Monitoring Global Agriculture Production with MODIS and Landsat Imagery

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.

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/)

  - LACIE (mid-1970’s): researched how to monitor agriculture with Landsat & NOAA satellite series.
Wheat, corn, and soybean prices continue to rise


2007 price hike from low global stocks, record droughts & US corn ethanol demand

1970’s price hike

Source: USDA/NASS Agricultural Prices
http://www.nass.usda.gov/Charts_and_Maps/Agricultural_Prices/
USDA’s Economic Information System

National Agricultural Statistics Service (NASS)

Joint Agricultural Weather Facility (JAWF)

Foreign Agricultural Service (FAS)

Economic Research Service (ERS)

Farm Service Agency (FSA)

World Agricultural Outlook Board

Domestic Production and Stocks Estimates

FAS Commodity Circulars

World Agricultural Supply and Demand Estimates (WASDE)

PSD (Production, Supply and Distribution) Online Data
USDA’s Economic Intelligence System

- 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.

World Agricultural Supply and Demand Estimates (WASDE) since 1973

USDA/FAS Economic Analysis
- Trade Policy
- Exporter Assistance & Export Programs
- Food Aid & Export Credit Programs
- UMR (Usual Marketing Requirements)

Chicago Board of Trade (CBOT) & other commodity markets

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

USDA/FAS/IPAD

Linking U.S. Agriculture to the World
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
  – PSD Online (historical archive from 1960-present)
    http://www.fas.usda.gov/psdonline/
Low stocks raise prices.

0.2 is 73-days (0.2*365) of stocks

Low stocks raise prices.
Global Agricultural Monitoring System (GAMS)

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

Crop Area
(16-days overpass)
Landsat (30-m)
DMC (22-m)

Crop Yield
(daily AM/PM overpass)
MODIS-NDVI (250-m)
(2000-present)

Area Estimates & Crop masks

Yield Estimates & Maps

(Landsat= free)  (MODIS= free)
• 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/
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 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
  - http://www.nateko.lu.se/timesat/timesat.asp

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

TIMESAT Definition

![Scaled NDVI over time graph](image)
GLAM-MODIS Yield Forecaster Summary

Large Integrals for Grain-filling Period

(i_{cms}) Adjusted Large Integral
(c) End of Greenup
(ms) Mid Senescence

(ir_{cms}) Raw Adjusted Large Integral
(c) End of Greenup
(ms) Mid Senescence
South Africa’s Corn Yields

Approximately 50% of production is divided between east and west.

West: Lower yields & greater corn area

East: Higher yields & less corn area

Maize yield estimation (Based on the ACRU Maize Yield Model)

Source: Department of Agricultural Engineering, University of Natal, Pietermaritzburg, South Africa
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

[Graphs showing MODIS NDVI Raw and Smoothed data over seasons.]
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.
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

USDA/FAS/OGA
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!