Implementation of IFS Cycle 47r1

Page updated on: 18 Jun 2020

Description of the upgrade

This cycle includes changes in the treatment of observations and improvements in the data assimilation and to the model. Quintic vertical interpolation in the semi-Lagrangian advection scheme has been introduced as well as the inclusion of a better surface albedo climatology making use of more data from the MODIS instrument.

New Metrics of Tropical Cyclone (TC) “size” will supplement the existing forecasts of TC track and intensity. We encourage users of these BUFР data to test their decoding software, see New Tropical Cyclone Wind Radii product.

NEWS!

18 Jun 2020 A test environment for time-critical applications is now available.
Please note that to prepare for the cycle upgrade changes to dissemination requirements will not be possible between 09:00 UTC on 29 June 2020 and 09:00 UTC on 01 July 2020.

02 Jun 2020 New climate fields, lake cover/depth and leaf area indices, have been added

28 May 2020 During the pre-operational (esuite) testing of cycle 47r1 (expver=74) a bug in the computation of certain shear-related parameters was discovered.

During the pre-operational (esuite) testing of cycle 47r1 (expver=74) a bug in the computation of certain shear-related parameters was discovered. The impact is:

A. Fields for the following parameters contain erroneous values in all esuite forecasts from data times prior to 00 UTC run on 20 May:

- Convective available potential energy shear index (ShortName=capes, ParameterID=228044)
- Maximum CAPES in the last 6 hours (ShortName=mxcapes6, ParameterID=228036)
- Vertical integral of northward water vapour flux (ShortName=viwvn, ParameterID=162072)

B. Fields for the following EFI/SOT parameter also contain erroneous values in all esuite forecasts from data times prior to 00UTC run on 23 June:

- Convective available potential energy shear index (ShortName=capesi, ParameterID=132044)
- Water vapour flux index (ShortName=wvfi, ParameterID=162045)

C. The esuite model climate fields used for the two EFI/SOT parameters in (B), stored in stream=efhs and type=cd, contain erroneous values for the following parameters for all data times prior to 22 June:

- ShortName=capes (parameterID=228044)
- ShortName=wvf (parameterID=162045)

The reason that there is more of a delay in correcting B and C above (compared to A) is the 5-week time window used for the model climate. Time needs to elapse before the erroneous re-forecasts already run are no longer needed to compute the 'current' model climate.

28 May 2020 Recording of latest webinars on the performance and products of the new model cycle is now available

20 May 2020 Near real-time release candidate test data will be available from the 00Z run on 2 June 2020

19 May 2020 CIN and EFI for CAPE and CAPE-shear have been reviewed. List of new and changed parameters now available

#IFS47r1 #newfcsystem @ECMWF
Meteorological content

The changes in this model cycle cover the Data Assimilation, treatment of observations and improvements to the model itself

Assimilation

LWDA uses first guess from Early Delivery

- The first guess used in LWDA now comes from the analysis derived in the early delivery window.
- This gives effectively 4 extra outer loops in the LWDA system, as they were computed in the early delivery window, albeit with fewer observations.

Weak-constraint 4D-Var

- A new estimate of the model error covariance matrix has been computed from a climatology of the model error vectors estimated by the current weak-constraint 4D-Var
- This new implementation of weak-constraint 4D-Var corrects the diagnosed cold and warm biases of the model over 100 hPa, reducing the mean error by up to 50%.

Revision of skin temperature background errors in the context of TOVS sink variable

- New spatially and in time varying back-ground errors for skin temperature have been derived based upon output from the Ensemble Data Assimilation (EDA) to improve the way the surface skin temperature is allow to adjust to the radiance assimilation scheme during the 4D-VAR. The approach enhances the characterization of the background-error variances for the skin temperature, by providing flow dependent background errors which vary spatially and in time during the 12-hour assimilation window. This is particularly important for land surfaces which can be very heterogeneous and where errors can change rapidly during the day, synoptically and seasonally.

