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Evidence of Tornado Storm Hit the Counties of Rio Branco do Ivaí and Rosario de Ivaí, Southern Brazil

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Abstract

A vortex originating from a cumulonimbus cloud, tapering toward the ground, and touching it is called a tornado. Feared and admired by man, the tornado is an atmospheric phenomenon that can cause a catastrophe to pass through. If it reaches an unsuspecting and unprotected population on inhabited urban and rural properties, it can lead to human losses and serious material damage. It causes serious losses with the death of wild and farmed animals. On June 6, 2017, an alleged tornado hit the municipalities of *Rio Branco do Ivaí* and *Rosário do Ivaí*, located in the state of Parana, southern Brazil. The images of the alleged tornado have been disseminated on social networks and in several newspapers in the country. Local officials reported the damage caused by the alleged tornado, causing a large number of homeless, with the destruction of houses, as well as the killing of animals and the destruction of rural properties. The occurrence of the tornado had not been confirmed by the country's meteorological institutes. A search was initiated to verify the probable cause of the losses and damages caused in these counties, by the supposed tornado. Analyzes indicate that not one, but probably more than one tornado hit the counties of the central region of Parana state.

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Introduction

The main objective of this work is to investigate and prove, whether or not occurred meteorological phenomenon - tornado, in the counties of *Rosário do Ivaí* and *Rio Branco do Ivaí,* on June 6, 2017. A vortex originating from a cumulonimbus cloud, tapering toward the ground, and touching it is called a tornado. Feared and admired by man, the tornado is an atmospheric phenomenon that can cause a catastrophe to pass through. If it reaches an unsuspecting and unprotected population on inhabited urban and rural properties, it can lead to human losses and serious material damage. It causes serious losses with the death of wild and farmed animals [1].

On June 6, 2017, an alleged tornado hit the municipalities of *Rio Branco do Ivaí* and *Rosário do Ivaí*, located in the state of Parana, southern Brazil. The images of the alleged tornado have been disseminated on social networks and in several newspapers in the country. Videos with one or more alleged tornadoes were made and disseminated on social networks such as youtube, whatsapp, facebook, blogs, among others, by several residents of stricken cities, on the afternoon of June 6, 2017, in the municipalities of *Rio Branco do Ivaí* and *Rosário do Ivaí* [2, 3]. Local officials reported the damage caused by the alleged tornado, causing a large number of homeless, with the destruction of houses, as well as the killing of animals and the destruction of rural properties. The occurrence of the tornado had not been confirmed by the country's meteorological institutes [2-4].

A tornado, the most violent windstorm on earth, is rapidly rotating columns of air that make contact with the ground [1]. Consider them to be intense, columnar vortices in contact with the ground are capable of inflicting damage. They are either connected to or are situated underneath a cumuliform, buoyant convective cloud above. Tornadoes are sometimes, but not always, visible as a funnel cloud when the pressure deficit in them is low enough that water vapor condenses and cloud particles form. When the air is too dry or the pressure not low enough for a condensation funnel to form or to extend down to the ground, the tornado may be visualized as a column of rotating dust or debris or not visualized at all if there are no visible particles available to be lofted. In some instances, they are encased in precipitation (‘‘rain-wrapped’’) and either not visible at all or visible only from a restricted viewing angle [6]. Tornadoes come in many colors, shapes and sizes. Some are gray, white, or even a pale shade of blue. Others are difficult to see until they pick up dirt or other debris, taking on the color of the soil, like brownish-red, or black [1].

All tornadoes are triggered by thunderstorms, but only the very biggest thunderstorms trigger tornadoes. Thunderstorms begin when unstable air rises. To be “unstable,” a deep layer of air must be less dense than the air immediately above it. Being less dense, it rises as denser air sinks beneath it and raises it. It goes on rising until it lies beneath air that is less dense than it and therefore can rise no higher [7-24]. Its rise may begin when the ground in a particular location is warmed strongly by the Sun. The warmed air expands and this makes it less dense than the air above it, so it is pushed upward. That is how summer storms begin. Alternatively, moving air may be forced to rise as it crosses hills or mountains, and warm air may be lifted by denser air at an advancing cold front [7-24]. Just because air is forced to rise, it does not follow that a thunderstorm will develop or, indeed, that any kind of clouds will form. If stable air is made to rise, it will reach a level beyond which it can rise no higher, and then sink again. As it rises, the air cools adiabatically and as it sinks it warms [7-24].

