Report of the 1st Workshop on Monitoring Tropical Deforestation for Compensated Reductions

as part of the
GOFC-GOLD Symposium on Forest and Land Cover Observations

Friedrich-Schiller University
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Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD) is a coordinated international effort to ensure a continuous program of space-based and in situ forest and other land cover observations to better understand global change, to support international assessments and environmental treaties and to contribute to natural resources management.

GOFC-GOLD encourages countries to increase their ability to measure and track forest and land cover dynamics by promoting and supporting participation on implementation teams and in regional networks. Through these forums, data users and providers share information to improve understanding of user requirements and product quality.

GOFC-GOLD is a Panel of the Global Terrestrial Observing System (GTOS), sponsored by FAO, UNESCO, WMO, ICSU and UNEP. The GOFC-GOLD Secretariat is hosted by Canada and supported by the Canadian Space Agency and Natural Resources Canada. Other contributing agencies include NASA, ESA, START and JRC. Further information can be obtained at http://www.fao.org/gtos/gofc-gold

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Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD)
a panel of the Global Terrestrial Observing System of the United Nations (GTOS)

Land Cover Implementation Team Project Office

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Executive summary

The workshop on "Monitoring Tropical Deforestation for Compensated Reductions", held 21.-22. March 2006 in Jena brought together an international group of more than 30 recognized scientists and experts in the field of earth observation and tropical forest cover. Taking note of the recent UNFCCC decision related to the reduction of emissions from deforestation in developing countries, the workshop participants developed a consensus and concerted response on the technical feasibility of space-based monitoring of deforestation and reduced carbon emissions in a transparent, timely and cost-effective manner.

Comprehensive experiences on methods and techniques for monitoring tropical deforestation from Earth observation already exist at the project level within the framework of the CDM, at the national level for some countries (e.g. Brazil, Peru and India) and at regional or global level from international organizations (FAO) or research institutes. Satellite observations have proven to provide consistent, transparent, and cost-effective measurements of forest cover and change in high spatial and temporal detail over large geographic areas, in particular for tropical regions. Thus to be effective, an operational deforestation monitoring system for developing countries should consider satellite observations. Large deforestation areas, which reflect the majority of carbon emissions from forest change are most easily detected using current observation capabilities. Detection of forest degradation and small deforestation patches require more specific and regionally tuned approaches. Considering existing satellite databases and assuming continuity for future satellite mission, forest changes can be monitored for assessing and comparing historical and future rates of deforestation. Current satellite observations do not allow for a direct operational estimation of changes in carbon stocks at a national scale. A combination of ground-based or detailed remote surveys is anticipated to estimate net carbon emissions from satellite-observed changes in forest area; such an approach has been proposed by the IPCC 2003 good practice guidance.

Based on the consensus achieved, the international community present at the workshop has agreed to start developing technical guidelines and protocols for monitoring emissions from deforestation in developing countries. Specific aspects of such a monitoring framework have been discussed in designated breakout groups including 'best' practices and outlines on:

- Monitoring deforestation
- Monitoring forest degradation and regeneration
- Estimating biomass/forest types in relation to carbon emissions
- Historical deforestation and projections
- Verification
- Structure of 'best' practices report and input to SBSTA workshop

The agreement reached during the workshop was communicated to accredited observers of the UNFCCC, in particular GTOS, to be considered for the submissions to the SBSTA due 31. March 2006. A first draft of the technical development will be completed for the upcoming SBSTA meeting in Bonn in May 2006.

Despite the earth observation potentials, further capacity development is needed to establish operational deforestation monitoring systems at the country level in developing countries, and for ensuring the continuity of long-term satellite observation and appropriate data dissemination mechanisms.

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1 Background and objectives

Official international discussions were initiated at the COP-11 of the UNFCCC in Montreal in December 2005 on issues relating to reducing emissions from deforestation in developing countries. A related workshop was held previously in July 2005 at the Carnegie Institution, Washington DC, jointly with Environmental Defense, to discuss the technical feasibility of determining historical deforestation and monitoring future tropical deforestation that would enable developing countries to obtain carbon credits for decreasing deforestation (DeFries et al., 2005).

Global Observation of Forest and Land Cover Dynamics (GOFC-GOLD) is a coordinated international effort to ensure a continuous program of space-based and in situ forest and land cover observations to better understand global change, to support international assessments and environmental treaties and to contribute to natural resources management. GOFC-GOLD encourages countries to increase their ability to measure and track forest and land cover dynamics by promoting and supporting participation on implementation teams and in regional networks. Through these forums, data users and providers share information to improve understanding of user requirements and product quality. GOFC-GOLD is a Panel of the Global Terrestrial Observing System (GTOS), sponsored by FAO, UNESCO, WMO, ICSU and UNEP.

GOFC-GOLD established an ad hoc working group on this issue in fall 2005. The role/goal of this GOFC-GOLD working group is to provide technical guidance on current and future capabilities for monitoring deforestation within the context of the UNFCCC's present discussions. Regular communications have resulted in an outline for the terms of reference and specific activities to develop and demonstrate internationally agreed and accepted technical guidelines and protocols for space-based monitoring of deforestation for compensated reductions. As a result, this workshop was organized by the GOFC-GOLD ad hoc group and focused on the following objectives:

- Finalize the terms of reference of the ad hoc working group coordinated by GOFC-GOLD
- Provide feedback and discussions on activities in progress:
    - Define needs and requirements based on what is suggested or intended by the UNFCCC and related activities
    - Assess standard practices for monitoring tropical deforestation (nationally, internationally) with particular focus on the role of Earth Observation
- Outline future activities towards a complete draft technical document with particular focus on consensus and development guidelines for best practices
- Identify the key requirements and current limitations of implementing monitoring in tropical countries

Given the potential scientific and technical implications of the UNFCCC COP-11 decision related to the reduction of emissions from deforestation in developing countries (FCCC/CP/2005/L.2), the overall goal of the workshop was to develop a consensus and concerted response of the earth observation community on the technical feasibility of space-based monitoring of deforestation and reduced carbon emissions in a transparent, timely and cost-effective manner.

2 Participants

The workshop brought together more than 30 recognized scientists and experts in the field of earth observation and tropical forest cover. Participants included GOFC-GOLD land cover implementation members, representatives from developing countries concerned with avoiding deforestation, scientists from research institutions, technical experts from non-governmental organizations or private companies, as well as a few representatives from space agencies. The full list of participant is provided in Appendix A.

3 Agenda

The workshop included one day of presentations and one day of breakout group discussions. The presentations were organized in different sessions to emphasize the different workshop objectives:

- Background and overview on tropical deforestation
- UNFCCC: needs, requirements, proposals
- Assessment of current practices including presentations on key national monitoring systems (i.e. Brazil, India, Peru, Indonesia) and international earth observation experts

The six breakout group discussions focused on the development of a consensus on best current practices and technical guidance, an outline of shortcomings, a framework for implementation and defining the next steps:

1. Best practices – Monitoring deforestation (chair: Mayaux).
2. Best practices – Monitoring degradation and regeneration (chair: De Souza).
3. Best practices – Biomass/forest types especially in relation to carbon (chair: Brown).
4. Historical deforestation and projections (co-chairs: Schlamandinger/Vereau)
5. Verification (co-chairs: Pandey/Seifert-Grazin)
6. Structure of best practices report and input to SBSTA Workshop (co-chairs Achard/Defries)

A detailed agenda is shown in Appendix B.

4 Summary of presentations and discussed topics

4.1 Tropical deforestation

Tropical deforestation processes are related to a variety of issues including carbon cycle and biotic emissions/sequestration, ecosystem functioning and biodiversity, water and the hydrologic cycle, land use and cover change dynamics and natural resource management. Of most concern to the UNFCCC is the release of 1-2 PgC/yr during the 1990's, which constitutes about 15-35 % of the annual fossil fuel emissions. These emissions are the most significant carbon source in the tropical zone. Considering the emissions of other greenhouse gases (i.e. methane, nitrous oxide etc.) as well, tropical deforestation accounted for 20 - 25 % of the total anthropogenic emissions in the 1990's (Houghton, 2005).