Timestep for last 4D-Var minimisation

- The time step in the last minimisation cycle in the 4D-VAR has been set the same for the outer and inner loop to correct spurious gravity-wave-like increments generated during the 4D-Var analysis.
- This change leads to better balanced initial conditions and a statistically significant increase in forecast skill.

Observations

ATMS observation error correlations

- In Cycle 46r1 inter-channel error correlations were accounted for in Suomi-NPP ATMS.
- In Cycle 47r1 inter-channel error correlations will be introduced for NOAA-20 ATMS consistently with Suomi-NPP ATMS.

Channel-specific aerosol rejections for IR sounders

- The use of infrared (IR) data (AIRS, IASI, CrIS) is enhanced by allowing high-peaking channel radiances to be assimilated at those locations where lower-peaking channels are rejected due to being contaminated by aerosol. Previously, the aerosol detection scheme did not distinguish between affected and unaffected channels, but instead rejected full IR spectra where presence of aerosol was found.

Spline interpolation in the 2D GPS-RO bending angle operator

- A cubic spline interpolation is introduced for vertical interpolation of Log(refractivity) within the GPS-RO forward operator.
- This removes unphysical structure in the vertical leading to more realistic vertical variability of the forward modelled bending angle background departures.

Model
Surface albedo changes

- A number of improvements have been made to the specification of the shortwave albedo of the land surface, snow and sea ice. This includes: 1) the use of six climatological fields from MODIS, 2) a better handling of the spectrum from the MODIS datasets and 3) the removal of the artificial adjustment for the prognostic albedo which is now obsolete because of the changes in 2).

Update to greenhouse gases and total solar irradiance

- In Cycle 47r1 the Total Solar Irradiance (TSI) and Green House Gases (GHG) timeseries are updated with more recent ones from CMIP6.

Quintic interpolation in semi-Lagrangian advection

- As the horizontal resolution increases, more small scale waves are resolved in the horizontal direction but their representation in the vertical direction poses a challenge when vertical resolution is not appropriately increased. As increasing the vertical resolution is expensive, a more cost-effective solution was found by increasing the order of vertical interpolation of advected fields to the departure point in the semi-Lagrangian advection of temperature from third order (i.e. cubic, where a Lagrange polynomial of degree 3 interpolates a field using 4 neighbouring points) to fifth order (i.e. quintic, where a Lagrange polynomial of degree 5 interpolates a field using 6 neighbouring points).

Drag coefficient for very strong winds

- The drag coefficient over the oceans is reduced for strong winds to account for observational evidences whereby the drag coefficient reduces sharply for high winds.

Convection scheme

- Stability corrections to the mid-level and deep convective closures (neutral) and reduced bounds for parcel perturbations
- Rewriting the diffusion momentum solver as for scalars (neutral)
- Revision of the CIN diagnostic using virtual potential temperature instead of equivalent potential temperature. The revised CIN is now much reduced and is closer to values expected by forecasters.

Tangent-linear physics

- The mass-flux limiter, used in the tangent-linear and adjoint convection schemes to ensure that the CFL criterion is fulfilled in the vertical, is now reduced for time steps shorter than 900 seconds. The mass-flux limiter is dependent on the model time step to avoid the occurrence of instabilities in the 4D-Var minimizations.

Meteorological impact

New metrics for Tropical cyclones

- Metrics of Tropical Cyclone (TC) “size” will supplement the existing forecasts of TC track and intensity (minimum central mean sea level pressure and maximum wind around a TC).

TC “size” will be represented by radii for mean 10m wind thresholds of 18, 26 and 32 m/s (34, 50 and 64 knots) to denote the furthest distance (in metres) away from the centre of the TC at which each of the wind speed thresholds are exceeded. Each of these are computed for each of four earth-relative quadrants, i.e. in NE, SE, SW and NW, delivering a total of 12 “size metrics” for each TC at each time step.

To arrive at these metrics the code scans, in outwards fashion, all model gridpoints within each quadrant. Values are computed for the HRES and ENS for all TCs that are either present in the initial conditions, or that develop during the forecast integrations (i.e. TC “genesis”).

The new values, which we will call “wind radii”, are included as supplementary information within the BUFR message that currently contains the TC tracks (pairs of latitudes and longitudes) and the TC intensities (minimum pressure and overall maximum wind speed).

