Improving the estimation of canopy interception in Great Britain

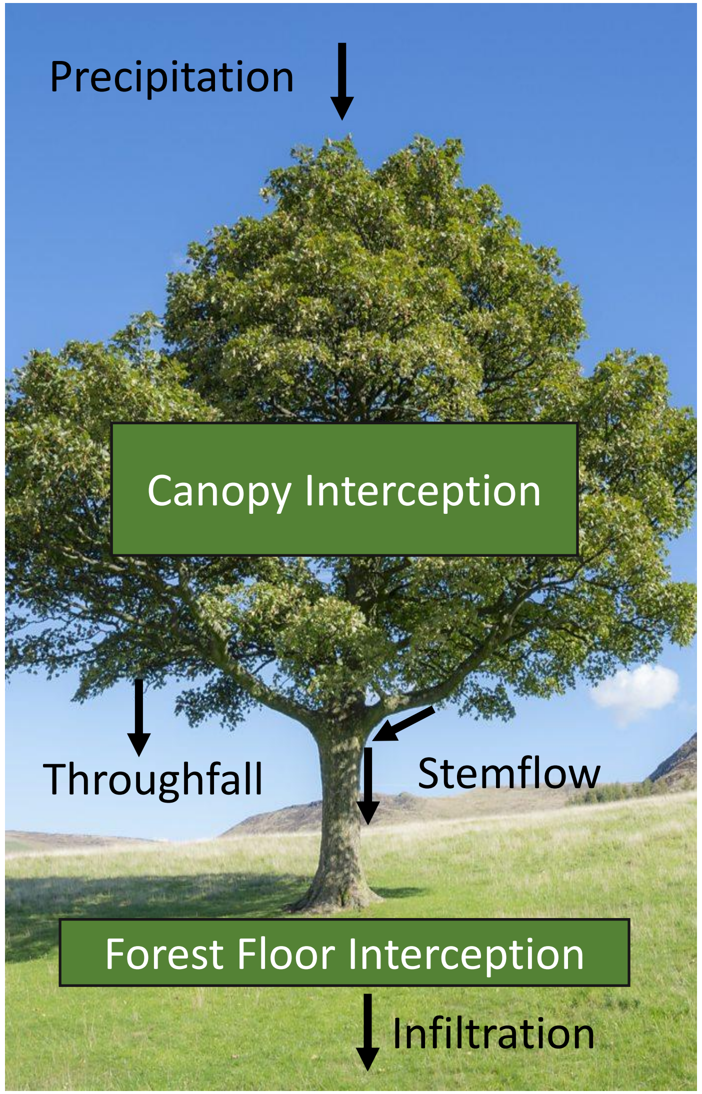
Walter Thompson[1], Rafael Rosolem[1], Eleanor Blyth[2]

[1] University of Bristol, Bristol, UK
[2] Centre for Ecology and Hydrology, Wallingford, UK

Note: This talk was submitted for undergraduate assessment at the University of Bristol

Canopy interception is an important process in GB's water cycle

- Approximately up to 50% of precipitation over a forest is intercepted (depends on leaf type)
- Fraction of intercepted water has big influence on water cycle (affects ET + runoff)
- Therefore, important we model accurately!

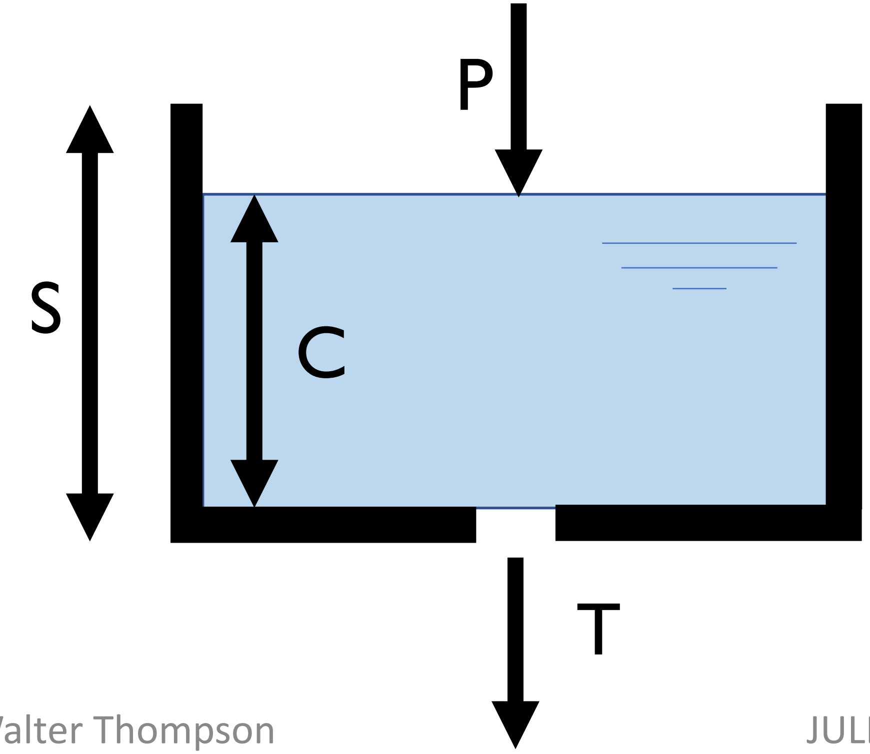


Shuttleworth (2012)

JULES interception parametrisation was developed in 1992

$$T = P\left(1 - \frac{C}{S}\right)\exp\left(\frac{-\mu S}{P\Delta t}\right) + P\frac{C}{S}$$

