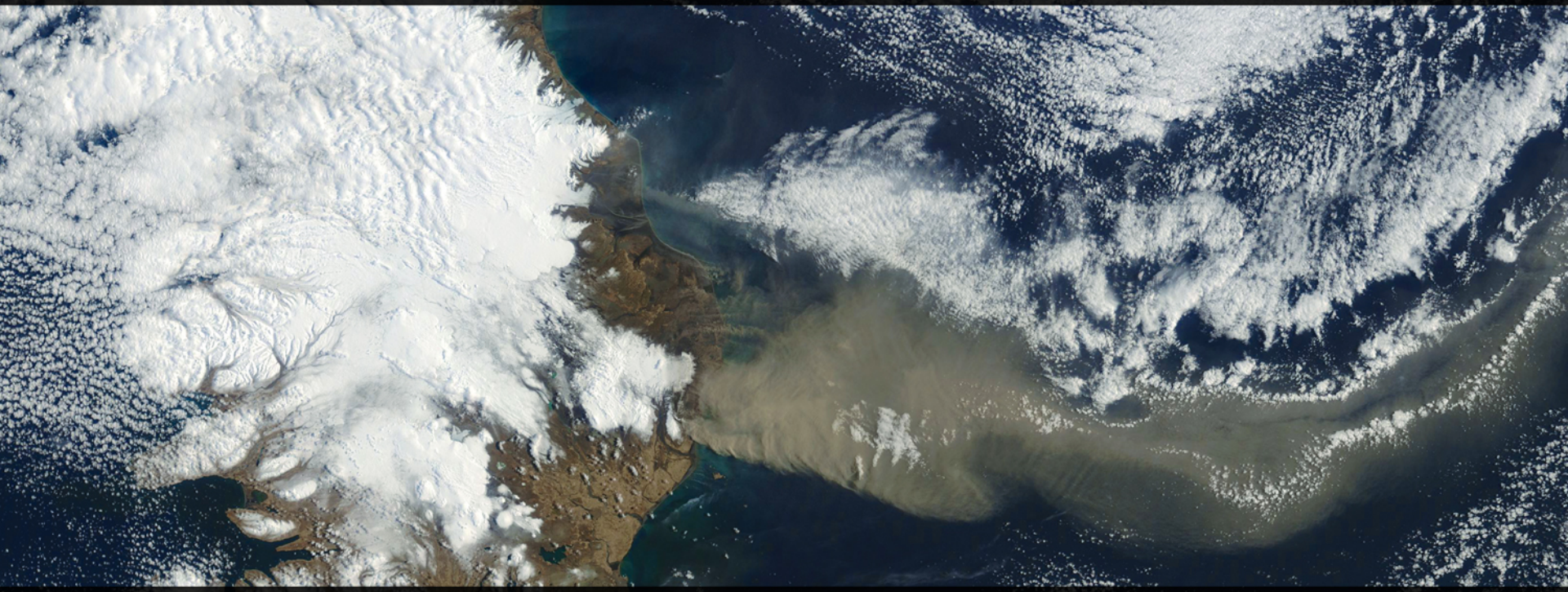
National Aeronautics and Space Administration

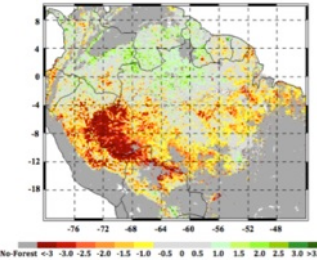


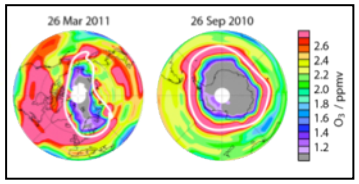
Earth Science

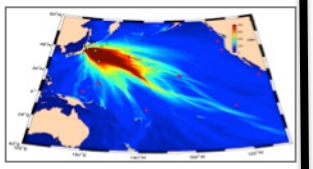
Bradley Doorn, NASA
Western States Water Council, Water Resources Committee
22 March 2016

