GEOForest Carbon Tracking Task
2nd SCIENCE ANDDATASUMMIT
Meeting Summary and Action Items[1]
FAO HQ, Rome, Italy: 8 - 10 February 2011

Tuesday, February 8, 2011

1. Welcome and Opening Remarks

Peter Holmgren, the FAO representative for UN-REDD, opened the meeting and welcomed the participants. He said that the Cancun agreement gave a green light to REDD+. Now countries need support to work on REDD and get paid for it. REDD must be robust and transparent, but not perfect. Everyone should be able to use it, and we should understand the error bars. He said that there is sometimes a blurred line between science and implementation, but we should make a clear line between the two. A systematic review of methods for establishing carbon stocks and changes is underway now. People are waiting for the results of the FCT task.

2. SDS#2 Summit Objectives and Outcomes

Alex Held presented the objectives as follows:

- Identify R&D requirements to support implementation of the GFOI (including in-situ measurement, remote sensing, modelling and integration)
- Identify R&D and data needs by the National Demonstrator (ND) Countries, as they develop their MRV (Monitoring, Reporting and Verification) systems from ND Summit
- Develop technical support mechanisms by GEO FCT to address these ND R&D needs, including:
    - Satellite data product development progress reports & presentation of FCT demonstration products
    - PD team assessments of Key Remote Sensing Science Questions
    - Satellite data processing methodology issues and towards common standards
    - Technical issues/options for in-situ, RS and model integration, for national MRV systems
- GEO-FCT Key Document coordination - working group session
- GEO-FCT - UN-REDD - FAO (FRA and NFMA) synergies
- GEO-FCT – UNFCCC relationship consolidation.

3. GEO-FCT Background, Status and Future Plans

Giovanni Rum introduced the GEO FCT task and REDD+. There is a need for comprehensive, continuous and systematic information on the state of the world's forests to underpin national Measurement, Monitoring, Reporting and Verification (MRV) Systems for REDD+ implementation. Nepal is about to join the ND countries, making eleven. Building on the

[1]The presentations for this meeting can be found at http://www.fao.org/forestry/fra/55919/en/. This meeting summary does not intend to duplicate the presentations.

framework and on the 2009-2010 achievements of the GEO FCT task, the planning of the implementation phase, called GFOI (Global Forest Observation Initiative), has started.

4. UN-REDD Introduction (Background, Status and Future Plans)

Alberto Sandoval presented UN-REDD, which is a collaborative partnership between FAO, UNDP and UNEP. The principles are:

- Country-driven
- National circumstances
- Consistent with development goals
- Consistent with adaptation needs
- Equitable financing
- Results-based.

Countries are encouraged to reduce emissions through:

- Reduce deforestation
- Reduce forest degradation
- Forest conservation
- Sustainable management
- Enhancement of forest carbon stock.

Safeguards have been put in place to ensure:

- Transparent + effective governance
- Rights of communities
- Stakeholder participation
- Conservation of biodiversity
- Avoid reversals
- Avoid displacement.

5. FAO Forest Monitoring – GEO Tasks and FRA, Remote Sensing Survey and NFMA

Adam Gerrand outlined the work FAO does in forest monitoring through the Global Forest Resources Assessment (FRA 2010), Global Forest Remote Sensing Survey (RSS) and the National Forest Monitoring and Assessment (NFMA). FAO has been reporting on the world's forests every 5 to 10 years since 1946.The FRA 2010 report was released in Oct 2010 and was the culmination of 5 years work. One of the sad facts in FRA 2010 is that Forests continue to be lost at an alarmingly high rate, either through deforestation – the cutting down of trees and conversion of the area to other uses such as agriculture, settlements or infrastructure – or due to natural causes such as volcanic eruptions or extended periods of drought. On the positive side, a key message from FRA 2010 is that while the rate of deforestation and loss of forest from natural causes is still high, it is slowing down.

The Global Forest Remote Sensing Survey is a partnership between FAO, the EC Joint Research Centre (JRC) and other technical agencies working closely with countries to do the validation. The RSS samples using a systematic grid, with 10 by 10 km samples located at the intersection of each Latitude and Longitude line (every second degree on high latitudes). There are over 13,000 of these sample points across the globe, with about 9,000 of them expected to have some tree cover (excluding deserts, bare and ice and snow areas). Statistics on tree cover change and forest gain and loss will be calculated for global, regions and biomes (but not national level). For

each of these samples, we have Landsat satellite imagery representing 1990, 2000 and 2005 and intend to build on this into the future (http://www.fao.org/forestry/fra/remotesensing/portal).

