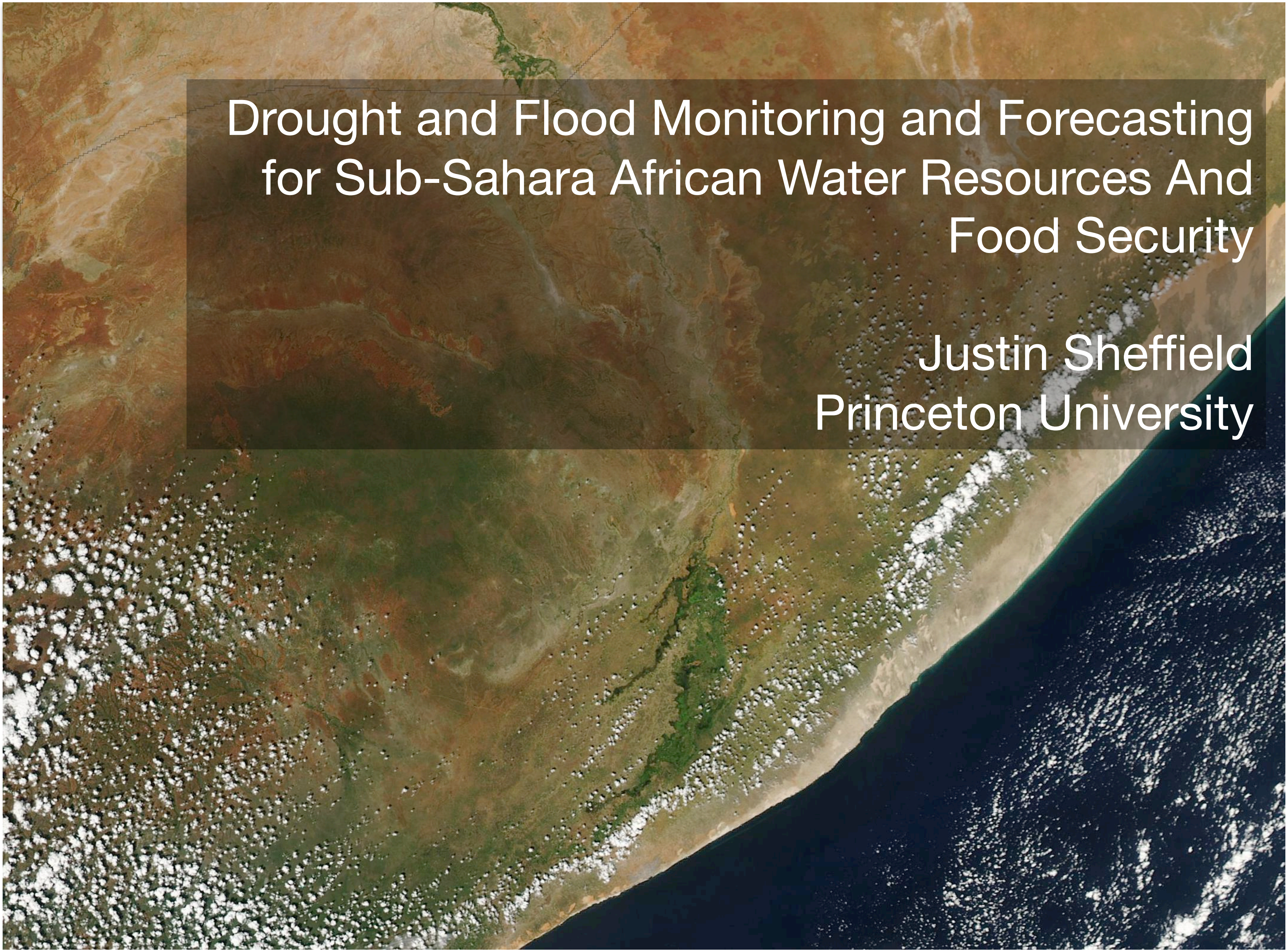
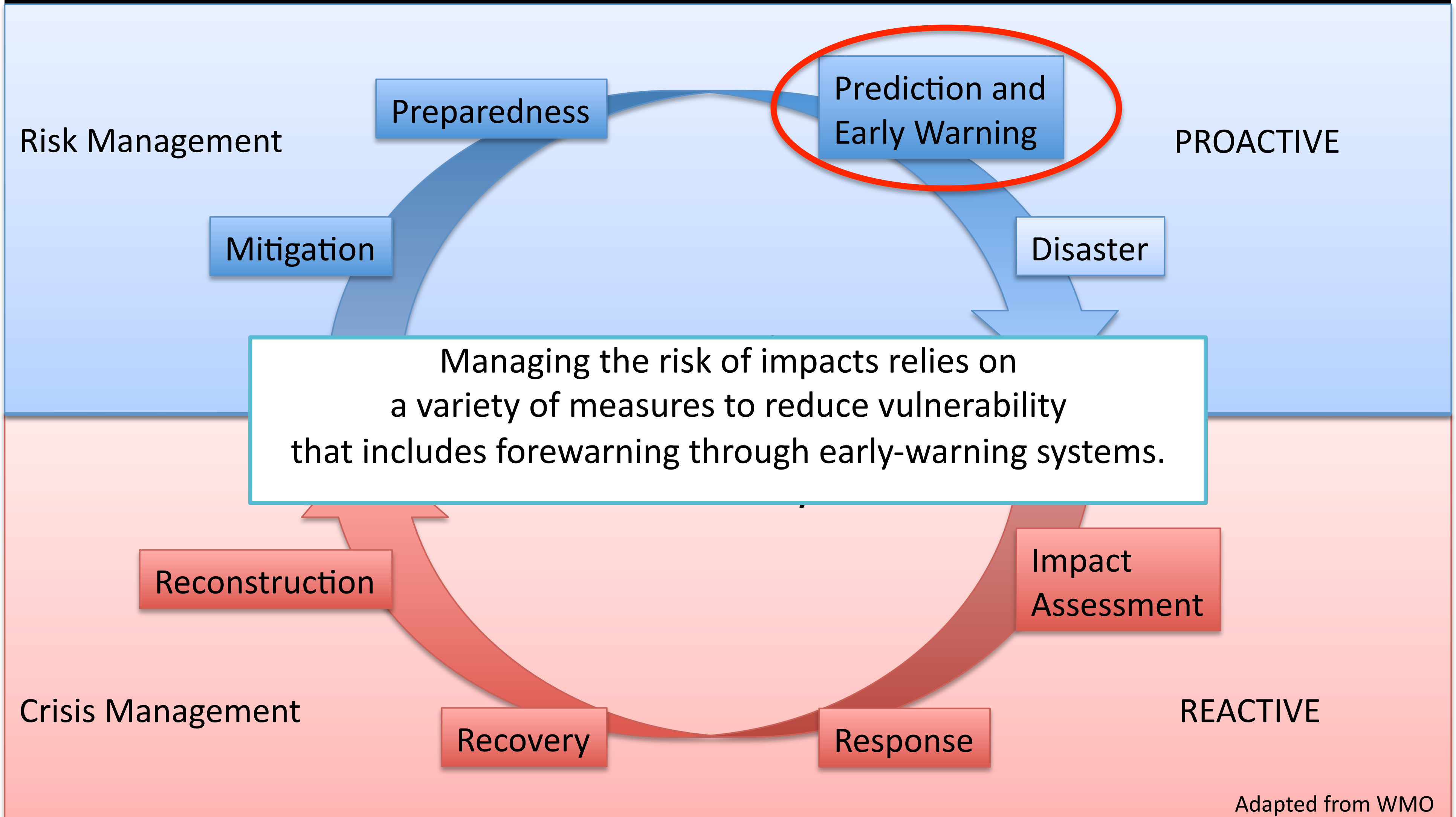


Drought and Flood Monitoring and Forecasting for Sub-Sahara African Water Resources And Food Security

Justin Sheffield
Princeton University

How do we reduce the impacts of drought?



US Federal Emergency Management Agency (FEMA) and other disaster management organizations estimate that for every $1 spent on reducing vulnerability to disaster $4 is saved.

