NASA Contributions to GEO

David Toll – NASA International Water
Brad Doorn - NASA Water Resources & Agriculture
Nancy Searby - NASA Capacity Building
Rick Lawford – NASA Water Consultant
Christine Lee – NASA Associate

26 March 2014

Workshop on Earth Observations and the Water-Energy Food Nexus

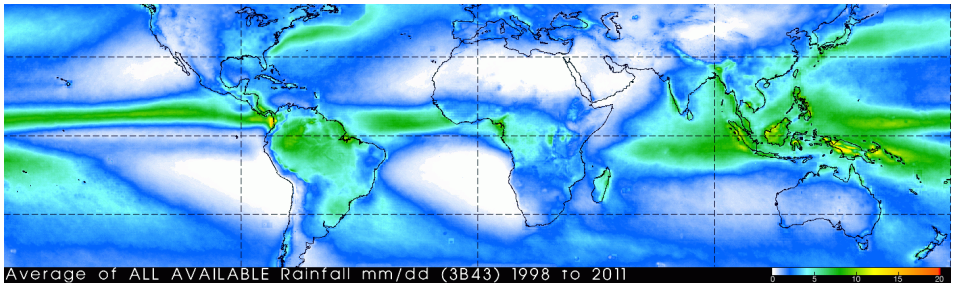
New Satellite & Observations Systems


Earth Science Missions
in Operation
Aquarius
OSTM/Jason 2 (NOAA)
Jason
QuikSCAT*
TRMM & GPM
EO-1
Landsat-7 (USGS)
Aqua
ACRIMSAT
Terra
SORCE
GRACE (2)
Aura
CALIPSO
CloudSat
SUOMI NPP
Landsat-8

Precipitation from Space

Tropical Rainfall Measurement Mission (TRMM)

- Global precipitation measurement (core) implemented with other satellites (50S-50N)
  - Active & passive radiometers
  - Critical water resources information
  - 1997 to present



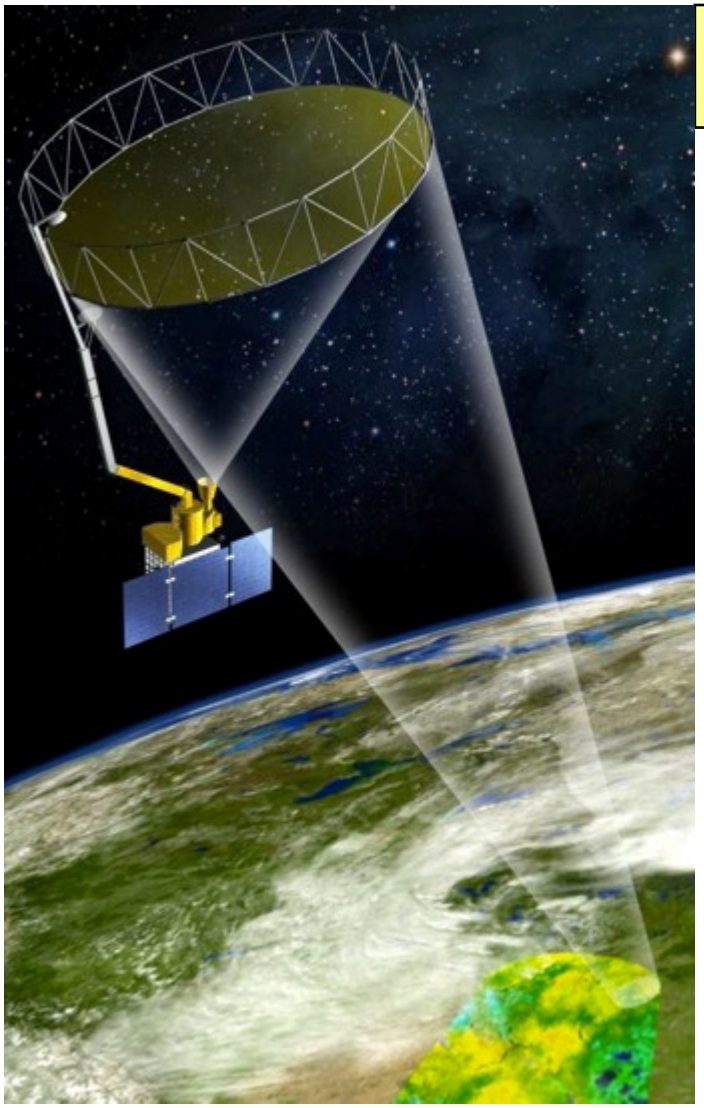
TRMM 14-year mean rainfall

Global Precipitation Measurement (GPM)

The GPM Core Observatory will provide improved measurements of precipitation from the tropics to higher latitudes

- 27 February 2014 launch
- Inputs from constellation of satellites to increase space and time coverage:
  - Better accuracy and coverage (0.1^0)
  - Rain & snow observations every 3-hours with 3-hour latency (near real time)
  - Longer record length
  - High latitude precipitation (snowfall)

Soil Moisture Active Passive (SMAP)



http://smap.jpl.nasa.gov/

SMAP will provide global observations of mapped soil moisture & freeze/thaw data with unprecedented accuracy, resolution & coverage

Objectives:

- **Global, high-resolution mapping of soil moisture and its freeze/thaw state to:**
  - **Extend weather and climate forecast skill**
  - **Improved flood and drought monitoring with predictions**
  - **Improve estimation for productivity (agriculture & natural) and evapotranspiration (consumptive water loss)**
  - **Engage end users and build support for applications**

Mission Implementation

Partners	• **JPL** (project & payload management, science, spacecraft, radar, mission operations, science processing) • **GSFC** (science, radiometer, science processing)
Risk	• 7120-81 Category 2; 8705.4 Payload Risk Class C
Launch	• Oct. 2014 on Delta II system
Orbit	• Polar Sun-synchronous; 685 km altitude
Duration	• 3 years
Instrument & Products	• Active and Passive 'L' Band Radiometers • Resolution 3 km, 9 km, 36 km • 12 hours, 50 hours & 7 Days Data Latency

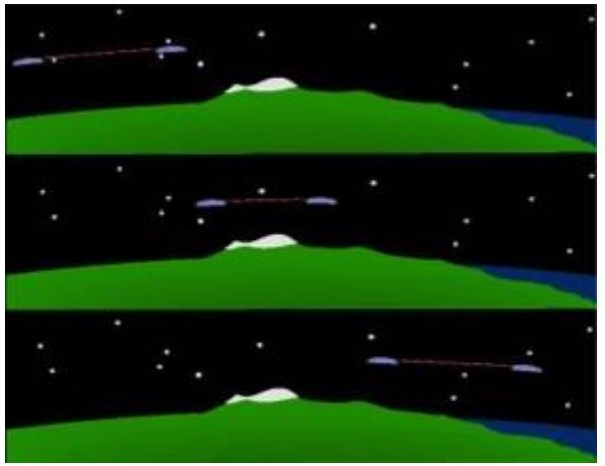
GRACE Derived Terrestrial Water Storage Variations

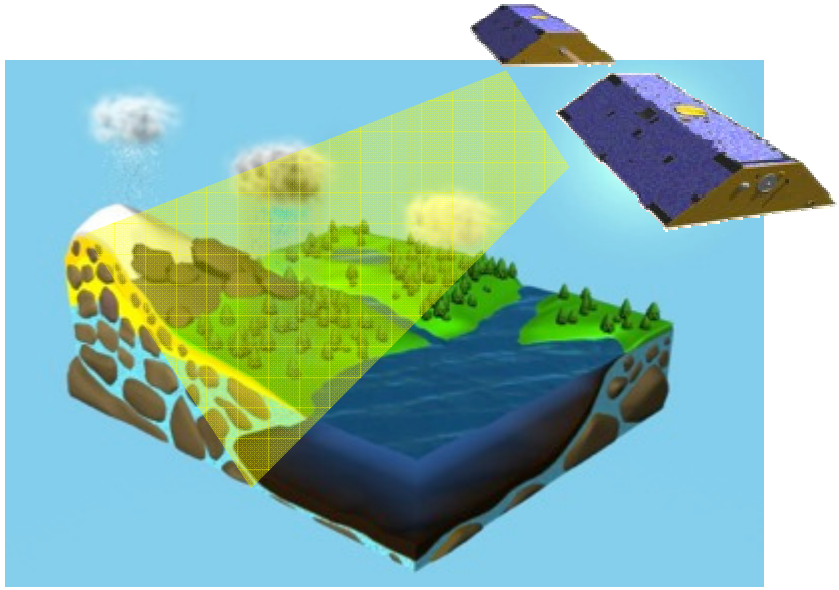
GRACE Science Goal: High resolution, mean and time variable gravity field mapping for Earth System Science applications

Instruments: Two identical satellites flying in tandem orbit, ~200 km apart, 500 km initial altitude