The FAO support to National Forest Monitoring and Assessment (NFMA) work has collaborated with many countries over 10 years with 10 countries completed, 10 currently in progress and 11 starting or under preparation. The NFMA has developed methods of forest monitoring through a series of guidelines, manuals, databases and training materials to support the national forest inventory systems in the field. The work includes technical support on software, hardware, planning and implementation of all phases of the work from design, data collection, processing and dissemination. There are potentially strong linkages between these various FAO areas of work and the GEO-FCT work and collaboration and synergies are encouraged.

6. Towards a Global Forest Observation Initiative-GFOI

Gary Richards presented GFOI. In the Kyoto Protocol, monitoring was left because of the lack of confidence in the methods, so it is important to raise the confidence level of monitoring techniques at this time. FCT works through countries, not as an independent assessment. It supports national implementations and embraces remote sensing technologies. But the remote sensing must be integrated with national data collection, rather than replacing it. There is a shift in GEO from science to an institutional role in support of operations.

7. Reports from National Demonstrator Summit Country FCT Action Plans

Brief reports were given by each of the ND countries (except Peru who were absent). It was stated that Brazil already has 22 years of operational experience in monitoring their forests (forest/non-forest estimates). In Guyana, the rate of deforestation is very low, only 0.6%, but the forest degradation is serious, and is a key issue. Most of the NDs identified the need for capacity building. Cloud cover was a common problem in tropical regions, so the ability to use radar data will be important. For more details, please see the minutes of the ND Summit on 7 February 2011.

8. The CEOS Coordination of Satellite Observations

Frank Martin Seifert, CEOS Point of Contact, made this presentation on behalf of the data coordination team from ESA, JAXA, CSA and USGS. CEOS is the focal point for international coordination of Space-related Earth Observation activities, and the "space arm" of GEO. The objective of the GEO-FCT coordinated acquisition campaign is to cover the NDs twice per year with SAR and at least once per year with optical sensors, although the dry season is preferred for both optical and SAR sensors. In total, more than 64,000 scenes were acquired up to autumn 2010. With the new NDs added in 2010, the total area of the NDs doubled to over 10 million km^2! A strategy for acquiring data over the NDs and the UN-REDD and Congo Basin countries in future years was presented. This strategy has not been approved yet by CEOS, but will be discussed in March 2011 together with the 2011 data requirements at the CEOS SIT meeting in Tokyo. It was noted that in order to assure that data policy issues do not inhibit space agencies' capacity to undertake systematic acquisitions of satellite data, the issues of data acquisitions on one hand, and processing and distribution on the other are treated as separate issues (in accordance with discussions at the CEOS Plenary in Rio de Janeiro in October 2010). The CEOS members operate under a range of data policies, and some of the missions are commercial. In addition, the data is often provided with user licenses, which varies from mission to mission.

9. Satellite Data Processing and Product Development Plan

Ake Rosenqvist presented the Satellite Data Processing and Product Development Plan, GEO FCT Guidance Document 004. The document is a "hand book" for the Product Development teams which indicates the PD team, ND authority and space agency contact points, as well as clarifies the procedures to access satellite data from the space agencies and data providers participating in the FCT. The document also provides a summary of the PD team product development plans and delivery targets. Space agencies and data providers were asked to check, and if necessary revise, the relevant satellite data access information in the document.

It was emphasised that the Product Development (PD) teams were established by FCT as an interim solution while building in-country capacity, while in the long-term, it is anticipated that the countries will develop the capacity to undertake these tasks independently. Initially, a first goal is for PD teams and participating ND organisations to jointly develop a number of 'Horizon 1' products that provide spatially explicit information about the the forest status and changes in the country, and that can be used as input to an emerging national MRV system. These products are[2]:

1a – Forest/Non-Forest coverage maps (ultimately annually wall-to-wall national coverage)
1b. - Forest change maps (direct/indirect derivative of dual- or multi-year Horizon 1a products or input data)
1c – Land-use map (with six broad land use categories - forest land, cropland, grazing land, wetlands, settlements, other land)[3] (for use in estimation of area change and land-use conversion as per IPCC GPG)
1d. – Land-use change and conversions (direct/indirect derivative of Horizon-1c products or input data).

Based on the 2010 version of the Satellite Data Processing and Product Development Plan, a technical report summarising the PD team activities during 2010 was put together for the CEOS Plenary and GEO-VII meetings in late 2010. An updated version of the technical report, based on the PD team input during the SDS#2 meeting, will be put together by Ake and the PD team leads for the CEOS SIT meeting in March, 2011.

10. Reports from PD Teams Working with the Various NDs

The PD teams working the various NDs reported on their progress to date.

Some NDs are at an early stage; they are sometimes lacking electricity! The basic problems need to be solved first, then we can address questions like software licenses. INPE provides open source software tools and data with an open data policy when they work in Africa.

Brazil has a goal, established by a former president, to reduce deforestation from the 2005 level by 80% by 2020, and they are on track to accomplish this. In Brazil, deforestation is increasingly occurring in small parcels, so high resolution data is important. INPE is ready to replicate its MRV system elsewhere if asked.

