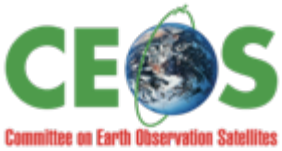
CEOS ACQUISITION STRATEGY FOR GEOGLAM

Version 2.0 – October 2014



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Executive Summary

The Group on Earth Observations (GEO) Global Agricultural Monitoring (GEOGLAM) initiative aims to support agricultural production estimates through the use of Earth observations. It was developed in response to the G20 Agricultural Ministers' concern about market volatility for the world's major crops. The initiative's goal is to strengthen the international community's capacity to produce and disseminate relevant, timely and accurate forecasts of agricultural production at national, regional and global scales through the use of Earth observations. GEOGLAM data outputs will directly support the Agricultural Market Information System (AMIS), a partner initiative launched by the G20 Agricultural Ministers and endorsed by the G20 heads of states. The R&D component of GEOGLAM, called JECAM (Joint Experiment for Crop Assessment and Monitoring), has been operating since 2011, with support from the Committee on Earth Observation Satellites (CEOS).

In July 2013, the GEOGLAM Implementation Plan (IP) was approved by GEO Executive Committee, proposing four phases developed in consultation with CEOS. This Strategy outlines the CEOS response to the IP, covering the period 2014-2015. GEOGLAM's IP presents a phased approach as follows:

- Phase 1 (2012-2014): Foundation activities, building on existing activities and pilot projects for a few countries, and scoping out the programme for the following phases.
- Phase 2 (2014-2016): Review and expand Phase-1 activities with new starts;
- Phase 3 (2015-2017): Completion of the Phase-1 and Phase-2 projects and geographical expansion; and
- Phase 4 (>2017): Operational Phase.

The first version of this CEOS Acquisition Strategy for GEOGLAM was endorsed with a phasing approach to echo the phases from the GEOGLAM IP. As the timeline for Phase 1 has grown to a close, there has been some confusion regarding what signifies the completion of one phase and marks the commencement of another phase. It has become clear that an alternative approach is necessary, and it is now proposed that the GEOGLAM effort utilize two phases: the Development Phase and the Operational Phase. The Development Phase encompasses all Phase 1, 2, and 3 activities, including foundation activities, pilot projects, geographical expansions, thematic expansions, and the incorporation of new data streams. A broader discussion of this new phasing approach can be found in Section 2.5.

The Strategy considers the satellite observations required as three data streams:

- **Core (expected to best meet the requirements, in most cases freely available):** MODIS (on Aqua and Terra), Landsat-7/8, RADARSAT-2, Sentinel-1A, GCOM-W1, RapidEye, and GPM;
- **Contributing (used for evaluation in the event the primary data stream is not available or for extended research to evaluate complementarity with core datasets):** Suomi-NPP, Proba-V, SMOS, SPOT-5/6, Pleiades, Resourcesat-2, RISAT-1, ALOS-2, TerraSAR-X, COSMO-SkyMed; and
- **Future (to be assessed in future GEOGLAM phases):** SMAP, Sentinel-2A, Sentinel-3A, RCM, GCOM-W2, RISAT-1A, SPOT-7, and CBERS-4.

Data acquired from these missions will support the development of a range of target products. These products imply a wide range of spatial and temporal coverage by satellites, from monthly (for moderate resolution coverage such as Landsat) through daily (for MODIS and GCOM-W). The Strategy defines acquisitions by relevant CEOS agency missions to

support the target products and GEOGLAM Implementation Plan during 2014-2015. The strategy is:

- to address the minimum space data provision necessary for GEOGLAM pilot countries to engage in crop forecasting activities in 2014-2015;
- continue support to GEOGLAM R&D and application development under JECAM;
- to assess country-based space data archives for national agricultural forecast information systems;
- to respond to the current GEOGLAM Implementation Plan, but anticipate GEOGLAM's future phases, and the launch of additional satellites within the next few years which will improve CEOS capacity and the prospects for support; and
- to adapt to changes in requirements, and to space agency supply plans; further revisions and editions of the CEOS Acquisition Strategy for GEOGLAM should serve as the basis for on-going communication with, and coordination of, the CEOS agencies in support of GEOGLAM.

Noting the existing significant commitments of many of the same CEOS agencies and missions in support of GEO's Global Forest Observations Initiative (GFOI), the GEOGLAM acquisition strategy will be harmonised as far as possible with the equivalent CEOS strategy for GFOI, to ensure maximum efficiency in data acquisitions.

1 Introduction

1.1 Purpose of the Document

The purpose of this document is to explain how space agencies from the Committee on Earth Observing Satellites (CEOS) will coordinate their relevant Earth observing satellite systems to acquire data to support information requirements arising from the Group on Earth Observation's (GEO) Global Agricultural Monitoring initiative (GEOGLAM) for 2014-2015. The document has been prepared by the CEOS Ad-hoc Working Group on GEOGLAM and the primary audience is the CEOS community.

1.2 Scope

This document focuses on CEOS support for GEOGLAM in 2014-2015, and is the CEOS response to the GEOGLAM Implementation Plan (GEOGLAM IP, July 2013). According to the GEOGLAM IP, Phase 1 "*…focuses on foundation activities, building on existing activities and pilot projects for a few countries, and scoping out the programme for the following phases*". CEOS support to Phase 1 of the GEOGLAM IP has been ongoing since 2013. Phase 2 (2014-2016) of the GEOGLAM IP expands on activities from the prior phase and includes additional regions of study. A total of four GEOGLAM phases, the first three of which comprise the Development Phase for this CEOS Acquisition Strategy, are foreseen through to the start of a global, operational monitoring capability for GEOGLAM beyond 2017 (see Section 2.5 for an enumeration and description of GEOGLAM Phases).

The Ad-hoc Working Group concluded that annual review of CEOS support to GEOGLAM, and annual updates to the Strategy are required because:

- The institutional framework for GEOGLAM remains a work in progress and confidence in a sustained future for the initiative can develop as capacity is seen to grow in the Project Office and elsewhere, with CEOS seeing demonstrable capability to acquire and manage the significant volumes of space data being requested for acquisition;
- GEOGLAM is the second global initiative in recent years requiring significant satellite observations of the land surface (following GFOI, the Global Forest Observations Initiative) and CEOS and its agencies will need to find a way forward that ensures efficiencies in the acquisition, processing and distribution of the data;
- Current capacity to support major land surface imaging acquisition programmes with freely available satellite data streams is limited to the Landsat series; but the launch of Sentinel-1A (C-band SAR) in April 2014, and a number of important missions anticipated to follow in the coming two years – which should support an expansion of ambitions for significant data acquisitions of the kind envisioned for later phases of GEOGLAM; and
- There is a need to develop, review, share and operationalize monitoring techniques and to validate the results in a stepwise fashion.

1.3 Contents

Section 2 provides more background on GEOGLAM and its precursor the Joint Experiment for Crop Assessment and Monitoring (JECAM).

Section 3 defines the requirements communicated by GEOGLAM that determine the approach to a supporting space data acquisition strategy. It includes target product specifications, satellite observation requirements, and temporal and spatial sampling needs.

Section 4 describes how CEOS agencies will **implement** the strategy and identifies the contribution of individual agencies and satellites.

Section 5 proposes the **next steps** for CEOS in relation to its support for GEOGLAM.

Appendices A-C include additional information on JECAM Test Sites (A), GEOGLAM data streams (B), detailed data stream implementation requests (C).

1.4 Revision History

Version 1.0 of the Strategy focused on CEOS support to GEOGLAM Phase 1 (2013-2015), and was endorsed by the 27th CEOS Plenary in Montreal, Canada, November 2013.

Version 2.0 of the Strategy focuses on the evolution of CEOS support to GEOGLAM for the period 2014.2-15, and will be presented for endorsement at the 28th CEOS Plenary in Tromsø, Norway, October 2014.

2 GEOGLAM

2.1 Overview

GEOGLAM aims to enhance agricultural production projections through the use of Earth observations, in order to address concerns about market volatility for the world's major crops raised by the G20 Agricultural Ministers. It hopes to strengthen the international community's capacity to produce and disseminate relevant, timely, and accurate projections of crop and livestock production at national, regional, and global scales through the use of Earth observations. In the GEOGLAM context, both croplands and rangelands (grazing lands or pasturelands) fall under the purview of agriculture. Presently, the monitoring of croplands is the dominant focus, both thematically and geographically, as the rangeland monitoring activity (Rangeland and Pasture Productivity (RAPP) is in its nascent stages.

The GEOGLAM Work Plan outlines six components that makeup GEOGLAM:

1) **Enhancing** global agricultural production monitoring systems;
2) **Building capacity** at the national level to utilize Earth observations;
3) **Supporting monitoring** of countries at risk to improve food security;
4) **Improving coordination** of Earth observations for agricultural monitoring;
5) **Coordinating R&D** in support of improved operational agricultural monitoring; and
6) **Disseminating data**, products, and information.

As noted in Section 1.2, a phased approach to GEOGLAM is proposed, with the GEOGLAM Task Team developing an Implementation Plan for Phases 1 and 2, which was endorsed by the GEO Executive Committee in July 2013. This Plan calls for CEOS to contribute to Components 1, 4, and 5 of the GEOGLAM Work Plan.

Component 1 – coordinating space data support for the Asia-RiCE countries and a number of other (see Section 2.4 and 2.5).

Component 4 – coordination, as the space arm of GEO, and increased use of Earth observations to improve operational agricultural monitoring.

Component 5 – coordinating continuing support to GEOGLAM R&D efforts through JECAM (see Section 2.2).

The GEOGLAM IP is currently in the process of being updated, and it is anticipated this update will be completed by the end of 2014.

2.2 JECAM

JECAM provides the foundation for the research and development towards operational monitoring enhancements for GEOGLAM. CEOS has been providing support to Component 5 of the GEOGLAM Work Plan through JECAM since 2011. The EO data that was provided to the JECAM test sites in 2013 is shown in Appendix A.

