Global Agricultural Monitoring
International Coordination: GEOGLAM

Chris Justice

Inbal Becker-Reshef, Christina Justice, Brian Barker, Michael Humber
The Center for Agricultural Monitoring Research,
Department of Geographical Sciences,
University of Maryland, USA
GEO is the international program focused on the use of Earth Observations for societal benefit

- GEO was initiated in 2005
- Agriculture is one of the GEO societal benefit areas
- GEOGLAM is GEO’s Agricultural initiative
- c. 2005 UMD/NASA working with USDA to transition crop analysis from AVHRR to MODIS.
- Developed the Global Agricultural Monitoring (GLAM) System crop condition interface
- Provided to other countries e.g. Australia, Mexico, Argentina, Brazil, Colombia
Initial GEOSS/IGOL Agricultural Monitoring Workshop July 2007, UN-FAO

- IGOL/GEO workshop to develop a strategy for global agricultural monitoring in the framework of GEO
- 47 participants representing 25 national and international organizations attended and established the ‘GEOSS/IGOL Agricultural Monitoring Community of Practice’
- Reviewed the current state of agricultural monitoring, identified gaps and developed a set of priorities and recommendations
- Recognized that international and national programs faced the same obstacles and challenges and that the full potential of EO had yet to be realized

Today the Community of Practice has over 300 members representing over 40 countries and organizations
Thematic Workshop Series to Identify “Community of Practice” Priorities and Best Practices

- November 2009, Kananaskis, Canada: SAR data for Agricultural Monitoring
- May 2011, Curitiba, Brazil (SBSR): JECAM South America Workshop
- September 2011, Nairobi, Kenya: CRAM Agricultural Capacity Building Workshop
- October 2012, Beijing, China: Workshop on Agricultural Water Availability
- November 2012, Buenos Aires, Argentina: Regional Workshop on Agricultural Monitoring
- October 2013, Moscow, Russia: Workshop on Agriculture in Northern Eurasia
Building a Community Agenda: Identifying and Addressing Common Issues facing Agricultural Monitoring

- Timeliness in obtaining EO data (satellite and in-situ)
- Accessibility to international satellite data
- Continuity of satellite data for operational monitoring
- Robustness of methods for national, regional to global application – lack of field level validation data, absence of best practices for different cropping systems and regions
- Difficulty in transitioning research methods into operational use
- Need for capacity building and support to use EO data in many operational monitoring institutions - including new sensors
- Quality and timeliness of global/national agricultural data and statistics
- Decline and privatization of in-situ weather data
- Accuracy of seasonal forecast data
- In general a low investment in agricultural research and agricultural extension services
Open Community made up of individuals from international and national agencies concerned with agricultural monitoring including Ministries of Ag, Space Agencies, Universities, & Industry
Nominal wheat price in US $/metric Ton

2010/11 Price hikes
Droughts: Russia USA

1971/2’s price hike
Landsat 1 Launched (1972)

2008 Price hikes
Droughts: Australia & Ukraine

1996 price hike

GEO Ag Task
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 and

Need to increase food production by 50%-70% by 2050 to meet demands (FAO)
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.
GEOGLAM: a GEO Initiative

• Vision: the use of coordinated, comprehensive and sustained Earth Observations to inform decisions and actions in agriculture... through a system of agricultural monitoring systems

• Aim: Strengthen the international community’s capacity to utilize Earth Observations to produce and disseminate relevant information on agricultural production at national, regional and global scales

• Approach: Building on existing monitoring systems – strengthening international and national capacity

• Emphasis on: producer countries (G20+), countries-at-risk and national capacity building

• http://www.earthobservations.org/geoglaml.php
The GEOGLAM Components

- Global Monitoring System Coordination
- Monitoring System Enhancement
- Earth Observation Data Coordination
- GEOGLAM IT Infrastructure
- Operational Research and Development
- Capacity Building Coordination
- GEOGLAM Regional Initiatives: ASIA Rice
- Latino America
- Rangeland Monitoring Coordination (RAPP)
inter-Agency Platform to enhance food market transparency and encourage coordination of policy action in response to market uncertainty.
AMIS requested GEOGLAM to generate a monthly international consensus of crop conditions, from the various international/national monitoring systems.

