

Understanding quasi-stationary Rossby wave behaviour

QUASI-STATIONARY ROSSBY WAVES

JET STREAMS

STORM TRACKS

TELECONNECTIONS



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EXPERTISE

Large-scale atmospheric dynamics

SUMMARY

Annual to decadal trends in features like jet streams and Rossby waves occurring on multi-day to weekly timescales have implications for climate extremes in the mid-latitudes, especially in Europe. Using data-driven methods alongside physics-based models can improve our ability to identify Rossby wave source regions and evaluate the processes by which these waves propagate from the tropics to the extratropics. A better understanding of the physical mechanisms underlying these teleconnections helps build trust in climate projections of extreme events and their impacts.

Can you explain why your field of research is related to climate change drivers?

Rikke Stoffels: My curiosity about understanding the climate system started with an interest in geography, as I was fascinated by atmospheric circulation patterns and the climatic zones they create. By starting a bachelor's degree in «Earth System Sciences» in Wageningen, the Netherlands, I was introduced to climate science in more detail.

As a result, I specialised in the field of atmospheric dynamics, focusing on jet stream variability. I study transient synoptic-scale weather systems, such as extratropical cyclones and anticyclones, which propagate along this jet stream in so-called storm tracks. Another focus of my research is quasi-stationary Rossby waves (Figure 1). These are hemispheric waves that strongly influence weather patterns across the mid-latitudes. When they slow down and amplify, the associated weather conditions can persist for several days to weeks, contributing to prolonged extremes such as heatwaves. Understanding the mechanisms that lead to their amplification and persistence is therefore essential, particularly if these conditions become more frequent in a changing climate.

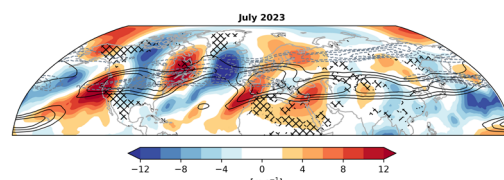


Figure 1: Example of Northern Hemisphere quasi-stationary Rossby waves during July 2023. Colour shading shows the meridional wind (v , north-south winds), whose alternating positive and negative anomalies indicate persistent Rossby waves. Black crosses mark midlatitude regions that experienced strong heatwaves (lasting more than 5 days) during the month. Solid black lines show the long-term mean zonal wind (east-west winds), and dashed grey lines show waveguides. From Lembo et al. (2024).

Within EXPECT, what's the focus of your research?

R-S: Extratropical cyclones are more frequent and more intense during winter, but as EXPECT focuses on the summer season, I am studying the precipitation characteristics and moisture transport pathways of summertime storms. In parallel, I am identifying quasi-stationary Rossby waves using data-driven approaches. We study changes in their behaviour and use machine learning (ML) to try to pinpoint key regions in the tropics that drive trends in the mid-latitudes. Temperature anomalies in these regions can influence the generation and propagation of Rossby waves, eventually affecting weather patterns across Europe.

My aim, however, is not to develop a ML model that maximises predictive skill for the mid-latitudes. Instead, we hope to gain insight into what the model has learnt and whether this could be linked to existing physical mechanisms. For this purpose, we will use explainability techniques. Based on the new insights, we could for example then design idealised experiments to test the influence of the tropical regions highlighted as most important by the model.

What is a key recommendation that you have?

R-S: Sharing my curiosity and helping others understand the climate system is part of my research. But communicating climate information requires explaining the uncertainty that comes with it. We, as scientists, love to include statements about the uncertainty in our results at the cost of potentially overcomplicating our work and losing our target audience. It's very challenging to translate those aspects of uncertainty into a convincing message for society.

To work around that tricky situation, we need communication scientists, not just climate scientists. We could think of different ways to disseminate our results than through publishing a report or paper (e.g. Figure 2), and benefit from communication partners such as ARCTIK in the case of the EXPECT project.

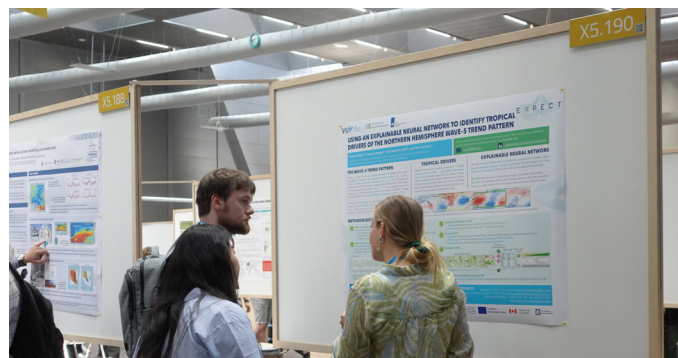


Figure 2: Rikke Stoffels presenting her research on neural networks during a poster session at the European Geosciences Union (EGU) General Assembly 2025 in Vienna

LOOKING FORWARD



We are still in the early stages of this research, but the intention is to connect insights into climate system drivers with efforts to improve climate prediction. After getting a better understanding of the changes in Rossby wave behaviour and pinpointing areas in the tropics that explain these mid-latitude trends, climate projections should accurately represent the processes occurring in these regions. Moreover, similar machine learning approaches could be used to link atmospheric circulation trends to extreme events such as heatwaves at national or regional scales, provided that the underlying mechanisms are well understood and validated. By combining targeted experiments with detailed case studies, we can produce results that are robust, physically grounded and suitable for peer-review publication.

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Through short, focused questions, project researchers share what they study, why it matters, and how their investigations lead to real-world findings.



By opening up the day-to-day challenges and thinking behind climate research, these explainers make science more accessible, transparent, and trustworthy for other researchers and decision-makers alike.



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