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A damaging supercell hailstorm on 6 July 2023 in Vitoria-Gasteiz, the Basque Country

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Abstract. We analyze a severe supercell that affected Vitoria-Gasteiz (Basque Country, northern Spain) on 6 July 2023, producing 4–5 cm hail and rainfall rates close to $30\,\mathrm{mm\,h^{-1}}$. The main objective of this work is to improve the forecasting and early-warning capabilities for similar high-impact storms in the Basque Country. This region lies on the northern edge of one of the most active supercell areas of the Iberian Peninsula, but remains relatively understudied. The synoptic and convective environment is examined using GFS analyses and the 1 km operational WRF configuration of Euskalmet, while the storm evolution and surface impacts are characterized through radar, rain gauge and disdrometer data. Environmental parameters were substantially above the median of Spanish very-large-hail supercells, with surface-based CAPE near $2000\,\mathrm{J\,kg^{-1}}$, 0–6 km bulk shear of 20–$25\,\mathrm{m\,s^{-1}}$ and 0–3 km storm-relative helicity slightly above $200\,\mathrm{m^2\,s^{-2}}$. The storm originated from a splitting cell and rapidly intensified as a right-moving supercell, reaching cloud-top heights of 14–15 km and reflectivity values of 60–65 dBZ. This case also shows that convective initiation and storm splitting west of Basque Country must be monitored, as right-moving cells from these areas can affect the Basque Country when the vertical wind profile shows cyclonic curvature.

1 Introduction

Severe convective storms, particularly those capable of producing very large hail (> 5 cm in diameter, Púčik et al., 2019), have drawn increasing attention in recent years due to their socio-economic impact. Incidences of very large hail are almost always associated with supercells (Markowski and Richardson, 2010), i.e., the most organized, severe and long-lasting form of isolated deep convection occurring in environments with strong vertical wind shear.

Observational evidence indicates that the Iberian Peninsula frequently experiences damaging convective storms, often involving very large hail (Quirantes et al., 2014; Martín et al., 2021; Calvo-Sancho et al., 2022). Recent studies have documented giant-hail events along the Mediterranean coast, including the record-breaking Girona case of August 2022, with hailstones reaching 12 cm in diameter (Martín et al., 2024).

While most studies on Spanish supercells have focused on the Mediterranean basin and the Ebro Valley (Castro et al., 1992; Martín et al., 2021; Martín et al., 2024) – regions known for frequent severe convection –, the Atlantic sector of Spain remains comparatively less documented. Within this area, the Basque Country stands out as the *most stormy* subregion of the Cantabrian coast (Feldmann et al., 2025), owing partly to the relatively warm summer sea surface in the Bay of Biscay and its proximity to the rugged Iberian mountain range (Iberian System) and Middle Ebro Valley (Castro et al., 1992; Martín et al., 2021). Recent events, such as the two supercells in the southern Basque Country that produced tornadoes in the last decade (Gaztelumendi et al., 2016, 2019) and the 2009 storm that produced giant hail of up to 6–8 cm in diameter in Vitoria-Gasteiz (Gaztelumendi et al., 2011), illustrate the potential of the region for severe weather. Moreover, supercell reports in Álava are relatively frequent per unit area and comparable to those of eastern Spain (Quirantes et al., 2022), suggesting that the region, and particularly the city of Vitoria-Gasteiz, occasionally hosts environments conducive to severe convective development (Martín et al., 2021).

These environments in the Basque Country typically occur between May and September, with most events concentrated in June–August, mainly during the afternoon hours (Egaña et al., 2017a). Storms normally initiate in the south or southwest outside the Basque Country, although they can also be generated within the region, depending on the convergence areas at low levels and instability degree (Egaña et al., 2017b). In fact, supercells occurring in the Middle Ebro Valley tend to initiate along the foothills of the Iberian System and generally track from the west and southwest, to the east and southeast and typically move eastward or northeastward across the valley (Martín et al., 2021).

From an operational perspective, severe-thunderstorm forecasting in Euskalmet (Basque Meteorology Agency) follows an ingredient-based approach (Schultz, 2010), in which forecasters examine model-predicted synoptic and mesoscale patterns to assess the potential for deep and organized convection. This includes evaluating large-scale ascent, low-level moisture and warm-air advection, mid-level cooling, and upper-level jet structures, together with mesoscale features such as orographic forcing and localized convergence. Key convective parameters and vertical wind profiles are routinely evaluated to identify environments supportive of supercell development.

In such environments, buoyancy and vertical wind shear play complementary roles in storm organization. High CAPE provides the vertical accelerations needed for strong and sustained updrafts, favoring hail growth by keeping hydrometeors suspended within the hail-growth zone. Deep-layer shear promotes the tilting and separation of the updraft and downdraft, a key mechanism that prevents storm disruption and enables supercell longevity. Storm-relative helicity quantifies the streamwise vorticity available in the inflow; once tilted and stretched by the updraft, it contributes to mesocyclone formation. Confirming the presence of a mesocyclone is operationally important because it provides direct evidence that a convective cell is a supercell. These mechanisms justify the selection of the key convective parameters and reinforce their value for operational forecasting.

Following this forecasting framework, the present work documents and analyzes the hailstorm that affected the city of Vitoria-Gasteiz on 6 July 2023. The main objective is to characterize the atmospheric environment that favored the development of the supercell responsible for intense short-duration rainfall and abundant hail (approximately 4–5 cm in diameter), with the aim of improving forecasting and early-warning of similar severe thunderstorms in the Basque Country. Case studies such as this one help refine the forecasting process by illustrating how severe-storm environments manifest in the region. Using high-resolution Weather Research and Forecasting (WRF) model forecasts, we investigate the synoptic and mesoscale conditions that supported supercell development, while radar and surface observations are used to analyze the evolution of the storm and its impacts. A secondary objective is to contribute to the expansion of Euskalmet's severe weather catalog for the Basque Country (Gaztelumendi et al., 2024), providing a reference for future climatological analyses of supercells in the region. Our results are also compared with the climatological characteristics of supercells in Spain to assess whether the environmental parameters were near or above the Spanish median.

The article is structured as follows. Section 2 describes the data and methodology. Section 3 analyzes the environmental conditions that contributed to the formation of the supercell. Section 4 focuses on storm generation and evolution. Section 5 analyzes the surface observations and main impacts of the hailstorm, and finally, Sect. 6 presents the summary and conclusions.

