COMPARATIVE ANALYSIS OF OBSERVED METEOROLOGICAL DATA IN THE CONVENTIONAL AND SURFACE AUTOMATIC STATION AT BRAZILIAN NATIONAL INSTITUTE OF METEOROLOGY

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ABSTRACT

This work makes a comparative analysis based on data of air temperature, relative humidity, and rainfall collected from an Automatic Weather Station Surface and a Conventional Weather Station Surface, in three distinct hours 00:00, 12:00 and 18:00 UTC. These stations are located in cities where the first automatic weather stations of the Brazilian National Institute of Meteorology (INMET) were installed. The results show a common problem in the automatic stations characterized by a possible change in the average level of the bias after a failure in the station.

INTRODUCION

Since the year 2000 the Brazilian National Institute of Meteorology (INMET) has been adding to its network weather stations the technology automatic stations. At the beginning five stations were purchased and installed in different localities where there were conventional weather stations. Currently, the INMET has a network of about 450 automatic stations and 293 conventional stations. With the start of operation of automatic weather stations, the INMET has adopted a new operational model for its network of meteorological stations. This new proposal seeks unified control and integrated procedures for preventive and corrective maintenance, given the new context in which the National Meteorology is going.

Reduction in the time of data collection, much information in a shorter time and real-time monitoring, among others, are some of the advantages of the automation of meteorological data. Moreover, the quality of meteorological data from automatic stations depends on the good condition of its sensors, which requires a new management strategy in preventive and corrective maintenance, replacement of sensors and equipment, and this requires budgetary allocations at significant levels.

In the last decade several researchers have conducted studies comparing the meteorological data obtained by Automatic Weather Stations (AWS) and Conventional Weather Stations (CWS), among these, we highlight the work of Sentelhas et al (1997), Fisch and Santos (1997), Souza et al (2003), Teixeira et al (2003).

Sousa et al. (2003) make a comparative study between conventional and automatic weather stations in Maringá/PR, they compared the average, maximum and minimum temperatures, atmospheric pressure and relative humidity data daily. The authors obtained correlation coefficients 0.90 and 0.96 for the average temperature and atmospheric pressure, respectively. The mean value of average temperature was 0.04 º C in the average difference in pressure at 2.81 atm. Teixeira et al. (2003) compared the crop coefficient of guava (Kc) derived from data from an automatic weather station and a conventional weather station, and found variations between phases of vegetative growth and the end of harvest. According to the authors this difference is due to higher values of potential evapotranspiration (ET_0) obtained at the automatic station.

This paper shows a comparative analysis between the meteorological data observed in an AWS and CWS installed on the same site, to evaluate the measures regarding its accuracy and possible systematic errors.

EXPERIMENTAL DATA AND METHODS

We selected the data observed at stations conventional and automatic of Brasilia/DF, Porto Alegre/RS and Salvador/BA, which are part of the network of the Brazilian National Institute of Meteorology, from June 2000 to June 2010. The characteristics of the stations are shows in Table1. Important to note that there was an interruption of the data in some periods mainly in the automatic stations, as shown in the Bias Graphs of the three times studied.

Table 1: Characteristics of the stations observed.

City	Conventional Station	Automatic Station	Latitude	Longitude	Founding Date*
Salvador	83229	A401	13,01S	38,31W	10/2000
Porto Alegre	83967	A801	30,03S	51,10W	09/2000
Brasília	83377	A001	15,47S	47,56W	05/2000

* Founding date of the station automatic

The meteorological parameters measured were: air temperature, relative humidity and daily rainfall. The comparison was made with the values read at the time of data collection at 00:00, 12:00 and 18:00 UTC, and was the difference between readings from two stations, also known as gross bias:

$$\boldsymbol{Bias = m_{CWS} - m_{AWS}}$$

where: m_{CWS} and m_{AWS} are the measured values at station conventional and automatic respectively.

The weather stations dates were compared through Bias Graphs of the time series between the two stations, then calculated the variance, coefficient of variation, standard deviation, square of correlation coefficient of Pearson (R^2) and the coefficient of concordance Willmott Index (d), (Willmott et al., 1985).

Willmott's index indicates the degree of association between two features from a series of observations, is a dimensionless value ranging from 0 for no correlation and 1 for a good agreement. The coefficient of variation (cv) expresses the variability of the data by eliminating the influence of the magnitude of the variable. This represents an alternative to standard deviation, calculated on the average, if comparing the dispersion of distributions with distinct averages. The Pearson correlation coefficient measures the degree of correlation (and the direction of this correlation, for example, whether positive or negative) between two variables scale metric. Note that some dates meteorological from conventional stations are observed at different synoptic times as show table 2.

Table 2. Meteorological parameters and synoptic hourly.

Meteorological Parameters	00:00 UTC	12:00 UTC	18:00 UTC
Air Temperature (°C)	X	X	X
Relative Humidity (%)	X	X	X
Daily Rainfall (mm)		X	

RESULTS AND DISCUSSION

The time series of two stations in one location should, ideally, coincide. The study of the difference between these values identified errors that oscillate around a mean that change throughout the year. In general, the mean bias ranged from near zero, with a standard deviation below and the correlation coefficient was high (Tables 3, 4 and 5). The R^2 found in this study is very close to those found by Sousa et al. (2003). Teixeira et al. (2003) also obtained good agreement between the statistical indices in the comparison of temperature data. These achievements were in fact already expected, due to the small amplitude of variation, throughout the Day of the observed parameters.

The analysis simple of time series of a given parameter is already showing a lot of information, such as seasonal fluctuations and gaps in records for certain periods. Initially, were eliminated outliers found, because the graphs identified abrupt changes in the average level of oscillation of the bias, often caused by interruptions in the data series and failures in sensors of automatic stations. This problem was not detected by statistical indexes used in this work, however, perceived in the visual analysis of time series of the bias graphs of the parameters analyzed (Figures 1, 2 and 3). Another point that can not be discarded in the analysis is the possibility of errors in readings of observers at the conventional station, so each case must be recorded separately so you can take a position in the analysis.

Melo, et al (2006), concludes that the analysis of bias is important because there are cases where changes in average heights are so small that it becomes very difficult to identify them by direct observation of time series of meteorological records. Analysis less accurate could interpret these changes as resulting from climate changes that, in fact, not occurred.

Among the parameters analyzed, the rainfall measurements had greater discrepancies in the bias graphs and the statistical indices applied. Some writers as Tanner (1990) and Torre Neto (1995) already reported, emphasizing that these errors are usually associated with the intensity of rainfall. Another point which should also be noted is the type of gauges used and its characteristics as an area of capitation edge, and ease of clogging. In general, the sensors and measuring instruments used in automatic and conventional stations in Brazilian Network is quite efficient, however, must be prioritized strategy of preventive and corrective maintenance that takes into account the periodicity of inspection techniques and life of the sensors between other factors, in order to have quality assurance and reliability in the data series recorded.

The analysis of data such as maximum and minimum temperature, dew point temperature and evaporation are directly related to quality of temperature and humidity sensors evaluated here already, so were not compared in this work. Unfortunately, this paper was not performed in comparison with data from atmospheric pressure.

In summary, all data recorded from conventional and automatic weather station, require a quality control, mechanism with another source of validation, as validation between the existing stations, weather radar, satellite image and others.

CONCLUSIONS

The comparative study of observed meteorological data from automatic and conventional stations showed satisfactory results in statistical indices applied. However, changes in average level of bias occur frequently and are associated with systematic errors that can vary from interruptions in the data series and crash sensors on the automatic station until reading errors of the observers on conventional stations. Indices as average, correlation, coefficient of variation and percent error are not able to detect such errors, only noticeable by observing the bias graphs of the parameters. A detailed analysis of the data series from the two stations must be made for further applications in different uses.

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ATTACHMENTS:

Table 3. Statistical values of the variables in the comparison stations Brasilia/DF

Parameters	Time UTC	standard deviation	Variance	CV	R^2	Willmottô Index
Air Temperature (°C)	00:00	2,02	4,08	3,99	0,96	0,98
	12:00	2,45	6,03	5,95	0,98	0,99
	18:00	2,71	7,37	7,22	0,96	0,98
Relative Humidity (%)	00:00	18,39	338,03	333,54	0,97	0,98
	12:00	15,48	239,71	235,78	0,97	0,98
	18:00	18,47	341,26	336,54	0,97	0,99
Daily Rainfall (mm)	1200	9,86	97,32	96,56	0,98	0,99

Table 4. Statistical values of the variables in the comparison stations Porto Alegre/RS

Parameters	Time UTC	standard deviation	Variance	CV	R^2	Willmottô Index
Air Temperature (°C)	00:00	4,59	21,06	20,89	0,99	0,99
	12:00	5,43	29,51	29,07	0,98	0,99
	18:00	5,79	33,53	33,25	0,99	0,99
Relative Humidity (%)	00:00	10,04	100,80	91,51	0,89	0,90
	12:00	12,99	168,67	148,10	0,90	0,80
	18:00	16,24	263,92	250,08	0,93	0,96
Daily Rainfall (mm)	1200	9,84	96,81	95,25	0,98	0,98

Table 5. Statistical values of the variables in the comparison stations Salvador/BA

Parameters	Time UTC	standard deviation	Variance	CV	R^2	Willmottô Index
Air Temperature (°C)	00:00	1,56	2,93	1,75	0,60	0,72
	12:00	2,15	4,64	3,83	0,72	0,85
	18:00	2,22	4,92	4,11	0,71	0,87
Relative Humidity (%)	00:00	7,45	55,46	27,25	0,48	0,67
	12:00	10,08	101,52	71,24	0,69	0,72
	18:00	9,36	87,69	62,63	0,67	0,63
Daily Rainfall (mm)	1200	10,91	118,96	111,71	0,89	0,94

