The Estimation of Snow Depth Distribution by satellite data.

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Abstract

Two estimation methods of snow depth distribution in extremely wide area (approximately 1,600 km^2) were investigated. One is the evaluation by ground data,and the other is by satellite data.

The snow depth distribution by ground data was compared with existing meteorological observatory data and aero-video data,while the snow depth distribution data by satellite data was evaluated by applying well known Degree Day Method.

In this paper,the relationship between two methods is discussed.

As a conclusion,it seems that only satellite data will be sufficient to estimate snow depth distribution in near future.

1. Introduction

How one can know the depth of snow in extremely wide area? One simple solution is to go to the field,although this is not an economical and practical way. The investigation was carried out to make use of satellite data to estimate the snow depth.

2. Outline of the method

In order to know the relation between satellite data and ground data,each snow depth was calculated in the following way.

2-1 Snow depth distribution from ground data

Meteorological observatory is available at approximately every 50 km ,however,it is not enough to estimate snow depth distribution minutely in both horizontal and vertical directions.

Therefore,aero-video by helicopter was taken to interpolate ground data. Before snow falling season,the snow poles were set at arbitrary points on the ground. After taking aero-video imagery,snow depths were interpreted.

2-2 Snow depth distribution by satellite data

The significant information by satellite data is snow lines only. It is not feasible to estimate the snow depth directly from satellite data. Therefore,well known Degree-Day method was applied. By applying Degree Day Method,meteorological data and topographic data are indispensable.

3 Detail of this method

In order to estimate snow depth distribution in extremely wide area. Digital Terrain Model has to be established based on the topographic information such as altitude,slope direction,slope angle and undulation.These values are plotted onto every 500 m mesh.

Nevertheless,the snow depths obtained by ground and aero-video data do not coincide with this mesh. Therefore,regression method was applied to coincide topographic information mesh with snow depths mesh.

On the other hand,in the case of satellite data,interpretation of snow lines was carried out at first. In order to know the relation between mesh altitude and water quantity of snow coverage accurately,several satellite scenes are required in snow melting season. In this investigation,several scenes from the end of March to the end of June were used,because high altitude mountains (over 2,000 m) were being included in this investigated area.

Since Degree Day Methd provides with water quantity of snow coverage,snow depth can be obtained by adding lapse rate and average density of snow coverage in snow melting season to it.

Whole area has been devided into three catchment area in order to get snow depth distribution more accurately. And the relations between altitude and water quantity of snow coverage for three sub-divided area were obtained independently.

However,the result obtained by this method is a total quantity of snow fall for whole winter. Therefore,in order to compaie the snow depth from satellite data with ground data,melted snow depth from satellite data with ground data, melted snow quantity has to be computed and be subtracted from a total quantity of snow fall.

4 Result

4-1 Topographic characteristics of survey area

Figure- 1 shows the relation between altitude and each catchment area.

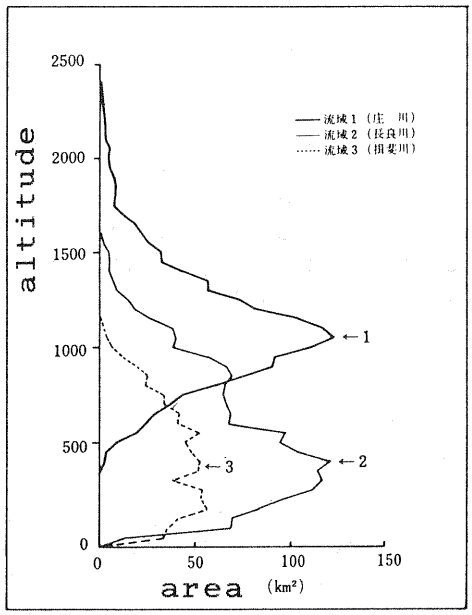
4-2 Snow depth distribution by groud data

The standard deviation is approximatelly 20 cm to the meteorological ,approximately 50 cm to the snow pole,and 40 cm to the meteorological and snow pole data.

