Changing water cycle

Rivers in the sky: can they help characterise future floods in response to climate change?

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- AR detection in atmospheric reanalyses and links with British winter floods
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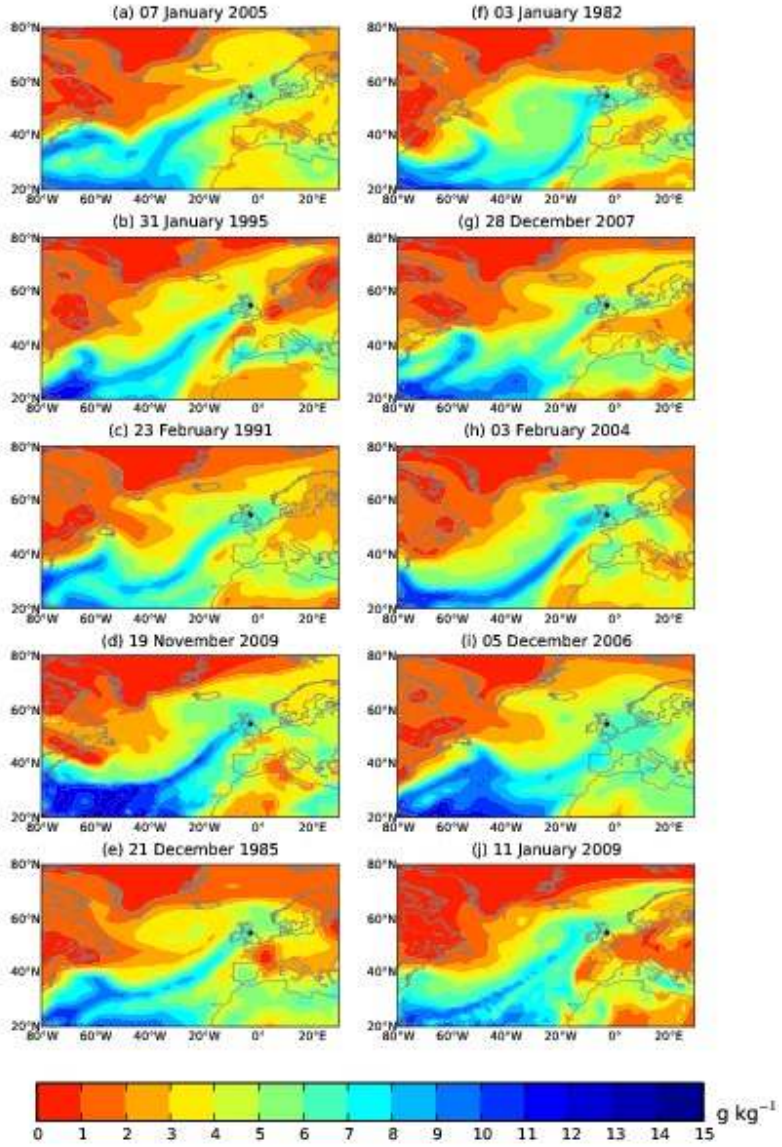
Review – Atmospheric Rivers (ARs)

- ARs are regions of enhanced moisture transport from the subtropics to the mid-latitudes.
- Located within warm sector of extra-tropical cyclones.
- Most AR-flood research undertaken in western North America.

Review: Top 10 winter floods in Eden



- Persistent ARs located over basin in these floods.
- ARs have consistent location and orientation.