- Four major crops: wheat, maize, soybean, rice (9 total seasons)
- Focus: stabilizing/calming markets, avoid unexpected food price shocks

* [http://www.geoglam-crop-monitor.org](http://www.geoglam-crop-monitor.org)

- Consensus process, interface, submissions, telecons
- Summary information only
GEOGLAM AMIS Crop Monitor Partners

> 35 Partners and Growing
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)
G20 Agricultural Ministers

2011 Action Plan on Food Price Volatility and Agriculture

AMIS – Markets/Stocks

GEOGLAM – Condition/Supply

http://www.amis-outlook.org/amis-monitoring

https://cropmonitor.org/
GEOGLAM Best Available Multi-Season Crop Masks
20 contributors and counting w. on going improvements

Winter Wheat

Spring Wheat

Rice

Maize

Soybeans
Best Available Multi-Season Crop Calendars

Winter & Spring Wheat

Maize 1 & Maize 2

Rice 1, Rice 2 & Rice 3

Soybean 1 & Soybean 2

Calendars reflecting multiple cycles of the same crop.
Next Steps for GEOGLAM /AMIS collaboration

• Develop more quantitative indicators of crop growing condition and production

• Broaden national and sub-national (state) participation in the Crop Monitor providing monthly updates on crop condition

• Strengthen linkages between the EO-based ag monitoring community and the AMIS community at the national level
Early Warning Crop Monitor Countries
Crop Monitor for Early Warning Bulletin

www.cropmonitor.org

CROP MONITOR FOR EARLY WARNING

NO. 19
August 2017

The Crop Monitor for Early Warning brings together international, regional, and national organizations monitoring crop conditions within countries at risk of food insecurity. The focus is on developing timely consensus assessments of crop conditions, recognizing that reaching a consensus will help to strengthen confidence in decision making. The Early Warning Crop Monitor grew out of a successful collaborative relationship, the AMIS Crop Monitor (www.amis-outlook.org), which monitors the main producing countries.
The reporting process is carried out globally every month on the web-based Crop Assessment Tool.
Example discrepancy map

- Hashed areas show conflicting crop condition entries from different agencies.

July assessment had 710 entries over 61 countries and 39 subnational regions with crop condition discrepancies that were discussed and ultimately we reached a full consensus.
Crop Specific Maps and Pie Charts per Region

- Crop specific & regional synthesis map
- Pie charts inform users as to the percent production per country in each crop conditions and why

Quick and easy to interpret crop conditions oriented for policy communities
CM4EW as a consensus bulletin

• Need for expanded participation and increased national representation – monthly national reporting on crop condition
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Recognition that cropping systems are inherently diverse which dictates the
monitoring observations and methods
No one system can meet agricultural monitoring needs

Goals of the EO Data Coordination Component.
• Articulate data requirements for agricultural monitoring
• Coordinate international satellite acquisition over agricultural areas during the growing season
• Promote near-real time data availability
• Increase the frequency of moderate resolution data
• Standardize processing of data, facilitating data interoperability
• Promote easy data access for operational users
• Advocate for continuity of critical data streams/products

Developing the EO Data Requirements for GEOGLAM: through a CEOS/GEOGLAM Ad Hoc Working Group
GEOGLAM CEOS: EO Data Requirements Table

