

**Sub-task Number:** CL-09-03b

**Sub-task Title:** Forest Carbon Tracking

**Overarching Task:** Global Carbon Observation and Analysis System

**Area:** CLIMATE

**Related Communities of Practice:** Carbon Cycle (former IGCO) and Forest

**Relevant Committee:** (to be determined in 2009)

**Related Targets:** (to be included in 2009)

**Sub-task Definition** (as given in the 2009-2011 Work Plan):

This task will demonstrate that coordinated Earth Observations can provide the basis for reliable information services of suitable consistency, accuracy and continuity to support Forest Carbon Tracking. This task builds upon existing and planned GEO efforts in forest monitoring, associated modeling and use of these tools for timely provision of observations required for their routine use world-wide. In close collaboration with national governments, space agencies, and relevant technical experts, the task will demonstrate this capability initially via establishment of robust methodologies, satellite acquisition plans and a series of regional pilot studies, which will provide a template for roll-out of a consistent and reliable global carbon monitoring system.

Start-up activities include: (i) establishment of several regional reference test-sites; (ii) consolidation of observational requirements and associated products; (iii) secure coordination of observations, including their long-term continuity; (iv) coordinated assessment of tools and methodologies at these sites, (v) coordination of the production of reference datasets, and (vi) improved access to observations, datasets, tools and expertise associated capacity building activities.

**Leads** (GEO Member or PO, Entity carrying out the work, Contact: e-mail):

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### **Motivation/Background**

State-of-knowledge assessments by the United Nations Framework Convention on Climate Change (UNFCCC) and its Intergovernmental Panel on Climate Change (IPCC), have documented the urgency for mitigating global warming driven by anthropogenic greenhouse gas emissions. The IPCC scientific consensus has shown that global carbon emissions could be reduced by as much as 20% by reducing deforestation and forest degradation, preserving ancient forests, reforesting wastelands, and improving related agricultural practices. Despite past extensive efforts, there is still a lack of sufficiently comprehensive, international consistent and accurate spatially explicit data on global forest change and carbon stocks, emissions, trends and UNFCCC reporting guidelines for national reporting. Where technically possible, the preferred resolution for monitoring has been identified to 0.05-0.1 hectare. An annual wall-to-wall mapping approach is needed to avoid issues of 'leakage', where reductions in carbon losses are simply displaced rather than mitigated. Time-series mapping is also required to ensure that mitigation efforts are sustained, and represent long-term reductions or stabilisation.

A GEO sub-Task on 'Forest Carbon Tracking' has been established to directly address these concerns. The task will seek to ensure information is accessible on a regular basis (annually) to the global community, via

the appropriate international bodies and national space agencies. This will be done in close coordination with technical expert groups (eg. GOF-C-GOLD; Kyoto-Carbon Group) and UN-REDD bodies such as FAO, and will ultimately provide increased confidence to negotiators, the science community and users at large, that regular provision of comprehensive, repetitive global data on forest cover and extent is achievable, though efficient use of earth observation technologies.

**Outputs** (e.g. products and services which result from the activities of the Task/sub-task; outlined in the form of deliverables with timelines)

Planned:

1. Regional reference test-sites established in consultation with national governments, FAO, NGO's and expert teams.
2. Optical + SAR satellite data acquisition strategy agreed and established by space agencies
3. Technical methodology report for annual, mid-resolution global forest-change monitoring, including satellite data orthorectification, correction methods and accuracy assessment, widely agreed and documented through a mid-term task report
4. Orthorectified satellite data mosaics (optical+SAR) routinely provided by space agencies, initially over reference sites
5. Regional capacity-building workshops covering methodology, access to in-country data (satellite & in-situ), expertise and available tools.
6. Description of and reports from each of the regional pilot projects

