

# ***Interactive comment on “Seasonal, Spring-Neap and Tidal Variation of Hydrodynamics and Water Constituents in the Mouth of the Elbe Estuary, Germany” by Jens Kappenberg et al.***

## **Anonymous Referee #1**

Received and published: 20 July 2016

Measurements of several parameters (e.g. water level, current velocity, turbidity, dissolved oxygen, salinity, wind) at a station named HPA-Elbe 1 in the mouth of the Elbe estuary are presented for the years 2012 and 2013. For comparison the measurements of two neighbouring stations (LZ2 and MPM Otterndorf) are used. To explain the overall estuarine context, data from surface samples taken by helicopter along a transect from the mouth of the Elbe to the weir Geesthacht are shown.

During the two years presented periods with low, high and extremely high (June 2013) river runoff are found. Periods with high westerly wind are found during winter.

For 9 days during the river flood in June 2013 all measurements at HPA-Elbe 1 are shown and discussed. In addition the measurements of salinity and turbidity respec-

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tively water temperature and oxygen saturation and the tidal average of the measured values are shown for 2012 and 2013. The comparison with the transect measurements of salinity and suspended particulate matter concentration respectively water temperature and dissolved oxygen saturation allows to compare the point measurements for several specific dates with the distribution along the estuary. The position of the mixing zone MZ and the estuarine turbidity maximum ETM are important for the understanding time series of the point measurements.

The measurements of salinity and turbidity and the tidal average of the measured values are shown for the neighbouring stations LZ2 (2012 and 2013) and MPM Otterndorf (2013), too.

All measured datasets are analysed in order to find seasonal, spring-neap and tidal variations of hydrodynamics and water constituents. The length of the time series did not allow for finding seasonal variations. Spring-neap variations were found in the measured water levels, current velocities and salinities. Tidal variations can be found in nearly all measurements. For 28 tides in March and April 2013 averaged time series of current velocity, water level, salinity and turbidity as well as tidal trajectories of the averaged variables are shown for station HPA-Elbe 1. For comparison averaged time series of current velocity and turbidity as well as tidal trajectories of the averaged variables are shown for station LZ2, too. The differences in the patterns observed are described but could not be explained without additional areal information.

The authors conclude that long-term measurements with a high temporal resolution at fixed positions are a crucial contribution to understanding of estuarine processes. The measurements should be representative for a larger region, which is difficult to guarantee in the area surrounding HPA-Elbe 1 with tidal flats and a branching river. As the authors could not explain all patterns found in the measurements they hope that results from numerical models of the Elbe estuary could help to close the gap between point measurements at different locations and the areal distributions of the physical quantities in the estuary.

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## General remarks

This paper gives an overview of measurements at three stations in the mouth of the Elbe during the years 2012 and 2013 describing the observed patterns in the measurements. The aim of the paper should be clarified more precisely. Please explain, why the station HPA-Elbe 1 was positioned in this area, what is the aim of the complex measurements at this position, why did you choose to investigate the variations on different time scales with the data of this station.

The quality of the measurements is not mentioned but should be discussed. The hydrological and meteorological situation should be described in addition to time series of river run off with e.g. time series of wind characteristic for the mouth of the Elbe (at Scharhörn) and time series of water level at the mouth of the Elbe estuary (situation of North Sea).

The measured quantities are presented in elaborated figures. Unfortunately due to the size of the figures it is difficult to detect all details mentioned in the text.

The severe river flood of June 2013 is mentioned in the abstract. All measured data are shown for this period, too. Explaining and analyzing the differences in the parameters measured before, during and after this extreme event should be a main emphasis of section 4. It would be interesting to see the development in time of the tidal trajectories during this period and compare these trajectories with the tidal trajectories of the averaged variables.

The authors hope for a better understanding of the measurements with the help of results from numerical modeling. Please discuss too, what kind of additional measurements could improve the understanding of the existing data, e.g. more stations, more trajectories along the Elbe during specific events, data on cross sections close to existing stations, etc.

I suggest a major revision of the paper before publication.

Specific points:

line 9: please do not use unexplained abbreviations.

line 45: specify the region where the large tidal range can be found.

line 49: ... drains 132000 km<sup>2</sup> until Neu Darchau.

line 53: wrong quote. Bergemann 1995 analyses the "Lage der oberen Brackwassergrenze im Elbeästuar" (upper limit of the brackish water on the Elbe Estuary) and finds that for low discharges (< 400 m<sup>3</sup>/s) it moved upstream between 5 and 20 km between 1953 and 1994. Please correct your line of arguments.

line 83: "bei vollem Ebbstrom ca 1 h vor Tnw", is it correct to translated this as maximum ebb current?

line 90: section 2.2 Please explain (or refer to a document with a detailed description of the measuring campaign), how the measured parameters are converted into the parameters shown here, e.g. how is the water level or salinity measured und what is the expected error using this method.

line 111: figure 3 gives a rough overview of fresh water discharge and periods with operating stations for 2 years. In order to understand the hydrological situation the water level at the mouth to the North Sea (Bake A/Z or Cuxhaven) should be given too. "Higher water levels in the North Sea due to meteorological circumstances can generate higher salinity levels compared to the mean values of the lower Elbe (Boehlich and Strothmann, 2008)". Please add information about the water level of the North Sea.

line 112: the runoff in JFM2012 seems quite high. Why is 2012 described as a year with low runoff? Please give some statistical values supporting your argument.

line 115: a week of data is missing at HPA-Elbe 1?

line 124: Is the measurement at Scharhörn describing the meteorological / wind situa-

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tion at HPA-Elbe 1? Please explain why you decided to use this place.

line 128 ff and figure 4: Do the years 2012 and 2013 show a characteristic distribution of wind speed and wind direction for this area of the Elbe? Why is there no high wind speed from 270 (west)? How many events with high wind speed were found in 2012 and 2013? Please explain why analysed data and not time series of wind are shown in this context.

line 138 figure 5: shows all parameters measured during the period of extreme discharge in June 2013. Please add the time series of Q at Neu Darchau and mention in the text the amount of time that the discharge signal needs to reach HPA-Elbe 1. Please give the reference system for water level.

Is the wind measured at HPA-Elbe 1 or at Scharhörn? What is meant by “accidentally” (line 155)? Is the wind strong enough to influence the measurements?

line 144: Flutstromkenterung - slack water time of flood current (DIN 4049-3 2.4.3.16) Please check translation of technical terms.

Line 168: here tide is defined as ebb current duration plus flood current duration?

Line 167 ff and figure 6: This figure gives a qualitative overview over 2 years of measurements. The details described in the text are hard to find due to the size of the figure. Please improve the figure. Why are transect 1 and 6 so different? What do transects look like in April 2012 and April 2013?

Line 175: Please give more detailed information, why the westerly winds and not any other process (e.g. higher water levels in the North Sea) cause this increase in salinity and up-stream shift of the turbidity.

Figure 7: Please describe the event flood June 2013 in more detail: Give the date for the points 1 to 4 (start increase of discharge in Neu Darchau, maximum discharge, ...). How many days will it take for this signal to reach Geesthacht, Hamburg and HPA-Elbe 1?

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Line 310 ff: Please give a reference for this method to determine the averaged tide. Please give some statistical evidence (standard deviation), that the 12 mean values are characteristic for this period in March / April 2013.

Line 360 and figure 17: which process produces the 2 maxima in turbidity during flood?

Technical remarks:

Line 33: please check: Dyer, 1977

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