GEOGLAM
Global Agricultural Monitoring

Chris Justice
on behalf of the GEOGLAM CoP

GEOGLAM RAPP Workshop, July 23rd 2014, INRA
G-20 GEOGLAM: A GEO Initiative on Global Agricultural Monitoring through the use of earth observations

- **Aim:** Strengthen the international community’s capacity to produce and disseminate relevant information on agricultural production at national, regional and global scales, through earth observations

- **Building on existing monitoring systems**

- **Focus on producer countries and countries-at-risk**
GEO the Group on Earth Observations
an Intergovernmental Organization with 90 Members
and 77 Participating Organizations

Led to the Establishment of a
Global Earth Observing System of Systems (GEOSS)
Initial GEO Agricultural Monitoring Workshop
July 2007, UN-FAO

• IGOL*/GEO AgMon Workshop to develop a strategy for global agricultural monitoring in the framework of GEO
  – Attendance: 25 national and international organizations
  – Establishment of the ‘GEO/IGOL Agricultural Monitoring Community of Practice’

• Agricultural Monitoring Community: many common issues of data frequency, timeliness, policy, availability and continuity

• Agricultural Monitoring Research Community: little that could be adopted as ‘operational’
  – Reviewed the current state of agricultural monitoring, identified gaps and developed a set of priorities and recommendations

IGOL*: Integrated Global Observation of Land, a GEO programme
Volatility of Agricultural Prices (1/2)

- International recognition of critical need for improved real time, reliable, open information on global agricultural production prospects.

Monthly Wheat Prices 1960-2011($/Metric Ton)

Source: World Bank, nominal prices

- 2008 Price hikes
  Droughts: Australia & Ukraine
- 2010/11 Price hikes
  Drought: Russia

Landsat 1 Launched (1972)

1971/2’s price hike

Nominal wheat price in US $/metric Ton

Becker-Reshef
### Volatility of Agricultural Prices (2/2)

#### Link with Production Forecasts

Aggregation of Wheat Production Forecasts from Main Wheat Export Countries vs. International Market Price: 2010, 2012

<table>
<thead>
<tr>
<th></th>
<th>Price ($/Ton)</th>
<th>Production Forecasts 1,000 MT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Final Estimate</td>
<td></td>
</tr>
</tbody>
</table>

**Critical period for EO**

- **2010**
- **2012**

![Graph of Volatility of Agricultural Prices (2/2)](image)

Becker-Reshef
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" (GEOGLAM) 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...

- Two initiatives to increase information availability, quality and transparency:
  
  GEOGLAM : improve information on supply
  
  AMIS : improve information on markets
GEOGLAM Actors
GEOGLAM Community of Practice

Open Community made up of international and national agencies concerned with agricultural monitoring including Ministries of Ag, space agencies, universities, & industry
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 - Phase 1 Support

- **EU FP 7**
  - SIGMA project

- **EU-ESA**
  - Sentinel-2 for Agriculture project

- **US-NASA**
  - Land Cover/Use Change
  - Crop Monitor
  - Global Soy Area Estimation
  - Wheat Yield Forecasting prototype
  - GEOGLAM operations

- **US-USDA**
  - Pakistan Capacity Building
  - GEOGLAM Operation w. NASA

- **Canada-Belgium (UCL)**
  - JECAM office

- **China**
  - CropWatch project

- **CSIRO**
  - RAPP Office

- **Japan**
  - Asia-RICE Project (JAXA + ADB)

- **France**
  - Secondment of GEOGLAM project coordinator

- **Gates Foundation**
  - STARS Project (Africa & Asia)

- **Germany**
  - Indicated interest to support GEOGLAM

- **Argentina (Ministry of Ag)**
  - National capacity building initiative

- **Mexico (SIAP)**
  - National capacity building initiative

- **CSIRO**
  - RAPP Office

- **Japan**
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- **Mexico (SIAP)**
  - National capacity building initiative

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**CEOS**

- **CEOS** = Committee on Earth Observation Satellites
- Provision of satellite imagery to GEOGLAM

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10/35
GEOGLAM Component #1
Global Agricultural Monitoring

Focus on major export and producer countries
Development of Baseline Datasets as inputs to Agricultural Monitoring Strategy

Where? Cropland Distribution
(Fritz et al., IIASA)

![Cropland Distribution Map]

When are the crops growing?
(Whitcraft et al., UMD)