Output & Deliverables				
Doc #	Title	Deliverable (est. date)	Responsibility	Remarks
1	Regional reference test-sites established	3-5 initial large, regional test sites (June 2009)	GEO Co-Leads and task partners	Regional sites to be nominated as per standardised guidelines for pilot projects definition and execution This will be done in consultation with national governments, NGO's and expert teams.
2	Optical + SAR satellite data acquisition strategy agreed and established by space agencies	Documents on (1) preferred SAR and (2) optical data modes and acquisition strategies (February 2009)	GEO co-Leads, CEOS and CEOS LSI-Constellation study team, JAXA's Kyoto-Carbon Program, & collaborators (eg GTOS)	Updated yearly in consultation with CEOS-member agencies.
3	Technical specification and methodology report for annual, mid-resolution global forest-change monitoring, including satellite data orthorectification, correction methods and accuracy assessment, widely agreed and documented through a mid-term task report	1 <sup>st</sup> draft Technical report, by May 2009.  Final document December 2011	GEO co-leads, CEOS LSI-Constellation study team, JAXA's Kyoto-Carbon Program, GOF-C-GOLD & collaborators	"Interim" document to be used as guide to regional workshops and to guide agreements with the CEOS Land Imaging Constellation team

4	Orthorectified satellite data mosaics (optical+SAR) routinely provided by space agencies, initially over reference sites	Annual, medium-resolution, orthorectified mosaics for nominated regional test-sites (start March 2009 – 3 years)	GEO co-leads, CEOS Member agencies operating the nominated satellite sensors. (Coordinated through CEOS LSI team)	Documents produced in Objective 3 are to be used as guide to data acquisition and processing
5	Regional capacity-building workshops covering methodology, access to in-country data (satellite & in-situ), expertise and available tools.	Initiated bi-annual regional workshops by October 2009.	GEO co-leads, FAO and GTOS (GOFC-GOLD)	It will be updated yearly to incorporate feedback from consolidation of observation plans and results from pilot projects
6	Description of and reports from each of the regional pilot projects	Several 'country-reports' from December 2010 onwards	GEO task-leads, and national government agencies (coordinated by FAO – GOFC-GOLD)	Documents will be published on a regular basis, made available via GEO and UNREDD portals, and updated as required

*Produced (current status): ...*

*Activities (operations or work processes through which resources are mobilized to produce specific outputs; outlined in the form of milestones including timelines)*

*Planned:*

Task main activities

- a) Establishment of several regional reference test-sites, to demonstrate capability in support of climate policy needs
- b) Consolidation of observational requirements and associated products
- c) Secure coordination of observations, including their long-term continuity
- d) Coordinated assessment of analysis tools and methodologies
- e) Coordination of the production of reference datasets
- f) Improve access to observations, datasets, tools and expertise and associated capacity building activities

Details

**A) Establishment of several regional reference test-sites, to demonstrate capability in support of climate policy needs (end to end projects at country/regional level, with an emphasis on developing countries)**

*(Potential National Contributors: Australia, Norway, Japan, Indonesia, Brazil, Niger)*

Build on existing inter-governmental programs to establish demonstration test-sites and projects. They will ensure broad representation by regional participants; ultimately address different types of forests – but with an initial emphasis on tropical forests; test accuracies, validate methodologies/tools and build local capacity. The conclusion of each group of projects could be marked by a dedicated workshop, to assess the utility of different approaches and the accuracy of carbon estimates, for sharing experiences and consolidating methodologies.

This GEO sub-Task will establish a number of reference test-sites to demonstrate and develop approaches and methods for using current remote sensing capabilities for long-term, operational forest-cover change and carbon monitoring. Where possible, geographic overlaps and synergies will be chosen with the regional sites nominated by the CEOS Land Surface Imaging Constellation study team, FAO, and GOF-C-GOLD.

