Department for Environment Food & Rural Affairs
Department for Energy Security & Net Zero
Department for Science, Innovation, & Technology
Met Office Hadley Centre
Environment Agency

UKCP Guidance: Extreme rainfall features in UKCP Local

This document describes an issue that has been found with precipitation data from UKCP Local and provides guidance for those who have already used or are planning to use the dataset. Impacts on both the 2.2 km and 5 km regridded versions of the dataset are outlined. If you need any further information after reading this document, please contact the UKCP team at www.metoffice.gov.uk/research/approach/collaboration/ukcp/about/contact.

What is the issue with rainfall extremes in UKCP Local (2.2 km)?

UKCP Local (2.2 km) contains occurrences of high rainfall whose spatial characteristics are physically unrealistic (see Figure 1). They predominantly appear as linear features aligned with the climate model grid. These events only occur for a limited set of specific conditions and are a result of limitations in how the climate model represents the movement of air parcels. The frequency of these events could affect estimates of present-day extreme rainfall and future changes.

The issue can be found in all seasons and all years and mainly occur where convection is strongest. This means that during December, January and February they predominantly occur over the sea and those that do occur over land are mainly near the coast. During June, July, August they are predominantly over land.

The issue contributes a significant proportion of the very highest hourly rainfall rates present in UKCP Local at the 2.2 km grid scale but becomes increasingly less apparent as the spatial scale of the rainfall is increased, i.e., it has less impact on extremes at 5 km (or coarser) scales. Aggregating in time, from hourly to daily, is not found to make a significant improvement. This is somewhat counterintuitive and not yet fully understood.

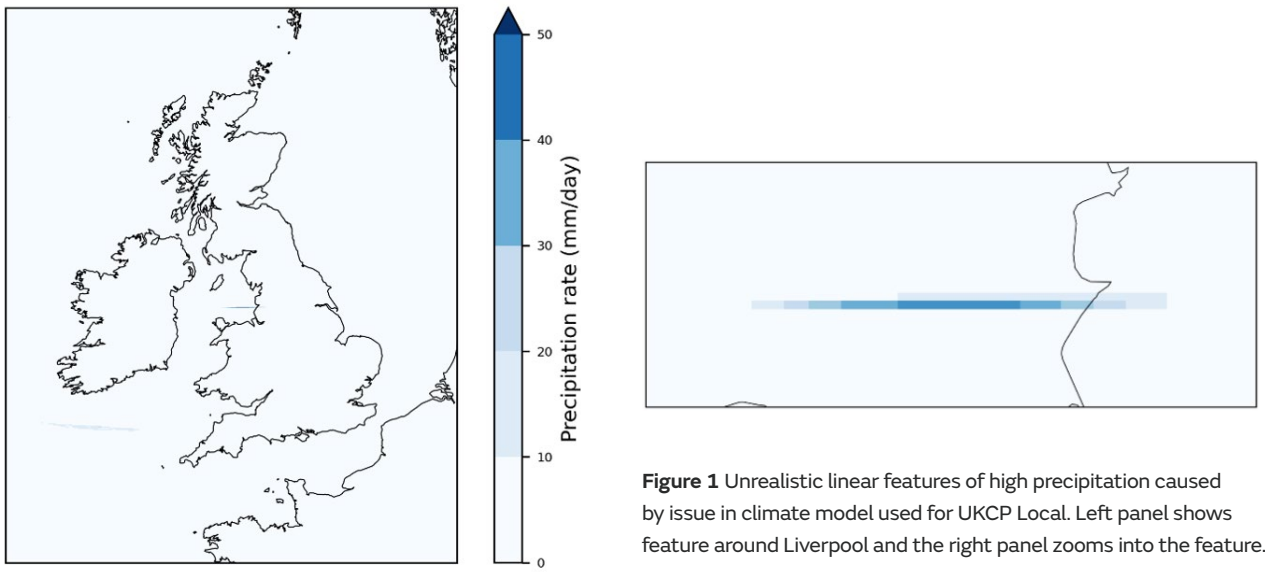

Figure 1 Unrealistic linear features of high precipitation caused by issue in climate model used for UKCP Local. Left panel shows feature around Liverpool and the right panel zooms into the feature.

What is the scale and impact of this issue?

UKCP Local is available at its native spatial resolution at 2.2 km as well as a regridded version at 5 km spatial resolution in the Ordnance Survey's British National Coordinates. The latter underpins the FUTURE-DRAINAGE uplifts (Dale et al, 2021) and the Environment Agency's rainfall allowances tool[1]. For both 2 km and 5 km datasets, the issue can result in extreme rainfall events which are unrealistic in both physical shape and intensity.

