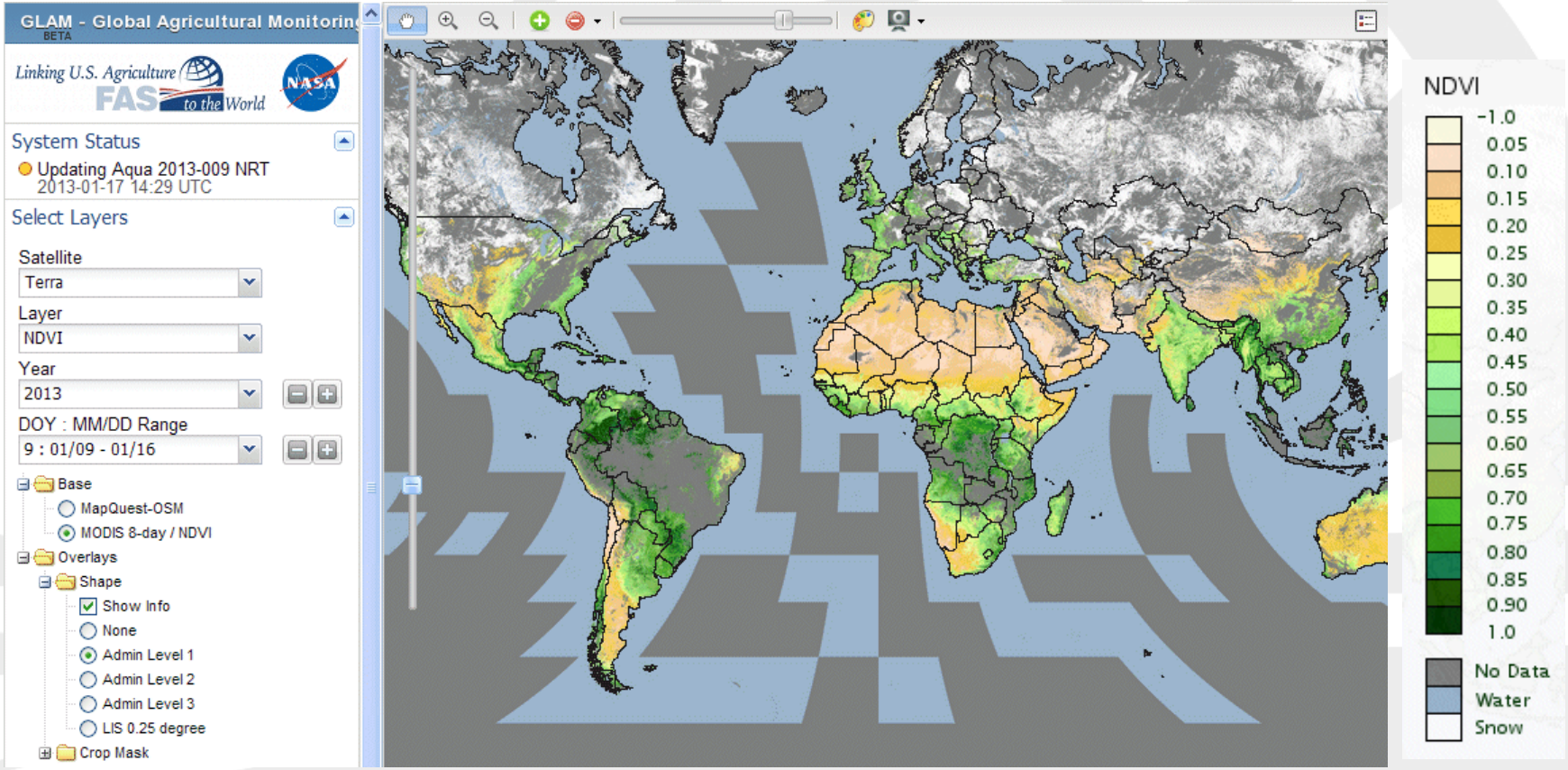
Monitoring Global Agriculture Production with MODIS and Landsat Imagery



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

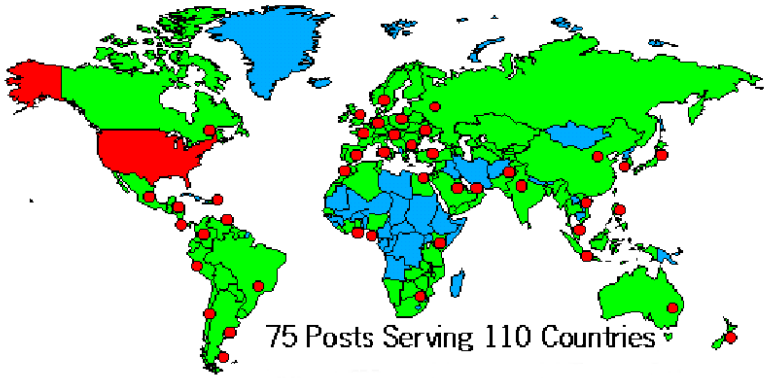
USDA's Foreign Agricultural Service (FAS)

International Production Assessment Division (IPAD)

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

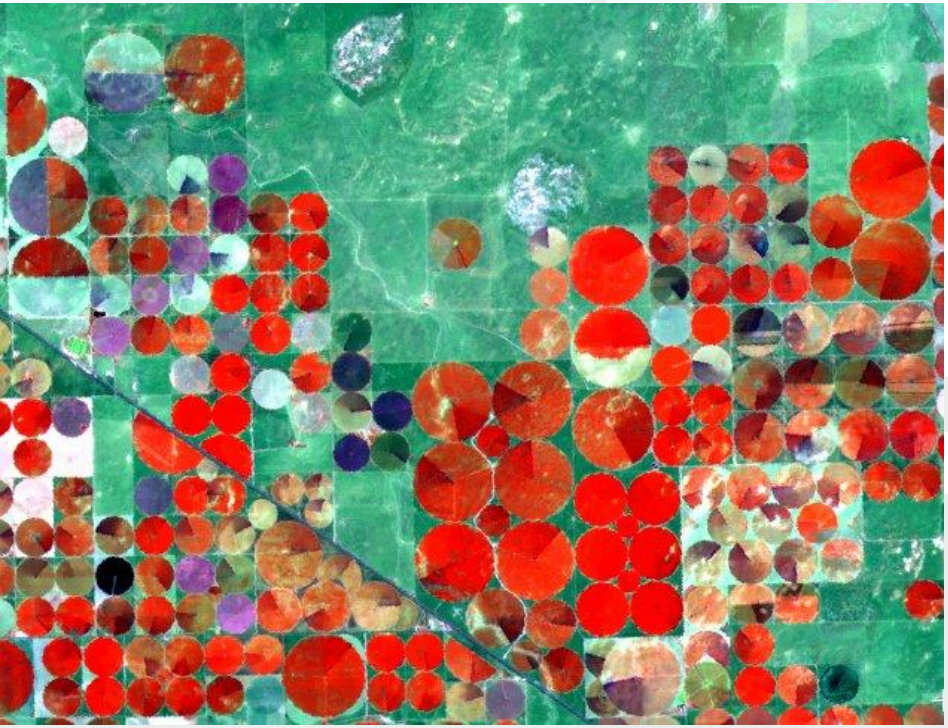


- FAS is primarily responsible for USDA's:
  - Overseas activities with attachés located at 75 posts
  - Market development,
  - International trade agreements and negotiations,
  - Collection and analysis of statistics and market information.
- *http://www.fas.usda.gov/aboutfas.html*

FAS Office of Global Analysis (OGA)
International Production Assessment Division (IPAD)

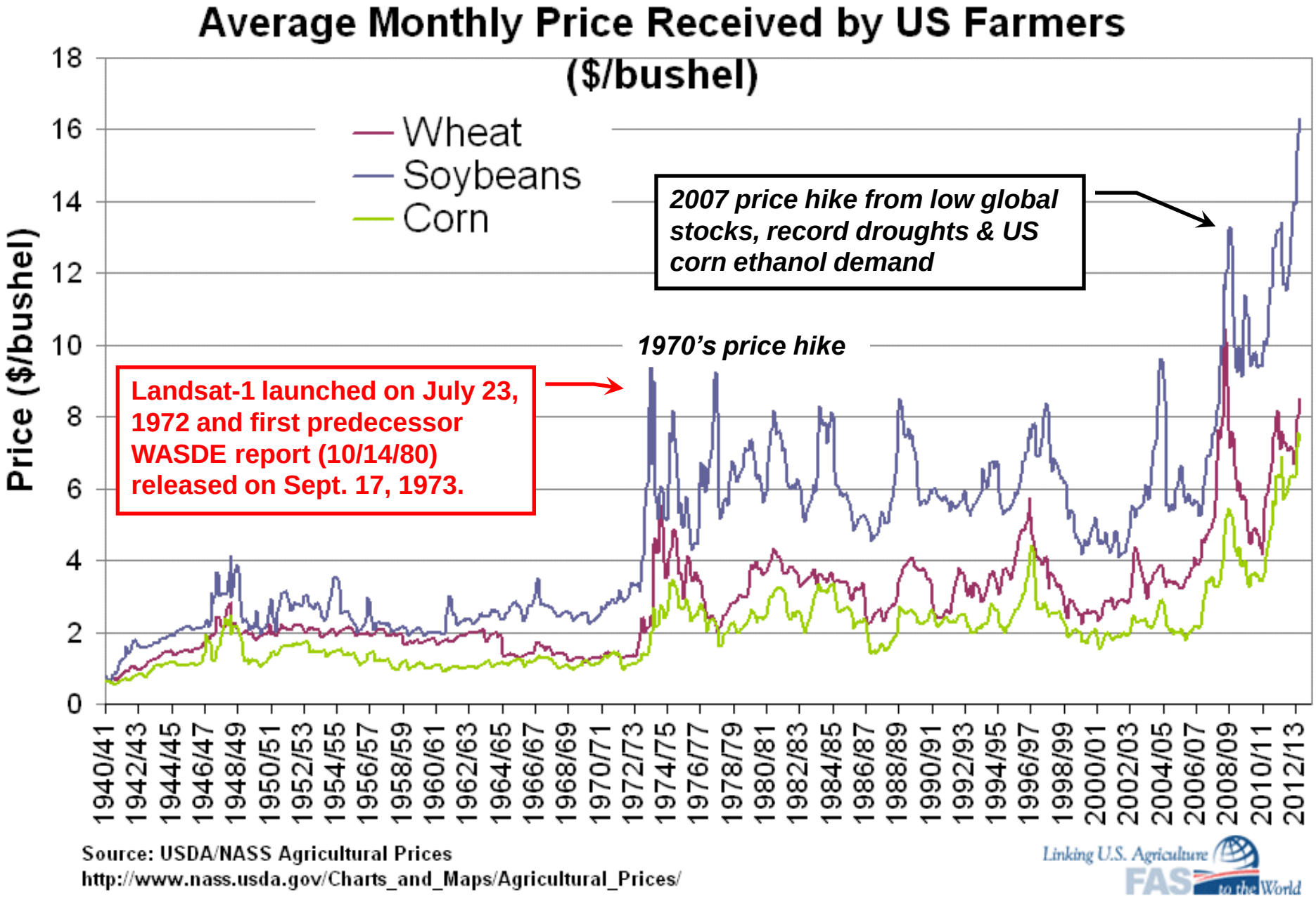
IPAD's Mission Statement:

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).

