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Journal of Atmospheric Science Research
https://ojs.bilpublishing.com/index.php/jasr

ARTICLE

Cyclone Bomb Hits Southern Brazil in 2020

Ricardo Gobato1* Alireza Heidari2

1. Green Land Landscaping and Gardening, Seedling Growth Laboratory, 86130-000, Parana, Brazil
2. Faculty of Chemistry, California South University, 14731 Comet St. Irvine, CA 92604, USA

ARTICLE INFO

Article history
Received: 16 July 2020
Accepted: 28 July 2020
Published Online: 30 July 2020

Keywords:
Atmospheric phenomenon
Cyclone Bomb; Brazil
Chapecó
Extratropical cyclone
Parana
Santa Catarina
Rio Grande do Sul
Santa Catarina
Winter

ABSTRACT

An "explosive extratropical cyclone" is an atmospheric phenomenon that occurs when there is a very rapid drop in central atmospheric pressure. This phenomenon, with its characteristic of rapidly lowering the pressure in its interior, generates very intense winds and for this reason it is called explosive cyclone, bomb cyclone. With gusts recorded of 116 km/h, atmospheric phenomenon - "cyclone bomb" (CB) hit southern Brazil on June 30, the beginning of winter 2020, causing destruction in its influence over. One of the cities most affected was Chapecó, west of the state of Santa Catarina. The satellite images show that the CB generated a low pressure (976 mbar) inside it, generating two atmospheric currents that moved at high speed. In a northwest-southeast direction, Bolivia and Paraguay, crossing the states of Parana and Santa Catarina, and this draft that hit the south of Brazil, which caused the destruction of the affected states. Another moving to Argentina, southwest-northeast direction, due to high area of high pressure (1022 mbar). Both enhanced the phenomenon.

1. Introduction

With winds of 100 km h "explosive extratropical cyclone" [1] left a trail of destruction in Santa Catarina, Paraná and Rio Grande do Sul on Tuesday, June 30, 2020. The phenomenon known as the "cyclone bomb" caused heavy rains, where gusts of wind destroyed houses, caused tree falls, debris and the destruction of the energy network.

The cyclone that hit the state on June 30, which reached 168.8 km/h in the most affected regions. The winds will calm down and the last days of the week will be marked by cold and dry weather, with sun during the day and the possibility of frost [2].

1.1 Weather News and Warnings

According to the Civil Defense of the southern states of Brazil, ten deaths were recorded [1]. Nine deaths occurred in Santa Catarina, the most affected state, and at least one person is missing in the municipality of Brusque. Another fatal victim in Rio Grande do Sul.

Based on the use of American and European numerical models, which simulate the atmosphere, the center

**Corresponding Author:*
Ricardo Gobato,
Green Land Landscaping and Gardening, Seedling Growth Laboratory, 86130-000, Parana, Brazil;
Email: ricardogobato@hotmail.com; ricardogobato@gardener.com

DOI: https://doi.org/10.30564/jasr.v3i3.2163

detected the formation of the CB near the south-Brazilian coast and to which an alert was sent to the states [1].

A rare climatic phenomenon will happen between Tuesday and Wednesday and will cause heavy rain with an incidence of winds with intensities above normal even for storms. Caused by the drop in atmospheric pressure, the phenomenon will attract polar air and cause the minimum temperature to fall below 5°C, especially at dawn on Wednesday. Tuesday's winds, which could reach 100 km/h in isolated bursts, could cause damage such as fallen trees, debris and damage to the electricity supply. On Wednesday the wind stops and the cold and humidity remain at work. On Thursday the polar air gets reinforced and on Friday the minimum should be one of the most bays of the year so far and can stay at around 3°C [3].

1.2 Cyclone Bomb (CB)

The occurrence of cyclones is relatively common for the region at this time of year, but the recent phenomenon has been exacerbated by other meteorological and atmospheric factors [1].

According to L. Calvetti, head of the Center for Meteorological Forecasting and Research at the Federal University of Pelotas (Ufpel), the so-called "explosive extratropical cyclone" occurs when there is a very rapid drop in central atmospheric pressure. Based on the use of American and European numerical models, which simulate the atmosphere, the center detected the formation of the CB near the south-Brazilian coast and to which an alert was sent to the states [1].

