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Vortex Storms in the West of Santa Catarina

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ABSTRACT

The objective of this work is to analyze the occurrence or not of tornadoes in the city of Guatambu, state of Santa Catarina (SC), southern Brazil, at the end of the night of 13, at dawn on September 14, 2021. Alerts by the official agencies of the region of the probable occurrence of tornadoes and strong storms in the area between the northeast of Argentina, Uruguay and Rio Grande do Sul. A tornado is the most violent windstorm on earth. The tornado is a rotating column of air that extends from a cloud to the ground. The analysis of satellite maps indicated the occurrence of storms, with probable formation of tornadoes in the municipality of Guatambu. Thus, confirming reports from residents, official bodies such as the Civil Defense of Santa Catarina, and the state's meteorological system. It is likely that the formation of a tornado in the municipality of Guatambu occurred between 01:20 UTC on and 02:10 UTC on Sep 14, 2021.

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1. Introduction

1.1. Tornadoes

A tornado is the most violent windstorm on earth. Tornadoes can form anywhere, but severe tornadoes are more common in the central plains. A tornado is a rotating column of air that extends from the cloud to the ground. A rendered is usually visible as a funnel cloud, but not always. A funnel cloud is a rotating column of air made up of water droplets. A funnel cloud is made only if it touches the ground (Armentrout & Armentrout, 2006).

Tornadoes come in many shapes and sizes, and they are often visible in the form of a condensation funnel originating from the base of a cumulonimbus cloud, with a cloud of rotating debris and dust beneath it. Most tornadoes have wind speeds less than 110 mph (180 km/h), are about 250 feet (80 m) across, and travel a few miles (several kilometers)

before dissipating. The most extreme tornadoes can attain wind speeds of more than 300 mph (480 km/h), are more than two miles (3 km) in diameter, and stay on the ground for dozens of miles (more than 100 km) (Wurman, 2015; Edwards, 2006).

Tornadoes grow out of extremely violent thunderstorms, and thunderstorms develop in air that is highly unstable. Any thunderstorm that is capable of generating tornadoes is said to be tornadic. The appearance of tornadic storms is a little different from that of squall-line storms (Allaby, 2014).

Most tornadoes form inside powerful thunderstorms. These strong storms are called supercells. They form when masses of warm, wet air meet masses of cool, dry air. The warm and cold air masses travel at different speeds. They travel in different directions. Most tornadoes last only 5 to 10 minutes. Very strong tornadoes may last for hours and travel more than 100 miles (Doeden, 2008).

When warm, moist air rises rapidly and meets cool, dry air it creates an unstable environment. Unstable air masses can produce thunderstorms. Some severe thunderstorms can produce tornadoes. Thunderstorms in different stages of development can merge forming a multicell. storm. A line of multicell storms, called a squall line, can sometimes produce a tornado. Most violent tornadoes, though, form from very large, organized thunderstorms called supercells

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(Armentrout & Armentrout, 2006; Howard, 2013; Gobato et al., 2020).

1.2. Guatambu



Fig. 1. Image with map of the location of the municipality of Guatambu, represented in red color, western of state Santa Catarina, south of Brazil

Source: Guatambu - Wikipedia. En.wikipedia.org. (2021).

Guatambu is a municipality in the state of Santa Catarina in the South region of Brazil, of central city coordinates 27° 7' 54.84" S, 52° 47' 13.92" W. Its main ethnical compositions are italian, german and cabocla (Guatambu - Wikipedia. En.wikipedia.org, 2021). Of area Total 204.757 km² (79.057 mi²), and bordering municipalities: Caxambu do Sul, Planalto Alegre, Chapecó, and Rio dos Índios (Guatambu - Wikipedia. En.wikipedia.org, 2021).

2. Materials and Methods

2.1. News, Storm Logs in Guatambu

The Civil Defense of Santa Catarina confirmed that a tornado passed through the municipality of Guatambu, in the west of Santa Catarina, during the storm this Monday (13). The occurrence, according to the agency, was identified based on the records of damage sent to the Civil Defense and the radar and satellite images analyzed (Fernandes, 2021).

The phenomenon occurred around 11 pm and roofed houses and broke trees. According to the agency, the reports of residents who had their homes destroyed also served as a basis for confirming the occurrence (Fernandes, 2021). "I woke up with a very loud noise, I was even surprised and opened the window. But soon the wind turned and a whirlpool appeared that looked like it was going to lift the house off the ground," said a resident consulted by agents of the agency. This phenomenon occurred in which Tornado roofed houses and broke trees (Fernandes, 2021).

