RHEAS

The Regional Hydrological Extremes Assessment System

Jet Propulsion Laboratory, California Institute of Technology

Presentation for the Mekong River Commission Joint Steering Committee

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Presentation Objectives

Introduce the RHEAS in the context of the East Africa Drought and Crop Productivity Assessment Project.

Describe the project components, outcomes, outputs, and the implementation.

Discuss RHEAS implementation in the context of regional needs.

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The Regional Hydrologic Extremes and Assessment System: A Modeling Framework

NASA/JPL has developed an infrastructure that consists of a data ingestion framework and a hydrologic and crop model.

- The infrastructure takes advantage of data from several sources including satellites, models, and others.
- Provides an interface to proven physical models that produce estimates of hydrologic variables, drought probability and crop yields now and into the future.

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RHEAS

THE REGIONAL HYDROLOGICAL EXTREMES ASSESSMENT SYSTEM

JET PROPULSION LABORATORY, CALIFORNIA INSTITUTE OF TECHNOLOGY

- Began as a project focused on California and the Western United States.
- Implemented for East Africa.
- Designed as a flexible modeling framework.
- Has a hydrologic model at its core – the widely used Variable Infiltration Capacity (VIC) Macroscale Hydrologic Model (http://vic.readthedocs.org/en/master/)
- Uses best available data (including NASA Earth observations) as inputs for the model.

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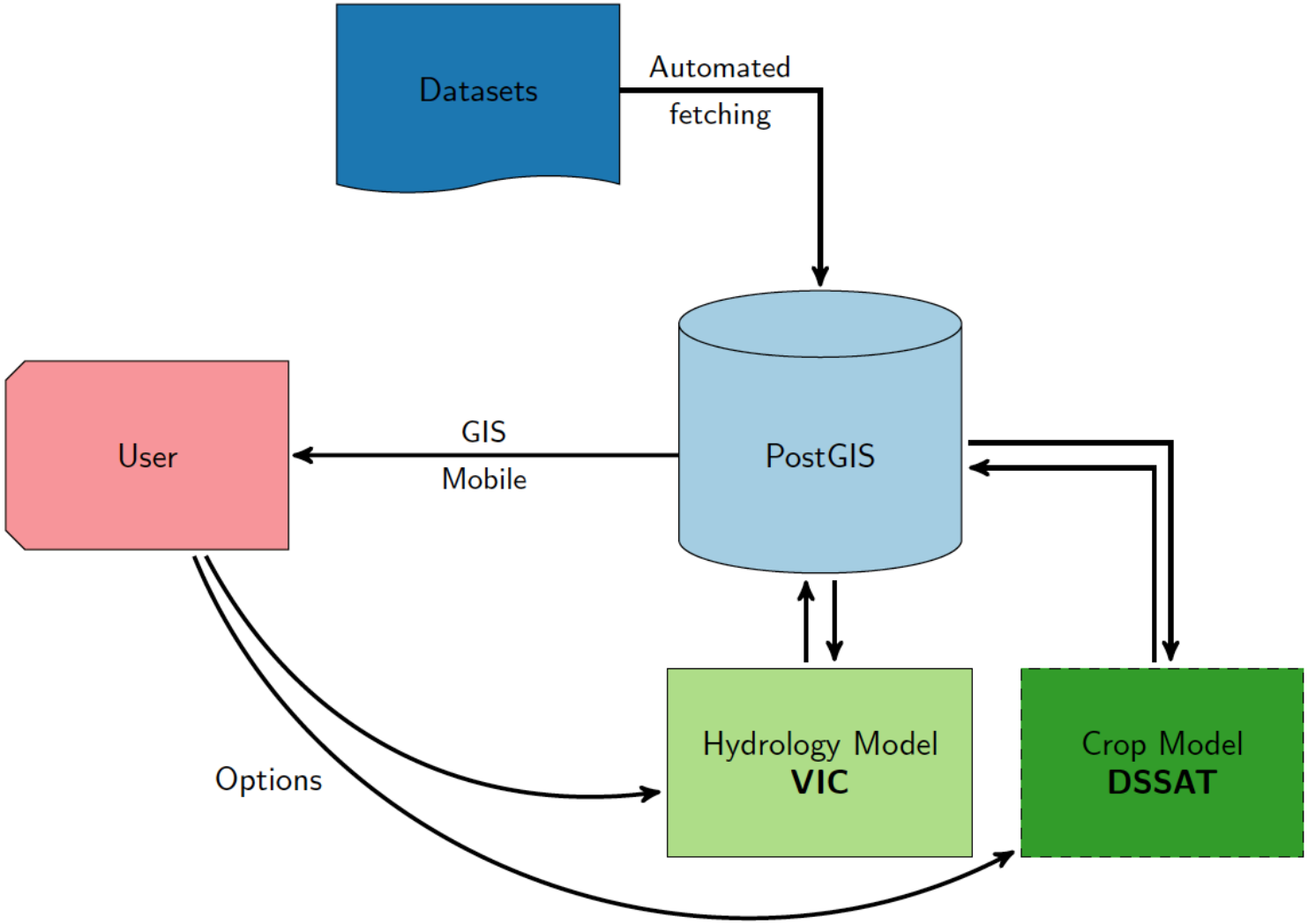
RHEAS Software Architecture