The carbon emissions due to tropical deforestation are expected to increase in the following decades (Table 1). Thus, avoiding tropical deforestation may have a very significant impact for reducing future emissions.

Table 1: Context of carbon emissions due to projected tropical deforestation (Source: Mollicone et al, submitted)

Time frame	Estimated CO^2 emissions due to tropical deforestation	Increase compared to 1990s
1990s	+ 1.6 ± 0.6 $GtCyr^{-1}$	
2000s	+ 2.5 $GtCyr^{-1}$	+ 56 %
2010s	+ 3.9 $GtCyr^{-1}$	+ 114 %

The study of deforestation processes has emphasized its dynamic and complex nature. Deforestation occurs through a range of states, from forest clearing and land conversions to subtle modifications or degradation in concert with regeneration processes. The intensity of forest changes varies over time and place. Deforestation dynamics result in a landscape mosaic of various cover types and cover states reflecting a "memory" of the changes. Changes in forest area and forest density are intrinsically linked to carbon fluxes and emissions. The landscape patterns today emphasize long-term sources and sinks in regrowth and soil organic matter storage. There is an asynchrony of deforestation (fast) and regeneration rates (slow) in the context of the overall carbon budget; that must be considered in any carbon accounting system.

The complexity of deforestation poses particular challenges for monitoring purposes. There is a need for high resolution data (i.e. a few 10s m) to identify the variety of processes (clearing, logging, fire, degradation) and quantify the extent of forest cover and their density for estimating carbon emissions. Appropriate tools to measure change in carbon stocks are in-situ forest inventories and remote sensing approaches. National forest field inventories are usually a common source of good-quality data for developed countries but may be inappropriate for large remote areas in many developing countries, and often lack international comparability. Earth observation approaches have successfully demonstrated their ability to complement traditional forest surveys by overcoming some of these issues, in particular by providing consistent, transparent, and cost-effective measurements of forest cover, density and change in high spatial and temporal detail over large geographic areas.

4.2 UNFCCC developments and requirements on reducing emissions from deforestation

Following a submission by the governments of Papua New Guinea and Costa Rica (on behalf of many supportive Nations), the UNFCCC Conference of the Parties at its eleventh session (COP-11) in Montreal (December 2005) opened an official discussion on how to stimulate action towards reducing emissions from deforestation in developing countries (Agenda Item 6 of the COP-11). The submission by Papua New Guinea and Costa Rica called for the Parties to take note of present rates of deforestation within developing nations, acknowledge the resulting carbon emissions, and consequently open the dialogue to develop scientific, technical, policy and capacity responses to address such emissions resulting from tropical deforestation.

The UNFCCC already includes a commitment by all Parties to: " …*promote and cooperate in the development, application and diffusion, including transfer, of technologies, practices and processes that control, reduce or prevent anthropogenic emissions of greenhouse gases not controlled by the Montreal Protocol in all relevant sectors, including the…agriculture [and] forestry…sectors, and to promote sustainable management, and promote and cooperate in the* *conservation and enhancement, as appropriate, of sinks and reservoirs of all greenhouse gases not controlled by the Montreal Protocol, including biomass [and] forests" (UNFCCC, Art.4).* Despite this commitment, the UNFCCC by itself provides neither a mandate nor an incentive for reducing emissions from deforestation.

The discussions held at COP-11 in Montreal resulted in UNFCCC conclusions, shown in Appendix C. According to the decisions made, Parties and accredited observers are invited to submit their views on issues relating to reducing emissions from deforestation in developing countries, focusing on relevant scientific, technical and methodological issues. The submissions are to be considered at the 24th session of the Subsidiary Body for Scientific and Technological Advice (SBSTA-24) in May 2006. A specific workshop on this issue is anticipated before the following SBSTA (25th session, November 2006). SBSTA-27 will report back to the 13th session of the Conference of the Parties in December 2007 including recommendations on relevant scientific, technical and methodological issues for reducing emissions from deforestation in developing countries.

A number of side events discussing proposals, experiences and technical issues accompanied the policy level discussions were held in Montreal. Prominent events included:

- Noel Kempff project (Bolivia) side-event on emissions reductions from avoided deforestation with focus certification of emissions reductions through forest protection
- Amazonian government's proposal for reducing emissions from deforestation
- JRC side-event on accounting for avoided conversion of intact forests with focus on technical options and a proposal for a policy tool
- IPAM side-event on reduction of tropical deforestation and climate change including the release of a book on "Tropical Deforestation and Climate Change" edited by IPAM and Environmental Defense

Several key technical issues are to be considered during the forthcoming SBSTA discussions. They include additionality (addressed through national deforestation baseline rates), leakage (focus on deforestation at national level), permanence (establishment of a carbon banking mechanism), and monitoring. The latter point calls for the consideration of satellite remote-sensing technologies with a clear potential to monitor and estimate deforestation and reduced carbon emissions in a transparent, timely and cost-effective manner.

4.3 Ad hoc working group coordinated by GOFC-GOLD

An ad hoc working group was formed under the coordination of GOFC-GOLD after the workshop on "Remote Sensing Analysis of Tropical Deforestation and Baselines for Carbon Crediting". This workshop was held jointly with Environmental Defense in July 2005 at the Carnegie Institution, Washington DC. International experts in earth observation for deforestation and forest disturbance monitoring started discussions on the technical feasibility of determining historical deforestation and monitoring future deforestation that would enable developing countries to obtain carbon credits for reducing deforestation (DeFries et al., 2005). Several major issues emerged from this workshop:

- Access to data from multiple satellite sensors is crucial
- National-level institutional capabilities and regional partnerships to monitor tropical deforestation need to be developed

- Techniques for monitoring tropical deforestation are available as a basis for developing best available practices and standards
- Transition from the research domain for monitoring deforestation to operational systems requires a commitment from international institutions

The focus of these discussions is whether the capabilities exist to monitor deforestation at a national-scale to implement compensated reductions. The role of the GOFC-GOLD ad hoc group is to provide technical guidance on current and future capabilities. There is a strong need for such an independent advisory group to develop an international consensus among the actors involved in earth observation, and to foster the implementation of related activities. International cooperation and communication is ensured through the GOFC-GOLD land cover team including; international actors and scientists in earth observation and deforestation assessment, experts and representatives from national level institutions in developing countries, and related organizations such as NGO's and UN bodies. The goals of the group are to:

- Develop and demonstrate internationally agreed upon protocols and accepted technical guidelines for earth observation-based monitoring of deforestation for compensated reductions.
- Communicate with actors involved to ensure general acceptance and implementation, to build upon existing experiences and to avoid duplication.
- Foster GOFC-GOLD activities to overcome known challenges for implementation, i.e. consistency and continuity of satellite and in-situ observations and to promote the open sharing of the international satellite data needed to generate the deforestation products and the open sharing of output products and results of analysis.

In addition, the group may get involved in providing a data port for data and data product dissemination or help define some methodological components of an accounting system. The group represents technical experts and its technical outcomes need to be policy-relevant without getting directly involved in the political decision process. To reach the goals mentioned above, the ad hoc GOFC-GOLD working group focuses on several specific activities:

- Outline the needs and requirements to understand what exists, as required by UNFCCC, the Kyoto protocol, and IPCC good practice guidance.
- Assess standard practices for monitoring deforestation. This includes a review of national level deforestation observation systems with respect to UNFCCC, an outline of activities by other organizations for developing such guidelines and to define the role and need for Earth Observation (requirements versus capability and efficiency).
- Develop guidelines for best practices in monitoring deforestation at a national scale considering a range of forest types and land uses, different forest change processes and most suitable methods for their analysis, and related data requirements.
- Recommend key requirements and identify current limitations in the implementation of monitoring in developing countries. This includes the definition of baselines, minimum requirements (transparency, interoperability, and validation), foreseen data shortcomings and known uncertainties, and avenues for implementation and capacity building.
- Develop and participate in demonstration projects to establish baselines and monitor deforestation in developing countries.
- Provide an interface for policy discussions within the UNFCCC on monitoring capabilities to implement a framework for compensated reductions.

