Prediction and trends in hydro-meteorological hazards

Simon Dadson
UKCEH and University of Oxford

Hydro-JULES

Centre for Ecology & Hydrology
NATURAL ENVIRONMENT RESEARCH COUNCIL

British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

National Centre for Atmospheric Science
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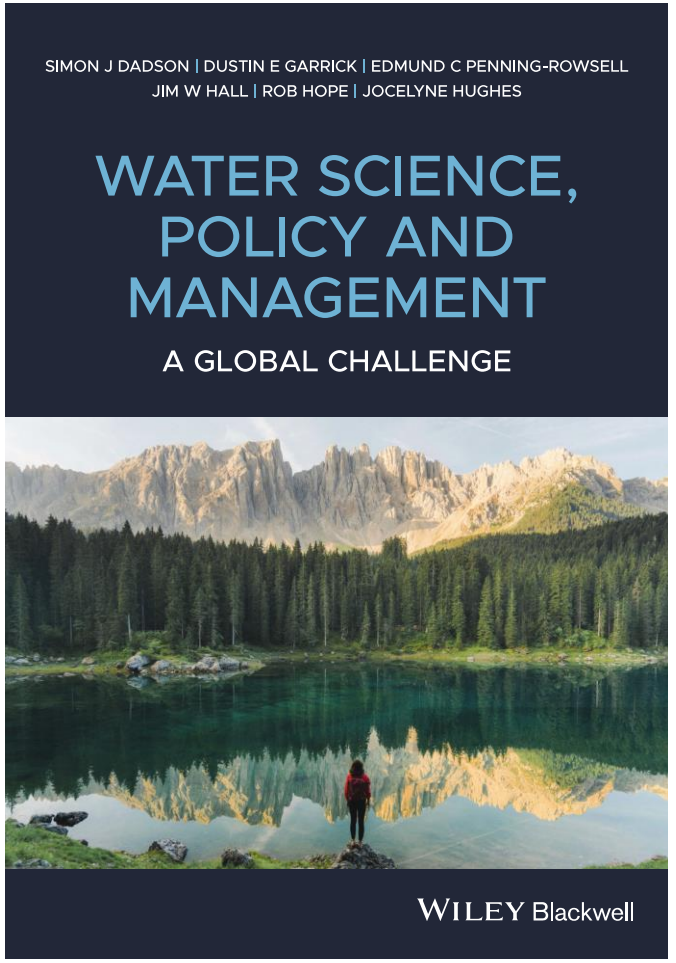
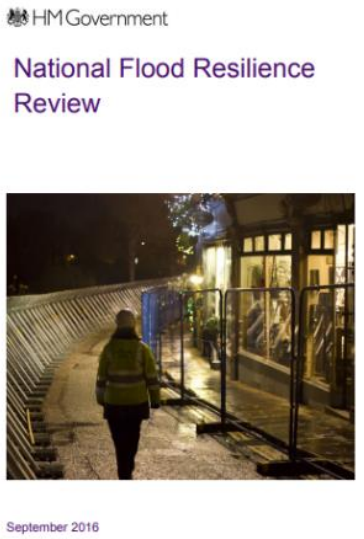
Motivation

- Critical human impacts and interactions take place at the land-atmosphere interface
- Improved scientific understanding of land hydrology requires interdisciplinary collaboration
- New and extended observational and modelling capability are needed to address these questions



- Climate and land-cover change
- New modelling and observational capabilities
- Coupled natural and human hazards



UN CLIMATE CHANGE CONFERENCE UK 2021

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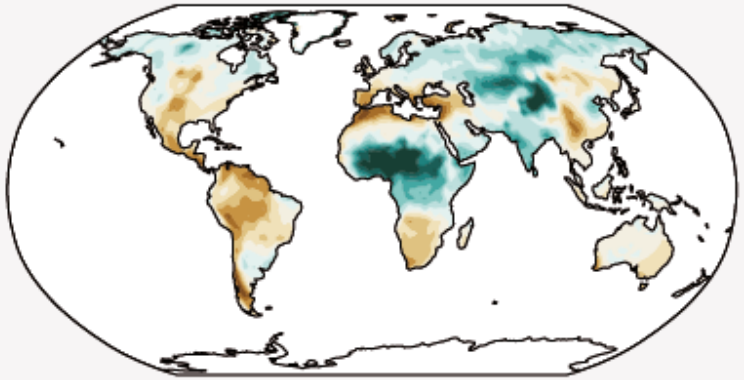
IPCC Summary for Policymakers Change in Soil Moisture due to Global Warming

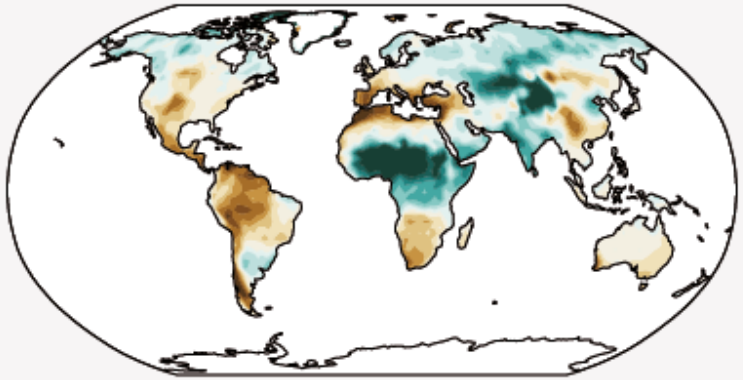
(d) Annual mean total column soil moisture change (standard deviation)

Across warming levels, changes in soil moisture largely follow changes in precipitation but also show some differences due to the influence of evapotranspiration.

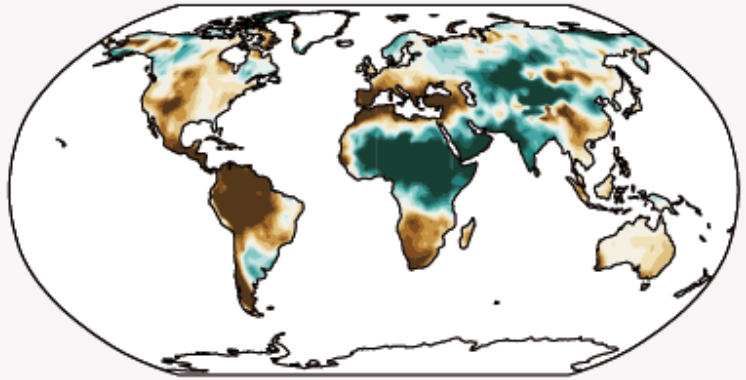
Simulated change at **1.5°C** global warming



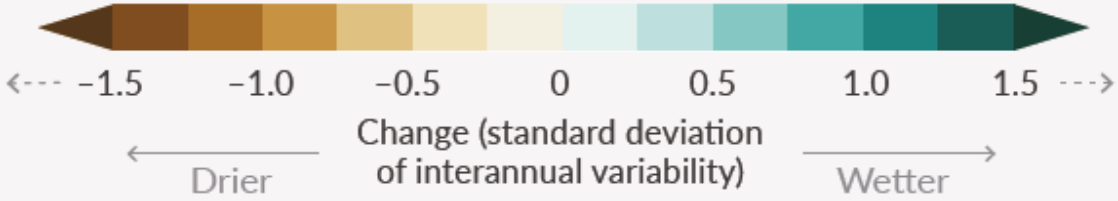
Simulated change at **2°C** global warming



