Space Applications as a tool for enforcement of international environmental regulations

René Oosterlinck
Director for external relations and of security office ESA
Professor Space Law at the RUG

Overview of some Multilateral Environmental Agreements (MEAs)

- Since the 1972 Stockholm Conference on the Environment many environmental agreements have been elaborated.

- Today, more than 240 global and regional environmental agreements are in force

Overview of some Multilateral Environmental Agreements

- The 1992 Earth submit was at the base of three major conventions:
- The Convention on Biological Diversity (CBD)
- The Convention to Combat Desertification (CCD)
- The Framework Convention on Climate Change (FCCC)

Relevant space applications for MEAs

- Satellite based remote sensing including meteorology
- Global Satellite Navigation Systems

Relevant space applications for MEAs (2)

Use of space applications	Remote sensing	navigation
Support in the elaboration of MEAs and/or national legislation	**X**	
Support in monitoring at global level	**X**	**X**
Support in verification of compliance	**X**	
Means for enforcement of MEAs and/or national legislation	**X**	**X**

Remote Sensing – How does it work

Remote sensing – how does it work

- Remote sensing may be defined as a system for acquiring spectral, spatial and temporal information about objects without direct contact from space through use of electromagnetic radiation.
- Two ways of obtaining data: passive remote sensing using only natural sources of radiation and active remote sensing using artificially generated radiation e.g. radar.

Remote sensing – how does it work (2)

- The reflected data for a specific object/area is called the signature for that object. The spectral composition of the signal defines the object.
- The reflected data will not only allow to determine the nature of the object but also its characteristics e.g. type of vegetation and the state of its health.

Remote sensing – how does it work (3)

- Remote sensing is classified in three types depending on the wavelength of signals used:
  - Visible optical wavelength
  - Thermal emissive infrared
  - Microwave (active)

Optical Remote Sensing Images (1)

Four main types of information contained in an optical image are often utilized for image interpretation:

- Radiometric Information (i.e. brightness, intensity, tone),
- Spectral Information (i.e. colour, hue),
- Textural Information,
- Geometric and Contextual Information

Optical Remote Sensing Images (2)

Radiometric information: brightness, intensity, tone

Optical Remote Sensing Images (2)

spectral information
colour, hue

Optical Remote Sensing Images (3)

Textural information

Optical Remote Sensing Images (4)

Geometric and contextual information

Optical Remote Sensing Images (5)

- Panchromatic images consist of only one frequency band and is composed of grey scale images. The brightness of a pixel is proportional to the intensity of solar radiation reflected by the target.
- Multi-spectral images consist of several frequency bands. Each picture is composed of grey scale images.

Optical Remote Sensing Images (6)

True colour composite

- If a multi-spectral consist of the three primary colours i.e. red, green and blue the bands may be combined to produce a so-called “true colour” image corresponding on what would be seen by human eyes.

Optical Remote Sensing Images (7)

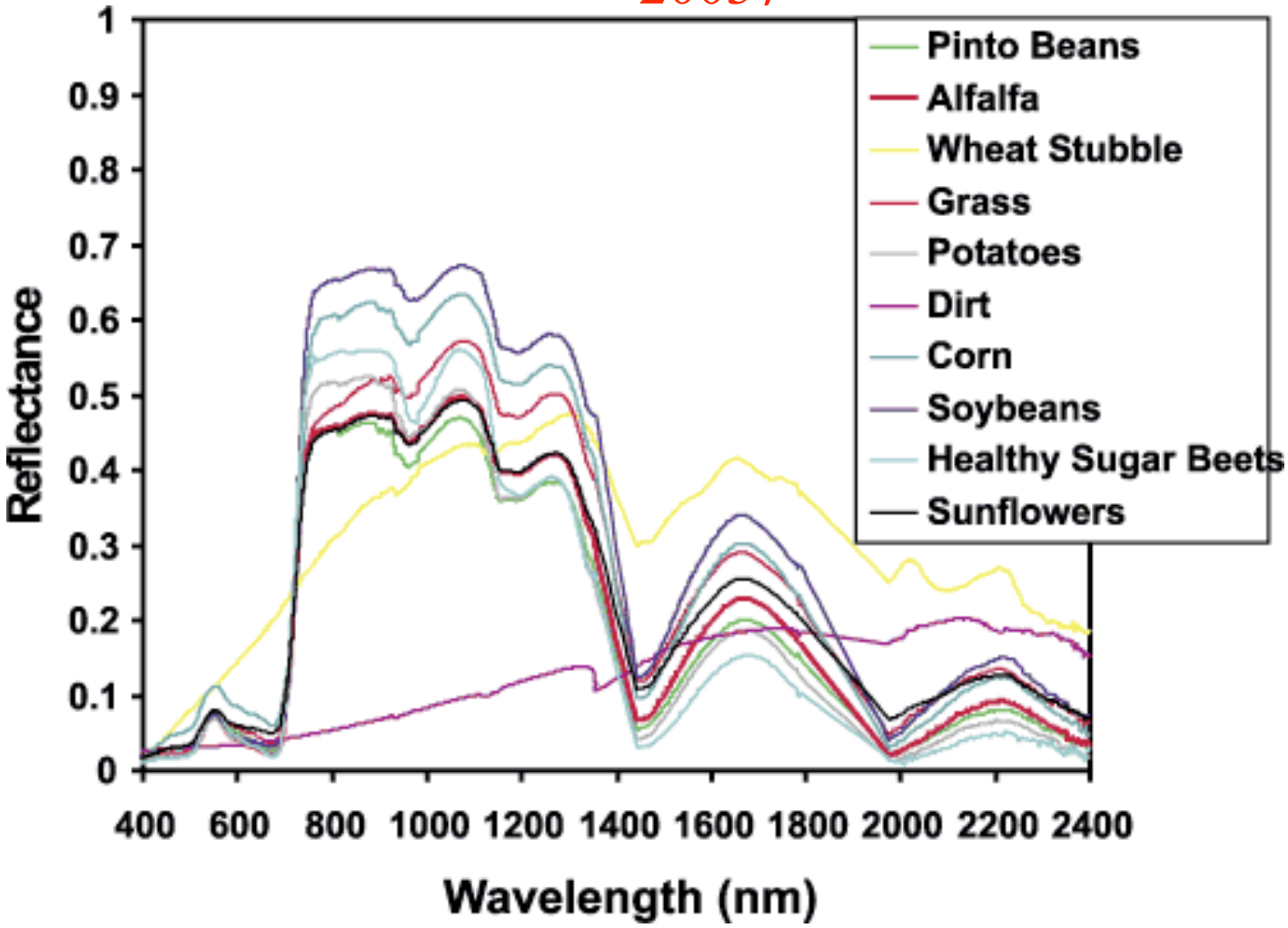
False Colour Composite

- The colour assignment may be done in an entirely arbitrary manner. This approach allows to differentiate within the picture certain specific elements i.e. vegetation will be shown differently depending on the type of vegetation, its condition etc
- Clear water appears dark blueish, turbid water cyanic etc

