GEO FOREST CARBON TRACKING
2011 DATA REQUIREMENTS FOR NATIONAL DEMONSTRATORS
FOR THE PERIOD May – DECEMBER 2011

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GEO FOREST CARBON TRACKING

GROUP ON
EARTH OBSERVATIONS

List of contents

Executive Summary

The GEO Task on Forest Carbon Tracking seeks to demonstrate the feasibility of forest monitoring information generated from coordinated Earth observation as input to future national forest and carbon monitoring systems. This Task was assigned the highest priority in 2009 by both GEO and CEOS, in particular to demonstrate the value of linking coordinated acquisition of satellite data with standardised processing methods, forest inventory and ecosystem models.

To provide early proof that global, annual, medium resolution wall-to-wall coverage of the world's forests is feasible through coordinated satellite data acquisition strategies – combining both Optical and SAR sensors, the GEO Task on Forest Carbon Tracking requested the assistance of CEOS space agencies in the targeted acquisition of satellite data over key areas of interest. To show rapid progress, the Task seeks to demonstrate this capability initially at selected national scales – in a number of "National Demonstrator (ND)" countries, where inter-governmental agreements already exist to conduct these studies.

In the Rio Statement issued during the CEOS Plenary 2010 the continuation of CEOS to focus on high-priority initiatives and implement strategies for their realization in the coming years was confirmed for GEO Forest Carbon Tracking and the GEO Global Forest Observations Initiative (GFOI).

This document is in continuation of the 2009 and 2010 Data Requirement Document and developed in accordance with WP1000 of the GEO FCT Implementation Plan, which calls for the definition of satellite data requirements and securing data continuity. The 2011 edition takes into account findings and results from the 2nd FCT Science and Data Summit in February 2011 at FAO in Rome. It outlines the satellite data requirements for the period May to December 2011.

1 Introduction

1.1 Context

Urgent coordinated international action and monitoring has been called for by the Intergovernmental Panel on Climate Change (IPCC), which has documented the need for mitigation of global warming driven by anthropogenic greenhouse gas emissions. The IPCC has shown that global carbon emissions could be reduced by as much as 20% by reducing deforestation and forest degradation alone. To achieve this, global agreement on robust and comparable national monitoring, reporting and verification (MRV) systems will be necessary, so that certainty can be provided (i.e. in terms of robustness and consistency) in the various national forest carbon emissions estimates. GEO rose to the challenge in late 2008 and formally established a Forest Carbon Tracking Task, to demonstrate that satellite observations of forests can provide such robust and reliable contributions to national forest monitoring programs and reporting schemes.

Therefore the Task was assigned the highest priority in 2009 and 2010 by both GEO and CEOS. If successful, the initiative could see global forest monitoring emerge as the first international application of Earth observation outside meteorology to achieve operational status. In brief, Forest Carbon Tracking is seen by many as the biggest opportunity for the promotion of satellite Earth observations for public good applications for the foreseeable future – and with the potential of providing a major success story for GEO in its attempts to implement the GEOSS, including through recognition within UN frameworks.

1.2 The CEOS Role

CEOS and member agencies' support for this task is pivotal. In the CEOS 'Communiqué on Forest and Carbon Monitoring' of March 4th, 2009, willing member agencies have agreed "… to ensure availability of current and future data supply on a basis adequate for the implementation and operation of continuous services.", associated with the satellite data needs expressed by the GEO Forest Carbon Tracking Task. The Task team therefore asks for CEOS member agencies' assistance in meeting these challenges.

The coverage (global) and update frequency (at least annual) ultimately required in support of post-Kyoto climate agreement frameworks will require satellite data as a technical foundation. Broadly accessible supply of mid-resolution satellite data, both optical and radar, needs to be shown to be affordable, continuous, and supported by processing. The data must be relevant for derivation of mid-resolution forest cover information (areas of deforestation and degradation). Jointly, we need to demonstrate surety of information supply as the first step to showing the policy community both feasibility and commitment.

Achieving the required coverage, and facilitating participation of as many contributing space agencies and missions as possible, will require the technical process to include a wide range of both optical and SAR data. Optical mid-resolution data have an important role to play in establishing baselines since the

1970s, as well as continuity in observation, specifically as provided by the Landsat satellite programme. SAR data are regarded as crucial in many tropical areas where cloud cover can be especially prevalent.

CEOS is critical for the Task, in coordinating the necessary satellite data acquisitions, so that we can jointly demonstrate the ability to provide medium, and fine resolution satellite data in support of climate policy frameworks. It needs to be shown that interoperability and complimentarity among different kinds of radar and optical sensors is a very practical solution for achieving consistent and repeatable results – all to provide confidence to the climate negotiators and that negotiated agreements can rely on viable MRV systems which will be supported by space agency programmes.

