Manuscript title: *"The impact of a new high-resolution ocean model on the Met Office North-West European Shelf forecasting system". by M. Tonani et al.*

Bold: referee's comment
Not bold: author's answer

The referee's comments are copied in this document for ease of reading.

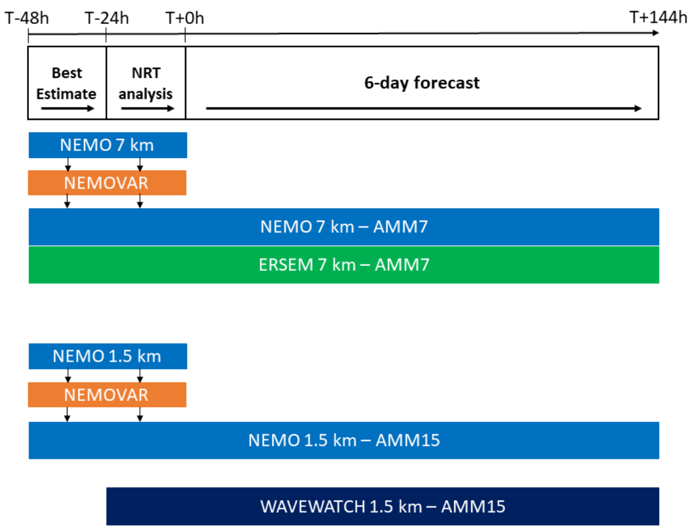
General comment:

The paper "The impact of a new high-resolution ocean model on the Met Office North-West European Shelf forecasting system" presents in a really useful and interesting way the main components of the high resolution regional ocean forecasting system and the validation protocol and results. Main novelties and innovative works in this study concern the high resolution of this regional forecasting system including data assimilation of the main available observations. As mentioned by the authors, it seems difficult to exhibit really significant improvements link to the higher resolution especially because the validation protocol is based on standard comparison between model and observations even if authors used specific high resolution observations based on glidersor HF radars. Nevertheless the study present an exhaustive comparison to available observations (assimilated or not) and validation diagnostics for most of the physical variables, these information are really useful for users of these operational forecast products and for developers of ocean forecasting system. I recommend the publication of this paper if the following minor revisions are taking into account in the final version.

1.Introduction

1. **It could be useful to have a schematic view of the operational schedule of the system. The figure 2 with more information for example**

Thanks for this suggestion. We had added this information, the new figure 2 is:



2. **Could you provide more precise information on the number of observations assimilated in the system thanks to the chosen assimilation cycles?**

From the manuscript:

"The system runs forecast cycle every day to provide 6-day forecast .... By assimilating observations in this way, the FOAM system incorporates information from considerably more observations than would be available in near-real time with a single 24-hr window, due to the addition of late-arriving observations".

The timeliness of the NRT observations could vary and be delivered with more than 24hr delay. For SST the delivery is usually within the 24-hr, therefore the impact is effectively zero for SST. NRT analysis (0h-24h) and Best estimate (24h-48h) have almost the same number of observations. The number of sub-surface profiles of temperature and salinity instead increases by ~15% by taking two days assimilation window instead of one. Given the low number of profiles this could be significant.

The number and quality of SLA observations increase in the file used for the Best estimate compared to the one available for NRT analysis. This is due to the production process of the SLA data, As described in Figure 2 in the Product User Manual (http://resources.marine.copernicus.eu/documents/PUM/CMEMS-SL-PUM-008-032-062.pdf) of this product.

The value available for the NRT analysis cycle are marked in orange in Figure 2 and are produced using altimeter fast-delivery input (Operational Geophysical Data Record, OGDR, or L2P Near Real Time). The value available for the Best Estimate cycle instead, in yellow, are produced using the altimeter real time data (Interim Geophysical Data Record, IGDR, or L2P Short Time Critical). The fast delivery input data have less measurements and lower accuracy.

