A Land Data Assimilation System for Famine Early Warning

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NASA ASP Water Resources PI Team Meeting
September 6, 2012 – NASA Ames Research Center

U.S. Department of the Interior
U.S. Geological Survey

Famine Early Warning Systems Network

An activity of the Office of Food for Peace at USAID, which directly supports its goal:

"*to ensure that appropriate… emergency food aid is provided to the right people in the right places at the right time and in the right way*"

FEWS NET is a food security

<u>decision support system</u>

with its own <u>climate services</u>

FEWS NET Implementing Partners

Chemonics International
(Prime Contractor)

US Agency for International
Development (USAID)
Office of Food for Peace

USGS EROS

University of California,
Santa Barbara (UCSB)

FEWS NET
FAMINE EARLY WARNING SYSTEMS NETWORK

NOAA CPC, NOHRSC, ESRL

NASA GSFC

USDA FAS

FEWS NET Land Data Assimilation System

- Early detection and monitoring of agricultural drought
- Characteristically data-sparse, with heavy reliance on satellite observations and atmospheric model analyses and forecasts
- An instance of LIS specifically for the domains, data streams, and monitoring - forecast requirements of FEWS NET
- Ready integration of gridded satellite observations and climate model forcings

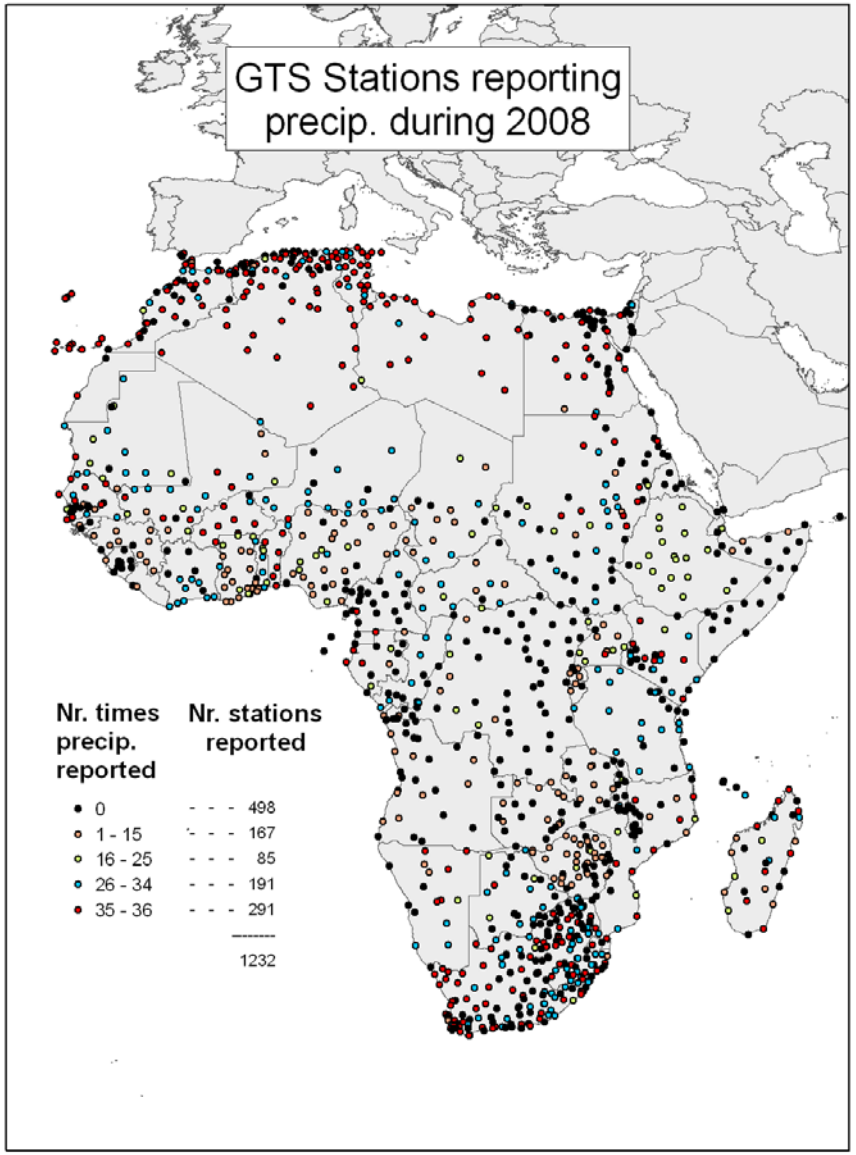
Gaps: Rainfall Station Reporting

Systematic sample on the 1st, 11th, and 21st of month

Of the 1232 GTS stations in Africa:

25% missed one or zero reports

40% did not report on any of the 36 days of the sample



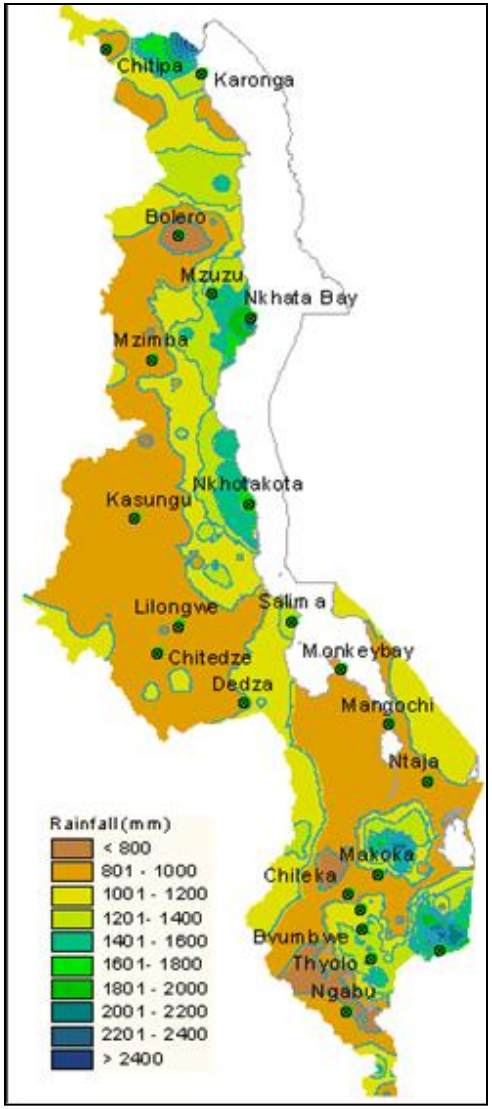
Issues of climate data management, data rescue

USGS

FEWS NET
FAMINE EARLY WARNING SYSTEMS NETWORK

Malawi test case

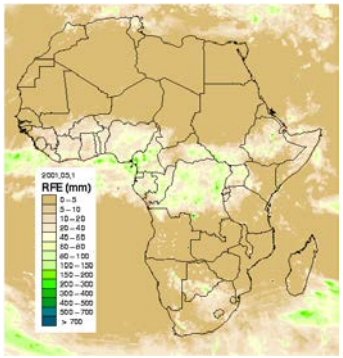
- Ran Noah LSM with default parameters
- Results
  - WRSI better represented agricultural drought than Noah
    - Default Noah vegetation type exaggerated presence of forest
    - Greater rooting depth resulted in reduced drought impact
  - LSM vegetation type and rooting depth must be updated for agricultural monitoring



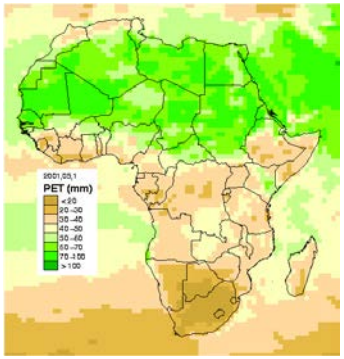
Water requirement satisfaction index (WRSI)

WRSI = f (ppt, pet, WHC, Crop Type, SOS, EOS, LGP)

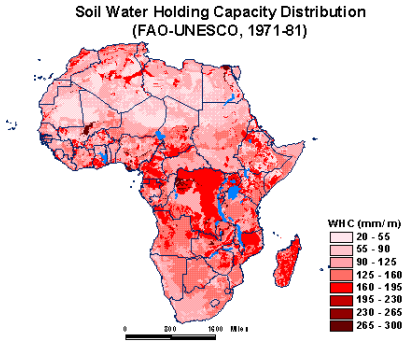
RFE2 (NOAA)



