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Initiations of Mesoscale Convective Systems in the Middle Reaches of the Yangtze River Basin Based on FY-4A Satellite Data: Statistical Characteristics and Environmental Conditions

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Motivation

- Different synoptic circulations often lead to different environmental conditions, and the interactions of environmental conditions, topography, underlying surface and other factors are highly nonlinear, which makes it difficult to forecast the initiation and development of mesoscale convective systems (MCSs).
- Previous studies involving the MCS life cycle are still limited in terms of understanding its formation. At present, thanks to high spatial-temporal resolution satellite data, the development of an MCS from initiation to formation can be accurately captured through backward tracking.
- The middle reaches of the Yangtze River Basin (YRB) are located in the transitional zone between the second-step terrain (mountains) and the plains over East China, with complicated orography and various underlying surfaces. The Mei-yu fronts are very active in this area, and their precipitation and convection have unique characteristics and complicated mechanisms.
- In the present study, the MCSs over the middle reaches of the YRB are identified and tracked first, and then, the MCS initiation is detected through backward tracking. Next, the temporal-spatial distribution and features of the MCS initiation are investigated. Finally, the synoptic circulations in this region are objectively classified into different patterns to find the circulations and environmental conditions favorable for the initiation of an MCS.

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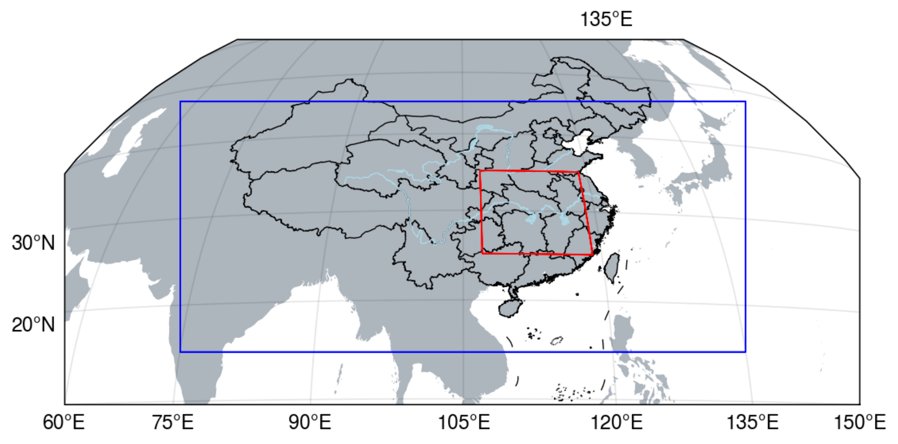
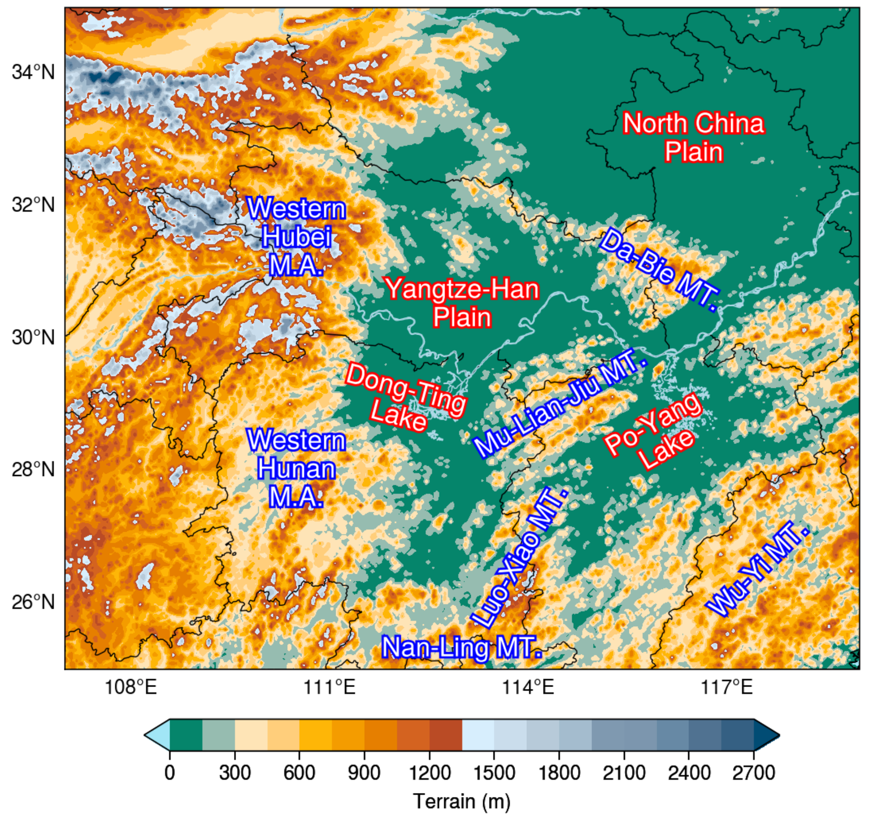
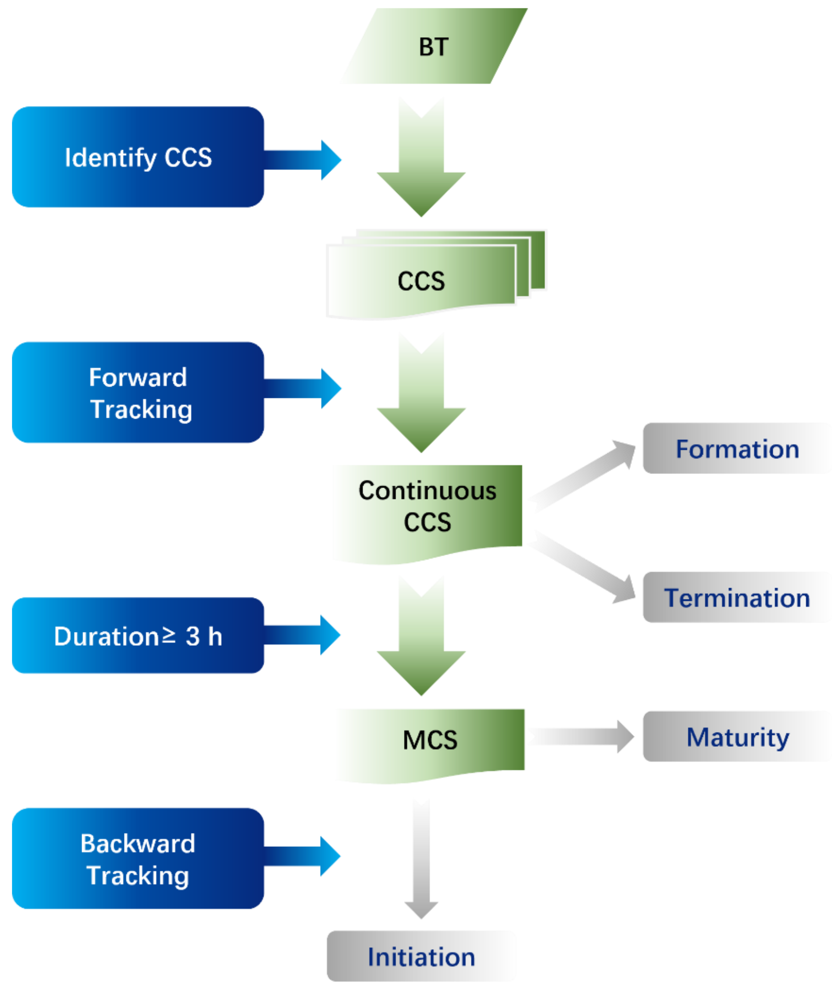
Data and methodology



