Accelerated increase in tropical cyclone heat potential within typhoon rapidly intensifying region during 1955-2019

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The changes in the tropical cyclone heat potential (TCHP) within the rapidly intensifying region (RIR) of typhoon over the past six decades, from 1955 to 2019, are investigated by using the objectively analyzed (1° grid) annual and 3-month climatological data of temperature [Locarnini et al., 2010] and salinity [Antonov et al., 2010] from the World Ocean Atlas 2009[1] , and the annual and 3-month anomaly data of temperature from 1955 to 2019 and salinity from 2005 to 2019 [Levitus et al., 2012][2]. 3-month periods from January to March, from April to June, from July to September, and from October to December are referred as winter, spring, summer, and fall, respectively, for season. The RIR is defined as 6-24°N and 124-170°E, based on the locations of onset of rapidly intensifying tropical cyclone (RITC). The RITC is defined as a wind speed increase of 30 kt or more in a 24-h period and is detected by using the best track data from the Regional Specialized Meteorological Center of Tokyo–Typhoon Center of the Japan Meteorological Agency[3]. Figures 1 (a) and (c) show time series of annual TCHP anomalies (TCHPA) averaged in global and RIR and their 31-y linear trends, respectively. Figures 1 (b) and (d) are the same as (a) and (c) but for seasonal and only within RIR. The trends which are not statistically significant at the 95% confidence level are indicated by broken lines in Figs 1 (c) and (d). There is a clear shift toward positive TCHPA within RIR during the 1990s (Figs. 1(a) and (b)). The annual TCHPA trends exhibit increasing trends in both global and RIR (Fig. 1(c)), but those in RIR are not significant from 1970 to 1983. It is identified that the insignificant increasing trends are accelerated and turn to be significant increasing trend in all seasons (Fig. 1(d)). These results indicate that the past six decades is possible to be separated into the two periods of three decades of the early half (33-y period 1955-1987) with smaller trends and latter half (32-y period 1988-2019) with larger trends. The centroids of the early and latter sub-periods are around 1971 and 2003, respectively. Geographical distributions of the difference of mean TCHPA [10^8 J/m^2] are shown in Fig. 2. Only the values those are statistically significant at the 95% confidence level are colored. It is revealed that the increase of mean TCHPA from the early half period to the latter half period is statistically significant in almost all locations in RIR for all seasons.

[1] Available from https://www.ncei.noaa.gov/products/world-ocean-atlas.

[2] Available from https://www.ncei.noaa.gov/access/global-ocean-heat-content.

[3] Available from http://www.jma.go. jp/jma/jma-eng/jma-center/rsmc-hp-pub-eg/besttrack.html.

