International Geosciences & Remote Sensing Symposium (IEEE, IGARSS 2000), Hawaii 2000, vol.I, p.328-330.

SIR-C/X Space Shuttle Images Contribution in Assessment of Flood Risk. The Case of Athens Basin.

Parcharidis Is.[1], Lekkas E.[2] and Vassilakis E[2]
1. Earthquake Planning and Protection Organization
Xanthou 32,154 51 Athens, Greece
+30 1 6728000, parchar@geol.uoa.gr
2. University of Athens, Dept. of Geology
Panepistimioupoli, 15784 Athens, Greece
+30 1 7274410, elekkas@geol.uoa.gr

ABSTRACT

This study describes the investigation conducted for flood risk assessment in urban areas using SIR-C data. The Athens basin is a densely populated area with approximately four million inhabitants, affected very often by destructive flash-floods. These flood phenomena occur mainly at the margins of the urban area very close to the surrounding mountains. The SIR-C image, acquired on October 2nd, 1994, has been processed for speckle reduction and additionally a non-linear stretching has been applied. After the first observations at every single image, a false colour composite image was created using L-band HV, C-band HH, and L-band HH as R,G,B. The captured information concerns morphology (topography, slopes, gullies), land use and land cover, drainage characteristics and building shell extension, density and block orientation.

INTRODUCTION

Radar imaging has been used for a couple of decades in geology. SAR (Synthetic Aperture Radar) is sensitive in topography, in many cases even more than optical instruments with the same spatial resolution. Moreover, radar is unique as the produced images are valuable for regional landform studies, especially if the variations in landform units are manifested in terms of differences in surface roughness, relief, vegetation, soil type, soil moisture, drainage etc. [1]. The SIR-C provides increased capability over other previous Radar systems by acquiring digital images simultaneously at two microwave wavelengths L-band = 23.5 cm and C-band = 5.8 cm. These vertically and horizontally polarized transmitted waves are received on two separate channels, so that SIR-C provides images of the magnitude of radar backscatter for four polarization combinations: HH (horizontally transmitted – horizontally received), VV (vertically transmitted, vertically received) named like-polarized, HV and VH named cross-polarized [2]. This study describes the investigations that have been conducted for flood risk assessment in urban areas using SIR-C/X-SAR data. Athens basin is a densely populated area with about four millions habitants that is affected, very often, during winter season by destroying floods. The phenomena of flooding occur especially in the margins of the urban areas very close to the slopes of the surrounding mountains as in the case of Piraeus on 9/8/96, in Glyfada and Voula on 27-28/10/97 and recently in Ilion on 25-26/3/98.

PHYSICAL PARAMETERS OF URBAN FLOOD RISK

Reference [3] describes three groups of interrelated factors constituted important flood characteristics: the transient phenomena including the most common cause of flooding which is the heavy precipitation [4], the second group is relative with the basin characteristics, drainage network and channel characteristics (geometry, slope etc.), and finally there is a clear relationship between urbanization and changes in the unit hydrograph [5]. According to [6] and [7] the flooding events in urban areas seem to be increased and became more destroyed mainly because of:

(i) Forcedly constraint of the streambeds at the urbanized areas due to uncontrolled urbanization.
(ii) The barring of the streambeds either by buildings or by debris, especially where failed technical constructions have been made.
(iii) The forest fires and the loss of trees, in general, taking place inside the watersheds around an urban area
(iv) The decrease of the infiltration along with the increase of surfacial run off as a result of the urbanization.
(v) The failure in the constructed flood technical works that are not compatible with the environment and in general with the geodynamic settings that take part around the particular area.

SITE DESCRIPTION

Generally the study area is a graben of NE-SW direction that is located between the mountains of Aegaleo in western, Parnis in the northern, Penteli in the northeastern and Hymettus in eastern. As far as geology, Attica is composed of Alpine formations and Neogene and Quaternary deposits. Reference [8] divides the Pre-Neogene formations in autochthonous unit, Neohellenic tectonic nappe and the Pelagonian zone. Reference [9] recognized four units that are

Almyropotamos, Attica, Laurium and Sub-Pelagonian. According to [10] the first three formations belong to Attic-Cycladic zone. The expansion of Athens city during the last three decades contributes to the sprawl building of the slopes facing the basin and this expansion in synergy with the fires produce a high-risk environment.

DATA USED DESCRIPTION AND PROCESSING

The space radar images of the study area was acquired by the Spaceborn Imaging Radar-C/X-band Synthetic Aperture Radar on 2 October of 1994 on board the Space Shuttle Endeavour during the mission STS-68 30-9/11-10/1994. The different radar frequencies and polarizations recorded during this flight over Athens and used in this study are:

(i) L-band: horizontally transmitted and received
(ii) L-band: horizontally transmitted and vertically received
(iii) C-band: horizontally transmitted and received

The image covers an area of 45 kilometers by 45 kilometers and is centered at 37^0.9 degrees north latitude, 23^0.7 degrees east longitude.