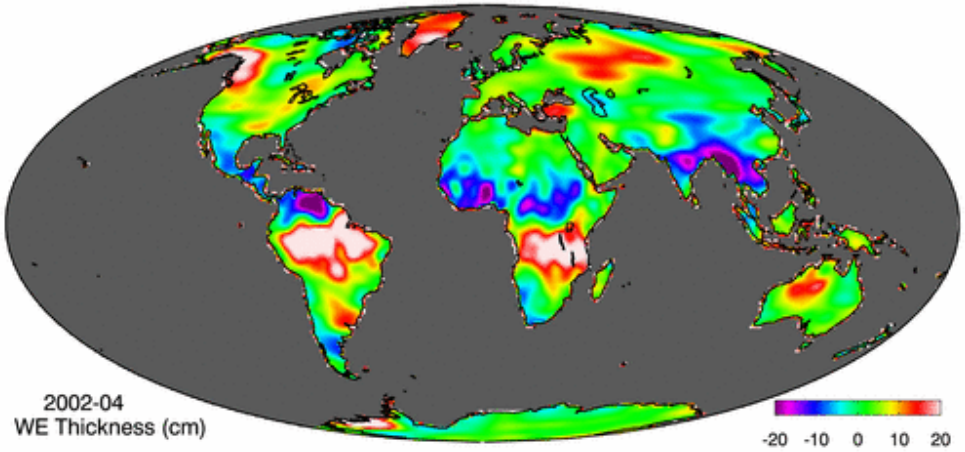
Key Measurement: Distance between two satellites tracked by K-band microwave ranging system

Key Result: Information on water stored at all depths on and within the land surface





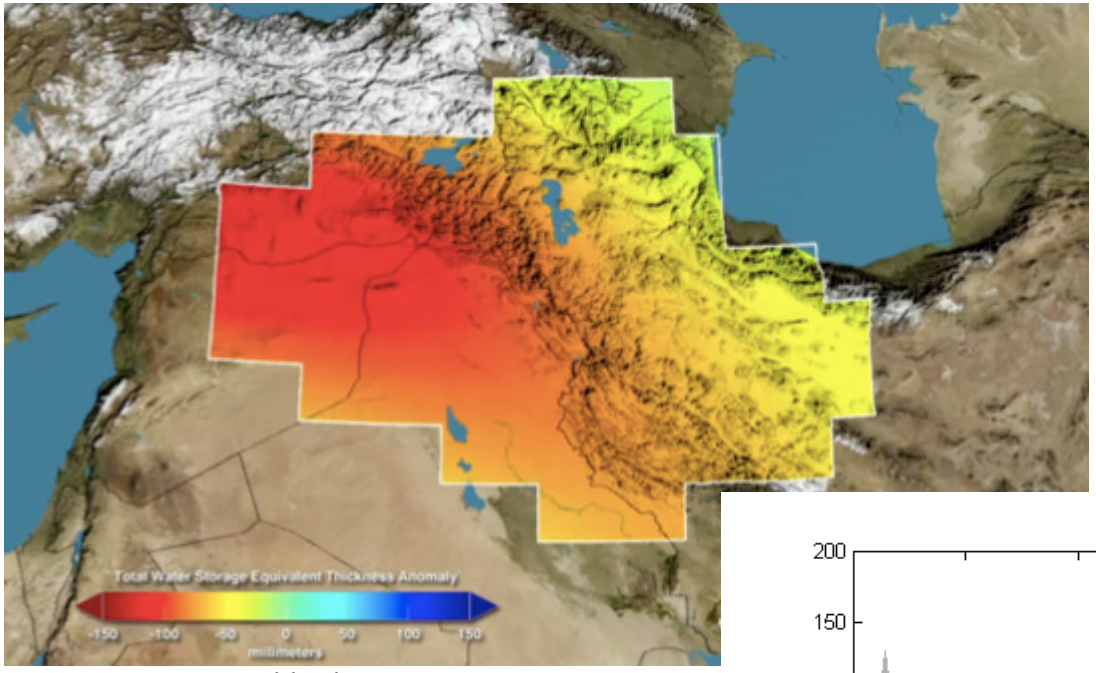
GRACE measures changes in total terrestrial water storage, including groundwater, soil moisture, snow, and surface water.



Animation of monthly GRACE terrestrial water storage anomaly fields. A water storage anomaly is defined here as a deviation from the long-term mean total terrestrial water storage at each location.

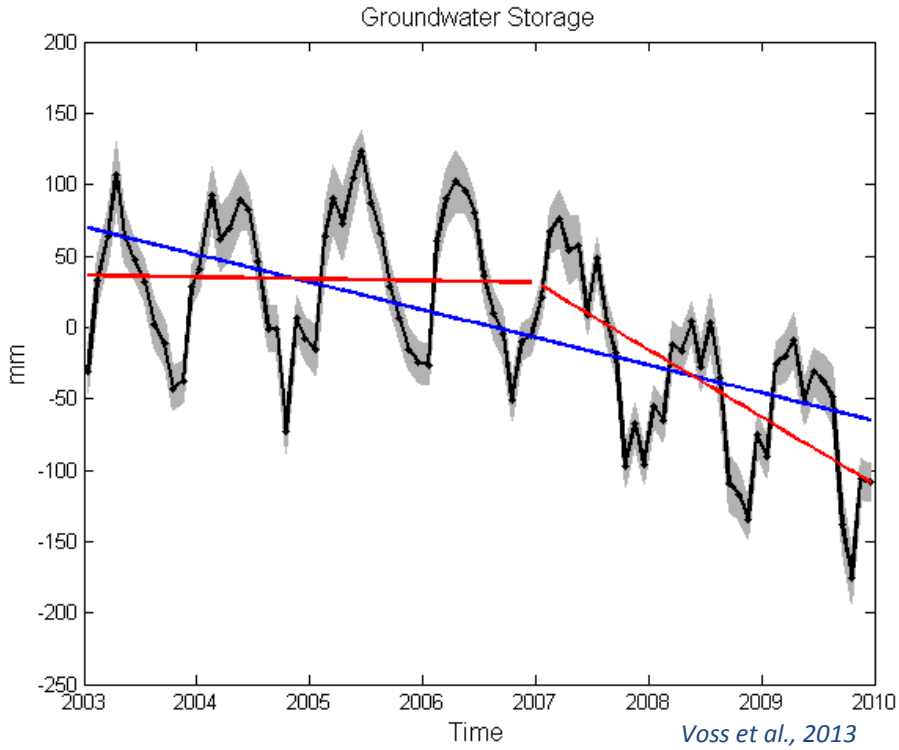
Groundwater depletion in the Tigris-Euphrates-Western Iran region from GRACE, 2003-2009

J. Famiglietti/UC-Irvine



Courtesy NASA Goddard, UCCHM, NCAR

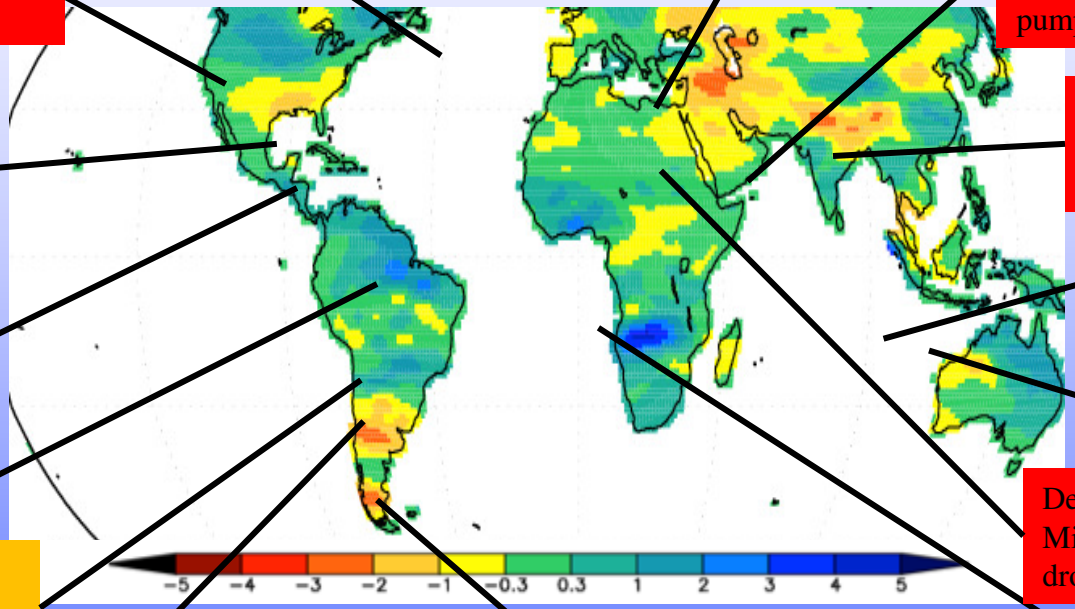
- Nearly 144 km^3 of freshwater lost between 2003 and 2009
- Equivalent to the volume of the Dead Sea
- Roughly 60% of the total water loss is attributed to a loss of groundwater (90 km^3) used for irrigation



Voss et al., 2013

Emerging Trends in Global Freshwater Storage

Trends in terrestrial water storage (cm/yr), including groundwater, soil water, lakes, snow, and ice, as observed by GRACE during 2003-12



Greenland's ice sheet is thinning at a rate of up to 286 km^3/yr

Russian droughts in 2010 and 2012

Groundwater is being depleted across northern India at rate of about 54 km^3/yr due to pumping for irrigation

