FLOOD DISASTER MONITORING USING RADAR AND OPTICAL SATELLITE DATA

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Abstract: *Since the creation of the International Charter on Major Disasters, the Earth Observation data become a needful tool helping the authorities due to the new "Rapid Mapping" concept. The paper describes some activities performed by Romanian Space Agency (ROSA), as well as the working methods for mapping the flood affected areas. Examples regarding processing methods of radar and optical data acquired during the floods on Danube in 2006 and Siret in 2005 are exemplified. Beside the technical approach, a new dimension of this process is considered by the implication of the Faculty of Land Reclamation and Environmental Engineering as international training partner center of ROSA in the recently constituted UN-SPIDER Regional Support Office(RSO) Romania. The* ***U****nited Nations Platform for* ***Sp****ace-based* ***I****nformation for* ***D****isaster Management and* ***E****mergency* ***R****esponse (****UN-SPIDER****) was established for "ensure that all countries and international and regional organizations have access to and develop the capacity to use all types of space-based information to support the full disaster management cycle".*

Keywords: *rapid mapping, flooding, radar and optical data, UN-SPIDER*

1. Introduction

Due to the increasing occurrence of natural disasters, humanitarian emergency situations and civil endangerment, the growing need for timely information on rapidly evolving events becomes the subject of detailed analyses regarding the use of earth observation data. The experience of the past few years shows increasing demands for comprehensive, cvasi real time covering wide areas satellite data, for a large spectrum of civilian crisis situations (Murlidharan, 2003).

Since 2005 floods were the most devastating natural disasters touching the Romanian territory affecting small isolated (flush floods) or/and large areas generating significant economical and social damages.

Satellite imagery is a valuable source of information offering the main tool for mapping of flood extent, which requires rapid acquisition, processing and analysis of data fulfill the requirement of fast supply of data during floods (Horrit et al., 2003; Wang, 2004 ; Schneiderhan et al., 2007). The remote sensing data have different geometric resolution and varying flood / water detection potential, so it is important to know these limitations when processing the flood mask in GIS operations or when generating flood maps. In this case,

flood mask are combined with DEM data to exactly locate the land –water extent in a digital terrain model (Mason et al., 2007; Ling at al., 2008).

The paper describes some aspects regarding of used procedure to activate the International Charter on Major Disasters for flooding affecting Romania in 2005 and 2006, in view of radar and optical data acquisition for estimating the affected land cover/ land use categories, in the benefit of decision makers authorities.

2. Charter "Space and Major Disasters" activation

Following the UNISPACE III conference held in Vienna in July 1999, the European (ESA) and French Space Agencies (CNES) initiated the International Charter "Space and Major Disasters" having as main objective to support at international level any of affected countries with space-based data and expertise in case of emergencies caused by major natural or atrophic disasters. The expertise is oriented for:

disaster response;
multi-satellite data acquisition planning,
achieve retrievals and spacecraft tasking,
data processing at a pre-determinant level;
space agencies contribution in image/data;
space agencies initiative for value- added data fusion.

After the initial moment of a natural or man-made disaster, the necessity of fast and reliable spatial information is critical not only for emergency centers but also for relief organizations and rescue teams. In these cases, earth observation data are required and it is necessary to take into consideration all possibilities for obtaining spatial information. Evidently, the recommended solution is the activation of the International Charter following compulsory procedures (Fig. 1).