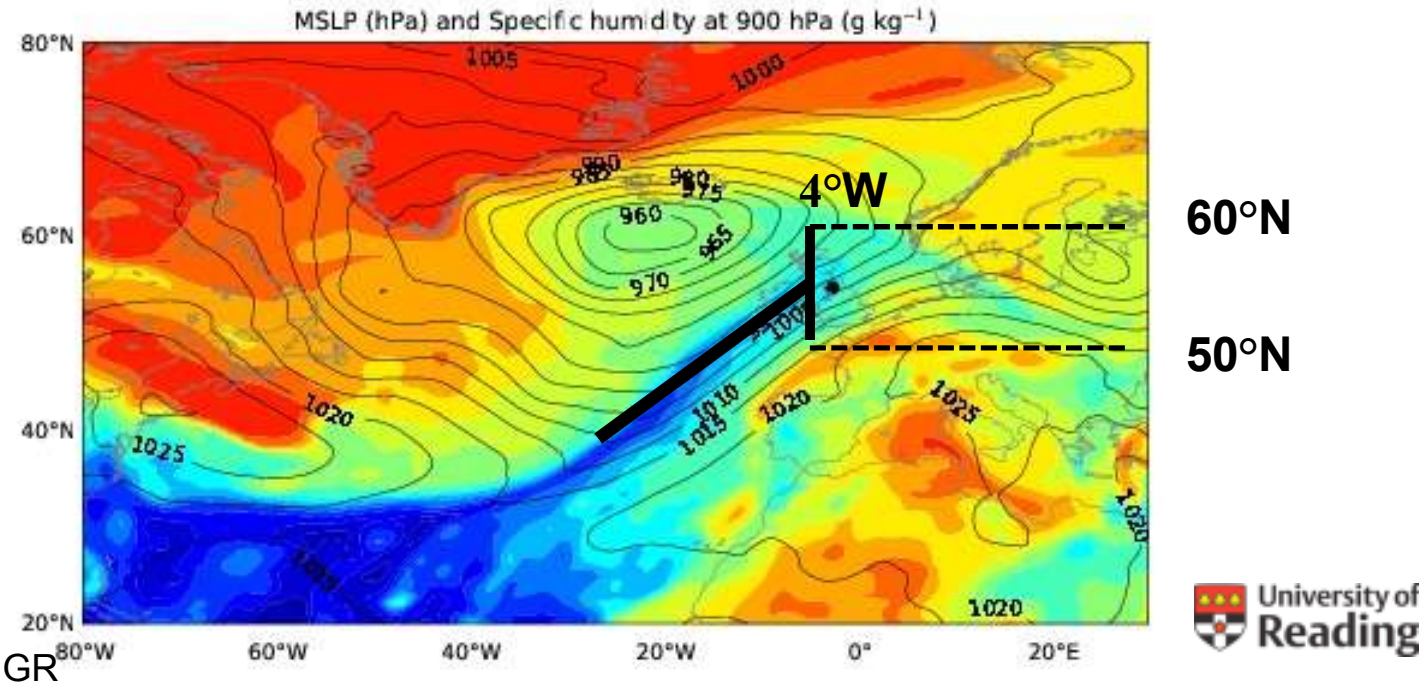
Data source: 20th Century / ECMWF ERA-Interim reanalyses.