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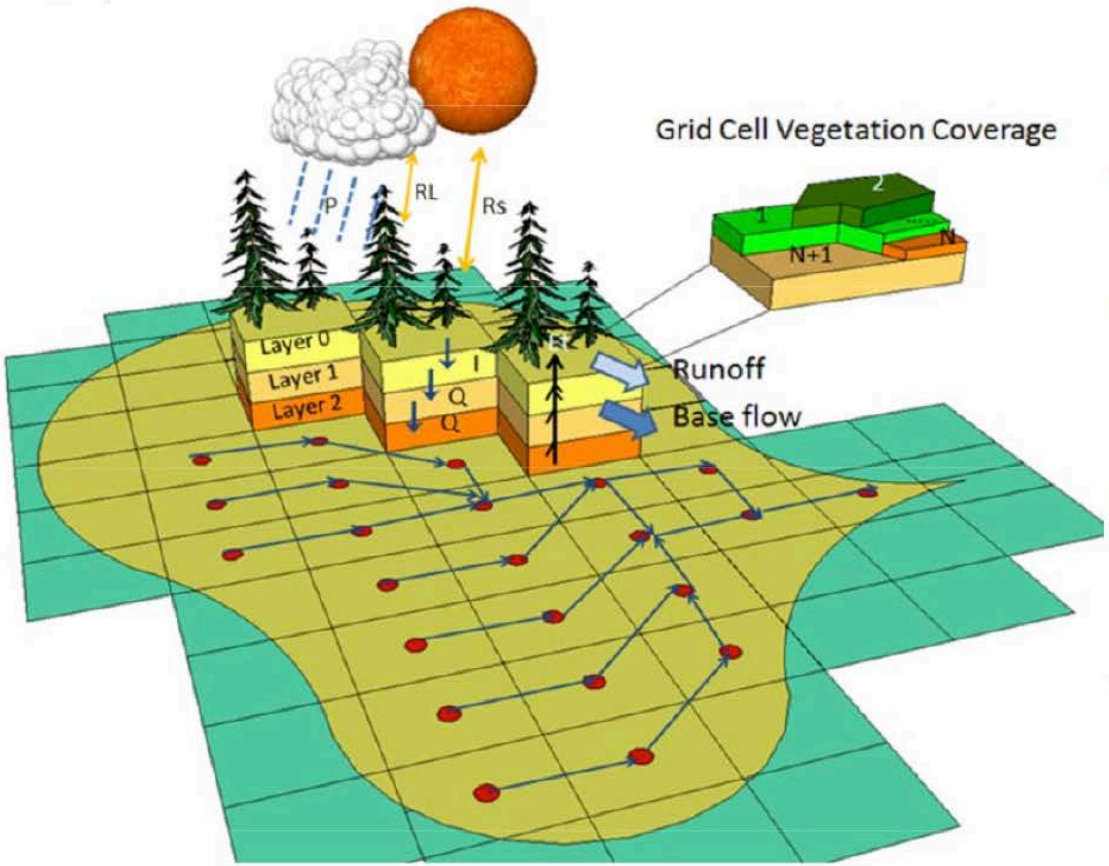
Variable Infiltration Capacity (VIC) Hydrology Model



Source: Carrasco and Hamlet, Final Report for the Columbia Basin Climate Change Scenarios Project, Chapter 6, 2010.

- Grid-based land surface representation.
- Simulates land surface-atmosphere exchanges of moisture and energy
- Developed for coupled simulations
  - Only recently used
- Off-line simulations for most uses:
  - Debugging, model improvement
  - Calibration
  - Module development

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Decision Support system for AgroTechnology (DSSAT)

