

Reviewer#2

Summary: The authors present a multi-faceted study of MCSs and their associated hazards across the AMR. The authors use various datasets, both satellite and land based, to examine the frequency of MCSs, the hazard production of MCSs, and trends in MCSs across the region. I generally find the manuscript well written and adding some interesting information to the body of literature of MCSs in the region. However, I do have a few comments about the analysis and the use of land-based observations. While these I do not think rise to the level of major revisions, they are close. I defer to the editor in making this decision. I am happy to read the paper again.

We thank the reviewer for the insightful and constructive comments. We have carefully considered all points raised and provide our detailed responses below. For clarity, our responses are highlighted in blue.

Recommendation: Minor Revisions

Minor Comments (Comments are not listed in order of importance):

1. First, I would like to apologize to the authors on the lateness of this review. Between conferences and classes, it slipped through the cracks. My apologies.

We thank the reviewer for the time and effort devoted to reviewing our manuscript and for the helpful comments provided.

2. Section 1: There need to be some spaces between certain words and the parenthetical citations that follow.

Thank you for pointing this out. We will check and correct this formatting issue throughout the revised manuscript.

3. Section 1: Please state your hypotheses for this manuscript. This is critical to the scientific processes and will greatly improve the motivation for the scientific analysis that follows.

Thank you for this valuable suggestion. We agree that clearly stating the scientific hypotheses of this study would help strengthen the motivation and logical framework of the manuscript. We will therefore add a clear statement of these hypotheses in Section 1 of the revised manuscript.

Specifically, this study is guided by two main hypotheses. First, MCS activity is closely related to the occurrence of hazardous weather in the study region, particularly strong winds and heavy precipitation, and this relationship exhibits clear spatiotemporal characteristics. Second, under a warming climate, the long-term changes in MCS activity in the study region and in its relationship with hazardous weather

deserve further attention, yet a clear quantitative understanding of these changes remains lacking. Based on these considerations, this study uses long-term observational data to quantitatively examine both the association between MCS activity and hazardous weather and the long-term changes in MCS activity and in its relationship with hazardous weather in the study region.

4. Lines 115: A think a bit more clarification on the heavy precipitation threshold here is needed. Is the 20 mm/hr a rate or an accumulation threshold? The prior means this could be achieved in a sub-hourly timeframe, where 20m mm of rainfall did not actually fall in an hour (i.e., 5 mm fell in 15-minutes). If it is an accumulation, meaning 20 mm rainfall actually fell in an hour, please indicate. This also needs to be discussed for the HRE criteria.

Thank you for this valuable comment. The precipitation data used in this study are half-hourly snapshot estimates. According to the documentation of the V07 data product, “The term ‘snapshot’ for half-hourly estimates reflects the fact that individual satellite overpasses are the basis for these data, and that the resulting satellite estimates are not ‘instantaneous’, but represent an interval that can exceed an hour.” Therefore, this variable should not be strictly interpreted as an instantaneous rain rate, but rather as an indicator of the intensity of precipitation sustained over a certain time interval, derived from precipitation estimates within that interval. In this study, heavy precipitation was identified using a threshold of 20 mm hr⁻¹, equivalent to 10 mm of accumulated precipitation in 30 minutes. For HRE identification, this variable was further used in the statistical analysis to estimate daily accumulated precipitation, and a day with daily accumulated precipitation exceeding 50 mm was classified as an HRE. We agree that this treatment should be described more clearly in the manuscript. In the revised version, we will clarify the interpretation of this variable, the rationale for using the 20 mm hr⁻¹ threshold, and the procedure used to identify HREs.

5. Throughout: The severe wind, hail, and tornado reports are likely quite biased by population. This is a known problem in severe weather hazards databases across the globe. I believe some more discussion (and caveats) about this needs to be included in terms of understanding the results. The attempt to look at this in terms of prefectures still likely is biased by population, as prefecture size is also dependent on local population.

Thank you for pointing this out. We agree that this issue does exist, particularly for hazard records such as hail and tornado events. We will add relevant discussion in the revised manuscript and explicitly

acknowledge this potential limitation. For example, the hail and tornado records used in this study are mainly derived from the Yearbook of Meteorological Disasters in China. Due to possible observational biases in sparsely populated areas, as well as the potential underreporting of weak-intensity events in the yearbook itself, the spatial distributions of hail and tornado events, as well as their statistical associations with MCSs, may be affected to some extent. In the revised manuscript, we will further emphasize this data bias and clarify that the related results represent statistical associations obtained under the current observational and reporting conditions, rather than a strict attribution of the mechanisms responsible for hazard occurrence.

