EARTH OBSERVATION FOR IDENTIFICATION OF NATURAL DISASTERS EOFIND

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Commission II, Working Group 5

KEY WORDS: Environment, Hydrology, Change Detection, Monitoring, SAR, Satellite, Thematic, User

ABSTRACT:

EOFIND is an Application Proof-of-Concept study that is performed in the frame of the pathfinder phase of the Centre of Earth Observation (CEO) of the European Commission to evaluate the feasibility of CEO for disaster management. The objective of this study is to demonstrate how disaster management can be supported by using satellite Earth observation images as a part of the CEO Programme.

In order to meet the user requirements EOFIND is performed under the umbrella of the secretary of the IDNDR in Geneva, as a response to the conference on disaster reduction in Yokohama in 1994. A survey of the needs of civil protection organisations and non-governmental organisations (NGO´s) is included. The study shall help to reduce the reluctance of NGO´s against space technology. A first step towards this goal was an international workshop which was held successfully at the premises of Kayser-Threde on December 12th, 1995.

1 INTRODUCTION

The main goal of EOFIND is to demonstrate the utilisation of existing space and ground infrastructure for disaster management to governments and aid organisations. This includes the collection of user requirements, examples of successful applications, promotion materials and the creation of a dedicated EOFIND webpage. Based on that, it is investigated how CEO can provide adequate means to serve the needs of organisations in charge of disaster prevention and relief.

Based on two case studies executed between 1991 and 1993 the potentials, as well as still existing limitations of satellite remote sensing for disaster management, are discussed in detail. These studies investigated the use of EO data to inventory storm damages in Central European forests and to assess forest fire risks in Greece. Special emphasis has been put on its applicability under the current international conditions and their impacts to the CEO-concept. In addition, a short study on the flood in January 1995 in Central Europe is executed. This study concentrates on the operational aspects of data acquisition, distribution, value-adding and provision of results to final users in charge of disaster relief using ERS-1 data provided by the RAIDS system and electronic networks (INTERNET, WWW).

The RAIDS demonstration has provided valuable insight into several key issues to be considered in developing an operational service for data suppliers. The major problems which need to be overcome have been highlighted.

2 USER FEEDBACK ANALYSIS

In the frame of EOFIND several means are applied to inform users about the possibilities of using satellite Earth observation for disaster management. The general tendency shows that currently for disaster management only small amounts of satellite EO data are used, whereas traditionally, in-situ data sources are widely employed.

The typical users in disaster management are specified in the following:

- The „scientific user" in disaster management is usually working in a university or an institute and already trained to work with satellite Earth observation data (e.g. Institute for Cartography, Dresden; Joanneum Research Centre, Graz).
- The „commercial user" in disaster management is mainly based in insurance companies.
- The naive „end user" is working in a disaster management or civil protection organisation.

All these users are having different types of requirements. But all these users have one thing in common: the current usage of satellite EO data by these organisations is minimal. This implies, that the benefit that could be achieved by the presence

of the CEO is substantial. Especially, since there is a lot of stimulation and information required to demonstrate to these organisations the advantages of using satellite EO data.

Different users are working in different phases and types of disasters. Disaster management comprehends the aspects of prevention (assessing vulnerability or hazard analysis), monitoring (disaster warning or early warning) and disaster relief (rescue). Remote sensing has made significant contributions to these phases, notably in areas such as integrating land-use and hazard maps.

2.1 Communication

Several ways of communication have been used throughout the study to inform potential users about EOFIND. The INTERNET was used as basic information tool as much as possible.

The results of the catastrophes that are analyzed in the EOFIND study (storms, floods, forest fires) are published on INTERNET. They can be observed in the CEO Enabling Service - European Wide Service Exchange (http://ewse.ceo.org/) - and in the Kayser-Threde-homepage (http://www.kayser-threde.de/eofind).

