Responses to Reviewer 1

Review of "Meteotsunami prediction in km-scale regional systems coupled at high frequency"

The manuscript presents an operational, km-scale coupled atmosphere–ocean workflow with 10-minute exchanges, and demonstrates the procedure by simulating the 18 June 2022 meteotsunami. The paper requires major revision to be accepted for publication.

We thank Reviewer 1 for their time to review our manuscript and for the useful comments and suggestions. We have taken them into account and believe the manuscript has improved.

Major comments

1) Verification of resonance

The meteotsunamis are amplified by several resonances - Proudman, Greenspan, harbor/bay. It is necessary that the suggested scheme can properly capture these resonances. Although the local(bay/harbor) resonances can be captured using finer grids, it is necessary to add two concise, idealized verifications (can be included in appendix or supplementary):

- **Proudman test (uniform depth): Force with a translating Gaussian pressure and report SSH amplitude vs translating time when the translating speed is equal to the resonance speed.**
- **Greenspan / edge-wave test (sloping shelf): Apply an alongshore-moving pressure near the shelf-mode speed and demonstrate a sustained steady alongshore response (shape and phase). This confirms the solver's behavior near the steady state.**

We thank the reviewer for this valuable and constructive suggestion. We agree that verifying the ability of the ocean configuration to reproduce the main resonance mechanisms (Proudman, Greenspan, and harbor/bay resonances) is an important assessment.

Nevertheless, the primary focus of the present study is to evaluate the performance of coupled systems which represent realistic meteorological forcing, rather than testing the ocean-only component part of the systems with idealised meteorology. These systems are built to perform well across many applications (weather forecasting, marine forecasting, climate projections), rather than for specific applications (Berthou et al., 2025b). Our objective is therefore to assess how these coupled systems represent real-event conditions and to identify their strengths and weaknesses in representing different types of events, of which meteotsunami is one. In this article, we focused on real-event validation, while recognising that idealised tests are standard tools to isolate mechanisms. We have made this clearer in the introduction:

"In parallel to a growing understanding of meteotsunamis on the Northwest European Shelf, km-scale regional coupled systems have been under active developments for their ability to provide simultaneous weather and marine forecasts, including coupled feedbacks, important in complex coastal shelves (Pianezze et al., 2022; Berthou et al. (2025b)). These systems are designed to have good ability for multiple purposes across weather and marine forecasting and climate projections: wave prediction, sea level prediction, sea surface temperature forecasting, wind storms, thunderstorm, land temperatures and precipitation for example (Berthou et al., 2025a). In this study, we investigate their ability of representing meteotsunamis, a phenomena currently not forecast at all for the Northwest European shelf."

Nevertheless, the model's ability to represent both atmospheric gravity waves (we added new plots showing pressure disturbances of similar magnitude and timing as in the observations added) and an amplified meteotsunami imprint (0.9m reached in one of the gauges for UKC4) is consistent with the system capturing the dominant resonance mechanisms. In section 4.2, we identified in a similar way to Renzi et al (2023) that Proudman resonance was likely at play, as the propagation speed of the pressure disturbances in the atmospheric model match the local long-wave speed over the shelf in the ocean model bathymetry. We added the following sentence in Section 4.2:

"We note that Renzi et al. (2023) identified Proudman resonance as the main resonance mechanism responsible for this event. The meteotsunami signal presented in Figure 6 is organised in coherent stripes, which do not show particularly strong coastal enhancement, therefore also suggesting Greenspan resonance was not captured by the model."

We also acknowledge the scientific value of targeted idealised tests, in particular to understand why the AROBASE system did not capture the event in the present case, to disentangle whether it is an ocean configuration or an atmospheric configuration issue. To address this point, we have added a note at the end of the Conclusions section highlighting that implementing these resonance-focused verifications in future studies would provide useful diagnostic insight:

"Future work should include test cases with the standalone NEMO configurations used in this study with idealised atmospheric pressure forcing (Proudman/Greenspan/edge-wave test (Proudman, 1929; Greenspan, 1956), to reveal whether the issues with the AROBASE system come from the ocean or the atmospheric model configuration. In addition, assessing the operational performance of meteotsunami prediction through a systematic analysis of false alarm and hit rate ratios across multiple cases will be an important step toward improving forecast reliability."

