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Seasonal forecasting of groundwater levels in natural aquifers in the United Kingdom

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Thursday 1st May 2014, EGU, Vienna.

Background

•Benefits of forecasting groundwater levels

- Societal
- Environmental
- Economic

•Past research

- ‘Black-box’ hydrological modelling approaches
- Exploit memory (response time) of system
- Deterministic

•A new approach...

- Seasonal weather forecasts (GloSea5)
- Conceptual groundwater models (AquiMod)
- Ensemble groundwater level forecasts



Hydrological Outlook UK

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Latest Outlook
water levels in the river are likely to be normal in the river aquifer with a possibility of standing over
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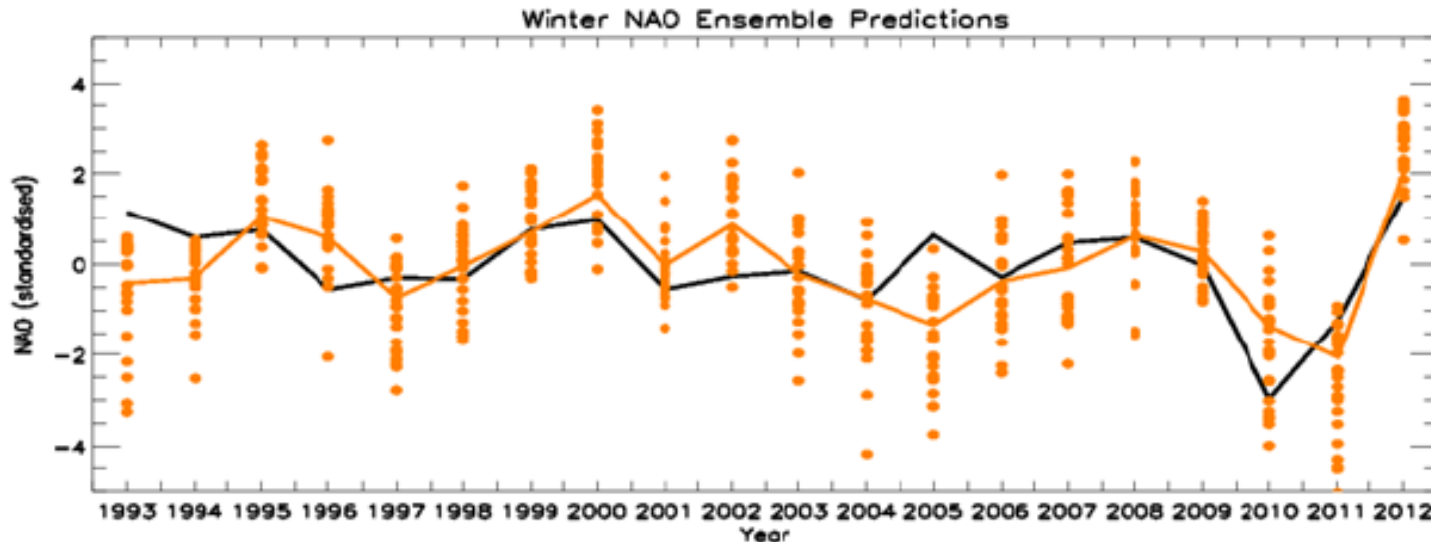
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Met Office Global Seasonal forecast System (GloSea5)