During the course of the EOFIND study the EWSE system at the Joint Research Centre in ISPRA was used to place information about Kayser-Threde into the exchange database. The major advantage of the EWSE system is that companies willing to provide information are able to change the information from a web browser anywhere without the need to contact responsible persons at the JRC. The EWSE system may prove as a valuable tool for information retrieval. This is due to its decentralized approach and the fact that more and more people in general and thus more potential users of EWSE are using INTERNET as an information resource.

2.2 User requirements

Satellite EO data can be a useful tool in all types and phases of a disaster. The typical users are attracted by this tool but there are still some obstacles that have to be overcome in the future:

- Insufficient geometric and/or radiometric resolution
- Frequent cloud coverage (for sensors working in the optical domain of the electromagnetic spectrum)
- Data availability in terms of time lag or data acquisition, processing and delivery
- Insufficient expertise on data interpretation
- Insufficient technical facilities for data evaluation under disaster conditions.

Thus, EOFIND investigates the possibilities and obstacles of modern remote sensing technology and electronic networking for data dissemination in detail. The requirements on the temporal, spatial and spectral resolution as well as on the coverage area differ too much from one type of disaster to another to specify them in general.

They are addressed in detail in the case studies for the three different types of disasters.

In general the main user needs that have been identified in this study can be summarized as follows:

- Improvement of geographical cartography of exposed areas
- Improvement of vulnerability data availability
- Improvement of routine risk monitoring
- Improvement of monitoring during crisis
- Development of post-crisis monitoring
- Development of forecasting models
- Reinforcement and extension of monitoring networks.

3 CASE STUDIES

The case studies concentrate on the three major natural risks (fire, storm, flood) mentioned already above. Their impacts and the needs of managers (users) for prevention, emergency management and relief are described. This is followed by a discussion of the possibilities of modern remote sensing and the role of CEO in the framework of an European Network concerning natural hazards. During the EOFIND study users have been directly involved. Their needs and current barriers in using EO data for the three disaster types have been analysed.

The first case study concentrated on forest fires in Greece. Landsat TM data were used to assess the current vegetation cover and the related fuels for risk assessment and the damage caused by wild fires on the Sithonia Peninsula, Halkidiki, Greece.

The second case study dealt with storm damages caused by a hurricane in Central Europe, using multitemporal Landsat TM data. The satellite images provided important preliminary information about the areas damaged on wide scale. This information is needed to start direct response actions on regional and national level and to get an overview over of the economic influence on the European timber market.

In the third study ERS-1 SAR images were used to interpret the damage caused by a flood in 1995 in Central Europe. The Rapid Information Dissemination System (RAIDS) of MATRA was employed to provide EO-data as fast as possible. The produced flood map was used by naive end users as well as commercial users for damage and risk assessment. In the flood study special emphasis was put on timeliness and operationality to demonstrate fast information delivery after a disaster for immediate help actions. The respective data flux from a data provider to a value adding (VA) company and back to potential customers has been analysed.

In the following the experiences made in the three case studies are outlined in short.

3.1 Forest Fires

As the reasons for the occurrence of forest fires are manifold and their impacts very complex, depending on the local situation the issues of fire management are very complex, too. Thus EO data will play only a minor, but nevertheless important part of any Fire Management System (FMS).

In the following cases EO data can be used on a semi-operational level as was proven by several pilot projects:

- Using current weather satellite data:
  - Detection and localisation of fires (in remote areas only; e.g. in Scandinavia or Eastern Europe)
  - Provision of meteorological data (wind speed, temperature and humidity) on national and European level to support fire management authorities in risk assessment and prevention.
- Using high resolution EO data for medium mapping scales and for modelling purposes:
  - Mapping and monitoring of current land use and related fuels
  - Fire risk assessment
  - Damage assessment
  - Monitoring of relief and protection activities (regrowth, fuel breaks etc.).

As was demonstrated in the study, local authorities are very much interested in the use of EO data. However, technical as well as organisational problems like the:

- Insufficient knowledge about EO data and the related technologies
- Lack of equipment and trained personnel
- Existence of strong traditions
- Data costs

are the main barriers which hamper the use of EO data for fire management purposes.

