Introduction to the ESA Earth Observation Programme. Projects and tools for Education

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The purpose of ESA

An inter-governmental organisation (18 member states) with a mission to provide and promote (for exclusively peaceful purposes) the exploitation of:

• Space science, research & technology
• Space applications
All Member States participate in activities related to space science and in a common set of programmes (mandatory programmes).

In addition, members chose the level of participation in optional programmes:

- Human spaceflight and Exploration
- Microgravity research
- Earth observation
- Telecommunications
- Satellite navigation
- Launcher development
For over 30 years ESA’s space science projects have shown the scientific benefits of multi-nation cooperation.

Space environment of the Earth

Solar-terrestrial interaction

Interplanetary medium

Moon, planets and other objects

Stars and the universe

Fundamental Physics.
Earth Observation

ESA has developed and launched:

- the Meteosat and MSG series of weather satellites;
- METOP;
- the environmental and climate research and monitoring satellites ERS-1 & 2 and Envisat;
- its first Earth Explorer.

Respectively for:

- Meteorology
- Environmental & climate monitoring
- Earth resource management & other applications
- Better understanding of the earth

The quest for information about the Earth
Europe's first weather satellites

The first Meteosat was launched in 1977. Five more followed and the seventh was launched in 1997.

- Placed in geostationary orbit
- Take pictures of the Earth every 30 min
- Distribute meteorology data

Since 2002: MSG (Meteosat Second Generation): series of 4 geostationary (enhanced) meteorological satellites

Since 2006: METOP (series of Meteorological Operational Polar Orbiting Satellites)

Eumetsat owns and exploits these satellites
The ERS (European Remote Sensing) satellites use radar instruments to survey the Earth's surface day & night and in all weather conditions.

- A second ERS satellite (ERS-2) was launched in 1995, with an additional instrument for ozone monitoring. A constant flow of data from ERS-2 provides information on status and changes of:
  - Ocean currents, sea surface and ocean winds
  - Polar ice caps & ice movement
  - Atmospheric ozone.
ENVISAT: focusing on the environment.

ENVISAT is the largest and most ambitious Earth observation satellite ever built.

8 ton spacecraft launched in 2002 by an Ariane-5 into polar orbit at an altitude of 800 km. Payload consisting of 10 instruments to monitor the earth system and providing:

- a smooth transition from the measurements taken by ERS-1 and ERS-2 (radar in particular)
- new data on marine biology and atmospheric chemistry.

Along with ERS-2, it provides a continuous supply of services to scientists and operational users over almost 20 years in the field of:

- Crop inventories and forest management
- Tropical deforestation
- Biodiversity
- Natural disasters / damage assessment (flooding, forest fires, earthquakes, volcanic eruptions, etc.)
- Generation of digital terrain models
- Ozone layer / monitoring of ozone layer depletion and greenhouse effect.
ENVISAT mission: 7 years!

- First images: Mar 02
- Calibration Review: Sep 02
- Validation Workshop: Dec 02
- MERIS Workshop: Nov 03
- InSAR Workshop: Dec 03
- Envisat Symposium: Sep 04
- MERIS (A)ATSR Workshop: Sep 05
- InSAR Workshop: Dec 05
- Altimetry Conference: Mar 06
- Atmospheric Science Conference: May 06
- Envisat Symposium: Apr 07
- InSAR Workshop: Dec 07

Key Events:
- Prestige tanker oil slick: Mar 02
- Global air pollution: Sep 03
- MERIS Workshop: Dec 02
- Bam earthquake: Nov 03
- InSAR Workshop: Sep 05
- Hurricane Katrina: Dec 03
- Ozone hole 2003: Mar 06
- B-15A iceberg: Apr 07
- Chlorophyll concentration: Dec 07
- Tectonic uplift (Andaman): May 06
- Arctic 2007

~2000 scientific projects and several GMES pre-operational projects.
A sad recent application:
Abbruzzo earthquake deformation field mapping with radar interferometry

