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Interactive comment on "Model uncertainties of a storm and their influence on microplastics / sediment transport in the Baltic Sea" *by* Robert Daniel Osinski et al.

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Osinski et al. numerically simulated the transport and dispersal of high-density plastic particles in the Baltic Sea during a storm event, and demonstrate how atmospheric models can predict microplastic concentrations in seafloor sediments in shallow waters. These predictions could guide seabed sampling campaigns and potentially help to estimate seafloor plastic budgets. This paper, I believe, will be of interest to the readership of Ocean Sciences as it is, as far as I know, the most comprehensive study integrating atmospheric and sediment transport models to predict sediment transport on the seafloor.

A particular storm event ('Alfrida', 1st – 4th Jan 2019) was simulated using freely available and established numerical models. Field measurements of water level changes and wave height at different stations were used to validate the accuracy of the model. A storm generates movement of the water underneath the sea surface, at a depth range and intensity depending on the amplitude of the surface waves. The here presented model predicts by combining atmospheric with sediment transport models, whether the water movement at the seabed might mobilize and suspend sediment. Assuming an initially homogenous distribution of spherical microplastics on the seabed, the model then estimates the transportation and re-distribution of these particles during the storm. This allows to identify areas on the seabed which are enriched or depleted in microplastics relative to the initial concentration. Further the authors test different variations of the models to assess the accuracy of different steps in their model chain.

Despite these positive aspects, I feel, however, that the authors should include a more detailed discussion on the basic role of storms and sea-surface waves in the transport and distribution of clastic sediment and plastics on the seafloor. The assumptions for the modeling are all mentioned in the manuscript, but their implications for the results and conclusions are not discussed sufficiently. I also think that the text could be clarified in places, making the paper more accessible to non-experts on atmospheric modelling. Below I included some comments to the authors.

Yours sincerely, Florian Pohl

Main comments

– I missed a discussion on the relevance of storms as a sediment transport mechanism on the seafloor. What about other sediment transport processes such as seafloor currents (e.g. tidal, thermohaline, hyperpycnal flows, river discharges etc.) and sediment gravity flows (e.g. slides or turbidity currents – likely to be triggered by storm events)? To which water depth can a storm event affect the seabed? Typically, the storm-weather wave-base is located at 150 – 200 m, and sediments below this base are unaffected. Could the authors explain how storms can transport sediment across the seafloor? In the rock record, storm deposits (Hummocky cross-stratification) indicate mainly reworking of sediment on the seafloor, rather than lateral transportation.

– The sediment transport model could be explained clearer. I struggle to understand what this model is doing exactly. How was the bed shear stress calculated and what are the assumptions for these calculations? What type of movement is simulated at the seabed (oscillatory water motion by waves or unidirectional flow)? What are the values of the calculated shear stress and do these make sense when comparing to field and laboratory measurements? I think the outreach of the paper would increase significantly if it becomes clearer to non-experts what this model is doing. In particular as this paper will be of high interest and relevance for readers from other research fields. I cannot evaluate the atmospheric models, as this is not my field of expertise.

– The used criterion for the movement or suspension of sediment is not clear. The Shields curve describes the initiation of movement of sediment on the bed, which means transportation as bedload. There exist additional curves to estimate the threshold for suspension of sediment (e.g. (Bagnold, 1966; van Rijn, 1993; Nino et al., 2003)). Could the authors be more specific which criterion they used and why? Also, the Shields criterion describes the movement of particles under unidirectional flow. How would this translate through to oscillatory water motion, as caused by wave movement?

– Assumptions and limitations of the model should be discussed. The authors specifically state all assumptions and simplifications in their calculations, but I was missing a discussion on how these assumptions (e.g. spherical particles) might affect the results and conclusions.

Comments made while reading the manuscript:

Page 1, line 7: Can you mention to which depth these surface waves would reach down the water column?

Page 1, line 13-15: Would this also depend on the ocean depth? Maybe you mean this with 'bathymetry'? I suggest to specifically mention that the ocean depth plays a major role in whether or not particles on the seafloor can be resuspended due to increased surface wave intensity.

Page 2, line 2-3: Could you back this up with a reference? At least in deep-marine sedimentology, sediment transport models still have issues and results often do not match observations.

Page 2, line 8-9: Who assumes that? What about other sediment transport processes such as seafloor currents or sediment gravity flows?