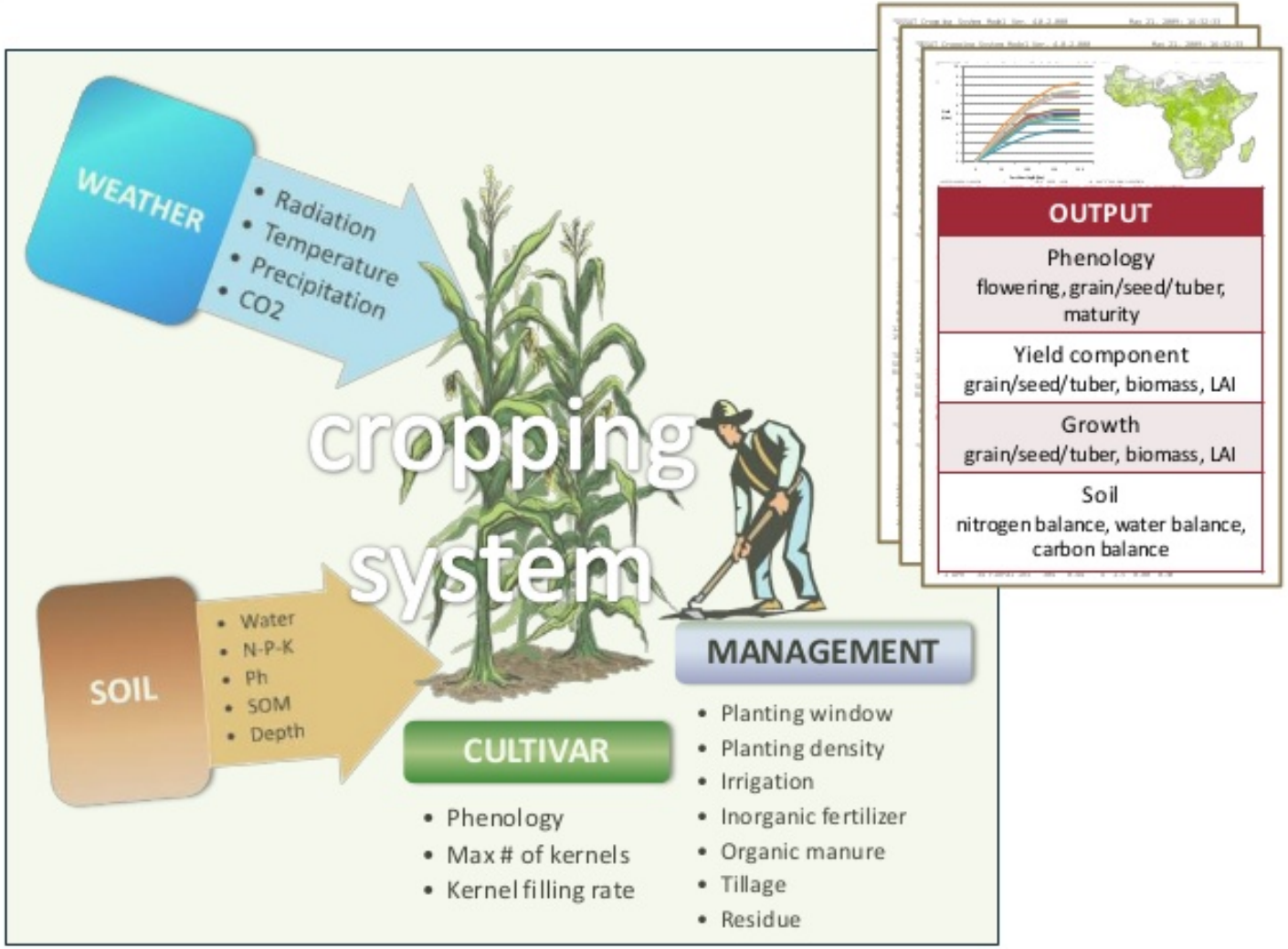

Image credit: Harvest Choice

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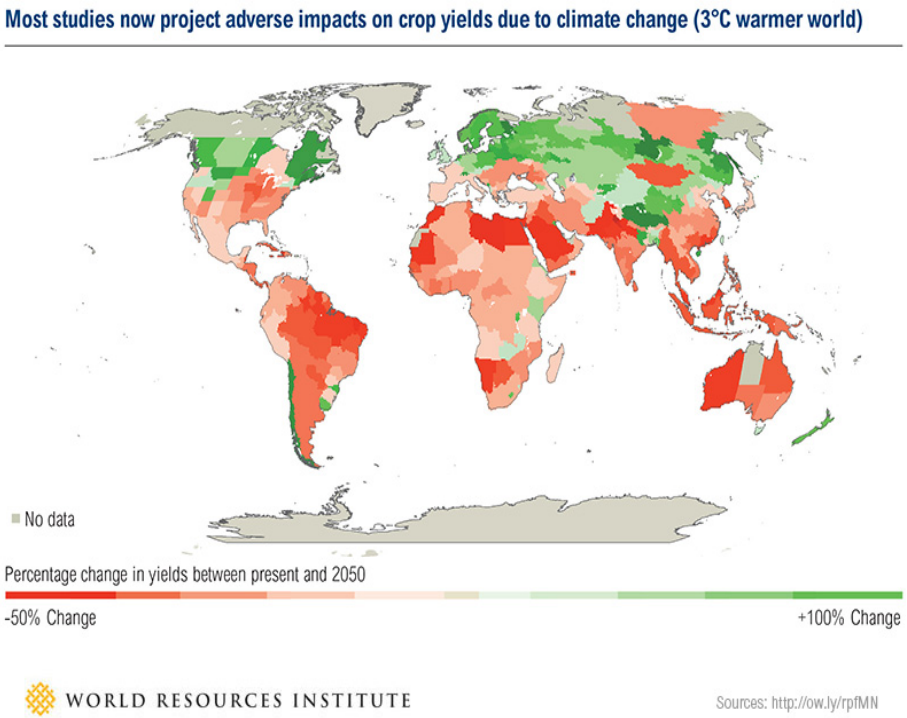
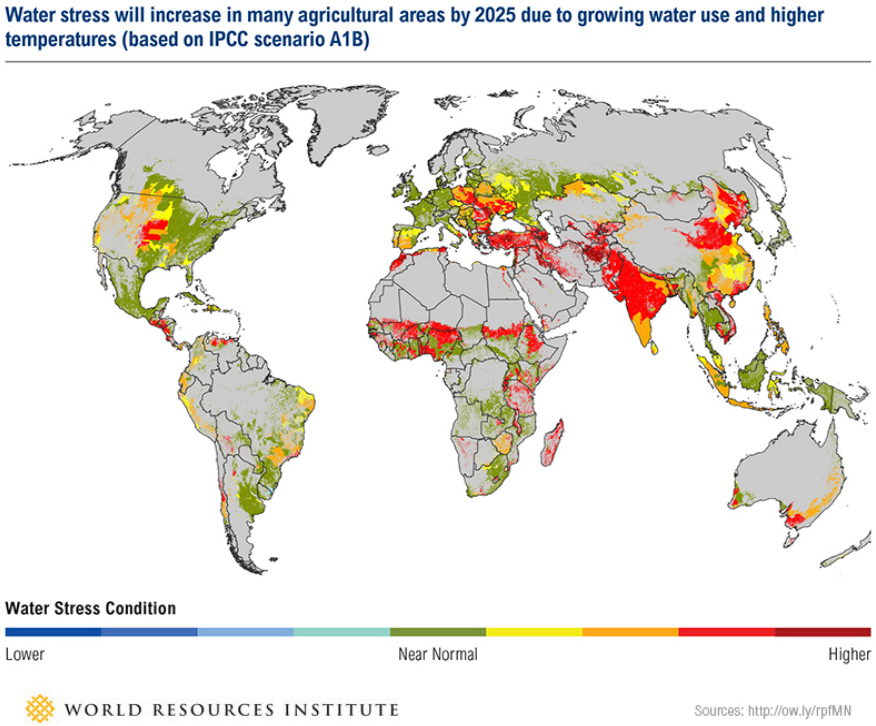
A Cross-cutting Challenge: Water, Agriculture and Climate Change





A key conclusion of the IPCC Working Group II authors is that climate change will increase the risk of reduced crop productivity associated with heat and drought stress.

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East Africa Drought and Agricultural Productivity Assessment and Prediction

