Department of Geography and Environment

Enhanced climatology of large hail in the UK

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1. Introduction

- Large hail (diameter of at least 20 mm) is one of the hazards associated with severe convective storms and can cause significant damage and injury.
- Compared to continental Europe, large hail is relatively rare in the United Kingdom[1]. However, damaging events do occasionally occur[2].
- Understanding of the atmospheric environments conducive to large hail is built on databases of past events, often relying on crowdsourced reports[1,3].
- UK large hail climatology has not been updated in more than 15 years[4] and the two main report databases have not previously been merged.
- Further, most reports from the last 20 years are missing a precise time of day.

2. Data & Methods

- Merge large hail reports since 1979 from the Tornado and Storm Research Organisation (TORRO)[5] and the European Weather Severe Database (ESWD)[6].

ESWD + TORRO ⇒ **~800 reports** across **~400 events**

- Using Met Office radar reflectivity data[7], verify and assign time of day and basic storm mode (isolated, clustered or linear) to 260 reports since 2006.
- First mode classification of storms producing large hail in the UK.

3. Results

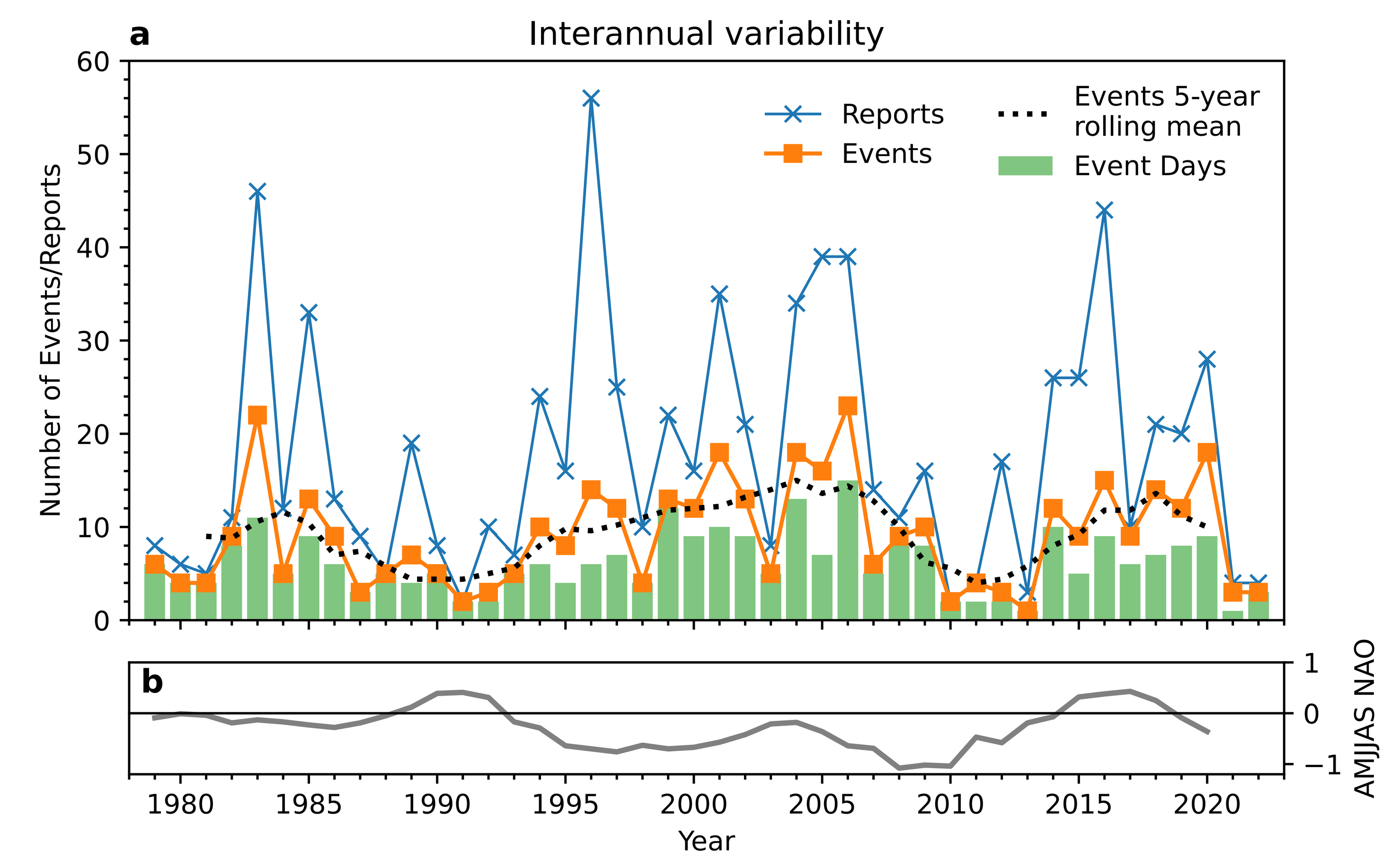

Figure 1. Interannual variability of UK large hail reports. **(a)** Number of reports (blue crosses), events (orange squares) and event days (green bars) per year. Centred 5-year rolling mean of events (dotted black). **(b)** Centred 5-year rolling mean of April–September North Atlantic Oscillation.

