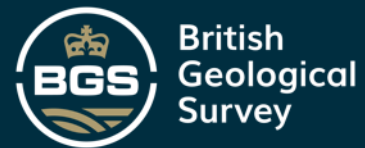




EQUIPT4RISK

Evaluation, quantification and identification
of pathways and targets for the assessment
of shale gas risk

PAULINE SMEDLEY





Project Partners



Acknowledgements: Grant Allen (WP1), Dave Lowry (WP1), Tom Randles (WP2), Andy Newell (WP2), Brain Baptie (WP3), Max Werner (WP3), Fred Worrall (WP2,4), Chris McDermott (WP5), Gus Fraser Harris (WP5), Andrew Hughes (WP5) and the rest of the project team

Work Packages and Science Questions

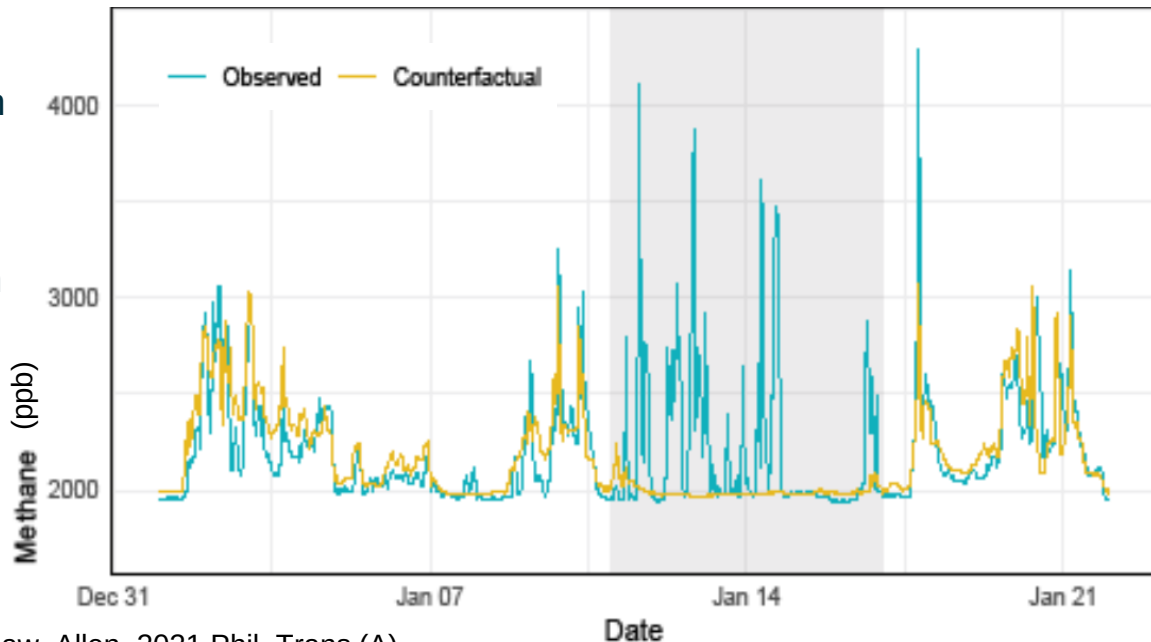
Evaluation, quantification and identification of pathways and targets for the assessment of shale gas risk

- 1) Properties, parameters, processes important for characterizing key SPR linkages and combinations?
- 2) Actual/potential contaminant fluxes and seismic hazard characteristics (and uncertainties) and how do these evolve?
- 3) Indicators of environmental change/impact most sensitive to the stresses induced by deep subsurface operations?
- 4) How can risks be integrated and up-scaled for a fully developed industry, to evaluate cumulative and whole lifecycle risks?



