ERS SAR POWER SATELLITE IMAGE INTERPRETATION AND URBAN CHARACTERISTICS: THE CASE OF ATHENS

Parcharidis I., Delladetsimas P., Kourkouli P.

Harokopio University of Athens, Dept. of Geography, El. Venizelou 70, 17671 Athens

Abstract

This study concerns the use of an ERS SAR Power image in order to detect and/ or recognize different urban characteristics based on its power values. As pilot area the Athens broader area has been used. Starting from an ERS SAR SLC scene and after a complex processing a power image has been generated. The interpretation of the power image it has enhanced specific urban characteristics. Specifically, high values in the power image coincide with building blocks having E-W orientation and lower values for all other directions. Additionally, the power image show high values for the metallic structures (e.g. fount-tanks).

Key words: Backscattering, SAR image, Power image, urban characteristics

1. Introduction

The radar waves transmitted from ERS's satellite antenna, they are reflected from the Earth's surface and part of the waves return back to the receiving antenna from where the data are transmitted back to the Earth. The SAR sensor is right-side looking this involves that most of the waves are reflected away from the instrument. Furthermore, the signal backscattering depends mainly on the surface roughness, the moisture content and the geometry of the illumination. The aim of this work is to observe the signal backscattering in the study of urban growth dynamics and land use intensity. The Athens metropolitan area is used as the case study.

2. SAR Images: Components and Structure

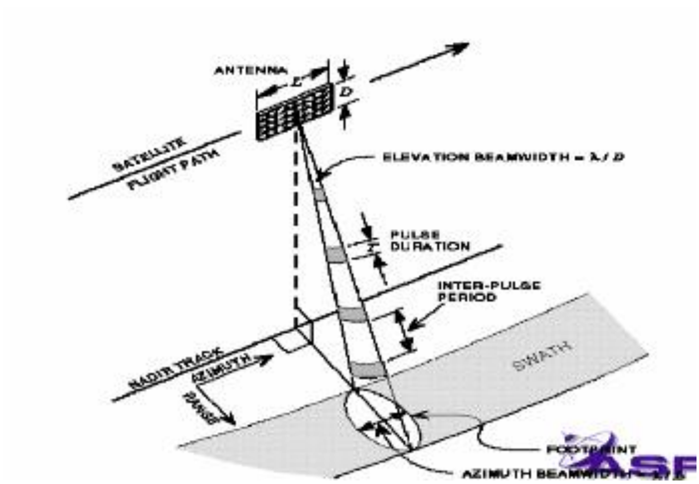


Figure 1. SAR geometry (Source ASF)

SAR generates a two-dimensional and high-resolution remote sensing imagery. The intensity of each pixel, composing the SAR image, represents the magnitude of microwave backscattered from that area on the ground which depends on a variety of factors: types, sizes, shapes and orientations of the scatterers in the target area; moisture content of the target area; frequency and polarisation of the radar pulses. In general a SAR image consists of the structure, texture, speckle, general texture and radiometry.

SAR Power or intensity images are related to the radar brightness of the scene and gives information about the amplitude. The amplitude is the measure of the strength or the height of an electromagnetic wave which shown in images as grey level intensity values. In addition, the power image expresses the strength of a field or of a distribution such as an image file, proportional to magnitude, squared.

It is important to mention that the power image consists of values (that they are power ratios expressed in decibels (dB). Decibels often are used in radar, such as in measures of reflectivity, for which the dynamic range may span several factors of ten. The dB values are just 10*log (power), where power is the processed image values.

