The 2009 GEO Beijing Workshop on Developing an Agricultural Monitoring System of Systems

In February 2009, another major planning workshop took place that focused on developing an agricultural monitoring system of systems. This event was held jointly with the partner GEO Tasks on Agricultural Risk Management (*AG 07-03b*) and Agricultural Capacity Building (*AG-07-03c*). Over 100 attendees representing more than 50 national and international organizations concerned with agricultural monitoring and global food security participated in the workshop. The goals of the workshop were to:

- refine the requirements, the system components, and the data policies and practices needed for an effective agricultural monitoring system;
- outline a best practices document agricultural monitoring and risk management;
- update and refine the agriculture monitoring task work plan and the 2015 task targets; and
- increase the visibility and participation of Chinese agricultural monitoring efforts.

Workshop Summary

The workshop opened with an introductory session that included talks by the Deputy Director of the Bureau of International Cooperation of CAS and by the Deputy Administrator USDA/FAS on projections and economics of global food supply and demands. Chris Justice, *GEO AG-0703* task co-lead provided a vision for the GEO GLAMSS. A series of overview presentations followed that reviewed the state of the science, and each focused on one of the four main functions of an agricultural monitoring system which include: (1) agricultural production monitoring; (2) famine early warning; (3) monitoring of agricultural land cover change; and (4) seasonal to annual agricultural forecasting and risk reduction.

A strong case was made for establishing a free and open data policy in order to allow for effective implementation of a monitoring system of systems. Representatives from the Committee on Earth Observing Satellites (CEOS), IRSA and the World Meteorological Organization (WMO) also gave overview presentations on current and future systems and data initiatives for agricultural monitoring. A session on the vision and goals for a GLAMSS focused on the near-term priorities, challenges, opportunities, and future directions for agricultural monitoring.

A special session highlighted Chinese efforts in Agricultural Monitoring and included presentations on the three operational Chinese agricultural monitoring systems operated by CAS: *CropWatch*, the Chinese Ministry of Agriculture, and the China Meteorological Administration. The last day of the workshop included a special summary session for Chinese policy makers and included presentations from the former Minister of the

Environment, the Vice-President of CAS, a Chinese Meteorological Administration administrator, a member of the Congress of the Ministry of Agriculture, and a deputy director from the National Bureau of Statistics. The participants of this session were enthusiastic about the progress of GEO agricultural monitoring, promised strong Chinese support and cooperation, and proposed hosting a dedicated GEO Agricultural Monitoring center.

Through a series of breakout sessions and discussions the workshop participants:

- discussed the adequacy of the current observation systems for agricultural monitoring;
- developed an outline for a best practices report for agricultural monitoring;
- identified the priority observation enhancements for *in-situ* and satellite components of the monitoring system; and
- developed a near-term implementation plan for the GEO agricultural monitoring task and the 2015 task targets.

GEO Task 0703 Near-Term Implementation Plan

Through the discussions and breakout sessions the CoP proposed a series of activities that were grouped into four near-term initiatives:

A Production, Acreage, Yield (PAY) multi-source online database Initiative

At present four different groups generate agricultural statistics on a regular basis for multiple countries: the USDA FAS, JRC-Ispra MARS, IRSA *CropWatch* and the UN FAO Global GIEWS. The crop statistics from these programs are a critical factor in determining global commodity prices and identifying countries in need of food aid. To allow for comparisons between crop statistics generated by these agencies, the participants decided to develop a common centralized online database of Production, Area, and Yield (PAY). This PAY database will enable identification of agreements and disagreements in national level crop statistics, providing a convergence of evidence for similar statistics and helping identify areas that should be looked at more carefully where statistics differ significantly. Initially the database will be populated with national level estimates from the four programs identified above and will later be expanded to include statistics from individual countries.