A search was initiated to verify the probable cause of the losses and damages caused in *Rio Branco do Ivaí* and *Rosário do Ivaí* municipalities, by the supposed tornado. The videos posted by the local residents on social networks [2-4] and images obtained by meteorological satellites were collected on the REDEMET website, in the visible spectrum and highlighted infrared channel, as well as the image of the GOES 13 / NOAA / USA - Infrared Channel highlighted [5]. The meteorological phenomenon caused the destruction of urban properties - with the destruction of houses, and the gymnasium of sports, that was completely destroyed. In rural properties and localities, property damage and the death of livestock and wild animals were seen [2-4].

Data and evidence collection

Supposed tornado caused damage in the interior of Parana

According to news, an alleged tornado hit the city of *Rio Branco do Ivaí*, north of Parana, on Wednesday afternoon [7], according to the city's municipality. The Simepar Meteorological Institute said it has not yet evaluated the phenomenon. "We have not had information yet, let's look at the case," said meteorologist S. Paz [2]. According to the mayor of

Fig 1 Snapshot video posted on YouTube through social network on June 8, 2017 [2]. In the picture, one can see the well-defined shape of a tornado.

the municipality, the strong wind caused havoc in the city. "We had damages in the gymnasium of sports, our block was completely destroyed and six houses were discovered, mainly in the rural town D. Izalino. Trees fell and interdicted streets, utility poles were damaged leaving part of the city without electricity grid" he said. A city hall staff works to free the interdicted places [2].

The municipality continues the survey of the damages caused by the supposed tornado. "They are still being hurried. It's sad, but at the same time I'm happy because nobody was injured, it was only material damage", he said [2]. The orientation of the city hall is that the affected families seek the Civil Defense and the Social Action Secretariat of the municipality. The bulletin released at 12h this Thursday (8) by the Civil Defense of Parana indicates that 20 people were hit and seven houses were damaged (Fig. 1) [2].

Thunderstorm: Gale in *Rosario do Ivaí* and *Rio Branco do Ivaí*

News: Tuesday, June 6, 2017. Reports of residents of some neighborhoods, such as Caneleira and Vila União (*Rosário do Ivaí*), are that animals that died and houses were damaged. In *Rio Branco Ivaí*, there were also havoc and images of a funnel cloud. On the afternoon of this Tuesday, June 6, 2017, residents of Rural Districts of *Rosário de Ivaí*, called the report of the Blog of Berimbau and Radio Nova Era, to report that a gale hit some locations, among them Bairro da Caneleira and Vila União. "It looked like a tornado, it was taking everything, destroying houses and even causing animals to die, like cattle," said a farmer living in Vila União. Another rural producer said tomato greenhouses and other cultures, have also been damaged. By telephone, H. Sílva, a contributor to our report, also brought personal accounts of the affected regions, narrating the moments of fear and concern. In *Rio Branco do Ivaí*, it also rained hard and residents came to make the video of a cloud funnel, stating that it was a tornado. The mayor issued a note, through the advisor F. Barbosa, with the following information: "*Rio Branco do Ivaí* was hit by a tornado and houses were discovered in the Rural Village D. Izalino and next to the gymnasium of sports Cidão. A few days later, our press office together with sports secretary, Mr. G. Oliveira, were in the affected areas, thank God no one was injured, only material damages". M. Gerôncio was also accompanying and lamented the fact, "says a note from the city of Rio Branco. (Collaboration of P. Gruber and Letícia, from *Rio Branco do Ivaí*, and H. Silva, *Rosário*, and Soldiers from cup officer on duty [3].