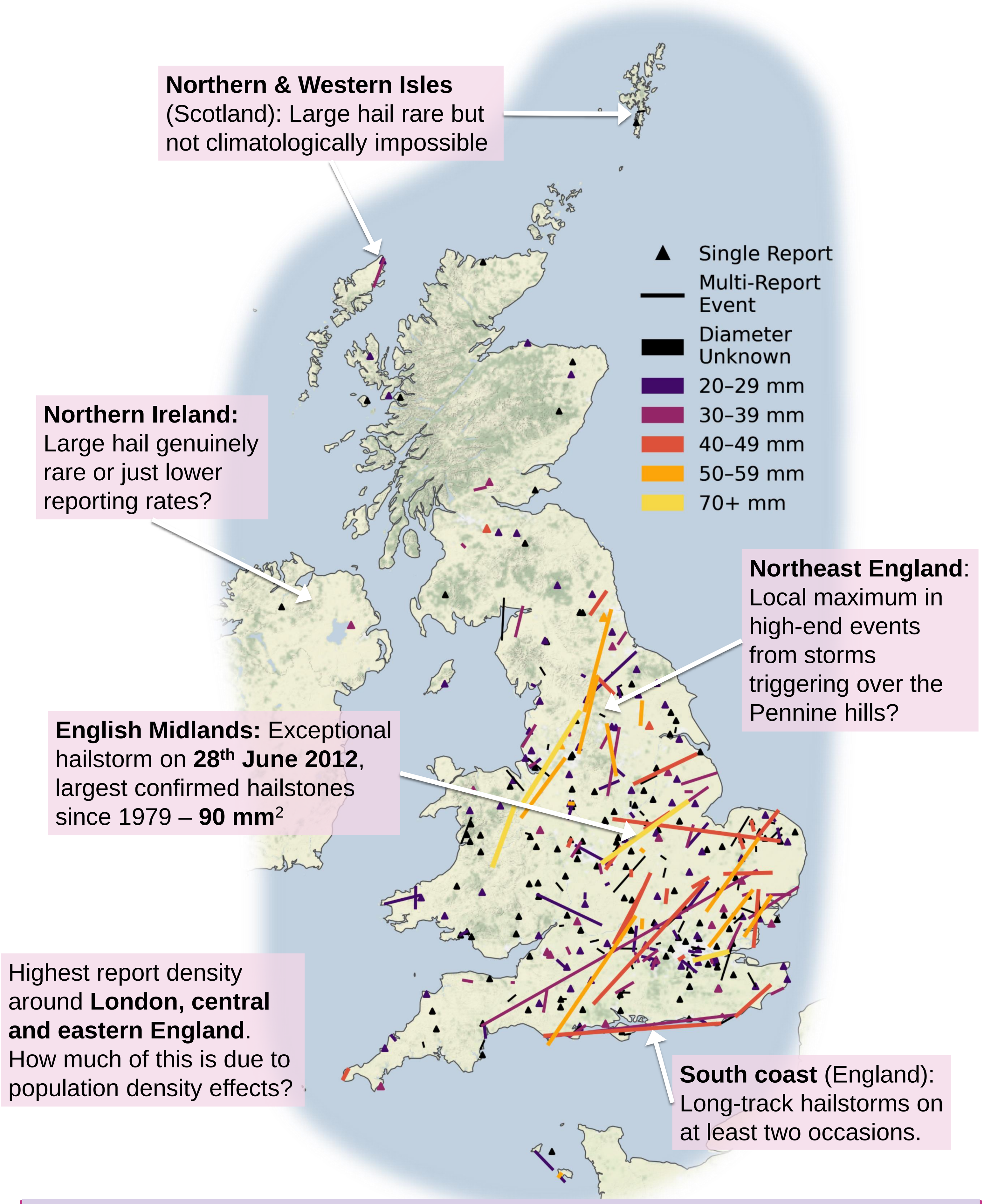

Figure 2. Map of UK large hail reports and hailswaths, coloured by maximum reported hail diameter.

