Practical method of Forecasting Snow Melting Flood

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Abstract:
In cold regions, flooding with snow melting occasionally happens to bring serious damages to people dwelling in low lying areas. In recent years, actually heavy rainfall attacked many countries in the season when snow melts and serious disasters occurred in places over the world. Typical cases which caused significant damages and casualties were reported in the Po river (Italy), the Glama river (Norway) and the Rhin river (Netherlands).
Flood forecasting in river administrative organization, in practical processes, mainly focuses to compute summer flood by heavy precipitation. Spring flood however is rarely forecasted because of complexity of snow melting dynamics and spatial heterogeneity of snow deposit.
This paper shows the practical method of forecasting flood with snow melting in some rivers in Hokkaido, Japan. Scale of the rivers in drainage area upper than the focusing points is some thousand square km or less. Duration of the high water caused by the snow melting is some weeks in spring. Leading time of the forecasting is no more than 24 hours.
In the forecasting, simplified calculation was applied and proofed to be acceptable to the extent that practical use of the output for flood warning and flood preparedness would be capable.

Spring Flooding in Rivers in Hokkaido

In north-west side of the Japan isles, we have much snow in winter by wet wind from the Japan sea.
In Hokkaido, as will be shown in the presentation, we generally have snow on western areas in winter. Snow deposit in Sapporo city for example is amounting about 3 meter thick in annual total.

Ishikari river, Shiribetsu river, Mukawa river and Saru river are the typical basin in those snowy areas which produce spring runoff from beginning of April till end of May in normal years.

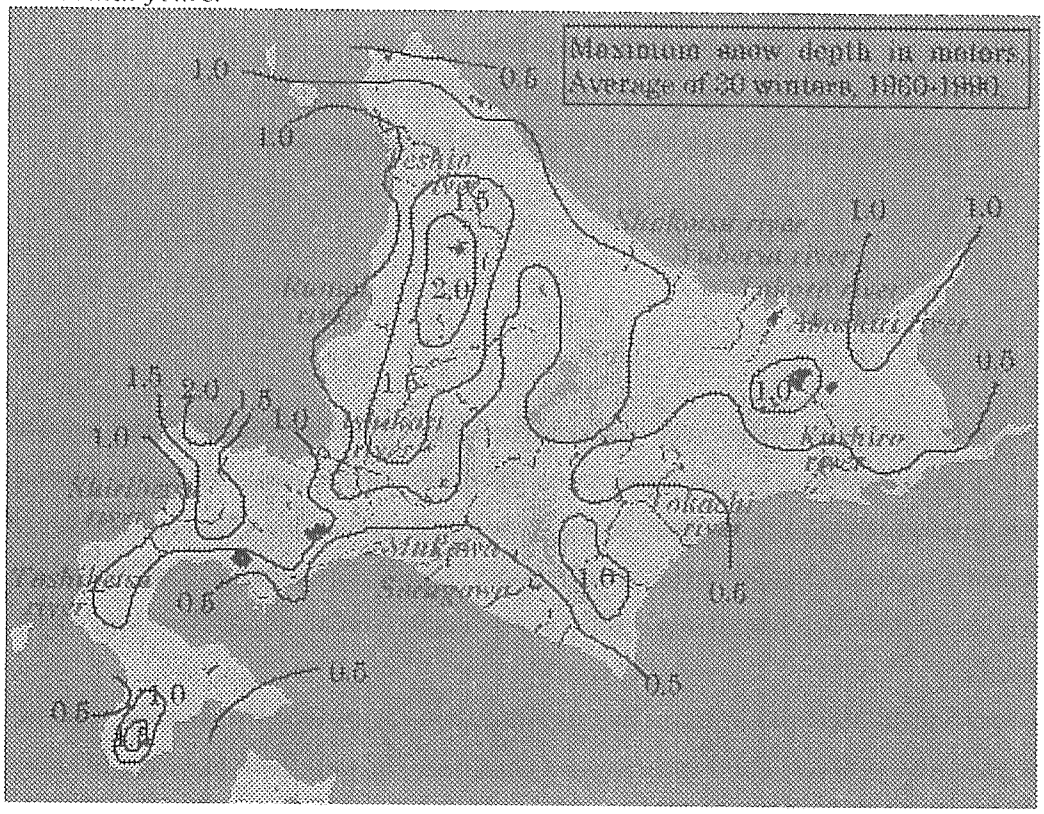

Fig-2. Main rivers and snowy area in Hokkaido

Ishikari river, as a river representing such snowy ones, is the third largest river in Japan, lying on central west area of Hokkaido. It rises on Mt.Ishikaridake(1,967m above sea level) of the Taisetsuzan mountain range. The river first flows north-west through the narrow valley into the Kamikawa flat basin before turning south-west. In Kamikawa basin, Asahikawa city, the second largest city of Hokkaido, is developed under pressure of flood by Ishikari river and some creeks which are confluencing to the main river in the city.

