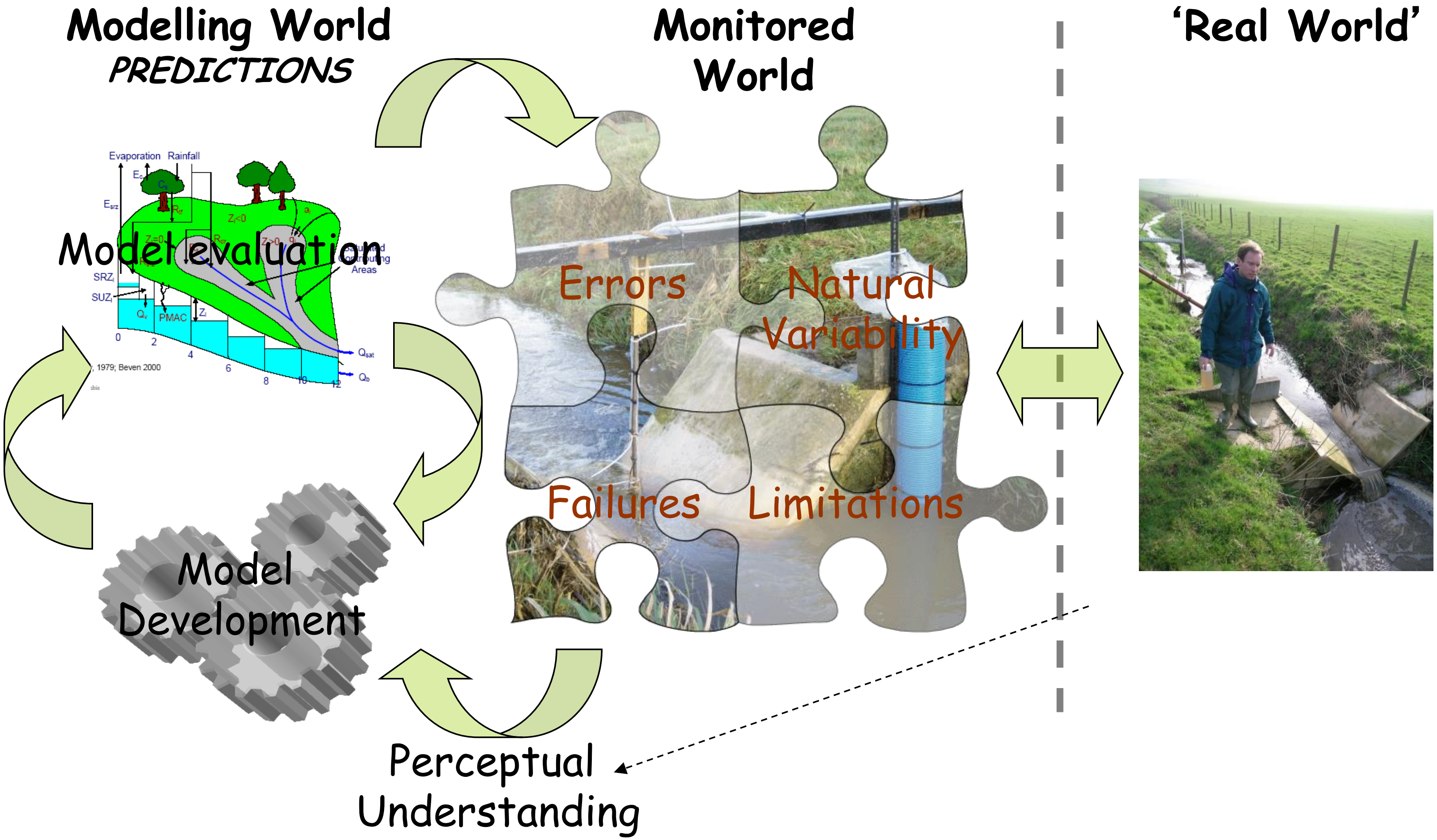
University of BRISTOL

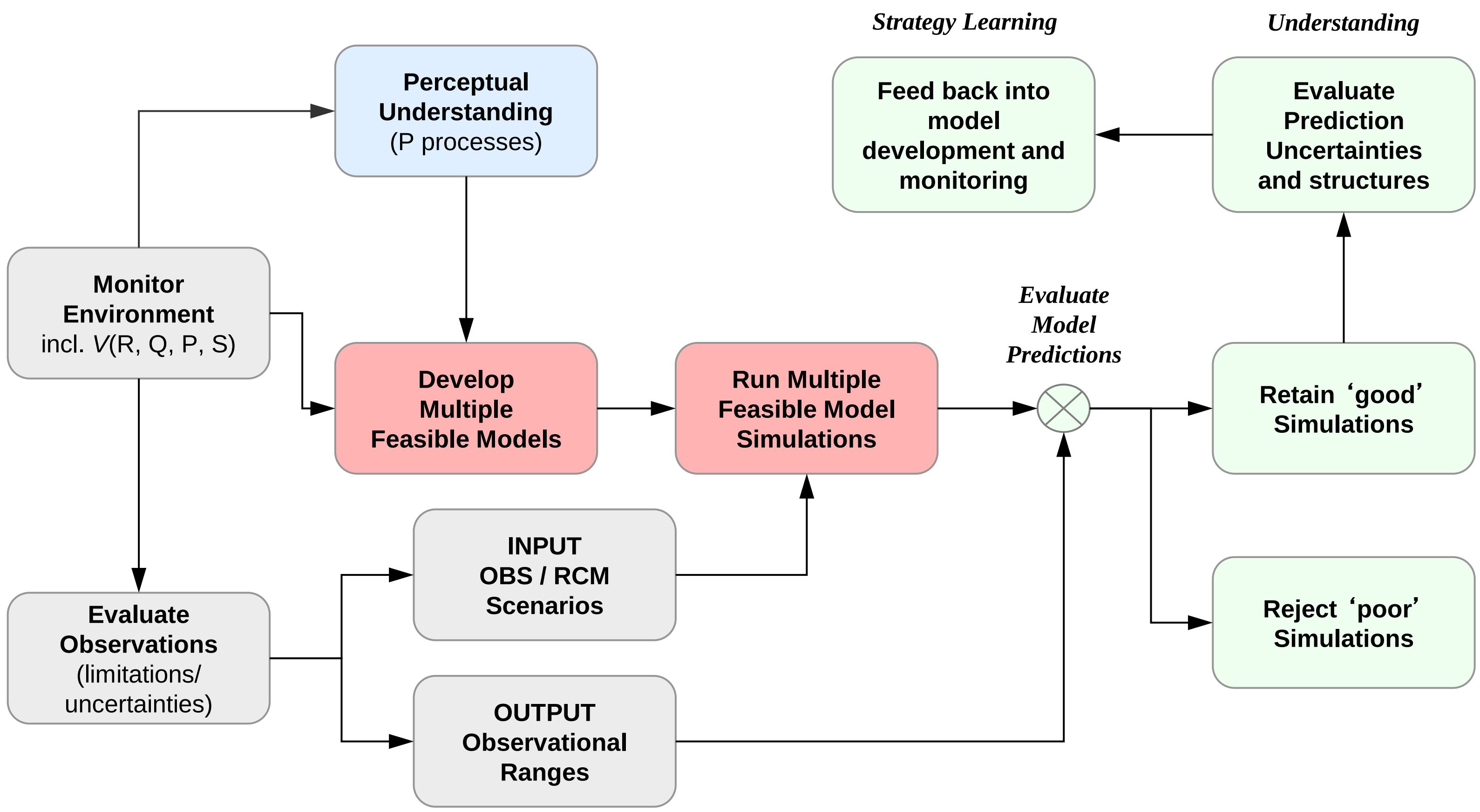
Developing a framework for including uncertainty analysis approaches in the evaluation of high frequency data to estimate catchment nutrient fluxes and behaviour