(April 2009)
ENVISAR ASAR ascending geometry

Model (P.Briole, ENS Paris)
The challenge of global change

The IPCC Report 2007

Model: *Global temperature increase between + 2.4 and 6.4 degrees until 2100*

- **Arctic:** ice-free as of 2nd half of the century
- **Permafrost:** up to 90% melting until 2100, freeing high amounts of Methane gas
- **Precipitation:** decrease in arid regions and increase in wet areas
- **Storms and surges:** less in number but significantly stronger in intensity
- **Gulf Stream:** significantly weakened
- **Sea level rise:** up to 48cm until 2100 due to thermal expansion of water only

Space-based data contribute to global change monitoring
Major scientific results of ENVISAT and ERS

- **Climate change:** Global sea level rise of ~3mm/year and sea surface temperature increase of ~0.1 deg. C since 1992
- **Atmosphere:** Worldwide monitoring of air pollution, evidence of fast growing air pollution in China since 1995
- **Polar areas:** Daily monitoring of sea ice motion and observation of Antarctica ice-shelves collapse
- **Oceanography:** Quantification of global chlorophyll concentration, an index of the oceanic phytoplankton biomass
- **Tectonics:** Identification of the blind tectonic fault at the origin of the Bam earthquake in December 2003
Northwest Passage open (orange line) and Northeast passage only partially blocked (blue line). The dark grey colour represents the ice-free areas, while green represents areas with sea ice.
Measurement of Residual Trends in Global Sea Surface Temperature

ERS-1/2 ATSR data
*trend: 0.13°C / decade*

AVHRR data
*trend: 0.09°C / decade*

higher gradient
The ENVISAT altimeter provides continuity to the measurements initiated in the early 1990s.

- **Sea level rise Trend**: +3 mm/yr

**Graph**
- **TOPEX**: Linear trend = 3.13 mm/yr, Annual (4.22 mm) removed
- **ERS-1**: Linear trend = 3.29 mm/yr, Annual (2.85 mm) removed
- **ERS-2**: Linear trend = 2.64 mm/yr, Annual (6.37 mm) removed

*Courtesy of Remko Scharroo, NOAA, US*
UNFCCC Conference 2007 Bali Action Plan

“parties should describe the status of their programmes for contributing observations of the essential climate variables (ECVs) to the international community”

- Earth observation from space plays a vital role in this endeavour
- ESA through CEOS has committed to deliver global observations of ECV and associated products
- ESA has 30 years of archived data and will concentrate on those ECV which can be fed by ESA data
The International Charter on Space and Major Disasters

- Unified system of space data acquisition & delivery in case of natural or human-made disasters
- Data delivery to civil protection agencies, emergency & rescue services

Examples of activations:

- Bam Earthquake 2003
- Darfur Crisis 2004
- Tsunami Catastrophe 2004/2005
- Hurricane Katrina 2005
- Fires in the Mediterranean region (Italy, Greece) 2007
- Cyclone Nargis 2008
Application to oil spill monitoring:

Oil slick of “Prestige” tanker accident viewed by Envisat
GMES (Global Monitoring for Environment and Security). Jointly led by ESA and the European Commission, it will be the European contribution to the Global Earth Observation System of Systems (GEOSS), for environment and security monitoring.

GMES space segment (after 2011):
- Sentinel-1: Imaging radar mission (all weather, day/night)
- Sentinel-2: Land monitoring mission (Superspectral imaging)
- Sentinel-3: Global ocean (and land) monitoring mission
- Sentinel-4,5: Atmospheric chemistry missions in GEO and LEO.

GMES ground segment:
- Provision of Earth observation data for GMES services
- Access to ESA, Eumetsat, national and third party missions.
The Earth Explorer Missions

In order to better understand the Earth

Research oriented, focused on specific topics/techniques
The Earth Explorer Missions

GOCE: Gravity field and steady-state Ocean Circulation Explorer
The Earth Explorer Missions

GOCE: Gravity field and steady-state Ocean Circulation Explorer

Applications:

Precise measurement of earth gravity field in order to better understand the earth interior and ocean circulation (geodynamics, oceanography, geodesy...)

