Extraction of Digital Elevation Models from Aster Images in the Ecuador's Southern Highlands.

Fernando Oñate-Valdivieso

***Abstract*—It is a higher important question to have a digital elevation model (DEM) in diverse branches of the science because, starting from it, can be extracted a series of indispensable morphological variables. The generation of elevation models can be carried out applying a series of methodologies according to the available information base. The ASTER images offers a tri-dimensional view of a portion of land allow a very efficient generation of digital elevation models among others capacities. The present work describes the process for the generation of a DEM starting from ASTER images, in a mountainous area in southern Ecuador, and its validation with currently available cartography of the area.**

Index Terms—**ASTER, DEM extraction.**

I. INTRODUCTION

A digital elevation model (DEM) is a simplified representation of a variable measured on a tri dimensional wavy surface [1]. Two of those dimensions refers to the rectangular axes X and Y and the third one measure the height, Z of the thematic variable represented in each point of the space [1].

A DEM can be used to represent precipitations, temperature, mineral composition of a ground data, and so on. But it's most usual application is the representation of a land portion, the called "digital terrain model" (DTM).

A DEM has diverse applications as for example: to automatically define hydrographical basins, to calculate their main geo morphological characteristics, to calculate the slope and the orientation of the land, to define flood plains, to perform corrections of the topographical effect on satellite images, to define visual basins for telecommunications, among others.

There are diverse ways to obtain a DEM, either applying interpolation of punctual data, from digitalized level curves, from stereoscopic pairs on air photographs or satellite images or even from radar images applying interferometry.

In the present study there are processed ASTER images for the generation of a digital elevation model that will allows the acquiring of base cartographic information.

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II. MATERIALS AND METHODS

The Advanced Space Borne Thermal Emission and Reflection Radiometer (ASTER) is an orbital observation system in operation since 1999 as a result of the cooperation between NASA, the Ministry of Economy, METI and ERSDAC from Japan, and its fundamental purpose is the monitoring of phenomena related to the environment and the exploitation of natural resources. It is also part of the EOS (Earth Observing System).

The covering of an ASTER scene is 61.5 Km from 63.0 Km. The ASTER images capture information in 15 bands of the electromagnetic spectrum: four in the visible and the near infrared regions (VNIR, 0.5-1.0 um) with a space resolution of 15 m; six in the Infrared short wave region (SWIR, 1.0-2.5 um) with 30 m of space resolution, and five in the thermal infrared region (TIR, 8-12 um) with a 90 m space resolution.

In the VNIR, ASTER images possess a view in the nadir (3N band, 0.76-0.86 um) and a backward-looking (3B band, 27.7º of the nadir) that allows to have a stereoscopic view of a determined region in the direction of the satellite flight. The temporary difference between two observations is 55 seconds, so the variations in optic and atmospheric conditions are minimum, Therefore it could be expected an excellent correlation in the images. The precision of a DEM generated from an ASTER image ASTER lays in the order from ±7 to ±50 m [2].

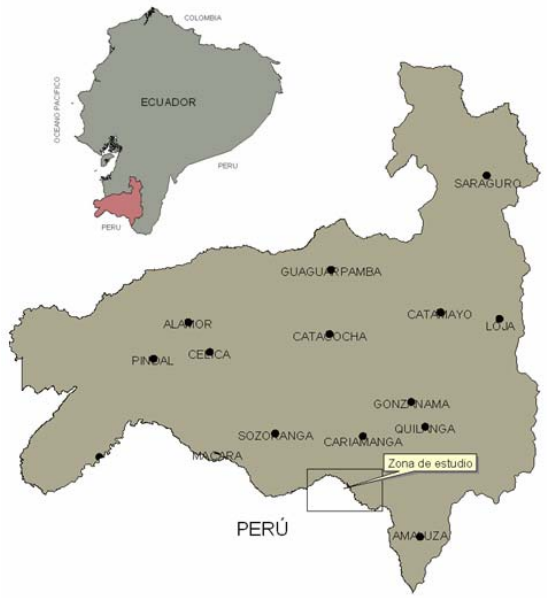

Fig. 1. Location of the study area

In the present study was used an 1B level ASTER image from March 31, 2001, taken on the Loja province, located in southern Republic of Ecuador, in the border area with Peru. The study area is between the coordinates (640094, 9519793 and (676902, 9498612). Weather conditions of the east portion of the Loja province causes the presence of a cloudy covering most of the year, so the acquisition of clear images is not the most frequent case. The used scene posses a 12% of cloud cover and will be used, in addition to the model development, to know the effect of the cloudy presences on the effective image potion.