Implementation of the TC wind radii product was motivated by continuing model developments such as the recent re-tuning of the Charnock parameter for very high wind speeds, which goes live in model cycle 47r1, and which improves lower tropospheric wind speeds around intense storms.

Computation of the wind radii values is executed after the TC tracking, in a post-processing step, using code developed by NOAA which is available in the public domain.

The wind radii values are non-zero wherever the wind thresholds are exceeded, otherwise they are set to zero. If the track is missing at specific time step(s) then values are replaced by a missing value indicator. No changes were made to the TC tracker software.

- Wind attributes for Tropical cyclones

Each tropical cyclone identified in an IFS forecast has 10m mean wind attributes associated. In previous cycles this was just the maximum within the cyclone circulation, now there are also TC size metrics (see above). Historically such metrics were adjusted upwards, compared to raw model values, by multiplying by 1.08, in part to provide more realistic values. This dates back to a time when model resolution was much lower than it is now. With cycle 47r1 we have chosen to remove this adjustment factor. This decision coincides with a concurrent model change that increases the 10m winds slightly in extreme conditions (see meteorological content section).

ECMWF output that references such values includes the TC BUFR files, and on the web the TC-related Lagrangian meteograms. The TC classifications used for TC strike probabilities (and their ecCharts counterparts) are also impacted.

It is unlikely that users will notice a difference.
Convective inhibition

For Convective Inhibition (CIN) the following two changes will be implemented:

- CIN is computed with a completely revised code using virtual temperature correction;
- CIN and Convective Available Potential energy (CAPE) both refer to the same (most unstable) parcel curve.

This will provide an estimate for CIN which is much more in line with parcel theory and forecasting practice and will improve usability for diagnosing deep moist convection.

Additional details: Changes in CIN to concur with forecasting practice

EFI

For the computation of EFI and SOT in IFS cycle 47r1 mxcape6 and mxcapes6 will be used instead of cape and capes, respectively. This change is aiming for a better sampling in the computation of the 24-hour maxima needed for the EFI. In effect with the change we extract the maximum within 24 hourly values, instead of using 4 6-hourly values.

Additional details: The EFI (and SOT) for CAPE and CAPE-shear start using mxcape6 and mxcapes6 parameters

Evaluation

The new model cycle brings improvements throughout the troposphere in the order of 0.5% in extra-tropical upper-air forecasts. The improvements are most apparent in the ENS scores, both against own analysis and against observations.

In the extra-tropical stratosphere, the new cycle brings large improvements, such as 2-5% error reductions for temperature and geopotential at 100 hPa and 5-15% at 50 hPa. In the tropics, there is an apparent degradation in the order of 1-3% in upper air scores when forecasts from each cycle are verified against those cycles’ own analyses, but when forecasts are verified against observations the impact is neutral. Verification against observations shows that upper-air changes in the tropics are overall neutral, with small improvements and deteriorations balancing each other out. One exception is 250 hPa temperature in the tropics, where a deterioration of 1-3% is seen also against observations. This is mainly due to a small (about +0.1 K) shift in the mean, resulting from the model changes in the new cycle.

The new cycle improves forecasts of several near-surface parameters, most notably 2m temperature and humidity (by about 0.5%) both in the extra-tropics and, when verified against observations, also in the tropics. Extra-tropical 10m wind in the HRES is slightly improved, as well as total cloud cover both in ENS and HRES. Tropical 10m wind is very slightly deteriorated. Significant wave height is mostly neutral against observations and improved against own analysis.

Changes in forecast performance for tropical cyclone (TC) tracks are statistically neutral. There is a small deterioration in TC intensity in terms of central pressure, but the pressure-wind relationship has been improved, and there is a small improvement in mean maximum wind speed errors.

The impact of 47R1 on weekly mean anomalies in the extended-range forecasts is overall neutral, except for some improvement in 50hPa meridional velocity and temperature while there is a slight degradation in week 1 in the tropical troposphere. The MJO is 3-4% weaker in the extended-range in the new cycle, which implies a slight degradation.