The main Ishikari river flows through the narrow valley again, then into the Ishikari plains where is the largest fertile plain in Hokkaido. Near Sapporo City the flow changes its course to north-west and empties into the Ishikari Bay.

Fig-3 shows a typical distribution of annual water discharge at gauge site of Ishikari-oohashi, near Sapporo. As shown, in April and May, water discharge increased by snow melting rises up to three to four thousand qms in normal year.

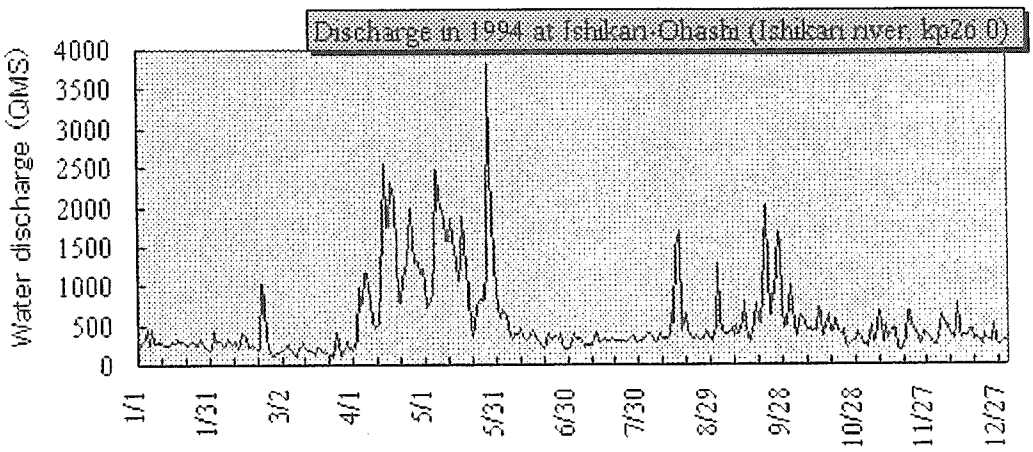

Fig-3. Annual water discharge in Ishikari river, example in 1994

Toyohira river, one of the tributaries, running through the middle of Sapporo City, is being as the most familiar water field for about 2 million population of the city. The stream provides people with clear water resource, a huge and continuous recreational space, and greenbelted landscape in the central city.

Spring flood with snow melting in such urbanized river space is generally less damaging compared with summer flood caused by heavy rainfall. But problem rarely occurs in destroying facilities on flood plains or restricting people's activities.

Ground of flood plain nearby the stream of Toyohira river is highly developed for multipurpose use. Hence, flood forecasting of whether waterlevel would rise upper than the plain or lower must be concerned seriously.

Mukawa river, 135km long with area of 1,270 square km, flows from north end of Hidaka mountain range where is also snowy area.

Existing Flood Forecasting

Existing system of Flood forecasting of measure rivers maintained by Hokkaido Development Bureau was mainly developed for calculation of summer flood. It runs only at alarming situation under heavy rainfall mainly in summer. Forecasting system is being operated independently from river information system which is running 24 hours all year around.

Model used for the runoff equation of the forecasting is developed by Hoshi(1982). Computing system using the model works in practical operation with less error of results satisfactory. It is however not able to apply to spring flood which has no precipitation.

Water Runoff with Snow Melting

Snow melt dynamics could be explained as energy conservation process of snow deposit and surrounding space. Niwa and Moriya(1990) developed a snow melt model utilizing equations containing snow surface exposure effect, energy conduction effect of air circulation, same effect of precipitation and cooling effect of radiation. The developed model was applied to calculate runoff of a specific field of snowy basin upper than a dam. In order to calculate runoff over river basin, with such a model, one must provide with many parametric preparedness varying areally. Among those, geomolphological parameters efficient to surface exposure, distribution of sunshine intensity, snow depth and snow density are essencial to compute energy conservation process. But it is difficult to observe these in real-time at snow melting season. Few available parameters to get in real-time and areally conjectivelly are air temperature and precipitation.

In practical way of river management, it would be usefull if one could compute snowmelt runoff by currently available meteorological data input.

On the other hand, runoff model of Hoshi has an excellent advantage in absorbing miscellaneous errors of input data into flexible output curve of runoff. It means that even if input to the runoff model (i.e. precipitation or corresponding precipitation produced from snow melting) contains an extent of error, which has regular range of error diffusion from real value, the output (i.e. runoff forecast) could be calculated in which result would be satisfactoly coincident to observed value.