Lloyd, C. E.M., **Freer, J.E.**, Collins, A.L., Johnes, P. J. and Hampshire Avon DTC team

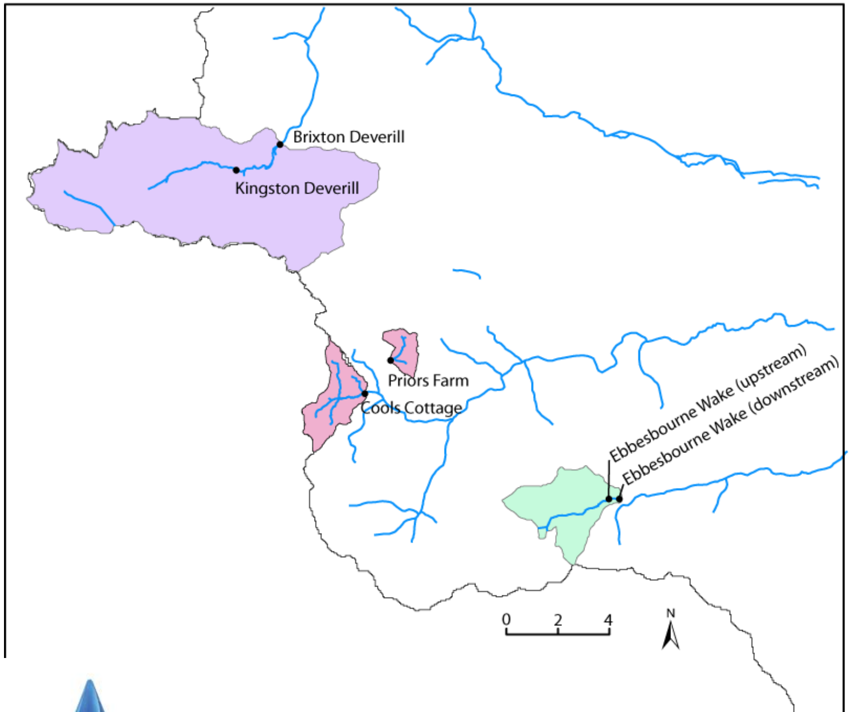
Dealing with observational uncertainties

