Earth Observations for Early Detection of Agricultural Drought in Countries at Risk:

Contributions of the Famine Early Warning Systems Network

Jim Verdin[1], Chris Funk[1,2], Diego Pedreros[1,2], Gabriel Senay[1], Jim Rowland[1], Greg Husak[2], Hari Jayanthi[1]

1. USGS Earth Resources Observation and Science Center

2. Climate Hazards Group, University of California, Santa Barbara

Drought-stunted maize, Kenya, 2002

USGS

Food Security, Earth Observations and Agricultural Monitoring
November 21, 2013 – Brussels

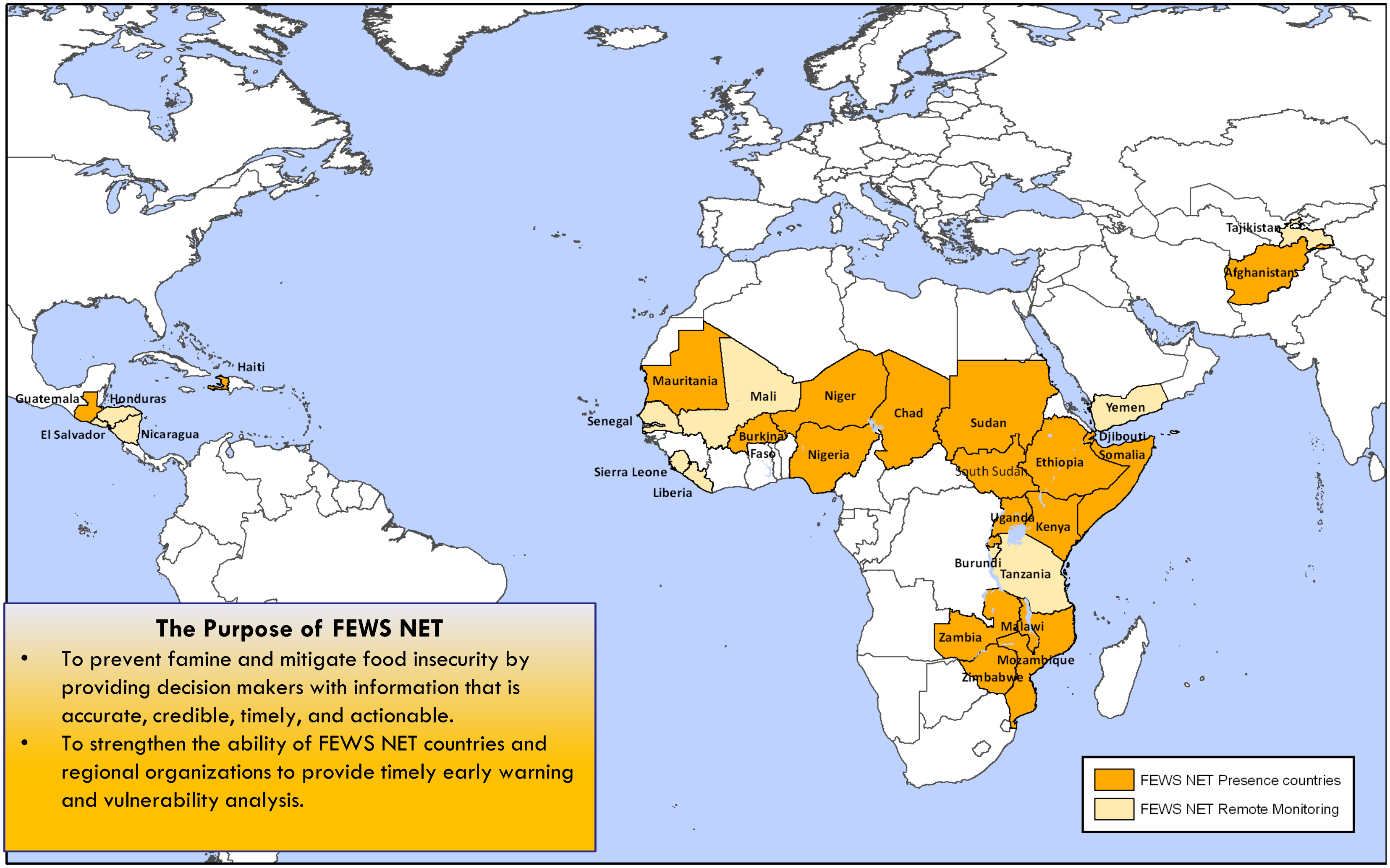
FEWS NET
FAMINE EARLY WARNING SYSTEMS NETWORK

Famine Early Warning Systems Network

An activity of the USAID Office of Food for Peace supporting 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*”

The FEWS NET World



The Purpose of FEWS NET

- To prevent famine and mitigate food insecurity by providing decision makers with information that is accurate, credible, timely, and actionable.
- To strengthen the ability of FEWS NET countries and regional organizations to provide timely early warning and vulnerability analysis.

USGS

Food Security, Earth Observations and Agricultural Monitoring
November 21, 2013 – Brussels

FEWS NET
FAMINE EARLY WARNING SYSTEMS NETWORK

Famine Early Warning Systems Network

- Livelihood systems are based on subsistence agriculture and/or pastoralism, and are highly climate-sensitive
- Conventional climate station networks are sparse and/or late reporting
- Satellite remote sensing and models fill the gap, and provide the basis for early detection of agricultural drought

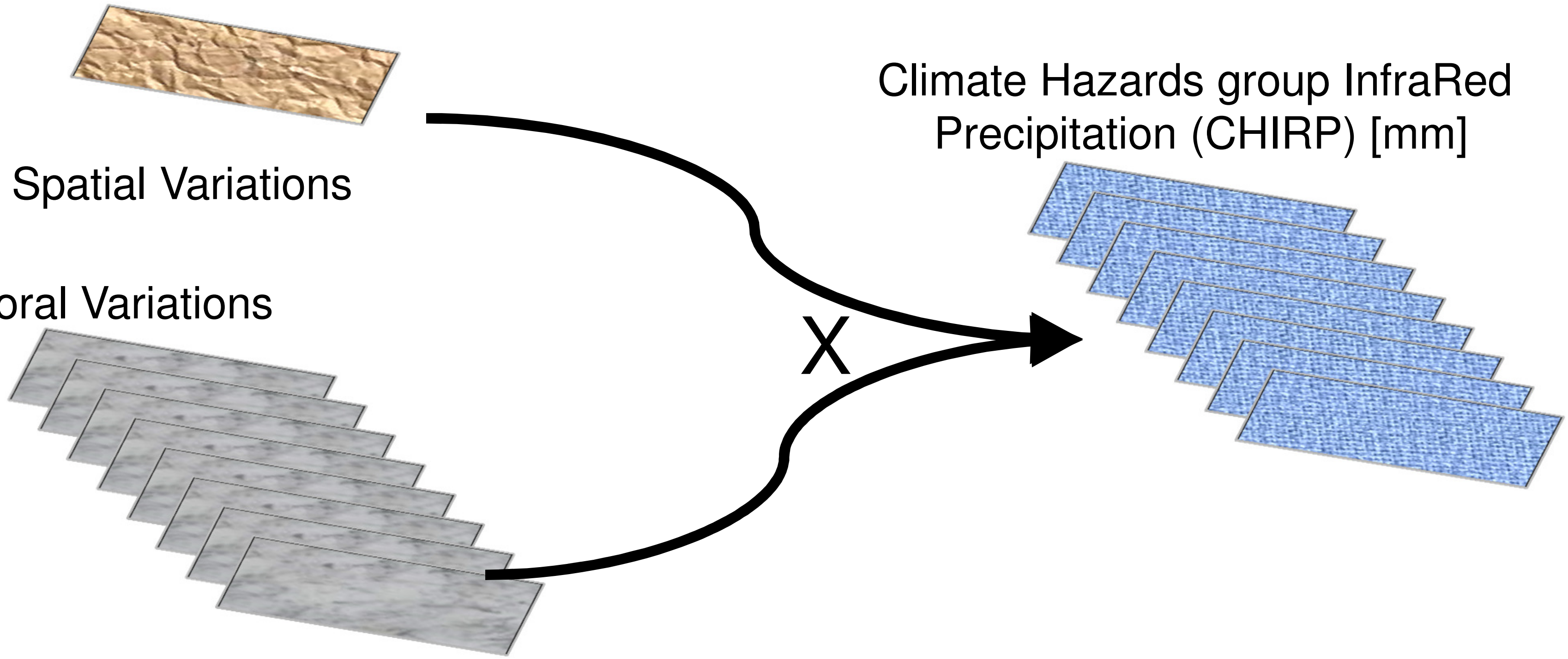
UCSB Climate Hazard Group Rainfall Estimation

Climate Hazards Group Climatology [mm]

Mean Spatial Variations

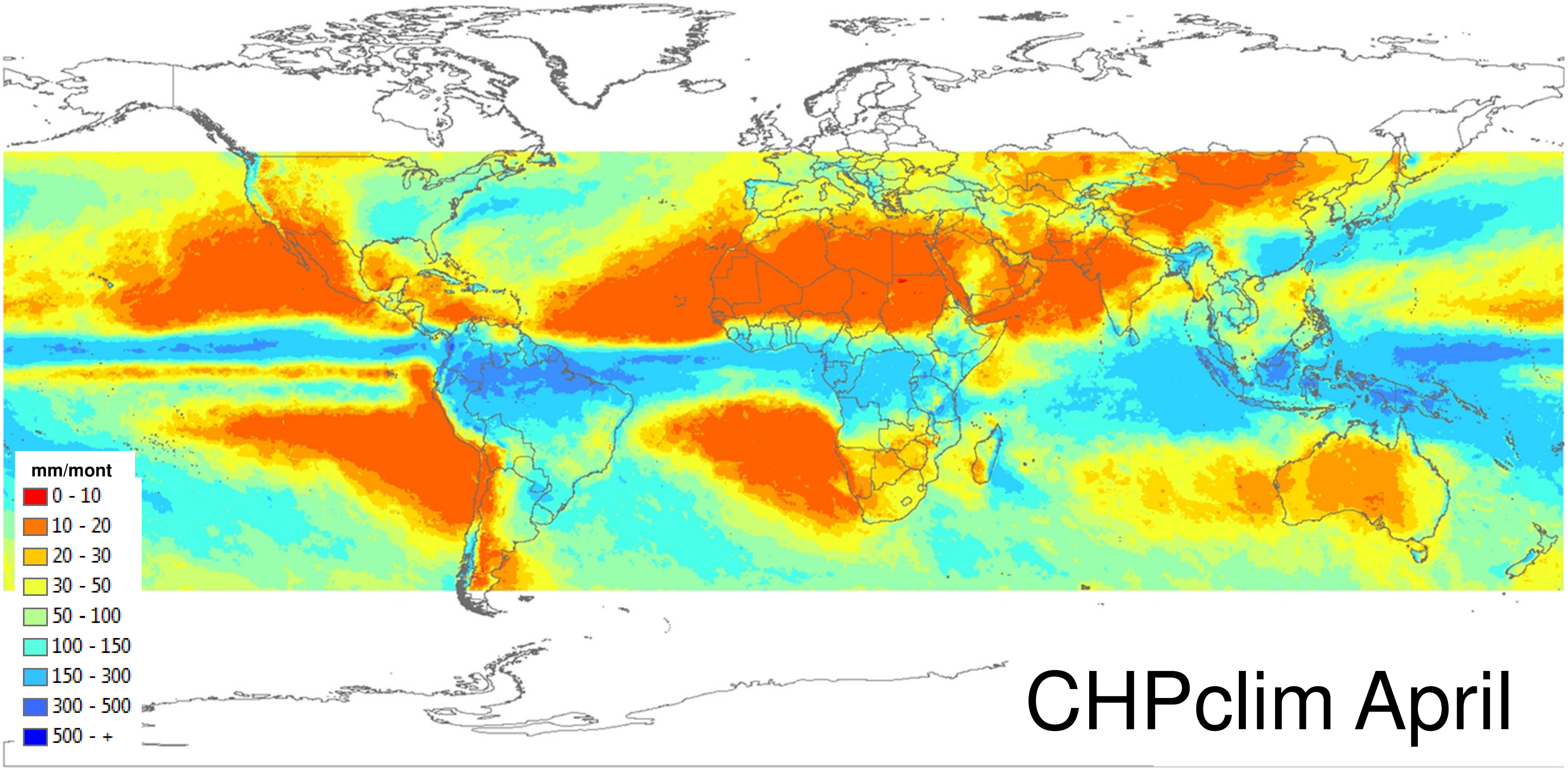
Temporal Variations

Climate Hazards group InfraRed Precipitation (CHIRP) [mm]



Cold Cloud Duration Precipitation Anomalies [%]

The CHG Precipitation Climatology



USGS

Food Security, Earth Observations and Agricultural Monitoring
November 21, 2013 – Brussels

