Modeling of noise effect on self-similar mode of ice surface softening during friction

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Softening of ice surface under friction is explored in terms of the rheological model for viscoelastic matter approximation. The nonlinear relaxation of strain and fractional feedbacks are allowed. Additive non-correlated noise associated with shear strain, stress as well as with temperature of ice surface layer, is introduced, and a phase diagram is built where the noises intensities of the stress and temperature define the domains of crystalline ice, softened ice, and two types of their mixture (stick-slip friction). Conditions are revealed under which crystalline ice and stick-slip friction proceed in the self-similar mode. Corresponding strain power-law distribution is provided by temperature fluctuations that is much larger than noise intensities of strain and stress. This behavior is fixed by homogenous probability density in which characteristic strain scale is absent. Since the power-type distribution is observed at minor strains it meets self-similar rubbing mode of crystalline ice surface. An analysis of the time dependences of friction force was carried out by using a fast Fourier transform. Fluctuations are detected with the spectral power density of the signal, which is inversely proportional to the frequency and demonstrates the realization of $1/\omega^{\alpha}, 0 < \alpha < 2$ or "pink" noise. It was found that the behavior of the spectrum is related to the course of the prehistory of nonequilibrium rubbing process. Research of autocorrelation function form of random fluctuations of friction force allowed to reveal the frequency characteristics of rubbing. The presence of weak correlation is shown. The obtained results reflect the real frictional conditions and can be used for predicting the rubbing force value or ice surface states (phases) during a certain correlation time. Thus, it is possible to establish the necessary external conditions to achieve the desired stable ice friction mode.