Response to reviewer 1

Dear reviewer,

We appreciate your constructive and relevant comments and suggestions to our manuscript. Below, your reviews are reproduced in **black**, while our comments are in **blue**.

Since the reviewer #2 also raised important points, we have made substantial changes throughout the manuscript. Some of these changes may also address your comments or provide useful context for the paper, so we kindly suggest to take a look at our responses to Reviewer #2 as well.

Please, note that all **line numbers** in our responses refer to the clean version of the manuscript, not the tracked-changes version.

"Dense shelf-water and associated sediment transport in the Cap de Creus Canyon and adjacent shelf under mild winter regimes: insights from the 2021–2022 winter" by Arjona-Camas et al.

General Comments:

This manuscript presents a well-written and carefully conducted observational study of dense shelf water cascading (DSWC) and associated sediment transport in the Cap de Creus Canyon during a mild winter (2021–2022). The authors employ a multi-platform approach—including gliders, moorings, ship-based CTD profiles, and reanalysis data—to describe the cascading evolution and to estimate transport of water masses and suspended sediments.

The manuscript is well structured and clearly written, with high-quality figures and solid data processing. However, the conceptual novelty is limited, as the key findings align closely with what is already established in the DSWC literature. Specifically, prior studies—including Mahjabin et al. (2019, Continental Shelf Research; 2019, JMSE; 2020, Scientific Reports)—have demonstrated:

- That DSWC can occur under mild to moderate wind forcing;
- That wind direction is a key modulator of cascading strength;
- That such events result in substantial sediment and biogeochemical transport.

Moreover, these studies introduced predictive frameworks such as the Simpson number and energy balance models, and examined canyon-free shelf settings under similar climatic regimes. These works are not cited in the current manuscript.

While the present study is geographically focused on the Cap de Creus Canyon, the manuscript could benefit from a deeper exploration of canyon-specific dynamics—such as flow steering, internal hydraulics, or sediment redistribution mechanisms—which are only briefly mentioned. Additionally, while the observations are carefully described, the broader significance of this mild-winter case for global DSWC understanding is not yet fully articulated. A more explicit discussion of the study's unique contribution—particularly in terms of sediment asymmetry, constrained cascade depth, and implications for WIW formation—would significantly enhance the manuscript's impact.

Reply: We appreciate this overall positive assessment of our manuscript, and we thank you for pointing out both its strengths and the areas for improvement.

We agree that the Introduction would benefit from citing other studies of DSWC in different settings. We have added a paragraph in the Introduction (lines 34-43) about dense shelf water cascading, as well as its implications in the global ocean. We have also added references to documented cases of DSWC around the world, including the studies you recommended on cascading off Australia (Mahjabin et al., 2019, 2020).

We acknowledge that concepts such as flow steering, internal hydraulics, and sediment redistribution mechanisms are important canyon-specific processes. Our data do not allow for a full dynamical analysis of these mechanisms. However, we have expanded the discussion of our paper by including:

- Lines 518-536: Determination of the Richardson (Ri) and Froude numbers (Fr), which provide insights into the stability and dynamical behavior of stratified flows. Ri values showed a general increase between 150 and 300 m depth, which roughly corresponds to the vertical extent of the dense shelf water plume. The maximum Ri observed reached 0.18 at 270 m depth in the upper canyon, and 0.16 at 180 m in the mid canyon. These values are below the critical threshold of 1 that separates laminar (Ri >1) from turbulent flow regimes, thus indicating a predominantly turbulent flow (Mack and Schoeberlein, 2004). This suggests that fluid instabilities likely enhanced vertical mixing and lateral spreading of the dense water plume. Additionally, we obtained Fr ~1.10. This value lies just above the critical threshold of 1, indicating a supercritical flow regime where inertial forces become more significant, potentially favoring more unsteady and turbulent flow conditions (Cenedese et al., 2004).

- Lines 552-569 and lines 570-580: Discussion on how the geomorphology of the canyon influences the redistribution of sediments in the canyon. In addition, we have added lines 718-721 to acknowledge that future research would benefit for an in-depth analysis of the physical dynamics that drive DSWC. Thank you again for these constructive suggestions.

Specific comments:

1) On novelty and contextualization

The Gulf of Lions is among the most studied regions globally for DSWC, with numerous works documenting both mild and extreme cascading events. While the present manuscript focuses on a specific mild winter (2021–2022), the authors should more clearly state what new understanding this adds. For example: Is the sediment asymmetry across the canyon novel? Is the observed upper canyon confinement unusual for mild winters? More detailed differentiation from earlier work is encouraged.

Reply: We appreciate your suggestion to better state the relevance of our study. For that, we have rewritten the Introduction and added some lines with the knowledge gap and enhance the novelty of our study.