Dolman and Gregory, 1992



T = Throughfall

P = Precipitation rate

C = Current storage of leaves **(i.e. intercepted water)**

S = Maximum storage of leaves

μ = Rainfall intensity factor

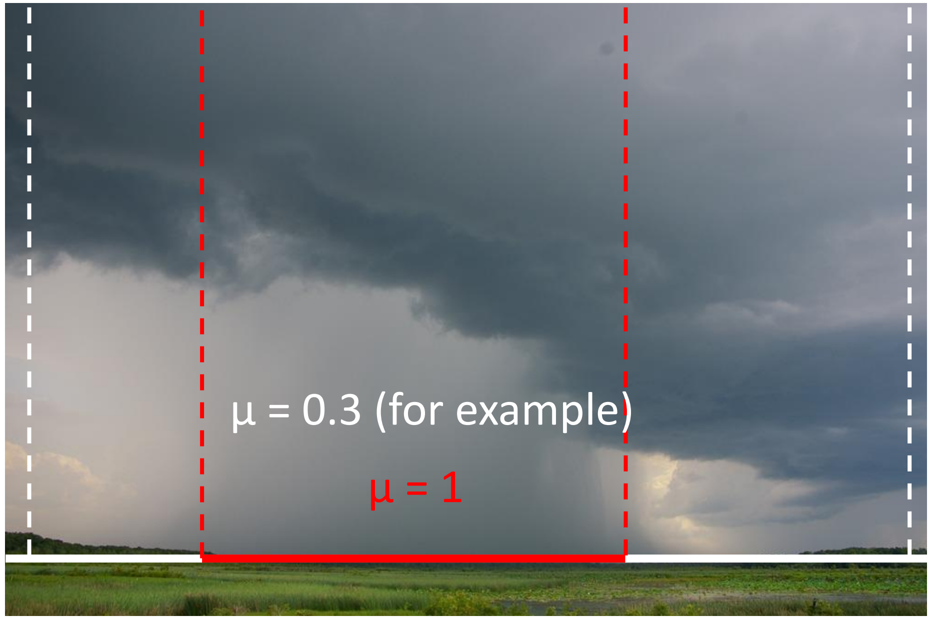
It uses two values for rainfall intensity, also chosen in 1992

- By default, μ = 0.3 used for convective rainfall (air temperatures at least 20 °C)
- μ = 1 used for large scale precipitation (air temperatures less than 20 °C)
- These are constant values

Type:	`real`
Permitted:	`0 <= confrac <= 1`
Default:	`0.3`

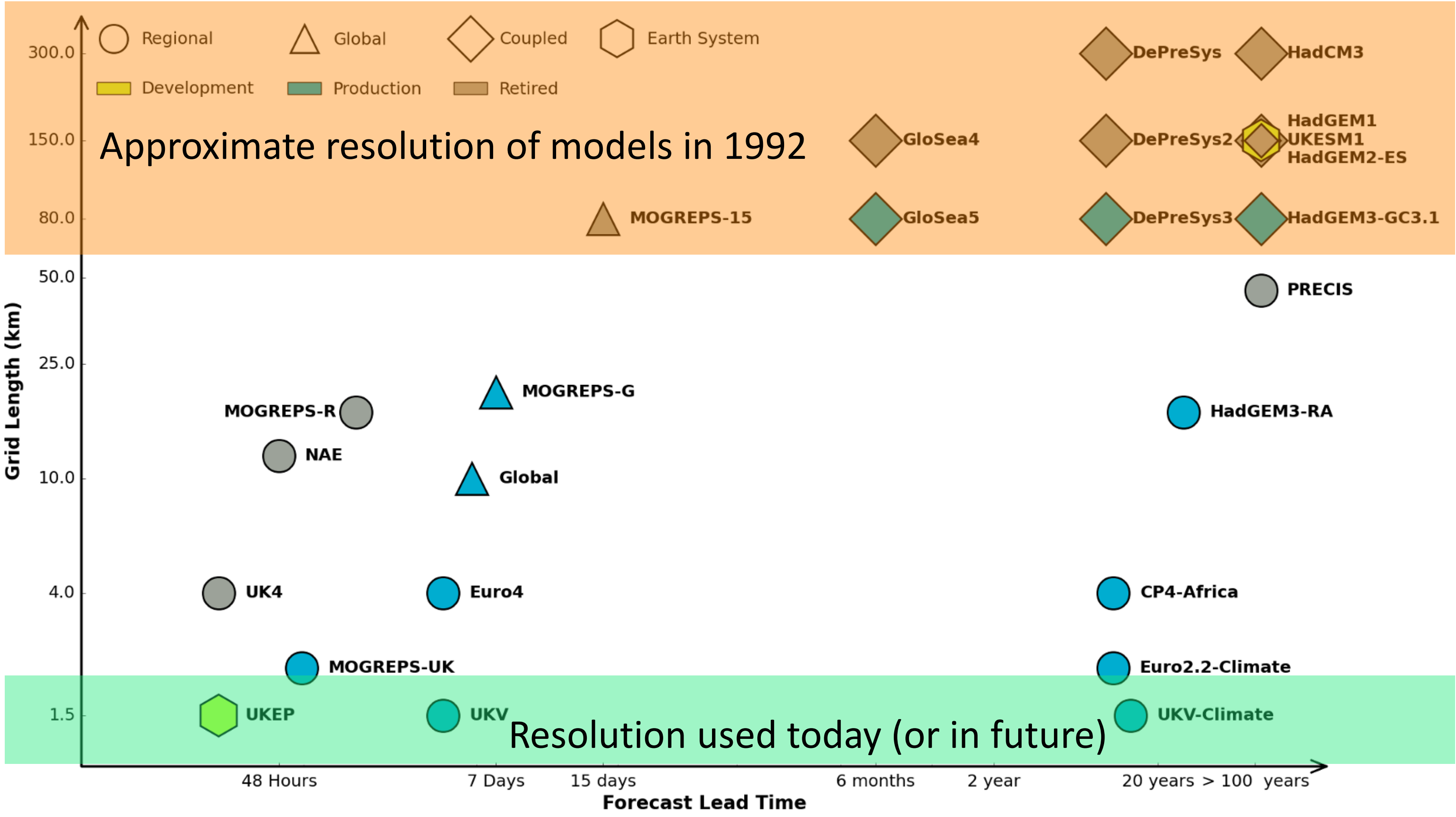
The fraction of the gridbox assumed to be covered by convective precipitation.