National/Regional Capability for Drought Monitoring

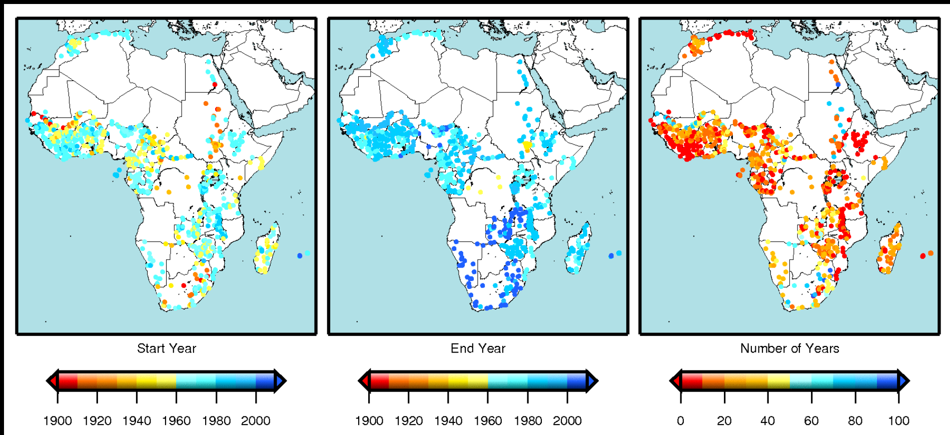
One Conceptual Framework	Level 1 (NADM Model)	Level 2	Level 3
Drought Experts	In-house expertise for monitoring, forecasting, impacts, research, planning, education	Limited in-house expertise	Rely on external expertise
National Climate Observing Network	Extensive data networks, near-real time daily observations	Limited networks (spatial density and/or timeliness)	Rely on national CLIMAT/ WWW reports and external observations (e.g., satellite obs & global models)
National Drought Assessments	National Drought Monitor already routinely produced timely (monthly or more frequently)	National assessments produced to support regional/continental monitoring	Rely on external expertise to produce national assessments
International Data Exchange	Station data exchanged for creation of regional or continental standardized indicators	Limited data exchanged internationally	Only CLIMAT or WWW data exchanged internationally
International Collaboration	National experts collaborate to create regional or continental Drought Monitor	Some national input to regional or continental Drought Monitor	Rely on external experts to produce national assessment for regional/ continental Monitor
IT Infrastructure	ArcGIS, web, email	Limited ArcGIS, web, and/or email access	No IT infrastructure, rely on alternatives

