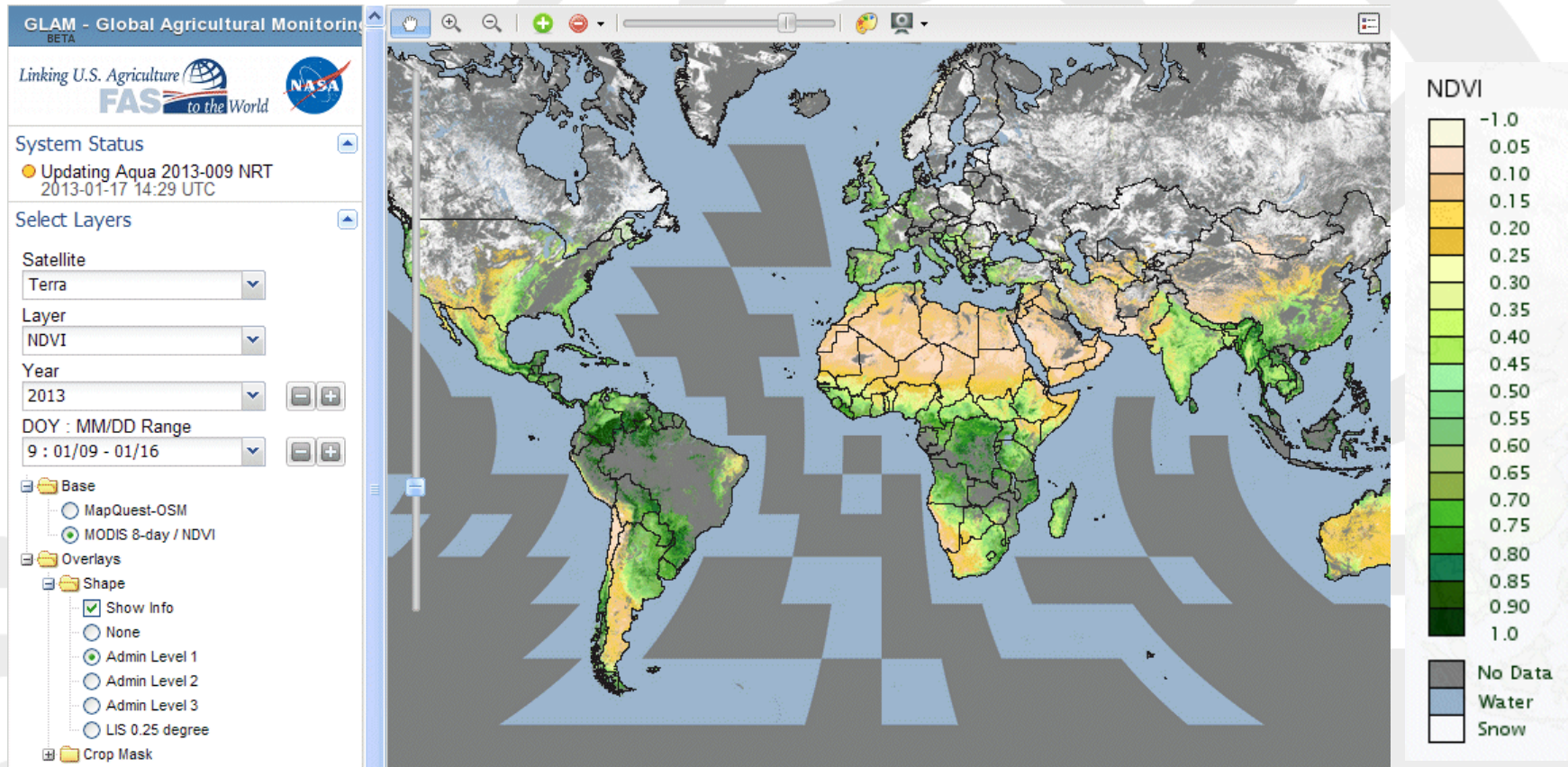


Monitoring Global Agriculture Production with MODIS and Landsat Imagery



Source: USDA/NASA Global Agriculture Monitoring System (GAMS)- <http://glam1.gsfc.nasa.gov/>
MODIS-Aqua 8-day NDVI Image (Jan 9-16, 2013)

Curt.Reynolds@fas.usda.gov
USDA's Foreign Agricultural Service (FAS)
International Production Assessment Division (IPAD)

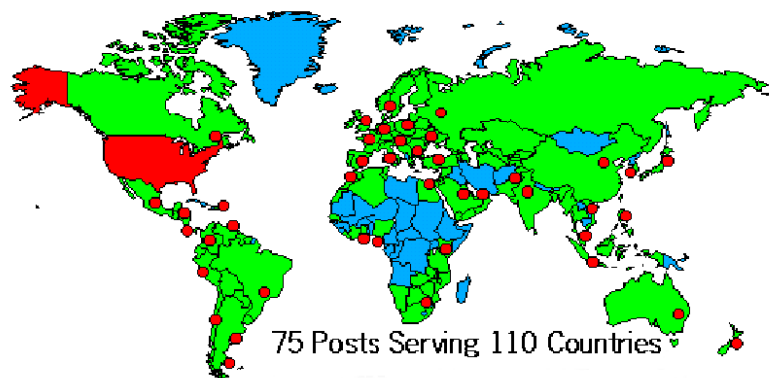
USDA/FAS/IPAD



Foreign Agricultural Service (FAS) of USDA

Create economic opportunity for American agriculture by expanding global markets.....

FAS Attachés Cover Over 70% of Global Land Area, and 85% of Foreign Global Population



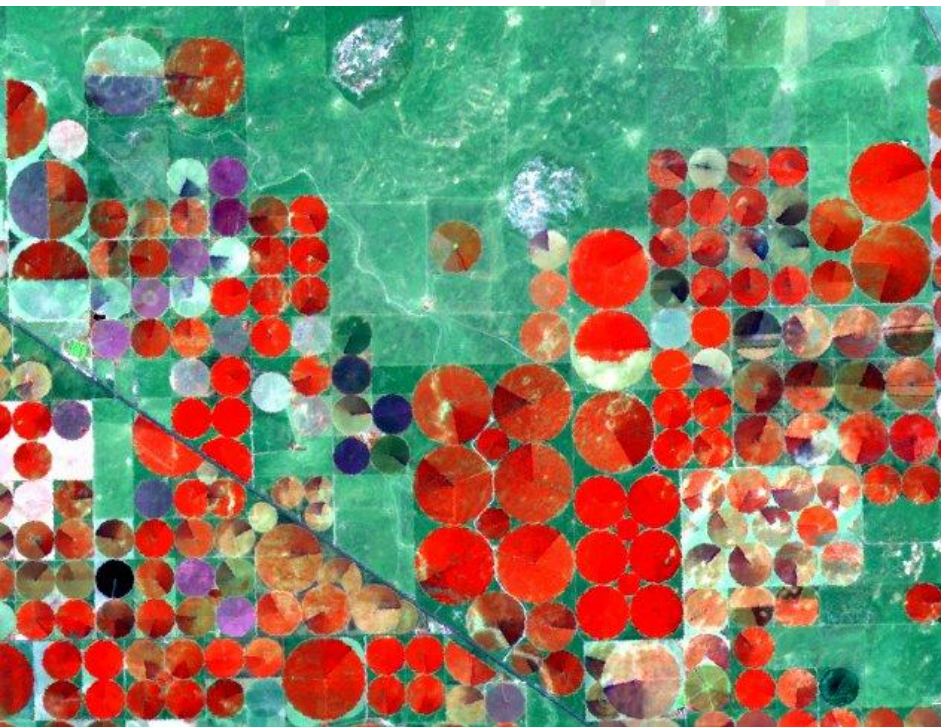
- FAS is primarily responsible for USDA's:
 - Overseas activities with attachés located at 75 posts
 - Market development,
 - International trade agreements and negotiations,
 - **Collection and analysis of statistics and market information.**
- <http://www.fas.usda.gov/aboutfas.html>

FAS Office of Global Analysis (OGA)

International Production Assessment Division (IPAD)

IPAD's Mission Statement:

Produce the most objective and accurate assessment of the global agricultural production outlook, and the conditions affecting food security in the world.

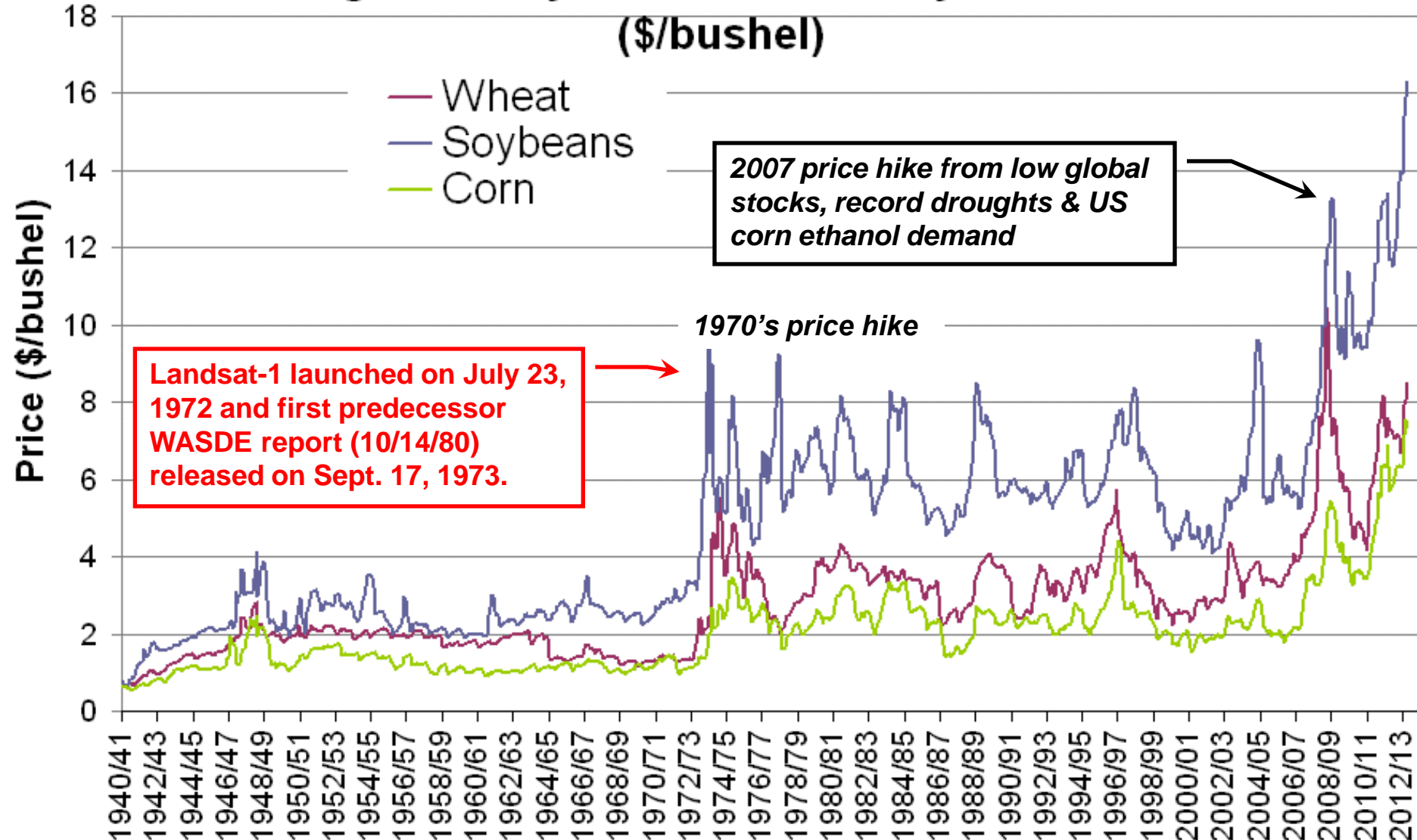


- **USDA's "Production and Supply Database"** (PSD Online) is used for market intelligence (<http://www.fas.usda.gov/psd/>)
- **IPAD's Heritage**- Joint **USDA/NASA/NOAA** remote sensing programs from 1975-1988.
 - **LACIE** (mid-1970's): researched how to monitor agriculture with **Landsat & NOAA** satellite series.
 - **AGRISTARS** (1980's): developed automated applications using Landsat, NOAA, and weather data from U.S. Air Force Weather Agency (AFWA).