Simulated change at **4°C** global warming

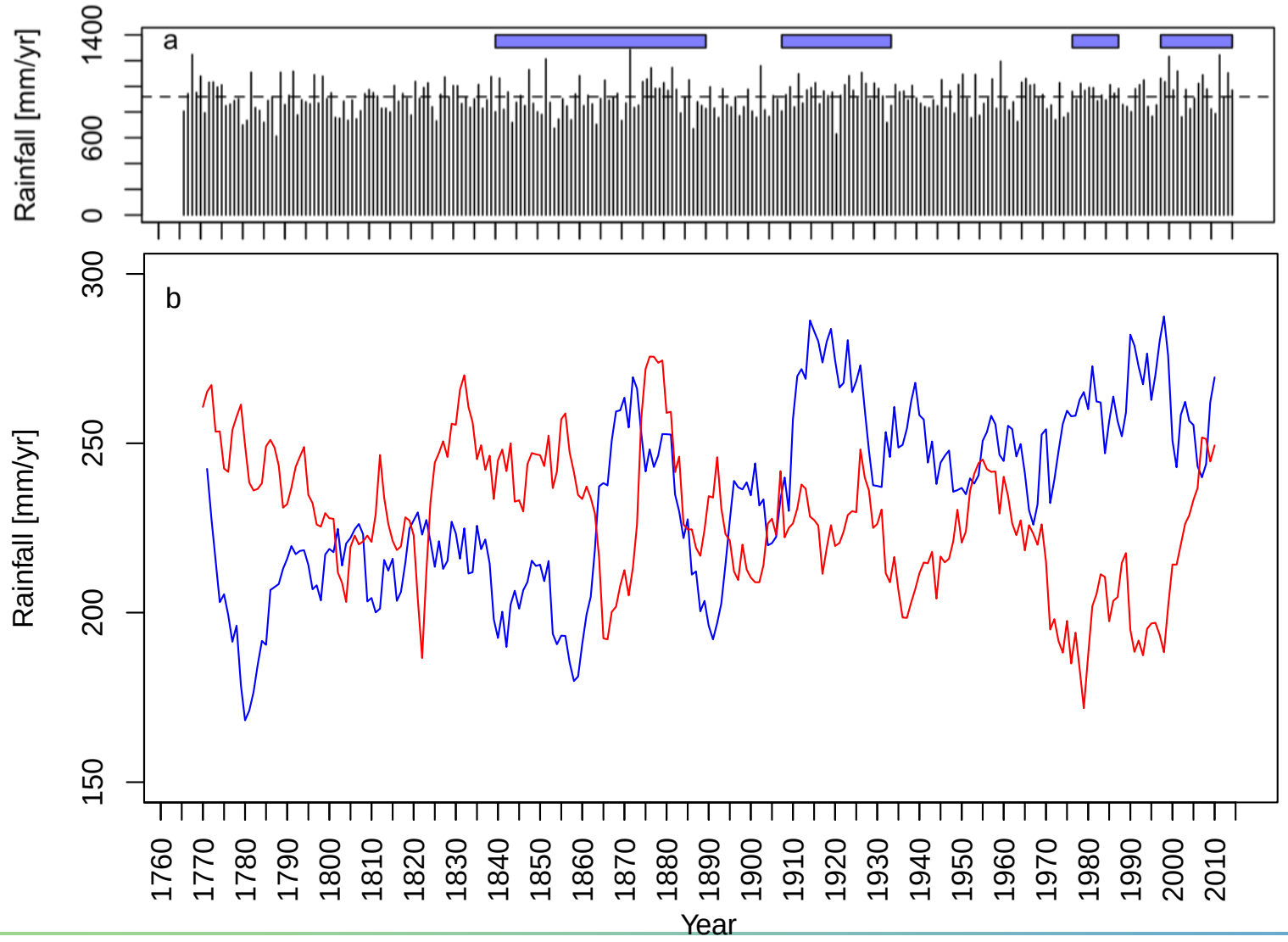


Relatively small absolute changes may appear large when expressed in units of standard deviation in dry regions with little interannual variability in baseline conditions.



SPM Fig 5, Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (Masson-Delmotte, V., et al., doi:10.1017/9781009157896.001.)

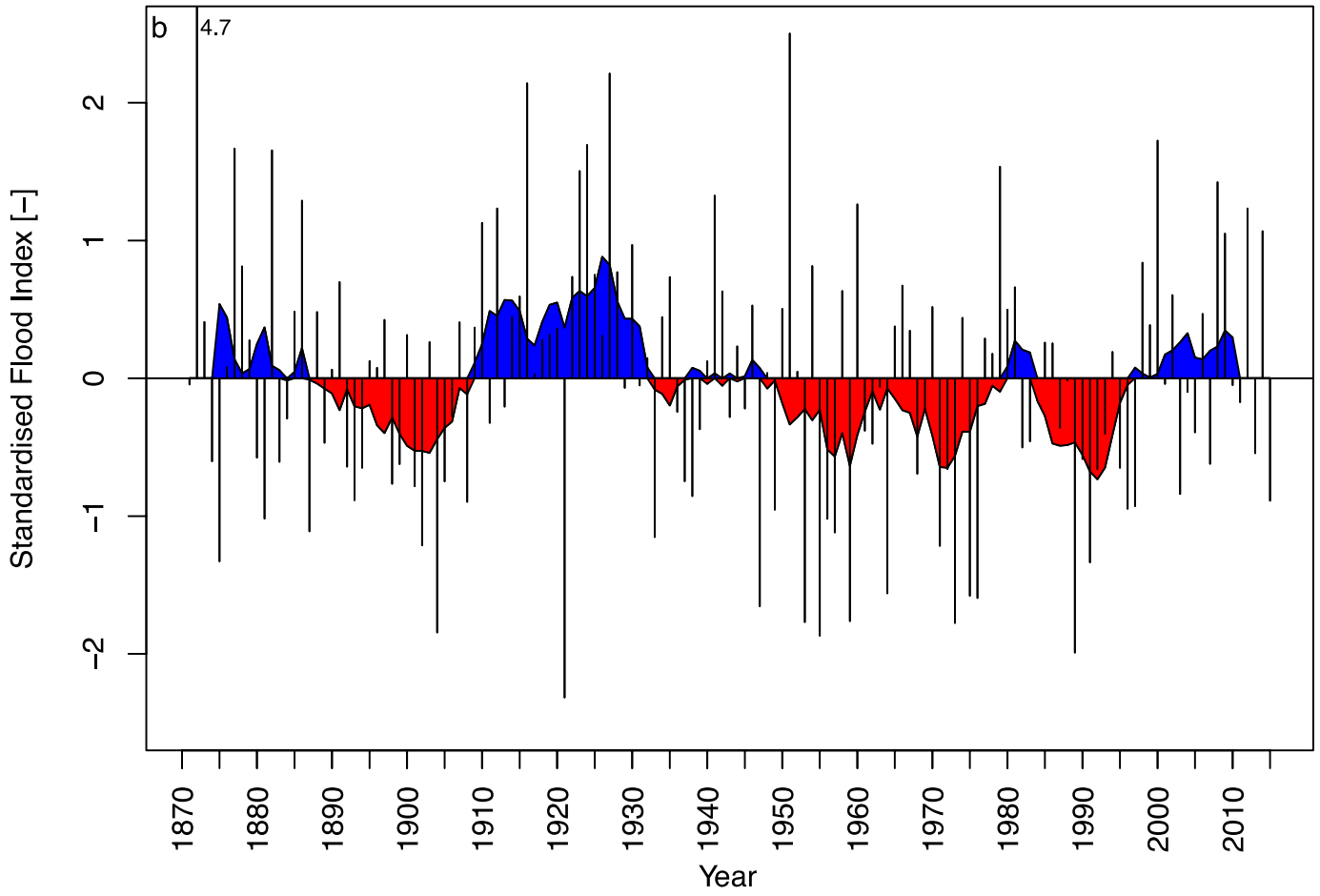
England and Wales precipitation (1776-2015)



