

## A REVIEW OF RECENT RESTORATION OF THE CHUGUGI RAINFALL DATA (1770~1910) IN KOREA

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### ABSTRACT

The ancient rainfall gauge, “*Chugugi or Chuk-Woo-Kee*”, was invented in 1441, in the Joseon Dynasty. Precipitation data for Seoul have been recorded since 1770, representing one of the world’s longest instrumental measurement in daily precipitation. The *Chugugi* is a cylinder with a diameter of 14.7 cm and a height of about 45.5 cm. The depth of precipitation collected in the *Chugugi* is measured with a standard ruler. It was installed at the Palace and Meteorological Agency in the capital area and at the supervision of each province offices in the local area. Wada firstly introduced the *Chugugi* and compiled a monthly precipitation data set. Lim and Jung re-compiled the *Chugugi* data set from two sets of royal diaries from the Joseon Dynasty, “*Seungjungwonilgee*” and “*Ilseungrok*” for the Seoul. Jhun and Moon reconstructed daily precipitation record. Another rainfall record set were founded in official local government reports, “*Gaksadeungnok*” for the whole province. The *Wootaek* is an indirect method of measuring the amount of rainfall into the soil. There are 372 rainfall stations including *Chugugi* and *Wootaek* in nation-wide after 1770. These precipitation data were restored and can be a guidance to understand the climatic tendency of 19th century of Korean peninsula.

*Keywords:* Chugugi, Wootaek, Joseon Dynasty, annual rainfall variation, rainfall observation network

### 1. INTRODUCTION

The history of rainfall observation in Korea goes back to 1441, in the early period of the Joseon Dynasty. The “*Chugugi or Chuk-Woo-Kee*”, was invented by the King Sejong and distributed to nation-wide. According to the annals of Joseon Dynasty, heavy rains and severe drought alternated in early 15<sup>th</sup> century. But the invented instruments were lost and the rainfall observation network was collapsed after the wars (1592~1598, 1636~1637) against Japan and Qing, China. In 1770, King Yongjo made bronze rain gauges in accordance with the specification established by the King Sejong in 1441. He also reconstructed nation-wide rainfall observation network. A reliable precipitation data for Seoul have been recorded since 1778, representing one of the world’s longest instrumental measurement in daily precipitation. The *Chugugi* is a cylinder with a diameter of 14.7 cm and a height of about 45.5 cm. The depth of precipitation collected in the *Chugugi* is measured with a standard ruler. It was installed at the Palace and Meteorological Agency in the capital area and at the supervision of each province offices in the local area.

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These rainfall data were restored and can be a guidance to understand the climatic tendency of 19th century of Korean peninsula. In this study, the brief history of the instrumental rainfall gauge, *Chugugi* and the national rainfall observation network and report system in the Joseon dynasty, and recent research using the rainfall data of the *Chugugi* will be introduced.

