Implementation of IFS Cycle 47r2

Description of the upgrade

In the IFS Cycle 47r2 single-precision for ENS (forecast up to day 46 and hindcast) and HRES (forecast) will be introduced. Moreover, the ENS vertical levels will be increased to 137 to bring it in line with HRES.

Users of ENS model levels (in particular users of Time-Critical Applications or customers retrieving or receiving model levels) are advised to check the Technical content below.

A set of 12 auxiliary surface fields will be added to the ENS control forecast.

This cycle will use WMO BUFR tables version 35 for Tropical Cyclone tracks in BUFR format. Furthermor e, new Tropical Cyclone tracks from the 06/18 UTC forecast cycles will become operational and also be made available as WMO essential products, including graphical product. We encourage users of these BUFR data to take note of the Update to Tropical Cyclone tracks and test their decoding software.

⚠ Implemented: 06 UTC cycle on 11 May 2021

#IFS47r2 #newfcsystem @ECMWF

News

12 May 2021 Cycle 47r2 has been implemented with the 06 UTC run on 11 May 2021

11 May 2021 Comments on Tropical Cyclone Activity/Probability products have been added to current evaluation

10 May 2021 Added a grib_filter rules file to convert 91 sparse ENS model level GRIB fields into consecutively numbered 91 levels

07 May 2021

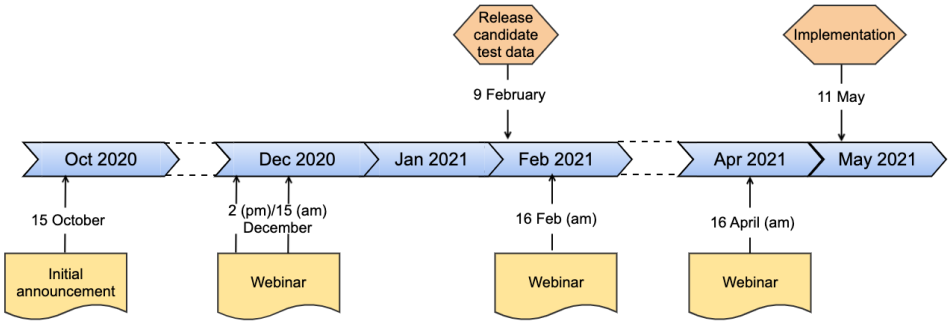
- Comments on convective index behaviour in 47r2 have been added to the current evaluation
- Reminder: Access to the operational PREd will be closed at 9 UTC on 10 May. Any changes to the operational requirements can be implemented after 10 UTC on 12 May

19 Apr 2021 Recording of the webinar on Cycle 47r2 performance, products and technical aspects is now available

31 Mar 2021

- Updated information on recommended software versions
- Graphical products based on 47r2 test data will become available on 6 April

Timeline of the implementation



Datasets affected

- HRES (days 1 to 10)

Contents of this page

Related links

- News article
- Forecast scorecards
- Forecast User Guide
- Detailed IFS documentation

- ENS (days 1 to 15)
- Tropical cyclone track

Resolution

Resolutions in bold increased/changed from previous IFS cycle.

	Component	Horizontal resolution		Vertical resolution [levels]
Atmosphere	HRES	O1280	~9 km	137
	ENS	O640	~18 km	**137**
	ENS extended	O320	~36 km	**137**
Wave	HRES-WAM	0.125°	~14 km	-
	ENS-WAM	0.25°	~28 km	-
	ENS-WAM Extended	0.5°	~55 km	-
Ocean	NEMO 3.4	0.25°	~28 km	75

Meteorological content

In this model cycle single precision for ENS (forecast up to d+46 and hindcast) and HRES (forecast) will be introduced. The idea to use single precision in the IFS emerged from a research project at the University of Oxford and was tested in the OpenIFS model, a portable version of the IFS for research and educational use at institutes and universities. Followed by further research carried out at Météo-France and ECMWF it was shown that it is possible to significantly reduce the arithmetic precision of many of the calculations performed in numerical weather prediction models without compromising the quality of weather forecasts. ‘Single precision’ forecasts have the advantage of being computationally less expensive than traditional ‘double precision’ forecasts. Such efficiency savings will greatly facilitate the introduction of higher-resolution ensemble forecasts and other model improvements in line with ECMWF’s Strategy to 2025. The article 'Progress in using single precision in the IFS' provides additional information.