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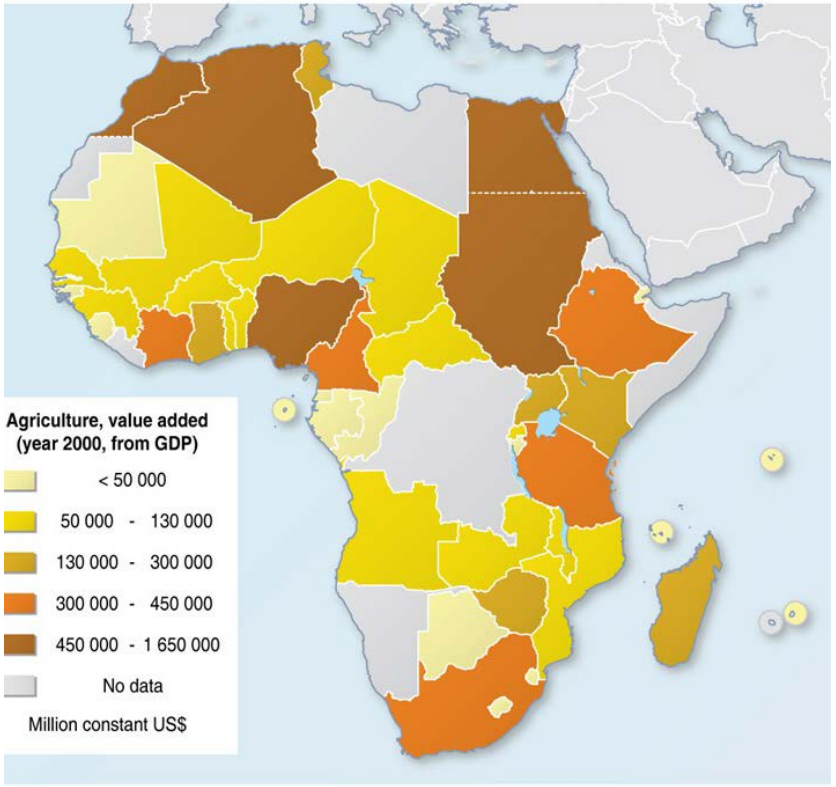
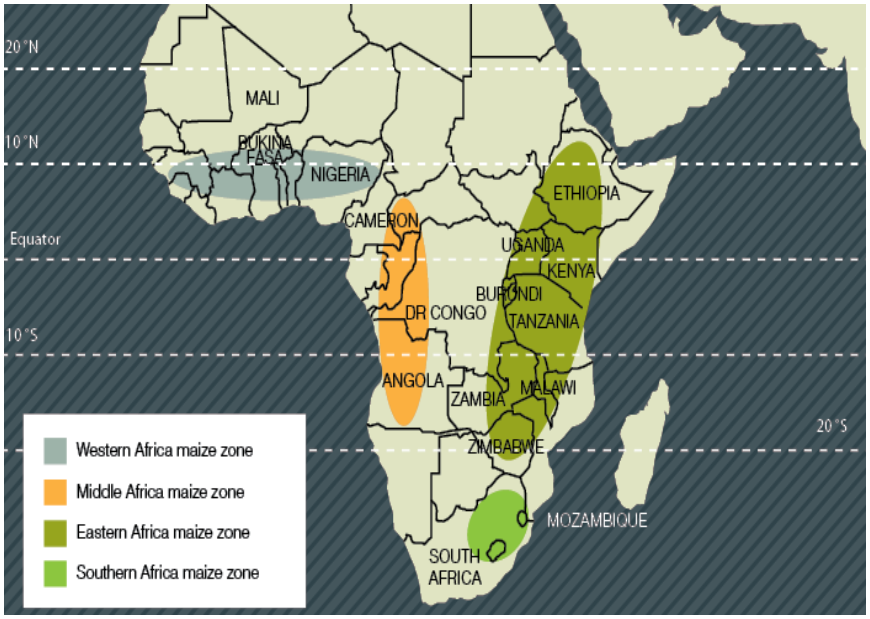
SERVIR RCMRD ICIMOD CATHALAC USAID NASA

Agriculture in Eastern and Southern Africa



Source: World Bank, World Development Indicators, through UNEP DEWA/Geneva Data
http://geodata.grid.unep.ch/ Accessed January 2006

Credit: Hugo Ahlenius, UNEP/GRID-Arendal
Source: http://www.grida.no/graphicslib/detail/agriculture-in-africa-value-added-out-of-gdp_10e3#



Credit: Australian Center for International Agricultural Research
Source: /http://aciar.gov.au/files/mn-158/s5_4-maize-sub-saharan-africa.html

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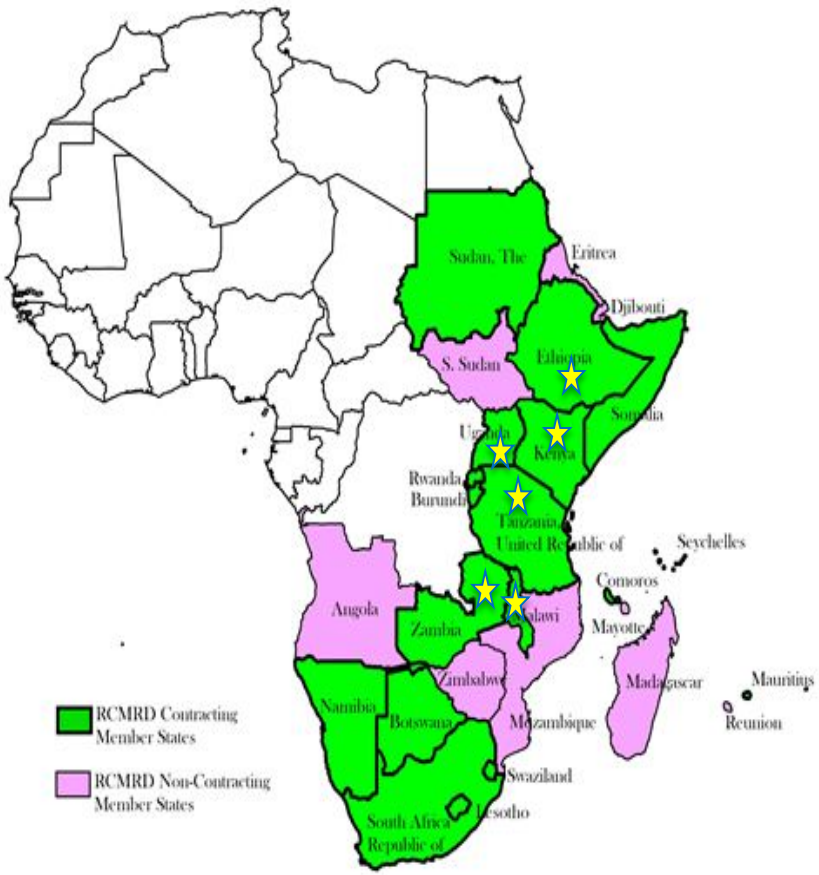
Current: Provide SERVIR-Africa with linked drought and crop productivity nowcasts and forecasts.



Who

- Regional Center for Mapping Resources for Development (RCMRD)
- Collaboration with Jim Hansen, CGIAR/CCAFS lead

Decision Support

- Inform farming practices by helping farmers adjust the timing of crops based on the projected outlooks of drought/dry spell probability tied to crop yield.
- Inform decisions at the district and/or ministry level by providing projections of maize yield with associated error bars.

