Report from the Rapporteur on Radiosonde Compatibility

Tim Oakley Met Office, Exeter, UK.
tim.oakley@metoffice.gov.uk Tel +44 (0) 1392 885644 Fax +44 (0) 1392 885681

Upper-air temperature and geopotential height observations by radiosondes are produced daily at around 820 land stations and 30 ships world-wide. Ideally, all the equipment in use would provide measurements of similar quality, but this is not yet the case. The Expert Team on Upgrading the Global Radiosonde Network established by CIMO-XIII in 2002 was tasked with improving the compatibility of these observations. However, it is first necessary to identify the equipment types in use and also the radiosonde stations where significant errors (systematic or random) remain uncorrected. To help in the task, CIMO-XIII tasked a specific Rapporteur to study “Radiosonde Compatibility Monitoring” results. This Rapporteur has worked under the guidance of the Co-chairman of the Working Group on Upper-air Measurements to provide information to working group members. The Rapporteur’s report is a summary of monitoring results obtained between 2004 and 2005 for every station in the global network and provides long term averages of operational monitoring statistics for each radiosonde station. These averages allow detailed investigations of the magnitude of the random errors and the systematic bias in radiosonde geopotential height (equivalent to mean layer temperature) observations. Results are summarised for the main radiosonde types in use. The information should be used in planning future observing policy, identifying areas where upper-air observing practice or equipment need to be improved, and flagging potential problems with the long term stability of the main radiosonde types.

Detailed analysis and interpretation of observations from upper-air stations requires accurate and up to date information on the radiosondes and ground equipment being used at each station. Information on the radiation corrections being applied to the temperature observations and other local practices, e.g. whether a mixture of radiosondes are used, is also necessary. Hence, at the thirteenth session of the Commission for Instruments and Methods of Observation (CIMO-XIII, 2002) it was agreed that the Rapporteur for Radiosonde Compatibility Monitoring would continue to have a term of reference to maintain and update a directory of Upper-air stations. The final publication of a *Catalogue of Radiosondes and Upper –air Wind Systems in Use by Members* was in 1998 along with the Rapporteur’s report in Instruments and Observing Methods Report No.72 (WMO/TD –886).However, the catalogue has been regularly updated since and is now made available on the WMO web page:- http://www.wmo.ch/web/www/ois/volume-a/vola-home.htm

At the beginning of 2006 there were 823 upper-air stations world-wide with at least two soundings reported on the Global Telecommunications System in the year. 671 (82%) of the land stations reside in the northern hemisphere with 410 (50 %) in the latitude band 30° to 60° N. The southern hemisphere had a total of 152 stations, 18 % of the total network. This distribution of upper-air stations has changed very little since previous reports in 2002 and 1998. The following table summarises the world usage of the various radiosonde types in early 2006.

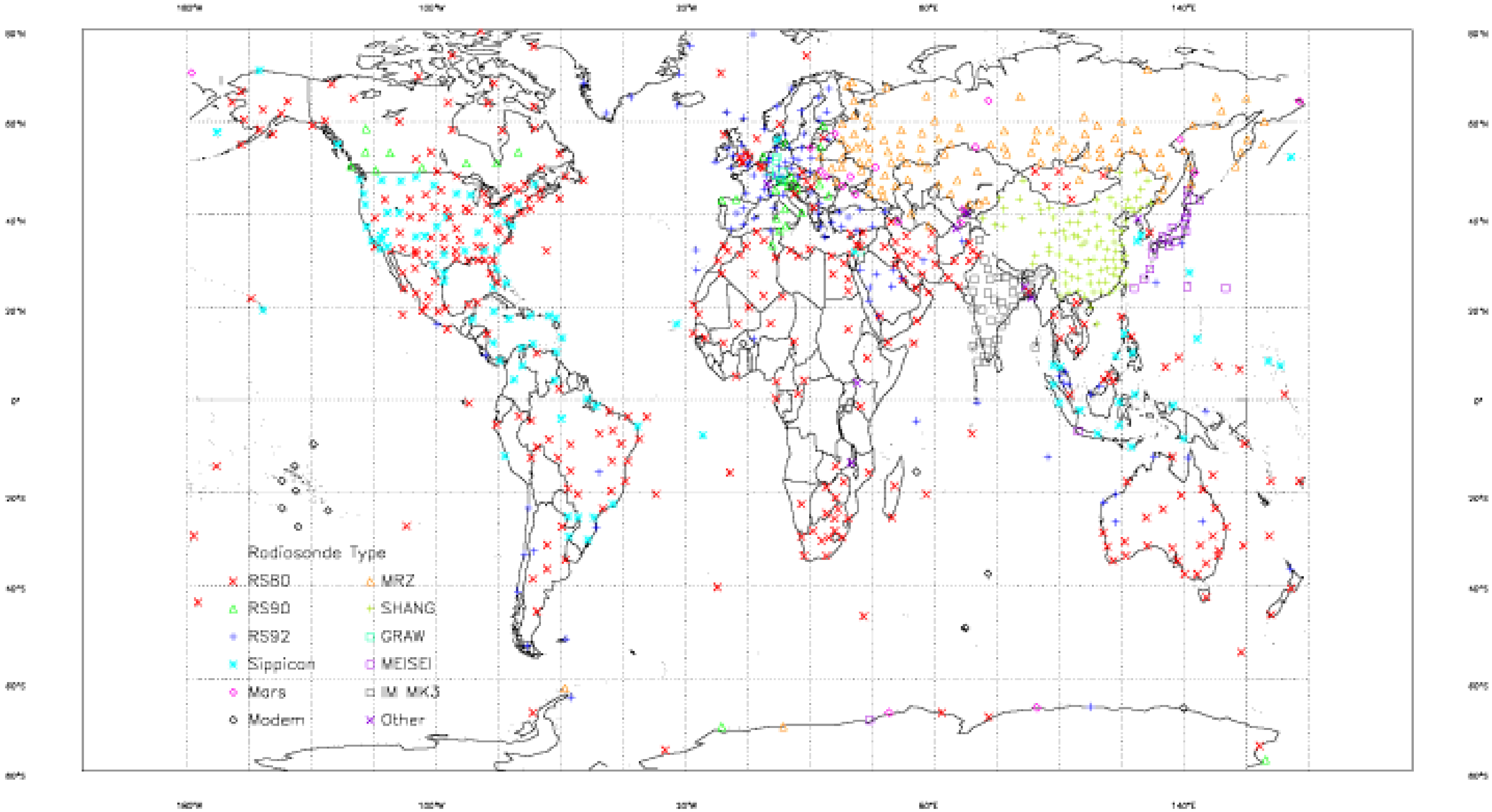
Manufacturer or Country of origin	Radiosonde type	Number of stations where used	Percentage of global network
Finland (Vaisala)	RS80 (PTU only) RS80 GPS RS80 Loran	118 130 37	33 [48]
	RS90 (PTU only) RS90 GPS RS90 Loran	1 12 25	4 [6]
	RS92 (PTU only) RS92 GPS RS92 Loran	9 106 18	16 [0]
	Total:	**456** [431]	**53** [54]
'VIZ' TYPES	VIZB MSS Microsonde II JYANG **Total:**	49 4 29 3 **85** [76]	**10** [9]
Former USSR	MRZ MARS (Meteorit) **Total:**	107 13 **120** [115]	**14** [15]
China	SHANG	**90** [89]	**11** [11]
India	IM - MK3	**35** [34]	**4** [4]
Japan	MEISEI (R80/R91)	**20** [24]	**2.5** [3]
France	MODEM (MK2K)	**20** [0]	**2.5** [0]
Others:	GRAW(German) ML-SRS (Swiss) POIN (N Korea) Total:	8 1 1 **10** [7]	**1** [1]
Unknown	Unknown	**20** [21]	**2** [3]
TOTALS		**856** [797]	**100** [100]

