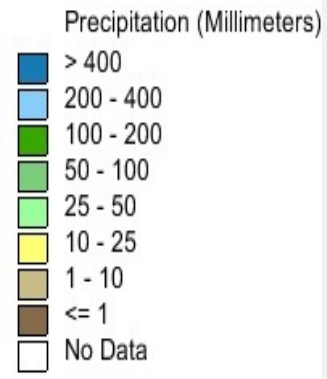
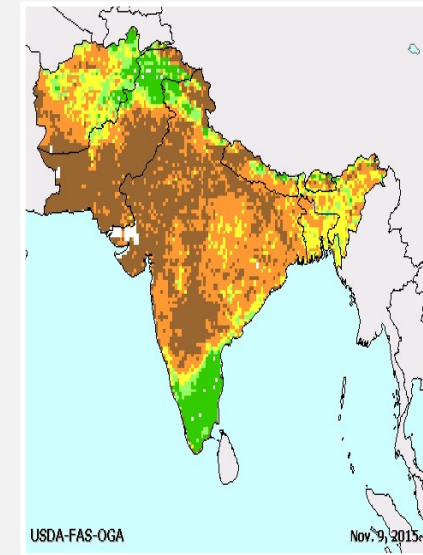
Precipitation



Model Only



Model + Satellite



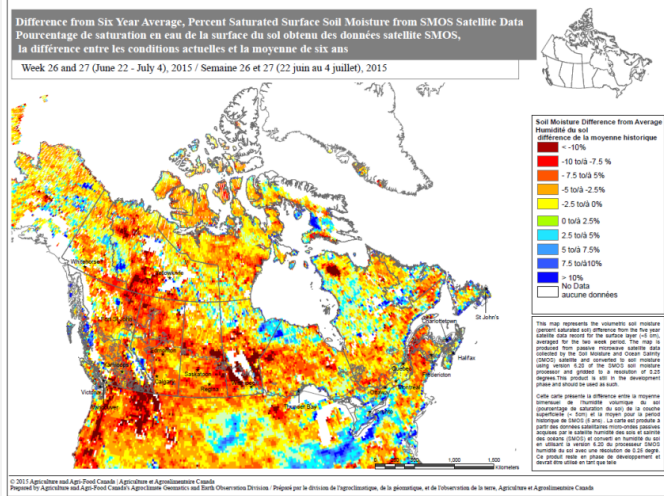
Precipitation artifact carried over to surface soil moisture

Artifact corrected with satellite imagery for better variability

NASA and USDA, John Bolten, Iliana E. Mladenova, Wade Crow, and Curt Reynolds

AAFC Production Risk Assessment

Routine Mapping of Soil Moisture Anomalies



Soil Moisture Ratings for Alberta 2015

| | March 30 - April 1 | April 13 - April 26 | April 27 - May 10 | May 11 - May 24 |
|-------------------------------------|--------------------|---------------------|-------------------|-----------------|
| Central | 2.87 | -3.31 | -3.43 | -3.41 |
| COUNTY OF PAINTEARTH NO. 18 | 5.69 | -2.69 | -4.46 | -4.15 |
| COUNTY OF STETTLER NO. 6 | 2.54 | -3.62 | -2.90 | -3.39 |
| KNEEHILL COUNTY | 4.42 | -3.03 | -2.00 | -1.56 |
| LACOMBE COUNTY | -0.85 | -7.03 | -3.10 | -3.75 |
| MOUNTAIN VIEW COUNTY | -0.04 | -9.00 | -7.23 | -4.00 |
| MUNICIPAL DISTRICT OF ACADIA NO. 34 | 2.87 | -2.08 | -4.30 | -7.52 |
| RED DEER COUNTY | 1.54 | -5.43 | -2.94 | -2.94 |
| ROCKY VIEW COUNTY | 0.05 | -3.18 | -4.58 | -1.62 |
| SPECIAL AREAS NO. 2 | 4.53 | -1.29 | -3.99 | -5.26 |
| SPECIAL AREAS NO. 3 | 5.15 | -1.46 | -4.24 | -4.34 |
| SPECIAL AREAS NO. 4 | 6.42 | 1.37 | -0.64 | -0.31 |
| STARLAND COUNTY | 4.77 | -1.91 | -1.23 | -3.10 |
| WHEATLAND COUNTY | 0.20 | -3.67 | -3.04 | -2.40 |
| Northeast | 3.78 | -2.01 | -2.35 | -1.13 |
| BEAVER COUNTY | 2.76 | -2.79 | -1.80 | -1.22 |
| CAMROSE COUNTY | 3.87 | -3.86 | -1.77 | -1.01 |
| COUNTY OF MINBURN NO. 27 | 3.12 | -2.63 | -2.25 | -1.68 |
| COUNTY OF ST. PAUL NO. 19 | 2.94 | -1.93 | -2.62 | -1.68 |
| COUNTY OF TWO HILLS NO. 21 | 7.55 | -2.00 | -2.53 | -1.95 |
| COUNTY OF VERMILION RIVER | 0.23 | -1.11 | -4.15 | -2.30 |