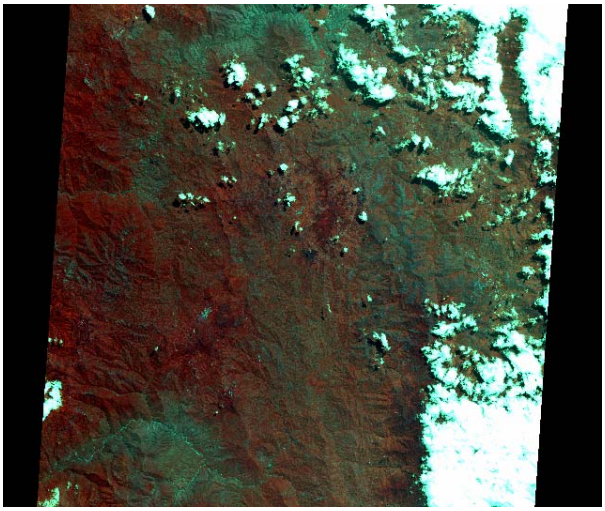

Fig. 2. Used ASTER scene.

For the DEM generation its been used 3N and 3B bands directly acquired to the software from the scene in HDF-EOS format. Then applying co linearity and co planarity models a bipolar pair of bipolar images is generated, such images keep altitude parallax in only one direction. The DEM is extracted through a comparison of their respective grey levels [2].

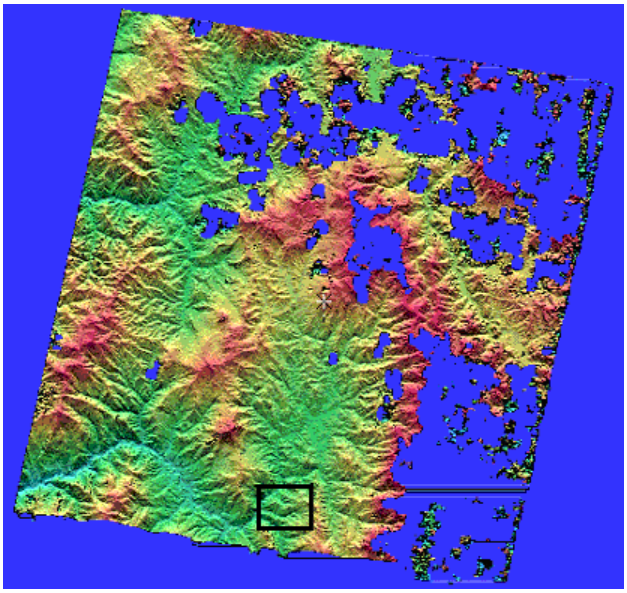

Fig. 3. Obtained DEM. The blue colour areas correspond to areas without information due to the presence of clouds. The area considered for validation is locked in a rectangle.

With the aim of improving the calculation pattern, 20 common points between the two images were located (Tie Points). It was not developed the taken of ground control points, so it was obtained a relative georeferented DEM based on orbital information of the image with a 30 m spatial resolution.

Having no availability of a reliable DEM of the area, for validation purposes, there were generated level curves from the DEM to compare them with 1:50 000 digital cartography format of the Military Geographical institute (IGM, 1980), such cartography was generated based on stereo graphic analogical photo restitution of pairs in aerial pictures.

The extraction process was carried out applying the PCI Geomatics 9.1.4 OrthoEngine module.

III. OBTAINED RESULTS

The obtained digital elevation model is shown in Figure 3 and the comparison between the level curves generated from the obtained DEM and those of the existent cartography are shown in the Figure 4. The derived variables of the obtained DEM (slope, orientation of the slope and flow lines) are shown in the figures 5, 6 and 7.

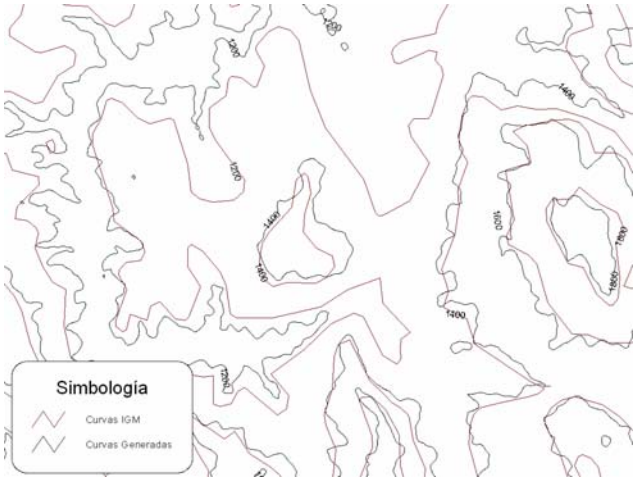

Fig. 4. Part of the comparison between generated level curves (blue) and the curves of the IGM (red).

