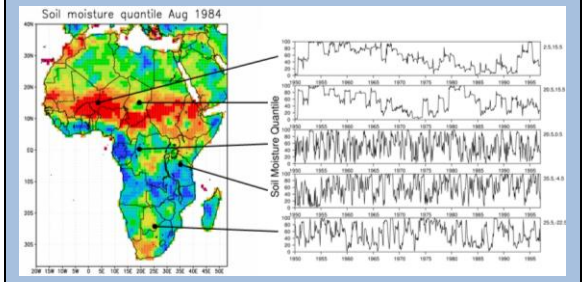
Development of an Experimental African Drought Monitoring and Seasonal Forecasting System: A First Step Towards a Global Drought Information System

Eric F. Wood,
Princeton University

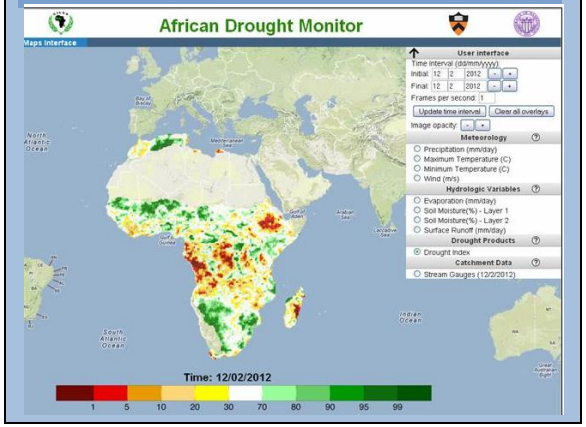
Invited Lecture to CE 374K Hydrology
University of Texas at Austin
26 February 2013

Timelines of analysis for an “enhanced” GDIS information system – areas of potential science

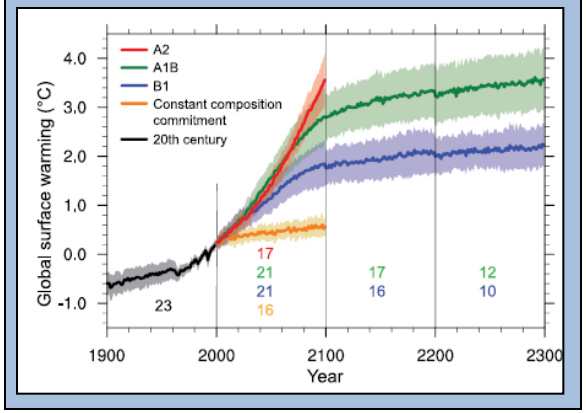
Historic Climate Analysis

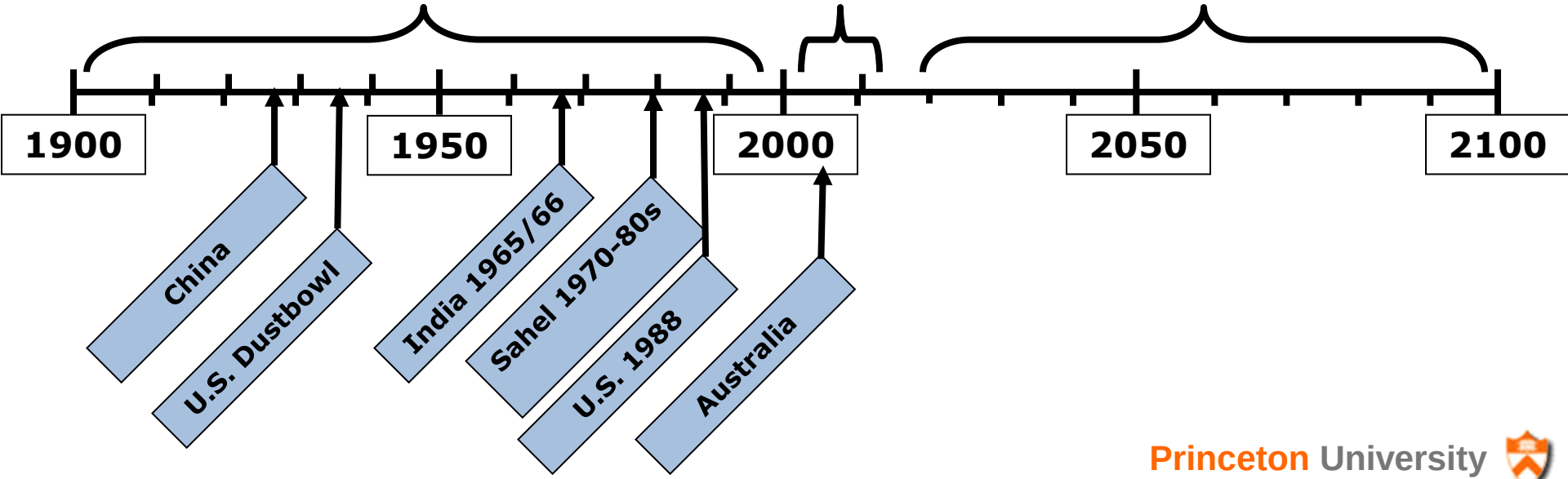


Climate Monitoring and Forecasting



Future Climate Projections





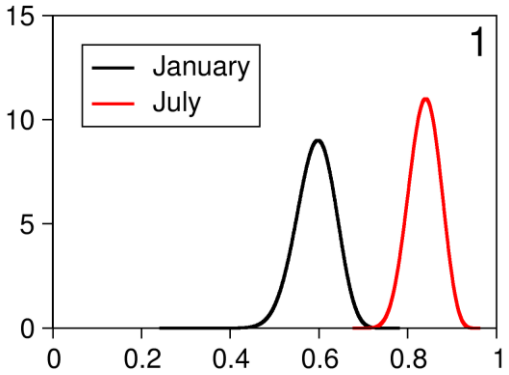
Development of our Objective Drought Index

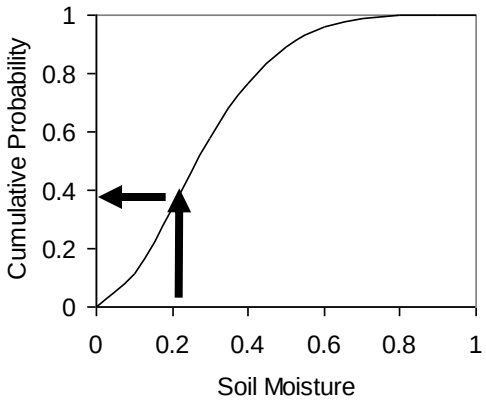
1) Retrospective Simulation

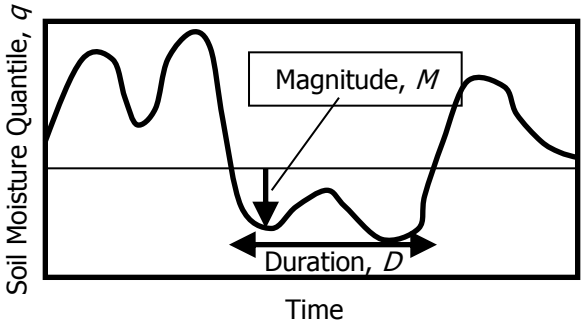
Forcings → **VIC Model (MME LSM)** → **Retrospective Soil Moisture**

2) Calculate Drought Index: drought = run of low soil moisture

Fit beta distribution → **Soil Moisture Percentile** → **Drought Index**



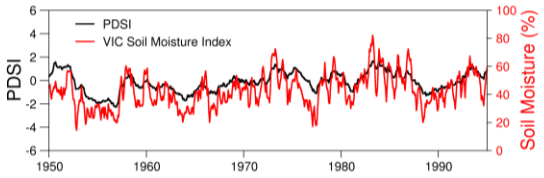


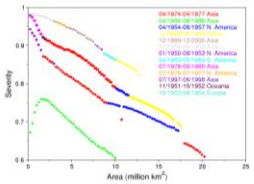


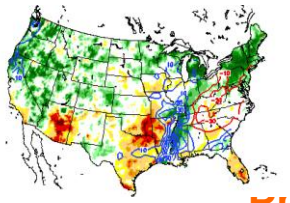
Severity, $S = D \times M$
Extent, A = area in drought