→ Decreasing capability

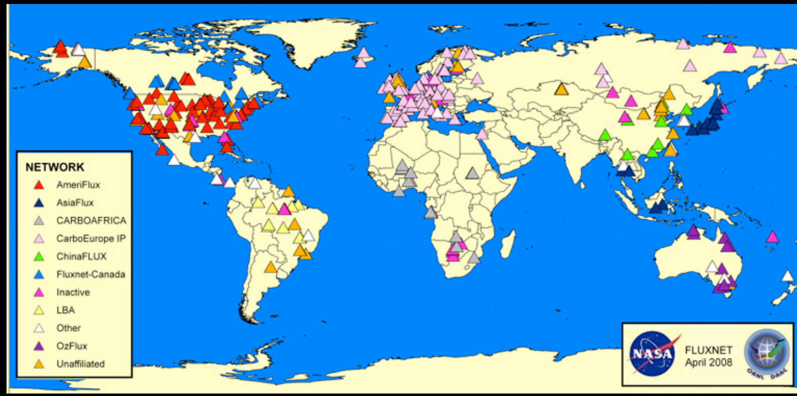
Slide from Richard Heim, NCDC, US

Real-time hydrological monitoring is sparse in Africa

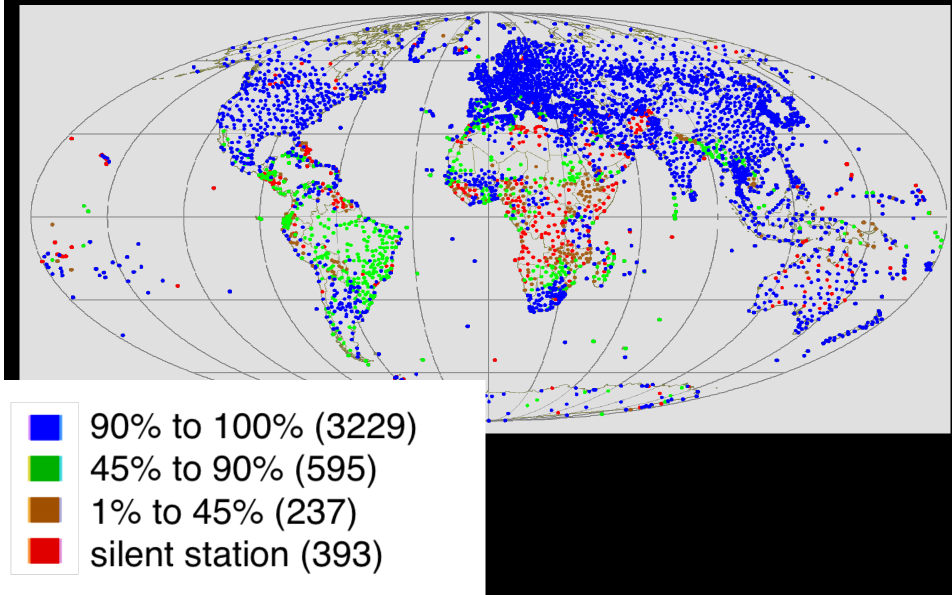
GRDC Streamflow Records



Fluxnet



WMO Real-Time Gauges

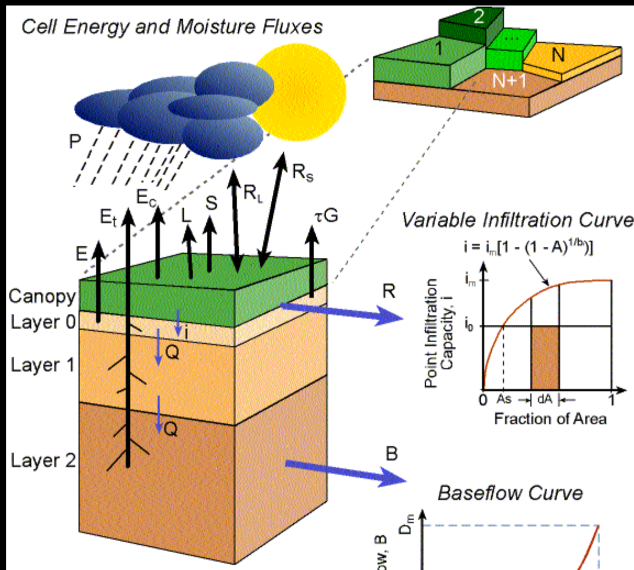


AMMA Network 2006-2011

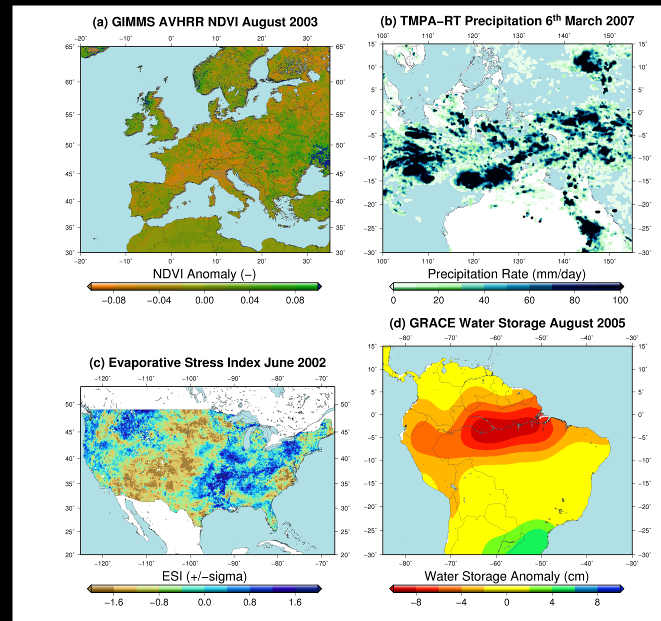
CARBOAFRICA Network 2002-2010

Data and Tools for Drought Monitoring and Prediction

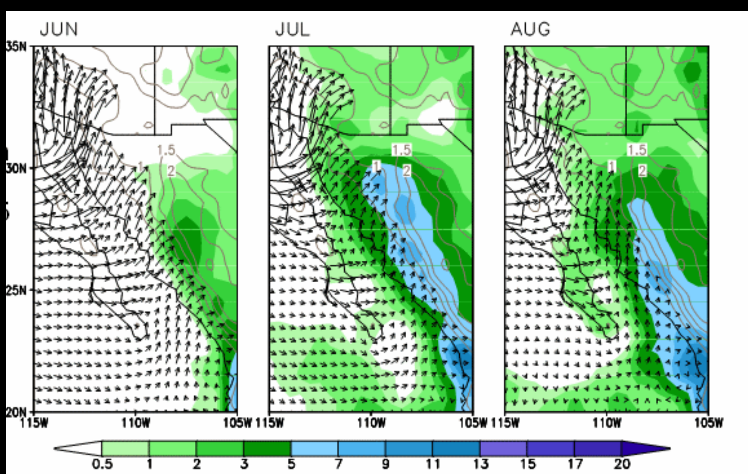
Hydrological Modeling



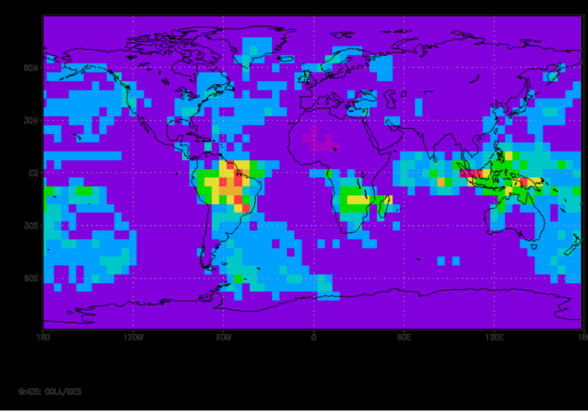
Satellite Remote Sensing



