Response to comment

RC1: 'Comment on egusphere-2025-6170', Anonymous Referee #1, 19 Jan 2026

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Review

Grounding of Drifters in the Wadden Sea Inform the Transport of

Floating Macroplastic by Schneiter,

Hut and van Sebille

General comments

The manuscript presents results of a measurement campaign where 30 drifters were released in the Dutch Wadden Sea (24 in a first release and six in a second release). The main goal of the paper is to first to identify the interaction events of the drifters with the coast and mudflats (groundings and wettings), and second, to relate these events to the coinciding wind characteristics and the tidal phase. 150 grounding events were identified. Due to the complex geometry of the system, the different locations of drifters, and the differences in the forcing (wind and tidal) conditions, it is not possible to perfectly link the grounding events to specific forcing conditions, but clear trends in the data are identified.

The paper has a concise and clear introduction. Then, the methods are described. These include the campaign, the drifters, and finally, the data collection and processing. The results give first a general description of the trajectories and the occurrence of grounding events. Then, they present a comparison of the methods to identify the grounding and wetting events. Finally, the results show under which conditions (tidal phase and wind velocity) the events occur.

In general, I find the results to be interesting and the campaign to be very important for the region, since it is the first Lagrangian field study. Although this paper is restricted to the analysis of grounding events motivated by the transport of macroplastic, this work can later complement recent Lagrangian numerical studies and earlier field and numerical work that related the transport to the forcing. However, I find that there is no attempt to put the results in context by discussing them in relation to what is already known about the system.

We appreciate the feedback and detailed reflection of the reviewer on the manuscripts content.

Specific comments

Although the results and the paper are mostly clear, I find certain passages to be difficult to follow because the authors obviate certain things, that are needed to fully grasp the methodology and the results. Hence, the paper would benefit from explicitly mentioning these things (as described in detail below).

l. 22 The formation of freshwater plumes is not the only effect of river runoffs. There is, for example, the estuarine circulation. In general, this sentence is a bit strange because to all the effects of the forcing mechanisms are mentioned.

The reviewer raises a very valid point, we adapted the sentence at now L20f as follows (changes in bold):

> *Its dynamics result from interactions between the semidiurnal tides of the region and residual currents of the North Sea, from wind stress that generates waves and surface currents, from* ***freshwater inputs by river runoffs****, and from the bathymetry and shape of the coast*

This sentence should both highlight important hydrodynamic processes of the Wadden Sea region and motivate the complexity of linking them to drifter measurements (eg the grounding events) for the discussion later on.

Figure 1. Why are there steps in the water level? Notice also that “water level” are two words.

We extend the caption of now Figure 2. with an explanation for the steps and adjusted the spelling of ‘water level’ :

> *Steps in the water level time series result from subsequent positions of the trajectory being closest to two different grid cells of the water level dataset.*

L. 153. This is, in general, not the correct way to compute the average of an angle, but I understand that it works here because it is the average of the absolute value and $-180° \leq \alpha \leq 180°$. This should be more explicitly mentioned here.

To improve clarity, we now mention the range of possible angles in the definition at L131, and we reformulate the sentence at L154 :

L131 *... and locally define angles between displacements* $\measuredangle(p_2-p_1, p_3-p_1) \in [-180°, 180°]$ *from a projection of the positions to Cartesian coordinates.*

L154 *In order to quantify this characteristic behavior, the average A(t,ΔT) of the absolute directional changes* $|\alpha(t_i)| \in [0°, 180°]$ *during a time interval ΔT can be computed as*

L. 225. It is unclear how do you “extract the tidal phase”. Is it based on extracting only the M2 constituent or do you consider the maxima?

The phase is determined for the M2 constituent. Accordingly, the sentence in L226 now reads (changes in bold):

> *Since tides are the main drivers of dynamic changes in the Wadden Sea, we extract the tidal phase* ***from the M2 constituent of the 48 hours water level time series at an event*** *location.*

L. 226 -231 and Appendix C. The discussion about coastlines and shores is unclear. Sometimes, the drifters ground in the middle or edge of a mudflat. Are mudflats considered coastlines and shores? It seems to me that the wind direction is computed with respect to the local gradient in the bathymetry. If this is the case, it would seem clearer to define it in this way.

The reviewer raises a valid point. We use the local gradient of the bathymetry to determine the local (coast- or) shoreline orientation, and combining transitions at the coast and on a mud flat in this way is ambiguous. To improve the accuracy of the descriptions, we replace the imprecise uses of the term ‘coastline’ with ‘shoreline’ and change the description in L337 of now Appendix H as follows:

> *The local wind direction at grounding sites is determined by computing the shoreline orientation of the coast or mudflat from the bathymetry map and determining the wind direction with respect to this orientation.*

Figure 2. Consider splitting it into different subfigures for the different releases. It is currently difficult to follow the paths of the different releases. For example, I cannot distinguish if the events (grounding or beaching) are associated to green, red, yellow or blue lines when several come close together.

We add four detailed versions of Figure 2 for each release group in a new Appendix A.

