

# SOME STEP OF QUALITY CONTROL OF UPPER-AIR NETWORK DATA IN CHINA

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## Abstract

Some step of quality control of upper-air data have been made by China Meteorological Administration (CMA) recent years. The routine monitoring of daily TEMP and analysis of the upper-air network data set by reference to WMO method is conducted and special emphasis is given to the questionable and erroneous TEMP records. Various error resources from flight operation at station or communication department have been identified and informed to related stations or community to overcome. Preliminary analysis results of the monthly mean bias are presented. China is carrying on a program of replacement of the upper-air sounding system. The overlapping radiosonde flights for a period of one month are conducted at each replacement station. The preliminary comparison results of a total of 24 stations are also presented.

## 1 Introduction

It is well known that the WMO's evaluation report of the compatibility of radiosonde geopotential height observations based on comparisons with the First Guess field of the ECMWF model (T. Oakley, 1998; J. Elms, 2002) is very useful for the monitoring of long-term system performance of all upper-air stations in the Global Observing System. We obtain much valuable information of the performance of our network from the reports. However the evaluation reports are published just for quarterly results and the statistics are only generated for the 100hPa geopotential height and the (100-30hPa) geopotential height increment. Further more, they cannot be searched from the website in time, for example the next quarter. Therefore, the CMA has arranged the National Meteorological Center (NMC) and the Chinese Academy of Meteorological Sciences (CAMS) to take on the routine monitoring of Chinese upper-air TEMP reports by reference to the WMO method. The NWS is responsible to provide differences between observed values (OB) and the First Guess (FG) field of the NWS model. The CAMS takes charge for further analysis of the upper-air network data set. The statistics for differences are generated not only for geopotential height and temperature but also for wind speed and wind direction for each standard pressure levels. Some results of the analyses are presented in this paper.

There are a total of 124 upper-air stations operated in China to satisfy the requirements in synoptic scale meteorological analysis. Recent year, the L-band digital radiosonde GTS1 (Li Jiming and Feng Deli, 2000) and modernized secondary wind-finding radar GFE(L) system is being deployed to replace the obsolete mechanical radiosonde GZZ2 (Guo Yatian and Huang Bingxun *et al*, 2002) and

P-band secondary wind-finding radar (type 701) system. By the end of 2004, 36 stations have completed the replacement program. And about 32 stations will also be equipped by the new system before the end of 2005. Prior to the application of the new system at network, some function tests and field tests including the inter-comparison with Vaisala's RS80 system had been conducted at Beijing several years ago. To assess the impact of the replacement to the continuity of upper-air meteorological records, the comparison flights lasted one month between the new and the old upper-air sounding systems at all related station are conducted according to the special arrangement by the CMA. The preliminary comparison results are informed.

## 2 Quality monitoring of the TEMP report

### 2.1 Graphic display of the bias and checking on unwanted report

Generally, we draw bias curves on monthly base to show the differences between each TEMP report and the First Guess field. From the figures, we can find out intuitively the general situation of each station on the bias and deviation from the First Guess field. Especially, any particular unwanted bias curve can allure your attention. In some time, we can immediately estimate the origin of the questionable TEMP report from the graphic display of the bias curves.

The following Fig.2.1 shows the monitoring statistics of the geopotential height (in the left) and the temperature (in the right) on September 2004 for the station.52652 as an example. This station has been equipped with the new sounding system. The broad red curve represents the mean bias of the month. The narrow chromatic curves represent the bias of each day. And the two broad pink curves are the borderlines of the normal bias. The borderline is defined by the averaged standard deviation of whole Chinese stations applied the same type of radiosonde. Usually, the bias curve is within the borderlines. Once a curve is outside of the borderlines, it is affirmative that some mistake had happened. For example, at 00Z September 25, the geopotential height is 90gpm lower than the First Guess field and in parallel with the monthly mean bias but the temperature is not off normal. It can be estimated that the instant pressure value of the flight was keyed-in falsely.

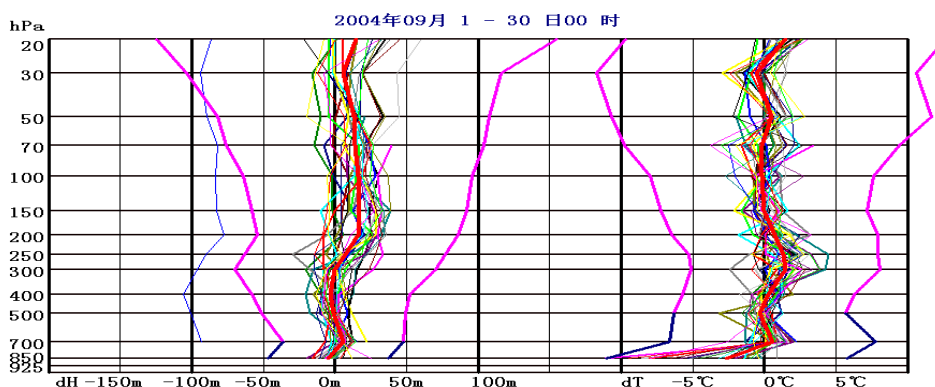


Fig.2.1, Monthly bias display with an unwanted geopotential bias.

