Research priorities for studying tropical cyclone climate in East Asia

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In the last few decades, many city clusters (megacities) have developed along the East Asia coast and more are expected in the future. Over 20 tropical cyclones (TCs) make landfall on this extremely long coastline every year, causing tremendous loss of life and property, and damage to infrastructures, which will worsen with the increasing number of such megacities. A good understanding of the past and present TC climate is therefore essential so that local and national governments can better prepare for the potential disasters brought by TCs. In addition, a more accurate projection of possible future changes in TC activity due to natural and anthropogenic forcings can provide useful information in new building design as well as long-term infrastructure and societal development and coastal protection.

Many studies in the past have identified the physical processes responsible for the climate variability in the genesis location, intensity and movement of TCs over the open ocean for the Asian region (see e.g. Chu [1]). Future projections of the trends of some of these TC characteristics have also been made (e.g. Lok [2]; Knutson [3]). However, a number of outstanding questions related to TC climate associated with landfalling TCs should be addressed to advance the science and at the same time meet the needs of society.

One research priority is to identify the drivers of landfalling TC activity on sub-seasonal time scales. Previous studies have found relationships between TC formation and the Madden-Julian Oscillation and the quasi-biweekly oscillation [4]. However, how these intraseasonal oscillations or other atmospheric/oceanic conditions may lead to the variation of the number of landfalling TCs, their intensities, sizes and rainfall distributions near, at and after landfall in a particular region on such time scales have yet to be investigated. Understanding the drivers of such variations is very useful in disaster preparedness especially for the ever-growing coastal cities in Asia because long lead times are necessary to set up the contingency measures in order to reduce the impact of these landfalling TCs.

With the advances in satellite technologies, estimates of TC intensity have improved significantly. However, estimates of TC size (e.g. radius of gale-force winds) and rainfall distributions are far from satisfactory. Damages from TC winds are not just from the most intense winds near the TC centre. A large gale-force wind radius can cause damage over a very extensive area, not only through direct destruction of buildings and blowing down trees, but also high storm surges. However, because of the lack of data over the ocean, a long-term size dataset has yet to be available for studying the climate and evolution of TC size. Although Mok [5] proposed to use reanalysis datasets to estimate TC size, whether such an approach can give reasonable estimates still needs to be determined. Other new methodologies making use of various satellite observations need to be developed to create a good TC size dataset. In addition,
The definition of TC rainfall varies among the different studies, making it difficult to gauge changes in TC rainfall over time. Thus, another research priority should be to establish a good database for size and rainfall in order to investigate the mechanisms and the climate drivers governing the size and rainfall distributions for landfalling TCs.

Most climate models only project future TC activity over the entire ocean basin. While such information is useful in understanding how climate change might affect TC activity, it is not very useful for long-term disaster preparedness as this requires projections of landfalling TC activity. A few studies have downscaled global model projections to investigate the future frequencies of landfall in various locations along the East Asia coast [2, 6–7]. However, intensity projections have not been the main focus. In addition, these studies were made before the availability of the model outputs from the Coupled Model Intercomparison Project Version Six. Thus, similar research should be carried out for all coastal regions in East Asia using these latest model outputs through the use of statistical and dynamical downscaling. In dynamical projections of future intensity of landfalling TCs, it is also important have a model system that is capable of including air-sea interaction processes. Thus, climate models for projecting such characteristics (i.e. frequency, intensity, size and rainfall) should consist of a fully air-sea coupled modeling system.

Analyses of TC data for the past 70 years or so have suggested an apparent northward migration of the TCs [8] as well as a decrease of their translation speed [9]. However, both conclusions have been contested by other researchers who pointed out that they might not be physical and are likely a consequence of the inhomogeneities of data distribution over land and ocean [10–14]. Liu [15] further found a meridional oscillation in the occurrence frequency between the South China Sea and the ocean south of Japan. Another research priority would therefore be the acquisition of past data to the extent possible so as to provide answers on such apparent discrepancies among various studies.

To conclude, because of the increase in the number of megacities along the East Asian coast, the potential damage due to landfalling TCs will almost certainly increase. Hence, substantial research efforts must be made to understand how the characteristics of such TCs have changed in the past and to develop better tools to project how they might change in the future as a result of the natural variability of the atmosphere and the ocean, as well as anthropogenic forcing.

References


