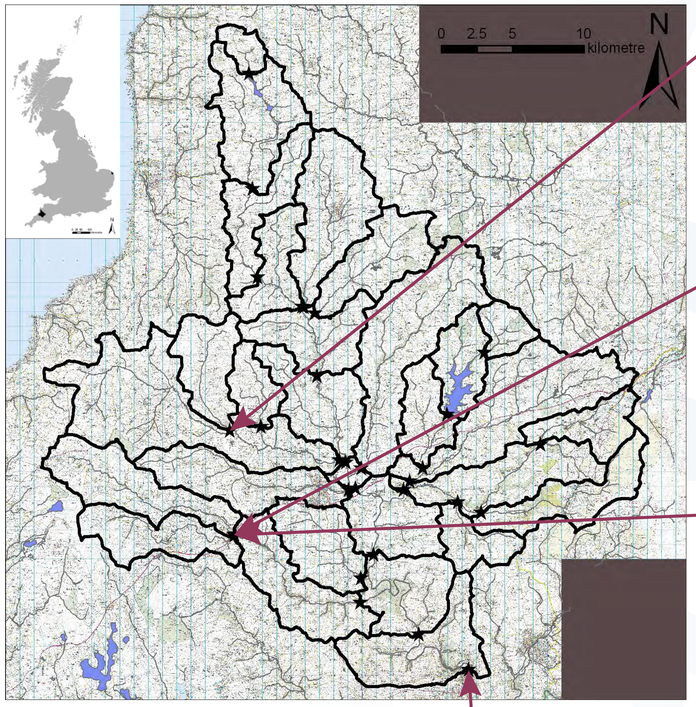
Reducing epistemic errors in water quality modelling through high-frequency data and stakeholder collaboration: The case of an industrial spill

Tobias Krueger[1], Alex Inman[2], Nick Paling[3]
[1]IRI THESys, Humboldt-Universität zu Berlin, Germany (+49 30 2093-66342, tobias.krueger@hu-berlin.de), [2]Independent consultant, UK, [3]Westcountry Rivers Trust, UK

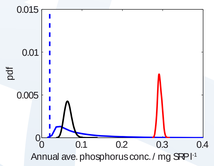
Study: Tamar catchment, SW England

- Simulation target: Soluble Reactive Phosphorus (SRP) concentration
- Temporal scale: 5-year annual average (Oct 2007 - Sep 2012)
- Spatial scale: subcatchment
- Model: extended nutrient Export Coefficient Model
- Phosphorus sources: Sewage Treatment Works (STWs), agriculture (14 landuse & 4 livestock classes), other industry, septic tanks, roads & tracks
- Uncertainty assessment: Bayesian parameter estimation



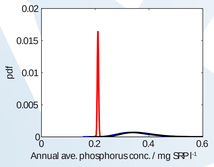
1 Anomaly

The simulated concentration pdf for the Caudworthy subcatchment (**-**) was in the upper tail of the concentration pdf estimated from low-frequency monitoring data (**-**). It was an order of magnitude higher than the estimate from high-frequency Demonstration Test Catchment (DTC) data for the subperiod Oct 2011 - Sep 2012 (**--**). When correcting for an industrial spill (see below), the simulated pdf assumed more probable values (**-**).



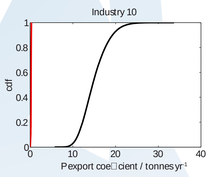
2 Explanation

The simulated concentration pdf for the upper Inny subcatchment (**-**) was in the lower tail of the concentration pdf estimated from the monitoring data (**-**), pointing to a missing P source here. Through good contacts to the local Environment Agency, the missing source could be identified as an industrial spill. When correcting for the spill, the simulated pdf assumed more probable values (**-**).



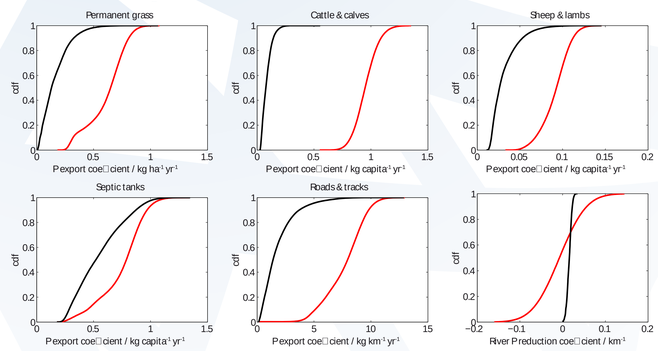
3 Correction

The magnitude of the spill remained unknown. However, increasing the prior range of P export from the industry in question by 2 orders of magnitude (**-**) beyond what was estimated from the consented discharge (**-**) accommodated more probable concentration simulations for all subcatchments.



