Enhancing USAID Famine and Malaria Early Warning Systems with NASA Earth Science Results

(FEWS – MEWS)

NASA Science Mission Directorate
Cooperative Agreement Notice NN-H-04-Z-YO-010-C
"Decision Support Through Earth Science Results"

1st presentation on FEWS
2nd presentation on MEWS

Enhancing Famine Early Warning

NASA Public Health Program Review

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Enhancing Famine Early Warning: Key Goals

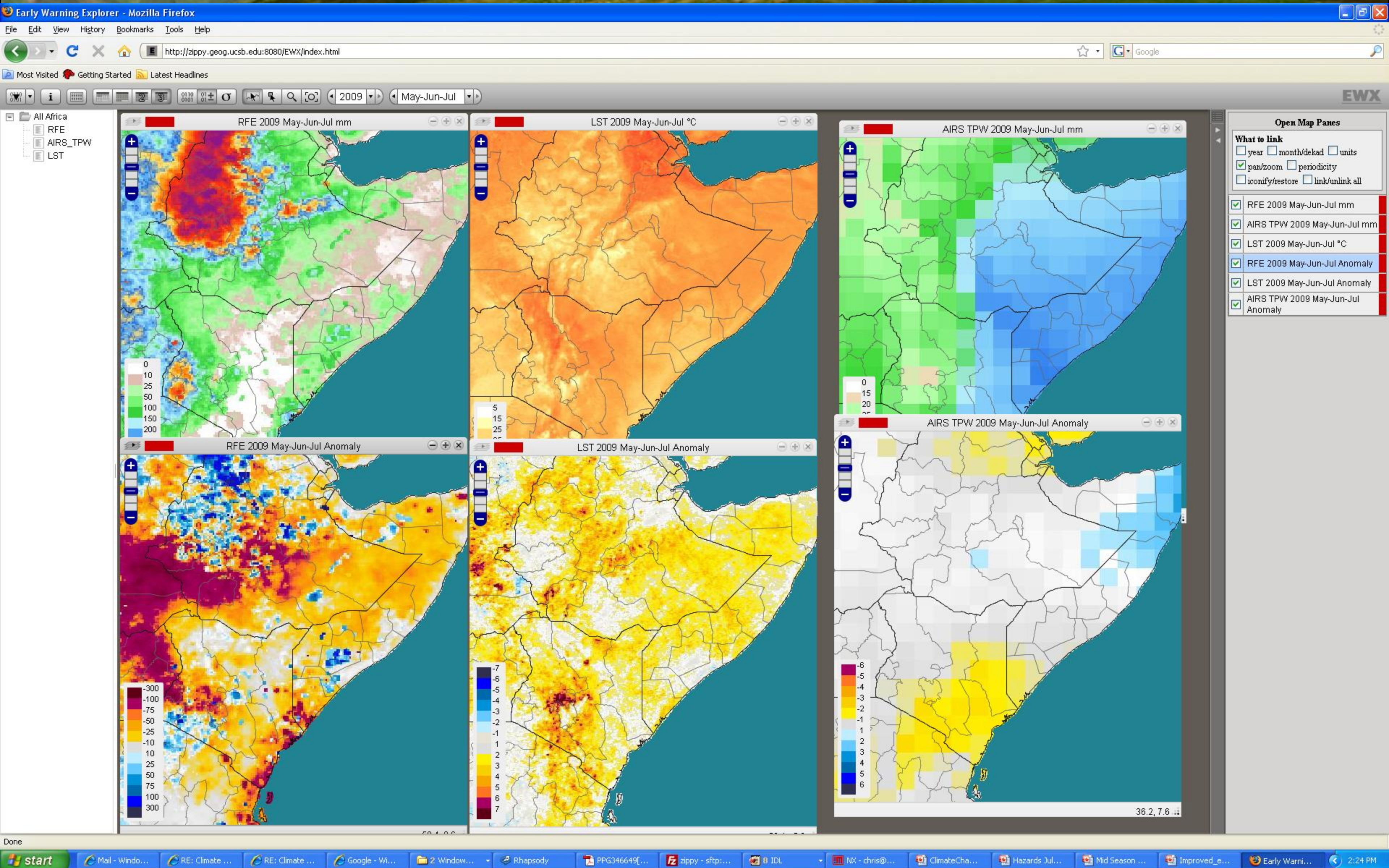
- Produce standardized indices of precipitation, land surface temperature, total precipitable water, and NDVI
- Develop a web-based data analysis and mapping tool – the Early Warning Explorer (EWX) – to facitate use of the products
- Perform requirements analysis and benchmarking