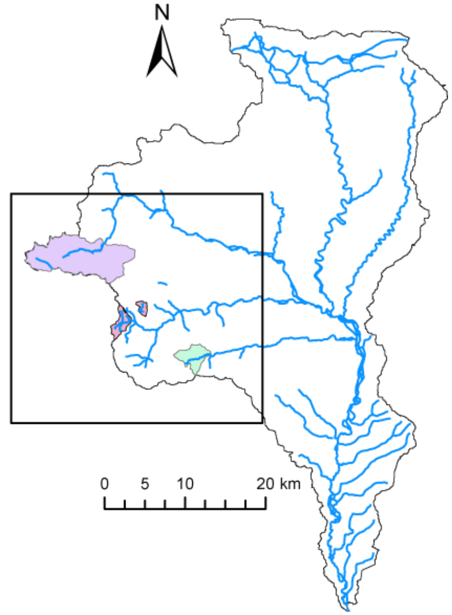


An Uncertainty Learning Framework for Environmental Modelling

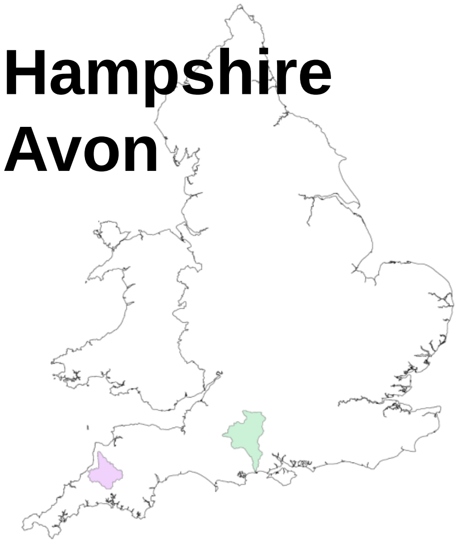


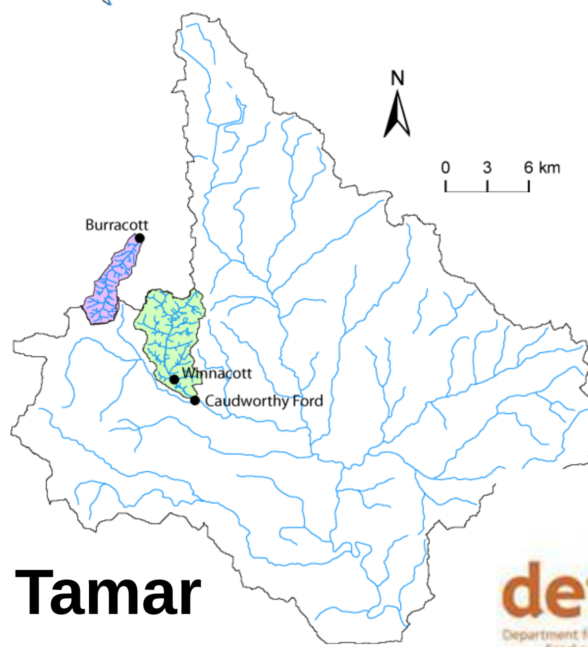
Hampshire Avon DTC





Hampshire Avon





Tamar

C. Lloyd, J. Freer, P. Johnes, A. Collins
and the Hampshire Avon DTC team

Hampshire Avon
Demonstration Test Catchment

defra
Department for Environment Food and Rural Affairs

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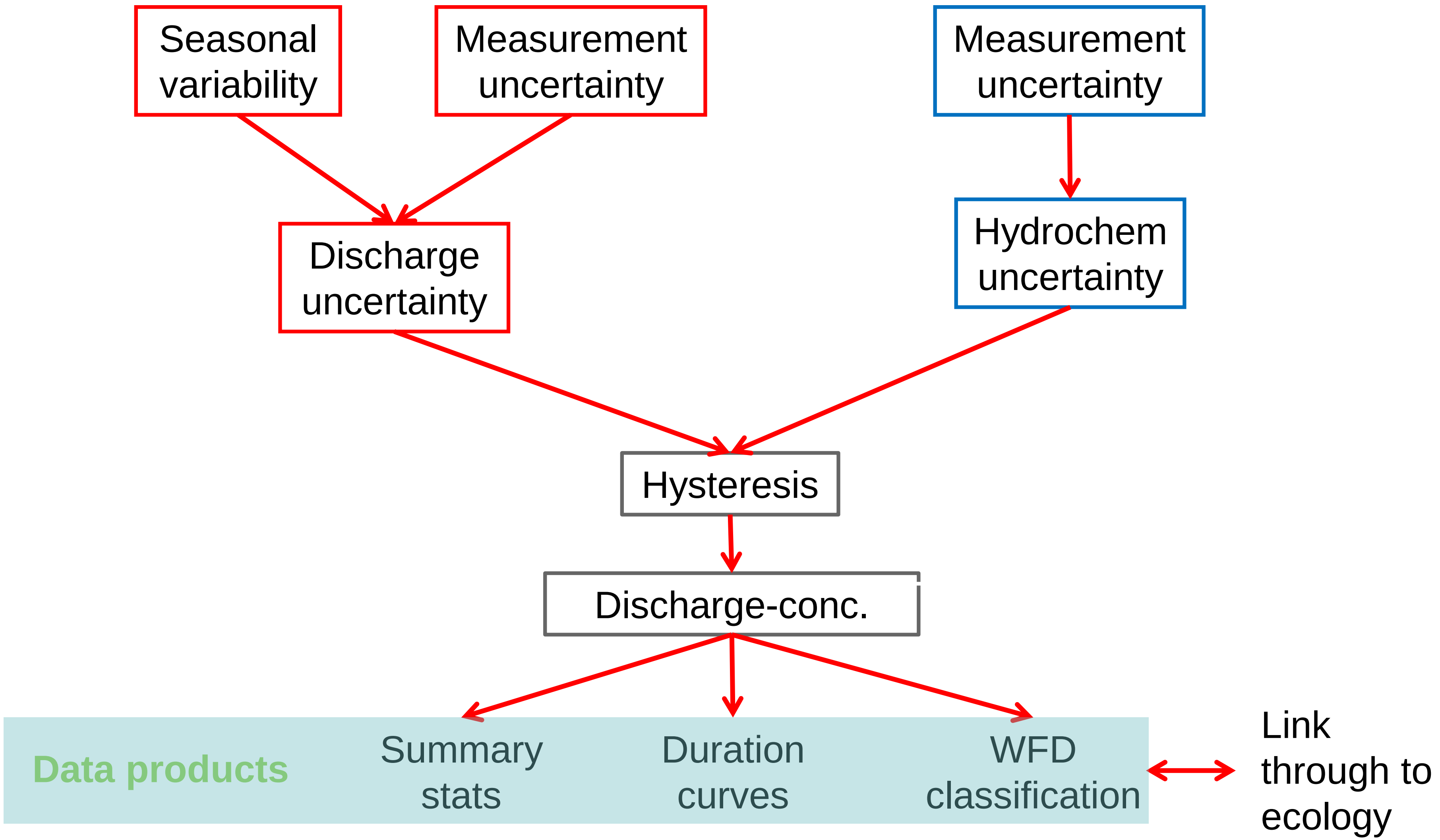
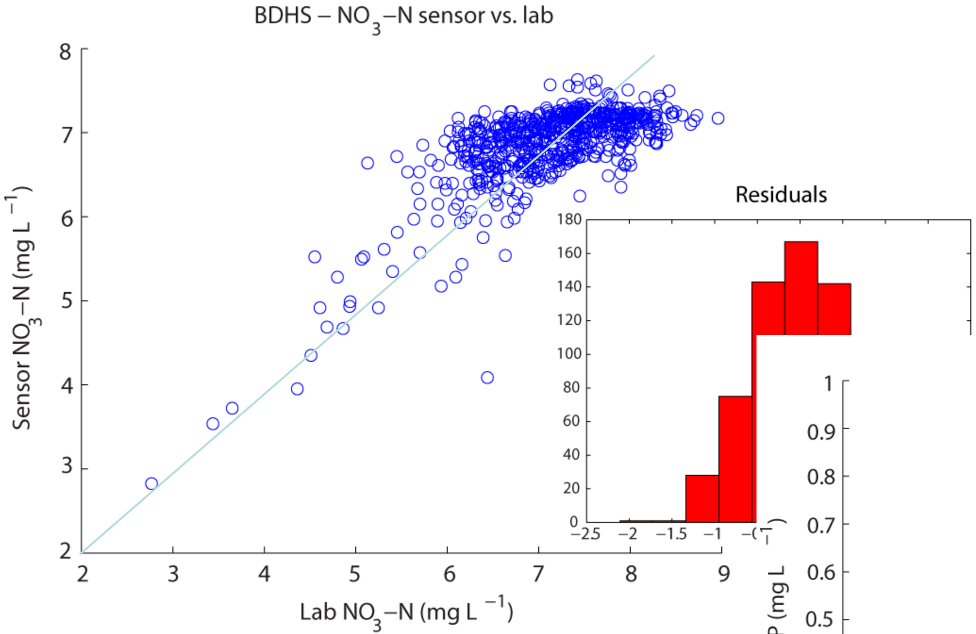
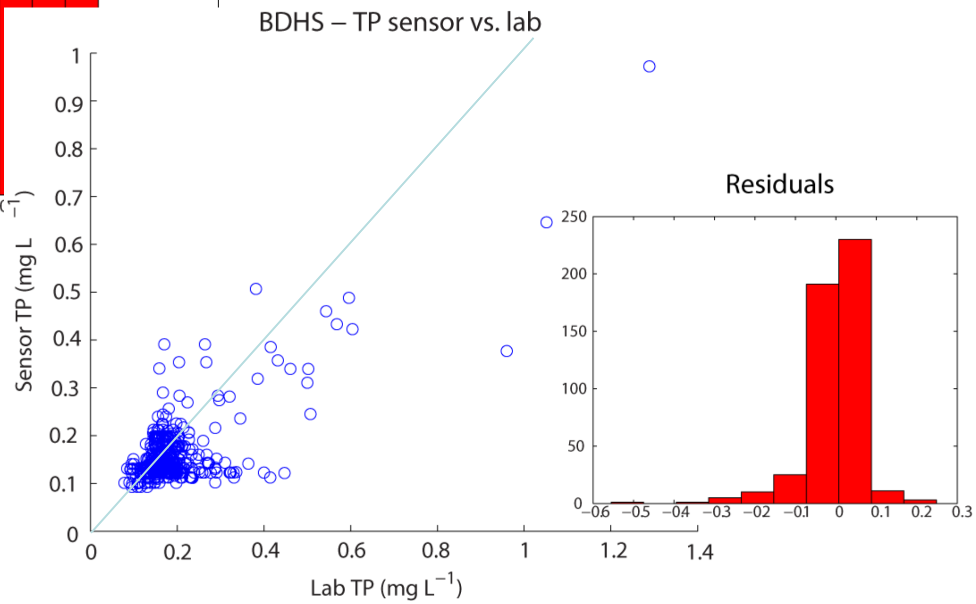
Conceptual framework



