IAC-03-IISL.1.17

THE USE OF REMOTE SENSING TO SUPPORT THE APPLICATION OF ENVIRONMENTAL TREATIES

Nicolas Peter [(1) (2)]
[(1)] International Space University (ISU)
[(2)] Institut du Droit de l'Espace et des Télécommunications (IDEST). Université Paris Sud XI

Corresponding Author: Nicolas Peter (peter@isu.isunet.edu)
International Space University (ISU) Parc d'innovation, 67400 Illkirch, France
Phone + 33 3 88 65 50 19 Fax: +33 3 88 65 54 47

ABSTRACT

There is a growing realization of the increasingly varied and interesting possibilities for the use of earth observation data to ensure compliance with international obligations generally, and treaty obligations in particular. Most efforts at examining the application of earth observation data to monitoring states' compliance with international obligations focus on the environmental sector. This paper is contemplating the use of remote sensing satellites for the support of multilateral environmental agreements (MEAs) especially land monitoring MEAs such as the Convention on Wetlands of International Importance especially as Waterfowl Habitat (1971) [1]; the Convention on Biological Diversity (1992) [2] the United Nations Convention to Combat Desertification (1994) [3] and also the United Nations Framework Convention on Climate Change (1992) [4] and the Kyoto Protocol (1997) [5].

INTRODUCTION

In the last thirty years the rapid growth in the number of multilateral environmental agreements (MEAs) has been an encouraging sign of international commitment to protect the environment. The proliferation of treaties has resulted in an increasing need for spatial data on the Earth's biophysical systems. Although the existing satellites were not designed to meet the information requirements of environmental treaties, they can be used to generate key information necessary for developing and implementing international environmental treaties.

MULTILATERAL ENVIRONMENTAL AGREEMENTS

Recently, MEAs have proliferated as environmental protection has become a major issue worldwide. The 1992 Rio Conference, and the 1972 Stockholm Conference before it, reflected the rise of concern for the global environment and each was a catalyst for the creation of new accords. MEAs currently address a wide range of environmental phenomena, both regional and global in nature [6].

The proliferation of MEAs has resulted in an attendant need for spatial data on the health of the Earth. This information contributes to the design of improved policy instruments [7].

MEAS AND REMOTE SENSING

Earth Observation systems are tools, developed in recent decades, which have become essential for effectively conducting different types of environmental management and environmental research applications. However, although over 200 MEAs addressing a broad range of environmental issues and concerns have come into existence during the last few decades, but few explicitly incorporate or depend on data and information from space-based technology [7].

The International Convention for the Prevention of Pollution from Ships [8] is one of the only MEA explicitly referring to remote sensing in his articles as potential support in marine oil pollution monitoring.

At the World Summit on Sustainable Development, held in Johannesburg, South Africa, in 2002, state representatives adopted the Johannesburg Declaration, which identifies future environmental and development goals. The Johannesburg Declaration's supporting Plan of Implementation has identified earth observation as a crucial information source for a number of relevant disciplines to sustainable development. Earth observation is specifically mentioned as a key decision-making tool for better management of water resources, natural disasters monitoring, climate and desertification monitoring etc.

Despite the fact that Earth Observation systems are capable of assisting the MEA process, there are number of significant problems. These include lack of consistency and standardisation of data sets and fragmented and inadequate data archives. Remote Sensing technology may provide significant new types of data, as well as simply more or better quality data, but linking Remote Sensing data to policy is not straightforward.

The American Institute of Aeronautics and Astronautics highlighted that remotely sensed data can be used for various aspects of MEAs [9]. The application of Earth Observation systems to support MEAs can range from the identification of an new environmental problem (pre-negotiation phase) to the monitoring (negotiation phase) and assessment (implementation phase) of that problem, to the verification of compliance and subsequent enforcement (compliance and dispute resolution). However it is important to note that there is no binding international regime specifically addressing verification through remote sensing even though the concept of verification through remotely sensed data is not new (provisions in the 1970s' Strategic Arms Reduction Treaties) [10].

REMOTE SENSING DATA AND INTERNATIONAL JURISDICTION

Another issue is whether satellite data is accepted as legally binding proof when it comes to enforcement of treaties. In the past satellite images used for control purposes have been considered mainly as an indication tool that needed to be confirmed by ground verification rather than a complete system of proof by itself [10]. Remote sensing needs to be accepted by the court as legal evidence. This important aspect is not presented in this paper. Several cases exist were remote sensing has been used as proof :

One case when satellite imagery has been accepted as legal evidence in court is the Singapore "Song San" case. In 1996 oil pollution in the straight of Malacca was detected with satellite imagery together with laboratories analysis, the Singaporean tanker "Song San" was identified as the source of marine pollution. On the basis of the satellite data, legal proceedings in Singapore were initiated [11].

