Weather and Climate

The spatial distribution of climate in Korea is determined by key climate factors such as latitude, elevation, geographical location, land/sea heating properties, ocean current, the East Asian Monsoon system, and air mass. During the summer, it is hot and humid, but during the winter, it is cold and dry in response to the East Asian Monsoon.

The difference in temperature between the northern area and the southern area is clear. This is because the amount of solar energy received and difference in length of daylight vary with latitude, for the north-south stretched characteristic of the Korean Peninsula. The difference in annual mean air temperature between Seogwipo (16.6˚C), located at the southernmost tip of South Korea (33˚ 14' N), and Cheorwon (10.2˚C), located at the northernmost tip (38˚ 08' N) of South Korea, demonstrates a wide variation in air temperature with latitude.

The climate features vary depending on elevation. The annual mean air temperature at Daegwallyeong (773 m), the highest located observation station in South Korea, is 6.6˚C, which is 3.7˚C lower than that at Hongcheon (10.3˚C), which is at 141 m and located at a similar latitude. The difference in the mean air temperature is also found in the southern area between Imsil (248 m) and Jeongeup (45 m), with 11.2˚C and 13.1˚C, respectively.

The geographical location also makes a difference in climate. The Taebaeksanmaek (Taebaek Mountain Ranges) acts as a barrier to the flow of air and brings a marked difference in climate between the Yeongseo area (windward side) and Yeongdong area (leeward side). When a cold northwesterly wind dominates over the Korean Peninsula during the winter, the air temperature at Chuncheon, located in the Yeongseo area, is low. Whereas in Sokcho, located in the Yeongdong area, the temperature increases. The average temperature for the warmest month, August, in Chuncheon (24.6˚C) is higher than that in Sokcho (23.7˚C), while the average temperature for the coldest month, January, in Chuncheon (-4.6˚C) is much lower than that in Sokcho (-0.3˚C). However, as a northeasterly wind blows over the Taebaeksanmaek, Chuncheon becomes warmer while Sokcho becomes colder. In addition, when the northeasterly wind crosses the East Sea with its warm current flows and is forced to rise over the mountain barrier, heavy snow occasionally falls in Yeongdong area as a result.

Korea is largely characterized by a continental climate due to the effects of the Eurasian continent. However, the climate of the coastal areas, which is mostly governed by the ocean, differs from that of the inland areas. The annual mean temperature range for Daejeon is only 0.3˚C greater than that of Boryeong, which is adjacent to the coast. The average temperature during the summer (months of June, July, and August) in Daejeon is approximately 1.3˚C higher than that in Boryeong.