Under these circumstances the CEO may support the following issues:

- Coordination of international activities with meetings and user / data provider groups on INTERNET
- Facilitation of the access to historical data
- Fostering of public relation activities to reach the inexperienced user groups (foresters, fire brigades, land use managers) especially outside the INTERNET, because most members of this group do not have access to electronic mail.

3.2 Storm damages

The experiences of the storm disaster of 1990, which caused the most severe storm damages ever known in Central Europe, can be summarised as follows:

- High resolution optical EO data are the only economic means for regional storm damage assessment (*when they are available shortly after the event*!)
- Despite the fact that the forest services in charge of relief and mitigation activities possess only little knowledge about EO data the interest in using them is high.

But there still exist severe barriers in using such data:

- Data availability, due to frequent cloud coverage during the most endangered seasons and the orbit configurations of the current EO systems
- Lack of knowledge about the possibilities of EO data
- Lack of equipment and trained personnel for the creation of thematic maps from EO data by the forest services themselves.

In order to improve the situation and to prepare the forest services for new disasters the CEO should consider the following issues:

- Foster public relation activities to reach the decision makers of the Central European forest services (normally key persons in the departments of forest planning and inventory). Because most members of this group currently do not have access to electronic mail other information dissemination means have to be used
- Offer training activities for key personnel (which in many cases will include funding for travel expenses, too).

3.3 Assessment of Flooded Areas

Floods have recently become a very important peril and risk in Europe. Fast assessment of flooded areas is essential for any relief action and loss calculation. Two potential customer groups, their needs and the contribution of CEO to support their relief activities have been identified:

1. ***European Assosiation of Fire Brigades*** (e.g. fire brigades working on cross-border relief, see the flooding in Jan. 1995 in Germany, Belgium and The Netherlands). To start any relief actions one of their first tasks is the fast assessment of inundated areas enabling better relief coordination issues:

   The conventional way implicates mapping of flooded areas by in-situ observation on the ground. Due to non representive point sampling character of this survey often a precise mapping is not possible. In addition this method is time consuming and expensive. A fast delineation of the inundated areas by using EO data could improve this process. An inundation map derived from a EO system could serve as a basis for the mapping process. It may help to locate quickly the flooded areas and a simple verification of the map can be executed much quicker.

   In order to meet the requirements from the Fire Brigades (End User) the data must keep the following constraints:

   - timeliness
   - delineation of flooded areas; the extent and the areas affected delineated on a topographic map showing infrastructure (important for the orientation)
   - scale 1: 50,000
   - high temporal resolution (an image is needed when there is a flood event), the delivery of the product must be reliable in terms of timeliness and quality
   - currently the map should be analogue.

2. ***Insurance Companies*** (working on an European Level) and ***Re-insurance Companies*** (working on a world-wide level). They need data about the flooded areas for:

   - more accurate rating calculation and fast loss assessment.

   Taking into account the object and the amount of money insured an inappropriate rating of the risk will cause severe economic losses for the insurance or reinsurance companies. Due to this fact the knowledge

of the risk e.g. flooding gets more and more important. Whereas in the past the ratings have been calculated very unprecisely the exact location of the object insured and the location of the risk is very important. EO data may contribute for a better risk management and a better portfolio management in case of a flood

The requirements of this user group (commercial user) concerning information content and the data quality are:

- accurate, fast flood damage assessment for a quick appraisal of losses (the knowledge of the cost of an catastrophic events in different loss scenarios with respect to their portfolio),
- historical inundation maps
- most accurate DGMs in order to calculate the premiums, and to calculate the loss potential for the future - a special service for the insurers from the reinsurers (the simulation of an flood event and evaluation of economic losses).
- information should be in digital format for direct input into their already existing GIS.