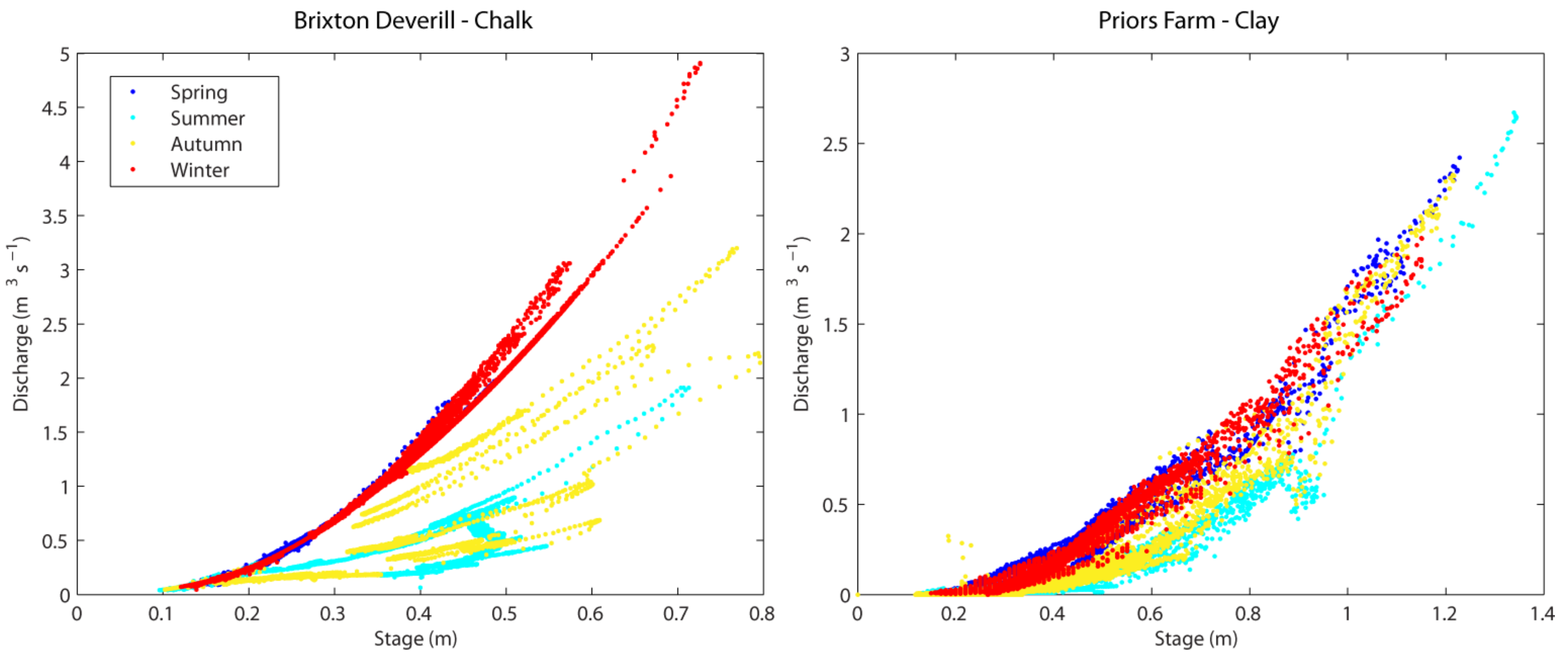
Characterising sensor uncertainty to lab analysis?





