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Application of machine learning methods to identify englacial seismicity in a Distributed Acoustic Sensing dataset from Store Glacier, West Greenland

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Seismic surveys are widely used to study the properties of glaciers, basal material and conditions, ice temperature and crystal orientation fabric. The emerging technology of Distributed Acoustic Sensing (DAS) uses fibre optic cables as pseudo-seismic receivers,
reconstructing seismic measurements at a higher spatial and temporal resolution than is possible using traditional geophone deployments. DAS generates large volumes of data, especially in passive mode, which can be costly in time and cumbersome to analyse. Machine learning tools provide an effective means of automatically identifying events within these records, avoiding a bottleneck in the data analysis process. Here we present initial trials of machine learning for a borehole-deployed DAS system on Store Glacier, West Greenland. Data were acquired in July 2019, using a Silixa iDAS interrogator and a BRUsens fibre optic cable installed in a 1043 m-deep borehole. The interrogator sampled at 4000 Hz, recording both controlled-source Vertical Seismic Profiles (VSPs), made with hammer-and-plate source, and a 3-day passive record of cryoseismicity.

We used a Convolutional Neural Network (CNN) to identify seismic events within the seismic record. A CNN is a deep learning algorithm that uses a series of convolutional filters to extract features from a 2-dimensional matrix of values. These features are then used to train a model that can recognise objects or patterns within the dataset. CNNs are a powerful classification tool, widely applied to the analysis of both images and time series data. Previous research has demonstrated the ability of CNNs to recognise seismic phases in time series data for long-range earthquake detection, even when the phases are masked by a low signal-to-noise ratio. For the Store Glacier data, initial results were obtained using a CNN trained on hand-labelled, uniformly-sized windows. At present, these windows have been targeted around high signal-to-noise ratio seismic events in the controlled-source VSPs only. Once trained, the CNN achieved accuracy of 90% in recognising whether new windows contained coherent seismic

energy.

The next phase of analysis will be to assess the performance of the CNN when trained and tested on large passive DAS datasets. The method will then be used for the identification and flagging of seismic events within the passive record for interpretation and event location. The identified signals will be used to provide information on the glacier's seismic velocity structure, ice temperature and ice crystal orientation fabric and anisotropy. Basal reflections were identified and will be used to provide information on subglacial material properties and conditions of Store Glacier. The efficiency of the CNN allows detailed insight to be made into the origins and style of glacier seismicity, facilitating further advantages of passive DAS instrumentation.