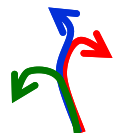


Main EPS configuration changes since 2002

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Major changes in the ECMWF EPS configuration

	Description	Singular Vectors's characteristics						
		HRES	VRES	OTI	Area	past	future	sampl
Dec 1992	Oper Impl	T21	L19	36h	globe	NO	SVINI	simm
Feb 1993	SV LPO	"	"	"	NHx	"	"	"
Aug 1994	SV OTI	"	"	48h	"	"	"	"
Mar 1995	SV hor resol	T42	"	"	"	"	"	"
Mar 1996	NH+SH SV	"	"	"	(NH+SH)x	"	"	"
Dec 1996	resol/mem	"	L31	"	"	"	"	"
Mar 1998	EVO SV	"	"	"	"	SVEVO	"	"
Oct 1998	Stoch sch SPPT	"	"	"	"	"	"	"
Oct 1999	ver resol	"	L40	"	"	"	"	"
Nov 2000	FC hor resol	"	"	"	"	"	"	"
Jan 2002	TC SVs	"	"	"	(NH+SH)x+TC	"	"	"
Sep 2004	sampling	"	"	"	"	"	"	Gauss
Jun 2005	rev sampl	"	"	"	"	"	"	"
Feb 2006	resolution	"	L62	"	"	"	"	"
Sep 2006	VAREPS	"	"	"	"	"	"	"
Mar 2008	VAREPS-mon	"	"	"	"	"	"	"
Sep 2009	Rev SPPT	"	"	"	"	"	"	"
Jan 2010	hor resol	"	"	"	"	"	"	"
Jun 2010	EDA EPS	"	"	"	"	EDA	"	"
Q4 2010	Rev Stoch scheme	T42	L62	48h	(NH+SH)x+TC	EDA	SVINI	Gauss

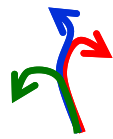
Forecast characteristics						
HRES	VRES	Tend	#	Mod Unc	Coupling	refc suite
T63	L19	10d	33	NO	NO	NO
"	"	"	"	"	"	"
"	"	"	"	"	"	"
"	"	"	"	"	"	"
TL159	L31	"	51	"	"	"
"	"	"	"	"	"	"
"	"	"	"	STP	"	"
"	L40	"	"	"	"	"
TL255	"	"	"	"	"	"
"	"	"	"	"	"	"
"	"	"	"	"	"	"
TL399	L62	"	"	"	"	"
TL399(0-10) / TL255(10-15)	"	15d	"	"	"	"
"	"	15d/32d	"	"	from d10	5*18y
"	"	"	"	"	"	"
TL639(0-10) / TL319(10-15)	"	"	"	revSTP	"	"
"	"	"	"	"	"	"
TL639(0-10) / TL319(10-15)	L62	15d/32d	51	revSTP+BS	from d10	5*18y



Planned changes for 2010-2011

❖ 2010/11:

- ❖ Implementation of a multi-scale SPPT (Q3 2010)
- ❖ Implementation of the stochastic back-scatter (SPBS) scheme (Q3 2010)
- ❖ Increase vertical resolution (Q4 2010/Q1 2011)
- ❖ Add surface initial perturbations (Q1/Q2 2011)



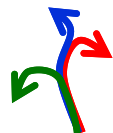
List of changes in 2010

❖ **26 Jan 2010 (IFS cycle 36r1):** higher-resolution EPS

- Increase of the horizontal resolution from T_L399 to T_L639 (with 1200s time step) up to day 10, and from T_L255 to T_L319 (with 2700s time step) afterwards.
- The horizontal resolution of the coupled wave system is also increased:
 - the grid resolution increases from 1 to 0.5 degrees for the whole forecast range;
 - the number of frequencies from 30 to 36 up to day 10 and from 25 to 30 from day 10 onward,
 - the number of directions from 24 to 36 up to day 10, and from 12 to 24.
- The resolution of the EPS unperturbed (control) analysis also increases following the increase of the data assimilation (and of the single high-resolution forecast) from T_L799 to $TL1279$

▪ **Q2 2010 (IFS cycle 36r2):** Use of EDA-based perturbations in the EPS

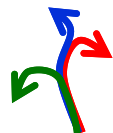
- Change in the definition of the EPS initial perturbations, with the replacement of the evolved SVs with EDA-based perturbations. Since this change, the initial perturbations are defined with a combination of EDA-based perturbations and initial-time SVs (with a 10% smaller amplitude than before)



List of changes in 2009

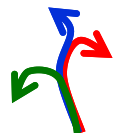
- ❖ **10 Mar 2009 (IFS cycle 35r2):** 15d/32d EPS re-forecast suite
 - Use of ERA-interim instead of ERA-40 to define the initial conditions of the re-forecast suite