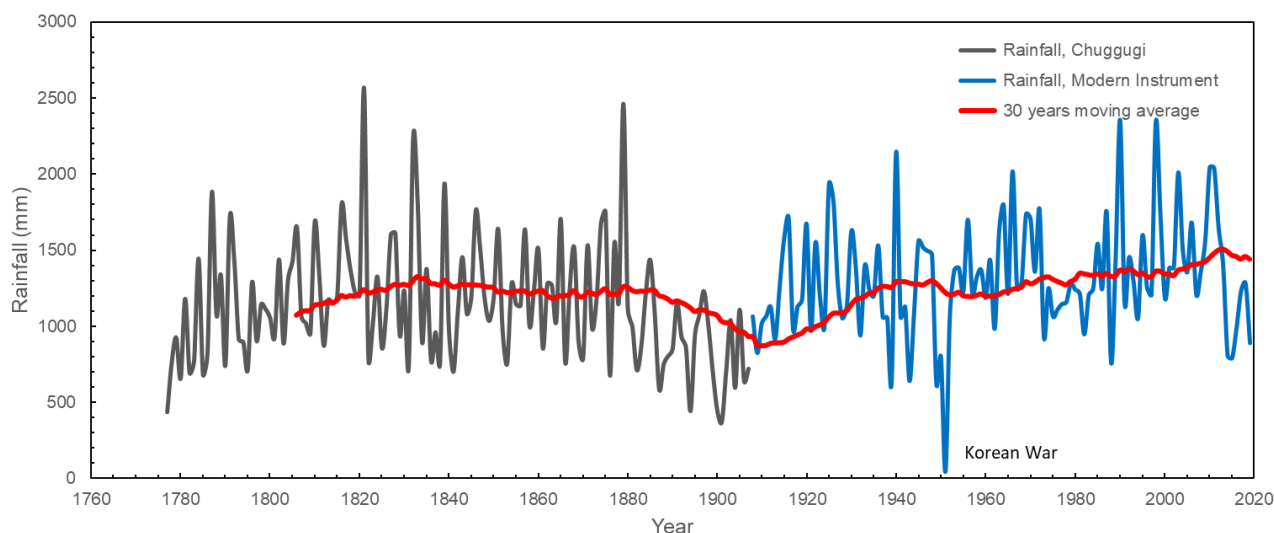


Figure 1. The variation of annual rainfall and thirty years moving average from 1778 to 2019 measured by ancient and modern rainfall gauge in Seoul, Korea. There is a big drought spell in the late 19<sup>th</sup> century and one year of rainfall record (Nov. 1950 ~ Nov. 1951) was missing by the Korean War.

Table 1. Research reports and articles on the *Chugugi* and using rainfall data measured

SOURCES	YEAR	MAIN FINDINGS
<b>KING SEJONG</b>	1441	Invention of rainfall gauge, <i>Chugugi</i> , nation-wide network
<b>KING YONGJO</b>	1770	Rebuild <i>Chugugi</i> , nation-wide network
<b>WADA</b>	1910, 1917	Introduce, re-compile monthly rainfall data set
<b>TADA</b>	1938	Annual precipitation
<b>JEON</b>	1963	Introduce <i>Chugugi</i> to Science History Society
<b>KIM</b>	1976	Summer precipitation
<b>CHO AND NA</b>	1979	Secular variation of the rainfall
<b>LIM AND JUNG</b>	1992	Interannual variability with annual rainfall data
<b>JHUN AND MOON</b>	1997	Reconstruction of daily rainfall data set
<b>CHUN AND JEON</b>	2005	Introduce <i>Chugugi</i> to Meteorology History Society
<b>BOO ET AL.</b>	2006	Restoration of 18 years rainfall in Gongju
<b>WANG ET AL.</b>	2006	Summer monsoon precipitation
<b>HA AND HA</b>	2006	Interannual fluctuation with monthly rainfall data
<b>KIM ET AL.</b>	2010	Interdecadal variability of monsoon precipitation
<b>KIM ET AL.</b>	2012	Restoration 19c rainfall data in Wonju, Hamheung, Haeju
<b>CHO ET AL.</b>	2015	Review and introduce the rainfall observation network
<b>JANG ET AL.</b>	2017	Drought frequency analysis using annual rainfall data
<b>YOO ET AL.</b>	2018	Comparison of annual maximum rainfall events
<b>KIM AND JANG</b>	2019	Compare extreme floods with daily rainfall data

## 2. RESTORATION AND ANALYSIS OF ANCIENT RAINFALL, *CHUGUGI*

### 2.1 First phase (1910s~1980s)

In this period, the rainfall measuring instrument, *Chugugi*, and document of rainfall data that were recorded were found and introduced by a Japanese meteorological scientist, Wada Yuji (1859~1918). In 1910, he firstly reported the Korean meteorology – old and new, in *Nature* (Wada, 1910). He also reported the ancient meteorological observation of Korea in 1917. In this report, he analyzed monthly rainfall data and suggested correction factor for ancient rainfall to modern. Tada (1938) analyzed the periodicities of annual rainfall and Arakawa (1956) reported the reliability and secular characteristic. The meteorological history of the Joseon

Dynasty was introduced by Jeon (1963) and secular variation analysis (Kim, 1976; Cho and Na, 1979) were carried out.

