EQUIPT4RISK
Evaluation, quantification and identification of pathways and targets for the assessment of shale gas risk

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UKUH Unconventional Hydrocarbons in the UK Energy System

Natural Environment Research Council

Economic and Social Research Council

BGS British Geological Survey

EQUIPT4RISK
Air · Water · Seismic

Project Partners

Acknowledgements: Grant Allen (WP1), Fred Worrall (WP4), Brain Baptie (WP3), Max Werner (WP3), Gus Fraser Harris (WP5), Andrew Hughes (WP5) and the rest of the project team

Work Packages and Science Questions

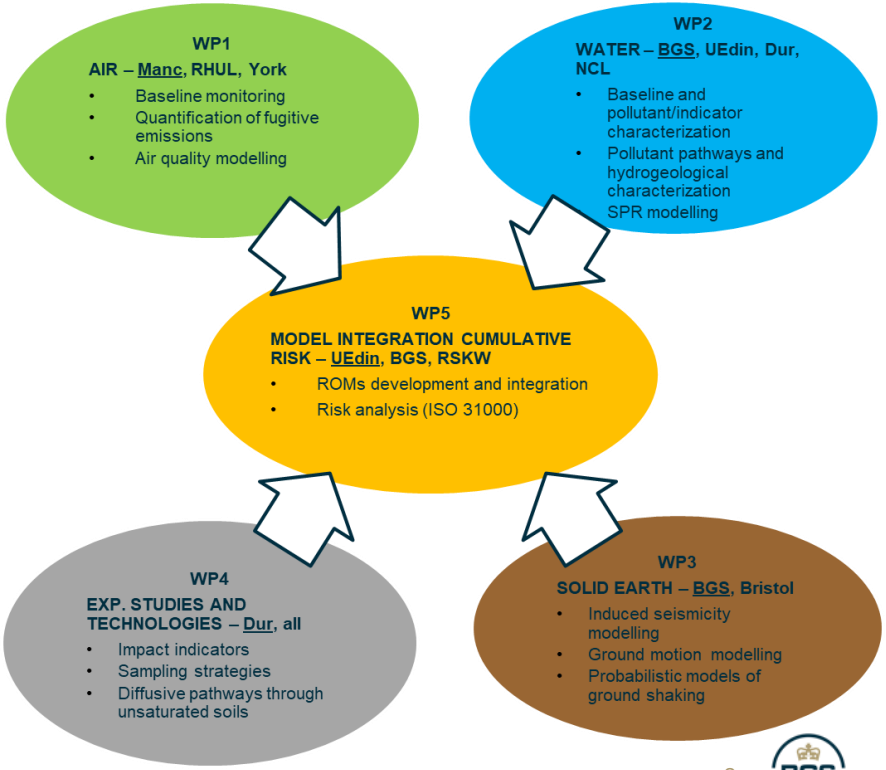
Evaluation, quantification and identification of pathways and targets for the assessment of shale gas risk

1) What properties, parameters, and processes (geochemical/physical) are important for characterizing the key SPR linkages and combinations?

2) What are the actual/potential contaminant fluxes and physical (seismic) hazard characteristics (and uncertainties) and how do these evolve?

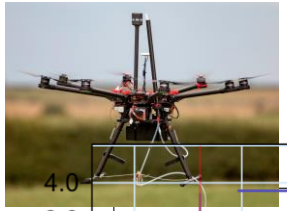
3) What proxies/indicators/measures of environmental change/impact are most sensitive to the stresses induced by deep subsurface operations?

4) How can risks be up-scaled and integrated for a fully developed industry, to evaluate cumulative and whole lifecycle risks?

