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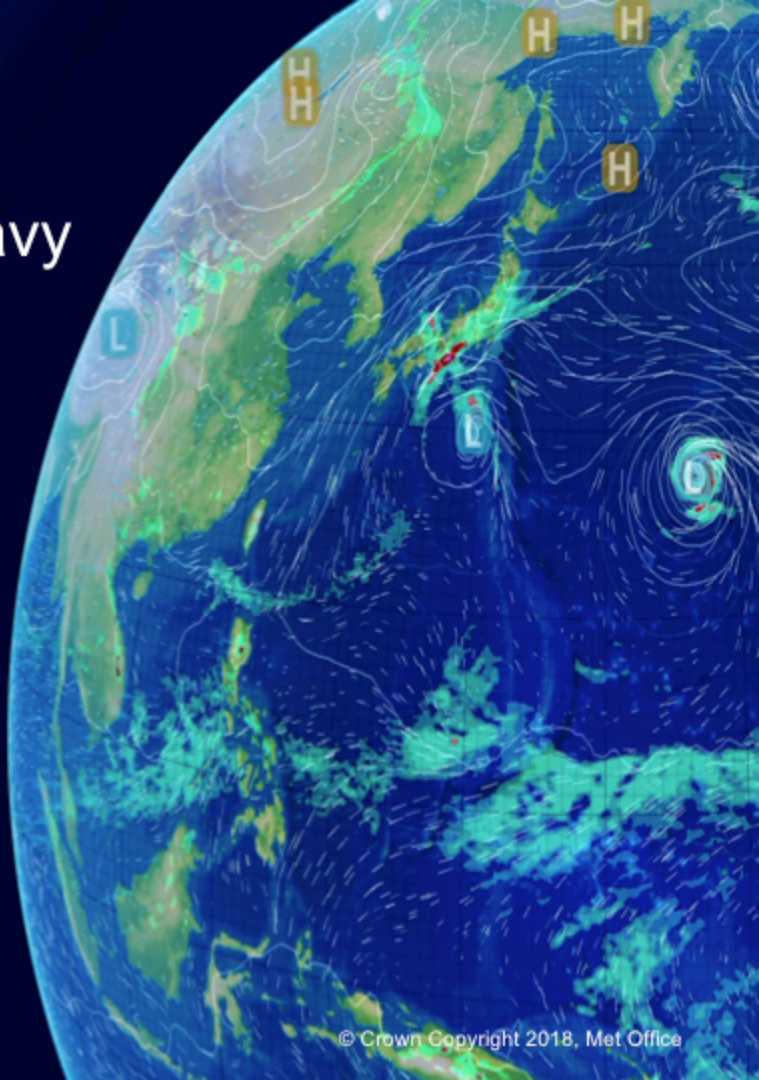
Hadley Centre

Representation of heavy precipitation and its future change in convection-permitting models

Lizzie Kendon, Segolene Berthou, Giorgia Fosser, Steven Chan, Rachel Stratton, Simon Tucker



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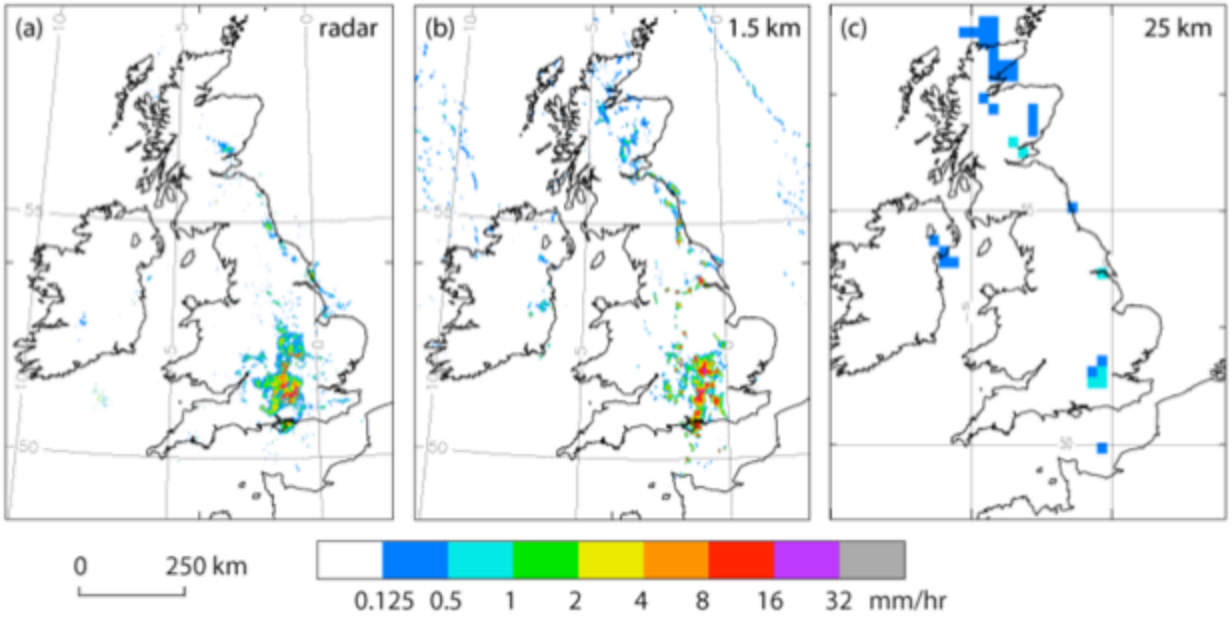
Improved representation of convective storms in 1.5km forecast model



