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Korea Climate Change trend with the changing of precipitation

Ihn-Cheol Seong[1)], Eun-Byul Kim[2)], Baek-Jo Kim[3)], Woo-Sik Jung[1)], Jong-Kil Park[4)#+]

[1] Dept. of Atmospheric Environment Information Engineering, [2] Atmospheric Environment Information Research Center(AEI), Inje University, South Korea
[3] National Institute od Meteorological Sciences, South Korea [4] Dept. of Environmental Engineering , AEI, Inje University, South Korea
[#]Corresponding author: envpjk@inje.ac.kr [+]Presenter

INTRODUCTION

- In the Korean Peninsula, the total annual amount of precipitation in the 2010s increased by approximately 19% compared to the 1910s(NIMA, 2009). In particular, precipitation patterns and intensities have changed, with the result that localized heavy rain frequently comes in summer with higher intensity. Accordingly, meteorological disasters of greater magnitude have occurred, causing more extensive damage(Park et al., 2008).
- Recently, according to climate change, annual total precipitation in most regions of South Korea, including Busan, has increased slightly, while average hourly precipitation intensity has increased significantly and morning shift phenomenon has pronounced, which is an increase in the frequency and intensity of hourly precipitation during the morning(Seong, 2012, Park et al., 2013; 2014).
- Although studies on the transition to subtropical climate regions and changes in precipitation patterns in the Korean Peninsula have been conducted continuously, studies specifically on the concrete changes in precipitation patterns caused by transition to subtropical climate regions and the effects of such changes on the occurrence of meteorological disasters have been lacking.
- it is essential to project more accurate future climate for an assessment of climate change impact and adaptation strategy.

Objective

- The purpose of this study is to the climate change trend from under-standing the variation of precipitation pattern and intensity in Korea using observed 40-year(1971-2009) data.

DATA and METHODS

Data

❖ **Data**

- In order to analyze the characteristics of changes in the amounts of precipitation, precipitation frequencies and precipitation intensities.
- Station : 26 points(long-term meteorological observation)
- Period : from 1970 to 2009(40 years)

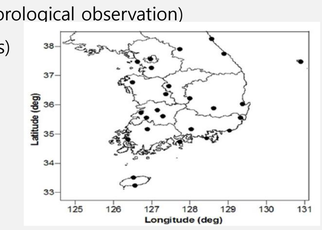


Fig. 1. Geographical distribution of meteorological observation sites

❖ **Selection of effective data**

- Three points, **Jeongeup**, **Ismail** and **Buan**, had observational data for three years from 1970 to 1972, but covering only 33.3% of this period. Therefore, these points were excluded from analysis for this period.

Method

❖ **Hourly precipitation and intensity**

- days with precipitation phenomena generally means days in which the daily precipitation is 0.1mm or more

❖ **Hourly precipitation and intensity**

- hourly amount of precipitation [P(h), mm] means the amount of precipitation observed for one hour at an observation point. And the number (F(h)) of hours with precipitation means the number of times when the hourly amount of precipitation is at least 0.1mm
- hourly precipitation intensity [PI(h), mm/h] refers to the value obtained by dividing the sum of hourly amounts of precipitation by the number of hours with precipitation during a given period of time

$$PI(h) = \sum P(h) \div F(h)$$

- IRA(increase rates based on average) of the hourly amounts of precipitation at 01:00 for 40 years was defined as follows;

$$IRA_{(01h)} = (TPe_{(01h)(2009)} - TPe_{(01h)(1970)}) \ / \ AP_{(01h)(1970\text{-}2009)}$$

❖ **Classification of daily variation type of precipitation**

- Morning shift phenomenon or not : A type characterized by a more than 55 % of daily precipitation is focused on the morning(morning shift phenomenon), or not b type and M-shaped type which is precipitation peak in morning and afternoon relatively, was classified C type.
- Morning shift deepening or not : a type characterized by the precipitation rate trend line of the morning is greater than 1.5 times of that of the afternoon, or not b type.