Fig.2.2 shows a very unwanted bias of the geopotential height and the temperature at the height lower than 70hPa at 12Z January 12 for the station.52681, which is still operated with the old sounding system. The bias of the geopotential height is very correlative with the bias of the temperature. After

searching the former TEMP reports, we found that the TTA report for 12Z January 12, 2004 is the same for 12Z December 12, 2003. Then it was found out that the mistake had happened in transmission of TEMP report.

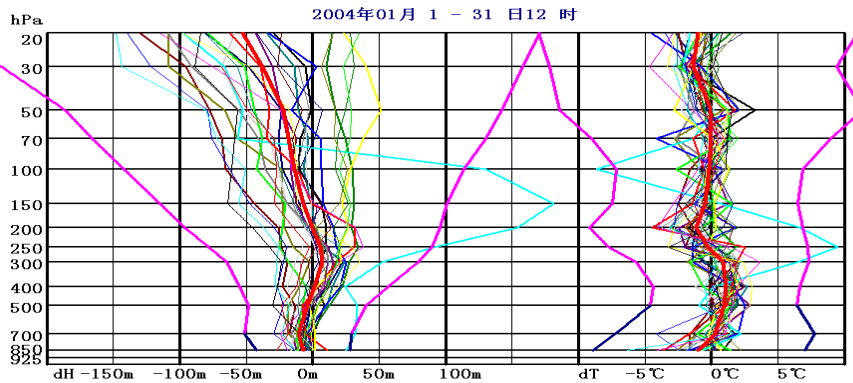


Fig.2.1, Monthly bias display with unwanted geopotential and temperature bias.

We have found various unwanted TEMP reports induced from miss-operation at station or communication department since 2003. In order to attract attention of observers in station and supervisors of all levels, our monthly monitoring reports are issued on the website. The main content of our monthly monitoring report is the bias graphics and analysis on the unwanted TEMP report. A station rank in the light of the quality of TEMP report is also included in the monthly monitoring report. The quality of TEMP report has been digitized according to the quantity of the unwanted TEMP reports.

## 2.2 Monthly and annual mean bias and deviation

Now a total of 36 stations have been equipped with the new upper-air measuring system operating at 1675MHz until December 2004. It is concerned about that if there is a notable systematic difference between the data sets provided by the new and old system. Fig.2.3 and Fig.2.4 show the monthly mean bias of geopotential height and temperature for station 54857 at the east coast of China and 51656 at the west desert area respectively. The darkish curves are denoted to the monthly average of the old system and the azury one to the new system. The bright red and navy blue curves are denoted to the annual average of the old system and new system respectively. In average, there is no notable systematic difference of geopotential height and temperature between the new and old system for station 54857. However, there is some fewer systematic bias of geopotential height and temperature of the new system than the old one for station 51656.

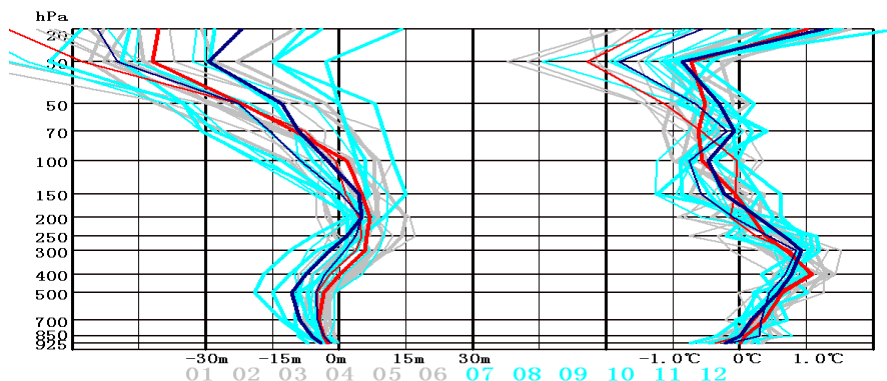


Fig.2.3, Monthly mean bias of geopotential height and temperature for station 54857