Assessment of Production Risk Conditions Every Two Weeks

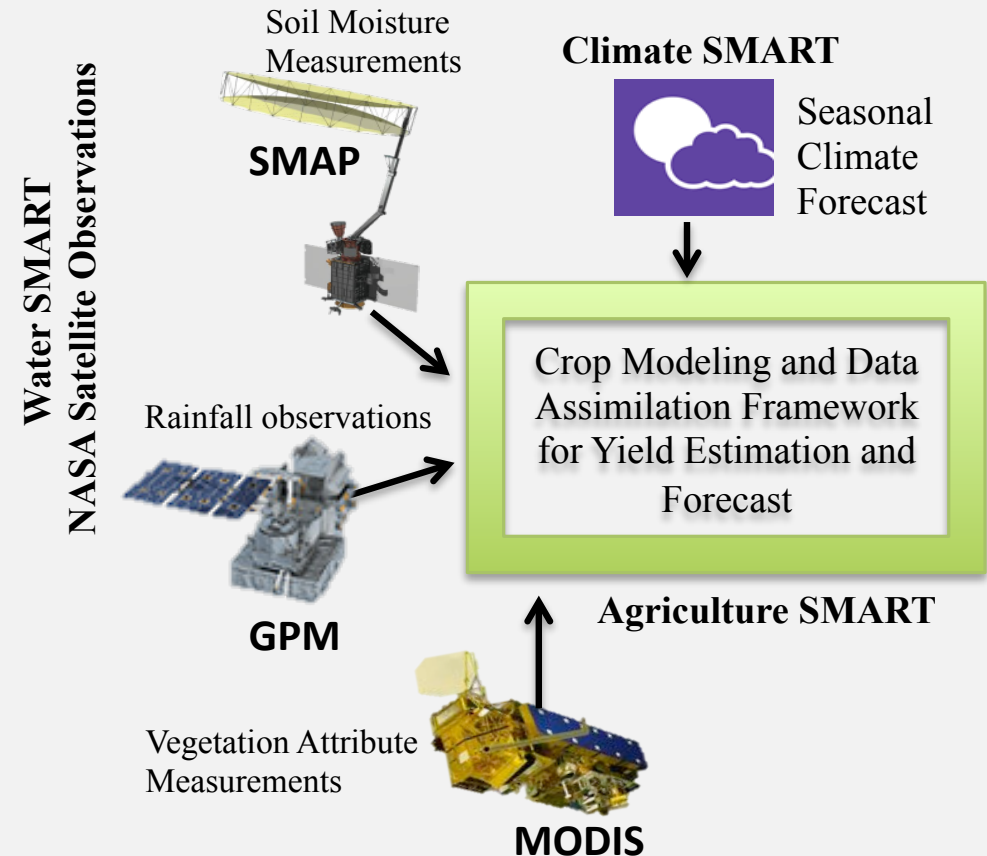
| Two week forecast | NATIONAL DASHBOARD | | | | | | |
|--------------------|--------------------|--------------------------|-----------------|---------------|------------------------|-----------------|---|
| | BC | AB | SK | MB | ON | QC | ATL |
| Two week forecast | stable | stable | stable | stable | stable | worsening | worsening |
| September 29, 2015 | drought | drought, excess moisture | excess moisture | | | | |
| September 15, 2015 | drought | drought, excess moisture | excess moisture | | | | hail |
| September 1, 2015 | drought, wildfire | drought | dry, frost | | | | |
| August 18, 2015 | drought | drought | drought | | | excess moisture | |
| August 5, 2015 | drought | drought | drought | | excess moisture | | |
| July 21, 2015 | drought, heat | drought, heat | drought | | excess moisture | | |
| July 7, 2015 | drought | drought | drought | drought | excess moisture | | |
| June 23, 2015 | drought | drought | drought | dry | rain, delayed planting | rain, flooding | excess moisture, delayed operations, flooding |
| June 9, 2015 | drought | drought | drought | frost | | | delayed operations |
| May 26, 2015 | drought | drought | drought | frost | drought | | delayed operations |
| May 12, 2015 | drought | | | cold, drought | drought | | excess moisture, delayed operations |

Green/Yellow/Orange/Red is a continuum of 'No significant risk' to 'Large or Urgent risk'. Text in black indicates the event is currently occurring, gray text highlights risk.