2 Data and Methodology

The analysis focuses on the Basque Country, and specifically in the region Álava and the surroundings of Vitoria-Gasteiz (Fig. 1). To describe the synoptic and mesoscale environment, we used data from the Global Forecast System (GFS) of the National Centers for Environmental Prediction and from Euskalmet's mesoscale forecasting system WRF-EUS03 (Gelpi et al., 2024).

The GFS is a hydrostatic global numerical weather prediction model with a horizontal grid spacing of approximately 13 km with hourly output files (NCEP, 2025). The WRF-EUS03 configuration is one of Euskalmet's operational non-hydrostatic mesoscale models, based on the WRF modeling system (Skamarock et al., 2019). The model is run with 45 vertical levels and a 1 km horizontal grid spacing in the inner domain, where deep convection is mostly resolved by the model dynamics, while a scale-aware Grell–Freitas cumulus parameterization (Grell and Freitas, 2014) is applied to represent the remaining subgrid convective processes. GFS data are used as initial and boundary conditions.

To investigate the formation and evolution of the supercell, as well as the surface impacts, several datasets from the Basque observation system were employed: the Kapildui weather radar, the automatic weather station (AWS) tipping-bucket rain gauges and disdrometer data. By using Kapildui radar data (Gaztelumendi et al., 2008), the movement and evolution of the severe storm were analyzed, and classical supercell signatures were identified. Observations from the AWS rain gauges (Gaztelumendi et al., 2018; Hernandez et al., 2022) and the disdrometer network (Gaztelumendi et al., 2022) were used to assess rainfall accumulation and intensity across the region, particularly in the city of Vitoria-Gasteiz. Disdrometer data complemented the tipping-bucket rain gauge observations from the Arkauti AWS, located in the east of Vitoria-Gasteiz, enabling a finer temporal characterization of rainfall intensity and hydrometeor type.

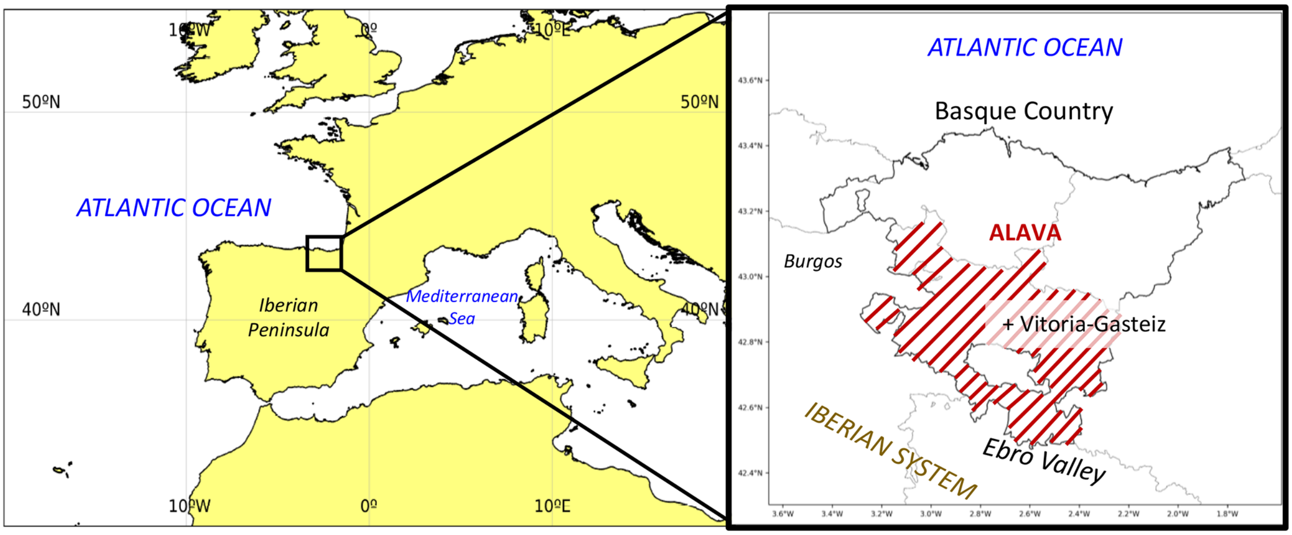


Figure 1. Map showing the location of the Basque Country in Southwestern Europe, in the Iberian Peninsula. The region of Álava is hatched with garnet diagonal lines. The location of Vitoria-Gasteiz city, the province of Burgos and the main affecting geographical features are also indicated.

