I. Project Background Mission and Goals

Project Background NASA/UDSA MOU

The U.S. Department of Agriculture (USDA) and the National Aeronautics and Space Administration (NASA) recently signed a Memorandum of Understanding (MOU) to strengthen future collaboration. In support of this collaboration, NASA and the USDA Foreign Agricultural Service (FAS) jointly funded a new project to assimilate NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) data and products into an existing decision support system (DSS) operated by the Production Estimates and Crop Assessment Division (PECAD) of FAS. Building on NASA's investment in the MODIS Science Team, the project is implementing a user-friendly system that will allow for the integration and analysis of MODIS data products in PECAD's DSS.

FAS Mission & Tasks

FAS promotes the security and stability of U.S. food supply, improves foreign market access for U.S. agricultural products, reports on world food security, and advises the U.S. government on international food aid requirements.

FAS bears the primary responsibility for USDA's overseas activities: market development, international trade agreements and negotiations, and the collection and analysis of statistics and market information. It also administers USDA's export credit guarantee and food aid programs, and helps increase income and food availability in developing nations by mobilizing expertise for agriculturally led economic growth.

PECAD's Scope

The FAS, through PECAD, provides agricultural information for global food security. It produces objective, timely and regular assessments of global agricultural production outlook and the conditions affecting food security. PECAD is responsible for global crop condition assessments and estimates of production and yield of grains, oilseeds, and cotton. PECAD assessments are an integral component of the monthly crop assessments issued by USDA's World Agricultural Outlook Board - a primary source for agricultural information worldwide.

The Application of NASA EOS MODIS Data to FAS Agricultural Assessment and Forecasting

To meet its objectives, FAS/PECAD uses satellite data and data products to monitor agriculture worldwide and to locate and keep track of natural disasters such as short and long term droughts, floods and persistent snow cover which impair agricultural productivity. FAS is the largest user of satellite imagery in the non-military sector of the U.S. government. For the last 20 years FAS has used a combination of Landsat and NOAA-AVHRR satellite data to monitor crop condition and report on episodic events.

FAS is upgrading and enhancing the satellite component of its PECAD decision support system through an information delivery system for MODIS data and derived products. NASA's Moderate Resolution Imaging Spectroradiometer (MODIS) on board two platforms of the Earth Observing System (EOS), was designed in part to monitor subtle vegetation responses to stress, vegetation production and land cover with regional-to-global coverage. Hence, integration of MODIS data and derived products into the PECAD FAS DSS provides FAS with better characterization of land surface conditions at the regional scale and enables monitoring of changes in the key agricultural areas of FAS focus regions in a more timely fashion and at a higher resolution than previously possible with NOAA-AVHRR data.

MODIS: An Operational Prototype

Although MODIS is a NASA experimental mission, the instrument's capabilities will be extended by the launch of the Visible Infrared Imager Radiometer Suite (VIIRS) in 2008, part of the National Polar Orbiting Environmental Satellite System (NPOESS), which will become fully operational in 2009. Thus the methods and system developed through this research project can be transitioned into a fully operational domain.

II. Project Components:

A. Delivery and integration of MODIS Rapid Response data into the FAS monitoring system to facilitate improved monitoring of the impact of climate hazards, such as drought, large scale flooding, and snow storms, on agricultural production.

B. Development and delivery of a long term database of MODIS composite Vegetation Index (VI) time series including analysis tools and a graphic user interface that provides mosaicking, reprojection capabilities, and easy access to the moderate resolution image archive.

C. Establishment of the relationship between MODIS VI data and the long-term archives from the AVHRR and SPOT-VEGETATION used by FAS/PECAD.

D. Development of enhanced MODIS cropland products including a crop mask, a crop type map, new band combination products, and a crop stress index.

A. MODIS Rapid Response

The MODIS Rapid Response (RR) system provides rapid access to MODIS data collected twice daily from the Terra satellite in the morning (10:30am) and the Aqua satellite in the afternoon (2:30pm).

The RR system provides FAS analysts with access to georeferenced, calibrated, mosaicked daily global MODIS imagery for FAS regions of interest within 2-4 hours of satellite acquisition. RR data are available to FAS analysts at spatial resolutions of 250m, 500m and 1km in different band combinations.

Such rapidly accessible data allows the FAS analysts to evaluate, and asses, in near real time, the effect of disaster events on crops.

Fig.1a - MODIS RR web interface with PECAD Crop Explorer showing clickable regions for which RR data is available. The Highlighted red square is the FAS region 'Brazil3'.