Table 3.1 Criteria for classifying 26 sites into several groups

Type / Trend	Morning shift(A)	Not morning shift(B)	M-shaped pattern(C)
Growing severely in morning concentration (a)	Aa	Ba	Ca
Not growing severly in morning concentration (b)	Ab	Bb	Cb

RESULTS

Classified pattern with their criteria

❖ **Table 3.2 List of classified pattern with their criteria**

Items / Sites	Ratio of precipitation in the morning (%)	Slope of trend curve of precipitation in the morning (SM)	Slope of trend curve of precipitation in the afternoon (SA)	Slope ratio of SM curve to SA curve	other features	classified pattern
Buan	56	2.53	0.78	3.2	-	Aa
Busan	57	4.39	2.22	2.0	-	Aa
Cheongju	54	1.24	2.19	0.6	M-haped	Cb
Chuncheon	54	3.22	2.4	1.3	-	Bb
Chupungnyeong	50	2.39	1.43	1.7	M-haped	Ca
Daegu	52	0.56	1.87	0.3	-	Bb
Daejeon	52	3.41	1.26	2.7	M-haped	Ca
Gangneung	50	2.9	5.0	0.6	-	Bb
Gwangju	53	0.86	1.94	0.4	M-haped	Cb
Imsil	53	1.25	2.24	0.6	-	Bb
Incheon	57	1.51	4.05	0.4	-	Ab
Jeju	57	2.03	1.13	1.8	-	Aa
Jeongeup	52	2.1	1.52	1.4	M-shaped	Cb
Jeonju	52	1.56	2.03	0.8	M-shaped	Cb
Jinju	54	1.03	0.14	7.4	M-shaped	Ca
Mokpo	56	0.61	2.33	0.3	-	Ab
Pohang	53	2.2	2.59	0.8	-	Bb
Seogwipo	55	4.35	0.44	9.9	-	Aa
Seosan	58	0.99	2.42	0.4	-	Ab
Seoul	55	2.7	5.54	0.5	-	Ab
Sokcho	52	3.45	3.27	1.1	M-shaped	Cb
Suwon	54	1.14	2.94	0.4	-	Bb
Tongyeong	57	3.9	1.1	3.5	-	Aa
Ulneungdo	53	6.45	5.64	1.1	-	Bb
Ulsan	54	1.78	1.18	1.5	-	Ba
Yeosu	56	2.1	0.78	2.7	-	Aa
Average	54	2.33	2.25	1.82	-	-
Median	54	2.1	2.11	1.1		

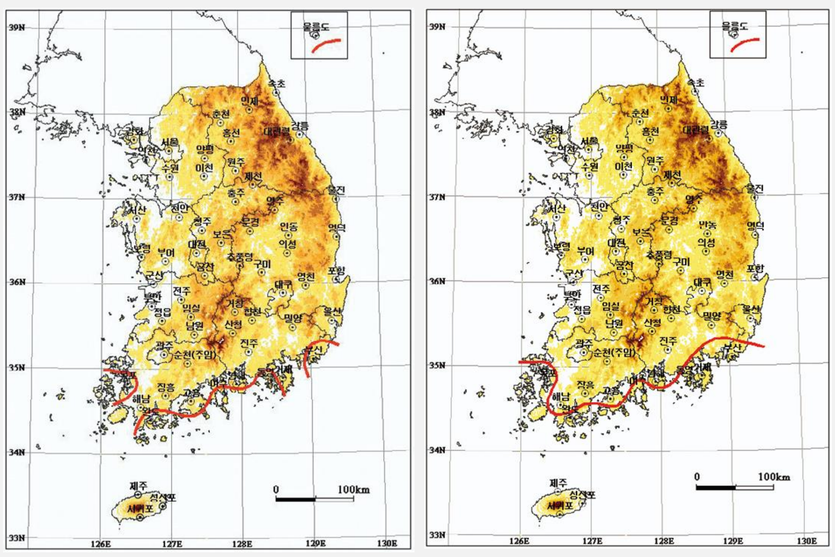
List of percentage and site names in each class and group

❖ **Table 3.3 List of percentage and name of sites in each class and group.**

Group / Class	Site names(Number of site)	%
A — Aa	Buan, Busan, Jeju, Seogwipo, Tongyeong, Yeosu (6)	23.1
A — Ab	Incheon, Mokpo, Seosan, Seoul (4)	15.4
B — Ba	Ulsan (1)	3.9
B — Bb	Chuncheon, Daegu, Gangneung, Imsil, Pohang, Suwon, Ulneungdo (7)	26.9
C — Ca	Chupungnyeong, Daejeon, Jinju (3)	11.5
C — Cb	Cheongju, Gwangju, Jeongeup, Jeonju, Sokcho (5)	19.2
Total	26 sites	100