This phenomenon, with this feature to lower the pressure inside quickly generates very strong winds and so that name of explosive cyclones [1,4].

Information released by Rio Grande Energy and the State Electricity Company of Rio Grande do Sul, indicate that, in total, 639 thousand people were without power in the state. Already the Fire Department of Santa Catarina totaled more than 1,600 occurrences attended in the last 24 hours, post-phenomenon. For large-scale occurs, the tropical cyclones influence and are influenced by the weather and other atmospheric phenomena point of view, the call synoptic condition. A very intense circulation of heat and humidity from the North region, with emphasis on the Amazon and Bolivia, increased the occurrence of the cyclone more sharply, reaching Paraguay, Uruguay and northern Argentina, as well as the south-Brazilian coast [1].

Figure 1. Picture of the destruction caused by the cyclone pump in an urban area of the county of Chapecó in Santa Catarina, which is one of the hardest hit [1]. Photo: Chapecó City Hall (SC)

Figure 2. Santa Catarina State was the most affected by the cyclone; On image, area registration destroyed in Chapecó [1]. Photo: Chapecó City Hall (SC)

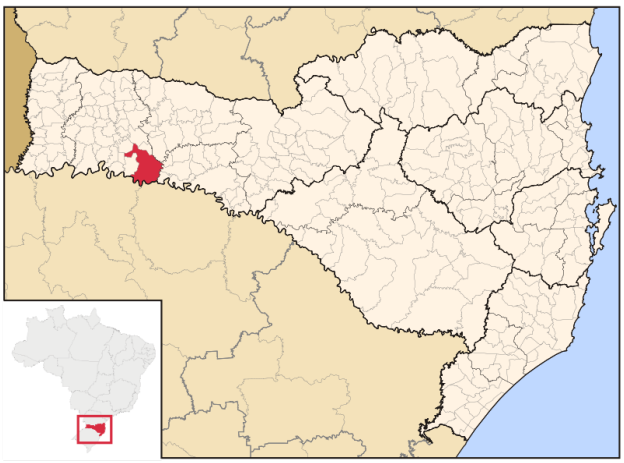

Figure 3. Map with the location of the County of Chapecó, west of the state of Santa Catarina [5].

The Chapecó located 27°06'17"S 52°36'51"W [6], the

Figures (1-3) was the most affected by cyclone.

2. Theoretical Foundation

2.1 Tropical Cyclones

Tropical cyclones are stronger versions of tropical storms. They are intense circular storms that originate over warm tropical oceans and are characterized by low atmospheric pressure, high winds, and heavy rain. Drawing energy from the sea surface and maintaining its strength as long as it remains over warm water, a tropical cyclone generates winds that exceed 119 km (74 miles) per hour. In extreme cases winds may exceed 240 km (150 miles) per hour, and gusts may surpass 320 km (200 miles) per hour. Accompanying these strong winds are torrential rains and a devastating phenomenon known as the storm surge, an elevation of the sea surface that can reach 6 m (20 feet) above normal levels. Such a combination of high winds and water makes cyclones a serious hazard for coastal areas in tropical and subtropical areas of the world. Every year during the late summer months (July-September in the Northern Hemisphere and January-March in the Southern Hemisphere), cyclones strike regions as far apart as the Gulf Coast of North America, northwestern Australia, and eastern India and Bangladesh [4].

Tropical cyclones are known by various names in different parts of the world. In the North Atlantic Ocean and the eastern North Pacific they are called hurricanes, and in the western North Pacific around the Philippines, Japan, and China the storms are referred to as typhoons [4].

In the western South Pacific and Indian Ocean they are variously referred to as severe tropical cyclones, tropical cyclones, or simply cyclones. All these different names refer to the same type of storm [4].

2.1 The Anatomy of a Cyclone

Tropical cyclones are compact, circular storms, generally some 320 km (200 miles) in diameter, whose winds swirl around a central region of low atmospheric pressure. 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 [4-13].

The wind field of a tropical cyclone may be divided into three regions. First is a ring-shaped outer region, typically having an outer radius of about 160 km (100 miles) and an inner radius of about 30 to 50 km (20 to 30 miles). In this region the winds increase uniformly in speed toward the centre. Wind speeds attain their maximum value at the second region, the eyewall, which is typically 15 to 30 km (10 to 20 miles) from the centre of the storm. The eyewall in turn surrounds the interior region, called the eye, where wind speeds decrease rapidly and the air is often calm. These main structural regions are described in greater detail below [4-13].

