TROPICAL CYCLONES IN THE WESTERN NORTH PACIFIC OCEAN: CHANGES OF THEIR TOTAL ACTION DURING PAST DECADES

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The analysis has been performed for the tropical cyclones (TC) action S as an integral characteristic of their energy impact. Similar analysis was done in [4] for total action of atmospheric blockings and in [5] for total action of extratropical cyclones. This value S has a dimension [energy]x[time]. Action S of individual climate structure, in particular for TC, can be defined as follows

$$S \sim \int_0^\tau E(t)dt,$$

where integration over time t is performed from 0 to τ, τ is the vortex life time, E is the vortex energy. The kinetic energy of an atmospheric vortex can be expressed via $(\Delta P)^2$, where ΔP is a pressure difference between the vortex centre and periphery [1,2]. The integral action S_Σ for an ensemble of TCs is defined as a sum of values of action for individual TCs.

Here we present results of the TC action analysis for the Western North Pacific Ocean (WNPO) basin. This basin is characterized by the largest TC number N_{tc} per year. According to observations for recent decades, on average 44% of TCs in the Northern Hemisphere are formed in the WNPO [3,6]. At the same time, annually about 9 of 25 TCs in the WNPO basin are transformed into extratropical cyclones (ETC) and a significant positive trend was noted - with an increase in the number of transformation events (N_{etc}) by 1 cyclone in 14–15 years or more than 4% per decade for N_{etc}/N_{tc}. In this regard, estimates of the TCs energy are relevant, including the energy of TCs reaching extratropical latitudes, in particular in the WNPO.

Our analysis is based on the RSMC data (http://www.jma.go.jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/RSMC_HP.htm) for TCs in the WNPO for the period 1951-2019. Figure 1 shows interannual changes in the normalized TCs total action S_Σ in the WNPO during 1951-2019 with a significant increase during past three decades of the interannual variations range. According to Fig. 1, in the past three decades several times it reached and even exceeded the double mean level for the base period 1951-1980. The mean S_Σ values since the second part of 1980s are remarkably larger than for the base period despite the presence of years with very low S_Σ values.

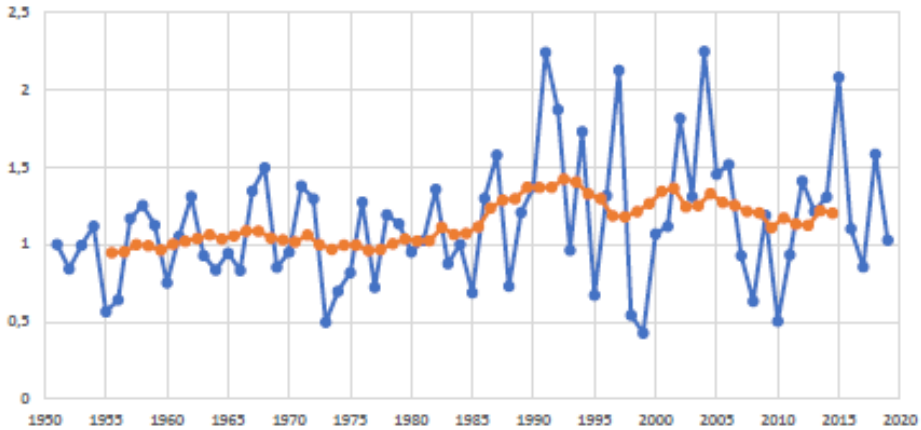

Fig. 1. Interannual changes of the normalized total action $S_\Sigma(N_{tc})$ of N_{tc} TCs in the WNPO in 1951-2019. Estimates of $S_\Sigma(N_{etc})/N_{etc}$ are normalized to the average value for the period 1951-1980 (blue line). The red line corresponds to 10-year means with moving averaging.

Figure 2 shows the interannual changes in the normalized total action $S_\Sigma(N_{etc})/N_{etc}$, corresponding to the mean individual ETC in the WNPO in 1951-2019. A general increase in $S_\Sigma(N_{etc})/N_{etc}$ during the last decades is accompanied by significant interannual variations.

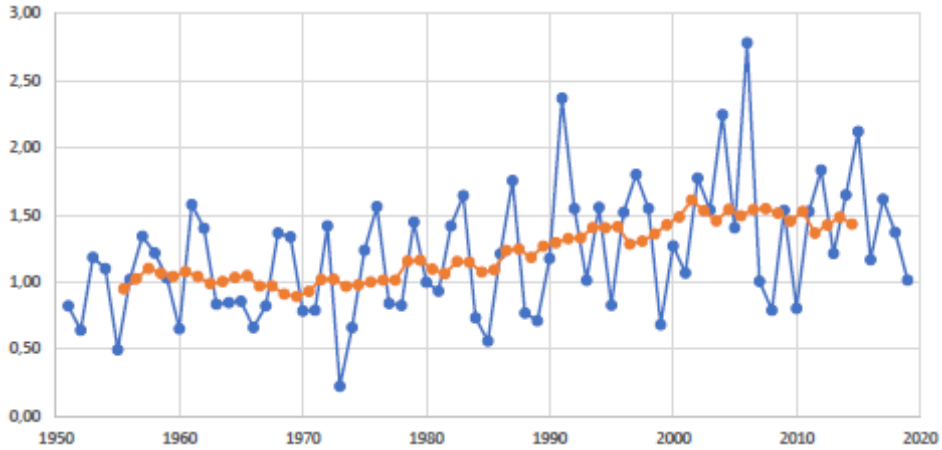

Fig. 2. Interannual changes of the normalized action $S_\Sigma(N_{etc})/N_{etc}$, corresponding to the mean individual ETC in the WNPO in 1951-2019. Estimates of $S_\Sigma(N_{etc})/N_{etc}$ are normalized to the average value for the period 1951-1980.

The results obtained for tropical WNPO cyclones indicate a high variability of their action with a general growth in recent decades and an increase in the risk of their effects in extratropical latitudes.

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