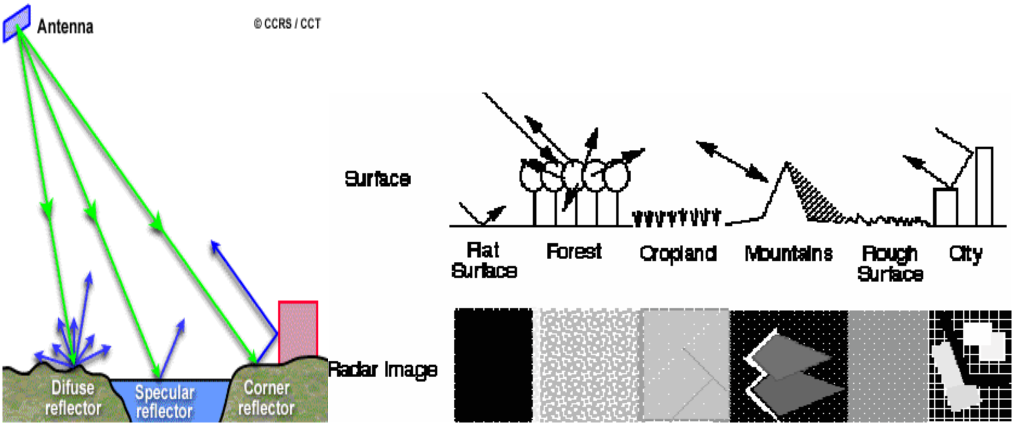


Figure 2. The mechanism of Backscattering (Source: CCRS/CCT)

The pixel intensity values are often converted to a physical quantity called the backscattering coefficient (sigma0) or normalised radar cross-section measured in decibel (dB) units with values ranging from +5 dB for very bright objects to -40 dB for very dark surfaces.

The sigma0 values depend on the illuminating geometry and the nature of the scattering of the radio wave from the targets. Sigma0 values range from -18 dB (the noise level of the data) to values greater than 1 (0dB). However, it can be greater than 0 dB if the radio waves are reflected back to the radar. In this study, the area of study is an urban area. This means that the area of Athens is dominated by double bounce reflects as the radio waves reflects off the streets and then off the buildings and finally it returns back to the radar. On the other hand, areas that are covered with not much vegetation, the ground will be smooth. This will cause these areas of the image to look dark (water or roads or pasture land). For the same reason, rivers and lakes are also quite dark in the image. Moreover if there are mountains or hills, the radar image will be brighter on the side of the mountain or hill facing towards the radar.

3. Data used and Processing

In this study were used SAR data of the ERS-2 satellite. The scene that was acquired covers the area of Athens (Figure 3).The preliminary data was a Single Look Complex (SLC) image which transformed to a Power image after a composite processing. It must be noted that Single Look Complex images products are in slant range coordinates and each pixel is represented by complex (I and Q) numbers to preserve the magnitude and phase information. Specially, in the SLC image was performed the processing of Multilooking in order to improve the quality of the Power image. Hence, the multilooked image generated from an SLC image by averaging the power (square of absolute value of the complex image) across a number of lines in both the azimuth and range directions. The multi-look intensity image was created with a default of 5 Azimuth looks and 1 Range look. This option is convenient for the ERS satellite. The number of looks are chosen in order to obtain a sampling of the multi-look image which gives almost square pixels (the ground range length and azimuth length are almost equal).