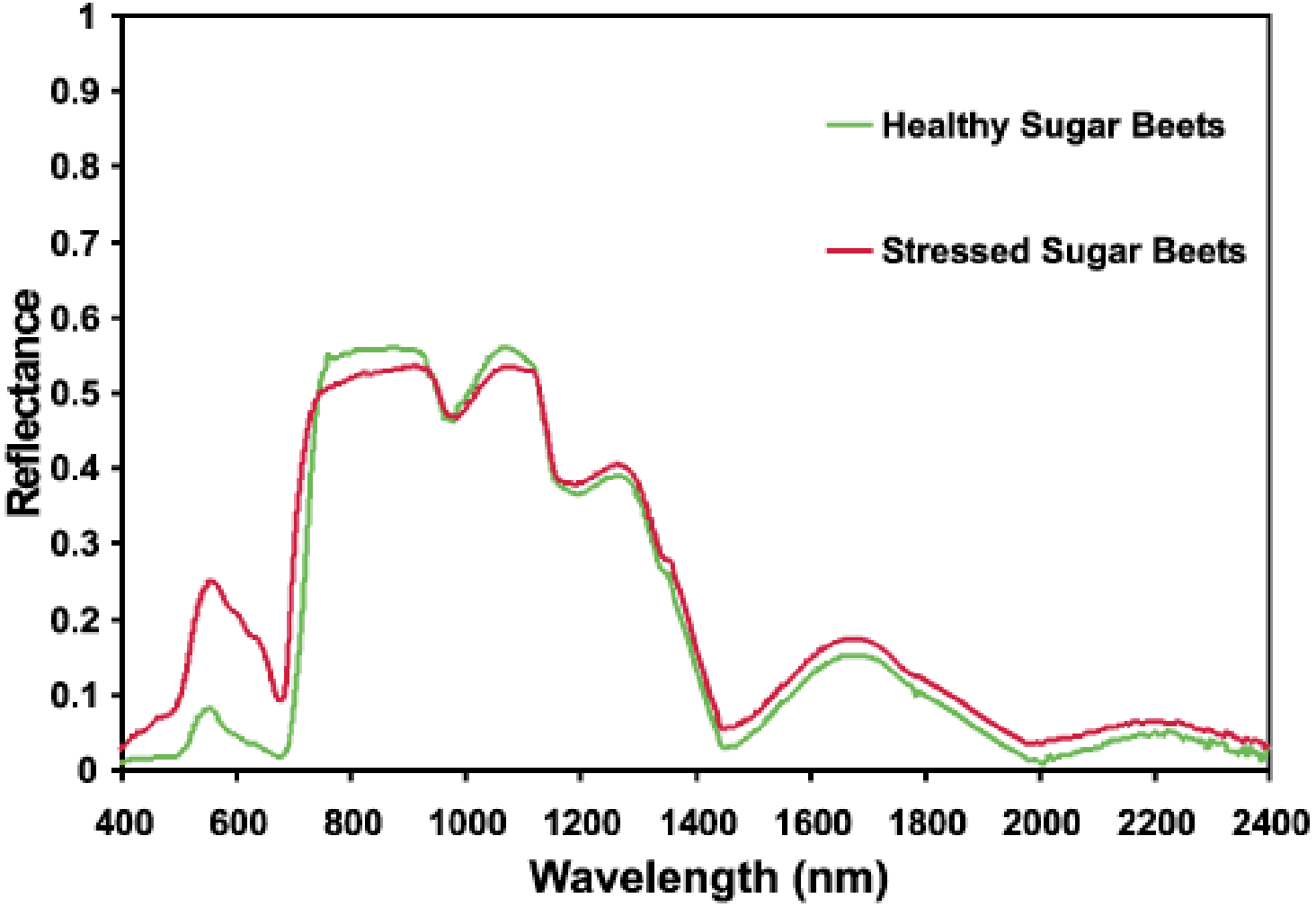
Optical Remote Sensing Images (8)

False colour composite multispectral SPOT image

Remote sensing – signature (1) (picture Kyllo 2003)



Remote sensing – signature (2) (picture Kyllo 2003)



Overview of some Multilateral Environmental Agreements (MEAs)

Overview of some Multilateral Environmental Agreements (MEAs) (1)

- **UN Framework Convention on Climate Change (UNFCCC), 1992**
- Provides for future action to regulate greenhouse gases (GHGs) in the atmosphere. 1997 Kyoto Protocol commits parties to legally binding targets to limit emissions.
- **potential use of remote sensing data:** land use, land cover and forestry (LULUCF); afforestation, reforestation and deforestation; climate change.

UN FRAMEWORK CONVENTION ON CLIMATE CHANGE (1)

- Article 4.1(g) Promote and cooperate in scientific, technological, technical, socio-economic and other research, **systematic observation and development of data archives** related to the climate system and intended to further the understanding and to reduce or eliminate the remaining uncertainties regarding the causes, effects, magnitude and timing of climate change and the economic and social consequences of various response strategies;

UN FRAMEWORK CONVENTION ON CLIMATE CHANGE (2)

- Article 4.2(d) The Conference of the Parties shall, at its first session, review the adequacy of subparagraphs (a) and (b) above. Such review shall be carried out in **the light of the best available scientific information** and assessment on climate change and its impacts, as well as relevant technical, social and economic information.

UN FRAMEWORK CONVENTION ON CLIMATE CHANGE (3)

- Article 5(b) Support **international and intergovernmental efforts to strengthen systematic observation and national scientific and technical research capacities** and capabilities, particularly in developing countries, and to promote access to, and the exchange of, data and analyses thereof obtained from areas beyond national jurisdiction; and

Kyoto – Protocol

potential areas where remote sensing technology may be applied,

- 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)