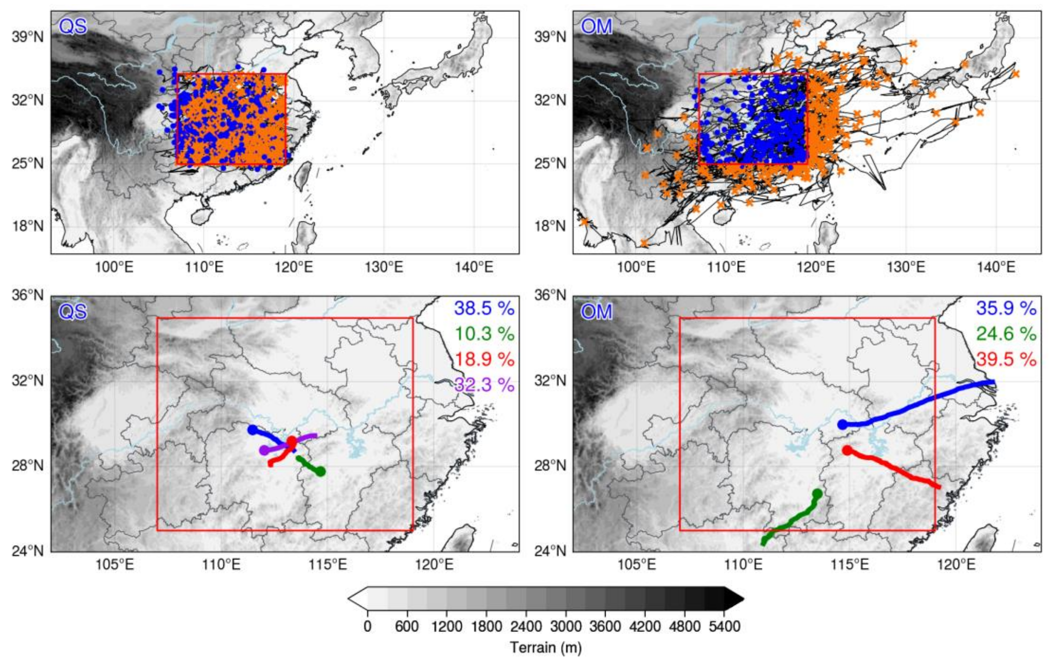




Data	FY-4A 10.8 μm BT ERA5
Classification	k-means silhouette coefficient
MCS tracking	optical flow areal overlap
MCS identification	BT≤−52℃ and extent≥5000km^2 duration≥3 h