Wheat, corn, and soybean prices continue to rise

Average Monthly Price Received by US Farmers

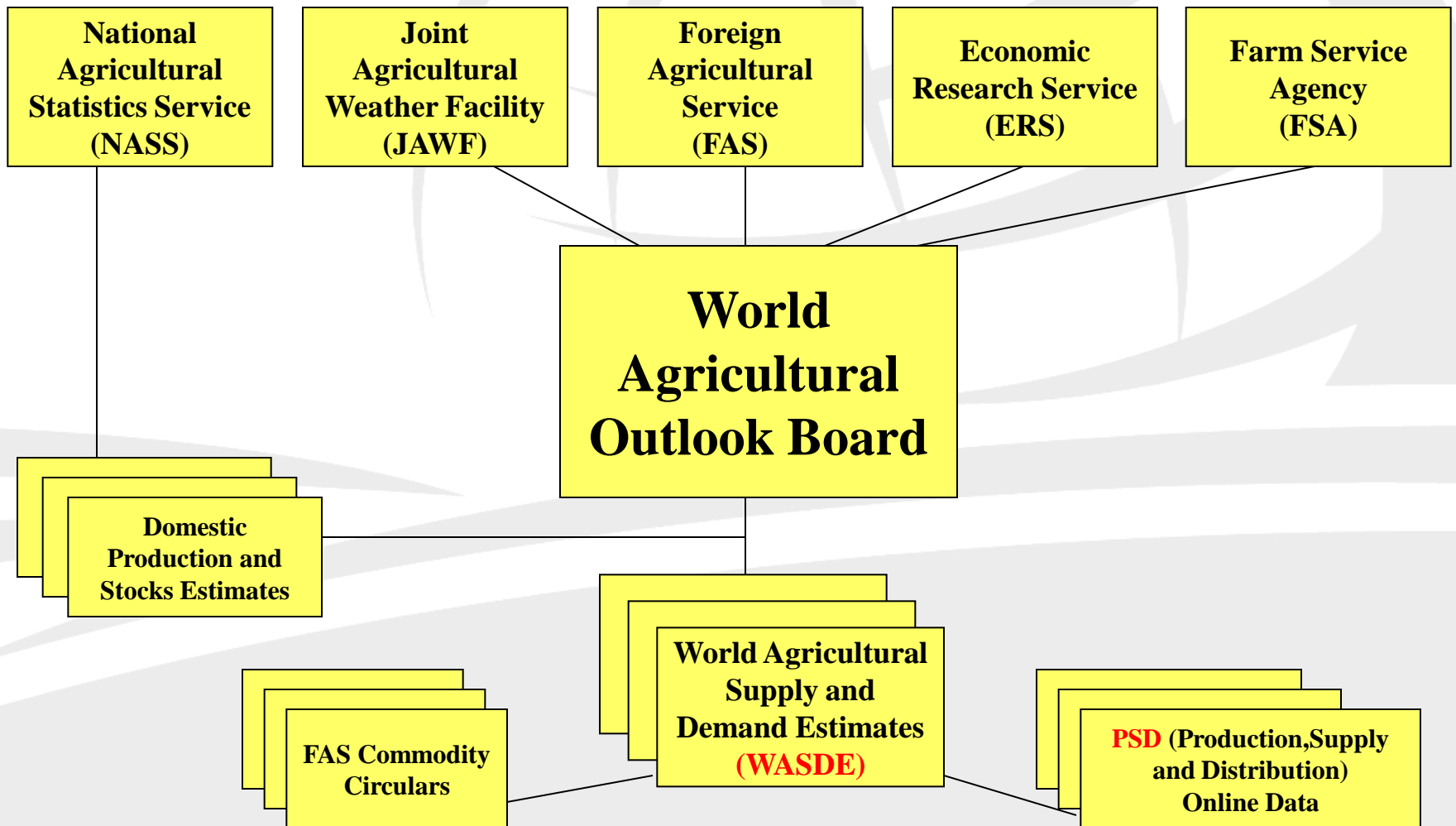
(\$/bushel)



Source: USDA/NASS Agricultural Prices

http://www.nass.usda.gov/Charts_and_Maps/Agricultural_Prices/

USDA's Economic Information System



USDA's Economic Intelligence System

World Agricultural Supply
and Demand Estimates
(WASDE) since 1973

PSD (Production, Supply &
Distribution) Online Archive
from 1960-current

PSD Online stores historical estimates
for crop production, imports,
exports, consumption, & stocks for
most commodities and countries.

USDA/FAS
Economic
Analysis

Chicago Board of Trade
(CBOT) & other
commodity markets

USDA
Publications

- # Trade Policy
- # Exporter Assistance & Export Programs
- # Food Aid & Export Credit Programs
- # UMR (Usual Marketing Requirements)

- # USDA decision-makers
- # U.S. Ag Producers & Traders
- # Commodity Price Discovery
- # Commodity Price Adjustments

USDA's Economic Intelligence System

- USDA monthly crop estimates and trade reports are released at specific times to commodity markets:
 - **WASDE Circular from WAOB** released on the **9-12th day of each month at 12:00 noon.**
<http://www.usda.gov/oce/commodity/wasde/>
 - **Monthly World Production, Market and Trade Reports**
<http://www.fas.usda.gov/currwmt.asp>
 - **PSD Online (historical archive from 1960-present)**
<http://www.fas.usda.gov/psdonline/>

USDA United States Department of Agriculture
Office of the Chief Economist

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Commodity Forecasts

World Supply and Demand Estimates

The World Agricultural Supply and Demand Estimates (WASDE) report provides USDA's comprehensive forecasts of supply and demand for major U.S. and global crops and U.S. livestock. The report gathers information from a number of statistical reports published by USDA and other government agencies, and provides a framework for additional USDA reports.

Latest WASDE Report

The most recent WASDE report is available in TXT and PDF. In 2007, reports will be released at 8:30 a.m. on the following dates:

- Aug 10, Sep 12, Oct 12, Nov 9, and Dec 11

Cotton Estimates

Related Topics

- How the WASDE Report is Prepared
- Historical Revisions
- Archive
- Subscribe to the WASDE
- Commodity Specialists
- Understanding USDA Crop Forecasts

Announcements and Events

- WASDE Release Dates

USDA United States Department of Agriculture
Foreign Agricultural Service

Linking U.S. Agriculture FAS to the World

U.S. agricultural exports support about 925,650 jobs. Show Factoids

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World Agricultural Production (WAP) - Current Report

World Agricultural Production (WAP) reports are prepared by the FAS International Production Assessment Branch (IPA).

The reports use information from the Foreign Agricultural Service's (FAS) global network of agricultural attachés and counselors, official statistics of foreign governments and other foreign source materials, and the results of economic and satellite imagery analysis.

WAP - Current Report

Circular Series
WAP 06-07
June 2007

World Agricultural Production in **PDF format**.
View **Area, Yield and Production Tables**.

USDA United States Department of Agriculture
Foreign Agricultural Service

Linking U.S. Agriculture FAS to the World

Production, Supply and Distribution Online

PSD Online Home About PSD Online Help Contact Us

You are here: FAS Home / Market and Trade Data / PSD Online Home / Custom Query

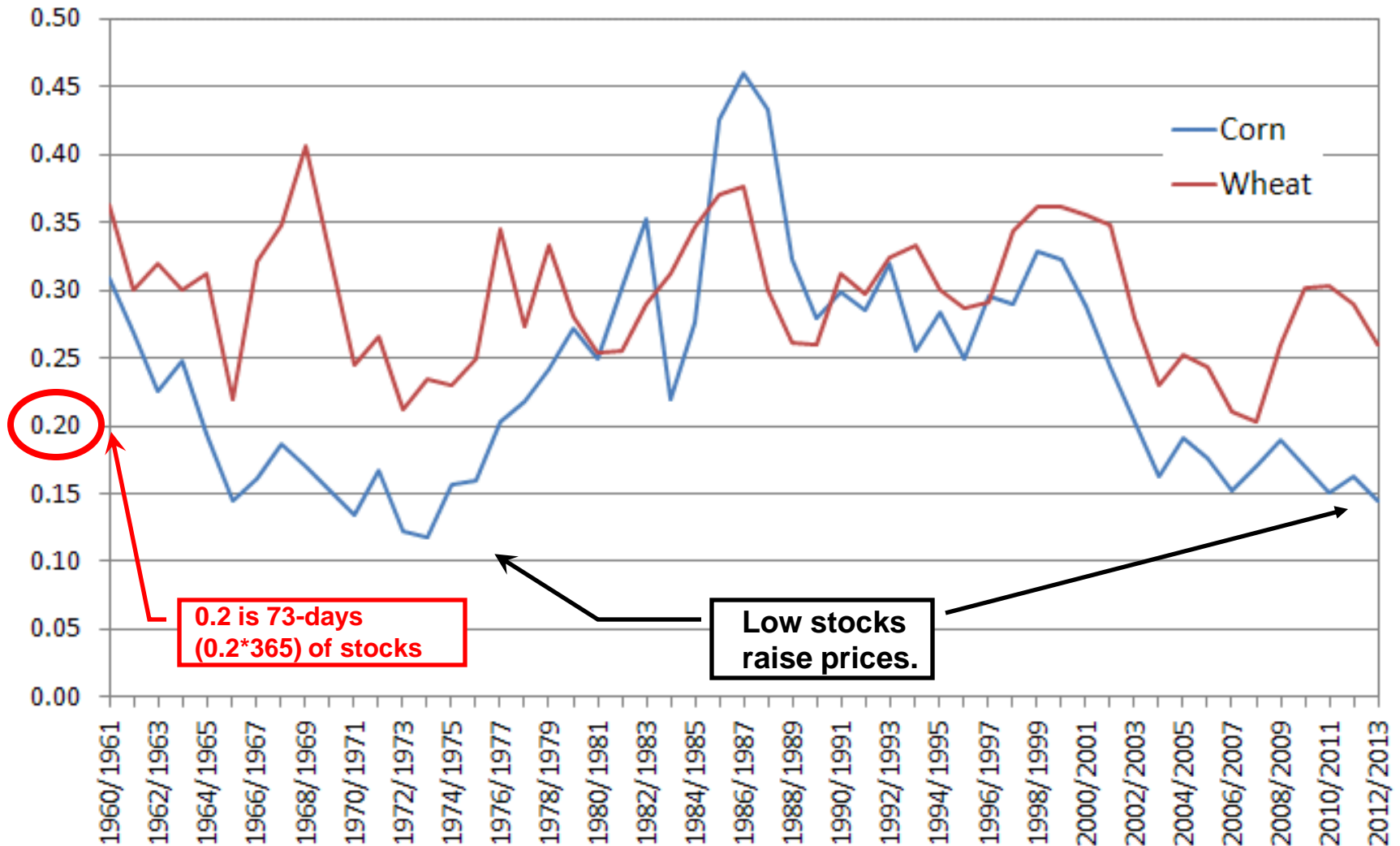
Commodity	Data Type	Country	Year
Filter: All Commodities		WORLD TOTAL	2008
		ALL COUNTRIES	2007
		Afghanistan	2006
		Africa, NEC	2005
		Albania	2004
		Algeria	2003
		Angola	2002
		Anguilla	2001
		Antigua and Barbuda	2000
		Argentina	1999
		Armenia, Republic of	1998
		Aruba	1997

Report Options

Column: Year Sort Order: Commodity/Attribute/Country Top Countries

Low stocks raise prices

Global Stocks to Use Ratio



Global Agricultural Monitoring System (GAMS)

(Joint USDA/NASA Project to produce quantitative crop area & yield estimates from remote sensing data)

↓ (Landsat= free)

↓ (MODIS= free)

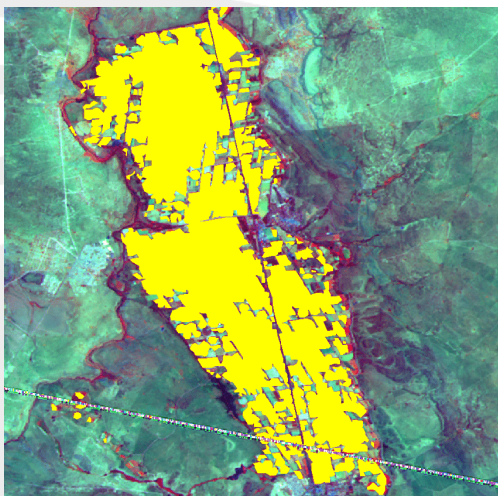
Crop Area
(16-days overpass)

Crop Yield
(daily AM/PM overpass)