Agriculture and Agri-Food Canada, Catherine Champagne, Patrick Cherneski

SMAP for Agricultural Crop Yield and Food Security Applications

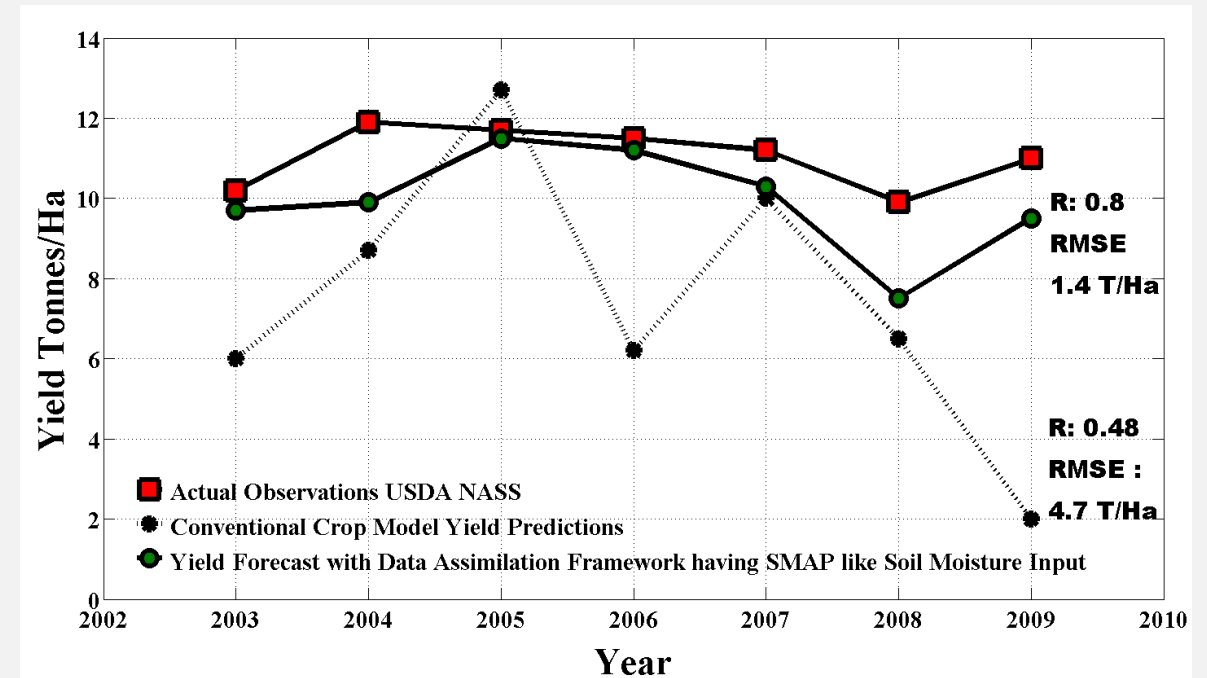
- **Water** is the defining link between climate and agriculture
- Better quality and use of soil moisture and water information leads to:
 - improved agricultural drought decision support systems
 - ensures food security



Courtesy of Narendra Das - JPL

SMAP for Agricultural Crop Yield and Food Security Applications

- **Water** is the defining link between climate and agriculture
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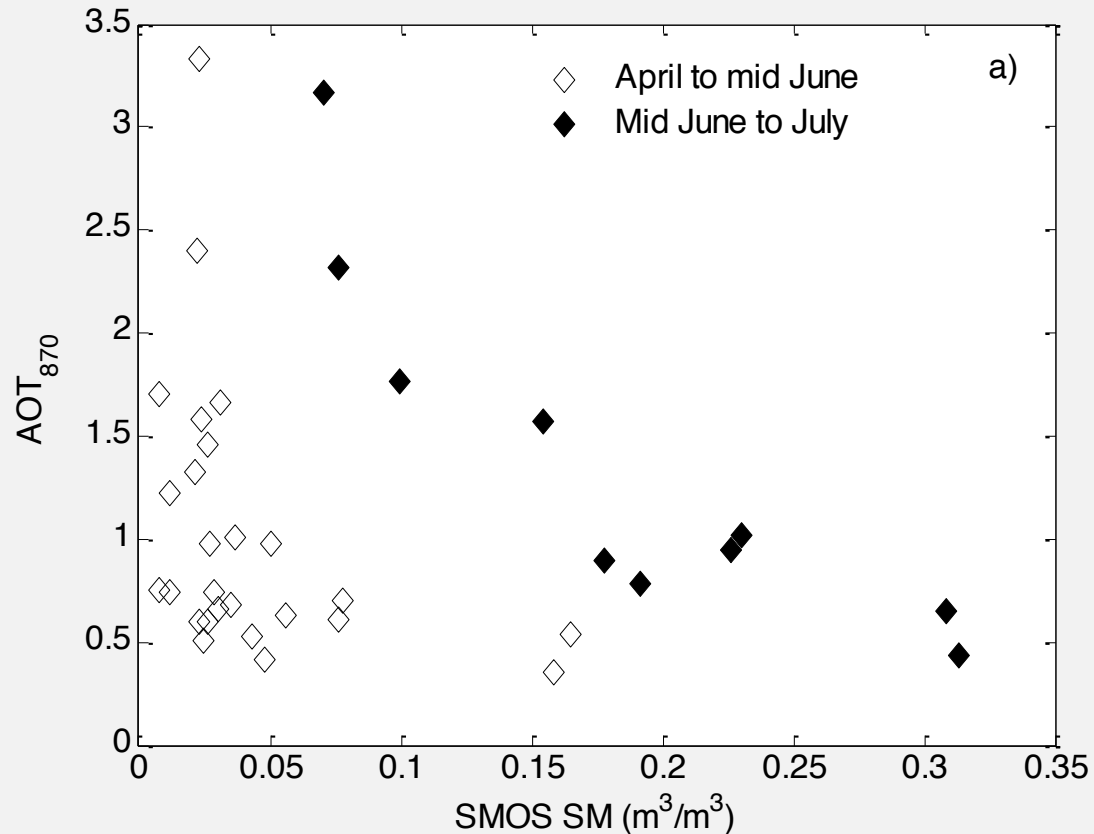
Ines, Das et al., 2013. Assimilation of Remotely Sensed Soil Moisture and Vegetation with a Crop Simulation Model for Maize Yield Prediction. RSE-D-12-00872R2: Remote Sensing of Environment, In Press

A topographic map showing a river system and surrounding terrain. The map uses a color gradient from green (low elevation) to brown (high elevation). A semi-transparent rectangular box is overlaid on the map, containing the text "Human Health" and a horizontal line below it. The river flows from the top right towards the bottom left, with several meanders and tributaries. The terrain is rugged with many small ridges and valleys.

