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# Extratropical cyclones in British Overseas Territory in the South Atlantic

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November 3, 2025

## Abstract

The work is based on the analysis of an extratropical cyclone that passed west of the South Georgia Islands in late winter 2025. This extratropical cyclone (hereinafter referred to as Georgia) and others that commonly pass through the South Atlantic Ocean have a strong influence on the region's climate, with winds above 80 km/h. The Georgia cyclone that formed south southeast, of South Georgia Island. It traveled 74 km in 7.5h towards the north-northwest, when it was 320 km of core from South Georgia Island. It moved at an average speed of 9.81 km/h (6.1 mi/h). The highlighted turbulent cyclonic vortex exhibits two Cote's curves. The shape of Georgia and other cyclones that hit this region has already been well characterized, having the shape of a Cote's spiral curve, also similar to spiral galaxie, Gobato et al. (2020-24) such as Messier 77 and the Great Dark Spot (GDS) of Neptune.

## 1 Introduction

Extratropical cyclones are common in the South Atlantic. They generally arise with the passage of cold fronts to the south of the South American continent, crossing the south of Chile and Argentina. (Gobato, Mitra, and Mullick, 2023; Gobato, Mitra, and Mullick, 2024; Gobato, M.R.R.Gobato, and Heidari, 2020; Gobato and Hedari, 2020; Gobato, Mitra, and Hedari, 2020; Gobato, Hedari, and Gobato, 2022; Gobato,

Mitra, and Hedari, 2022; Gobato, A.Hedari, and A.Mitra, 2022; "Cyclone" 2022)

A cyclone is a large air mass that rotates around a strong center of low atmospheric pressure, counterclockwise in the Northern Hemisphere and clockwise in the Southern Hemisphere as viewed from above (opposite to an anticyclone). ("Cyclone" 2022) A subtropical cyclone is a weather system that has some characteristics of a tropical cyclone and some characteristics of an extratropical cyclone. They can form between the equator and the 50th parallel. ("Cyclone" 2022; Landsea, 2009)

The winds are driven by this low-pressure core and by the rotation of the Earth, which deflects the path of the wind through a phenomenon known as the Coriolis force. As a result, tropical cyclones rotate in a counterclockwise (or cyclonic) direction in the Northern Hemisphere and in a clockwise (or anticyclonic) direction in the Southern Hemisphere. ("Cyclone" 2022; Landsea, 2009)

South Georgia and the South Sandwich Islands is a British Overseas Territory in the southern Atlantic Ocean. It is a remote and inhospitable collection of islands, consisting of South Georgia and a chain of smaller islands known as the South Sandwich Islands. The South Georgia Group lies about 1,390 km (860 mi; 750 mi) east-southeast of the Falkland Islands, at 54°-55°S, 36°-38°W. It comprises South

Georgia Island itself, by far the largest island in the territory, and the islands that immediately surround it and some remote and isolated islets to the west and east-southeast. It has a total land area of 3,756 km<sup>2</sup> (1,450 mi<sup>2</sup>), including satellite islands, but excluding the South Sandwich Islands, which form a separate island group. (Gobato, Mitra, and Mullick, 2023)

## 2 Messier 77

Messier 77 (M77), also known as NGC 1068 or the Squid Galaxy, is a barred spiral galaxy in the constellation Cetus. It is about 47 million light-years (14 Mpc) away from Earth, and was discovered by Pierre Méchain in 1780, who originally described it as a nebula. Méchain then communicated his discovery to Charles Messier, who subsequently listed the object in his catalog. Both Messier and William Herschel described this galaxy as a star cluster. Today, however, the object is known to be a galaxy. It is one of the brightest Seyfert galaxies visible from Earth and has a D25 isophotal diameter of about 27.70 kiloparsecs (90,000 light-years). (“Messier 77” 2025a)

The apparent rotation of a spiral galaxy (clockwise or counterclockwise) depends on the observer’s point of view. A galaxy rotates in only one direction, but an observer on Earth might see it rotating clockwise or counterclockwise depending on which way they look, much like a wheel rotates in opposite directions depending on which way you look. Some research suggests that the universe may have a rotation asymmetry, with more galaxies rotating in one direction than the other. (“Messier 77” 2025a)