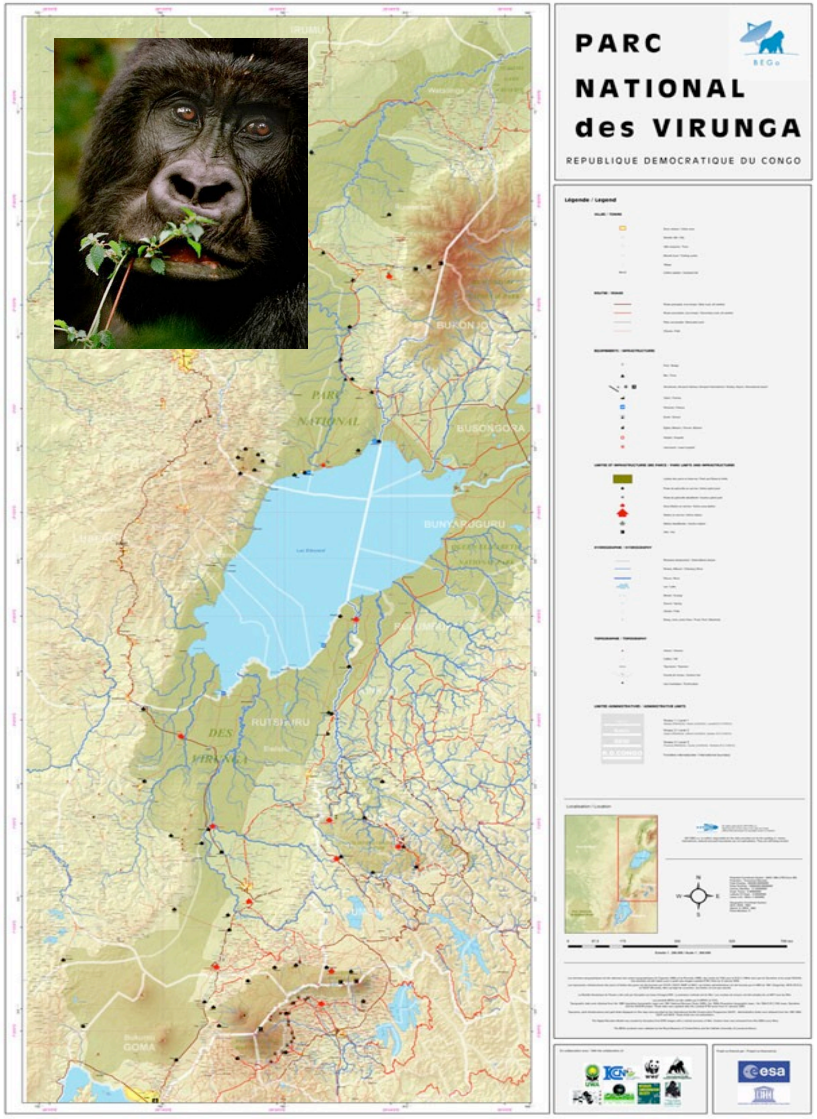
Overview of some Multilateral Environmental Agreements (MEAs) (2)

- **UN Convention to Combat Desertification (CCD), 1992**
- Aims to combat desertification and mitigate effects of drought through long-term integrated strategies.
- **potential use of remote sensing data:** desertification, drought; vegetation cover and stress.

Overview of some Multilateral Environmental Agreements (MEAs)(3)

- **United Nations Convention on Biological Diversity (CBD), 1992**
- Aims to conserve biological diversity, promote sustainable use of its components and encourage equitable sharing of benefits from utilising genetic resources.
- **potential use of remote sensing data:** vegetation; wetlands; land use and land cover.

Managing Gorilla Habitat

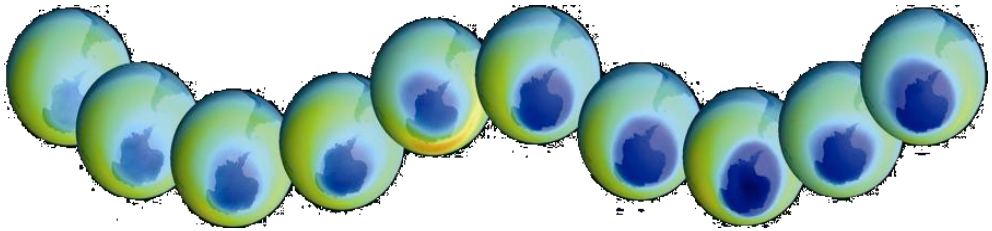


Satellites deliver synoptic information on the habitat of mountain gorillas in Africa (e.g. land cover, topography), which is used to manage the National Park of Virunga (UNESCO World Heritage site).

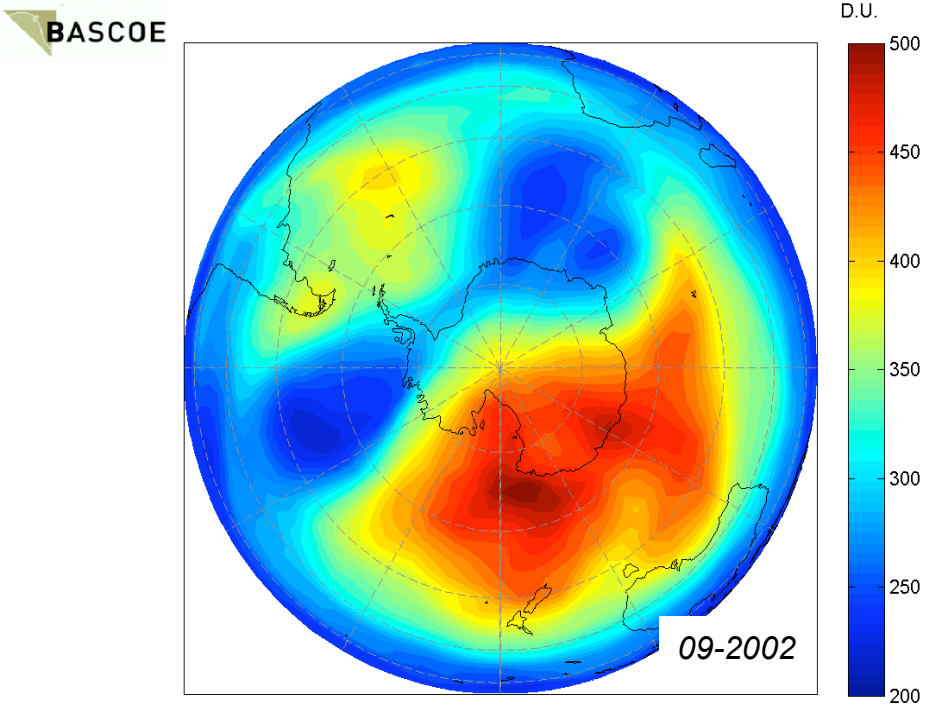
Overview of some Multilateral Environmental Agreements (MEAs) (4)

- **Montreal Protocol and Vienna Convention on Protection of the Ozone Layer, 1987**
- The Protocol sets out legal obligations in the form of timetables for progressive reduction and/or
- elimination of production and consumption of certain ozone-depleting substances.
- **potential use of remote sensing data:** atmospheric ozone concentration; concentration of other atmospheric trace gases critical to ozone formation/destruction.

Ozone Depletion



Growth of Antarctic ozone hole over 20yrs observed by satellite



Chemical forecasting of the ozone hole split in 2002 by BASCOE.
© ESA, BIRA, BASCOE

Depletion of ozone hole in Antarctica

Evidence from satellites of thinning of the Ozone layer led to the Montreal Protocol for reducing CFC's.

