

## Guideline on the exchange and use of EPS verification results

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### 1. Introduction

World Meteorological Organization (WMO) CBS-XIII (2005) recommended that the general responsibilities for a Lead Centre for Verification of EPS be added to *the Manual on the global data processing and forecasting system (GDPFS) (WMO-No.485; available at <http://www.wmo.int/pages/prog/www/manuals.html>)* and that the President designate RSMC Tokyo (Japan Meteorological Agency; JMA) as the Lead Centre.

JMA hosts two Internet sites for the Lead Centre works; a Web site and a FTP site. The FTP site is used for EPS producing centres to upload their statistics of EPS verification and the Web site is used to publish them. The Internet sites enable EPS producers to make their own statistics of EPS verification open to the WMO Members. The Internet sites also enable the WMO Members to obtain not only the statistics but also their visualized images.

This guideline is organized as follows. Section 2 describes definitions of the EPS verification. Section 3 describes how to record and read the statistics on the Internet sites for EPS producers and the WMO Members, respectively. Section 4 describes the rule of the report, and section 5 describes how to obtain the EPS verification scores. Section 6 describes how to post the statistics on the FTP site only for EPS producers.

### 2. Definition of standard EPS verification

It is defined at *the Attachment II.7, Table F, Section III of the Manual on the GDPFS* (See Appendix A) that standard verification of an EPS are exchanged monthly to measure the forecast skill of ensemble mean, spread and probability with respect to the analysis and/or climatology. The factors and definitions of the measure are also explained in Table 1.

### 3. The statistics of EPS verification

#### 3.1 The verification table of ensemble mean and spread

The verification table, called the deterministic table here, is defined as follows: A header line, which starts with “#”, should be put at the head of the deterministic table. The header line should consist of 5 elements as follows:

# <Center name> <Element> <Year> <Month> <Area>  
where <term> indicates a keyword which is listed up in Table 2.

The first, second, third, fourth and fifth column of the table following the header line indicates the number, forecast time, anomaly correlation coefficient of the ensemble mean, root-mean-square (RMS) error of the ensemble mean and spread (standard deviation), respectively.

Some spaces, at least one, are necessary among each column as a separator.

A comment line, which starts with “!”, can be put anywhere.

### 3.2 Reliability table

The table is complied with Standardized Verification System (SVS) for long-range forecasts (LRF) (*Table 6 in Attachment II.8 of the Manual on the GDPFS*). The table is quoted as Table 3 in the document.

A header line, which starts with “#”, should be put at the head of the reliability table. The header line should consist of 7 elements as follows:

# <Center name> <Element> <Threshold> <Year> <Month> <Area>  
<Forecast time>

where <term> indicates a keyword which is listed up in Table 2.

The first, second, third, fourth and fifth column of the table following the header line indicates the bin number, the number of members forecasting occurrence of the event, the number of members forecasting non occurrence of the event, observed occurrences and observed non-occurrences, respectively.

Some spaces, at least one, are necessary among each column as a separator.

A comment line, which starts with “!”, can be put anywhere.

### 3.3 The verification table of continuous rank probability score (CRPS)

The verification table, called the CRPS table here, is defined as follows: A header line, which starts with “#”, should be put at the head of the CRPS table. The header line should consist of 5 elements as follows:

# <Center name> <Element> <Year> <Month> <Area>  
where <term> indicates a keyword which is listed up in Table2.

The first, second, third and fourth column of the table following the header line indicates the number, forecast time, CRPS for EPS forecast distribution, CRPS for the control forecast in EPS, respectively. CRPS for deterministic forecast is equal to the mean absolute error. If CRPS for the control forecast in EPS is not being reported, the fourth column has to be set “-1” instead.

Some spaces, at least one, are necessary among each column as a separator.

A comment line, which starts with “!”, can be put anywhere.

#### 4. Rule of the report on the verification table

The reliability table, the CRPS table and the deterministic table should be reported with an ascii file(s)(See Appendix B, C and D). The file name of the verification table should comply with the following rule;

<Center name>\_<Classification>\_<Year><Month>.txt

where <term> indicates a keyword which is listed up in Table 2.

If EPS producer would like to add and/or update the verification table after reporting it, she/he has to overwrite it using the same file name.

#### 5. How to get the verification table

JMA operates a Web site for both exchanging the statistics and publishing them. The name and address of the Web site are EPSV and <http://epsv.kishou.go.jp/EPSv/>, respectively.

#### 6. How to post the verification table

JMA operates a FTP site which is used for EPS producers to report their statistics of EPS verification. The name and address of the ftp site are FTPEPSV and <ftp://ftpepsv.kishou.go.jp>, respectively.

