NASA's Contribution to Water Research, Applications, and Capacity Building in Africa

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[2]NASA GSFC International Water Specialist

[3]Morgan State University Water Specialist

AfCCI Workshop, February 4 - 5. 2013

Capacity-building: Enable the effective use of water management tools in the US and internationally

How do we build the capacity to impact decisions and society?

SERVIR: regional and in-country government stakeholders
Geographic Areas: US, East Africa, Mesoamerica, Hindu Kush Himalaya

Gulf of Mexico Initiative (GOMI): regional stakeholders
Geographic Areas: US, Mexico

DEVELOP: regional and US/state/local government stakeholders and future workforce
Geographic Areas: US, Colombia, Mexico, Nepal

Applied Remote SEnsing Training (ARSET): regional and US/state/local government stakeholders
Geographic Areas: US, Colombia

Applied science research: Build water resource management tools

How do we use applied science to manage water resources?

- Water Quality and Resources Monitoring
- Drought Monitoring
- Climate Impacts
- Agriculture: Water Delivery and Irrigation
- Flood Forecasting
- Agriculture: Water Delivery and Irrigation
- Snowpack Monitoring and Management
- Flood Forecasting
- Climate Impacts
- Drought Monitoring

Basic science research: NASA Energy and Water Cycle Study

What processes drive the cycle of water and energy on Earth?

- Soil Moisture Assessment (AMSR-E/SMOS/SMAP)
- Change in Groundwater Storage (GRACE)
- Water Quality Assessment
- Precipitation Assessment (TRMM/GPM)
- Evaporation Estimation (LDCM)
- Snowpack and Melt Assessment (AMSR-E/MODIS)
- Improved Seasonal Forecasting (AQUARIUS/MERRA)
- Integrated Water Cycle Assessment (NEWS)

National Aeronautics & Space Administration

Earth Science Division
Water Resources Program Element

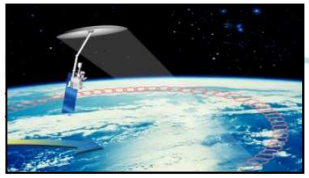
NASA's Water and Energy Satellites

Water Cycle Missions

ICESat
- Ice elevation
- Cloud height

GRACE
- Column water-content

TRMM and GPM
- Global precipitation



SMAP
- Global Soil Moisture

Water and Energy Cycle Missions

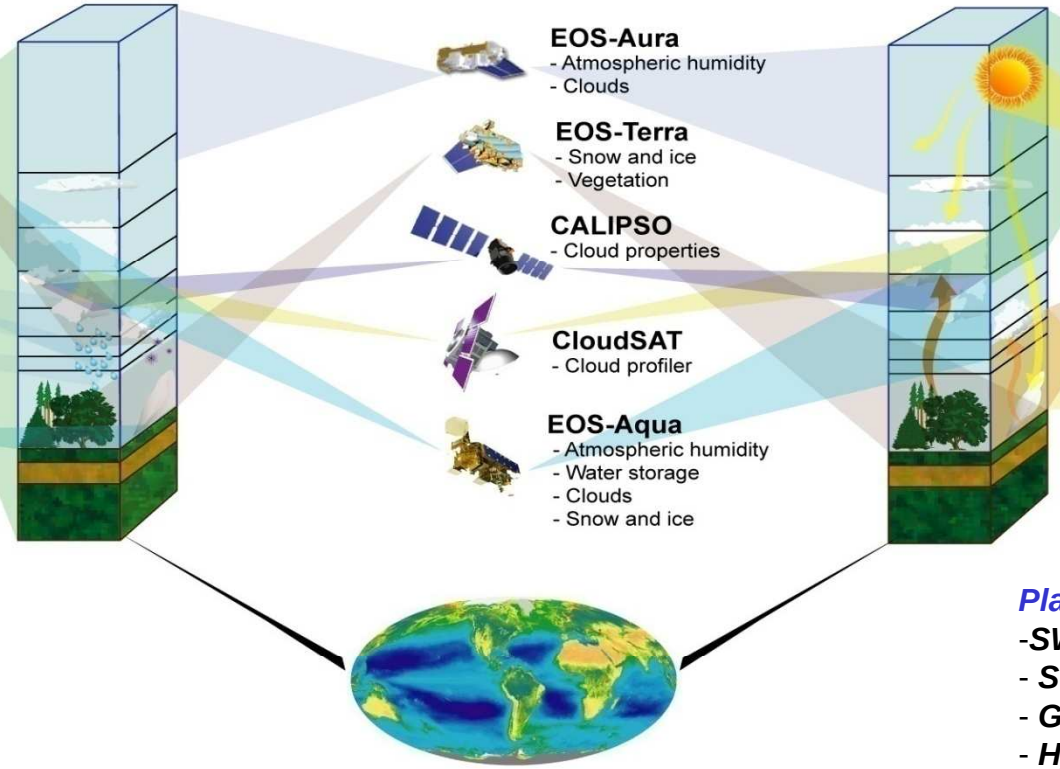
EOS-Aura
- Atmospheric humidity
- Clouds

EOS-Terra
- Snow and ice
- Vegetation

CALIPSO
- Cloud properties

CloudSAT
- Cloud profiler

EOS-Aqua
- Atmospheric humidity
- Water storage
- Clouds
- Snow and ice



Energy Cycle Missions

TOMS
- Total column ozone

SORCE
- Total Irradiance measurements

SAGE
- Air quality
- Climate change

UARS
- Carbon management
- Air quality

Planned
- ***SWOT (Streamflow)***
- ***SCLP (Snowpack)***
- ***GRACE-II (Groundwater)***
- ***HyspIRI (Water Quality, Land Surface Hydrology)***

Complementary Water and Energy Cycle Missions

QuikSCAT
- Sea-surface wind velocity

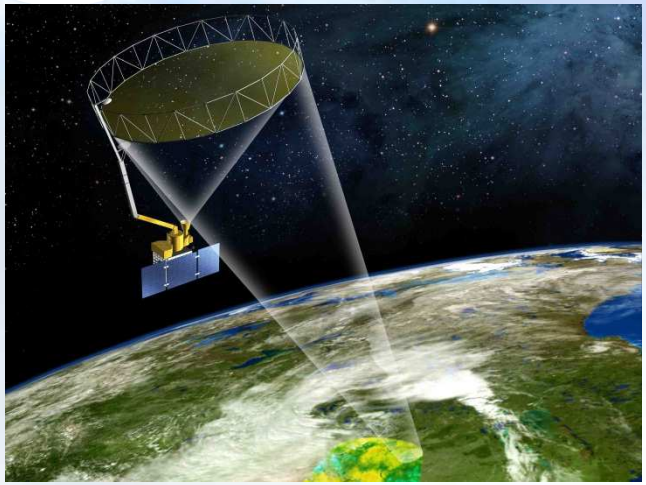
EO-1 LANDSAT and NMP EO-1
- Land cover

NPOESS
- Global environmental conditions

GOES
- Weather

Aquarius
- Global sea surface salinity

The Future…



The Soil Moisture Active Passive (SMAP) Mission

- Global observations of mapped soil moisture and freeze/thaw data with unprecedented accuracy, resolution, and coverage
- Planned Launch for 2014

The Global Precipitation Mission (GPM)

- International network of satellites that provide the next-generation global observations of rain and snow
- Planned Launch of Core Observatory for 2014

Goal: Integrating Remote Sensing Data with Modeling for Local to Global Assessment of Water Resources
Example: Land Information System (LIS)

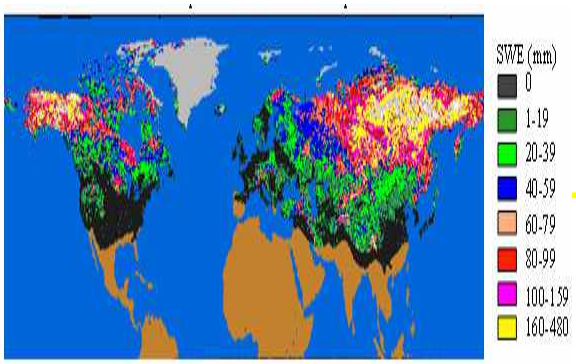
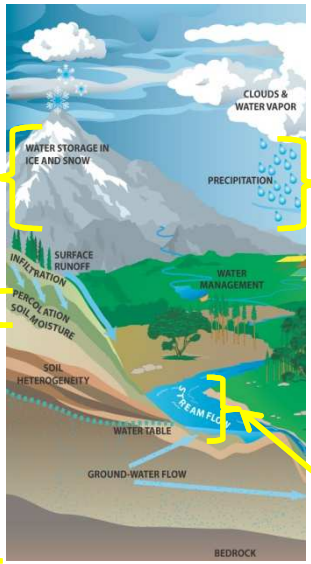


Figure 1: Snow water equivalent (SWE) based on Terra/MODIS and Aqua/AMSR-E. Future observations will be provided by JPSS/VIIRS and DWSS/MIS.