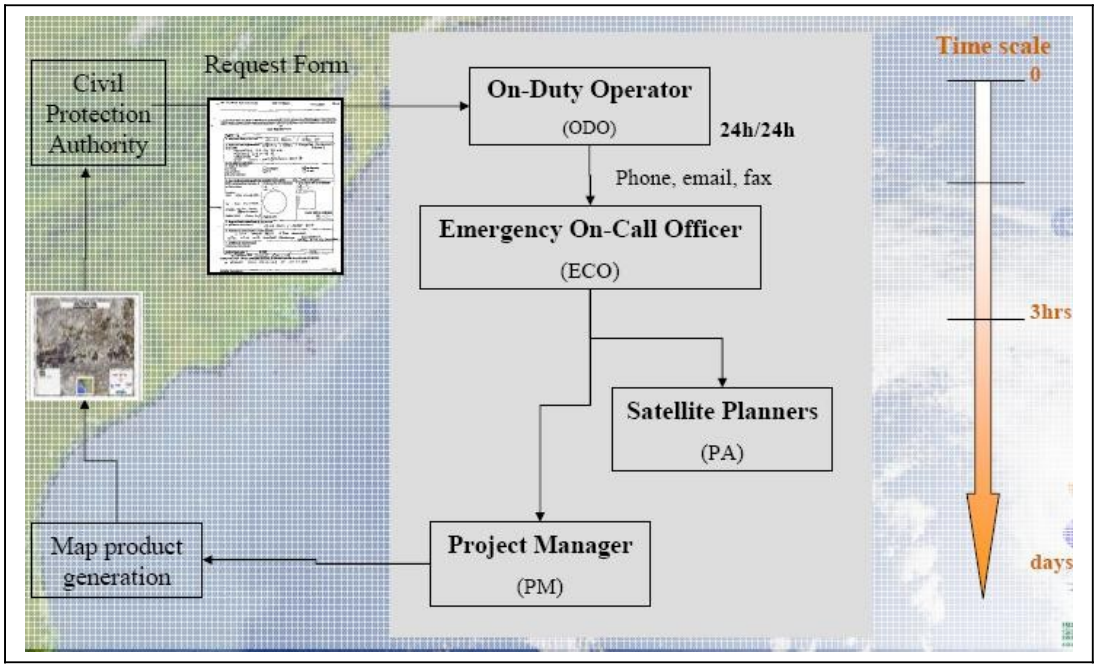

Fig. 1 The International Charter's information flow

After the initiation phase, an organization nominated as project manager coordinates the Charter project as interface between the authorized user and involved local partners. The

responsible project manager (PM) checks the satellites availability for data acquisition on affected areas and prepares the compatibility of additional vector information like infrastructure data, road network, contour lines and administrative boundaries, ensuring that processed and interpreted data are sent to the end users. Finally, after closing the post disaster activity, a very detailed report is submitted to the International Charter Executive Secretariat and the resulted geo-spatial information and conclusions are published on the charter's web site. This site, has a world wide visibility being accessible by the GEO / GEOSS geoportal way.

The International Charter has been six times activated by the Romanian Space Agency (ROSA) helping the Romanian General Inspectorate for Emergency Situations and other national authorities during the floods affecting our country in 2005, 2006 and 2008 when have been used optical and radar data from SPOT, ERS, ENVISAT, MODIS, FORMOSAT-2, LANDSAT and RADARSAT, DMC satellites.

The coordination of the local expertise was lead by ROSA. Experts in Earth Observation, belonging different organizations, trained to work in crisis situations, ensured the preparation of ancillary reference data and delivered in real time thematic map products to the end users.

It is useful to remind some details concerning the April 2006 Charter's activity. The Danube River flow has greatly increased the water level so that several villages were covered by the flood. Romanian authorities decided to send a request for the activation of the International Charter (call ID 121).

The project manager (PM) was assigned German Space Agency (DLR) which decided to transfer the main processing activities to the team coordinated by ROSA, in Romania. The Romanian working team included experts from ROSA, National Meteorological Authority (ANM) – Remote Sensing and GIS Laboratory (RSGISL), CRUTA (Romanian Center for Remote Sensing Apply in Agriculture).

One example of useful products based on RADARSAT imagery is shown in the figure 2. We have to mention the crucial element for processing the radar imagery: the collection of ground points for orthorectification. The identification of points has to be realized by experienced interpreters able to identify the right features hidden by speckle and specific texture of radar images.