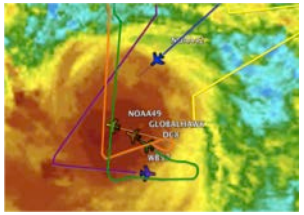
NASA's Earth Science Division

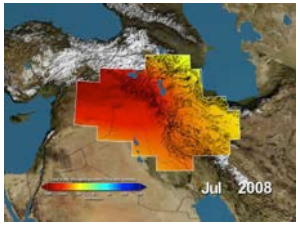
Research

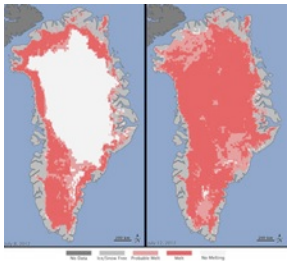




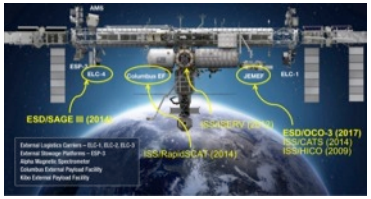




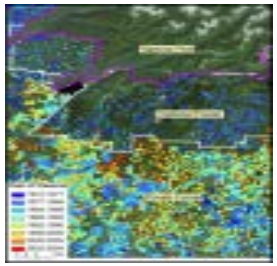


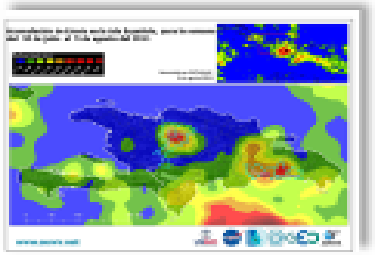


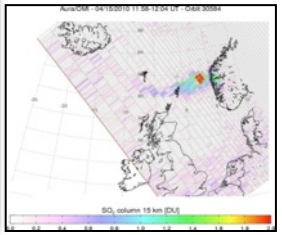
Flight

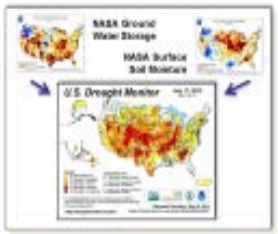


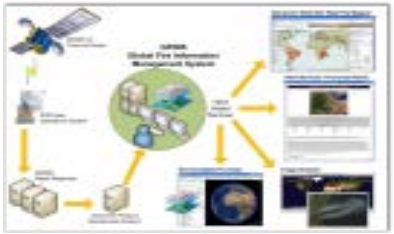
Applied Sciences

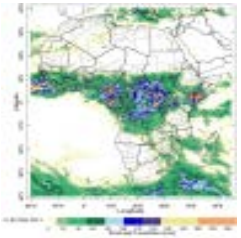




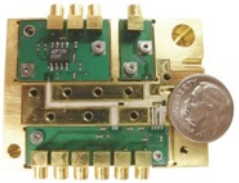


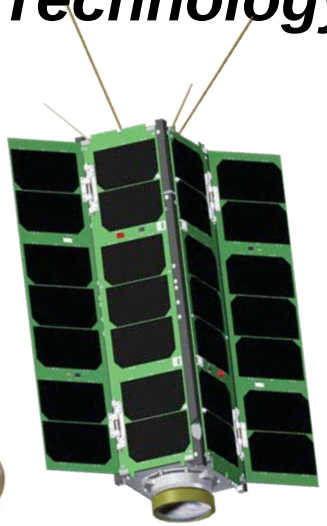






Technology





Earth Science Missions and Instruments

Land Imaging Evolution

While recognizing the scientific need for continuity with the 43-year Landsat record, we are seeing new trends & opportunities in land remote sensing

- *Evolving user needs for…*
  - *Improved temporal revisit*
  - *Additional spectral coverage & resolution*
  - *Integration with other modalities (lidar, radar)*
- *Increasing use of "small sat" platforms and distributed architectures*
- *Increasing number of commercial imaging systems*
- *Potential synergy with international systems (e.g. Sentinel-2)*
- *High-performance computing and increased emphasis on information rather than images*

Our challenge is to advance the measurement capability, while preserving continuity and constraining program costs

