Degree of Experience and Durability — Indices for Two Types of Extrapolating Sea Extremes

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ABSTRACT

Extrapolation plays an essential role for evaluating sea extremes frequencies, which is why the concept of return period has been introduced. But we use the return period (or the extrapolation) without being aware of the hidden double meanings. Speaking shortly, the return period employed in handling the past record is substituted for the period of the coming successive event in the future. We can obtain the design force (the return level) by extrapolation of the observed data in the past years, while we should apply it for the future by the extension, which is another extrapolation.

KEY WORDS: Return period, degree of experience, durability, Gumbel distribution

INTRODUCTION

Surprising mega disasters are encountered recently over the world, though it should occur rarely. Japan Tohoku Earthquake and Tsunami disaster, Hurricane Irene’s direct hit to New York City, and Thailand vast flooding in 2011, Pakistan and China floods 2010, the England’s worst recorded day of rain in the Nov. 2009, and other many cases to mention in the histories of the world. Whenever such an exceptional event is happend, we have somehow tried to interpret the data set by fitting it to an extreme value distribution. In many previous literatures, Petrukas and Aagaard (1970), Goda (2010) and etc., Weibull distribution (which has no upper bound, and is distinguished with the EV type III) has been employed, because of the flexibility for goodness of fit. However it wasn’t always rewarded. Otherwise, we conclude that it is not rare event, but it becomes to happen likely due to the climate change, which will be very difficult to verify in most cases. We were getting into a dead end.

One of the most essential aspects of extreme value analysis is extrapolation. There should be an limit to extend the extrapolating line. In this study, firstly we introduce the degree of experience, which gives the critical condition for the limit. Secondly, we will show another type of extrapolation for the extreme value analysis. Return period has been applied without respecting its two aspects: local and global ones. The return values are generally calculated by considering the reciprocal number of return period as an occurrence rate (or exceedance probability) per one year, which is an instantaneous quantity defined in the local aspect. On the other hand, the return period should be literally confirmed as the averaged time interval for the successive occurrences, which is the global sense. In the latter viewpoint, we invent the durability, which is additionally derived from the degree of experience, to demonstrate the estimation error accompanied with the passage of time even for the stationary time series of extremes. As the consequence, for an honest example, the validity of the estimated 50 year return level, based on the 50 years observation record, will not last over 50 years, even though any trend is not supposed due to the climate change.

RETURN PERIOD AND THE OCCURRENCE RATE

Primary we employ the definition of return period:

$$R = \frac{1}{\lambda(x_R)}$$  \hspace{1cm} (1)

where $\lambda(x)$ is the occurrence rate of exceeding the level $x$, which will be described later in detail. It differs from the usual definition of return period: $\varepsilon$

$$\varepsilon R = \frac{1}{1 - F(x_R)}$$  \hspace{1cm} (2)

where $F(x)$ is the cumulative probability function of the annual maximum level $x$. The return period is the expected time interval of the successive occurrences of exceeding the level. Frankly speaking, it is the mean period, and the frequency is the occurrence rate per unit time. The difference of both definitions of return period is due to the unit time for the occurrence. For the usually employed definition of Eq. (2), the unit time is one year and the event is annual maximum. So, it is one or zero time that the annual maximum will exceed the level. It is never twice. On the other side, for the definition of Eq. (1), it takes into account several times of annual occurrence. It will be said that it is the return period for Peaks Over Threshold (POT). The definition can be allowed to use, even though the wave data is not recorded as the POT but the annual maximum or the annual largest values of sea extremes (wave heights, sea levels and so on).

From Eq. (1), the return level $x_R$ is linked to the parameters $\mu$, $\sigma$ and $\xi$, which will be shown in the case of a generalized extremes value distribution, and the occurrence rate.