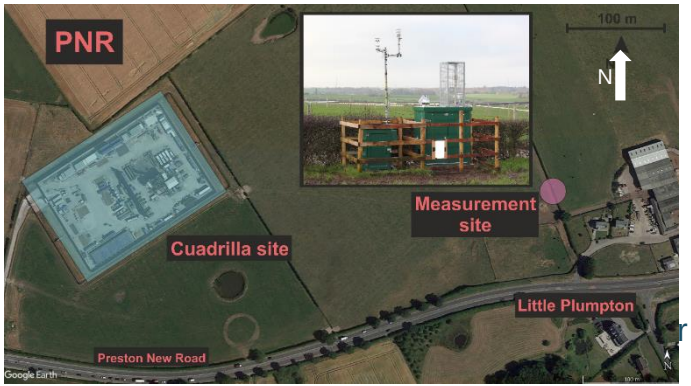


Event detection using baseline exceedance algorithm

N_2 lift operation and gas release from shale gas well



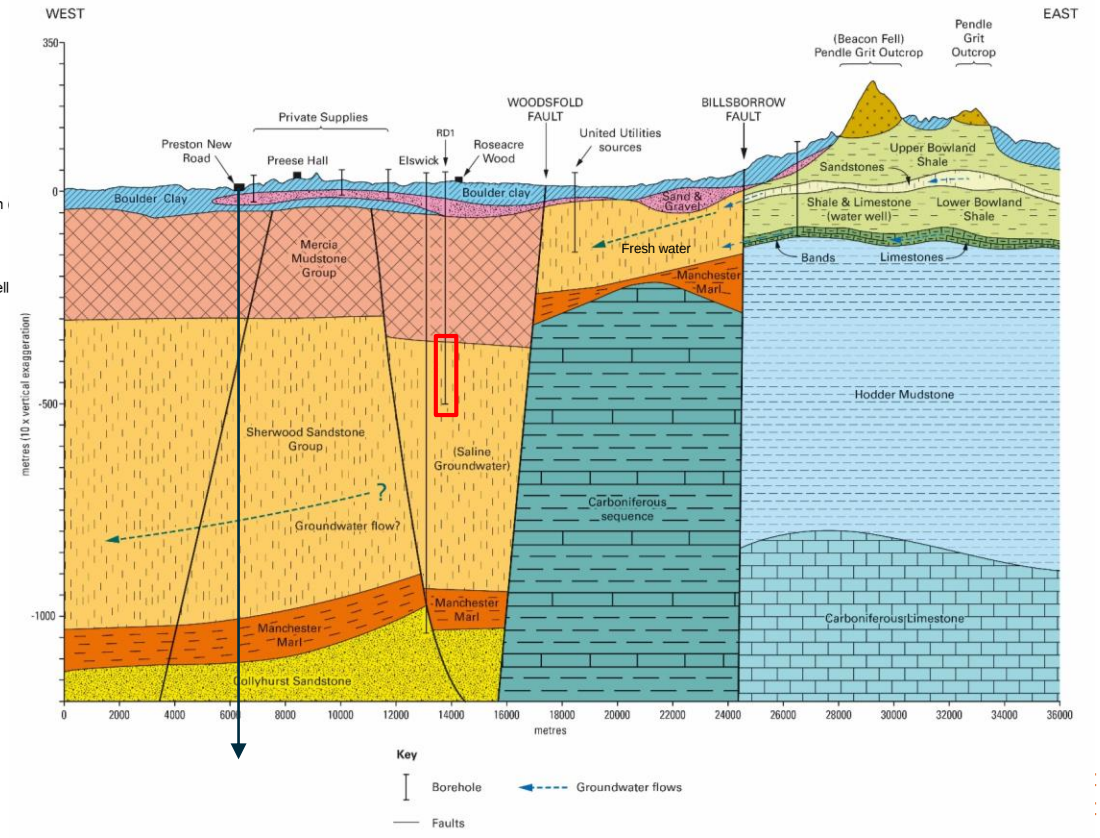
- Change detection algorithm indicated baseline exceedance
- Enhanced CH_4 due to N_2 lift
- One week period in January 2019
- Max CH_4 concentration = 12.8 ppm



Shah et al., 2019. DOI: 10.5194/amt-2019-289
Shaw et al., 2019. DOI: 10.1016/j.scitotenv.2019.05.266
Shaw et al., 2020. JAWM (accepted)