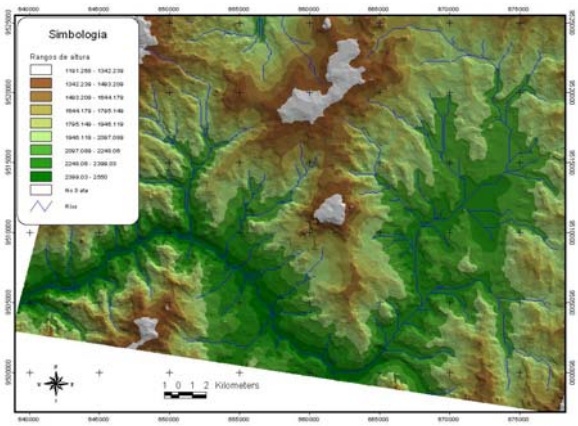

Fig. 5. Extracted DEM representing height ranges and generated flow lines.

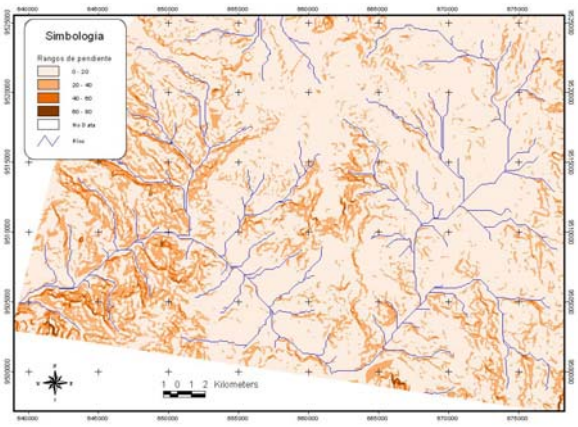

Fig. 6. Slope ranges.

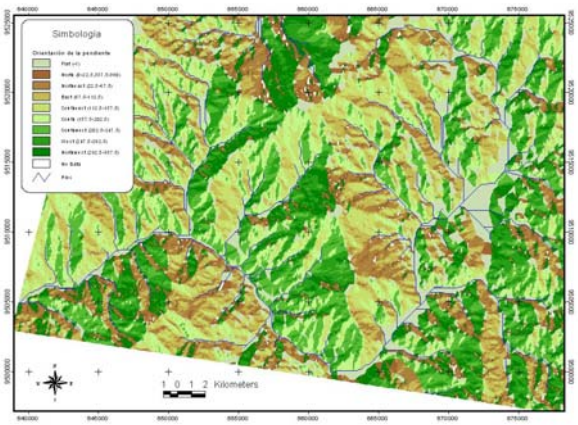

Fig. 7. Orientation of the slope.

IV. ANALYSIS OF RESULTS

In figure 4 it can be observed the high degree of correspondence, between the generated level curves and those corresponding to the already existent cartography. Although, is necessary to highlight the accuracy achieved by the curves generated from the DEM from the ASTER images. The presence of clouds impedes the full use of the image, since the area without information is almost twice in the DEM generated as result of the lack of correspondence between the images in such area produced by the clouds and their shade. In the clear areas the extraction of the pattern is carried out in efficient form.

Several places where there was no correspondence between the existent topographical information and that derived from the pattern of digital elevation were observed. In such places there is a decrease of the contrast in the initial image, due to the sun heat, so that is possibly the cause of the errors.

The quality of the extracted DEM depends mainly on the quantity and overall on the quality of the collected Tie Points, since during the extraction process they were carried out several rehearsals that demonstrated the sensibility of the process on these information.

Regarding the altitudinal error that an extracted DEM from an ASTER image could present, the literature reports a variation range among 10 and 50m, that, in order scales between 1: 50 000 to 1: 100 000 are admissible.

The DEM derived information presents part of the geo morphological analysis capacities that it possesses.

V. CONCLUSIONS

The capture of stereoscopic images with the ASTER system reduces the radiometric variations that a stereo multi temporary pair presents, since contrary to these, the capture is performed in the same instant.

The errors of the extracted DEM are not only due to the presence of clouds, but they can take place for coherence errors between the two considered bands, since the solar exhibition can reduce the pixel to pixel contrast in an image, generating them.

The generated pattern presents a good accuracy level and a correspondence with the existent cartography, what evidences the extraction capacity that the ASTER images allow, those, because of their good space resolution (15 m in the VNIR) provide great detail in the obtained products. The automation of the extraction processes that simplifies the procedure execution as well as the low costs of the images, are factors that transform this technology into a very good alternative to generate cartography at a half scale (1: 50 000) size.

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