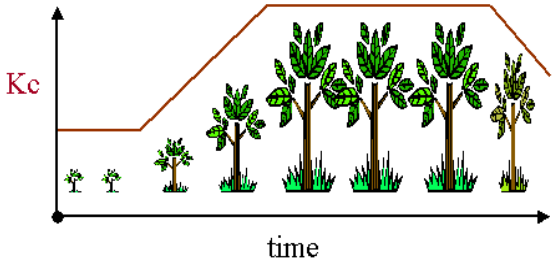
calculated from NOAA GDAS at EROS



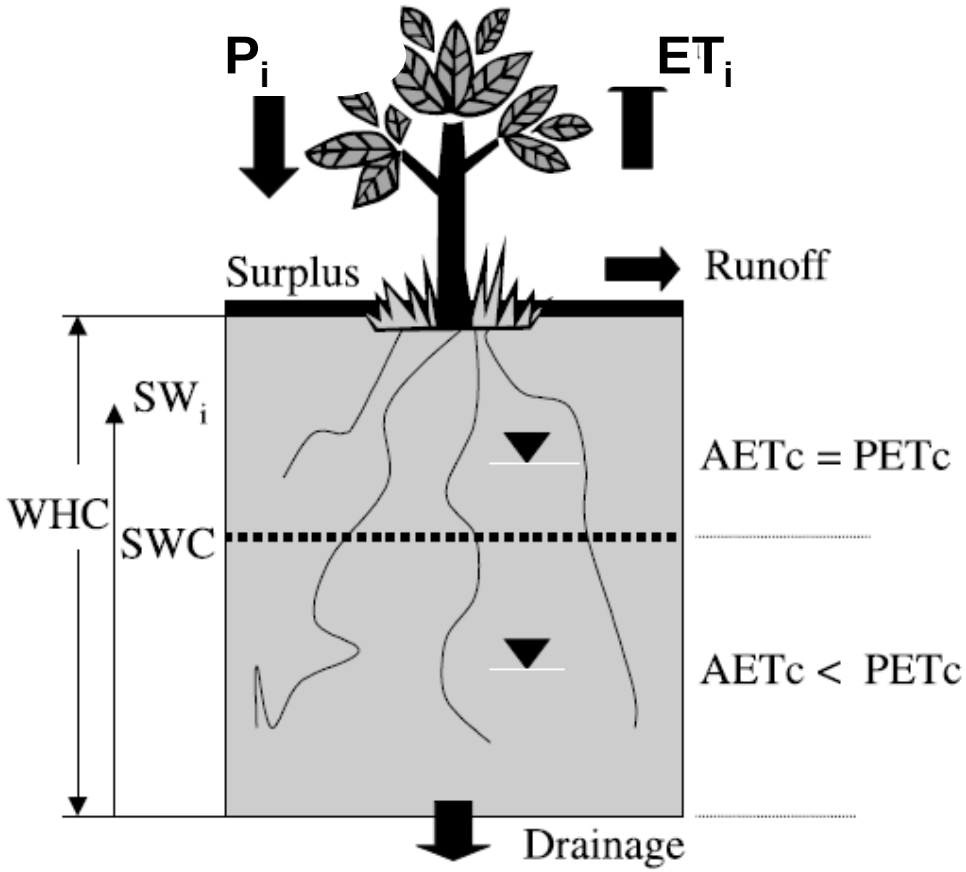
FAO soils map of the world



Kc (FAO)



WRSI – Bucket model



Senay and Verdin (2003)

$$\frac{\overline{dS}}{dt} = \overline{P} - \overline{D} - \overline{E_a} - \overline{Q}$$

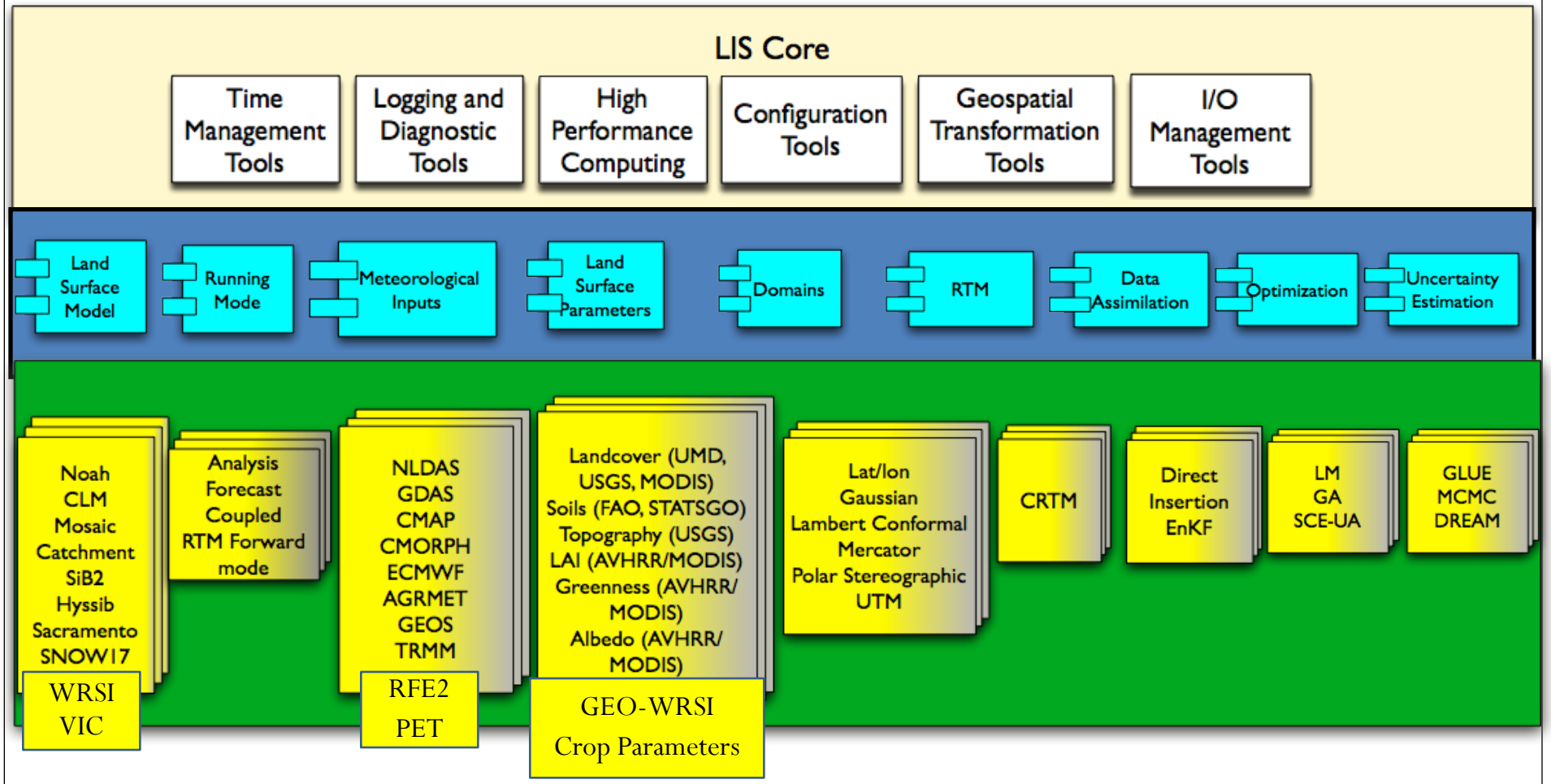
P – Precipitation

D – Deep percolation or drainage

ET – Evapotranspiration

Q - Runoff

LIS Architecture for NASA product-based FEWSNET Land Data Assimilation System (FLDAS)



Kumar, S. V., C. D. Peters-Lidard, Y. Tian, P. R. Houser, J. Geiger, S. Olden, L. Lighty, J. L. Eastman, B. Doty, P. Dirmeyer, J. Adams, K. Mitchell, E. F. Wood and J. Sheffield, 2006. Land Information System - An Interoperable Framework for High Resolution Land Surface Modeling. *Environmental Modelling & Software,* Vol. 21, 1402-1415.