Mesoscale convective system at 0000 UTC 14 June 2014.
(Clark et al, 2016, Meteorological Applications)

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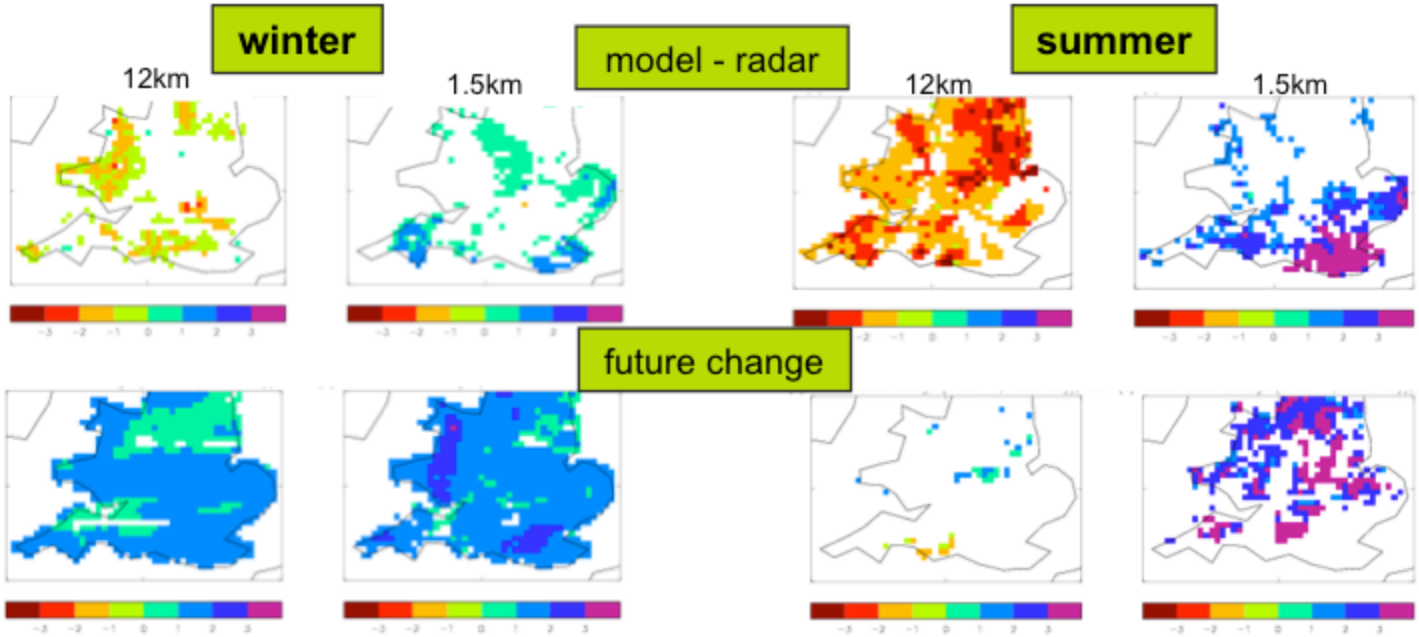
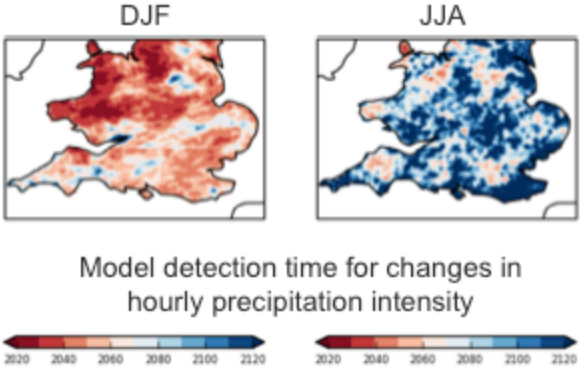
Heavier summer downpours with climate change in 1.5km climate model



