The manuscript is well written and provides sufficient detail regarding the changes the authors made to the Tiedtke scheme in TGFS v1.1, as well as the experimental design used to demonstrate the positive effects of these changes. Most of the modifications to the Tiedtke scheme are derived from other schemes. From a dynamical perspective, these modifications are not entirely independent in their effects on controlling precipitation strength associated with unresolved convection.

The authors thank Referee #3 for the supportive assessment and constructive feedback. Our point-by-point responses are provided below and marked in blue text.

For readers like me, it is important that the manuscript include discussions that clarify which changes are most effective at alleviating precipitation forecast biases. I recommend that the authors revise the manuscript to expand Figure 3 by incorporating results from all experiments summarized in Table 2 for the afternoon thunderstorm case, as in Figure 6 for the southwesterly flow case.

We thank the reviewer for the valuable suggestion. The expanded version of Fig. 3 is shown here in Fig. R3, which incorporates results from all experiments in Table 2 (and additionally the "RSP" experiment discussed later) for the afternoon thunderstorm case. Unlike the southwesterly flow case discussed in Section 5.2, the differences among these new experiments are relatively smaller. Except for CRH and RSP, the results from adj_SCA, CUP, and TOP are not very different from the SCA experiment; CRH leads to a smaller peak amount of rainfall, which is more close to the observation, and shifts the rainfall location slightly southwestward, but the overall rainfall pattern does not show an improvement; RSP will be discussed later.

We think that the modifications beyond SCA are likely more effective under conditions with strong synoptic forcing, such as in the southwesterly flow case that exhibits a strong interaction between the convective systems and the prevailing environmental flow. We also note that, as we explained in the manuscript, the primary motivation for the series of modifications beyond SCA is the recurrent overprediction of rainfall during the summertime, for which southwesterly flow heavy rainfall events are more representative. Therefore, considering the course of the development in this study and the insensitivity of these modifications in the afternoon thunderstorm case, we would like to retain the original structure of the manuscript, restricting the afternoon thunderstorm case (Section 5.1) to the ORI and SCA experiments only, and reserving all the discussion of the subsequent modifications for the southwesterly flow cases (Section 5.2) and the two-month evaluation (Section 5.3).

We will add a short paragraph in the revised manuscript to briefly describe the additional experiments with the afternoon thunderstorm case and the smaller sensitivity of these modifications in this case.

For related discussion with the southwesterly flow case, especially for the discussion associated with the newly added RSP experiment, please see our response to your next point below.