The overarching purpose of JECAM is to compare data and methods for crop area, crop condition monitoring and yield estimation, with the aim of establishing 'best practices' for different agricultural systems. The goal of the JECAM experiments is to facilitate the inter-comparison of monitoring and modelling methods, product accuracy assessments, data fusion, and product integration for agricultural monitoring. These international shared experiments are being undertaken at a series of sites which represent many of the world's main cropping systems. The approach is to collect and share science and data, including: i) time-series datasets from a variety of Earth observing satellites useful for agricultural monitoring, and ii) in-situ crop and meteorological measurements for each site. Additional information is available from the JECAM website (JECAM.org).

Synthesis of the results from JECAM will enable the following outcomes:

- Development of international standards for agricultural monitoring and reporting protocols;
- A convergence of the approaches to define best monitoring practices for different agricultural systems; and
- Identification of requirements for future EO systems for agricultural monitoring.

The JECAM sites are looking at a common range of monitoring needs over a very diverse range of landscape conditions and cropping systems, including:

- Crop identification and acreage estimation;
- Yield prediction;
- Near Real Time Crop condition / Crop stress;
- Land management; and
- Soil moisture.

There are currently 35 JECAM sites, of which two are brand new in July 2014, and 24 submitted an annual progress report in February 2014; these 24 sites are in the countries shown in Appendix A. Some of these are very active, while others are dormant. There is already significant bi-lateral collaboration between JECAM sites planned and underway. Use of the site network to support research external to JECAM is already taking place.

In July 2014, an international JECAM Science Meeting was held in Ottawa, Canada. At this time, two documents were proposed as new JECAM standards: Minimum EO Data Sets, and Guidelines for Field Data Collection. Consensus was achieved on certain key points, but the agreement of standards is ongoing. There was also consensus on key research topics, namely:

- What are the different performing features/metrics to discriminate the cropland/crop type for the different agricultural landscapes (including smallholders' agriculture)?
- What are the limitations to extend the currently operational SAR method for crop mapping, soil moisture and biophysical variables?
- How to develop multisource approaches (sensor independent methods)?
- How to scale up from finer to coarser resolution?
- What are the stratification approaches to move from site level to regional/national level?
- How to detect/focus on change from one year to another (crop type, crop yield, cropland)?
- What are the yield models to be developed in data rich environment?
- How to input crowd sourcing and expert knowledge into an EO-driven system?
- How to detect water stress (indicators, etc) including thermal IR?

The JECAM network plans to continue to address these key topics and feed the results to GEOGLAM.

At the centre of many discussions that have occurred over the past year is the need for justification for sharing CEOS-coordinated data between and across JECAM sites and participants. As the goal of JECAM is to derive best practices for agricultural monitoring, and to develop methodologies that are generalizable between diverse agricultural landscapes, it is crucial that data be available to JECAM site participants worldwide

regardless of whether a given participant's principal involvement is with only one specific region. Moving forward, it is an important activity of the CEOS Ad Hoc Team for GEOGLAM to clearly communicate this scientific need to involved space agencies.

Requirements for JECAM, while continuing to be supported by ongoing CEOS activities, were not explicitly addressed in the CEOS Acquisition Strategy for GEOGLAM Phase 1, nor are they explicitly addressed herein. It is expected that in subsequent years, as the methodologies mature, the JECAM data requirements may in fact grow together, or be blended or further harmonized with the mainline GEOGLAM requirements.

2.3 Support to the Agricultural Market Information System (AMIS)

The GEOGLAM IP calls for direct support to the AMIS, a partner initiative launched by the G20 Agricultural Ministers and endorsed by the G20 head of states and a key beneficiary of the GEOGLAM outputs.

As of September 2013, GEOGLAM has operationally provided monthly crop outlook reports to AMIS as inputs to their Market Monitor. These products are derived from a number of observations, including satellite data contributions from CEOS agencies which are inputs into satellite derived agro-meteorological information such as NDVI anomaly, water stress, soil moisture, land surface temperature, and accumulated rainfall. Output products typically include synthesis maps which describe both the condition of the crops under cultivation, as well as the drivers of that condition, and pie charts indicating crop conditions for main producer and main exporter countries.

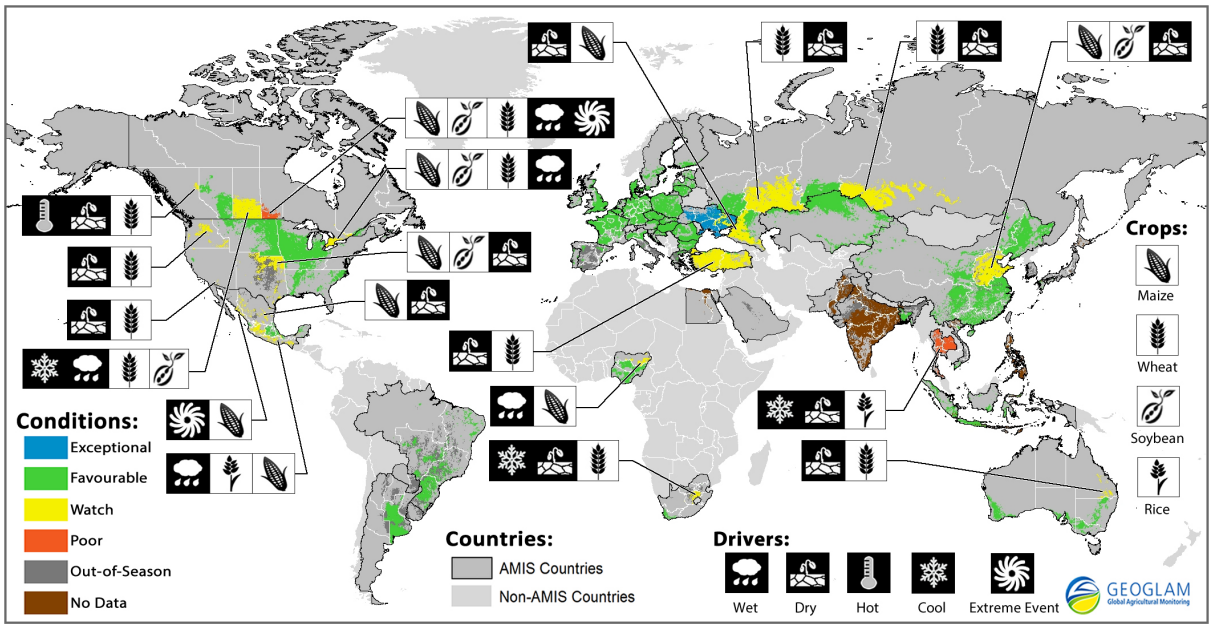

Figure 1 Synthesis map produced in the context of AMIS reporting. This map, produced with information current as of 28 July 2014, shows the conditions and drivers (excess moisture ('wet'), dryness, excessive heat, excessive cold, and extreme events (e.g. tornado, hurricane, flood, etc.)) for four global crops (maize, wheat, soybean, and rice).

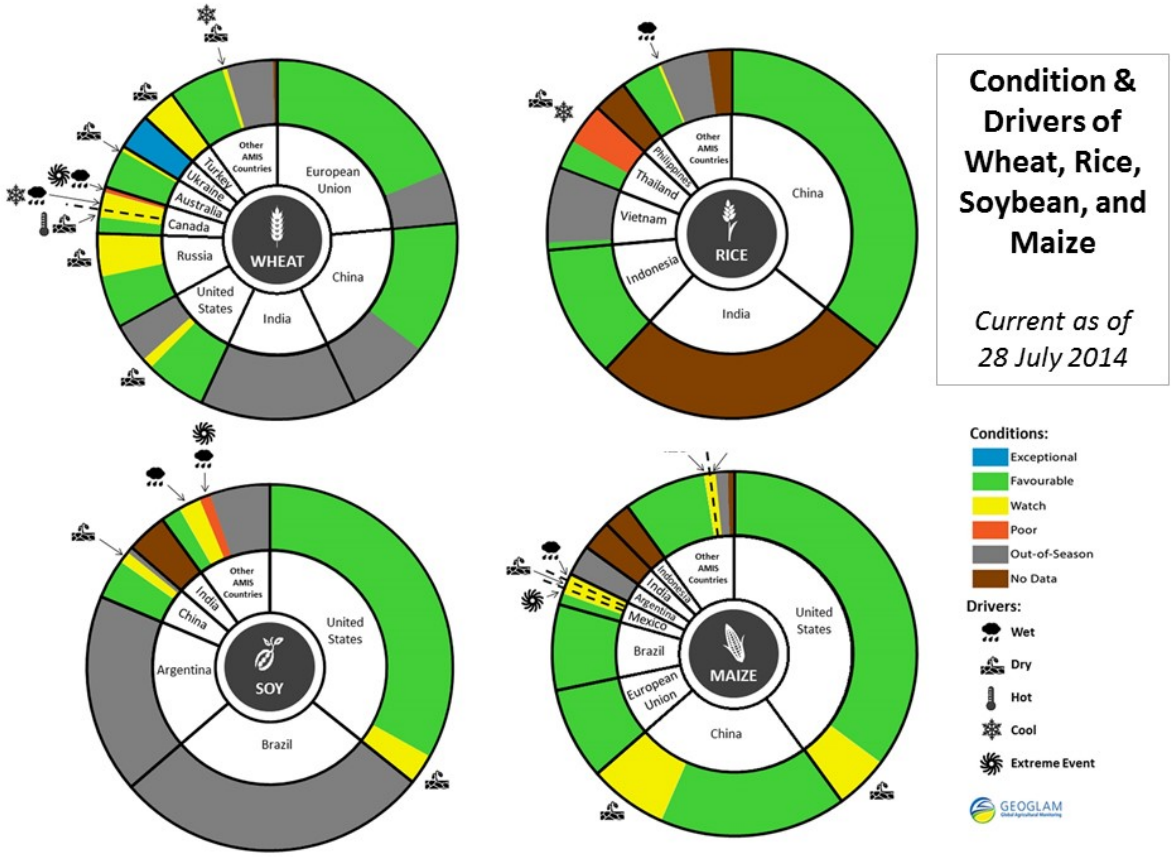

Figure 2 Pie charts produced in the context of AMIS reporting, summarizing crop conditions (and drivers) of the four main global crops for main producer countries.