Sustainable Land Imaging (SLI) in the President's FY17 Budget

A 3-part program for a sustainable and responsible land imaging program through 2035:

1. **Landsat 9** (fully Class-B rebuild of Landsat 8) anticipated to launch in FY 2021
   - Low programmatic risk implementation of a proven system with upgrades to bring the whole system to Class B
2. **Land Imaging Technology and Systems Innovation**
   - Hardware, operations, and data management/processing investments to reduce risk in next generation missions
3. **Landsat 10**, Class B full spectrum, to launch ~2027-2028
   - Mission architecture to be informed by the technology investments (2015-), leading to definition ~2020

SLI: NASA Present Status

Landsat 9 Project initiated with FY15 funds

- Directed to NASA's Goddard Space Flight Center (GSFC)
- Project Office established and substantially staffed
- OLI-2 Instrument and Landsat 9 spacecraft procurement actions in work
- TIRS-2 development in progress
- Launch ASAP, likely NET 12/2020 – there is sufficient funding authority for FY16

Technology studies underway for Landsat 10 definition and long-term technology infusion

- Detector component development
- Overall instrument size reduction using advanced technologies
- ROSES SLI Technology call released (ROSES 2015 A.47 released 23 Dec 2015 with proposals due 30 Mar 2016)

NASA solicited, selected, and initiated science investigations focused on construction of multi-system fusion data sets ("Multi-Source Land Imaging Science")

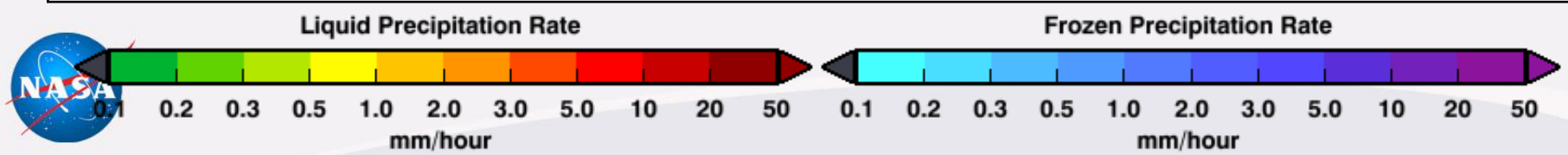
- "…[W]e solicit for efficient use and seamless combination with Landsat, of satellite sensor data from international Landsat-type moderate resolution (~30 m ground resolution), multispectral sources on continental to global scales. A primary focus is on developing algorithms and prototyping products for combined use of data from Landsat and Sentinel-2 toward global land monitoring. However, we also welcome proposals combining Landsat with other sources of moderate resolution data, such as IRS and/or CBERS…"
- 7 investigations selected, $1.3M/year total, 3-year studies (see later slide)

Copernicus data access agreements with EU signed (including all Sentinel-2 data)

