

Evaluating the Small-scale Space Time Structure of Rainfall in the Convection Permitting Model of UKCP18

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Introduction

Background

Sub-daily rainfall at Km-scale resolution is critical in a wide range of hydrological applications.

Question?

How credible is the UKCP18 local projection for hydrological use?

Our study

Evaluation is needed, particularly on it's small-scale feature.

Data and Methods

UKCP18 Local(2.2Km) Projection(1)

- Resolution: 1hour, 2.2km, over the UK
- Length: 12 ensemble members, 1980-2000

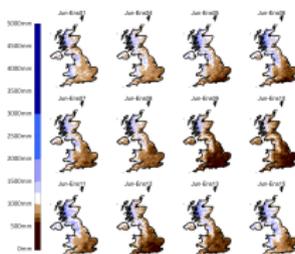


Figure 1: Mean rainfall (mm/yr) in July from 12 ensemble members

Observations

Three observation dataset, (including CEH-GEAR (2), HadUK-Grid(3) and UKMO C-band radar composite(4)), were used for comparison.

- ✓ Quality controlled
- ✓ Conservatively remapped to 2.2 Km resolution.

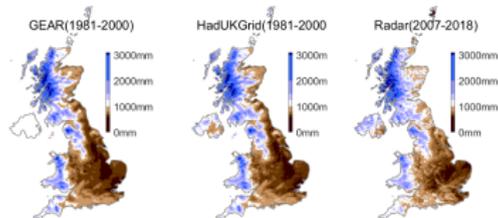


Figure 2: Mean precipitation intensities from a) CEH-GEAR. b) Haduk-Grid. c) C-band Radar Composite

Statistical Analysis

We analysed:

Mean bias:

Mean precipitation, Correlation in space, Temporal Statistics;

Spatial structure of heavy rainfall:

Characteristics of rainfall cells, Clustering feature, Areal reduction factors

Mean bias

Mean precipitation

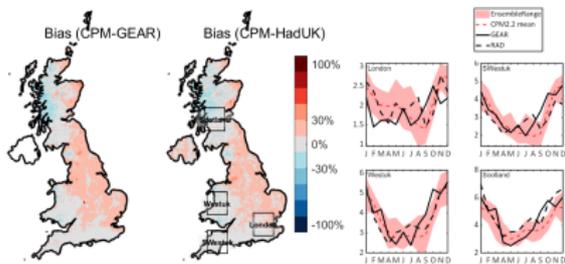


Figure 3: Relative bias of annual mean precipitation between CPM2.2 and observation a) relative bias between CPM2.2 and CEH-GEAR. b) relative bias between CPM2.2 and HadUK-Grid. Non-significant difference at 5% level is shown as grey color. c) Averaged monthly rainfall pattern for areas marked in b).

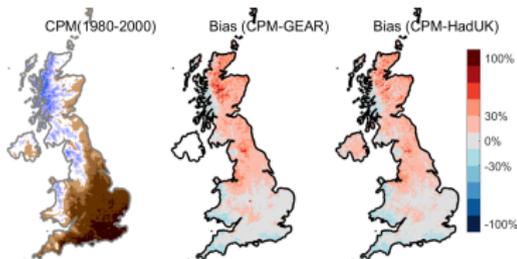


Figure 4: Precipitation in JJA a) CPM, b) and c) same as Figure3, but for JJA.

Temporal Feature

Rainfall events were extracted (in space-time domain).

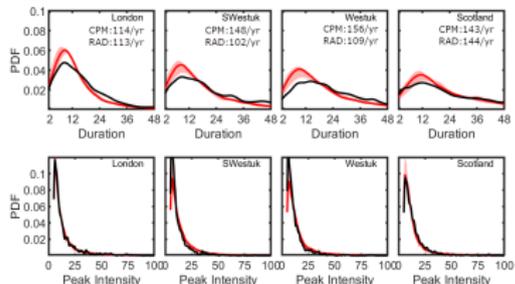


Figure 5: PDFs of event duration and peak intensity.