http://jules-lsm.github.io/vn5.8/namelists/drive.nml.html?highlight=confrac



Land Surface Models have evolved in the last few decades, and are continuing to do so

- Global (satellite based) hyper-resolution models
- Gap between observations and models is ever decreasing
- 2019 UKV model runs at 1.5km spatial resolution on 3 hourly timestep



Wood et al. (2011)

Research Questions

1. Does the JULES **interception model perform well** when using modern datasets?

2. At 1x1 km resolution, how does measured rainfall intensity **differ from the JULES parametrisation**?

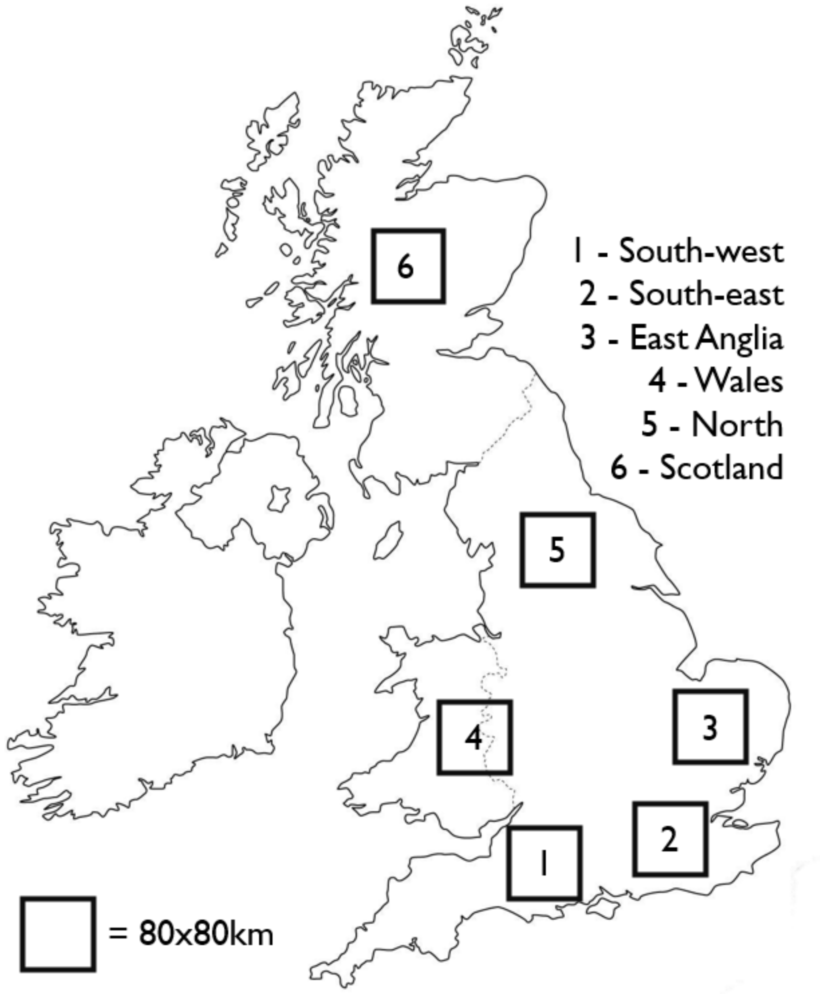
3. If there is a difference in measured rainfall intensity compared to the JULES default, **how does this affect interception estimates**?

