Elements of a Global Drought Information System and Early Warning Framework

Will Pozzi

The Future?

Lower Colorado River Authority (LCRA) during Texas Drought

Overview of Talk Subjects

1. Language of the 2010-2015 Work Plan and what has been realized.
2. International Partnerships have sustained capacity building and development of the Global Drought Information System
3. Global Drought *Information System*—linkages to the Global Earth Observation System of Systems Common Infrastructure
4. Global Floods Monitoring and Forecasting

WHAT HAS BEEN ACCOMPLISHED BY WA-01-C2 BY THE END OF THE 2010-2015 WORK PLAN?

Language actually contained in 2010-2015 Work Plan

- **Priority Actions**
- Construct a global, multi-model and multi-ensemble flood and drought information platform to assemble existing sources of real-time flood and drought information (forecasts and observations), while providing a common risk-management framework for early warning and risk management. Build upon the European Floods Alert System (EFAS) and ongoing end-to-end projects (see DI-01), as appropriate
- Establish a global drought observing system to correct errors in precipitation, soil moisture, evapotranspiration, and terrestrial water-storage change derived from land-surface/hydrological models
- Establish a global drought monitor to link together continental and regional drought monitoring efforts and produce a web-based, real-time, geographic information system. Develop a regional drought impacts monitor to assess drought vulnerability by establishing a water usage and demand baseline
- Establish a global drought information system, capitalizing on drought observing, monitoring, and impact systems, to enable early-warning systems to more effectively respond to drought at national/regional levels. Start with a prototype system focusing on documented test-cases in specific regions

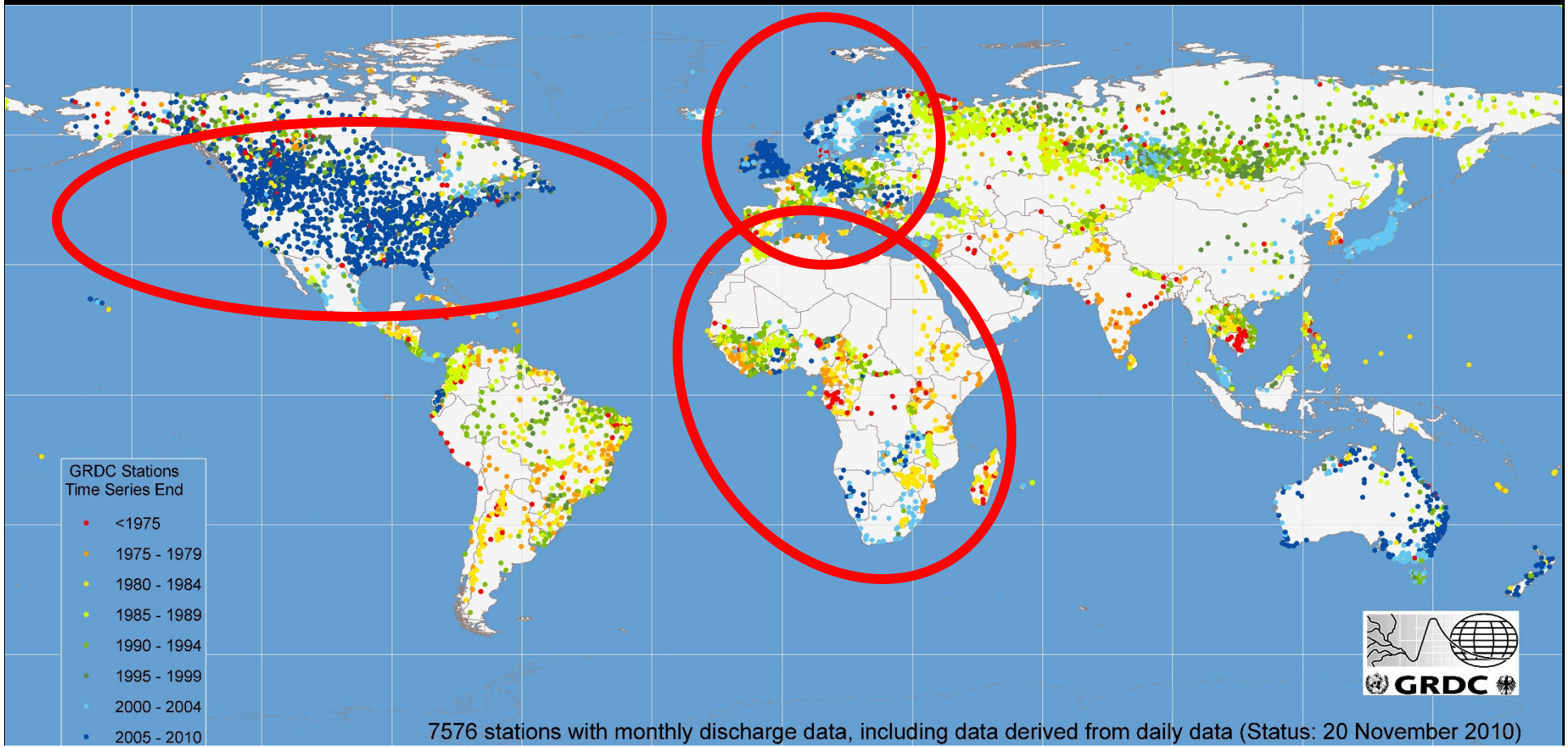
Language actually contained in 2010-2015 Work Plan

2010-2015 Work Plan

- Establish a global drought monitor to link together continental and regional drought monitoring efforts and produce a web-based, real-time, geographic information system.

