

# Climate variability and its influence on the resilience of water resources: Examples from Scotland

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# Outline

- \* The variability and periodicity of precipitation in Scotland
- \* The influence of climate variability on water supply systems
- \* Climate change impacts on water resources
- \* Weather types and rainfall variability

# Variability of precipitation in Scotland

- \* Increase in total annual precipitation across Scotland, especially since the 1970s



Fig. Trends in total annual precipitation computed for the period 1961–2000 using the Theil–Sen approach. Source: Afzal et al. (2015)

# Rainfall variability in Scotland

- \* In addition to increasing trends in the magnitude of rainfall, there is evidence of an increase in rainfall variability

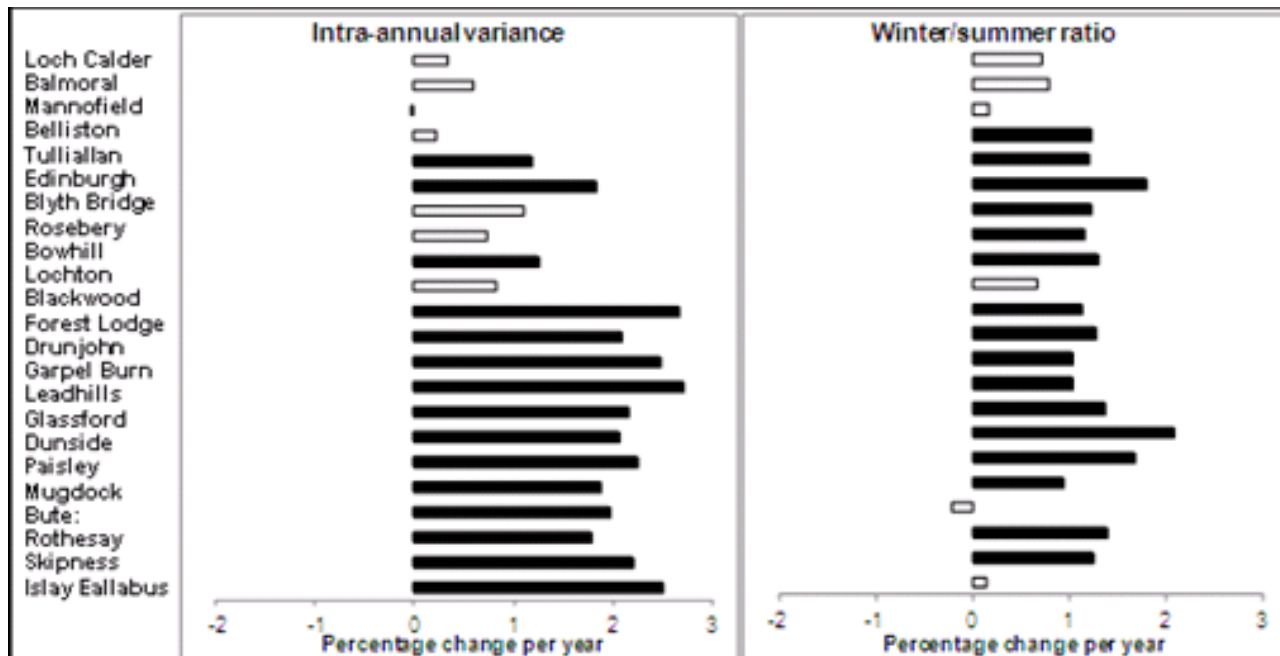


Fig. Change in the variability of precipitation in Scotland according to two measures of variability during the period 1961-2000. Source: Afzal et al. (2015)

# Periodicity of precipitation in Scotland

- \* The variability of rainfall is also evident in terms of regular repeating patterns of varying periodicities