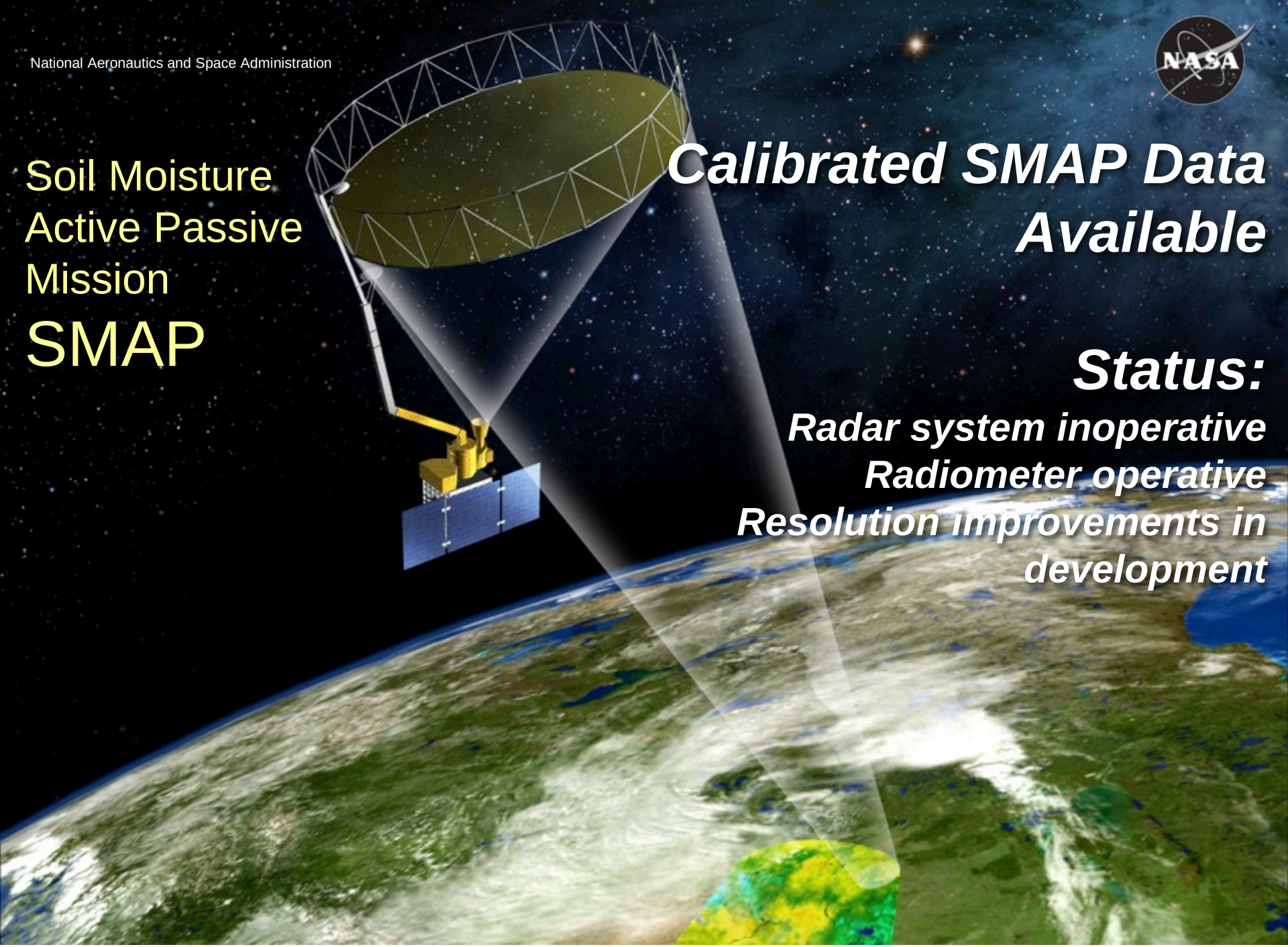
- Sentinel-2 data is now available from USGS EROS Data Center

Multi-Satellite Precipitation Data (30 min, 10km by 10km)

IMERG: Integrated Multi-satellitE Retrievals for GPM



Soil Moisture
Active Passive
Mission
SMAP



Calibrated SMAP Data Available

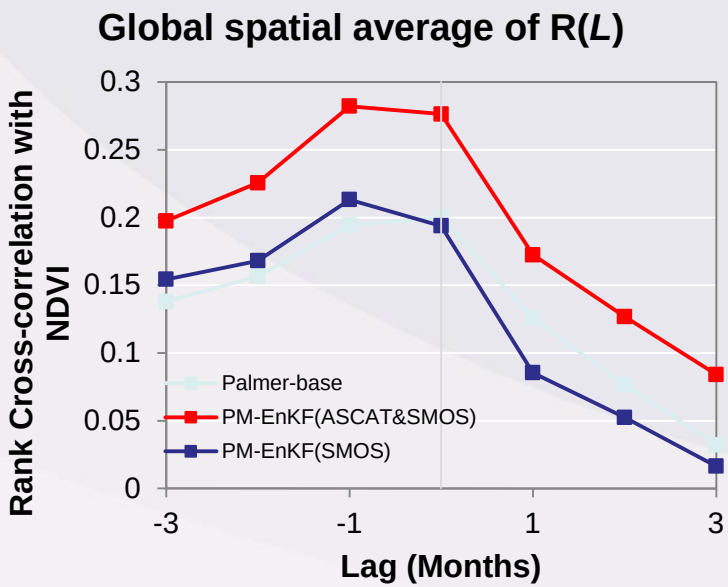
Status:

Radar system inoperative
Radiometer operative
Resolution improvements in development

Enhancing the USDA-FAS Global Crop Modeling Using SMAP and ASCAT Soil Moisture Products

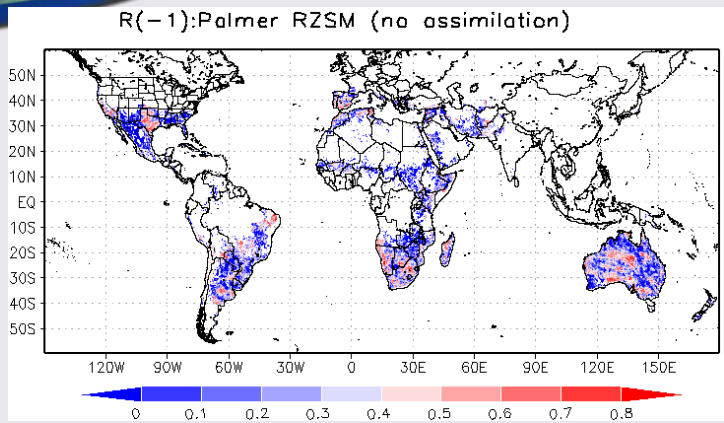
Curt Reynolds (USDA-FAS), John Bolten & Iliana E. Mladenova (NASA-GSFC), Wade Crow (USDA-ARS)

Prototype ready to begin ingesting the SMAP data!

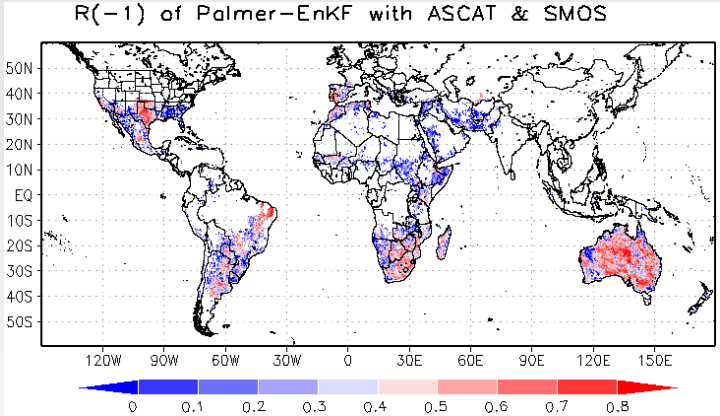


R(L) between NDVI and the model only soil moisture, no assimilation
R(L) between NDVI and the modelled soil moisture after assimilating SMOS only
R(L) between NDVI and the modelled soil moisture after assimilating both SMOS and ASCAT