3. Rapid Mapping

Due to increasing number of emergency situations the European GMES initiative proposes setting up a rapid mapping service for flood monitoring that can be used in the framework of the International Charter and extended into the field of post-crisis management, flood prevention and risk assessment. In near real time the service provides 8 hours after EO receipt maps of flood extent. Optical data and height resolution radar data with its exclusive cloud penetration are jointed with the digital elevation models and other geo-information to provide additional support for flood risk management.

Rapid mapping is defined as a production system implemented as a service, producing and disseminating geo information on disasters during the crisis (Allenbach, 2008). The information produced is

- geo-located,
- describes the event and/or its consequences,
- is delivered during the crisis,
- is used by risk and emergency managers using information systems

The reference maps and event maps are the usual specific rapid mapping products. Other data processed or not, geo referenced or not, have to be considered as useful during and after the disaster:

- raw satellite imagery,
- commented images,
- space maps for delineation of affected areas (the essential product),
- space maps for intensity of damages,
- impact space maps

The repeated experience of Romanian experts demonstrated that the exploitation of remote sensing data and derived information is maximized when the production and operations are chained. In order to create an operational chain at national level it is necessary to:

1. Develop methods and processes of data mining Earth Observation,
2. Produce information from remote sensing images,
3. Add information in existing geo datasets,
4. Publish information to users,
5. Increase the potential of EO as a source of information by educational development (see the section 4).

The space maps shown below based on a RADARSAT image, exploits the capability of microwave data to create a precise watermask. Evidently, the accuracy of processing depends of the set of transformation parameters and correct datum parameters used by the interpreter.

Unfortunately, the STEREO 70, projection is not clearly and correctly defined by the professional image processing and GIS software. ERDAS Imagine assimilates the national projection with the Double Stereographic projection, but, it is necessary to introduce verified coefficients in the transformation parameters library. So, it is possible to ensure a correct automatic transformation of high resolution satellite image data covering large areas (the case of RADARSAT).

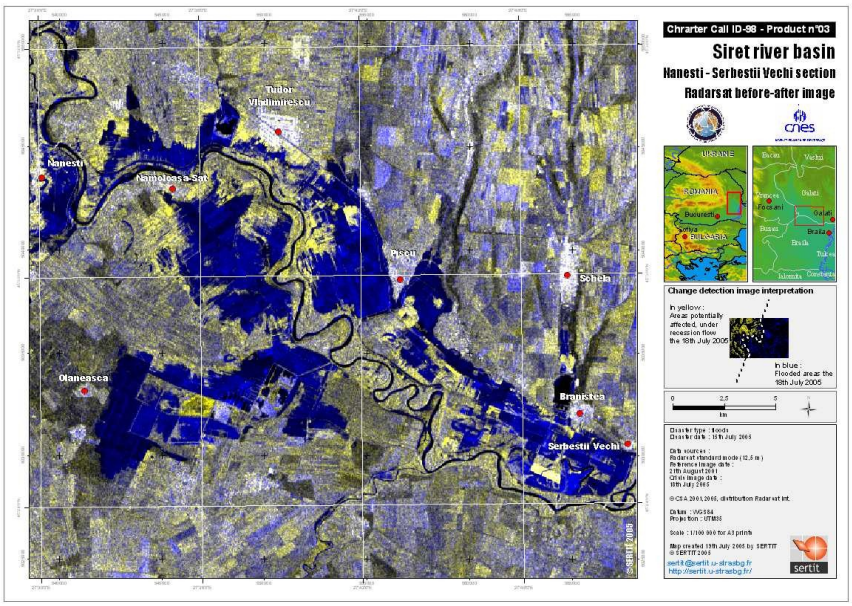

Fig. 2 Detailed space map showing the flodded area on the lower Siret river basin and an overlapped water mask having as background a RADARSAT image (copyright CSA-Canadian Space Agency)