There has been surprisingly little change in the distribution of radiosonde types since the last Rapporteur's Report in 2002. However areas of significance reflected in the above table are:-

- The gradual introduction of the Vaisala RS92 radiosonde as a replacement for the RS80 & RS90.
- The majority of the former USSR network using the MRZ design.
- The introduction of the French MODEM design at a number of sites.

The following plot shows the global distribution of different radiosonde types.

Distribution of Main Operational Radiosonde Types (2006)



The analyses in the Rapporteur's report are based on statistics of radiosonde height biases and random errors for each station throughout the world, obtained by comparing the mean observations of geopotential height with the model field. The data used to generate these statistics were originally produced by the European Centre for Medium Range Forecasting (ECMWF). They are assimilated from monthly summaries of the mean difference and standard deviation of the differences between radiosonde observations (OB) and collocated ECMWF First Guess (FG) fields. The ECMWF FG fields are forecasts from an analysis based on observations produced 6 hours earlier than the observations under evaluation. These monthly values have been averaged together for 3 months. The resultant database supports system evaluation of UK radiosonde operations and the specialised investigations of the Commission for Instruments and Methods of Observation (CIMO) Rapporteur.

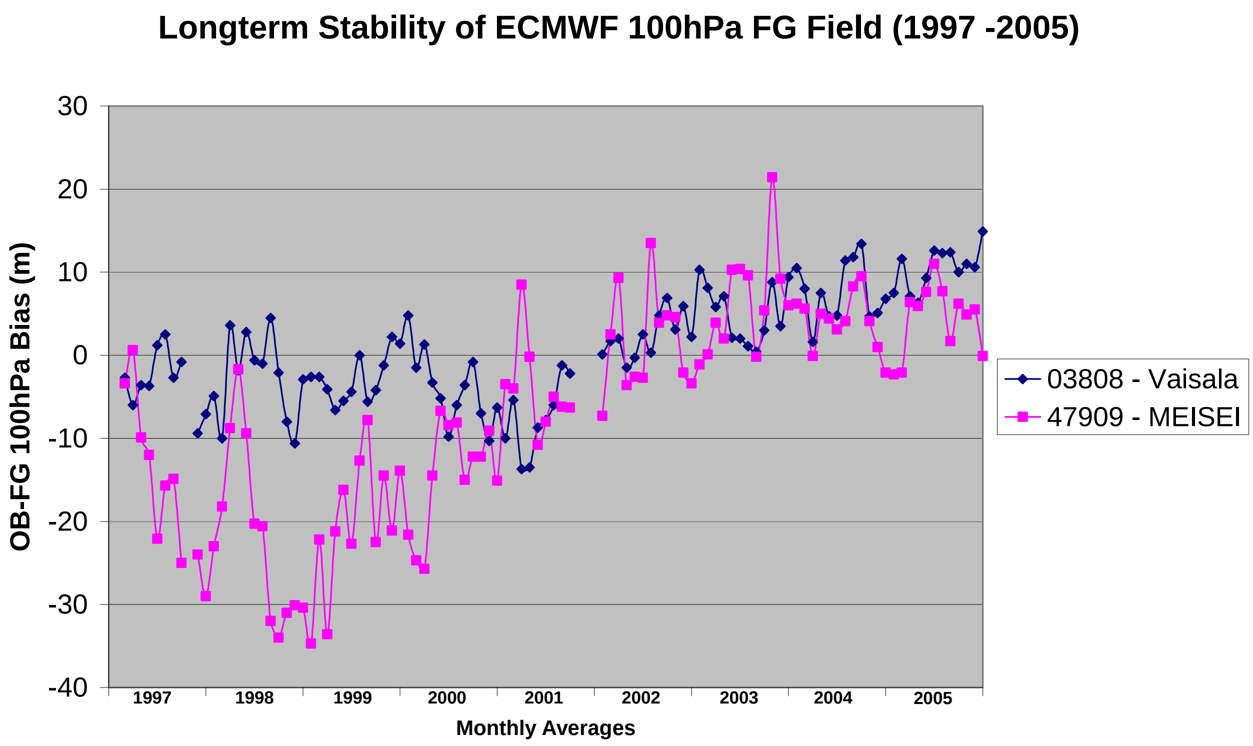
The 100 hPa and 30 hPa geopotential FG fields are used as working references for the observations in this study because the random errors in first guess forecast errors at these heights are relatively small. In addition, it has been found that the forecast fields are not influenced too heavily by local errors in geopotential height observations. This is probably because the forecast heights are consistent with and influenced by local upper wind observations.