4-3 The relation between altitude and water quantity of snow coverage about 1Km. (Fig- 2)

4-4 The relation of snow depth between ground data and satellite data.

The result is shown in Fig- 3 .
The standard deviation is 22 cm in the range of 90cm to 110cm,and is 47 cm in the range of 290cm to 310cm.



altitude-area distribution

Fig-1

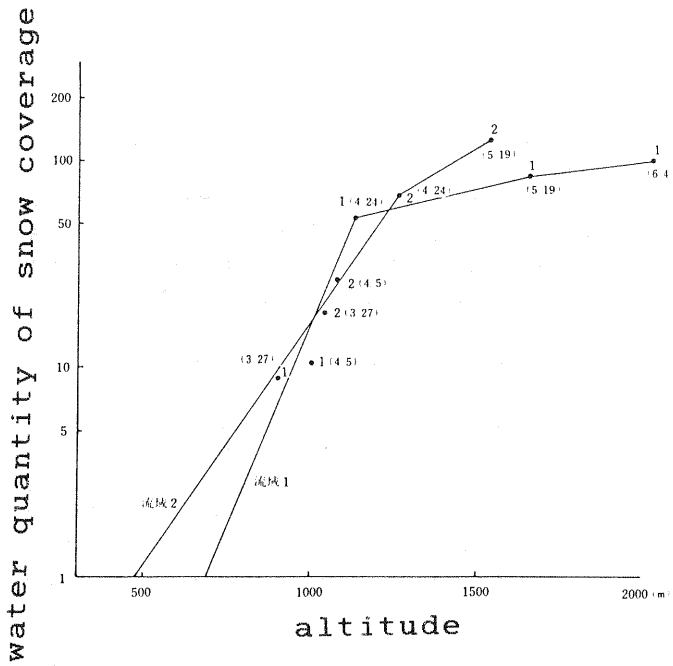


Fig-2

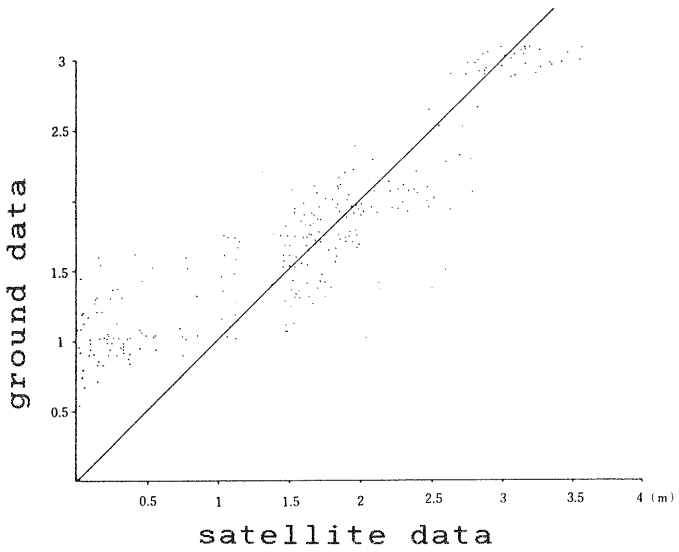


Fig-3

5 Conclusion

5-1 Snow depth distribution from meteorological observatory data and snow pole data

Because almost all of meteorological observatory are distributed under 500 m altitude,it was estimated that the extrapolation error became remarkable at higher altitude. In fact,the result shows the snow depth was increased at higher altitude. To minimise this extrapolation error,snow pole data were found very effective.

5-2 Degree Day Method

The water quantity of snow coverage by Degree Day Method is increased by altitude linearly up to approximately 1,200 m. However,it was found that this linearity should not be applied over 1,200 m. In order to veryfy this result,satellite data in May,Jun and even July were analysed,because some area especially over 1,500 m has snow even in this season.

5-3 Comparison of ground data with satellite data

It seems that snow depth under 1 m on the ground can not be identified by satellite imagery due to the resolution. For example,Landsat has 30 m for TM and 80 m for MSS,and NOAA has 1.1 km. Therefore,woody area or patch pattern of snow coverage can not be recognised as snow coverage.