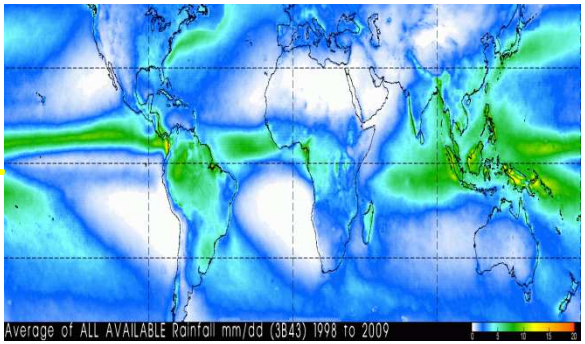


Figure 2: Annual average precipitation from 1998 to 2009 based on TRMM satellite observations. Future observations will be provided by GPM.

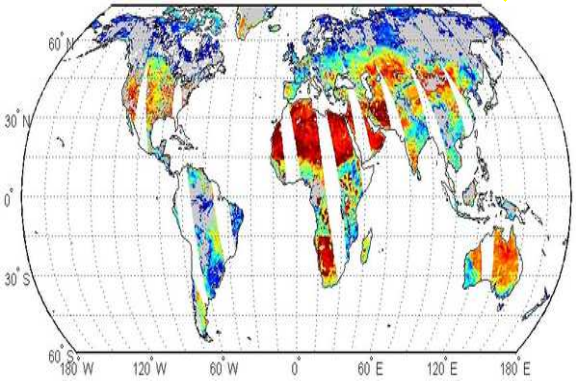


Figure 3: Daily soil moisture based on Aqua/AMSR-E. Future observations will be provided by SMAP.

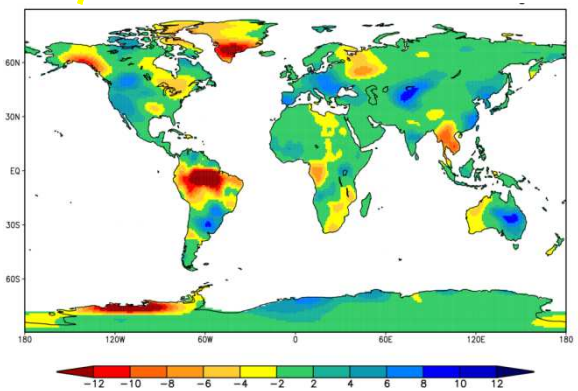


Figure 4: Changes in annual-average terrestrial water storage (the sum of groundwater, soil water, surface water, snow, and ice, as an equivalent height of water in cm) between 2009 and 2010, based on GRACE satellite observations. Future observations will be provided by GRACE-II.

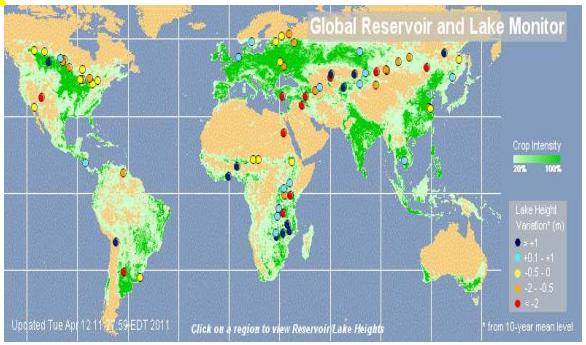


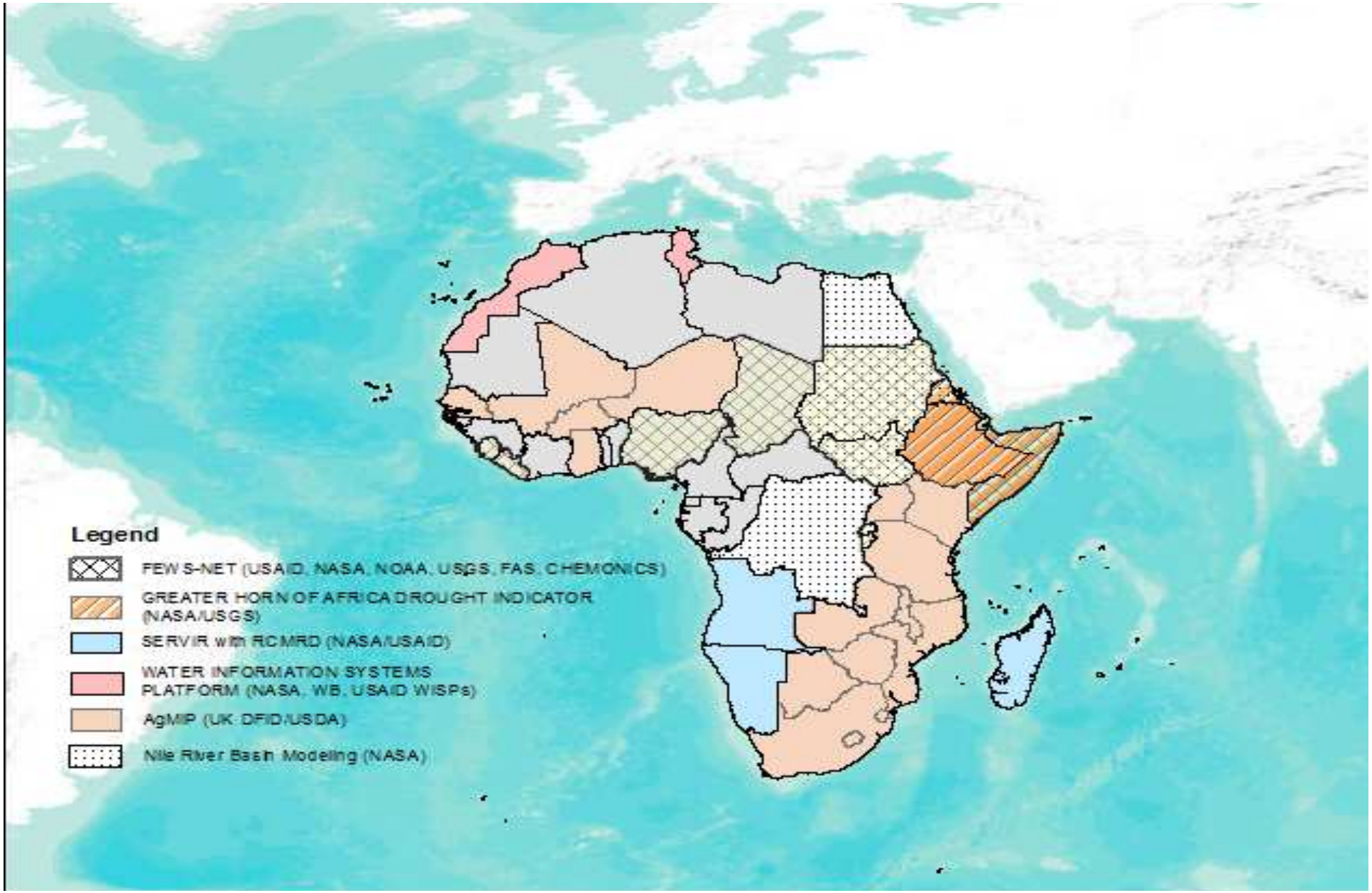
Figure 5: Current lakes and reservoirs monitored by OSTM/Jason-2. Shown are current height variations relative to 10-year average levels. Future observations will be provided by SWOT.

Peters-Lidard,
NASA/GSFC

National Aeronautics &
Space Administration

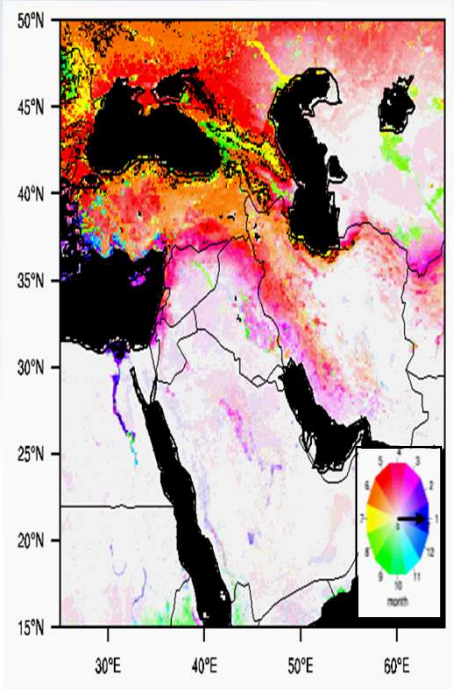
Earth Science Division
Water Resources Program Element

