

Developing a framework for including uncertainty analysis to estimate catchment nutrient fluxes and behaviour.

Charlotte Lloyd



<u>Lloyd, C. E.M.</u>, Freer, J.E., Collins, A.L., Johnes, P. J., Coxon, G. and Hampshire Avon DTC team.









Towards a general analysis framework for robust statistical interrogation of data

Controls on Natural Variability and Change Drivers of Variability and Change Catchment Filters to Change Changing Process Dynamics Climate Geology and Soils Mobalisation and Connectivity Base flow index Preferential Flowpaths and delivery Extreme events Landuse (intensification/extensification) Pollutant Hot Spots and critical flow pathways In Stream Processes Historical inputs Source to channel connectivity Antecedent Conditions Urbanisation and Infrastructure Diffuse and point sourse apportionment Soil Moisture Prior manipulations and measures Storage and Residence times Seasonality **Farming Rotations** Farming Practice Change dynamics and understanding Longer Shorter Connectivity Area of mitigation Monitoring station CHANGE **POINT** SOURCES In-stréam transformations Groundwater CATCHMENT OUTLET The interplay between Evidence, Analysis and Objectives of Change

Lloyd et al. (2014) Journal of Hydrology Vol. 514 pp. 297–312

DemonstrationTestCatchments





Change Objectives and Purpose
Pollutant type
Diffuse or point source contribution
Storm, Seasonal or Annual
Abrupt or long term Change
Multi-factor or single factor

Declare change detection success?

Analysis of Change

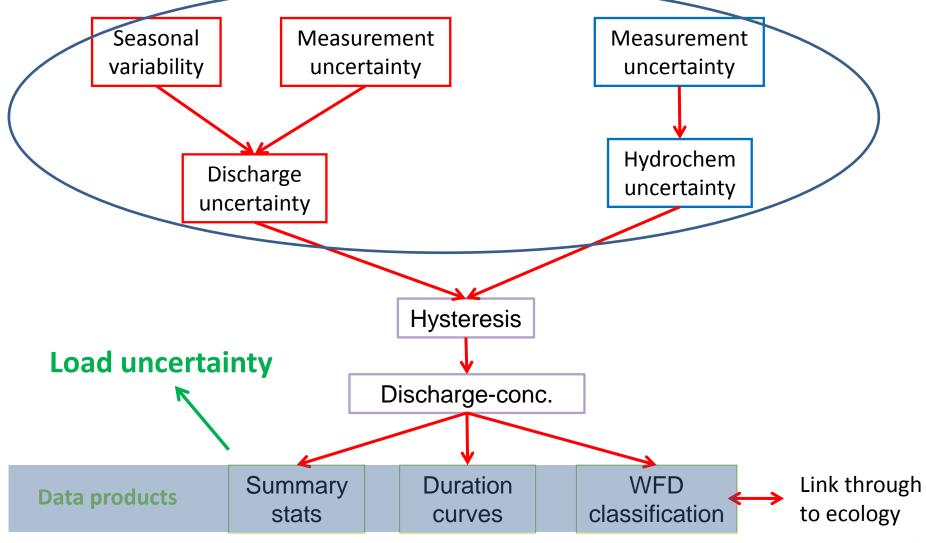
Non-normality Non-stationarity Autocorrelation Outliers

Sparseness and missing data
Hysteresis





Conceptual framework



DemonstrationTestCatchments

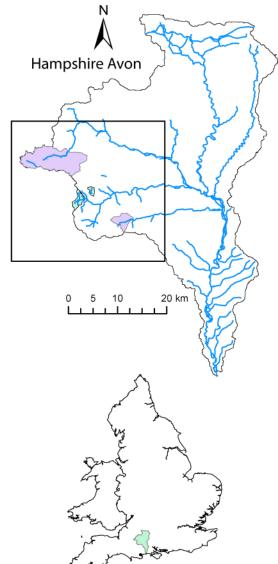


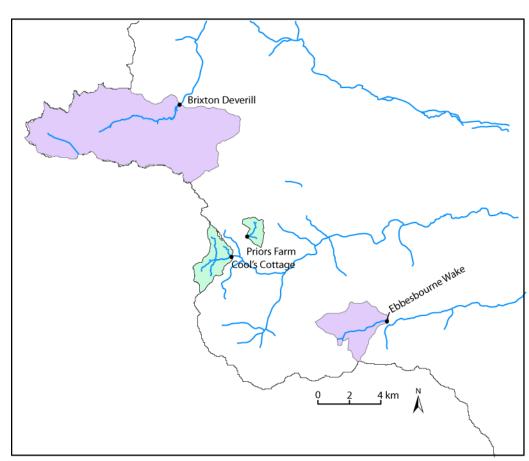






Field sites















Data

- 15 min paired stage-height and velocity
- 30 min nitrate (Nitratax) and TP (Phosphax)
- Daily nitrate and TP (ISCO and laboratory)