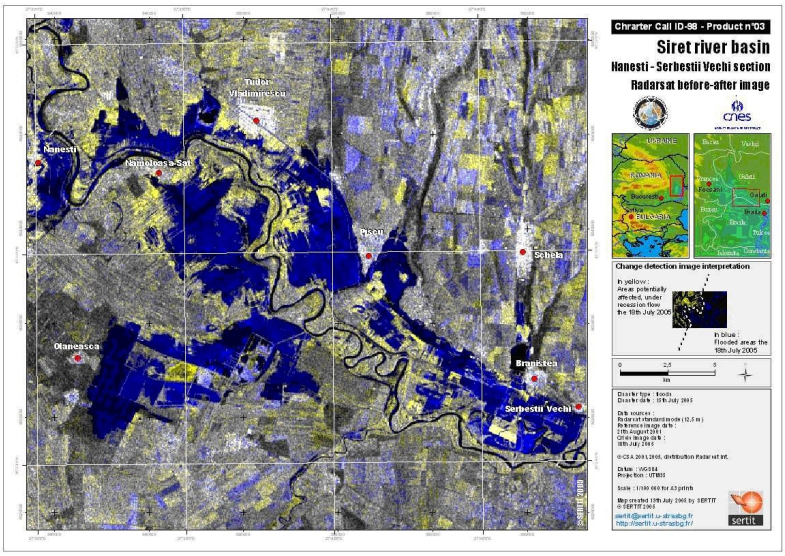

Fig. 3 Space map showing a damaged area (Hârşova, 25.05.2006) having as background a RADARSAT image (copyright CSA-Canadian Space Agency)

In order to ensure the correct superposition of vector ancillary data, essential for end users without basic GIS and image processing background, we have to mention that the implicit definition of STEREO ’70 parameters containing information reffering to “GCS_Dealul Piscului (!?) is dangerous and not professional:

**PROJCS["Stereo_70",GEOGCS["GCS_Dealul_Piscului_1970",DATUM["D_Dealul_Piscu
lui_1970",SPHEROID["Krasovsky_1940",6378245.0,298.3]],PRIMEM["Greenwich",0.0
],UNIT["Degree",0.0174532925199433]
],PROJECTION["Double_Stereographic"],PARAMETER["False_Easting",500000.0
],PARAMETER["False_Northing",500000.0],PARAMETER["Longitude_Of_Origin",25.0
],PARAMETER["Scale_Factor",0.99975],PARAMETER["Latitude_Of_Origin",46.0
],UNIT["Meter",1.0]]**

For reducing the risk of radial displacements for GIS viewing and processing it is necessary to use a correct [.prj] file for vector data with the following structure:

**PROJCS["Stereo_70",GEOGCS["GCS_Pulkovo_1942",DATUM["D_Pulkovo_1942",SPH
EROID["Krasovsky_1940",6378245.0,298.3]],PRIMEM["Greenwich",0.0
],UNIT["Degree",0.0174532925199433]
],PROJECTION["Double_Stereographic"],PARAMETER["False_Easting",500000.0
],PARAMETER["False_Northing",500000.0],PARAMETER["Longitude_Of_Origin",25.0
],PARAMETER["Scale_Factor",0.99975],PARAMETER["Latitude_Of_Origin",46.0
],UNIT["Meter",1.0]]**

In case of using of a not updated version of GIS software, is recommended to work without using the projection specifications avoiding the risk of error. For this reason, the processing of RADARSAT images was performed using the transformation and projection definition capabilities of ERDAS Imagine by modifying and replacing the correct [speroid.tab] and [*.plb] files.

We consider that the most important condition for the creation of a correct hydrographic dataset is the multidisciplinary approach, asking a compulsory collaboration of experts with a geodetic background with geographers specialized in hydrology. The operations realized by ROSA, CRUTA and Meteo Romania are the proof of a professional

approach and have to be taken into account by the entire local remote sensing and GIS community.

The following space map, based on SPOT 5 2,5m resolution data, processed using P+XS fusion solutions shows the usefulness of this kind of imagery for less experienced users of data.