2.4 Asia-RiCE

A group for coordination of observations for Asian rice crops known as Asia-RiCE (Asian Rice Crop Estimation, Monitoring, and Outlook) was created under the leadership of JAXA and ISRO in support of GEOGLAM. The Asia-RiCE initiative has been organised to develop the rice crop monitoring component of the GEOGLAM initiative. This group has been focused on defining observational requirements, working with a number of Asian countries to define Technical Demonstration sites for GEOGLAM Phase 1 in 2013-2015. These sites are described in Asia-RiCE Implementation Plan (http://asia-rice.org/), and coordination has been on going to refine the data requirements for these sites – in particular for SAR. The Asia-RiCE team has also focused on supporting the Demonstration sites in securing the required flow of data, and analysing this data along with ground based information and the models to estimate paddy field planting area, rice crop growth and production, and generate other related products. The Asia-RiCE team has also responded to Announcements of Opportunity from a number of CEOS agencies such as CSA (SOAR-JECM), DLR (TerraSAR/TanDEM-X), and JAXA (Kyoto and Carbon Phase 4) to promote research into the utilisation of multiple SAR data types (L-/X-/C-bands) by the Demonstration sites. The team has also coordinated with ISRO for access to RISAT data, and with ESA for Sentinel-1 and -2 early acquisition planning.

In addition with rice crop area and production estimation, Asia-RiCE contributes rice crop outlook to the GEOGLAM crop monitoring system using JAXA's agro-meteorological information system (JASMIN) and other information sources and knowledge, and in cooperation with ASEAN+3 food security information system (AFSIS) projects and national

experts. 15-day composites of NDVI, land surface temperature, PAR, soil moisture and drought index (KBDI) that are produced from MODIS, TRMM/GPM, GCOM-W, MTSAT and other satellites. The anomaly information for these 15-day composites, generated relative to climate information, is provided to AFSIS and national experts by JASMIN.

The Asia-RiCE group has provided significant inputs to both the Phase 1 Strategy, as well as the GEOGLAM IP via the Asia-RiCE Implementation Plan and requirements documents.

2.5 GEOGLAM and CEOS Phasing

GEOGLAM Phasing: In the first version of the GEOGLAM Acquisition Strategy, a phased approach was presented to segment the development of pre-operational activities leading up to the full operational phase in beyond 2017. These phases were:

- Phase 1 (2012-2014): Foundation activities, building on existing activities and pilot projects for a few countries, and scoping out the programme for the following phases.
- Phase 2 (2014-2016): Review and expand Phase-1 activities with new starts;
- Phase 3 (2015-2017): Completion of the Phase-1 and Phase-2 projects and geographical expansion;
- Phase 4 (>2017): Operational Phase

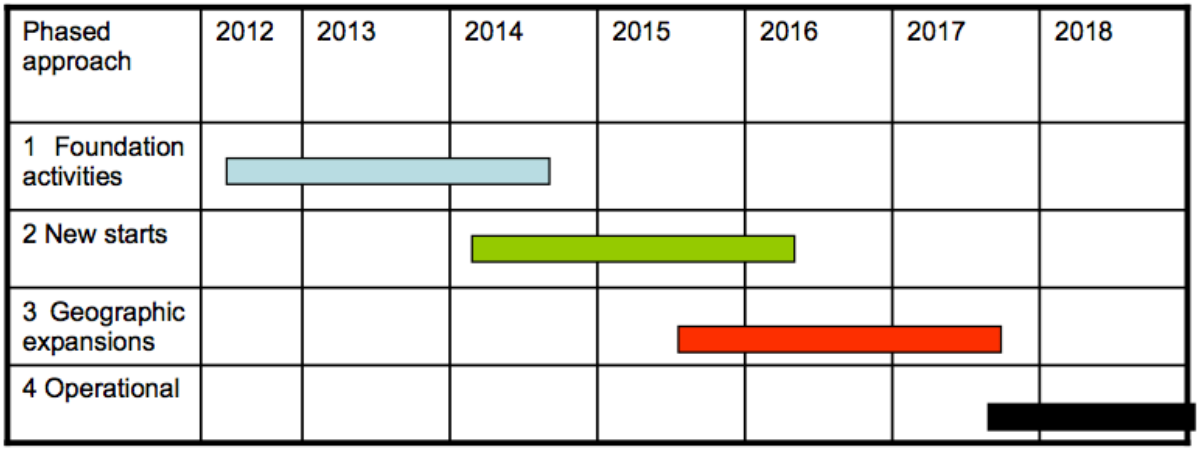

Figure 3 The GEOGLAM Phased Implementation Calendar (*Figure 3 from the GEOGLAM IP July 2013***)**

As the timeline for Phase 1 grows to a close, there has been some confusion regarding what signifies the completion of one phase and marked the commencement of another phase. It has become clear that an alternative approach is necessary, and it is now proposed that the GEOGLAM effort utilize two phases: the Development Phase and the Operational Phase. This implementation approach is complementary to that which is currently endorsed by CEOS, but allows for flexibility in the development plans without an emphasis on calendar years. The activities of the Development Phase are still the same as Phases 1, 2, and 3 (as above) and include the following goals:

- Develop, review, share and operationalize monitoring techniques and validate those results,
- Develop sampling strategies that reduce and/or optimise product generation inputs and process,
- Integrate new sensors as they become available (e.g. Sentinel),
- Create, process, assimilate and distribute new information products into decision making processes,
- Allow countries time to build capacity to collect and process earth observation data and incorporate the results into their management and decision making,

- Expand the number of countries, including at-risk countries, and
- Build capacity, particularly in at-risk countries for ingestion and processing of earth observation data.

It is expected that this report, and specifically this section, will be updated annually to reflect the accomplishments of the development phase and the plans for the coming year. Ultimately, this Development Phase will lead toward a self-sustaining operational program in 2018.

Development Progress (through 2014): CEOS, as the space arm of GEO, is a crucial player in GEOGLAM's success. The CEOS endorsement of the first GEOGLAM acquisition strategy has helped direct the attention of space agencies and non-governmental organizations toward agricultural monitoring, thereby improving recognition of and aiding in the securement of funding for GEOGLAM activities. Already, considerable successes in data coordination have been realized within the GEOGLAM pilot projects, the JECAM initiative, and the Asia-RiCE initiative. Some those successes are summarized below:

- Baseline data requirements have been established and continually refined as best-practices for cropland monitoring evolve.
- Targeted space-based acquisitions have been coordinated by CEOS and provided to GEOGLAM countries and/or their associated pilot projects to accommodate growing seasons in both hemispheres.
- Successful testing of monitoring techniques and product development using small-scale sampling, with the exception of wall-to-wall measurements in Thailand (Asia-Rice project).
- Establishing a co-community of suppliers (CEOS) and users (countries) to discuss end-to-end goals and issues surrounding operational agriculture monitoring.
- Initiating the development of minimum space data provisions for global operational crop yield forecasting while considering the breadth and complexity of agricultural monitoring.
- Developing preliminary plans for JECAM data services prototypes to acquire, distribute and process data in developing nations that lack technical infrastructure.
- Completion of an Asia-Rice Data Services pilot project to supply Indonesia with online cloud-based storage and processing tools for Radarsat-2 SAR data.

Though there have been many successes since the inception of GEOGLAM in 2012, some challenges have also been discovered during this recent development period, all of which provide insight into how to proceed with implementation. These include:

- GEOGLAM requires better inter-project communication to optimize the benefits of various cropland monitoring projects, Asia-RiCE projects, and JECAM research. This is being addressed internally within GEOGLAM through the establishment of an implementation team.
- Several GEOGLAM projects have arranged their data directly with space agencies rather than requesting the data through CEOS. This is due to a mismatch between CEOS data coordination and GEOGLAM project timelines, wherein studies are designed and funded with guaranteed data streams in mind, then upon adoption as a GEOGLAM country are no longer in need of, nor able to, assimilate additional CEOS-coordinated data.As an example, agricultural monitoring science could be advanced through access to, and incorporation of, high temporal resolution, fine-to-moderate spatial resolution data (such as would be the case if Landsat 7/8 were supplemented by AWiFS, before and after Sentinel-2A comes online), but their availability would need to be virtually assured at the start of a project in order to be incorporated into study and operational design.

- There is a need for baseline datasets on a regional-to-global basis, most notably crop type and crop calendars for the major crops. These baseline products can be generated from archival data from ALOS, Sentinel-1A, Radarsat-2, TerraSAR-X, ResourceSat-2 (AWiFS), RapidEye and SPOT-4/5/6 missions.

Development Plans for 2015: A summary of the development plans for 2015 are noted below. This list represents some, but not all, of the efforts of GEOGLAM pertaining to data acquisition planning, as supported by CEOS:

- Continue to expand the efforts of existing pilot projects with a desire to operationalize monitoring techniques for future GEOGLAM products,
- Expand the testing of sampling strategies to reduce and/or optimize data usage,
- Integrate new datasets from Proba-V, Sentinel-1A, ALOS-2, RISAT-1, SPOT-7, CBERS-4, and Sentinel-2A,
- Expand the number of countries utilizing CEOS-coordinated space-based data within the GEOGLAM development projects,
- Develop and secure space agency data acquisition plans within a single growing season for specific geographical regions in order to guarantee data stream integration for future GEOGLAM projects.
- Develop requirements and initiate a JECAM Data Services Pilot Project for cloud-based storage and processing of SAR data. Sites will include: Ukraine, Belgium, South Africa, Argentina, Germany, Canada, and
- Investigate the development of a common "JECAM Data Sharing Policy" that will include definition of users, space data, insitu data, cloud-based storage and processing, and documentation. Work with the CEOS SEO, CEOS WGISS, GEO, ESA, CSA, and JECAM team members.
- Expand the number of missions within the COVE tool that link to acquisition metadata archives. Use this data to conduct an analysis of data availability over croplands and within growing seasons to develop global crop type and crop calendar products. These results could then be used to request datasets from respective space agencies and potentially test the utilization of data services tools.
- Initiate data acquisition planning for within-season, near-real time datasets in order to prepare CEOS agencies to discuss long-term plans to meet future operational coverage goals.