However, to ensure maximum success and long term operation, as well as in-country national involvement, these test-sites additionally need to have key characteristics to qualify and to be endorsed in support of this task, as follows:

- Sites should be located in countries with own stated intent to develop national forest carbon monitoring systems, and requiring capacity building support
- Donor countries and/or donor NGO's clearly identified for long-term involvement
- Countries with proposed test-sites and their government institutions having commitment for capability to support ground observations (includes involvement by relevant forest management authorities in host countries)
- Clear management and governance arrangements being outlined
- Resources for the acquisition and analysis of the data clearly identified
- Timely and specified reporting on progress and deliverables, including specific data products, for each site
- Initial focus will be on cloud-affected areas with active forest management, including deforestation – afforestation activities
- Large areas (to demonstrate repetitive, wall-to-wall, accurate wide-area forest mapping capabilities - e.g. Borneo, Congo Basin, Amazon Basin)
- Sites to include representative scientific projects on forest change, with appropriate in-situ observations
- Availability of archived SAR and optical data to demonstrate changes is preferred

At a high-level , the following test-sites already fulfill the above requirements (with further sites to be added as they emerge)

1. Amazon region in Brazil
2. Borneo, with focus on the Indonesian part
3. Tanzania, with focus on mountain forest
4. Tasmania (Australia)
5. tbd

This first group of reference sites, to start in the 2009/2010 timeframe, will require assembly of archive and near real-time optical satellite databases, and be complemented by progressive use of new observations and methodologies, one specific component being multi-band SAR observation.

The initial sites are expected to be within the **Congo Basin, Amazonia (Brazil), Kalimantan (Indonesia)**; additional regional sites are likely to include **Tanzania (Africa), Tasmania (Australia), Cameroon, China and Bolivia**. Additional sites can be proposed, provided these fit the above criteria and there is adequate national government-level interest, expert involvement, and funding available by relevant actors and donors.

Involvement of national forest ministry/authorities is essential for each site, - to gain better access to NFI's (National Forest Inventories), dedicated in situ measurements for validation purposes, and prospects of capacity building. As a co-Lead in this task, FAO would assist in establishing the necessary links and coordinating regional workshops in participating countries.

A preliminary list of national/regional locations, quite well balanced in terms of geography and type of forest has been identified, by reviewing on-going initiatives:

Location	Supported by
<b>Africa</b>	
Cameroon	ESA
Congo Basin	Congo Basin Forest Fund (Norway + UK)
Ghana	Australia ?
Niger	tbd
Tanzania	Norway, Australia?
<b>Asia and Pacific</b>	
China	Australia, China
Indonesia	Australia, Japan, Indonesia
Papua N. Guinea	Australia
Cambodia	Australia, Japan
<b>South America</b>	
Bolivia	EU,ESA
Brazil	USA, Brazil, Norway
Colombia	tbd

Feedback from pilot projects is expected to have an important role in the progressive consolidation of recommended methodologies and the associated observation plans at global level. Early dialogue with relevant policy bodies will be essential to ensure that the technical solutions satisfy their information needs.

Near term objectives: Identify key pilot sites and consolidate a coordinated observations and field data approach by February 2009.

### **B) Consolidation of observational requirements and associated products**

Once the initial sites are identified, we will ask CEOS members to work with space agencies to secure the necessary Earth observation datasets and possible additional support from agencies for some of the data processing.

Based on technical expert, stakeholder and user consultation, the main thrust of this activity will be the definition of a set of top level requirements concerning observational requirements and “standardized products” of global relevance. The definition will be conducted in order to identify capabilities to be offered rather than specific user requirements to be met (link to GEO task US-06-02 and the CEOS Land Surface Imaging Constellation project). The process will require iteration and consultations with “users” and data “providers”. Definition of observational parameters to be taken into consideration will include, but not limited to:

- Spatial Resolution
- Wall-to-wall mapping approach vs. sampling of specific areas
- Periodic update of the global product
- Required sensors

Near term objectives: First draft to be worked by e-mail and be ready by February 2009

### **C) Coordination of systematic, long-term observations, including securing satellite continuity**

The activity, coordinated through GEO and CEOS, is centered in the definition of a worldwide coordinated, systematic satellite observations plan and in securing continuity and sustainability. To-date, primarily optical remote sensing technologies have been used for routine land-use-change mapping (eg NOAA AVHRR, NASA-MODIS, Landsat, SPOT, Envisat-MERIS, etc.). However, increasingly SAR missions are also becoming operational and providing global coverage data for wall-to-wall, multi-year mapping. SAR will provide the added capabilities of data acquisition for forest monitoring, even in cloud-affected areas and at night. Thus, efforts will be made within this task in conjunction with relevant CEOS-member agencies to

secure the required continued access to optical and SAR data archives (if available) and real-time data – in support of the envisaged information services.

