Protecting World Heritage from Space: The Activities of ESA

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***Abstract* — The World Heritage Convention aims to define and conserve natural and cultural sites whose outstanding values should be preserved for all humanity and to ensure their protection through a closer co-operation among nations. Earth Observation technology represents a primary source of geo-information to support national and local authorities and conservation institutions in managing and monitoring natural and cultural sites. This paper provides an overview of the different activities that the European Space Agency is carrying out to support UNESCO in the conservation of our World Heritage.**

Keywords: Earth Observation, World Heritage Convention, base mapping, land cover, land-cover change, DEMs.

I. INTRODUCTION

The UNESCO General Conference adopted in November 1972, the World Heritage Convention (WHC). WHC aims to define and conserve the world's heritage, by drawing up a list of sites whose outstanding values should be preserved for all humanity and to ensure their protection through a closer co-operation among nations. By signing the Convention, each country pledges to conserve the WHC identified sites situated on its territory. Their preservation for future generations then becomes a responsibility shared by the international community as a whole. Today, the Convention, under administration of UNESCO, is a success: 174 (as per Aug. 2002) States are signatory parties to the Convention. These countries get together at least twice a year in the meetings of the Bureau and the Committee to approve new inscriptions of sites, to review the state of conservation of the inscribed sites and to agree upon on various other actions dedicated to the conservation of the 730 (as per Aug. 2002) World Heritage sites that are inscribed today on the World Heritage list.

To foster this objective, UNESCO and the European Space Agency (ESA) [1] have proposed to undertake a joint initiative demonstrating the application of Earth Observation and other Space Technologies (e.g. Navigation and Positioning, Communication) in support to State Parties signatories of the Convention. At present, the most urgent tasks are to assist developing countries in fulfilling the main goals of the World Heritage Convention, and to establish a framework of cooperation, open to Space Agencies and other organizations.

As a part of this initiative, ESA initiated several projects aimed at supporting national and local authorities, conservation institutions and Non-Governmental Organizations (NGO) in preserving and managing different natural and cultural sites:

- BEGO (Build Environment for Gorilla), [2], [3] aimed at developing user-oriented information products and services based on EO technology to support the efforts of the conservation community to protect the gorilla habitat in Central Africa.
- VENEZIA project [4], set up in order to provide the best knowledge of the subsidence process occurring in the Lagoon of Venice and its surroundings (World Heritage site since 1987) to the authorities managing the area. SAR-based monitoring techniques (differential SAR interferometry and the interferometric point target analysis) have been integrated with levelling and GPS surveys into an overall database and information system for regional and administrative authorities.
- GlobWetlands, [5]-[7] aimed at providing an EO-based information system to support countries, local authorities and wetland managers to conserve, monitor and manage Ramsar sites [6] and wetlands protected under the World Heritage Convention worldwide.

This paper provides an overview of the different activities that ESA is carrying out in the context of the WHC and how EO technology may contribute to support national and local conservation authorities, Non-governmental agencies and other national and international agents involved in the conservation of our world heritage.

II. THE BEGO PROJECT

UNESCO and the ESA launched in 2003 the BEGO project. BEGO represent a contribution to the conservation efforts of the national authorities of the Democratic Republic of Congo, Uganda and Rwanda to preserve the last habitats and homes of the Mountain Gorillas: a world heritage in danger.

This trans-boundary area has a number of features shared by the three countries. It comprises the central part of the Albertine Rift, which is the western branch of the Great Rift of Africa: a major hotspot in terms of biological and landscapes diversity in the world. In fact, the region harbors a wide variety of wildlife, including the Mountain Gorilla, but also includes

an incredible range of habitats and landscapes, ranging from lowland forests to glaciers, grasslands, mountain forests, wetlands and active volcanoes.

For more than 10 years, the region has been seriously disturbed by unrest and insecurity, and a number of wars have had devastating consequences both on the human populations and on the environment.

Inside the BEGO study area, the project focused on the 5 main national parks and protected areas under the World Heritage Convention: the *Bwindi* and *Mgahinga* National Parks, in Uganda, the *Virunga* and *Kahuzi-Biega* National Parks, in DRC and the trans-boundary *Volcanoes* conservation area.

Figure 1. Area of Interest of the BEGO project

The parks have long boundaries that run across inaccessible and hardly mapped territory, with no compatible maps available across national borders. An influx of refugees into the area in recent years has led to illegal forest clearing for agriculture or fuel, as well as illegal poaching for food, reducing the living space left for the gorillas.

To carry out this project, ESA and UNESCO has established a strong partnership with the user community including the main actors in the conservation of the Mountain Gorillas, such as the International Gorilla Conservation Program, The WWF, the Dian Fossey Foundation and the World Conservation Society as well as the national authorities of the Democratic Republic of Congo, Uganda and Rwanda.