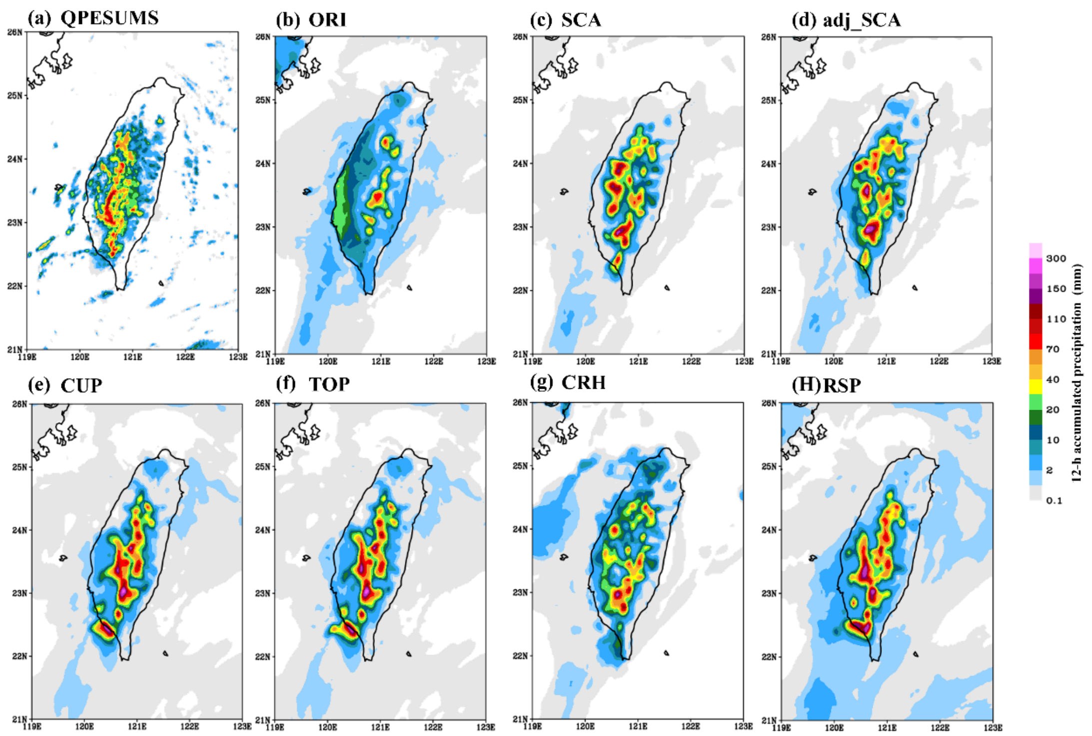

Figure R3: 12-h accumulated precipitation (mm) from 00 to 12 UTC on 26 August 2023 in (a) QPESUMS observation and TGFS nested-domain forecasts from the (b) ORI, (c)SCA, (d) adj_SCA, (e) CUP, (f) TOP, (g) CRH, and (h) RSP experiments initialized at 00 UTC on 26 August 2023.

Given the partition of resolved and unresolved air motion within the TGFS numerics, the modified Tiedtke scheme—due to its suitability for gray-zone resolutions—should represent the unresolved convective mass flux relative to the resolved counterpart in a manner that diminishes as grid size decreases. Therefore, I also recommend that the revised manuscript include a discussion, supported by numerical evidence if necessary, addressing whether the overestimate of precipitation shown in Figure 4 for the SCA experiment can be alleviated solely by reducing the mass flux scaling factor. This discussion is essential to help readers determine whether the other changes, aside from the mass flux scaling, are equally important in making the modified Tiedtke scheme scale-aware.

We thank the reviewer for providing valuable feedback. To address the question whether the overestimated precipitation in SCA can be alleviated solely by decreasing the scaling parameter σ_1, we conducted a sensitivity experiment denoted as RSP (reduced scale-aware parameter) for both the afternoon thunderstorm case (Fig. R3h) and the southwesterly flow case (Fig. R5g). The RSP experiment was based on adj-SCA, but we changed the constant $\Delta 1$ in the equations for the scale-aware parameter σ_1 [Equation (2) in Kwon and Hong 2017] from 5000 m to 4000 m, which effectively reduced σ_1 from 0.55 to 0.28 at the grid size in the TGFS nested simulation, 4.8 km (Fig. R4). We selected adj-SCA rather than SCA as the base experiment because, as discussed in Section 3.1, it is more reasonable to apply the scaling factor before checking CFL criterion to avoid a double reduction of convective mass flux.

As shown in Fig. R3 and Fig. R5, by reducing the value of σ_1 by almost half at a 4.8-km grid size, RSP exhibits distinct rainfall behaviors from adj-SCA in both cases. However, the overestimates of heavy precipitation (> 200 mm/12 h) are not much mitigated. Regarding the rainfall locations, the rainfall pattern in the afternoon thunderstorm case is not improved; the location of the rain band along the southwestern coastal area is not changed and thus the onshore bias of the rain band is not corrected. On the other hand, the widespread light precipitation (< 10 mm/12 h) is significantly increased in both cases, which becomes a notable issue in RSP and contributes to degrading the precipitation forecast skill.

These results support that the various modifications in this study, including the constrains on convection, the revised cloud top criterion, and the increased dependency on RH, are not entirely critical in the afternoon thunderstorm case but are necessary in other summertime rainfall cases especially for those with strong southwesterly flow, as they not only reduce overestimated precipitation but also inhibit unrealistic convective initiation, improve spatial distribution, and achieve a more reasonable convective structure. Merely lowering the mass flux scaling parameter σ_1 without implementing the other physical constraints is insufficient to solve the problem but leads to larger overall precipitation biases especially for the light precipitation.

