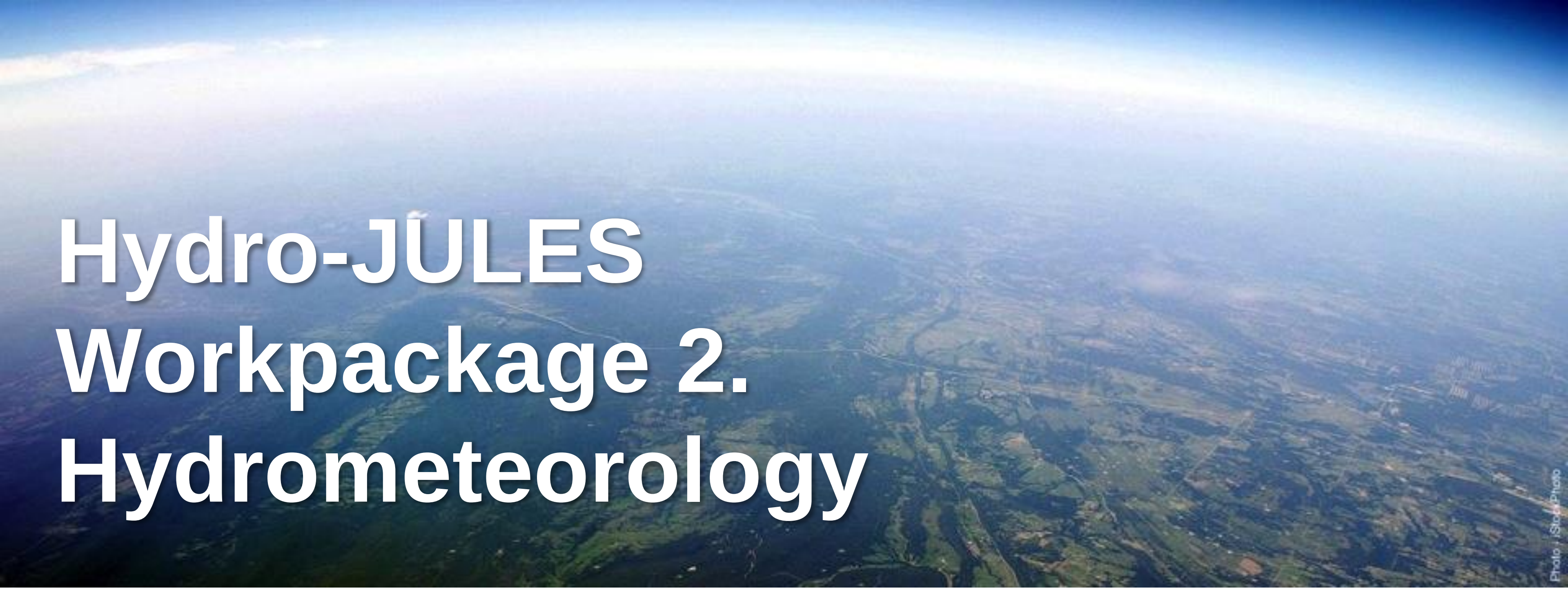

Hydro-JULES Workpackage 2. Hydrometeorology

WP leader: Eleanor Blyth
Task leaders: 2.1: Steve Cole, 2.2: Matt Fry, 2.3: Alison Kay and 2.4: Eleanor Blyth

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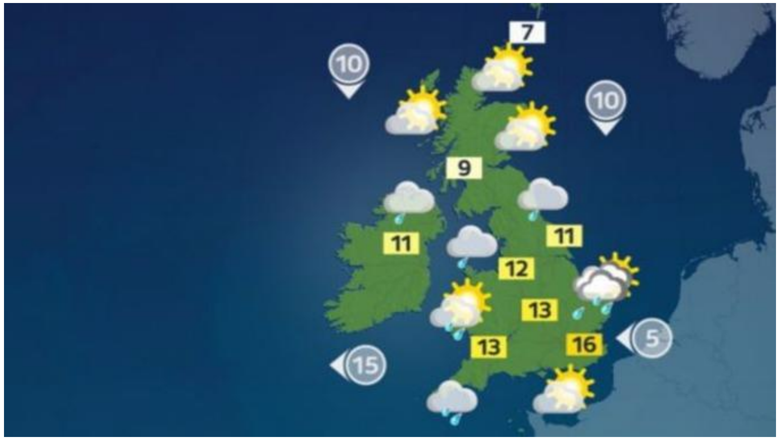
Relations between Climate/Weather and Hydrology



Weather is very variable and affects our everyday life.

Hydrology has three impacts:

1. In its normal mode, it is implicit in almost everything: food production, carbon cycle, snow on the ground, types of food, water resources