6. Section 3.2: Was any attempt to examine the characteristics as a function of seasonality made? This seems to be a pretty important aspect of the analysis, given the seasonality of the monsoon circulation. This might also help with supporting the conclusion in lines 235-238.

Thank you for this comment. We agree that examining these characteristics from a seasonal perspective is important, particularly given the pronounced seasonality of the monsoon circulation. We conducted a preliminary analysis of their seasonal variations, although these results were not presented in detail in the original manuscript.

The seasonal variations in MCS characteristics (Fig. 1) show that, over the Tibetan Plateau, MCS_H and MCS_P are in relatively good agreement in the warm season. In contrast, although both MCS_H and MCS_D are high in the cold season, MCS_P remains very low, suggesting that the combination of low temperatures and high elevation in this region may contribute to an overidentification of MCSs. We will add the corresponding seasonal analysis to the Supplementary Material and provide additional discussion of seasonality in Lines 235–238 of the revised manuscript.

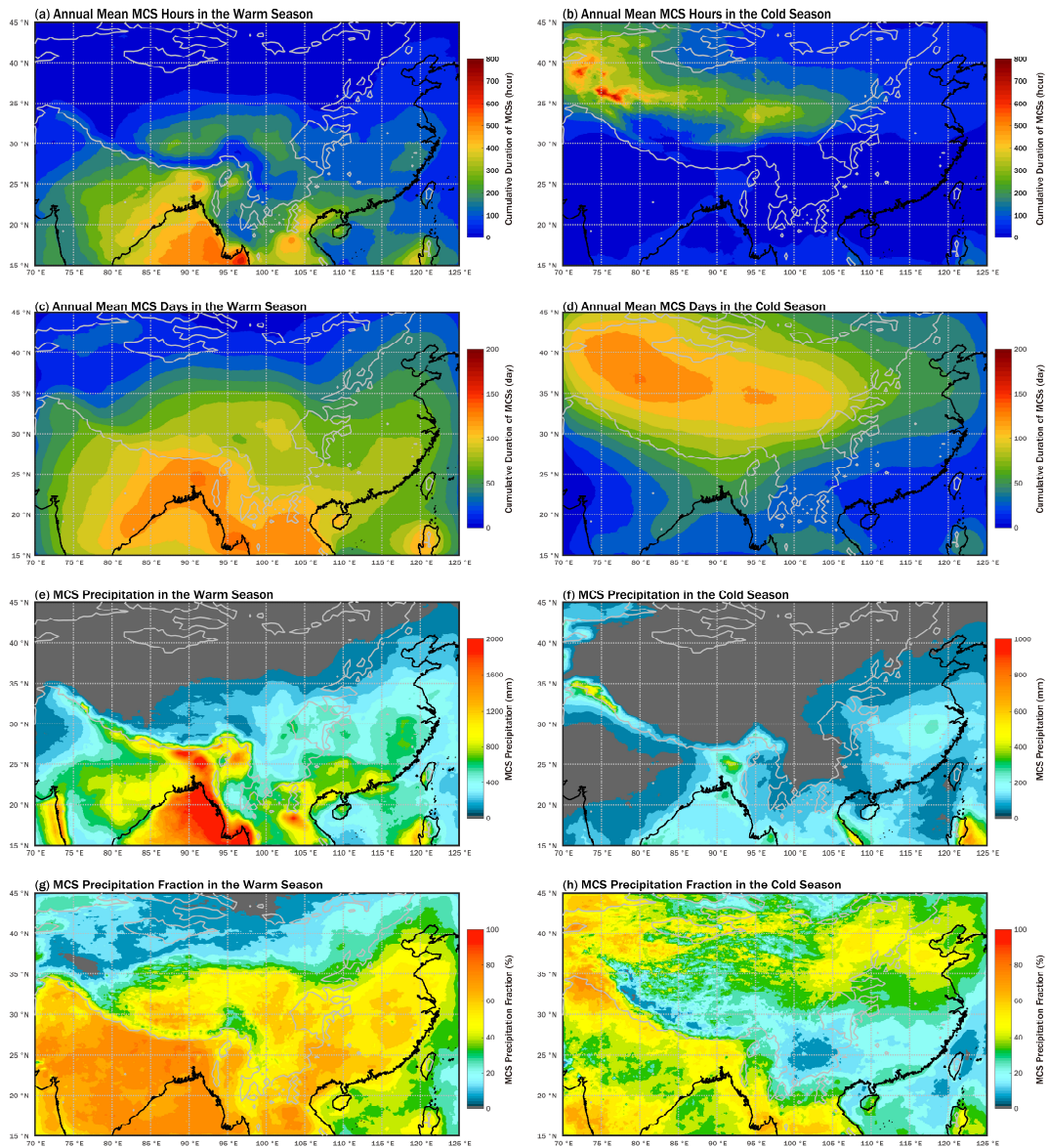


Figure 1: Annual mean spatial distributions of (a, b) MCSH, (c, d) MCSD, (e, f) MCSP, and (g, h) MCSPF, with warm-season results shown in the left column and cold-season results in the right column. The black solid line represents the coastline, and the gray solid line represents the 1000 m elevation contour. Color shading indicates: annual mean (a, b) cumulative MCS duration (hours), (c, d) number of MCS days (days), (e, f) cumulative MCS precipitation (mm), and (g, h) MCS precipitation fraction (%).