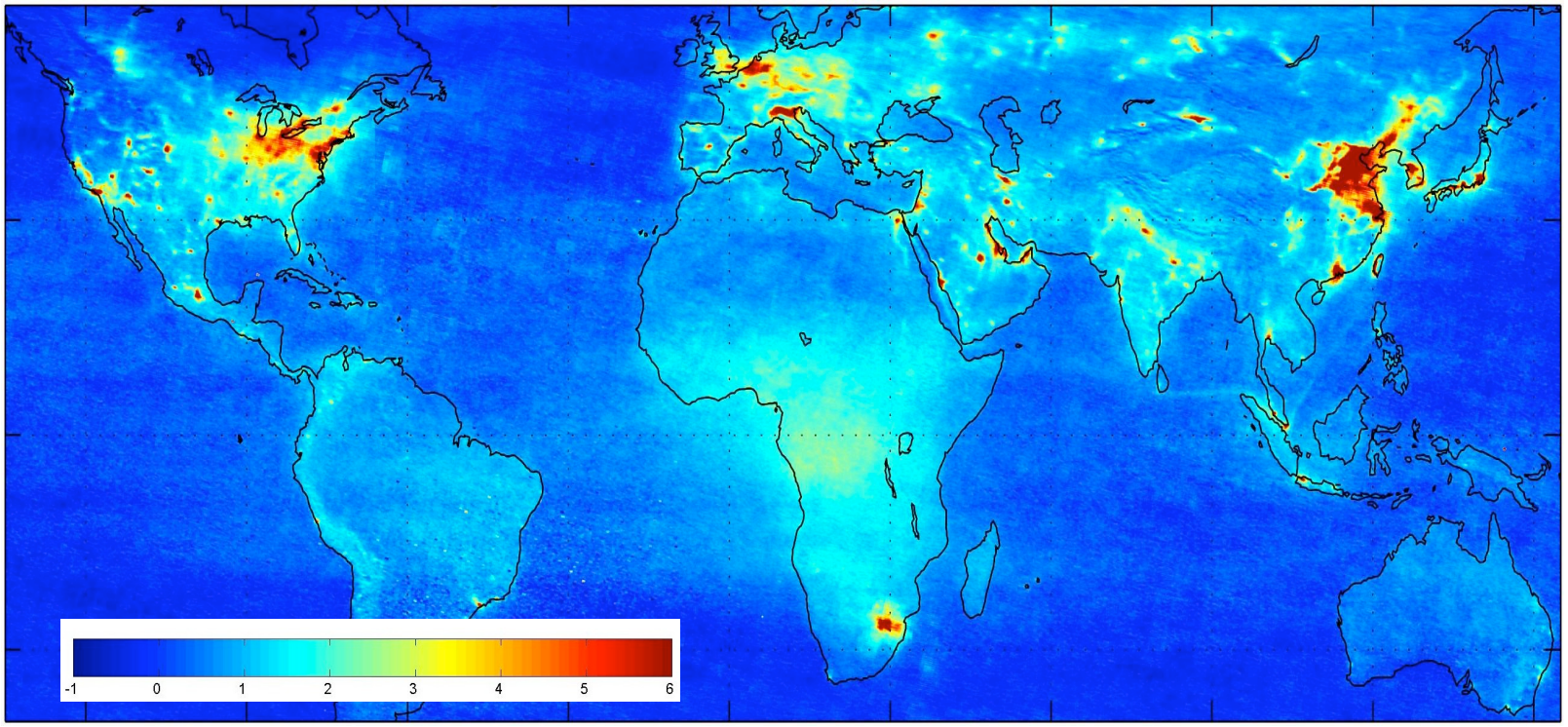
The mathematical model BASCOE (Belgian Assimilation System of Chemical Observations from ENVISAT) at the Belgian Institute for Space Aeronomy is used to simulate the ozone chemistry & accurately predicted the split of the ozone hole in 2002.

Overview of some Multilateral Environmental Agreements (MEAs) (5)

- **Convention on Long-Range Transboundary Air Pollution (CLRTAP), 1979**
- Aims to limit, gradually reduce and prevent air pollution, including long-range transboundary pollution.
- **potential use of remote sensing data:** concentrations of atmospheric trace gases (such as CO_2, NO_x, CH_4, water vapour); impact of pollution on vegetation.

Transboundary Pollution

Global pollution by NO2

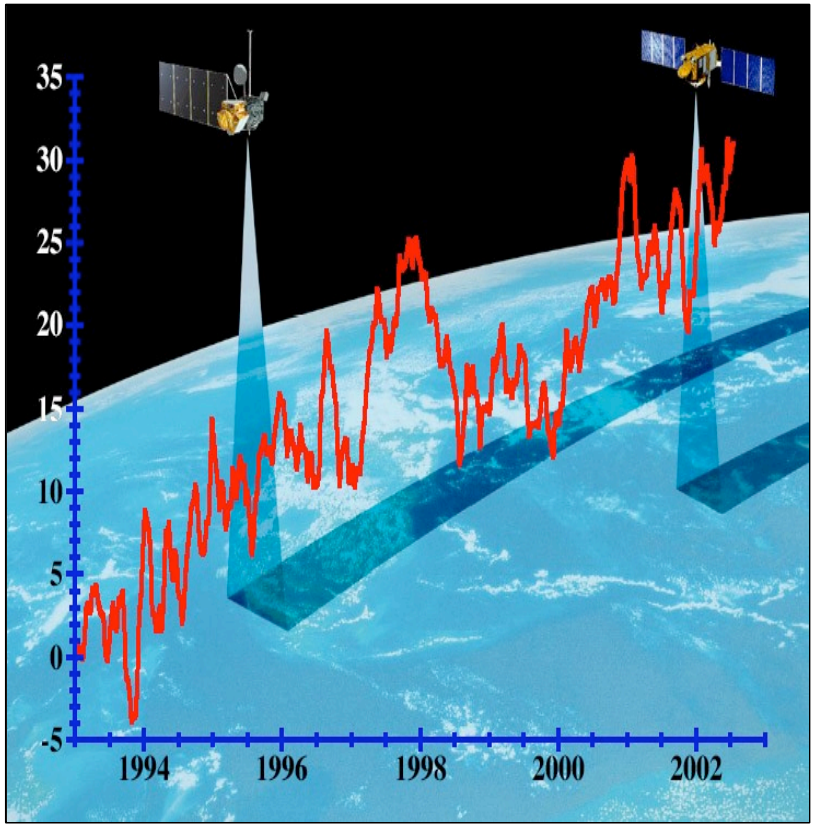


Satellites provide global information on the chemical composition of the atmosphere (e.g. trace gases) supporting assessment of air quality and identification of sources of transboundary pollution (e.g. peak of NO_2 over China due to economic growth).