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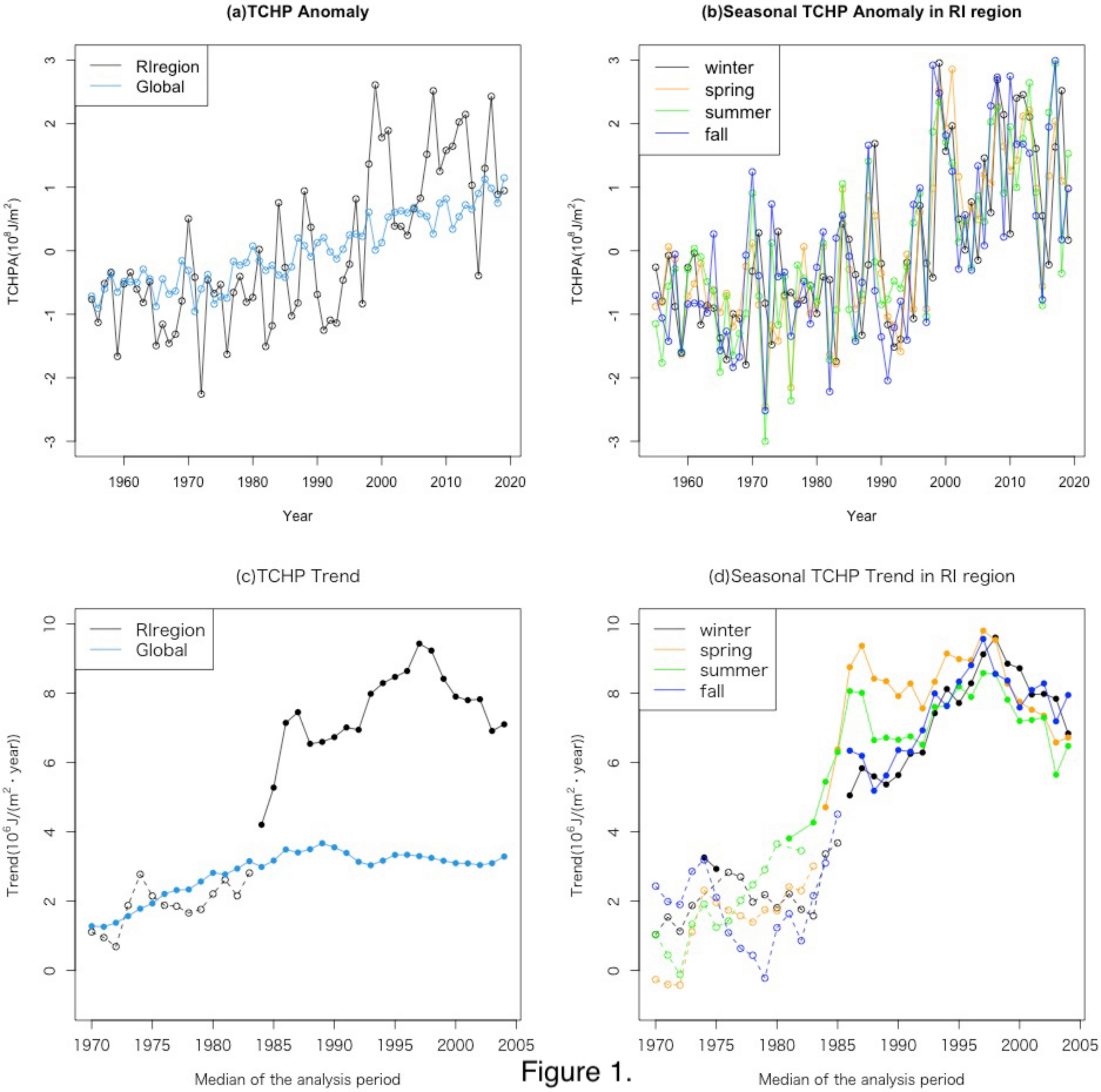
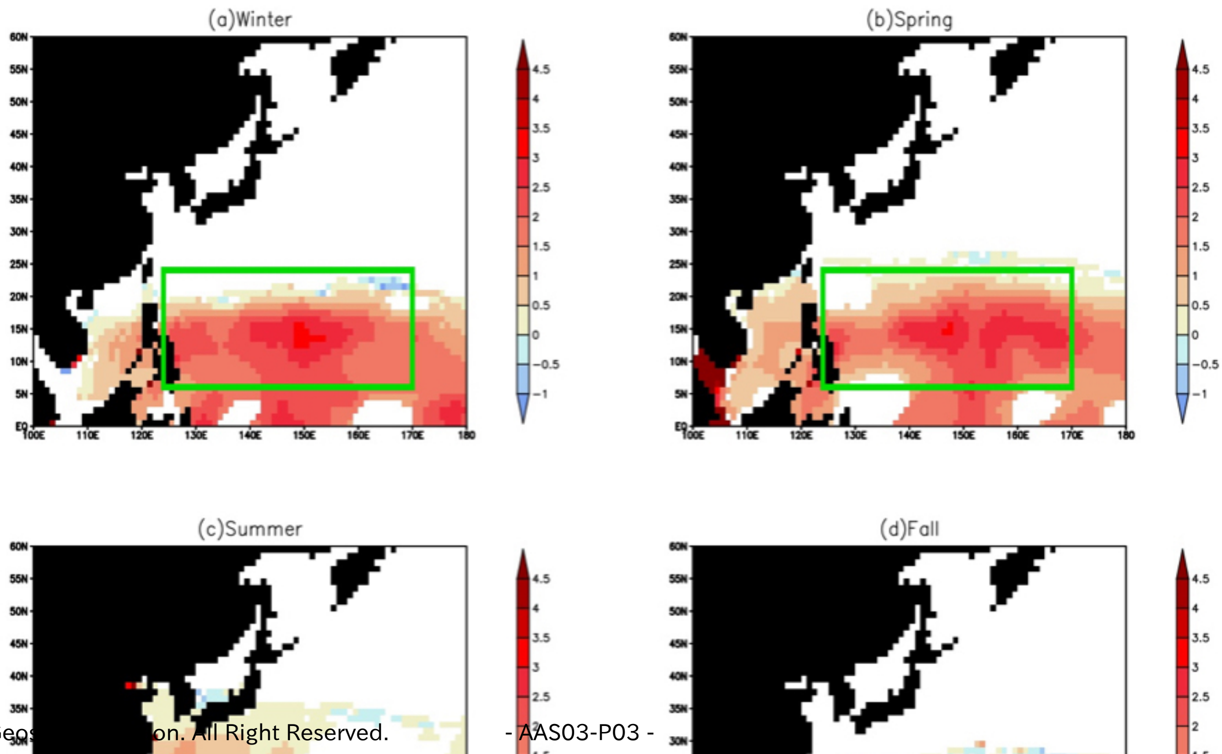

(a)TCHP Anomaly
RIregion
Global
TCHPA(10^8 J/m^2)
Year
(b)Seasonal TCHP Anomaly in RI region
winter
spring
summer
fall
TCHPA(10^8 J/m^2)
Year
(c)TCHP Trend
RIregion
Global
Trend(10^6 J/(m^2 · year))
Median of the analysis period
(d)Seasonal TCHP Trend in RI region
winter
spring
summer
fall
Trend(10^6 J/(m^2 · year))
Median of the analysis period

Figure 1.


(a)Winter
(b)Spring
(c)Summer
(d)Fall