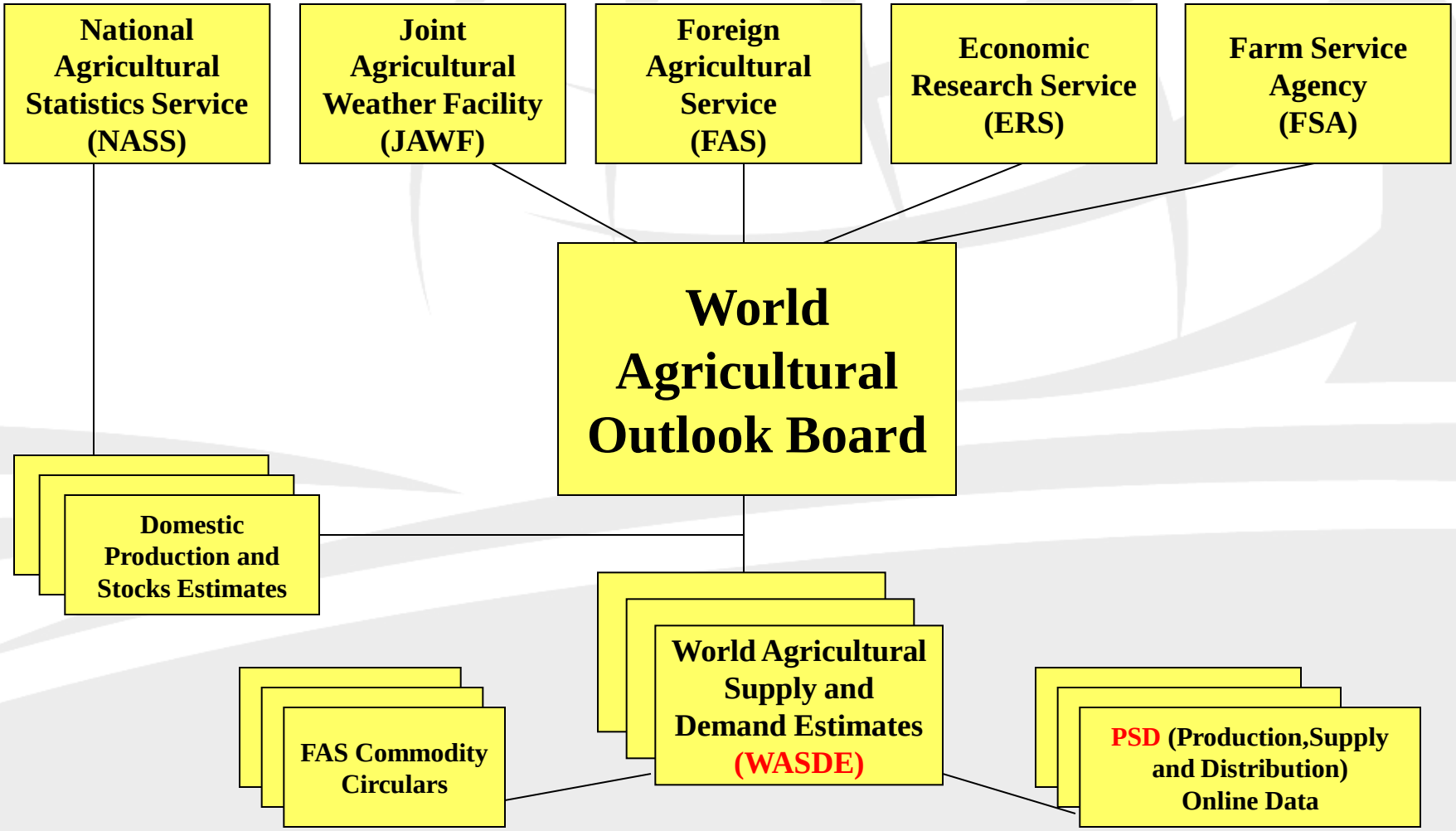
Wheat, corn, and soybean prices continue to rise



Source: USDA/NASS Agricultural Prices
http://www.nass.usda.gov/Charts_and_Maps/Agricultural_Prices/

Linking U.S. Agriculture FAS to the World

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

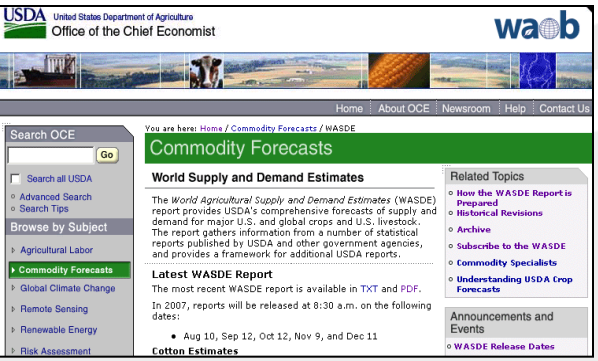
USDA Publications

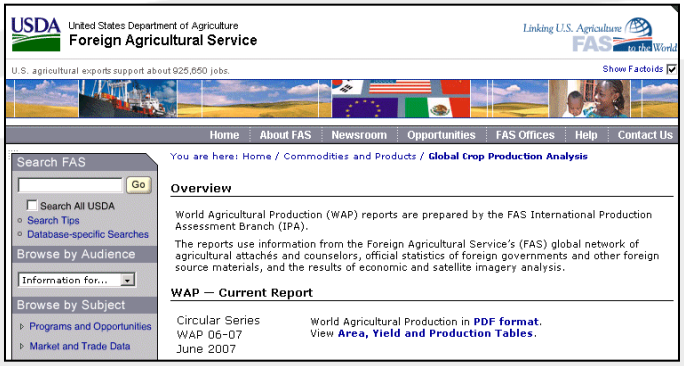
- **Trade Policy**
- **Exporter Assistance & Export Programs**
- **Food Aid & Export Credit Programs**
- **UMR (Usual Marketing Requirements)**

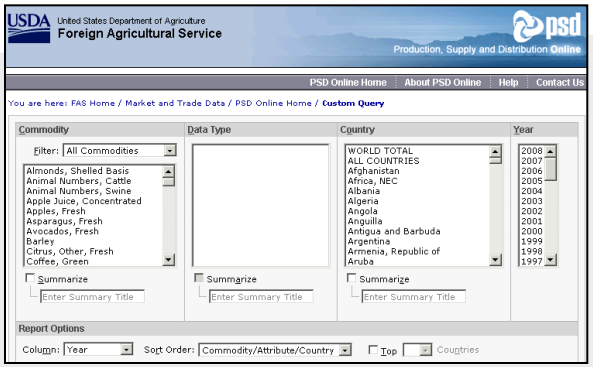
- **USDA decision-makers**
- **U.S. Ag Producers & Traders**
- **Commodity Price Discovery**
- **Commodity Price Adjustments**

USDA's Economic Intelligence System

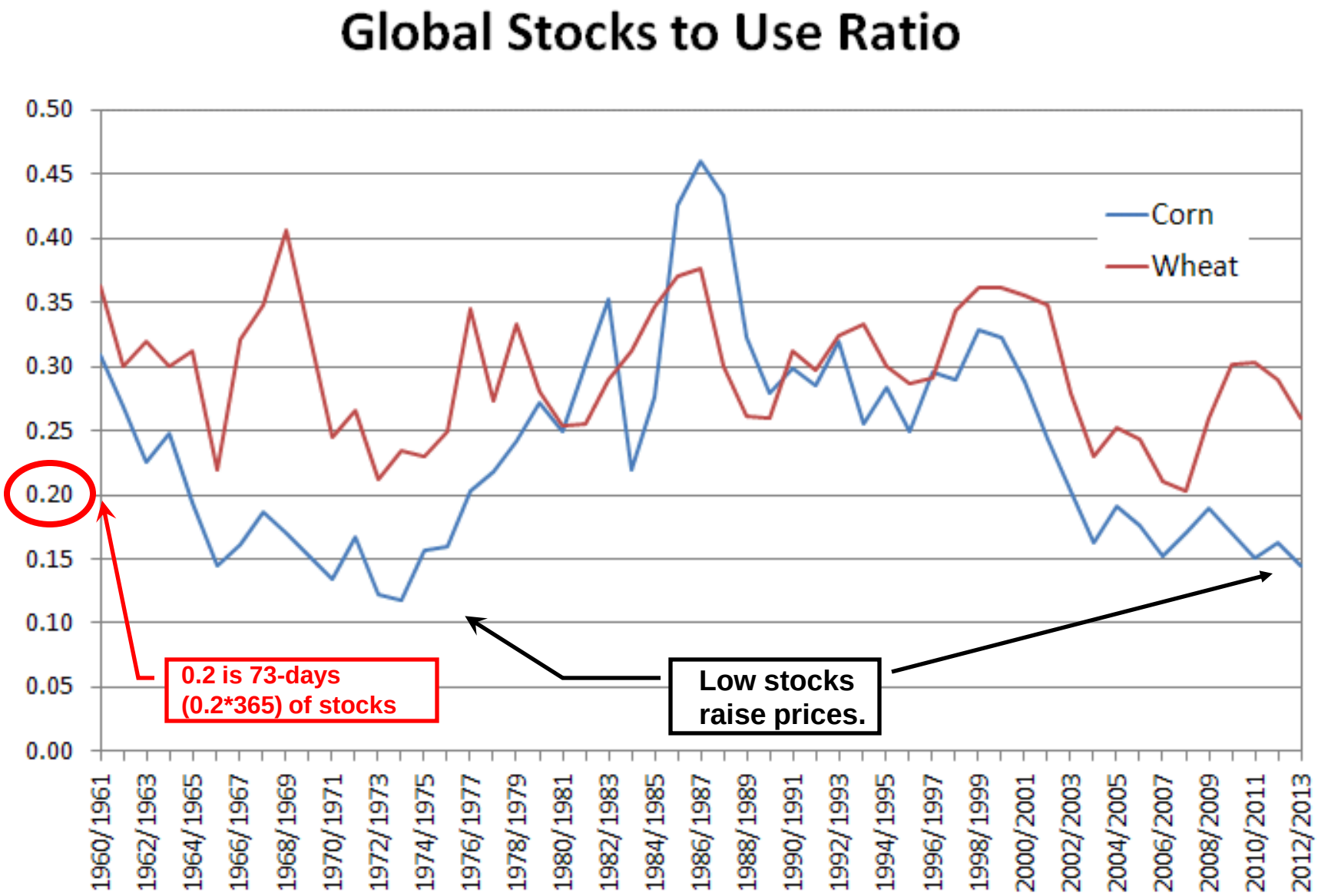
- **USDA monthly crop estimates and trade reports are released at specific times to commodity markets:**
  - **WASDE Circular from WAOB released on the *9-12th day of each month at 12:00 noon.***
    http://www.usda.gov/oce/commodity/wasde/
  - **Monthly World Production, Market and Trade Reports**
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







Low stocks raise prices



Data Source: USDA's PSD Online
http://www.fas.usda.gov/psdonline/psdquery.aspx

Linking U.S. Agriculture FAS to the World

Global Agricultural Monitoring System (GAMS)

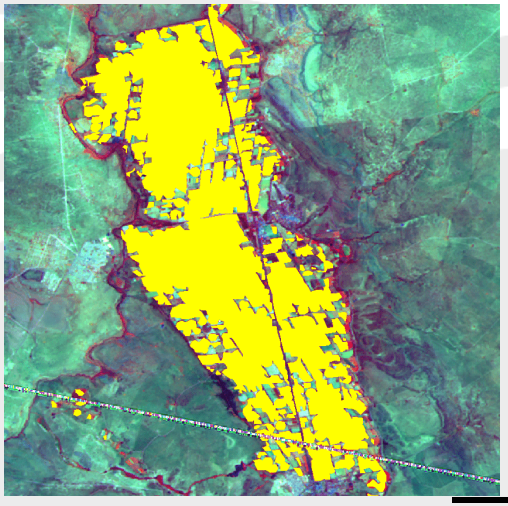
(Joint USDA/NASA Project to produce quantitative crop area & yield estimates from remote sensing data)