[2]Satellite Forest Information Product Specification, GEO FCT Guidance Document 003
[3]From IPCC Good Practice Guidelines [http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf.html].

For technical capacity building, Josef Kellndorfer introduced the WHIPS (Woods Hole Image Processing System and Service), an open-source based toolkit for generation of calibrated multi-source, multi-temporal satellite image time series. Josef and his team are willing to share the toolkit with Colombia and Mexico and provide training.

In his presentation about Guyana, Dirk Hoekman reported that "Radar gives more information on wetlands and wetland dynamics (than optical sensors). It may also improve stratification of eco-zones." The biomass in Guyana is about 200 t/ha, compared to about 400 t/ha in Borneo.

Dirk requested wall-wall coverage in L-band and C-band at least twice per year, plus dense time series of the VS at L and C band, with some coverage of VS at X-band. There was discussion of whether the wall-wall coverage at C-band should be once or twice per year. Dirk suggested that since Guyana is a small country, it is a good place to try twice per year and learn. The minimum is once per year in the dry season, since there is less contrast in the wet season. For land cover, it is good to have both wet and dry season; for year to year change detection, it is better to use the dry season. For quick-response change detection, a dense time series is recommended. It is also desirable to test interoperability between sensors (e.g. ASAR and RADARSAT-2). Dense time series can help us to prepare for the era of Sentinel-1 and RCM (RADARSAT Constellation Mission).

More data improves the classification results. This reinforces JAXA's conviction to continue with the systematic coverages by ALOS and ALOS-2. This is hard for space agencies but it demonstrates the value of time series analysis for change detection and forest type classification.

Action FCT SCIENCE & DATA A2-1[4]: PD team leads and NDs will identify wet and dry season dates for each ND country, and send these to Ake Rosenqvist by 1 March 2011.

In Guyana, there is very little deforestation, so change is slow, but we need a good baseline to detect future changes. In contrast, in Borneo, the forest is changing more quickly.

Tony Milne said that, based on his work in Tasmania, SAR tends to over-estimate forest and ETM tends to under-estimate it. However, although the location results can differ, the Landsat and SAR predict total amounts of forest area that are very close.

Optical data cannot see some of the vegetation distinctions that radar can see. However, radar signatures are very dependent on environmental conditions, such as recent rain. L-band appears to be more effected by environmental conditions than C-band.

The limited resolution of the SRTM DEM poses some problems in hilly terrain.

There was discussion about a case where the remote sensing analysis produced results which disagreed with official government estimates, and the media covered this difference. The

[4] Action items for the FCT Science & Data Summit will be numbered as FCT SCIENCE & DATA An-m, where 'n' refers to the number of the meeting and 'm' refers to the mth action item for meeting 'n'. Since this is the second SDS meeting, n=2 for this meeting.

scientific results should be published, but we must be careful not to embarrass national governments, who are FCT GEO partners.

Masanobu Shimada said that there was an action item during the ND Summit on 7 February to estimate the geometric accuracy of PALSAR. He calculated this accuracy to be less than 11 metres, which is very good.

The PD teams were requested to update their plans and schedules, prior to the CEOS SIT meeting in March 2011.

Wednesday, February 9, 2011

11. Current Status and Outcomes of REDD Negotiations under UNFCCC

Maria Sanz-Sanchez presented an overview of the REDD process, the outcomes of COP 15 and 16, and the outlook for the future. The only decision taken at COP 15 was methodological guidance on REDD. For the first time, 'remote sensing' was mentioned in the guidance.

The IPCC Emission Factor Database is a useful tool which will be promoted in the future.

COP 16 launched the REDD mechanism, and identified which activities are recognized under the mechanism. Forest activities are in the context of broader land use (e.g. agriculture). Countries will not be rewarded for changing forests to plantations.

COP 17 will take place in Durban in December 2011. (The original presentation indicated Mexico, but that was an error and has been fixed on the version on the website.)

In answer to a question of whether the cost of remotely sensed data could be counted as contributions to REDD, Maria said that it is not excluded, but the convention will not pay for data.

Regarding leakage, REDD is a national program, and so countries can deal with leakage within their borders by improving the MRV. International leakage cannot be solved because it is a voluntary program. We need to provide incentives for everyone to be engaged.

12. Key Remote Sensing Science Questions

Ake Rosenqvist opened this session with an introductory presentation on the key remote sensing science questions. He noted that while the current discussions are focused on RS issues, the importance of open issues related to ground data, the integration of ground and remotely sensed data, and linking to emission models are duly recognised and will need to be covered in forthcoming discussions, probably during the next SDS meeting.
There were four key RS questions addressed, each introduced with a summary presentation by a lead researcher in the field:

- **Sensor interoperability**
    - Optical/optical interoperability (lead presenter: Julio Dalge, INPE)
    - Optical/SAR and SAR/SAR (lead: Josef Kellndorfer, WHRC)

Ake defined sensor interoperability as "Obtaining the same thematic results from different sensors" (i.e. to what extent can one sensor be replaced by another - e.g. for replacement in case of data contingencies, or to increase data acquisition opportunities).