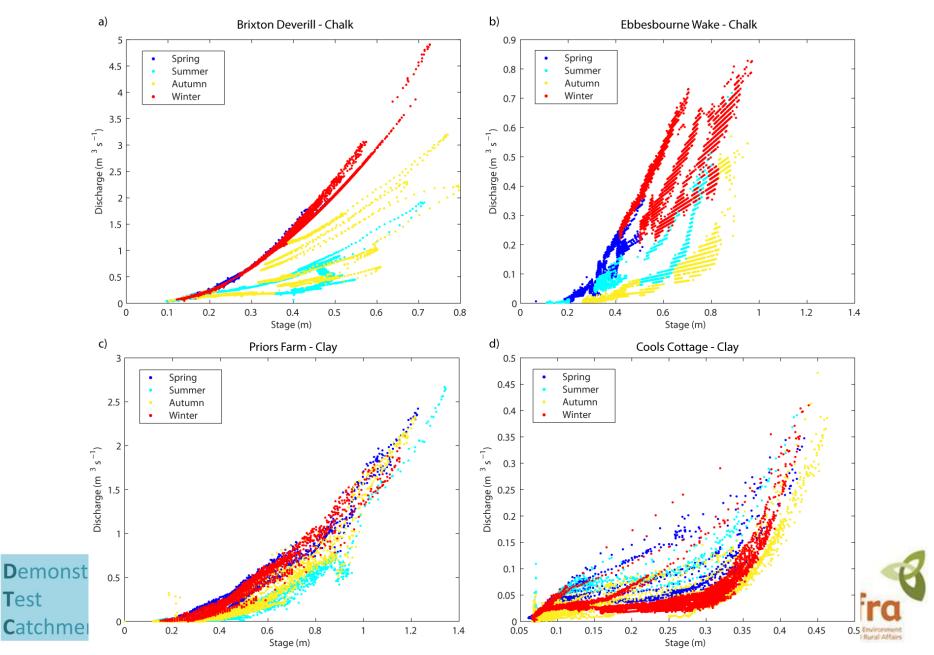








Stage-discharge relationships



Test

Discharge uncertainty – non-parametric method

Choose a stable period (usually winter) so that uncertainty represents observational uncertainty not structural changes.

Lowess fitting – calculate curve and variance a. Original Data b. Local fitting within window Estimated value and variance d. Global lowess fit Line fitted by Estimated value Get subset of data of discharge for weighted least Data window central value squares determined by regression of stage cross-validation Weights based Estimated on distance variance from central value