Lavers et al., 2011 GRL

ARs and British winter floods – from an *atmospheric* stand-point

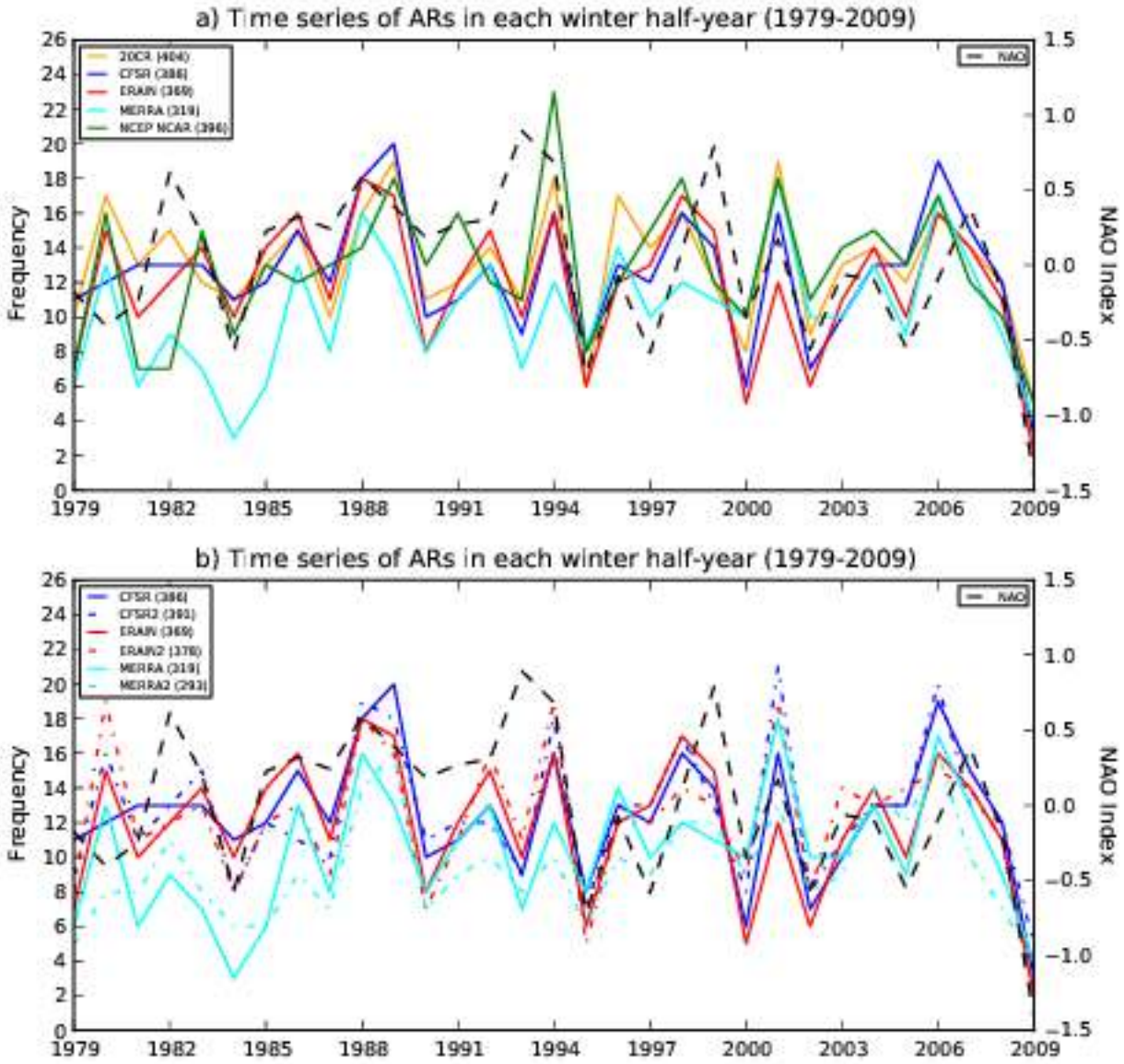
AR screening in atmospheric reanalyses

- At 900 hPa search between 50°N and 60°N (at 4°W) for q > 5 g/kg and uv > 12.5 m/s; these criteria must exist across North Atlantic (for 20° longitude).
- If these conditions exist for 3 time steps over a *specific* region then a persistent AR is identified (only 4.5° latitude movement).
- Applied to the winter half-year (Oct-Mar) over 1979–2009 in five reanalyses.



