

# Long term trend of heavy precipitation around Japan

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## Abstract

Using daily and hourly precipitation data in Japan, and ERA40 monthly 500 hPa geopotential height (z500), long term trend of heavy precipitation around Japan and the associated large-scale trend are analyzed. Frequencies of three hourly heavy precipitation averaged over 7 stations in Japan at the 1990s are higher than those at and before the 1950s. More increasing trend in early morning heavy precipitation is seen. These heavy precipitation events occur mainly in June to September. When the early summer (June-July) and the late summer (October-September) are separately analyzed, heavy precipitation in the late summer has more increasing trend than those in the early summer and in the whole summer. Those trends are compared with z500 from ERA40 in the period from 1958 to 2002. Some resemblance between the two correlation patterns implies favorable large-scale condition for heavy precipitation increases recently. Analysis for the early and late summers reveals that in the late summer correlation pattern of the heavy precipitation with z500 has strong resemblance to trend pattern of z500; negative center in the East China Sea surrounded by positive circular belt region. This result is consistent with the above observation about the different trends in the early and late summer.

*Keyword: climate extreme, heavy precipitation.*

## 1. Introduction

Precipitation is one of the key factor of the monsoon activity and heavy precipitation events have a great social influence. We analyze trend of heavy precipitation in Japan and a possible link to large-scale field around Japan.

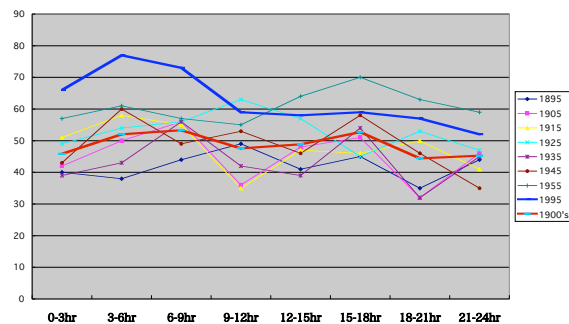
## 2. Data and method

Data used are daily precipitation data in Japan from 1951 to 2002 compiled by Japan Meteorological Agency (JMA). Total number of stations are 130 from North Japan to the Southwestern Islands. Also hourly precipitation data for 1901-1960 and 1990s at 7 stations (Sapporo, Tokyo, Nagoya, Osaka, Fukuoka, Nagasaki, and Kumamoto) are used.

Monthly mean geopotential height at 500 hPa (z500) from ECMWF ReAnalysis-40 (ERA40). from 1958 to 2002 is used for study of large-scale field around Japan.

## 3. Results

Fig. 1 illustrates change of occurrences of 3 hourly heavy precipitation for each local time averaged over 7 stations in Japan. Frequencies of three hourly heavy

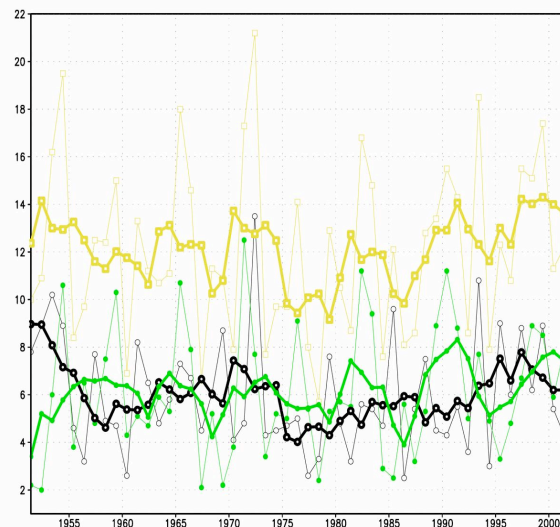


**Fig. 1:** Change of occurrences of 3 hourly heavy precipitation for each local time averaged over 7 stations in Japan. Legend is shown in the right hand.

precipitation averaged over 7 stations in Japan at the 1990s are higher than those at and before the 1950s. Heavy precipitation centered in the early morning prominently increases.

Fig.2 shows time series of frequencies of days with more than 100 mm/day in summer (June to September), in early summer (June to July) and in late summer (August to September) in Japan. Although none of them has any clear increasing or decreasing trend, frequency in the late summer tends to have a little increasing trend.

Horizontal distribution of heavy precipitation trend is shown in Fig. 3. Trend patterns are clearly different

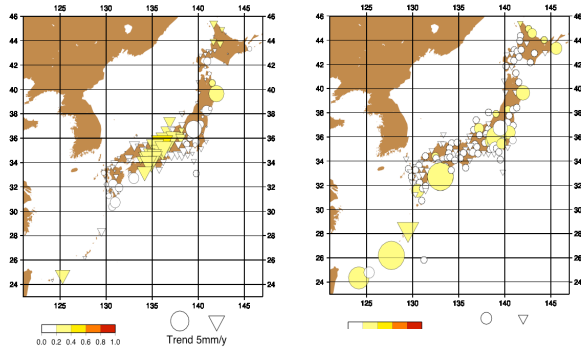


**Fig. 2:** Time series of frequencies of heavy precipitation days with more than 100 mm/day in June to September (Yellow line), in June to July (Black line) and in August to September (Green line) in Japan. Thin (thick solid) lines denote original (5 year running mean) time series.

between in early summer and in late summer. Hereafter

analysis is made separately for the early summer and the late summer.

