RADAR BACKSCATTER AND COHERENCE INFORMATION SUPPORTING HIGH QUALITY URBAN MAPPING

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ABSTRACT

The potential of a synergetic use of different data sources for a high quality mapping of urban features is described in this paper. In the urban application domain, beside the different EO-sensors and products there are a lot of high resolution and high quality GIS- and digital map databases available (e.g. ATKIS in Germany), provided by public authorities but also by private industry. Fusing this ground-based data with remotely sensed information is resulting in high quality thematic datasets.

Using ATKIS Geodata, IKONOS multispectral- and ERS-SAR / ENVISAT-ASAR data as input, in the research described we implemented a GIS-based expert system to derive in a first step the degree of sealing in the regions of interest (ROI). Joining the reclassified ATKIS-data with a vegetation index, the backscatter- and the coherence information, the output of the processing chain is a vector data layer dividing the ROI in different classes of sealing. Adding the SAR-/ASAR derived backscatter and coherence data into the spatial analysis results in a partial improvement of the classification process, especially in rural areas.

Keywords: spaceborne earth observation, SAR interferometry, coherence analysis, GIS, map overlay, urban mapping, data integration

1 MONITORING THE EFFECTS OF URBANISM

The unplanned Megacities are representing the extreme manifestation of the recent worldwide trend to uncontrolled growth of urbanized areas. Especially, these Megacities affect and are affected by natural cycles. They import water, energy and materials which are transformed into services. The procedure is triggering local, regional and global problems.

When these cities are expanding into the surrounding agricultural areas, pastures, forests and other land use areas the impact on the environment is significant. There is not only direct impact by the growth of the cities on the environment, but also growing infrastructure, sewage, air pollution and solid waste problems. That means that monitoring the existence, distribution, changing patterns and growth of settlements in each order of magnitude plays a very important role in conservation of natural resources and planning economic growth in a prudent manner. On the other hand, even in industrialized coutries, monitoring the urbanization process is a must to come to a sustainable development of settlement activities especially with view to the natural resource soil.

2 DATA INTEGRATION APPROACH

Traditional ground based methods of gathering information and mapping urban areas are no longer sufficient to serve the requirements of local and regional governments or companies. Therefore, the implementation of urban information systems (UIS) is an option for many urban agglomerations to integrate EO data and GIS methods for better management of the targeted areas.

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With the overall availability of high quality geodata provided by public authorities (e.g. ATKIS) but also by industry we are able to use EO-data to add thematic layers to the geodatabase or, vice versa, to use the geodata for a fine tuning of the algorithms in our thematic processors. Both was done in the case study described.

The GIS database ATKIS (Authoritative Topographic-Cartographic Information System) is a trademark of the working committee of the surveying authorities of the states of the federal republic of Germany (AdV). Components are object-based digital landscape models (DLM) and digital topographic maps with a high positional- (horizontal +/- 3 m, vertical +/- 0,5m) and semantic accuracy [1]. The coverage is nationwide with an update cycle of 5 years. To have an idea about the geometric and semantic accuracy of the ATKIS data please see the figures below.

Fig. 1. IKONOS-PAN

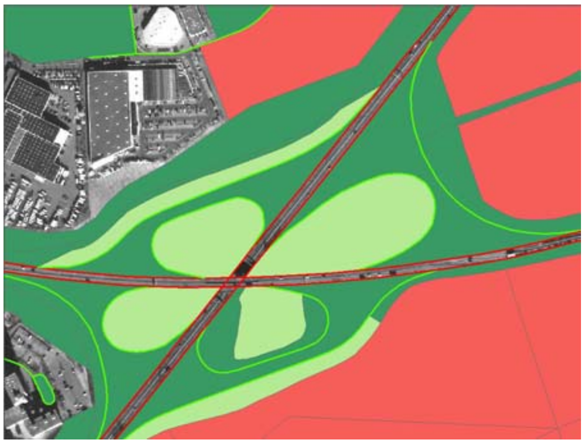

Fig. 2. IKONOS-PAN overlayed by ATKIS geodata

3 EARTH OBSERVATION DATA PROCESSING

3.1 Sealed area monitoring

Within the first iteration of the system design, we used the sealed area mapping as case study to develop our demonstrator system. Region of interest was the city of Mainz /Rhine (Germany) with a high availability of GIS-data provided by the local administration and the landsurvey authority of Rhenania-Palatinate.

The sealed area application domain is of high interest in monitoring urban sprawl in general. Today, it became of further interest because of taxation activities related to the size of sealed area (e.g. waste water tax). Traditionally, the EO data analysis for sealed area detection is done based on a vegetation index, sometimes in combination with thermal infrared data (airborne). Interfering artefacts as material inhomogeneities (e.g. concrete, asphalt, buildings), vegetation layers covering sealed soil or shadow effects are traditionally resulting in misclassifications. This problems can be reduced using multisource multitemporal data provided by EO and GIS community.