Lavers et al., submitted JGR

AR totals in each winter half-year

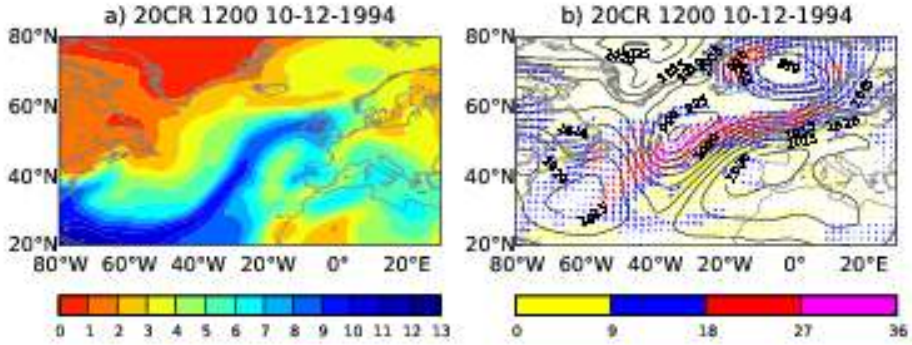


Twentieth Century 404
CFSR 386
ERA-Interim 369
MERRA 319
NCEP-NCAR 396

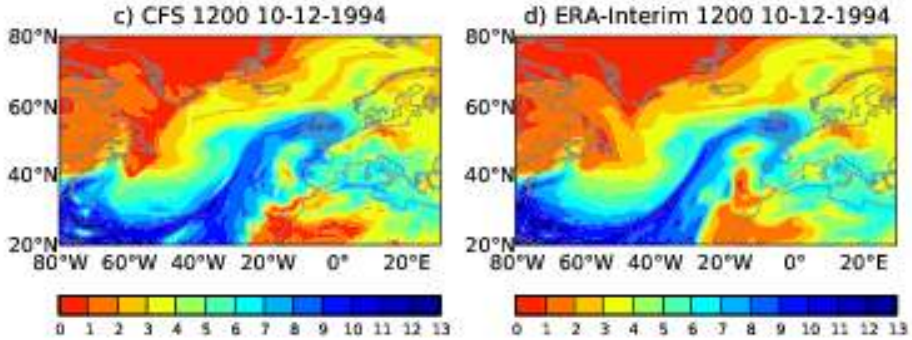
Positive NAO (hence stronger westerly winds over the N. Atlantic) tends to be associated with more ARs.

An AR example

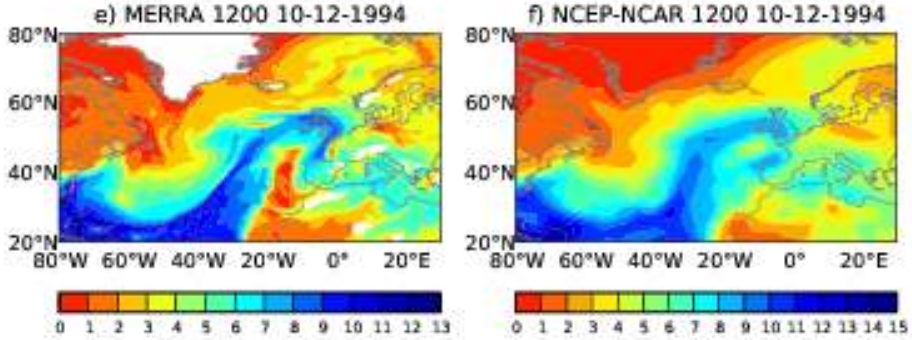
AR behind largest flood in Ayr river basin (Scotland).



Winds at 900 hPa.