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The Framework Takes Advantage of a Number of Data Sources as Input

Parameter	Product
Precipitation	Tropical Rainfall Measurement Mission (TRMM), Global Precipitation Mission (GPM), CHIRPS, Meteorological Stations as available
Evapotranspiration	MODIS, Penman Monteith-JPL (PT-JPL)
Soil Moisture	Advanced Scanning Microwave Radiometer – EOS (AMSR-E) historic soil moisture records, Soil Moisture and Ocean Salinity Satellite (SMOS), Soil Moisture Active Passive (SMAP)
Wind Speed, Tair, precipitation	NCEP Climate Forecast System Reanalysis
Soil Statistics	Harmonized World Soil Database, AfSys
Crop Statistics (planting dates, crop types, cultivars, yield)	Surveys, government statistics, documents
Land cover/crop specific	MODerate resolution Infrared Spectrometer (MODIS)
	Sentinel
	NISAR (future)
Seasonal predictions	Net Probability Estimates, International Research Institute (IRI), Columbia University
	National Multi-Model Ensemble (NMME)
Climate scale projections	NASA, WorldClim

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Outputs

Product	Decision-making activity	Who
Soil moisture, temperature, and precipitation	Determines the break of season, potential for growth, onset and duration of rapid growth.	ESA, Farmer, Ministry
Change in soil moisture with time	Quantify depletion rates and provide outlook on growth potential	ESA, Farmer, Ministry
Drought onset, recovery and duration	Dry conditions control timing of crops, food storage planning and security.	ESA, Farmer, Ministry
Drought severity	Can control how aggressive actions need to be to alleviate problems.	ESA, Farmer, Ministry
Greeness/vegetation health	Related to health of crops during the growing season.	ESA, Farmer, Ministry
Crop yield	Outlook on expected yield to support risk management.	Ministry

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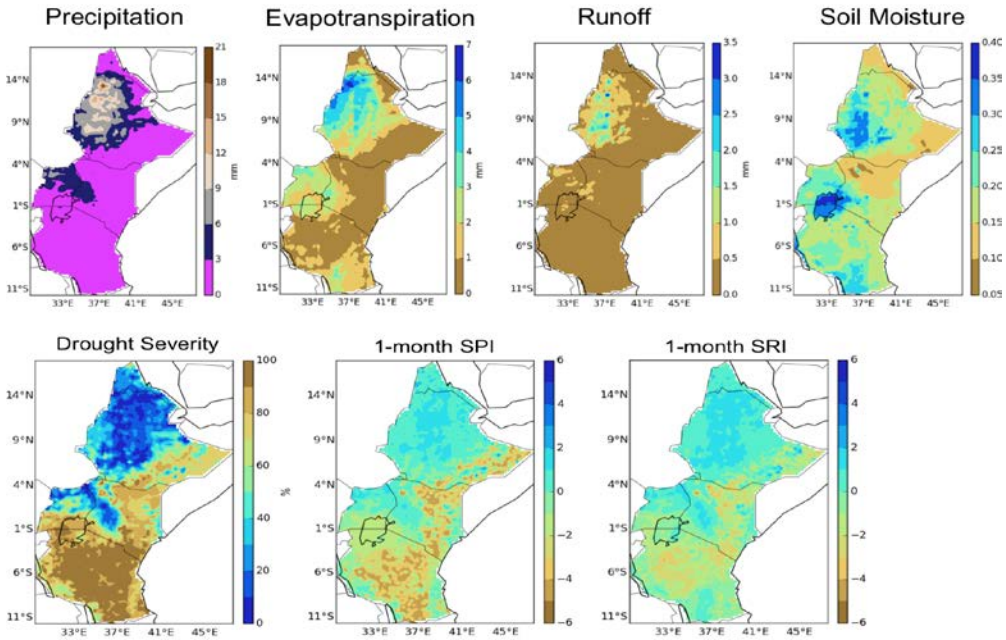
RHEAS Hydrologic and Drought Forecast Examples

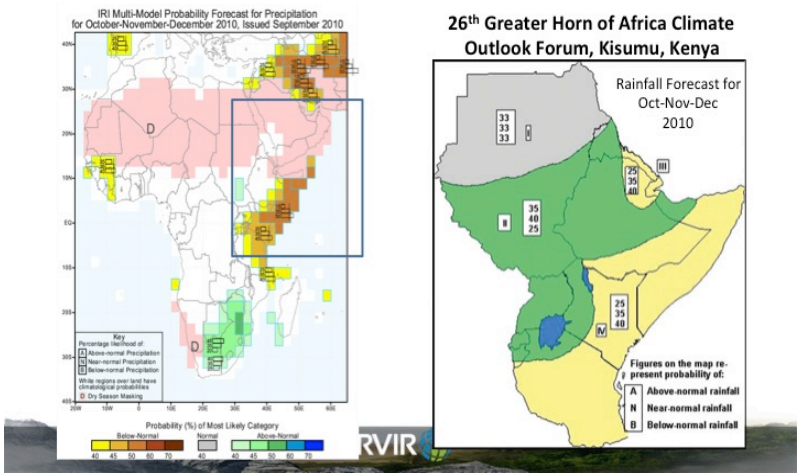
RHEAS Hydrologic outputs as forecasts.

The system was run in forecast mode using the disaggregated IRI Net assessment data developed for the short rains (OND). Drought indicators are given in Panels 5 and 6



Seasonal Rainfall Forecasts for the Greater Horn

Example of an IRI Seasonal Forecast (left) for Oct-Nov-Dec 2010, Issued in Sept 2010. Shading indicates probability of the most likely category. Right shows forecast probabilities for Above, Near and Below average from the Climate Outlook Forum.