The mechanisms to achieve this will be:

- Close consolidation with the CEOS Land Surface imaging constellation (GEO task DA-07-03), together with expert groups such as members of GOF-C-GOLD and the ALOS Kyoto-Carbon Group - asking them to specifically address observational requirements for forest cover assessment requirements raised by this task;
- New coordination measures put in place via CEOS, GOF-C-OLD and the Kyoto-Carbon Group to evaluate the suitability of developing specific operational satellite data ortho-rectification and deforestation and forest degradation products derived from systematic multi-band SAR observations. Different aspects will be considered, such as best suited SAR instrument modes, information content in different “situations”, definition of a “test plan” for observations and assessment over a limited number of sites, definition of observations plans addressing forest monitoring and carbon tracking for current operational and for forthcoming SAR missions operating in C, L and X bands. This effort will advocate the need for satellite mission continuity using all available CEOS mechanisms – such as Constellations or other frameworks.
- In addition to the optical satellite emissions already considered by the CEOS LSI team, these include:

#### SAR Missions in Operation

- |                             |                                       |
|-----------------------------|---------------------------------------|
| - ALOS-Daichi (Japan)       | L-band; continuation approved         |
| - ERS and ENVISAT (EU)      | C-band; continuation approved         |
| - RADARSAT-1 and-2 (Canada) | C-band; continuation approved         |
| - TerraSAR-X (Germany)      | X-band; continuation approved         |
| - COSMO-SkyMed (Italy)      | X-band; constellation of 4 satellites |

#### Future Optical & SAR Missions Under development and planned:

Landsat-follow on (USA)	optical, multi-spectral
Sentinel-2A/B (ESA/EU)	optical, multi-spectral
HypIRI (USA)	optical, hyperspectral
ALOS-follow-on (Japan)	L-band + optical
DESDynI (USA)	L-band+Lidar
DMSAR	C/X-band
MAPSAR	L-band
RADARSAT Constellation (Canada)	C-band
RISAT	C-band
SABRINA	X-band
SAOCOM (Argentina)	L-band
Sentinel-1A/B (ESA/EU)	C-band
TerraSAR X follow-on (Germany)	X-band
WSAR	X-band

A second line of activities will be devoted to the identification of requirements for the use of remote sensing data for validation purposes. This activity should identify the use of: airborne sensors; very high spatial and spectral resolution satellite sensors; LIDAR; together with in situ measurements and assessments, for the validation of the global products.

*Near term objectives: CEOS space agencies to nominate points-of-contact for participation in this task. SAR coordination meeting through CEOS LSI SAR sub-team, early 2009, co-located with the next CEOS SIT meeting (March 2009, Florida, USA) and/or UNFCCC/SBSTA event.*

#### D) Coordinated assessment of analysis tools and methodologies

A coordinated assessment of available tools and methodologies will be undertaken in conjunction with technical experts from GOFC-OLD and the Kyoto-Carbon Group – with the main outputs being:

- Identification of current capabilities and limitations
- Quantification of accuracy and uncertainty of sensor systems and mapping methods ;
- Satellite data processing methods for accurate orthorectification and terrain correction for use in multi-year forest-change and trend analyses
- Definition of suitable (simple and robust) tools and methodologies to support periodic reporting in support of global carbon accounting needs, including definition of the role of in situ and remote observations (airborne and satellite based);

This activity will directly support the continuous improvement and update of a technical methodology report;

*Near term objectives: Prospective Task participants take part in Forest and Carbon Workshop at Stressa, Italy, May 2009, an possible GEO Forest Monitoring Symposium, Thailand, August – September 2009. Workshops to agree on initial data processing approaches (optical + SAR), September 2009.*

### **E) Coordination of the production of reference datasets**

The main output of this activity will be the definition of the « Carbon tracking reference datasets » and the coordination of their progressive production.