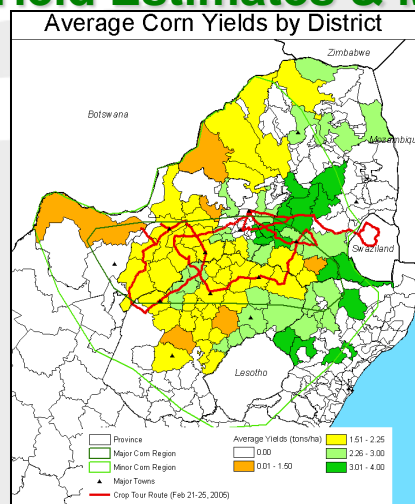
Landsat (30-m)
DMC (22-m)

MODIS-NDVI (250-m)
(2000-present)

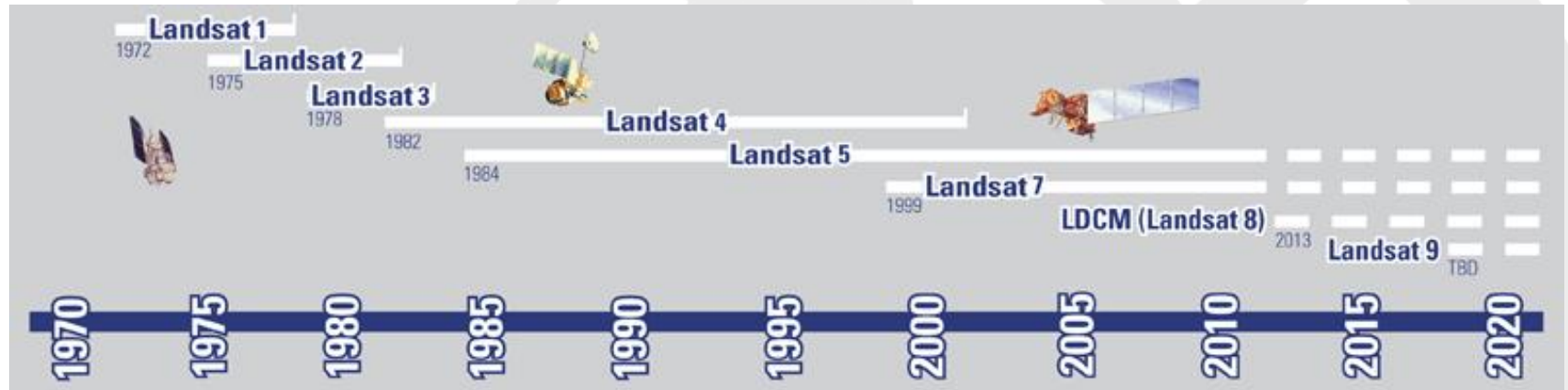
Area Estimates & Crop masks



Yield Estimates & Maps



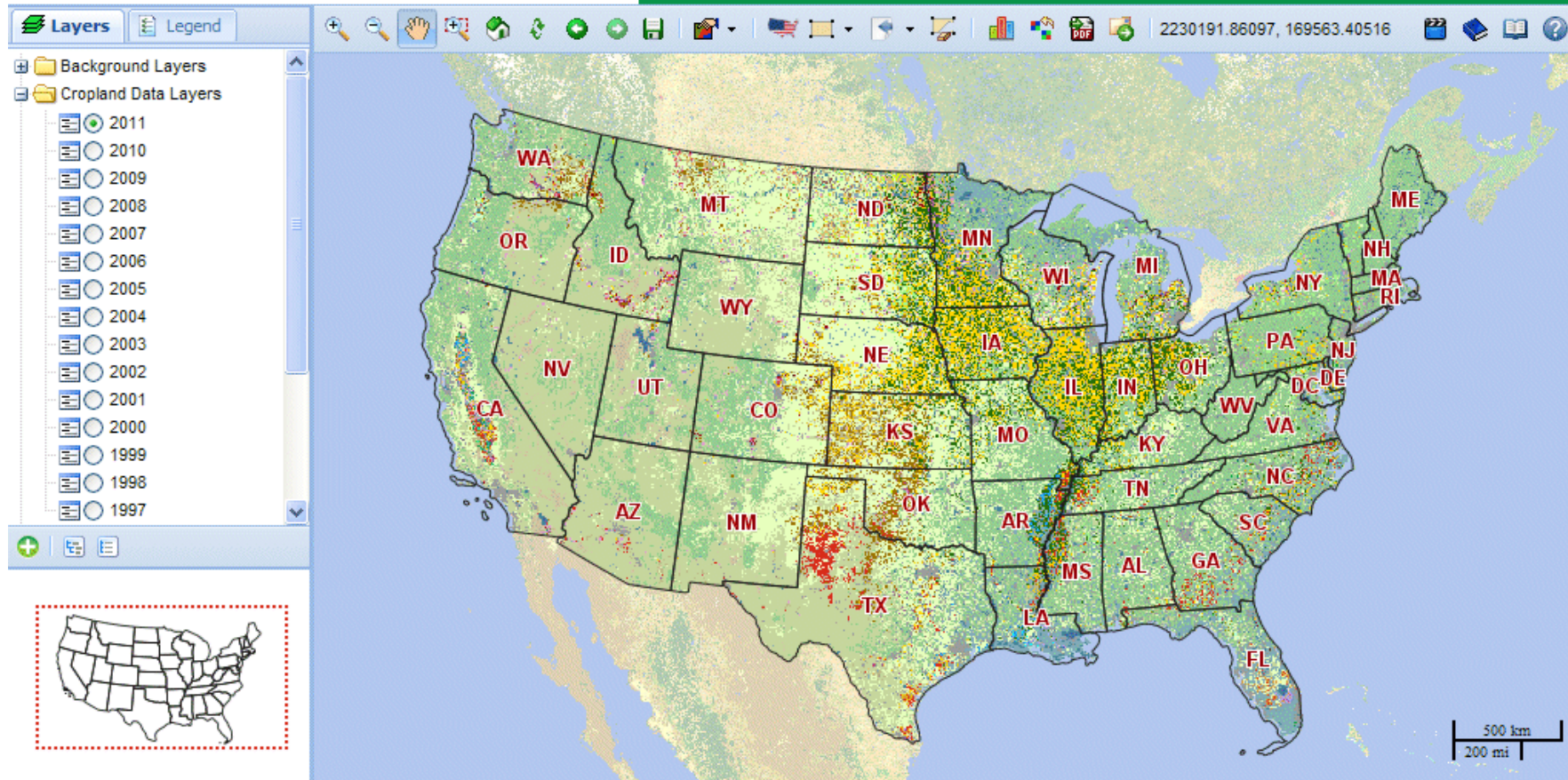
Landsat (30m)/DMC (22-m) (for Crop Area Estimates)



Bridge for “Landsat data gap” = AWiFS (2005-2010)/DMC (2011-12)

- Landsat-7 Scan Line Corrector (SCL) failed on May 31, 2003
- Landsat “data gap” filled with AWiFS (2005-2010) and DMC (2011-2012) imagery
- Landsat-8 to be launched on February 11, 2013**
- All Landsat imagery became **free** on October 1, 2008 and it is critical infrastructure for USG
- Free Landsat imagery** is US Government’s gift to mankind to understand planet Earth and for recording seasonal/annual vegetation changes.

2012 NASS CDL (Crop Data Layer) will be released on January 2013



Land Cover Categories (by decreasing acreage)

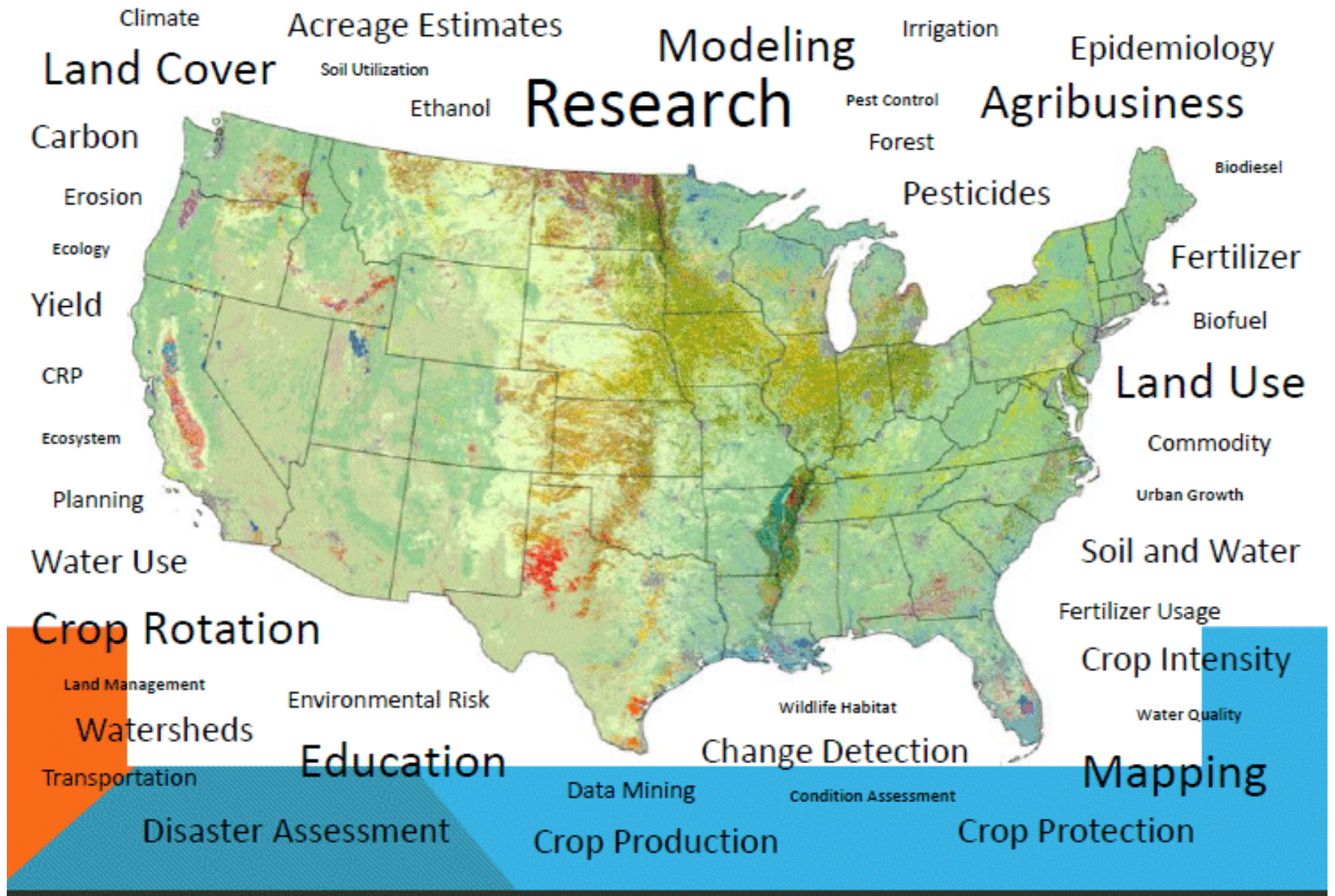
Agriculture

- | | | |
|---|--|---|
|  Pasture/Grass |  Fallow/Idle Cropland |  Vegetables/Fruits/Nuts |
|  Corn |  Alfalfa |  Other Small Grains |
|  Soybeans |  Cotton |  Rice |
|  All Wheat |  Other Crops | |
|  Other Hays |  Sorghum | |

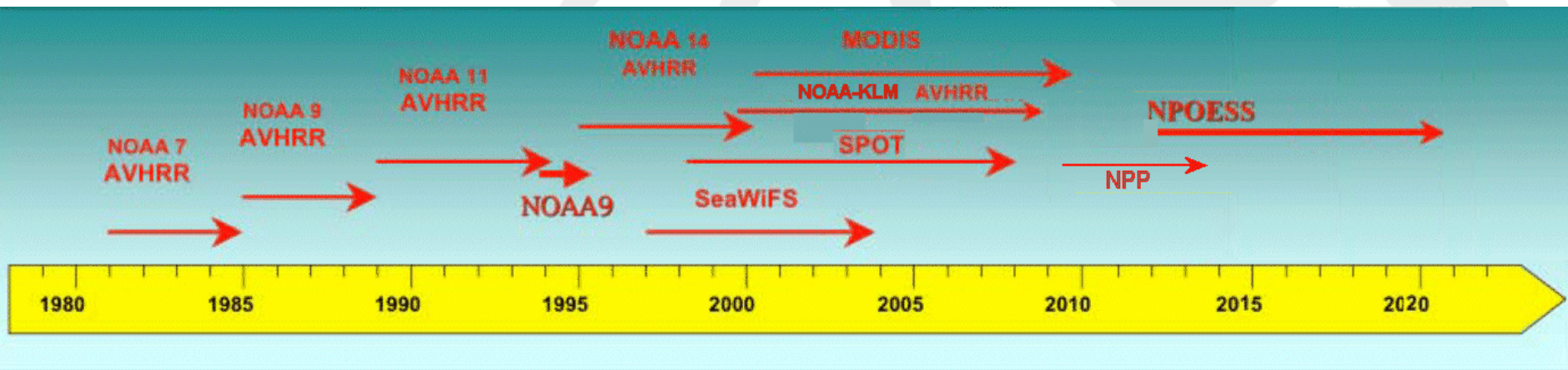
Non-Agriculture

- | | |
|---|--|
|  Woodland |  Barren |
|  Shrubland |  Perennial Ice/Snow |
|  Urban/Developed | |
|  Wetlands | |
|  Water | |