In order to check the stability of the ECMWF fields, the values of (OB-FG) for Vaisala RS80 (Finland), Sippican (USA) and Meisei (Japan) at 00UTC and 12UTC were averaged for 2004 to 2005 inclusive. These are compared with the values for 1998 to 2001 and 1995 to 1997 in the Table below. These 3 radiosonde types are considered the most reproducible of the current types in use and represent about 65% of systems used throughout the world. The table shows that the zonal biases for 2004 to 2005 have increased on average by about 20m from those of 1998 to 2001, which at the 100 hPa height corresponds to a change of about 0.3 K in mean layer temperature from the surface to 100 hPa. (When compared to the 1995-1997 figures the increased bias is 13m corresponding to a change of about 0.2K)

	60S to 30S	**30S to 0S**	**0N to 30N**	**30N to 60N**	**60N to 90N**
100 hPa 00UTC 2004-2005	**16 (26)**	**19 (53)**	**17 (65)**	**13 (198)**	**5 (36)**
100 hPa 12UTC 2004 -2005	**16 (30)**	**20 (55)**	**18 (76)**	**11 (200)**	**7 (37)**
100 hPa 00UTC 1998-2001	-4 (25)	-5 (48)	-10 (64)	-5 (192)	-8 (35)
100 hPa 12UTC 1998 -2001	0 (25)	2 (48)	-9 (72)	-8 (190)	-8 (36)
100 hPa 00UTC 1995-1997	3 (25)	-3 (48)	0 (75)	1 (170)	-2 (34)
100 hPa 12UTC 1995-1997	7 (22)	7 (40)	0 (75)	-2 (170)	-1 (36)

Table 8: Variation of Mean (OB-FG) 100 hPa Geopotential Height (m) Bias with Latitude

It is likely that this increase in the zonal bias can be attributed to a change in the ECMWF model fields rather than a large scale change in the performance of the global radiosonde network. The plot below shows a nine year time series of monthly statistics for 2 radiosonde stations (Camborne, UK 03808 using Vaisala equipment and Naze, Japan 47909 using MESEI equipment). Although the performance of the system at Naze is somewhat less reliable before mid-2000 it is clearly evident that both stations show a positive trend in their OB-FG Bias measurements, representing a shift of around 15m at these latitudes.



The Rapporteur's final report (copies available at the conference) will provide a more detailed analysis of the performance of different radiosonde types within the global network. The following plots show typical performance statistics of bias and standard deviation (July – Sept 05) as follows:

Plot 1: Vaisala Radiosonde Type 100hPa OB-FG Bias (00utc & 12utc v Solar Elev.)

Plot 2: Vaisala Radiosonde Type 100hPa OB-FG SD (00utc & 12utc v Solar Elev.)

Plot 3: Sippican Radiosonde Type 100hPa OB-FG Bias (00utc & 12utc v Solar Elev.)

Plot 4: Sippican Radiosonde Type 100hPa OB-FG SD (00utc & 12utc v Solar Elev.)

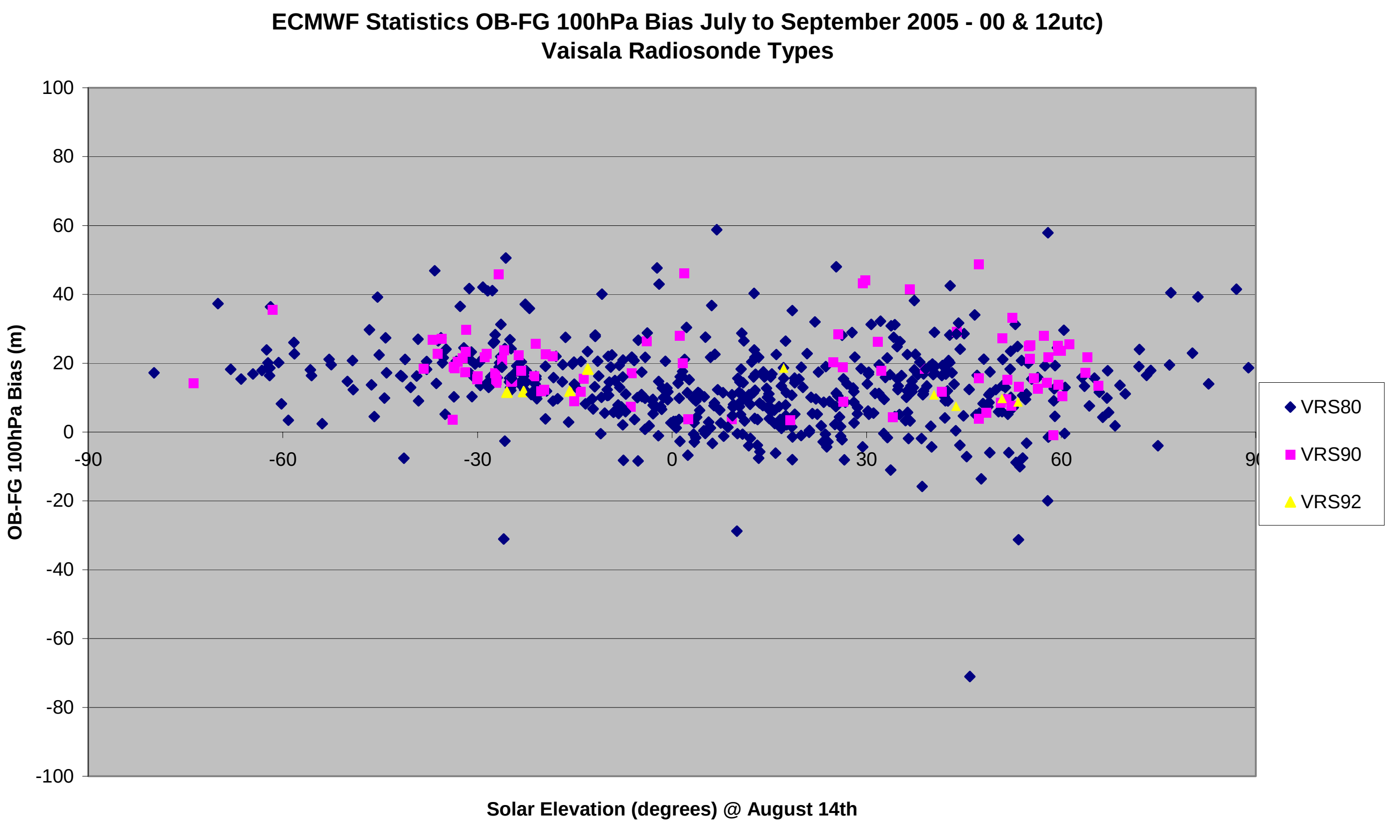
Plot 5: MRZ/MARS/GRAW Type 100hPa OB-FG Bias (00utc & 12utc v Solar Elev.)