Famine Sub-Project Team

Jim Verdin, USGS
Project Coordinator/PI
Oversight, coordination

- James Rowland / Michael Budde
  FEWS Project Leaders, USGS EROS
  Project coordination & data portal design
- Molly Brown, NASA Validation lead/Co-PI
  Project benchmarking, coordination w/ FEWS
- Kenton Ross / Lauren Underwood, NASA SSC
  Project benchmarking, validation & verification
- Chris Funk, USGS/UCSB Science lead/Co-PI
  Forecasting, design, technical management
- Greg Husak, UCSB, Research Scientist
  Statistical indices, NDVI analysis
- Prof. Joel Michaelsen, UCSB
  Guidance on statistical techniques
- Greg Ederer, UCSB, Java Programmer
  GeoServer, web mapping, in situ data
- Pete Peterson, UCSB, IDL Programmer, Image analysis, model implementation

EWX Screen Shot of Standardized Indices



precipitation land surface temp total precipitable water

Early Warning Explorer System

<u>Images</u>
Precipitation
Temperature
NDVI
Precipitable H20

<u>In Situ Obs</u>
Precipitation
Temperature

<u>Coverages</u>
Sub-national
polygons

raw data
percents
std devs

<u>Server</u>
Java
GeoServer

Dekadal
Monthly
Two Monthly
Three Month

<u>Client</u>
OpenLayers
Javascript

Pan
Zoom
Plot time series
Multiple windows
Data Extraction

