PhD position at the St Andrews Climate Dynamics Lab

Connecting warming patterns to clouds: the role of atmospheric circulation

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Project summary

Uncertainty in climate projections is driven primarily by uncertainty in how clouds will respond to global warming. But how clouds respond to climate change depends strongly on the geographic pattern of warming: the so-called 'pattern effect' (e.g. Rugenstein et al. 2023). This recently-discovered phenomenon is crucial to narrowing uncertainty in climate projections (Wills et al. 2022) yet fundamental understanding of the processes underpinning the pattern effect is underdeveloped.

The pattern effect in sea surface temperatures (SSTs) was proposed to explain how cloud feedbacks evolve with time (Ceppi & Gregory 2017; Andrews & Webb 2018). In essence, while global mean SST is an important metric through which to study the effects of a warming climate, the geographic pattern of SST warming modulates the magnitude of climate feedbacks – and therefore climate sensitivity estimates. Central to the pattern effect are cloud feedbacks and their links to tropical SSTs. However, our understanding of the mechanisms through which the pattern effect impacts clouds is largely qualitative and key questions remain unanswered. In particular, the potential role of changes in atmospheric circulation as a crucial link between warming patterns and cloud feedbacks remains unclear. This project aims to build this missing link and address the question: How do atmospheric circulation changes influence the pattern effect, cloud feedbacks and – ultimately – climate sensitivity?

The goal of this PhD project is to advance fundamental physical understanding of the processes controlling circulation and cloud responses to patterned SST warming. The PhD project will involve performing idealised simulations with the Isca global climate model (Vallis et al. 2018) to test the effects of different hypothesised mechanisms. In particular, the project will:

1. Directly answer the question of which regions produce the strongest cloud response when warmed, and the regional characteristics which determine this;
2. Determine the role of non-uniform changes in upper-tropospheric temperature in modulating cloud and circulation responses as a result of patterned warming;
3. Understand how the role of dry-air entrainment into convecting plumes shapes the circulation and cloud responses.

The PhD project will be part of a wider project at the University of St Andrews probing the role of circulation in the pattern effect, and there is scope to adapt the project to align with the candidate's research interests.

Training & Skills

Through this PhD project, you will be trained in several aspects of physical climate science including atmospheric dynamics, climate modelling and climate change. You will also be trained in highly sought-after technical skills in computational modelling, high-performance computing, and 'big data' analyses.

Research Environment

You will become a member of the St Andrews Climate Dynamics Lab within the School of Earth and Environmental Sciences. The overarching goal of the Climate Dynamics Lab is to advance fundamental knowledge of climate change, the defining issue of this generation. Our research philosophy is distinctive, combining state-of-the-art computer models with real-world data and theory to develop a robust understanding of the climate system. You will also become a member of the newly formed 'Climate, Ocean, and Atmosphere at St Andrews' (COASt) research group which has broad expertise across paleoclimate, climate dynamics, oceanography, ocean biogeochemistry and atmospheric dynamics.

What we're looking for, how to apply and deadline

This PhD position is suitable for a student with an undergraduate/masters degree or equivalent in physics, mathematics, engineering, atmospheric science, computer science, or a related field. **A strong background in mathematics and physics is more important than previous experience in climate science.**

Further details on entry requirements, application procedures and to apply can be found on the postgraduate application page:

https://www.st-andrews.ac.uk/study/apply/postgraduate/research/

Deadline for applications: 24th January 2025

Informal enquiries about the position: Please email arm33@st-andrews.ac.uk

References

- Andrews & Webb, *J. Climate*, 31, 641–654 (2018)
- Ceppi & Gregory, *Proc. Natl. Acad. Sci.*, 114 (50) 13126-13131 (2017)
- Rugenstein et al., *EOS*, 104, (2023)
- Vallis et al., Geosci. Model Dev., 11, 843–859 (2018)
- Wills et al., *Geophys. Res. Lett.*, 49, e2022GL100011 (2022)