Plot 6: MRZ/MARS/GRAW Type 100hPa OB-FG SD (00utc & 12utc v Solar Elev.)

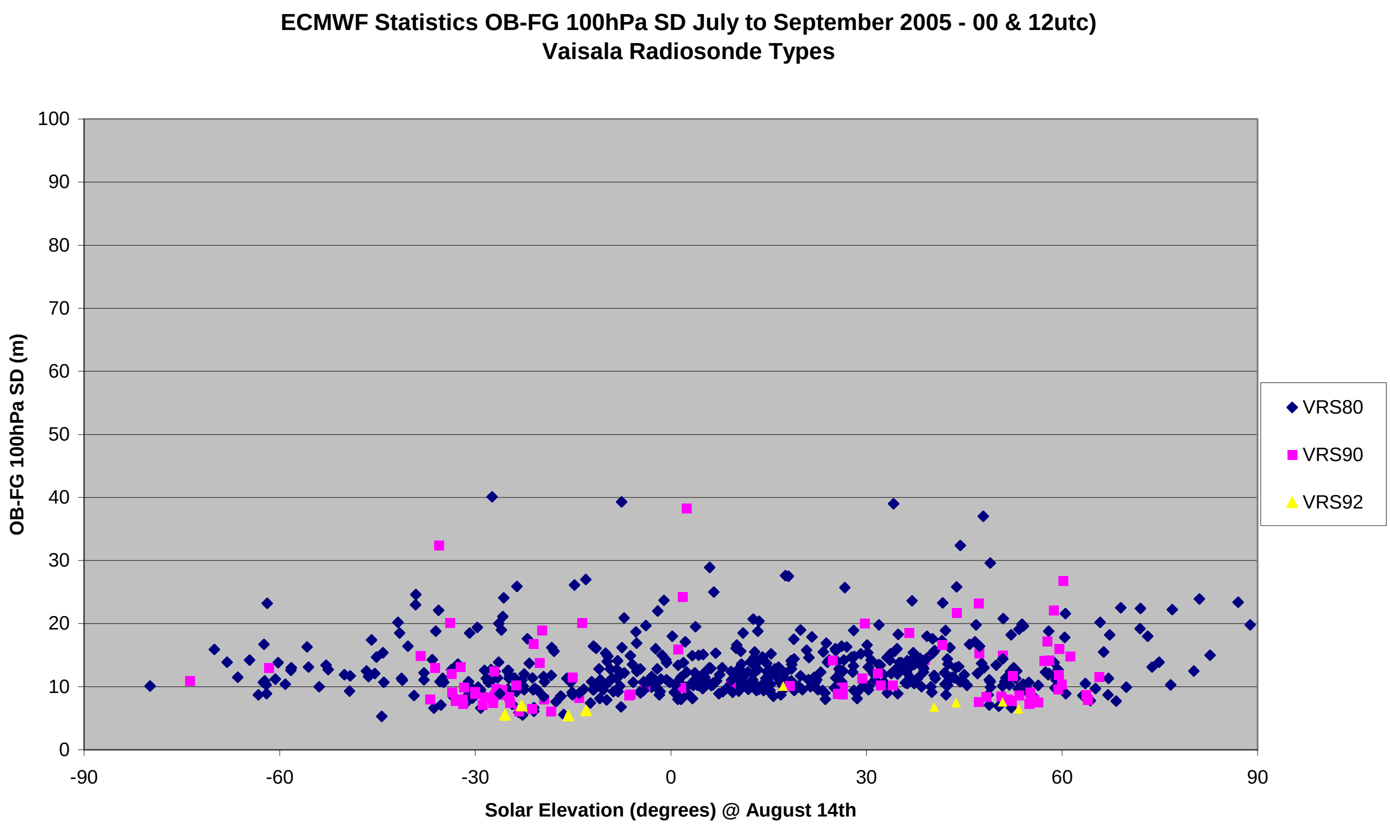
Plot 7: China/India/Japan Type 100hPa OB-FG Bias (00utc & 12utc v Solar Elev.)

Plot 8: China/India/Japan Type 100hPa OB-FG SD (00utc & 12utc v Solar Elev.)