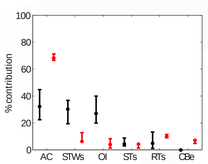
4 Epistemic error effect on parameters

The need for large P inputs into the upper Inny subcatchment led to unduly large export coefficients for the dominant sources in that subcatchment (**-**) compared to the corrected case (**-**). The river P reduction coefficient pdf extended to negative values, simulating the river channel acting as a P source (which in theory could have been possible through legacy P pools). These parameter estimates increased the concentration simulations also in the other subcatchments while remaining within the observed uncertainty bounds (albeit in the upper tails of the pdfs).



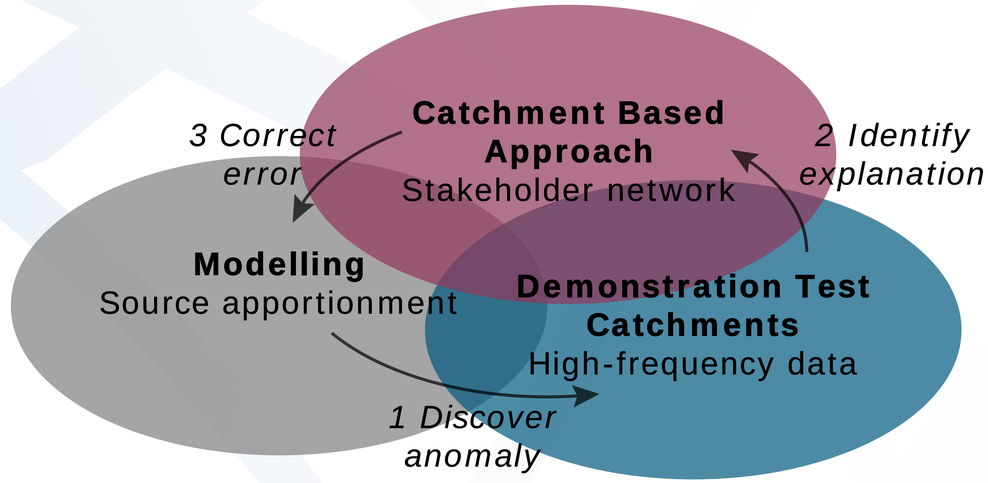
5 Epistemic error effect on source apportionment

Neglecting the industrial spill would have overestimated the contributions from agriculture (AC), roads & tracks (RTs) and the channel (CBe) and would have underestimated the contributions from industry (OI) and STWs (**-●-** median with 90% credible interval) compared to the corrected case (**-●-** median with 90% credible interval).

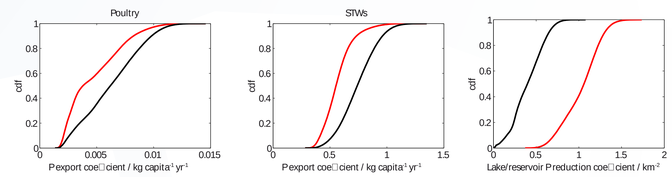


Conclusions

- The anomaly was discovered through high-frequency data that contained more information than traditional monitoring data
- The explanation was identified through good contacts to the local Environment Agency that had developed over 5 years of stakeholder collaboration where such sensitive information could be shared
- The various pieces of information were enabled through different policy initiatives that came together somewhat incidentally
- Although uncertainties were accounted for in the model, epistemic errors rendered them altogether meaningless
- Here this required revisiting the priors which does not sit well with the Bayesian learning paradigm
- We suggest that missing important sources is an often overlooked epistemic error in water quality modelling
- Such errors may be corrected through high-frequency data and the collective intelligence of stakeholder networks



The positive concentration bias was in parts compensated by unduly small export coefficients for sources not dominant in the upper Inny subcatchment and unduly large P reduction in lakes and reservoirs (**-**) compared to the corrected case (**-**). This compensation effect made the error harder to detect initially.



Tobias Krueger
IRI THESys
Humboldt-Universität zu Berlin
Mail: Unter den Linden 6, D-10099 Berlin, Germany
Tel.: +49 30 2093-66342
Fax: +49 30 2093-66335
E-Mail: tobias.krueger@hu-berlin.de
Web: www.iri-thesys.org/research_themes/jrg/land_water

NATURAL ENVIRONMENT RESEARCH COUNCIL
Westcountry Rivers Trust
University of East Anglia

IRI THESys
Integrative Research Institute on Transformations of Human-Environment Systems
Humboldt-Universität zu Berlin
Mail: Unter den Linden 6, D-10099 Berlin, Germany
Tel.: +49 30 2093-66336
Fax: +49 30 2093-66335
E-Mail: iri-thesys@hu-berlin.de
Web: www.iri-thesys.org