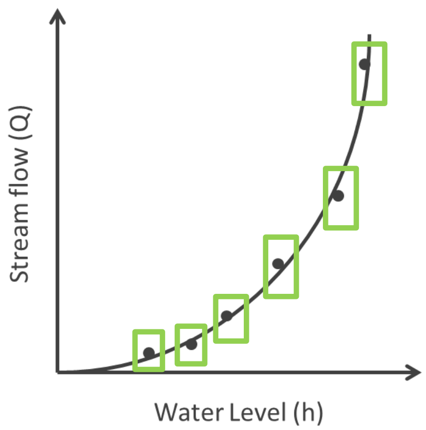
from Brixton Deverill catchment

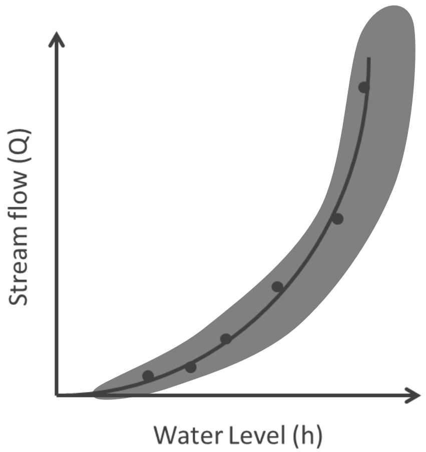
Discharge measurements and seasonality

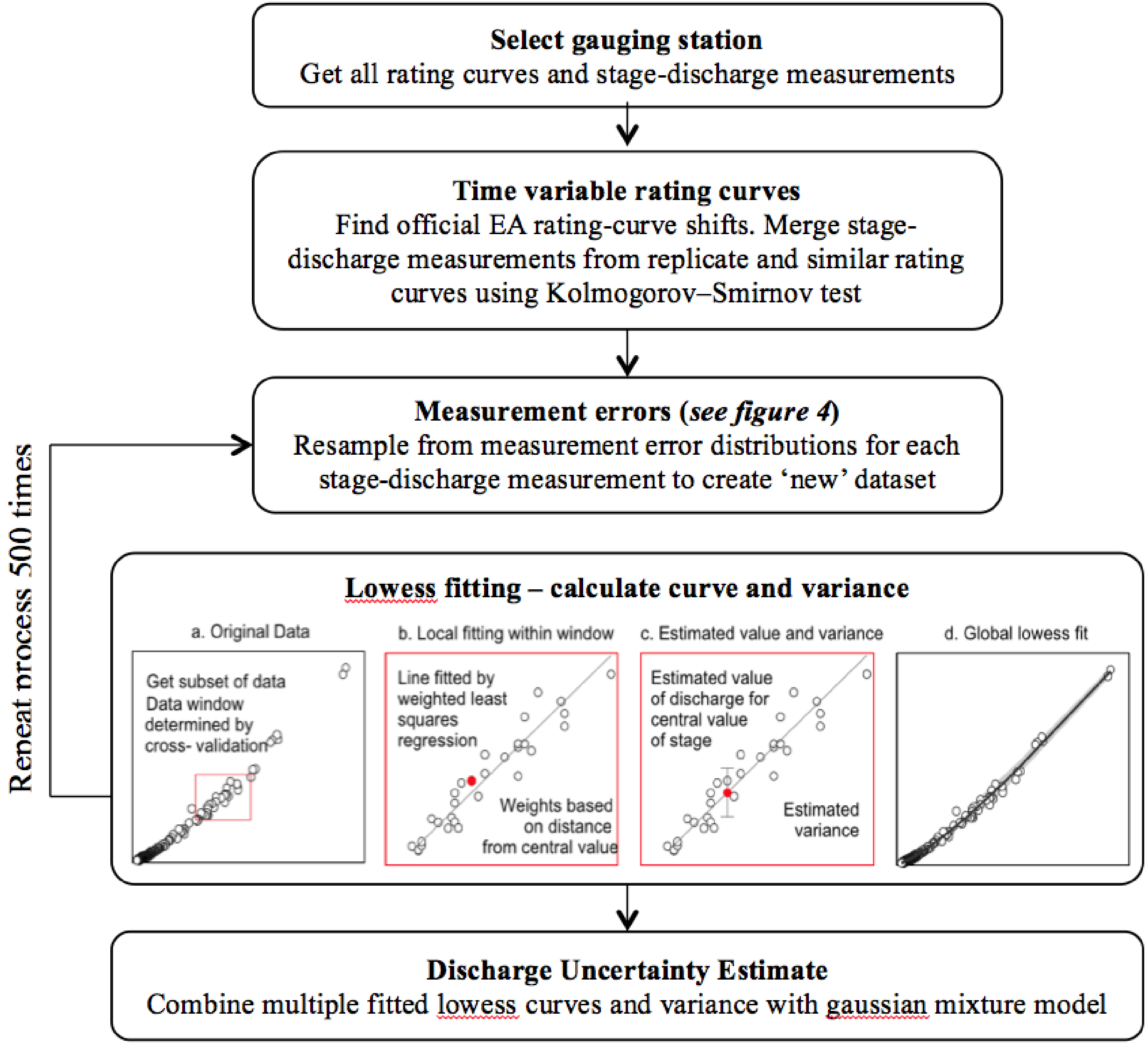


- Seasonal variation in stage-discharge relationships
- Error in discharge estimation has large impact on simple metrics such as nutrient loads

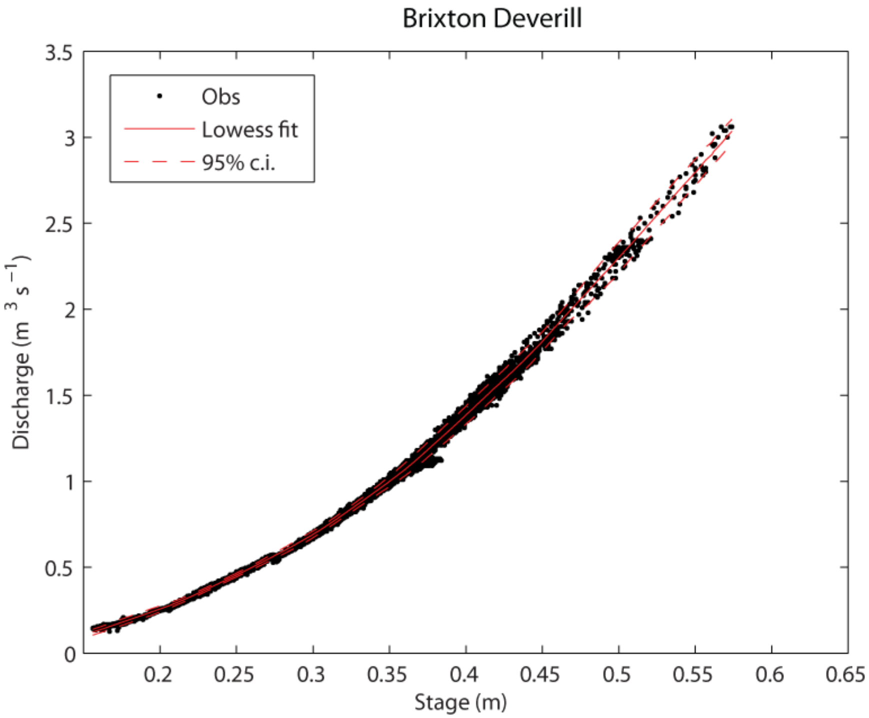
Discharge estimation

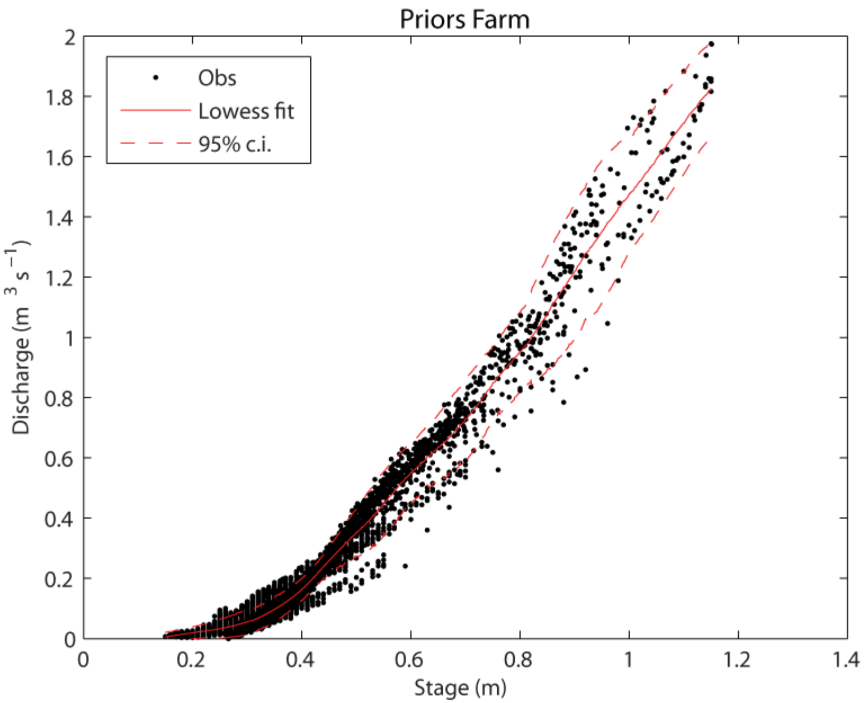






Resultant discharge uncertainties





'Stable' winter data to express measurement uncertainty

Note – there is a standard EA gauge that does not reflect the seasonal changes (structural errors)