NASA African Water Projects

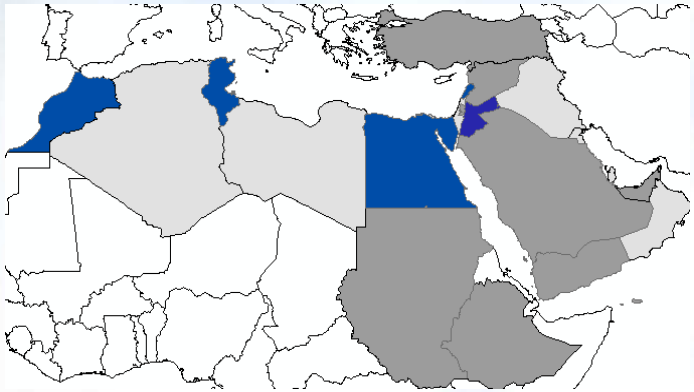


NASA Water Information System Platforms (WISP's) for the 'MENA'

NASA Partnering with the World Bank, USAID & MENA Countries Using Earth Observation and Modeling Data for the Sustainable Use of Water Resources



Mapping Vegetation and Food Production



5 WISP's Planned for the MENA

Training and Capacity Building

- **Satellite, Modeling, Ground Based Data**
- **Integrative Environmental Systems**
- **Visualizations**
- **Decision Support Tools**
- **Informed Policy Making**
- **Training & Partnership Opportunities**

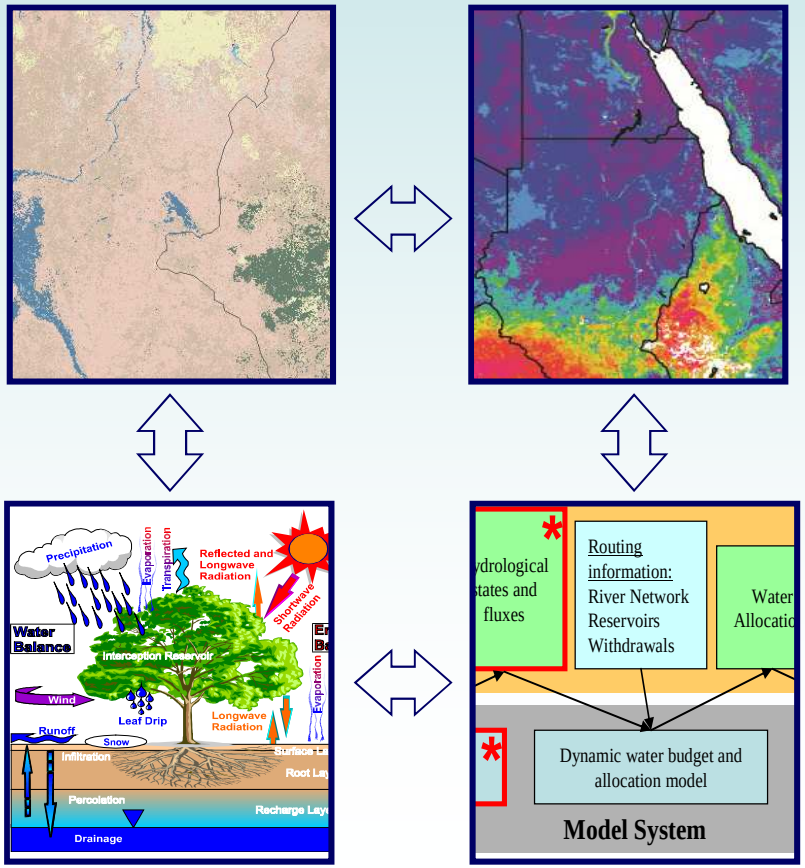
JOHNS HOPKINS UNIVERSITY
GLOBAL WATER PROGRAM

NASA *Project Nile*

***Goal*: improved hydrometeorological information for research, planning, and water management**

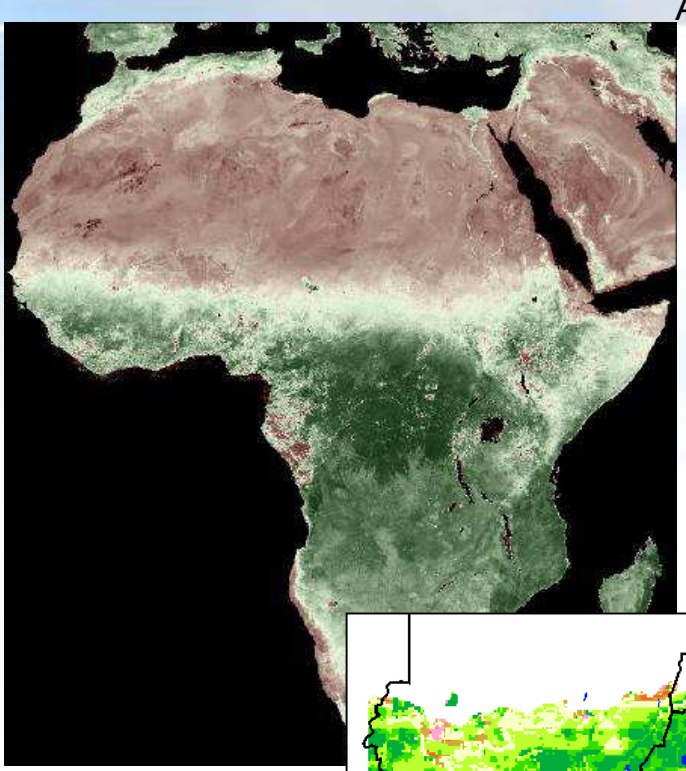
Components:

1. *Land cover mapping and simulation*
2. *Satellite-derived evapotranspiration*
3. *Optimized models for hydrological analysis*
4. *Decision Support and Capacity Building*



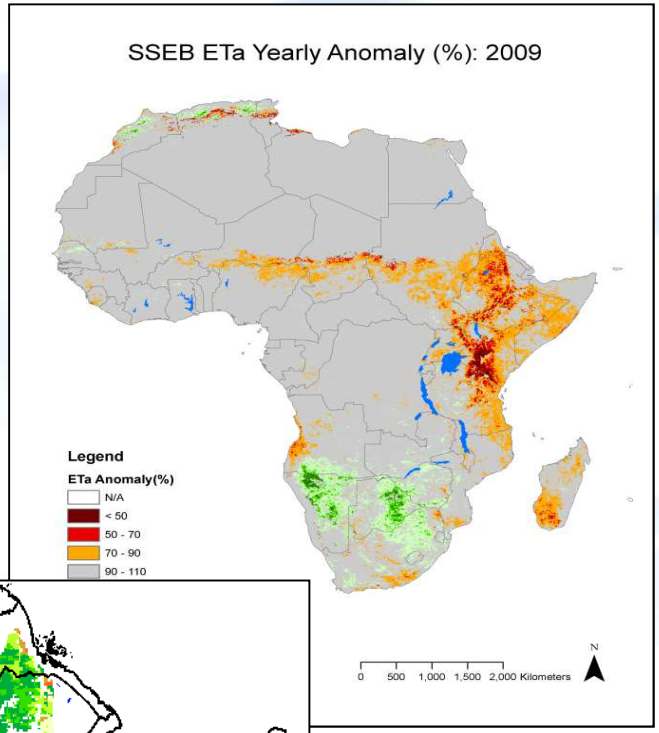
Famine Early Warning System Network (FEWS-NET)
Satellite Assisted Data Products

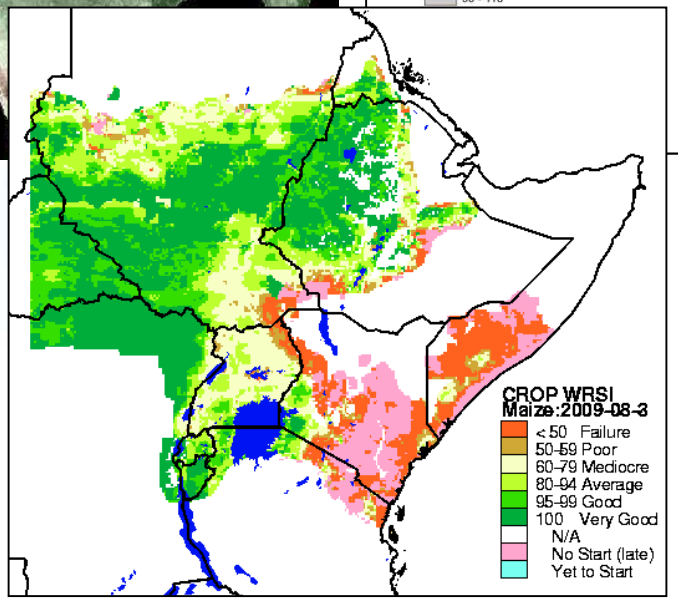
- **NASA satellite products such as from MODIS are key inputs in to FEWS-NET http://earlywarning.usgs.gov/fews/africa/index.php**
- **Vegetation density ('NDVI') & precipitation**
- **Evapotranspiration or Consumptive Water Loss**
- **Modeled Food Production**



Near Real time 250m MODIS

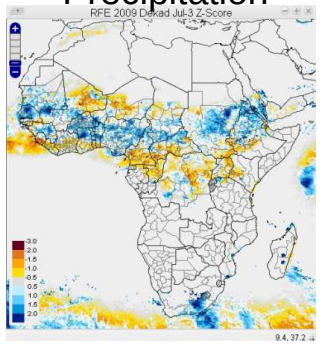
Actual Evapotranspiration - Satellite Data