2. In its extremes (flood and drought), it has a bigger impact than weather

3. Feedback into the weather and climate

Hydrology in the news – always the extremes

Oxford flooding

2007. 200 properties affected

Drought in Ethiopia, 2016:
Hydrology affects timing and drought recovery

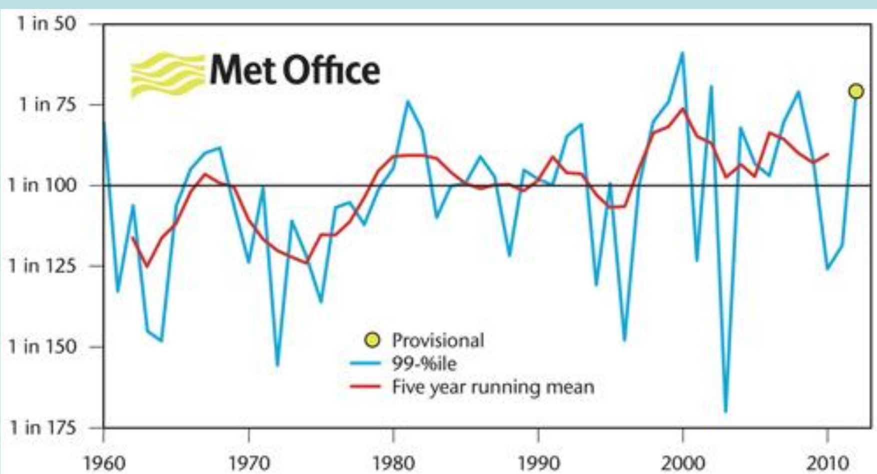
<u>Big Question: Are Floods and Droughts ‘business as usual’ for Hydrology?</u>

Are storms intensifying?

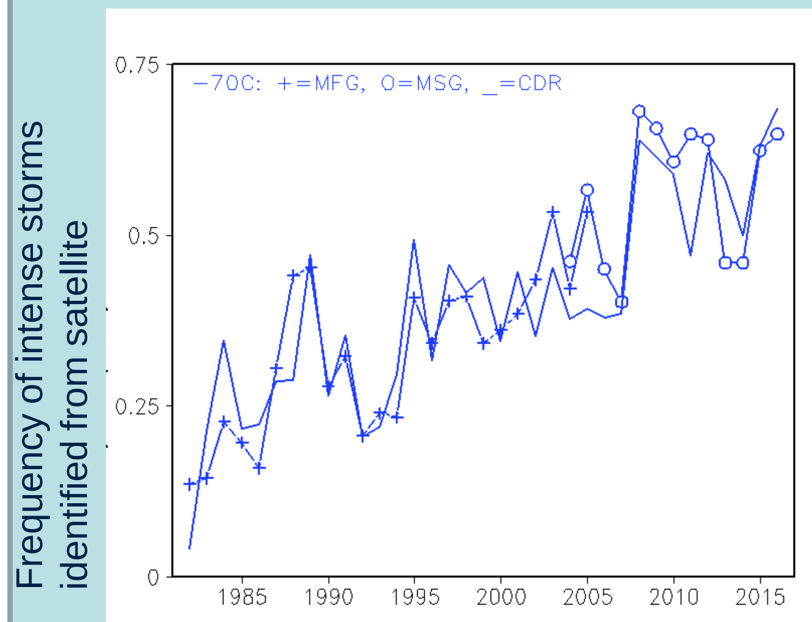
Also note: changes in Temperature, and CO_2.

In the UK:

Climate models are showing us that the more intense rainfall (1 in a 100 years) is occurring more and more frequently



In West Africa, intense storms are happening 3 times more over the last 30 years



Taylor et al, Nature, 2017

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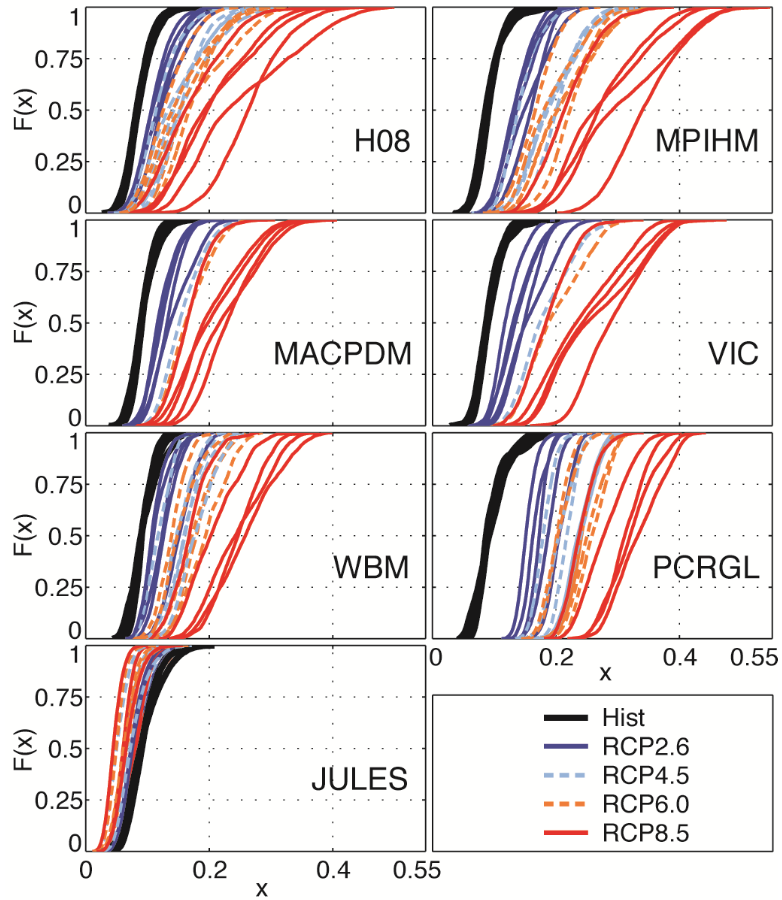
Are droughts becoming more frequent or extended?

FUTURE CLIMATE

- x: proportion of land under ‘drought’ at the same time
- F(x): cumulated time this happened.