Fig.1b - Example of RR imagery available for Brazil3 on March 12th 2005, including false color and true color composites, and NDVI at 250m, 500m and 1km resolutions. The highlighted blue box shows soy croplands.

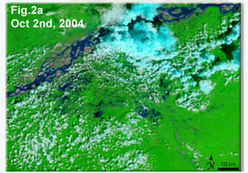
Fig.1c - Highlighted soy croplands at 250m resolution band combination 7-2-1.

Monitoring floods in October 2004, in northern India and Bangladesh using MODIS RR imagery

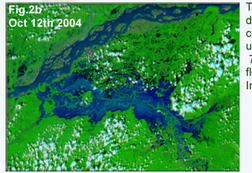
In **Fig.2b** the Jamura River (tributary of the top, Brahmaputra river) expands from a barely visible line in **Fig.2a** to a lake that is more than 125km wide.

Such hazardous events can be monitored in near real time with RR imagery.

Prior to Flood



Post flood



The images are displayed as a false color composite using MODIS bands 7-2-1 showing flooding in northern India/ Bangladesh

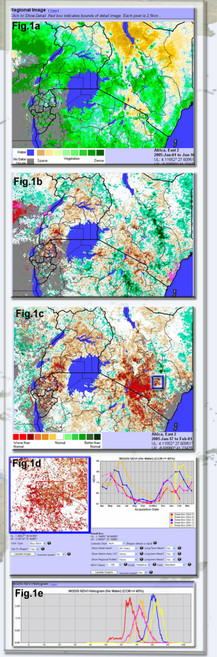
B. Long Term Database of MODIS Composite Vegetation Index Time Series

In monitoring crop conditions for a specific region, remotely sensed vegetation index data are used to track the evolution of the growing season compared to reference long-term mean conditions. A global normalized difference vegetation index (NDVI) is produced from MODIS data, and is referred to as the "continuity index" similar to the existing archive of NOAA-AVHRR derived NDVI.

A global NDVI time-series database, with a spatial resolution of 250 meters has been assembled using a 16-day compositing period, allowing for interannual comparisons of growing season dynamics. This MODIS NDVI dataset is automatically reprojected and mosaicked to suit the FAS regions of interest. The time-series data are accessible to FAS analysts through a powerful web interface and analysis tool. From this stand-alone interface the analysts can query these data by pre-defined sub-regions, by interactive regional subsetting, and by implementing crop/water masks to:

- plot time-series graphs over the crop growing seasons to quickly assess crop conditions and anomalies.
- monitor current conditions.
- view spatially, NDVI anomalies comparing current conditions to previous year, or historical mean.
- plot histograms of current and historical NDVI data.

These data and utilities are fundamental for crop yield forecasts and can serve as an early warning system for regions suffering from crop loss and food shortages.



Kenyan drought depicted by the MODIS time series web

Kenya experienced a severe drought in Jan 2005 leaving up to 2.7 million people in need of food aid. Using the MODIS composite NDVI time series FAS analysts tracked this drought and its effects on agricultural lands.

Fig.1a - NDVI composite Jan 1st -16th 2005. Greens correlate to increasingly higher NDVI values, browns correlate to lower NDVI values.

Fig.1b - NDVI anomaly image: Jan1st - 16th 2005 versus the mean NDVI for this time-step. Reds/browns indicate lower than the multi-year mean NDVI values. Greens indicate higher than mean NDVI values.

Fig.1c - NDVI anomaly image: Jan 17th - Feb 1st 2005 versus the mean NDVI for this time step. Showing worsening of drought conditions especially in southern Kenya. The highlighted blue box shows affected corn growing region.

Fig.1d - Zoom-in to affected corn region with a graph presenting 4 years of NDVI data through time. The red line, consistently lower than the others, depicts the 2004-05 season exhibiting the effects of the drought on this region.

Fig.1e - Histograms for the Jan 17th-Feb 1st time-step for years 2001-2005 for the highlighted corn region. The red histogram shows that the NDVI values for 2005 were lower than the previous years.

