Verification of Land-Use, Land-Use Change and Forestry Activities as specified by the Kyoto-Protocol: The role of remote sensing and GIS within a scientific verification concept

Wolfgang Wagner[1], Richard Kidd[1], Sten Nilsson[2], Matthias Jonas[2], Christian Hoffmann[3].

Abstract

Every international treaty requires a solid solution on verification (Cooper, 2000). Currently for the verification of Kyoto reports it is suggested that countries that are parties to the protocol submit baseline data and their inventory mechanisms for external review. However, only independent observations can lead to meaningful verification. Particularly Europe, with a leading role in the post-Kyoto negotiations, should further strengthen its position by establishing an autonomous European verification capacity of potential global outreach. This paper presents the key elements pertaining to a solid Scientific Verification Concept (SVC) and, based on this, further highlights the use of remote sensing and GIS for a cost-efficient, practical independent mechanism to verify Kyoto Land Use, Land Use Change and Forestry (LULUCF) activities.

1 Introduction

At the 7th Conference of the Parties to the UN Framework Convention on Climate Change (UNFCCC), held in Marrakesh, Marcocco, in October/November2001 (COP7) guidelines for review teams were produced that outline quality control and quality assurance activities. Review teams shall “verify that data quality objectives were met, ensure that the inventory represents the best possible estimate of emissions and sinks given the current state of scientific knowledge and data available, and support the effectiveness of the QC (quality control) programme”(UNFCCC,

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1 Institute of Photogrammetry and Remote Sensing, Vienna University of Technology, Austria. http://www.ipf.tuwien.ac.at, ww@ipf.tuwien.ac.at

2 International Institute for Applied Systems Analysis, Forestry Project, Laxenburg, Austria http://www.iiasa.aca.at, nilsson@iiasa.ac.at

3 GeoVille, Informationssysteme und Datenverarbeitung GmbH, Innsbruck, Austria http://www.geoville.com, hoffmann@geoville.com

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2001). In reality, however, this convenient agreement is not sufficient for an in-depth verification of reported fluxes (Nilsson et al, 2001). Only independent observations can lead to meaningful external verification. In fact, verifiability, rather than measurability per se, may be the key issue with respect to biospheric sinks and sources in an international agreement (Noble, 2001). With the first commitment period approaching fast, there is now an urgent need to establish a sound scientific, technological and institutional basis for an independent verification mechanism, which can be used to support and/or improve the present institutional framework of verification. Otherwise, no party to the treaty will have final assurance that its competitors ignore commitments to their advantage.

The use of remote sensing as an independent, consistent, non-intrusive verification tool in the control of area-based agricultural activities has been well established across the EU by the Control with Remote Sensing (CwRS) programme and is enforced by Council regulations. The basic idea presented here is that a solid verification framework is set up within which techniques from the CwRS will be built upon and extended to the Kyoto Protocol by introducing LULUCF specific verification methods (Wagner, 2002). The experiences from CwRS will help to identify technological needs, to identify institutional frameworks, to intelligently use remote sensing, to guarantee efficient integration of existing GIS techniques and data and to keep control of the costs.

2 A Scientific Verification Concept

Verification has to be built on a solid scientific concept that embraces appropriate knowledge and independent observations from site inspections and satellite imagery. System and data integrity and harmonisation is an important requirement, together with the efficient reuse of data such as GIS data related to topography, soil, vegetation, forest inventory, region boundaries, and other land and landscape information.

A verification mechanism must also include a scientific analysis of accounting methods: the Intergovernmental Panel on Climate Change (IPCC) guidelines represent a rough framework of possible approaches towards assessing the Greenhouse gas (GHG) balances, but simply cannot cover specifics of individual countries of the EU and the rest of the world, and are not designed for an in-depth assessment of the various methods in connection with GHG balances, notably sinks. Another important aspect deals with the contradiction caused by the current partial character of all Kyoto recommendations. This could generate a direct disparity between reported results and spirit and ultimate goal of the UNFCCC. The platform for verification is full greenhouse gas accounting. Any “Kyoto deliverables” should be verified based on this accounting, in particular at the national (regional) level. The verification must operate on an independent basis, as the accounting, in order to promote a persistent process of improving the results and reporting schemes. Critical issues of verification are quality control (reveal dubious figures), compliance with other international conventions, confidence levels of reported figures, verification of National Reports, and the effect of LULUCF activities upon the GHG balance.