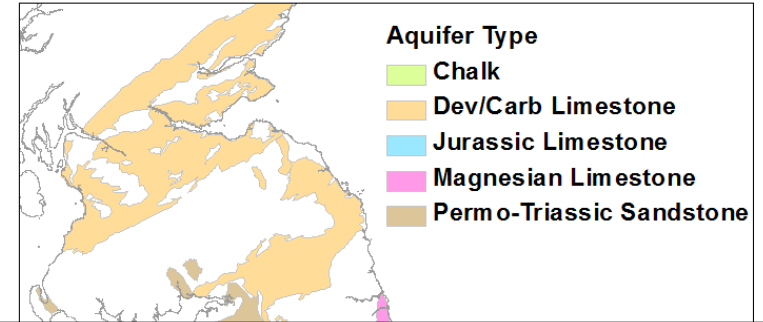
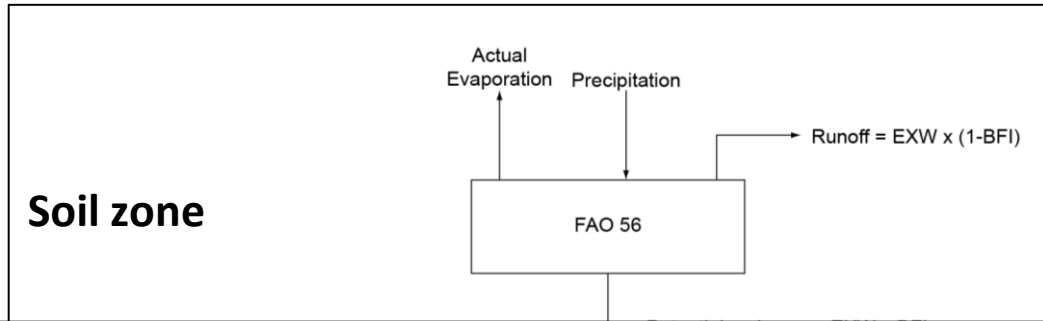
- Climate model core - HadGEM3
- Ensemble forecasts
 - Historical period = 24 members
 - Real time = 42 members
- Monthly, up to 3 months ahead



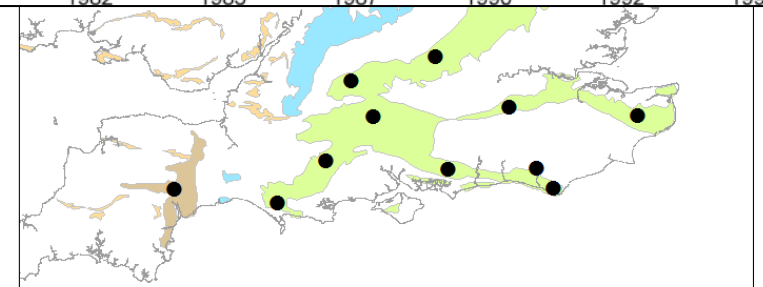
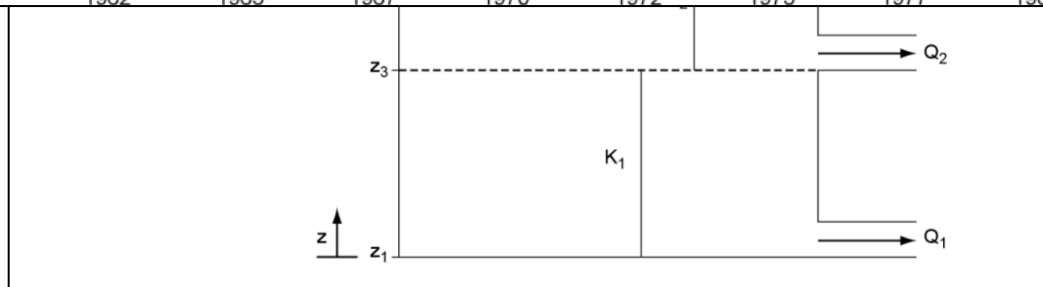
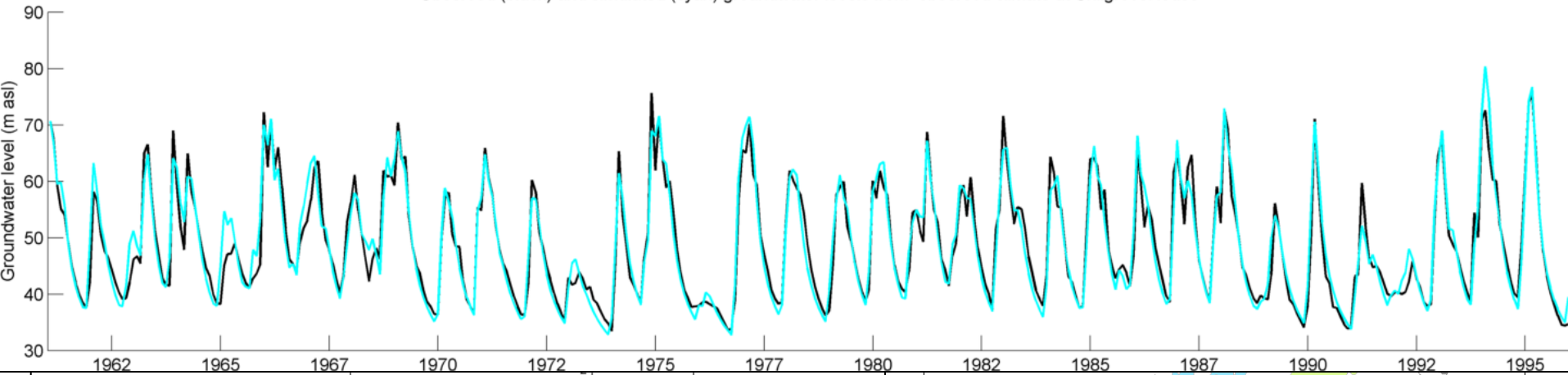
- Correlation coefficient = **0.62** at 99% confidence level

