Integrating SAR Data into Geographical Information Systems (GIS)

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Since the 1960s, satellite remote-sensing has increasingly become a primary source of information on our planet. Direct distribution of the resulting data has, however, been mainly limited to a small community of users. Meanwhile, it has become evident that direct access to this data is also desired by a wider range of users – such as urban planners, Earth resource managers and insurance brokers – who have been managing territorial information using Geographical Information Systems (GIS).

In order to fulfil the requirement of moving relevant and current data into these types of systems, data must be extracted from the satellite sensors into a compatible format. In a study performed for ESA, Planetek (I) investigated whether new GIS-oriented products could provide ERS-1 and ERS-2 SAR data to these user communities. The study was focused on two key issues: to identify an end-user product and to specify an appropriate format for product distribution.

Definition of SAR GIS products

Since Geographical Information Systems are not generic, we – the study team – extensively considered and analysed several application domains. In each case, potential GIS products were identified according to two criteria: firstly, their feasibility (ability to satisfy the application requirements) and, secondly, their potential market.

The candidate product types were then ranked according to the following criteria:

Data source
Is the information contained in existing ERS-SAR products, such as the precision image (PRI), sufficient for generating the product, or are other data, such as precise orbit information (PRC), also required?

Product accuracy
In this case, accuracy is defined as its compliance to application requirements rather than final product precision. For each product type, we assessed the accuracy from results already published as well as our practical experience.

Degree of automation
This is a fundamental parameter, since it indicates to what extent an operator must be involved in the processing chain for final product realisation. The degree of automation affects not only the cost of the product, but also the objectivity of the final result (as personal judgement may be involved) and, consequently, product reliability.

Need for ancillary data
Remote-sensing data applications can always benefit from the use of ancillary data, but the type and amount of ancillary data needed to guarantee a satisfactory product must be determined. The provision of additional data beyond this requirement could be considered as a means of further improving product accuracy.

Application maturity
This parameter is a tentative assessment of the degree of consolidation of each application, measured by years of study carried out by the scientific community and by the number of application examples. This is not necessarily related to product accuracy and, therefore, it does not infer any quality assessment of the GIS product. Some recently developed

applications may present quite accurate results, but they have not been tested on a wide range of varying situations and the limitations may not yet be clearly understood. On the other hand, other applications, although less accurate, have been fully analysed and validated in terms of reliability. Therefore, from a market point of view, product maturity indicates to what extent the customer is likely to be able to rely on a GIS product. A low level of maturity has been attributed to applications which still have some open issues, whereas the more consolidated applications have been considered as mature.

Cost/benefit ratio with respect to traditional products
For each product type, this criterion accounts for the cost/benefit ratio with respect to the same product obtained by using sources other than SAR data. They include, for instance, field measurements, bathymetric campaigns, aerial photograph interpretation and optical remote-sensing data processing.

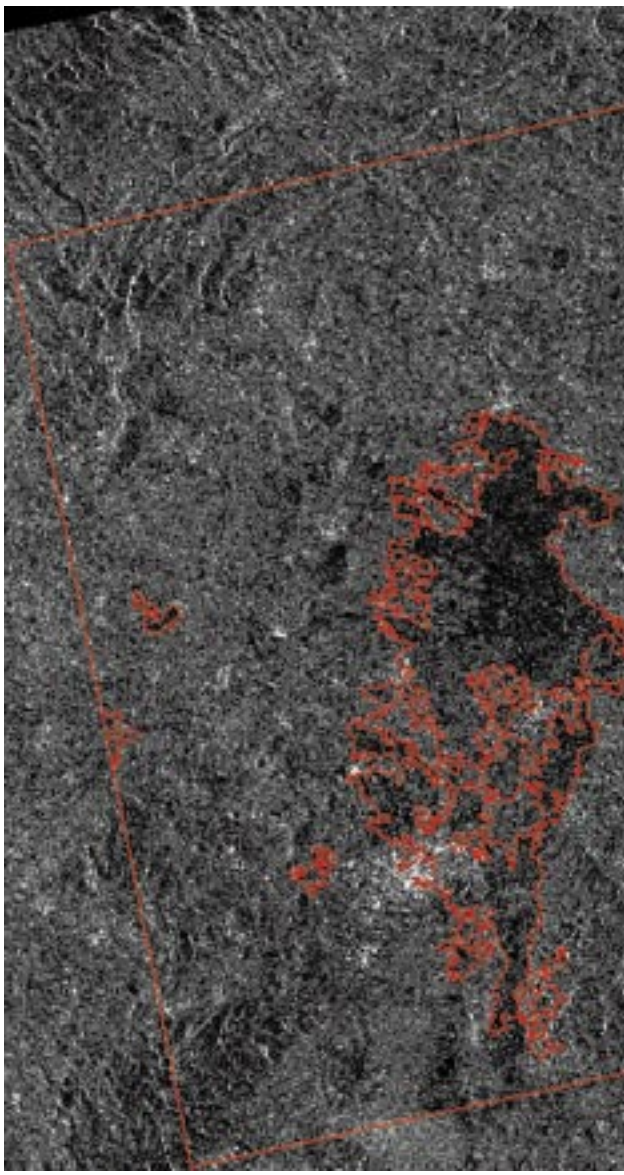
Product versatility
This parameter refers to scientific or operational interest and product flexibility. In general, all of the defined applications can be both scientific and operational but, strictly speaking, some products may be identified which appeal only to the scientific community or other very specific users (e.g. public administration or oil exploration industry). A product is marked as flexible if it can be used directly in more than one application. A Digital Elevation Model (DEM) is a typical example of a flexible product, used in civil engineering as well as in hydrogeology.