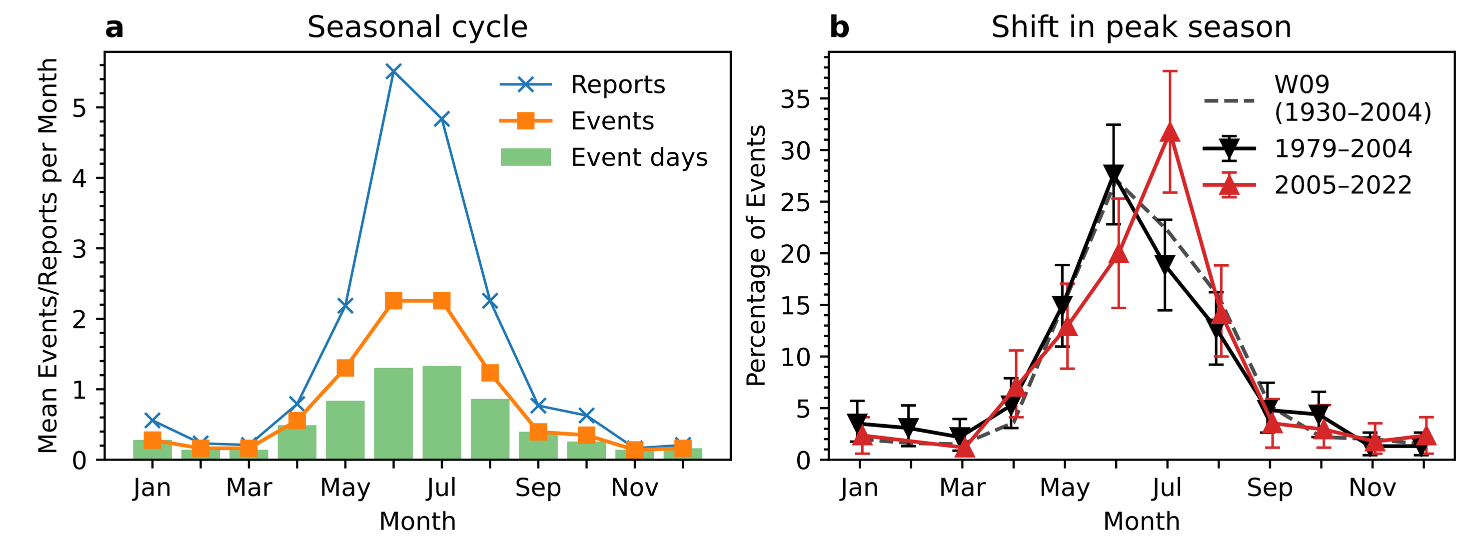

Figure 3. Seasonal cycle of UK large hail reports. **(a)** Mean number of reports (blue crosses), events (orange squares) and event days (green bars) per month. **(b)** Percentage of events taking place in each month for 1979–2004 (black) compared to 2005–2022 (red). Error bars show bootstrapped 5%–95% confidence intervals. Corresponding values from Webb et al. 2009[4] (dashed grey), visually estimated from their Fig 5.

- Mean of 9 large hail events per year, with no indication of a long-term trend (Fig 1).
- Multiannual periods of enhanced reduced activity e.g. early 2010s lull followed by peak. No consistent relationship with NAO.