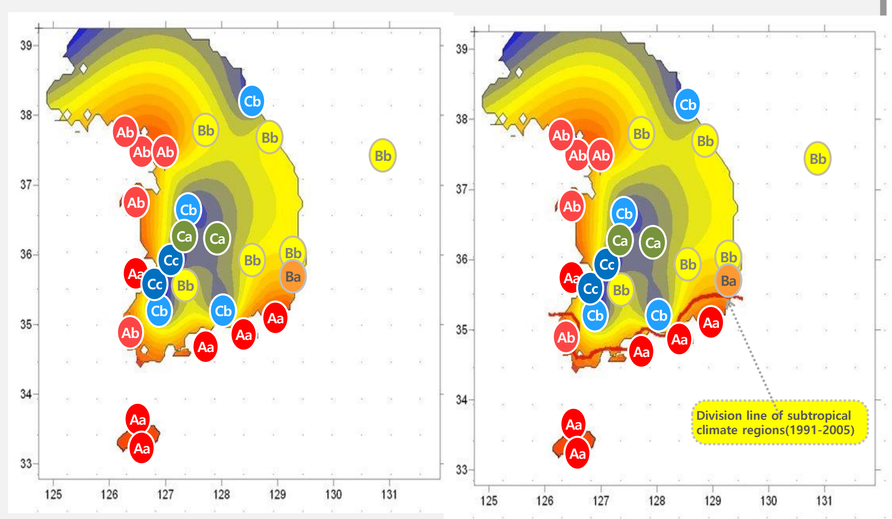
Sub-tropical climate regions in Korea

❖ **Sub-tropical climate regions(1976-1990(Left) and 1991-2005(right)) by Trewartha's climate classification In Korea(Kwon et al., 2007; NIMR, 2006)**

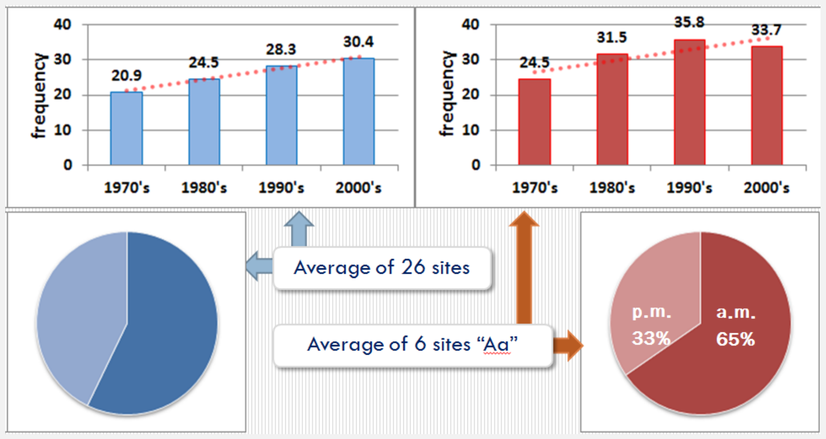


Sub-tropical climate regions classified by this study in the Korean peninsula

❖ **Distribution of classes categorized according to the patterns of daily variation of precipitation(left) and subtropical climate regions applied to division line of Trewartha's climate regions(19971-2005).**



❖ **Frequency of torrential heavy rainfall increases in all areas of the Korean peninsula(1970-2009)**



CONCLUSIONS

- Using the hourly precipitation data collected over 40 years (1970-2009) from 26 weather stations in the Korean peninsula, we analyzed the daily change patterns of precipitation and the deepening of morning shift phenomenon.
  ➔ the distribution of Aa type, which is concentrated precipitation of more than 55 percent (morning shift phenomenon) and the precipitation rate trend line of the morning is greater than 1.5 times of that of the afternoon, revealed at the southern coast of Korea, including Jeju-do and these regions were already classified as a subtropical climate region in the 1970's.
  ➔ the distribution of Ab type, which is concentrated precipitation of more than 55 percent (morning shift phenomenon) and the precipitation rate trend line of the morning is less than 1.5 times of that of the afternoon, revealed at the western coast of Korea.
- Therefore we could expect these regions will become a subtropical climate and estimate degree of climate change from these methods.

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