- ❖ **8 Sep 2009 (IFS cycle 35r3):** 15d/32d EPS revised stochastic scheme
 - Implementation of a revised version of the stochastically perturbed parameterization tendency (SPPT) scheme (the so-called stochastic physics scheme operational since 1998)



List of changes in 2008

- ❖ **11 Mar 2008 (IFS cycle 32r3v):** 15d/32d EPS with re-forecast suite
 - Merge of the 15-day VAREPS and coupled monthly forecasting system, and resolution increase of the monthly system from T_L159L62 to variable T_L399L62(d0-10)-T_L255L62(d10-32)
 - Use of persisted SST anomalies in all atmospheric forecasts
 - Daily ocean-coupling of days 10 to 15 of 0000 UTC EPS forecasts
 - Monthly Forecast run once per week from 0000 UTC on a Thursday as an extension of the 15 day EPS forecast from this base time
 - Modified EFI products using the new unified re-forecasts
 - New GRIB description for all Monthly Forecast products, analogous to the current medium-range EPS data
 - Re-forecast suite (5-member, 32-day EPS run for 18 years once a week) starting from ERA-40 initial conditions



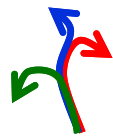
List of changes in 2007

❖ **6 Nov 2007 (IFS cycle 32r3):** revised initial perturbations

- 30% reduction of the initial perturbations (the reduction compensated for the more active model, and led to a similar level of spread between forecast days 2 and 7)
- New moist physics is used in the computation of the tropical SVs

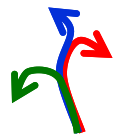
❖ **5 June 2007 (IFS cycle 32r2):** revised moist TL/AD physics in TR-SV

- Explicit numerical treatment of convection in the moist tangent linear model used in the calculation of tropical singular vectors.



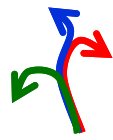
List of changes in 2006

- ❖ **12 Dec 2006 (IFS cycle 31r2):** Start dissemination of 15-day VAREPS
- ❖ **12 Sep 2006 (IFS cycle 31r1):** VAREPS(d0-15)
 - Leg-1 (d0-10): $T_L399L62(d0-10)$ with wave model with 30 frequencies and 24 directions
 - Leg-2 (d9-15): $T_L255L62(d9-15)$ with wave model with 25 frequencies and 12 directions
 - Leg-2 starts at d9 (1-day overlap) to reduce the impact of the change of resolution
 - 15d VAREPS products are not yet disseminated, and the extension to 15-days is still considered 'experimental'. The 15d VAREPS will be declared operational once few more required software changes (IFS, MARS, Metview) are in place
- ❖ **1 Feb 2006 (IFS cycle 30r1):** $T_L399L62$ EPS
 - Higher-resolution system ($T_L399L62$ from $T_L799L91$ analysis)
 - Initial perturbations:
 - 30% reduction of the amplitude of the evolved-SVs component to compensate for faster growth of $T42L62$ perturbations in the $T_L399L62$ system
 - Reduction of the γ coefficient of the Gaussian sampling scheme from 0.023 to 0.020 to compensate for changes in the analysis error statistics



List of changes in 2005

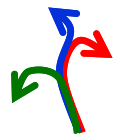
- ❖ **25 Nov 2005:** safeguard against spurious analysis-error local minima
 - Initial perturbations: apply smoothing to analysis-error estimate
- ❖ **28 Jun 2005 (IFS cycle 29r2):** revised Gaussian sampling
 - Initial perturbations:
 - Re-introduction of the symmetry in the initial perturbations generating using Gaussian sampling
 - Use of 50 instead of 25 initial and evolved extra-tropical SVs
 - Revise Gaussian sampling scaling algorithm, and introduction of the γ coefficient that controls the initial perturbations' amplitude: γ set to 0.023 for initial extra-tropical SVs, and 1.5×0.023 for the evolved (extra-tropical) SVs and tropical (initial) SVs
- ❖ **5 Apr 2005 (IFS cycle 29r1):** switch off NNMI
 - Initial perturbations: Nonlinear normal mode initialisation discontinued in SV computation and in ensemble forecasts



List of changes in 2004

- ❖ **28 Sep 2004 (IFS cycle 28r3):** Gaussian sampling and TC-SVs revision
 - Initial perturbations:
 - Introduce Gaussian sampling method also for the extra-tropical SVs
 - Revision of the definition of the areas used to compute the SVs for in areas of tropical storm development
 - Revise 'early delivery' timing following changes in the 'early delivery' system: all SVs are computed around a trajectory starting from a 6h instead of a 12h forecast

