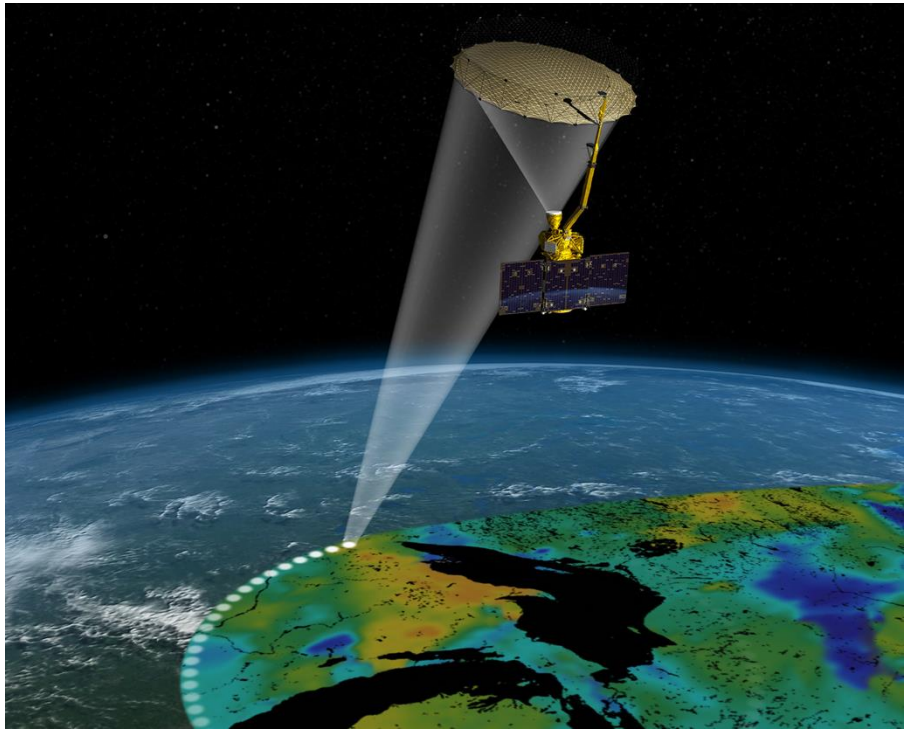
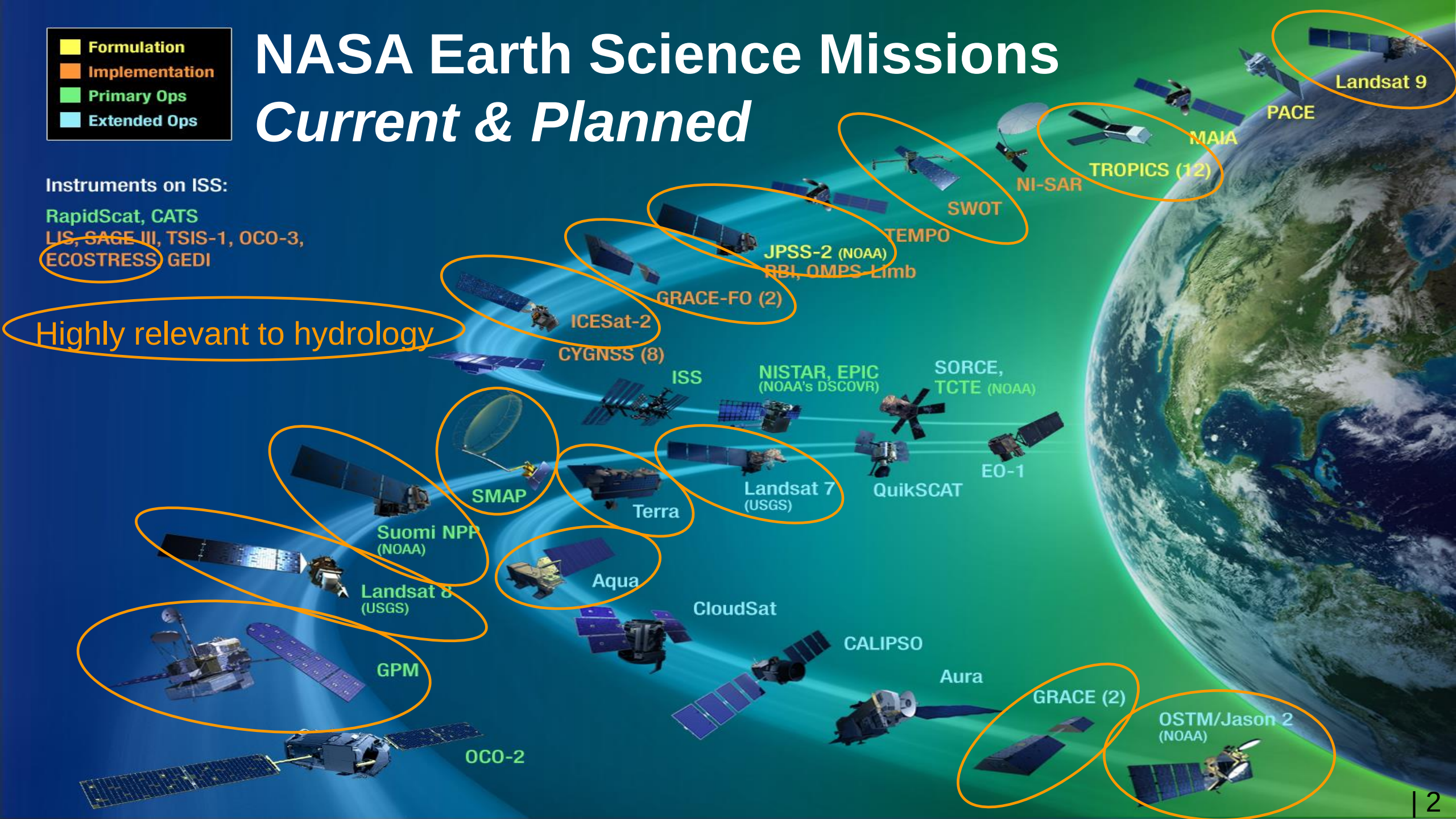
Soil Moisture Active Passive (SMAP)