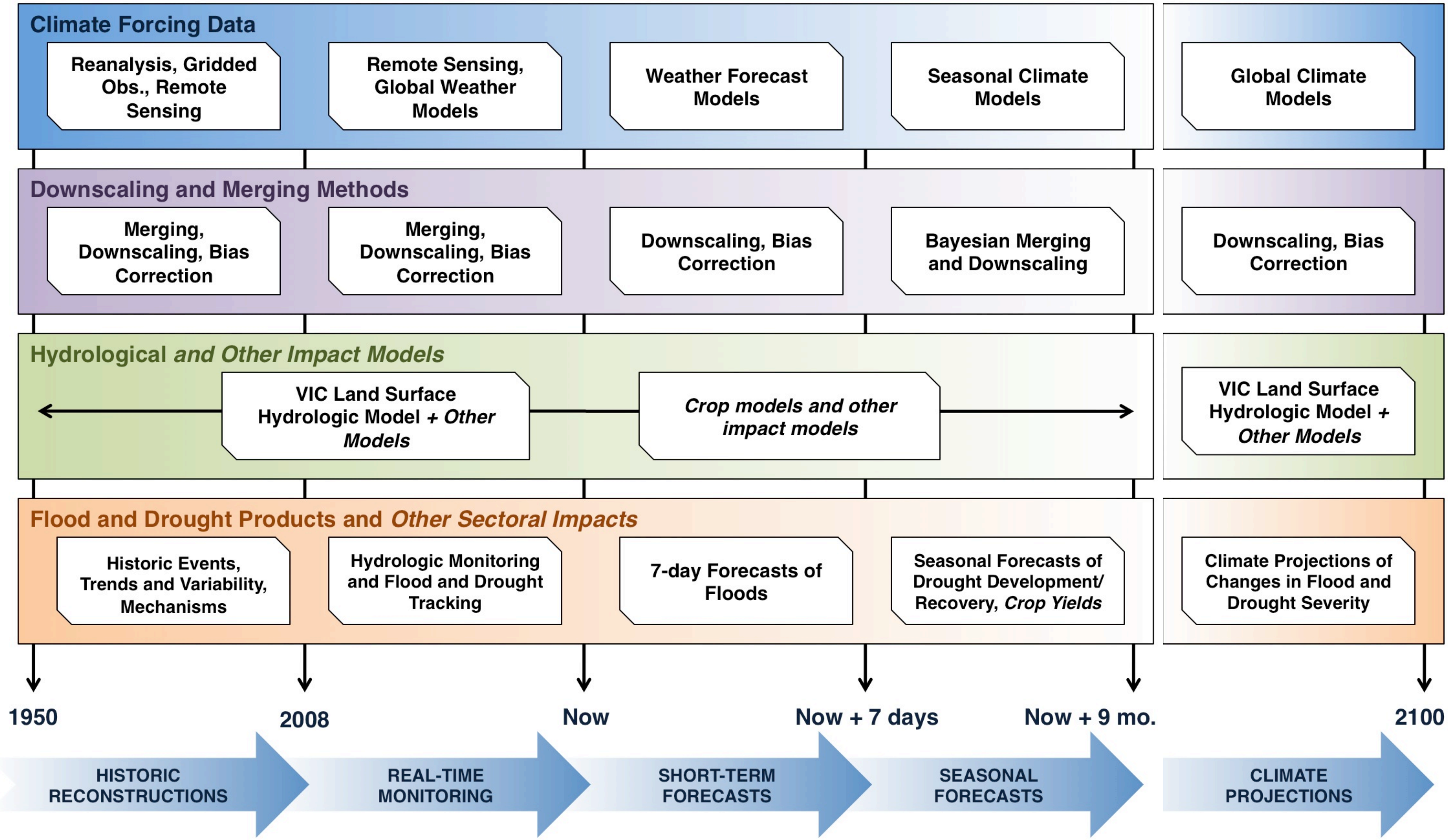
Reanalysis, Analysis



Regional/Global Climate Models, Statistical Prediction

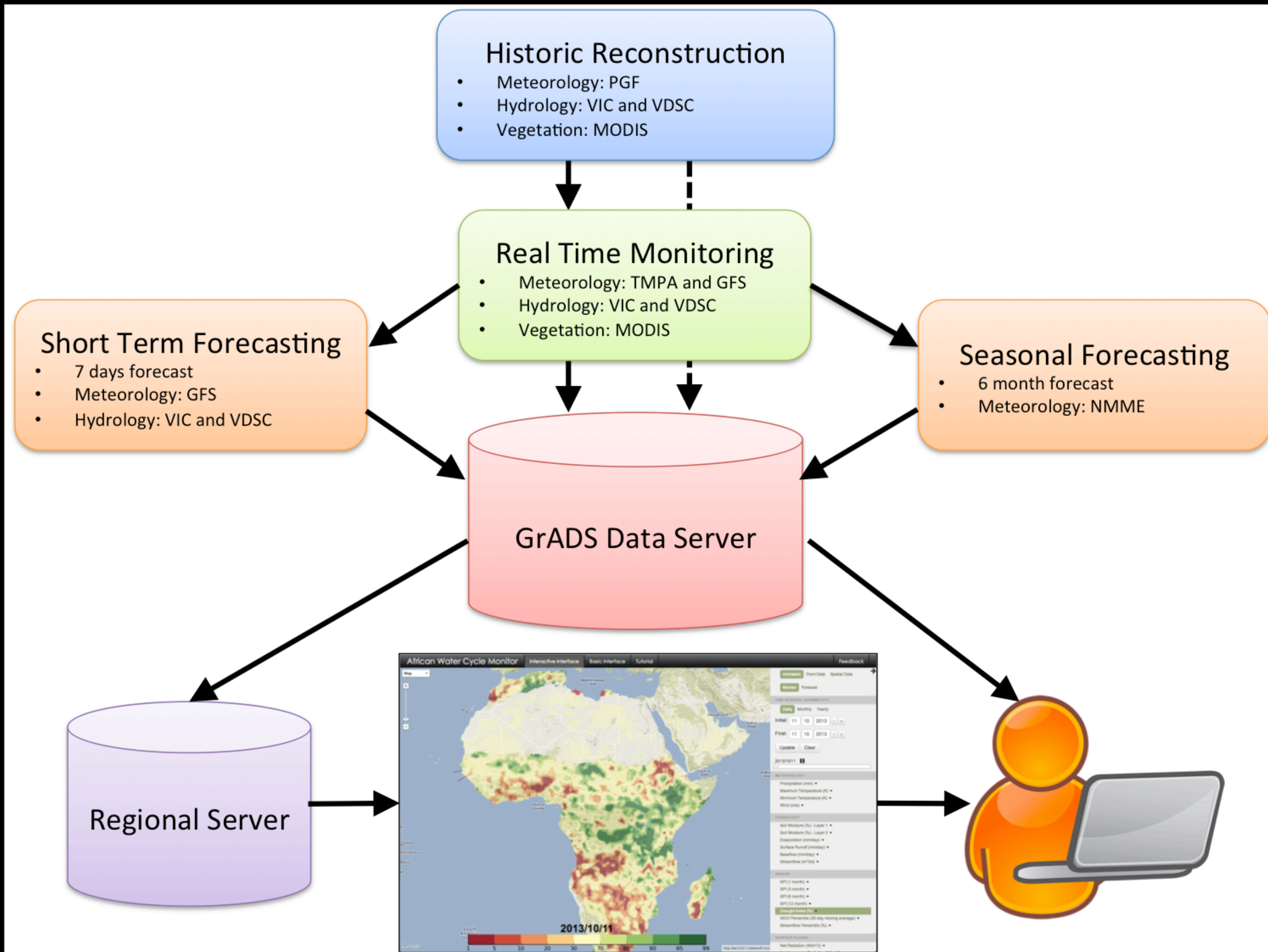


Bringing it all together: A Seamless Monitoring and Prediction Framework Across Time Scales

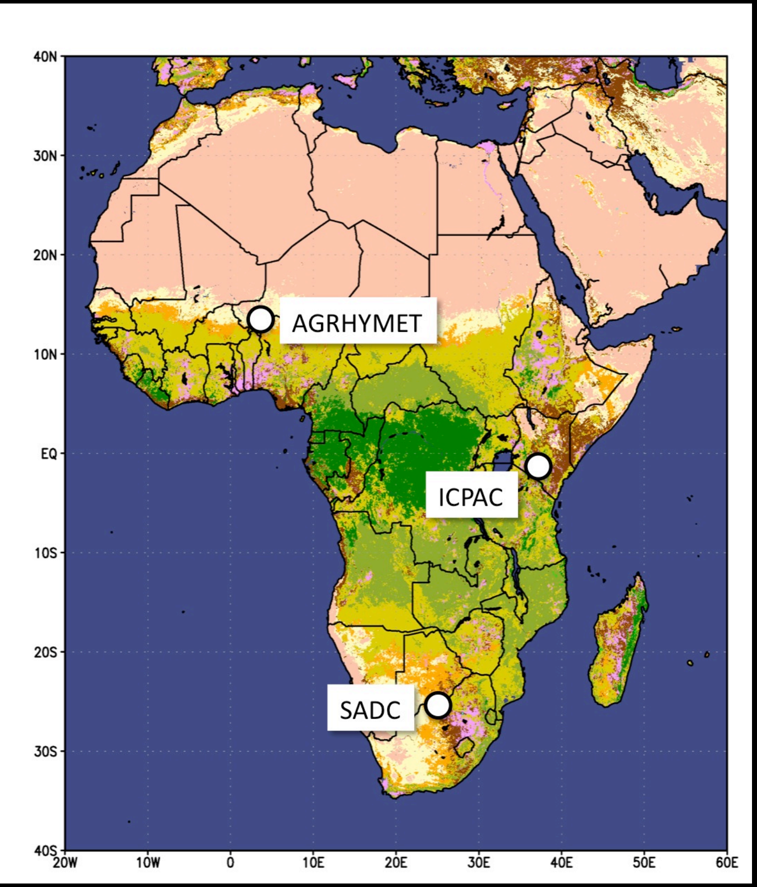


Sheffield, J., et al., 2014; A drought monitoring and forecasting system for sub-Sahara African water resources and food security. *Bull. Am. Met. Soc.*

Technical Framework of the System



We have implemented the system at African Regional Centers

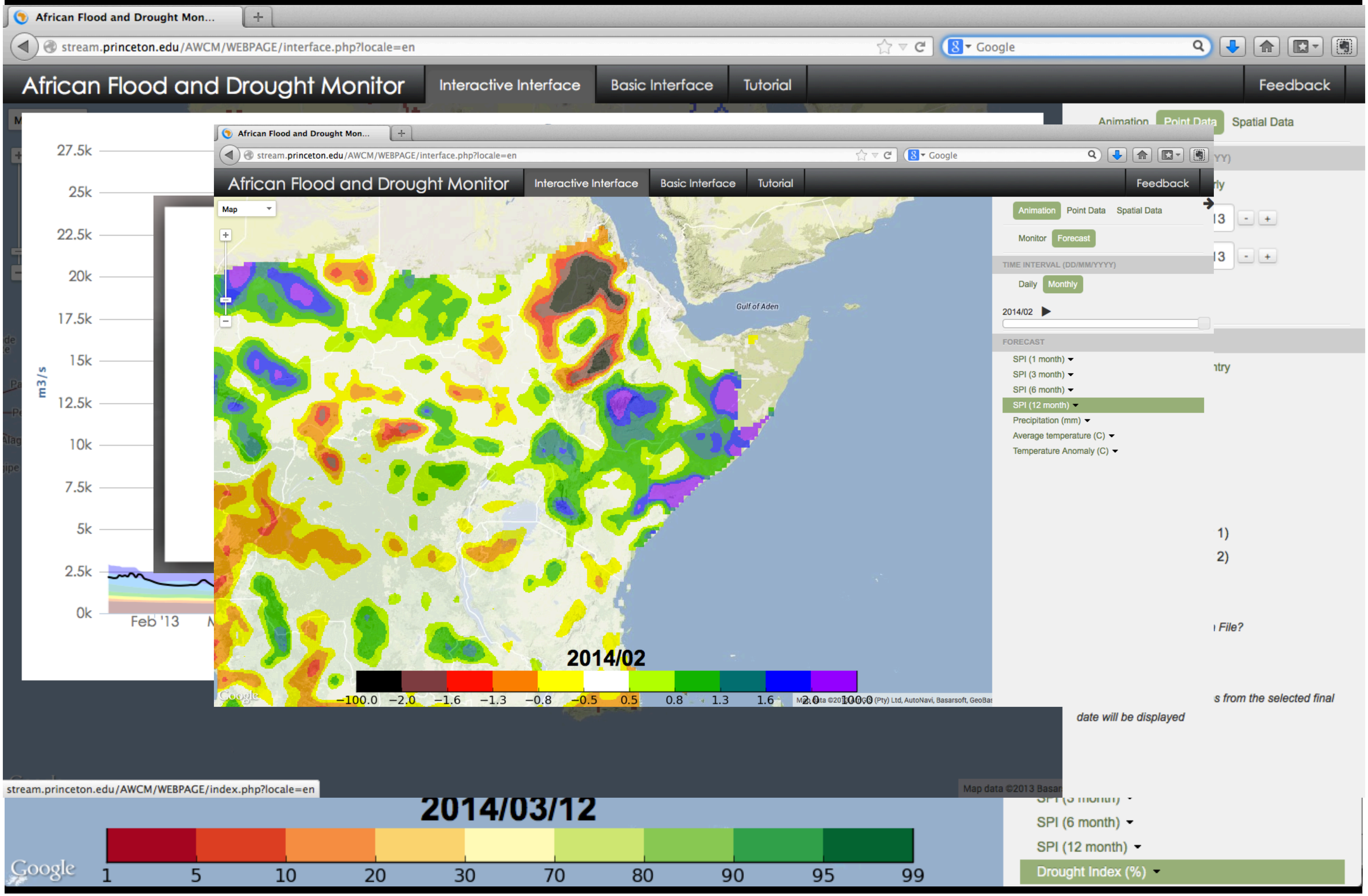


Goals:

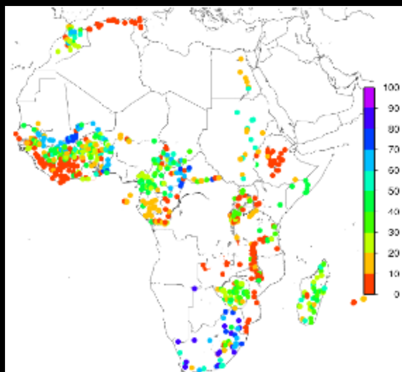
- Adapt the monitoring system to the region.
- Improve data dissemination, knowledge exchange
- Provide training and allow for feedback (participatory exercises)
- Followed by validation plans, operational evaluations, exchange visits, …

African Flood and Drought Monitoring (AFDM) System

http://hydrology.princeton.edu/adm

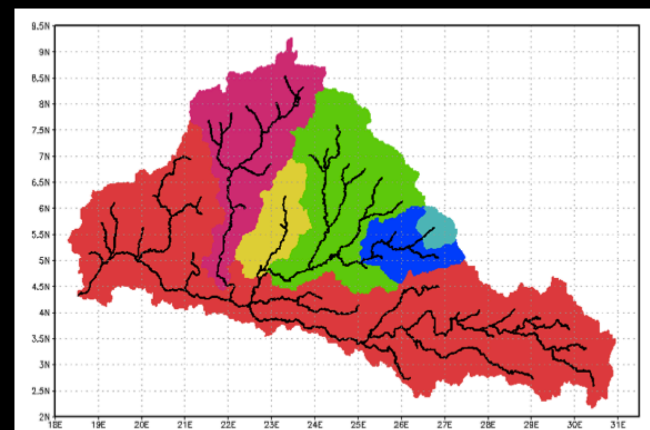


Strategy for Parameter Estimation

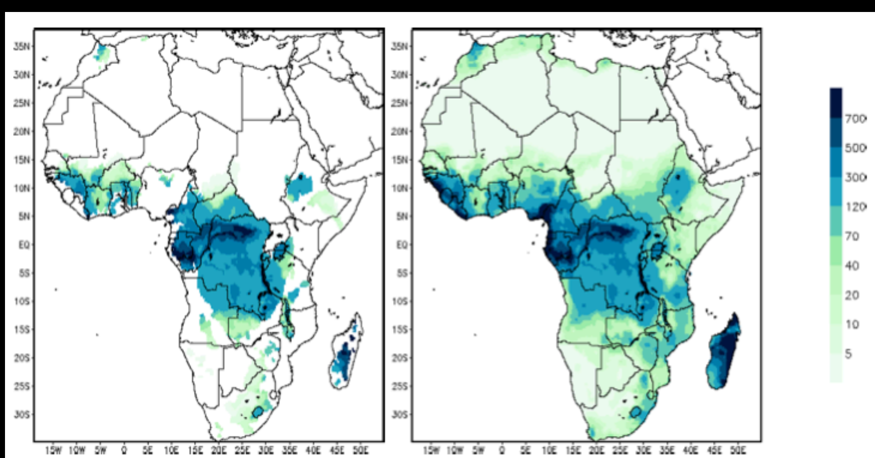


a) 966 GRDC gauges. Remove gauges with upstream dams and short records – 600 gauges

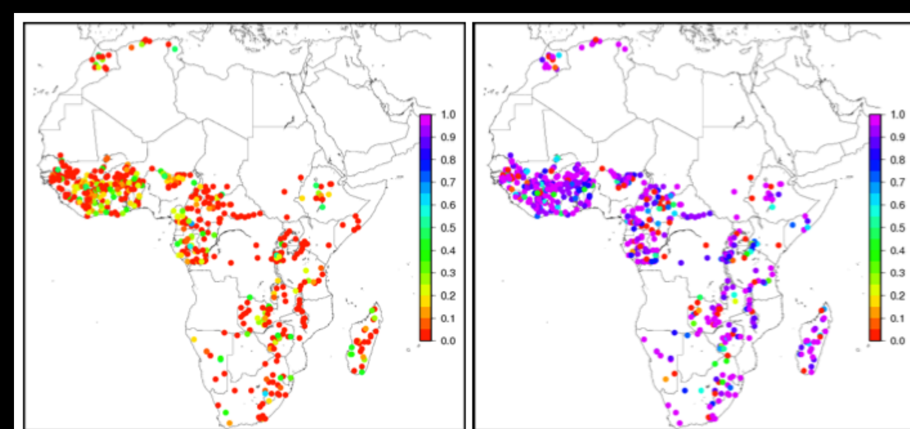
b) Disaggregate observed gauge records to runoff fields by scaling runoff fields from a baseline model run to match observations when routed



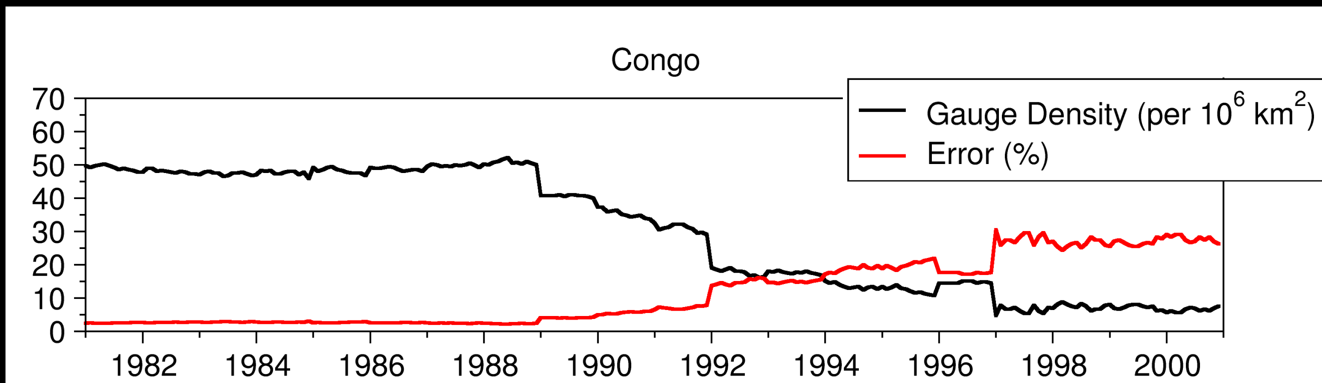
c) Interpolate to whole continent based on runoff ratios and calibrate model at each grid cell



Median NSE:
-0.0363 (baseline), 0.930 (scaled)

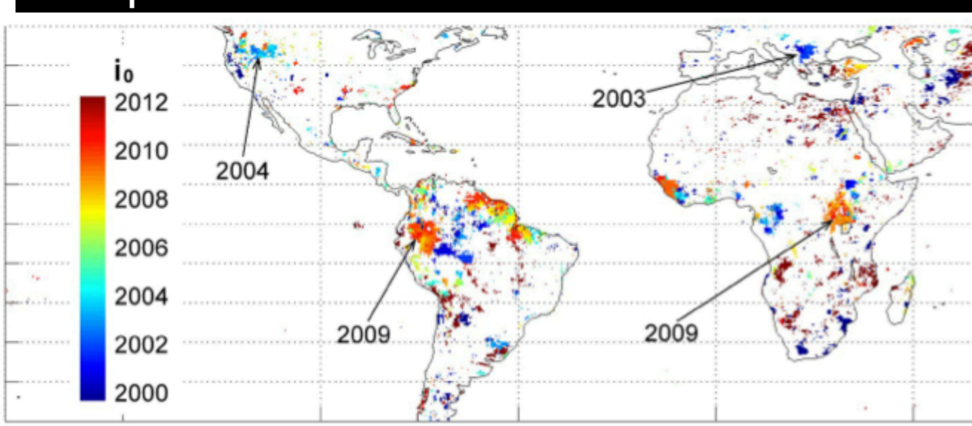


Gridded gauge rainfall products have problems; Satellite precipitation has systematic and random errors