Tornado is registered in the northern region of Parana

News: An amateur video made in recent days by the popular, in the Ivaí Valley (northern region of Parana), shows the supposed formation of a tornado (Fig. 2). The storm has killed animals, felled trees, fired houses and several streets in the cities of *Rosário* and *Rio Branco do Ivaí*, among other cities, ended up blocked [4]. Note from the mayor. The mayor of *Rio Branco do Ivaí*, G. C. Rosa, issued a note on the ravages caused by rain in the municipality: "*Rio Branco do Ivaí* was hit by a tornado, houses were discovered in the Rural Village Duarte Izalino and

Fig 2 A snapshot of a video of the supposed tornado in *Rosário de Ivaí* and *Rio Branco do Ivaí* posted on YouTube through social network on June 8, 2017 [3]. In the image, one can observe the defined format of a tornado.

near the gymnasium sports Cidão and a few days later, our press office along with sports secretary, G. Oliveira, were in the affected areas, and thank God there was only damage materials and no one was injured, " said G. C. Rosa [4]. The Civil Defense of *Parana* published an updated bulletin in which it informed that thirty-three municipalities were affected by the heavy rains since last Sunday (4) in the State. In total, 10,719 people were affected and 158 were displaced or homeless; 1,817 houses were damaged by the rains and 12 were completely destroyed [4]. News: June 6, 2017. With the accumulated rains of yesterday and this dawn, we have already passed from the expected to the month of June. This autumn has already surpassed the autumn of last year, which had already been rainy in the months of April and May. The fall of this year already had rain above the historical average in the month of April (35%), May (155%) and June until today in the morning (3%). The current national climate models put rain above the historical average for that month, around 50 mm, not reached until that moment. Normality for the month of July and above the average for August. We are in climatologically neutrality with a tendency to warm up, but without reaching *El Niño* (Fig. 3) [25].

Fig. 3 Photos of damage caused by alleged Tornado in *Rio Branco do Ivaí* [3]. The destruction of property (**A**), home (**B**), and poles of the electric power grid (**C**) is clearly evident.

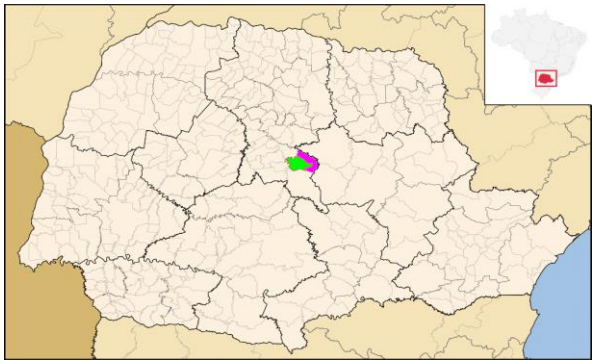

Fig 4 Map of the state of Parana, with the prominent location of the municipalities of *Rio Branco do Ivaí*, in lime green color and *Rosário do Ivaí*, in pink color (Adapted) [29, 30].

Locations

Rio Branco do Ivaí

It has an area of 386 km² representing 0.1935% of the state, 0.0684% of the region and 0.0045% of the entire Brazilian territory. It is located at latitude 24°19'26" south and a longitude 51°18'46" west, being at an altitude of 650 m. Its estimated population in 2000 was 3,758 inhabitants [29].

Rosário do Ivaí

The municipality is characterized by a fairly rugged relief, in which approximately 50% of the area of the municipality is under the phases of the strong undulating and mountainous relief, 29% is under soft undulating relief and 21% under undulating relief. It has an area of 371,248 km² representing 0.1863% of the state, 0.0659% of the region and 0.0044% of the entire Brazilian territory. It is located at latitude 24°16'40" south and at a longitude 51°16'30" west, being at an altitude of 675 m. Climate subtropical Cfa (Fig. 4) [30].

Analysis of images

For the accomplishment of this work, the images of satellite GOES 13/NOAA/USA - Infrared Channel more enhancement, available June 6, 2017, local time: 06:40, South of Brazil and Central and South America and the Caribbean, Cooperative Institute for Research in the Atmosphere, Colorado State University, USA, modified by LabClima/UNIVALI, was obtained (Fig 4). 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 [26].