WSWC WIMS Workshop, Pasadena, CA, Jan 2018

John Bolten, Associate Program Manager, Water Resources, NASA Applied Sciences
Raha Hakimdavar, Presidential Management Fellow, NASA Goddard Applied Sciences


Formulation
Implementation
Primary Ops
Extended Ops
NASA Earth Science Missions
Current & Planned
Instruments on ISS:
RapidScat, CATS
LIS, SAGE III, TSIS-1, OCO-3,
ECOSTRESS, GEDI
Highly relevant to hydrology
Landsat 9
PACE
MAIA
TROPICS (12)
NI-SAR
SWOT
TEMPO
JPSS-2 (NOAA)
RBI, OMPS-Limb
GRACE-FO (2)
ICESat-2
CYGNSS (8)
ISS
NISTAR, EPIC
(NOAA's DSCOVR)
SORCE,
TCTE (NOAA)
EO-1
SMAP
Terra
Landsat 7
(USGS)
QuikSCAT
Suomi NPP
(NOAA)
Aqua
Landsat 8
(USGS)
CloudSat
CALIPSO
GPM
Aura
GRACE (2)
OSTM/Jason 2
(NOAA)
OCO-2

Overview of SMAP

Instruments
- Radar(1.26 GHz)
  - ✓ High resolution, moderate accuracy
- Radiometer (1.4 GHz)
  - ✓ Moderate resolution, high accuracy

Shared antenna
- Constant incident angle: 40 degrees
- 1000 km wide swath

Orbit
- Sun-synchronous
- 6 am (Descending) / 6 pm (Ascending)
- 685 km altitude
- Global coverage every three days

Spatial Resolution:	9 km
Temporal Resolution:	daily

Launched on January 31, 2015
Data available from March 31, 2015 to present

Animation of SMAP launching and collecting data. Courtesy of NASA JPL.

Overview of SMAP

Animation of local water balance. Courtesy of NASA Goddard Media Studios.

IMPROVING

Weather Forecasts

Providing accurate soil moisture information to numerical weather forecasting models improves their prediction accuracy and extends their lead-times.

Weather forecasting requires continuously observing the atmosphere, soil moisture and water sources on the ground.

Weather forecasts are used intensively to ensure personal safety and economic well-being.

Nearly 90% of the emergencies declared by FEMA, and approximately 70% of air traffic delays, are caused by weather, at a cost of billions of dollars per year.

MONITORING

Droughts

SMAP provides direct monitoring of agricultural drought and provides critical information for drought early warning.

Climate projections of global warming indicate the possibility of three times more frequent drought by the end of the 21st Century.

A sustained drought can result in crop failure, deaths of livestock, increasing likelihood of wildfires, and ultimately deaths of people.

A U.C. Davis study estimates that the economic cost to the State of California of the 2014 drought is $2.2 billion, with a total loss of 17,100 seasonal and part-time jobs.

PREDICTING

Floods

SMAP's high fidelity measurements will improve flood warnings by assessing how wet the soil is before a rainstorm.

Floods are the #1 natural disaster in the United States and account for 40% of all natural disasters worldwide.

Flash flooding is the leading cause of weather-related deaths in the U.S and accounts for approximately 89 deaths per year.

Flood loss averages $8.2 billion/year in the U.S. Coastal flood damage will rise greatly in the 21st century as sea levels rise and more people and assets are threatened.

ASSISTING

Crop Productivity

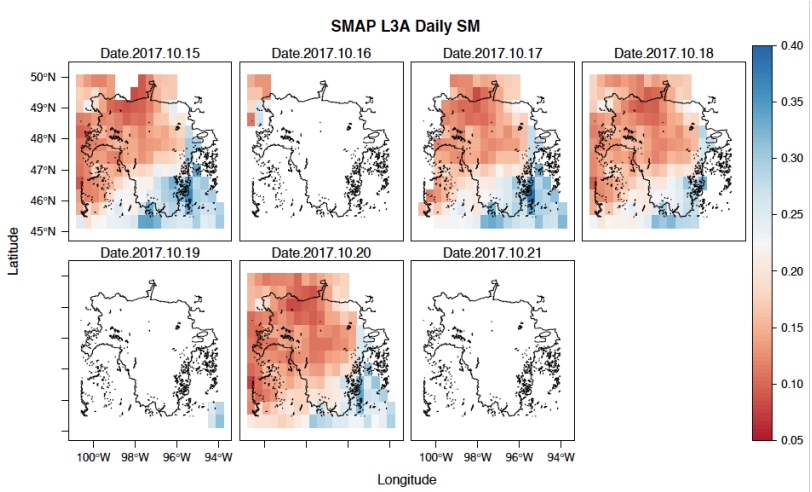
SMAP will provide information on soil moisture, which is critical for healthy plant growth and will help improve crop yield forecasts around the world.