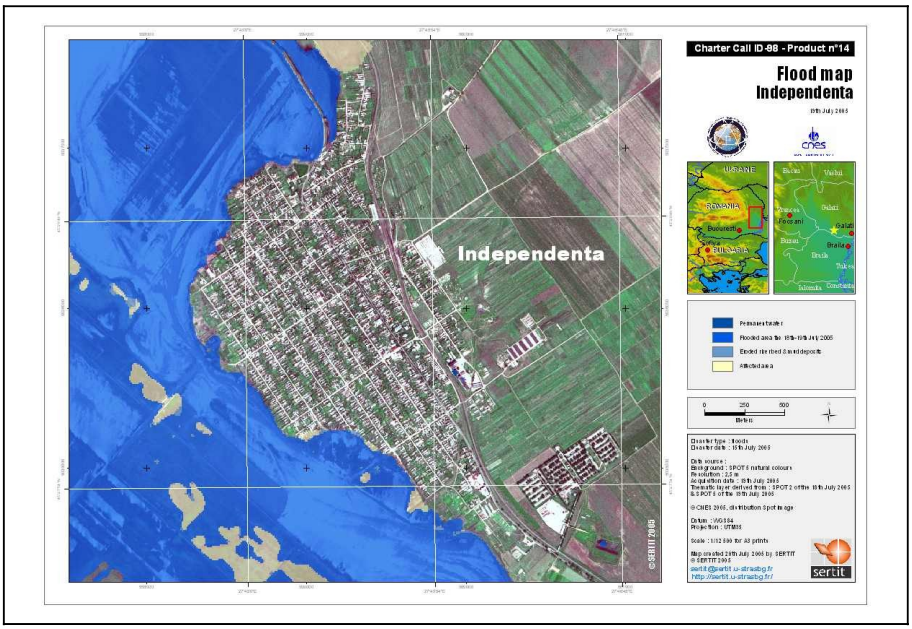

Fig. 4 Space map based on SPOT 5 data
(overlaping the transparent water mask on the P+XS image)

In fact, it is not necessary to find other arguments for demonstrate that the detailed descriptions offered by the geo-referenced processed data are the indispensable complement of other classic approaches regarding the event and ads value of data provided by in situ sensors and modeling tools.

4. UN-SPIDER

Science 2006 the United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER) was established as a new UN programme whose main objective is to provide universal access to all types of space-based information and services relevant to disaster management. UN SPIDER has to be one of modern gateways to space information for disaster management support, connecting the disaster management with space communities and facilitating capacity-building and institutional strengthening, in particular for developing countries.

Obviously the core task of UN-SPIDER is the mediation of worldwide access to existing sources of space information and services (figure 5.). The UN-SPIDER instruments’ are dissemination of knowledge, moderation of discourses and fostering of alliances. UN-SPIDER does not provide space data and services, but offers meta-information on how these data and services can be accessed and used for offering a propagation platform with international visibility and an internationally acknowledged mandate.

UN-SPIDER is implemented as an open network of providers of space-based solutions to support full disaster management cycle including disaster preparedness, risk reduction, early warning and recovery monitoring.