(Landsat= free) **(MODIS= free)**

Crop Area (16-days overpass)

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

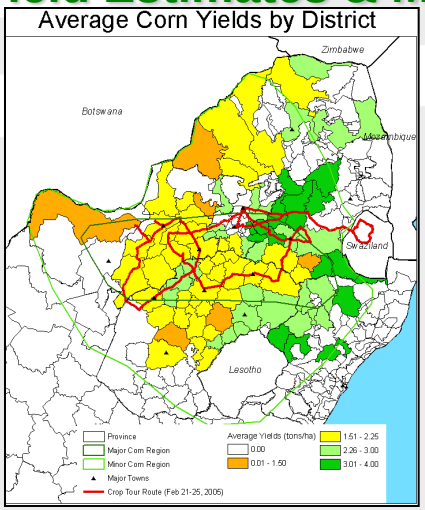
Area Estimates & Crop masks



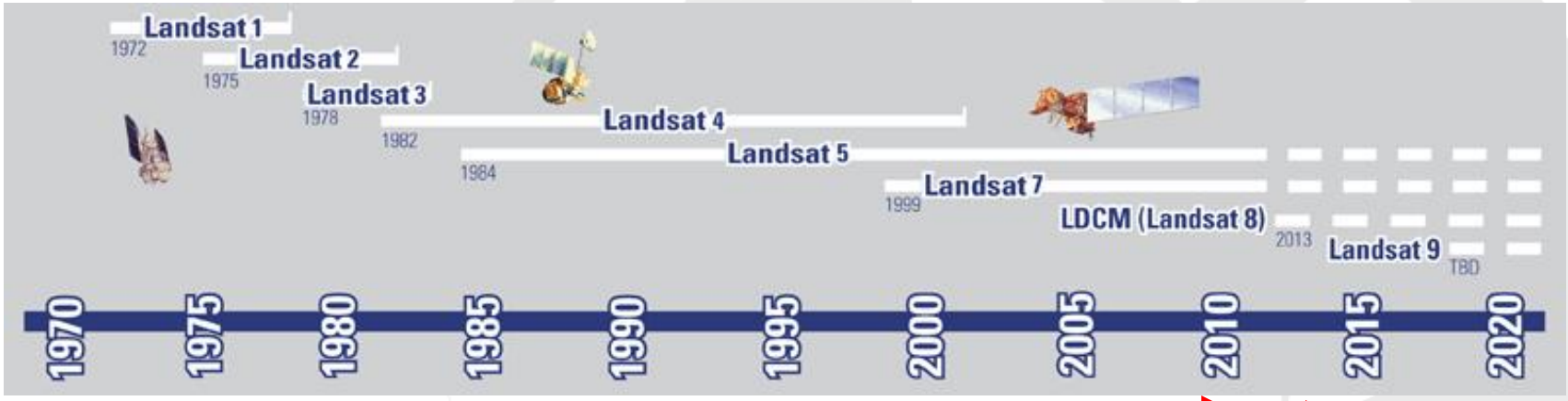
Crop Yield (daily AM/PM overpass)

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

Yield Estimates & Maps



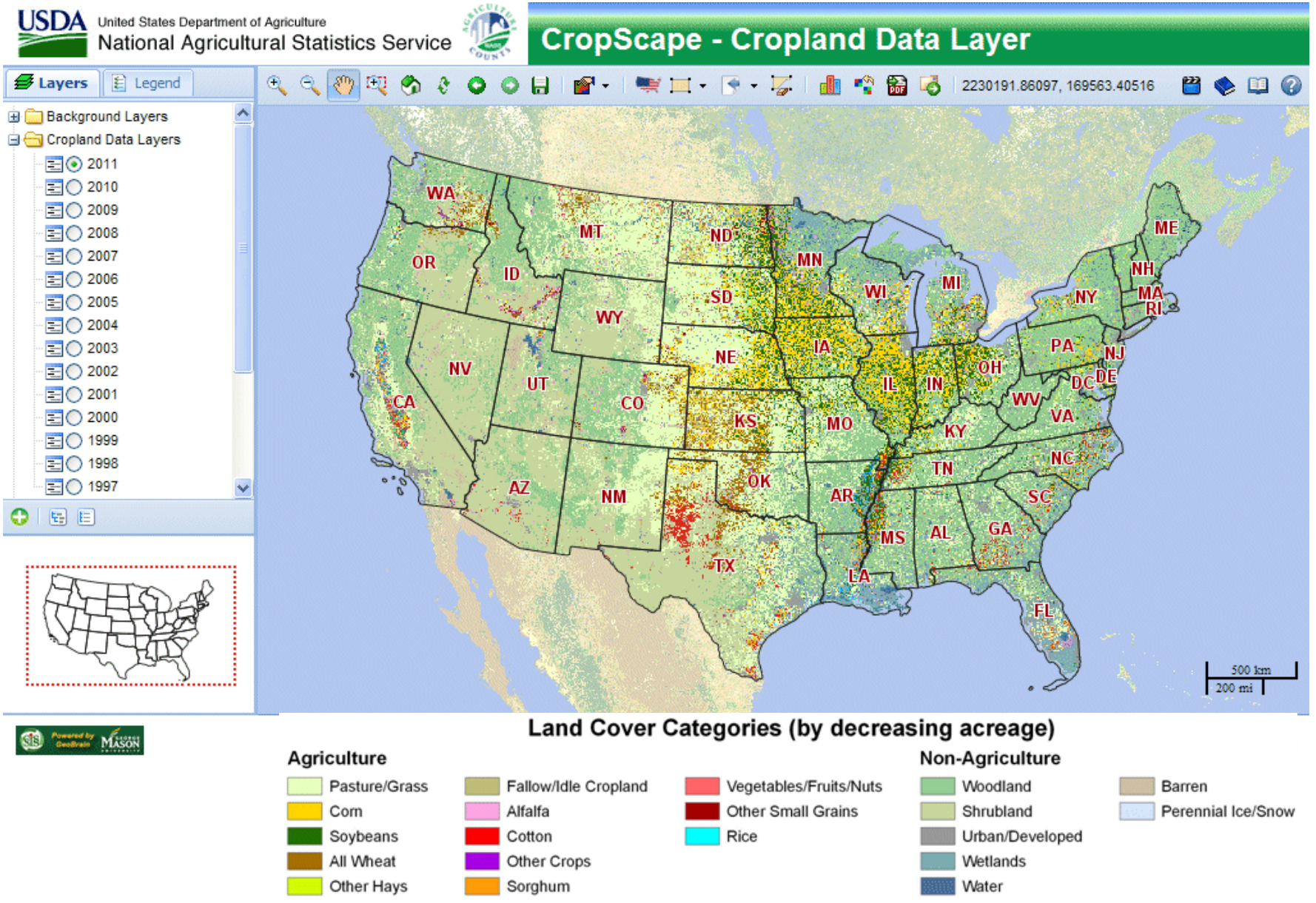
Landsat (30m)/DMC (22-m) (for Crop Area Estimates)



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

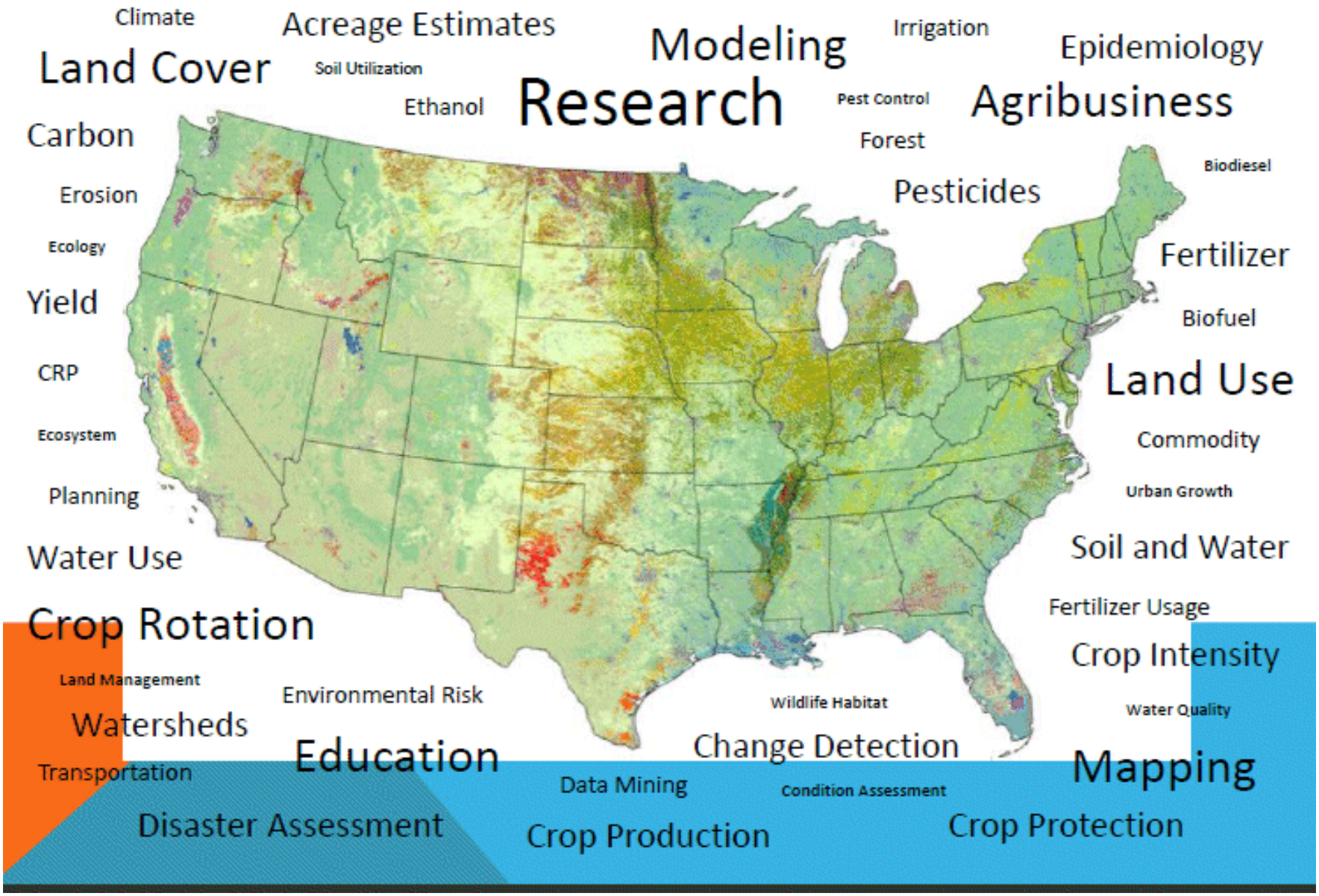
- Landsat-7 Scan Line Corrector (SCL) failed on May 31, 2003
- Landsat "data gap" filled with AWiFS (2005-2010) and DMC (2011-2012) imagery
- **Landsat-8 to be launched on February 11, 2013**
- All Landsat imagery became free on October 1, 2008 and it is critical infrastructure for USG
  - Free Landsat 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

