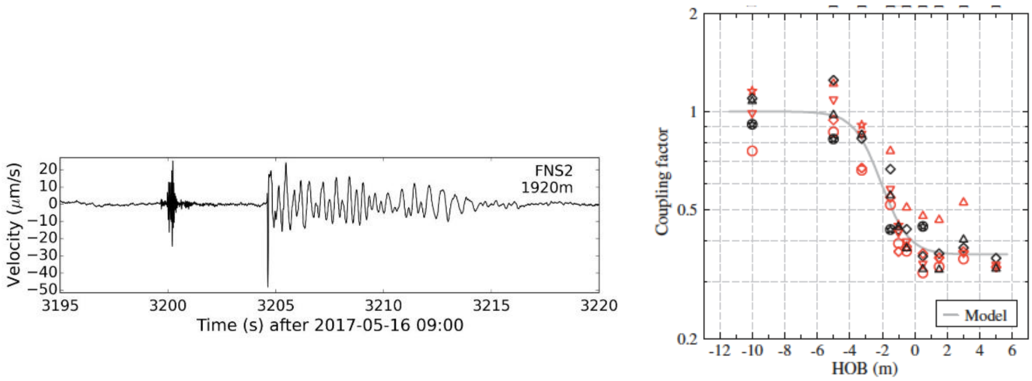
Project Title: Understanding Seismo-Acoustic Coupling from Near Surface Explosions

Lead Supervisor: Dr Nick Teanby & Prof. James Wookey, University of Bristol, School of Earth Sciences

Industrial Supervisors: Dr. David Green & Dr. Stuart Nippress, Forensic Seismology, AWE Blacknest

Project Enquires: j.wookey@bristol.ac.uk ; stuart@blacknest.gov.uk

Project Keywords: seismology, acoustics, explosions, air-to-ground coupling



Left: Signal from an explosion recorded on a seismometer at a distance of ~2 km. Energy that travelled purely as a seismic wave is seen at 3200 s, while energy that travelled through the atmosphere before coupling to the ground around the seismometer is seen at 3205 s. Right: Example seismic coupling curve generated for explosions in the US (modified from Ford et al., 2014).

Project Background

Near-surface chemical explosions excite waves that propagate both through the atmosphere (as a blast wave) and the ground (as seismic waves). The proportion of available energy transmitted into the ground is a function of both the explosive altitude above the ground (height-of-burst) and the geological medium in (or above) which the explosion takes place. Understanding the wavefields generated by near-surface explosions, and the variability in seismic coupling produced by explosions above and within different geological media, allow explosions to be better characterised. This is important for the forensic assessments of explosions, for example the recent (August 2020) accidental detonation of ammonium nitrate at the Port of Beirut. This seismic coupling work can also be applied to further our understanding of signals that may be generated by surface impacts, both here on Earth (e.g., from meteors) and potential seismic sources for planetary seismology (e.g., signals recorded by the InSight mission on Mars).

Staff at AWE Blacknest have, for 60 years, been researching techniques to distinguish seismic signals generated by underground nuclear explosions from those generated by earthquakes. Such techniques are part of the verification system for the Comprehensive Nuclear-Test-Ban Treaty which is currently being ratified by United Nations member states. In addition, Blacknest scientists develop techniques to analyze signals generated by explosions in the atmosphere, in the oceans, and at the interfaces between these media. Experts within the team provide advice to the UK Government upon request.

Project Aims and Methods

The successful applicant will work alongside researchers in the Forensic Seismology team at AWE Blacknest to analyse seismic and acoustic signals generated by near-surface chemical explosions detonated in dedicated trials. They will utilize both previously collected data from US trials, and data being collected during 2021 from trials on Foulness Island, UK. The results of this analysis will help constrain models for the proportion of energy generated by near-surface explosions that is converted into seismic waves (in a variety of geological media) via both near-source coupling and via air-to-ground coupling close to the sensor. The student will benefit from working with experts in explosion monitoring from AWE Blacknest during regular visits.

Candidate Requirements

This project would suit a candidate with a strong physics and/or signal processing background. Some geophysics knowledge would be advantageous, as would experience with scientific programming and time series analysis. Willingness to engage and communicate with colleagues across the AWE Blacknest team will be crucial to identify solutions to issues or problems. We welcome and encourage student applications from under-represented groups. We value a diverse research environment. Please note, we will only consider British nationals for this position.

Training

The student will gain an advanced skillset in the handling, analysis and interpretation of seismic and low-frequency data sets, alongside developing the ability to undertake seismic signal simulations. These are highly transferrable skills, closely related to those required in industrial geophysics and wider signal processing applications. The student will also gain a broad range of knowledge regarding explosion monitoring. On the technical side, the student will gain valuable experience with data analysis software development. The successful applicant will also have access to a very wide range of University courses which will further enhance research and transferrable skills. The student would be expected to regularly visit colleagues at AWE Blacknest, and present results to AWE Nuclear Threat Reduction leadership.

Support

This project is offered with support to cover tuition fees, research expenses and a stipend of £14,025, and is restricted to students qualifying for UK home fee status (see https://www.ukcisa.org.uk/Information--Advice/Fees-and-Money/England-fee-status).

Background reading and references

Ford, S. R., et al. "Partitioning of seismoacoustic energy and estimation of yield and height-of-burst/depth-of-burial for near-surface explosions." *Bulletin of the Seismological Society of America* 104.2 (2014): 608-623.

Ford, Sean R., et al. "Joint Bayesian Inference for Near-surface Explosion Yield and Height-of-burst." *Journal of Geophysical Research: Solid Earth* 126.2 (2021): e2020JB020968.

Pilger, Christoph, et al. "Yield estimation of the 2020 Beirut explosion using open access waveform and remote sensing data." *Scientific reports* 11.1 (2021): 1-14.

Green, D., et al. "Sixty years of forensic seismology at AWE Blacknest." *Astronomy & Geophysics* 62.4 (2021): 4-36.

Useful Links:

http://www.bristol.ac.uk/earthsciences/courses/postgraduate/

http://www.blacknest.gov.uk