Recent findings from the James Webb Space Telescope (JWST) suggest that approximately two-thirds of distant galaxies appear to rotate clockwise, which contradicts the long-held assumption of a random, 50/50 split in rotation directions. This observed asymmetry could imply that the universe has a subtle preferred spin or that current measurement techniques might be influenced by the Milky Way’s own motion. While some previous studies have indicated a random distribution, more recent analyses of JWST data show this non-random pattern. (“Messier 77” 2025b)

## 3 Great Dark Spot (GDS)

The Great Dark Spot (also known as GDS-89, for Great Dark Spot, 1989) was one of a series of dark spots on Neptune similar in appearance to Jupiter’s Great Red Spot. In 1989, GDS-89 was the first Great Dark

Spot on Neptune to be observed by NASA’s Voyager 2 space probe. Like Jupiter’s spot, the Great Dark Spots are anticyclonic storms. However, their interiors are relatively cloud-free, and unlike Jupiter’s spot, which has lasted for hundreds of years, their lifetimes appear to be shorter, forming and dissipating once every few years or so. Based on observations taken with Voyager 2 and since then with the Hubble Space Telescope, Neptune appears to spend somewhat more than half its time with a Great Dark Spot. Little is known about the origins, movement, and disappearance of the dark spots observed on the planet since 1989. (Shamir, 2024; “Great Dark Spot” 2024; “Cote’s Spiral in Neptune Great Dark Spot”)

The Great Dark Spot was captured by NASA’s Voyager 2 space probe in Neptune’s southern hemisphere. The dark, elliptically shaped spot (with initial dimensions of 13,000 km × 6,600 km or 8,100 mi × 4,100 mi), was about the same size as Earth. (Shamir, 2024; “Great Dark Spot” 2024; “Cote’s Spiral in Neptune Great Dark Spot”)

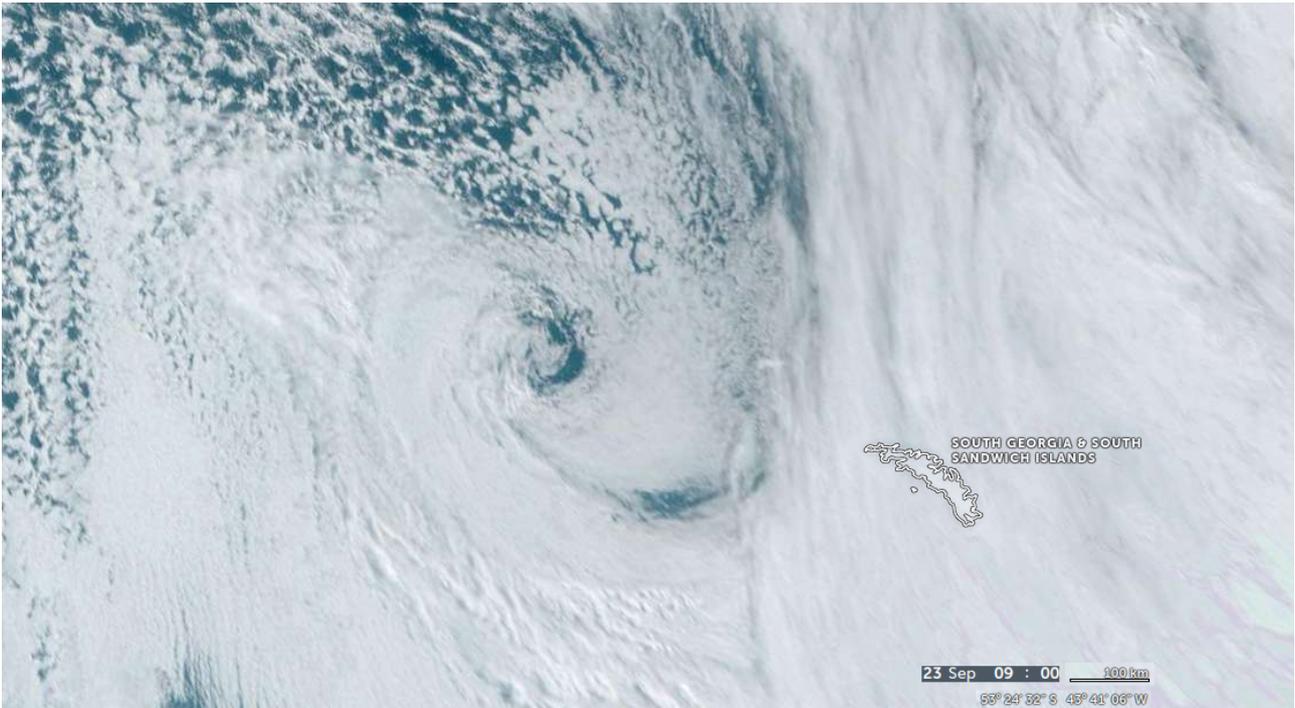
The Great Dark Spot (GDS) presents a characteristic that resembles a Cote’s Spiral. Its ellipsoidal shape is due to the rotation of the different planetary rotation layers in opposite directions, increasing and compressing the GDS, from the lower to upper layers of Neptune’s atmosphere. (“Great Dark Spot” 2024)