Moreover, the ENS vertical levels will be increased to 137 to bring it in line with HRES.

Meteorological impact

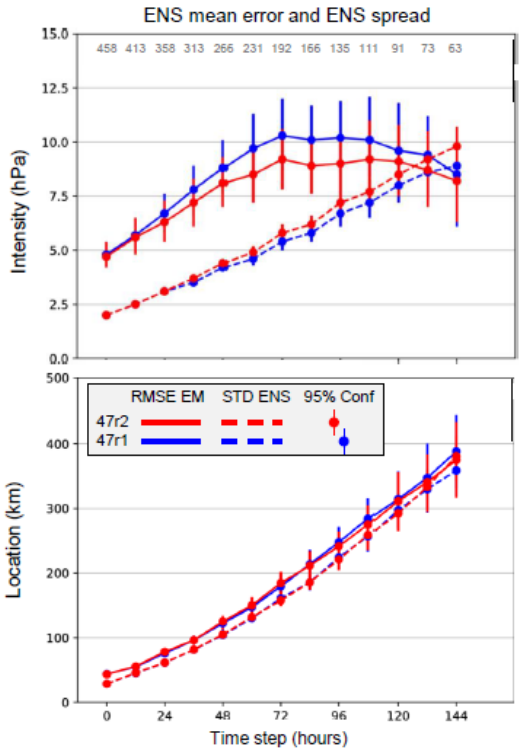
The two changes at 47r2 were a reduction to single precision in our HRES and ENS forecasts and (with the computational savings made) an increase from 91 to 137 levels in the ENS forecast. Our deterministic and ensemble analyses, including background forecasts, remain at double precision, and so are unaffected.

All IFS cycles

- Terminology for IFS testing
- Implementation of IFS Cycle 48r1
- Implementation of IFS Cycle 47r3
- Implementation of IFS Cycle 47r2
- Implementation of IFS Cycle 47r1
- Implementation of IFS cycle 46r1
- Implementation of IFS cycle 45r1
- Implementation of Seasonal Forecast SEAS5
- Implementation of IFS cycle 43r3
- Implementation of IFS Cycle 43r1
- Implementation of IFS cycle 41r2
- Introducing the octahedral reduced Gaussian grid
- Horizontal resolution increase
- Boundary-Condition Programme ENS at 06 and 18 UTC
- Implementation of IFS Cycle 41r1
- IFS cycle upgrades pre 2015

Tropical Cyclones in the Ensemble (all basins)

The ensemble scores for Tropical Cyclones show reduced intensity errors (largely associated with reduced bias: ~2hPa mean reduction in central pressu increased spread, and improved reliability as measured by the spread-error agreement. The cycle is neutral in terms of track errors.



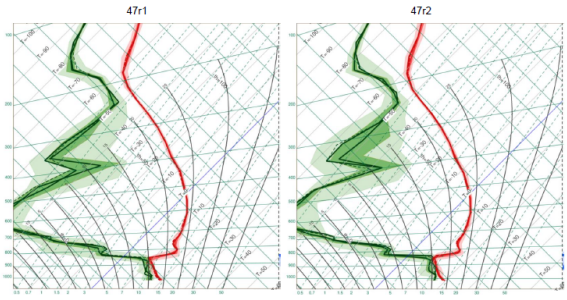
Root mean square errors in the ensemble mean of tropical cyclone (TC) intensities and locations, along with the standard deviation (spread) of TC intens the ensemble members. Results are based on all TC basins for the periods 20191125-20200228 and 20200510-20201130. The numbers at the top of th number of TCs which could be evaluated at each lead time.

Tropical Cyclone Activity/Probability products (medium and extended ranges)

In tandem with the reduction in mean central pressure for tropical cyclones in the ENS in 47r2, referenced above, there are also modest increases, on av counts, as represented on tropical cyclone activity / genesis / strike probability charts, for medium range (here) and extended range (here). For the exten encouraged to reference tropical cyclone activity *anomaly* charts: such products should be more consistent through cycle changes because we are norm climates for the respective cycles.