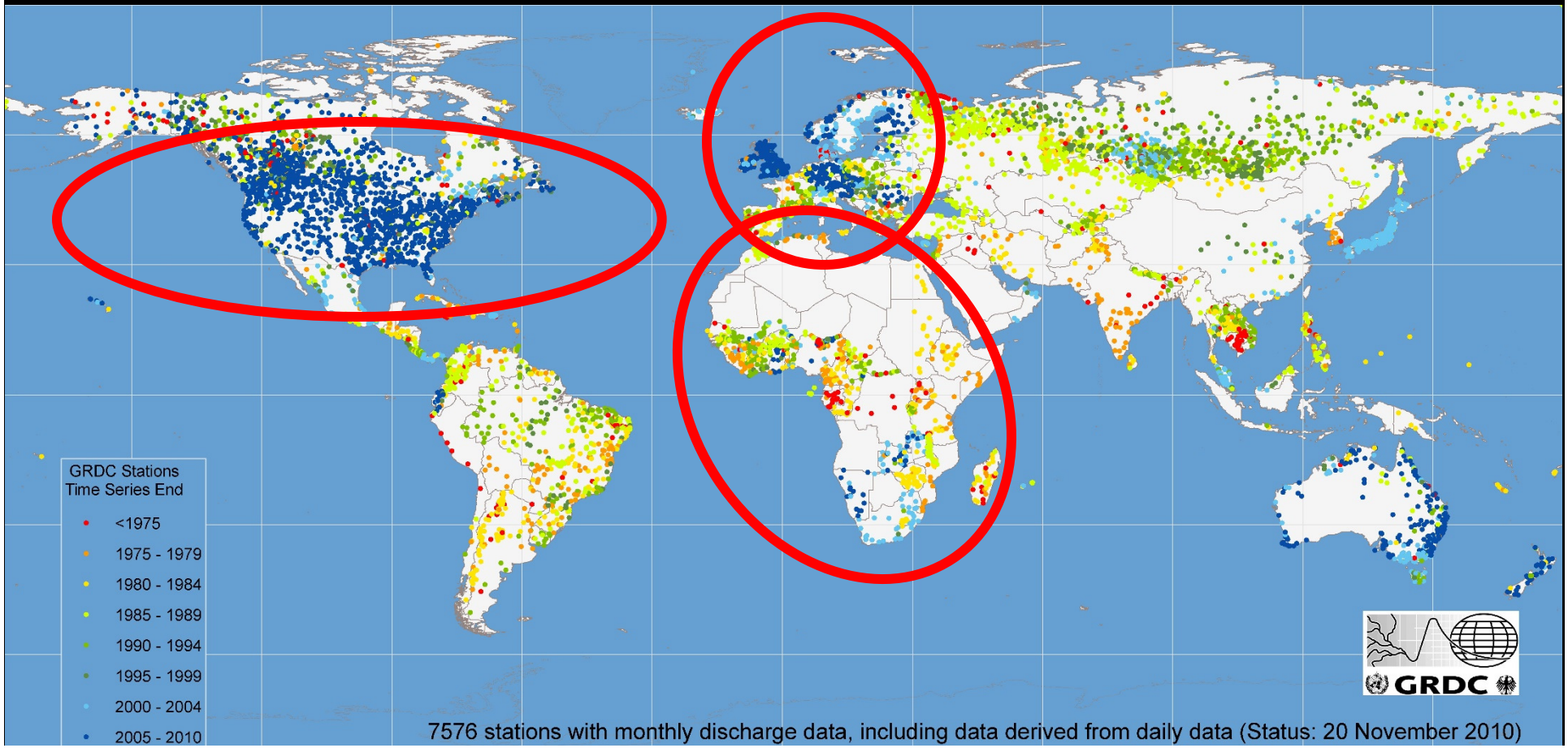
GLOBAL DROUGHT INFORMATION SYSTEM

--AT ITS OUTSET



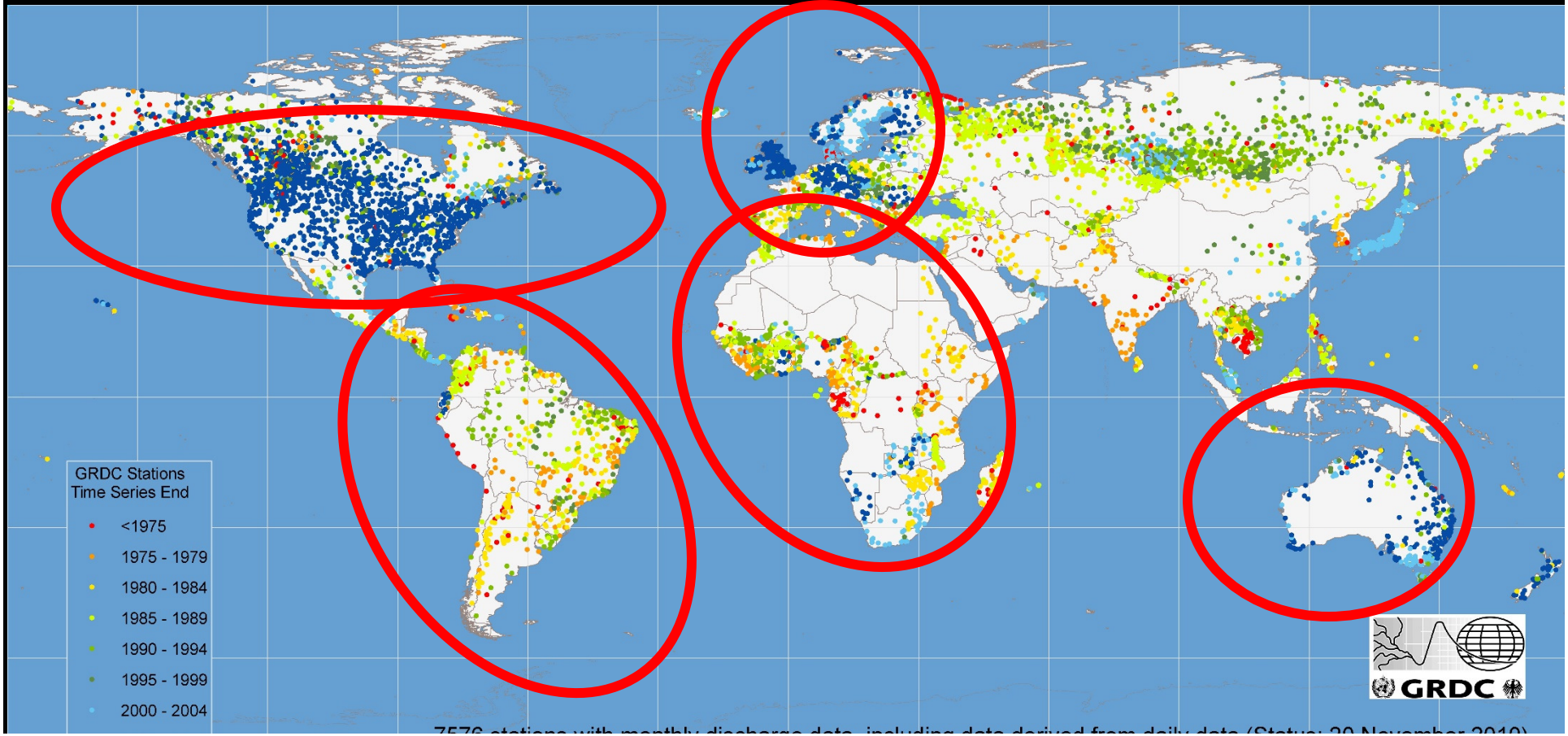
GLOBAL DROUGHT INFORMATION SYSTEM

--AT ITS OUTSET



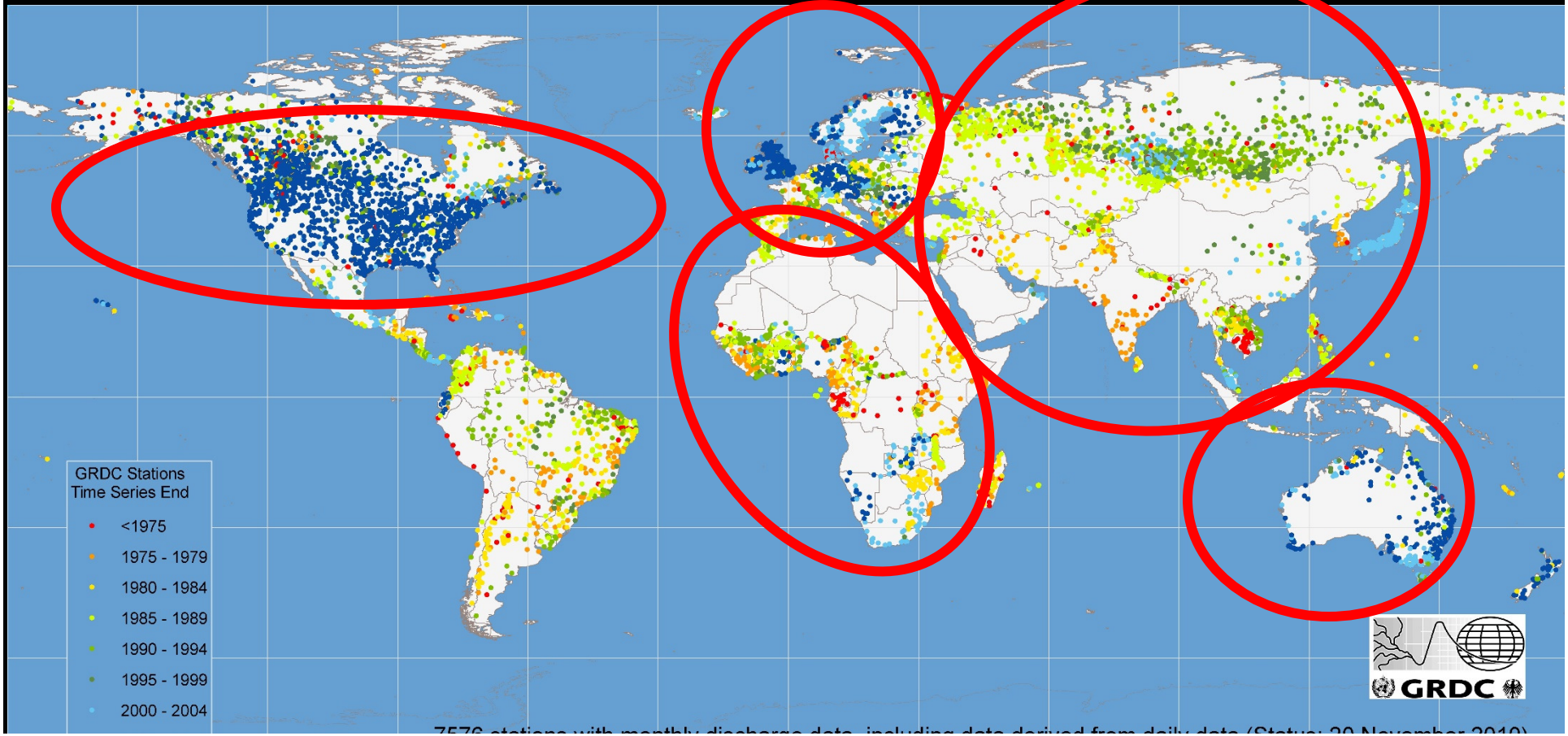
GLOBAL DROUGHT INFORMATION SYSTEM

-- CURRENTLY



GLOBAL DROUGHT INFORMATION SYSTEM

-- ADDITION OF 2015-2020 WORK PLAN



Language actually contained in 2010-2015 Work Plan

2010-2015 Work Plan

- Establish a global drought monitor to link together continental and regional drought monitoring efforts and produce a web-based, real-time, geographic information system.

Realized

- All continents have coverage, excepting Asia (which has coverage under the global coverage) and parts of West Asia (Arab world)

Language actually contained in 2010-2015 Work Plan

2010-2015 Work Plan

- Establish a global drought observing system to correct errors in precipitation, soil moisture, evapotranspiration, and terrestrial water-storage change derived from land-surface/hydrological models

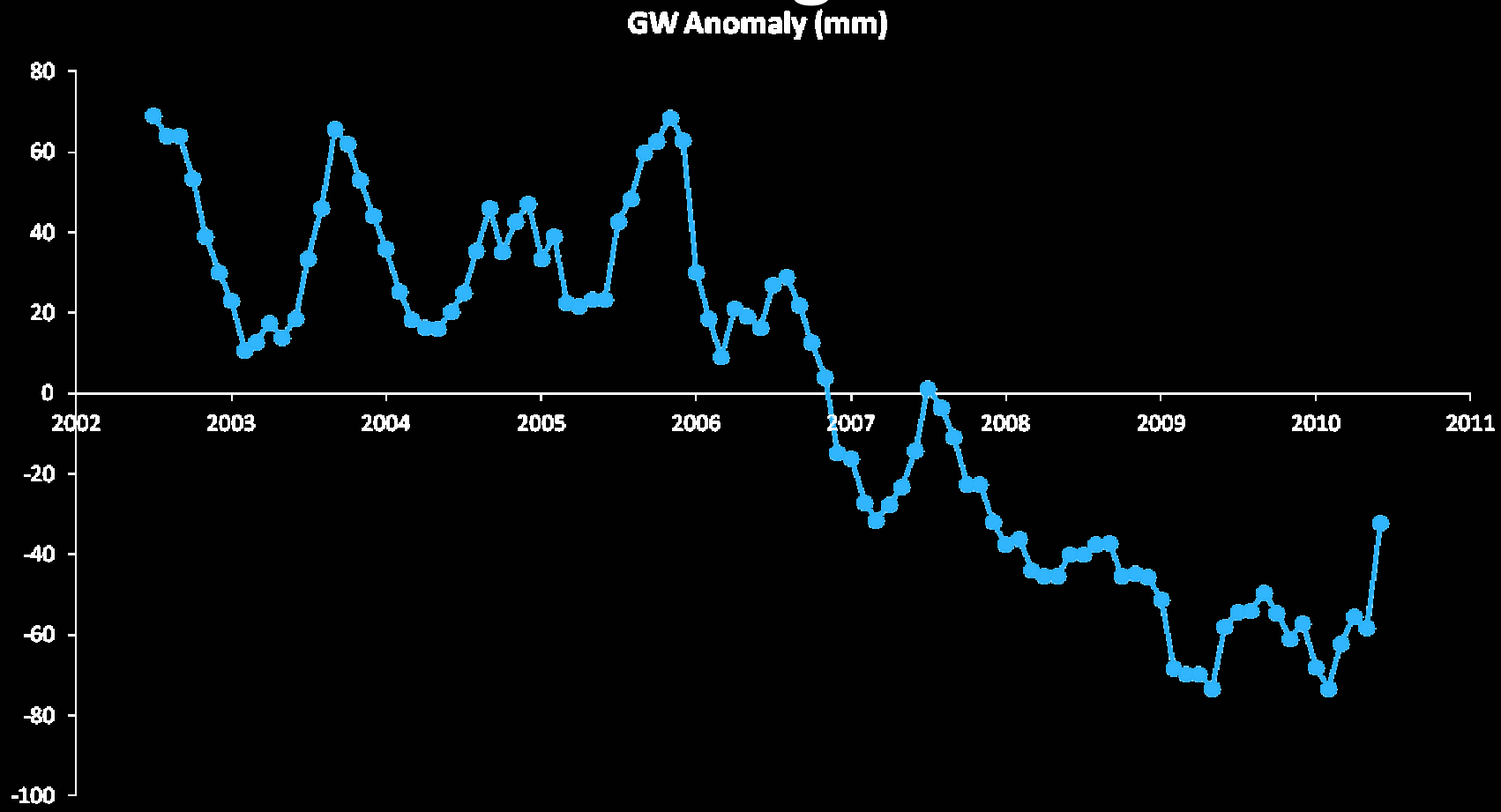
Realized

- A global system for monitoring root zone soil moisture and groundwater storage change from GRACE is being started this year with a 3 year project life

- A global system for monitoring Evaporative Stress Index from evapotranspiration is being started this year

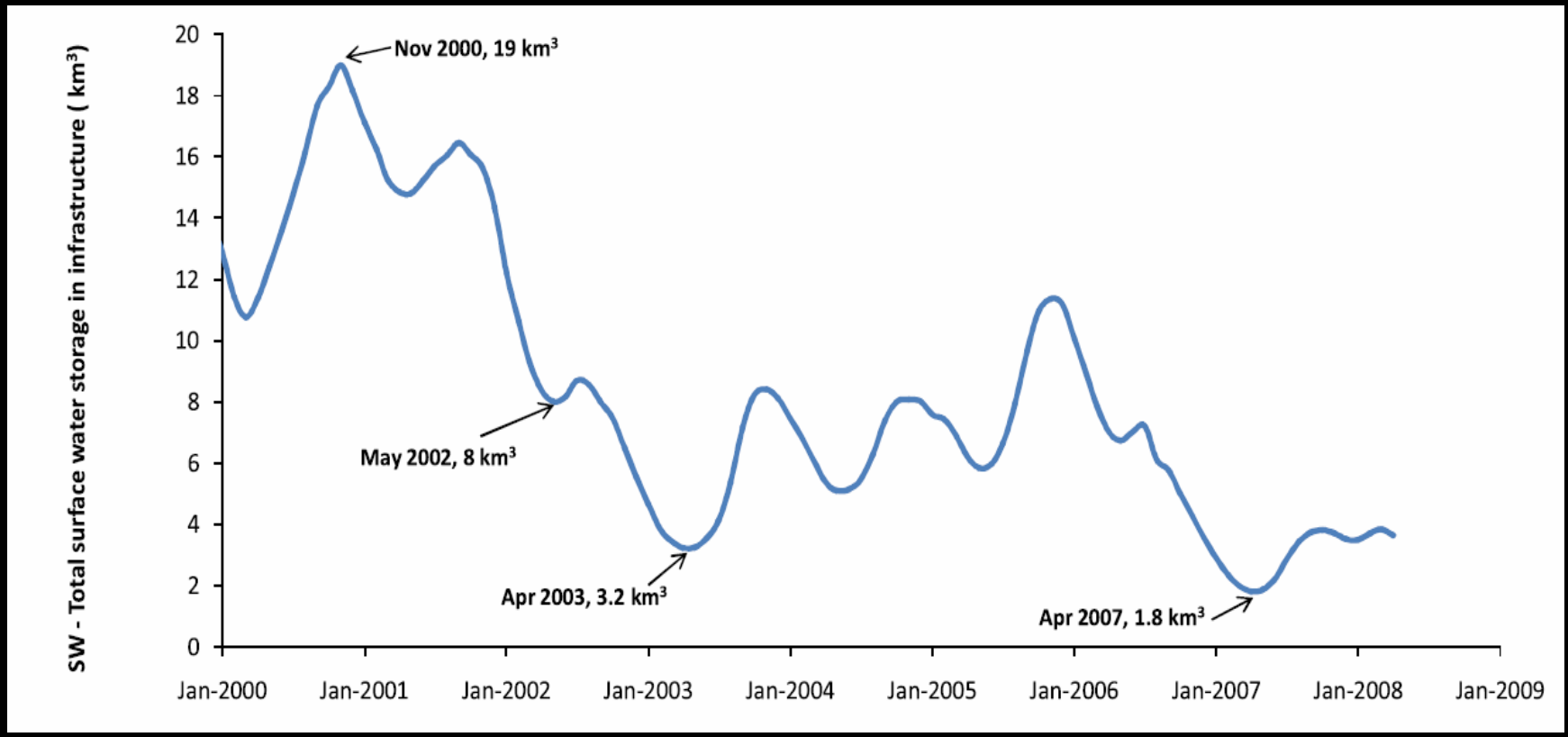
Murray River, Australia

Groundwater Elevation Drop during the course of the Australia Millennial Drought



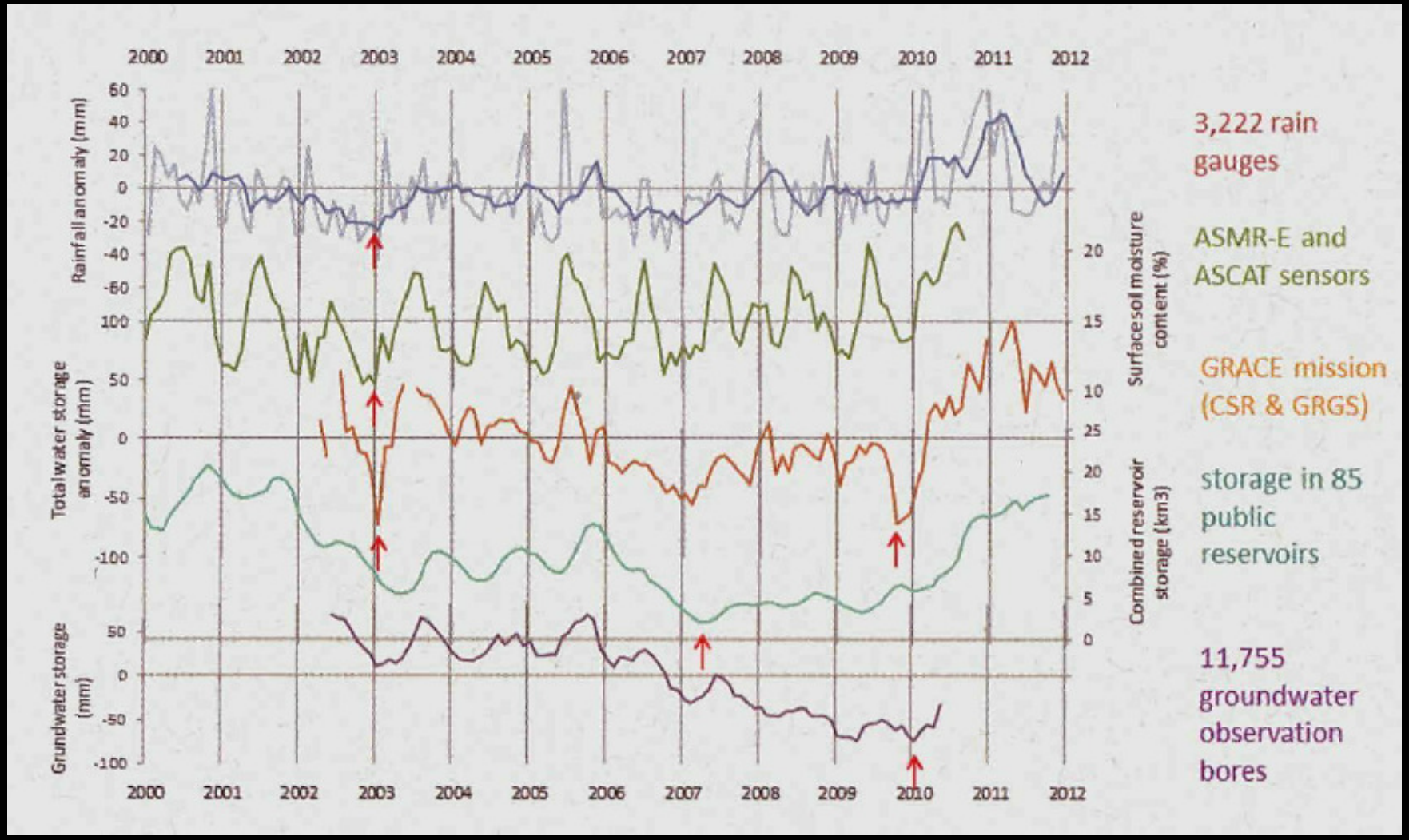
Source: Albert Van Dijk, CSIRO & Australia National University