The International Court of Justice has accepted remote sensing imagery as proof in certain situation. In the Qatar/Bahrain Case, the Nigeria/Cameroon, Botswana/Namibia case the Court accepted satellite imagery as supportive tools for the chains of evidence to be created.

Satellite data has also considerably supported the work and judgements of the International Claims Tribunal for the Former Yugoslavia (ICTY) in The Hague.

The European Community Commission is using remote sensing in support of its agricultural, environmental and research policy through the Monitoring Agriculture with Remote Sensing (MARS) project, in order to calculate the compensations due. MARS project which aims among others to verify that the policy of fallow land is well implemented has established an operational agricultural monitoring system which monitors and predicts yields for the 10 most common crops across the European Union using field-sampling methods.

Remote sensing satellites for verification purposes is more and more recognized and utilized, even if it is not perfect. Despite the fact that Earth Observation systems are capable of assisting the MEA process, there are number of significant problems. These include lack of consistency and standardisation of data sets and fragmented and inadequate data archives.

APPLICATION OF A MEA FOR LAND MONITORING

This section provides examples of applications of remote sensing in four domains: The Ramsar Convention on Wetlands of International Importance Especially as Waterfowl habitat, The Convention on Biological Diversity (CBD) and The Convention to Combat Desertification in those Countries Experiencing Serious Drought and / or Desertification, particularly in Africa (CCD) and the Convention on Climate Change.

Convention on Wetlands of International Importance especially as Waterfowl Habitat

The Convention on Wetlands of International Importance especially as Waterfowl Habitat, signed in Ramsar, Iran, in 1971, is an intergovernmental treaty which provides the framework for national action and international cooperation for the conservation and wise use of wetlands and their resources. The Convention's mission is the conservation and wise use of wetlands by national action and international cooperation as a means to achieving sustainable development throughout the world.

Remotely sensed data could be useful to inform the Secretariat of the Convention, "at the earliest possible time if the ecological character of any wetland in its territory and included in the list has changes, is changing or likely to change as the result of technological developments, pollution or other human interference (Article 3.2). Remote sensing can help to do a survey of the actual wetlands repartition and extension (Article 8).

As key outcome of the United Nations Conference on Environment and Development or Earth Summit in Rio in 1992 several environmental issues such as : biodiversity, climate change and desertification were addressed. This resulted by the adoption of several international environmental agreements which defined specific government commitments to address these issues.

Convention on Biological Diversity

The overarching aim of the Convention on Biological Diversity (CBD) is the conservation and sustainable use of biological resources. This convention makes commitments to integrate the sustainable use and conservation of biodiversity into national and international decision-making, including:

- Scientific and technical cooperation: including access to and transfer of biotechnology
- Natural resource management: Establishment of protected areas and rehabilitation. Restoration of degraded ecosystems and threatened species. Prevention/control and eradication of alien species which threaten biodiversity.

According to the CBD remote sensing can help for habitat suitability mapping would help to "rehabilitate and restore degraded ecosystems and promote the recovery of threatened species, inter alia, through the development and implementation of plans or other management strategies" (Article 8, Paragraph f). This information would also help "develop, where necessary, guidelines for the selection, establishment and management of protected areas" (Article 8, Paragraph).

The Meso-American Biological Corridor is an excellent example of habitat suitability mapping. This biological corridor is a planned combination of protected areas and managed landscapes that forms a continuous wildlife migration route from Panama to the Mexican border. This project is a collaboration between the University of Maine, the Jet Propulsion Laboratory and the NASDA.

Convention to Combat Desertification

The Convention to Combat Desertification seeks to not only tackle the impacts of desertification but also to mitigate the effects of droughts in countries experiencing serious drought and/or desertification, particularly in Africa, through effective action at all levels, supported by international cooperation and partnership arrangements. Under the convention desertification refers to dryland areas vulnerable to over-exploitation and inappropriate land-use as a result of poverty, political instability, deforestation, overgrazing and bad irrigation. Implementation is defined at a regional level since the convention breaks down into five regions, as defined in the "Implementation Annex" of the convention. The regions are: Central and Eastern Europe, Africa, Asia, Latin America and Caribbean and the Northern Mediterranean.

The areas, which could directly benefit from use of spaceborne Earth Observation technology in the implementation framework of the Convention to Combat Desertification fall under three main headings:

- The collection and analysis of short-term and long-term data and information to identify causal factors, both natural and human, contributing to land degradation, desertification and/or drought;

increase knowledge of the processes leading to land degradation, desertification and drought;

- The systematic observation of the state of the environment to assess qualitative and quantitative trends in natural resources; evaluate the causes and consequences of desertification, notably ecological degradation; and monitor the effects of land degradation and desertification to improve the value of strategies to combat desertification; and
- The establishment and/or strengthening of early warning systems to evaluate the impacts of natural climate variability on regional drought and desertification and generate seasonal to inter-annual climate predictions to improve the efficiency of programs mitigating the effects of droughts on affected population.

