Review of: *"Forcing-dependent submesoscale variability and subduction in the coastal sea area (Gulf of Finland, Baltic Sea)"* by Salm K. et al., 2025

The manuscript presents glider-based hydrographic observations during three missions conducted in the Gulf of Finland in the summers of 2018 and 2019, supported by high-resolution GETM model simulations. The authors aim to investigate the dependence of submesoscale variability on atmospheric forcing and background hydrographic structure, and to explore mechanisms of tracer subduction driven by topographic and baroclinic instabilities. Tracer variance is quantified via the "spice" parameter, which represents thermohaline variability that does not affect density.

The topic is relevant and timely, and the integration of observational and high-resolution modeling approaches is promising. However, the manuscript requires major revisions to meet publication standards and to convincingly support its stated objectives. Below are my detailed comments:

General Comments

- **Clarity and Structure**: The manuscript requires significant reorganization and revision for clarity. The writing style is often unclear, with missing or incorrect articles, tenses, and sentence structures throughout.
- The **Introduction** lacks a clear narrative and needs to better articulate the study's motivation, background, and novelty relative to existing work in the GoF.
- **Consistency and Rigor**: A number of concepts, such as "spice", "tracer variance", and various metrics (e.g., Rossby number, buoyancy gradients), are introduced too late, without sufficient explanation or justification. Terminology should be defined clearly and used consistently.
- **Use of Observations vs. Model**: The manuscript leans heavily on the model results, and the glider observations appear to be used mostly for validation. This raises concerns about how well the observational data actually constrain or inform the main findings.
- **Figures and Analysis**: Several figures are difficult to interpret due to inconsistent domains, axes, or color scales. Some key diagnostics are not shown (e.g., vertical velocity, currents (depth vs time)), limiting the reader's ability to assess the conclusions about subduction and mixing.
- A **Conclusion section is missing** and the Discussion lacks direct references to the figures and results.

Specific Comments:

Abstract: the abstract has to be improved so it matches text body and the analysis and it is self-explanatory so the reader knows what exactly was done.

- L2: Rephrase the second sentence—it's unclear and does not reflect the analysis accurately.
- L4: Specify what "tracer variance" refers to (i.e., spice variance).
- L6: Clarify "around UML" – upper mixed layer? Provide depth range.
- L10–13: Specify what atmospheric forcing is meant; consider merging sentences.
- L14: "likely SMS flows" – was this demonstrated? If so, how?
- L15: Be specific—"high tracer variance" of what exactly?
- L16: The final sentence is vague—was this shown, or is it speculative?

Introduction (L20–85): this needs to be seriously improved as the writing style is not good, the paragraphs need to be reorganized so the background, motivation and what will be done and why is clear to a reader.

- L20: Replace "forces" with a clearer term
- L21: Expand the second sentence to explain the background of SMS dynamics.
- L23: Explain why SMS features are important—link to physical or biogeochemical processes.
- L25: Add citations to definitions of SMS.
- L28: Rephrase the final sentence and state the region explicitly.
- L31–42: Revise for English grammar and completeness. "The" and "of" are frequently missing.
- L36–38: Add "semi-enclosed" to describe the Baltic Sea.
- L41: Specify freshwater input sources—mention the main rivers.
- L45: "In contrast to the open ocean" implies salinity is unimportant there—rephrase.
- L46–47: Sentence unclear—needs rewording.
- L48: Clarify whether Lips (2009) and Vali (2017) estimated mixing or just described it.
- L57–58: Replace "captured" and "prevalence" with more precise terms.
- L60–61: What is the key modeling advantage? State it up front.
- L62–64: Introduce the glider earlier; explain why the upper half of the water column is the focus.
- L65: Provide the exact mission durations.
- L66: Rephrase "favored".
- L68: Define "tracer variability" – first mention needs explanation.
- L70–72: Why is only spring-summer analysed? given the model covers a longer period. The two summers you analyze are similar or different?
- L72–75: Clarify the relation to Salm (2018)—same dataset?
- L77: Explain why spice is used and what it captures. This is not a common term.
- L81–85: The hypotheses should be clearly formulated and tested in the Results.

2. Materials and Methods

2.1 Glider Observations

- L90: Grammar issues—"Three missions were performed…"
- Specify exact dates, transect directions, and water depth coverage.
- How was data quality-controlled? Cite appropriate methods.
- Why were transects oriented differently between missions?
- L98: Describe how the data were interpolated (vertical/horizontal resolution).
- Fig. 1b: Include a broader regional map with coastline for context.