Drop in Combined Surface Water Elevation during the Australian Millennial Drought



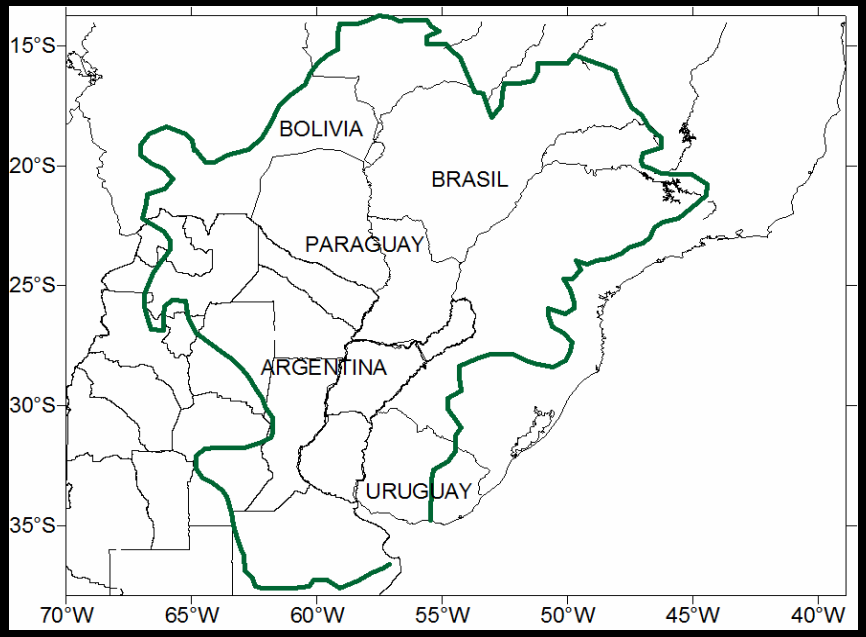
Australian Bureau of Agricultural Resource Economics and Sciences (ABARES) Surface Water Monitor

Combined Impacts of Australia Millennial Drought upon all Water Stores



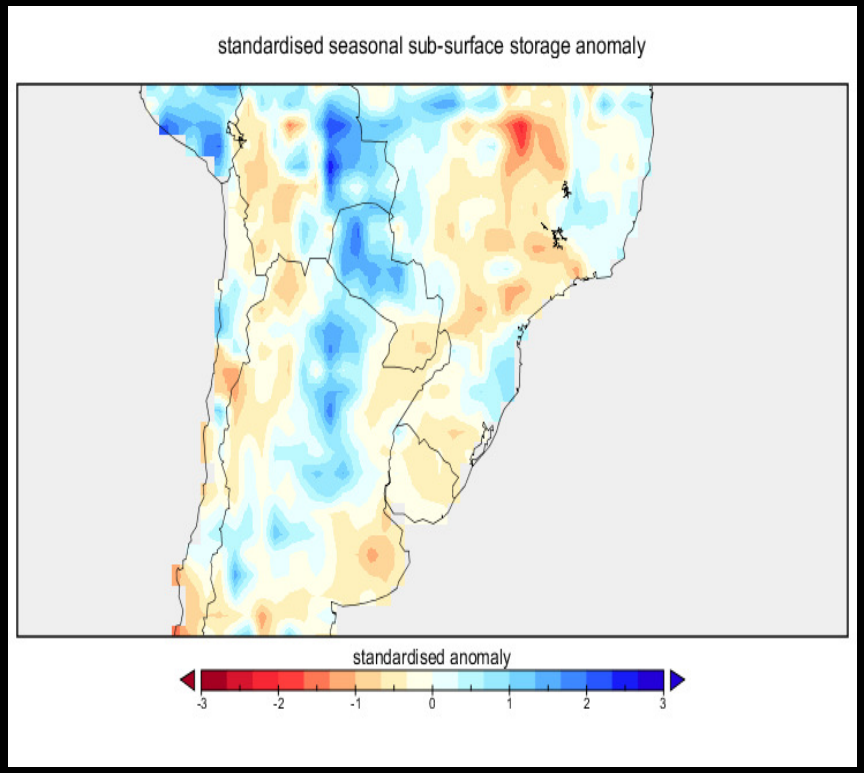
Pozzi, et al 2013 **Toward Global Drought Early Warning Capability: Expanding International Cooperation for the Development of a Framework for Monitoring and Forecasting, Bulletin AMS**

WHAT DOES THIS LOOK LIKE IN THE REAL WORLD?

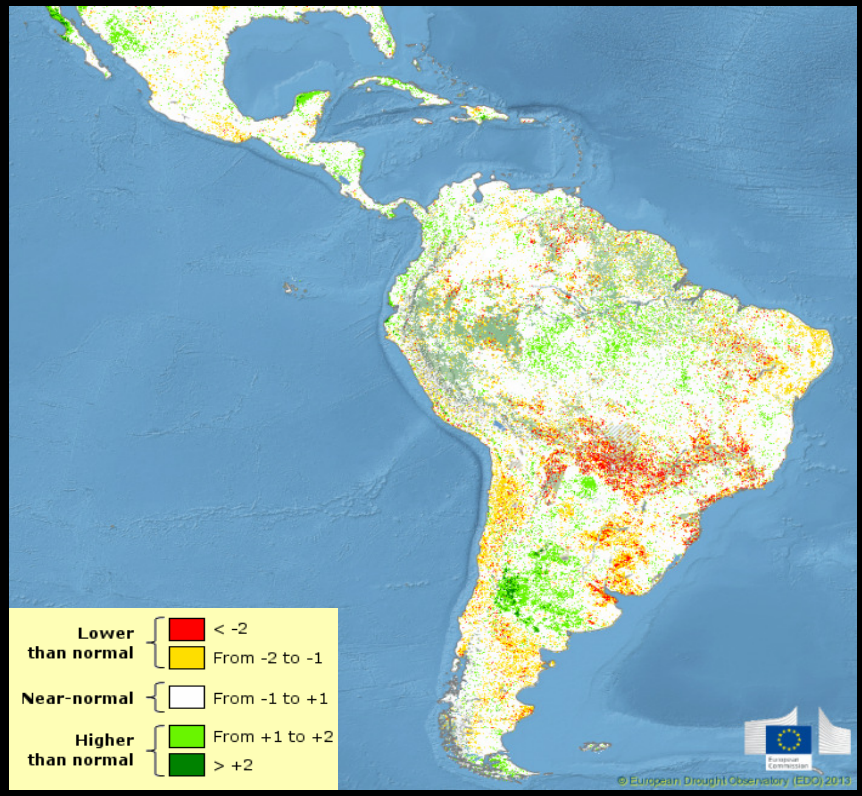


La Plata Basin South America Pre-Drought Onset

Pre-drought conditions over Northern Argentina Feb 2008

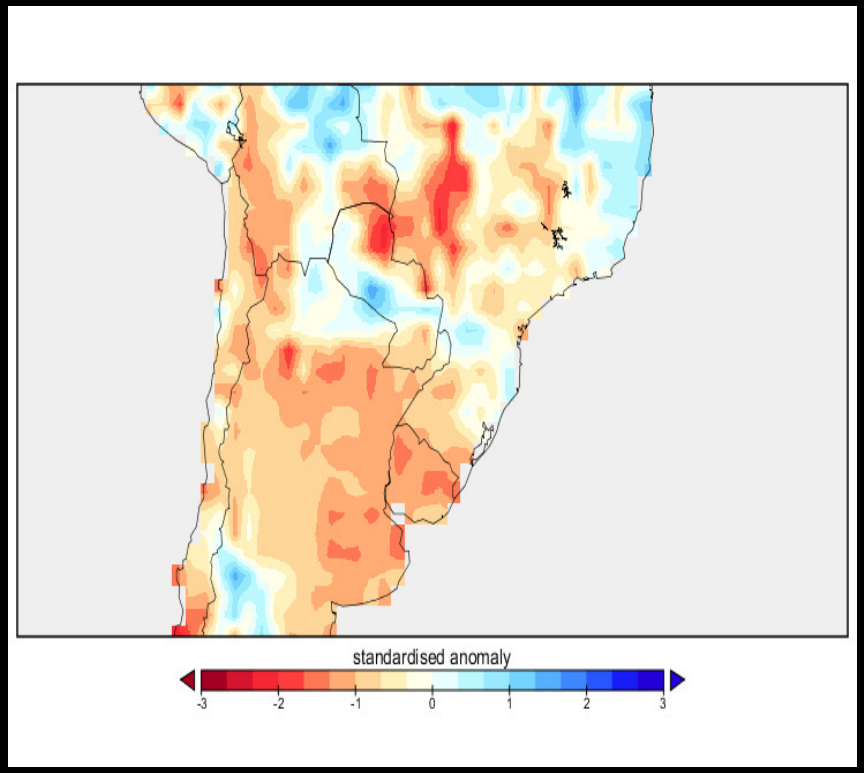


GRACE-based Subsurface Standardized Seasonally-adjusted Water Storage Anomaly (Albert van Dijk, Australian National University)

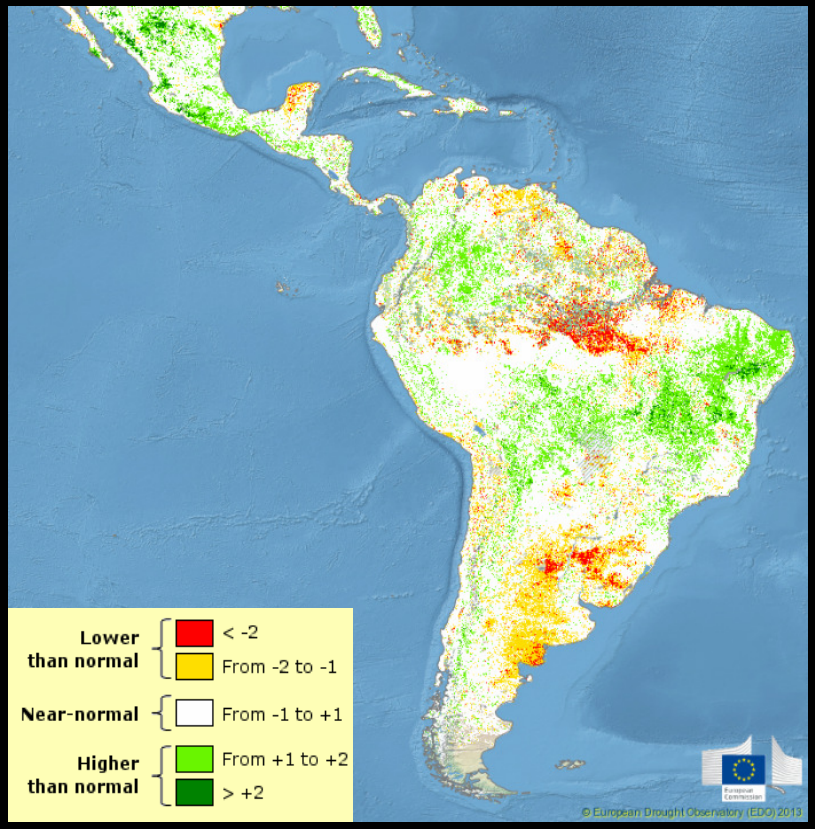


Surface anomalies of fraction of absorbed Photosynthetic Active Radiation (fAPAR) (European Commission Joint Research Centre EuroCLIMA)

Deep drought conditions over Northern Argentina June 2009



GRACE-based Subsurface Standardized Seasonally-adjusted Water Storage Anomaly



Surface anomalies of fraction of absorbed Photosynthetic Active Radiation (fAPAR)

Conclusion

GLOBAL DROUGHT MONITORING (AND PREDICTION) REQUIRES SIMULTANEOUS GLOBAL WATER CYCLE MONITORING

Objective: Monitoring Drought using multiple stores of water will increase the accuracy of detecting drought onset and improve prediction of drought severity

2. INTERNATIONAL PARTNERSHIPS WHICH HAVE MADE POSSIBLE THE DEVELOPMENT AND CAPACITY BUILDING COMPRISING GLOBALLY-WIDE DROUGHT MONITORING AND FORECASTING

Operational Activities for Climate Monitoring

- ***Perform*** **climate diagnostics including** ***analysis of climate*** **variability and** ***extremes***, at regional and sub-regional scales;
- Establish an historical reference climatology for the region and/or sub-regions;
- Implement a regional Climate Watch.

