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Complex quality control of Barcelona radiosounding database

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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.

Procedure

Different filters have been developed to detect errors. The control has been applied to the two files generated after every launch:

ASCII file (with a temporal resolution of 10 or 2 s)
- A1: Detection of the climatological outliers.
- A2: Detection of the duplicity in pressure or geopotential height.
- A3: Verification of the hydrostatic equation.
- A4: Detection of vertical gradient inconsistencies.

TEMP report (applied to mandatory levels)
- B1: Extreme value checking.
- B2: Detection of temporal inconsistencies.

Some of them have been devised following the Integrated Global Radiosonde Archive project done by Durre et al. in 2008. As a result of more than 8000 soundings was required to implement the filtering process by programs in C++ language.

Meteorological variables	Min. threshold	Max. threshold
Temperature	-75ºC	38ºC
Geopotential	94 m	31000 m
Pressure	12 hPa	1030 hPa
Relative humidity	1% RH	100 %RH
Wind velocity	0 m/s	95 m/s
Wind direction	0º	360º
Dew point	-100ºC	30ºC

TABLE I. Climatological outliers (check A1).

Time interval	Pressure	Geopotential	Temperature	Relative humidity	Wind velocity
10 s	15.0 hPa	150 m	3.0ºC	60% RH	20 m/s
2 s	8.0 hPa	60 m	2.0ºC	30% RH	10 m/s

TABLE II. Vertical gradient (check A4).

Mandatory level	Temperature	Geopotential / pressure	Wind velocity
Surface (98 m)	1ºC – 33ºC	990 hPa – 1020 hPa	< 15 m/s
1000 hPa	-5ºC – 30ºC	10 m – 500 m	< 25 m/s
925 hPa	-8ºC – 27ºC	550 m – 900 m	< 25 m/s
850 hPa	-14ºC – 25ºC	1250 m – 1700 m	< 30 m/s
700 hPa	-18ºC – 14ºC	2800 m – 3300 m	1 m/s – 35 m/s
500 hPa	-35ºC – -5ºC	5300 m – 5950 m	1 m/s – 50 m/s
400 hPa	-45ºC – -15ºC	6800 m – 7600 m	5 m/s – 60 m/s
300 hPa	-55ºC – -35ºC	8800 m – 9700 m	5 m/s – 70 m/s
250 hPa	-65ºC – -40ºC	10000 m – 11000 m	5 m/s – 80 m/s
200 hPa	-70ºC – -40ºC	11400 m – 12500 m	5 m/s – 70 m/s
150 hPa	-70ºC – -45ºC	13200 m – 14300 m	1 m/s – 50 m/s
100 hPa	-70ºC – -50ºC	15800 m – 16700 m	1 m/s – 45 m/s

TABLE III. Extreme values (check B1).

Results

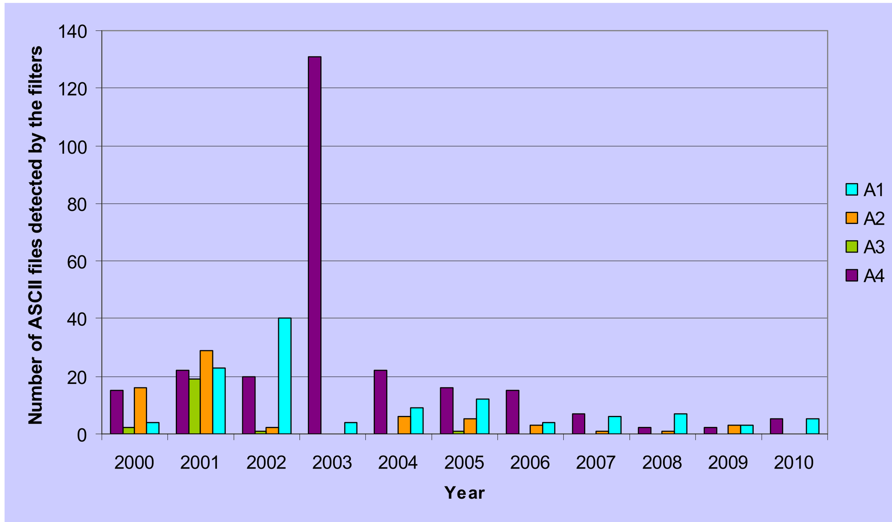
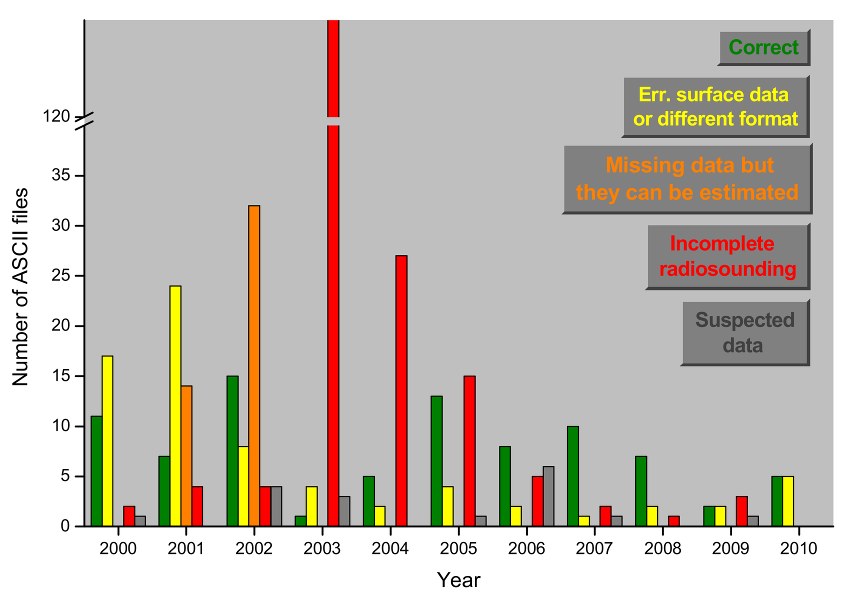


