ESTIMATION OF DISCHARGE OF AMAZON RIVER AND ITS BRANCHES FROM JERS-1 SAR IMAGES

Kyoichiro KATABIRA*

Susumu OGAWA*

Takako SAKURAI**

Mikio TAKAGI**

*Faculty of Geo-Environmental Science, Rissho University

1700 Magedhi, Kumagaya, Saitama 360-0194 JAPAN

Tel:(81)-48-539-1652 Fax:(81)-48-539-1632

E-mail: 001w00115@ris.ac.jp

**Dept. of Applied Electronics, Science University of Tokyo

JAPAN

KEY WORDS: image processing, enhanced filter, river geomorphology, discharge, SAR

ABSTRACT: We visualized some traces of the Amazon River and its branches, which were not found in the original SAR, images with the SFP and enhanced SFP filters. We extracted the characteristic of the river shapes such as a meandering wavelength or the amplitude with Fourier analysis. Next, we compared the quantity of characteristic of the river shapes with the existing discharge data, and obtained some regression equations. Finally, we estimated the discharge of the Amazon River and its branches from the SAR images, which were independent of the weather.

1. INTRODUCTION

The JERS-1 SAR image, which we used in this study, is all weather type sensor, and suited for observation of tropical rain forest of the Amazon. This study, by using some strong scatters lining up intermittently, a few hundred meters apart, observed to being on the riverside in this tropical rain forest, we visualized some thin rivers which were not found in the original SAR images. By this technique, it did not affect an image of low resolution of 200m and the thin river traces could be regard as "the bright characteristic". Besides, it was clear that the width of a river became large to 200m. In this visualized river, we extracted the quantity of characteristic of the river shapes: the meandering wavelength, amplitude, and width of river. Furthermore, we extracted the meandering wavelength with Fourier analysis. As a result, we found a good correlation among the quantities of characteristic of the river shapes, the quantitative value that was calculated by Fourier analysis, and the discharge of the Amazon River. By this technique, we estimated the discharge of the Amazon River and its branches from the SAR images independent of the weather.

2. METHODS

2-1. DATA

(a) Satellite data: We used 7 scenes of Level 2.1, 4-look JERS-1 SAR data of a tropical rain forest of the Amazon: Path=415, Row=306, 316, 318, 319 observed on March 31, 1997; Path=416, Row=315 observed on April 1, 1997; Path=419, Row=315 observed on April 4, 1997; Path=414, Row=306 observed on June 26, 1997. (Fig.1)

(b) Hydrological data: Monthly discharge data at Manaus of the Amazon River, Porto Velho of the Madeira River, and Tabajara and Ji-Parana of the Jiparana River (Table.1). But we used the mean of discharge at Porto Velho and Tabajara. On the other hand, we converted the discharge of Manaus by the basin area ratio using a Hack's rule from discharge data at Obidos.

$$L = aA^{0.6} \qquad (1)$$

2-2. Extract the quantity of characteristic of the river shapes and Fourier analysis

First, in order to remove speckle noise of the original SAR images, we used the SFP (Small Feature Preserving) filter and the enhanced SFP filter, and integrated two images. By this technique, small feature was remained, while the noise was removed. Next, we emphasized difference of surroundings in order to extract a thin river from the bright characteristic. We prepared a 5 by 5 window, and calculated the sum of the absolute difference between a center pixel and the surrounding pixel values. By moving the sum value in the center pixel, we emphasized isolated string scatters. Then, we visualized the thin river, where the width of a river was around 20m, from the bright characteristic (Fig.2.1-2.5).

Next, we extracted the characteristic quantity of the river shapes: the meandering wavelength, amplitude, and width of a river (Fig.3.1-3.3). This method is that tied up the corners of the meandering of river shapes in neighborhood of measurement points of river discharge, and we calculated some means in length of the line and a wavelength of the river. In addition, I took down a perpendicular line from one corner to the line, which tied up corners of the front and back and calculated some average amplitude of the river. And about the large river with the width of more than 200m, we measured the width of the river to put about 1km and we calculated the average width of the river.

Furthermore, in the image that visualized river shapes, we binalized it (Fig.5) and carried out two-dimensional Fourier conversion (Fig.6). In a provided image, we extracted some periodical stripes and measured the number of pixel of their width and calculated the average (Fig.7). Because periodical stripes from each stripe corresponding to a half wavelength of a river, we measured two striped intervals by the number of pixel. For true distance of the original image width, we multiplied reciprocal number of provided average pixel and obtained the value of a meandering wavelength. A unit is 200m for 1 pixel. For quantitative data provided by this method, we compared the existing data in real river discharge and calculated regression equations.