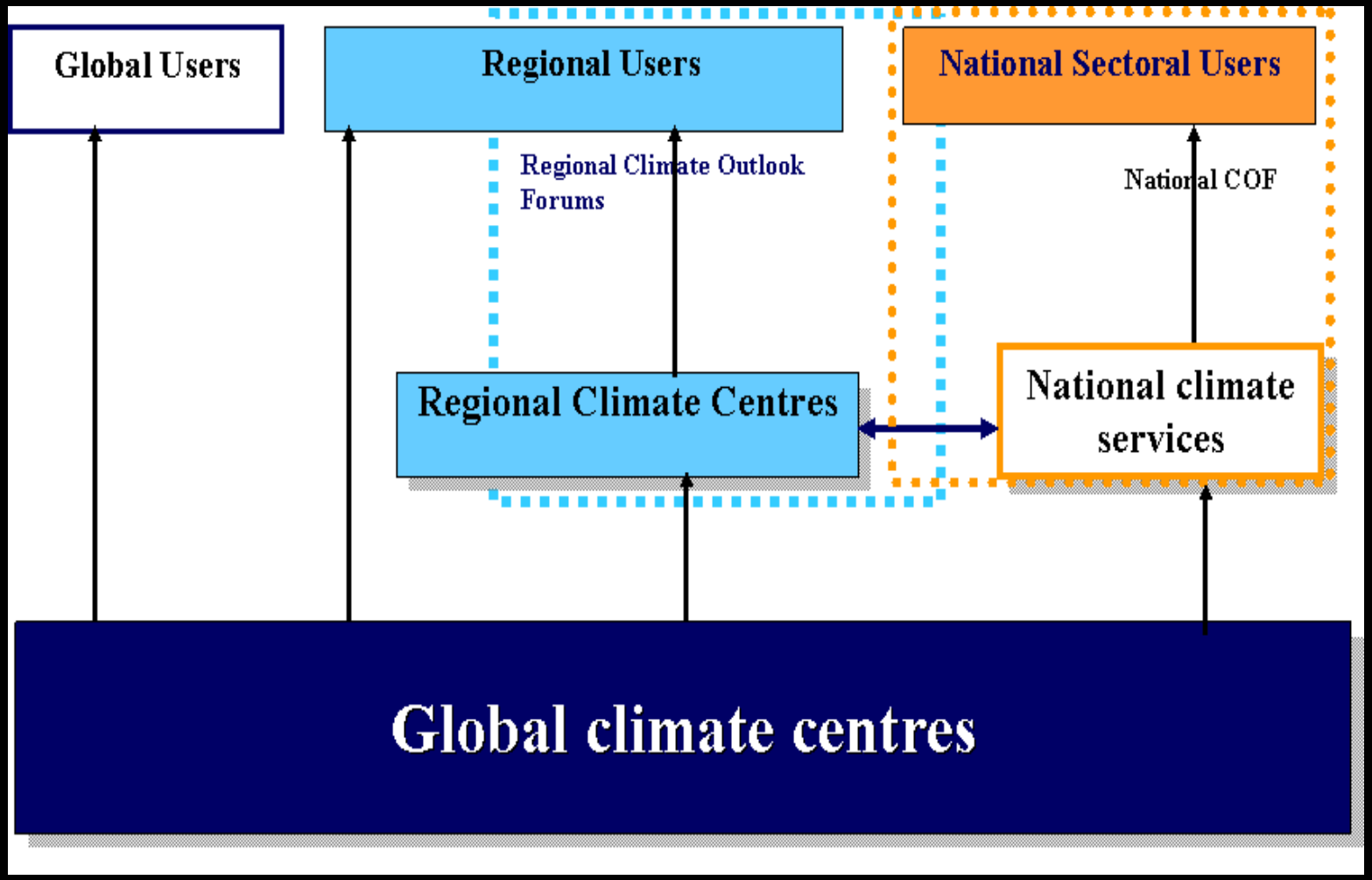
The Existing Regional Climate Outlook Forum (RCOF) framework does not provide information on the spatial extent and intensity of droughts, as it (I.e., RCOF) is mainly based on station data.

Mwangi, E., F. Wetterhall, E. Dutra, F. Di Guiseppe, and F. Pappenberger, 2014, "Forecasting droughts in East Asia," Hydrology & Earth System Science (HESS), **18**, 611-620

Global Climate Services Structure—Drought's role within it

- The Global Framework on Climate Services activities and linkages:
  - Global climate institutions (GPCs)
  - Regional (Continental) institutions (Regional Climate Centers)

Elements of Climate Services Information System



What are “Climate Services?”

- The term “climate services” refers to the delivery of climate information and predictions from the scientific sources to end-users

- A service is a service only when it is used; our goal is to make people use climate services in real-world context

Rupa Kumar Kolli “Global Framework for Climate Services—An Insight”

“Climate Services”-2

- Generating and providing information on past, present and future climate, and on its impacts on natural and human systems
  - Historical climate data sets
  - Climate monitoring
  - Climate watches
  - Monthly/Seasonal/Decadal climate predictions
  - Climate change projections
- Helping the user
  - access the right product for decision making, and
  - use it appropriately including aspects of uncertainty

Rupa Kumar Kolli “Global Framework for Climate Services—An Insight”

IMPLEMENTING GFCS OVER SOUTH AMERICA & AFRICA

--AND PLANS FOR DROUGHT INCLUSION

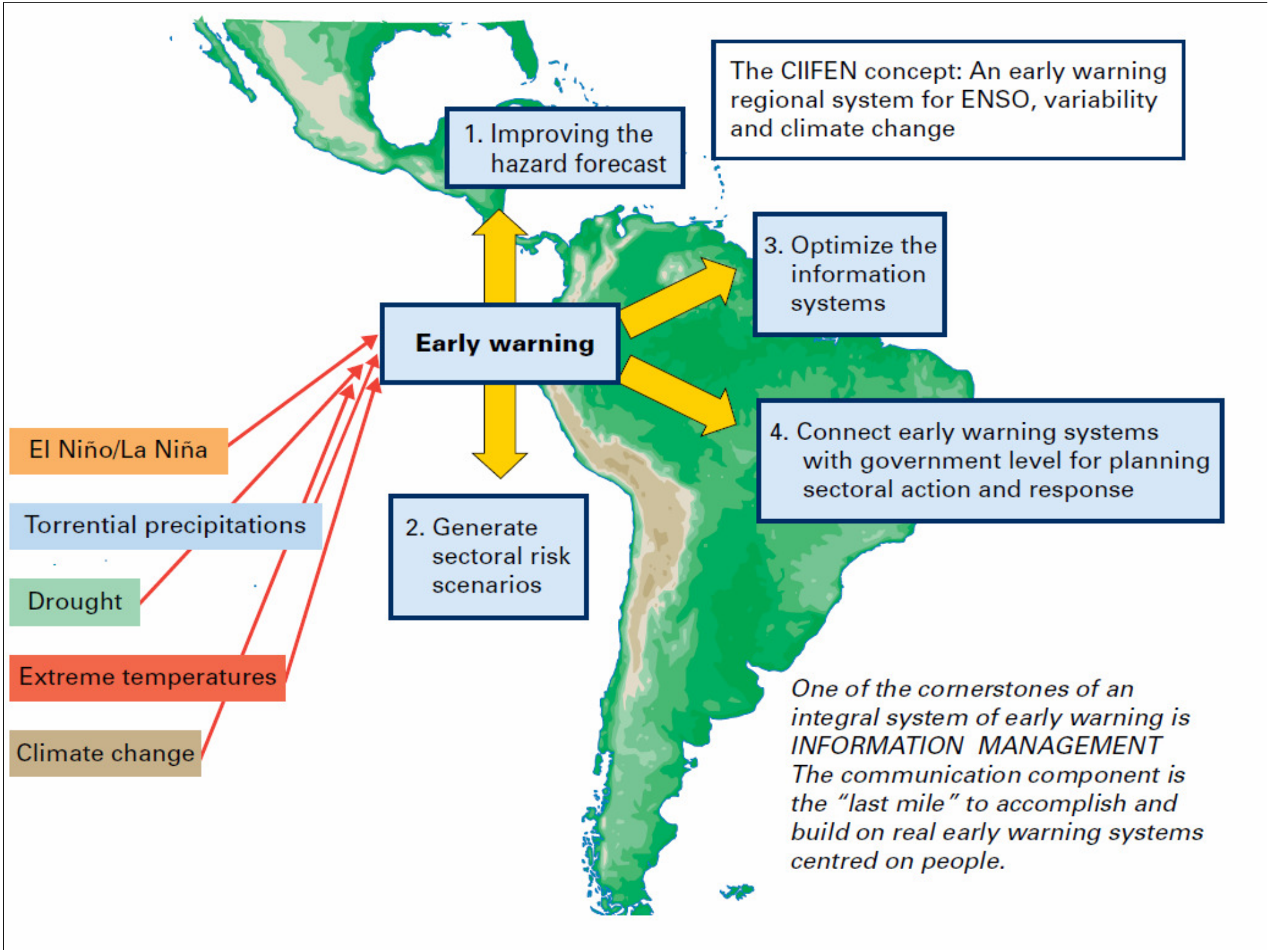
South America

- Expert Team on Climate Risk and Sector-Specific Climate Indices (ET-CRSCI) held a workshop held in Guayaquil, Ecuador in June 2013; included within this program was a special session on drought monitoring and indices. was included. SPI and SPEI indices in order to develop a regional drought monitoring mechanism which could be coordinated by CIIFEN.

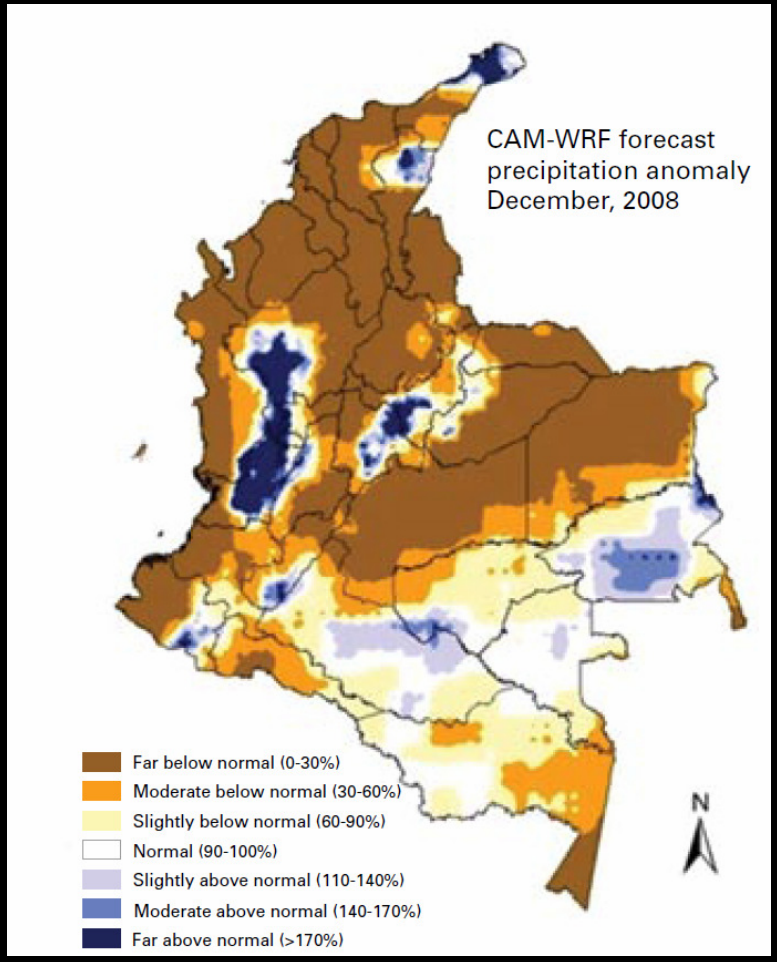
CIIFEN

The XIII Climate Outlook Forum for Western South America, during November 2013, agreed to start the implementation of a regional drought monitoring system, using 400 designated climate stations from Bolivia, Chile, Colombia, Ecuador, Peru and Venezuela.

These stations are being quality controlled and homogenized and have record lengths of 30-40 years.


The CIIFEN concept: An early warning regional system for ENSO, variability and climate change
1. Improving the hazard forecast
3. Optimize the information systems
Early warning
4. Connect early warning systems with government level for planning sectoral action and response
2. Generate sectoral risk scenarios
El Niño/La Niña
Torrential precipitations
Drought
Extreme temperatures
Climate change
One of the cornerstones of an integral system of early warning is INFORMATION MANAGEMENT
The communication component is the "last mile" to accomplish and build on real early warning systems centred on people.

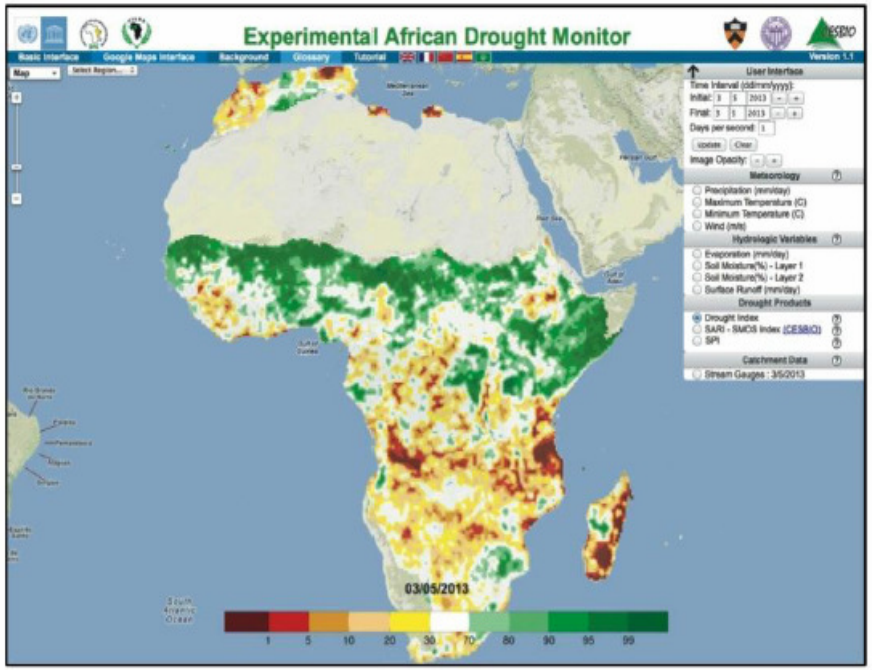
Early CIIFEN RCOF Results prior to Start up Drought Monitoring Network

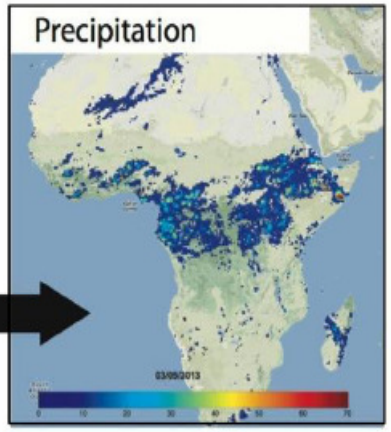


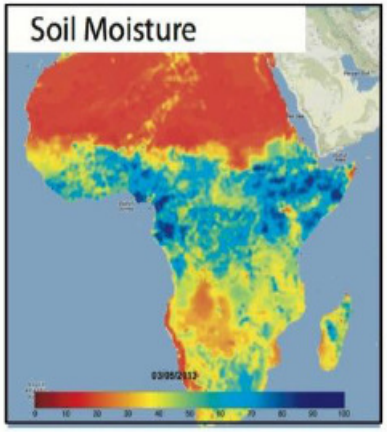
Africa

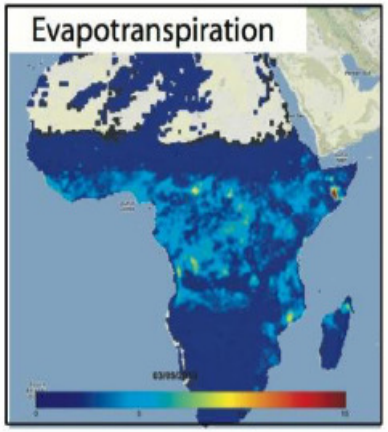
- The Western and Eastern Africa Regional Drought Centers are in the developmental phase of being considered for designation as Regional Climate Centers under the Global Framework for Climate Services (GFCS).