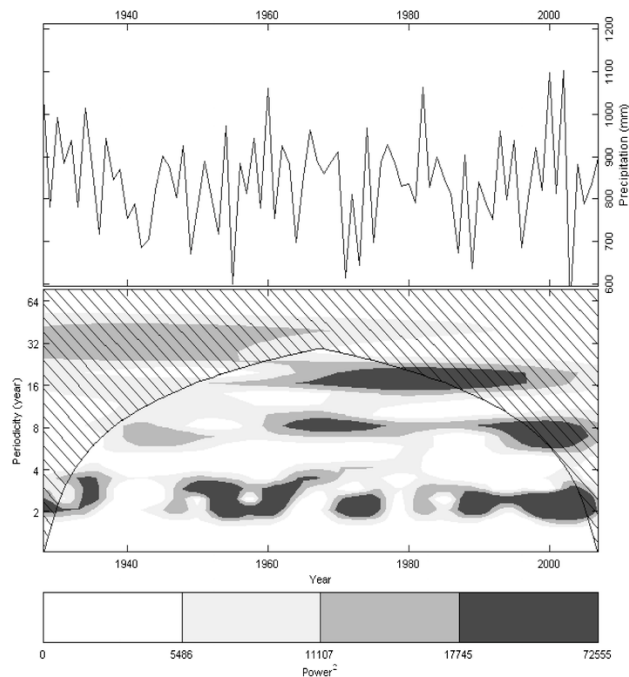


Fig. Total annual precipitation at Balmoral (top) and wavelet analysis of that time series (bottom) for the period 1928–2007. Source: Afzal et al (2015)

# Rainfall variability and water resources

- \* Water resource systems are developed on the basis of a stationary climate, hence changes in rainfall variability are important to water resource managers
- \* The critical parameters are the amplitude and period (or frequency) of the variations



Fig. Loch Dhu reservoir, Scotland

# Water resources in Scotland

- \* Scotland is dependent on surface water
- \* Although the overall yield of developed resources is 32% greater than total demand, the majority of Scotland's population lives in the lowland belt where the yield to demand surplus is low and the demand exceeds the available yield in some areas
- \* In the drier areas of the East irrigation is more common, creating further strains on water resources, with rivers occasionally drying up

# Rainfall variability and reservoir reliability in Scotland

- \* The measures of variability related to the distribution of rainfall within the year show strong correlation with the reliability of storage reservoirs

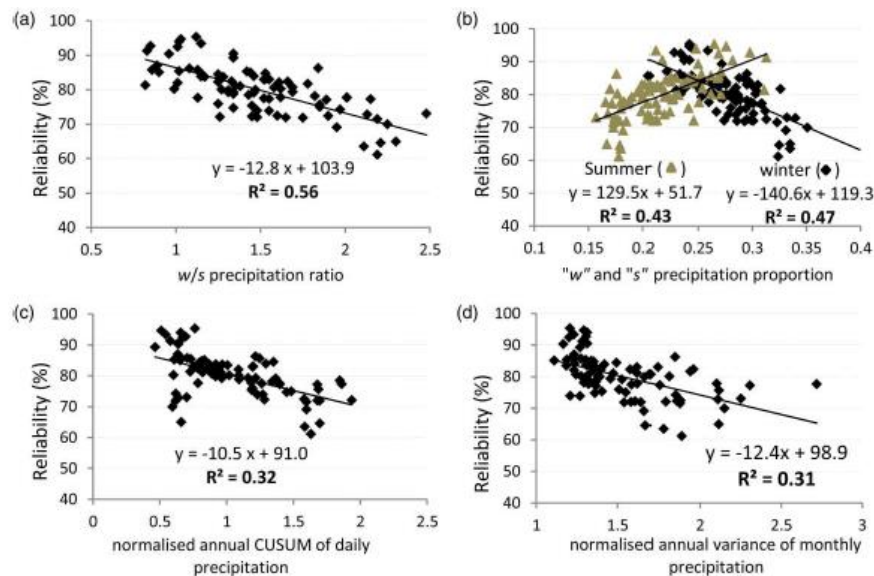


Fig. Relationship between the reliability of a notional reservoir having the mean characteristics of six case study reservoirs and various measures of rainfall variability. Source: Afzal et al. (2016a)



# The influence of rainfall variability on water supply systems

- \* Water distribution during the year and particularly w/s precipitation ratio influence reservoir reliability
- \* Variability of rainfall between years was also found to influence reservoir reliability
- \* However, for river intakes schemes the distribution of rainfall during the year and its variability between months were found to be the most important variables influencing reliability

# Variability of precipitation in a changing climate

- \* Total annual precipitation and rainfall variability are projected to increase throughout the 21<sup>st</sup> century