FEWS NET
FAMINE EARLY WARNING SYSTEMS NETWORK

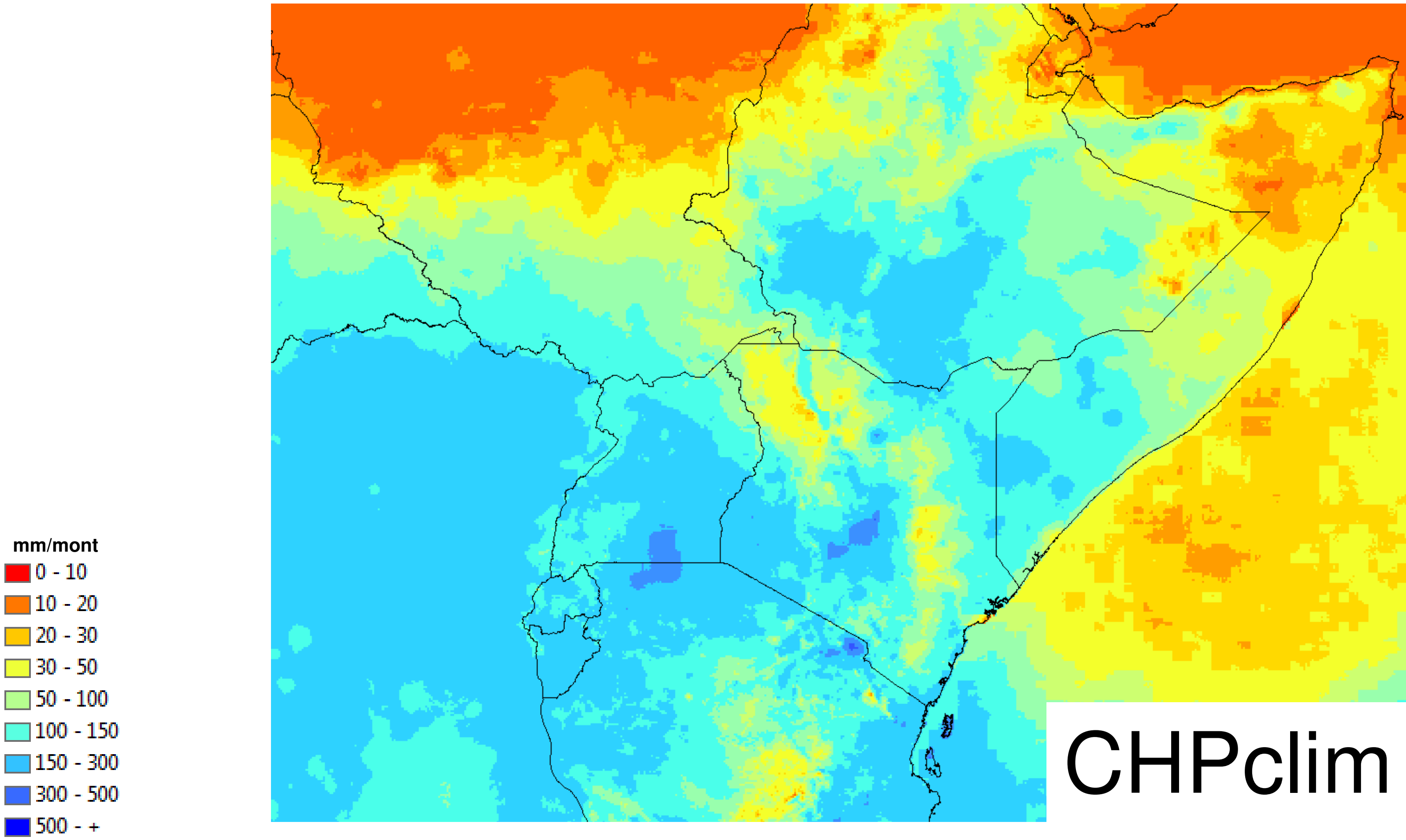
CHG Station Database

CHG climatology based on UN Food and Agriculture Organization (FAO) and Global Historical Climate Network (GHCN) precipitation normals, 1980-2009 baseline.

Gridded Climatology
Moving Window Regression - Predictors

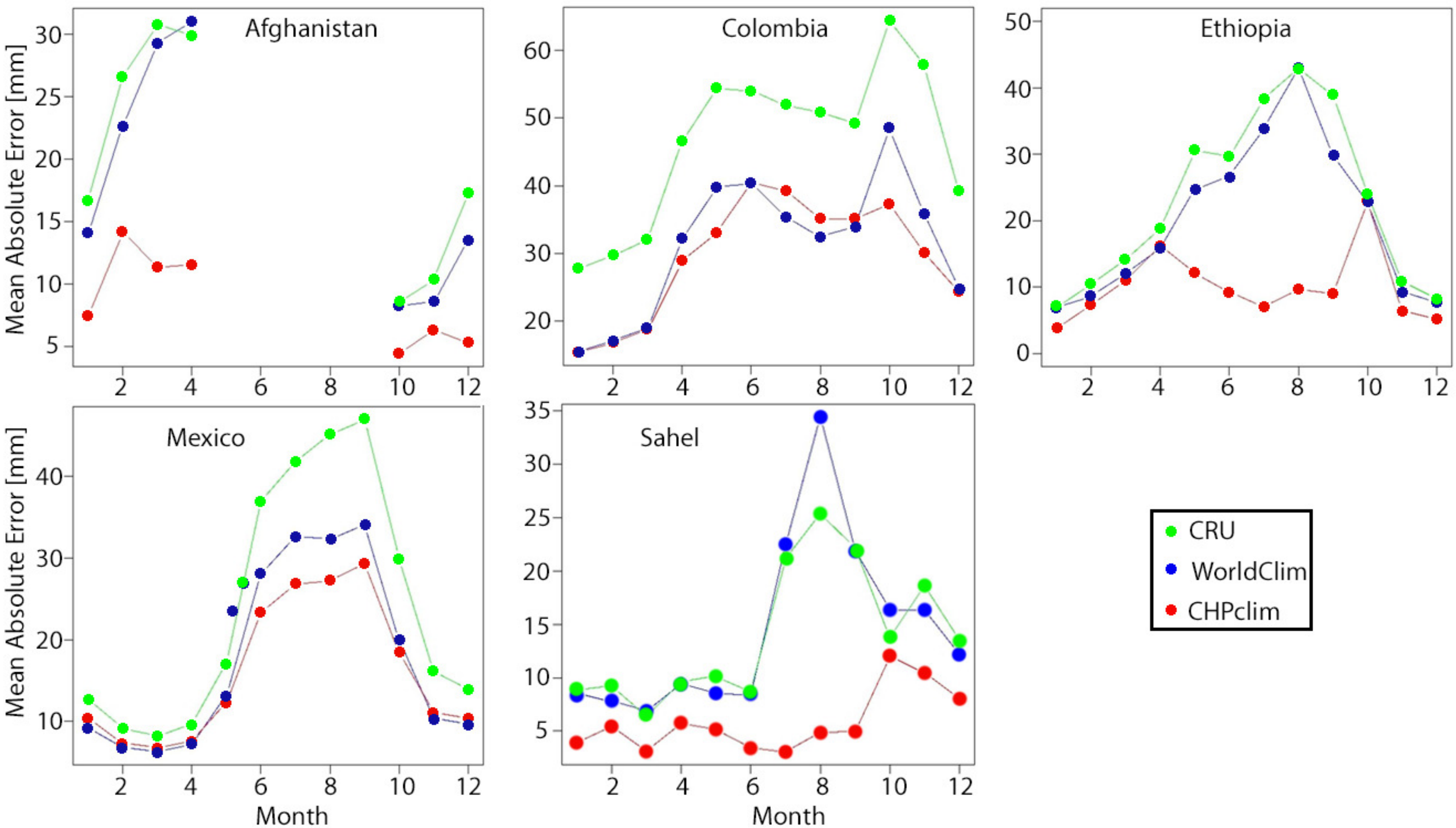
- Physiographic Predictors
  - Latitude, Longitude, Digital Elevation Model, Slope
- Satellite mean fields
  - CMORPH mean precipitation
  - Tropical Rainfall Monitoring Mission (TRMM) mean precipitation
  - MODIS mean Land Surface Temperatures
- Global (50°N-50°S), 0.05° resolution, monthly

The CHG Precipitation Climatology



CHPclim April

Mean absolute error time series [mm $month^{-1}$]



