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PREDOMINANT ATMOSPHERIC PRESSURE FIELDS IN THE SANTA CATARINA REGIONS

Campos de pressão atmosférica predominantes nas regiões de Santa Catarina

Campos de presión atmosférica predominantes en las regiones de Santa Catarina

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Abstract: Atmospheric pressure is a meteorological element that governs the dynamics of the movement of the atmosphere. Therefore, due to the rare existence of bibliographic material, the objective of the article is to characterize the climatological patterns of atmospheric pressure and evaluate its possible trends in the different seasons of the year for the State of Santa Catarina. For this, historical series of atmospheric pressure from six meteorological stations, Florianópolis, Indaial, Campos Novos, Chapecó, São Joaquim and Lages will be used. The data will be filtered and submitted to a descriptive statistical analysis and later will be submitted to the variance test (ANOVA). After this procedure, a trend analysis of atmospheric pressure will be performed for the six regions, using the Mann-Kendall test. With the results achieved by the present study, it was found that atmospheric pressure is influenced by both meteorological factors and meteorological elements, depending on the

prevailing climate of the state. And for most regions, significant positive trends in atmospheric pressure were observed.
Keywords: Centers of Atmospheric Pressure. Regional Variations. Seasonal Variations.

Resumo: A pressão atmosférica é um elemento meteorológico que rege a dinâmica da movimentação da atmosfera. Logo, em função da rara existência de material bibliográfico, o objetivo do artigo é caracterizar os padrões climatológicos da pressão atmosférica e avaliar suas possíveis tendências nas diferentes estações do ano para o Estado de Santa Catarina. Para isso, serão utilizadas series históricas de pressão atmosférica de 6 estações meteorológicas, Florianópolis, Indaial, Campos Novos, Chapecó, São Joaquim e Lages. Os dados serão filtrados e submetidos a uma análise estatística descritiva e posteriormente serão submetidos ao teste da variância (ANOVA). Após esse procedimento será realizada uma análise de tendência da pressão atmosférica para as seis regiões, por meio do teste de Mann-Kendall. Com os resultados alcançados pelo presente estudo constatou-se que a pressão atmosférica sofre influência tanto de fatores meteorológicos como de elementos meteorológicos, em função do clima predominante do estado. E para a maioria das regiões observou-se tendências significativas positivas de pressão atmosférica.
Palavras chaves: Campos de Pressão Atmosférica. Variações Regionais. Variações Sazonais.

Resumen: La presión atmosférica es un elemento meteorológico que rige la dinámica del movimiento de la atmósfera. Por lo tanto, debido a la escasa existencia de material bibliográfico, el objetivo del artículo es caracterizar los patrones climatológicos de la presión atmosférica y evaluar sus posibles tendencias en las diferentes estaciones del año para el Estado de Santa Catarina. Para ello, se utilizarán series históricas de presión atmosférica de 6 estaciones meteorológicas, Florianópolis, Indaial, Campos Novos, Chapecó, São Joaquim y Lages. Los datos serán filtrados y sometidos a un análisis estadístico descriptivo y posteriormente serán sometidos a la prueba de varianza (ANOVA). Luego de este procedimiento, se realizará un análisis de tendencia de la presión atmosférica para las seis regiones, utilizando la prueba de Mann-Kendall. Con los resultados alcanzados por el presente estudio, se encontró que la presión atmosférica está influenciada tanto por factores meteorológicos como por elementos meteorológicos, dependiendo del clima predominante en el estado. Y para la mayoría de las regiones, se observaron tendencias positivas significativas en la presión atmosférica.
Palabras clave: Campos de Presión Atmosférica. Variaciones Regionales. Variaciones estacionales.

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1. INTRODUÇÃO

The climate comes from the dynamic process of exchange relations between the atmosphere and the Earth's surface, that is, the Surface Atmosphere System (SSA). These interrelationships are determined by meteorological elements, which are conditioned by meteorological factors, resulting in climate dynamics in a certain period of the year and place (SANTOS; SILVA and SCHNEIDER, 2011).

According to Mendonça and Danni-Oliveira (2017), the meteorological elements that make up the climate are: air temperature, air humidity and atmospheric pressure, which vary spatially and temporally under the influence of geographic climate factors, such as latitude, altitude, sea level, continentality, vegetation and human activities.

Atmospheric pressure is a meteorological element that consists of the weight of air on the earth's surface, defined by the product of the relationship between the mass of the atmosphere and the gravitational force of the planet (JARDIM, 2011).

Like other meteorological elements, are measured by surface weather stations and altitude weather stations (OLIVEIRA; AMORIM and DERECZYNSKI, 2018), atmospheric pressure is measured through sensors installed in automatic stations (AEROEXPO, 2021). At altitude meteorological stations, atmospheric pressure is measured using a radiosonde, which corresponds to a small PVC box with internal styrofoam parts composed of sensors, transmitters, GPS antenna, processor and battery, which record and transmit the pressure values of the vertical profile of the atmosphere (MCA, 2015).

Atmospheric pressure is a determining element in the general circulation of the atmosphere, considering that the movement of air masses comes from differences in atmospheric pressure between locations or regions. At the surface level, air masses move from zones of high pressure to low atmospheric pressure. Along with the difference in air temperature, in the vertical profile of the atmosphere, there are variations in air density that, with the action of the gravitational force, generates the movement of air masses (BERGAMASCHI and BERGONCI, 2017). Another important factor in the movement of air masses is the translation and rotation of the earth. Due to the tilt of the Earth in relation to its axis, together with the translational movement around the sun, the hottest band moves seasonally and this phenomenon is responsible for the formation of the seasons or the seasonal effect (ZUFFO, 2015).

This leads to the formation of synoptic systems, which come from the dynamics of the behavior of atmospheric circulation, resulting from ascending movements of moist air, which expands with decreasing pressure at altitude and cooling. Soon, part of the water vapor condenses, starting the formation of clouds (SILVA; CHAVES and LIMA, 2009). Consequently, atmospheric pressure is directly related to precipitation regimes on a global scale, as during the austral summer, there are high percentages cloudiness over tropical land areas in the Southern Hemisphere, in part due to convection along the Intertropical Convergence Zone, and in subpolar oceanic areas due to advection of moist air. Minimum cloud cover is associated with subtropical high pressure regions throughout the year, while maximum cloud cover occurs over the Southern Ocean storm belt at 50-70°S and over much of the ocean area north of 45° N (BARRY and CHORLEY, 2013).

On the mesoscale, altitude is a meteorological factor that establishes the atmospheric pressure values of a given region, following the following relationship: the higher the altitude of a relief, that is, its elevation in relation to sea level, the lower the atmospheric pressure. Through this relationship, atmospheric pressure indirectly influences the dynamics of other meteorological elements. Air temperature can be considered as the main element influenced by atmospheric pressure, because normally, it decreases with the elevation of altitude around 6.5ºC/Km (thermal gradient). This cooling rate develops as a function of a rising air mass is subjected to decreasing pressure, increasing its volume and decreasing the temperature (BINDA; MENDES and KOCHEMBORGER, 2016; FRITZSONS; MANTOVANI and AGUIAR, 2008). Second Viera; Cupolilo (2021), factors such as relative humidity and air temperature directly influence atmospheric pressure values, with variations by decentrics.

Due to the rare existence of bibliographical references referring to the subject, the objective of the article is to characterize the climatological patterns of atmospheric pressure and evaluate its possible trends in the different seasons of the year for the State of Santa Catarina.

2. METHODOLOGY

State of Santa Catarina is located in the southern region of Brazil, with a territorial domain of 95,730,684 km^2 and an estimated population of 7,164,788 in habitants (IBGE, 2019).

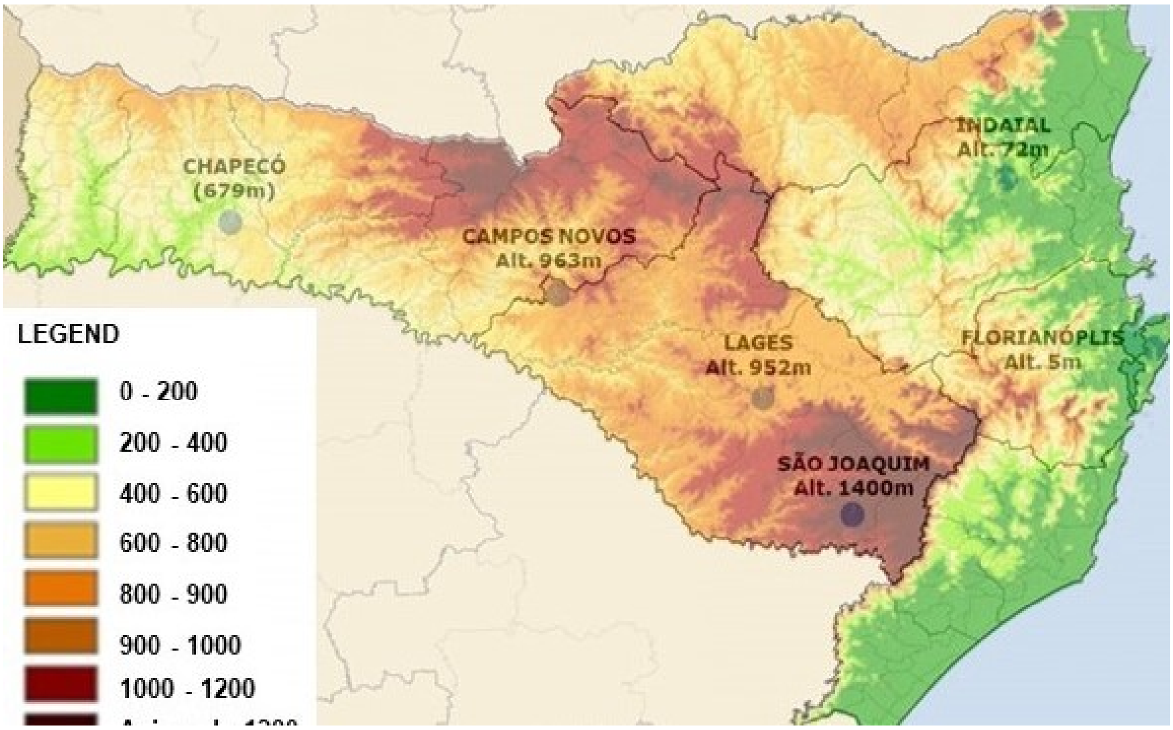
The territory of Santa Catarina is characterized by presenting an highland with a slight slope to the west and an area that develops from the edge of the plateau to the sea, called, respectively, the Highland Region and the Coastal and Slopes Region (JÚNIOR, 1986).

According to the KÖPPEN classification, the climate of the State of Santa Catarina was defined as humid mesothermal, with no dry season (*Cf*), including two subtypes, humid subtropical climate (*Cfa*) and humid maritime temperate climate (*Cfb*) (DUBREUIL, 2018).

Due to its geographic location, Santa Catarina is one of the states in the country with the best distribution of annual precipitation, the main responsible systems being the cold fronts, active at all times of the year, with a weekly frequency, which cause changes in temperature, wind and atmospheric pressure (SATYAMURTY and MATTOS, 1989; RODRIGUES *et al*, 2004). These systems are accompanied by cold air masses, inserted in high pressure centers that cause sudden temperature declines (ALVES and MINUZZI, 2018). Other important systems that cause sudden changes in pressure in Santa Catarina are the cyclones that move over southern Brazil causing rain (PEREIRA and AMBRIZZI, 2011).

For the development of the study, data from historical series of atmospheric pressure from six Meteorological Stations located in the following locations were used: Campos Novos, Indaial, Lages, Chapecó, São José and São Joaquim, covering different regions of the Santa Catarina territory (Figure 1).

Figure 1- Location of EPAGRI and INMET meteorological stations.



Source: Adapted Jesus (2017).

These weather stations were used depending on the availability of historical series with older records, in this case from 1990 to 2019, covering a period of 30 years. Data were obtained from the network of meteorological stations of the National Institute of Meteorology (INMET), and Agricultural Research and Rural Extension Company of Santa Catarina (EPAGRI) / Santa Catarina Environmental Resources and Hydrometeorology Information Center (CIRAM).

For the characterization of the predominant atmospheric pressure centers in the State of Santa Catarina, initially it was verified the amount of existing faults in the historical series used in the study. According to the methodology used by Sá *et al*. (2018). Monthly averages were calculated from daily data from conventional and automatic stations.

Subsequently, atmospheric pressure data from meteorological stations were analyzed separately through descriptive statistical analysis (Microsoft Excel Software[1]) and analysis of variance (ANOVA), on a seasonal scale - Summer (Dec/Jan/ Feb), Autumn (Mar / Apr /May), Winter (Jun /Jul/ Aug) and Spring (Sep/Oct/ Nov).

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[1] *Microsoft Excel®*

For the development of a conceptual model of the dominant atmospheric pressure centers for the State of Santa Catarina, the reduced atmospheric pressures at sea level were obtained by INMET. From the pressure value obtained at each point, the atmospheric pressure isolines were drawn manually over the state of Santa Catarina and thus digitized. Each isoline represents an atmospheric pressure value and are spaced every 2hPa, which makes it possible to identify areas of greater or lesser pressure. According to Dereczynski and Menezes (2015), when a meteorological phenomenon meets the basic standards of its respective conceptual model, such as atmospheric pressure behavior, among others, it becomes possible to carry out analyzes through its database. Therefore, through a conceptual model it is possible to identify characteristic areas of a certain meteorological element, that is, average maps that define climatological patterns (average positioning of atmospheric systems).

Historical records of atmospheric pressure were submitted to the Mann-Kendall test (MANN, 1945; KENDALL, 1975), to verify the existence of positive or negative trends in the atmospheric pressure data in each region studied. It is noteworthy that the Mann-Kendall test is widely applied in studies that aim to perform analyzes of climatological historical series of the most diverse meteorological elements such as air temperature and precipitation (GAVRILOV *et al*., 2016), considered non-parametric.

The test is based on Equations 1 and 2 (JÚNIOR and LUCENA, 2021).

$$S = \sum_{i=2}^{ni} \sum_{j=1}^{i=1} sinal(xj - xi) \tag{1}$$

Where S is the value resulting from the sum of the counts of (xj -xi); xj is the first value after xi, n is the number of data in the time series. The following values are assigned to each data pair:

$$sinal = \begin{Bmatrix} 1\ se\ (xj - xi) > 0 \\ 0\ se\ (xj - xi) = 0 \\ -1\ se\ (xj - xi) < 0 \end{Bmatrix} \tag{2}$$

In general, a distribution approaches a normal distribution when it has a high number of observations with zero mean and variance given by Equation 3, where t_i represents the number of connections *i* (SÁ *et al*., 2018).

$$Var(S) = \frac{n\ (n-1)\ (2n+5) \sum_{i=1}^{n} ti\ (i)(i-1)(2i+5)}{18} \tag{3}$$

The significance of S for the null hypothesis can be obtained through a two-sided test, and it can be rejected for large values of the Z(t) statistic characterized according to Equation 4 (SANTOS and PORTELA, 2007).

$$ZMK = \begin{cases} \dfrac{S-1}{\sqrt{Var\ (S)}} & se\ S > 0 \\ 0 & se\ S = 0 \\ \dfrac{S+1}{\sqrt{Var(S)}} & se\ S < 0 \end{cases} \tag{4}$$

Finally, the evaluation takes place through the acceptance or rejection of the null hypothesis (H0) based on the significance level adopted, in this case 5%. Adopting this level of significance, H0 was not rejected whenever -1.96 < ZMK < 1.96. Upward or downward trends result in positive or negative values, respectively, of ZMK (BLAIN, 2010).

3. RESULTS AND DISCUSSION

The results obtained by the descriptive statistics analysis are shown in Table 1. It is noteworthy that the values considered were those that, after checking the historical series of the six meteorological stations in the present study, did not present more than 15% of failures, avoiding possible interferences approaching in more coherent values to portray the real situation of the behavior of the atmospheric pressure in these regions.

It was found that the highest annual averages of atmospheric pressure correspond to the cities of Florianópolis (1015.61 hPa) and Indaial (1007.46). However, the lowest averages of atmospheric pressure correspond to the cities located at high altitudes such as São Joaquim and Lages, 862.18 hPa and 909.60 hPa, respectively. This result was predicted, because low altitude regions are characterized by higher values of atmospheric pressure, while regions with higher altitudes, in relation to sea level, are characterized by lower mean values of atmospheric pressure. When exploring the amplitudes, maximum and minimum values, resulting from each region in isolation, it is noted that for all regions, even in months of transition between seasons, the average values of atmospheric pressure are characterized by a low amplitude, that is practically they do not differ during the 3 months equivalent to each of the four seasons, but between seasons. However, when comparing the average values of maximum and minimum between the different regions studied, again the segmentation of each region becomes explicit.

Table 1 - Descriptive statistical analysis of seasonal averages of atmospheric pressure (hPa) for each station.

Station	Analysis	Lages	São Joaquim	Florianópolis	Campos Novos	Indaial	Chapecó
Spring	Average	908.88	861.47	1015.61	909.61	1007.31	937.4
	Standard deviation	1.36	1.15	2.19	1.28	2.22	1.51
	variance	1.84	1.33	4.79	1.65	4.94	2.28
	Minimum	907.58	860.4	1013.48	908.39	1005.18	936
	Maximum	910.29	862.69	1017.85	910.95	1009.61	939
Summer	Average	907.52	860.82	1012.03	908.05	1003.83	935.65
	Standard deviation	0.56	0.74	0.31	0.56	0.48	0.76
	variance	0.32	0.55	0.09	0.31	0.23	0.58
	Minimum	906.98	860.02	1011.75	907.59	1003.41	935.11
	Maximum	908.1	861.48	1012.36	908.67	1004.35	936.52
Autumn	Average	910	862.68	1015.49	913.43	1007.5	938.65
	Standard deviation	0.95	0.51	1.82	0.78	1.77	1.06
	variance	0.9	0.26	3.32	0.62	3.14	1.13
	Minimum	908.98	862.09	1013.67	912.62	1005.68	937.57
	Maximum	910.84	863.02	1017.31	914.18	1009.23	939.7
Winter	Average	911.99	863.77	1019.3	912.43	1011.18	940.81
	Standard deviation	0.19	0.36	0.5	0.12	0.32	0.3
	variance	0.04	0.13	0.25	0.01	0.1	0.09
	Minimum	911.81	863.36	1018.75	912.35	1010.84	940.45
	Maximum	912.19	864.03	1019.73	912.57	1011.46	940.99

According to Machado (2018), this dynamic refers to the air density, which is inversely proportional to altitude, so with increasing altitude, there is a reduction in air density. Also according to the author, this relationship also applies to atmospheric pressure, since the atmospheric pressure at a given altitude corresponds to the force exerted by the weight of the air column above the altitude in question.

Another important result achieved with the application of descriptive statistics was the variance of atmospheric pressure in the different regions studied. According to the results, the variability is influenced according to the seasons of the year. In the spring and autumn seasons there was a greater variability of atmospheric pressure records, especially in the low altitude regions, Florianópolis and Indaial. This result is expected, as spring and autumn are the transition seasons, when both cold and warmer periods are observed. And especially in spring, there is a greater variation in temperatures, with longer periods of action of cold air masses in September and well heated periods with action of the Equatorial mass in November, which occurs mainly in the northernmost locations of Santa Catarina, more influenced by the performance of the Equatorial mass (NIMER, 1989). In winter, the difference in variability between the different regions studied is low, with Florianópolis being the most prominent municipality, reaching a variability of approximately 0.25. In autumn the values correspond to 3.32 and 3.14, and in the spring period the variance increases for both municipalities, reaching values of 4.79 and 4.94 for Florianópolis and Indaial, respectively. However, in the summer period, the behavior of atmospheric pressure variability is completely opposite. In this station, it was verified that the greatest variability of atmospheric pressure corresponds to regions with higher altitudes, such as São Joaquim, Chapecó, Lages and Campos Novos, which reached values of 0.55, 0.58, 0.32 and 0.31, respectively.

Atmospheric pressure centers undergo seasonal changes due to the dynamics of polar mass movement in central and southern Brazil. In the warmer months, there is a recession of the Polar mass that advances preferentially through the ocean. However, in the coldest months, there is a predominance of the movement of the Polar mass over the continent, causing continental cooling, providing the formation of high atmospheric pressure systems and reducing instability conditions. In autumn and spring, the polar mass acts with oscillations, causing years in which the dynamics of movement resemble those of winter, and eventually be even higher (BORSATO and MENDONÇA, 2015). As the regions located at higher altitudes, the air temperature changes are more accentuated in the period of polar mass incision, these regions tend to have less variance in winter periods and greater variance in summer periods. It is noteworthy that due to this event, the opposite happens for regions located at lower altitudes.

Boyle and Charles' laws demonstrate that the three variables, pressure, temperature and volume, are completely interdependent, so any change in one of the variables will lead to a modification in the compensation in one or even in both variables (BARRY and CHORLEY, 2013). Sousa *et al*. (2015) consider the air temperature as one of the main meteorological elements that influence the atmospheric pressure, because when the air is cooled, the atmospheric pressure increases and vice versa. This relationship was demonstrated in the study carried out by Kruk and Freitas (2017), where the authors, when comparing these meteorological elements, identified reductions in atmospheric pressure with the increase in air temperature and the increase in atmospheric pressure with the decrease in air temperature.

From the results obtained in Table 1, a conceptual model of the distribution of atmospheric pressure in the State of Santa Catarina was determined. For this, the pressure at mean sea level (PNMM) was initially calculated, which represents the reduction in the value of atmospheric pressure measured at the station (values in table 1) to the level closest to the surface (average sea level). This reduction is necessary so that the pressure values can be compared with each other. Figures 2 and 3 show the conceptual model, which is similar for the summer and winter months.

Figure 2 - Winter atmospheric pressure (hPa) synoptic centers.

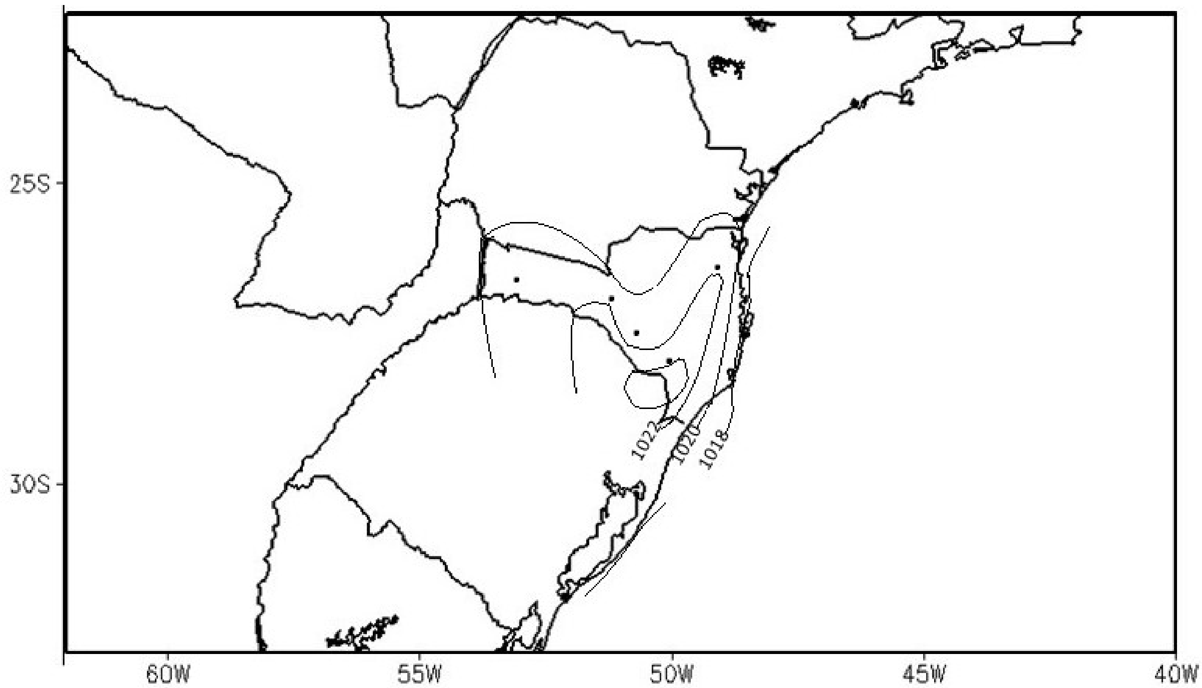
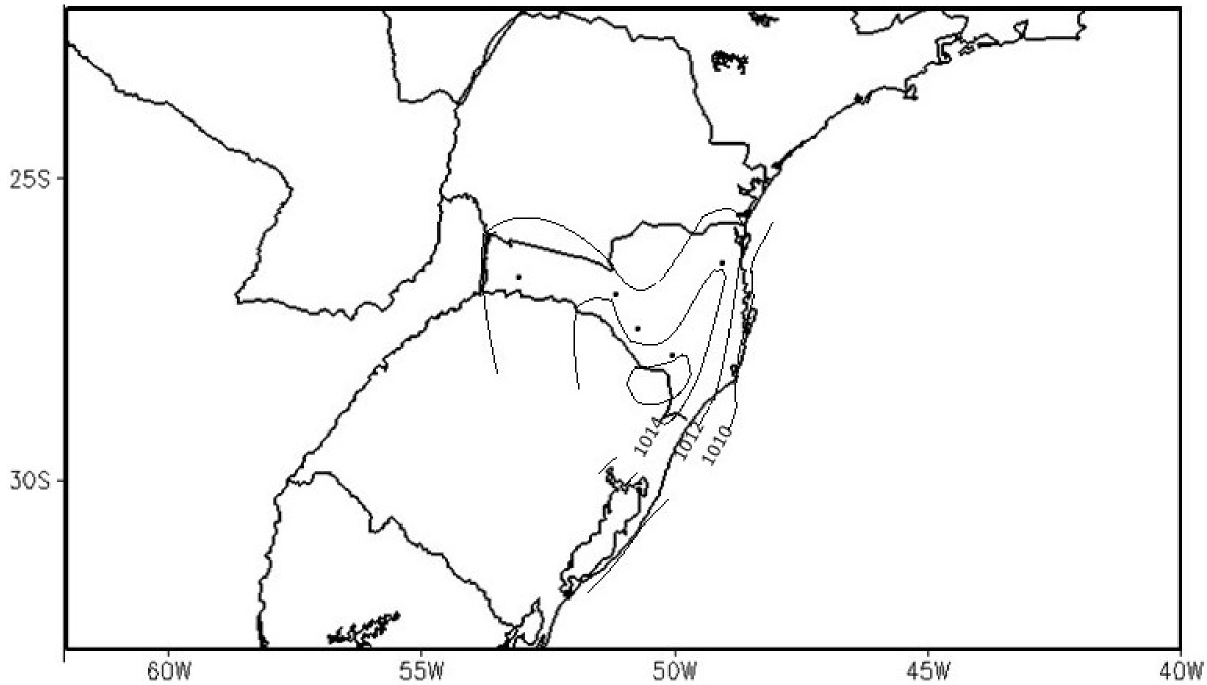


Figure 3 - Summer atmospheric pressure (hPa) synoptic centers.



In Figures 2 and 3, it is observed that the pressure lines are very close to each other in the southern areas of Santa Catarina, which represents a strong pressure gradient (variation). This is a region with great variation in altitude, where the cliffs of the mountains are very close to the coast. The pressure isolines are much more spaced towards the west of Santa Catarina, where there is a plateau area, without great variations in altitude. In the northern part of the state, great variations in relief are also found, with the region of Vale do Itajaí located in the midst of mountainous areas, but this contrast is smaller in relation to the south of Santa Catarina. That is, even with the reduced pressure at sea level, the strong influence of the relief on the distribution of the atmospheric pressure field in Santa Catarina is observed.

With these findings related to these oscillations, both temporal and spatial, it was considered appropriate to submit these values to the variance test, in order to identify the relationship existing in these scales. The results are presented in Table 2.

Table 2 - Anova test applied to atmospheric pressure data.

source of variation	SQ	gl	MQ	F	p-value	F critical
Sample	263.14	3	87.71	72.82	6.96E-18	2.8
columns	217144.93	5	43428.99	36055.81	1.53E-84	2.41
interactions	42.81	15	2.85	2.37	0.01	1.88
Inside	57.82	48	1.2			
Total	217508.7	71				

The results achieved show that there is a significant difference both in temporal and spatial scales. Therefore, the synoptic pattern maps of atmospheric pressure and the application of the Mann-Kendall test must be carried out separately, in order to detect and expose the diversification of atmospheric pressure averages according to each scale.

Table 3 shows the trend results of the average atmospheric pressure, obtained by the Mann-Kendall method by season: summer, autumn, winter and spring, for the six regions evaluated by the study. Subsequently, through Figures 4, 5, 6, 7, 8 and 9, the trend lines that were traced over the last 30 years analyzed are presented, at a seasonal level for each of the locations.

Table 3 - Mann-Kendall test.

County	Seasons			
	Summer	Autumn	Winter	Spring
Chapecó	3.18	4.28	3.7	3.11
Lages	-2.63	-2.48	-3.7	-2.92
Florianópolis	5.79	5.3	5.11	4.38
São Joaquim	1.86	-1.7	1.13	0.79
Campos Novos	3.5	5.8	3.14	2.71
Indaial	-0.05	0	1.46	-2.04

Figure 4 - Average annual trend of atmospheric pressure in the municipality of Chapecó.

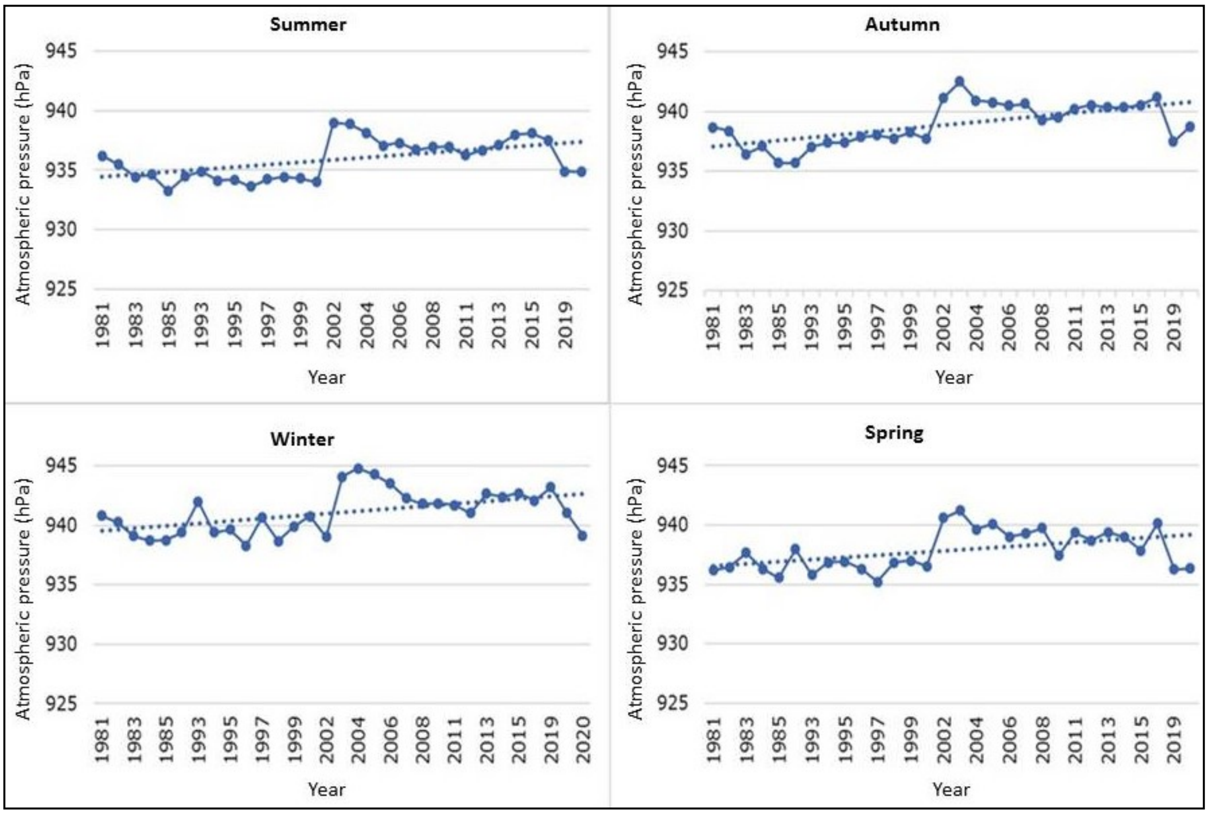


Figure 5 - Average annual trend of atmospheric pressure in the city of Lages.

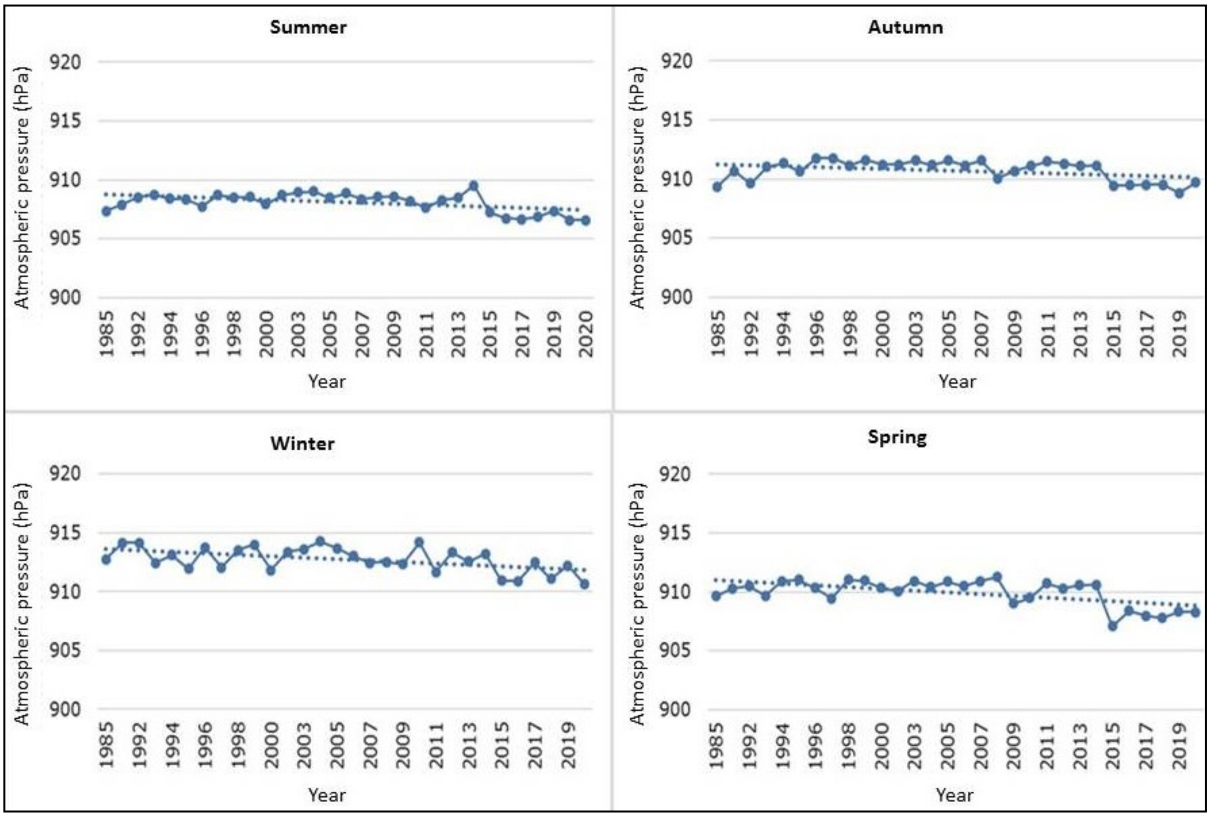


Figure 6 - Average annual trend of atmospheric pressure in the city of Florianópolis.

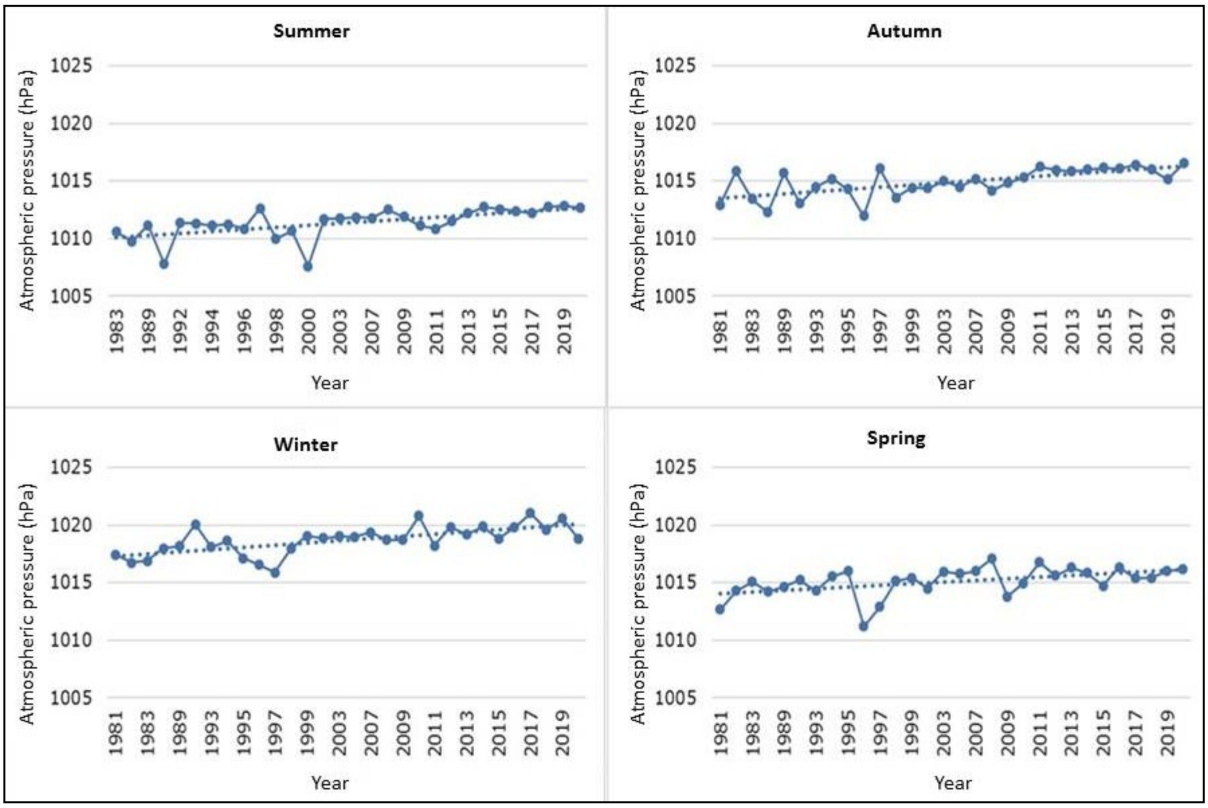


Figure 7 - Average annual trend of atmospheric pressure in the municipality of São Joaquim.

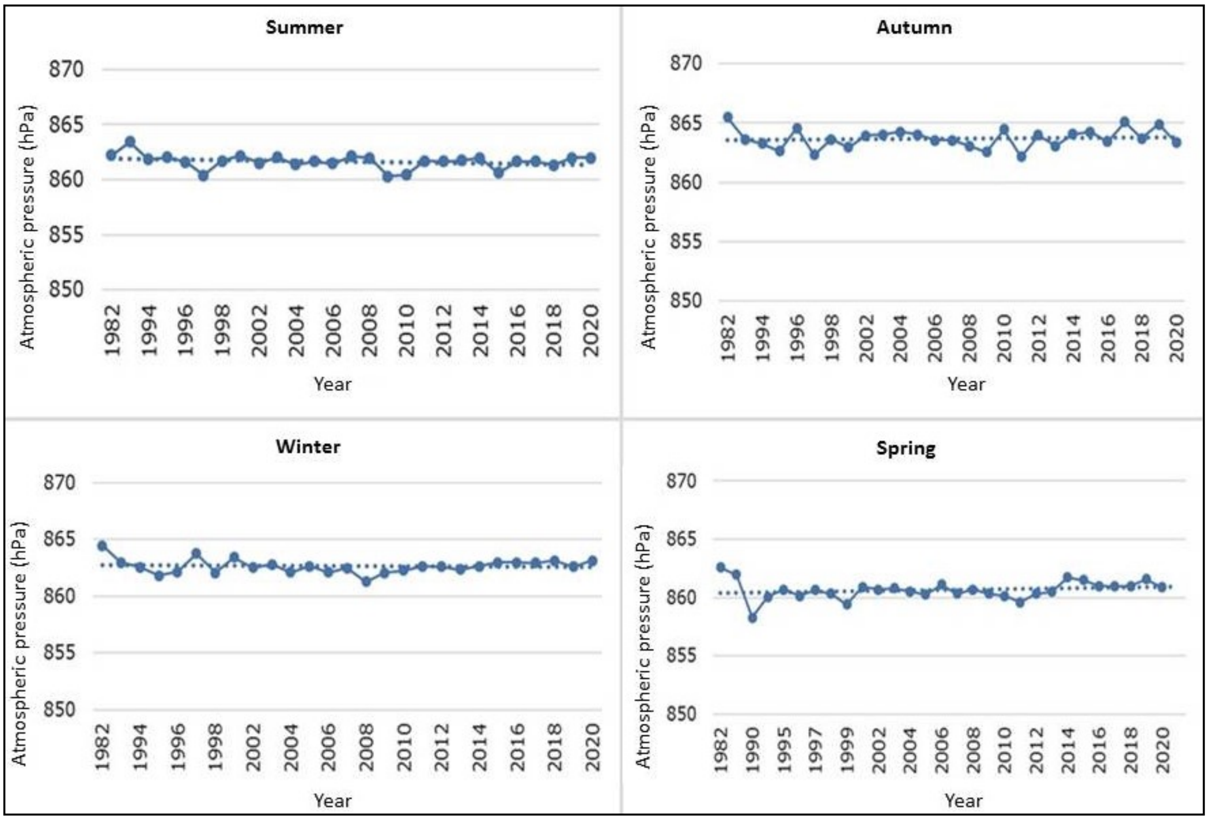


Figure 8 - Average annual trend of atmospheric pressure in the municipality of Campos Novos.

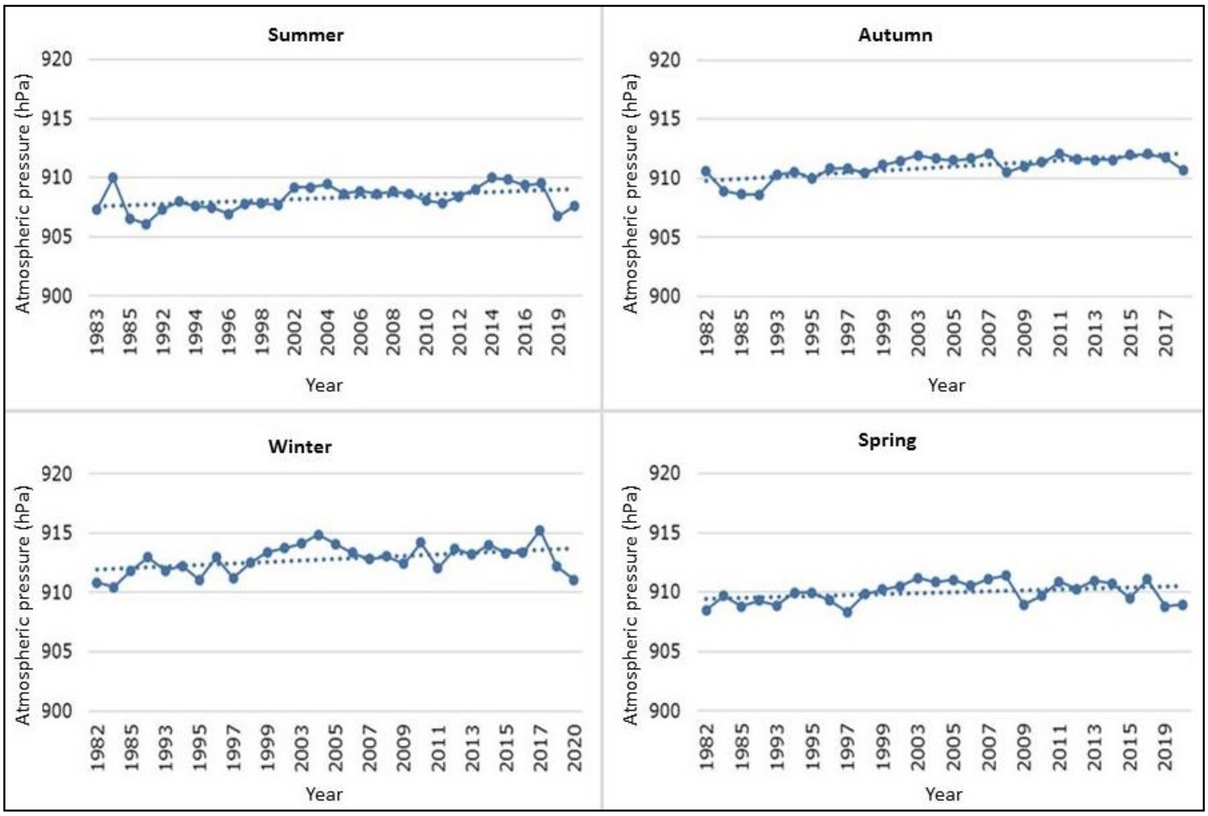
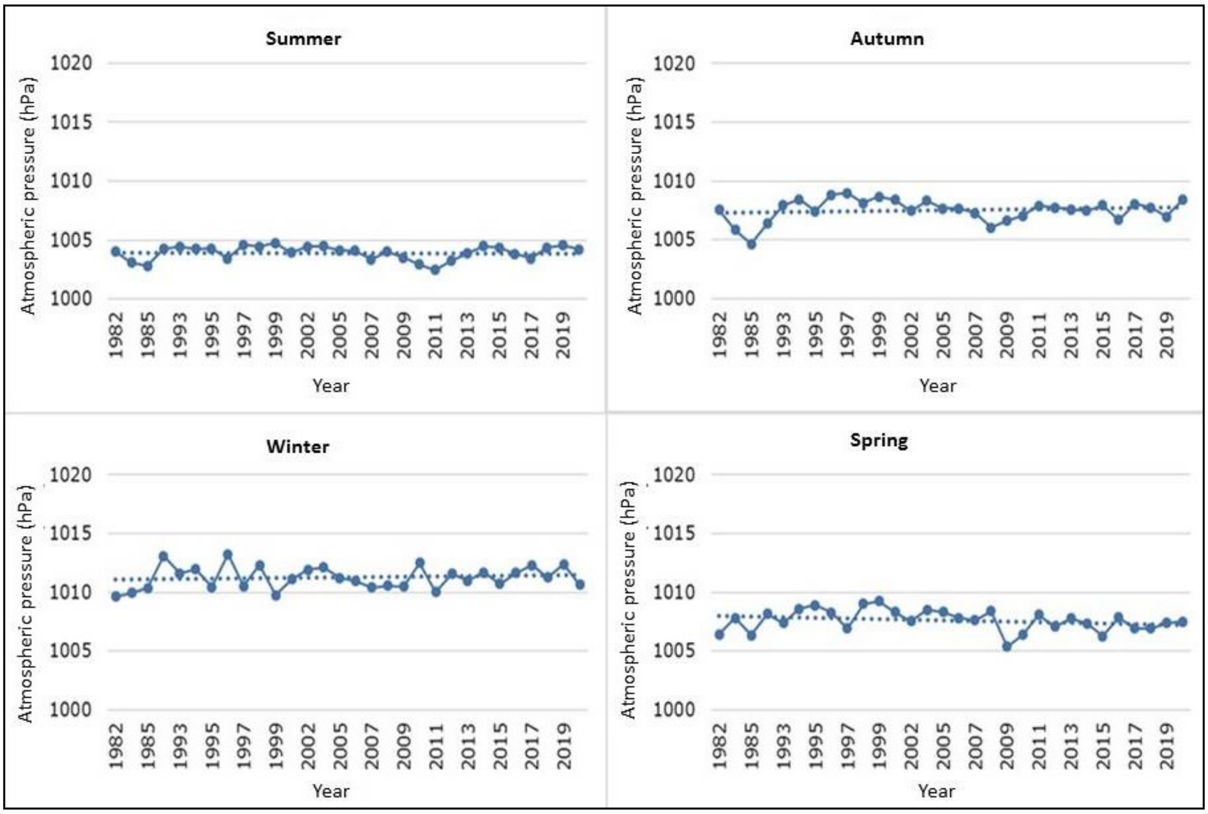


Figure 9 - Average annual trend of atmospheric pressure in the municipality of Indaial.



Overall, similar results were found in the study by Teodoro and Araújo (2012), where seasonal variation in atmospheric pressure is evident, in addition to having identified a repetition of such variations in a given period, in this case every 365 observations. The regions of São Joaquim and Indaial did not obtain significant trends by the Mann Kendall test (Table 3).

The Lages region was distinguished from the other regions, characterized by negative trends for atmospheric pressure. That is, atmospheric pressure values are lower in more recent years, indicating a predominance of lower pressures. According to Minuzzi (2010), the minimum air temperature has a positive trend, this increase being more significant than the increase in the maximum air temperature, so, consequently, there is an increase in the average air temperature, due to the decrease in the thermal amplitude air temperature, characteristic of the region.

The regions of Florianópolis, Campos Novos and Chapecó showed positive trends in atmospheric pressure. Among these regions, the region of Florianópolis stood out over the other regions due to the high values indicating a positive trend for the location, it is noteworthy that these values remained positive and high for the four seasons, summer, autumn, winter and spring.

This situation is linked to the results achieved in the study prepared by Nóbrega and Santiago (2014). In this study of the series of sea surface temperature anomalies for both the Atlantic and the Pacific Oceans, the authors identified positive trends for an increase in temperature. Souza Neto, Silva and Almeida (2021) found that because the southern hemisphere has a larger ocean area than the northern hemisphere, in the southern part of these oceans the heating is higher than in the northern part due to the greater absorption of energy. In addition, they identified that in the southern part of the oceans in question, there is more variability of anomalies when compared to the northern part.

As in warmer periods, like summer, the polar mass moves preferentially through the interior of the Atlantic and after the tropic line it joins the Atlantic Tropical mass (BORSATO and MENDONÇA, 2015), consequently, after a frontal system passage, there is a large drop in temperature and an increase in atmospheric pressure (CARDOZO; REBOITA and GARCIA, 2015). Therefore, taking into account the geographic location of Florianópolis, it is possible to affirm the direct influence of the Atlantic Ocean on the region.

Low atmospheric pressures are associated with upward vertical movements, favoring the formation of clouds, increased cloud cover and the occurrence of rain. In summer, convective rains, associated with these patterns, favor heavy rainfall. However, changes in pressure patterns over the years may be related to mesoclimatic changes.

4. CONCLUSION

It was found that the atmospheric pressure in the State of Santa Catarina, in addition to being directly influenced by meteorological factors, such as altitude and continentality, are also directly influenced by other meteorological elements, such as air temperature. This behavior in the dynamics of Santa Catarina's atmospheric pressure fields can be explained due to the characteristic climate of the state, which is characterized as humid subtropical.

Most regions of the state showed significant positive trends in atmospheric pressure, that is, an increase in pressure values over the years. Furthermore, the atmospheric pressure trend results found in this study coincide with the trend results that were found in studies that aimed to identify the behavior of other meteorological elements, such as air temperature and sea surface temperature, which influence atmospheric pressure.

It is extremely important to carry out new studies that seek to analyze the variation of atmospheric pressure fields as a function of the main synoptic-scale meteorological systems, such as frontal systems, cyclones and anticyclones, dug, among others, that act on the State of Santa Catarina.

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REFERENCES

AIR EXPO. **Sensor di press barometric**. 2021.

ALVES, Maikon Passos; MINUZZI, Rosandro Boligon. Climatology of winter cold waves in Santa Catarina – Brazil. **Journal of Geography**, [*s.l.*], v. 35, no. 3, p. 308 – 323, 2018. https://doi.org/10.51359/2238-6211.2018.229410.

BARRY, Roger G.; CHORLEY, Richard J. **Atmosphere, Weather and Climate**. 9. ed. Porto Alegre: Bookman, 2013. 495 p.

BERGAMASCHI, Homero; BERGONCI, Ito. **Plants and the climate**. 1. ed. Guaíba: Agrolibros, 2017. 351 p.

BINDA, Andrey Luis; MENDES, Jonathan; KOCHEMBORGER, Matheus. Urban topoclimates in Chapecó/SC: interactions between urbanization and the urban site. **Geography Bulletin**, [*s.l.*], v. 34, no. 1, p. 154-171, 22 oct. 2016. http://dx.doi.org/10.4025/bolgeogr.v34i1.27078.

BLAIN, Gabriel Constantino. Detection of monotonous trends in monthly rainfall series in the state of São Paulo. **Bragantia**, [*s.l.*], Campinas, v. 69, no. 4, p. 1027-1033, Dec. 2010. https://doi.org/10.1590/S0006-87052010000400031.

BORSATO, Victor da Assunção; MENDONÇA, Francisco de Assis. Participation of the Atlantic polar mass in the dynamics of the atmospheric systems in Brazil's South Center. Mercator. v. 14, n. 1, p. 113-130, 2015. https://doi.org/10.4215/RM2015.1401.0008.

CABRAL JÚNIOR, Jório Bezerra; LUCENA, Rebecca Luna. Statistical analysis of precipitation and air temperature in semi-arid environments. **Magazine in between-place**, [*s.l.*], v. 12, n. 24, p. 170-191, 30 dec. 2021. http://dx.doi.org/10.30612/rel.v12i24.15139.

