COMPLEX QUALITY CONTROL OF BARCELONA RADIOSOUNDING DATABASE

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I. INTRODUCTION

Since 1998 the Meteorological Service of Catalonia and the University of Barcelona perform a radiosounding at 00 and 12 UTC through Vaisala equipment. During its 1 or 2 hours ascent from the surface into the low stratosphere, a radiosonde transmits its measurements to ground receiving station where they are processed into pressure, temperature, dewpoint depression and geopotential height. Wind direction and speed are obtained by tracking the position of the balloon during its ascent.

Although radiosonde observations have traditionally been taken primarily for the purpose of operational weather forecasting, they are critical to other applications, including model verification, climate-change studies and the verification of satellite measurements (Free et al. 2002). Therefore we have devoted this study to develop appropriate quality-checking methods.

II. PROCEDURE

In general, quality assurance procedures for sounding data rely on principles of internal consistency, basic physical relationships, and/or statistical methods (Collins 2001).

Thus, different filters have been developed to detect errors provided in tables I and II. The control has been applied to the two files generated after every launch: the ASCII file with a temporal resolution of 10 or 2 seconds and the TEMP report. Some of the filters have been devised following the Integrated Global Radiosonde Archive project done by Durre et al. in 2008.

ASCII files			
A1	A2	A3	A4
Detection of the climatological outliers	Detection of the duplicity in pressure or geopotential height	Verification of the hydrostatic equation	Detection of vertical gradient inconsistencies

TABLE I: Definitions of filters applied to ASCII files.

TEMP files	
B1	B2
Extrem value checking	Detection of temporal inconsistencies

TABLE II: Definitions of filters applied to TEMP files.

As a result of more than 8000 soundings was required to implement the filtering process by programs in C++ language.

III. RESULTS AND CONCLUSIONS

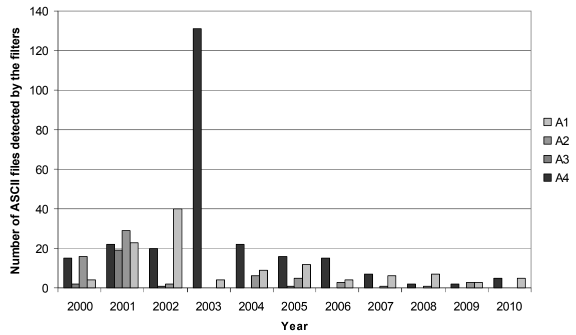

FIG. 1: Number of soundings (ASCII files) detected by year and filter.

Figure 1 illustrates that the number of files which present some error, in general, is gradually reduced in recent years. However, note that numerous soundings contain vertical gradient inconsistencies during 2003. Figure 2 shows a sounding detected by A4 filter for this year.

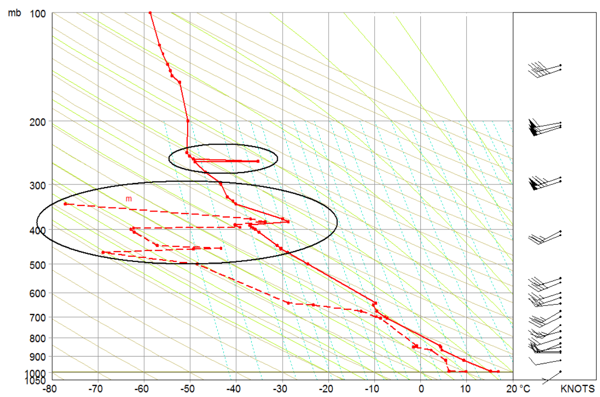

FIG. 2: Emagram 03042012 (YYMMDDHH) plotted by RAOB program.

The reason why this period presents a remarkable peak is probably due to (human) calibration errors as well as bad behaviour sensors of temperature or humidity. Nevertheless, most of sensor errors are located above 100 hPa, where meteorological significance is minor.

Obviously, not all soundings detected present erroneous data. For instance, in some cases of A1 check the threshold set (between -75ºC and 38ºC) is exceeded. When the latter situation does occur we have verified this datum by comparing with nearby radiosoundings (Palma de Mallorca and Zaragoza) and the synoptic field.

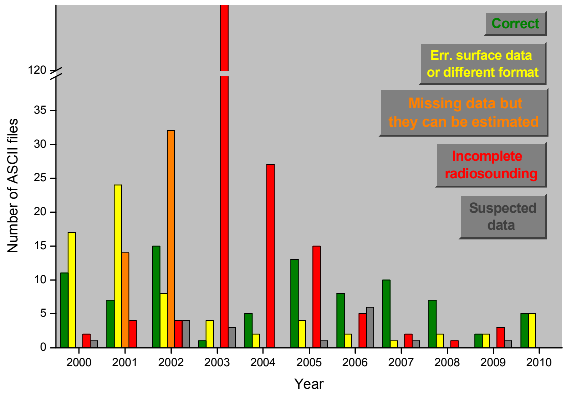

FIG. 3: ASCII files analized after checking.

