Towards an improved understanding of flood extremes

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FRIEND WATER – Floods theme coordinator

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FRIEND – Flow Regimes from International Experimental Network Data

A global hydrological research network program that aims at:

- improving water science
- sustainable use of current and future water resources
- running for over 25 years.

FRIEND-Water goals are achieved through:

- [ ] **collecting and exchanging river flow and other hydrological data, particularly in an international context**

- [ ] **enhancing scientific understanding of hydrological processes across scales from local up to global**

- [ ] **developing innovative analytical tools for further improvement of water resource management and reduction of hydrohazards' risk (floods and droughts)**

- [ ] **educating and developing capacity building pathways through PhD and MSc courses and technical training courses**

- [ ] **disseminating knowledge in publications, books, conferences, workshops and <u>cooperating with other international networks</u> and professional organizations**

FRIEND - Global Geographical Coverage

EUROPEAN FRIEND (EU FRIEND)

MEDITERRANEAN FRIEND (MED FRIEND)

ASIAN PACIFIC FRIEND (AP FRIEND)

LATIN AMERICAN & CARIBBEAN FRIEND (AMIGO FRIEND)

THE HINDU-KUSH HIMALAYAS FRIEND (HKH FRIEND)

FRIEND NILE (FN)

WEST & CENTRAL AFRICA FRIEND (AOC FRIEND)

SOUTHERN AFRICA FRIEND (SA FRIEND)

EU FRIEND / MED FRIEND

HKH FRIEND / AP FRIEND

FRIEND NILE / SA FRIEND
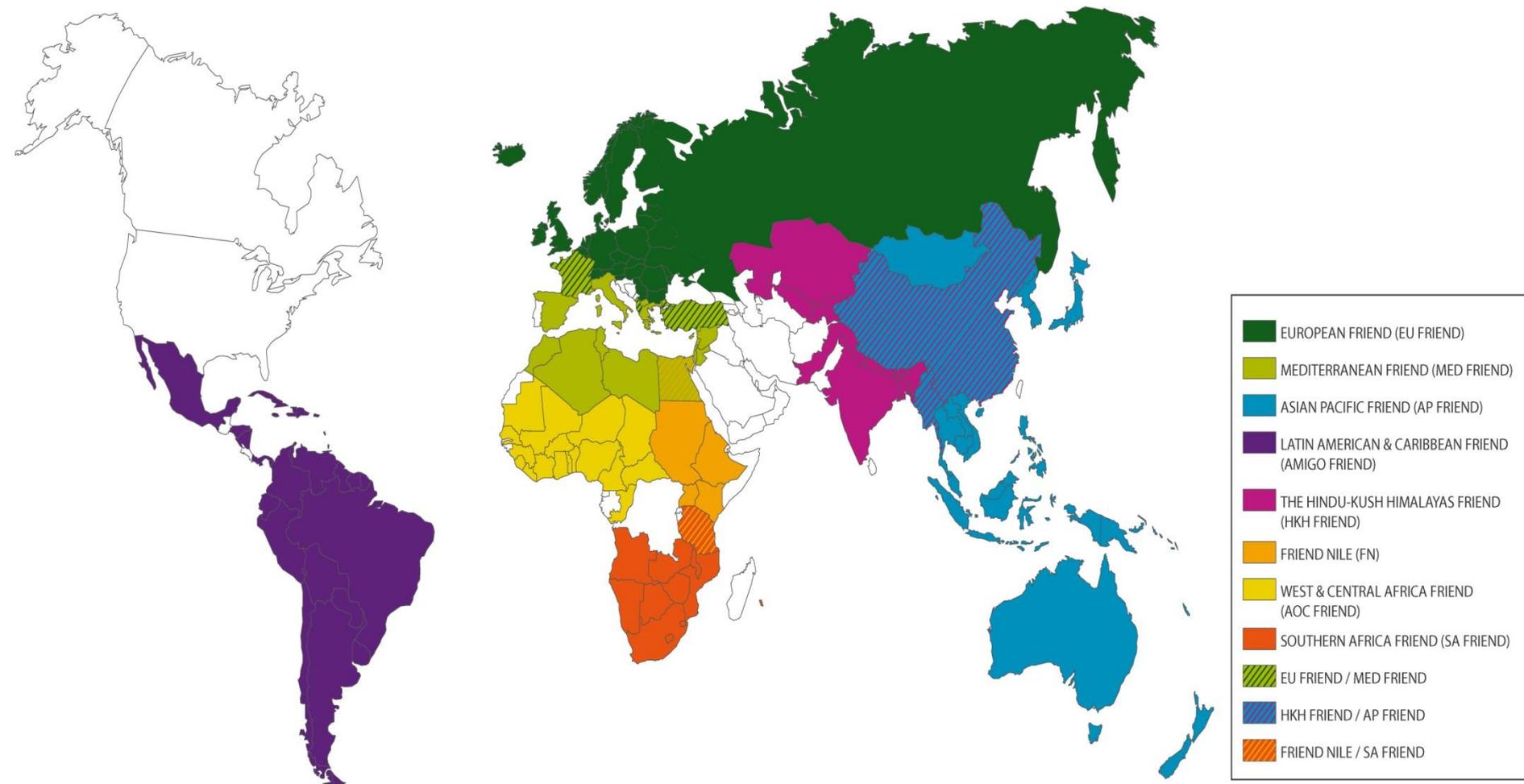
FRIEND Water Themes

