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Changes Log

Version	Date	Changes
1.0	07/07/2017	First version

List of Changes

Version	Section	Answers to RID	Changes

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1 Introduction

The operational Integrated Forecasting System (IFS) of the European Centre for Medium-Range Weather Forecasts (ECMWF) will be upgraded to CY43R3. The change is expected to happen on 11 July 2017. In preparation for the change, an experimental suite (e-suite) based on CY43R3 similar to the operational one (o-suite based on CY43R1) except of the model version is being run in parallel. The e-suite covers the period that starts on 26 March 2017 and will extend in real time till the operational implementation of CY43R3.

Estimation of the path delay of the altimeter radar signal due to the existence of the atmosphere is very important to compensate for it in the sea surface height and ice measurements by radar altimeters. This delay can be divided into two components: dry and wet. The former, also known as dry tropospheric correction (DTC), is due to the existence of the (dry) air while the latter, also known as wet tropospheric correction (WTC), is due to the existence of the atmospheric water vapour. The WTC delay can be estimated using microwave radiometers that are typically installed together with the radar altimeter (MWR) on the same platform (e.g. Sentinel-3 and Jason-3). Another way to estimate the wet delay is by using atmospheric fields produced from numerical weather prediction (NWP) models. This is usually favoured due to its availability. Some satellite missions like Cryosat-2 lack the MWR facility and therefore rely on model estimations. On the other hand, the only available option for the estimation of DTC is the model fields.

This short note provides estimates of the impact of the new IFS changes (CY43R3) on the DTC and WTC computed from the model fields. On average, the impact of the model changes on DTC is negligible (less than a millimetre almost everywhere). The impact on the WTC is expected to be within 3, 6 and 0.5 millimetres over the ocean, land and polar ice, respectively, with a global overall average of about 1 millimetre.

The main related model changes are summarised in Section 2. The followed procedure is introduced briefly in Section 3. The results of the comparison between the new system and the operational one are presented in Section 4. Finally, the conclusions are listed in Section 5.

Note that in this report the terms “o-suite”, “operational”, “current” and “CY43R1” are all referring to the current operational ECMWF model. On the other hand, the terms “e-suite”, “experimental”, “new” and “CY43R3” are all referring to the system that is scheduled to become operational on 11 July 2017.

2 Main CY43R3 Related Changes

The main related changes that are included in the new system (based on CY43R3) compared to the operational system (based on CY43R1) are as follows:

- Improved humidity background error variances directly from the Ensemble Data Assimilation (EDA) like for all other variables.
- Increased use of microwave humidity sounding data by adding new sensors (SAPHIR, GMI 183 GHz channels)
- Activation of 118 GHz channels over land from MWHS-2 instrument on-board FY-3C
- Improved quality control for radio occultation observations and radiosonde data.
- New, more efficient radiation scheme with reduced noise and more accurate longwave radiation transfer calculation.

The full list of the changes and all other related information about CY43R3 can be found in:
https://software.ecmwf.int/wiki/display/FCST/Implementation+of+IFS+cycle+43r3

One important note about the related changes is that they are mainly in the data usage and data assimilation. Therefore, the impact on the model analysis and forecast needs to be investigated.

3 Procedure

ECMWF runs an experimental stream (e-suite) of the new model based on cycle 43R3 (version 0071) parallel to the current operational model that is based on cycle 43R1 (version 0001). The model fields from each version between 26 March and 12 June 2017 were used to compute the DTC and the WTC following Abdalla (2013a and b). This will highlight the differences but does not necessarily show if one model performs better than the other.

Verification of both models against Sentinel-3A Microwave Radiometer (MWR) WTC observations was also carried out. Sentinel-3A data are grouped in super-observations composed of 13 individual (1 Hz) observations. Quality control is carried out where erroneous and suspicious observations are removed. This comparison allows the verification over the areas covered by Sentinel-3A MWR which are water surfaces. Therefore, it is not clear if the results of this verification are valid over land and in the Polar Regions.

WTC and DTC are not products of the ECWMF IFS. However, the "Total Column Water Vapour" (TCWV), which represents the total amount of water vapour in the atmospheric column and is directly related to WTC, is an official product that is produced routinely. TCWV is used to assess the impact of the change in the short forecast range.

It is important to note that the results presented here are computed based on the same principles that used for the correction (DTC and WTC) computations usually included in the official altimeter products. However, the details of both methods differ. This should not matter much as far as the differences (not the absolute values) are concerned.

4 Results

The dry tropospheric correction (DTC) and wet tropospheric correction (WTC) from the analyses of the current operational model (CY43R1, Version 0001) and the new one (CY43R3, Version 0071) were computed over the period from 26 March till 12 June 2017. The global mean values of DTC and WTC at major synoptic times were computed and the difference between the new model and current model is plotted in Figure 1. It is clear that the difference in the DTC is negligible (fluctuating around the zero with a maximum amplitude of about 0.05 mm). Note that these are global averages covering all the surfaces.

The spatial distribution of the mean DTC difference between the new and the old models over the same period is shown in Figure 2. The average differences over the whole period are within 0.2 mm over the vast majority of the ocean surfaces with few patches of 0.5 mm mainly in the Weddell Sea. The difference is mainly positive, i.e. the new model produces slightly higher DTC over most of the globe.