The Forest Resources Assessments performed and in preparation by FAO (GEO task AG-06-04) will be considered as one of the reference datasets, and their suitability for Carbon tracking will be assessed, in particular considering the potential need to move from a “sampling” methodology to a global “wall to wall” mapping products.

The implementation and validation of an agreed Systematic land cover classification and of land use changes (GEO task DA-07-02), as the reference to apply further carbon tracking specific methodologies will be assessed, also considering the definition and application of standards for collection of key terrestrial observations for climate (GEO task CL-09-02b)) and the use of observations and products coming from Global Ecosystem Observation and Monitoring (EC-07-01).

*Near term objectives*

*First draft definition of “Carbon tracking reference datasets” available mid 2009*

### **F) Improve access to observations, datasets, tools and expertise and associated Capacity Building activities**

A key component of this task includes the need to provide those national governments and their relevant agencies who wish to develop their forest monitoring capabilities further, the necessary methodology, access to satellite data and reference datasets, expertise and necessary tools to undertake this work. Therefore, specific activities may include, but not be limited to:

- In close coordination with ongoing bi-lateral or multi-lateral programs, as well as in-country activities associated with UN FAO FRA, hold regional capacity-building workshops to discuss methodology, access to in-country data (satellite & in-situ), expertise and available mapping and reporting tools.
- The constitution of a dedicated GEO Community of Practice, by engaging Forest and Climate CoP's, that could bring together Science Community, Governments, NGO's and Private Sector (ref GEO task US-06-02) and to ensure key contributions, such as the one from CPR alliance
- The effective use of regional information-delivery systems (such as Sentinel Asia, SERVIR, etc.), as well as global systems such as GEONETCast, for wide and open data and products distribution
- The definition of a dedicated section in the GEO website (now) and in the GEO Portal (in future)

- The building of Capacity on observation systems infrastructure, information extraction and its use for decision making, implementing the Seville Roadmap, concentrating the intervention in ensuring independent assessment capabilities at Country level

*Progress (current status): ...*

**Resources** (indication of resources – e.g. financial, human – contributed by GEO Members or Participating Organizations to produce outputs)

**Australia:** In-Kind: The Australian Department of Climate Change, AusAID and associated institutions (CSIRO, Geoscience Australia, ANU, Cooperative Research Centre for Spatial Information) are undertaking several regional activities which contribute resources to the sub-task activities. These fall under Australia's "International Forest Carbon Initiative - (IFCI)", its partnership with the Clinton Climate Initiative and the establishment of a dedicated Remote Sensing Research Program to support some of the technical implementation requirements of IFCI'.

- Personnel: Part-time sub-task co-Lead (A. Held), and part-time task project manager (S. Ward)
- Other:
  - Assembly of regional optical and radar satellite data archives, covering South-East Asia (in collaboration with GISTDA – Thailand and JAXA-Japan)
  - Establishment of new satellite-downlink facility in Northern Australia for use in regional programs
  - Collaborative bi-lateral government-to-government programs with Indonesia, including remote sensing and carbon emissions methodology development
  - Support for technical exchange and methodology development in China

Norway:

Japan:

FAO:

GOFC-GOLD:

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### **Capacity Building Component**

*(capacity building is defined to include the development of capacity related to: (i) Infrastructure and technology transfer (Hardware, Software and other technology required to develop, access and use EO); (ii) Individuals (education and training of individuals to be aware of, access, use and develop EO) and (iii) Institutions – building policies, programs & organizational structures to enhance the value of EO data and products).*