(Scaife *et al.* 2014)

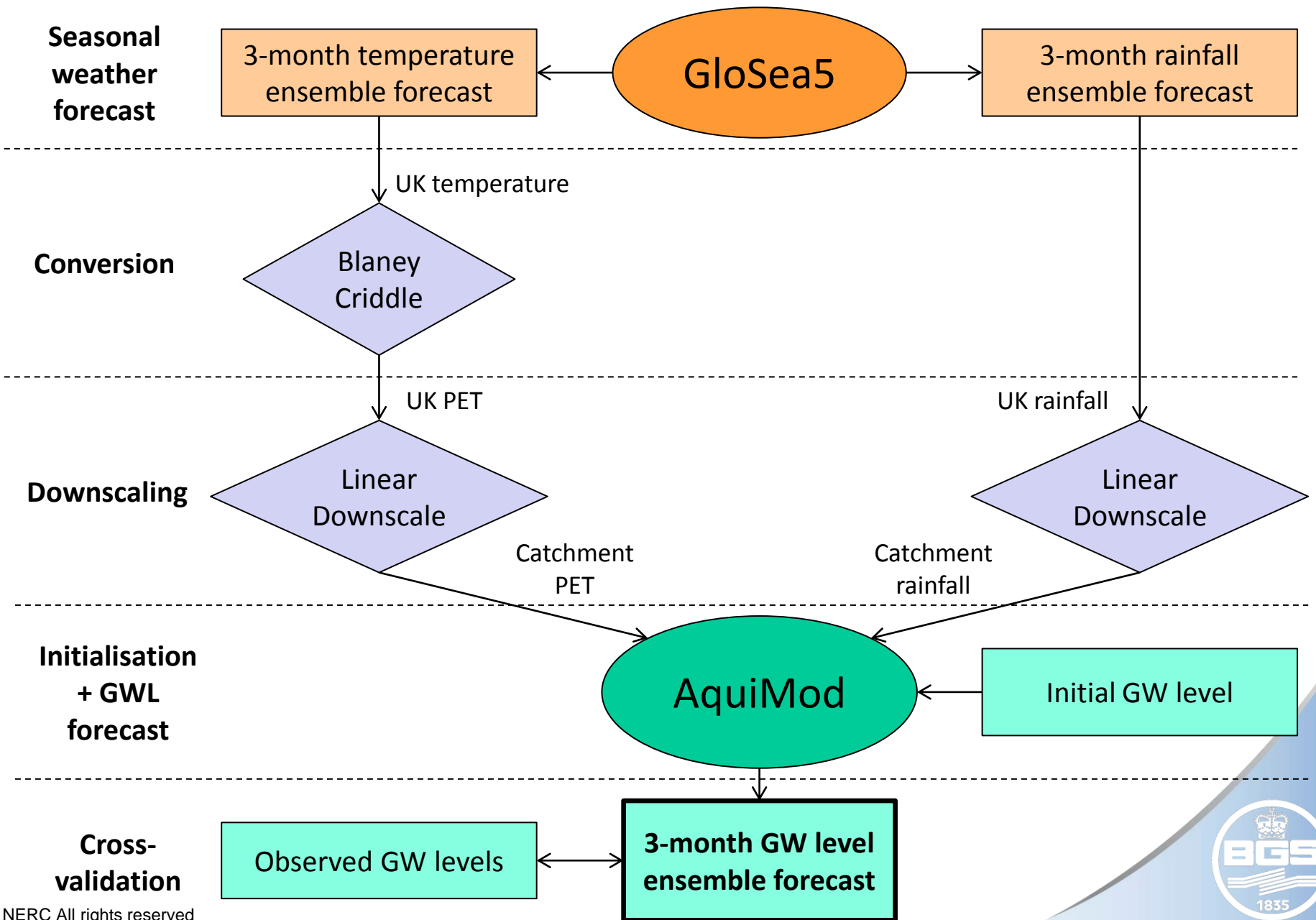
BGS lumped conceptual groundwater model (AquiMod)