Figure 1. The ERS spacecraft

Geographical extent
Some products cover only a limited part of the Earth. This may impact applications such as sea ice investigations or studies on desert areas which have geographical limitations.

As a result of the analysis, seven potential products have been selected: flood map, oil spill map, slope map, low-resolution DEM, ice-edge line, coastline map and forest-/non-forest map.

Product format specification
A key factor for the success of any of these new products is their usefulness to the GIS user community. The proposed products must be compatible (be directly readable by) the existing systems. According to our survey, most GIS software packages currently in use are application-specific (related to e.g. hydrology, urban planning) and are primarily based on one or two industry standards. We decided to look for a solution acceptable for most, if not all, of these software packages.

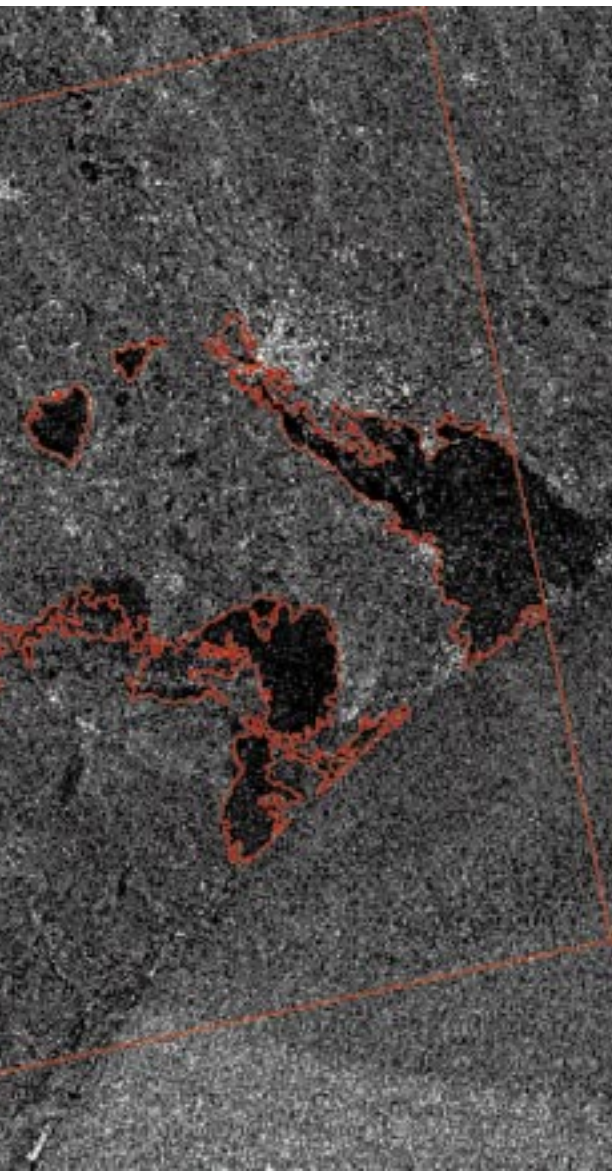


The proposed GIS product format is based on a main file which contains metadata information and pointers to all the relevant geographical data, tabular data and auxiliary files, including the relevant documentation. These secondary files, which may be distributed with the main file or made accessible via a network, form the full product along with the main file. The data file formats chosen are:

– GeoTIFF for raster data
– DXF for vector data
– ASCII, tab separated, for attribute tables.

The list may be expanded, especially for vector data format.

In fact, DXF has several drawbacks in describing GIS data, mainly due to its inability to associate attribute tables with graphical features. These problems can be overcome, but it is worth noting that other formats store GIS data better than DXF. DXF has been chosen for its currently wide distribution.



An example: the flood map

In order to validate the concept proposed in this study, we performed a detailed study of one product.

Due to ESA's focus on disaster management, we selected the flood map. A sample product was prepared for the floods around Béziers in Southern France in January 1996, which was studied elsewhere.

The production followed a preliminary phase of detailed product specification based on application and user requirements. A suitable algorithm was identified using both amplitude SAR images and interferometric coherence images. The result is a vector map of the flooded zones in a format which can be immediately employed by end users. The data is displayed over a raster SAR image of the flooded area (left).

Conclusion

Based on the interest shown by a wide range of user communities, we have proposed high-level GIS-oriented products that we hope will contribute to bringing remote-sensing data to a wider market place than the traditional remote-sensing community. Further work is foreseen to develop additional products such as the oil spill map and the slope map.

Acknowledgements

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Figure 2. The flooded area around Béziers delineated in red. The outer red square is the SAR scene