Main research themes by regional FRIEND groups	EURO	MED	SA	AOC	NILE	HKH	AP	AMI-GO
Database	✓	✓	✓	✓	✓	✓	✓	✓
Low flows and droughts	✓	✓	✓	✓	✓	✓	✓	
Regime variability and large scale hydrological variation	✓	✓		✓		✓		✓
Change detection and attribution		✓						
Techniques for extreme rainfall & Flood runoff estimation	✓	✓	✓	✓	✓	✓	✓	
Rainfall runoff modeling	✓	✓	✓	✓	✓	✓	✓	
Physical processes of streamflow generation in small basins	✓							✓
Catchment hydrological and biogeochemical process in a changing environment	✓							
Karstic hydrogeology		✓						
Erosion and solid transport		✓	✓					
Water quality				✓		✓		
Snow and glaciers						✓		
Integrated catchment management		✓			✓	✓		
Human influences	✓						✓	✓
Information management						✓	✓	✓
Water resources assessment		✓	✓			✓	✓	✓
Coastal ecohydrology		✓						

Techniques:
- satellite data assimilation
- uncertainty representation

INTERNATIONAL HYDROLOGICAL PROGRAMME (IHP)
EIGHTH PHASE

STRATEGIC PLAN
IH-VIII 2014-2021

- Water-related Disasters and Hydrological Change
- Groundwater in a Changing Environment
- Addressing Water Scarcity and Quality
- Water and Human Settlements of the future
- Ecohydrology, Engineering Harmony for a Sustainable World
- Water Education, Key for Water Security

IHP's two cross-cutting programmes, FRIEND and HELP, interact with all IHP themes through their operational concepts. IHP's associated programmes cover projects and activities that contribute to the development and implementation of IHP themes, and are often interlinked with joint and interagency programme components.

FRIEND (Flow Regimes from International Experimental and Network Data)

An international research programme that helps to set up regional networks for analyzing hydrological data through the exchange of data, knowledge and techniques at the regional level.

Making a difference to flood preparedness: operational use of ensembles
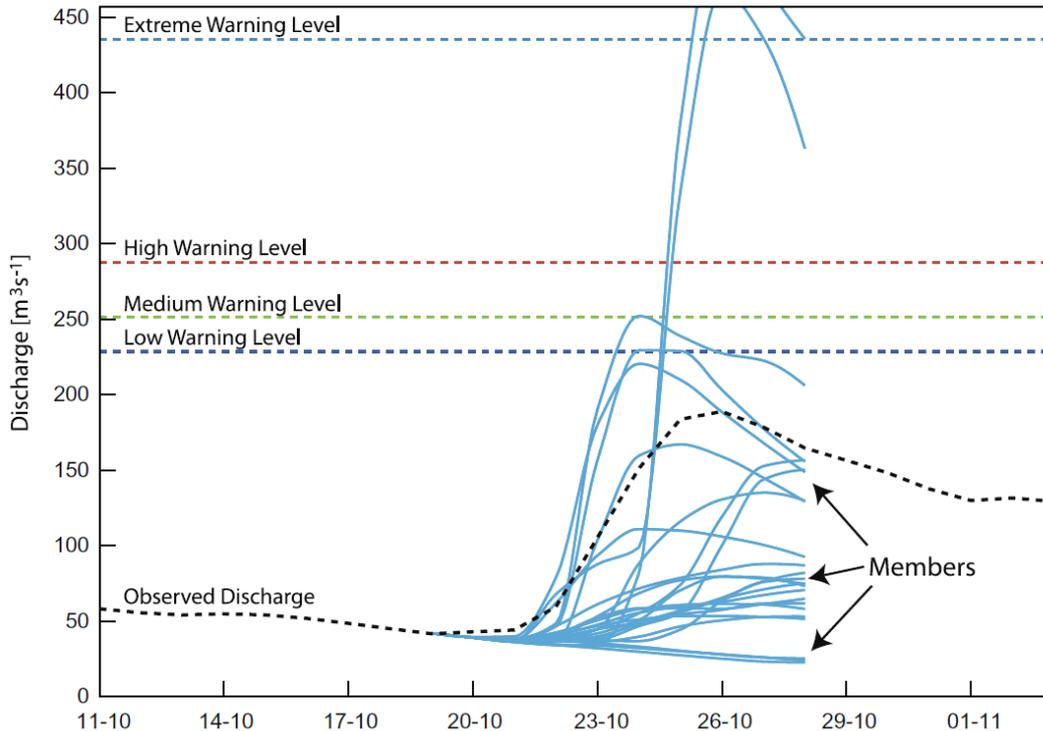
Cloke & Pappenberger (2009) Ensemble flood forecasting: a review. Journal of Hydrology. 375 613-626

Purley residents rescued as River Thames rises

8 January 2014 Last updated at 20:56 GMT

Residents living close to the Thames have been warned to prepare for a possible rise in water levels over the next 24 hours.

Some residents in Purley - one of the worst hit areas - have been marooned in their houses for over a week.

Stephens E & Cloke HL (2014) **Improving flood forecasts for better flood preparedness in the UK (and beyond)** The Geographical Journal doi: 10.1111/geoj.12103

Floods in Central Europe June 2013

- EFAS: pioneer of ensemble flood forecasts
- June 2013, EFAS warnings and alerts were issued for all major rivers in central Europe (Elbe, Danube, Rhine) up to 8 days in advance

Pappenberger et al (2011) The impact of weather forecast improvements on large scale hydrology: analysing a decade of forecasts. Hydrological Processes. 25: 7

Hydrology - Floods in Central Europe June 2013

The image shows the EFAS multi-model streamflow prediction for Passau, Germany. Forecast date is 30/05/2013 12 UTC. The colours indicate the different alert levels.

The box plots show the ECMWF EPS, the red line the ECMWF Highres, the black line the DWD COSMO.

