Atmosphere blocking dynamics: Persistence, re-intensification and interaction with other weather systems

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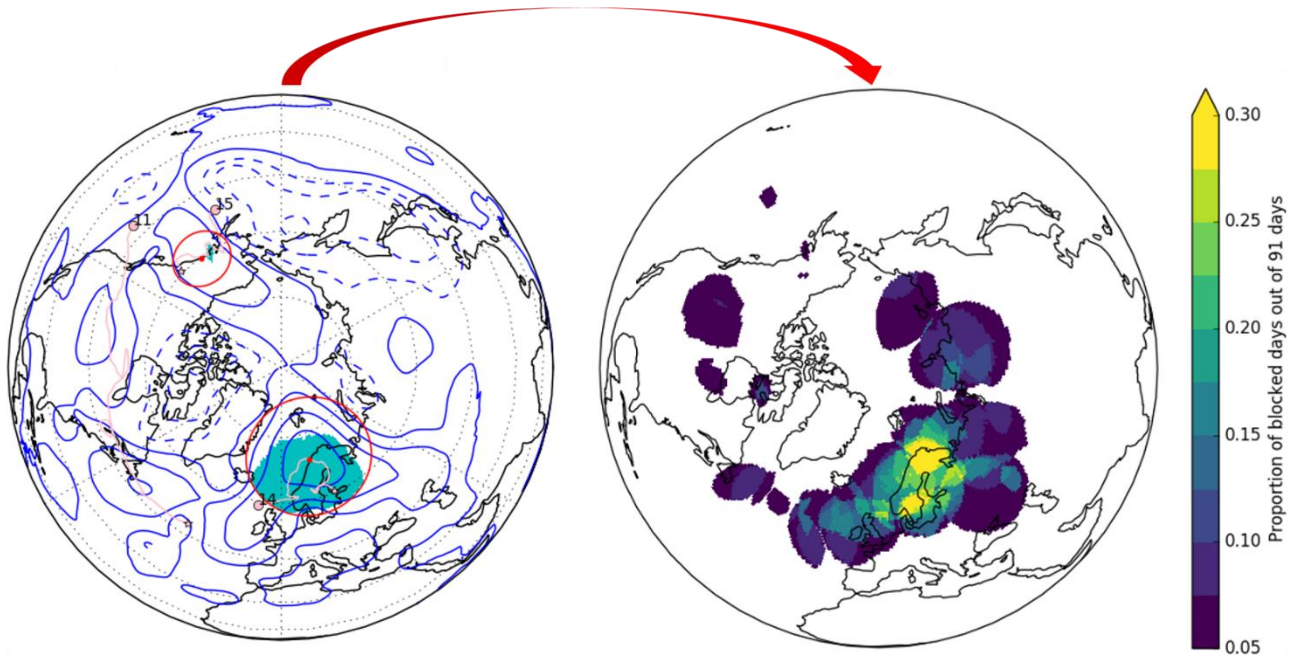
Atmospheric blocking occurs when persistent high-pressure systems (or anticyclones) remain quasi-stationary over a given location or region at mid- or high-latitudes. These blocks act to disrupt the normal passage of low-pressure systems over such regions. Blocking events have high impact on human activities with a variety of effects depending on the time of the year in which they occur. In summer, the regions under the influence of high pressure can experience heat waves, abnormally dry periods, and stagnant-air conditions. In winter, they may be associated with prolonged cold spells. Outside the blocked regions, the opposite effects can take place leading to, for example, abnormally high precipitation. All these effects can have important repercussions for a given population's health, agriculture, water supply and energy production and demand. Despite these important consequences, forecasting atmospheric blocking in weather and climate models remains a challenging task. One major contributing factor is the lack of a complete theory to explain the onset, persistence and decay of atmospheric blocking events (Woollings et al. 2018).

There are several large-scale circulation patterns that can be associated with atmospheric blocking. However, the influence of these patterns on features such as block persistence and surface effects (e.g. precipitation and surface temperature) are not fully understood. Moreover, several aspects of extremely long-lived events remain to be investigated. This project aims to answer the following science questions:

- Do some large-scale circulation patterns lead to more persistent blocking events?
- Are extremely persistent events the result of a single pattern that undergoes a continuous re-intensification?
- Or alternatively, do they result from the co-existence and interaction of several patterns that follow their own life-cycles?

To answer these questions we will use a combination of newly developed methods to track anticyclones (Estareja 2018) and processed-based techniques (Martínez-Alvarado et al. 2016), to investigate the processes that affect the development, evolution and persistence of blocking anticyclones. The methodology will be applied to three types of datasets: long-term observationally constrained reanalyses, which provide an accurate representation of past and current atmospheric states; high-resolution free-running climate simulations, which enable experimentation under past, present and future conditions; high-resolution NWP simulations, which enable an evaluation of blocking-related error development in operational weather forecasting. Comparisons between these datasets will help to identify shortcomings in the current weather forecast and climate models and potentially lead to important improvements.



Anticyclone tracks and blocked regions – 9 October 2016 Seasonal blocking frequency – Autumn 2016

Blocking over Europe. Blocking anticyclones (red circles) contributing to blocked regions (light blue) for at least five days (left panel) and to the seasonal blocking frequency (right panel)

Training opportunities:
The student will be able to attend courses in the NCAS training programme of relevance to the PhD topic such as the Climate Modelling Summer School in 2021 and the Introduction to the Unified Model. Having the Met Office, a world-leading institution in numerical weather and climate prediction, as a project partner will open the potential for the student's research to influence future model development. The student will visit Dr Ackerley at the Met Office in Exeter to learn more about the process of model evaluation and development at the Met Office and experience working in a non-academic environment.

Student profile:
This project will be suitable for a highly self-motivated student with an interest in developing science without losing view of its consequences on and applications to everyday life. The project will be suitable for students with an academic degree with a substantial level of numeracy (e.g. mathematics, physics, engineering or other closely related environmental of physical science).

Funding particulars:
This project is co-sponsored by a Met Office CASE studentship.

References: (optional)

Estareja, B. J. N. (2018) "Tracking Blocking High Pressure Systems", MSc Thesis, University of Reading, 46pp
Martínez-Alvarado et al. (2016): Diabatic Processes and the evolution of two contrasting summer extratropical cyclones. *Mon. Weather Rev.,* **144**: 3251–3276
Woollings, T. et al. (2018): Blocking and its response to climate change. *Current Climate Change Reports* **4:** 287–300.

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