Organizational activities of the group include regular teleconferences and interaction with GOFC-GOLD participants, organization of workshops, preparation and distribution of reports, documents and newsletters, and participation in key events. The terms of reference provided the framework for the workshop.

4.4 Assessment of current practices

4.4.1 Overview

The workshop included a number of presentations from the research community, national representatives, and other international experts. The first objective was to summarize the current practices in monitoring deforestation and carbon stock changes using remote sensing. It was emphasized that considerable progress has already been made and some international consensus already exists (see also DeFries et al., 2005). Several related documents have been circulated prior to the workshop (Appendix D). The workshop discussions focused on the issues to be resolved for preparing technical guidelines. There was a need to be realistic about what can be achieved operationally using earth observation. The participants recognized the opportunities to influence data providers, e.g. space agencies, for future satellite missions and data dissemination strategies. The workshop emphasized tropical deforestation issues, which is the most prominent component of forest cover change in developing countries.

The complexity of deforestation poses particular challenges to identify and quantify different disturbance processes including clearing, (selective) logging, fire, and other forms of degradation. Not all forest disturbances are caused by humans; natural occurrences and disasters are not considered in these discussions. In any event, earth observation has proven capabilities to monitor deforestation and forest disturbances through direct observation of changes in forest extent (both increase and decrease) and density. They allow consistent measurements in both space and time over large geographic regions. Satellite observations can build upon multiple sensors for different measurements essential for a continuous global perspective. Suitable earth observation datasets have existed since the 1970's and 80's. Such historical observations can be re-processed to assess previous land and forest changes and link them to current and future developments.

Table 2. Examples of existing, satellite-derived analyses of tropical deforestation at regional and global scales (adopted from DeFries et al., 2005)

Data	Time period	Spatial coverage	Source
Country-wide GEOCover Landsat analyses	1990-2000	10 countries	Conservation International
AVHRR analysis	1982-2000	Global deforestation hotspots	(Hansen and DeFries 2004)
TREES analysis	1990-97	Pan-tropics hotspots	(Achard et al. 2002)
Landsat Pathfinder	1980-90	Pan-Amazon/central Africa	University of Maryland/Michigan State University
Geocover	1980-90	Albertine Rift, Africa	(Plumptre et al. 2003)

With regard to the UNFCCC, space-based observations of land change dynamics and their impacts on climate, for updating climate change estimates, are already embedded in the area of “systematic research and observations”. Improvements towards a consistent global perspective are fostered through Global Climate Observing System (GCOS) and Global Terrestrial Observing System (GTOS). The related Implementation Plan (GCOS, 2004) is the most advanced international earth observation plan for implementing a UN convention with specific tasks for land and forest cover. They include the development of standards for land characterization and validation, issues of data continuity, and the development of consistent global land change datasets on different scales. Satellite observations provide firm scientific underpinnings for the development and implementation of different UN conventions and the Kyoto protocol in the context of forests (see documents in Appendix D).

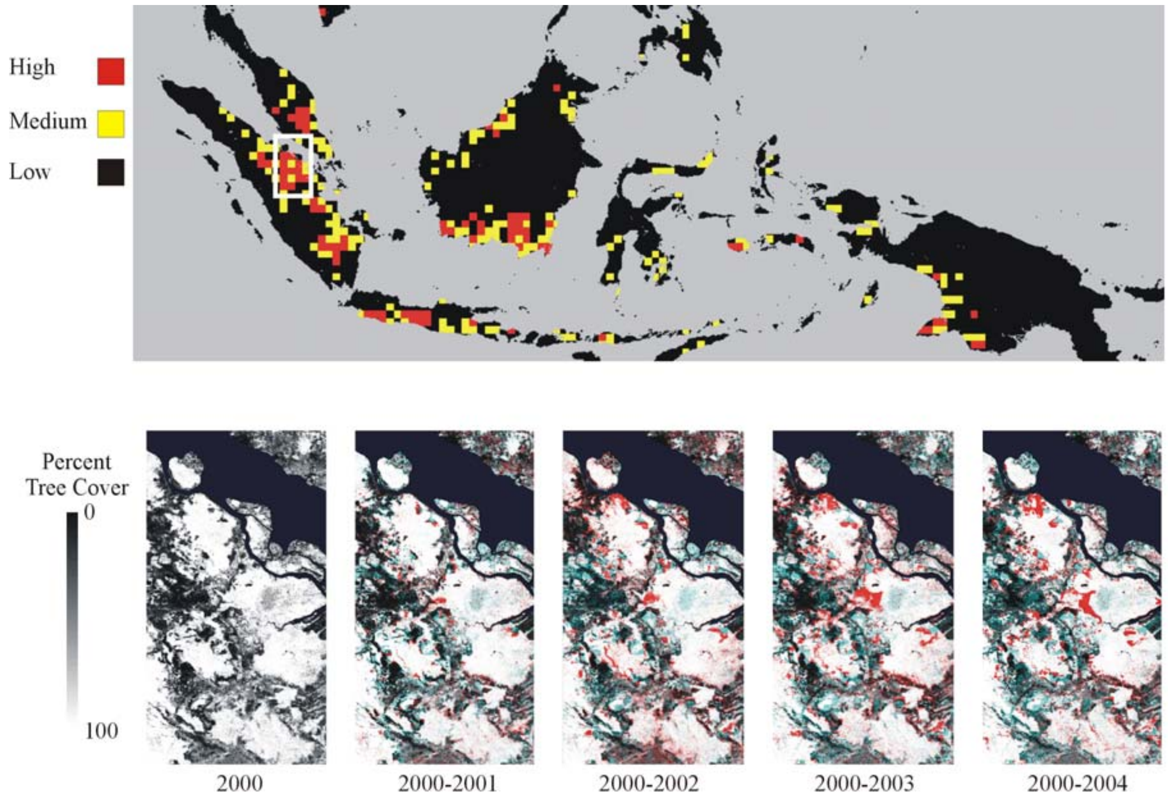

Figure 1: Example of broad identification of forest change in coarse resolution 500 m MODIS data for insular South-East Asia for the period of 2000-2004 using vegetation continuous fields data. Such analysis can be routinely done on global scales to support detailed national level investigations (Source: M. Hansen).

4.4.2 International experiences

There have been a number of regional and global deforestation studies (Table 2). The UN Food and Agriculture reports on the state of the world’s forest resources include two types of assessments: country reporting at the national level and remote sensing at continental to global scales. Wall to wall forest change mapping uses an exhaustive change detection approach with complete spatial coverage for the area of interest. This usually provides sophisticated information about change trajectories and has been carried out for some tropical countries for the 1970’s and 1980’s (Skole and Tucker 1993). Some examples on regional and global scales have used a “hotspot” approach. Known areas of rapid change are studied for more detailed analyses with high-resolution data. Hotspots can be identified by regional experts (Achard et al. 2002) or coarse-resolution data (Hansen and DeFries 2004). The latter case is exemplified in Figure 1. Continuous global observations using 250-500m data helps to indicate where forest change has occurred. Fine resolution datasets (10-30 m) can then be applied to derive spatially explicit estimates of forest cover change.