There are several studies conducted in the GoL investigating both intense dense shelf water cascading (IDSWC) events -such as Heussner et al. (2006), Canals et al. (2006), or Durrieu de Madron et al. (2013)- and mild DSWC (MDSWC) in the Cap de Creus Canyon -such as Ulses et al. (2008a), Martín et al. (2013), Rumín-Caparrós et al. (2013), or Mikolajczak et al. (2020)-. These studies are mostly based on mooring time series acquired in the canyon head and/or model outputs and numerical simulations to detect the presence of dense waters and infer their export pathways, which offer limited spatial resolution and lack direct observations on shelf-slope transports. To our knowledge, there has been no comprehensive observational characterization of dense water and sediment transport from the shelf to the slope in the Cap de Creus Canyon under moderate winter conditions during MDSWC events. To address this gap, we offer a combination of hydrographic and velocity measurements collected concurrent within the canyon and the adjacent shelf to resolve the shelf-to-slope transport of dense waters and associated suspended sediment, along with reanalysis data to determine the temporal extent of the 2021-2022 MDSWC event and place it in the context of cascading events observed in the Gulf of Lion over the last 26 years. This latter part is new, but we believe it will help us to strengthen the importance of our work and generalize our conclusions.

2) Wind Direction and Episodic Forcing

The manuscript appropriately links SE wind events to episodic downwelling and DSWC initiation. However, this connection is largely descriptive. Including wind stress time series or Ekman transport estimates would strengthen the argument and provide a more quantitative link to the observed cascading pulses.

Reply: We appreciate your suggestion and fully agree that a quantitative analysis of different forcings, such as wind stress time series or Ekman transport estimates, could provide a more quantitative characterization of the observed DSWC. However, this goes beyond the scope of the present study, which does not aim to investigate the physical dynamics of DSWC or the processes driving the initiation and evolution of cascading in detail. However, and in agreement with previous studies, we can still infer aspects on the dynamics of the dense water plume based on existing theoretical frameworks. For example, if we schematize the behavior of the cascading plume observed in our study for winter 2021-2022 using the classification of Shapiro and Hill (2003) (which describe the effect of friction on dense water plumes), our observations suggest a "head-up" configuration. This means that most of the dense fluid remains upslope, while only a thin tail drains downslope. Also, the steepest isopycnals occur on the upslope (western) side, while the downslope side (toward the shelf break) remains thinner. We have added a line discussing this interpretation in the Discussion section (lines 518-522). As previously stated, we have also estimated the Richardson and Froude numbers to determine the flow regime of the plume. We now discuss it in lines 518-536.
That said, we acknowledge the importance of conducting a more quantitative analysis of the different forcings involved, and we agree that future work would benefit from this detailed exploration of the physical dynamics of DSWC (lines 718-721).

3) Canyon-Specific Dynamics
While the Cap de Creus Canyon is central to the title and framing, the manuscript does not deeply examine its dynamic role beyond being a conduit. Consider discussing whether canyon morphology contributes to observed sediment asymmetries or restricts flow depth. Alternatively, consider softening the canyon emphasis if the goal is to document a shelf-wide mild DSWC event.

Reply: We acknowledge that canyon morphology contributes to the sediment asymmetries observed in our transects. We have expanded the discussion to include a more detailed explanation on how the canyon's morphology may have influenced the increased SPM concentrations associated with dense waters on the southern canyon flank (see section 5.2.)

4) Citation Inclusion
Please cite the following prior studies if relevant:

- Mahjabin, T., Pattiaratchi, C., & Hetzel, Y. (2019a). *Wind effects on dense shelf water cascades in south-west Australia.* Continental Shelf Research, 189, 103975.
- Mahjabin, T., Hetzel, Y., & Pattiaratchi, C. (2019b). *Spatial and temporal variability of dense shelf water cascades along the Rottnest continental shelf in southwest Australia.* JMSE, 7(1), 30.
- Mahjabin, T., Pattiaratchi, C., & Hetzel, Y. (2020). *Dense shelf water cascading around the Australian continent.* Scientific Reports, 10, 9930.

These studies support the notion that DSWCs can occur under non-extreme conditions and offer theoretical and methodological insights that are directly relevant here.

Reply: Thank you for the suggestion. We agree that these studies are relevant to our work, as they provide insights into DSWC under non-extreme conditions in other continental margins. As recommended, we have now cited Mahjabin et al. (2019b; 2020) in the Introduction to reinforce the broader context in which DSWC occurs across diverse continental margins and latitudes.

Technical Corrections
Abstract: The opening sentence *"This study examines…"* is generic and does not effectively convey the study's context or significance. I recommend replacing it with a more engaging and informative sentence that introduces DSWC and the knowledge gap being addressed. For example: *"Dense shelf water cascading (DSWC) is a key process in transferring water masses and sediments from*

continental shelves to deep basins, yet its dynamics under mild winter regimes remain poorly characterized."

Reply: We have now added this informative sentence in the abstract (lines 9-10).

Introduction: While DSWC is mentioned early, it is not clearly defined. I recommend including a short, reader-friendly definition in the introduction, such as: *"DSWC refers to the downslope flow of cold, dense water formed on continental shelves due to surface cooling and/or evaporation, which descends under gravity into deeper ocean basins."*

Reply: Thank you for pointing this out. We agree that a clearer introduction to the process of dense shelf water cascading was necessary to improve clarity for the reader. Following your suggestion, we have included a new paragraph in the Introduction (lines 34-43) describing DSWC and its global implications.

Line 236: Typo — "metter" should be corrected to "meter".

Reply: Changed.

References:

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