With regard to TEMP reports, fortunately, the number of errors is smaller than ASCII files since TEMP files have been only analyzed mandatory levels (TTAA code). Each check is performed independently and only then the results are combined to make the data quality decision and a correction where possible.

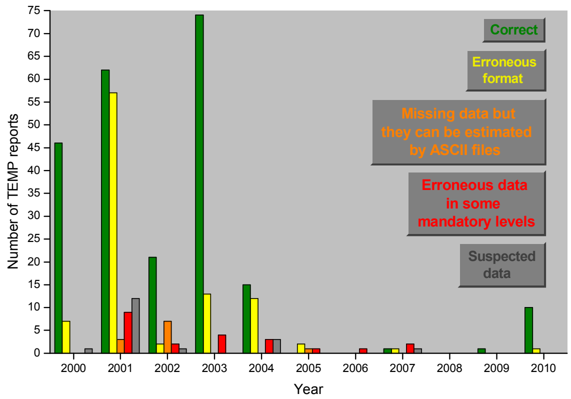

FIG. 4: TEMP files analized after checking.

After these steps, we have found that about 4% of our ASCII files and 2% of our TEMP files database contain erroneous data, most of them during its earlier years. After an update of the Vaisala equipment, the number of errors became practically negligible.

Temperature time series

Here we present the short temperature series for the period of 2000-2009, although it is convenient to mention that occasionally the balloon does not reach the pressure of 100 hPa[1]. As a consequence, data continuity for all levels is not guaranteed. On the other hand, for last years this fact is seldom because of the improvement of the radiosonde among other factors.

[1] At the moment, these measurements are not technically climatological time series because of only ten years working. However, after applying four tests for homogeneity (the standard normal homogeneity test, the Buishand range test, the Pettitt test and the Von Neumann ratio test) the series is classified as 'useful' since only one test rejected the null hypothesis at 95% confidence level.

Level	Mean (ºC)	Standard Deviation (ºC)
98 m	18.1	0.78
1000 hPa	17.4	0.40
925 hPa	12.9	0.71
850 hPa	9.3	0.38
700 hPa	-0.1	0.34
500 hPa	-16.8	0.30
400 hPa	-28.9	0.26
300 hPa	-44.1	0.22
250 hPa	-52.1	0.20
200 hPa	-57.4	0.36
150 hPa	-58.2	0.35
100 hPa	-60.4	0.31

TABLE III: Mean and standard deviation for temperature during a decade (2000-2009).

Table III shows that the variability of temperature in the low troposphere is more notable than middle or top of this layer. Furthermore, the lowest stratosphere presents a standard deviation similar to middle troposphere. The 1000 hPa datum is not very confident owing to lack of data since this pressure level is below the observation many days.

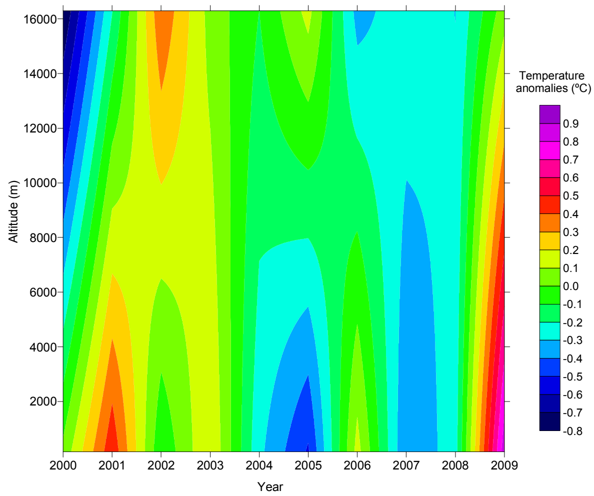

FIG. 5: Vertical profile of temperature anomalies respect to mean values.

Figure 5 depicts the difference between annual mean temperature and 10 years average. From this result, it becomes clear that there is no significant trend for upper air temperature for this period.

The figure displays, in general, different behaviour between low troposphere and low stratosphere in a same year. The maximum value took place in the lowest part of atmosphere for 2009 whereas the most important negative anomalies were measured at the beginning of the decade in the lowest stratosphere.

IV. REFERENCES

Collins W. G., 2001: The operational complex quality control of radiosonde heights and temperatures at the National Centers for Environmental Prediction. *J. Appl. Meteor.*, 40 137-151.

Durre I., Vose R., Wuertz D., 2008: Robust Automated Quality Assurance of Radiosonde Temperatures. *Bull. Amer. Meteor. Soc.*, 47 2081-2095.

Free M, Angell J. K., Lanzante J.R., Durre I., Peterson T.C., and Seidel D.J., 2004: Using first differences to reduce inhomogeneity in radiosonde temperature datasets. *J. Climate,* 17 4171-4179.