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.

<table>
<thead>
<tr>
<th>Param ID</th>
<th>Short Name</th>
<th>Name</th>
<th>Units</th>
<th>Component &amp; type</th>
<th>GRIB edition</th>
<th>Level type</th>
<th>MARS</th>
<th>Added to Catalogue</th>
<th>ecCharts</th>
<th>Dissemination</th>
</tr>
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<tbody>
<tr>
<td>26</td>
<td>cl</td>
<td>Lake cover</td>
<td>(0 - 1)</td>
<td>ENS CF</td>
<td>1</td>
<td>sfc</td>
<td>✔</td>
<td>TBC</td>
<td>✔</td>
<td>TBC</td>
</tr>
<tr>
<td>228007</td>
<td>dl</td>
<td>Lake depth</td>
<td>m</td>
<td>ENS CF</td>
<td>1</td>
<td>sfc</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>TBC</td>
</tr>
<tr>
<td>66</td>
<td>lai lv</td>
<td>Leaf area index, low vegetation</td>
<td>m² m⁻²</td>
<td>ENS CF</td>
<td>1</td>
<td>sfc</td>
<td>✔</td>
<td>TBC</td>
<td>✔</td>
<td>TBC</td>
</tr>
<tr>
<td>67</td>
<td>lai hv</td>
<td>Leaf area index, high vegetation</td>
<td>m² m⁻²</td>
<td>ENS CF</td>
<td>1</td>
<td>sfc</td>
<td>✔</td>
<td>✔</td>
<td></td>
<td>TBC</td>
</tr>
<tr>
<td>229</td>
<td>iews</td>
<td>Instantaneous eastward turbulent surface stress</td>
<td>N m⁻²</td>
<td>HRES AN¹</td>
<td>1</td>
<td>sfc</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>230</td>
<td>inss</td>
<td>Instantaneous northward turbulent surface stress</td>
<td>N m⁻²</td>
<td>HRES AN¹</td>
<td>1</td>
<td>sfc</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>210186</td>
<td>aluvpi</td>
<td>UV visible albedo for direct radiation, isotropic component</td>
<td>(0 - 1)</td>
<td>HRES AN</td>
<td>1</td>
<td>sfc</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
</tr>
<tr>
<td>210187</td>
<td>aluvpv</td>
<td>UV visible albedo for direct radiation, volumetric component</td>
<td>(0 - 1)</td>
<td>HRES AN</td>
<td>1</td>
<td>sfc</td>
<td>✔</td>
<td>✔</td>
<td>✔</td>
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</table>
Changes to existing GRIB parameters

<table>
<thead>
<tr>
<th>Param ID</th>
<th>Short Name</th>
<th>Name</th>
<th>Description</th>
<th>Units</th>
<th>Component &amp; type</th>
<th>GRIB edition</th>
<th>Level type</th>
<th>MARS</th>
<th>ecCharts</th>
<th>Dissemination</th>
</tr>
</thead>
<tbody>
<tr>
<td>131089</td>
<td>pts</td>
<td>Probability of a tropical storm</td>
<td>Probability of a tropical storm or stronger (surface wind speed above 17 m/s)</td>
<td>%</td>
<td>ENS EP</td>
<td>1</td>
<td>sfc</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>131090</td>
<td>ph</td>
<td>Probability of a hurricane</td>
<td>Probability of a hurricane (surface wind speed above 32 m/s)</td>
<td>%</td>
<td>ENS EP</td>
<td>1</td>
<td>sfc</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>131091</td>
<td>ptd</td>
<td>Probability of a tropical depression</td>
<td>Probability of a tropical depression or stronger (surface wind speed above 8 m/s)</td>
<td>%</td>
<td>ENS EP</td>
<td>1</td>
<td>sfc</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

For the Event Probability (type EP) parameters listed above the GRIB header has changed from using localDefinitionNumber=19 (extreme forecast index) to localDefinitionNumber=5 (forecast probability). Please note that the descriptions of these parameters in the Parameter Database have not yet been updated to the ones given in the table above.

