ANALYSIS OF THE PERFORMANCE OF THE WRF MODEL IN HIGH LATITUDE REGION OF THE SOUTHERN HEMISPHERE

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1. INTRODUCTION

This study analyzes the performance of the microphysics and boundary layer parameterizations of the WRF model in three cities in the south of Brazil, with different geographical conditions: one with high altitude (Lages), one in the coastal region (Chapecó), and one in the middle of the continental region (Florianópolis). The use of mesoscale meteorological models such as WRF is essential to enable exposure-response studies between atmospheric conditions and air quality-related diseases. The absence of local meteorological data makes it impossible to carry out assessments on the relations between air pollution, climate, meteorology, and hospital admissions. So, it was necessary to establish which parameterization has the best results considering the local conditions.

Meteorological modeling then serves as a relevant tool to support the search for understanding meteorological relationships and factors that affect health, being used in past studies such as (Sahu et al. 2020; de Almeida Albuquerque et al. 2018)

However, it is common for these studies to adopt a parameterization without reporting the process of choosing these parameters or even if another parameterization would present better results (Huang and Gao 2018; Ramos et al. 2013). Even in sensitivity analysis studies, the model is usually concentrated in the northern hemisphere. Thus, the search for a parameterization that presents a better correlation with the measured results would be able to reduce the errors produced in health analyzes, especially in the southern region of the globe.

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2. METHODOLOGY

In this work, we chose to focus on the state of Santa Catarina, located in the center of the southern region of Brazil. This region has average cardiorespiratory morbidity above the rest of the country as shown in Figure 1.

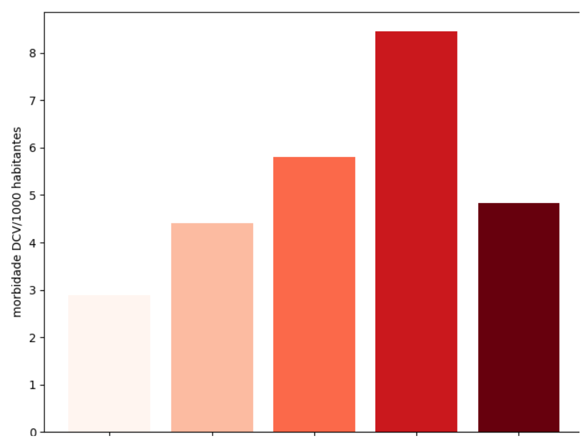

Figure 1 - Number of hospitalizations per 1000 inhabitants in each of the 5 Brazilian regions.

The state presents an important meteorological variation between its regions and a temperature variance between the relevant regions. Presenting the lowest temperatures in Brazil. Figure 2 shows the average temperature for the state, owing to the temperature difference between e regions, and how it is linked to the terrain altimetry.

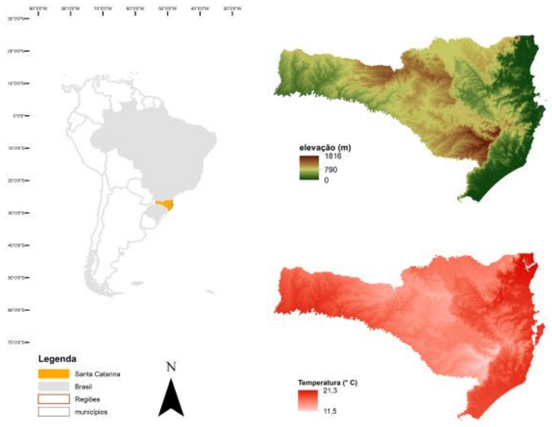

Figure 2 - location map of Santa Catarina with elevation map and average temperatures.

For the sensitivity analysis and comparison of the results, parameterizations referring to cloud microphysics (WSM6, Thompson, Morrison), planetary/superficial boundary layer (YSU / MM5, AMC2 / Pleim-XU), ground cover models (NOAH) were used) short/longwave radiation (RRTM / RRTM) and Atmospheric Turbulence (Tiedtke, kain-Fritch). Summarized in Table 1.

These vestments were tested in rounds containing 1 year (2018), for the cities of Chapecó, Lages, and Florianópolis, these being in the west, highlands, and east of the state, respectively. The tests were performed using data from the final analysis, GFSanl, provided by NOAA, for the year 2018, with a spatial resolution of 0.5 degrees. Subsequently, the modeled data were compared with data from INMET, the Center for Weather Forecast and Climate Studies CPTEC, and data collected at airports, to choose a specific configuration to be applied to the rest of the work. to find the WRF configuration.

Table 1 - Parameterizations used in the WRF namelist in the 6 tests performed.

Simulation number	microphysics option	boundary-layer option
1	6 - WSM 6-class graupel scheme	7 - ACM2 (Pleim) scheme
2	8 - Thompson graupel scheme	1 - YSU scheme
3	6 - WSM 6-class graupel scheme	1 - YSU scheme
4	8 - Thompson graupel scheme	7 - ACM2 (Pleim) scheme
5	10 - Morrison 2-moment scheme	7 - ACM2 (Pleim) scheme
6	10 - Morrison 2-moment scheme	1 - YSU scheme

The tests were done with two nested domains, with a reduced rate of 1/3. the largest domain, which involved the entire state, had a spatial resolution of 45 km x 45 km, thus generating resolutions of 15 km x 15 km in the smaller domains represented in Figure 3.

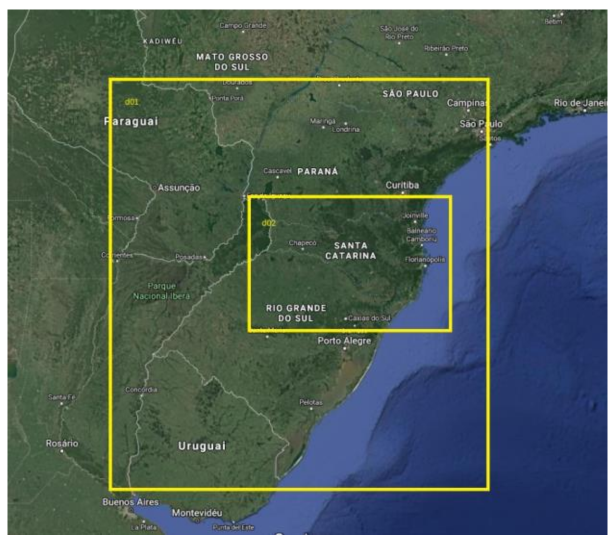

Figure 3 - Modeling domains of the WRF.

The results were analyzed in terms of errors and correlation. for this, the spermann correlation metrics, Bias, RMSE, and D-Pielke were used. In addition to the application of the factor of Two in the scatterplot analysis.

3. RESULTS

The results found are ranked using a simple system. A point was assigned to the parameterization that obtained the best result within a given metric. For example, when analyzing the temperature results, we notice that a given parameterization presented the smallest BIAS, in this case, that parameterization gains a point.

After all, points were awarded, these were added up and we reached a result. Also, the percentage difference between the best result and the others was measured. In the end, this percentage difference was also added up, reaching an accumulated percentage of deviation, shown in Table 2. This was also analyzed, to test the consistency of the results and served as a second decision factor on the results found.

Table 2 - Score and the accumulated percentage difference between configurations for each of the cities.

city	Simulation	score	Accumulated percentage difference
Florianópolis	1	3	30%
	2	5	33%
	3	3	19%
	4	1	47%
	5	1	39%
	6	7	17%
Lages	1	4	20%
	2	2	46%
	3	4	23%
	4	4	34%
	5	2	16%
	6	4	20%
Chapecó	1	9	6%
	2	2	13%
	3	0	10%
	4	1	19%
	5	4	7%
	6	4	7%

Thus, it is possible to note that the best WRF result for each of the cities evaluated was different. However, the accumulated percentage variation between the parameterizations used varies between 1% and 4% comparing the best option and the second-best option, so it can be conveniently chosen to work with the second-best configuration

3.1 Analysis

Analyzing the scatterplots and boxplots, we were able to assess the sensitivity of the modeling about the measured data, for this, we present here the graphs generated for the parameters analyzed in the city of Florianópolis for the best result found.

3.1.1 Temperature

For temperature, the results show correlations between 0.46 and 0.65, with bias below one degree Celsius. Pielke-D presented results below two for the cities of Chapecó and Florianópolis, and close to two for the city of Lages.

Looking at the boxplot chart, Figure 4, we can see that the WRF tends to underestimate average temperatures in the coldest months (April to September) and overestimate them in the hot months (October to March). The result was similar for all the cities analyzed.

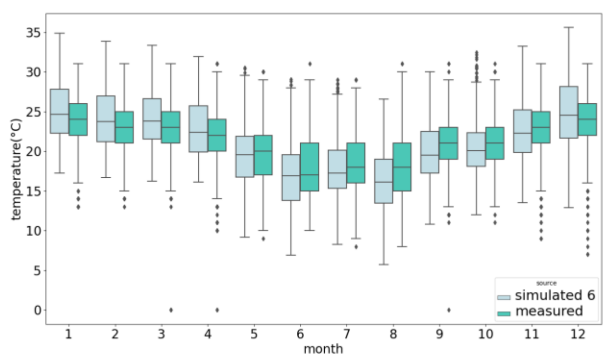

Figure 4- simulated and measured temperature boxplot in Florianópolis for 2018.

The scatterplot, Figure 5, analysis shows a combined increase in simulated and measured temperatures, highlighting that more than 95% of the data are within the factor two range. These results were repeated for the other cities analyzed.

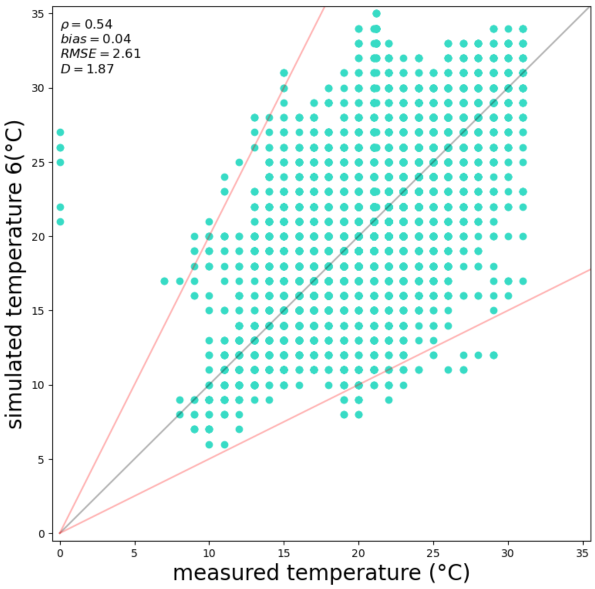

Figure 6 - simulated and measured temperature scatterplot in Florianópolis for 2018, with the factor of two lines.

3.1.2 Relative humidity

As for relative humidity, the results of the correlations are 0.59 for Chapecó. For the cities of Lages and Florianópolis, these values were between 0.07 and 0.12. The bias was low for the cities of Chapecó and Lages, only in the city of Florianópolis, it appears in 4%. The Pielke-D shown is less than 2 for the cities of Chapecó and Lages and close to 2 for Florianópolis, although greater than 2. The boxplot graphs, Figure 6, show the difference between cities. In Chapecó, WRF underestimated data in the hot months and overestimated in the cold months. For Lages, the WRF is overestimated every month, while in Florianópolis it is underestimated every month. However, the analysis with a factor of 2 in the scatterplot Figure 7 shows the adequacy of most data.

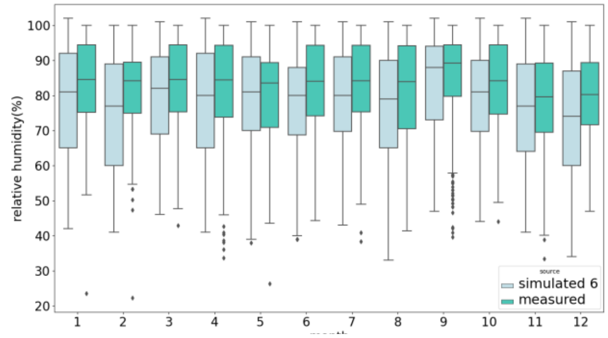

Figure 5 - simulated and measured relative humidity boxplot in Florianópolis for 2018.

The analysis with a factor of 2 in the scatter plots shows the adequacy of most data, Figure 7. However, it is notable that the measured values are limited to present ranges of values. This being a data source problem.

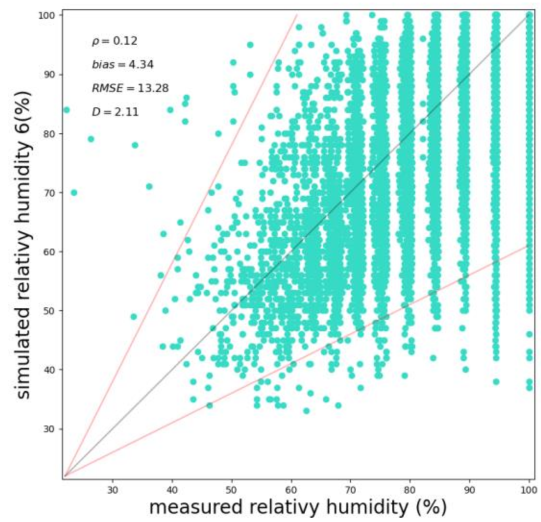

Figure 7 - simulated and measured relative humidity scatterplot in Florianópolis for 2018, with the factor of two lines.

3.1.3 Wind speed

The analysis of wind speed shows the worst results in this study, with correlations between 0.13 and 0.38, and a bias that reached 15% of the maximum value. The D was all about 2, between 2.4 and 2.7. The best results were for Florianópolis, where the BIAS was 0.6 m / s.

Boxplot analysis shows that the values are often underestimated, Figure 8, unlike other study done on the wind in the state. (Oliveira. 2017) The low resolution used may have affected this analysis more seriously.

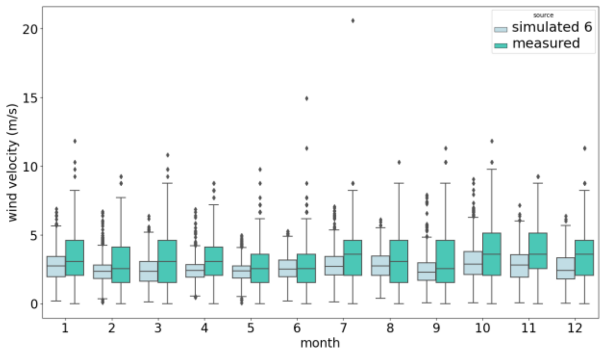

Figure 8 - simulated and measured wind speed boxplot in Florianópolis for 2018.

The scatterplot, Figure 9, highlights the poor results mainly for Chapecó and Lages, where factor 2 shows the inadequacy of most data. For Florianópolis the results of the factor of two display that the results present poor adequacy.

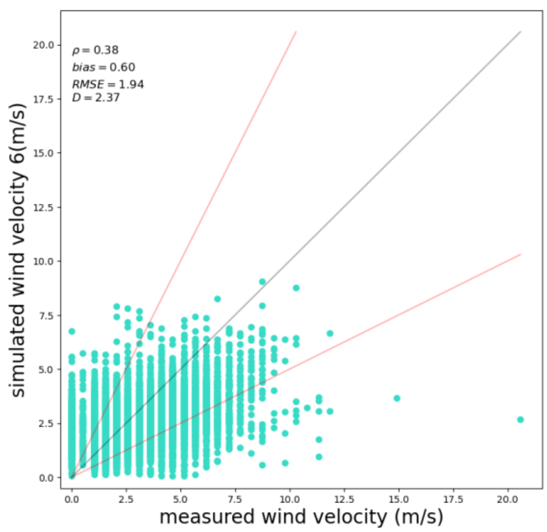

Figure 9 - simulated and measured wind speed scatterplot in Florianópolis for 2018, with a factor of two lines.

3.1.4 atmospheric pressure

The results for atmospheric pressure are interesting. Two cities had high BIAS, Chapecó, and Florianópolis, but the results of the correlation show a good adjustment for them, standing at 0.73, while the city of Lages showed a correlation of 0.63. We believe that this BIAS is due to the difference in altitude between the measurement point and the grid point used for comparison. The OD presented above two for the cities of Florianópolis and Chapecó, and below 2 for Lages. The analysis of the boxplot, Figure 10, shows a close variation in the three cities, even with the impaired analysis by BIAS.

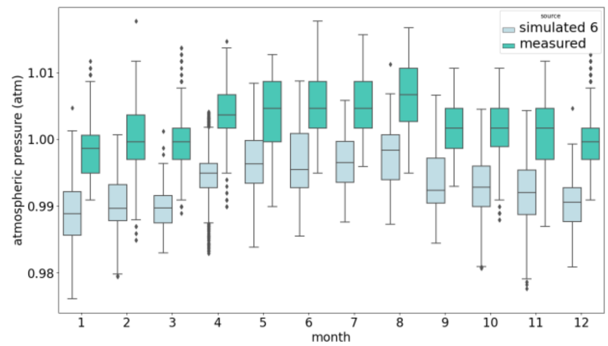

Figure 10 - simulated and measured atmospheric pressure boxplot in Florianópolis for 2018.

The analysis of factor 2 ends up being impaired, however, it is possible to observe the adequacy of the data in the scatterplot, Figure 11.

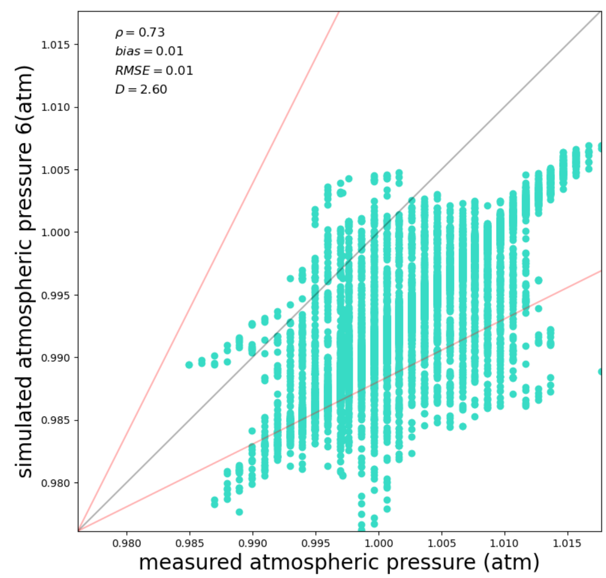

Figure 11 - simulated and measured atmospheric pressure boxplot scatterplot in Florianópolis for 2018, with the factor of two lines.

4. CONCLUSION

The WRF can be used as a tool to support research that relates to meteorological factors and health. To ensure better results, it is necessary to know the best configuration for the study site, seeking better results in the modeling. In this study, I learned 3 cities to analyze the sensitivity of

6 combinations of different configurations and we showed that there are relevant percentage variations between the results achieved with each of them.

Thus, for the study situation, it was decided to carry out two different simulations, with different configurations that best suit each region.

We emphasize that the idea would be to use specific configurations for each type of data, but due to the necessary computational work and the long time required for modeling, this is not a viable reality. Another idea would be to make several rounds with different configurations and use the average of the results, thus guaranteeing a better adjustment, analysis of known assets. However, this would greatly increase the computational work. We emphasize that the results presented here were made with a resolution of 15x15 km, but the final data will be made with a higher resolution of 3x3, so we hope to obtain better results, mainly for the wind speed.

5. REFERENCES

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