Figure from CMEMS PUM:

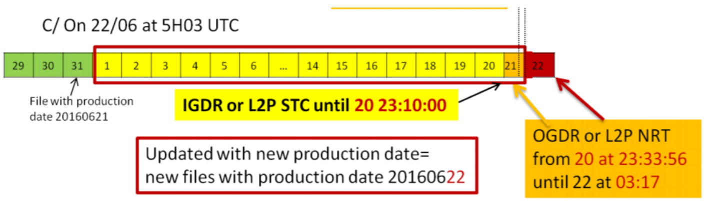


Figure 2: Data delivery flow for Global NRT SL-TAC products

Providing an estimation of the different number of observations and quality it's complicated by our assumption to assimilate data only where the depth is higher than 700m. An estimation of the differences between the SLA data available for the Best Estimate and the NRT Analysis are:

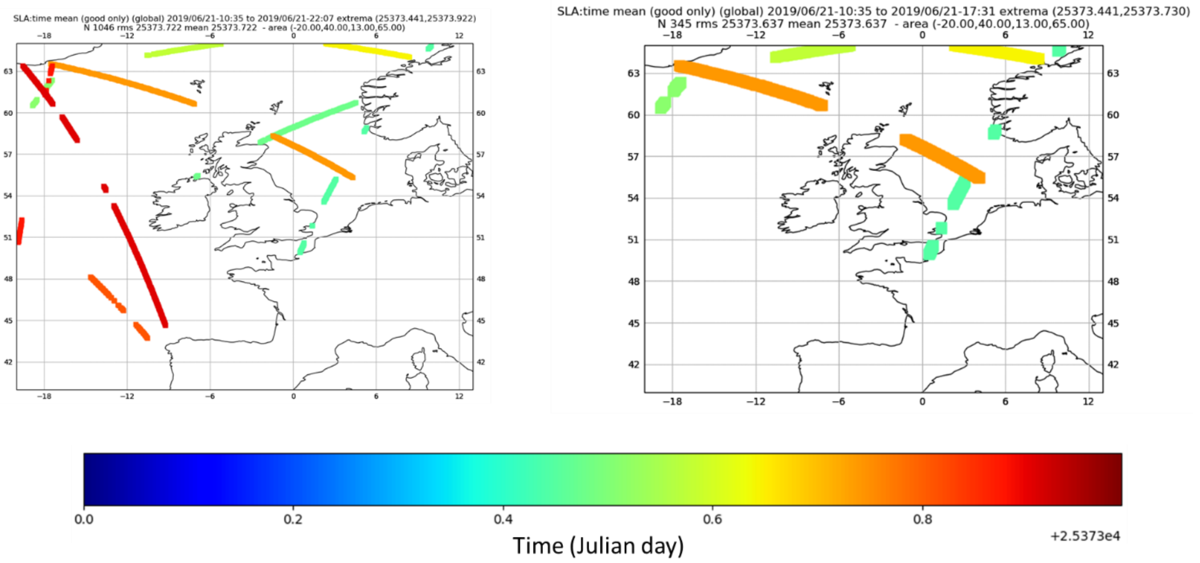


Figure: SLA observations available for the Best Estimate (left panel) and for the NRT Analysis (right panel). The value along the track represents the time associated with the measurements. The time is represented in Julian day. All the values taken after ~21:00 are not included in the NRT but are in the Best Estimate Analysis. Also measurements taken before 21:00, could be missing in the NRT data (e.g.: green line between 57 N- 61N).

3. **You mentioned the on going development of physic-biogeochemistry coupled system and the operational constrain. It's not the topic of the paper, but I suggest there is too much or not enough information for readers. Could you add few words about the time constrain and what kind of development is expected to reach the goal.**

The first version of the biogeochemical model coupled at 1.5km was made available at the end of year 2018. The preliminary tests required an extensive use of computational resources, not compatible with the operational requirements. One day (24 hours) of coupled model run required ~ 2.5 hours. The production of a full forecast cycle would have been around ~ 25 hours, for the 2 days with data assimilation and the 6 -day forecast. This number are prohibitive for a daily production cycle. These tests are running on the Met Office HPC – Cray XC40 super computer using 48 nodes and 1536 processors.

R&D activities are trying to improve the use of the resources and investigate different solutions for the coupling like a coarser time step or grid for the biogeochemical model.

The manuscript has modified:

"The upgrade of the NWS system to AMM15 does not yet include the biogeochemical component as the computational cost is prohibitive, because the production time exceeds the 24-hr for a full hindcast-forecast cycle."

<u>2.System Development</u>

<u>2.1.Core model Description</u>

1. **One specificity of the model configuration is the vertical coordinate system based on z*-σ. There is no justification in the description paragraph concerning the number of vertical levels which is the same than in the lower resolution system. Is there theoretical or experimental justification to reduce the rmax coefficient to 0.1 in this high resolution configuration and what is the expected impact (except the numerical stability)?**

The major aim of this model configuration is to resolve the Rossby Radius on the shelf, therefore the focus was on increasing the resolution from 7 to 1.5 km. more than increasing the vertical resolution.