3 The role of remote sensing and GIS

The legal basis concerning the remote sensing control of arable and forage land area based subsidies (CwRS) under the Common Agricultural Policy, (CAP), is laid down within a number of EU regulations[4]. These regulations establish the basis for the EU's Integrated Administration Control System (IACS) and the typically termed LPIS (Land Parcel Identification System); its primary aim is the establishment of uniform reporting and control measures on national expenditures in the agricultural sector, allowing fraudulent cases to be easily identified and sanctioned. Within these regulations it is stated that the control of declarations for area-based subsidies may be implemented with the use of remote sensing techniques in addition to the required administrative controls. Although there is no legal requirement to specifically adopt CwRS, currently 13 of the 15 Member States (exceptions; Luxembourg and Austria) do so.

The overall, albeit simplified, declaration and control procedure for area based subsidies is outlined in the following: All farmers (applicants for area aid) must annually provide a declaration consisting of both tabular and a graphical element. Declarations are then collated and integrated at a national level. A three-phase control process is then applied within the framework of the IACS system.

- Administrative control (i.e. completeness check, legality of declaration)
- Control of area and declared cover type (a specific number of all dossiers ~5% are required to undergo this control i.e. is the declared area within tolerance? is the declared cover likely to be correct?)
- On the spot control (i.e. when an anomaly is found a field check, ground check, is initiated)

If the ground check reveals a fraudulent, or erroneous claim the Member State may take action against the applicant. The remote sensing component in the control is only apparent in the control of a declared area and the identification of crop or cover type. The EU cannot enforce a standard unique control with remote sensing methodology but over the last nine years, with the guidance of the Monitoring Agriculture with Remote Sensing (MARS) project of EC Joint Research Centre (JRC) a series of common technical specifications have been developed and agreed upon.

[4] http://mars.aris.sai.jrc.it/control/regulations/

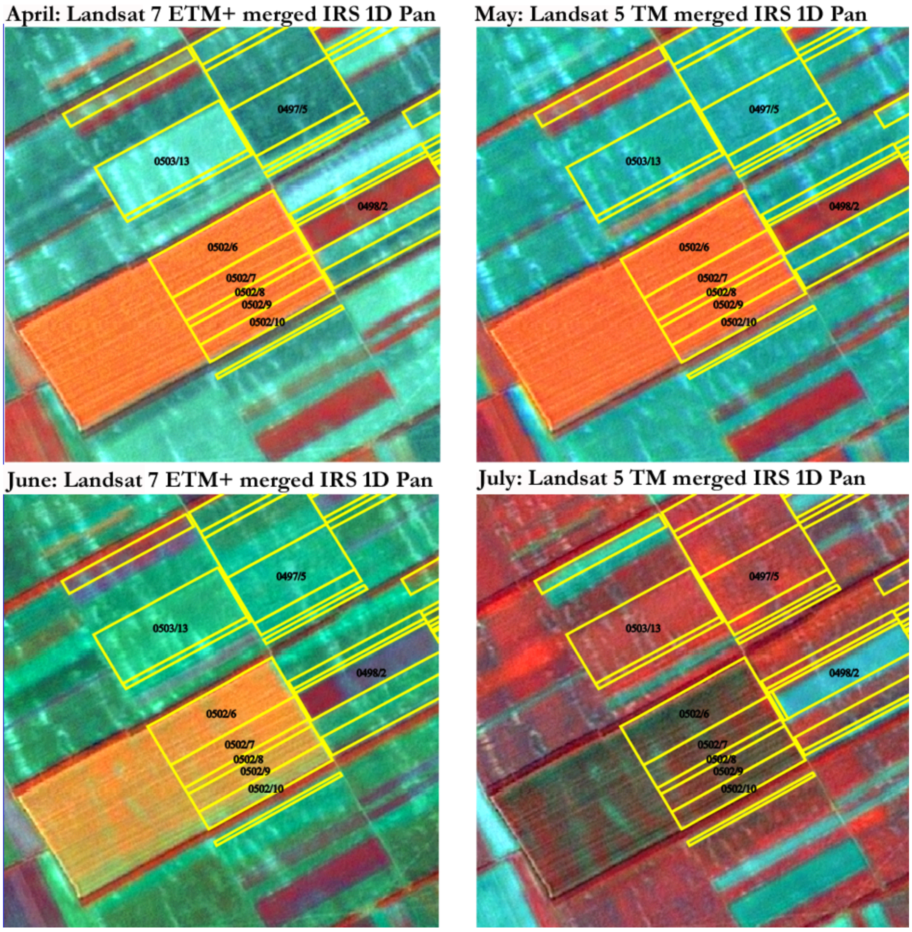

Fig. 1: An extract from a Control Document showing an erroneous declaration Imagery and data courtesy of Institute of Geodesy, Cartography and Remote Sensing (FÖMI), Budapest, Hungary.

