Global NWP Index documentation

The global index is calculated in two ways, against observations, and against model analyses. Observations are sparse in some parts of the world, and using full gridded analyses greatly increases the sample size.

Introduction

The Global Numerical Weather Prediction (NWP) Index (henceforth called the Index) is a measure of the forecasting skill of the global NWP model over persistence for up to 5 days ahead worldwide.

It is based on global model forecasts of selected parameters out to 5 days ahead for regions covering the whole globe verified by comparison with observations and model analyses, and is based on 36 months of data. A skill score is calculated for each forecast included in the index by normalising the forecast root mean square (*rms*) error against the persistence *rms* error. These errors are computed in accordance with the method recommended by WMO's Commission for Basic Systems (CBS). The skill scores for each parameter are then combined to form a single value using weights reflecting the agreed mission of the Met Office.

The Index is compiled from the following parameters

- mean sea-level pressure (PMSL)
- 500 hPa height (H500)
- 850 hPa wind (W850)
- 250 hPa wind (W250)

verified over the following areas

- Northern Hemisphere (NH)
- Tropics (TR)
- Southern Hemisphere (SH)

at the following forecast ranges

- T+24
- T+48
- T+72
- T+96
- T+120

The forecasts that are used to compute the Index are taken from the normal operational run of the global model that provides products to customers. Very occasionally operational problems occur which prevent this happening. In these cases backup forecasts from the previous normal run of the model are used to issue products to customers. Because these backup forecasts are actually 12 hours older than the normal forecasts, they are not used in the calculation of the Index.

This document gives a detailed description of the mechanisms used to calculate the index. It describes all of the stages from interpolation to the observation positions, through the calculation of *rms* errors and skill scores, to the final compilation of the Index.

For observations: interpolation from model grid to observation positions

(a) Horizontal

Currently the global NWP model has a horizontal grid length of 25 km at mid-latitudes. From 1st April 2000 WMO standard verification versus observations (see Appendix) is carried out on the model grid. A simple bilinear interpolation is used to calculate forecast values at the observation positions.

(b) Vertical

Verification of height and wind is carried out on standard pressure levels (i.e. 850 hPa, 500 hPa, 250 hPa). The interpolation from model levels to standard pressure levels and also the calculation of mean sea level pressure are carried out within the output processing of the Unified Model (UM), and are described within UM Documentation Paper S1.

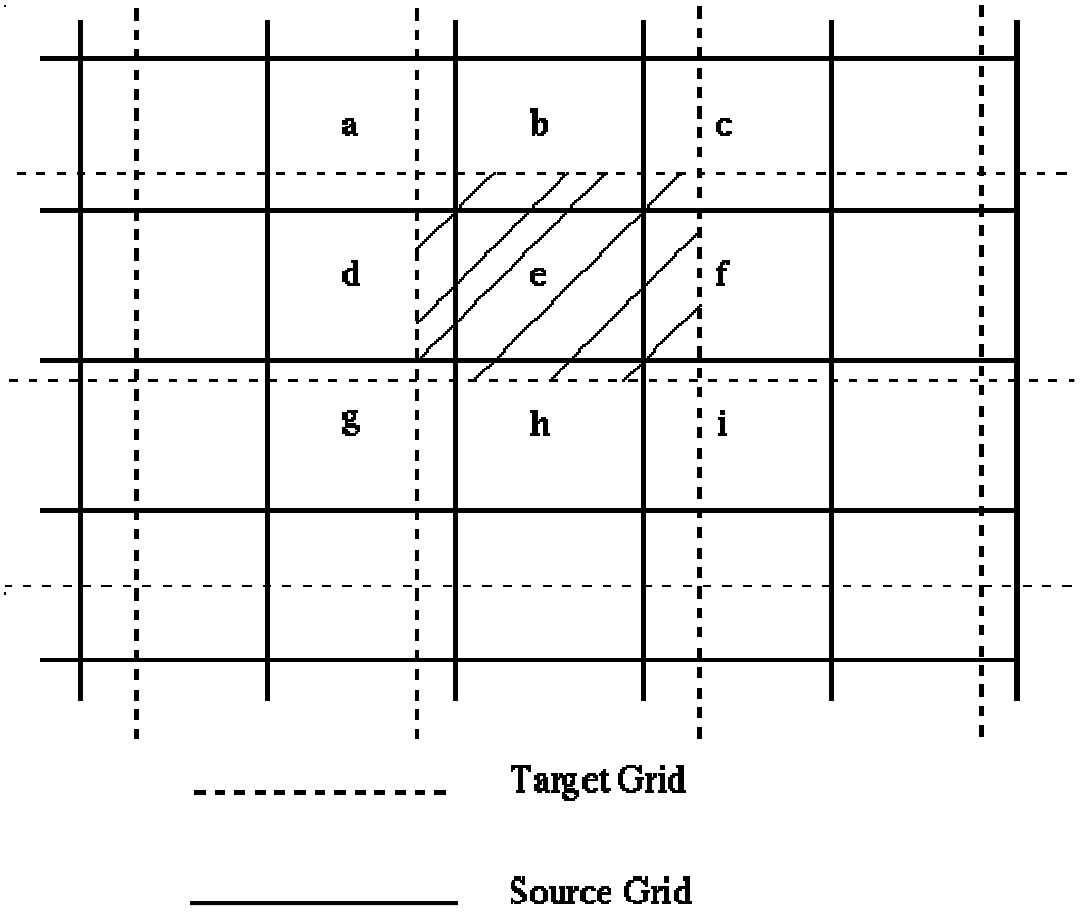
For analyses: interpolation from model grid to verification grid

(a) Horizontal

Currently the global NWP model has a horizontal grid length of 25 km at mid-latitudes. WMO standard verification versus analyses (see Appendix) is carried out on a grid of 2.5^{o} longitude by 2.5^{o} latitude.