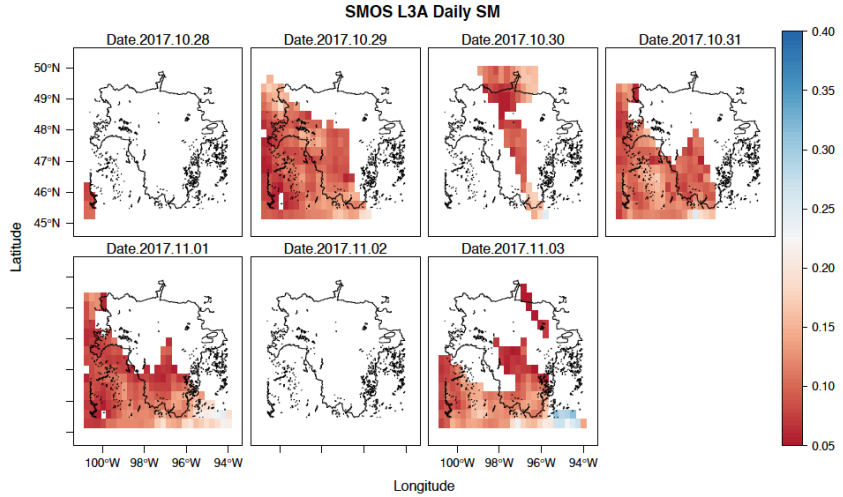
Monitoring global food production will improve targeting of humanitarian food assistance.

Studies estimate that climate change will increase the number of undernourished people worldwide in 2080 by 5-26%.

Monitoring global food production will improve targeting of humanitarian food assistance.

Satellite Enhanced Snowmelt Flood Predictions in the RRB





Objective:

- Enhance the NOAA National Weather Service's (NWS) North Central River Forecast Center's (NCRFC) snowmelt flood predictions capacity in the Red River of the North Basin (RRB)
- The RRB borders eastern North Dakota and western Minnesota

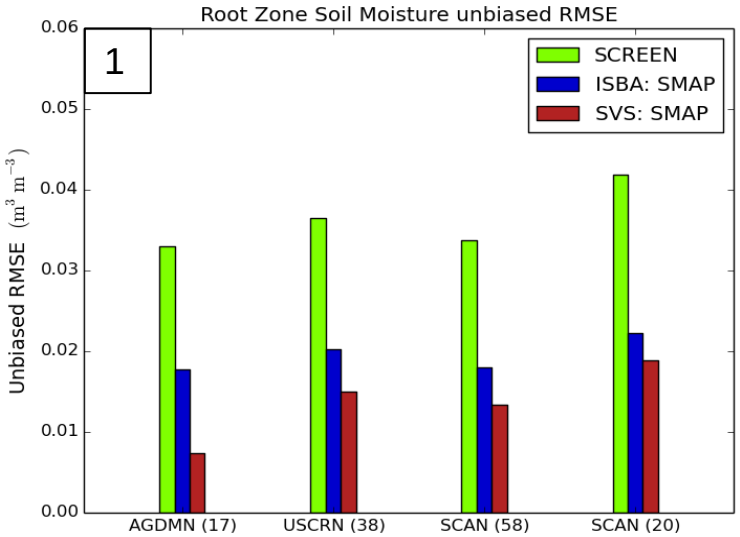
Challenges:

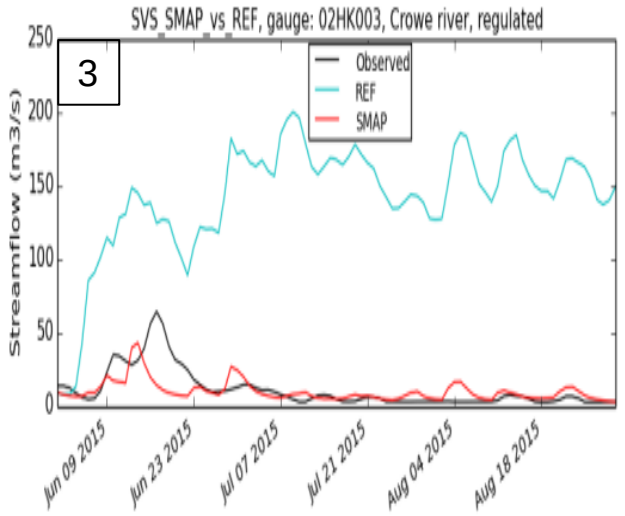
- Ground observations of soil moisture and snow water equivalent (SWE) are relatively scarce in the RRB, which makes accurate forecasting difficult
- Lack of antecedent SM conditions prior to winter onset causes errors in airborne gamma SWE estimates
- Lack of understanding of snowmelt processes and soil infiltration during soil freeze and thaw