NASS Cropland Data Layer Applications



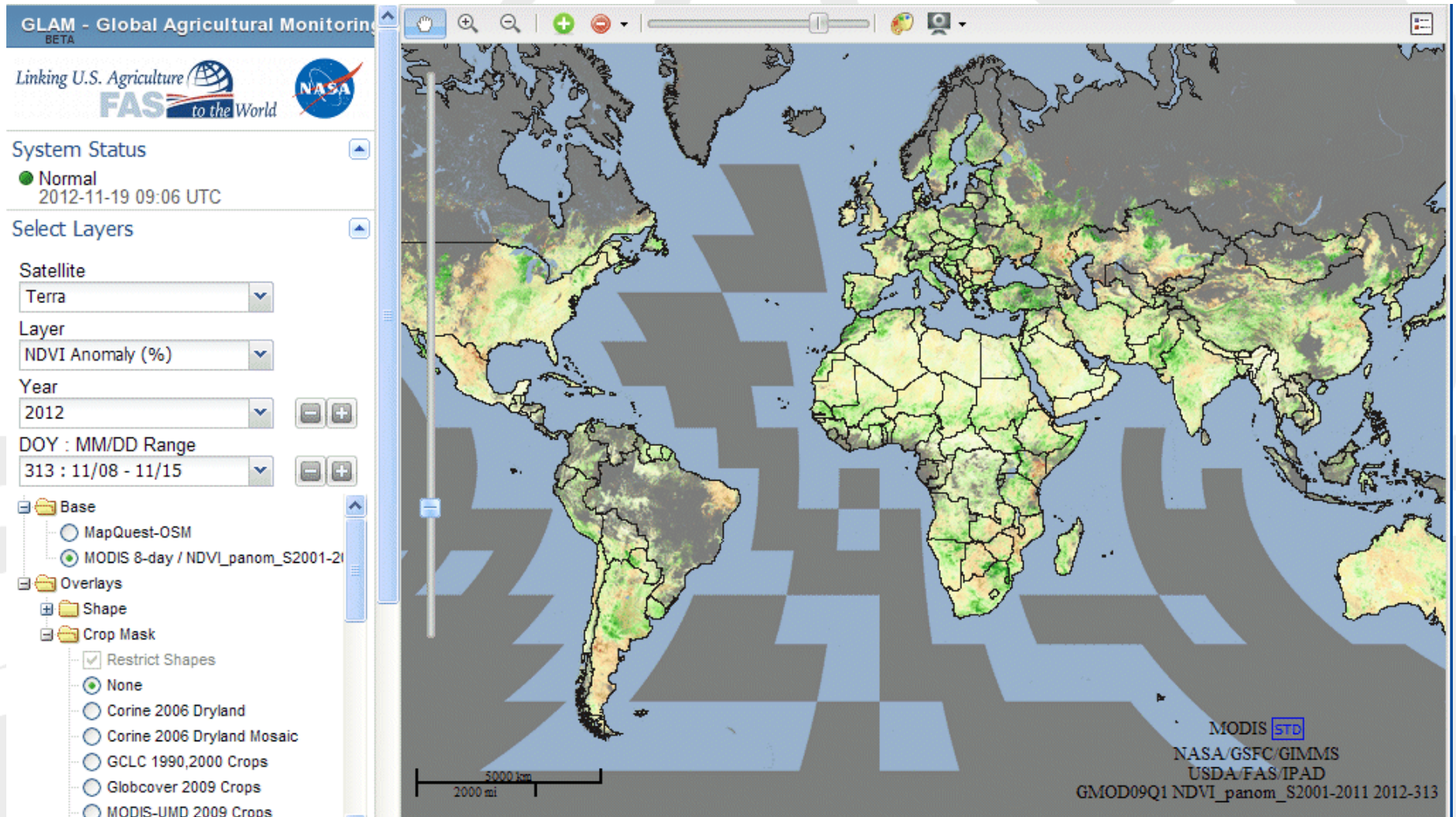
NOAA-AVHRR, Terra/Aqua-MODIS, & NPP/JPSS-VIIRS (for Relative Crop Yield Estimates)



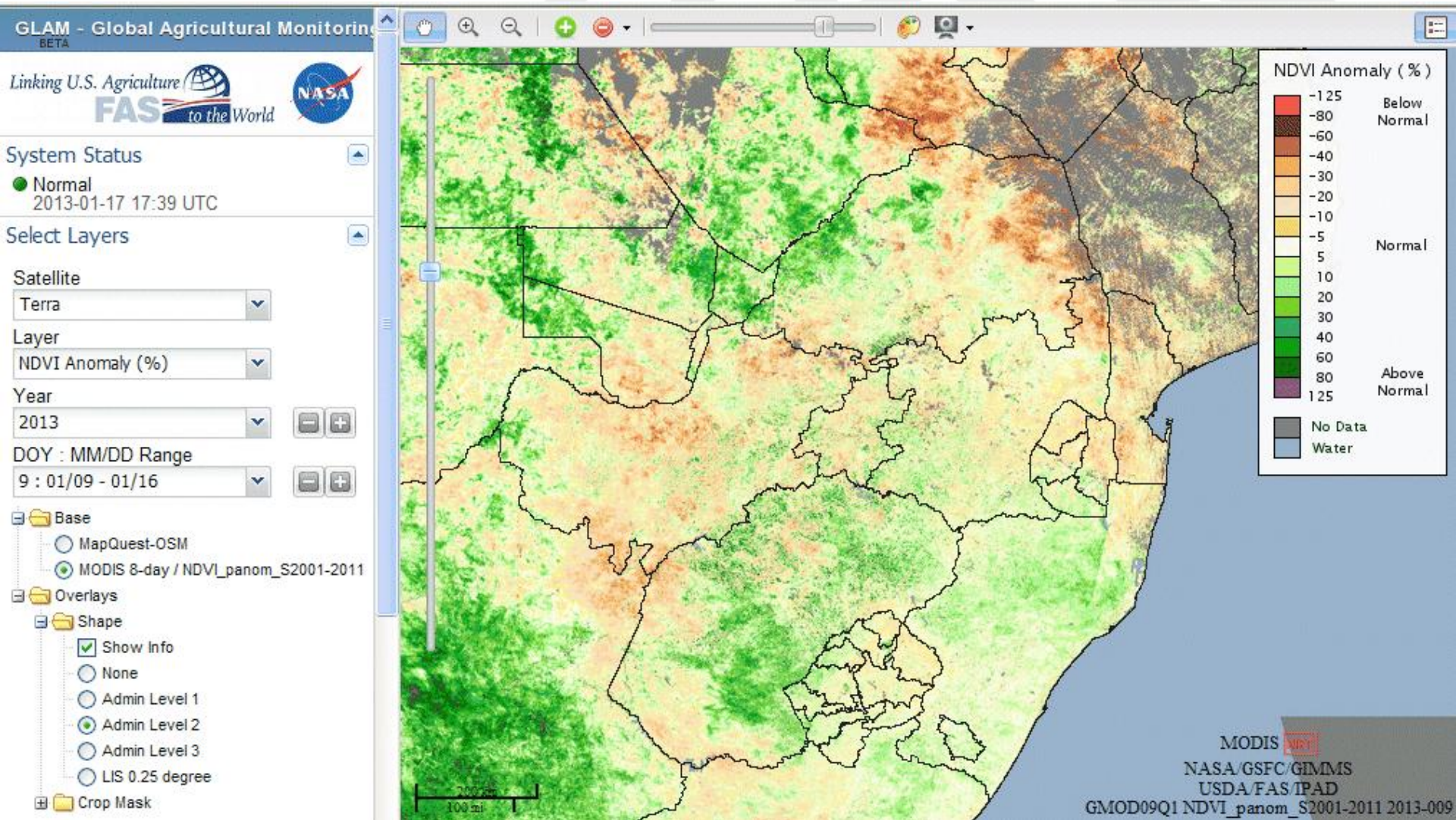
- MODIS sensor on Terra beginning to show stripes
- Suomi NPP/VIIRS launched on October 28, 2011
 - VIIRS (Visible Infrared Imager/Radiometer Suite) sensor on NPP (NPOESS Preparatory Project) and JPSS.
 - NPOESS (National Polar-orbiting Operational Environmental Satellite System) renamed to JPSS (Joint Polar Satellite System) and JPSS to be launched in 2016.
- NPP & JPSS to serve all U.S. Government federal agencies.

MODIS-NDVI (250-meter) Time Series Database for Relative Yield Analysis via Cropland Data Drilling:

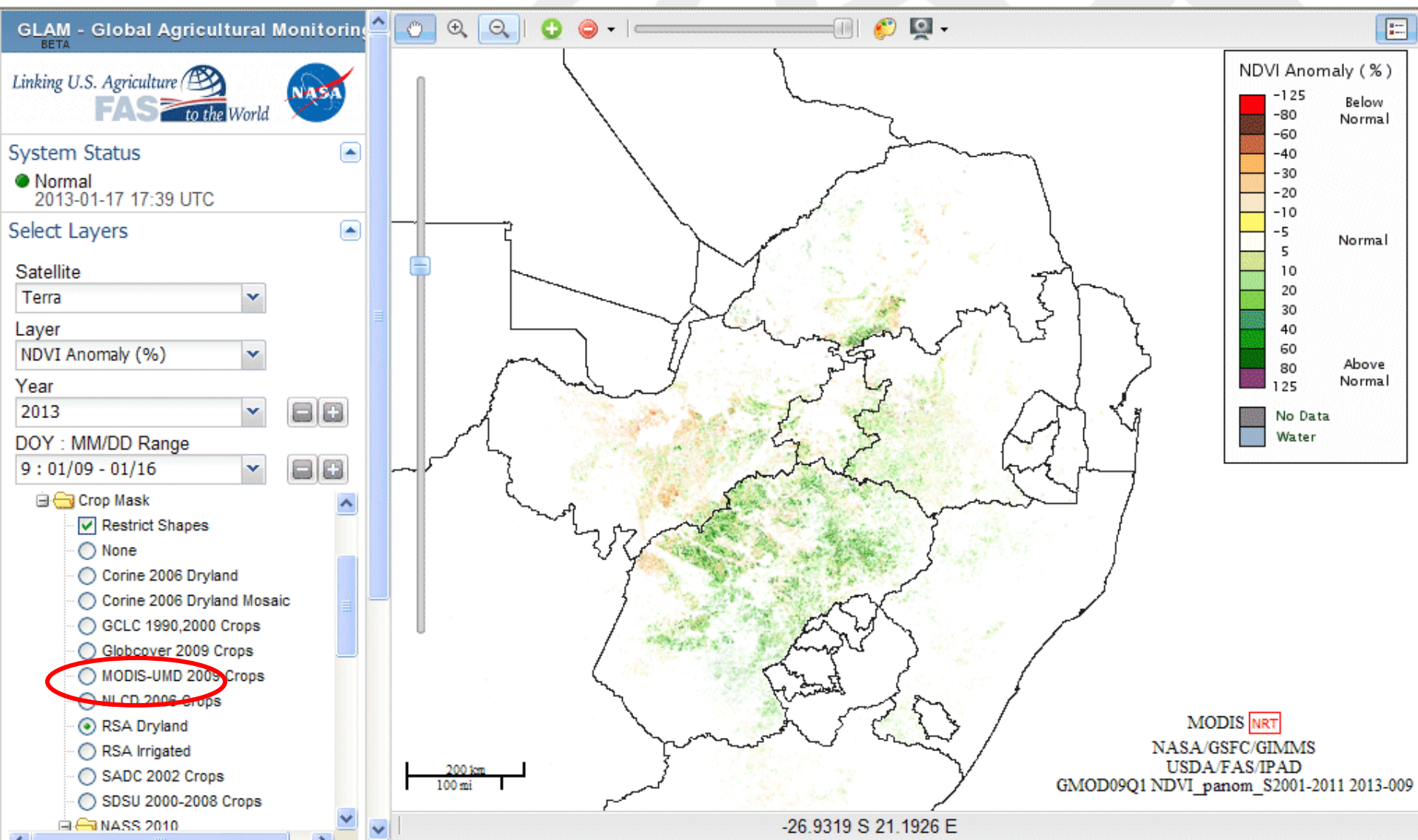
<http://glam1.gsfc.nasa.gov/>



MODIS-NDVI Anomaly (250-meter) (Aqua-Jan 9-16, 2013)