3. RESULTS

We found a good correlation between the discharge of the Amazon River and the characteristic of river geo morphology: the extracted meandering wavelength, amplitude, and width of river. The wavelength was also calculated by Fourier analysis (Table.2). By this method, the following regression equations were obtained for river discharge, Q (m^3/s), meandering wavelength, ? (m), amplitude, A (m), and width of river, B (m).

$$\lambda = 136B^{0.69} \qquad (R^2 = 0.98) \qquad (2)$$

$$A = 0.083\lambda^{1.12} \qquad (R^2 = 0.96) \qquad (3)$$

$$Q = 0.0004A^{2.17} \qquad (R^2 = 0.99) \qquad (4)$$

$$Q = 0.17B^{1.75} \qquad (R^2 = 0.997) \qquad (5)$$

$$Q = 0.000001\lambda^{2.48} \qquad (R^2 = 0.99) \qquad (6)$$

The meandering wavelength of river calculated by Fourier analysis became the following value.
The average pixel numbers of an interval of the stripe in a Fourier conversion image at Tabajara (Path=416, Row=315) in the Jiparana River = 13.728 (pixels)

$$400 \times \frac{1}{13.728} = 29.138\ (pixels)$$

$$\lambda = 29.138 \times 200 = 5827.5\ (m)$$

4. DISCUSSION

We analyzed the SAR images about 7 scenes observed in 1997, and found out characteristic of river geomorphology and discharge of the Amazon River correlated well. However, in visualizing a thin river, where the width of the river is about 20m, by processing to emphasize a difference of surroundings, the width of a thin river is not suited as a quantity of characteristic because of an error of approximately 200m.
Besides, it is hard to think about a big change of quantity of characteristic to estimate such a small change as a season change of the discharge. However, we can estimate the minute change that coped with a seasonal change if we take precipitation data, branch length, the number of branches, brightness of a river and a basin area into account. Moreover, meandering wavelength calculated by Fourier analysis is near to a value measured by a manual way. Therefore, it is also an effective method to estimate river discharge.

REFERENCES

1) Takako Sakurai-Amano, Joji Iisaka, and Mikio Takagi, Detection of narrow open-water channels from JERS-1 SAR images of Amazon forests, Proc. of SPIE's Second International Asia-Pacific Symposium on Remote Sensing of the Atmosphere, Environment, and Space, pp.120-130. October 2000, Sendai, Japan.

2) Sakurai, *et al.*, A year change and monthly division precipitation of a river in the Amazon forest, japan Soc.of photgrammetry andRemote Senseng, Toyama, 2001

3) Kouji Ishida, A quantity of water change and monthly division precipitation of a river in the Amazon forest observed with JERS-1 SAR, Science University of Tokyo, A master's thesis, 2002

4) Shigemi Takagi, River Morphology, Kyoitu publication, 1974

Table.1 Monthly discharge data in each points

River name	Point name	Observation period
MADEIRA	Porto Velho	May, 1967 to Dec, 1979
AMAZON	Obidos	Jan, 1928 to Dec, 1983
JIPARANA	Tabajara	Jan, 1978 to Jun, 1988
JIPARANA	Ji-Parana	Jan, 1978 to May, 1997

Table.2 Quantity of characteristic of river shapes and estimated discharge

River (city)	Date	Wavelength λ(m)	Amplitude A (m)	Width of river B (m)	Discharge Q (m^3/s)
Jiparana river (TABAJARA)	April 1, 1997	5690	1456	273	2682
Jiparana river (JI-PARANA)	March 31, 1997	5576	1262	180	1709
Madeira river (PORTO VELHO)	April 4, 1997	18724	3746	1053	30400
Amazon river (MANAUS)	June 26, 1997	31239	10770	2635	174286

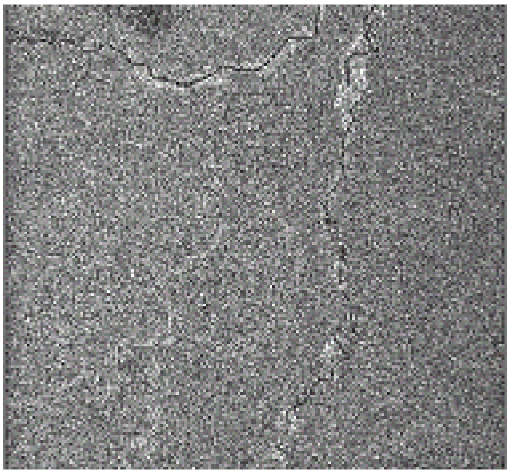

Fig.1 SAR original image, Tabajara (Path=415, Row=316)