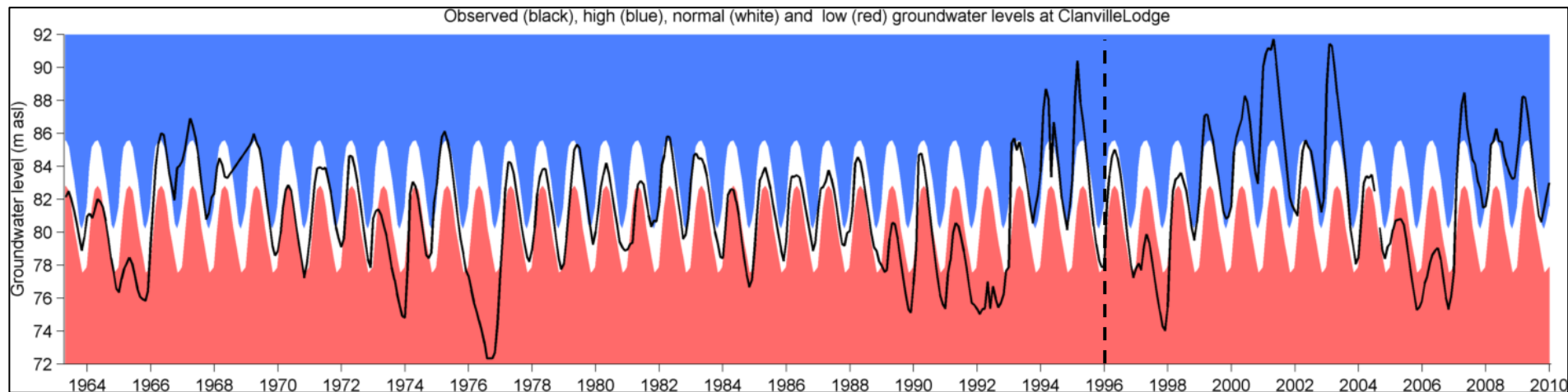
Observed (black) and simulated (cyan) groundwater levels from observed climate at ChilgroveHouse



