Appendix A.II.2.1.1-a

MINIMUM LIST OF GLOBAL DETERMINISTIC NWP PRODUCTS TO BE MADE AVAILABLE ON THE WIS

Parameter	Level	Resolution	Forecast range	Time steps	Frequency
Geopotential height	850/500/250	1.5º x 1.5º	Up to 3d / Beyond 3d up to 6d	Every 6h / Every 12h	Twice a day (00 and 12 UTC) / Once a day
Temperature	850/500/250				
u,v	925/850/700/500/250				
Relative humidity	850/700				
Divergence, vorticity	925/700/250				
MSL pressure	Surface				
2m Temp 10m u, 10m v Total precipitation	Surface				

Additional recommended products

- Tropical storm tracks (lat/lon locations, maximum sustained wind speed, MSLP)~~None~~

Appendix A.II.2.1.2-a

MINIMUM LIST OF LIMITED AREA DETERMINISTIC PRODUCTS TO BE MADE AVAILABLE ON THE WIS

Parameter	Level	Resolution	Forecast range	Time steps	Frequency
Geopotential height	925/850/700/500/250	0.5° x 0.5°	1d	Every 6h	Twice a day
Temperature	925/850/700/500/250				
u,v	925/850/700/500/250				
Relative humidity	925/850/700/500				
Divergence, vorticity	925/850/700/500/250				
MSL pressure	Surface				
2m Temp 10m u, 10m v Total precipitation	Surface				

Additional recommended products

- Vertical velocity
- Cloud cover
- Tropical storm tracks (lat/lon locations, maximum sustained wind speed, MSLP)

Appendix II.2.1.2-b

CHARACTERISTICS OF LIMITED AREA DETERMINISTIC NWP SYSTEMS

1. System
System name
Date of implementation
2. Configuration
Domain
Horizontal resolution of the model, with indication of grid spacing in km
Number of model levels
Top of model
Forecast length and forecast step interval
Runs per day (Times in UTC)
Is model coupled to an ocean, waves, sea ice models? Specify which models
Integration time step
Additional comments
3. Initial conditions
Data assimilation method
Additional comments
4. Surface Boundary Conditions
Sea-surface temperature? If yes, briefly describe method(s).
Land surface analysis? If yes, briefly describe method(s).

Additional comments
5. Lateral Boundary Conditions
Model providing lateral boundary conditions
Lateral boundary conditions update frequency
6. Other details of model
What kind of soil scheme is in use?
How are radiations parametrized?
What kind of Large scale dynamics is in use (e.g. gridpoint semi-Lagrangian)? Hydrostatic or Nonhydrostatic?
What kind of boundary layer parametrization is in use?

What kind of convection parametrization is in use?

What Cloud/Microphysics scheme is in use?

Other relevant details?
7. Further Information
Operational contact point
URLs for system documentation
URL for list of products

2.1.3. Global Ensemble Numerical Weather Prediction

Centres participating in activity 2.1.3, global ensemble numerical weather prediction, shall:

- Produce global ensemble forecast fields of basic and derived atmospheric parameters
- Make available on the WIS a range of these products. The minimum list to be made available is given in Appendix A.II.2.1.3-a
- ~~Produce~~ Make verification statistics available to the Lead Centre(s) for EPS Verification according to the standard defined in Appendix A.II.2.3.2, ~~and make them available to the Lead Centre(s) for EPS Verification~~
- Make available on a web site up-to-date information on the characteristics of its global ensemble numerical weather prediction system. The minimum information to be provided is given in Appendix A.II.2.1.3-b

RESPONSIBILITY			
CHANGES TO ACTIVITY SPECIFICATION			
To be proposed by:	CBS/ET-OWFPS		
To be approved by:	CBS		
To be decided by:	EC / Congress		
CENTRES DESIGNATION			
To be approved by:	RA	CBS	
To be decided by:	EC / Congress		
COMPLIANCE			
To be monitored by:	CBS/ET-OWFPS		
To be reported to:	CBS/ICT-DPFS	CBS	