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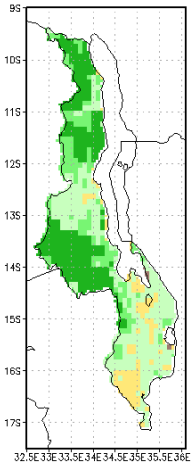
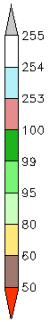
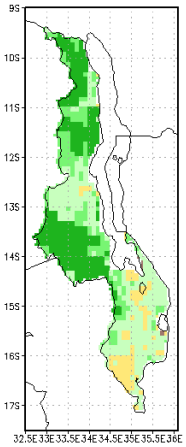
WRSI Implementation Benchmark - Spatial

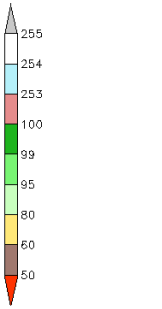
GEO- WRSI | FLDAS-WRSI | Difference

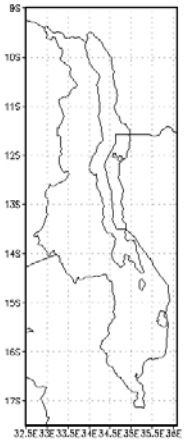
eosWRSI



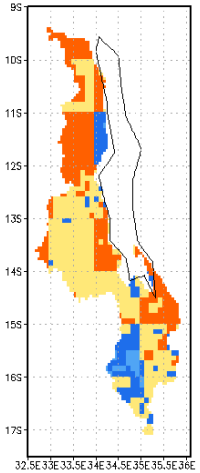


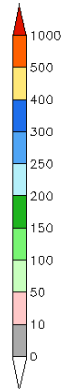


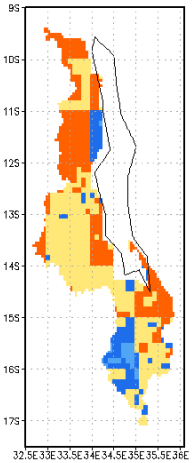


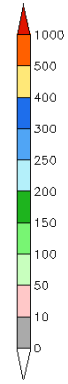


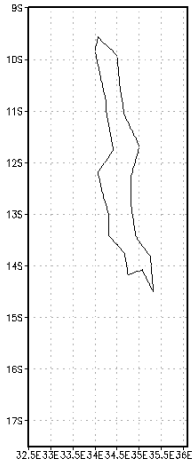
eosSumET











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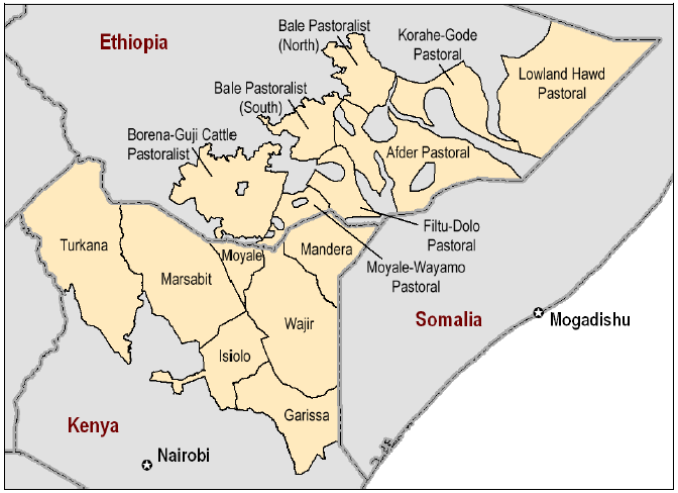
Lessons Learned in 2011

- **Current season monitoring with MODIS NDVI, NOAA RFE, and MODIS LST (for ET) is robust**
- **Historical drought is not well characterized**
  - **A long term (~30 yr) precipitation data set needed**
  - **Then, force FLDAS WRSI to give a 30-yr drought chronology**
  - **FLDAS WRSI, forced with bootstrapped precipitation, and used with yield reduction functions, will give hundreds of agricultural drought outcomes**
  - **Use these to build loss exceedence curves, a fundamental tool of risk management and reduction**
- **Seasonal forecasts used only indirectly to infer agricultural outcomes**
  - **FLDAS will make possible direct use of climate model forecasts**

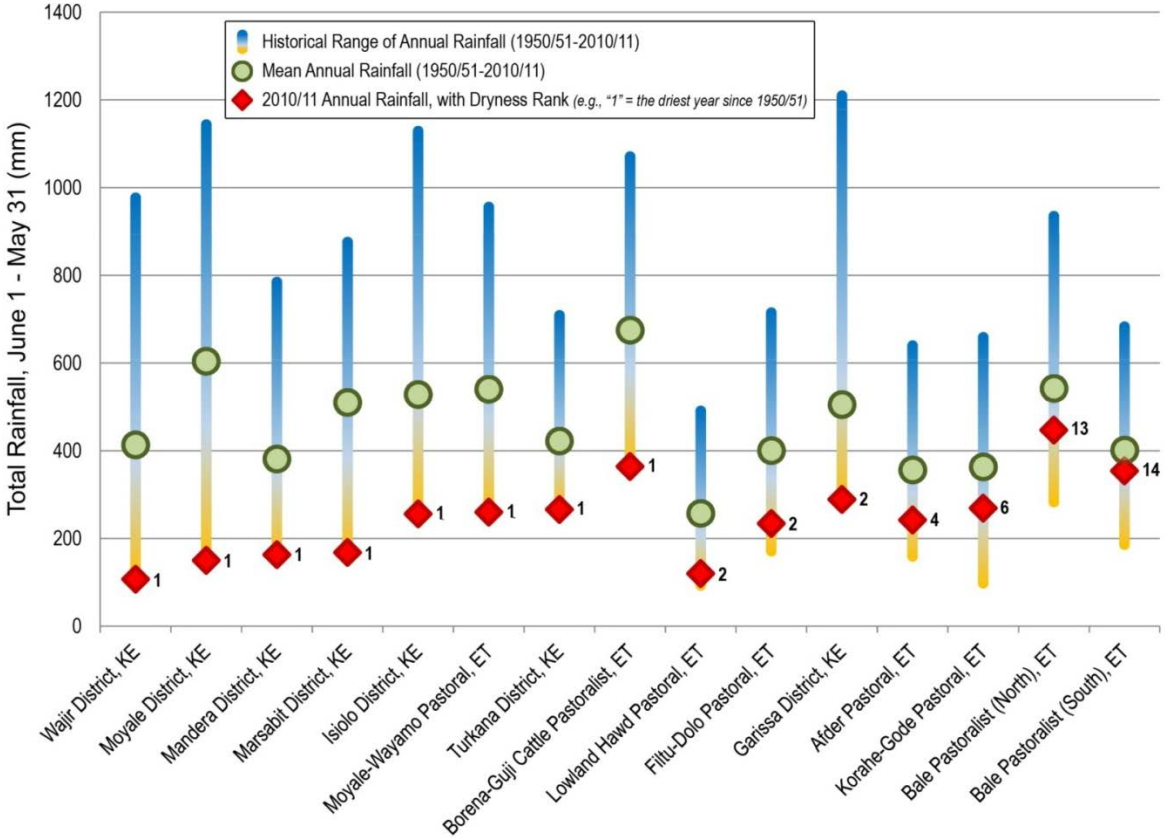
Declaration of Worst Drought in 60 Years

Figure 1. Selected drought-affected pastoral areas of northern Kenya and southern Ethiopia.