3. Analysis of Satellite Images and Synoptic Charts of CB

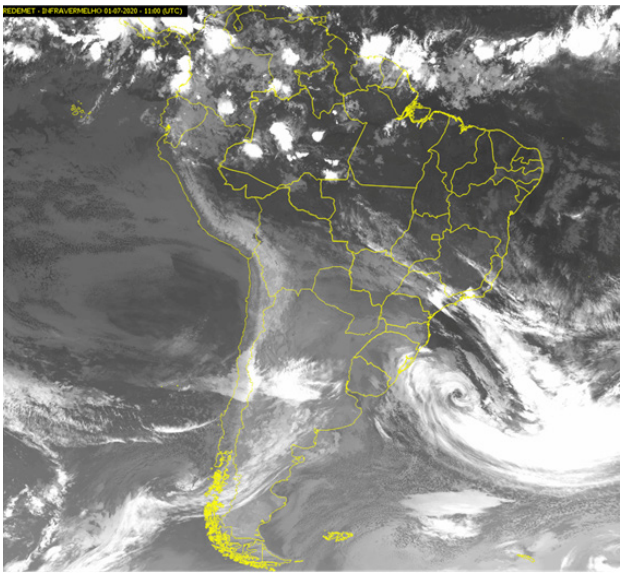

Figure 4. Image of the "bomb cliclone" moving to the Atlantic Ocean. Image in the infrared spectrum, July 1, 2020, 11:00 UTC. REDEMET [6,7]

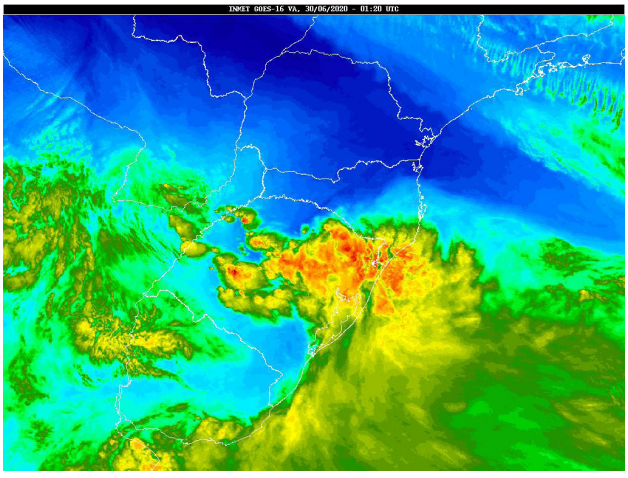

Figure 5. Enhanced image obtained by GOES-16 satellite, from June 30, 2020, at 01h20 UTC [3,5,14]

DOI: https://doi.org/10.30564/jasr.v3i3.2163

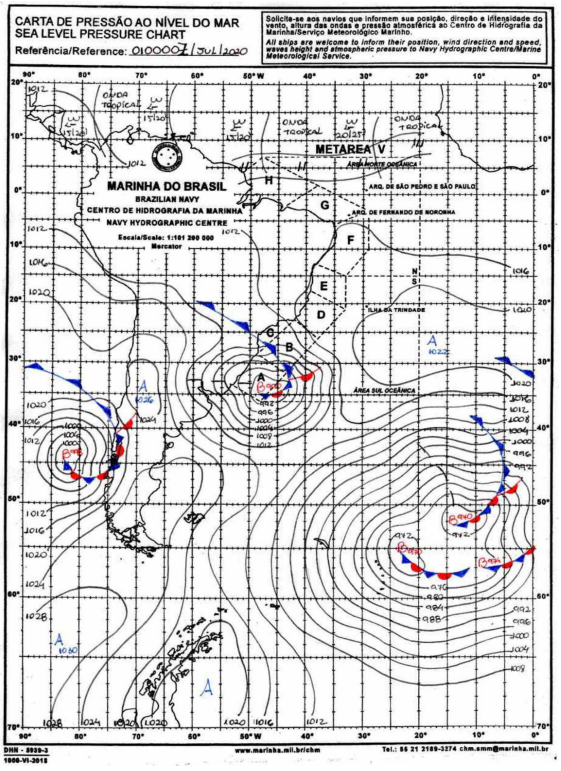

Figure 6. Synoptic Letters, from July 1, 2020, at 00h00 UTC. Navy Hydrography Center. Brazil's navy. Synoptic Letters [15]

