MONITORING THE KYOTO PROTOCOL & BEYOND: Greenhouse Gases Observation & the Global Forest Carbon Monitoring System

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Masami Onoda

JAXA Industrial Collaboration Department/

Kyoto University Graduate School of Global Environmental Studies

onoda.masami@jaxa.jp

1. Introduction

As we are to talk about "Legal Implications of Space Applications for Global Climate Change: Institutions and Instruments" in this symposium, I would like to try to identify in my presentation the exact meaning of "monitoring" by taking up the cases of space application s for the Kyoto Protocol and beyond. Early forms of the use of satellite Earth observation data in international institutions can be seen in the arms control regimes, where satellite imagery was used as National Technical Means of verification, and then as "open source information" for verification by the International Atomic Energy Agency. After the cold war, there has been an emerging trend of international cooperation to achieve international common interests, leading to the increasing need of transparency. "Environmental monitoring" is thus a general and core requirement to achieve transparency and reassurance, in decision-making and implementation or compliance of the regime.

This could be shown in an institutional model of environmental treaties, where policy is based on scientific information in a manegerial framework based on treaty procedures: Information is gathered on a certain risk; States may acknowledge the risk and make political decisions; and measures (e.g. emissions reduction) will be carried out. Monitoring can broadly mean two functions in this model: (a) Environmental monitoring, or "systematic observations" in the Vienna Convention for the Protection of the Ozone Layer[1] and UNFCCC[2], or monitoring compliance or verification of treaty obligations by States. We will now look into these functions of "monitoring", and the role satellite data could play therein.

2. Satellite Earth Observation as "Systematic Observation"

Most multilateral environmental treaties call for improvement of information in both functions of "monitoring", i.e. provided in the treaty text in terms such as "research and systematic observation" (including "monitoring" in general) and compliance monitoring as "self-reporting" or in other terms in the treaty text. Those treaties include the 1985 Vienna Convention (Arts 2.2 (a), 3, Annex II for the former; and Arts 5 and 6 for the

[1] Vienna Convention for the Protection of the Ozone Layer, Mar. 22, 1985, T.I.A.S. No. 11,097, 1513 U.N.T.S. 293 [hereinafter Vienna Convention].
[2] Framework Convention on Climate Change, 31 ILM (1992), 851[hereinafter UNFCCC].

latter), the 1987 Montreal Protocol (Art 6; Art 7), [3] the 1992 UNFCCC (Arts 4.1(g), 5; Art 12), and its Kyoto Protocol[4] of 1997 (Art 10 (d); Arts 7 and 8), the 1979 LRTAP (Arts 4, 6, 7, 9; Art 8),[5] the 1982 UNCLOS (Arts 200 and 204; Arts 205 and 206),[6] and the 1992 Biodiversity Convention (Arts 7, 12, 17, 18; Art 14).[7] While this is not a complete nor comprehensive list of relevant treaty provisions, it indicates the extensive use of provisions on environmental monitoring in treaty texts.

The Vienna Convention, adopted in 1985, was the first multilateral legal instrument to adopt the term "systematic observations". In the former draft Convention, the definitions for "monitoring" was: "a system of observations, collation of the results of these observations, and assessment and forecasting of change in the amount and vertical distribution of ozone and substances having a significant impact on the state of the ozone layer on the basis of factual data." [8] During the negotiations,[9] it was agreed that throughout the draft convention and associated texts, "monitoring" would be replaced by "systematic observations."

The UNFCCC Preamble recalls the Vienna Convention and its Montreal Protocol, and provides that all parties shall "[p]romote and cooperate in scientific, technological, technical, socio-economic and other research, systematic observation and development of data archives ...."[10] It also provides that parties shall support and further develop international and intergovernmental programs and networks or organizations, taking into account the need to minimize duplication of effort.[11]

The Kyoto Protocol provides that: "[p]arties ... shall ... cooperate in scientific and technical research and promote the maintenance and the development of systematic observation systems and development of data archives ... and promote the development and strengthening of endogenous capacities and capabilities to participate in international and intergovernmental efforts, programs and networks on research an systematic observation, taking into account Article 5 of the Convention."[12]

"Research and Systematic Observation" has been a regular agenda item of the UNFCCC' Subsidiary Body for Scientific and Technological Advice (SBSTA)[13] since its 17th session. The 9th Conference of Parties (COP 9) (Milan, December 2003) adopted a decision on global observing systems for climate.[14] This decision calls for the preparation of an implementation plan for global climate observations to be coordinated by GCOS in collaboration with the Group on Earth Observations (GEO). [15] COP 10