Human Health

Mapping of the Extent of Saharan Dust Emissions

Soil Moisture from ESA SMOS Observatory



- As soil moisture values increase, the dust emission decreases.
- With satellite estimates of soil moisture, dust predictions improved by up to 50%

Masdar Institute, UAE, Hosni Ghedira, and Imen Gherboudj

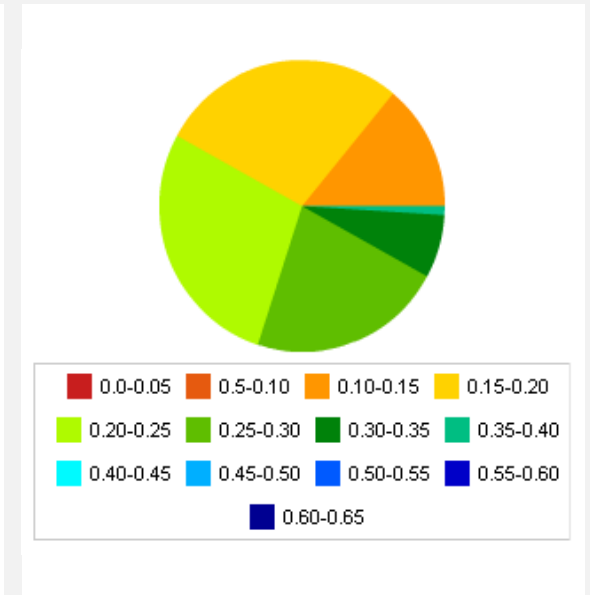
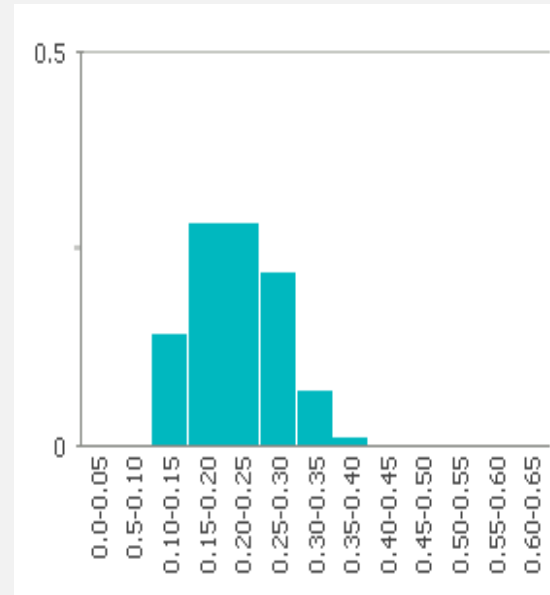
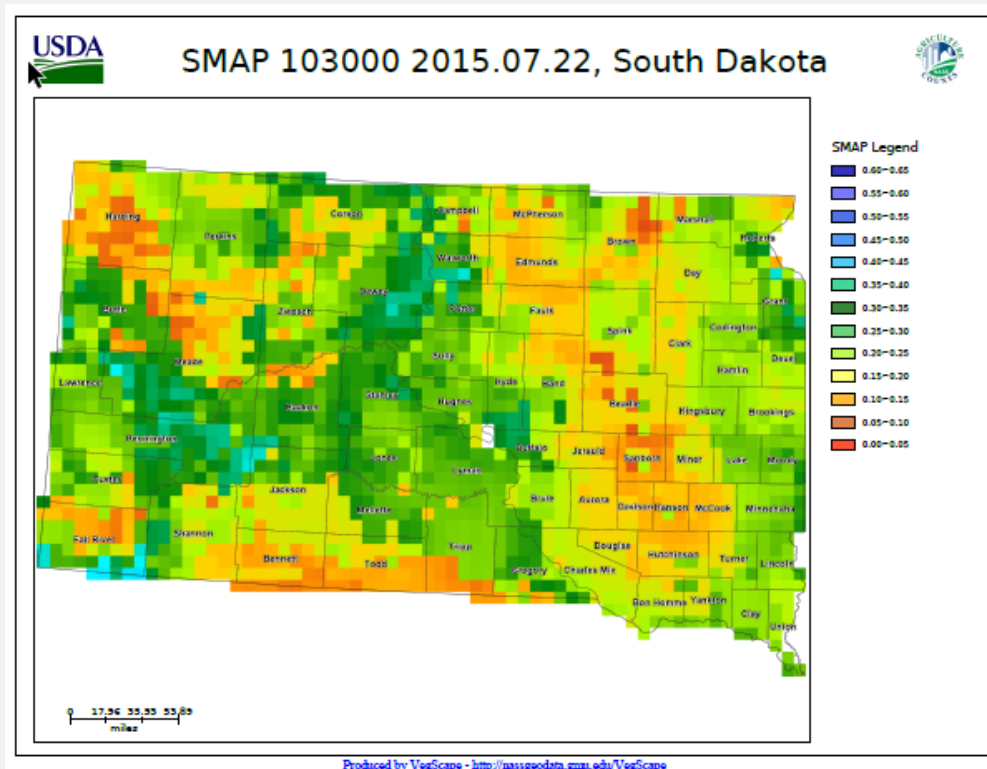
A topographic map showing a river system. The map uses a color gradient from green (low elevation) to brown (high elevation) to represent terrain. A prominent river flows from the top right towards the bottom right, with several tributaries. A semi-transparent white rectangular box is overlaid on the map, containing the text "Decision Support Tools" and a horizontal line below it.