- **Sensor complementarity** (lead: Tony Milne, CRC-IS)

Sensor complementarity was defined as "Obtaining additional thematic information through the (synergetic) use of two or more different sensors" (i.e. clarifying the relative importance of the satellite data sources available for the derivation of the key FCT forest information products).

- **Optimising information extraction from C-band SAR** (lead: Dirk Hoekman, U-Wageningen)

While the utility of both optical data and L-band SAR for forestry monitoring is rather well established, the best use of C-band SAR data in this domain is still largely unexplored and needs to be clarified, in particular given the foreseen availability of large amounts of C-band SAR data by near-future public-good satellite systems. In the near-term, there is a need to clarify whether the current FCT acquisition strategy for C-band SAR (semi-annual wall-to-wall) makes best use of the sensor.

- **Applications and optimal use of X-band SAR** (lead: Christiane Schmullius, FSU-Jena)

The issue of X-band SAR is similar to that of C-band SAR data, where the most efficient use of the sensor for forest monitoring applications needs to be clarified.

The lead speakers explored full and partial interoperability between optical and optical sensors, between optical and SAR, and between SAR and SAR sensors.

There was discussion of whether the processing can be totally automated or whether a human in the loop was necessary. The advantage of total automation is that differences between operators are removed, whereas having a human in the loop reduces false alarms.

It was noted that in working with optical sensors at different resolution, interoperability can be challenging.

There was consensus that combining the data from sensors in different portions of the electromagnetic spectrum, and multi-temporal data, improve confidence in the data and reduce risk of sensor unavailability. While the case studies presented showed that optical data (in particular with a MIR band), followed by L-band SAR, contain most thematic information, the analyses also indicated that all sensors available to the PD teams did indeed provide additional thematic information and no sensor was suggested to be excluded from the FCT acquisition plan. Ake noted that the issue with C-band (and X-band) was hence to find ways to improve information extraction by modifying the FCT acquisition strategy to make the most out of the C-band sensors. Two key questions to be clarified were whether dual-season wall-to-wall is the best strategy, and how many coverages per year are required.

On the issue of L/C-band complementarity, Dirk Hoekman noted that while L-band generally is more useful than C-band for forest- and land cover mapping, C-band was found to be better for detecting burn scars, and to distinguish between certain low vegetation and forest types (e.g. heath forest and a peat forest). Shortly after a burn, there is smoke and subsequent rain and clouds, so optical sensors are hampered in their ability to map burns.

A potential strength of C-band data (from Sentinels and LCM) is very dense time series and Dirk reported that tests with ASAR had resulted in a map delivered to the field two days after the acquisition, whereas an optical change detection had taken 10 months to be delivered due to cloud cover. So C-band has a potential for quick change detection, where quick reaction allows authorities not only to report, but also to enforce.

Dirk also showed that L-band or optical data can be used to create a forest mask baseline, while C-band time-series can be used to monitor changes.

It was a general observation relevant for all types of satellite data, that since land cover transitions (e.g. forest – clear cut – regrowth) can occur quickly, and since seasonality has a major effect on the appearance of the satellite data, denser time series provide improved accuracy in both classification and for change detection. The denser, the better.

In the era of Sentinel-1 and RCM, there is a potential for dense time series (available under an open and free data policy), and these will provide important input to FCT/GFOI. In order to investigate how many C-band coverages per year that would provide the best trade-off between satellite resources and thematic information contents, it was suggested that the FCT coordinated acquisition strategy be modified to program ASAR and RADARSAT-2 to acquire dense time series over a limited number of selected Validation Sites, to "mimic" the capacity of the future C-band SARs. In addition, this would accommodate further analysis of the level of interoperability between ASAR and RADARSAT-2. The PD teams were asked to get back to Ake and Frank Martin with specifications on which VSs to be used for the study.

Action FCT SCIENCE & DATA A2-2: PD team leads will identify VS for dense C-band times series of ASAR and RADARSAT and send these to Ake Rosenqvist / Frank Martin Seifert by 11 March 2011.

In addition to the science questions, there was a discussion on accuracy metrics. Shaun Quegan said that the term accuracy is a poor metric for a 2-class classification where one of the classes dominates, as ‘forest’ does in a forest/non-forest map. Curtis Woodcock said that confidence intervals on the area estimates are better than accuracy metrics.