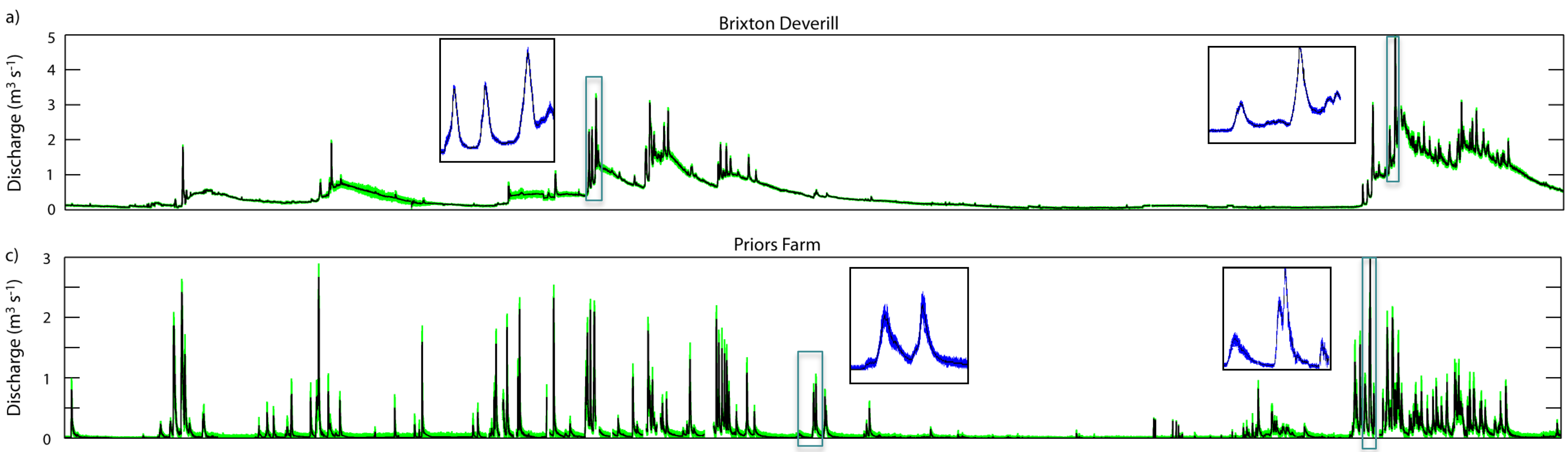
Error modelling

1st order autoregressive model

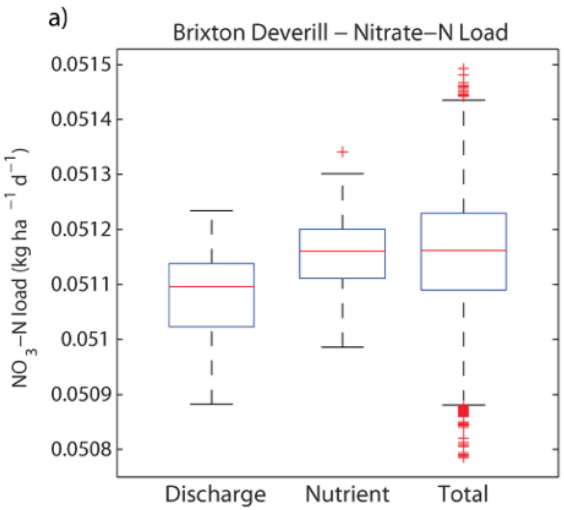
$$q_k = \alpha q_{k-1} + \sqrt{1-\alpha^2} W_k$$

where q_k is the error at time k, α is temporal autocorelation and W_k is random white noise at time k.

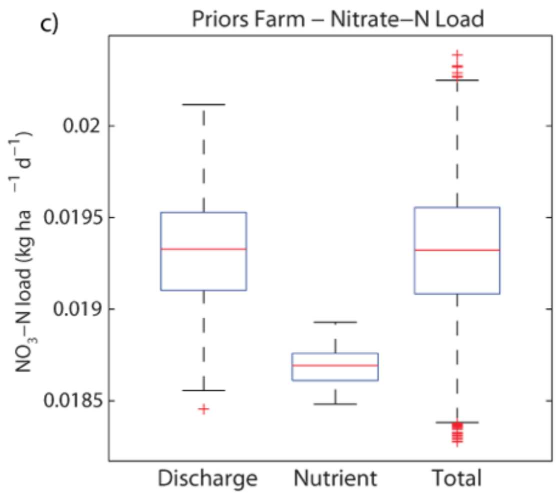
Time series of residuals from LOWESS fit → Calculate lag-1 correlation (α) → Generate random noise component (W_k) → Scale W_k by standard deviation of residuals at each stage height → Add to original time series



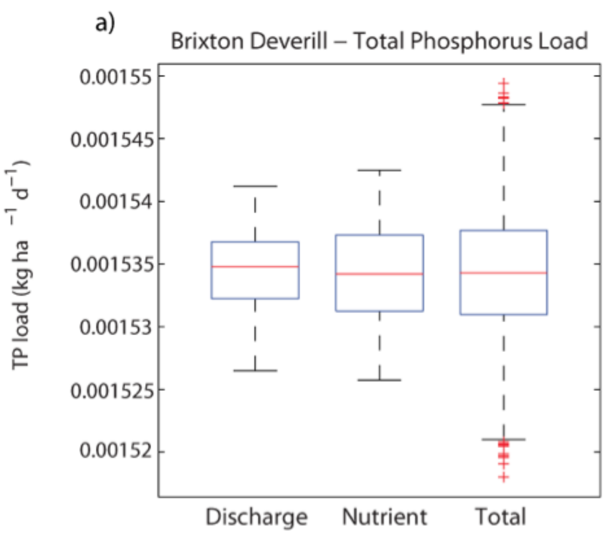
Load Uncertainties from Discharge and Nutrients – lab data