PARTICULAR CASE OF THE CONVENTION ON CLIMATE CHANGE

Climate change, caused by the rapid and uncontrolled increase of greenhouse gases in the Earth's atmosphere during the past 150 years, is a major public, political and scientific concern worldwide.

Convention on Climate Change

Public concern resulted in the 1992 United Nations Framework Convention on Climate Change (UNFCCC) which is an official acknowledgement of the climate change phenomenon, as well as a recognition by international policy makers that immediate cross-border actions are required to halt and reverse the current destructive trend.

The convention sets an "ultimate objective" of stabilizing atmospheric concentrations of greenhouse gases at safe levels. Such levels, which the convention does not quantify, should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change. To achieve this objective, all countries have a general commitment to address climate change. The UNFCCC commits all parties to prepare "national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol, using comparable methodologies to be agreed upon by the Conference of the Parties".

The convention then divides countries into two groups: those listed in its Annex I (known as "Annex I Parties") and those that are not so listed (so-called "non-Annex I Parties"). The Annex I Parties are the industrialized countries who have historically contributed the most to climate change. They include both the countries that were members of the Organization for Economic Co-operation and Development (OECD) in 1992, and countries with "economies in transition". The principles of equity and "common but differentiated responsibilities" enshrined in the Convention therefore require these Parties to take the lead in modifying longer-term trends in emissions. All remaining countries have a time frame for the submission of their initial national communications, including their emission inventories, constraining than for Annex I Parties.

The Kyoto Protocol

The UNFCCC was in 1997 strengthened with the Kyoto Protocol which contains quantified, legally binding commitments to limit or reduce greenhouse gas emissions in the atmosphere that are related to human

induced interference with the climate system to 1990 levels. The Kyoto Protocol commits Annex I Parties to limit or reduce their greenhouse gas emissions, adding up to a total cut of at least 5% from 1990 levels in the "commitment period" 2008-2012. The targets cover emissions of the six main greenhouse gases : carbon dioxide (CO_2); methane (CH_4); nitrous oxide (N_2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6).

Two of the main greenhouse gases under the scope of the Kyoto Protocol which can be addressed by the Remote Sensing community are the methane and the carbon dioxide [12]. While CO_2 released by burning of fossil fuels and methane by wetlands destruction constitute the most important emission source, the Kyoto Protocol allows emissions to be balanced by vegetation. Vegetation, which may sequester or release atmospheric carbon and methane depending on the land use, and this is where remote sensing potentially may come into relevance.

Earth observation can provide information about forest area, type, density and health. Satellite sensors can also be used to monitor agricultural activities and other important parameters include such as type, productivity of crops.... Taking several images during the growth cycle makes it possible to draw conclusions about field management practices, such as crop rotations, irrigation cycles and harvesting times.

The Kyoto Protocol sets specific resolution standards. Forest area must be determined using a spatial resolution no larger than 1 hectare, corresponding to a satellite sensor resolution of less than 100 metres. This limits data collection from earth observation sensors to two main types, available in 1990. These are the sensors on board the Landsat (US) and Spot (France) satellite series. Since 1990, a number of new sensors have become available for monitoring land inventories activities either so called passive (ADEOS series) and active systems (Radarsat series).

Earth observation is a very appropriate tool to provide the land-cover information required by the Kyoto Protocol [13]. However, a challenge remains in converting this information (land-cover information) into equivalent carbon stock figures. Some progress has been made since the establishment of the Kyoto Protocol, but more is needed in order to standardise methods.

Relevance of Earth Observation to the Kyoto Protocol

They are five specific areas where remote sensing may support the treaty:

- Provision of systematic observations of relevant land cover (Art. 5, Art. 10);
- Support to the establishment of a 1990 carbon stock baseline (Art. 3);
- Detection and spatial quantification of change in land cover (Art. 3, Art. 12);
- Quantification of above-ground vegetation biomass stocks and associated changes therein (Art. 3 Art 12);
- Mapping and monitoring of sources of anthropogenic CH_4 (Art. 3, Art. 5, Art. 10);

Within the context of the Kyoto Protocol, Article 10 can be recognised as a key driver, in which contributions can be made to provide systematic observations and data archives in order to reduce uncertainties in the global terrestrial carbon budget . [12]

For biomass retrieval as in the context of the Kyoto Protocol it is an absolute requirement that data acquisitions are performed in a consistent manner providing systematic, repetitive observations over large areas is potentially one of the strengths of remote sensing technology [14]. There is a general inadequacy of current data archives because high resolution satellites are not generally collecting data on a homogeneous way over large areas, but instead they are collected in a fragmented manner over several local sites that have been specifically requested by commercial or scientific users.