## 2.2 Second phase (1990s~2000s)

In this period, the ancient rainfall data set was re-constructed through the comprehensive and massive investigation on historical documents, “*Seungjungwonilgee*” and “*Isungrok*”. Lim and Jung (1992) re-compile annual rainfall and analyze interannual variability using modern statistic skills. Jhun and Moon (1997) reconstructed daily precipitation record. The fluctuation of monthly rainfall for the monsoon season was also suggested (Ha and Ha, 2006; Wang et al., 2006). Boo et al. (2006) found 18 years rainfall data observed by the *Chugugi*, in Gongju from the ancient official document, “*Gaksadeungnok*”.

## 2.3 Third phase (2010s~)

In the recent period, more expanded investigation to find ancient rainfall data set was performed. The records of “*Wootaek*” were found in “*Gaksadeungnok*”. The *Wootaek* is an in-direct method of measuring the amount of rainfall into the soil. During the reign of King Yongjo, the nation-wide rainfall observation network was re-established with 14 *Chugugi* observation stations and the 352 local authorities such as Bu, Gun, Hyeon to conduct by the *Wootaek*. Later on, six more *Chugugi* stations were established (Fig 2).

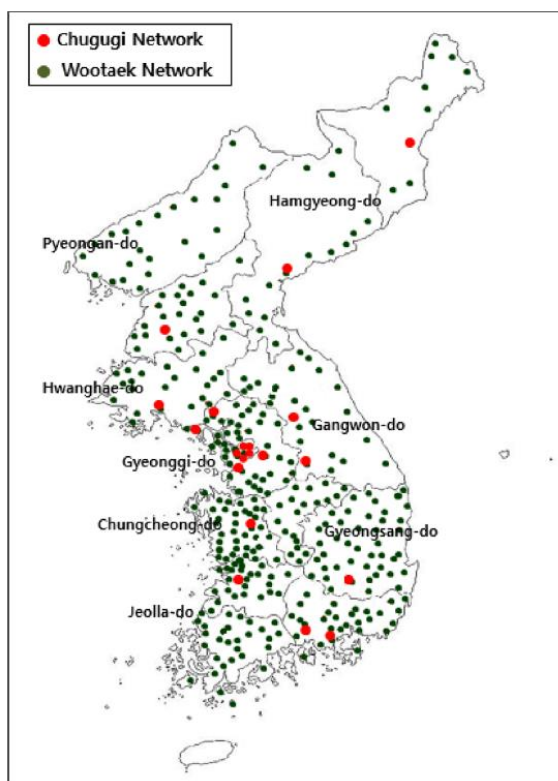


Figure 2. The rainfall observation network of *Chugugi* and *Wootaek* by province during Joseon Dynasty, after 1770. The total number of rainfall stations is 372; 20 (*Chugugi*), 352 (*Wootaek*) in 1897. (Cho et al., 2015).

In addition, the research field using the ancient rainfall was spread out to the hydrology and water resources (Jang et al., 2017; Lee and Kim, 2018; Kim et al.; Yoo et al., 2018; Kim and Jang, 2019). Kim and Jang (2019) reported the relation of extreme rainfall and severe flood events. The largest daily rainfall observed in Seoul, 394 mm was measured on July 16, 1885 and 520 houses were swept away. The flood on July 19, 1832 was most severe with 348 mm. Over 3,100 houses were washed out and 64 persons were drowned.

## 3. CONCLUSIONS

The valuable one of the world’s longest ancient rainfall data set in Seoul, Korea was investigated from earth 20<sup>th</sup> century. The reliability was proved by successive researches and the recent investigations revealed more rainfall data set in nation-wide with direct and indirect rainfall measurement. The interannual periodicity and fluctuation of monthly rainfall using over 200-years long term rainfall records were carried out and compared

with recent meteorological characteristics. The international cooperative research is anticipated to understand the climatic tendency of Asian countries and reduce the water-related disaster.

## ACKNOWLEDGMENTS

This research was supported by the research program (20200041-001) of the Korea Institute of Civil Engineering and Building Technology.

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