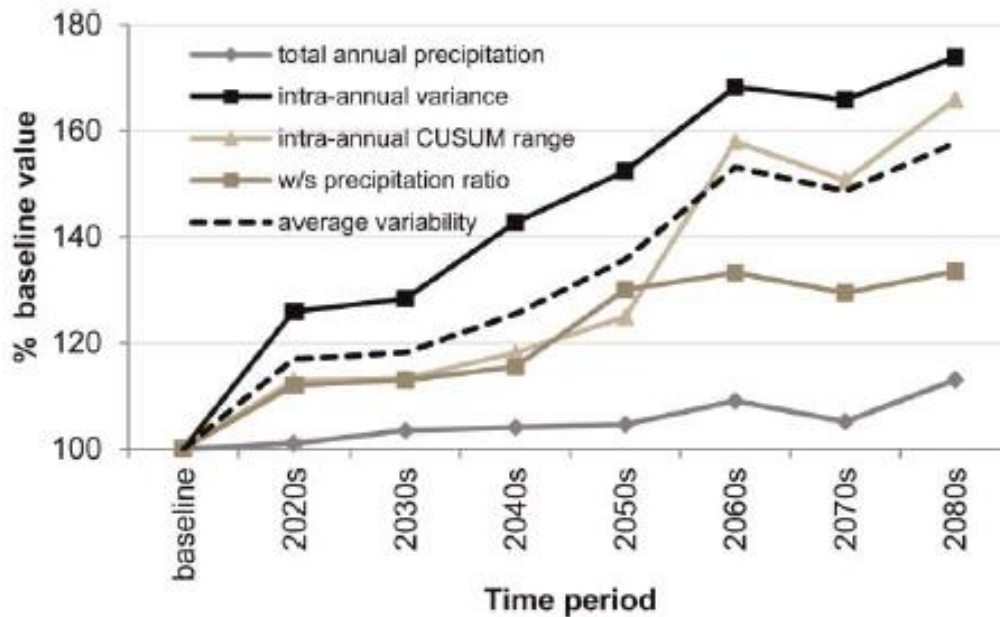


Fig. Projected changes in total annual precipitation and in the variability of rainfall for the 50% probability level of the UKCP09 medium GHG emission scenario. Source: Afzal et al (2016b)

# Adaptation in Scotland

- \* Under the Climate Change Act , Scottish Water has duties to reduce its carbon footprint in addition to ensuring that its services are resilient to a changing climate
- \* The work on mitigation has focused on reducing leakage , energy efficiency measures and generating renewable energy at their facilities
- \* The work on adaptation focuses on increasing their understanding of the potential risks that climate change poses.