Alaska's glaciers have been melting at 84 km^3/yr

Drought gave way to flooding in the Missouri River basin in 2011

Overexploitation of freshwater resources in the North China Plain

Recent and ongoing droughts in the southeastern U.S. and Texas

Return to normal after wet years in early 2000s

Drought recovery and flooding

Recovery from 2004-05 drought in the Amazon

Depletion of water resources in Middle East exacerbated by drought

Drought in southern Argentina and gravity step due to 2010 Maule Chile earthquake

Patagonian glacier melt

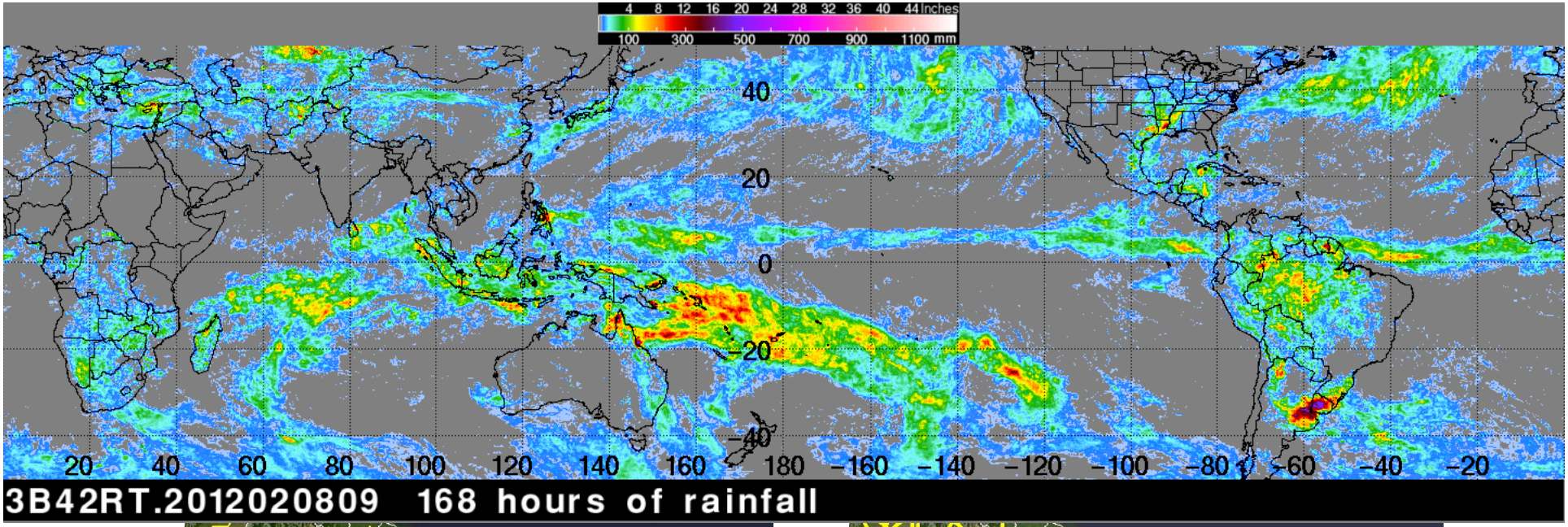
The western Antarctic ice sheet is thinning at a rate of up to 246 km^3/yr

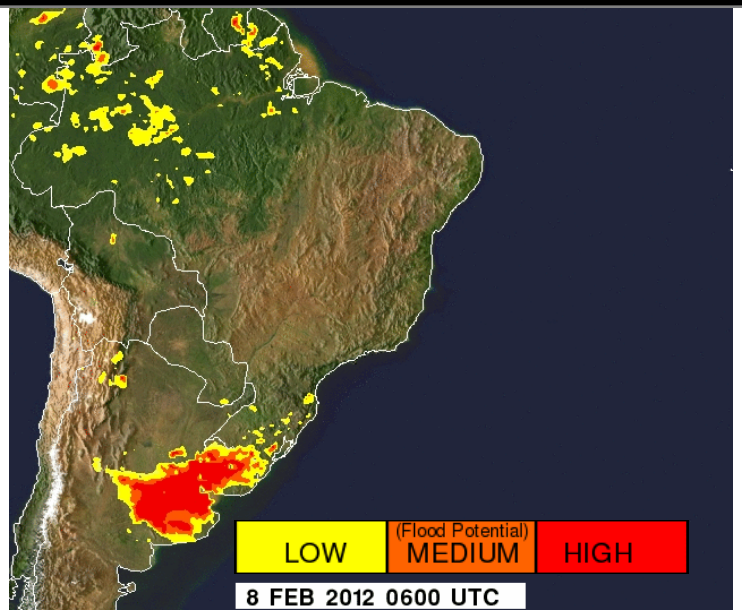
Return to normal in the Okavango Delta after drought ended in 2007

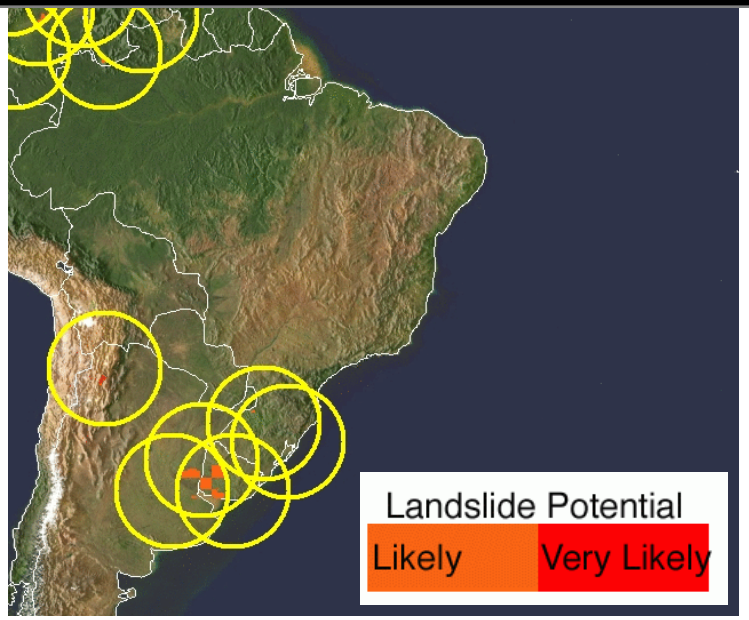
GRACE observes changes in water storage caused by natural variability, climate change, and human activities such as groundwater pumping

Building Robustness to Extreme Events of Floods and Drought

Satellite Precipitation (Near Real Time) for Flood and Landslide Monitoring & Prediction





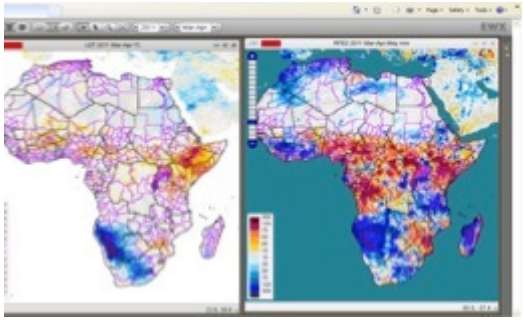


Adler/UM-d

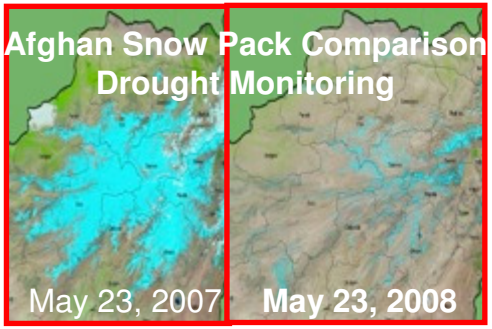
Satellite Based Drought Monitoring Systems

(see http://wmp.gsfc.nasa.gov)

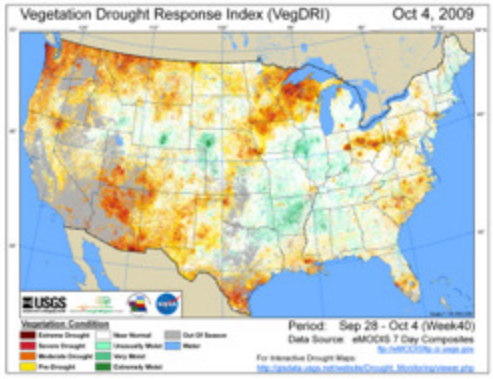
NASA-USDA-Univ MD Global Cropland Drought Monitoring Using MODIS (Justice/U-MD)



NASA & USGS Assisting USAID with Famine Early Warning System, see http://earlywarning.usgs.gov (Verdin/USGS)