Erik Naesset said that if the field sampling strategy is done well, biases will be taken out of the estimation. This view was challenged by Tony Milne who said that errors in data or geo-referencing are not fixed by the sampling strategy. In order to measure change, we need to combine layers from different dates. Each layer must have sub-pixel accuracy geolocation, or the errors will inevitably be introduced in the resulting change estimates.

13. Near-future C-band SAR Missions Relevant to GFOI

Frank Martin Seifert presented the Sentinel missions, which are:

- Sentinel-1: SAR Imaging; launches in 2013 and 2015+
- Sentinel-2: Multi-spectral imaging; launches in 2013 and 2015+
- Sentinel-3: Ocean and global land monitoring; launches in 2013 and 2015+
- Sentinel-4 & 5: atmospheric missions.

The Sentinel Data Policy will be free and open. The Sentinel missions are built to serve operational GMES users. The main focus is on Europe, the North Atlantic and the Arctic.

The ESA Sentinel-2 team is working in close cooperation with the Landsat Data Continuity Mission (LDCM) of USGS. LDCM is expected to launch in December 2012.

Yves Crevier presented the RCM. The three main thrusts will be:

- Maritime Surveillance
- Environmental Monitoring
- Disaster Management.

The mission will focus on Canadian government priorities, potentially including international priorities like FCT. The planned launch dates of the 3 satellites are 2014, 2015 and 2015. The mission plans are pre-defined and pre-programmed routine data acquisitions, defined pursuant to the requirements of well-established operational users. The Data Policy calls for interoperability with Sentinel-1 from a User's perspective.

CSA and ESA are cooperating and harmonizing the missions to deliver the most service for the user communities.

Per Erik Skrovseth noted that the ground segments for the Sentinels are being designed now, and input must be provided to the ESA design teams without delay to ensure that the FCT needs are accommodated. This applies to RCM as well.

Ake Rosenqvist noted that the global systematic acquisition strategy that is already in operation for ALOS was developed pre-launch by JAXA. It was designed for global forest-, land cover and wetlands monitoring with the aid of an international science advisory panel within the within the Kyoto & Carbon Initiative (K&C) framework. Development of the acquisition strategy for ALOS-2, which is scheduled for launch in mid-2013, is planned to commence in 2011. It is planned to be consistent with the ALOS-1 strategy, and will also be developed with scientific advice from the K&C international science group.

Action FCT SCIENCE & DATA A2-3: The SAR working group will formulate the C-band needs of this community for forest observations, and communicate it to the Sentinel-1 and RCM mission managers. Josef Kellndorfer will take responsibility for this action. This action is urgent for the case of Sentinel-1. The SAR Working Group will consist of Frank Martin Seifert, Josef Kellndorfer, Dirk Hoekman, Christiane Schmullius, Ake Rosenqvist, Yves Crevier and Tony Milne.

Thursday, February 10, 2011

14. GEO FCT – UNFCCC Secretariat Coordination

Maria Sanz-Sanchez discussed the coordination between FCT and UNFCCC. She said that it is important and a unique opportunity for foresters and remote sensers to do the design together. Countries are putting together their national programs and monitoring is a huge part of that. REDD is part of the mitigation of climate change.

This is part of the estimation side, not the accounting side. The accounting side will be more political, and we do not know what the market will do.

The countries themselves will do the monitoring and estimation, so they must have ownership for a long time in the future. UNFCCC provides advice, but is not an implementing agency. Although the technologies are promising, some countries are starting at a low level, and the PD teams should help them to move toward maturity slowly.

National estimation numbers are very sensitive, and they must be treated carefully, because they could cause a negative reaction and a step backwards. It was pointed out that FCT is verifying the products, not the numbers. We are helping to produce techniques, not numbers, unless the countries ask us to. Maria replied that when there are legal obligations, MRV is very important. Parties get nervous when 'reporting' and 'verification' are mentioned.

It was suggested that people are nervous about 'verification', and that 'validation' would be a better word, which would not make people so nervous.

15. Document Outline and Review Process

Giovanni Rum introduced the FCT Document Outline and Review Process. He presented the list of key documents. The key issues are:

1. Is the document set complete?
2. Linking the documents to the FCT activities in the NDs
3. Hierarchy of the documents: is there a clear understanding of interdependencies among the documents?
4. Is the Table of Contents for each document stable, so that the content can be finalized?

There was discussion about whether the documents should be free-form or a rigid hierarchy. They are guidance documents for the parties. One view was that the documents are mostly science discussions and a lack of rigidity is healthy. Another view was that the documents need to be maintained, and if they are too free-form, they will be a hodge-podge.

16. GD-002: In-situ Forest Measurement Standards and Protocol

Chris Brack discussed this guidance document, which is partly written. There are a number of definitions, such as 'ground level', 'breast height' and 'course wooded debris' which must be clearly specified. There are alternatives in the way in which in situ measurements are done; the alternatives are different, and one is not necessarily better than another, but the alternative selected must be consistent within the country and with the historical inventory. If done badly, the in situ measurements can introduce huge errors. There are direct and indirect methods for measuring biomass. Issues to resolve include the plot size correlated to the remote sensing, and sampling considerations. We should make the countries aware of alternative approaches that they can choose from.