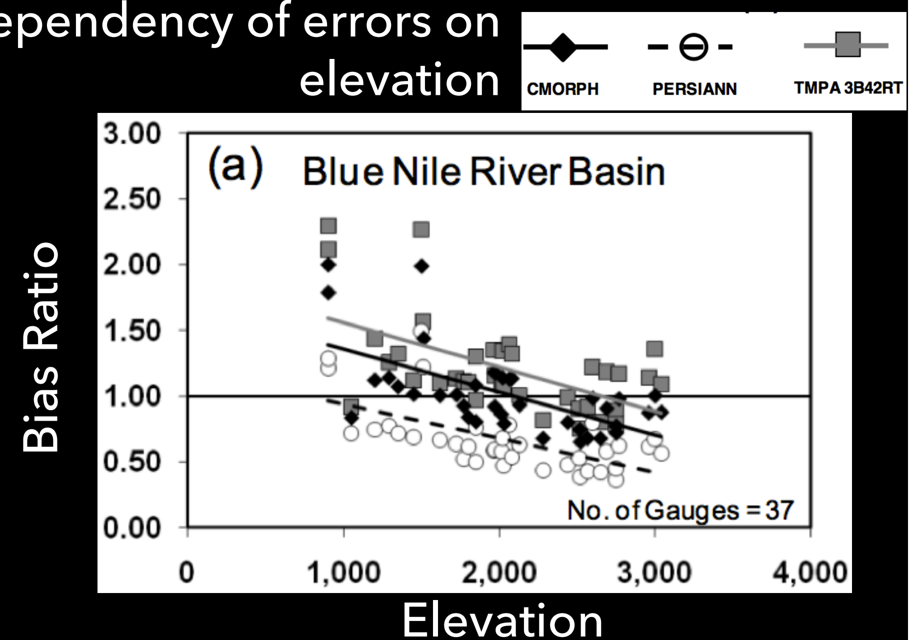


e.g. uncertainties in basin average precipitation can be large and vary over time

Time at which there is a detectable shift between the TMPA satellite research (gauge-corrected) product and the real-time product.