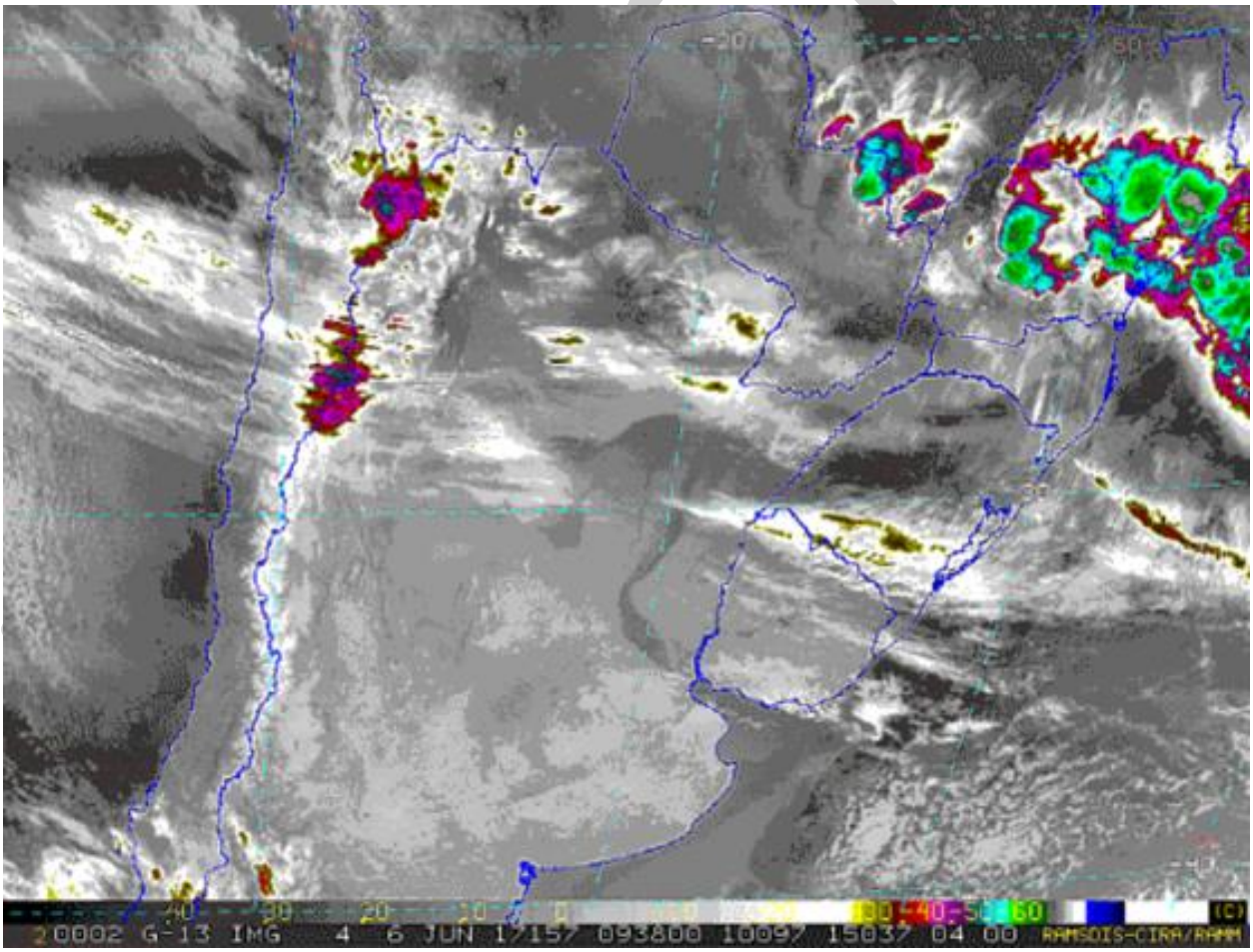

Fig 5 Image of satellite GOES 13/ NOAA/USA - Infrared Channel + enhancement - 06/06/2017 - Local time: 06:40 - South of Brazil. Source: RAMSDIS Online - Central and South America and the Caribbean, Cooperative Institute for Research in the Atmosphere, Colorado State University, USA, modified by LabClima/UNIVALI [25].