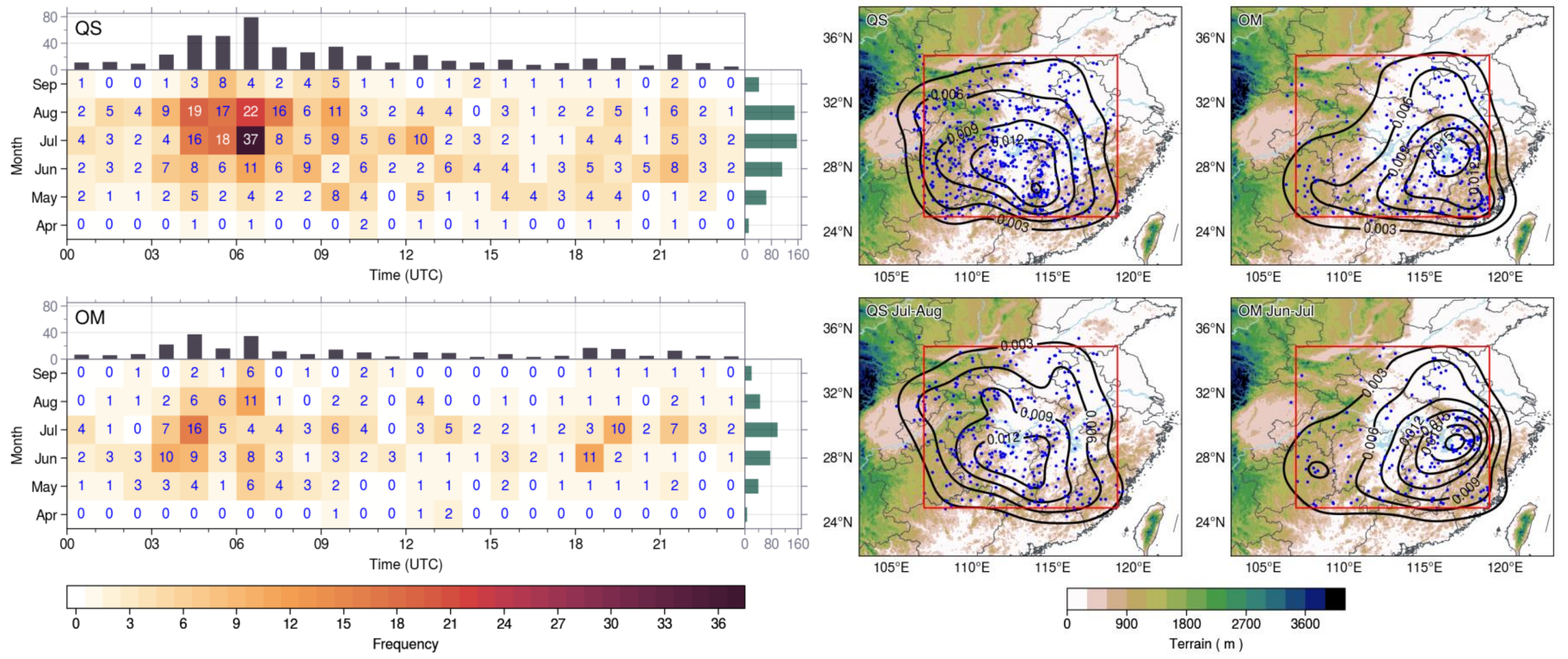
Results and conclusions

MCS trajectories and paths



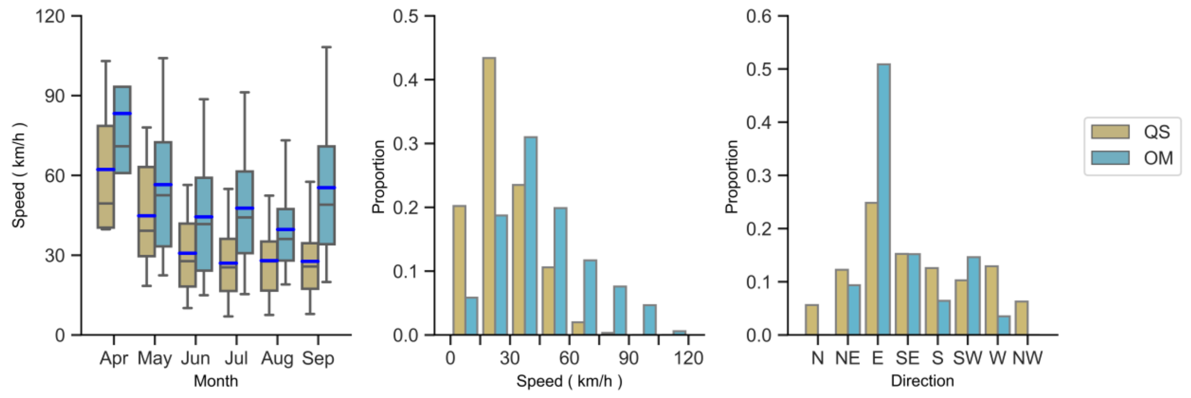
- During Apr–Sep of 2018–2021, 800 MCSs are identified in the middle reaches of the Yangtze river basin, where 524 are quasi-stationary (QS) type and 276 are outward moving (OM) type.
- The trajectories of QS (OM) MCSs are classified into 4 (3) main paths using k-means algorithm.
- Convections are initiated in mountainous areas and propagate to the plains.

Temporal-spatial distribution of MCS's initiations



- The QS MCSs primarily occur in July and August and are mainly initiated in the afternoon. The OM MCSs mostly occur in June and July with two initiation peaks at noon and late night, respectively.
- QS MCSs are mainly initiated in mountainous areas and caused by local thermal effects, while OM MCSs are mostly triggered in plain areas, which is related to synoptic circulation forcings.

