

ORGANIZATION AND INTERNAL STRUCTURE OF PRECIPITATION INDUCED BY TYPHOONS OVER JAPAN

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ABSTRACT: This study explores the temporal precipitation organization of 126 landfalling typhoons around Japan during 2006–2019. The internal structure particularly the cell sizes and spell durations of precipitation induced by these 126 typhoons are investigated from the Radar Automated Meteorological Data Acquisition System (Radar-AMeDAS) observed hourly precipitation dataset. The best track data from the Regional Specialized Meteorological Center (RSMC) Tokyo are utilized to identify the typhoon locations. We first stratified the independent precipitation cell sizes and precipitation spell durations with intensity exceeding various thresholds into different bins. Then the frequency distribution of the precipitation sizes and durations in each bin are computed. Our results indicate that the occurrence of typhoon induced heavier precipitation is higher compared to the typhoon induced lighter precipitation. The typhoon induced heavier precipitation over Japan last up to a day, while the lighter precipitation last about 12 hours. The long-lived precipitation cases are also noticed that last up to 2 days, but they don't occur so frequently. We analyzed the spell durations over different regions of Japan with various radii from the typhoon center starting from 10 km to 300 km. The results also indicate that the pattern of spell durations are mostly same over all the regions within 300 km radius.

Keywords: Precipitation structure, Typhoon, Radar-AMeDAS.

INTRODUCTION

Typhoons are considered as one of the most dangerous extreme weather events in the world that triggered widespread flooding in the landfall area. Plenty of typhoons have approached Japan over the year and many of them have impacted lots of properties by bringing heavy rainfalls (Takemi et al., 2016a; Chen et al., 2018; Takemi, 2019; Nayak and Takemi, 2019a, 2019b, 2020a; Morimoto et al., 2021). In a recent study, Nayak and Takemi (2020b) investigated the spatial and temporal characteristics of four typhoons that landfalled over Northern Japan and highlighted that these typhoons brought relatively more frequent heavy precipitation (> 20–30 mm/h) that last from 6 to 9 hours over northern Japan. However, studies are limited to understand the spatiotemporal structure of precipitation over other regions across Japan. In this study, we analyzed the precipitation characteristics from 126 typhoons that approached Japan during 2006–2019 (Fig. 1).

DATA AND METHODS

We analyzed the precipitation datasets from the Radar Automated Meteorological Data Acquisition System (Radar-AMeDAS) which are available at ~1 km spatial resolution over Japan. The best track data from the Regional Specialized Meteorological Center (RSMC) Tokyo was utilized to identify the typhoon tracks along and their active periods over Japan. To capture the

typhoon-induced precipitation amount and the duration over a region of various radii (10–300) from the typhoon center, we computed the precipitation intensity over the overlapping area between the target region and the typhoon located region at each hour for all the 126 typhoons at each grid point of $0.5^\circ \times 0.5^\circ$ over Japan land.

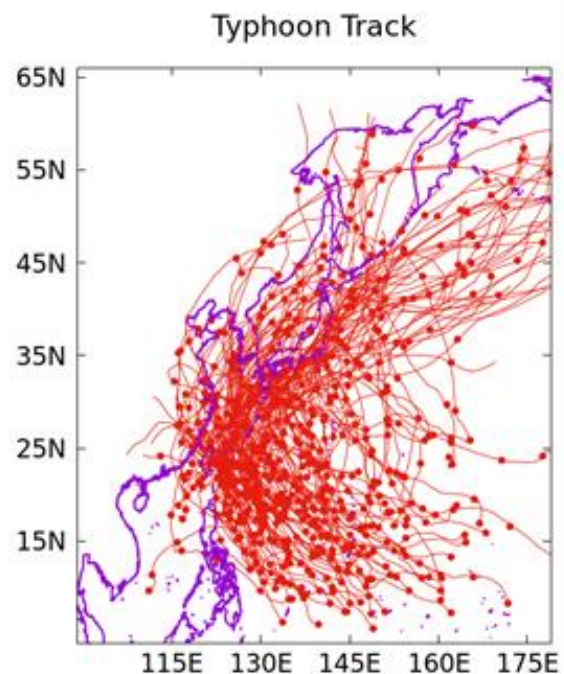


Fig. 1. Track of 120 typhoons approached through Japan during 2006–2019.

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RESULTS

Figure 1 represents the tracks of the 126 typhoons that landfalled/passed near Japan during 2006–2019. It shows the typhoons approaching Japan mostly form in the region of 5N–15N and move initially northwestward and, after recurving, northeastward to the southern coast of Japan. The tracks indicated that the typhoons mostly landfalled in the Pacific Ocean side of Japan during 2006–2019 and are more in numbers compared to those landfalled in the Sea of Japan side. Figure 2 shows the probabilities of the spell durations of precipitation exceeding various thresholds of 5, 10, 20 mm over the different regions of

Japan viz. Sea of Japan side of eastern (ES), western (WS), and northern (NS), Pacific Ocean side of eastern (EP), western (WP), and northern (NP) and Okinawa (OK). The spell durations are computed for the precipitation intensity over 30 different radii from the center of a target region at 10-km interval. For clarity, we presented 3 radii, hereafter referred to as the target regions with radius 100 km, 200 km and 300 km. The results indicated that the spell durations, obtained from all three types of precipitation thresholds, are qualitatively the same for all the radii selected in this study. The heavier precipitation cases show higher probability and last up to a day, while the lighter precipitation last about 12 hours. The long-lived precipitation cases are also noticed for all the three types of precipitation cases which lasts up to 2 days and more, although they don't occur so frequently. The occurrences of spell durations are found to be the same over all the target regions within 300 km radius, perhaps due to the fact that the size of most of the typhoons is in general higher than 300 km. Thus results may be different if higher radii values are considered.