In 2009, the GEO Forest Carbon Task stated that an initial CEOS coordination effort to achieve satellite data coverage for a number of "National Demonstrator (ND)" activities – meaning wall-to-wall coverage is required for a country (or large region at least) from each of South America, Africa, Asia and Oceania. And further, that intensive data acquisitions will be requested for certain local validation and intensive observation sites ("Validation sites") within those countries, in support of technical comparison and validation work. The CEOS agencies responded favourably to this request and initiated a comprehensive and coordinated acquisition effort over the National Demonstrators in the period June through September, 2009, in accordance with the FCT data requirements specifications. This effort has been repeated on a semi-annual basis and seeks now continuation with an updated strategy. Other space data providers are also invited to participate with coordination support provided by the CEOS team.

In the Rio Statement issued during the CEOS Plenary 2010 the continuation of CEOS to focus on high-priority initiatives and implement strategies for their realization in the coming years was confirmed for Forest Carbon Tracking. Provision of coordinated satellite data observations and processing in support of the GEO Global Forest Observations Initiative (GFOI), to foster sustained availability of satellite and ground observations in support of national forest information systems, and support countries in the use of observations for their national forest information systems. The GFOI will support the long-term observation needs of the United Nations Framework Convention on Climate Change (UNFCCC) and the implementation of a REDD+ mechanism.

1.3 Contents

This document is the output from the GEO CT Implementation Plan Work Package 1200, and defines the specific acquisition requirements from May to December 2011 based on experience from previous campaigns and the two GEO-FCT Science and Data Summits. Section 2 summarises the concept of National Demonstrators, their planed expansion and the associated information requirements that are expected to be addressed through the FCT Task. Section 3 gets into technical details about the required modes for optical and SAR sensors respectively – and concludes with requirements for data from specific agencies/missions.

1.4 Authors

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2 National Demonstrators and Validation sites

2.1 Introduction

To provide proof that global, annual, wall-to-wall coverage of the world's forests is feasible through coordinated satellite data acquisition strategies – combining both Optical and SAR sensors, the GEO Task on Forest Carbon Tracking has required the assistance of CEOS space agencies in the targeted acquisition of satellite data over key areas of interest. To show rapid progress, the Task seeks to demonstrate this capability initially at national scales – in a number of selected countries (called here "National Demonstrators" (NDs)) spanning different continents. These demonstrations are intended to show the feasibility of inclusion of satellite-based forest monitoring information as compliment to forest-inventory-based and/or ecosystems modelling of carbon emissions, in future national carbon accounting systems.

2.2 Selection criteria

Countries (or large regions) are being selected based on a number of key criteria listed in the FCT Implementation Plan WP2000, including:

- they represent countries with a stated intent to develop national forest monitoring systems;
- in-country government agency or ministry participation is essential to optimise prospects for the GEO Task leading to establishment of such systems;
- they represent large areas (to demonstrate repetitive, wall-to-wall, accurate wide-area forest mapping capabilities;
- where relevant, donor countries/organisations have been clearly identified for long-term involvement, should support be required;
- they include recognised local scientific study 'Validation sites' with appropriate in-situ observations.

2.3 National Demonstrators and Validation sites

Based on the above criteria a list of seven initial priority NDs were selected for coverage during then period June 2009 – May 2010 (**black**), and from June 2010 onwards three additional ones (**blue**). Nepal is a candidate country (**red**) in 2011.

Americas: Mexico, Brazil, Guyana, Peru, Colombia

Africa: Cameroon, Tanzania, D.R. Congo

Asia: Indonesia (Borneo/Kalimantan, Sumatra), Nepal

Oceania: Australia (Tasmania island)

The seasons with prevailing low precipitations are indicated in Table 1.

National Demonstrator	Dry Seasons
Brazil	July / August for Xingu, none for overall Amazon basin
Guyana	July - September
Mexico	January - May
Peru	May - September in the Andes, rain (Selva) and cloud forest (Montaña) experiences a hot, humid tropical climate, whereas the coastal zone is dry
Colombia	generally high humidity, but less rainfall during December - March and July / August
Cameroon	November - March and additionally in the South from June - August
Tanzania	December - March and June - October
DR Congo	generally tropical wet climate, with 2 dryer seasons December - February and May- July at the equator and one dry season (May - Sept) in the South
Borneo (Indonesia)	June - September, but strong variations over the island
Sumatra (Indonesia)	generally tropical wet climate, with less precipitation in July - September
Tasmania	February / March (cool temperate climate)

Table 1: Prevailing dry seasons in NDs

Those periods are specifically favourable for acquisition by optical sensors (outlined in section 3) , or when deforestation events need to be identified quickly. Therefore over coming years, satellite data acquisition time windows would be optimised for each region to provide the maximum benefit from the point of view of capturing key forest-change events.

In each of the NDs several validation sites (VS) have been identified. Their purpose is manifold ranging from validation of the remote sensing-derived products, to accuracy assessments, calibration of forest carbon models as well as development of new processing algorithms and data integration approaches (cf. FCT Continuous Improvement Program – WP5000).