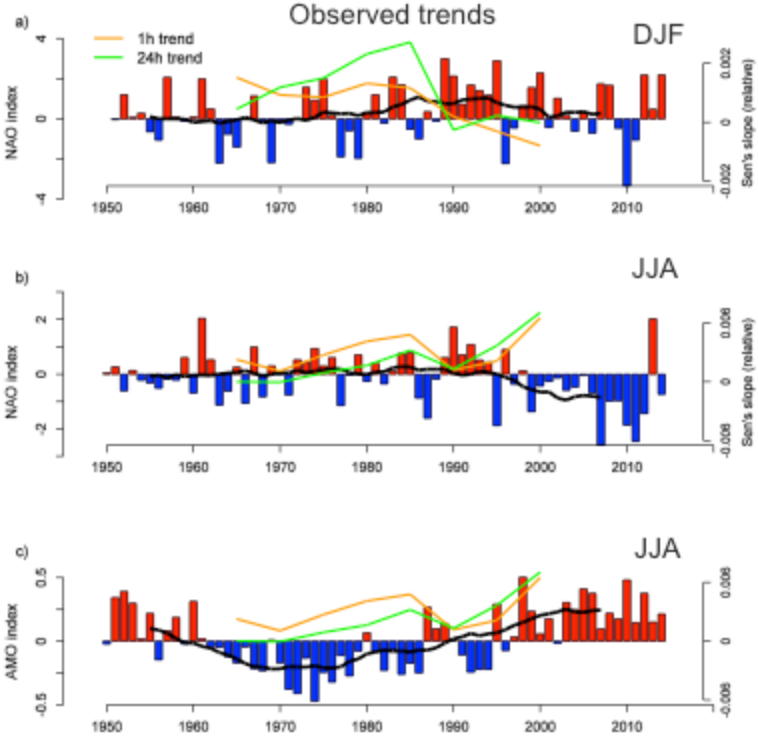
White = model biases and future changes not significant at the 1% level

Kendon et al, 2014, Nature Clim. Change

Timescale for detecting changes in UK precipitation extremes in 1.5km model



- Changes in short-duration intensities detectable in winter over next few decades, but in summer not for several decades
- In 1.5km model detectable changes in hourly rainfall rates emerge before changes in daily totals => will manifest as increases in pluvial flooding



Kendon et al, 2018, J Climate

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Convection-permitting climate simulations over Europe and Africa

Global model (25km)

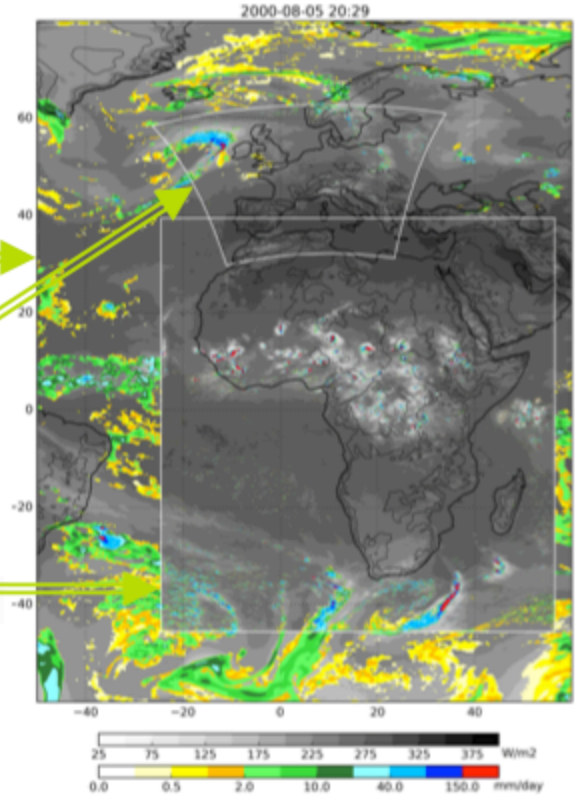
UKMO present day + future time-slice

Euro 2.2km (1536 x 1536 x 70)