##### 6.1 Registration

The ftp site is allowed to access only from the registered site. The EPS producer should notify the administrator ([epsv-admin@naps.kishou.go.jp](mailto:epsv-admin@naps.kishou.go.jp)) of the IP address(es) (for example, 11.22.33.44) of her/his own site.

JMA will send the EPS producer the login information of FTPEPSV, such as user name, at least in one month after the notification.

##### 6.2 Post

The EPS producer is able to login FTPEPSV with the user name and the password provided. She/He put the monthly verification table on her/his home directory of FTPEPSV.

The verification table is available by accessing EPSV (see section 5) in a day after they are put on FTPEPSV.

Table 1: Factors and definitions used in the EPS verification

Area	Northern hemisphere extratropics (90N-20N) Tropics (20N-20S) Southern hemisphere extratropics (20S-90S)
Grid	Verifying analysis and climatology are the centre's on a latitude-longitude grid 2.5x2.5
Ensemble mean	$\tilde{F}_i = \frac{1}{m} \sum_{j=1}^m F_{i,j}$
Spread (Standard Deviation)	$\sqrt{\frac{1}{m} \sum_{j=1}^m (F_{i,j} - \tilde{F}_i)^2}$
Root Mean Square Error	$\sqrt{\overline{e_i^2}}$
Mean Absolute Error	$\overline{ e_i }$
Anomaly Correlation Coefficient	$\frac{\sum_{i=1}^n (f_i - \bar{f}_i) (a_i - \bar{a}_i) \cos \varphi_i}{\sqrt{\sum_{i=1}^n (f_i - \bar{f}_i)^2 \cos^2 \varphi_i \cdot \sum_{i=1}^n (a_i - \bar{a}_i)^2 \cos^2 \varphi_i}}$
Brier Score	$\overline{(P_i - O_i)^2}$
Continuous Rank Probability Score	$\int_{-\infty}^{\infty} [\hat{P}_i(x) - \hat{O}_i(x)]^2 dx \quad \dagger$

where  $F_i$ : forecast value,  $A_i$ : corresponding verifying value,

$C_i$ : corresponding climatological value,

$P_i$ : probability,  $O_i$ : {observed:1, or not-observed:0},

$m$ : the ensemble size,

$n$ : the number of grid points in the verification area,

$\cos \varphi_i$ : cosine of latitude of grid point  $i$

$$e_i = F_i - A_i, \quad f_i = F_i - C_i, \quad a_i = A_i - C_i,$$

$$\hat{P}_i(x) = \frac{1}{m} \sum_{j=1}^m H(x - F_{i,j}), \quad \hat{O}_i(x) = H(x - A_i),$$

$$H(x) = \begin{cases} 0 & (x < 0) \\ 1 & (x \geq 0) \end{cases},$$

$$\bar{X}_i = \frac{\sum_{i=1}^n X_i \cos \varphi_i}{\sum_{i=1}^n \cos \varphi_i}.$$

<sup>†</sup> E.g. H. Hersbach, 2000: Decomposition of the continuous ranked probability score for ensemble prediction systems. *Wea. Forecasting*, **15**, 559-570

Table 2 : List of keywords

Element	Keyword (Bold)			
<Center name>	<b>BOM,CMA,CMC,CPTEC,EC MWF,JMA,KMA,MF,NCEP,RUMS,UKMO</b>		Abbreviation of EPS producer	
<Classification>	<b>RELTBL , ACCERRSPD or CRPS</b>		RELTBL	The reliability table
			ACCERRSPD	The scores of ensemble mean forecast and the spread
			CRPS	The continuous rank probability scores of ensemble forecast and deterministic forecast
<Element >	<b>Z500anm T850anm PMSLanm Z500 T850 PMSL W850 U850 V850 U250 V250 PR24</b>		Z500anm	Anomaly for 500hPa geopotential height (unit:m)
			T850anm	Anomaly for 850hPa temperature (unit:K)
			PMSLanm	Anomaly for mean sea-level pressure (unit:hPa)
			Z500	500hPa geopotential height (unit:m)
			T850	850hPa temperature (unit:K)
			PMSL	Mean sea-level pressure (unit:hPa)
			W850	850hPa wind speed (unit:m/s)
			U(V)850	850hPa u(v) wind component (unit:m/s)
			U(V)250	250hPa u(v) wind component (unit:m/s)
			PR24	24-hour accumulated precipitation (unit:mm)
			<Threshold>	Z500anm, T850anm or PMSLanm
lt	Abbreviation of 'less than'			
sd	Abbreviation of 'Standard deviation'			
W850	<b>gt10mps,gt15mps or gt25mps</b>	mps		Abbreviation of 'm/s'
U850, V850, U250 or V250	<b>gt10P,gt25P,gt75P or gt 90P</b>	P		Abbreviation of 'percentile point of climatological chance (%)'
PR24	<b>gt1mm,gt5mm, gt10mm or gt25mm</b>	mm	Unit of precipitation	