http://zippy.geog.ucsb.edu:8080/EWX/index.html

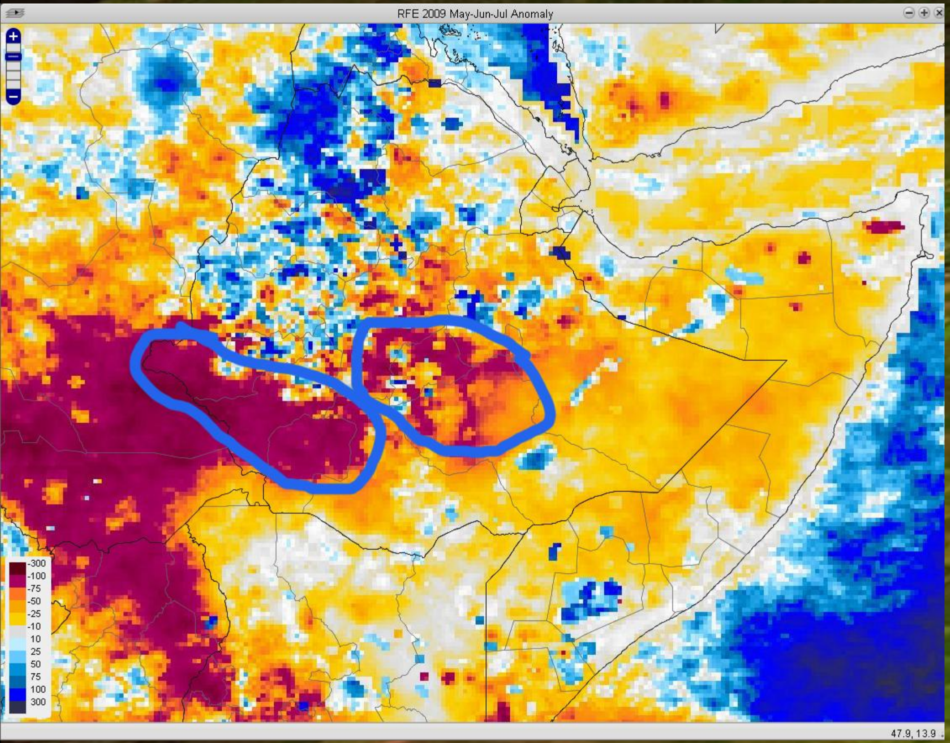
Early Warning Explorer

- Major improvement over the existing USGS African Data Dissemination Service (ADDS)
- Provides standardized indices of precipitation, land surface temperature, total precipitable water for dekads, 1 month, 2 month and 3 month accumulations
- Based on an installation of GeoServer
- Developed thin-client web-based data analysis and mapping tool – the Early Warning Explorer (EWX)
  - Based on Javascript with OpenLayers, and Yahoo User Interface
  - The EWX displays multiple linked map panes
  - Supports zoom/pan/query
  - Dynamic overlay of population and topography
- Link: http://zippy.geog.ucsb.edu:8080/EWX/index.html

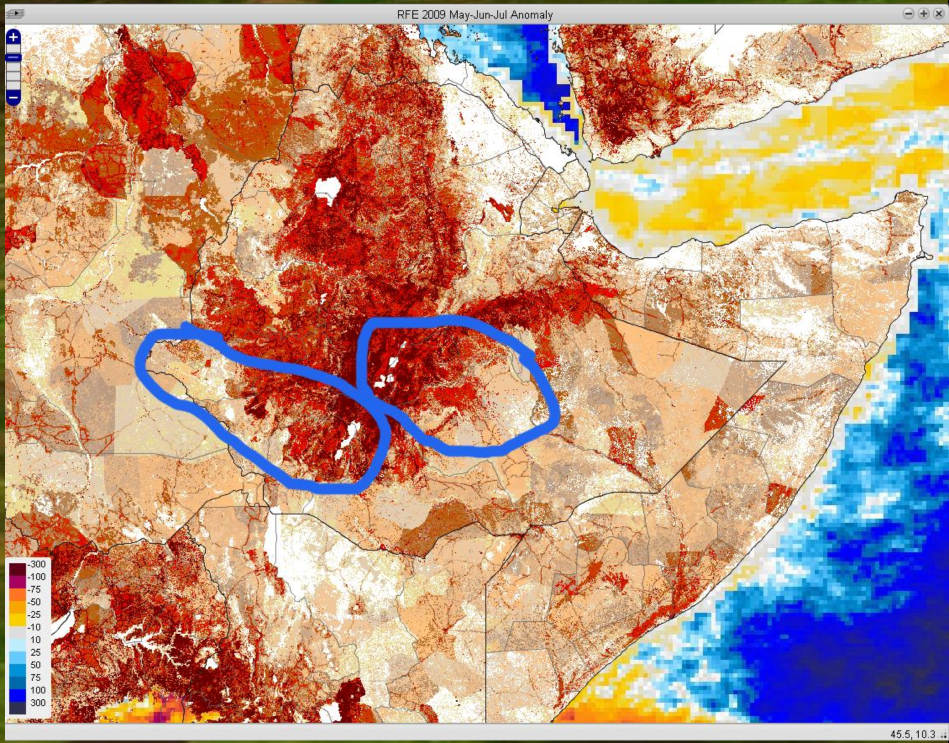
Early Project Impacts

- During March-April-May of 2009, parts of Kenya and Ethiopia experienced severe drought
- The EWX tool supported effective analysis, identifying significant moisture deficits in high population, subsistence agricultural areas
- Convergence between remote sensing data sets supported overall convergence of evidence (market prices, livelihood impacts, etc)
- FEWS NET assessments supported USAID decision to provide aid to Kenya ($40M) and Ethiopia ($90M)

