Paper presented at the 22nd Asian Conference on Remote Sensing, 5 - 9 November 2001, Singapore.

PROFILING OF MAJOR RIVER SYSTEMS AROUND MAYON VOLCANO USING AIRSAR IMAGES

Rowena B. QUIAMBAO, Ronnie C. Torres
Philippine Institute of Volcanology & Seismology
C.P. Garcia Street, University of the Philippines Campus
Diliman, Quezon City 1101
PHILIPPINES
T: (632) 426 14 68 to 79
F: (632) 920 70 58, 927 45 24
weng@phivolcs.dost.gov.ph

KEY WORDS: river channels, manual method, field-derived method, longitudinal profile, remote sensing

ABSTRACT: Profile data across major river systems around a volcano was generated. Major river channels around Mayon Volcano (lat-long), Philippines were treated as the study area. This paper involves two component studies: the generation of transects across the major river channels around Mayon Volcano using radar image; and the comparative analysis of this procedure with the traditional (or non-remote sensing) methods.

Airborne Synthetic Aperture Radar (AIRSAR) images of Mayon Volcano were processed using the software Environment for Visualizing Images (ENVI, version 3.1). The profiling module of ENVI was used to obtain depth values across the major river channels around Mayon Volcano. The Digital Elevation Model file of Mayon AIRSAR derived from the C-band file was used. This profile data set based on radar image was correlated, compared, and analyzed with the manual profiling and the field-derived methods.

Using the latest topographic map of Mayon Volcano area, profiling of the major river channels around it was calculated. This is the second data set. It involved the projection of points around the river channel across the elevation line to determine the depth pattern. This will be referred to as the manual profiling method. Finally, the third data set is the field-derived procedure of profiling across the river channels. This method relies on actual measurements of distance, elevation, and angles in the field using the available measuring instruments.

Comparison of the techniques was made in terms of the accuracy, costing, amount of time involved, availability of resources, among others.

The profiling from radar images could be done on a regular basis, depending on the availability of the AIRSAR images. Setting aside this constraint, a trend could be established after a regular profiling is done. After a certain number of profiles have been generated, a regularity (or irregularity) of the cross-section of the river channels could be established. This could fit into a modeling scheme of the river system in terms of its transect.

1. INTRODUCTION

Profiles of river channels give data on its length, width, and depth. Measurements along and across the river system could have varying intervals.

For river channels within the vicinity of an active volcano, volcanic products could be deposited when an explosion occurs. Measurements derived from river profiles could then give the amount of volcanic deposits in the channel. Thus, it could result to the mapping out of areas vulnerable to encroachment of the volcanic products. Examples would be river channels with pyroclastic flow deposits being highly susceptible to lahar encroachment.

For this study, there are three data sets used: the Airborne Synthetic Aperture Radar (AIRSAR) image data, topographic maps, and field data measurements. Correspondingly, these data sets were processed, analyzed, and/or acquired using the remote sensing software Environment for Visualizing Images (ENVI, version 3.1), Excel software, and readings from handheld Global Positioning System (GPS) units, range finder, measuring tape, altimeter, clinometer, and Brunton compass.

Three profiling methods are considered in this study, namely: profiling/transect module of the ENVI software; manual profiling with the use of topographic maps; and profiling based on measurements derived from the field. As output, all three methods produce the longitudinal profile of the river channels.

2. THE DATA SETS

For this research, the data sets of Mayon Volcano and vicinity used were as follows: AIRSAR images; 1:33,000 and 1:50,000 scale topographic maps; and internal reports on field-derived profiles of river systems around the volcano.

2.1 AIRSAR IMAGES and ENVI

There are two AIRSAR image strips taken in 1996 that comprise the aerial flight in the Mayon Volcano area. Within the study area for Mayon Volcano, the two strips comprise the following latitude-longitude extent based on the header files of the images: 12°55´37.7″-13°28´34.75″N latitude and 123°21´49.9″-123°55´32.9″E longitude. Transect of the image could be done in the Digital Elevation Model (DEM) image of AIRSAR data since the elevation value of the topographic surface is correctly included. The DEM image was derived from the C-band file of the AIRSAR image.

2.2 Topographic Maps

The 1:33,000 topographic map covers the extent of 13°07´-13°23´30″N latitude and 123°30´-123°48´E longitude. It is a one-sheet map. There are two 1:50,000 topographic map sheets covering the study area. The coverage of the two maps combined is 13°10´-13°20´N latitude and 123°30´-124°E longitude.

2.3 Internal Profile Reports

Fieldwork reports on the profiling of major river channels around Mayon Volcano were used (see references). These internal reports contain graphs of the river profile: cross-section and longitudinal.