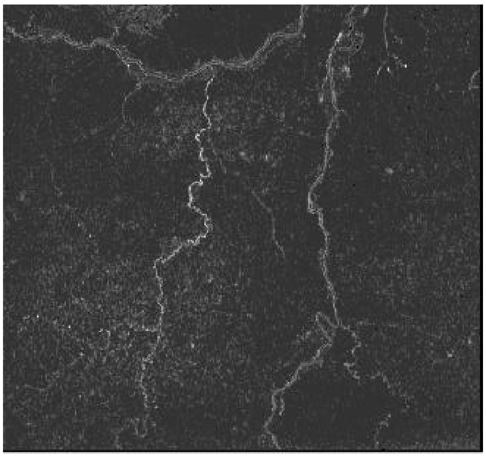

Fig.2-1 Tabajara (Path=415, Row=316)

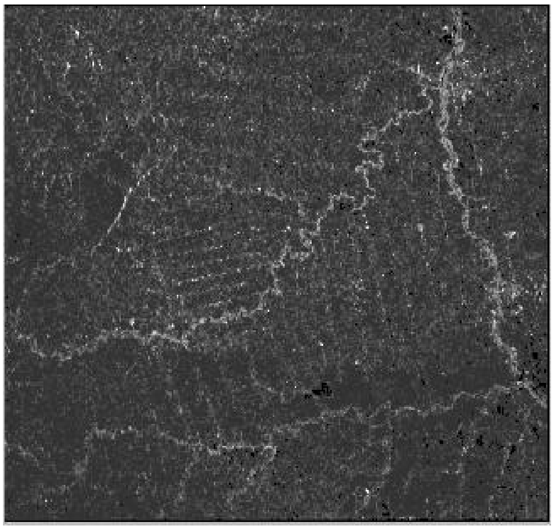

Fig.2-2 Ji-Parana (Path=415, Row=319)

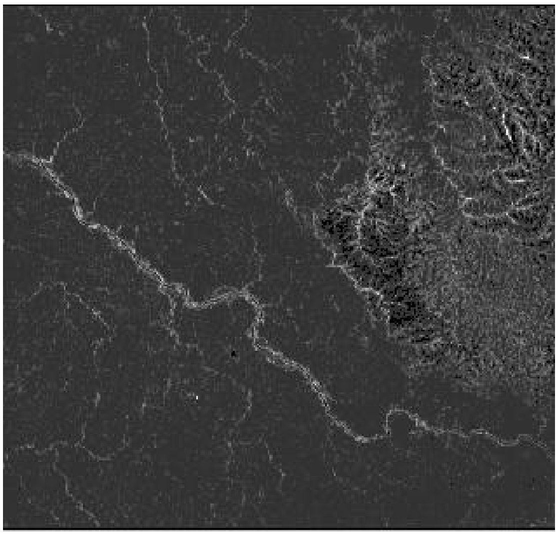

Fig.2-3 Tabajara (Path=416, Row=315)

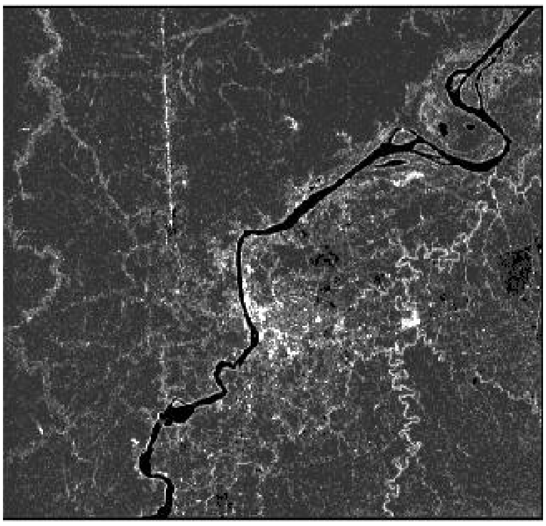

Fig.2-4 Porto Velho(Path=419, Row=315)

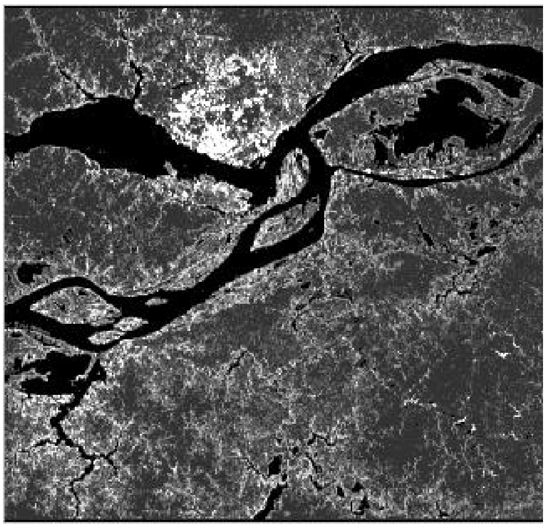

Fig.2-5 Manaus(Path=414, Row=306)

