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Anatomy of a subduction zone – seismicity structure of the northern Chilean forearc from >100,000 double-difference relocated earthquake hypocenters

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We present a catalog of >100k well-located earthquake hypocenters for the northern Chilean forearc region, between the latitudes of 18.5°S and 24°S. The detected events cover the timespan 2007-2014 and were extracted from the IPOC permanent station network dataset. Previously published earthquake catalogs for the region contain significantly fewer earthquakes. Using this new, high-resolution set of hypocenters, we can outline the slab structure in unprecedented detail, allowing e.g. the determination of along-strike changes in slab dip angle or the resolution of structures inside the zone of intermediate-depth seismicity.

For the compilation of the catalog, we relied on an automated multi-step process for event detection, association and phase picking. Thus retrieved earthquake hypocenters were then relocated in a 2.5D velocity model for the Northern Chile forearc region with a probabilistic approach that also allows the determination of uncertainties. In a final step, double-difference re-location incorporating cross-correlation lag times was performed, which sharpened event clusters through relative location.

We estimate that the completeness magnitude of the catalog is around 3. The majority of all >100k earthquakes are located at intermediate depths (between 80 and 140 km) inside the subducted slab. This area of pervasive activity extends along the entire strike of the investigated area, but shows a clear offset at 21°S, which may hint at a slab tear at this location. Events of comparable hypocentral depths to the south of this offset are located further east than the ones to the north of it. Further updip, a triple seismic zone at depths between 40 and around 80 km is visible, which grades into the highly active event cluster at intermediate depths: below the plate interface, which is clearly delineated by seismic activity, a second parallel band of hypocenters only about 5 km below likely corresponds to earthquakes occurring within the oceanic crust or close to the oceanic Moho. A third band of earthquakes, paralleling the other two at about 20-25 km below the interface, clearly indicates the presence of seismicity in the oceanic lithospheric mantle. Seismicity in the upper plate is pervasive throughout the entire crustal thickness near the coast but gets shallower towards the volcanic arc. Shallow clusters related to regional mining activities are also clearly visible.