The GEO Global Agricultural Monitoring Initiative (GEOGLAM): Overview

Chris Justice (UMD)
GEO the Group on Earth Observations
an Intergovernmental Organization with 90 Members
and 67 Participating Organizations


Led to the Establishment of a

Global Earth Observing System of Systems (GEOSS)
GEO is focused on societal benefit

Agriculture is one of the GEO societal benefit areas
GEO provides an international framework for collaboration
GEOGLAM vision

...the use of coordinated, comprehensive and sustained Earth observations to inform decisions and actions in agriculture

...through a system of agricultural monitoring systems
International recognition of critical need for improved real time, reliable, open information on global agricultural production prospects.

Critical for agricultural policies, stabilizing markets, averting food crises.

Need to increase food production by 50%-70% by 2050 to meet demand.

Intensification to close crop yield gaps – Extensification band use change.

Plus increasing frequency of extreme events and climate change.
Context For GEOGLAM
Monthly Wheat Prices 1960-2011 ($/Metric Ton)
Source: World Bank

- 1971/2’s price hike
- 2008 Price hikes
  Droughts: Australia & Ukraine
- 2010/11 Price hikes
  Drought: Russia USA
- 1996 price hike

Landsat 1 Launched (1972)
Initial Thematic Workshop Series to Identify “Community of Practice” Priorities and Best Practices

- April 2011, ISRSE, Sydney: Workshop on Rangelands and Pasture Monitoring
- May 2011, Curitiba Brazil (SBSR): JECAM South America Workshop
- June 2011, Vienna Austria: Agricultural Land Cover Mapping Workshop
- September 2011, Nairobi Kenya: Agricultural Capacity Building Workshop
- October 2012, China: Workshop on Agricultural Water Availability
Who We Are
Open Community made up of international and national agencies concerned with agricultural monitoring including ministries of Ag, space agencies, universities, and industry

We have preliminary involvement with Kazakhstan

Where are the other countries of Central Asia?
G20 Final Declaration

44. We commit to improve market information and transparency in order to make international markets for agricultural commodities more effective. To that end, we launched:

- The "Agricultural Market Information System" (AMIS) in Rome on September 15, 2011, to improve information on markets ...;

- The "Global Agricultural Geo-monitoring Initiative" (GEO-GLAM) in Geneva on September 22-23, 2011. This initiative will coordinate satellite monitoring observation systems in different regions of the world in order to enhance crop production projections and weather forecasting data.
GOAL AND SCOPE

• To strengthen the international community’s capacity to produce and disseminate relevant information on agricultural production at national, regional and global scales, through reinforced use of Earth Observations.

• GEOGLAM is a ‘coordination program’, aiming at:
  – supporting, strengthening and articulating existing efforts through the use of EO
  – developing capacities and awareness at national and global level
  – disseminating information
The GEOGLAM Components

1. GLOBAL/ REGIONAL SYSTEM OF SYSTEMS
   Main producer countries, main crops

2. NATIONAL CAPACITY DEVELOPMENT
   for agricultural monitoring using Earth Observation

3. MONITORING COUNTRIES AT RISK
   Food security assessment

4. EO DATA COORDINATION

5. METHOD IMPROVEMENT through R&D coordination (JECAM)

6. Data, products and INFORMATION DISSEMINATION
GEOGLAM Monthly Crop Monitor for AMIS

• Objective: develop consensus crop condition and prospects assessment in primary agricultural production areas highlighting potential hotspots of stress/bumper crops

— inputs from international and national agencies, based on evidence from satellite, weather, agromet, and national expert assessments
Crop Condition Global Outlook: Building International Consensus
Assessment of Crop Conditions in Northern Hemisphere- input to AMIS

Component 1  Phase 1 (2012-2103)

Crop NDVI Anomaly, August 13th, 2012

Crop Condition Global Outlook: Building International Consensus
Assessment of Crop Conditions in Northern Hemisphere- input to AMIS
GEOGLAM Prototype Global Crop Assessment

