

## Review #1

Process-Level Diagnostics of Marine Stratocumulus in TaiESM1:  
Insights into Parameterization Successes and Deficiencies  
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The manuscript aims to investigate how physical processes governing Stratocumulus clouds are represented in the TaiESM model. To achieve this, the authors compare various model configurations, including climate simulations, hindcasts, and a single-column configuration, with satellite observations and data from the DYCOMS field campaign.

The study identifies turbulent moisture transport, the cloud macrophysical scheme, and cloud liquid diffusion as key contributors to cloud formation in the model. It also highlights an apparent issue with excessive diffusion of cloud liquid into the subcloud layer.

Evaluating cloud processes in models requires the use of appropriate diagnostic tools that enable physically-based analysis of cloud formation and associated biases. In this regard, the use of hindcasts and single-column models (SCMs) is well established and has been shown to be highly effective. Additionally, analyzing model tendencies is particularly valuable, as it can yield insights directly relevant to model development.

However, in its current form, the manuscript does not convincingly demonstrate either clear strengths or deficiencies of the model. The process-level analysis remains relatively superficial, and the study falls short of establishing causal relationships between parameterized processes and the simulated cloud behavior. As a result, the conclusions remain largely descriptive.

To strengthen the study, I recommend that the authors perform targeted sensitivity experiments aimed at isolating and quantifying the impact of key processes controlling boundary-layer clouds. Such analyses would help establish causality and significantly enhance the scientific contribution of the work. This would also be interesting for future model development.

Overall, I recommend that the manuscript be rejected in its current form. However, I encourage the authors to consider resubmission after conducting a more in-depth, process-oriented analysis that leads to clearer causal conclusions.

## Specific Comments

- Line 86 and Figure 1: While TaiESM appears to represent low clouds reasonably well in subsiding regimes, it exhibits some of the largest biases in the stratocumulus-to-cumulus transition regions (in the South Pacific) and near coastal areas in the northeastern region. This raises questions about the choice of the DYCOMS region as the primary case study for stratocumulus processes. In the manuscript, DYCOMS is mainly used as a reference for liquid water content and vertical structure, information that could also be obtained from other field campaigns. Moreover, the inclusion of LES results does not appear to add substantial value in the current analysis.

- Line 168: Please clarify whether this refers to the native GCM radiation scheme.
- Lines 269–284: It would be useful to examine the origin of the winds and assess whether there is wind shear at the top of the boundary layer, as this could influence cloud structure and differences between days.
- Line 341: This appears to be the only sensitivity experiment in this study. While it indeed illustrates the delicate balance between turbulence and macrophysics, this is already well known in stratocumulus parameterization. The study would benefit from going further to explain how this balance specifically manifests in the TaiESM model.
- Figure 5: Although the explanation of the model behavior is informative, its relevance to the analysis of hindcast simulations is unclear. This section would benefit from clearer motivation and linkage to the study objectives.
- Figure 6: It is unclear whether it is well established that LES models struggle to reproduce the RF01 DYCOMS case. Do the authors know if this is indeed the case?
- Figure 6: The apparent improvement in the 5-day hindcast compared to earlier days is not explained. Is this random behaviour? Further discussion is needed to clarify this behavior.
- Lines 624–626: The study by Lee et al. (2022) is cited but not used. However it may be relevant as it suggests that vertical resolution plays a key role in representing stratocumulus clouds, which could also be important in the present model, particularly given the inversion structures shown in Figures 7 and 8.