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

Contributions of the Famine Early Warning Systems Network

Jim Verdin¹, Chris Funk², Diego Pedreros¹, Diego, Gabriel Senay¹, Jim Rowland¹, Greg Husak², Hari Jayanthi¹

1. USGS Earth Resources Observation and Science Center
2. Climate Hazards Group, University of California, Santa Barbara

Drought-stunted maize, Kenya, 2002
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 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.
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

CHPclim April

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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

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

NOAA NCDC

ISCCP B1 Infrared Imagery Data Rescue

Basis for Cold Cloud Duration (CCD) Calculation

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Estimating Rainfall based on CCD

\[ P_{est} = b_0 + b_1 \times CCD \]

Pentadal Accumulation

TRMM v7 Precipitation

Food Security

CCD [fraction of time colder than 235K]

Lots of Cold Anvils

Lots of Hot Surface
Coastal “Warm Cloud” Rain

September 2013

RFE2

CHIRP

NDVI

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Climate Hazard group Infra Red Precipitation with Stations (CHIRPS)

CHIRP + stations = CHIRPS
239 independent stations with complete monthly values in 2009
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
  - BASICS: 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)

NDVI

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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

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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
Actual ET with Landsat 8 TIR Data

Dese, Ethiopia 2013 – ETa at 100m
Water Point Monitoring

Landsat, SRTM, satellite rainfall

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Water Requirement Satisfaction Index

\[ \text{WRSI} = f (\text{ppt}, \text{ pet}, \text{ WHC}, \text{ Crop Type}, \text{ SOS}, \text{ EOS}, \text{ LGP}) \]

calculated from NOAA GDAS at EROS

FAO soils map of the world

\( \text{RFE} \) (NOAA)

\( \text{Kc} \) (FAO)
Monitoring Agricultural Drought

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Millet vulnerability model - Niger

Relative yield deficit

\[
\frac{Y_{\text{reference}} - Y_{\text{actual}}}{Y_{\text{reference}}}
\]

End-of-season (EOS) WRSI

\[
\frac{\text{Actual evapotranspiration}}{\text{Water requirement}}
\]

\[
y = 1.9057x - 0.1823 \\
R^2 = 0.64
\]
Loss exceedance curve for millet

AAL = 83,550 MT

1 in 25 year production shortfall ≈ 500,000 MT

EP = 0.04 or 1 in 25
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

\[ y = 3.1538x \]
\[ R^2 = 0.81 \]

Drought vulnerability model for groundnut using MODIS Actual ET

WFP-IFAD
WRMF
Senegal Study

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Constructing an Insurance Product

% yield deficit = 3.4712 * % relative AET deficit

Trigger

Threshold point for starting payout (Rel.cum.AET. deficit > 3%)

Total crop failure (Rel.cum.AET deficit > 25% of seasonal total average ETa)

Slope 3.4712

Relative groundnut yield deficit (%)

Exit (100% payout)

Payout (% of sum assured)

Relative maize yield deficit (%)

Threshold point for starting payout (Rel.yield. deficit > 10%)

Total crop failure (Rel.cum.AET deficit > 25% of the seasonal total average ETa)
GIS Tool for Flood Inundation

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