In order to reduce the speckle and enhance the image interpretation we test by applying two different filters to the images. The first one was the Sigma filter with a 5*5 kernel size using Imagine of ERDAS software and the second one Enhanced Lee adaptive filter [11] with 7*7 kernel size using Radarsoft of PCI software. In the Sigma filter the central pixel is replaced by the average of all pixels within the moving window (5*5) that fall within a defined range about the center pixel.

DN (Digital Number) = center pixel +/- sigma

Sigma is statistically one standard deviation. An initial average value of 0.15 is set but multiplicated by 2. The Enhanced Lee filter is primarily used on radar data to remove high frequency noise while preserving high frequency features (edges). In the two slightly different products a linear and a non-linear stretching have been applied in order to enhance the image acquiring the full range of gray levels after the filter application.

DATA ANALYSIS AND INTERPRETATION

Using the three bands, L-band HV, C-band HH and L-band HH, a false color composite image has been created as RGB as well as each band separately were taken in consideration. The two images of L-band present belts of noise in the sea area but particularly the cross-polarized L-band HV presents a periodical noise also in the continental part. The information capture by the above data for the main parameters of flood risk could be summarized in the following delineations:

Land use

The land use types are well defined by the FCC radar image (fig. 1). In the image the natural vegetation is presenting by the reddish colors (high backscattering of the L-band HV signal) passing to magenta color (high back-scattering of the L-band HH and L-band HV signals) and locally bluish colors are found, caused by a high back-scattering of L-band HH. The reddish colors present open scrub vegetation while the blue zones is dense forest. The green areas (high backscattering signal from C-band HH) on the image represent a land cover type from bare rocks and soils to low and open scrub. In the urban area cyan color (high backscattering from C-band HH and L-band HH) represents zones of densely constructed and/or with a high coefficient of construction (higher buildings). Small patches in the urban area of various geometry of green or magenta color correspond to small hills. Important and innovative information regards the build up shell in Athens metropolitan area and concerns to the density and height of the buildings represented with cyan color (information provided by the like polarized bands). After a detail examination of these cyan areas (the corresponding building blocks have been digitized) we noted some of these didn't correspond to dense and high buildings but the strong backscattering is due to the orientation of the building blocks which is perpendicular to the direction of the radar signal. The urban road network and the human features are better recorded in Lband-HV

Topography

The sensitivity of the radar to relief offers an opportunity for the exploration of the slopes surrounding Athens basin. Observing the three bands separately we deduced that Lband-HH (fig. 2) and Cband-HH (fig. 3) (generally the Cband-HH has an homogenous aspect in gray values both in flat and high relief areas) provide most of the information regarding the topography. The characteristics of the slopes, surrounding the city of Athens, like gradient, length, profile, microrelief in many cases could be recognized. The Lband-HV (fig.4) shows high backscattering signal in the high relief areas and along the slopes (very bright pixels), a characteristic that mask the relief detection.

Hydrology

The drainage network is better inferred from the like polarized C and L band. The drainage system in the basin is very simple with streams running parallel to the maximum dip of slopes. In many cases it is possible to have information about channel characteristics like geometry and slope as well as the barring of the streambeds either by buildings or by garbage debris. In the case of C band the collected information about stream and erosional patterns is given indirectly creating a representation of the surface by imaging variations in the heights of treetops, because the local geomorphology is mimicked in the tree canopy. To the skilled interpreter, radar imagery creates an image as though the forest cover is removed.