From a technical viewpoint, BEGO addresses on one of the main problems affecting the conservation community in this area: the lack of accurate and updated maps of the Gorilla habitat.

To overcome this problem, ESA contracted an European consortium of experts and value adding industries, leaded by the Dutch company Synoptics, to find a suitable solution to generate and validate the BEGO maps in close collaboration with the user community.

The required geo-information was defined by the user themselves expressing the main lacks of the area and the major needs for updated geo-information in their daily working practices: Digital Elevation Models, Updated Vegetation and Land use maps (Figure 2), Change detection maps identifying the main changes occurred in the area in the last 20 years and Base maps (Figure 3) that will help users to better access the parks and organize their in-situ campaigns.

To generate the required maps, the BEGO team faced several technical problems including the difficulties to collect suitable ground data, the almost continuous cloud coverage and the intense vegetation cover.

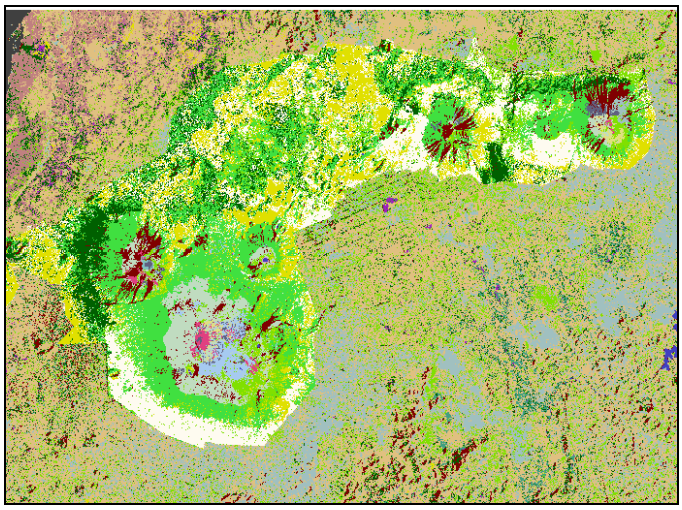

Figure 2. Land cover map of the Volcanoes Area.

To overcome this problems specific technical solutions were applied by exploiting the advantages and synergies of different types of satellite data, such as the ENVISAT Advance Synthetic Aperture Radar (ASAR) and Optical data from the Landsat series as well as ancillary data and ground measurements gathered by the users, who collaborated with the team during the whole project lifetime: from the definition of the products to their final validation.

The different uses of the BEGO maps by the user community include several applications related to their conservation activities. For instance, the Institut Congolais pour la Conservation de la Nature (ICCN) is using the BEGO maps to render their anti-poaching efforts more effective and to clarify the exact location of the national park boundaries, improving the national biological inventories of the parks, and plan out gorilla eco-tourism.

Combining the GIS layers provided by BEGO project with GPS data collected in the field, gaps in existing anti-poacher patrol coverage could be identified and redressed, and the migration of gorilla groups could be followed across national boundaries.

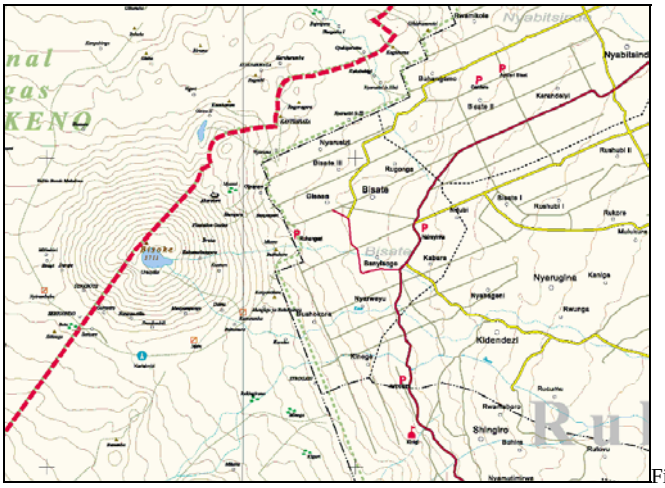

Figure 3. Portion of the Base Map produced during the prototyping phase of the BEGO project.

III. THE VENEZIA PROJECT

The main objectives of VENEZIA have been to define and implement a land subsidence monitoring service in the Lagoon of Venice based on the combined used of differential SAR interferometry (DInSAR) and Interferometric Point-Target Analysis (IPTA) integrated with ground based leveling surveys and GPS measurements. In the lagoon of Venice, traditionally subsidence rates are monitored with varying temporal and spatial frequency depending on the ground measurement networks.