![Crops Growing Map]

At what scale? Field Size Distribution
(Fritz et al., IIASA)

![Field Size Distribution Map]

How do clouds impact clear views?
(Whitcraft et al., UMD)

![Cloud Impact Map]
GEOGLAM Crop Monitor

- **Objective:** develop transparent, timely, crop condition assessments in primary agricultural production areas highlighting potential hotspots of stress/bumper crop
- **Reflect** international consensus of crop conditions
- **Assessments published monthly in the AMIS Market Monitor**
- **http://www.geoglam-crop-monitor.org**

Coordinated by Center for Global Agricultural Monitoring Research, UMD
October 2014 Crop Monitor issue

Crop Conditions in AMIS countries (as of September 28th)

During the spring season, wheat is sown in a large number of countries, including Argentina, Brazil, China, India, and Pakistan. In Argentina, wheat conditions remain generally poor due to heavy rainfall and flooding. In Brazil, conditions are generally good, with improved rainfall and temperature conditions since April. In China, conditions are generally good, with improved rainfall and temperature conditions since April. In India, conditions are generally good, with improved rainfall and temperature conditions since April. In Pakistan, conditions are generally good, with improved rainfall and temperature conditions since April.

Soybeans in AMIS countries (as of September 28th)

Soybeans are a major crop in many AMIS countries. In Argentina, soybean conditions are generally good, with improved rainfall and temperature conditions since April. In Brazil, soybean conditions are generally good, with improved rainfall and temperature conditions since April. In China, soybean conditions are generally good, with improved rainfall and temperature conditions since April. In India, soybean conditions are generally good, with improved rainfall and temperature conditions since April. In Pakistan, soybean conditions are generally good, with improved rainfall and temperature conditions since April.

El Niño situation update

Outbreaks released in mid- and late September by the Australian Bureau of Meteorology, the International Research Institute for Climate and Society, and the U.S. National Oceanic and Atmospheric Administration put the probability of an ENSO event during the 2014-2015 southern hemisphere growing season above 50%. Predictions suggest the event will not be as strong as the 1997/98 event. However, some regions in the southern hemisphere may be affected by El Niño conditions. For example, in South Africa, drought conditions are expected to persist, while in Australia, a significant increase in rainfall is anticipated. In general, the southern hemisphere conditions should improve as the season progresses.
## GEOGLAM Crop Monitor Partners

> 30 partners & growing

<table>
<thead>
<tr>
<th>Country</th>
<th>Organization/Agency</th>
<th>Country</th>
<th>Organization/Agency</th>
</tr>
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<tbody>
<tr>
<td>Argentina</td>
<td>INTA</td>
<td>Japan</td>
<td>JAXA</td>
</tr>
<tr>
<td>Asian Rice Countries</td>
<td>AFSSIS ASEAN +3</td>
<td>Mexico</td>
<td>SIAP</td>
</tr>
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<td>Asia RiCE</td>
<td>Russia</td>
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<td>CSIRO</td>
<td>South Africa</td>
<td>GeoTerraImage</td>
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<td>OAE</td>
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<td>CAS</td>
<td>Ukraine</td>
<td>NASU-NSAU</td>
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<td>EC JRC MARS</td>
<td>Ukraine</td>
<td>UHMC</td>
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<tr>
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<td>ISRO</td>
<td>Uruguay</td>
<td>MGAP</td>
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<td>LAPAN</td>
<td>USA</td>
<td>NASA</td>
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<tr>
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<td>MOA</td>
<td>USA</td>
<td>UMD</td>
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<tr>
<td>International</td>
<td>CIMMYT</td>
<td>USA</td>
<td>USDA (FAS, NASS)</td>
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<td>FAO</td>
<td>USA</td>
<td>USGS - FEWS NET</td>
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<tr>
<td>International</td>
<td>IRRI</td>
<td>Vietnam</td>
<td>VAST</td>
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<tr>
<td>International</td>
<td>IFPRI</td>
<td>Vietnam</td>
<td>VIMHE-MARD</td>
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</tbody>
</table>
Refining the Communication Interface for Crop Condition Assessments

- Overlay #1: NDVI Anomaly 18th (NASA/UMD)
  - Opacity: 100%

- Overlay #2: Temperature Sum Anomaly (NOAA/JMD)
  - Opacity: 100%

Crop Mask:
- Wheat: ON
- Maize: OFF
- Soybean: OFF
- Rice: OFF

Crop Calendar & Monitoring:
- Month: September
- Season: Spring Wheat
- Crop Calendar Assessment: ON