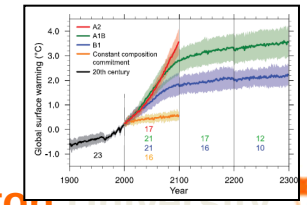
3) Drought Analysis

Trends/Var **Characteristics** **Monitoring** **Climate Change**

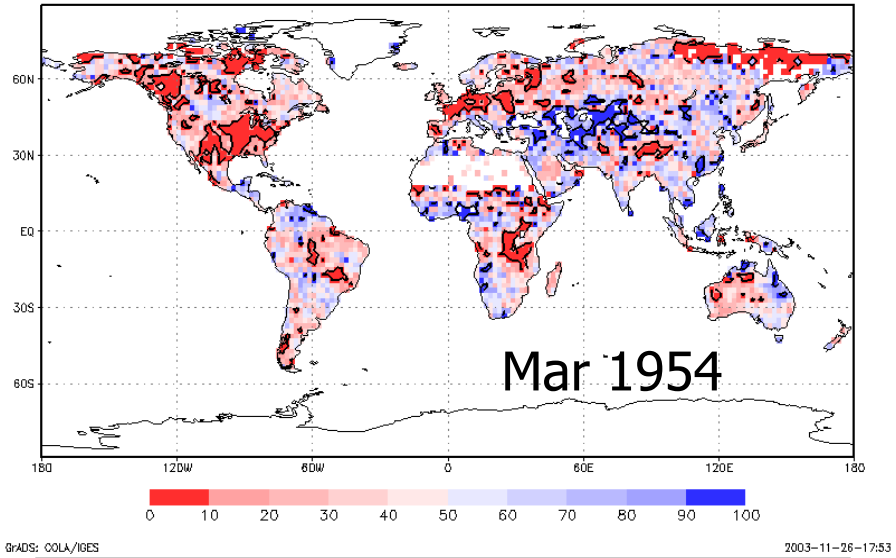


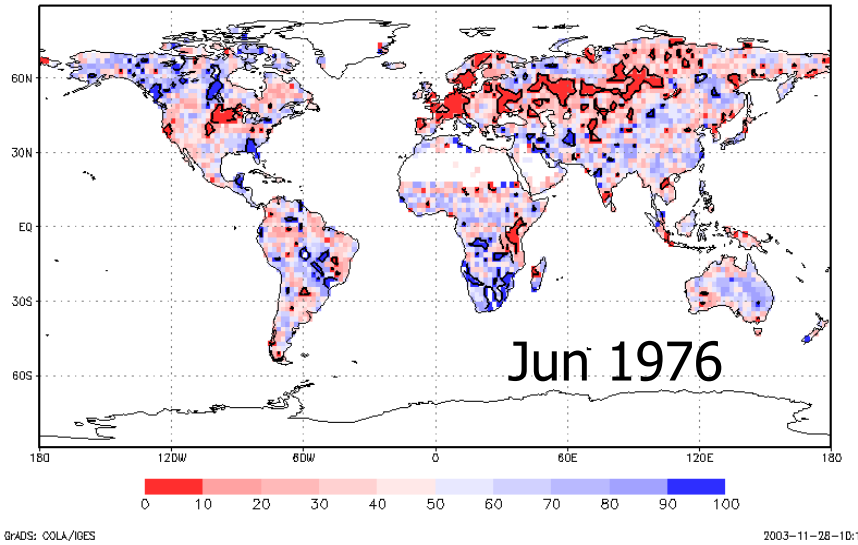


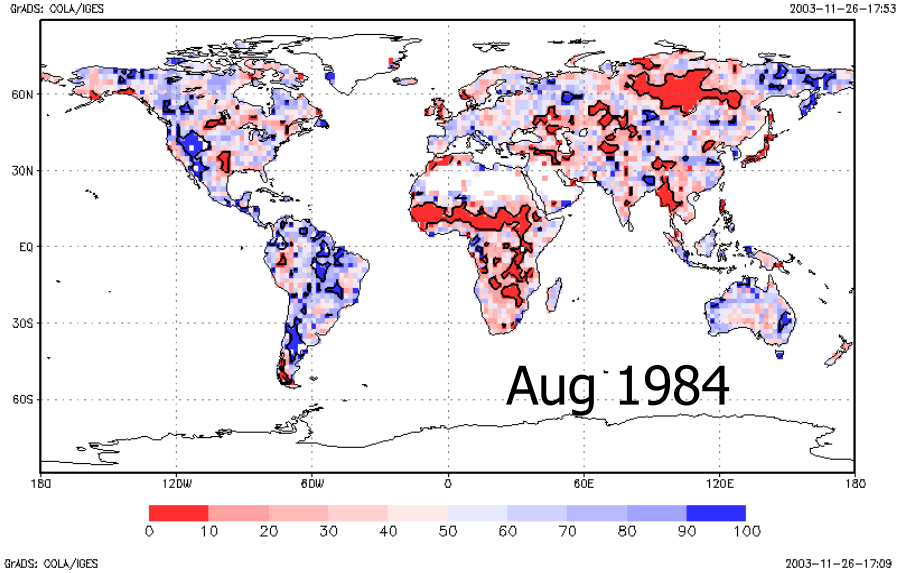


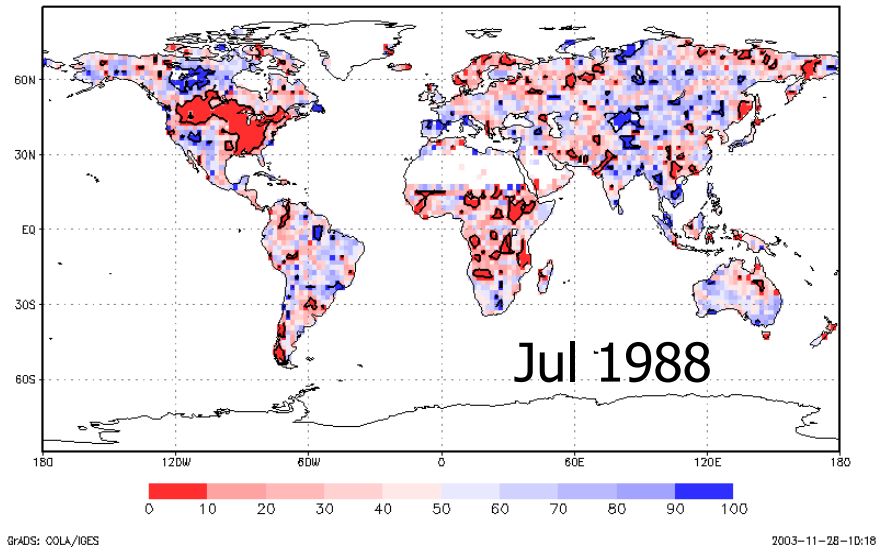


Historical Drought Quantiles

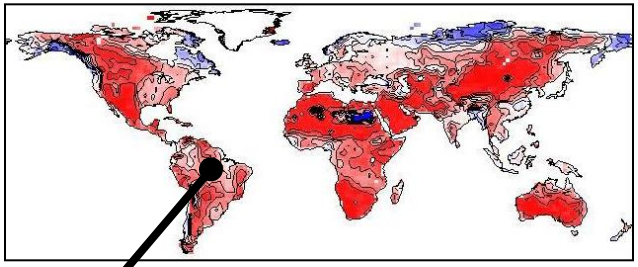




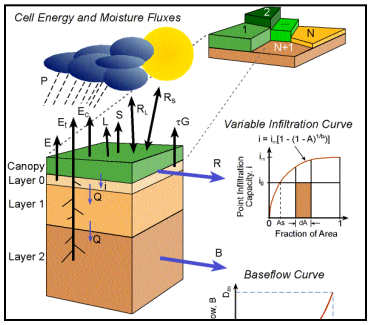




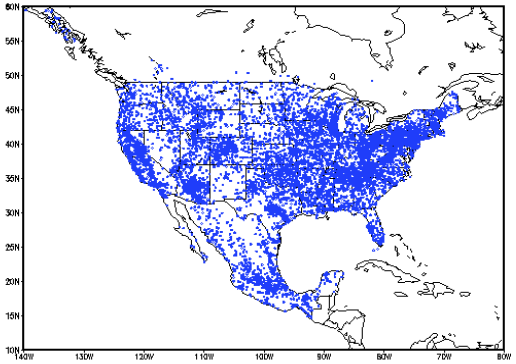
Climate Monitoring and Forecasting: Data and Tools



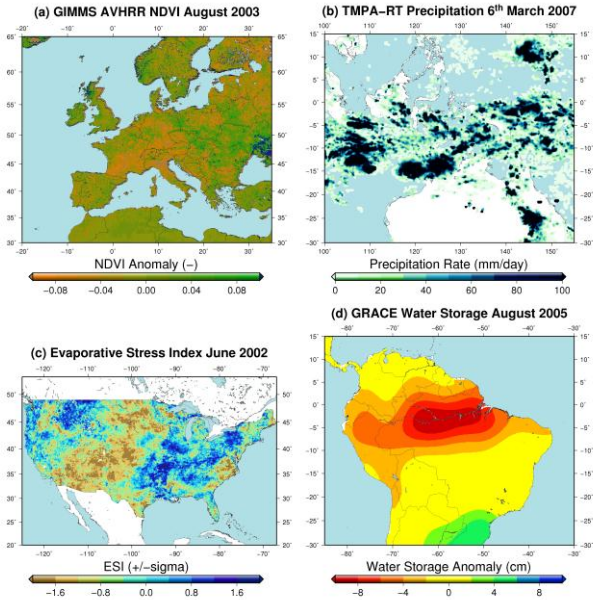
Hydrological Modeling



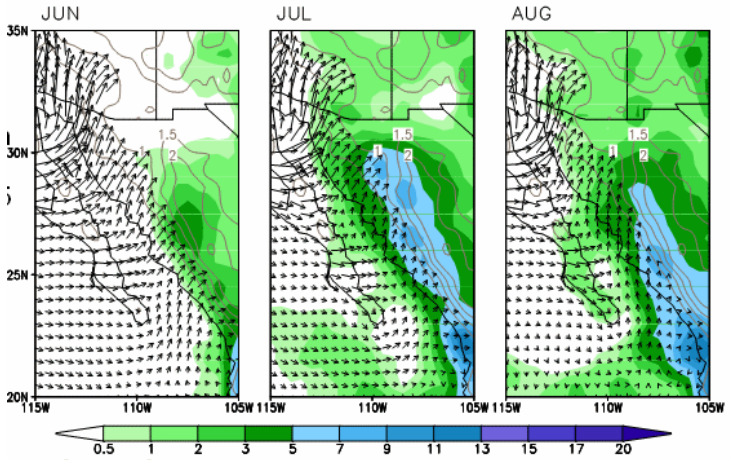
Ground Observations



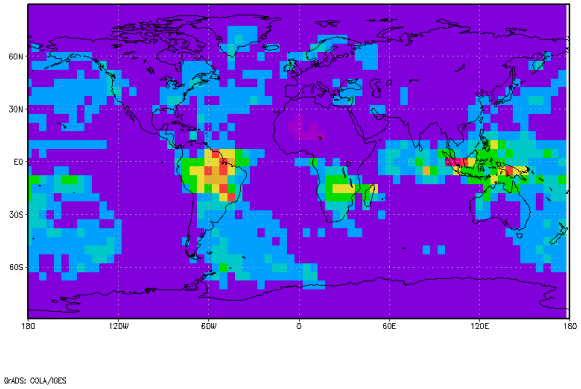
Satellite Remote Sensing



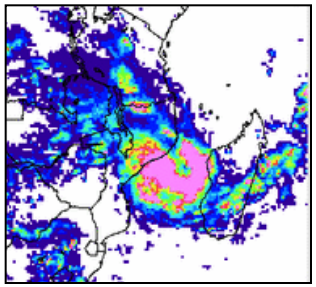
Reanalysis



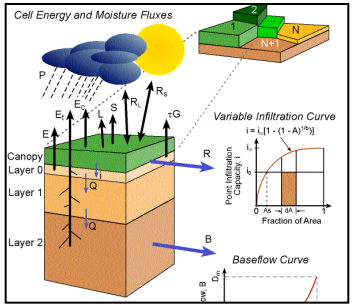
Regional/Global Climate Models, Statistical Prediction