Blue, winter (DJF); Red, summer (JJA)

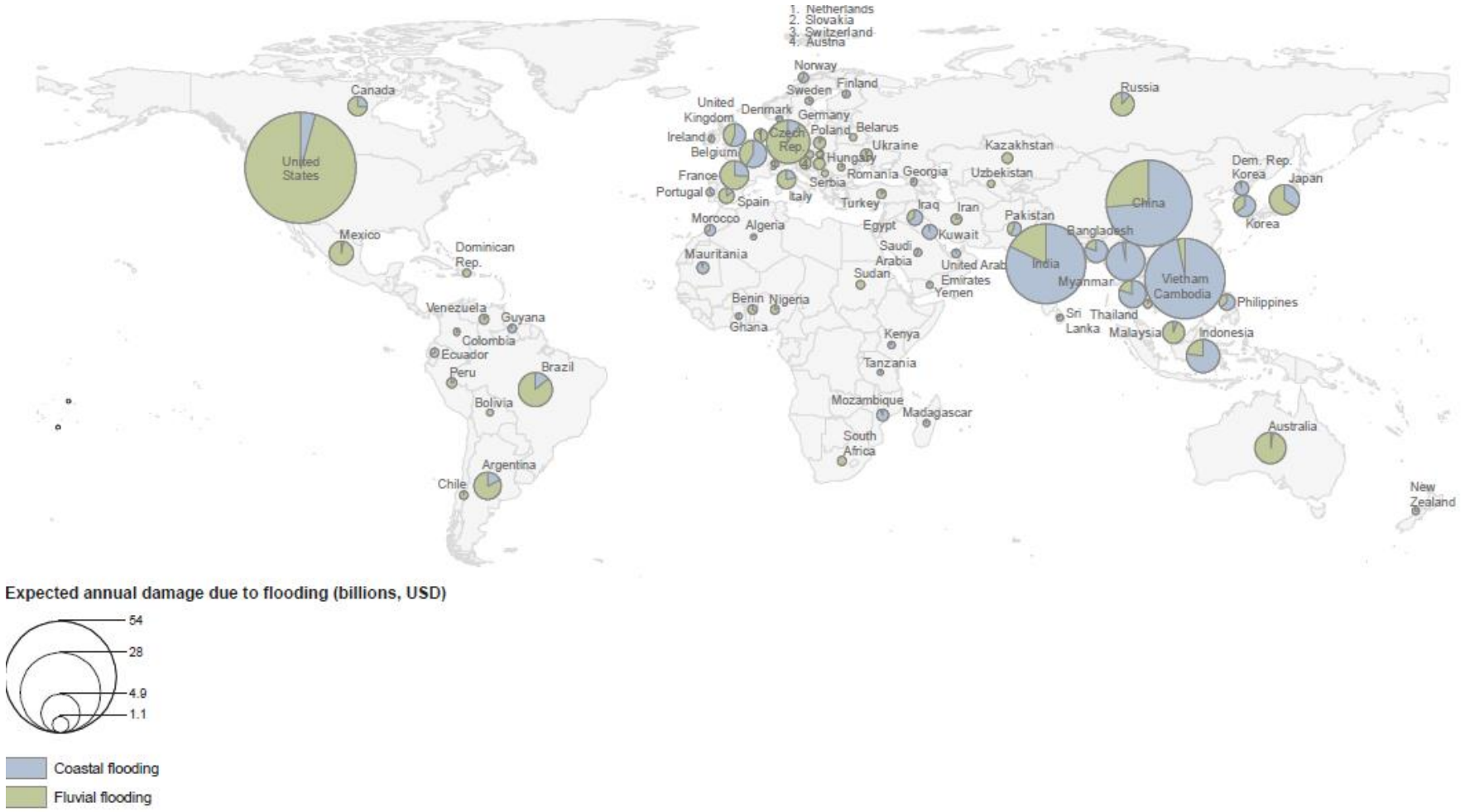
Data: Alexander and Jones (2001); http://www.metoffice.gov.uk/hadobs/hadukp/.

Flood-rich and flood-poor periods in the historical record



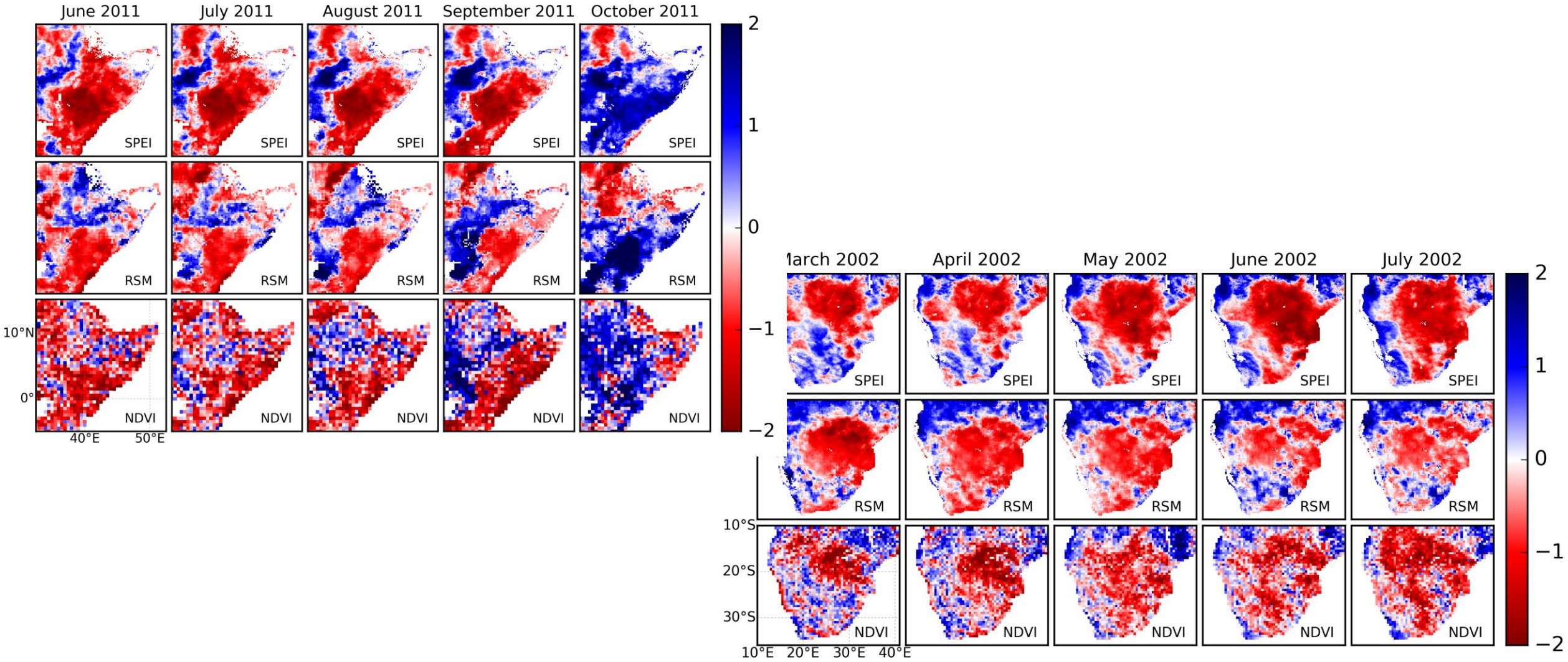
Data: Wilby and Quinn (2013); https://crudata.uea.ac.uk/cru/data/lwt/.

