the period of snow cover. These observations were obtained from meteorological and resource satellites, and from scanner data of medium and high resolution. Also important are observations of changes in the outline of glaciers, times of snowfall and character of the distribution of snow, and its redistribution due to avalanches and snowstorms. High-resolution space photographs, small-scale aerial photographs, and aerovisual observations provide the data for these observations. It has been determined that the area of the glaciers of Mount El'brus has been reduced by 1% in the last 25 years, i.e. the rate of its deglacierization dropped sharply as compared to preceding decades.

The role of quantitative information gains importance in the medium-scale level of monitoring. Topographical maps of separate glaciers compiled from aerial photographs or data from ground stereo-photogrammetric surveys constitute the base maps at this level. The main methods used in monitoring were large-scale surveys from aircraft, perspective surveys from helicopters, and phototheodolite surveys. Multi-date surveys of the glaciers provide data about the changes in their outlines and height, the character of their relief, their moraines, the amount of snow accumulation and ablation in separate years, the surface rates of ice flow and their fluctuations. The techniques by which quantitative information is obtained about changes in the glaciers are derived from processing the data of multi-date surveys. The organization and techniques of phototheodolite surveys have been improved. A theory evolved for determining the surface-ice movement by stereo-photogrammetric means and the technique for it has also improved; algorithms and programs for machine processing of the data of multi-date surveys (ground and from aircraft) have been produced.

At this level of monitoring, it has been found that the retreat rate of most glaciers has slowed down and several glaciers are now in equilibrium. Several glaciers became active at the beginning of the 1970s and 1980s; this was accompanied by an increase in their height and forward movement. For example, activation of Kyukyurtlyu Glacier has been recorded (higher surface and increasing flow rate) which has caused the glacier to move forward 100 m. Surveys at an interval of 2 years recorded the beginning of the process of retreat of this glacier.

Detailed monitoring is used to detect the mechanism of the dynamic processes and to study it on local representative sectors. On a glacier it may take the form of annual surveys of its tongue, which makes it possible to observe the processes of formation of moraines and glacio-fluvial relief. Studies may also be made of the mechanism of the movement of avalanches and landslides, deducing their quantitative characteristics and appraising the results of avalanches and landslides. Multi-date surveys of sectors of the slopes provide information about processes in the periglacial zone. At this level, regularly repeated ground stereo-photogrammetric surveys are the main means of observation.

Glaciological remote-sensing monitoring provides a wealth of data for theoretical development in the field of glaciology. It makes it possible to forecast and produce warnings about hazardous processes and phenomena.

METHODS OF CALCULATION AND REMOTE-SENSING MEASUREMENTS FOR THE SPATIAL DISTRIBUTION OF GLACIER ANNUAL MASS BALANCES

(Abstract)

by

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ABSTRACT

The areal distribution of glacier annual mass balance $b(z)$ is an important characteristic of the existence of glacierization and its evolution. At present the measured value of annual mass balance at different elevations is only available for a limited number of mountain glaciers of the globe, because of the great amount of labour required for such measurements.

The analysis of long-term mass-balance measurements made at Abramova Glacier, Limmerngletscher, White Glacier, Hintereisferner, and Peyto Glacier has revealed that for each year the spatial distribution of annual mass balance is well described by quadratic equations. The main variable in these equations is altitude (z). The various parameters of these formulae are estimated by the author for mean weighted height of the ablation and accumulation areas, and for the glaciers as a whole. It is found that the parameters of annual mass balance for each glacier can be calculated from formulae which include combinations of the following variables: annual balance at one of the three weighted altitudes, maximum annual snow-line elevation, annual and seasonal amounts of precipitation, and air temperatures at nearby meteorological stations.

Therefore, in order to calculate the distribution of annual mass balance as a function of absolute altitude, it is sufficient to obtain a value for mass balance measured only at a single point on a glacier, and common meteorological observational data. A comparison of actual and calculated values of mass balance has shown good agreement between them.

Considering the successful use of aerial remote-sensing for the measurement of snow depth in mountains by means of special stakes, it is satisfactory to accept this method for the assessment of annual mass balance at the mean weighted altitude of the ablation zone. It is possible to use aerial photo-surveys or stereophotogrammetry to resolve this problem. Then annual mass balance for the whole area of a glacier is calculated by using data from one point together with data from a nearby meteorological station.