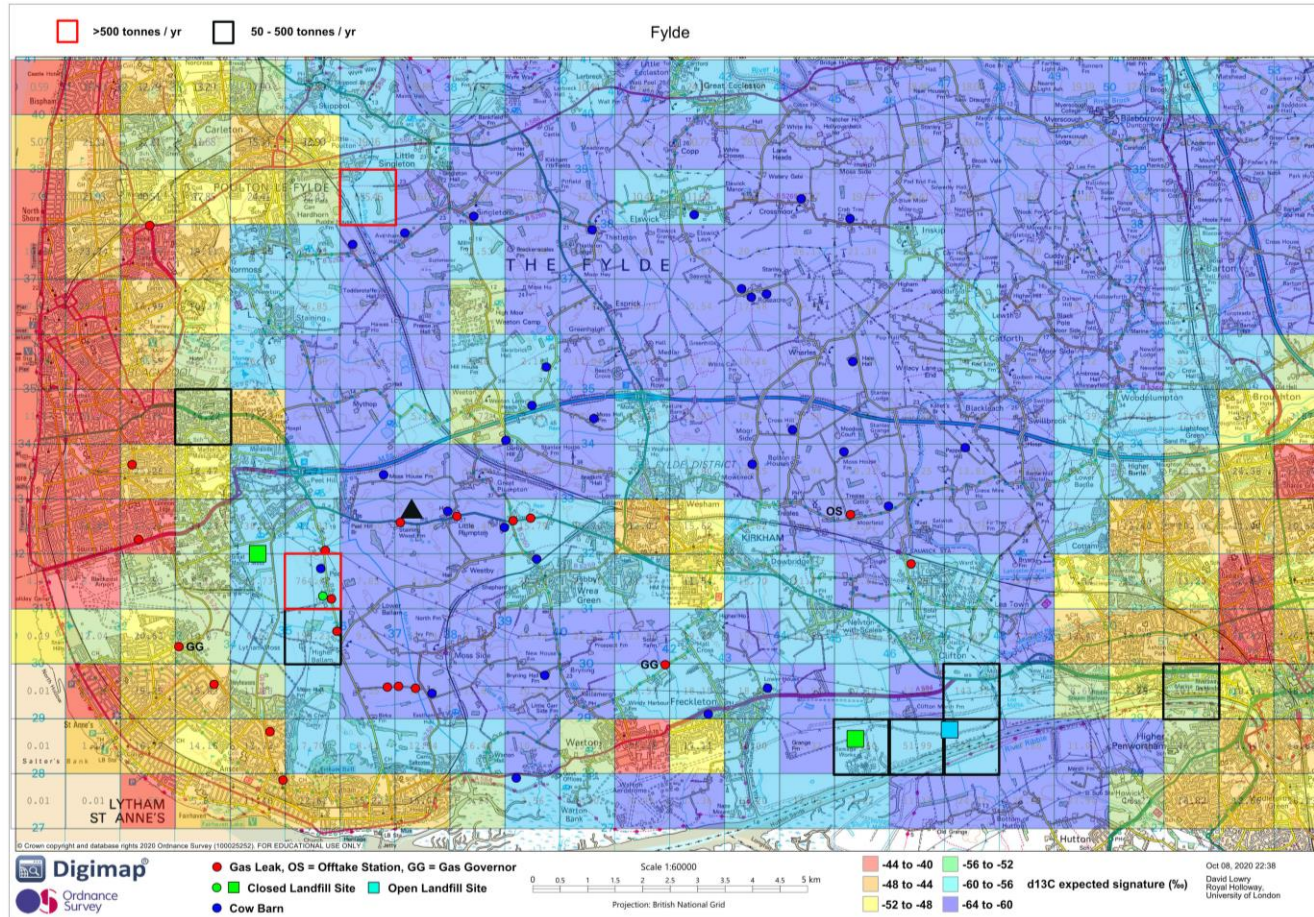
Air: Machine learning tools for new emission detection

- Machine learning algorithms applied to detect general emission reductions during COVID-19 lockdowns
- Random forest model trained with 3 years' data prior to fracking (2016-2018)
- Model simulates relation between CH_4 and all other parameters and flags periods of unexpected change (pollution events)
- Model tested for January 2019 N_2 lift event (cold vented CH_4)



