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ANY OTHER BUSINESS

Global criteria for tracing the improvements of radiosonde over the last two decades

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Summary and purpose of document

This document contains proposal of criteria for tracing radiosonde improvements.

Action proposed

The meeting is invited to comment and develop further the proposal of criteria for tracing radiosonde improvements.

Global criteria for tracing the improvements of radiosonde over the last two decades

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A contribution to the WMNO-CIMO ET meeting on RS UAT&T, Geneva, 14-17 March 2005

1. Task

At the last CIMO expert team meeting on upper-air systems intercomparisons (ET on UASI-1, Geneva, 17-20.03.2004), the following task was defined:

Develop performance measures to demonstrate the continuous improvement

in the quality of upper-air observations.

The required action is to "elaborate global criteria for tracing the improvements, based on previous intercomparisons and recent radiosonde development, and including remote sensing". The deliverable will be an "IOM report on global criteria for tracing the improvements of radiosondes"[1]

Here we propose to focus on the definition of appropriate criteria which should later be used by the CIMO, the National Meteorological and Hydrological Services (NMHS), and the manufacturers in order to trace the improvements in the quality of upper-air observations.

Ideally such criteria should be based on data already available in the previous IOM reports, and should also be defined as guidance to be included in any further CIMO UASI field campaigns and national or international intercomparisons to ensure the required continuous tracing.

Finally any manufacturers or National Meteorological and Hydrological Services could use these criteria to trace the quality improvements of their radiosondes and sounding stations.

2. Preliminary analysis

Radiosonde sensor suite technology has improved over the last several decades, but tracing the sensor improvement requires appropriate criteria. Four possible ideas of analyses are suggested by either: (1.) using the previous IOM reports, (2.) comparing radiosonde measurements with model values, (3.) elaborating first a general CIMO questionnaire to the NMHSs, or (4.) extracting numbers from the open literature. They are briefly commented below:

<u>Time evolution of selected statistical parameters reported in the different WMO international radiosonde comparisons</u>. Apart from the Low-level Intercomparison Experiment, USA, 1979, all intercomparisons with IOM report took place between 1984 in the UK (phase I), 1985 in the USA (phase II), 1989 in the former USSR (phase III), 1993 in Japan (phase IV), and 2001 in Brazil. The last one took place at Mauritius in February 2005. The statistical parameters (systematic biases, standard deviations, etc) based on differences between the measurements obtained with different types of radiosondes for simultaneous measurements represent a valuable tool for comparison over the last two decades. Each of these campaigns used "link radiosondes" in order to define one reference value (or standard) and have it compared with the other measurements. Nevertheless, Tables 5.3-4 in the Phase II report point to a possible problem with the time continuity of the link radiosondes between Phase I-II-III. At standard

[1] A similar task will be related to the surface measurements and some coordination would be fruitful. The inclusion of upper-air remote sensing criteria is not addressed in this first draft.

levels, we may be able to show better (smaller) differences and perhaps tighter means or RMS values. Such an analysis has partially been conducted so far: in Table 10, Elms (2003) provides a comparison of the estimated reproducibility of geopotential heights between 500 and 10 hPa for the main radiosonde types obtained from the WMO intercomparisons. Tables 6-8 of phase IV report provide comparisons between the link radiosondes between phases III and IV.

Time evolution of selected statistical parameters reported in the different IOM analyses on the compatibility of radiosonde geopotential measurements (1988, 1990-1992, 1995-1997, 1998-2001, plus Excel files for the very last years). In this analysis the comparison is made between radiosonde measurements and the first guess of NWP models, the latter being considered as a relatively stable working reference (Oakley, 1998) although the numerical models underwent singificant improvements in the last decades. Thus a criteria based on the comparison between measurement and model results will inherently have the drawback of adding errors induced by the method of observations together with errors induced by the model results. Here we may nevertheless benefit from well defined parameters used in the previous analysis: e.g. the bias and std. dev. of the geopotential altitude of the 100 hPa level as well as the height increment from 100 to 30 hPa and its std. deviation, at 00 and 12 UTC. This analysis gives some valuable information about the sondes' performances as they are operated by the different NMHSs (quality of operational upper air observations). Oakley compares the monitoring results for the main radiosonde types in section 3.1.3 of his report of 1998: "In general about 70% of the radiosonde stations in the period 1995 to 1997 were producing observations within the suggested quality limits, this compared with 65% in 1992". In the next report of Elms (2003), in section 5.1.2, a worsening of the performance of many stations appears compared to the previous period, but its conclusion in section 6.4 states that "the overall measurement quality of the radiosonde network has continued to improve".