The number of vertical levels is the same because the focus of this model is on the shelf (depth < 200m), where 51 z-sigma levels are enough for proving a very high vertical resolution. The resolution is of the order of 20cm the shallower part of the model domain, where the minimum depth is 10. More levels will increase the model vertical resolution in the deepest part of the domain, not on shelf (Siddorn et al., 20016). Another possible approach is using vertically adaptive vertical coordinates so that you focus resolution on the thermocline. This is done in other models but not here and will be considered in the future configurations.

All the technical details of the implementation and the validation of the model, without data assimilation, are presented in Graham et al., 2018 that is the precursor work to this paper.

The justification for the rmax choice is Graham et al. 2018a:

"With terrain-following coordinates, large slopes between adjacent grid cells can lead to pressure gradient errors. To reduce such errors, vertical cells can be masked over slopes which exceed a specified value, rmax, where r =(hi −hi+1)/(hi +hi+1), and hi,i+1 are adjacent bathymetry points. Terrain-following coordinates are fitted to a smoothed envelope bathymetry, with the level of smoothing based on the chosen rmax value. In regions where the smoothed model levels become deeper than the input bathymetry, these levels are then masked. Thermax value was chosen here to be 0.1. This is a lower value than used in previous configurations. However, with increased resolution, the model bathymetry is rougher, resolving steeper gradients and canyons along the shelf break. This value was then chosen to ensure stability in the configuration without the need to smooth the input bathymetry".

2. **You impose a minimum of 10m depth on the bathymetry (this characteristic is also mentioned in the conclusion as a limitation), could you justify this choice, is only due to model stability?**

This is down to the tidal limits and lack of wetting and drying. 10m ensures that no locations dry out (e.g. Bristol channel).

This information is now added in the manuscript:

"*The model minimum depth is forced to be 10m, due to the tidal limit and lack of wetting and dry. This choice ensures that no locations dry out, due to the tides.*"

3. **How do you justify such difference (2 orders of magnitude) between the diffusion coefficient on tracer and advection?**

These values we chosen over a series of sensitivity tests. We aimed to keep diffusion parameters as low as possible (due to resolving processes at higher resolution), opting for bi-laplacian diffusion along model levels primarily to ensure stability. For momentum, the value was chosen to account for processes that are still missing (e.g. smaller scale frictional processes). For tracers, we initially started with the same order of magnitude. However, these results appeared to be too diffusive, so following tests opted for a less diffusive value, but one that would still provide stable conditions under long simulations.

2.1.1Boundary and surface forcing

1. **Could you add in the table 2 information concerning the difference of solar flux penetration in the two configurations and information on the tidal forcing at lateral boundaries**

Yes, thanks for the correction. The tidal forcing information have been added to table 2. The differences concerning the solar flux penetration are in Table 1.

Updated Table 2:

Forcing	AMM7	AMM15
Surface forcing	Met Office Global Unified Model (MetUM) Atmospheric model NWP analysis and forecast fields, calculated in the MetUM using COARE4 bulk formulae (Fairall et al. 2003).	ECMWF Integrated Forecasting System (IFS)-Atmospheric Model High Resolution (HRES) operational NWP forecast fields using CORE bulk formulae (Large and Yeager 2009)
Surface forcing resolution	Horizontal grid: ~10 km (2560 x 1920 grid points) Frequency: 3 hourly mean fluxes of long and short wave radiation, moisture, 3 hourly mean air surface temperature but hourly 10m winds and surface pressure	Horizontal grid: ~14 km (0.125°x0.125°). Frequency: 3 hourly instantaneous 2m dew point temperature, surface pressure, mean sea level pressure, and 2m air temperature. 3 hourly accumulated surface thermal and solar radiation, total precipitation, and total snow fall.
River run-off	Daily climatology of gauge data averaged for 1950–2005. Climatology of daily discharge data for 279 rivers from the Global River Discharge Data Base (Vörösmarty et al., 2000) and from data prepared by the Centre for Ecology and Hydrology as used by (Young and Holt, 2007).	Daily climatology of gauge data averaged for 1980–2014. UK data were processed from raw data provided by the Environment Agency, the Scottish Environment Protection Agency, the Rivers Agency (Norther Ireland), and the National River Flow Archive (personal communication by Sonja M. van Leeuwen, CEFAS, 2016). For major rivers that were missing from this data set (e.g. along the French and Norwegian coast), data have been provided by the same climatology used by AMM7 (Vörösmarty et al., 2000 and Young and Holt, 2007).
Tidal constituents	M2, S2, N2, K2, K1, O1, P1, Q1, M4, MS4, L2, T2, S1, 2N2, MU2, NU2 (15) from a tidal model of the North-East Atlantic (Flather, 1981).	M2, S2, N2, K2, K1, O1, P1, Q1, M4, MS4, MN4 (11) from Topex Poseidon cross-over solution (Egbert and Erofeeva, 2002; TPX07.2, Atlantic Ocean 2011-ATLAS).
Lateral boundaries	Met Office FOAM North Atlantic (1/12°; 6 hourly fields) and CMEMS Baltic Sea (2km, 1 hourly fields).	
	AMM7 and AMM15 have Atlantic and Baltic boundaries in a different geographical location.	

