EGU2020-3809, updated on 31 Jul 2021
https://doi.org/10.5194/egusphere-egu2020-3809
EGU General Assembly 2020

Deep learning Q inversion from reflection seismic data with strong attenuation using an encoder-decoder convolutional neural network: an example from South China Sea

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The seismic waves exhibit various types of attenuation while propagating through the subsurface, which is strongly related to the complexity of the earth. Anelasticity of the subsurface medium, which is quantified by the quality factor Q, causes dissipation of seismic energy. Attenuation distorts the phase of the seismic data and decays the higher frequencies in the data more than lower frequencies. Strong attenuation effect resulting from geology such as gas pocket is a notoriously challenging problem for high resolution imaging because it strongly reduces the amplitude and downgrade the imaging quality of deeper events. To compensate this attenuation effect, first we need to accurately estimate the attenuation model (Q). However, it is challenging to directly derive a laterally and vertically varying attenuation model in depth domain from the surface reflection seismic data. This research paper proposes a method to derive the anomalous Q model corresponding to strong attenuative media from marine reflection seismic data using a deep-learning approach, the convolutional neural network (CNN). We treat Q anomaly detection problem as a semantic segmentation task and train an encoder-decoder CNN (U-Net) to perform a pixel-by-pixel prediction on the seismic section to invert a pixel group belongs to different level of attenuation probability which can help to build up the attenuation model. The proposed method in this paper uses a volume of marine 3D reflection seismic data for network training and validation, which needs only a very small amount of data as the training set due to the feature of U-Net, a specific encoder-decoder CNN architecture in semantic segmentation task. Finally, in order to evaluate the attenuation model result predicted by the proposed method, we validate the predicted heterogeneous Q model using de-absorption pre-stack depth migration (Q-PSDM), a high-resolution depth imaging result with reasonable compensation is obtained.