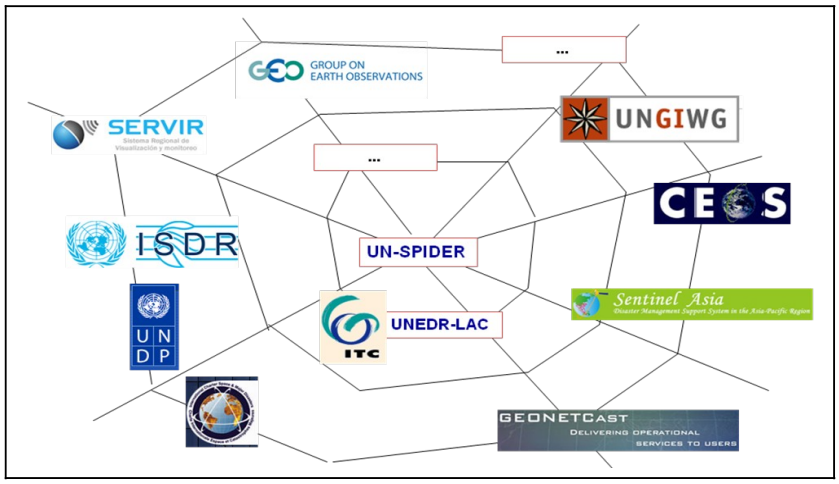

Fig. 5 Cooperation between UN-SPIDER and spatial data organizations

The UN-SPIDER tools are:
A web-based knowledge portal which is under development;
The organization of international workshops and expert meetings, and
Demand driven Technical Advisory Missions.

UN-SPIDER Program is leading by the Director of the Office for Outer Space Affairs which is responsible for its overall implementation. The Director is assisted by a Program Coordinator to help plan and coordinate all activities, including coordinating closely with the Network of Regional Support Offices.

The organizational framework of UN-SPIDER has three cornerstones:

- the UN-SPIDER staff,
- the Network of Regional Support Offices
- National Focal Points

Since 2009, based on the cooperation agreement signed between ROSA and UNOOSA the Romanian UN-SPIDER Regional Support Office (RSO) become a real support for other countries for developing similar activities. In order to increase the potential of EO as a source of information by educational development, a strong partnership with the Faculty of Land Reclamation and Environmental Engineering of Bucharest supports the use of geoinformation training facilities for implementing the UN-SPIDER program in Romania. The Faculty disposes of advanced remote sensing and GIS labs and experts involved in national and international research projects. The concepts of UN-SPIDER are disseminated among students increasing awareness on the use of space-based information for disaster risk reduction and emergency response.

This infrastructure allowed faculty in 2009 to co-organize with ROSA, ESA and DLR an international training course focused on radar remote sensing theory and applications, particularly on mapping of Czech floods in March-April 2006 (in the same period with Danube River floods) and mapping of oil spills. The Cadastre and Terrestrial Measurements department hosted a training course on use of geoportals where 120 inspectors of National Environmental Protection Agency specialists learn about national spatial data infrastructure and how to explore, query and use environmental datasets and services through metadata catalogue, metadata search functionality, search results process and a map viewer component.

These capabilities have made the Faculty of Land Reclamation and Environmental Engineering of Bucharest to become a powerful certified international training facility helping for accomplishing the obligations of Romania as UN-SPIDER Regional Supporting Office.

5. Final remarks

Considering the implementation of the INSPIRE directive, the constitution of coherent reference vector and raster geo-datasets, free of charge for public use, should facilitate the rapid reaction of the experts for processing the EO data provided by the Charter. Evidently, the recently created Romanian Geoportal has to offer wider access to geographic data and services, serving as main way for capacitate in case of disasters the small community of Remote Sensing specialists to share the competences and efforts for rapid reaction.

This manner of understanding offers the possibility to provide a set of tools to easily discover, query, and access reference information on geospatial data holdings and services, including the ability to interactively display and query the data and services. Tacking into account the experience accumulated during the working campaigns happened until now, it is necessary to facilitate the rapid dissemination of the processed EO products. The GEO/GEOSS/INSPIRE/CHARTER/UN-SPIDER synergic concepts are the engine of the efficient action to be implemented as soon as possible by the authorities in charge with the emergencies response.

The satellite positioning solutions are ensuring the rapid and objective up-dating of the datasets. The National Permanent Reference Stations becomes the compulsory support for the integration of new useful data in the system. In fact, this is the reason to implement the GNSS and GMES concepts and constitute the SDI at national, regional and wide world scale, keeping in mind the EU regulations for ensuring the interoperability between the interior (local, regional, national) and EU level.

For estimation and modeling the runoff, but especially the flooding, the SDI have an important role allowing both organizing, visualize and most of all processing and analysis but also improving hydrological models using physical-geographical information and the efficiency of the models.

6. References

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