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 resolution</th>
<th>Spectral range</th>
<th>Effective observ. frequency (cloud free)*</th>
<th>Swath / Extent</th>
<th>Regional Characteristics &amp; Geographical Extent</th>
<th>When?</th>
<th>Derived Products &amp; Monitoring Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>MODIS (aquamarine)</td>
<td>2000 - 500 m</td>
<td>thermal IR + optical</td>
<td>Once a week (high cloud cover, 2-week period)</td>
<td>~30 km</td>
<td>global</td>
<td>maturity, production</td>
<td>NRT products (PS)</td>
</tr>
<tr>
<td>MODIS (optical + SWIR)</td>
<td>100-300 m</td>
<td>optical + SWIR</td>
<td>Once a week</td>
<td>~30 km</td>
<td>global</td>
<td>maturity, production</td>
<td>NRT products (PS)</td>
</tr>
<tr>
<td>MODIS (optical + SWIR)</td>
<td>1-15 m</td>
<td>optical + SWIR</td>
<td>Daily</td>
<td>~30 km</td>
<td>global</td>
<td>maturity, production</td>
<td>NRT products (PS)</td>
</tr>
<tr>
<td>MODIS (optical + SWIR)</td>
<td>5-20 m</td>
<td>optical + SWIR</td>
<td>Once a week</td>
<td>~30 km</td>
<td>global</td>
<td>maturity, production</td>
<td>NRT products (PS)</td>
</tr>
<tr>
<td>MODIS (optical + SWIR)</td>
<td>5-10 m</td>
<td>optical + SWIR</td>
<td>Once a week</td>
<td>~30 km</td>
<td>global</td>
<td>maturity, production</td>
<td>NRT products (PS)</td>
</tr>
<tr>
<td>MODIS (optical + SWIR)</td>
<td>&lt; 5 m</td>
<td>optical</td>
<td>Once a week</td>
<td>~30 km</td>
<td>global</td>
<td>maturity, production</td>
<td>NRT products (PS)</td>
</tr>
</tbody>
</table>
Access Summary

- Open (no registration) = 36%
- Open (simple registration) = 21%
- Open (advanced approval) = 5%
- Restricted = 33%
- Unknown = 5%

Comments

- This summary includes **205 missions** launched since 1990 and 615 mission-instrument combinations.
- 62% of CEOS mission data is OPEN and accessible.

Are the data acquired for Ag areas during the growing season?
Are they easily accessible?
Requirement for Near Real Time Data for Agricultural Monitoring

Timely data are critical for crop monitoring

- NASA EOS near-real-time daily observations are processed and provided < 3 hours from observation
- VIIRS now available
## Sentinel contribution to JECAM & GEOGLAM

### Primary missions for all targets

<table>
<thead>
<tr>
<th>Req#</th>
<th>Spatial Resolution</th>
<th>Spectral Range</th>
<th>Effective observ. frequency (cloud free)*</th>
<th>Sample Type</th>
<th>Field Size</th>
<th>Target Products</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
<td></td>
<td></td>
<td>Crop Mask</td>
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<tr>
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<td>X</td>
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</tbody>
</table>

### Coarse Resolution Sampling (>100m)

1. **500 - 2000 m**
   - thermal IR + optical
   - Daily
   - Wall-to-Wall
   - All
   - **Sentinel-3**

2. **100-500 m**
   - optical + SWIR
   - 2 to 5 per week
   - Cropland Extent
   - All
   - **SMOS**

3. **5-50 km**
   - microwave
   - Daily
   - Cropland Extent
   - All

### Moderate Resolution Sampling (10 to 100m)

4. **10-70m**
   - optical + SWIR + TIR
   - Monthly (min 2 out of season + 3 in season). Required every 1-3 years.
   - Cropland Extent
   - All
   - **Sentinel-2**

5. **10-70m**
   - optical + SWIR + TIR
   - Weekly (min. 1 per 16 days)
   - Sample
   - All
   - **Sentinel-2**

6. **10-100m**
   - SAR
   - Weekly (min. 1 per 2 weeks)
   - Cropland Extent of persistant cloudy areas/Rice
   - All
   - **Sentinel-1**

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*Source: CEOS ACQUISITION STRATEGY FOR GEOGLAM PHASE 1*
Toolbox for 4 S2-based products in line with the GEOGLAM core products

- Binary map identifying annually cultivated land at 10m, updated every month
- Monthly cloud free surface reflectance composite at 10-20m
- Open source toolbox for capacity building and training
- Vegetation status map at 20m delivered every 10 days (NDVI, LAI, pheno index)
- Crop type map at 10m for the main regional crops including irrigated/rainfed discrimination
First S2-based prototype product
Toulouse area (France) - Sentinel-2 – 06 July 2015