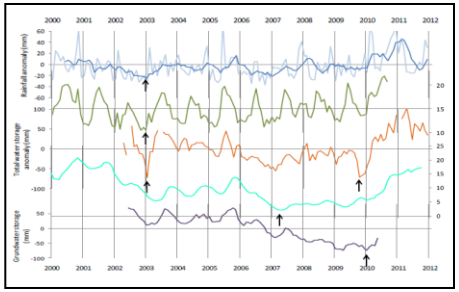


Hydrological and Drought Monitoring System: Conceptual System



Real-time Weather

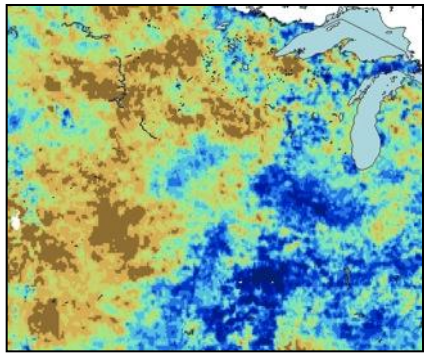


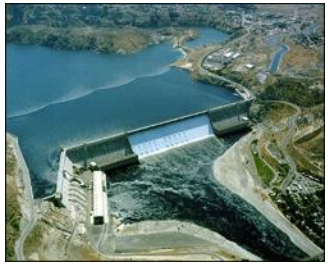


Land surface (hydrology) models

Initial Conditions

Hydrological Variables, Streamflow, Drought Indices



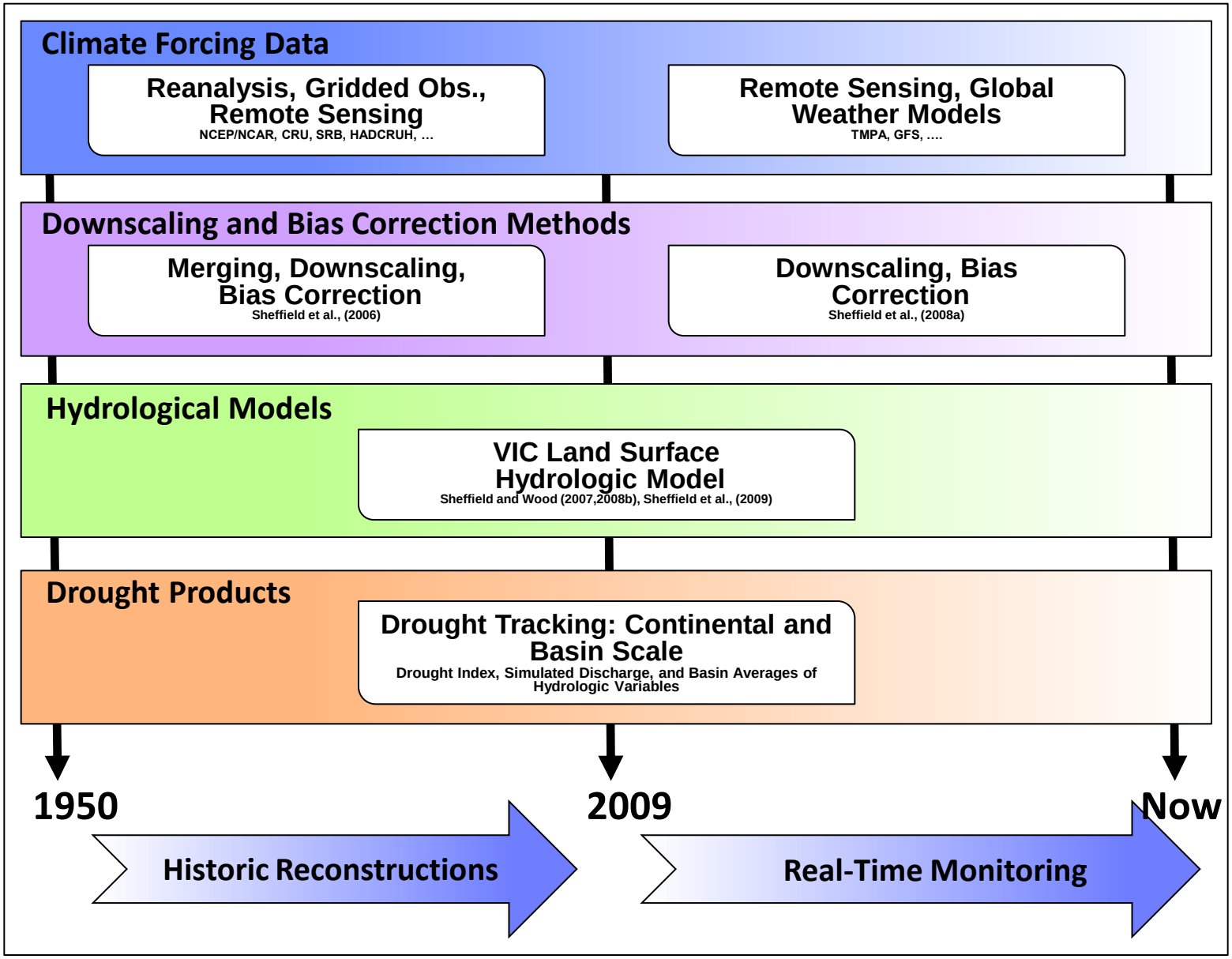


Management/Mitigation

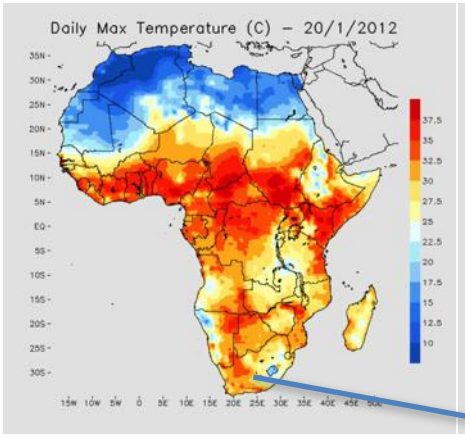
Princeton African Drought Monitor: Motivation

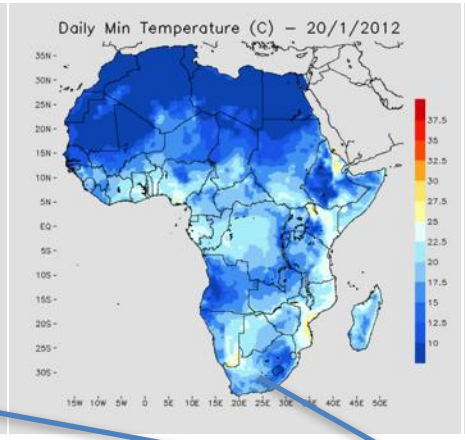
- **Princeton University:** Experience with drought monitoring over the United States (NLDAS)
- **UNESCO interest in 2009**: Request to adapt our system for Africa and install at drought centers over Africa (AGRHYMET and ICPAC).
- **Milestones for Monitoring System**
  - Adapt the monitoring system to the region.
  - Improve data dissemination
  - Training workshop in Niamey, Niger (AGRHYMET) and Nairobi, Kenya (ICPAC)

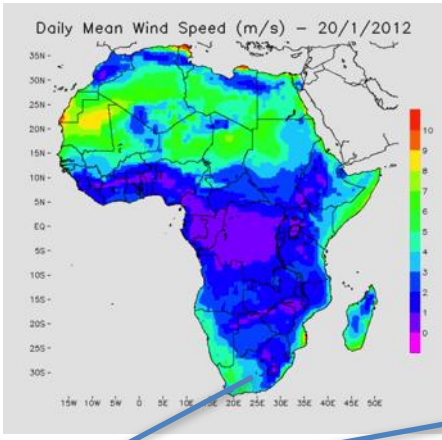
Princeton African Drought Monitor

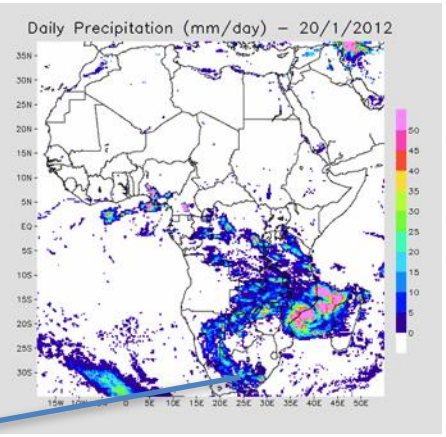


Land Surface Model Generated Hydrology









Daily max temperature

Daily min temperature

Daily mean wind

Daily precipitation

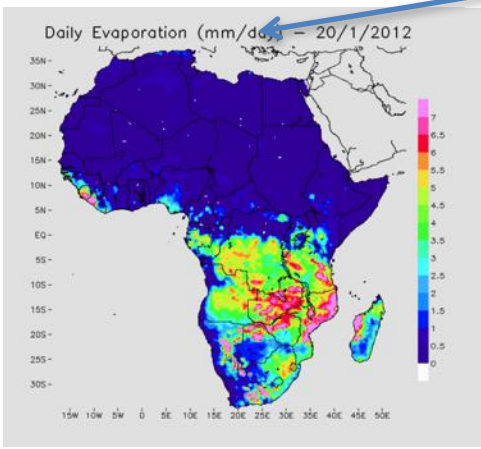
Variable Infiltration Capacity Model provides the hydrology. (Plans for a multi-model system)