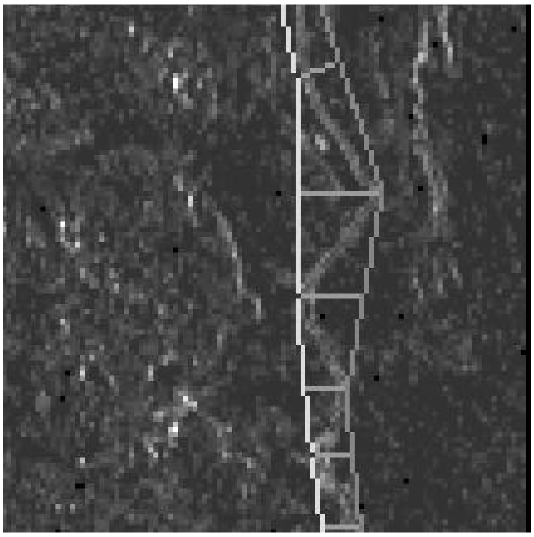

Fig.3-1 Characteristic of extraction image(Ji-Parana)

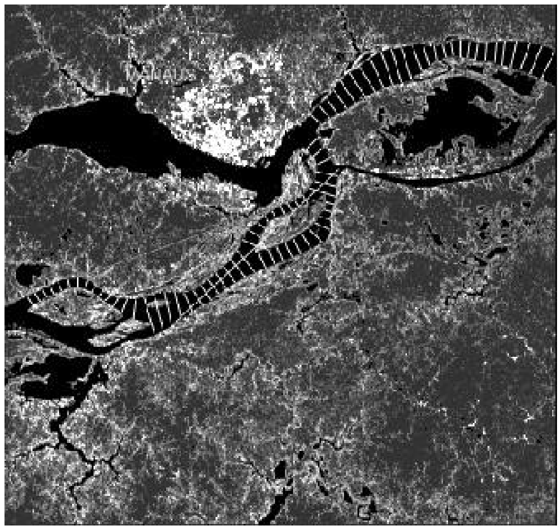

Fig.3-2 Characteristic of extraction image (Manaus)

Fig.3-3 Characteristic of extraction image (Porto Velho)

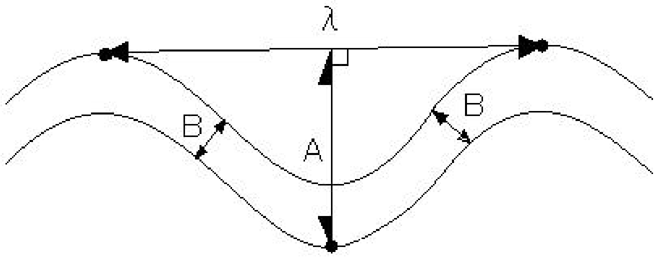

Fig.4 Method of extraction for river characteristic

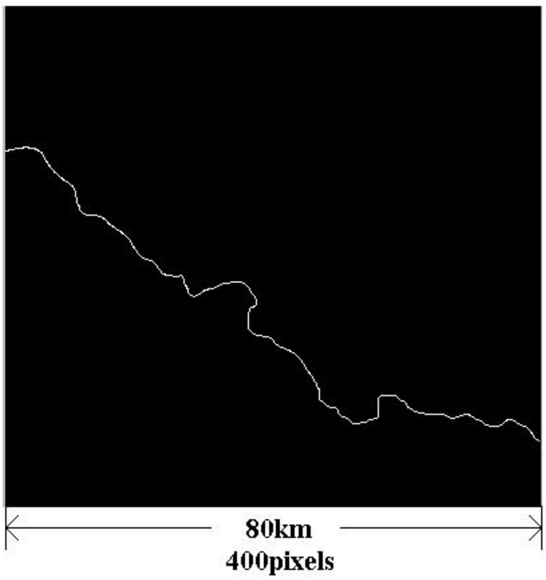

Fig.5 Tabajara (Path=416, Row=315)