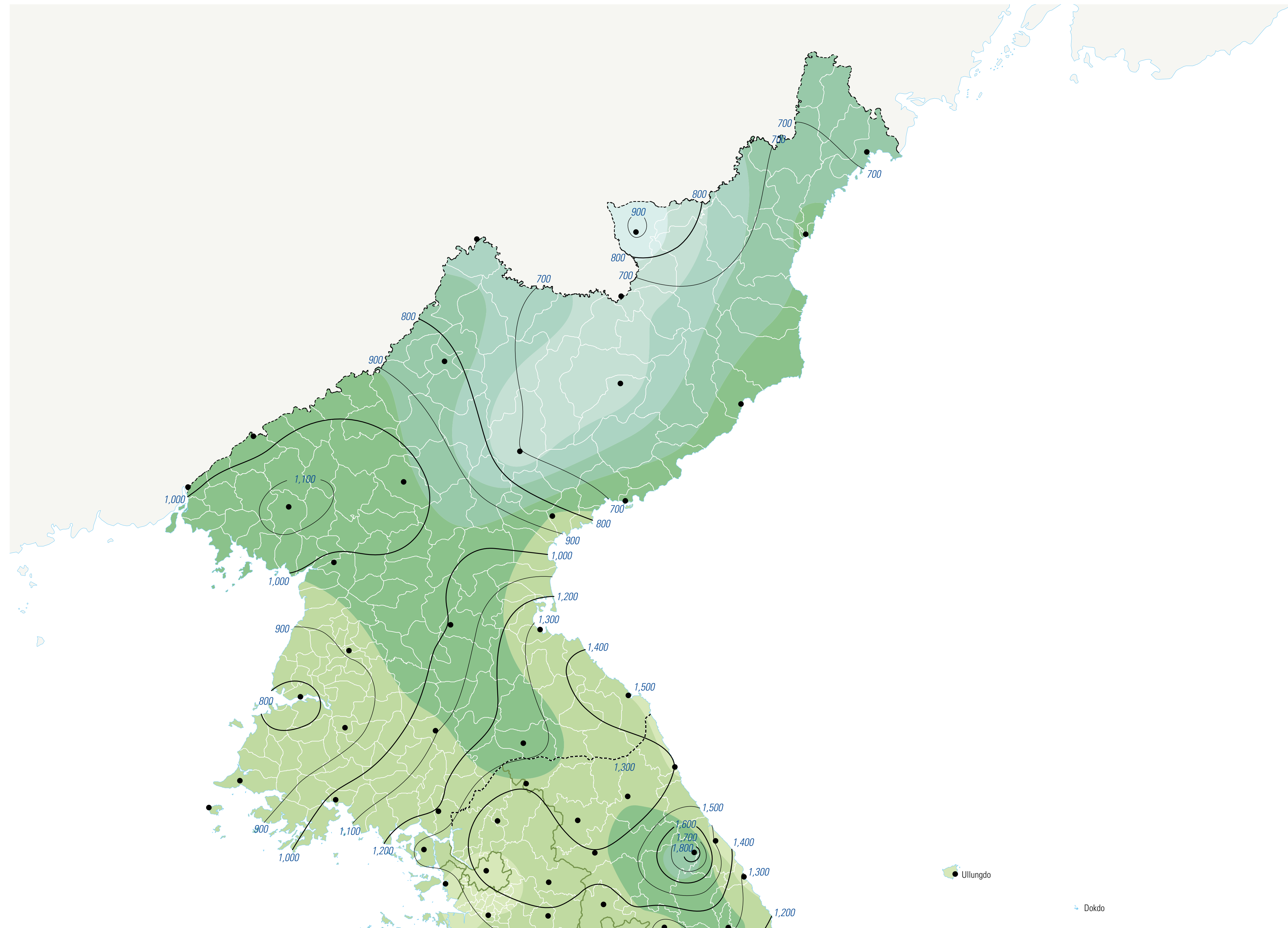
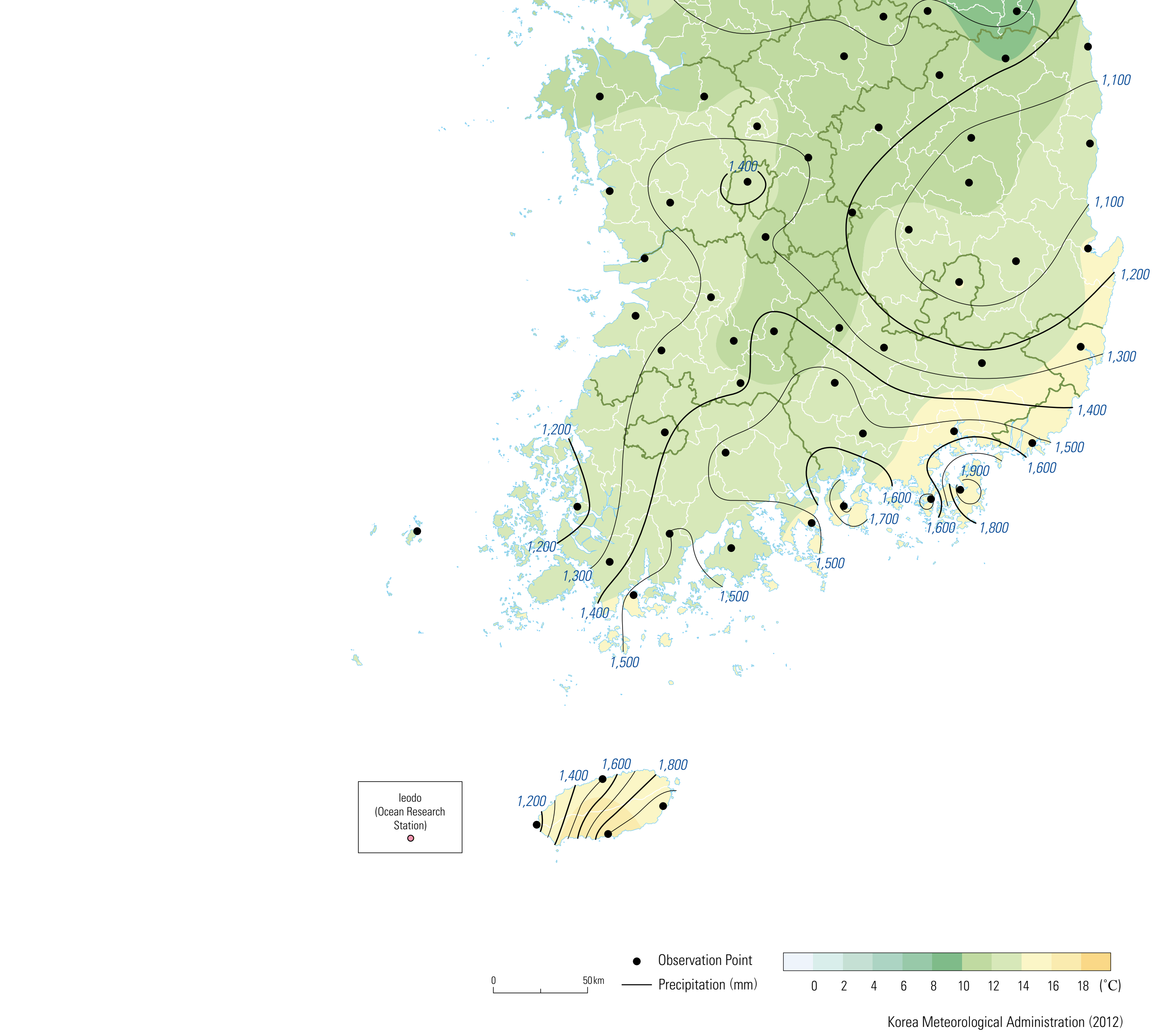
Ocean currents can also affect the climate of Korea: the East Korean Warm Current and North Korean Cold Current in the East Sea, and the Yellow Sea Warm Current in the Yellow Sea. The East Korean Warm Current, diverging from the Tsushima Current at the eastern end of the Korea Strait, flows along the eastern coast of Korea and provides warm ocean water up to the latitude of 37˚ – 38˚ N. Part of the current flows north up to the coast of Goseong, Gangwon-do, and affects the climate of the surrounding area. The North Korean Cold Current, a part of the Liman Current flowing from the Sea of Okhotsk, flows southward along the coast of Hamgyeong-do and reaches down to the southern region of Gangwon-do during the winter. The Yellow Sea Warm Current, a tributary of the Tsushima Current, flows from the western waters of Jejudo to the southern part of the Yellow Sea and occasionally exerts influence on the climate of the west coast. The northward movement of the Yellow Sea Warm Current weakens during the winter, while the inflow becomes stronger during the summer.