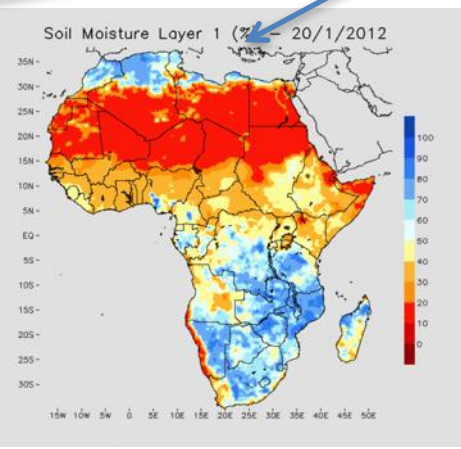
Daily evaporation

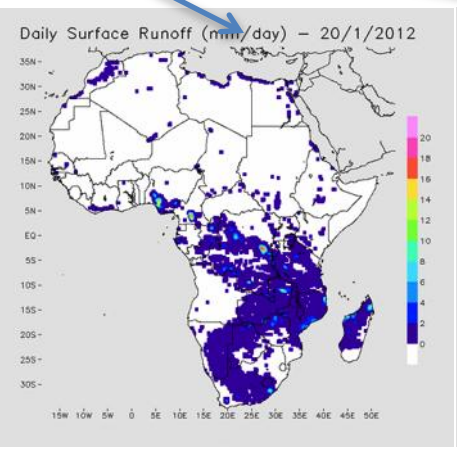
Soil moisture

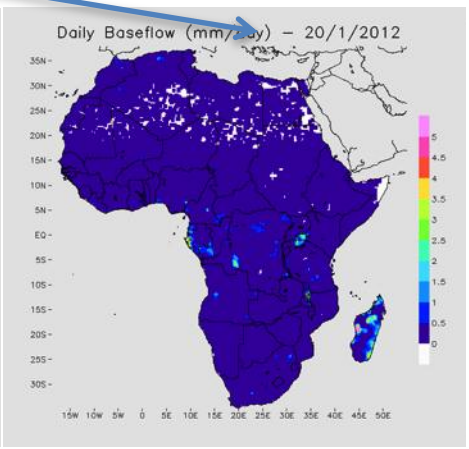
Daily surface runoff

Daily baseflow



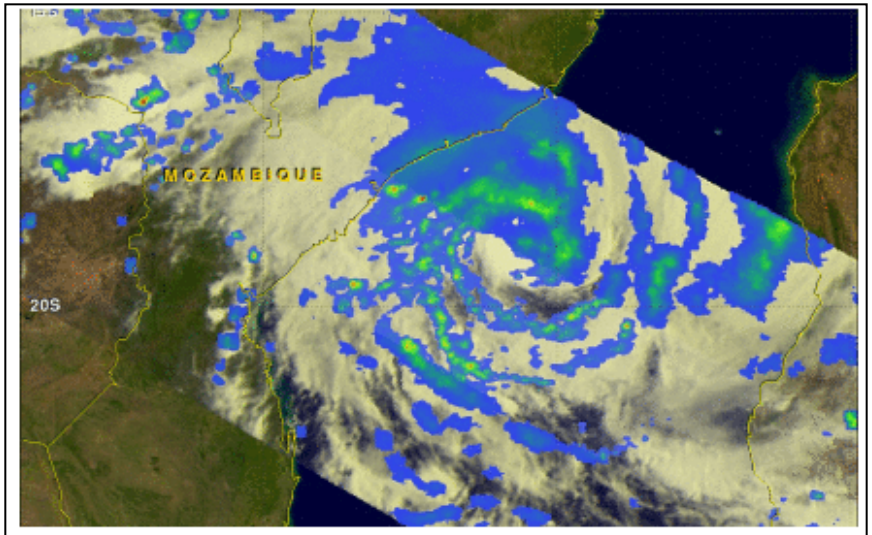






Real-Time Weather: Precipitation Data

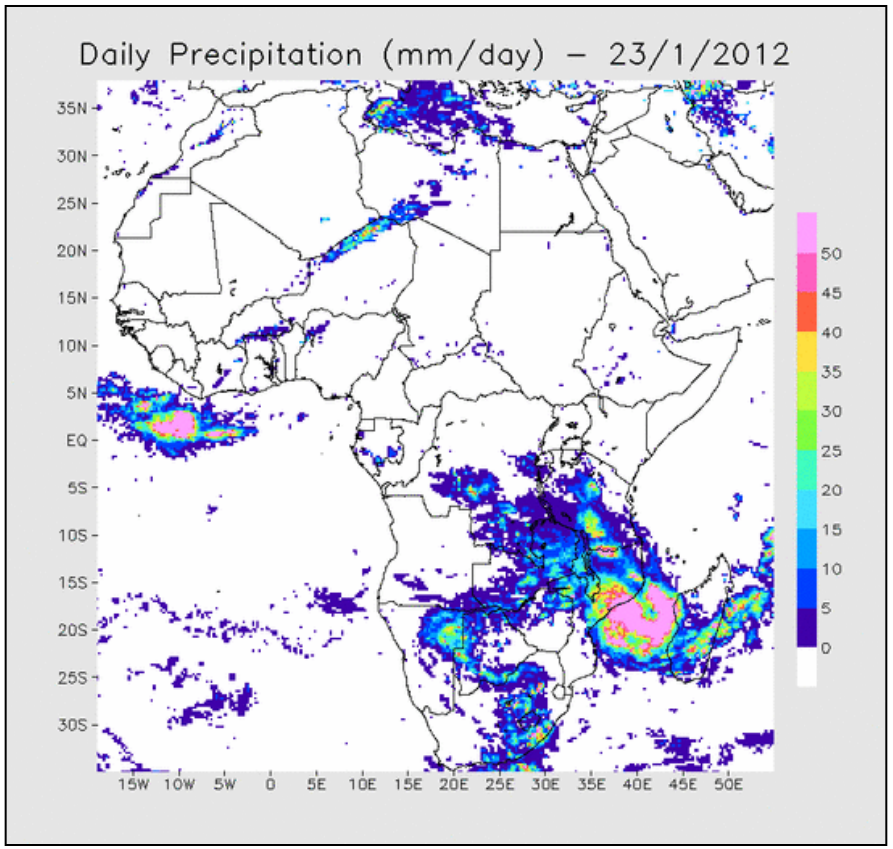
Satellite Precipitation – TMPA (TRMM Multi-satellite Precipitation Analysis



Monday January 23, 2012

TRMM sees Powerful Tropical Cyclone FUNSO

The TRMM satellite had a good view of powerful tropical cyclone Funso battering the Mozambique coast when it flew over on 23 January 2012 at 1451 UTC. TRMM data shows that Funso was dropping moderate to heavy rainfall in bands covering the Mozambique channel from eastern Mozambique to western Madagascar. Storms and floods from Funso have killed at least 22 people and forced tens of thousands from their homes in Mozambique.



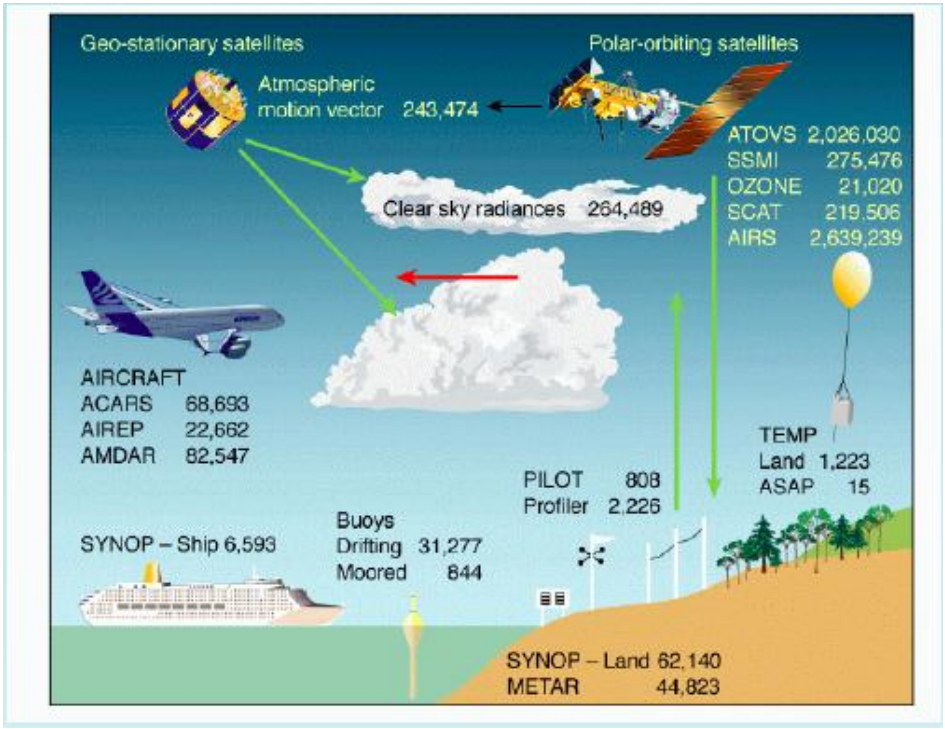
Real-Time Weather: Weather Model

Global Forecast System

1. Global weather forecasting model.
2. Run by NOAA (National Oceanic and Atmospheric Administration).
3. Run every 6 hours at 00,06,12,18 hours UTC.