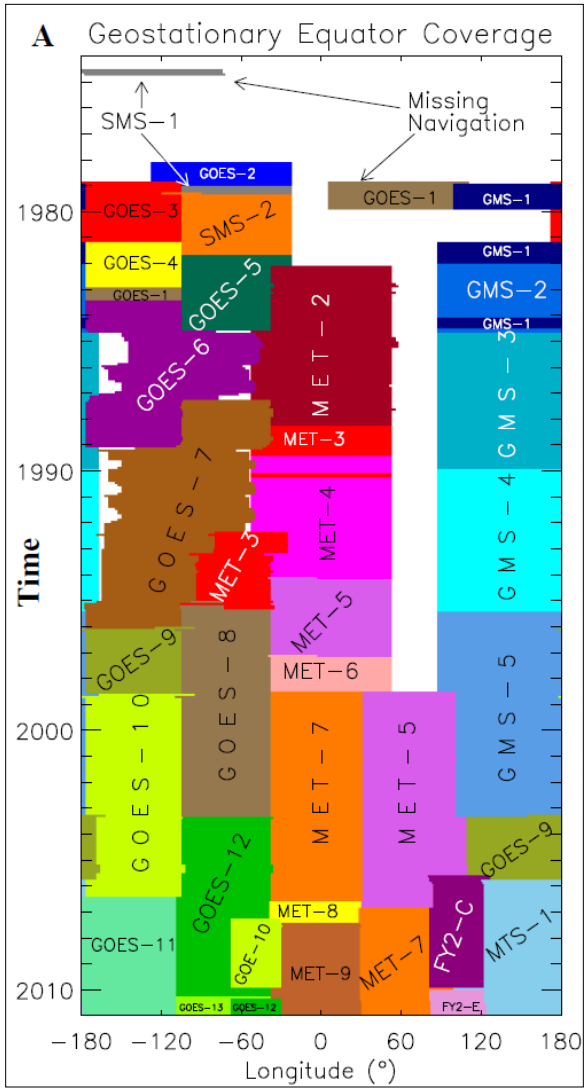
Chris Funk, USGS

2010/11 rainfall compared to historical totals since 1950/51 in select pastoral areas of Kenya and Ethiopia

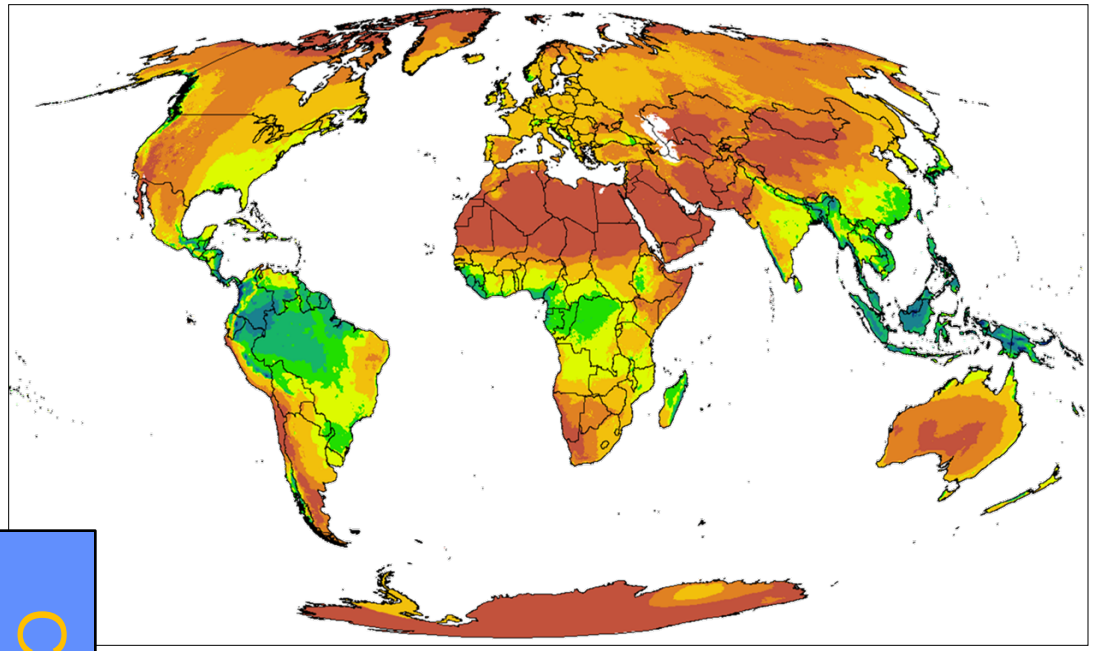


Source: *FEWS NET*

B1 InfraRed Precipitation (BIRP)



B1 (Ken Knapp, NOAA)



CPC IR

FEWS NET Climatology (FCLIM) @ 0.05°

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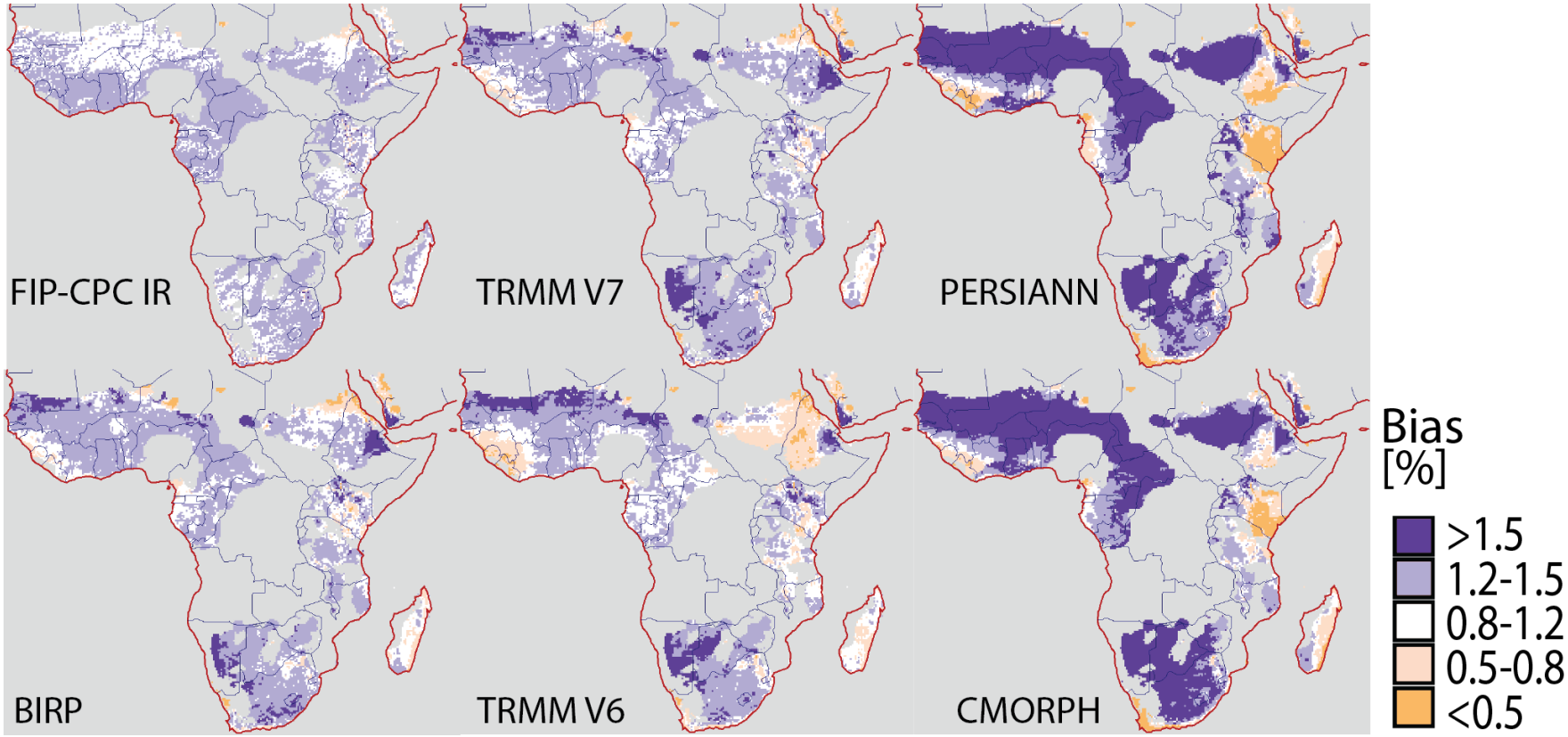
September 6, 2012 – NASA Ames Research Center