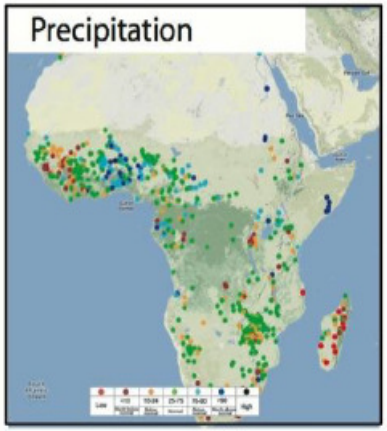
- Princeton University, an early partner of the Global Drought Information System, is involved in technology transfer and capacity building of drought monitoring and forecasting in Africa



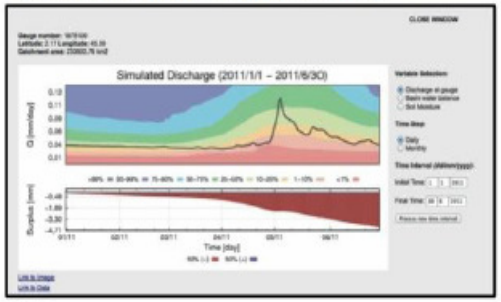




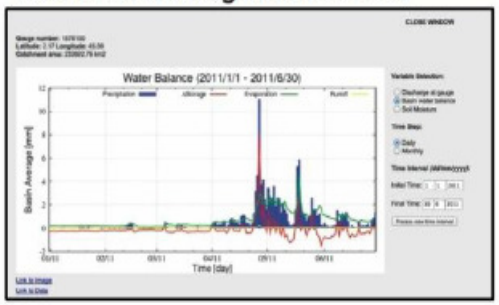




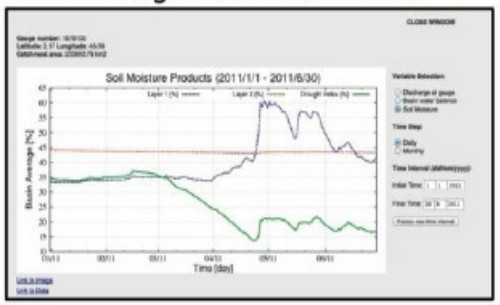
Basin streamflow time series

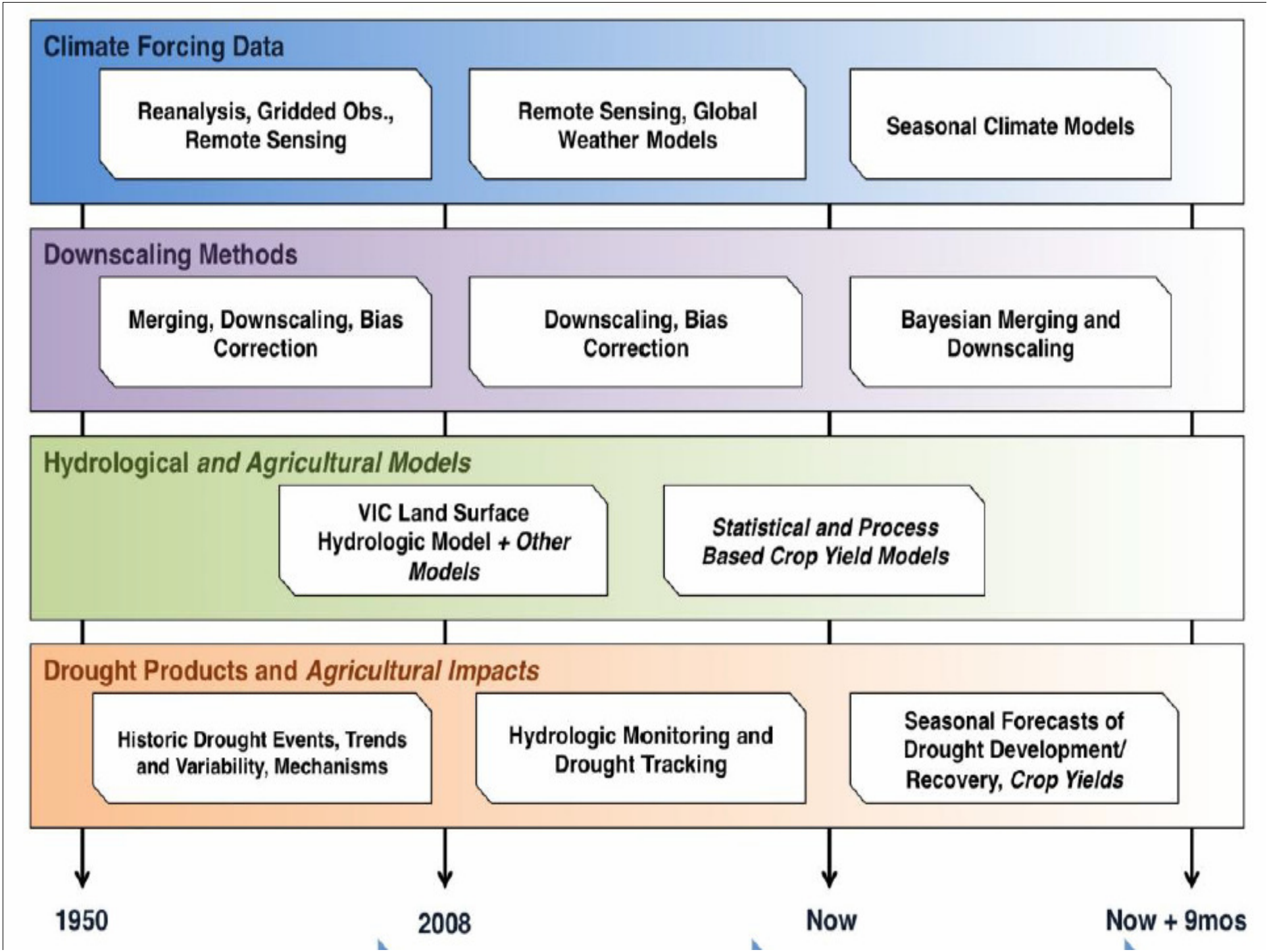


Basin water budget time series



Basin drought index time series




Climate Forcing Data
Reanalysis, Gridded Obs., Remote Sensing
Remote Sensing, Global Weather Models
Seasonal Climate Models
Downscaling Methods
Merging, Downscaling, Bias Correction
Downscaling, Bias Correction
Bayesian Merging and Downscaling
Hydrological and Agricultural Models
VIC Land Surface Hydrologic Model + Other Models
Statistical and Process Based Crop Yield Models
Drought Products and Agricultural Impacts
Historic Drought Events, Trends and Variability, Mechanisms
Hydrologic Monitoring and Drought Tracking
Seasonal Forecasts of Drought Development/ Recovery, Crop Yields
1950
2008
Now
Now + 9mos

- In 2012, a system to detect droughts via soil moisture anomalies, using the Variable Infiltration Capacity (VIC) model, was transitioned and tested for operational usage by African collaborators in January 2012 at the AGRHYMET (Centre Régional de Formation et 399 d'Application en Agro météorologie et Hydrologie Opérationnelle) régional center in Niamey, Niger

- The drought monitor software and data were installed on center servers and hydrological scientists and professionals were trained in the operational running of the system and interpretation of the data output.

Capacity building was also implemented at the second regional drought center (and developing Regional Climate Center), that of the Intergovernmental Authority on Development (IGAD) Climate Prediction and Applications Center (ICPAC) in Nairobi, Kenya. A workshop was held in June 2012 for training and use of the VIC model for detecting soil moisture anomalies during drought.

Justin Sheffield, Eric F. Wood, Nathaniel Chaney, Kaiyu Guan, Sara Sadri , Xing Yuan, Luke Olang, Abou Amani, Abdou Ali, Siegfried Demuth, and Laban Ogallo, 2014: "A Drought Monitoring and Forecasting 1 System for Sub-Sahara African Water Resources and Food Security," *Bulletin American Meteorological Society*

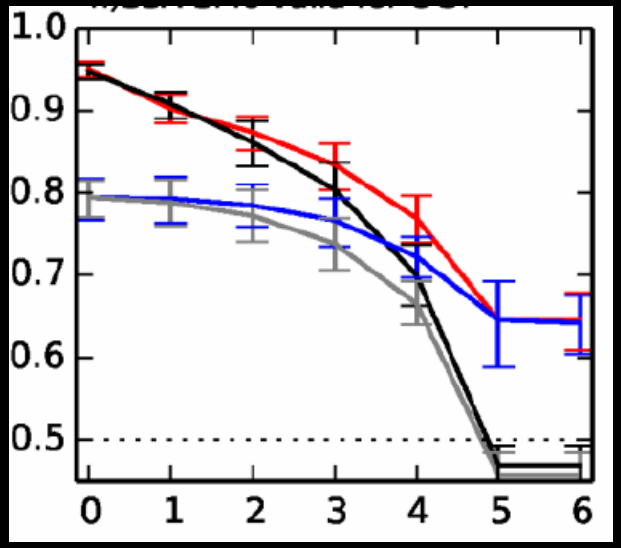
FURTHER CAPACITY BUILDING DROUGHT DEVELOPMENTS IN SOUTH AMERICA

- CPTEC is developing “regional” (this is WMO terminology, meaning continental-wide) drought forecasting capability for South America
- CPTEC drought prediction developmental effort is being carried out in association with GEO (WA-01-C2), testing CPTEC drought predictions against ECMWF drought predictions.

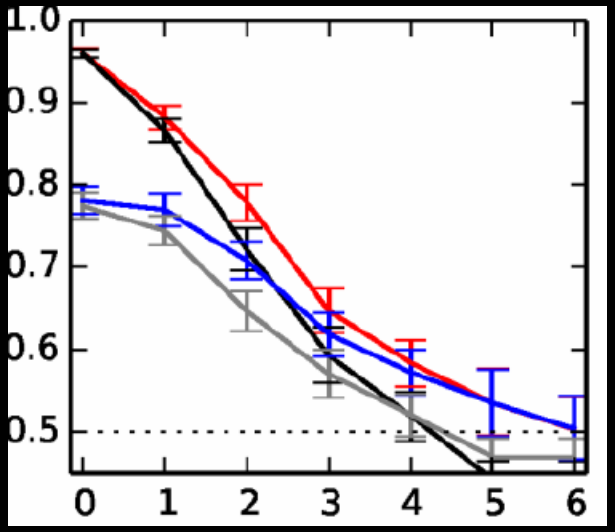
Another GEO Exclusive under WA-01-C2

First global *regional (continental)* assessment of drought forecasting skill (carried out with ECMWF)

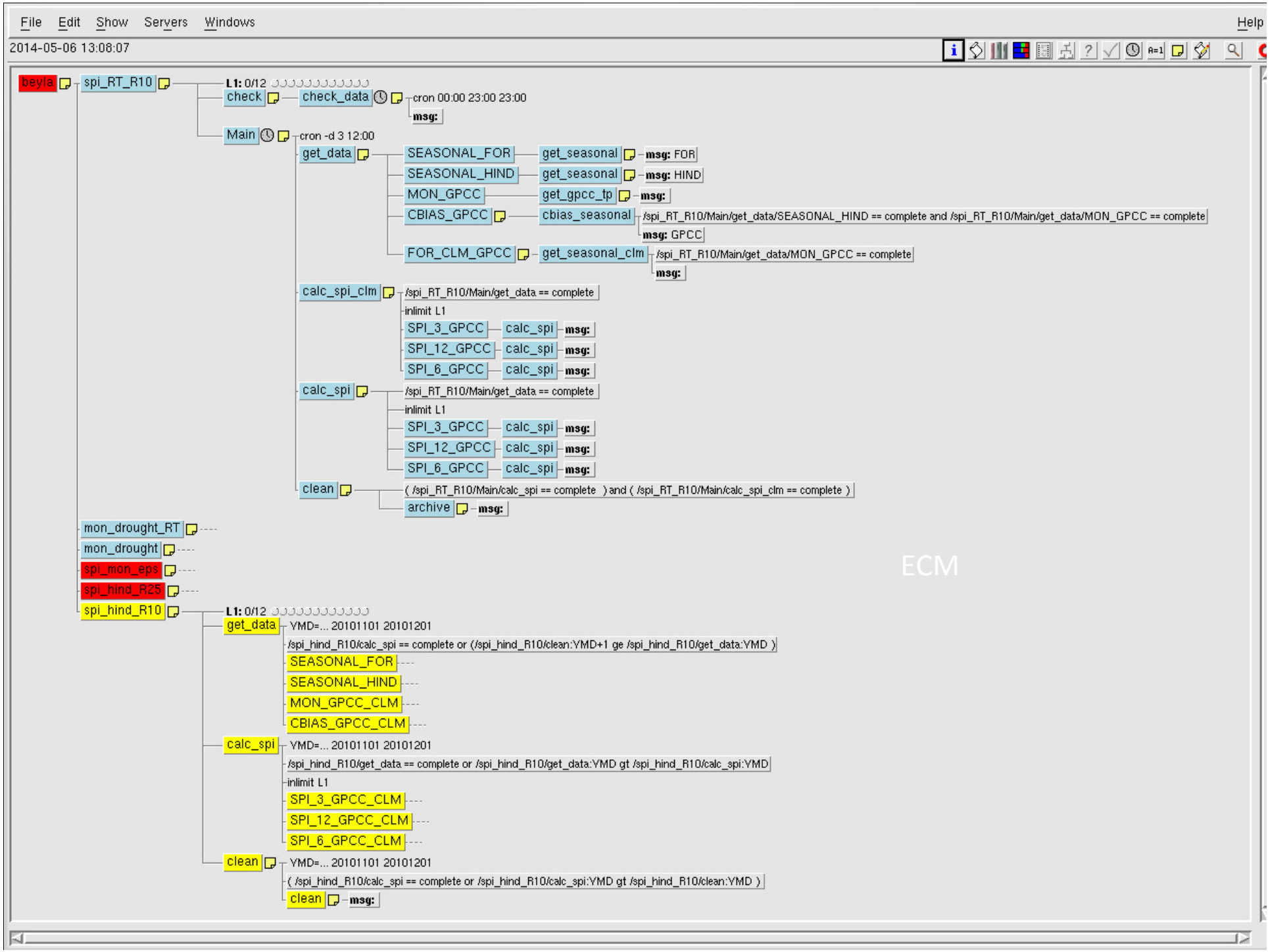
Southern South American Region ROC Score



East Asia (China) ROC Score



For each SPI time-scale the evaluation each panel displays a specific Relative Operating Characteristics score as a function of lead time (horizontal axis) for a specific verification date (in the title) for the GPCC S4 forecasts (red), GPCC CLM (black), ERAI S4 (blue) and ERAI CLM (grey). Area under the ROC curve for SPI forecasts below –0.8.


