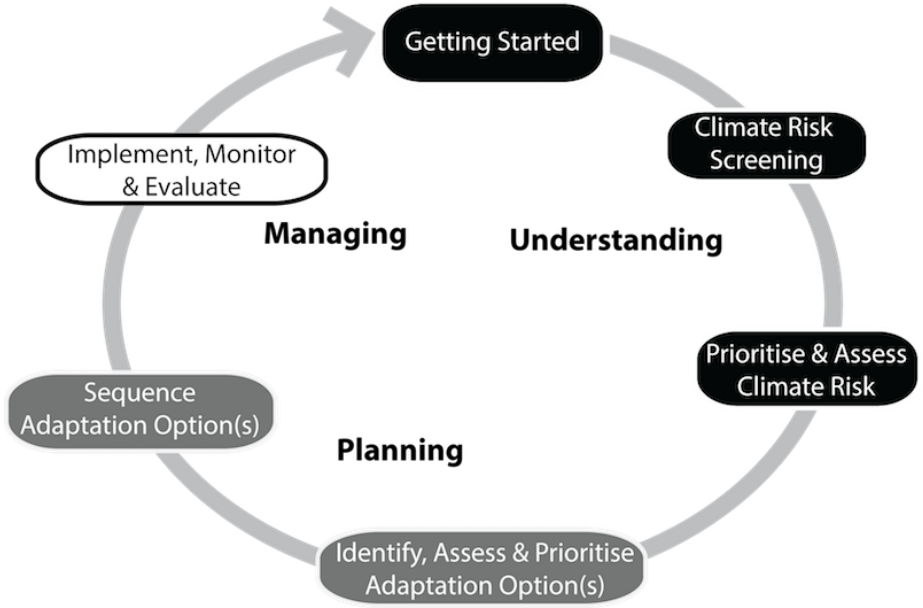
Climate Change – Adapting to changing flows

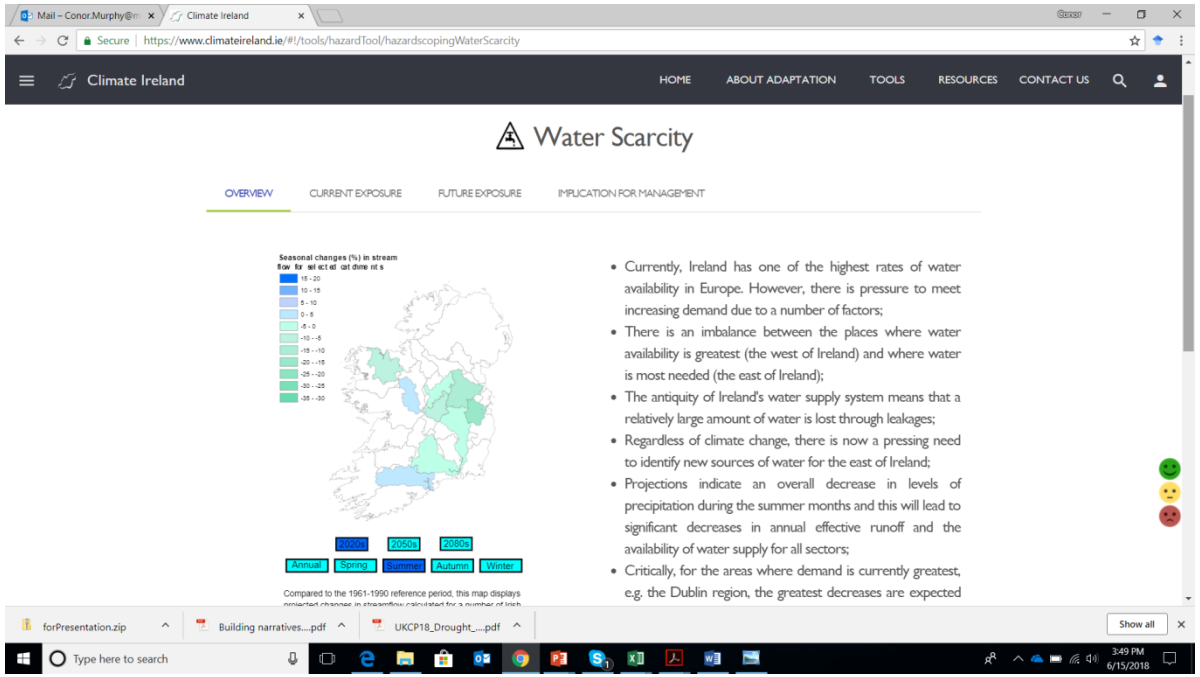
Dr. Conor Murphy,
Irish Climate Analysis and Research UnitS (ICARUS)
Department of Geography, Maynooth University
Conor.murphy@mu.ie

EPA National Water Event
Pathways to Progress
20th June 2018
Galway Bay Hotel

Information for decision making

- Good decisions depend on the types, diversity and quality of information used to inform adaptation
- We risk building fragility into adaptation as not accounting for uncertainty plus short observational records.
- Climate information is required for;
  - assessing the current adaptation baseline (which involves identifying extremes in the historical record and examining vulnerabilities/impacts from these)
  - assessing future climate risks
  - identifying, assessing and prioritising adaptation options.





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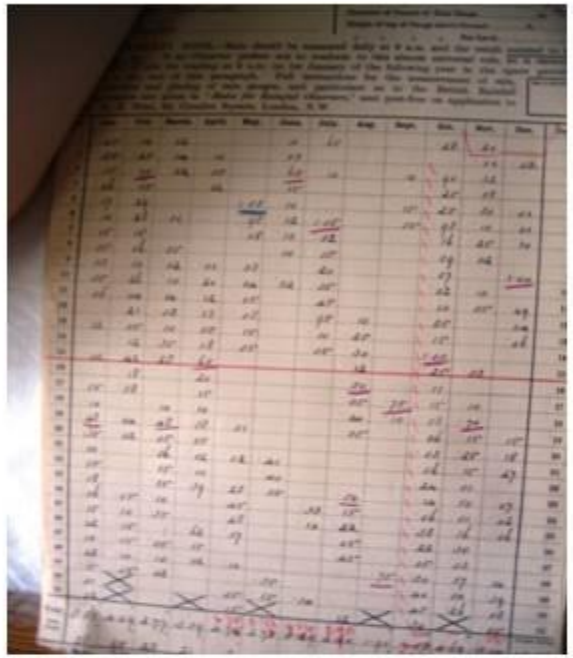
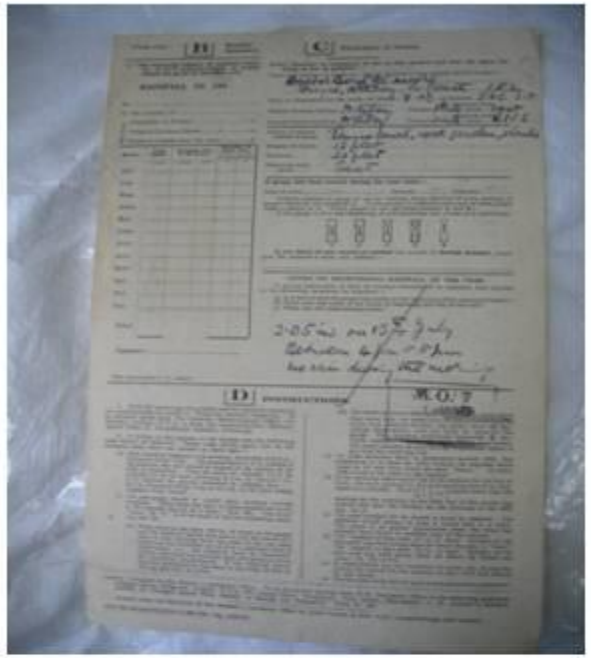
Historical Data for Decision Making

- Long term quality assured rainfall series
- Reference Hydrometric Networks
- River flow reconstructions
- Contextualising extremes
- Understanding variability and change at inter-annual to decadal timescales
- Stress testing system vulnerability

Archived hand written precipitation records held at Met Eireann





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Island of Ireland Precipitation Network

- Homogenisation Software in R (HOMER)
- 1850 to present
- Monthly
- Potential for daily data

http://www.met.ie/news/display.asp?ID=337

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Noone, S., Murphy, C., Coll, J., Matthews, T., Wilby, R.L., Walsh, S. (2015) Homogenisation and analysis of an expanded long-term monthly rainfall network for the Island of Ireland (1850-2010). ***International Journal of Climatology,*** *36*(8), 2837-2853