17. GD-003: Satellite Forest Information Product Specification

Alex Held presented this document, saying that we want a realistic and practical specification from a user point of view. He discussed the drivers for IPCC and UNFCCC. He discussed accuracy and discussed guidance on the minimum mapping unit (0.05 – 1.0 hectares). The

suggested minimum geometric resolution is 25 – 30 m, since this takes advantage of the longest operational time series, and allows countries to report changes at sub-hectare level. The accuracy of the products will rely on the validation process, and the products should have been peer reviewed. However, some of the products under discussion have not yet been peer reviewed. Long time series are important for accuracy. The national forest wall-to-wall information will need to track the land on a grid basis, which may be at pixel level, or larger. High resolution data is needed for validation. See the definition of the Horizon 1 products in section 9.

18. **GD-005: Satellite Interoperability and Processing Methods**

Peter Caccetta described this document, which is written as a set of guidance principles while avoiding being overly prescriptive. Peter presented the following 7 guiding principles:

1. In general, automated analysis (computer-based) is preferable to visual interpretation of imagery to promote consistency.
2. When attempting to map forest change, it is generally more accurate to find change by comparing images as opposed to comparing maps derived from images.
3. When data are available from many time-steps, it is better to use the information from the whole time-series of images in one analysis than comparing only two dates.
4. Accuracies and precision in the processing chain should be quantified and documented.
5. The effects of using data from different sensors on estimating forest extent and change should be quantified (for example forest change statistics).
6. Monitoring systems should be at least as accurate as available global defaults.
7. End-to-end processing of satellite imagery is a complicated and demanding technical task; where appropriate users should leverage existing pre-processing capabilities to facilitate product generation.

This document can reference existing documents such as the GOFC-GOLD Sourcebook. The definitions of the Horizon products in this document differs from those in GD-003, but it was agreed that the definitions in GD-003 should be the official ones.

19. **GD-006: Methods on Validation of Remote Sensing Data Products and Accuracy Metrics**

Curtis Woodcock said that Kim Lowell wrote about Quality Assurance Concepts for Image Processing in National Carbon Accounting Systems. Subsequently, the co-authors agreed that the document should be more practical and cookbook. What is really needed is Methods for Accuracy Assessment of Remote Sensing Maps and Area Estimation, in particular area estimates of forest and forest change. Curtis proposed that the only meaningful indicator regarding accuracy of remote sensing products for area estimation are confidence intervals on area estimates. He showed that the confidence interval can be as large as the mean of the parameter being estimated! Accurate maps can have high bias. Sampling design is important for this.

20. **GD-007: Linking of In-situ Forest Measurements, Remote Sensing and Carbon Models**

Shaun Quegan talked about carbon models. The authors are trying to set principles that relate to IPCC guidelines. There is 60% uncertainty in total land use change, and this leads to large biomass uncertainty. FCT can contribute by improving the land use change estimates. Shaun presented a number of models of varying complexity. Climate matters; for example, the 2010

drought released an additional 8 GtC into the atmosphere, which is about equal to the global annual fossil fuel emissions. Also conditions such as site attributes, management and disturbance patterns affect the rate of carbon accumulation. It was suggested and agreed that a sample of case studies of the approaches being taken by developing countries be added to the document.

21. **Document Session Discussion and Conclusions**

Giovanni Rum said that the authors should work together to produce the next draft of the documents at the end of March or early April. He asked for more volunteers to join the drafting teams. George Dyke will help to put them all together.

22. **Special Presentation on FORAF/OFAC Activities in the Congo Basin**

Andreas Brink and Catherine Bodart presented the work of the Observatory of Central African Forests (OFAC or Observatoire des Forêts d'Afrique Centrale). This is an innovative collaborative approach that builds on the global RSS one degree grid with a more intensive sampling at half degree to develop national and regional estimates of forest cover and forest cover change for 1990, 2000 and 2005. They estimate the following types of land cover changes: deforestation, reforestation, degradation and regeneration. The maps were validated by experts from the countries of the Congo Basin. This work was done in collaboration with COMIFAC, local and regional partners, JRC, FAO and OSFAC (Observatoire Satellital des Forêts d'Afrique Centrale, the Central Africa regional GOFC-GOLD network).

23. **Special Presentation on Lidar**

Eric Næsset presented some plans for FCT in Tanzania and some aspects of field surveys and remote sensing. The airborne lidar does not saturate at high biomass. They are working on a biomass estimator based on lidar data. The lidar approach produced a lower error at a lower cost than alternative methods. He stressed that the field survey design needs to be done jointly with the remote sensing design. He also said that REDD+ will require field data for sustainable management, and remote sensing cannot provide this data.