The Asian monsoon system over East Asia (including Korea, China, and Japan) is formed due to the land-sea distribution and the associated difference in heating properties. While cold, dry wind blows into the Korean Peninsula in the winter due to the continental effect, hot and humid wind blows into Korea during the summer due to the effect of the North Pacific. The climate of Korea is also under the influence of various air masses such as the Siberian, the North Pacific, the Okhotsk Sea, and equatorial air mass.

The classification of natural seasons based on the criteria of daily mean air temperature, daily maximum air temperature, and daily minimum air temperature results in regional differences in beginning date and number of days for each season. Spring comes the earliest in Busan (February 10), apart from Seogwipo, while it comes the latest in Daegwallyeong (April 10). Besides Daegwallyeong (August 8) and Sokcho (July 8), summer mostly begins between late May and early June, lasting about 70 – 120 days. Autumn starts around the middle of September, with shorter duration (60 – 80 days) than spring and summer. Winter generally commences around late November, lasting about 100 – 130 days.

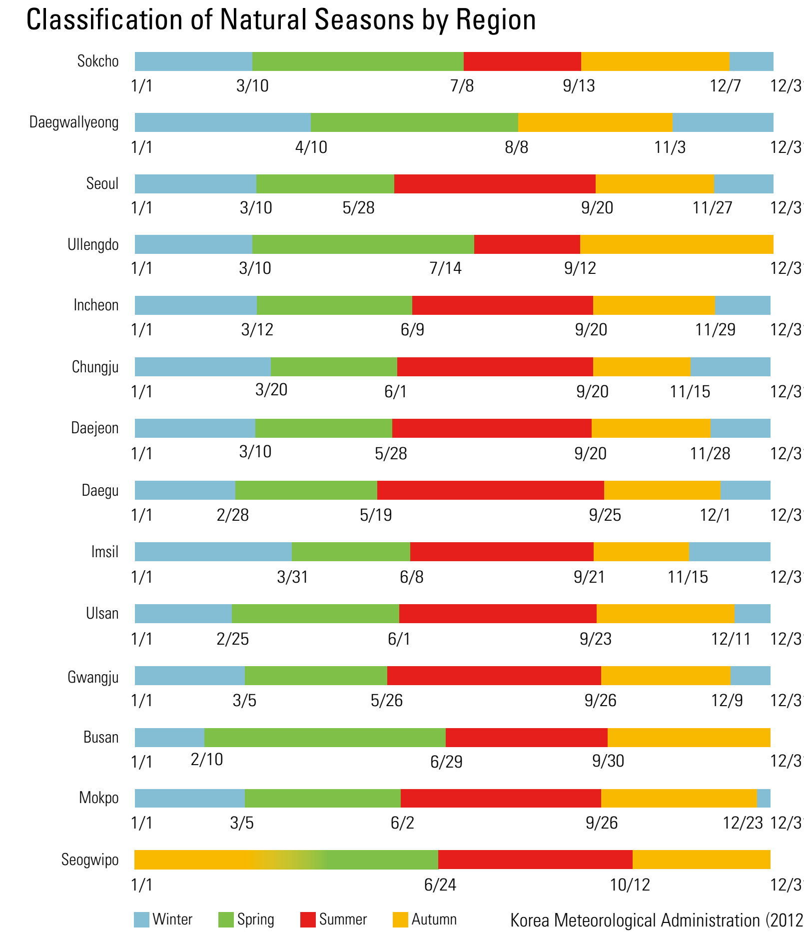
Climate Overview

Annual Mean Air Temperature and Precipitation

Korea Meteorological Administration (2012)

Classification of Natural Seasons by Region



Korea Meteorological Administration (2012)

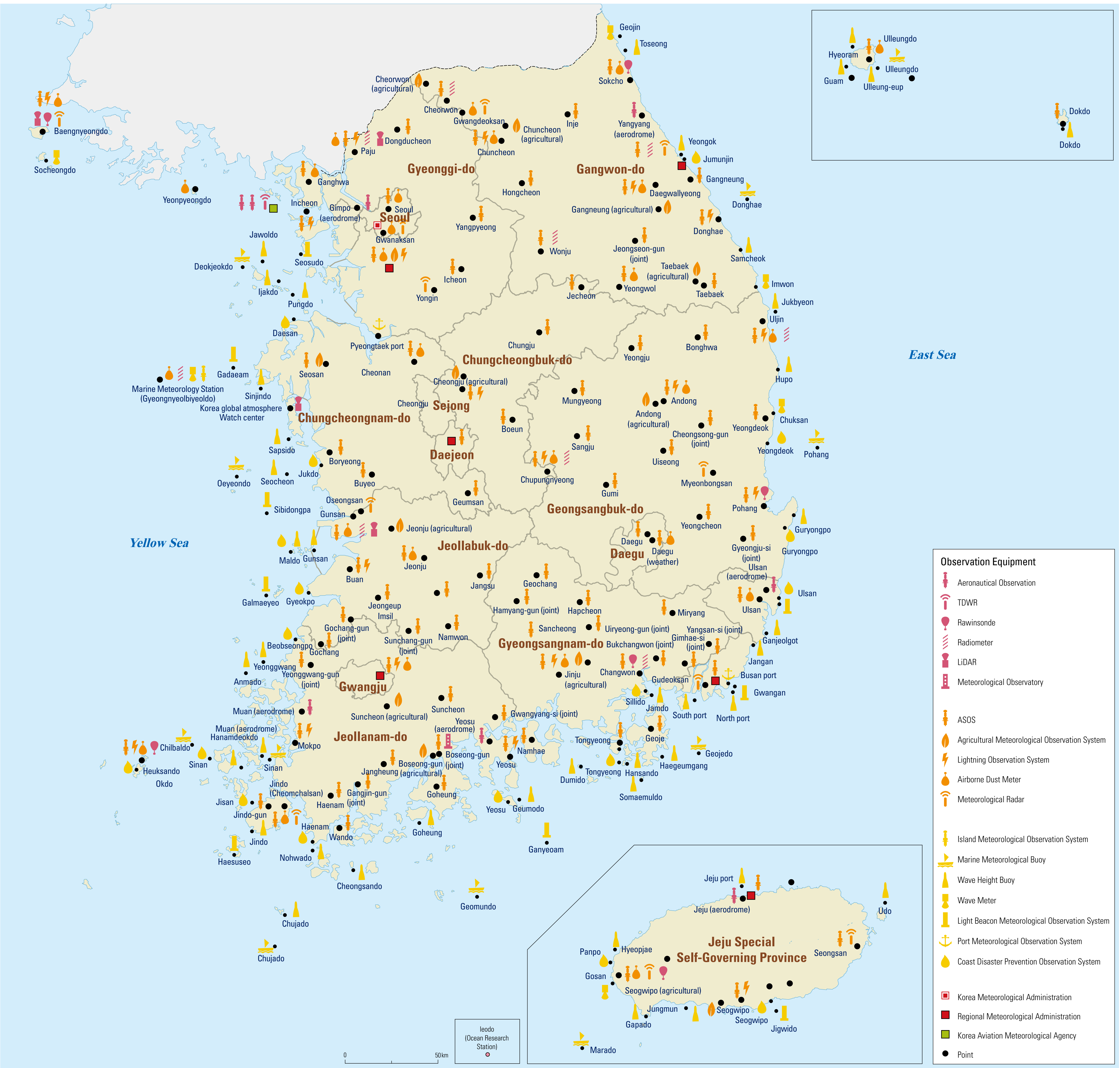
Criteria for Classification of Natural Seasons

