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Research Article

Cote's Spiral Doubles in Georgia Cyclones Alike Messier 77 and the Great Dark Spot of Neptune

Ricardo Gobato[1,2*], Abhijit Mitra[3], Sufia Zaman[3] and Ibtihal Kadhim Kareem Dosh[4]

[1]*Green Land Landscaping and Gardening, Seedling Growth Laboratory, 86130.000, Parana, Brazil.*

[2]*Parana Secretary of State of Education, Londrina Regional Education Core, 86130.000, Parana, Brazil.*

[3]*Department of Marine Science, University of Calcutta, 35 B. C Road, Kolkata, 700019, West Bengal, India.*

[4]*Department of Chemistry, Kufa University, An Najaf, Iraq.*

***Corresponding Author:** Ricardo Gobato, Green Land Landscaping and Gardening, Seedling Growth Laboratory, 86130.000, Parana, Brazil, Parana Secretary of State of Education, Londrina Regional Education Core, 86130.000, Parana, Brazil.

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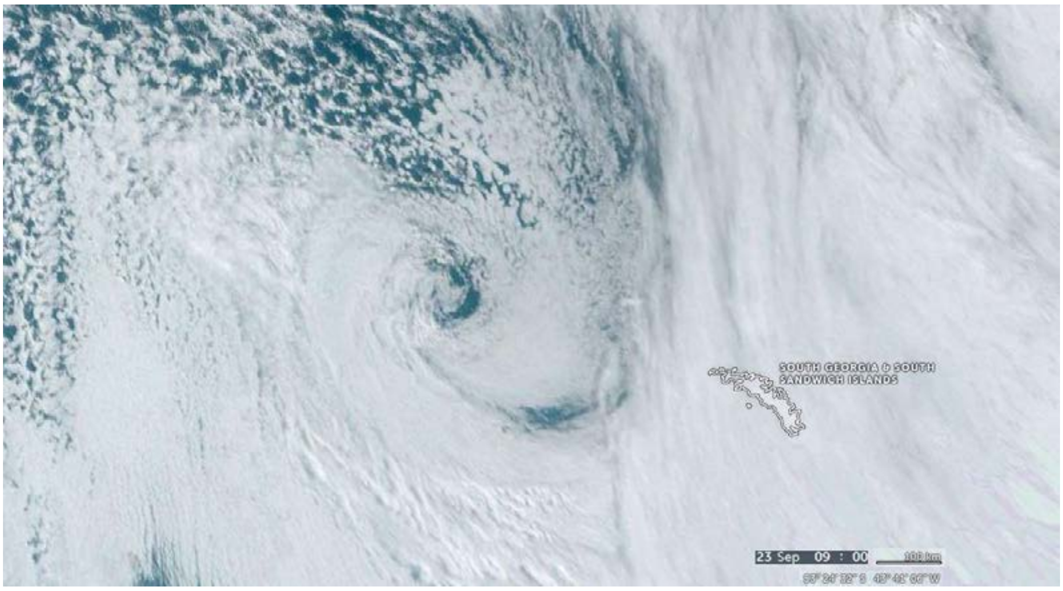
Abstract

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.

Keywords: Vortex, Atmospheric Phenomenon, Mathematics, Extratropical Cyclones, South Georgia and South Sandwich Islands, Great Dark Spot (Gds), Messier 77

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, [1-9]. 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) [9]. 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 [9,10]. 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 [9,10]. 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 andeast-southeast. It has a total land area of 3,756 km2 (1,450 mi2), including satellite islands, but excluding the South Sandwich Islands, which form a separate island group [1].