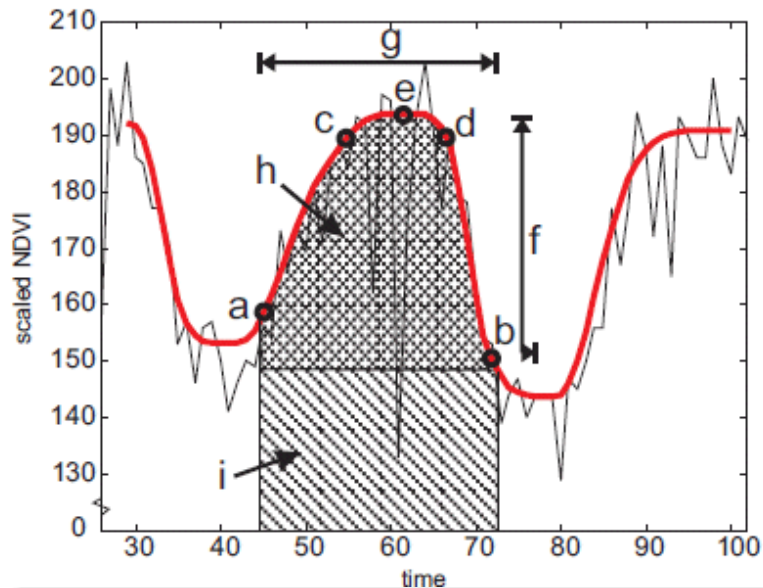
MODIS-NDVI Anomaly (with Crop Mask) (Aqua-Jan 9-16, 2013)



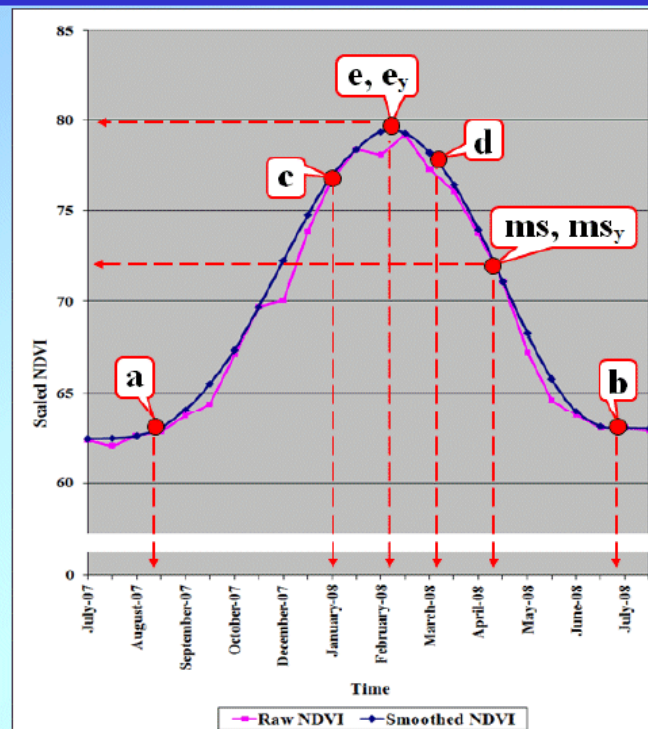
GLAM-MODIS Yield Forecaster Summary

- Seasonal MODIS-NDVI metrics defined by modified TIMESAT program
 - JÖNSSON, P. and EKLUNDH, L. (2004). TIMESAT - a program for analysing time-series of satellite sensor data, *Computers and Geosciences* **30**, 833-845.
 - <http://www.nateko.lu.se/timesat/timesat.asp>

TIMESAT Definition



Critical Growing Season Metrics

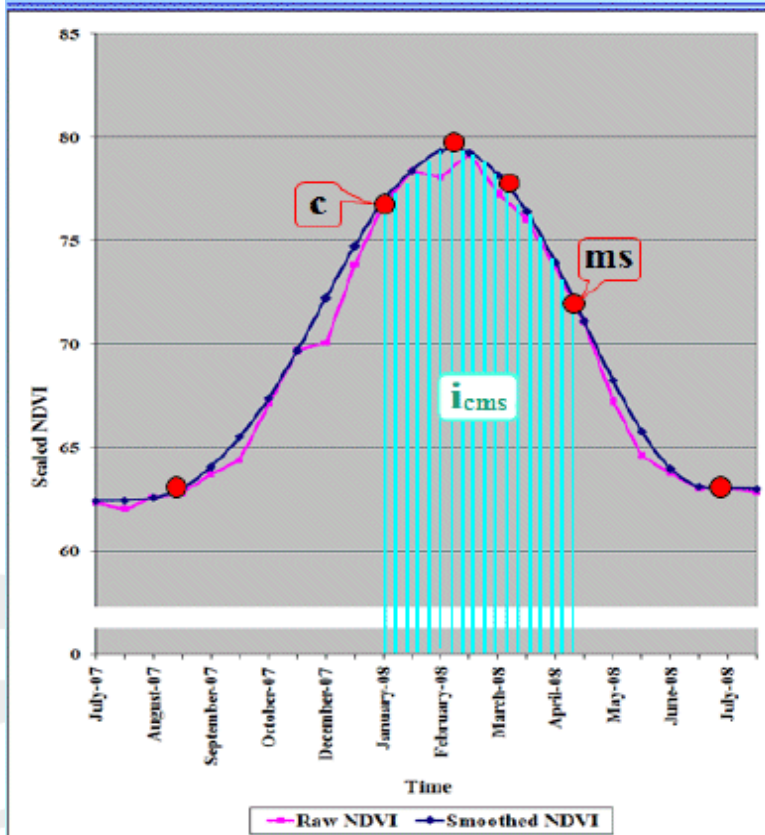


- (a) Start of Season
- (b) End of Season
- (c) End of Greenup
- (d) Start of Senescence
- (e) Peak NDVI
- (ms) Mid Senescence



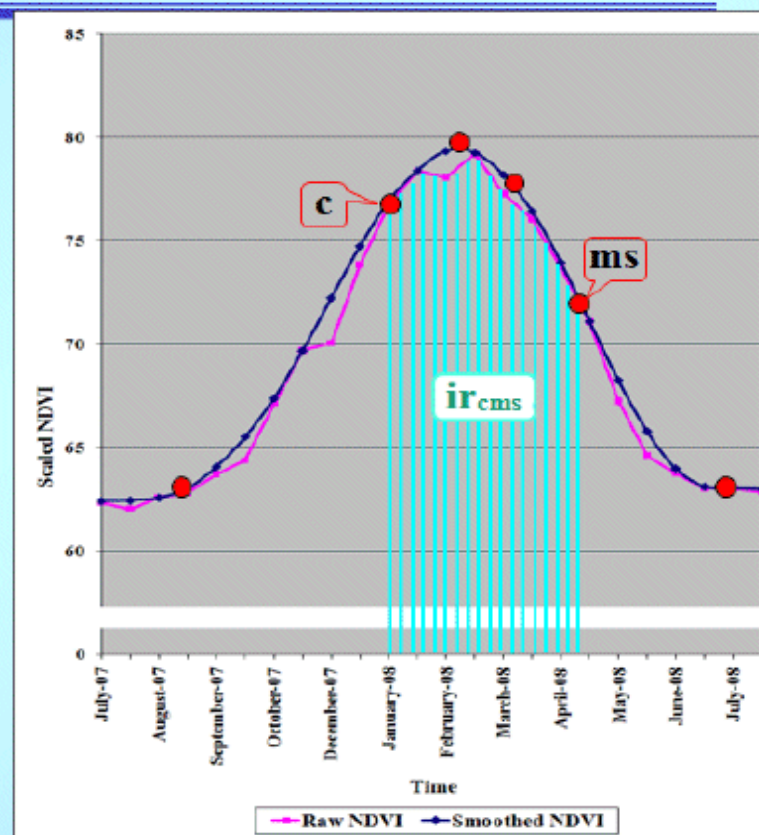
GLAM-MODIS Yield Forecaster Summary

Large Integrals for Grain-filling Period



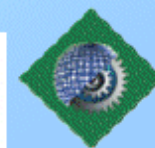
(i_{cms}) Adjusted Large Integral

(c) End of Greenup
(ms) Mid Senescence



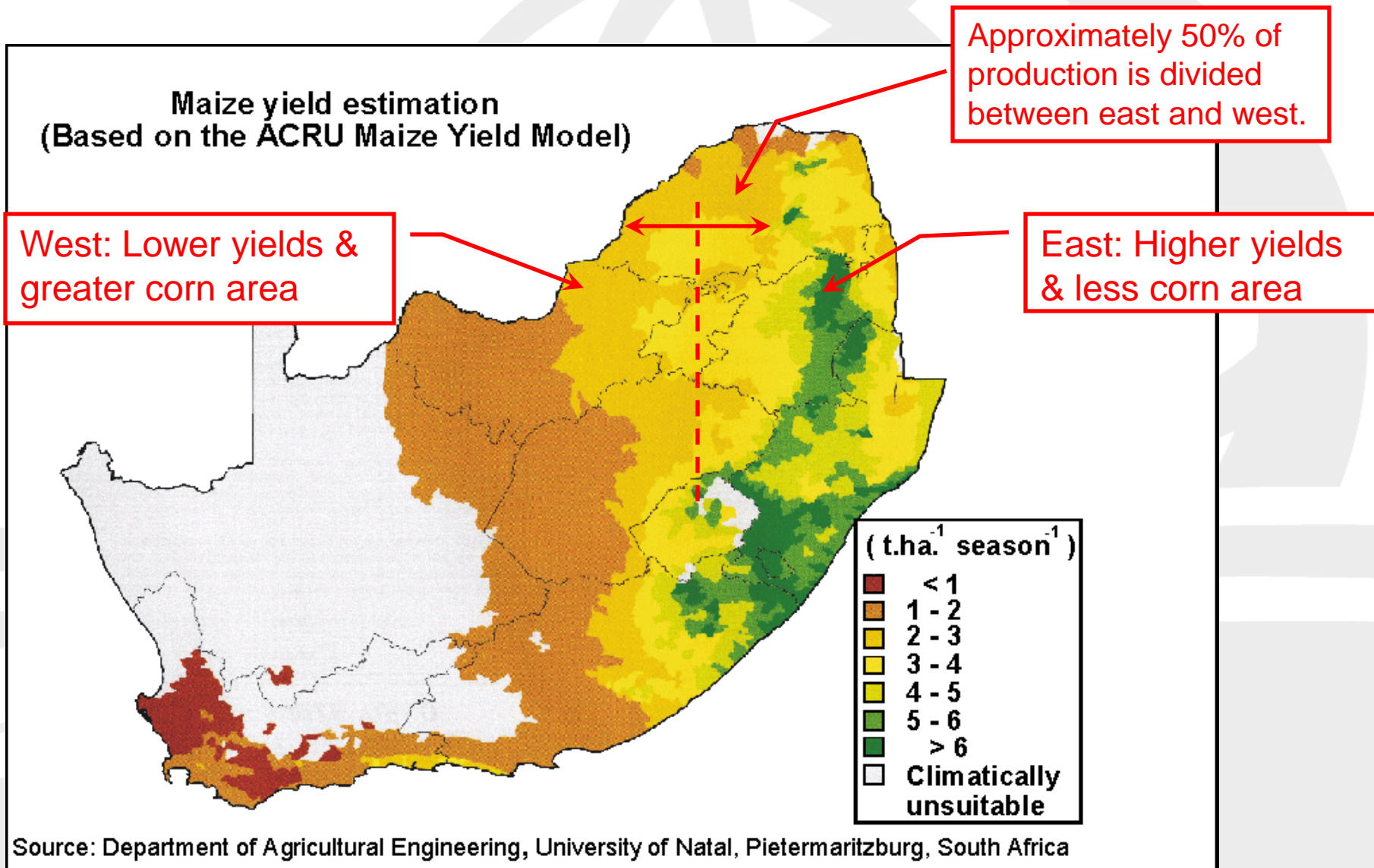
$(i_{r_{cms}})$ Raw Adjusted Large Integral