Changes to existing BUFR parameters

<table>
<thead>
<tr>
<th>Obstype</th>
<th>Name</th>
<th>Component &amp; type</th>
<th>BUFR edition</th>
<th>MARS</th>
<th>ecCharts</th>
<th>Dissemination</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>Tropical Cyclone track</td>
<td>HRES/ENS</td>
<td>3/4</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>

Technical content

Changes to BUFR encoding.

A new BUFR sequence has been designed to accommodate the new TC information. Technical information is available at:
New Tropical Cyclone Wind Radii product

Software

The software packages listed below provide full support for the new IFS Cycle 47r1 and will become the default on ECMWF platforms on Wednesday 3 June 2020, see Change of default versions of ECMWF and third-party software packages - June 2020:

- ecCodes 2.17.1
- Magics 4.3.3
- Metview 5.8.3

Availability of IFS cycle 47r1 test data

Test data in MARS

IFS Cycle 47r1 release candidate test data will be available from MARS with experiment version 0074 (MARS keyword EXPVER=0074) starting from the 00 UTC on 02 Jun 2020

The data can be accessed in MARS from:

- HRES (class=od, stream=oper, expver=74)
- HRES-WAM (class=od, stream=wave, expver=74)
- ENS (class=od, stream=enfo, expver=74)
- ENS-WAM (class=od, stream=waef, expver=74)
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 47r1 test data from the release candidate stage will be available through the test dissemination system, starting from the 00Z run on 02 Jun 2020. Users of ECMWF dissemination products can trigger transmission of test products by logging in to the test ECPDS system at https://ecpd s-xmonitor.ecmwf.int/ (or https://msaccess.ecmwf.int:7443) 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)

The IFS Cycle 47r1 test products are available as version number 74 (files naming ending with ‘74’). The test products are generated shortly behind real-time and based on the operational dissemination requirements and the IFS Cycle 47r1 test data for HRES, HRES-WAM, ENS, ENS-WAM and ENS extended.

Should you require any assistance with IFS Cycle 47r1 test dissemination products, please contact Data Services.

Graphical display of IFS cycle 47r1 test data using ecCharts

From the run 00Z run on 02 Jun 2020 onwards, the IFS cycle 47r1 layers are available in ecCharts. Cycle 47r1 layers are identified by the label "0074" in their title and a black border around test data layers for better visual identification.

Web charts based on IFS cycle 47r1 test data

ENS meteograms based on IFS cycle 47r1 test data are available from the 00Z run on 02 Jun 2020 and can be viewed by selecting the "IFS cycle 47r1" model run in the ENS meteograms interface.

WMO Essential and Additional test data

IFS cycle 47r1 WMO Essential test data starting from the 00Z run on 02 Jun 2020 is 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 47r1 test data by using the limited EAccess 'events' set up for this purpose:

<table>
<thead>
<tr>
<th>Event</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1633 e_ms090</td>
<td>At this stage, the e-suite step 090 (HRES-BC) has been generated.</td>
</tr>
<tr>
<td>1634 e_ms144</td>
<td>At this stage, the e-suite step 144 (ENS-BC) has been generated.</td>
</tr>
<tr>
<td>1635 e_ms240</td>
<td>At this stage, the e-suite step 240 (HRES) has been generated.</td>
</tr>
<tr>
<td>1636 e_ms360</td>
<td>At this stage, the e-suite step 360 (ENS) has been generated.</td>
</tr>
<tr>
<td>1638 e_ms1104</td>
<td>At this stage, the e-suite step 1104 (ENS extended) has been generated.</td>
</tr>
<tr>
<td>1639 e_msrefc</td>
<td>At this stage, the e-suite step refc (REFORECAST) has been updated.</td>
</tr>
</tbody>
</table>

For these events, MSJ_EXPVER environment variable is set to 0074 and can be used to specify the IFS Cycle 47r1 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 47r1 test data retrieved from MARS or received in Dissemination.

Resources

| Webinar on ’Cycle 47r1 overview’ | Webinar on ’Cycle 47r1 performance and products’ |
The webinar slides are available to download.