We also computed the area averaged precipitation intensity over different regions of Japan during the passage of 126 typhoons with northward direction. The peak precipitation intensities over northern Japan are noticed when the typhoon centers are located at 38–39N. The eastern and western Japan show strong precipitation intensities at 33–35N latitudinal typhoon locations. The Okinawa experience peak precipitation intensity when the typhoon centers are found at 25–26N. We further investigated the area averaged maximum precipitation intensity during the passage of the typhoons over each region (Figures not shown here). On the typhoon-days, the area averaged maximum precipitation intensity is noticed ~10 mm h⁻¹ over northern Japan, ~12 mm h⁻¹ over ES, WS and WP, ~15 mm h⁻¹ over EP, and ~30 mm h⁻¹ over OK.

Overall, our results indicate that the duration and intensity of the precipitation induced by the typhoons are significant over entire Japan and maybe expected even more under future warming climate, because atmosphere can hold more moisture under warmer air temperature according to the Clausius-Clapeyron equation (e.g. Nayak and Dairaku, 2016; Nayak, 2018; Nayak et al., 2018, 2019c, 2020c). Several studies also documented the responses of the typhoon intensities to the global warming conditions (e.g. Takemi, 2016a, 2016b, 2016c; Ito et al., 2016; Nayak and Takemi, 2019a, 2019b, 2020a). Therefore, a future study with warming datasets is suggested to understand the global warming impact on the duration and intensity of the precipitation induced by the typhoons.

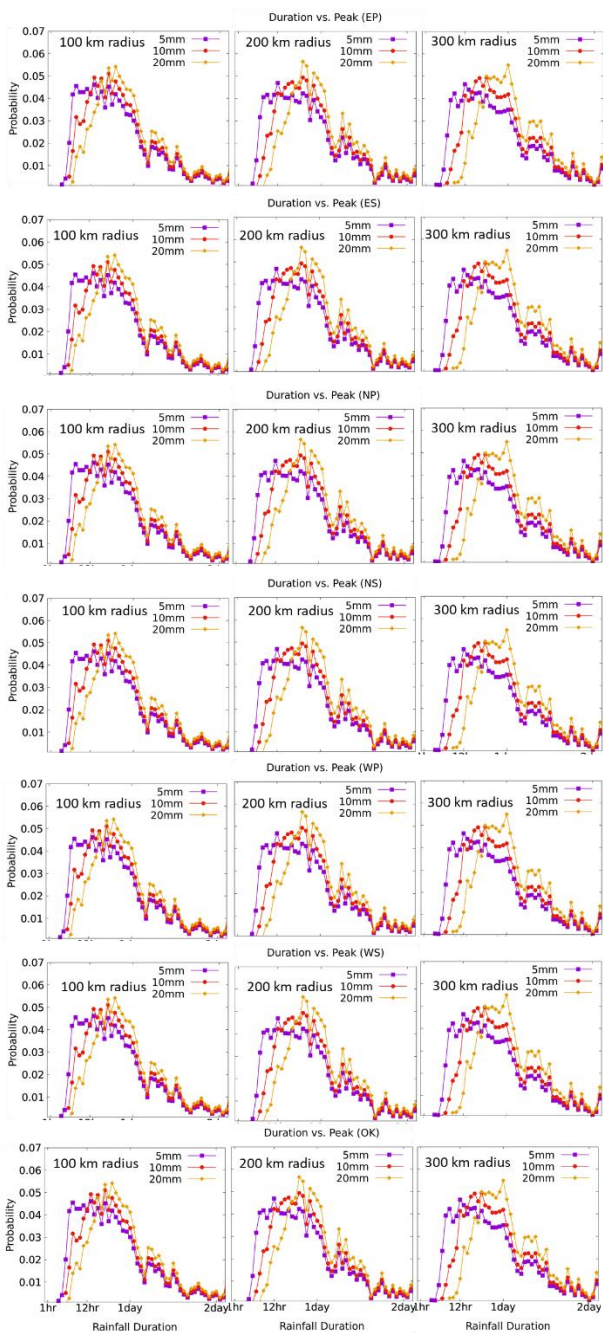


Fig. 2. The probability of precipitation durations induced by the 126 typhoons approached over different regions.

SUMMARY

In this study, we have investigated the spell duration of the precipitation carried by 126 typhoons and their internal structure over the different regions of Japan during 2006–2019. Our results indicated that the heavier precipitation occurred more frequently during the typhoon active periods and last up to a day compared to lighter precipitation cases which last about 12 hours. The long-lived precipitation cases are also found that last up to 2 days, but they don't occur so frequently. The peak intensity of precipitation carried by the typhoons to Japanese regions are found when the typhoon center are located within 25–39N. The area averaged maximum precipitation intensity is noticed as about 30 mm h⁻¹ over OK, while that of over other regions of Japan varies within ~10–15 mm h⁻¹. Our overall results indicate that the duration and intensity of the precipitation induced by the typhoons are significant over entire Japan.

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