August 1, 2013

Wheat

WHEAT (major growing regions in AMIS @ 17 Countries)

Wheat Comments and Highlights

Overall wheat conditions have been favorable. In the United States winter wheat has mostly been harvested, with some early July 14% of spring wheat was at or beyond the heading stage, and close to 70% is reportedly in good to excellent conditions according to USDA. In Canada, crop conditions are favorable across the country for reproductive spring grains with only minor delays and delay in disease issues. Winter wheat harvest is in progress in Ontario and early reports indicate excellent yields. In some western winter wheat has mostly been harvested. Widespread sowings revealed favorable conditions for heading spring wheat in the Volga District while warm and dry conditions are affecting the southern Urals and Southern District. Rainfall eastern Russia and Kazakhstan improved yield prospects for heading spring wheat, while winter wheat harvest was in progress in early September. In China, winter wheat has mostly been harvested, in Europe this agricultural year has so far been marked by an unusually prolonged winter and central Europe and heavy rainfall in May and June. Crop conditions are favorable across China, and the wheat harvest is expected to be well ahead of schedule. Forecasts for France are the largest producer show some yield losses expected to the year, whereas higher yield trends are forecast in Spain, Romania, Bulgaria and Hungary. In South Africa winter wheat is in emergence stage. Although still early in the season, vegetation index anomalies indicate some stress and one or two significant rainfall events are needed in coming months. Growing conditions for Australia winter wheat crops are generally favorable across most of the country. Recent rainfall in Western Australia has reversed the dry conditions of the past few weeks. Southeast production areas are in good condition. Better than average conditions in southern New South Wales offset the area of concern in northern New South Wales due to extended dryness in July. In Argentina winter wheat planting is mostly complete. Cool weather slowing early wheat development. In Brazil winter wheat is in vegetative stages with cool temperatures affecting the southern portions of the country. 

GEOGLAM Global Agricultural Monitoring

Market Monitor

No. 11 – September 2018

CROP MONITOR

Crop Monitor (as of 28 August)

This is the first GEOGLAM Crop Monitor developed for AMIS. It summarizes latest crop conditions for AMIS crops based on regional expertise and analysis of satellite data, ground observations, and meteorological data, and was conducted by experts from global, national and regional monitoring systems. For each of the four crops, a paragraph summarizing current conditions is provided, accompanied by a satellite-based indicator map. Each map depicts crop vegetation growth index from August 28th through to the previous year, averaged over the entire growing regions within AMIS countries.

Wheat: Prospects are favorable in the northern hemisphere. Winter wheat harvest is complete and spring wheat is in late maturity to harvest stage. In the US, Canada, Russia and Kazakhstan spring wheat conditions are good through good yields will depend on favorable weather coming in the harvest. In the Southern Hemisphere, crops in early vegetative to reproductive stage condition is generally favorable. In Australia, winter wheat conditions are average to above average but outlook for the next month will be critical as there are some concerns over dry conditions in parts of the country. In Argentina conditions are good although additional rains are needed. In Brazil, floods caused some significant crop damage and there are some concerns over moisture issues. In south Africa winter wheat conditions have improved since early July, following widespread precipitation.

Maize: General conditions are good, in the US approximately half of the maize is in good to excellent condition and in spite of dry weather and rising temperatures in August, a bumper production is expected largely due to increased planted area. In Canada, conditions are favorable and yields are expected to be above average in the US, prospects are good except in northern Illinois, Kansas, Nebraska and Minnesota where there is concern due to late planting and dry and hot conditions. In Mexico, current yield trends are favorable with above average production in the south. In China, India and Indonesia conditions are generally good in Brasil the second maize crop harvest at about complete and it is expected to be favorable.