Table 2 provides the location of the associated Validation sites, each a circle with 20 km radius. Information on the VSs include a priority level, in case of acquisition resource constraints. The listed VSs are requested to be covered on a semi-monthly/bi-monthly basis during the remainder of 2011 (outlined in section 3).

ND	VS	Name	lat	long	Priority
Mexico	MEX-1	Chiapas-1	N17.00	W93.55	1
	MEX-2	Chiapas-2	N16.33	W90.65	2
	MEX-3	Campeche	N18.52	W92.25	2
	MEX-4	Oaxaca	N17.58	W96.46	2
	MEX-5	Hidalgo	N20.62	W98.62	1
	MEX-6	Nuevo León	N25.43	W98.52	2
	MEX-7	Michoacán	N19.57	W101.18	2
Colombia	COL-1	Andes-Huila	N1.74	W76.18	1
	COL-2	Choco-Cajambre	N3.40	W77.18	1
	COL-3	Pacifico-Bajo_Mira	N1.65	W78.76	2
	COL-4	Amazonia-Tinigua	N2.17	W74.15	1
	COL-5	Andes-Antioquia	N7.83	W76.45	2
Peru	PER-1	Bosques de Pomac	S6.48	W79.77	1
	PER-2	Alpahuayo Mishana	S3.93	W73.54	1
	PER-3	Manglares de Tumbes	S3.55	W80.32	2
	PER-4	San Matias San Carlos	S10.77	W74.93	2
	PER-5	Cordillera Azul	S6.97	W76.11	2
	PER-6	Cuenca baja del VRAE	S11.68	W73.84	2
	PER-7	Ambito de Barranquita	S6.12	W76.17	2
Brazil*	BRAX-1	Xingu-1	S11.91	W52.58	1
	BRAX-2	Xingu-2	S13.06	W52.38	1
Guyana	GUY-1	GFC-1	N6.00	W60.00	1
	GUY-2	GFC-2	N7.00	W59.00	1
	GUY-3	GFC-3	N3.00	W59.00	2
	GUY-4	Fairview	N4.65	W58.69	2
	GUY-5	Crashwater-N. Rupununi	N3.86	W59.05	2
	GUY-6	Apoteri	N4.04	W58.59	2
Cameroon	CAM-1	East Region (Ndelele)	N3.92	E14.99	2
	CAM-2	Adamawa Region (Tibati)	N6.52	E12.48	2
	CAM-3	Adamawa Region (Mbakaou)	N6.22	E12.76	1
	CAM-4	Pallisco Concession Area	N3.21	E13.74	1
	CAM-5	Direct Biomass Assessment 2	TBD in July 2011		2
	CAM-6	Direct Biomass Assessment 3	TBD in July 2011		2
D.R. Congo	DRC-1	Luki Reserve	S5.67	E13.17	2
	DRC-2	Bikoro	S0.25	E18.67	2
	DRC-3	Lisala Bumba	N2.83	E21.83	1
	DRC-4	Kisangani Sud	N0.17	E25.83	2
	DRC-5	Basankusu	N0.83	E20.17	2
	DRC-6	Mambasa Sud	N1.17	E29.67	1
	DRC-7	Oshwe	S4.17	E20.33	2
	DRC-8	Lubumbashi	S11.0	E27.33	2
Tanzania	TNZ-1	FAO_FRA-1	S4.00	E32.00	2
	TNZ-2	FAO_FRA-2	S10.00	E36.00	2
	TNZ-3	FAO_FRA-3	S10.00	E38.00	2
	TNZ-4	Nilo Forest Reserve	S4.92	E38.66	2
	TNZ-5	Amani	S5.13	E38.63	1
	TNZ-6	Liwale	S9.30	E38.00	1
Indonesia (Borneo)	BOR-1	E-Kalimantan/Sbh	N4.33	E117.01	2
	BOR-2	SW-Kalimantan	S1.82	E111.61	1
	BOR-3	SE-Kalimantan (KFCP REDD)	S2.24	E114.48	1
	BOR-4	C-Kalimantan/Srwk	N2.55	E115.08	2
	BOR-5	Berau	N1.91	E116.85	2
Indonesia (Sumatra)	SUM-1	Jambi REDD	S2.47	E101.53	1
	SUM-2	Harapan	S2.20	E103.38	1
	SUM-3	Riau Pelalawan	N0.0	E102.00	2
Tasmania	AU-1	Mathinna	S41.37	E147.76	1
	AU-2	Takone	S41.19	E145.60	2
	AU-3	Warra	S43.11	E146.90	2

*Table 2 Validation sites (VS) locations over which high repetition acquisitions are requested in addition to the dual-season ND coverage. * Xingu in Brazil is a methodology development site*

Nepal is a current candidate for inclusion into the GEO FCT task as National Demonstrator. In Table 3 Validation Sites have been defined for Nepal.