<Year>	<b>2003, 2004, ...</b>	(Numeric) Target year	
<Month>	<b>01, 02, 03, 04, 05, 06, 07, 08, 09, 10, 11 or 12</b>	(Numeric) Target month	
<Area>	<b>NH, SH or TR</b>	NH	Northern Hemisphere extratropics (20N-90N)
		SH	Southern Hemisphere extratropics (20S-90S)
		TR	Tropics (20S-20N)
<Forecast time>	<b>24, 48, 72, 96, 120, ...</b>	(Numeric) forecast time (unit:hour)	

Table 3: The definition of reliability table (Source: *SVS for LRF of the Manual on the GDFFS*)

**Table 6**  
**General ROC contingency table for probabilistic forecasts of binary events with definitions of the different parameters. This contingency table applies when probability thresholds are used to define the different probability bins**

Bin number	Forecast probabilities	Observed occurrences	Observed non-occurrences
1	0-P <sub>2</sub> (%)	O <sub>1</sub>	NO <sub>1</sub>
2	P <sub>2</sub> -P <sub>3</sub> (%)	O <sub>2</sub>	NO <sub>2</sub>
3	P <sub>3</sub> -P <sub>4</sub> (%)	O <sub>3</sub>	NO <sub>3</sub>
...	...	...	...
n	P <sub>n</sub> -P <sub>n+1</sub> (%)	O <sub>n</sub>	NO <sub>n</sub>
...	...	...	...
N	P <sub>N</sub> -100 (%)	O <sub>N</sub>	NO <sub>N</sub>

In Table 6:

$n$  = the number of the  $n^{\text{th}}$  probability interval or bin  $n$ ;  $n$  goes from 1 to  $N$ ;

$P_n$  = the lower probability limit for bin  $n$ ;

$P_{n+1}$  = the upper probability limit for bin  $n$ ;

$N$  = the number of probability intervals or bins;

$O_n = \sum W_i (O)_i$ , ( $O$ ) being 1 when an event corresponding to a forecast in bin  $n$ , is observed as an occurrence; 0 otherwise. The summation is over all forecasts in bin  $n$ , at all grid points or stations;

$NO_n = \sum W_i (NO)_i$ , ( $NO$ ) being 1 when an event corresponding to a forecast in bin  $n$ , is not observed; 0 otherwise. The summation is over all forecasts in bin  $n$ , at all grid points  $i$  or stations  $i$ ;

$W_i = 1$  when verification is done at stations or at single grid points;  $W_i = \cos(\theta_i)$  at grid point  $i$ , when verification is done on a grid;  $\theta_i$  being the latitude at grid point  $i$ .



Appendix A : Latest standard verification measures of EPS (Source: *the Attachment II.7, Table F, Section III of the Manual of the GDPFS*) (To be modified to reflect the latest revision)

### **III – STANDARD VERIFICATION MEASURES OF EPS**

#### **EXCHANGE OF SCORES**

Monthly exchanges:

##### **Ensemble mean**

For verification of ensemble mean, the specifications in this table of the attachment for variables, levels, areas and verifications should be used.

##### **Spread**

Standard deviation of the ensemble averaged over the same regions and variables as used for the ensemble mean.

##### **Probabilities**

Probabilistic scores (excluding the CRPS) are exchanged in the form of reliability tables. Details of the format of the exchange of verification data are provided on the website of the Lead Centre for verification of EPS.

##### *List of parameters*

PMSL anomaly  $\pm 1$ ,  $\pm 1.5$ ,  $\pm 2$  standard deviation with respect to a centre-specified climatology. Verified for areas defined for verification against analysis.

Z500 with thresholds as for PMSL. Verified for areas defined for verification against analysis.

850 hPa wind speed with thresholds of 10, 15, 25 m s<sup>-1</sup>. Verified for areas defined for verification against analysis.

850 hPa u and v wind components with thresholds of 10<sup>th</sup>, 25<sup>th</sup>, 75<sup>th</sup> and 90<sup>th</sup> percentile points with respect to a centre-specified climatology. Verified for areas defined for verification against analysis.

250 hPa u and v wind components with thresholds of 10<sup>th</sup>, 25<sup>th</sup>, 75<sup>th</sup> and 90<sup>th</sup> percentile points with respect to a centre-specified climatology. Verified for areas defined for verification against analysis.

T850 anomalies with thresholds  $\pm 1$ ,  $\pm 1.5$ ,  $\pm 2$  standard deviation with respect to a centre-specified climatology. Verified for areas defined for verification against analysis.

Precipitation with thresholds 1, 5, 10, and 25 mm/24 hours every 24 hours verified over areas defined for deterministic forecast verification against observations.