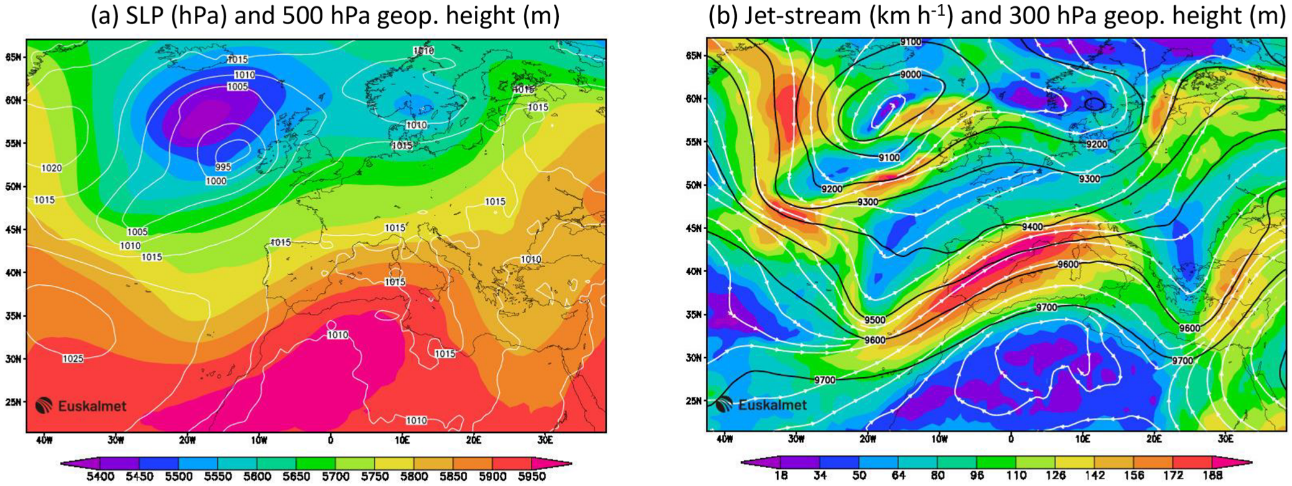
3 General and convective environments

On 6 July 2023, the surface weather situation over the Iberian Peninsula was characterized by a weak pressure gradient (Fig. 2a), and the presence of the typical daytime summer thermal low (not visible in the figure). In the lower atmospheric layers, warm and moist air from the Mediterranean Sea was advected toward the Atlantic region through the Ebro Valley, although this regional-scale advection is not visible in Fig. 2a due to the map scale. Precipitable water values were around 25–30 $\mathrm{kg\,m^{-2}}$ in the Basque Country (not shown). In the middle and upper troposphere southwesterly flow dominated, influenced by a weak trough embedded in a wavy subtropical jet stream, with its upstream branch extended over the Iberian Peninsula (Fig. 2b). This synoptic pattern aligns with the composite environment of Spanish supercells described by Calvo-Sancho et al. (2022). At upper levels, a trough west of the Peninsula enhances cyclonic vorticity advection and divergence aloft, while at low levels a thermal low over central Spain favors moist easterly inflow along the Mediterranean coastline and through the Ebro Valley.

To assess the potential for severe convection and supercell development, several instability indices are examined in the three-panel Fig. 3, along with the Skew-T atmospheric profile from the 1 km WRF-EUS03 simulation (Fig. 4), given the absence of radiosonde observations in the region. The analysis corresponds to 16:00 UTC, roughly 2 h before the supercell passed over Vitoria-Gasteiz. At this time, no convective cells had yet developed in the 1 km WRF-EUS03 domain, ensuring that the diagnosed environment represents pre-storm conditions and is temporally closed to the event. As background, previous studies (Calvo-Sancho et al., 2022; Feldmann et al., 2025), indicate that supercells in this region typically peak between 15:00 and 18:00 UTC, shortly after the daily insolation maximum.

The potential for severe convection was high at 16:00 UTC, as indicated by the instability indices. Surface-based CAPE (SBCAPE) exceeded 1500 $\mathrm{J\,kg^{-1}}$ across a broad area around Vitoria-Gasteiz and surpassed 2000 $\mathrm{J\,kg^{-1}}$ in southern Álava (Fig. 3a), providing the buoyant energy needed for strong vertical accelerations that favor hail growth by keeping hydrometeors suspended within the hail-growth zone. The subtropical jet strengthened the mid- to upper-tropospheric southwesterly flow, increasing 0–6 km shear to 20–25 $\mathrm{m\,s^{-1}}$, with local maxima reaching 25–30 $\mathrm{m\,s^{-1}}$ (Fig. 3b). Such shear promotes the tilting and separation of the updraft and downdraft, a key mechanism for maintaining storm organization and longevity. The 0–3 km storm-relative helicity (SRH) reached 200–250 $\mathrm{m^2\,s^{-2}}$ over much of Álava (Fig. 3c), indicating a substantial amount of streamwise vorticity that can be tilted and stretched into a mesocyclone by the updraft.

To further illustrate the atmospheric instability, Fig. 4 presents a simulated Skew-T profile from the 12:00 UTC 1 km WRF-EUS03 run for a grid-point within Vitoria-Gasteiz at 16:00 UTC. The layer roughly between 750 and 500 hPa was conditionally unstable, with a lifting condensation level (LCL) around 850 hPa, and substantial buoyant energy extending above the 0 °C level, conditions that can favor hail growth when combined with adequate storm organization and deep-layer shear. Although high LCL in sufficiently unstable environments have been associated with an increased likelihood of large hail in Europe (Púčik et al., 2015), hail production depends on a broader set of ingredients, including CAPE available above the freezing or


(a) SLP (hPa) and 500 hPa geop. height (m)

(b) Jet-stream (km h^{-1}) and 300 hPa geop. height (m)

Figure 2. (a) Sea level pressure and 500 hPa geopotential height, and **(b)** jet-stream and 300 hPa geopotential height, on 6 July 2023 at 12:00 UTC from GFS analyses.

−10 °C levels, mid-tropospheric lapse rates and moisture, and deep-layer shear that supports supercell structure (Johns and Doswell, 1992; Dennis and Kumjian, 2017; Taszarek et al., 2020; Battaglioli et al., 2023).

The hodograph includes the Bunkers decomposition (Bunkers et al., 2000). The right-moving (RM) vector points from the northwest toward the southeast (Fig. 4), while the upper-level flow is from the southwest, indicating a favorable environment for cyclonic-supercell intensification. Further intensification of the RM cell is commonly observed in other regions of the world. Numerous studies have shown that left-moving (LM) supercells typically have shorter lifetimes and weaker organization than their RM counterparts (Weisman and Klemp, 1984; Bunkers et al., 2000; Markowski and Richardson, 2010). In the United States, RM supercells account for the vast majority of hail-producing supercells (Homeyer et al., 2025).