ND	VS	Name	lat	long	Priority
Nepal	NEP-1	Bharatpur	N27.54	E84.60	1
	NEP-2	Kathmandu/Shivapuri	N27.80	E85.41	1
	NEP-3	Annapurna	N28.33	E84.16	2
	NEP-4	Bhang / Bajura	N29.68	E81.31	2
	NEP-5	Western Terai	N28.82	E80.82	2
	NEP-6	Gulmi / Baglung	N28.09	E83.28	2
	NEP-7	Taplejung	N27.29	E87.54	2

Table 3 Validation sites (VS) locations in Nepal as potential new ND

The current FCT data acquisition strategy foresees progressive increase of systematic acquisitions over key strategic areas. This includes the overall Congo Basin and UN-REDD pilot countries[1] until 2012.

[1] Bolivia, Cambodia, Democratic Republic of the Congo (DRC), Ecuador, Indonesia, Panama, Papua New Guinea, Paraguay, the Philippines, Solomon Islands, Tanzania, Viet Nam and Zambia

3 CEOS Coordination of Satellite Data Acquisitions

3.1 Acquisition Approach

As defined in the FCT Task Implementation Plan, a key component in the establishment of long-term national monitoring systems for Forest Carbon Tracking is the development of an operational satellite data acquisition strategy and plan that provides coordinated and consistent multi-sensor acquisitions, by both optical and SAR sensors, over the global forest cover on a repetitive basis, for linkage to integrated forest inventory and emissions modelling frameworks. These acquisitions are designed to serve both the expanding operational wall-to-wall annual forest monitoring needs by countries (WP1500 and WP3000), as well as the "Continuous Improvement" and research goals by the FCT (WP5000).

Given the need to show early progress, the development has been being carried out in a number of successive steps, with the aim of having an operational strategy for global forest carbon monitoring in place by 2012.

- Phase 1 – Initial Demonstration Phase (June 2009–May 2010): Demonstration of coordinated acquisitions over a small number of National Demonstrators and associated Validation sites. Phase 1 concluded with the 1st Science Data Summit (May 2010) with a first scientific evaluation of acquired multi-sensor data and amendments towards a refined acquisition strategy.
- Phase 2 – Expanded Demonstration Phase (June 2010–December 2012): Coordinated acquisitions over National Demonstrator countries on a semi-annual basis. Minor modifications to the acquisition strategy if required. 2011 is as well the planning phase and 2012 the start-up phase for GFOI.
- Phase 3 – Operational Phase (2013 onwards): Systematic acquisitions over the global forest cover on a continuous basis (GFOI).

Phase 1 - Initial Demonstration: The first step comprised the execution of near-simultaneous wall-to-wall optical and SAR satellite data acquisitions over the first set of seven nominated National Demonstrator regions, which were undertaken in two campaigns (June-September 2009 and January-April 2010) - to capture a dual-season coverage over each of the NDs to maximise thematic contents and improving classification accuracies. These wall-to-wall acquisitions were supplemented by a series of local-scale observations at monthly/bi-monthly repeat frequency during the period January–May, 2010 over a limited number of selected Validation sites within the ND regions.

On a best efforts basis, and in close coordination by CEOS with 5 SAR agencies and the LSI team, the aim of the Phase 1 campaign has been to coordinate the collection of consistent, medium resolution wall-to-wall national-scale coverage over each of the selected regions, with contributions from each supporting sensor type (optical – various sensors, and SAR: L-, C- and X-band sensors).

As the NDs are predominantly located in the tropical zone, cloud cover poses a serious limitation to the collection of consistent **optical** coverage within the initial time windows. Satellite resources permitting, contributing optical sensors should therefore preferably be programmed as soon as possible and optimally during for **local dry season** and every cycle, to reduce cloud impact.

Multi-sensor **SAR** acquisitions are requested to be scheduled as close in time to each other as possible. Since clouds pose no limitation, narrow time windows (July-August, and January-February) have been set to attain near-simultaneous multi-sensor wall-to-wall snapshots of the entire NDs. Acquisitions +/- 1 month from these windows were considered acceptable.

For comparison and interoperability reasons a main acquisition window for all types of sensors would we favourable. To ease the cloud coverage problem of optical sensors their acquisition period can be extended over these optimal windows.

Validation sites have been requested to be acquired on a high repetitive basis (2-8 weeks intervals) during the entire Phase 1 period for intensive analysis of sensor synergy and prototype product development.

The first GEO FCT **Science and Data Summit (SDS#1)** was held at Woods Hole Research Centre in May, 2010, when initial analysis of the multi-sensor data (primarily over a number of the Validation sites) acquired during Phase 1 had taken place by the FCT Product Development teams.

Phase 2 - Expanded Demonstration: The "GEO-FCT Data Requirement document - Mid 2010" was issued in May 2010, comprising refined acquisition requirements for the mid-2010 acquisition campaign, modified in accordance with the scientific guidelines from the first Science Data Summit (SDS#1), held in Woods Hole, May, 2010). The number of National Demonstrators was in 2010 increased from the initial 7 with another 4 regions, effectively doubling the demonstration area.

Data Requirement documents are issued by GEO-FCT on a semi-annual basis during Phase 2. As scientific analysis of the data acquired will continue, minor modifications to the acquisition strategy can be anticipated.