## 4 Methods

The images obtained by meteorological satellites were collected on the REDEMET Aeronautical Command Meteorology Network) website, in the visible spectrum, and highlighted infrared channel, as well as the image of the GOES 13 / NOAA / USA - Infrared Channel highlighted. (“Satellite Images, Sep 23, 2025” 2025) All Zoom Earth website. (“Zoom Earth, Live Weather Map” 2025)

A reanalysis using the National Centers for Environmental Prediction (NCEP) model was made. The processing and analysis of the data were performed in the decoded and separated into their quantified RGB color channels. The technique consists of the analysis of the pixels of the images of primary light sources. (Ting, Klein, and Knio, 2007; Howe, 2003; Hunt and Vassilicos, 2010; Kobayashi, 2003; L’vov and Procaccia, 2003; R. Gobato, 2017a; R. Gobato, 2017b)

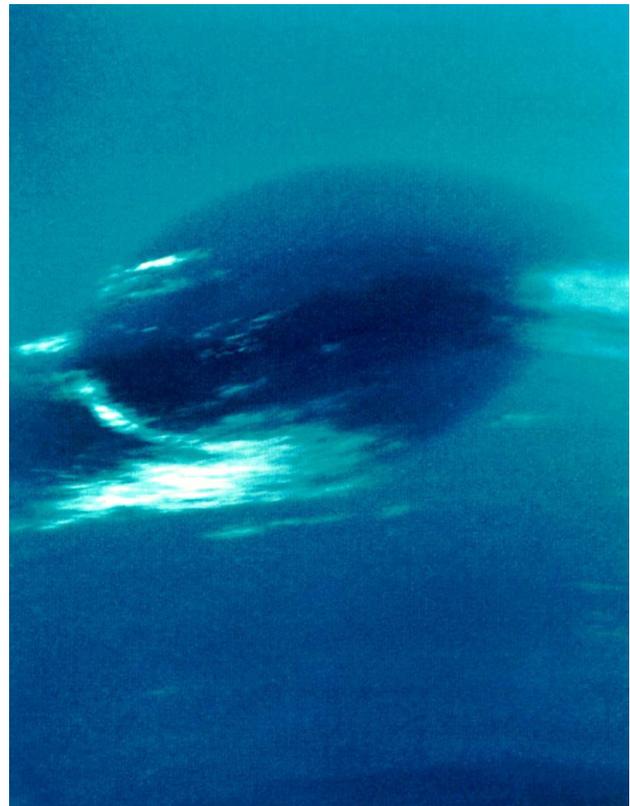
The images were obtained from the REDEMET website for Sep 23, 2025, from 10:30 (UTC) and 18:00 (UTC), visible spectrum, at 20 minutes of intervals. The images are in the visible spectral, in black and white. They represent the reflectance factor from zero to 80%, Figure (4). The images were obtained from