Shaw, Allen, 2021 Phil. Trans (A)
Shaw, Allen, et al. 2020 J. Air & Waste Man. Assoc, 70,1324
Milkov, et al. 2020 Nature Scientific Reports, 10, 4199
Nisbet et al. 2020 Rev Geophys, 58
Shah et al. 2020 Env Res Comm, 2, 021003

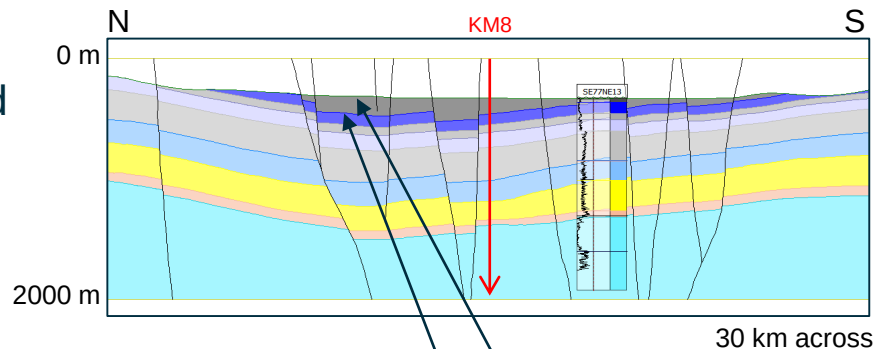
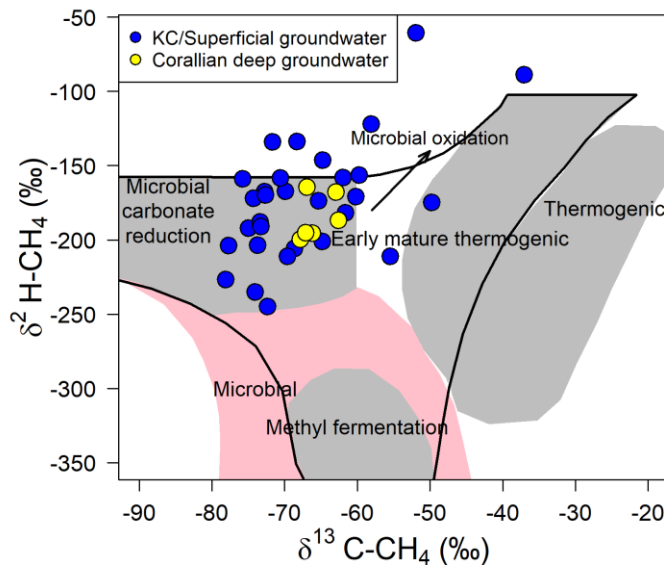
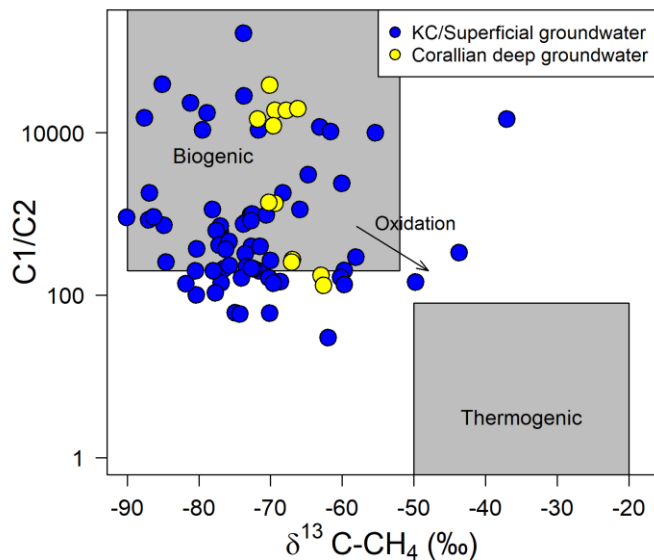
Atmospheric methane isotopic map for the Fylde