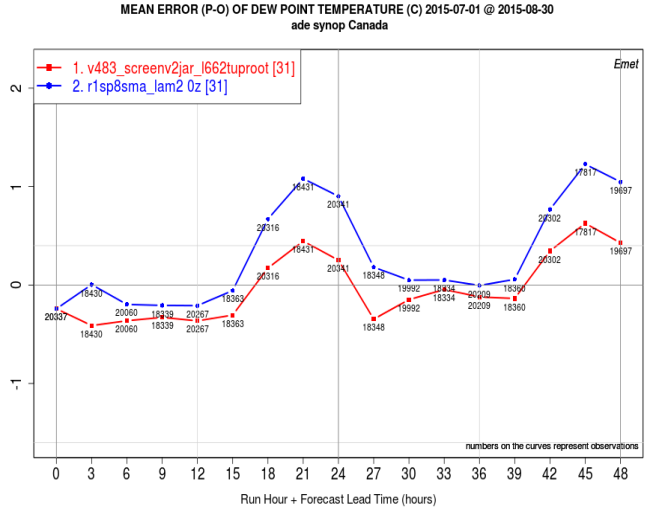
Model:

- The Community Hydrologic Prediction System (CHPS) with the Sacramento Soil Moisture Accounting (SAC-SMA) model and SNOW-17 snow model

Improved Weather & Streamflow Prediction in N. America



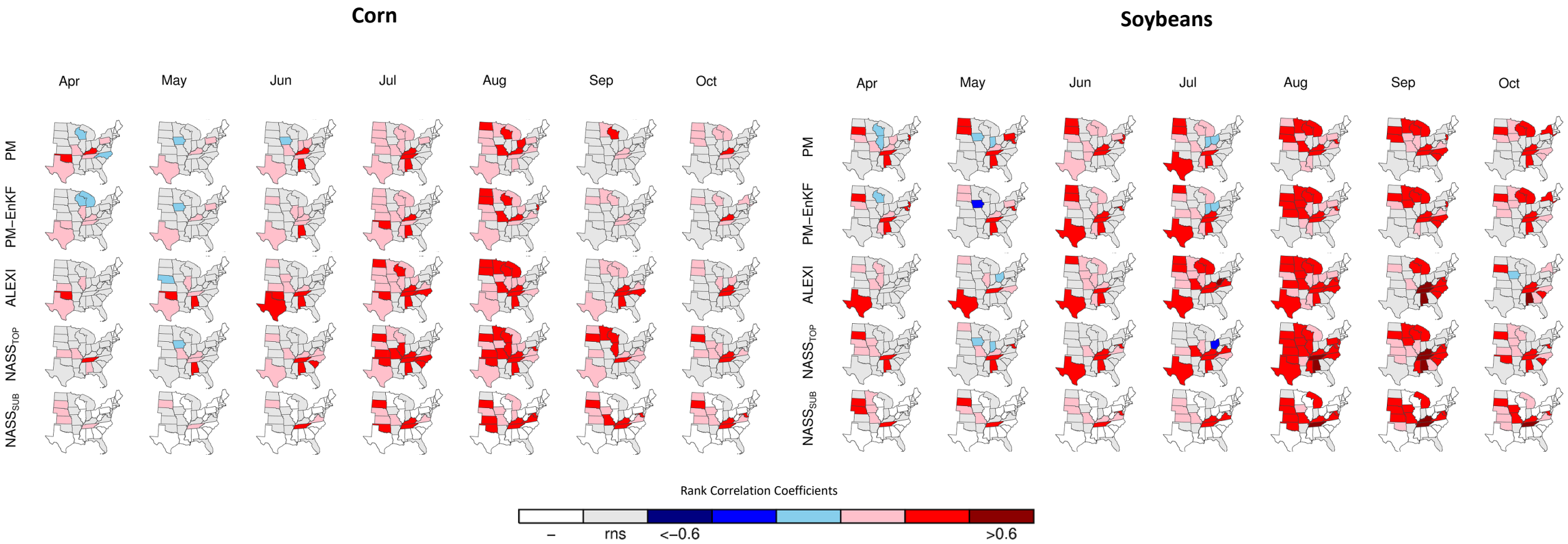




- The Canadian Land Data Assimilation System (CaLDAS) used for numerical weather prediction over North America
- Use of SMAP data in CaLDAS has resulted in a significant positive impact on numerical weather prediction in North America and streamflow forecasts for the Lake Ontario basin.
- **The operational implementation of CaLDAS-SMAP is targeted for Spring 2018.**

Application: Weather Forecasts. Environment & Climate Change Canada.

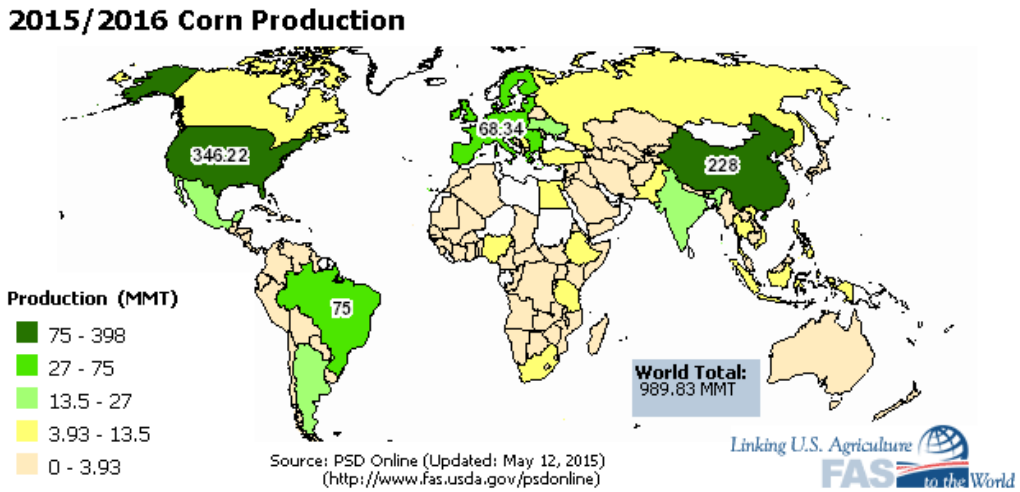
Agricultural Monitoring and Yield Prediction