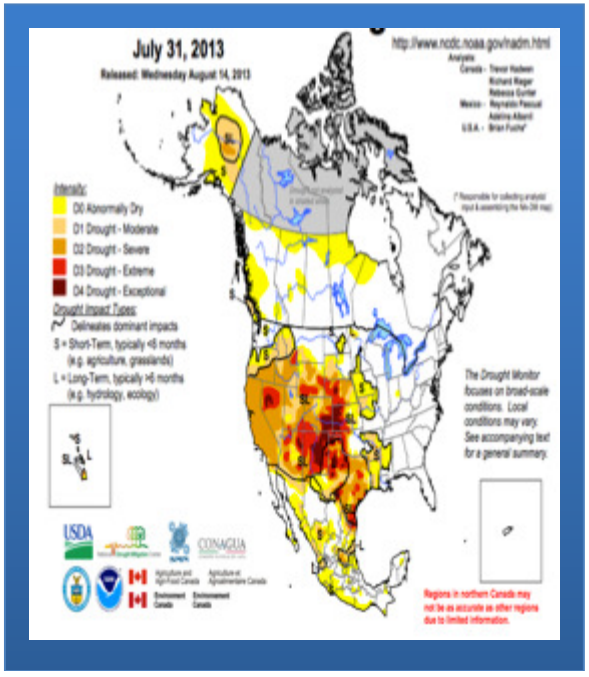


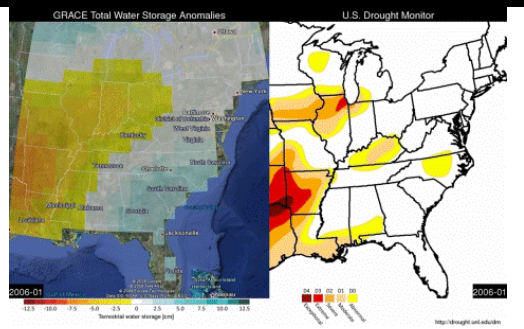
'NOAA-USGS-NASA' Central Asia Snow Pack Monitoring (Fall/NOAA)



'VEGDRI' Using MODIS Satellite in Near Real time for Info to 'County Level' (Verdin/USGS)

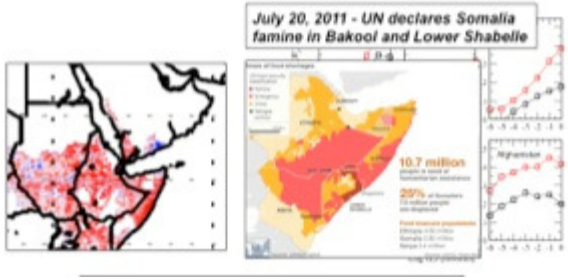
North American Drought Monitor





GRACE Satellite & Modeling for Ground Water Changes for Drought Monitoring (Rodell/NASA)

Drought Monitoring for Brazil Using Cloud Computing Showing MODIS Derived Water Anomalies (May – July 2012) (Vivoni/ASU)

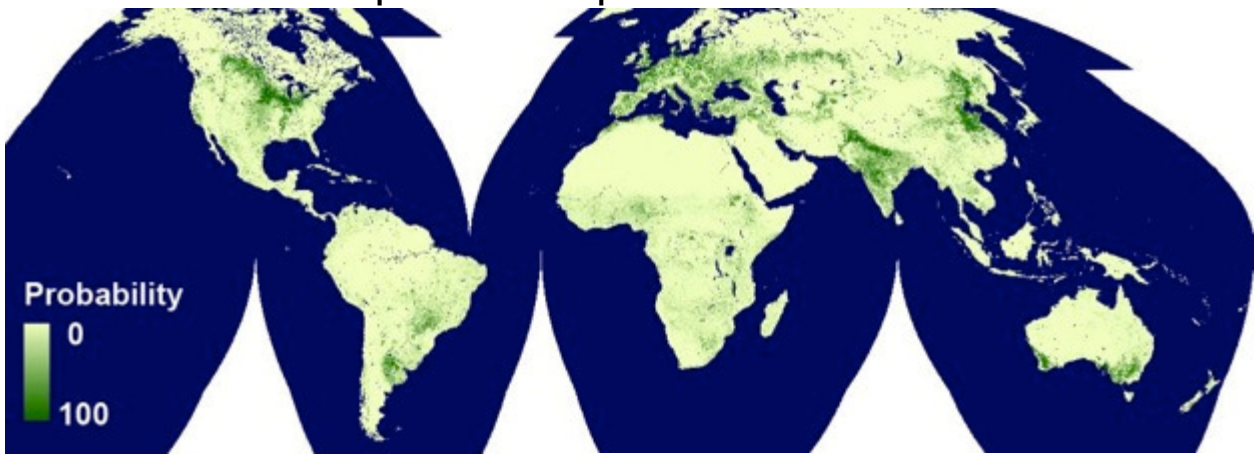


USDA-NASA Using AMSR-E for Crop Models for Horn of Africa Drought (Bolten/NASA)

Earth Observation Tools to Adapt Water for Food

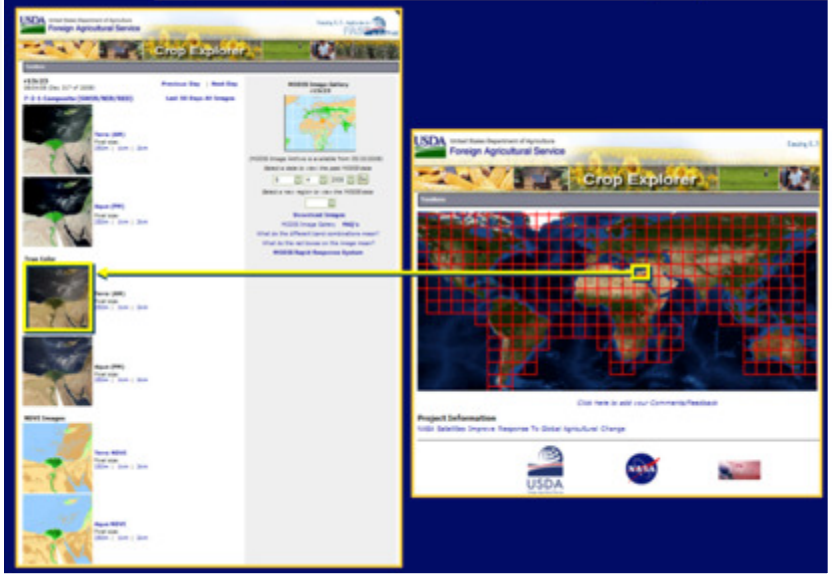
Global Agriculture Monitoring Using NASA MODIS Satellite Data

GLAM Global Croplands Map derived from MODIS Time Series



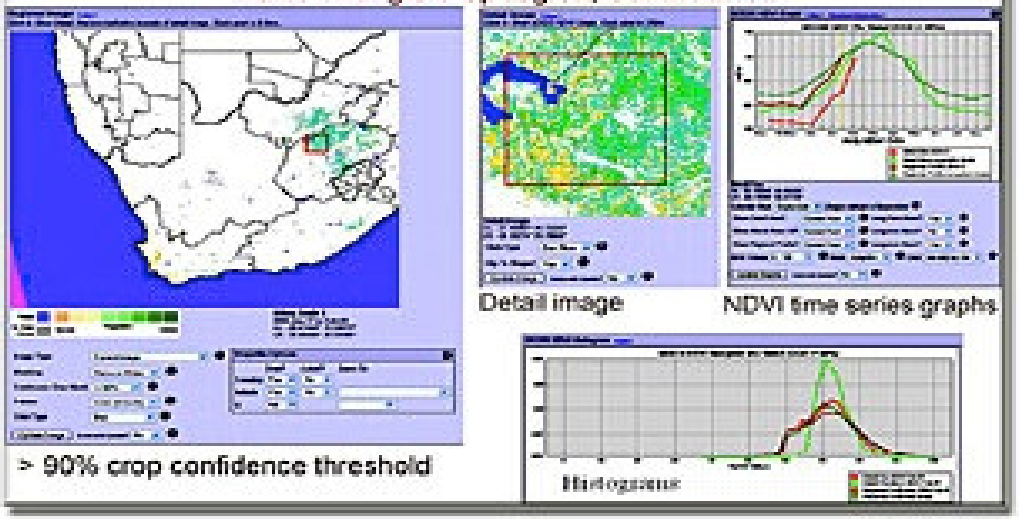
C. Justice/UMd

MODIS Rapid Response Interface with FAS Crop Explorer



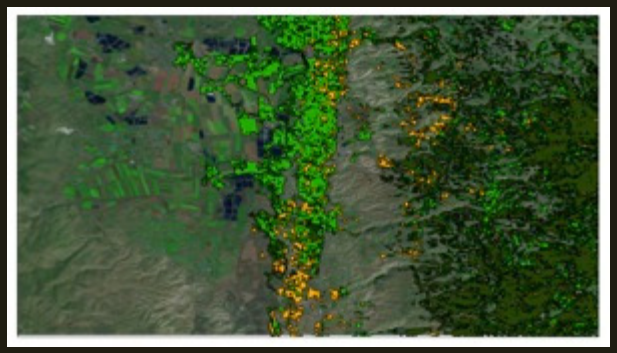
Continuous crop mask (CCM) functionality within MODIS NDVI time-series web interface

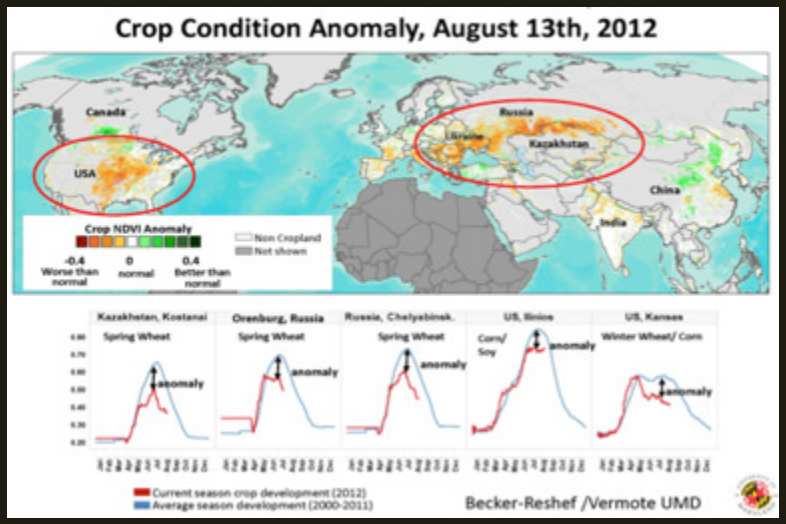
Maize Triangle crop region, South Africa



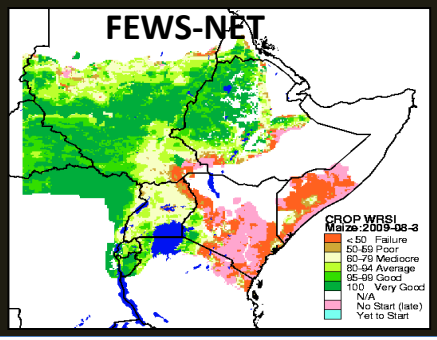
Remote Sensing: Water for Food

Jordan Irrigation Mapping Ozdogan/UWisc





Justice/UMd



Verdin/USGS

Mapping of Irrigated Lands

-Uses unique spectral and temporal features.