Lowry et al., 2020
STOTEN

Water: Characterising groundwater methane baseline

- Vale of Pickering: Kimmeridge Clay (KC) and Corallian aquifers
- High dissolved CH_4 concentrations
- Characterised C and H isotopic composition

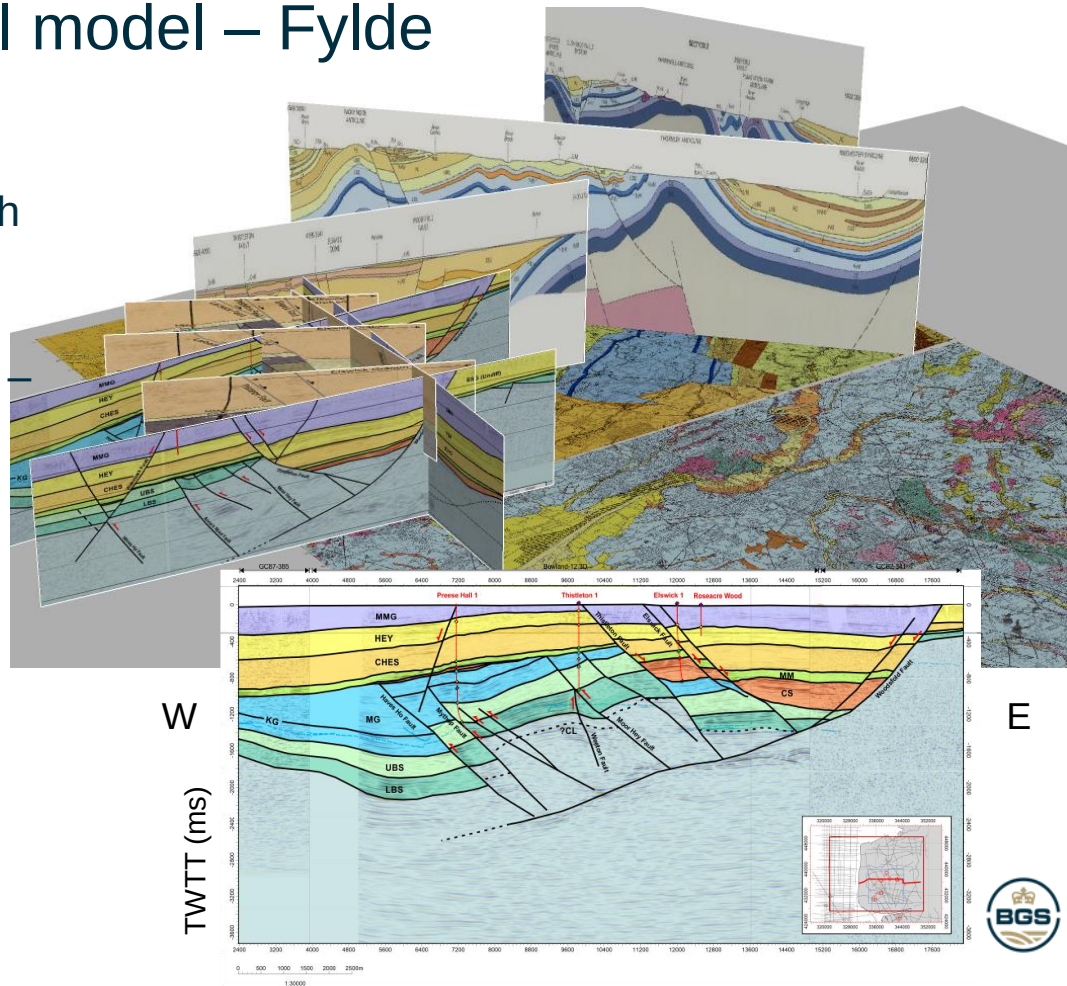


Kimmeridge Clay

Corallian

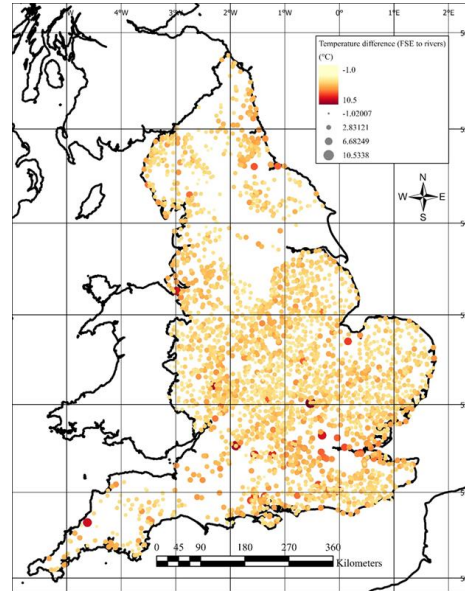
Improved 3D geological model – Fylde

- Composite model using 2D and new 3D seismic data coupled with BH data improves structural interpretation