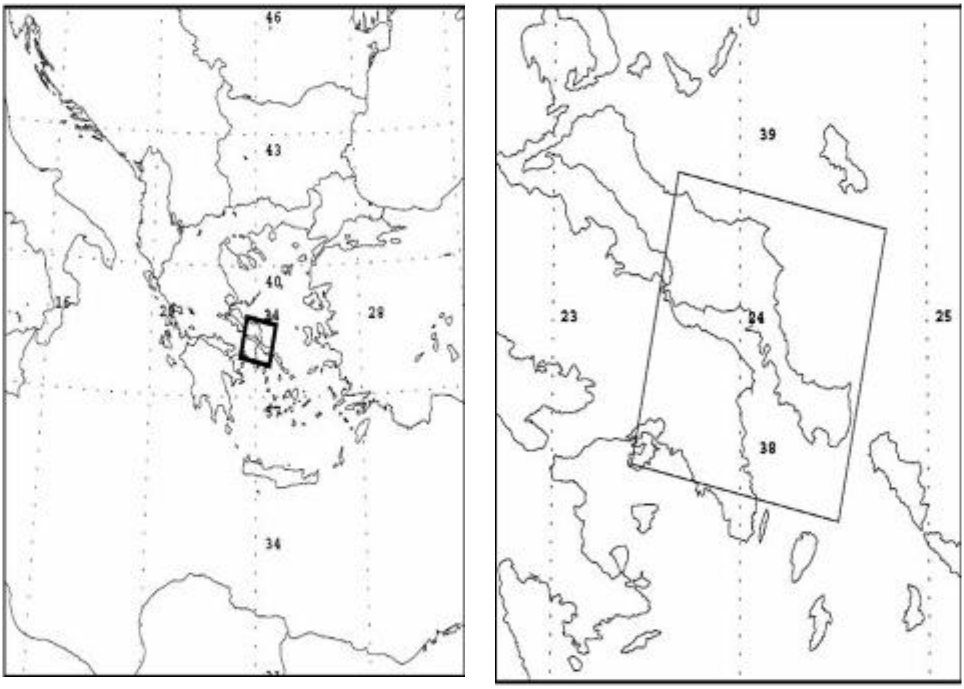


Figure 3. Scene acquired from ERS satellite (Athens)

In addition, it has performed the Speckle processing in order to reduce the typical noise of the Radar image. Then, it used an adaptive filter (Enhance Lee Filter) for further reduce the component of Speckle. Afterwards, it was processed Geocoding with using Ground Control Points (GCPs). This process allowed the transformation from radar coordinates into UTM/WGS 84' cartographic system. During the geocoding carried out the radiometric calibration (removal of topographic induced radiometric distortions) which is based on the radar equation. Moreover, radiometric calibration is performed for distributed targets. Hence, it is possible to find pixels (point targets), in the radiometrically calibrated data, whose value is higher than 1. Especially, radiometric calibration of the SAR images involves corrections for:

- The scattering area: each pixel is normalized for the actual illuminated area of each resolution cell, which may be different due to varying topography.
- The antenna gain pattern: the effects of the variation of the antenna gain in range are corrected, taking into account topography or a reference height.
- The range spread loss: the received power must be corrected for the range distance changes from near to far range

Finally it is important to mention that images geocoded to Geo-Global system (LAT/LONG coordinates) can be automatically displayed into the Google Earth environment.

Consequently, the final image transformed after a short processing into a KML file which is a format that can be used to display geographic data in an Earth Browser such as Google Earth and it is based on the XML language. Afterwards, the KML file inserted into Google Earth as a layer and overlapped to the QuickBird high-resolution image as a transparent image (Figure 4).