2.2Assimilation method

Some information are missing in the description:

1. How is implemented the IAU method?

We have rephrased the manuscript sentence: "*The increments are applied to the model fields at each time-step using the incremental analysis update procedure (IAY, Bloom et al. 1996)*" with the following: *"After the assimilation step, the model is re-run for the same period with a fraction of the increments applied to the model fields at each time step (the incremental analysis update procedure, Bloom et al. 1996)*".

We hope this clarifies to the readers how the IAU method is implemented.

2. What is the SLA bias correction?

We have expanded page 7, line 14 adding the following text: " *The Met Office implementation of NEMOVAR includes bias correction scheme for both SST and altimeter data. The SST bias correction aims to correct for biases in the observed SST due to the synoptic scale atmospheric errors in the satellite retrievals, while for SLA we apply a slowly-evolving bias correction to correct for errors in the MDT (Lea et al. 2008)".*

3. How do you use the 2 correlation length scale in the assimilation scheme? Do you perform 2 analysis?

There is only one analysis. The correlation operator used in the specification of the background errors within NEMOVAR is a linear combination of functions with different length-scales (see Mirouze et al. 2016). This allow us to define a correlation operator that features high correlations within a short scale and weak correlations at large scales.

We added this reference is the manuscript.

Mirouze, I, Blockley, E. W., Lea,D.J., Martin, M.J., Bell, M.J.: A multiple length scale correlation operator for ocean data assimilation, Tellus A 2016, 68, 29744, http://dx.doi.org/10.3402/tellusa.v68.29744, 2016

4. In table 4, what are the differences between the 2 in situ data sources. How do you manage observation available in the two data bases?

The differences are in the data format, distribution protocol, timeliness. Some of the data sources are in common and therefore we perform a duplicate check before ingesting the observations in the analysis.

5. In table 4, there is no information on the mean dynamic topography used to assimilate the SLA.

We use the CNES-CL09 mean dynamic topography (MDT, Rio et al. 2011) to calculate observations of the SSH from the observed SLA which can be compared to our model SSH fields. We have added this information to table 4.

Data Assimilation	AMM7	AMM15
NEMOVAR version	V3	V4
SST bias correction scheme:	Offline observations-of-bias scheme. Reference dataset: in-situ.	Variational scheme in addition to observations-of-bias. Reference datasets: in-situ (drifters only) and VIIRS satellite data.
Correlation operator short scale: 3-times grid scale	~20 km	~5 km
Mean Dynamic Topography	CNES-CL09 mean dynamic topography (MDT, Rio et al. 2011)	

6. There is no information on methodology applied to assimilate the SLA in the model including tides.

We added the following to page 7, line 12: *"… as detailed in Table 4. The SLA observations assimilated in this model are provided through CMEMS and include the corrections necessary to add back the signals due to tides and wind and pressure effects necessary for use with a wind and pressure forced, tidal coastal model (King et al. 2018)".*

2.3Operational production

1. How is computed the QC error threshold for the observations?

The QC error threshold for the observations is defined on the base of the model-observation difference and varies with depth. Temperature and salinity have a different threshold error. The details on the background check are described in Ingleby et al., 2007. We added this reference to the manuscript. We corrected also the typo 1/3 with "*1/2*".

Ingleby, B., Huddlestone, M.: Quality control of ocean temperature and salinity profiles — Historical and real-time data, Journal of Marine System, Vol. 65, Issue 1-4, pp. 158-175, https://doi.org/10.1016/j.jmarsys.2005.11.019, 2007.

