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Improvements of Travel-time Tomography Models from Joint Inversion of Multi-channel and Wide-angle Seismic Data

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Commonly multichannel seismic reflection (MCS) and wide-angle seismic (WAS) data are modeled and interpreted with different approaches. Conventional travel-time tomography models using solely WAS data lack the resolution to define the model properties and, particularly, the geometry of geologic boundaries (reflectors) with the required accuracy, specially in the shallow complex upper geological layers.
We plan to mitigate this issue by combining these two different data sets, specifically taking advantage of the high redundancy of multichannel seismic (MCS) data, integrated with wide-angle seismic (WAS) data into a common inversion scheme to obtain higher-resolution velocity models (Vp), decrease Vp uncertainty and improve the geometry of reflectors.
To do so, we have adapted the tomo2d and tomo3d joint refraction and reflection travel time tomography codes (Korenaga et al, 2000; Meléndez et al, 2015) to deal with streamer data and MCS acquisition geometries. The scheme results in a joint travel-time tomographic inversion based on integrated travel-time information from refracted and reflected phases from WAS data and reflected identified in the MCS common depth point (CDP) or shot gathers.

To illustrate the advantages of a common inversion approach we have compared the modeling results for synthetic data sets using two different travel-time inversion strategies:
We have produced seismic velocity models and reflector geometries following typical refraction and reflection travel-time tomographic strategy modeling just WAS data with a typical acquisition geometry (one OBS each 10 km).
Second, we performed joint inversion of two types of seismic data sets, integrating two coincident data sets consisting of MCS data collected with a 8 km-long streamer and the WAS data into a common inversion scheme. Our synthetic results of the joint inversion indicate a 5-10 times smaller ray travel-time misfit in the deeper parts of the model, compared to models obtained using just wide-angle seismic data. As expected, there is an important improvement in the definition of the reflector geometry, which in turn, allows to improve the accuracy of the velocity retrieval just above and below the reflector. To test the joint inversion approach with real data, we combined wide-angle (WAS) seismic and coincident multichannel seismic reflection (MCS) data acquired in the northern Chile subduction zone into a common inversion scheme to obtain a higher-resolution information of upper plate and inter-plate boundary.