Lines 235-245. The discussion of Fig. 4 is rather limited, while there are several interesting points that can be highlighted and used later for the interpretation of the results. For example, the beaching of most drifters from the first release coincides with strong southerly winds, while the beaching of the drifters from the second release coincides with strong northwesterly winds. If one could easily follow the trajectories in Fig. 2, it might be possible to also observe a pattern on the locations of the beachings. This would highlight the importance of different wind directions and help motivate some of the later choices.

Furthermore, these events of strong winds play a crucial role, as observed again in Fig. 7.

We agree with the reviewer that the discussion of Figure 4 is limited, with respect to the potential information and insights that are represented in it. We extend the discussion in L253 but avoid diving deeper into separating and characterizing the individual or groups of deployments and clustering of trajectories here. This involves dedicated effort that we did not attempt to include in this article. Figure 4 is intended, together with Figure 2 and Figure 3 to give an overall summary or impression of the collected observations.

L253 *Since the number of events associated with either of these clusterings is about one order below the total of 151 observations, they make up a significant part to the characterization statistics. The statistics are thus correlated with these clusterings.*

Fig. 3+Fig. 4. I am confused when I see the wind rose in Fig. 3 and the time series of wind in Fig. 4. First, it seems that the authors are not using the convection for the wind rose that it indicates the origin of the wind. Even after fixing this, I am having a difficult time seeing that the statistics of the time series are reflected in the wind rose.

We adapt the standard notation for wind direction and verified that the statistics of Figure 3 agree with the time series in Figure 4 by examining and reiterating the underlying algorithms. The choice of colors used in Figure 3 may be misleading, they correspond to wind speeds of 6m/s, 12m/s and 18m/s respectively which are the maximum values of the chosen bins [0-6,6-12,12-18]m/s. The more intuitive choice of 3m/s, 9m/s and 15m/s gives rise to colors that are difficult to distinguish. We now recompiled the wind rose with colors for 0m/s, 9m/s and 18m/s which hopefully is more intuitive to read.

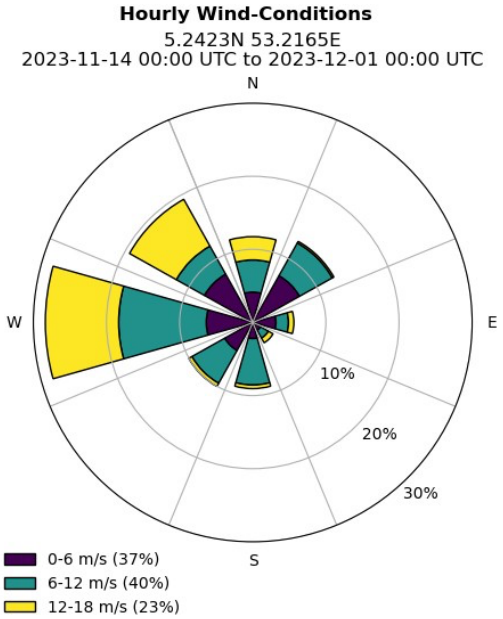


Fig. 4. There is no discussion about the drifter that has the longest signal and gets grounded on 24/11 and remains grounded until December. Does it start floating eventually, and that is the reason why it is not considered as beached? What are the implications for understanding the results for the other drifters?

We update the caption of Figure 4 to clarify the cutoff sections of this and the second drifter that were grounded on December 1st:

The timeline is cut off before the end of two recordings from drifters that remain grounded after 30 November.

Fig. 5 + section 3.2. The explanation and interpretation of Fig. 5 is too limited. Are values of 65% or 45% acceptable? Good or bad? Or what does this mean for the use of the grounding statistic and the other results of the paper?

We add a brief statement to extend the discussion of the Figure in L259. We intend this figure to be a reference table rather than a test that is then discussed.

L259 *Predictions based on eight or more positions are correct up to a few percent, and the precision based on four positions remains above 90%.*

Conclusions. There is little attempt to explain the physical mechanisms behind what is observed or to relate the results to what is already known about the system. Furthermore, I disagree with the statement “The drifters were exposed to mostly south to east directed winds”.

The underlying physical processes are very interesting, however, in this paper we look at the possibility to detect grounding from data only. Follow up work that includes the physics as potential boundary condition or constraint would be valuable.

We correct the statement about the wind conditions in now L318f :

The drifters were in the water during prevailing west wind

Technical corrections

L. 64. The first figure that is mentioned is Fig. 2.

We rearrange the Figures such that Figure 2 now is Figure 1.

L. 64. I suggest moving the information of the redeployment of six drifter to the beginning of the paragraph. I was first confused when looking at Fig. 2 and seeing eight release locations. L. 80. Mention explicitly that GNSS gives the 3D location of the drifter.

We have rearranged the paragraph of L64ff as suggested.

L. 96. The part of the sentence “… removed excess … by people on land” is unclear.

We adapt the following formulation in now L96f :

We collected the transmitted measurements and manually removed any sections at the end of the recordings that originated from the transport of the drifters by people on land.