New red-edge band to discriminate summer crops: maize vs sunflower

Contains Copernicus data (2015)
Merging Sentinel-2 and Landsat data streams can provide **2-3 day global coverage**

Goal is “seamless” near-daily 30m surface reflectance record including atmospheric corrections, spectral and BRDF adjustments, regridding

Project initiated as collaboration among GSFC, UMD, NASA Ames
HLS Algorithms overview and status

<table>
<thead>
<tr>
<th>Algorithm</th>
<th>Current (V1.2)</th>
<th>Other Options</th>
</tr>
</thead>
<tbody>
<tr>
<td>Geographic registration</td>
<td>AROP (Gao et al. 2009, JARS)</td>
<td>-</td>
</tr>
<tr>
<td>Atmospheric Correction</td>
<td>OLI and MSI: Landsat-8 6S algorithm</td>
<td>CNES MACCS</td>
</tr>
<tr>
<td>Cloud/Shadow Mask</td>
<td>OLI: Landsat-8 6S algorithm output</td>
<td>CNES MACCS</td>
</tr>
<tr>
<td></td>
<td>MSI: BU MSI Fmask</td>
<td></td>
</tr>
<tr>
<td>BRDF Adjustment</td>
<td>Fixed BRDF (Roy et al. 2016, RSE)</td>
<td>Downscaling MODIS BRDF + Fixed BRDF as Backup</td>
</tr>
<tr>
<td>Band Pass Adjustment</td>
<td>Fixed, per-band linear regression</td>
<td>Regression-tree (based on spectral shape)</td>
</tr>
<tr>
<td>Temporal Compositing</td>
<td>TBD</td>
<td></td>
</tr>
</tbody>
</table>
Harmonized Landsat / Sentinel-2 Products
Laramie County, WY

Seasonal phenology (greening) for natural grassland (blue line) and irrigated alfalfa fields (red line) near Cheyenne, Wyoming observed from Harmonized Landsat/Sentinel-2 data products. The high temporal density of observations allows individual mowing events to be detected within alfalfa fields. HLS Products available from https://hls.gsfc.nasa.gov
Websites and Public Interface

**HLS website**
- [https://hls.gsfc.nasa.gov](https://hls.gsfc.nasa.gov)
- Public access
- Sample data available (via FTP)
- Algorithm & Product descriptions

**NEX project page**
- [https://nex.nasa.gov/nex/projects/1371](https://nex.nasa.gov/nex/projects/1371)
- Registered user access
- All HLS data available
- Documents (slides, user guides)
Image Data

- Multispectral optical data can adequately classify crop if available during critical time periods
- Accuracies decrease significantly when gaps in data collection occur
- Operational burden of cloud masking
- Accuracy increases with SAR; magnitude depends on crop, timing of acquisitions and amount of optical data available

Courtesy Thierry Fisette and Leander Campbell, AAFC
**In Development: Early Season Crop Identification**

South Nation Watershed, Ontario Canada

End of season TerraSAR-X crop classification: Ottawa 2012
Overall accuracy: **97.2%**

Early season: Corn can be identified at V6 or 6th leaf collar stage (about 6 weeks after planting)

RADARSAT Constellation Mission


- Evolution of the RADARSAT Program → 3 satellites – 600 km orbit, 32 minutes separation
- Multi-pol and fully polarimetric, high-resolution
- 15 min/orbit imaging (avg) x 3 satellites
- Average daily global access; 4-day exact repeat
- Focus on Marine Surveillance, Disaster Management and Ecosystem Monitoring (including Agriculture)
- Open data policy?
Seeing a Changing Playing Field – Small Sat optical systems

Very Fine Resolution Systems (m)
- Ikonos .8
- Quickbird .6
- WorldView-1 .5
- Geoeye .4
- WorldView-2 .5
- WorldView-3 .3
- Cartosat 3 .3
- Pleiades 2A,2B .7
- Kompsat 3 1

