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The tipping times in an Arctic sea ice system under influence of extreme events

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In light of the rapid recent retreat of Arctic sea ice, the extreme weather events triggering the variability in Arctic ice cover has drawn increasing attention. A non-Gaussian α -stable Lévy process is thought to be an appropriate model to describe such extreme events. The maximal likely trajectory, based on the nonlocal Fokker–Planck equation, is applied to a nonautonomous Arctic sea ice system under α -stable Lévy noise. Two types of tipping times, the early-warning tipping time and the disaster-happening tipping time, are used to predict the critical time for the maximal likely transition from a perennially ice-covered state to a seasonally ice-free one and from a seasonally ice-free state to a perennially ice-free one, respectively. We find that the increased intensity of extreme events results in shorter warning time for sea ice melting and that an enhanced greenhouse effect will intensify this influence, making the arrival of warning time significantly earlier. Meanwhile, for the enhanced greenhouse effect, we discover that increased intensity and frequency of extreme events will advance the disaster-happening tipping time, in which an ice-free state is maintained throughout the year in the Arctic Ocean. Finally, we identify values of the Lévy index α and the noise intensity ε in the $\alpha\varepsilon$ -space that can trigger a transition between the Arctic sea ice state. These results provide an effective theoretical framework for studying Arctic sea ice variations under the influence of extreme events.