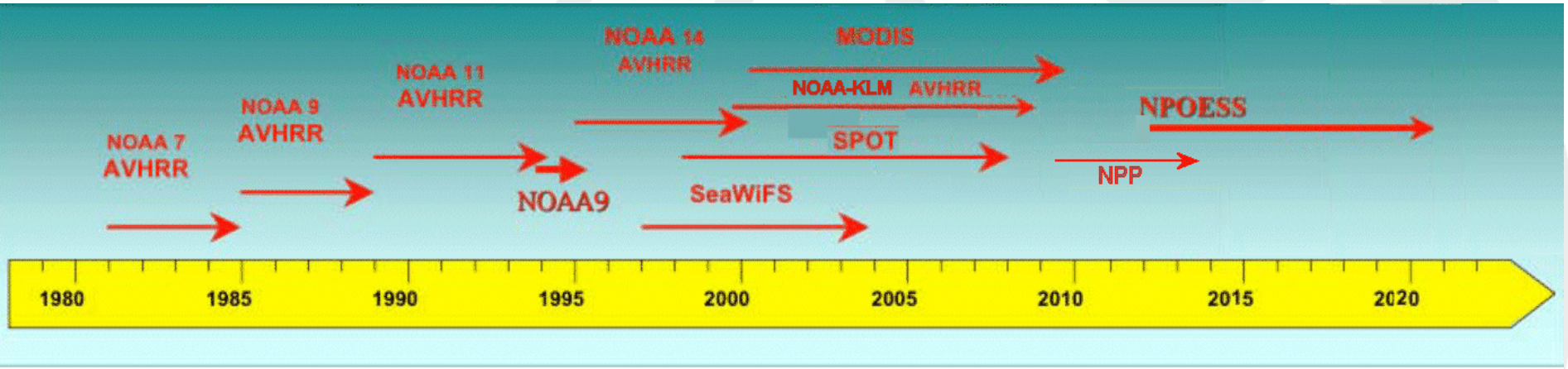


Source: http://nassgeodata.gmu.edu/CropScape/

NASS Cropland Data Layer Applications



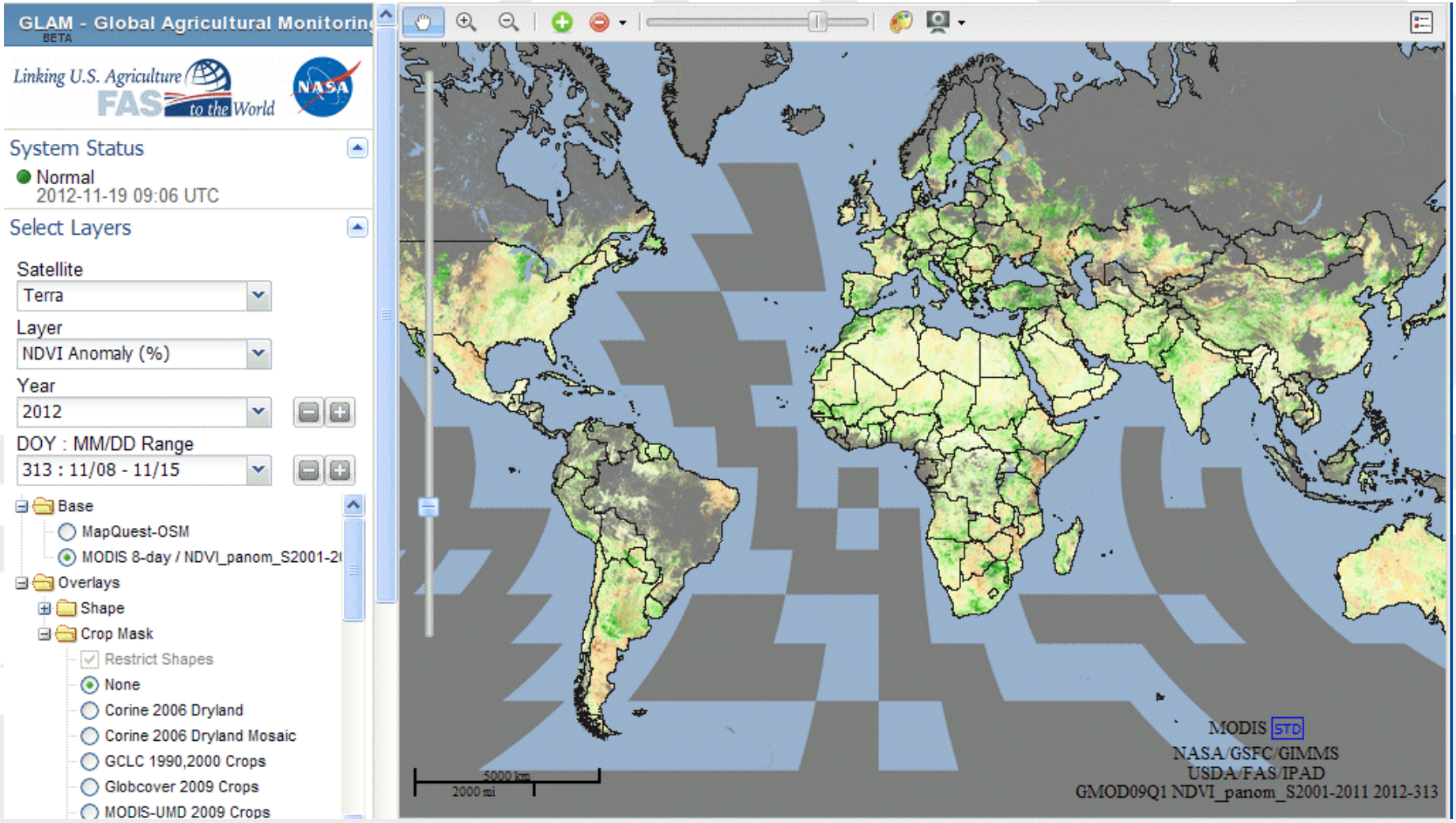
NOAA-AVHRR, Terra/Aqua-MODIS, & NPP/JPSS-VIIRS (for Relative Crop Yield Estimates)



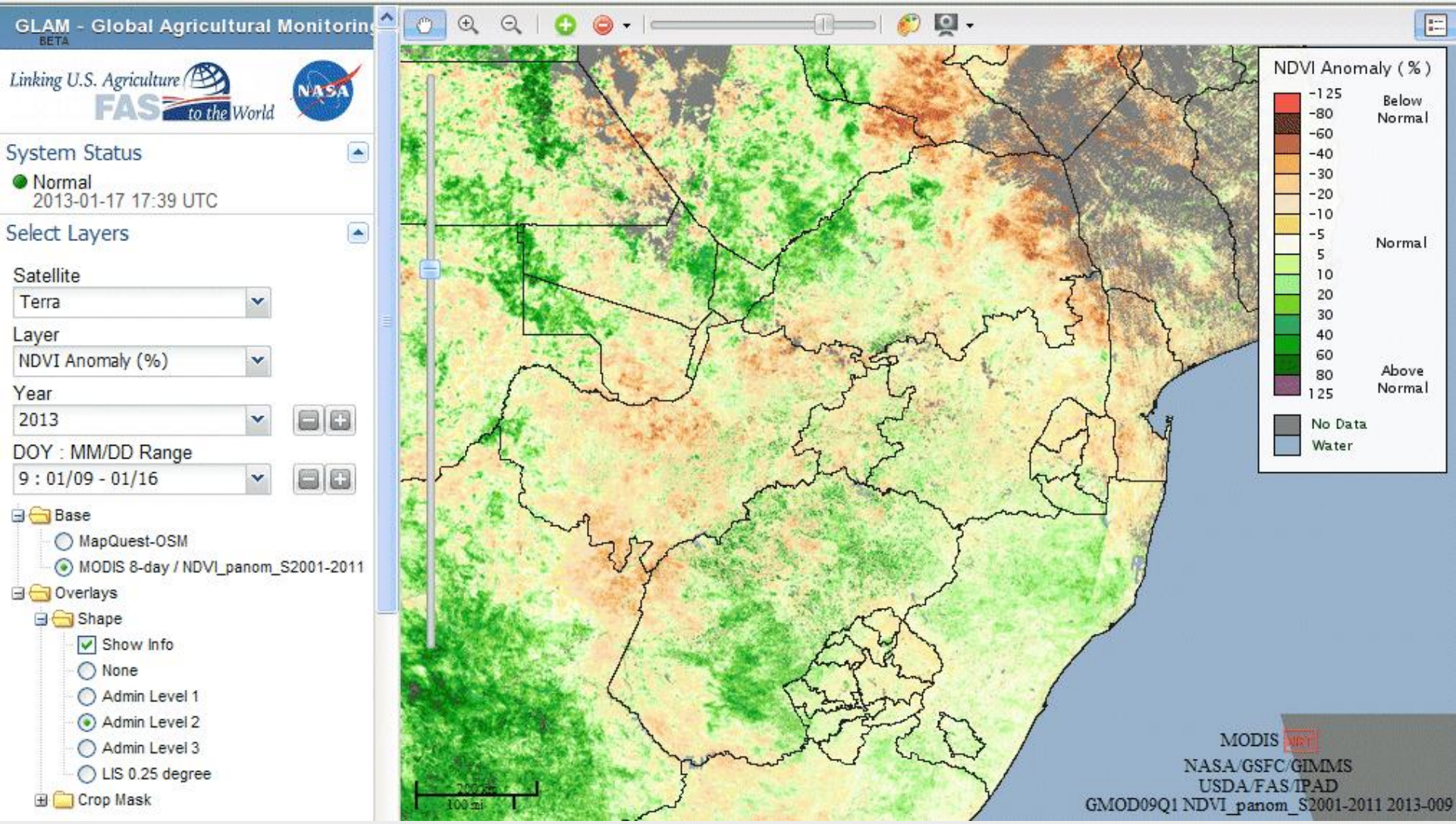
- MODIS sensor on Terra beginning to show stripes
- Suomi NPP/VIIRS launched on October 28, 2011
  - VIIRS (Visible Infrared Imager/Radiometer Suite) sensor on NPP (NPOESS Preparatory Project) and JPSS.
  - NPOESS (National Polar-orbiting Operational Environmental Satellite System) renamed to JPSS (Joint 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:

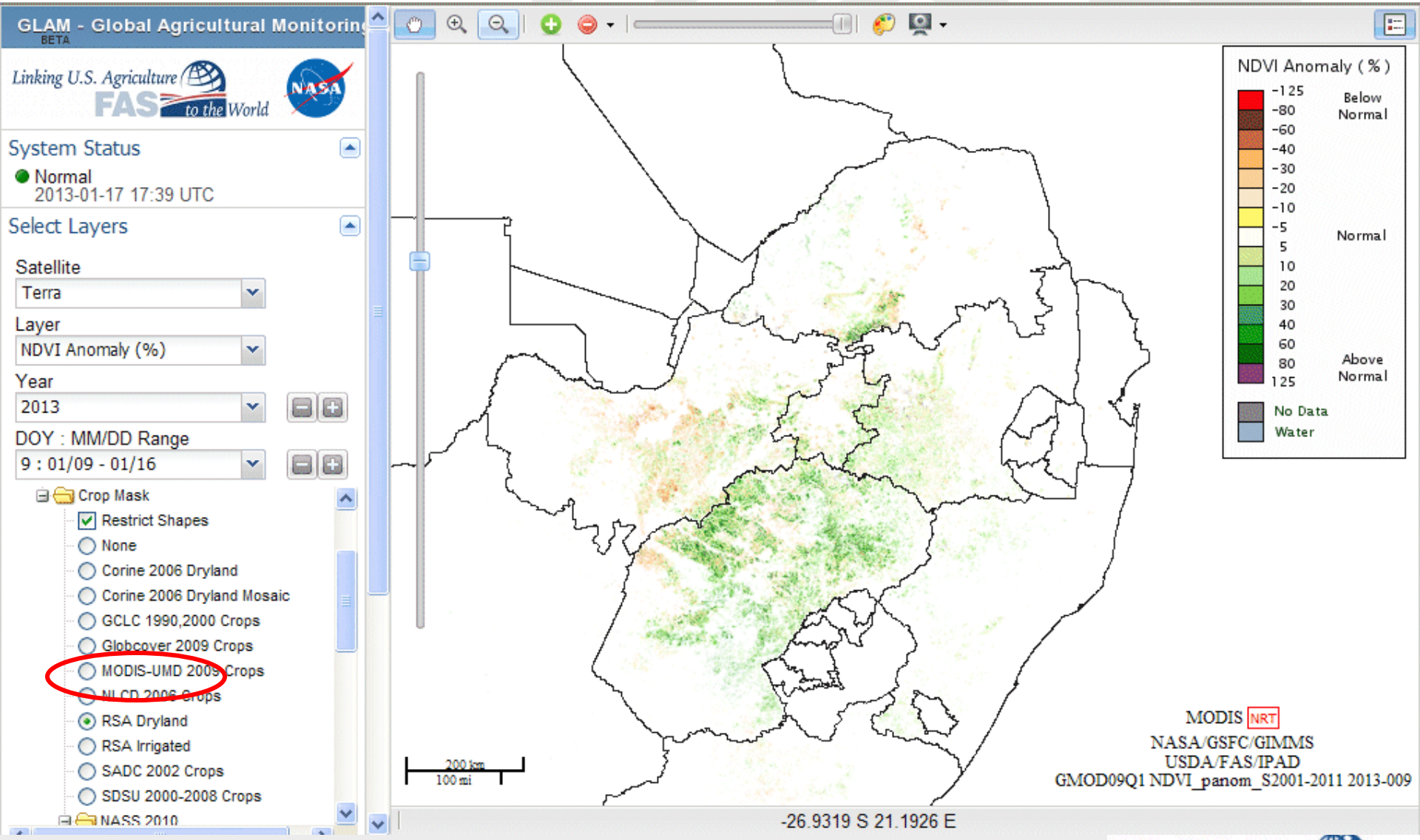
http://glam1.gsfc.nasa.gov/



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



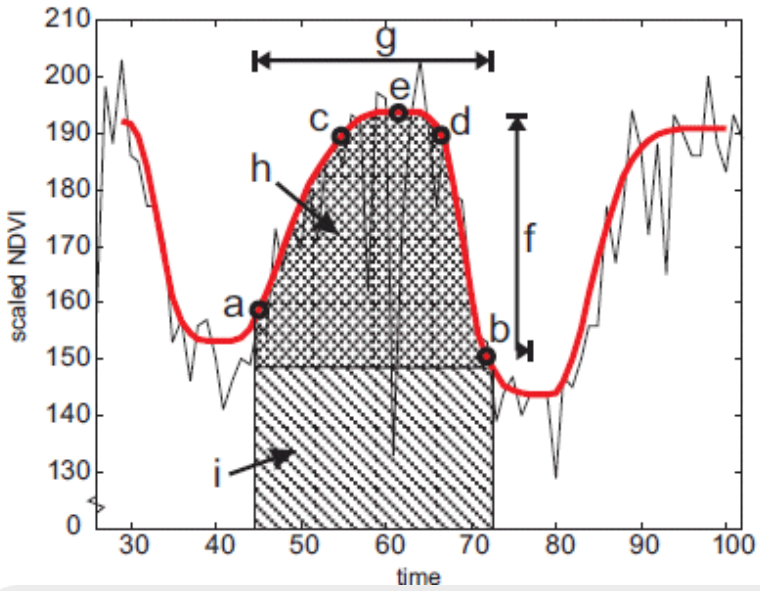
MODIS-NDVI Anomaly (with Crop Mask) (Aqua-Jan 9-16, 2013)



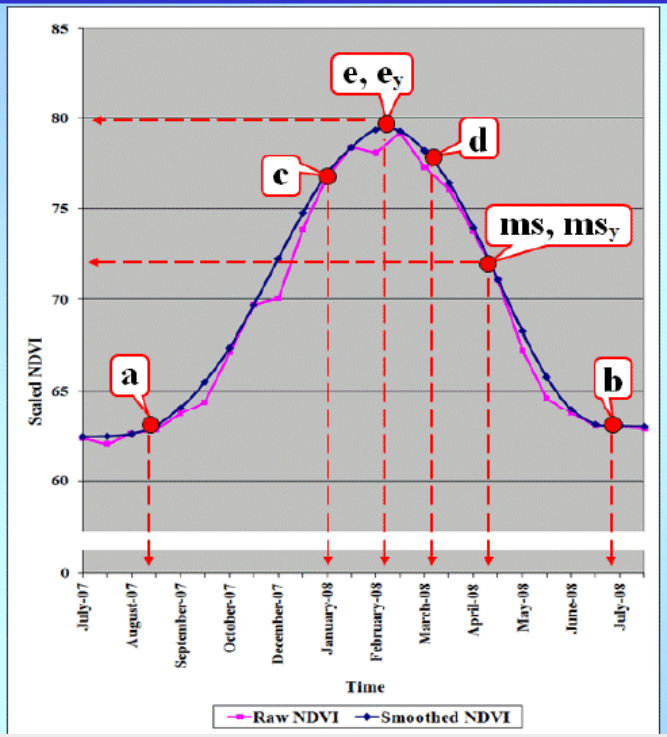
GLAM-MODIS Yield Forecaster Summary

- 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

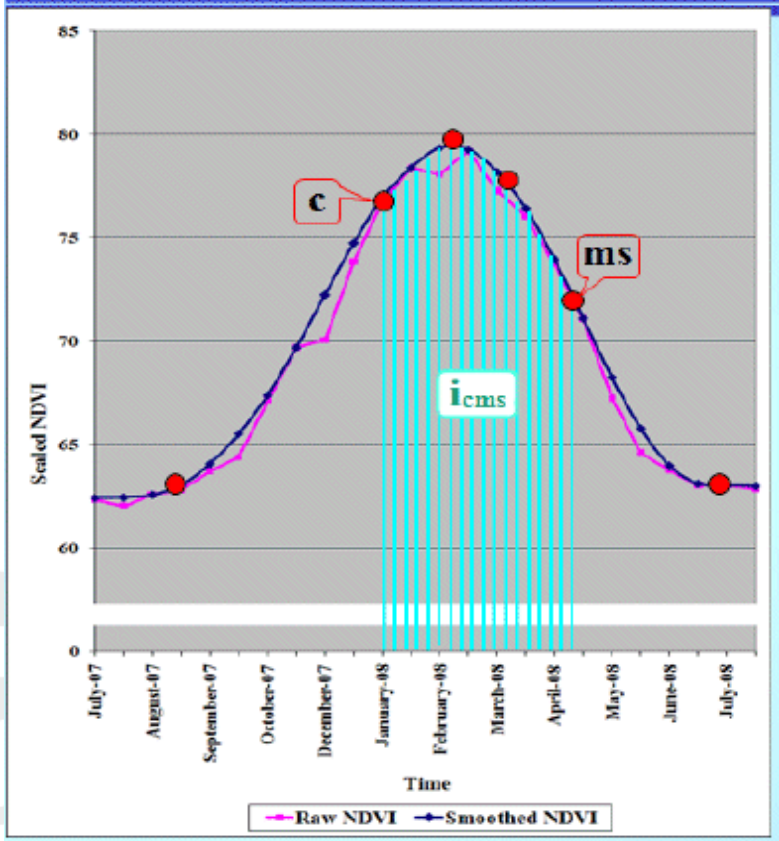
FAS USDA

GDA Corp.