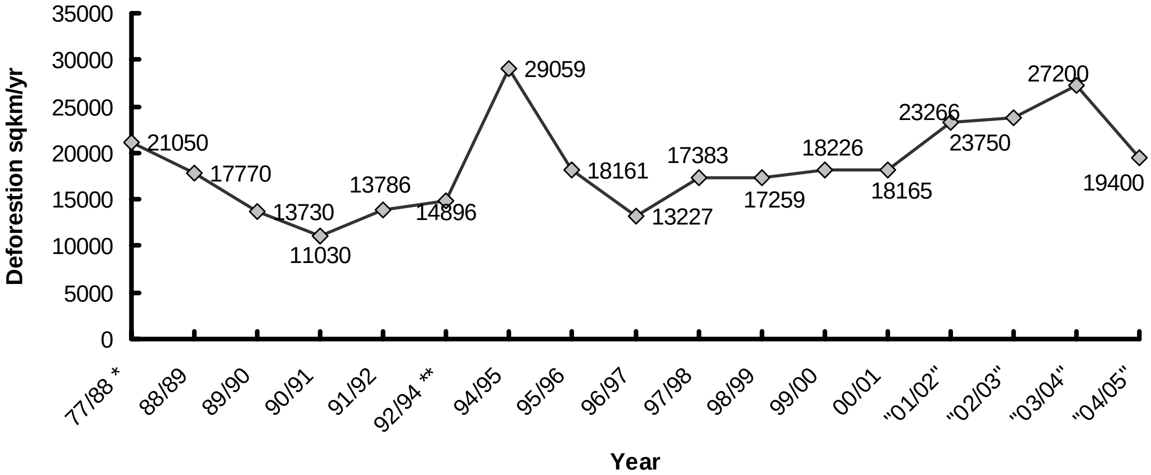

Figure 2: Annual deforestation rates estimated for the Brazilian Amazon derived from space-based observations (Source: INPE, 2006). The total gross deforestation for this period: 681.343 sqkm. (Note: * decade mean; ** bi-annual mean)

4.4.3 National programs

National and regional capabilities for routine forest monitoring do not exist in many developing countries. There are, however, prominent examples of effective space-based forest monitoring systems. Brazil's digital PRODES program distributes spatially explicit estimates of annual deforestation throughout the Brazilian Amazon (Figure 2). The monitoring is based on Landsat satellite data (30x30 m pixel size) with a minimum mapping unit of 6.25 ha. The PRODES system requires 229 Landsat scenes to cover the whole Amazon. Visual interpretations of image printouts were used for the period 1988-2002. Since then, the mapping has been more effective using digital image processing assisted visual interpretation on computer screens.

Table 3. Forest assessments completed by the Forest Service of India using satellite observations (Source: D. Pandey).

<table>
<tr><th>Cycle</th><th>Year of assessment</th><th>Satellite and sensor</th><th>Spatial resolution</th><th>Mapping scale</th></tr>
<tr><td>I</td><td>1987</td><td>Landsat MSS</td><td>80 m x 80 m</td><td>1:1 million</td></tr>
<tr><td>II</td><td>1989</td><td rowspan="3">Landsat TM</td><td rowspan="3">30 m x 30 m</td><td rowspan="6">1:250.000</td></tr>
<tr><td>III</td><td>1991</td></tr>
<tr><td>IV</td><td>1993</td></tr>
<tr><td>V</td><td>1995</td><td rowspan="2">IRS-1B / LISS-II</td><td rowspan="2">36 m x 36 m</td></tr>
<tr><td>VI</td><td>1997</td></tr>
<tr><td>VII</td><td>1999</td><td>IRS-1C / LISS-III</td><td>23 m x 23 m</td></tr>
<tr><td>VIII</td><td>2001</td><td>IRS-1C/1D / LISS-III</td><td>23 m x 23 m</td><td>1:50.000</td></tr>
<tr><td>IX</td><td>2003</td><td>IRS-1D / LISS-III</td><td>23 m x 23 m</td><td>1:50.000</td></tr>
</table>

The Forest Service of India has successfully completed a series of forest assessments for the whole country (Table 3). Since the first assessment in 1987 the FSI has been mandated to monitor the forest cover of the country on a two-year cycle with nine surveys completed to date. The efforts benefit from the strong national earth observing program. The digital and visual image interpretations have been integrated with in-situ assessments of growing stock, biomass and carbon to fulfill India's obligations under the UNFCCC.

4.4.4 Deforestation versus degradation

From an earth observation perspective, large forest clearings and complete removal of forests (i.e. for mechanized agriculture in the Amazon) represents the 'easiest' case for space-based monitoring. Given the international and national examples, effective methods exist for monitoring and, depending on the size of the clearing; such deforestation can usually be accurately detected. Identifying clearings for small fields, forest fragments, selective logging or other degradations requires higher resolution data and more specific analysis tools. There are positive examples for mapping forest degradation along with deforestation (Souza et al., 2003, Asner, 2005). However, the mapping tools vary for different types of forest and disturbances and there is no ultimate method appropriate for all situations. Degradation studies are often not comparable and require research at this point. Thus, currently it is harder to come up with consensus methods than for the deforestation case. The proposal of the Joint Research Center suggests that 'intact' and 'non-intact' forests be considered to account for this in the framework of compensated reductions (Mollicone et al., submitted).

During the workshop different breakout groups (1 + 2, see chapter 6) were designated to independently discuss technical issues concerning deforestation and degradation to reflect these requirements.

4.4.5 Satellite data

The most common satellite data for national level deforestation analysis have been from Landsat/Spot-type optical sensors (10-30 m spatial resolution). Such data could be the primary source for operational national deforestation monitoring either using wall-to-wall coverage or through hotspot sampling. Historically, such data are globally available to identify deforestation in the 1990's and even before. There is a current Landsat observation gap due to sensor failures. Both the US and ESA have committed new Landsat-class satellites beyond the year 2011 to keep continuity in observations. Other sensors currently exist (Landsat TM 5, TERRA-ASTER and SPOT-MSS), however, with limited geographic coverage. Some nations (i.e. Brazil, China, and India) maintain strong earth observation programs with a regional focus and the availability is currently unknown for operational deforestation monitoring. A coordinated international observation strategy could contribute to an appropriate global coverage given the Landsat-type data gap in the current decade.

Coarse resolution optical sensors such as NOAA-AVHRR, MODIS, ENVISAT-MERIS and SPOT-VEGETATION provide intra-annual global coverage with 250 m – 1 km spatial resolution. They allow timely detection of large deforestation events (>10-20 ha, see for example www.obt.inp.br/deter) and areas of rapid forest clearing activities to guide more detailed surveys relevant for regional scale assessments (Skole et al., 1997). Thus, the advantage is a consistent annual global perspective that can guide and help to assess regional and national level efforts.

Cloud cover may challenge the availability of optical remote sensing data for tropical regions in particular. Although not operational for national monitoring at this point, the use of Radar remote sensing can help to overcome data problems in such cases. Available Radar satellite sensors include ALOS-PALSAR, ENVISAT-ASAR, and RADARSAT.

4.4.6 Estimating carbon emissions

Optical satellite observations can provide changes in forest area and (to some degree) forest density. However, the ultimate objective is to estimate changes in carbon stocks resulting from deforestation and degradation with “compensations” referring to accurate and credible carbon credits. There are no internationally agreed upon methods for mapping forest biomass on regional scales. Remote sensing methods like LIDAR and long-wave RADAR have some potential for direct biomass measurements but are not operational for national monitoring (Rosenqvist et al., 2003).

Certainly, there is a relationship between observed land change in forest area and density, and net carbon emissions. The location, type, and intensity of forest change determine the initial and final stocks. The IPCC GPG on LULUCF and the upcoming AFOLU guidelines already provide a number of approved concepts using satellite observed land use change in conjunction with other data sources to derive changes in carbon stocks. The methodology for reporting under the Kyoto protocol requires spatially explicit observations of land use and land use change. They maybe obtained either by sampling or through complete wall-to-wall mapping or a combination of both. Important criteria for the land change observations are adequate land characterization, appropriate spatial and temporal resolutions, transparent and consistent methods and validated results. Different sources of information may be used to link land cover dynamics and carbon stock change. Common sources are ground reference data, national and regional forest inventories, FAO statistics, and specific remote sensing observations.