3. THE PROFILING METHODS

Comparative analysis of profiling methods of river channels around a volcano was one of the major aspects of this research. There were three approaches to generate the spatial profile of major river channels used: 1) processing of the AIRSAR images using the RS software ENVI; 2) manual profiling of river channels using the available topographic maps; and 3) profile generation based on actual field measurements.

Initial assessment of the available data and information led to the decision to select the major river channels taken profile graphs. The controlling factors considered were as follows: 1) what river channels were actually taken field measurements; and 2) among these, which ones could be identified and seen in the AIRSAR images.

3.1 Transect Module of ENVI

Arbitrary transect of the C-DEM AIRSAR image was made using ENVI. With the aid of the topographic model of the image, arbitrary points along the river channel was selected as measurement points comprising the profile. The topographic model was also derived from the C-DEM AIRSAR image using ENVI as well. By clicking on the points traversing the river channel, a transect line was generated resulting into the spatial profile graph. Basing on the plot of the GPS points derived from the field, points along the river channel in the C-DEM image were chosen. ENVI generates an automatic spatial profile graph based on the points selected.

3.2 Manual Plot of the Profile

The 1:50,000 topographic map was used to plot the profile of the river channels. This method involved projection of the points along the river channel intersecting with the contour line onto an X-Y plane parallel to the river channel. This results into an X-Y profile of the river channel by following the intersection points of the projection lines (lying along the x-axis) and the contour intervals (lying along the y-axis). Using appropriate intervals, the points were plotted using the Excel software.

3.3 Field Measurement of River Profile

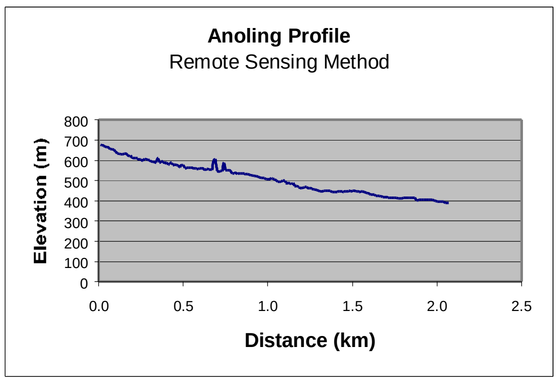
Parameters such as length, width, and elevation levels of the river channels as well as angles of river bends and curves were measured from the field. These data were gathered using measuring devices such as the handheld GPS units, range finder, measuring tape, altimeter, clinometer, and Brunton compass.

Excel software was also used to plot the distance traversed along the river channel and the elevation of the points from the GPS readings to generate the spatial profile of the river.

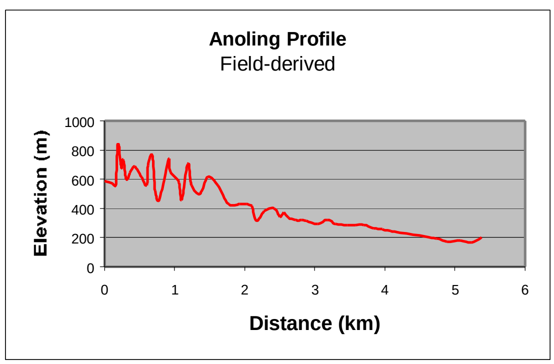
This data set could only be reproduced in this paper, as the actual data derived from the field could not be used. For this reason, the points in the profile could only be approximated based on the graph of the river profile, with the graph taken from the original report of the abovementioned fieldwork.

3.4 The Profile Output

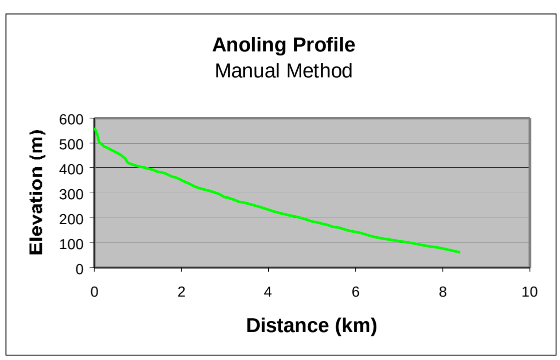
A total of eight (8) river channels are included for this study. Considering that some of the river channels around Mayon Volcano, which were taken measurements in the field, could not be identified in the AIRSAR images, and vice versa, only these eight (8) river channels were included in this research. Longitudinal profiles of two river channels are shown in this paper, the Anoling and Mi-isi Channels. The three profiles for each of these two river channels – transect using ENVI, manual profile, and the field-based profile – are illustrated in Figures 1 and 2.



a.



b.



c.

Figure 1. Longitudinal profiles of Anoling Channel, Mayon Volcano, Philippines using a) remote sensing data and software; b) measurements from the field; and c) manual method.

