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Interactive comment on "Forecasting the mixed layer depth in the north east Atlantic: an ensemble approach, with uncertainties based on data from operational oceanic systems" *by* Y. Drillet et al.

Anonymous Referee #1

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My first impressions of this manuscript are that this is an interesting and well constructed inter-comparison of model mixed layer depth. In general the paper reads very well - particularly so given that the authors are not native English speakers - and the methodology is easy to follow.
I have a few questions and comments for the authors and some recommended minor changes to the text & figures. Once these minor corrections are made I would recommend this article for publication in Ocean Science.

1 Larger questions/issues

1. There little or no discussion as to what the results mean. The lower resolution global model is clearly worse than the 1/12 degree and 1/36 degree models but are we to believe that this is purely owing to horizontal resolution? In particular the IBI 1/36 degree system has some considerable differences in the model physics (including a different vertical mixing scheme). What impact would these changes be expected to have? Additionally simply increasing the resolution of your model is not generally a guarantee that you will get better results. In particular if using more 'traditional' validation metrics such as RMS error higher resolution models often fair worse than coarser models owing to the 'double penalty' effect. If the improvement is owing to resolution only then this is an interesting result and so it would be nice to see some more discussion in this area.

2. It is not entirely clear to me what the MLD criterion is that is used here. De Boyer Montegut et al. 2004 (DBM04) discuss a MLD based purely on a 0.2 degC temperature difference - which I suspect is what is used here, but they also discuss (and present results from) density-based schema. The MLD introduction in Section 2 should be modified to better detail the MLD criterion rather than expecting readers to dig through DBM04. Furthermore if the criteria used is purely based on temperature difference then it would be nice to see some discussion on the use of a density-based scheme. The main down-side to a density-based schema cited by DBM04 is the lack of availability of salinity observations but for this study the OSMOSIS gliders are recording both T & S so it could be a useful/interesting extension to this work? I am certainly not suggesting that this work is redone using a density-based MLD scheme but I think it should be discussed.

3. I found myself a little confused regarding the sign/direction of your surface fluxes (i.e. heat & fresh water). Figure 6 and Section 4.1 should be modified to make it clearer which direction the fluxes are (see discussion for Fig. 6 & Section 4)

4. Finally there is no real motivation for the use of mixed layer depth in the assessments. Why is it useful to know the mixed layer depth etc.? It would be nice to see an additional sentence or so in the introduction.

2 Minor corrections/recommendations

Title

I don't think that 'oceanic' is a strong enough description of the systems - would the authors consider replacing 'operational oceanic systems' with 'operational ocean forecasting systems'?

Abstract

Line 12: replace 'in any case better' with 'consistently better'

Section 1

P1437 l1-2: It might be better to say that the systems are forecasting your area of interest i.e. change 'four systems...are now available...' to 'four systems...are providing ocean forecasts in this area...'

P1437 l3: 'data base' should probably be 'database' (both are acceptable English but the latter is much more common and hence easier to read).

Section 2

P1438 l5: 'analysis' should be 'analyses'

P1439 l11: 'all type of in situ observations' should be 'all types of in situ observations'

P1439 l21: the phrase 'the availability of the criterion' does not make sense and I'm not entirely sure what you mean. Do you mean that Fig. 3 shows 'the criterion applied to the area of interest'?

P1439 l28: 'temperature gradient ... exceeds 0.2 C' is wrong as the gradient would have units deg C/m. I suspect that you mean 'temperature difference' rather than 'temperature gradient'?

P1440 l15/16: 'mesh' and 'meshes' should be changed to 'grid cell' and 'grid cells'. A mesh (or grid) should strictly be a collection of 'cells' (or boxes).

P1440 l10-19: you say 'the model cannot simulate all the smaller scales...' but you have multiple models. Are you saying that all of your models cannot represent these features (which is perhaps not true for ibi36?) or that NEMO itself is incapable of doing so? I suspect that your key point is that not ALL of the models can hope to represent these features and so you limit your investigations to longer space/time scales. It might be best to tidy this up slightly to say that more clearly?

Section 3

P1441 l26/7: the following sentence does not really make sense: 'The RMS error (Table 2) confirms on previous results with a smaller error for Ibi36 and the ensemble mean (between 15m and 18m RMS) and a larger RMS error for Glo4 (between 27m and 30m RMS).' Are you trying to say that Table 2 'confirms previous results' or 'builds on previous results'?

P1442 l9/10: You say 'This diagnostic gives the same information with the same rank among the systems'. Do we really need to show both plots then? (See discussion on Figure 5 below)

P1442 l17/18: 'obtained for all the forecast length' should be either 'obtained, for all forecast lengths,' or 'obtained, for the whole forecast,'

P1442 l19/20: you say 'Removing the Glo4 estimate... showing that each estimate of the ocean state gives pertinent information' but it is not clear whether you mean all 4 or the remaining 3 (i.e. without Glo4). If the latter then you could change 'showing that each estimate of the ocean state' to 'showing that each remaining estimate of the ocean state'?