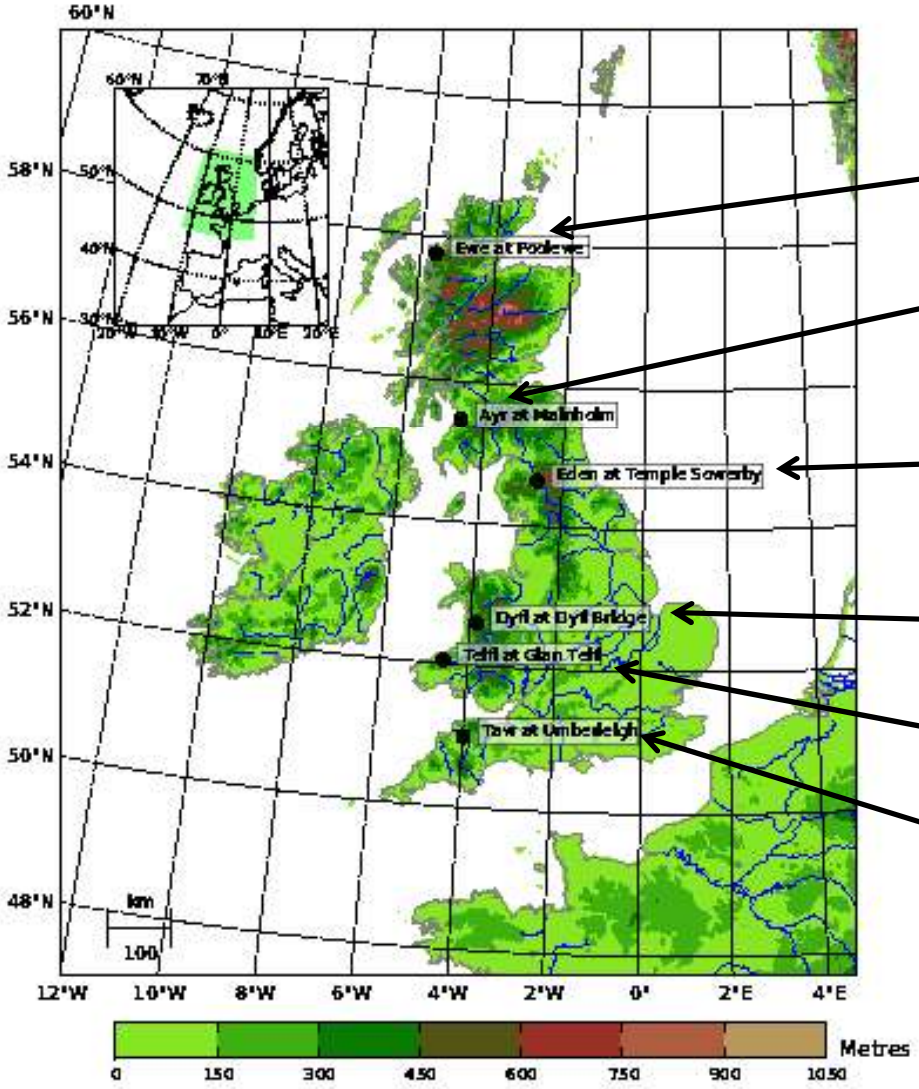
Specific humidity at 900 hPa.