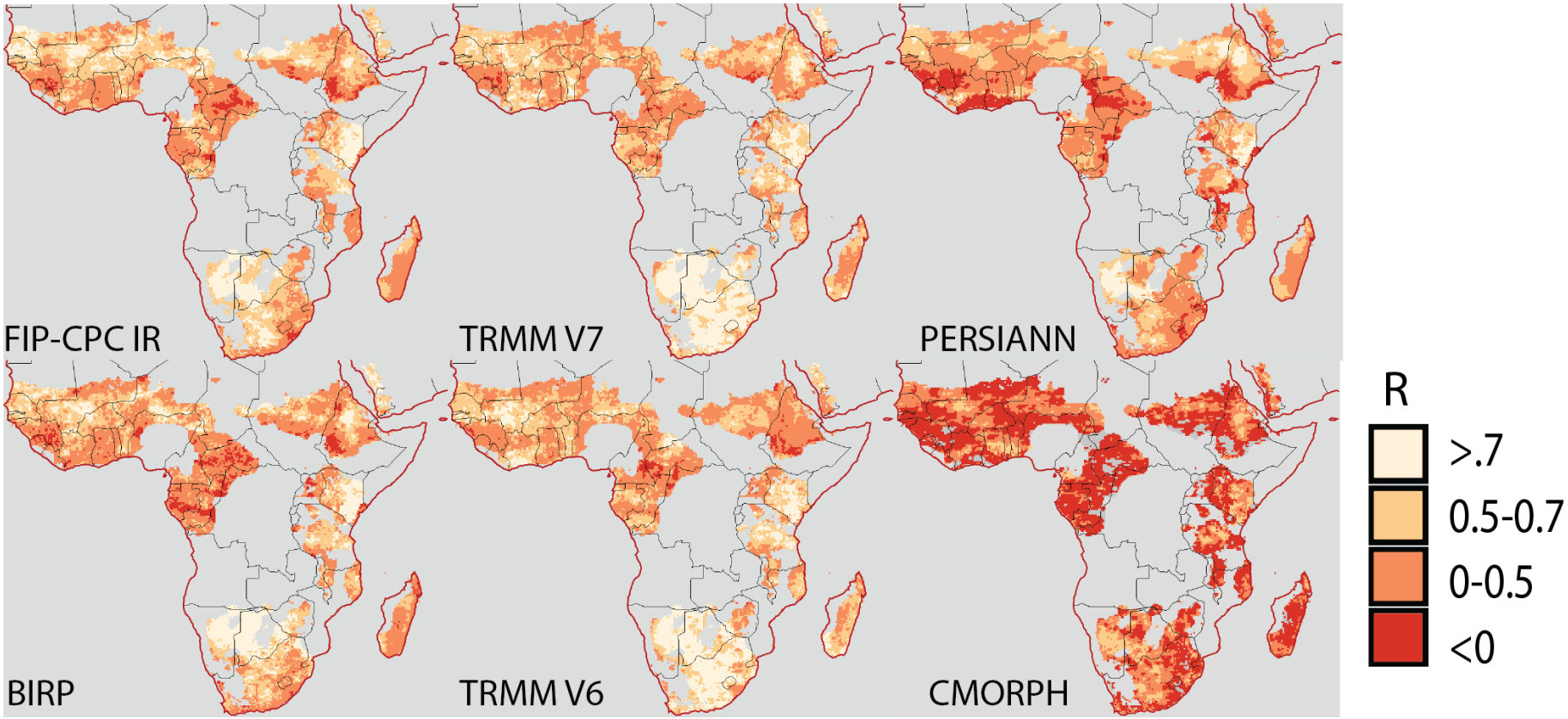
FEWS NET FAMINE EARLY WARNING SYSTEMS NETWORK

Main growing season mean bias maps

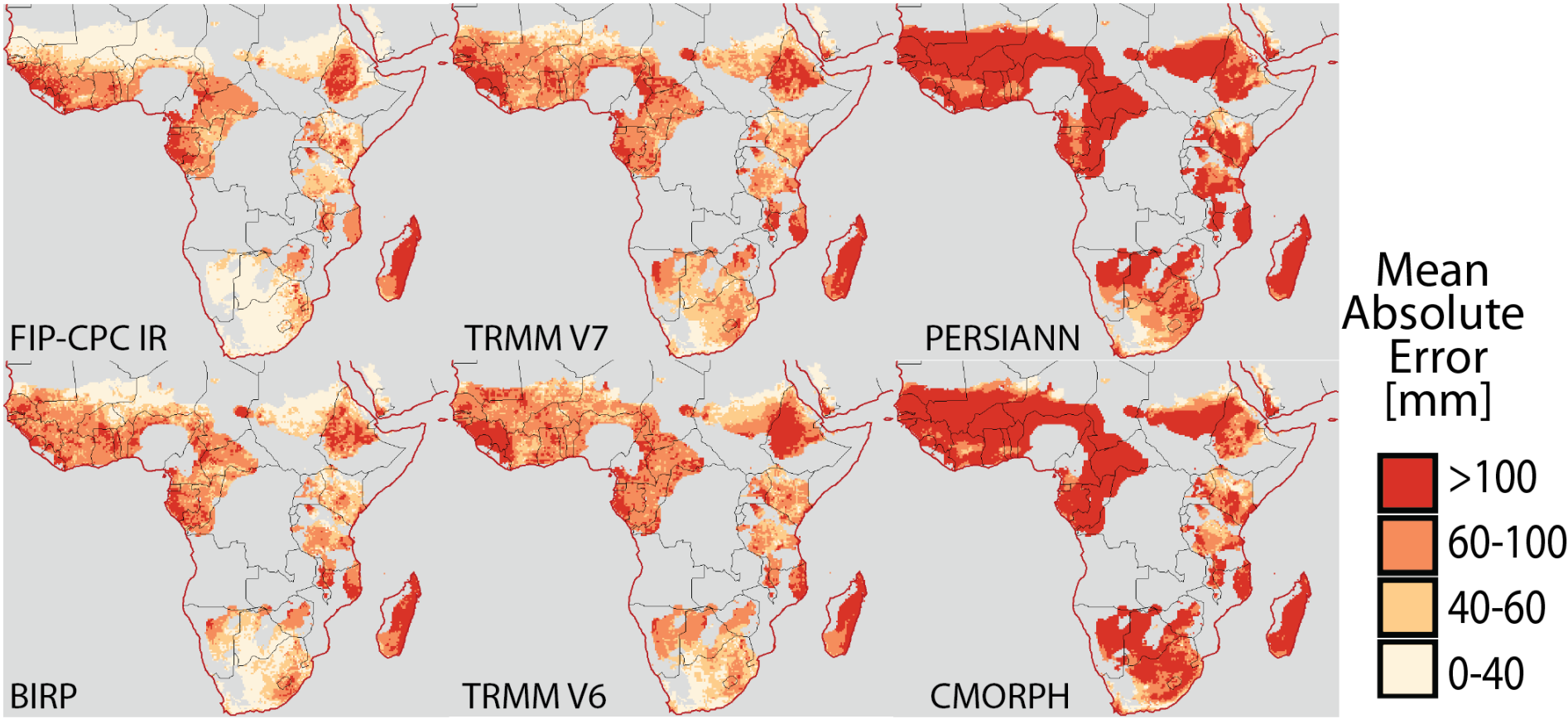


Data masked if mean rainfall < 50 mm or average kriging error > 40%

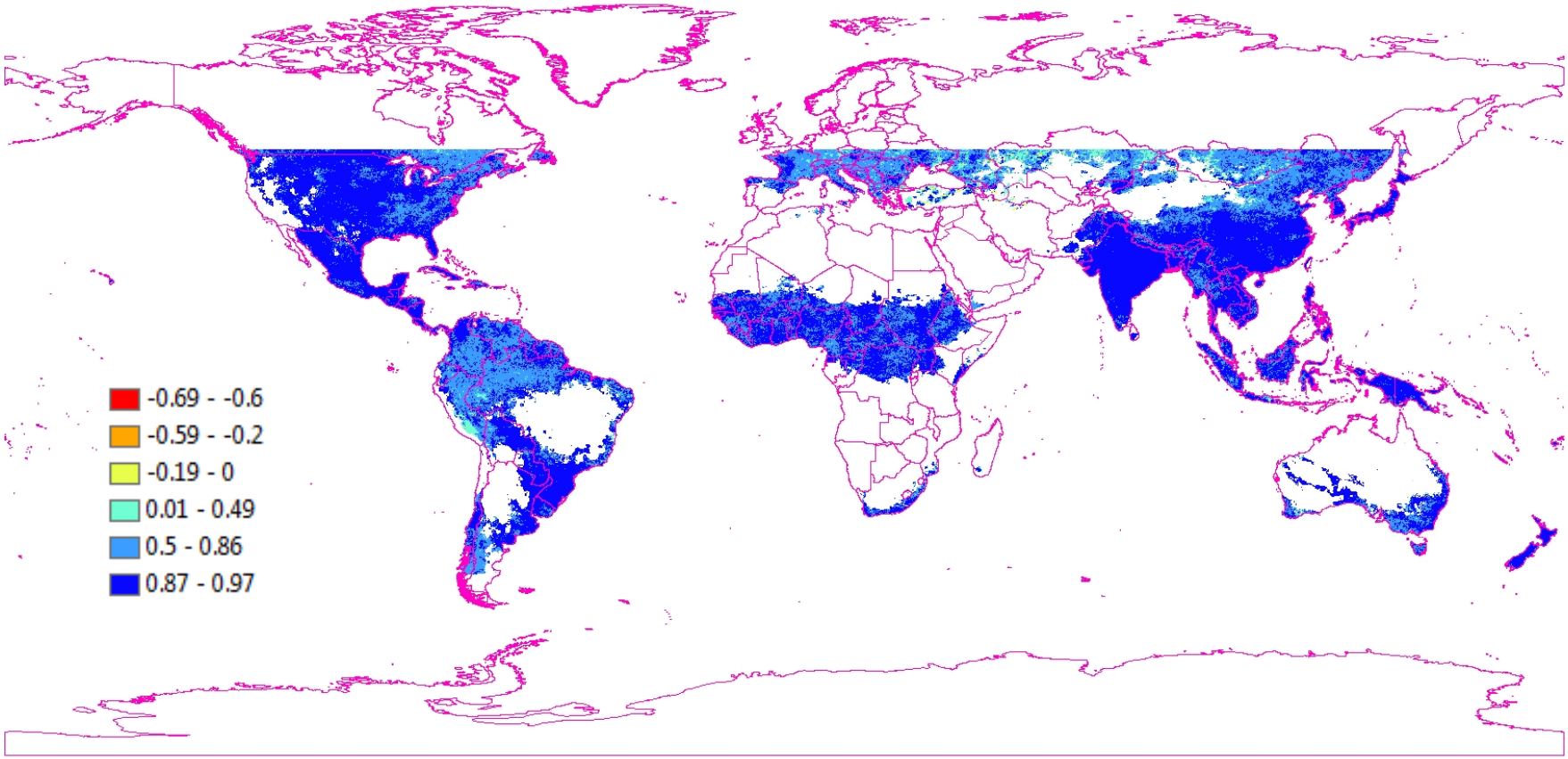
Main growing season correlation maps



Main growing season mean absolute error maps



Correlation coefficient, pent 01 Jul



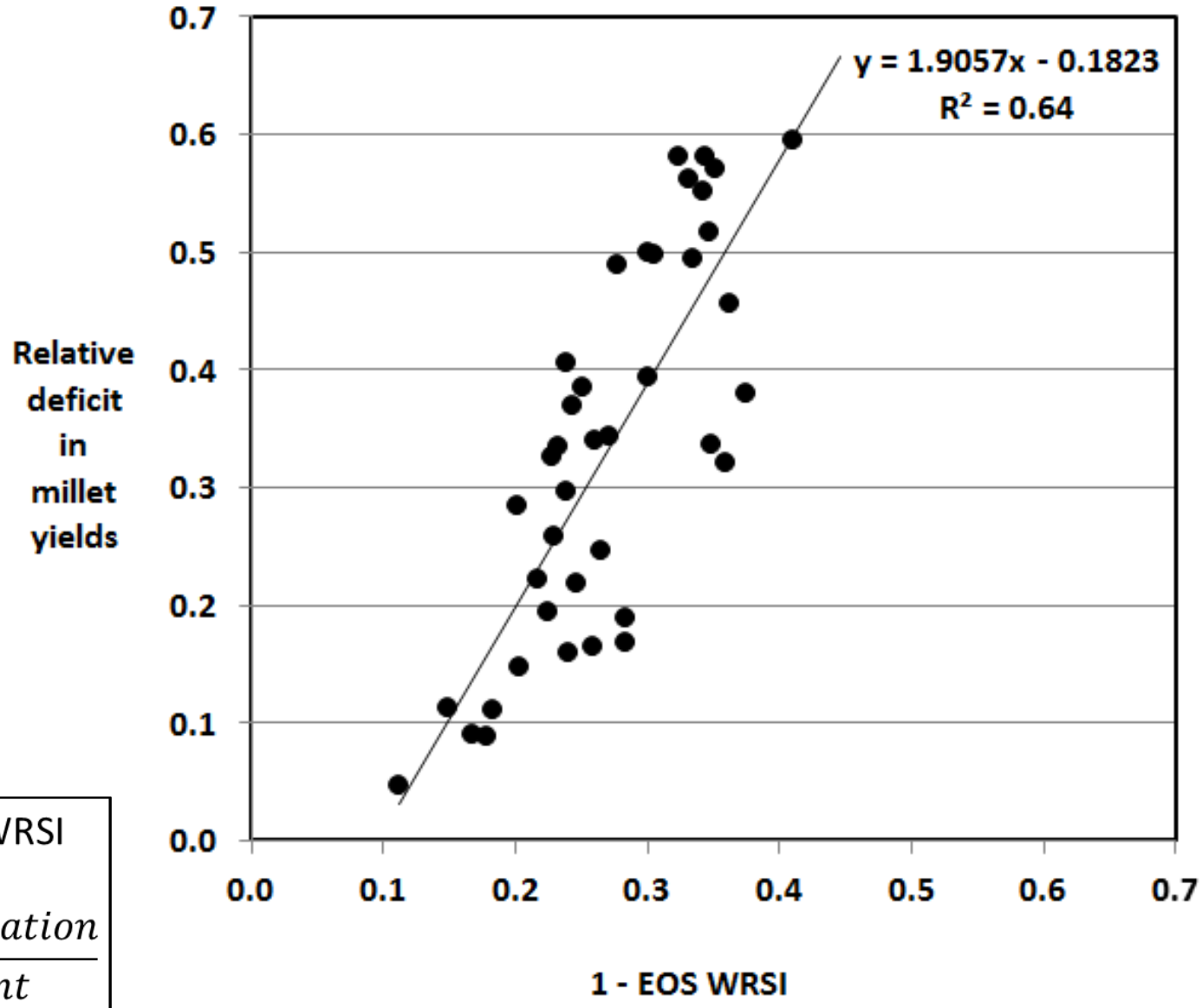
Millet vulnerability model - Niger

Relative yield deficit

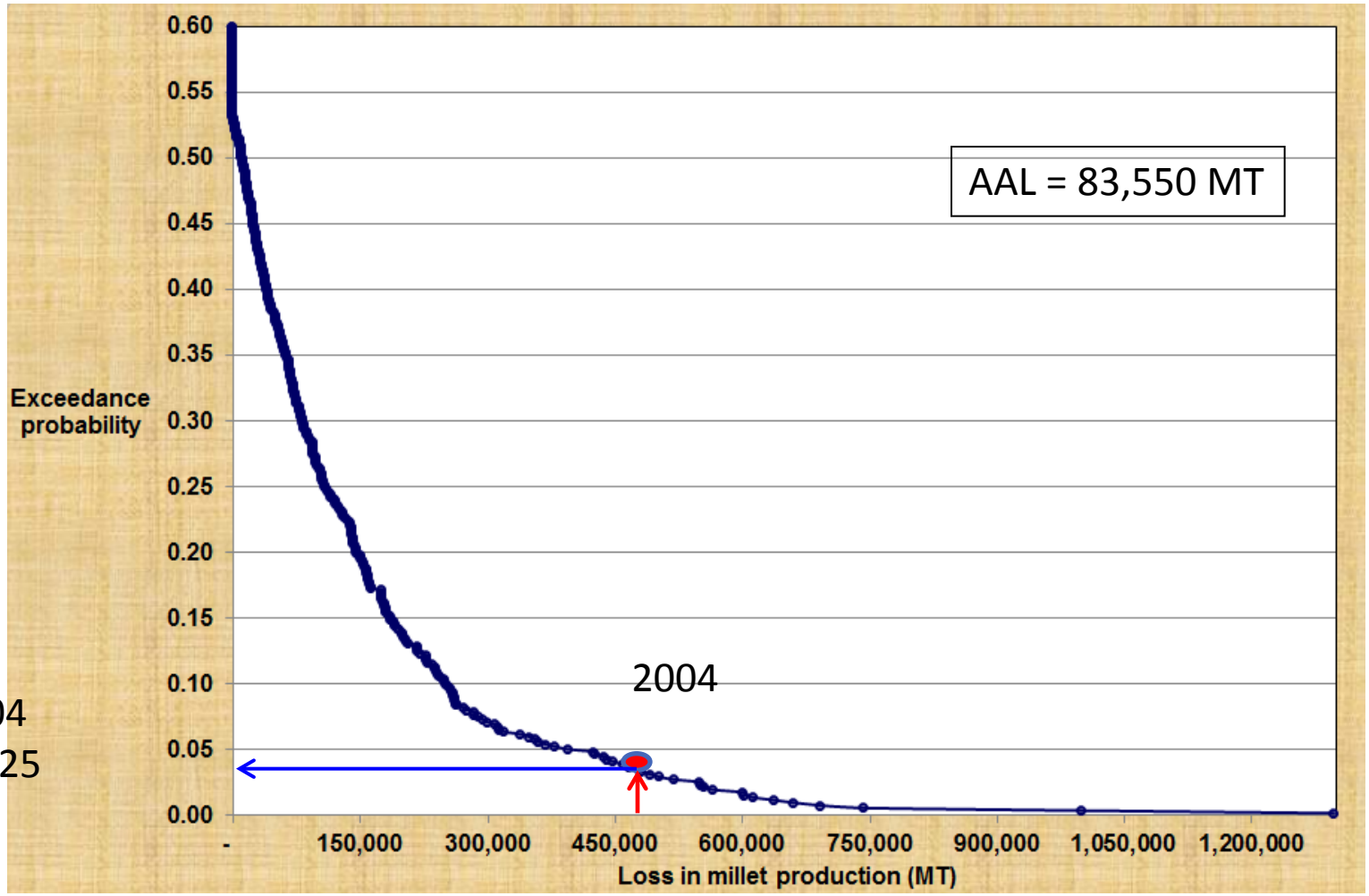
$$\frac{Y_{reference} - Yac_{tual}}{Y_{reference}}$$