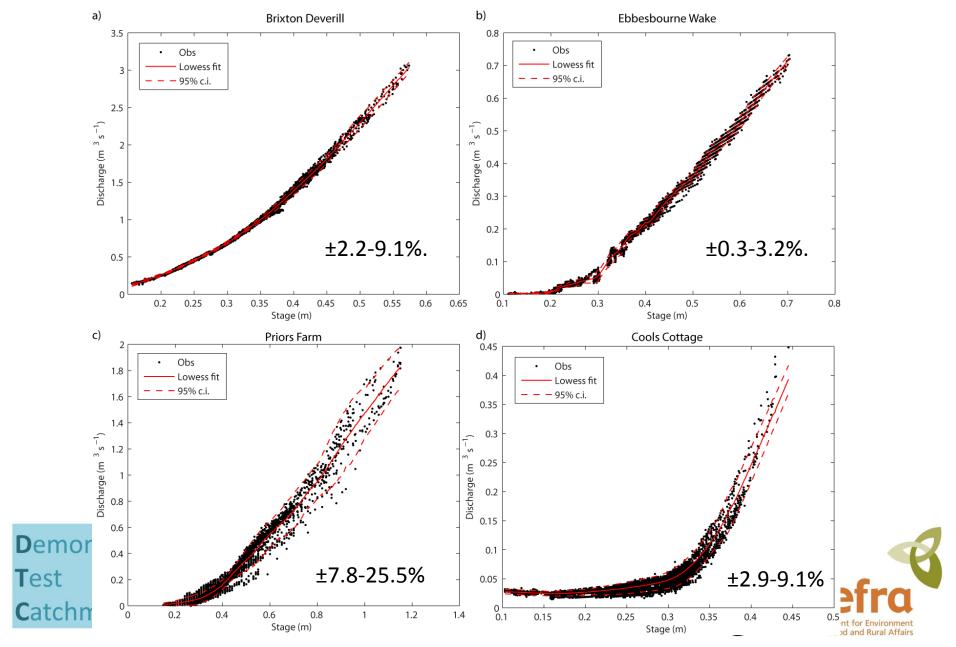




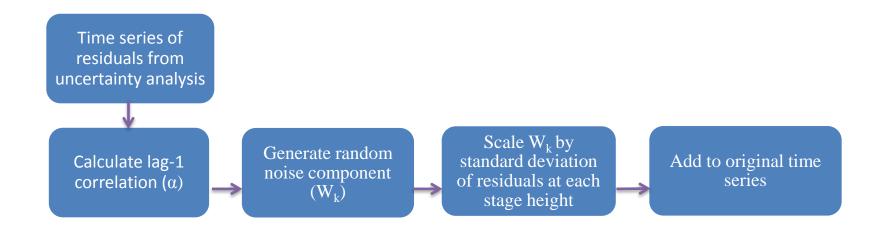




Discharge uncertainty



Error modelling





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

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

Lag-1 autocorrelation

White noise (scaled by st. dev)



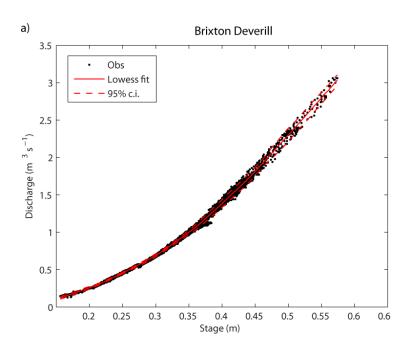




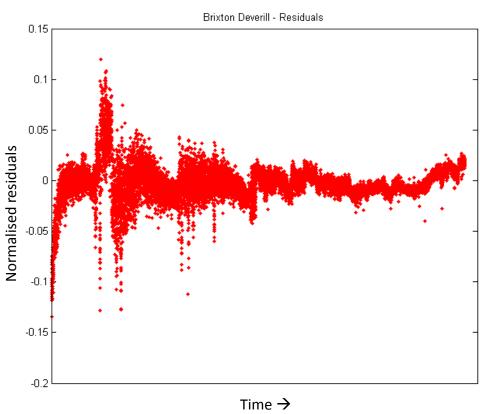




Discharge uncertainty



Residuals have structure over 2 seasons however are independent over short time-scales \rightarrow represented as random noise.



DemonstrationTestCatchments

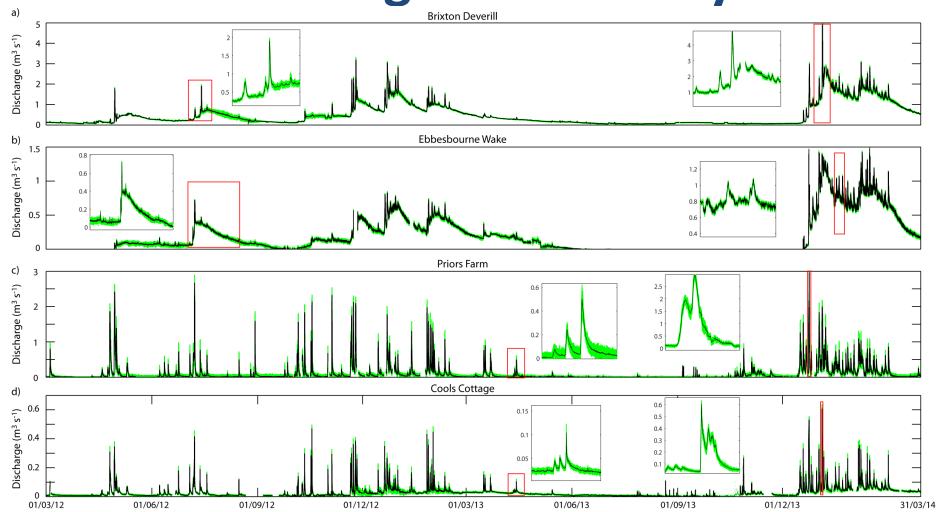








Discharge uncertainty













Nutrient uncertainty - Lab

- Repeated lab standards at a variety of concentrations
- Calculate the mean error and standard deviation of error
- No temporal autocorrelation in the errors as samples run in a random order
- Errors were heteroscedastic → larger st. dev errors (%) at lower concentrations