Worldwide flood losses



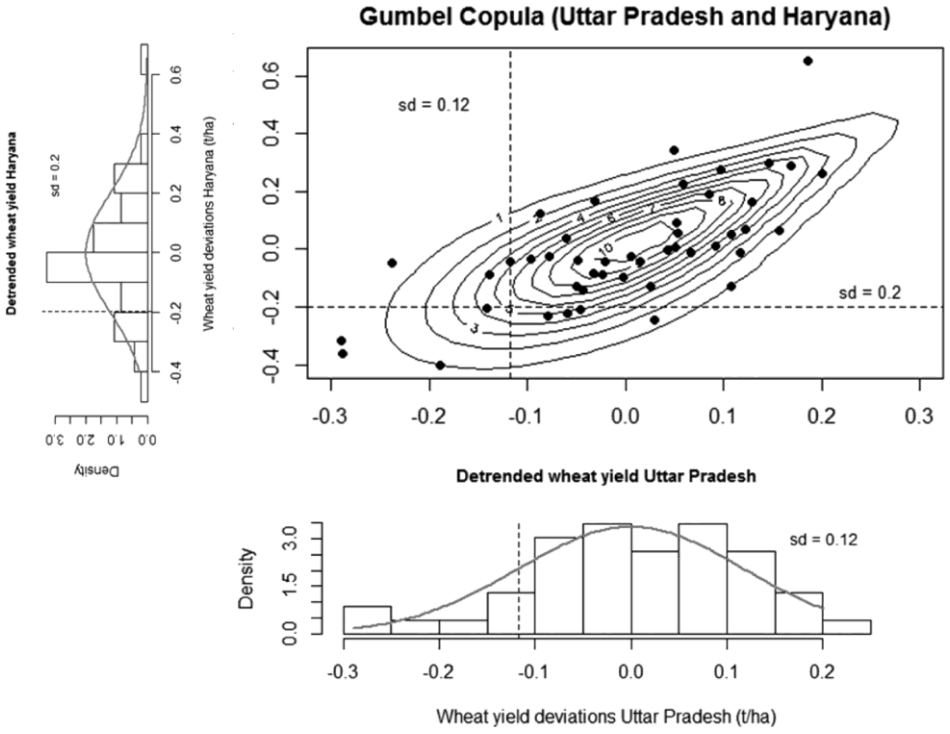
Sadoff, C.W., Hall, J.W., Grey, D., Aerts, J.C.J.H., Ait-Kadi, M., Brown, C., Cox, A., Dadson, S., Garrick, D., Kelman, J. and McCornick, P., 2015. *Securing Water, Sustaining Growth*. Report of the GWP/OECD Task Force on Water Security and Sustainable Growth.

2011 East Africa Drought & 2002 Southern African Drought



Peng., J., Dadson, S. J., Hirpa, F., Dyer, E., Lees, T., Miralles, D. G., Vicente-Serrano, S. M., Funk, C., under review, A pan-African high resolution drought index dataset.

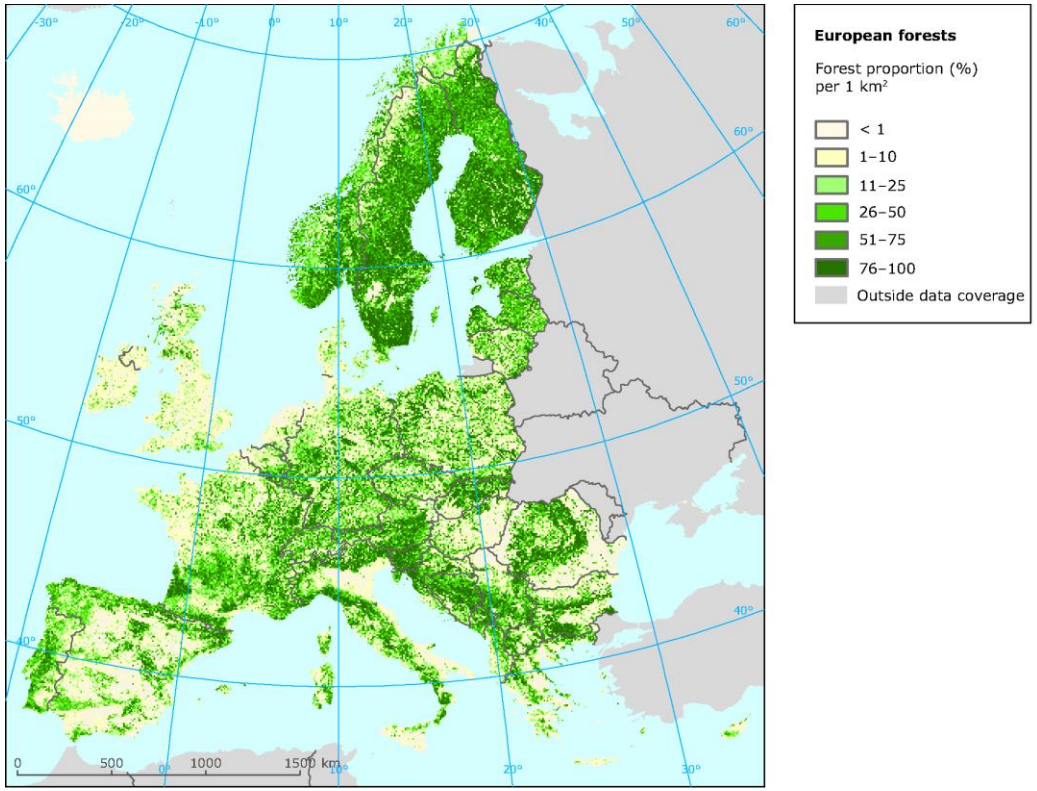
Correlated hydrological risks



Gaupp, F., Pflug, G., Hochrainer-Stigler, S., Hall, J., and Dadson, S. J. 2016. Dependency of crop production between global breadbaskets: A copula approach for the assessment of global and regional risk pools. *Risk Analysis* 10.1111/risa.12761

- Simultaneous drought poses serious threat to food and water security
- Variable dependency structure between major crop-producing regions
- Potential for inter-regional risk-pooling strategies

