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Editorial: Observation characteristics and formation mechanisms of severe weather events

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Editorial on the Research Topic
Observation characteristics and formation mechanisms of severe weather events

Under global warming, disastrous weathers (e.g., rainstorms, thunderstorms, high winds, heat waves, etc.) show a notable increasing trend in their occurrence frequency and social impacts (IPCC, 2023), particularly in China (Song, 2018). In order to further the understanding of disastrous weathers and to enhance the capability of disaster prevention and mitigation, we organized this Research Topic. The primary purposes of this Research Topic are to unravel the observation characteristics of severe convective weather events; to clarify the formation mechanisms of convective systems, special heavy rainfall and thunderstorm high-wind events; to develop forecast methods of severe convective weather events; and to show the climate variability of severe weather events. All these are currently the most concerned scientific issues in the research field of severe weathers (Markowski and Richardson, 2010; Sun et al., 2019; Luo and Coauthors, 2020; Cui et al., 2021; https://public.wmo.int/en/programmes/world-weather-research-programme). There is a total of 12 published papers in this Research Topic, covering almost all the primary research objectives mentioned above. The new findings from these researches would contribute to an in-depth understanding of the severe weather events.

For the observation characteristics, Chen et al. explored key microphysics features of the outer rainband of Typhoon "Mekkhala" by using the dual-polarization radar. They pointed out that the precipitation below the freezing level was mainly composed of moderate to light raindrops, and large raindrops mainly appeared in the mid to upper levels. Huang et al. analyzed the spatial distribution of the rainstorms associated with the Northeast China cold vortices based on 20-year station observations. They determined five typical types of events by using the Self-Organizing Maps method, and found that different types were accompanied by distinctive large-scale circulation backgrounds, thermodynamic and moisture conditions. These findings based on observational data filled the knowledge gaps in existing researches.

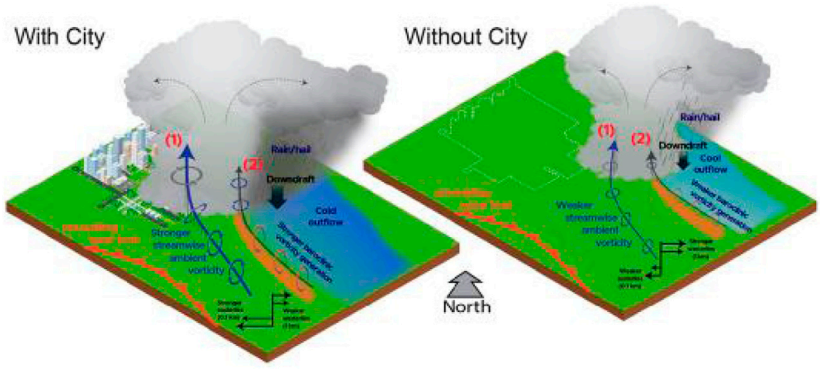

FIGURE 1
Urbanization enhances the tornado potential through two pathways: 1) enhanced low-level storm-relative streamwise horizontal vorticity (SRSHV) feeding updrafts due to stronger east-west pressure perturbation gradient as a result of faster, stronger storm outflow, and 2) intensified near-surface SRSHV which is more aligned with the easterly storm-relative inflow because of stronger cold pool front which increases southeasterly winds. Both pathways are associated with a stronger storm at the initial and developing stages resulting from the Kansas City urbanization. Derived from Fan et al.