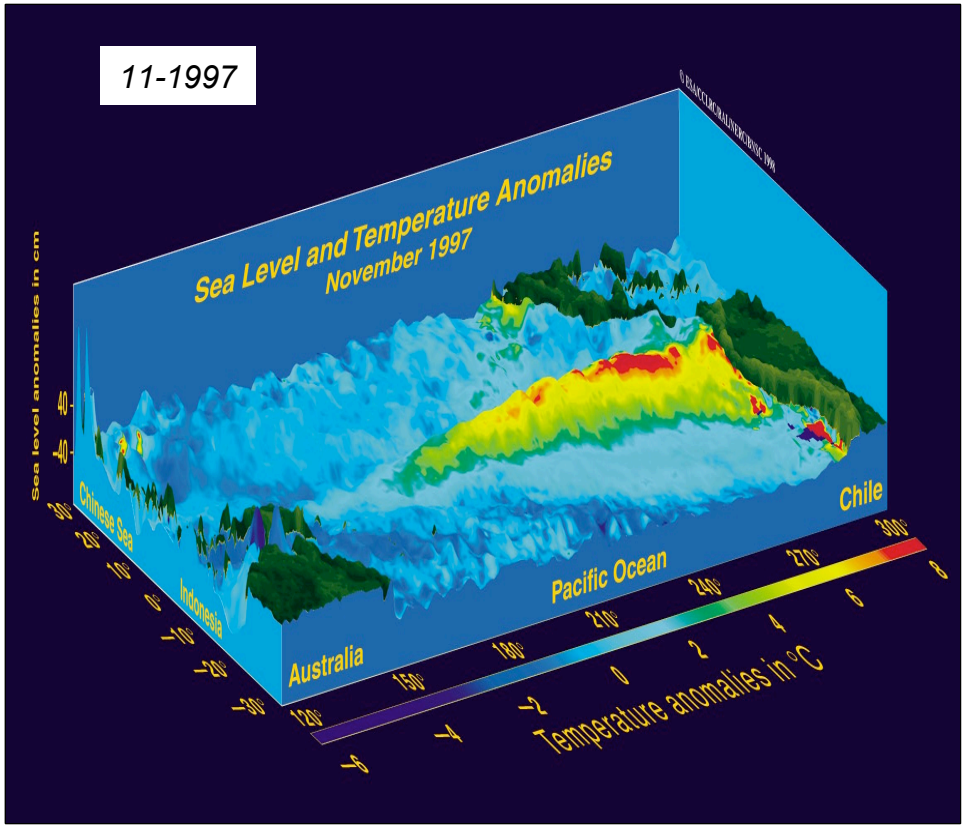
Image of global tropospheric NO_2 as derived from GOME / ERS and SCHIAMACHY / ENVISAT.

Climate Monitoring

Global Sea Level Rise

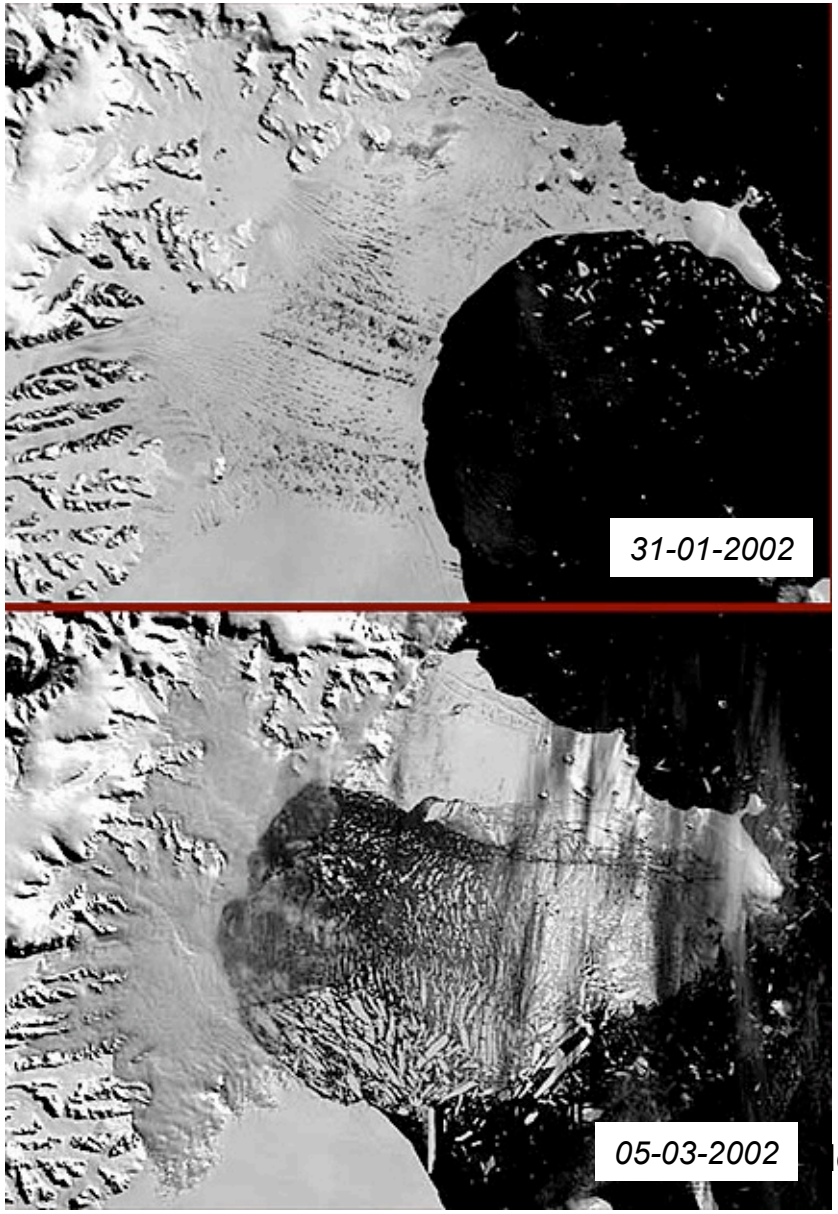


El Nino seen by Envisat



Satellites constantly monitor the state of our climate, its seasonal-to-decadal variability (e.g. El Nino Southern Oscillation) as well as its long-term changes (e.g. global temperature, sea level).

Melting of ice sheets



Collapse of Larsen B ice shelf, Antarctica

In early 2002, the Larsen B ice shelf (about 220m thick), which was stable for the last 400 years, lost about 3250 km^2 of ice into the ocean in one month.

MEAs and monitoring

- Article 10.1. of the convention for the protection of the Mediterranean sea against pollution (1976) The Contracting Parties shall endeavour to establish, in close co-operation with the international bodies which they consider competent, complementary or joint programmes, Including, as appropriate, programmes at the bilateral or multilateral levels, for pollution monitoring in the Mediterranean Sea area and shall endeavour to establish a pollution monitoring system for that area.