Geostationary IR Composites

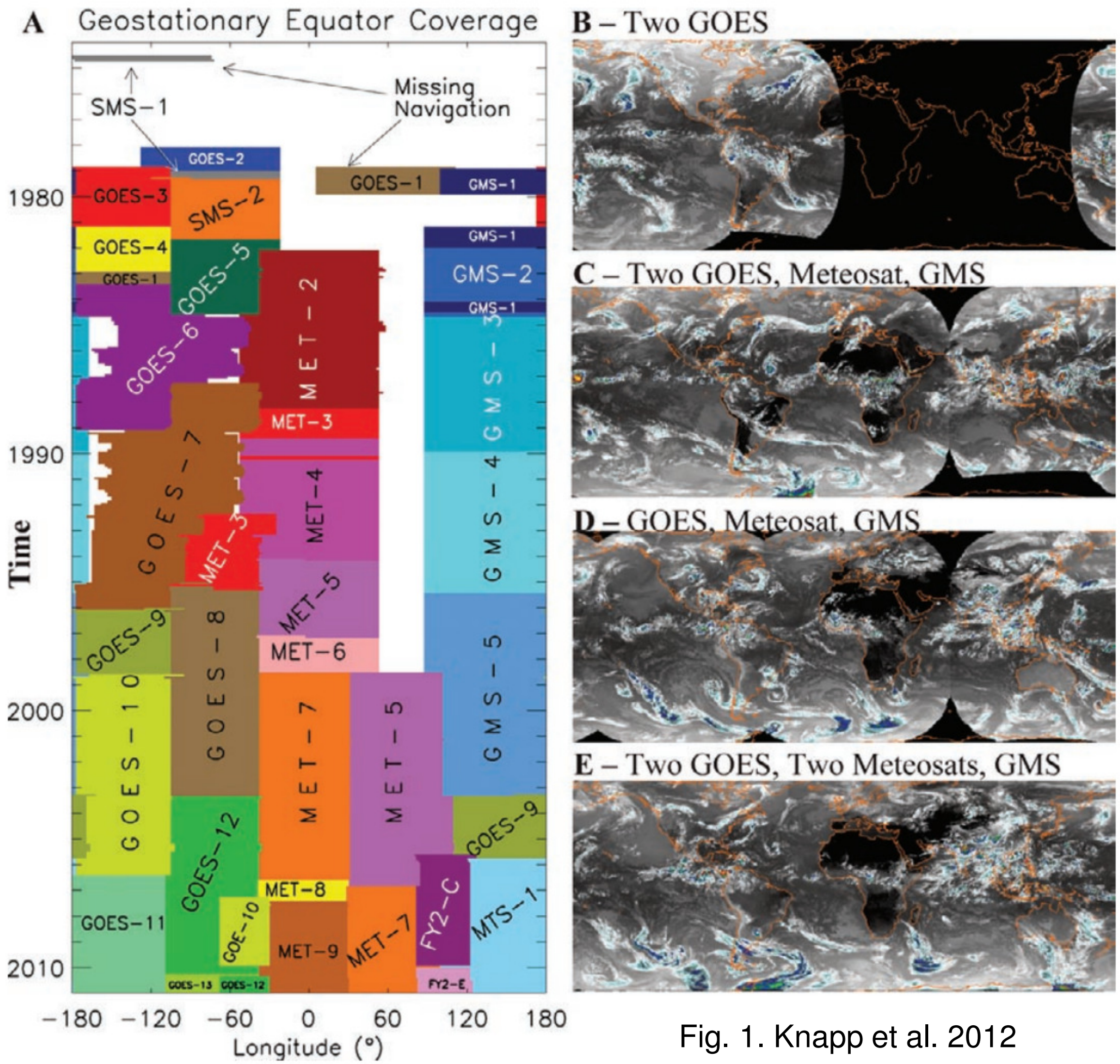


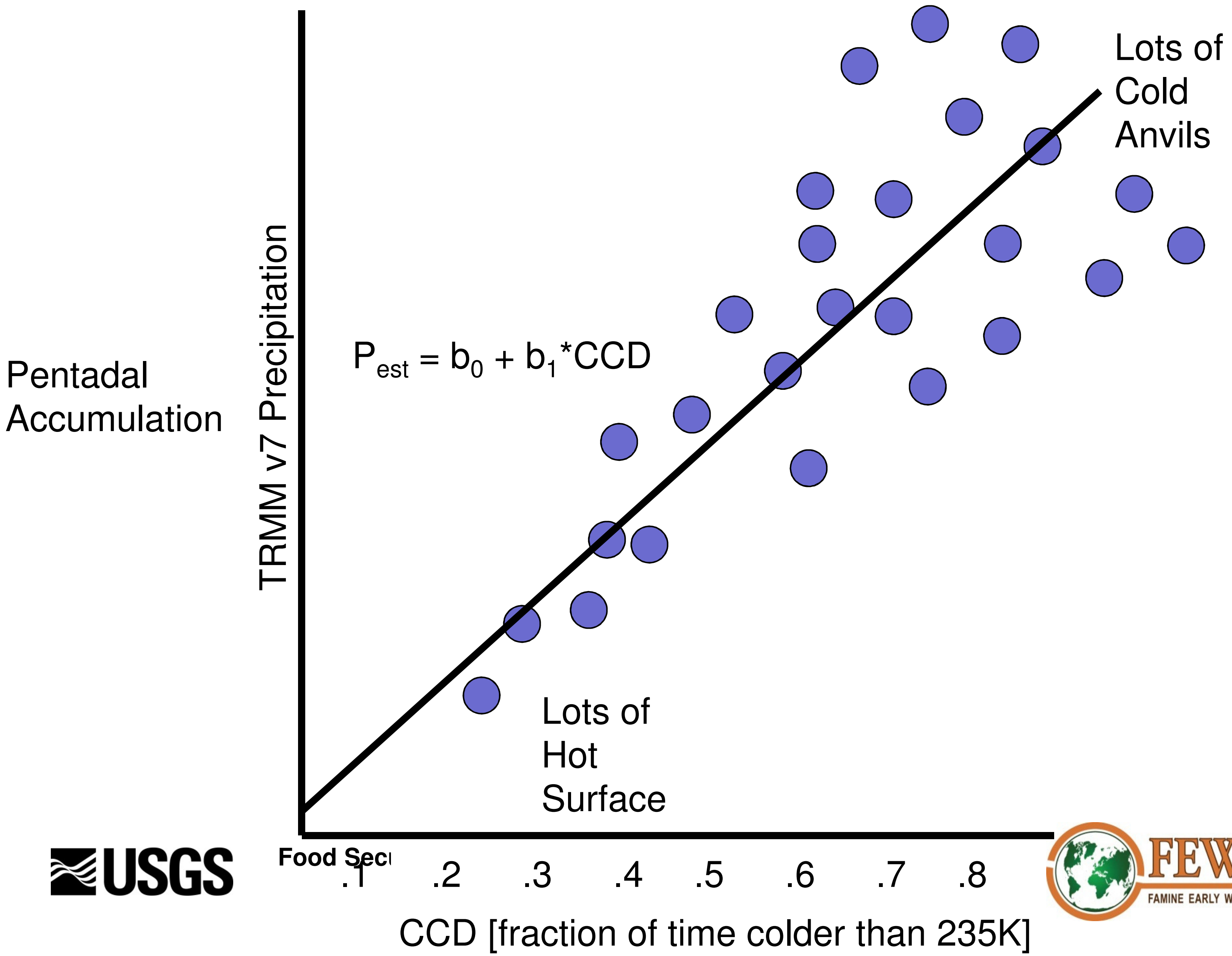
Fig. 1. Knapp et al. 2012

NOAA NCDC

ISCCP B1 Infrared Imagery Data Rescue

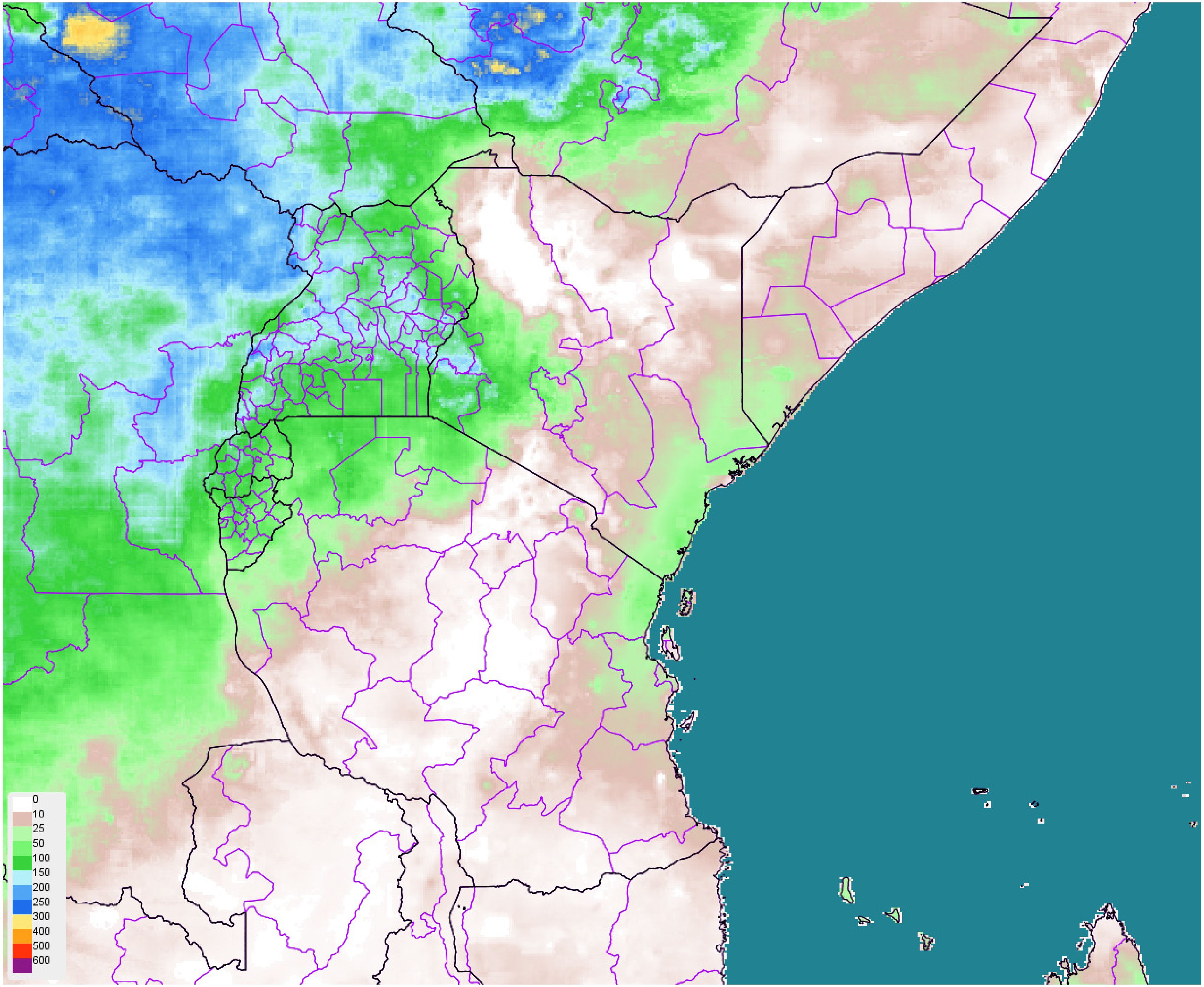
Basis for Cold Cloud Duration (CCD) Calculation

Estimating Rainfall based on CCD



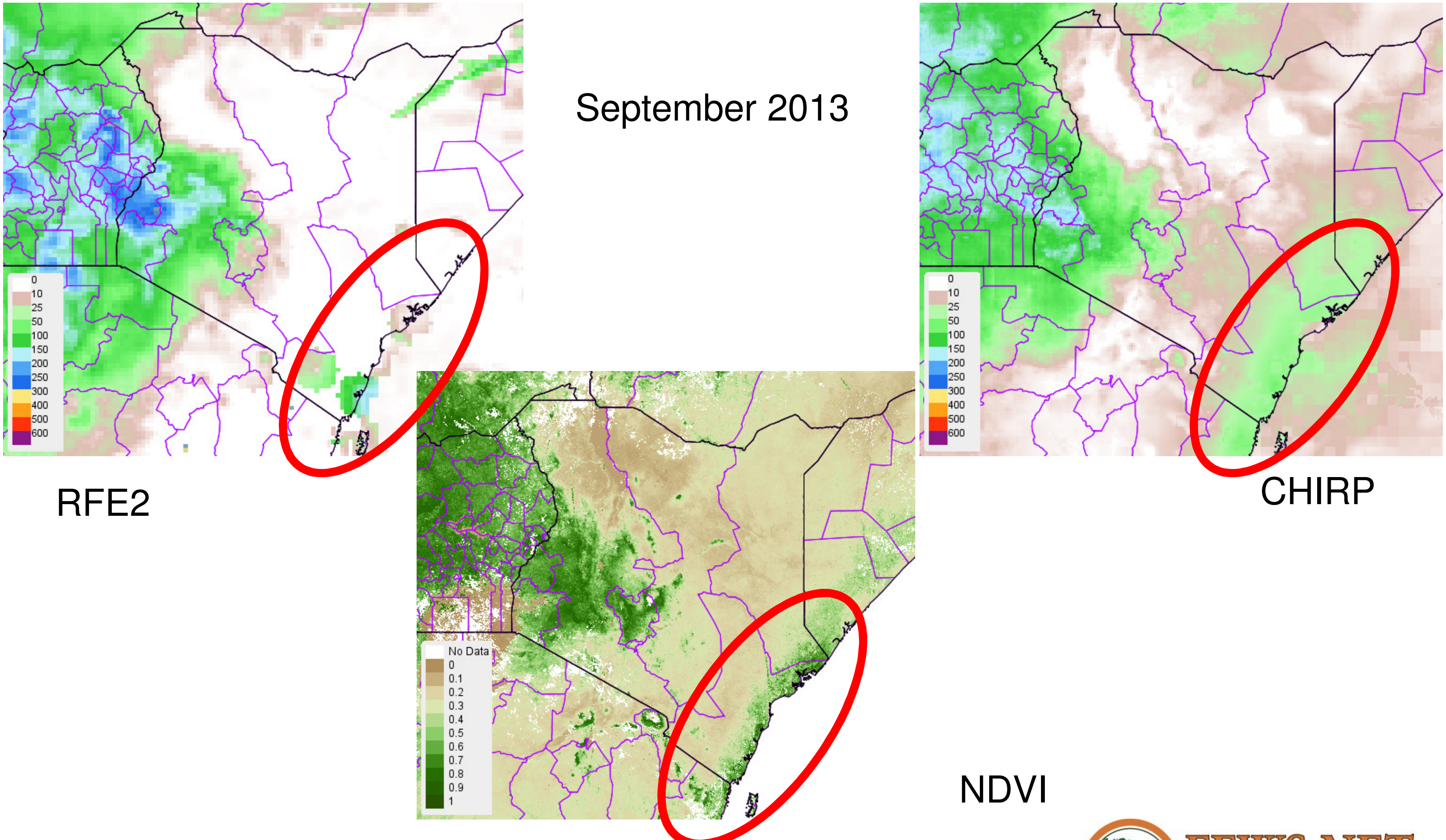
Food Seci

CHIRP Time Series, Jan-Sep 2013



Coastal “Warm Cloud” Rain

September 2013

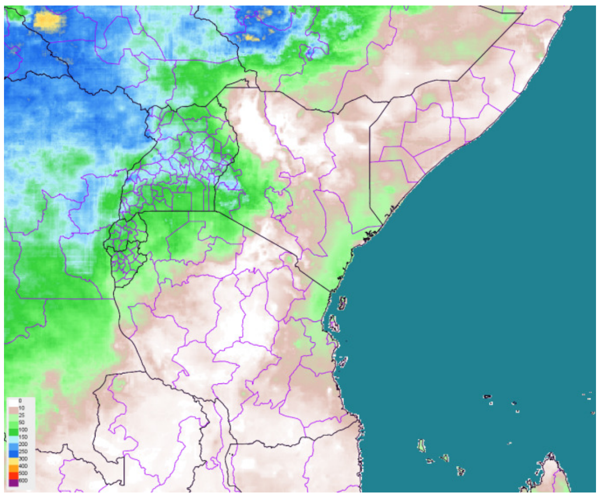


USGS

Food Security, Earth Observations and Agricultural Monitoring
November 21, 2013 – Brussels

FEWS NET
FAMINE EARLY WARNING SYSTEMS NETWORK

Climate Hazard group Infra Red Precipitation with Stations (CHIRPS)