FIG.1: The number of files which present some error, in general, is gradually reduced in recent years. However, note that numerous soundings contain vertical gradient inconsistencies during 2003. The reason why this period presents a remarkable peak is probably due to (human) calibration errors as well as bad behaviour of T or U sensors .



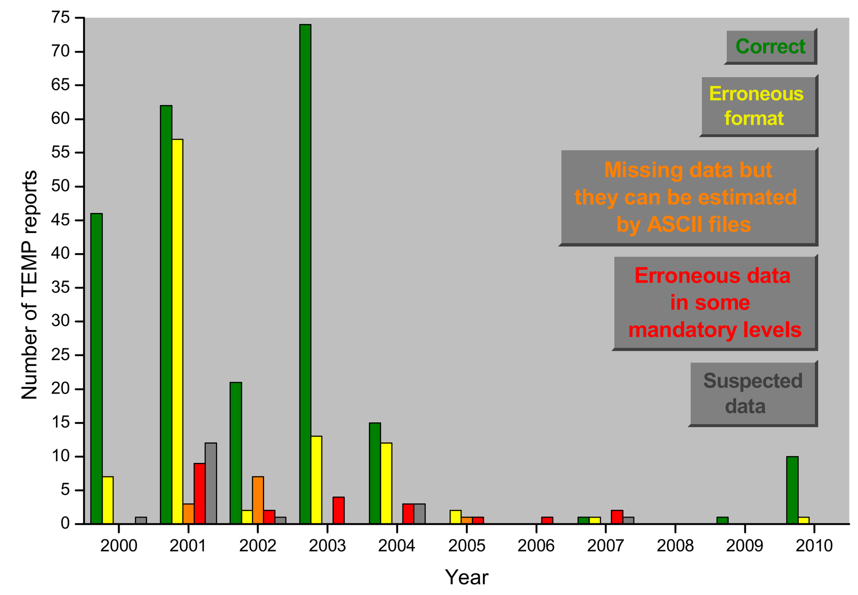
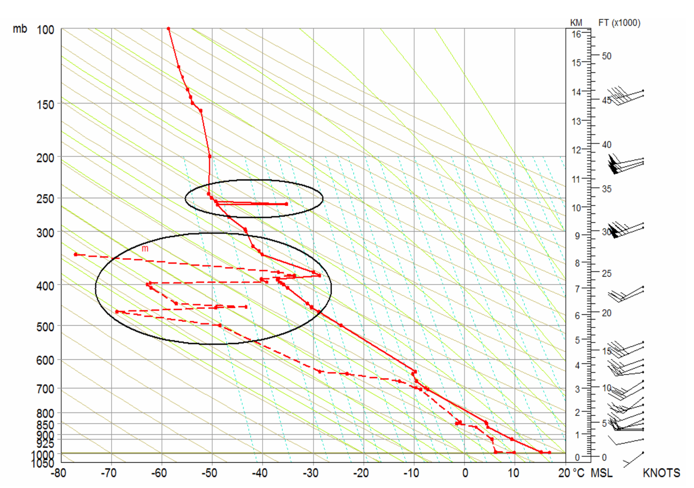


FIG.2 a *(left)*: Obviously, not all soundings detected present erroneous data. For instance, in some cases of A1 check the threshold set (between -75ºC and 38ºC) is exceeded. When the latter situation does occur we have verified this datum by comparing with nearby radiosoundings (Palma de Mallorca and Zaragoza) and the synoptic field.