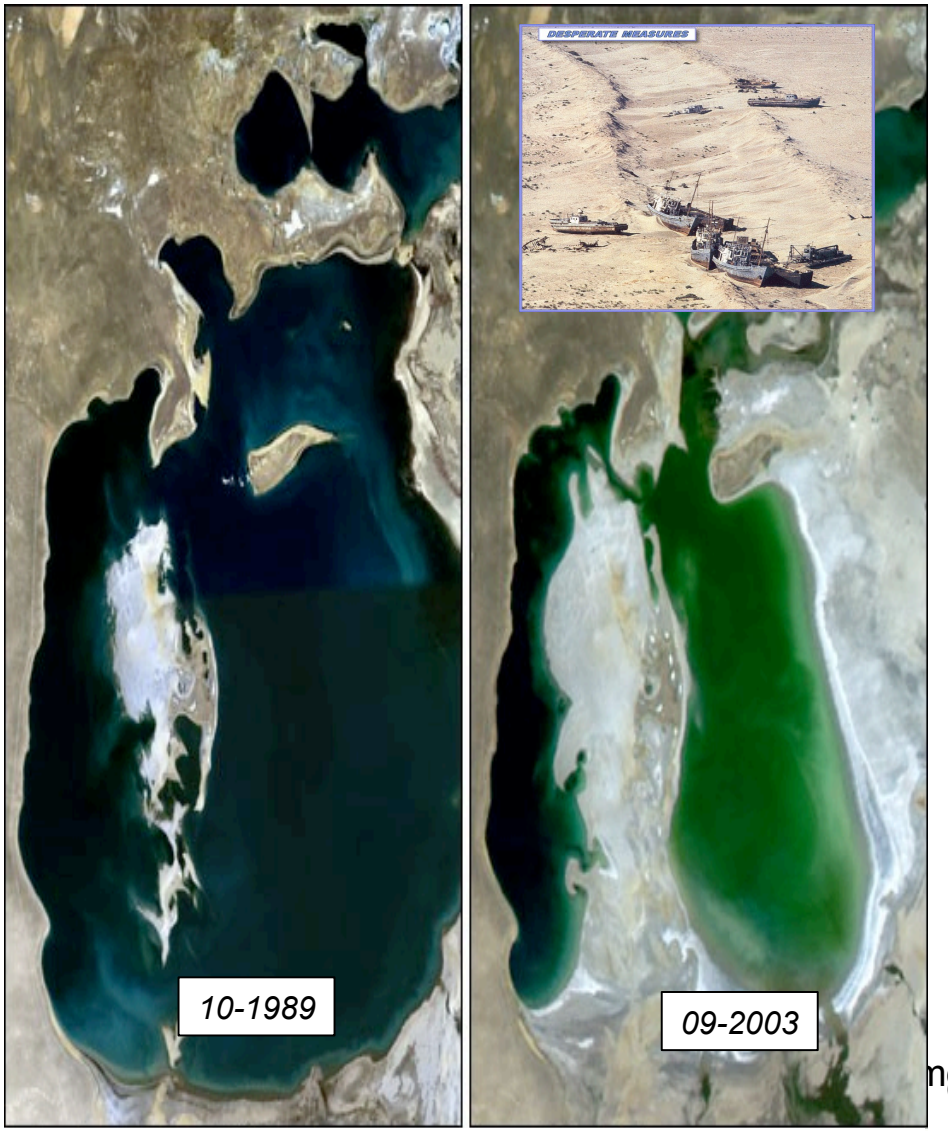
MEAs – systematic observation

Section 2, Article 16 of the convention to combat desertification - Information collection, analysis and exchange

- The Parties agree, according to their respective capabilities, to integrate and coordinate the collection, analysis and exchange of relevant short term and long term data and information to ensure systematic observation of land degradation in affected areas and to understand better and assess the processes and effects of drought and desertification.

Desertification

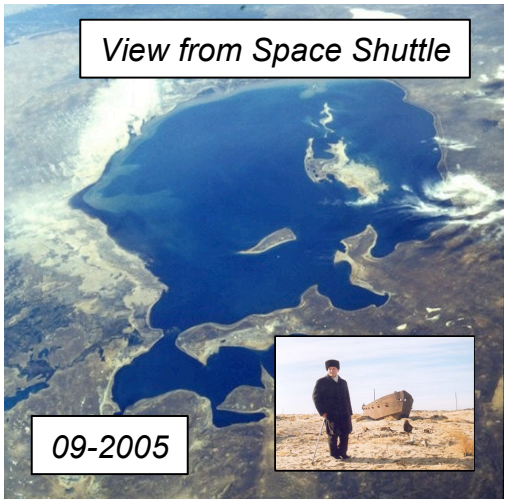
Dying of the Aral Sea



In 1960, the Aral Sea was the world's fourth-largest lake.

Today, it has shrunk by 80% in volume and 60% in surface.

The unique vantage point of space enables one to appreciate the scale of the damage resulting from irrigation activities.



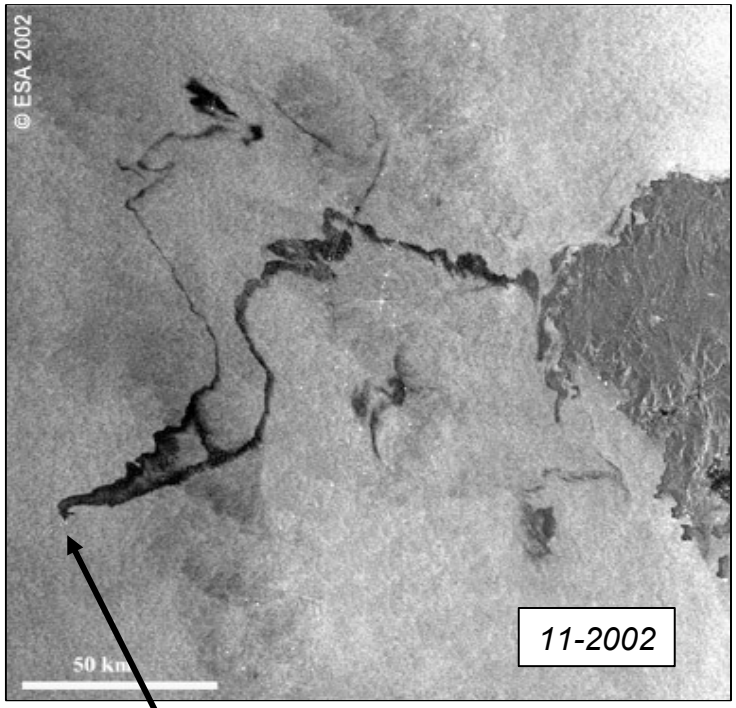
MEAs violations and enforcement

Article 6 of the International Convention for the prevention of pollution from ships, 1973 Detection of violations and enforcement of the convention

- Parties to the Convention shall co-operate in the detection of violations and the enforcement of the provisions of the present Convention, using all appropriate and practicable measures of detection and environmental monitoring, adequate procedures for reporting and accumulation of evidence.