Linking U.S. Agriculture FAS to the World

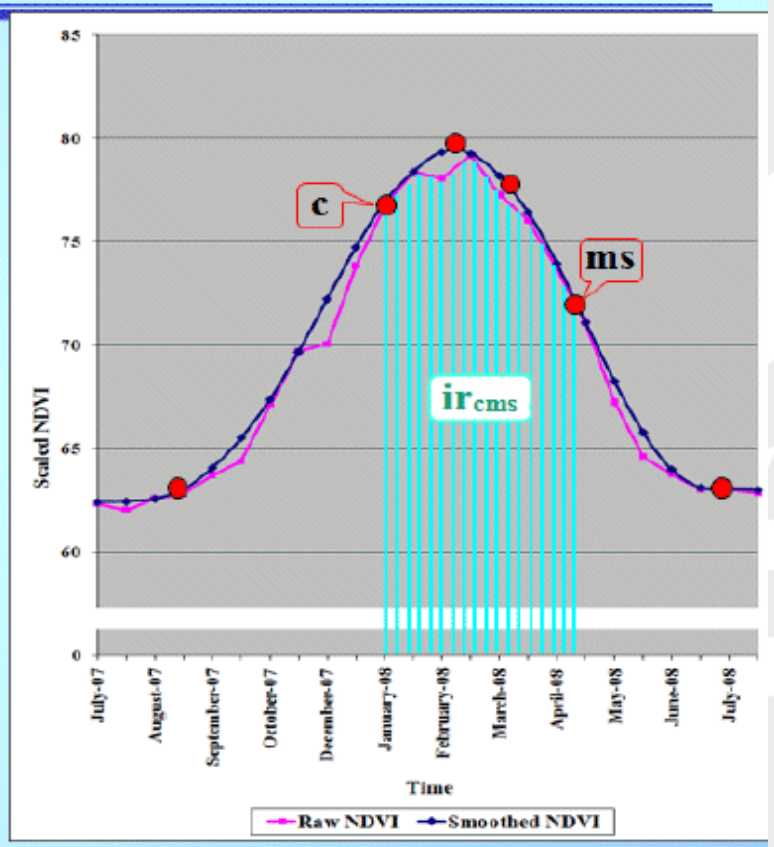
GLAM-MODIS Yield Forecaster Summary

Large Integrals for Grain-filling Period



(icms) Adjusted Large Integral

(c) End of Greenup
(ms) Mid Senescence



(ircms) Raw Adjusted Large Integral

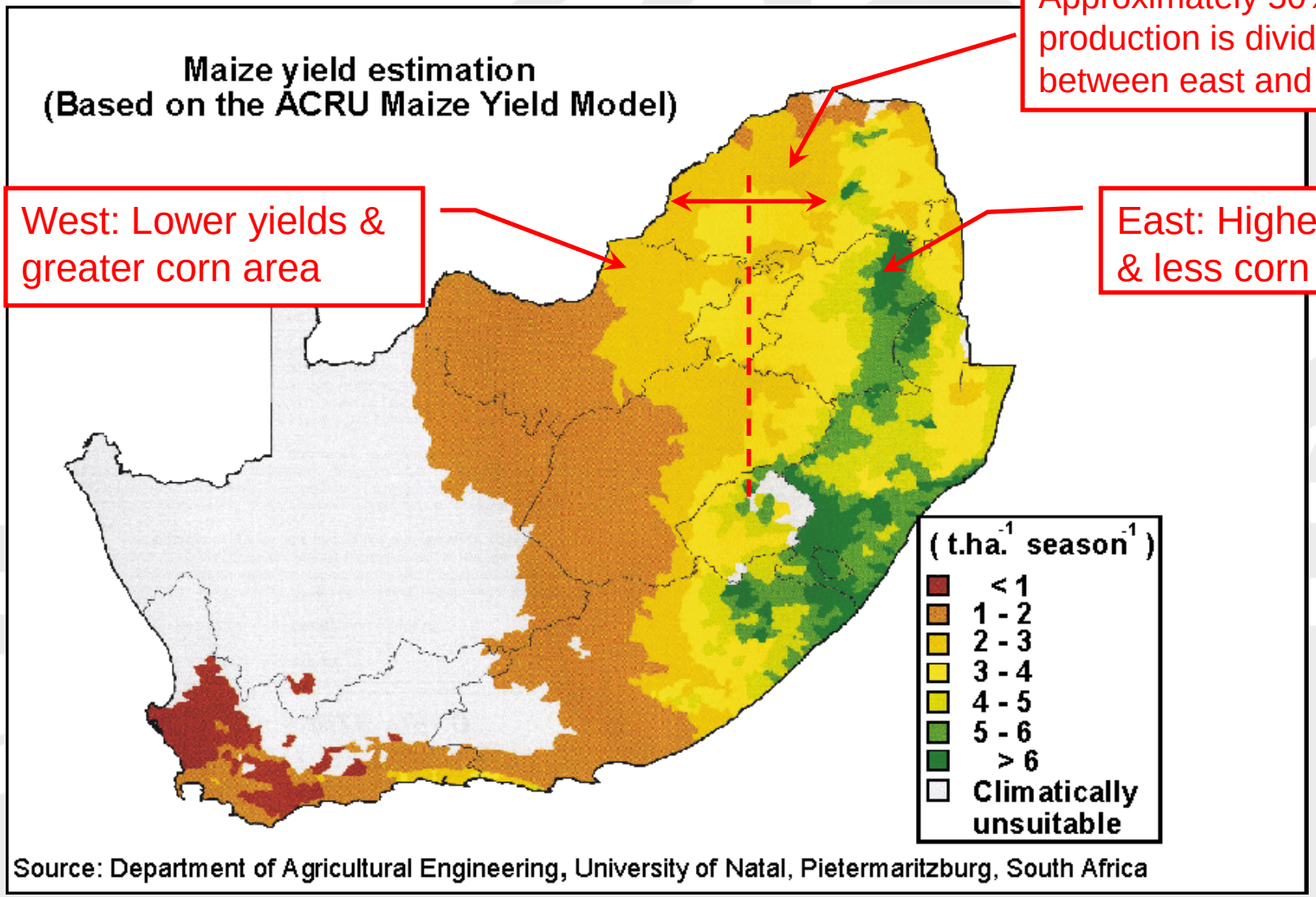
(c) End of Greenup
(ms) Mid Senescence

FAS USDA

GDA Corp.

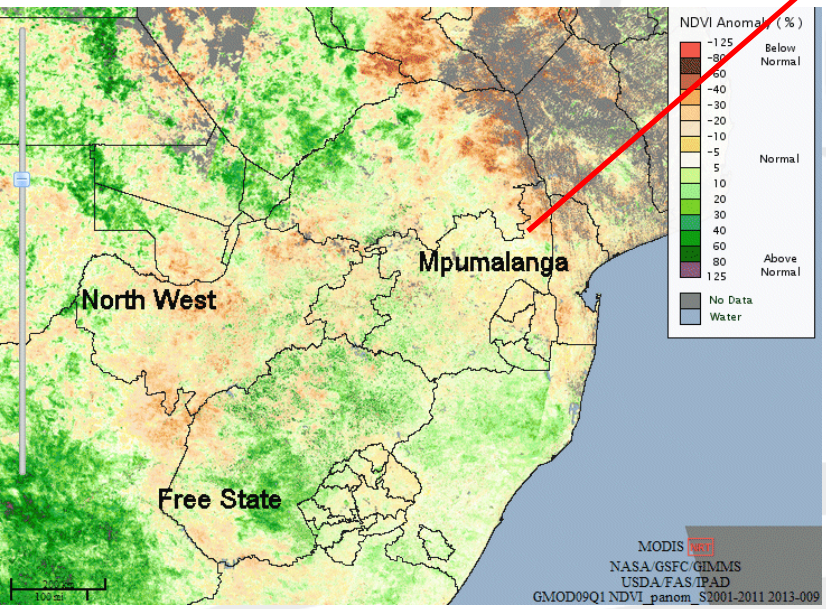
Linking U.S. Agriculture FAS to the World

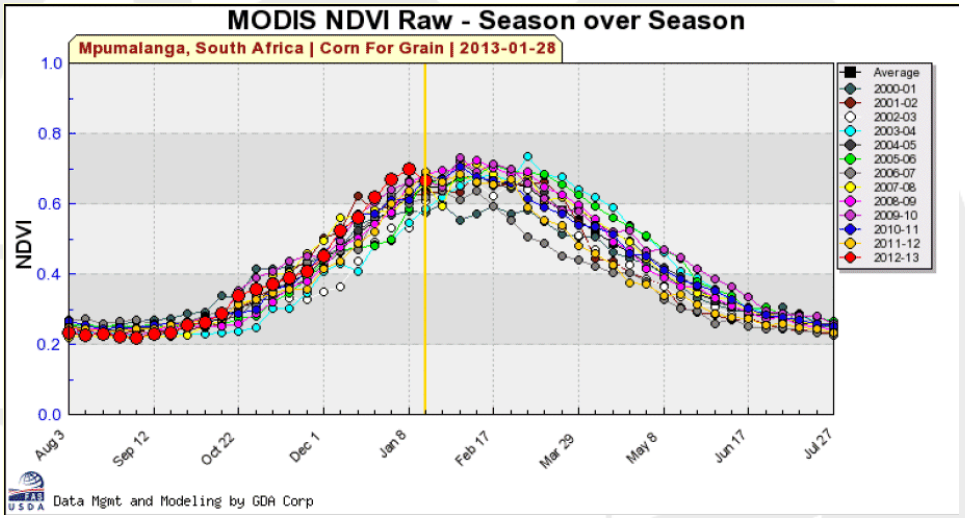
South Africa's Corn Yields

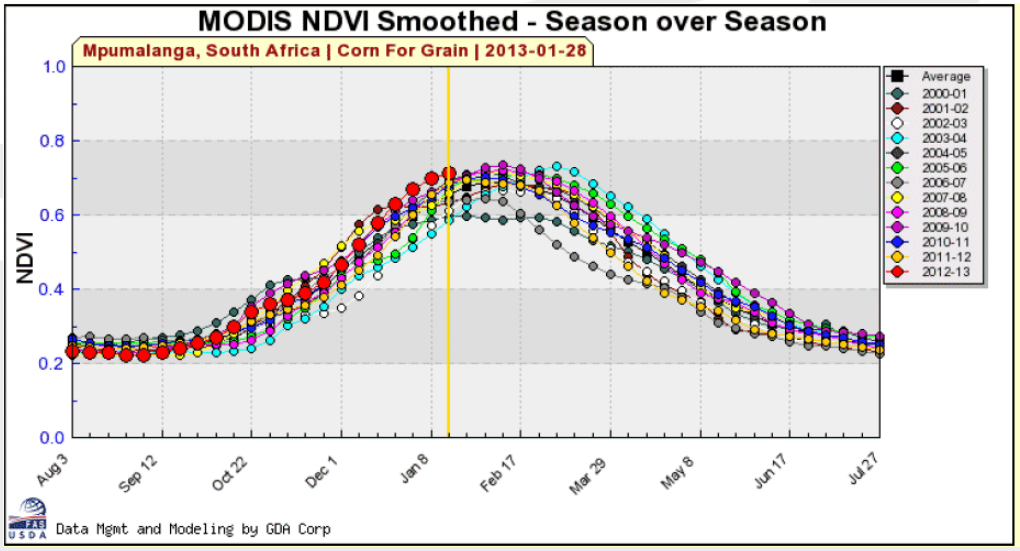


GLAM-MODIS Yield Forecaster Summary

- Smoothed seasonal MODIS-NDVI metrics defined by modified TIMESAT







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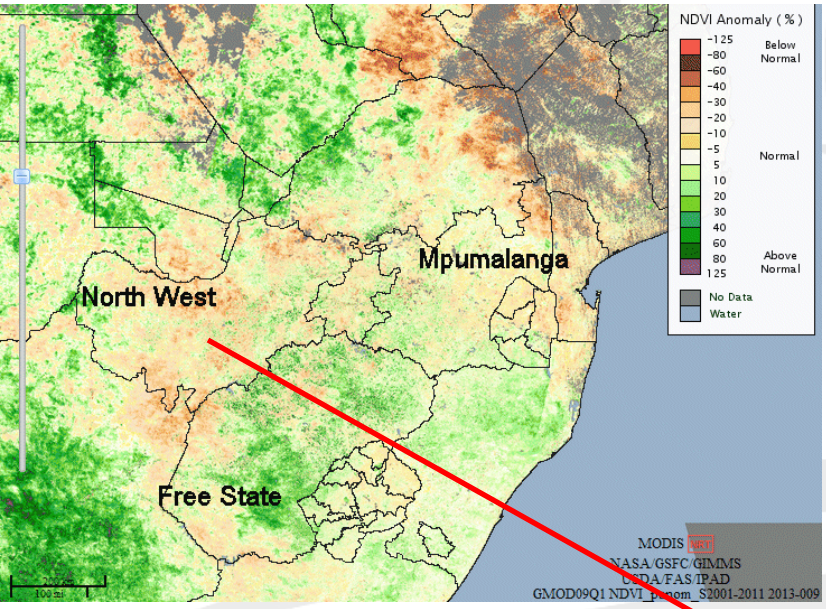
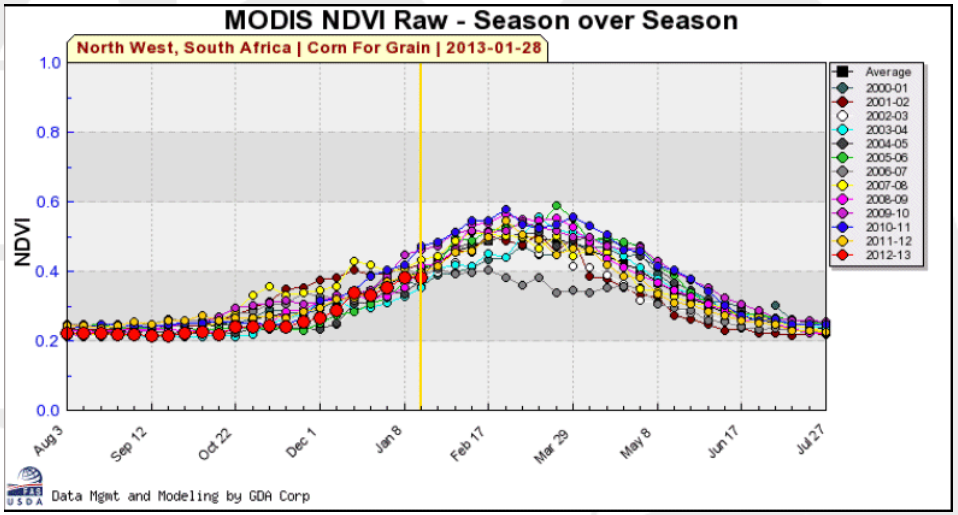
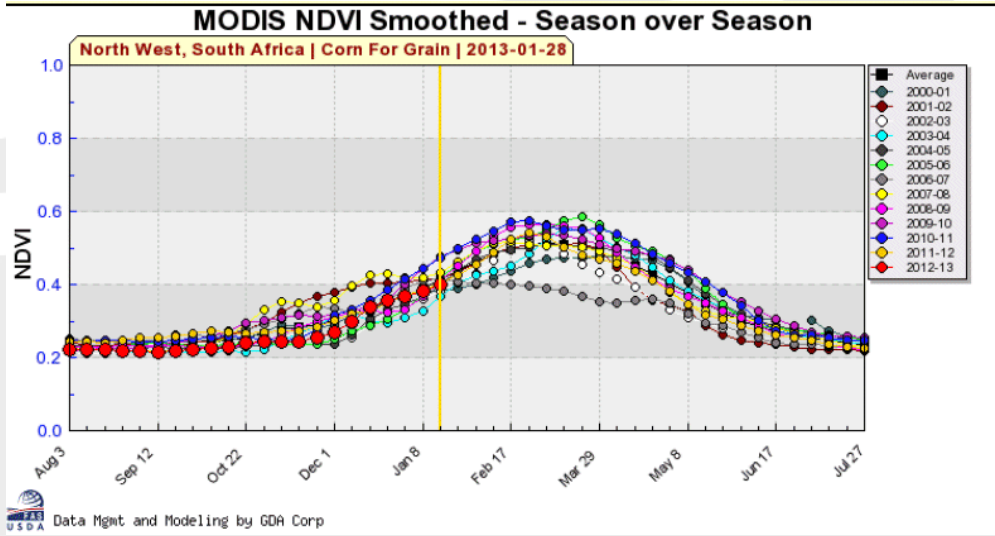
- Smoothed seasonal MODIS-NDVI metrics defined by modified TIMESAT