2. You provide output fields on a standard vertical grid, how do you provide the information at the surface (0m)? Is there a specific extrapolation to the surface?

The surface level is the model first level, we don't apply any specific extrapolation at the surface. We have substitute 0 with "*surface*" in the manuscript to avoid confusion.

3. Additional information concerning computational resources for this operational system could be useful (number of CPU, computer characteristics…)

These operational systems are running on the Met Office HPC – Cray XC40 super computer. The information in terms of number of nodes and processors used by each component of the system are in the following table:

System	Component	# of nodes	# of processors
AMM7	NEMO	8	256
	XIOS	--	--
	NEMOVAR	2	64
AMM15	NEMO	48	1536
	XIOS	8	256
	NEMOVAR	48	1536

XIOS is for the I/O of NEMO. The small size of AMM7 model grid doesn't require dedicated nodes for this task.

We have added this information in the manuscript.

4. More information could be added on figure 2 as for example, the observations, the atmospheric forcing, the restart and the assimilation and forecast sequence.

We have increased the number of information in figure 2, providing more details on the forecast production cycle. (see answer Question 1, Introduction).

4.Validation

4.1Tides

1. **M2 is the dominant tidal signal and probably the most important in an operational system for applications, user needs …. One unexpected result increasing the resolution is perhaps the degradation of the mean M2 solution. It will be important in this section to discuss this point and highlight origin of this degradation.**

AMM15has a higher mean error (few cm higher than AMM7) but a better RMSD than AMM7. This is explained in Graham at al. 2018:

"For AMM7, while the RMSE has a similar magnitude to AMM15, compensating errors in both amplitude and phase are found around the UK, reducing the apparent mean bias."

Yes, the referee is correct, it is important to improve the tidal forcing of AMM15, in terms of tidal constituents and atlases. Research activities are ongoing to validate the impact of using a different model, FES2014, with many more tidal constituents.

4.2Sea Surface Height

The section concerning SSH, as it is, is not really useful and could be removed. But as the SSH is assimilated in the system it's important to quantify impact of these observations. I suggest to add few diagnostics in comparison to SSH as for example:

Statistic/comparison with altimetry in open ocean where observation are assimilated. Along track comparison could be performed. It's important to understand in the paper why SLA is assimilated in the system

Spatial power spectra to quantify spatial resolution of the system

Variability or eddy kinetic energy

The point of this short section is not to quantify the impact of assimilating SLA, this was done in King et al. 2018, but to verify that we can achieve similar accuracy (in terms of bias and RMSD) with the higher resolution model. The current altimeter assimilation is limited and there are plans to extend the assimilation into the shallow water regions which are tidally dominated.

We describe in the paper the procedure for the validation of the trial experiments for the pre-operational implementation of this system. The evolution of the model and data assimilation components are those described in Graham et al 2018 for the model and King et al. 2017 for the data assimilation.

4.3 Sea Surface Temperature

Temporal variability from seasonal cycle to high frequency is validated comparing model output to satellite observations and in situ time series. As expected there are few differences between the two models, main difference between the models being the horizontal resolution, even if the authors exhibit interesting higher frequency processes in the high resolution system. Even if it is not feasible with the observations why any spatial power spectra (or other diagnostics) has been performed to quantify differences between the 2 models?

As the referee is pointing out, it is difficult to identify an SST L4 product with a resolution comparable or higher than AMM15. We have done seasonal gradient maps from AMM7, AMM15 and OSTIA (not shown in the paper) and it's difficult to validate the increased variability of AMM15. The power spectrum plots shown in the manuscript show bigger differences between AMM15 and AMM7 during the autumn, probably due to the different stratification of the two models in that area. We copied here the details preferee#2 on figure9:

The power spectra shown in Figure 9 is for the FINO 3 buoy (number 2 in Figure 4). The buoy is in the German bight, where the bathymetry is shallow (~20m). The 12h energy peak overestimation is remarkable in SON (wrongly marked as DJF in the manuscript, now corrected), at the end of the summer when probably the two models have different stratifications. The water column is moved by the tides (M2 in the predominant tide) and this could bring to differences in the SST variability. The stratification is this area could also be enhanced by the fresh water contribution of two major rivers, Elbe and Weser. This hypothesis is supported also from the analysis of the map of SST gradients (not shown in the paper) where AMM15 shows stronger gradients than AMM7. Further studies are needed to understand better the SST variability in AMM5.