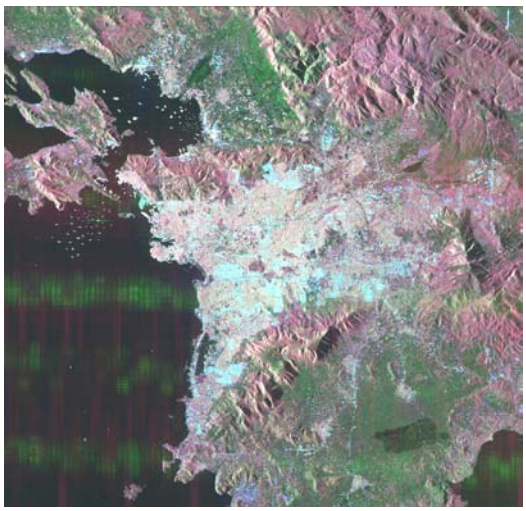

Fig. 1

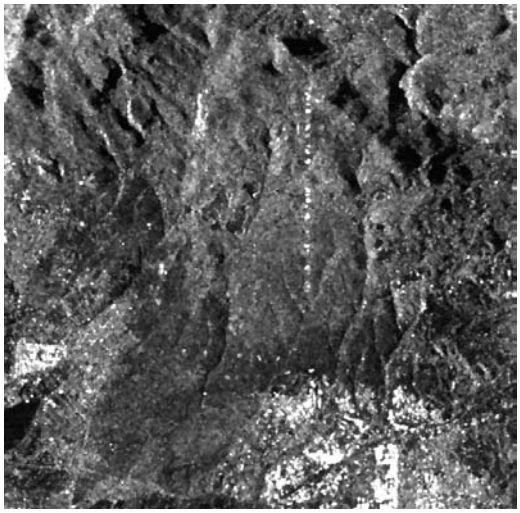

Fig. 2

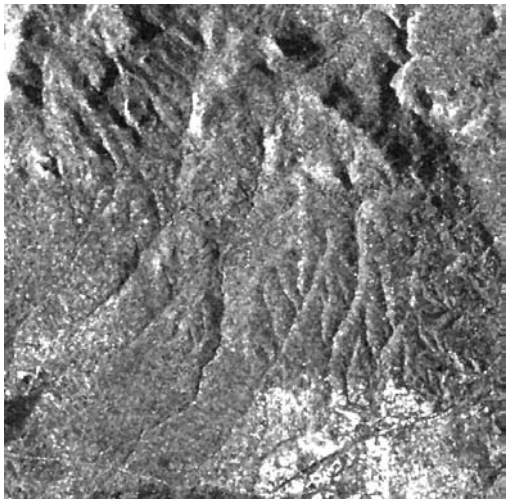

Fig. 3

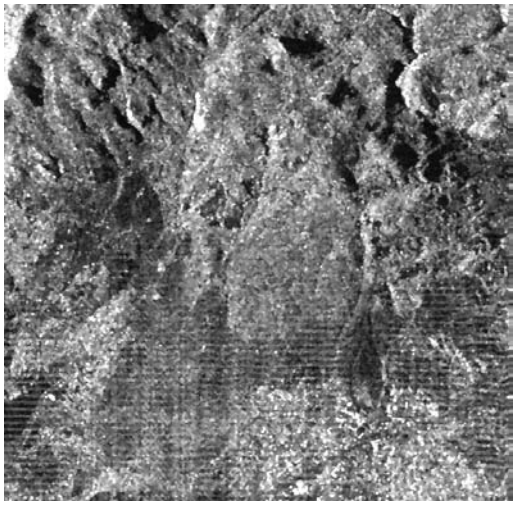

Fig. 4

REFERENCES

[1] R.P. Gupta, "Remote Sensing Geology", Springer-Verlag, Berlin, p. 356., 1991.

[2] R.L Jordan., B.L. Huneycutt and M. Werner, "The SIR-C/X-SAR Synthetic Aperture Radar system", IEEE Trans. Geosc. Remote Sensing, 33(4), p. 829-839, 1995.

[3] R.U. Cooke and J.C. Doornkamp, "Geomorphology in environmental managemen,.Clarendon Press, Oxford, p. 410, 1990.

[4] R.G. Barry and R.J. Chorley, "Atmosphere, Weather and Climate", Methuen, London, 1982.

[5] G.E. Hollis, "Man's impact on the hydrology cycle in the UK", Geobooks, Norwich UK, 1979.

[6] D. Alexander, "Natural Disasters", UCL Press, London, p. 632, 1993.

[7] E. Lekkas, "Natural and Technological Disasters", Access Publ., Athens, p. 278, 1996.

[8] G. Katsikatsos, G. Migiros, M. Triantaphyllis and A. Mettos, "Geological structure of Internal Hellenides (E. Thessaly-SW, Macedonia – Euboea – Attica - Northern Cyclades islands and Lesvos", IGME, Geol. & Geoph. Res., Special Issue, p. 191-212, 1986.

[9] D. Papanikolaou, "Are the Medial Crystalline Massifs of the Eastern Mediterranean drift Gondwanian fragments?", Geological Soc. Of Greece, Sp. Pub., No 1, 1989.

[10] D. Mountrakis, E. Sapountzis, A. Kilias, G. Elefteriadis & G. Christofides, "Paleogeographic conditions in the western pelagonian margin in Greece during the initial rifting of the continental area", Canadian journal of Earth Sciences, 20, p. 1673-1681, 1983.

[11] A. Lopes, E. Nezry, R. Touzi and H. Laur, "Structure detection and statistical adaptive speckle filtering in SAR images", International Journal of Remote Sensing, vol. 14, n. 9, p. 1735-1758, 1993.