- Increased number of fault blocks – N-S and E-W - greater degree of compartmentalisation in Carboniferous
- Potential implications for groundwater flow and contaminant migration
- Links to Challenge 3

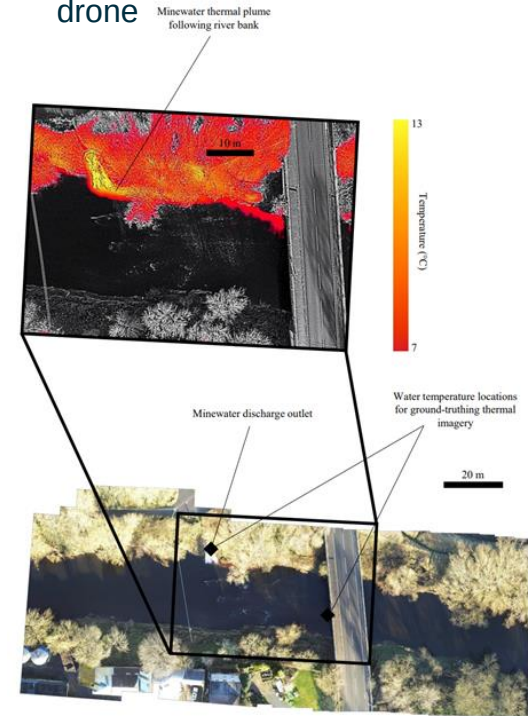


Pollutant pathways and properties

- Investigations of temperature
 - Surface water not helpful in identifying deep groundwater flux to surface
 - Sewage discharge temperatures above ambient river temperature (potential for heat recovery)
 - Drone surveys detect warmer minewater discharge