The second **GEO FCT Science and Data Summit (SDS#2)** was held at the Food and Agricultural Organisation FAO in Rome, February 2011. The meeting provided further insight to open science questions relating to the optimal utilisation of single and multi-sensor information for forest carbon tracking.

In terms of recommendations to CEOS, space agencies and other data providers, it was recommended to

- continue with the dual-season wall-to-wall coverage twice per year (for optical and SAR sensors).

- investigate the possibility for the CEOS agencies to apply a differentiated the timing of the FCT acquisition time windows to target one of the two annual acquisitions during the predominant dry season of each of the NDs. This is particularly important for the optical sensors with respect to cloud coverage and the C-band sensors which are more sensitive to moisture conditions.
- provide combined dense time series of ASAR and RADARSAT-2 over certain VS to increase experience towards Sentinel-1 and RCM.
- Acquire Very High Resolution data - both optical and SAR - over selected VSs.

Phase 2 - fifth ND coverage: Optimal acquisition time window: June through August, 2011 (+/- 1 month)

Phase 3 - Operational: The third step is the recently approved Global Forest Observation Initiative (GFOI), aimed for implementation in 2013. The details of the operational coordinated acquisition strategy are yet to be defined, and its development is an aim of the research activities currently undertaken within the FCT. It is however certain to comprise national-wide acquisitions on a multi-annual basis by a number of core satellite sensors, as the availability of long time-series of consistent data is widely acknowledged as the most important technical criteria for the establishment of national MRV systems.

3.2 Specific Data Acquisition Requirements

The first priority during the rest of 2011 and 2012 is to undertake wall-to-wall acquisitions over the National Demonstrator countries on a repetitive basis – at this stage without any requirement on the space agencies to actually commit to provide these data within the FCT. The aim of this caveat is to assure that consistent archives of time-series of wall-to-wall data can be established without creating conflicts for agencies with restrictions on data distribution. As data acquired during different seasons generally contribute to improved thematic contents and refined classification accuracy, dual-season wall-to-wall coverage are requested over each of the National Demonstrators at least once by each of the different sensor types (during Phase 1 and 2 – all sensors, during Phase 3 – selected key sensors).

In addition, optical and SAR data acquired at monthly/bi-monthly repetition are requested over the local Validation sites for methodology development and research on key science questions related to forest carbon tracking and the development of an operational coordinated acquisition strategy. Distribution of these data to the FCT NDs and Product Development teams are of key importance for the progress of the FCT Task and requires clear commitments on the level of engagement by the space agencies.

3.2.1 Optical sensor acquisition requirements

As already highlighted by the CEOS LSI activity, optical sensors vary in the percentage of path data they may acquire (duty cycle), their ability to image at different viewing angles, and in some cases bands and resolutions that may be recorded. While the Landsat series of satellites has fixed modes of observations, many of the other newer sensors have 'pointable', off nadir acquisition modes.. The IRS sensors provide a number of modes including fine and broad scale acquisition options.

For medium resolution wall-to-wall acquisitions, the following attributes are preferred for the purposes of this Task: cloud free observations and pointing modes at nadir or near-nadir. Where single pass cloud free observations are not possible, then compositing of cloud free observations from multiple overpasses. Possible multiple sensor combination and mosaicing will be investigated by the Product Development Teams (see Requested Products 3.4). This suggests that each sensor should be acquiring data from each overpass in at least the acquisition time window. The timing of acquisition is geographically dependent on cloud cover and forest state, and the acquisition time window would need to be assessed for each region. This may be done by assessing available archived data - such as the Landsat archive where it exists – and will be established for the acquisition phase 2.

This GEO FCT Task therefore asked for assistance by CEOS member agencies and the LSI team in the coordinated acquisition of the following optical datasets (including all available spectral bands) over the NDs for Phase 1, including historic baseline data for 1990, 2000, 2005 and 2010:

Satellite	Spectral Bands	Geometric Resolution	Swath Width	Repeat Cycle
Landsat 5, 7	VNIR, SWIR, TIR	30 m / 120 m (TIR)	185 km	16 days
IRS: AWiFS	VNIR, SWIR	56 m	740 km	4 days
IRS: LISS-III	VNIR, SWIR	23 m	140 km	24 days
AVNIR-2	VNIR	10 m	70 km	46 days
SPOT 4, 5	VNIR, SWIR	20 m / 10 m	60 km	26 days
Kompsat-2	VNIR	1 m / 4 m	15 km	28 days

Table 4: Potential contributing optical sensors

Table 4 provides the information on the various optical instruments on board of CEOS agencies satellites. It provides the available bands, geometric resolution, swath width and the repeat cycle (nadir looking). It does not take into account the pointing capabilities of some of the sensors. The list is not exclusive and other mid-resolution optical sensors with similar capacities in the visible and NIR domain are welcome to contribute to the task, as coordinated through the LSI team.

