NEW RECORD-BREAKING FREQUENCY OF ANNUAL MAXIMUM DAILY PRECIPITATION IN JAPAN

Graduate School of Engineering, Hokkaido University, Student Member, Chhay Ngorn SEANG
Faculty of Engineering, Hokkaido University, Official Member, Tomohito J. YAMADA

1. BACKGROUND

The changes of daily temperature extremes in global scale have affected the weather and climate extreme events (IPCC, 2014). Yamada et al.; (2014) illustrates that the water vapor and convective instability follow the Clausius-Clapeyron-like rate of change with 99th percentile hourly precipitation intensity[5)]. Lehmann, J. et al. (2015) proposed a statistical model in relation of warming air temperature and water holding capacity which also simply refers to the Clausius-Clapeyron model[4)]. This study, therefore, tries to investigate the characteristic of the record-breaking frequency of extreme events in Japan.

2. METHODS

Aphro_JP is used to calculate number of new record-breaking (Kamiguchi, K. et al, 2010). This data is the product of APHRODITE dataset, with 0.05°×0.05°grids except for some small islands. The gridded data is derived from rain-gauge data observed by the Japan Meteorological Agency. The number of rain gauges changed from less than 200 before 1977 to more than 1300 after 1977 when AMeDAS was launched[3)].

Estimated new record-breaking is done with an assumption in a steady state climate, followed by Independent Identical Distribution (iid)[1); 2)]. Theoretical new record-breaking is as follow, in time series with iid continuous distribution i = 1,2,3…,n is $X_i = x_1, x_2, x_3, \ldots, x_n$ which has a probability $1/n$ for x_n is a record. The probability written as $P_n(x_n = 1) = 1/n$ when the nth observation has higher value than previous observation, $x_n > \max(x_1, x_2, \ldots x_{n-1})$. Then $P_n(x_n = 0) = 1 - P_n(x_n = 1) = (n-1)/n$ is the probability of not having new record as $x_n \le \max(x_1, x_2, \ldots x_{n-1})$. If N is the different independent simultaneous observation, the probability of at least one new record breaking occur can be defined as $P_n^N(x_n = 1) = 1 - P_n^N(x_n = 0) = 1 - (1 - 1/n)^N$.

The probability is then simply denoted as

$$\begin{cases} P_n(x_n = 1) = \dfrac{1}{n};\ x_n > \max(x_1, x_2, \ldots x_{n-1}) \\ \qquad new\ record \\ P_n(x_n = 0) = \dfrac{n-1}{n};\ x_n \le \max(x_1, x_2, \ldots x_{n-1}) \\ \qquad no\ new\ record \end{cases}$$

For N is the different independent simultaneous observation

$$\begin{cases} P_n^N(x_n = 0) = \left(1 - \dfrac{1}{n}\right)^N;\ x_n \le \max(x_1, x_2, \ldots x_{n-1}) \\ \qquad no\ new\ record \\ P_n^N(x_n = 1) = 1 - P_n^N(x_n = 0) = 1 - \left(1 - \dfrac{1}{n}\right)^N; \\ \qquad x_n > \max(x_1, x_2, \ldots x_{n-1}) \\ \qquad new\ record \end{cases}$$

The Frequency analysis is followed by Gaussian Distribution for N different independent observation.

3. RESULTS

New record-breaking increases in both cases from 1978 to 2011 (**Fig.1**) and from 1951 to 2011 (**Fig.2**). The current result shows the observed number of new record trend mostly appears higher than the mean estimated by theory, yet the observed values noticeably increase only within mean and 1st standard deviation of the theory. By analyzing the daily precipitation data from 1978, the observed mean value is very close to the theory of the following year. On the other hand, the analysis using the same daily precipitation data from 1951 reveal the same condition but higher close to the first standard deviation. This result can be inferred that the longer time steps reveals the higher number of new record-breaking of extremes events.

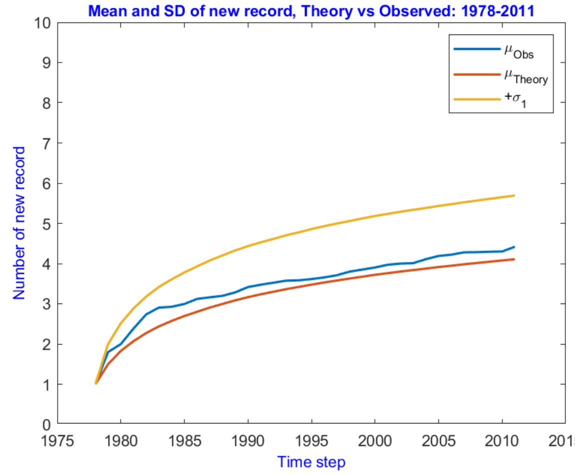

Fig.1 *Mean value of new record-breaking of Aphro_JP vs theory from 1978 to 2011.*