Spatial Correlation

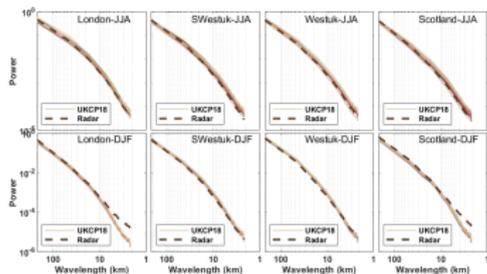


Figure 6: Radially averaged power spectrum (RAPS) at four locations (110Km x 110Km per each). Upper: JJA. Lower: DJF

Spatial Structure of Heavy Rainfall

Clustering feature (5)
 Clustering feature at a daily scale: observation is within ensemble range. At an hourly scale: tends to be more dispersed.

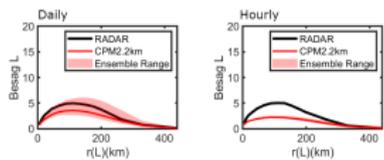


Figure 7: Clustering features for extreme rainfall during summer (heaviest 48 hours/season/yr), using Besag-L function. a) at daily resolution. b) at hourly resolution

Areal Reduction Factors
 Based on fixed-area method (6)

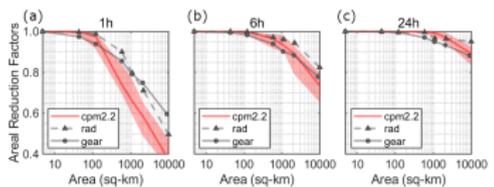


Figure 8: Areal Reduction Factors (ARFs) for precipitation in southern UK. a) 1h duration. b) 6h duration. c) 24h duration.

Heavy Rainfall Cells
 We examined occurrence of rainfall cells (centroid) during JJA.

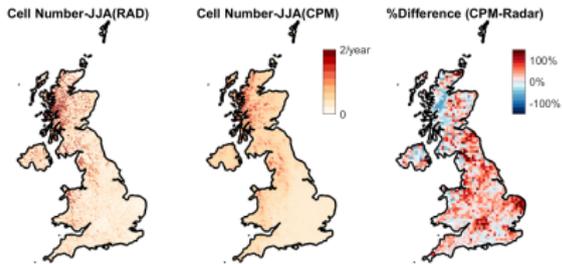


Figure 9: Spatial distribution of numbers of heavy rainfall cell "hotspot" (> 3mm/h) during summer. a) Radar observation. b) model simulation. c) Relative difference

Summary
 In our study, the 2.2Km CPM overall shows a satisfying performance and it captures rainfall organisation both on space and time. In term of heavy rainfall: clustering feature at a daily scale is well reproduced, but a bit worse at an hourly scale. Correspondingly, the simulation produces too many heavy-rain cells. It gives slightly overestimated spatial reduction (lower 1-hour ARFs) for large catchments (1000-10000Km²).

References

- [1] Met Office Hadley Centre. Ukcp18 convection-permitting model projections for the uk at 2.2km resolution, 2019.
- [2] M. Tanguy, H. Dixon, I. Prosdocimi, D.G. Morris, and V.D.J. Keller. Gridded estimates of daily and monthly areal rainfall for the united kingdom (1890-2017) [ceh-gear], 2019.
- [3] Dan Hollis, Mark McCarthy, Michael Kendon, Tim Legg, and Ian Simpson. Haduk-grid—a new uk dataset of gridded climate observations. *Geoscience Data Journal*, 6(2):151–159, 2019.
- [4] Met Office. Met office rain radar data from the nimrod system. ncas british atmospheric data centre, 2016.
- [5] Steven C. Chan, Elizabeth J. Kendon, Hayley J. Fowler, Stephen Blenkinsop, Christopher A. T. Ferro, and David B. Stephenson. Does increasing the spatial resolution of a regional climate model improve the simulated daily precipitation? *Climate Dynamics*, 41(5):1475–1495, 2013. ID: Chan2013.
- [6] C. Svensson and D. A. Jones. Review of methods for deriving areal reduction factors. *Journal of Flood Risk Management*, 3(3):232–245, Sep 2010.
- [7] Giorgia Fosser, Elizabeth Kendon, Steven Chan, Adrian Lock, Nigel Roberts, and Mike Bush. Optimal configuration and resolution for the first convection-permitting ensemble of climate projections over the united kingdom. *International Journal of Climatology*, 2019.