Appendix A.II.2.1.3-a

MINIMUM LIST OF GLOBAL EPS PRODUCTS TO BE MADE AVAILABLE ON THE WIS

Parameter	Level	Thresholds	Resolution (lat/lon grid)	Forecast range	Time steps	Frequency
Probability of Precipitation	Surface	1, 5, 10, 25, 50 mm and 100 mm/24 hours	1.5º x 1.5º	10d (or the maximum range if less)	Every 12h	Once a day
Probability of 10 m sustained wind and gusts	Surface	10, 15 and 25 m s^{-1}				
Probability of Temperature anomalies	850	± 1, ± 1.5, ± 2 standard deviations with respect to a reanalysis climatology specified by the producing Centre				
Ensemble mean + spread (standard deviation) of Geopotential height	500					
Ensemble mean + spread (standard deviation) of MSL pressure	Surface					
Ensemble mean + spread (standard deviation) of wind speed	850/250					

Additional recommended products

- Location-specific time series of temperature, precipitation, wind speed, depicting the most likely solution and an estimation of uncertainty (“EPSgrams”). The definition, method of calculation and the locations should be documented.
- Tropical storm tracks (lat/long locations, maximum sustained wind speed, MSLP from EPS members).

Appendix A.II.2.1.4-a

MINIMUM LIST OF LIMITED AREA EPS PRODUCTS TO BE MADE AVAILABLE ON THE WIS

Parameter	Level	Thresholds	Resolution (lat/lon grid)	Forecast range	Time steps	Frequency
Probability of Precipitation	Surface	1, 5, 10, 25, 50 mm and 100 mm/24 hours	0.5º x 0.5º	2d (or the maximum range if less)	Every 6h	Once a day
Probability of 10 m sustained wind and gusts	Surface	10, 15 and 25 m s^{-1}				
Probability of Temperature anomalies	850	± 1, ± 1.5, ± 2 standard deviations with respect to a reanalysis climatology specified by the producing Centre				
Ensemble mean + spread (standard deviation) of Geopotential height	500					
Ensemble mean + spread (standard deviation) of MSL pressure	Surface					
Ensemble mean + spread (standard deviation) of wind speed	850/250					

Additional recommended products

- Location-specific time series of temperature, precipitation, wind speed, depicting the most likely solution and an estimation of uncertainty (“EPSgrams”). The definition, method of calculation and the locations should be documented.
- Tropical storm tracks (lat/long locations, maximum sustained wind speed, MSLP from EPS members).

Appendix II.2.1.4-b

CHARACTERISTICS OF LIMITED AREA EPS

1. Ensemble System
Ensemble name (version
Date of implementation
2. Configuration of the EPS
Horizontal resolution of the model, with indication of grid spacing in km
Number of model levels
Top of model
Forecast length and forecast step interval
Runs per day (Times in UTC)
Is there an unperturbed control forecast included? (Y/N)
Number of perturbed ensemble members (excluding control)
Is model coupled to an ocean, waves, sea ice models? Specify which models
Integration time step
Additional comments
3. Initial conditions and Perturbations
Initial perturbation strategy
Optimisation time in forecast (if applicable)
Horizontal resolution of perturbations (if different from model resolution)
Initial perturbed area
Data assimilation method for control analysis
Are perturbations to observations employed? (Y/N)
(If Yes, which observation types are perturbed?)
Perturbations added to control analysis or derived directly from ensemble analysis
Perturbations in +/- pairs? (Y/N)
Additional comments
4. Model Uncertainty Perturbations
Is model physics perturbed? If yes, briefly describe method(s).
Do all ensemble members use exactly the same model version, or are, for example, different parameterization schemes used? Please describe any differences.
Is model dynamics perturbed? If yes, briefly describe method(s).
Are the above model uncertainty perturbations applied to the control forecast?
Additional comments
5. Surface Boundary Perturbations
Perturbations to sea-surface temperature? If yes, briefly describe method(s).
Perturbations to soil moisture? If yes, briefly describe method(s).
Perturbations to surface wind stress or roughness? If yes, briefly describe method(s).
Any other surface perturbations? If yes, briefly describe method(s).
Are the above surface perturbations applied to the control forecast?
Additional comments
6. Other details of model
What kind of soil scheme is in use?
How are radiations parametrized?