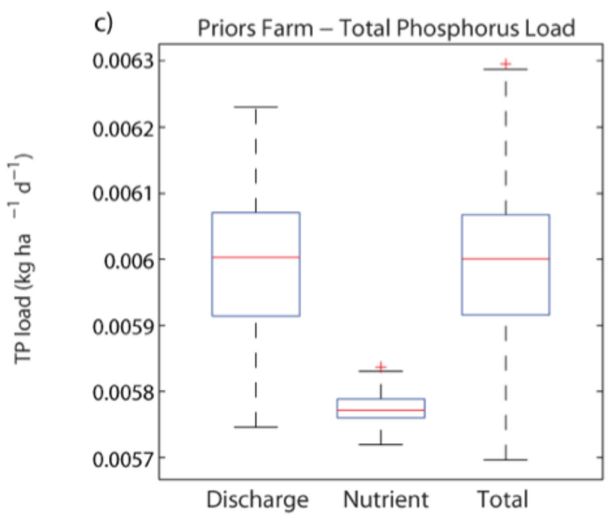
0.2 kg ha y^{-1}
(1.3%)



0.8 kg ha y^{-1}
(11.5%)



0.01 kg ha y^{-1}
(3%)



0.11 kg ha y^{-1}
(5.3%)

Load Uncertainties from Discharge and Nutrients – Sensor data

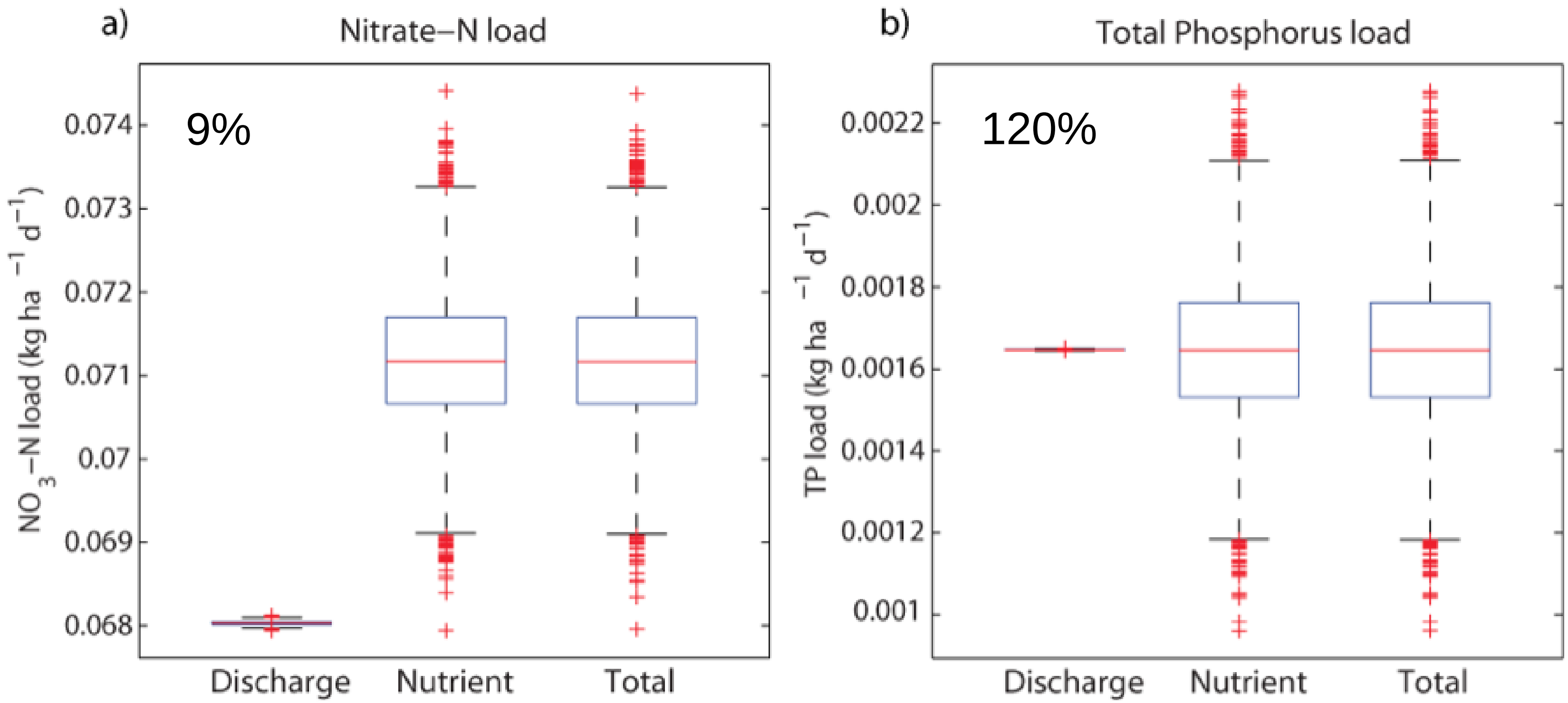
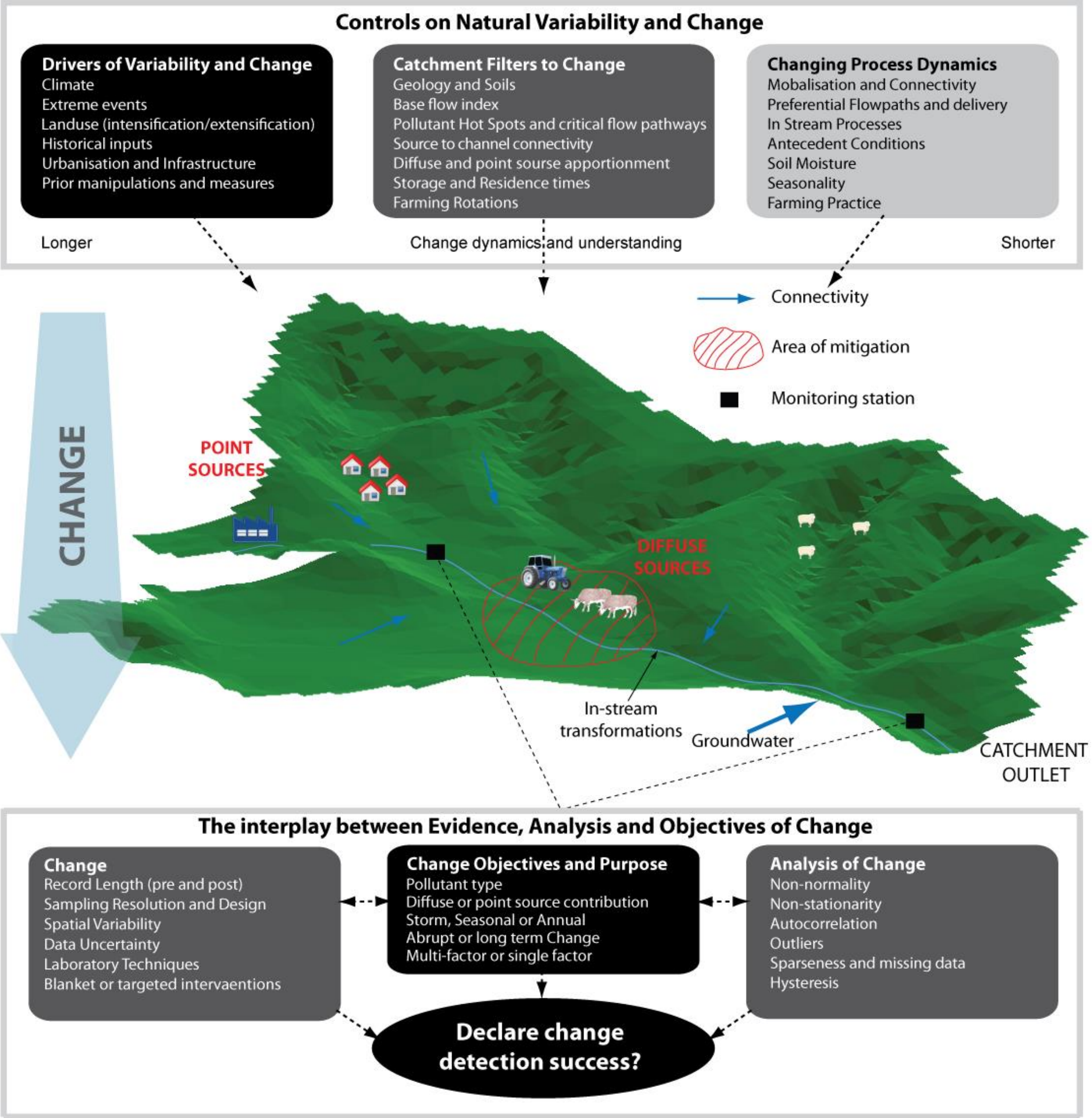