End-of-season (EOS) WRSI

$$\frac{Actual\ evapotranspiration}{Water\ requirement}$$



Loss exceedence curve for millet



EP = 0.04
or 1 in 25

Recent FLDAS Accomplishments

•Completed integration of RFE2 and USGS PET readers in LIS6.x

•Completed integration and testing of WRSI and VIC4.1.1 in LIS6.x

•Began testing of LIS/WRSI and LIS/VIC for FEWS-NET historical period in East Africa.

- FLDAS (LIS-WRSI) East Africa End of Season WRSI Benchmark 2009-2010 season. Compared to FEWS-NET archive and GeoWRSI
- FLDAS East Africa SWI and SOS Benchmarks 2009-2010 season
- VIC benchmark for Africa. The triangle and diamond locations and time series correspond to unstressed and stressed areas from East Africa WRSI run.

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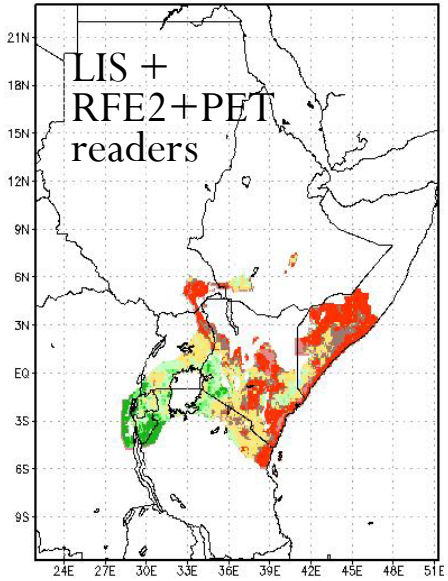
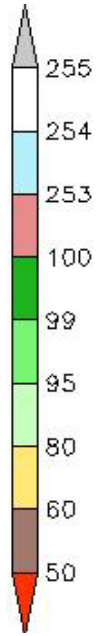
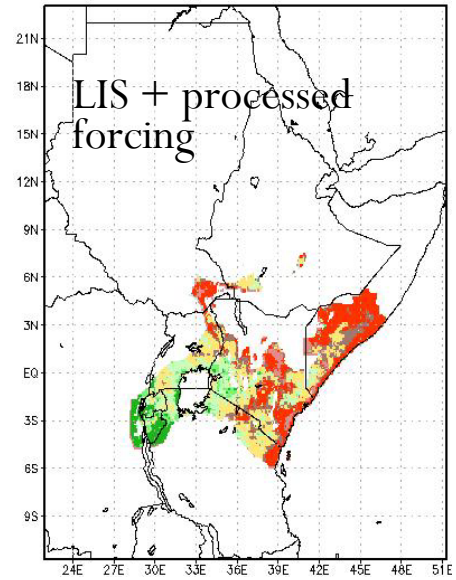
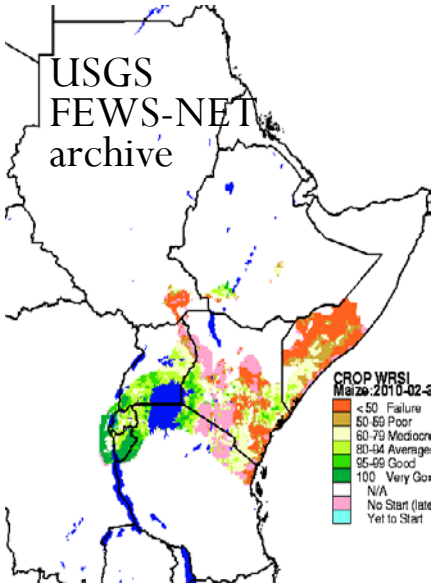
FLDAS East Africa Benchmark: 2009-2010 Oct-Feb End-of-season WRSI



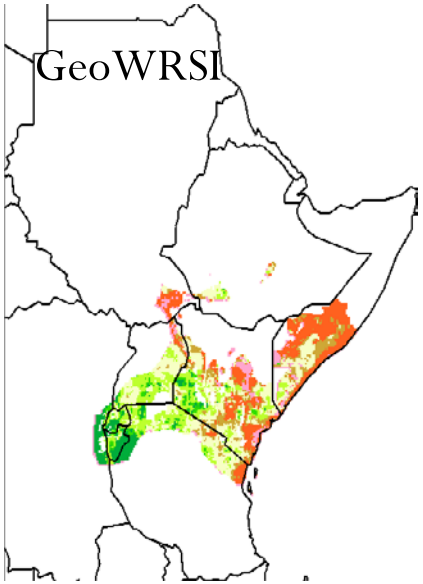






WRSI

- < 50 Failure
- 50 - 60 Poor
- 60 - 80 Mediocre
- 80 - 95 Average
- 95 - 99 Good
- 99-100 Very Good
- N/A
- No Start
- Yet to Start