<u>4.4Water Column</u>

On figure 10 larger bias and larger differences between AMM15 and AMM7 is located at 100m depth. Is it linked to Mediterranean water? How do you explain this difference if the two configurations have the same constrains at the boundary and assimilates the same observations?

The large AMM7 bias is due to the vertical level discretization. With terrain-following coordinates, large slopes between adjacent grid cells can lead to pressure gradient errors. To reduce such errors, vertical cells can be masked over slopes which exceed a specified value, rmax. (Graham et al. 2018). AMM15 has a smaller value of Rmax (0.1) than AMM7 (0.3). The vertical discretization of AMM7, when the slope is too large over the shelf break, could end up with cells connected horizontally that are very different in vertical position. This means that the model is mixing in the horizontal sense water from two very different depths. Reducing the allowed slope, as it is in AMM15, prevents this artificial (or reduces) diapycnal mixing.

This is why AMM15 has a reduced bias at depth compared to AMM7.

<u>4.4.2Moorings German Bight</u>

Few more information or hypothesis will be useful to explain some description. –"The high frequency is better reproduced". Do you compute the correlation between the time series ? It's not clear on figure 11.

We added this sentence:

"The improvement is more evident in the summer (JJA) when AMM7 has a fresh bias of ~0.5 PSU while AMM15 has values very close to the observation."

No, we didn't compute the correlation between the time series.

-"at the bottom AMM15 is more accurate". Why? Is it link to the bathymetry or link to vertical projection of increments?

This is probably due to both. AMM15 bathymetry is more accurate and the higher resolution improves the representation of the model bottom, especially in these shallow areas.

-Table 8 : what is the depth of the bottom of each Buoy position?

Thanks for this comment, we added the depth of each buoy in table 8. The depth of these moorings varies from 18 to 35 m.

The updated table 8:

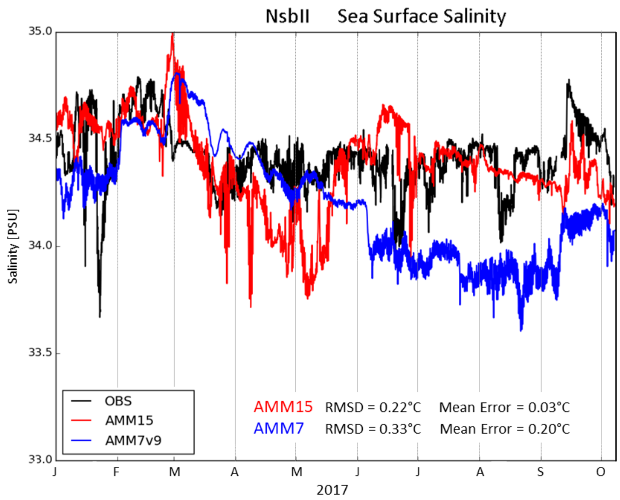
Buoy [bottom depth]	Temperature (C°)							
	Surface				Bottom			
	RMS Difference		Mean Errors		RMS Difference		Mean Error	
	AMM7	AMM15	AMM7	AMM15	AMM7	AMM15	AMM7	AMM15
1 Fino1 [25m]	0.32	**0.21**	**0.03**	-0.05	0.31	**0.21**	0.07	**-0.03**
2 Fino3 [18m]	0.38	**0.37**	**-0.02**	-0.04	0.96	**0.59**	-0.38	**-0.24**
3 NsbII [35m]	0.30	**0.25**	0.12	0.12	0.59	**0.49**	**-0.13**	-0.14
4TWEms [30m]	0.28	**0.26**	0.13	**-0.02**	0.28	**0.16**	0.11	**0.00**
5 UFSDeBucht [20m]	0.50	0.50	0.10	**0.01**	0.95	**0.75**	**-0.31**	-0.33
Mean value	0.36	**0.32**	0.07	**0**	0.62	**0.44**	**-0.13**	-0.15