Water Requirement Satisfaction Index

NASA Satellite Precipitation



Verdin/USGS

National Aeronautics & Space Administration

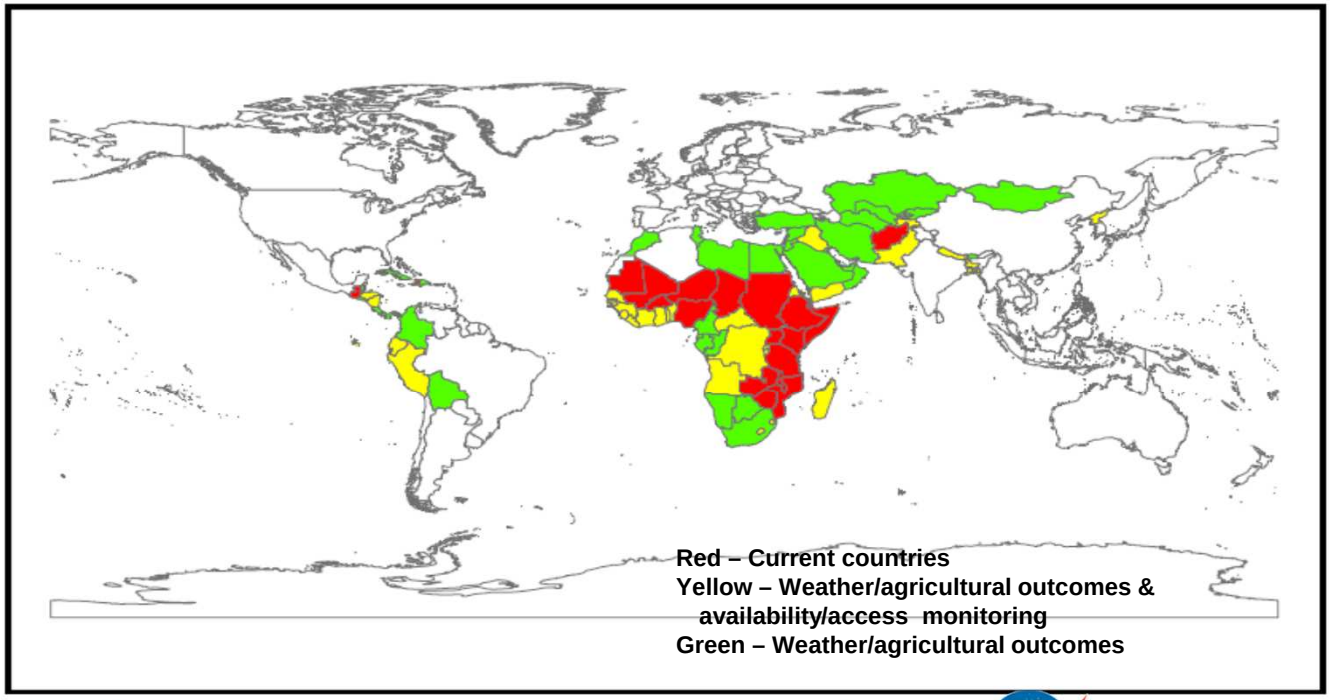
Water Resources Program

The Famine Early Warning Systems Network

(FEWS-NET)

- **Using NASA Land Information System (LIS) to Help Extend Coverage beyond Sub-Sahara**
- **Satellite Precipitation**
- **Satellite Snow Cover and Snow Water Equivalent**
- **Satellite Vegetation Greenness**
- **Yield Forecasting**

FEWS NET
FAMINE EARLY WARNING SYSTEMS NETWORK



USGS science for a changing world

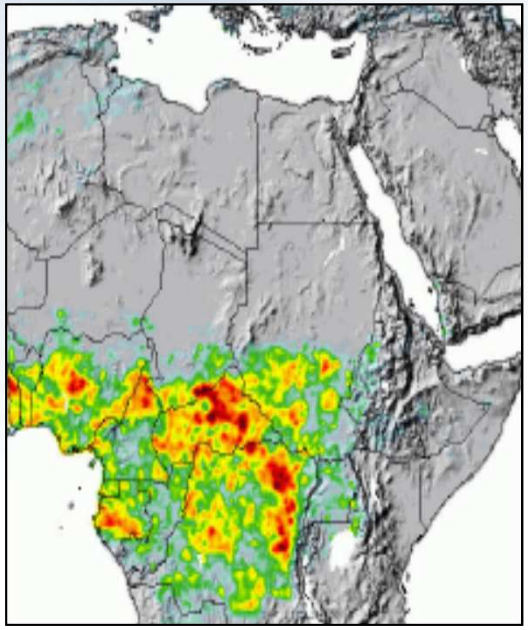
NOAA

FAS

NASA

What is 'SERVIR'

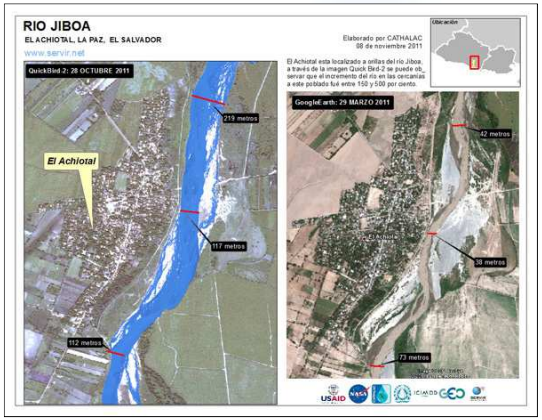
A NASA and USAID collaboration with countries and stakeholders to improve environmental management and resilience to climate change by strengthening the capacity to integrate Earth observations and geospatial technologies into development decision-making. Three international SERVIR nodes with plans for additional nodes.



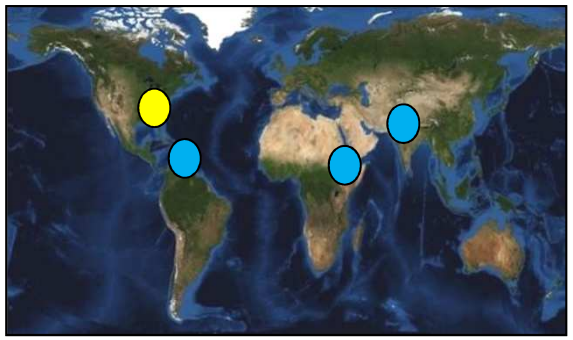
Flood Potential in Africa
(NASA/GSFC)

Training and Capacity Building

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



Flood Monitoring and
Post-Disaster Assessments



SERVIR Network

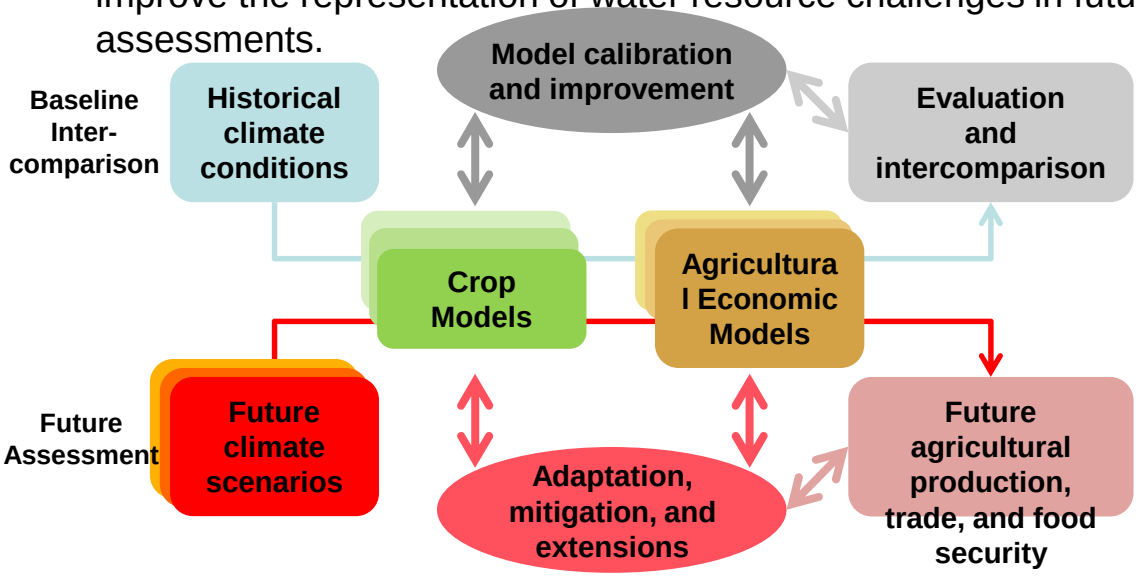
National Aeronautics
Space Administratio

