"Evaluation of low-level jets in the Southern Baltic Sea: a comparison between ship-based lidar observational data and numerical models"

Rev v2

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Authors response to reviewer comments

We would like to thank the referees for their time and effort in reviewing our work. We appreciate their feedback and comments, and we have carefully considered their criticisms to improve and clarify our work.

Below, we addressed the additional comments of referee #2 and replied to them point by point. First, the referee's comment is included (in italics and bold font), followed by our answer and the new excerpt from the revised version of the manuscript (in blue font) when applicable.

Anonymous Referee, Referee #2

Referee #2 general comments

1) ***The manuscript has been improved and objectives clarified. However, some of my main concerns from my initial review still remain. From my initial comment nr 1: how to separate spatial and temporal effects? You state that this is not a problem as you rather try to evaluate the models not study climatology. Nevertheless, you present such results: For instance, Figure 7a shows a clear diurnal cycle which might be due to spatial effects rather than a temporal. You discuss this in the text connected to the figure but it shows the problems with this type of data sets. You raise the problem again in the discussion that what you observe is "a combined influence of both temporal and spatial effects" (line 509-510 in the track changes version).***

What we stated in our answer to the referee´s first comment is that although we are aware of the limitations of this dataset for long-term statistics evaluations (climatology) in a particular site, it provides an opportunity to investigate the accuracy of models' retrievals (in terms of LLJs main characteristics and occurrence) when they are affected by various temporal and spatial conditions.

This is now more clearly highlighted in the abstract: The findings of this study show that the non-stationary nature of ship-based lidar systems allows evaluating the accuracy of the models when retrieving jets' characteristics and occurrence under different temporal and spatial effects.

As the referee has already mentioned, separating the temporal and spatial effects is not straightforward. However, we still think that the high variation shown in Figure 7a of the manuscript is due partly because of the temporal variations along the different day times, and partly because of the different spatial characteristics along the ship´s route. In order to clarify and discuss this, we have partly modified Section 3.2.2:

One of the challenges of the ship-based lidar measurements is that it is not trivial to separate how the various spatial and temporal effects along the vessel route influence the jets' occurrence and characteristics…

Finally, when we say that what we observe is “a combined influence of both temporal and spatial effects”, we mean that the fact that the LLJ frequency has a particular value at a particular hour is not only a consequence of the time variability (as it may be derived from a usual daily frequency figure), but a consequence of the ship being in a particular location (space) at a specific hour (time). Therefore, a combination of both temporal and spatial effects. This has been also clarified in the manuscript:

Lines 546 – 548: This means that the observed LLJ frequency at a particular time is not only a consequence of the time variability of the jets, but also dependent on the specific position at that time.

2) ***On the other hand: Later in the discussion you fully interpret some results as pure spatial variation e.g. at line 523 (in the track changes version) and onwards you present it as you get higher values in LLJ core speed at the offshore points compared to the onshore. However, again this can also be an effect of the ferry not being close to shore when maybe a strong nocturnal jet would be present. The same comment can be made for the FBIAS results.***

In this part of the paper, we do not pretend to compare the core speed or elevation of the jets between the offshore and onshore sites (which, as mentioned by the author, may result in a bias due to the presence or not of nocturnal jets), but qualitatively compare the values retrieved by the models and the measurements under different constraints. First, we highlight that the models suffer from a consistent underestimation of the core height independently of the considered location. Secondly, we mention that even though there are considerable differences between the numerical models and the measurements regarding the mean core speed, the three datasets agree on the trend of showing higher mean values offshore than onshore. We have clarified this in the discussion of the new version of the manuscript:

Lines 561 – 569: Regarding the core height, both reanalyses show a consistent underestimation of the jets' mean height at the four evaluated sites. Even though there are considerable differences between the two numerical models and the measurements concerning the mean core speed, all the datasets agree on higher offshore mean core speeds compared to the onshore ones. Additionally…

… Furthermore, the reader must be aware that despite ship-mounted lidar measurements allow evaluating models accuracy in these different locations, they also may lead to a bias in the mean values of the jets frequency, core height, and core speed. Therefore, the differences between the considered locations in Figure 7a may be partially induced by the incomplete temporal representation at each site.

Similar reasoning can be applied to the FBIAS. We do not pretend to evaluate the reason why there are more jets far away from the shore, but we try to investigate the relation between the distance to the shore and the amount of LLJs detected by the measurements that are (or not) modeled by the numerical outputs. Therefore, it is not a comparison between offshore and onshore jets, but between the capabilities of the models to retrieve these phenomena in onshore regions versus these capabilities offshore.

3) ***On the same topic, you state in the abstract that “the findings of this study show that the non-stationary nature of ship-based lidar systems allows them to capture the variability of the jets’ characteristics due to both temporal and spatial effects”. As mentioned above, it is not clear how you can separate the temporal from the spatial effects, this should be mentioned also in the abstract.***

With this excerpt from the text, we mean that the variability of the daily cycle is not only due to the temporal changes (as it would be expected from a standard daily cycle) but that it is also a consequence of the different ship locations at different times. As suggested by the referee, this has been clarified in the abstract:

The findings of this study show that the non-stationary nature of ship-based lidar systems allows evaluating the accuracy of the models when retrieving jets' characteristics and occurrence under different temporal and spatial effects.

Regarding the discussion about the separation of temporal and spatial effects, further mentions and considerations have been included in the new version of the manuscript, as stated in our answers to comments 1 and 2.

4) ***The main outcome of this study, comparison between the lidar measurements and the reanalysis products has been made previously (as mentioned in the initial review). Although the ship-based lidar cover a certain spatial area which is new compared to previous studies, it has the drawbacks as presented above (which you also highlight at the end of the discussion) and also the limited time duration. This makes the type of analysis presented here difficult to interpret. The measurements are potentially interesting but as I mentioned in my comment nr 2 and 4, I would like to see some additional analysis to make this a novel study and this has not been addressed in the revised version.***

As suggested by the referee, we have included some further analysis in the last version of the manuscript. Since one of the main differences of this study compared to previous literature is the non-stationarity of the measurements, we have extended Section 3.4 in order to more deeply evaluate the influence of models' temporal and spatial shift in their performance and their sensitivity to different strategies to account or dismiss this shift. Additionally, we have included Section 3.5, in which a detailed evaluation of a particular LLJ event and the spatial and temporal differences between the models and the observations is included. Finally, we also discuss future research topics linked to this study in both the conclusion and discussion.

Referee #2 specific comments

Figure 11: x-axis label "Alarms" should be "False alarms"

This has been corrected.