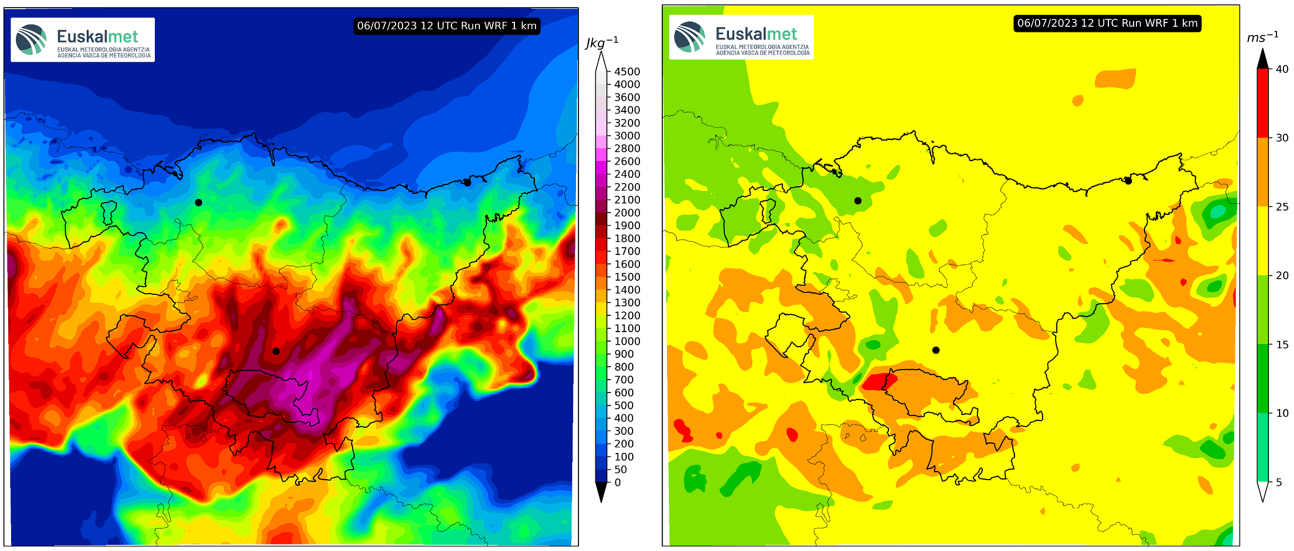
When compared with previous severe-storm climatologies, the indices during this event fall within the upper range of environments associated with very large hail in Spain. SBCAPE, 0–6 km shear and 0–3 km SRH all exceed the median values reported for supercells producing hail > 5 cm in Spain between 2011 and 2020 (1231 J kg^{-1}, 19.6 m s^{-1} and 111 $m^2\,s^{-2}$, respectively; Calvo-Sancho et al., 2022). SBCAPE values of 1800–2000 J kg^{-1} approach the upper-range values ($\sim$ 2000 J kg^{-1}) reported for severe hailstorms in the Basque Country during the 2001–2016 (Egaña et al., 2017a) and even surpass those of the 2009 very-large-hail (6–8 cm) storm in Vitoria-Gasteiz (1500 J kg^{-1}). The 0–6 km bulk shear (20–25 m s^{-1}) is slightly lower than in the giant-hail-producing Girona storm of 2022 (24 m s^{-1}; Martín et al., 2024). Similarly, the 0–3 km SRH (200–250 $m^2\,s^{-2}$) lies above the 90th percentile of Spanish supercells producing very-large hail (Calvo-Sancho et al., 2022). The high Supercell Composite Parameter (SCP = 7) further supports the presence of a strongly favorable environment for organized severe supercells.

4 Supercell formation and evolution

Given the highly favorable convective environment described in the previous section, we now examine the different stages of the severe storm that affected Vitoria-Gasteiz: convective initiation, supercell formation and subsequent evolution. Our analysis focuses on the convective cell that impacted the city, which exhibited supercellular structure and a clear west–east trajectory. Radar observations are used to document its characteristics and evolution.

Figure 5 provides a timeline illustrating the key stages of the storm, while Fig. 6 displays a 10 min time-lapse to illustrate its evolution as it approached Vitoria-Gasteiz. We use 2 km Constant Altitude Plain Position Indicator (CAPPI) radar data (100 km range) to analyze the horizontal structure of the storm, complemented by vertical cross-sections (Fig. 7) and Doppler radial wind data (Fig. 8) to confirm the presence of a mesocyclone.

The storm initially developed in northern Burgos (west of Vitoria-Gasteiz, Fig. 1) around 15:30–15:40 UTC (Fig. 5a). Around 16:10–16:20 UTC, a storm split occurred, producing a left-moving (LM) and a right-moving (RM) cell (Fig. 5b). The RM cell intensified following the upper-level wind profile and the clockwise-curved hodograph (Fig. 4). Consistent with classical theory, the cell deviated to the right of the deep-layer shear vector (Weisman and Klemp, 1984). The higher reflectivity values (50–55 dBZ) observed at 17:02 UTC (Fig. 5c), as the storm entered Álava from the west, mark the onset of intensification. The RM supercell continued to strengthen and reached Vitoria-Gasteiz around 18:10–18:20 UTC (Fig. 5d). Radar reflectivity in the lower levels (with peak values of 60–65 dBZ) exhibited a hook-


(a) CAPE 16:00 UTC

(b) 0–6 km Bulk shear 16:00 UTC

(c) 0–3 km SRH 16:00 UTC

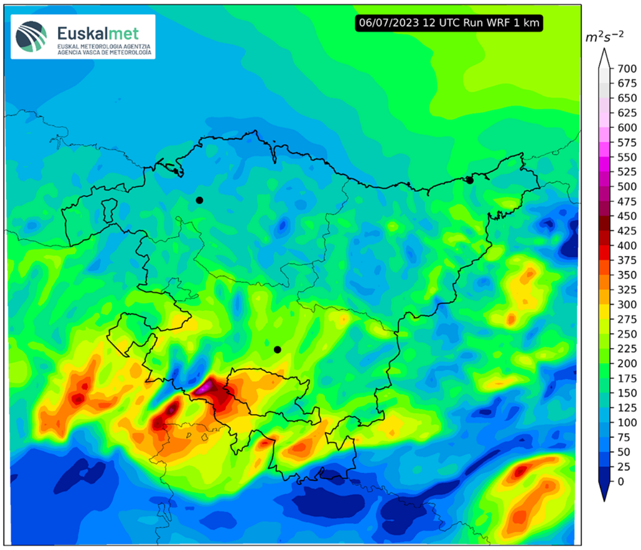


Figure 3. Some convective indices at 16:00 UTC from the WRFEUS3-1km modelling configuration (6 July 2023 12:00 UTC run). **(a)** SB-CAPE, **(b)** 0–6 km bulk shear and **(c)** 0–3 km SRH.

shaped echo from 17:32 to 18:12 UTC (Fig. 6), along with a strong reflectivity gradient: hallmark features of a classic supercell.

Before reaching the city, at around 17:40 UTC, the supercell showed pronounced vertical development. The Echo top product, which indicates the maximum altitude where radar reflectivity exceeds the operational threshold (15 dBZ in our case), reached 13–14 km, with local maxima of 14–15 km (Fig. 7). This large vertical extent is also reflected in the maximum reflectivity values within the 2–15 km layer (Fig. 7), along with intense electrical activity. In Álava, a total of 3935 cloud-to-ground lightning strikes were recorded during the afternoon and evening.

Shortly afterward, around 17:50 UTC, a hook echo was again identified at 0.5° Plain Position Indicator (PPI) reflectivity west of Vitoria-Gasteiz (Fig. 8a). Simultaneously, the 2 km CAPPI radial wind field (Fig. 8b) showed two closely spaced inbound and outbound maxima, forming a velocity couplet approximately perpendicular to the radar beam direction. This pattern confirms the presence of a mesocyclone and, therefore, the supercell character of the storm.