For the mechanisms, Fan et al. discussed the impacts of Kansas City urbanization on the tornado potential. By using sensitivity simulations, they found that urbanization might enhance tornado potential by strengthening the low-level streamwise vorticity in the storm inflow region, and intensifying near-surface horizontal vorticity near the boundary of the forward-flank cold pool (Figure 1). Li et al. analyzed a trough which induced a catastrophic rainstorm in Kyushu, Japan. They found that, the trough was transformed from a Tibetan Plateau vortex, and the horizontal potential-vorticity flux convergence acted as the primary contributor to the trough's maintenance and eastward displacement. Yin et al. examined an eastward-moving heavy rainfall event in South China in winter and discovered that the Rossby wave train propagating along the subtropical westerly jet played an important role in "pushing" the eastward displacement of the rainfall event. Yang et al. explored the correlation between extreme precipitation over the middle and lower reaches of the Yangtze River and their atmospheric circulations, and found that, the Western Pacific Subtropical High showed the most significant impact, and the South China Sea high ranked the second. Tang et al. analyzed the moisture transport for the famous "7.20" rainstorm event in Henan, China. By separating the effects from tropical cyclones one by one, they found that In-fa dominated the main water vapor transport for the rainfall in the meridional direction, Cempaka mainly affected intermediate moisture transport, and the Tibetan Plateau exerted a modulation effect on the remote moisture transport associated with the two typhoons. Airflow decomposition (Ma et al.) and theoretical derivation methods (Zhou et al.) were applied in the numerical simulation analyses of the snowstorms and deep convections in Xinjiang Province, respectively. Of these, Ma et al. found that the flow-around and flow-over components from the near-surface wind field resulted in symmetric instability and stratified instability, which played a dominant role in moisture convergence and snowfall triggering, respectively. Zhou et al. pointed out that, the three-dimensional divergence showed a better correlation with precipitation, and the local change in pressure was affected mainly by the three-dimensional divergence forcing term. Three-dimensional convergence in the lower layers converted to divergence with height, leading to air mass loss in the upper layers. The air mass redistributed vertically owing to the positive vertical gradient of three-dimensional divergence. This motivated the upward vertical pressure gradient force, which was highly correlated with the vertical velocity. All these new findings contributed to render a more comprehensive understanding of the formation mechanisms of the severe weathers.

For the forecast methods, Huang and Bai evaluated the performances of seven planetary boundary layer schemes in reproducing the low-level urban atmosphere over the Greater Bay Area, South China, and they found that the MRF scheme showed an overall better performances than all the other schemes. This provided a useful reference for the forecasts of severe weathers in this region. Li et al. conducted a series of simulations by using 72 different physical parameterization scheme combinations. Their purpose was to determine the optimal cumulus convection scheme and the land surface process schemes in the upper reaches of the Yangtze River Basin by using the RegCM4 model. They pointed out that, the Kain-Fritsch scheme and the Biosphere-Atmosphere Transfer Scheme could better reproduce the precipitation and temperature characteristics of the targeted region than the remaining schemes. This provided a baseline for the localization of the RegCM4's parameterization schemes in China. Li et al. contrasted and analyzed the differences between the two-moment bulk scheme (BULK) and the spectral bin microphysics scheme (BIN) in forecasting the precipitation, radar reflectivity, and cloud microphysical processes for a heavy snowfall event in Beijing during the 2022 Winter Olympics. They found that, while the 24-h accumulated precipitation in both simulations was lower than the observation, the BIN simulation was closer to the observation, in terms of the trend of precipitation rate and radar reflectivity during the period of heavy precipitation. This provided useful information for forecasting the snowfall in China during the cold season.

For the climate variabilities, Yang et al. analyzed the observed precipitation data from 1979 to 2015, and found that, an overall increase appeared in the frequency, intensity, and duration of precipitation in the middle and lower Yangtze River basin. The

areas with large extreme precipitation indices are mainly concentrated in the Poyang Lake basin. These results would provide effective reference bases for policymakers.

Overall, the severe weathers pose a significant threat to human society (IPCC, 2023), and how to cope with disastrous weathers is a common challenge faced by all meteorological society (https://www.cma.gov.cn/2011xwzx/2011xmtjj/202205/t202205264856882.html). Our Research Topic has provided some useful results for furthering the studies on severe weathers, however, as the spatiotemporal scales of these systems are relatively small, and the physical mechanisms governing their formations are quite complicated, we encourage scholars in relevant fields to conduct more studies in the future, which would contribute to reach a more comprehensive understanding of the severe weathers.

Author contributions

S-MF: Conceptualization, Data curation, Formal Analysis, Funding acquisition, Investigation, Project administration, Supervision, Validation, Writing–original draft, Writing–review and editing. T-TH: Writing–original draft, Writing–review and editing. J-HS: Supervision, Writing–review and editing. Z-GW: Writing–original draft.

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Conflict of interest

Author Z-GW was employed by Research Institute of State Grid Zhejiang Electric Power Company.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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