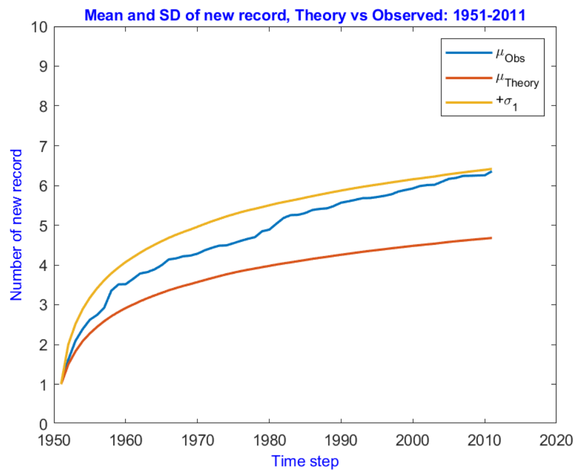

Fig.2 *Mean value of new record-breaking of Aphro_JP vs Theory from 1951 to 2011.*

However, this assumption is not totally sufficient when considering the historical change of the number of rain gauges before and after 1977.

Moreover, the increasing of observed number of new record-breaking can relate to the Clausius-Clapeyron relation with rising of 1℃ temperature cause increasing 7 % vapor pressure.

For more longer time step, two in situ observatories data are shown to be increased of extreme event in the past 117 years. With the significant extreme event curve of both data from rain gauges Sapporo station(**Fig.3**) and Tokyo station(**Fig.4**), end up with the similar increase within the past 2 decades.

From this result, the key point is thereby to denote the factor influent this rising of extreme events. The developing of new record theory, non-stationary climate, for not only thermodynamic change but also dynamical change can be the next target.

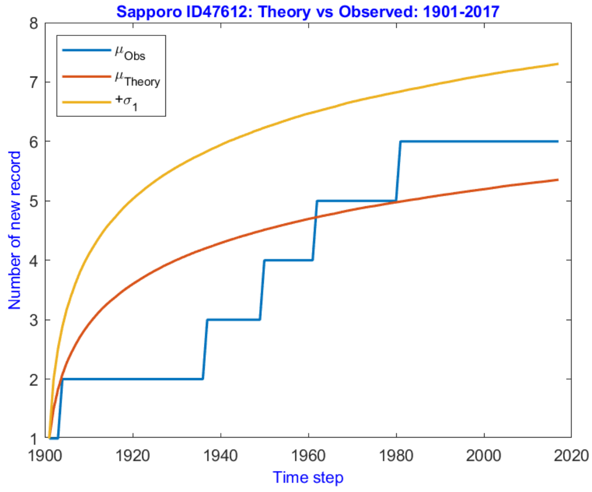

Fig.3 *New record-breaking of Sapporo station between a long term observation vs theory.*

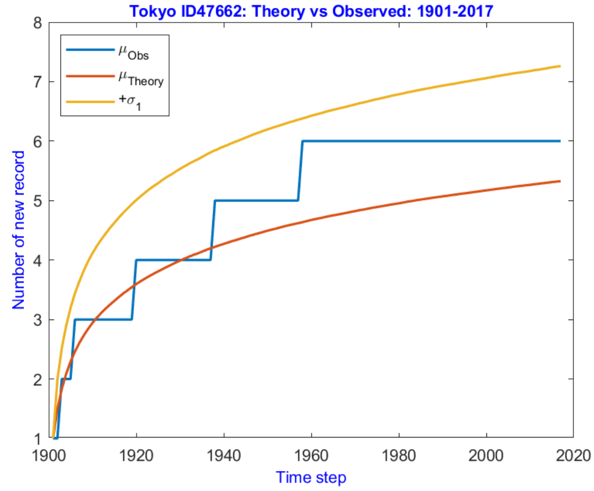

Fig.4 *New record-breaking of Tokyo station between a long-term observation vs theory.*

REFERENCES

1) Benestad, R. E.: 'How often can we expect a record event?', Climate Research, 25(1), pp. 3–13, 2003
2) Benestad, R. E.: 'Record-values, nonstationarity tests and extreme value distributions', Global and Planetary Change, 44(1–4), pp. 11–26, 2004
3) Kamiguchi, K. et al.: 'Development of APHRO _ JP, the first Japanese high-resolution daily precipitation product for more than 100 years', 64, pp. 60–64, 2010
4) Lehmann, J. et al.: "Increased record-breaking precipitation events under global warming." Climatic Change, 132(4), 501–515, 2015
5) Yamada, T. J. et al.: 'Extreme precipitation intensity in future climates associated with the Clausius-Clapeyron-like relationship', Hydrological Research Letters, 8(4), pp. 108–113, 2014