- Full period (1979–2022) shows early summer maximum, but this masks a shift in peak month from June to July (Fig 3).
- Therefore radar-derived diurnal cycle and storm mode are from period (2006–) with different seasonality to earlier climatologies[4,8].

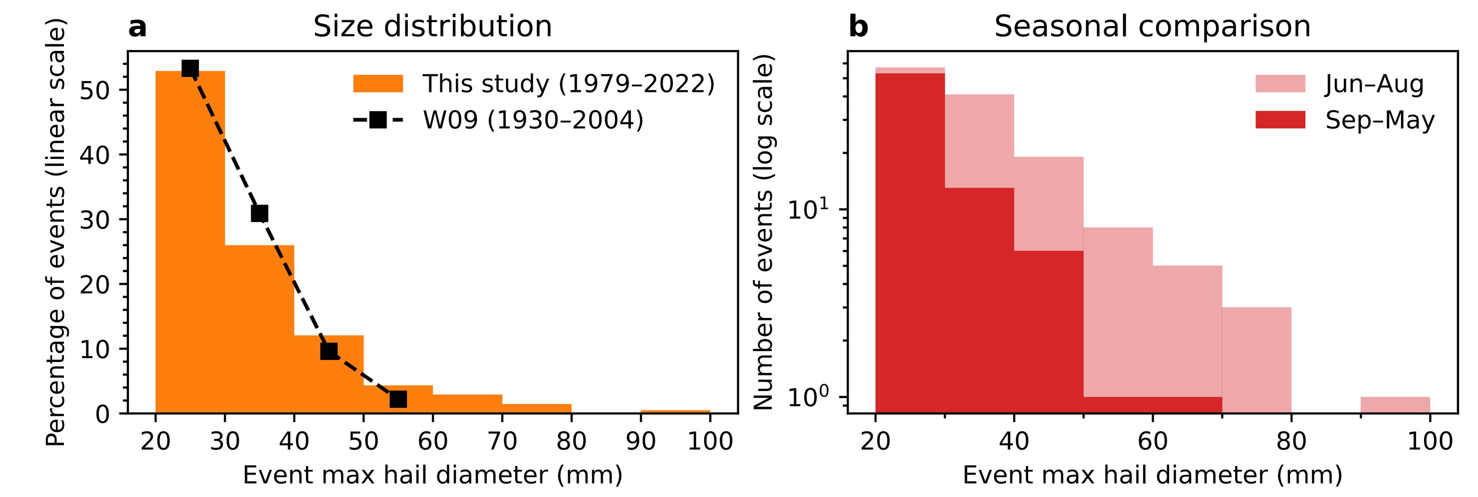

Figure 4. Size distribution of UK large hail reports. **(a)** Percentage of events with hail diameter in 10 mm bins (orange). Corresponding values from Webb et al. 2009[4] (dashed black), visually estimated from their Fig 1. **(b)** As in (a) but comparing peak season (Jun–Aug, pink) and off-season (Sep–May, red) against a logarithmic scale.