Condition & Trend:
- Condition: Exceptional
- Trend: Stable
- Provenances: International Sources
- Observed Date: 05/07/2014

Drivers & Impacts:
- Wet: Minor Positive
- Dry: Select Impact
- Hot: Select Impact
- Cold: Select Impact

Comments:
Slightly higher than average rainfall should result in increased crop yield.
Current Crop Monitor Products for AMIS: Synthesis Condition Maps (other versions available online)

Crop Conditions as of September 28th, 2014

Crop condition map synthesizing information for all four AMIS crops.

Crops that are in other than favorable conditions are displayed on the map with their crop symbol.

(Cropland area shown is an aggregation of all cropland areas)
Pie Charts, with crop condition drivers
Crop Conditions as of September 28th, 2014
As share of:
Wheat Production
Wheat Exports (available online)

A country’s slice represents its portion of the 5 year average of the total AMIS countries production
Crop Specific Crop Condition Maps with Crop Calendar inserts (available online)

Crop Conditions as of September 28th, 2014

**Soybean 1 Conditions for AMIS Countries**

**Maize 1 Conditions for AMIS Countries**

**Spring Wheat Conditions for AMIS Countries**
Crop Monitor Crop Masks and Calendars

New Crop Monitor products
Reflect best available crop type distribution based on multiple national & global products

Sources: IFPRI/IIASA SPAM 2005 [beta version; released 2013], USDA/NASS CDL 2013, AAFC Annual Crop Inventory Map 2013, SIAP (Mexico) Crop Type Maps, GLAM/UMD wheat and soy masks, Australian Land Use and Management Classification (Version 7), ARC South Africa, Nigeria, and EC JRC MARS crop type masks. Asian Rice countries to be added in August.
Crop Monitor Website

www.geoglaml-crop-monitor.org

Crop Monitor Assessments

The Crop Monitor provides data with an international and transparent multi-source, consensus assessment of crop growing conditions, status, and agro-climatic conditions, likely to impact global production. This activity covers the four primary crop areas (wheat, maize, rice, and soy) within the major agricultural producing regions of the AMIS countries. These assessments have been produced operationally since September 2013 and are published in the AMIS Market Monitor. The Crop Monitor reports provide a geographic and temporal summary of crop conditions as of the 28th of each month, according to crop type.

Synthesis Maps:

Crop Conditions for AMIS Countries (As of April 28th):
Asia-RiCE – Asian Rice Monitoring

- **A multi-national project** led by Japan (JAXA), with collaborations in ASEAN+3 countries and India
- **A regional view** using agro-meteorological data derived from low resolution optical satellite imagery (MODIS, GCOM-W, TRMM and others)
- **A local view** to estimate rice crop area and production using available radar and other satellite data with ground observation data and statistical information (test-sites in Indonesia, Thailand and Vietnam)

http://www.asia-rice.org
GEOGLAM Component #2
Capacity Building
Example: Pakistan Agricultural Information System
(Collaboration among CRS, FAO, SUPARCO, UMD & USDA)

Crop condition

Crop type classification

Province Bulletins

EO Wheat Production Forecasting

Project information
• BMGF Funded project, launched by University of Twente
• A project on the application of satellite images in African and Asian agriculture
• Partners:
  – ITC
  – ICRISAT
  – CIMMYT
  – CSIRO
  – UMD
Development of new monitoring products - UKRAINE

- **Project and initiatives**
  - JECAM and GEOGLAM
    - MDA SOAR-JECAM project
    - SIGMA
  - ESA Sentinel-2 for Agriculture

- **Applications**
  - Crop mapping
  - Biophysical parameters estimation

- **Data**
  - Take5 – SPOT4 + RapidEye (5 days interval)
  - SOAR-JECAM – Radarsat-2 (~12 days interval)

- **Ground observation campaigns**
  - 2013: 350 fields inspected (crop type), 30 ESU bio. params
  - 2012: 300 fields inspected
Use of MODIS LST data to monitor growing conditions in Kazakhstan

LST anomaly

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<tr>
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<tbody>
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<td>May</td>
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<td>June</td>
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<td>July</td>
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<td>August</td>
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<tr>
<td>September</td>
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</tbody>
</table>