For JULES the maximum land extent under drought is 20% (0.2) and is reached under historical climate; for H08 maximum drought extent is ~ 55%

When JULES is run without dynamic CO_2, the maximum land area under drought is 40%.



Prudhomme, C., et al. (2013) Hydrological droughts in the 21st century, hotspots and uncertainties from a global multimodel ensemble experiment. PNAS

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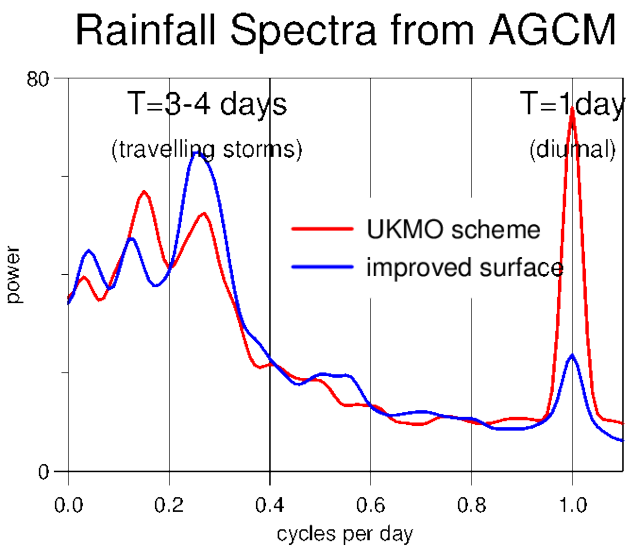
Importance of feedbacks in the land-atmosphere system

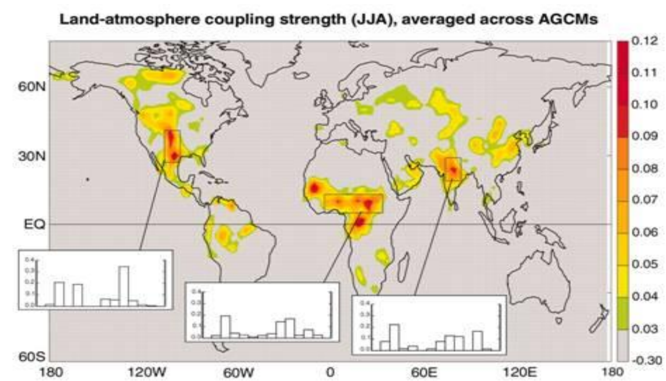
Taylor and Blyth: 2000. JGR. Rainfall controls on evaporation at the regional scale: an example from the Sahel.
Taylor and Clark: 2001. QJRMS. Diurnal cycle and African easterly waves: a land surface perspective



Made some changed including changes to the vegetation structure **and the way that the water drains through the soil when it arrives in clumps rather than spread out**.

Result: less frequent triggering of daytime convective events. Warmer deeper boundary layer, more prolonged rainfall.

Land-atmosphere coupling strength diagnostic for boreal summer: Koster et al., 2004



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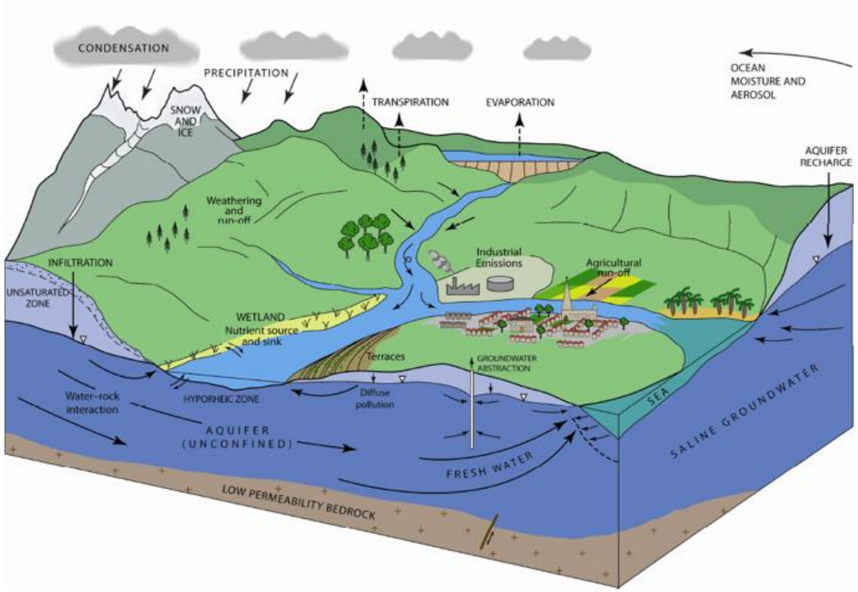
Hydrometeorology to the rescue!



Precipitation – short and long term
Floods and droughts modelling
Transpiration and evaporation

<u>Questions being asked in this workpackage</u>

- What are the extremes in precipitation?
- How can we observe them?
- How do changes in extremes affect floods and droughts?
- Does uncertainty in precipitation impact on uncertainty in hydrology?
- What are the feedbacks in the system?