Decision Support Tools

USDA Crop Condition Report

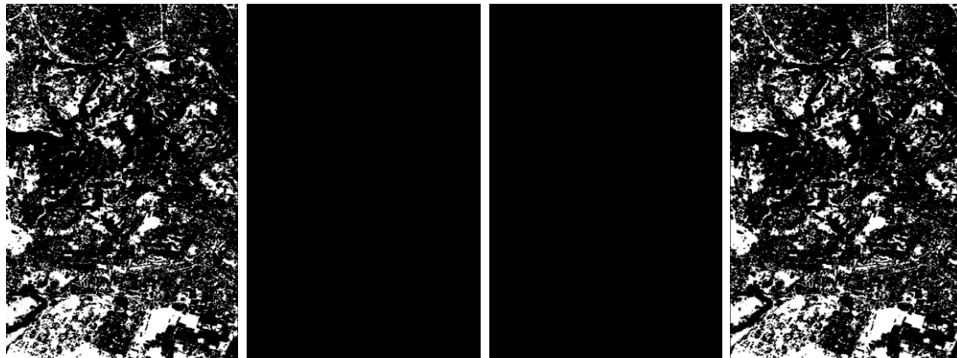
USDA NASS VegScape Visualization, Analytics, and Dissemination Tool

Soil Moisture Statistics for South Dakota July 22, 2015

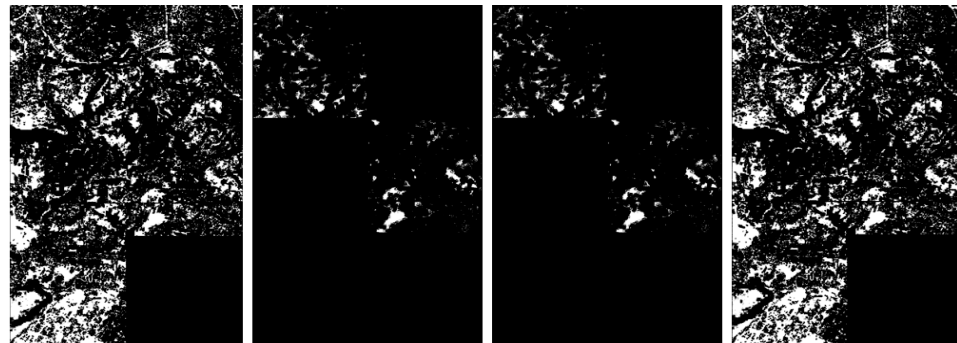


Military Vehicle Mobility

Mobility Map **Without** SMAP Data



Mobility Map **Using** SMAP Data



Humvee

ATV

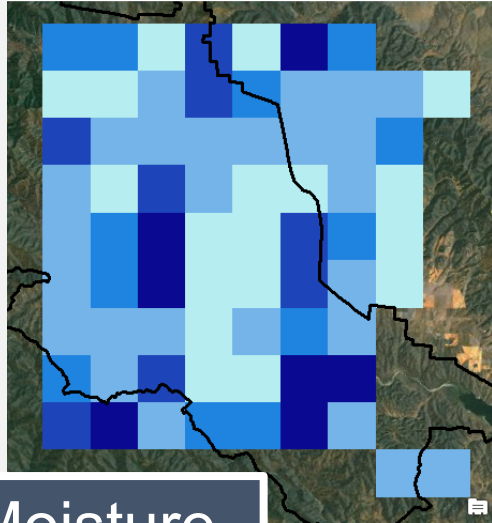
Transport
Truck

Light
Truck

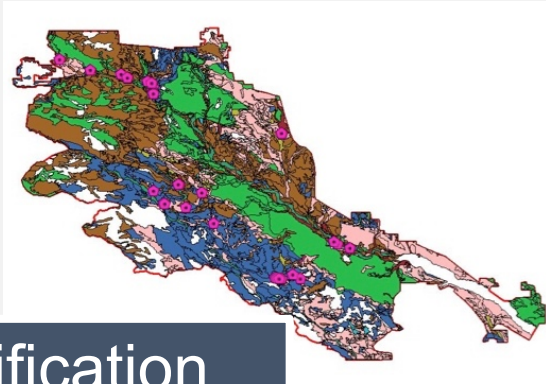
- White denotes areas identified as go mobility for four vehicle types
- With SMAP, we are better able to predict mobility of vehicles in Central Indonesia
- NATO Reference Mobility Model is the basis for the calculations