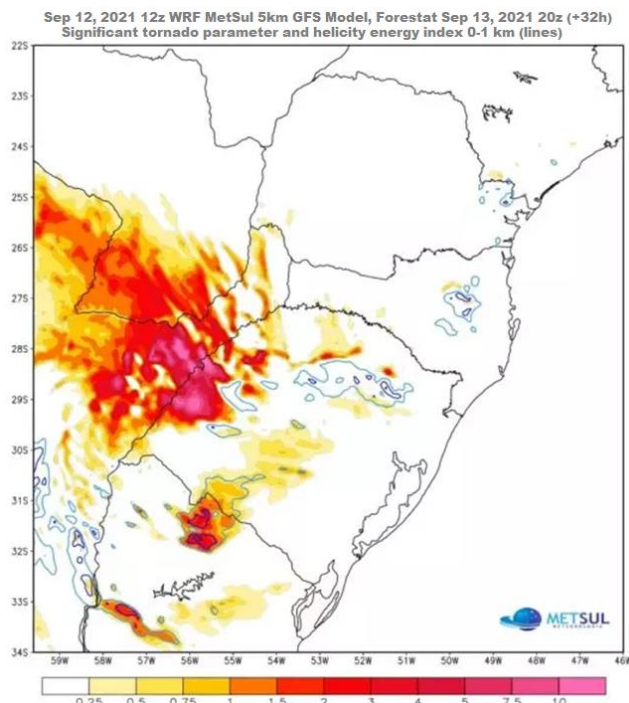


Fig. 2. Synopsis chart of MetSul meteorology is storm forecast model of 20Z (+032h) of Sep 09, 2021. Represented in pink, index ≥ 1 , there are areas with the highest risk of tornadoes

Source: ND, 2021, Adapted Author

The meteorological organization's own forecasting model indicates "an enormous area with extreme risk of hail, in which stones of varying sizes may fall", in the area between the northeast of Argentina, Uruguay and Rio Grande do Sul (ND, 2021). Thus, there is a "worrying" scenario for occurrences of "very intense and destructive winds in which tornadoes or atmospheric microexplosions can occur". MetSul meteorology clarifies that hailstorms are often accompanied by very strong winds (ND, 2021). "The very high helicity values with high levels of significant parameter of tornadoes indicated by the model for the afternoon and evening of the Monday between the Northeast of Argentina, Uruguay, the South of Paraguay and the West of Rio Grande do Sul draw a lot of attention. Such values suggest a high risk of tornadoes", concludes the MetSul meteorology forecast. Until then, no tornado risks were recorded for the State of Santa Catarina (ND, 2021).

2.2. News after storm

Between the night of Monday Sep 13, 2021 and this Tuesday Sep 14, 2021 a cold front advanced through SC, causing storms with intense rain and wind in much of the state, stronger in the western region. With rain from 50 to 90 mm (darker blue tones) in the West, Midwest and South Plateau. The smallest accumulated occurred in the North Coast (less than 10mm) (Gilsânia & Rodrigues, 2021).

In addition to intense rain, storms were associated with gales with wind gusts above 90 km/h in several municipalities in the West and in the South Plateau, and almost 80 km/h in the South Coast. The western region was the one that registered the greatest destruction (Gilsânia & Rodrigues, 2021). Despite the atmospheric conditions conducive to the occurrence of severe storms in SC, meteorologists from Epagri/Ciram do not confirm the

occurrence of tornado and microexplosion, based on the information available so far (Gilsânia & Rodrigues, 2021).

Table 1

Maximum wind speed recorded in SC on 13 and Set 14, 2021

Region	Municipality	Maximum Wind (km/h) / (mph)		September day/time (local) +3UTC	
Far West	Caibi	96.84	60.1736	13	23:00
West	Chapecó	94.21	58.5394	14	00:00
West	Concórdia	87.16	54.1587	14	00:00
West	Água Doce	84.67	52.6115	13	13:00
Far West	São Miguel do Oeste	62.64	38.9227	13	12:00
West	Ponte Serrada	59.08	36.7106	13	13:00
West	Xanxerê	53.28	33.1067	13	14:00

