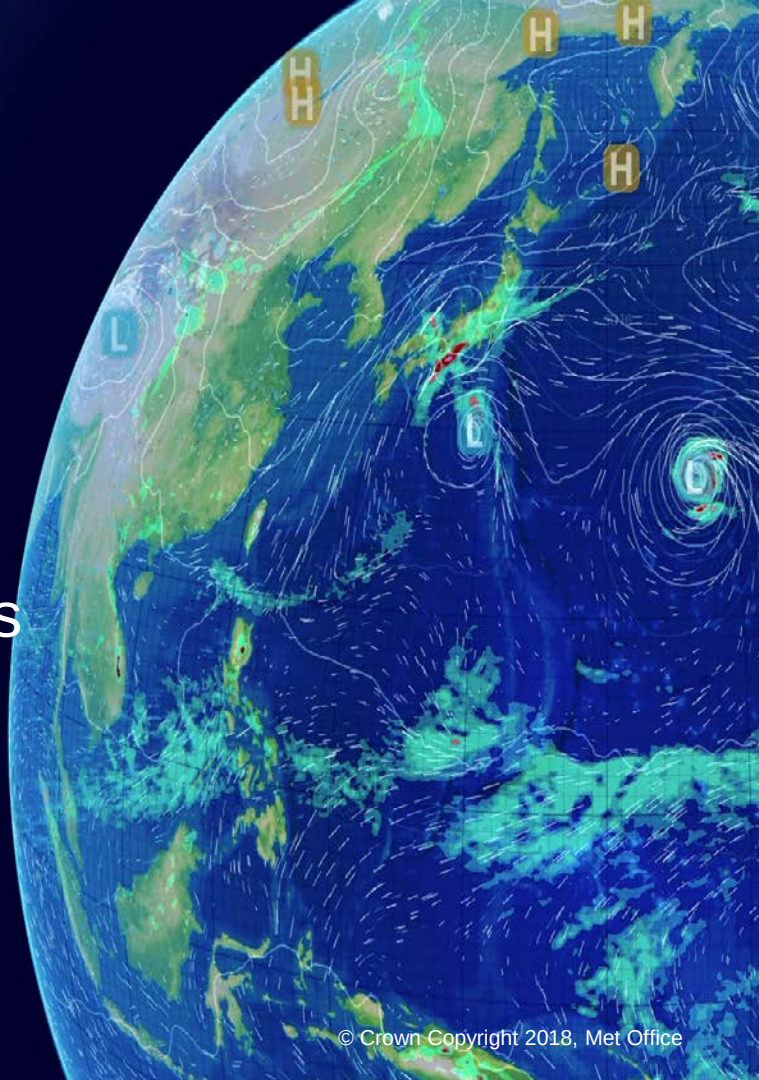
Met Office
Hadley Centre

First ensemble of climate projections at convection-permitting scale for the UK: optimal configuration and preliminary results

Giorgia Fosser, Lizzie Kendon, Steven Chan, Adrian Lock, Nigel Roberts, James Murphy, Mike Bush



Background

- Improved realism of rainfall in CPMs
- Largest benefits of CPMs for precipitation at hourly timescales, and for regions/seasons where convection dominates (e.g. Africa, Europe in JJA)
- UKMO and ETHZ 2.2km models show qualitatively similar results but need for more CPM simulations to estimate uncertainty
  - CORDEX-FPS (coordinated multi-modelling effort for Europe)
  - UKCP18 (will allow first estimate of uncertainties at hourly/km-scales to support UK risk assessment studies)