Rice: Growing conditions are favorable. The monsoon season in South and Southeast Asia has maintained good moisture across most of the region. In India, conditions are favorable as monsoon rains have been well distributed. In Thailand, precipitation has been adequate, though there are some concerns over localized dryness. Favorable conditions were maintained in Vietnam and the Philippines with some concern over areas across moisture and flooding. In China, good moisture conditions were maintained in the North China Plain and though there are some concern over flooding in the southwest and eastern maize in the southwest. Meanwhile, south of the Yangtze River, dry conditions and above normal temperatures raise concern. In Japan, conditions are mostly favorable in the south for early developing rice.

Soybeans: Growing conditions are favorable. In the US, about half of the crop is in good to excellent condition although prolonged dry conditions in the southwest are raising concerns. In China, conditions are favorable in the north China Plain production region. In India, favorable conditions are favorable in the south and east of the country.
Example of cereals state map Kazakhstan

MAP of crop state
end of July 2006

very good
good
not bad
bad
very bad
cloud

AKMOLA oblast

Terekhov et al
5 Classes of Crop State: Spring Wheat Kazakhstan

Typical classes of spring wheat state (end of July)
phase: flowering.

Terekhov et al
Changes in key parameters of agriculture in Kazakhstan

Cereals productivity in Kazakhstan

Official data

Terekhov et al
Recognition that cropping systems are inherently diverse which dictates the monitoring observations and methods
No one system can meet ag monitoring needs
Identifying Information and Product Types

**Information Products**
- Crop outlook / Early warning
- Area estimate
- Yield forecast
- Production estimate
- Food Sec/vulnerability report
- Statistics reports

**EO Data Products**
- Cropland mask /Pasturelands
- Ag practices
- Crop condition indicators
- Crop type
- Biophysical variables
- Environmental variables (soil moisture)
- In-situ Weather
developed taking into consideration the observation needs, the derived products they will serve, and regional specificities; CEOS-GEOGLAM July 2012 Montreal

<table>
<thead>
<tr>
<th>SENSOR MISSION</th>
<th>SPATIAL RES.</th>
<th>SPECTRAL RES.</th>
<th>TEMPORAL RES.</th>
<th>EFFECTIVE OBSERV. FREQUENCY (CLOUD FREE)*</th>
<th>WHERE? (+ CROP LAYER &amp; SAMPLING SCHEME)</th>
<th>WHEN?</th>
<th>DERIVED PRODUCTS &amp; MONITORING APPLICATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODIS (Aqua, Terra), VIIRS, NPP, Vegetation (SPOT-5)</td>
<td>2000 - 500 m</td>
<td>Thermal IR + Optical</td>
<td>few per day</td>
<td>Global</td>
<td>w2w</td>
<td>NRT products (PS)</td>
<td></td>
</tr>
<tr>
<td>MODIS (Optical: Near, SWIR), Sentinel-3 (Terra), CMA FY (Future)</td>
<td>1000 - 500 m</td>
<td>Optical + SWIR</td>
<td>2 to 5 per week</td>
<td>Global</td>
<td>w2w</td>
<td>NRT products (PS)</td>
<td></td>
</tr>
<tr>
<td>ETM (Landsat-7), ASTER (Terra), TRMM, MODIS (GEOS-4)</td>
<td>50 - 110 m</td>
<td>Passive Microwave, SAR dual pol. (KACE142), thermal</td>
<td>daily</td>
<td>Global</td>
<td>w2w</td>
<td>NRT products (PS)</td>
<td></td>
</tr>
<tr>
<td>Sentinel-3 (Landsat, Terra, EO-1, ResourceSat-2, CBERS-3, Sentinel-2)</td>
<td>5 - 20 m</td>
<td>SAR dual pol. (KACE142)</td>
<td>5 per season weekly</td>
<td>Crops</td>
<td>s</td>
<td>NRT products (PS)</td>
<td></td>
</tr>
<tr>
<td>MODIS (Optical), RapidEye (optical)</td>
<td>5 - 10 m</td>
<td>Optical (SWIR)</td>
<td>1 per week</td>
<td>Crops</td>
<td>s2</td>
<td>NRT products (PS)</td>
<td></td>
</tr>
<tr>
<td>MODIS (Optical), RapidEye (optical)</td>
<td>5 - 10 m</td>
<td>Optical (NIR/SWIR)</td>
<td>1 per week</td>
<td>Crops</td>
<td>s3</td>
<td>NRT products (PS)</td>
<td></td>
</tr>
<tr>
<td>&lt; 5 m</td>
<td>Optical</td>
<td>1 to 2 per month</td>
<td>Crops</td>
<td>s</td>
<td>NRT products (PS)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