Figure 11: Boxplots showing the range of a) NO3-N and b) total phosphorus loads at Brixton Deverill using 30 min resolution sensor data, including discharge uncertainty, nutrient uncertainty and total uncertainty.

BD T Yr^{-1} Nitrate (best estimate): Lab: 93 Sensor 130 EA rating curve 176

Towards a general analysis framework for robust statistical interrogation of data



Lloyd et al. (2014)
Journal of Hydrology
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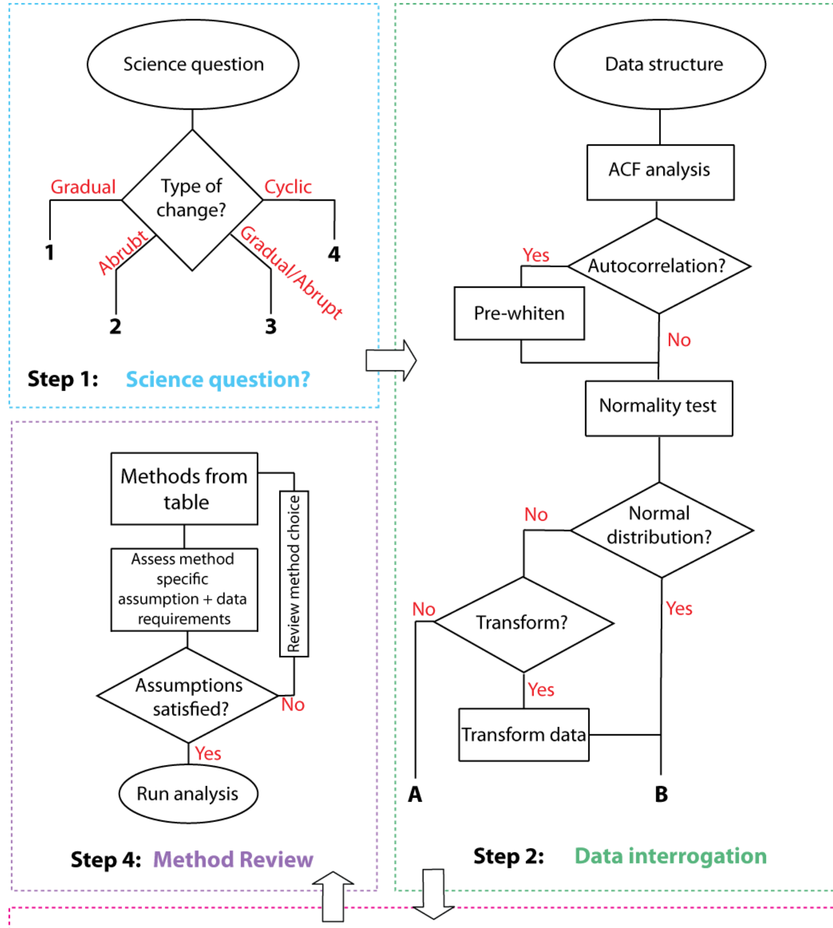
Towards a general analysis framework for robust statistical interrogation of data 2



	1	2	3	4
A	Linear regression (see table 1)	t-test, Yamamoto, ANOVA (see table 1)	Change-point analysis e.g. segmented regression (see table 1)	Wavelet analysis – e.g. Fourier transform (see table 4)
B	Spearman's Rho, Mann-Kendall, Sen's slope estimator, Seasonal-Mann-Kendall, Partial Hirsch-Slack (see table 3)	Mann-Whitney, Pettitt, Lepage, Kruskal-Wallis H-test (see table 2)	Non-parametric change-point analysis	LOWESS, Wavelet analysis – e.g. Morlet and Z transform (see table 4)

Step 3: Method Selection

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Some final thoughts…

Discharge uncertainty can be an important part of load estimation and determining WFD metrics – Understanding local conditions are important, as is seasonality

A generalised uncertainty evaluation procedure is critical for:

- Reflecting the quality of different data and comparative analysis between catchments
- Important to have frameworks from data rich to data poor sites
- Needed in a '*limits of acceptability*' approach to model evaluation

Need to ensure that analysis of the data is robust and statistically acceptable – particularly if interested in trends and change

May provide new information about catchment behaviour and what might change under mitigation – using hysteresis change

Dealing with uncertainty is critical to making sure predictions, no matter what they are used for, are understood in context….