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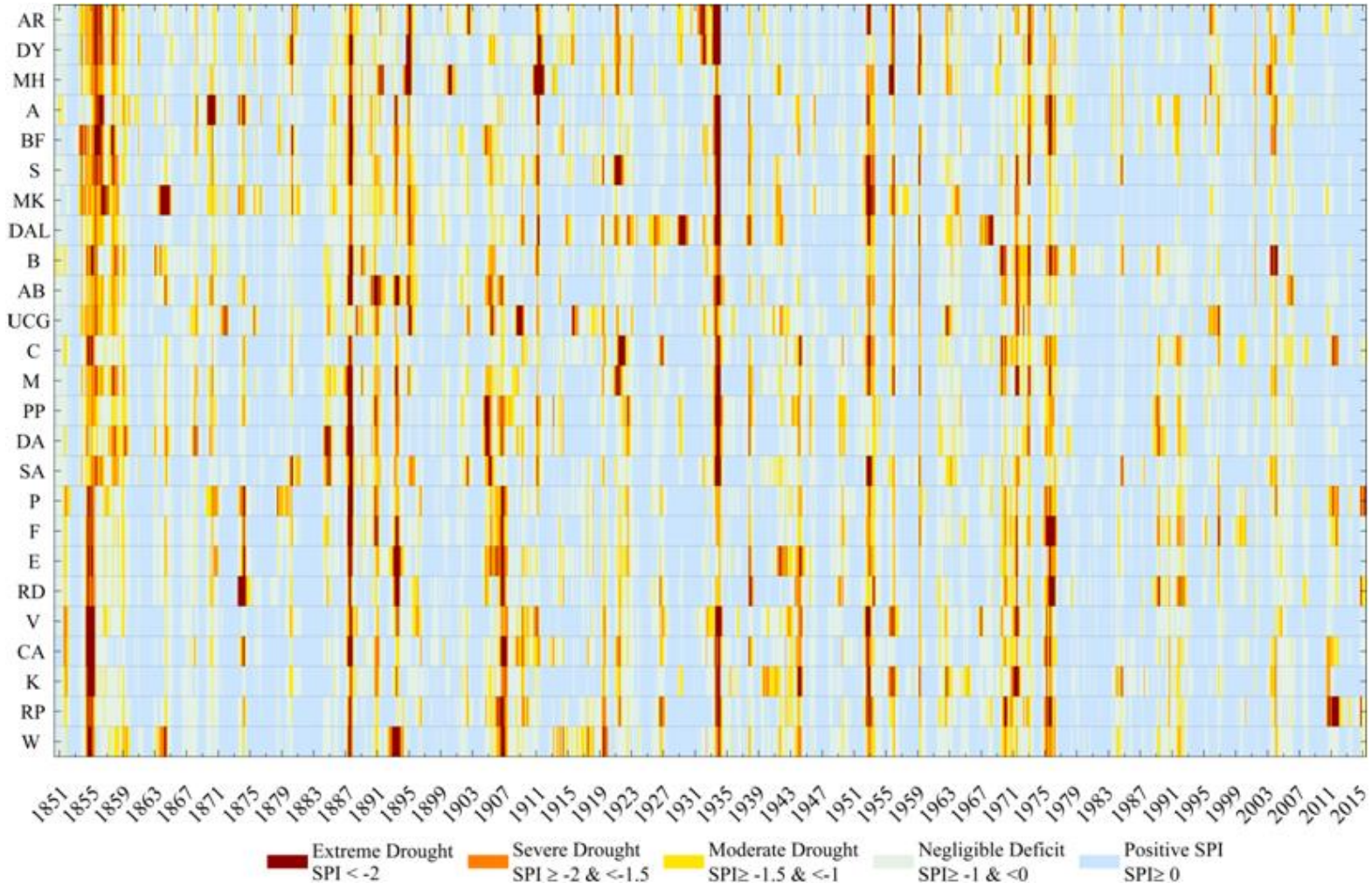
DNA of Irish Drought



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Noone, S, Broderick, C., Duffy, C., Matthews, T., Wilby, R.L., Murphy, C. 2016. A 250-year drought catalogue for the Island of Ireland (1765-2015**).** ***International Journal of Climatology****, 37*(S1), pp.239-254

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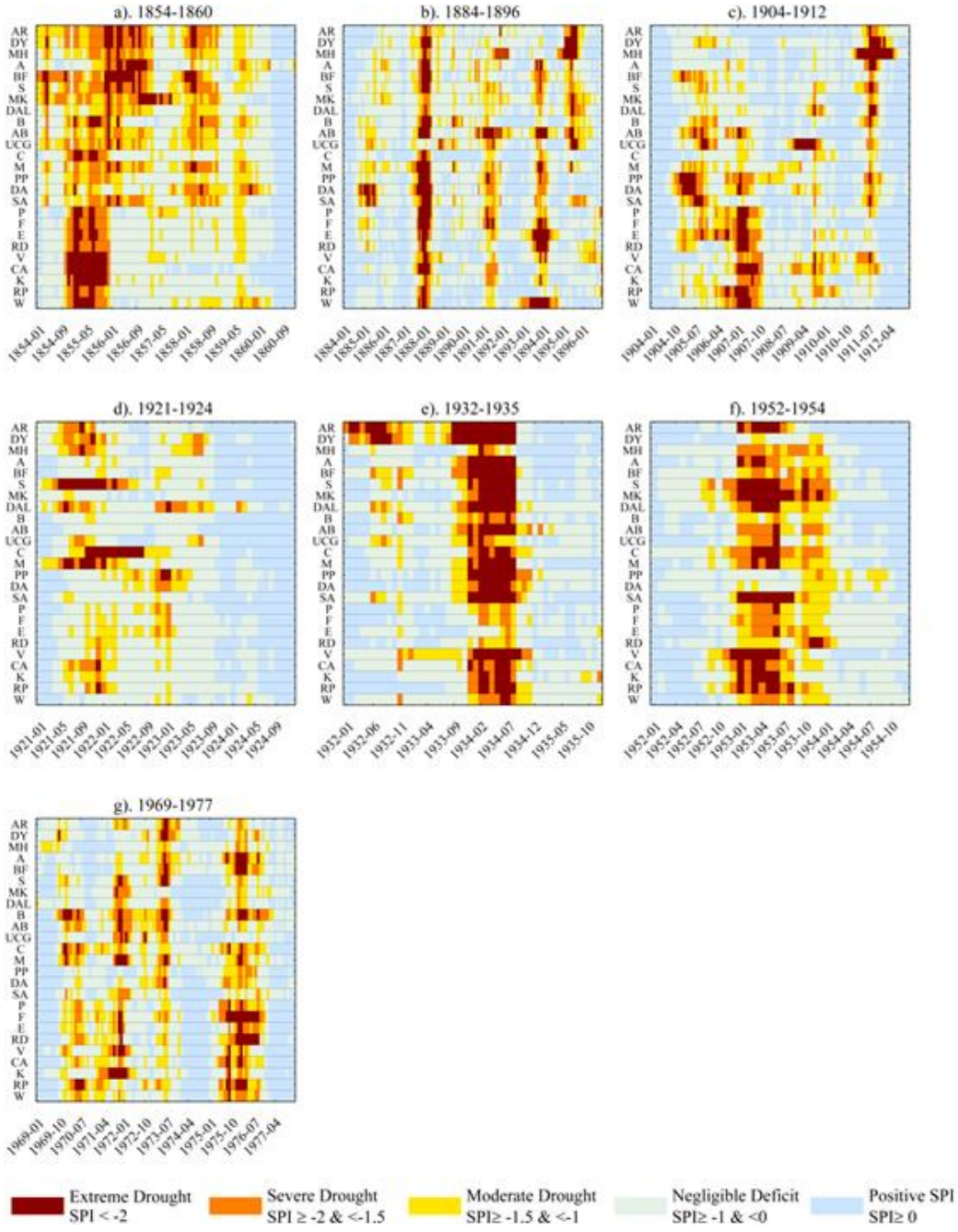

- Complexity of drought signatures
- Integration into planning
- Assessment of impacts

Noone, S, Broderick, C., Duffy, C., Matthews, T., Wilby, R.L., Murphy, C. 2016. A 250-year drought catalogue for the Island of Ireland (1765-2015)**.** ***International Journal of Climatology****, 37*(S1), pp.239-254

