The workshop "Tipping phenomena in environmental dynamical systems"

May 10th, 2024

Brunel University London, UK

Room: ESGW 111 (Eastern Gateway Building)

Organizers: Valerie Livina (National Physical Laboratory, UK)
Ivan Sudakow (The Open University, UK)
QingPing Yang (Brunel University London, UK)

Tipping points represent critical thresholds in dynamical systems, where small perturbations can lead to disproportionate and potentially irreversible changes. These thresholds can manifest in various components of the Earth system, including the climate, ecosystems, and socio-economic structures. By leveraging the expertise of researchers studying tipping points in climate and ecology and integrating insights from industry stakeholders, this workshop aims to advance our collective understanding of tipping points in the context of sustainable development. Through collaboration and knowledge exchange, we can develop robust strategies to safeguard environmental systems and foster a more sustainable future.

The workshop is supported by the London Mathematical Society (LMS) and aligns with the strategic domain of "Energy and Environment" at the National Physical Laboratory (NPL).

To take part in the workshop, please register at https://forms.office.com/e/wKHY0P5Aij
Participation is free of charge, but the number of available places is limited.
The workshop registration will be closed on Monday, April 29 at 11:59 pm BST.
Accepted participants will be notified by May 1st, 2024. They may also consider giving a poster presentation.

The Workshop Program

Morning Plenary talks (40 min +5 min for questions)
Chair: Ivan Sudakow

09:00-09:45 Jan Sieber (University of Exeter, UK)
Tipping in a cellular automaton modelling forest-fire feedback in tropical forest
joint work with Bert Wuyts (University of Exeter)

Tropical forests have been hypothesised to exist as alternative stable states to tropical savannas, implying that they may collapse abruptly under gradually increasing pressure due to climate change or deforestation. A key assumption in its proposed mechanism is that fires spread on grass and are effectively blocked by

forest, which is as a consequence only damaged near its edges. We simulate a recently proposed probabilistic cellular automaton that obeys these rules. Taking into account that spreading processes occur near the forest perimeter, with fire spread occurring on the fast and forest spread on the slow time scale, we find an emergent relation between forest structure and macroscopic dynamics. This relation matches simulations with high accuracy and can hence be used to test where fire-vegetation feedbacks are strong enough to cause bistability and tipping.

09:45 -10:30 Valerie Livina (National Physical Laboratory, Teddington, UK)
Tipping point analysis of real-world complex systems

In the recent years, tipping point analysis became popular in diverse applications, from ecology to structure health monitoring. These techniques help anticipate, detect and forecast critical transitions in dynamical systems. The methodology combines monitoring short- and long-term memory in time series with potential analysis that analyses and extrapolates the system states. For anticipating tipping points, early warning signal (EWS) indicators utilise dynamically derived lag-1 autocorrelation (ACF, [Held & Kleinen 2004]), power-law scaling exponent of Detrended Fluctuation Analysis (DFA, [Livina & Lenton 2007]), and the power-spectrum-based EWS indicator (PS, [Prettyman et al 2018]). A few applications in engineering systems [Livina et al 2014; Livina et al, 2020; Mesa et al, 2021; Billuroglu and Livina, 2022] broaden the range of the tipping point analysis in real-world complex systems and provide a methodology for data-driven failure analysis and prevention.

10:30 -10:45 coffee break

Morning short talks *(20 min + 5 min for questions)*
Chair: Valerie Livina

10:45-11:10 Shobin John (National Physical Laboratory, Teddington, UK)
Integration of data and knowledge in remote monitoring

11:10-11:35 Muhammad Osama (University of Strathclyde, Glasgow, UK)
Capturing uncertainty in CFRP electrical behaviour under fault conditions

11:35-12:00 Ivan Sudakow (The Open University, Milton Keynes, UK)
Can permafrost microbes cause a climate tipping point? A mathematical analysis.

12:00-13:00 - Lunch

Afternoon plenary talks (40 min + 5 min for questions)
Chair: QingPing Yang

13:00-13:45 - Andrew Morozov (University of Leicester, UK)
Regime shifts, species extinctions and long transients in ecological models

Predicting critical transitions and regime shifts in ecosystems has long been a key point of biological conservation and ecological management. Traditionally, mathematical models of regime shifts focused on long-term, asymptotic behaviour of ecosystems. Therefore, critical transitions were expected to occur in the case of lack of system's resilience, as a quick response to changes in environmental parameters. However, recently, an alternative scenario of regime shifts in ecology has been explored, which accounts for long-term transient dynamics. According to the transient-based scenario, there may be no underlying proximal source of a regime shift, or alteration of the system could have occurred long ago before the transition. Despite the recognition of the importance of long transients in ecology, and more generally, in environmental sciences, this research area seems to be at its early stage in terms of lack of systematic studies, developing appropriate research techniques, and linking theory to practical applications. In this talk, I will briefly review main types of transient regimes occurring in deterministic and stochastic mathematical models. This study suggests that not only are long transients ubiquitous in ecological models, but there is also a great variety of them. The omnipresence of long transients in mathematical models, supported by data, emphasizes the need to account for them in long-term forecasting and crisis anticipation.

13:45-14:30 - Lee Stokes (Mace, London, UK)
Sustainability in the global built environment

What does industry best practice look like for low carbon construction, existing building carbon-led retrofit & biodiversity net gain. Could reducing the 12 GtCO2e that buildings produce annually (21% of global emissions) be a primary factor in avoiding one of the climate tipping points. How can mathematical modelling, ML or AI be used to fix the problems that industry faces in delivering carbon reductions and other sustainability related co-benefits like wider social value.

14:30-14:45 coffee break

Afternoon short talks *(20 min + 5 min for questions)*
Chair: Sergei Petrovskiy

14:45-15:10 QingPing Yang (Brunel University London, UK)
Risk management of tipping based on EWS monitoring and FMEA.

15:10-15:35 Joaquín Mesa Jiménez (Arthur D. Little, London)
Early warning signals of failures in building management systems

15:35-16:00 Dmitri Kondrashov (University of California, Los Angeles, USA)
Predicting summer arctic sea ice concentration

16:00-17:00 Discussion: Navigating Critical Shifts: Understanding Tipping Points in Climate and Sustainability.
Facilitator: *Sergei Petrovskiy, University of Leicester, UK*
Panel: Jan Sieber, Valerie Livina, Andrew Morozov and Lee Stokes.