Analysis on sediment movements in a watershed by means of aircraft-mounted laser profiler

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1. Introduction

To cope with disasters due to sediment discharge, it is necessary to monitor the balance of sediment in a watershed identifying the mode of sediment transportation in both spatial and temporal dimensions.

The method so far employed to estimate the volume of sediment in a specific reach of a channel was to integrate the area of cross section at particular points along the channel. This method provides however an approximation of the volume of sediment by converting a two-dimensional value into a three-dimensional value. The accuracy of the data is therefore not always high enough.

The newly developed technology employing the airborne laser profiler (hereinafter called ALP) enable us to monitor the balance of sediment in a watershed in three dimensions precisely and efficiently.

This report introduces the analysis on the sediment balance employing ALP technology in Amahata river basin, the right branch of Hayakawa river in the Fuji river (Figure-1) basin in which sediment yield and associated sediment transportation are frequent and rampant.

Figure-1 Catchment Area of the Fuji River

2. Morphological survey employing ALP

The dimensions and performance of the device for the ALP are shown in the Table-1.

Table-1 Dimensions and Performance of the device for the ALP

Name of the ALP system	LASER BIRD Ⅱ
Operational altitude（m）	175～3,000m
Unit monitoring width	0.72×terrain clearance (m)（Max）
Pulse Frequency	25,000Hz/33,000Hz
Altitude Precision（1σ）	15cm（Altitude 1,000m）
Lateral Precision（1σ）	1/2,000×Altitude（m）
Camera	Color Digital Camera (4K×4K)

The ALP monitoring system consists mainly of laser distance meter and POS (position and orientation system). The function of laser distance meter is to scan ground surface by irradiating objects on the ground with a laser. A laser beam irradiated covers narrow swath which is called a foot print.

The position irradiated and the direction of a laser beam are monitored and recorded by the subsystem called POS which, as illustrated in Figure-2, consists of IMU (Inertial Measurement Unit) and GPS (Ground Positioning System).

Figure-2 ALP method

The Aircraft Laser Profiler provides three-dimensional data of ground surface by processing the data acquired by IMU and GPS. The size of the foot print is adjustable depending on variables such as flight velocity, flight height, laser irradiation frequency and scanning frequency. The preset conditions applied this time is as shown in Table-1. The precision of the products by the ALP operation this time is as good as the ones which could be acquired by manual ground survey. In order to avoid reduction in monitoring accuracy, a monitoring operation must be conducted operation in dry season in which lesser reflection of laser beam from vegetation cover and water surface is expected.

3. The area of operation and timing

As shown in Figure-3, the monitoring operation was conducted in the area of the upper reaches of Amahata River, the right branch of Hayakawa River in the Fuji River Basin.

The monitoring operations conducted twice, in December 2001 and November 2003 covered two major landslides, Oikeno-Sawa Landslide located in the east side of the area and Yashio-Kuzure Landslide in the west side of the area, which are responsible for massive

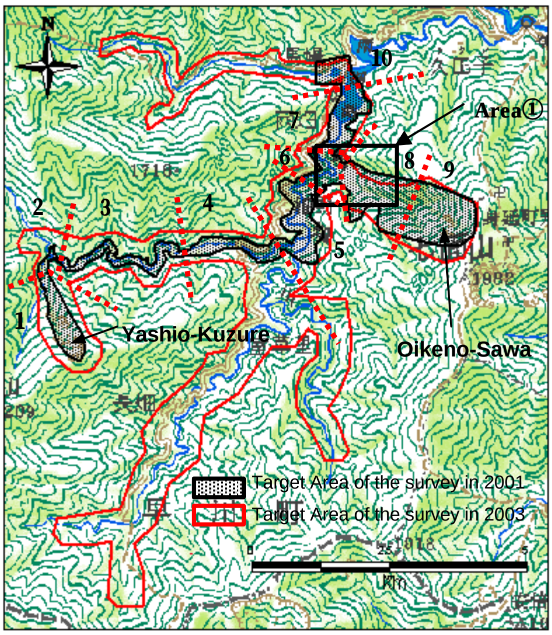

Figure-3 Target Area of the survey

sediment yield and transportation.

