

## Mapping seismic data to slow slip using machine learning

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We show that the Cascadia subduction zone is apparently continuously broadcasting a low-amplitude, tremor-like signal that precisely informs of the fault displacement rate throughout the slow slip cycle. Using a method based on machine learning previously developed in the laboratory, we analysed large amounts of raw seismic data from Vancouver Island to separate this signal from the background seismic noise. We posit that this provides indirect real-time access to fault physics on the down-dip portion of the megathrust, and thus may prove useful in determining if and how a slow slip may couple to or evolve into a major earthquake.

In a parallel approach, we show that tremor can be accurately detected on a single seismic station by a deep convolutional neural network. Seismic tremor is posited to provide information on the physical state of the slowly slipping portion of the megathrust, and a single station tremor detector gives a direct access to the tremor signal and its physical characteristics. A deep learning model trained to detect tremor in Cascadia recognizes catalogued tremor in other subduction zones, arguing for the universality of tremor and slow slip characteristics. The detection rate of a deep learning model trained to recognize tremor in Cascadia and applied on waveforms from Northern Chile shows strong correlation with surface displacement rate, arguing for episodic tremor and slip detection where slow earthquakes and associated tremor had not been seen so far, presumably taking place too deep to have been detected using conventional multi-station methods.

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