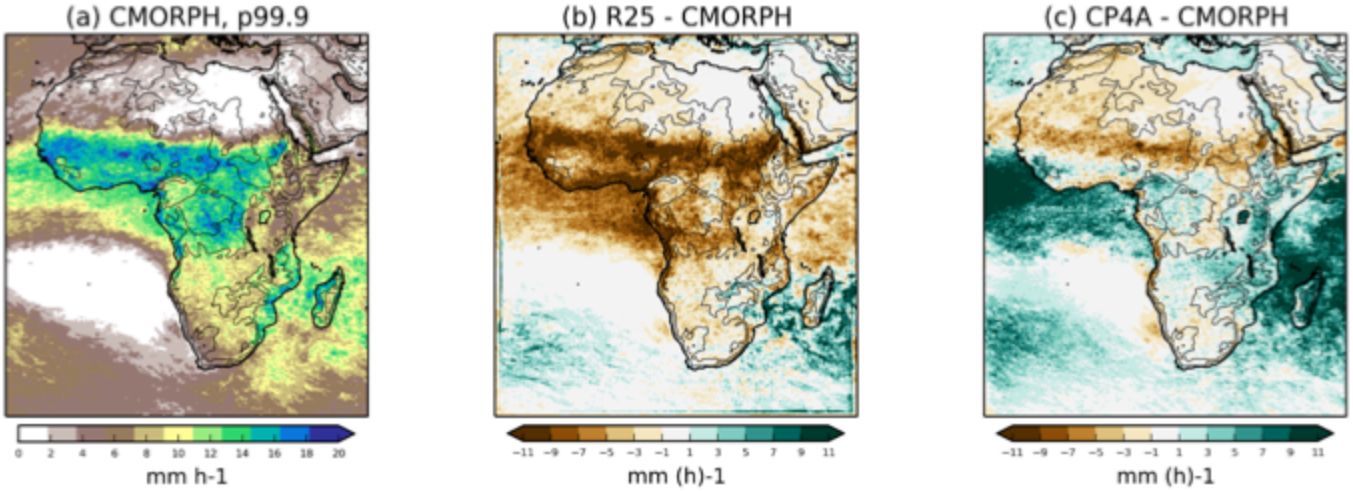
10-year simulations
Hindcast simulations: UKMO + ETH-COSMO
UKMO present day + future time-slice

CP4Africa 4.5km (2000 x 2100 x 80)

10-year simulations
UKMO present day + future time-slice



Improved representation of extreme rainfall over Africa in 4.5km versus 25km model



- Improved representation of extreme 3hrly precipitation (99.9th percentile during wet season) in 4.5km (CP4A) compared to 25km (R25) model