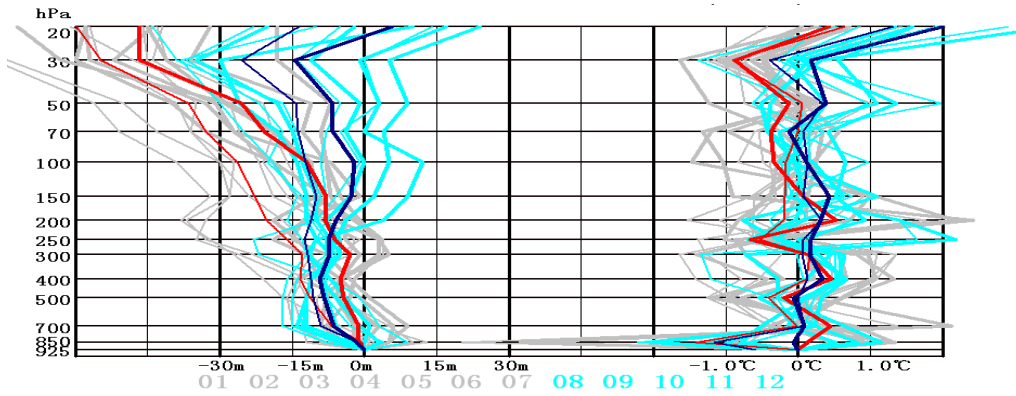


Fig.2.4, Monthly mean bias of geopotential height and temperature for station 51656

From Fig.2.5, it is apparent that the mean standard deviation of geopotential height bias from new system is much smaller than the old one. Above the height of 100hPa, the mean standard deviation of geopotential height bias of new system is only about 50% of the old system. The mean standard deviations of the temperature, wind speed and wind direction bias (see Fig.2.6.) of the new system are also improved in some degree

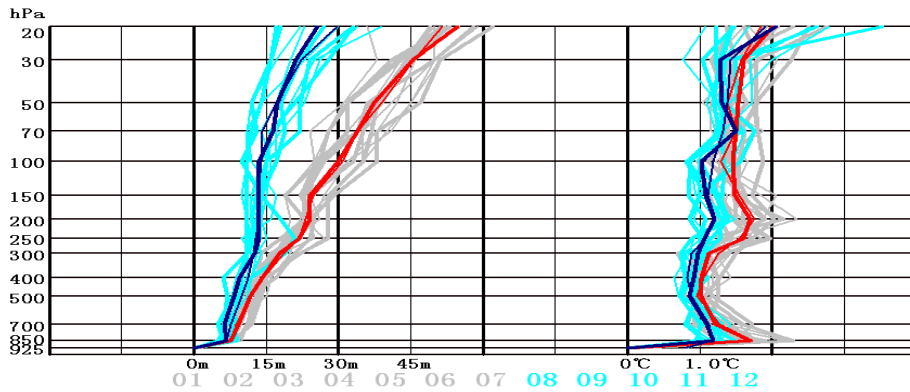


Fig.2.5, Monthly mean standard deviation of geopotential height and temperature bias

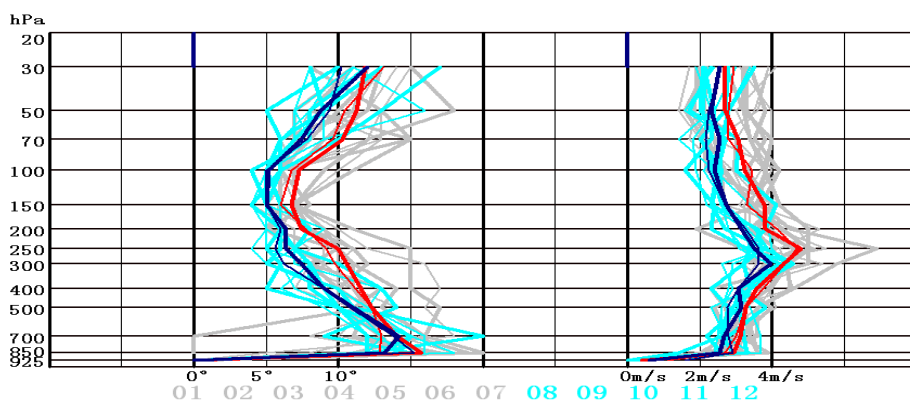


Fig.2.6, Monthly mean standard deviation of wind speed and wind direction bias

Fig.2.7 shows the overall monthly mean biases (narrow chromatic curves) and overall annual mean biases (broad chromatic curves) of the 78 old radiosonde stations in 2003. We can see that the overall monthly mean biases are different in some degree in different month and at different time of the day. In warm season and at the daytime, the temperature is in somewhat higher than that in cold season and at nighttime.

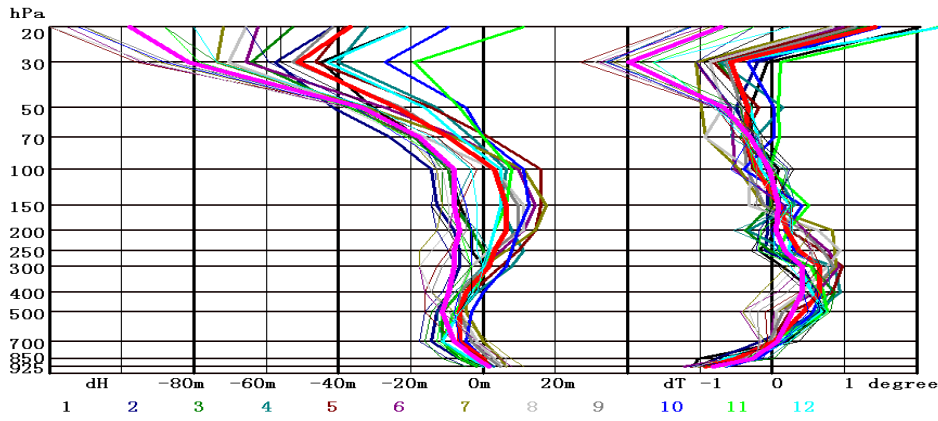


Fig.2.7, Overall monthly mean biases and annual mean biases of the 78 old radiosonde stations in 2003.