Season	Daily Mean Temperature	Daily Maximum Temperature	Daily Minimum Temperature
Spring	≧ 5℃		≧ 0℃
Summer	≧ 20℃	≧ 25℃	
Autumn	≦ 20℃	≦ 25℃	
Winter	≦ 5℃		≦ 0℃

The Korean Geographical Society (1979)

Meteorological Observations

Spatial Distribution of Weather Stations



Korea Meteorological Administration (2016)

Korea has made rapid advancements in meteorology in the 2000s. In 2010, Korea became the seventh country in the world to operate an independent weather satellite with the completion of the National Meteorological Super Computer Center. In the following year, a weather ship began conducting comprehensive ocean observations.

Currently, the Korea Meteorological Administration (KMA) is in charge of the weather service. The KMA consists of its headquarter, the National Institute of Meteorological Sciences (NIMS), 6 regional offices, 3 branch offices, 7 weather observatories, the National Meteorological Satellite Center (NMSC), the Weather Radar Center, and the Aviation Meteorological Office (AMO).

Meteorological observation requires not only traditional equipment and methodology, but also state-of-the-art observation equipment such as the Automatic Weather Station (AWS), radar, satellite, and weather ship. In Korea, there are a total of 590 AWSs where weather conditions are automatically monitored every minute. The observation density of weather stations in Korea is high because they are spaced on average about 13 km apart, which is closer than those in Japan (about 15 km) and the United States (about 20 km).

There are a total of 7 upper-air observation stations that measure vertical atmospheric conditions at altitudes of 0 – 35 km using rawinsonde. Rawinsonde observations are conducted twice a day under regular weather conditions, and four times a day under severe weather conditions. In addition, wind profilers are installed at 9 stations to observe wind direction and wind speed at 0 - 5 km above land surface. Radiometers are installed to measure air temperature and humidity every 10 minutes at 0 - 10 km above land surface.

The observations cover the entire Earth, East Asia, and the surroundings of the Korean Peninsula at 3-hour intervals, 15-minute intervals, and 8-minute intervals, respectively, via Chollian, Korea's first geostationary meteorological satellite launched in 2010. The data collected by the satellite are not only significant for detecting typhoons, fog, Asian dust, and forest fires, but also widely applied in various fields such as hydrological and environmental management. In addition, the Meteorological Satellite Data Analysis System is used for the process of reception, processing, analysis, and utilization of the data collected from multiple geostationary and polar-orbiting weather satellites.

Because of its topographic characteristic, a peninsula surrounded by water on three sides, Korea carries out marine weather observations at major points along the coast by placing marine weather buoys, wave height buoys, drift buoys, the Coastal Disaster Prevention Observation System, Port Weather Observation System, light beacon weather observation system, and wave meters.

A total of 12 weather radars, including one for experimental purposes, are operated to understand precipitation extent and intensity. The radar images are synthesized every 10 minutes to identify precipitation patterns.

History of Meteorology in Korea

History

The Period of the Three States

BC 35 The first meteorological observation is recorded in *The Chronicles of the Three States* (Cloud, the 3rd year of King Dongmyeong of Goguryeo).

633 The oldest astronomical observatory in the east, Cheomseongdae, was constructed (the 2nd year of Queen Seondeok of Silla).