Observations for EPS verification should be based on the GCOS list of surface network (GSN). Verification of precipitation may alternatively be against a proxy analysis i.e. short range forecast from the control or high-resolution deterministic forecast, e.g. 12-36h forecast to avoid spin-up problems.

NOTE: Where thresholds are defined with respect to climatology, the daily climate should be estimated.

#### *Scores*

Brier Skill Score (with respect to climatology) (see definition below\*)

Relative Operating Characteristic (ROC)

Relative economic value (C/L) diagrams

Reliability diagrams with frequency distribution

Continuous Rank Probability Score (CRPS)

NOTES: Annual and seasonal averages of the Brier Skill Score at 24, 72, 120, 168 and 240 hours for Z500 and T850 should be included in the yearly Technical Progress Report on the Global Data-processing System.

In the case of CRPS, centres are encouraged to submit this for both EPS and the deterministic (control and high-resolution) forecast as well – CRPS for deterministic forecast is equal to the mean absolute error.

Appendix B : A sample of the content of a deterministic table

--- start ---

# JMA PMSL 2003 10 NH

1 24 0.977 1.727 2.126

2 48 0.944 2.673 2.929

3 72 0.892 3.659 3.791

4 96 0.829 4.566 4.673

5 120 0.755 5.374 5.482

6 144 0.681 6.024 6.179

7 168 0.606 6.552 6.697

8 192 0.523 7.040 7.029

9 216 0.446 7.405 7.316

! comment

# JMA T850 2003 10 NH

1 24 0.969 1.032 1.104

2 48 0.936 1.477 1.493

3 72 0.893 1.893 1.907

4 96 0.840 2.283 2.338

5 120 0.774 2.671 2.726

6 144 0.705 3.008 3.054

7 168 0.634 3.293 3.295

8 192 0.567 3.509 3.451

9 216 0.506 3.676 3.563

--- end ---

Appendix C : A sample of the content of a reliability table

--- start ---

# JMA PMSLanm gt1.5sd 2003 10 NH 24

1 0 25 22.05 55781.09  
2 1 24 22.3 2227.46  
3 2 23 26.95 1167.75  
4 3 22 30.56 728.55  
5 4 21 29.36 567.3  
6 5 20 30.33 453.26  
7 6 19 28.95 371.56  
8 7 18 36.06 314.66  
9 8 17 32.78 242.68  
10 9 16 34.58 228.72  
11 10 15 49.14 216.17  
12 11 14 50.52 206  
13 12 13 55.21 166.8  
14 13 12 54.14 124.92  
15 14 11 64.04 133.85  
16 15 10 70.51 97.28  
17 16 9 83.12 80.33  
18 17 8 77.79 72.42  
19 18 7 84.46 68.86  
20 19 6 118.51 54.69  
21 20 5 110.96 58.49  
22 21 4 149.15 54.08  
23 22 3 178.97 56.57  
24 23 2 223.6 55.37  
25 24 1 304.71 42.21  
26 25 0 1706.48 57.91

# JMA PMSLanm gt1.5sd 2003 10 NH 48

1 0 25 44.16 53376.69  
2 1 24 53.03 2873.91  
3 2 23 49.89 1417.19  
4 3 22 35.38 960.68  
5 4 21 35.32 703.11

6 5 20 43.64 581.41  
7 6 19 46.73 469.66  
8 7 18 52.89 424.78  
9 8 17 45.92 350.8  
10 9 16 44.21 336.88  
11 10 15 59.71 272.31  
12 11 14 63.77 230.68  
13 12 13 74.05 208.44  
14 13 12 67.93 206.62  
15 14 11 80.56 181.75  
16 15 10 89.66 165.36  
17 16 9 105.09 133.48  
18 17 8 109.73 135.43  
19 18 7 122.6 109.76  
20 19 6 125.97 110.21  
21 20 5 160.89 82.79  
22 21 4 187.03 81.05  
23 22 3 242.3 75.05  
24 23 2 258.44 51.92  
25 24 1 378.68 47.92  
26 25 0 1097.7 41.37  
--- end ---

Appendix D : A sample of the content of a CRPS table

```
--- start ---  
# JMA Z500 2009 01 NH  
1 24 5.328 7.095  
2 48 9.639 13.141  
3 72 14.797 20.579  
4 96 20.439 28.571  
5 120 26.131 36.681  
6 144 31.698 44.742  
7 168 36.586 51.677  
8 192 40.981 57.883  
9 216 44.582 63.157  
!comment  
# JMA Z500 2009 01 SH  
1 24 4.657 -1  
2 48 8.545 -1  
3 72 12.980 -1  
4 96 17.446 -1  
5 120 22.148 -1  
6 144 26.941 -1  
7 168 31.453 -1  
8 192 35.108 -1  
9 216 37.920 -1  
--- end ---
```