Country	Croplands	JECAM	Asia-Rice
Algeria	X		
Argentina	X	X	
Australia	X		
Belgium		X	
Brazil		X	
Burkina Faso		X	
Canada		X	
China		X	X
Ethiopia	X		
France		X	
India			X
Indonesia			X
Italy		X	
Japan			X
Laos			X
Madagascar		X	
Malaysia			X
Mexico		X	
Morocco		X	
Pakistan	X		
Paraguay		X	
Philippines			X
Russia	X	X	
South Africa		X	
Taiwan			X
Taiwan		X	
Tanzania	X	X	
Thailand			X
Tunisia		X	
Uganda	X		
Ukraine	X	X	
United States		X	
Vietnam			X

Table 1 Active Countries

Country Engagement Summary (through 2014):
Through its Croplands projects, research and development activities (JECAM) and Asia-Rice project, GEOGLAM has engaged with a large number of countries, since its inception (see table). This list of countries will continue to expand along with the complexity of efforts. In

addition to the categories noted in the table, there are also several other current and emerging efforts that will have a future impact to GEOGLAM and could be added to future versions of this table. Those include AMIS (Agricultural Market Information System), Space Data Services Pilot Projects led by the CEOS Systems Engineering Office (SEO), SIGMA (Stimulating Innovation for Global Monitoring of Agriculture) led by Vito, Sentinel-2 for Agriculture led by ESA/UCL, and GEOGLAM Rangelands and Pasture Productivity (RAPP).

3 Requirements

3.1 Target Product Specifications

The GEOGLAM Task Team has defined a number of thematic crop information product specifications including multi-annual, annual, near real-time/weekly products. These products serve as inputs to crop information systems such as the AMIS. A number of these products are to be produced in-season, and therefore near real time data distribution is required. A note on latency appears in Section 3.3.

Note that the requirement numbers referenced below are linked to Table 2 in Section 3.2.

Cropland Mask: A generalized map of cultivated areas, to be updated every 1-3 years, at Landsat scale. Finer resolution (requirements #7 - #11) may be required for smaller at-risk countries. This product requires monthly observations of cropland extent and regional Rice crop samples to enable differentiation between croplands and non-cropped lands. Monthly cloud-free Landsat scenes (minimum 2 out of season, 3 in season) are needed (requirements #4 and #5) at least every 3 years, ideally annually. In persistently cloudy areas, there will be a need to integrate additional optical and/or radar data. For example, Asia-RICE regions will utilise MODIS-class imagery (requirement #2), and will also investigate the utility of SAR imagery (requirement #6) to produce yearly cultivated rice area.

Crop Type Area and Crop Calendar: Annual derived cropland area estimates and crop calendars based on monthly observations over cropland extent (requirement #4), and weekly observations over cropland samples (requirement #5). In South-East Asia, there can be up to 3 rice crops in a year. For Asia-RiCE regions, MODIS-class (requirement #2) will be used, with monthly observations using SAR (requirement #6) having started being investigated end 2013. Observations should be optimized for periods where crop types can be differentiated from each other. Overall, there is a need for 4 to 6 cloud-free observations during the growing season of one crop cycle (i.e., Argentina has 2 soy crops within the same year so additional observations are needed). In addition to Landsat data, fine resolution data (e.g RapidEye) are needed monthly (requirements #7 - #11) in order to calibrate the Landsat derived area estimates.

Crop Condition: The health and growing condition of croplands based on coarse resolution data (e.g. MODIS, SAR or microwave) for the detection of disease, flooding or droughts. Daily (requirement #1) to near-daily (requirement #2) observations will yield parameters including NDVI, LAI, FPAR, VHI, TCI, ET, precipitation, LST and Soil Moisture (microwave, requirement #3). Multi-year time series fine resolution (requirement #8) and moderate resolution (requirements #5 and #6) are used to define the normal growing season to allow anomaly comparisons. In addition, this product requires integration with ground observations (e.g. crop production statistics).

Crop Yield: Derived cropland output (yield) is based on empirical information and crop growth information (e.g. NDVI, LAI, FAPAR, LST) from near-daily coarse resolution observations (requirement #2) and microwave measurements of precipitation, temperature

and ET (requirement #3). While still in the research phase, in future biomass estimation using SAR will be considered. In addition, this product requires integration with ground observations (i.e., crop production statistics).

Crop Biophysical Variables: Crop variables (e.g. LAI, NPP, Nitrogen content, Chlorophyll content, Water content) from various resolution observations (requirements #1 - #3, #5, #6, and #8). In addition, this product requires integration with ground observations for calibration and validation.

Environmental Variables: Environment variables (e.g. soil type, soil moisture) from microwave, and moderate and fine resolution observations (requirements #3, #5, #6, and #8).

Agricultural Practices / Cropping Systems: Derived cropland products (i.e., field size, number of cropping cycles per season, diversity of crops) from all types of observations (i.e. coarse, moderate, fine and very fine) resolution observations (requirements #2, #4 - #6, #8, #10, and #11).

3.2 Satellite Observation Requirements for Target Products

Table 2 summarises the satellite observations required to support the generation of the target products defined in Section 3.1. This includes the required spatial resolution, spectral range, effective observation frequency, and sample type for each product. 11 requirements have been defined in support of the target products.

	How ?		When ?	Where ?		What ? Information Products and Applications						
Req#	Spatial Resolution	Spectral Range	Effective observ. frequency (cloud free)*	Sample Type	Field Size	Crop Mask	Crop Type Area and Growing Calendar	Crop Condition	Crop Yield	Crop Biophysical Variables	Environ. Variables	Ag Practices / Cropping Systems
	Coarse Resolution Sampling (>100m)											
1	>500-2000 m	optical	Daily	Wall-to-Wall	All			X		L		
2	100-500 m	optical	2 to 5 per week	Cropland Extent	All	X	X	X	L	L	X	L
3	5-50 km	microwave	Daily	Cropland Extent	All			X	X	X	X	
	Moderate Resolution Sampling (10 to 100m)											
4	10-70m	optical	Monthly (min 2 out of season + 3 in season). Required every 1-3 years.	Cropland Extent	All	X	L/M					X
5	10-70m	optical	~Weekly (8 days; min. 1 per 16 days)	Sample	All	X	X	X	X	X	X	X
6	10-100m	SAR Dual Polarization	~Weekly (8 days; min. 1 per 16 days)	Cropland Extent or Sample	All	X	X	X	X	X	X	X
	Fine Resolution Sampling (5 to 10m)											
7	5-10 m	VIS, NIR, SWIR	Monthly (min. 3 in season)	Cropland Extent	M/S	M/S	M/S					
8	5-10 m	VIS, NIR, SWIR	~Weekly (8 days; min. 1 per 16 days)	Sample	All		M/S	X		X	X	X
9	5-10 m	SAR Dual Polarization	Monthly	Cropland Extent or Sample	M/S	M/S	M/S					M/S
	Very Fine Resolution Sampling (<5m)											
10	< 5 m	VIS, NIR	3 per year (2 in season + 1 out of season); Required every 3 years	Cropland Extent	S	S	S					
11	< 5 m	VIS, NIR	1 to 2 per month	Refined Sample	All		X		X			X

Table 2 GEOGLAM Phase 1 Satellite Observational Requirements for Target Products
Field size variation: small (S ~ <2.5 ha), medium (M = ~2.5 ha-15 ha), and large (L = ~ >15ha)
** Cloud free < 10% average cloud cover across the scene.*

Additional notes on Table 2:

- 'X' indicates data required for all field sizes; if data are to be used for only (or a combination of) large, medium, and/or small fields, the 'X' is supplanted with the field size designation.
- Optical data refers to data spanning the visible, near-infrared, shortwave infrared, and long-wave infrared (thermal). Data requirements spanning less or different portions of the spectrum are specified accordingly.
- Data should be made available near-real time, particularly for within season assessments;
- Requirements have maximum and minimum ranges for spatial resolution, temporal resolution, and in some cases geographic extent;
- Spatial resolution requirements are generated relative to field size; this is preliminary and could be refined/improved with a consideration of landscape heterogeneity and spatial pattern;

- Meteorological parameters (snow cover, temp., rainfall, etc.) are not included in this table and will be addressed in another forum; and
- Samples need to be coordinated and nested, but at present have been developed largely in the context of specific project needs and considerations.

In order to try and ease the requirement on cropland extent coverage for fine and moderate resolution data streams, a sampling strategy (described in Section 3.4) has been proposed. This sampling strategy means that requirement #4 calls for coverage a minimum of every 1-3 years. While the sampling strategy is expected to be able to mitigate coverage gaps, the derived products are a less accurate estimate. Annual coverage of requirement #4 will optimise the quality of the end products, and is therefore desired.

Several different sample types are referred to in Table 3, ranging from national wall-to-wall, cropland extent, sampling, and refined sampling.

Sample Type	Description
Cropland Extent	Border to border coverage of national cropland regions.
Sampling (s)	40 x 40 km blocks (Argentina, Australia)
Refined Sampling (rs)	A sub-set of the sampling blocks will be chosen for refined sampling.

Table 3 Satellite Acquisition Sample Types

3.3 Spatial and Temporal Coverage

Spatial Coverage: Large Scale Regions and Technical Demonstrator Sites

As discussed in Section 2.5, spatial coverage for GEOGLAM consists of national cropland extent coverage over several countries, a combination of wall-to-wall (Thailand) and sample coverage for rice-producing countries and numerous small-scale (25-km) sample regions for JECAM over ~20 countries.

Figure 4 summarizes the large-scale region coverage of croplands and rice through mid-2014. There has been a particular focus on Argentina, Australia and Thailand (Asia-Rice) during this period. Similarly, Figure 5 summarises the Asian rice crop sample regions for GEOGLAM through mid-2014. As described in Section 2.5, GEOGLAM desires to expand the number of countries with cropland pilot projects. There may also be some adjustment to the sampling regions for JECAM and Asia-Rice.