Figure 1



No assimilation scenario

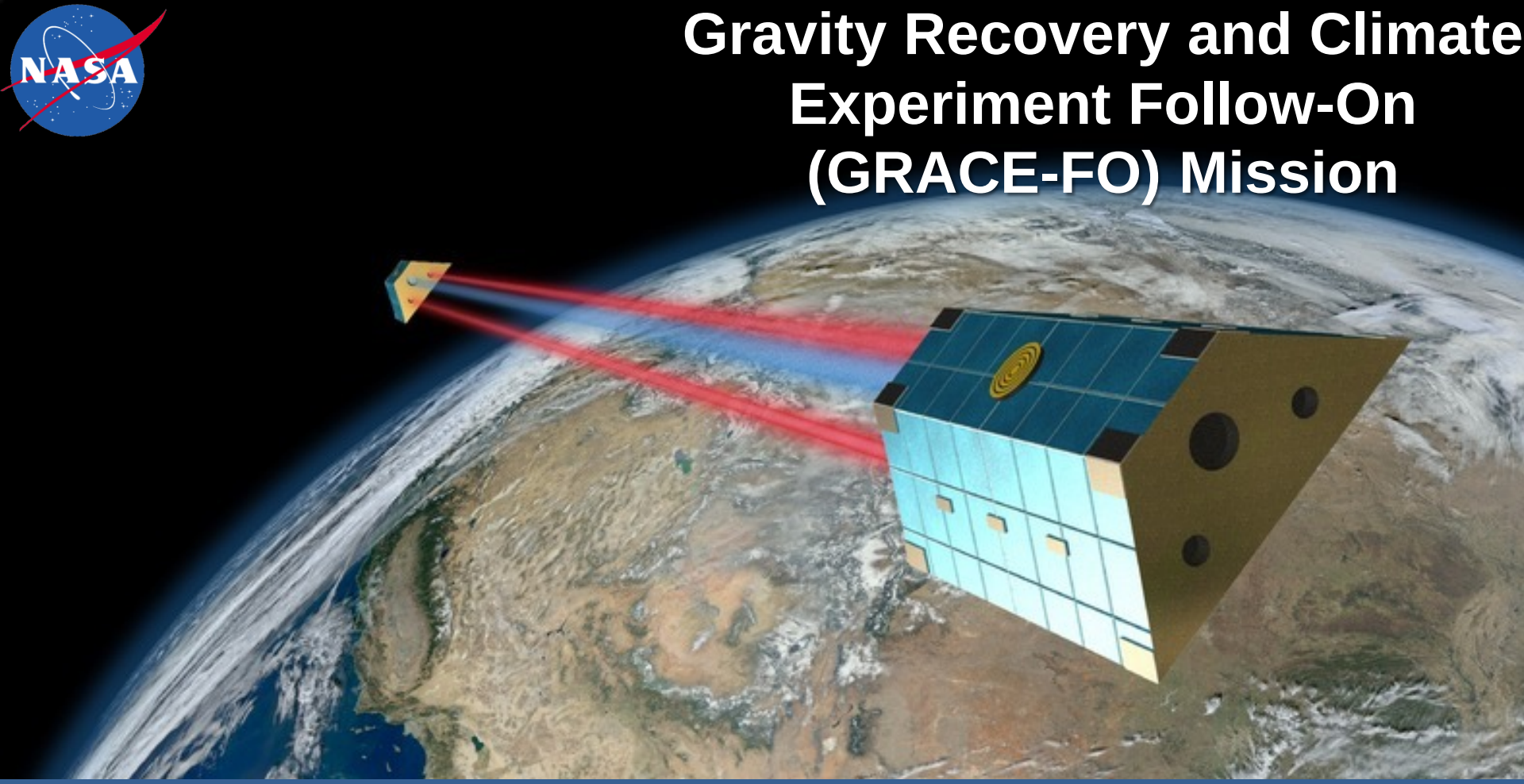


After assimilating SMOS and ASCAT

Figure 2

- R is the lagged rank cross-correlation coefficient computed between soil moisture (SM) and NDVI
- **Changes in SM precede the changes in vegetation conditions** as captured by NDVI (i.e. negative lags).
- **R is the greatest when we assimilate both SMOS and ASCAT simultaneously**
- Agreement is **greatest at L = -1** (i.e. SM precedes the changes in NDVI by 1 month)
- The **spatial variability** in R at L=-1 is shown in Figure 2

Gravity Recovery and Climate Experiment Follow-On (GRACE-FO) Mission



GRACE Launched on 2002 still in action

GRACE-FO launch date 2017

GRACE II planned recommended by Decadal Survey

Improved GRACE Data Assimilation Based Wetness Indicators

M. Rodell, B. Li, H.K. Beaudoing, S. Kumar, and A. Getirana (NASA/GSFC)

Highlight:

- Improved wetness/drought indicators now being generated by NASA/GSFC and served by the National Drought Mitigation Center
- Gridded (as opposed to basin-average) assimilation of Gravity Recovery and Climate Experiment (GRACE) data within the Catchment land surface model driven by NASA's Land Information System (LIS)
- Spatial resolution increased from 0.25° to 0.125°

Relevance:

- The GRACE data assimilation based wetness/drought indicators provide valuable and heretofore unavailable information on groundwater and deep soil moisture conditions that are used by water resources managers, drought specialists, and agricultural interests
- These products make use of and enhance the value of observations from NASA's GRACE and (in 2017) GRACE Follow On missions
- Results shown here are a first step towards seasonal wetness/drought forecasts that will make use of NASA satellite data and models