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[3] Montreal Protocol on Substances That Deplete the Ozon Layer, 26 ILM 1541, 1989.
[4] Protocol to the Framework Convention on Climate Change (Kyoto), 37 ILM, 1998 [hereinafter Kyoto Protocol].
[5] Convention on Long-Range Transboundary Air Pollution, 18 ILM 1442, 1979.
[6] United Nations Convention on the Law of the Sea, 21 ILM 1261, 1982.
[7] Convention on Biological Diversity, 31 ILM, 818, 1992.
8 *Revised Draft Convention for the Protection for the Ozone Layer, with Additional Commentary,* UN Doc. UNEP/WG/78/10 (1983), p.3.
[9] *Second Revised Draft Convention for the Protection of the Ozone Layer, with Additional Commentary,* UN Doc. UNEP/WG.94/3 (1983), p.2.
[10] UNFCCC, Art. 4(1)(g).
[11] *Ibid.*, Art. 5.
[12] Kyoto Protocol, Art. 10.
[13] See UNFCCC, Research and Systematic Observation, at http://unfccc.int/methods_and_science/research_and_systematic_observation/items/2312txt.php (last visited 25 Mar. 2008).
[14] Conference of the Parties, Milan, Italy, Dec. 1-12, 2003, *Report of the Conference of the Parties on its Ninth Session, Addendum,* FCCC/CP/2003/6/Add1, 11/CP.9, (Apr. 22, 2004), pp.20-22.
[15] See generally, Group on Earth Observations, *Homepage, at* http://earthobservations.org/ (last visited Mar. 25

also adopted a decision on research and systematic observation.[16] SBSTA 22 (Bonn, May 2005) welcomed the endorsement of the 10-year Implementation Plan at the third Earth Observation Summit in February 2005, which establishes the Global Earth Observation System of Systems (GEOSS) as an important development in systematic observation to contribute to the enhancement of climate change research.[17]

The potentials and implications of systematic observation is that firstly, satellite Earth observation is an integral part of systematic observation, as an international obligation in the Vienna Convention and UNFCCC. Secondly, the fundamental issue is the coordination of national law and policies, including programme planning and data policy. Although there has been almost 30 years of history of international harmonisation of space programmes and data policy, what has been achieved is a common largest denominator at best. It is yet to be clear if GEOSS could provide effective coordination tools for national policies or successfully link satellite Earth observation to environmental treaties. Thirdly, synergy between space and environmental law and policy is essential for the effective application of space technologies.

3. Potential Compliance Monitoring

Next, I will argue the potentials and issues of compliance monitoring in two cases, atmospheric greenhouse gases monitoring, and monitoring emission sinks by land remote sensing.

3.1 Atmospheric Greenhouse Gases Monitoring

Today, two missions exist with the aim of atmospheric greenhouse gases observation from space: Japan is developing the Greenhouse gases Observing SATellite (GOSAT)[18] and the U.S. is developing the Orbiting Carbon Observatory (OCO)[19]. GOSAT mission has a certain political focus in relation to the Kyoto Protocol,[20] while OCO objectives are mainly scientific.

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[16] Conference of the Parties, Buenos Aires, Arg., Dec. 6-18, 2004, *Report of the Conference of the Parties on its Tenth Session, Addendum*, FCCC/CP/2004/10/Add1 (Apr. 19, 2005), p.2.

[17] Subsidiary Body for Scientific and Technological Advice , Bonn, Germany, May 19-27, 2005, *Report of the Subsidiary Body for Scientific and Technological Advice on its twenty-second session,* at 14, FCCC/SBSTA/2005/4 (Jul. 29, 2005). Also see *The Global Earth Observation System of Systems (GEOSS) 10-Year Implementation Plan* (Feb. 16, 2005) *available at* http://earthobservations.org/docs/EOS%20III/10YR%20IMPLEMENTATION%20PLAN.doc (last visited 25 Mar. 2008).

[18] Greenhouse Gases Observing Satellite (GOSAT) , *Homepage, at* http://www.jaxa.jp/missions/projects/sat/cos/gosat/index_e.html (last visited Mar. 25 2008).

[19] Orbiting Carbon Observatory, *Homepage, at* http://oco.jpl.nasa.gov/ (last visited Mar. 25 2008).

[20] Japan Aerospace Exploration Agency (JAXA), Plan to Achieve the Mid-term Goal of the Japan Aerospace Exploration Agency, at 11, available (only in Japanese) at http://www.jaxa.jp/missions/plan/pdf/mid-term_plan.pdf (last visited Sept. 20, 2006) ; National Institute for Environmental Studies (NIES) Center for Global Environmental Research, GOSAT brochure, *available at* http://www-cger.nies.go.jp/cger-e/e_pub/e_pamph/pamph_index-e.html (last visited Mar. 25 2008).