Earth Observation: a tool for multidisciplinary Education in secondary schools
Explaining to kids why “Earth Observation”?

Answering mankind questions... where we are and how the earth system works
The satellite "earth"

Historical references:
- heliocentric and geocentric system
- Galileo, Kepler, Kopernicus
- universal gravitational law
- Keplerian orbits
- Orbital elements
geostationary satellites

- Meteosat, MSG
- 36,000 km from earth (6 earth radii)
- GEO Orbit

Applications:
- METEOROLOGY
- CLIMATOLOGY

- Many images per day (MSG: one every 15 min)
- Low Space resolution, very large coverage
geostationary satellites
Polar Satellites

Heliosynchronous orbits, LEO
• LEO “Low earth orbits”
800 km height from the earth surface
• polar “LEO”
• high space resolution ... smaller coverage but with details
• polar "LEO"
• high space resolution ... smaller coverage but with details

Download recent ones from MIRAVI
ESA Earth Observation Education: available tools for schools
The CEOS strategy for Earth observation education and training is the creation of an effective coordination and partnership mechanism among CEOS agencies and institutions offering education and training.

http://www.eohandbook.com/
The CEOS Working Group on Education and Training (WGEd) links to a large database of free EO Educational material

http://www.acrors.ait.ac.th/ceos/home1_e.html

http://wgedu.ceos.org reference to courses, case studies, satellite data, links to education sites of various institutions through the internet
International Co-operation with Africa:

TIGER Training Courses

(following the 2002 Johannesburg World Summit on Sustainable Development), focusing on the use of space technology for water resource management in Africa. Series of training courses on a variety of applications and techniques.

http://www.tiger.esa.int/training_main.asp
TIGER-Innovators: New NSTT Projects

- Wetlands Mapping
- Rivers-Lakes-Water levels
- Soil Moisture-SADC
- Nile Awareness Kit
- Land and Topo.-Ghana.
- Hydrogeo. Model-Ghana
- Lake Quality-Victoria
- Lake Quality-Egypt
- IS for IWRM-Morocco
- IS for IWRM-Mozambique
- IS for IWRM-Zambia
- IS for WRM-Burkina Faso
- AQUIFER
- Water & Ground str.-Niger
- EPIDEMIO
- Malaria-mapping
The European Earth Observation Web Site for Secondary Schools
Eduspace
Target Groups

- Secondary school teachers who want to incorporate EO into their curricula
- Secondary school students to extend on what they have learned in class
- University students pursuing related academic studies
- Access to website www.esa.int/eduspace is free
Modules
Europe/Africa/Himalaya from Space; ENVISAT for schools; Global Change; Disaster Monitoring
In preparation: Polar Module, World Heritage, Latin America from space

A large **Image Data Bank** (complete European coverage with Landsat and ERS-1&2 SAR, to be soon extended outside Europe and enlarged to more sensors)

**SW and GIS**
Latest upgrade: Leoworks v.3.2 (June 2008).
Leoworks 4.0 (2010) will be an open-source, free and platform-independent Image Processing optical-radar SW and extended GIS for High Schools. Beta versions available from June 2009.
LEOWorks 3.0
Image Processing Software (with GIS functionality)

- View images, histogram, pixel values, header info
- Crop, invert, stretch, layer stack, etc
- Image arithmetic, filters
- Classification, PCA, geometric correction, pan sharpening
- GIS tools
INTERNATIONAL CHARTER “SPACE AND MAJOR DISASTERS”

- target: primary/lower secondary level (8-12 years)
- objective: make the role of space facilities to manage natural and technological disasters more visible to youngsters
- product: a children supplement in 5 languages (En, Fr, It, Sp, Ger) downloadable in pdf from the Charter website http://www.disasterscharter.org/ecoles_e.html
- includes 3 worksheets to be used in the classroom as exercises and to stimulate the discussion
SCHOOL KIT (alias TEACHER's PACK)