7. Section 3.3: Please make sure it is clear these results are over a certain region for a given time and should not necessary be generalized to other regions. They can be compared to similar analyses in other regions on the globe.

Thank you for this comment. We agree that these results are specific to the study region and period. We will clarify this point in the revised manuscript.

8. Line 322-327: I am not sure this is correct/can be justified based upon what is presented. We know that descending rear-inflow jets in MCS can cause severe wind. These clearly depend on rainfall

characteristics and background thermodynamics/moisture profiles.

Thank you for this comment. We agree that the mechanisms responsible for severe winds in MCSs are complex and involve both internal storm dynamics and environmental thermodynamic conditions. We also agree that the interpretation in Lines 322–327 may have been stated too strongly given the results presented. Our original intention was to highlight the spatial correspondence between SWE occurrence and regions with pronounced topographic transitions, rather than to attribute the mechanism directly to topographic effects. In the revised manuscript, we have revised the relevant sentences to make this interpretation more cautious and to clarify that topography may modulate SWE occurrence, but that the specific physical processes cannot be determined from the present analysis alone.

9. Section 3.3.3: Choosing a daily timescale for the tornado and hail events associated with MCSs does not seem valid. We know in convective scenarios that, within a diurnal cycle, we often see upscale growth from discrete isolated convection to MCSs. This analysis does not, to my understanding, account for the fact that these discrete cells could be producing the main hazards. This is even more true since it is aggregated on the prefecture level and is again compounded by the population bias in the hail/tornado data. This is probably my most major comment and almost warrants a major revisions decision. The only reason I am not, is I think this section can be removed from the manuscript and it still be publishable.

Thank you for this important comment. We agree that the reviewer has raised a more fundamental issue: given the temporal and spatial resolution of the available tornado and hail records, our analysis cannot distinguish whether the reported hazards occurred during the early stage of discrete convection or during the later stage after organization into an MCS, and therefore cannot support strict event-level attribution.

In response to this comment, we will revise the relevant statements in the manuscript to make clear that this analysis is intended to describe the statistical correspondence between MCS activity and tornado/hail records at the regional climatological scale, rather than to provide a strict hazard-attribution analysis. In addition, expressions such as “associated with MCSs” will be replaced with more neutral wording, such as “occur on MCSs,” and terms such as “trigger,” which may suggest direct causation, will be removed.

On the basis of these revisions, we would prefer to retain this section in the revised manuscript. This is because the currently available tornado and hail records in China are generally limited to daily

resolution and are typically reported at the prefectural level, and therefore do not support more precise event-level matching. Under this practical limitation, the analysis can still be used to characterize the statistical correspondence between MCS activity and these two types of hazard records at the daily and regional scales, thereby providing supplementary information for understanding their regional-scale relationship. To avoid misinterpretation, we will also further clarify its scope and limitations in the revised manuscript.

10. Figure 7: This figure is very channeling to see. The dots and the terrain overplotting blend together. Please find a way to make this clearer.

Thank you for this suggestion. We have revised Figure 7 to improve its readability. In addition, for consistency in presentation, we made corresponding adjustments to Figure 12. The updated figures are shown below and will replace the original figures in the revised manuscript.