The forecasts gives a clear indication of a flooding in 3-4 days
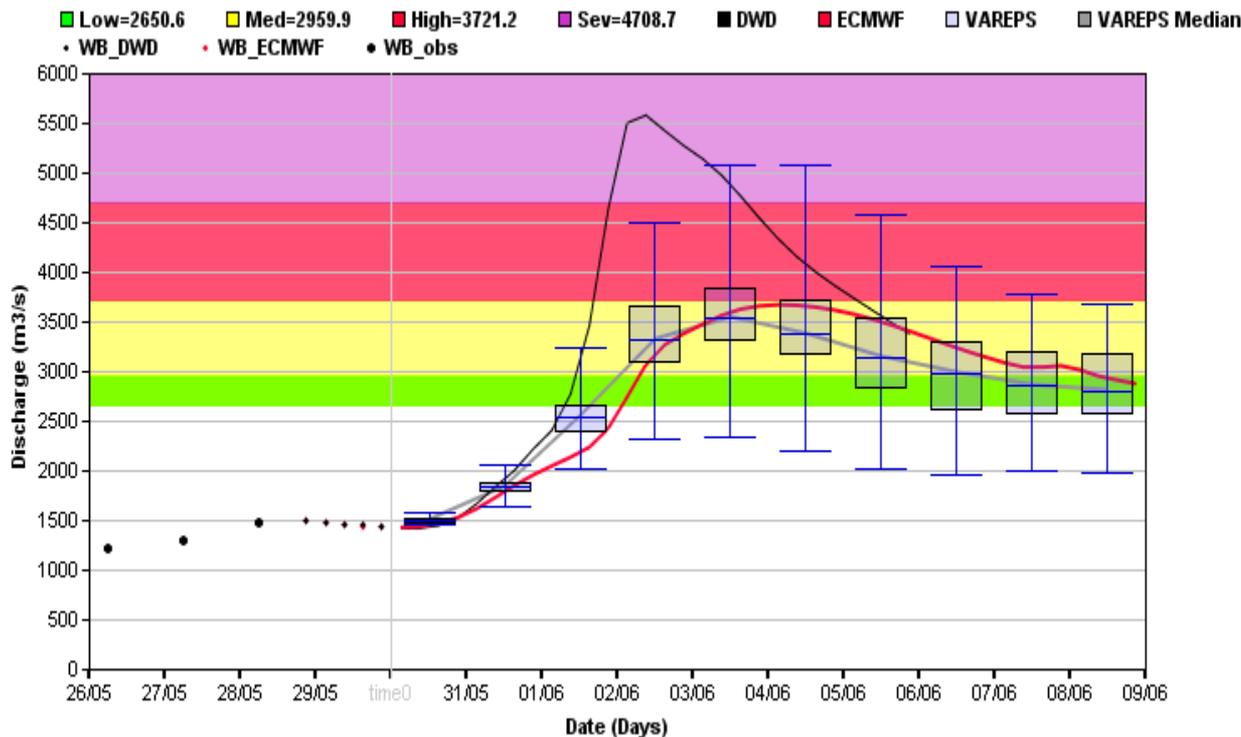
Somerset Levels, February 2014

This winter (2013/14) coastal storms and an unprecedented amount of rainfall led to significant and widespread flooding across the southern UK.
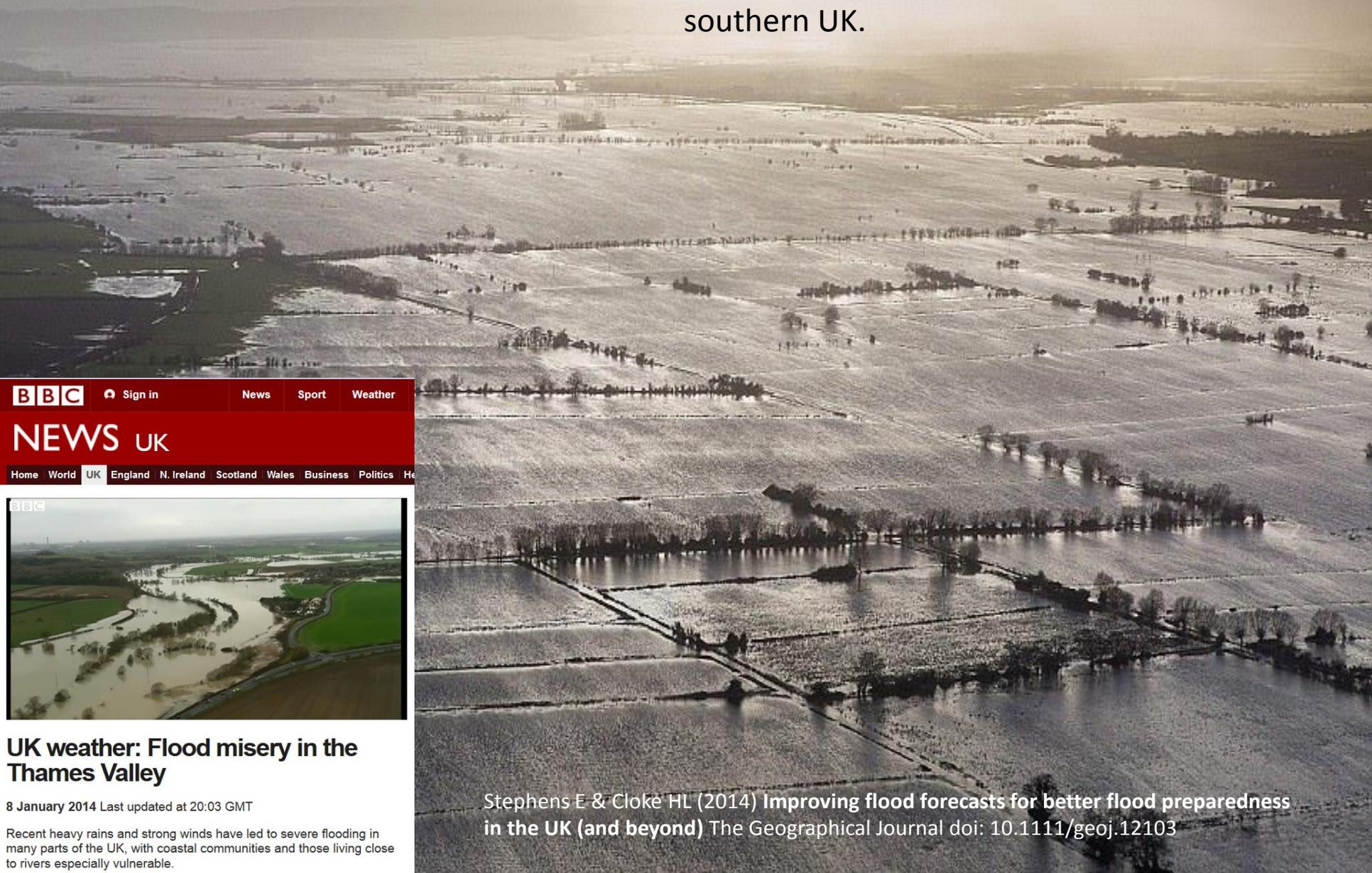
UK weather: Flood misery in the Thames Valley