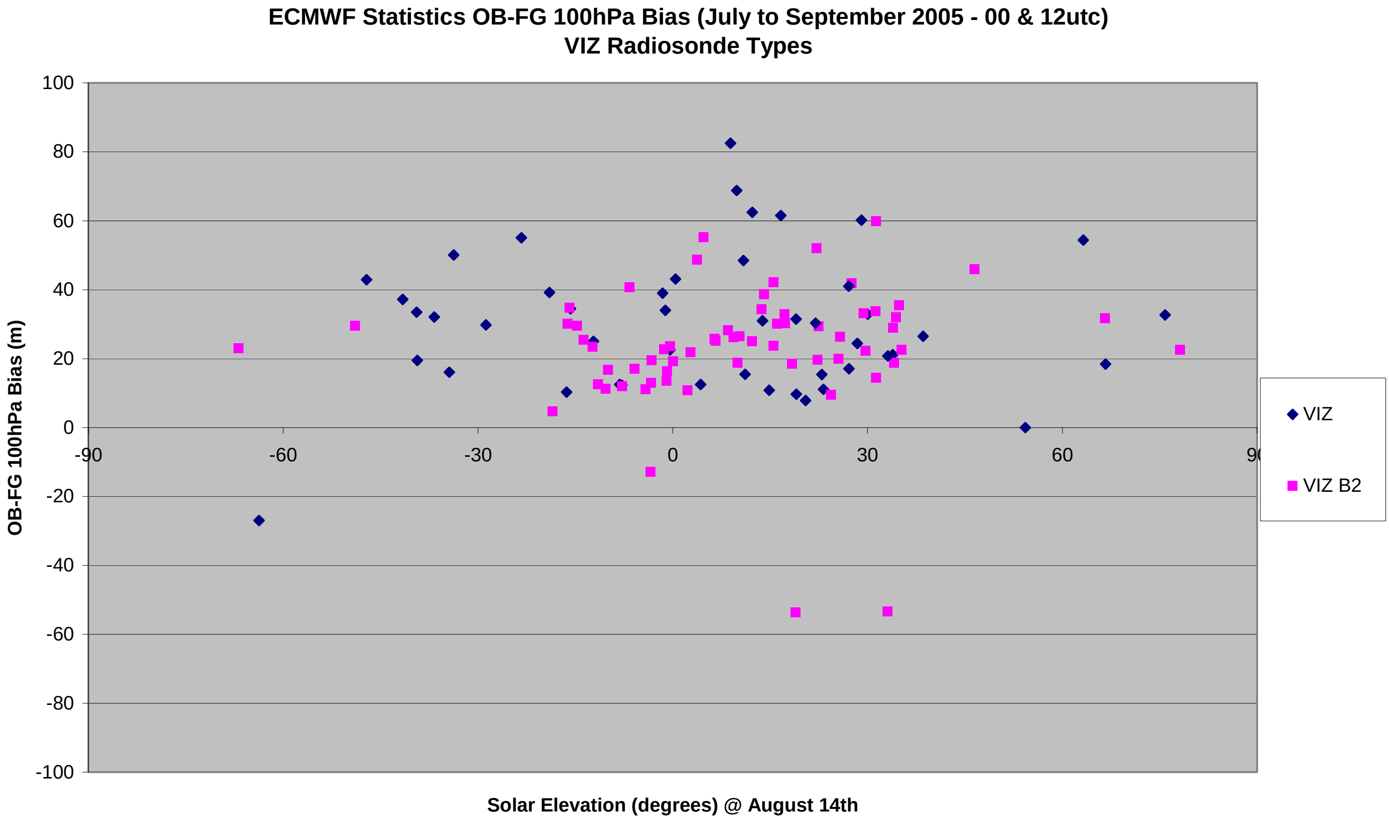
Plot 1


ECMWF Statistics OB-FG 100hPa Bias July to September 2005 - 00 & 12utc)
Vaisala Radiosonde Types
100
80
60
40
20
0
-20
-40
-60
-80
-100
-90
-60
-30
0
30
60
90
OB-FG 100hPa Bias (m)
Solar Elevation (degrees) @ August 14th
VRS80
VRS90
VRS92

