

APPENDIX 2.2.6. CHARACTERISTICS OF GLOBAL EPS

1. Ensemble system	
Ensemble (version)	Global EPS (GEPS1701)
Date of implementation	19 January 2017
2. EPS configuration	
Model (version)	Global Spectral Model (GSM1603E)
Horizontal resolution/grid spacing	Spectral triangular 479 (TL479), reduced Gaussian grid system, roughly equivalent to $0.375 \times 0.375^\circ$ (40 km) in latitude and longitude
Vertical resolution (model top)	100 unevenly spaced hybrid levels (0.01 hPa)
Forecast length (initial time)	11 days (00, 12 UTC) 132 hours (06, 18 UTC)
Members	One unperturbed control forecast and 26 perturbed ensemble members.
Coupling to ocean/wave/sea ice models	--
Integration time step	720 seconds
Additional comments	<p>Forecasts from initial times at 06 and 18 UTC is operated when any of the following conditions is satisfied at the initial times:</p> <ul style="list-style-type: none"> • A Tropical cyclone (TC) of tropical storm (TS*) intensity or higher is present in the RSMC Tokyo - Typhoon Center's area of responsibility ($0^\circ - 60^\circ\text{N}$, $100^\circ\text{E} - 180^\circ$). • A TC is expected to reach TS intensity or higher in the area within the next 24 hours. • A TC of TS intensity or higher is expected to move into the area within the next 24 hours. <p>* A TS is defined as a TC with maximum sustained wind speeds of 34 knots or more and less than 48 knots.</p>
3. Initial conditions and perturbations	
Initial perturbation strategy	Singular vectors (SVs) and LETKF
Optimization time in forecast	Among three targeted areas of SVs, 48 hours for Northern Hemisphere ($30^\circ\text{N} - 90^\circ\text{N}$), 24 hours for Tropics ($30^\circ\text{S} - 30^\circ\text{N}$), 48 hours for Southern Hemisphere ($90^\circ\text{S} - 30^\circ\text{S}$).
Horizontal resolution of perturbations	<p>SVs: Spectral triangular 63 (T63), quadratic Gaussian grid system, roughly equivalent to $1.875^\circ \times 1.875^\circ$ (180 km) in latitude and longitude</p> <p>Perturbations from LETKF: Spectral triangular 319 (TL319), reduced Gaussian grid system, roughly equivalent to $0.5625^\circ \times 0.5625^\circ$ (55 km) in latitude and longitude</p>
Initial perturbation area	Global
Data assimilation method for control analysis	Four-dimensional variational (4D-Var) method is used for the Global Analysis (GA). The control analysis is prepared by interpolating the high-resolution (TL959) analysis of the GA.
Initial conditions for perturbed members	Perturbations are added to the control analysis. SV-based components of perturbations are added in +/- pairs.
Additional comments	See the tables below for the specifications of SVs and LETKF.
4. Model uncertainty perturbations	
Model physics perturbations	Stochastic perturbation of physics tendency

Model dynamics perturbations	--
Additional comments	<ul style="list-style-type: none"> All ensemble members use exactly the same model version. The above model uncertainty perturbations are not applied to the control forecast.
5. Surface boundary perturbations	
Sea surface temperature perturbations	Perturbations representing climatological distribution of analysis and forecast error of prescribed SST sampled from the past realizations of the analysis increment and forecast error of SST in the same season.
Soil moisture perturbations	--
Surface wind stress/roughness perturbations	--
Other surface perturbations	--
Additional comments	The above surface perturbations are not applied to the control forecast.
6. Other model details	See specifications of GSM1603E below.
7. Products	
Method of the calculation (if not unique)	
Other specifications as necessary	Products of forecasts from initial times at 06 and 18 UTC are not externally provided on an operational basis.
8. Further information	
Operational contact	
System documentation URLs	http://www.jma.go.jp/jma/jma-eng/jma-center/nwp/nwp-top.htm http://www.jma.go.jp/jma/jma-eng/jma-center/nwp/report/2015_Japan.pdf
Product list URLs	http://www.jma.go.jp/jma/jma-eng/jma-center/nwp/report/2015_Japan.pdf