(c) End of Greenup
(ms) Mid Senescence



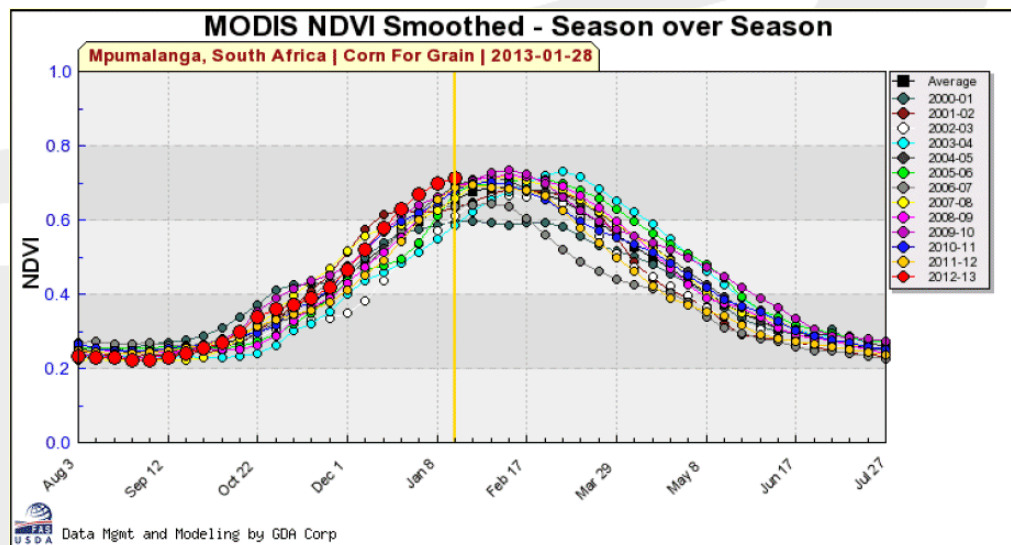
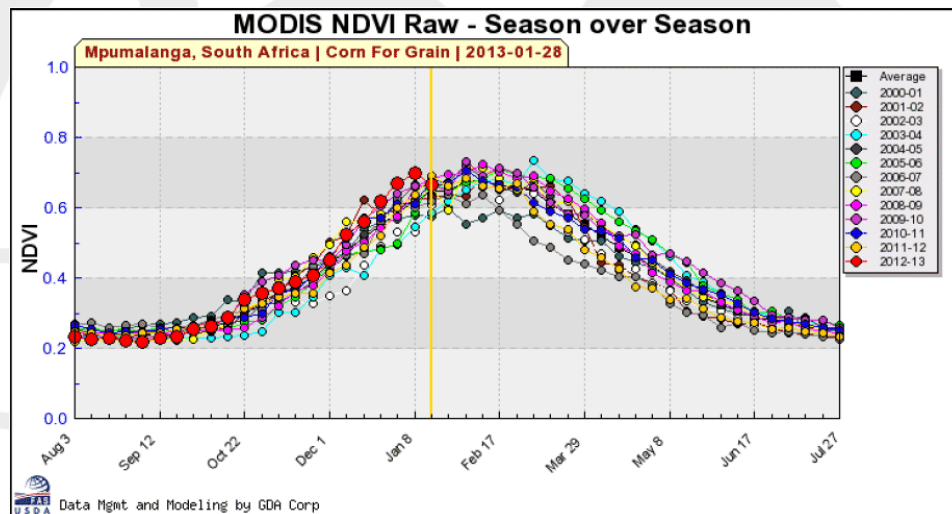
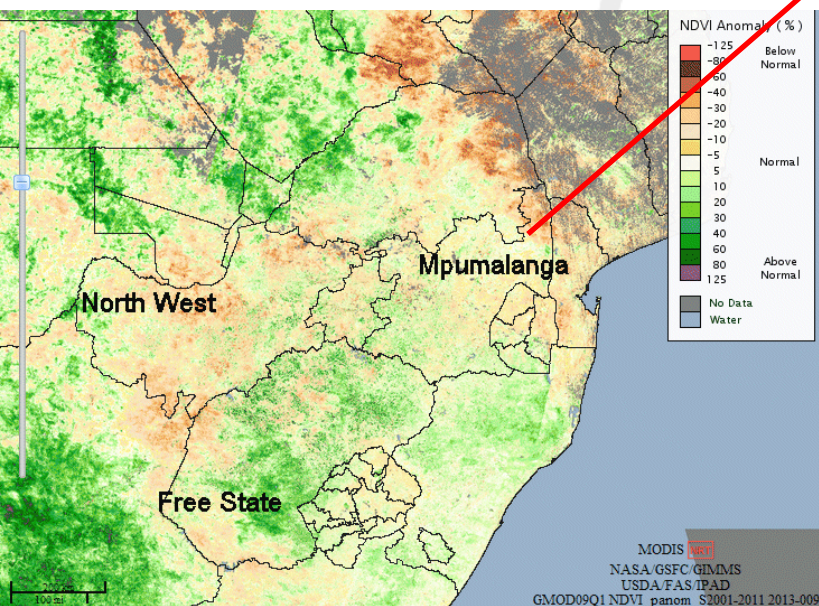
GDA Corp.

South Africa's Corn Yields



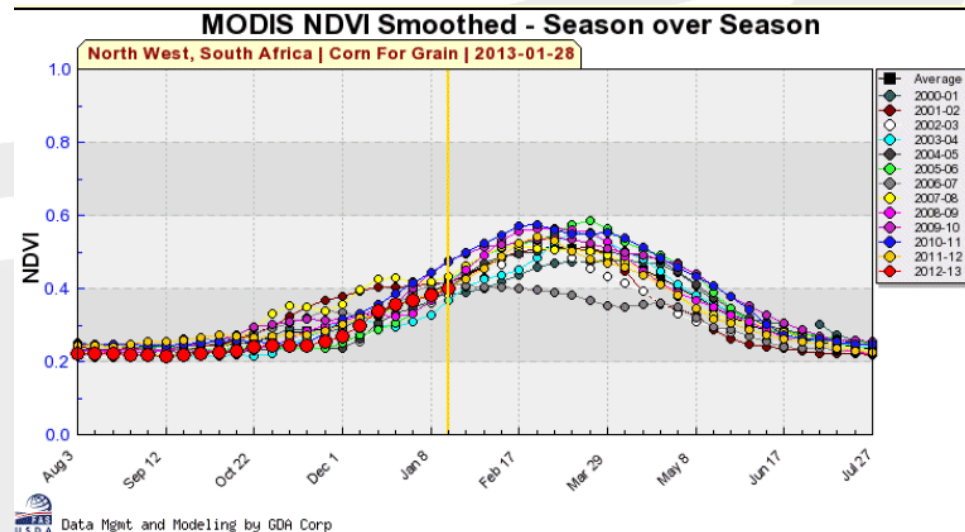
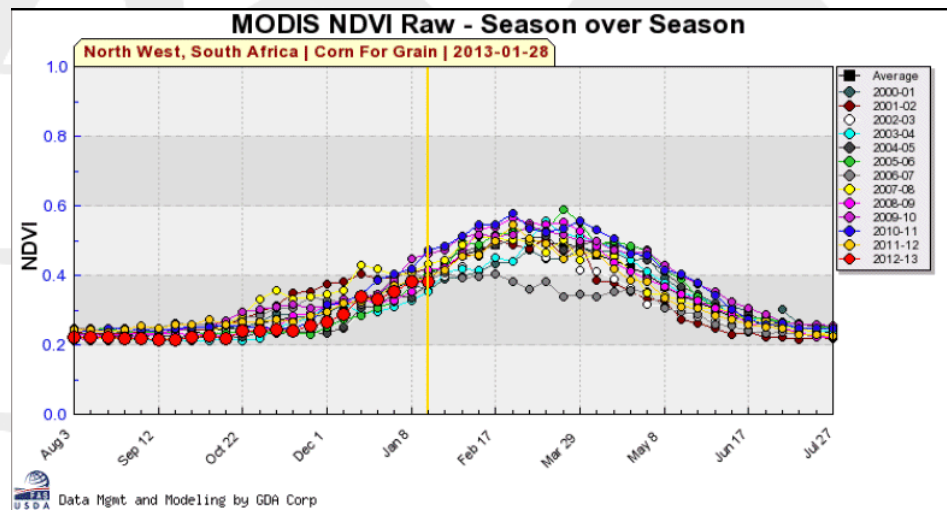
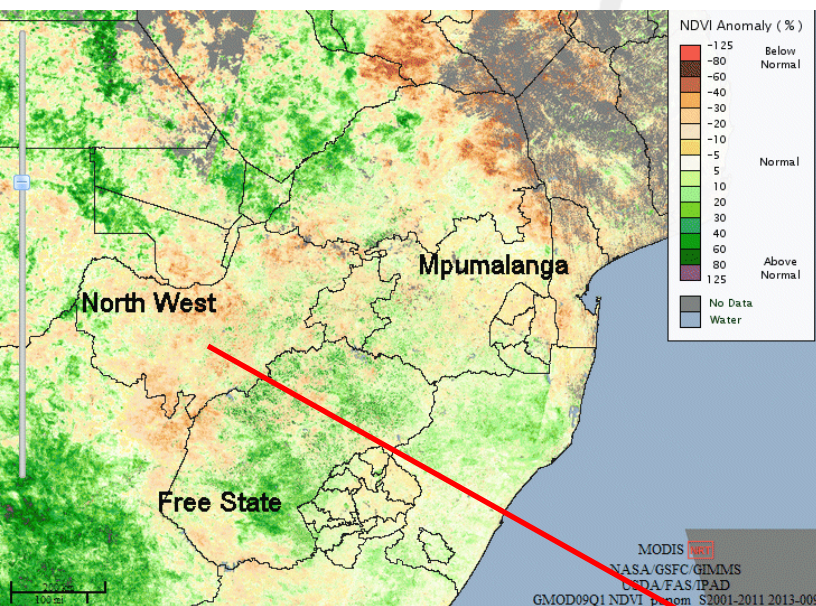
GLAM-MODIS Yield Forecaster Summary