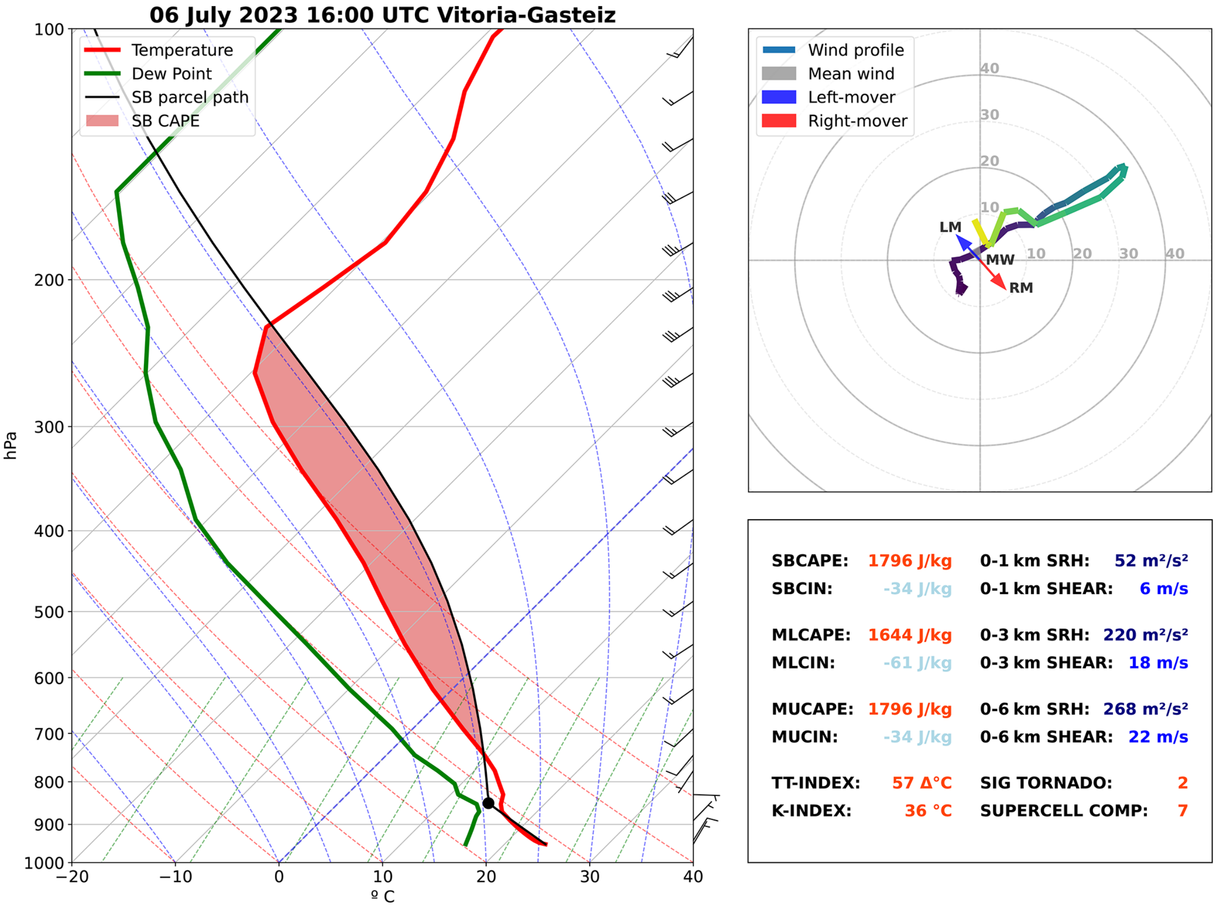


Figure 4. Skew-T diagram in Vitoria-Gasteiz for the 6 July 2023 at 16:00 UTC. The LCL is shown with a black dot and the SBCAPE is shaded in red. The 0 °C isotherm is highlighted in blue. The predicted hodograph (up, right-hand side) shows the Bunkers decomposition from the Bunkers storm motion method. The panel of the bottom right side shows the values of several convective indices and parameters associated with the potential likelihood of supercells.

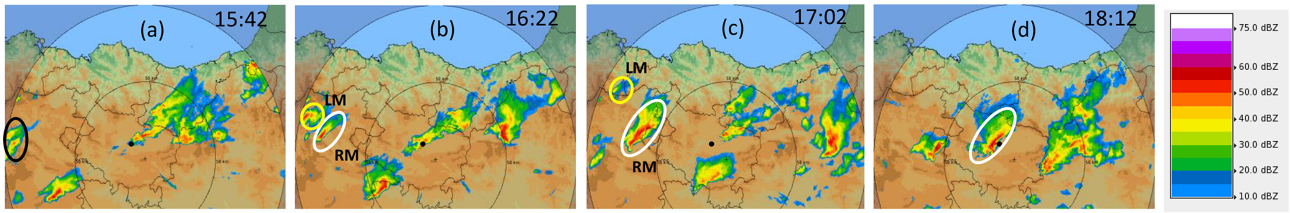


Figure 5. Storm timeline of the supercellular storm that affected Vitoria-Gasteiz (pinpointed with a black dot), with the most relevant phases **(a)** storm birth, **(b)** storm splitting, **(c)** intensification of RM cell and **(d)** storm hitting Vitoria-Gasteiz. Reflectivity images from the 2 km CAPPI of the 100 km-range radar are shown. A black ellipse is used to indicate the initial storm, a yellow ellipse for the LM cell and a white ellipse for the RM cell.

5 Surface records and damage

Following the spatiotemporal analysis of the supercell, we examine its impacts, focusing on precipitation measurements from the disdrometer and AWS network, and on the hail-related damages in Vitoria-Gasteiz.