Lockheed Martin, Derek Ward

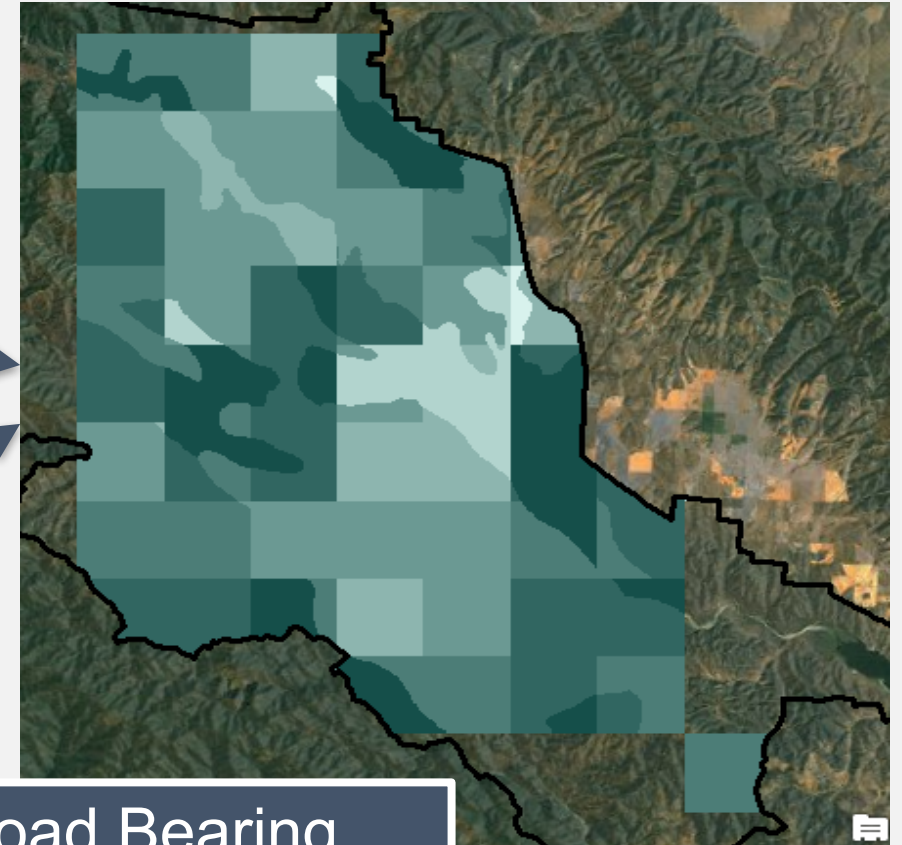
Load-Bearing Capacity of Soils for Building Roads