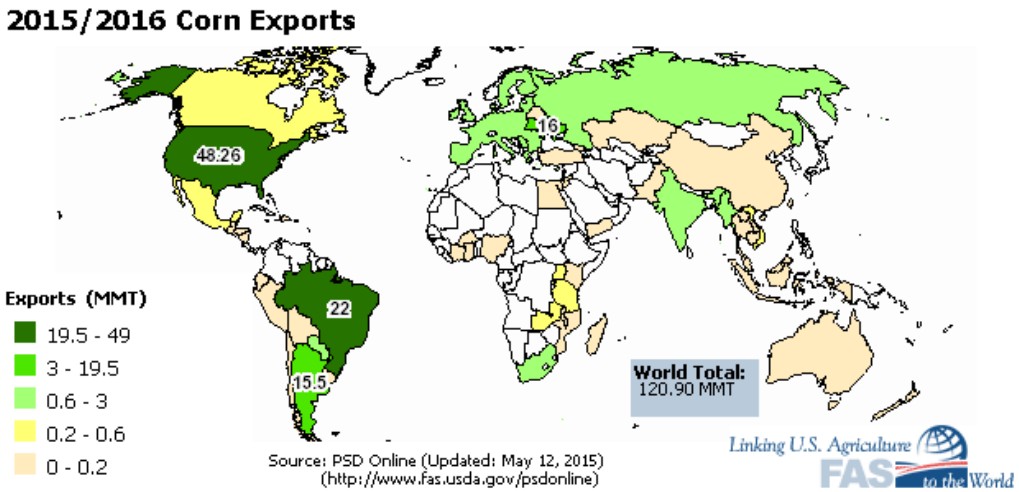


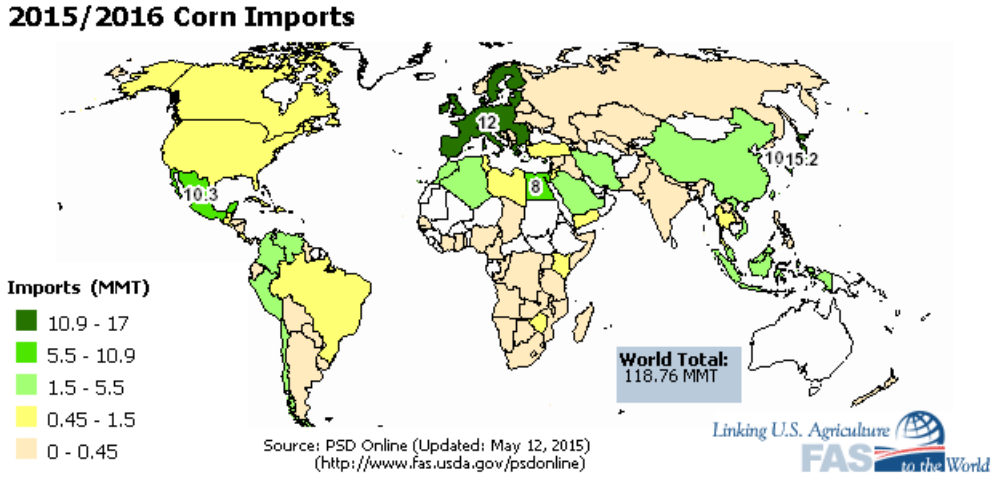
- PM stands for Palmer Model (hydrologic model used by USDA FAS) .
- PM-EnKF is an enhanced version of the PM generated by assimilating satellite-based soil moisture observations.
- ALEXI – soil moisture proxy estimated using an energy-based model that is driven by thermal imageries acquired from GOES.
- NASS – survey-based soil moisture product.

Application: Crop Productivity & Agriculture. Iliana E. Mladenova and John Bolten, NASA GSFC.