Landsat and IRS are with their respective characteristics well suited for large area coverage. Spot demonstrated already in 2006 a wall-to-wall coverage of French Guiana complementing earlier SAR mosaics by ERS and ASAR related to Kyoto Protocol reporting. In 2006 SPOT together with IRS-LISS-III accomplished a full coverage of Europe (6 million sqkm) serving EEA and GMES purposes (reference IMAGE 2006 and IMAGE 2009).

Due to its small swath SPOT as single sensor is regarded suitable for wall-to-wall mapping of smaller NDs and even more the frequent coverage of VS. Kompsat-2 should be considered purely for VS mapping.

Summary requirement for all optical satellites:

- Acquisition preferably at nadir or near-nadir
- Cloud free observations are preferred (cloud removal compositing may be required to achieve total cloud removal by multiple scenes, therefore specific maximum cloud cover percentages are stated)
- All available spectral bands
- Time window – yearly, with emphasis during dry season (Table 1)

3.2.2 SAR sensor acquisition requirements

General Considerations: In contrast to the optical sensors which provide fixed sets of spectral channels at fixed spatial resolutions, the SAR sensors offer a multiple choice of polarisations, incidence angle steps, ground resolution modes etc. On one hand, this provides substantial operational flexibility on where, when and how to acquire data. But on the other hand, if active care is not taken to develop a consistent acquisition plan, data collection would result in the creation of data archives which are too heterogeneous in time and space to be useful for the type of national-scale monitoring objectives required to support forest carbon tracking. Six SAR systems are presently contributing to the FCT Task (Table 5) up to now. On 22 April 2011 ALOS had suffered from a power generation anomaly and stopped operating. Hence no L-band sensor is today available.

Satellite	Frequency / Polarisation	Geometric Resolution	Swath Width	Repeat Cycle
ALOS PALSAR *	L-band (23.6 cm) / full pol	7 m – 154 m	30 – 360 km	46 days
RADARSAT-1	C-band (5.6 cm) / HH	9 m – 100 m	45 -500 km	24 days
RADARSAT-2	C-band (5.6 cm) / full pol	3 m – 100 m	20 - 500 km	24 days
ENVISAT ASAR	C-band (5.6 cm) / dual pol	30 m – 150 m	56 - 400 km	35 days
TerraSAR-X	X-band (3.1 cm) / full pol	1 m – 16 m	5 - 100 km	11 days
COSMO-SkyMed	X-band (3.1 cm) / full pol	1 m - 100 m	10 - 100 km	16 days

** until 22 April 2011*

Table 5: Contributing SAR sensor

Spatial and temporal consistency

Collection of consistent, gap-free wall-to-wall SAR data coverage over the entire ND regions is a critical requirement in the GEO FCT Task. Satellite resources permitting, acquisitions should preferably be undertaken within a single satellite repeat cycle in order to maximise temporal consistency of the data. Missed acquisitions and data gaps that inevitably will occur, should be re-programmed for fill-in acquisitions the next satellite cycle.

Fixed single observation mode

One key point for each of the sensors is to remain consistent with one single observation mode selected to maximise band sensitivity to forest parameters, and successively build up a uniform and homogeneous multi-temporal coverage over each of the targeted regions. In particular it should be noted that a change in the SAR off-nadir look angle is directly incompatible with the objective of gap-free wall-to-wall acquisitions.

Specific SAR Acquisition Requirements for Phase 1 and 2

For the Phase 2 acquisitions, a number of sensors, wavelengths and polarisation characteristics are being evaluated for forest carbon tracking. Therefore optimal sensor parameters have been listed below for each of the six selected SAR sensors, based on known scientific and operational trade-offs.

This selection is based on long-term research experience with JERS-1, ERS, RADARSAT, ALOS PALSAR and ENVISAT ASAR, and can be considered as established, and in general agreement with current scientific research results worldwide. The mode selections for the X-band sensors (TerraSAR-X, COSMO-SkyMed) can be considered more tentative due to the novelty of the sensors and limited research results presented to date, but are not expected to deviate significantly from those of the L-band and C-band (i.e. multi-polarisation and large off-nadir angles).

Similar sensor modes are requested for the C-band sensors (Envisat ASAR and RADARSAT) for the purpose of accommodating sensor interoperability.

For X-band, fine spatial resolution modes are requested, when feasible with multi-polarisations and high temporal revisit frequency.

In anticipation of the more comprehensive recommendations for a coordinated multi-sensor acquisitions, that is to be developed during the GEO-FCT demonstration phase, the FCT acquisition plan for SAR sensors for 2011 and 2012 can be summarised as follows:

L-band: Repetitive wall-to-wall coverage of all (original + new) National Demonstrators has been achieved until 22 April 2011.

C-band: At least one dual-season wall-to-wall coverage of all NDs. All Validation Sites requested to be covered continuously on a monthly/bi-monthly basis. Additional focus for the mid-2011 campaign for C-band is a high repeat coverage of few VS regions by ASAR and Radarsat-2.