Kendon et al, in prep

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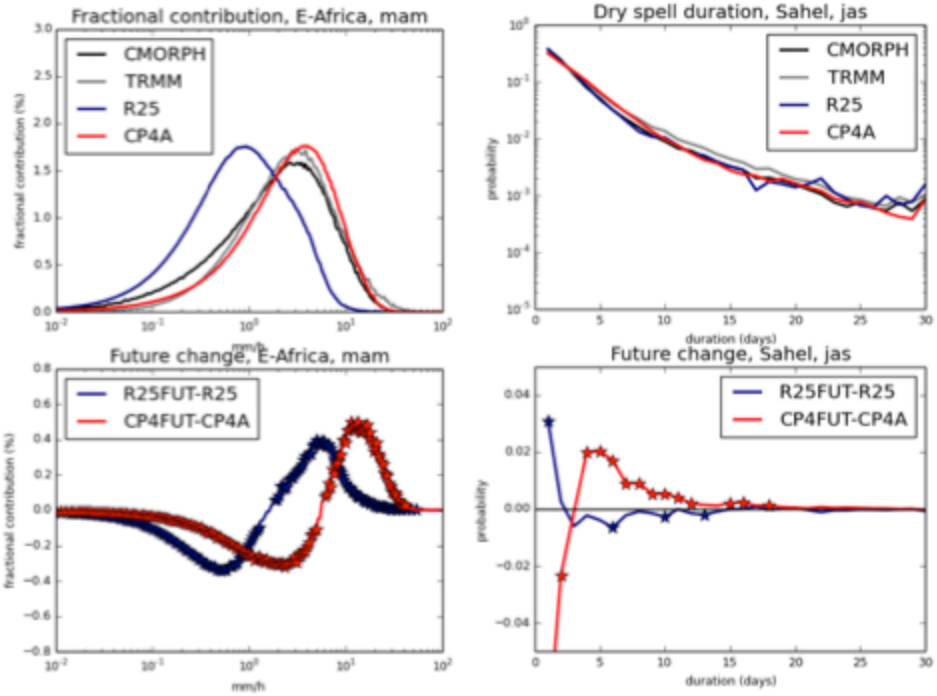
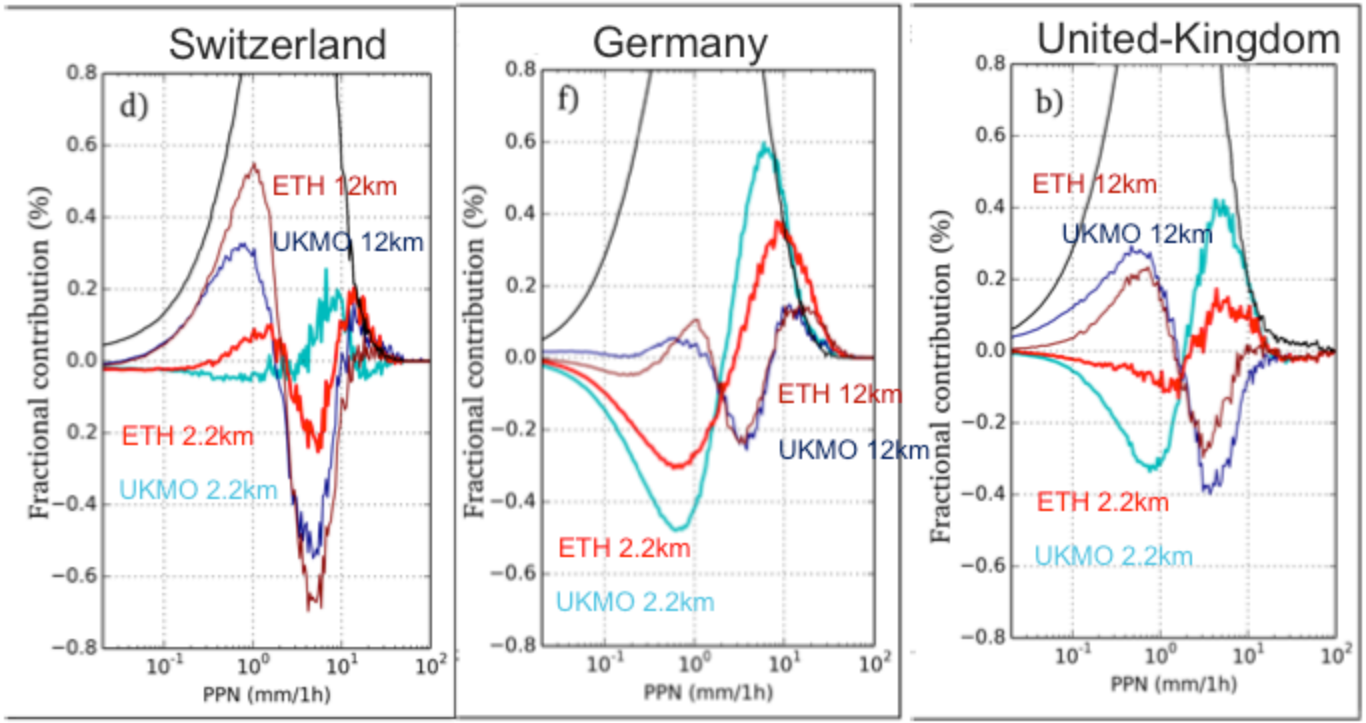
Enhanced future changes in wet and dry extremes over Africa in CP4A



- CP4A shows greater future increases in the fractional contribution from high rain rates compared to 25km model
- CP4A shows future increases in dry spell length over west/central Africa not seen in 25km model

Kendon et al, in prep

More intense hourly precipitation over Europe in 2.2km versus 12km model



Berthou et al, 2018, Clim. Dyn.