# Impacts of climate change on water resources in Scotland

- \* Decrease in reliability for storage reservoirs and river intake schemes

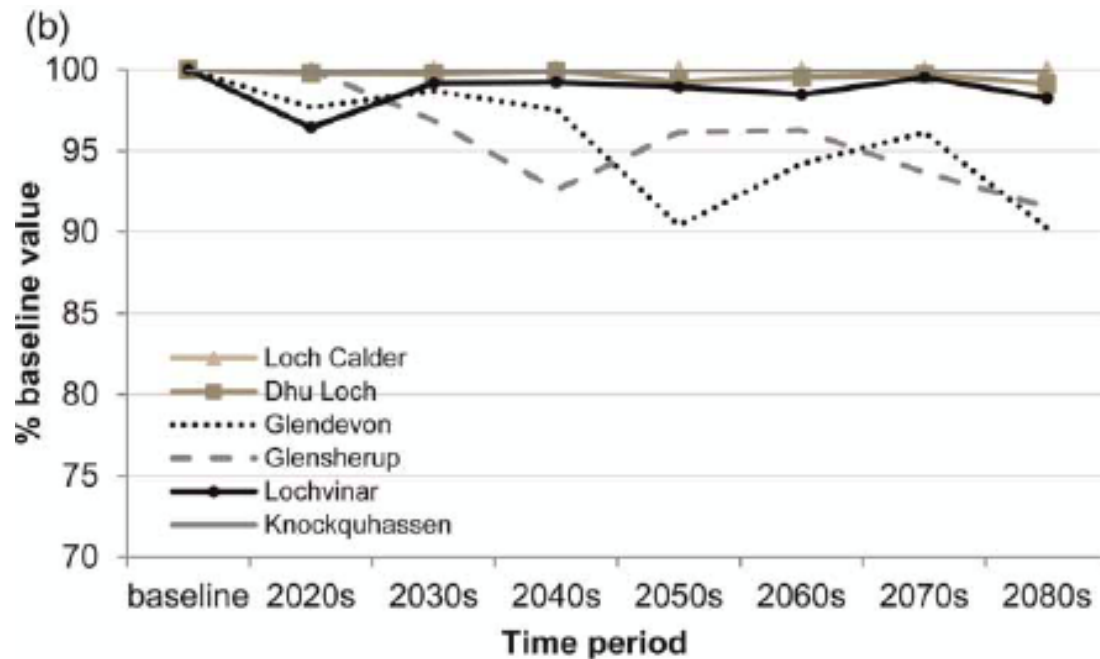


Fig. Projected changes in the volumetric reliability of six case study reservoirs using the projected changes in precipitation and evapotranspiration

# Vulnerability of case study reservoirs

- \* Vulnerability measures the severity of failure of a water supply system. It is calculated as the average maximum shortfall occurring in each failure period (McMahon and Adeloye, 2005)

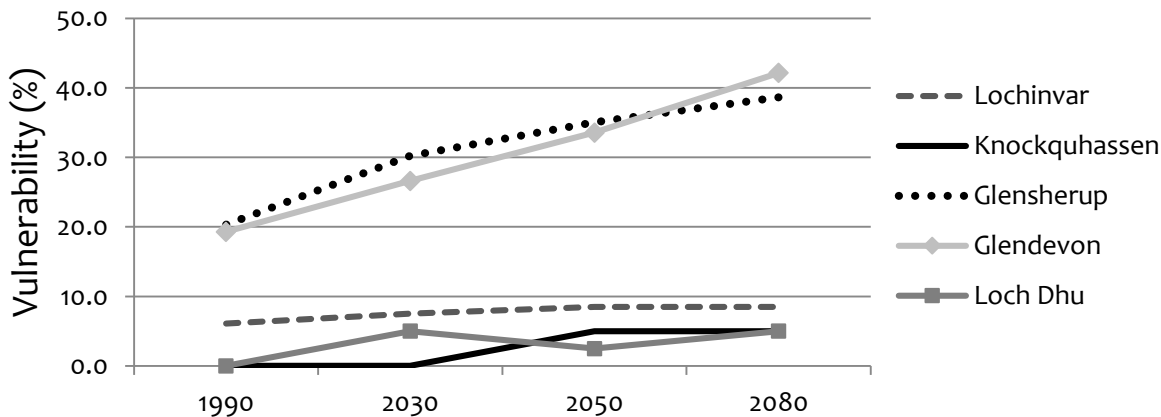


Fig. Vulnerability of the case study reservoirs

# Synoptic climatology

- \* Changes in atmospheric circulation as a potential explanation for the temporal and spatial variability of rainfall in Scotland

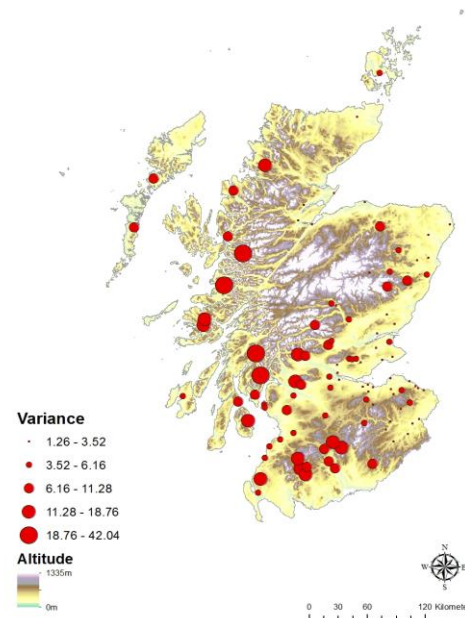


Fig. Variance of precipitation per LWT

Thank you,

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