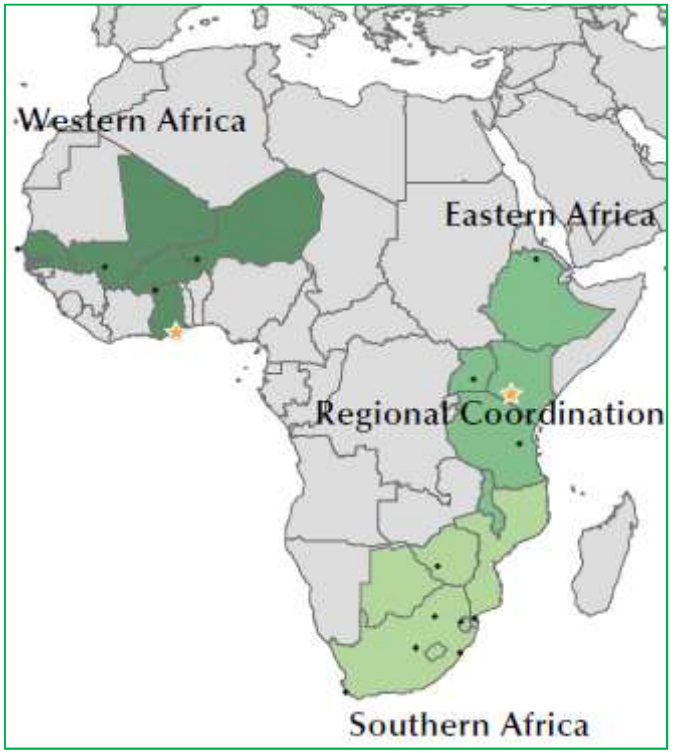
Water Resources Pr

AgMIP The Agricultural Model Intercomparison and Improvement Project

The Agricultural Model Intercomparison and Improvement Project (AgMIP) is a is a major international effort to evaluate model performance and climate impacts on the agricultural sector utilizing a cutting-edge climate, crop, and economic modeling framework enabling the assessment of future food security

- Launched in 2010, AgMIP's global activities include 5 regional research teams performing integrated assessments in Sub-Saharan Africa.
- AgMIP is building connections between the climate, hydrology, water systems, agricultural, and economics communities and plans to improve the representation of water resource challenges in future assessments.



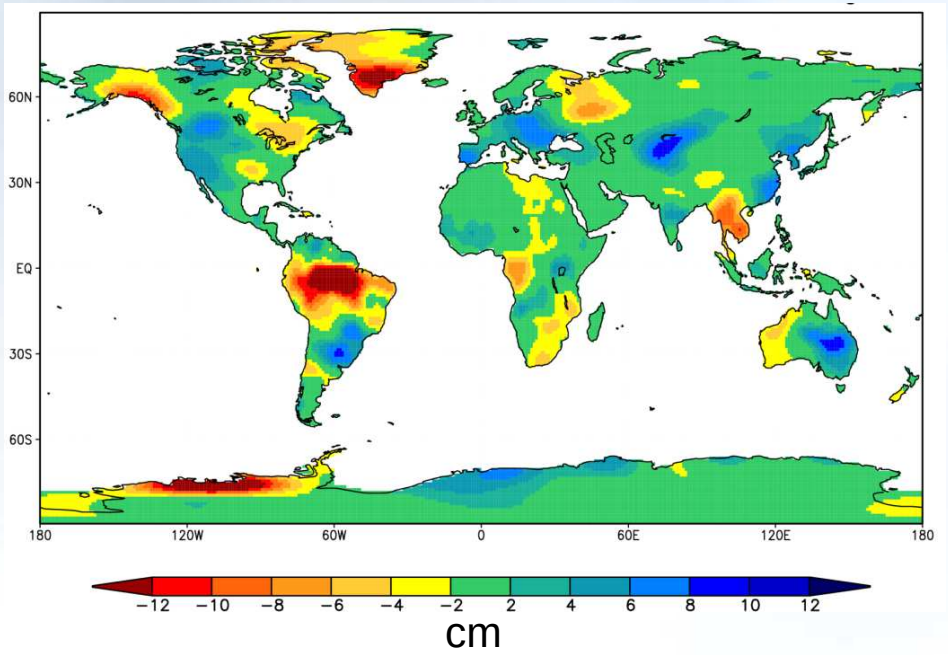


For more information, contact Alex Ruane: alexander.c.ruane@nasa.gov
Also see www.agmip.org and Rosenzweig et al., 2012 (Ag and Forest Meteorology)

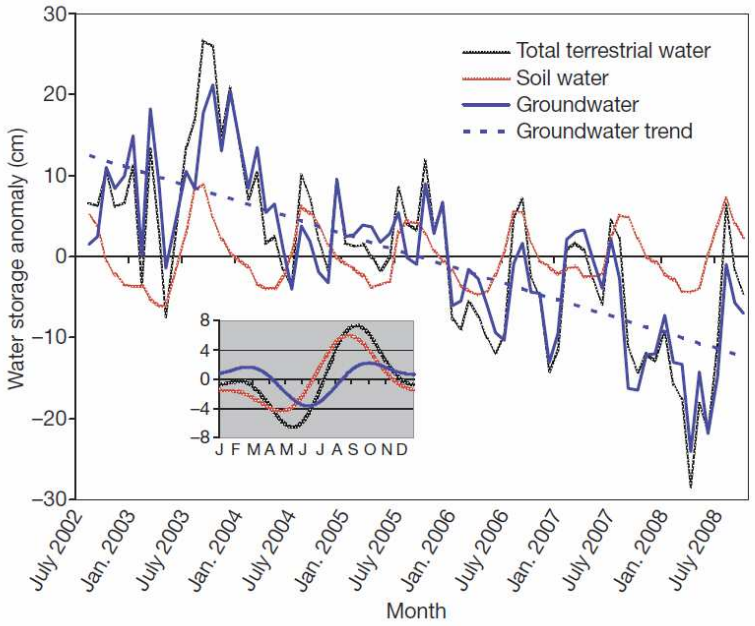
UKaid from the Department for International Development
USDA

Identifying Areas of Water Stress and Replenishment

Changes in Annual-Mean Terrestrial Water Storage Between 2009 and 2010



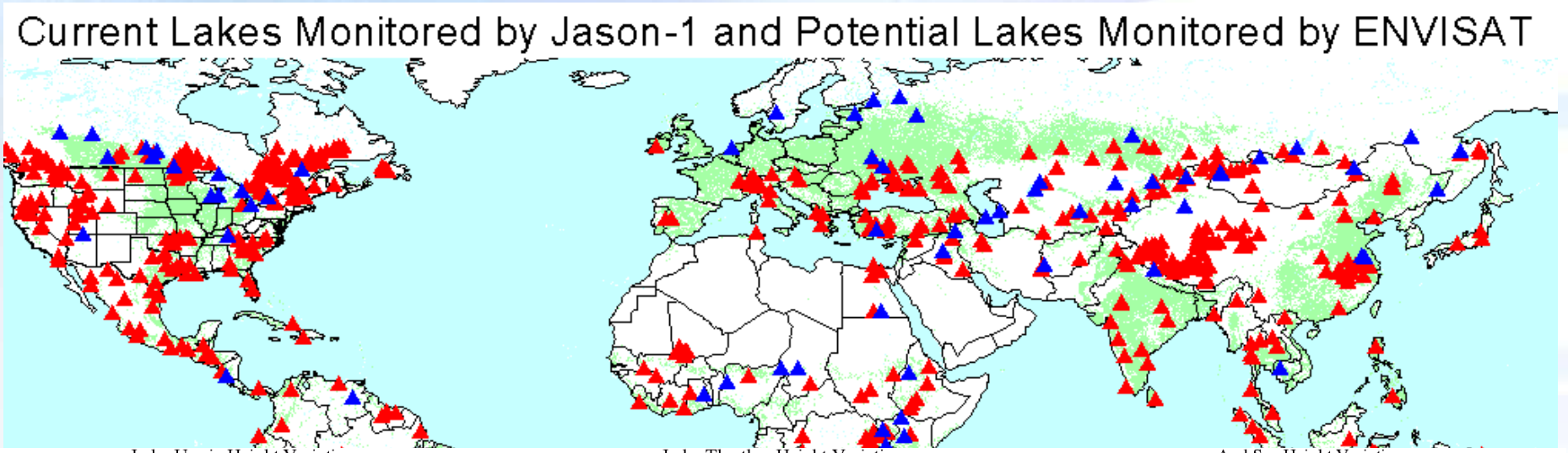
Water Storage Anomalies in Northwestern India