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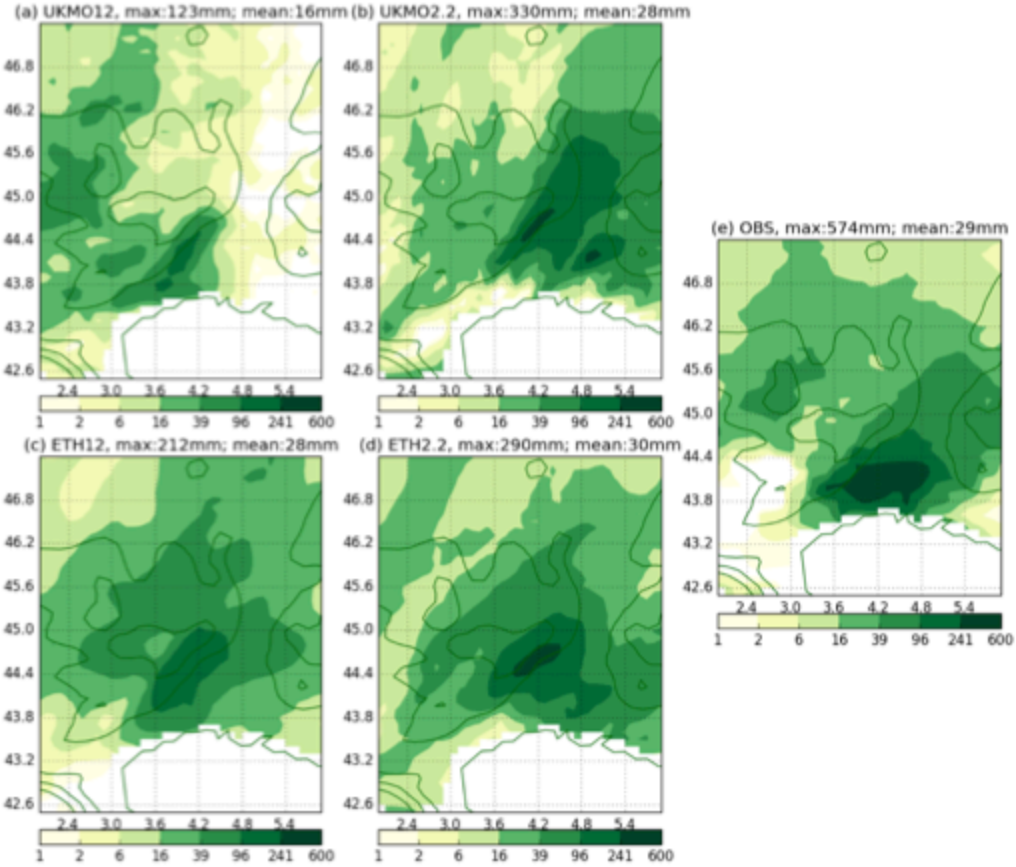
Mediterranean heavy precipitation events better represented in 2.2km model

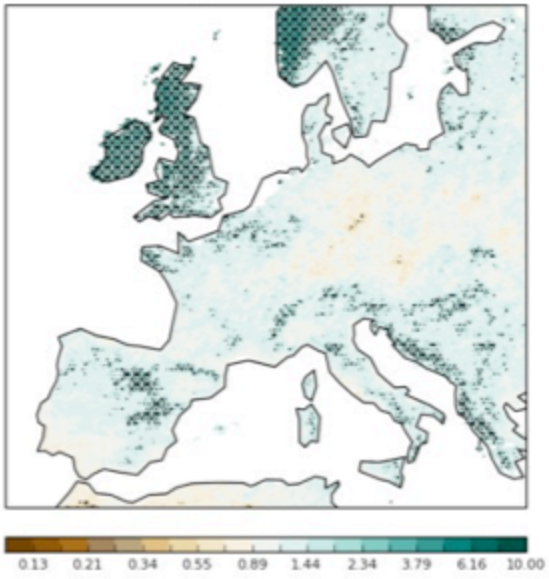
Gard case study (8-9 Sept 2002)



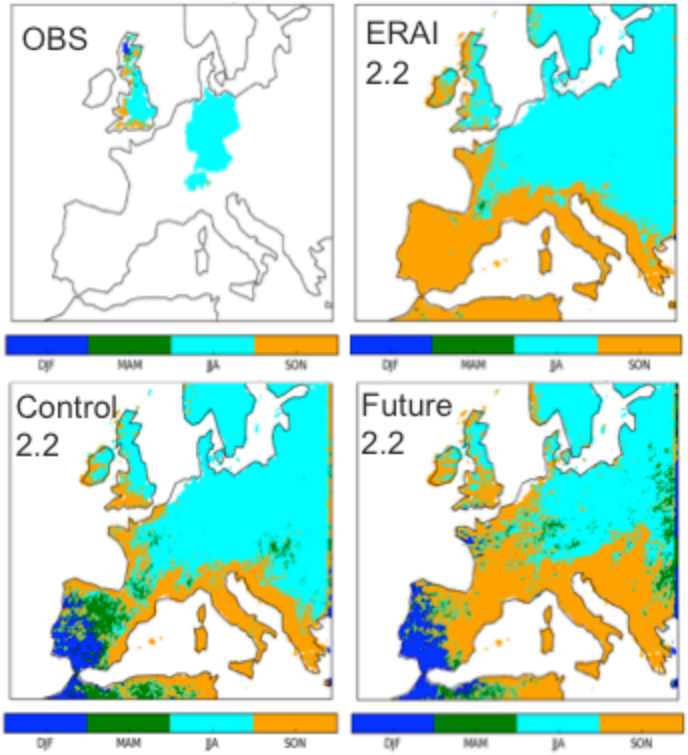
Berthou et al, 2018, Clim. Dyn.