NEO LST anomaly – regime of Northern Kazakhstan cropland (3 oblasts) during vegetation season of 2013 year

A. Terekhov
Integrated Soil Moisture Monitoring System using Active and Passive Microwave in Canada

Use historical record of passive microwave soil moisture to derive anomalies

Passive Near Real Time Data

Weekly coarse resolution passive microwave derived soil moisture in near real time

Near Real Time Monitoring Using Active Microwave (RadarSat 2 and RCM)

Derive field-scale information on soil moisture from targeted Radarsat acquisitions over areas of interest

Anomaly Detection

Data quality assessment through in situ stations

Ian Jarvis (Agriculture Canada)
Target area: Multiple provinces

GISTDA

Optical Satellite Data

Data Processing

Radar satellite Data

Optical Satellite data (MODIS)

Software1: paddy field cultivated area mapping

Initial Rice Area Map

Modified Rice Area Map

Rice Area Map

GISTDA/OAE

Field Survey (GPS)

Users (OAE, NSO, etc.)

Statistics Data

Field Survey Sample Plot (Crop Cutting)

National Agricultural Statistics

Rice Crop Yield Estimation

Yield per unit by KKU model and/or database

Software2: rice yield estimate with crop model

Calculation

Agro-weather data
South Africa
SoyaBean Comparison: 2007 vs 2008

Spatial Distribution
- Cultivated area
- Crop type classification

District level comparison:
✓ Soya area / district

T. Newby
Countries At Risk For Food Insecurity

Primary focus area for GEOGLAM

2013 Global Hunger Index

- ≥ 30.0 Extremely alarming
- 20.0–29.9 Alarming
- 10.0–19.9 Serious
- 5.0–9.9 Moderate
- ≤ 4.9 Low
- No data
- Industrialized country

Countries at risk

- **Subsistence Agriculture & Pastoralism**
  - basis of livelihood systems in many countries
  - highly climate-sensitive

- **Climate station networks not well working** (sparse, bad or late reporting)

- **Satellite remote sensing & models can fill the gap**
  - and provide the basis for early detection of agricultural droughts

- **On all continents:**
  - **Africa**: Senegal, Mauritania, Mali, Burkina, Niger, Chad, Somalia, Sudan, Eritrea, Ethiopia, Djibouti, Somalia, Kenya, Uganda, Rwanda, Tanzania, Zambia, Mozambique, Zimbabwe, Botswana, South Africa, Lesotho, Swaziland...
  - **Central America**: Guatemala, Honduras, El Salvador, Nicaragua
  - **Caribbean**: Haiti
  - **Central Asia**: Afghanistan

J. Verdin
Gaps in Rainfall Station Reporting

• For one year, systematic sample on the 1\textsuperscript{st}, 11\textsuperscript{th} & 21\textsuperscript{st} of month (3x12=36 samples)

• 1232 African GTS stations:
  – 40\% did not report on any of the 36 days of the sample
  – only 25\% sent all reports or missed only one

GTS = Global Telecommunication System

Verdin et al.
Satellite Information for Crop Monitoring

Evapotranspiration Yearly Anomaly 2009

Daily Rainfall estimate for 6 Apr., 2003

Satellite Vegetation Index (NDVI) Difference 2009

Water Requirement Satisfaction Index

Legend
- Eta Anomaly(%)
  - N/A
  - < 50
  - 50 - 70
  - 70 - 90
  - 90 - 110
  - 110 - 130
  - 130 - 150
  - > 150
- Boundaries
- Lakes

Verdin et al.
First Prototype FEWS NET Crop Condition Maps as of 30 September 2014

Synthesis:

Millet:
GEOGLAM Component #4
Cooperation with Space Agencies

CEOS – Committee on Earth Observation Satellites
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
GEOGLAM CEOS: EO Data Requirements Table

developed taking into consideration the observation needs, the derived products they will serve, and regional specificities; CEOS-GEOGLAM