Fig.2.8 indicates that the overall annual mean biases of the old sonde stations in 2004 are nearly completely the same with that in 2003, especially at 12Z, because most of the radiosonde flight is in local nighttime after 12Z in China.

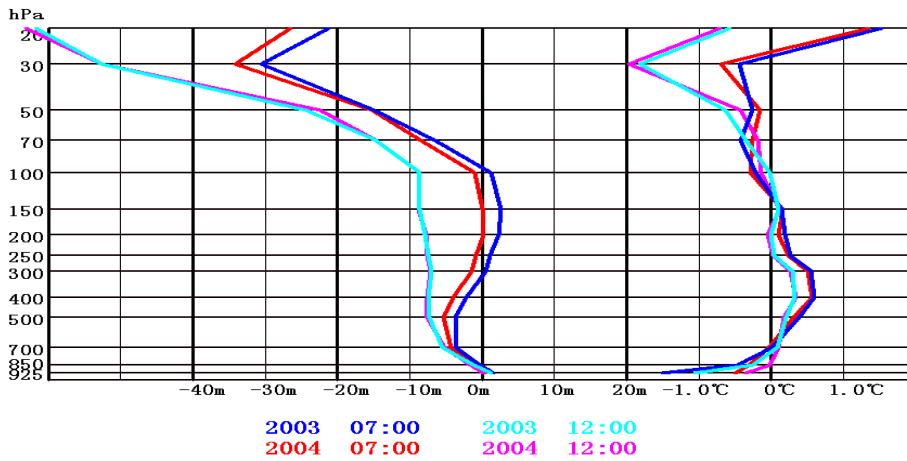


Fig.2.8, Overall annual mean biases of the old radiosonde station in 2004 and in 2003

Fig.2.9 shows the overall monthly mean biases of the 24 new sonde stations in 2004. The results are also different in some degree in different month and at different time of the day. In warm season and at the daytime, the temperature is in somewhat high.

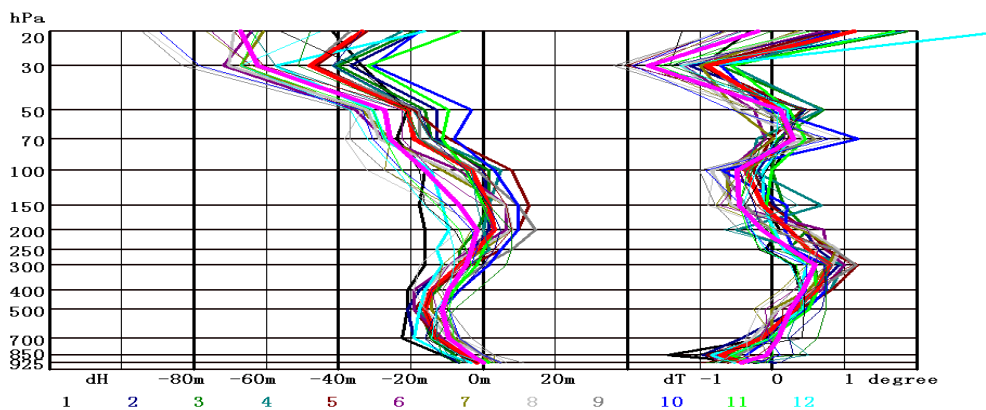


Fig.2.9, Overall monthly mean biases of the 24 new radiosonde stations in 2004

Fig.2.9 gives the compare of overall annual mean bias between the 78 stations equipped with old system and the 24 stations equipped with new system in 2004. Below the height of 50hPa, the temperature difference is less than 0.5°C and the geopotential difference is less than 10gpm.