Future changes in extreme precipitation in Europe 2.2km model

Future/present exceedance of extreme hourly events in Eur2.2km



Season with the most hourly events



Greatest changes occur in seasons that not historically associated with hourly extremes

Chan et al, see poster

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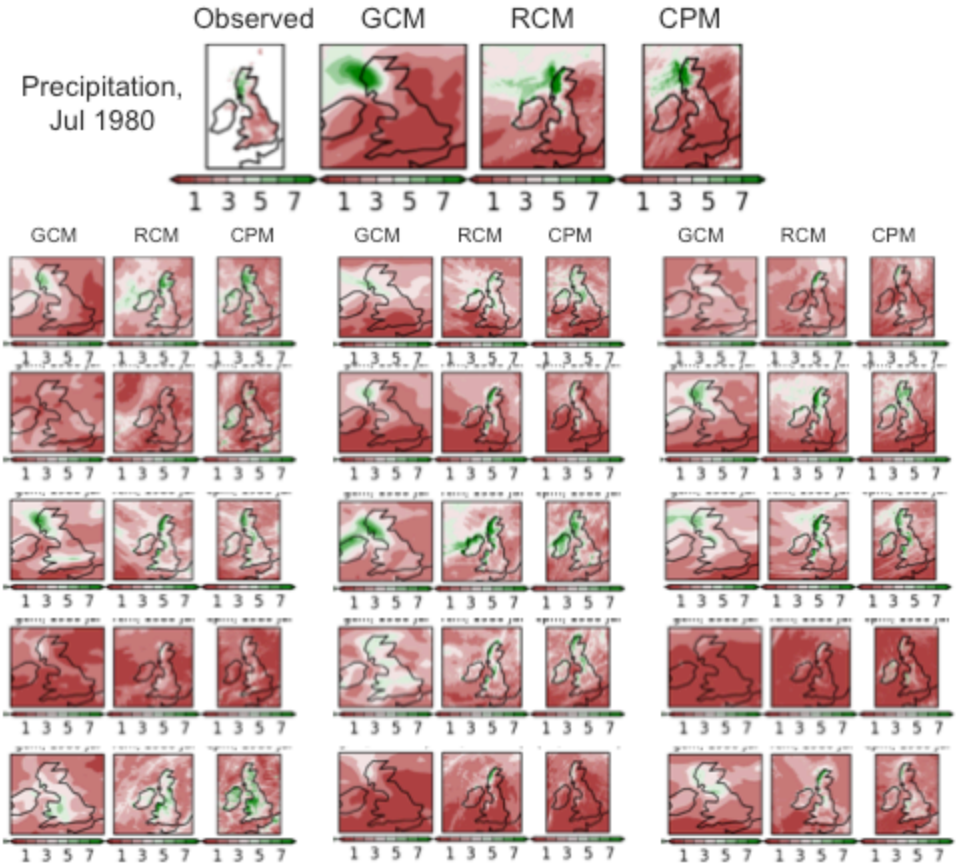
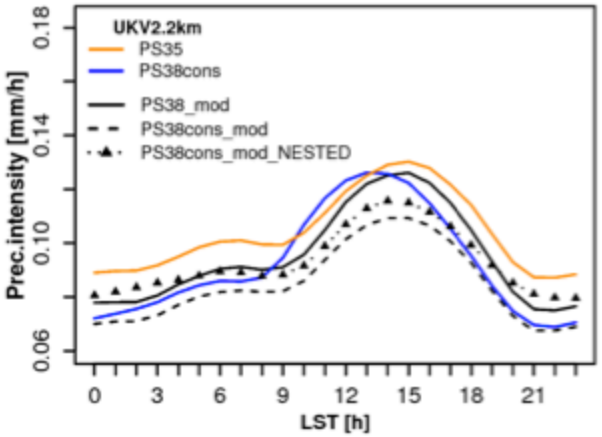
UKCP18: a new step forward