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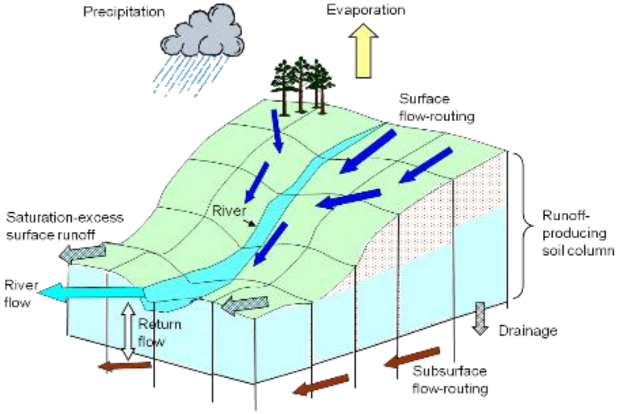
Modelling to deal with future climates

- *Rainfall intensity and distribution*
- *Interception of rainfall*
- *Evaporation and transpiration*
- *Snow packs and snow melt*
- Runoff generation (saturation vs infiltration excess)
- Soil physics including freezing
- River routing and inundation
- Ground Water

WP2



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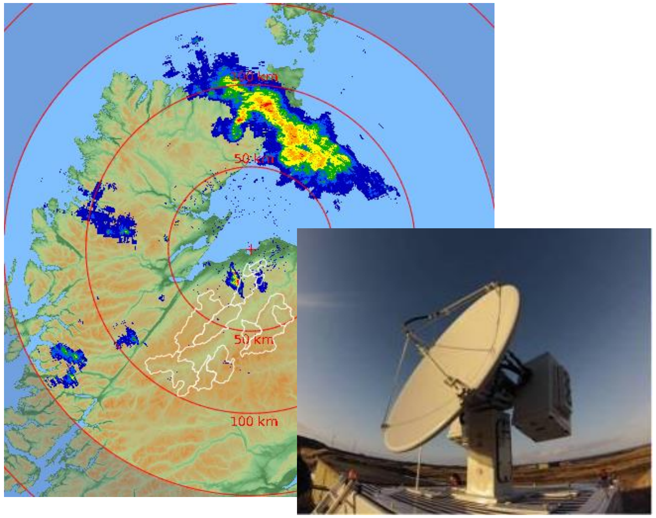
Task 2.1: Improve understanding of hydro-meteorological extremes

Exploit novel measurement techniques for observing and understanding extreme events

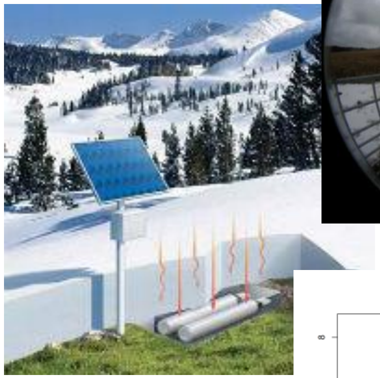
NCAS X-band dual-polarisation radar

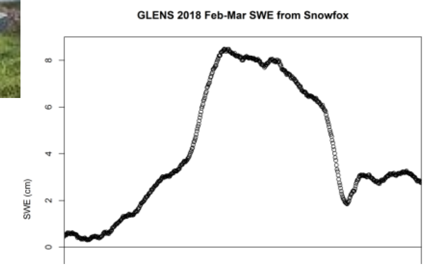
- *High resolution data (500m)*
- *Uncertainty estimates*
- *Hydrometeor classification (rain/snow)*



Snowfall/pack observations

- *COSMOS-UK (CEH) and Snow Pack Analyser sensors (SEPA) (17/18 winter)*
- *New Snow Water Equivalent datasets*





Datasets available for community use

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Task 2.1: Improve understanding of hydro-meteorological extremes

Demonstrate benefits for hydrological modelling and scalability to national scales

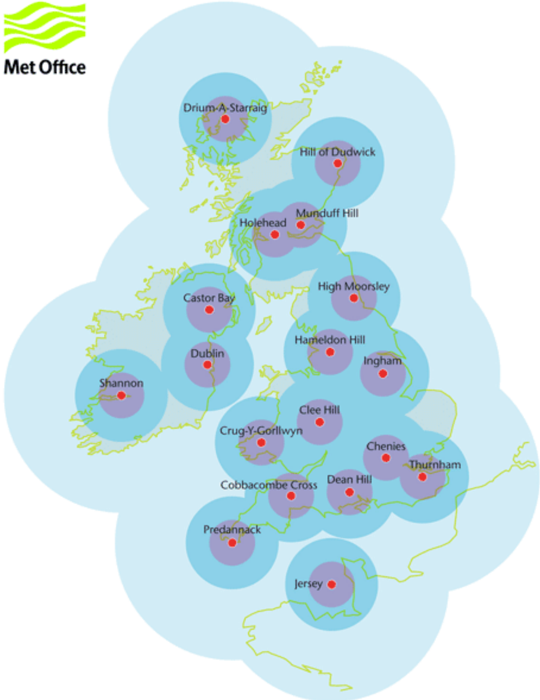
Applications to national C-band weather radar network (with Met Office)

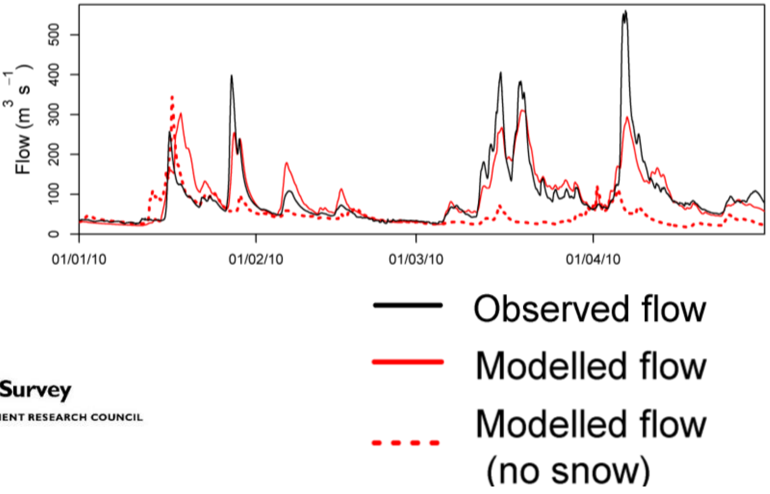
- *Merging local X-band with national C-band radar networks*
- *Wider use of dual-polarisation techniques*