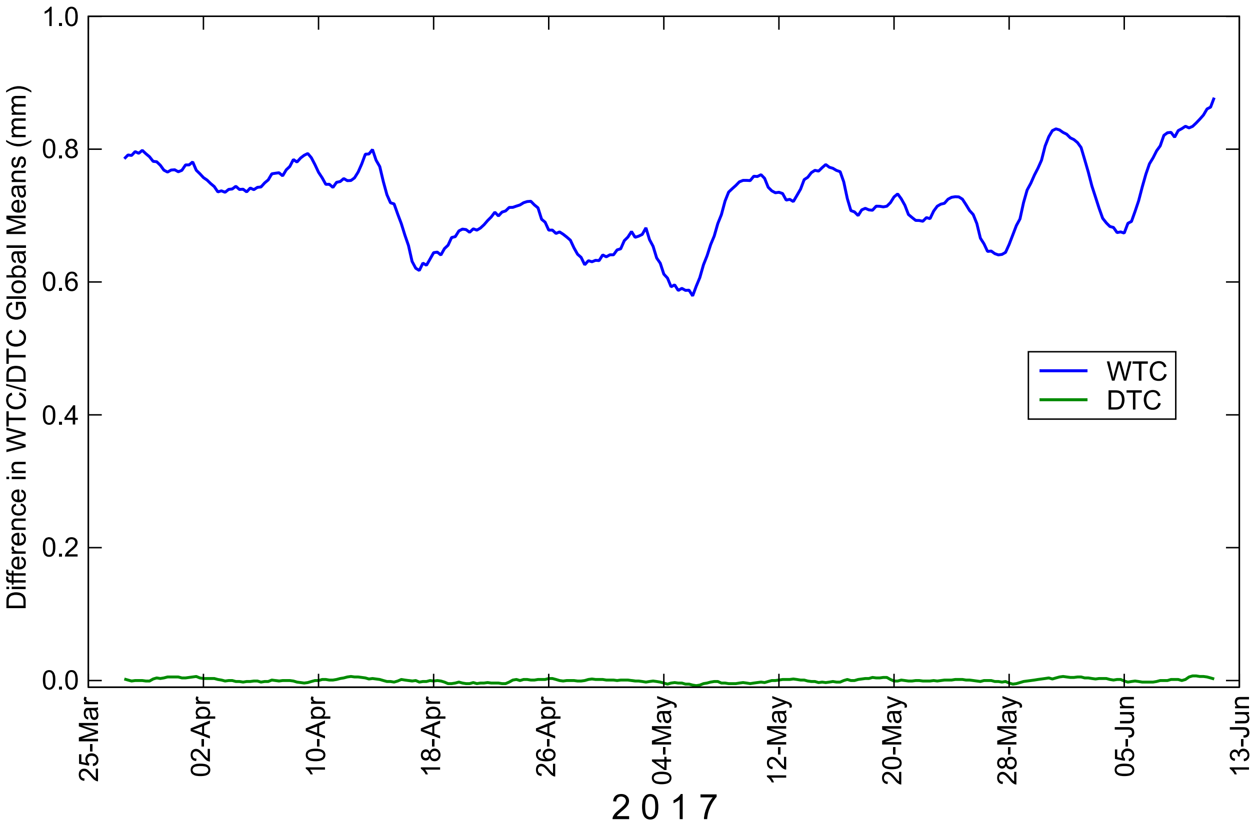

Figure 1: The time series of the difference in global means of DTC and WTC between the analyses of the new model (CY43R3) and the current operational version (CY43R1). The shown curves are for 3-day running means.

The mean global WTC difference between the two model analyses for all surfaces is fluctuating between 0.6 and 0.9 mm as shown in Figure 1. The spatial distribution of the mean differences over the whole period is shown in Figure 3. The difference is positive everywhere indicating that the new model is wetter or produces higher WTC values. Over the open ocean, the differences are mainly within 3 mm. Higher values can be seen over land especially towards the north of India and in eastern Africa.

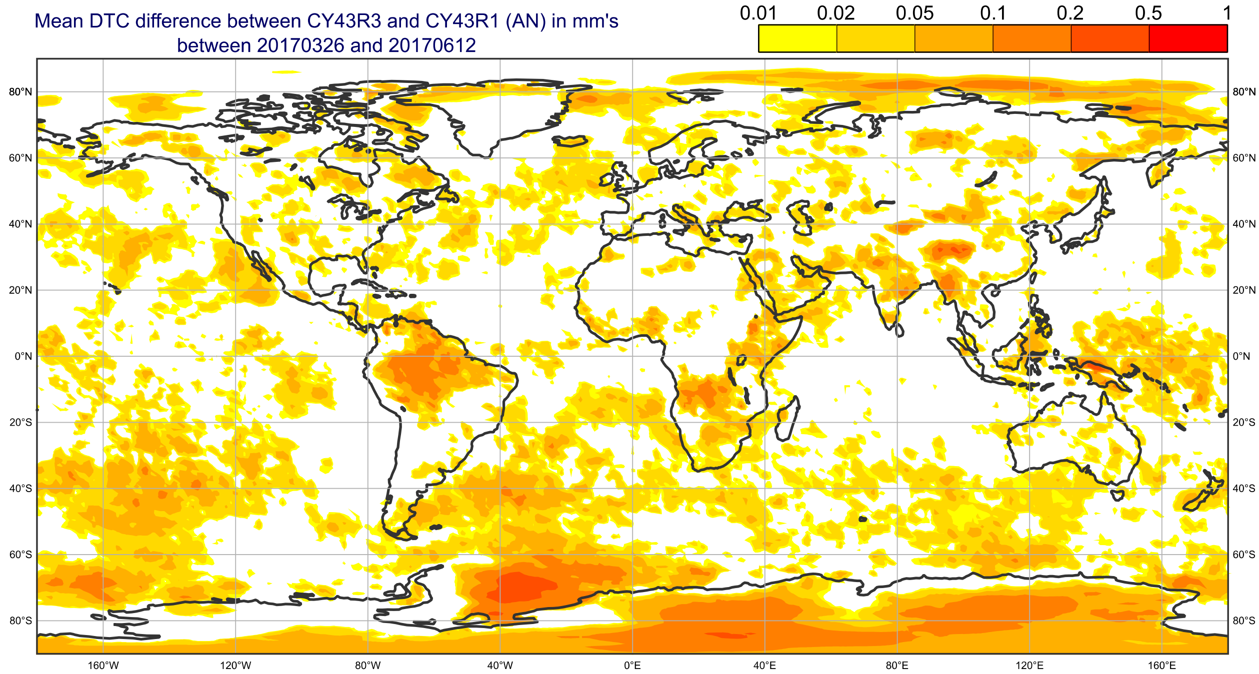

Figure 2: The mean DTC difference, in mm's, between the analyses of the new model (CY43R3) and the current operational version (CY43R1) during the period from 26 March to 12 June 2017.