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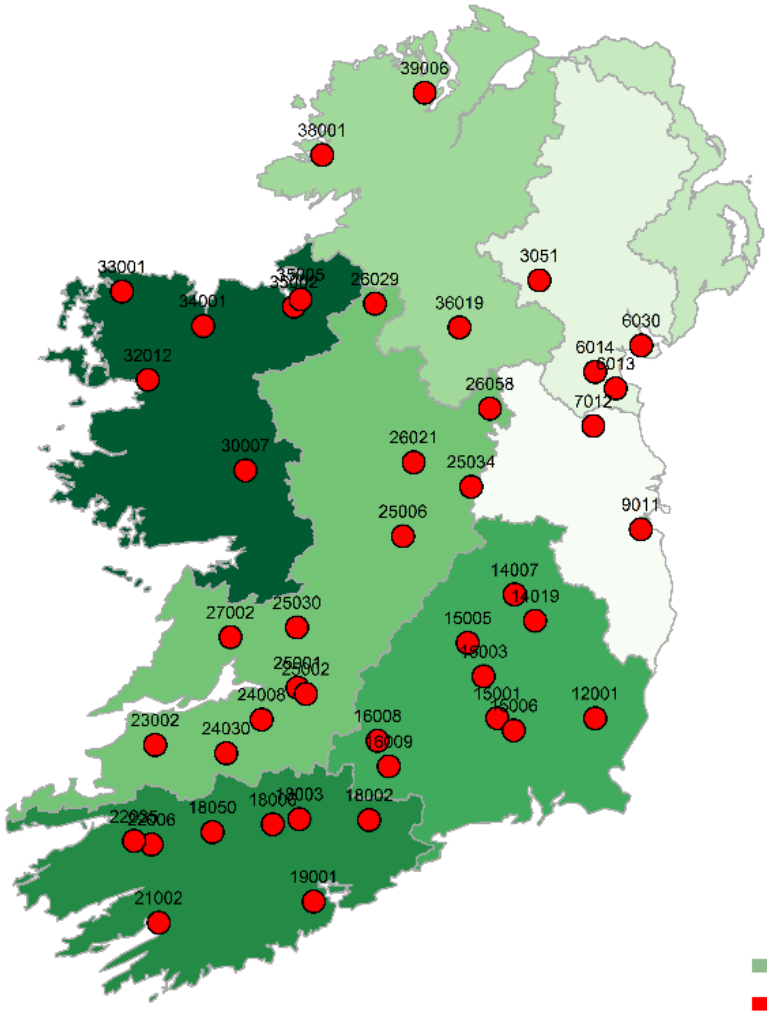
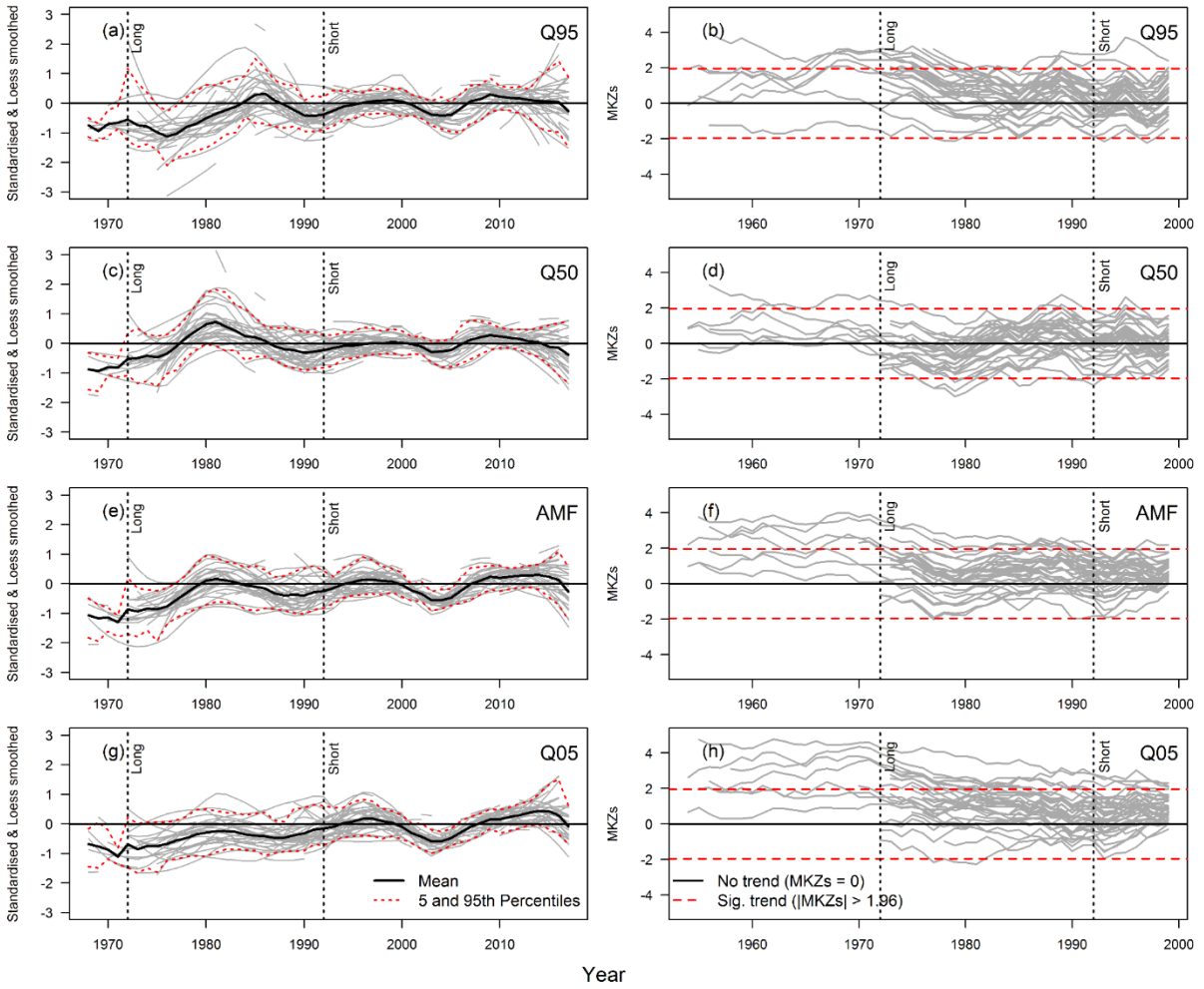
Irish Reference Network – Updated to 2017





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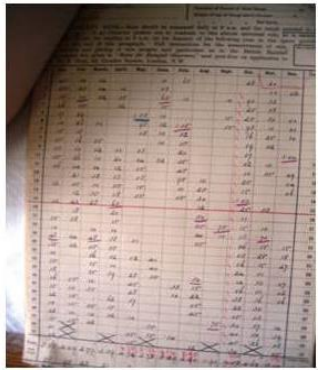
Extending River Flow Network

- Ensemble reconstruction of river flows for IRN stations
  - Annual water balance – 1700
  - Continuous monthly flows – 1780
  - Daily flows – 1851
- Multiple hydrological models and scenarios of landuse change
- Linking with historical rainfall data rescue
- Assessment of hydrological variability, drought, low flows, water planning, flood reconstruction

Data rescue in the classroom: research-led teaching to extend historical records

Ciara Ryan[1], Catriona Duffy[1], Ciaran Broderick[1], Peter W. Thorne[1], Mary Curley[2], Séamus Walsh[2], Conor Daly[2], Mairéad Treanor[3,4], Conor Murphy[1]



IRISH RESEARCH COUNCIL
An Chomhairle um Thaighde in Éirinn

[1]Irish Climate Analysis and Research Units, Department of Geography, Maynooth University, Maynooth, Co. Kildare, Ireland.

[2]Climatology and Observations Division, Met Éireann, Dublin, Ireland.

[3]Library, Met Éireann, Dublin, Ireland.

[4] The Oireachtas Library, Houses of the Oireachtas.

Correspondence to: Ciara Ryan (ciara.ryan@mu.ie)

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Ryan et al. 2018 Integrating data rescue into the classroom. **BAMS,** In Press

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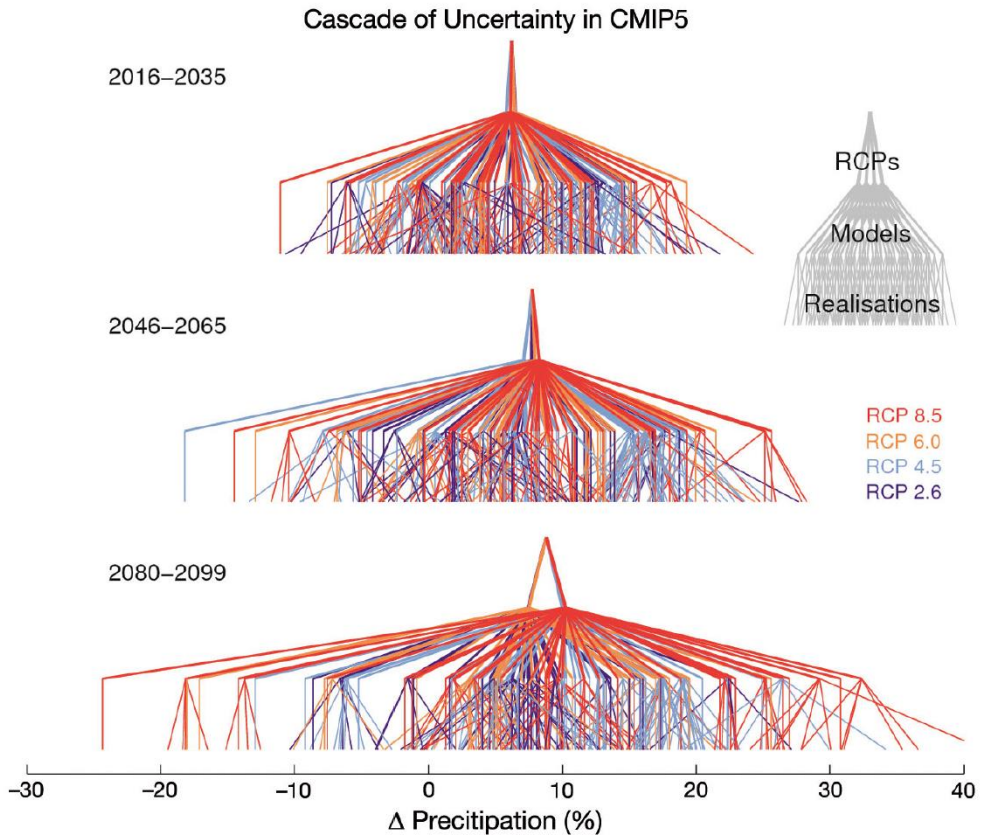
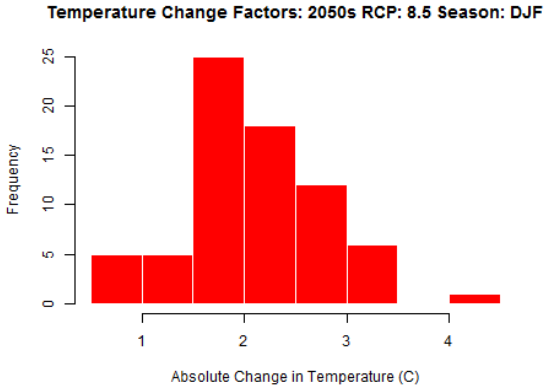
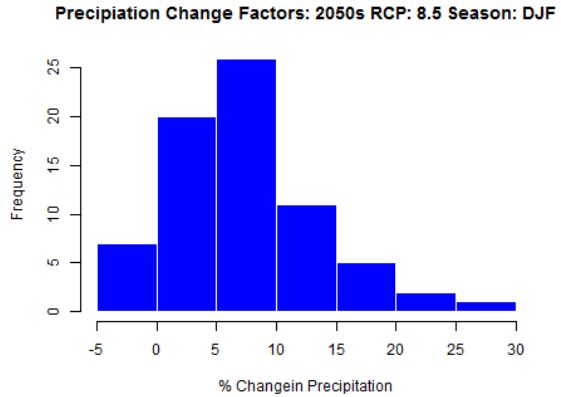
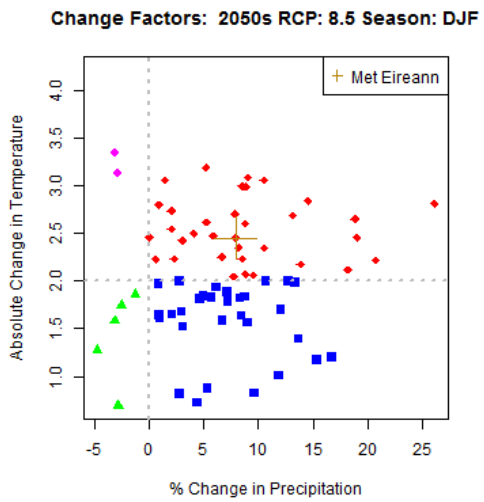
MET éireann