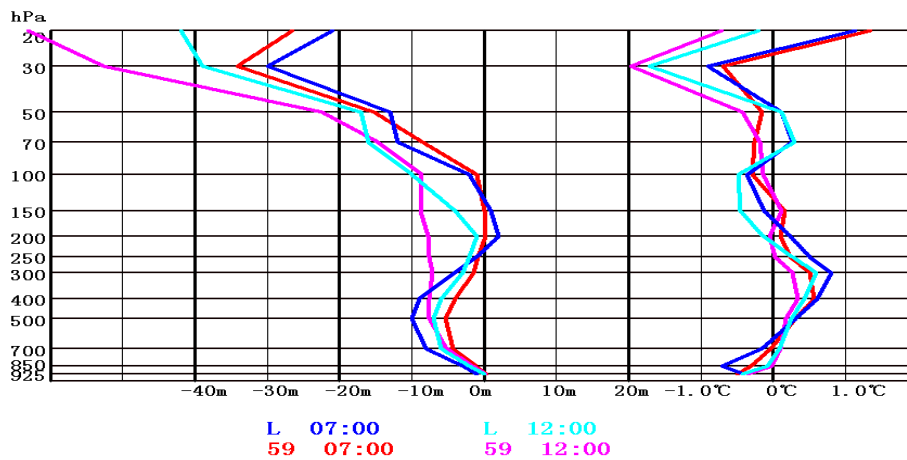


Fig.2.9, Comparing of overall annual mean bias between the old and new system in 2004.

Fig.2.10 shows the difference of overall annual mean bias between the station 45004 equipped with the Vaisala's radiosonde system and 24 stations equipped with the new system in 2004. Below the height of 100hPa, the temperature difference is less than 0.5°C. And below the height of 200hPa, the geopotential difference is less than 10gpm. However, the geopotential difference reaches 20gpm when the height higher than 200hPa.

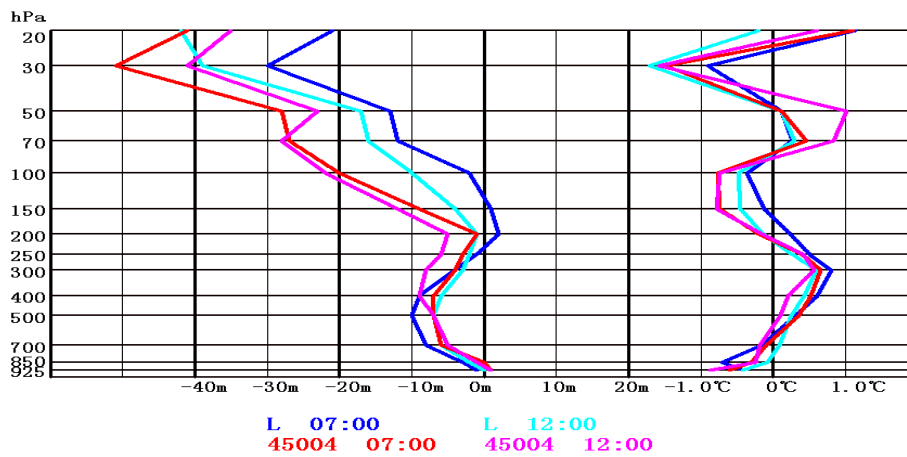


Fig.2.10, Difference of overall annual mean bias between the station 45004 and the 24 new systems in 2004.

Fig.2.11 shows the difference of overall annual mean bias between the station 45004 and its 4 neighborhood stations equipped with old system in 2004. The geopotential and temperature differences are in somewhat degree bigger than that in Fig.2.10.

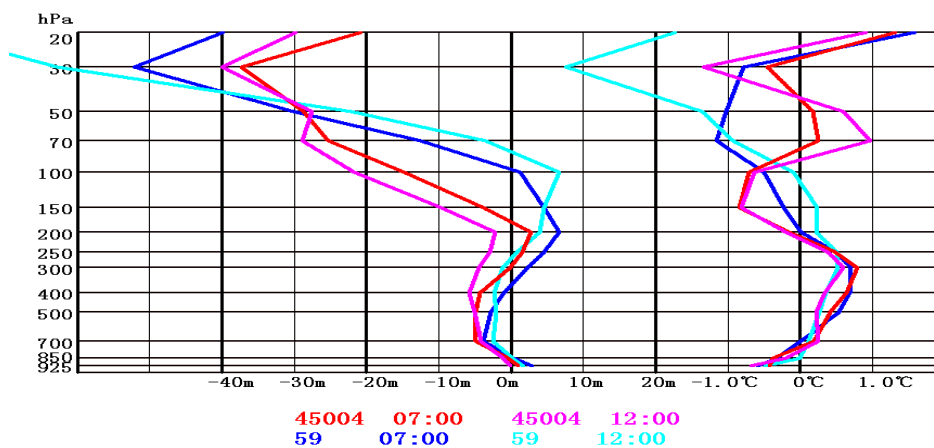


Fig.2.11, Difference of overall annual mean bias between the station 45004 and its 4 old system in 2004

It must be explained as supplement that the processing method of correcting the systematic error for the old GZZ2 sonde had been changed (Guo Yatian and Huang Bingxun *et al*, 2002) since July 2000 and the NWS model and its related initial meteorological parameter database are replaced since January 2003. In general, as discussed in this paragraph, the initial database is compatible with the in-situ observations from the upper-air network of China.

### 3 Flight comparison between the new and the old radiosonde

The first guess field offers usually a relatively stable reference for evaluating observation quality of network stations. However, it is not assumed that the FG fields have zero systematic error in each region and in any time. This implies that the direct flight comparison is still required for identify the quality performance and differences of the records between the new and the old observation systems.