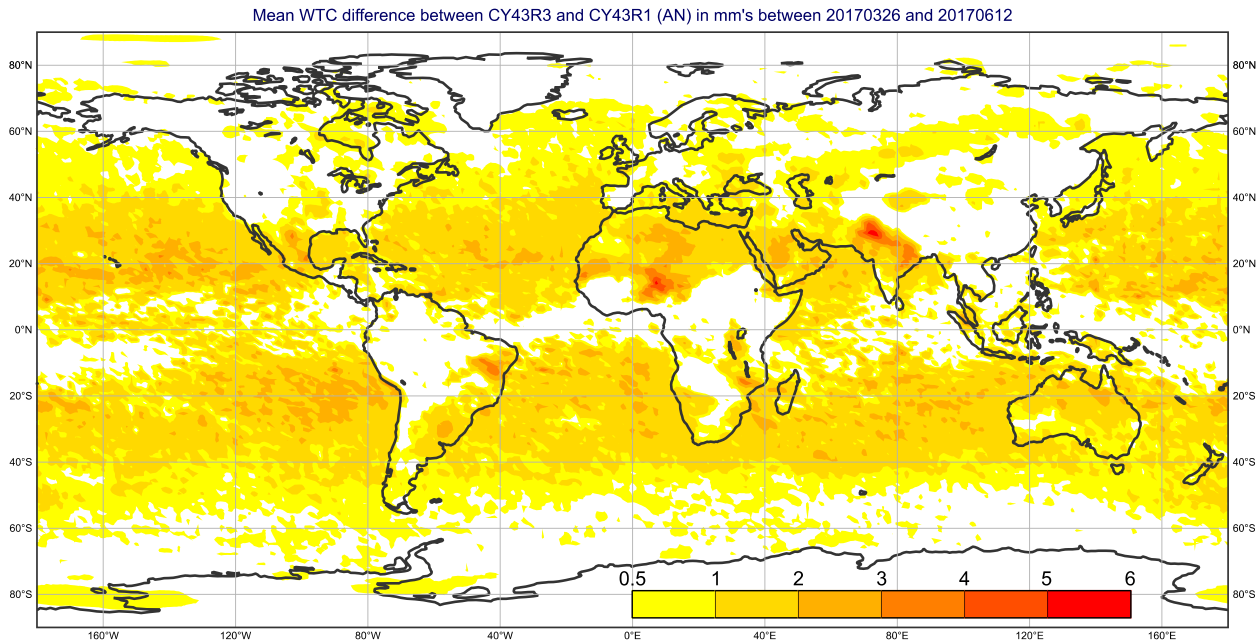

Figure 3: The mean WTC difference, in mm's, between the analyses of the new model (CY43R3) and the current operational model (CY43R1) for the period from 26 March till 12 June 2017.

Since the major model changes are around handling the data for the data assimilation, the impact is expected to reduce with the increase of the forecast lead time. This is relevant for near real time altimeter products which include parameters based on model forecasts. Unfortunately, the WTC computations based on the model forecast required long time to finish and they were not ready in time for this report. Instead the readily available "total column water vapour" (TCWV) which is directly correlated to the WTC can be used.

The time series of the mean difference between the TCWV from the two models (new – current) over the whole globe is shown in Figure 4. The reduction of the difference with respect to the forecast lead is very clear. The geographical distribution of the TCWV difference between the two models is shown in Figure 5, Figure 6 and Figure 7 for the model analyses, and 1-day and 2-day forecasts, respectively. Apart from few areas in the tropics with negative differences (possibly due to different calibrations), the geographical distributions of the WTC (Figure 3) and TCWV (Figure 5) are very similar. The reduction of the difference along the forecast lead time can be seen by comparing Figure 6, and Figure 7 to Figure 5. Similar decrease is expected for the WTC.