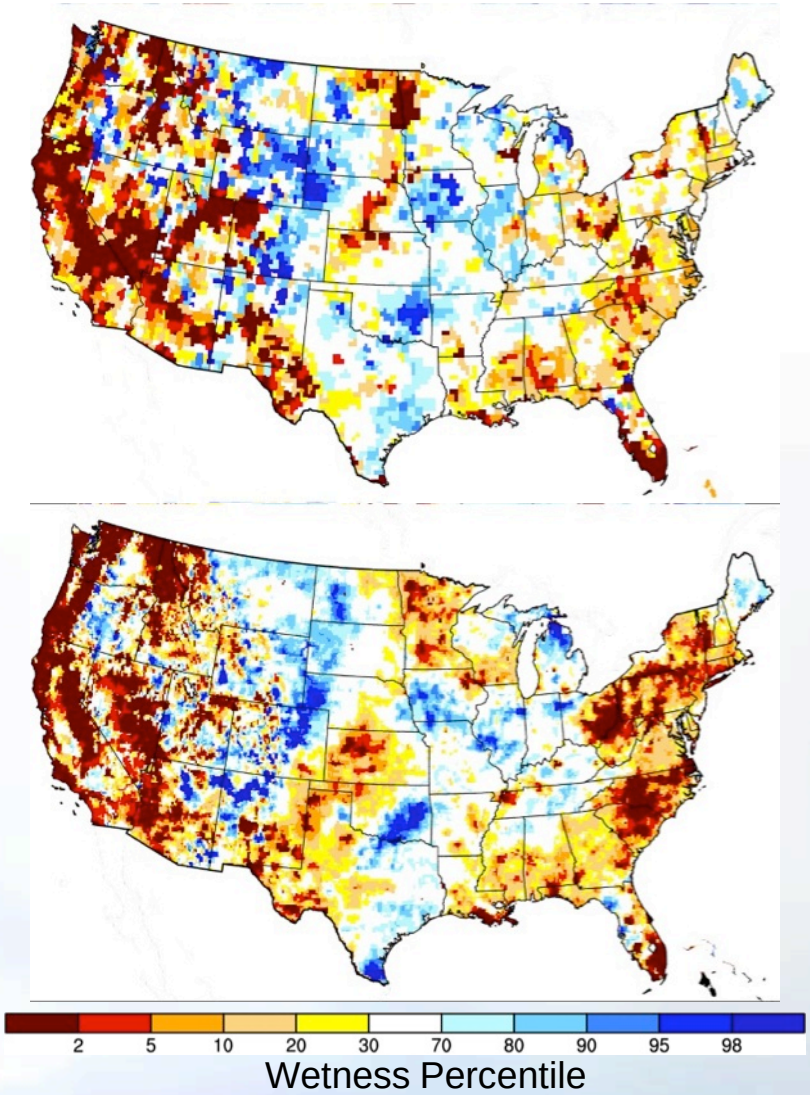
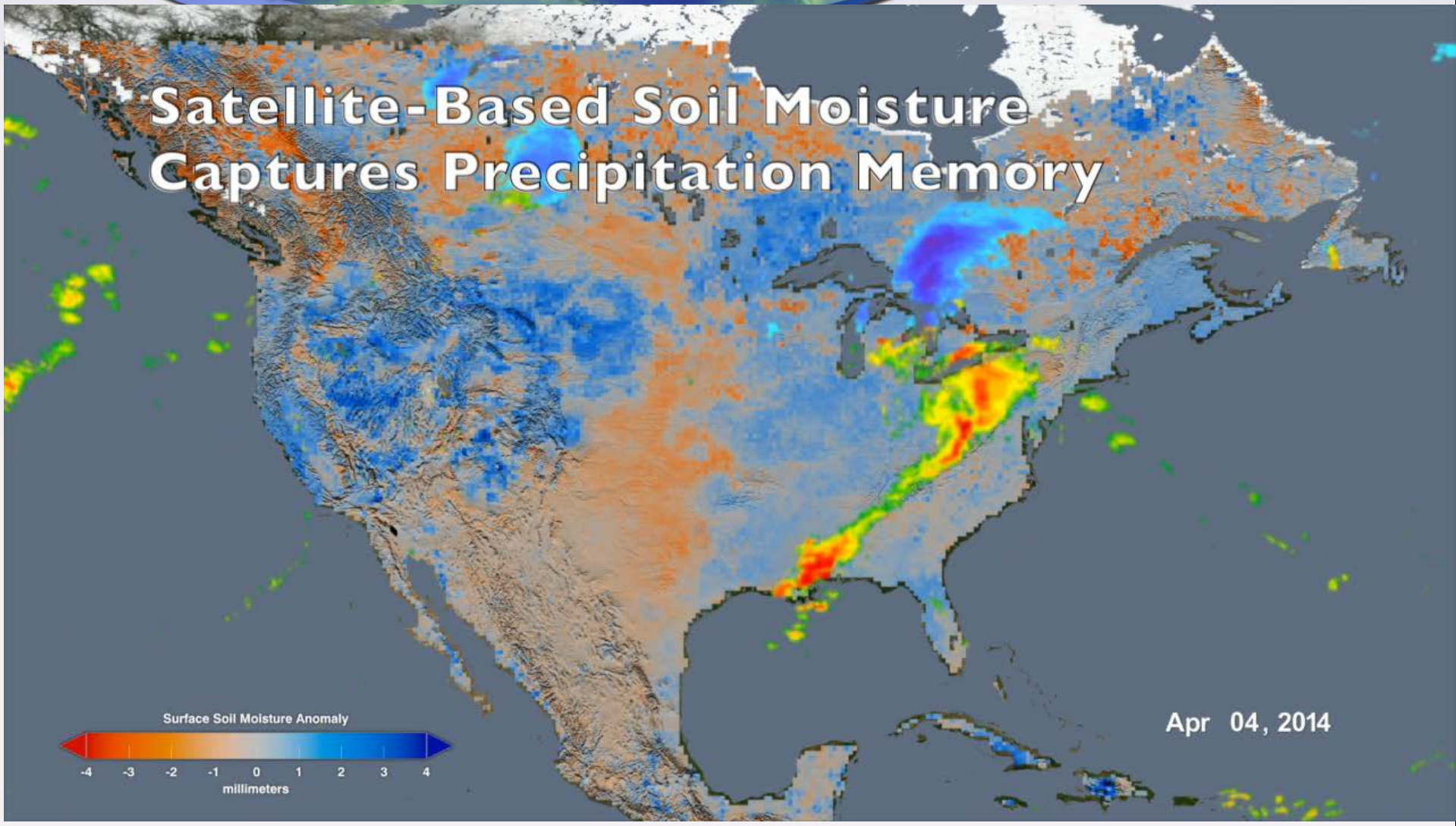