Minewater discharge surveyed by thermal imaging drone

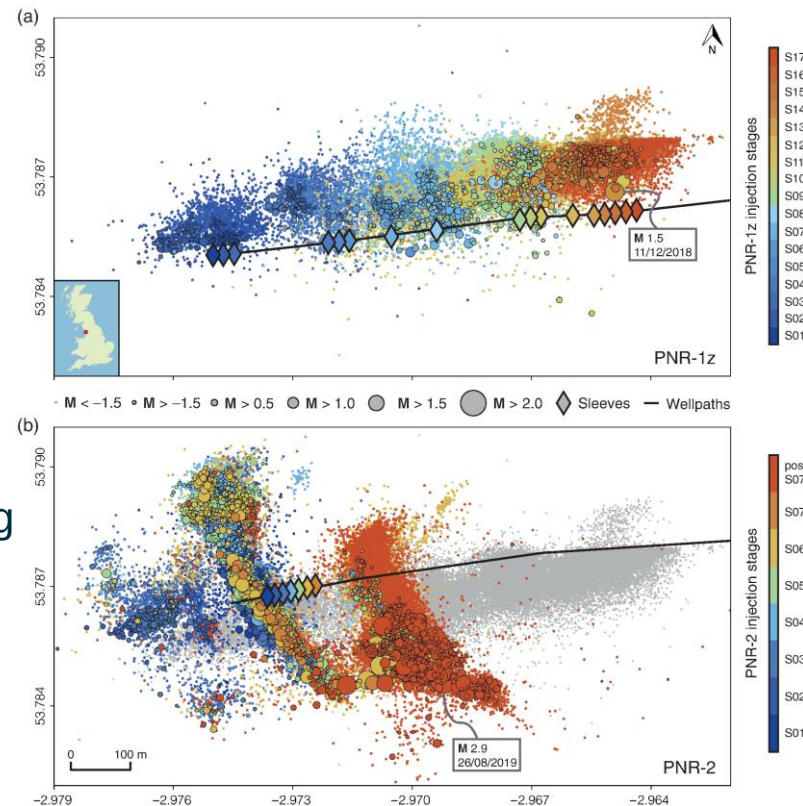
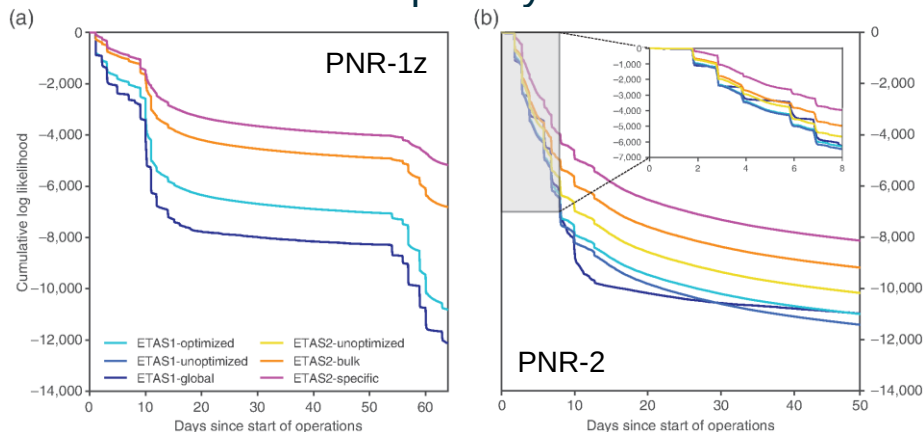


Wilson et al., 2020 Hydrol Proc, 24, 3271

Wilson and Worrall, 2021 Env Sci Water Res Tech

Earth: Probabilistic seismic forecasting - PNR

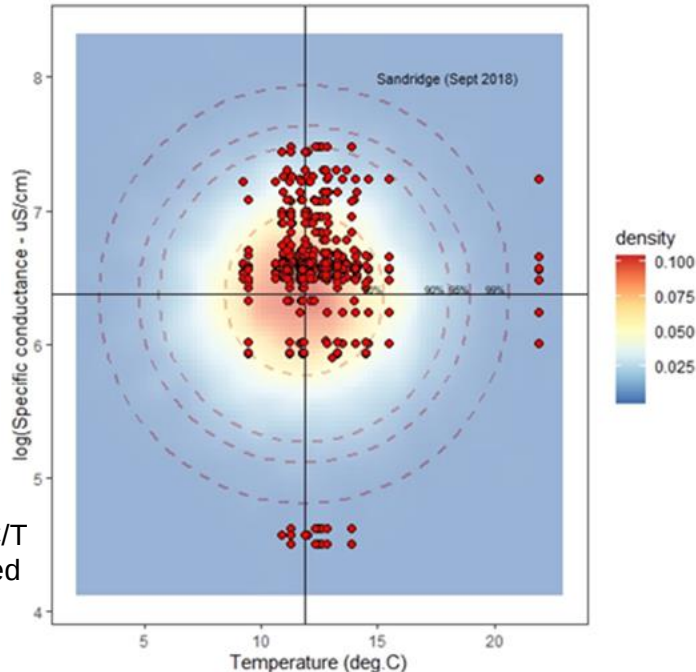
- ETAS (Epidemic-type aftershock sequence) statistical models used to predict HF-induced seismicity
- Standard and injection-related ETAS models
- Injection-related outperform standard models especially at high seismicity
- Predictive capability in real-time decision making



Mancini et al., 2021.
Seismol Res Lett.