Forecasting Sequence



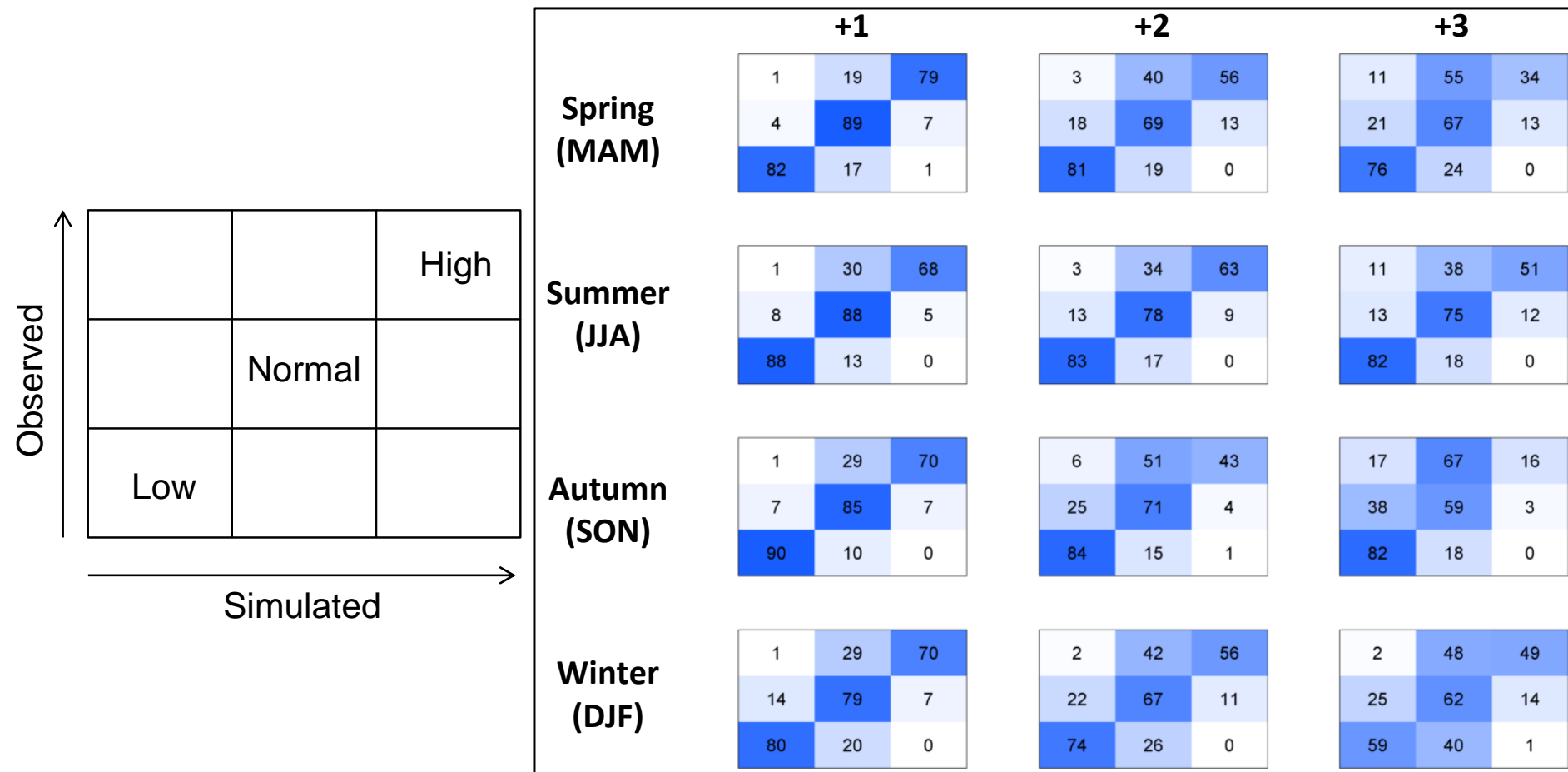
Groundwater level hindcasts: Setup



- Groundwater models calibrated to pre-1996 data
- 14 years of 3-monthly GloSea5 hindcasts (March 1996 to February 2010)
- **Percentile thresholds** for high (72) and low (28) groundwater levels