Page 2, line 16-20: Could you please be more specific here. The Shields curve would give you the critical shear stress at which particles would start to move as bedload. Other curves describe the initiation of suspension (e.g. (Bagnold, 1966; van Rijn, 1993; Nino et al., 2003)). Also, this diagram estimated the critical shear stress with a unidirectional flowing current. It is not clear to me how this would translate through to oscillatory water motion, as caused by wave movement.

Page 2, line 20: How have you calculated the shear stress exerted on the seabed due to wave motion of the sea surface?

Page 7, line 3-7: This needs more explanations. These sentences are difficult to understand.

Page 7, line 9: What is the difference between wave and current induced bed (shear) stress? I guess this relates back to my comment on page 2, line 16-20.

Page 7, line 10: Does this mean that the wave induced oscillatory motion of the water at the seafloor is neglected? Looking at ancient storm deposits in the rock record, oscillatory motion appears to be a dominant sedimentary process.

Page 7, line 10-13: It is not clear to me what this means. If this is important, it should be explained. If not, these sentences might be removed from the manuscript.

Page 7, line 15: Sea surface elevation = water level?

Page 8, line 9: Why did you chose these particular grain-size range? What about particles between 10 and 200 μm?

Page 9, line: 17: Please amend to: Figure 7c-f.

Page 9, line 19-21: Was there a predominant current direction? Could you indicate this direction in figure 7? Could this current explain the pattern of erosion and deposition (i.e. erosion on northeast and deposition on southwest dipping slopes)? Would this pattern change if the direction of the storm surge is different?

Page 9, line 22-24: I think it is very important to state that surface waves can only re-distribute sediments and plastics to a certain water depth. Storms are important for the MP distribution in coastal areas and shallow seas (e.g. large areas of the Baltic Sea), but apparently play a minor role in the distribution of MPs on the seafloor for most parts of the world's oceans (below the storm weather wave base). I would think that MPs are frequently re-mobilized by storms and thus get transported until they are deposited below the storm weather wave base. Here water depth is too deep and plastics cannot longer be re-mobilized by storms. This would suggest that MP concentrations are probably highest just below the storm weather wave base.

Page 9, line 24-26: What about changes in the wind direction?

Page 10, line 5: Why is the color scheme in figure 9b c different compared to figure 7 8? This is confusing and makes a comparison difficult.

Page 10, line 12: Again, why where these grain-size classes chosen? Wouldn't it make more sense to spread the size classes more evenly in-between the two end-members (10 and 300μm)?

Page 11, line 5-9: I think I finally understood that you model both, oscillatory motion and unidirectional flow. Is this correct (see my comment on page 7, line 10)? How high are the calculated bed shear stresses?

Page 12, line 1-2: Does atmospheric forcing mean the generation of a unidirectional current at the seabed? If yes, what is the current velocity and how did you account for interactions with the bathymetry?

Page 14, line 1-2: What about sediment transport mechanism other than storm induced movements? Tidal currents for example. Although tidal currents are not very strong in the Baltic Sea, they play a significant role in the North Sea. Storms may also trigger sediment gravity flows such as turbidity currents which could transport MPs on the seafloor (Pohl et al., 2020). Also seafloor currents due to thermohaline circulation can transport and re-distribute MPs (Kane et al., 2020). I think other processes should be discussed.

Page 14, line 2: This is an interesting point. Could the authors be more specific on how these budget methods would work?

Page 15, line 12-13: The authors use in their model only spherical particles, although most MPs have more complex shapes (angular and oblate fragments, fibers etc.). I fully understand that the simulation of more realistic shapes would add another level of complexity, or might be even impossible to model as we don't fully understand the hydrodynamics for these complex shapes (Khatmullina and Chubarenko, 2019). However, the authors should mention possible deficiencies of the model due to the assumption of spherical particles. Nevertheless, I think these models are crucial for understanding MP distributions and the assumption of spherical particles is a good starting point.

Page 15, line 15-16: I don't understand this sentence. Size difference in what? MPs? Sediment? Could the authors please rephrase and make this clearer?

Page 15, line 18-20: Only because they have the same settling velocity? I think that this is too simple.

Page 15, line 31-32: This is only valid for shallow waters above the storm weather wave base.

Page 16, line 10-13: This is very interesting! Could these models predict particular microplastic sinks on the seafloor? To which water depth would storms affect the seafloor distribution of MPs?

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