# Projections of extreme hourly precipitation by hi-resolution models – caveats in model physics

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# Introduction

CONVEX - Convective Extremes. Project key modelling objectives include:

- Present extremes: Can they be trusted? Higher resolution good?
- Future extremes: What are the model projections?

# Model and Data

Met Office 12- and 1.5-km RCM regional climate model (RCM) simulations[Kendon et al, 2012]:

- The 1.5-km simulations are one-way nest-down of the 12-km simulations
- The 1.5-km simulation uses no convective parameterisation

12-km RCM lateral boundary conditions are:

- 1990-2008 ERA-Interim (12R, 1.5R) [Dee et al, 2011]
- 13-yr time-slice N216 ($\approx$ 60km) HadGEM3 present- (12GP,1.5GP) & future-climate (12GF,1.5GF) simulations [Mizielinski et al, 2014]

Observations: Met Office 2003-2010 gridded hourly radar [Golding, 1998] and 1991-2007 daily gauge [Perry and Hollis, 2005] data

# Peaks-over-Threshold (PoT)

Extremes defined by *FREQUENCIES* and *NOT* by *INTENSITIES*. Return levels are estimated by fitting the Generalized Pareto distribution to declustered extremes [Coles, 2001; Ferro and Segers, 2003]:

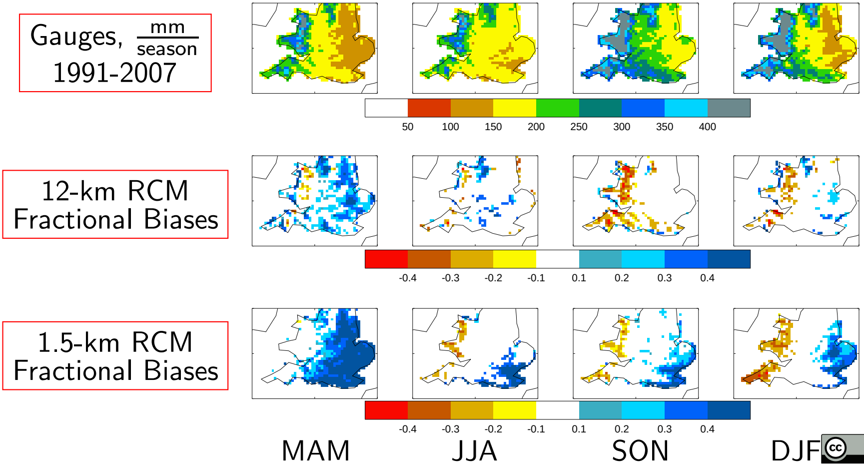
$$z\left(n|t,\sigma,\xi\right) = \begin{cases} t + \frac{\sigma}{\xi}\left[(\lambda n)^{\xi} - 1\right] & \xi \neq 0 \\ t + \sigma \ln\left[\lambda n\right] & \xi = 0 \end{cases} \tag{1}$$

- $n =$ Return period (yr); $z =$ Return level (mm/...)
- $t =$ Extreme threshold (mm/...; $Q_{95}$ of "wet values" $\geq$ 0.1mm/...)
- $\sigma =$ Scale parameter (akin to standard deviation; mm/...)
- $\xi =$ Shape parameter (akin to skewness; dimensionless)
- $\lambda =$ Event frequency (yr$^{-1}$)

In a nutshell: This is just a standard way to characterize the probability distributions of the extreme events and extrapolate return levels
Note: Change of intensities $\neq$ change of return levels (former is conditional to non-negligible intensities)

# Reanalysis simulations: Mean biases

The 1.5-km RCM has positive intensity biases; mean biases are lower for the 12-km RCM [Kendon et al, 2012; Chan et al, 2012].



# Summer (JJA) return levels - present & future

Upper: *Spatially-averaged* return levels for radar & reanalysis-downscaling

Lower: Climate change signal from the GCM-downscaling simulations

Confidence intervals are estimated by jackknifing.