Dependency of errors on elevation

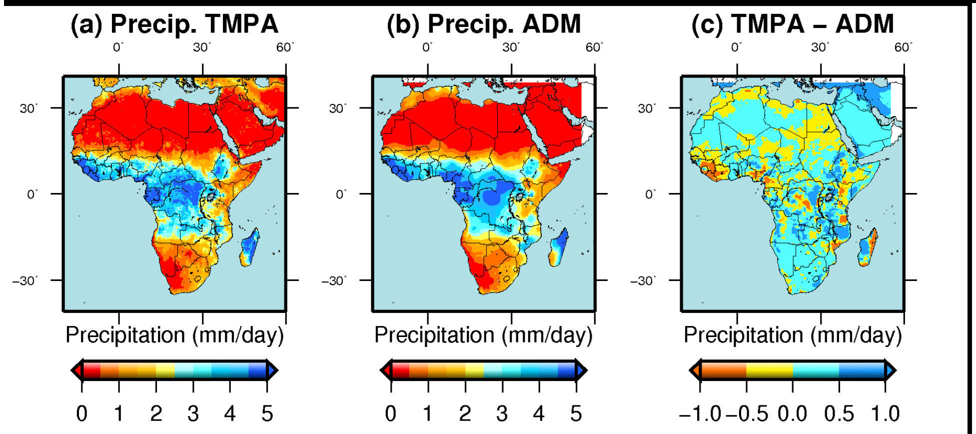


Lettenmaier et al., 2013

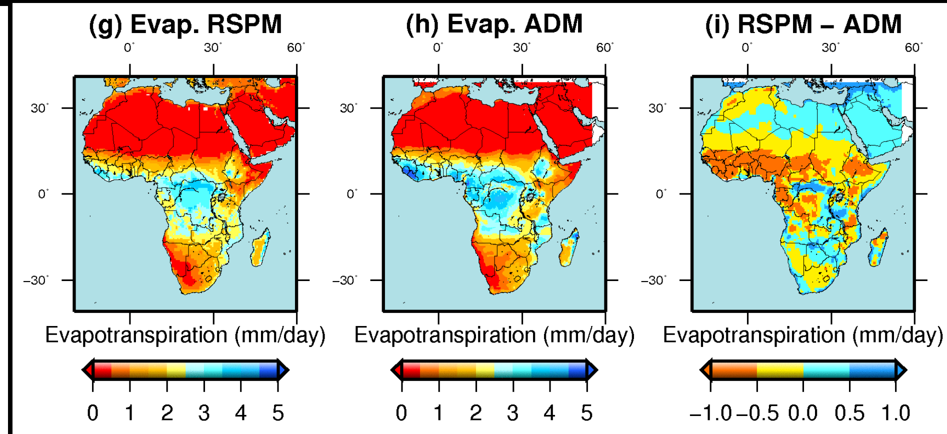
Romilly and Gebremichael, 2011

Validation – Continental Scale

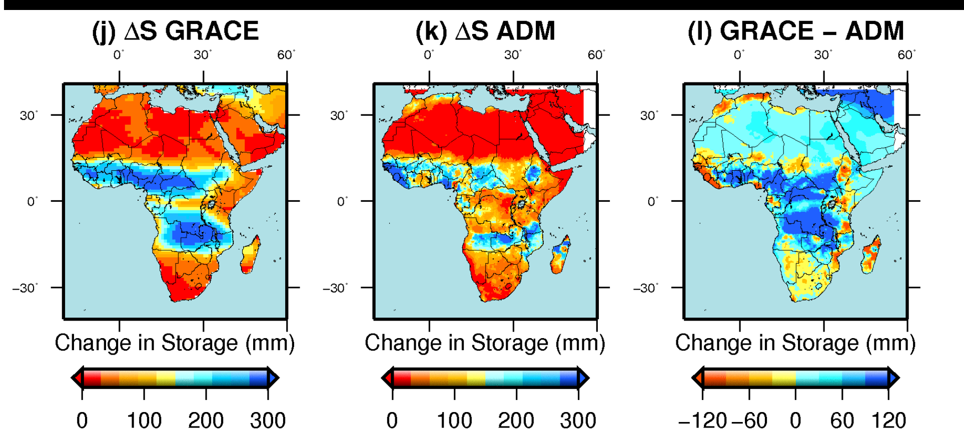
Precipitation



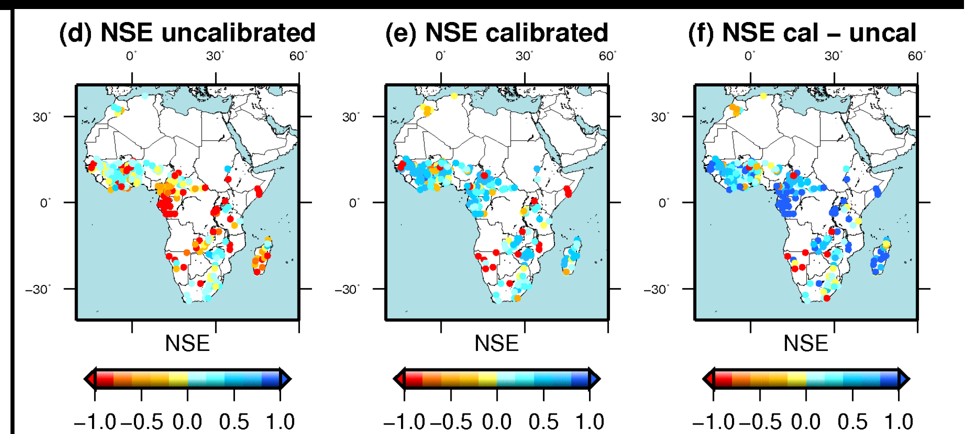
Evapotranspiration



Change in Seasonal Water Storage



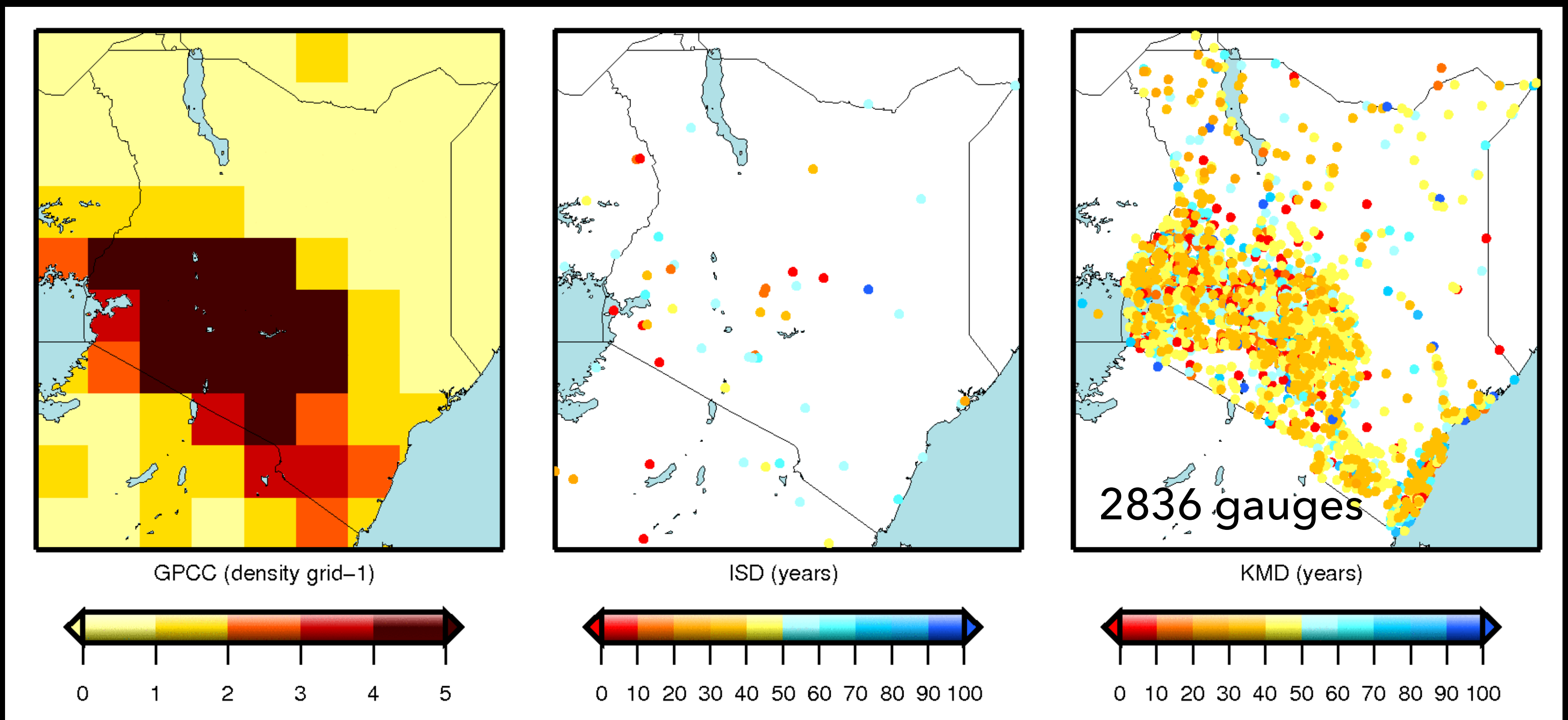
Streamflow



Validation at Local Scales

Global precipitation datasets rely on a handful of gauges but many more are potentially available

GPCC Global Gridded Product   Integrated Surface Database   Kenyan Met Dept.

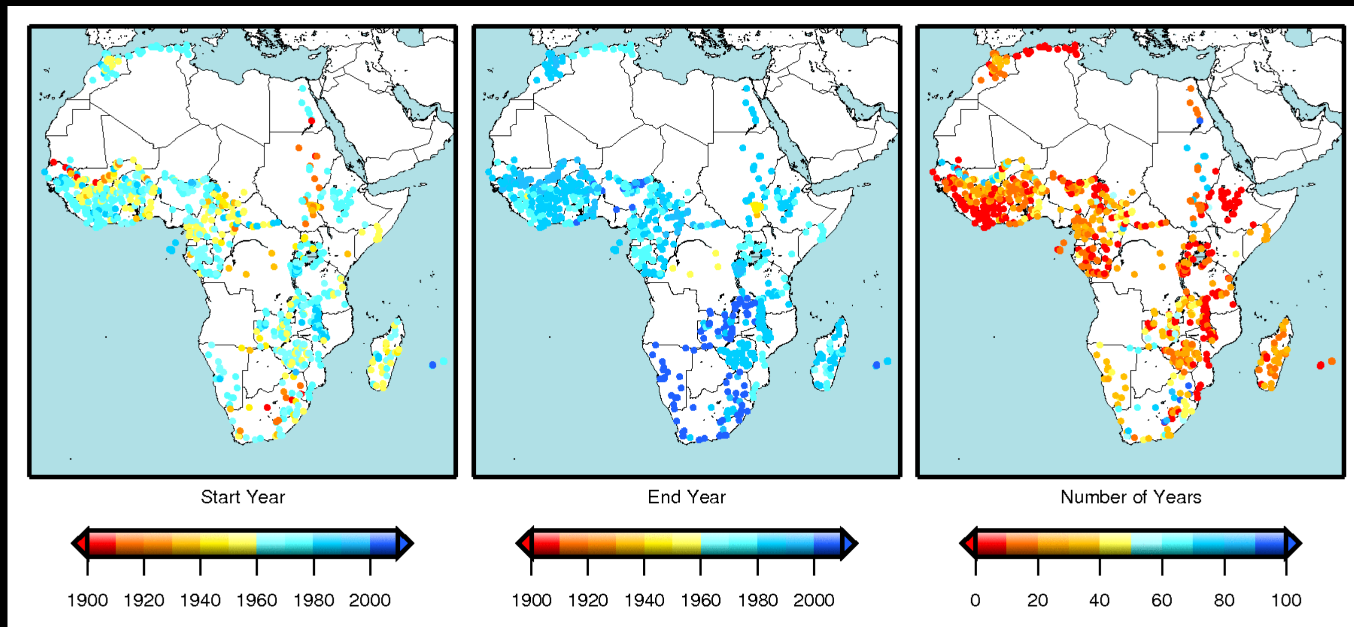


Estimated errors in P due to sampling
5 gauges per 1-degree box → ~5%
2 gauges per 1-degree box → ~20%

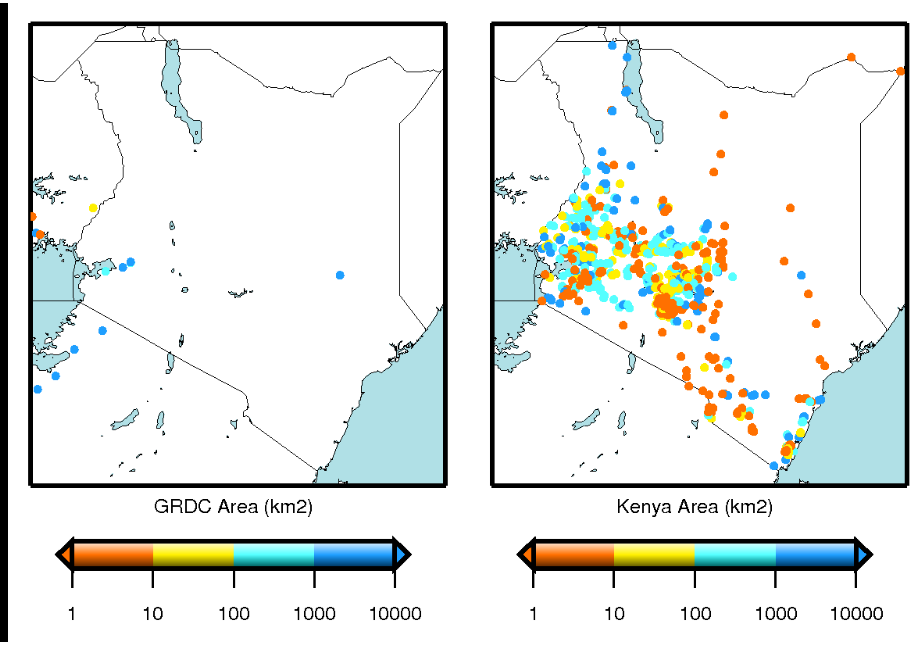
Caveats: many pentad records on paper; often not real time; perhaps the best case scenario in Africa