X-band: Current X-band acquisitions focus on Validation sites (high temporal repetition, fine spatial resolution, multi-polarisation).

ENVISAT ASAR (ESA)

NDs (regional)

Observation mode:	Alternating Polarisation (AP)
Polarisation:	VV + VH
Beam mode (inc. angle range):	IS4(1) (inc. 30.8°~36.2°)
Pass direction:	Descending
Geographical coverage:	Brazil (X), Guyana, Cameroon, Tanzania, Tasmania (2), DR Congo, Peru, Colombia, Sumatra (3)
Observation time window:	July - August, 2011 (+/- 1 month)
Comments/justification:	(1) IS4 corresponds to the AP beam with largest incidence angle range with maintained Equator swath overlap. (2) Coverage by ASAR and/or RADARSAT-2 as agreed between ESA and CSA. (3) Consultation between ESA and CSA w.r.t. Peru, Colombia and Sumatra resulted in acquisitions by both systems.

Validation sites (local)

Observation mode:	Alternating Polarisation (AP)
Polarisation:	VV + VH
Beam mode (inc. angle range):	IS4(1) (inc. 30.8°~36.2°)
Pass direction:	Descending
Geographical coverage:	All Priority-1 Validation sites (20) (2) Priority-2 VS if feasible
Observation time window:	Every 35-day cycle April – Dec. 2011
Comments/justification:	(1) IS4 corresponds to the AP beam with largest incidence angle range with maintained Equator swath overlap. (2) Hyper-temporal repeat together with Radarsat-2
ASAR mode sources:	http://envisat.esa.int/handbooks/asar/

Radarsat-2 (CSA/MDA)

NDs (regional)

Observation mode:	Wide Beam (150 km)
Polarisation:	VV + VH (1)
Beam mode (inc. angle range):	Wide Beam #3 (2)
Pass direction:	Ascending
Geographical coverage:	Guyana, Mexico, Borneo, Tasmania, Peru, Colombia, Sumatra (4)
Observation time window:	June – Dec., 2011 (+/- 1 month)
Comments/justification:	(1) VV+VH same as Envisat ASAR. Complementing RADARSAT-1 (fixed HH). (2) Large incidence angle required to improve forest sensitivity. If operationally unavailable, alternative mode Wide Beam#2. (3) Coverage by ASAR and/or RADARSAT-2 as agreed between ESA and CSA (4) Consultation between ESA and CSA w.r.t. Peru, Colombia and Sumatra resulted in acquisitions by both systems.

Validation sites (local)

Observation mode:	Quad Pol Fine Beam (25 km)
Polarisation:	HH+VV+HV+VH
Beam mode (inc. angle range):	Fine Quad Beam #10 - 20 (1)
Pass direction:	Ascending and descending
Geographical coverage:	All Priority-1 Validation sites (20) (2) Priority-2 VS if feasible
Observation time window:	Every 24-day cycle June – December 2011
Comments/justification:	(1) Large incidence angle required to improve forest sensitivity. (2) Hyper-temporal repeat together with Envisat
Radarsat-2 mode source:	http://www.radarsat2.info/product/RS-2_Product_Details_2008_Dec_11.pdf

Radarsat-1 (CSA)

NDs (regional)

Observation mode:	Wide Beam (150 km)
Polarisation:	HH (fixed)
Beam mode (inc. angle range):	Same as RADARSAT-2 (Wide Beam #3)
Pass direction:	Ascending (Same as RADARSAT-2)
Geographical coverage:	Mexico
Observation time window:	July/August, 2011 (+/- 1 month)

Validation sites (local)

Observation mode:	Wide Beam (150 km)
Polarisation:	HH (fixed)
Beam mode (inc. angle range):	Same as RADARSAT-2 (Wide Beam #3)
Pass direction:	Ascending (Same as RADARSAT-2)
Geographical coverage:	Mexico
Observation time window:	Every 24-day cycle June - December 2011

Radarsat-1 mode source:	http://www.asc-csa.gc.ca/eng/satellites/radarsat1/components.asp

COSMO-SkyMed (ASI)

NDs (regional)

Observation mode:	ScanSAR Wide (100 km) (1)
Polarisation:	HH (cycle 1), HV (cycle 2) (2)
Beam mode (inc. angle range):	Beam 1: Incidence angle range 40°~50° Beam 2: Incidence angle range 50°~60° (3)
Pass direction:	Ascending
Geographical coverage:	All feasible National Demonstrators
Observation time window:	July - August, 2011 (+/- 1 month)
Comments/justification:	(1) ScanSAR Wide selected for wide swath and medium (30m) resolution (2) Only Single-polarisation possible at ScanSAR Wide, and two consecutive passes (at same angle) are thus required to achieve dual-polarisation. (3) For gap-free wall-to-wall coverage at ScanSAR Wide mode (100km swath), acquisitions at TWO adjacent beams - each at two polarisations - are required to assure swath overlap. Can be achieved with two satellites during two cycles (2x16 days), or one satellite during four cycles.