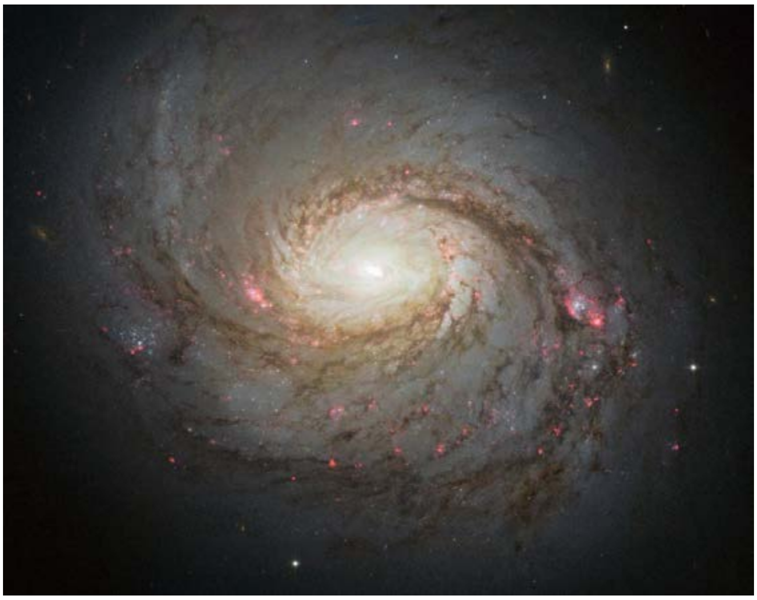


Source: [16].

Figure 1: Image of Extratropical Cyclone Georgia (ECG), Scale 1:100, September 23, 2025, 09:00 AM Brasília, Brazil - 12:00 (UTC), and Nucleus at the Coordinates Given in the Image 56°24’32”S 43°41’06”W

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 [8]. 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) [11]. 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 [11].



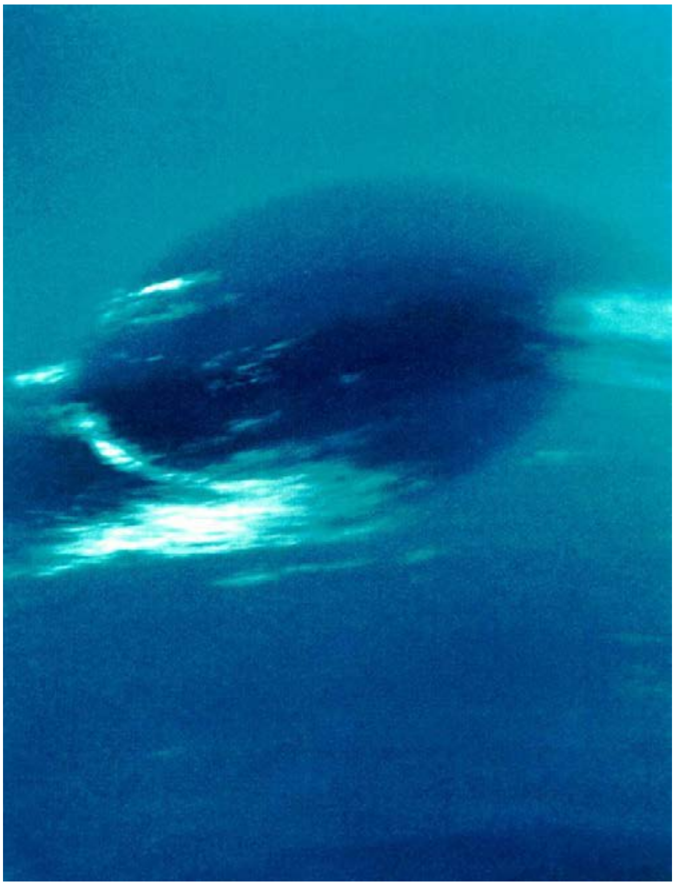
Source: [11]

Figure 2: Messier 77 (M77), also Known as NGC 1068

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 [12].

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 [13-15]. 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, [13-15].



Source: [13-15]

Figure 3: The Great Dark Spot in Exaggerated Color as Seen from Voyager 2

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 [14].

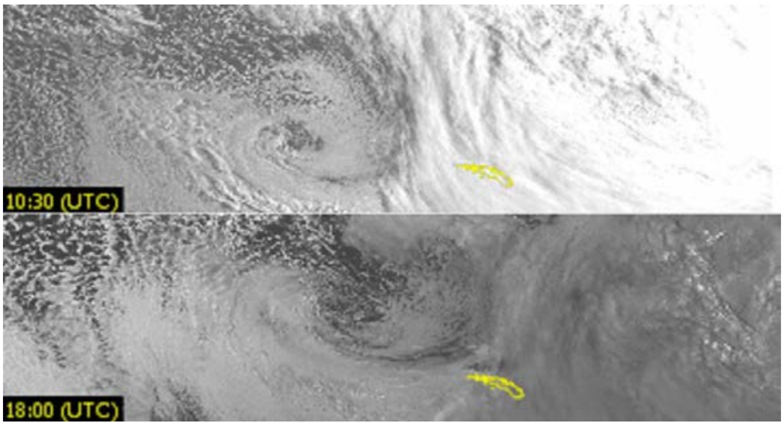
4. Methods

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. All Zoom Earth website [16,17]. 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 [18-24]. 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 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) [16,18-24].