Upper figures in Figs. 4 and 5 are linear trends in z500 from ERA-40 for June to July and August to September, respectively. In June to July there are positive trends in the north and south of Japan and negative trends in Japan

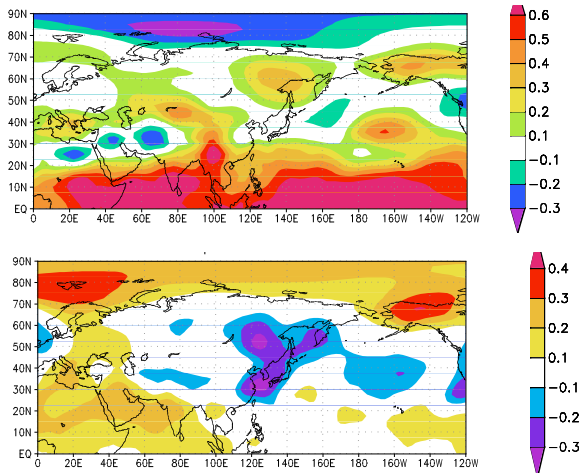


**Fig. 3:** Linear trend of heavy precipitation days with more than 100 mm/day in June to July (left figure) and in August to September (right figure) from 1951 to 2002 in Japan.

extending northwestwards and northeastwards. The northern positive trend corresponds to recent tendency of strengthening of the Okhotsk high over the Sea of Okhotsk.

Trend pattern in August to September is similar to that in June to July, but negative trend from the Yangtze River, the East Sea and through South Japan is more prominent and positive trend surrounds the negative trend. Center.

Lower figures in Figs. 4 and 5 are horizontal distributions of correlation coefficient between the z500 and heavy



**Fig. 4:** (a) Linear trend of ERA-40 geopotential height at 500 hPa (z500) during June to July in the period of 1958-2002. (b) Horizontal map of correlation coefficient between z500 and time series of heavy precipitation during June to July in Japan.

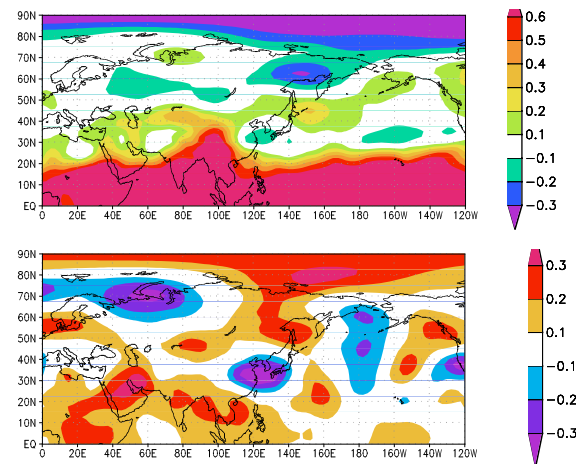
precipitation in the early summer and the late summer, respectively. These figures are considered to represent patterns favorable for occurrence of heavy precipitation. If the z500 trend pattern (upper figure) and the pattern of the correlation coefficients (lower figure) in Figs. 4 and 5 resembles to each other around Japan, more increasing tendency of the heavy precipitation over Japan is expected.

in the early summer (From Fig. 4) some qualitative similarity is seen as negative around Japan and positive in the south of Japan. No positive pattern corresponding to the strengthening of the Okhotsk high, however, is recognized in the lower figure. On the other hand in the late summer (Fig. 5), correlation pattern of the heavy precipitation with z500 has strong resemblance to trend pattern of z500; negative center in the East China Sea surrounded by positive circular belt region.

Above result suggests that change of large-scale fields is consistent with more increasing trend of heavy precipitation in August to September than in June to July.

#### 4. Summary

Frequencies of three hourly heavy precipitation averaged over 7 stations in Japan at the 1990s are higher than those at and before the 1950s. More increasing trend in early morning heavy precipitation is seen. When the early summer (June-July) and the late summer (August-September) are separately analyzed, heavy precipitation in the late summer has more increasing trend than those in the early summer and in the whole summer. Some resemblance between the two correlation patterns implies favorable large-scale condition for heavy precipitation increases recently. Analysis for the early and late summers reveals that in the late summer correlation pattern of the heavy precipitation with z500 has strong resemblance to trend pattern of z500. These results imply that change of large-scale field in the late summer around Japan brings about favorable condition for heavy precipitation in Japan.



**Fig. 5:** The same as Fig. 4 except for August to September.