-Extent field to global scale. Needs to be optimized locally. Useful for inventorying irrigated areas, cover types & productivity.

Global Agricultural Monitoring Program (GLAM)

-Remote sensing based on using MODIS satellite data.

-Provides country risk and assessments with global monitoring and alerts.

-Combines Agricultural Expertise (GEO, CoP, FAO), with Meteorological Expertise (WM0) and Earth Observational Expertise (CEOS).

Famine Early Warning System-Network

-NASA & USGS assistance to USAID system

-Produces 'Water Requirement Satisfaction Index' for rain-fed agriculture

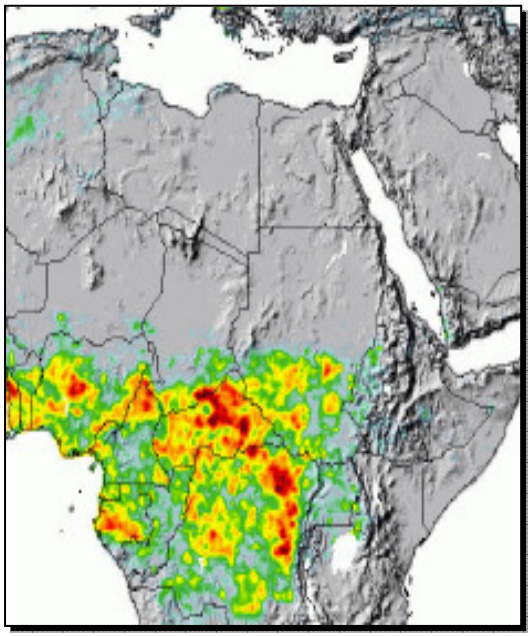
-Using NASA products and integrated modeling to expand to additional developing countries.

-Extensive data sets, freely available (http://earlywarning.usgs.gov/)

Geospatial Centers & Integration Tools

NASA & USAID 'SERVIR'

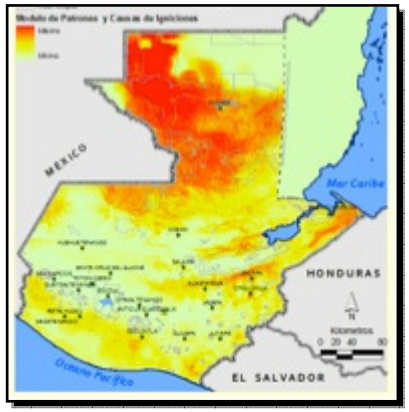
A NASA and USAID collaboration with countries and stakeholders to improve environmental management and resilience to climate change by strengthening the capacity to integrate earth observations and geospatial technologies into development decision-making. New Southeast Asia Node recently announced.



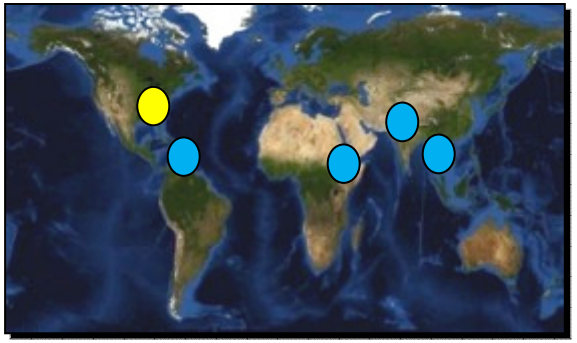
Flood Potential in Africa
(NASA/GSFC)

Training and Capacity Building

- **Remote Sensing Data/Models**
- **Integrated with other Geo Data**
- **Visualizations**
- **Decision Support**
- **Training/Capacity Building**
- **Partnerships**

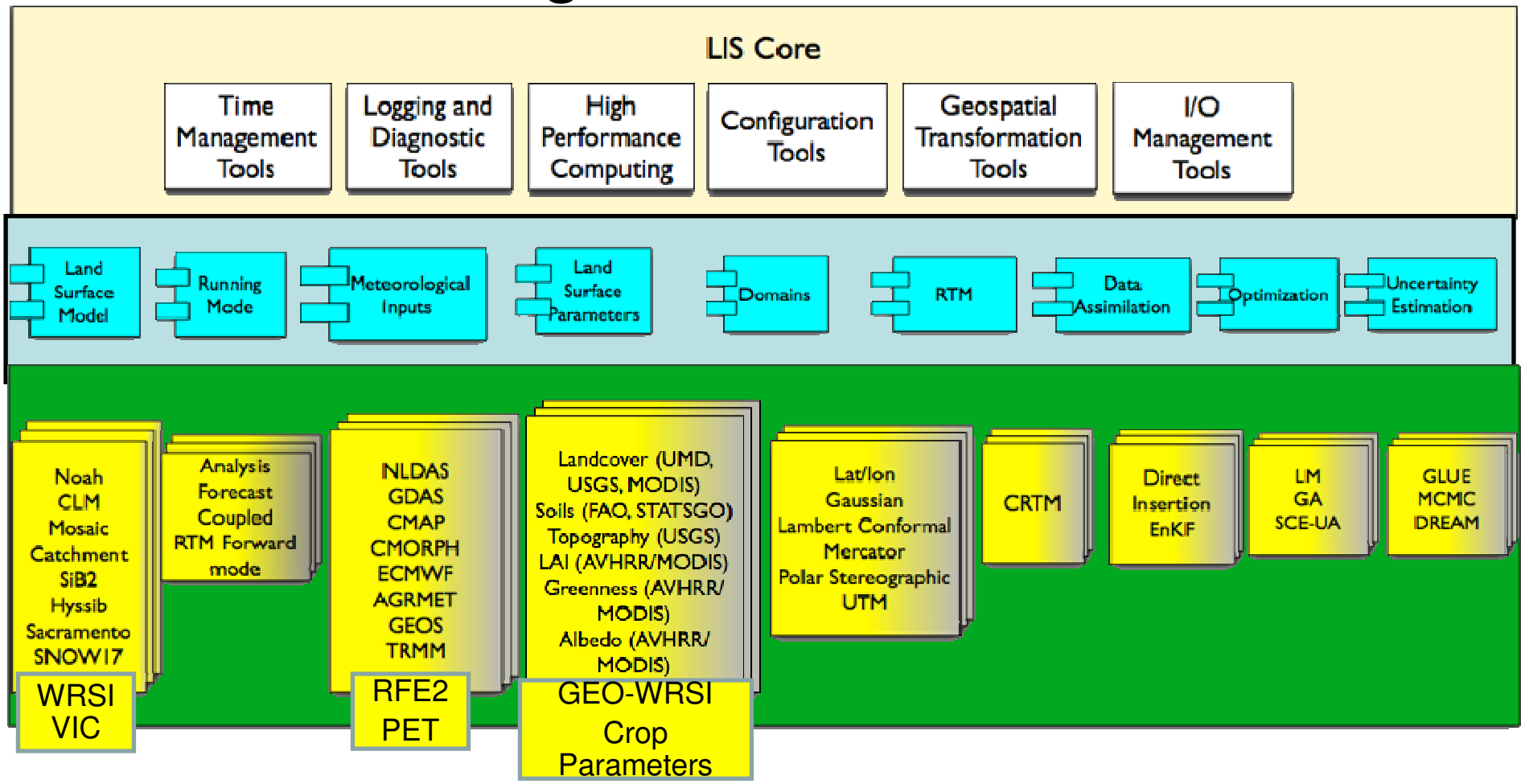


Fire Forecasting in Mesoamerica



SERVIR Network

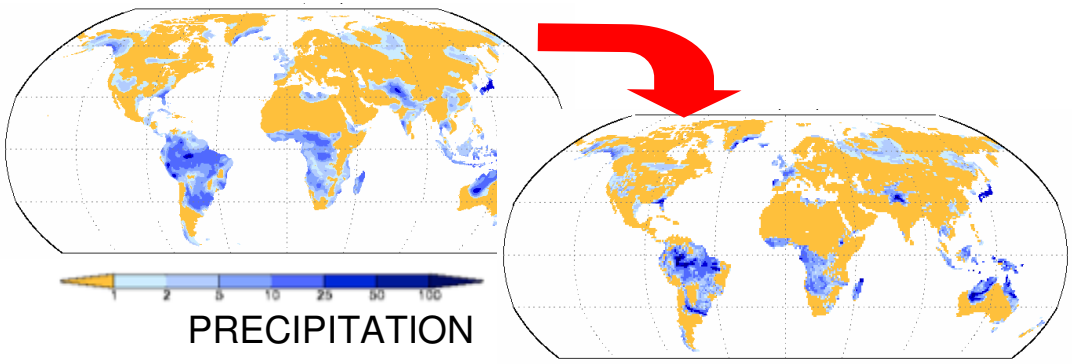
NASA Land Information System (LIS)
Data Integration and Assimilation