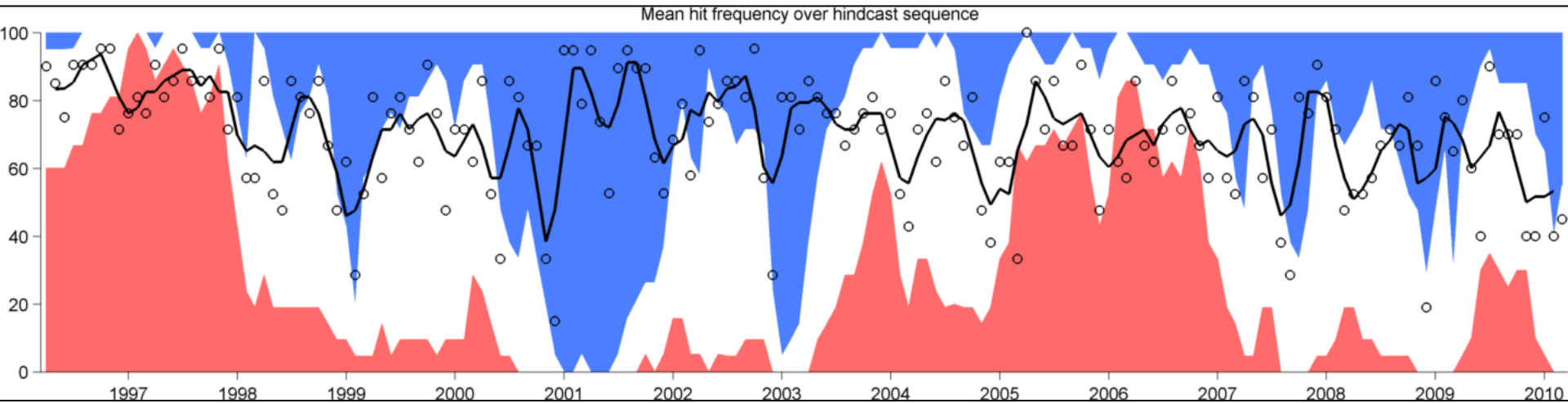
	Spring (MAM)	Summer (JJA)	Autumn (SON)	Winter (DJF)
Low	10	10	10	7
Normal	14	15	13	12
High	6	6	5	9