Although the radiosonde network is established for short-term weather forecasting rather than long-term environmental monitoring, it has the potential to be an extremely useful tool for climate analysis and forms a foundation for calibrating and validating many satellite measurements.

The replacement of upper-air network often brings useful improvements in precision and accuracy, but they also result in the problems in continuity of the records from the perspective of climate change analysis. Data continuity is defined as the compatibility of past, present, and future data such that the observational record is free of in-homogeneities caused by instrument changes, launch and sampling procedure changes and data processing changes. Instrument biases can vary with altitude, atmospheric and ground conditions, solar elevation, time of day, and other changes. In the absence of overlapping observations, the adjusting temperature data provide by the radiosonde to remove in-homogeneities is a very complex task. Thus multi-season, multi-location comparison is necessary to understand all instrument-induced differences.

The more comparison flights, the lower the error will be in the calculations of continuity adjustments. But also the more comparison flights, the higher the costs will be. How many comparison flights are enough? It is still a strategy under discussed. However, to save the payout, CMA has decided to conduct the dual sonde flights in the train period of observers of replacement station. In order to avoid to

influence the flight state of the sonde, the comparison radiosondes ascent independently, but synchronously or with short times between their launches. The comparison flights last usually for one month and a total of 60 pairs of comparison records can be obtained. The data from the comparison flights will be used to calculate the mean difference between the old and new sondes. Until preparing of this paper, preliminarily analysis of the differences from the 24 replacement stations has been completed

Fig. 3.1 shows the mean differences of geopotentials and temperature between the old and the new radiosondes for the 24 stations (azury curves) and the overall average of the 24 stations (red). In general, the overall average below the height of 100hPa is not obvious although the comparison results for the 24 stations are differ obviously. The overall temperature average is less than 0.3°C and the overall geopotential average is less than 5gpm. But the overall temperature average reaches 1°C and the overall geopotential average reaches 30gpm at the heights of 70-50hPa.

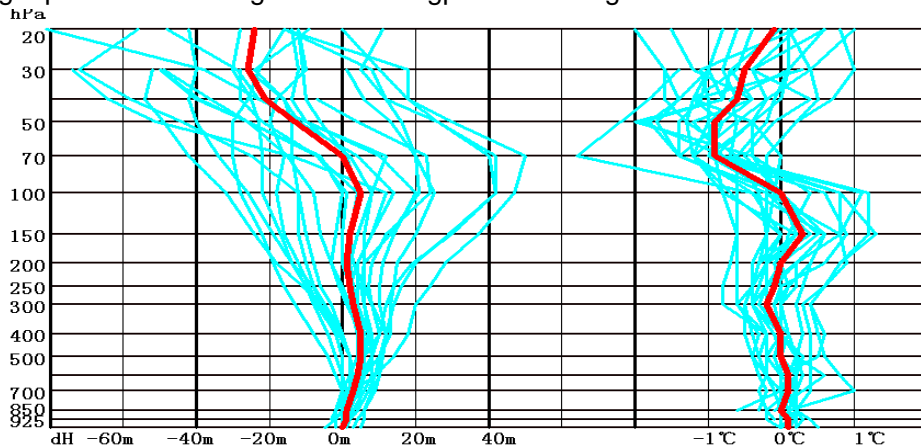


Fig.3.1, Mean differences of geopotentials and temperature between old and new radiosondes

The farther analysis has revealed that the biggest positive difference from 56187,57957 and 57972, see Fig.3.2, is related to the radiosondes produced by the factory in ShanXi province, but others produced by the factory in Shanghai with the same drawing.

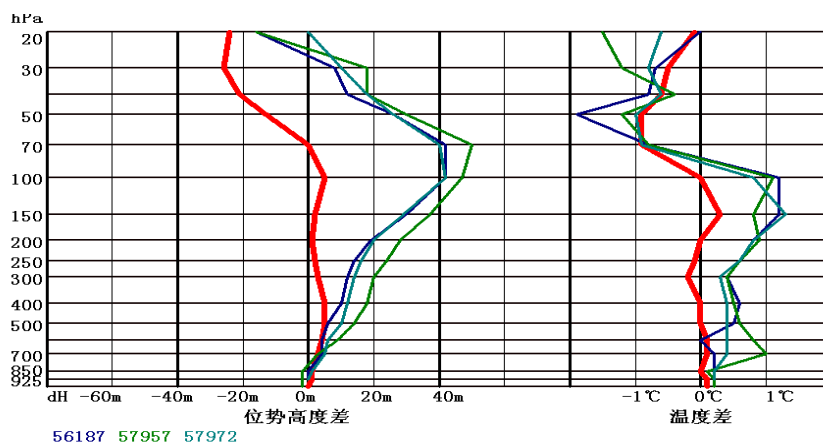


Fig.3.2, The biggest positive difference from 56187,57957 and 57972

The fact can also be validated by the analysis of the monthly monitoring (OB-FG) bias. For example, Fig.3.3 shows large negative variation of the monthly mean bias from July when old sonde was released to August when new sonde was released for station 57972. Fig.3.4 shows farther large negative variation of the monthly mean bias from the month before July to that after August for station 57972.