Spatially-averaged Return Levels: Radar & Reanalysis Downscaling

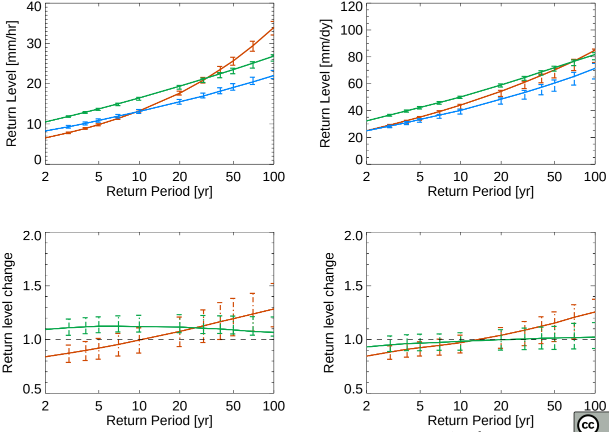
Blue = Radar

Green = 1.5-km

Orange = 12-km

Change Signal

$\left[\frac{\text{Future}}{\text{Control}}\right]$




1-hr

1-dy

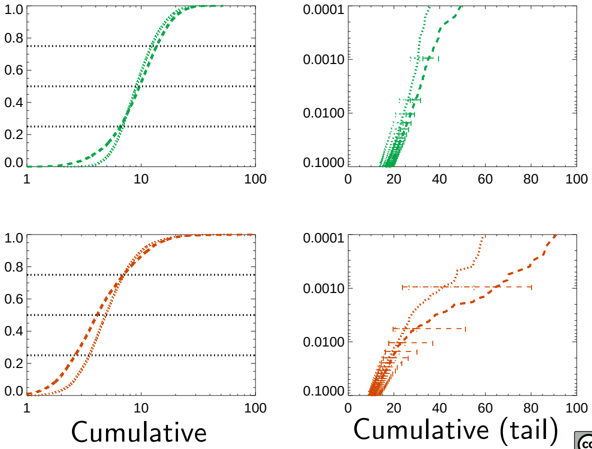
# Empirical Distributions of the summer extremes

*Spatially-pooled* seasonal JJA maximums (spatial correlation unaccounted)
- note the 12-km slope and high values above 20mm/hr:

1.5-km RCM

Dashes = Future
Dots = Control

12-km RCM



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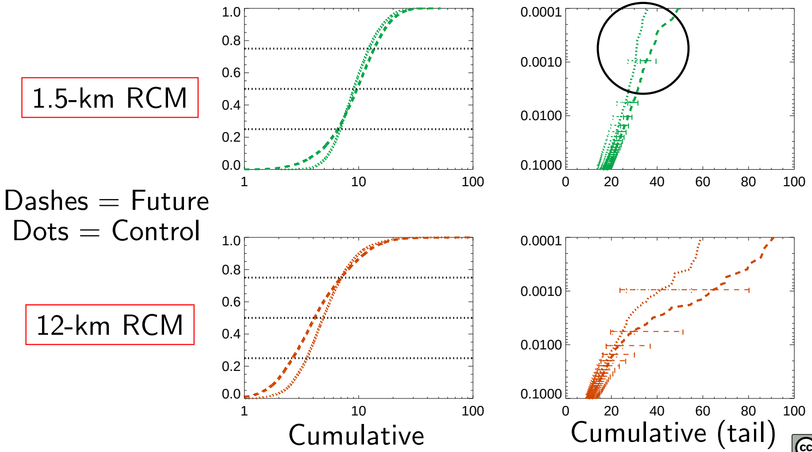

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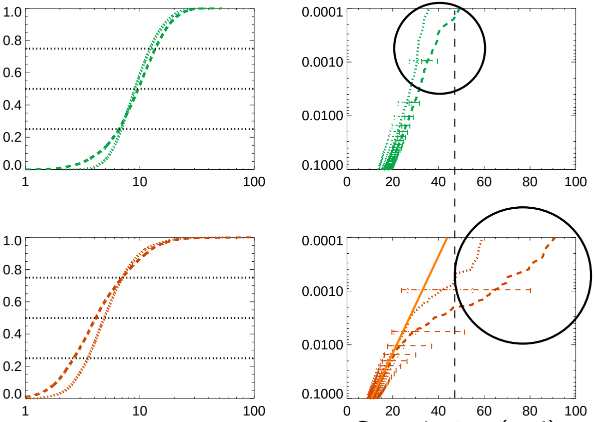
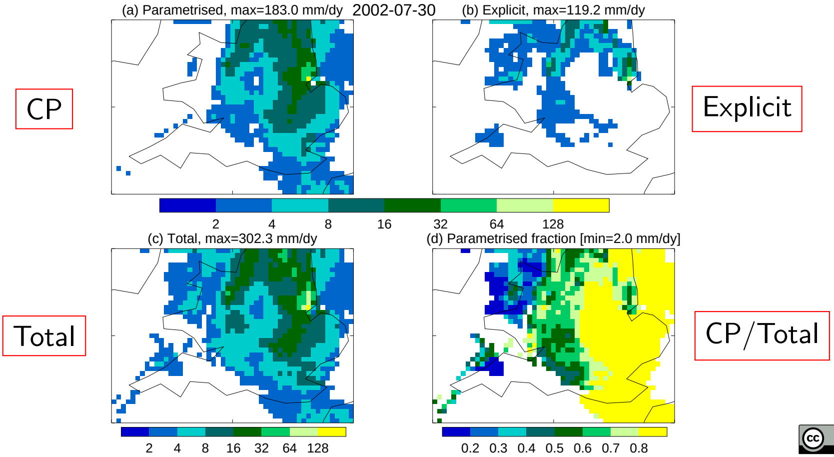