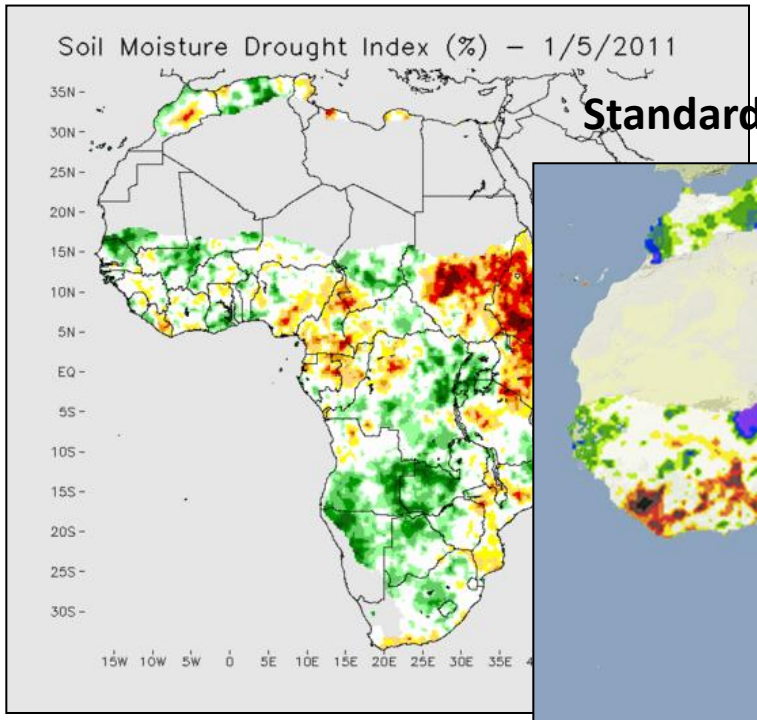
GFS analysis fields

- Initial conditions are necessary at the beginning of each forecast.
- The Initial conditions come from GDAS (Global data assimilation system)
- Merge multiple data sources

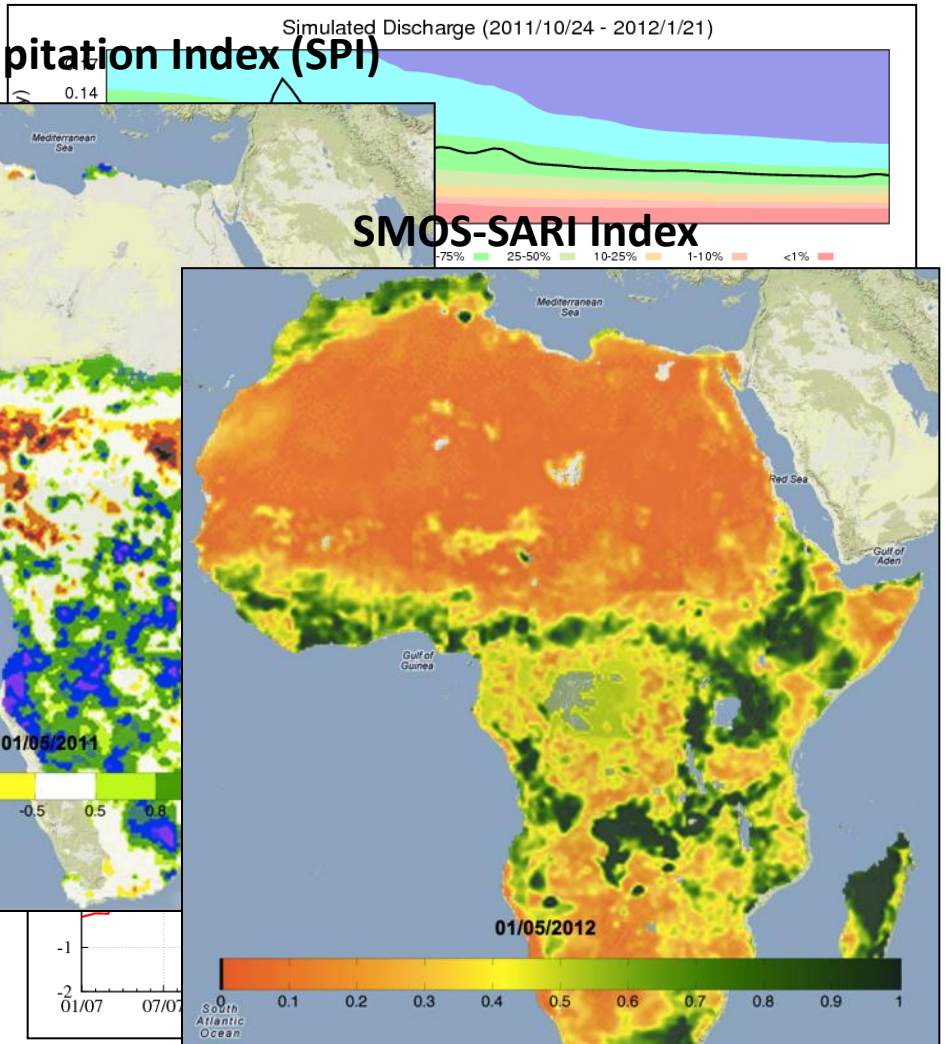


Drought Products

Drought Index



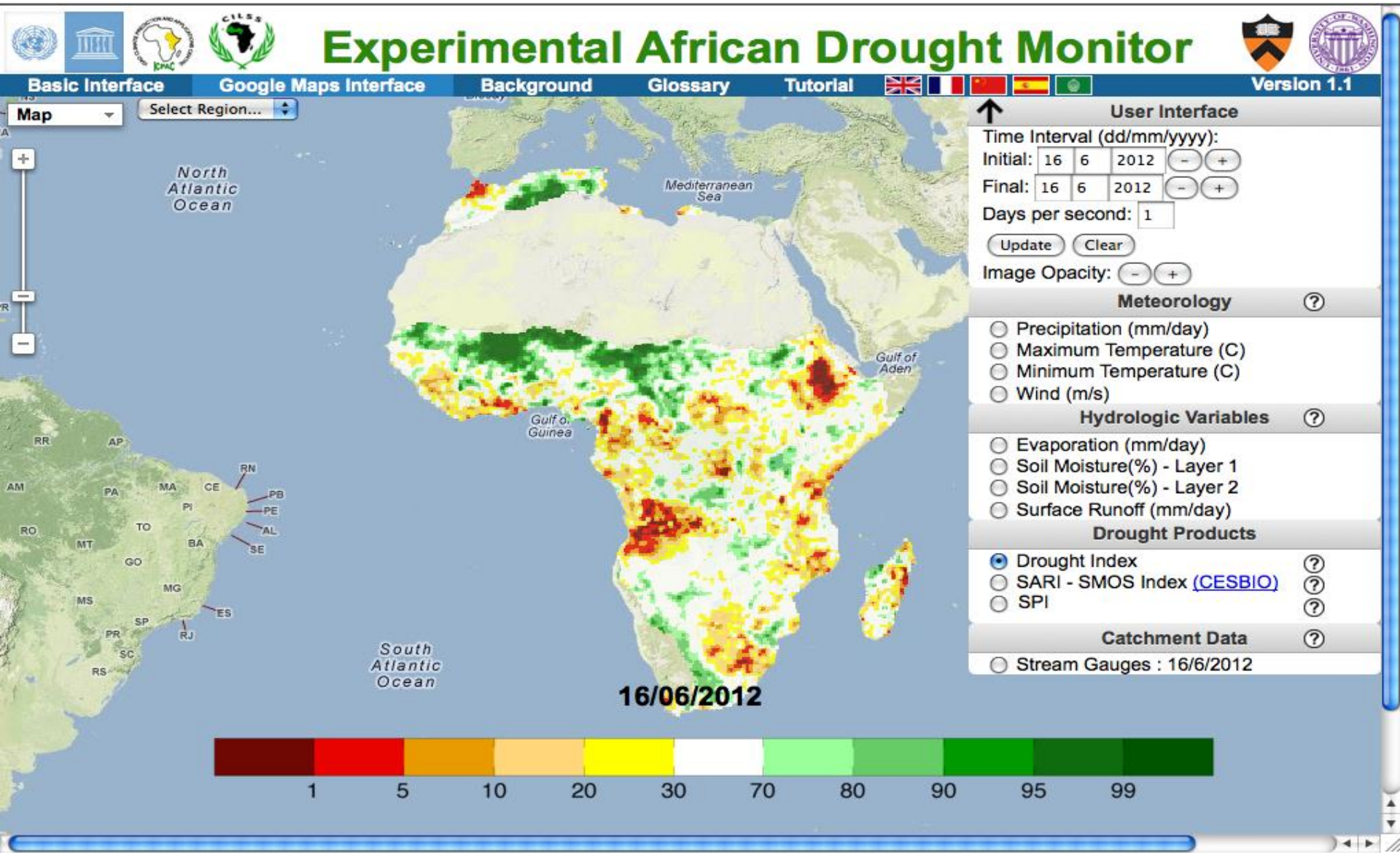
Simulated Discharge Products



Standard Precipitation Index (SPI)

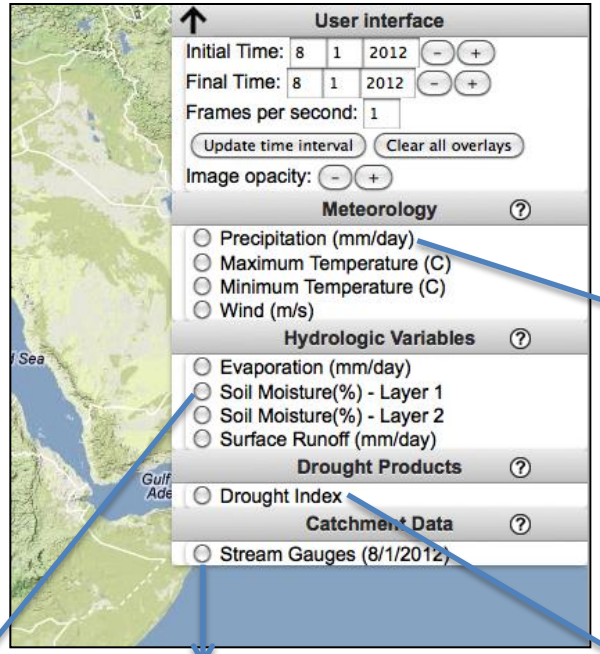
SMOS-SARI Index

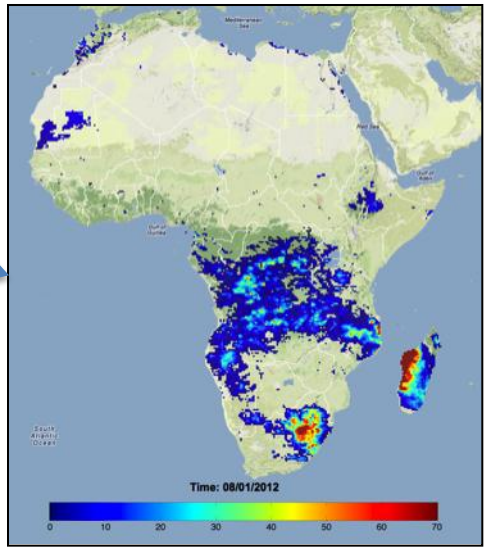
Princeton African Drought Monitor: Interactive User Interface