Courtesy of Kendon, GEWEX May 2018, Canmore

UKCP18: a new step forward

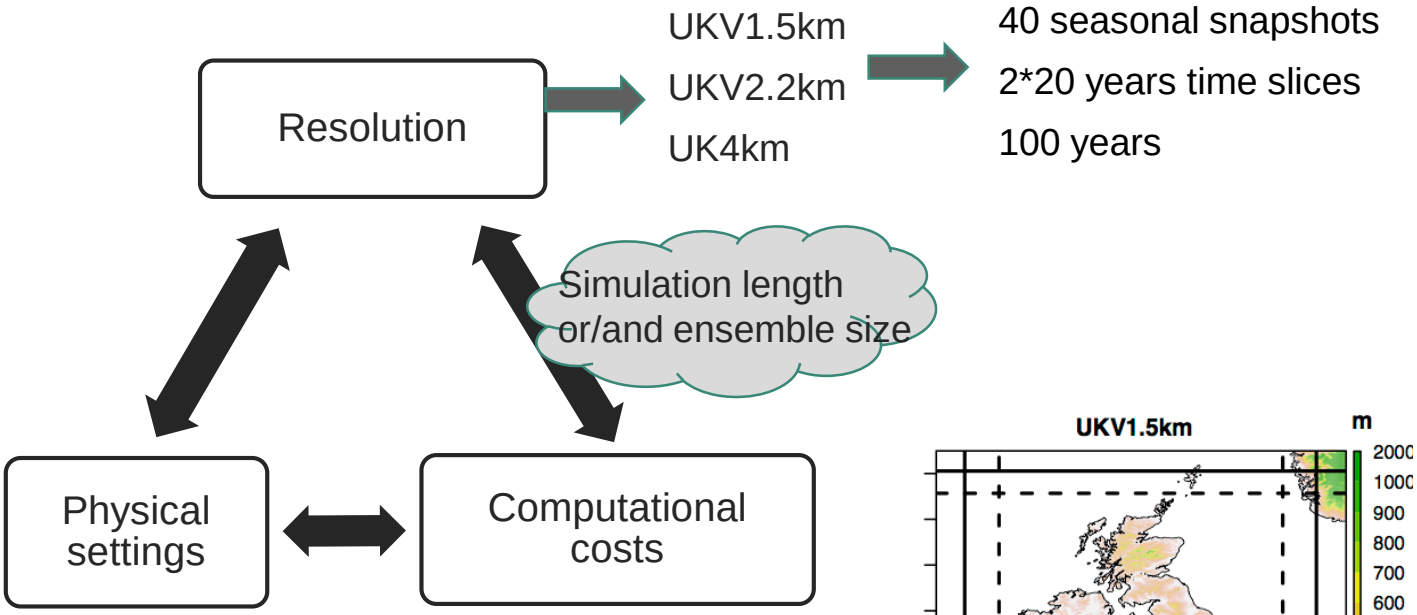
- First ensemble of projections at convection permitting scale
- driven by the ensemble of global climate simulations (HadGEM3-GC3 model, at ~60km) sampling both modelling uncertainty and variability
- run over UK with +12 ensemble members
- allow estimate of uncertainty at km-scale
- support UK risk assessment studies

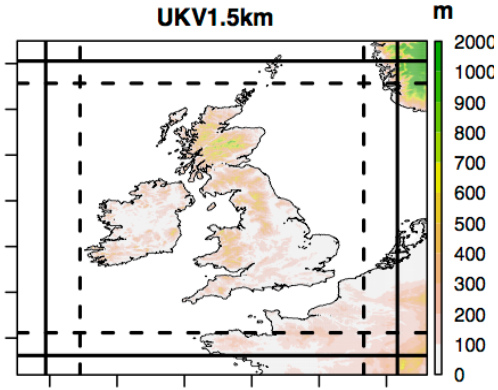
PHASE 1 → Identify the suitable UK domain, resolution and experimental design for convective-scale projections ensemble using ERA Interim driven CPMs simulations

PHASE 2 → Run and evaluate an CPM ensemble over the UK domain selected in phase 1