4. How is the modelling of interception affected by **climate change**?

Data and Methods

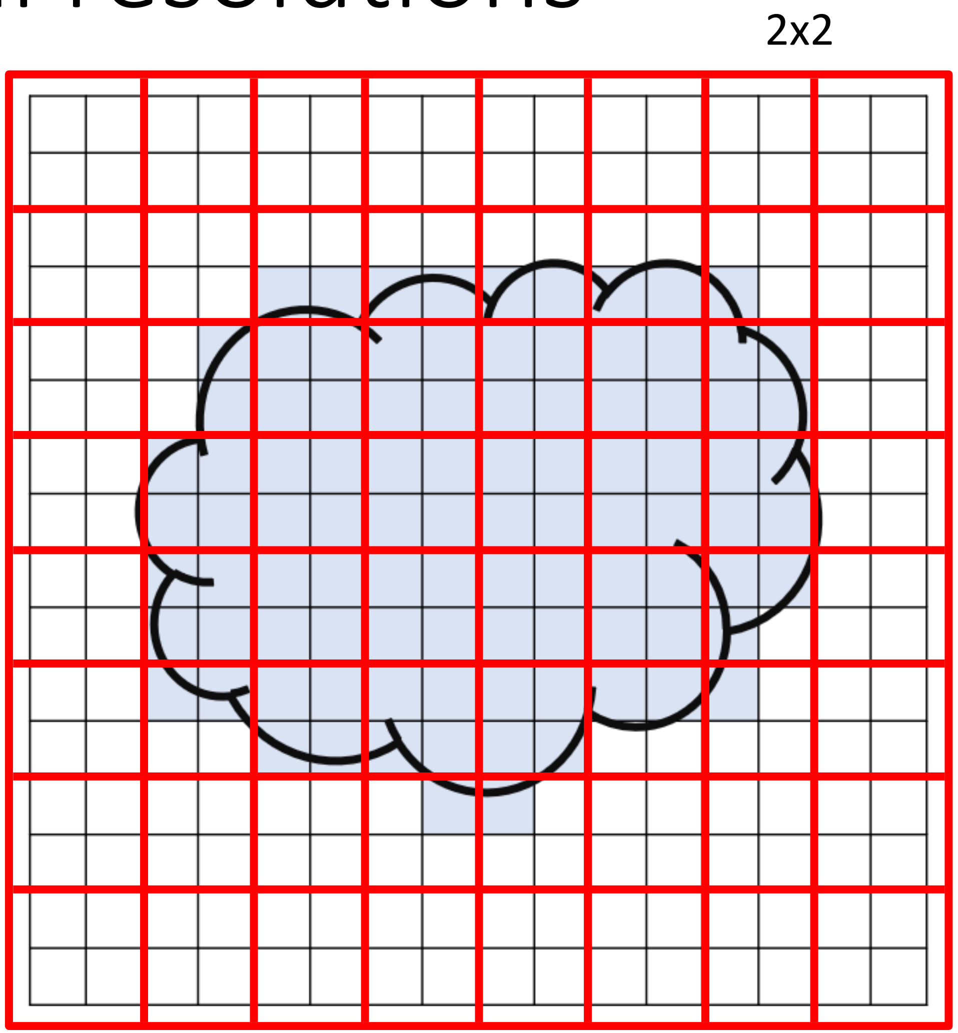
We tested our approach on six sub-domains within Great Britain

- Processing entire GB out of project scope
- 6 domains chosen to represent regional climates
- CHESS, GEAR & UKCP18 data used
- More towards the south as convective rainfall is more common here
- Test resolutions are 80, 40, 20, 10, 5, 2 km



We used a mesh-type approach to compute μ for a wide range of spatial resolutions

- GEAR 1x1 km hourly dataset used for precipitation
- CHESS 1x1 km daily dataset used for temperature
- Count rainy cells and compare to total number of cells
- 25 years of data used



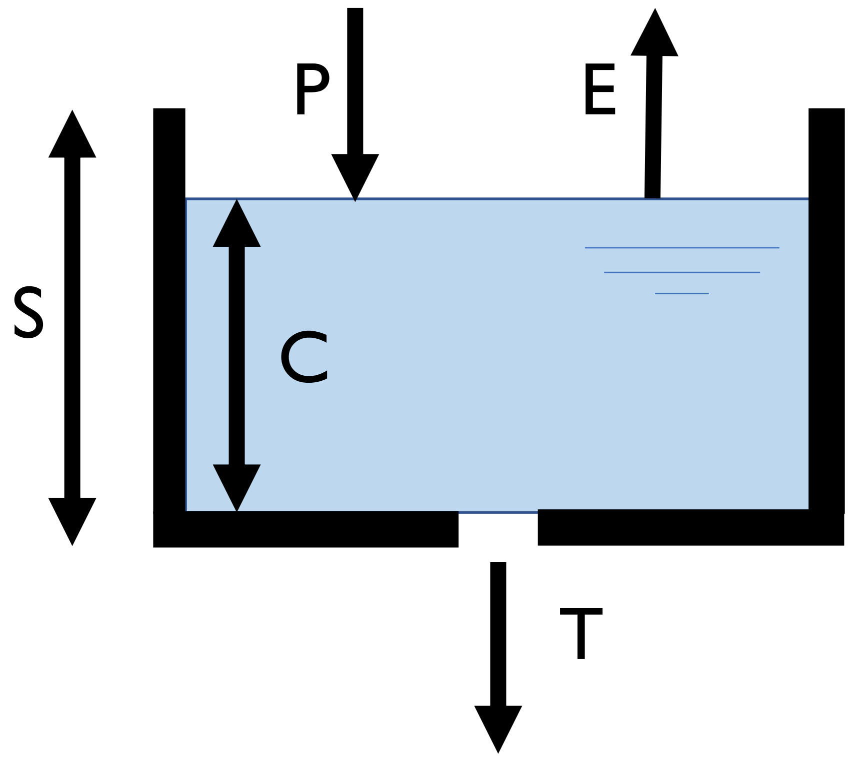
A simple 'bucket' model was used to describe the canopy water balance

- Interception model used in JULES replicated in MATLAB, allowing control over parameters

- CHESS data used (temperature, daily temp. range, pressure and radiation)

4 experiments:

- JULES Default (μ = 0.3 when temp. > 20 °C)
- Seasonal (μ = 0.3 in summer, μ = 1 in winter)
- μ = 1
- μ = 0.3