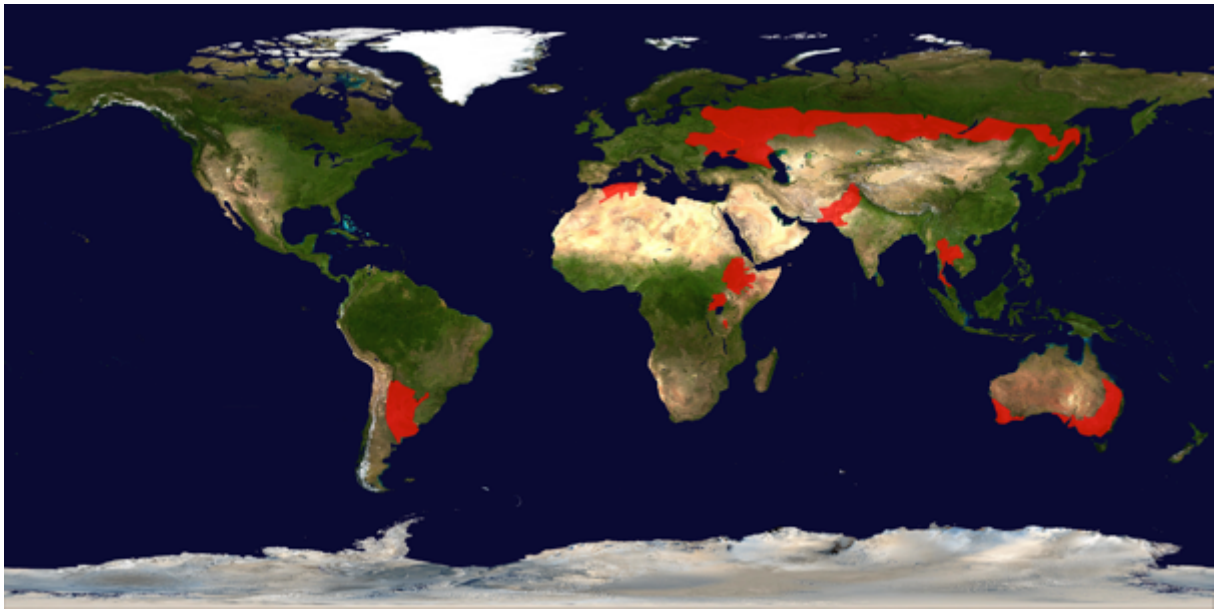

Figure 4 GEOGLAM Large-scale Coverage

Figure 5 GEOGLAM Rice Sampling Regions

Temporal Coverage: Agricultural Growing Season Calendars

Figure 6 summarises the median values for the start and end of the crop growing seasons for Argentina and Australia. These regions demonstrate the extent and diversity of growing seasons and the need for near-continuous monitoring. Growing seasons for other regions will differ, but the details of crop masks and crop calendars are critical to defining acquisition plans.

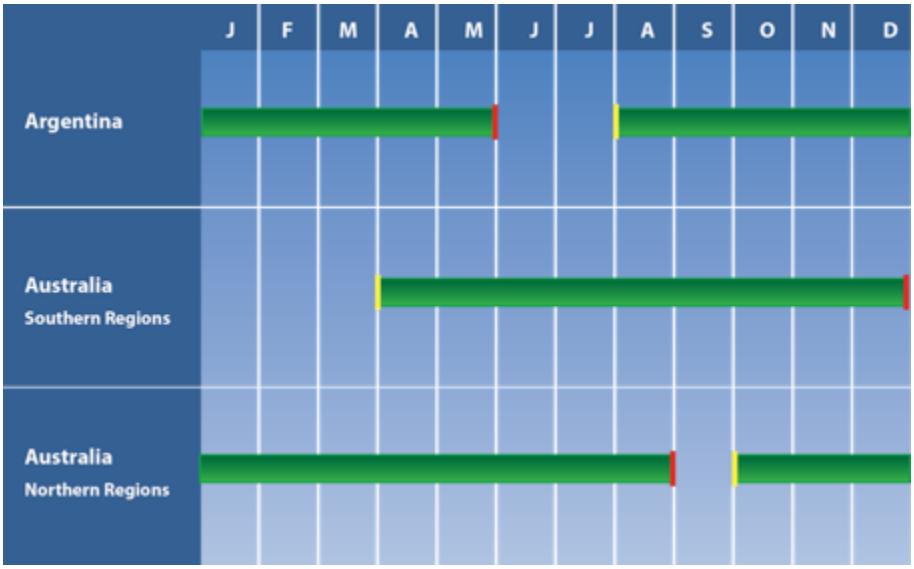

Figure 6 Australia and Argentina Growing Seasons

Figure 7 summarises the rice crop growing cycles for the Asia-RiCE Technical Demonstration sites. The typical growth cycle for Asian rice crops is 85-150 days. During a typical 120 day growth cycle, 4-5 satellite observations are required in order to achieve all monitoring objectives. These observations should be evenly spaced across the growing season.

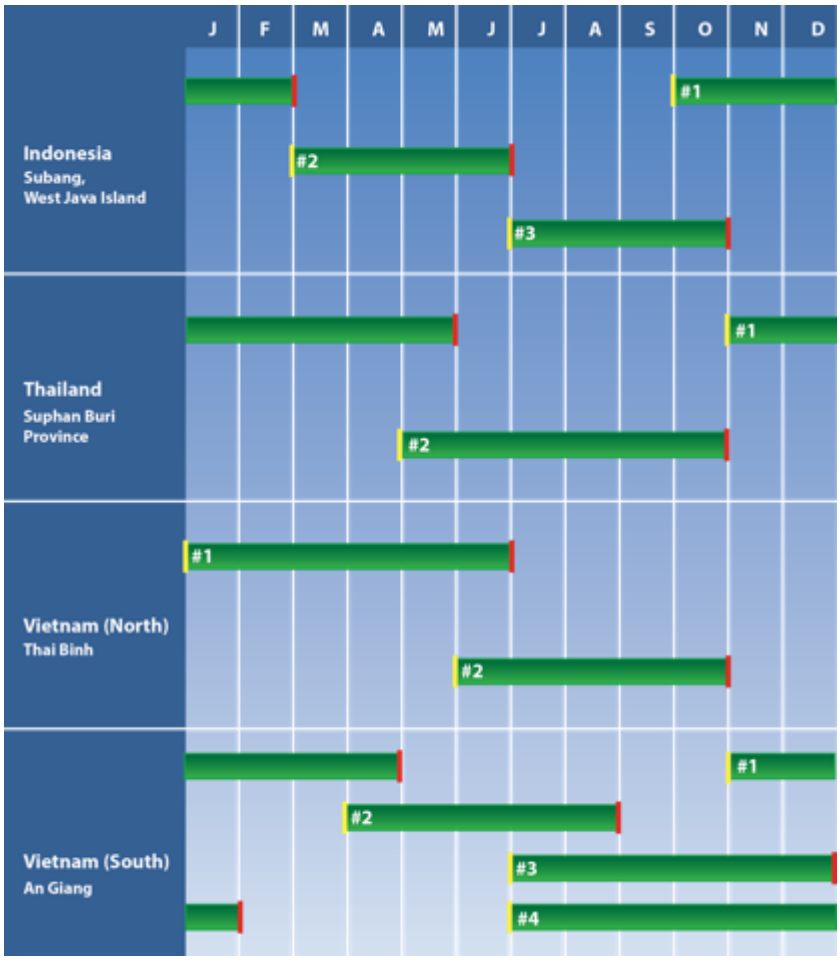

Figure 7 Asian Region Growing Seasons

Figures 6 and 7 are a summary of more detailed growing season information developed in support of the development of this acquisition strategy. As described in Section 3.5, it is essential to develop accurate and detailed crop mask (location and type) and crop calendars using existing archive data. As this information is developed, it will impact the acquisition strategy presented here.

3.4 Sampling Strategy Development Support

In order to scale GEOGLAM to global operations, the development of sampling strategies is required. The objective of these sampling strategies is to reduce the need for frequent full cropland extent acquisitions by employing small-scale sample blocks of approximately 40 x 40 km within croplands. Data from these sample blocks will be used to evaluate effective methods for product calibration and validation, and to scale up products such as crop production estimates. It is possible that a national sampling strategy (regular or stratified sampling) can reduce the moderate spatial resolution (e.g., Landsat) cropland extent acquisition frequency requirements. However, it should be noted that when feasible, cropland extent multi-temporal moderate spatial resolution observations are preferred.

Thus far in early GEOGLAM studies, Argentinian soy and wheat sampling strategies coupling RapidEye (6.5 m VIS-NIR) to Landsat (30 m VIS-SWIR) are being investigated with the aim of demonstrating that RapidEye-class sampling can reduce wall-to-wall fine to moderate spatial resolution coverage requirements. Based on the results from this initial study, future GEOGLAM studies will consider the development of multi-sensor sampling strategies in order to fully leverage all available data streams.

While current sampling strategies for Argentina are not optimised from the satellite acquisitions perspective, the team developing the sampling strategies is aware of the need to take satellite acquisition planning into account in order to realise the greatest efficiency in the long term. As the design of the sampling strategies requires the balancing of a number of factors, including statistical constraints and crop type distribution, it is acknowledged that satellite acquisition planning considerations should be integrated during the sampling design development.

Argentinian Sampling Strategy

The GEOGLAM Task Team has designed a sampling strategy for Argentina that utilises 75 sample blocks (40 x 40 km), distributed throughout the soybean croplands. GEOGLAM desires monthly high-resolution (RapidEye) acquisitions over these sample areas during the growing season.

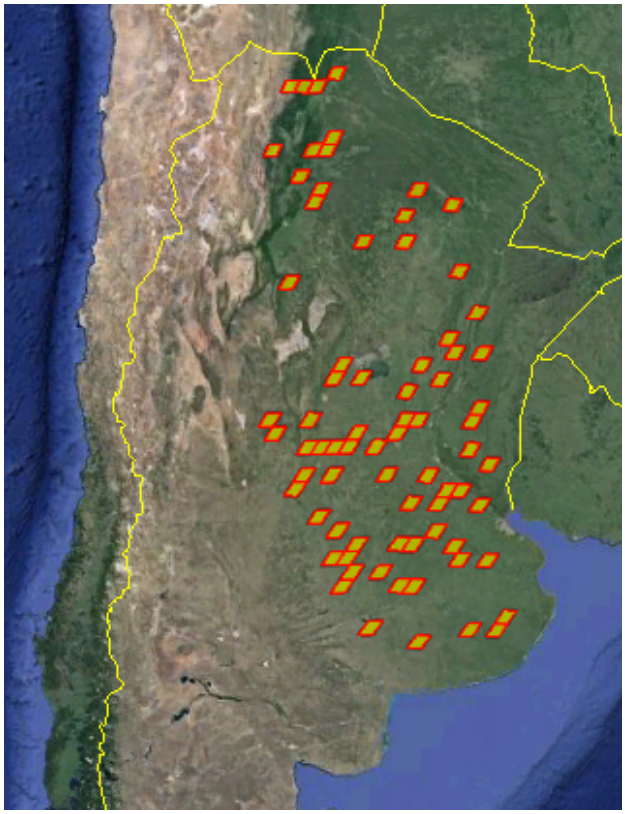

Figure 8 Argentina Sample Blocks: 75 blocks, 40km x 40km each

A similar strategy, also featuring about 75 sample blocks, is currently being designed for Australia covering wheat crops in the Murray Darling Basin region.