(1) GOSAT Mission

GOSAT is a joint project of the Japan Aerospace Exploration Agency (JAXA) and the Ministry of Environment (MOE), and the National Institute for Environmental Studies (NIES). It will be the first satellite to observe the concentrations of CO_2 and CH_4 from space. The results will not only contribute to a deeper scientific understanding of global warming, but also provide fundamental information for refining climate change prediction and formulating global warming countermeasures.[21]

The mission targets are: (i) to observe CO_2 and CH_4 column density at 100-1000km spatial scale, with 1% relative accuracy for CO_2 and 2% for CH_4, during the Kyoto Protocol's first commitment period; and (ii) to reduce sub-continental scale CO_2 annual flux estimation errors by half[22]. This challenging mission certainly has many technical issues to overcome, but scientifically, there would be an important value of global repetitive data collected over a continuing period. Currently, the profile of greenhouse gas concentration is mapped by some 300 ground and airborne observations, while GOSAT will be capable of providing 56,000 observation points. Such measurement by satellite is expected to significantly enhance the current observation network capability.

(2) Monitoring Procedures of the UNFCCC & Kyoto Protocol

If we understand "compliance" as the degree of implementation by Parties of the treaty obligations, we must first examine the treaty obligations in order to identify the potential role of satellite Earth observation in treaty compliance. The ultimate objective of the UNFCCC being to achieve stabilisation of greenhouse gases concentrations, in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system, it sets forth differentiated commitments to Parties, including systematic observation, and reporting and review. Specifically, it requires as commitments of all Parties, to make available national inventories; formulate programmes; develop technologies; sustainable management of sinks and reservoirs; cooperate in preparing for adaptation; research and systematic observation; information exchange; education and training; and communication.[23] It also provides that Annex I Parties[24] shall adopt national policies and measures on mitigation of climate change, and communicate detailed information[25]. Annex II Parties[26] shall provide new and additional financial resources; and transfer of technology.[27] The Conference of Parties shall review the adequacy of national policies and measures communicated.[28]

The Kyoto Protocol to UNFCCC provides regulations for specific numeric goals for emissions reduction by Annex I Parties of the UNFCCC,[29] as well as the procedures for

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[21] Ministry of Environment, National Institute for Environmental Studies and Japan Aerospace Exploration Agency, *GOSAT Project*, published by the Center for Global Environmental Research, NIES, Nov. 2007.
[22] Akihiko Kuze, Kayoko Kondo, Yutaka Kaneko & Takashi Hamazaki, Greenhouse Gases Observation from the GOSAT Satellite, A14C-03, presented at the American Geophysical Union Fall Meeting, San Francisco, 2005, p.3.
[23] UNFCCC, Art 4.1.
[24] *Ibid.*, Annex I; Annex I countries include the industrialized countries that were members of the OECD (Organisation for Economic Co-operation and Development) in 1992, plus countries with economies in transition (the EIT Parties), including the Russian Federation, the Baltic States, and several Central and Eastern European States.
[25] *Ibid.*, Art. 4.2.
[26] *Ibid.*, Annex II;OECD Members.
[27] *Ibid.*, Art.4.3.
[28] *Ibid.*, Art 4.2.
[29] Kyoto Protocol, Art. 3.1.

Parties to conduct research and systematic observation,[30] conduct emissions estimation, reporting and review,[31] and cooperation between developed and developing countries, and commercial entities through the market mechanism, to achieve emission reduction goals.[32] These provisions of the UNFCCC and Kyoto Protocol constitute an elaborate set of rules and procedures of political goals, regulations and economic incentives, based on scientific information, to which satellite Earth observation may partly contribute, if not for all the treaty requirements.

(3) Potentials and implications

The GOSAT mission, in addition to the scientific goals, has a certain political focus. In the usages of terms in the political rationale of the GOSAT satellite mission, there seems to be a mixture of focus in "validating (verifying)" "understanding (clarifying, estimating)" and "predicting". The role satellite Earth observation can play in the Kyoto Protocol procedures is, however, still limited at the present stage, especially with regard to compliance monitoring. The Kyoto Protocol calls to ensure that "their aggregate anthropogenic carbon dioxide equivalent emissions of the greenhouse gases... do not exceed their assigned amount". The estimation guidelines for establishing national inventories are based on calculations of CO_2 equivalence of anthropogenic emissions using global warming potentials as accepted by Intergovernmental Panel on Climate Change and agreed upon by the Conference of Parties.[33] On the other hand, it is not possible to identify and measure anthropogenic emissions by satellite observation. Because of the technical limitations of inverse modelling using satellite data, as opposed to forward calculation methods that is adopted by the treaty procedures, it is not realistic to expect satellite observation to be able to contribute directly in the reporting and review process of national inventories, or to replace such data in this process in the Kyoto Protocol.