File Edit Show Servers Windows Help
2014-05-06 13:08:07
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spi_RT_R10
L1: 0/12
check
check_data
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cron -d 3 12:00
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SEASONAL_FOR
get_seasonal
msg: FOR
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get_seasonal
msg: HIND
MON_GPCC
get_gpcc_tp
msg:
CBIAS_GPCC
cbias_seasonal
/spi_RT_R10/Main/get_data/SEASONAL_HIND == complete and /spi_RT_R10/Main/get_data/MON_GPCC == complete
msg: GPCC
FOR_CLM_GPCC
get_seasonal_clm
/spi_RT_R10/Main/get_data/MON_GPCC == complete
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calc_spi_clm
/spi_RT_R10/Main/get_data == complete
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SPI_3_GPCC
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calc_spi
msg:
SPI_6_GPCC
calc_spi
msg:
calc_spi
/spi_RT_R10/Main/get_data == complete
inlimit L1
SPI_3_GPCC
calc_spi
msg:
SPI_12_GPCC
calc_spi
msg:
SPI_6_GPCC
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spi_hind_R10
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ECM

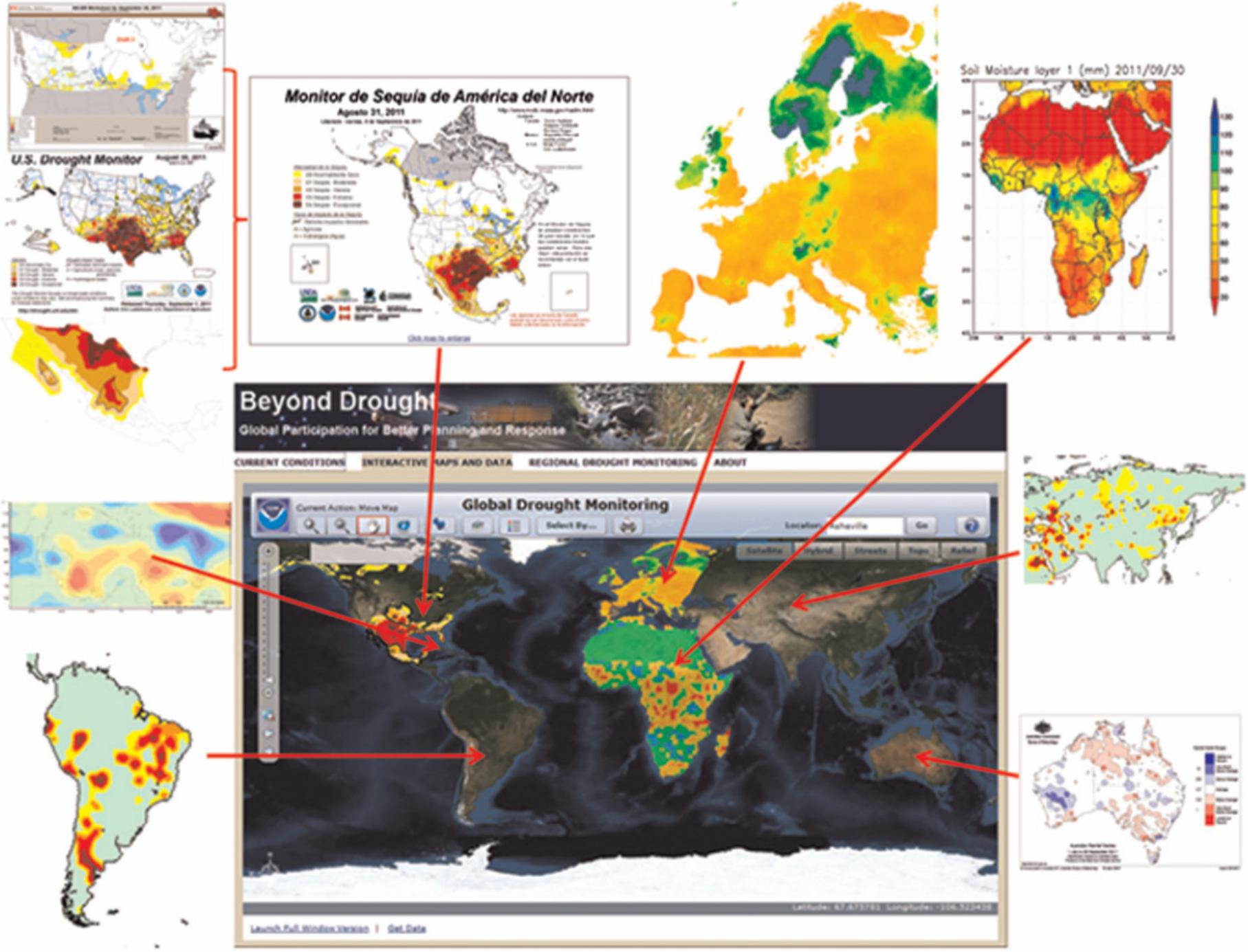
South America Regional Climate Centers

- The Southeast South America Regional Climate Center (Brazil, Argentina, Paraguay, Uruguay, and Bolivia) are also developing a regional drought monitoring network

"Bottom-up" Protocols between the South American RCC drought activities and the Global Drought Information System (GDIS) Global Drought Display

The monthly drought maps (monitoring from the two regional climate centers) and the drought prediction map from CPTEC will constitute the South American portion of drought coverage within the Global Drought Monitor (i.e., housed on the NIDIS portal).

The monitoring product is not simple model data but is the observational-based product from the NMHSs.


U.S. Drought Monitor
Monitor de Sequía de América del Norte
Agosto 31, 2011
Soil Moisture layer 1 (mm) 2011/09/30
Beyond Drought
Global Participation for Better Planning and Response
CURRENT CONDITIONS
INTERACTIVE MAPS AND DATA
REGIONAL DROUGHT MONITORING
ABOUT
Global Drought Monitoring
Launch Full Window Version
Get Data

USERS ARE BEING ENTRAINED, SINCE BY USING THE REGIONAL CLIMATE CENTERS AS BUILDING BLOCKS, USERS ARE ALREADY IDENTIFIED THROUGH THE NATIONAL METEOROLOGICAL AND HYDROLOGICAL SERVICES

2.B. OTHER PARTNERSHIPS

1st Global Drought Information System Workshop

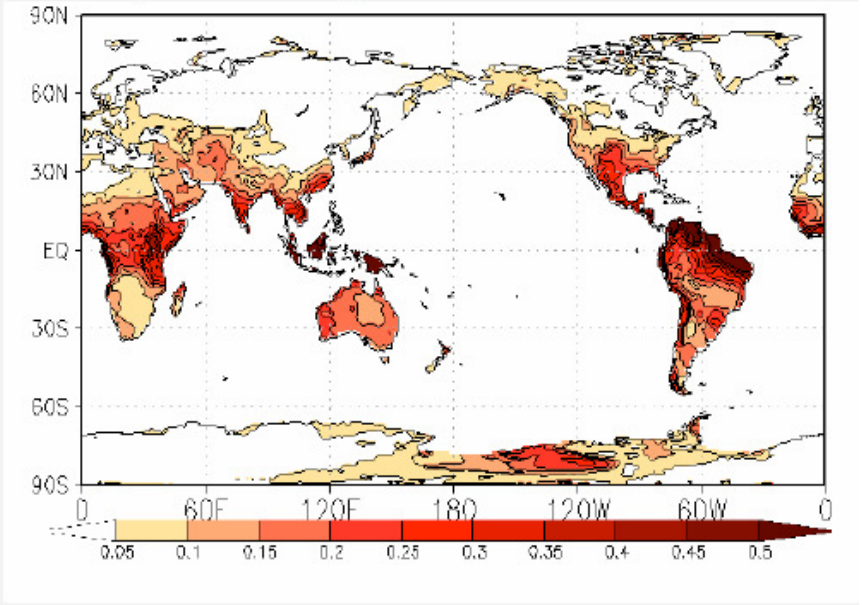
The Global Drought Information System (GDIS)

An initiative of the international WCRP Drought Interest Group

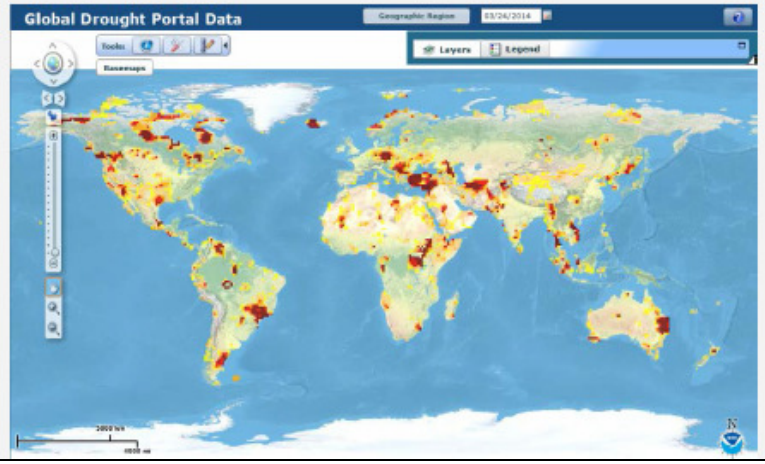
--and GEO

- Advance understanding of drought mechanisms and predictability
- Advance regional climate information and decision support
- Develop an experimental global real time monitoring and prediction

