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Editorial: Landfalling tropical cyclones: Physical processes, forecasting, and impacts

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Editorial on the Research Topic
Landfalling tropical cyclones: Physical processes, forecasting, and impacts

Tropical cyclones (TCs) are one of the most catastrophic weather systems, regularly causing severe winds, torrential rainfall, and secondary disasters such as storm surges, mudslides, and municipal flooding. Particularly during landfall, the threats to lives and properties become even greater with TCs. It has been widely recognized that the risks induced by landfalling TCs are tightly linked to changes in TC track, intensity, and structure. In addition, on a longer temporal scale, variations in TC activity can also significantly modulate the possible menace triggered by TC landfalls. The multi-scale physical processes controlling TC track, intensity, and structure changes are complicated, and there remain quite a few hanging questions concerning these processes. Therefore, a Research Topic, Landfalling Tropical Cyclones: Physical Processes, Forecasting, and Impacts, was featured in Frontiers in Earth Science–Atmospheric Science. Recent related research advances are presented in this Research Topic.

Interactions between the TC circulation, ambient weather systems, and the underlying surface complicate the TC intensity change during landfall. These complex processes were discussed in the Topic. A study by Qing and Wu examined the possible environmental influence on the eyewall expansion during Hurricane Helene (2006)'s rapid intensification (RI) and found that the synoptic-scale features resulted in additional low-level inflow and upper-level outflow that contributed mainly to the eyewall expansion. Gao et al. investigated the strong turbulent kinetic energy within the eyewall of Super Typhoon Rammasun (2014), pointing out that the strong turbulent kinetic energy was involved in horizontal rolls. A series of studies of the RI of Super Typhoon Lekima (2019) indicated that deep convection contributed to the development of the upper-level outflow, thus, decreasing the upper-level vertical wind shear (VWS) and that the cloud–radiation interaction also furnished positive feedback between the tilting-induced convective asymmetry and the build-up of the upper-level outflow channel (Huang et al.; Huang et al.). Liu et al. assessed the performance of three exponential decay models in estimating post-landfall TC intensity change over China and suggested that the TC intensity at landfall contributed approximately 18% to the model errors. Thomas and Shepherd utilized a machine-learning method to diagnose inland TC maintenance and intensification and found that the variables that were important at the time of TC's arrival were also important the day before.

Along with the structure and intensity changes, landfalling TC rainfall is also characterized by a complex nature. Zhao et al. addressed extreme rainfall events induced by landfalling TCs in China and showed that monsoonal surges regulate the TC-associated extreme rainfall by directly influencing the maintenance of the TC circulation and slowing down TC movement. An observational study of Tropical Storm Rumbia (2018), which made landfall in Shanghai, China, showed that the low-level convective instability and deep-layer environmental VWS tended to deepen the inflow boundary layer and contribute to the redevelopment of the secondary circulation. As a result, heavy rainfall was enhanced in the northeast quadrant of Rumbia after landfall (Tang et al.). Yao et al. evaluated the Dynamical-Statistical-Analog Ensemble Forecast model's precipitation forecasts of landfalling northward-moving typhoons and indicated that the model could capture reasonably well the distribution of precipitation in most cases, with better forecasts of typhoons hitting the southern coast of China.

The boundary-layer processes and dynamics are essential for the structure and intensity changes of landfalling TCs. Jiang et al. employed a large-eddy simulation technique to evaluate the drag coefficient within TCs. The results show that the drag coefficient leveling off or decreases, which is observed in strong wind conditions, are not produced when TC–ocean interactions are excluded in the model. Xu and Wang documented that a grid spacing of sub-100-m in a large-eddy simulation is required to capture more fine-scale structures of horizontal rolls and tornado-scale vortices within the TC boundary layer. Tower observations showed the presence of a stress internal boundary layer within the circulation of landfalling typhoons, and integrated dissipative heating increased with increasing wind speed above the internal boundary layer (Zhou et al.).

Variations of landfalling TC activities are also investigated in the Topic from a climatological perspective. The spring North Atlantic Oscillation was found to have cross-basin impacts on the summer and autumn TC genesis frequency in the North Hemisphere (Zhang et al.). A slowdown in the decay of landfalling TCs in the Asian continent was revealed from 1966 to 2018 (Song et al.), and a significant increasing trend in the average 24-h intensity change of western North Pacific TCs before landfall was found between June and November during the period 1970 to 2019 (Liu et al.). It is also indicated that TC intensification over the marginal seas of China likely occurred when TCs underwent relatively large intensity, weak VWS, small translation perpendicular to the coastline, relatively large fullness, strong upper-level divergence, low-level relative vorticity, and high inner-core precipitation rate (Li et al.). Cluster analysis showed that an abrupt decrease in western North Pacific TC formation after 1998 was related mainly to a decrease in the class located in the southern and eastern parts of the western North Pacific, and an increase after 2010 occurred due to the class located in the northwestern part of the western North Pacific (Tian et al.). Yu et al. classified the tracks of northward-moving TCs that hit Northeast China during July–September into two groupings based on a machine learning algorithm. They further examined the characteristics of large-scale factors associated with each grouping. Lakshan et al. examined the variation in large-scale parameters associated with two types of El Niño and their impacts on TC activity over the Bay of Bengal from 1980 to 2019. It is shown that the relationship between the genesis potential index and El Niño-Southern Oscillation (ENSO) in the primary TC peak season exhibits a distinct meridional feature over the southwestern to northeastern parts of the Bay of Bengal, with the ENSO-modulated VWS contributing the most to increasing the likelihood of TC genesis over the southwestern portion of the Bay of Bengal. Yu et al. identified two leading modes of the late-season TC track frequency and indicated that the circulation anomalies associated with the two modes are relevant to the concurrent ENSO but with different locations of the warmest sea surface temperature. Li et al. examined the climatological characteristics and interannual variations of TCs making landfall in mainland China in the peak TC seasons from 1980 to 2020. They found that the TC landfall frequency in mainland China and South China decreased significantly in 1995/1996 and 1996/1997, respectively. A statistical seasonal forecasting model was developed by Zhang et al. to predict the number of TC landfalls in South China based on preseason environmental conditions, and the hit rate could be up to 90% during the period 1979–2020.

Author contributions

YH conceptualized the idea of the Research Topic. QQ wrote the first draft of this editorial with editing and additional contributions from YH.

Conflict of interest

The 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.

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