Cumulative

Cumulative (tail)

# A JJA extreme from the 12-km RCM

Daily total of a 12-km RCM extreme event: 300 + mm/dy precipitation in one single 12-km grid box. High "large-scale precipitation" fraction: both the convection and large-scale precipitation scheme were firing up:



# Winter (DJF) return levels

Upper: DJF Return levels radar and reanalysis downscaling

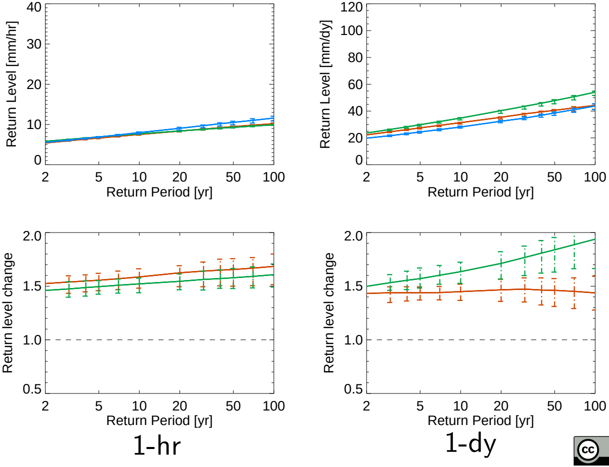
Lower: Climate change signal from the GCM-downscaling simulations

Spatially-averaged Return Levels: Radar & Reanalysis Downscaling

Blue = Radar
Green = 1.5-km
Orange = 12-km

Change Signal

$$\left[\frac{\text{Future}}{\text{Control}}\right]$$



# “Grey Zone” vs “Convective Permitting”

“Grey Zone”:
The 12-km RCM uses CP [Gregory and Rowntree, 1990]. CPs are not supposed to work properly at the highest intensities as intense storms are getting resolved explicitly. Yet it still needs the CP for unresolved convection. CPs create regime separations that do not exist in nature [Molinari and Dudek, 1992]. The 12-km RCM projected future change appears to come from the high intensities, which we do not trust.

“Convective Permitting”:
One can alternatively go for even higher resolution, and disable CP (i.e. 1.5-km RCM). That creates other problems (i.e. higher mean biases), and don’t forget the even smaller convective motions!

# Conclusions

- JJA $z(10+\text{yr})$ is projected to increase for the 12-km RCM, but we do not trust those high intensities
- 1.5-km RCM shows $\approx 10\%$ constant increase in JJA return levels for all return periods
- 12-km hourly intensities surge when intensities approach 20mm/hr; caused by large storms?
- DJF extremes show larger $(40+\%)$ increase than JJA extremes, and both models give similar projections
- Low-res model work gives similar DJF projections [Frei et al, 2006]
- The value for 1.5-km model is limited for DJF

Fruit for thought: Clausius-Clapeyron hypothesis [Trenberth et al, 2003] says per $^\circ\mathrm{C}$ warming gives $\approx 6.5\%$ precipitation intensification. JJA & DJF surface air warmings are $6.4\,^\circ\mathrm{C}$ & $4.9\,^\circ\mathrm{C}$. Remember: Intensity changes $\neq$ return level changes (visit us in the poster presentation!).

# Bibliography - Postscript

## Extreme value analysis with R
## Presentation by LaTeX Beamer and PGF/TikZ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