Land cover and land management

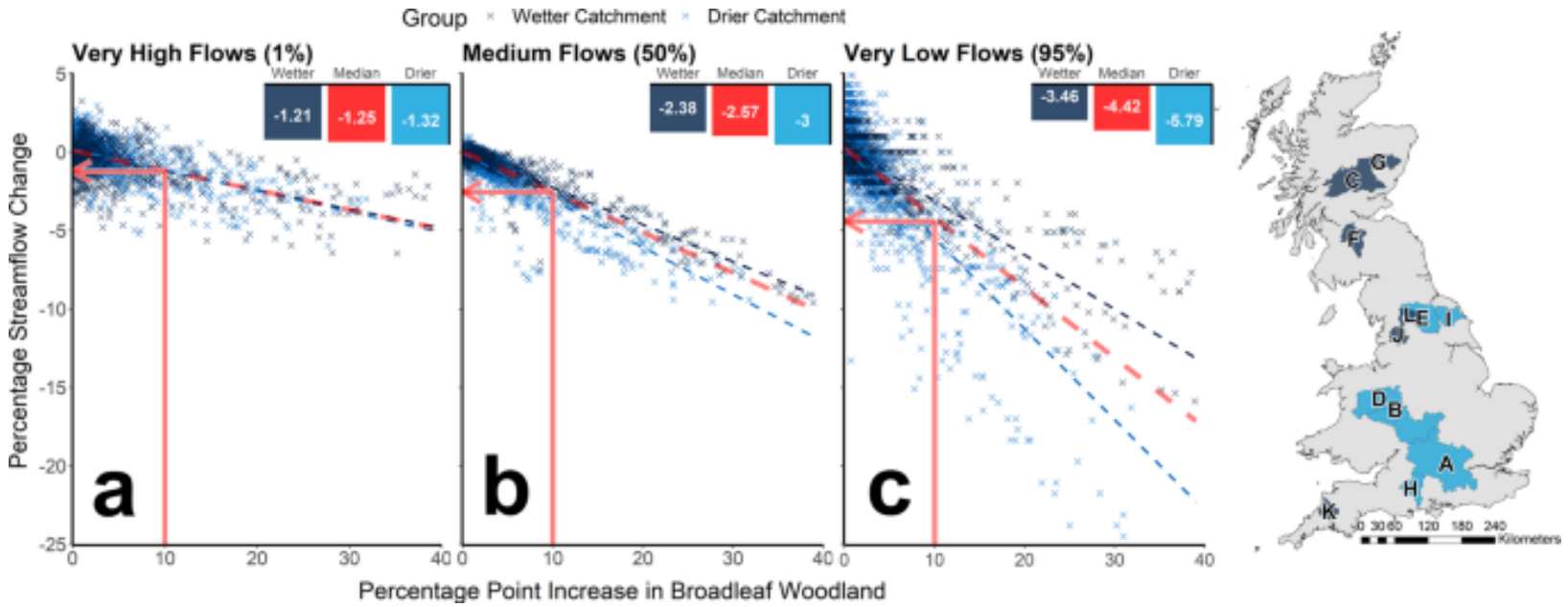


- Prehistoric forest cover of most of the UK
- Reduced to 6% in 1930s; currently 12% (2007)
- Post-1950 intensification of farming practices

http://www.eea.europa.eu/data-and-maps/figures/pan-european-forest-and-non-forest-map-2000

Effect of afforestation on high, median and low flows across Great Britain

- Afforestation consistently decreases median and low streamflow.
- Median modelled flow reduced by ~3% for each ten-percentage point increase in catchment broadleaf woodland.
- No nationally-consistent reduction of extreme floods.



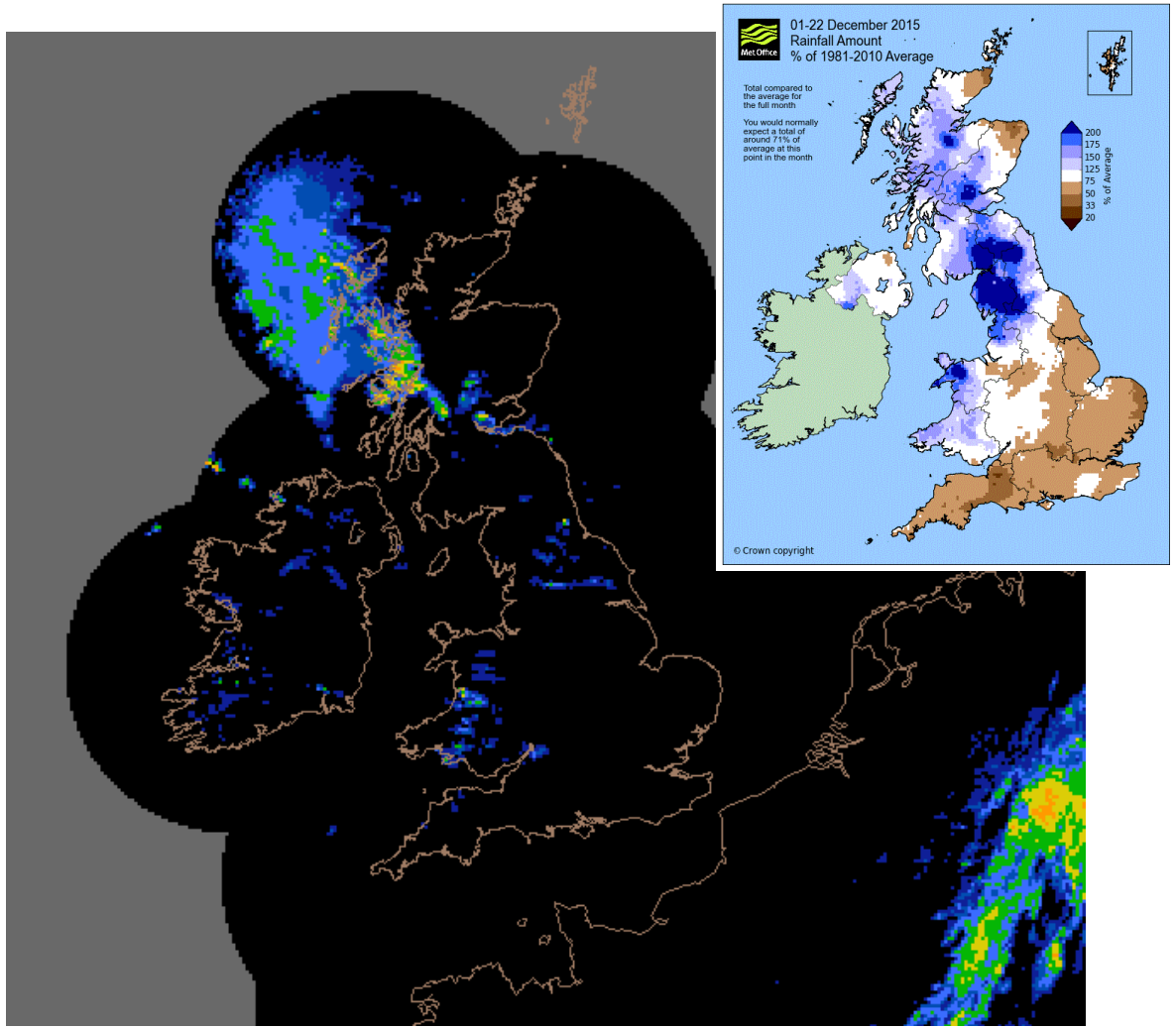
Buechel et al., 2021. *Nature Communications Earth and Environment* 3(1):1-10.