3.2 EO data processing

The solution proposed in our work is based on an integrated analysis of multitemporal multisensor data (IKONOS multispectral- and ERS-SAR data from tandem acquisitions). The potential value of the SAR/ASAR instrument in the urban application domain must be viewed based on the two major information we will derive from the Synthetic Aperture Radar (SAR) instrument [2]:

- the intensity (backscatter) of the signal return, and
- the pase information.

The phase information of the radar signal is able to deliver important additional data from the earth's surface that cannot be detected by optical instruments or even backscatter analysis. Especially from the coherence information we expected additional information for a better discrimination of the sealed land surface.

The coherence measures the correlation between master and slave image, which means the changes between two image acquisitions. High coherence means no or small changes whereas no coherence indicates a high degree of change. A certain grade of coherence can be correlated to a special landcover type or gives information about weather changes between the two acquisitions of the SAR images. For urban monitoring the coherence tool can provide information useful in detecting the expansion activities. The coherence in settled, mainly built-up areas is higher than in areas covered with vegetation [3].
The intesity of the signal return can be used as additional indicator for built up areas [4, 5]. Therefore, averaged intensity images were derived from superimposed images. Figure 3 shows the aggregated radar information of the region of interest within the interferometric signatures visualization (coherence, averaged backscatter, backscatter difference).

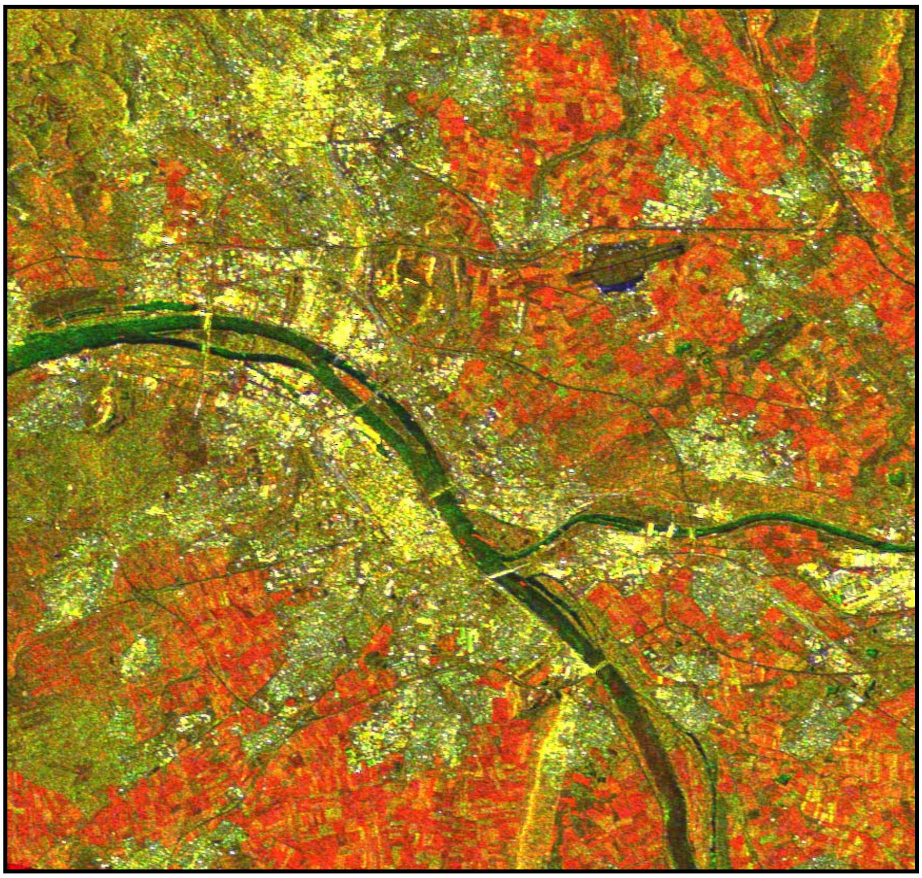

Fig. 3. ERS-SAR interferometric signatures

After the pre-processing, of each data set separately (NDVI, average intensity, coherence), a pixel-based classification of the sealing information was done for each thematic layer (winter / late spring acquisitions).

The classification process was performed based on masked regions defined by the ATKIS object classes. Isolated classifications using ground truth data were done for each object class derived from the ATKIS database (e.g. settlement, forests, agricultural areas, industrialized areas and areas with a mixed landuse). With this multi-masking approach, we were able to come to a better discrimination of the landcover types by excluding interfering information coming from other object classes.