Buoy [bottom depth]	Salinity (PSU)							
	Surface				Bottom			
	RMS Difference		Mean error		RMS Difference		Mean Error	
	AMM7	AMM15	AMM7	AMM15	AMM7	AMM15	AMM7	AMM15
1 Fino1 [25m]	1.17	**1.02**	0.97	0.97	1.10	**1.02**	0.95	**0.95**
2 Fino3 [18m]	1.06	**0.73**	**0.35**	0.48	0.90	**0.62**	0.53	**0.38**
3 NsbII [35m]	0.33	**0.22**	0.20	**0.03**	0.37	**0.17**	0.26	**0.03**
4 TWEms [30m]	1.05	**0.51**	0.85	**0.29**	1.08	**0.45**	0.89	**0.26**
5 UFSDeBucht [20m]	**0.99**	1.07	**0.55**	0.87	1.08	**1.02**	**0.86**	0.90
Mean value	0.92	**0.71**	0.58	**0.53**	0.91	**0.66**	0.70	**0.51**

-Figure9: why there is no model information in October? Add the correlation on the figure

Thanks for this comment, we have done a new picture, covering only the period January-October to avoid confusion. There are no measurements from the NsbII mooring in October, due to maintenance or malfunction of the sensor, the comparison model-observation is not possible. We double checked the other moorings and none of them is without interruptions.

We have added this information in the label of the new picture.



"*Figure 1: Sea surface salinity at the NsbII mooring for January-September 2017. Observations for October-December are not available*"

4.4.3Glider transects

Could you precise if the glider observations are assimilated or not in the system?

No, the glider observations are not assimilated in AMM7 nor AMM15. Both systems assimilate glider observations but not the profiles from the MASSMO4 2017 campaign.

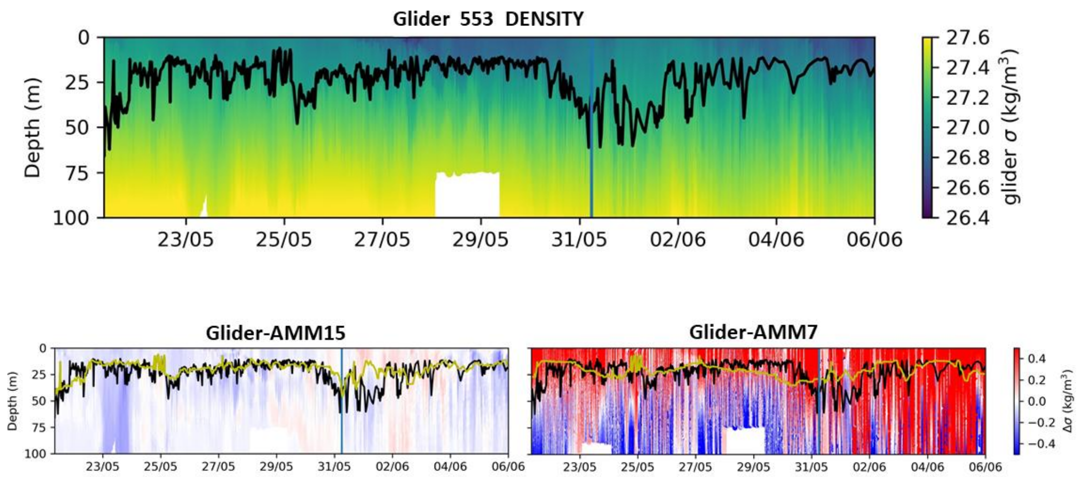
4.4.4Mixed Layer depth

I suggest adding the mixed layer depth for AMM15 and AMM7 on figure 15 for example.

Thanks for the comment, we have added the model MLD to these figures (Yellow line for AMM15 and AMM7 respectively. The black line represents the MLD from the observations).

We added this information in the manuscript:

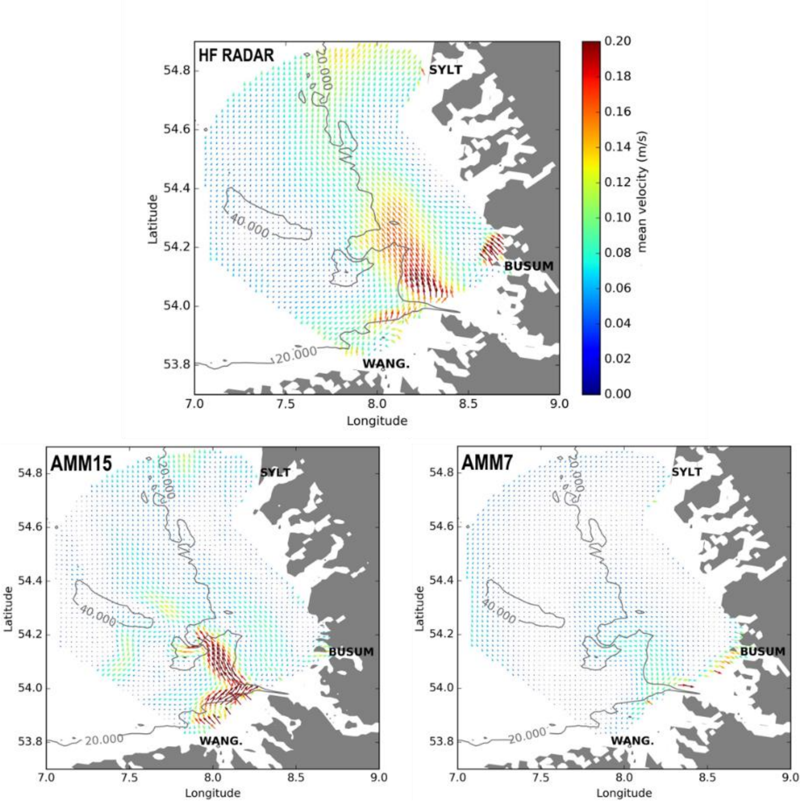
"*...with AMM15 and AMM7 in the corresponding locations (yellow line in Figure 15)*" and in the caption of the figures.



<u>4.5Currents</u>

The comparison with HF radar observations is very useful and seems to be more relevant to compare high and low resolution model outputs. I suggest adding the statistics (mean, rms, correlation on amplitude and direction) which seems to be encouraging for the high resolution model as it is explain in the text but without the figures.

Thanks to this comment we realised that we used in the manuscript the map of velocities before the cleaning of data instead of after. We substituted Figure 16 with the corrected Figure



We added the following text to the manuscript:

"One month, March 2017, of HF radar surface current velocity data were used to compare AMM7 and AMM15 in the German Bight where the bathymetry is shallow (Figure 4) and AMM15 is expected to performed better. The total surface velocity data from the COSYNA (Coastal Observing System for Northern and Arctic Seas) observing network (Gurgel et al., 2011), available through the EMODnet Physics data portal, are computed from radials of three HF radars installed on the islands of Sylt and Wangerooge, and in Büsum (as shown on Figure 6). Data are averaged every 20 minutes on a grid of resolution of ~3 km. At the operating frequencies used, the total surface velocities represent an integrated velocity over a depth between 1 and 2 m. Relative error provided with the dataset was used to keep only data with error smaller than 15%. Model output were interpolated at the time and locations when and where observations were available to avoid applying gap-filling technics.

Temporal coverage over the domain is larger than 75% everywhere except along the base line between Büsum and Wangerooge where the temporal coverage is ~29%."

Figure 17 is nice to exhibit differences between the 2 models. It could be even better to add map with high resolution observations on the same area. Is there any SLA, SST or ocean colour map that can be used to compare front and meso scale structure?

We agree with the reviewer, but we are not aware of any satellite map at a comparable resolution of AMM15. CMEMS has several products but the resolution varies from 1/4 -1/8 of degree with the exception of the ocean colour data from OLCI or the Odyssee SST L4 product. The ocean colour data have several gaps and it could be very difficult to make a comparison. We tried to look at the SST L4 data from Odyssee but since currents like the Norwegian coastal currents and the Scottish coastal currents are mainly salinity driven there is no signal in the SST maps, at least not at the resolution of the currents of AMM15.

We followed the suggestion of the referee#2 and we removed this part from the validation. We moved it at the end of the trial description, adding a new section.

5Conclusion and future developments

Something is missing in the conclusion, even if it is not obvious to validate and quantify improvement link to the higher resolution a discussion on expected improvements and link with user needs on this domain will be useful

We added the following sentence:

"*The users' benefit, using the newly improved European shelf product AMM15, will vary depending from their applications. Higher resolution currents fields with an improved representation of the coastal areas should improve the results of applications like drifting models simulating pollutant or oil spill dispersion and all the applications that need a high resolution currents field. All the acoustic applications, strongly depending on the density stratification and its variability, will benefit from these new products since they have a better representation of the water masses. A general positive impact is expected for most of the users like public bodies responsible for marine environmental regulation, aquaculture industries, marine renewable oil and gas industries*."

Typo, figures or format correction

1. **Section Boundary and Surface Forcing should be 2.2 and then 2.3 Assimilation method, 2.4 operational system**

Done

2. **Table 4 is cited before table 3**

Corrected

3. **Conclusion l 7 spatial/temporal**

Corrected