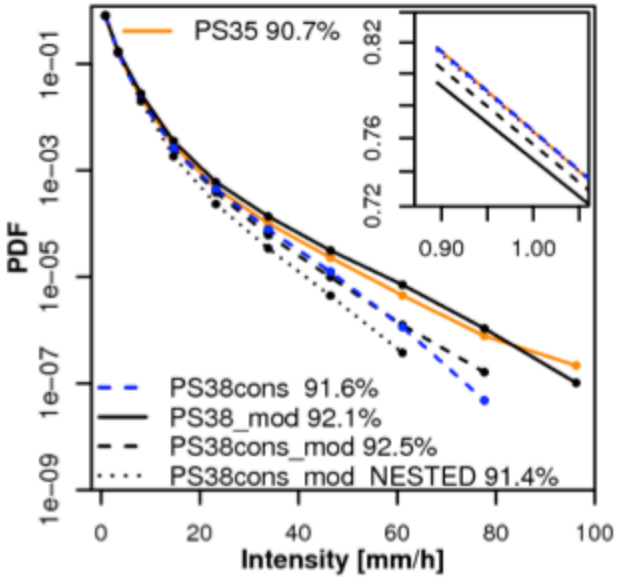
- First ensemble of projections at convection permitting (2.2km) scale
- Run over UK with 12+ ensemble members
- 1980-2000, 2020-40 & 2060-80 periods
- Supports UK risk assessment studies related to extreme precipitation events



Demonstration ensemble: not actual UKCP18 results

Optimal configuration for 2.2km UKCP18 CPM



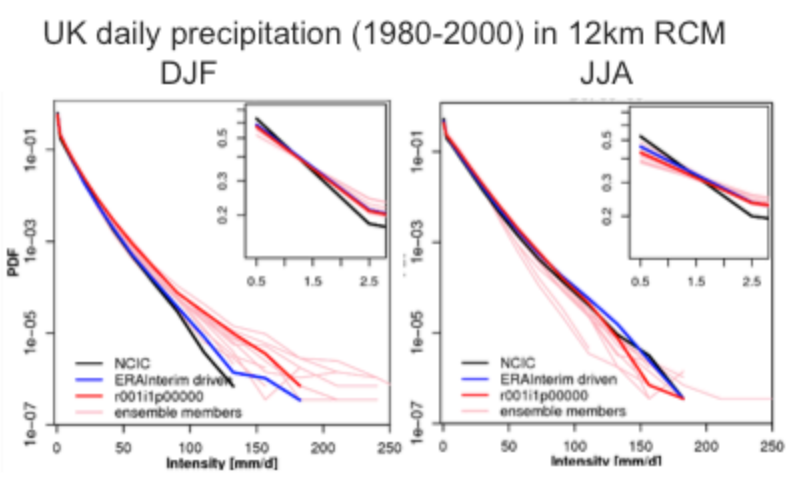


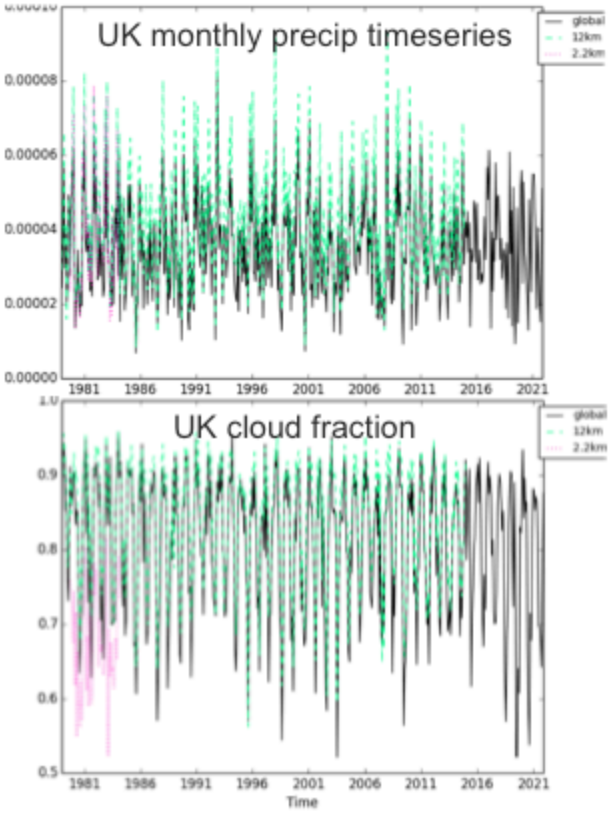
Optimal configuration

- ✓ Use of conservation fix (reduced high hourly intensities)
- ✓ Greater (PS38) mixing (earlier morning development and peak)
- ✓ Nesting in 12km (improves spin-up at boundary)

Fosser et al, in prep

UK precipitation in UKCP18 12km RCM and 2.2km CPM ensembles





- 12km RCMs underestimate no. of dry days and have too much light rain => mean too wet
- ERAI driven RCM gives good agreement with observations for heavy daily intensities, but biases seen for GCM-driven-RCMs
- 2.2km CPM ensemble results emerging: show quite different cloud amounts

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Summary

- 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)