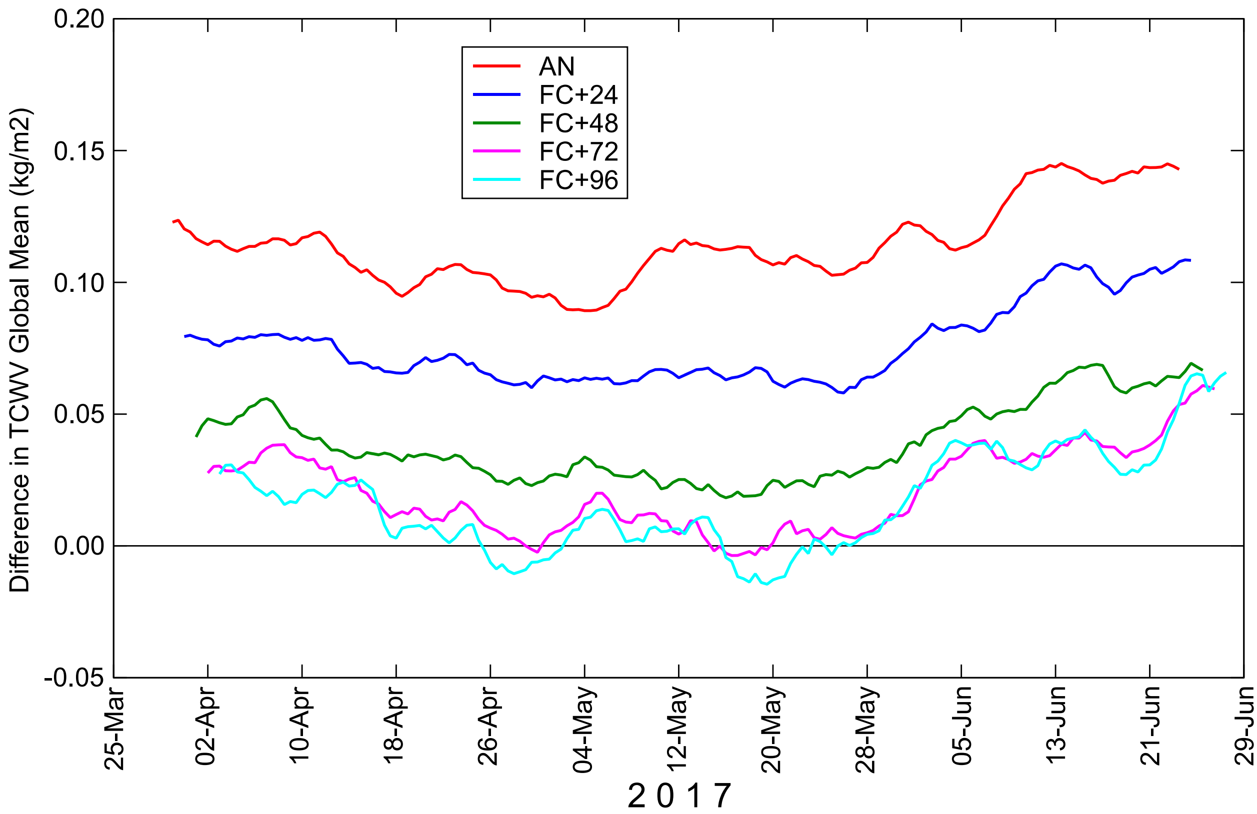

Figure 4: The time series of the difference in global means of TCWV between the new model (CY43R3) and the current operational version (CY43R1) at analysis time and different forecast lead times in hours. The shown curves are for 3-day running means.

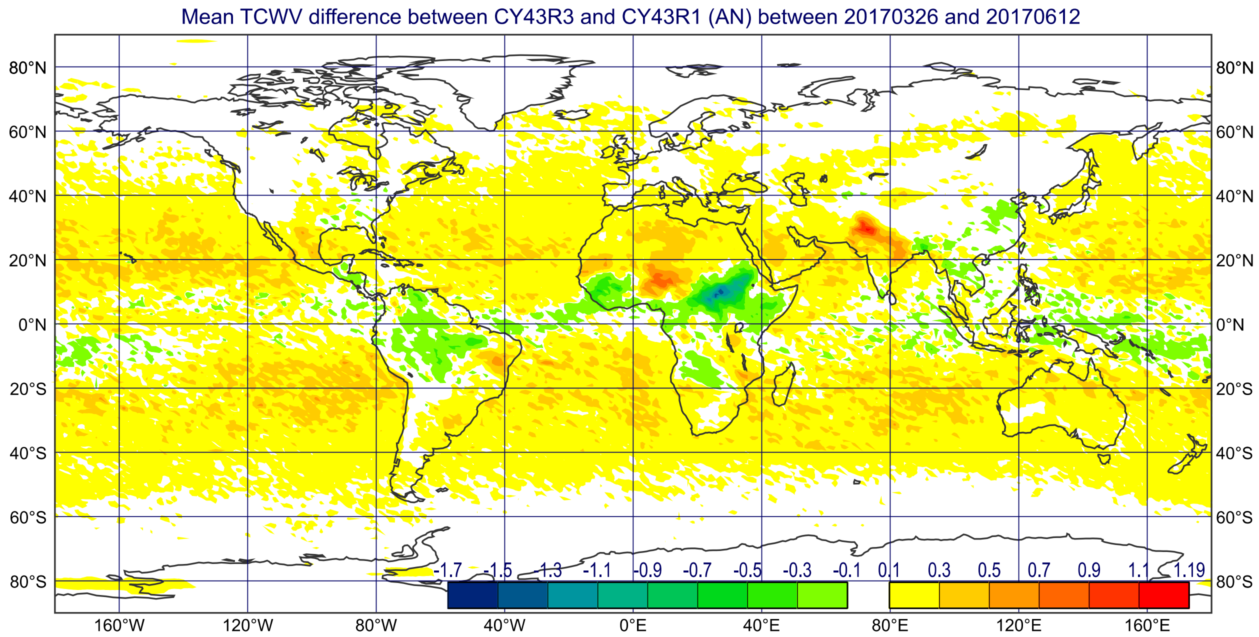

Figure 5: The mean TCWV difference, in kg/m², between the analyses of the new model (CY43R3) and the current operational model (CY43R1) for the period from 26 March till 12 June 2017.