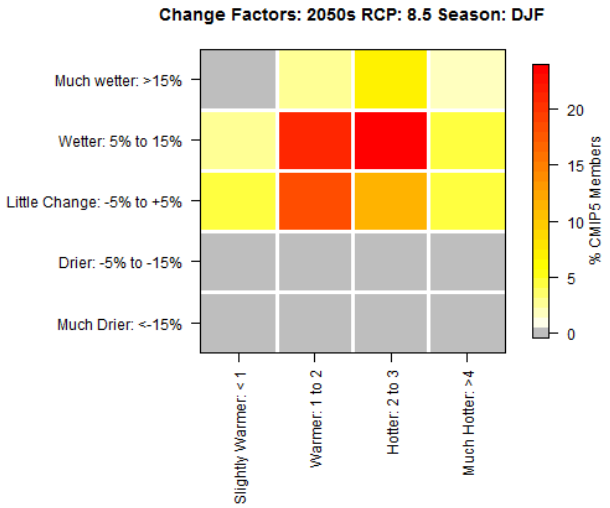
Future Flows: Cascade of Uncertainty CANNOT be ignored











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Smarter use of climate model projections

- Uncertainty is critical to successful adaptation – use it!
- Value of analogues for scoping vulnerability, risk and adaptation
- Climate change projections for understanding system vulnerability
- Using climate information to stress test adaptation options
- DON'T use climate model projections in a deterministic sense

WCRP CMIP5
World Climate Research Programme

- 35 models; most run with different initial conditions and physics parameterizations
-
  - Total of **298** realizations (future climates) for the Island of Ireland

WCRP CORDEX

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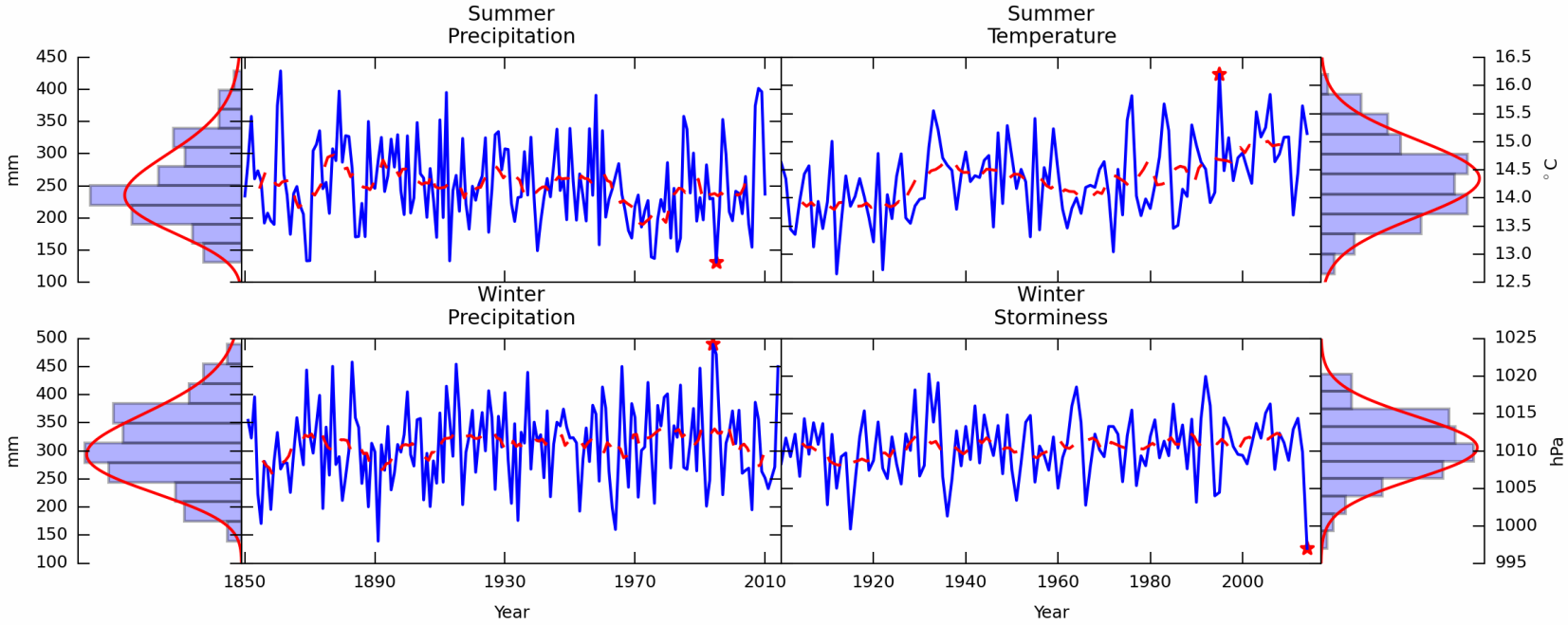
Memorable extremes – how has their likelihood changed?



Direct personal experience of climate-related weather events may act as a strong 'signal' or 'focusing event' around which the otherwise futuristic and abstract nature of climate change may become more tangible, and crucially trigger more substantive public engagement and policy response (Capstick et al., 2015)

Matthews, T., Mullan, D., Wilby, R.L., Broderick, C. and Murphy, C., 2016. Past and future climate change in the context of memorable seasonal extremes. *Climate Risk Management*, *11*, pp.37-52.

How frequent may those Irish events become in future?

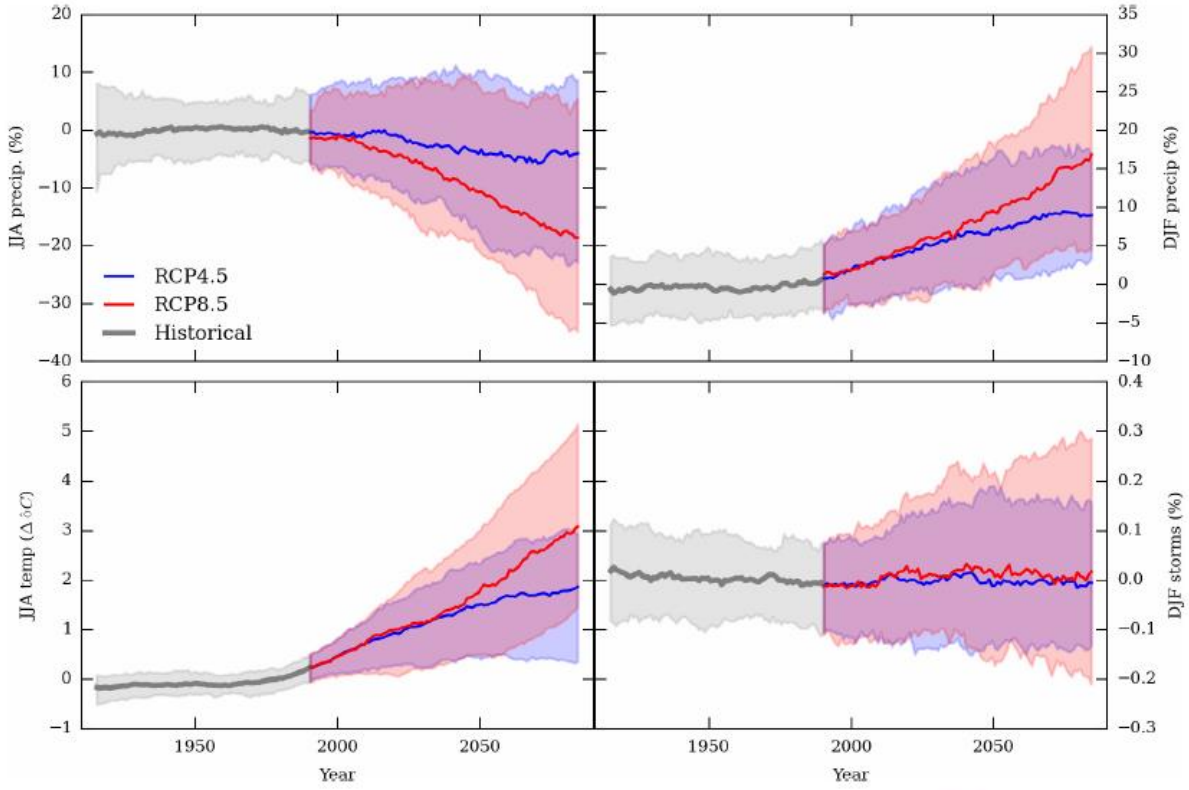
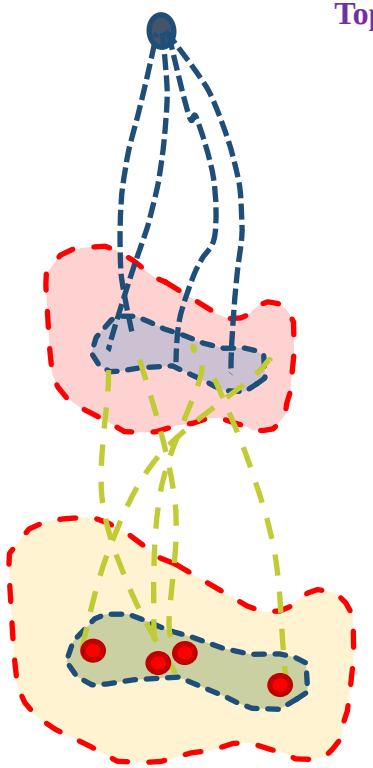