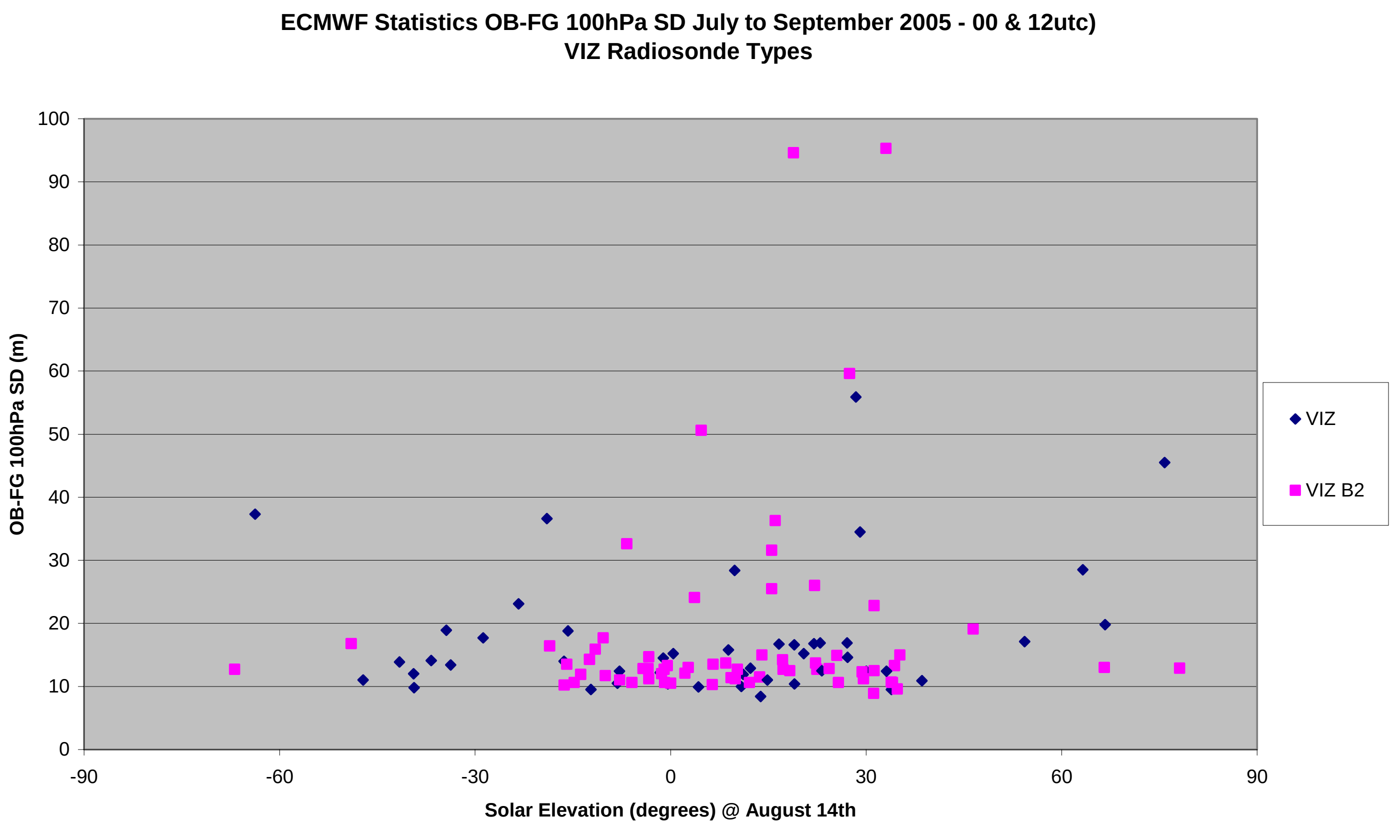
Plot 2


ECMWF Statistics OB-FG 100hPa SD July to September 2005 - 00 & 12utc)
Vaisala Radiosonde Types
100
90
80
70
60
50
40
30
20
10
0
-90
-60
-30
0
30
60
90
OB-FG 100hPa SD (m)
Solar Elevation (degrees) @ August 14th
VRS80
VRS90
VRS92

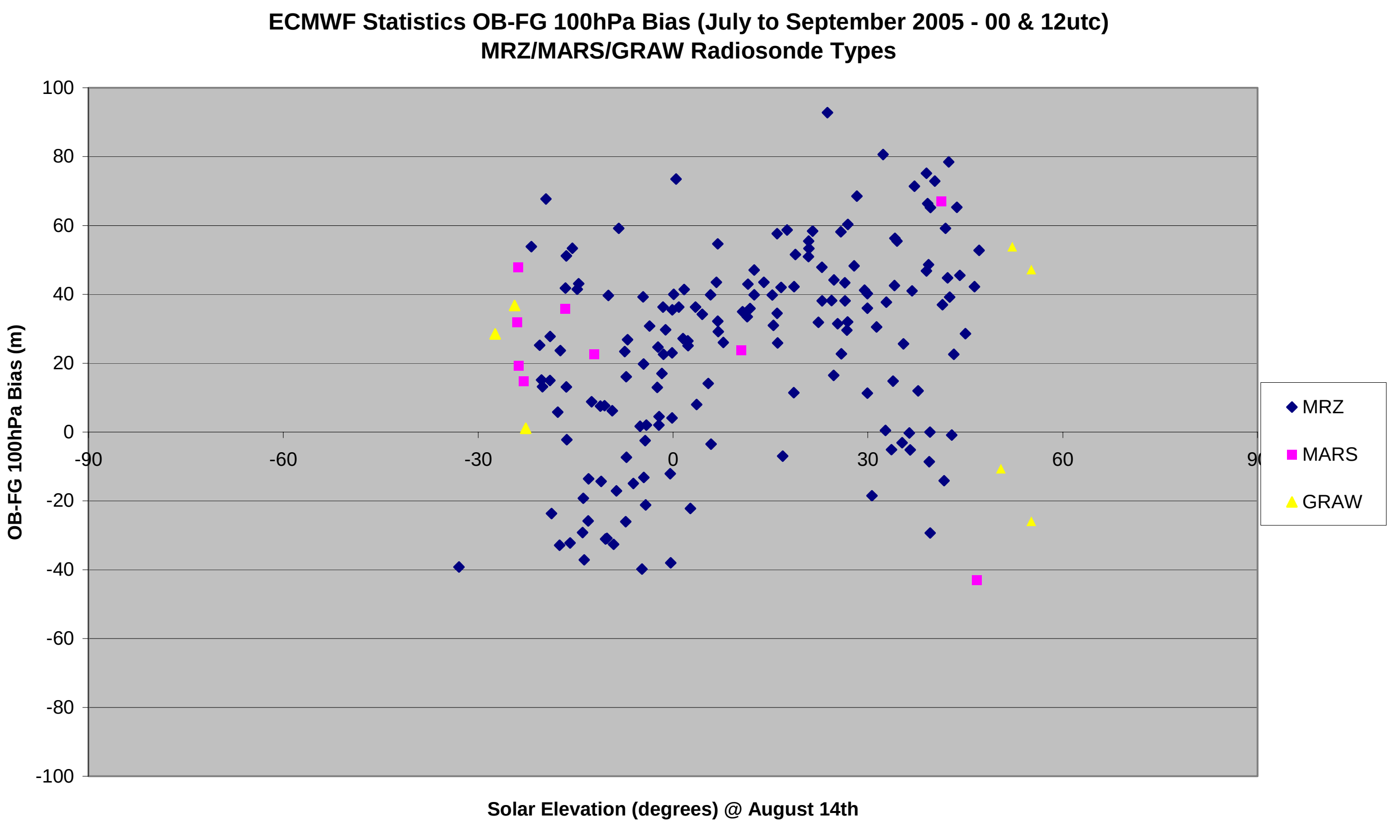
Plot 3


ECMWF Statistics OB-FG 100hPa Bias (July to September 2005 - 00 & 12utc)
VIZ Radiosonde Types
OB-FG 100hPa Bias (m)
100
80
60
40
20
0
-20
-40
-60
-80
-100
-90
-60
-30
0
30
60
90
Solar Elevation (degrees) @ August 14th
VIZ
VIZ B2