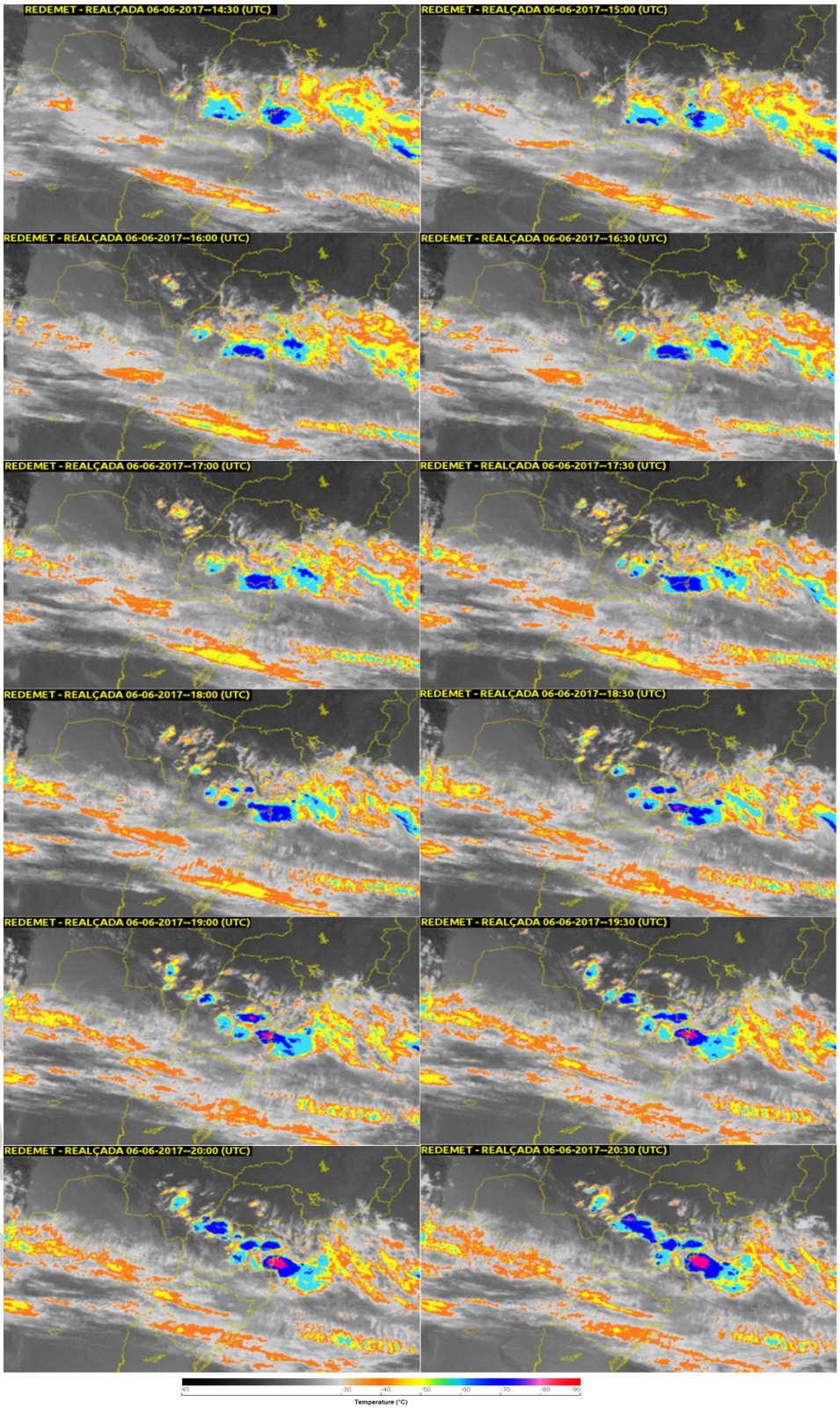

Fig 6 The images obtained from the REDEMET (*Rede de Meteorologia do Comando da Aeronáutica*. GT-REDEMET) website for June 6, 2017, from 2:30 p.m. to 8:30 p.m. (UTC) at 30-minute intervals. The images highlight and indicate the temperature from 45°C to -90°C (Adapted) [5].