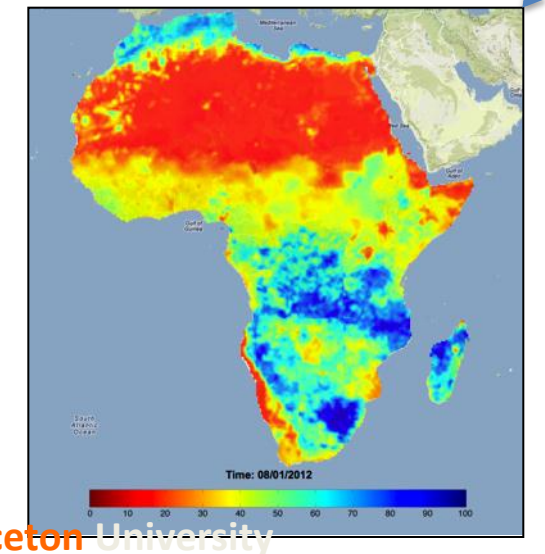


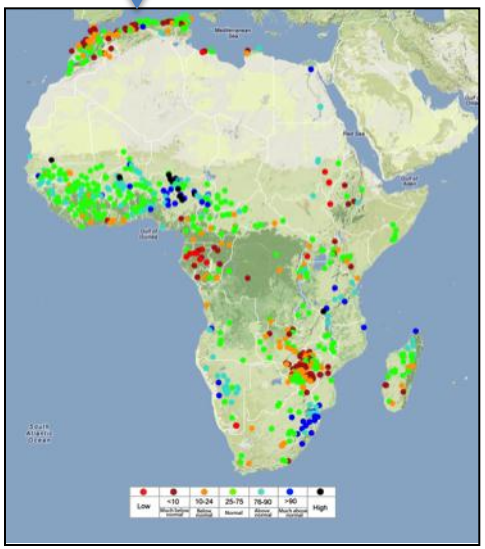
Princeton African Drought Monitor: Interactive User Interface

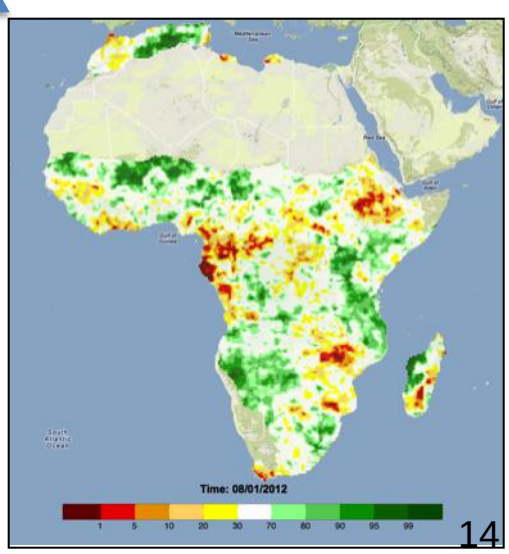
- Animation of hydrologic variables
- Catchment data
  - Over 800+ basins from the GRDC network and FAO Reservoir database.
- User control is enhanced.
- Overlay basin maps
- Zoom in to regions of interest
- Access data record from 1950 – present.