8 January 2014 Last updated at 20:03 GMT

Recent heavy rains and strong winds have led to severe flooding in many parts of the UK, with coastal communities and those living close to rivers especially vulnerable.

Stephens E & Cloke HL (2014) **Improving flood forecasts for better flood preparedness in the UK (and beyond)** The Geographical Journal doi: 10.1111/geoj.12103

Ensemble surge elevation for North Shields (NSHL 0032)

Ensemble surge elevation for Lowestoft (LOFT 0024)

Ensemble surge elevation for Dover (DVER 0012)

hours from 18Z on 1/12/2013 – solid/dotted black: alert minus harmonic/model tide
Residuals are coloured as in key below:

UK Winter Floods 2013/2014

Some ensemble systems implemented. Others in testing.

2 scenarios shown in the ensemble surge forecasts;

- Most likely = just crossing alert thresholds.

- 'Reasonable worst case' = significant surge.

- 7/8 days before event – early discussions with civil protection.

Dale et al (2013) **Applying probabilistic flood forecasting in flood incident management.** Technical Report. Project SC090032. DEFRA/Environment Agency joint Flood and Coastal Erosion Risk Management Research and Development Programme.

Stephens & Cloke (2014) **Improving flood forecasts for better flood preparedness in the UK (and beyond)** The Geographical Journal doi: 10.1111/geoj.12103
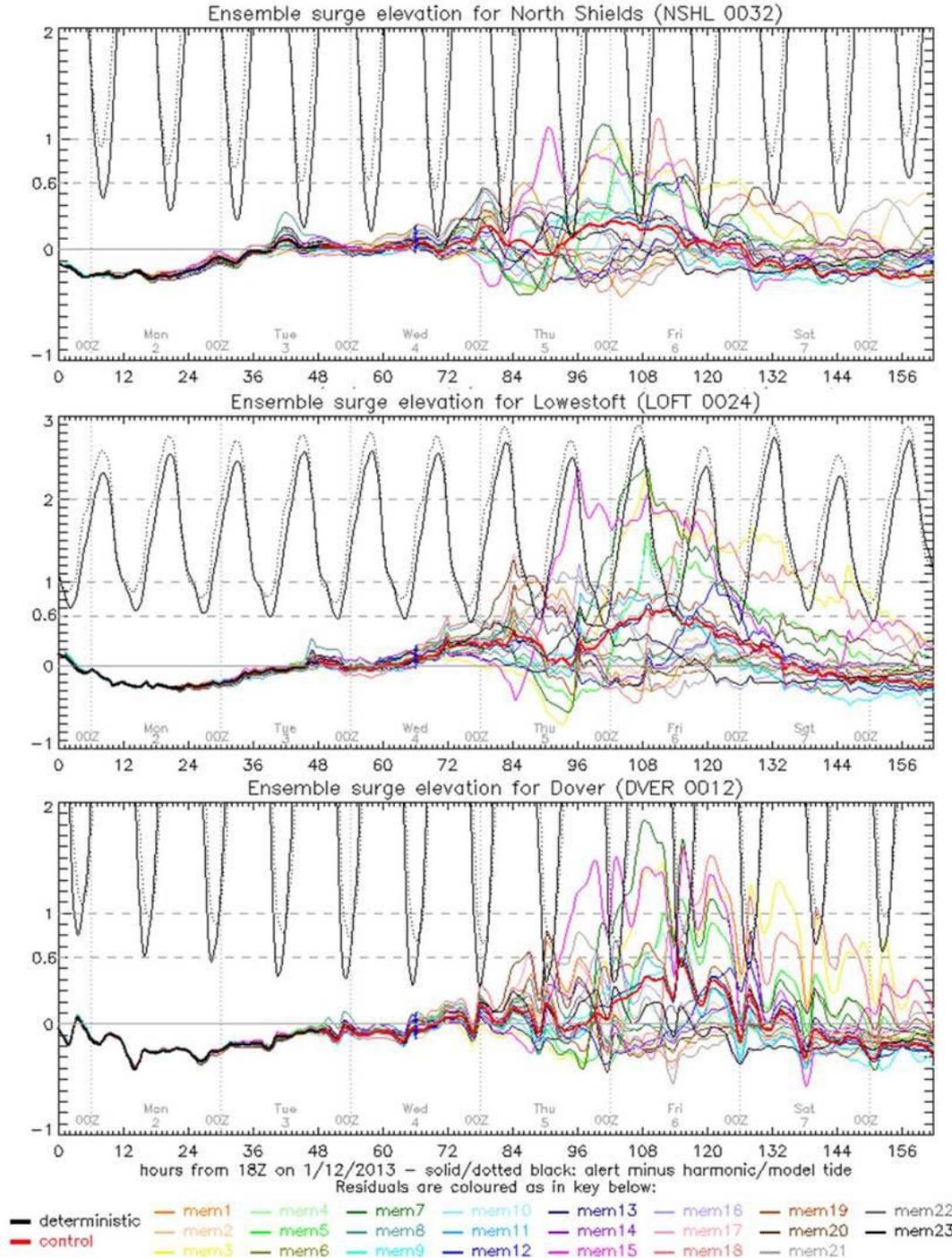
Flood Warnings – 6 Dec 14:00