Hydrological modelling assessments at local and national scales

- *Improve process representation in hydrological models for extremes*
- *Quantify modelling benefits of new observation sources*

Met Office





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Task 2.2: Data for **current** and future scenarios for flood and drought risk modelling

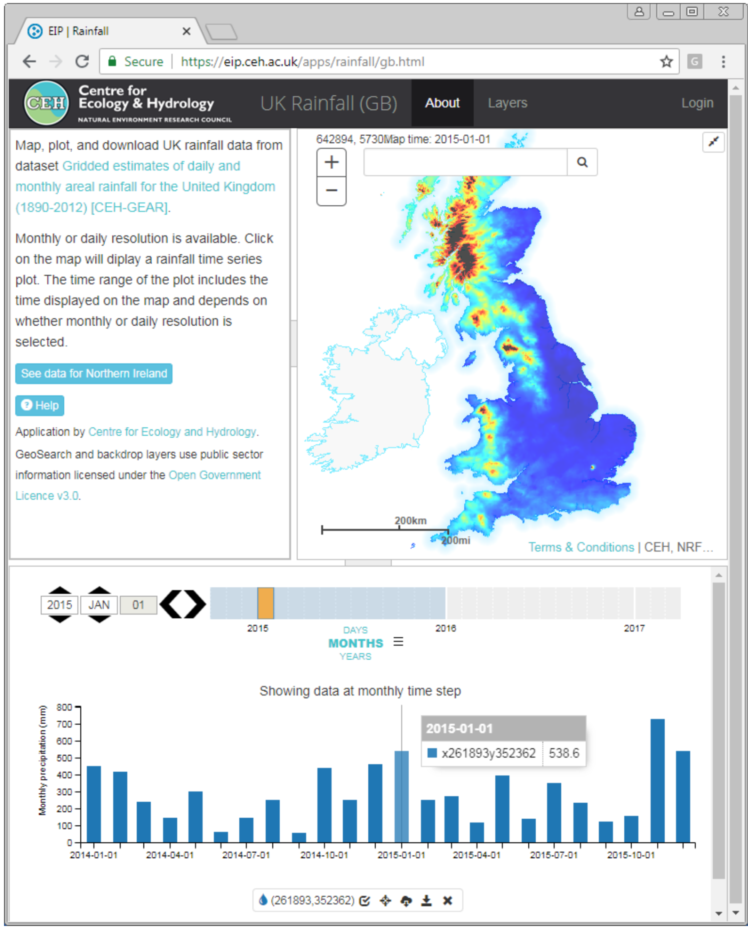
Publish UK sub-daily gridded rainfall dataset

- ***Hourly**, 1km gridded data for GB based on full set of raingauges from EA, Met Office, NRW, SEPA*
- *Incorporate into baseline UK driving dataset, update annually*
- *Assess benefit and requirements for 15 minute gridded rainfall data*

15 minute river flow data for the UK

- *Working with the National River Flow Archive and the UK Measuring Authorities / regulators*

Enable access to datasets for community use (tools for catchment extraction, etc.)



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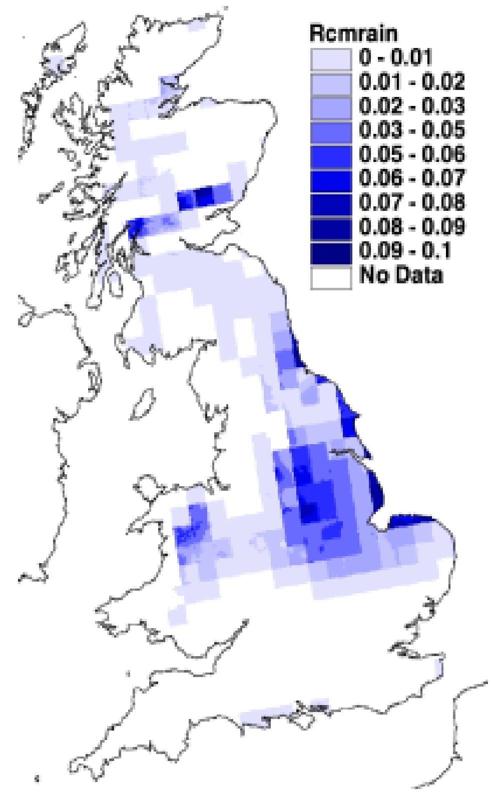
Task 2.2: Data for current and **future** scenarios for flood and drought risk modelling

Assess UKCP18 high resolution ***RCM*** *outputs for future scenarios*

- *Enable easier access to UCKP18 data for hydrological modelling*
- *Easy access to CORDEX (RCM) data*
- *Produce UKCP18 Potential Evaporation datasets for future scenarios*