Lavers et al., submitted JGR

Basins for AR-flood link assessment

BFI = Base Flow Index



Ewe at Poolewe; BFI=0.64, 441.1km^2

Ayr at Mainholm; BFI=0.29, 574km^2

Eden at Temple Sowerby; BFI=0.37, 616.4km^2

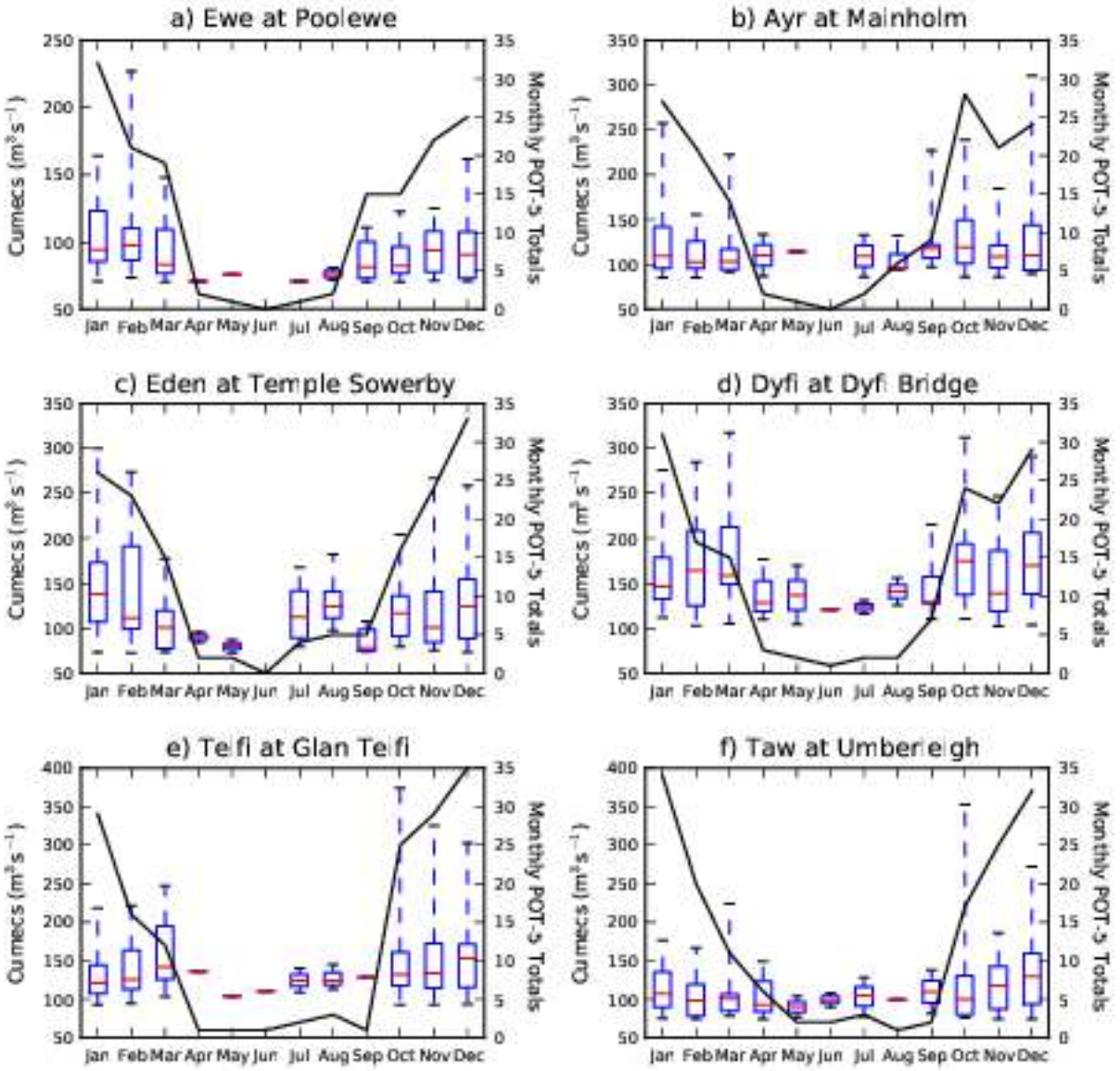
Dyfi at Dyfi Bridge; BFI=0.39, 471.3km^2

Teifi at Glan Teifi; BFI=0.54, 893.6km^2

Taw at Umberleigh; BFI=0.43, 826.2km^2

Lavers et al., submitted JGR

Seasonality of floods (POT-5)