Fig. 1 illustrates a typical visual control of crop type. In this particular example, claims are referenced to cadastral parcels, which are shown as yellow polygons (light grey lines). With the exception of one polygon (0498/2) all polygons are claimed to be the same crop. Since in the multi-temporal image series show quite a different behaviour, a field check was carried out which confirmed a false declaration. It must be stressed that the verification mechanism must goes far beyond what is illustrated within this example. However, “simple” structural parameters such as area or cover type are not only considered as a priority but also as the basis for addressing functional parameters related to carbon stocks like growing stock volume.

The adaptation of this existing system to the verification of LULUCF activities has many benefits, including reuse of resources and hence lower costs and higher efficiency, lower risks of failure and disturbances, and the relative ease of implementation. Potential parallels between the CwRS and its application to Kyoto LULUCF activities are outlined in Table 1. In this methodology the CwRS principles and techniques are embedded in the SVC in a scientifically and technically sound way; the SVC provides the larger framework and CwRS provides the technological basis.

	CwRS	Kyoto LULUCF activities
Methodology	Defined, integrative	TBD but many parallels
Key elements	Sampling, area measurement, verification	TBD, fixed sample, biomass, multi-annual
Accuracy	Strictly defined	Subject to study
Complexity	Medium, but increasing (environmental indicators)	High (LULUCF, biodiversity)
Overlap	Area, land use ID, registers	Bio-indicators
Institutional	Bureaucracy in place	TBD
Legal basis	EU Law	Kyoto protocol and COP resolutions
Incentive	Income aid	Compliance, trade
Beneficiaries	EU farmers	EU member states, “mankind”
Status	Operational	(pre-) conceptual
Completeness	100 % for agriculture	Fragmented for forestry and agriculture
Acceptance	EU wide, candidate member states	TBD, potential through dual use

Table 1: Comparison between CwRS and application to Kyoto LULUCF activities (TBD = to be determined).

From a methodological point of view, verification using remote sensing is less demanding than using remote sensing as a primary tool for reporting. The fundamental reason is that for verification purposes remote sensing only has to answer the question “How likely is it that the reported LULUCF activities correspond to reality?” which is more easily done than providing accurate numbers from remote sensing data alone (Wagner, 2002). Also, it should be recalled that the strengths of remote sensing – objectivity and consistency – make it an ideal technique for verification and control activities across borders (and hence different inventory systems).

Another important aspect relates to the spatial resolution required for verification. Here the major point to consider is that LULUCF activities take place on land units of vastly different size, from units smaller than one hectare to several hundreds of hectares. Therefore it is obligatory to use high-resolution satellite images, despite their relatively high costs. The enhanced spatial resolution of the latest generation of imaging satellites (e.g. IKONOS, Landsat-7, ENVISAT) and of future systems like TerraSAR will significantly improve remote sensing capacities for verification. In Fig. 2 a forest classification showing three density classes (in shades of green) derived from Landsat 7 data has been overlaid on an IKONOS image, the round dots represent the location of sample plots that have been used to compile a forest inventory.