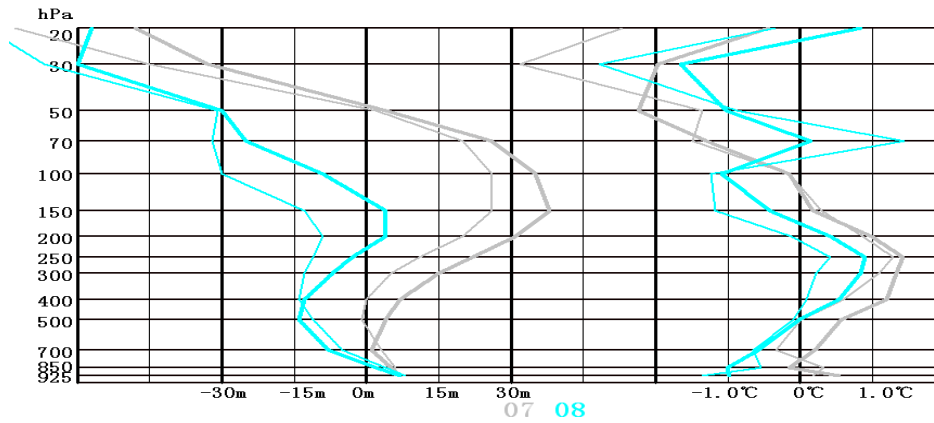


Fig.3.3, Large negative variation of the monthly mean bias from July to August for station 57972

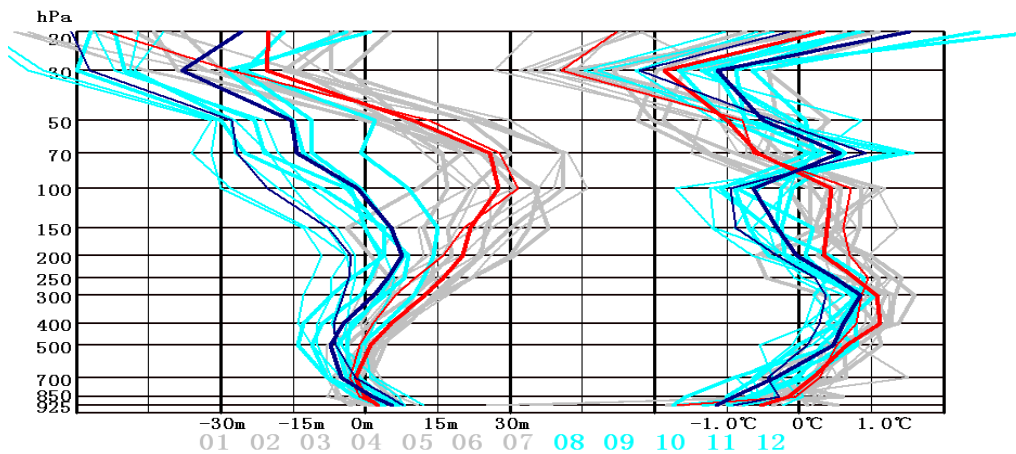


Fig.3.4, Large negative variation of the monthly mean bias from the month before July to that after August for station 57972.

The farther analysis has still revealed that the negative geopotential differences showed in Fig.3.5 are from stations 51656 to 53614 in the west China.

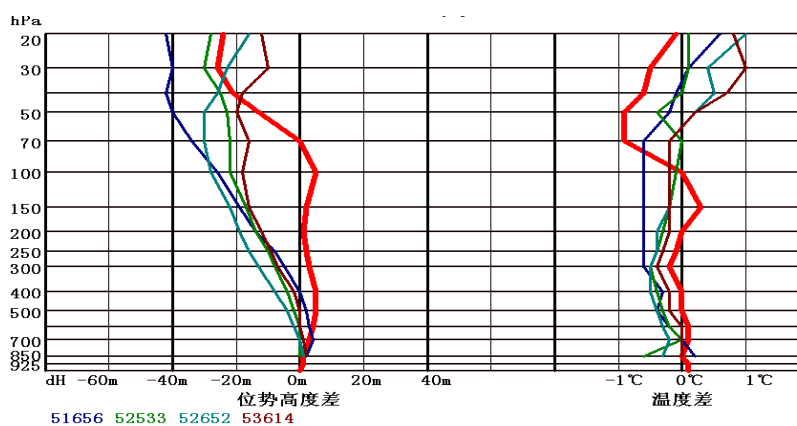


Fig.3.5, Negative geopotential differences from stations 51656 to 53614 in the west China

The fact can also be made sure by the analysis of the monthly monitoring (OB-FG) bias. For example, Fig.3.6 shows large positive variation of the monthly mean bias from July when old sonde was released to August when new sonde was released for station 51656. Fig.3.7 shows farther large positive variation of the monthly mean bias from the month before July to that after August for station 51656.

