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Population dynamics under climate change: persistence criterion and effects of fluctuations

The current talk is concerned with population dynamics under climate change. The evolution of species is modelled by a reaction-diffusion equation in a spatio-temporally heterogeneous environment described by a climate envelope that shifts with a time-dependent speed function. For a general almost-periodic speed function, we establish the persistence criterion in terms of the sign of the approximate top Lyapunov exponent and, in the case of persistence, prove the existence of a unique forced wave solution that dominates the population profile of species in the long run. In the setting for studying the effects of fluctuations in the shifting speed or location of the climate envelope, we show by means of matched asymptotic expansions and numerical simulations that the approximate top Lyapunov exponent is a decreasing function with respect to the amplitude of fluctuations, yielding that fluctuations in the shifting speed or location have negative impacts on the persistence of species, and moreover, the larger the fluctuation is, the more adverse the effect is on the species. In addition, we assert that large fluctuations can always drive a species to extinction. Our numerical results also show that a persistent species under climate change is invulnerable to mild fluctuations, and becomes vulnerable when fluctuations are so large that the species is endangered.