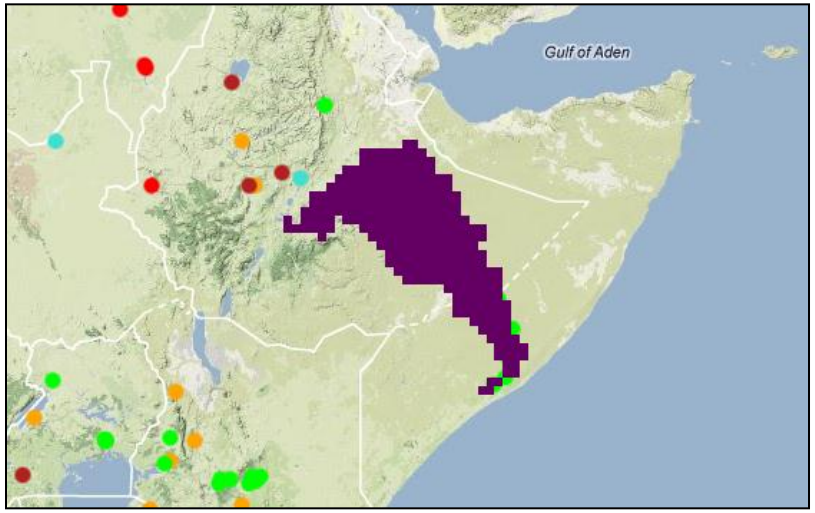


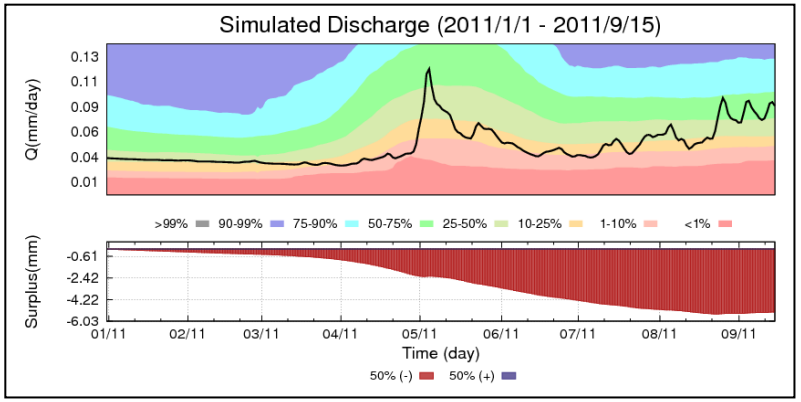


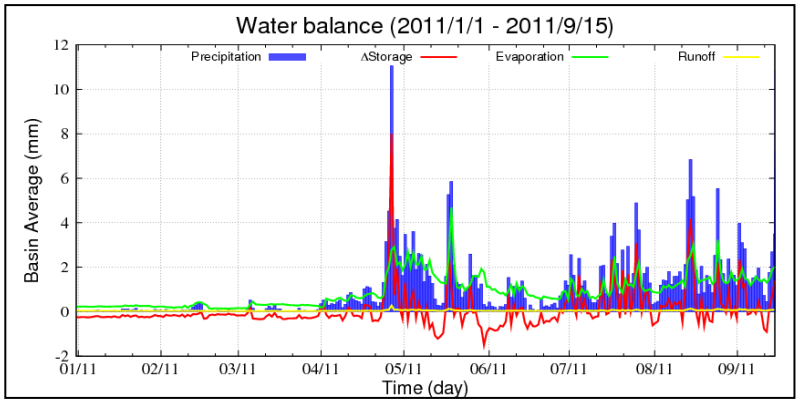


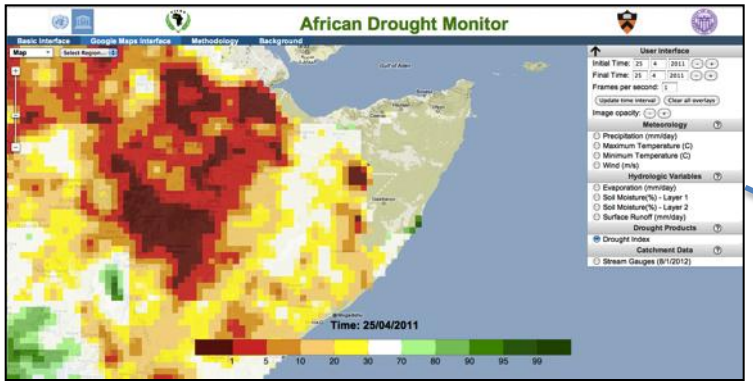


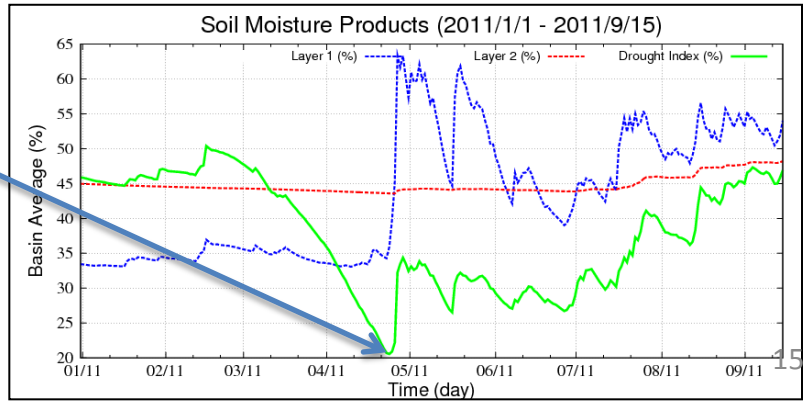
Horn of Africa (2011) - Shebelle River



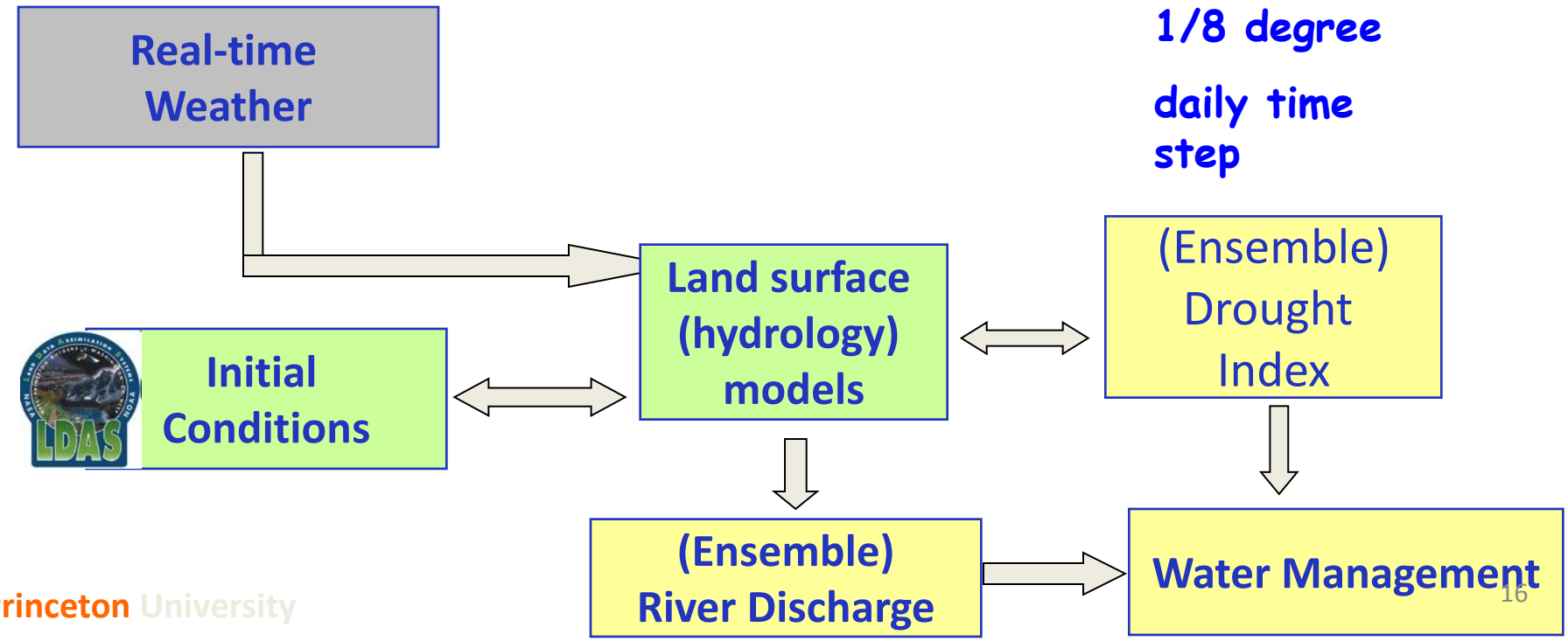




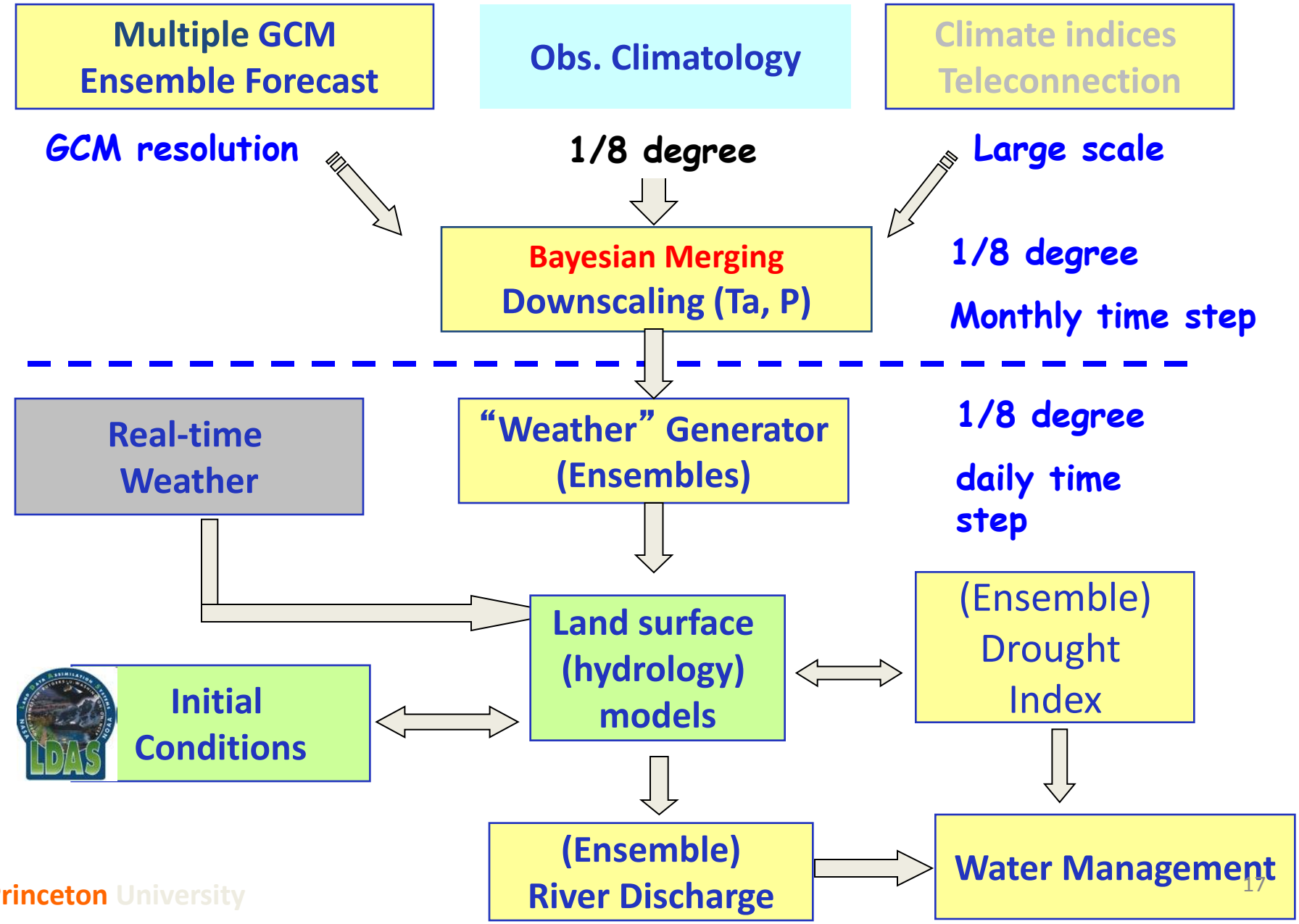




Real-time Monitoring System

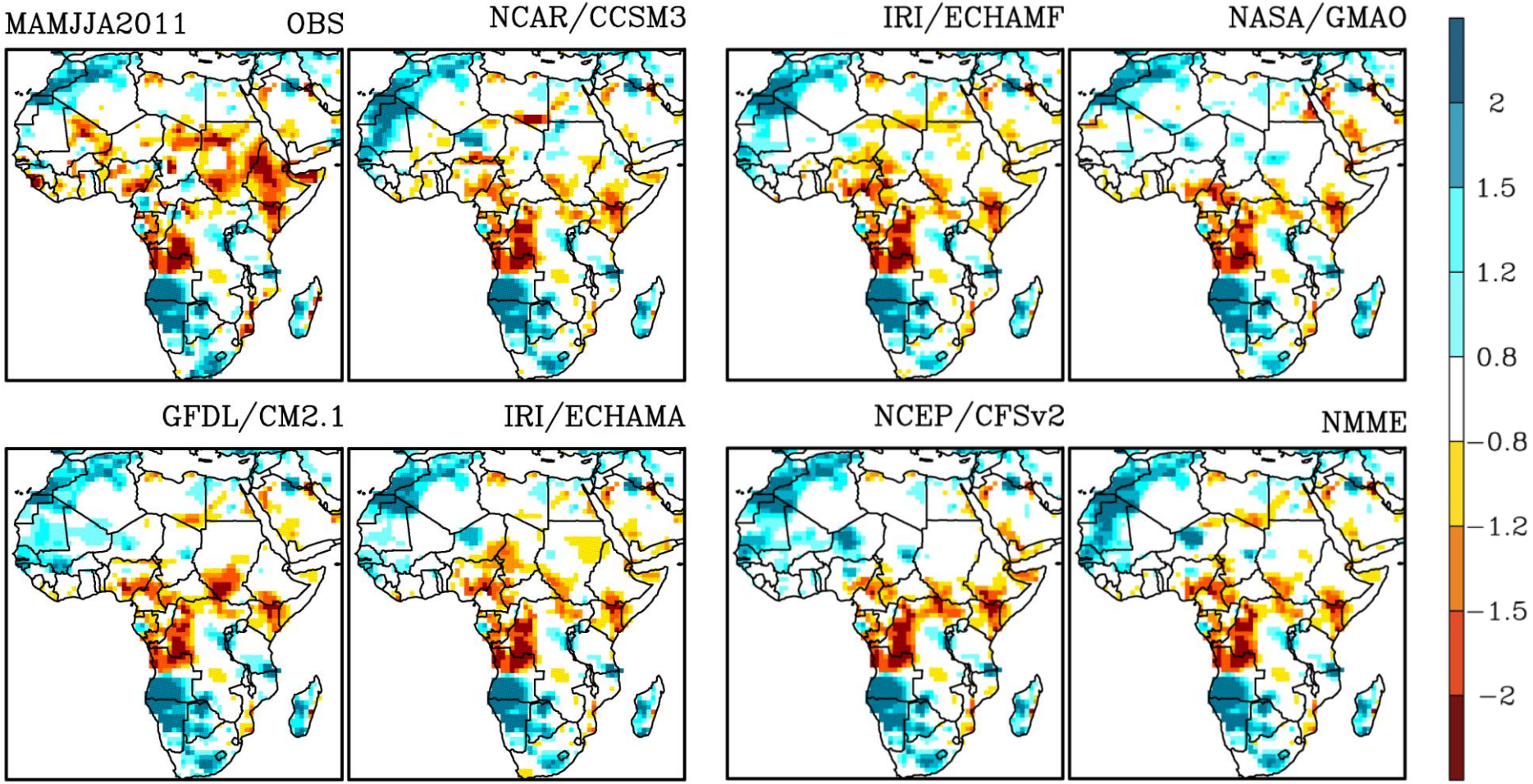


Real-time Monitoring and Seasonal Prediction System



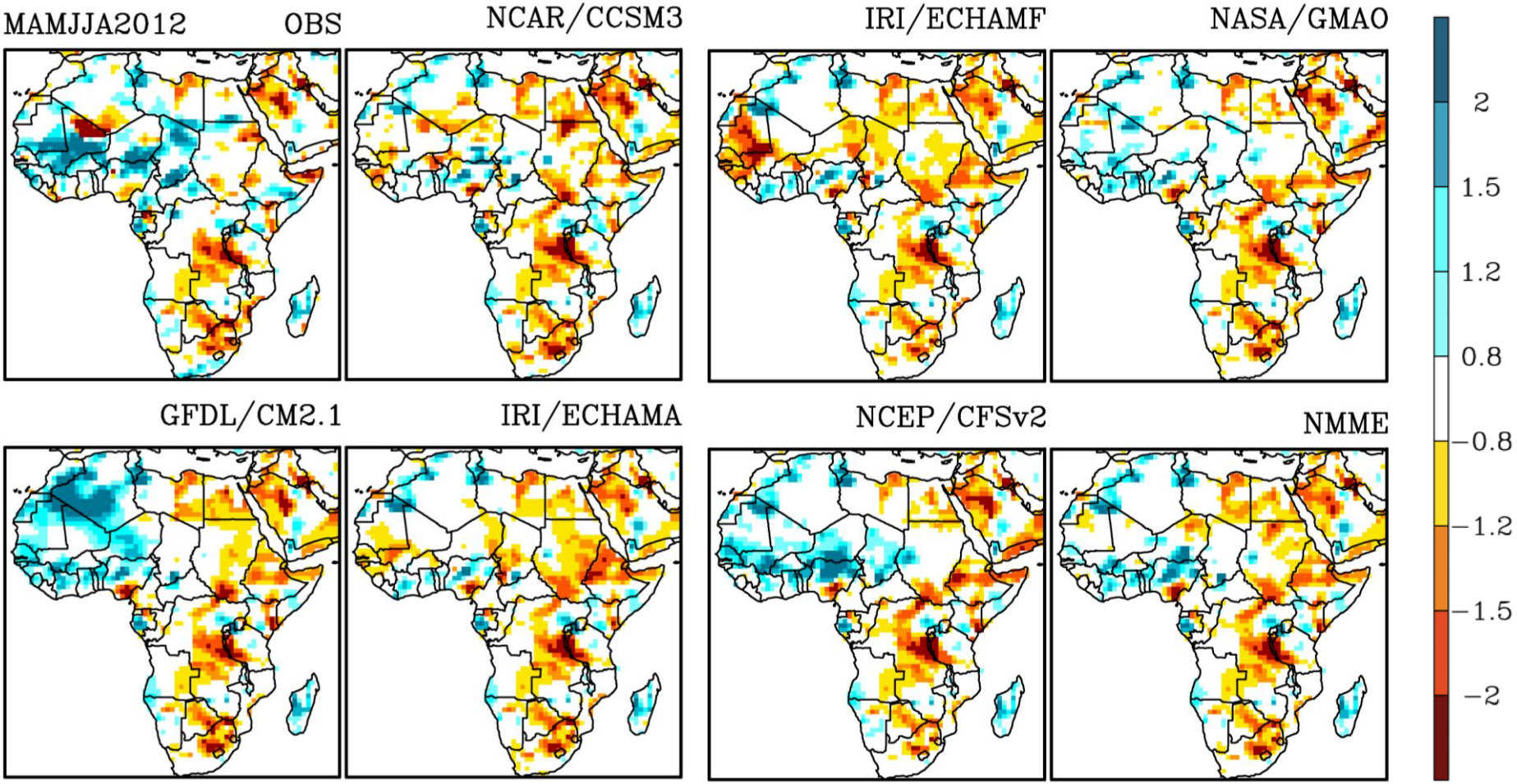
Seasonal Forecasting – Some initial Products

SPI6 for MAMJJA, 2011



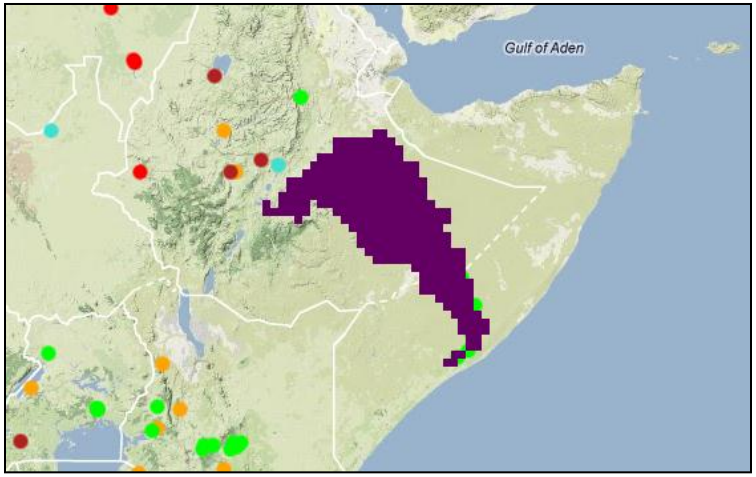
Seasonal Forecasting – Some initial Products

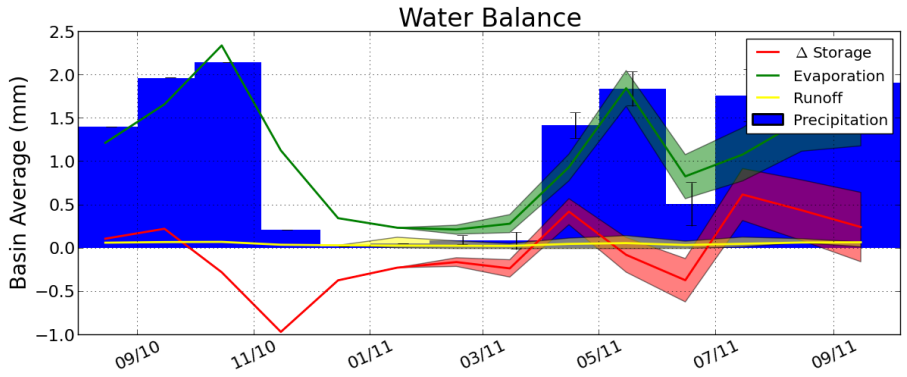
SPI6 for MAMJJA, 2012

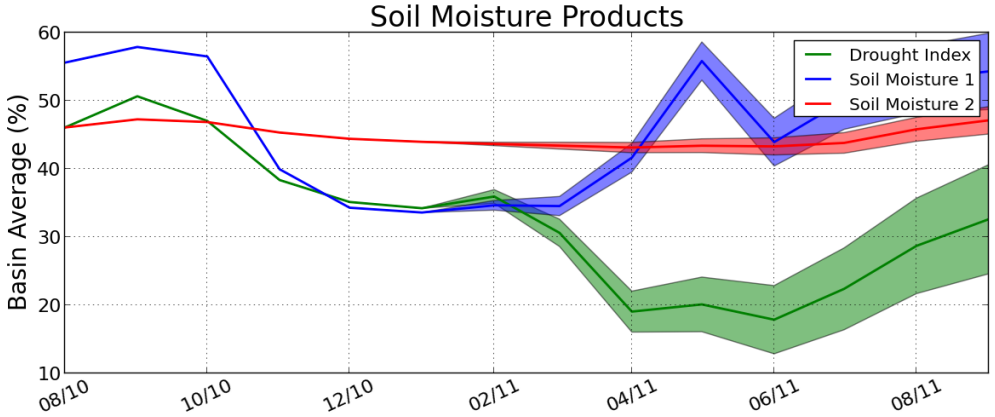


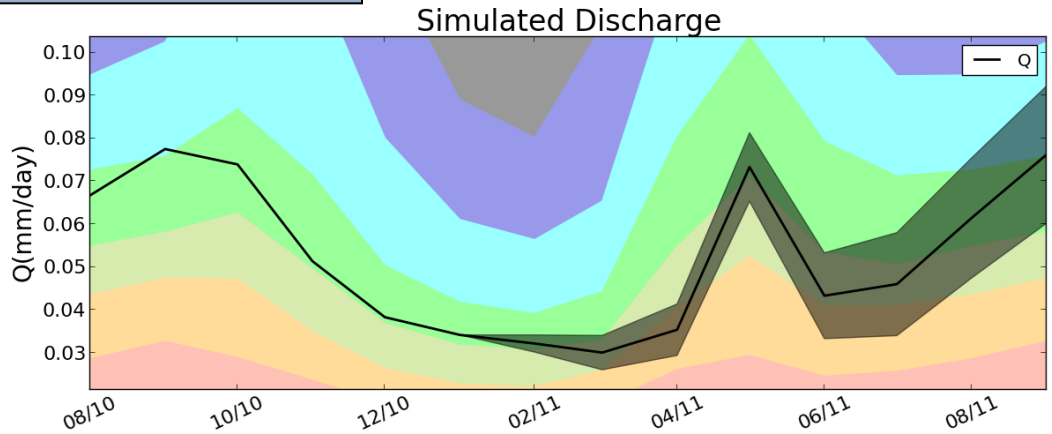
Hydrological Seasonal Forecasting for the Monitor

- Goal: Portray seasonal forecasting information for individual catchments.
- Example: Shebelle River - 2011 Horn of Africa drought.









Transfer to AGRHYMET (1/2012) and ICPAC (June,2012)

Transfer of drought monitoring systems and information portals to local centers for assimilation of local knowledge/data and with training is critical.

Future Work

- Add a seasonal forecasting component to the monitor (Short-term).
- Assimilate real-time meteorological data into the system at a daily to monthly basis (Short-term).
- Include other remote sensing products including leaf area index, NDVI, evaporation, groundwater (Medium-term).
- Increase accessibility to the monitor's output through the online interface (Medium-term).
- Address concerns of how applicable current hydrologic models are for arid regions (Long-term).
- Increate the spatial resolution and time resolution of the hydrologic model simulations.

- Expand to all global regions (medium term) within the same ADM framework.
- FUNDING – NONE EXISTS


Thank you