Launch Spring/Summer 2019

Optimal configuration for ensemble





- UK (limited domain)
- Focus on precipitation

Optimal configuration for ensemble

Resolution

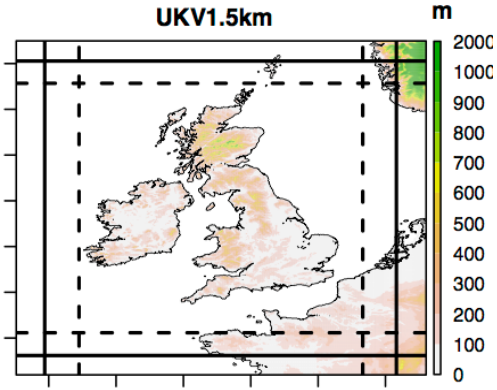
UKV1.5km
UKV2.2km
UK4km

40 seasonal snapshots
2*20 years time slices
100 years

To what extent the advantages of increasing resolution in terms of the representation of precipitation outweigh the extra computational cost

Physical settings

Computational costs



- UK (limited domain)
- Focus on precipitation

Test strategy

- ERA Interim reanalysis-driven simulations
- Run from March1996 – 2008
- Focus on summer JJA and precipitation

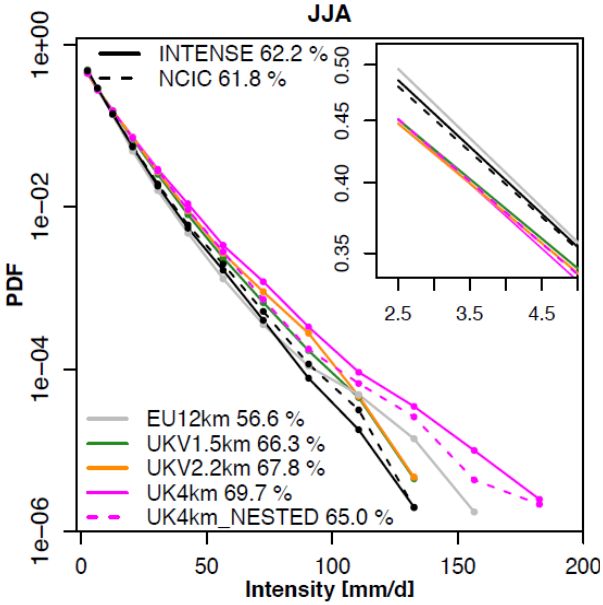
Impact of resolution

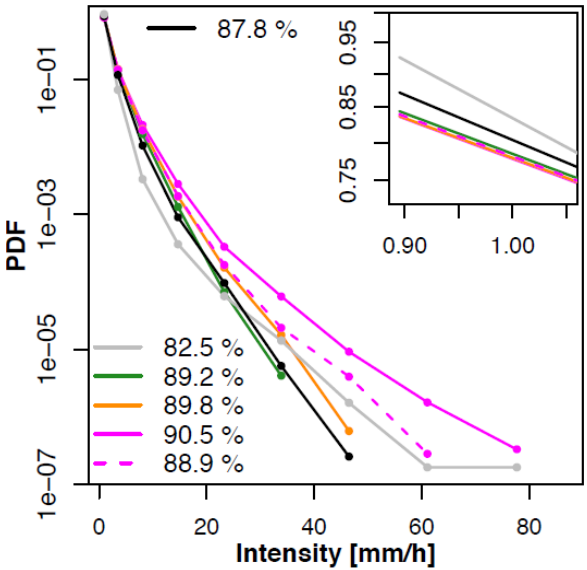
- UKV1.5km
- UKV2.2km
- UK4km
- UK4km_NESTED

Impact of physical packages

- PS38 Current operational configuration
- Higher mixing length and perturbation as PS35
- Conservation scheme
  - Nesting at 2.2km
  - CAPE closure at 4km

