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# Natural hazard events dataset for the Garrotxa Region (Catalonia, Spain): a foundational step toward multi-hazard risk assessment

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**Supplementary Information S1**

This section explains how data from the different sources were incorporated into the final dataset for each natural hazard. To remove duplicate values, a script was run on all collected data.

Regarding earthquakes, both datasets obtained from the ICGC were merged into a single Excel table. The date was standardized into a DD/MM/YYYY format and geographical coordinates were converted to UTM. Duplicate records were identified and removed when necessary. Finally, the earthquakes were sorted by date and incorporated into the final dataset.

In the case of landslides and rockfalls, two additional fields were created (*Non-precise initial date* and *Non-precise final date*) when lacking exact dates in the written and oral sources consulted. Also, due to lack of data, a volume classification in cubic meters ($m^3$) was established: Small (0–10), Medium (10–100), Large (100–1,000), and Very large (>1,000). Aerial photographs or descriptions provided in the news articles were consulted in order to infer the information. The field was left blank if not enough reference could be gathered. In some cases, local experts helped identify the exact geographical coordinates of the rockfall or landslide occurrence. Seismic amplification and lithology values were added to each recorded event. The seismic amplification map was developed separately, and each value was then assigned to the corresponding events using QGIS. Landslide and rockfall events triggered by tunnel construction or mining operations were excluded. Landslides occurring on roadside slopes were retained due to their relevance in the Garrotxa region as active hazards.

As for wildfires, the Alta Garrotxa dataset provided by SIGMA included wildfire events that had originated outside the study area. A buffer analysis was performed to decide which should be included in the final dataset. The following criteria was used: 1) Wildfires originating more than 5 km beyond the regional boundary were excluded. 2) Wildfires within the 5 km buffer were analyzed individually. Those affecting less than 10 hectares were disregarded. 3) A second buffer (1 km) was applied to further refine the dataset. Wildfires affecting more than 0.5 hectares within this zone were included. For wildfires known to have burned less than 1 hectare but without exact data available, the value *-1* was used in the *Magnitude* variable. Local experts assisted in identifying specific locations of the ignition points when data was missing. When coordinates could not be established, the event was included in the dataset with only the affected municipality specified. Maximum air temperature and maximum recorded wind speed were added to each wildfire record. These values were obtained for the specific day of each event and from the nearest available meteorological station. A script was developed to standardize and harmonize all meterological data as they were provided in different formats by Aemet and Meteocat. Regarding anthropogenic influence on wildfire occurrence in the region, the majority of wildfires are human-induced. Nevertheless, all events affecting forested areas were included, as their environmental impact was considered significant. In the case of the information gathered during the oral citizen science workshop, the recorded events were collected separately in an Excel table, validated using ortophotos and included if not duplicated.

In relation to ground subsidences, the *Non-precise initial date* and *Non-precise final date* fields were also applied when specific event dates were unavailable. These temporal ranges were determined by consulting aerial images of the area. For collapses identified on the earliest available imagery (1945 and 1956), the initial date of occurrence was left blank. Each sinkhole location was individually reviewed by local geologists to ensure that the assigned coordinates were as accurate as possible.

Concerning floods, in the dataset obtained from Llasat et al. (2022), each flood record included all the municipalities affected by that event in a single field. A script was executed to split each flood record into individual entries by municipality. A unique flood identifier (*flood_id field*) was assigned to each event to ensure that these entries were not counted as separate flood events. Finally, the dataset was filtered to retain only records referring to municipalities within Garrotxa. If georeferenced information lacked, insights from the citizen science workshop and close collaboration with regional experts were used to identify probable flood locations within each municipality. A QGIS point layer was created to represent the most probable overflow locations. For each flood event, rainfall on the day of the flood from the nearest meteorological station was added. In cases where heavy rainfall was continuous throughout the month, the variable *Duration* was marked as *Monthly*. All flood events potentially exacerbated by human negligence or land-use changes were fully included in the dataset.

**References used in S1:**

Llasat, M.C., Llasat-Botija, M., Pardo, E. and Esbrí, L.: Base de dades d'inundacions i Visor AGORA [data set], https://experience.arcgis.com/experience/484172e12fae4cbb934441203ee04e36/#data_s=id%3AdataSource_1-1804c92b61d-layer-10-1804c925200-layer-4%3A671, 2022.

