Review of “Assessing Cloud Representation in Two Microphysics Schemes of MPAS-Atmosphere Model (version 8.2.2) over the Maritime Continent with Himawari-9 AHI Observations”
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Recommendation:
Major revisions:

General comments:

This manuscript evaluates cloud characteristics simulated by MPAS with two cloud microphysics schemes using observations from the Himawari-9 Advanced Himawari Imager (AHI). The two schemes examined are the single-moment bulk microphysics scheme WSM6 and the two-moment NSSL scheme. The authors performed a set of twelve 48-hour simulations with different initialization dates over the Maritime Continent, centered near Singapore. The satellite radiative transfer model RTTOV was applied to the MPAS output to simulate brightness temperatures, which were then compared with Himawari-9 AHI observations in ten spectral channels of infrared radiation. Based on these comparisons, the authors attempt to identify and characterize the differences between the two microphysics schemes.

The methodology adopted in this study using satellite simulators has become relatively common in recent years. The distinctive aspect of this paper is the comprehensive use of all ten AHI infrared channels. Since the different channels are sensitive to different cloud microphysical and macrophysical properties, they provide valuable information for evaluating model performance.

The authors tried to describe various aspects of the difference between the results from the two schemes. The manuscript presents results from many channels and discusses specific aspects of cloud characteristics. However, it is difficult to understand the characteristics of the two schemes in terms of the physical space. Cross sections of cloud microphysics are not so informative, because their generality is unclear. The reviewer suggests some alternative analysis below to show more robustness of the differences. If the manuscript is substantially revised to improve the clarity and consistency of the analysis, I believe it could be suitable for publication in *Geoscientific Model Development (GMD)*.

First, the reviewer requests a comparison of the horizontal distributions of brightness temperatures in selected AHI channels between the observations and the two model simulations. Instead, the authors attempt to draw general conclusions primarily from a few sample cross sections (e.g., Fig. 2). Horizontal maps would more clearly illustrate the differences in cloud coverage and spatial cloud structures between the observations and the two microphysics schemes.

Second, the reviewer suggests that the authors should compare physical variables between the observations and the models. The cloud characteristics of the models are generally evaluated by daily mean horizontal distributions of outgoing longwave radiation (OLR) and outgoing shortwave radiation (OSR) by comparing the CERES observations. For the cloud distribution, the ISCCP diagram analysis is the standard method of model evaluation. How these physical-space analyses can be used to interpret the AHI-based analysis presented in this study is an interesting question. In addition, the domain-averaged vertical distributions of cloud hydrometeors (Fig. 8) help illustrate differences among the models. However, it is not clear how these differences in the vertical cloud profiles are consistent with the results shown in Figs. 5 and 6. Please clarify the relationship between these diagnostics.

Third, the simulated cloud microphysical characteristics are generally affected by model spin-up during the initial stage of the simulations. In general, the first 12 hours of the simulations should be excluded from the analysis. The authors should examine the temporal evolution of the cloud microphysical characteristics to ensure that the results are not significantly influenced by the spin-up process.

In addition, the choice of the cross-sections S0-2 for the analysis of the topographic clouds is unclear. Generally, the clouds are characterized in the normal direction to the Sumatora island. Please refer to Yokoi et al. (2017) and Okugawa et al. (2023).

The most pronounced differences in brightness temperature between the two schemes appear to be associated with thin, high-level clouds. Such clouds are highly sensitive to the parameterization of cloud microphysical processes, and even small changes in model parameters can produce substantial changes in the simulated brightness temperatures. For example, the fall speed of cloud ice has often been adjusted to improve the simulated outgoing longwave radiation (OLR). However, the recently launched EarthCARE satellite now provides direct observations of cloud-ice fall speeds, offering a more physically based constraint for evaluating and improving cloud microphysics parameterizations. Therefore, the differences presented here may primarily reflect the sensitivity of high thin clouds to parameter tuning rather than fundamental differences between the two microphysics schemes.