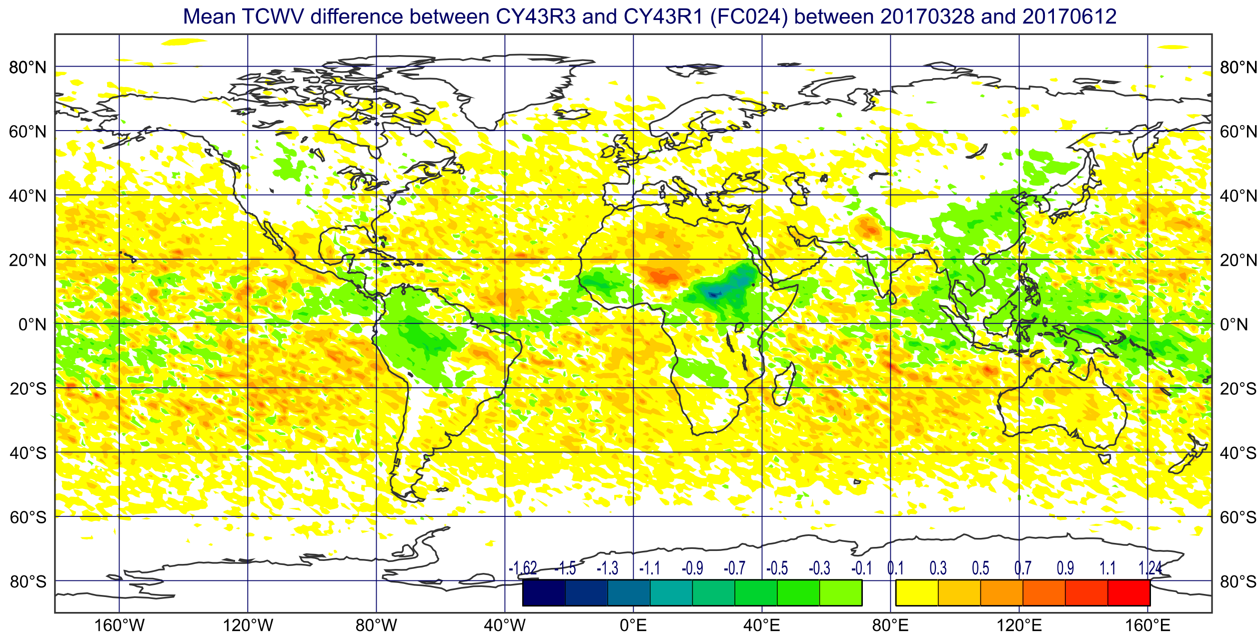

Figure 6: Same as Figure 5 but for the model 1-day forecasts and for the period from 28 March till 12 June 2017.

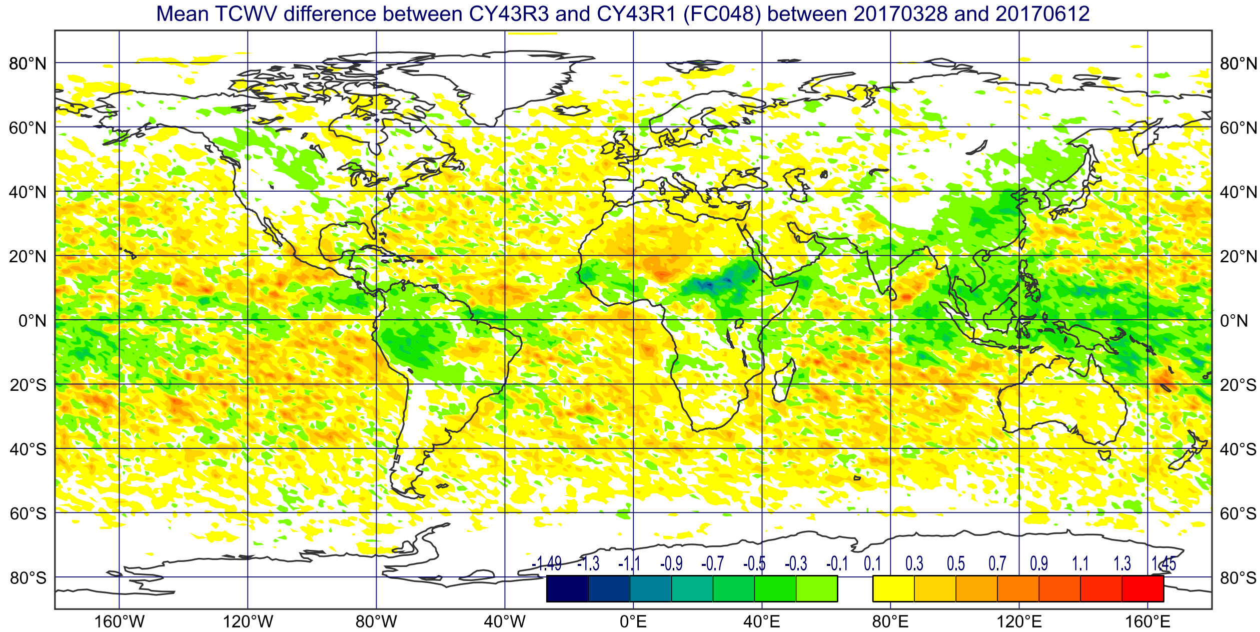

Figure 7: Same as Figure 5 but for the model 2-day forecasts and for the period from 28 March till 12 June 2017.

The previous assessment was based on the model fields and covered all Earth surfaces. For an oceanic assessment that is relevant for Sentinel-3A (and similar satellites like CryoSat-2), the results from both models are compared against Sentinel-3A Microwave Radiometer (MWR) measurements.

The comparison between WTC from Sentinel-3A and the model analyses for both models can be summarised in Figure 8. Along the Sentinel-3A track, the bias in the upper panel of Figure 8 is defined as the model WTC – Sentinel-3A WTC. While the WTC from the current model (CY43R1) is higher than that of Sentinel-3A by about 2-3 mm, the new model (CY43R3) provides WTC values that are 3-4 mm higher than those of Sentinel-3A and about 0.8 mm higher than the current model. The standard deviation of the WTC difference (SDD) between Sentinel-3A MWR and the model is lower for the new model compared to the current model. Keeping in mind that SDD is a proxy to the random errors when a common base of reference is used (which is Sentinel-3A here), the new model is slightly better than the current model.

The time series of the WTC bias and the SDD between Sentinel-3A MWR and the model forecasts are shown in Figure 9 and Figure 10 for 1-day and 2 day forecast leads, respectively. The bias and the SDD curves are getting closer to each other by increasing the forecast lead time. The differences between the two model curves at the analysis time and the two other lead times are plotted in Figure 11. The difference between the two models reduces from about 0.9 mm in the analysis time to about 0.7 mm at 1-day forecast to about 0.5 mm at 2-day forecasts (note that the bias is already negative and when the curves in the upper panel of Figure 11 go up means a reduction in the bias). The improvement of new model with respect to the current model in terms of the random error (as indicated by the SDD) also decrease with the increase of the forecast lead time.