Plot 4

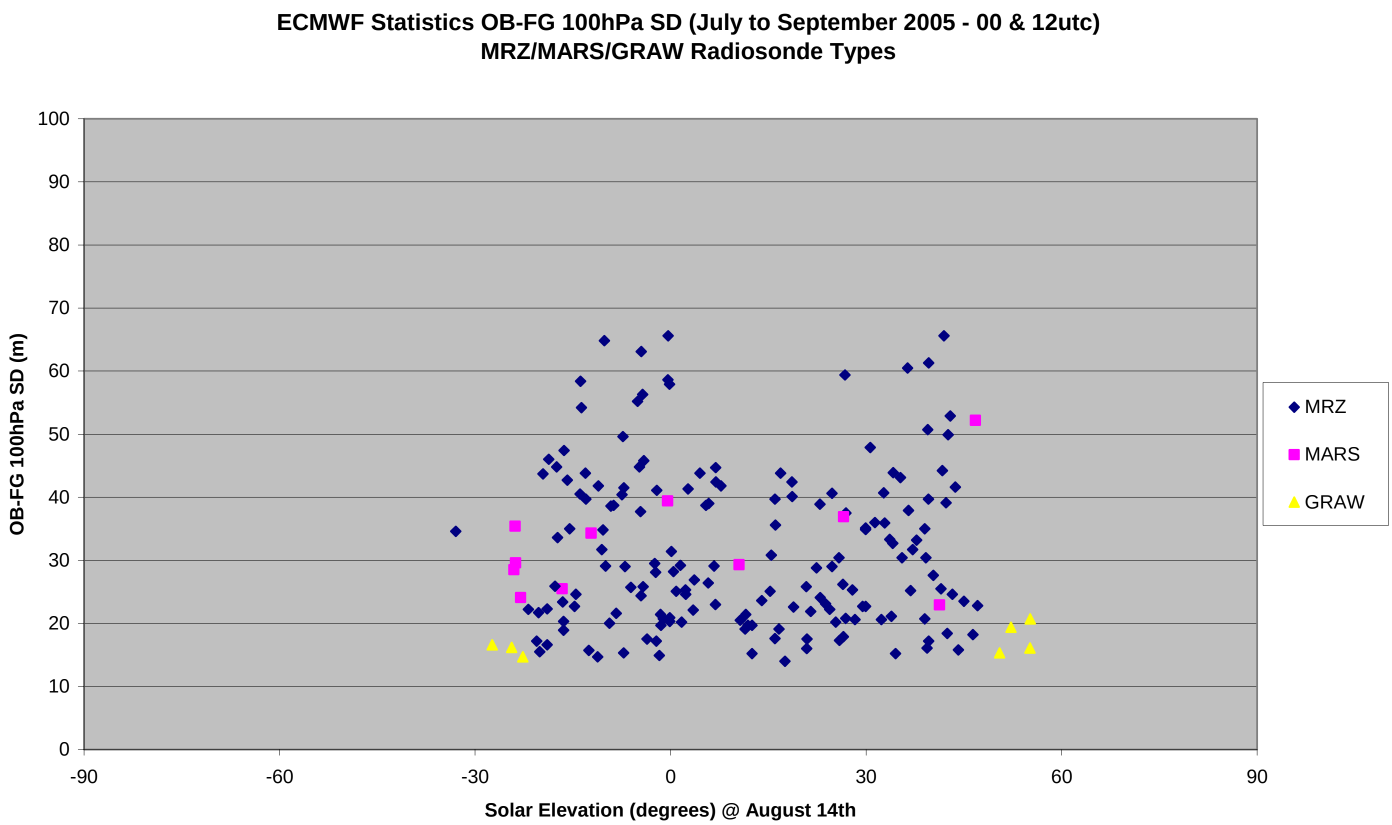

ECMWF Statistics OB-FG 100hPa SD July to September 2005 - 00 & 12utc)
VIZ Radiosonde Types
OB-FG 100hPa SD (m)
100
90
80
70
60
50
40
30
20
10
0
-90
-60
-30
0
30
60
90
Solar Elevation (degrees) @ August 14th
VIZ
VIZ B2

Plot 5



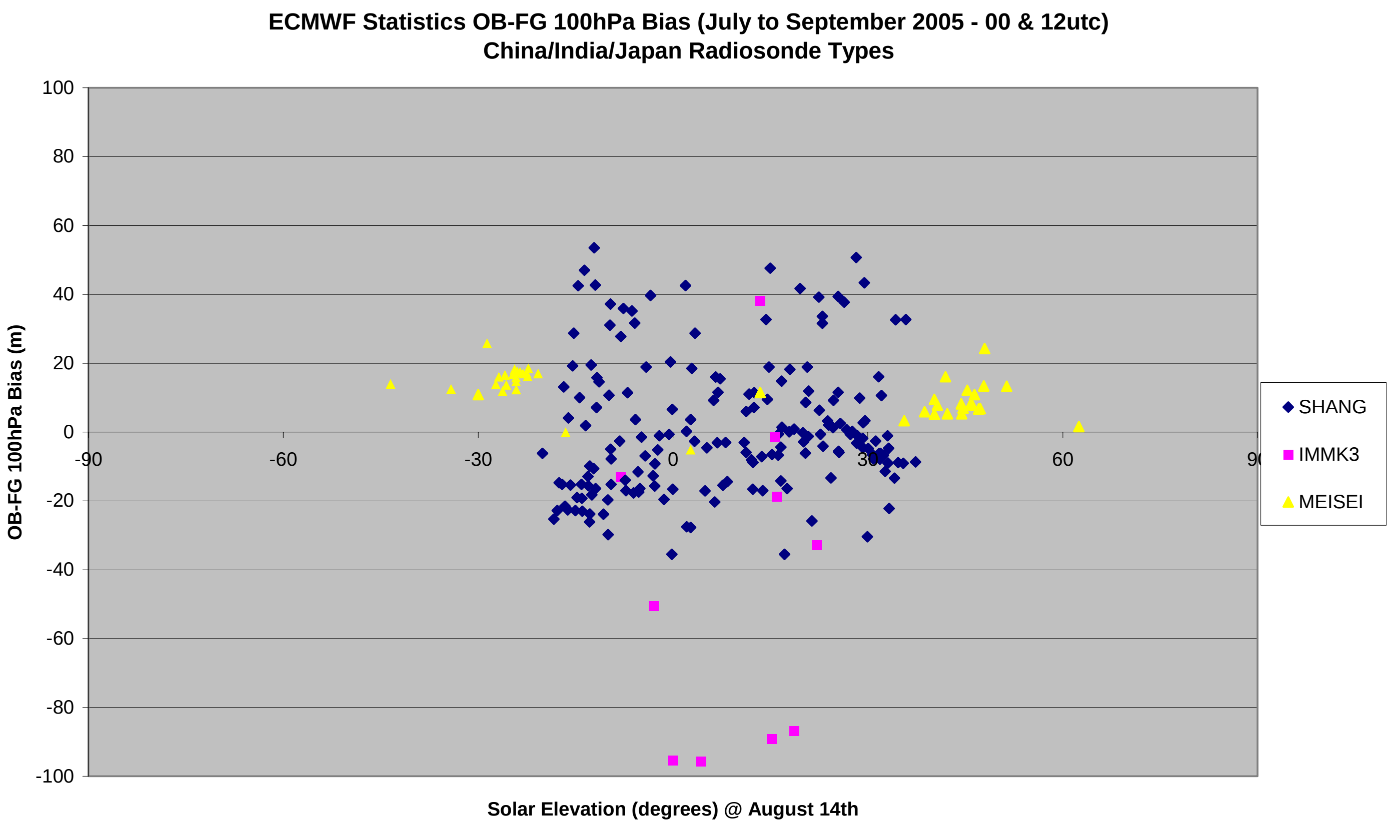
ECMWF Statistics OB-FG 100hPa Bias (July to September 2005 - 00 & 12utc)
MRZ/MARS/GRAW Radiosonde Types
OB-FG 100hPa Bias (m)
100
80
60
40
20
0
-20
-40
-60
-80
-100
-90
-60
-30
0
30
60
90
Solar Elevation (degrees) @ August 14th
MRZ
MARS
GRAW