71 severe flood warnings

Over 160,000 warning messages sent to homes and businesses

43000 flood warnings issued in 1 hour (6 Dec)

Environment Agency

Ensemble forecasts and warnings can only reach their full potential if they are understood and acted upon by the person receiving

Coproduction of warning systems

Demeritt D, Nobert S, Cloke HL, Pappenberger F (2013) **The European Flood Alert System (EFAS) and the communication, perception and use of ensemble predictions for operational flood risk management.** Hydrological Processes, 27 (1). pp. 147-157.

Wetterhall F, Pappenberger F, Cloke HL et al + 30 authors (2013) **Forecasters priorities for improving probabilistic flood forecasts**, Hydrology and Earth System Sciences, 17, 4389-4399

# Resolution v Representation of uncertainty
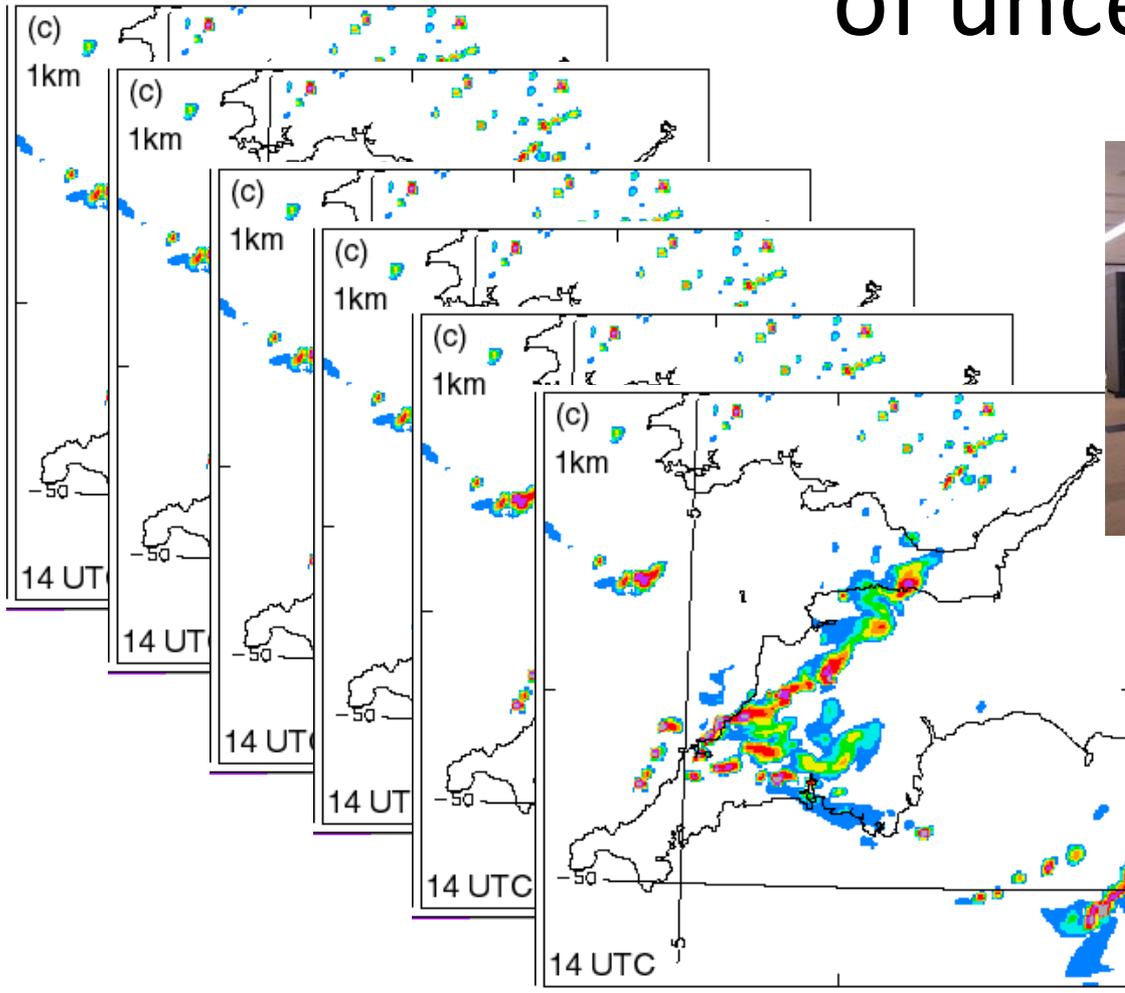
Computational cost

Beven, K. J. and H. L. Cloke (2012), Comment on "Hyperresolution global land surface modeling: Meeting a grand challenge for monitoring Earth's terrestrial water" by Eric F. Wood et al., *Water Resour. Res.*, 48, W01801, doi:10.1029/2011WR010982.