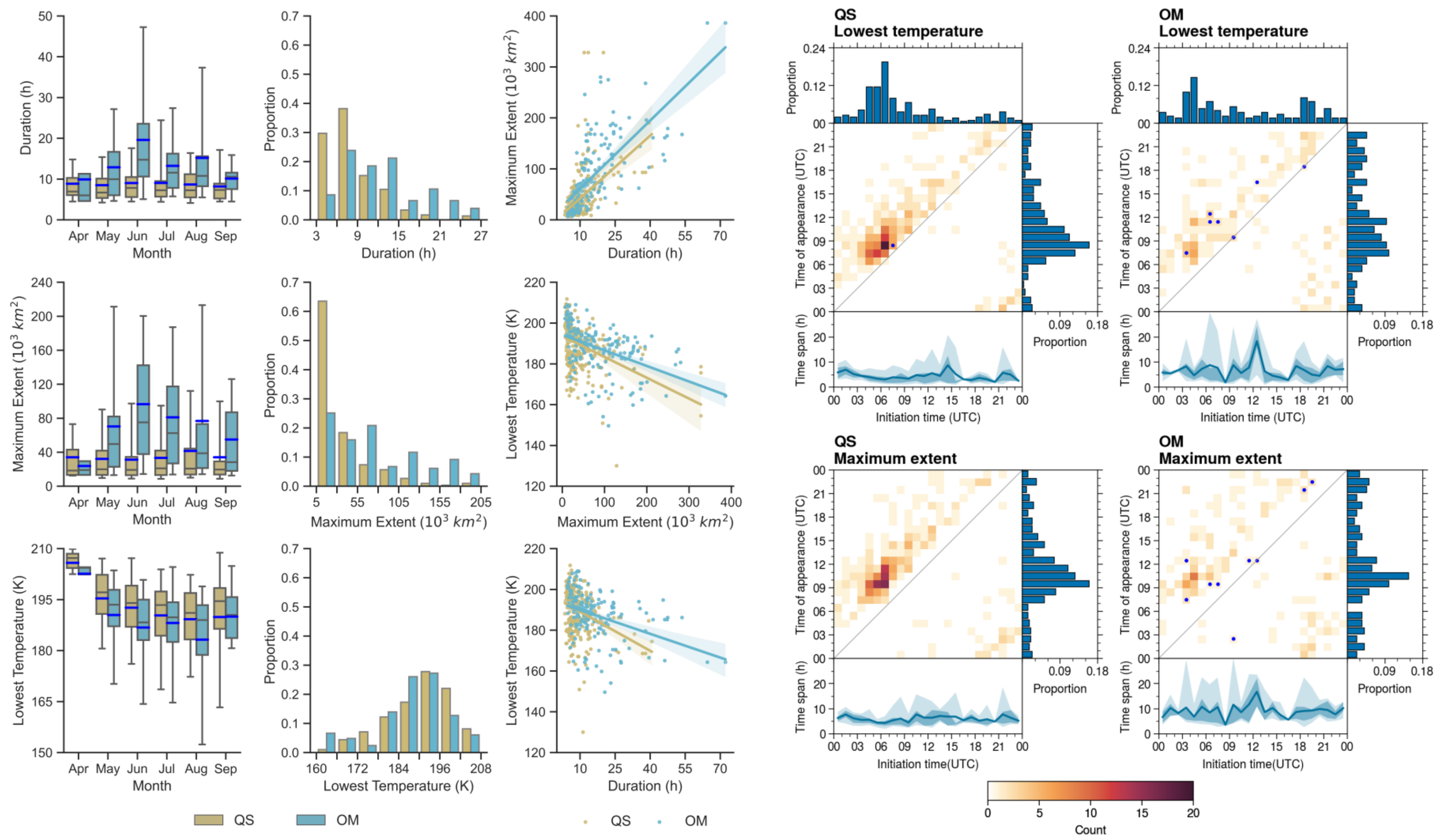
Features of MCSs' movement



- The OM MCSs move faster than the QS MCSs and mostly propagate eastward.