We therefore believe that the manuscript remains robust without these additional experiments and that its main aims and scientific contributions are not compromised.

New references:

Greenspan M (1956) Propagation of sound in five monatomic gases. The Journal of the Acoustical Society of America, 28: 644–648. https://doi.org/10.1121/1.1908432.
Proudman J (1929) The Effects on the Sea of Changes in Atmospheric Pressure. Geophysical Journal International, 2: 197–209.

2) Atmospheric pressure input

Because MSLP is the input of the meteotsunami genesis, it is necessary to provide what field is exchanged, and how 10-min fields are temporally interpolated to the ocean time step.
Thank you for your comment. A clarification has now been included now in model descriptions. Lines begin as "Instantaneous Mean Sea Level Pressure (MSLP) is output from the UM and is interpolated by the OASIS coupler onto the 1.5km NEMO grid using bi-linear interpolation weights computed with the Earth System Modelling Framework (ESMF) library." for UKC4 and "Instantaneous Mean Sea Level Pressure (MSPL) is send from AROME through OASIS, which is used by NEMO using bi-linear interpolation computed with the Spherical Coordinate Remapping and Interpolation Package (SCRIP) inside OASIS." for AROBASE.

Then, cross-validate your pressure against the records used by Renzi et al. 2023 for the same event using the same filtering.

Thank you for this suggestion. We agree that cross-validation of the atmospheric pressure forcing is valuable and had done it in Figure 12 for the English Channel. We have included additional comparison with more pressure records used in Renzi et al. (2023) using consistent filtering in the Appendix for stations that lie within the model domain. This provides additional validation of the models. We added the following sentence in reference to them in the manuscript: *“To further assess the ability of the two models to capture atmospheric perturbations, additional validation of the atmospheric pressure forcing is provided in Appendix Fig. A4. This analysis is based on the same Irish stations used in Renzi et al. (2023), with data processed using consistent filtering. The results corroborate the findings discussed above 380 and offer further insight into why UKC4 outperforms AROBASE. As shown in Fig. A4, UKC4 exhibits very good agreement with the observations, clearly reproducing the 2 hPa pressure jump. Although minor discrepancies in timing are present, the overall representation remains adequate. In contrast, AROBASE shows weaker performance at the two stations within its domain: the pressure jump is less pronounced, which likely contributes to a reduced amplification of the meteotsunami signal."*

3) Grid resolution vs tide-gauge representativeness

At 1–2.5 km, many harbors and tide gauges may not be properly captured and local seiching/geometry effects may not be solved by the model. Please specify how the model handles this situation and the limitations related to the size of the grid.

Thank you for your comment. We agree that the mismatch between model grid resolution (1–2.5 km) and the fine-scale geometry of harbors and tide gauge locations is an important limitation, particularly for representing local resonance and seiching effects.

We have now strengthened and clarified these limitations in the Discussion and Conclusions sections. Specifically, we emphasise that the model resolution may not adequately resolve small-scale coastal features, which can lead to underestimation of meteotsunami amplitudes at certain tide gauge locations.

The revised text can be found in Discussion – Success and Challenges: *“It is important to note that amplitude underestimations may result from coastal resolution limitations, which prevent the system from capturing additional resonant effects (e.g., within harbours) or from the proximity of certain locations to the edge of the model domain.”*

And in the conclusions: *“Additionally, some limitations may arise from the systems' resolutions, particularly when further amplification occurs along the coastline due to features such as harbours and other fine-scale structures that the system cannot adequately resolve. Indeed, with 1.5km (UKC4) and 1.8-2.4km (AROBASE) and a minimum depth of 10m, the NEMO-based ocean models of this study cannot by design represent finer-scale seiching than twice their grid-scale – hence missing most of the harbour resonance / thin estuary resonance or coastal amplification by energy conservation. One way to address this would be to increase the ocean model resolution; however, this usually comes with a decrease in domain size to balance costs, which could then miss the shelf-wide amplification of meteotsunamis. Using an unstructured grid with variable resolution in the ocean would enable this compromise, but NEMO does not offer this feature and the cost of supporting a different system than NEMO is prohibitive for both the Met Office and Météo France. Since most of the meteotsunami signal can already be effectively captured from UKC4, and its ensemble forecasts supports the development of an early warning system, we believe that increasing the resolution is not sufficiently justified in this context.”*