The Joint Experiments on Crop Assessment and Monitoring Initiative (JECAM)

The goal of the JECAM experiments is to facilitate the inter-comparison of monitoring and modeling methods, product accuracy assessments, data fusion, and product integration, for agricultural monitoring. The plan to accomplish this is to set up a number

of regional experiments in cropland pilot sites around the World that are representative of a range of agricultural systems. The idea is to collect time series datasets from a variety of earth observing satellites and *in-situ* data sources at each site. To this end the Committee on Earth Observing Satellites (CEOS) as the space-arm of GEO, and other data providers are supporting this activity with the acquisition and timely provision of data for the experiments.

The objective of JECAM is to compare data from disparate sources, methods, and results over a variety of cropping systems; to reach a convergence of the approaches; and to develop monitoring and reporting protocols and best practices for different agricultural systems. It is hoped that these comparative experiments will enable international standards to be developed for data products and reporting. JECAM–China was proposed at the workshop and datasets for this site are currently being assembled and will be openly distributed to the CoP. Several other regional experiments have been proposed and are currently in the design phase. These include JECAM–Canada, JECAM–Argentina, JECAM–Brazil and JECAM–Ethiopia.

The minimum requirements for JECAM participation include:

- leadership by a space agency and a half-time scientist for the overall experiment coordination;
- a pilot site manager for each site;
- a full time data analyst to help with data inter-comparisons;
- five JECAM workshops to be held over the next three years; and
- a commitment from data providers to supply satellite data for the test sites.

It was recommended that the following categories of Earth observing data-sets be provided by the GEO-partner space agencies:

- Very high resolution imagery for area estimate production and crop mapping validation: 3 acquisitions over samples distributed in the site (i.e., ALOS 2.5-m-sensor and Resourcesat VHR sensor.
- Wide swath instrument for crop mapping and crop monitoring: all possible acquisition (i.e. AWifs and HJ-1.)
- Coarse resolution data for crop condition monitoring: daily (i.e. MODIS and MERIS.)
- SAR data for crop area indication in cloudy regions: all possible acquisitions (i.e. ENVISAT ASAR and ALOS PALSAR.)

The Coordinated Data Initiatives for Global Agricultural Monitoring (CDIGAM) Initiative

A priority for builiding a global monitoring system is accessibility to timely and frequent satellite data during the growing season, and ensuring the conituity of these observing

systems. Several data initiatives have been identified under CDIGAM. At present, NASA's MODIS data is one of the primary data sources that the main agricultural monitoring systems rely on, and thus both the timely delivery of these data and the continuity of this data class are fundemental for the success of a global agricultural monitoring sytsem. A partnership with the GEO Task *DA 0903* led by the USGS and NASA, has been fostered to develop a global moderate resolution, ortho-rectified data set (60–30-m) from multiple international data sources for 2010. This will build on the previous NASA/USGS Global Land Surveys for 1990, 2000, and 2005, and will provide data needed for monitoring agricultural land use change. Under CDIGAM the FAO GIEWS program is leading an effort to compile the best available information on global agricultural areas, crop calendars, and cropping systems. The USAID Famine Early Warning System (FEWS) and the World Meteorological Organization (WMO) are leading an effort to identify critical gaps in the current *in-situ* meteorological observations for Africa and to explore the means that can be used to fill these gaps. Other data initiatives that have been proposed include the development of a global field size database using multi-resolution data and the formulation of a coordinated global satellite data acquisition strategy for agricultural areas.

A free and open data policy remains a high priority for the Global Agricultural Monitoring community and will to a large degree determine the success of the Task and ultimately GEOSS as a whole. The GLAMSS CoP is committed to promoting an equitable data policy, allowing sharing of data amongst the community. Recent developments such as the free and open access to Landsat data and the entire Landsat archive by the USGS, the continued free and open availability of MODIS data by NASA, and recent data commitments by China and Brazil provide some positive steps by data providers in the right direction.