Model Development Priorities

- Groundwater
- Soil hydraulics
- Evaporation
- Inundation
- Anthropogenic influences
- Uncertainties in process chain
- Interoperable components
- Data assimilation from novel sources

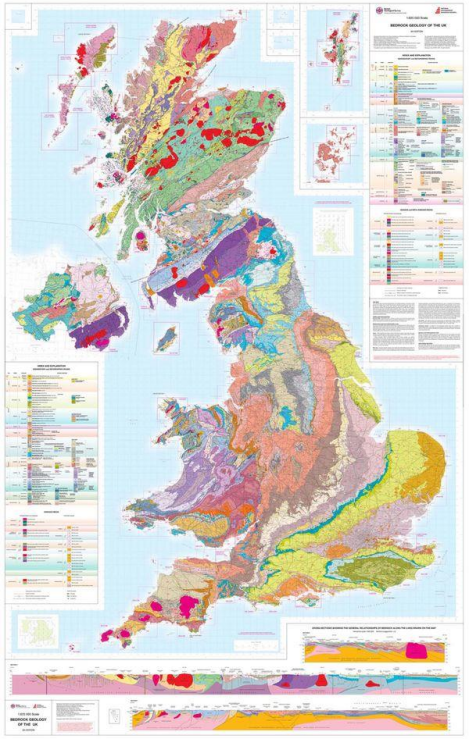
Radar precipitation estimates for hydrological modelling

- High-resolution precip data
- X-Band polarimetric radar
- Improved accuracy for QPE



Neely, R. R et al. Radar Applications in Northern Scotland. *J. Hydromet/* 22(2): 483-498. doi:10.1175/JHM-D-19-0184.1

3D Geological Framework Model



1:625,000 scale mapping

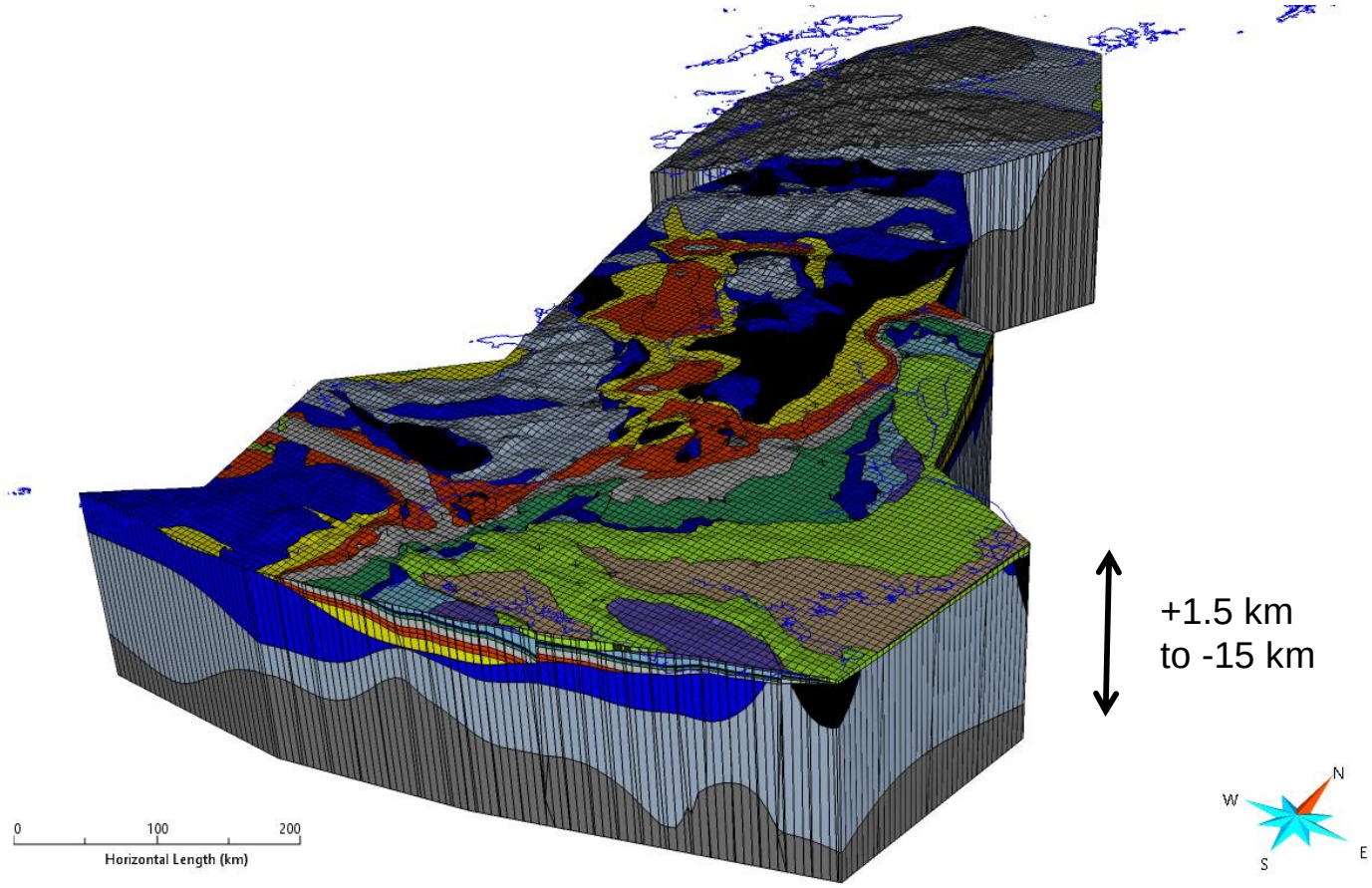


Image credit: Andy Newell, British Geological Survey

Soil moisture assimilation from *in situ* and satellite sources

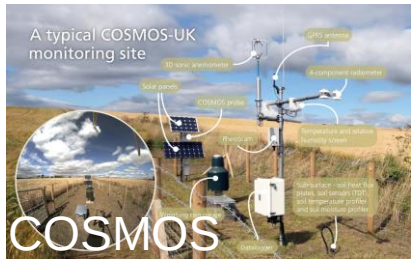
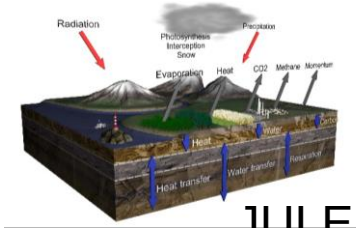
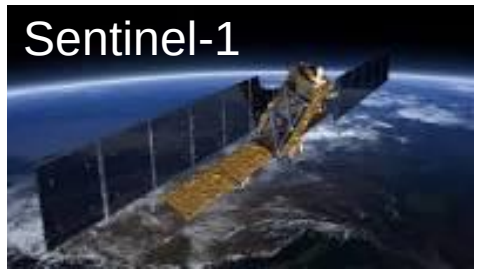
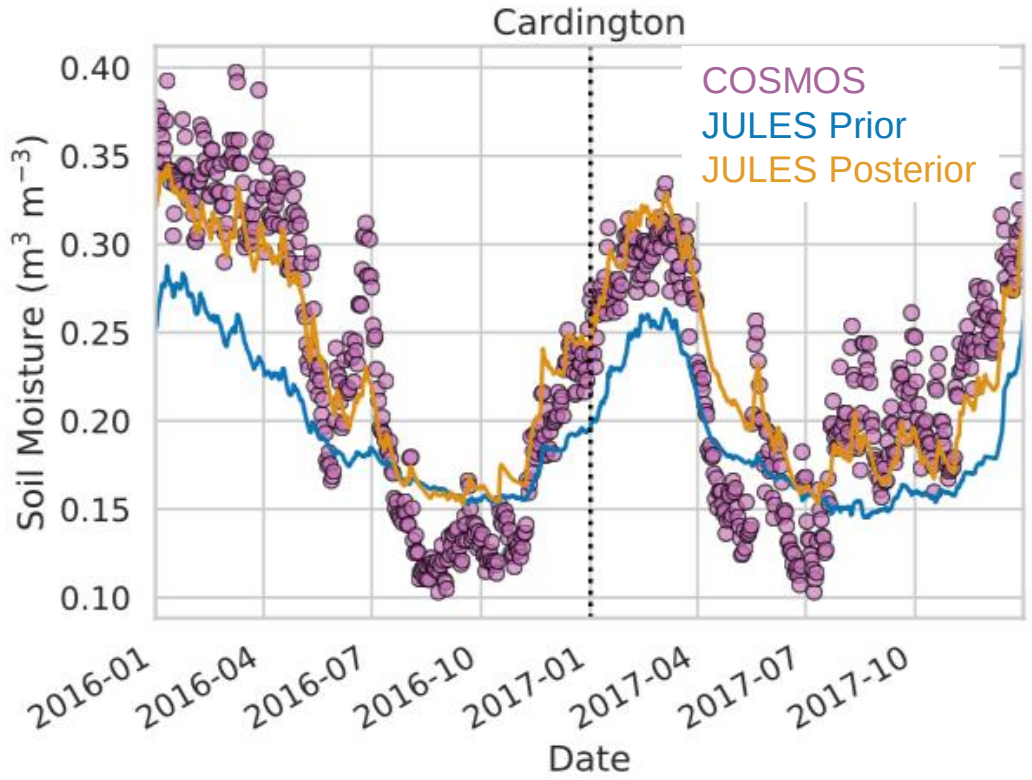