Groundwater level hindcasts: Results

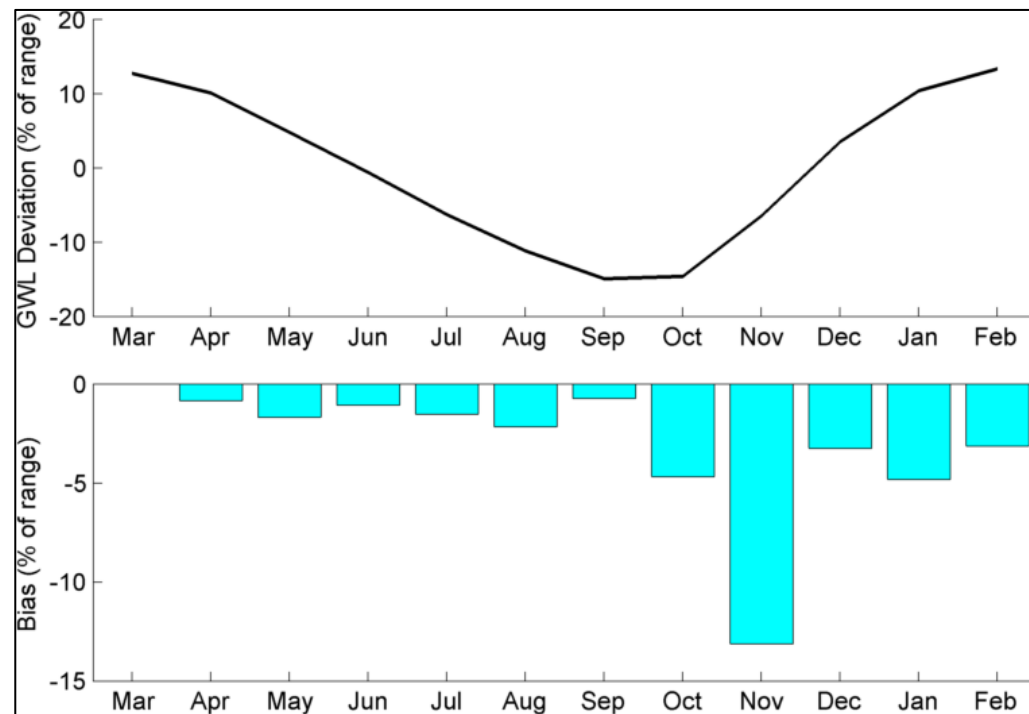
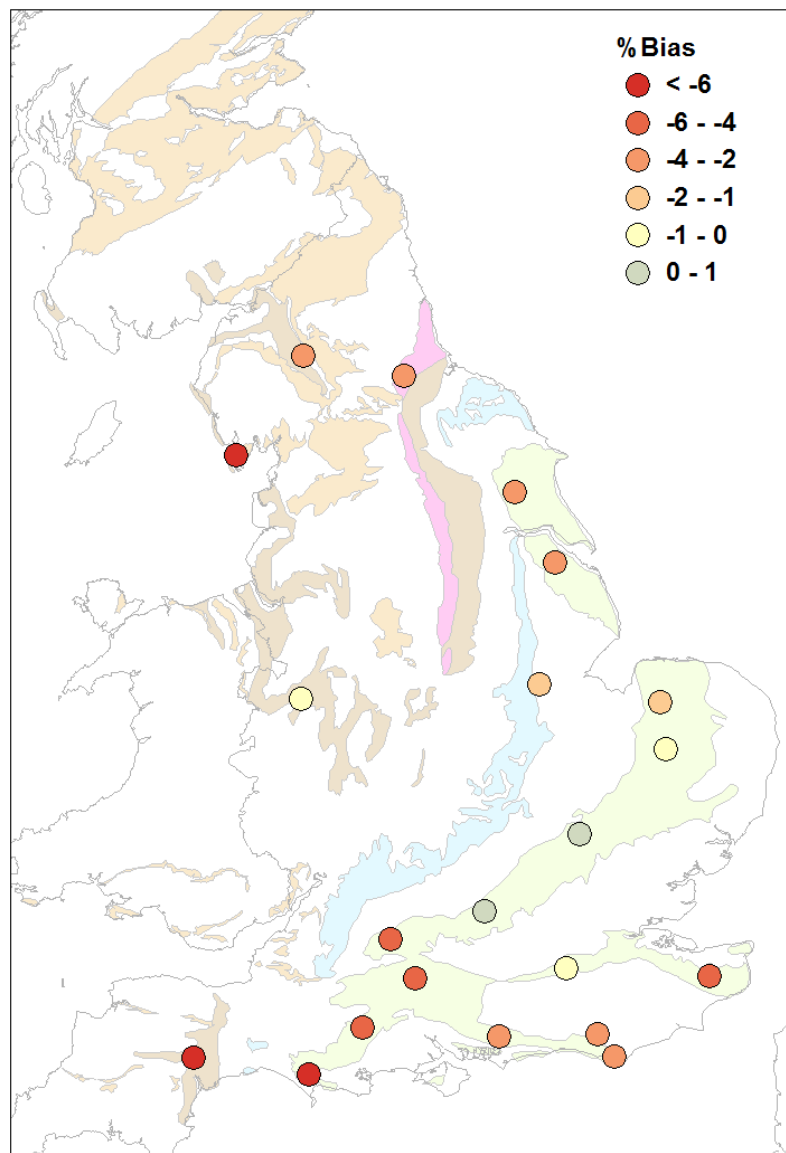


- Overall hit frequency = **70%**
- Comparison to persistence forecast: RPSS = **0.14**