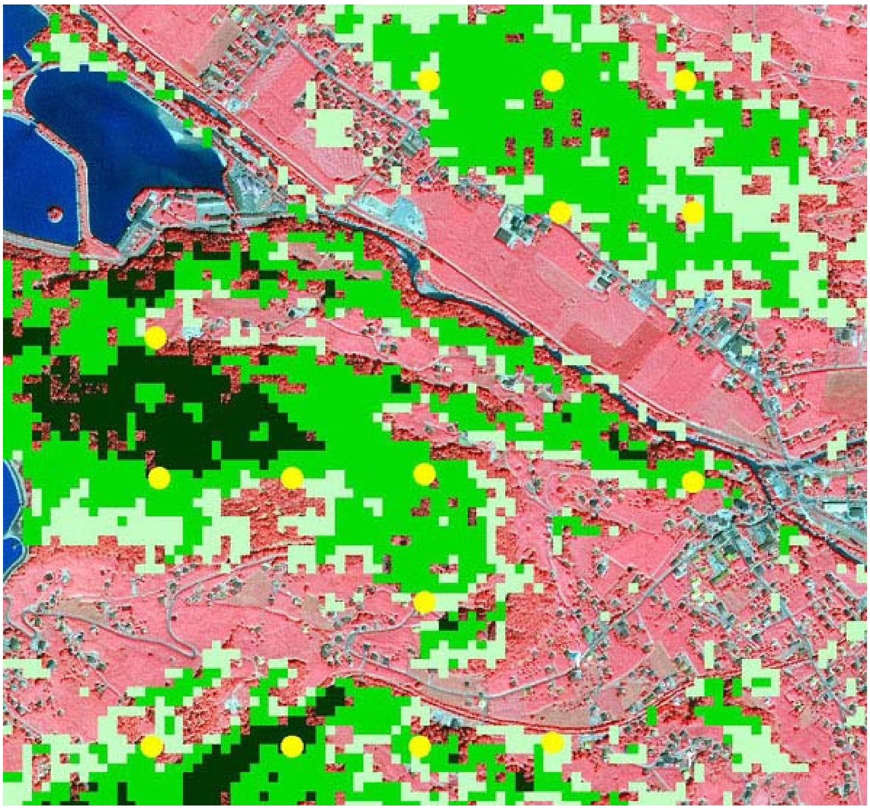

Fig. 2: Spatial resolution is a key question in verification. Composite image over an area in the southern part of Vorarlberg, Austria. Imagery and data courtesy of Geo-Ville, Informationssysteme und Datenverarbeitung GmbH, Innsbruck, Austria

In Fig. 3 the two examples show state-of-the-art ortho-imagery, which is currently being used for the control of area declarations under the EU CAP. Ortho-imagery at this spatial resolution (1:40,000 scale, 1 m pixel spacing) allows the identification of landscape features as small as 0.01 ha. The accepted area measurement accuracy, at this resolution is better than 5% for areas larger than approximately 0.6 ha. The use of colour-infrared photo emulsions allow the separation of coniferous and deciduous forest types, as is evident from the right hand image in the example (e.g. upper right corner). Also, indicators on tree spacing and structure can be derived from this imagery, for example, with the help of digital image morphology filters. The use of ortho-photos for area control, within CwRS is expected to be widespread in 2005.

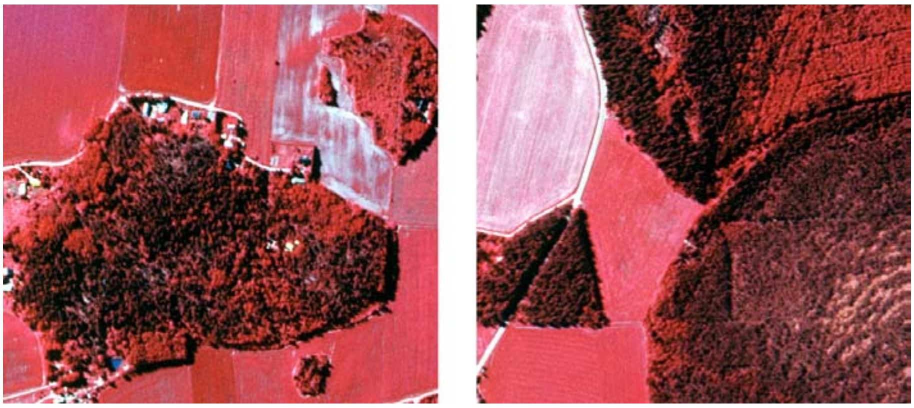

Fig. 3: High Resolution Colour Infrared Ortho-imagery allows for delineation of forest type and forest management activities. Imagery used by MARS project of the JRC.

4 Concluding Remarks

With Council decision 93/389/EEC for a monitoring mechanism of community CO_2, amended by 99/296/EC, the EU established a Monitoring Mechanism for anthropogenic CO2 and other GHG emissions in the EC. Analysis of the first reporting results by EU Member States on the basis of these decisions shows, however, a considerable lack of transparency, consistency and completeness of the reported figures (Löwe, 2000). Proposals to review the reporting mechanism along the guidelines given by IPCC (IPCC, 1997, IPCC 2000b) are expected to find their way in new Council decisions aimed at harmonising GHG budget reporting throughout the Community.

The underlying aim of this methodology to establish a harmonized measurement, reporting and verification methodologies at an EU scale is valid, as the EU will need to report the GHG accounts to the Kyoto Process as a single entity, with the reporting delegated to Member States. The application of commonly agreed standards in reporting should avoid creating internal frictions that may undermine the common EU position at the global level or between individual Member States.

With the recent legislative amendment to IACS introducing the obligatory use of a graphical system by 2005, and recommended use of ortho-imagery many Member State and regional administrations are strongly considering expanding the use and functionality of the IACS for other land management purposes.

The emphasis on agricultural conservation measures to increase carbon sequestration in soils (UNFCCC 2001, Bush 2002) are closely linked to aspects of the EU agri-environmental measures; support of afforestation, conservation, set-aside and minimum tillage. All these measures are to be managed under the IACS system. There are many obvious similarities between the methodological and system requirements for the foreseen adaptation of IACS and for the GHG accounting and verification mechanism.

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