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

Lizzie Kendon, Segolene Berthou, Giorgia Fosser, Steven Chan, Rachel Stratton, Simon Tucker
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)
Heavier summer downpours with climate change in 1.5km climate model

Winter
12km

Model - radar
1.5km

Summer
12km

Future change
1.5km

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

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.
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 (99.9\textsuperscript{th} percentile during wet season) in 4.5km (CP4A) compared to 25km (R25) model

Kendon et al, in prep
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

Mediterranean heavy precipitation events better represented in 2.2km model

Gard case study (8-9 Sept 2002)

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
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)
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
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)