ENS vertical profile product at 20°S 90°W (VT = 20210123 at 12UTC)

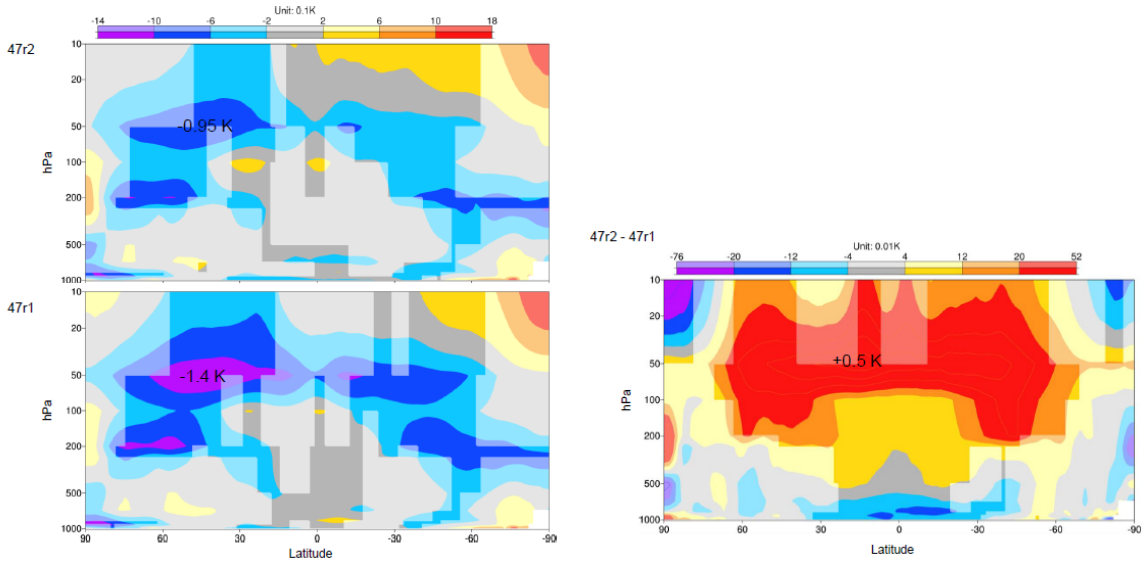
The extra levels mean that sharper inversions can be resolved. For example, the ensemble vertical profile product now uses 34 model levels below 700h 22. The 47r2 test profile, which uses the new mapping of model levels, shows little obvious change although the thermal inversion is indeed a little sharp ***to ensure that they extract the correct model levels when creating their own forecast products.*** Over the testing period, the root-mean-square-erro T850 is reduced in the subtropics.



ENS vertical profile tephigram product for forecasts started on 20210121 at 0UTC and at lead time 60h, for temperature (red) and moisture (dewpoint, gr the minimum, 25th and 75th percentiles and maximum for temperature and dewpoint distributions at each level. The median value is shown by a thin sol represents HRES and a thick dashed line represents the Control.

Zonal-mean Temperature bias in Control forecast (day 10)

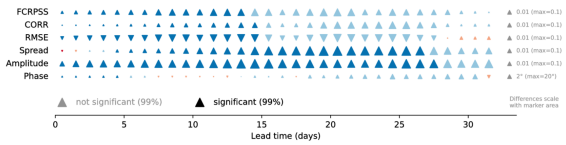
The extra levels also allow the ENS to better resolve gravity waves in the vertical, and this helps reduce the cold bias in the upper troposphere / lower str
33% at day10. This improvement persists into the extended range.