Groundwater vulnerability and characterisation

British Geological Survey
THE UNIVERSITY of EDINBURGH
Durham University

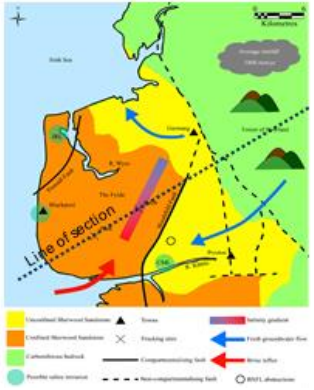


Vulnerability of shallow groundwater and surface water to pollution from depth

- Demonstrated fault-driven groundwater compartmentalisation
- Compartmentalisation does not affect surface waters

Hyd

- salinity
-
-

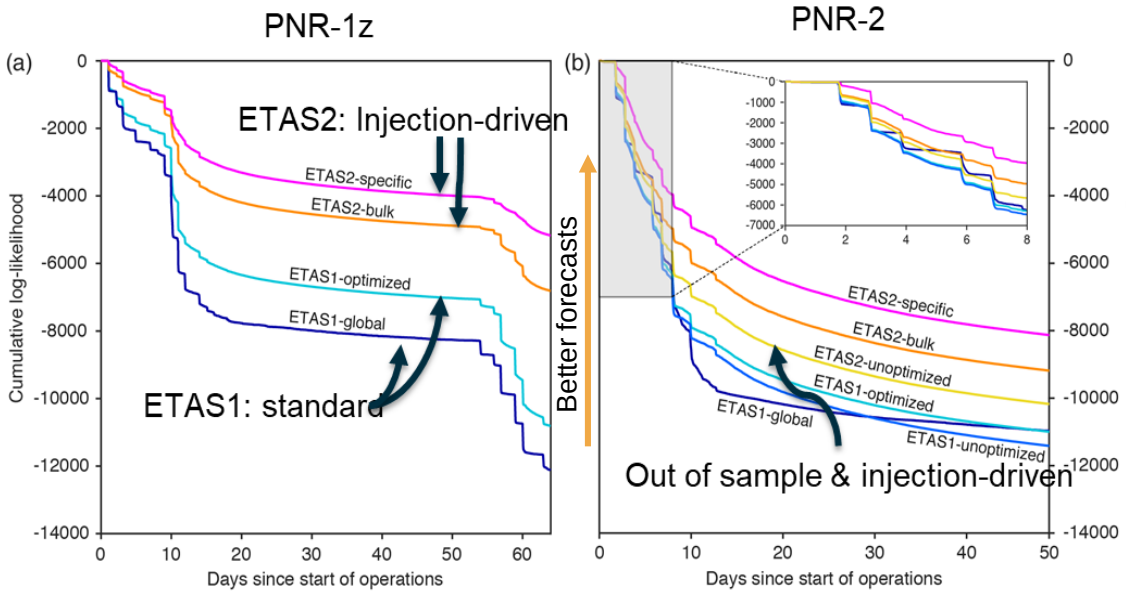


al., 2020. Hyd Proc. 34(15) 3271-3294
al., 2020. Environ. Sci.: Proc Impacts, 2019,21, 352-369

Probabilistic forecasting of induced seismicity using an injection-rate driven ETAS model

WP3

University of BRISTOL



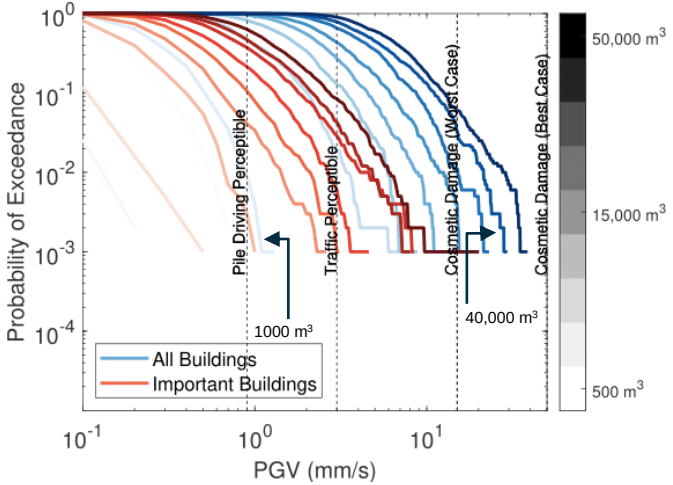
- Different ETAS models tested to reproduce the temporal evolution of PNR induced seismicity
- The best-performing ETAS is parameterized on well-specific seismicity driven by injection rates
- ETAS models provide informative time-dependent forecasts for operators and decision-makers
- Results show that a model calibrated using PNR-1z data could have proved an informative forecast for PNR-2