The use of satellite derived subsidence measurements helps to improve the spatial and temporal frequency to every 25m and at least 35 days (repeat pass orbits in the case of ERS and ASAR) in the case of DInSAR and IPTA. The combination of ground and satellite measurements helps to confirm the accuracy and cross validation of the satellite derived measurements as well as providing improved and more detailed maps of subsidence in the Lagoon and surrounding area (Figures 4 and 5).

A new development for subsidence monitoring in the Lagoon of Venice, has been the use of IPTA processing and the generation of subsidence maps. DInSAR is limiting for subsidence mapping in rural areas due to temporal phase de-correlation. However through the use of long time series SAR images, phase stable point targets within a scene can be identified. These are usually returns from man-made structures or buildings. In the Lagoon and surrounding area, these are distributed in both urban and rural areas. So there is further potential to improve the spatial coverage for subsidence mapping. An important aspect of the study has been the development of the IPTA processing chain and removal of atmospheric artefacts that cause within scene and between scene random phase noise signal variations.

The understanding of the detailed end user requirements, the product definition and the service capability have been achieved by partnership between value adding companies experts in remote sensing and the authorities and consortia with responsibility for monitoring and maintaining land stability in the Lagoon of Venice and the surrounding area.

The project results demonstrate how remote sensing can be an accurate and cost-effective tool to monitor not only natural sites, but also cultural world heritage sites such as city centers, archeological sites and even buildings.

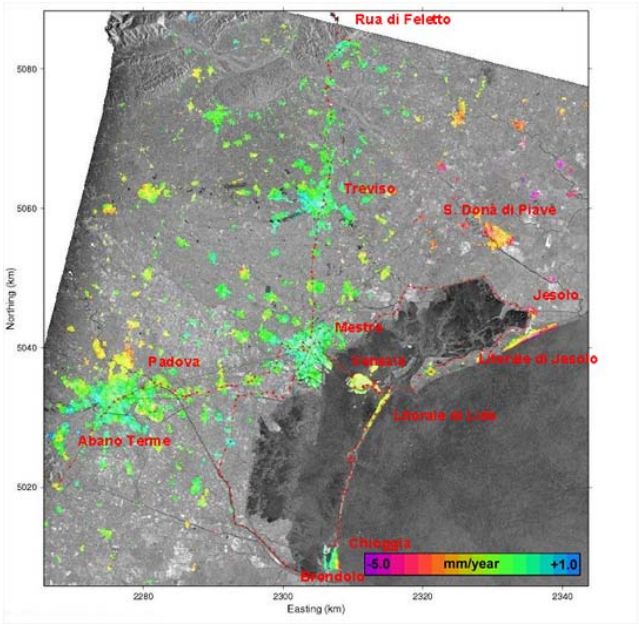

Figure 4. INSAR land subsidence map (in mm/year) of the Lagoon of Venice for the time period 1993-2000 with ground based levelling network superimposed

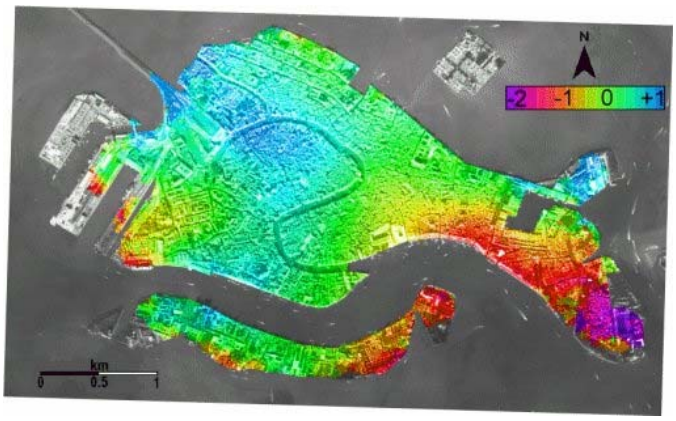

Figure 5. Zoom over the Venice city center

IV. THE GLOBWETLAND PROJECT

Achieving the vision of the World Heritage Convention is a complex and challenging task, especially when the object for conservation is a delicate habitat such as wetlands. Both the World Heritage Convention, and more specifically the Ramsar Convention on Wetlands, requires that all the national and international bodies involved in the conservation of these important habitats have access to suitable information to better understand wetland areas, their processes and their significance in the global environment, to manage efficiently wetlands so that they may yield the greatest continuous benefit to present and future generations, to inform the general public and policy makers of the importance of wetlands and promote their conservation and protection worldwide.

Existing and future Earth Observation technology may play an increasingly important role in supporting these activities. In this context, ESA decided to initiate the GlobWetland project as a contribution to support the wetlands conservation community. The primary objectives of the GlobWetland project is the development of a user-tailored information service based on EO technology to support national and local authorities in reporting to the Ramsar and the World Heritage Convention and managing wetlands worldwide.