24. **French Commitments for REDD+**

Benoît Mertens presented French initiatives for REDD+ and potential contributions to GEO FCT. IRD (Institut de recherché pour le développement), AFD (Agencefrançaise de développement) and CNES (Centre national d'études spatiales) are working on initiatives to give Congo Basin countries access to Earth Observation (image programming, data access, processing facilities) and capacity building (research and training) in the framework of development projects for natural resources management and conservation. REDD+ licensing is being issued between the REDD end user and the data provider. The Libreville ground station in Gabon was approved last summer.

25. **Google Earth Engine**

Rebecca Moore presented Google Earth Engine, which was launched in Cancun in December. This is a philanthropic project. Google was asked by scientists to contribute technology to FCT, and Google recognizes FCT to be globally significant and time-sensitive. The Google cloud computing paradigm fits this problem. They are concerned that science is often trapped in laboratories; they want transportability, reproducibility, open science. Google has a hosted version of Earth Engine and an off-line open source version.

They will host the last 25 years of Landsat data of most tropical countries. The underlying engine is thoroughly vetted but some aspects of the human interface may be rough. There are thousands of computers at the Google data centre at users' disposal. The Landsat data catalogue contains Landsat-5 & 7 data with 50% cloud cover or less. They are now moving north and south from 23 degrees latitude. Google thanks the EROS Data Center and the Moore Foundation.

Earth Engine APIs can be used to build new apps. See http://earthengine.googlelabs.com/#intro. Every dataset and algorithm has a 'details' page. Featured maps include Mexico percent tree cover, Water Mask of Central Africa and NDFI (Normalized Difference Fraction Index) over the Amazon. The GOFC-GOLD REDD Sourcebook mentions Google Earth Engine under Emerging Technologies. Google is donating 20 million CPU hours toward environmental MRV. They are also seeking ideas for collaboration. Google hopes that this will strengthen the capacity of the REDD community.

In answer to a suggestion of putting links to the Google on-line tools in the guidance documents, Rebecca thought this was a great idea, that it would bring the guidance documents to life, and make the system more operational. Rebecca also said that they want to go to central Africa this year.

26. **Congo Basin Tropical Forest Monitoring**

Didier Rigal presented the French initiatives to tropical forest monitoring in the Congo Basin. This is related to the project in Section 24 above. Astrium and AFD have formed a public-private partnership. The project will give access to the SPOT archives and also to the best of current technology: resolution, geometry, know-how. The deliverables of the current contract (phase 1) are:

1. Images – 1998-2002 archive of Central African Republic, VHR SPOTMAPS, 2008-2010 archive, and recent programming to fill gaps in the archive.
2. Methods and results: historical analysis maps.
3. Web access for users.

National authorities can re-allocate licenses to end users, and there are special licenses for REDD users. REDD+ widens the gate of what is admissible under a REDD license.

This is a long term commitment, to at least 2015. They are already working on phases 2 and 3 of the project. This provision of data and services is the French contribution to GEO.

27. **FCT/GFOI Science Road Map**

Gary Richards made some comments on the current status of affairs. He said that the global community is gaining confidence that when remote sensing is integrated fully with the work on the ground, it is a useful tool that can contribute to the REDD agenda and forest monitoring in general.

GEO faces challenges as it moves towards discussion of operations. It is finding its way in its new role. We have had science demonstration activity to date and we are now starting to talk about operational activities in support of governments. We must be clear about the goals; we

must not map for the sake of mapping. The work needs to show what it is solving and what it is demonstrating. We must capture what we have seen in this meeting. We need a better dialogue with the GEO Secretariat about whether the work to date supports their goals. We need more clarity about what standing the methods documents have within the operations of GEO. We need to produce organizational products, not just science products.

Gary reminded us about the ISRSE workshop in Sydney on April 15 (http://www.isrse34.org/). Questions of interoperability and next steps will be discussed.

The Journal of the International Society of Digital Earth wants to publish a special issue on forest monitoring centred around the products of GEO FCT. Gary has been asked to co-edit this special issue, and he asked participants to send in papers. He solicited ideas of ways to pull the materials together and contribute to this issue.

Gary asked participants to work with the GEO principles in the countries, so that they operate as a focal point for the countries. The work of GEO now spans several government departments in each country, and the principles need to be well informed of all the results of the GEO tasks.

28. Linkages between UN-REDD and the GEO Activities

Alberto Sandoval spoke about global linkages between UN-REDD and GEO activities. He talked about the impact of scale and how global programs relate to local initiatives and benefits. He listed the many UN-REDD activities in FAO. These include scientific review of MRV&M and support to country implementation of MRV&M governance. He mentioned agricultural systems in the REDD+ context and how they are linked to food security and sustainable food production. Future workshops will link FCT and FAO, focused on capacity building and information sharing.