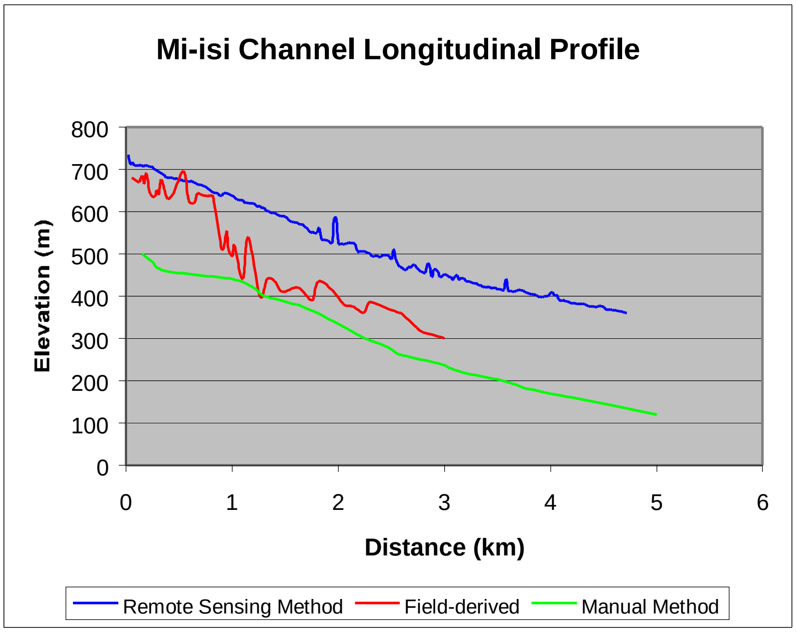


Figure 2. Combined longitudinal profile of Mi-isi Channel, Mayon Volcano, Philippines using three methods: remote sensing, field measurements, and manual.

4. DISCUSSION OF RESULTS

Illustratively, the trend of all three graphs for each of the river channels are in agreement with each other. In other words, whatever is the profiling method used, it results to similar profile trend line. This conclusion is highly remarkable in the agreement of the profile trends between the transects using the remote sensing method (data and tools) and using the field measurements. Discrepancy in the high and low points along the profile between the two could be very well accounted for by the time difference of the two data sets – the AIRSAR data being taken in 1996 and the field measurements being made in 2000.

Obviously, the manual profile could not be compared in detail with any of the two other profiles as these are based on circa 1956 1:50,000 topographic maps (reprinted May 1990). Regardless of the time element, the manual profile method still, however, shows similar trend in the profile of the river channels.

For all the channels considered in this study, the three profiles for each of them all follow the same trend line. Because of this generality, the three profiling methods are concluded to be comparable with each other. Detailed differences of the three methods could be attributed primarily to the time element. Owing to the time difference between each data set, the actual high and low points along the traverse line could also vary with one another.

Aside from the time element, these other factors and generalizations could be made on the three profiling methods:

1) **Spatial profile of the river channel is fastest to obtain using the remote sensing method.**
   Starting from the point when all the other data needed is on hand, using the ENVI software to generate the spatial profile of the AIRSAR image is the fastest since it is just a "point-and-click" away, in the computer that is. Whereas, for the manual method and the field-derived method, the actual point to be graphed will first be located in the topographic map and then later on be put in Excel to generate the spatial profile.

2) **Manual profiling of the river channel using topographic map is the cheapest.**
   This is very true since for manual profiling the materials needed are just the topographic maps, some papers, pen, and straight rule. For the field measurement, instruments such as the handheld GPS, range finder, measuring tape, altimeter, clinometer, and Brunton compass are needed. While for the RS method, the digital copy of the image is required. Assuming that the computer software and hardware needed to process and/or analyze the data for all the three methods are equal, then the cost of materials needed is cheapest for the manual method.

3) **Actuality of the spatial profile is best obtained from field measurements.**
The high points, elevation drops, and flat terrains along the river profiles are best derived from actual field measurements. These are data actually taken from the field, while the profile from the RS and manual methods are image-dependent and topographic map-dependent, respectively. For the three methods, human error factors such as measuring bias and inaccuracy are all regarded equal.

4) **Of the three methods, measurement in the field poses the most danger in obtaining the data.**
Accessibility of the river channels, especially within the vicinity of an active volcano, makes this method the most difficult and dangerous to obtain the river profile.

5. CONCLUSIONS

Three methods to generate spatial profile of river channels around Mayon Volcano were found to be comparable with each other. The spatial profiles were found to follow similar trend lines for each of the river channels. These three methods are 1) transect generation using remote sensing image and software; 2) profiling using field measurements; and 3) manual profiling using topographic maps.

The RS method is the fastest way to obtain spatial profile; the manual method is the cheapest; while field measurement gives the more actual spatial profile. However, measurement in the field is also the most dangerous of the three methods.

6. REFERENCES

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