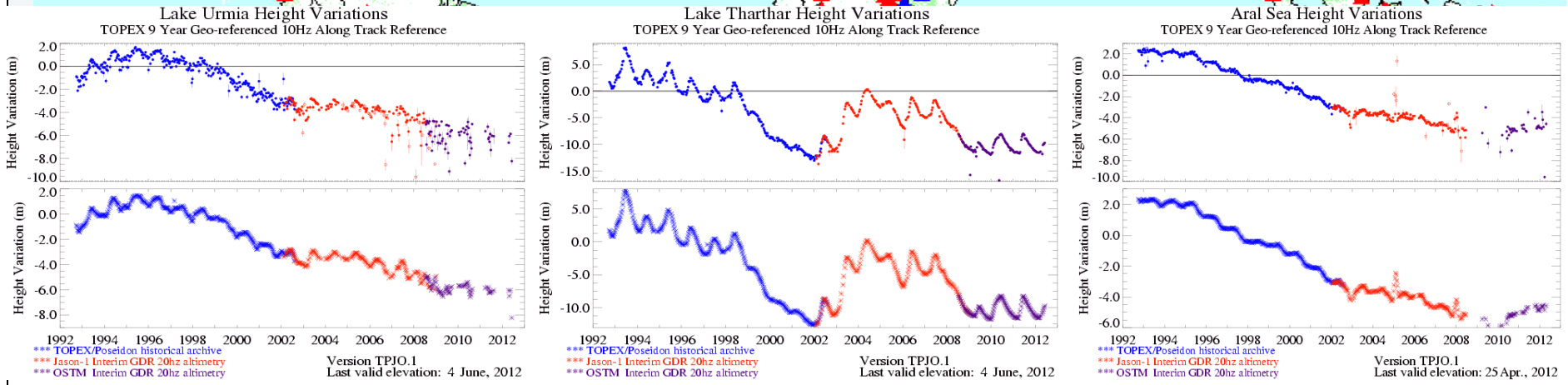


Observations from NASA's Gravity Recovery and Climate Experiment (GRACE) mission provide estimates of terrestrial water storage variability (the sum of groundwater, soil water, surface water, snow, and ice).

Source: Matt Rodell, NASA GSFC

Lake and Reservoir Monitoring





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

NASA Provides a Global Soil Moisture Product for the USDA Crop Forecasting System

John D. Bolten, Code 614.3, NASA GSFC

The integration of Aqua AMSR-E soil moisture estimates into the USDA Foreign Agricultural Service (FAS) crop forecasting system provides better characterization of surface wetness conditions which enables more accurate crop monitoring in key agricultural areas.

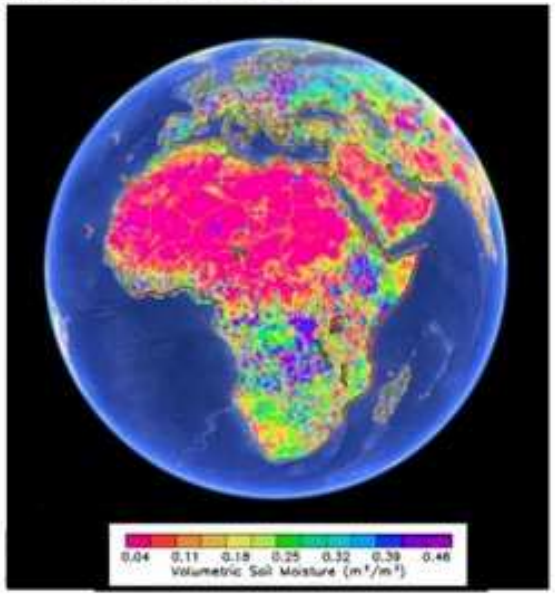


Figure 1. NASA/USDA blended soil moisture product

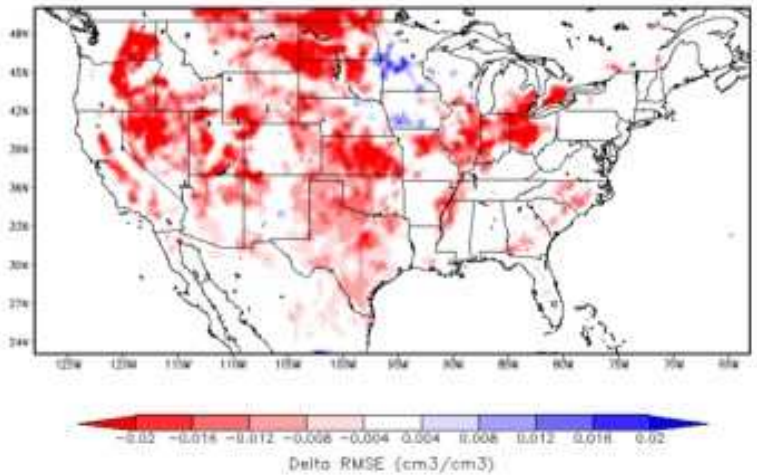


Figure 2: Soil moisture error reduction (red) or increase (blue) over the continental U.S.

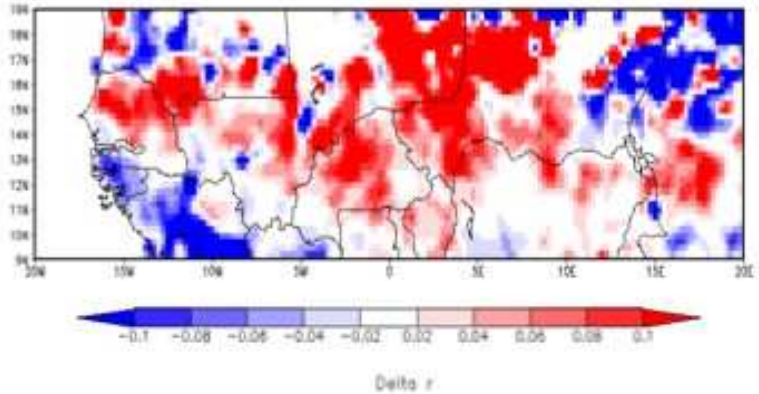
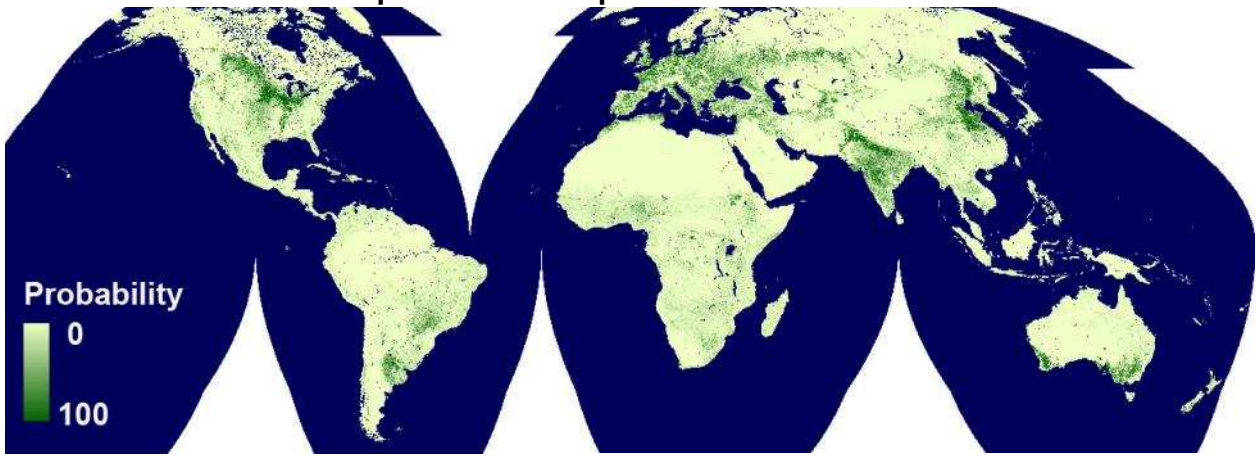


Figure 3. Soil moisture error reduction (red) or increase (blue) over West Africa

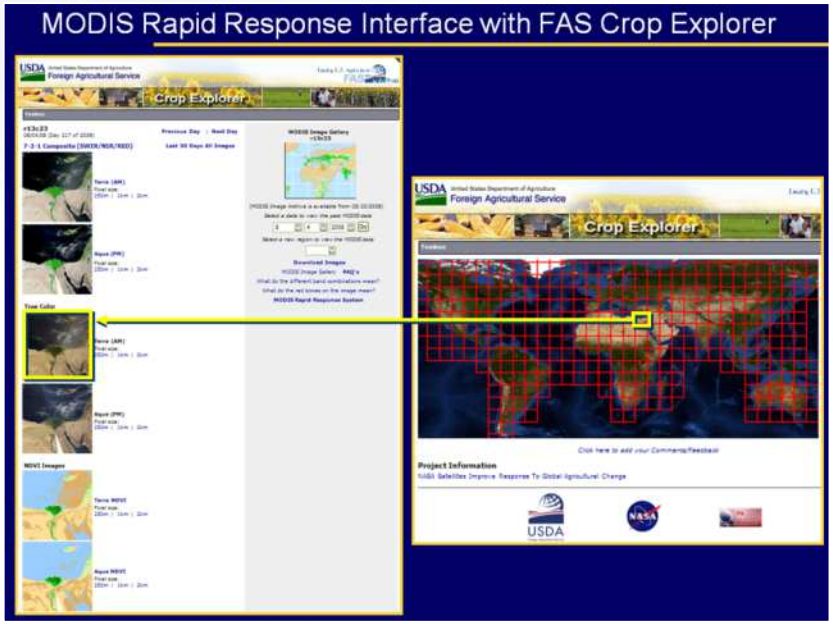
Global Agriculture Monitoring Using NASA MODIS Satellite Data