2009 Ethiopian Agricultural Drought

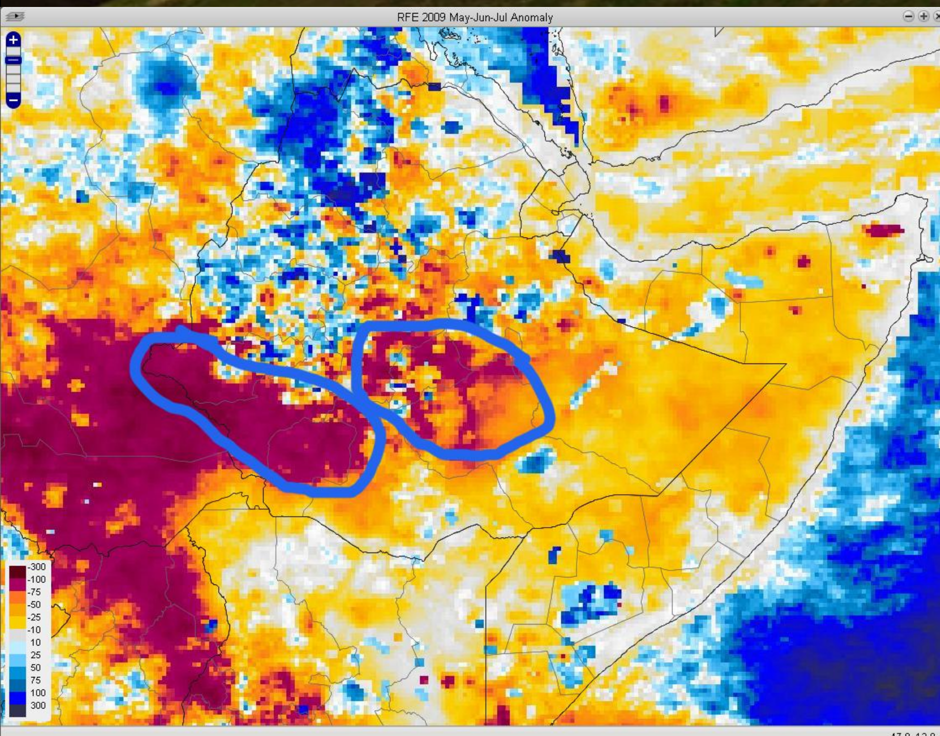


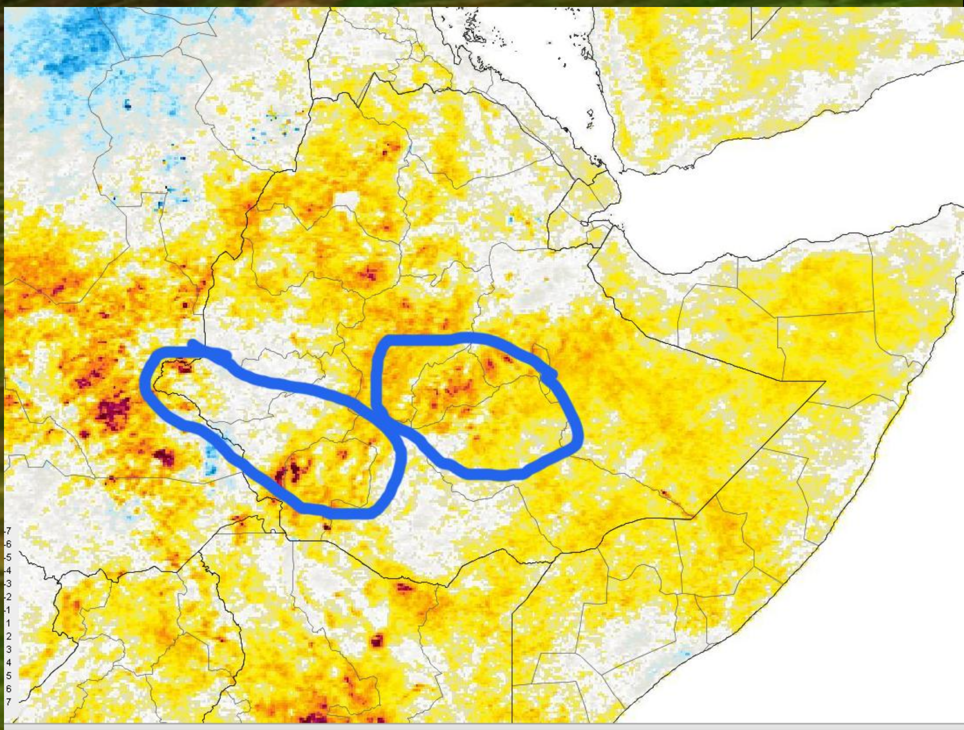
May-Jun-July negative precipitation anomalies….



Coinciding with large, vulnerable rural populations

2009 Ethiopian Agricultural Drought





May-June-July negative precipitation anomalies….