3.5 Archive Data

There is a need for – as well as interest in and research capacity available for – the development of baseline datasets on a global basis, most notably crop type and crop calendars for the major crops (wheat, rice, maize/corn, and soybean). As GEOGLAM has evolved and grown, it has relied on "best-available" products for both its acquisition strategy development as well as for some of its cropland monitoring applications. Broadly speaking, these products have been derived through the intercomparison of existing products (cropland area mask), auxiliary or crowd-sourced data (field size data distribution layer), or analysis of continuous (time series) historical coarse spatial resolution data (growing season calendars and cloud cover analyses). The accuracy of these baseline products could all be improved through the incorporation of fine-to-moderate spatial resolution data (<100m, approximately), improving cropland monitoring activities as well as ensuring a more finely-tuned acquisition strategy moving forward.

These baseline products can be generated through the incorporation of archival data from a suite of fine-to-moderate spatial resolution active microwave (SAR) and passive optical sensors, including the Landsat, ALOS, Radarsat, Terrasar-X, ResourceSat, RapidEye, SPOT and RISAT missions.

This can be realized through a few incremental steps, each with additional benefits which advance us toward an operational monitoring program:

1. CEOS SEO incorporates acquisition metadata from these missions into COVE.

    a. Benefits: Establishes a pipeline of these metadata, which will be valuable moving forward for many CEOS activities; generates a database which GEOGLAM can evaluate for sufficient data sampling rate for target product activity.
2. COVE analysis run to identify data granules acquired over croplands (defined by current best-available cropland mask), within growing season (defined by current best-available growing season calendars); GEOGLAM identifies which data granules comprise a sufficient record to develop crop type and crop calendar products.
    a. Benefits: Provides a basis for evaluation of new data streams; generates baseline products which will make future data acquisitions (when & where) more precise.
3. CEOS requests data granules from respective space agencies.
    a. Benefits: Establishes a process by which data are requested by GEOGLAM, with CEOS coordinating through space agencies; takes advantage of already acquired data, rather than new acquisitions.
4. Data placed in one (or more) of the data services prototypes.
    a. Benefits: Provides an opportunity to test the data services prototypes.

Providing the archive contains data of sufficient quantity and availability for their production, these data products would become the new standard for GEOGLAM activities. As agriculture is a dynamic process both within and between years, the products would require updating every 1-3 years, thereby in the future relying on near-real time acquisitions. The specific frequency of updating of the baseline products (including crop mask, crop type, and crop calendar) can be found in the requirements table (Table 2).

4 Acquisition Strategy

4.1 Basic Strategy for GEOGLAM Development Phase

The CEOS Acquisition Strategy for GEOGLAM may be characterised as:

- aiming to address the minimum space data provision necessary for GEOGLAM countries to engage in crop projection activities;
- based on acquisitions from a number of data streams – as agency data policy allows, provide access to the resulting data archives by countries for national agricultural forecast information systems;
- responding to the current GEOGLAM Implementation Plan, but anticipating future phases, and the launch of additional satellites within the next few years which will improve CEOS capacity and the prospects for support to future GEOGLAM phases; and
- adaptive to changes in requirements, and to space agency supply plans; further revisions and editions of the CEOS Acquisition Strategy should serve as the basis for on-going communication with, and coordination of, the CEOS agencies in support of GEOGLAM.

The Strategy focuses on activities in the 2014-2015 timeframe, in support of the GEOGLAM Development Phase (2013-2017), consistent with the objectives of supporting the development of GEOGLAM, while also allowing the opportunity to assess GEOGLAM development and evolving data requirements before defining and committing to potential CEOS support for future phases.

The geographic extent of pilot countries support is limited to the countries listed in Table 1 in order to ensure the coverage area (approximately 1.3 million km^2) remains manageable. This acknowledges the need for GEOGLAM to demonstrate activities at scale, while also

recognising that it is still in its formative stages, and does not yet have the capacity to support a global program.

The Strategy identifies Core and Contributing data streams to support implementation, with the aim of communicating the prospective roles of the data providers. These data streams are characterised by their data access policy, maturity and availability, and their fitness to support the generation of the target products specified by the GEOGLAM Task Team.

4.2 Data Streams

Discussions between CEOS agencies active within the JECAM task, and the GEOGLAM Task Team have resulted in consensus on a working list of CEOS agency satellite missions that represent the candidate GEOGLAM data streams. These data streams fall into one of two categories: Core and Contributing.

Core data streams are the current source of data that are expected to best meet the requirements. In most cases these data are freely available, but in some cases (e.g. RapidEye) these datasets may require a fee or special negotiation with an agency or commercial partner. GEOGLAM would like to pursue free and open access to all Core datasets for its development phases with the intention of securing funding for these data for long-term operational use should needs warrant.

Contributing data streams are the source of data that would be used for evaluation in the event the Core data streams are not available. It is possible that evaluation of Contributing data will result in improved results such that a Contributing data source may be considered as a Core dataset in the future. GEOGLAM would like to pursue free and open access to all Contributing datasets for its development phases with the intention of securing funding for these data for long-term operational use should needs warrant.

Table 4 shows how the GEOGLAM Core and Contributing data streams relate to the target product requirements defined in Section 3.2.

	How ?				Where ?	When ?	
Req#	Core Missions (future)	Contributing Missions (future)	Spatial Resolution	Spectral Range	Sample Type	Effective observ. frequency (cloud free)*	Growing Season Calendar
	Coarse Resolution Sampling (>100m)						
1	Aqua/Terra (1000m)	Suomi-NPP (750m) Proba-V (1000m) SPOT-5 (1150m)	>500-2000 m	optical	Wall-to-Wall	Daily	all year
2	Aqua/Terra (250/500m) Sentinel-3A (500m)	Suomi-NPP (375m) Proba-V (100/333m)	100-500 m	optical	Cropland Extent	2 to 5 per week	all year
3	Aqua GCOM-W1/W2	SMOS SMAP	5-50 km	microwave	Cropland Extent	Daily	all year
	Moderate Resolution Sampling (10 to 100m)						
4	Landsat 7/8 (30m) Sentinel-2A/2B (10-20m)	ResourceSat-2 (56m) CBERS-4 (20-40m)	10-70m	optical	Cropland Extent	Monthly (min 2 out of season + 3 in season). Required every 1-3 years.	all year
5	Landsat 7/8 (30m) Sentinel-2A/2B (10-20m)	ResourceSat-2 (56m) CBERS-4 (20-40m)	10-70m	optical	Sample	~Weekly (8 days; min. 1 per 16 days)	growing season
6	Sentinel-1A/1B (C) Radarsat-2 (C), RCM (C) ALOS-2 (L)	RISAT-1/1A (C) RISAT-3 (L)	10-100m	SAR Dual Polarization	Cropland Extent or Sample	~Weekly (8 days; min. 1 per 16 days)	growing season
	Fine Resolution Sampling (5 to 10m)						
7	RapidEye	SPOT-5/6, SPOT-7 CBERS-4	5-10 m	VIS, NIR, SWIR	Cropland Extent	Monthly (min. 3 in season)	growing season
8	RapidEye	SPOT-5/6, SPOT-7 CBERS-4	5-10 m	VIS, NIR, SWIR	Sample	~Weekly (8 days; min. 1 per 16 days)	growing season
9	Sentinel-1A/1B (C) Radarsat-2 (C), RCM (C) ALOS-2 (L)	RISAT-1/1A (C) RISAT-3 (L)	5-10 m	SAR Dual Polarization	Cropland Extent or Sample	Monthly	growing season
	Very Fine Resolution Sampling (<5m)						
10		Pleiades, SPOT-6, SPOT-7	< 5 m	VIS, NIR	Cropland Extent	3 per year (2 in season + 1 out of season); Required every 3 years	all year
11		Pleiades, SPOT-6, SPOT-7	< 5 m	VIS, NIR	Refined Sample	1 to 2 per month	growing season

Table 4 GEOGLAM Phase 1 Target Product Observational Requirements Core and Contributing Data Streams

A summary of all data streams relevant to the GEOGLAM data strategy, including a summary of data policies and measurement capabilities, can be found in Appendix B.

4.3 Individual Roles of the Data Streams

The requirements outlined in Section 3.2 can be addressed by a combination of data streams from four basic instrument classes: coarse, moderate, fine and very fine resolution data streams.

Coarse Resolution: > 100m

MODIS will be the main workhorse for coarse resolution optical, thermal IR, and SWIR during GEOGLAM Phase 1. There are known continuity concerns, with **Terra and Aqua**

operating well past their end of design life (expected >2020), and so contributing continuity options such as **Suomi-NPP**, and **VEGETATION** on **SPOT-5** and **Proba-V** will also be evaluated. The future Sentinel-3A mission will be considered after 2015.

TRMM, Aqua, GPM and GCOM-W1 will provide the required microwave data stream for precipitation data with GCOM-W2 as a future continuity option. TRMM, Aqua and GCOM-W1 will provide the required microwave datastream for soil moisture with **SMOS** as a contributing option, and **SMAP** and GCOM-W2 as potential future options.

MODIS (Terra and Aqua) *Requirements #1 and #2*	**Standard products utilised at a daily frequency over the cropland extent to provide optical, thermal IR, and SWIR data streams.**
GCOM-W *Requirement #3*	Utilised at a daily frequency over the cropland extent to provide a microwave data stream.
Contributing	Suomi-NPP, SPOT-5, Proba-V, SMOS (microwave)
Future	Sentinel-3A, SMAP (microwave)

Table 5 GEOGLAM Phase 1 Coarse Resolution (>100m) Data Streams

Moderate Resolution: 10 to 100m

It is expected that **Landsat**, along with the **Sentinel-2** satellites (once operational), will be the optical workhorses of GEOGLAM, providing moderate resolution coverage on a global scale. **Landsat** is available for GEOGLAM Phase 1, while **Sentinel-2A** (currently planned for launch not before 30th of April 2015) will be available at the start of Phase 2. **RESOURCESAT-2** represents a contributing optical source which could be evaluated if the data are consistently available over the test sites. The requirement for annual crop extent optical data is potentially reduced by plans to employ a sampling strategy, described in Section 3.4.