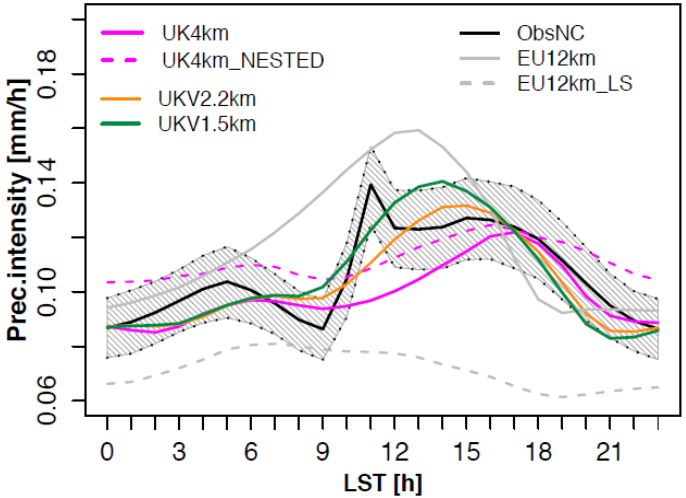
Results resolution comparison





- The EU12km fails in representing hourly statistics correctly
- UKV1.5km and 2.2km show an hourly pdf in line with observations
- UK4km consistently higher hourly precipitation intensities
- UK4km_NESTED pdf and dry days percentage closer to UKV1.5km