Many tropical countries have no recent forest inventories and to make new forest inventories would require substantial resources. The same is true for ground sampling since many tropical regions are large and inaccessible. In addition, traditional inventory surveys are often not optimal for carbon accounting or for serving the evolving carbon markets. However, building upon existing inventories and experiences, targeted field observations of key metrics determining biomass stocks (i.e. tree crown area and height) could be linked and calibrated with remote measurements to provide effective estimates of carbon stocks and changes. Basically, remote sensing observations should complement field biomass inventory data and allow for more accurate emission estimates through their combination with satellite-based measurements of deforestation and forest degradation (Casperson et al., 2000).

Breakout group 3 was designated to further discuss this issue (chapter 6).

4.4.7 Baselines and projections

The idea of compensation for avoided deforestation implies a reduction compared to a reference, target or measured historical level of emission. The historical database of satellite observations is adequate to determine previous deforestation rates in 1990’s. The inter-annual variability of deforestation is rather large (Figure 2), at least compared to fossil fuel emissions, and a single baseline year for historical reference deforestation levels may not be appropriate.

For future projections, the use of extrapolated historical measurements may not be viewed satisfactorily. Deforestation rates are linked to socio-economic conditions. Other driving forces are also important (Geist and Lambin, 2002). It should be determined if land use-carbon models coupled with econometric models can provide reliable projections.

The issue of historical levels and future projections in the context of avoided deforestation was discussed in breakout group 4 (chapter 6).

4.4.8 Verification

Verification and validation is a key component of an operational monitoring system. Thorough validation is not routinely done in current deforestation monitoring activities mainly due to the comprehensive cost, effort needed, and lack of standardized verification tools. For land cover and forest observations, GOFC-GOLD and CEOS working groups have already developed consensus protocols for map accuracy assessments that may be of value in setting up a technical validation framework. Verification on the ground can only realistically be done for a small subset of locations. Targeted overflights and very high-resolution satellite data such as IKONOS and QuickBird provide robust and consistent reference data for large area verifications by reducing cost and processing efforts. Verification procedures should be in place for all components of a deforestation monitoring system including the methods and products for forest change mapping, historical baselines, and carbon emission estimates. Validation implies the use of an independent reference and raises the issue of third party verification of accredited certifiers.

Verification as a key issue has been discussed in breakout group 5 (chapter 6).

4.4.9 Capacities and challenges

Two main technical issues need to be addressed in order to develop operational deforestation monitoring systems at the national level: data acquisition and distribution, and national capabilities.

A suite of satellite observations exists historically and supposedly for the future. There are no major technical challenges in optical remote satellite operations, basic data acquisitions, and methods to produce the map products. However, coordinated and continuous data acquisition and dissemination scenarios require significant improvement to make the appropriate observations available for all developing countries interested in compensated reductions.

A major challenge relates to current limitations in national and regional technical capacities. A few developing countries such as Brazil and India already maintain operational monitoring systems. Other countries have experiences on a project level basis but some would require the establishment of all essential capabilities. These include resources and infrastructure to acquire, process, and analyze satellite, and refine, integrate and disseminate to products and results.

4.5 Development of best practices

An overall objective of the workshop was to develop a document of technical guidelines proposing “best practices” for monitoring deforestation and forest degradation using satellite earth observation. The term ‘best’ does not imply ‘perfect’; it should rather reflects the largest consensus among the international community on current operational earth observation methods and should emphasize to what extent a framework of compensated reductions would be technically feasible.

Forest disturbance is a global phenomenon but regional and national characteristics vary significantly. This complex process requires a flexible suite of monitoring options. There is a need for defined internationally standardized rules and earth observation has great potential to provide this minimum level of standardization. Thus, the international community should work towards making global/regional results compatible with national-scale results and vice versa. On a generalized level, this should allow for a harmonized global perspective. To get broad country participation, however, flexibility should be possible for regional or country-specific approaches to reflect:

- Different types of forest, and variety of forest change dynamics and national priorities in forest use
- Different forest definitions and other land category thresholds
- Different land area, socio-economic developments and baseline periods of importance
- Varying degrees of existing national forest monitoring infrastructure and capacities

A detailed outline and objectives for a technical best practices document was developed during the breakout group 6.

5 Breakout group discussions

The workshop included two sets of three parallel breakout group discussions. The following sections contain the notes from the breakout groups that were presented to all workshop participants.

5.1 Best practices – Monitoring deforestation

This group was chaired by P. Mayaux.

What are the characteristic types of deforestation/devegetation/degradation?

1) Types of deforestation are defined by country. Flexible definitions of deforestation (forest/non-forest) are needed to account for the variety of forest change dynamics to reflect national priorities regarding forest uses.
2) Definitions of forest include both cover, use and ecological aspects.
3) Minimum mapping units reflect local realities, and earth observation data sets must be evaluated to test if they adequately capture change at this scale.
4) Differentiating deforestation from degradation is a function of both the mapping scale and basic definitions of forest/non-forest.
5) National definitions of deforestation fit particular national priorities, but at some level should be compatible with other national systems (regional scale) to permit inter-comparison. Economies of scale can be achieved through regional cooperation to derive a common set of deforestation definitions.
6) International community should offer a top-down approach and work towards making global/regional results compatible with national-scale results. This would allow for harmonization of the national-scale monitoring results at global/regional scales.

What is the priority for monitoring in terms of compensated reductions?
Monitoring at a national scale must be flexible in its implementation, in both temporal and spatial scales. National priorities will prevail in detailing a minimum monitoring requirement. Baseline reference data are necessary as is a subsequent repeatable monitoring methodology. High spatial resolution products (10-30 m) are required to quantify deforested area.

What methods are available for monitoring? Which data streams (optical, radar, etc.) are most useful? Are these ready to be used operationally?

Medium spatial resolution products at global/regional scale are useful for hot spot monitoring. National scale mapping of deforestation requires high spatial resolution data inputs (10-30 m). High spatial resolution mapping can be done through an exhaustive full coverage or sampling approach (stratified or non-stratified). Optical data are currently more operational. However, radar data are becoming more usable in an operational sense and indeed are critical to monitoring where adequate optical data are unavailable. Multi-data fusion approaches are advocated.

What time frequency for monitoring is needed to capture the dynamics of clearing?
Annual updates are needed to adequately capture forest change dynamics. However, current capabilities indicate, for high-resolution optical imagery, a 5 year interval is a more reliable deliverable.

What is the minimum size of clearings that can reasonably be detected?
High-resolution – 0.5-1 ha
Moderate-resolution – 10-20 ha
Probability distribution of size of change events per country can be used to find the best observation scale for monitoring.

What are the key constraints to operational monitoring (methods, data continuity etc.)?
High-resolution data continuity and associated costs.
Institutional capacity at the national level (expertise and computing infrastructure).
Methods that are repeatable and consistent through time.

Which methods are acceptable, good, and best practices depending on a country's resources and capabilities?
Automated, hybrid and purely photointerpretive mapping approaches are available. Employed methods reflect national capabilities, resources, etc. All methods must be validated through accuracy assessments to justify their use.

What is the required ground component?
Change/no change classes require special consideration. It is possible to make a generic protocol for validating change maps. This would feature a sliding scale of rigor. For example, visual interpretation of imagery could be a rudimentary first cut, and field visits a more intensive validation effort. Need to differentiate between land use and land cover.

5.2 Best practices – Monitoring degradation and regeneration

This group was chaired by C. de Souza.

What is forest degradation?
Anthropogenic activity that leads to partial loss of forest biomass.
Degradation would still be considered forest based on the political definition of land use (>10% forest cover).
Regeneration?

Why is it important?
Partial removal of biomass affecting the ecosystem. Can be significant.

What are the characteristic types of degradation?