RADARSAT-2 and **Sentinel-1A** (launched April 2014) will be the radar (C-band) workhorses for early GEOGLAM phases, providing coverage of the Asia-RiCE Technical Demonstration sites. It is also expected that RISAT-1 (C-band) will make a contribution to Asia-RiCE monitoring, and will also be evaluated. As GEOGLAM moves towards operations, it is expected that radar data will be required for rice crop monitoring, with **Sentinel-1** expected to contribute a significant portion of the required C-band data. **ALOS-2** is a potential L-band data stream which will be evaluated once it becomes available (launched in May 2014, but still under checkout, with data policy to be confirmed). COSMO-SkyMed and TerraSAR-X data is being used by JECAM for X-band evaluations. Finally, limited coverage CBERS-4 data will be evaluated in the future.

Landsat-7 and Landast-8 *Requirements #4 and #5*	**Landsat will be used over cropland extent for 2-3 in season, and 2-3 out of season acquisitions, repeated at a minimum every 1-3 years, annually optimal. The Landsat data will also be used as a part of the sampling strategy discussed in Section 3.4 every two weeks.**
RADARSAT-2, Sentinel-1A *Requirement #6*	A combination of these two sensors will provide C-band coverage over Asia-RiCE sampling sites. For 2014-2015, wall-to-wall coverage over Thailand is being planned.

Contributing	ALOS-2, RISAT-1, RESOURCESAT-2, COSMO-SkyMed, TerraSAR-X
Future	Sentinel-2A, RCM, RISAT-1A, CBERS-4

Table 6 GEOGLAM Phase 1 Moderate Resolution (10 to 100m) Data Streams

Fine Resolution: 5 to 10m

RapidEye will be used as a part of a sampling strategy being put in place to reduce the reliance on crop extent coverage by the Landsat (and eventually Sentinel-2) data streams.

RapidEye *Requirements #7 and #8*	**RapidEye will provide optical and SWIR data over** refined **sampling sites (r**s and rs2) **discussed in Section 3.4. Data over rs sites will be monthly, three times in season. Data over rs2 sites will be weekly, a minimum of once every two weeks.**
Contributing	SPOT-5 (ending 2015), SPOT-6
Future	SPOT-7, CBERS-4

Table 7 GEOGLAM Phase 1 Fine Resolution (5 to 10m) Data Streams

Very Fine Resolution: <5m

At present, no very fine resolution core data streams have been identified, though **Pleiades** could be evaluated as a part of early GEOGLAM phases.

No Missions *Requirement #9*	**-**
Contributing	Pleiades, SPOT-6, Worldview-2/3 are all under consideration
Future	SPOT-7

Table 8 GEOGLAM Phase 1 Very Fine Resolution (<5m) Data Streams

5 2014-2015 Implementation

5.1 Introduction and Overview

This section outlines by agency, the Core, Contributing and Future data streams required to support the implementation, and address the requirements defined in Section 3 following the strategy defined in Section 4. It is intended to give guidance to satellite operators and EO data providers.

5.2 Primary Data Stream Implementation Actions

Table 9 indicates the Core data streams required for the successful implementation of GEOGLAM Phases 1 and 2. Agencies are requested to make these data streams available to the GEOGLAM community to the greatest extent possible. A detailed breakdown by data stream can be found in Appendix C.

NASA	USGS	CSA	ESA	JAXA	DLR
Aqua and Terra (MODIS) standard optical land products and TRMM, Aqua and GPM standard precipitation products	Landsat standard products maximizing the LTAP for increased acquisitions over cloudy regions	RADARSAT-2 for Asia-RiCE regions	Sentinel-1A for Asia-RiCE regions	GCOM-W1 standard products	Support in sourcing RapidEye standard products for sampling

Table 9 Core Data Stream Support by Agency for GEOGLAM Phases 1 and 2

While standard Landsat products are the core data stream for moderate resolution optical sampling for early GEOGLAM phases, in areas of extreme cloudiness, or for weekly cloud-free images (requirement #5), there may be a need to consider requesting the modification of the Landsat Long Term Acquisition Plan (LTAP) for additional acquisitions.

5.3 Contributing Data Stream Implementation Actions

Table 10 indicates Contributing data streams to be evaluated for their potential to contribute to GEOGLAM, and in order to assure continuity of future data streams. Requests for data from these data streams should be coordinated individually. Agencies are asked to confirm the appropriate point of contact for the coordination of requests.

NASA	ESA	CNES	ISRO	DLR
Suomi-NPP by request	Proba-V VEGETATION by request	SPOT-5 VEGETATION by request	RISAT-1 by request	TerraSAR-X by request
	SMOS by request	SPOT-5 and SPOT-6 (HRG) by request	ResourceSat-2 (AWIFS) by request	
		Pleiades 1A/1B		

		(HIRI) by request		

Table 10 Contributing Data Streams for Evaluation by Agency for early GEOGLAM phases

5.4 Future Data Stream Implementation Actions

Table 11 indicates Future data streams, which may be evaluated in the future for their potential to contribute to GEOGLAM, and in order to assure continuity of current data streams. Some of these data streams may not be available during early GEOGLAM phases, and requests for data from these data streams should be coordinated individually. Agencies are asked to confirm the appropriate point of contact for the coordination of requests.

NASA	ESA	CSA	CNES	ISRO	JAXA	INPE
SMAP by request when available	Sentinel-2A when available	RCM for Asia-Rice regions	SPOT-7 (HRG) by request	RISAT-1A, by request	ALOS-2 by request for evaluation; confirmation of data policy required	CBERS-4 when and where available
	Sentinel-3A when available				GCOM-W2 standard products	

Table 11 Potential Data Streams for Evaluation by Agency for GEOGLAM Phase 1 Areas of Interest

6 Next Steps

As outlined in Section 1.5, GEOGLAM has proposed a Development Phase and culminating in an Operational Phase starting in the 2018 timeframe. At present, CEOS is responding to the GEOGLAM IP (July 2013), and is focused on near term activities in 2014-2015. This enables CEOS to support the evolution of GEOGLAM, but ensures that support is commensurate with the development and maturation of GEOGLAM.

It is anticipated that the GEOGLAM Implementation Plan will be updated by the end of 2014, and that the Strategy will need to be updated in response.

Several follow-up items for CEOS are proposed:

- That the 28th CEOS Plenary (October 2014, Tromsø, Norway) endorse the continuation of the CEOS ad hoc Working Group on GEOGLAM to continue to manage CEOS support and interactions with GEOGLAM.
- That CEOS identify and endorse the nominated GEOGLAM lead agencies (NASA, CNES) to ensure strong leadership going forward.
- That the Working Group will coordinate implementation of the Strategy, and provide an update to SIT-30 (March-April 2014, Paris, France). The update will cover the implementation of the CEOS Acquisition Strategy for GEOGLAM, and development progress of GEOGLAM, and the GEOGLAM Implementation Plan.
- That the Working Group will provisionally target the development of an update to the Strategy for endorsement at the 29th CEOS Plenary (2015, Japan). This update would include changes to reflect the updated GEOGLAM IP.

Appendix A: JECAM Test Sites

The following table summarizes data used by JECAM test sites in 2013 and 2014. The data was compiled in April 2014 for the JECAM Annual Report.

	Low/Moderate Optical						Moderate SAR				Fine/Very Fine Optical					
JECAM Site	**Terra/Aqua**	**Landsat**	**ResourceSat-2**	**EO-1**	**HJ-1**	**UK-DMC-II**	**RADARSAT-2**	**TerraSAR-X**	**Cosmo-SkyMed**	**ALOS**	**RapidEye**	**SPOT**	**Pléaides**	**Quickbird**	**Worldview-2**	**Formosat-2**
Argentina	x	x	x			x	x	x	x	x	x	x		x		
Belgium/France		x					x				x	x				
Brazil – Eucalyptus	x	x								x				x	x	
Brazil – Tapajos	x	x									x					
Burkina Faso		x									x	x	x			
Canada/Red River		x	x			x	x	x			x	x				
Canada/South Nation		x	x			x	x	x			x	x				
China/Heilongjiang	x	x			x	x	x	x	x							
China/Jiangsu							x									
China/Shandong	x	x			x	x	x	x	x		x	x				
France		x				x						x	x			x
Italy Apulian Tavoliere		x							x	x	x	x		x	x	
Madagascar		x										x	x			
Mexico	x	x	x				x				x	x		x		
Morocco	x	x										x		x		
Paraguay		x				x	x				x	x				
Russia	x	x														
South Africa	x	x									x	x				
Taiwan	x	x		x			x	x			x	x		x		x
Tanzania															x	
Tunisia	x	x						x	x			x		x		
Ukraine	x	x	x	x			x				x	x				
U.S.A.		x				x						x				

