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Interactive comment on "Residual circulation and fresh-water transport in the Dutch Wadden Sea: a numerical modeling study" *by* M. Duran-Matute et al.

M. Duran-Matute et al.

matias.duran-matute@nioz.nl

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We would like to thank Referee #2 for his/her comments. The review was made based on an early version of the manuscript which was previous to the proof corrections. Hence, the line numbers do not match the ones in the version available online. Below, you will find a detailed response to all the comments and suggestions.

Major comments: (1) The methods section is overly long, perhaps the description of GETM in section 2.1 could be moved to an appendix?

The description of the model was moved to an appendix.

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(2) The final discussion of flushing times / residence times (lines 704-718) could be cut, using different reference salinities to come to different values for the times seems to only confuse the message, and doesn't add much.

The discussion was cut.

(3) Figure 13 is unclear, it is difficult to understand what is being shown, and colouring panel (b) by wind direction does not show clearly what is happening. Perhaps a time series of directional arrows might be better? Panel (a) might be improved by splitting it into 3, so Marsdiep, Vlie and the Watershed transport are presented separately?

We have tried different configurations to make Figure 13 clearer. Finally, we have split the figure into two: one figure for 2009 and one for 2010. We have also changed the aspect ratio and line thickness. The time series of directional arrows is not clear due to the high temporal resolution of the wind time-series, and if the resolution is reduced, important details are lost. On the other hands, splitting panel (a) into three makes the relation between the residual flow at the three inlets less clear.

Minor comments:

> Line 36: reword "How is the residual circulation"

This sentence reads now: "What is the residual circulation pattern in the Wadden Sea?"

> Lines 39-43 and 51-53: When defining tidal prisms in each inlet, please could you refer back to the labels defined in Figure (1) here, this would help readers who do not know the geography of your study area.

We now refer to the labels.

> Line 56: Where is the Marsdiep basin? please could you also mark the extents of basins on the map in Figure 1.

This sentence has been rephrased, and the term "Marsdiep basin" is no longer used. The sentence now reads: "However, it was later shown, by expanding the analytical

model to include wind effects, that the residual circulation between the Texel and Vlie inlets is highly variable due mainly to local wind stresses".

> Line 89: Consider replacing 'Like for...' with "As for the residual..."

It has been replaced.

> Line 93: Does this suggest that flushing rate was enhanced through the Texel inlet at this time?

The northerly winds maintained a high surge level. It was probably the case that the flushing rate was enhanced through the Texel Inlet, but it cannot be concluded from the measurements.

> Line 94: replace 'questions have remained' with "questions remain"

This paragraph was rewritten.

> Line 96: replace 'from measurements or numerical' with "from measurements or numerical models"

It has been replaced.

> Lines 98 - 100 : rephrase this sentence, or cut into 2 shorter, it is unclear

This sentence now reads: "In general, this exchange can be expected to show a lot of variability, depending on the fresh-water discharge rate, wind direction and speed, water level surges, and on the phase in the spring-neap cycle."

> Line 184 (Equation 10). Is there no surface freshwater input (evaporation minus precipitation?) it is worth mentioning in the text, if this is not being considered. (see comment re line 256)

Surface freshwater input is taken into account in the model. It is implemented and calculated. This is not taken into account in Equation (10), but as a boundary condition at the surface for that equation.

> Line 200: I haven't heard of the Rijksdriehoek projection, perhaps you could explain why this is used? Is this standard with GETM / in this region?

This has been clarified in the text. The Rijksdriehoek projection is the standard projection for the Dutch Government. It is convenient to use here since the bathymetric data is provided in this projection.

> Line 207: space inserted before the comma

It has been deleted.

> Line 216: Did the datums for the 2 different bathymetry data sets match-up OK?

The bathymetry data set for the North Sea is a compendium of measurements carried out at different times. However, the bathymetry itself matches well.

