

## Supplementary Materials

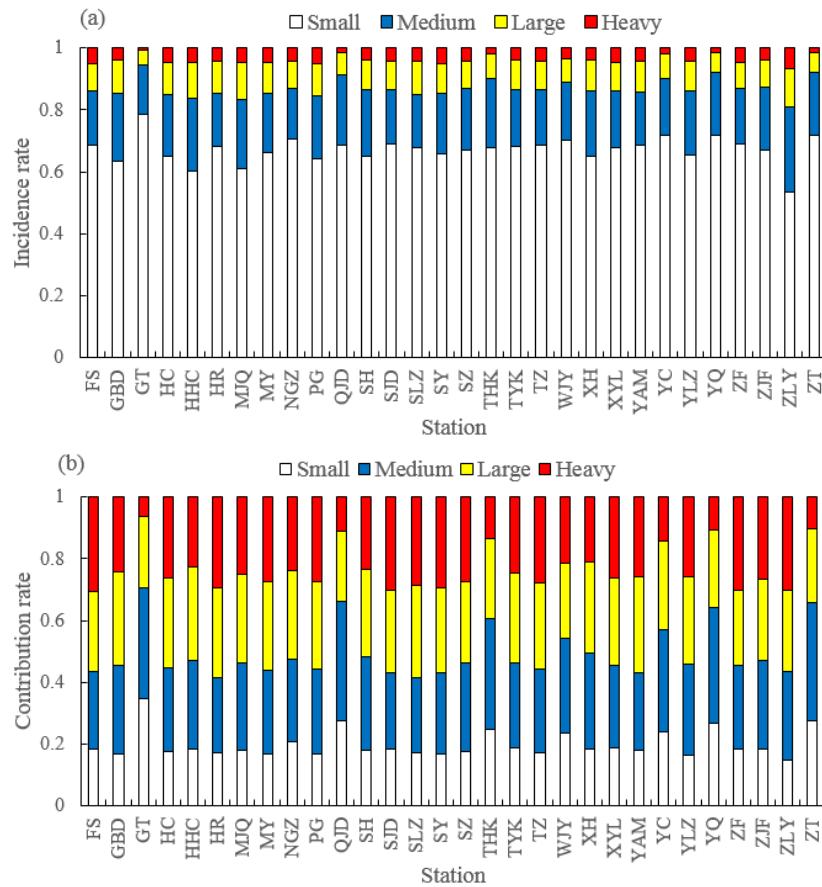


Figure S1: The incidence (PI) and contribute (PC) of different precipitation grades to the total frequency and amount for the 30 stations during 1960-2012.

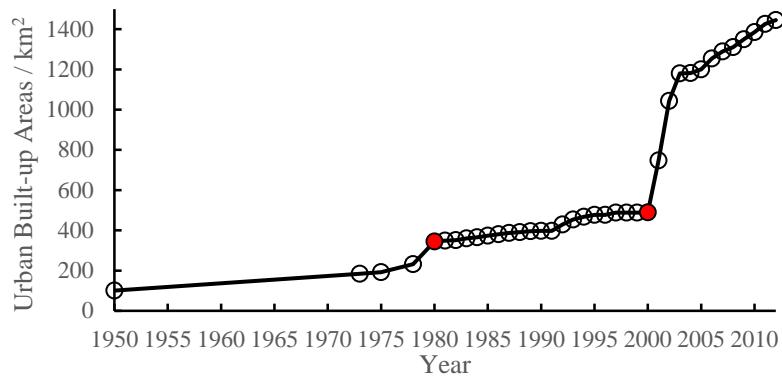


Figure S2: The urban built-up areas in Beijing during 1950-2012.

## **Supplementary Material Description**

In order to further discuss the precipitation frequency and amount for different grades in different stations, the indices PI (precipitation incidence) and PC (precipitation contribution) were used based on the work from Song et al. [39]. PI can be calculated by Eq.S1

$$PI_i = \frac{PD_i}{\sum_{i=1}^n PD_i} \times 100\% \quad (S1)$$

and PC can be calculated by Eq.S2

$$PC_i = \frac{PA_i}{\sum_{i=1}^n PA_i} \times 100\% \quad (S2)$$

where  $n$  is the number of precipitation grades (in this work,  $n=4$ ) and  $i$  means the  $i$ -th precipitation grade, such as small, medium, large and heavy. PD means the number of precipitation day for the  $i$ -th precipitation grade in a year. And PA means the precipitation amount for the  $i$ -th precipitation grade in a year.

The results of PI and PC for different grades in the different stations are shown in Figure S1. Overall, the largest PI is small precipitation, followed by medium and large precipitation, and the lowest is heavy precipitation. All the PI values except ZLY station for small precipitation are larger than 60%, ranging from 53.4% to 78.4% with a mean of 67.1%. The PI for medium precipitation ranges from 16% to 27.6% with a mean of 19.7%. While the mean PI values for large and heavy precipitation are both smaller than 10%. From the view of precipitation amount, the PC for small precipitation is the lowest, ranging from 15% to 34.7% with a mean of 20%, followed by heavy precipitation (23.4%, ranging from 6.3% to 30.5%) and large precipitation (27.5%, ranging from 22.6% to 30.9%), and the largest is medium precipitation (29.2%, ranging from 24.1% to 38.6%). Generally, small precipitation has the largest contribution in frequency but the least in amount. While heavy precipitation has the least contribution in frequency but a relatively higher in amount.

In this work, we also discussed the effects of urbanization on the precipitation pattern during the different periods. We took the urban built-up areas as an index to assess the urbanization levels in Beijing. The data came from the Beijing Statistical Yearbook, as shown in Figure S2. We can see that the urbanization in Beijing can be classified into three phases with two change points (1980 and 2000). As we all known, the pace of urbanization in China was relatively slow even stagnant before the Reform and Opening in 1978. The urban expansion in Beijing mainly started in 1980, and the urban built-up areas increased from 345km<sup>2</sup> in 1980 to 490km<sup>2</sup> in 2000 with a gentle speed. However, the urban expansion became accelerated in 2001 due to the requirements for Beijing Olympic Games.