To assess the impact of these unphysical events, filters designed to identify linear features, which are a single grid box wide and aligned with the grid, were applied to the rainfall hourly fields. Grid box values above a given threshold (that was determined from visual inspection of unphysical features) were deemed to be errant and replaced with missing data for this sensitivity analysis (see later for alternatives). It should be emphasised that determining the extremal properties of rainfall is difficult and subject to significant uncertainty, and the chosen methodology can have a significant effect on the diagnosed impact of the unphysical events. Thus, the values reported below should only be seen as indictive of the scale of the issue and that individual applications and approaches may be affected by a greater or lesser degree.

For the 2.2 km products, using the methodology of Shooter and Brown (2024), England hourly 30-year grid point return levels are found to differ by (3% to 5%) and (-6% to 5%) for the periods (1980-2000) and (2060-2080) respectively on replacing unphysical features with missing data, uplifts differed by (-14% to 2%). Corresponding daily values are (8% to 12%), (10% to 16%) and (6% to 10%).

The impacts of the unphysical events are reduced for the 5 km dataset due to the smoothing effect of the regridding. For the 5 km products, again using the methodology of Shooter and Brown (2024) England hourly 30-year return levels are found to differ by (2% to 3%) and (1% to 5%) for the periods (1980-2000) and (2060-2080) respectively, uplifts differed by (-2% to 3%). Corresponding daily values are (3% to 8%), (4% to 12%) and (3% to 7%).

We note that the above numbers giving a quantitative estimate of the size of the impact are based on preliminary filtering of linear features (aligned along the grid lines). This approach is not expected to capture all unphysical values. Thus, this filtering approach is not perfect and the results above regarding the size of the impact should just be seen as indicative. It is not clear how many of these events have been spuriously created by the model limitations and how many are legitimate extreme rainfall events, but for which the rainfall intensity may be overestimated. This hinders replacing the erroneous rates with more meaningful values. Some approaches have been explored, including replacing the erroneous values with the equivalent percentile in the remaining rainfall field. However, these choices are subjective and do not resolve the unphysical shape of some of these events.

Which UKCP products are affected?

Only UKCP Local is affected. For this, the 2.2 km precipitation datasets are most obviously affected. It is also possible there are some localised impacts on other variables in the 2.2 km dataset, such as surface temperature and wind gusts.

[1] https://environment.data.gov.uk/hydrology/climate-change-allowances/rainfall

What if you've already used or are planning to use the data?

If you have only used or are planning to use the 5 km regridded version, we advise that you to continue to use it and the FUTURE-DRAINAGE uplifts. While this is best climate model data that we have for future hourly precipitation over the UK, our confidence in the dataset is now lower because of the issue.

We advise against using the 2.2 km hourly rainfall data for analysis that supports decision-making. If you have used or are planning to use the 2.2 km data, we recommend that you perform a visual inspection of the precipitation data to understand the potential effects of the issue on your analysis. We have not yet found a robust method to completely remove or substitute the unphysical values. However, we can provide some data where filtering of linear features and their replacement (using values from the remaining distribution, or with zeros) has been carried out to allow some sensitivity testing of the likely impact on your analysis. Should you wish to do this, we can provide further advice if you contact us using the form at www.metoffice.gov.uk/research/approach/collaboration/ukcp/about/contact.

Many applications also include a bias-adjustment step (see bias correction guidance[2]) before carrying out a threshold exceedance analysis or impacts model simulation. Depending on the bias-adjustment approach selected, the issue could be magnified or reduced.

As stated in our guidance, always consider using the breadth of products across the full suite of UK Climate Projections. This will allow sampling a wider range of potential outcomes, including uncertainties, within the projections.

When will the data be updated or further guidance issued?

We are not planning on replacing the UKCP Local datasets. However, we will continually assess the need for updated data to support decisions affected by this issue as part of our wider UKCP provision. If you use the 2.2 km dataset and require further guidance on its appropriate use, or methods to identify and potentially replace affected values, please contact us using the form at www.metoffice.gov.uk/research/approach/collaboration/ukcp/about/contact.

[2] Available at www.metoffice.gov.uk/research/approach/collaboration/ukcp/data/guidance

References

Dale M, 2021. FUTURE DRAINAGE. Guidance for Water and Sewerage Companies and Flood Risk Management Authorities: Recommended uplifts for applying to design storms. Available at https://artefacts.ceda.ac.uk/badc_datadocs/future-drainage/FUTURE_DRAINAGE_Guidance_for_applying_rainfall_uplifts.pdf.

Shooter R and Brown SJ, 2024. High-resolution estimation of daily precipitation extremes in the United Kingdom using a generalised additive model framework. In review.