5.1 Disdrometer data

Figure 9 provides a detailed view of precipitation recorded in Vitoria-Gasteiz using the disdrometer located near the Arkauti station, in the eastern part of the city (Fig. 10). The instrument recorded 36.6 mm in 20 min (18:20–18:40 UTC), including 32.9 mm in the 10 min between 18:22 and 18:32 UTC, and 7.7 mm in a single minute (Fig. 9a). Thus,

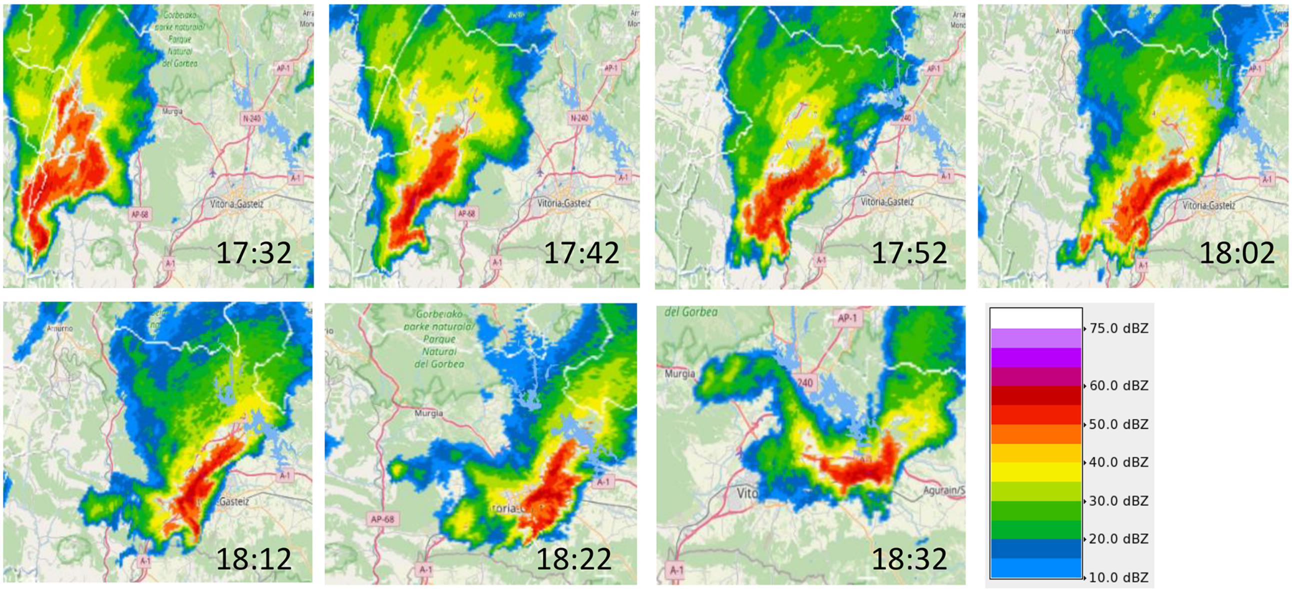


Figure 6. Time lapse of CAPPI – 2 km Radar product (from 17:32 to 18:32 UTC every 10 min) where we can appreciate the eastward movement of the supercell affecting Vitoria-Gasteiz.

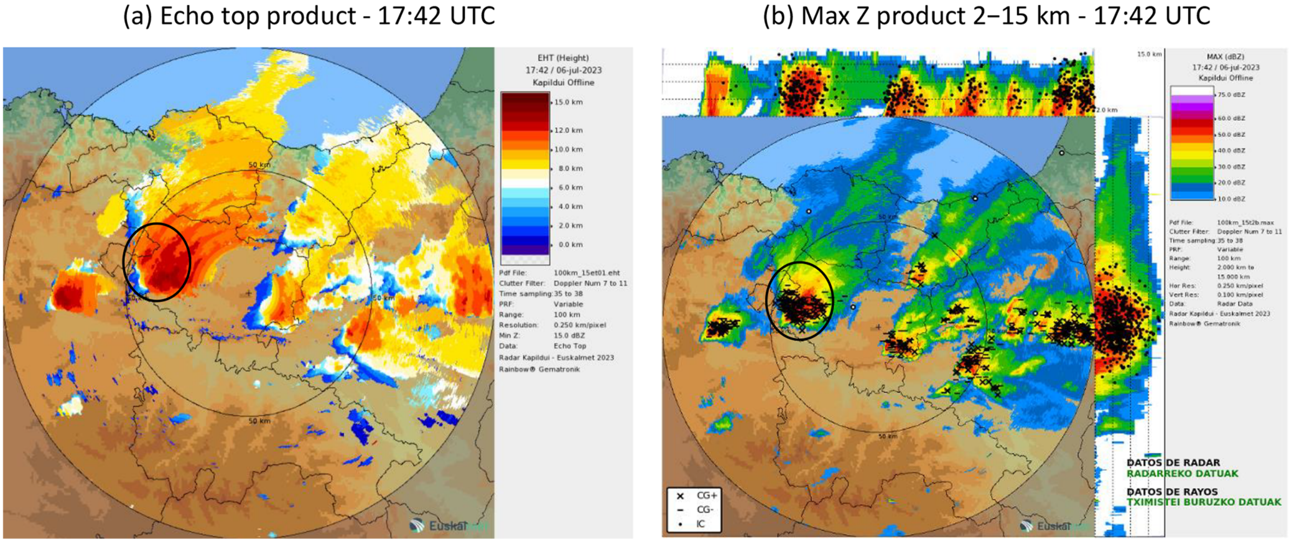


Figure 7. **(a)** Echo top product of 15 dBZ at 17:42 UTC and **(b)** Maximum reflectivity product in the 2–15 km layer at 17:42 UTC with electrical discharge from Euskalmet lightning data.

most of the precipitation occurred in an exceptionally intense 10 min interval, during which estimated reflectivity reached 70–72 dBZ (Fig. 9b). From 18:24 to 18:31 UTC, most hydrometeors detected by the disdrometer were hail (not shown), with an instantaneous liquid-equivalent peak intensity of 462 mm h^{-1} at 18:29 UTC, coinciding with the 7.7 mm 1 min accumulation.

5.2 Rain gauge data

To assess the impacts of the supercell precipitation across Vitoria-Gasteiz and Álava, tipping-bucket rain gauge data from the AWS are analyzed and shown in Fig. 10. Rainfall intensity varied substantially across stations: in Abetxuko (north of the city) 12.1 mm h^{-1} were recorded between 18:20 and 19:20 UTC, with 10 min maximum of 8.8 mm at 18:30 UTC. In contrast, Arkauti (east of the city) recorded 25.6 mm h^{-1} between 18:30 and 19:30 UTC, most of it within 20 min, with a 10 min peak of 14.7 mm at 18:32 UTC.