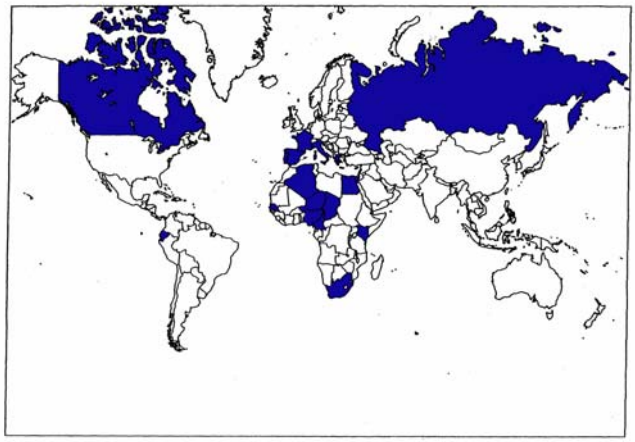

Figure 6. GlobWetland participant countries

The GlobWetland project is conceived as a user-oriented project, where the final information service should provide a clear response to specific user needs. Therefore, the project is built up around the information requirements provided by a User Group made up of the National Authorities responsible for the implementation of the Ramsar Convention in 21 countries worldwide (see Figure 6).

Figure 7. GlobWetland GIS facility over the Aliakmon Delta in Greece.

These user requirements include several EO-based products that will be generated, validated and delivered over 50 wetland sites worldwide. These products include range from base mapping, water cycle monitoring and land cover/use and change to automatic wetland identification, terrain dynamics monitoring or biophysical parameters estimation.

The generation of these maps is based on different types of EO data (SAR, optical) at different resolutions (from very-high resolution to low resolution imagery) depending on the nature, and size of the wetland and involves a significant component of integration with ancillary data and in-situ information provided by the users. Geographic Information System (GIS) are used as a platform to integrate and display the information to support the daily work of wetland manager. In addition, a Web-GIS facility is being put in place linked to the Ramsar database to allow an easy access to the environmental information generated in the project.

V. CONCLUSIONS

The present paper provides an overview of different activities that ESA is carrying out to support UNESCO and the national and local conservation authorities in their efforts to maintain, protect and manage our world heritage. Several applications have been shown, ranging from base mapping, habitat inventorying, assessment and monitoring, to land motion measurements in urban environments. All these applications demonstrate how EO technology represents a key tool for managing natural and cultural world heritage sites.

The integration of EO with other space applications, such as navigation, and other technologies, such as GIS and Web-base services, represent a significant step forward towards the development of efficient and cost effective tools to “observe”, map and monitor protected areas worldwide.

REFERENCES

[1] O. Arino, D. Fernández-Prieto, M. Paganini, E. Volden and F.M. Seifert, “Earth Observation Supporting Multilateral Environmental Agreements: The Initiatives of the European Space Agency”, *Proc. of the 2003 Int. Geoscience and Remote Sensing Symposium (IGARSS’2003)*, Toulouse, France, 21-25 July, 2003.

[2] D. Fernández-Prieto, M. Hernández, O. Arino, L. Fusco, “Managing World Heritage Sites from Space: The BEGo project”, *Proc. of the 2004 Earsel Symposium*, Dubrovnik, Croatia, May, 2004.

[3] D. Fernández-Prieto, M. Hernández, O. Arino, L. Fusco, P. Matos, “Building Environment for Gorilla: A new action in the joint UNESCO-ESA initiative to support the World Heritage Convention”, *Proc. of the 2003 Int. Geoscience and Remote Sensing Symposium (IGARSS’2003)*, Toulouse, France, 21-25 July, 2003.

[4] L. Tosi, L. Carbognin, P. Teatini, T. Strozzi, and U. Wegmüller, Evidence of the present relative land stability of Venice, Italy, from land, sea, and space observations, Geophysical Research Letters, Vol. 29, No. 12, 10.1029/2001GL013211, 2002

[5] D. Ball, D. Fernàndez Prieto, F. Ahern, G. Walter and M. Buchheit, “Operational Wetlands Monitoring for the Ramsar Convention: TESEO Powers a Breakthrough”, *Proc. of the 2003 Int. Geoscience and Remote Sensing Symposium (IGARSS’2003)*, Toulouse, France, 21-25 July, 2003.

[6] D. Fernández Prieto, and O. Arino, "On the Use of EO Technology to Support the Implementation of the Ramsar Convention", *Information document of the COP VIII of the Ramsar Convention on Wetlands*, Valencia, Spain, November 2002.

[7] D. Ball, D. Fernàndez Prieto, F. Ahern and J. Wesels, “What Information Do Wetland Managers Really Need”, *Backscatterg*, Spring 2002.