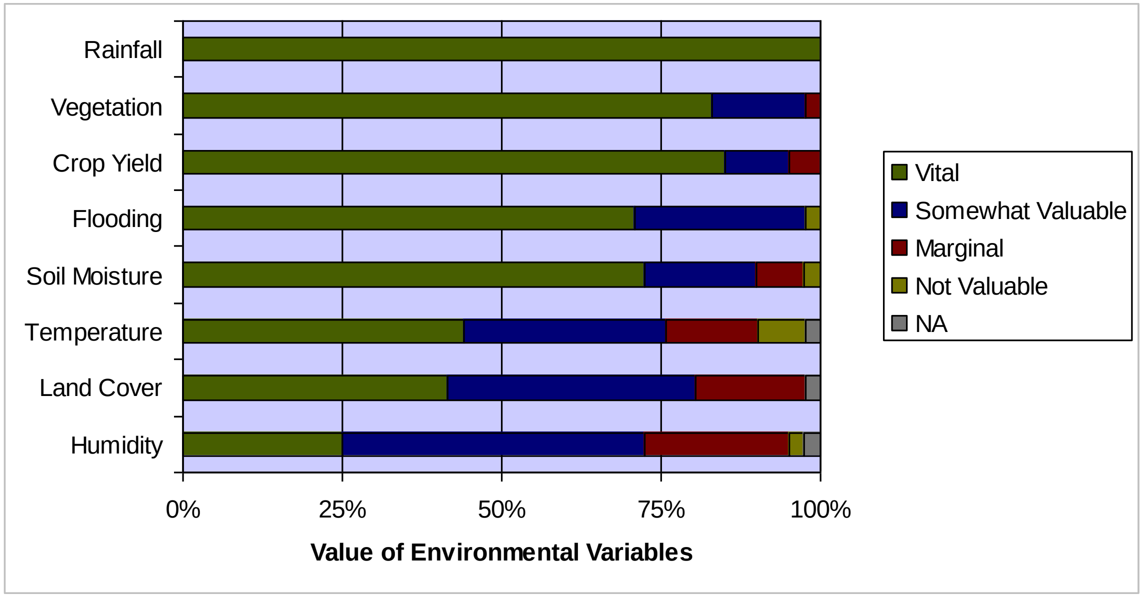
Accompanied by May-June-July warm land surface temperature anomalies

Review of FEWS NET biophysical monitoring requirements

- NASA funded efforts to enhance FEWS NET with a suite of satellite-based standardized products for climate monitoring i.e. precipitable water; precipitation; temperature; vegetation
- Before these enhancements were incorporated, NASA and its partners needed to define the requirements for FEWS NET analyses and to learn how the U.S. Geological Survey's FEWS NET African Data Dissemination Service was currently used
- 43 FEWS NET expert end-users responded to on-line questionnaire to quantify FEWS NET satellite remote sensing requirements, including
  - Environmental variables, i.e. rainfall, vegetation
  - Spatio-temporal requirements
  - Accuracy requirements for rainfall and vegetation

Overall questionnaire results

- Rainfall was collectively expressed as an essential component for famine early warning
- Crop yield estimates and vegetation were considered vitally important –by clear majority of respondents
- Both of these products were frequently used:
  - 30% used RFE daily and 75% used it weekly;
  - NDVI was not as commonly used on a daily basis, but approximately 60% of respondents used the product on at least a weekly basis.



FEWS NET inferred requirements based upon questionnaire results

<table>
<tr><th colspan="2">Property</th><th>User Requirement</th><th>Drivers</th></tr>
<tr><td rowspan="2">Spatial Resolution</td><td>General/Vegetation</td><td>250 m to 1 km</td><td>Need to capture variations to support district level analysis</td></tr>
<tr><td>Rainfall</td><td>2 km to 5 km</td><td>Somewhat relaxed because of convolving effects of topography, soils, etc.</td></tr>
<tr><td colspan="2">Spatial Extent</td><td>2000 km to 4000 km across</td><td>Need to capture synoptic views at country/regional scale</td></tr>
<tr><td colspan="2" rowspan="2">Temporal Frequency</td><td>Dekad (primary)</td><td>Established operational practice; need to capture variations from typical phenology (dekadal data satisfies those with “Monthly” needs as well)</td></tr>
<tr><td>Daily (secondary)</td><td>Need to capture sudden onset hazards, such as flooding</td></tr>
<tr><td colspan="2">Latency</td><td>≤1 day</td><td>Need to quickly address sudden onset hazards</td></tr>
<tr><td colspan="2">Prediction Time Scale</td><td>1 week and 1 month</td><td>Need to analyze and prepare for both faster and more slowly evolving hazards</td></tr>
</table>