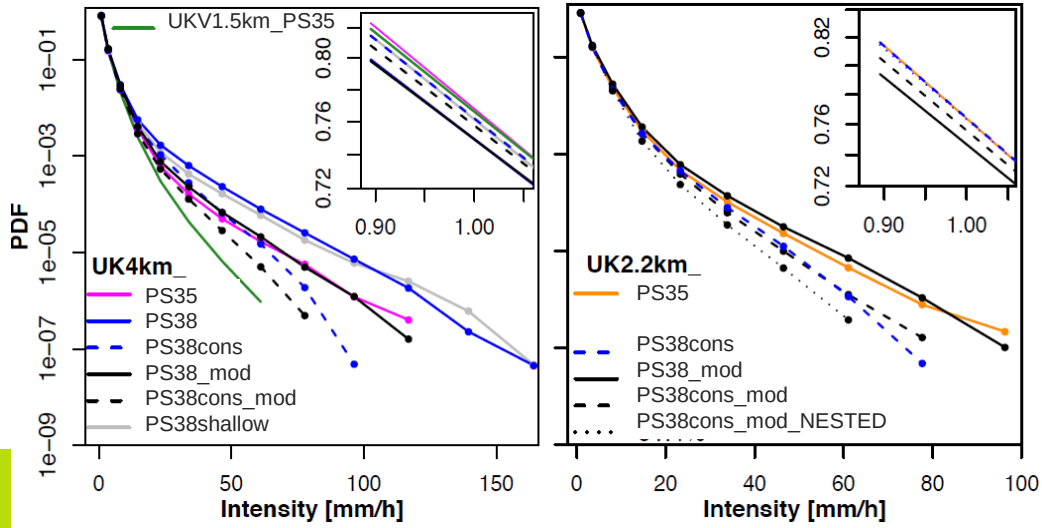
Results resolution comparison



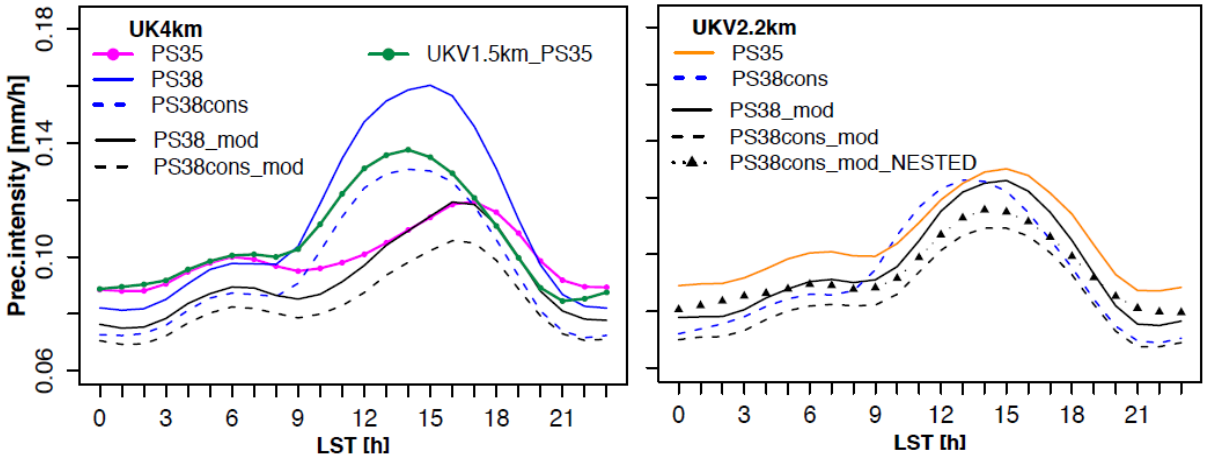
- The diurnal cycle in the CPMs more realistic than in the 12km RCM
- UK4km greater delay compared to UKV1.5km
- Relative contributions from convective events versus large-scale events are different between the nested and non-nested simulations

Results physical packages comparison

- PS38 triggers too intense and frequent events without resolving the underestimation of lower intensities (blue versus pink line)
- Conservation scheme reduce the probability of intensities above 10 mm/d and 5 mm/h in favour of lower intensities (dashed versus solid black/blue lines)
- Nesting UKV2.2km reduces further the probability of intensities above 10 mm/h in favour of lower intensity precipitation below 2 mm/h (dotted versus dashed black line)

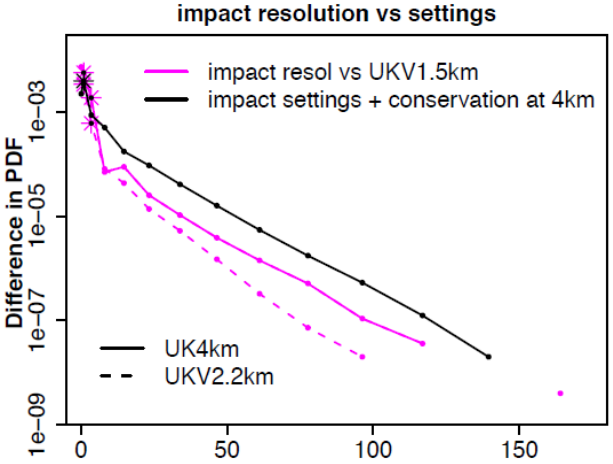


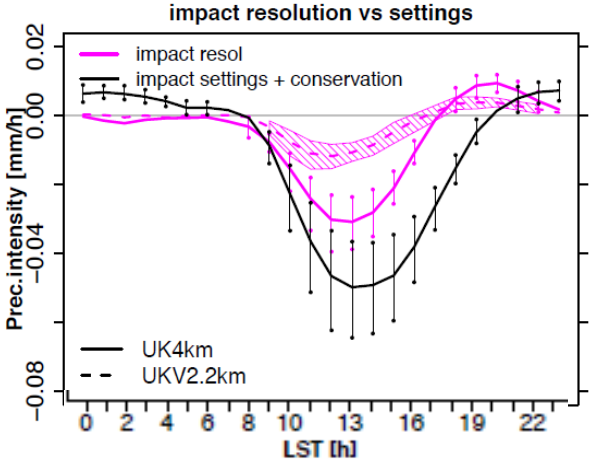
Results physical packages comparison



- PS38 leads to a steeper afternoon peak occurring 2 hours before that in the PS35 showing a similar diurnal cycle to the UKV1.5km
- The conservation scheme (dashed versus solid lines) reduces the mean precipitation intensities especially in the afternoon

Physical packages versus resolution





Changes to the physics (even within the limitations of recent operational configurations) may have a bigger impact than the changes in resolution especially for coarser convection-permitting scales