Time evolution of selected statistical parameters that would be asked from the NMHSs in a world wide enquiry. A detailed questionnaire could be elaborated, in order to highlight the time evolution for radisonde measurements worldwide. For example, statistical values such as the percent of soundings reaching the 100, 30 and 10 hPa levels, for the day and the respective night temperature and geopotential differences at 100, 30 and 10 hPa, could be helpful values in order to trace this improvement over the years. This would require an important contribution from the NMHSs.

Compilation of the articles published in the scientific journals. Information directly taken from the open literature may be an other source of information about such global criterian for tracing the im provement of radisonde performances over the years. A number of intercomparison campaigns and reviews have already been published for research projects such as ALPEX, TOGA, climate, and others. This fourth possibility could also represent an extension of the previous ones. Phase II report gives a list of radiosondes comparisons before the 1980s, the very first ones at Payerne in 1950 and 1956.

Here we propose to start with the first option by using the previous IOM reports and defining some statistical criteria on measured data. The other options will be explored afterwards if needed. Note that the next IOM reports on the compatibility of radiosonde geopotential measurements should allow a continuous analysis of more than 10 years. If the quarterly statistical parameters can be put in the excel file for a longer period (e.g. 1988) or could be recalculated on the base of ERA40, they would allow a very valuable complement to the results of the radiosonde intercomparisons.

3. Candidate performance measures

Candidates are presented in Table 1. As no absolute reference exists, the "references" for calculating biases and standard deviations are based on the data obtained using as reference the “link radiosonde”. Note that in the actual draft of our document “Global criteria for tracing the improvements of radiosonde over the last two decades”, Table 1 shows a first selection of possible criteria: this choice will be reviewed, and additional/other criteria e.g. relative humidity measurements will be added.

Table 1. Candidate criteria

Criterion	Remarks
Temperature difference @10 hPa, @ night time	The 10 hPa level is the highest standard level in the TEMP messages. Meeting a high quality goal at this level is a demanding task. Temperature errors are different during night and daytime (noon). The standard deviation might better describe the improvements than the systematic deviation.
Temperature difference @10 hPa, @ daytime (noon)	
Standard deviation temperature difference @ 10 hPa, @ night time	
Standard deviation temperature difference @ 10 hPa, @ daytime (noon)	
Geopotential difference @ 10 hPa, @ night time	In addition to previous remarks, geopotential measurements from radiosonde (without GPS) accumulate the temperature error between surface and this level, as well as partly those in pressure. At some intercomparison sites high performance radars could precisely position the radiosonde altitudes.
Geopotential difference @ 10 hPa, @ daytime (noon)	
Standard deviation geopotential difference @ 10 hPa, @ night time	
Standard deviation geopotential difference @ 10 hPa, @ night time	
Geopotential difference @100 hPa, @ night time	The 100 hPa level is the primary level used in the quality control of upper air data based on comparison with numerical model outputs.
Geopotential difference @ 100 hPa, @ daytime (noon)	
Standard deviation geopotential difference @100 hPa, @ night time	
Standard deviation geopotential difference at 100 hPa, night time	
Systematic relative humidity difference in the temperature range between -35 and -45 degree Celsius (only tropospheric values)	Or two ranges : between -20 and -30C as well as between -40 and -50C
…	

Table 2. Proposed layout for the results of the international radiosonde comparisons:

	Phase -	Phase I	Phase II	Phase III	Phase IV	Phase V	Phase +
Criterion							
Sonde							
….							
Meisei RS2-80 (JP1)							
Meisei RS2-91 (JP2)							
Vaisala RS80-15N (FN1, FN3)							
Vaisala RS80-15LH (FN2)							
Vaisala RS90, RS92							
AIR							
VIZ 1392							
VIZ Mark II (VIZ1,2,3)							

As a first example, the systematic temperature differences @10 hPa, @ night time is reported on the Excel file below, and also as a plot. In a similar manner the systematic temperature differences @10 hPa, @ daytime (near noon), and also the geopotential height @ 10 hPa @ night time are reported on the two next plots. The following comments may be addressed on this first analysis:

- The intercomparison reports for the 5 Phases present their results in rather different forms!
- Some intercomparisons were in particular addressing a certain class of parameters and thus do not present results for the other ones.
- The Brazil 2001 was in particular reporting on relative humidity measurements in the tropics and on performance of the GPS sondes. So far the Brazil results are not added to this draft. The Mauritius 2005 results are not shown as well.
- There is no true reference sonde, but “link radiosondes”: as a consequence only relative numbers may be extracted.
- There are not only different sondes, but different data postprocessing (correction of the radiation error on temperature, etc.)

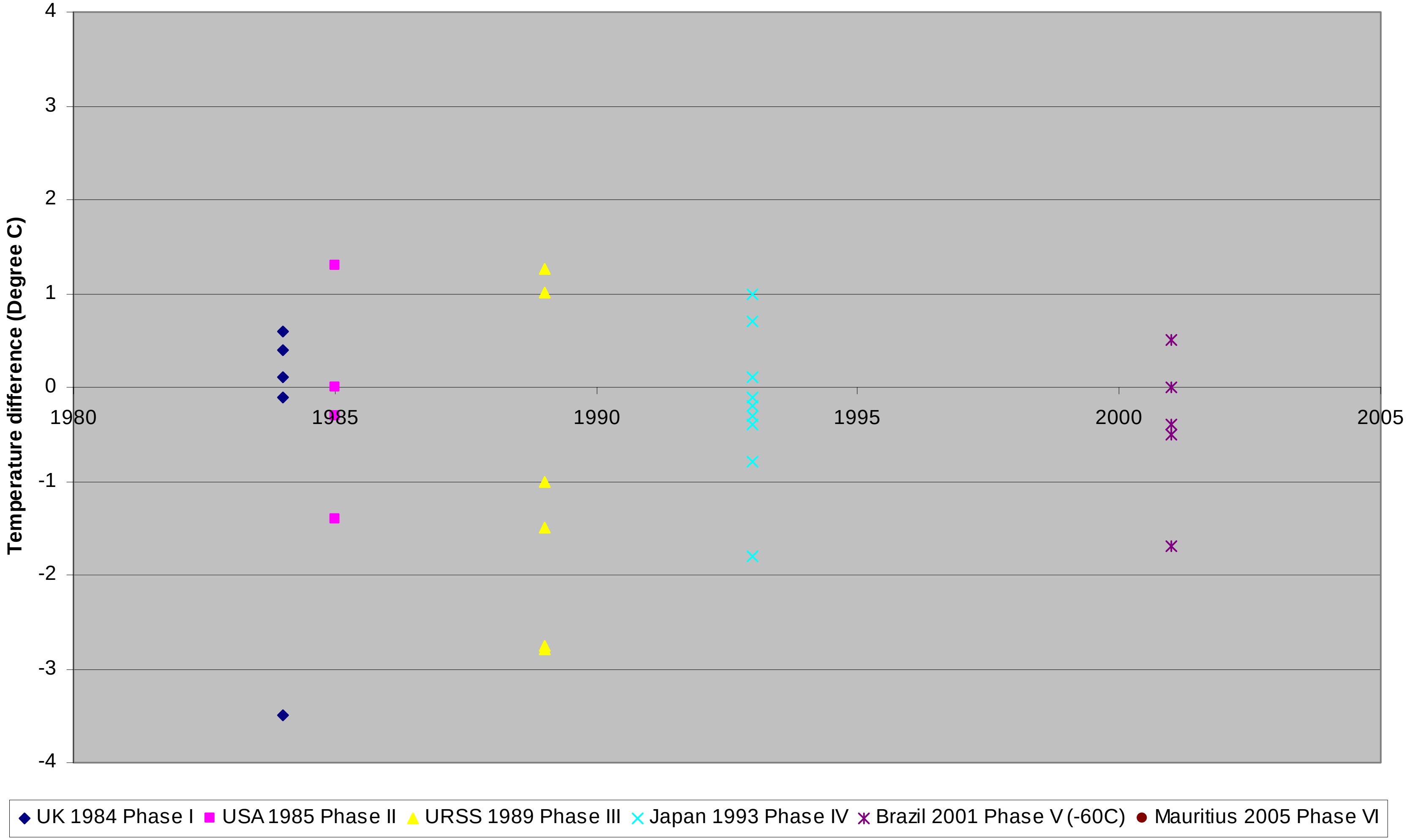
Even though the different points that are listed here above bring some clear limitation to this analysis, one can examine the 3 plots at the end of this draft and depict clear improvements for radiosonde measurements over the last two decades.

