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Measurements of seismometer orientation and clock instability at stations from the Seismic Network of Chile (C1)

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Corresponding to the tectonically active western margin of South America, the Andes constitute a natural laboratory to better understand how different tectonic plates interact with each other at convergent plate boundaries. Seismological techniques such as receiver function, seismic tomography and shear-wave splitting analysis are essential to unravel the Earth's structure beneath such complex environments and often shed light on the mechanisms behind plate tectonics. In this context, it is paramount for seismologists to have high quality data at their disposal. Here, we investigate station orientation and possible timing issues at 70 stations belonging to the Seismic Network of Chile (C1), which is one of the largest and most well-established permanent networks in South America. To do so, we use 10 years of data from large earthquakes (> 6.0 Mw) at selected epicentral distances (5º ≤ Δ ≤ 100º and 140º ≤ Δ ≤ 180º), based on the GCMT catalog. The fetched seismograms are windowed around the first P-wave arrival (± 150 s). Our analysis starts by automatically rejecting low quality waveforms; high quality seismograms must adhere to quality criteria such as signal-to-noise ratio greater than 10, high similarity between the vertical and the radial traces, and low transverse-to-radial energy ratio. For each recording, a grid-search is then carried out to find the direction that maximizes the cost function, and the circular difference between this direction and the theoretical backazimuth provides a single estimate of the station misalignment. To mitigate the effect of scattering on the final orientation error, we further refine the observations used to compute it in one of the following ways: (i) if the estimates can be grouped into time variable clusters - for instance, when a seismometer was misaligned for some time and then corrected during field work -, we use the DBSCAN algorithm to discard outlier observations and to identify such clusters; (ii) alternatively, if the estimates are unimodal, we only use estimates between the Q1 and Q3 percentiles. The final orientation error and its deviation are given by the circular mean and circular standard deviation of these refined individual estimates. Out of 70 stations analyzed, our results indicate that 10 stations (AP02, BI06, CO04, MG01, MG03, MT04, MT16, MT18, VA02 and VA03) show orientation errors larger than |± 10º|. Additionally, station TA02 presented an orientation error of -36.8º between June 2016 and September 2018, but it has been reoriented and now shows an average orientation error of -3.2º. Station AF01 shows a strong scattering of estimates during the entire period of operation and the reason for this issue needs to be further investigated. Possible clock issues are tracked by the difference between measured (picked with the Akaike Information Criterion) and theoretical (obtained via the TauP ray-tracing algorithm) P-wave arrivals from several seismograms. We found no particular timing instability at stations of the Seismic Network of Chile. The results reported here are not only important to deep Earth structure imaging studies, but also to accurate determination of source parameters from earthquakes, which is a very important task in a country that is strongly affected by earthquakes such as Chile.