Beven et al (in press) Hyperresolution information and hyperresolution ignorance in modelling the hydrology of the land surface. Science China

Assimilating remotely sensed soil moisture into a hydrological model

Detection of topographic signal in high resolution ASAR data.
Improving initial conditions for hydrological and land surface modelling of FFIR events.
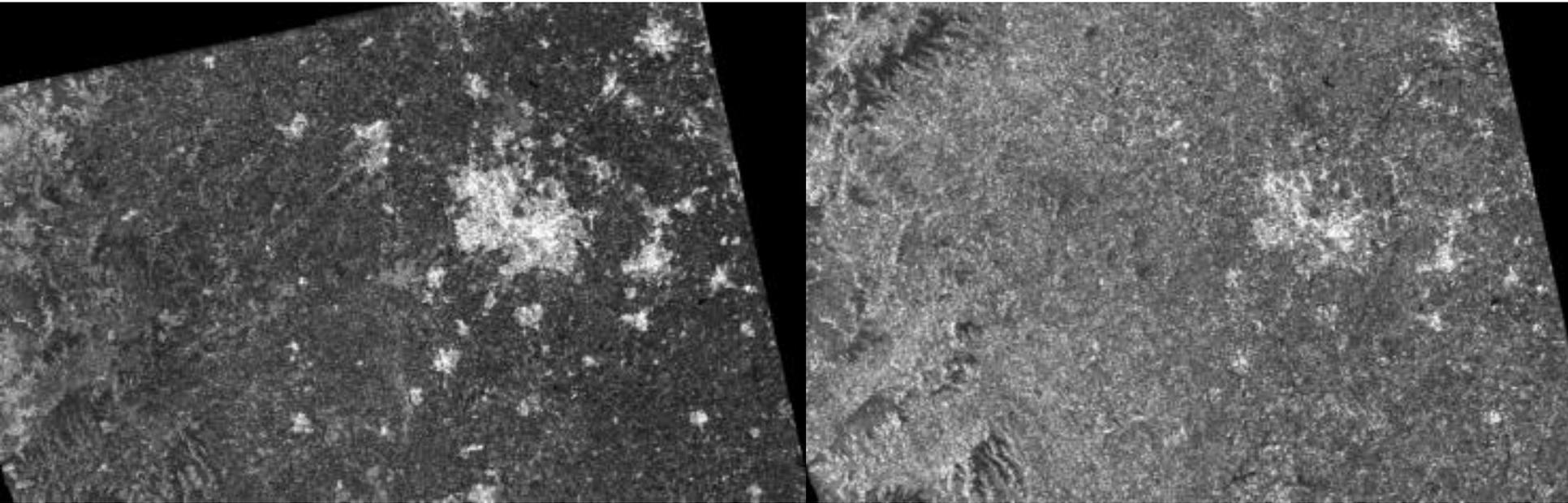
Backscatter over Severn/Avon for (left) dry, (right) wet period (brighter soil = wetter).

Mason et al (in review) Evidence of a topographic signal in surface soil moisture derived from ENVISAT ASAR Wide Swath data. International Journal of Applied Earth Observation and Geoinformation