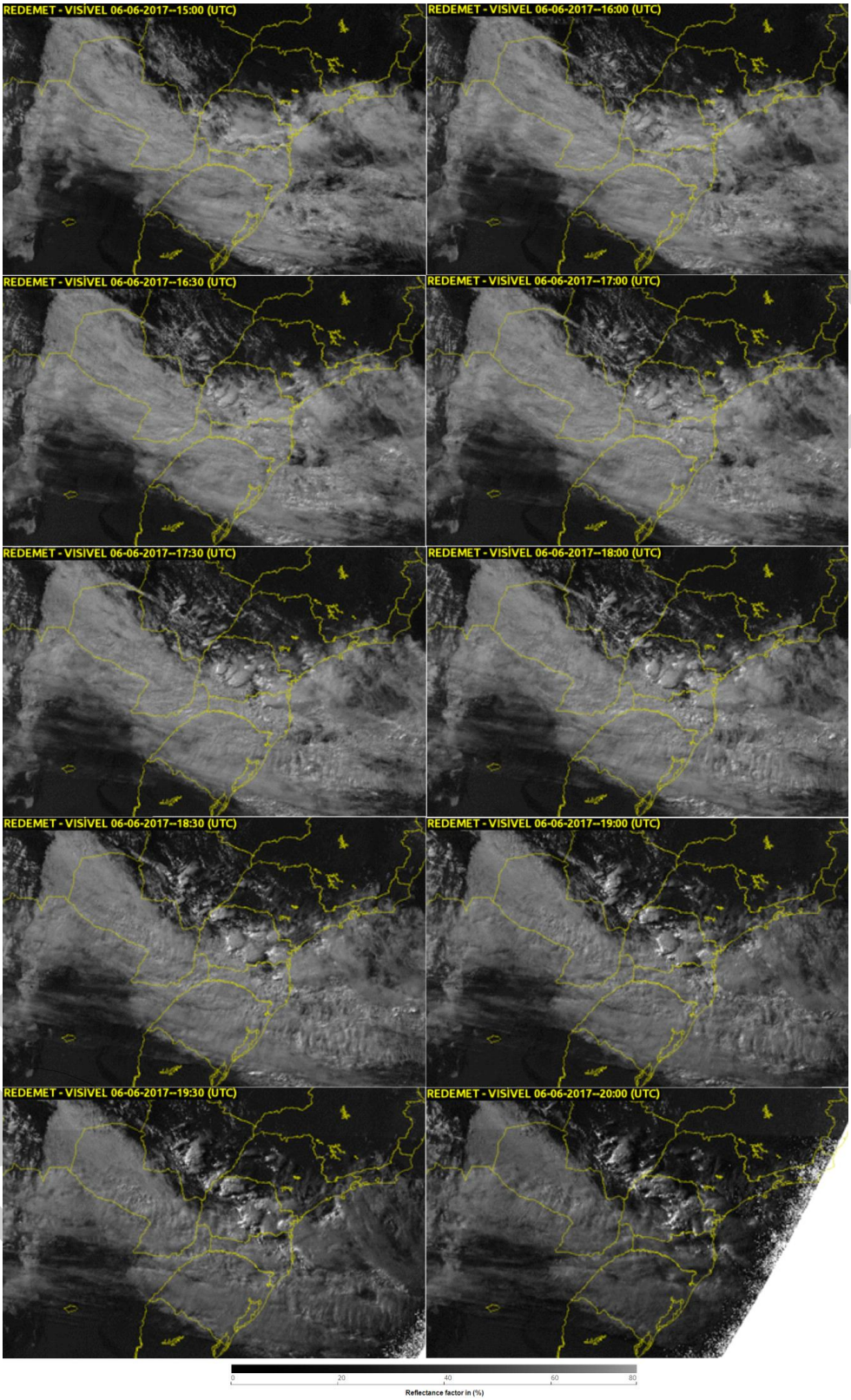

Fig 7 The images were obtained from the REDEMET (*Rede de Meteorologia do Comando da Aeronáutica*. GT-REDEMET) website for June 6, 2017, from 2:30 p.m. to 8:30 p.m. (UTC) at 30-minute intervals. The images are in the visible spectral, in black and white. They represent the reflectance factor from zero to 80%. (Adapted) [5].