GLAM Global Croplands Map derived from MODIS Time Series



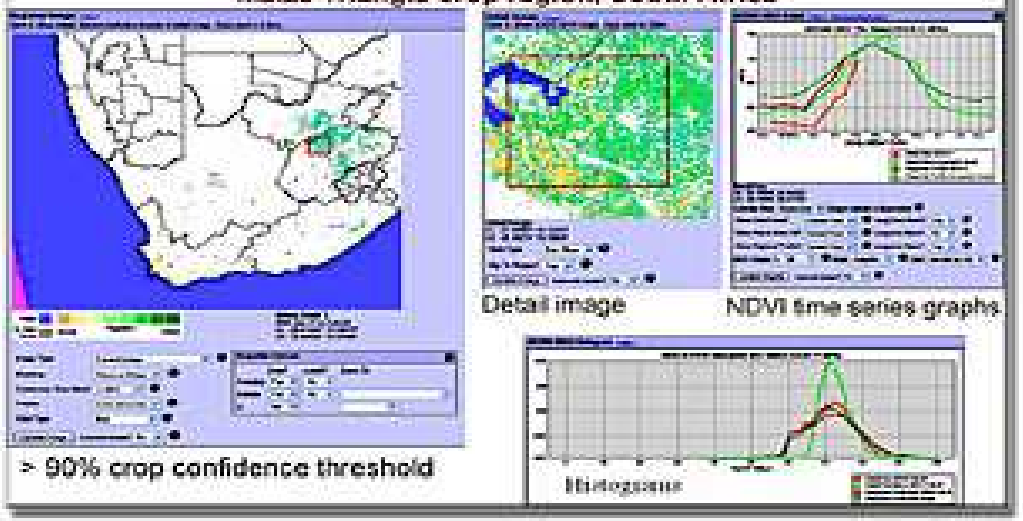
C. Justice/UMd

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



National Aeronautics & Space Administration

Water Resources Program

SUMMARY & NEXT STEPS

- **NASA has a free and open exchange of its satellite data**
  + Over 40 current projects on international water activities with an estimated value of $21M.
  + Numerous data products (e.g.'s precipitation, land cover, vegetation indices, 'LDAS', 'NPP', etc.)
  + Many products provided **in near real time** (vegetation indices, fire products & precipitation)

- **NASA has several ongoing <u>African</u> projects**
  + NASA/USAID African SERVIR
  + Nile Basin Remote Sensing and Modeling Project
  + NASA assisted USAID Famine Early Warning System Network (FEWS NET)
  + NASA/World Bank/USAID MENA-Water Information Systems Project
  + Greater Horn of Africa Drought Project (NASA/GSFC with USGS)
  + Several global projects (' Flooding', 'Drought', 'GLDAS', 'GLAM') may be optimized for Africa.

- **Strengthen African <u>Partnering</u> w/ GEO, USAID, World Bank, stakeholders, etc.**

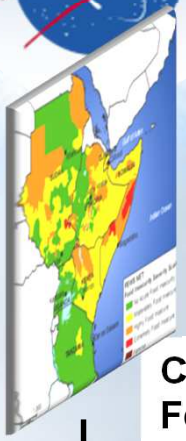
- **Possible Next Steps with GEO and AfWCCI**
  + Coordinate Geo-Water Portal activities
  + Expand and coordinate training and public outreach efforts
  + Coordinate with GEO on African basins and countries where possible
  + African SERVIR engagement with AfWCCI activities

THANK YOU

A Summary of NASA-supported Water Activities in Africa

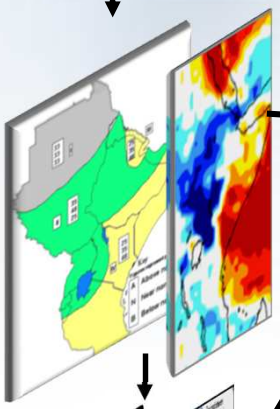
- North Africa – Water Information Systems Platform (WISP)
- Nile Basin – Project Nile
- Sub-Saharan – FEWS-NET
- East & South Africa – SERVIR
- West Africa – SERVIR MyCOE
- Africa - AgMIP
- Global
  - Water availability
  - Lake & reservoir monitoring
  - Flooding and droughts
  - Water for food & ecosystems

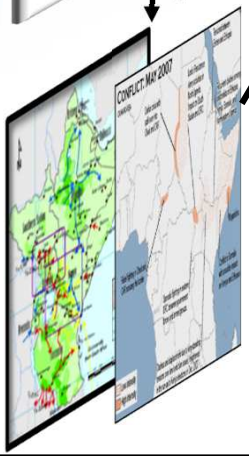
USAID FEWS-NET Food Security Outlooks



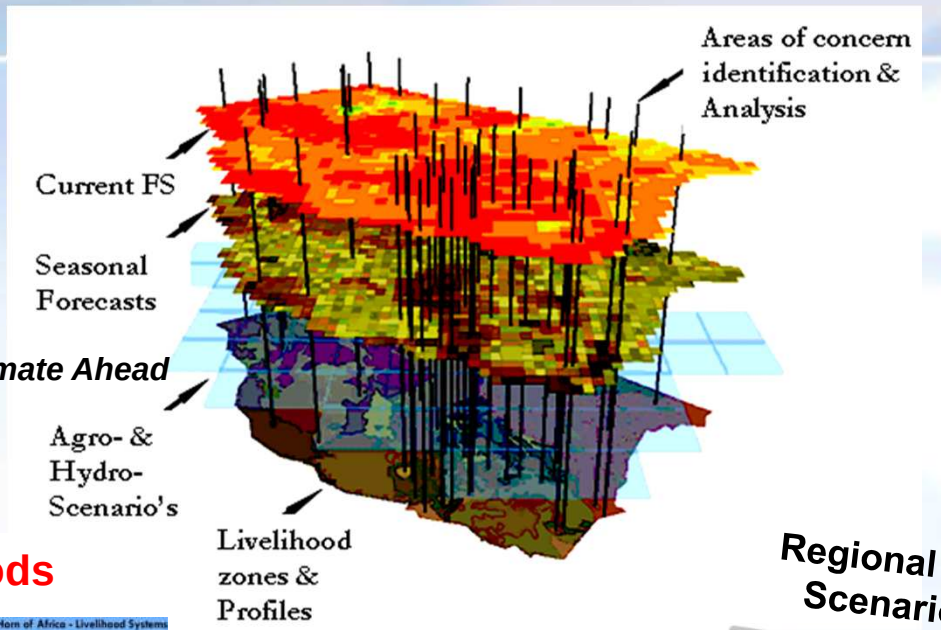
Current FS status

Climate Forecasts

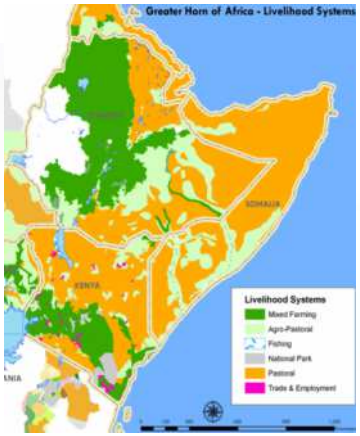




Other info: Trade, Conflicts, Health…

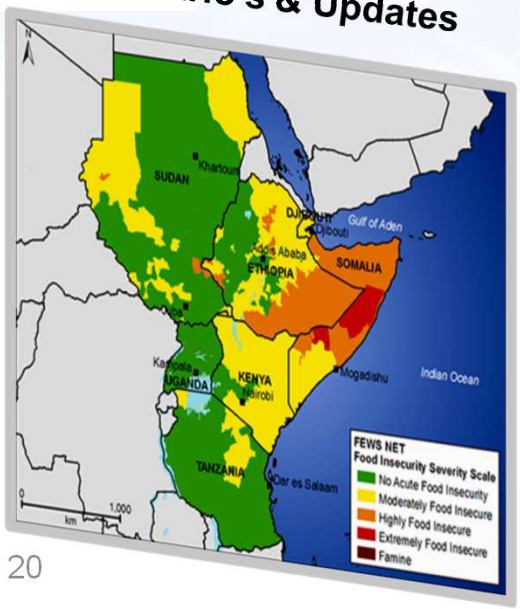


Livelihoods



Seasonal Calendar

Regional & National FSO Scenario's & Updates

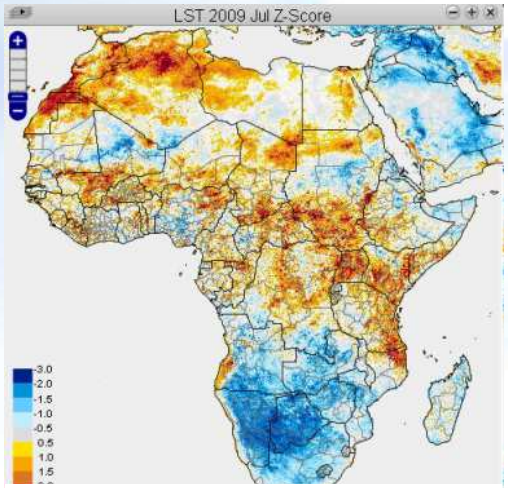


NASA Collaborates with the US Geological Survey through the U.S. Agency for International Development (USAID)