CARDOZO, Amanda Balbino *et al*. Climatology of cold fronts in south america and its relationship with the southern annular mode. **Brazilian Journal of Climatology**. v. 17, [*s.l.*], no. 1, p. 9-26, 2015. http://dx.doi.org/10.5380/abclima.v17i0.40124.

FRITZSONS, Elenice; MANTOVANI, Luiz Eduardo; AGUIAR, Ananda Virgínia de. Relationship between altitude and temperature: a contribution to climate zoning in the state of Paraná. **Journal of Environmental Studies**. v. 10, no. 1, p. 49-64, 2008. http://dx.doi.org/10.7867/1983-1501.2008v10n1p49-64.

GAVRILOV, Milivoj B. *et al*. Analysis of annual and seasonal temperature trends using the Mann-Kendall test in Vojvodina, Serbia. **Quarterly Journal Of The Hungarian Meteorological Service**. v. 120, no. 2, p. 183-198, 2016.

IBGE. **Cities and States**. 2019.

JARDIM, Carlos Henrique. Relationships between temperature, relative humidity and atmospheric pressure in an urban area: hourly comparison between two neighborhoods in the city of São Paulo - SP. **geographies**. v. 1, no. 7, p. 128-142, 2011. https://doi.org/10.35699/2237-549X%20..13313.

JESUS, Fernando Soares de. **Hypsometric map of the State of Santa Catarina**. 2017.

JÚNIOR, Victor Antônio Peluso. The relief of Santa Catarina's territory. **Geosul**. v. 2, no. 2, p. 1-69, 1986.

KENDALL, Maurice G.. **Rank correlation methods**. London: Charles Griffin, 2013.

KRUK, Francieli; FREITAS, Andreza Rocha de. Rhythmic analysis applied to the understanding of extreme hydrological events in the Rio das Antas watershed, Irati – PR. **The Challenges of**

Physical Geography at the Frontier of Knowledge, [*s.l.*], p. 1908-1918, 2017. INSTITUTE OF GEOCIENCES - UNICAMP. http://dx.doi.org/10.20396/sbgfa.v1i2017.2401.

MACHADO, Antonio Jaschke. Predictability of local atmospheric pressure from altimetric fluctuations recorded in Oeste Paulista. **Geographies Magazine**. p. 96–105, 2018. https://doi.org/10.35699/2237-549X%20..13437.

MANN, Henry B. Nonparametric Tests Against Trend. **Econometrica**, [*s.l.*], v. 13, n. 3, p. 245, july. 1945. http://dx.doi.org/10.2307/1907187.

MENDONÇA, Francisco de Assis; DANNI-OLIVEIRA, Inês Moresco. **Climatology**: basic notions and climates in Brazil. 1. ed. São Paulo: Texts Workshop, 2017.

MINISTRY OF DEFENSE AERONAUTICS COMMAND. Decea Ordinance N° 423/ **Dgcea**: Manual of altitude meteorological stations. São Paulo: Signus Editora, 2015. 31 p.

MINUZZI, Rosandro B.. Tendências na variabilidade climática de Santa Catarina, Brasil. **Revista Brasileira de Engenharia Agrícola e Ambiental**, [*s.l.*], v. 14, n. 12, p. 1288-1293, dec. 2010. http://dx.doi.org/10.1590/s1415-43662010001200006.

NIMER, Edmon. **Climatology of Brazil.** 2nd ed. Rio de Janeiro: IBGE, 1989.

NÓBREGA, Ranyére Silva; SANTIAGO, Gabriela Ayane Chagas Felipe. Sea surface temperature trend in the Atlantic and Pacific Oceans and rainfall variability in Pernambuco. **Mercator**, [*s.l.*], v. 13, n. 1, p. 107-118, 30 apr. 2014. http://dx.doi.org/10.4215/rm2014.1301.0008.

OLIVEIRA, F.P.; AMORIM, H.s.; DERECZYNSKI, C.P. Investigating the atmosphere with radiosonde data. **Brazilian Journal of Physics Teaching**, [*s.l.*], v. 40, n. 3, p. 1-2, 19 feb. 2018. http://dx.doi.org/10.1590/1806-9126-rbef-2017-0352.

OMETTO, José Carlos. **Plant bioclimatology**. São Paulo: Agronomic Ceres. 1981.

PEREIRA Nadiara; AMBRIZZE, Tércio. **Extratropical cyclones and extreme rainfall events over the Rio de la Plata basin**. Dissertation (Master in Meteorology), Department of Atmospheric Sciences, University of São Paulo, 2011.

RODRIGUES, Maria Laura Guimarães; FRANCO, Davide; SUGAHARA, Shigetoshi. Climatology of cold fronts on the coast of Santa Catarina. **Brazilian Journal of Geophysics**, v. 22, no. 2, p. 135-1514, 2004.

SÁ, Eder Alexandre Schatz *et al*. Trends in daily precipitation in highlands region of Santa Catarina, southern Brazil. **Environment and Water - An Interdisciplinary Journal Of Applied Science**, [*s.l.*], v. 13, n. 1, p. 1, 16 feb. 2018. http://dx.doi.org/10.4136/ambi-agua.2149.

SANTOS, João Felipe; PORTELA, Maria Manuela. Trends in Monthly Rainfall Series in Mainland Portugal: Application of the Mannkendall Test. 8th Symposium on Hydraulics and Water Resources in Portuguese Speaking Countries, 2007.

SANTOS, Vladimir Aparecido; SILVA, Charlei Aparecido; SCHNEIDER, Heverton. The characteristics of the climate of dourados (ms) and its connections with the regional atmospheric systems. **Brazilian Journal of Climatology**, [*s.l.*], v. 9, n. 1, p. 1-2, 31 dec. 2011. http://dx.doi.org/10.5380/abclima.v9i0.27711.

SATYAMURTY, Prakki; MATTOS, Luiz Fernando. Climatological lower tropospheric frontogenesis in the midlatitudes due to horizontal deformation and divergence. **Monthly Weather Review**, vol. 117, no. 6, p. 1355-1364, 1989. https://doi.org/10.1175/15200493(1989)117<1355:CLTFIT>2.0.CO;2

SILVA, Fernando Moreira da; CHAVES, Marcelo dos Santos; LIMA, Zuleide Maria C.. **Physical Geography II**. Christmas: EDUFRN, 2009.

SOUZA NETO, Pedro Fernandes de; SILVA, Djane Fonseca da; ALMEIDA, Henrique Ravi Rocha de Carvalho. Analysis of the Climate Variability of the Atlantic and Pacific Oceans. **Brazilian Journal of Physical Geography**, [*s.l.*], v. 14, no. 4, p. 1861-1879, 2021. http://dx.doi.org/10.26848/rbgf.v14.4.p1861-1879.

SOUSA, Roberto Pequeno de *et al*. Probabilities for atmospheric pressure in the municipality of Mossoró-RN. **Green Journal of Agroecology and Sustainable Development**, [*s.l.*], v. 10, no. 5, p. 132, 31 dec. 2015. http://dx.doi.org/10.18378/rvads.v10i5.3426.

TEODORO, Valiana A.; ARAÚJO, Mirian F. C.; ARAUJO, Lúcio B. Study of the atmospheric pressure of Uberlândia through time series. **National Congress of Applied and Computational Mathematics**. v. 2, no. 1, p. 810-811, 2012.

VIEIRA, Cristiano Alexandre; DUARTE, Neimar de Freitas; CUPOLILLO, Fúlvio. Estudo da atuação do anticiclone subtropical do Atlântico Sul sobre a umidade relativa do ar no entorno do Parque Estadual do Rio Doce por meio de revisão sistêmica da literatura. **Forscience**, [*s.l.*], v. 9, n. 2, p. 1-18, 27 july. 2021. http://dx.doi.org/10.29069/forscience.2021v9n2.e771.

ZUFFO, Antônio Carlos. The Sun, the engine of climate variability. **Dae Magazine**, [*s.l.*], v. 63, n. 198, p. 6-24, 2015. http://dx.doi.org/10.4322/dae.2014.142.