**Table S1: Summary of the coordinate reference system used to build the natural hazard dataset as well as the variables considered for each natural hazard, providing a description and its units, where necessary.**

| **Metadata** | | |
|---|---|---|
| **Coordinates Reference System:** ETRS89<br>Code: EPSG:25831 | | |
| **Common variables** | | |
| **Code** | **Description** | **Units (if applicable)/ Examples** |
| code | Identification event code | e.g. L01 (for landslides) |
| ini_date | Initial date | DD/MM/YYYY |
| fin_date | Final date | DD/MM/YYYY |
| np_ini_date | Non-precise initial date: Earliest possible date when the event is known to have occurred. | DD/MM/YYYY |
| np_fin_date | Non-precise final date: Latest possible date when the event is known to have occurred. | DD/MM/YYYY |
| duration | Event duration | Number of days |
| latitude | Geographic coordinate in terms of latitude for the event occurrence | Meters (m) in projected coordinate system UTM 31N |

| | | |
|---|---|---|
| longitude | Geographic coordinate in terms of longitude for the event occurrence | Meters (m) in projected coordinate system UTM 31N |
| **Earthquakes** | | |
| depth | Epicenter depth | Kilometers (km) |
| local_magnitude | Earthquake local magnitude | e.g. 0,7 |
| intensity | Earthquake intensity as measured by the European Macroseismic Scale (1998 version) | e.g. IV |
| **Floods** | | |
| flood_id | Identification code for the same rainfall episode | e.g. 1 |
| affected_municipality | Municipality affected by the flood | e.g. Sant Feliu de Pallerols |
| total_rain | Daily rainfall of the area closest to the flood | Tenths of a millimeter |
| **Ground subsidences** | | |
| date_formation | Year of formation/identification of the ground subsidence | Year (YYYY) |
| perimeter | Perimeter of the ground subsidence | Meters (m) |
| area | Area of the ground subsidence | Square meters ($m^2$) |
| depth | Depth of the ground subsidence | Meters (m) |
| average_depth | Average depth of the ground subsidence | Meters (m) |
| volume | Volume of the ground subsidence | Cubic meters ($m^3$) |
| nearest_distance_collapse | Distance from the nearest collapse | Meters (m) |
| evaporite_unit | Geological formation of the type of evaporite rock where the sinkhole occurred | e.g. Serrat Formation |
| geomorphic_unit | Geomorphical unit where the collapse occurred | e.g. Bedrock |
| activity | Indicates whether the sinkhole is active (showing signs of movement) or inactive (no current movement) | Active/Inactive |
| **Landslides and Rockfalls** | | |
| volume | Volume of the event | Cubic meters ($m^3$) |
| volume_classification | If the volume is not precise, the following classification is used: small (0-10), medium (10-100), large (100-1.000) and very large (more than 1.000) | Cubic meters ($m^3$) |
| lithology | Lithological classification of the rock where the gravitational process is located. Source: ICGC | e.g. Limestones and dolomites |

| | | |
|---|---|---|
| stratigraphic_sequence | Stratigraphic sequence extracted from the ICGC layer description (Geological map 1:50.000) | e.g. Lower section of the Vallfogona Formation |
| age | Lithology age extracted from the ICGC layer description (Geological map 1:50.000) | e.g. Holocene |
| topography | Terrain slope where the gravitational process was produced | Degrees (º) |
| clas_amplitsismica | Six different classifications according to the seismic amplification values attributed to each type of terrain | e.g. 1 |
| vs30 | Average shear-wave velocity in the top 30 meters of the terrain | m s-1 |
| vmed | Mean shear-wave velocity | m s-1 |
| fa | Site amplification factor for short periods | e.g. 0,86 |
| fv | Site amplification factor for long periods | e.g. 0,76 |
| **Wildfires** | | |
| affected_municipality | Municipality affected by the wildfire | e.g. Sant Aniol de Finestres |
| hatree | Tree forest area burned | hectares |
| hanotree | Scrub, herbal or pasture forest area burned | hectares |
| hanoforest | Non forested (urban and agricultural) burned area | hectares |
| haforest | Forested area burned | hectares |
| hapasture | Pastures area burned | hectares |
| area | Total area burned | hectares |
| temp_ext | Daily temperature of the area closest to the wildfire | ºC |
| wind_velocity | Wind velocity of the closest area to the wildfire | km $h^{-1}$ |