We will include the RSP experiment for the southwesterly flow case in the revised manuscript (Section 4; Table 2; Figure 6), and will add the above discussion in a new paragraph in Section 5.2 and also in the conclusion section to clarify the limitation of the pure adj-SCA approach and better demonstrate the respective importance of the different modifications to the Tiedtke scheme.

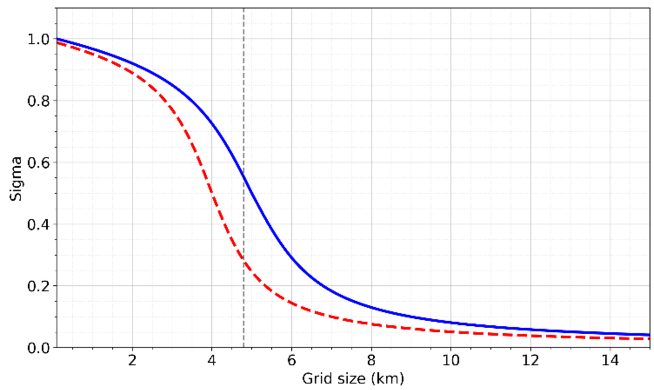

Figure R4: Variation of the scale-aware parameter σ_1 with model grid size. The blue solid line represents the parameter based on Kwon and Hong (2017), which is used in this study. The red dashed line denotes the decreased parameter applied in the RSP experiment. The vertical black dashed line indicates the 4.8 km grid size.

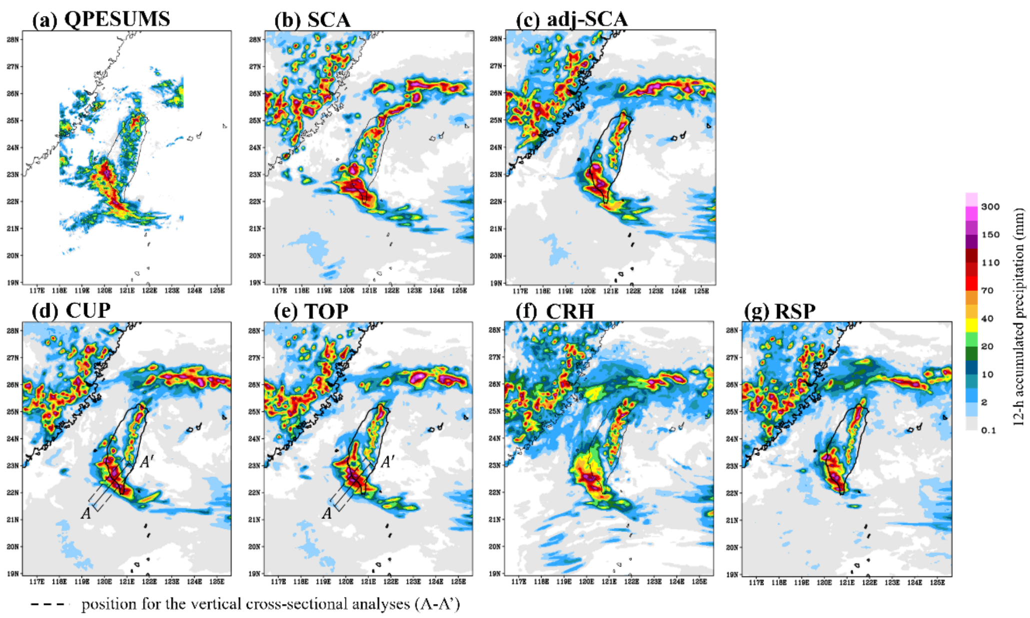

Figure R5: (a) 12-h accumulated precipitation (mm) from 00 to 12 UTC on 10 August 2023 based on QPESUMS observation. The 48–60-h accumulated precipitation forecasts valid at the same period from the (b) SCA, (c) adj-SCA, (d) CUP, (e) TOP, (f) CRH, and (g) RSP experiments.