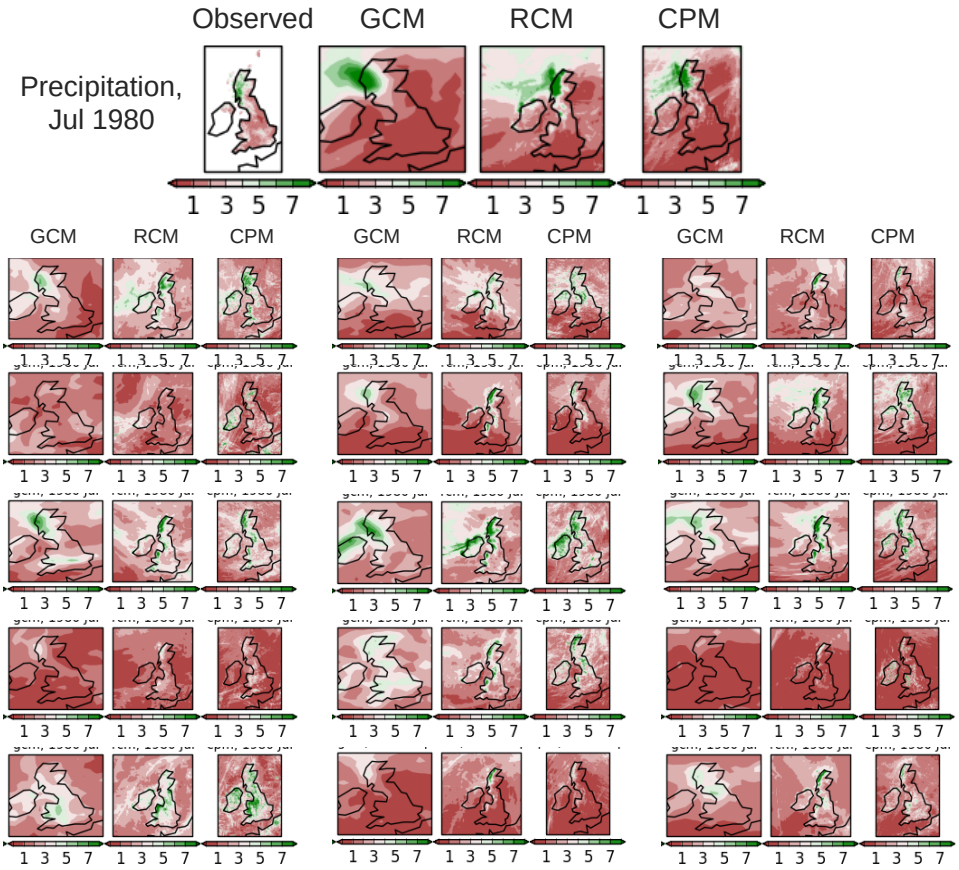
Conclusions

- In the 4km model rainfall is too intense and initiates too late, while the 2.2km model performs as well as the 1.5km model
- Using an intermediate nest can help overcome the intrinsic difficulty of spinning up convection especially at 4km
- Strong impact of reduced the mixing length and stronger perturbations
- Importance of the mass conservation

- The added-value becomes smaller for each resolution increase (within the CP-regime), while the computational costs substantially increase with increasing resolution.
- Changes in the physical configuration may have as much impact as the resolution increase, and even more in some cases.
- The direction or sign of the impact of changes in the physical settings examined here are not resolution dependent although the changes are larger for coarser convection-permitting resolution.

UKCP18: a new step forward

- First ensemble of projections at convection permitting (2.2km) scale
- Reduced mixing length + mass conservation + nesting
- Run over UK with 12+ ensemble members
- 1980-2000, 2020-40 & 2060-80 periods
- Supports UK risk assessment studies related to extreme precipitation events



Demonstration ensemble: not actual UKCP18 results

Met Office
Hadley Centre

Questions?