Fig. 10. Centred 30-year running means of the respective variables, expressed as anomalies from 1901–2005. See Fig. 8 caption for further details.

- In a business as usual world..
- 1 in 8 years as dry as 1995
- 1 in 8 years as wet as 1994
- 1 in 7 years ***as cool as*** 1995
- BUT these graphs also allow us to consider vulnerability to future change

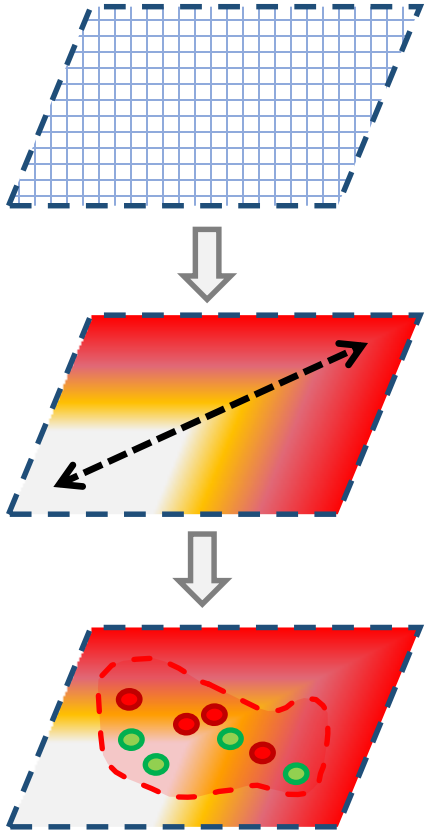
Matthews, T., Mullan, D., Wilby, R.L., Broderick, C. and Murphy, C., 2016. Past and future climate change in the context of memorable seasonal extremes. *Climate Risk Management*, *11*, pp.37-52.

Using climate projections to understand sensitivity, risk and decision making



Top-down/scenario-led

1. Download large-scale climate model projections.
2. Process model output to produce climate data commensurate with temporal and spatial requirements.
3. Simulate hydrological (low flow) response using model output as forcing data.
4. Identify whether the system is vulnerable to these scenarios.



Bottom-up/scenario-neutral

1. Identify domain for sensitivity testing
2. Develop rainfall runoff - model under observed conditions
3. Simulate hydrological (high flow) response to incremental changes in climate parameters: precipitation amount and seasonality.
4. Overlay climate projections to assess exposure
5. Explore available infrastructure design and management options

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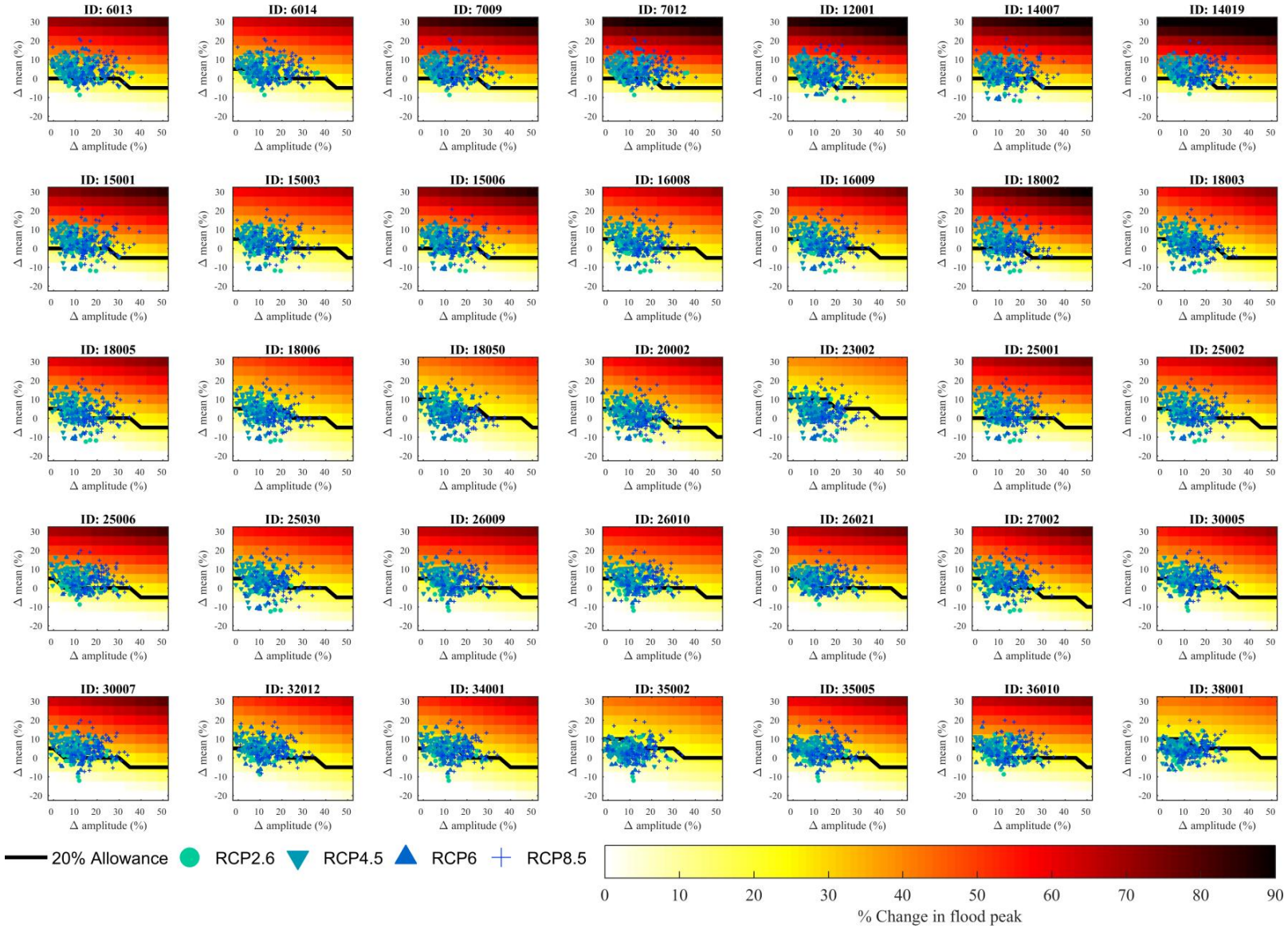

- Assessment of changes in Flood Risk – 35 IRN catchments
- Change in 20 year RP event
- Start by exploring sensitivity without climate models
- Overlay climate model projections to assess ranges of change
- Assess adaptation decisions