Earth Observation based flood forecasting:
Assimilating remotely sensed flood water levels
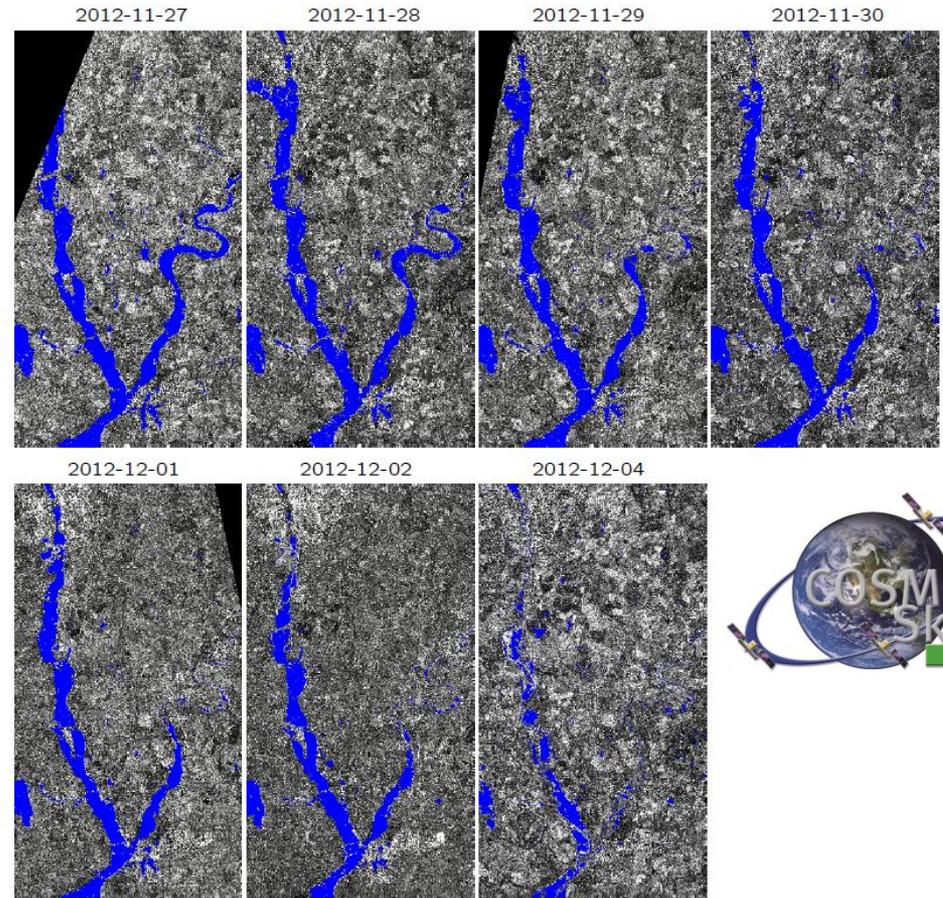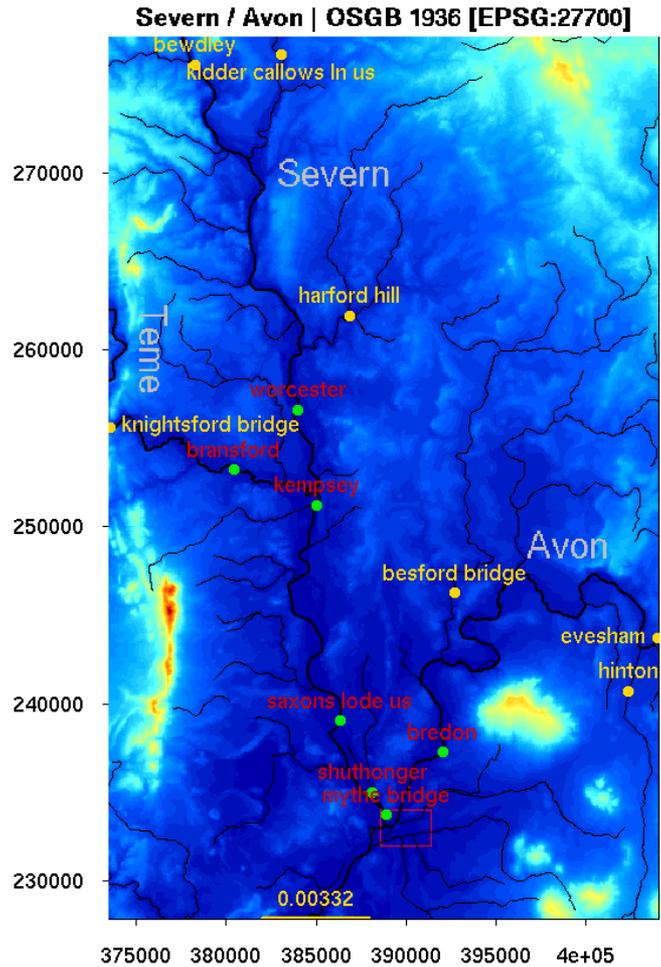
evaluating the assimilation of WLOs obtained from a sequence of real SAR overpasses (the X-band COSMO-Skymed constellation) with Ensemble Transfer Kalman Filter

Garcia-Pintado et al (in review) **Satellite-supported flood forecasts in river networks**. Journal of Hydrology

Mining of archives.

Edmonton Daily Bulletin.
MORNING EDITION

RIVER AT 3 A.M. SHOWED NO SIGNS OF RECEDING

HEIGHT THIS MORNING GREATLY EXCEEDS FAMOUS FLOOD OF 1898

Property Damage Likely to Reach Three-Quarters of Million Dollars

Money, Provisions And Clothing Needed at Once

GREAT BATTLE IS NOW RAGING ON RIVER SAN

WORK OF RELIEF WENT ON ALL DAY WITHOUT STOP

Tens of Thousands Watched Flood From Vantage Points on Hillside

MEN AT POWER PLANT DID HERCULEAN WORK ALL DAY TO KEEP PLANT RUNNING

RECRUITING FOR 66th BEGINS TODAY IN CITY

Improving our evidence base:

Joint archive of flood events and impacts
Mining newspaper and administrative records

Public-sourced evidence/social media

Dynamic flood levels in Morpeth reconstructed from public-sourced evidence

Flood depth (m)
0 - 0.5
0.5 - 1
1 - 1.5
1.5 - 2

5pm, 6 Sept 2008

Hayley Fowler, Stephen Blenkinsop, Geoff Parkin & David Archer: Newcastle University

Hayley Fowler, Stephen Blenkinsop & David Archer: Newcastle University
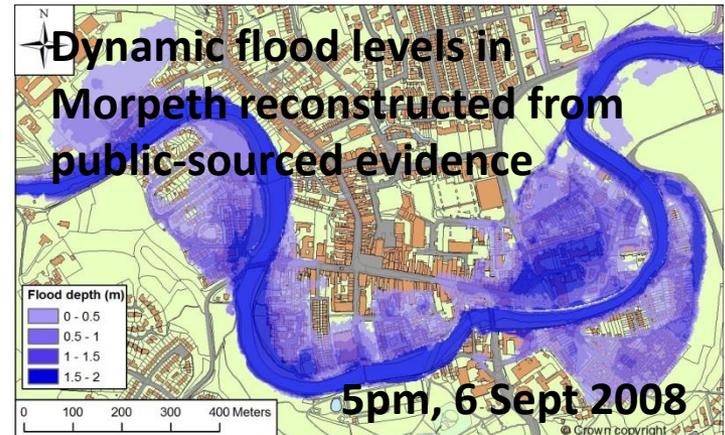
What will happen in the future?