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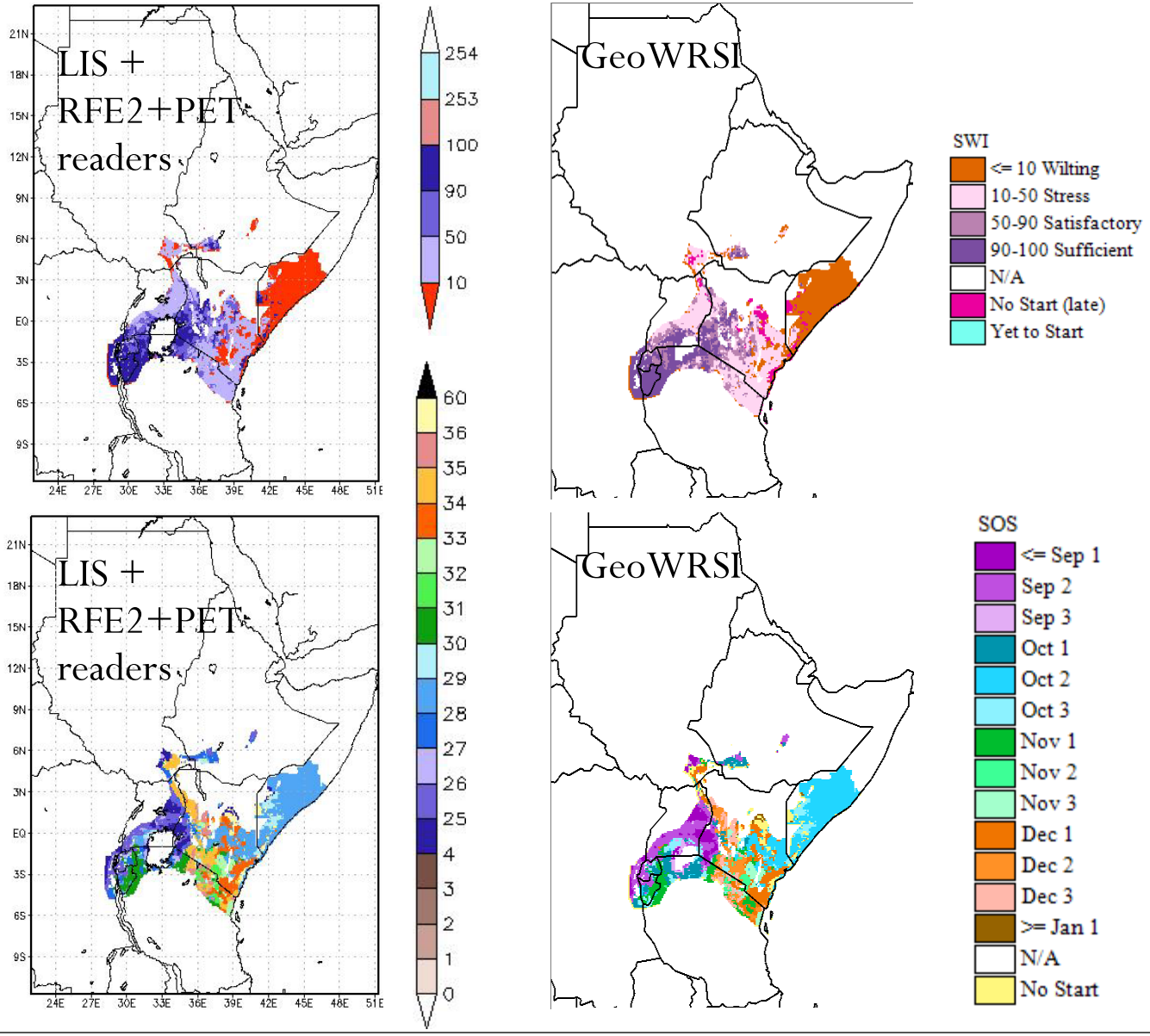
FLDAS East Africa Benchmark: 2009-2010
Oct-Feb End-of-season SWI and SOS

SWI

SOS



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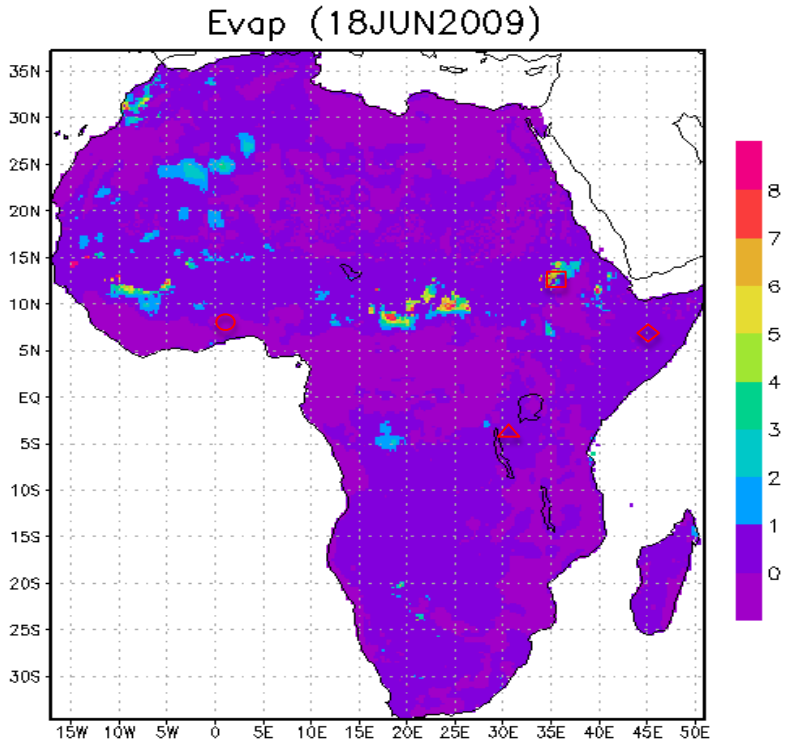
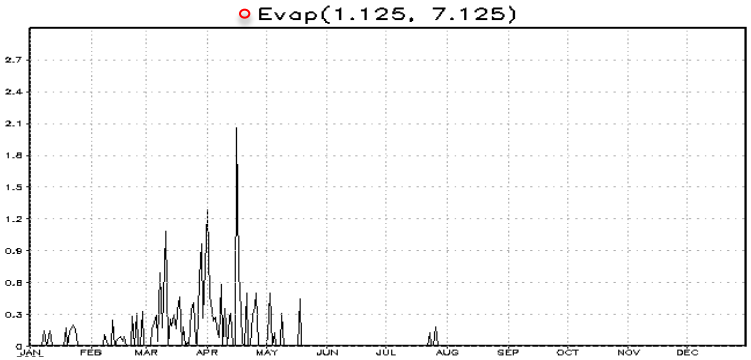
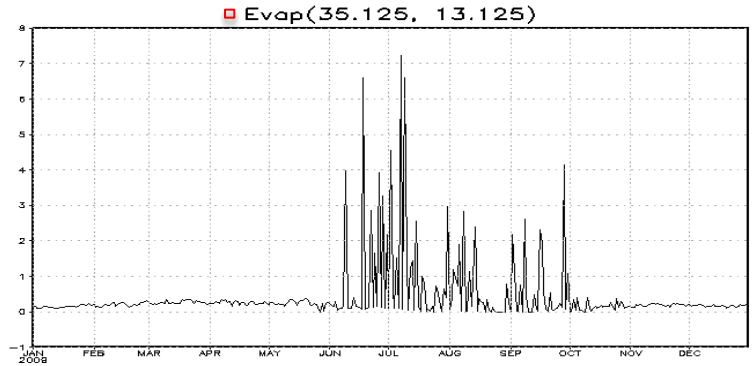
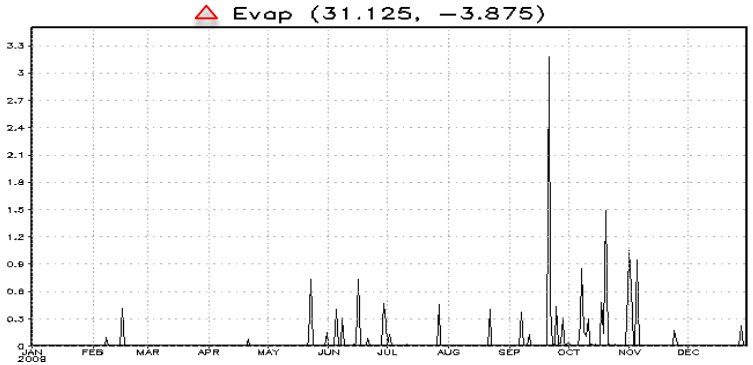
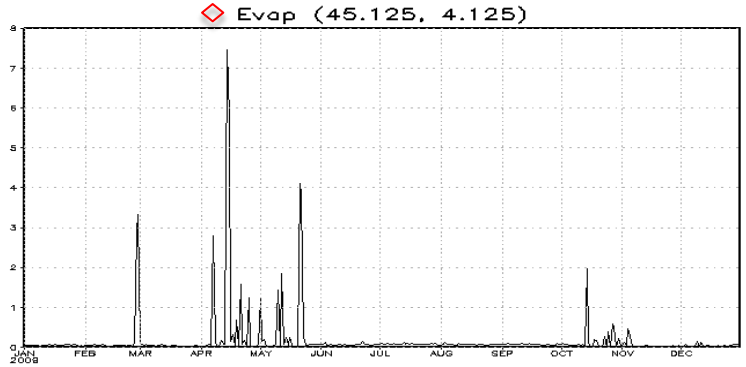
VIC Africa Benchmarking











Thank you