Development of dynamic baselines

- Use of Bayesian hierarchical models to assess change (deviation from baseline)
- Predict the distribution of a monitored value to assess anomalies

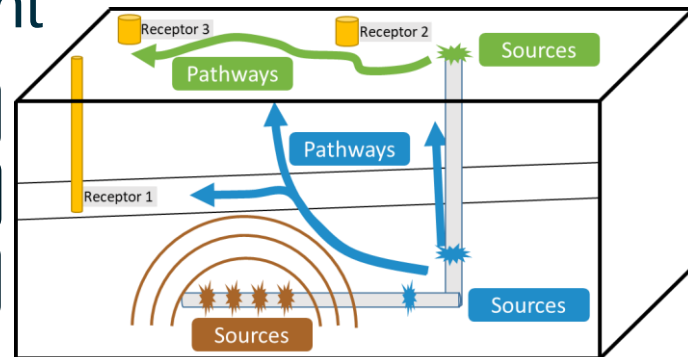
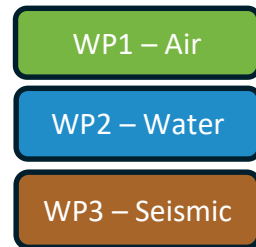
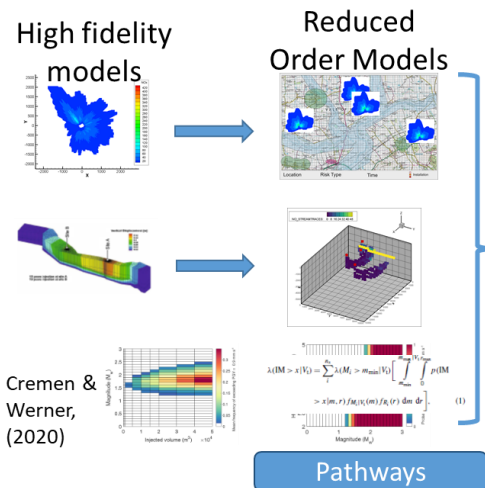


Observed vs modelled SEC/T data for a frequently sampled borehole – probability distributions

Worrall et al., 2021. Env Sci Proc Impacts, 23, 1116
Wilson et al., 2020. STOTEN 711, 134854
Worrall et al., 2019. J Hydrol, 572, 516

Model integration and risk assessment

- Integrated risk from SG operations within the context of the ISO31000 risk management framework



- Different source types
- Different pathways
- Different receptor interactions
- Different timescales of impact
- Different modelling approaches
- Different stages of development
- Plus cumulative risk of multiple wells

Impact → Probability ↓	Low	Medium	High
Low		Leakage into protected area	Exposure of pollutants to population
Medium			Railway Damage
High			Water Well Contamination

Equipt4Risk ongoing work



- WP1
 - Using data to drive cumulative flux models and air-quality impact models
- WP2
 - Source parameterisation (rock hydraulic, geochemical properties)
 - Regional groundwater flow models
- WP3
 - Source parameters for PNR events (stress drops, source mechanisms, rupture dimensions)
 - Site corrections for Bowland Basin including calibration of proxy Vs30 measurements
 - Induced seismicity at United Downs (SW England)
 - Improved hazard and risk models
 - Intensity modelling and public perceptions
 - Baseline monitoring UKGEOS – Glasgow
- WP4
 - Bivariate statistical approaches to change detection
- WP5
 - Integrated model development and risk framework