3.3. Map Overlay

The final processing of the sealed area information was done based on a GIS-based map overlay algorithm [6]. To apply a map overlay algorithm successfully, a high accurate geocoding, data matching and resampling of each layer included is strongly recommended.
After this process, the values of each pixel derived from the different sources can be used as input to the map overlay operation. The optimised algorithm used for the sealed mapping task can be inquired at the authors. The processing principle is shown in the figure 4 below. As input we used the classified NDVIs derived from IKONOS-MS summer/winter acquisitions, classified multitemporal coherence and backscatter information and the rasterized ATKIS landuse object classes (shown from left to right). Output data set is one layer including the results of the overlay calculations.

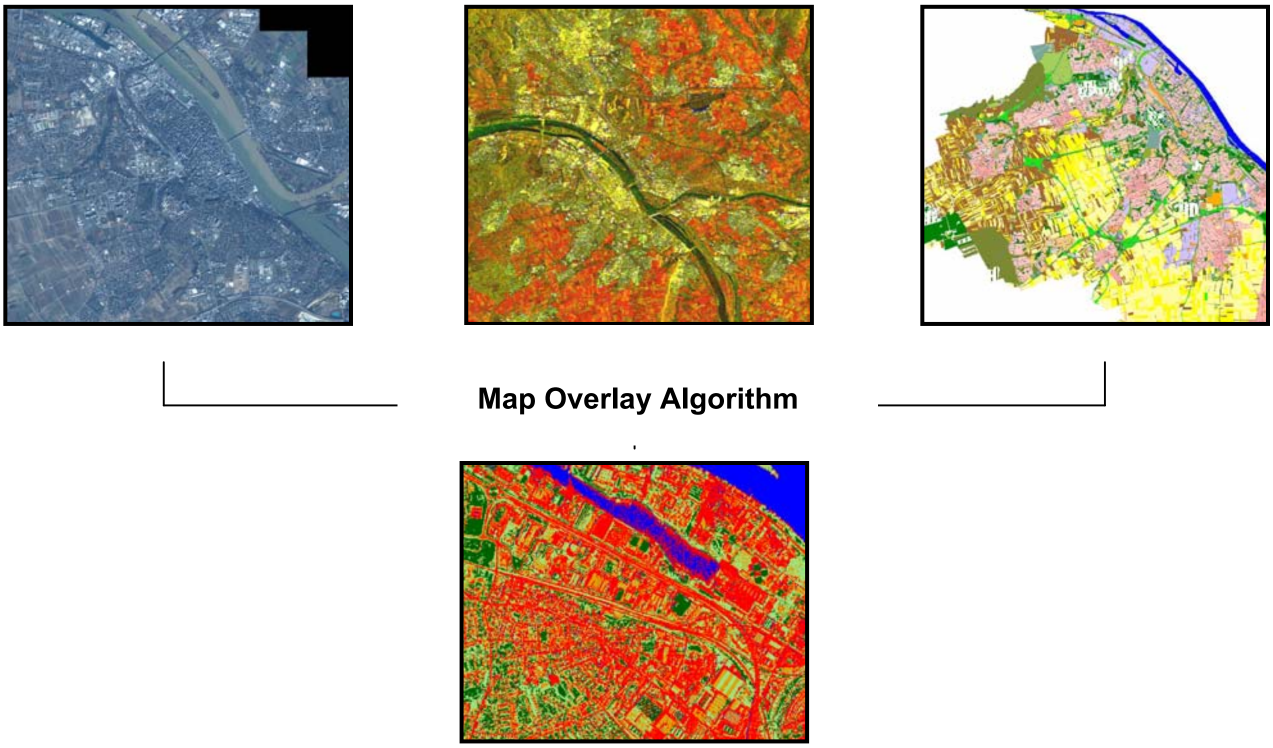

Fig. 4. principle of the map overlay operation resulting in one information layer

4 PRELIMINARY RESULTS

Summarizing the first results of our integrated EO/GIS-data processing approach, we made very good experiences with the masked EO data processing based on the ATKIS object classes, not only with view to the sealed area mapping. With this multi-masking approach we could increase the quality of the landcover mapping significantly compared to the traditional methods.

With special view to the SAR data used, we made the experience that due to the medium resolution in combination with the double bounce scattering effects and the corner reflections occurring in highly built up city centres, ERS-SAR data has a low impact on the improvement of the classification results in a detailed mapping of sealed areas within cities. In comparison, we detected a higher sensitivity of the backscatter and coherence information in rural regions which was leading to an improvement of the results of the feature extraction process.
Further investigations are ongoing to improve the overlay based analysis of multisource multitemporal data including also polarimetric data from the ASAR instrument especially with view to the extraction of biophysical features.

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