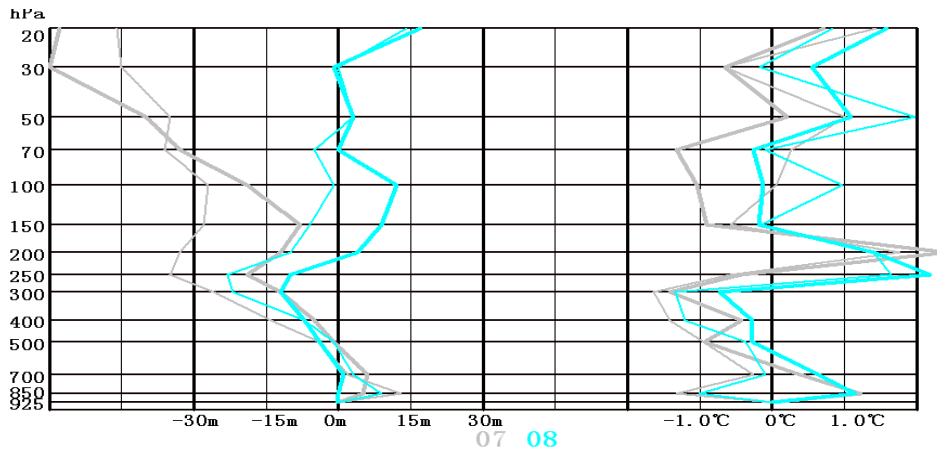


Fig.3.6, Large positive variation of the monthly mean bias from July to August for station 51656

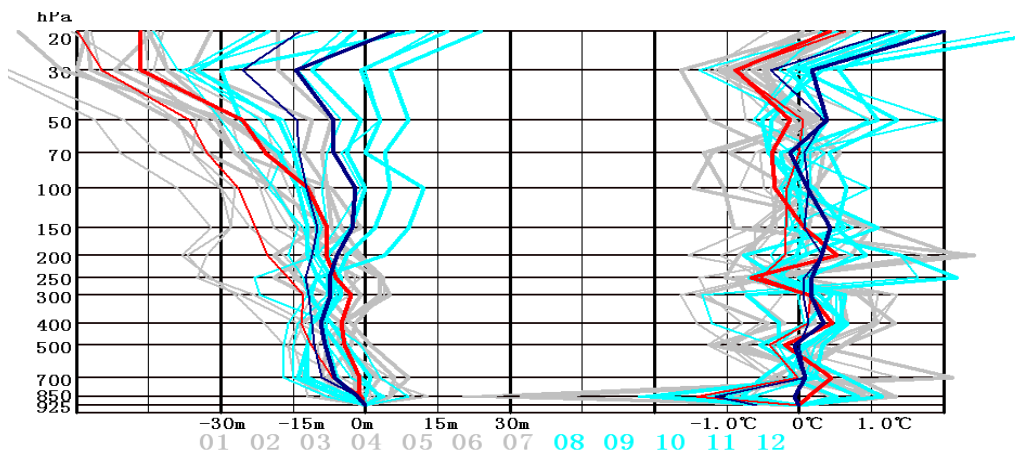


Fig.3.7, Large positive variation of the monthly mean bias from the month before July to that after August for the station 51656

It is clearly that the preliminary results are very rough to identify the systematic differences between the old and the new radiosondes mainly due to the different manufactory of the old sonde, different area of the country, different local time of the day, different cloud cover and physiognomy and *et al.* However, we will obtain useful evidence from this widely conducted comparison flights to design cost-effective comparison flights at definite stations in the different climate area and for a definite long time. And after that we hope reach the goal to obtain the mean values that could be applied to adjust the earlier data sets to make them homogeneous with the new data sets.

## 4 Conclusion

Conducting monthly evaluation of the compatibility of geopotential height, temperature, wind speed and wind direction observations based on comparisons with the First Guess field of the NWS model is very useful for the monitoring of long-term system performance of all Chinese upper-air stations. Due to the evaluation, various unwonted TEMP reports had been discovered and then are being overcome through some administrative and/or technical measures. Based on the monthly evaluation of the compatibility of upper-air records from various station, different launch time of the day, different producing factory and different radiosonde type, we hope to reveal some performance of the sonde that is difficult to be discovered in laboratory conditions.

However, direct dual flight comparison is still required to calculate the systematic differences between the new and the old network radiosondes and then to keep the continuity of the network records. Utilizing the opportunity of operational train of the new observing system for observer, to conducting comparison flight last such as one month at numerous replacement stations is a cost-effective measure. Nevertheless, much more strict dual flight comparison at some stations having some representations is certainly necessary to obtain adjusting values of the old record to the new record, especially for GCOS stations.

## References

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