Response to Reviewer 2

Title: Implementation of a sigma coordinate system in PALM-Sigma v1.0 (based on PALM v21.10) for LES study of the marine atmospheric boundary layer

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We take this opportunity to thank the editor and reviewers of our paper for their kind collaboration to the improvement of this manuscript. We have taken into account all the concerns raised and we have made suggested modifications, marked by yellow background in the revised manuscript.

Comments and responses

Reviewer #2

General comments: The authors present the implementation of a sigma coordinate system in the LES code PALM and show its application to the marine atmospheric boundary layer. The authors show how their code development significantly improves the representation of the interaction between a wavy water surface and the marine boundary layer. Their comparison between different cases with and without waves with and without movement is done with great detail and reveals significant changes in the mean properties and the turbulent structure of the marine boundary layer if the new sigma coordinate system is used with moving waves. Their findings also agree with other results reported in the literature. Therefore, I recommend accepting the manuscript for publication in EGUsphere. However, I would like to ask the authors to consider the following comments.

Response: We greatly appreciate your recognition of our work and the constructive suggestions. We have carefully addressed each of your concern and have provided detailed responses below.

Major Comments:

1. p.3, l.63: "PALM" should be used as a fixed name, not as an abbreviation as stated in Maronga et al. (2020).

Response: We thank the reviewer for pointing this out. The expansion of PALM as "Parallelized Large-Eddy Model" has been removed, and PALM is now consistently treated as a fixed model name throughout the manuscript.

2. p.3, l.87: theta_v stands for the *virtual* potential temperature (in Table 1, it is already correctly defined).

Response: We thank the reviewer for pointing out this inconsistency. The definition of theta_v has been corrected to "virtual potential temperature" in the text, consistent with Table 1.

3. p.10, l.222: "In parallel, it updates the wave field [...]" I doubt that this happens in parallel (meaning that a part of the computing units does the update of the wave fields while other units integrate the prognostic equations) but more likely one after the other.

Response: We thank the reviewer for this clarification. We would like to express here that the velocity field and wave surface are updated independently without exchanging information. The term "in parallel" was indeed not precise and misleading in this context. The text has been revised to clarify that the velocity tendencies are computed first, followed by an update of the wave field and sigma coordinate metrics within each time step.

4. p.10, l.227: "Finally, all simulation data ware written to output files." In standard PALM, this is done within the time-stepping loop to allow, e.g., hourly data output.

Response: We thank the reviewer for this clarification. The text has been revised to reflect the standard PALM output strategy, where simulation data are written at user-defined output intervals during the time-stepping loop, and subsequently organized and aggregated into the final output files after completion of the simulation.

5. Fig.1: The figure does not show what is written in the text. On the left, the pressure solver and the prognostic solver should be switched. The Boundary-condition update is not mentioned in the text. Also, the flow structure is not that well represented. I recommend updating the figure to better show the program structure. An example would be Fig. 10 in Maronga et al. (2015, doi:10.5194/gmd-8-2515-2015) which shows the flowchart of an older version of PALM.

Response: We thank the reviewer for this detailed and helpful comment. Figure 1 and

the corresponding manuscript text have been revised to better reflect the program structure and time-stepping procedure of PALM-Sigma.

In the original version, the time-stepping loop was shown to start with the pressure solver because, in PALM, the pressure solver can be invoked immediately after initialization to improve the zero-divergence condition before time integration. However, following the reviewer's suggestion, we have revised Fig. 1 to place the prognostic solver ahead of the pressure solver, which better aligns with the standard fractional-step method used during time integration. To avoid ambiguity, we have added a clarifying note in the text (in parentheses) explaining this design choice.

Furthermore, the arrows within the prognostic solver have been modified to more accurately represent the numerical procedure. In particular, advection, diffusion, and the remaining tendency terms are now shown as being applied sequentially rather than in parallel, consistent with their actual execution order in the model.

Finally, the boundary condition update, which was previously only shown in the figure, is now explicitly described in the revised manuscript text and clearly indicated within the time-stepping loop in Fig. 1.

Overall, Fig. 1 has been redesigned to more clearly illustrate the solver sequence and program flow, following the general style of the PALM flowchart presented in Maronga et al. (2015), and the text has been revised accordingly to ensure full consistency between the figure and the description.

6. p.13, l.279: From my understanding of the figures, the words "windward" and "leeward" should be swapped in this sentence.

Response: We thank the reviewer for pointing this out. The side of the wave facing into the wind is "windward" and the side of the wave sheltered from the wind is "leeward." They are misused in the original manuscript. This has been corrected in the revised manuscript to ensure consistency with the flow patterns shown in the figures.

7. Fig.4: Please add which cases are represented in each row.

Response: We thank the reviewer for this suggestion. Panel labels (a) – (f) have been added to Fig. 4, and the figure caption has been revised to explicitly indicate that panels (a,b), (c,d), and (e,f) correspond to the FW, OW, and SW cases, respectively.