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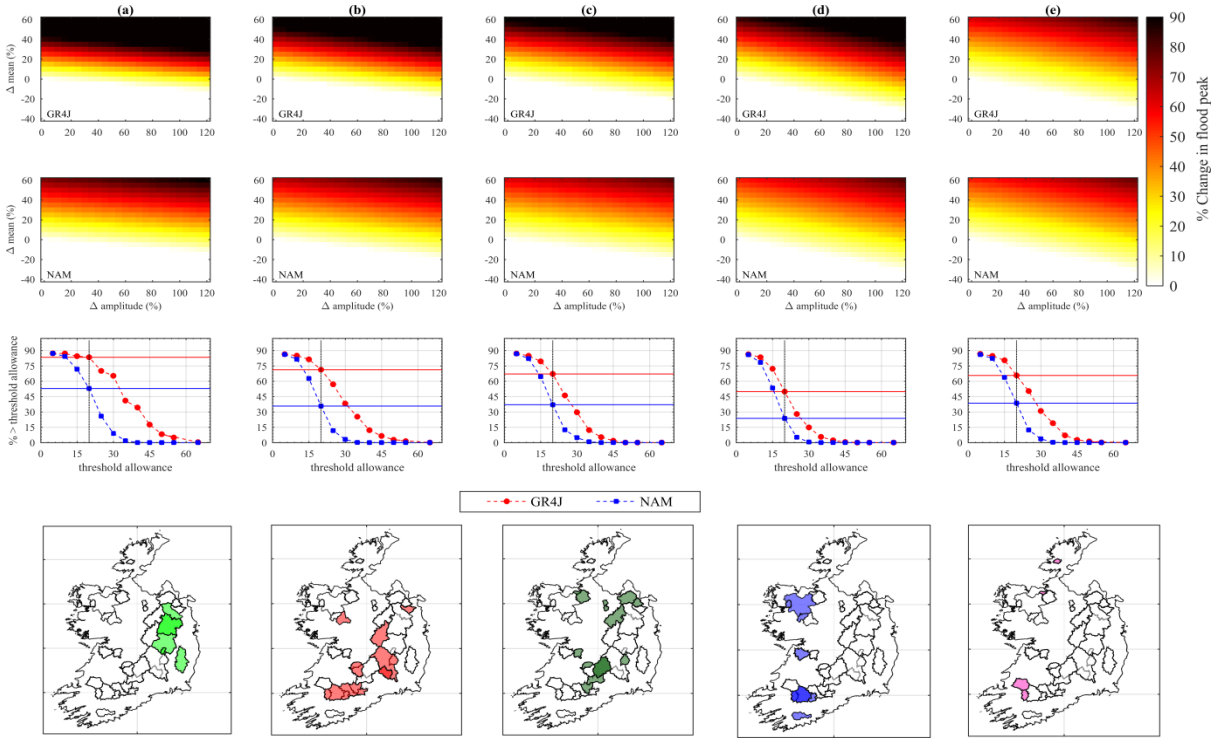
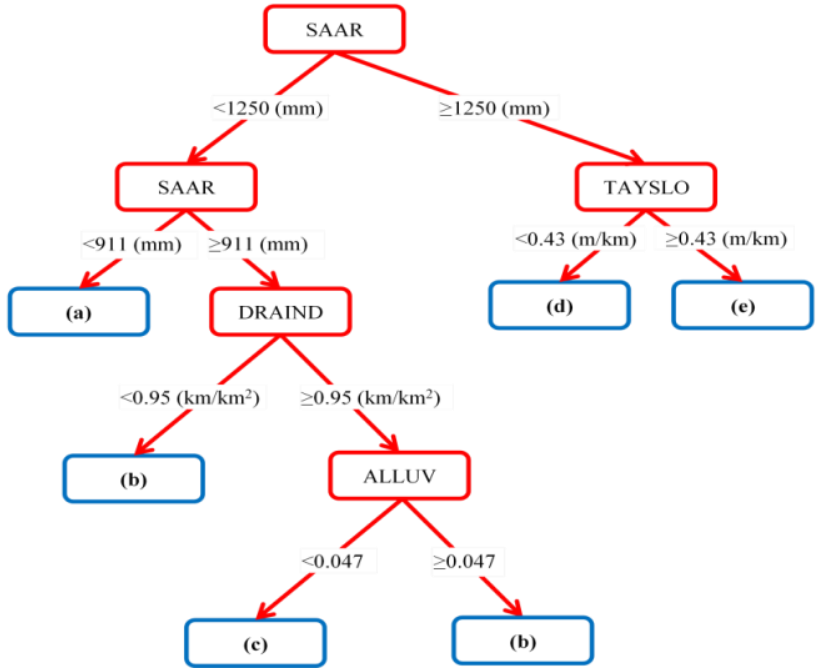
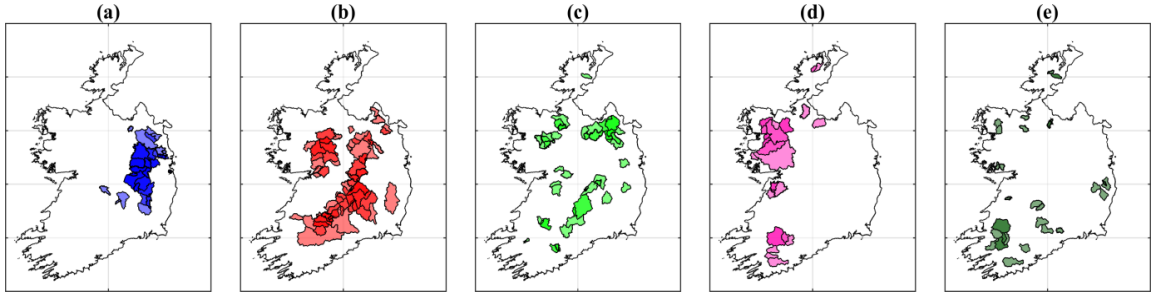
Regional typologies of flood sensitivity and stress testing of adaptation decisions







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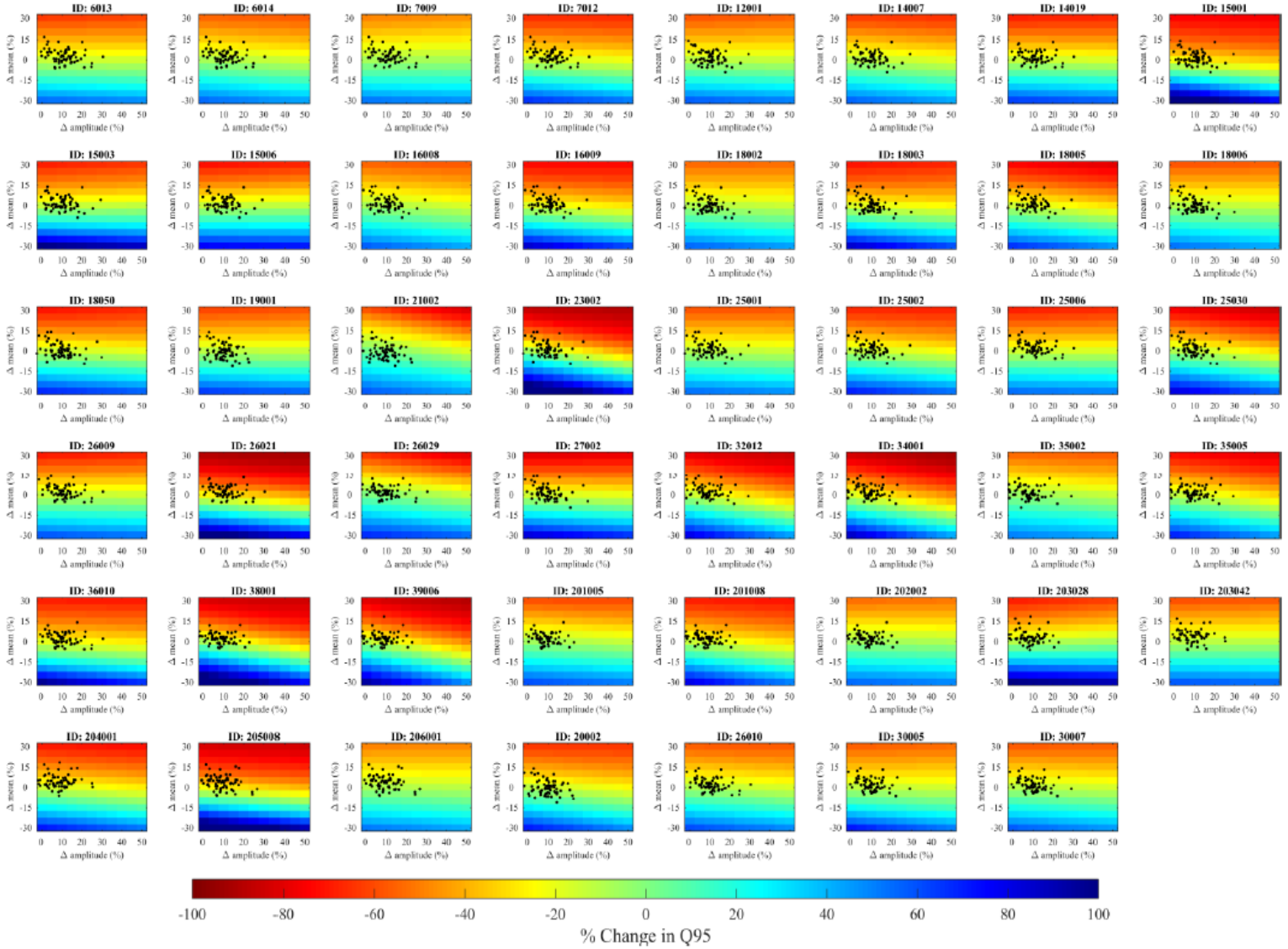

- Can take same approach for low flows Q95
- 47 updated IRN catchments
- Low flows sensitive to temperature changes also
- This is for the 2080s with warming limited to 2ºC – so conservative
- In the process of linking with catchment descriptors to regionalize sensitivity to low flows