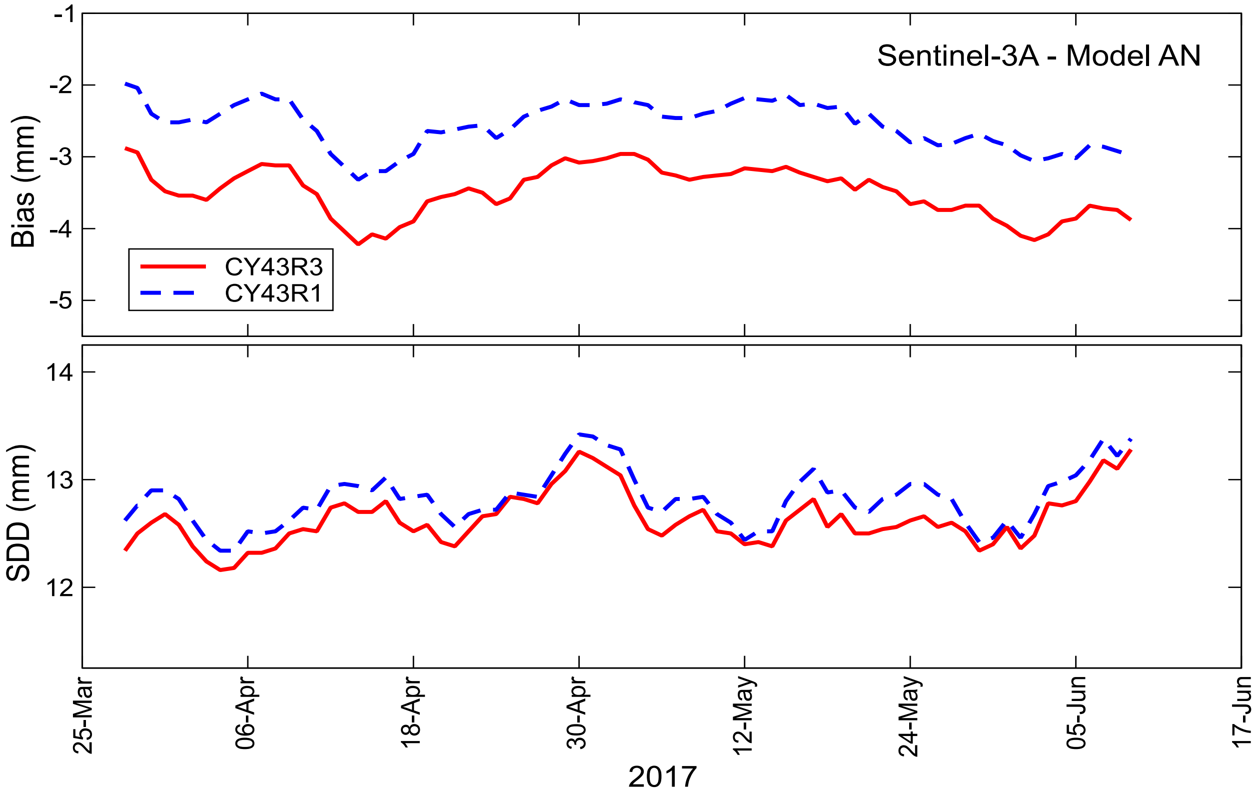

Figure 8: Time series of the difference (bias) between Sentinel-3A MWR and the model analysis of wet tropospheric correction (upper) and the standard deviation of the difference between the two (lower).

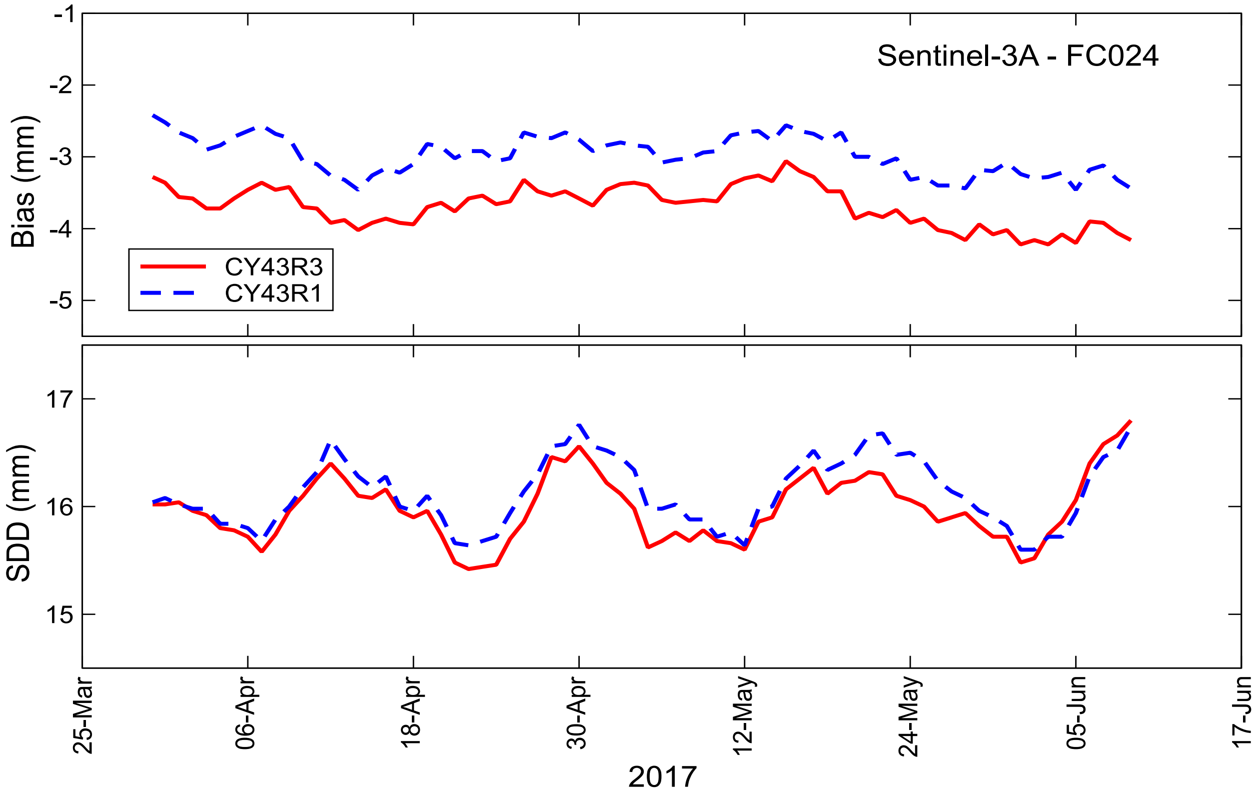

Figure 9: Same as Figure 8 except for the use of the model 1-day forecast.

