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Supporting environmental treaties with remote sensing data – An example of the application of a multilateral environmental agreement: The Kyoto Protocol

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ABSTRACT: In the last 30 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 attendant need for spatial data on the health of the Earth's biophysical systems. Remotely sensed imagery can provide both snapshots and data over times that address environmental issues on global, regional and national scales. It can provide these in consistent formats and in ways that complement national level data collection efforts, which are often under-resourced and inconsistent from country to country. 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 MEAs. The main purpose of this paper is to see the link between Remote Sensing in support of Multilateral Environmental Agreements, with an example of a "MEA application": The Kyoto Protocol.

1 MULTILATERAL ENVIRONMENTAL AGREEMENTS

International environmental policy is typically cast in the form of bilateral or multilateral environmental agreements, which are agreements contracted between governments to collectively address an environmental problem. Recently, multilateral environmental agreements (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 (Kline and Raustiala 2000). A sampling of existing agreements illustrates the diversity

- The Ramsar Convention on Wetlands of International Importance Especially as Waterfowl habitat (1971)
- The Convention on Biological Diversity (1992)

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 (de Scherbinin and Chandra 2001).

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 (de Scherbinin and Chandra 2001). The International Convention for the Prevention of Pollution from Ships (the MARPOL Convention 1973) is 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 sus-

tainable 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 (AIAA 2001). 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).

2 REMOTE SENSING LEGAL ASPECTS

The monitoring of the environment by satellite, like any other activity in outer space, is governed by the general principles of space law, to be found mainly in the five United Nations treaties that lay down the general conditions of access and use of outer space. The first text to be considered is the 1967 Outer Space Treaty, which determines that there is freedom of scientific investigation in space for governmental, intergovernmental and non-governmental entities. All nations have the non-exclusive right to use space. The Outer Space Treaty does not address the status of remote sensing satellites specifically.

Specific principles governing remote sensing of the earth from space were elaborated. These are a set of fifteen principles adopted by consensus by the United Nations General Assembly on 4th December 1986 (Resolution 41/65). These principles define the general purpose of space-based earth observation and regulate the rights and duties of states conducting or being sensed by earth observation. This resolution confirms, among other things the freedom to record images, more specifically that “remote sensing shall promote the protection of the Earth’s natural environment and the protection of mankind from natural disasters”. Moreover according to the principles, the sensed state shall have access to the primary data and the processed on a non-discriminatory basis and at reasonable cost. This specific legal regime is not binding since they were adopted in UNGA Resolution, and such have a customary value.

3 AN EXAMPLE OF THE APPLICATION OF A MEA: THE KYOTO PROTOCOL

3.1 *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.

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.

3.2 *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 (CO2); methane (CH4);

nitrous oxide (N2O); hydrofluorocarbons (HFCs); perfluorocarbons (PFCs) and sulphur hexa-fluoride (SF6).

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 (CH4) and the carbon dioxide (CO2) (Rosenqvist et al, 1999). While CO2 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) and active systems (Radarsat).

Earth observation is a very appropriate tool to provide the land-cover information required by the Kyoto Protocol. 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.

4 THE 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 CH4 (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 (Rosenqvist et al, 1999).

5 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”.

6 DATA ACQUISITION STRATEGY

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 (Rosenqvist 2001). However, high resolution remote sensing data are generally not acquired systematically, neither in time nor in space, and this is considered a serious impediment to extensive use of the technology, and for the development of operational applications (Rosenqvist et al., 2000). 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 (Rosenqvist 2001). 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 (Rosenqvist 2001). 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 (Rosenqvist 2001).

7 EXAMPLE OF THE USE OF REMOTE SENSING: THE KYOTO AND CARBON INITIATIVE

The Kyoto and Carbon Initiative is a project launched by NASDA in 2001, with the aim to provide adequate data and information in support of terrestrial carbon cycle science and international treaties, and particularly the Kyoto Protocol.

NASDA's Kyoto and Carbon Initiative is based on Advanced Land Observing Satellite (ALOS) PALSAR and Advanced Earth Observing Satellite (ADEOS) II GLI remote sensing data. ALOS is a satellite following on from the Japanese Earth Resources Satellite-1 (JERS-1). ADEOS-II, is the successor to ADEOS. The Kyoto and Carbon Initiative is based on the conviction that remote sensing data and specifically ALOS PALSAR and ADEOS II GLI systems can play a significant role to support, partly or fully, some of the Kyoto Protocol information. The Kyoto and Carbon Initiative aims to respond to the Kyoto Protocol need through the establishment of a dedicated data acquisition strategy in which spatial and temporal consistency, adequate repetition frequency, and timing are taken into account as far as possible.

It is duly acknowledged that Kyoto Protocol reporting requirements cannot be fully met with ALOS PALSAR and ADEOS II GLI data. The Kyoto Protocol relates to changes in total carbon (above ground, below ground, soil and litter), while remote sensing at best can provide information about the above-ground component only. Remote sensing is however more suitable for providing information about land cover spatial repartition and temporal dynamics.

The Kyoto and Carbon Initiative is unique in several respects: though its vision of a global data acquisition plan with high resolution on an annual basis over a long time period and also though its synergy between several sensor types (optical – radar) with different resolutions: spatial and temporal (coarse and high, bi-weekly or monthly). This project is a leading example for the potential link between remote sensing and MEAs, and may also be helpful to partly support MEAs other than the Kyoto Protocol (Peter 2002).

CONCLUSIONS

In the last thirty years, international environmental agreements 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 of them was a catalyst for the creation of new accords. 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. They can prompt new agreements, influence behaviour under existing agreements, and evaluate past performance and effectiveness.

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