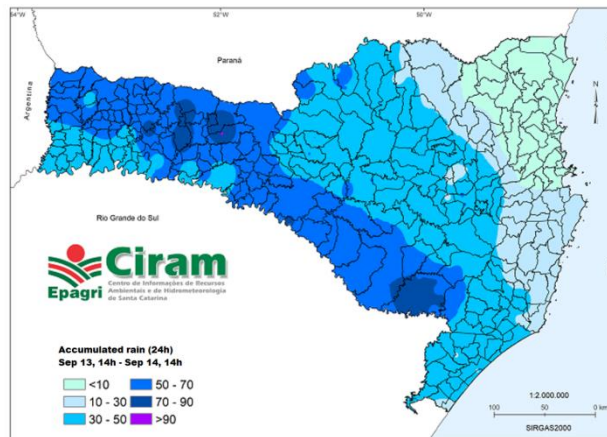


Fig. 3. Map of accumulated rainfall in SC, from 2:00 (time local) on Sep 13, 2021 to 2:00 pm (time local +3UTC) on Sep 14, 2021

Source: Gilsânia & Rodrigues (2021)

3. Results & Discussion

3.1. Analysis of Satellite Images and Synoptic Charts

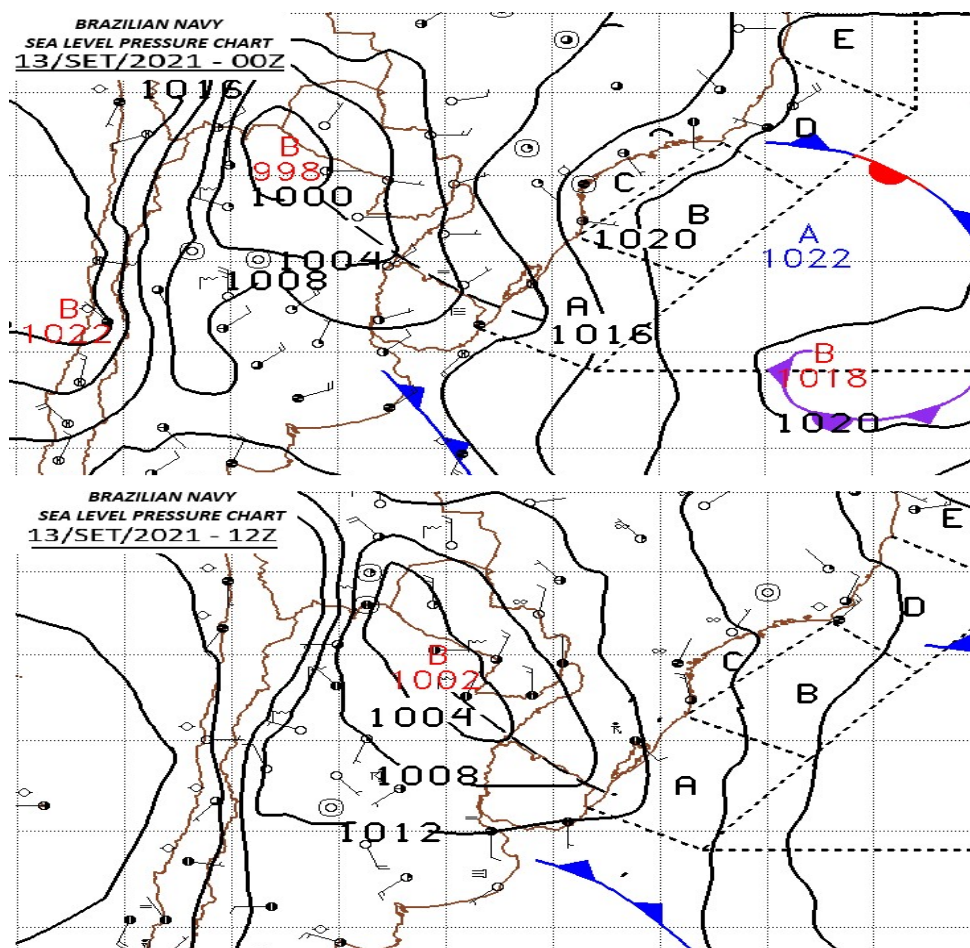


Fig. 4. Brazilian Navy sea level pressure synoptic chart of 00:00 UTC and 12:00 UTC of Sep 13, 2021

Source: Brazilian Government Portal (2021).