- Smoothed seasonal MODIS-NDVI metrics defined by modified TIMESAT



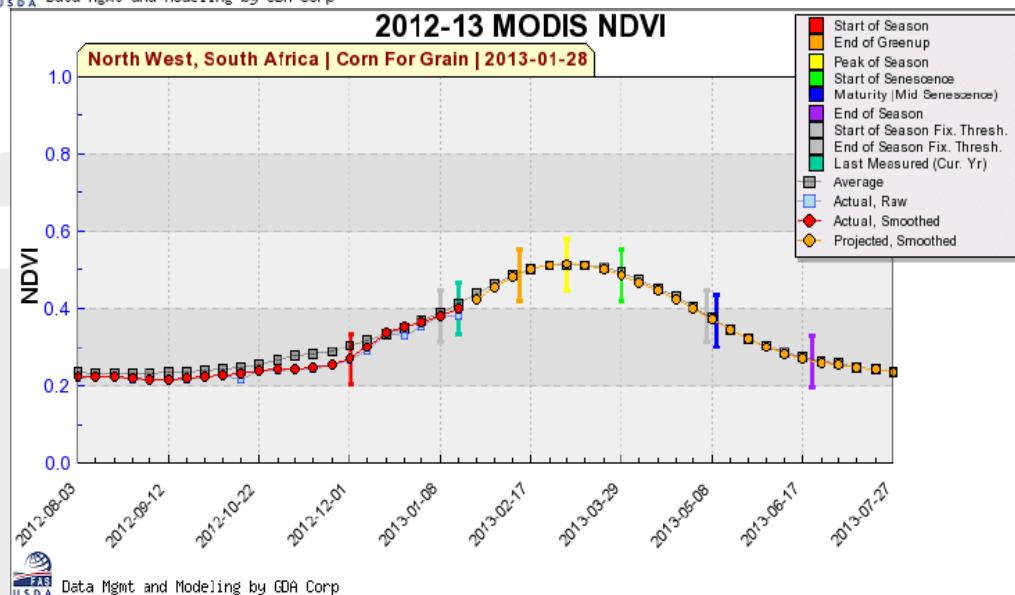
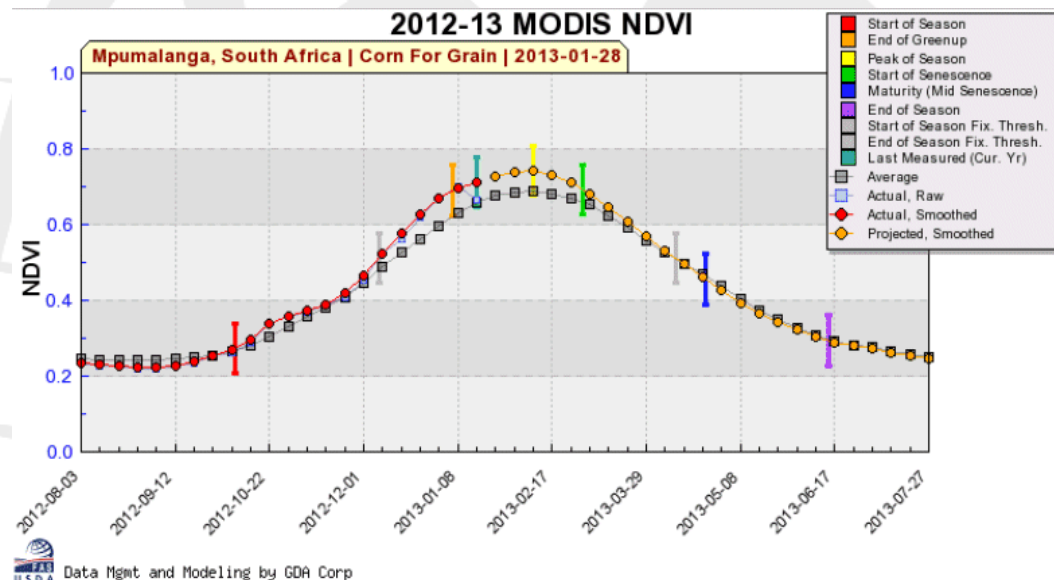
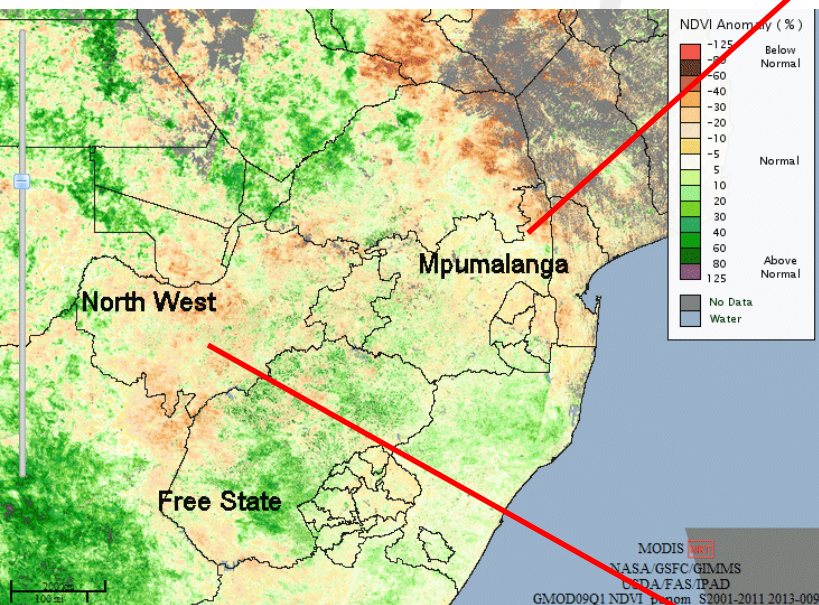
GLAM-MODIS Yield Forecaster Summary

- Smoothed seasonal MODIS-NDVI metrics defined by modified TIMESAT



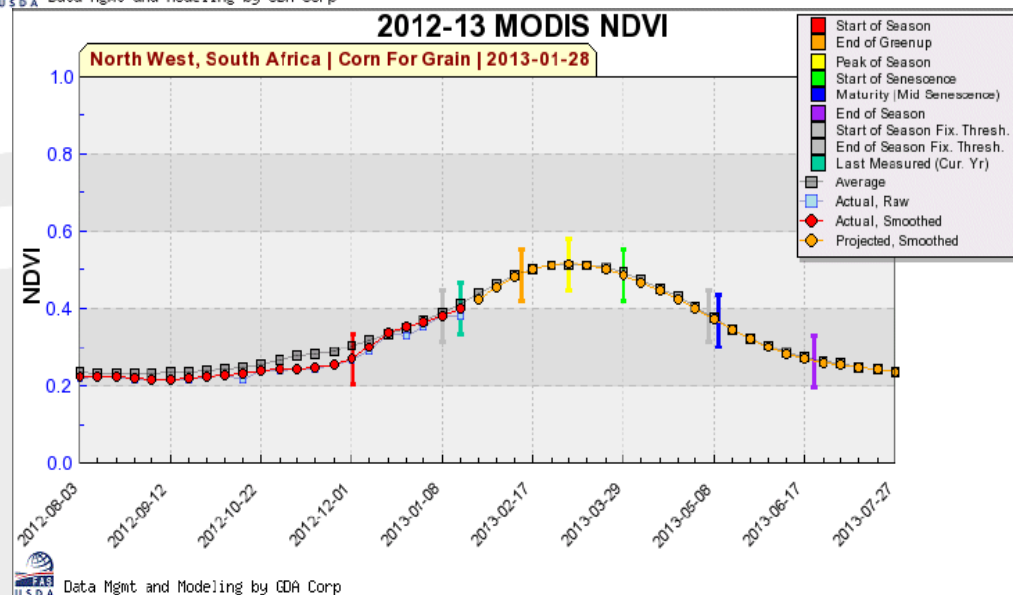
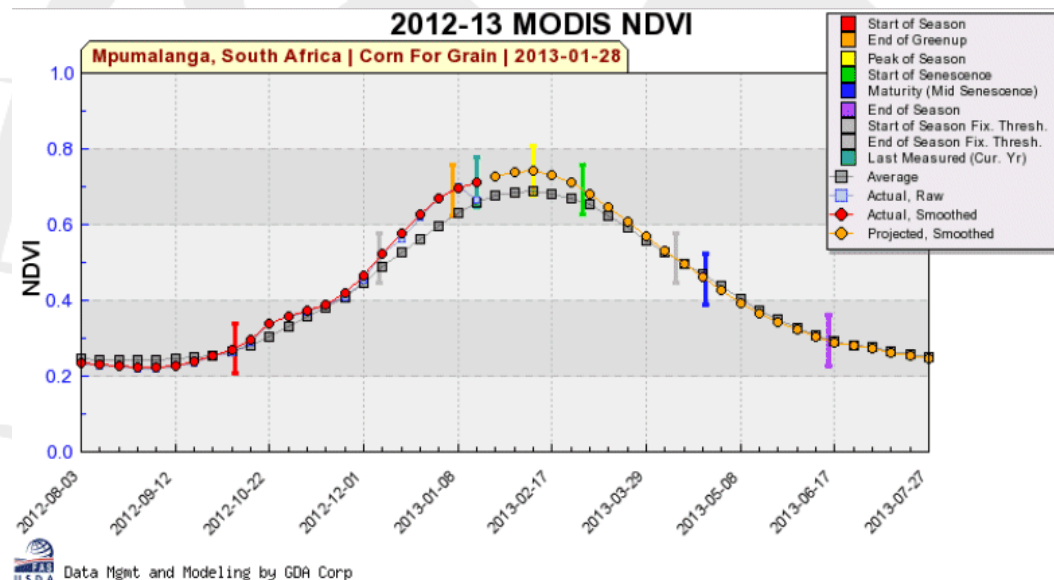
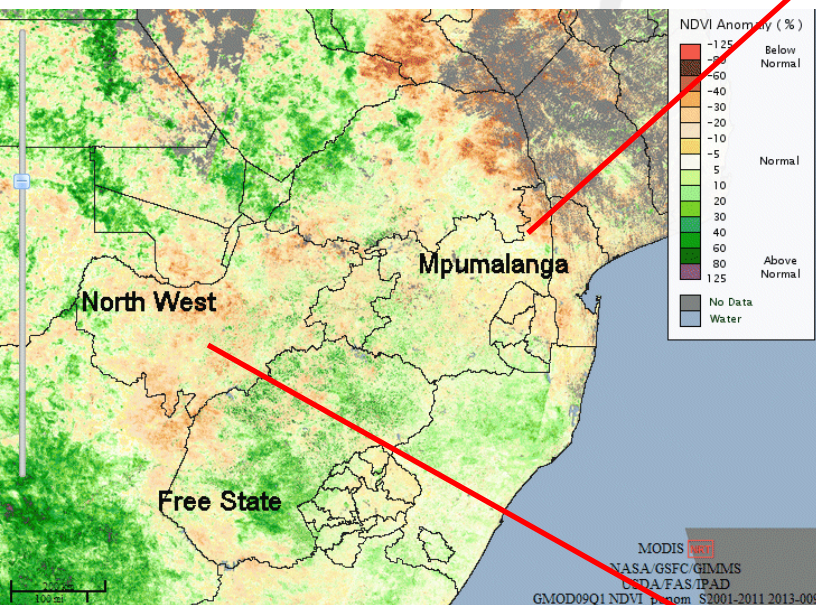
GLAM-MODIS Yield Forecaster Summary

- Smoothed seasonal MODIS-NDVI metrics defined by modified TIMESAT



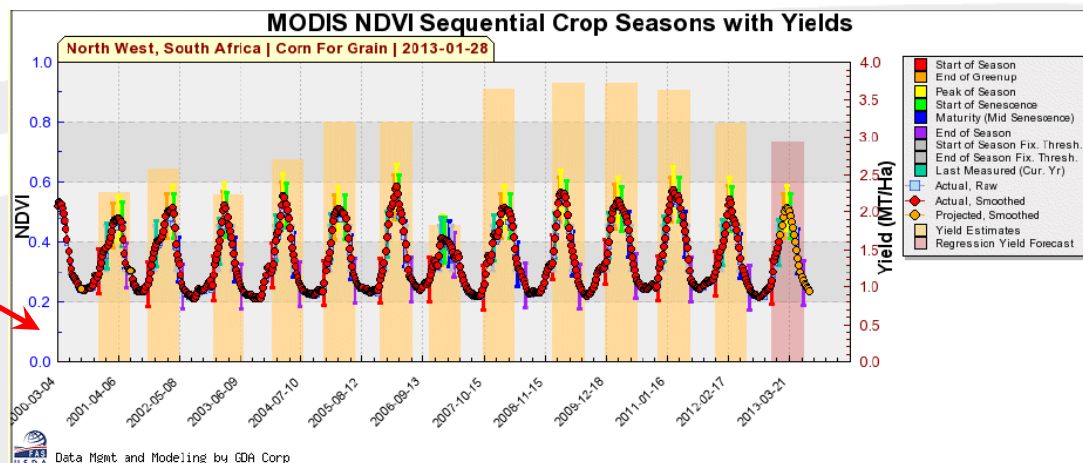
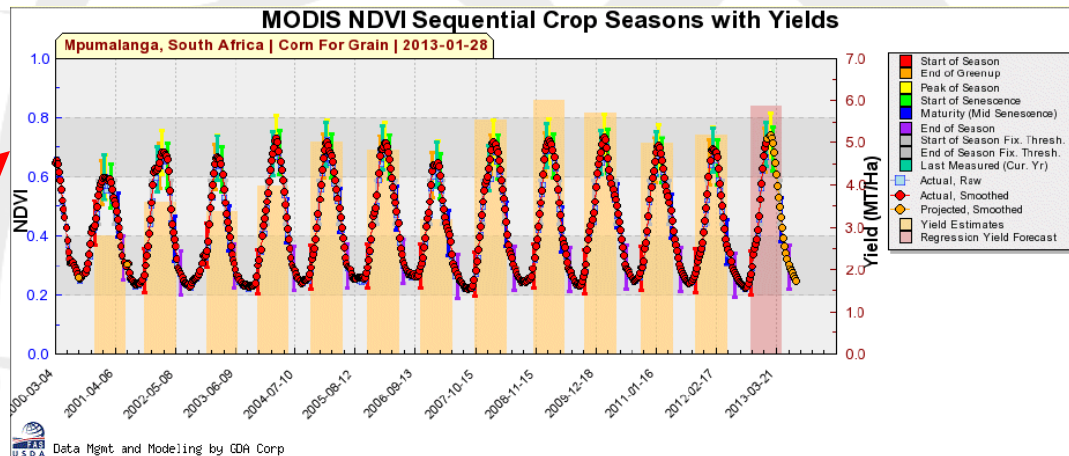
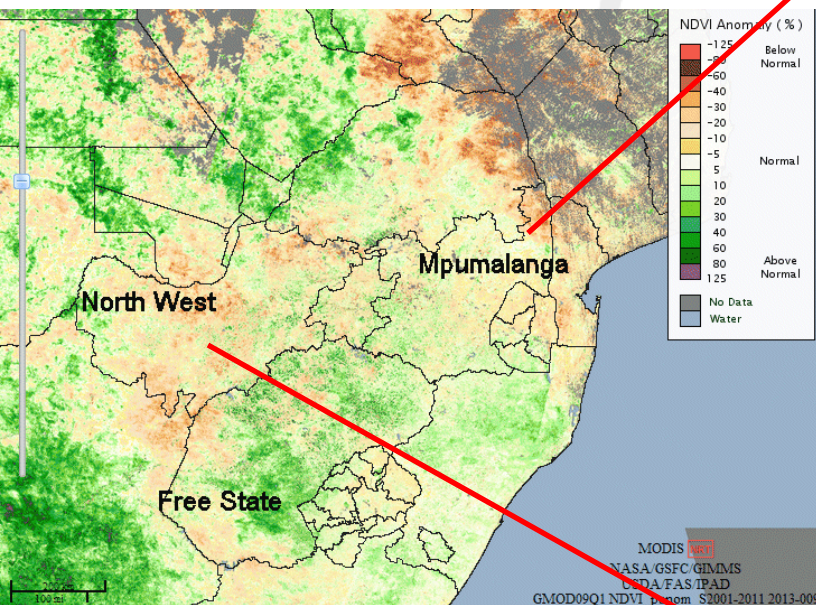
GLAM-MODIS Yield Forecaster Summary