Conclusions based upon survey results

- Survey questionnaire served to establish a baseline for the benchmarking effort
- Consider measures to increase attainment of 1-day latency for FEWS NET products
- Increase the spatial resolution of certain enhanced FEWS NET products; i.e., near real-time vegetation monitoring product
- Consider 1-week precipitation forecasts
- Use 1-month through 4-month forecasts in FEWS NET
- Published results: Ross, Brown, Verdin and Underwood, 2009. Review of FEWS NET biophysical monitoring requirements, *Environmental Research Letters,* **4** 024009 (10pp) doi: 10.1088/1748-9326/4/2/024009

Benchmarking Timeline

- Complete questions for second survey……………………...9/15
- Field questionnaire…………………...9/25
- Close questionnaire………………...10/20
- Complete questionnaire analysis…11/13
- Submit benchmark reports & FEW NET requirements…………12/21
- Publish results, i.e. World Development……………..TBD

Thank you

Related FEWS NET research outputs

Declining Per Capita Agricultural Production and Climate Change Threatens Food Security in 2030

Funk and Brown (2009) Food Security J.

Per capita agricultural production is likely to continue to decline due to population expansion, lack of investment and threats to rainfall due to climate change.

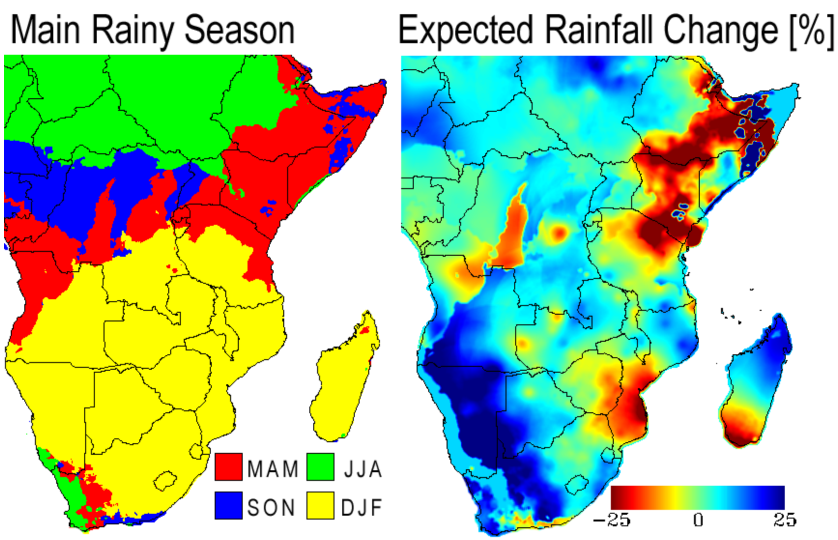


Figure 1 shows projected change in TRMM rainfall in 2050 using a hybrid dynamic-statistical precipitation reformulations. We expect large declines in rainfall in east and southern Africa.

Disparity in yields is both a threat and an opportunity.