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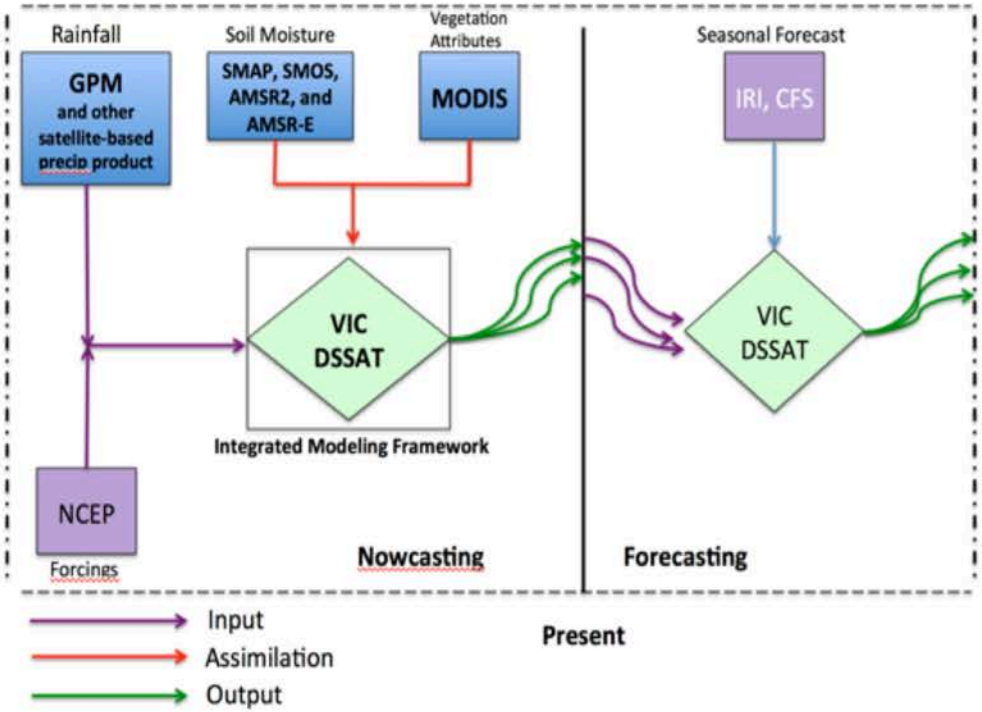
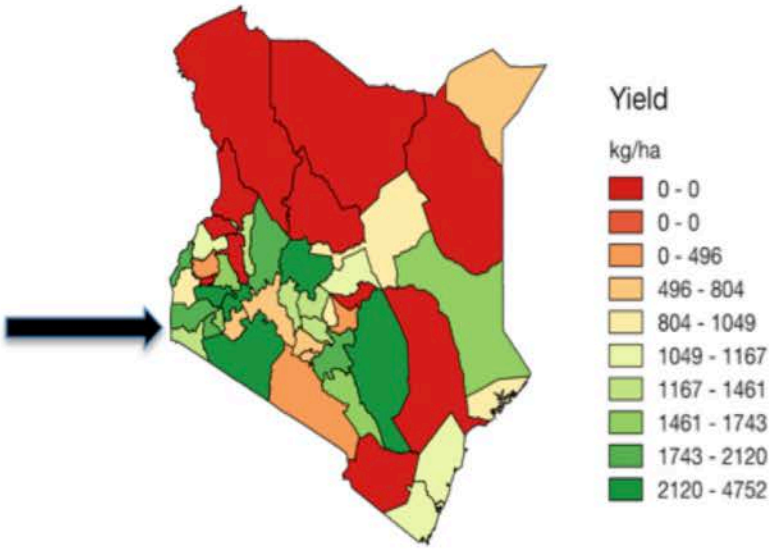
RHEAS Schematic

- Provide linked drought and crop productivity nowcasts and forecasts for RCMRD-member countries.





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Capacity Building Framework

BOTTOM-UP

- How
  - Inception Workshops
  - Technical Workshops
  - Trainings
  - Wiki/blog space
  - Skype
- When
  - Early in the project to develop requirements and get feedback on products and tools.
  - Frequent interaction throughout.
- Outcomes
  - Ideas generated and implemented.
  - Products and tools co-developed.
  - Staff skills, understanding, participation improved.
  - Co-author academic papers, conference proceedings

TOP-DOWN

- How
  - Formal Meetings/Presentations
- When
  - Early in the project for organizational buy-in
  - Regular, occasional interaction throughout.
- Outcomes
  - Organizational/institutional buy-in
  - Resources allocated

PARTNERSHIPS

- How
  - Introductory workshops
  - Formal meetings
  - Technical workshops
  - Trainings
  - Student internships
  - Wiki/blog space
- When
  - Mid-project when there are tools to demonstrate and data to share.
  - Less frequent meetings, interaction
- Outcomes
  - Collaborations and information sharing
  - Facilitate ownership

COMMUNITY ORGANIZING

- Who
  - Community Groups
  - Extension Agents
- How
  - Introductory workshops
  - Technical workshops
  - Trainings
- When
  - Mid-project, when there are tools to demonstrate and data to share
  - Regular interaction
- Outcomes
  - Participation of different interest groups
  - Establishment of clear criteria for appropriate actions
  - Community ownership

Continuous Process

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Workshops and Technical Capacity Building

- 2014-2015: Inception workshops and technical capacity building in Kenya, Tanzania, Zambia. Malawi, and Ethiopia.
- 2016: Technical capacity building for RCMRD personnel in Nairobi, Kenya

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SERVIR East-Africa Notable Accomplishments

- RHEAS was granted open source license in late 2015.
  - All codes are available on the NASA Github
- RHEAS transitioned to RCMRD in February 2016 for testing in operational setting.
  - Two more deliveries planned in 2016.
- RHEAS-Africa demonstrated for the Mekong region during Asia Disaster Preparedness Center (ADPC) Subject Matter Expert (SME) meeting in October 2015.

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Next steps in support of existing East Africa project

- Incorporate Climate-scale projections for 3 emissions scenarios.
  - RCP2.6 (low)
  - RCP4.5 (medium)
  - RCP8.5 (high).
- Development of user-friendly front-end (GIS).
- Final Delivery to RCMRD.

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Benefits and Innovation

- The core models have been modified to use remote sensing observations in addition to point data.
- Allows incorporation of global observations from satellites.
  - Remote sensing observations provide homogeneous data across borders.
- Provides linked hydrology, drought and yield for monitoring current conditions.
- Incorporates seasonal and climate-scale projections of hydrology, drought and yields to assess future trends for effective drought planning and risk mitigation
- Scalable to other regions.

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Notional RHEAS Implementation for the Lower Mekong River Basin

- Implement RHEAS for the LMB to provide:
  - Weekly spatial maps of current conditions of precipitation, soil moisture, temperature, drought indices (e.g., SPI3, PDSI, etc.) linked to estimates of rice yield for the LMB
  - Spatial maps showing seasonal projections (1-3 months) of the above.
  - Spatial maps showing projected future conditions for specific times of the year (e.g., dry season, rainy season) and different climate change scenarios.
  - Spatial maps of confidence intervals (at various levels, e.g. 90%) of each variable of interest into the future. Maps of vulnerabiliy/ risk (i.e. probability) of crop failure, temperature/precipitation exceeding/being below certain thresholds.
- Provide capacity building in the technical aspects of RHEAS.