*Zonal means of mean temperature errors at a lead time of 10 days in the ensemble control forecast. More saturated colours indicate statistical significan
test accounting for temporal correlation. Evaluated over all forecasts started 20191125-20200228 and 20200510-20201107.*

Madden Julian Oscillation (assessment of bivariate index)

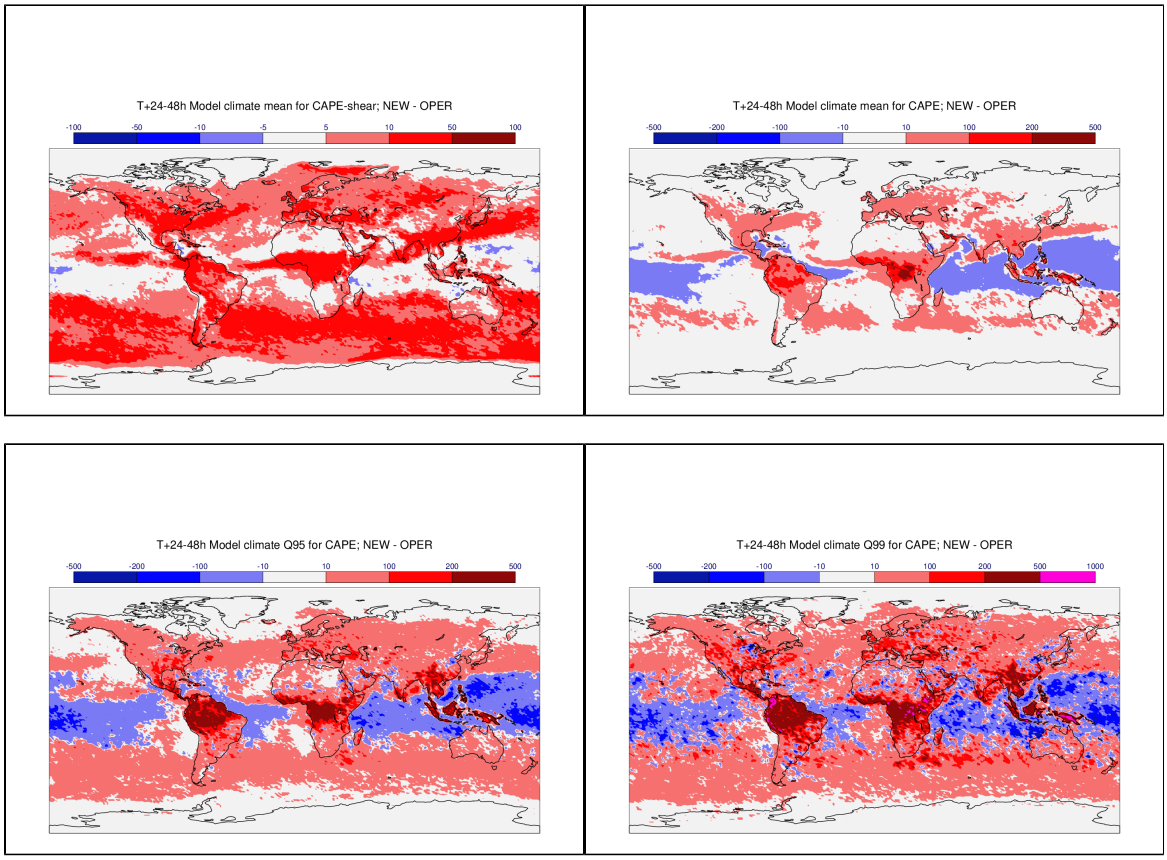
In the extended range we also see the amplitude of the Madden-Julian Oscillation (MJO) being better sustained (amplitude loss by day 15 is now ~15% r
~20%), increased MJO spread and improved scores. Changes come mostly from improvements in tropical zonal winds at 200hPa.



*Score differences (47r2 minus 47r1) for the Wheeler and Hendon (2004) bivariate Real time Multivariate Madden Julian Oscillation (RMM) index based o
the start of each month for the period 1989-2016. The differences shown are for (i) the fair version of the Continuous Rank probability Skill Score (FCRI
anomaly correlation (CORR), (iii) the bivariate root mean square error (RMSE), (iv) the bivariate spread of the ensemble with respect to ensemble mean,
index, and (vi) the phase of the RMM index. Bivariate scores are calculated following Gottschalck et al. (2010) and verified against the RMM index consti
analysis. Triangles indicate increased (pointing up) and decreased (pointing down) values, which are significant when the shading is with more saturated*

Indicators related to convection

The introduction of more levels in ENS has slightly changed the values of some convective indicators. CAPE and CAPE-shear are slightly higher, on ave they were in the 47r1 ENS. Lightning density is also slightly higher in 47r2 - global data for April 2021, for example, showed an increase of 20%. Meanwh parameters in HRES have not changed. Whilst it is difficult to verify the value increases seen in ENS, a significant plus for users is that HRES and ENS r CAPE-shear and Lightning Flash Density become more compatible. The plots below show examples of differences between 47r2 and 47r1, for CAPE an maxima, in the Model Climate.