Selective logging, managed logging, unplanned logging, forest fragments/forest edges
Burned forest, logged and burned forest, woody removal (charcoal)

What is the priority for monitoring in terms of compensated reductions?
Reporting the amount of:
Managed forest area annually (excluding this class from degradation).
Forest to Degraded Forest
Degradation to deforestation

What methods are available for monitoring?
Spatial resolution:
 Wall-to-wall: 20-30 m (1 ha) for national to global scales
 Hierarchical: 1000 m to 1-4 m for project scale (needs refinement).
Frequency of measurement: 1 year

Which data streams (optical, radar, etc.) are most useful?
 Optical: Landsat, SPOT
 Radar: potential

Are these ready to be used operationally?
There are many pilot/research projects (TREE, Greg Asner, MSU, Imazon, others), but can be done at the operational level.

What time frequency for monitoring is needed to capture the dynamics of degradation?
One year.
Maybe challenging for some areas, use of upcoming satellite constellation primarily targeted for disaster monitoring.

What is the minimum size of degraded forests that can reasonably be detected?
20 – 30 m pixel size.

What are the key constraints to operational monitoring (methods, data continuity etc.)?
Data continuity of high spatial resolution (20 – 30 m).

Which methods are acceptable, good, and best practices depending on a country's resources and capabilities?
Visual interpretation:
Log landings and road detection
Temporal change detection
Canopy damage detection
Mapping active fire
Country may have to stratify on their degradation areas

What is the required ground component?
Ground verification for accuracy assessment.
Accuracy: 80-94%

5.3 Best practices – Biomass/Forest types especially in relation to carbon

This group was chaired by S. Brown.

No standard practices are currently accepted for measuring forest biomass remotely at regional to national scales

Carbon pools:

Focus should be on aboveground biomass in trees only
Default values from literature should be used for other pools
Soil C pool: should be voluntary whether to include or not. There are IPCC approved methods for including soil. If a country can verify default data then it could count soil pools. Otherwise, soil carbon pools can be excluded and the country would produce more conservative carbon "credits" for avoided deforestation activities.

Frequency:
Updates of biomass stocks should be provided on same frequency as land use/land cover change in affected areas –no less than 5 yr

What do we use presently to estimate carbon stocks?

Products/scale	weaknesses	Degree of uncertainty	Cost (1-3; low to high)
1. Traditional forest inventories –could be national or regional	Could be out of date or more recent Often focused on forests of commercial value	Depends on age of inventory and if updated—low to medium confidence based on date of inventory	3
2. Forest inventory with additional data on canopy cover/type and related to high resolution RS data; update biomass stocks with new high res RS data interpreted for change in canopy density (models relate canopy density to biomass)	Often focused on forests with commercial value	High to medium confidence	Costly initially to get field inventory (3), reducing costs with updates (2-1)
3. FAO data –by country and subregion	Default data	Low confidence	1
4. Compilation of "ecological " plots	Not sampled from population of interest	Low confidence	1

Sources of data influences the availability of carbon stock data by forest type as indicated by level of disturbance—e.g. secondary, mature, logged, fallow, etc.

Sources 1 and 2 potentially can report by forest types: mature, intensely logged, lightly logged, fallow, etc .
Source 3 reports national stock with no regard for status—some stratification into main ecological zones.
Source 4 may report stocks for different uses/cover types depending on nature of scientific studies

Which of these would be considered "best practice"?
Potentially two types of countries—voluntary reductions and committed targeted reductions (next commitment period). For voluntary, could use any method for biomass presently available—this allows for more participation and does not set the "bar" too high for participants.
For any committed reduction, method two would likely be needed to reduce uncertainty based on more recent inventories.

How present sources of biomass data could be improved with remote sensing data?
(MI =Moderate improvement, SI =some improvement, NI = no improvement)

Type of "field data"/RS imagery	Very high (e.g. Lidar/digital imagery-3D)	High –e.g. Landsat/SPOT/India	Medium –e.g. MODIS
National forest inventory-post 1980s	SI	SI	NI
National forest inventories-post 2001	MI	MI	SI
Regional forest inventories-post 1980s	SI	SI	NI
Regional forest inventories-post 2001	MI	MI	SI
FAO FRA reports	SI	NI	NI
"ecological plots"	SI	SI	SI

Remote methods
Possible best practices for new approaches for directly measuring carbon stocks of forests using remote means—remote means to be used in a sampling mode to sample areas where deforestation is occurring.

1. **Airborne Lidar plus aerial digital images**—plus field data to develop new equations for converting metrics to biomass—needs to be more widely deployed over a range of areas in tropics to further test—needs to be done within the next 2-3 yr period to demonstrate use, estimate range of uncertainties, and its applicability. Will need the development of new field based allometric regression equations based on crown area/height and biomass. This could work for all forest types.

- This technology can be implemented currently
- Airborne LIDAR and aerial imagery are costly, but has economies of scale

- Aerial imagery is less costly than airborne LIDAR

2. **High resolution optical sensor/data**: useful for assessing different forest types and biomass assessments if combined with ground truth data and inventory data

Spaceborne (0.6 to 30 m)

Airborne (0.1 m to 5 m)

High resolution airborne particularly is useful for degradation sampling, especially selective logging, and can give change in stock directly (extracted tree and damage) (Brown presentation on logging)

- These techniques are effective at present—space borne data available (e.g. IKONOS and Quickbird), but costly. However, costs could be reduced if used in a sample mode
- Airborne—see above under 1.

3. SAR data for biomass mapping-no satellites yet deployed

Experimental studies reveal the potential of multi-frequency (X-/L-band) data for forest type mapping and quantitative analysis

- improved assessment of vegetation structure parameters
- horizontal structure (crown structure / density, gaps)
- vertical structure (roughness, height)
- synergy of optical and SAR data

Requires field data for calibration:

- forest inventory / ecological plots

Challenges / limitations

- geometric and radiometric processing
- availability of ready-to-use data ("images") to national authorities
- definition of physical models (move beyond empirical regression analysis)

Precision / uncertainty

- high precision (dependent on availability of cal / val data)

Sensors

- ALOS-PALSAR (L-band, multi-polarimetric) (mid of 2006)
- TerraSAR-X (X-band, multi-polarimetric) (early 2007)
- TanDEM-X (TerraSAR-X) (2009?)
- Radarsat / Envisat-ASAR (C-band, multi-polarimetric) (operational)

Minimum detectable area:

0.5 to 1 ha

Costs:

- raw data will be available at low cost to R&D users
- considerable costs for processing and product development

5.4 Historical deforestation and projections

This group was co-chaired by B. Schlamandinger and V. Vereau.

Assuming that we are in a carbon market system or in any other kind of incentive to determine a reference scenario historical is not the only way, business as usual can be added, among others, the objective should be to establish reliable deforestation information

If historical deforestation is considered:

1. It is important to get a comparable data base about: affected area and emissions
2. To start the historical scenario we should not go too far into the past to minimize satellite or methodology changes over time
3. Time series and methodology consistency among projections and history must exist and maintained
4. Flexibility for the countries to choose periods of times ranges of 5 to 10 years to avoid inter-annual variations is recommended
5. The support information from the past to determine the forest biomass is needed.
6. We can try to ensure data continuity with tools to recalculate the past deforestation rate
7. The availability of data will influence the methodology to use.
8. A good practice guideline should rely on the most cost effective assessment of information for example remote sensing, permits, projects, large infrastructure projects, and forest inventories among others.

Projections

Projections have to include the difference and complexity of deforestation drivers which varies from one country to another. Countries should project their deforestation rates according to their national circumstances, using some sort of national parameter, this will also help them to identify areas where particular plans could be developed
Because of the complexity of deforestation drivers the projections should not go to far into the future, they should be reassessed every 5 years to have consistency, countries should have the right to in a dynamic way adjust the reference scenario

Remote sensing can provide forest area change and some information on infrastructure and drivers of deforestation. Both measurements can provide important input in making projections. Projections only based on remote sensing data products may not be sufficient; other sources of information (i.e. socio-economic) should be considered.