FIG.2 b *(right)*: With regard to TEMP reports, fortunately, the number of errors is smaller since these have been only analyzed mandatory levels (TTAA code).

Examples of erroneous data detected

Emagrams YYMMDDHH → *year_month_day_hour*



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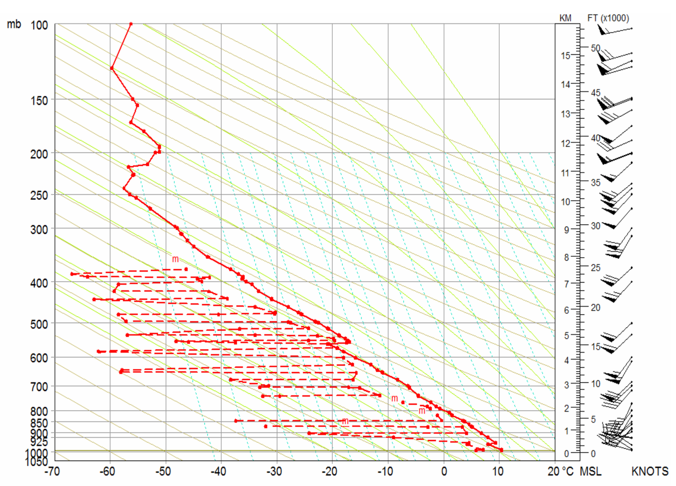
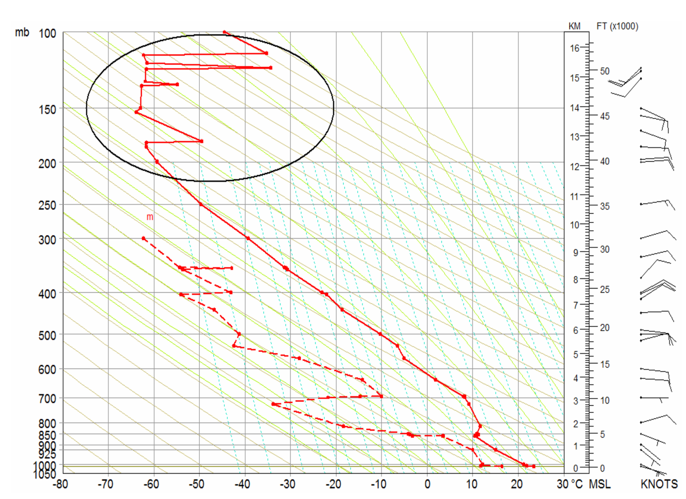
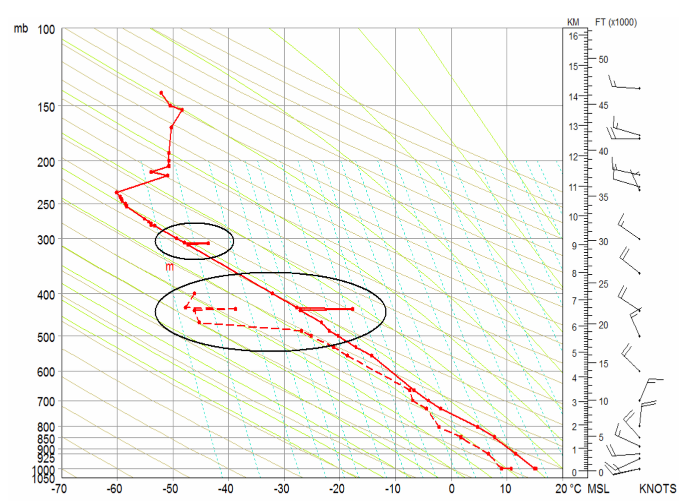