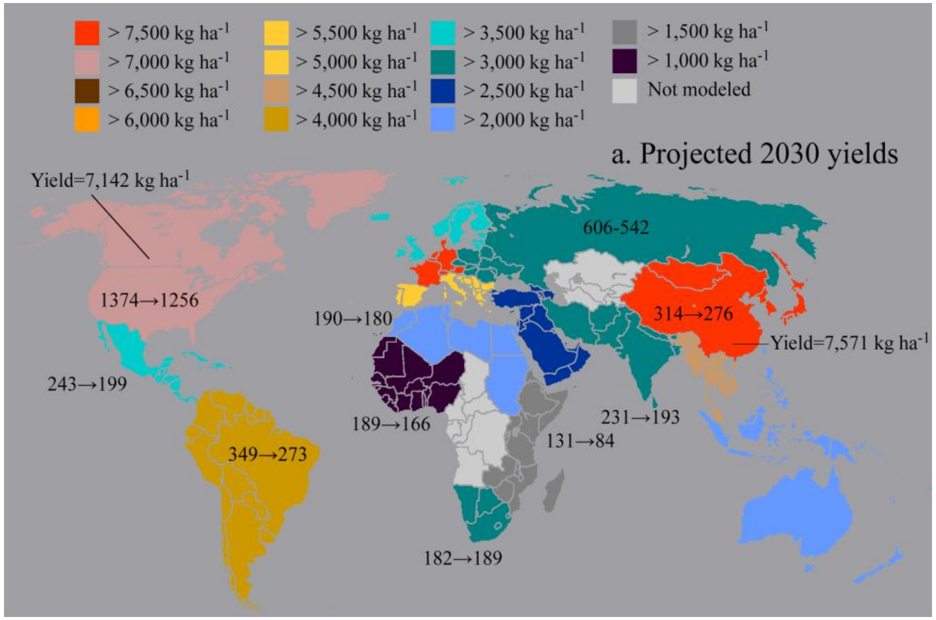


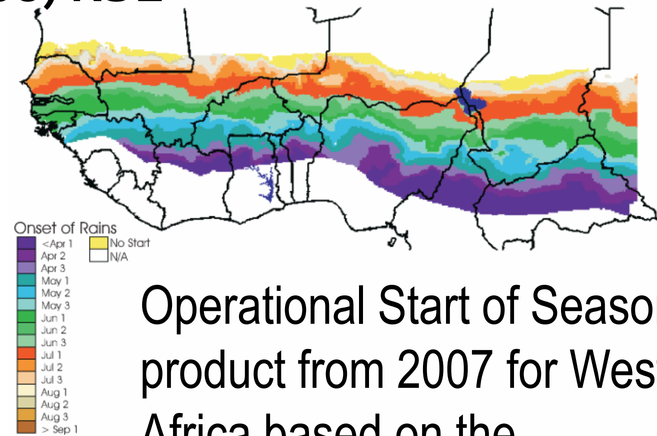
Figure 2

Numbers on the map show likely changes in per capita agricultural production in 2030 under a ‘business as usual’ scenario, based on historical 1961-2007 trends, including both precipitation changes (TRMM) and population expansion.

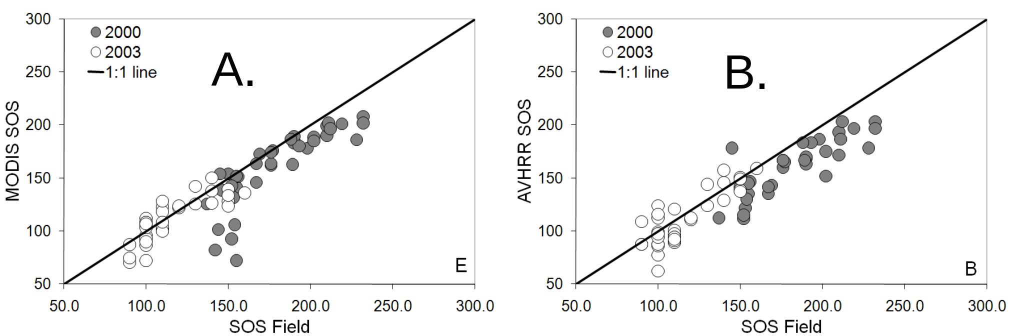
Start of Season estimates from Vegetation Index Datasets

Brown and de Beurs (2008) RSE

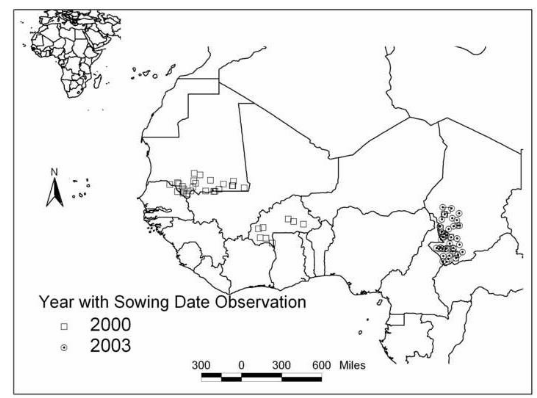
The Start Of Season (SOS) is a critical parameter for food security monitoring and pre-harvest assessment is an important task for early warning purposes in order to anticipate production shortfalls. We focus on deriving SOS from multiple commonly used satellite remote sensing vegetation datasets and evaluated existing methods using ground observations of sowing date, comparing the same metric across multiple sensors and to rainfall-based SOS.