The Period of the Goryeo Dynasty

Beginning of the Dynasty Operated Taebogam and Taesaguk, handling weather and astronomical phenomena

1023 -1275 Taebokgam ▸ Sacheondae ▸ Sacheongam ▸ Gwanhuseo ▸ changed the name back to Sacheongam

1308 Sacheongam, Taesaguk ▸ integrated into Seoungwan (the 34th year of King Chungnyeol of Goryeo)

* ▸: Name change

The Period of the Joseon Dynasty

1441 The world's first rain gauge, Cheugugi, was invented (the 23rd year of King Sejong of Joseon).

1442 National rainfall observation network was constructed (the 24th year of King Sejong of Joseon).

1466 Seoungwan ▸ Gwansanggam (the 12th year of King Sejo of Joseon).

1818 A meteorological-astronomical book, *Seoungwanji*, was published (the 18th year of King Seonjong).

Modern Period

1883 The Joseon Maritime Customs was established in Incheon, Wonsan, and Busan commencing meteorological observation in modern times (the 20th year of King Gojong of Joseon).

1894 -1895 Gwansanggam ▸ Gwansanguk ▸ Gwansangso

1904 Temporary weather stations were established in Busan, Mokpo, Incheon, Yongampo and Wonsan controlled by the Central Meteorological Observatory of Japan.

1907 A meteorological observatory (Incheon) and local observatories (Busan, Mokpo, Wonsan, Yongampo, Seongjin) were established by the Japanese Resident-General of Korea along with establishment of weather stations (Pyeongyang, Daegu, Gyeongseong) by the Korean Empire.

1910 The Korean Empire's meteorological services were transferred to the meteorological observatories of the Japanese Government-General of Korea.

1945 The name of the Meteorological Observatories of the Japanese Government-General of Korea was changed to the Meteorological Observatories of the Ministry of Education under the U.S.-Backed Government.

Contemporary Period

1949 The National Central Meteorological Observatory was founded under the Ministry of Education.

1956 Korea became the 68th member of the WMO.

1961 The enactment of the Weather Service Act

1967 Transferred to the Ministry of Science-Technology

1978 Meteorological Research Institute established

1982 Renamed from the National Central Meteorological Observatory to the Central Meteorological Observatory

1989 Began meteorological observation in Antarctic King Sejong Station

1990 Promoted to Korea Meteorological Administration

1991 Started operating numerical forecasting

1998 KMA moved its headquarter from Songwol-dong to Sindaebang-dong.

1999 Newly introduced supercomputer (1st), followed by 2nd, 3rd, and 4th supercomputers, respectively, in 2005, 2010, and 2015.

2005 Status of KMA elevated to sub-ministerial level, while Weather Service Act was amended into Weather Act and Method of Meteorological Observation was enacted.

2007 KMA became a part of the WMO Executive Council.

2008 The superior authority of KMA was transferred to the Ministry of Environment, followed by the establishment of the National Typhoon Center and the beginning of *dongnae* (town-wide) forecasting.

2009 The enactment of the Weather Industry Promotion Act, the establishment of the National Meteorological Satellite Center and WMO-LC LRFMME (WMO Lead Centre for Long Range Forecast Multi Model Ensemble)

2010 The Chollian satellite was launched, the Weather Radar Center was established.

2011 The Gisang 1, weather ship, in service

2012 GISC – established in Seoul

2014 The enactment of the Act on Observation and Warning for Earthquakes, Tsunamis, and Volcanoes

2015 KMA reorganized (the expansion of the National Institute of Meteorological Sciences, the establishment of metropolitan offices: 5 regional KMA offices and 35 weather stations → 6 regional KMA offices, 3 branch offices, and 7 weather observatories).

Korea Meteorological Administration (2016)