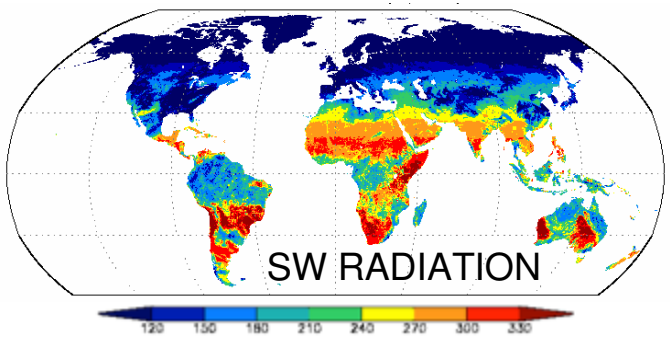


Kumar, S. V., C. D. Peters-Lidard, Y. Tian, P. R. Houser, J. Geiger, S. Olden, L. Lighty, J. L. Eastman, B. Doty, P. Dirmeyer, J. Adams, K. Mitchell, E. F. Wood and J. Sheffield, 2006. Land Information System - An Interoperable Framework for High Resolution Land Surface Modeling. *Environmental Modelling & Software,* Vol. 21, 1402-1415.

LIS/LDAS Data Integration

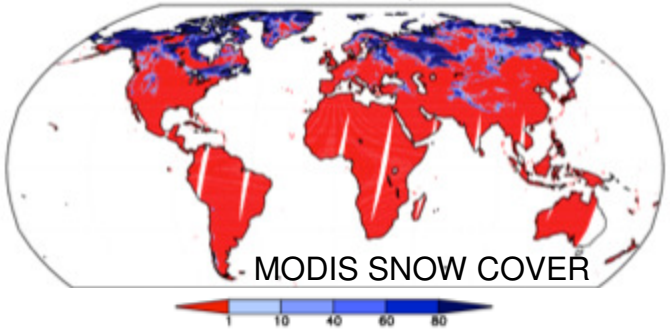
INTERCOMPARISON and OPTIMAL MERGING of global data fields

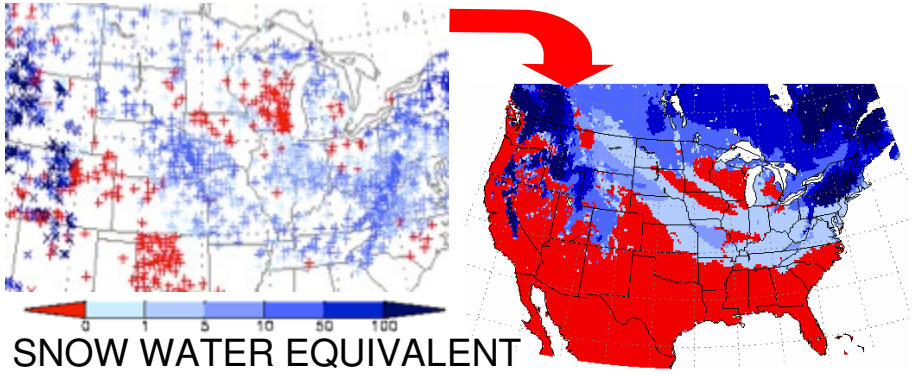




Satellite derived meteorological data used as land surface model FORCING

ASSIMILATION of satellite based land surface state fields (snow, soil moisture, surface temp, etc.)