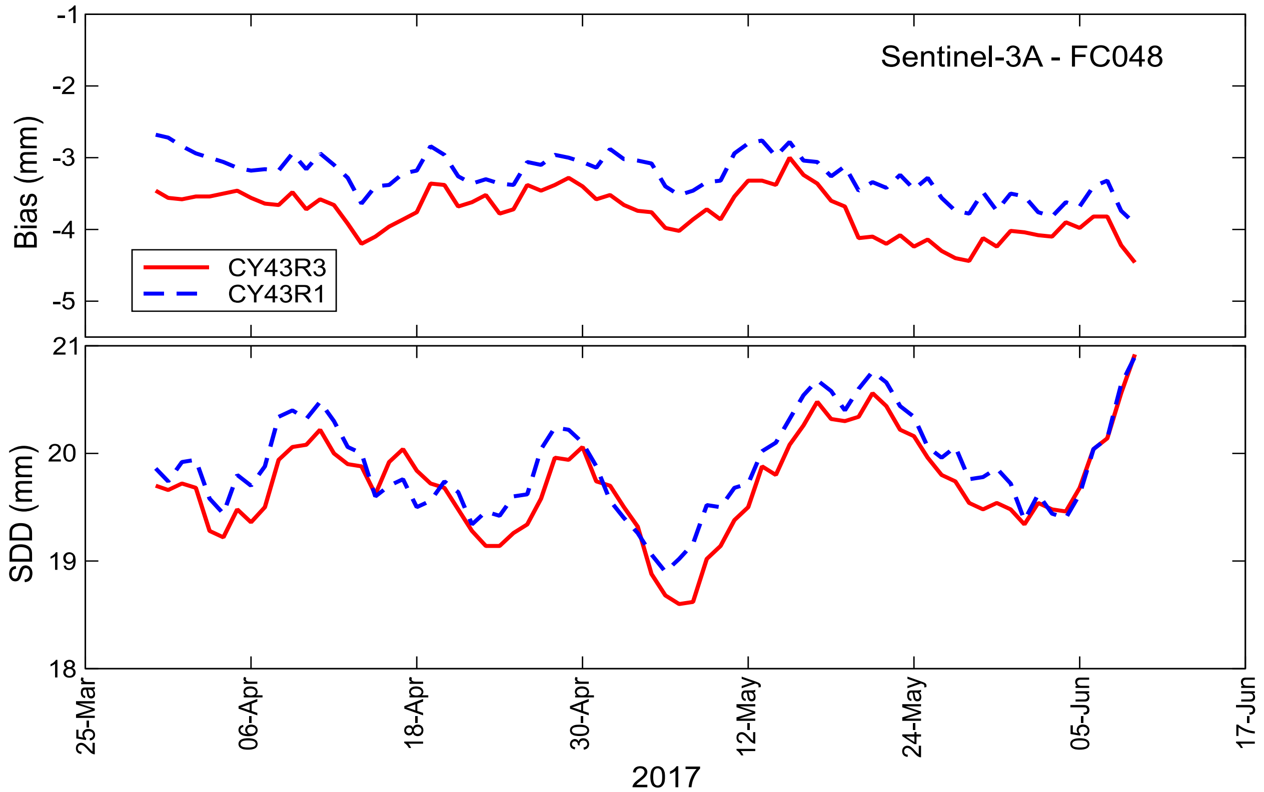

Figure 10: Same as Figure 8 except for the use of the model 2-day forecast.