The Global Agricultural Monitoring system of Systems (GLAMSS) Thematic Workshop Series [GTWS] Initiative

Additional community workshops are needed to discuss a number of thematic and methodological topics to improve communication amongst the CoP, to develop *best practices* and standards, and to encourage cooperation and coordination. A number of thematic workshops have already been held by the CoP. NASA, through the GLAM project, has been instrumental in organizing and supporting these workshops. In 2008 the Joint Research Centre (JRC), Ispra hosted a Workshop on Crop Area Estimation. A *best practices* document developed at this workshop can be found at: mars.jrc.ec.europa.eu/mars/Bulletins-Publications/Best-practices-for-crop-area-estimation-with-Remote-Sensing. The JRC also hosted a workshop on Satellite Rainfall Estimation in 2008 and a follow-up workshop will be held later this year. Canada is hosting a thematic workshop on the use of Synthetic Aperture Radar /Optical Agricultural

Monitoring, to be held in Banff, Canada, in October 2009 (www.cgeo.gc.ca/announce/sar-ros-eng.pdf). India is hosting a joint workshop of the ISPRS WGVIII/6 and the GEO Task Ag 0703 on Climate Change and Agriculture to be held at the ISRO Satellite Applications Center (SAC) in Ahmedabad, in December 2009 (www.commissions8.isprs.org/wg6.)

Workshop Recommendations

The workshop recommendations fall into three primary categories: (1) recommendations to the GEO Secretariat and working groups; (2) recommendations to the GEO partners including CEOS as the satellite arm of GEO and WMO as the primary international in-situ observation coordination body; and (3) recommnendations to the GEO agriculture monitoring CoP. The primary recommendations are specified below:

- The implementation of GEO Task Ag 0703a will require free, open and timely access to satellite data and products for global agriculture monitoring. Thus the GEO Secretariat should establish a GEO Data Policy that:
  - Adopts equitable pricing policies for coarse & moderate resolution data resulting in the free and open data access and data sharing
  - Encourages a reduction in price of very fine resolution (1m-10m) data
  - Helps minimize delays in data access, enabling timely assessment of crop condition.

  Special attention should be given to enhancing the capacity of developing country data users and collectors

- Operational agricultural monitoring requires the continuity of earth observations. Thus CEOS, as the satellite arm of GEO should:
  - Secure operational status for moderate resolution (60-10m) sensing systems, providing global cloud-free* coverage every 5-10 days during agricultural growing seasons
  - Ensure continuity of coarse resolution morning and afternoon polar orbiters and data products used for agricultural monitoring (e.g. surface reflectance, vegetation indices, leaf area index, surface temperature)
  - Ensure overlap between consecutive missions with similar capabilities to enable inter-calibration and operational continuity between instruments
  - Ensure the availability of thermal/SWIR bands for moderate resolution observations for agricultural monitoring.

  * It should be noted that: a) to obtain cloud free coverage in some regions during the growing season may require higher than 5-10 day temporal frequency coverage with optical systems and even so in some regions

cloud free coverage may not be feasible, b) microwave systems are not subject to cloud cover problems experienced with optical systems.

- Operational Agricultural Monitoring necessitates the timely availability and access to satellite data and the dependence on multiple sources of satellite data with different temporal and spatial resolutions. This in turn necessitates interoperability of data from different systems. Thus CEOS as the satellite arm of GEO and WMO as the primary international in-situ observation coordination body should improve data accessibility and interoperability by:
  - RS Specifics
    - *Increasing availability of moderate resolution data from thermal and microwave sensors and their integration with data from optical sensors?*
    - *Coordinating a moderate (30m) resolution data initiative providing global coverage every 5 years until 2010 (i.e. GLS 2005, GLS 2010) and then annually thereafter, from the available international assets (CEOS LSI)?*
    - *Devising and implementing a long term acquisition strategy to enable daily coverage of global cropland areas at 10m resolution during growing season*
    - Devising and implementing a short term acquisition strategy to enable the following coverage of global cropland areas during the growing seasons:
      - Daily global coverage at 200-250m resolution
      - 2-4 images per month at 60-10m resolution
      - 1-2 images per month 5-1m
    - Ensuring that available EO data and products are rapidly and easily accessible to all agricultural monitoring agencies including in developing countries