Plot 6



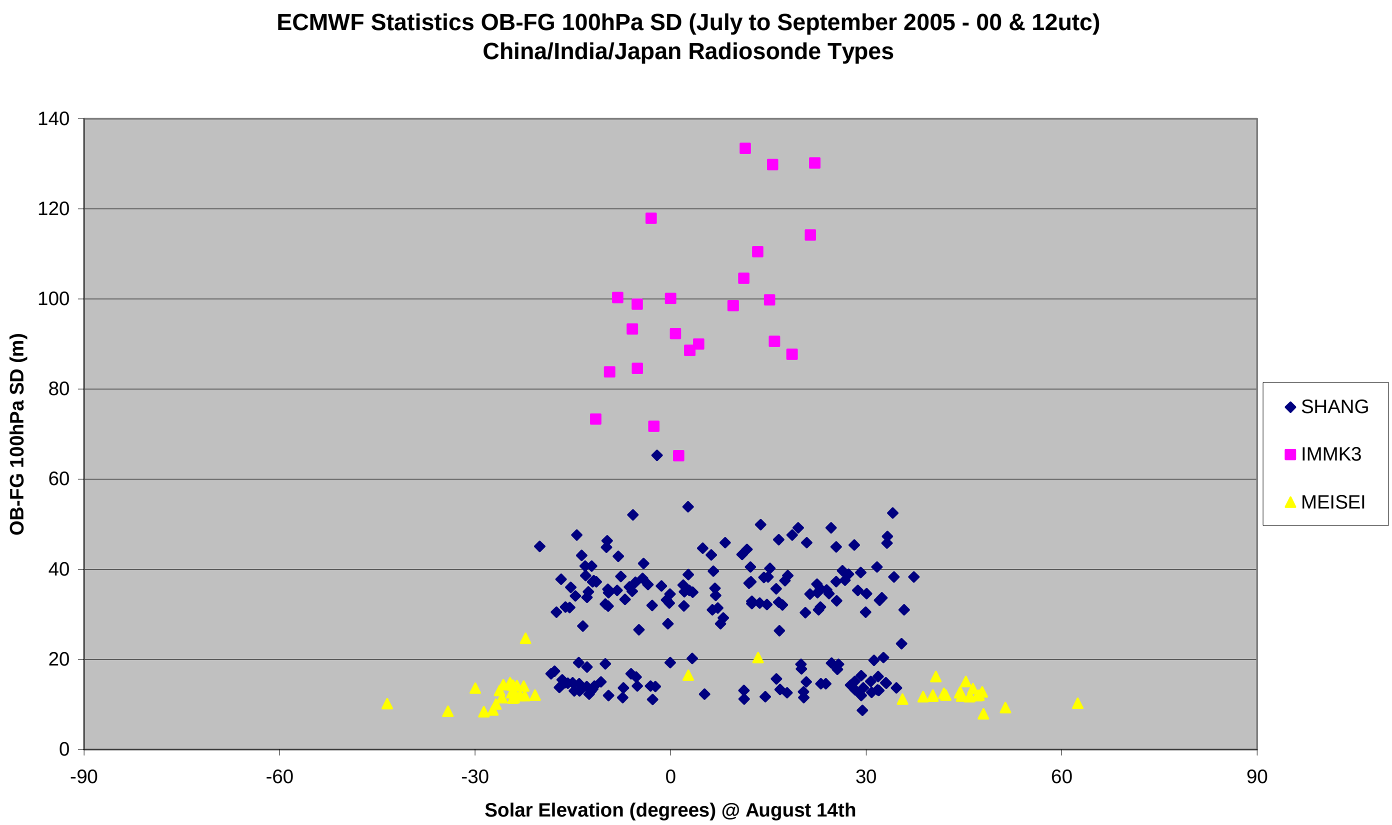
ECMWF Statistics OB-FG 100hPa SD (July to September 2005 - 00 & 12utc)
MRZ/MARS/GRAW Radiosonde Types
OB-FG 100hPa SD (m)
100
90
80
70
60
50
40
30
20
10
0
-90
-60
-30
0
30
60
90
Solar Elevation (degrees) @ August 14th
MRZ
MARS
GRAW

Plot 7



ECMWF Statistics OB-FG 100hPa Bias (July to September 2005 - 00 & 12utc)
China/India/Japan Radiosonde Types
OB-FG 100hPa Bias (m)
100
80
60
40
20
0
-20
-40
-60
-80
-100
-90
-60
-30
0
30
60
90
Solar Elevation (degrees) @ August 14th
SHANG
IMMK3
MEISEI

Plot 8



ECMWF Statistics OB-FG 100hPa SD (July to September 2005 - 00 & 12utc)
China/India/Japan Radiosonde Types
OB-FG 100hPa SD (m)
140
120
100
80
60
40
20
0
-90
-60
-30
0
30
60
90
Solar Elevation (degrees) @ August 14th
SHANG
IMMK3
MEISEI