The most significant role of greenhouse gases observations by satellite is, in the context of implementation of Kyoto Protocol obligations, that they can provide an integral part of systematic observation on greenhouse gases (CO_2 and CH_4) by enhancing observation capacities and providing accurate estimates of the flux of greenhouse gases on a subcontinental basis. This would improve the quality of information and understanding on the long-term and general status of climate change, thus reducing the uncertainty of the scientific basis of the treaty.

3.2 Forest Carbon Monitoring System

(1) The Kyoto Mechanism and Earth observation

As the Kyoto Protocol requires quantification of afforestation, reforestation, and deforestation (ARD), [34] revegitaton and land used management, [35] and to establish a baseline of carbon stocks for 1990,[36] existing and historical remote sensing data could

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[30] *Ibid.*, Art 10 (d).
[31] *Ibid.*, Art 5.1, 7.1&2, Art 8.
[32] *Ibid.*, Art 6, 12, 17 on the Kyoto Mechanism.
[33] Intergovernmental Panel on Climate Change, *Revised 1996 Guidelines for National Greenhouse Gas Inventories, available at* http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm (last visited 25 Mar. 2008).
[34] Kyoto Protocol, Art 3.3.
[35] *Ibid.*, Art 3.4.
[36] *Ibid.*, Art 3.1.

play and important role in supporting the establishment of these information. As the negotiations of the COP has defined specific arrangements for the so-called "Kyoto Mechanisms", it turned out that in the Clean Development Mechanism (CDM) projects on emission sinks, remote sensing or GIS data is not being fully utilised. On the other hand, the IPCC Good Practice Guidance[37] encourages the use of spatial data and the use of GIS for monitoring and evaluation of sinks.

In 2005 at COP11, "Reducing Emissions from Deforestation & Degradation" (REDD) was proposed by Papua New Guinea, leading the Coalition of Rainforest Nations. A formal decision was adopted at the recent COP13 in Bali. [38] REDD is a concept in which reduction of emissions from deforestation and forest degradation can be compensated through payment of carbon credits generated from deliberate actions and policies to reduce or avoid deforestation and degradation. While only afforestation and deforestation are applicable under the Kyoto Protocol CDM, avoidance or deduction of deforestation is not. It is hoped that starting after 2012, REDD can start as an international mechanism where "reduced" emissions can be certified and transacted in carbon markets. It is expected to provide a sustainable source of financing for forest conservation, by giving incentives to preserving forests. This poses another demand for satellite data. In order to quantify the amount of carbon "conserved", and credits duly issued, it is necessary to establish means of accurately quantifying the baseline data and to monitor deforestation and degradation.

(3) The Forest Carbon Monitoring System (FCMS) Research Project

The Ministry of Environment of Japan, JAXA and Tokyo University, together with international partners, has initiated a 3-year research project for the development of a Forest Carbon Monitoring System (FCMS) based on the synergetic use of in-situ measurements and Earth Observation data, for quantitative estimates of CO_2 emissions induced by deforestation and degradation. The prime data source for baseline mapping and annual change monitoring is the L-band Synthetic Aperture Radar (PALSAR) onboard ALOS. The aim of the FCMS project is to develop a system for mapping and monitoring of forest carbon stocks and of changes therein, through the synergetic use of in-situ networks and Earth Observation data. In particular, the project aims to assess the utility of using ALOS PALSAR data to derive information about the status of the forest cover mapping and for identification and spatial quantification of changes in the forest cover as a result of deforestation, forest degradation and regeneration. The project also aims to develop operational methodologies for forest monitoring and quantitative carbon accounting – an FCMS system – which, depending on the outcome of UNFCCC post 2012 regime agreements, can support the potential implementation of international climate change regulations for the REDD as a part of a post 2012 regime. In this sense, the FCMS research project is a precursor initiative that is foreseen to lead to the development of an operational international monitoring system for quantitative assessment of deforestation and degradation.