- target: lower secondary level (11-14 years)
- objective: provide teachers with a working tool to introduce EO themes in schools.
- available in 4 languages (En, Fr, Sp, Ned). German translation is ongoing
- product: a folder containing 11 worksheets on EO themes related to teaching subjects such as geography, life and Earth sciences, physics. Each worksheet is composed of 3 colour pages recto-verso (triptych), plus an exercise sheet and a teacher information note
SCHOOL KIT

TOPICS

1. Earth observation satellites
2. The Earth viewed from space
3. Humans on Earth
4. Africa and environmental diversity
5. Asia and rice-growing
6. Europe: a developed continent
7. Living species and their environments
8. Water on Earth
9. Volcanoes: Mount Etna, a case study
10. Flood monitoring
11. Colours in satellite imagery
EARTH EXPLORER MISSIONS

- target: secondary level (15-18 years)
- product: CD-Rom in 2 languages (En, Fr)
WINDOW ON THE WORLD

- target: teenagers

- products:
  - stand-alone terminal for exhibitions, museums and educational events
  - PC version on DVD, bilingual (En, Fr)
  - similar to Google Earth (navigation and zooming in on the Earth), but with an important educational content
WINDOW ON THE WORLD
ESA School Atlas – Funded by ESA, produced by GEOSPACe

Targeting secondary schools and first university courses:
Realistic views of the Earth’s surface, combined with thematic maps demonstrate the dynamic processes of our globe.

The atlas is accompanied by a Teachers’ Handbook, a digital version on 2 DVD's and is also connected to Eduspace and its SW Leoworks.

The Atlas is available in both English and German from the Geospace website at a special concessionary price for schools.

Order from: www.geospace.co.at
ESA School Atlas

1) Introduction to ESA (10 pages)
2) Earth Observation (8 pages)
3) Global Overview (20 pages)
4) Continental Overview (82 pages)
5) The Natural Sphere (60 pages)
6) The Cultural Sphere (78 pages)
Index (18 pages)
PLANET EARTH, HEAVENS ABOVE!

- **target:** primary level (8-10 years)
- **objective:** present EO themes (e.g. atmosphere, water, Earth’s ice cover) to children trying to amuse and interest them (game approach)
- **product:** CD-Rom in 7 languages (En, Fr, Du, De, It, Sp, Port)
Projects with external partners: University of Heidelberg

Web-based EO Games for kids  www.ph-heidelberg.de/esa
Welcome...

... to the homepage of the Science Education through Earth Observation for High Schools (SEOS) Project.

SEOS is an initiative for using remote sensing in science education curricula in high schools funded under the 6th Framework Programme of the European Commission (EC). The project is implemented by 11 different partners from several European countries in cooperation with the European Space Agency (ESA).

Based on current research results, 15 internet-based eLearning tutorials will be developed on selected topics in earth observation. The tutorials will be tested in co-operation with different European partner high schools.

The first draft tutorials are now available: Draft Modules

If you would like to be informed about the publication of new modules or if you want to provide feedback to the existing modules you may send an email to rainer.reuter@uni.oldenburg.de.
Final Remarks

- EO education and capacity building is becoming increasingly more important in view of climate change, more frequent natural disasters (storms, flash floods, etc…), natural & cultural heritage degradation and need of preservation

- ESA and many other space agencies are taking this very seriously and aim to promote EO to an increasingly large, world wide audience

- All audiences including schools are targeted as decision makers and disaster managers of tomorrow are sitting in the classrooms today! EO and Space Education should be available for youngsters in schools, well before university level…..
USEFUL ADDRESSES

- education portal: www.esa.int/education
- eduspace: www.esa.int/eduspace
- to order EO material: education@esa.int or eohelp@esa.int