**Figure 1:** Image of Extratropical Cyclone Georgia (ECG), scale 1:100, Sep 23, 2025, 09:00 AM Brasilia, Brazil - 12:00 (UTC), and nucleus at the coordinates given in the image 56°24'32"S 43°41'06"W. ("Zoom Earth, Live Weather Map" 2025)



**Figure 2:** Messier 77 (M77), also known as NGC 1068. ("Messier 77" 2025a)



**Figure 3:** The Great Dark Spot in exaggerated color as seen from Voyager 2. (Shamir, 2024; "Great Dark Spot" 2024; "Cote's Spiral in Neptune Great Dark Spot")

the REDEMET website for Sep 23, 2025, from 10:40 (UTC) and 19:00 (UTC) at 20 minute of intervals. They are highlighted and indicate the temperature from 45°C to -90°C, Figure (5). (“Zoom Earth, Live Weather Map” 2025; Ting, Klein, and Knio, 2007; Howe, 2003; Hunt and Vassilicos, 2010; Kobayashi, 2003; L’vov and Procaccia, 2003; R. Gobato, 2017a; R. Gobato, 2017b)

Analyzes of the GOES-13 satellite were used observing the formation and dissipation of the storm along Sep 23, 2025, with a temporal resolution of approximately every 30 minutes. (Ting, Klein, and Knio, 2007; Howe, 2003; Hunt and Vassilicos, 2010; Kobayashi, 2003; L’vov and Procaccia, 2003) Then, the gray level ( $N_c$ ), for the brightness temperature ( $T_b$ ) was analyzed using the following equation:

$$T_b = 320 - 0.625N_c \quad (1)$$

The images analyzed for  $T_b$  were classified in order to find areas that had the lowest  $T_b$  values, thus indicating more intense convection. The classification adopted was unsupervised, that is, the user does not properly determine the classes that are to be found by the classifiers, Figure (5). (Ting, Klein, and Knio, 2007; Howe, 2003; Hunt and Vassilicos, 2010; Kobayashi, 2003; L’vov and Procaccia, 2003)

The graph in Figure (6), as well as all the others, characterizes a Cote’s spiral. (Weisstein, 2025; Cotes, 1722), (Weisstein, 1988; Symon, 1971), (Whittaker, 1944)

An adjustment in Equation Cote’s spiral (Weisstein, 2025; Cotes, 1722; Weisstein, 1988; Symon, 1971; Whittaker, 1944) is necessary to obtain the graph of Figure (5). Then, adding the constants  $A$ ,  $B$  and  $C$  for  $\mu < h$ ,

$$r = B.A.\sec(k.\theta + s) + C \quad (2)$$

where

$$k^2 = 1 - \frac{\mu}{h^2} \quad (3)$$

Figure (6), when  $\mu < h^2$ .

## 5 Discussions

The Georgia cyclone present form of spiral galaxy especially NGC [New General Catalogue of Nebulae and Clusters of Stars] 1068, in the constellation Cetus. With an area of core vortex size of around 3,491 km<sup>2</sup>, and size of Georgia 545,417 km<sup>2</sup> it moved slowly in a south southeast direction, with an average speed of 76 km/h, with winds of 7 km/h at 80 km/h from

the nucleus, as it passed a south southeast Georgia Islands.

In the data collected and analyzed from the Georgia cyclone, it is clear that all extratropical cyclones that appear south of the South American continent, below 40° latitude, have the shape of a spiral curve, like the spiral galaxy. Most of these are in the form of a double Cote’s spiral curve (Gobato, Hedari, and Gobato, 2022; Gobato, Mitra, and Hedari, 2022; Gobato, A.Hedari, and A.Mitra, 2022; “Cyclone” 2022; Landsea, 2009; “Messier 77” 2025a; “Messier 77” 2025b; Shamir, 2024; “Great Dark Spot” 2024; “Cote’s Spiral in Neptune Great Dark Spot”; “Zoom Earth, Live Weather Map” 2025; “Satellite Images, Sep 23, 2025” 2025; Ting, Klein, and Knio, 2007; Howe, 2003; Hunt and Vassilicos, 2010; Kobayashi, 2003), (Gobato, A.Hedari, and A.Mitra, 2022; “Cyclone” 2022).