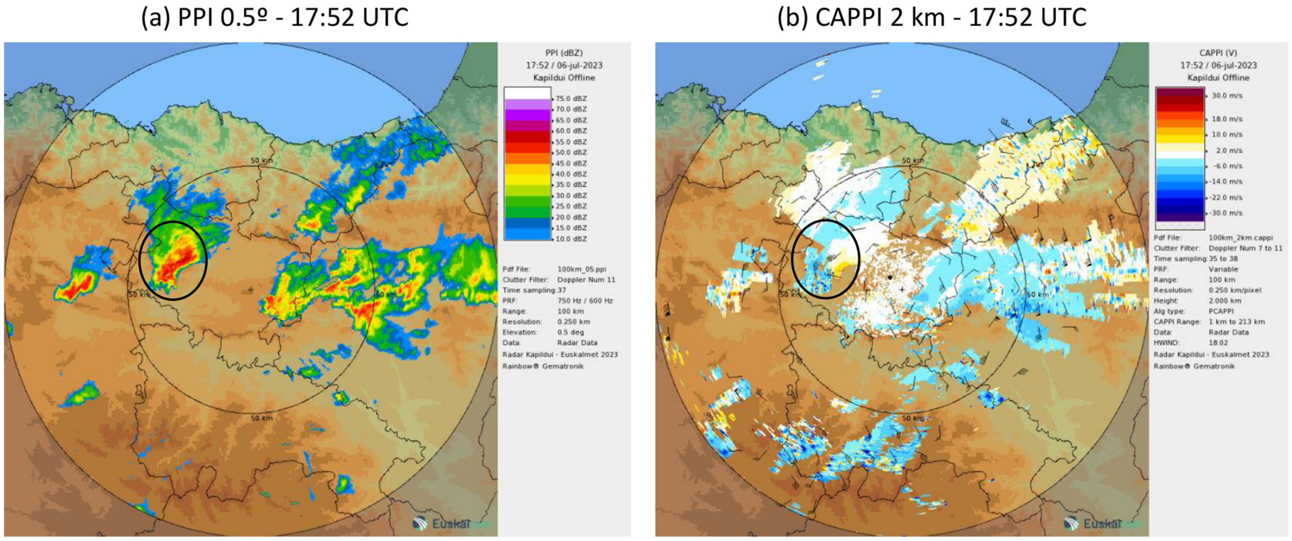

(a) PPI 0.5º - 17:52 UTC
(b) CAPPI 2 km - 17:52 UTC

Figure 8. **(a)** PPI of 0.5° at 17:52 UTC and **(b)** the radial wind at the CAPPI at 2 km at 17:52 UTC.

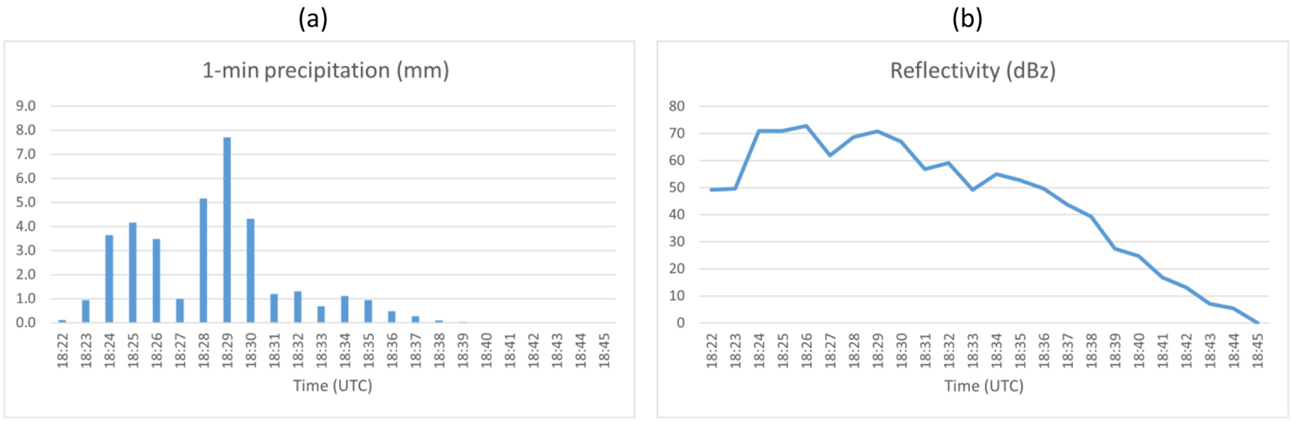

(a)
(b)

Figure 9. **(a)** Accumulated 1 min precipitation and **(b)** estimated reflectivity from the Arkauti disdrometer between 18:22 and 18:45 UTC.

This sharp gradient over only ∼ 5 km illustrates the highly localized nature of severe convective precipitation. Furthermore, radar reflectivity between 18:02 and 18:22 UTC (Fig. 6) did not clearly indicate that the eastern part of the city would experience the strongest impact, highlighting the inherent challenges of nowcasting such events.

The discrepancy between Arkauti AWS rainfall (25.6 mm) and the disdrometer total (36.6 mm) during the supercell passage is likely due to the combination of very large hail (up to 4–5 cm diameter) and strong wind gusts (∼ 70 km h^{-1}). Under such conditions, disdrometers often overestimate liquid-equivalent precipitation because some hailstones may be misclassified as raindrops, while tipping-bucket gauges may underestimate precipitation due to wind-induced undercatch and splash losses (Friedrich et al., 2013; Tokay et al., 2014).

Heavy precipitation was also recorded at other stations due to additional convective cells. For example, before the supercell, a previous storm produced intense rainfall at Arkauti between 16:10 and 17:00 UTC (Fig. 5b). Another storm affected the mountains of Álava, with heavy rainfall in Kanpezu. Etura and Ozaeta stations, east of Vitoria-Gasteiz, set new July records for hourly and 10 min rainfall with 20.9 and 26.6 mm h^{-1} respectively. Other high values recorded during this day include: Kanpezu 27.4 mm h^{-1}, Arkauti 26.7 mm h^{-1}, and Tobillas 20.6 mm h^{-1} (Fig. 10).