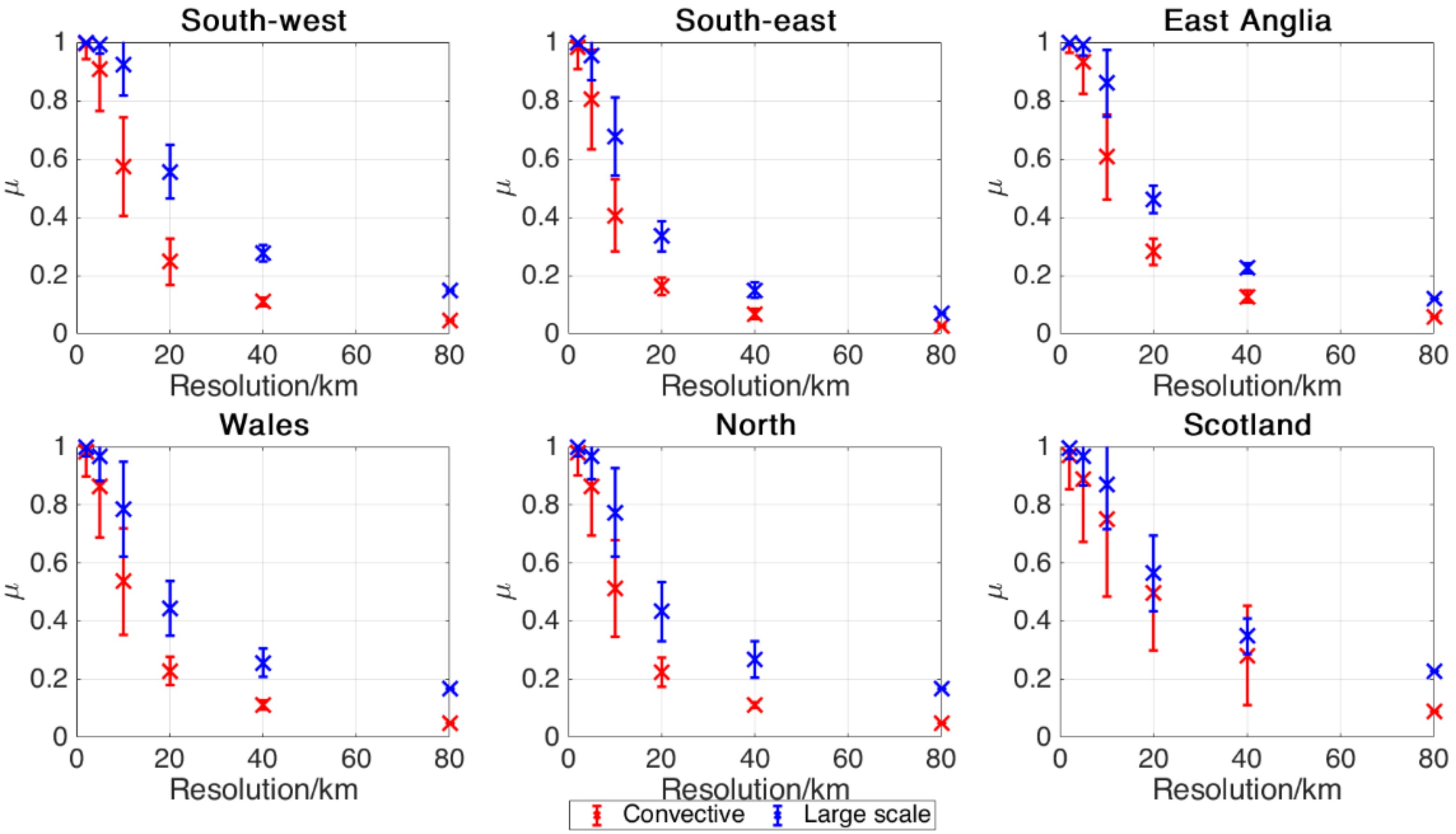


$$C = P - T - E$$

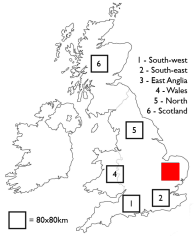
Results

Clear dependence of μ on spatial resolution of input data - μ tends to 1

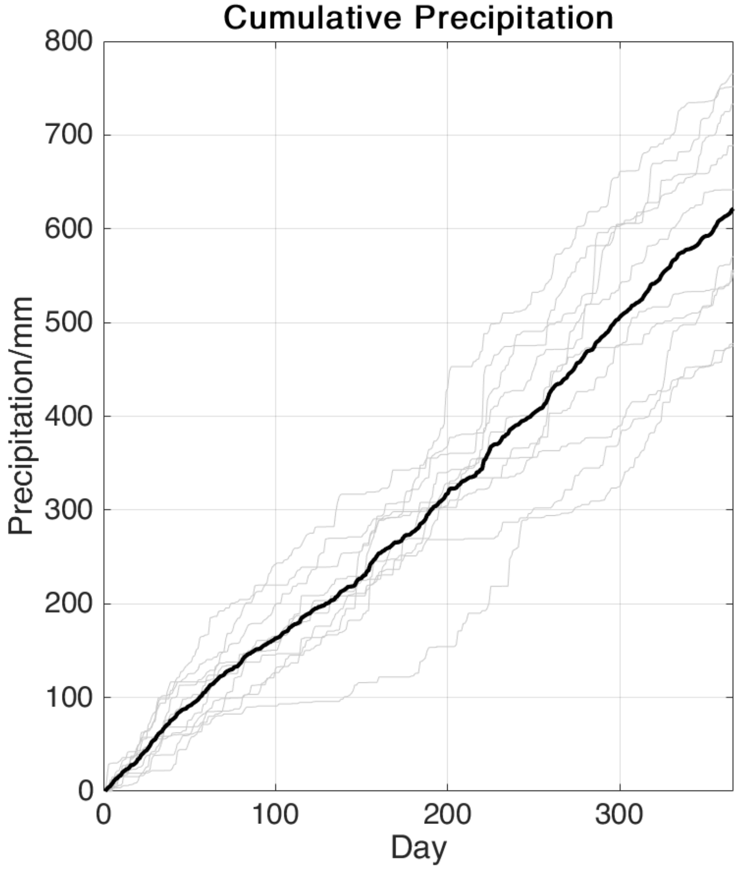
- μ increases exponentially as resolution increases
- At 2x2 km resolution, $\mu = 1$ across the UK
- Difference between convective and large-scale rain reduces too

