Review of Lake-Mountain synergy in convective clouds and precipitation over the Tibetan Plateau: a large-eddy simulation study

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General Comments

Motivated by a better understanding of convection and precipitation associated with lake-mountain environments in the Tibetan Plateau, this manuscript presents results from CM1 idealized large-eddy simulations of convection. The simulations vary the height of terrain and the presence of a lake located upstream of the terrain. There are a few key findings from this work, including that a lake provides the moisture source required to initiate convection and that the height of terrain downstream of the lake impacts the intensity and distribution of precipitation. This manuscript fits within the scope of Atmospheric Chemistry and Physics and would be suitable for publication after some modifications are made.

Major Comments

1. **Characterization of the Tibetan Plateau geomorphology**

   Much of the introduction focuses on important processes such as convection, cloud microphysics, lake breezes, and surface heterogeneity, which provides helpful background for the manuscript. However, the introduction lacks a discussion of the characteristics of the Tibetan Plateau itself. The authors should share some information about typical terrain elevations, typical lake sizes, the number of lakes, the fraction of the year during which the lake is frozen, general meteorological characteristics, etc. The map in Fig. 1a can aid with this discussion.

2. **Hydrometeor mass growth and loss (Figure 9)**

   The authors should reexamine their calculation of Q_{growth} and Q_{loss} in Fig. 9. In the figure, it appears that these variables have the same magnitude, and $Q_{\text{loss}}$is simply $Q_{\text{growth}} \times -1$, which would make one of the subfigures redundant. Thinking about this physically, it is implausible for Q_{growth} and Q_{loss} to peak at the exact same time (as referenced in L440-442) when calculated over the same domain. It is most likely that the authors have either calculated Q_{growth} or Q_{loss} incorrectly. Following Eq. (6), Eq. (7), and Gowan et al. (2021), Q_{growth} and Q_{loss} should be calculated by integrating all instances in which q_{ten} is positive and negative, respectively. In the current manuscript, it appears that the authors may have calculated $q_{ten_{pos}}$ and simply multiplied that by -1 to find $q_{ten_{neg}}$.

3. **Flow in Figure 10b.**

   In Fig. 10b, it appears that the zonal wind goes from the right side of the domain to the left. Is that correct? It is possible that the authors' use of the perturbation wind contributes

to this. If so, what is the justification for the use of the perturbation wind? It seems to mislead a reader who would examine the figure without much other context.

4. **Moist Froude number (section 2.4.3 and Figure 11)**

The authors should think more carefully about their use of the moist Froude number. First, in section 2.4.3, the authors provide a thorough derivation of the N_m and justify some modification of the standard Durran and Klemp (1983) equation due to the presence of mixed-phase clouds over the Tibetan Plateu. Could the authors consider placing this derivation in an appendix to not disrupt the flow of the manuscript? Figure 11 shows cross sections of time- and y-averaged FR_m. Typically, though, the Froude number is calculated at a site upstream of the mountain range and uses a layer depth for the calculation of N_m and U. It is unclear how showing FR_m at 1 km and 4 km, for instance, gives insights into blocked or flow over regimes. Additionally, there is no utility to showing FR_m at a site on or downstream of the mountain range, which the current figure does. The authors should consider calculating N_m and U over a layer depth at a site upstream of the mountain and presenting values in a table for each sensitivity study, rather than using cross sections to display FR_m.

5. **Interpretation of trajectories**

There are dramatic differences in the trajectories in the different sensitivity studies, but the current discussion lacks a thorough comparison between them. The authors should discuss the lack of air parcel movement in the LM_750, OL, and OM trajectories and explain the lack of water vapor depletion in those, despite moderate precipitation amounts (especially in OM; Fig. S2).