Next to airborne data, spaceborne ERS-SAR radar data proved to be a potential help for flood mapping tasks (if the problem of time resolution can be overcome). Considering the requirements of the user under catastrophic conditions a fast processing chain has to be applied. To assure the timeliness for acquisition and processing in this study the MMS Raids System, which can provide ERS-SAR quarter scenes within 12 hours after acquisition, was employed. It can be stated that EO data provision services like RAIDS are the right step towards an operational, near real time flood monitoring system.

For EOFIND the following work has been carried out: Two ERS-SAR scenes of the Nijmegen area were acquired via the RAIDS system using the INTERNET. The area covers the rivers Meuse, Lower Rhine and Waal. The interpretation was done on basis of the combination of multitemporal scenes (30.01.95/24.12.94) and the ratio of the two dates. Inundated areas were delineated and two products have been generated: one - emphazing the inundated areas - and the other superimposing the flooded areas on a topographic map.

Several potential customers contacted during EOFIND showed big interest in these EO derived products and stated that EO based flood maps would allow a faster comprehension of the flood disaster situation. However, for both user groups there exist significant barriers which still hamper the use of EO data:

- the end user and the higher administrative level is not yet aware of the benefits of EO data and products due to missing "real life" application examples
- data availability is not timely enough due to slow interaction time between data provider and value adding agency (the fire brigades do need information immediately following the occurrence of a flood event)
- data collection is not timely (the fire brigades do need this information when there is a flood and not every 35 days)
- at this stage the costs to acquire EO data products are to high for relief organizations as well as for insurance industry despite their strong financial background.

Benefits of CEO to overcame these deficiencies:

- establish a service that provides and distributes information and products to the different users (fire brigades, insurances).
- get in contact with potential end users by organizing workshops at the user sites in order to overcome the financial restrictions e.g. no travel budgets available; organizing workshops is mandatory because the communication via INTERNET is currently not the appropriate way to contact this user group
- demonstrate in a real environment applications of EO data for flood mapping in pilot projects financed by CEO in closer cooperation with the user to increase the acceptance of the results of EO data which is not only depended on the availability and accuracy of the final thematic maps but on the possibilities to integrate such information in the daily work. That means that if a potential user finally accepts this data as a new source of information it may lead to a complete change of the current internal work flow. Thus ergonomic aspects must be considered in order to overcome the obstacles belonging to human or governmental „traditions"
- initiate European product harmonization essential in border and organization crossing relief operations

4 CONCLUSIONS

EOFIND is, for the time being, the only European initiative on Earth observation for disaster management which directly involves users and works on concrete applications. The following conclusions were derived on one hand directly from the study and on the other hand from the long term experience of the study team concerning EO data analysis, value adding and data management.

1. Satellite EO products can be a useful tool to support different types of users in different types and phases of disasters.

2. The market for satellite EO products has a potential to grow rapidly in the next years, when the users are better trained and the prizes for the products are reduced.

3. CEO should offer international fora (on INTERNET and within meetings and workshops) to discuss and co-ordinate the European role for dedicated missions for disaster mitigation and relief support from a user-driven point of view.

4. The current lack of E-mail connections by most inexperienced users leads to the need of communication and public relation activities outside the INTERNET. Here, several possibilities can be discussed:

   - Announcement and presentation of CEO and EO examples in specific international journals as well as in more popular newspapers and journals
   - Organisation of workshops for specific user groups (e.g. from forestry, landuse management, insurance companies, fire brigades)
   - Creation of a multimedia show (e.g. in a bus) which travels directly to potential customers showing them, for example, image processing means, INTERNET, satellite communication etc..

5. Development of better data compression tools suitable for EO data should be considered and be made available for public domain. Here, the creation of (perhaps much less sophisticated) alternatives to existing nets - especially, suitable for developing countries and for disaster conditions - should be envisaged, too.

6. Another effect of CEO, in collaboration with the IDNDR secretary and other international institutions like the IAF committee on space and natural hazards reduction, might be the stimulation of a political discussion leading to the creation of interest in using satellite EO data for disaster management.