The interpolation from the model grid to the WMO grid is carried out using an "area-weighted" technique. This technique weights the model grid points according to the fraction of the model grid square surrounding each model grid point, which overlaps the grid square surrounding each grid point on the WMO grid.

The following diagram illustrates the concept:



This diagram shows a target grid (dashed lines) overlaying a source grid (solid lines). One of the target grid squares is shaded. This square happens to cover nine of the source grid squares, and these are labelled 'a' to 'i'. The value placed into the shaded target square will consist of a weighted mean of the shaded source squares weighted in proportion to the amount of square which is shaded, e.g. source square 'e' will have a weight of 1, while source square 'g' will have a very small weight.

(b) Vertical

Verification of height and wind is carried out on standard pressure levels (i.e. 850 hPa, 500 hPa, 250 hPa). The interpolation from model levels to standard pressure levels and also the calculation of mean sea level pressure are carried out within the output processing of the Unified Model (UM), and are described within UM Documentation Paper S1.

Calculation of rms errors

Once the forecast values and the observations (or analysis fields on the verification grid) are available, the *rms* errors may be calculated. This process is performed according to standardised verification methods recommended by WMO, which are contained in Table F of Attachment II.7 of the Manual on the Global Data Processing System (WMO No. 485). (See Appendix.)

The WMO document describes two different standards of comparison - (a) against analyses, and (b) against observations. For the purposes of compiling the Index, we use the “verification against observations” standard. This requires using forecast values at observation positions (or analysis values at verification grid points) and calculating *rms* errors over 3 areas:

- NH (90N - 20N)
- TR (20N - 20S)
- SH (20S - 90S)

As stated in the Introduction, the Index is based on persistence skill scores. A persistence forecast is one where the fields remain the same as the initial conditions throughout the forecast period. Hence the calculation of, say, T+48 *rms* errors of the persistence forecast verifying at day N is achieved by comparing the analysis value at day N-2 with the observations or the analysis fields at day N.

Calculation of area and monthly averages

The second note at the end of the observation section of Table F of the WMO document states that:

"Values for these statistics should be computed daily (0000 UTC and 1200 UTC separately) for each specified network. Monthly averages should then be computed from the daily values of all forecasts verifying within the relevant month."

Note that for the purposes of calculating the Index, the networks referred to above are not used. Instead, all surface and upper air radiosonde observations, which have passed quality control within the global NWP model data assimilation, are used in the calculation of the statistics for each of the areas. This is in accordance with the first note at the end of the observation section of Table F which states that:

"The observations used for verification should be screened to exclude those with large errors. In order to do this, it is recommended that centres exclude values rejected by their objective analysis."

Calculation of skill scores

Once the forecast and persistence *rms* errors have been determined for a particular combination of parameter/area/forecast range and for a particular month, the monthly skill score may be calculated. This is defined in terms of Reduction of Variance, i.e.

$$SS = 1 - \frac{r_f^2}{r_p^2}$$

where:

r_f is the *rms* forecast error
r_p is the *rms* persistence error.

The smaller the ratio between forecast and persistence errors, the closer the skill score will be to 1 (perfection). If the forecast error is greater (worse) than the persistence error, then the skill score will be negative.

Compilation of the index

There are several further stages in the compilation of the Index from the skill scores.

Firstly a weighted average, S_j, of the individual skill scores for month j is calculated, the weights reflecting the agreed mission of the Met Office; many combinations of parameter/area/forecast range are given zero weighting.

$$S_j = \frac{1}{\sum_i w_i} \left(\sum_i \left(w_i SS_{i,j} \right) \right)$$

where:

w_i is the weight for the i-th component (see table below)
$SS_{i,j}$ is the skill score for the i-th component for month j.

The following table defines the weights, w_i, for each parameter/area/forecast range:

		Forecast Period				
		T+24	**T+48**	**T+72**	**T+96**	**T+120**
NH	**PMSL**	**10**	**8**	**6**	**4**	**4**
	H500	**6**	**4**	**2**	**-**	**-**
	W250	**12**	**-**	**-**	**-**	**-**
Tropics	**W850**	**5**	**3**	**2**	**-**	**-**
	W250	**6**	**-**	**-**	**-**	**-**
SH	**PMSL**	**5**	**4**	**3**	**2**	**2**
	H500	**3**	**2**	**1**	**-**	**-**
	W250	**6**	**-**	**-**	**-**	**-**

Once the weighted sum, S_j, has been calculated the monthly Index value, N_j, is defined as:

$$N_j = \sqrt{\frac{1}{1 - S_j}}$$

This has the effect of removing the restriction of 1 on the upper limit.

Then a 36-month mean, N, is calculated by simple averaging over the previous 36 months:

$$N = \frac{1}{36}\sum_{j} N_j$$

The Index, I, is normalised so that the value is equal to 100 on 31st March 2000.

Thus, the Index is defined as:

$$I = \frac{N}{N_0} \times 100$$

where:

N_0 is the value of N on 31st March 2000.

Precision

The preceding calculations are carried out partly on the supercomputer and partly on the workstation. All calculations are carried out 'exactly' using floating point arithmetic, and using the following units: PMSL in Pascals, heights in metres and winds in metres per second.

The Global NWP Index (Observations) is then combined with the Global NWP Index (Analyses) to produce the Global NWP Index.

Appendix

WMO No. 485 "Manual on the Global Data Processing System" can be downloaded from the following link:
http://www.wmo.int/pages/prog/www/DPS/Manual/WMO485.pdf
Table F of Attachment II.7 is on pages 120-127, and is referenced from p88.

Owner: verification team
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