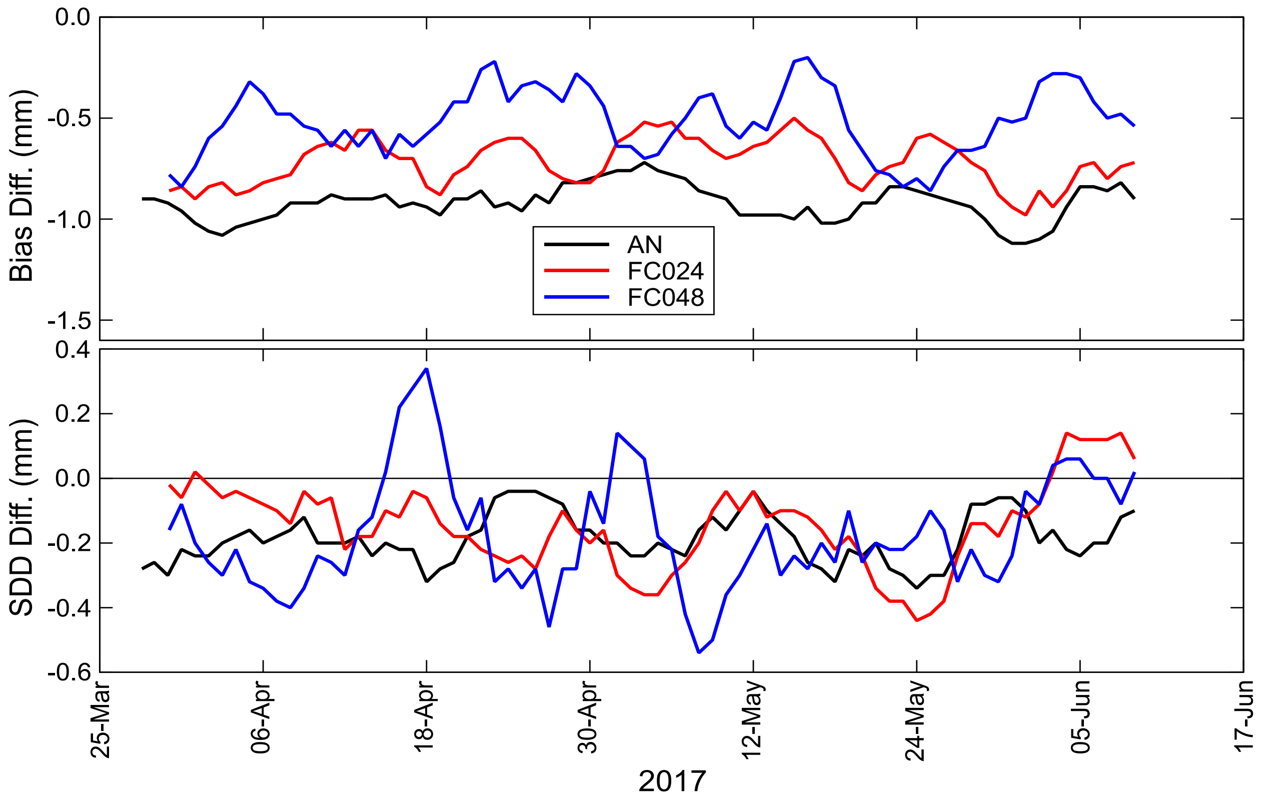

Figure 11: The time series of the mean difference in the bias and the standard deviation of the difference between Sentinel-3A MWR and the model.

Figure 12 shows the WTC bias difference between the two models with respect to Sentinel-3A averaged over the period from 28 March (dictated by the 2-day forecast from 26 March) to 12 June 2017. The reduction of (absolute) bias difference with the increase in lead time indicates the reduction of the impact of the new model at longer forecast times.

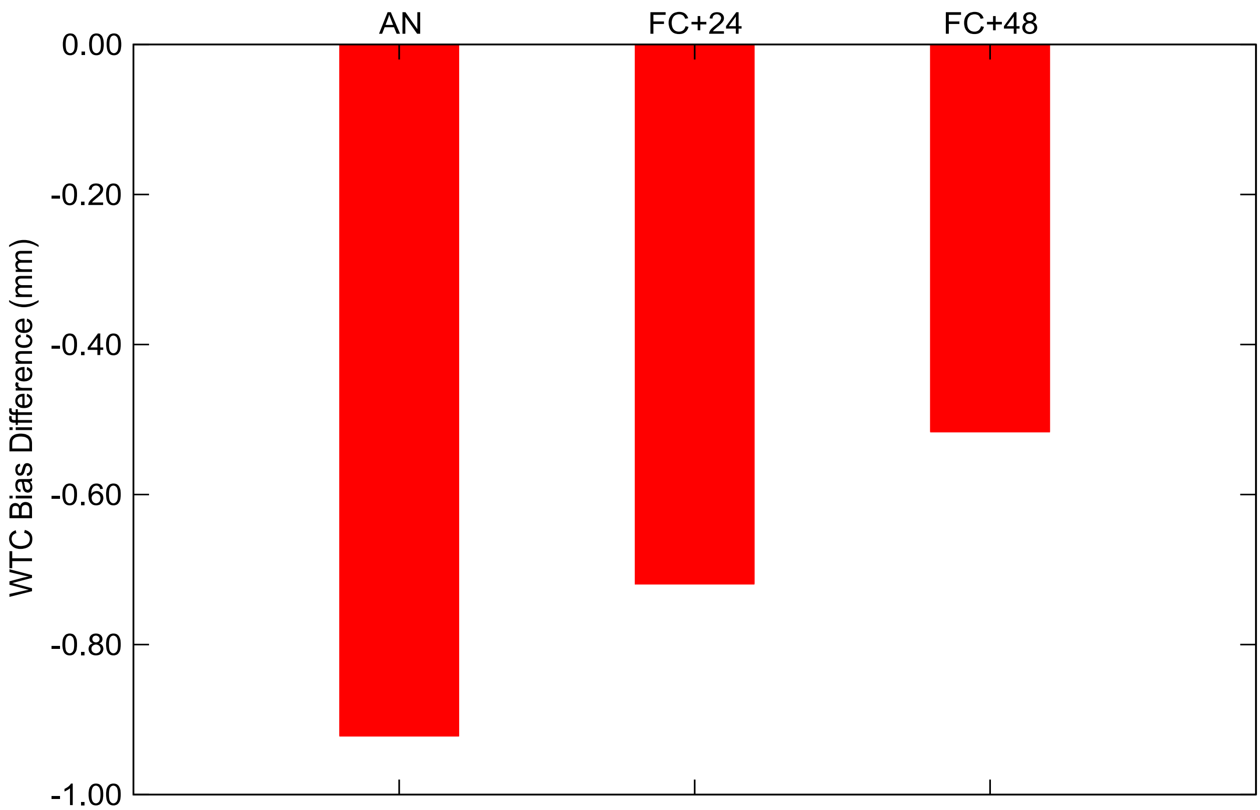

Figure 12: The mean difference in the bias between Sentinel-3A MWR and the model over the period from 26 (or 28 for the forecasts) March to 12 June 2017.

5 Conclusion

The new version of ECMWF IFS HRES model Cycle 43R3 is scheduled for operational implementation on 11 July 2017. The new version will include several changes that have an impact on the atmospheric humidity and the atmospheric water vapour content.

The impact of the new changes on the computations of the dry tropospheric correction (DTC) is very small (in the order of few tenths of millimetres).

The impact of the new changes on the computations of the wet tropospheric correction (WTC) is relatively small. The new model can increase the WTC on average by about 0.8-0.9 mm if the model analyses are used. The impact fades away with the increase in the forecast lead times and can be halved if 2-day model forecasts are used.

Of course local instantaneous changes (not shown) can be twice as much as the average values quoted above.

6 References

Abdalla, S. (2013a): "Practical considerations for the computations of radar altimeter path delay", ESA Living Planet Symposium 2013, 9-13 Sep., Edinburgh, ESA Proceedings SP-722 (CD).

Abdalla, S. (2013b): "Evaluation of radar altimeter path delay using ECMWF pressure-level and model-level fields", a report for ESA, Contract 21519/08/I-OL, 27 pp: http://www.ecmwf.int/en/elibrary/7637-evaluation-radar-altimeter-path-delay-using-ecmwf-pressure-level-and-model-level

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