Section 4

P1443 l3: I think that 'total heat flux' should be changed to 'total upward heat flux' to provide a clearer definition for the reader

P1443 l4: as for above 'fresh water budget' should be changed to 'upward fresh water flux' or 'net upward fresh water flux'

P1443 l17: you say 'following excess precipitation'. This would mean 'too much precipitation' which I don't think is what you mean? If not then I suggest changing to 'following excessive precipitation' or 'following high precipitation'.

P1443 l24: 'associated with a large (less than -80 W m^{-2})$heatloss'isabitmisleading/confusingbecausethenumberinbracketsisnegativeandyouus$
$80heatloss(i.e.aheatgainof80)?Eitherwaythisshouldbere-$
$wordedtobelessambiguouswhichcouldbedonebychanging'(lessthan-$
$80Wm^{-2})'tosomethingalongthelinesoflike'(anupwardheatfluxoflessthan....)'$

P1443 l26/7: I am a little confused about the wording of this sen-

tence 'ocean absorbs heat with total fluxes greater than 100 W m^{-2}$'becauseyourfluxisupwardmeaningthatapositivefluximpliesoceancooling?Aswiththeco$

P1444 l7: 'during the maximum of wind speed' is not very good English. This should be changed to something like 'during the wind speed maxima' or 'when wind speed is at a maximum'

P1444 l9: I don't like 'observations in the box for the day' here which is not very specific. As this is a time series (i.e. all days) 'for the day' should be changed to 'for each day' or 'for every day in May 2013'. Additionally it is not clear if this is the box shown in Fig.2 or the whole area shown in Figs. 9 & 10. The next sentence suggests the Fig. 2 box but this should probably be made clearer. This can be done by specifying lat/lon values or tying to the actual observations in Fig 2.?

P1444 l20: 'place' is not a very scientific word so I would recommend changing this to 'location'

P1445 l3-4: 'There is then a re-stratification event (S1), the largest with Glo12 and nothing with Glo4' is a bit confusing. This statement should be expanded slightly to explain further. Is this just in the models or do we see it in the data? If in the data which model is better?

P1445 l6: 'Figures 9 and 10 ... for 13 and 16 May' would probably be clearer with the addition of 'respectively' on the end.

P1446 l4/5: 'It is closest to observation with the Ibi36 and Atl12 hindcasts.' This sentence is a bit short and not very good English. Please can it be reworded? I would suggest that it can be merged with the sentence before to say something like: 'The M1 event is too fast and too strong with Glo4 and Glo12 compared with the observations whereas the Ibi36 and Atl12 hindcasts are much closer to the observed values.'

P1446 l17: I would recommend changing 'for the 9 May no 4 day forecast simulates the mixing' to something like 'for the 9 May none of the model 4 day forecasts simulates

the mixing'

P1446 l21: 'underestimation on the wind fields' should be changed so 'on' is replaced with either 'of' or 'in'

P1446 l22: 'forecast length' should be 'forecast lengths'

P1447 l5: 'forecast' should be 'forecasts'

P1447 l5: 'observation' should be 'observations'

P1447 l10/1: 'there is no more forecast of S1 re-stratification event with Glo4' is not good English and should be reworded. Perhaps 'the S1 re-stratification event is not forecast with Glo4'?

P1447 l27: 'scale' should be 'scales'

P1447 l28: 'contour' should be 'contours'

P1449 l4: 'windspeed' should be 'wind speed' P1449 l4: 'analysis' should be 'analyses'

P1449 l28: 'wind field ... other fluxes' is misleading here because the wind field is speed and not a flux. I would recommend changing 'other fluxes' to 'other forcing fields'

P1450 l17: 'scale' should be 'scales'

P1450 l28: is there a superfluous 'rather' here? Is this required?

P1451 l5: 'increment' should be 'increments'

P1451 l10: you have 'meso scale' here but use 'meso-scale' throughout the paper so this should be changed to 'meso-scale' (although I'd prefer 'mesoscale' throughout).

P1451 l11: 'northern' should be changed to 'further north'

P1451 l14: 'increment' should be 'increments'

P1451 l15: 'profile' should be 'profiles'

P1451 l15: 'illustrates' should be 'illustrate'

P1451 l17: 'observation' should be 'observations'

P1451 l26-29: This sentence is very long with a significant deviation in the middle. It's not easy to remember what was being discussed at the start when you get to what is illustrated at the end. I would recommend re-organising this. However as it stands there are a few problems with pluralisation as follows: P1451 l26: 'line' should be 'lines' P1451 l28: an extra unwanted comma which should be removed from 'week, and' P1451 l29: 'illustrates' should be 'illustrate'

P1452 l8: 'system' should be 'systems'

Section 5

P1452 l15 & l21: as in the title I would recommend changing 'oceanic' to 'ocean forecasting'

P1452 l16: 'differences as horizontal resolution' should be 'differences in horizontal resolution'

P1453 l7: I think 'best resolution' should be changed to 'highest resolution'. This highest resolution model may be the best in this case but I think calling it 'best resolution' is a bit of a generalisation.