Systematic temperature difference at 10 hPa, night time in Degree Celsius	Phase -		UK 1984 Phase I		USA 1985 Phase II		URSS 1989 Phase III		Japan 1993 Phase IV		Brazil 2001 Phase V	
Sonde	1980		1984		1985		1989		1993		2001	
OCAN 1524-511			**-2.8**	4a								
RS 3 (UK)			**-0.7**	4a								
RS4 MK3(Aus)					**0.1**	5.8						
MK-III (India)					**1.3**	5.8						
Graw 78 C (D)			**-3.4**	4a								
Graw DFM97 (D)											**-1**	6.3.1.b
SMA-TC-1 (SMT)												
SMA-GZZ (SMG)							**-1.47**	5.9				
MARS-2 (MRS)							**-0.12**	5.9				
MRZ-3A (MRZ)							**-0.29**	5.9				
Meisei RS2-80 (JP1)									**-0.9**	2.1a		
Meisei RS2-91 (JP2)									**0.1**	2.1a		
Vaisala RS80-15N (FN1)			**0.7**	4a	**2.8**	5.8	**1.74**	5.9	**1.3**	2.1a	**0**	6.3.1.b
Vaisala RS80-15N (FN3)									**0.5**	2.1.c		
Vaisala RS80-15LH (FN2)												
Vaisala RS90-…											**0.3**	6.3.1.b
AIR IS-4A- (AR1)							**-1.06**	5.9	**-1.3**	2.1a		
AIR IS-4A- (AR2)									**-1.3**	2.1a		
AIR IS-4A- (AR3)									**-0.1**	2.1.c		