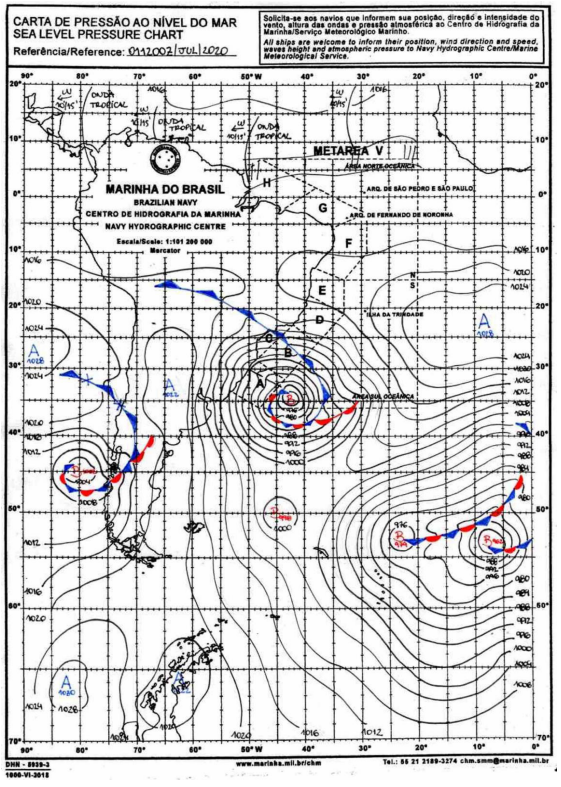

Figure 7. Synoptic Letters, from July 1, 2020, at 12h00 UTC. Navy Hydrography Center. Brazil's navy. Synoptic Letters [15]

The Figures (1-3) was the most affected by cyclone. The Chapecó located 27°06'17"S 52°36'51"W [6].

Figure (4) shows an image in the infrared spectrum of the cyclone moving towards the high seas, that is, the Atlantic Ocean. The eye of the cyclone is crisp, and gains intensity when advancing towards the ocean. Image of the "bomb cliclone" moving to the Atlantic Ocean., July 1, 2020, 11:00 UTC.

In Figure (5) enhanced image obtained by GOES-16 satellite, from June 30, 2020, at 01h20 UTC. In the dark blue color, an atmospheric current travels from Paraguay and Mato Grosso do Sul, crossed the states of Parana and Santa Catarina, going into shock with current coming from Argentina.

The synoptic chart Figure (6) shows a low pressure center of 990 mbar, with coordinates 35ºS 45°W, near the coast of Uruguay and Rio Grande do Sul, at 01:00 UTC on July 1, 2020.

A high pressure area 1026 mbar, over Argentina coordinates 35°S 70°W, moving in the direction to Paraguay. The synoptic chart in Figure (7) shows a 976 mbar low pressure center, coordinates 35ºS 40°W, next to Uruguay and Rio Grande do Sul coast, but away from the coast, 12:00 UTC on July 1, 2020.

The formation of the CB is clear, in Figures (4) and (7). An area of high pressure of 1022 mbar, over Argentina, with coordinates 35°S 65°W, continuing its movement towards Paraguay, acquiring greater amplitude and intensity.

4. Conclusion

The occurrence of cyclones is relatively common for the southern region of Brazil at this time of year, that is, winter, but the recent phenomenon is augmented by other meteorological and atmospheric factors.

CB generated a strong low pressure in its interior, creating two air streams which have worsened the phenomenon. An atmospheric current moved at high speed, in northwest-southeast direction, Bolivia, Paraguay, through the Paraná and Santa Catarina, and this airflow that hit the south of Brazil causing destruction. Another one traveled through Argentina in a southwest-northeast direction, colliding with the draft from Bolivia and Paraguay. Both of them clashed over the three southern states of Brazil. Only the outer edge of the CB reached the coast of the three states in the southern region of Brazil, Paraná, Santa Catarina and Rio Grande do Sul.

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DOI: https://doi.org/10.30564/jasr.v3i3.2163