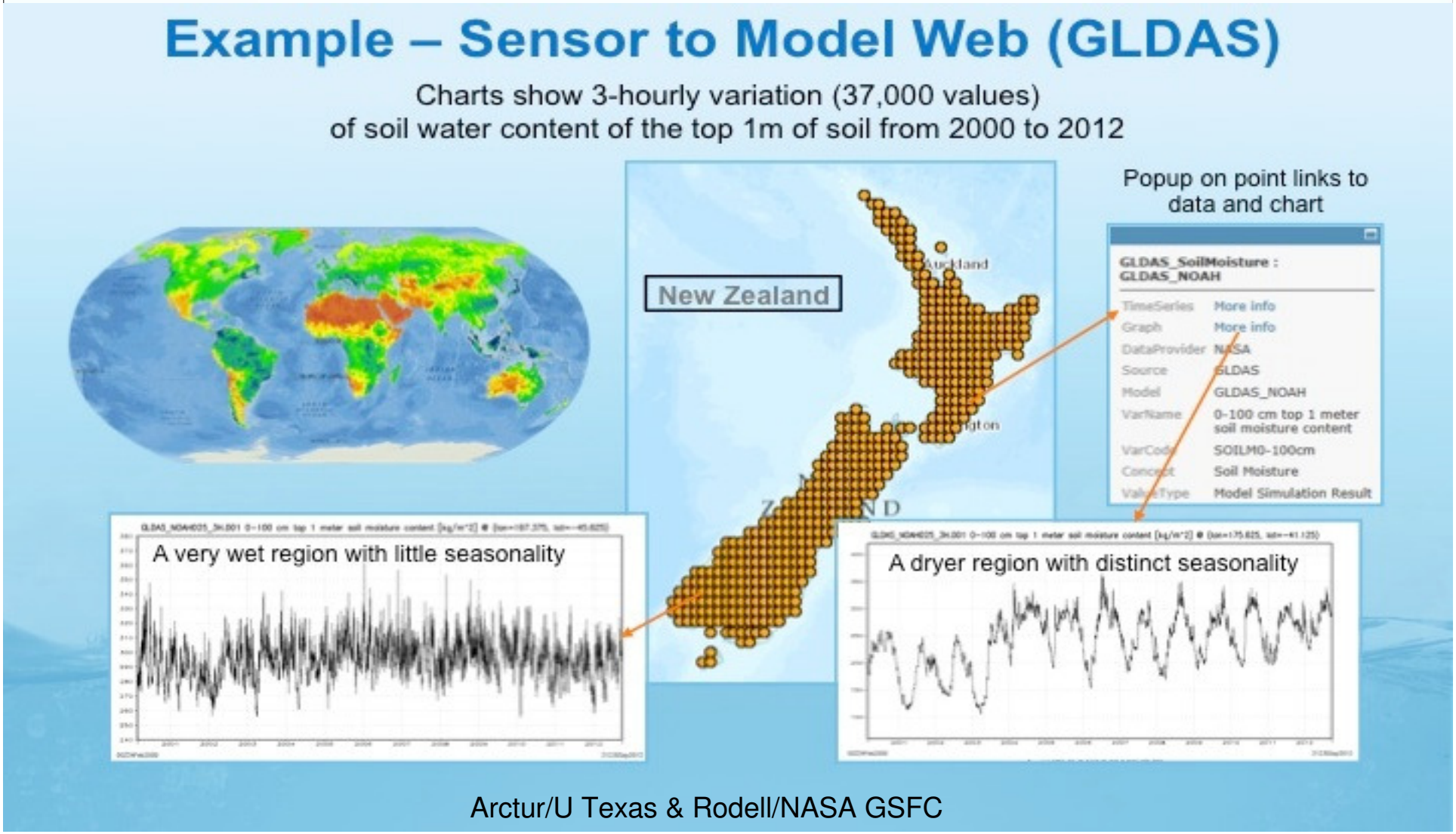


Ground-based observations used to VALIDATE model output

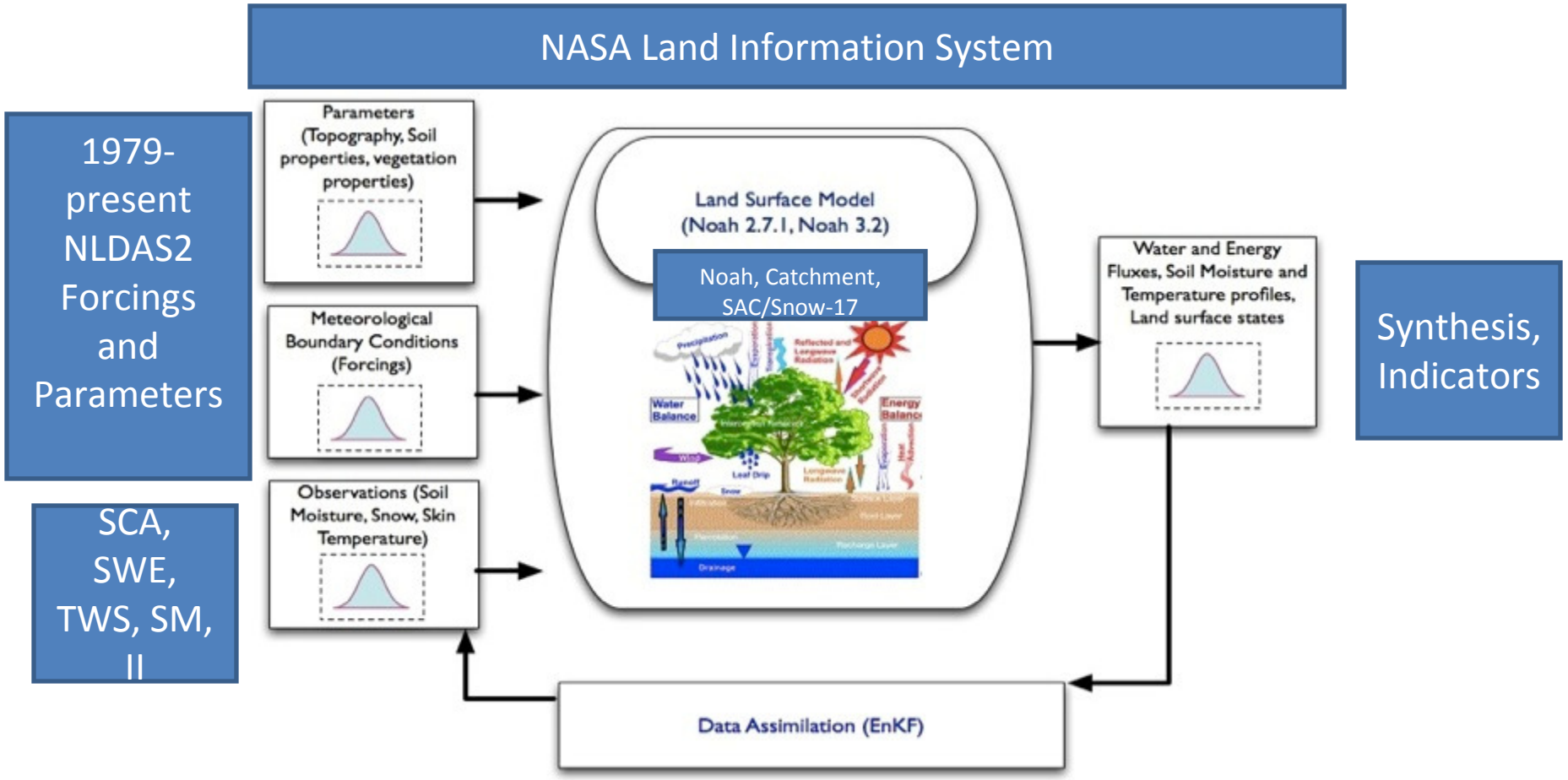
http://lis.gsfc.nasa.gov/
http://ldas.gsfc.nasa.gov/

Matt Rodell
NASA GSFC

Integrated or Higher Level Water Cycle Products and Services (GEO Task): The overall objective is to develop strategies for coordinating global water cycle observing systems, and to make progress towards an integrated water cycle observation system uniting data from various sources (e.g. satellites, *in-situ* networks, field experiments, etc.) with emerging data assimilation and modeling capabilities. A 'data rods' implementation and a Water 2 format conversion for enhanced user access.

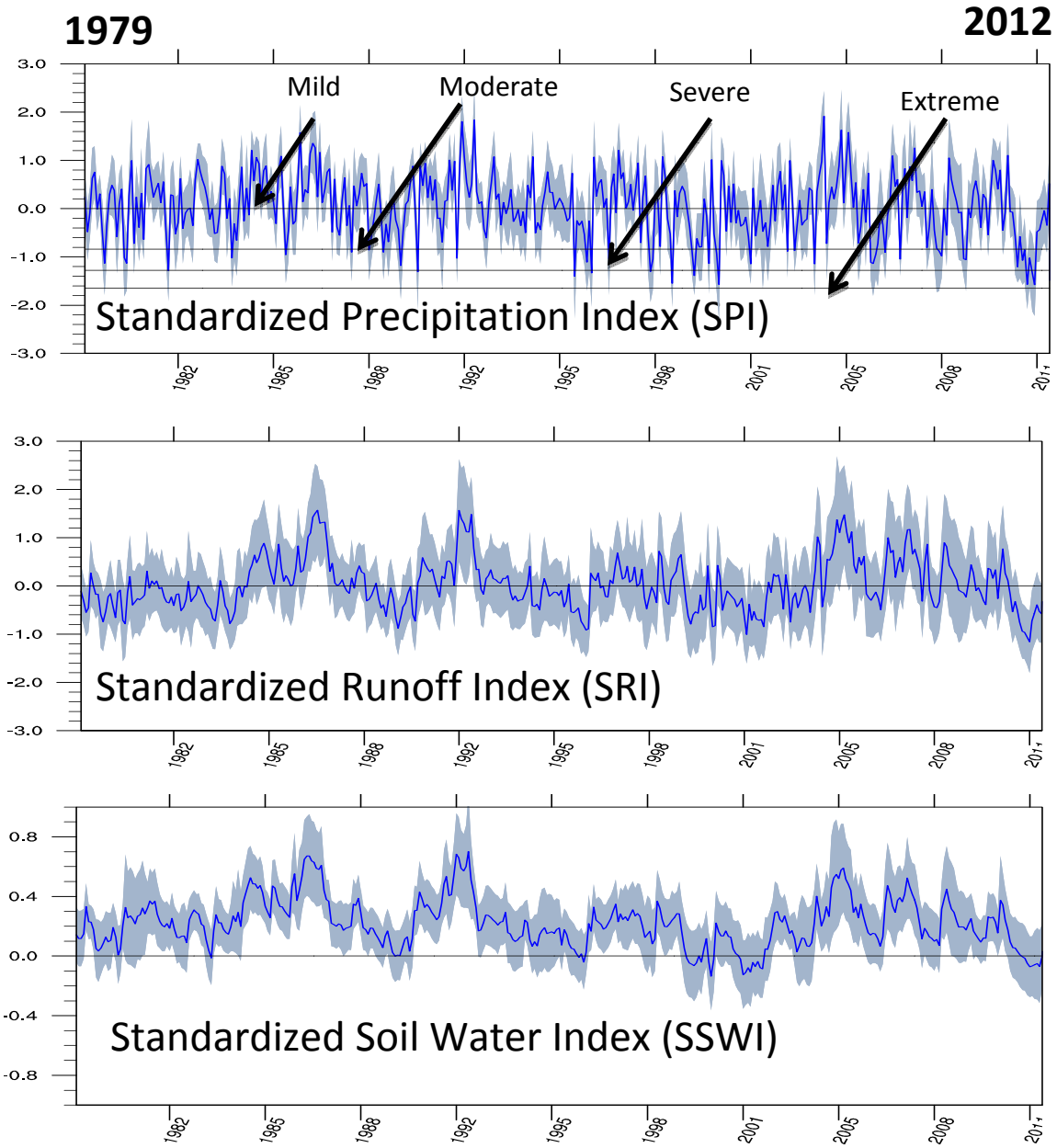


CLIMATE ASSESSMENT TOOL



- SCA (Snow Covered Area), SWE (Snow Water Equivalent), TWS (Terrestrial Water Storage), SM (Soil Moisture), II (Irrigation Intensity)
- Assimilates NASA's satellite soil moisture, snow water equivalent, snow cover area, terrestrial water storage & irrigation products to assess continental scale water budget including drought and floods. Examines long term water fluxes & provides effective 'climate water indicators'.

Drought indicators for the Colorado River Basin from the Noah (v3.3) LSM within 'LIS7' using 'NLDAS-2 forcing'



The figures present indices used to characterize different types of drought. The standardized precipitation index (SPI) is a measure of meteorological drought, standardized runoff index (SRI) is a measure of hydrological drought, and standardized soil water index (SSWI) is a measure of agricultural drought. These indices are generated by fitting a gamma distribution to fit climatological time series data (precipitation for SPI, runoff for SRI, and root zone soil moisture for SSWI). Negative numbers indicate more severe droughts. The blue line and the gray shading indicate the domain average and spatial standard deviation for the Colorado Basin, respectively. These indices also confirm the 1990, early 2000s, and late 2011 droughts.