2.2 Model

- Clarify whether "adaptive vertical coordinates" refers to sigma or z-coordinates.
- L110: Why was the model vertically interpolated? Was this to match glider data?
- Use consistent tenses (past for methods).

2.3 Analysis

- L122: Why use 4 km filtering? What would 2 or 7 km yield? Discuss sensitivity.

- L128–130: Refer to Alenius et al. (2003); discuss how scale selection affects variance.
- L140: Define how spice variance is calculated—add the equation.
- L148: "For it" – unclear, remove.
- L150–155: How was N^2 calculated? What vertical spacing and smoothing were used?
- L155- this is a Result or it could be also in the Introduction- move it
- Why the features can be displaced in the model- this should be covered in the introduction
- Parameters such as Rossby number, Ri , buoyancy gradients should be at least mentioned in the Introduction, what the analysis will be performed and why?
- L170: central 'difference' ? 'above' missing words
- Why the wind components were smoothed?
- Fig 2. This should be presented in the separate section e.g model validation or section 3.1 , the spice is shown in density domain, but the rest in time-depth domain, why? What about the currents and vertical velocities? They are important for SMS, maybe not in the observations but the dynamics can be shown in the model.

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3. Results: While the section presents several relevant observations and model outputs, it lacks key quantitative metrics to support the conclusions. If the main findings rely primarily on model-derived interpretations of physical processes, this should be substantiated with appropriate statistics and objective measures. For example, the influence of topographic steering is not sufficiently demonstrated, and vertical velocities—crucial for diagnosing subduction or vertical exchange—are not shown. Including such diagnostics would significantly strengthen the analysis and the credibility of the inferred processes.

3.1 Validation:

- Correct the language, there are some missing words e.g in the title etc.

- L181–185: Provide not only mean differences but also standard deviations.
- L190: Define "slight" differences numerically.
- L192–196: Indicate which depths the model fails to resolve secondary maxima.
- L197: If stratification was weaker, state it clearly.
- L205: Are the largest spice values associated with maximum T/S gradients? Clarify.
- Fig. 3: Instead of mean-removed slices, show actual matched cross-sections (as in Fig. 4).
- Fig. 4: Difficult to compare due to gaps in glider profiles. Consider interpolating data.
- L220: This sentence is confusing—aims should be explained in the Introduction.
- L225–235: Clarify whether text refers to model or observations.
- Fig. 5: Clearly label data sources (glider vs. model).

3.2 Wind Forcing

- Are wind differences between years sufficient to explain SMS variability?
- Fig. 7: Add mean wind arrows for reference.

3.3 Submesoscale Indicators

- L279: 'Maxima of relative vorticity'—show this in a figure.
- L300: "Changing wind forcing" – specify exact changes.
- Fig. 8: Why show minimum temperature instead of UML?
- Relationship between surface Ro and spice variance should be discussed quantitatively. E.g correlations etc.
- Discuss limitations of model—e.g., can EO data be used for validation? In the summer this should be possible
- Fig. 10: Use consistent axes (depth vs. density space); add vertical velocity if available.

- L345: “Probable” – vague. Can this be quantified?
- Fig 11. Why you not use UML or vertical currents? For comparison with spice?

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4. Discussion

- L367–374: General background not linked to results—consider trimming.
- L385–395: Was vertical velocity shown anywhere? If not, speculative statements must be softened.
- Discuss how “elongated regions” of spice relate to fronts or subduction processes.
- Consider plotting spice vs. Ro for correlation.
- L400: Discussion on winter SMS processes seems out of place—study only covers summer.
- L402: “SMS only visible with T and S gradients”—is this a limitation of the method?
- L409–411: Clarify whether this is your result or literature-based.
- L423–428: Cite figures for all claimed results.
- L437–443: Strong claims based on limited evidence—can they be supported by broader statistics?
- L444–452: This paragraph appears unrelated to the study and could be removed.

Missing Conclusion

- A summary of key findings and a clear answer to the hypotheses are needed.
- Clarify how glider data contributed—was it only for validation?
- Highlight the study's novelty and limitations clearly.

Recommendation: Major Revisions

The manuscript addresses a relevant topic and includes valuable datasets. However, substantial improvements in structure, clarity, and analysis are needed. The roles of observations and model outputs must be better defined, and the analysis should be aligned more closely with the stated objectives.