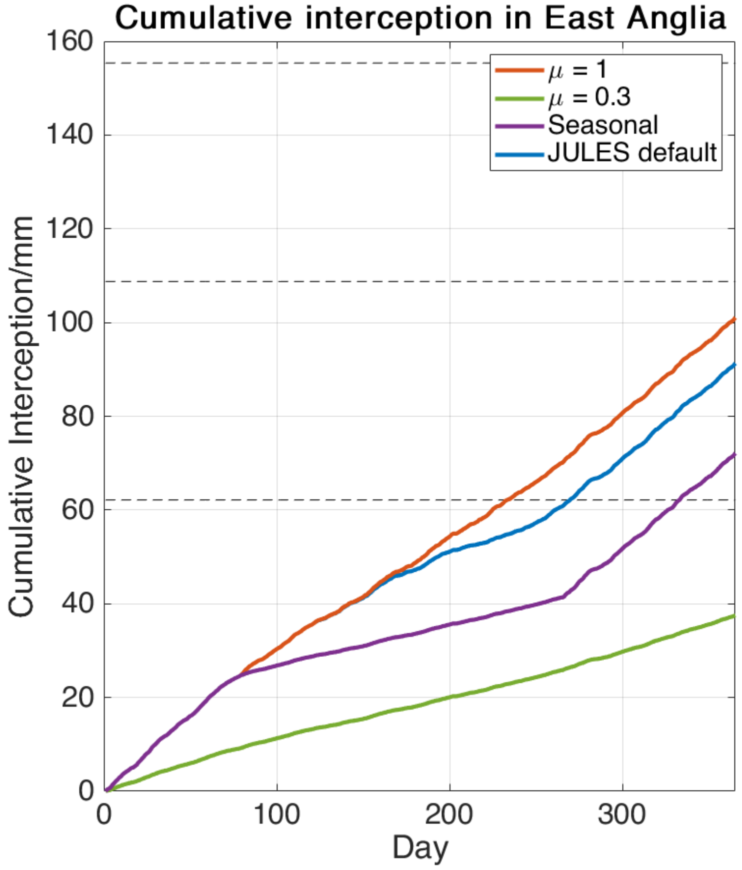


The use of incorrect μ values can result in poor interception estimates in GB



- All analyses hereafter at 1x1 km resolution
- JULES below μ = 1 by approximately 7.5%
- Change occurs in summer due to convective rainfall
- μ = 0.3 completely below expected interception



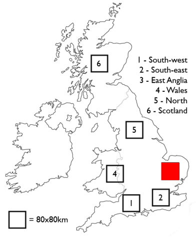


Expected interception range from Nisbet (2005)