III. Contact Information & Links

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Related Websites

GLAM Global Agricultue Monitoring
https://tripwire.geog.umd.edu/usda

MODIS Rapid Response System
http://rapidfire.sci.gsfc.nasa.gov/

GIMMS Global Inventory Monitoring and Modeling
http://ltpwww.gsfc.nasa.gov/gimms/htdocs

USDA Crop Explorer
http://www.pecad.fas.usda.gov/cropexplorer

USDA Foreign Agricultural Service
http://www.fas.usda.gov/

NASA USDA Partnership
http://www.esa.ssc.nasa.gov/pships/usda.aspx

University of Maryland, Geography Department
http://www.geog.umd.edu/

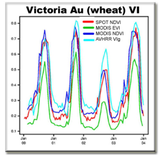
MODIS Land Discipline
http://modis-land.gsfc.nasa.gov/

C. Long-Term Monitoring

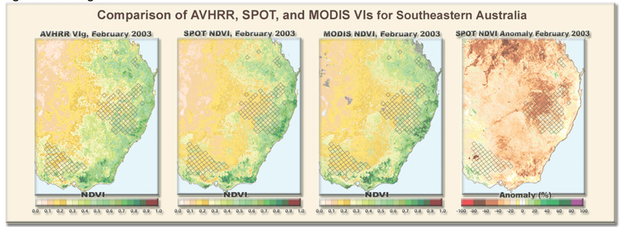
An inter-sensor Calibration

The Global Inventory Monitoring and Modeling Studies (GIMMS) group at NASA Goddard Space Flight Center (NASA/GSFC) provides USDA/FAS with global data stream of NDVI that spans over two decades (1981-present). The GIMMS NDVI is derived from measurements made by the Advanced Very High Resolution Radiometer (AVHRR), Global Area Coverage (GAC) data from the National Atmospheric Oceanic Administration (NOAA) polar orbiting series of satellites. GIMMS has inter-calibrated the data from the NOAA-AVHRR satellite series and performed atmospheric correction to minimize the effects of volcanic aerosols to produce and maintain a consistent NDVI archive. The NDVI archive from GIMMS provides the historic database for monitoring the response of vegetation to climatic conditions.

Linking the MODIS data to the long-term GIMMS AVHRR/NDVI, archive and SPOT Vegetation sensor data is a critical component of this project providing a consistent multi-source long-term data record for agricultural monitoring. This allows FAS analysts to compare current data with the spatial extent and severity of NDVI anomalies associated with heat stress, droughts and floods associated with crop failures.



VIs from different sensors are related by examining their temporal and spatial behavior (means, ranges, and anomalies) at target FAS agricultural regions throughout the globe and interpreting these statistical patterns with respect to the growing seasons for various crops. The aim of this project component is to build a consistent time series that best represents the vegetation dynamics over these agricultural regions.

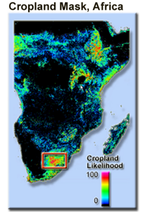


D. Enhanced Cropland Products using MODIS

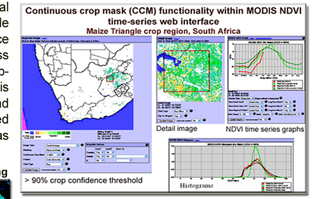
A Dynamic Continuous Cropland Mask for use with MODIS time-series web interface

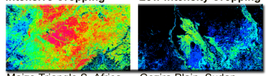
To successfully monitor worldwide agricultural regions and provide accurate agricultural production assessments, it is important to understand the spatial distribution of croplands. To do this, GLAM has developed a global croplands mask to identify all sites used for crop production.

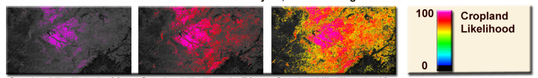
Croplands are highly variable both temporally and spatially. Croplands vary from year to year due to events such as drought and fallow periods, and they vastly differ across the globe in accordance with characteristics such as cropping intensity and field size. A flexible crop likelihood mask is used to help depict these varying characteristics of global crop cover.
This flexible croplands mask is generated by analysis of 4 years of MODIS data (2001-2004). Such a dynamic mask allows FAS analysts, through the MODIS time series web interface, to threshold cropland membership according to their needs and region of interest.



Regions featuring intensive agro-industrial farming practices such as the Maize Triangle in South Africa will have higher confidence values in the crop mask as compared to less intensively farmed regions in parts of Sub-Saharan Africa where cropland identification is partly confounded with natural background vegetation phenologies. Thus, a customized threshold can be employed to examine areas of varying cropping intensification.







GLAM Global Agriculture Monitoring

GLAM
Global Agriculture Monitoring

Enhancing the agricultural monitoring and crop production forecasting capabilities of the Foreign Agricultural Service using moderate resolution satellite data

A collaboration between NASA/GSFC, USDA/FAS, SSAI, and UMD Department of Geography