5.3 Hailstorm damages

In addition to the heavy rainfall, the supercell produced hail across Vitoria-Gasteiz, with diameters of 4–5 cm particularly in the eastern districts, according to eye-witness reports and photographic evidence. Disdrometer data confirm that the hailfall coincided with the supercell passage, not with earlier convective cells. In other areas of the city, hail size was smaller, but the accumulation was significant. The storm also generated strong wind gusts (∼ 70 km h^{-1} at Arkauti), al-

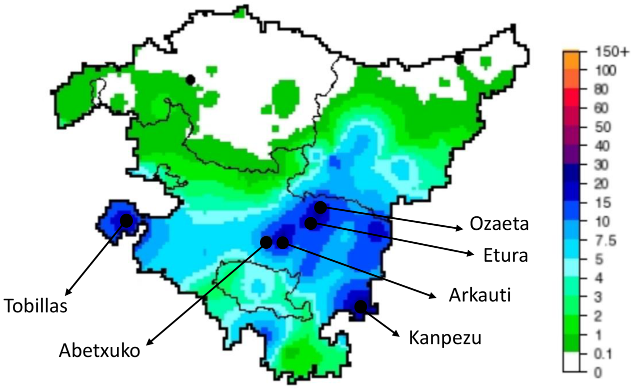


Figure 10. Maximum precipitation in 1 h ($\mathrm{mm\,h^{-1}}$) during the whole day (6 July 2023) in the Basque Country. Data are obtained from the AWS network and Kriging with external drift technique is employed for the representation.

though these do not appear to have caused any additional reported damage.

The hailstorm caused widespread disruption and substantial damage in Vitoria-Gasteiz, including 11 injuries from very large hailstones, destruction of thousands of vehicles, blocked streets, drainage failures, flooding of commercial premises and garages, and partial roof collapses in several buildings (Fig. 11). Agricultural losses were also substantial, with damage reported across 16 282 ha and 18 292 affected plots, primarily involving winter cereals in the Llanada Alavesa. According to Agroseguro, these losses are unprecedented in Álava for a single-day weather event.

According to data from the Spanish Insurance Compensation Consortium, 87 claims were accepted in Álava, 79 of them within Vitoria-Gasteiz, totaling EUR 256 000 (EUR 221 000 in the city). These included 29 residential claims, 18 vehicle claims, 2 office-space claims, 2 industrial claims and 36 commercial or miscellaneous claims.

6 Summary and conclusions

A severe supercell thunderstorm producing heavy precipitation and very large hail (4–5 cm) affected Vitoria-Gasteiz on 6 July 2023. This study analyzed the synoptic and mesoscale conditions that led to its development, as well as the evolution and impacts of the storm, contributing to the limited literature on case studies of severe convection in the Basque Country.

At the synoptic scale, the environment featured an upper-level trough west of the Iberian Peninsula, the upstream branch of the jet stream over the Peninsula, and an easterly warm and moist inflow though the Ebro Valley. This pattern is consistent with the composite environments associated with Spanish supercells, providing large-scale forcing, enhanced deep-layer shear and abundant low-level moisture.

Mesoscale analysis from the 1 km WRF-EUS03 revealed a highly favorable preconvective environment. Surface-based CAPE approached 2000 $\mathrm{J\,kg^{-1}}$, which lies within the upper range of values associated with severe storms in the Basque Country and even exceeds the values observed during the 2009 giant-hail event (6–8 cm) in the city. Deep-layer shear (0–6 km shear, 20–25 $\mathrm{m\,s^{-1}}$) and storm-relative helicity (0–3 km SRH, $\sim 200\,\mathrm{m^2\,s^{-2}}$) also exceeded the median values of Spanish very-large-hail supercells. Together with the simulated sounding and the clockwise-curved hodograph, these parameters indicated an environment highly conducive to supercell development.

From a forecasting perspective, this study helped identify synoptic patterns that can potentially lead to supercell development, and provided reference values of key instability and shear parameters associated with very large hail. With the operational forecasting tools available in Euskalmet, particularly the 1 km WRF-EUS03 configuration, these environments can be anticipated with increasing confidence.

Radar observations from Euskalmet allowed us to analyze the formation and evolution of the storm. The storm initially developed in northern Burgos, to the northwest of the Iberian System and west of Vitoria-Gasteiz, where it underwent a storm split. The right-moving cell subsequently intensified along its west–east trajectory, reaching reflectivity cores of 60–65 dBZ and cloud tops of 14–15 km, and deviated to the right of both the deep-layer shear vector and the surrounding convective cells. Radar signatures characteristic of supercells – including a hook-shaped echo, strong reflectivity gradients and a pronounced inbound–outbound velocity couplet – confirmed the presence of a persistent mesocyclone. Real-time identification of these deviations and signatures is therefore essential for early detection, nowcasting and warning operations.

Precipitation estimates from the Arkauti station (east of the city) revealed exceptional accumulations in roughly 20 min: the tipping-bucket rain gauge recorded 25.6 mm, while the disdrometer measured 36.6 mm. Of this amount, 32.9 mm fell within 10 min, including an extraordinary peak of 7.7 mm in a single minute, coinciding with the 7 min hailfall period indicated by the instrument. Differences between tipping-bucket and disdrometer records are explained by known measurement biases during hailfall. Thus, the actual precipitation intensity likely lies between both estimates, and is consistent with reported impacts: photographic evidence of 4–5 cm hail, widespread flooding and disruption, and 11 injuries.

Beyond the reported storm impacts, this case also highlights the importance of identifying upstream source regions of severe convection affecting the Basque Country. Although many severe Spanish supercells originate in the surroundings of the Iberian System under similar synoptic conditions, this event shows that regions west of the Basque Country, such as northern Burgos, must also be monitored closely. Storm splitting in these areas can produce right-moving cells that deviate from the main southwesterly flow into the Basque

Figure 11. Images of hail size, damages and hail-covered streets at different parts of Vitoria-Gasteiz city. (Images Source: Basque Government Security Department, map data: © OpenStreetMap contributors, ODbL 1.0).

Country when the vertical wind profile exhibits cyclonic curvature conducive to RM enhancement.

Finally, this event contributes to the expansion of Euskalmet's severe-weather database. As additional supercell cases are documented, the development of a regional climatology will enable more robust statistical analysis of instability fields and shear parameters, ultimately improving the diagnosis of environments conducive to severe hailstorms. This and other case studies are part of the severe-weather case set used in the ongoing training of forecasters at Euskalmet.

Code and data availability. The datasets and analysis code used in this study are available from the corresponding author upon reasonable request. Researchers interested in reproducing the results or accessing specific materials can contact the authors to obtain the necessary files.

Author contributions. JE defined the methodology, conducted the analysis of the case study and wrote the manuscript, JAA contributed to the interpretation of the results, was responsible for the design and preparation of some figures and wrote the manuscript, and SG led the conceptualization, contributed to the methodology, and was responsible for the review and editing of the manuscript. All the authors have revised and commented on the manuscript.

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