Max

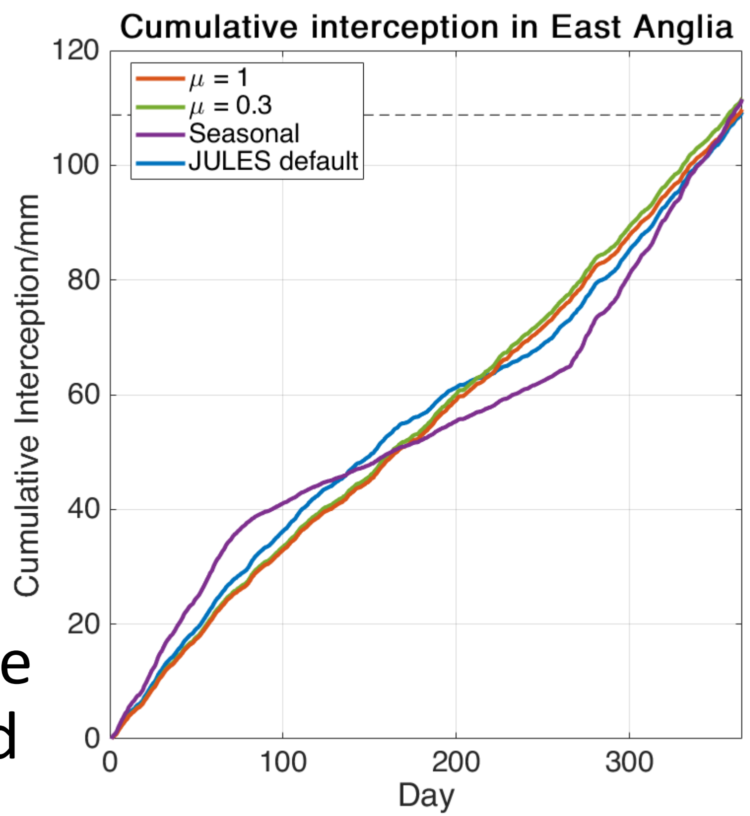
Mean

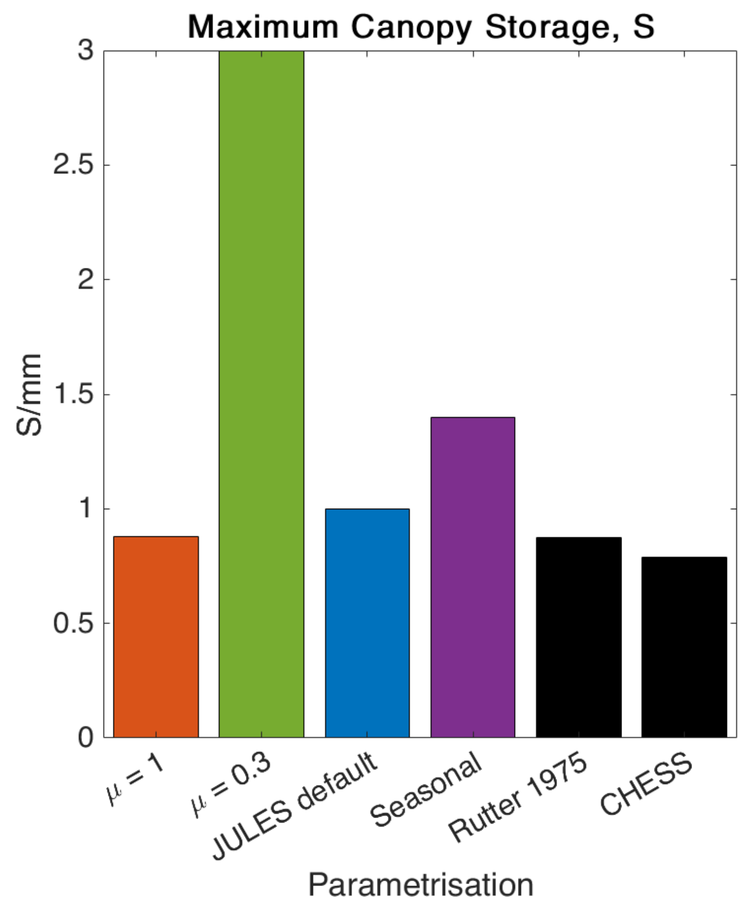
Min



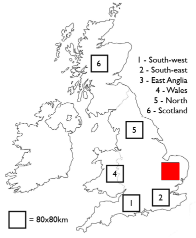
Interception can be manipulated by changing canopy storage although this is not ideal

- μ = 0.3 clearly too high
- μ = 1 closest to measured storage values
- Similar % difference between JULES and μ = 1 as before



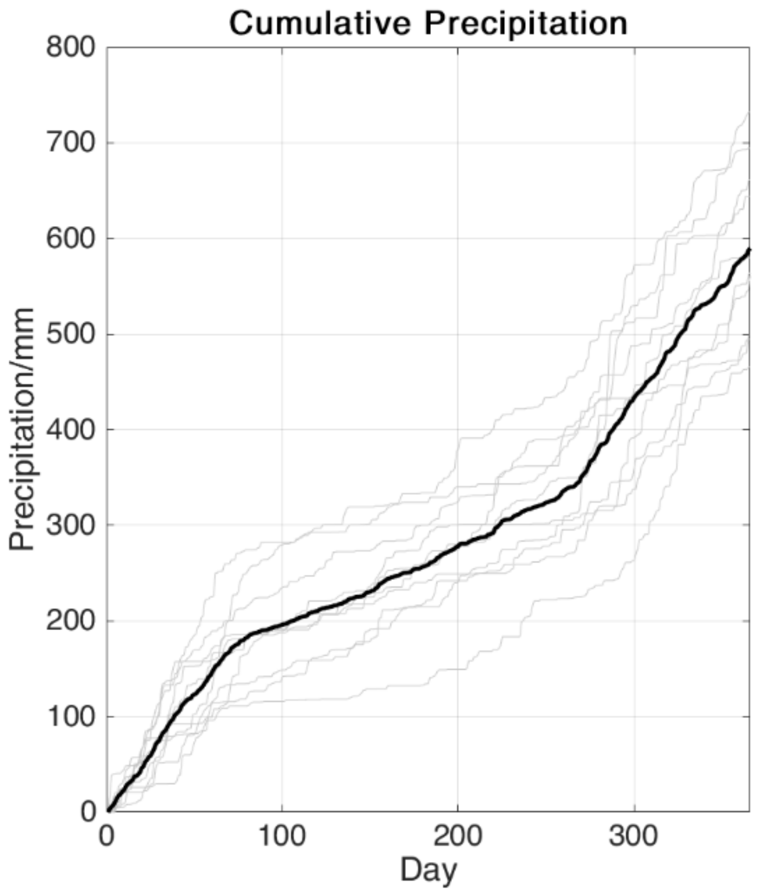


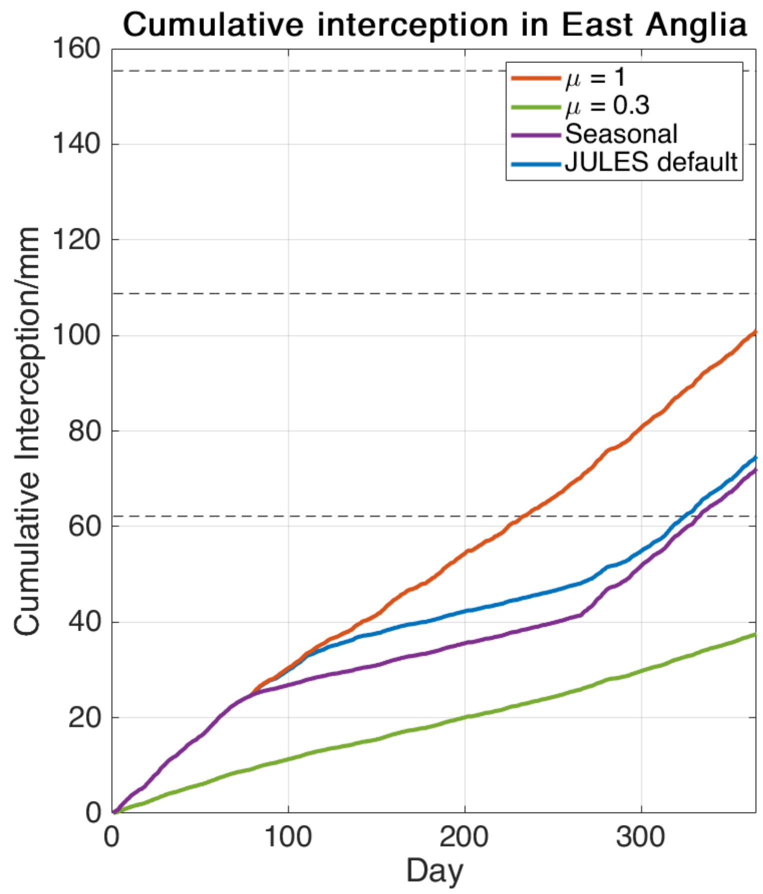
Current discrepancies are exacerbated significantly under future UK climate conditions (UKCP18)



