School of Mathematics and Statistics

Faculty of Science, Technology, Engineering and Mathematics

2024 PhD Projects

Project title	Mathematical models of phytoplankton dynamics living under rapid Arctic sea ice melting
Principal supervisor	Ivan Sudakow
Second supervisor	Pavel Berloff, Imperial College London
Discipline	Applied mathematics
Research area/keywords	dynamical systems, stochastic process, machine learning, climate, plankton, sea ice
Suitable for	Full time applicants, Part time applicants

Project background and description

Phytoplankton is a critical component of Earth's carbon cycle and thus plays an important role in the climate system [1]. Recent observations have shown that the plankton ecosystem exhibits an unusual massive phytoplankton bloom that was observed underneath the ice pack in the Arctic Ocean [2].

During the Arctic melt season, the sea ice surface undergoes a remarkable transformation to a complex mosaic of melt ponds, snow and ice. The transition in pond fractal geometry revolves around a critical length scale of about 100 m^2, as isolated ponds grow and coalesce into larger connected structures with complex, self-similar boundaries [3]. Moreover, the transition from isolated sunlight penetration associated with individual ponds to a continuous matrix of light associated with large connected pond configurations could help trigger the under-ice blooms and the following plankton bouncing and clusterization [4].

The project will focus on developing stochastic and deterministic mathematical models that are capable to describe critical transitions in phytoplankton population dynamics at different stages including their bloom, bouncing as well as clusterization on the free ice ocean surface. The toolkit for asymptotical analysis of the critical dynamics includes Markov networks [5], Lagrangian mechanics [6], dynamical systems [7], data analysis and machine learning [8].

Background reading/references

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3. Hohenegger C., Alali B., Steffen K.R., Perovich D.K., and Golden K.M. Transition in the fractal geometry of Arctic melt ponds Cryosphere 6 1157–62 (2012).
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7. Reimer, J.R., Adler, F.R., Golden, K.M., and Narayan, A. Uncertainty quantification for ecological models with random parameters. Ecology Letters, 25, 2232–2244 (2022).

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