> Line 225: I was initially concerned about the use of the vertical wall at the Eastern edge of the domain, but the model seems to be well validated away from here in your study area, so I think the concerns are unfounded.

We expect that the wall has a local effect on the residual flows, but it is probably confined to the easternmost basin.

> Line 244: What was the frequency for forcing at the boundaries? e.g. hourly tides? daily T&S?

The frequency for forcing the sea surface height is once every 10 min. For T&S is once every 2 hours. This has been added to the text.

> Line 256: Here you say that freshwater fluxes are included in the model, yet not included in Equation 10 (see comment re line 184)

They are implemented as a boundary condition to Equation 10.

> Line 299: What is 'internal pressure' is this relevant to include? Line 300-301 'In addition, background horizontal momentum diffusion of 5m2s-1'. Fragment sentence,

please rephrase.

The algorithm to calculate the internal pressure is important since it can be a source of important errors around steep bathymetric features. The sentence has been corrected.

> Line 304-308 is this necessary?

We think that this information can be useful for people interested in performing similar simulations.

> Line 355 change 'dubitable'.

It has been changed.

> Line 355 so the model output contains wind forcing, is it still OK to perform a harmonic analysis on this rather than a tide-only run?

As we are comparing the model results with tidal gauge measurements for which wind is also a factor, we believe that this is the fairest comparison. However, we added an additional comparison that takes into account the non-linear effects is needed to check if the wind effects are also reproduced.

> Line 368: please mark the position of the NIOZ jetty on the map

It has been marked in Figure 1.

> Line 380: extra full stop after variability

It has been deleted.

> Line 382: PSS?

PSS refers to the Practical Salinity Scale. This has been clarified.

> Line 465: 'Table C' do you mean "Table 2"?

It has been corrected.

> Line 483: Average over what period of time? Similarly line 484: Average maximum, how is this defined?

It is now specified that it is over period comprising the years 2009-2010.

> Line 494: These can be attributed to storm surges = can you back this up with meteorological data?

Indeed, it can actually be seen by comparing the times series of volume with that of wind speed and direction shown in Fig. 13b.

> Line 528: 'It can be seen that all periods..' This is not clear in the figure. Perhaps a time series of wind arrows would help clarify this figure?

The figure has been split in two. The wind arrow plot was too crowded and less clear.

> Line 549: Table C = Table 3?

It has been corrected.

> Line 579-582: Don't understand this section, are you proposing future work?

This sentence has been deleted.

> Line 655: consider replacing 'freshness' with "fresh water"

We have replaced "freshness" by "tracer".

> Line 665-666: Rephrase "For the outflow of freshness through..."

This sentence now reads: "The time series of the outflow of the tracer through the Terschelling watershed exhibits large peaks".

> Line 695: replace 'associated to' with "associated with"

It has been replaced.

> Line 705 replace 'higher' with "longer"

It has been replaced.

> Line 721: November 2009 not 2010?

It has been corrected.

> Line 735: replace 'includes' with "include"

It has been corrected.

> Line 752 - 754: restate the importance of the median values here.

The sentence now reads: "We find that, for each inlet, the probability distribution of the residual flow rate spreads around the typical value which is approximated better by the median than the average. The reason for this is that the distributions have a~clear skewness dictated by the wind's direction."

> Figure 6. Is this figure necessary? It is a nice agreement, but the content is covered by the discussion in the text.

We believe that the figure presents details that are not covered in the text and that it strengthens our point.

> Figures 10 and 11 can be combined into 2 panels of a single figure

We prefer to keep them apart since the caption would become too complicated if put together.

> Figure 12: please state in the caption over which period the average maximum and minimum volumes are defined.

It is now stated.

> Figure 13 is not helpful, and needs clarifying / replotting

This figures is split into two: one for each year. In addition, we have changed the aspect ratio and the line thickness. It is now less crowded and clearer.

> Figure 14 could also plot the mean value, to further highlight the skewness

The mean value is also plotted.