CREATING A TOPOGRAPHIC BASE IN THE AFTERMATH OF THE CHERNOBYL DISASTER

Thibault, Diane, Remote sensing project manager, Photosur Geomat International, 5160 Decarie Blvd., Room 300, Montreal, Quebec, Canada, H3X 2H9, Phone: 514-369-5056, Fax: 514-369-5059, E-mail: **dthibault@photosur.com**
Siegel, Charles, Project manager**,** Photosur Geomat International
Chaput, Joanne, Remote sensing specialist, Photosur Geomat International
Dombrowski, Alain, Project adminstrator, Photosur Geomat International
Palko, Stefan, Scientific advisor, member of the Steering Committee, Canada Centre for Remote Sensing, 615 Booth Street, Ottawa, Ontario, Canada, K1A 0E9, E-mail: **stefan.palko@nrcan.gc.ca**

Abstract

After the Soviet Union dissolved, Ukraine became responsible for territories contaminated as a result of the Chernobyl Nuclear Power Plant explosion. Base maps on which soils, land use, land cover, and farm limits are identified and delineated became necessary to support decision-making dealing with the consequences of the Chernobyl disaster. Satellite imagery was used to produce such maps. IRS panchromatic and SPOT panchromatic and multispectral images were compared. Two geometric correction methods, polynomial modeling and orthorectification using a mean elevation datum, were analysed. The thematic content of the three types of images was also evaluated. Results show that panchromatic images are suitable as a stand-alone product to create a geographic database and to provide basic land cover information and IRS images are recommended because of their higher resolution.

Introduction

Databases supporting the integration of various data layers such as soils, land use, land cover, and farm limits are fundamental to GIS application projects. Building such databases from a variety of sources requires a common reference base map. Up-to-date base maps at the scale of 1:25 000 – 1:100 000 were needed to support decision-making concerning the consequences of the Chernobyl disaster in Ukraine. Creation of a topographic base map for Chernobyl is part of the Institution Capacity Building for Remediation Activities project supported by Canadian International Development Agency and Photosur Geomat International contributions.

As it is difficult to obtain maps and data in Ukraine, use of satellite images was investigated. SPOT and IRS-C images were chosen and two geometric correction methods were evaluated, polynomial modeling and orthorectification using a mean elevation datum. The thematic content of SPOT multispectral and panchromatic images as well as IRS panchromatic images to produce base maps was then compared.

Project Context

When the Soviet Union dissolved at the beginning of the 1990s, responsibility for territory contaminated as a result of the Chernobyl Nuclear Power Plant explosion devolved on the reorganized Ukrainian state. Among the government agencies given responsibilities for the Chernobyl accident aftermath are:

- Ministry of Chernobyl Affairs, since combined with another agency to become the Ministry of Emergency Situations and Chernobyl Affairs (MESCA);
- Ministry of Environmental Protection and Nuclear Safety (MEPNS);
- Ukrainian Institute of Agricultural Radiology (UIAR), part of the Ukrainian Academy of Agricultural Sciences.

The Administration for the Protection of the Population from Radiation (APPR), a branch of MESCA, sets policy and coordinates programs to apply measures to protect the human food chain from radiation contamination. It evaluates requests for support from food producers and organizations throughout Ukraine. MEPNS is interested in the distribution of contamination throughout Ukrainian ecosystems. UIAR receives funding for research into radiological countermeasures to be applied in agriculture.

Another cabinet-level agency, the Main Administration for Geodesy, Cartography, and Cadastre (MAGCC), is the geographic/map information provider for Ukraine, with responsibility for base map information at all scales. However, state security considerations limit the dissemination of cartographic materials at scales larger than 1 : 200 000. Precise ground truth data are also tightly controlled.

The Chornobyl GIS project provides technical assistance to all of these agencies for the application of geomatics to the problems of radiation mapping and countermeasure application and administration.