Validation sites (local)

Observation mode:	Spotlight (10x10 km) (1)
Polarisation:	HH (cycle 1), VV (cycle 2)
Beam mode (inc. angle range): (2)	ONE beam with largest possible inc. angle range
Pass direction:	Ascending
Geographical coverage:	All Priority-1 Validation sites in GUY, CAM, BOR, TAS, and if possible PER, COL, DRC and SUM Priority-2 VS if feasible
Observation time window:	Monthly acquisitions during remainder of 2011
Comments/justification:	(1) Spotlight mode for finest resolution trial (2) Largest possible incidence angles required to improve forest sensitivity.

TerraSAR-X (DLR)

Validation sites (local)

Observation mode:	Stripmap (SM)
Polarisation:	Full polarisation
Beam mode (inc. angle range): [(1)]	ONE beam with largest possible inc. angle range
Pass direction:	Ascending
Geographical coverage:	All Priority-1 Validation sites (20) Priority-2 VS if feasible
Observation time window:	Monthly, June – December 2011 [(5)]
Comments/justification:	[(1)] Largest possible incidence angle required to improve forest sensitivity.

Source: http://www.dlr.de/en/desktopdefault.aspx/tabid-4219/8885_read-16050/

3.3 Requested products

Thematic product generation (e.g. maps of forest/non-forest and Land Cover) are being undertaken by the National Demonstrator authorities and designated FCT Product Development (PD) Teams.

The PD teams place Level 1 data processing requests with the space agencies/data providers in accordance with the mutually agreed procedures for FCT data access (see details in the GEO FCT Data Processing and Product Development Plan, GEO-FCT Key Document #6)

4 Other Data Requirements

4.1 Commercial, high-resolution data providers:

The Task team have asked the GEO secretariat to invite commercial data providers of fine resolution data to support on an initial trial basis targeted acquisitions for this Task, over selected validation sites

Several commercial providers indicated that their contribution is limited to the demonstration phase of the GEO FCT, currently until end of 2012 and on its geographic extension (number of National Demonstrators limited with validation sites of reasonable size). They expect that data need and value are clearly analysed with respect to necessary satellite resources and associated cost. Data licensing and data dissemination policy should be discussed in the light of the GEO data sharing principle and "free and open access" data provided by governmental agencies.

Satellite	Spectral Bands	Geometric Resolution	Swath Width	Repeat Cycle
GeoEye-1	VIS (3), NIR (1), PAN	2 m (MS) / 0.5 m (PAN)	15 km	3 days revisit time
Ikonos-2	VIS (3), NIR (1), PAN	4 m (MS) / 1 m (PAN)	70 km (MS) / 11 km (PAN)	14 days
Quickbird	VIS (3), NIR (1), PAN	2.4 m (MS) / 0.6 m (PAN)	16.5 km	20 days
RapidEye (5 satellites)	VIS (4), NIR (1)	6.5 m	78 km	1 day revisit time

Table 6: Commercial systems of interested providers

Digital Globe, E-Geos, ASTRIUM Geo Information Services participated at the 4th FCT Data Coordination meeting expressing their interest in contributing to FCT. Table 6 lists commercial satellites under private or PPP operation which are not listed previously in table 4 and 5. Line Steinbakk from Kongsberg Satellite Services is coordinating the contribution of commercial data providers for FCT.

4.2 Ancillary Data for Subsequent Processing

The GEO Secretariat have also been requested to assist the Task team in sourcing adequate resolution Digital Terrain Maps (preferably 30 m resolution or better) derived from past space borne acquisitions (eg. SRTM, ASTER, SPOT).

Currently the use of the 90 m SRTM DEM available for the whole tropical belt is envisaged related to its consistency and the experience gained within the EO community. The recently released 30 m ASTER DEM, available for the whole globe, needs further validation and quality assurance. The GEO FCT task team will carefully follow developments of those global DEMs and potential derivates and combinations.

5 Milestones 2011

1) 2nd FCT Science and Data Summit at FAO in Rome, 8-10 Feb 2011. FCT PD Teams report on multi-sensor analysis results and prototype forest product development
2) 4th FCT Space Data Coordination meeting at ESRIN, Frascati, 11 Feb 2011. Definition of space agency guidelines on how to optimise data acquisition strategy planning for the 2011 acquisition campaigns.
3) CEOS-SIT-26, ESRIN, Frascati, 23-25 May 2011. FCT and GFOI status, data acquisition report, future requirements and 5 years data strategy.
4) 5th acquisition period: Contributing space agencies schedule and undertake acquisitions over the National Demonstrators (July - August, 2011) and Validation sites (April - December, 2011) in accordance with the descriptions in section 3 above.
5) CEOS 25th Plenary (Lucca, Italy, Nov. 7-9, 2011) Contributing space agencies report on acquisition status and archive inventory results.
6) GEO VIII Plenary (Istanbul Nov. 16-17, 2011)
7) December, 2011. Release of 2012 version of the Data Requirement document