Detecting seismic phases from Tonga deep earthquakes using deep learning

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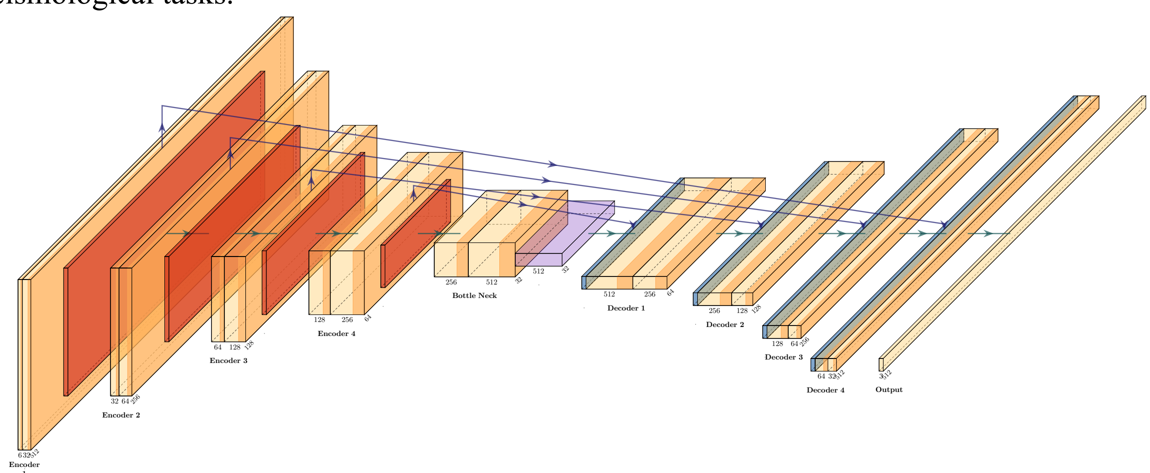
The P-to-S (PS) wave from a deep earthquake converted at the slab surface (top interface) can provide invaluable information regarding the geometry and structure of a subducted slab. However, identifying the PS phase in a large volume of seismic data is challenging because this phase appears over different frequencies, depending on the local attenuation structure. Here we modify PhaseNet, a widely used machine learning package, to detect seismic phases in the time-frequency domain, with a focus on PS waves. We then apply this new package (PhaseNet-FT) to the dataset of a 1-year amphibious seismic network in the Tonga subduction zone. A deep-neural-network model is trained on P, S, and PS arrivals manually picked by previous studies. PhaseNet-FT can achieve the same level of performance in detecting P and S arrivals as the original PhaseNet. More importantly, this package reliably detects PS arrivals from Tonga deep earthquakes. This valuable dataset will enable us to image the Tonga slab with a higher resolution. In general, converted phases have played a key role in the history of structural seismology and deep learning has the potential to improve that dramatically, as it has done for other seismological tasks.



The network architecture of PhaseNet-FT. The input is three-component spectrograms, whereas the output is 4 probabilities with the same length as input for P, S, and PS picks.