What kind of Large scale dynamics is in use (e.g. gridpoint semi-Lagrangian)? Hydrostatic or nonhydrostatic?

What kind of boundary layer parametrization is in use?

What kind of convection parametrization is in use?

What Cloud/Microphysics scheme is in use?

Other relevant details?

7. Regional Ensemble specifics

Regional domain descriptor (lat/long of boundaries)

Normal source of lateral boundary conditions

Are lateral boundary conditions perturbed?

Specification of lateral boundary conditions required.

Are lateral boundary condition requirements compatible with any other global models or standards? If so, please describe

Additional comments

8. Products

Method of the calculation, if the method is not unique.

Other detailed specifications, if necessary

9. Further Information

Operational contact point

URLs for system documentation

URL for list of products

Appendix A.II.2.3.2

II – STANDARD VERIFICATION MEASURES OF GLOBAL EPS

1. Introduction

This Appendix presents detailed procedures for the production and exchange of a standard set of verification scores for EPS forecasts produced by GDPFS centres. The goal is to provide consistent verification information on the EPS products of GDPFS participating centres for forecasters in the NMHSs and to help the GDPFS Centres compare and improve their forecasts. Scores will be exchanged between the participating producing centres via the Lead Centre for EPS Verification. The Lead Centre functions, as described in 2.3.2, include creating and maintaining a website for EPS verification information, so that potential users will benefit from a consistent presentation of the results.

EPS provides a complete estimation of the forecast probability distribution, including a best-estimate deterministic forecast from the ensemble mean as well as measures of forecast uncertainty and probabilities. Verification of the EPS therefore includes verification of the ensemble mean ~~as a deterministic NWP forecast following the guidance set out in Appendix A.II.2.3.1~~ as well as specific measures of the probabilistic performance.

The standardized verification should provide key relevant information appropriate to the state-of-the-art in EPS, while being as simple and as easy to implement as possible, and ensuring a consistent implementation across participating centres, in particular in the interpolation to verification grid, and use of a common climatology and set of observations.

2. Verification statistics

The following subsections define four sets of verification statistics. A mandatory set shall be provided by all participating centres. A set of additional recommended statistics is also defined which all centres should provide if possible. The detailed procedures are required to ensure it is possible to compare results from the different participating centres in a scientifically valid manner.

The four sets of statistics are summarised as:

Mandatory

- **Ensemble Mean** ~~- for verification of ensemble mean, the specifications in Appendix A.II.2.3.1 for variables, levels, areas and verifications shall be used.~~
- **Spread** - standard deviation of the ensemble averaged over the same regions and variables as used for the ensemble mean.
- **Continuous Ranked Probability Score (CRPS)**

Additional recommended

- **Probability Scores** – scores for probabilities of specific thresholds are exchanged in the form of reliability tables. Several different scores are computed by the Lead Centre(s) based on the reliability tables provided by participating centres.

Specifications of forecast verification set out in the paragraphs below apply to calculation of the CRPS and Probability Scores. Verification of the Ensemble Mean and Spread should follow the specifications set out in Appendix A.II.2.3.1 as stated above.

3. Parameters

Root mean square error and correlation coefficient between forecast and analysis anomalies of ensemble mean shall be calculated for the following set of parameters:

- Mean Sea Level Pressure (PMSL)
- 500 hPa geopotential height

- u and v wind components at 850 and 250 hPa
- 850 hPa temperature

Spread shall be calculated for the same set of parameters for ensemble mean.

Reliability tables for the calculation of probability scores shall be calculated for the following set of parameters and thresholds:

- ~~Mean Sea Level Pressure (~~PMSL~~)~~ anomalies ± 1, ± 1.5, ± 2 standard deviation with respect to the defined climatology
- 500 hPa geopotential height anomalies with thresholds ± 1, ± 1.5, ± 2 standard deviation with respect to the defined climatology
- 850 hPa wind speed with thresholds of 10, 15, 25 m s^{-1}
- 850 hPa u and v wind components with thresholds of 10th, 25th, 75th and 90th percentile points with respect to the defined climatology.
- 250 hPa u and v wind components with thresholds of 10th, 25th, 75th and 90th percentile points with respect to the defined climatology.
- 850 hPa temperature anomalies with thresholds ± 1, ± 1.5, ± 2 standard deviation with respect to the defined climatology.
- Precipitation with thresholds 1, 5, 10, and 25 mm/24 hours

NOTE: Where thresholds are defined with respect to climatology, the defined climatology is set out in paragraph 11 below.