P1453 l8: 'Ibi36, which has the best resolution, gives the best results close to the Atl12 system.' doesn't exactly make sense. I presume that you're trying to say that Ibi36 is best closely followed by Atl12? If so it might be better to say '...gives the best results closely followed by the Atl12 system.'

P1453 l9: '...since with the observations available it...' should be changed to '...since,

with the observations available, it...'

P1454 l5: 'Met Office and covering' should be 'Met Office covering'

P1454 l22: the sentence ending 'properly,' which should be changed to 'properly.'

P1455 l2: 'parameterization' should be 'parameterisations'

3 Tables/Figures

Table 1

I presume that all of Glo4, Glo12 and Atl12 are NEMO 3.1? It might be better/clearer to explicitly have this in the table. Why is there no definition of vertical resolution or atmospheric forcing for ibi36?

Figure 2

There is a lot of useful information in this figure. However I find it difficult to see the date numbers inside the smaller circles. Could these be made more prominent?

Figure 4

Again lots of interesting information in the figure but I don't think that some of the colours used are easy to distinguish from each another. In particular the light red used for 'MEAN' and dark red used for 'MEDIAN' are very similar to each other and quite similar to the purple used for 'ibi36'. Additionally the yellow GLO12 box in the legend is not clearly distinguishable from the background white. This could be easily fixed by

adding a black line around each colour box in the legend as has been done for the symbols on the Taylor diagram.

Figure 5

The coloured text on the legend is not very clear against the white background - particularly the light orange 'Glo12'. The nice think coloured lines in the legend are very clear however and so I would recommend simply changing the text to black and using the lines as colour indicators. Additionally I am not sure that both the upper and lower plots are needed. In the text at the end of section 3 you state that the lower plot 'gives the same information' as the upper plot although it more clearly shows the division of skill between the 3 regimes (i.e., Glo4, Glo12 and everything else). Could this just be shown with the lower plot? You could remove the upper plot and just refer to it in the text as '(not shown)' saying that it shows the same information as the lower plot?

Figure 6

The labelled events M1-3 & S1-3 are not clear enough when covered with the blue shading. I recommend that these are either moved slightly further away from the mean line to avoid the standard deviation shading or made clearer (i.e., larger or bolder). The concerns I have regarding the specification of heat and fresh water fluxes (see above) should be extended to this figure caption. The figures would be easier to understand if the direction of the fluxes were included in the text so I think 'total heat flux' should be 'total upward heat flux' and 'fresh water flux' should be 'net upward fresh water flux'. I would also recommend changing "...all systems negative flux means that ocean gets heat." to something like "...all systems. A negative flux means that the ocean gains heat."

Figures 7 & 8

I like these figures. The colours used are clearly distinguishable!

Figures 9 & 10

The 'dotted black box' is not very visible in these figures. It doesn't help that it is the same colour as the black contour lines. Perhaps white would show up better? Either way I think it needs to be made clearer. At 1st glance I thought I was looking at MLD for the small 1/2 x 1/2 box rather than a larger domain. As well as making the box more prominent it might make things clearer to change the 1st sentence of the Figure caption to say something like "Mixed layer depth ..... for 13th May in the area surrounding the area of interest"? It might also be good to reference back to Figure 2 when you describe the observations in the box i.e., say ...observations as shown in Figure 2.?

Figure 11

I think the caption may be wrong for this figure as it claims to be 'standard deviation of the forecast' but you use it as if it were 'standard deviation of the forecast error'. Is this correct or am I missing something? If so then 'forecast' should be changed to 'forecast error' in the 1st line and the Bottom panel description. Additionally the wording is a bit ambiguous with relation to the mixing/stratification event. The text says 'only the mixing event' but doesn't say which mixing event. However I suspect you mean 'all mixing events'? If so it might be better to say 'only the mixing events (M1-3)' instead of 'only the mixing event' and 'during the stratification events (S1-3)' instead of 'during the stratification event'

Figure 12

This figure needs some additional work. The text size is too small to read for the x/y latitude/longitude annotations and for the colour bar. The figure caption is also lacking in information - what are the units? metres? It presently says "Glo4, Atl12, Glo12. Mean SLA increment computed over May 2013 for GLo4, Atl12 and Glo12 systems." and this should probably be changed to (at least) something like "Mean SLA increment (in metres) computed over May 2013 for Glo4 (left), Atl12 (centre) and Glo12 (right) systems."

Figure 13

The figure caption says 'standard deviation (dashed line)' but there are multiple dashed lines - in particular 2 for each colour. Are these +/- 1 standard deviation departure from the mean or something else? The figure caption and Section 4.3.4 text should be modified to make this clear.

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