- JULES default falls dramatically, approximately equal to Seasonal

- Constant parametrisations remain similar as no convective switch in model

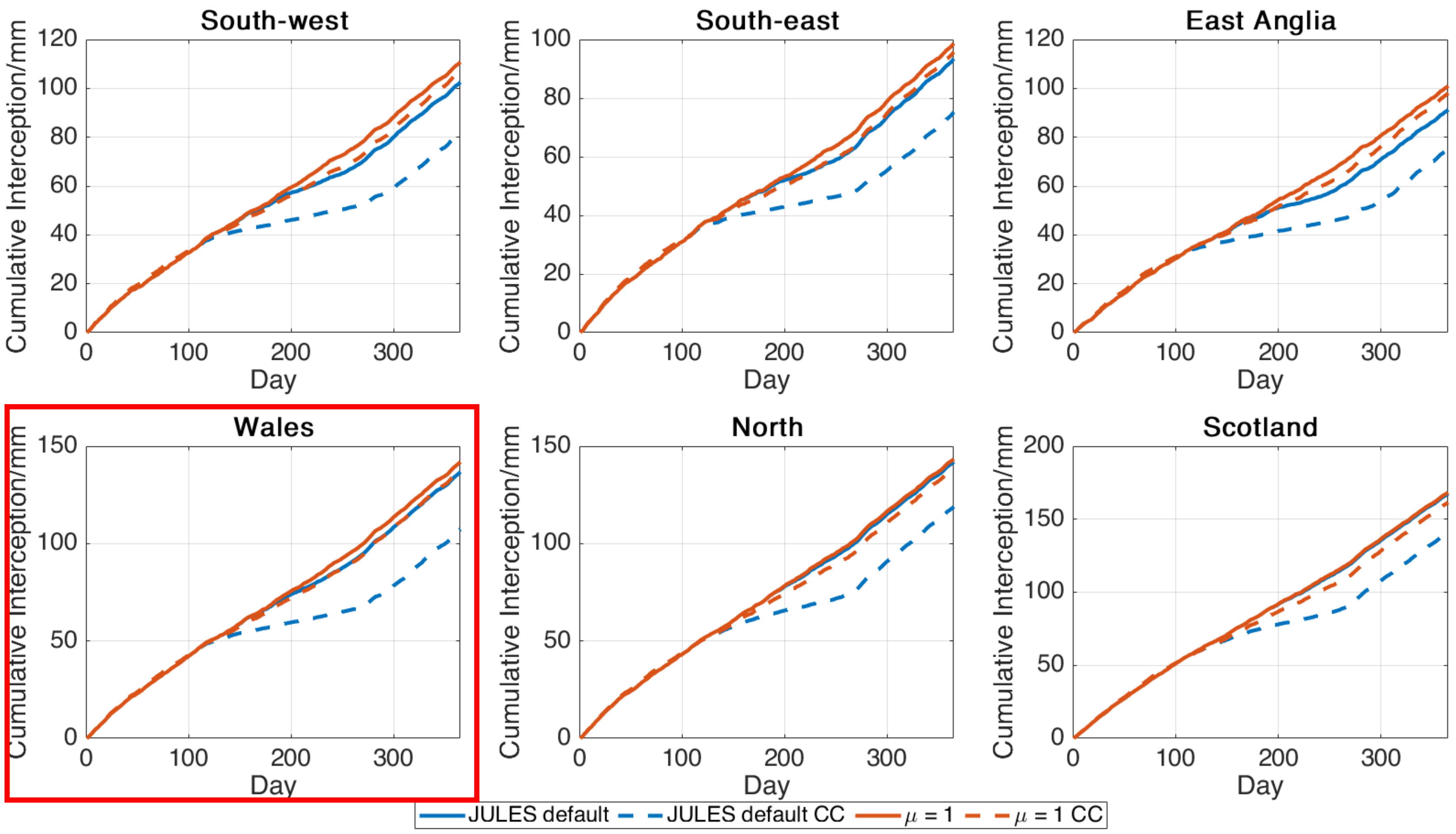




Future climate drastically impacts model performance in all subdomains

- In each region, interception is underestimated by default JULES using UKCP18

- Important to update model sooner rather than later!



Conclusions

Conclusions

1. JULES default parametrisation of rainfall intensity is **outdated**

2. **Hyper resolution models** (2x2 km resolution or higher) need **$\mu = 1$, and should never use $\mu = 0.3$**

3. In GB **interception is** slightly **underestimated** at the moment, but in the tropics it is expected to be much worse

4. **Climate change will drastically worsen** the performance of the current JULES model, even in areas such as the UK

Thank you very much for listening!