Specifications of GSM1603E

Surface boundary conditions	
Treatment of sea surface	Daily climatological sea surface temperature with daily analyzed anomaly Daily climatological sea ice concentration with daily analyzed anomaly
Land surface analysis	Snow depth: Two-dimensional optimal interpolation scheme Temperature: First guess Soil moisture: Climatology
Model dynamics and physics	
Land surface and soil	Simple Biosphere (SiB) model
Radiation	Two-stream with delta-Eddington approximation for shortwave (hourly) Two-stream absorption approximation method for longwave (hourly)
Numerical techniques	Spectral (spherical harmonic basis functions) in horizontal, finite differences in vertical Two-time-level, semi-Lagrangian, semi-implicit time integration scheme Hydrostatic approximation
Planetary boundary layer	Mellor and Yamada level-2 turbulence closure scheme Similarity theory in bulk formulae for surface layer
Convection	Prognostic Arakawa-Schubert cumulus parameterization
Cloud	PDF-based cloud parameterization
Gravity wave drag	Longwave orographic drag scheme (wavelengths > 100 km) mainly for stratosphere Shortwave orographic drag scheme (wavelengths approximately 10 km) only for troposphere Non-orographic spectral gravity wave forcing scheme

Specifications of SV computation

Tangent-linear and adjoint models	Lower-resolution versions of those used in the 4D-Var data assimilation system for the GSM until October 2011.		
Horizontal resolution of the model	Spectral triangular 63 (T63), quadratic Gaussian grid system, roughly equivalent to $1.875^\circ \times 1.875^\circ$ (180 km) in latitude and longitude		
Vertical resolution of the model (model top)	100 unevenly spaced hybrid levels (0.01 hPa)		
Norm	Moist total energy		
Targeted areas	Northern Hemisphere (30°N-90°N),	Southern Hemisphere (90°S-30°S)	Tropics (30°S-30°N)
Optional model dynamics and physics	Initialization, horizontal diffusion, surface fluxes and vertical diffusion		In addition to the left, gravity wave drag, large-scale condensation, long-wave radiation and deep cumulus convection.
Optimization time	48 hours		24 hours
Number of SVs used to generate perturbations	25	25	25

Specifications of LETKF

Model name (version)	Global Spectral Model (GSM1603)
Horizontal resolution	Spectral triangular 319 (TL319), reduced Gaussian grid system, roughly equivalent to $0.5625^\circ \times 0.5625^\circ$ (55 km) in latitude and longitude
Vertical resolution (model top)	100 unevenly spaced hybrid levels (0.01 hPa)
Analysis time	00, 06, 12, 18 UTC
Ensemble size	50 members
Data cut-off time	2 hours and 20 minutes
First guess	6-hour forecast of its own
Analysis variables	Wind, surface pressure, specific humidity and temperature
Observation (as of 19 Jan 2017)	SYNOP, METAR, SHIP, BUOY, TEMP, PILOT, Wind Profiler, AIREP, AMDAR, Typhoon Bogus; atmospheric motion vectors (AMVs) from Himawari-8, GOES-13, 15, Meteosat-7, 10; MODIS polar AMVs from Terra and Aqua satellites; AVHRR polar AMVs from NOAA and Metop satellites; LEO-GEO AMVs; ocean surface wind from Metop-A, B/ASCAT; radiances from NOAA-15, 18, 19/ATOVS, Metop-A, B/ATOVS, Aqua/AMSU-A, Megha-Tropiques/SAPHIR, DMSP-F17, 18/SSMIS, GPM/GMI, GCOM-W/AMSR2; clear sky radiances from the water vapor channels (WV-CSRs) of Himawari-8, GOES-13, 15, Meteosat-7, 10; GNSS RO bending angle data from Metop-A, B/GRAS, COSMIC/IGOR, GRACE-A,B/blackjack, TerraSAR-X/IGOR, zenith total delay data from ground-based GNSS
Assimilation window	6 hours
Perturbations to model physics	Stochastic perturbation of physics tendency
Initialization	Hamrud et al. (2015)
Covariance inflation	Adaptive multiplicative covariance inflation
Other characteristics	Fifty analyses are recentered so that the ensemble mean of them become consistent to the analysis of the Global Analysis (GA).