GEOGLAM data plan to be submitted to the CEOS plenary in 2013
Cultivated Land Distribution

Fritz et al. IIASA
ARABLE LAND
Satellite estimation

RUSSIA
KAZAKHSTAN

Information source:
- SRI AS, RUSSIA
- NC SRT, KAZAKHSTAN
Agriculture land use in river Ili basin

Landsat mapping (2010 year)

Legend:
- Cropland;
- Water;
- River;
- Urban

Kazakhstan  CHINA
AT WHAT LEVEL OF DETAIL (SPATIAL RESOLUTION)?

Field Size Distribution

Field Size

- Large
- Small
Typical steppe landscape in Northern Kazakhstan

Terekhov et al
Example of sowing data map using MODIS data

MAP of spring crop sowing date

It created on base of MODIS data

Akmola oblast

2004

Terekhov et al
WHEN?

Average End of Growing Season Date

Day of Year

365

1

0 1,500 3,000 Kilometers

Whitcraft et al. UMD
Example histogram of growing phases of spring wheat in Northern Kazakhstan route observation [207 fields], July 22.2009
HOW OFTEN?

July Repeat Time Required

Legend

Days

Whitcraft UMD
CEOS SEO Support to GEOGLAM

Data Acquisition Planning and Analysis
- Crop Masks, Crop Calendars
- Cloud Statistics (MODIS and ISCCP)
- Data Volume (# paths, duration, # scenes)

<table>
<thead>
<tr>
<th>Mission</th>
<th>Instrument</th>
<th>Total Paths</th>
<th>Total Duration of Acquisitions (min)</th>
<th>Total Scenes</th>
<th>Total Data Volume (GB)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Terra</td>
<td>MODIS</td>
<td>1</td>
<td>3.9</td>
<td>176</td>
<td>0.30</td>
</tr>
<tr>
<td>Aqua</td>
<td>MODIS</td>
<td>1</td>
<td>3.9</td>
<td>176</td>
<td>0.30</td>
</tr>
<tr>
<td>SPOT-5</td>
<td>Vegetation</td>
<td>1</td>
<td>6.6</td>
<td>295</td>
<td>0.53</td>
</tr>
<tr>
<td>NPP</td>
<td>VEIRS</td>
<td>1</td>
<td>7.1</td>
<td>270</td>
<td>0.55</td>
</tr>
<tr>
<td>Landsat 7</td>
<td>ETM+</td>
<td>9</td>
<td>20.4</td>
<td>54</td>
<td>22.41</td>
</tr>
<tr>
<td>LDCM</td>
<td>OLI + TIRS</td>
<td>9</td>
<td>20.4</td>
<td>54</td>
<td>22.41</td>
</tr>
<tr>
<td>Resourcesat-2</td>
<td>LISS -II</td>
<td>12</td>
<td>52.1</td>
<td>166</td>
<td>20.02</td>
</tr>
<tr>
<td>Resourcesat-2</td>
<td>AWARES</td>
<td>2</td>
<td>3.1</td>
<td>11</td>
<td>3.51</td>
</tr>
<tr>
<td>CBERS-3</td>
<td>WFI-2</td>
<td>2</td>
<td>13.7</td>
<td>51</td>
<td>5.31</td>
</tr>
</tbody>
</table>

B. Killough
Sampling Strategy for high resolution data for Phase 1a Countries
Timely data is critical for crop monitoring!!