The Georgia cyclone that formed south southeast, of South Georgia & South Sandwich Island, traveling 74 km in 7.5h towards the north northwest, when it was 320 km of core from South Georgia Island. It moved at an average speed of 9.81 km/h (6.1 mi/h), calculated from Figure (4).

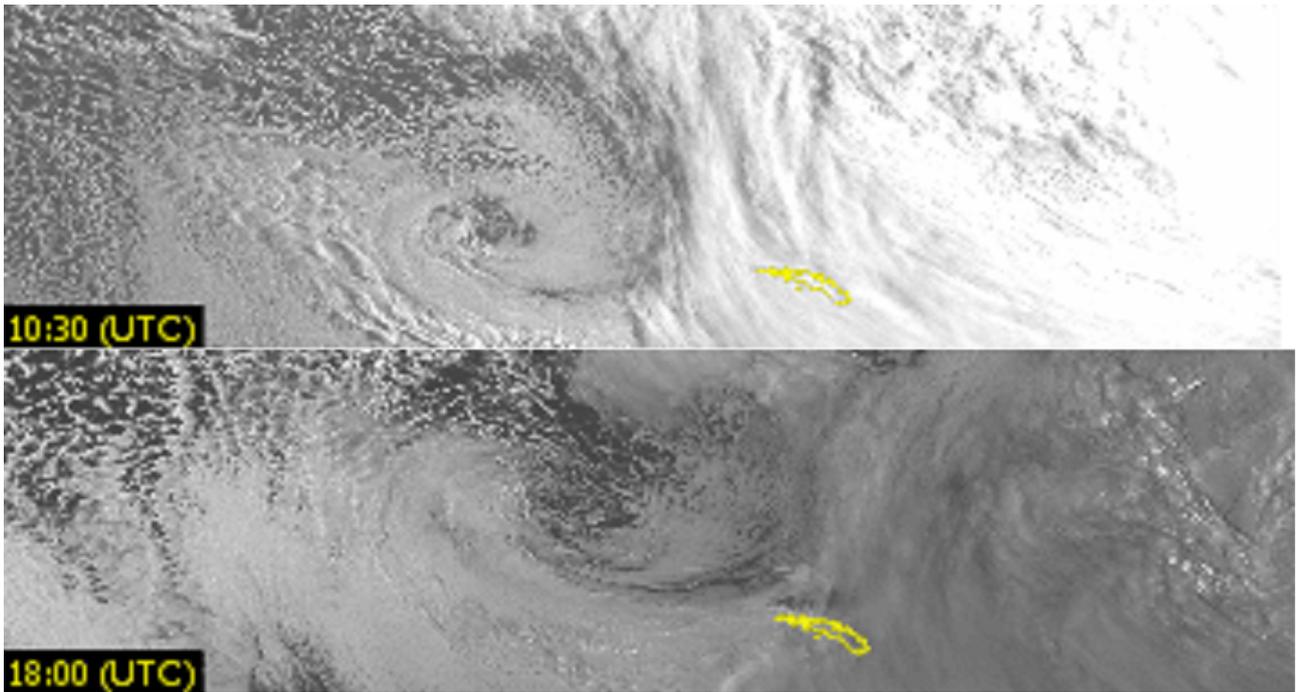
The temperature of core is 0°C, 273K, in 850 mbar of altitude.

During this time interval, it maintained an atmospheric pressure at sea level at its vortex close to 977 hPa. It presented rotational winds of 6 km/h approximately 10 km from the central vortex.

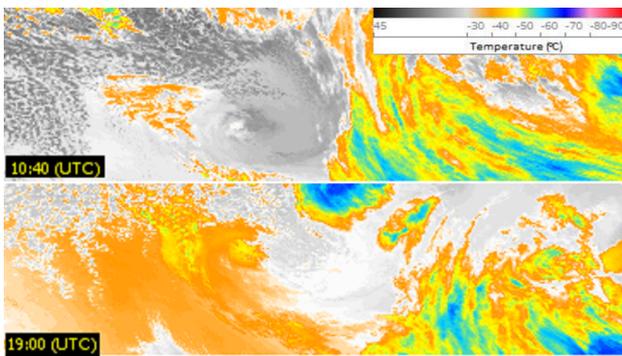
With an approximate dimension of 546 thousands km<sup>2</sup>, and an area of direct influence of 2,000 thousands km<sup>2</sup>, the subtropical cyclone Georgia moved at an average speed of 9.81 km/h (6.1 mi/h).