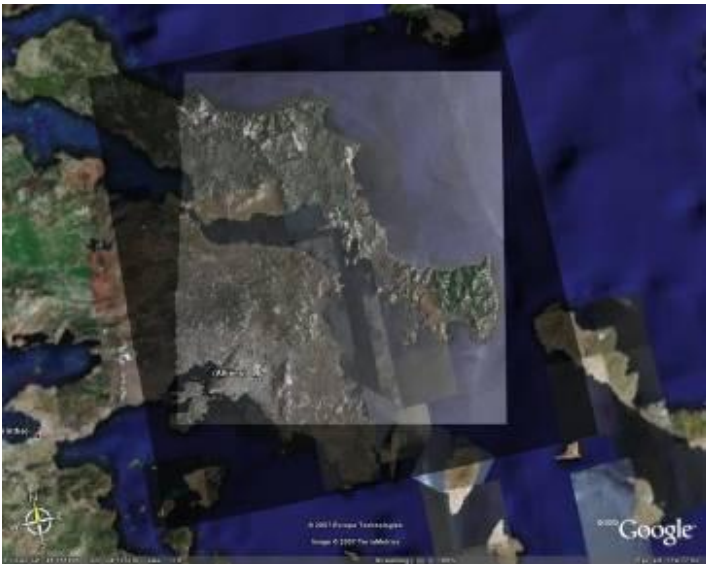
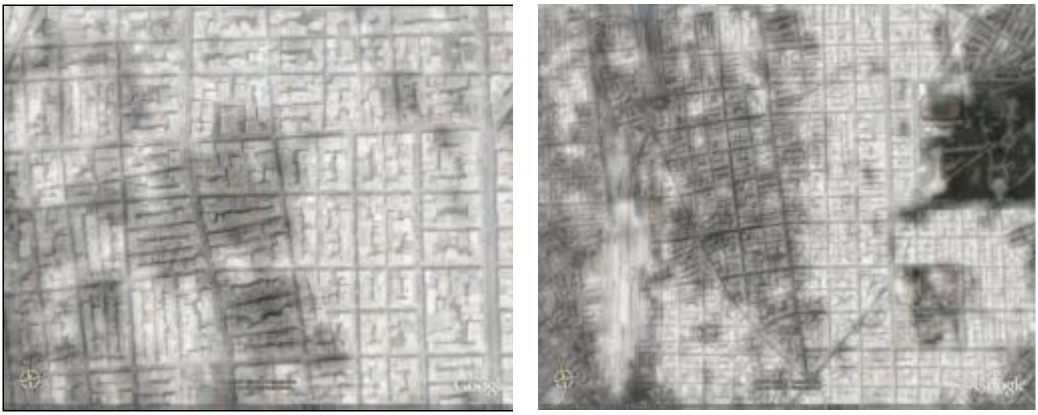


Figure 4. Power image of Athens displayed to the Google Earth as KML file

4. Results

An urban agglomeration can be in principle being represented as a complex of relatively regular shapes (such as rectangular plates, dihedral and trihedral corner reflectors) and open spaces. In cases where the urban surfaces are oriented towards the radar, the signal backscattering waves are directly reflected back to the radar (specular reflection-bright areas). Alternatively in cases where urban surfaces are not oriented towards the radar a double bounce wave's return is involved. In other words, the brightness or the darkness of the image depends on the orientation of the buildings related to position of the Radar's antenna. Hence, the Sensor-target orientation plays a major role in the detection of cubical objects (buildings) (Figures 5-6). This differentiation in signal backscattering, allows the detection of distinctive urban characteristics. Moreover, the level of the grey image's level depends on the material of construction of the building. Specially, if the building is made of metal then the backscattering is very high. Therefore, these areas are indicated as bright areas. A typical example is the fuel-tanks in the area of Elefsis and Aspropyrgos (Figure 7).

Figure 5. Urban area of Athens (area above of Leoforos Alexandras): The left (blue line) polygon shows a bright area which means that the orientation of building blocks is towards the Radar's. However, the right (red line) polygon covers a dark area which means that the orientation of the buildings is different than the Radar's antenna.



Kypseli *Square Attikis*

Fig. Figure 6. (a),(b): Even if occurs the smallest difference in the orientation of the building blocks, this influences the signal of the Radar.

Figure 7.The area of Elefsis which is covered with fuel-tanks. The area is shown as bright because of the M material of the fuel-tanks.

References

Freeman T., "What is Imaging Radar? ", Jet Propulsion Laboratory, Pasadena, CA.

Mansouri B, Shinozuka M., "SAR image power calibration by urban texture: Application to the Bam earthquake using Envisat satellite ASAR data", 3rd International Workshop on Remote Sensing Technologies and Disaster Response, September 12-13, 2005, Chiba, Japan.

Nicoll J., "SAR Geometry and Backscatter", Alaska (http://www.asf.alaska.edu/educational/seminarpdf/2002/)

Sarmap, ESA, "Synthetic Aperture Radar Land Applications Tutorial" (http://www.tiger.esa.int/training/SAR_LA1_th.pdf - http://www.eorc.jaxa.jp/JERS-1/GFMP/SEA-2A/docs/html/tutorial.htm)