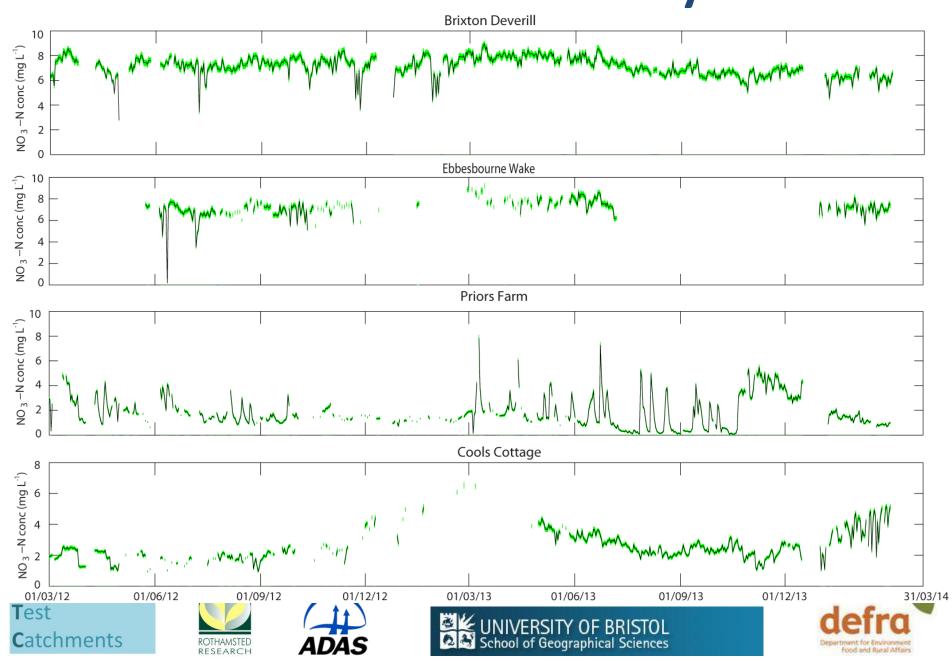






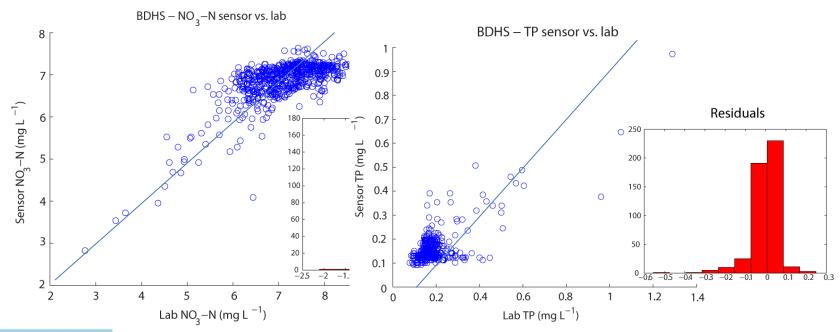


Nutrient uncertainty



Nutrient uncertainty - Sensor

- Sensor data series paired with lab samples (within 5 mins)
- All 100 iterations of lab data used to calculate error statistics for sensor data → uncertainty cascaded through analysis