Marine Pollution

Monitoring extension of Oil Spills



Oil spill extent from Prestige as derived from imaging radar ASAR on board ENVISAT.

Satellites imaging radar (SAR) deliver all-weather synoptic information on the extent of oil spill & seeps.

The European Maritime Safety Agency (EMSA) - in charge of overall maritime security in EU – will be using Earth Observation data to predict the extent of oil spill and to identify illegal discharges.

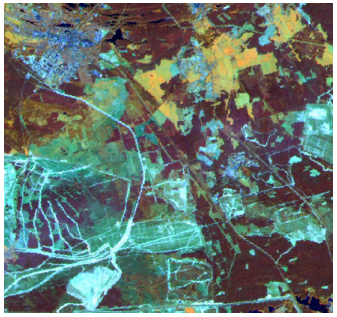
Oil & Gas companies are using Earth Observation data to monitor environmental impact of offshore platforms and localize oil seeps to identify potential oil reserves.

MEAs monitoring

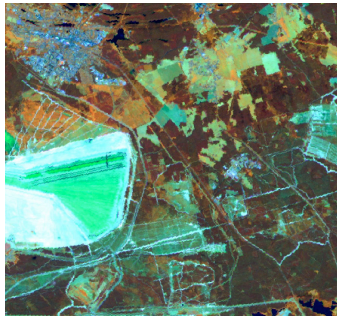
- Under Article 3.3 of the Kyoto Protocol, Parties decided that greenhouse gas removals and emissions through certain activities — namely, *afforestation* and *reforestation* since 1990 — are accounted for in meeting the Kyoto Protocol's emission targets. Conversely, emissions from *deforestation* activities will be subtracted from the amount of emissions that an Annex I Party may emit over its commitment period. Under Article 3.4 of the Kyoto Protocol, Parties could elect additional human-induced activities related to LULUCF, specifically, forest management, cropland management, grazing land management and revegetation, to be included in its accounting for the first commitment period.

Forest monitoring

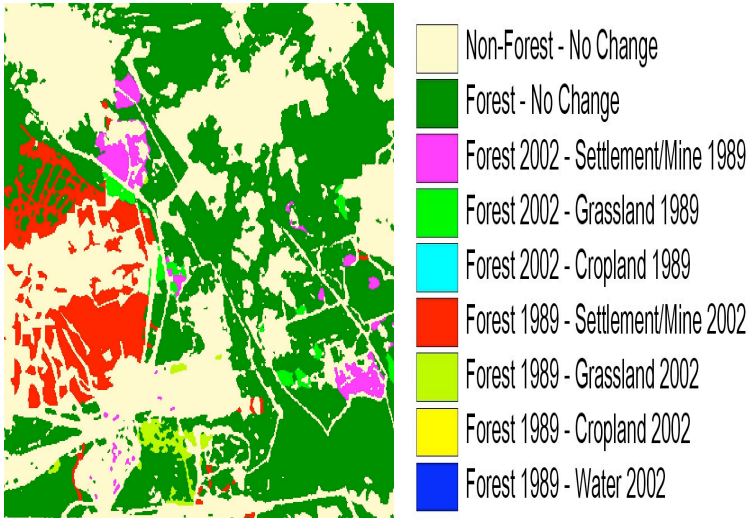
1990 (Kyoto baseline)



2002 (Landsat)



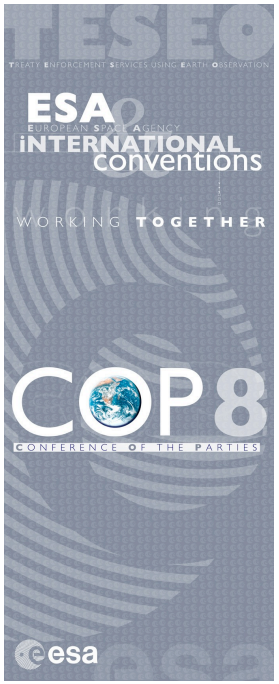
Forest change statistics from EO are used to quantify LULUCF activities in the framework of the **Kyoto Protocol**



Managing forests

Satellites constantly monitor forest biomass (e.g. land cover type, carbon stock, moisture) and fire risks.

Forest mapping from space supports sustainable forestry practices, detection of illegal logging as well as the implementation of international environmental conventions to protect climate (UNFCCC), wetlands, biodiversity and combat desertification.



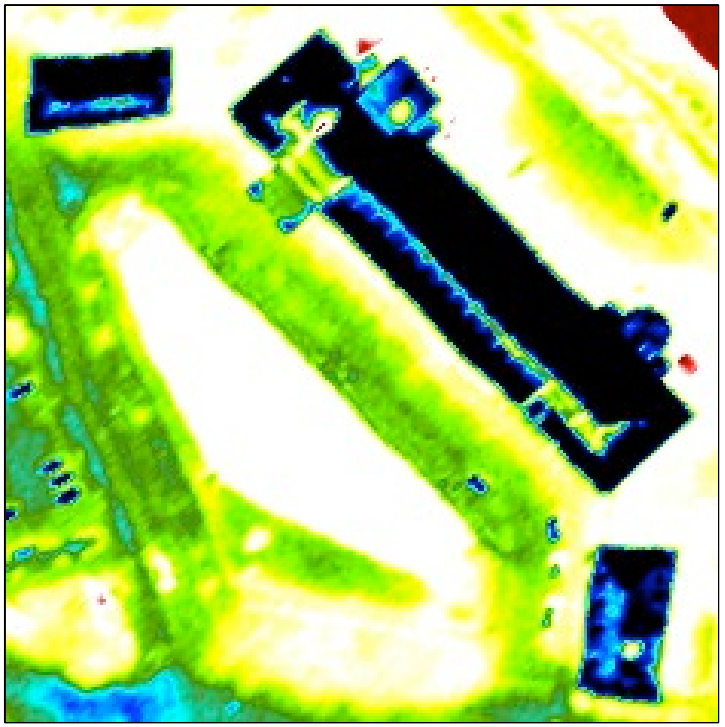
Remote sensing at regional level
Urban Thermal Services

Mortsel
een stad vooruit

Straalt je dak ?