SMAP Soil Moisture



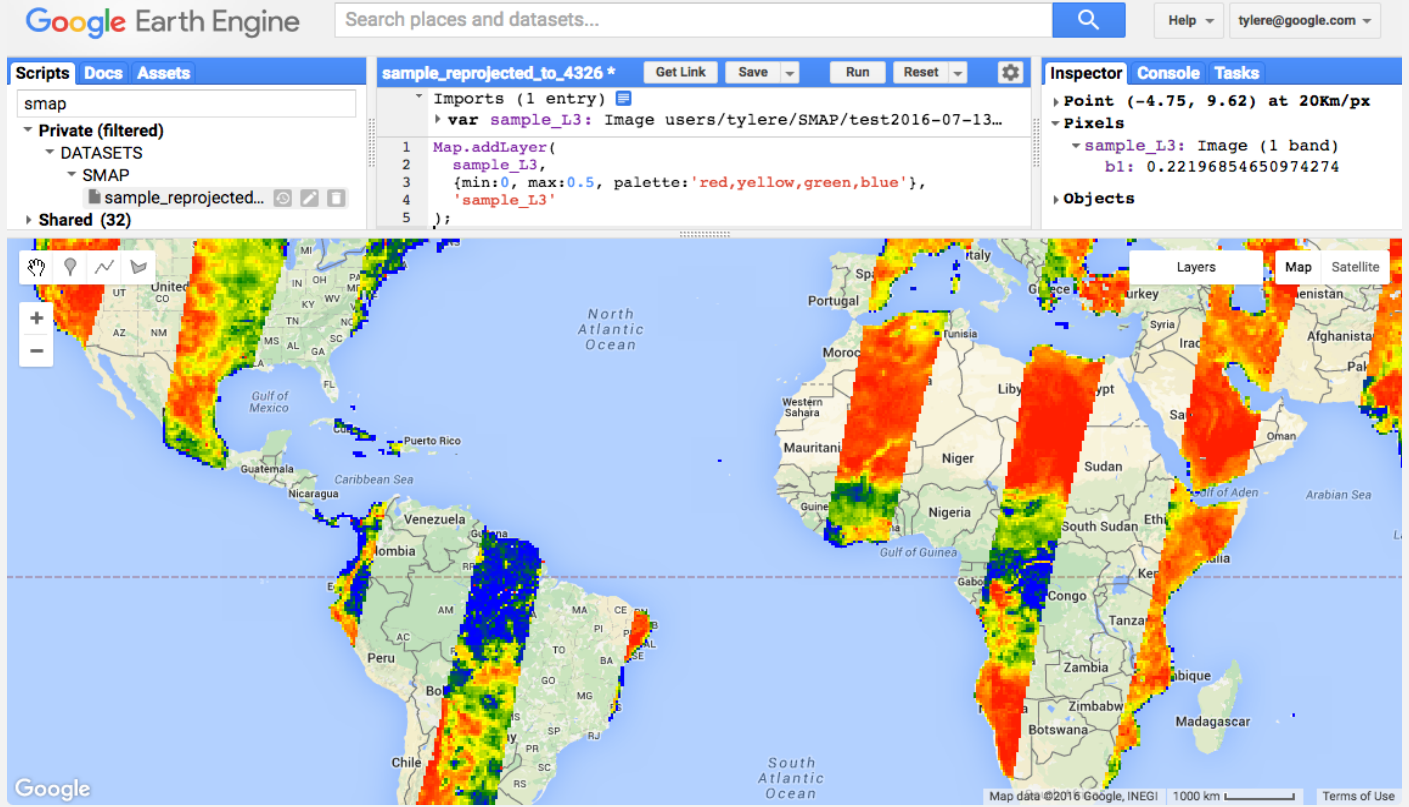
Soil Classification



Soil Load Bearing Capacity

U.S. Army Engineer Research and Development Center, John Eylander

Google Earth Engine Analysis Platform

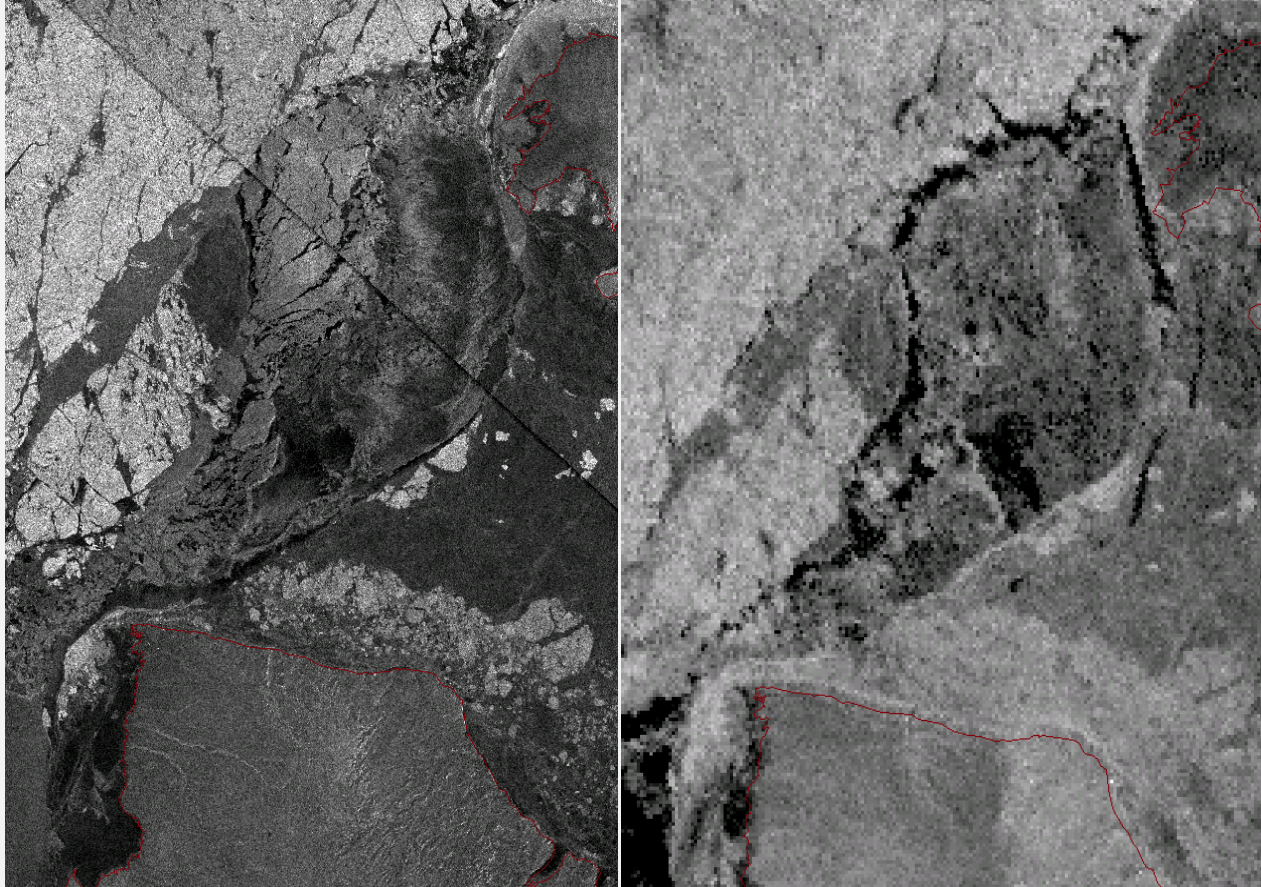


Screenshot of a SMAP L3 Soil Moisture Data Product Within the Google Earth Engine Platform

A topographic map of a river basin, showing a network of rivers and tributaries. The map uses a color gradient from green (low elevation) to brown (high elevation). A semi-transparent white rectangular box is overlaid on the map, containing the text "Other Uses of SMAP Data" and a horizontal line below it.