- ❖ **29 Jun 2004 (IFS cycle 28r2):** early delivery suite and use of FC-SVs
 - Initial perturbations:
 - All SVs are computed around a trajectory starting from a 12h forecast instead of the analysis



List of changes in 2003 & 2002

- ❖ **14 Jan 2003 (IFS cycle 25r2_en):** revise initial perturbations' amplitude
 - Initial perturbations:
 - RNORM parameter for scaling EPS initial perturbations reduced from 2.0 to 1.6 to compensate for changes in the analysis-error statistics (computed with new Jb generated using ensemble of analyses)
- ❖ **25 Mar 2003:** 00UTC EPS
 - From today the EPS is run twice a-day, at 00 and 12 UTC (51-members for each run, at the current TL255L40 resolution)
- ❖ **22 Jan 2002 (IFS cycle 24r3):** Tropical SVs
 - Initial perturbations: include initial-time tropical SVs in the initial perturbations



Bibliography on the ECMWF EPS

- Buizza, R., & Palmer, T. N., 1995: The singular-vector structure of the atmospheric general circulation. *J. Atmos. Sci.*, 52, 9, 1434-1456.
- Buizza, R., & Hollingsworth, A., 2002: Storm prediction over Europe using the ECMWF Ensemble Prediction System. *Meteorol. Appl.*, **9**, 1-17.
- Buizza, R., Bidlot, J.-R., Wedi, N., Fuentes, M., Hamrud, M., Holt, G., & Vitart, F., 2007: The new ECMWF VAREPS. *Q. J. Roy. Meteorol. Soc.*, **133**, 681-695 (also EC TM 499).
- Buizza, R., 2008: Comparison of a 51-member low-resolution (TL399L62) ensemble with a 6-member high-resolution (TL799L91) lagged-forecast ensemble. *Mon. Wea. Rev.*, **136**, 3343-3362 (also EC TM 559).
- Buizza, R., Leutbecher, M., & Isaksen, L., 2008: Potential use of an ensemble of analyses in the ECMWF Ensemble Prediction System. *Q. J. R. Meteorol. Soc.*, 134, 2051-2066.
- Buizza, R., 2010: The Value of a Variable Resolution Approach to Numerical Weather Prediction. *Mon. Wea. Rev.* , 138, 4, 1026-1042.
- Leutbecher, M. 2005: On ensemble prediction using singular vectors started from forecasts. *Mon. Wea. Rev.* , **133**, 3038-3046 (also EC TM 462).
- Leutbecher, M. & T.N. Palmer, 2008: Ensemble forecasting. *J. Comp. Phys.*, **227**, 3515-3539 (also EC TM 514).



Bibliography on the ECMWF EPS

- Molteni, F., Buizza, R., Palmer, T. N., & Petroliagis, T., 1996: The new ECMWF ensemble prediction system: methodology and validation. *Q. J. R. Meteorol. Soc.*, **122**, 73-119.
- Palmer, T N, Buizza, R., Leutbecher, M., Hagedorn, R., Jung, T., Rodwell, M, Virat, F., Berner, J., Hagel, E., Lawrence, A., Pappenberger, F., Park, Y.-Y., van Bremen, L., Gilmour, I., & Smith, L., 2007: The ECMWF Ensemble Prediction System: recent and on-going developments. A paper presented at the 36th Session of the ECMWF Scientific Advisory Committee (also EC TM 540).
- Palmer, T. N., Buizza, R., Doblas-Reyes, F., Jung, T., Leutbecher, M., Shutts, G. J., Steinheimer M., & Weisheimer, A., 2009: Stochastic parametrization and model uncertainty. ECMWF RD TM 598, Shinfield Park, Reading RG2-9AX, UK, pp. 42.
- Vitart, F., Buizza, R., Alonso Balmaseda, M., Balsamo, G., Bidlot, J. R., Bonet, A., Fuentes, M., Hofstadler, A., Molteni, F., & Palmer, T. N., 2008: The new VAREPS-monthly forecasting system: a first step towards seamless prediction. *Q. J. Roy. Meteorol. Soc.*, **134**, 1789-1799.
- Vitart, F., & Molteni, F., 2009: Simulation of the MJO and its teleconnections in an ensemble of 46-day EPS hindcasts. ECMWF RD TM 597, Shinfield Park, Reading RG2-9AX, UK, pp. 60.
- Zsoter, E., Buizza, R., & Richardson, D., 2009: 'Jumpiness' of the ECMWF and UK Met Office EPS control and ensemble-mean forecasts'. *Mon. Wea. Rev.*, 137, 3823-3836.