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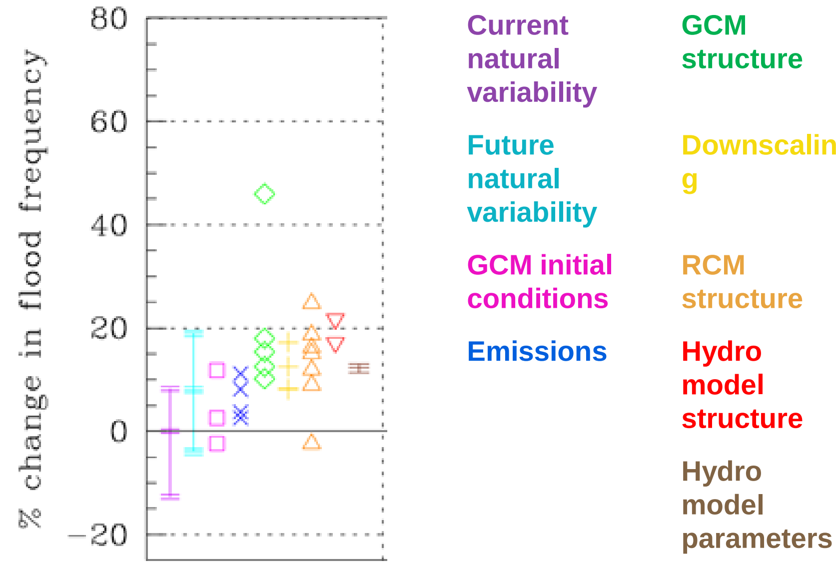
Task 2.3: Quantify uncertainty in hydrological predictions

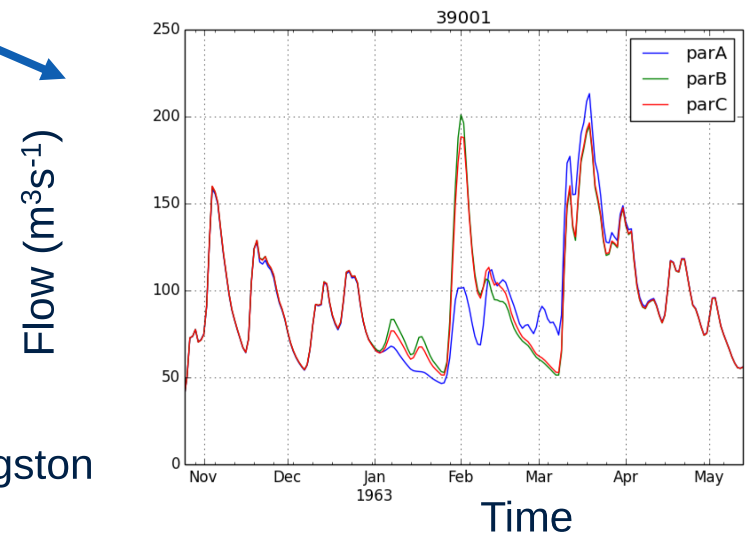
Sources of uncertainty in hydrological modelling include

- driving data (observed or modelled)
- ancillary data (e.g. soil datasets)
- model parameters
- model structure



Kay et al. (2009). *Climatic Change*

Investigate how these feed through to simulated river flows (especially extremes)