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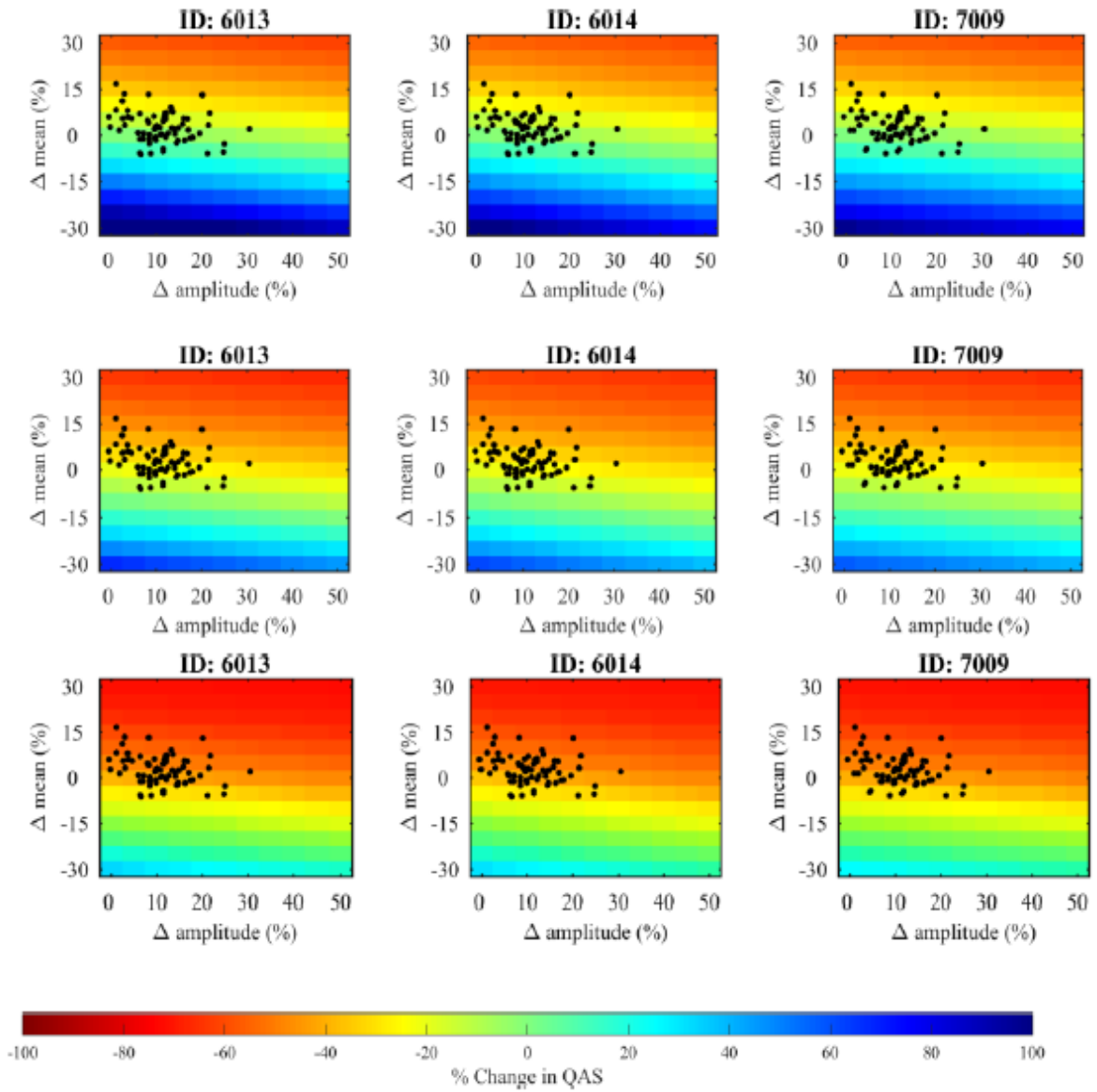
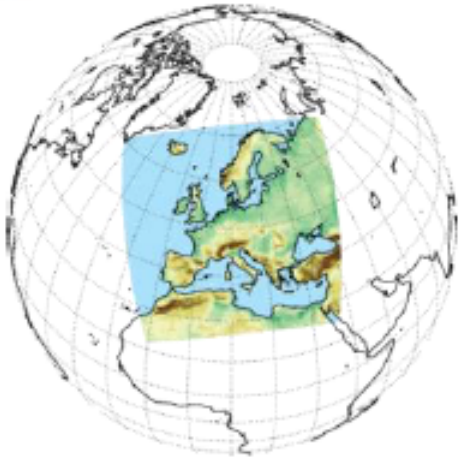


- Sensitivity of low flows to changes in temperature
- QAS – mean discharge from April to Sept
- Top – no change in mean annual temperature
- Middle – increase of 2 degrees
- Bottom – increase of 4 degrees

CORDEX - Coordinated Downscaling Experiment

- Internationally coordinated experiment to develop **an ensemble of RCM projections**
- A **19 member ensemble** derived using **13 RCMs** run at a **~11 km** resolution and forced using one or more of **6** different CMIP5 **GCMs**
- **Evaluated using 1 × 1km gridded observed** daily precipitation (1976-2005) - Met Éireann and CEH-GEAR datasets
- Future examined for two **30 year horizons** (e.g. 2040-2069; 2070-2099) for **Representative Concentration Pathways** (e.g. +4.5 and +8.5 W/m^2)
- Focus **on summer** (JJA) and **winter** (DJF)

WCRP CORDEX



Reg Environ Change (2014) 14:563–578
DOI 10.1007/s10113-013-0499-2

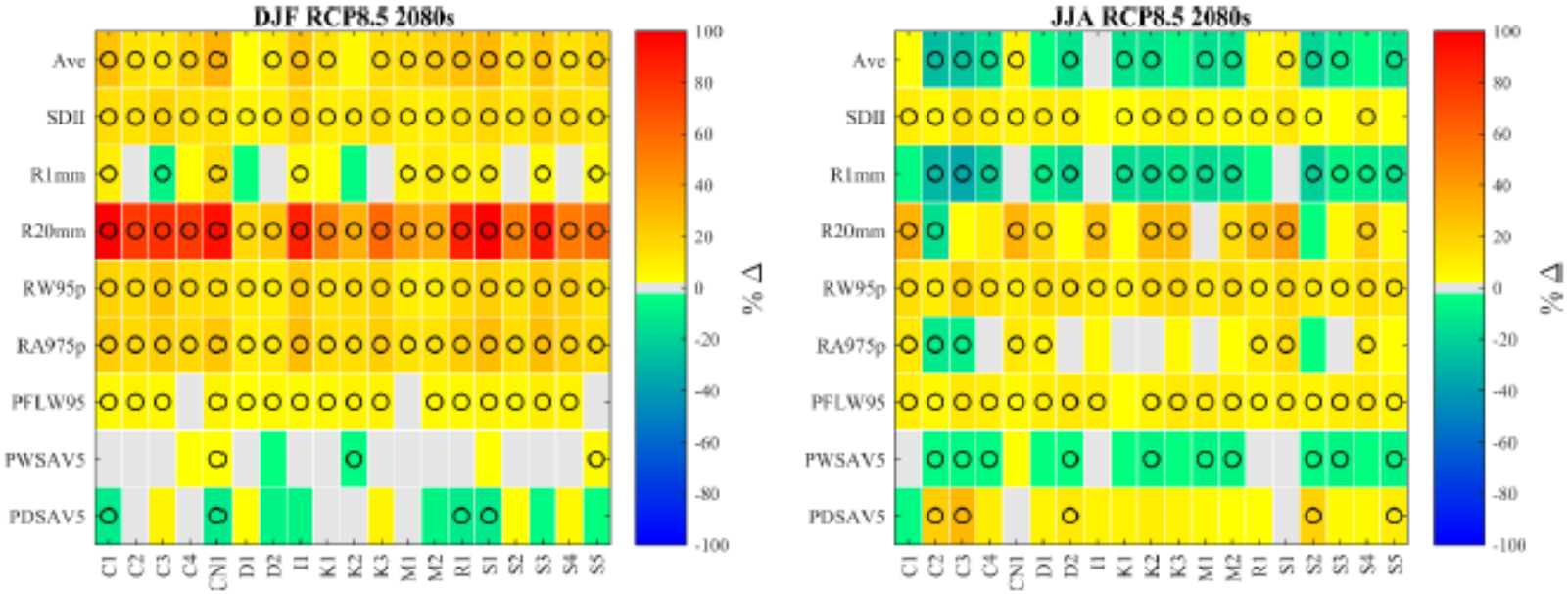
ORIGINAL ARTICLE

EURO-CORDEX: new high-resolution climate change projections for European impact research

http://cordex.org/ Sponsored by World Climate Research Program (WCRP; Jacob et al., 2014)