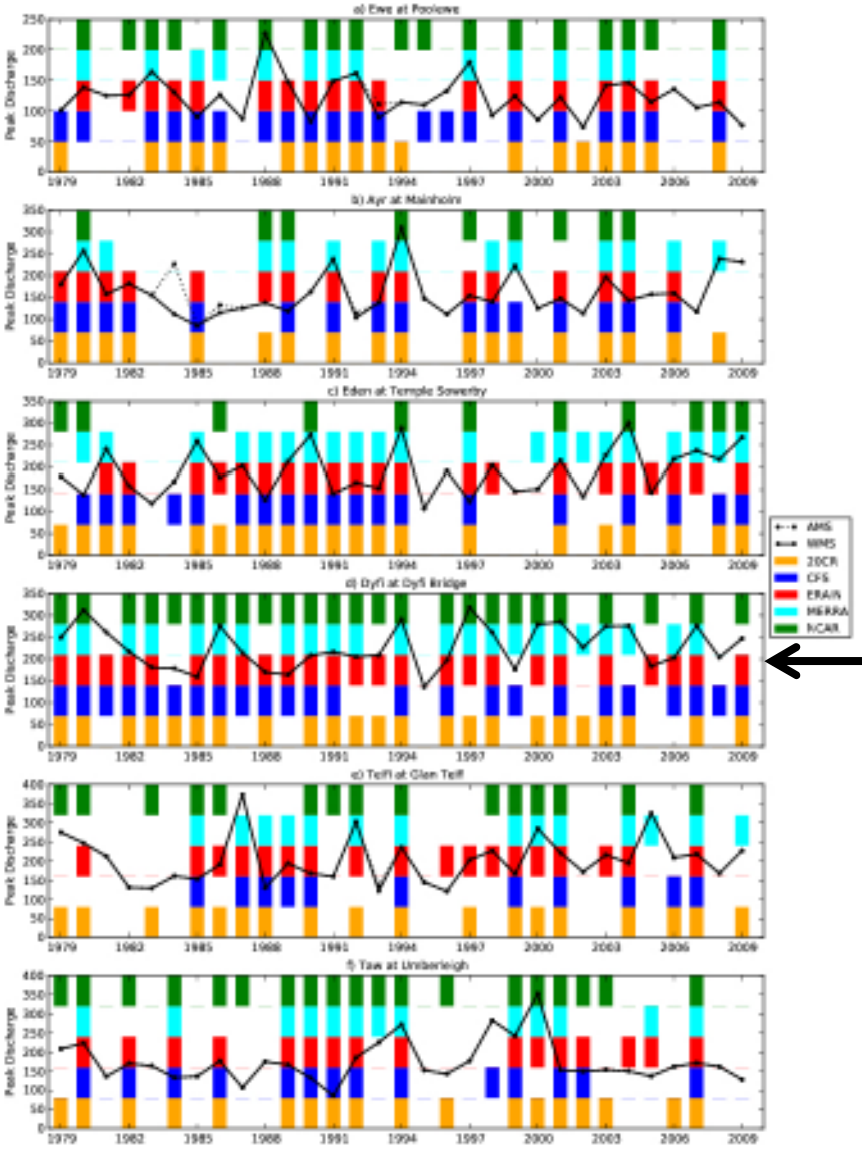
Peaks-over-Threshold (POT) with on average 5 floods per year (1979-2010).

The largest and the highest number of floods occur in winter.

ARs and AMS / WMS floods

1). Extract peak mean daily river flow in winter half-year (WMS) and water year (AMS). **AMS and WMS are generally equivalent.**

2). Persistent AR must start 2 days before or on day of flood.