Day 2 ***differences*** *(47r2 minus 47r1) in the (20-year) Model Climate (M-Climate) values, for a valid date of 6 May, for CAPE-shear (mean only), and CAI and 99th (Q99) percentiles), based in both cases on the daily maxima of hourly values. Red colours mean that the 47r2 ENS is delivering higher values o some systematic sense. Standard units apply to the legends (m^2/s^2 for CAPE-shear, J/kg for CAPE).*

Evaluation

The change to single precision is neutral in terms of HRES skill (less than a 0.3% change is typical for the troposphere, and the frequency of statistically significant differences is in line with what one might expect by chance), but there are benefits of the increased levels in the ENS.

The ensemble score card is overwhelmingly positive and statistically significant (occasional negative changes are small in magnitude.)

Scorecards presenting the new cycle performance are regularly updated:

- HRES scorecard
- ENS scorecard

New and changed parameters

New parameters

The table contains the list of parameters expected to be available with the model implementation. They will be available as part of the test data.

Param ID	Short Name	Name	Unit	Component & type	GRIB edition	Level type	MARS	Added to Catalogue	ecCharts	Dissemination
174096	2sh	2 metre specific humidity	kg kg^{-1}	HRES AN FC	1	sfc	✓	✗	✗	✓
210186	aluvpi	UV visible albedo for direct radiation, isotropic component	(0-1)	ENS CF	1	sfc	✓	✓	✗	✓
210187	aluvpv	UV visible albedo for direct radiation, volumetric component	(0-1)	ENS CF	1	sfc	✓	✓	✗	✓
210188	aluvpg	UV visible albedo for direct radiation, geometric component	(0-1)	ENS CF	1	sfc	✓	✓	✗	✓
210189	alnipi	Near IR albedo for direct radiation, isotropic component	(0-1)	ENS CF	1	sfc	✓	✓	✗	✓
210190	alnipv	Near IR albedo for direct radiation, volumetric component	(0-1)	ENS CF	1	sfc	✓	✓	✗	✓
210191	alnipg	Near IR albedo for direct radiation, geometric component	(0-1)	ENS CF	1	sfc	✓	✓	✗	✓
74	sdfor	Standard deviation of filtered subgrid orography	m	ENS CF[1]	1	sfc	✓	✓	✗	✓
160	sdor	Standard deviation of orography	m	ENS CF[1]	1	sfc	✓	✓	✗	✓
161	isor	Anisotropy of sub-gridscale orography	-	ENS CF[1]	1	sfc	✓	✓	✗	✓
162	anor	Angle of sub-gridscale orography	radians	ENS CF[1]	1	sfc	✓	✓	✗	✓
163	slor	Slope of sub-gridscale orography	-	ENS CF[1]	1	sfc	✓	✓	✗	✓
234	lsrh	Logarithm of surface roughness length for heat	-	ENS CF[1]	1	sfc	✓	✓	✗	✓

[1] Available at step 0 only.

Changes to existing BUFR parameters

Obstype	Name	Component & type	BUFR edition	MARS	ecCharts	Dissemination
32	Tropical Cyclone track	HRES/ENS	3/4	✅	✅	✅

Tropical Cyclone tracks from 06/18 UTC runs have been added to those already produced at 00/12 UTC. Technical information affecting all Tropical Cyclone tracks is available at Update to Tropical Cyclone tracks.

Technical content

Increase of ENS vertical resolution to 137 model levels

With this cycle upgrade the number of vertical model levels in ensemble forecasts (ENS) increases from 91 to 137, bringing it to the same vertical resolution as HRES. The L137 model level definitions and the correspondence between the L91 and L137 model levels are available online. Please note that the L137 model level data cannot be converted back to GRIB edition 1 without the loss of information.