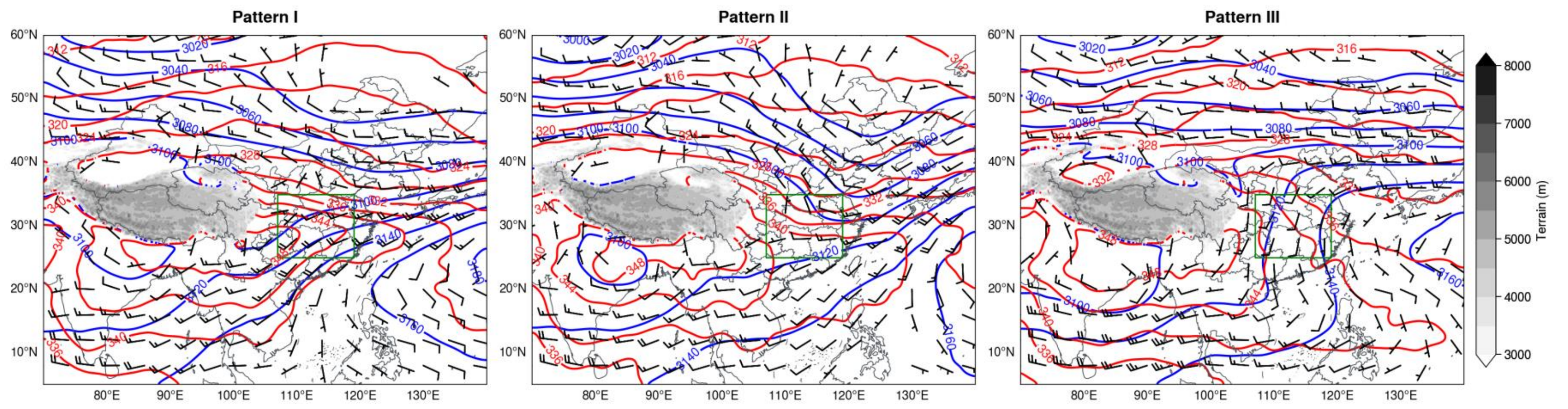
Results and conclusions

Duration, maximum extent and lowest temperature of MCSs



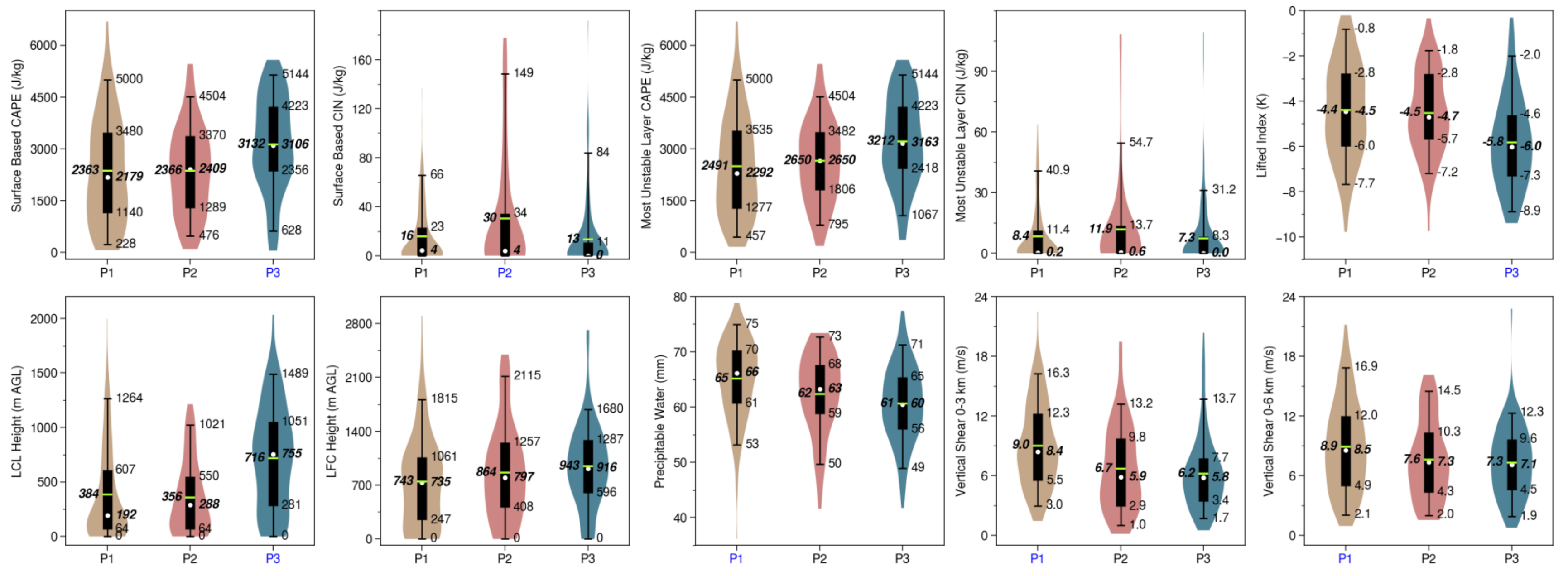
- The durations and maximum extents of QS MCSs show no obvious differences among different months, while those of OM MCSs vary among different months.
- The lowest brightness temperatures of QS MCSs mostly appear in the afternoon (0800–0900 UTC), but those of the OM MCSs exhibit no obvious diurnal variation.

Circulation patterns



- The composite circulation of P1 is consistent with the typical circulation of the Mei-yu front, and those of P2 and P3 are dominated by the northwesterly and the weak southerly, respectively.
- The mean initiation frequencies of the QS MCSs in P1 and P3 are the same and that in P2 is the lowest. The OM MCSs are initiated the most in P1, followed by P2, and they are initiated the least in P3.

Environmental conditions



- The low-level wind speed in P1 is relatively high, and the MCS initiations in P1 may be accompanied by low-level jets, which is more favorable for OM MCS initiation and propagation.
- The circulation in P2 is dominated by northwesterlies with a relatively stable layer in the low-level troposphere.
- The southerly in P3 accompanied by adiabatic warming establishes a dry-adiabatic or even a superadiabatic layer and further lowers the stability.