Table 12 Types of EO Data Used at each JECAM Test Site in 2013 and 2014

Appendix B: Summary of GEOGLAM Data Streams

Category	Mission	Instrument	Agency	Launch	Policy	Repeat or Revisit *	Swath	Resolution
Optical - Coarse Resolution (>100m)								
Core	Terra	MODIS	NASA	Dec 1999	Open	1 day	2330 km	250, 500, 1000m
Core	Aqua	MODIS	NASA	May 2002	Open	1 day	2330 km	250, 500, 1000m
Contributing	SPOT-5	VGT-2	CNES	May 2002	Fee	1 day	2276 km	1150 m
Core	Suomi-NPP	VIIRS	NASA	Oct 2011	Open	1 day	3000 km	375, 750m
Contributing	Proba-V	VGT-P	ESA/BELSPO	May 2013	Fee *	1 day	2285 km	100, 333, 1000m
Core	Sentinel-3A	SLSTR	ESA	Sep 2015	Open	4 days	1675 km	500, 1000m
Optical - Moderate Resolution (10 to 100m)								
Core	Landsat-7	ETM+	NASA/USGS	Apr 1999	Open	16 days	183 km	15, 30, 60m
Potential	NMP-EO-1	ALI	NASA	Nov 2000	Open	16 days	185 km	10, 30m
Potential	HJ-1A	HSI	CRESDA/CAST	Sep 2008	Open	31 days	50 km	100m
Potential	UK-DMC2	SLIM-6-22	UKSA	Jul 2009	Fee	7 days	640 km	22 m
Potential	Deimos-1	SLIM-6-22	Commercial	Jul 2009	Fee	7 days	640 km	22 m
Contributing	Meteor-M N1	KMSS	ROSKOSMOS	Sep 2009	Open	~ 4 days *	900 km	60 m, 120 m
Contributing	ResourceSat-2	AWiFS	ISRO	Apr 2011	Fee	5 days	740 km	56 m
Potential	ResourceSat-2	LISS-3	ISRO	Apr 2011	Fee	24 days	141 km	23.5 m
Core	Landsat-8	OLI + TIRS	NASA/USGS	Feb 2013	Open	16 days	183 km	15, 30, 100m
Contributing	CBERS-4	WFI-2	INPE/CAST	Dec 2014	TBD	5 days	866 km	73 m
Contributing	CBERS-4	MUXCam	INPE/CAST	Dec 2014	TBD	26 days	120 km	20 m
Contributing	CBERS-4	IRS (China)	INPE/CAST	Dec 2014	TBD	26 days	120 km	40, 80m
Core	Sentinel-2A	MSI	ESA	Jun 2015	Open	10 days	290 km	10, 20m
Core	Sentinel-2B	MSI	ESA	Jun 2016	Open	10 days	290 km	10, 20m
Optical - Fine Resolution (5 to 10m)								
Contributing	SPOT-5	HRG	CNES	May 2002	Fee	26 days	120 km	5, 10m
Potential	Formosat-2	MS	NSPO	May 2004	Fee	1 day *	24 km	8m
Core	RapidEye	REIS	DLR	Aug 2008	Fee	1 day *	78 km	6.5 m
Potential	ResourceSat-2	LISS-4 (SMX)	ISRO	Apr 2011	Fee	24 days	23 km	5.8 m
Potential	SPOT-6	HRG	Commercial	Sept 2012	Fee	~1 day *	60 km	8m
Potential	SPOT-7	HRG	Commercial	Jun 2014	Fee	~1 day *	60 km	8m
Potential	CBERS-4	PanMUX (China)	INPE/CAST	Dec 2014	TBD	26 days	60 km	5, 10m
Optical - Very Fine Resolution (<5m)								
Potential	IKONOS-2	OSA	Commercial	Sep 1999	Fee	3-5 days *	11.3 km	0.8, 3.2m
Potential	Formosat-2	Pan	NSPO	May 2004	Fee	1 day *	24 km	2m
Potential	GeoEye-1	GIS	Commercial	Sep 2008	Fee	~3 days *	15.2 km	0.5, 1.7m
Potential	WorldView-2	WV110	Commercial	Oct 2009	Fee	~1 day *	16.4 km	0.5, 1.9m
Potential	Quickbird		Commercial		Fee	~1 day *		0.65m
Potential	Pleiades-1A	HiRI	CNES	Dec 2011	Fee	1-2 days *	20 km	0.7 m
Potential	Pleiades-1B	HiRI	CNES	Dec 2012	Fee	1-2 days *	20 km	0.7 m
Potential	SPOT-6	HRG	Commercial	Sept 2012	Fee	~1 day *	60 km	2m
Potential	SPOT-7	HRG	Commercial	Jun 2014	Fee	~1 day *	60 km	2m
C-Band SAR								
Contributing	Radarsat-2	SAR-C	CSA	Dec 2007	Fee	1-6 days *	8 to 500 km	0.8 to 100 m
Contributing	RISAT-1	SAR	ISRO	Jul 2011	Fee	12 days	30 to 240 km	3 to 50 m
Core	Sentinel-1A	SAR	ESA	Apr 2014	Open	12 days	80, 250, 400 km	9, 20, 50 m
Core	Sentinel-1B	SAR	ESA	Sep 2015	Open	12 days	80, 250, 400 km	9, 20, 50 m
Contributing	RISAT-1A	SAR	ISRO	2015	Fee	12 days	30 to 240 km	3 to 50 m
Contributing	RCM	SAR-C	CSA	2018	Fee	4 days *	5 to 500 km	1 to 100 m
L-Band SAR								
Core	ALOS-2	PALSAR-2	JAXA	May 2014	TBD	14 days	25 to 490 km	10 to 100 m
Potential	SAOCOM-1A	SAR	CONAE/ASI	2016	TBD	16 days	20 to 350 km	10 to 100 m
Potential	SAOCOM-1B	SAR	CONAE/ASI	2017	TBD	16 days	20 to 350 km	10 to 100 m
Contributing	RISAT-3	SAR	ISRO	2016	Fee	12 days	10 to 120 km	1.5 to 35 m
X-Band SAR								
Contributing	TerraSAR-X	SAR	DLR	Jun 2007	Fee	11 days	5 to 100 km	1, 3, 16 m
Potential	COSMO SkyMed	SAR-2000	ASI	Jun 2007	Fee	5 days *	10 to 200 km	1 to 100 m
Contributing	TanDEM-X	SAR	DLR	Jun 2007	Fee	11 days	5 to 100 km	1, 3, 16 m
Soil Moisture and Precipitation								
Core	TRMM	PR/TMI (Rad/MW)	NASA	Nov 1997	Open	< 2 days *	215 to 790 km	5 / 18 km
Core	Aqua	AMSR-E (MW)	NASA	May 2002	Open	1-2 days *	1445 km	5 to 50 km
Core	SMOS	MIRAS (L-Band MW)	ESA	Nov 2009	Open	1-2 days *	1050 km	15 km
Core	GCOM-W1	AMSR-2 (MW)	JAXA	May 2012	Open	1-2 days *	1450 km	5 to 50 km
Core	GPM Core	DPR/GMI (Rad/MW)	NASA/JAXA	Feb 2014	Open	< 2 days *	125 to 885 km	5 / 10 km
Core	SMAP	SMAP (L-Band MW)	NASA	Nov 2014	Open	1-2 days *	1000 km	10 to 40 km
Core	GCOM-W2	AMSR-2 (MW)	JAXA	2016	Open	1-2 days *	1450 km	5 to 50 km

Table 13 Summary of GEOGLAM Core, Contributing and Future Data Streams

** Proba-V data carries a fee below 300m, 1000m data is open.*

Appendix C: Data Stream Detailed Agency Implementation Requests

The following tables summarize detailed agency requests to support GEOGLAM data needs. These tables only represent areas where CEOS Agency interaction is needed to support data access.

Core Data Streams	
Landsat-7 / Landsat-8 **USGS, NASA**	Landsat is the Primary data stream for moderate resolution optical sampling for GEOGLAM. In areas of extreme cloudiness, or for weekly cloud-free images (requirement 5), there may be a need to explore modification of the LTAP to provide additional acquisitions.
Sentinel-1A ***ESA***	Sentinel-1 launched in April 2014 and has completed its commissioning phase successfully at the end of September. This is a core dataset for Asia-RiCE and dedicated data have been already acquired. Data as early as possible during the ramp-up and operations phases is requested.
RapidEye ***Commercial***	The RapidEye Constellation is the core source of fine resolution optical sampling for GEOGLAM Phase 1. These data are available commercially, and support from DLR and other agencies may enable the acquisition and evaluation of sample datasets. To date, RapidEye data has been provided to many JECAM sites as a commercial purchase and part of SPOT4-Take5. Evaluation data is possible for free and DLR support is needed for 2015 (before Sentinel-2 era).
Contributing Data Streams	
Proba-V and SPOT-5 ***ESA and CNES***	There is a great interest in data from the Vegetation (VGT) instrument. Currently, only the 1000m data is free. 333m data is free for data older than 1 month or for BELSPO approved projects. 100m data products are under investigation. Availability of daily and 10-day composite data would greatly improve global crop masks and the measurement of crop condition and biophysical variables for short time periods (within 48 hours). Support is needed from ESA/BELSPO (Proba) and CNES/BELSPO (SPOT).
SPOT-5 ***Commercial***	SPOT-5 (HRG) is a contributing data source. These data are also fee-based, but support from CNES may allow acquisition and evaluation of free sample datasets. SPOT4-Take5 (2013) project has provided many images for JECAM but more are needed for 2015 (SPOT5-Take5). Older (>5 yrs) data is free, but processing will not be complete until 2017.
RESOURCESAT-2 ***ISRO***	Consistent acquisitions over multiple sites are needed to completely evaluate the AWIFS dataset as a possible supplement to the core moderate resolution datasets. ISRO has already acquired scenes over Argentina in 2011-2013 in support of support JECAM.

TerraSAR-X ***DLR***	Sample products from TerraSAR-X are desired for evaluation by the Asia-RiCE team for rice crop monitoring. DLR is working to make this data available through applications development channels. Data has been purchased by China, Canada, Taiwan, Argentina and Tunisia. There is a need for consistent TerraSAR data acquisitions for adequate multifrequency evaluation over multiple JECAM sites.
RISAT-1 ***ISRO***	Sample products from RISAT-1 are desired for evaluation by Asia-RiCE over the Technical Demonstration sites during early GEOGLAM phases. Some data has been acquired, but it is not currently available for evaluation.
Pleiades ***Commercial***	CNES has provided data to Burkina, France and Madagascar JECAM sites. More data is needed for all JECAM sites to evaluate field campaign support and detailed crop type mapping in small fields.
ALOS-2 ***JAXA***	It is expected that ALOS-2 will be available in late 2014. Potential applications for Asia-RiCE, and other crop types should be considered, though data policy and access remains to be clarified.
Future Data Streams	
Sentinel-2A ***ESA***	It is expected that Sentinel-2A data will be available in mid 2015. GEOGLAM and JECAM sites are requested to be included in early coverage plans.
Sentinel-3A ***ESA***	It is expected that Sentinel-3A data will be available in late 2015. GEOGLAM and JECAM sites are requested to be included in early coverage plans.
RISAT-1A ***ISRO***	Sample products from RISAT-1A are desired for evaluation by Asia-RiCE over the Technical Demonstration sites during future GEOGLAM phases.

Table 14 Data Stream Detailed Agency Implementation Requests