Reply to the comment on “Historical and recent large megathrust earthquakes in Chile”

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We sincerely thank the comment by Di Giacomo et al. (this volume) on our publication on the seismicity of Chile (Ruiz and Madariaga, 2018). We regret not having added a section where we could have properly acknowledged the origin of the data we used for the discussion of recent seismicity.

The goal of our work was to study ancient and modern data on earthquakes in Chile, separate intermediate-depth intraplate from interplate events, and to understand where the last occurred on the plate interface. We adopted from the beginning the hypothesis by Lay et al. (2012) that large earthquakes in Chile come in two flavors: those that break a fraction of the plate interface, which is the case for most Chilean events of magnitude up to 8.2–8.3; and those rare huge earthquakes that break the plate interface up to the trench and then propagate bilaterally. Until recently the difference between these two types of events and their consequences were not properly discussed in the literature on Chilean geophysics. Our work was in no way an attempt to compare catalogs and decide which of them is better.

We recognize the difficulty in determining the location, magnitude and depth of ancient events in Chile, because there were very few, poorly distributed stations that recorded them, and the estimation of magnitude was not well developed until the 1970s. There is a clear need to distinguish between events that occurred on the plate interface and those that occurred inside the down-going slab. The clearest evidence of this need is the incorrect determination of the depth of the 1939 Chillan earthquake which, until 1990s, led to the wrong conclusion that this event filled a gap that would later host the Maule 2010 megathrust event (see, e.g. Nishenko, 1991; Campos et al., 2002). Thus the depth of the 1922 Vallenar or Atacama earthquake discussed by Di Giacomo et al. (this volume) is of great importance.

The 11 November 1922 Vallenar earthquake was the second largest seismic event of the 20th century in Chile. As we said in Ruiz and Madariaga (2018) this event has often been mislocated and its depth was poorly determined until the 1990s. It was a tsunamigenic earthquake as reported by Willis (1929), contemporary news in Chilean newspapers like the “El Día” of La Serena, and the recent work by Carvajal et al. (2017) who modeled the tsunami records from Japan. To sum up, the Vallenar 1922 earthquake had a magnitude of 8.5–8.6 according to the works of many authors. Kanamori (1977) proposed a moment magnitude of Mw 8.5 based on its aftershock distribution, Abe (1979) proposed a tsunami-wave magnitude of Mt. 8.7, Oka (1992) proposed a mantle-wave magnitude of Mm 8.63 from Rayleigh waves and 8.56 from Love waves using a single record from UPP (Uppsala), and Beck et al. (1998) determined a duration of 75 s but could not determine its magnitude because they used diffracted body waves. Recently, Carvajal et al. (2017) proposed a magnitude Mw 8.45 to 8.63 from the modeling of the tsunami observed at 5 tidal gauges in Japan.

We thank Di Giacomo et al. (this volume) for reviewing the location of this event. The location of the epicenter of the event has converged now to 28.911°S, 70.870°W in the ISC-GEM catalog (www.isc.ac.uk/iscgem/) which is within 20 km of the location we adopted from the Centennial catalog (Engdahl and Villaseñor, 2002). The depth of the event that is often cited as 70 km or 0 km is now redetermined by ISC in their recent issue of the ISC-GEM catalog to be 35 km (Di Giacomo et al., this volume). This is an very important result that comforts our interpretation that the Vallenar earthquake of 1922 was a large megathrust event and not an intermediate-depth intraplate earthquake.

We regret that the authors think that we compared totally different catalogs on the basis of a single event. All we wanted to say is that, confronted with many alternative locations, depths and magnitude for events of the first 60 years of the 20th century, geophysicists working in
Chile should consider the Centennial catalog. We are encouraged to see that ISC has continued to improve those locations with the ISC-GEM catalog (Storchak et al., 2015; Storchak et al., 2013).

Finally there is now no room for doubt: the 22 November 1922 Vallenar event was the second largest Chilean megathrust earthquake of the 20th century and ruptured a large segment of this subduction zone from Caldera in the north, to Coquimbo in the south for length of almost 250 km.

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