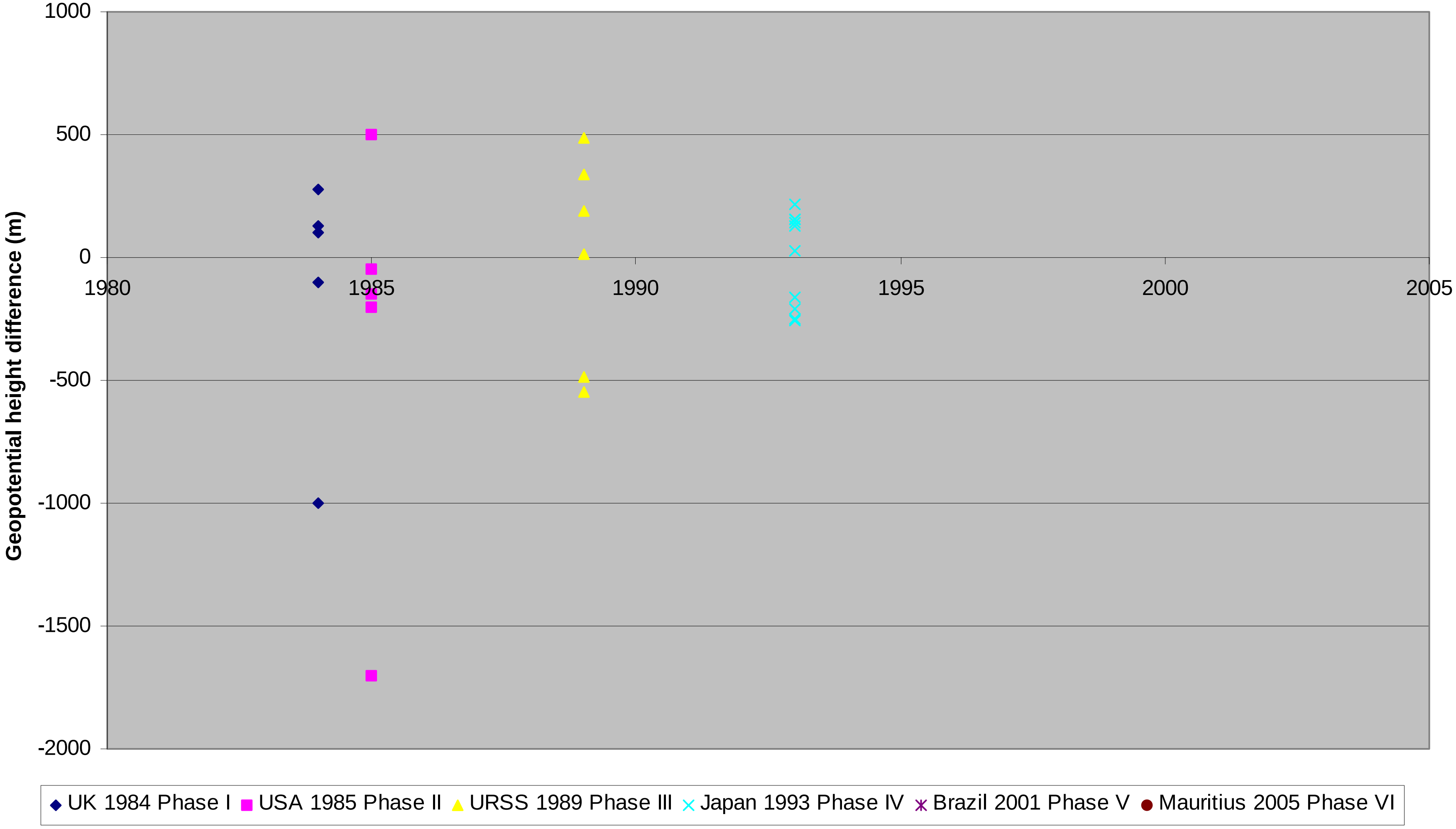
VIZ 1392 (VIZ0)			**-2.4**	4a	**0**	5.8	**-1.74**	5.9				
VIZ Mark II (VIZ)									**-1.2**	2.1a	**-0.1**	6.3.1.b
VIZ Mark II (VZ2)									**-1.5**	2.1.c		
VIZ Mark II (VZ3)									**-0.1**	2.1.c		
GL-98 (MODEM)											**0**	6.3.1.b
Reference used:			Mean(FIN,UK)		VIZ0		Mean(FN1,VIZ0)		Mean(FN1,AR1)		FN (RS80)	
Table used:			I:4a		II: 5.8 (2300UTC)		III: 5.9		IV: 2.1a, 2.1.c		V: 6.3.1.b	
			Analogic		Analogic		Digital		Digital		Analogic	
			also p84								at -80C (10hPa not sho	

In the table above, the exact source of each result is referenced with a figure number. In addition, the reference used in the intercomparison, the report and figure are given below. In the first reports, the graphs do not present the corresponding values: a direct “analog” reading of the values on the plots is then specified (in which case the absolute value reported may already be affected by this step!)

Temperature bias @ 10 hPa, day



Geopotential height bias @ 10 hPa, night



Temperature bias @ 10 hPa, night