# Hypocentral temperatures, geothermal gradients, crustal seismogenic depths and 3D thermal model of the Southern Caribbean and NW South America
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Ángela María Gómez-García[1,2], Álvaro González[3,1], Mauro Cacace[1], Magdalena Scheck-Wenderoth[1], Gaspar Monsalve[4].

*[1] GFZ German Research Centre for Geosciences. Telegrafenberg, 14473, Potsdam, Germany.*
*[2] Corporation Center of Excellence in Marine Sciences (CEMarin). Bogotá, Colombia.*
*[3] Centre de Recerca Matemàtica (CRM). Campus UAB, Edifici C. 08193, Bellaterra (Barcelona), Spain.*
*[4] Universidad Nacional de Colombia, Facultad de Minas, Medellín, Colombia.*

## 1. Licence



## 2. Citation

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## 3. Version history

**This is a new version of**

Gómez-García, Á. M.; González, Á.; Cacace, M.; Scheck-Wenderoth, M.; Monsalve, G. (2022): Hypocentral temperatures, crustal seismogenic thickness and 3D thermal model of the South Caribbean and NW South America. GFZ Data Services. https://doi.org/10.5880/GFZ.4.5.20202.005

**The main changes are:**

- New title.
- New earthquake dataset, compiled from different sources, with more accurate hypocentral determinations.
- Calculation of D95.
- D90 and D95 depth uncertainties calculated considering the propagation of the reported hypocentral depth errors.
- D10 values are no longer computed, as they are prone to large uncertainties.
- Calculation of the geothermal gradient (from the solid Earth surface down to 20 km depth) at each epicentral location.

Released on 19$^{th}$ February 2024

## 4. Data description

This data repository for the Southern Caribbean and NW South America contains a 3D thermal field computed down to 75 km depth, modelled hypocentral temperatures and geothermal gradients at the locations of crustal earthquakes, and the crustal seismogenic depths calculated from earthquake statistics.

All methodological details can be found in the main publication (see section 2).

## 5. Brief methodological approach

We used the uppermost 75 km of the gravity-constrained structural and density model of Gómez-García *et al*. (2020, 2021) to derive the 3D thermal configuration of the study area (5°-15° N, 63°-82° W). A steady-state approach was followed, in which upper and lower boundary conditions were set to run the thermal calculations using the software GOLEM (Cacace & Jacquey, 2017; Jacquey & Cacace, 2017).

A catalogue of earthquakes occurred within the study area and surroundings was compiled from public sources. In the database archived here, we provide data on selected, best located, crustal earthquakes within the boundaries of this area. For them, the source with the most reliable depth estimate for each earthquake was chosen according to the following order of preference: 1) The gWFM database (Wimpenny and Watson, 2020), based on synthetic body-waveform modeling, and updated to version 1.2, which includes earthquake locations calculated in the region by Wimpenny *et al*. (2018) and Wimpenny (2022). 2) Locations calculated by full-waveform modelling (with the ISOLA code; Sokos and Zahradnik, 2008, using records obtained at regional or local distances) by the Colombian Seismological

Survey (Dionicio *et al*., 2023; Servicio Geológico Colombiano –SGC–, 2023). 3) Locations with free (not fixed) hypocentral depth from the ISC-EHB dataset (Weston *et al*., 2018; Engdahl *et al*., 2020), which is compiled and curated by the International Seismological Centre (2023a). And 4) the prime (best determined) locations reported in the reviewed ISC Bulletin (International Seismological Centre, 2023b). For earthquakes in the surroundings of the study area (whose data is not reproduced here) apart from these sources, ISOLA locations by Quintero *et al*. (2023), and the 2008 Quetame mainshock location by Dicelis *et al*. (2016) were considered. The resulting catalogue covers the period from January 1980 to June 2021.

After selecting a preferred magnitude estimate for each earthquake, the catalogue was pruned of earthquakes below the calculated magnitude of completeness (4.6 until May 1993, and 3.5 since June 1993). Earthquakes without depth, or depth set as 0 km or fixed, as well as those with reported depth errors >15 km were also disregarded. Furthermore, only the crustal earthquakes were selected, that is, with hypocentre located between the topo-bathymetry from the GEBCO relief (Weatherall *et al*., 2015), and the Moho depth from the GEMMA model (Reguzzoni & Sampietro, 2015) interpolated to a resolution of 5 km.

For each earthquake we provide, additionally: the depth referred to the geoid (which approximates well the sea level in the study area, used as datum for the thermal model), the temperature at the earthquake source, the best estimate of moment magnitude, and the geothermal gradient (from 20 km depth to the Earth's surface) at the earthquake's location.

From the crustal earthquakes in the study area and surroundings, we computed the crustal seismogenic depth, as the 90$^{th}$ and 95$^{th}$ percentiles (D90 and D95), respectively, of the earthquake source depths. These percentiles were mapped on a latitude-longitude grid, using for each grid node its closest earthquakes (at least 20) as sample, located within a distance specified by the resolution radius of each node. Namely, this computation yielded the mean and standard deviation of those percentiles at each grid node, by combining a Monte Carlo approach (which accounted for the reported errors in earthquake origin depths) and bootstrapping (which propagated the uncertainties due to the finite sample size).

For more details about the data selection, modelling approach and interpretation of the results, we kindly ask the reader to refer to the main publication: Gomez-Garcia et al. (2024).

## 6. Description of files available in the data repository

This data publication includes the following files:

- **2023-002_Gomez-Garcia-et-al_Earthquake_catalogue_Supplements.xlsx**

This file contains the subset of crustal earthquakes for which the hypocentral temperatures and geothermal gradient were calculated. For each event it is reported: The source of its location data, followed by the temporal and spatial location and depth error provided by this source; the calculated hypocentral depth below the geoid; the preferred magnitude used, its type and author; the estimated moment magnitude; and finally, the modelled hypocentral temperature and geothermal gradient.

- **2023-002_Gomez-Garcia-et-al_D90_D95_&_Temperatures.xlsx**

This file includes, for each node of a latitude-longitude grid, the calculated depths of D90 and D95, their standard deviations, and the modelled temperature at those depths. Only those grid nodes where at least D90 is located within the crust are reported (since D95 is deeper than D90, it is below the Moho for some locations where D90 is not). The resolution radius (distance from the grid node to the furthest earthquake in the respective sample) is also provided.

- **2023-002_Gomez-Garcia-et-al_3DThermal_field_SouthCaribbean.e**

Exodus mesh resulting from the GOLEM simulations, providing the modelled 3D thermal field, the heat flow and the thermal parameters assigned to each lithospheric layer (radiogenic heat production and thermal conductivity). It can be read by diverse software, such as Paraview, Visit, Cubit, Tecplot, Ensight, exodus.py, and pyvista.

## 7. Software used in the research project

The 3D thermal model was computed using the software GOLEM (Cacace & Jacquey, 2017; Jacquey & Cacace, 2017).

## 8. Financial support

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