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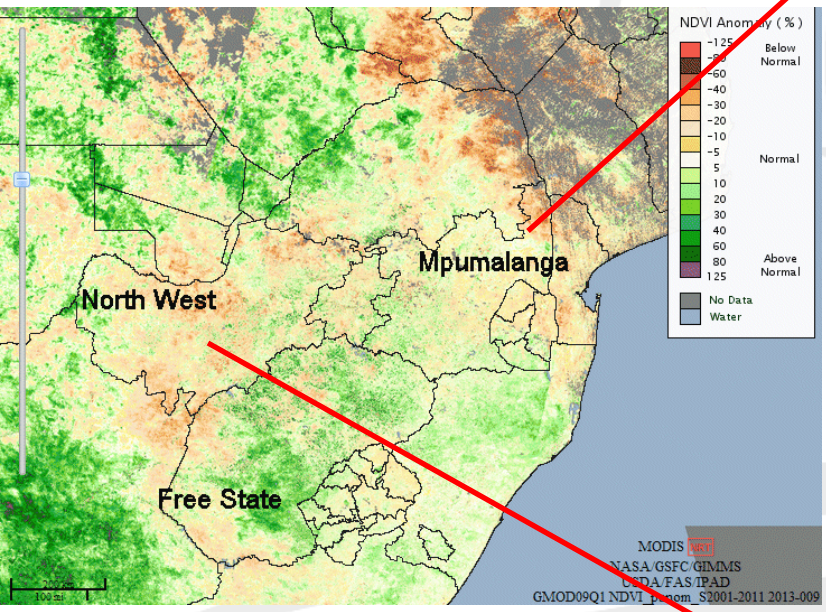
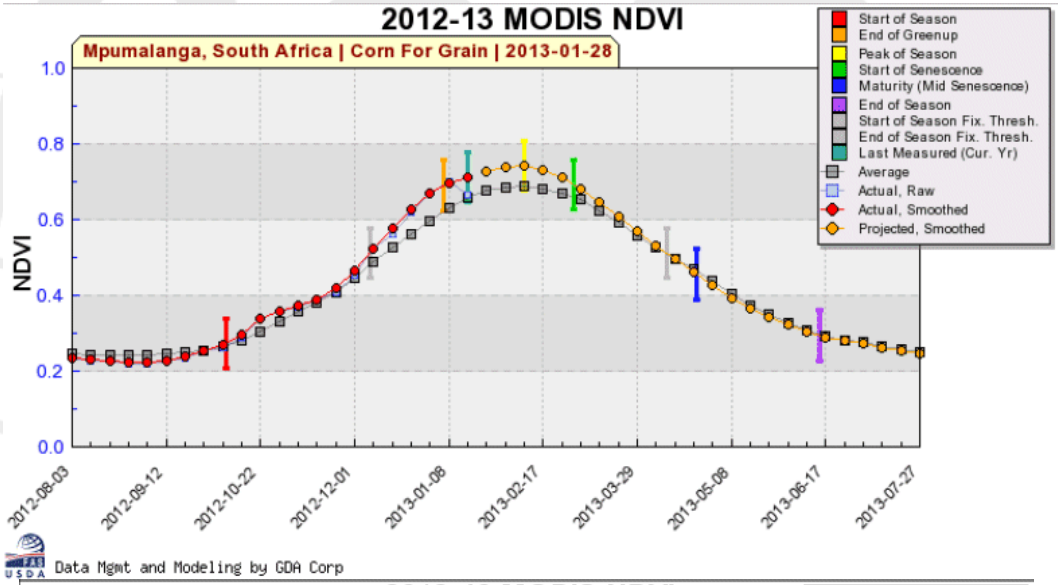
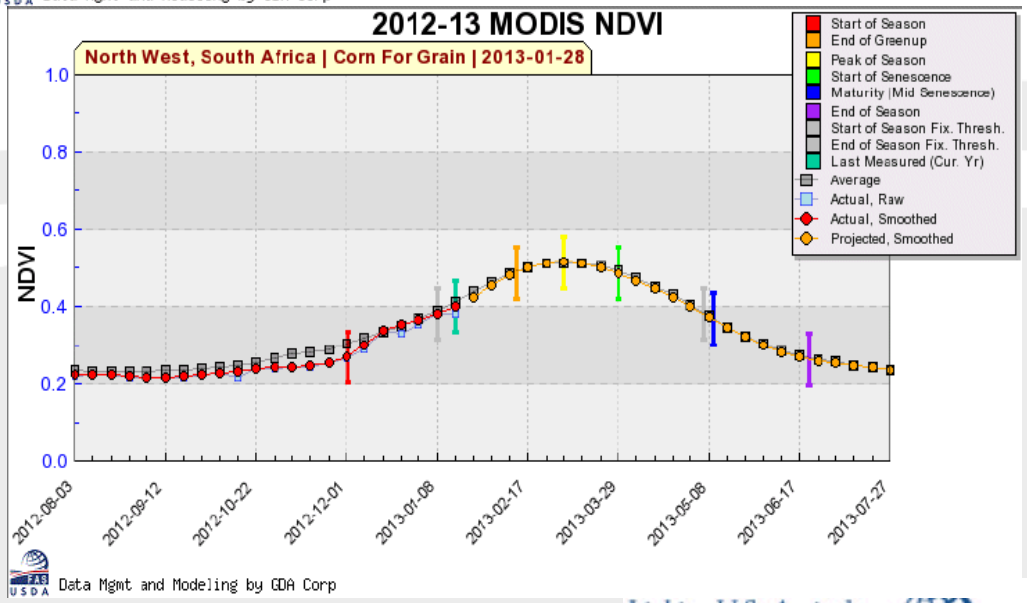


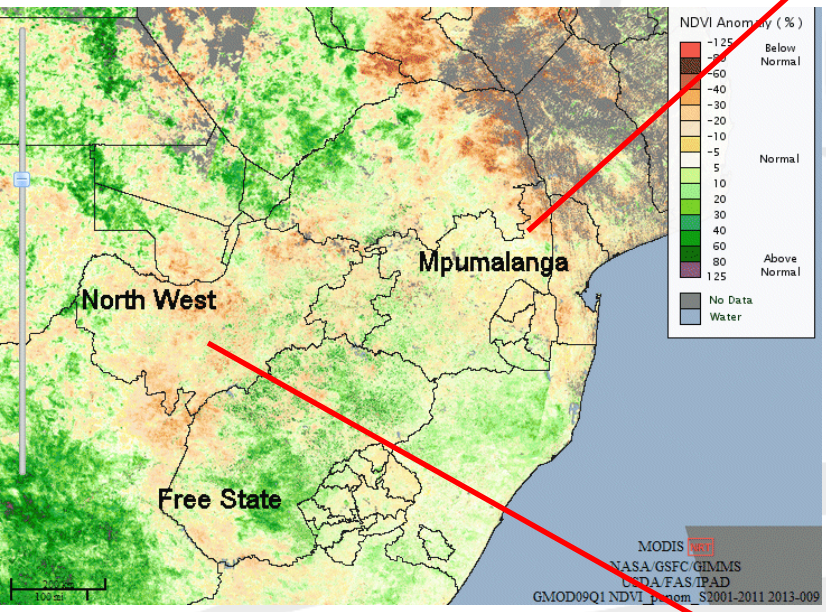


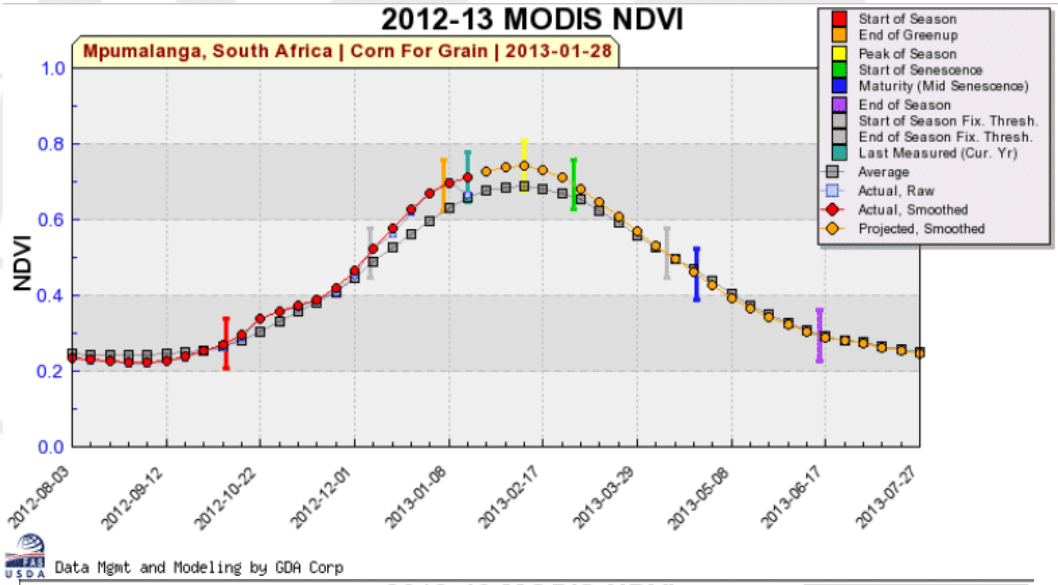


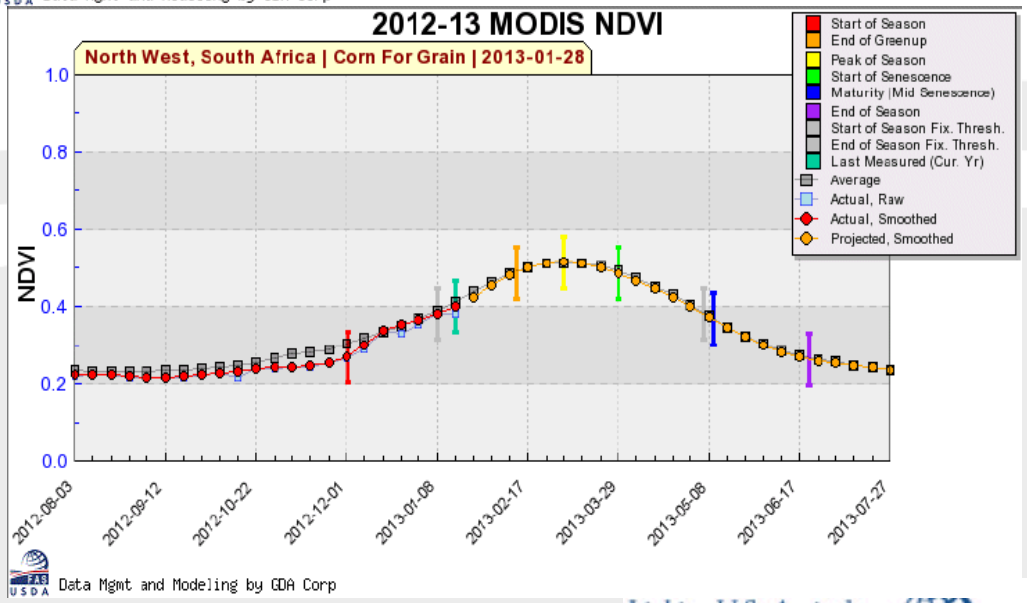
Linking U.S. Agriculture FAS to the World