Other Uses of SMAP Data

SMAP Radar for Operational Sea Ice Monitoring



RADARSAT-2

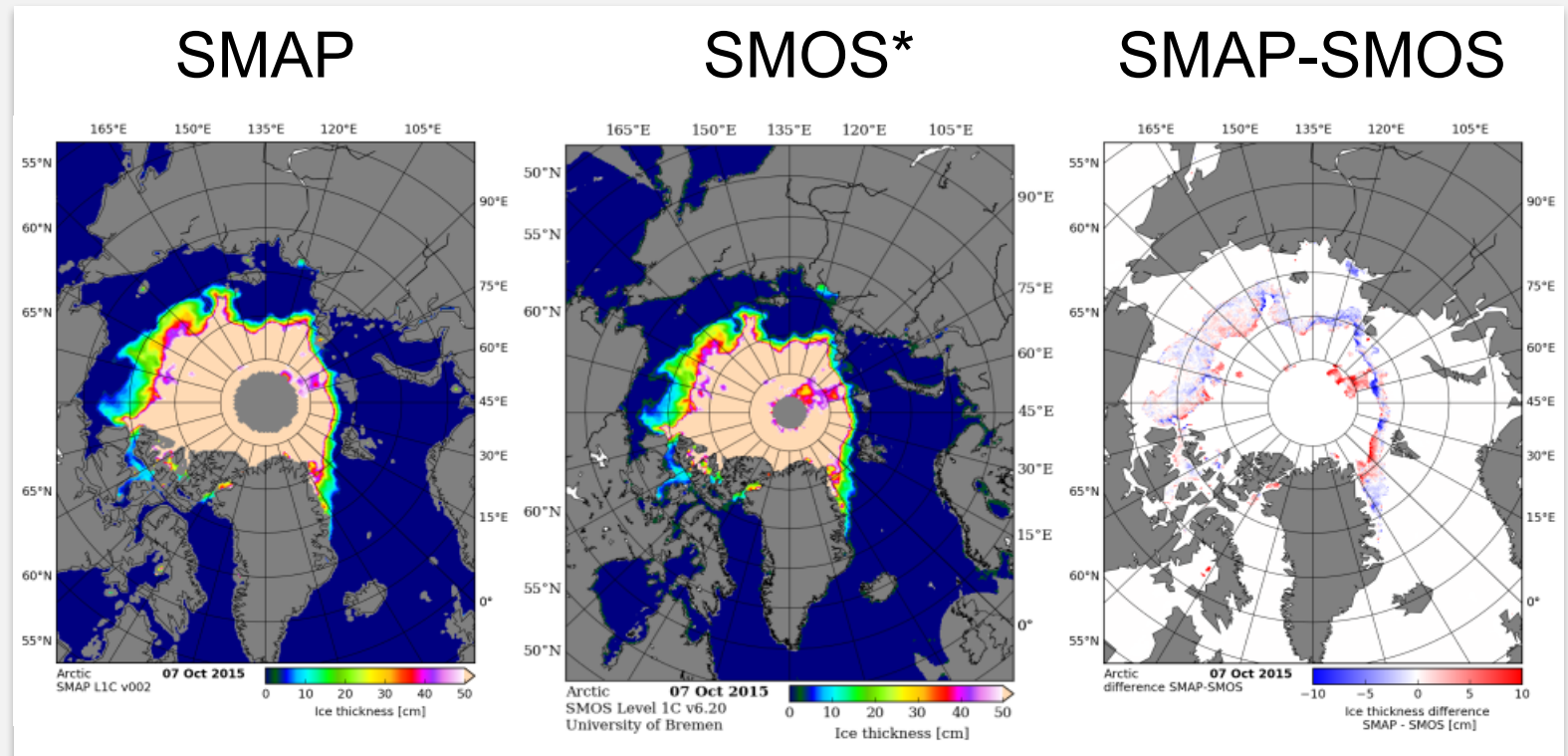
SMAP

SMAP L-band provides additional information about sea ice formation than the typical C-band data stream

Canadian Ice Service, Matt Arkett

SMAP-Ice: Retrieval of Sea Ice Thickness (SIT)

- SMAP map has smoother contours and less radio frequency interference (RFI)
- Differences occur mainly at edges to open ocean and thicker ice areas, probably due to different overflight times and footprint geometries



*ESA Soil Moisture and Ocean Salinity (SMOS)

A topographic map showing a river system. The map uses a color gradient from green (low elevation) to brown (high elevation) to represent terrain. A prominent river flows from the top right towards the bottom right. A semi-transparent grey rectangular box is overlaid on the map, centered horizontally. Inside the box, the word "Questions?" is written in a black, sans-serif font. Below the text, a solid black horizontal line spans across the width of the box.

Questions?