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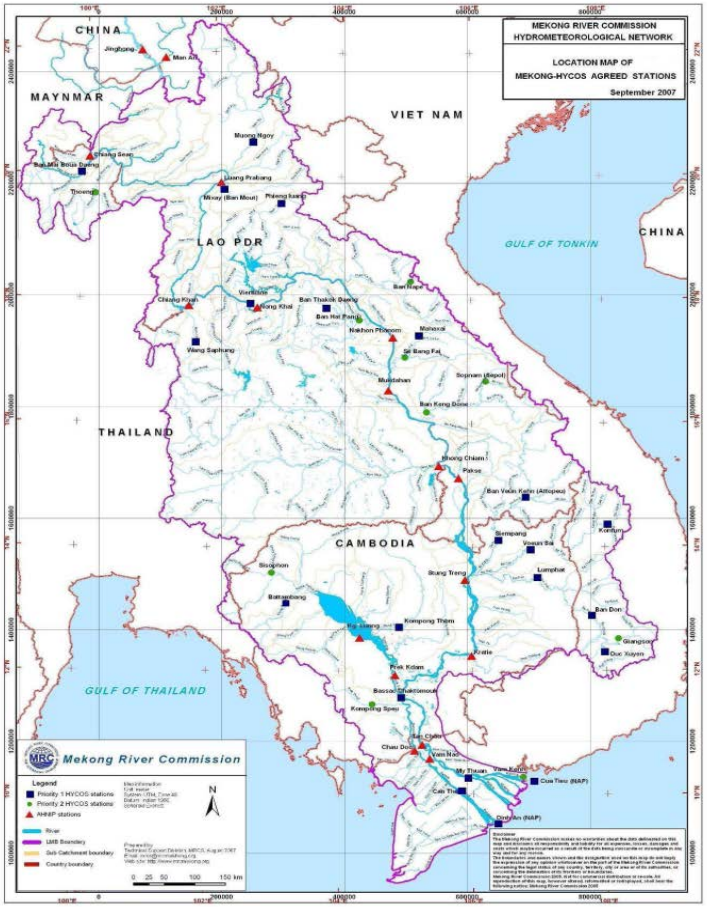
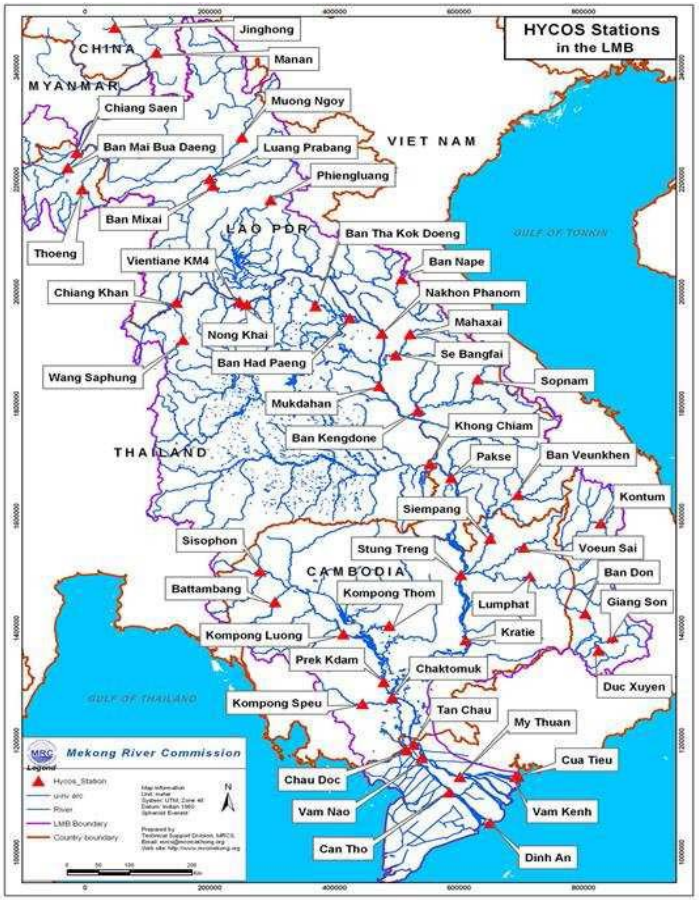
National Data Sets and Calibration

- National data sets such as the LMB hydro-met stations (shown below) or national agricultural statistics are critical for calibration and/or running of the models.





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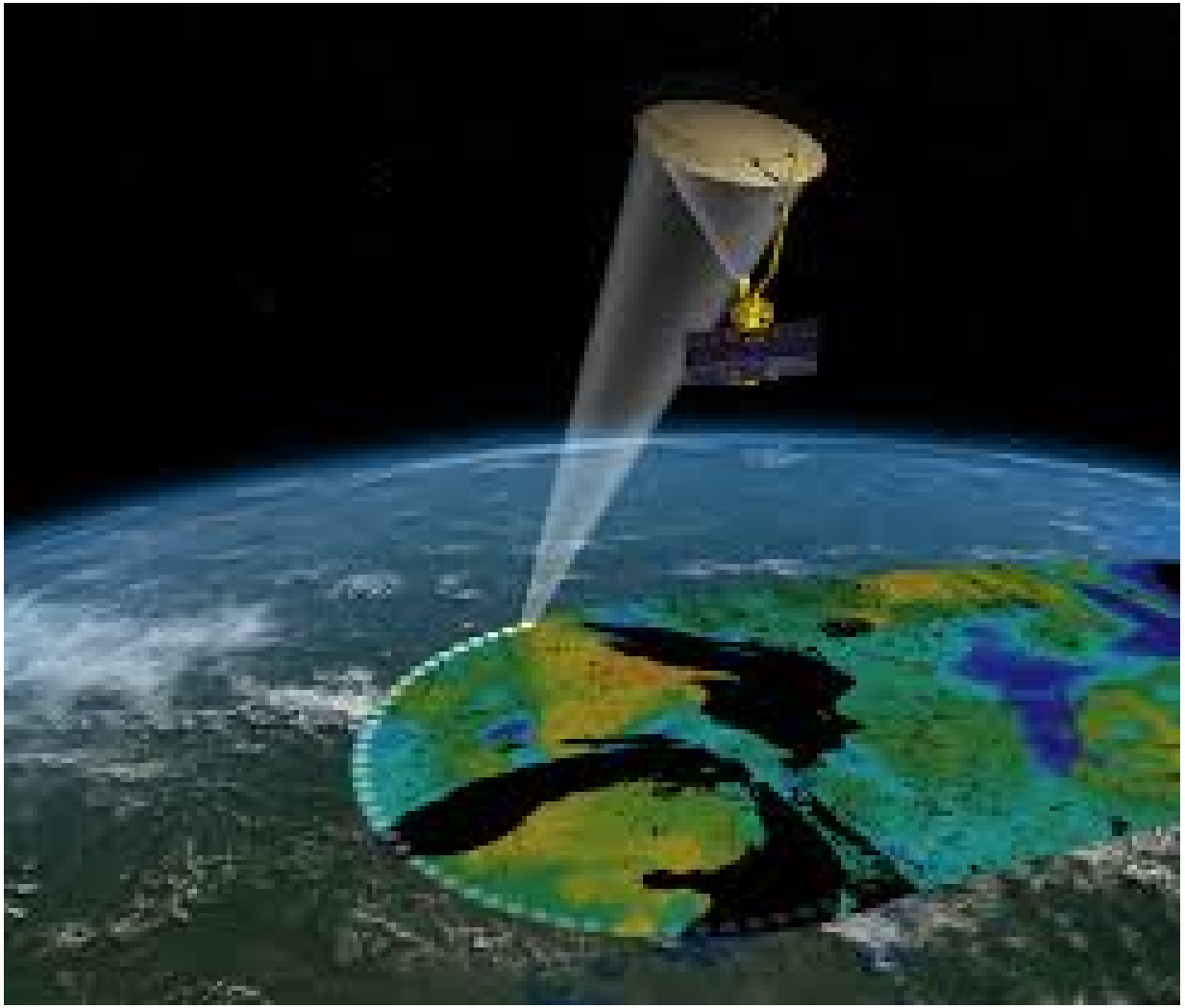
Soil Moisture Active Passive Mission (SMAP)