CRPS shall be calculated for the same set of parameters for probability score.

4. Forecast times

Scores shall be computed daily for forecasts initialised at times to be specified by the centre, but should include all forecast cycles made available on the WIS.

5. Forecast steps

Every 24h to the end of the forecast range.

6. Areas

Northern hemisphere extra-tropics	90°N - 20°N, inclusive, all longitudes
Southern hemisphere extra-tropics	90°S - 20°S, inclusive, all longitudes
Tropics	20°N - 20°S, inclusive, all longitudes

Verification against analyses for grid points within each area, including points on the boundary.

7. Verification against analyses

7.1 Grid and interpolation

All parameters except precipitation shall be verified against the centre's own analysis on a regular 1.5° x 1.5° grid.

In selecting the verification grid, consideration has been given to the variety of resolutions of current global NWP models, the resolved scales of models (several grid-lengths), the resolution of the available climatologies, the potential to monitor long-term trends in performance (including earlier, lower resolution forecasts) and computational efficiency.

Interpolation of higher resolution model fields to the verification grid shall be performed to retain features at the scale of the verification grid but not to introduce any additional smoothing. The following procedures shall be used:

- Spectral fields: truncate to equivalent spectral resolution (T120) for verification grid
- Grid point fields: use area-weighting to interpolate to verification grid

For scores requiring a climatology the climatology is specified in paragraph 11 below.

Verification of precipitation is recommended to be performed against observations (paragraph 8), but may alternatively be against a proxy analysis (i.e. a short range forecast from the control or high-resolution deterministic forecast, e.g. 12-36h forecast to avoid spin-up problems).

8. Verification against observations

8.1 Observations

Observations for EPS verification of precipitation should be based on the GCOS list of surface network (GSN). Producing centres shall have the right to omit certain observation sites should they fail a quality control.

8.2 Interpolation

Verification shall be made using the nearest native model grid point to the observation location.

8.3 Areas

The networks used in verification against observations consist of observation stations located in the areas listed in Section 6.

9. Scores

Root mean square error and correlation coefficient between forecast and analysis anomalies are to be calculated for all parameters by the participating centres and provided to the Lead Centre in the form specified on the Lead Centre website.

The following scores are to be calculated for all parameters *(computed by Lead Centre(s) based on reliability tables provided by participating centres)*

- Brier Skill Score (with respect to climatology)
- Relative Operating Characteristic (ROC)
- Relative economic value (C/L) diagrams
- Reliability diagrams with frequency distribution

The CRPS is to be calculated for all parameters by the participating centres and provided to the Lead Centre in the format specified on the Lead Centre website. Centres are encouraged to submit CRPS scores for both EPS and the deterministic (control and high-resolution) forecast - CRPS for deterministic forecast is equal to the mean absolute error.

10. Exchange of scores

Each centre shall provide scores monthly to the Lead Centre. Details of the procedure and the required format for the data are provided on the Lead Centre website. All scores for all forecasts verifying within a month shall be provided as soon as possible after the end of that month.

11. Climatology

To ensure consistency between results from different centres a common climatology shall be used for those scores requiring a climatology. All centres shall use the climatology provided via the Lead Centre website, which is the same climatology specified in A.II.2.3.1 and available from the LC-DNV website.

A daily climatology of upper-air parameters are available for both 00 UTC and 12 UTC. This provides an up-to-date estimate of climate characteristics for each day of the year, including climate mean, standard deviation and selected quantiles of the climate distribution. These latter statistics are required for the CBS standardized verification of EPS forecasts.

The data is made available in Grib format. Information on access to the data and further documentation are provided on the LC-DNV website.

12. Documentation

Participating centres shall provide to the Lead Centre information on their implementation of the standardized verification system annually, shall confirm to the Lead Centre any changes to its implementation (including the annual change of station list, changes in additional statistics) and changes in their NWP model.