In this project, a 3-step approach will be adopted for developing carbon accounting methods through the following 6 subtopics:

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[37] IPCC, Good Practice Guidance for Land Use, Land-Use Change and Forestry, 2003, at http://www.ipcc-nggip.iges.or.jp/public/gpglulucf/gpglulucf_contents.htm (last visited 26 Mar. 2008)

[38] UNFCCC, Decision 2/CP.13, *Reducing emissions from deforestation in developing countries: approaches to stimulate action*, Un Doc. FCCC/CP/2007/6/Add.1, pp.8-11.

(1) Developing carbon accounting methods
(2) Analysis of PALSAR data for identifying deforestation and degradation
(3) Analysis of forest inventories
(4) Estimating forest structure parameters using PALSAR
(5) PALSAR characterisation of vegetation disturbance
(6) Evaluating carbon balance with ecosystem models

Quantitative estimates of carbon emissions will not be possible to be derived from satellite data alone. Ancillary data will be required from other data sources such as *in-situ* observations. SAR data can provide information on *where the changes occurred, when they occurred* and the *spatial extent of the changes*. The SAR images can provide cloud-penetrating, periodical data on forest covered areas, which is especially useful for observation of the tropical region with persistent cloud cover.

(3) Potentials and Implications

The FCMS initiative is a challenging project integrating political requirements and technological solutions in to a operational system. Easily said than done, there are a number of issues to be overcome before it proves operational. While the ALOS SAR is a powerful tool in detecting land use and land cover change, it must be identified what can be delivered, in response to the political framework of international monitoring requirements. Data availability, as well as cost, at present and near-long term is crucial. In this sense, a single system is not sufficiently reliable as the source of information in the implementation phase. It is thus essential to achieve optimal institutional procedures and space system design; and collaborative approach between developed and developing countries through treaty mechanisms for sustainable forest conservation and emissions reduction. Although REDD is still in a very early stage of negotiations, it should never be too early to start such institutional coordination.

4. Legal Implications

As the first day of this symposium session extensively discussed "Principles and Rules", here, I will just point out a couple relevant points with relevance to international space law. With regard to the 1967 Outer Space Treaty[39], 3 principles are of relevance : free exploration and use of outer space (Art. 1); international cooperation (Art. 1,3,9); and due regard to interests of all other States (Art. 9).

The UN Remote Sensing Principles of 1986[40] attempts to coordinate the benefit and interests of all countries and national sovereignty issues. However, the following 3 points may be specified as remaining open for clarification: (1)Access rights: especially the issue of property position of holder of data (IV); (2)Equality and equity (promotion of international cooperation "shall be based in each case on equitable and mutually acceptable terms.") (V), while the OST states the norm of equality, and specific conditions for "non-discriminatory basis" (XII) ; or "cost terms" are left open; (3) As to

[39] Treaty on Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Treaty on the Non-Proliferation of Nuclear Weapons, 729 UNTS 161, 1967.
[40] UN, *Principles Relating to Remote Sensing of the Earth from Space*, UN Doc. A/RES/41/65, annex.

the disclosure of remote sensing environmental "information", there is no mention of cost, leading that information obligations are established at no cost, and environmental info is given special status of "public good."

As to the relevance to international environmental law, the improvement of environmental information is an established objective of international environmental law.[41] Various supervisory techniques are adopted, including reporting, inspection, non-compliance procedures, and "preventive global monitoring". In the Vienna Convention and UNFCCC, satellite data is referred to as part of systematic observation, which countries must promote and cooperate in, as treaty obligations.

Most of these legal implications pointed out above are of very general nature, regarding normative principles rather than specific State obligations or procedures. The ambiguity concerning the Remote Sensing Principles could be subject to future discussions when the procedures and legal issues become clearer, as instrumental frameworks on satellite Earth observation applications for global climate change further develop.

4. Conclusion

Satellite Earth observation is an integral part of *systematic observation* required in the UNFCCC and Kyoto Protocol. For *compliance monitoring* satellite data is not fully utilized because of the gaps between technical capabilities and the treaty methodology; thus, it is essential to generate political procedures and scientific capability in a compatible and consistent manner. For enhanced transparency with *cost-effective, independent & reliable data*, there is a need to design environmental-space systems and political institutions involving *non-state actors,* where *developed and developing countries* work together in treaty mechanism with joint economic incentives; and with *coordinated data rights and accessibility.*

However, space law is silent on these issues. It is thus expected that future research and discussions in this field will clarify the incompatibilities between technical capability and legal or policy procedures, so that satellite Earth observation can provide an effective observation basis for environmental data and scientific knowledge, upon which future regimes could be developed and implemented.

[41] See Sands, Philippe, *Principles of International Environmental Law,* Second Edition, Cambridge: Cambridge University Press, 2003.