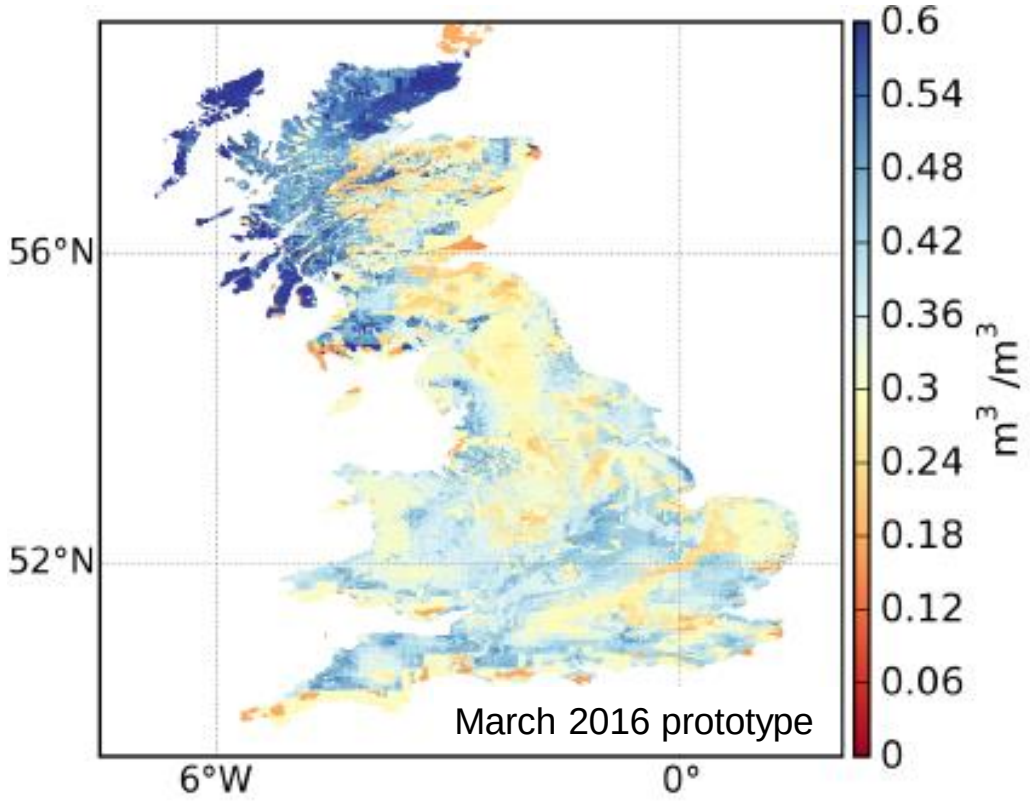
Image credit: UKCEH / COSMOS-UK



JULES



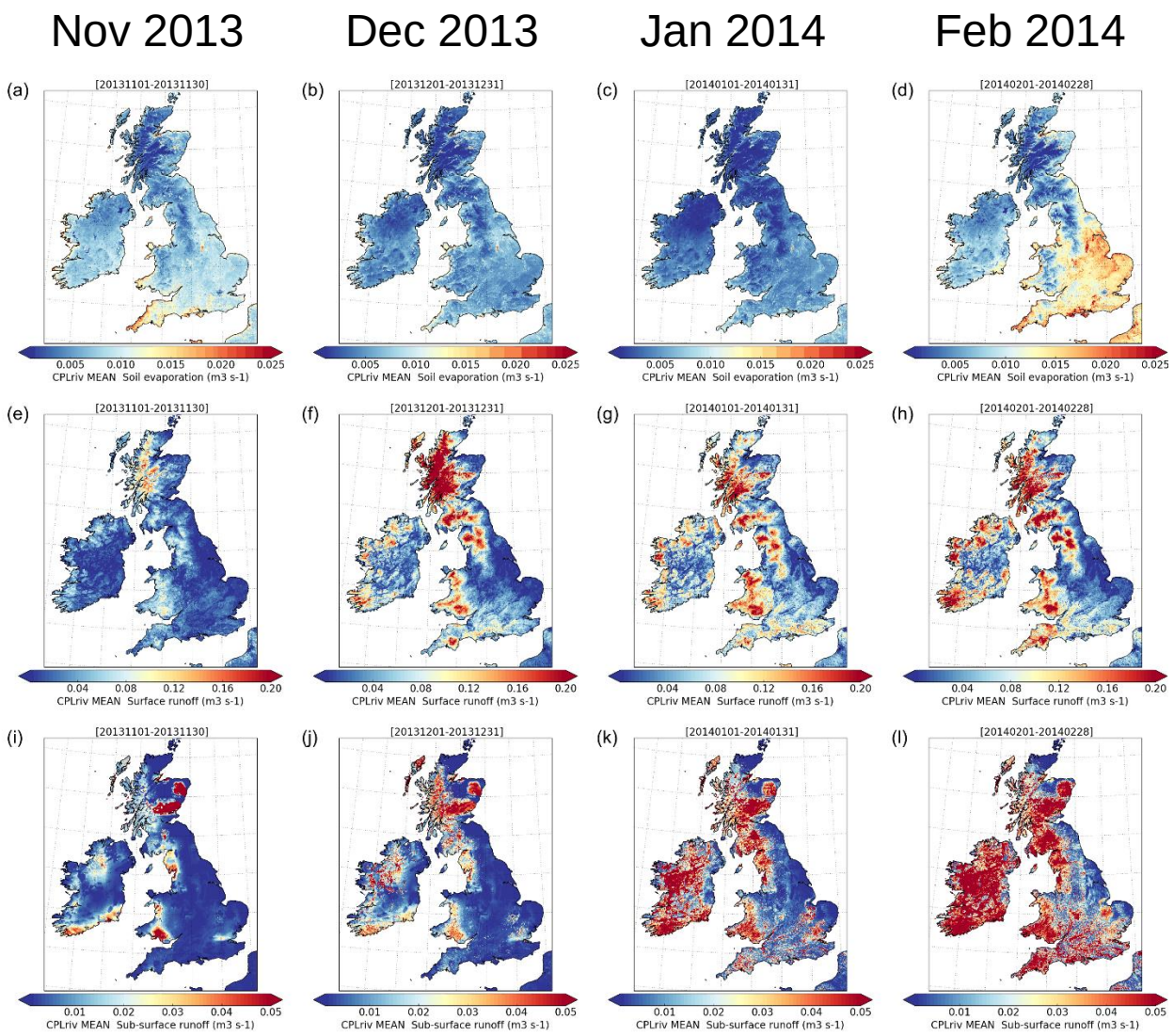




Figures: Dr. Elizabeth Cooper, Dr. Ewan Pinnington, Prof. Jian Peng

Coupled atmosphere – land – ocean model

- UK 2013/14 floods
- Integrated atmosphere, land, ocean study at 1.5 km (UKV)
- UM, JULES & NEMO
- Next phase:
  - Inundation extent
  - Anthropogenic effects
  - Macronutrient transport