Precipitation Signal/Total Variance

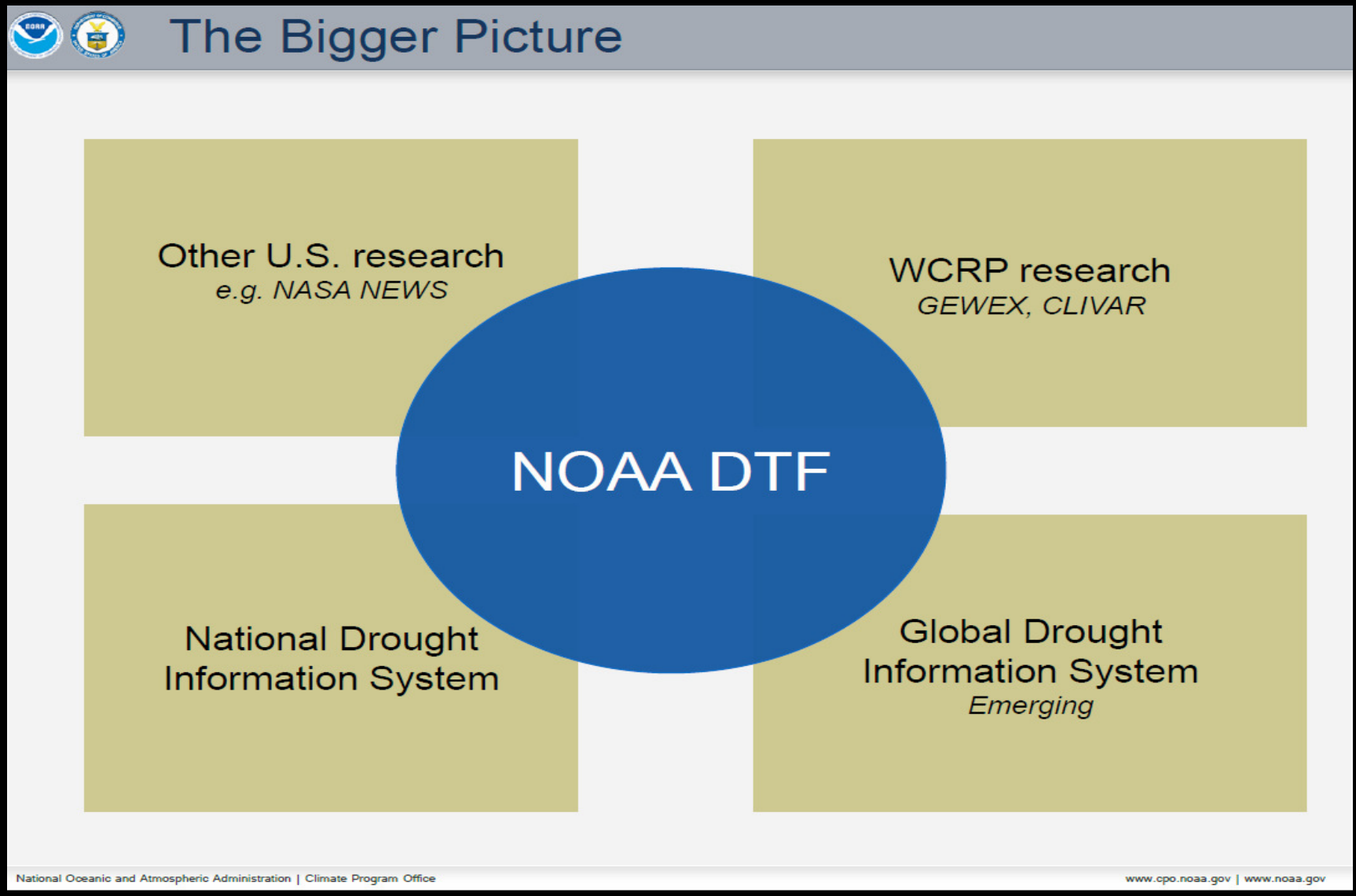


NIDIS & DTF research can be key to advance GDIS



Courtesy of S. Schubert

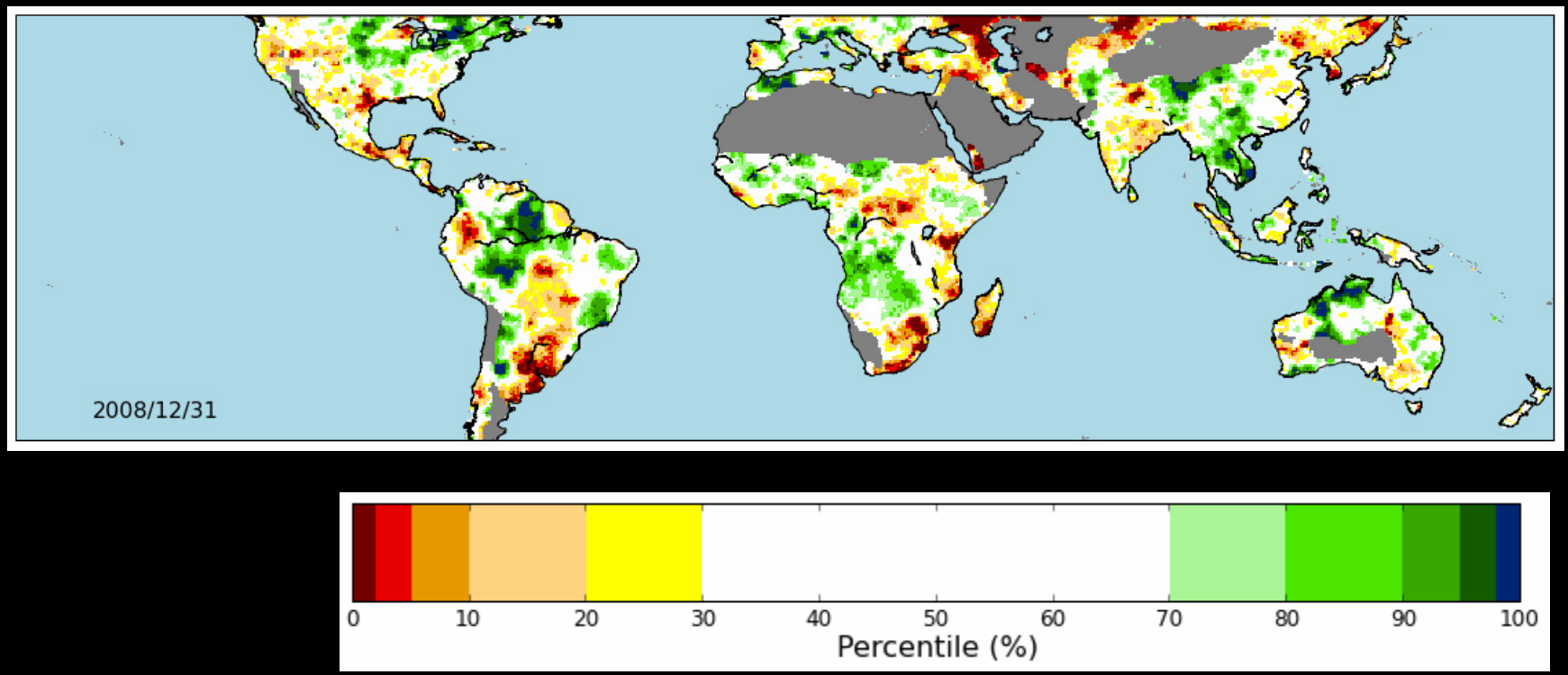
Another Partner: NOAA



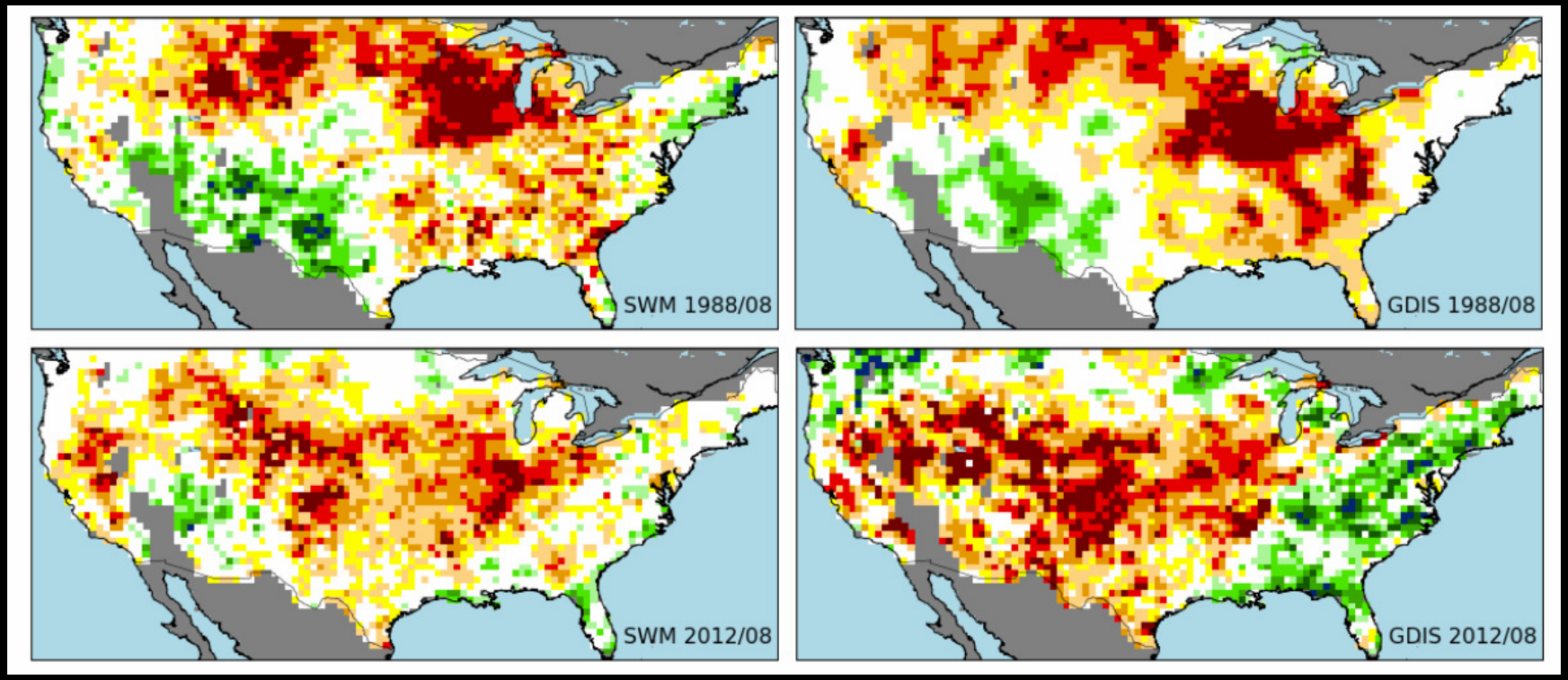
Note: “DTF” means “Drought Task Force.”

Another Partner: University of Washington Seattle

Global Drought Information System
Global Pilot 2008 Retrospective Run



Comparing the US drought coverage obtained from the Global Drought Information System US versus the Domestic Drought Coverage from the University of Washington Surface Water Monitor (different data sources)



Models used in Global Drought Detection and Monitoring

University of Washington GDIS Pilot Trial Run

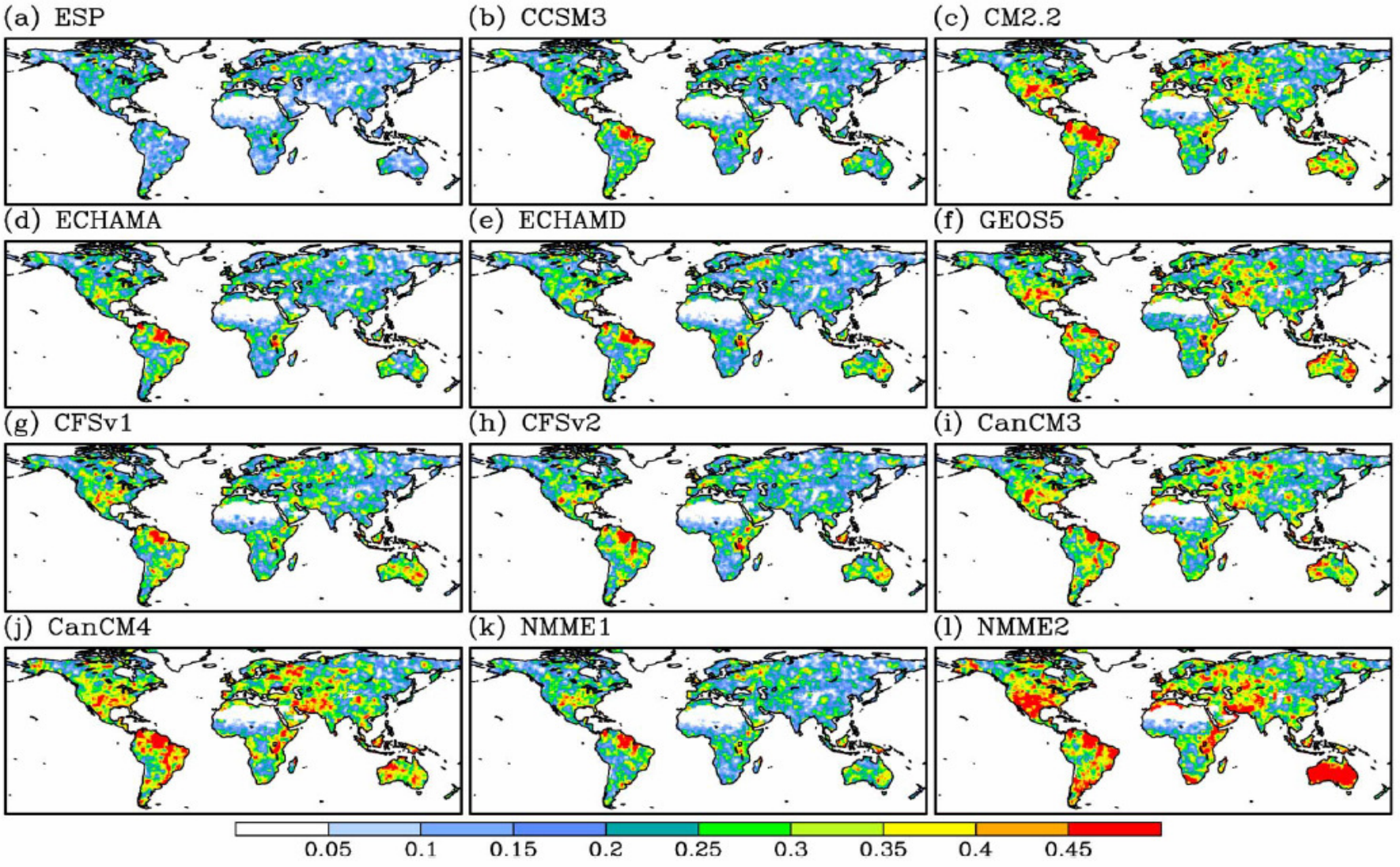
- Ensemble Members:
  - VIC
  - Noah
  - Sacramento Soil Moisture Accounting

2nd Global Drought Information System Global Pilot

- CPC GLDAS
- National Multi-model Ensemble
- ECMWF

Drought Forecasting Performance of National Multi-Model Ensemble

Drought Onset Forecasting Detection Skill for the National Multi-model Ensemble (Yuan and Wood 2013)



3. GLOBAL DROUGHT *INFORMATION SYSTEM*

Information System Aspects

- Robert Stefanski at World Meteorological Organization has likened the Global Drought Information System to a "*Global* NIDIS"
- The National Integrated Drought Information System (NIDIS) attempts to compress huge amounts of monitoring, forecasting, and some vulnerability information, maps, and results into a compact, easy-to-access, usable form.

What is the Role of GDIS and its linkages to the GEOSS Common Infrastructure and GEO Portal?

- NIDIS is specifically ArcGIS Server software
- Datasets serving as inputs to NIDIS have to be in formats amenable to import into a GIS
- The final result—within the GIS format—is probably more easily accessible to users using GIS-hydrology related software (like CUAHSI)
- The information in this form is more easily accessible to the GEO portal.

4. GLOBAL FLOODS MONITORING AND FORECASTING

Floods

- Global Floods Working Group is now linked to the Global Disaster Alert and Coordination Group (GDAC)

- The 4th meeting of the Global Floods Working Group was held at the European Center for Medium-range Weather Forecasting (ECMWF)

Global Flood Awareness System (GloFAS)

- Most GEO-WA-C2 work has involved the Joint Research Centre-ECMWF system GloFAS—a probabilistic flood forecasting system using the ECMWF medium range forecasting system--which is now being tested in pilots (including the Architectural Implementation Pilot (AIP).

Global Floods Work has lagged behind Global Drought Activity

- Lack of support for global coordination of WA-01-C2 has impeded the ability to attend meetings of the Global Floods Working Group, although many of the members of the drought cluster are also involved in this group.
- However, different phases of El Nino-Southern Oscillation, the Indian Ocean Dipole, the North Atlantic Oscillation, and other teleconnections create conditions predisposing towards, alternatively, droughts or floods.

Language actually contained in 2010-2015 Work Plan

Work Plan Language

- Construct a global, multi-model and multi-ensemble flood and drought information platform to assemble existing sources of real-time flood and drought information (forecasts and observations), while providing a common risk-management framework for early warning and risk management.