L. 102. Add a comma after “In the second step”.

OK (now L103)

L. 112. Remove one “z” from “summarized”.

OK (now L114)

Table 1. It might be good to explicitly mention that “drying” and “beaching” are two subcategories of grounding. As they are presented now, it seems at first that wetting, grounding, drying and beaching are four different things.

After reflecting on comments by both reviewers on the definitions of ‘wetting’, ‘drying’ and ‘beaching’, we changed the categorization of events into ‘groundings’ and ‘resuspensions’ only. We describe this adapted categorization in Table 1. The terms ‘grounding’ and ‘resuspension’ are more focused on the state of the drifters, and we distinguish the last/first transitions of a recording by focusing on what we know about the duration of the corresponding last/first sections. This changes how the events are integrated in the statistics that we use to characterize the transitions.

Figure 1. “water depth seabed level” is confusing. Is it the water depth? Or is it the seabed level with respect to NAP?

We changed the caption of now Figure 2 to ‘water depth below drifter’ to clarify that we show the water depth below the drifter, sampled along its trajectory.

Figure 1, caption. Add “, respectively” after “wetting events”.

OK (now Figure 2)

L. 132. Do you mean the “discrete time derivative”?

We clarify this formulation in L134 as follows :

The speed v(t) as a discrete time derivative of the position

Section 2.2.3. The adjectives to qualify certain quantities sound strange: the distance and the change in direction should be “small” not “low”.

The reviewer is correct in that the terms used in this section are imprecise, we thus replaced them where necessary.

L. 140. Change “on water surfaces” to “on the water surface” and “velocities” to “speeds”.

OK

Response to comment

RC2: 'Comment on egusphere-2025-6170', Anonymous Referee #2, 17 Mar 2026

Citation: https://doi.org/10.5194/egusphere-2025-6170-RC2

This manuscripts describes the results of an initial experiment that analyzed Stokes drifter's trajectories in the Dutch Wadden Sea, mostly affected by the tidal cycle and wind conditions. It sets a new methodology to automatize the analysis of GPS data in order to determine whether the drifter was moving floating on the water or stopped on the ground (mudflats, beach, etc.).

While the methodology is robust, the Stokes drifters used (1 kg - circular flat shape) may behave quite differently from many of the most common items found floating at sea in shape and floatability, which can be predominantly film type plastic fragments of only a few grams that are inmersed in the upper layer and not exposed to windage, or highly protuding and exposed to windage items like bottles or foam like polymer, again lower weight and different behaviour to wind. This brings the further question of how can different litter items respond to grounding events on the mudflat, given the different shapes and densities (or floatability) compared to the drifter's, could some get stuck (like glued). This is only discussed very briefly.

We thank the reviewer for their compliments on our robust method and agree with the reviewers point that the variety of plastic pieces and their floating behavior can be expected to have an impact on the grounding processes, and in particular that the Stokes drifters sample one specific instance of grounding processes. Accordingly, the discussion is now extended in L313f :

In contrast, marine macroplastics have widely varying shapes, weights and air-to-water drag ratios, which impacts their dynamical behavior.

Another issue is the lack of discussion on the nature of the groundings (or beaching), since other substrates than mudflats may have a high capacity to trap plastics, like vegetated saltmarshes.

Figure 4 now includes a table to characterize the nature of the events as mentioned here. We find that there are very few transitions in regions where vegetation is present, however, there are many instances where they occur close by or potentially under direct interaction with human-made structures. We decided not to dive deep into separating and characterizing the individual or groups of deployments/trajectories. This involves dedicated efforts that are beyond the scope of this article.

In general, the discussion of results is very limited. For example, on how could be defined the awaited specific parameter considering beaching that modelers could use to improve global plastic transport models.

We now specifically mention plastic modeling in L308 of the conclusions. Our intention is that we summarize in the conclusion section the factors (tides or more generally water level,

wind, duration of the grounded/floating section, complex local topography) that e.g. a modeler can take as input to formulate a grounding model.

Please find some minor questions/suggestions in the commented PDF file.

We refer and respond to the comments in the PDF file below here:

Table 1.

After reflecting on comments by both reviewers on the definitions of ‘wetting’, ‘drying’ and ‘beaching’, we changed the categorization of events into ‘groundings’ and ‘resuspensions’ only. We describe this adapted categorization in Table 1. The terms ‘grounding’ and ‘resuspension’ are more focused on the state of the drifters, and we distinguish the last/first transitions of a recording by focusing on what we know about the duration of the corresponding last/first sections. This changes how the events are integrated in the statistics that we use to characterize the transitions.

Figure 1.

We extended the caption of now Figure 2. to clarify the meaning of the times above the grounding/wetting lines:

The vertical green and blue lines mark grounding and resuspension events, respectively, and the times above these lines indicate the duration of the sections.

Line 147

We discuss the inaccuracies of GNSS systems for our application in Appendix C, where we now add a short sentence in L367 to explain how we determine the value for the Stokes Drifters at rest:

For the analysis here, we determine σ_{gnss} *from the trajectory of a drifter at rest*.

We did not investigate differences in accuracy between a mobile and immobile drifter.

Line 165

The reviewer is highlighting a crucial typo, the inequality should indeed be the other way around.