Users getting ENS data on model levels are advised to check their data requests and processing. Getting all model levels, 137 instead of 91, will increase the amount of data by a factor of 1.5. This will affect resources like disc space, array sizes, processing and transfer times. Users should adapt any limits and requirements, e.g. wallclock time, memory, accordingly.

Users who are currently retrieving all 91 model levels from MARS wishing to retrieve the same number of equivalent levels from Cycle 47r2 could specify

```
...
levtype=ml,
levelist=1/2/4/6/7/9/10/12/14/15/17/19/20/22/24/25/27/29/30/32/34/35/37/38/40
/42/43/45/46/48/49/51/52/54/55/57/58/59/61/62/63/65/66/67/69/70/71/73/74/76/77
/78/80/81/82/84/85/87/88/90/91/93/94/96/97/98/100/101/103/104/105/107/108/110
/111/112/114/116/117/119/120/122/124/126/128/129/131/133/134/136/137,
...
```

in their MARS requests. Users getting specific model levels should revise their selection based on the correspondence between the L91 and L137 model levels.

Please note that retrieval of non-consecutively numbered model levels could cause issues in down-stream applications. Therefore all users of ENS model level data are **urged to test their applications** using the available test data as described below. Users facing problems with non-consecutively numbered model levels might find this grib_filter rules file useful to convert 91 sparse model level GRIB fields into consecutive 91 level data.

Changes to GRIB encoding

The GRIB model identifiers (generating process identification number) for cycle 47r2 will be changed as follows:

GRIB 1 Section 1 Octets	GRIB 2 Section 4 Octets	eccodes key	Component	Model identifier	
				47r1	47r2
6	14	generatingProcessIdentifier	Atmospheric model	151	**152**
6	14	generatingProcessIdentifier	Ocean wave model	116	**117**

Changes to BUFR encoding

A new BUFR sequence has been designed to accommodate the new TC information. Technical information is available at:

Update to Tropical Cyclone tracks

Software

To handle the data of Cycle 47r2 we recommend to use the ECMWF software packages

ecCodes 2.21.0
Magics 4.6.0
Metview 5.11.1

which will become the default on ECMWF platforms on Wednesday 5 May 2021, see Change of default versions of ECMWF and third-party software packages - May 2021. **Users are strongly encouraged to test their software applications and data processing chain with the new versions of the various software packages before this change.**

The minimum ECMWF software packages to provide full support for the new IFS Cycle 47r2 are ecCodes 2.20.0, Magics 4.5.3 and Metview 5.10.2.

Availability of IFS 47r2 test data

The release candidate test data and products will be generated daily, shortly behind operational high resolution and ensemble runs and based on the operational dissemination requirements. The availability of the test data does not follow any strict schedule.

Test data in MARS

IFS Cycle 47r2 release candidate test data will be available from MARS with E-suite experiment version (expver) 0075 (MARS keyword EXPVER=0075) starting from the 00 UTC on 09 Feb 2021

The data can be accessed in MARS from:

- HRES (class=od, stream=oper, expver=75)
- HRES-WAM (class=od, stream=wave, expver=75)
- ENS (class=od, stream=enfo, expver=75)
- ENS-WAM (class=od, stream=waef, expver=75)

Only registered users of ECMWF computing systems will be able to access the test data sets in MARS. The data should not be used for operational forecasting. Please report any problems you find with this data to Service Desk.

Test data in dissemination

IFS Cycle 47r2 test data from the release candidate stage will be available through the test dissemination system, starting from the 00Z run on 09 Feb 2021. Users with access to ECPDS and the Products Requirements Editor (PREd) can login to the test system at https://ecpds-xmonitor.ecmwf.int/ (or https://msaccess.ecmwf.int:7443) and trigger the transmission of test products in the usual manner. To receive the test products, users have to have their firewall open to the relevant ECPDS Data Movers:

- Internet transfers: 193.61.196.104 (ecpds-xma.ecmwf.int), 193.61.196.105 (ecpds-xmb.ecmwf.int) and 193.61.196.113 (ecpds-xmc.ecmwf.int)
- RMDCN transfers: 136.156.8.132 (mspds-dm4.ecmwf.int) and 136.156.8.133 (mspds-dm5.ecmwf.int)

Access to the test PREd is provided at https://apps.ecmwf.int/webapps/esuite/products/requirements/

The IFS Cycle 47r2 test products are available as version number 75 (file names ending with '75'). The test products are intended to be generated shortly behind real-time. The test products will be based on the operational dissemination requirements from 08 Feb 2021 and will be available for HRES, HRES-WAM, ENS, ENS-WAM and ENS extended.