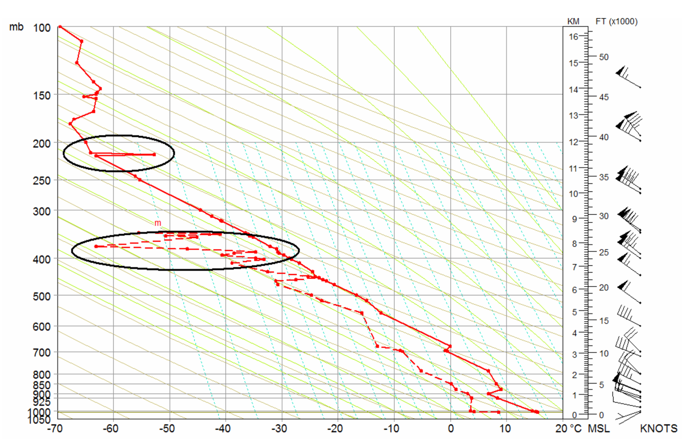
07012300



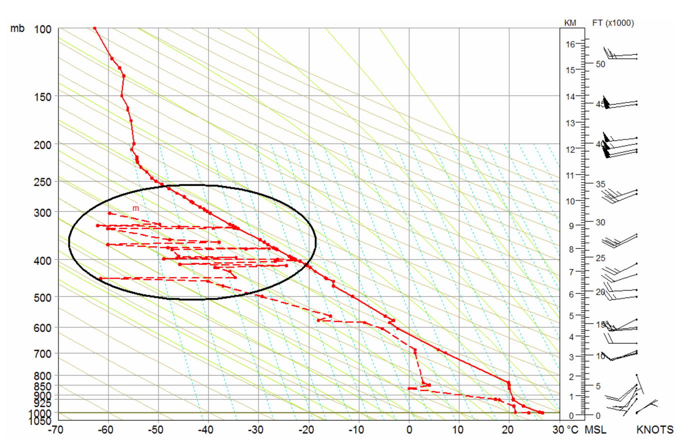
03091912



04051300



04010912



03082100

Temperature time series

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 IV. Mean and standard deviation for temperature during a decade (2000-2009).

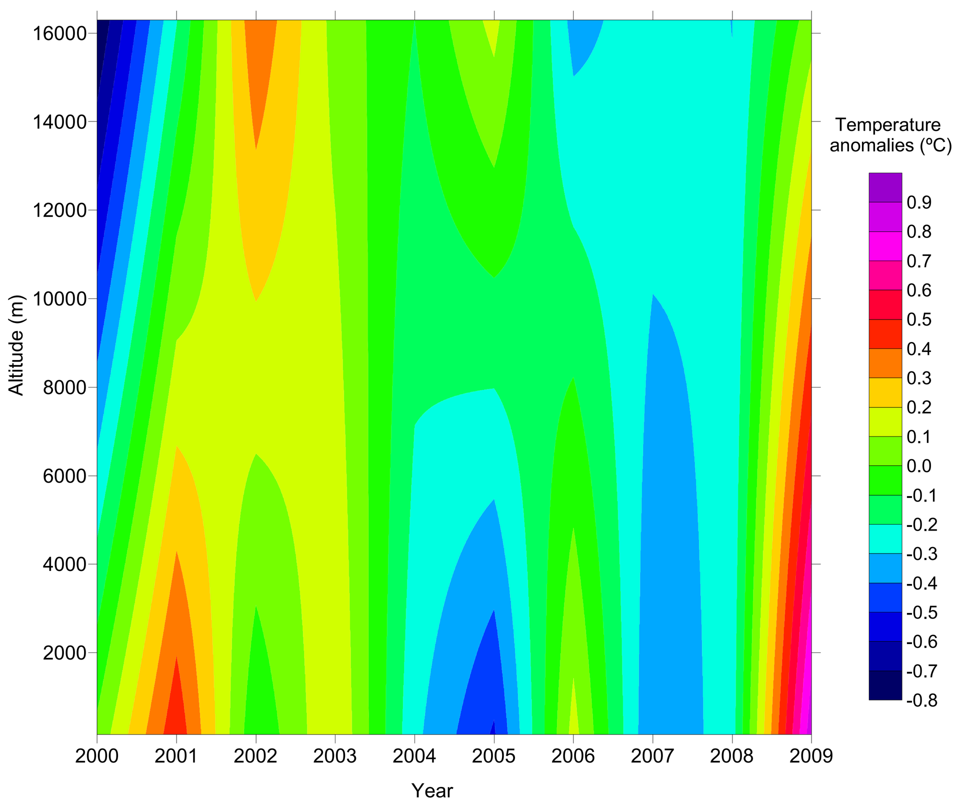


FIG. 3 Vertical profile of temperature anomalies respect to mean values (calculated from TABLE IV).

The variability of T in the lower troposphere is more notable than middle or top of this layer.

The 1000 hPa data are not very reliable owing to lack of values since this pressure level is below the observation altitude in many days. From the result of figure 3, 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.

Conclusions

- ✓ 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 equipment, the number of errors became practically negligible.
- ✓ Most of sensor errors are located above 100 hPa, where meteorological significance is minor.
- ✓ Each check is performed independently and only then the results are combined to make the data quality decision and a correction where possible.
- ✓ Data continuity for all levels is not guaranteed, especially during earlier years.

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 41 4179.

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