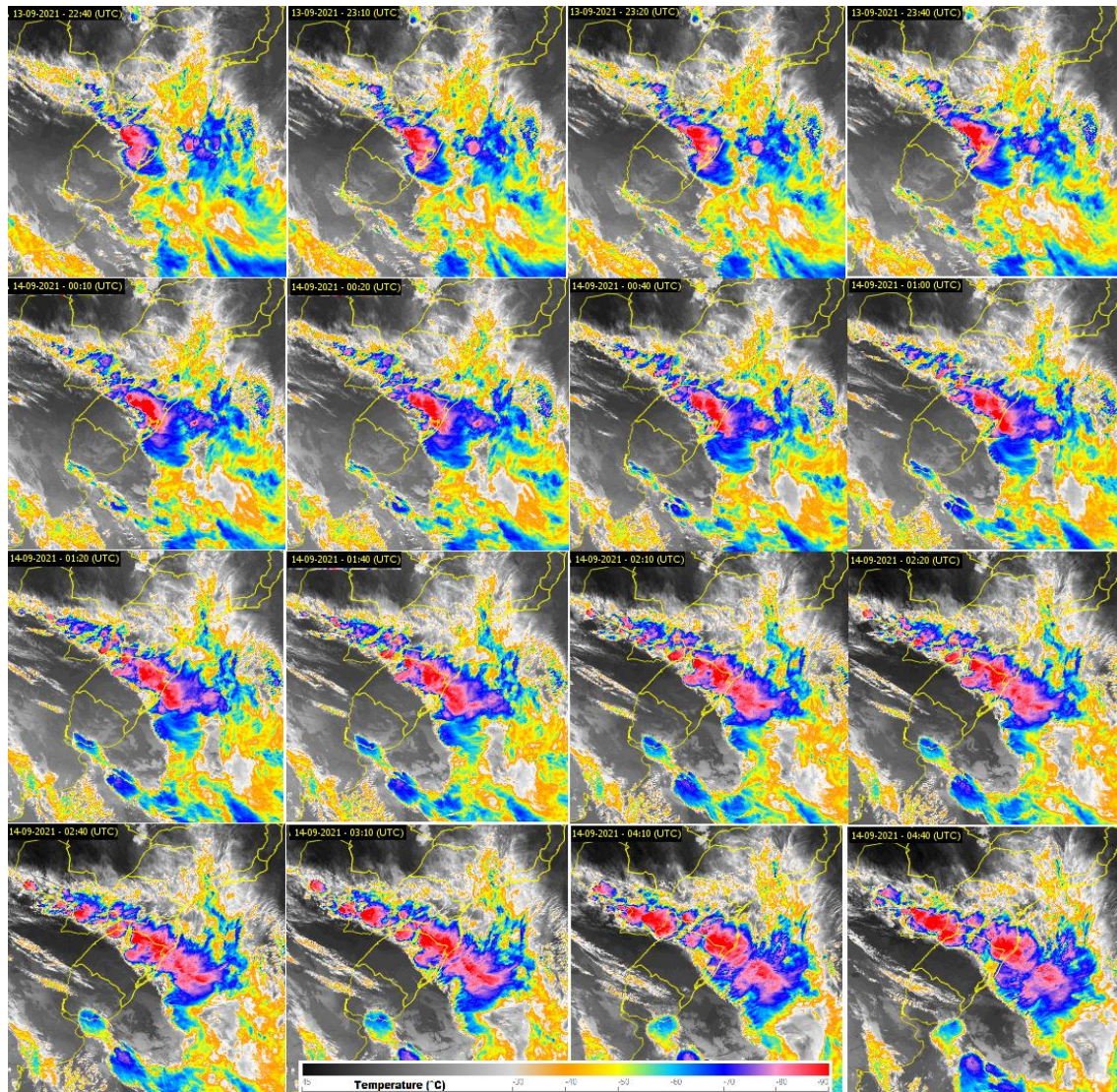


Fig. 5. Sequence of enhanced images obtained by satellite from the southern region of Brazil, between 22:40 UTC on Sep 13, 2021 and 04:40 UTC on Sep 14, 2021
Source: Brazilian Government Portal. (2021).

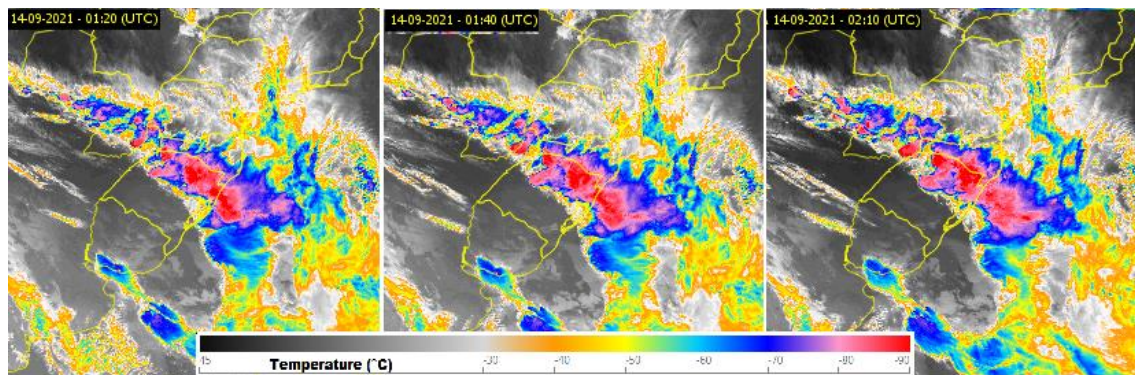


Fig. 6. Sequence of enhanced images obtained by satellite from the southern region of Brazil, between 01:20 UTC on and 02:10 UTC on Sep 14, 2021
Source: Brazilian Government Portal. (2021).