<table>
<thead>
<tr>
<th>Observation &amp; Sensor Type</th>
<th>Regional Characteristics &amp; Geographical Extent</th>
<th>Derived Products &amp; Monitoring Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spatial Res.</td>
<td>Spectral Res.</td>
<td>Temporal Res.</td>
</tr>
<tr>
<td>Sensor Mission</td>
<td>Spatial resolution</td>
<td>Spectral range</td>
</tr>
<tr>
<td>MODIS (aquea/Terra), AVHRR/NPP, Vegetation (SPOT 5), MERIS (satellite not operational, LMI-1700)</td>
<td>2000 - 500 m</td>
<td>thermal + optical</td>
</tr>
<tr>
<td>ETM+ (Landsat 7), AVHRR (Terra), TERRA/DMSP, AIRS (Terra)</td>
<td>100 - 300 m</td>
<td>optical + SWIR</td>
</tr>
<tr>
<td>M. Optical MLI-ResursSat-1, Terra, E-1: Resources-1, CEOS-1</td>
<td>5-15 km</td>
<td>optical + SWIR</td>
</tr>
<tr>
<td>HGA (SPOT 5), Rapid Eye (operational)</td>
<td>20-70 km</td>
<td>optical + SWIR</td>
</tr>
<tr>
<td>HGA (SPOT 5), Rapid Eye (operational)</td>
<td>3-10 km</td>
<td>optical + SWIR</td>
</tr>
<tr>
<td>HRI (Pascal), MICROD, SeaView, WorldView-1 (operational)</td>
<td>&lt; 5 m</td>
<td>optical</td>
</tr>
</tbody>
</table>
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>
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<tr>
<td>Aqua</td>
<td>MODIS</td>
<td>1</td>
<td>3.9</td>
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<tr>
<td>SPOT-5</td>
<td>Vegetation</td>
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<tr>
<td>NPP</td>
<td>VIIRS</td>
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<td>ETM+</td>
<td>9</td>
<td>20.4</td>
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<td>22.41</td>
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<tr>
<td>LDCM</td>
<td>OLI + TIRS</td>
<td>9</td>
<td>20.4</td>
<td>54</td>
<td>22.41</td>
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<tr>
<td>ResourceSat-2</td>
<td>LISS-III</td>
<td>12</td>
<td>52.1</td>
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<td>9.1</td>
<td>11</td>
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<td>WFI-2</td>
<td>2</td>
<td>13.7</td>
<td>51</td>
<td>5.31</td>
</tr>
</tbody>
</table>

Landsat Coverage
54 scenes

Crop Mask (wheat)

Cloud Assessment
Requirement for Near Real Time Data for Agricultural Monitoring

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)

lance.nasa.gov
Anomaly Product Continuity/Consistency

July 30 2012

EOS MODIS

JPSS VIIRS

Vermote (GSFC)
The picture shows the number of times LDCM and the Sentinel 2 satellites accessed areas on the ground over an 80 day period of time.

- 21 accesses indicates a maximum revisit interval of ~3 days 19 hours
- 46 accesses indicates a minimum revisit interval of ~1 day 18 hours

The large number of blue colored bands (>41 accesses) indicate that the revisit interval over the majority of the region is on the order of 2 days.
GEOGLAM Component #5
Research & Development
JECAM: Joint Experiment for Crop Assessment and Monitoring

- A network of sites representative of the world’s cropping systems
- A focus for international satellite data acquisition by CEOS
- R&D to support enhancements for operational agricultural monitoring systems
- JECAM Program Office coordinated by AAFC-Canada and UCL-Belgium
- Developing linkages with AgMIP sites and modeling community

www.jecam.org
JECAM GOALS

The overarching goal of JECAM is to reach a convergence of approaches, develop monitoring and reporting protocols and best practices for a variety of global agricultural systems. JECAM will enable the global agricultural monitoring community to compare results based on disparate sources of data, using various methods, over a variety of global cropping systems. It is intended that the JECAM experiments will facilitate international standards for data products and reporting, eventually supporting the development of a global system of systems for agricultural crop assessment and monitoring. The JECAM initiative is developed in the framework of GEO Global Agricultural Monitoring (GEOSS Task AG0703 a) and Agricultural Risk Management (GEOSS Task AG0703 b).
Current Status – Research Activities
Crop Condition – Crop Growth Parameters

2012 PASG Map, South Africa Site

PASG for 1 July to 31 December 2012

2012 Ukraine Site
Conclusion

• Interested in expanding GEOGLAM participation in Central and Eastern Europe e.g.
  – Routine involvement in Crop Monitor
  – Participation in JECAM – Field Site for method development and testing
  – Identifying priorities for National Capacity Building in the use of EO for Agriculture
  – Agricultural Land Use Change