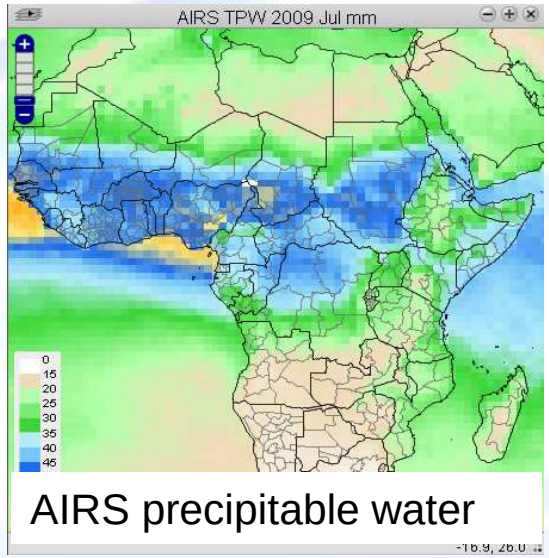
Famine Early Warning System – Network (FEWS –NET)

In agricultural economies, the majority of residents get some or all of their income from agricultural activity. In these regions, food security is highly related to weather-related food production deficits.

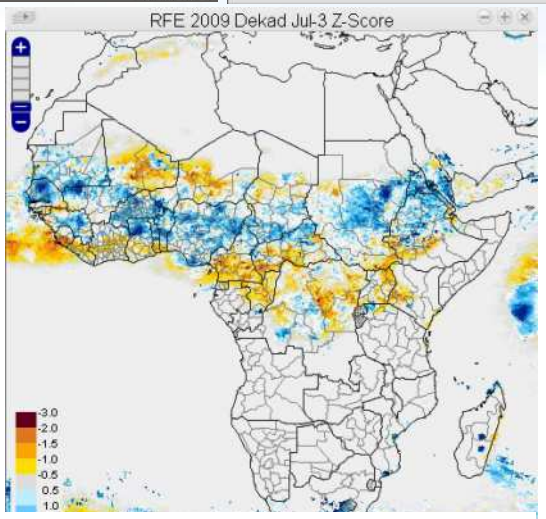
NASA satellite data and models are key input variables for organizations such as the USAID's Famine Early Warning Systems Network (FEWS NET). FEWSNET is a key resource for monitoring food aid needs and supporting food deficit countries.



MODIS land surface temp

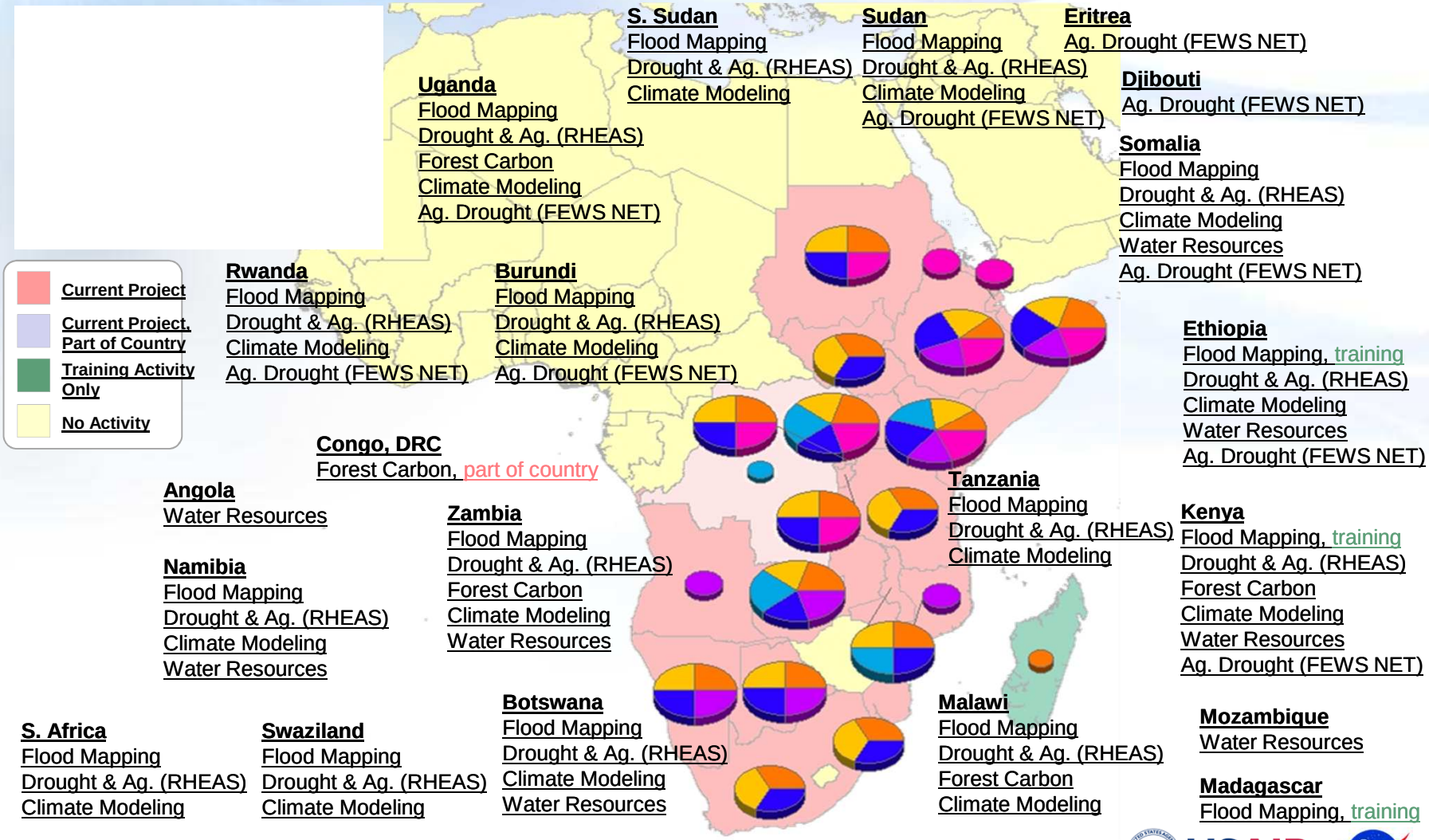


AIRS precipitable water



TRMM Rainfall data

SERVIR Country Impact
SERVIR Applied Sciences Team



S. Sudan
Flood Mapping
Drought & Ag. (RHEAS)
Climate Modeling

Sudan
Flood Mapping
Drought & Ag. (RHEAS)
Climate Modeling
Ag. Drought (FEWS NET)

Eritrea
Ag. Drought (FEWS NET)

Djibouti
Ag. Drought (FEWS NET)

Uganda
Flood Mapping
Drought & Ag. (RHEAS)
Forest Carbon
Climate Modeling
Ag. Drought (FEWS NET)

Somalia
Flood Mapping
Drought & Ag. (RHEAS)
Climate Modeling
Water Resources
Ag. Drought (FEWS NET)

Rwanda
Flood Mapping
Drought & Ag. (RHEAS)
Climate Modeling
Ag. Drought (FEWS NET)

Burundi
Flood Mapping
Drought & Ag. (RHEAS)
Climate Modeling
Ag. Drought (FEWS NET)

Ethiopia
Flood Mapping, training
Drought & Ag. (RHEAS)
Climate Modeling
Water Resources
Ag. Drought (FEWS NET)

Congo, DRC
Forest Carbon, part of country

Angola
Water Resources

Tanzania
Flood Mapping
Drought & Ag. (RHEAS)
Climate Modeling

Kenya
Flood Mapping, training
Drought & Ag. (RHEAS)
Forest Carbon
Climate Modeling
Water Resources
Ag. Drought (FEWS NET)

Zambia
Flood Mapping
Drought & Ag. (RHEAS)
Forest Carbon
Climate Modeling
Water Resources

Namibia
Flood Mapping
Drought & Ag. (RHEAS)
Climate Modeling
Water Resources

Botswana
Flood Mapping
Drought & Ag. (RHEAS)
Climate Modeling
Water Resources

Malawi
Flood Mapping
Drought & Ag. (RHEAS)
Forest Carbon
Climate Modeling

Mozambique
Water Resources

Madagascar
Flood Mapping, training

S. Africa
Flood Mapping
Drought & Ag. (RHEAS)
Climate Modeling

Swaziland
Flood Mapping
Drought & Ag. (RHEAS)
Climate Modeling

USAID FROM THE AMERICAN PEOPLE

NASA