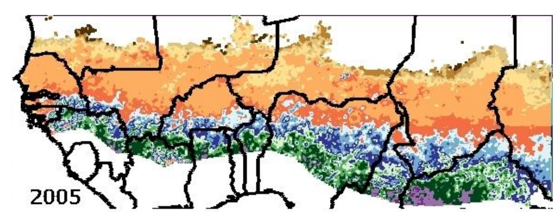
Operational Start of Season product from 2007 for West Africa based on the NOAA Rainfall Estimate (RFE) dataset at a 0.1° resolution



Above: A: SOS estimates based on 16-day, 8-km AVHRR data; B: SOS estimates based on 8-day, 8km MODIS data. The diagonal line represents the 1:1 line.



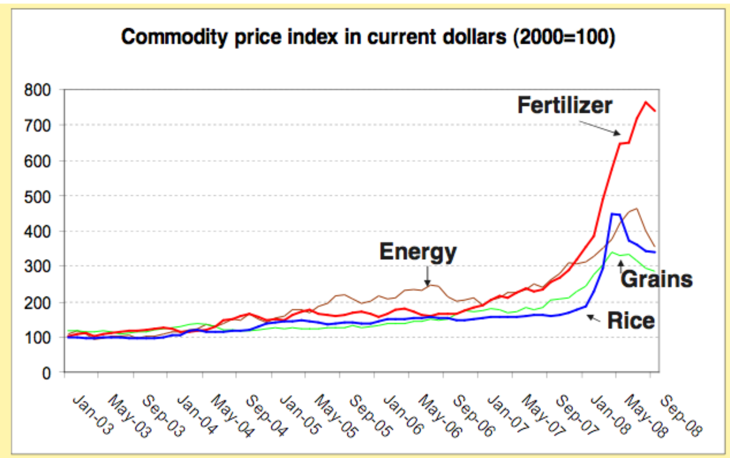
Locations with field observed SOS information.



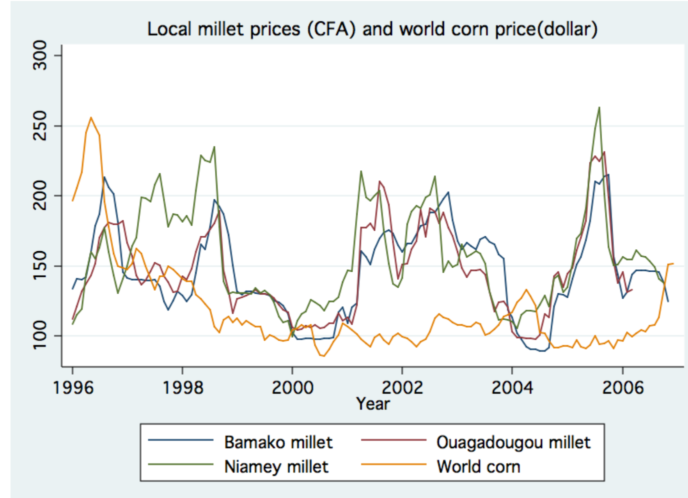
Markets, Climate Change and Food Security in West Africa

Brown, Higgins, Hintermann (2009) ES&T

Food prices are becoming a more important determinant of access to food, particularly since 2008 when fertilizer, grain and energy prices went up dramatically.



Above: Global commodity prices from 2003 to 2008



Local millet prices are much more variable than international prices during the same time period.

Below: Vegetation anomaly measured from space and a local market in Mali, West Africa.

Understanding the relationship between prices and food production, as monitored from satellites, is a key focus of this work.