6. **Supplemental material**

While Fig. S1 could reasonably be placed in a supplement, the other supplemental figures should be included in the main text, as they are referred to in the text and help tell the manuscript's story. Fig. S2, which shows the precipitation distribution, is quite important and would be better placed in the main text. Additionally, that figure's caption has text "(c) Difference in time-mean precipitation rate (mm h^{-1}) between LM_3000 and LM_1500. (e), (g), (i) As in (c), but showing the differences for LML, OL, and OM relative to ML", which does not describe anything in the figure and should be removed. Additionally, for Fig. S2, the authors should discuss the precipitation patterns and why they appear. For instance, why are there local maxima in precipitation in the lee of the mountain peak in LM_1500 and OM? And on Fig. S2, the authors should label the y-axis and include an outline of the bell-shaped mountain, rather than the dashed line showing where its summit is.

In Fig. S3, does the NLM simulation really produce no precipitation at all? If so, this could be an interesting finding suggesting that this environment *requires* a lake and/or mountain to generate precipitation. It appears that the caption for Fig. S3 does not line up

with the subfigures at all. The authors should reread the caption and make adjustments to align with the subfigure letters.

In Fig. S4, the caption refers to a left column, but the figure only includes a right column.

7. **Conclusions**

From the literature review, it appears that there has not been much research on the lake-mountain meteorology of the Tibetan Plateau, so the authors are making a useful, novel contribution to atmospheric science by studying it. The conclusion summarizes the findings well, but the authors should highlight how this work is new and how it could contribute to our understanding in other regions.

8. **Grammar**

There are several grammatical errors throughout the manuscript which impact its readability. The authors should carefully examine the manuscript for grammatical errors. Some examples:

L63: "… can profound influences…" should say "can have profound influences"

L275: "b" should say "by"

L320: "precipitation appears as a narrow in the leeward". A noun is required after "narrow".

L390: "shallower and hydrometeor … is reduced" should say "hydrometeor mixing ratio is reduced".

L479-480: "… hydrometeor of condensate growth and transport …" should say "condensate growth and hydrometeor transport"

L502-503: "the moisture supply leads to lower N_m. And further strengthen the FR_m." These two sentences should be combined.

L558-559: This sentence is repeated.

Figure 11 caption: "most" should say "moist".

Minor Comments

- **L155 and Table 1:** In Table 1 the authors present 6 experiments that they conducted. However, the results from one such experiment (NLM) are never presented in the manuscript (aside from in the supplement). The authors should either modify the manuscript to present results from NLM or remove the mention of that experiment from

Table 1. Additionally, in L173, the authors first mention that the control experiment is LM-1500. It would be helpful if this were highlighted in Table 1 as well.

- **L189:** How does this RKW-type wind profile compare with the Naqu Station radiosonde observations? Some justification of the RKW-type wind profile should be provided. Additionally, the authors should include the wind barbs for the profile in Fig. 3.
- **L270-275:** This section is used to derive the moist Froude number and N_m. The equations, however, do not clearly flow in the text. To improve readability, the authors should modify this section so that Eq. 16 and 17 are part of sentences and clearly flow in the text.
- **L293-294:** "However, introducing the lake … onset of convection." This sentence feels out of place. The authors had just discussed LM_2000 in L292 and then transition to LM_1500, so there is no introduction of the lake.
- **L356-358:** Is this sentence correct? Looking at Figs. 6 (b), (d), and (f), it appears that as the mountain height increases, CAPE over the lake decreases. CIN does decrease, though, but rather than "weakens", "decreases" would be better language to describe this.
- **L384 and L395:** Fig. 7f is mentioned here but there is no Fig. 7f.
- **L421:** Should the figure reference say "Fig. 8e" since the text is referring to the mountain?
- **L564:** The "reduced condensate production" is being compared to what? Other mountainous regions?
- **Figure 4:** What does the grey vertical dashed line represent in Fig. 4? The caption should clarify this.
- **Figure 5 caption:** The caption in Fig. 5 references subfigures (f), (h), (g), and (i), but those subfigures are not included in the figure.
- **Figure 8:** The font size of the y-axis labels on Fig. 8a should be increased. The first sentence in the caption is incomplete.
- **Figure 12:** At some point in the manuscript, the authors should state how many trajectories are plotted, at what time in the simulation they are released, and for how long they are run.