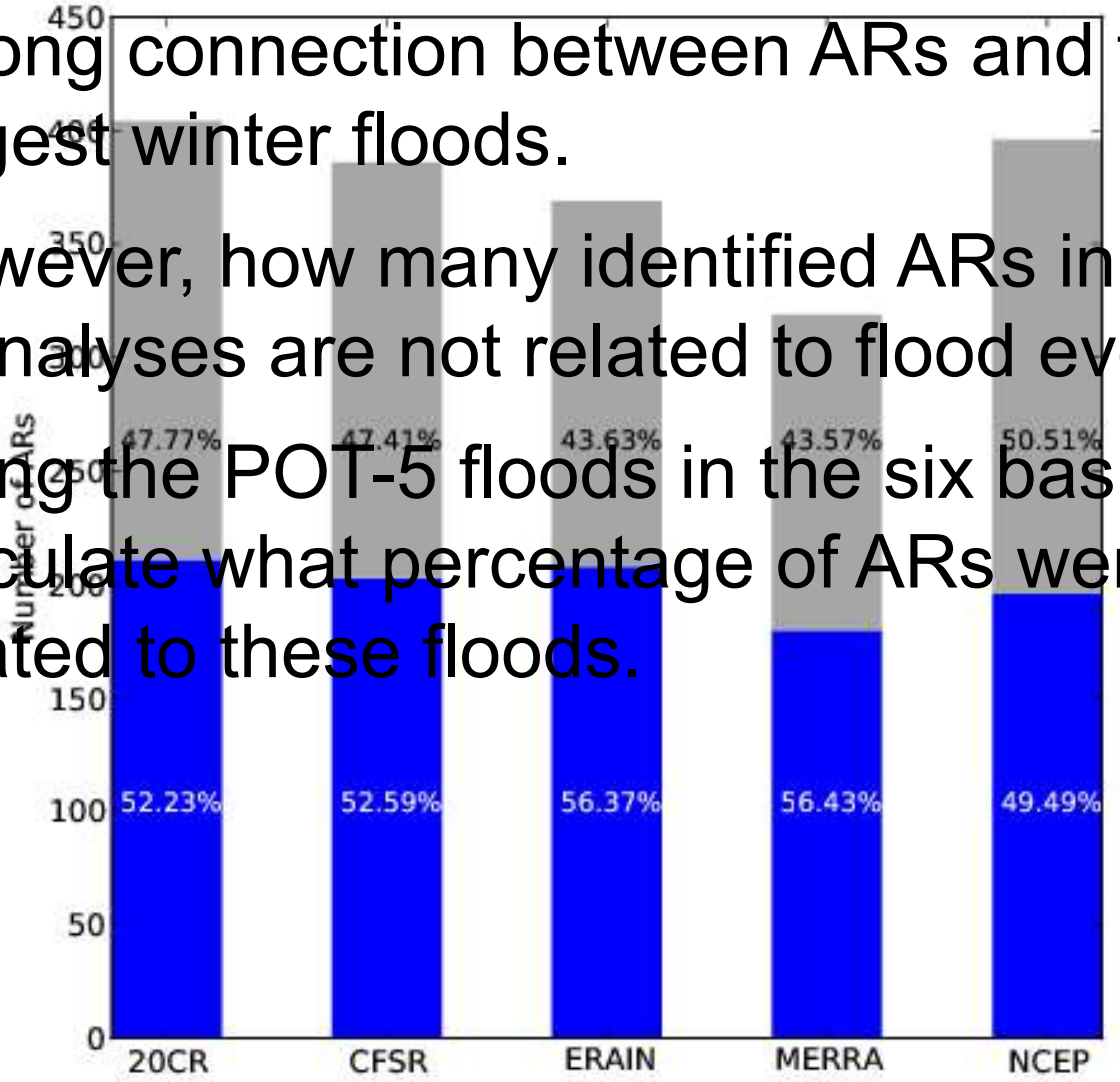
NCEP-NCAR
MERRA
ERA-Interim
CFSR
Twentieth Century

e.g., Dyfi has 30/31 years when an AR is linked to a flood.

Lavers et al., submitted JGR

AR-flood "hit rate"

- Strong connection between ARs and the largest winter floods.
- However, how many identified ARs in the reanalyses are not related to flood events?
- Using the POT-5 floods in the six basins, we calculate what percentage of ARs were related to these floods.



Lavers et al., submitted JGR

Main Results

- Algorithm detects persistent ARs.
- Good AR agreement between reanalyses.
- Winter floods are the largest.
- Strong connection between identified ARs and winter floods in six river basins; in Dyfi basin 30/31 years have AR-flood link.
- Up to 56 % of ARs related to POT-5 floods.

ARs in CMIP5 / UCL

- Starting '*efficient*' retrieval of CMIP5.
- *As algorithm has a strong AR-flood link, there is confidence that changes in ARs in CMIP5 could infer future changes to British winter floods.*
- AR algorithm applied to 20CR (reanalysis) from Jan1960-Dec2010 (at 2°W). AR occurrence/time step/humidity values/wind values have been given to UCL.
- Note that convective rainfall is not the focus of the algorithm.

Drought in SE England

- Multi-year events (two consecutive dry winters).
- Lambourn basin: linear regression suggests significant lags between rainfall and river discharge for 7 months.
- Possible drought predictors (e.g. North Atlantic sea surface temperature)
- What's the most appropriate statistical approach to link climate over longer time scales with drought / low groundwater?

Future work

- Apply AR algorithm to CMIP5 models to evaluate AR changes in the future.
- Investigate another AR algorithm based on integrated vapour transport (throughout whole atmosphere).
- Preliminary drought investigation.

Thank you for listening

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