**Introduction.** On the frame of the hazard component of project SARA (The Seismic Risk in South America, https://sara.openquake.org/), the goal of task 4 was to compile an earthquake catalogue for South America in the time window 1500-1963, in terms of Mw building on the CERESIS available data, recent national and international catalogues and studies and analysis conducted during the project; the determination of parameters by recent studies, including those
proposed by the ISC-GEM catalogue, and where available, the national catalogues that meet the criteria of transparency required by the project. In such a way we have been able to assess Mw for 2564 earthquakes; the lower threshold is Mw = 5[-0.2] for the Andean region.

South America has a long tradition of intensive historical earthquake investigation. The Regional Centre for Seismology for South America (CERESIS) published a first continental scale earthquake catalogue and macroseismic database in 1985 (CERESIS, 1985). Investigation continued on a national basis, mostly with reference to large earthquakes. Recently, at the request of the insurance industry, the Global Earthquake Model (GEM) promoted the compilation of a new earthquake catalogue for South America, homogeneous as far as possible, in terms of Mw.

Fig. 1 - Distribution of epicentres by data source.
We compiled the SARA catalogue before 1964 assembling, in a critical way, the available public material and some in progress national catalogues. The work was performed according to the following steps:

- inventorying and critically compiling the available material;
- selecting the most reliable parameters for each earthquake;
- assessing a robust value of Mw for all events.

While inventorying the material, some duplications have been removed. Data allowed to established the lower Mw threshold at 5 [-0.2] for the areas of the Andean; for Brazil, no lower threshold was established.

Fig. 2 - Distribution of epicentres by class of Mw (Mw \( \geq 5.0 \)).
Data sources. We first considered the following, public items available at a continental scale:

- CERESIS (1995) that is the catalogue of South America compiled for GSHAP;
- Engdahl and Villaseñor (2002), that is the “Centennial Earthquake Catalog”;
- Storchak et al. (2013), that is, the ISC-GEM instrumental earthquake catalogue.

CERESIS (1985) has been also considered, to get information on the available macroseismic data points (MDPs).

Next, national current catalogues made available by the partners of this project have been considered (Berrocal et al., 1984; Beauval et al., 2013; Funvisis, 2014; INPRES, 2015; Leyton et al., 2009; Observatorio de San Calixto, 2013; Servicio Geologico Colombiano, 2014; Tavera ed., 2001). In addition, we have consulted 34 earthquake studies; only part of them were considered by the compilers of the national catalogues. For the large earthquakes (M ≥ 7.0), the inventory compiled in the frame of the GEM-GEH project (GEH, 2013; Albini et al., 2014) has been an important source. The entries related to the same event have then been clustered. This operation has been performed in two steps: first, automatically, then manually. The last one has allowed to detect and eliminate several duplications, mainly inside CERESIS (1995), with respect to border earthquakes.

Time, location and depth. One entry for each earthquake has been selected as “preferred” with reference to time, location and depth. Priority was given according to the following order: 1) Storchak et al. (2013); 2) Engdahl and Villaseñor (2002); 3) recent earthquake studies; 4) national catalogues; 5) CERESIS catalogue (1995); 6) CERESIS (1985).

However, when entries from national catalogues clearly coincided with the one from CERESIS (1985), the last one was selected, as it was the root of them and it gives references. After compiling this material it is possible to say that, in the time-window before 1964, the CERESIS (1995) catalogue contains more entries than the national catalogues which have been submitted to the SARA project (Venezuela, Ecuador, Brazil, Bolivia, Colombia, Chile), or found in websites (Argentina, Peru). It appears that, in many countries, some entries from CERESIS (1995) were not included in the national catalogue because of size threshold. On the other hand, some entries unknown to CERESIS (1995) have been found in some national catalogues. Finally, for each earthquake we compiled a “Task 4” entry adopting time, location and depth from the preferred one.

Earthquake size. The data sources considered provide varied type of magnitude (M). CERESIS (1995) entries come with a variety of magnitude types and values; for some entries several M values of varied type are given. We decided to adopt one magnitude value according to the following priority scheme: Mw, Ms, mb, ML, other M. In addition, CERESIS (1995) provides intensity values.

Engdahl and Villaseñor (2002), too, provide varied types and values of magnitude, including some of unknown type (UK). Storchak et al. provide Mw. The most updated national catalogues provide varied types of magnitude. Bolivia gives Ms and mb; Brazil gives mainly mb; Colombia and Ecuador gives M of varied types; Chile gives Ms; Peru mostly Ms and some Mw; Venezuela gives Ms. As for the earthquake studies, the modern ones gives Mw of macroseismic origin, mainly assessed with the Bakun and Wentworth method. Magnitudes not assessed in terms of Mw, Ms or mb have been converted to Ms or mb according to data sources.

The magnitude of the “Task 4” entries have been compiled selecting the most reliable value available, according to the above mentioned priority scheme: Mw, Ms, mb, (ML), other M. In addition, if we have two or more Mw values, or two or more Ms, from two entries referred to the same earthquake, we selected one of them according to expert judgement. As a general rule we prefer M values the origin of which is known. At this stage, we had Mw values available for 34% of the entries: we had therefore the task of determining Mw for about 66% entries.

We considered a number of conversion relationships in literature. We preferred Scordilis relations (2006), which gives values similar to the ones proposed by ISC-GEM, in addition,
it provides uncertainty. We also considered Contreras Luarte (2009) for Chile, but its range of definition is very limited, and Assumpção et al. (2014) for Brazil. Only this one shows a different behaviour; therefore we adopted it for Brazil, only.

**Determining Mw from macroseismic data.** At this stage we still had hundreds of entries without Mw, half of them from Peru. For all the entries, we had Io given by CERESIS (1995) catalogue. The best would be to determine Mw from the macroseismic data points (MDPs), making use of repeatable procedures such as the models proposed Bakun and Wentworth (1997) or Gasperini et al. (2010), as it has already been done for some earthquakes in Venezuela, Colombia and Ecuador. However, this requires MDPs, which are not always available, and the determination of the regional coefficients of the models:

- to Colombia through a calibration process; this process was developed by the present study using the method of Bakun and Wentworth calibrated regionally for some events of 20-21\textsuperscript{st} century that have a sufficient number MDPs from Colombian Geological Survey (2013) and it was applied to 29 historical earthquakes of Colombian territory;
- to Venezuela and Ecuador, the strategy adopted was to use Mw/I empirical relationships available from literature (Beauval \textit{et al.}, 2010; Palme, 2005);
- to Peru-Chile, Colombia, Bolivia and Argentina from Mw/I linear empirical relationships determined in the present study.

For sake of homogeneity we have assessed the final Mw uncertainty as equal to 0.60 unit, that correspond to the mean of 95% confidence level to one intensity data point following the Bakun and Wentworth (1997) method.

**Results and conclusion.** We have established the lower Mw threshold at 5 (-0.2) for the areas of the Andean region; for Brazil, no lower threshold has been established. In such a way we got 2556 events, the distribution of which by data sources is presented in Fig. 1. Having now determined Mw for all these earthquakes, for the first time we can see the seismicity plotted in terms of Mw (Fig. 2). We can also show the earthquake history before 1964 (Fig. 3). We have still 1766 events with size below the adopted threshold, for most of which the Mw to other parameters regressions cannot be applied, because they are out of reliability range. In addition, we have 227 without any size.

\begin{figure}[h]
\centering
\includegraphics[width=\textwidth]{fig3}
\caption{Earthquake history before 1964 (Mw ≥ 5.0) of South America.}
\end{figure}
References