- Smoothed seasonal MODIS-NDVI metrics defined by modified TIMESAT



GLAM-MODIS Yield Forecaster Summary

- Smoothed seasonal MODIS-NDVI metrics defined by modified TIMESAT



GLAM-MODIS Yield Forecaster Summary

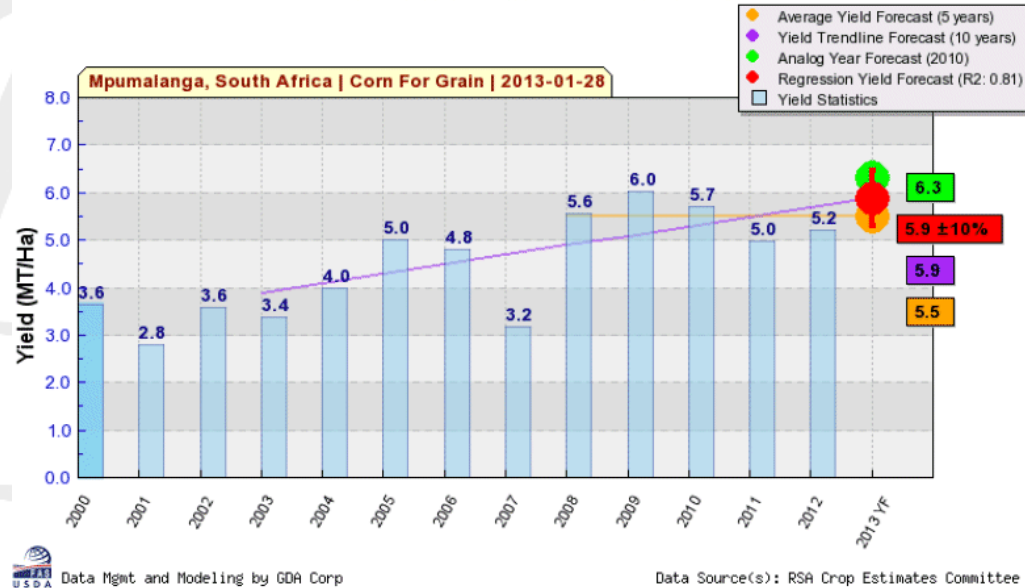
- Forecast Yield selected is the “best fit” from the MODIS-Yield Regression and Seasonal Metrics table.

NDVI Agricultural Seasonal Metrics (Smoothed)

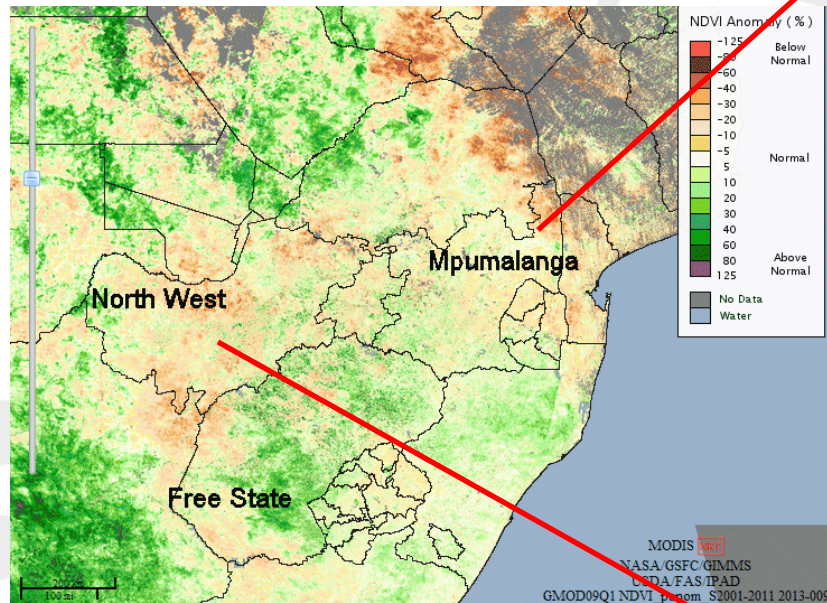
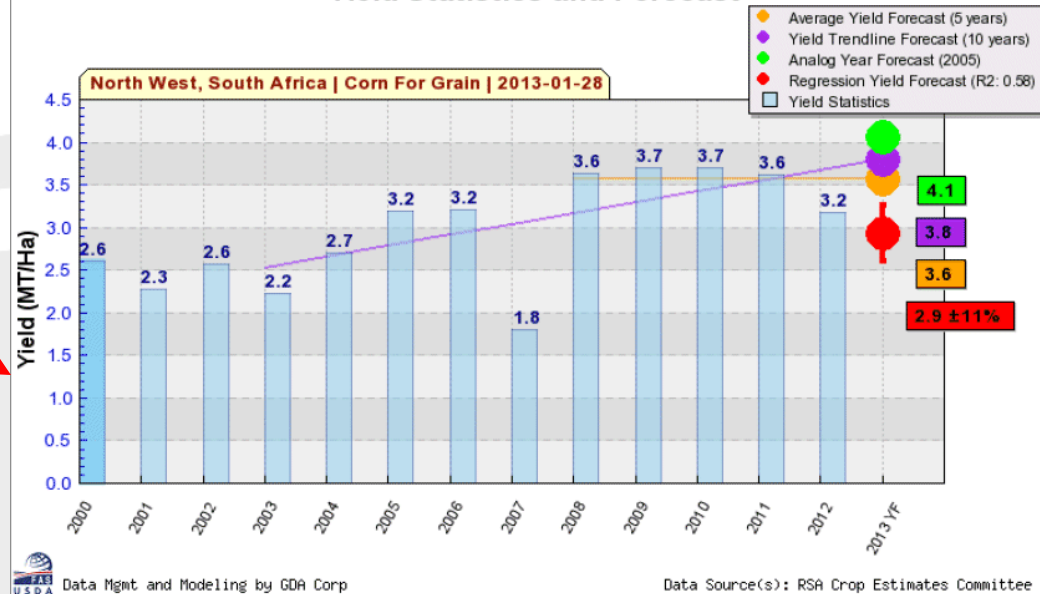
Annual Crop Season	Start of Season	End of Greenup	Peak of Season	Start of Senescence	Maturity (Mid Senescence)	End of Season	Start of Season Fix. Thresh.	End of Season Fix. Thresh.	Last Measured (Cur. Yr)	Large Integral (a) to (b)	Small Integral (a) to (b)	Large Integral (a) to (d)	Large Integral (a) to (ms)	Large Integral (c) to (ms)	Small Integral (Fixed TS)	Large Integral (a) to (last)	Small Integral (Fix TS) to (last)
2000-01	0.44	0.58	0.6	0.57	0.47	0.33	0.51	0.51	0.6	11.9	2.13	7.42	9.95	7.33	0.83	3.87	0.3
2001-02	0.28	0.64	0.68	0.64	0.39	0.27	0.51	0.51	0.62	15.2	2.37	10.78	13.47	7.47	1.85	5.24	0.46
2002-03	0.37	0.63	0.67	0.63	0.43	0.3	0.51	0.51	0.67	11.62	1.91	6.92	9.7	6.57	1.18	4.42	0.48
2003-04	0.28	0.68	0.73	0.68	0.45	0.29	0.51	0.51	0.68	15.38	2.56	9.63	13.19	7.06	1.88	6.1	0.46
2004-05	0.3	0.67	0.72	0.67	0.49	0.3	0.51	0.51	0.71	15.39	2.81	9.23	12.95	8.29	1.97	5.83	0.6
2005-06	0.3	0.67	0.71	0.67	0.5	0.31	0.51	0.51	0.7	15.5	3.06	9.79	13.21	8.78	2	6.27	0.66
2006-07	0.3	0.61	0.64	0.6	0.41	0.26	0.51	0.51	0.64	13.9	1.02	8.06	11.54	7.49	0.95	6.21	0.5
2007-08	0.27	0.67	0.72	0.67	0.44	0.29	0.51	0.51	0.63	16.58	2.87	10.46	14.23	8.09	2.04	5.39	0.34
2008-09	0.3	0.67	0.72	0.67	0.42	0.28	0.51	0.51	0.71	15.24	2.76	9.43	13	8.58	2.04	5.55	0.59
2009-10	0.28	0.68	0.73	0.69	0.5	0.29	0.51	0.51	0.68	17.53	3.26	10.07	14.5	8.15	2.12	6.3	0.53
2010-11	0.29	0.66	0.7	0.66	0.47	0.29	0.51	0.51	0.68	15.99	2.44	8.96	13.22	8.15	1.75	5.55	0.47
2011-12	0.28	0.65	0.69	0.65	0.38	0.27	0.51	0.51	0.69	14.97	1.36	9.21	12.74	8.02	1.49	6.56	0.63
2012-13	0.27	0.69	0.74	0.69	0.46	0.29	0.51	0.51	0.71	16.39	2.95	10.26	14.02	8.75	2.3	6.17	0.63
2012-13 vs. Worst Season	-38.3%	18.9%	24.2%	22%	-2.9%	-9.7%	0%	0%	19.2%	37.7%	38.4%	38.3%	40.9%	19.3%	175.8%	59.4%	111.6%
Avg Season	-11.1%	6.1%	7.1%	6.8%	2.5%	1.2%	0%	0%	6.7%	9.7%	23.9%	12%	10.9%	11.7%	37%	10%	25.2%
Best Season	-8.4%	2.3%	2.9%	2.9%	8.4%	3.3%	0%	0%	0.6%	7.5%	6.9%	8.9%	7.8%	2%	12.4%	11.2%	6.8%
R-square	0.38	0.66	0.65	0.65	0.04	0.02	0	0	0.43	0.61	0.32	0.35	0.56	0.61	0.64	0.28	0.21
Pearson Correlation	-0.62	0.81	0.81	0.81	0.21	-0.14	0	0	0.66	0.78	0.57	0.59	0.75	0.78	0.8	0.53	0.46

GLAM-MODIS Forecast Yields

Yield Statistics and Forecast



Yield Statistics and Forecast



Summary MODIS/NDVI-Yield Forecasts/Estimates

- Global 250-meter NDVI-MODIS-Terra & Aqua Archive for cropland data drilling available at:
 - <http://glam1.gsfc.nasa.gov/>
- Historical sub-national & national crop yield data available from national governments and USDA's PSD Online, respectively.
 - <http://www.fas.usda.gov/psdonline/>
- Seasonal Vegetation/Cropland Dynamics & Smoothing via modified Timesat program (JÖNSSON and EKLUNDH, 2004)
- Semi-automated NDVI-Yield regression and analog models used, but regressions models tend to:
 - Under-estimate yields during bumper years
 - Over-estimate yields during drought years

Acknowledgements

NASA's MODIS Global Agriculture Monitoring System (GAMS) at
Goddard Space Flight Center (GSFC) - Greenbelt, Maryland

Dr. Assaf Anyamba
Dr. Compton Tucker
Edwin Pak
Amir Majedi
Jennifer Small

GDA (Geospatial Data Analysis) Corporation
Semi-Automated MODIS-NDVI/Yield Regressions for
<http://glam.gdacorp.com/GLAMViewer/>

Dr. Stephanie Hulina
Dr. Dmitry Varlyguin



Thank you!