GLAM-MODIS Yield Forecaster Summary

- Smoothed seasonal MODIS-NDVI metrics defined by modified TIMESAT







Linking U.S. Agriculture FAS to the World

GLAM-MODIS Yield Forecaster Summary

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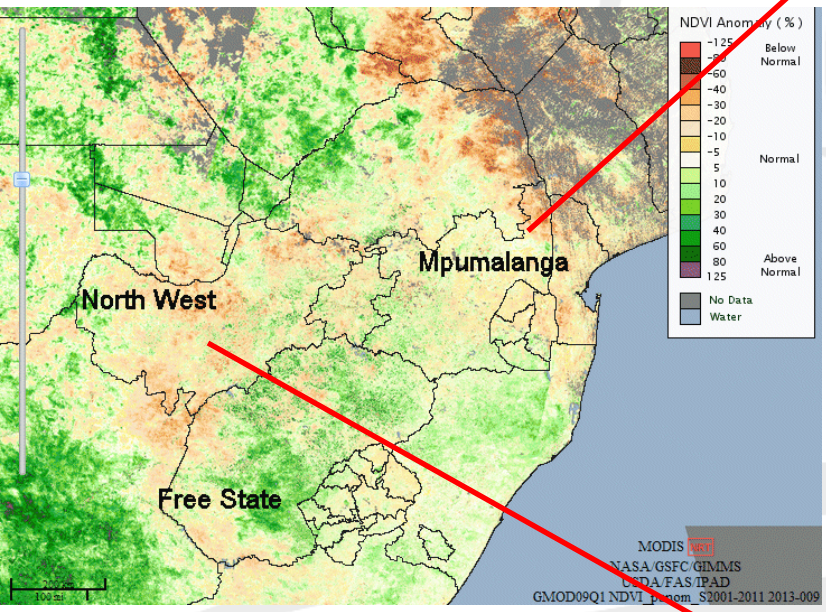
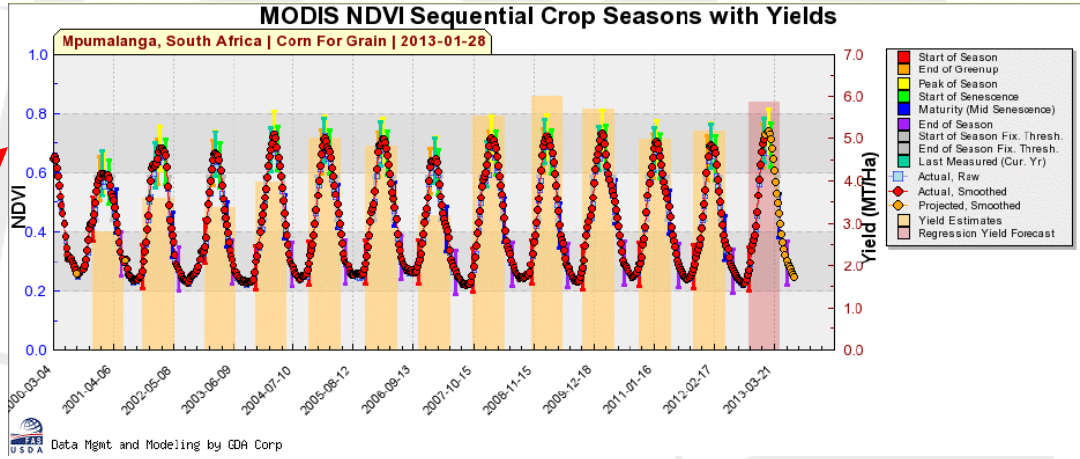
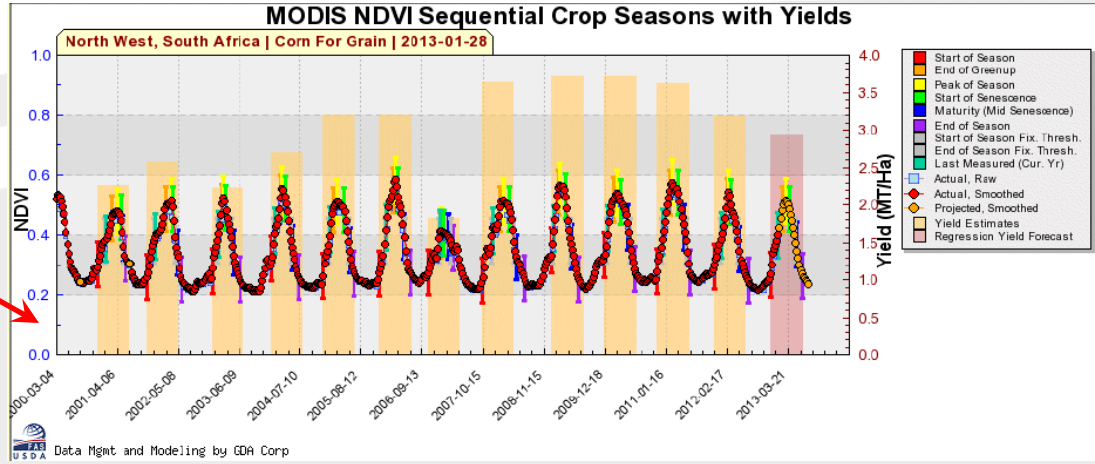






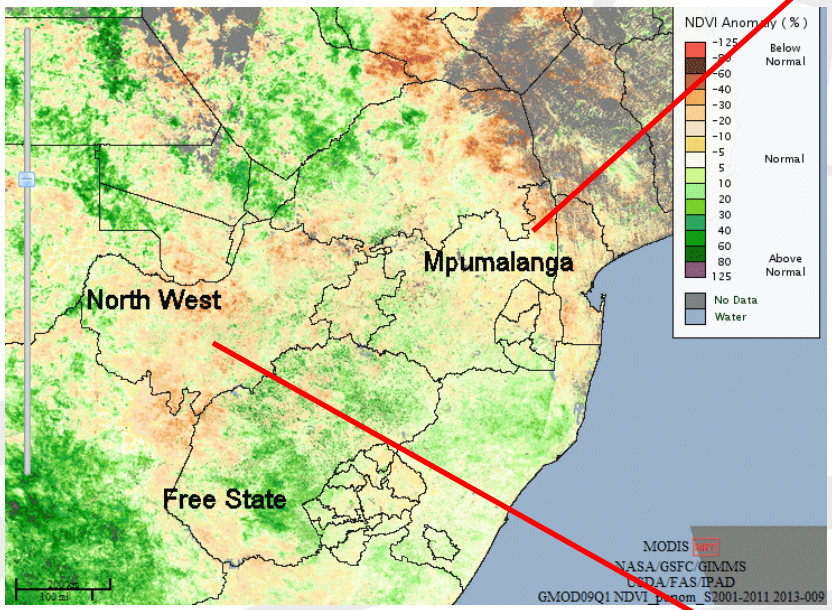
GLAM-MODIS Yield Forecaster Summary

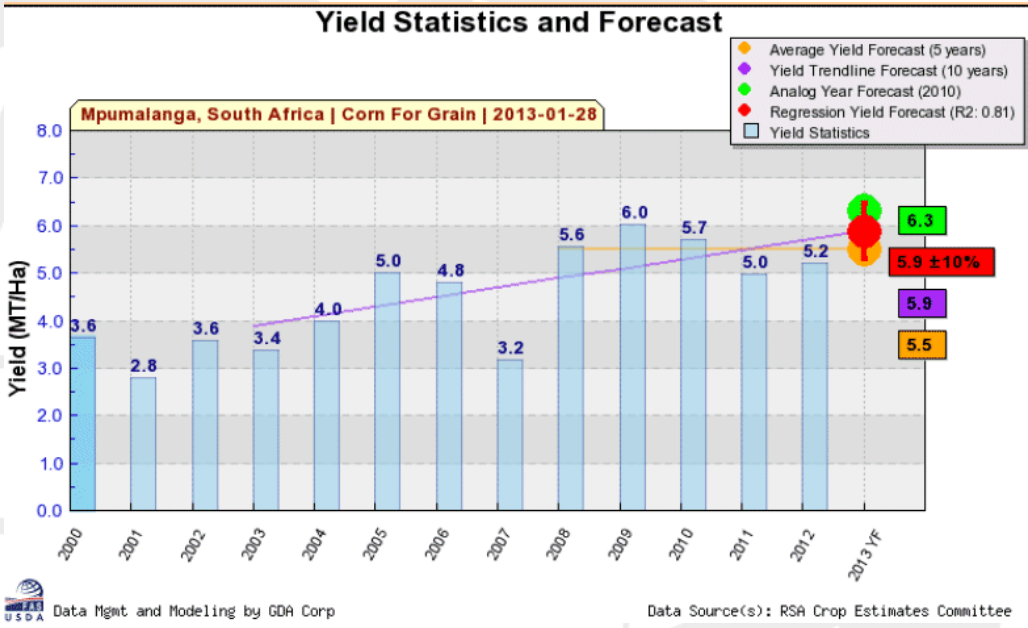
- Forecast Yield selected is the "best fit" from the MODIS-Yield Regression and Seasonal Metrics table.

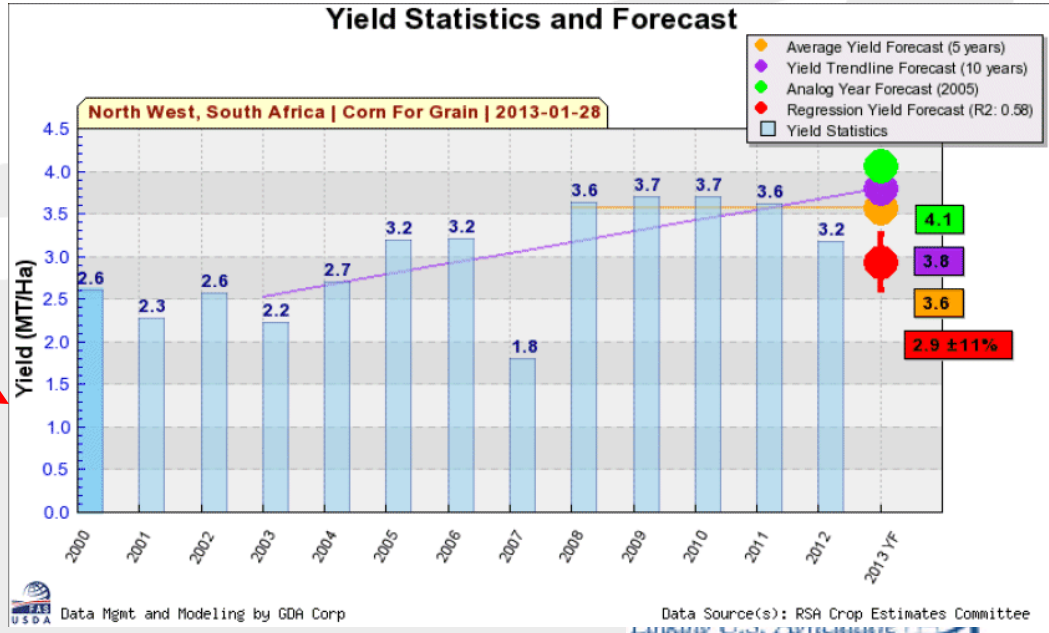
NDVI Agricultural Seasonal Metrics (Smoothed)

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







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

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Linking U.S. Agriculture FAS to the World

Thank you!