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Complexity of dynamic processes preceding river ice jams

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The statistical distributions of daily average water level prior to ice jams and in jam-free periods during spring breakups in the middle Lena river were calculated. A selected river reach is known by almost annual ice jams including rare catastrophic events. It has been found that the daily average water levels recorded in jam-free years were distributed by height in accordance with Poissonian-like (exponential) function that is in random manner. In contrast, the water level distributions in periods preceding ice jams followed a power law likewise various large scale hydrological phenomena, such as flood occurrence, rainfall intensity, ice pack dynamics, and other non-equilibrium natural processes [1]. However, the ice jam floods exhibited a particular feature. In most cases, the power exponent in a water level distribution (referred as the b-value in a Gutenberg-Richter relation) rosed sharply a few days before an ice jam. In other words, a plot of entire power law distribution consists usually of two portions differing in their slopes (multi-scaling). Each statistical feature contains an underlying physical origin. In terms of thermodynamics, an increase of the b-value means a decrease in the conservativity of the system [2]. To explain this trend in our case, one should take into account that the ice jams are frequently preceded by advances of ice with water openings which change the energy balance in the water-ice system. As a result, the power exponent in the water level distribution appears to be higher in the case of the partially fragmented ice cover. In 2001, a drop of the b-value in the distribution based on hourly data of the water level occurred to be coincided with the bombing of a highly consolidated ice jam during the catastrophic flood near the town of Lensk (2504 km from the Lena river mouth).

References

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