Groundwater level hindcasts: Results



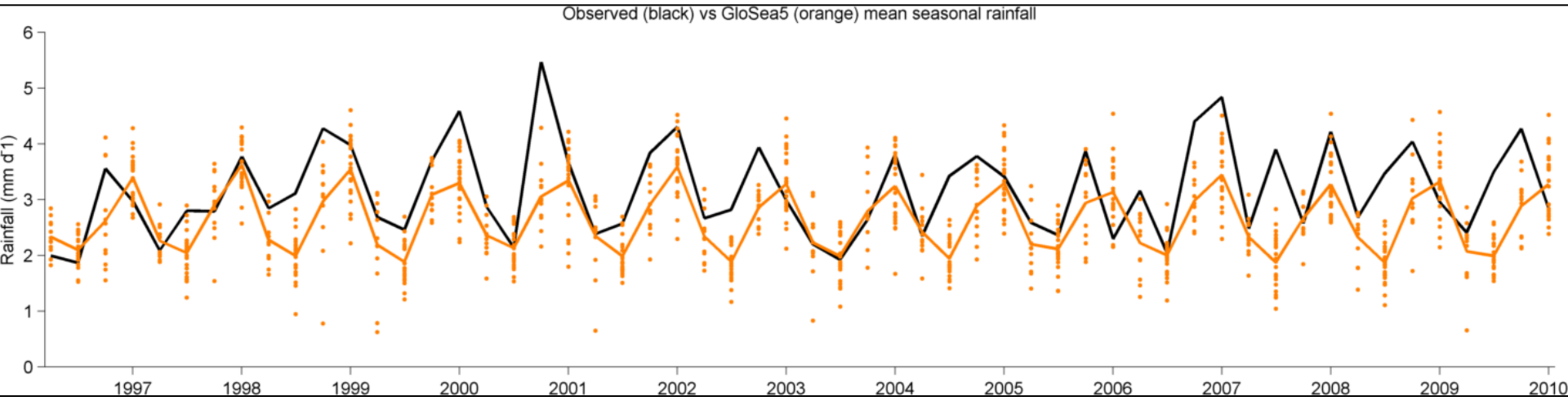
Groundwater level hindcasts: Results



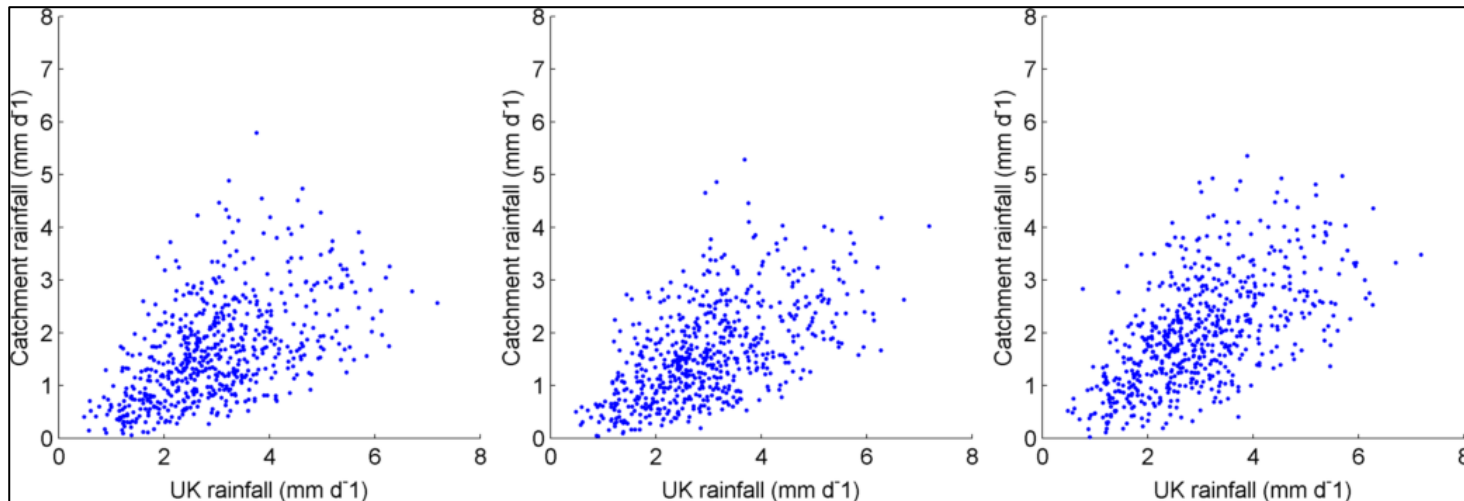
- Significant **negative** bias
- Greatest bias seen in **November**

Groundwater level hindcasts: Results

GloSea5 rainfall forecasts



Downscaling of rainfall



Summary

- Seasonal weather forecasts can be used in conjunction with simple conceptual groundwater models to forecast groundwater levels up to 3-months ahead with some skill.
- The forecasting system correctly differentiates between future low, normal and high events 70% of the time.
- The system shows least skill during periods of rapid transition where groundwater levels rise or fall rapidly.
- There is currently a systematic negative bias in the forecasts, especially at the start of the recharge season.
- Future work will include:
 - Bias correction techniques for GloSea5 rainfall forecasts.
 - More suitable non-linear downscaling approaches.
 - Continued development of AquMod
 - Incorporation of model parameter/structure uncertainty