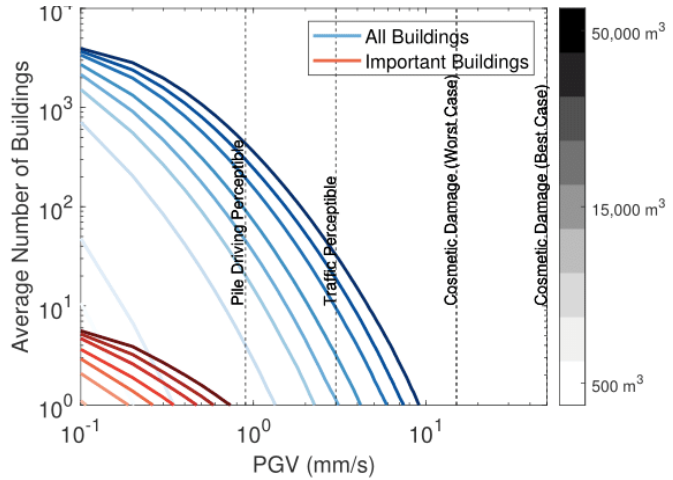
Mancini et al (2020). GRL, submitted

BGS

Injection-volume-based seismic risk and nuisance

University of BRISTOL





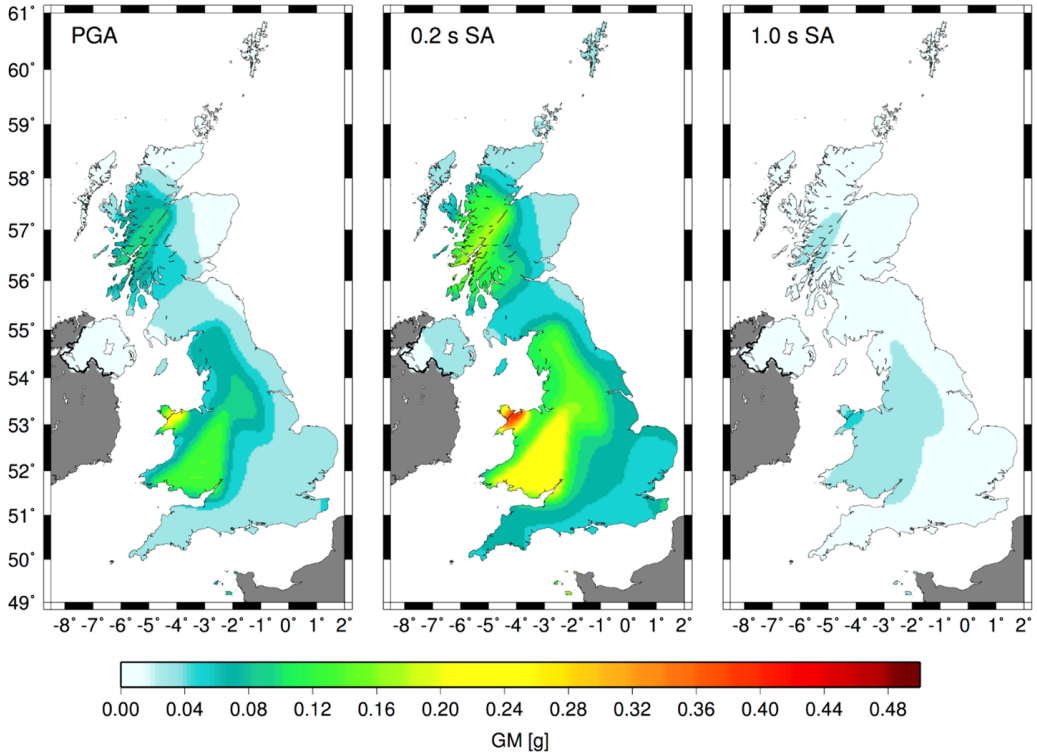
- Potential for nuisance felt ground motions linked to injection volume by combining:
  - Statistical forecast models for induced seismicity,
  - GMPEs, and
  - An exposure model of the affected area
- Results indicate:
  - Ground motion amplitude might exceed Pile Driving threshold at ≥ 1 building for injection volumes ≥ 1000 m^3 (M_L = 0.5)
  - Cosmetic damage might occur in at least one building for injection volumes ≥ 40,000 m^3 (Mw ≥ 2.1).
- Proposed framework can be used to control injection volume for risk mitigation and inform policy related to hydraulic-fracture induced seismicity.