Questions of Acquisition Frequency, Cloud Cover, Data Availability

In the US alone – 70 Companies, 50 Univ.’s and 15 Govt. Agencies involved w. SmallSat development

Fine Resolution Systems (m)
- SPOT 1-3 5, 10
- Rapideye 7
- Planet Labs (Dove) 5
- IRS 1C,1D 6
- CBERS 2 3
- THEOS 2
- SPOT 5/6 2.5
- SkySat 1 1
- Cartosat 1/2 2.5
- Ziyuan 2 3
- THEOS 2

1 Oil palm
2 Para rubber
99 Miscellaneous
500 Water body
High Resolution Sampling Strategy for Soybean Area in Argentina

- Some requirements (high temporal and/or spatial resolution) are for entire **cropland extent**; others are on a **sampled basis**
  - **Sampling strategy** in development;
  - For Phase 1A (e.g. Argentina):

*Argentina Sample Strata*

**Derived Rapid Eye Sample Blocks**
40 km x 40 km ; n = 75

(Matt Hansen, Carlos Di Bella, et al.)
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Spatial resolution / Revisiting capacities

- 5km - 1km: hourly images
- 1km - 250m: daily images
- 250m - 60m: 1-3 images / 15 days
- 60m - 10m: 1-2 images / month
- 10m - 1m: 1-2 images / season

Anomalies detection

Yield estimates

- + field report & socio-economic context by analyst
- + prod. quality, stocks & demand by info brokers

Food Security

Ag Prod Trade

Area outlook

Agric. map

Area estimate

Monthly bulletin

Early warning

Precision farming

Yield forecast

Prod estimate

Vulnreb. report

Int market report

Crop growth model

- Sample point interpretation
  - Regression estimate
  - + in situ obs.

Crop stages

Crop variables

Intra-parcel variability

Cropping / veg. conditions

Crop specific conditions

Anomalies detection

Crop type at parcel level

Crop type

Agriculture / veg. conditions

Crop growth

Agricultural Monitoring: EO data and Final products

Croplands mask

Area

Meteo cond.
Research Foci at the Joint Experiment for Crop Assessment and Monitoring (JECAM) Sites

Developing Methods for:

- Crop Type mapping
- Crop Condition monitoring
- Yield Estimation modeling
- Soil Moisture estimation
- Residue and Tillage monitoring

EC SIGMA Project, Sentinel 2 Agri and BMGF STARS are strengthening the JECAM field data collection protocols and intercomparison.

JECAM.org
→ Similar cropland mapping accuracy performances of all methods for a site
→ Different performances according the site: ag. landscape impact
→ Influence of the satellite data quality used as input
EO Data Coordination
Acquisition • Access • Continuity

In-situ & Crowd-sourcing
Ag Met & Climate Services

EO Data Coordination

Public Space Sector
Commercial Space Sector

Operational R&D
Method Development & Improvement

Research-to-Operations
Capacity Development for EO

Strengthened Monitoring Systems
National • Regional • Global

Science-Based Information
Decision • Policy • Action

Outlooks for Markets & Trade
National & International Food Policy
Agricultural Subsidies
Farm Advisory & Extension
Sustainable Development Goals
Vulnerability & Impact Assessments
Support to Food Aid Organizations
Insurance & Investments

Agricultural Subsidies
Insurance & Investments
Vulnerability & Impact Assessments
Support to Food Aid Organizations
So in Summary
What is GEOGLAM doing?

- Increasing communication and sharing experience amongst the Ag Monitoring Community of Practice and with related programs
- Helping improve national agricultural monitoring systems
- Translating EO data into policy relevant information
- Promoting EO-based approaches to agricultural monitoring and raising the importance of agricultural remote sensing
- Articulating and advocating for community requirements to the EO data providers
- Increasing the awareness of EO by the econ/policy community
- Method testing and inter-comparison, developing best practices
- Developing new monitoring capabilities and products