Figures & presentation

- **Figs 3–5 (SSH obs vs models): Improve readability with a clear style. Ensure axis units (m) and consistent y-limits. At Union Hall (Fig 3), show the full observed range (as reported in Renzi et al. 2023) and state whether the extremes were spikes removed by QC or retained after filtering.**

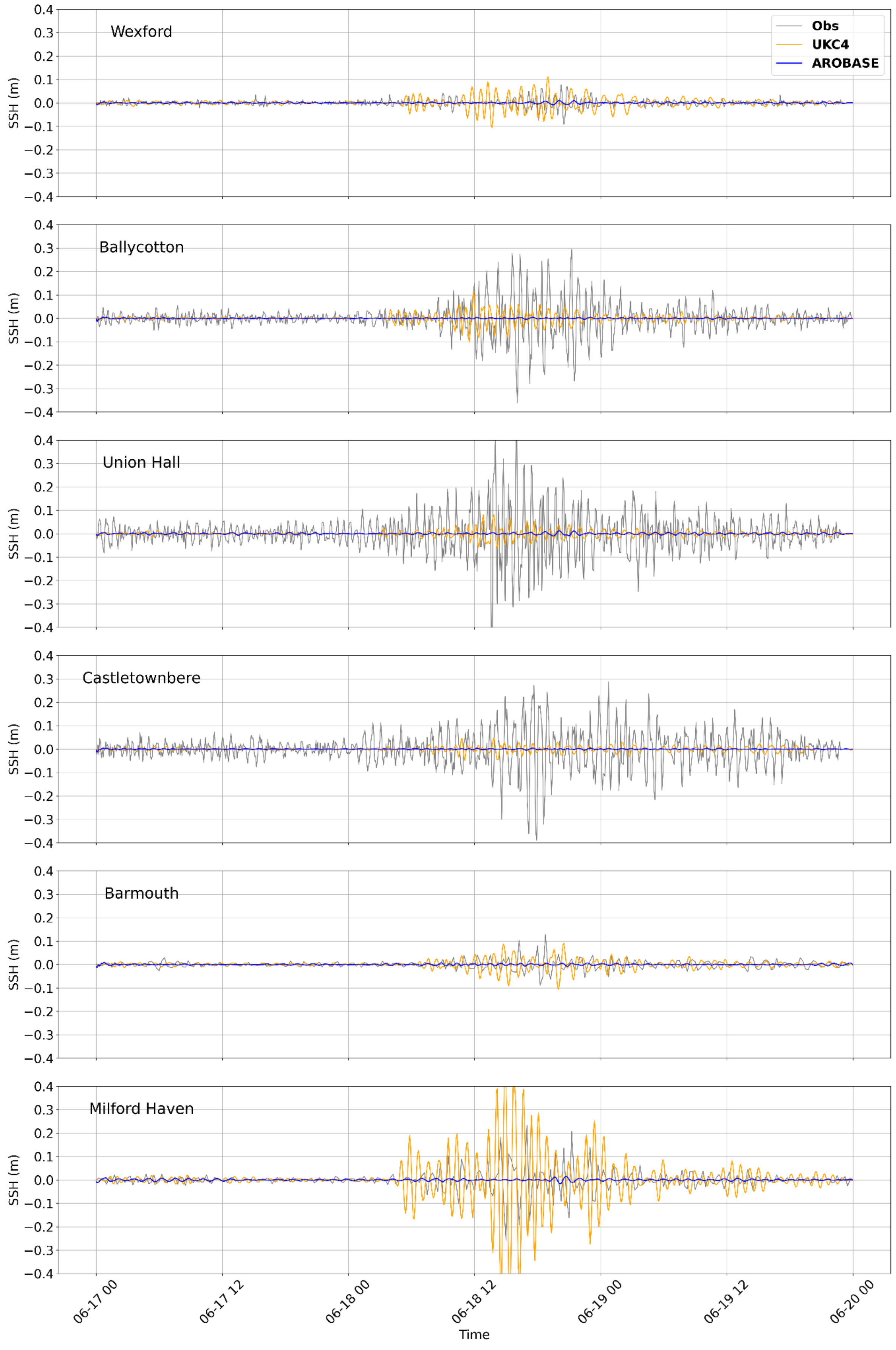
Thank you for your comment. We agree that clarity and consistency in the presentation of Figures 3–5 are important.