It is likely that the formation of a tornado in the municipality of Guatambu occurred between 01:20 UTC on and 02:10 UTC on Sep 14, 2021, Figure (6). The Figure (1) show of Image with map of the location of the municipality of Guatambu, represented in red color, western of state Santa Catarina, south of Brazil. The Table (1) has the maximum wind speed recorded in SC on 13 and Sep 14, 2021, West region of SC, Municipality of Chapecó, were Maximum Wind 94,21km/h, in day September 14, 00:00h local time. According to Epagri, we have the West region of SC, municipality of Chapecó, bordering municipalities with Guatambu, where winds of 94.21km/h (58.5394 mph) were recorded, at 0h (+3UTC) on Sep 14, 2021, Table (1). The Figure (2) show of synopsis chart of MetSul (ND, 2021) meteorology is storm forecast model of 20Z (+032h) of 13/09/2021.

Segundo o Metsul, "The very high helicity values with high levels of significant parameter of tornadoes indicated by the model for the afternoon and evening of the Monday between the Northeast of Argentina, Uruguay, the South of Paraguay and the West of Rio Grande do Sul draw a lot of attention. Such values suggest a high risk of tornadoes" (ND, 2021). Represented in pink, index ≥ 1 , Figure (2), there are areas with the highest risk of tornadoes. According to the MetSul forecast model, there was no forecast of tornadoes in the state of SC, but they did occur, considering that the storm energy was greater than expected.

The Figure (3) has of Map of accumulated rainfall in SC, from 2:00 pm (time local) on Sep 13, 2021 to 2:00 pm (time local +3UTC) on Sep 14, 2021 (Gilsânia & Rodrigues, 2021). In the municipality of Guatambu, there is an accumulation of between 30-70mm of rain, in 24 hours, Figure (3). The Figure (4) show Brazilian Navy sea level pressure synoptic chart of 00:00 UTC and 12:00 UTC of 13/09/2021 (Brazilian Government Portal, 2021).

The synoptic charts in Figure (4), Sep 13, 2021, 12Z, show evidence of air currents colliding. Winds from Northwest, Campo Grande, Mato Grosso do Sul; from the North, Foz do Iguaçú in Paraná; Southwest, Córdoba and Santa Rosa, Argentina; from the North-northeast, Curitiba, Paraná; from the North, Florianópolis, Santa Catarina; Southeast, Porto Alegre, Rio Grande do Sul; of the South, Punta del Este in Uruguay and Buenos Aires in Argentina. The Figure (5) show Sequence of enhanced images obtained by satellite from the southern region of Brazil, between 22:40 UTC on 09/13/2021 and 04:40 UTC on 09/14/2021 (Brazilian Government Portal, 2021).

The cold front that advanced through Argentina colliding with the hot and humid air mass of the states of Mato Grosso, Mato Grosso do Sul and Paraguay, collided and moved to the east, northeast, causing heavy rains and damage wherever it went, Figures (4-6), as already predicted by Gobato et al., (2018; 2019). It is likely that the formation of a tornado in the municipality of Guatambu occurred between 01:20 UTC on and 02:10 UTC on Sep 14, 2021, Figure (5) and (6).

4. Conclusions

The meteorological model used by MetSul predicted storms and tornadoes in the area between the northeast of Argentina, Uruguay and Rio Grande do Sul, were more intense and broader than expected. The MetSul forecast model, there was no forecast of tornadoes in the state of SC,

but they did occur, considering that the storm energy was greater than expected.

The cold front that advanced through Argentina colliding with the hot and humid air mass of the states of Mato Grosso, Mato Grosso do Sul and Paraguay, collided and moved to the east, northeast, causing heavy rains and damage wherever it went, as already predicted by Gobato et al., (2018; 2019). It is likely that the formation of a tornado in the municipality of Guatambu occurred between 01:20 UTC on and 02:10 UTC on Sep 14, 2021.

Competing Interests

The authors have declared that no competing interests exist.

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