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Spatiotemporal influence of permafrost thaw on anthrax diffusion

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The recent 2016 outbreak of anthrax disease affecting reindeer herds in Siberia has been associated to the presence of old infected carcasses released from thawing permafrost, underlying the emerging character of such disease in the Arctic region due to climate change. Anthrax occurs in nature as a global zoonotic and epizootic disease caused by the spore-forming bacterium *Bacillus anthracis*. It principally affects herbivores and causes high animal mortality. Transmission occurs mainly via environmental contamination through spores which can remain viable in permafrost for many decades.

We propose and analyze a novel epidemiological model for anthrax transmission specifically tailored for the Arctic region. It conceptualizes the transmission of disease between susceptible and infected animals in the presence of environmental contamination, considering also herding practices (e.g. seasonal grazing) and the seasonal environmental forcing caused by thawing permafrost. We performed stability analyses and implemented Floquet theory for periodically forced systems, and therefore applied our model to the 17-year-long records of permafrost thawing depth available at the Lena River Delta (northern Siberia). Accordingly, in order to spatialize potential anthrax incidence and consequently the possible hazardous areas in the Arctic, we used the Maximum Entropy (Maxent) approach considering environmental variables and, in particular, accounting for current and expected permafrost thawing rates.

Results show how temporal variability of grazing and thawing may influence and favor sustained anthrax transmission. Also, particularly warm years are associated to increased risk of anthrax incidence. Accordingly, we show that such risk could be mitigated with specific precautions involving herding practices, for example by anticipating or postponing seasonal grazing. Finally, a spatial map of the potential Arctic areas at risk is presented, providing a tool for local authorities in view of eventual targeted prevention measures.