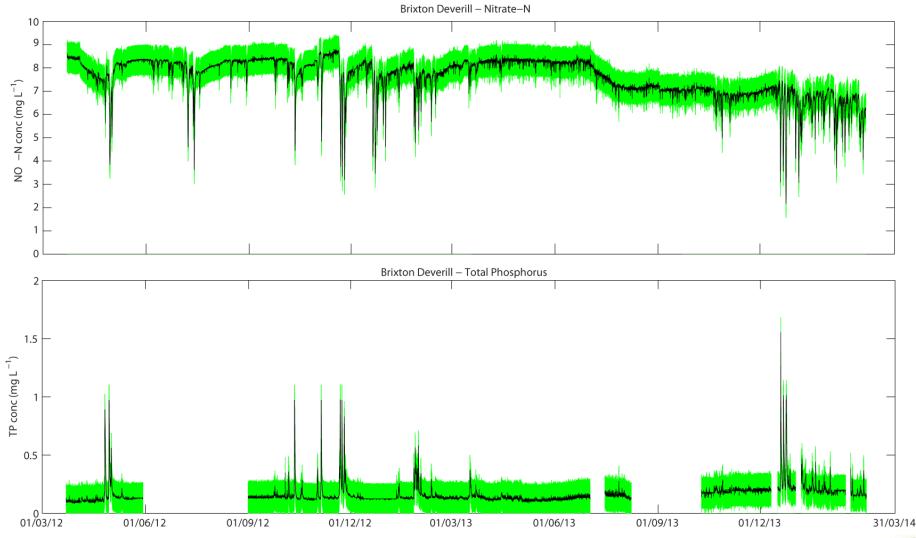








Nutrient uncertainty- Sensor





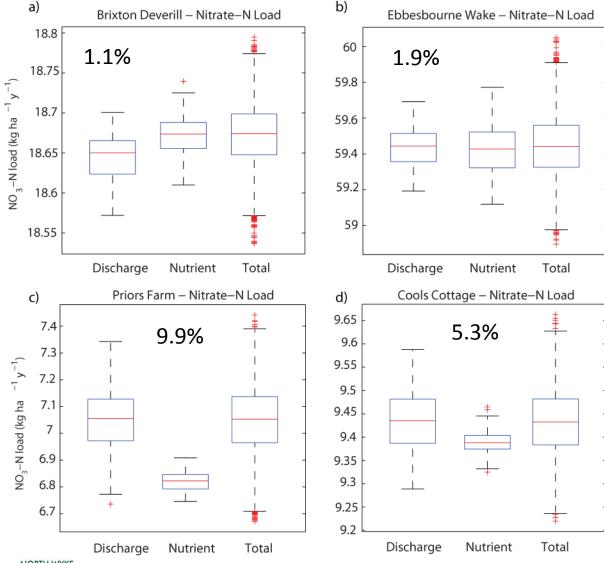








Impact on load estimation





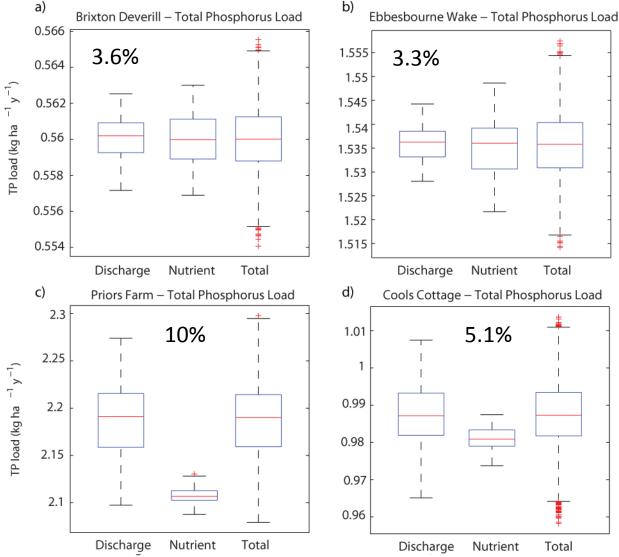








Impact on load estimation





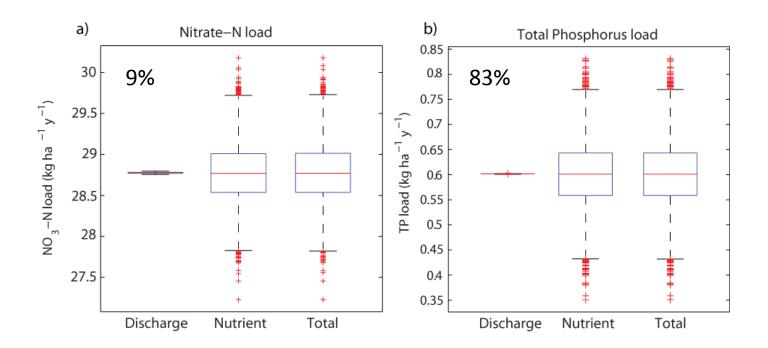








Impact on load estimation - sensor













Summary

- Using sensors to gain new insights into catchment processes
- Many challenges associated with sensor data collection and management
- Challenge the notion that high-resolution data is always better
- Highlights issues associated with the use of single rating curves
- Proposed a new methodology using non-parametric techniques which are more flexible
- Allows heteroscedasticity and temporal correlation to be taken into account
- Which is better: frequent but fuzzy data or infrequent and precise?