Tools exist to adapt methodologies for every country according to their specific needs

5.5 Verification

This group was co-chaired by D. Pandey and J. Seifert-Grazin.

Detecting Deforestation

To be clarified:
Verifying the EO product or the whole package (Baseline, monitoring procedures, etc.)?

Verification is an essential component of EO monitoring. Upfront financing is needed. Allocate sufficient funds for verification and validation.

Who should do verification: Third party solution (accredited certifiers? Other authority? – validated certificates)

1) Validation of the consistency of the methodology (Algorithms, procedures, etc.)
2) Ground truthing: Field observation (costly) stratification, strategy needed.

3) Accuracy assessment

1) Validation of methodologies
How?
By independent reproduction or third parties?

Criteria?
Replicability, consistency (Software level, input data)

1a) Description of procedures
- Precondition: Comprehensive standards for documentation of (new) methodologies needed (peer reviewed is not enough)
- Degree of comprehensiveness and role of expert judgment?
- Appropriateness of sensor, spectral resolution, spatial resolution referring objective
- How to treat property rights of new methodology? Potential conflict of interest!
- Scale of interpretation: Harmonization of scales needed

1b) Data Handling
- Standards of Metadata-Management (FGDC, ISO),
- Standards for Data Management/Storage (Version control) have to be applied

1c) Image processing
- Harmonization of classification schemes
- (Inter temporal) consistency of classification schemes
- Standards of preprocessing needed: georeferencing, orthorectification, etc.

2) Ground verification/observation
- Verification related to detected changes and applied classification schemes
- Cross comparison of data
- Access matters in field work!

3) Accuracy assessment
- Needs additional resources and has to be done on a national scale
- Accuracy must follow standard statistical sampling approaches; Targets between 80% and 95% are feasible for discrimination between forest and non forest.
- Error accumulation of combined methodologies (Types of intervention, Area, Biomass, projections)
- Accuracy related to costs and prices of possible certificates

Validation and harmonization are key issues – task for GOFC-GOLD to develop internationally agreed protocols, this process has already started in some areas

5.6 Structure of best practices report and input to SBSTA Workshop

This group was co-chaired by F. Achard and R. De Fries.

A best practices report should be prepared as an input to the SBSTA Workshop (to be held around (September 2006). A suggestion for the report title was made: “Reducing emissions from deforestation in developing countries: Recommended practices for measuring and monitoring". The report should start with a short positive statement such as: "the Earth observation community is ready to provide guidelines / protocols for monitoring emissions from deforestation in developing countries with an historical perspective and into the future. Changes in forest area can be monitored from space with confidence since 1990 (large sources of data are now available at low costs, e.g. around years 1990, 2000-2003; significant capacity exists in most countries to implement these procedures in a routine manner). Combining measurements of changes in forest area with estimates of carbon stocks enable the estimation of emissions"

The best practices report should be a short report (10 p.) A structure has been drafted:

Executive Summary (2/3 p.)

1. Context
    a. Agenda item 6 of COP-11
    b. Scope of the report: assessment of technical capabilities for estimating emissions from deforestation in developing countries

2. Monitoring changes in forest area
    a. Methods: wall to wall, sampling, synergy between data sources
    b. Operationality: Cost / national capacity (examples: Brazil, India, Peru)
    c. Accuracy / verification
    d. Data issues: availability, frequency, accessibility/cost after 2010 …
    e. Historical perspective

3. Monitoring forest degradation
    a. Box on peatland forest case

4. Monitoring carbon stock changes
    a. Estimates of carbon stocks are available for all countries (FAO)
    b. Different national situations
    c. IPCC defaults tables
    d. Related accuracy / uncertainty

5. Estimating emissions

    a. Building on existing expertise (IPCC)
    b. Historical perspective

Action items:

- A letter to be prepared as input to the submission (PNG through ED, GTOS)
- A First draft from WS inputs to be prepared in 2 weeks time, then to be reviewed by everybody (2 rounds)
- Report to be provided to SBSTA Workshop in September 2006
    - Seek GOFC-GOLD participation through UNFCCC secretariat and GTOS
    - Distribute report prior and during the SBSTA Workshop

References

Achard, F., H. Eva, H.J. Stibig, P. Mayaux, J. Gallego, T. Richards, and J.P. Malingreau, 2002: Determination of deforestation rates of the world's humid tropical forests. Science, 297, 999-1002.

Asner, Gregory P.; Knapp, David E.; Broadbent, Eben N.; Oliveira, Paulo J. C.; Keller, Michael; Silva, Jose N. 2005. Selective Logging in the Brazilian Amazon. Science, 310: 480-482

Casperson, J.P. et al. (2000) Contributions of Land-Use History to Carbon Accumulation in U.S. Forests. Science, 290: 1148-1151

DeFries, R., G. Asner, F. Achard, C. Justice, N. Laporte, K. Price, C. Small, J. Townshend 2005. Monitoring tropical deforestation for emerging carbon markets, in Paulo Moutinho & Stephan Schwartzman: Tropical Deforestation and Climate Change, pp. 35-46.

Geist, H.J. and E.F. Lambin, 2002: Proximate causes and underlying forces of tropical deforestation. BioScience, 52(2), 143-150.

Hansen, M. and R. DeFries, 2004: Detecting long term forest change using continuous fields of tree cover maps from 8km AVHRR data for the years 1982-1999. Ecosystems, 7(7), 695-716.

Hansen, M.C., R.S. DeFries, J. Townshend, M. Carroll, C. Dimiceli, and R. Sohlberg, 2003: Global percent tree cover at a spatial resolution of 500 meters: First results of the MODIS Vegetation Continuous Fields algorithm. Earth Interactions, 7(10), 1-15.

INPE, 2000: Monitoring of the Brazilian Amazonian Forest., Instituto Nacional de Pesquisas Especiais, Sao Paulo, Barzil.

Mollicone, D., Achard, F., Federici, S., Eva, H.D., Grassi, G., Belward, A., Raes, F., Seufert, G., Matteucci, G. and Schulze, E.-D., 2006, Avoiding Deforestation: An Incentive Accounting Mechanism for Avoided Conversion of Intact and Non-Intact Forests, Climatic Change, submitted,

Plumptre, A., N. Laporte, and D. Devers, 2003: Threats to sites. In: The Biodiversity of the Albertine Rift. Albertine Rift Technical Report No. 3, A. Pluptre, M. Behangana, T.R.B. Davenport, C. Kahindo, R. Kityo, E. Ndomba, D. Nkuutu, P. Owiunji, P. Ssegawa, and G. Eilu (eds.), Wildlife Conservation Society, New York, NY, 77-82.

Rosenqvist, A., A. Milne, et al. 2003. A review of remote sensing technology in support of the Kyoto Protocol. Environmental Science & Policy 6(5): 441-455.

Skole, D. and C. Tucker, 1993: Tropical deforestation and habitat fragmentation in the Amazon: satellite data from 1978 to 1988. Science, 260, 1905-1910.

Skole, D., C.O. Justice, A.C. Janetos, and J. Townshend, 1997: A land cover change monitoring program: A strategy for international effort. Mitigation and Adaptation Stategies for Global Change, 2(2-3), 157-175.

Souza, C.M., L. Firestone, L.M. Silva, and D. Roberts, 2003: Mapping forest degradation in the Eastern Amazon from SPOT 4 through spectral mixture models. Remote Sensing of Environment, 87, 494-506.