The figures were originally designed to maximise comparative readability across locations and between models. A key challenge is that AROBASE does not adequately capture the event, resulting in a much weaker signal. Expanding the y-axis range to fully encompass the observed extremes at Union Hall would significantly reduce the visibility of the AROBASE signal and hinder comparison at other sites, particularly those with smaller amplitudes (e.g., Barmouth). For this reason, we adopted consistent y-axis limits across all panels to facilitate direct comparison of amplitude and timing between models and observations.

To address the reviewer's concern, we have now included the full observed signal range for Union Hall and Milford Haven in the Appendix. This allows readers to examine the complete amplitude variability without compromising the readability of the main figures.

Regarding figure clarity, we have revised the plots to ensure that axis labels, units (m), and variable names are clearly and consistently indicated. Previously uniform y-axis across panels with any apparent discrepancies due to subplot formatting and shared axis ticks have now been separated for clarity.

This is the figure for the area of the Celtic Sea as an example:


Wexford
Ballycotton
Union Hall
Castletownbere
Barmouth
Milford Haven
Obs
UKC4
AROBASE
SSH (m)
0.4
0.3
0.2
0.1
0.0
−0.1
−0.2
−0.3
−0.4
06-17 00
06-17 12
06-18 00
06-18 12
06-19 00
06-19 12
06-20 00
Time

Finally, we thank the reviewer for highlighting the need to clarify the treatment of extremes at Union Hall. We have now explicitly stated whether these values were retained after filtering or removed during quality control in the manuscript, within the same paragraph describing the figure setup.

An explanation of these choices has been added to the revised manuscript as: "*All plots use consistent axis ranges to ensure comparability across locations and to allow signals at sites with weaker amplitudes to remain visible. As a result, for locations with stronger signals, such as Union Hall and Milford Haven, the full range is not entirely displayed. To address this, the complete signal for these two sites is provided in the Appendix (Fig. A1). It is important to note that, at most locations, the tide gauge data were received from the sea level station monitoring facility (https://www.ioc-sealevelmonitoring.org/) before quality control procedures, retaining the extreme values. However, at some sites, primarily in the UK, the quality controlled datasets excluded these extremes, and therefore raw data (Channel 2) were used to ensure that the meteotsunami signal was preserved.*"

Figs 9–12 (MSLP): Make captions and legends explicit about what's shown.
Thank you for spotting this. It is now corrected.

Legends & panel letters: Ensure legends in every multi-curve panel (esp. Figs 10–12, 19).
Thank you for the suggestion – now fixed.

Minor comments (grammar, wording, consistency)

- **"For the UK For the UK …" → "For the UK, …"**
  Thank you for spotting this – now corrected.
- **"5 mn / 1 mn" → "5 min / 1 min" (captions and text).**
  Thank you, now changed.
- ***Double words "the the" (e.g., around L 320 and L 480) → remove duplication.***
  Thank you for spotting this – now corrected.
- **Fig. 19 caption dates: use 2022 (not 2023) for the June event runs.**
  Thank you for spotting this – now corrected.
- **Replace "left/right hand-side" with "left/right panel" throughout figure captions.**
  Thank you, this has been now changed.
- **Keep tense consistent (present for methods, past for results), and ensure subject–verb agreement in captions.**

  Thank you for the suggestion. This has now been changed.