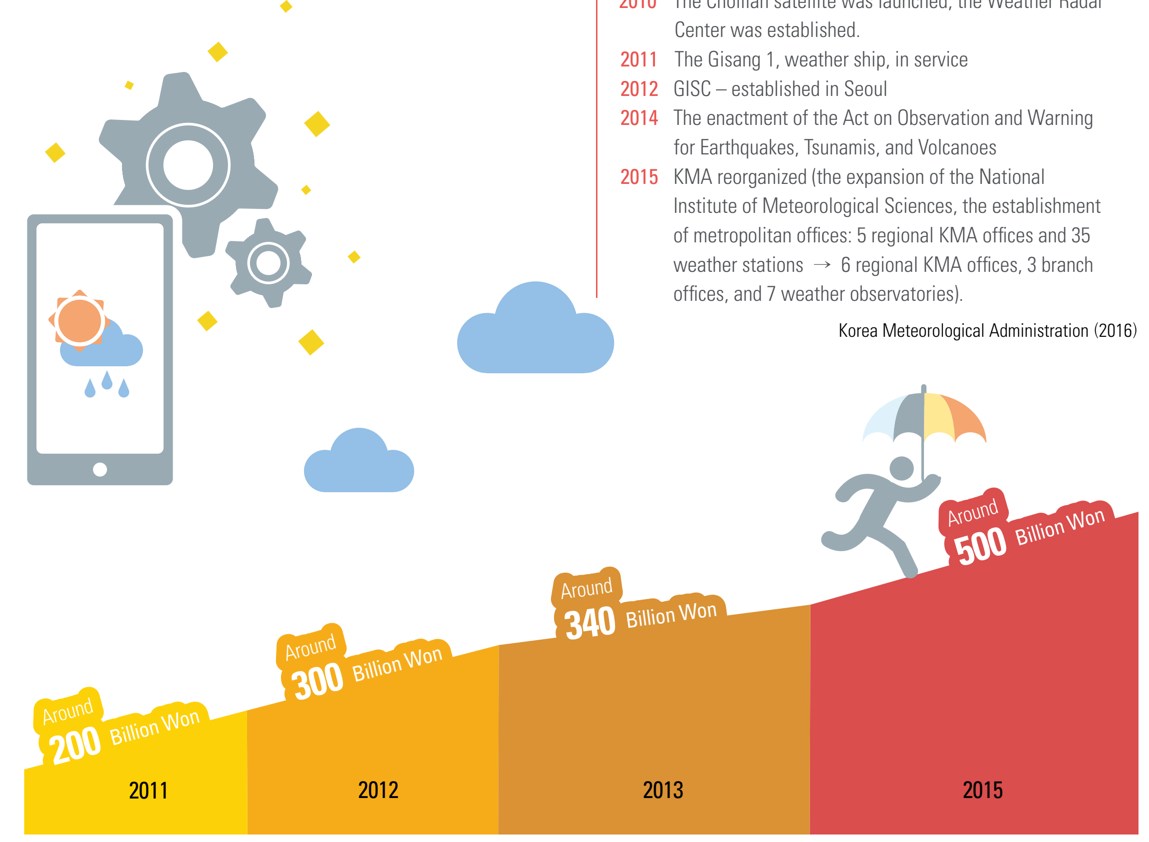
Weather Industry Sales Trend (2014)

Classification	Weather Industry Sales by Sub-Industry
Gross Sales (1)+(2)+(3)+(4)+(5)	369,330
(1) Weather Instrument, Equipment, and Related Product Manufacturing Business	172,653
Weather Observation Instrument and Equipment Manufacturing	49,158
Other Weather Observation Instrument Manufacturing	119,240
Weather Teaching Aid Manufacturing	4,255
(2) Weather Instrument, Equipment, and Related Product Wholesaling	40,414
Weather Observation Instrument and Equipment Wholesaling	19,378
Weather Related Product Wholesaling	21,036
(3) Weather Related Professional Service Industry	12,706
Weather Research and Development Industry	713
Weather Business Consulting Industry	9,036
Climate Impact Assessment Service Industry	2,036
Weather Appraisal Industry	0
Weather Forecasting Service Industry	921
(4) Weather Related and Information Service Industry	36,751
Weather Broadcasting Industry	0
Weather Information Portal and Internet Service Industry	0
Weather Related Software Development and Supply Industry	36,751
(5) Other Weather Related Service Industries	106,806
Weather Related Indemnity Insurance Industry	85,504
Weather Instrument, Equipment, and Related Product Repair & Maintenance Industry	21,302

(Million Won)

Korea Meteorological Administration (2015)

Scale of the Weather Industry in Sales (Won)



Korea Meteorological Administration (2016)

According to *Samguk yusa*, Korea's meteorological history began with Hwanung, the legendary founder of Gojoseon, who descended from heaven with 3,000 followers to Sindansu in Taebaeksan to rule the world, along with his ministers of cloud, rain, and wind, who were capable of controlling the basic weather elements. Since the period of the Three Kingdoms, there have been numerous meteorological observation records. During the Goryeo Dynasty, Seoungwan was established and operated as a government office dealing with weather and astronomical phenomena.

During the Joseon Dynasty period, great progress was made in meteorological observations. During this period, the world's first rain gauge, Cheugugi, was invented (1441), and a rainfall observation network was built on a national scale. Moreover, the first instruments for measuring the water level of the Cheonggyecheon and the Hangang were invented. There were also instruments for observing wind direction.