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Appendix B - agenda

GOFC-GOLD workshop on Monitoring Tropical Deforestation for Compensated Reductions		
Tuesday, March 21st at Rosensäle, Downtown Jena		
Welcome and setting the stage		
09.00 - 09.15	Start of Workshop / Organizational Issues / Logistics	DeFries/Herold
09.15 - 09.45	GOFC-GOLD intro / Meeting objectives	Townshend
09.45 - 10.30	Tropical deforestation – a status quo	Skole
10.30 - 11.00	Washington meeting outcomes (monitoring trop. def.)	DeFries
11.00-11.30 Break		
SESSION 1: UNFCCC: needs, requirements, proposals (Presentations + discussions)		
11.30 - 11.50	COP11 outcomes on reducing deforestation	Achard
11.50 - 12.10	JRC proposal of a compensated reduction framework	Mollicone
12.10 - 12.30	Noel Kempff project experiences	Seifert-Grazin
12.30 - 12.50	Methodological issues related to compensated reduction of deforestation	Schlamadinger
12.50-14.30 Lunch		
SESSION 2: Assessment of current practices (Presentations + discussions)		
14.30 - 14.50	Role of earth observation in monitoring deforestation	Skole
14.50 - 15.10	Role of earth observation for biomass assessment	Brown
15.10 - 15.30	National examples: Brazil	De Souza
15.30 - 15.50	National examples: Indonesia	Murdiyarso
15.50 - 16.10	National examples: India	Pandey
16.10 - 16.30	National examples: Peru	Vereau
16.30 - 16.50 Break		
SESSION 3: Assessment of current practices (Presentations + discussions)		
16.50-17.10	Coarse-resolution deforestation monitoring with MODIS	Hansen
17.10-17.30	Examples and potential of SAR data applications	Wielaard
17.30-18.30	Discussions and forming breakout group	Townshend
19.00-21.00	***Joint Ice Breaker and Workshop dinner at Jena Botanical Garden (Courtesy of GAF AG)***	
Wednesday, March 22nd at Rosensäle, Downtown Jena		
SESSION 4: Towards best practices (Breakout group presentations and discussions)		
09.00 - 10.00	Breakout group discussion (1st set) Best practices 1) Monitoring Deforestation & Devegetation (Mayaux) 2) Monitoring Degradation & Regenaration (DeSouza) 3) Biomass & Forest types in relation to carbon (Brown)	All
10.00-10.30 Break		
SESSION 5: Towards an implementation framework (Presentations + breakout group discussions)		
10.30 - 11.00	Breakout group presentations (1st set)	Mayaux/ DeSouza/ Brown
11.00 – 12.30	Discussions and forming breakout group on key requirements, current limitations and challenges (2nd set) 4) Historical deforestation & projections (Schlamadinger/ Vereau) 5) Verification (Pandey/ Seifert-Grazin) 6) Strucutre of best practices report (Achard/ DeFries/)	All
12.30-13.30	***Lunch***	

SESSION 6: Towards an implementation framework (Breakout group Presentations + discussions)		
13.30 – 15.30	Breakout group discussion (2nd set) Develop roadmap for implementation framework	All
15.30-16.00	***Break***	
SESSION 7: Summary and action items (Discussions)		
16.00 - 16.30 16.30 - 17.30	Breakout group presentation (2nd set) Summary and Synthesis Define action items and way forward Recommendations for GOFC-GOLD land cover IT meeting	Townshend (moderator)
18.00 - 21.00	***Workshop dinner at Scala Restaurant Jena-Tower***	

Appendix C - UNFCCC agenda item 6

Reducing emissions from deforestation in developing countries: approaches to stimulate action

UNFCCC Conference of the parties, Eleventh session, Montreal, 28 November to 9 December 2005

Agenda item 6 - draft conclusions proposed by the President

1. The Conference of the Parties (COP) took note of the submission by the Governments of Papua New Guinea and Costa Rica contained in document FCCC/CP/2005/MISC.1, and the statements made by Parties on this issue at its eleventh session.

2. The COP invited Parties and accredited observers to submit to the secretariat, by 31 March 2006, their views on issues relating to reducing emissions from deforestation in developing countries, focusing on relevant scientific, technical and methodological issues, and the exchange of relevant information and experiences, including policy approaches and positive incentives. The COP invited Parties also to submit recommendations on any further process to consider the issues. It requested the secretariat to compile the submissions from Parties in a miscellaneous document and to post those from accredited observers on the UNFCCC web site.

3. The COP requested the Subsidiary Body for Scientific and Technological Advice (SBSTA) to consider the information in the submissions referred to in paragraph 2, beginning at its twenty-fourth session (May 2006).

4. The SBSTA will report at its twenty-seventh session (December 2007) on issues referred to in paragraph 2, including any recommendations.

5. The COP requested the secretariat to organize, subject to the availability of supplementary funding, a workshop on this item before the twenty-fifth session of the SBSTA (November 2006), and to prepare a report of the workshop for consideration by the SBSTA at that session. The COP requested the SBSTA to consider the scope of the workshop at its twenty-fourth session, taking into consideration the submissions by Parties referred to in paragraph 2.

Appendix D - documents circulated prior to the workshop

UNFCCC:

UNFCCC/COP-11 draft decision
Draft conclusions for Agenda item 6: Reducing emissions from deforestation in developing countries

Good Practice Guidance for Land Use, Land-Use Change and Forestry
In particular Chapters 2 and 4:

Chapter 2: Basis for Consistent Representation of Land Areas
Chapter 4: Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol

GOFC-GOLD:

A Revised Strategy for GOFC-GOLD
Townshend J.R. and M.A. Brady, 2006. GOFC-GOLD report 24

JRC:

Accounting for avoided conversion of intact and non-intact forests: Technical options and a proposal for a policy tool.
Achard F., Belward A.S., Eva H.D., Federici S., Mollicone D. & Raes F. 2005

Land use change monitoring in the framework of the UNFCCC and its Kyoto protocol: Report on current capabilities of satellite remote sensing technology.
Mollicone, D., Achard, F., Eva, H., Belward, A.S., Federici, S., Lumicisi, A., Rizzo, V.C., Stibig, H.-J. and Valentini, R. 2003. Publications of the European Communities, EUR 20867 EN, Luxembourg. 48 p.

IPAM/Environmental Defense:

Tropical Deforestation and Climate Change
Moutinho, P. and S. Schwartzman (eds.). 2005. Belém - Pará - Brazil : IPAM - Instituto de Pesquisa Ambiental da Amazônia ; Washington DC - USA : Environmental Defense, 2005. ISBN: 8587827-12-X
In particular Chapters 3 and 4.

Chapter 3: Monitoring tropical deforestation for emerging carbon markets by Defries et al.
Chapter 4: Tropical deforestation and the Kyoto Protocol: an editorial essay by Santilli et al.

WINROCK/KEMPFF project:

Issues And Challenges For Forest-Based Carbon-Offset Projects: A Case Study Of The Noel Kempff Climate Action Project In Bolivia

Brown, S., M. Burnham, M. Delaney, R. Vaca, M. Powell, and A. Moreno, Mitigation and Adaptation Strategies for Global Change 5: 99-121

Measuring carbon in forests: current status and future challenges
Brown, S. 2002. Environmental Pollution 116: 363-372.

Finalizing Avoided-Deforestation Project Baselines
Brown, S. (Principal Investigator). 2003. Report prepared by Winrock International for the United States Agency for International Development.

General:

Tropical deforestation and the Kyoto protocol
M. Santilli, P. Moutinho, S.Schwartzman, D. Nepstad, L. Currran and C. Nobre. 2005, Climatic Change 71: 267–276

Optical remote Sensing For Monitoring Forest And Biomass Change In The Context Of The Kyoto Protocol
Skole, D.L. and J. Qi. 2001. CGCEO/RA01-01/w. Michigan State University, East Lansing, Michigan.

A review of remote sensing technology in support of the Kyoto Protocol
Rosenqvist, A., A. Milne, et al. 2003. Environmental Science & Policy 6(5): 441-455.

Tree allometry and improved estimation of carbon stocks and balance in tropical forests
J. Chave, C. Andalo, S. Brown, M. A. Cairns, J. Q. Chambers, D. Eamus, H. Folster, F. Fromard, N. Higuchi, T. Kira, J.-P. Lescure, B. W. Nelson, H. Ogawa, H. Puig, B. Riera and T. Yamakura 2005, Oecologia, 145, 87–99