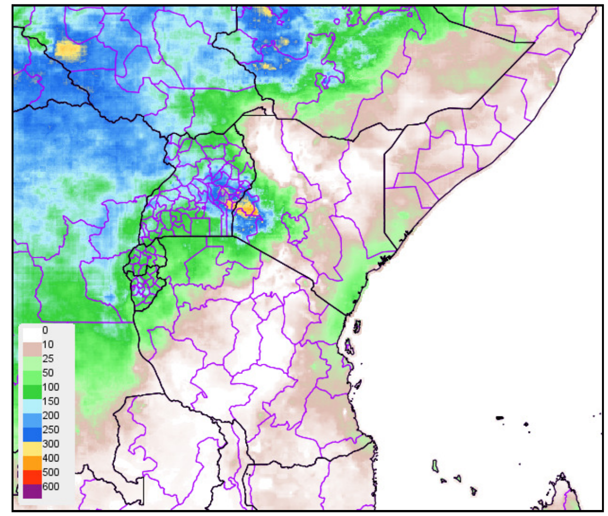


+

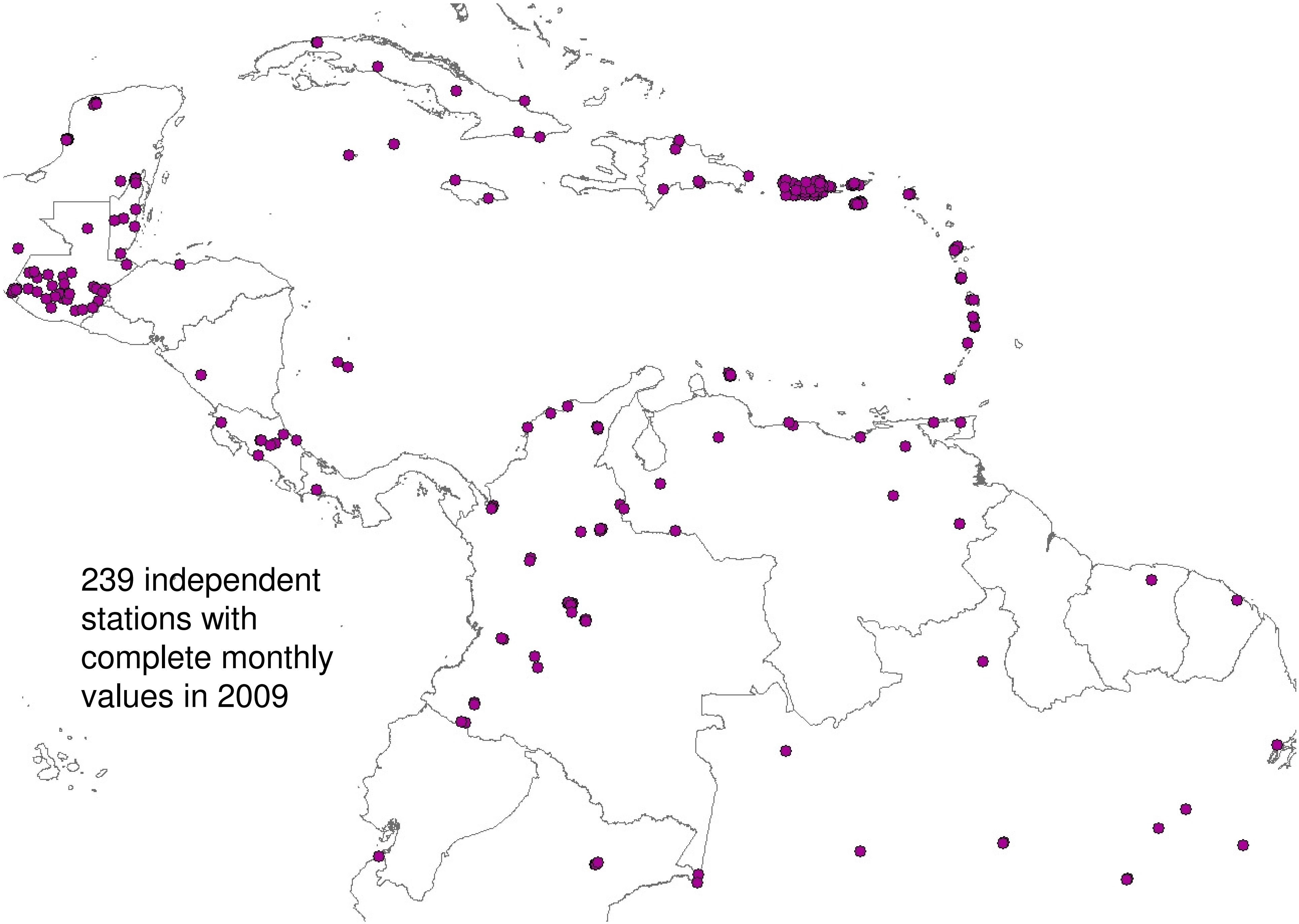
```
-90.4 15.46 101.5
-89.81 15.6 48.8
-89.64 15.39 123.
-89.93 15.3 284.9
-90.25 15.06 68.8
-90.78 14.77 122.
-90.91 14.68 88.2
-89.37 14.82 118.
-89.5 14.55 98.4
-90.82 14.38 161.
-90.79 14.26 196.
-90.83 13.93 240.
-91.05 14.32 299.
-90.53 14.58 143.
-90.45 14.77 242
```

CHG station database

=



CHIRP + stations = CHIRPS

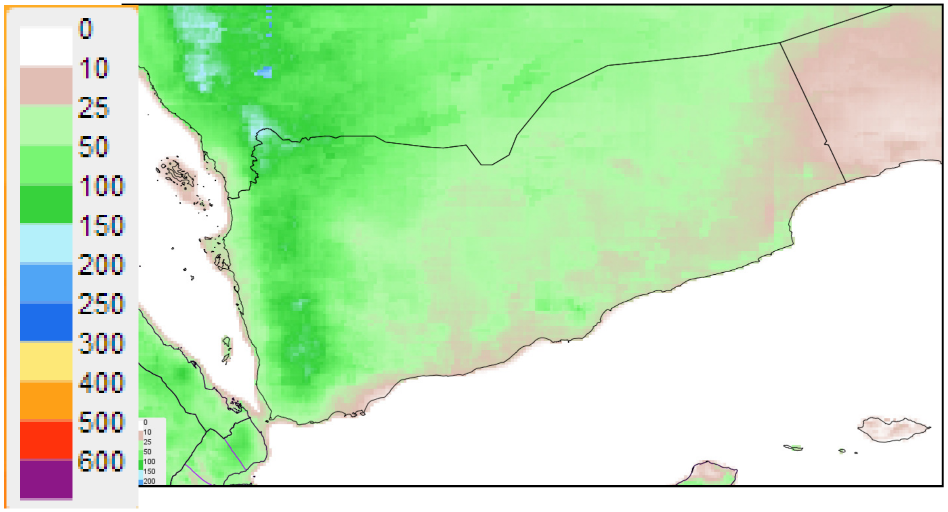

239 independent stations with complete monthly values in 2009

GeoCLIM

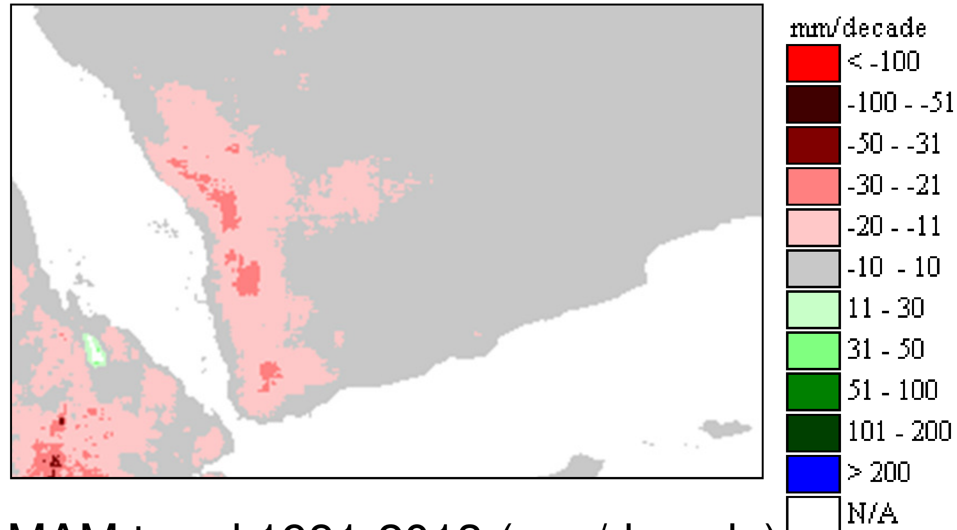
The GeoCLIM Manual covers the most commonly used tools in the GeoCLIM software

- Installation and First Setup
- Overview of GeoCLIM tools
- Data Management Tools
  - Import climatic data into GeoCLIM
  - Download climatic data archives
  - Define output options
  - View list of available data
  - BASIICS: Background Assisted Station Interpolation for Improved Climate Surfaces
- Change GeoCLIM settings
- Analytical tools
  - Climatological data analysis
  - View intra-seasonal rainfall summaries
  - Make contours
  - Calculate Long-term change in averages
- Automation tools
  - Batch assistant for developing automation scripts
  - Batch editor for editing automation scripts
- GIS tools
  - Displaying spatial data
  - Extract statistics from raster datasets

Yemen Precipitation Trend



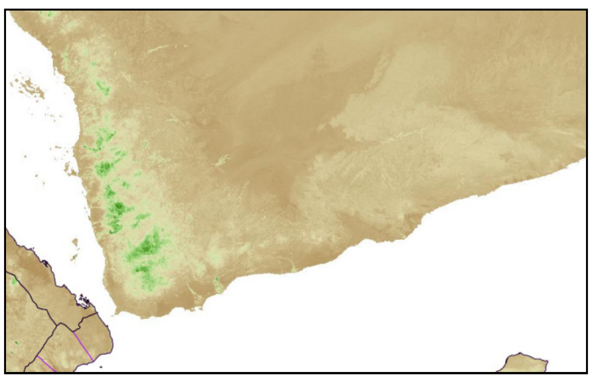
MAM 1998 rainfall (mm)



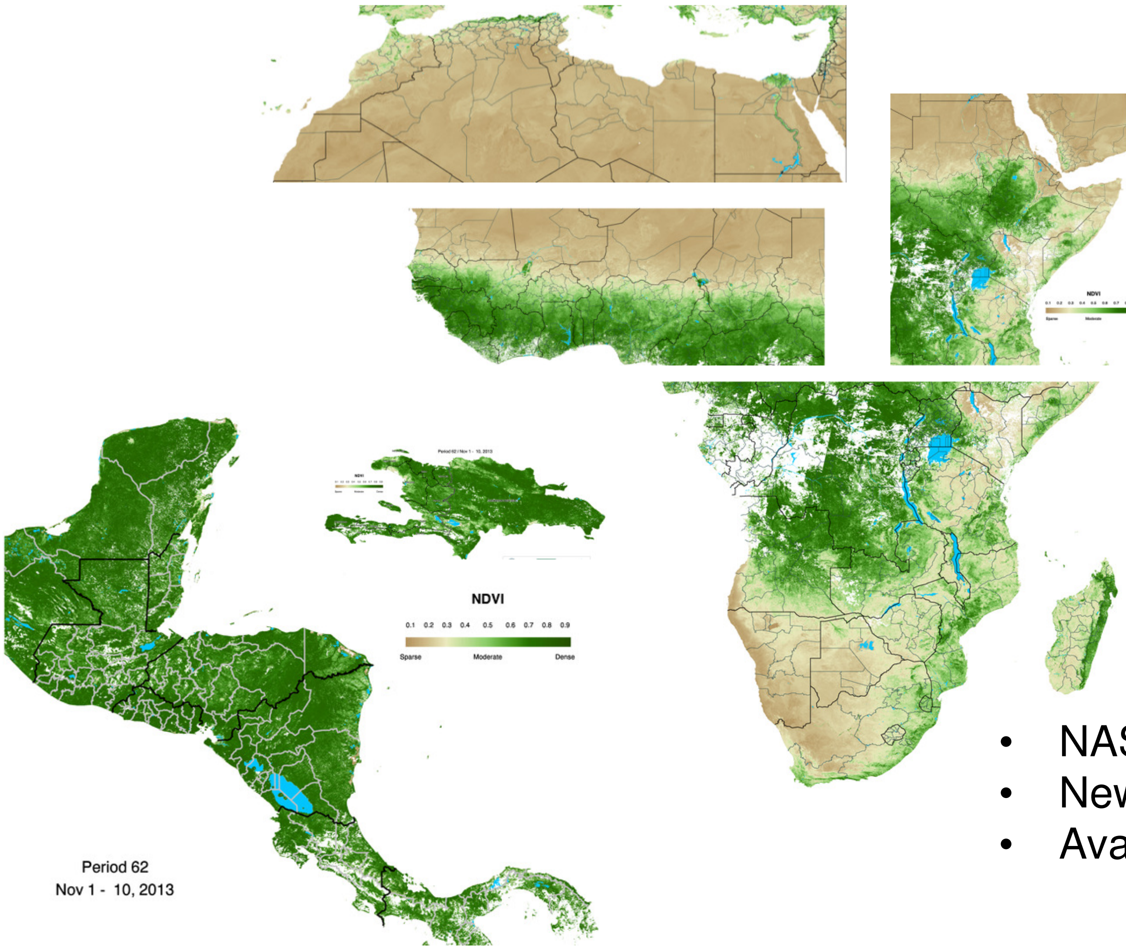
MAM trend 1981-2013 (mm/decade)