  - In situ Specifics
    - Increase coverage of meteorological stations especially in Africa where stations are sparse (WMO)
    - Identify where new stations are most needed (FEWS)
    - Enhance derived rainfall estimates (RFE) through better integration of satellite and met-station rainfall products
    - Devise appropriate telecommunications for rapid reporting of the in-situ observations needed for integration with satellite RFE and weather forecast models

** N.B. Integrated crop calendars and cropland maps can be used to identify the agricultural regions of interest and timing for data acquisition

- To achieve the desired enhancements to global agricultural monitoring it was recommended that the Agricultural Monitoring Community of Practice should foster improvements in the following general areas:
  - Develop standards to be used for agriculture monitoring including a set of standards for both in situ and EO data products, collection procedures, metadata, and product accuracy (CoP)
  - Assist the integration of satellite data into operational monitoring systems in developing countries (CoP)
  - Improve use and integration of seasonal forecasts for food security implications Enhance integration of EO derived biophysical and physical measures into crop yield models
  - Enhance timeliness of EO and in-situ data delivery

- The meeting recommended that in implementing the Ag 0703a Task, the Agricultural Monitoring Community of Practice should proceed with the following specific actions:
  - Compile a best practices source book for agricultural monitoring to address issues of crop production estimation, agricultural land-cover change, famine early warning, and seasonal to annual forecasting and risk reduction
  - Establish a convergence of evidence approach to achieve consensus on agricultural monitoring statements and products
    - Establish a multi-agency PAY (production, area and yield) Database to enable inter-comparison of forecasts from the different reporting systems
    - Increase multi-agency national crop assessment missions
  - Initiate a series of regional experimental studies - the Joint Experiments on Crop Assessment and Monitoring (JECAM) for development of improved monitoring methodologies, inter-comparison of modeling and monitoring methods, accuracy assessments (validation) of RS, in situ and derived products and data integration
    - Acquire the following EO data for the experiment sites from the GEO-partner space agencies:
      - very high res. imagery for area estimate production and crop mapping validation: 3 acquisitions over samples distributed in the site from ALOS 2,5m sensor and Resourcesat VHR sensor
      - Wide swath instrument for crop mapping and crop monitoring: all possible acquisition of AWifs and HJ-1
      - Coarse instrument for crop condition monitoring: daily FR MERIS
      - SAR instrument for crop area indicator: all possible acquisition using ENVISAT ASAR and ALOS PALSAR
  - Initiate a Coordinated Data Initiative for Global Agricultural Monitoring (CDIGAM). To:

- ensure the on-going, frequent and timely acquisition, accessibility of satellite data during agricultural growing season and the continuity of those observations necessary for agricultural monitoring
- compile a database of existing global cropping systems at the sub-national level to include field size, crop type, number of growing seasons, crop calendars, and typical inter-annual variations of yield and area
- fill the gaps in the current in-situ observations
- produce an annually updated global croplands map at 300-250m for monitoring of agricultural area change (SDSU/UCL)

- To achieve sustainable capacity building in support global agricultural monitoring it was recommended that the Agricultural Monitoring Community of Practice should focus in the following general areas:
  - Development and support for data sharing (exchange) protocols in countries with less developed information systems
  - Ensure optimal utilization of available observations (in-situ and satellite data) in support of Ag monitoring through pragmatic training programs based on "best-practice" by COP
  - Focus on sustainable capacity building strategies which leverages on building on existing resources with the support of satellite operators.

The workshop was successful and constructive and concluded that through commitment from the Space Agencies, the International Community and National Governments, the realization of an effective Global Agricultural Monitoring System of Systems is attainable in the near future. The essential components for such a monitoring system have been largely demonstrated in the research domain, in operational prototypes or in operational systems. Therefore the support from the international GEO partners in terms of open data policies, timely data delivery, ensuring continuity of earth observing missions, enhancement of *in-situ* networks, a commitment to capacity building, and the active participation of the community of practice in carrying out the specified task will lead directly to significant societal benefits, contributing to increased global food security and improved agricultural management.

Attendees at the GEO Agricultural Monitoring Workshop Beijing, February 2009