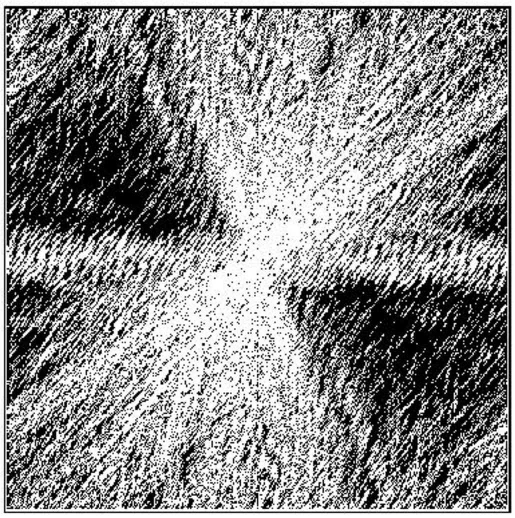

Fig.6 Two-dimensional Fourier image Binarized image

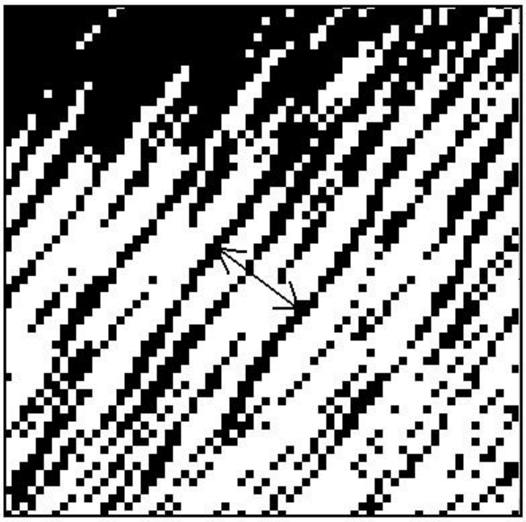

Fig.7 Enlarged image

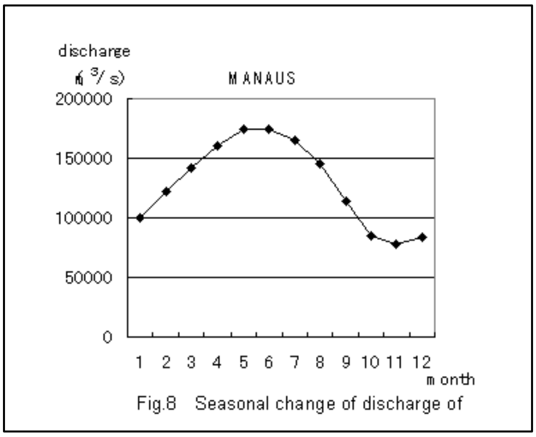

Fig.8 Seasonal change of discharge of the Amazon River

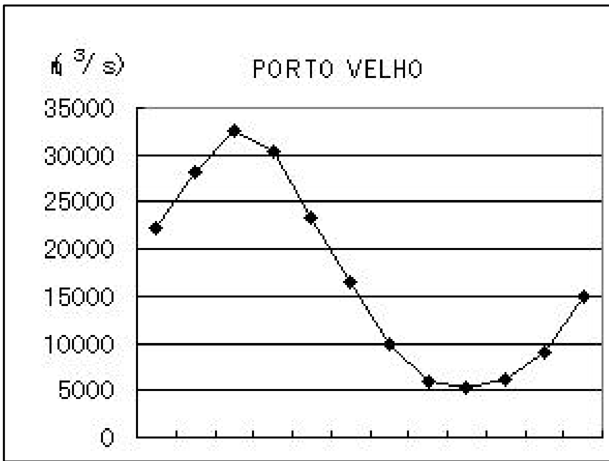

Fig.9 Seasonal change of discharge of the Madeira River

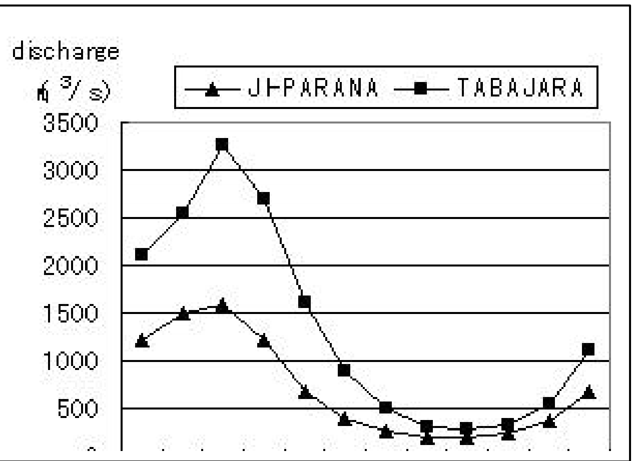

Fig.10 Seasonal change of dischargeof the Jiparana River