References:

Okugawa, R., K. Yasunaga, A. Hamada, and S. Yokoi, 2024: Numerical Study on the

Precipitation Concentration over the Western Coast of Sumatra Island. Mon. Wea. Rev., 152, 689–704, https://doi.org/10.1175/MWR-D-23-0037.1.

Yokoi, S., S. Mori, M. Katsumata, B. Geng, K. Yasunaga, F. Syamsudin, Nurhayati, and K. Yoneyama, 2017: Diurnal Cycle of Precipitation Observed in the Western Coastal Area of Sumatra Island: Offshore Preconditioning by Gravity Waves. *Mon. Wea. Rev.*, **145**, 3745–3761, https://doi.org/10.1175/MWR-D-16-0468.1.

Specific comments:

p. 8, Table 2, Channel 12: AHI cannot directly observe dynamic properties of the atmosphere. Potential vorticity is related to the Ozone distribution, but it is not adequate to be listed here.

L257-258: It is questionable whether fog is actually observed in this region. Is there any observational evidence?

L270-273: It is hard to draw the conclusion from the cross section shown by Fig. 3. The reviewer suggests showing the horizontal distribution.

L281-283, "It is also noteworthy that the observed cloud-top heights are lower than those simulated by both schemes. Such discrepancies likely stem from excessive condensate lofting through enhanced updrafts": Higher cloud top is generally associated with too strong intensity (vertical draft or precipitation) of convection. If excessive condensation is due to strong precipitation, this interpretation is incorrect.

L371-372: By comparing Fig. 5c with Fig 5f,i, we do not think WSM6 is particularly underpredicted. Both WSM6 and NSSL shows underpredecition of frequencies than the observation.

L383: What is the definition of cloud-top here in the observation? Is ECMWF IFS data used for the observational analysis?

L391-400: It is difficult to understand the description here. Are the biases of too-high CTP due to high thin clouds being overestimated in the simulations? The difference in the PDF of BT of Channel 13 is shown in Fig. 2. Both models show too much warmer BT frequency. However, Fig. 6 shows most CTP are near 100-200 hPa. The question is what the cloud structure representing BT > 280 K?

L414: “5g” should be “5h”.

L418, “multilayered ice clouds”: What is the definition of multilayered clouds?

L422-429: The reviewer does not find the analysis presented in Fig. 7 to be particularly informative. It is difficult to identify the differences between the two microphysics schemes. The effects of model spin-up in the first half a day would have also affected the results. The authors should reconsider their approach and adopt a more robust method for illustrating the differences in the simulated diurnal variations and their biases relative to the observations.

As a first step, the reviewer recommends analyzing the two most fundamental characteristics of the diurnal cycle: its phase and amplitude in BR of Channel 13. A comparison of these quantities between the observations and the simulations would provide a clearer and more quantitative assessment of model performance.

p. 22-24, Figure 8: This figure clearly demonstrates the differences in the cloud microphysical characteristics simulated by the two schemes. In particular, thin, high-level clouds are much more abundant in the NSSL scheme than in WSM6. How do these differences in high thin cloud coverage affect the results shown in Figs. 5 and 7?

The authors attempt to explain the underlying mechanism based on these results (pp. 23–24). However, the analysis presented is primarily diagnostic of relationships. It does not establish the physical mechanisms or causes responsible for the biases in the simulated diurnal variability. The authors should reconsider this section, ensuring that the conclusions are better supported by the results presented.

p. 27, Figure 10: What is the meaning of “Mean cross-section”? Is it the same as the domain average?

p. 25, Figures 10 and 11: It is difficult to gain insight into the general characteristics of convection over the topography from these figures. In particular, it is unclear what additional information Fig. 10, which is shown along the line S1 parallel to the mountain range, provides.

Instead, the authors are encouraged to analyze a cross section taken normal to the Sumatra mountain range (normal to S1). This would provide a much clearer representation of the general convective structure and its relationship to the topography.