Publicly available streamflow data is minimal in some countries, but data do exist

GRDC open database



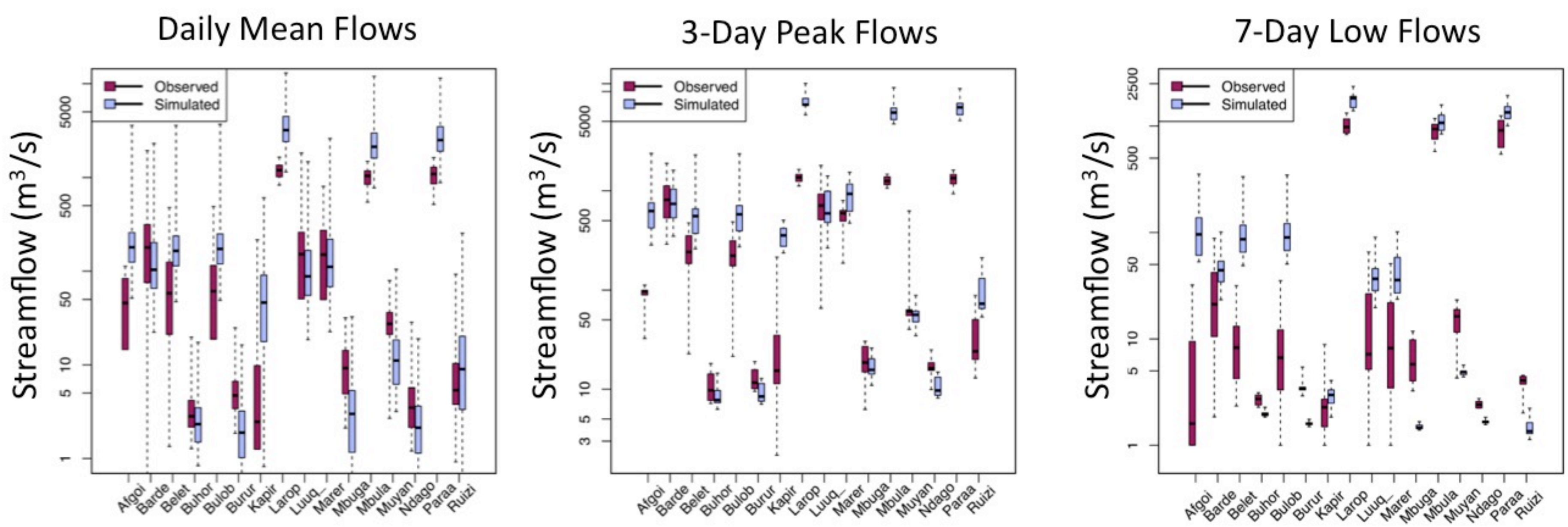
GRDC open database: 4 gauges in Kenya



Kenyan Ministry of Water
~ 850 gauges

Validation – Local Scale and User Driven

- ~40 sites across Greater Horn of Africa
- 100 to 150,000 km^2



Some Big Challenges

1. Identifying and developing new sources of observational data

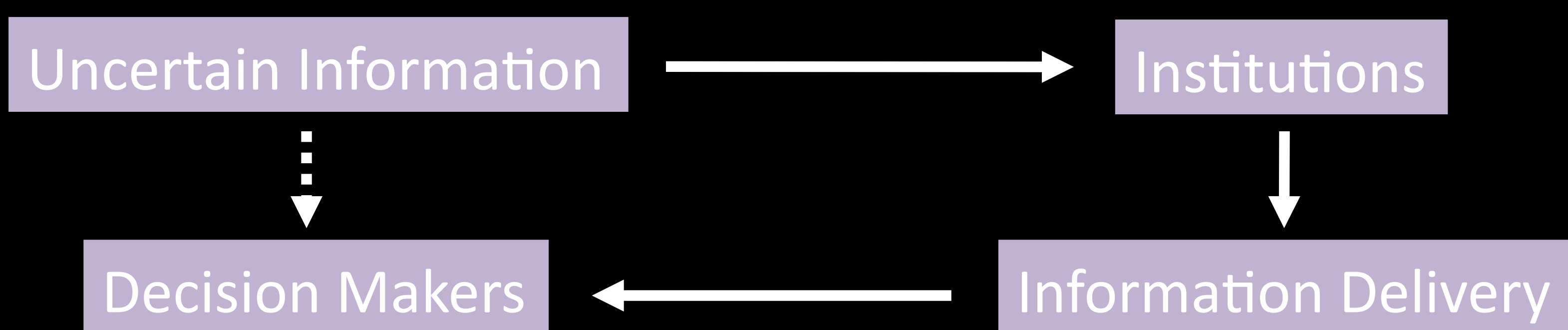
2. Carrying out local scale evaluations

3. Improving modeled processes to enhance real-time monitoring and forecast initialization

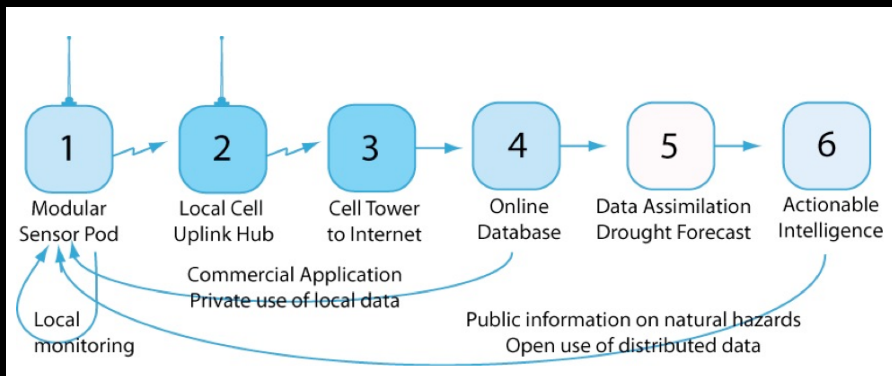
4. Improving forecast skill at time and space scales relevant for decision making

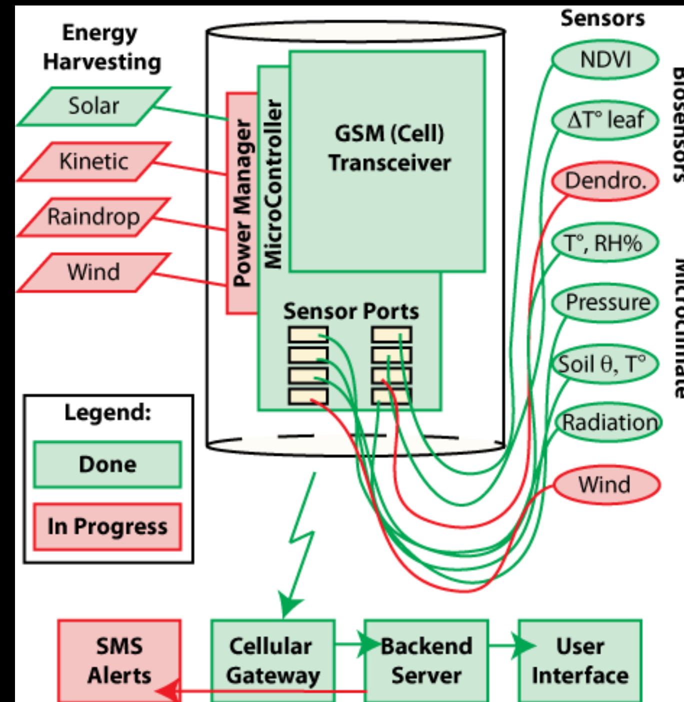
5. Understanding the utility of climate/drought information to
(i) inform policy making at national scales and
(ii) improve rural agricultural decision making

6. Transferring knowledge/technology to universities and practitioners for sustainable solutions to achieving water and food security, and improve livelihoods for mitigation and improved resilience



Overcoming the Lack of Observations: Potential of Low-Cost Environmental Sensors Communicating over the Cell Network





There's a large and rapidly growing cellphone network in sub-Saharan Africa

The infrastructure is maintained by private sector and is ubiquitous in populated areas