Cremen & Werner. 2020: doi.org/10.5194/nhess-2020-95

Improved baseline models for background tectonic seismicity in the UK

WP3

Hazard maps for PGA, 0.2 s SA and 1.0 SA for a 2475 year return period (Exceedance probability of 2% in 50 years).



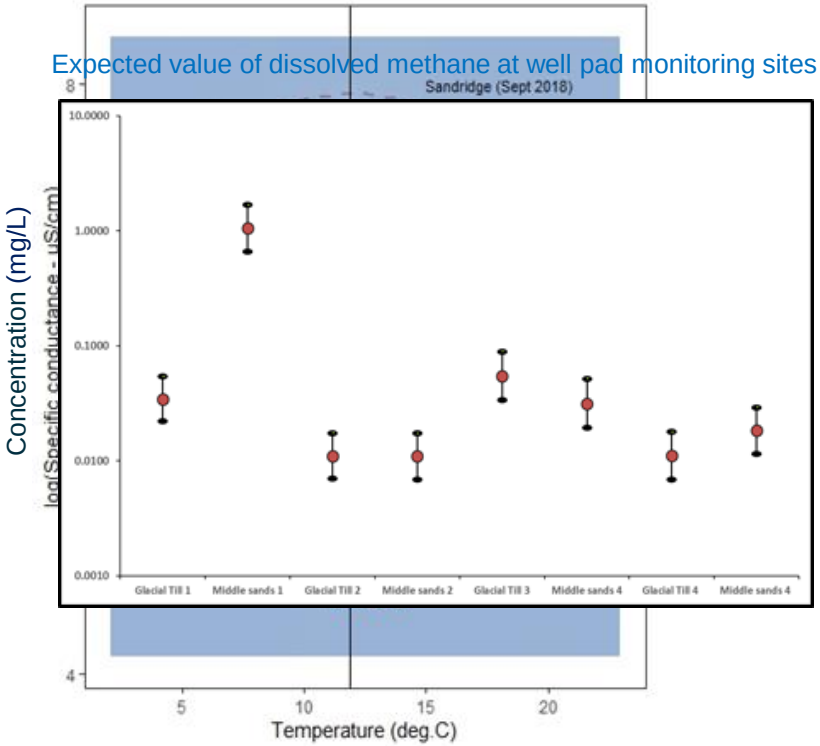
- New national seismic hazard maps for tectonic seismicity in the UK developed using a Monte Carlo-based approach
- The analysis is based on a composite earthquake catalogue consisting of data from multiple sources
- The maps show peak ground acceleration (PGA) and spectral acceleration (SA) at 0.2 s and 1.0 s for 5% damping on rock (Vs = 800 m/s) as a proportion of g and for return periods of 475, 1100 and 2475 years

Mosca et al, 2020

Case studies, technologies and their application

Observed vs modelled bivariate distribution for a borehole

Expected value of dissolved methane at well pad monitoring sites



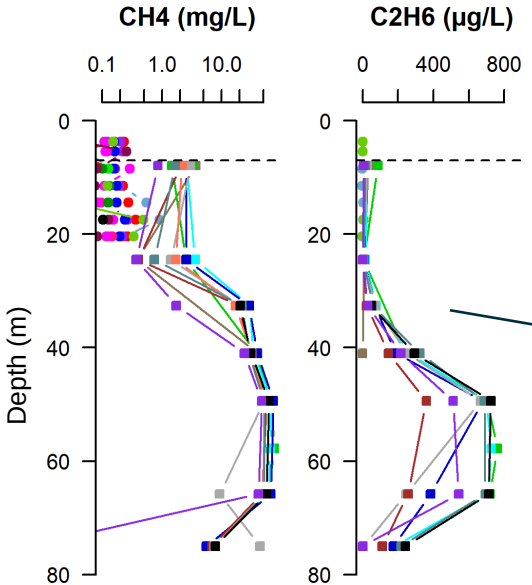
- Development of dynamic baselines
  - Develop Bayesian models to combine datasets
  - Predict the distribution of a monitored value to identify future anomalies
  - Estimated that groundwater releases 1.65 kt CH_4/year to air (0.7-3.12 range): equivalent to 40.3 kT CO_2eq
- Currently working on
  - Bayesian hierarchical (bivariate) modelling, e.g. SEC and T to improve change detection
  - Atmospheric pollutants