Figure 1: Groundwater wetness/drought indicators from basin-average GRACE data assimilation (DA) at 0.25° (top) and from gridded GRACE DA within LIS at 0.125° (bottom), valid 14 September 2015. Note the improvement in pattern definition. The new indicators are now being served from http://drought.unl.edu/MonitoringTools.aspx.

Watching the Hydrologic Cycle from GPM, SMOS(pre-SMAP), and GRACE



Call for Water Resources Applied Research in 2016

…This solicitation seeks to: a) advance the ability of organizations (public and private) to use Earth observations and apply computational and modeling capabilities that utilize **Earth observations**, and b) **enhance water managers' abilities to respond** effectively to the challenges presented by threats to the security and sustainability of water resources that are difficult to address with current water management tools. Proposed projects should develop or advance the usability of data products available to water managers that are derived from Earth observations and models, as well as address and **facilitate their use in operational decision making** through innovative data processing and delivery systems, such as high performance computing and rapid prototyping using cloud computing. Overall, the proposed work should **clearly demonstrate how the proposed effort would enhance** current decision-making processes employed by water managers and their stakeholders……

…Specifically, this solicitation focuses on two key components of enhancing water security: 1) in **water quality** OR 2) in **agriculture water use**.

Previous Calls with Active Projects: 2011 – **Drought**, 2013 – **In-season Prediction of Water Anomalies**