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 [18-22]. Then, the gray level (Nc), for the brightness temperature (Tb) was analyzed using the following equation:

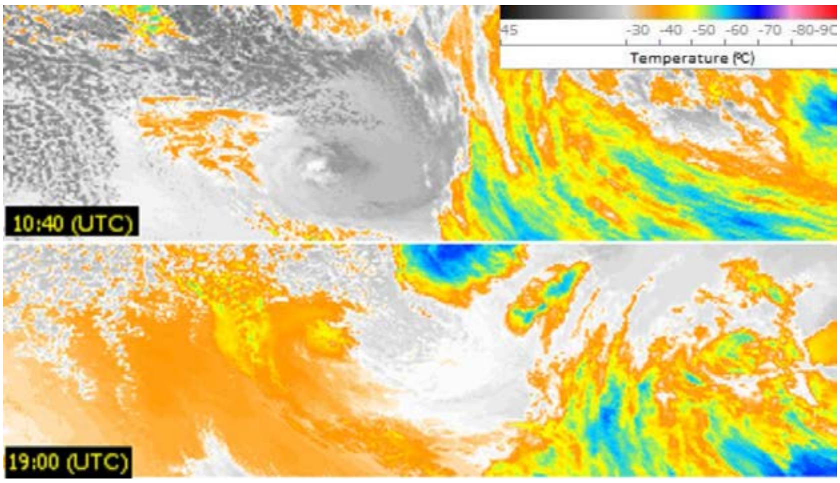
$$T_b = 320 - (0.625\ N_c) \qquad (1)$$

The images analyzed for Tb were classified in order to find areas that had the lowest Tb 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) [18,22].



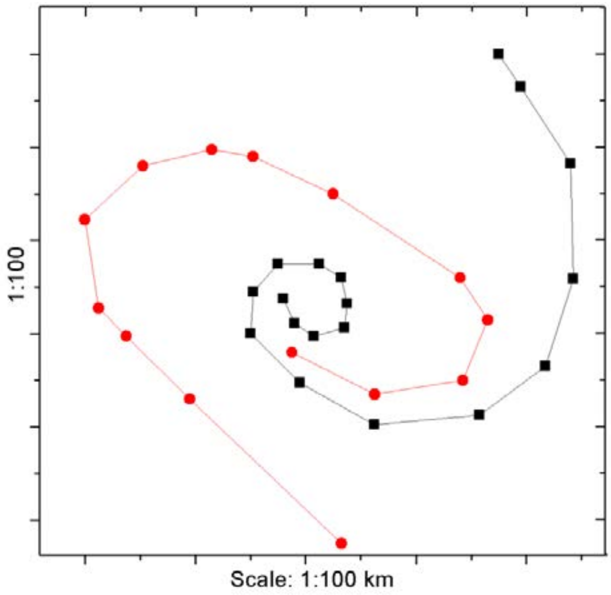
Source: [17, Adapted Authors].

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



Source: [17, 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



Source: 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

The graph in Figure (6), as well as all the others, characterizes a Cote's spiral [25-29]. An adjustment in Equation Cote's spiral is necessary to obtain the graphof Figure (5) [25-29]. 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 1068, in the constellation Cetus. With an area of core vortex size of around 3,491 km^2, and size of Georgia 545,417 km2 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 [6-21]. 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), calculed from Figure (4). The temperature of core is 0°C, 273K, in 500mbar of altitude. During this time interval, it maintained an atmospheric pressure at sea level at its vortex close to 971 hPa. It presented rotational winds of 6 km/h approximately 10 km from the central vortex. With an approximate dimension of 546 thousands km^2, and an area of direct influence of 2,000 thousands km^2, the subtropical cyclone Georgia moved at an average speed of 9.81 km/h (6.1 mi/h). The highlighted turbulent cyclonic vortex exhibits two Cote's spiral curves, Figures (1, 4-6) [30-33]. 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, but with the Cote's spiral double form, Gobato [1-8,13,30,33].

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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