Kyoto plan
Stad Antwerpen

Airborne Thermal view



Airborne Optical view

Urban Services GMES

Legal considerations space law

Air law – Space law

- Airborne remote sensing activities fall under the jurisdiction of international aviation law, which, among others, provides that airborne sensing activities be performed with the consent of the state being surveyed.
- Spaceborne remote sensing activities are governed by the UN Treaties on Outer Space according to which it can be performed, under certain conditions, without the permission of the sensed state. Moreover, any state may sense the entire Earth from outer space.
- Air law and space law make no distinction between passive and active sensing techniques (some restrictions exist with respect to the use of the frequency spectrum)

Remote sensing and Navigation – space law

- The UN treaties on Outer Space are applicable to all activities carried out in Outer space.
- No special rules exist for satellite navigation contrary to remote sensing for which the UN General Assembly has adopted a specific set of principles.

UN Treaties on Outer Space

- Treaty on the Principles Governing the Activities of States in the Exploration and Use of Outer Space, including the Moon and Other Celestial Bodies, entered into force October, 1967 (the "Outer Space Treaty")
- Agreement on the Rescue of Astronauts, the Return of Astronauts and the Return of Objects Launched into Outer Space, entered into force December,1968
- Convention on International Liability for Damage Caused by Space Objects, 1971
- Convention on the Registration of Objects Launched into Outer Space, 1974
- Agreement Governing the Activities of States on the Moon and Other Celestial Bodies,

UN Declarations and Principles governing space-related activities

In addition to the five international legal instruments the UN General Assembly has adopted the following five sets of declarations and principles governing space-related activities.

- Declaration of Legal Principles Governing the Activities of States in the Exploration and Uses of Outer Space (resolution 1962 (XVIII, adopted 1963)
- Principles Governing the Use by States of Artificial Earth Satellites for International Direct Television Broadcasting (resolution 37/92, 1982)
- Principle Relating to Remote Sensing of the Earth from Space (resolution 41/65, 1986)
- Principles Relevant to the Use of Nuclear Power Sources in Outer Space (resolution 47/68, 1992)
- Declaration on International Cooperation in the Exploration and Use of Outer Space for the Benefit and in the Interest of All States, Taking into Particular Account the Needs of Developing Countries

Principles relating to remote sensing (1)

- (a) The term "remote sensing" means the sensing of the Earth's surface from space by making use of the properties of electromagnetic waves emitted, reflected or diffracted by the sensed objects, for the purpose of improving natural resources management, land use and the protection of the environment;

Principles relating to remote sensing (2)

- (b) The term "primary data" means the raw data that are acquired by remote sensors borne by a space object and that are transmitted or delivered to the ground from space by telemetry in the form of electromagnetic signals, by photographic film, magnetic tape or any other means;
- (c) The term "processed data" means the products resulting from the processing of the primary data, needed to make such data usable;
- (d) The term "analysed information" means the information resulting from the interpretation of processed data, inputs of data and knowledge from other sources;

Principles relating to remote sensing (3)

Principle II

- Remote sensing activities shall be carried out for the benefit and in the interests of all countries, irrespective of their degree of economic, social or scientific and technological development, and taking into particular consideration the needs of the developing countries.

Principles relating to remote sensing (4)

Principle IV

- Remote sensing activities shall be conducted in accordance with the principles contained in article I of the Outer Space Treaty
- the principle of freedom of exploration and use of outer space on the basis of equality.
- These activities shall be conducted on the basis of respect for the principle of full and permanent sovereignty of all States and peoples over their own wealth and natural resources, with due regard to the rights and interests, in accordance with international law, of other States and entities under their jurisdiction. Such activities shall not be conducted in a manner detrimental to the legitimate rights and interests of the sensed State.

Principles relating to remote sensing (5)

Principle X

- Remote sensing shall promote the protection of the Earth's natural environment. To this end, States participating in remote sensing activities that have identified information in their possession that is capable of averting any phenomenon harmful to the Earth's natural environment shall disclose such information to States concerned.

Principles relating to remote sensing (6)

Principle XII

- As soon as the primary data and the processed data concerning the territory under its jurisdiction are produced, the sensed State shall have access to them on a non-discriminatory basis and on reasonable cost terms. The sensed State shall also have access to the available analysed information concerning the territory under its jurisdiction in the possession of any State participating in remote sensing activities on the same basis and terms, taking particularly into account the needs and interests of the developing countries.

Legal Consideration
Compliance
Enforcement
Evidence

Remote sensing data and compliance

Remote sensing data may be used as a means for the verification of compliance of Treaties and/or national legislation provided it satisfies the following conditions:

- Availability of data is guaranteed to all
- Repetitive coverage of specific areas is guaranteed
- Qualitative measurements are make according to certified procedures
- Data should be accurate, objective and comparable

Remains the fact that contracting parties must accept the use of data obtained outside their borders.

Remote sensing data and compliance

Agricultural parcels in Ieper (Belgium) derived from SPOT5 satellite at 2.5m resolution.

Crop monitoring & compliance to CAP

Satellites can assist the implementation of the Common Agricultural Policy (CAP) by monitoring crop types & areas (e.g. number of olive trees) but also by assessing compliance of parcels with the CAP reform related to farming practices and agro-environmental conditions (e.g. harvesting from center to periphery, respect of landscape features, direction of ploughing).

EUROSENSE®

Remote sensing data – enforcement/evidence

The use of remote sensing as a means for enforcement is facing the following problems:

- Raw data is as such not usable and need to be processed into useful data.
- Complex processing depends on mathematical models.
- Processed data remains subject of interpretation.

Remote sensing data used as evidence

Cases:

Song San: in January 1997 a Singapore Court used Song San crude oil tanker case satellite imagery to identify the polluting vessel.

In several cases brought forward to the International Court of Justice satellite date has been used.

Remote sensing data used as evidence

- Notwithstanding the fact that remote sensing data has been used as evidence it is far from being obvious that this is a general rule.
- The European Commission is financing a pilot project “APERTURE” aiming at developing a cost-effective methodology use remote sensing data in European and national environmental law.

Remote sensing data used as evidence

In the USA remote sensing data has been retained in some cases as supplementary evidence. The use of scientific data as evidence in court is ruled by a combination of “Frey” and Rule 702 of the Federal rules of Evidence.

- Criteria to be met are:
- Scientific method should be adhered to
- The information should be subject of peer review
- Scientific community must accept the information
- Error rates must be assessed
- Standards for operations must exist

GMES

- The Global Monitoring for Environment and Security (GMES) – Europe's Contribution to a Global Earth Observation System of Systems (GEOSS) will be an important step fore ward in the potential use of remote sensing data in verification /compliance / Enforcement / Evidence issues.

Belgian Remote Sensing Satellite

Sentinel Island, Indonesia, 2004

Pyramids, Egypt, 2004

PROBA

© ESA

Three Gorges Dam, China, 2003

Etna Plume, Sicily

Acknowledgments

- Marco Ferrazzani – Status of satellite remote sensing in international treaties – project 2001
- Tutorial of Centre for remote imaging, sensing and processing http://www.crisp.nus.edu.sg