*1) In accordance with the above definition does this Task have a capacity-building component? If so, please provide a short description of this component including a description of end users.*

*2) Have any additional CB needs for this Task been identified? Please provide a short description.*

Capacity-building is already embedded in a number of country-to-country partnerships in relation to this process. Once the necessary satellite data is secured and accessible to countries which wish to establish national forest change monitoring, and the processing methodologies (optical & SAR) are agreed and documented, several mechanisms will be used for capacity-building in this task. These would include bilateral capacity-building programs already associated to forest change and carbon emissions assessment and monitoring that are already underway among countries that fall within the nominated test areas. This is the case for example on bilateral programs between Australia and Indonesia, and Australia – China, where the programs provide in-country access to data, training on data processing methodologies and carbon accounting methodologies. Furthermore, programs coordinated through UN-agencies such as those linked to FAO FRA and UNESCO, as well as regional initiatives such as those by UN-ESCAP and the Asia Institute of Technology, would have a strong role in transferring these methods to national governments and their agencies, for use in forest change mapping and carbon emissions estimation.

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### ***User Engagement Component***

*(please briefly describe to what extent end users are engaged in this Task and influence the nature of the outputs produced)*

### ***Science and Technology (S&T) Component***

*1) Please briefly describe the elements of scientific research or technological development contained in this Task*

*2) In relation to the S&T component(s) of this task, please describe gaps, priorities, continuity needs, barriers, scientific expertise and additional resource needs (this information will be used for developing a gaps and needs assessment in Task ST-09-01)*

### ***Members and POs' Contributions to Outputs and Activities above:***

*(Input is optional. This section gives the chance to Members and POs to provide more details (3-5 lines) on their individual activities, making a clear connection with the outputs and activities outlined above).*

#### **Italy**

Contribute with the Italian experience in performing information systems aimed at identifying and tracking transparently land use changes according to the requirements of the Kyoto Protocol reporting rules. Italy designed a proper Land-use Inventory (IUTI) by using a mix statistical and Earth Observation approach in order to integrate on a spatial basis the ground information reported in the Italian Forest Inventory.

The Italian experience could serve as a testing of a sound and transparent methodology for land representation under the Kyoto Protocol which may be applied, in other Countries for building national capacities in the LULUCF sector.

#### **Japan**

JAXA: To contribute with the ALOS Kyoto & Carbon Initiative.

NIES: Supporting consolidation of observational requirements and associated products.

#### **Netherlands**

*WUR*: Development and documentation of algorithms, methodologies and products (land classification and change mapping) for humid tropical regions; capacity building.

*SarVision*: Development and demonstration of operational methodologies; production of maps for selected test-sites (reference data sets).

*Wetland International*: Research on CO<sub>2</sub> emission from peatlands.

*Alterra*: Research on CO<sub>2</sub> emission from peatlands.

*ITC*: Community based forestry - ground truth data acquisition & analysis.

**Norway**

*Norwegian Computing Centre*: Methods for reliable monitoring of changes in forest.

**Spain**

*Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria (INIA)*: INIA is the first institution in Spain to develop methodologies to evaluate biomass and forest Carbon storage using a combination of satellite images and the data of the Spanish Forest Inventory.

Experience in the development of numerical processes to elaborate cartography of burning areas using satellite images, having participated in Latin-American (with CYTED and AECED organizations).

**UK**

*CTCD, Sheffield*: Contribution from the Carbon Cycle theme in the UK National Centre for EO, and in particular lead an activity on C balance of the tropics, with the emphasis on forests. A related activity is co-proposing the ESA BIOMASS Mission and co-chairing the Mission Assessment Group.

**CEOS**

*JAXA*: Continue research on use of SAR data for biomass estimation.

*GISTDA*: Global Carbon Observation and Analysis System: Process of carbon credit assessment and mapping in mangrove forest.

*CSA* : SAR data for forestry.

**ESA**

ESA is contributing with SAR images over test sites and very supportive of the whole sub-task.

**Participation (Table to be filled in 2009):**

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