The initial requirements in the test system will in general be identical to the operational requirements. Any model levels specified for ensemble forecasts (ENS) will be replaced by the corresponding levels in the new cycle according to the correspondence between the L91 and L137 model levels, e.g. levelist=1/2/3/4/5 in the operational system will be replaced with levelist=1/2/4/6/7 in the test system. This approach is also applied if all model levels are requested in the operational system, i.e. they will be replaced by the 91 corresponding levels in the new cycle rather than by all 137 levels from the new cycle. Via the test PREd users will be able to test the full range of model levels. Once Cycle 47r2 becomes operational, the same approach is applied, i.e. any specified model levels from the current ensemble forecasts (ENS) will be replaced by the corresponding levels in the new cycle. Any changes made in the test system will not be ported to operations on implementation day. **Access to the operational PREd will be closed at 9 UTC on 10 May. Any changes to the operational requirements can be implemented after 10 UTC on 12 May.** The test PREd will be closed on 28 May.

Please note that in particular changes to the number of model levels will have a significant impact on the requested data volumes. For more information please watch our webinar on ENS model level handling in dissemination.

If you don't have access to the ECPDS system or PREd or should you require any assistance with IFS Cycle 47r2 test dissemination products, please contact Data Services.

Graphical display of IFS cycle 47r2 test data using ecCharts

Layers of IFS cycle 47r2 release candidate test data will become available in ecCharts on 06 Apr 2021. Cycle 47r2 layers are identified by the label "0075" in their title and a black border around test data layers for better visual identification.

Web charts based on IFS cycle 47r2 test data

The ENS meteograms based on IFS cycle 47r2 release candidate test data will become available on 06 Apr 2021. They can be viewed by selecting the "IFS cycle 47r2" model run in the ENS meteograms interface.

WMO Essential and Additional test data

IFS cycle 47r2 WMO Essential test data starting from the 00Z run on 09 Feb 2021is available at ftp://wmo:essential@xpds.ecmwf.int and WMO Additional test data at ftp://xpds.ecmwf.int using the relevant WMO user id and password.

Time-critical applications

Option 1 - simple time-critical jobs

Member State users of the "Simple time-critical jobs" framework can test that their scripts will work with the IFS Cycle 47r2 test data by using the limited ECaccess 'events' set up for this purpose:

1633	e_ms090	At this stage, the e-suite step 090 (HRES-BC) has been generated.
1634	e_ms144	At this stage, the e-suite step 144 (ENS-BC) has been generated.
1635	e_ms240	At this stage, the e-suite step 240 (HRES) has been generated.
1636	e_ms360	At this stage, the e-suite step 360 (ENS) has been generated.
1638	e_ms1104	At this stage, the e-suite step 1104 (ENS extended) has been generated.
1639	e_msrefc	At this stage, the e-suite step refc (REFORECAST) has been updated.

For these events, MSJ_EXPVER environment variable is set to 0075 and can be used to specify the IFS Cycle 47r2 test data in any MARS retrievals.

These events are intended for testing technical aspects only and should **not** be used for Time Critical activities.

Options 2 and 3

Option 2 or 3 time-critical applications can be tested with the IFS Cycle 47r2 test data retrieved from MARS or received in Dissemination.

Resources

Videos

Introducing the IFS Cycle 47r2 model

ENS model level handling in dissemination

Your browser does not support the HTML5 video element

Cycle 47r2 - Performance, products and technical aspects

References

- Peter D. Dueben, Michail Diamantakis, Simon Lang, Sami Saarinen, Irina Sandu, Nils Wedi and Tomas Wilhelmson. Progress in using single precision in the IFS. ECMWF Newsletter, 2018.
- Filip Vana, Glenn Carver, Peter D. Dueben, Simon Lang, Tim Palmer, Martin Leutbecher, and Deborah Salmond. Single-precision IFS. ECMWF Newsletter, 148, 2016