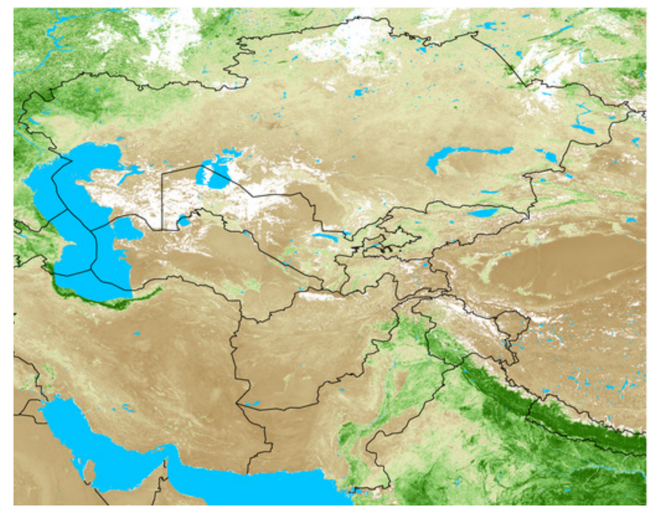
µ GeoCLIM

NDVI



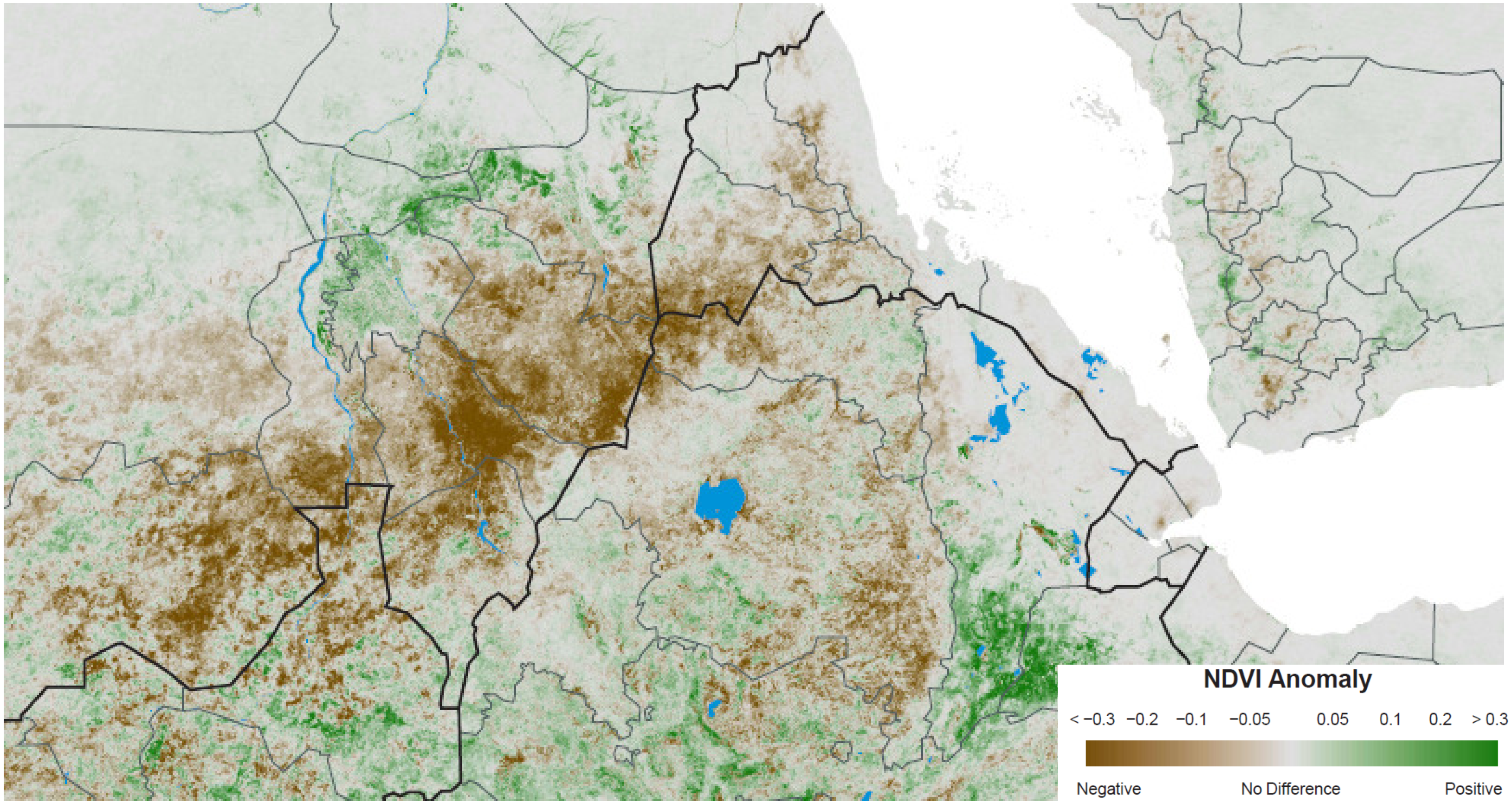
eMODIS NDVI at 250m





- NASA LANCE near real time feed
- New 10-day composites every five days
- Available next day

Poor Rains 2013 – Sudan, Ethiopia, Eritrea



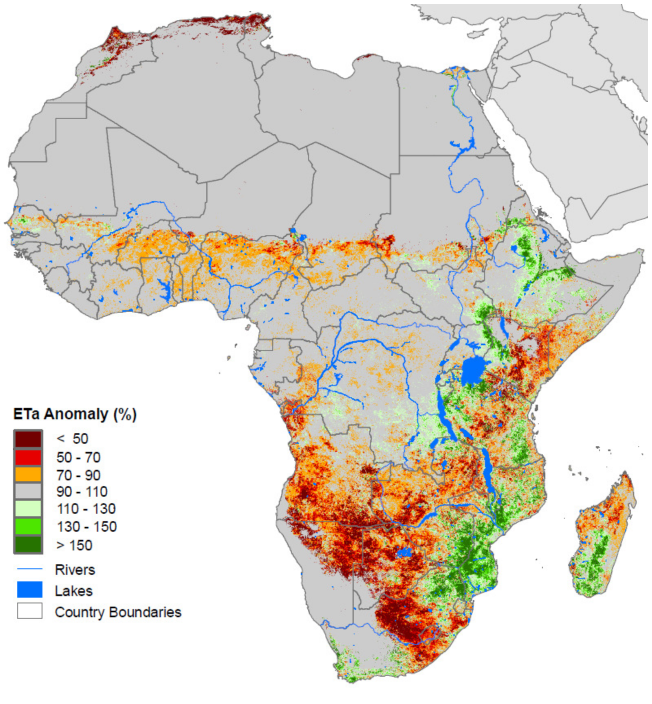
eMODIS NDVI anomalies at 250 m, August 6-15, 2013

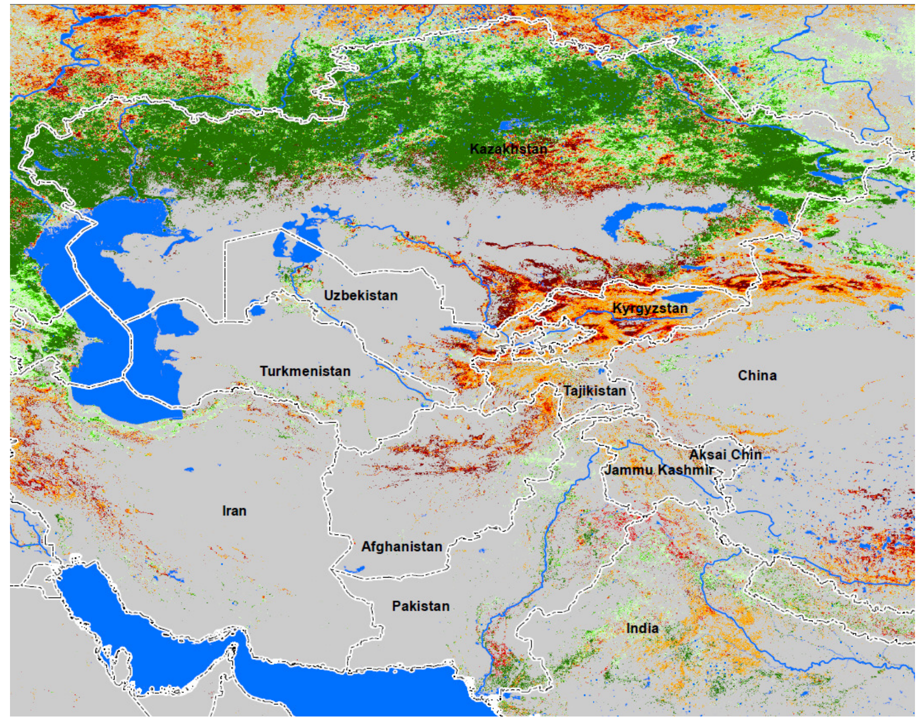
USGS

Food Security, Earth Observations and Agricultural Monitoring
November 21, 2013 – Brussels

FEWS NET
FAMINE EARLY WARNING SYSTEMS NETWORK

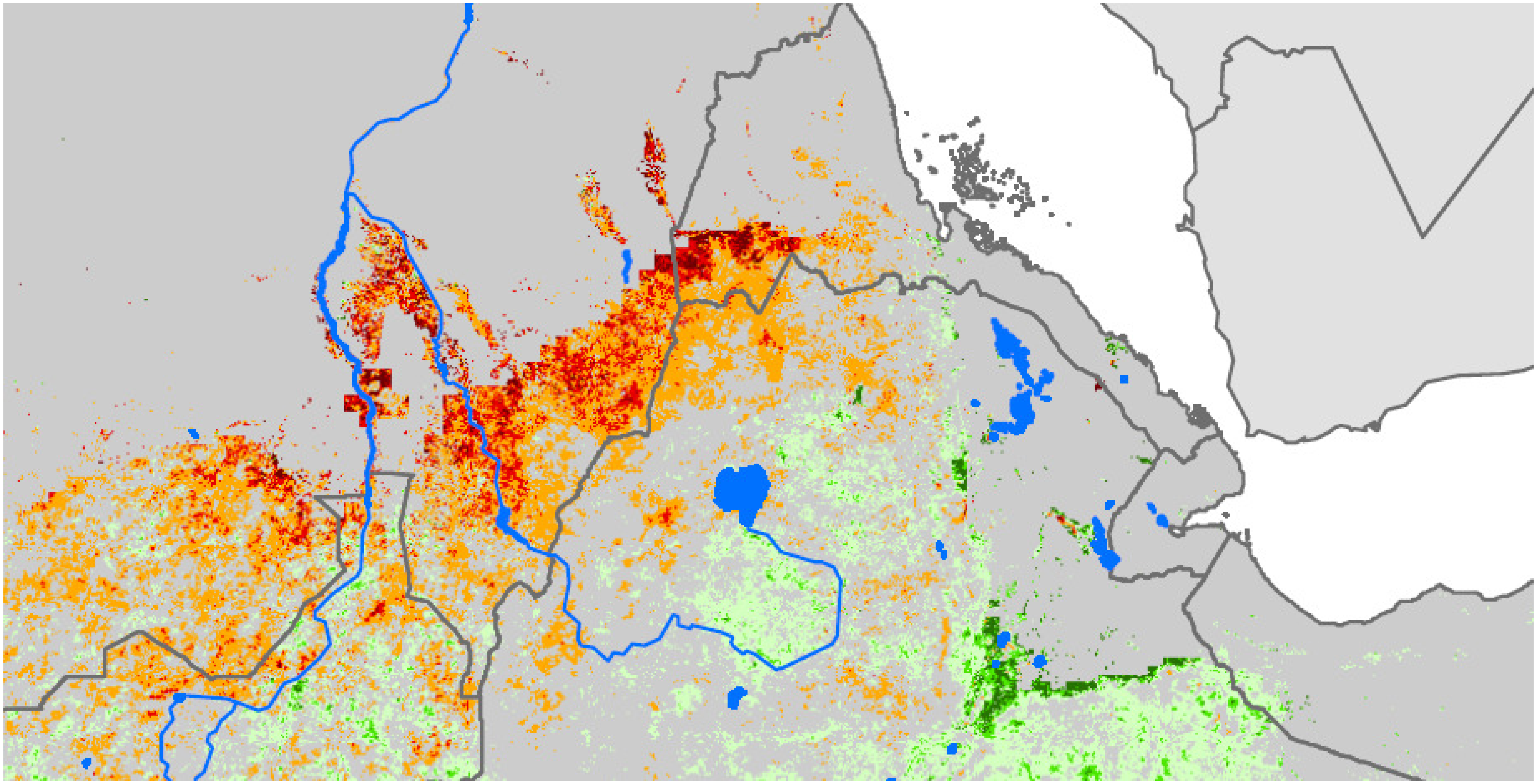
Actual ET from MODIS LST at 1 km





- Presently Africa and Central Asia using NASA DAAC feed of Terra LST
- Product updates every five days
- Moving to NASA LANCE feed of Aqua LST, global coverage in 2014