- Size distribution decays faster during off-season with few high-end events (Fig 4).
- Diurnal cycle peaks earlier during off-season, but uncertainties are large (Fig 5).
- Isolated cells are responsible for half of large hail events, while the contribution from linear storms is more than doubled during the off-season compared to June – August.

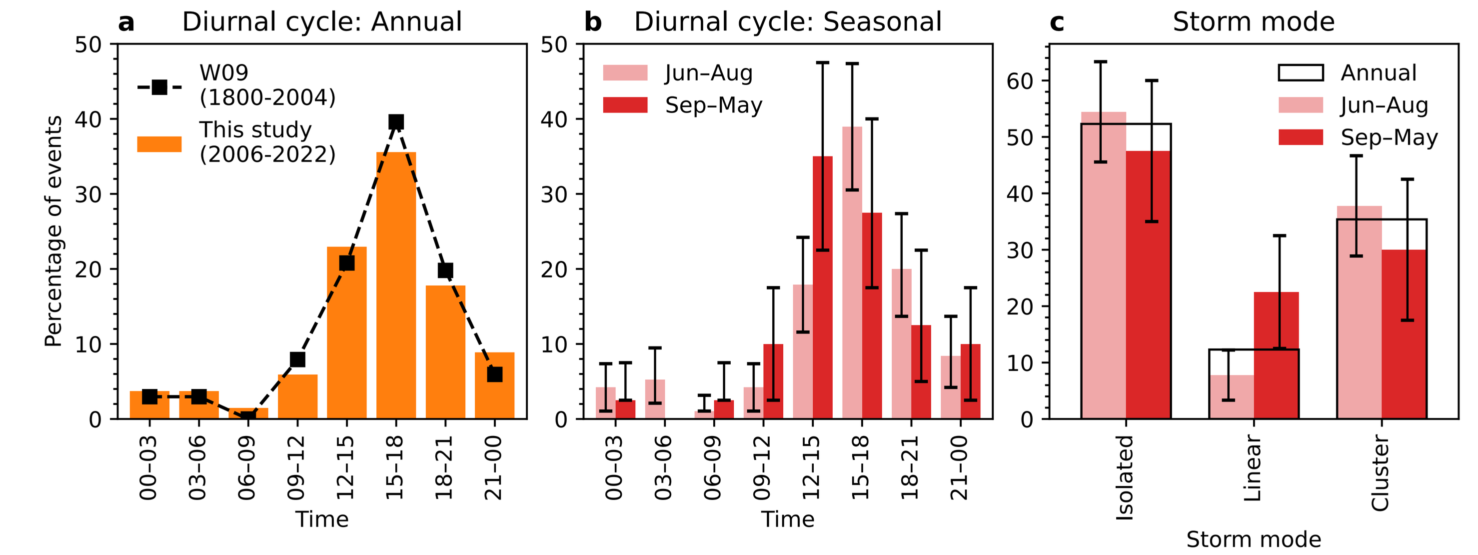

Figure 5. **(a)** Diurnal cycle of UK large hail events (orange bars), compared with Webb et al. 2009[4] (dashed black), visually estimated from their Fig 13. **(b)** As in (a) but comparing peak season (Jun–Aug, pink) and off-season (Sep–May, red). **(c)** Radar-classified storm mode of large hail events annually (unfilled black bars), and for peak season (Jun–Aug, pink) and off-season (Sep–May, red). Error bars in **(b)** and **(c)** show bootstrapped 5%–95% confidence intervals.

4. Further Work

- Hail is only one convective hazard – extend to UK tornadoes and heavy rainfall.
- What explains the multiannual variability and shift in peak months, and will it continue into the future? Build statistical models relating reports to background environment.
- Do hail-prone environments optimised for the UK look different to those based on pan-European data[9,10]? Are different sets of parameters useful for forecasting?

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Abstract: