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EVALUATION OF TEMPERATURE RECORDS OBTAINED BY AWS IN HAINAN PROVINCE AND ADJUSTMENT OF CLIMATOLOGICAL TIME SERIES

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Abstract: Based on the parallel air temperature data of automatic sounding and manual observations at 16 weather stations in Hainan province from 2004 to 2005, a comparative analysis and evaluation is made for validity according to relevant standards. The results indicate that there are daily and seasonal differences between temperature observations recorded by automatic weather stations (AWSs) and with conventional methods. The reasons for the differences are the systematic error, the sensitivity of the two types of instruments to the environmental temperature change, the difference of the observation time and the effect of solar radiation. Because the long-range data were obtained from manual observation, an empirical conversion formula between the temperature records obtained by the instruments is provided for continuous use of the climate data after the changes in instruments.

Key words: automatic weather station; temperature; evaluation; adjustment

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1 INTRODUCTION

To improve the abilities to monitor the atmosphere, the initial phase of the engineering construction of an automatic system for monitoring the atmosphere was started in 2001 in China. Differences of observations, which may be resulted in the due to varied principles and sampling time adopted by the AWSs and manual observational systems, will affect the homogeneity of temperature series in the country and eventually compromise the results of weather forecast and climate change study. It is an issue facing the application of AWSs data how to control the size of the difference within allowable constraints by meteorological routine operation to ensure the continuity of historical observations. For this purpose, many domestic and overseas researchers have been working to compare and study the two types of data [1 - 10]. As shown in the studies, the introduction of automatic observing instruments for air temperature observation will increase the monthly and annually averaged values by 0.2 – 0.3 °C and solar radiation has been the main cause for bringing about the difference between the instruments [11]. With varied geographical surroundings of the AWSs selected for research, different conclusions can also be resulted. One such example is seen in the comparison between the results of an analysis of the difference in maximum temperature between AWSs and manual observations using the measurement by the site of Gangcha, Qinghai province [11], and those obtained with the data from the site of Zhengzhou, Henan province [12] and from U.S.A. The fact that the mean value is assumed to be non-zero for the systematic error of the measurements is immediately affecting the results of climate change study [13]. It is then still necessary to have further study of the AWSs datasets for the specific environment of a particular region.

By January 1, 2004, AWSs construction had been completed at 16 of the weather stations in Hainan province and observation was carried out in parallel for operational comparison in 2004 and 2005. In this study, comparison and analysis are applied to the two years of observations taken at the AWSs and manual networks

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and the temperature datasets by the former are verified preliminarily based on the technical standards of National Climate Center for the assessment of AWSs data. Differences between the two types of observational means and the main reasons behind them are investigated. An empirical conversion formula is set up for the AWSs and manual measurements at Haikou and some ideas and methods are provided to ensure the continuity of climatological data and to enable the use of AWSs temperature datasets in weather forecast after correction.

2 DATA AND METHODS USED IN THE ANALYSIS

2.1 *Sources of data*

Made up of data at four different time (at 02:00, 08:00, 14:00 and 20:00, L.T., same below) for all 16 sites of the province and hourly data for two sites at Haikou and Dongfang and verified for correctness, the AWSs temperature data are covering a period of time from January 1, 2004 to December 31, 2005.

For the manual part of the observations, however, they are the temperature from dry bulbs at 02:00, 08:00, 14:00 and 20:00 for all the 16 sites and hourly measurements for Haikou and Dongfang. The two series cover the same duration as the AWSs and are also verified for correctness.

2.2 *Methods of analysis*

Following the technical requirements of National Climate Center, the AWSs datasets are assessed in terms of the indexes listed below. They are the rate of absent observation by AWSs, difference (between the AWSs and manual observation) and their monthly and annual mean, monthly standard deviation of the difference, rate of rough deviation (for indication of data anomalies) and the rate of consistency (for indication of the consistency between AWSs and manual observations on a monthly basis).

3 ASSESSMENT OF AWS TEMPERATURE DATA

The rate of absent observation is not significant for the 16 AWSs and falls within the range allowed. The monthly mean difference is well beyond normal deviation, especially at Haikou, Sanya and Danzhou. Good consistency is shown in the temperature data by AWSs, though the number of data anomalies increases dramatically in 2005 compared to 2004, which deserves more attention. A number of indexes for AWSs temperature data are beyond normal at Haikou and Dongfang.

4 ANALYSIS OF THE DIFFERENCE ON DIFFERENT TIME SCALES

In view of the fact that a number of indexes for AWSs temperature data are beyond normal at Haikou and Dongfang and the same type of AWS is being used at both sites, this study will explore intensively the causes and tendency of such deviation and study the methods of climatological correction.

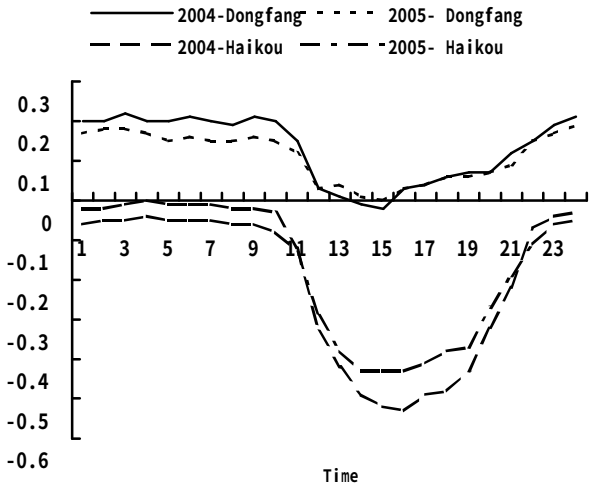

Fig.1 Hourly variation of the difference of annually averaged temperature between the two sites at Haikou and Dongfang in 2004 and 2005.

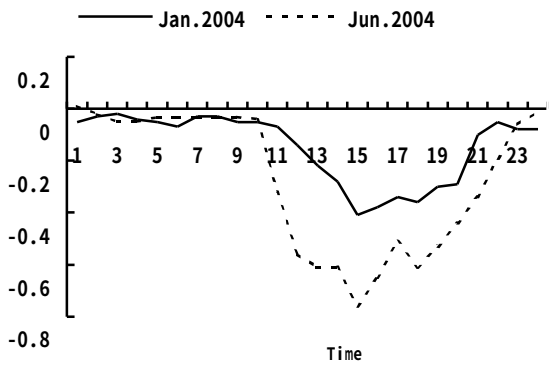

Fig.2 Hourly variation of the difference of representative monthly temperature in winter and summer at Haikou and Dongfang 2004.

It is known from Fig.1 that the annual mean is all negative for all of the hourly difference at the site of Haikou, suggesting a higher annual mean by AWSs than by manual measurement and showing the characteristics of three stages. It is seen from Fig.2 that the monthly averaged tendency of difference change

during the daytime at Haikou is similar to the annually averaged one, with general consistency among the temporal intervals of the three stages.

5 CORRECTION OF AWS TEMPERATURE OBSERVATIONS AT HAIKOU

Following the pattern of the difference between the Haikou AWS temperature measurements and the manual ones, fitting is done to a total of 1462 recorded samples, each of them containing 24 measurements, for the years of 2004 and 2005. The difference shows a three-stage characteristic based on which correction equations are formulated for each of the stages (details omitted). Then, they are applied to correct the observations by the AWSs for the two years to determine the mean difference between the two observation networks. After that, the correction results are verified using the AWS temperature observation for Haikou for the first six months of 2006 and the results are presented in Table 1.

See the Chinese edition of the journal for more details.

Table 1 Comparisons of the monthly mean difference between AWSs and manual observations around the correction of the Haikou AWS temperature measurements unit: °C

month	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual mean
Monthly mean of 2004 diff.	−0.16	−0.10	−0.17	−0.21	−0.19	−0.28	−0.24	−0.26	−0.23	−0.16	−0.18	−0.15	−0.20
Monthly mean of 2004 diff. with correction	0.02	0.08	−0.00	−0.05	−0.02	−0.10	−0.06	−0.09	−0.06	−0.00	0.00	0.02	−0.02
Monthly mean of 2005 diff.	−0.16	−0.19	−0.18	−0.19	−0.2	−0.19	−0.22	−0.21	−0.17	−0.16	−0.17	−0.14	−0.18
Monthly mean of 2005 diff. with correction	0.01	−0.02	−0.01	−0.02	−0.03	−0.04	−0.05	−0.04	−0.01	0.00	0.00	0.03	−0.02
Monthly mean of 2006 diff.	−0.15	−0.20	−0.15	−0.21	−0.20	−0.19			Six-month mean: −0.18				
Monthly mean of 2006 diff. with correction	0.09	0.09	0.10	0.05	0.04	0.04			Six-month mean: 0.07				

6 CONCLUSIONS

(1) For the temperature observations from the 16 AWSs in Hainan province in 2004 – 2005, the rate of absent observation is within the operational standard while the monthly rate of rough deviation and rate of data consistency are generally normal except at the sites of Dongfang and Haikou. It is worth noting that there are increasing temperature anomalies for 2005 and an increasing gap from the manually observed temperature can be anything but overlooked. Due to the fact that the difference between the two types of observational systems is generally beyond the normal range, the AWSs-recorded temperature data cannot be used until after correction or they will pose some degree of influence on the diagnosed and simulated results of climate change.

(2) The diurnal tendency is basically consistent for the temperature difference at Haikou and Dongfang. Subjected to solar radiation, it is much larger in summer than in winter in Hainan province, though the signs are the just opposite in the annually averaged difference. For one of the reasons, it may be the result of micro-climate, which has impacts on the particular observation sites. More study needs to be done to search for particular factors of climate or something else.

(3) The variations of the difference between the two types of observational networks for the years 2004 and 2005 are distinctively addressed by formulating a correcting relationship and running verification for the first six months of 2006. The results have been satisfying. As the difference is showing a consistent and stable trend across the province, the method of stage-dependent correction adopted for the site of Haikou is of some usefulness for other sites as well.

(4) Appropriate attentions should be paid to the difference between manual and AWSs measurements which are seen everywhere. In order to avoid possible effects on such research and routine operation as diagnosis and simulation of climate change, special precautions are needed when the observation is mainly carried out automatically to ensure a continuous and steady record of temperature across the transition from manual to automatic measurement by setting up qualified workflow patterns and correction approaches.

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