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Interactive comment on "Numerical issues of the Total Exchange Flow (TEF) analysis framework for quantifying estuarine circulation" *by* Marvin Lorenz et al.

Anonymous Referee #2

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The MS is devoted to practical implementation of Total Exchange Flow (TEF) analysis framework, which extends the applicability of historical Knudsen relations to real unsteady space-varying estuarine flows. The MS introduces an interesting analytical example that is used to analyze convergence of two slightly different TEF methods. It is shown, that "dividing salinity" method provides less noisy results than "sign" method in evaluating the volume flux of a specific salinity class from a large set of data. The "dividing salinity" method has been extended to multiple inflow and outflow ranges, allowing more than one dividing salinity. The method has been tested based on the Baltic Sea modelled data. Recommendations are also given to choose the parameters for proper estimation of TEF. The results of the MS are interesting and of significant

practical importance.

Essential part of the MS is devoted to finding optimum number of salinity bins in order to discretize the problem with acceptable noise level. The parameter search was done by a large number of trials, the essence of which is not easy to understand. MacCready (2011) noted in his founding paper of the TEF method, that discretization is analogous to finding histogram of transport versus salinity. Selection criteria of the number of bins are well known for histograms. Drawing parallels between traditional histogram bins and TEF salinity bins would hopefully improve readability of the paper for wider audience.

The central finding in the MS is that one of the TEF calculation methods, the "sign" method does not converge to the analytically determined exchange flow when the number of data points and the number of salinity bins both increase. The other method, the "dividing salinity" method reveals nice convergence and therefore is the preferred TEF calculation method. This result is mentioned in several places, but proof is presented only very shortly in Section 2 P4 L25 to P5 L7 based on Fig. 3. This figure contains many curves and is not easy to read. Alternative or complementary figures reflecting the conclusion should be welcome. Another issue with convergence presentation appears in the introduction on P3 L5-9 and L14-18 with infinite number of salinity bins. It remains unclear if eq (5) is mathematically derived or guessed from numerical experiments. The detailed parts could be moved to Section 2 in order to support analysis of the convergence of numerical results to analytical findings.

Proper selection of sampling interval (in present case, interval of model output) is very important for determination of Eulerian volume transports and salinity-space exchange flows, using reasonable computational resources. This aspect is shortly presented in Section 4.1 with an example of flows over Darss Sill in the Baltic Sea, mainly describing the curves in Fig. 8. The 3-hourly output values were averaged using a special method that description is not available at the moment. At the end of the section it is written "12-hourly model output is enough to resolve the exchange flow properly". The conclusions say on the same matter “Ideally, either results for all baroclinic time steps would be stored or the numerical model should do the binning into salinity classes of a chosen transect itself and save profiles of qc for desired tracers c”. It is not clear, how the conclusions match the findings in the previous chapters.

Some specific questions and comments are presented below.

P1 L11-12: The sentence “Since inflow and outflow occurring at the same salinity compensate, TEF characterises the net exchange flow with the ambient ocean” should be reformulated. The first part of the sentence could be understood that the net exchange flow is missing since inflow and outflow compensate. Perhaps it should be “Since oscillatory inflow and outflow components occurring at the same salinity compensate...”.

P3 L2: “TEF profiles computed from numerical model output can be noisy”, it should be useful to present some physical reasons of noisy results. Perhaps, within well-mixed space-time domains conversion from depth to salinity coordinates has errors. Other reasons may also exist.

P3 L19: “Obviously, this dividing salinity method only works for classical exchange flows”. Please consider if this sentence is needed at this point of introduction.

P4 L13: “To visualise why only the dividing salinity method is converging towards the real bulk values” is not clear, “why only” cannot be found. It is not explicitly written by which method Fig. 2a-c have been produced.

P4 L24: “The differences of the noises are because of ...”, it is not clear the noises of what quantities are considered. It is well known that integrating the discrete curve makes the result smoother, but taking derivatives amplifies the small-scale variations (noise).

P11 L23-25 : “...TEF bulk values, computed with the sign method. q becomes more noisy with increasing N and causes the sign method to converge towards the absolute exchange values.”. It is not clear what the absolute exchange values are and how the

convergence is proved.

I recommend publishing of the MS. I have given some recommendations of minor rewriting in order to improve the clarity and readability.

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