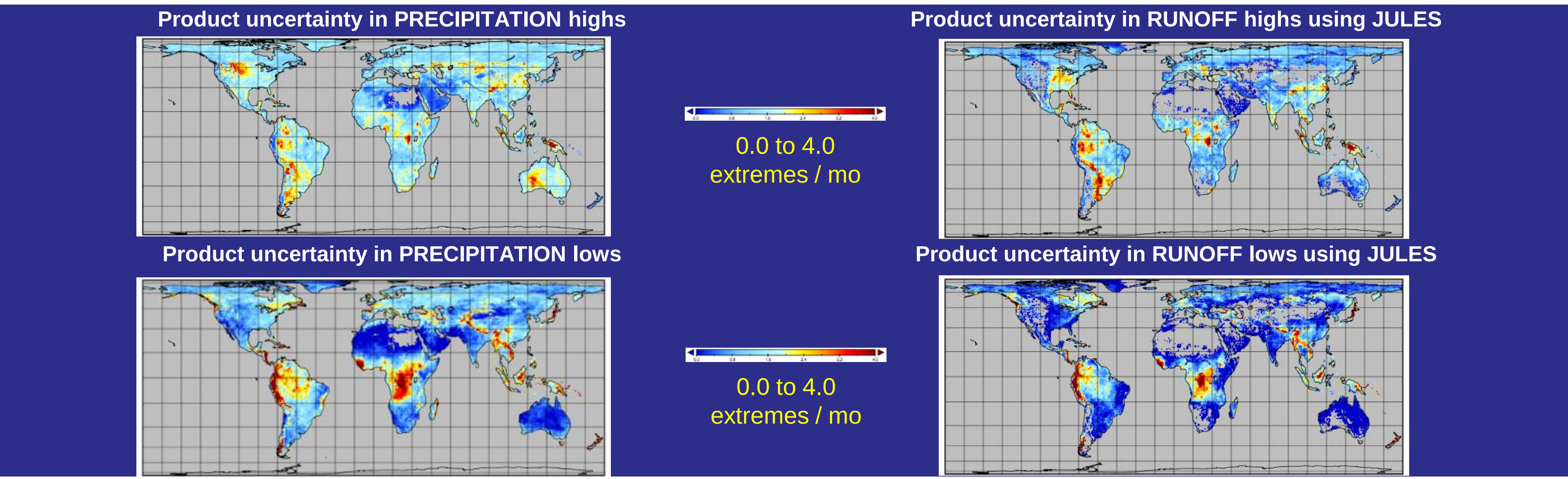
Thames @ Kingston

Task 2.3 Focus on

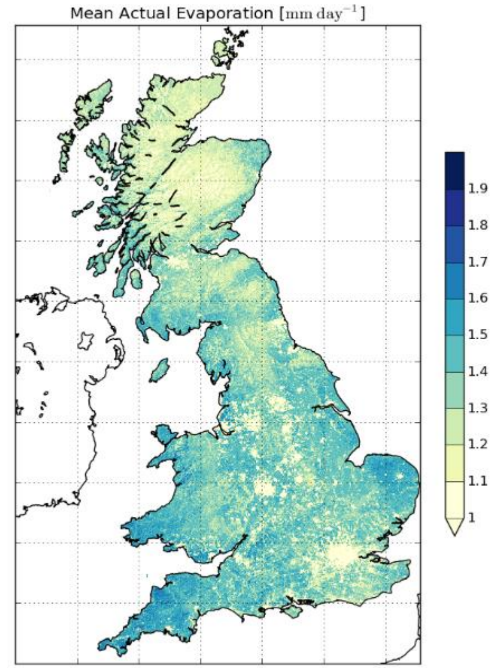
Spatial heterogeneity of rainfall extremes and its impact on extreme hydrology

Analysis of the uncertainty in extreme rainfall from satellite and its impact on hydrological extremes at the global scale

Legend: number of events PER MONTH where the Satellite data is greater than the 90 or 10% of an agreed standard:

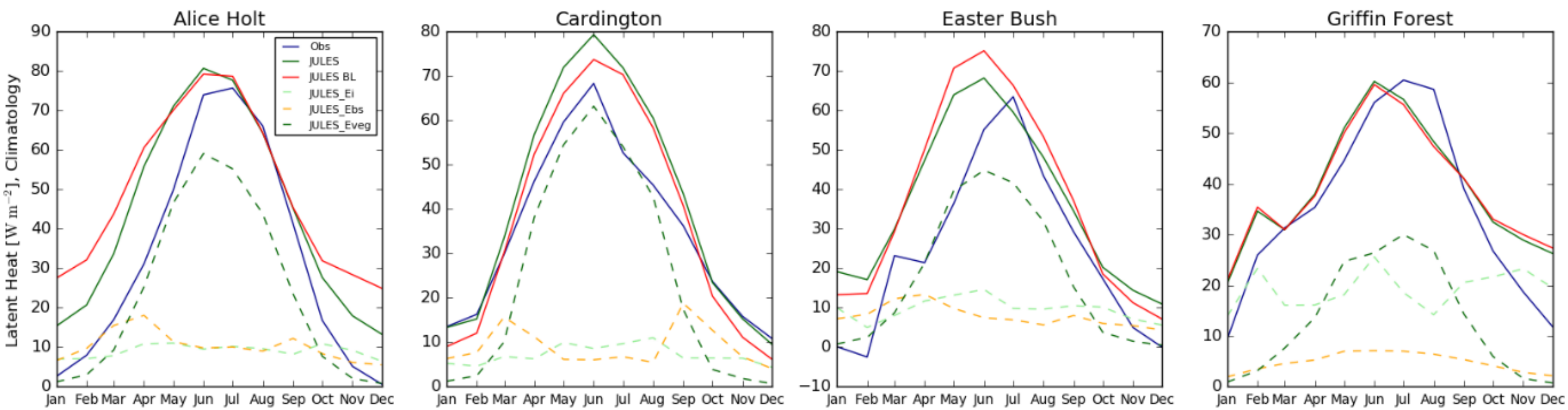


Task 2.4 Canopy processes and evaporation from multiple sources



How does JULES evaporation perform in the UK?

Mean states are well represented.
Overestimating winter evaporation.
Due to **interception** and **3-D nature of surface**



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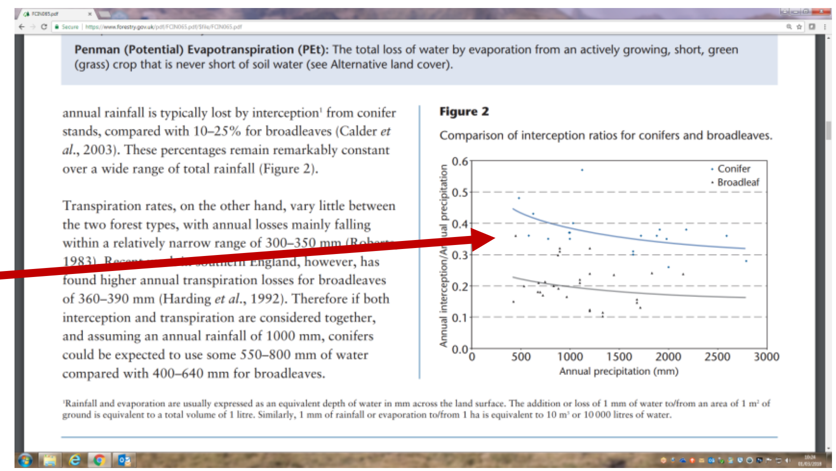
Task 2.4: Canopy processes and evaporation from multiple sources

Interception.

