Three-dimensional P- and S-wave velocity structure along the central Alpine Fault, South Island, New Zealand

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Abstract:

The Deep Fault Drilling Project (DFDP) on the central Alpine Fault, South Island, New Zealand, has motivated a broad range of geophysical and geological studies aiming to characterize the fault system in the locality of the drill site at various scales. We have been developing three-dimensional P- and S-wave velocity models of the region by double-difference tomography utilizing datasets from multiple seismic networks (WIZARD, SAMBA, ALFA, GeoNet, and others). In our previous work, the quality of the S-wave model was relatively poor due to the small number of available S-wave picks. We have utilized a new high-accuracy automatic S-wave picker to increase the number of usable S arrivals by an order of magnitude, thereby dramatically improving the S-wave velocity model. Compared to previous studies, e.g. Eberhart-Phillips and Bannister (2002) and Feenstra et al (2013), our updated P-wave model shows a clear high Vp body (Vp > 6km/s) at depths of 5 to 15 km near the drill site. With our better resolved S-wave velocity model, we can see a sharp high Vs body (Vs > 3.7 km/s) in the same region. Besides the newly added S-picks, we have done cross-correlation to calculate the differential times between event pairs in order to improve the precision of the relocations of the earthquakes. This in turn has highlighted the presence of earthquake swarms around an upper crustal low velocity zone in the vicinity of Mt. Cook. Together with the updated earthquake relocations, the P- and S-wave tomography results reveal the Alpine Fault to be marked by a velocity contrast throughout most of the study region. The fault dips steeply from 5 to 20 km depth with an average dip of 50-60° SE, as inferred from the velocity structure and the seismicity.