Poor Rains 2013 – Sudan, Ethiopia, Eritrea

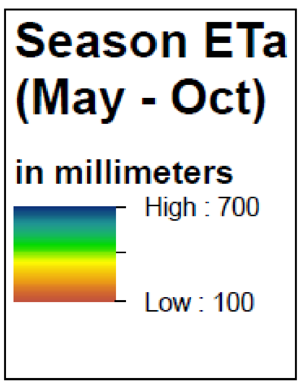


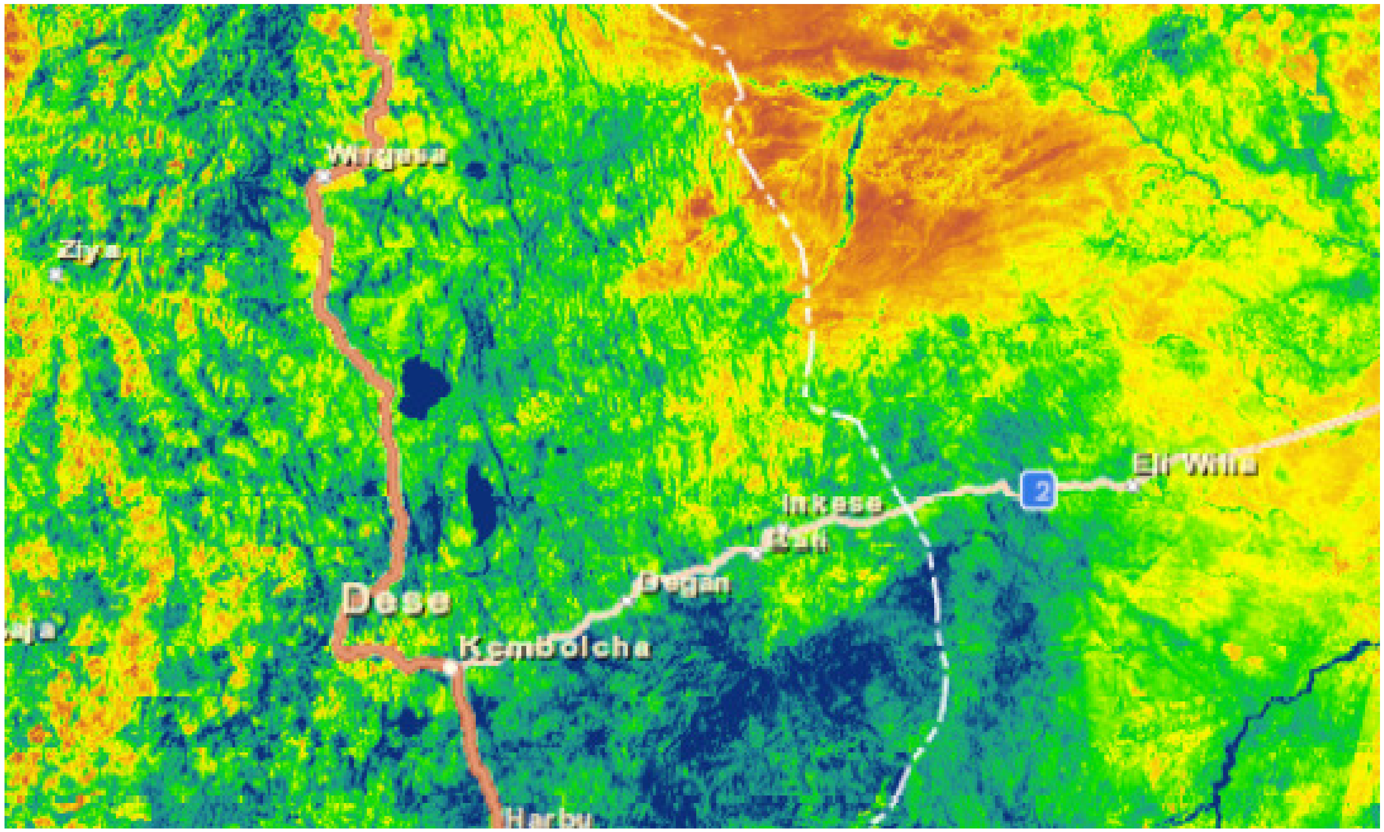
USGS

Food Security, Earth Observations and Agricultural Monitoring
November 21, 2013 – Brussels

FEWS NET
FAMINE EARLY WARNING SYSTEMS NETWORK

Actual ET with Landsat 8 TIR Data

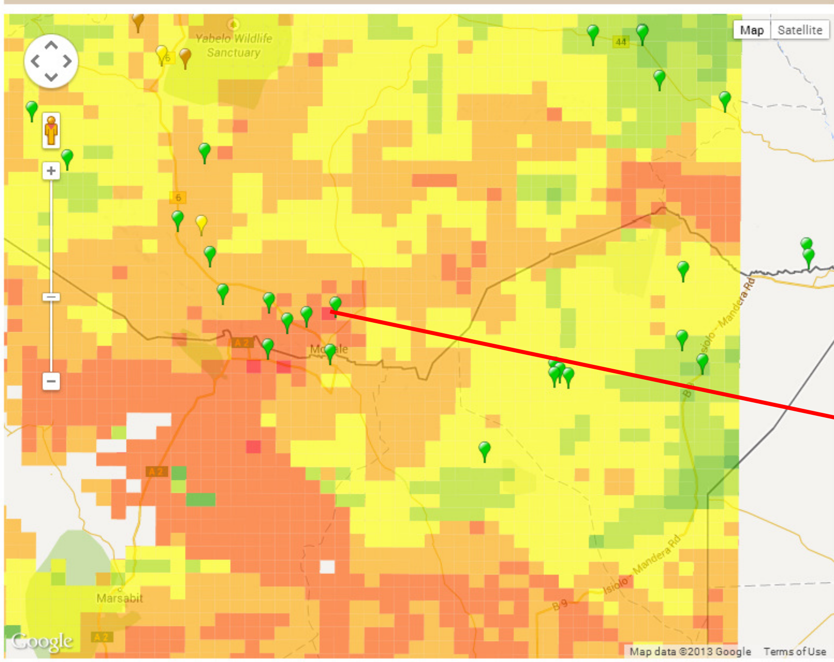




Dese, Ethiopia 2013 – ETa at 100m

Water Point Monitoring

Waterhole and Forage Monitoring Map



Waterholes | Forage

Name	Depth	Median Depth	Area (m^2)
Athiboghol	6.3%	11.9%	760
Beke	27.7%	29.7%	273463
Dabala Fachana	94.7%	33.2%	2610
Danbi Qorbaa	83.0%	17.2%	52200
Degodia	55.3%	17.5%	4335
Didikuro	76.9%	13.1%	7589
Dimtu	15.0%	16.0%	5445
Dingaamo	57.2%	15.4%	6652
ETH-1	90.6%	35.4%	33866
ETH-22	37.4%	33.0%	6655
ETH-33	42.2%	28.2%	16879
ETH-34	51.5%	33.3%	12100
ETH-37	46.3%	32.4%	1512
ETH-42	52.5%	27.4%	
ETH-44	90.9%	29.3%	
ETH-45	79.5%	42.5%	
ETH-46	80.1%	41.5%	
ETH-47	79.5%	41.4%	
ETH-48	81.3%	52.4%	
ETH-51	37.3%	23.5%	
ETH-9	93.2%	44.0%	
Gari	7.4%	4.5%	
Haro Amb	49.2%	20.4%	
Haro Bjidola	67.9%	40.1%	
Haro Burraa	3.8%	15.6%	
Haro Horbate	7.1%	20.9%	
Haro Korobissa	61.8%	20.7%	
Haro Qatelaa	100.0%	37.6%	

Condition of the Waterho

Good	Watch	Alert

Printable Map of Monitoring S

Hide Markers | Show Spatia

Landsat, SRTM, satellite rainfall

USGS

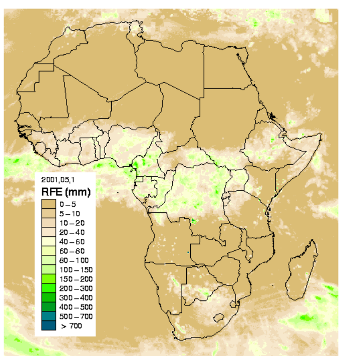
Food Security, Earth Observations and Agricultural Monitoring
November 21, 2013 – Brussels

FEWS NET
FAMINE EARLY WARNING SYSTEMS NETWORK

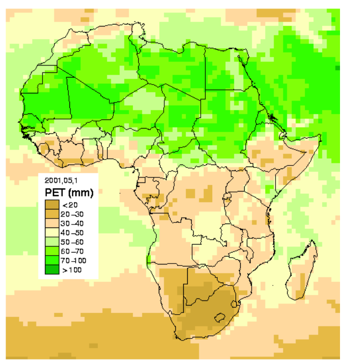
Water Requirement Satisfaction Index

WRSI = f (<u>ppt</u>, <u>pet</u>, <u>WHC</u>, <u>Crop Type</u>, SOS, EOS, LGP)

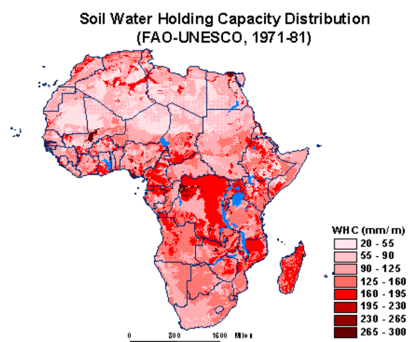
RFE (NOAA)



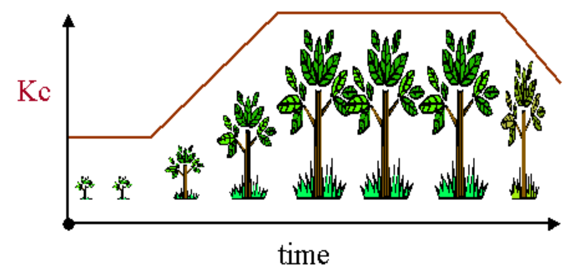
calculated from NOAA GDAS at EROS



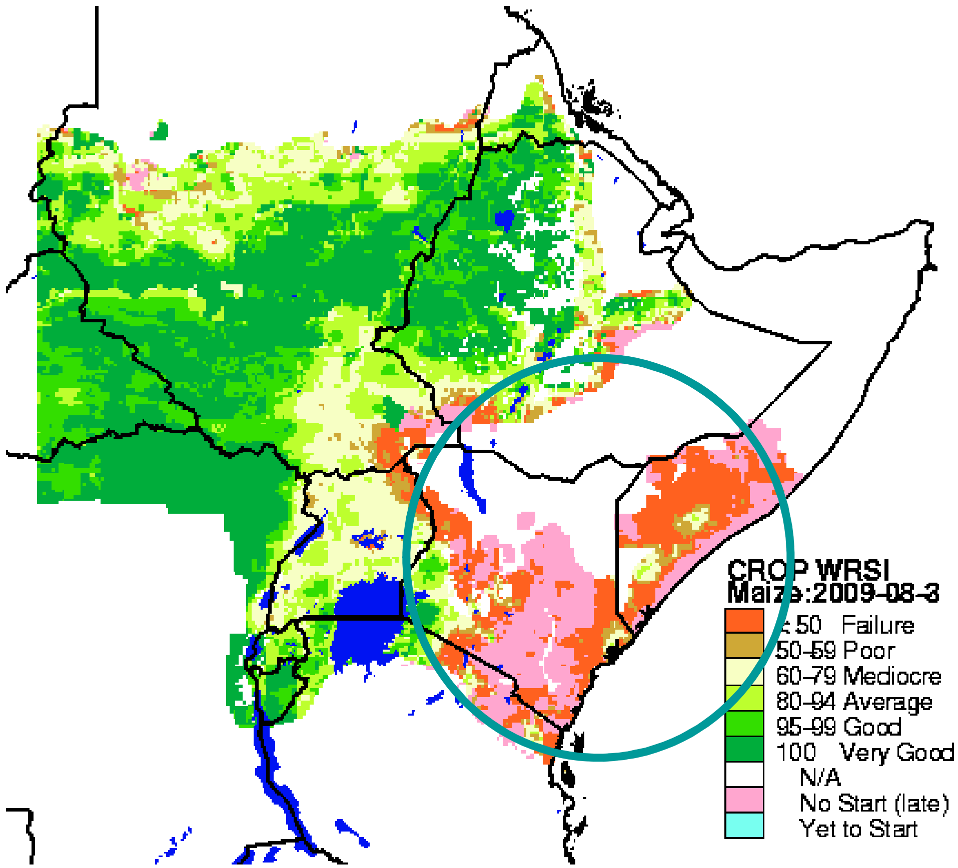
FAO soils map of the world



Kc (FAO)



