

Review of the Manuscript

A question of time and space: A model approach to the synchronicity of gypsum and halite during the Messinian Salinity Crisis

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The formation of salt giants, such as the Messinian Salt Giant during the Messinian Salinity Crisis (MSC, 5.97–5.33 Ma) in the Mediterranean Sea, remains a topic of ongoing scientific debate. Traditionally, it has been assumed that gypsum precipitated in the marginal areas before halite formed in the deeper basin, although this has not been definitively confirmed.

This study uses box modeling to explore different halite and gypsum distribution scenarios. Results show that, under certain conditions, both minerals could precipitate simultaneously but in different areas. The authors propose that halite may form in restricted margins as salinity increases before spreading to open areas when salinity reaches halite saturation. This modeling approach offers valuable insights into the dynamics of evaporite formation in semi-enclosed basins like the Mediterranean Sea during the MSC.

The manuscript presents a structured and well-thought-out investigation of the factors influencing gypsum and halite precipitation in the Mediterranean Sea. It adds to our understanding of evaporite formation and, with further refinement, could contribute significantly to the field. However, I believe this work might be more suited to a journal like *Geoscientific Model Development (GMD)*, focusing on model description and validation.

A few questions:

While the authors suggest that the model could be applied to other basins (e.g., the Red Sea), it is not clear how the specific model configurations (A1, A2, B) would translate to different geochemical settings. Could the model be adapted to explore other evaporite-forming basins more explicitly?

Regarding the title, you should mention the “Mediterranean Sea” because the MSC occurred in the Med Sea, and your study focused on the Med Sea.

The paper mentions that constant evaporation rates were used. How might a variable evaporation rate, could impact the model results? Could this change the timing or locations of gypsum and halite precipitation? Were there any sensitivity tests performed to explore this?

The manuscript does not provide sufficient discussion on the role of the Strait of Gibraltar in influencing Mediterranean circulation and salinity. A more detailed analysis of how restricted or variable water exchange through the Strait affects gypsum and halite precipitation patterns would add depth to the study.

Have you conducted sensitivity tests on key parameters such as evaporation rates, river water composition, or Strait of Gibraltar exchange? If not, how might these factors impact your results?

Missing punctuation occurs in multiple sentences where commas or periods could help separate clauses or clarify meaning (references style, the caption of the figure in bold, the table legends ...).

Abstract

The abstract could benefit from a clearer articulation of the novelty of the study. It touches on known issues but doesn't strongly emphasize how the modeling results diverge from or contribute to existing theories.

Introduction

The introduction references key studies and models that have addressed the MSC. The mention of studies that confirm or question these models (e.g., Meilijson et al., 2019; Manzi et al., 2018) highlights the ongoing scientific debate and the gaps in current understanding. The comparison with Simon & Meijer (2017) is helpful, but the contributions of the present study (e.g., density-driven dynamic overturning) could be more explicitly emphasized early on. For instance, the detailed breakdown of different studies (e.g., Meilijson et al., 2019 vs. Manzi et al., 2018) could be summarized more concisely to avoid overloading the reader with too many specific comparisons at the outset.

Citations are included in parentheses, but in some cases, they interrupt the flow of the text. For better readability, consider rephrasing sentences to integrate citations more naturally. Example: Instead of "5.97 to 5.33 Ma, (Roveri et al., 2008)," you could say "According to Roveri et al. (2008), the event occurred between 5.97 and 5.33 Ma." This would make the text smoother.

Consistency in citation formatting is needed. For example, in some instances, authors' names are written in all caps, which should be corrected., e.g. (Decima & WEZEL, 1971; Decima & Wezel, 1973)

The flow between ideas could be improved with clearer transitions between sections. For example, when moving from the discussion of modeling to the thermo-haline circulation section, adding transitional sentences can help guide the reader more smoothly from the background after the modeling approach.

The conversion from Atlantic water to more saline Mediterranean overflow water happens via an overturning cell in the Mediterranean Sea." Not clear, this sentence could be rephrased.

The abbreviation "MSC" for Messinian Salinity Crisis is introduced but not consistently used throughout the text. It would help to use the abbreviation after it's introduced to avoid repeating the full term, e.g. line 342.

Method section

The overall structure and technical content are strong, but enhancing transitions will improve readability.

While you define many variables, key terms could be better explained to ensure the reader fully understands. For example, explaining "net evaporation rate" in more detail would help if a reader is not familiar with the exact context. Similarly, more context around κ and why it's used differently from its traditional sense could be provided upfront to avoid confusion.

Some terms such as "anti-estuarine circulation," "driver flux," and "marginal basin" are used without sufficient context for non-expert readers.

After describing each configuration (A1, A2, and B), it might be helpful to summarize their key differences in a table. This would help the reader quickly differentiate between them.

What is the temporal resolution of your model, and how does it influence the results, particularly regarding the timing of halite and gypsum precipitation?

Results section

This section is a well-structured and detailed examination of the different box model configurations, demonstrating the complexities of salinity dynamics in semi-enclosed basins like the Mediterranean. The authors have done a commendable job breaking down the influences of key parameters, such as net evaporation (e) and strait restriction (q), and their effects on the system's salinity gradients and mineral precipitation.

The use of the strait restriction parameter (q) and its bulky unit $[(m^3/s)/(kg/m^3)]$ is well justified, but simplifying its interpretation would help make the section more accessible.

The model uses generic assumptions about river water composition to assess gypsum precipitation in the extra box. How significant are variations in river chemistry (e.g., calcium and sulfate concentrations) for altering the results, and were sensitivity tests performed with different river compositions?

The section compares the model results with the Mediterranean and Red Seas, I think that the appearance of the part about the Black Sea is very abrupt, and there is very little information about the Black Sea in the paper.

Discussion section

The discussion is rich in technical detail but sometimes lacks a clear "so what?" moment that emphasizes why these results are significant in the context of the Messinian Salinity Crisis or other studies on evaporite formation.

While the model's limitations are well discussed, it would be helpful to suggest what future studies could address based on these results. How could the model be improved? What future work is needed to fill the gaps identified in your study?

Conclusion section

The conclusion, while summarizing the key findings, could be strengthened by tying the results more explicitly to potential future research directions or practical implications. It currently ends somewhat abruptly and could benefit from a more definitive closing statement on the significance of the study.

For example, what does this timeline and model tell us about the general understanding of evaporite formation in restricted basins? How might these findings inform future models or field studies in similar settings?

A few grammatical errors and missing punctuation marks

There are a few grammatical errors and missing punctuation.

Legend of figures in bold?

Ensure that table legends appear at the top of the tables. This would align the manuscript with common publication standards.

A few suggestions:

Line 6 "Saltgiants" => "Salt giants" ?

Line 9: "could be not yet been confirmed" => "could not yet be confirmed".

Line 32: "reaches up to three km" => "reaches up to three kilometers".

Line 40: "unambiguous, since we, for example, cannot follow" should be "unambiguous since, for example, we cannot follow".

Line 48: "re-opened" => "reopened".

Line 80: "overturing" => "overturning".

Line 334: "The models presented here not a representation of the complexity..." => "The models presented here are not a representation..."

Line 340: a space between "per" and "1°C" (per 1°C)

Line 427: mayorly?