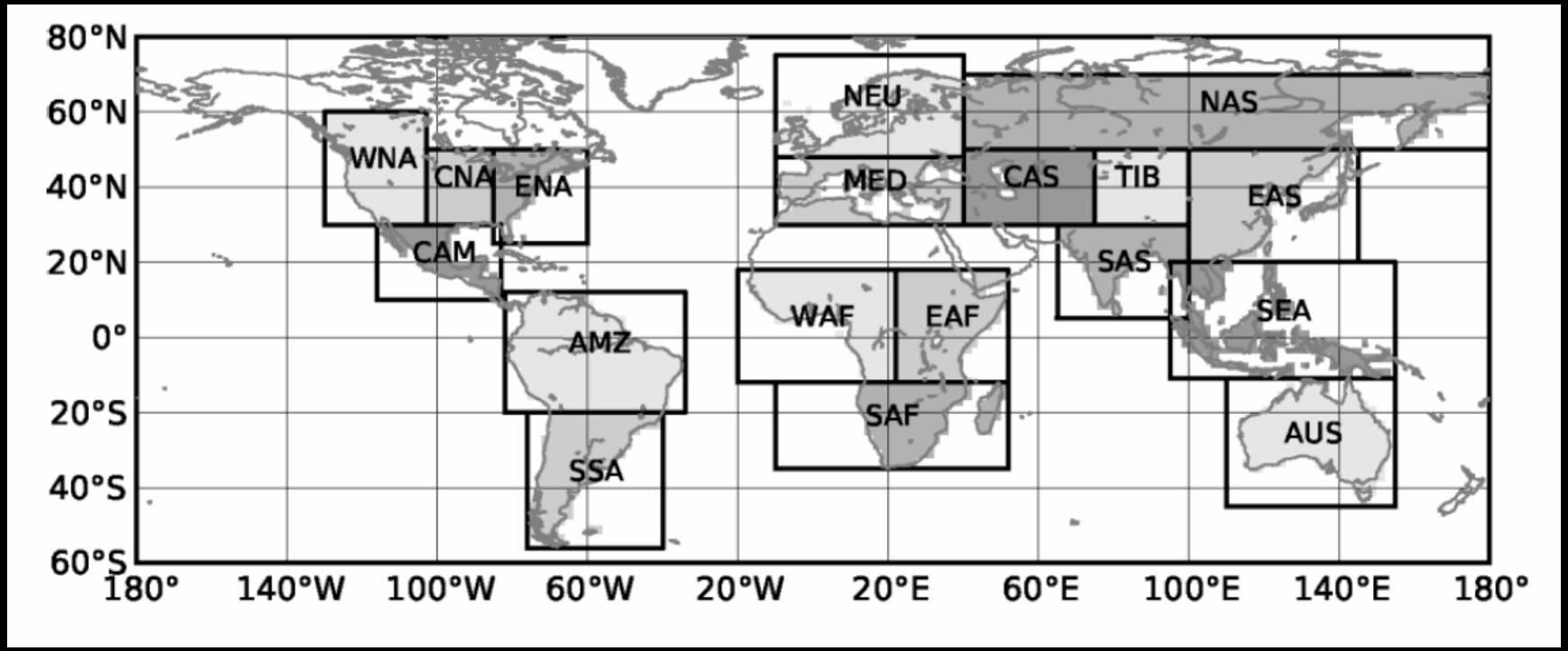

ありがとうございます。
Arigato Gozaimasu
Thank You!

EXTRA MATERIAL

Model	$p(y_1 \mid o_1)$	$p(o_0 \mid y_1)$	*ETS*
ESP	0.16	0.36	0.14
CCSM3	0.21	0.46	0.17
CM2.2	0.27	0.49	0.20
ECHAMA	0.21	0.42	0.17
ECHAMD	0.21	0.42	0.18
GEOS5	0.27	0.45	0.21
CFSv1	0.23	0.41	0.19
CFSv2	0.23	0.37	0.19
CanCM3	0.27	0.49	0.20
CanCM4	0.29	0.49	0.21
NMME1	0.22	0.33	0.19
NMME2	0.32	0.42	0.24

Model	POD	FAR	ETS
GPCC CLM	0.17 (0.27)	0.40 (0.57)	0.15 (0.21)
GPCC S4	0.30 (0.42)	0.47 (0.57)	0.25 (0.29)
ERAI CLM	0.14 (0.25)	0.85 (0.87)	0.09 (0.12)
ERAI S4	0.22 (0.31)	0.82 (0.84)	0.13 (0.14)
ESP	0.16	0.36	0.14
NMME2	0.32	0.42	0.24

POOLING ONE DEGREE GRID CELLS INTO REGIONS


80°N
60°N
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40°S
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WNA
CNA
ENA
CAM
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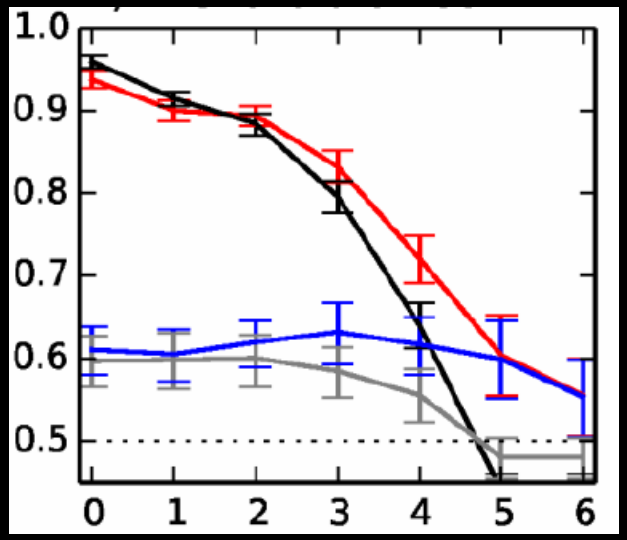
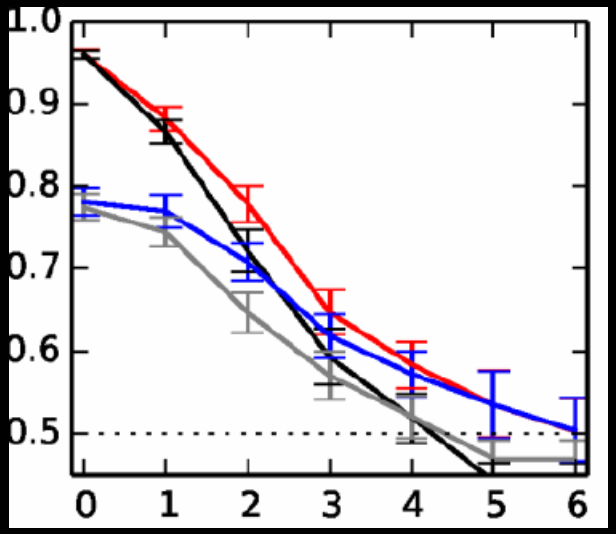
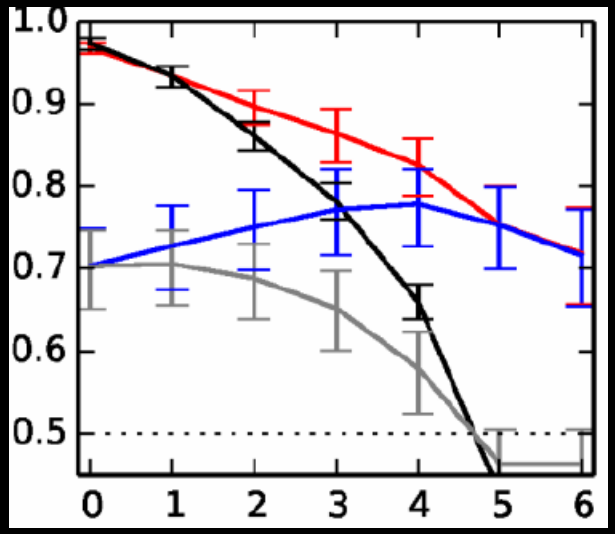
East Africa ROC Score



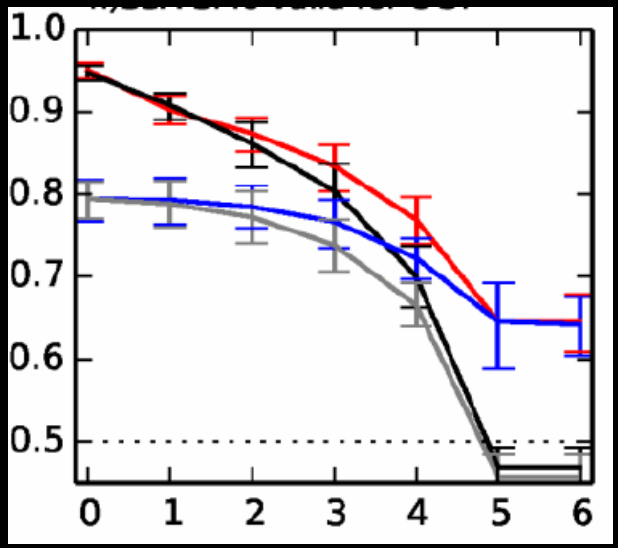
East Asia (China) ROC Score



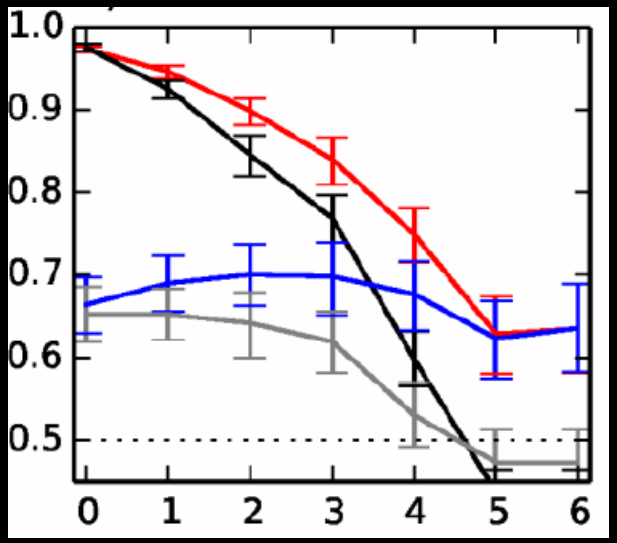
Southeast Asia ROC Score



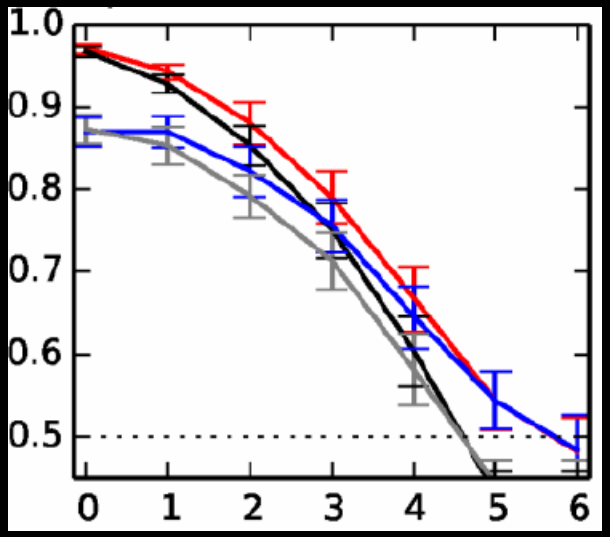
Southern South America ROC Score

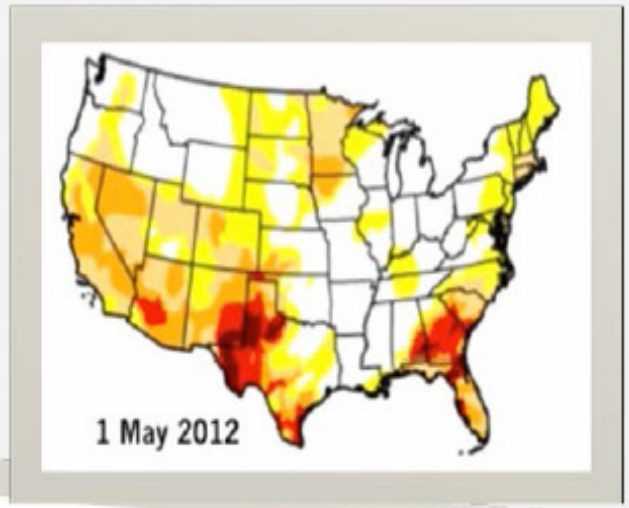


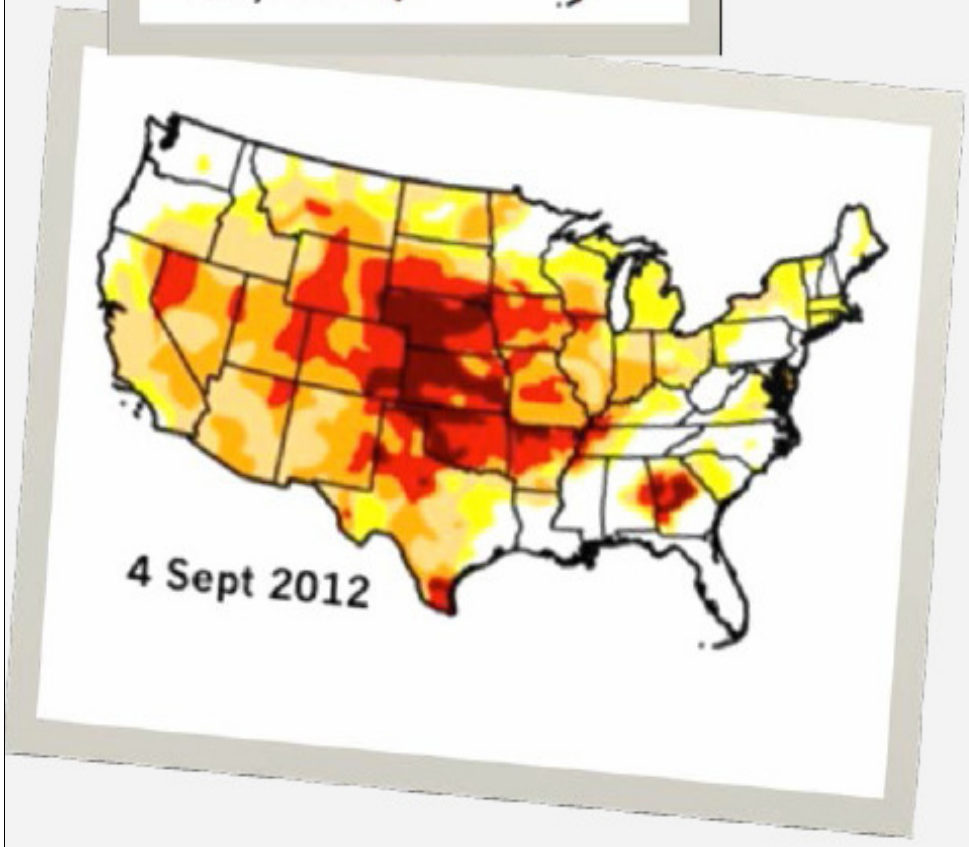
Amazon (Northern South America) ROC Scores



Mediterranean ROC Scores







Research questions:

- *When did the drought become apparent?*
- *Which systems first/best detected it and why?*
- *What caused the 2012 Central Great Plains Drought?*
- Was it predictable and on which timescales?
- Which prediction systems forecasted the event?
- Are we making progress in our capability to monitor/predict such events?