NASA EOS near-real-time daily observations are processed and integrated into USDA FAS system (< 3 hours from observation)

A contribution to GEO-GLAM

lance.nasa.gov
Component 4 Phase 1: Pilot Study on Data Interoperability

JPSS VIIRS / MODIS interoperability for agricultural monitoring
Assessment of the impact of the 2012 Northern Hemisphere Drought from the MODIS Climate Modeling Grid daily NDVI data. The anomaly image shows the cropland NDVI departure from the average (2000-2011) on July 30th 2012, highlighting hotspots of crops under stress during the 2012 droughts that affected the United States and the Black Sea region. The time-series curves below compare the daily development of croplands in 2012 (red) to average (2000-2011) in 3 important crop growing regions: Illinois, USA; Orenburg Oblast, Russia; Kostanay Oblast, Kazakhstan. The crop development through the season depicted by NDVI shows consistent negative anomalies with regard to a ten year average, with highest discrepancies during the crops peak development period. In 2012 crops in the US, southern Europe and the Black Sea region suffered from prolonged high temperatures and lack of moisture, which resulted in significantly reduced production. This information was available one month prior to harvest and several months before the release of official statistics.
A VIIRS NDVI anomaly (prototype) image computed for the same date (July, 30th 2012) as the MODIS NDVI anomaly shown in the previous slide, generated from data produced at the GSFC Land PEATE.

Vermote et al. 2012
GEOGLAM ‘National Capacity Building’
Generic Enhancement Process

Step 1. Regional Status Assessment, Needs and Priorities Workshop

Step 2. National Engagement / Commitments from interested parties

Step 3a. National Implementation

Step 3b. Regional Training / Information Exchange and continued regional networking

Linkages & feedback between the global/regional monitoring systems and activities
Pakistan Agricultural Information System
(Collaboration between USDA, FAO, SUPARCO, CRS, & UMD)
1038 full-time crop reporters continuously inspect agricultural fields in 1240 villages in Punjab Province.
• Collect data digitally in 1240 villages of Punjab.
• Use GPS-enabled cell phones, location-aware software.
• Automatic upload data to central spatial database.

Modernizing Crop Reporting Systems
GEO ODK : field data collection tool

- Environment for geographical software, tools, blogs, and ODK Collect plugins.
- Primarily used for agriculture monitoring and remote sensing validation and field work.
- Used in Brazil, Uganda, China, US and Pakistan.

Jon Nordling, Mike Humber UMD
Examples GEOGLAM Related Research Initiatives using satellite remote sensing : Kazakhstan

- Cropland Acreage Estimation
- Cereals production forecast
- Estimation of cropland weed infestation
- Estimation of parameters of crop-fallow rotation system
- Estimation of spring soil humidity of arable land
GEOGLAM Research Initiatives

Organizing GEOGLAM Sessions at Scientific Conferences: focusing on Operational R and D – engaging the broader research community e.g.

- American Geophysical Union Conference, Dec 11, 2013, San Francisco, USA (Justice/Doorn)

- Global Vegetation Monitoring and Modeling Meeting, Feb 3-7th 2014, Avignon, France (Defourny/Justice)
  - 27 requests for 8 oral presentation slots! 
Summary for Central Asia

- Central Asian countries are highly agrarian (45% of the population employed in agriculture - on average for 25% of GDP) – cotton and wheat primary crops
- Kazakhstan has systems in place for agricultural monitoring using EO and is participating in GEOGLAM?
- International community can help provide data and tools for ag. monitoring - US, EU, Russia, China
- New GEOGLAM initiative forming on livestock production (led by CSIRO Australia) relevant to C. Asia
- Is there an interest from other CA countries to participate - opportunities for regional capacity building through CARIN
THANK YOU!