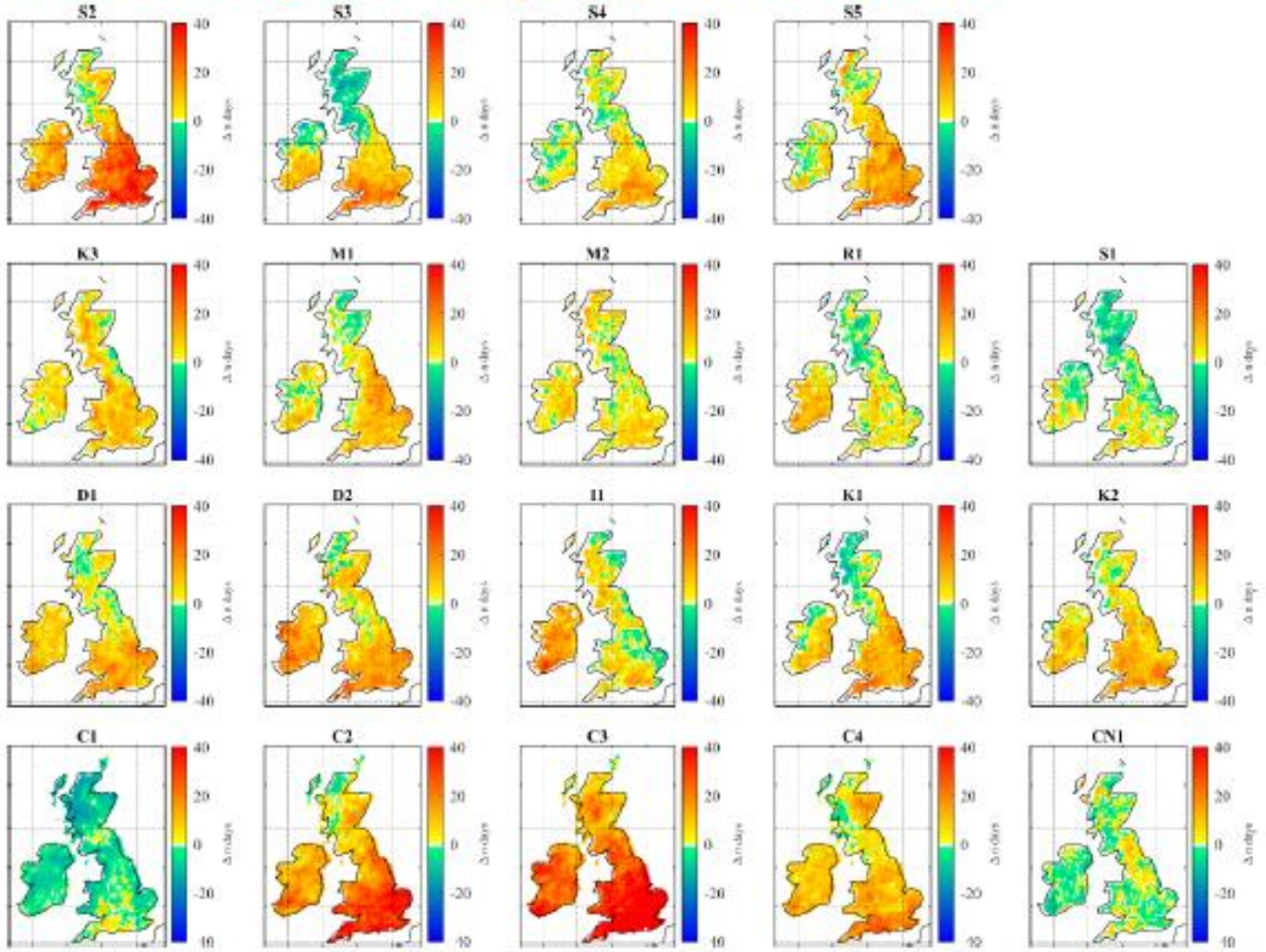
Projected changes – CORDEX ensemble

- Significant **increases** in rainfall **intensity**
- Suggested **larger proportion** of total precipitation will come **from heavy events** (>95th percentile)
- **Heavy rainfall days** (>20 mm) are likely to **increase** significantly
- **Less certainty** in wet and dry spell lengths
- Overall **increase/decrease** in number of **wet winter/summer days** (>1mm)



Projected changes in precipitation investigated using nine indices for RCP 8.5 and 2070-2099 relative to 1976-2005. Black circles denotes changes significant at the 95% level

Projected changes – dry summer spells

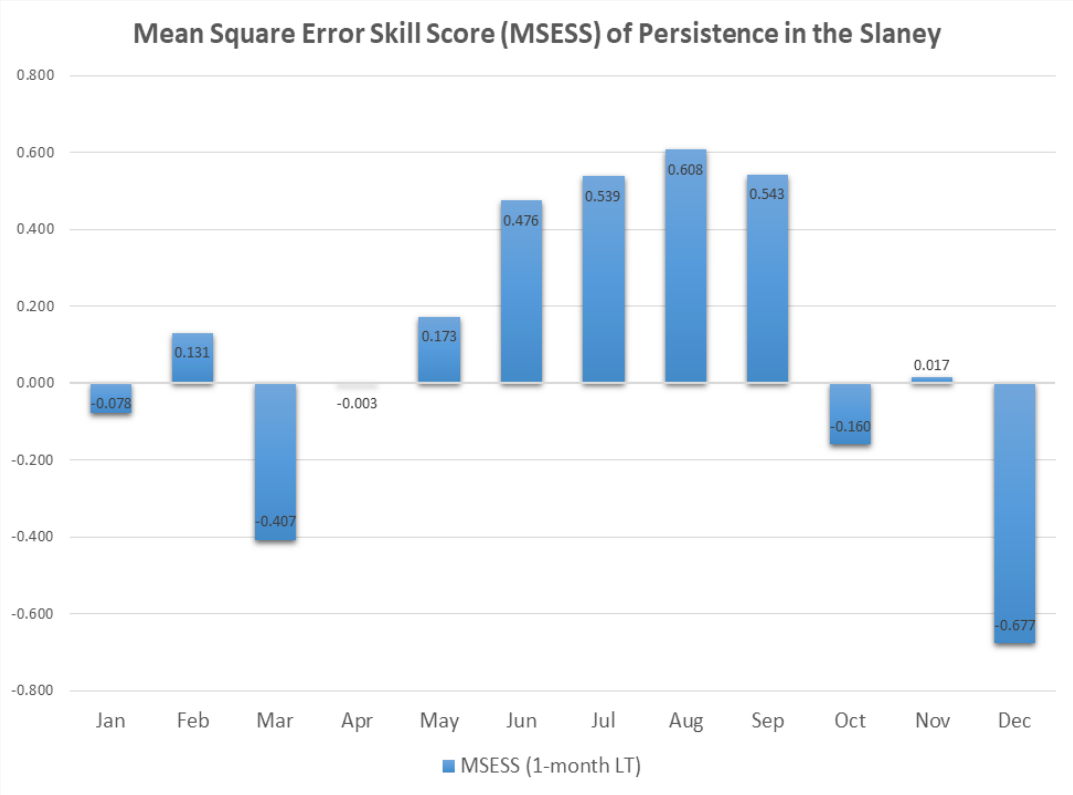


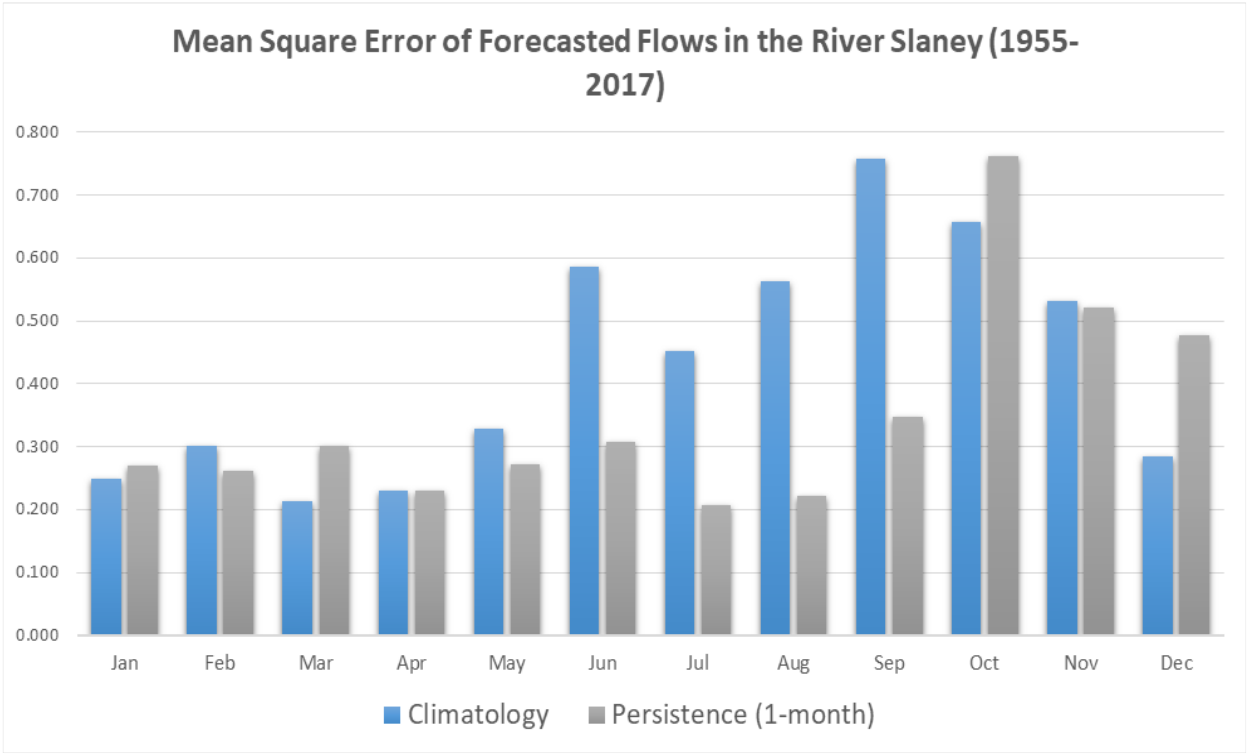
Projected changes in the average length of dry spells (PDSAV5) investigated for RCP 8.5 and 2070-2099 relative to 1976-2005.

Projections need to be forced through hydro model ensembles to explore changes.

Currently starting that process for 100 catchments

Seasonal Hydrological Forecasting – Skill can come for catchment memory





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Summary and Conclusions

- Climate change is likely to have significant implications for catchment hydrology and water resources – catchments are differently sensitive.
- Influence of climate variability is large – start by understanding and coping with this.
- Future climate information available for decision making needs updating!
- Monitoring networks, approaches to adaptation that embrace uncertainties and start with understanding catchment sensitivity offer considerable advantages.
- Climate models best used for assessing adaptation decisions/options.
- Tools other than climate models such as flood forecasting, seasonal forecasting, real time monitoring can build adaptive capacity.