Monitoring Agricultural Drought



WRSI

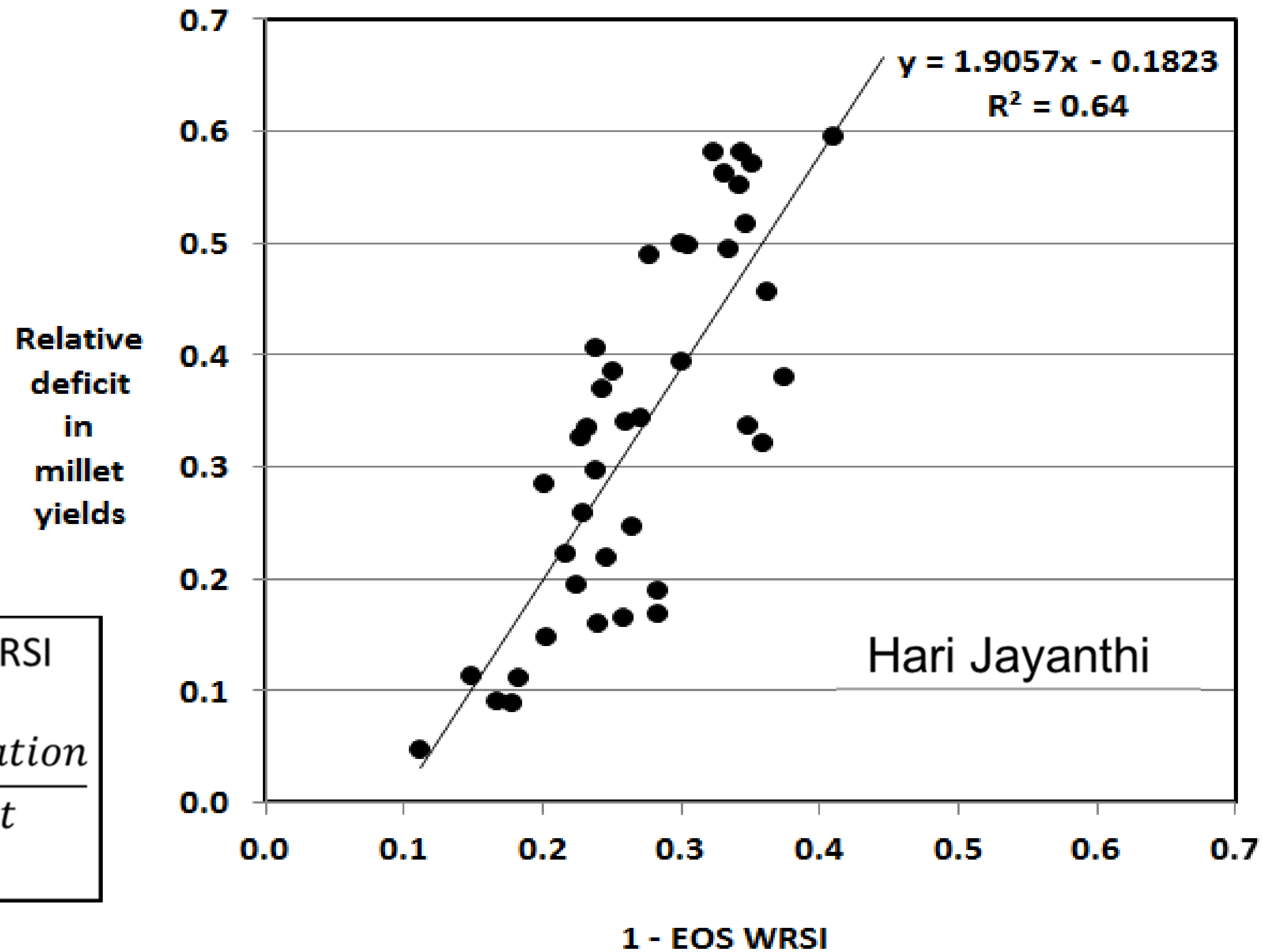
Millet vulnerability model - Niger

Relative yield deficit

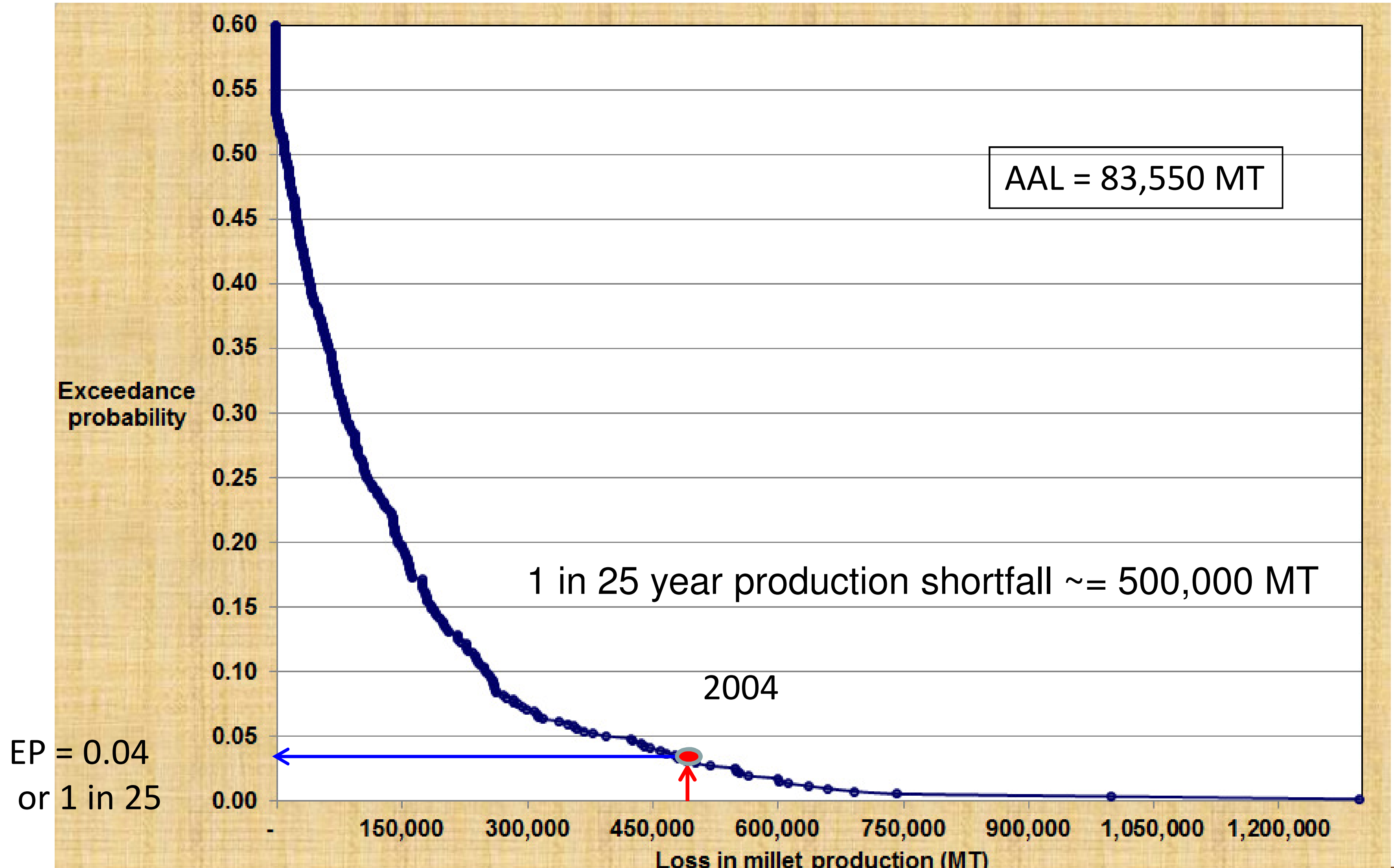
$$\frac{Y_{reference} - Yac_{tual}}{Y_{reference}}$$

End-of-season (EOS) WRSI

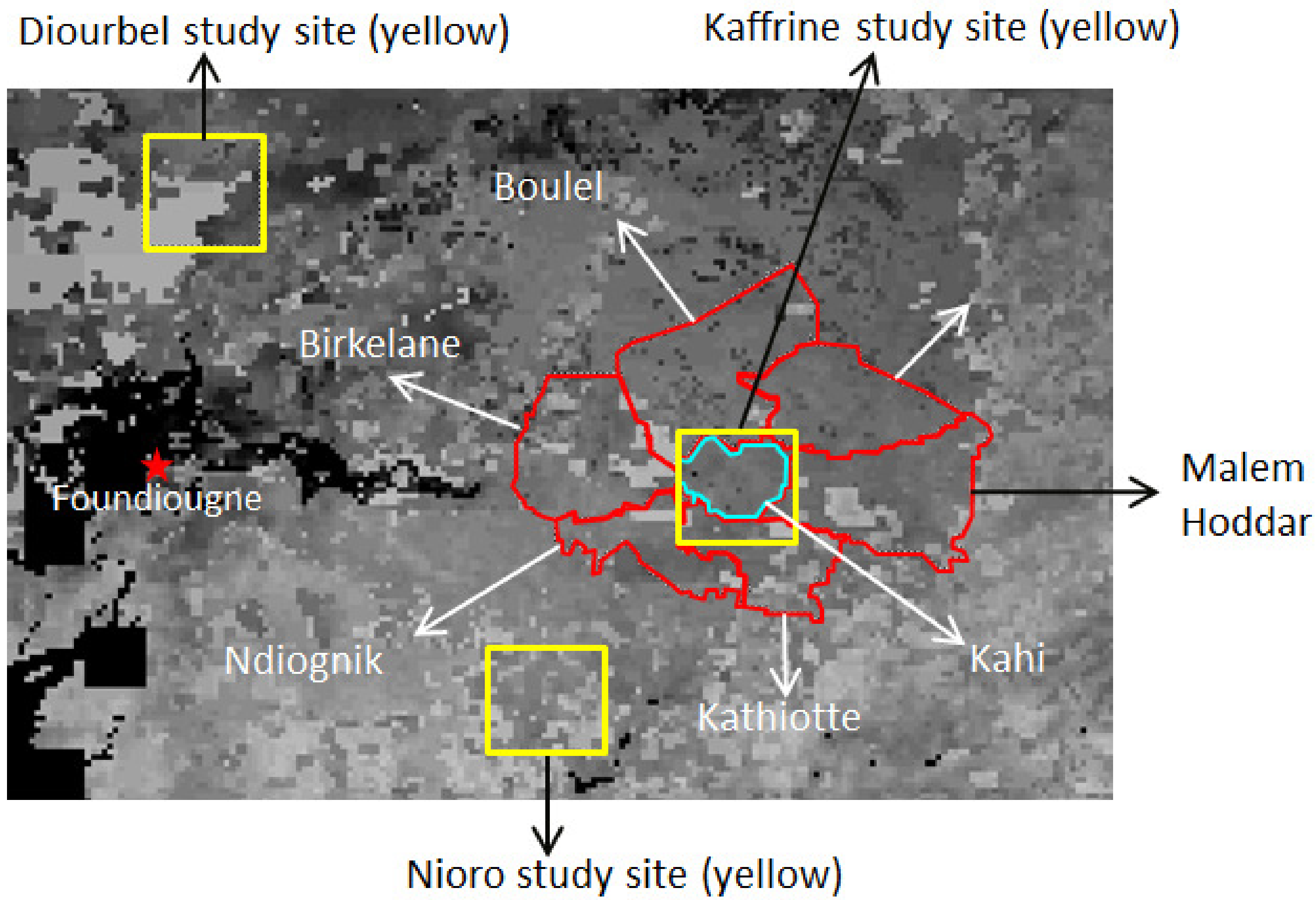
$$\frac{Actual\ evapotranspiration}{Water\ requirement}$$