Worrall et al., 2019. Jhydrol. 571: 516-527
Wilson et al., 2020. STOTEN, 711: 134854

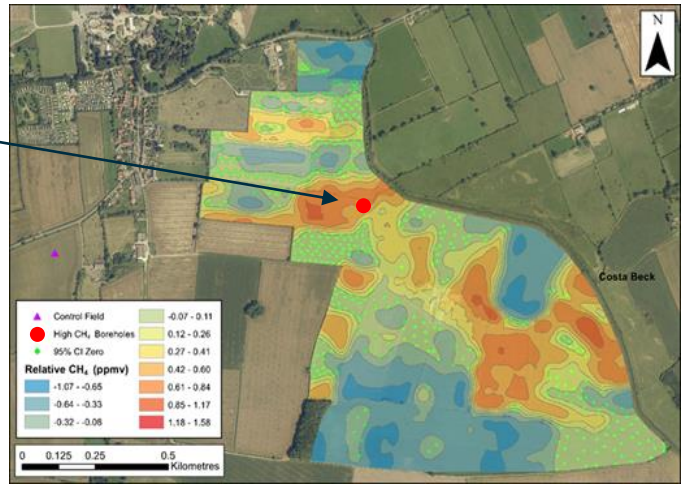
Case studies, technologies and their application

Are diffuse pathways for CH_4 to the surface significant?

Groundwater methane concentrations at a MLS



Map of soil gas CH_4 plotted relative to a control



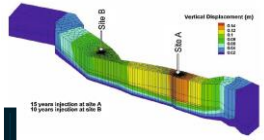
- Co-ordinated and integrated field campaign
- Measurement of methane flux across sub-surface/surface interfaces
  - Soil gas survey of farmland around borehole with known elevated levels of CH_4
  - Isotope study of HC reservoir gases, groundwater, soil gas and air

Ward et al., 2020. nora.nerc.ac.uk/id/eprint/527726/

Cumulative Risk Concept

WP5

High fidelity models (WP1-3)



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Reduced Order Models

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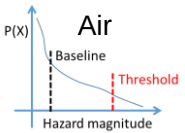
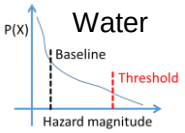
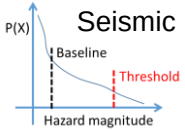
Stochastic Simulations

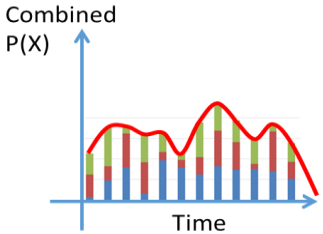
Multiple realisations of different parameter sets

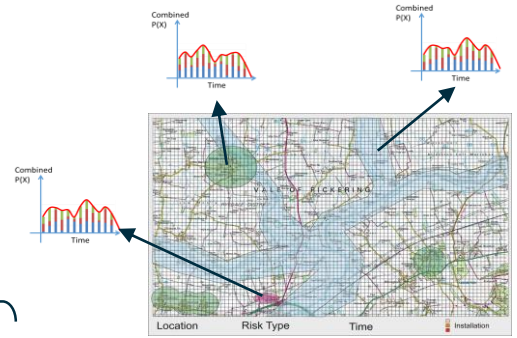
Receptor specific











Risk profile at each receptor for resource development through time

Disaggregation to determine critical Source-Pathway combinations

Critical to mitigation planning

Strategic Risk Assessment and high level mitigation based on ISO31000

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Geoscience Update

Q&A session