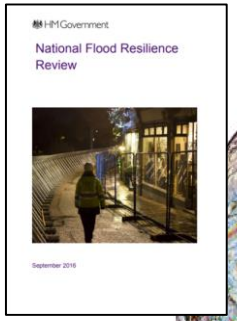


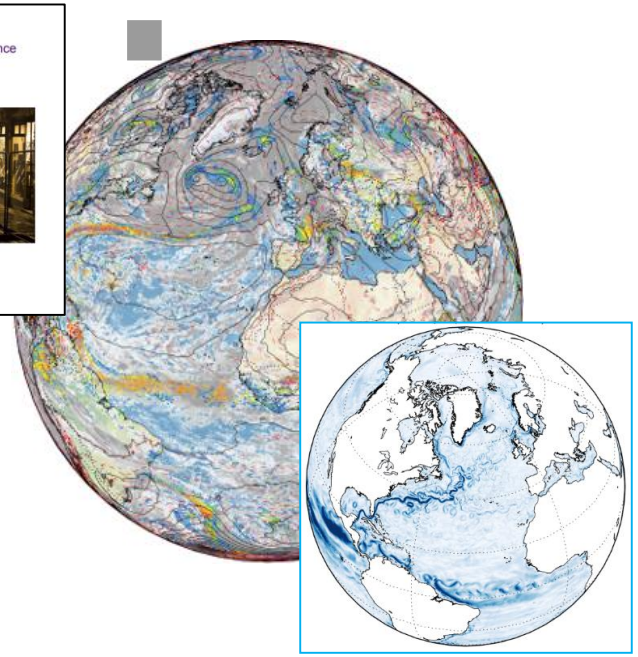
Met Office

UK Centre for Ecology & Hydrology

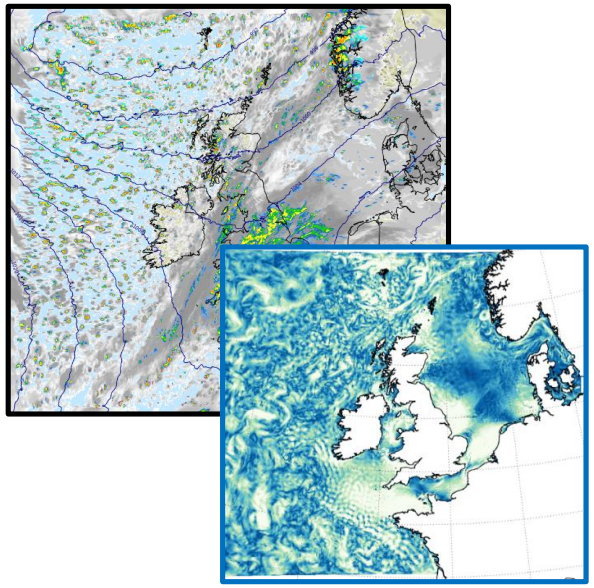
Lewis and Dadson, 2021. *Hydrol. Proc.* https://doi.org/10.1002/hyp.14438

Towards seamless hydrological predictions

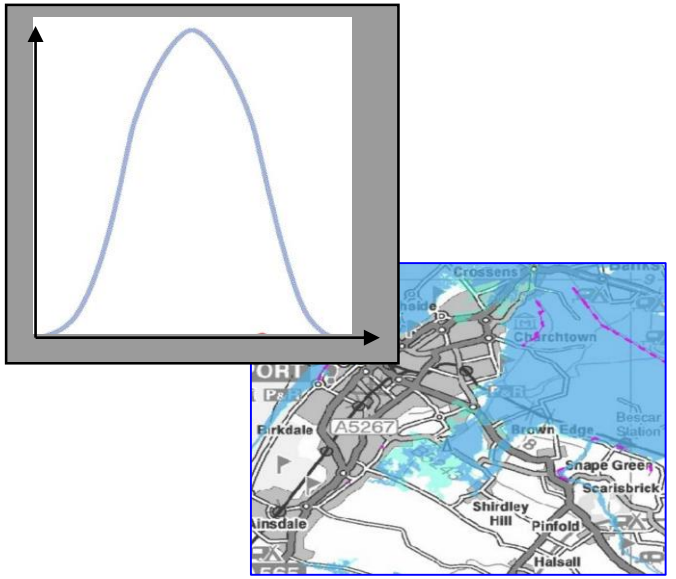




Synoptic-scale drivers in atmosphere, land and ocean



Local meteorology, surface and sea state

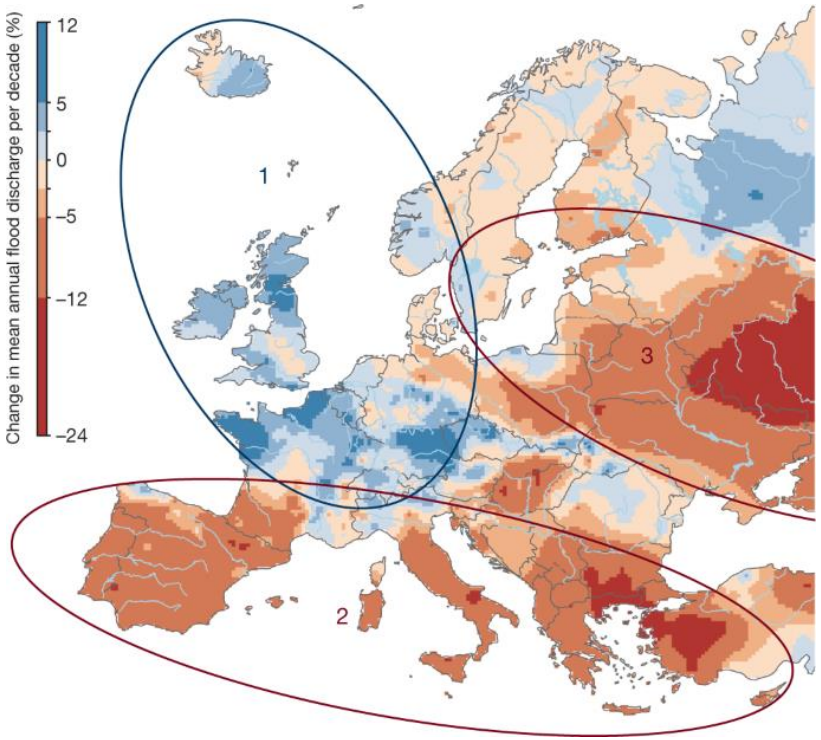


PDF of local hazard:
Impacts

Hydro-JULES Met Office

Image credit: Dr. Huw Lewis (Met Office)

Emerging challenges in modelling hydro-meteorological hazards



- Climate change
- Monitoring and modelling
- Coupled natural hazards

Q&A

Simon Dadson (sjdad@ceh.ac.uk)

@SimonDadson www.hydro-jules.org