The highlighted turbulent cyclonic vortex (Parker and Jeynes, 2019; Vasquez, 2002), (Leão and Rodrigues, 1989) exhibits two Cote’s spiral curves, Figures (1, 4-6).

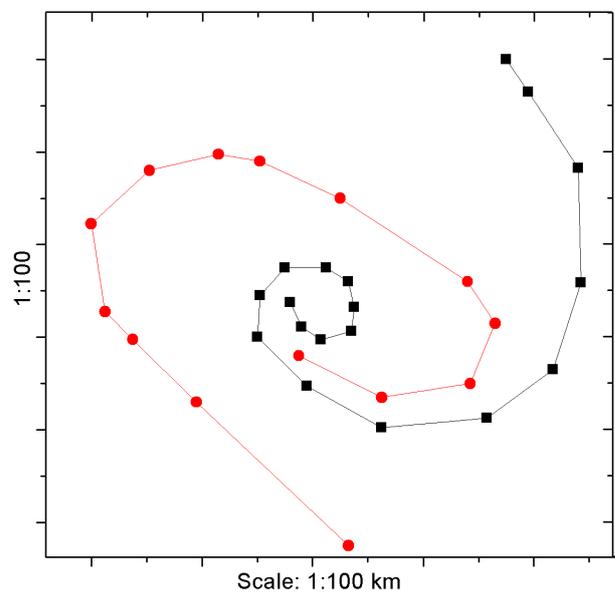
The have Georgia’s double spiral Cote’s shape. The analogous shape of Georgia and the spiral galaxies Messier 77 and GDS of Neptune, studied here, is clear. These present a double spiral, as studied by Lindblad [30], but with the Cote’s spiral double form, Gobato et al. (2020-2025). (Gobato, Mitra, and Mullick, 2023; Gobato, Mitra, and Mullick, 2024; Gobato, M.R.R.Gobato, and Heidari, 2020; Gobato and Hedari, 2020; Gobato, Mitra, and Hedari, 2020; Gobato, Hedari, and Gobato, 2022; Gobato, Mitra, and Hedari, 2022; Gobato, A.Hedari, and A.Mitra, 2022; Shamir, 2024).



**Figure 4:** Image of Extratropical Cyclone Georgia (ECG), scale 1:100, on Sep 23, 2025, 10:30 (UTC) and 18:00 (UTC), visible spectrum. Nucleus at the coordinates given in the image 56°24'32"S 43°41'06"W. ("Satellite Images, Sep 23, 2025" 2025) (Adapted Authors).



**Figure 5:** Image of Extratropical Cyclone Georgia (ECG), scale 1:100, on on Sep 23, 2025, 10:40 (UTC) and 19:00 (UTC), in Infrared Channel highlighted. Nucleus at the coordinates given in the image 56°24'32"S 43°41'06"W. ("Satellite Images, Sep 23, 2025" 2025) (Adapted Authors)



**Figure 6:** Graph obtained from the isobars in Figure (1), and nucleus at the coordinates given in the image 56°24'32"S 43°41'06"W, and scale 1:100. (Authors)

## 6 Conclusions

The Georgia cyclone that formed south southeast, of South Georgia Island. It traveled 74 km in 7.5h towards the north-northwest, when it was 320 km of core from South Georgia Island. It moved at an average speed of 9.81 km/h (6.1 mi/h).

The extratropical cyclone analyzed, presented a form the characteristic of a spiral galaxy, such as NGC 1068 e a Great Dark Spot (GDS) present em Neptuno. Mathematical analyzes of the shape of a double Cotes's Spiral.

The highlighted turbulent cyclonic vortex exhibits two Cote's curves.

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