The images were obtained from the REDEMET (Meteorology Network of the Aeronautics Command) website for June 6, 2017, from 2:30 p.m. to 8:30 p.m. (UTC) at 30-minute intervals. For Fig. 6, the images highlight and indicate the temperature from 45°C to -90°C. For Fig. 7, the images are in the visible spectral, in black and white and represent the reflectance factor from zero to 80%. Analyzes of the GOES-13 satellite were used observing the formation and dissipation of the storm along June 6, 2017, with a temporal resolution of approximately every 30 minutes. Then, the gray level (*Nc*), (Fig. 7) for the brightness temperature (*Tb*) was analyzed using the following equation:

$$T_b = 320 - (0.625\, N_c)$$

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 [27, 28].

Discussion

Fig. 5 is clearly demonstrating the formation of two supercells of storms in the central region of the state of Parana, with temperatures ranging from -50°C to -60°C. It is verified that the collision of cold fronts originating from the SO of Argentina with hot air masses coming from the NW of Brazil, from the Amazon, moving through *Rondônia*, *Mato Grosso and Mato Grosso do Sul*. When they meet, they collide by tapering from SO to OSO, and from NO to ONO, adding both coming from the West, and going east when entering the State of Parana. When they added up and collide, they move with great speed, provoking strong winds and intense rains, in a short period of time.

It was further concluded that at the temperature from 45°C to -90°C, the evolution of the storm was happening with the formation of several cores of supercells of the storm that advanced from west to east, crossing the state of Parana. Supercell peaks occurred in the central region of Parana, between 18:00 UTC and 19:00 UTC, with two storm supercells and a smaller one in the region of *Rio Branco do Ivaí* and *Rosario de Ivaí*.

The three cores appear well defined in the enhanced image from 18:00 UTC, with temperatures of approximately -70°C, for larger nuclei, and the lowest -90°C, represented in blue and red, respectively. Probably the core of -90°C occurred hail drop. At the same time, the image indicates four supercells. Three in the central region, one in the eastern region, and the other in the states of Parana, *Santa Catarina*. This one moves from the south coast of Parana, north of *Santa Catarina* and advancing offshore. The larger nucleus grows rapidly, decreasing its temperature, when approaching the region of the mountain range and when reaching the ocean.

Conclusions

With the collected images, published in social networks by residents, citizens of the counties of *Rosário de Ivaí*, *Rio Branco do Ivaí*, in the state of Parana, southern region of Brazil. With the published images of newspapers and blogs on the Internet and with the images obtained in GOES 13 satellites and published in REDEMET - Meteorology Network of the Aeronautics Command. There is strong evidence characterizing the formation of tornadoes in the central region of the Parana state, in these counties, on June 6, 2017, at 6:00 p.m. UTC and 7:00 p.m. UTC.

Conflict of interest

The authors declare that they have no conflict of interest

References

[1] Armentrout D, Armentrout P. Tornadoes. Series: Earth's Power. Rourke Publishing; 2007.

[2] Paraná Portal, 2018: Suposto tornado provoca estragos no interior do Paraná. Available in: May 18, 2018, URL: https://www.metrojornal.com.br/foco/2017/06/08/suposto-tornado-provoca-estragos-no-interior-parana.html.

[3] Senes RA. Temporal - Vendaval em Rosário do Ivaí e Rio Branco do Ivaí. *Rádio Nova Era*, *Blog* Berimbau; 2017. Accessed: 18 May 2018, http://www.blogdoberimbau.com/2017/06/temporal-vendaval-em-rosario-do-ivai-e.html.

[4] TNOnline, 2017: Tornado is registered in the northern region of Paraná. *TNOnline*, Available in: June 25, 2018, https://tnonline.uol.com.br/noticias/cotidiano/67,417692,07,06,tornado-e-registrado-na-regiao-norte-do-parana-veja-video.shtml.

[5] REDEMET, Rede de Meteorologia do Comando da Aeronáutica, 2018: GT-REDEMET, Imagens de Satélite, 06/06/2017, Available in: September 05, 2018, URL: https://www.redemet.aer.mil.br/index.php?i=produtos&p=imagens-de-satelite.