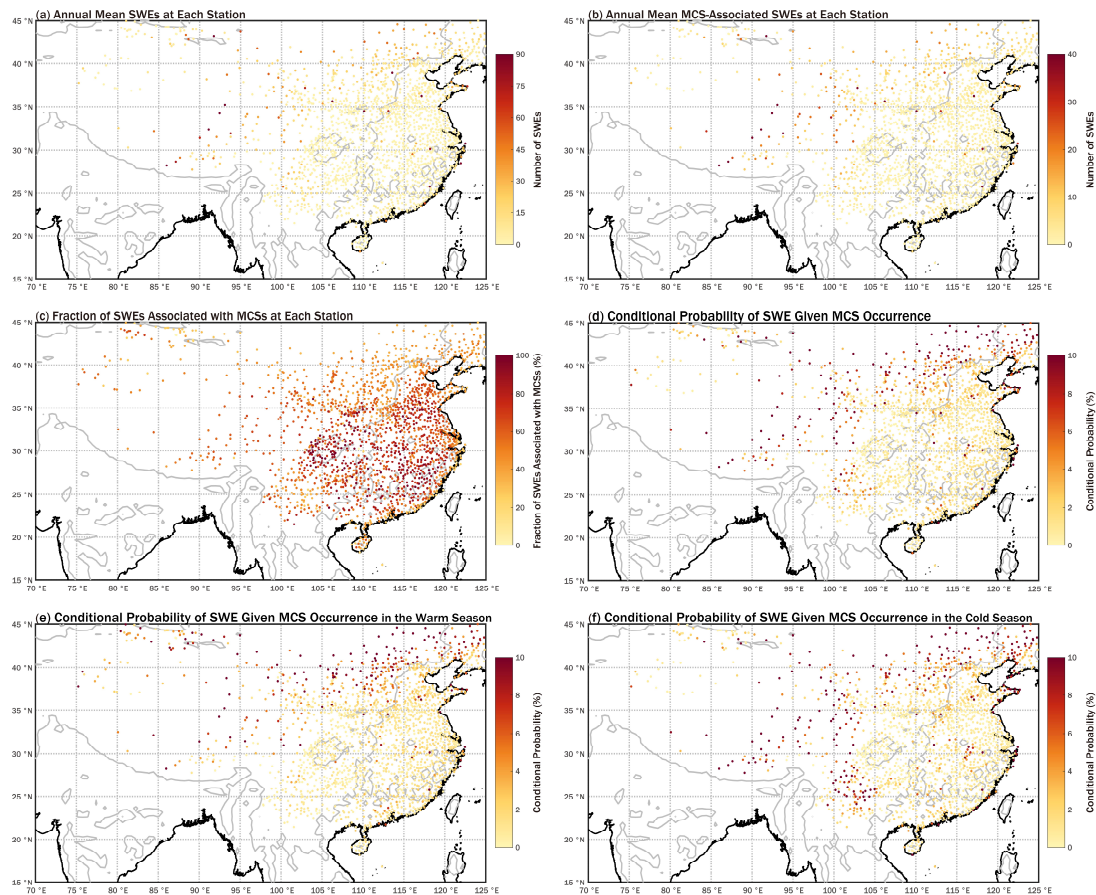


Figure 2 (Figure 7 in the manuscript): Annual mean spatial distributions of (a) SWEs, (b) MCS-SWEs, (c) MCS-SWE proportion, and $P(\text{SWE}|\text{MCS})$ for (d) the whole year, (e) the warm season, and (f) the cold season. The black solid line represents the coastline, and the gray solid line represents the 500 m elevation contour. The dots represent meteorological station locations. The color shading of dots indicates the annual mean number of events (days) for (a) and (b), the fraction of events associated with MCSs (%) for (c), and the conditional probability (%) for (d)-(f).

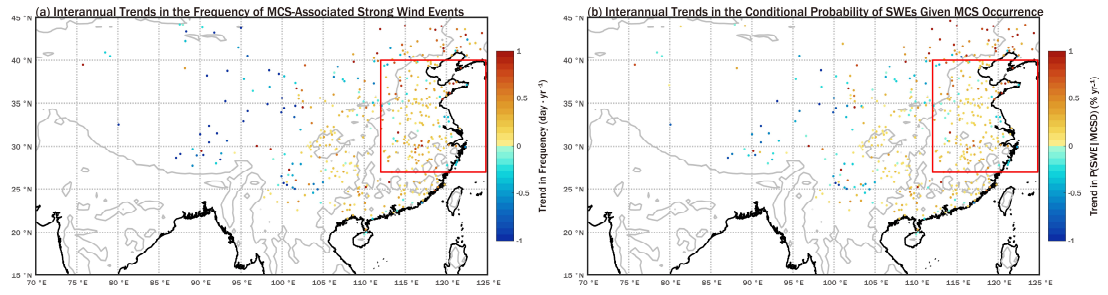


Figure 3(Figure 12 in the manuscript): Spatial distribution of interannual variation of (a) MCS-associated SWEs, (b) $P(SWE|MCS)$. The black solid line represents the coastline, and the gray solid line represents the 500 m elevation contour. The dots represent meteorological station locations. The color shading of dots in (a) denotes the annual trend of MCS-SWEs (unit: day · yr⁻¹). The color shading in (b) denotes the annual trend of $P(SWE|MCS)$ (unit: % yr⁻¹). Stations that do not pass the significance test are not shown in this figure. The red box indicates the range of ECAS in this study.