One would be realized that rough estimation of snow melting, if it could be, would be utilised for input to the model computation of spring flood. Fortunatelly, with above mentioned snow melt model, quantitative melting value is mainly regulated by energy conduction effect of air circulation and subsequently by other effects of surface exposure, precipitation and cooling of radiation. If one estimate snow melting only with energy conduction effect of air, the result will not be far from detailed computation with all necessary theoletical equations.

Practical Forecasting of Snow Melting Flood

Integration of Hoshi's runoff model and simplified snow melting calculation was tried and applied to spring flood at Mukawa river in 1996 which was typical case of snow melting discharge(Fig-7).

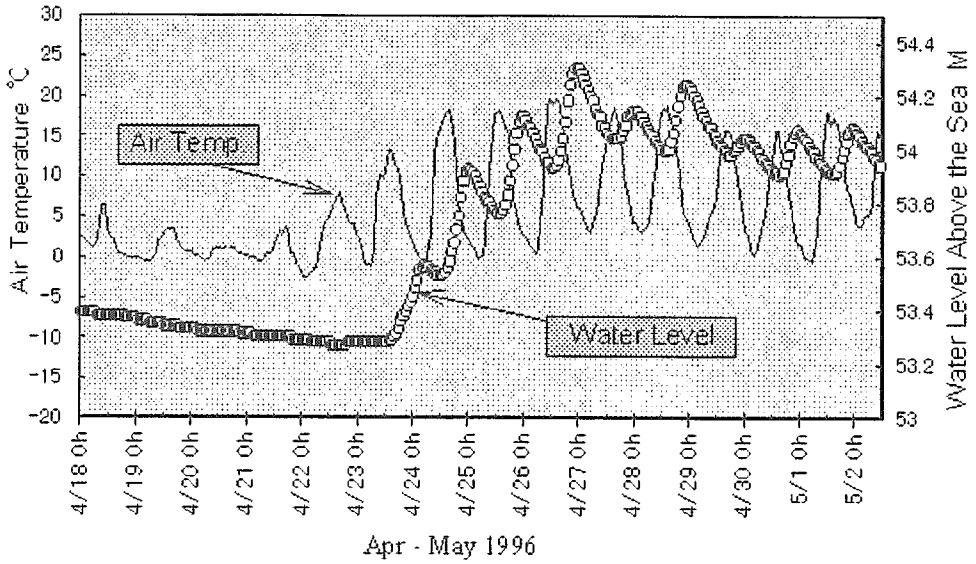

Fig-7 Flood applied to study [Hobetsu gauging site, Mukawa river]

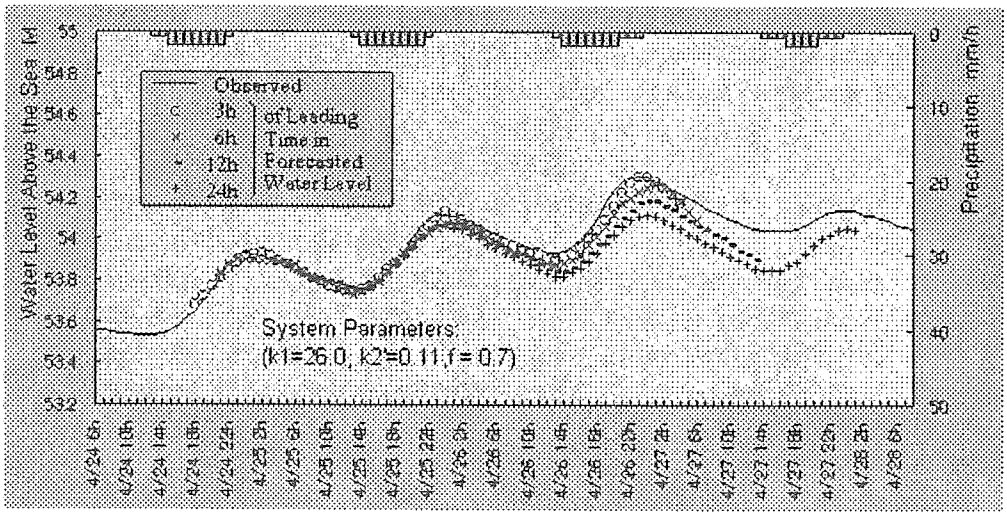

Fig-9 Results of Forecast and Prolonging Availability of System Parameters

It was resulted in good performance as shown in Fig-9. This showed that existing system of flood forecasting is satisfactory capable of forecasting not only summer flood by rainfall but also spring flood with snow melting when at least meteorological information is available to get.

In practical use of river management, 24 hours forecasting of water level in spring season is realized. Although above introduced method is not theoretically correct nor scientific, but tiny and generous way of calculation sometimes make good sense and practical significance.