4. Method of Sediment Discharge Analysis

Changes in sediment volume in a specific section can be estimated by transforming three-dimensional data on the landform of the designated section into a digital elevation model (DEM) which is acquired by slicing the three dimensional model at 2 meters intervals. The margin is calculated by subtracting the recent value of DEM from earlier value of DEM.

The result of sediment budget acquired by ordinary cross sectional ground survey and by ALP method is demonstrated as shown in Figure-3. The designated stretch is divided into 10 sections taking into account specific river morphology and structures such as sabo dam.

5. Sediment Budget

Figure-4 illustrates the results of an assessment by means of ALP targeting the lower stretch of Oikeno Sawa at which a landslide took place. (The location indicated by ① in Figure-3)

The result shows that as much as 20,000 m^3 of bed materials were lost from the 300 meters stretch from the second dam of Oikeno Sawa. On the contrary, as much as 96,000 m of bed materials were added in the 350 meters stretch between the second and the fourth consolidation dams of Oikeno Sawa The ALP technology provides us with reliable quantitative information on the morphologic changes.

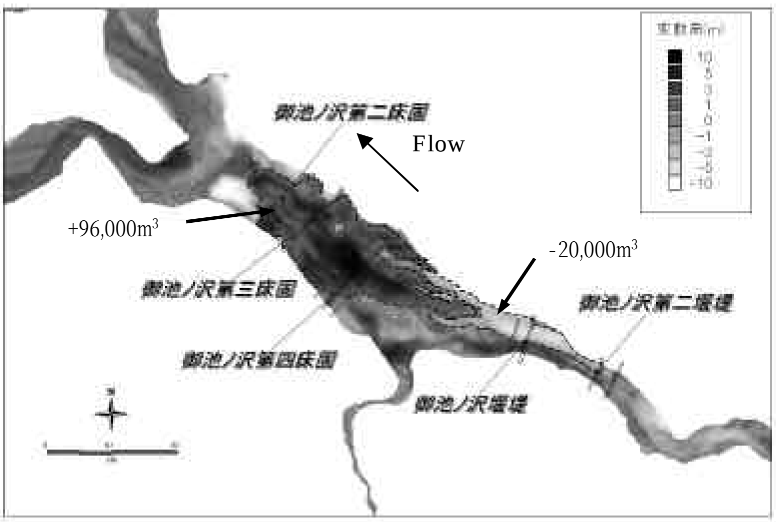

Figure-4 Area① (Downstream of Oikeno-Sawa)

Table-2 presents the results of quantitative analysis on the sediment budget acquired by means of the ALP and manual cross sectional survey. It must be noted that the stretch No.1 and 9 are located at the scarp of landslide so that the cross sectional survey cannot be conducted. The cross sectional survey was not conducted in the stretch of 7 and 10 either. Whereas the manual cross sectional survey can therefore hardly estimate the changes in sediment budget because of hardships in manual labor, the ALP cannot be applicable to the areas submerged. This is the major reason of the inaccuracy of the data.

Table-2 Sediment budget

Stretch No.	Sediment budget assessed by ALP（m^3）	Sediment budget assessed by cross sectional survey （m^3）
1	−67,484	—
2	1,374	−20,545
3	68,419	112,802
4	−119,558	−139,560
5	63,463	5,856
6	11,865	11,468
7	215,971	—
8	78,765	66,883
9	−519,478	—
10	59,699	—

6．Conclusion

The data acquired by means of the ALP need calibration depending on the conditions of ground surface, but the method is widely applicable to estimate changes in micro-topography. The ALP method can ensure safety of labor forces in the field.

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