5 OUTLOOK

The utilisation of space technology for disaster management will lead to improvements in all phases of disasters. Nevertheless, at the moment available space technologies do yet not fulfil the requirements of the civil protection organisations completely. In addition, these organisations currently do not yet know how to use them and are not yet aware of the capabilities of space technology. One of the main objectives of future activities therefore should be to increase the interest of users on space technologies on the one hand and to improve the service that can be provided by space systems on the other hand.

Real time pilot projects on an operational scale should be performed, including the users, the data providers and the value adding companies in a real disaster case. Training, education and more public relation work to promote the use of satellite Earth observation images in general and for disaster management in detail is needed. All types of potential users should be educated and trained in the use of Earth observation images and their capabilities as young as possible (e.g. schools, universities). CEO could play a vital role in these education and public relation task.

CEO and EOFIND could become a major part of the whole complex system that is required for effective disaster management. The next steps in the direction of a European disaster management system based on satellite Earth observation could look like:

- Establishment of a database linked to data providers and users, providing historical data of disaster prone areas and an expert system (this could became part of an operational EWSE), with links to international disaster networks.
- Emphasis has to be put on and time has to be invested in developing the market for satellite EO products in disaster management. The market - that means the potential customers - have been informed and attracted by EOFIND. Further implementation steps are now necessary to foster the market and increase the need.
- The contacts achieved during EOFIND to several insurance and reinsurance companies led into intensive discussions about the use of EO data for their premises. This brought up the idea of small pilot projects during real disasters in the next future where the insurance companies (commercial users) work close together with a VA-company and a data provider. In the following scenarios the respective insurance companies already committed their participation in a pilot study:
  - The contacts achieved during EOFIND to various disaster management organisations could be intensified in the future by involving these organisations in small, real-time, pilot projects, e.g. during the next flood in Europe. The organisations showed big interest in using satellite EO data but were very reluctant with regard to time and budget required. Therefore, a solution how to finance such implementation projects has to be found.
  - In order to enhance the acceptance of EO in the disaster management and to reduce the reluctance in using EO data, training courses and workshops should be organised in the frame of education programmes. A new technique or product is better accepted if it the user gets confidence by understanding the new product. Therefore basic skills in remote sensing and information networks on INTERNET have to be taught. A training on the job e.g. for students of the humanitarian aid, which would enable them to produce EO-products on their own for disaster management tasks might be a suggestion.
  - The contacts achieved through CEO to the THW led to the idea of an one day information event on what EO data could contribute for disaster management and how to find related information. Next to remote sensing examples, the enabling services of CEO would be demonstrated and the participants should use EWSE to find their required information. Despite the fact, that THW is aware of the existence of the EWSE, a training course on how to use the EWSE is required to overcome the technical barriers for non experienced INTERNET users.
  - The European Association of Fire Brigades is willing to cooperate, if the obstacles of timeliness and data availability can be overcome. There was high interest to learn more about modern EO data and information technology. It is already discussed to organise an international workshop, e.g. in the flood proned area of the Rhine-Waal, where Germany, Belgium and the Netherlands frequently suffer from flood impacts. Here, the firebrigades and the executive level should be informed in order to prepare this market and familiarize it with the new technology.
- Considering the fact, that in-situ data on ground will never become obsolete (at least for ground truthing) and that a combination of remotely sensed synoptical data with sampled point measurements will improve significantly all relief actions, sophisticated tools have to be created to combine both ways of data collection in an optimal manner.
  Supporting such a model Kayser-Threde is currently developing a field GIS for DG VI to support the European agricultural policy. The Computer Aided Data Collection System (CADCOS) is based on a Differential GPS (DGPS) linked to a pentop computer with sophisticated GIS-software for data assessment with high geometric accuracy. This system can be modified towards a field equipment suitable for catastrophic events. It would support the mapping process showing for example digital maps and the current position. It also offers tools for map manipulation and on-line help functions as well as online connections to remote control centers for information dissemination and for security reasons. During EOFIND we started discussions with fire brigades as well as with insurance companies to use this tool for their daily work with encouraging response.

6 LITERATURE

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