You can apply RCM output in climate studies, but you should be very careful in interpreting the output.
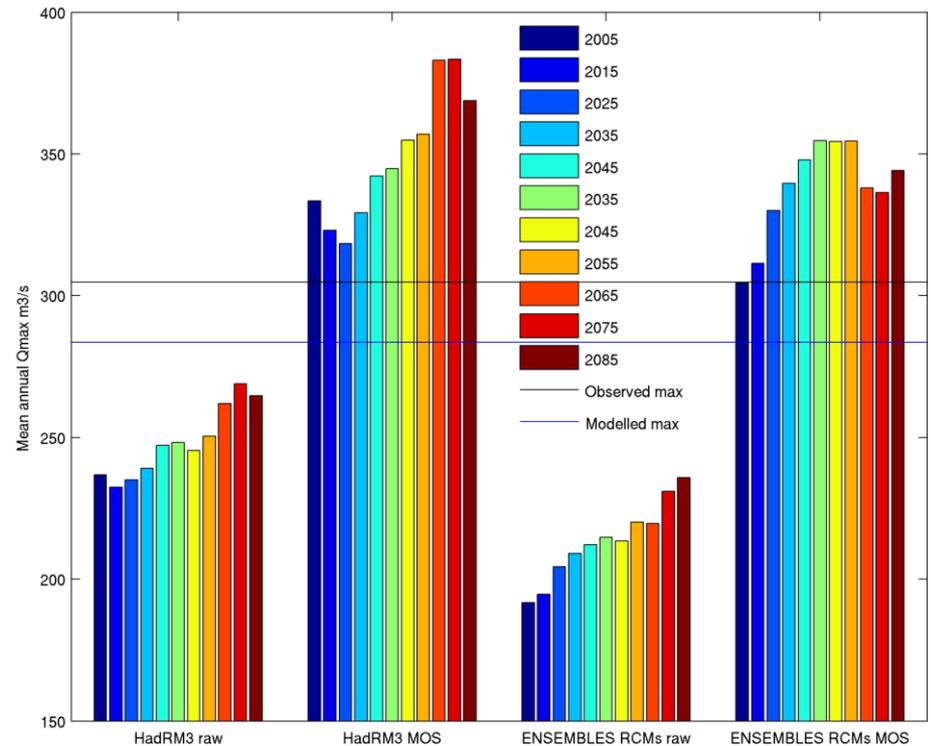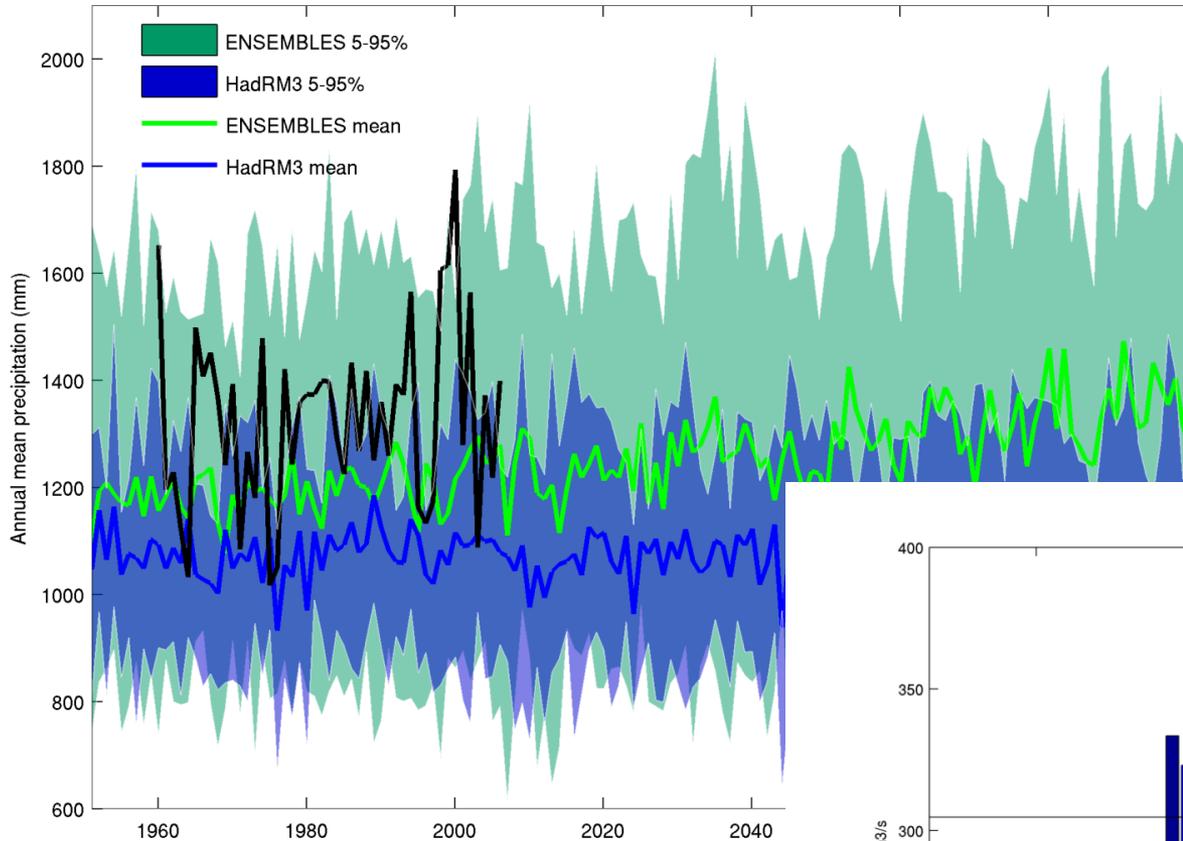
Cloke et al (2013) **Modelling climate impact on floods with ensemble climate projections**. QJRMS 139

Thankyou for listening

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University of **Reading**