MELTING AND EVAPORATION OF GLACIER SYSTEMS OF THE HINDU KUSH-HIMALAYAN REGION AND LIKELY CHANGES IN THE SYSTEMS AS A RESULT OF GLOBAL WARMING

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The Atlas of the World Snow and Ice Resources has been recently compiled in Russia. The snow cover and glaciers of the Central Asian Region are given considerable attention in the Atlas. Maps illustrate the climatic conditions, snow cover, avalanches, glaciers, and melt water runoff in the region of the Hindu Kush and the Himalayas.

This report demonstrates that the existence of glaciers in the region is largely dependent upon the high mountains and a steep-slope relief, due to which the concentration of snow in the nourishment areas is several times the annual amount of solid precipitation. The amount of precipitation decreases by 50% as we go from the northern Hindu Kush macro-slope, subjected to the Mediterranean cyclones, to the eastern part of the Himalayas, which comes under the severe effect of the Indian monsoon in view of the annual maximum of precipitation being shifted from winter to summer. A diagram of atmospheric circulation is given, along with the zoning of the region based on the value of the vertical gradient of annual precipitation; there is also a map indicating the annual precipitation at the height of the equilibrium line, specifying the ratio of summer precipitation and the prevalent type of precipitation.

The studies on glacier melting and evaporation processes, carried out on the basis of an enormous volume of in-situ observations and secondary sources, have revealed that the main factor influencing melting in the entire region is total solar radiation. During the summer months, at equal altitudes from the Hindu Kush to the eastern tip of the Himalayas, it declines by one third as a consequence of greater cloudiness and pressure of the water vapour in the air produced by the growing effect of the Indian monsoon. Frequent snowfall and abrupt rises of albedo serve to weaken the radiation factor of melting still further. At the same time, the length of the melting period from the northwestern to the southeastern part of the region increases from three summer months to a year, owing to greater influx of solar radiation during the autumn-winter-spring period. This increase in length of melting period is encouraged by the maximum of cloudiness and precipitation during the winter season in the Hindu Kush and their minimum in winter in the Himalayas. The ultimate annual value of ablation at equal heights of the equilibrium line is the same both in the Hindu Kush and in the Himalayas, even though the Himalayas are situated much more to the south.

Maximum evaporation from the glaciers (the first hundreds of millimeters per year) has been observed in the Hindu Kush, due to dry and clear weather during the melting period. Here, in the inner areas, the ratio of melting accounts for one fifth of the annual value of ablation. As we proceed to the eastern tip of the Himalayas, summer evaporation gives way to condensation, due to the saturating humidity of the monsoon air masses, and evaporation prevails for the rest of the year. The ratio of evaporation in the annual value of ablation amounts to the first few per cent.

The entire region under consideration is punctuated by local fields of penitents that are formed in the process of melting under conditions of a powerful influx of direct solar radiation, negative air temperatures and low pressure of water vapour. These conditions exist in summer in the Hindu Kush and in spring in the Himalayas. A map is given showing the value of annual ablation of glaciers at the height of their equilibrium line, the ratio of evaporation in it, and the areals of penitent growth. In the inset, one can see the annual ablation-to-mean summer air temperature curves for the Hindu Kush, and Western, Central, High, and Eastern Himalayas. The values of annual ablation are found from the annual march of radiation and heat balance components in each of the aforesaid mountain countries. The balance components are calculated in accordance with a special procedure developed on the basis of field observations.

To elucidate the impact of global warming, several options for air temperature change were adopted: temperature rise by one degree in winter, with the earlier regime of precipitation; the same for summer, similar changes of air temperature, with a 15% increase in annual precipitation. A map showing the current air temperature in summer and annual amplitude of air temperature at the height of the equilibrium line is also given. The areas of annual value of ablation decrease and increase, depending on the height of the equilibrium line subject to appropriate changes of climatic indicators, are shown.