Figure 1: Time series data of Bias from stations in Brasília/DF

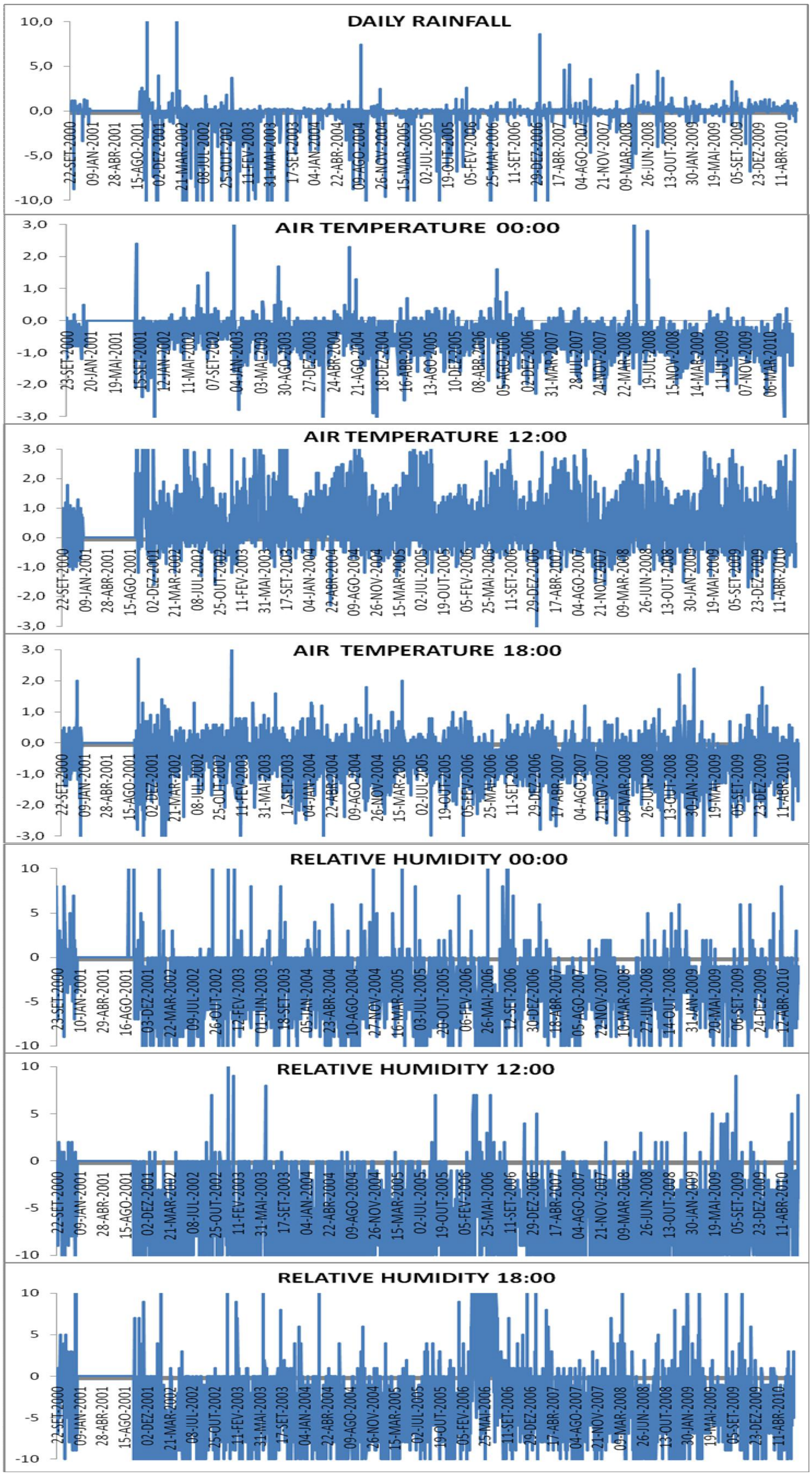

Figure 2: Time series data of Bias from stations in Porto Alegre/RS

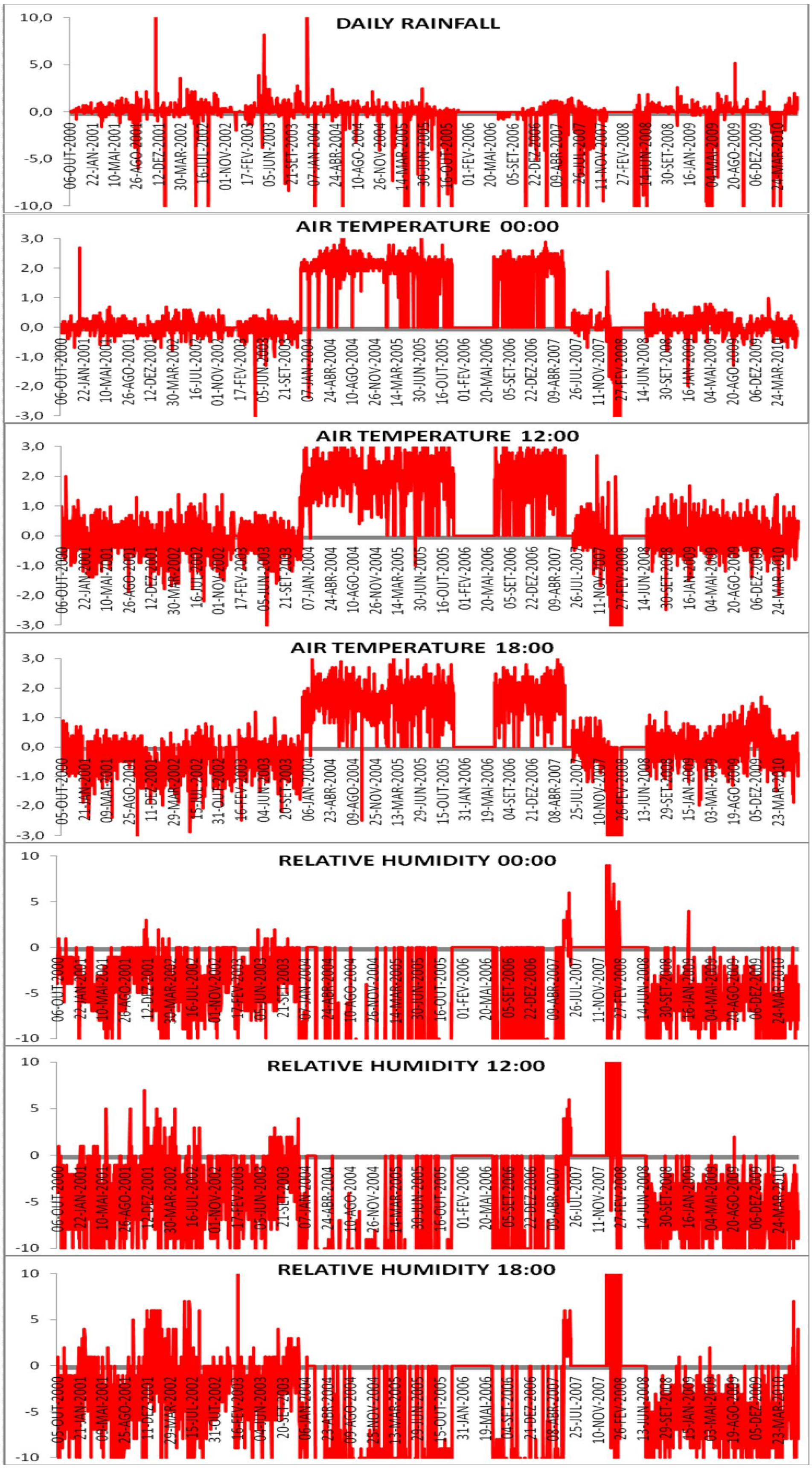

Figure 3: Time series data of Bias from stations in Salvador/BA