Improving Global Crop Forecasts



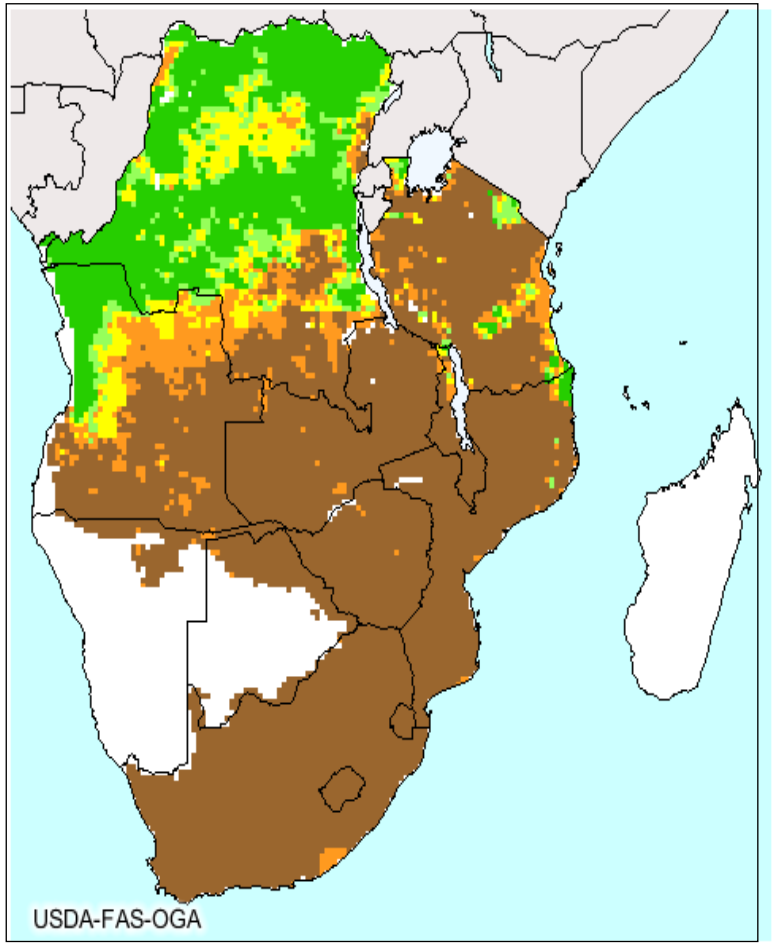




Application: Crop Productivity & Agriculture. Iliana E. Mladenova and John Bolten, NASA GSFC.