Proposed solution

Remote sensing data were chosen to create the base map, a general land use/land cover map, on which countermeasures, radiation data and other land use and farm data would be overlayed. The choice of the type of imagery used to produce the base map was based on several factors such as availability, resolution, costs, and performance. As shown in figure 1, the project was done in three steps. Two different types of geocoding were done and evaluated to obtain the best possible planimetric precision. SPOT images were first retained mainly because of their high resolution data. SPOT panchromatic (PLA) and multispectral (MLA) images were then compared individually and as an integrated product. Finally, a comparative analysis of SPOT-PLA and IRS-1C panchromatic (PAN) images was performed to assess their respective planimetric, radiometric and thematic content performances.

(Figure 1)

Geometric precision evaluation

Ground control points were to have been acquired using a Global Positionning System (GPS) to provide precise coordinates to geocode the scenes. However, because of secrecy, this type of data could not be acquired. A map at the scale of 1 : 200 000 was finally used to select ground control points. In order to obtain data as precise as possible, two types of corrections were compared. First, a conventional geocoding method based on polynomial fitness was used. Then an orthorectification of the image using ephemerids and a mean elevation datum was applied. Results show that the orthorectification method is more precise. Orthorectification provided an adequate background over flat areas, while requiring fewer ground control points and human resources than the polynomial modeling. However, in mountainous areas such as the Carpathian region, use of a digital elevation model is strongly recommended.

Comparison of SPOT panchromatic and multispectral images

The thematic content of SPOT multispectral (MLA) and panchromatic (PLA) data was compared, first to each other and then with an image integrating the two. The integration of the PLA channel to the MLA channels was performed to improve the overall precision. It was done through a RGB–IHS transform in which the intensity channel was replaced by the PLA channel. Finally an IHS–RGB transform was performed yielding the integrated image channels (figure 2).

(Figure 2)

Both SPOT-PLA and SPOT-MLA images yielded suitable results to produce base maps. SPOT-PLA images (10 m resolution) gave better planimeric results because of their higher ground resolution while SPOT-MLA images (20 m resolution) offered better spectral discrimination of the main cartographic features. The best solution was certainly the integration of both types of images which combined the qualities of both the PLA and MLA data. However, because of the costs related to the use of two images to cover a given area, it was decided that only one type of image would be retained. Ukrainian administrators considered the planimetric precision a priority. Therefore, in the second phase of the project, SPOT-PLA and IRS-1C PAN images were compared.

Comparison of SPOT-PLA and IRS-1C PAN images

Both types of images were considered to be suitable to produce base maps. But results show that IRS-1C PAN data (5,8 m resolution) are superior regarding the planimetric aspect.

SPOT and IRS images have a very similar radiometric potential. The differences reside in the appearance of the details due to the higher ground resolution attained by IRS, the variation of atmospheric conditions before and during the acquisition as well as the difference in the phenological stage and ground humidity due to the date of acquisition. Both images show a regular pattern of vertical stripes. The presence of such stripes generally does not constitute a problem but it is always possible, when necessary, to attenuate the effect by using a custom-made directional filtering algorithm.

Results also show that the higher resolution of IRS-1C PAN data allows a better discrimination of most land cover features. The examples shown in figure 3 illustrate the differences in precision and thematic content extraction of both types of images. However, IRS scene availability is not as great as that of SPOT scenes. IRS is fairly recent and has only a 42 day revisit schedule, but this problem should be solved in time with the launching of other satellites. Therefore, although IRS scenes are preferred, SPOT images can be used when IRS images are not available.

(Figure 3)

Conclusion

SPOT and IRS panchromatic data proved to be efficient to provide an affordable basic topographic and land cover map of an area where almost no other data are available. However, the use of IRS panchromatic data is suggested over SPOT-PLA for updating and creating base maps of Ukraine. Orthorectification is recommended.

Maps created from panchromatic satellite data were used to map farm data necessary to apply mitigation measures on contaminated soils affected by the Chornobyl nuclear explosion. This study was first done as a demonstration project and the results were satisfactory. Subsequently, IRS scenes were used to produce base maps of over 15 kolkhozes (collective farms) in two different oblasts (province).

Biography

During the last twelve years, Diane Thibault worked on many environmental studies, more specifically natural resources mapping using remote sensing data. Ms. Thibault has a Master's degree in remote sensing and she acquired a vast experience in that field while a project manager in specialized firms and remote sensing project coordinator at Hydro-Quebec. Ms. Thibault is now remote sensing project manager at Photosur Geomat International.