RATE-INDUCED TIPPING BY CROSSING ELUSIVE QUASITHRESHOLDS: ATMOSPHERIC WARMING AND ZOMBIE FIRES

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Surface wildfires are commonly thought to be the cause of the so-called Zombie fires observed in peatlands, which disappear from the surface, smoulder underground during winter, and “come back to life" in spring. Here, we propose rate-induced tipping (R-tipping) to a fire-friendly metastable state in bioactive peat soils as a main trigger of Zombie fires. Our hypothesis is based on a conceptual soil-carbon model subjected to realistic global warming scenarios.

Mathematically, R-tipping to the fire-friendly metastable state is a non-autonomous instability, due to the crossing of an elusive quasithreshold, in a multiple timescale dynamical system. To explain this instability, we provide a framework that combines a special compactification technique with concepts from geometric singular perturbation theory. This framework allows us to reduce an R-tipping problem due to crossing a quasithreshold to a heteroclinic orbit problem in the singular limit. We thus identify generic cases of such R-tipping by unfolding a codimension-two heteroclinic folded saddle-node type-I singularity, which in turn reveals new types of excitability quasithresholds.