Loss exceedance curve for millet

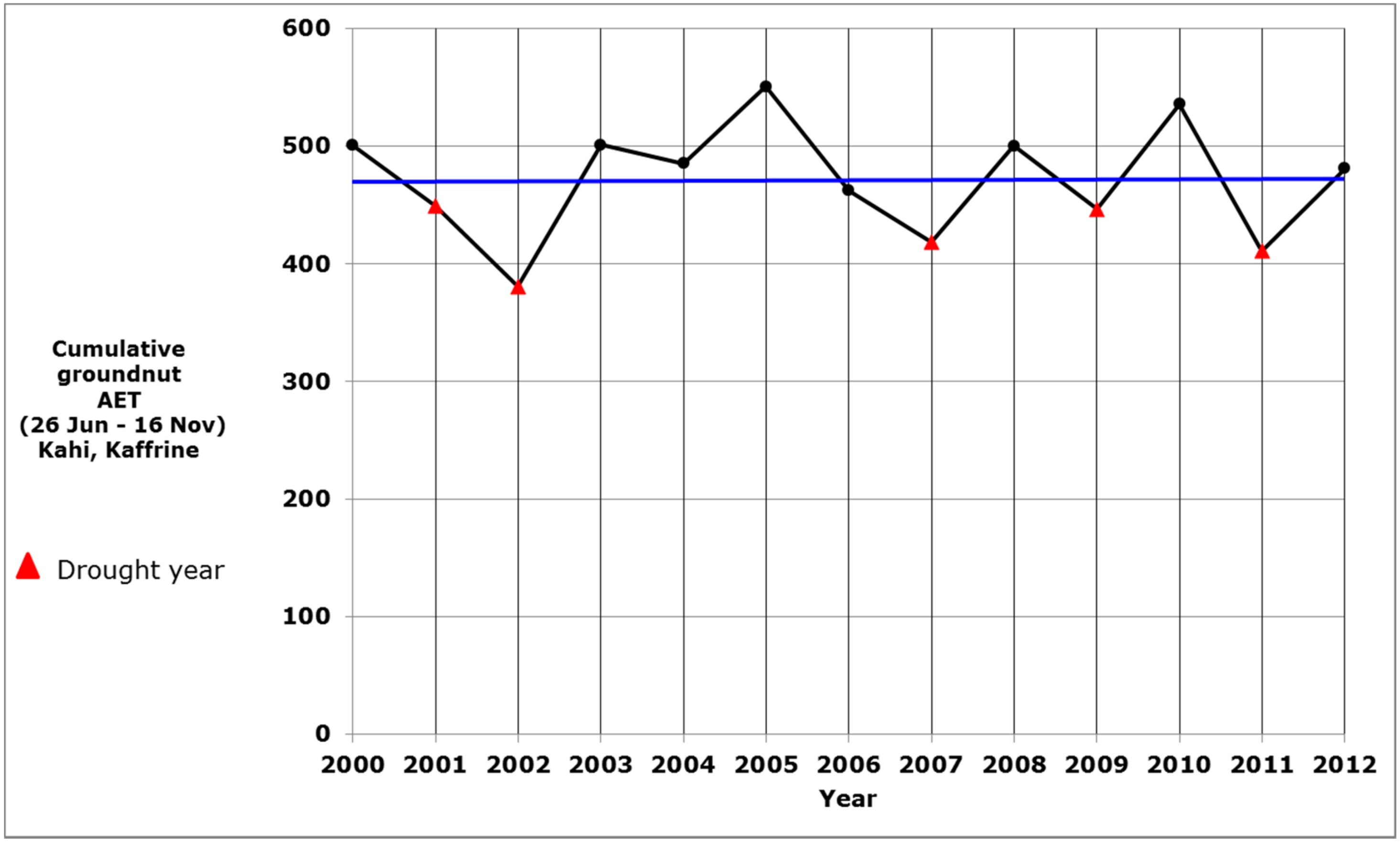


WFP-IFAD WRMF Senegal Index Insurance



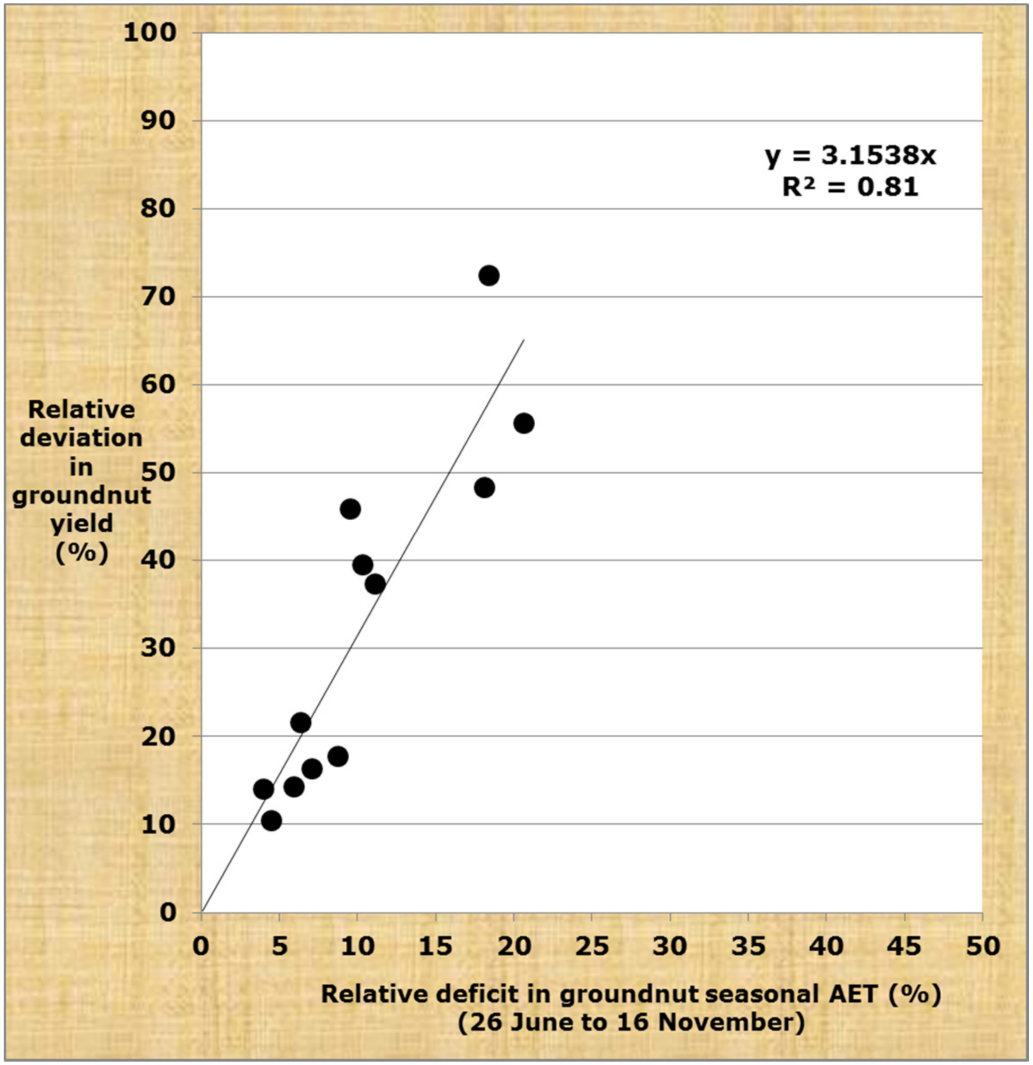
Energy Balance Actual ET from MODIS LST as a Candidate Index

Drought Threshold for Groundnut



Time-series trace of seasonal cumulative groundnut AET
Kahi CR, Kaffrine department, Senegal

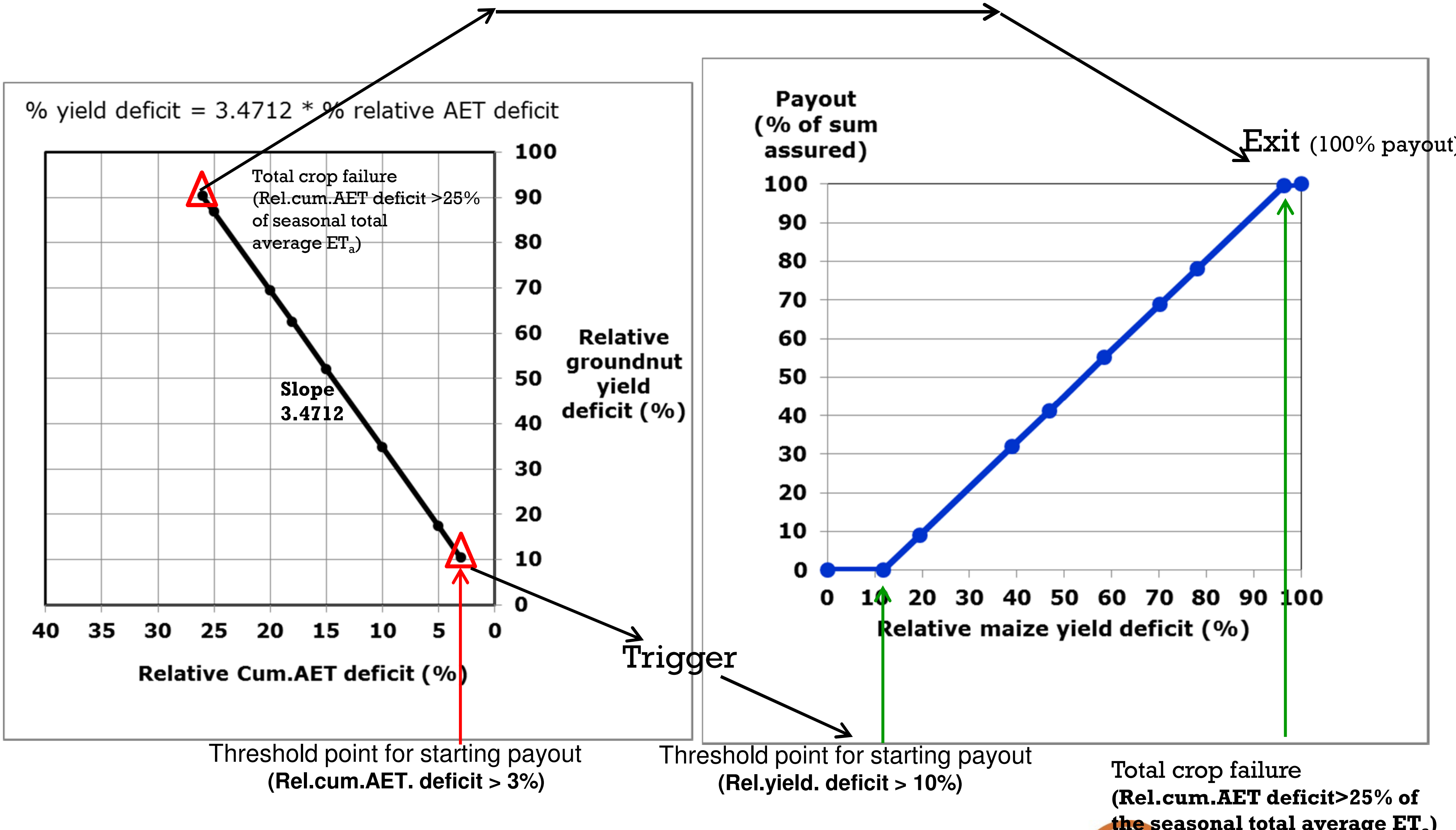
Yield Reduction Function for Groundnut



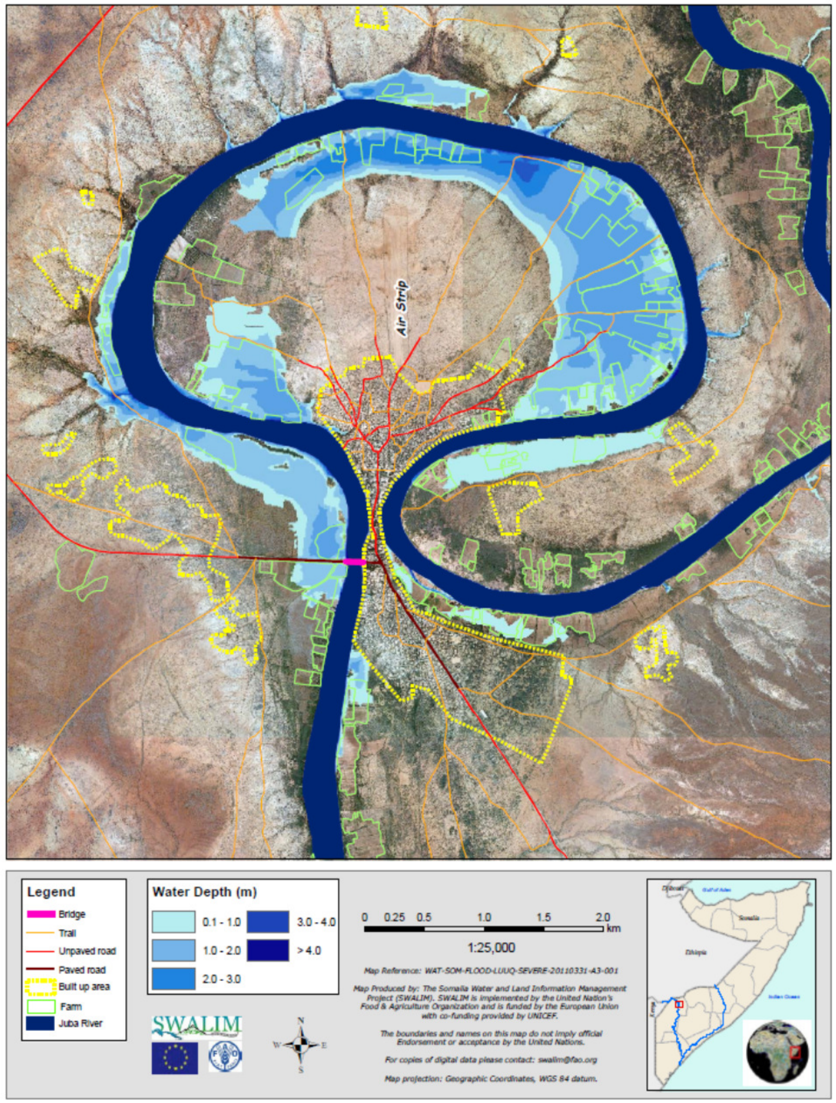
Drought vulnerability model for groundnut using MODIS Actual ET

WFP-IFAD WRMF Senegal Study

Constructing an Insurance Product



Flood risk map for Luuq - 50 year return period



GIS Tool for Flood Inundation

Software enhancements in cooperation with the Regional Center for Mapping of Resources for Development in Nairobi

Thank you