1. Evaporation from the wet canopy occurs at a higher rate than transpiration. It therefore has a different feedback to rainfall – causing rainfall recycling in continental systems (e.g. tropical forests)
2. Interception is a rainfall ‘loss’ to the land system
3. Dependent on distribution of rainfall, vegetation structure and turbulence

Report from UK Forestry commission based on data from CEH. Interception as much as **35% of rainfall**



Penman (Potential) Evapotranspiration (PEt): The total loss of water by evaporation from an actively growing, short, green (grass) crop that is never short of soil water (see Alternative land cover).

annual rainfall is typically lost by interception[1] from conifer stands, compared with 10–25% for broadleaves (Calder *et al.*, 2003). These percentages remain remarkably constant over a wide range of total rainfall (Figure 2).

Transpiration rates, on the other hand, vary little between the two forest types, with annual losses mainly falling within a relatively narrow range of 300–350 mm [illegible] 1983). [illegible] England, however, has found higher annual transpiration losses for broadleaves of 360–390 mm (Harding *et al.*, 1992). Therefore if both interception and transpiration are considered together, and assuming an annual rainfall of 1000 mm, conifers could be expected to use some 550–800 mm of water compared with 400–640 mm for broadleaves.

Figure 2

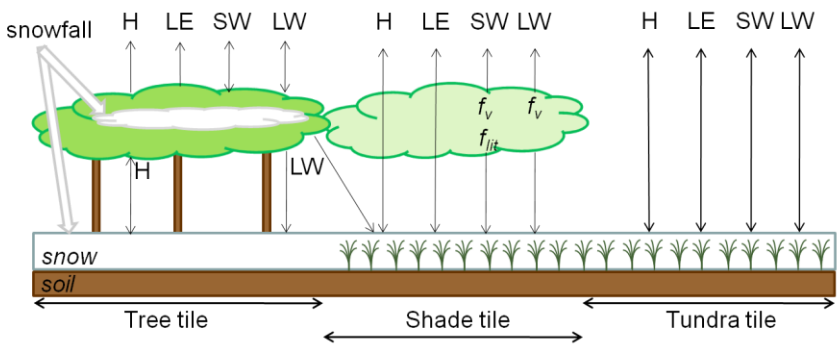
Comparison of interception ratios for conifers and broadleaves.

[1] Rainfall and evaporation are usually expressed as an equivalent depth of water in mm across the land surface. The addition or loss of 1 mm of water to/from an area of 1 m² of ground is equivalent to a total volume of 1 litre. Similarly, 1 mm of rainfall or evaporation to/from 1 ha is equivalent to 10 m³ or 10 000 litres of water.

3-D surfaces – how to represent them? (in 2-D)

Energy budgets are more complex than JULES single-surface temperatures.

New generation evaporation will address these issues.



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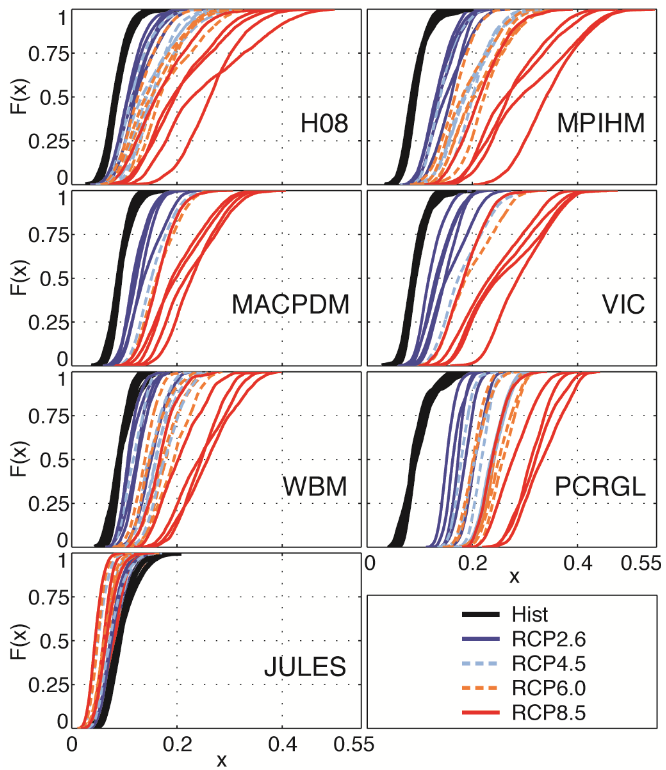
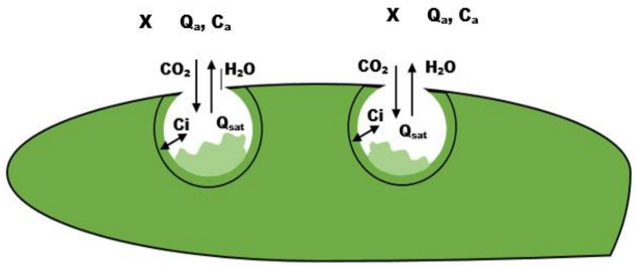
Linked Transpiration and Photosynthesis





In review in Plant Cell and Environment, Damour et al, 2010 show 35 different models

Links to the JULES community for research:
Soil Moisture Stress
Stomatal Conductance Modelling
Water Use Efficiency

- Prudhomme, C., et al. (2013) Hydrological droughts in the 21st century, hotspots and uncertainties from a global multimodel ensemble experiment. PNAS

Conclusions, links and further work

WP2 links to WP3 and WP4 which will be working on the modelling of Soil Physics, Runoff generation, inundation and routing, groundwater dynamics

In addition, links to the JULES community:
- soil moisture stress
- stomatal conductance models
- water use efficiency.

Thank you for listening.