For regional scale applications, such as biomass retrieval over extensive ecological regions, it is an absolute requirement that data acquisitions are performed in both a spatially and temporally consistent manner. Gaps that inevitably do occur occasionally should be covered during the next cycle for minimal impact [14]. Timing is an important component of repetitive observations, as seasonality may introduce bias in time series of data. Annual acquisitions should therefore preferably be planned during the same season every year [14]. Most of the terrestrial parameters that need to be characterized and quantified within the Kyoto Protocol are in a state of constant change and in many cases, it is these changes that the scientific community are interested in, and so the temporal dynamics of the terrestrial parameters need to be taken into account. The temporal repetition frequency of the acquisitions have to be adapted with respect to the land use, and a land use based stratification of the Earth may thus be required in a global data acquisition plan [14].

World Summit on Sustainable Development

The World Summit on Sustainable Development, held in Johannesburg, South Africa, in 2002, was an important political reunion reinforcing the critical issues related to climate change and the potential support that can play remote sensing. Article 36 of the Plan of Implementation states that: "The United Framework Convention on Climate Change is the key instrument for addressing climate change, a global concern, and we reaffirm our commitment to achieving its ultimate objective of stabilisation of greenhouse gas concentrations in the atmosphere. Actions at all levels are required to: (g) Promote the systematic observation of the earth's atmosphere, land and oceans by improving monitoring stations, increasing the use of satellites, and appropriate integration of these observations".

CONCLUSIONS

In the last thirty years, international environmental agreements have proliferated as environmental protection has become a major issue worldwide.

The environmental protection of the Earth has given birth to a corpus juris specialized in environmental law. These international regulations have a general weakness due to the lack of mechanisms of control or constraints that would make them more effective.

Earth Observation systems have become essential for effectively conducting different types of environmental management and environmental research applications. They can prompt new agreements, influence behaviour under existing agreements, and evaluate past performance and effectiveness. Remote sensing imagery has already been

accepted as legal evidence in court ("Song San" case) and in front of the International Court of Justice and is also used by the European Community Commission in support of its agricultural, environmental and research policy through the MARS project.

The use of remote sensing could be an important and effective support to MEAs. In order to fully achieve this goal the international community needs to move towards the legal recognition of the use of remote sensing imagery as proof, and as a decisive tool in the framework of the defense of the environment.

Remote sensing technology may provide significant new types of data, but linking remote sensing data to policy is not straight forward.

REFERENCES

[1] C.T.S. 9 as amended (1986) C.T.S. 46

[2] 31 *I.L.M.* 818

[3] *I.L.M.* 1328

[4] 31 *I.L.M.* 851

[5] 37 *I.L.M.* 22

[6] Kline, Raustiala. "International environmental agreements and remote sensing technologies". *Background paper prepared for the Workshop on Remote Sensing and Environmental Treaties: Building More Effective Linkages,* December 4-5, 2000:

[7] de Sherbinin, and Chandra "Remote Sensing in Support of Multilateral Environmental Agreements: What Have We Learned from Pilot Applications ?" *Paper prepared for presentation at the Open Meeting of the Human Dimensions of Global Environmental Change Research Community,* Rio de Janeiro. (6-8 October 2001).

[8] 12 *I.L.M.* 1319 (1973), as modified by the Protocol of 1978, 17 *I..L.M.* 546 (1978) (MARPOL 73/78) and Annexes

[9] American Institute of Aeronautics and Astronautics, *Sixth International Space Cooperation Workshop Report.* March 2001

[10] Hettling,: "The use of Remote Sensing Satellites for Verification in International Law", *Space Policy*, Volume 19 Number 1, February 2003, pp 33-41.

[11] Brehon, "Le Satellite au Service de l'Environnement", *Air & Cosmos*, 25-05-2001, p. 52.

[12] Rosenqvist, Imhoff, Milne, Dobson, "Remote Sensing and the Kyoto Protocol: A Review of Available and Future Technology for Monitoring Treaty Compliance". *Report.* Ann Arbor, MI, USA, October 20-22, 1999.

[13] Peter. "Supporting Environmental Treaties with Remote Sensing Data. An example of the application of a Multilateral Environmental Agreement : The Kyoto Protocol", *UNESCO / Eurisy Conference. Space Applications for Heritage Conservation.* Strasbourg, France 5-8 November 2002.

[14]Rosenqvist, "Systematic data acquisitions - a prerequisite for meaningful biophysical parameter retrieval ?" *3rd Symposium on Retrieval of Bio-and Geophysical Parameters from SAR Data for Land Applications,* Sheffield, U.K., Sept. 11-14, 2001

Acknowledgments

The author would like to thank Philippe Achilleas (IDEST) and Ake Rosenqvist (NASDA) who followed the work. The author would like also to thank Jill Ferrier (ISU) who played a major role with her valuable comments and suggestions.