29. Synergies and Linkages with FAO Activities

Adam Gerrand spoke about the synergies between GEO FCT and FAO activities. These include the Global Forest Resources Assessment (FRA2010), the Global Forest Remote Sensing Survey (RSS), the National Forest Monitoring and Assessment (NFMA) and others. FAO is involved in more than 9 GEO tasks. He presented the benefits of collaboration and the risks if we don't.

The aggregated data of the FRA, RSS, NFMA etc is owned by FAO and is publicly available. However, the raw data belongs to the countries and is up to them to distribute the data or not.

30. Remote Sensing Question Summary and Open Issues

Ake Rosenqvist led the session to summarize the remote sensing questions.

- Optical data most commonly used and with most rich information content. Weak points in cloudy areas and capacity to obtain targeted wall-to-wall acquisitions within short time windows with the currently available sensors. Upcoming (launch 2012/2013) LDCM and Sentinel-2 will have shorter revisiting times.
- L-band is the most commonly used SAR sensor due to the longer wavelength and the global systematic acquisition strategy already implemented for ALOS PALSAR.
- C-band has been demonstrated to provide useful additional information –in some cases even better differentiation than L-band (burn scars and low vegetation type discrimination).

- Initial X-band SAR results indicate potential, especially for identification of degradation and selective logging. More X-band data desired for further studies.
- X-band SAR and VHR little used so far, but highly desired for both classification training and for validation of the maps and product generated.
- The utility of time-series of data was emphasized – for all sensor types - both for change monitoring, as well as to improve classification accuracy (the longer time series - the better accuracy, corrections for regional/seasonal biases)
- Utilization of time-series of C-band SAR can be an important way to improve the utility of the data. Great hope was laced on the near-future operational C-band SAR systems RCM and Sentinel-1 with short revisiting times.
- Desired research task for the PD teams – analysis of simulated "Sentinel-1/RCM" time-series data sets over selected ND Validation Sites (dense time series of ASAR and R-2)
- Sentinel and RCM missions very promising, but guidance to ESA and CSA would be required from FCT community to assure useful acquisitions (Action Item) similar to what is currently being done for ALOS and ALOS-2. It was indicated that it is urgent to provide input to ESA and CSA. A SAR working group (Frank Martin, Yves, Josef, Dirk, Ake, Chris Schmullius, Tony) was proposed.

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).
- 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 was particularly important for the optical sensors with respect to cloud coverage and the C-band sensors which are more sensitive to moisture conditions.
- ASAR and RADARSAT-2 to provide a dense time series over certain VS
- Very High Resolution data - both optical and SAR over selected VSs.

Yves Crevier said that more clarity is required to convince the management of the space agencies to continue to support GEO FCT. He reminded the group that FCT started with 7 NDs and the space agencies agreed enthusiastically. The demonstration area doubled to 10 million km^2, and the NDs grew to 10. The imaging requirements are to be presented to CEOS to support the science requirements. The science requirements will include interoperability and complementarity. Yves does not think that we have clear science requirements yet. There is no end point in sight yet. What do we want to accomplish? The space agencies want to improve their efficiency in contributing, but the lack of clarity is making this difficult. CSA management needs a well stated user need in order to respond to future requests.

Gary Richards responded that the growth in the NDs cannot support an operational need, which the NDs are asking for. The mechanisms of NDs cannot be sustained into the operations period. The Science Plan for operations needs to be very clear.

The meeting was reminded that the space agencies would meet on 11 February to discuss the boundary conditions for data acquisitions at ESRIN in Frascati.

Gary Richards thanked Adam, Giovanni and Ake for the organisation and congratulated all participants. This work is changing international thinking. The scale and quality of the demonstrations give confidence in the role of remote sensing for forest monitoring. The organizers and FAO were thanked for hosting the meeting. The presentations have been placed on the FAO web site.

Action Item Summary

Action FCT SCIENCE & DATA A2-1: PD team leads and NDs will identify wet and dry season dates for each ND country, and send these to Ake Rosenqvist by 1 March 2011.

Action FCT SCIENCE & DATA A2-2: PD team leads will identify VS for dense C-band times series of ASAR and RADARSAT and send these to Ake Rosenqvist / Frank Martin Seifert by 11 March 2011.

Action FCT SCIENCE & DATA A2-3: The SAR working group will formulate the C-band needs of this community for forest observations, and communicate it to the Sentinel-1 and RCM mission managers. Josef Kellndorfer will take responsibility for this action. This action is urgent for the case of Sentinel-1. The SAR Working Group will consist of Frank Martin Seifert, Josef Kellndorfer, Dirk Hoekman, Christiane Schmullius, Ake Rosenqvist, Yves Crevier and Tony Milne.