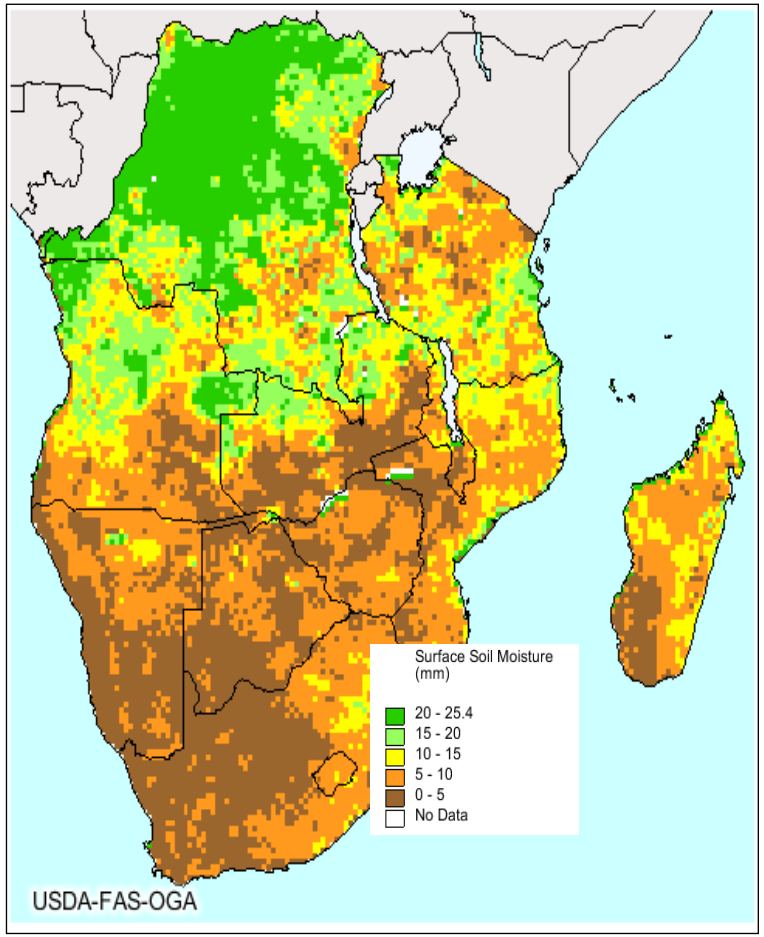
Improving Global Crop Forecasts

04/11/2014 - 04/20/2014



Model

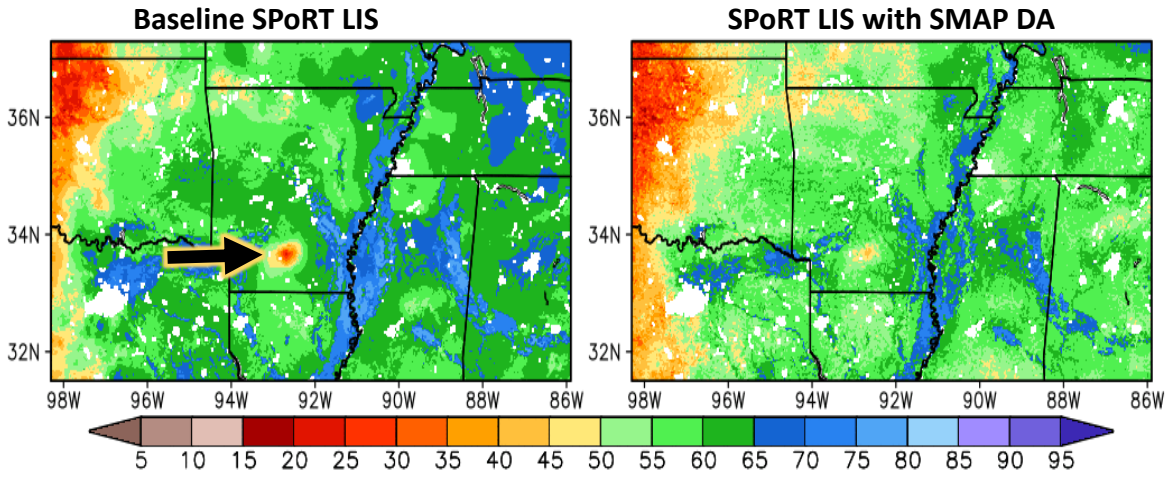
04/11/2014 - 04/20/2014



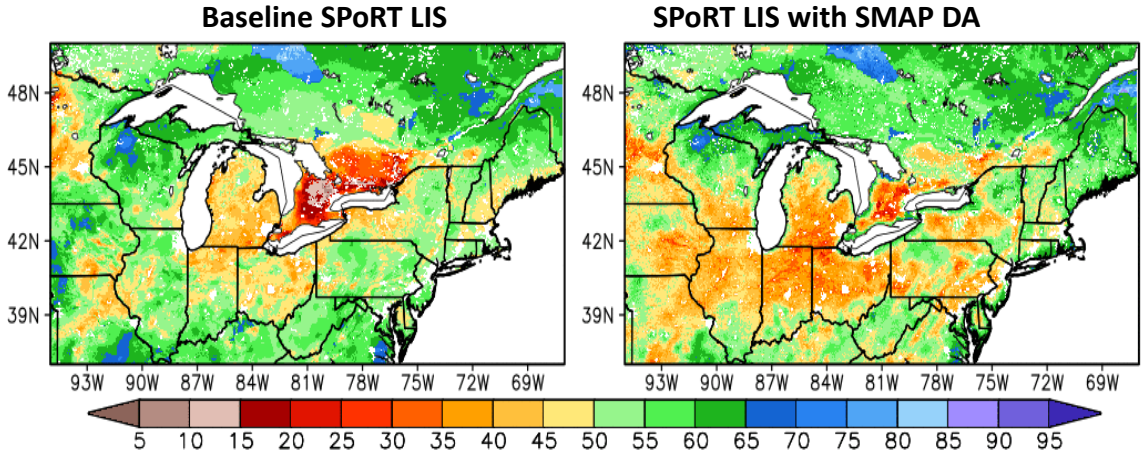
http://www.pecad.fas.usda.gov/cropexplorer/

Improved SM Analyses in the Land Information System (LIS)