Peters-Lidard/NASA

Building on Existing Programs for Coordination of Earth Observations

The USAID Famine Early Warning Systems Network

(FEWS NET)

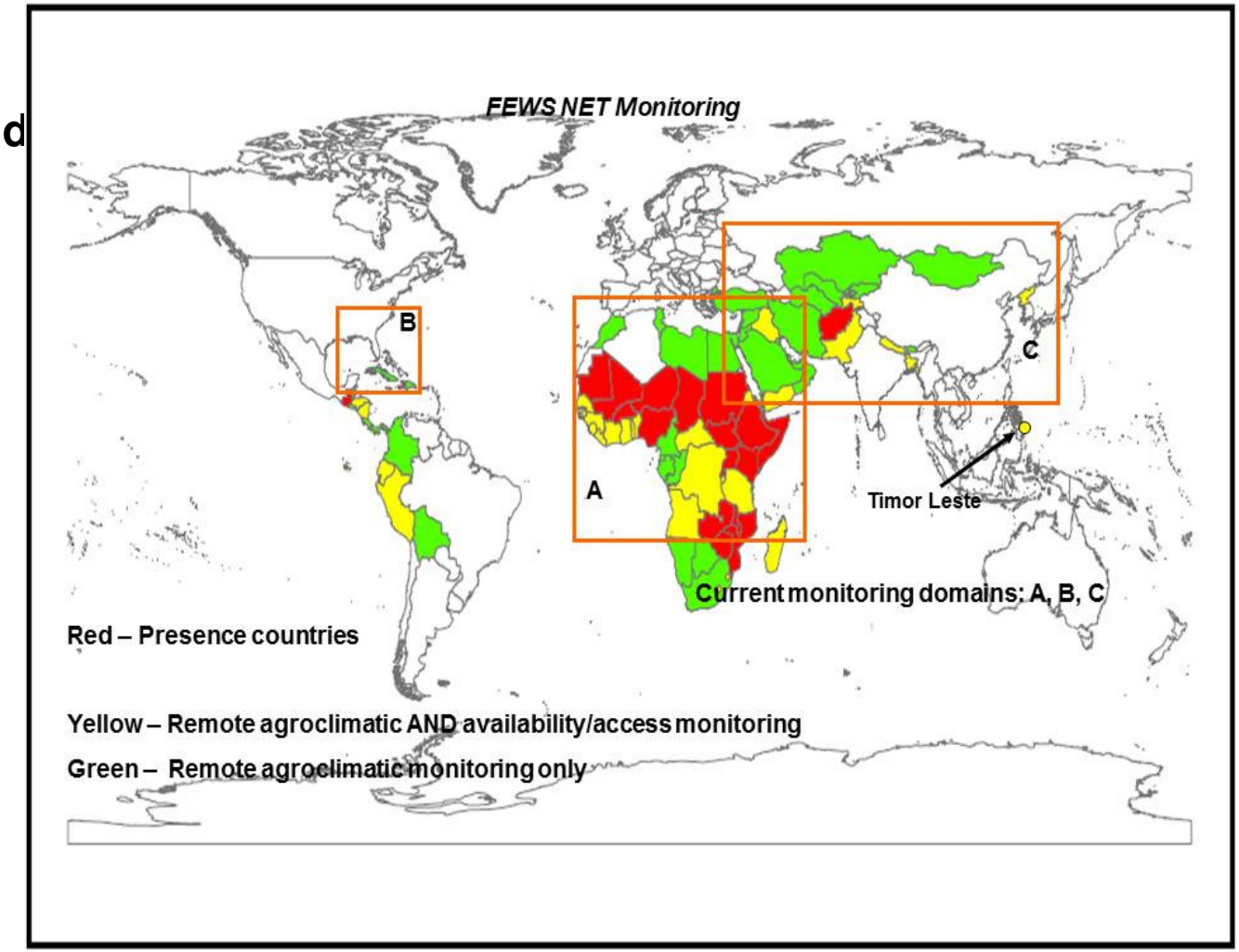
- **FEWS NET is expanding to many additional areas beyond Sub Saharan**
- **Remote Sensing and the NASA Land Information System (LIS) is planned to assist with the expansion**

✓ **Satellite Precipitation**

✓ **Satellite Snow Cover and Snow Water Equivalent**

✓ **Satellite Vegetation Greenness**

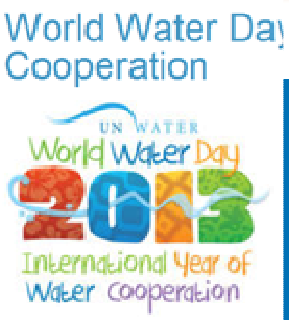
✓ **Yield Forecasting**

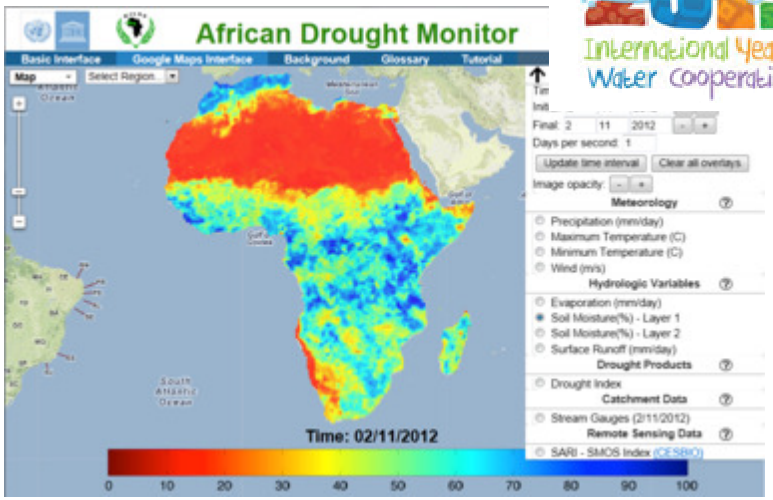


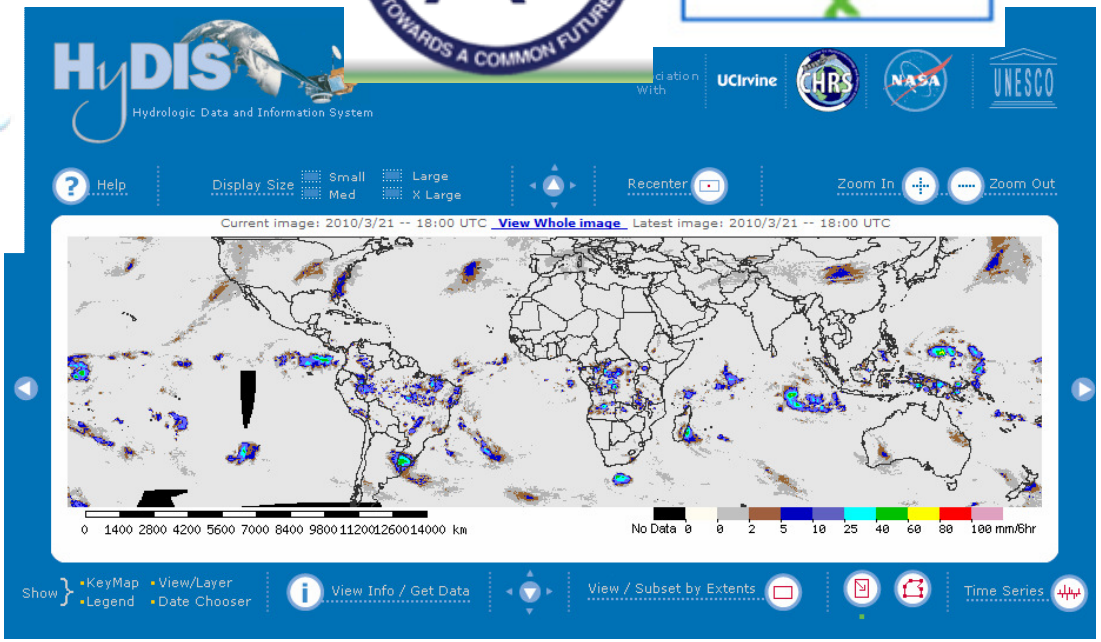
Verdin/USGS

Linkage with UNESCO-Related Programs and Projects

SERVIR GLOBAL







GEO - **voluntary partnership of governments and international** organizations

GEOSS - an integrating public infrastructure, interconnecting a diverse, growing array of Earth observing instruments and information systems

The international Water Task Target:

By 2015, produce comprehensive sets of data and information products to support decision-making for efficient management of the world's water resources, based on coordinated, sustained observations of the water cycle on multiple scales.

Within the GEO Water Task the US provides:

-Actively involved in most all components

-Numerous GEO tasks are coordinated by US investigators

-US GEO makes major contributions to Capacity Development that support international GEO Water initiatives (SERVIR, 'CIEHLYC', Water ML2).

SUMMARY & NEXT STEPS

- Recent Water Missions
  - ✓ Landsat-8 (Feb 2013 Launch)
  - ✓ Global Precipitation Measurement (GPM) (Feb 2014 Launch)
- Future Water Missions
  - ✓ Soil Moisture Active-Passive (SMAP) (Nov 2014)
  - ✓ GRACE Follow-on (2017)
  - ✓ Surface Water Ocean Topography (SWOT) (2020)
- International Water Activities
  - ✓ Over 40 current projects on international water activities with an estimated value of $21M over 5-years
  - ✓ New NASA & USAID SE Asia (Lower Mekong) SERVIR Node
  - ✓ NASA and USAID plan to open 2 sub-nodes in Africa to complement East Africa SERVIR
  - ✓ Working with the World Bank on new Geoportal, Coordination International Waters (CIWA), Nile Basin Initiative & Remote Sensing Working Group
  - ✓ New working relationships with Skoll Global Threats Fund, World Resources Institute, US Water Partnership, FAO
  - ✓ New NASA Water Resources Solicitation on Seasonal Hydrologic Forecasts
- ✓ Possible GEOSS Water Strategy Contributions
  - ✓ Help ID user needs and engagement
  - ✓ Assist with data issues and data interoperability
  - ✓ Help coordinate with GEO on Capacity Building in Asia, Africa and Latin America activities
  - ✓ SERVIR engagement with other GEO groups
  - ✓ Develop and implement a US GEO Water Strategy to complement GEOSS Water Strategy