[6] Ting L, Klein R, Knio OM. Vortex dominated flows - analysis and computation for multiple scale phenomena. Applied Mathematical Sciences, 2007; Springer, ISBN-13 978-3-540-68581-4.

[7] Allaby M, Garratt R. Tornadoes. Dangerous Weather Facts on File Science. 2004; libraryFacts on File.

[8] Barenghi CF, Donnelly RJ, Vinen WF, (eds.), Quantized Vortex Dynamics and Superfluid Turbulence. 2001; Springer-Verlag Berlin Heidelberg.
[9] Berger M. Do Tornadoes Really Twist? Scholastic Reference, Scholastic Question & Answer; 2000.
[10] Bluestein HB. Severe Convective Storms and Tornadoes, Observations and Dynamics. 2013; Springer-Verlag Berlin Heidelberg, DOI: 10.1007/978-3-642-05381-8.
[11] Doeden M. Tornadoes. Lerner Publications, Pull Ahead Books; 2007.
[12] Fedrigo DFG, Gobato R, Gobato A. Avro: key component of Lockheed X–35. Parana J Sci Educ 2015; 1:1–6.
[13] Gobato R, Gobato A, Fedrigo DFG. Harnessing the energy of ocean surface waves by Pelamis System. Parana J Sci Educ 2016; 2:1–15.
[14] Howe MS. Theory of Vortex Sound. Cambridge University Press, Boston University; 2003.
[15] Hunt JCR, Vassilicos JC. Turbulence Structure and Vortex Dynamics. Cambridge University Press; 2010.
[16] Kobayashi T. Vortex Electronis and SQUIDs. Topics in Applied Physics 91, Springer-Verlag Berlin Heidelberg; 2003.
[17] Boratav O, Eden A, Erzan A (eds.). Turbulence Modeling and Vortex Dynamics: Proceedings of a Workshop Held at Istanbul, Turkey, 2–6 September 1996. Springer Berlin Heidelberg; 1997.
[18] Marchioro C, Pulvirenti M. Vortex Methods in Two-Dimensional Fluid Dynamics. Springer; 1984.
[19] Maurel A, Petitjeans P. Vortex Structure and Dynamics workshop. Springer-Verlag Telos; 2000.
[20] Orr TB. Tornadoes. Cherry Lake Publishing, 21st Century Skills Library: Real World Math; 2012.
[21] Timmer R, Tilin A. Into the storm: violent tornadoes, killer hurricanes, and death-defying adventures in extreme weather. Penguin Group USA, Inc., New American Library; 2014.
[22] Saffman PG.: Vortex dynamics. Series: Cambridge monographs on mechanics and applied mathematics. First Edition, Cambridge University Press; 1992.
[23] Sokolovskiy MA. Verron J. Four-vortex motion in the two-layer approximation - integrable case. RXD; 2000.
[24] Tilin A. Into the Storme, Violent Tornadoes, Killer Hurricanes, and Death-defying Adventures in Extreme Weather. Penguin Group (USA); 2010.
[25] RBS Group Blogs, 2017: Tempo instável até quinta-feira, depois tempo bom e frio. Available in: June 26, 2018, URL: http://wp.clicrbs.com.br/brisa/2017/06/page/2/?topo=98%2C2%2C18%2C%2C%2C15.
[26] Crosta AP. Processamento digital de imagens de sensoriamento remoto. Campinas: IG/UNICAMP; 1992. 170 p.
[27] Gobato R, Simões FM.: Alternative method of RGB channel spectroscopy using a CCD reader. Ciência e Nat 2017; 39 202-210.
[28] Gobato R, Gobato A, Fedrigo DFG. Study of tornadoes that have reached the state of Parana. Parana J Sci Educ 2016; 2:1–17.
[29] Wikipedia, Creative Commons, (CC BY 4.0), 2017: Rio Branco do Ivaí. Available in: August 30, 2018, URL: https://pt.wikipedia.org/wiki/Rio_Branco_do_Iva%C3%AD.
[30] Rosário do Ivaí. Available in: August 31, 2018, URL: https://pt.wikipedia.org/wiki/Ros%C3%A1rio_do_Iva%C3%AD.