Reducing Errors due to Poor Quality Control in Forcing Data

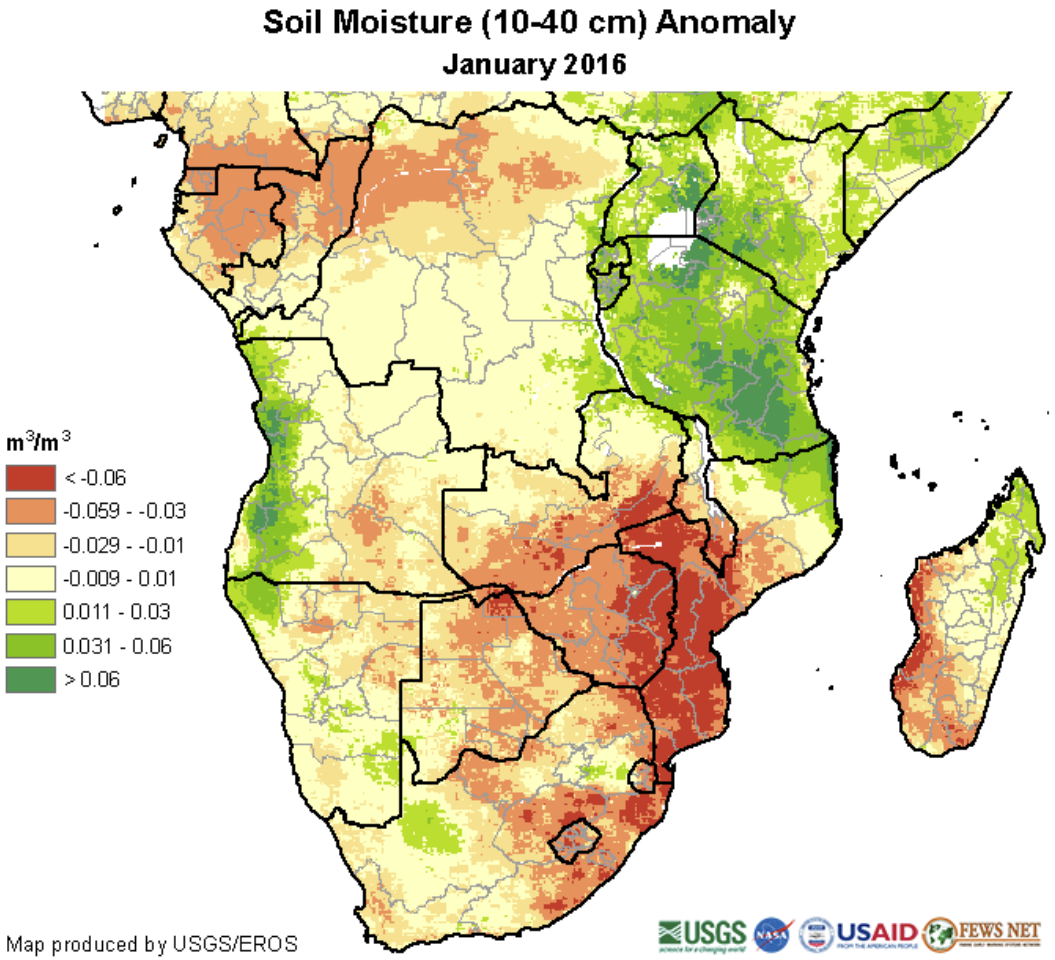


Better Blending of Soil Moisture Across US-Canada Border



Application: Land Information System model. SPoRT

Famine Early Warning Decision Support with LIS

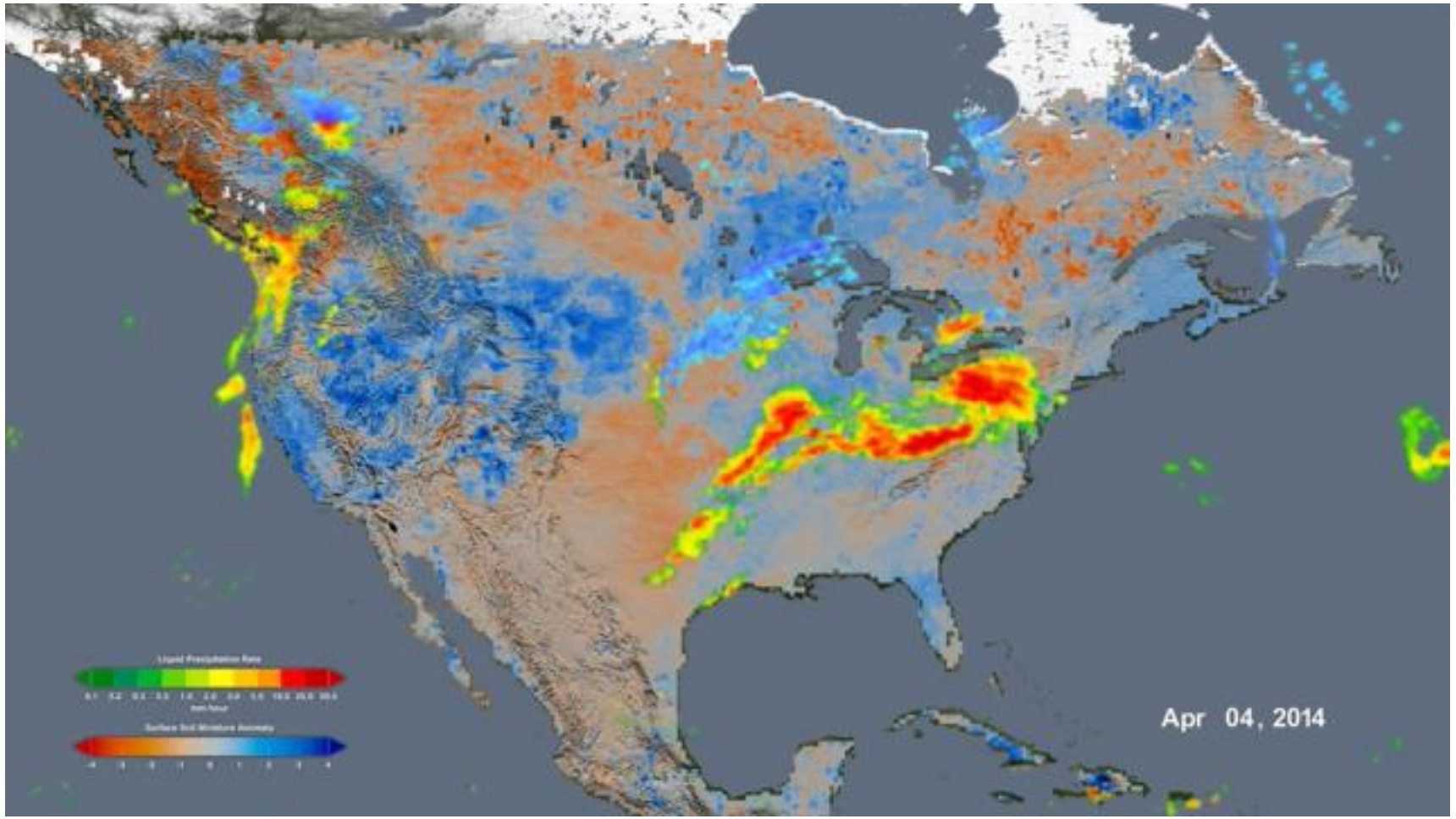


"Zimbabwe declares 'state of disaster' due to drought: More than quarter of population face food shortages as country hit by severe drought, with cattle dying and crops destroyed"

-The Guardian, 5 February 2016

Application: Droughts. A. McNally, J. Jacob, K. Arsenault, C. Peters-Lidard, S. Kumar

Understanding Essential Information for Decision Support



Soil Moisture/Precipitation Anomaly. Courtesy of NASA Scientific Visualization Studio.

NASA's Capacity Building Program

Engaging current and future decision makers in a spectrum of activities to improve skills and capabilities in the US and worldwide to access and apply NASA Earth science

ARSET

Online and hands-on NASA remote sensing training

Led by NASA Goddard

DEVELOP

Dual workforce capacity building using collaborative feasibility projects

Led by NASA Langley

SERVIR

Building international capacity in developing countries

Led by NASA Marshall

Applied Remote Sensing Training (ARSET)

http://arset.gsfc.nasa.gov/

GOAL: To Increase utilization of NASA observational and model data for decision-support through training activities for environmental professionals.

Application Areas: water resources, disasters, air quality, and land management.

Online courses: Live and recorded, 4-6 weeks in length.

In person training courses: In a computer lab, 2- 4 days.

Train the Trainers: Courses and training manuals for organizations interested in conducting their own remote sensing training, beginning in 2015

Accomplishments
(2008 – 2014)

- 35 trainings completed
- 1700+ participants worldwide
- 500+ Organizations