

First IMA meeting on “Mathematics for Climate, Environment and Sustainability”

Launching IMA's Special Interest Group on "Climate, Environment and Sustainability" (CES SIG)

De Morgan House, London, UK
23rd September 2025

1. Programme:

Time	Programme	Length	Chair
10:00a m	Arrivals and registration	30min	N/A
10:30a m	Welcome and Introduction	5min	Dawn et al.
10:35a m	Welcome by Rosalind Azouzi (IMA Executive Director)	5min	Dawn et al.
	Keynote talks:		
10:40a m	- "Tipping Points and Metastability of the Earth's Climate" (Valerio Lucarini, University of Leicester) - "IT Sustainability and the Future of Technology: Exploring the Environmental Impact and Opportunities of Modern Computing" (Alex Bardell, SDAdvocate)	25min + questions each	Dawn
11:40a m	Coffee break	20min	N/A
	Keynote talks:		
12:00p m	- <i>Title TBC</i> (Lindesay Scott-Hayward, CREEM, University of St Andrews) - Discussion with speakers	25min + questions each	Tiffany
1pm	Lunch and poster session	60min	Chris
	Breakout discussions (up to 6 groups of 10):		
2pm	- Round 1: Shaping the SIG and priorities for each discipline (climate, environment, sustainability) - Round 2: Shaping the SIG and priorities for each sector (academia, industry and policy)	30min each	Natacha
3:00pm	Coffee break	20min	N/A
3:20pm	Panel discussion: Mathematics and CES in industry, KE and decision making	40min	Francisco
4pm	Closing remarks	~5min	Francisco
4pm onwards	Reception and networking	90min	N/A

2. Abstracts

Keynote talk 1: "Tipping Points and Metastability of the Earth's Climate"

Prof Valerio Lucarini (University of Leicester, UK)

The ultralow frequency variability of the Earth's climate features an interplay of typically long periods of stasis accompanied by critical transitions between qualitatively different regimes associated with metastable states. Such transitions have often been accompanied by massive and rapid changes in the biosphere. Multiple transitions between the coexisting warm and snowball climates occurred more than 500 Mya and eventually led to conditions favourable to the development of multicellular life. The coexistence of such states is due to the instability associated with the positive ice-albedo feedback, Yet, this behaviour repeats itself across a wide range of timescales, spatial domains, and physical processes.

Building on Hasselmann's program, we propose here to interpret the time-evolution of the Earth system as a trajectory taking place in a dynamical landscape, whose multiscale features describe a hierarchy of metastable states and associated tipping points. We introduce the concept of climatic Melancholia states, saddle embedded in the boundary between the basins of attraction of the stable climates and explain under which conditions they act as gateways of noise-induced transitions. Using a hierarchy of numerical models, we discuss in detail the dichotomy between warm and snowball climate by bringing together the deterministic and stochastic viewpoint on the related global stability properties. We then discuss the paleoclimatically-relevant case where multiple competing climatic states are present and show the relevance of our angle for interpreting proxy data. Finally, if time allows, we will present some very recent results suggesting that our viewpoint might explain some intriguing aspects of the dynamical features of the tipping points of the Atlantic Meridional Overturning Circulation.

References:

- V. Lucarini and T. Bodai, Transitions across Melancholia States in a Climate Model: Reconciling the Deterministic and Stochastic Points of View, Phys. Rev. Lett. 122, 158701 (2019)
- G. Margazoglou et al., Dynamical landscape and multistability of a climate model, Proc. R. Soc. A.477 210019 (2021)
- D. D. Rousseau et al., A punctuated equilibrium analysis of the climate evolution of cenozoic exhibits a hierarchy of abrupt transitions. Sci Rep 13, 11290 (2023)
- J. Lohmann et al., Multistability and Intermediate Tipping of the Atlantic Ocean Circulation, Sci. Advances 10 DOI: 10.1126/sciadv.adi4253 (2024)

Keynote talk 2: BCS* Green – IT Sustainability and the Future of Technology: Exploring the Environmental Impact and Opportunities of Modern Computing

Alex Bardell (SDAdvocate)

This talk will delve into the crucial intersection of mathematics, computer science, and their increasing influence on the world particularly through the lens of sustainability. As high-performance computing (HPC) and risk calculations become more integral to daily operations, the energy demands of every CPU cycle come to the forefront, raising important questions about emissions and operational costs.

With the rapid development of artificial intelligence, tremendous opportunities emerge to leverage technology for addressing environmental challenges. However, the road to sustainable innovation requires a critical examination of resource usage and a commitment to reducing the energy footprint of our digital activities.

The talk will offer an overview of the UK data center landscape and highlight ongoing research initiatives focused on fostering more sustainable AI solutions. Attendees will gain insight into the strategies and technologies that are shaping a greener future in information technology.

BCS*: British Computer Society

Keynote talk 3: "Title TBC"

Dr Lindesay Scott-Hayward (CREEM, University of St Andrews, UK)

Abstract TBC.

3. Breakout groups

There will be two sessions of roughly 25 minutes each. In each session, participants will be split into groups as indicated below. Each group will have one chair and one note taker. At the end of the session, each group will report the key points and/or outcomes of their discussion.

- **Breakout discussions 1**: Shaping the SIG and priorities for each discipline (climate, environment, sustainability)

Participants will be split into groups according to their interest. There will be one group per discipline (climate, environment, sustainability). Groups might be further at the discretion of chairs (for instance if there are too many participants). Suggestive questions for all groups are below:

- Q1: What is the (main) role of mathematics in [this discipline]?
- Q2: What is required for mathematics and mathematicians to continue to be a key contributor to [this discipline]?
- Q3: How can this SIG support the community to achieve these aims and to contribute more widely?

- **Breakout discussions 2**: Shaping the SIG and priorities for each sector (academia, industry and policy)

Participants will be split into groups according to their interest. There will be one group per discipline (climate, environment, sustainability). Groups might be further at the discretion of chairs (for instance if there are too many participants). Suggestive questions for all groups are below:

- Q1: What were/have been the MS communities' past roles in CES?
- Q2: What are the top priorities for maths in 2 to 5 years and what levers do we have to get there?
- Q3: What do you want to achieve with this SIG and how can we help you achieve it?