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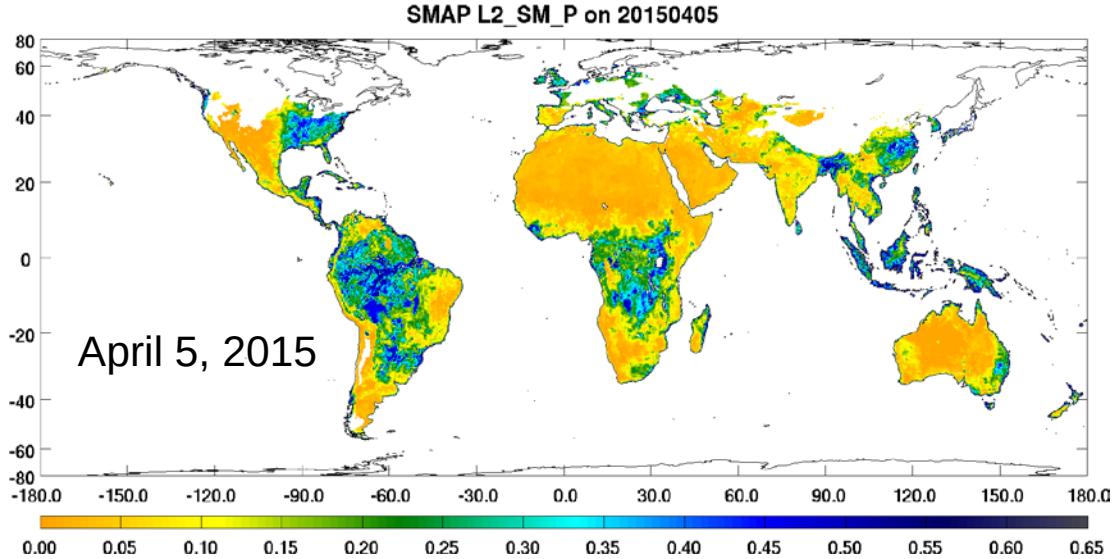
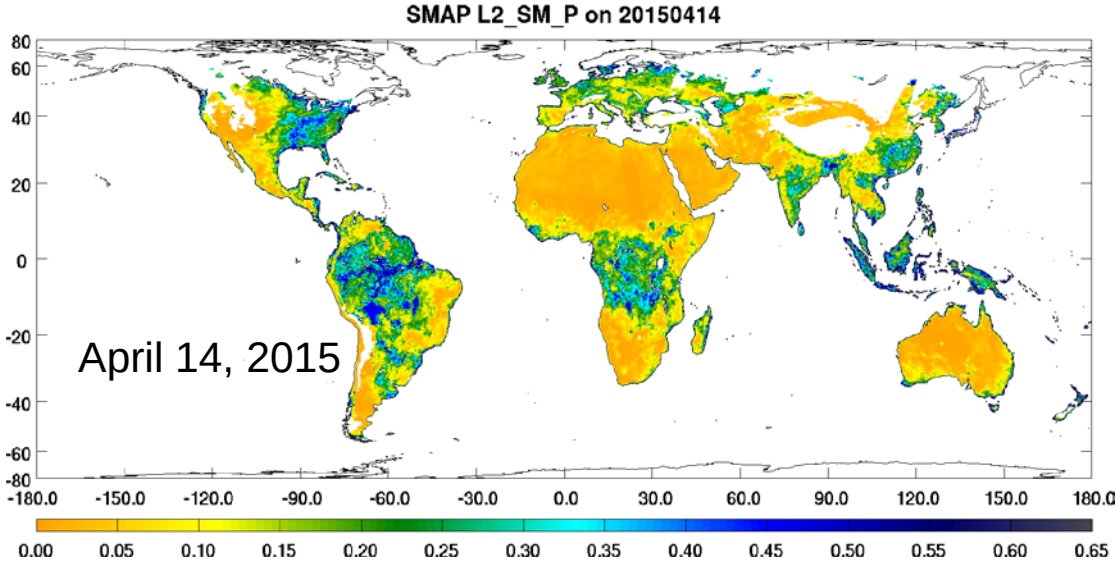
Soil Moisture - Observed Changes

- Passive (36 km) data processed into soil moisture 3-day global images centered on April 5 and 14, 2015
- Soil moisture patterns agree with expected geographical soil moisture





- Soil moisture changes are evident in the time-sequence
- Rainfall in India, Bangladesh, and Vietnam
- Dry-down in eastern Australia and Argentina

Thank you

Questions?

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