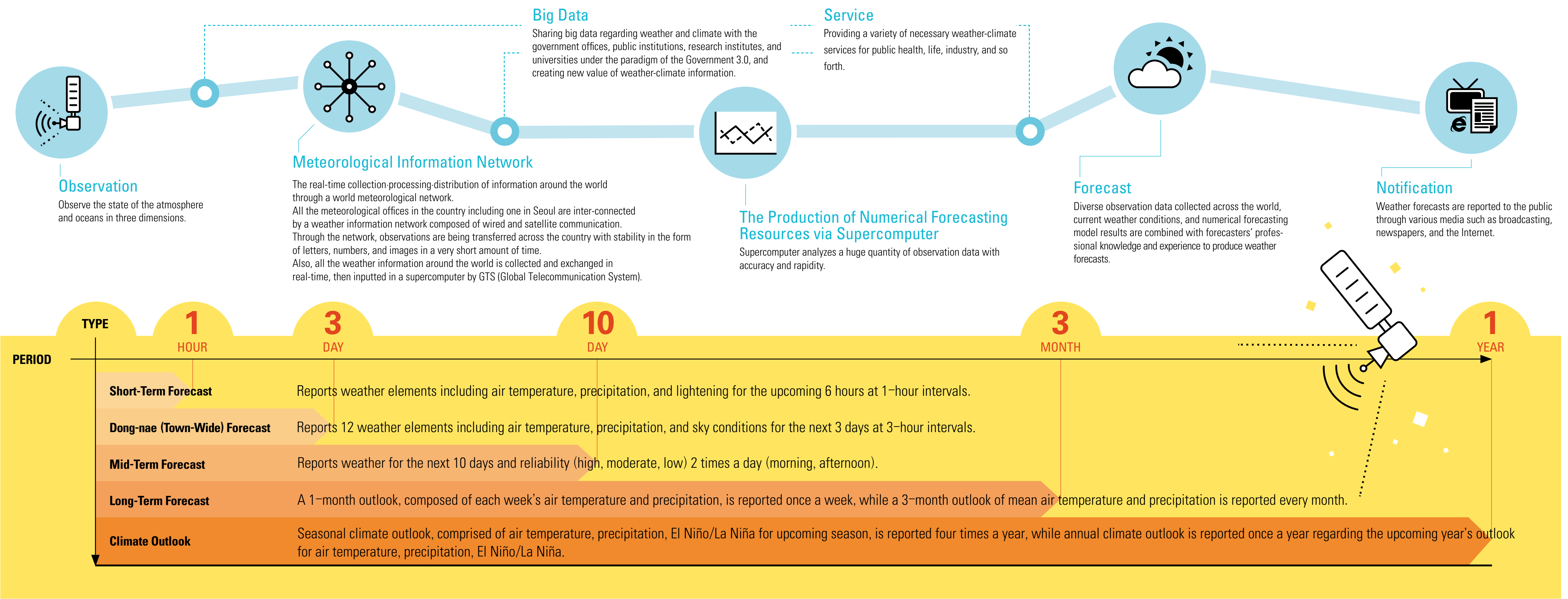
In the 19th century, meteorological observation was modernized when P. G. Von Moellendorf, a German appointed as the Inspector General of Marine Customs by King Gojong, the Emperor of the Joseon Dynasty, installed meteorological instruments at Incheon Port and Wonsan Port in 1884, and another at Busan Port in 1887. Beginning in 1904, five temporary weather stations were established in Busan, Mokpo, Incheon, Yongampo, and Wonsan, followed by stations at Seongjin and Jinnampo. These stations formed a meteorological network that laid the foundation for the modern weather service. In 1907, under the umbrella of the Incheon weather station, eight weather stations were established in Gyeongseong (currently Seoul), Pyeongyang, Yongampo, Daegu, Busan, Mokpo, Wonsan, and Seongjin. These stations began forecasting the weather as soon as standards for forecasting and storm warnings were established. Additional weather stations were installed in Gangneung (1911), Unggi (1914), and Junggangjin (1914) as parts of the network.

After establishment of the government in 1948, the Ministry of Education took charge of the meteorological service. In 1949, the Central Meteorological Office was founded as a part of the Ministry of Education. The period from 1949 until the 1960s saw the organization of laws and improvement in the Meteorological Communication (METCOM), which enabled the establishment of an immediate exchange system for meteorological observations and data analysis. All these efforts paved the way for international cooperation.

The 1970s was the decade that saw the most improvement since the beginning of modern meteorological service in the nation. The contemporary meteorological administration and technology system, including digitalization, satellite, and radar-related observation, were built during this period. During the following decade, Korea's weather service established a solid basis for contemporization with expansion of the meteorological network, modernization of equipment, implementation of local forecasting, objectification of forecast data, digitalization of the weather service, and the provision of climate data and industrial meteorological information.

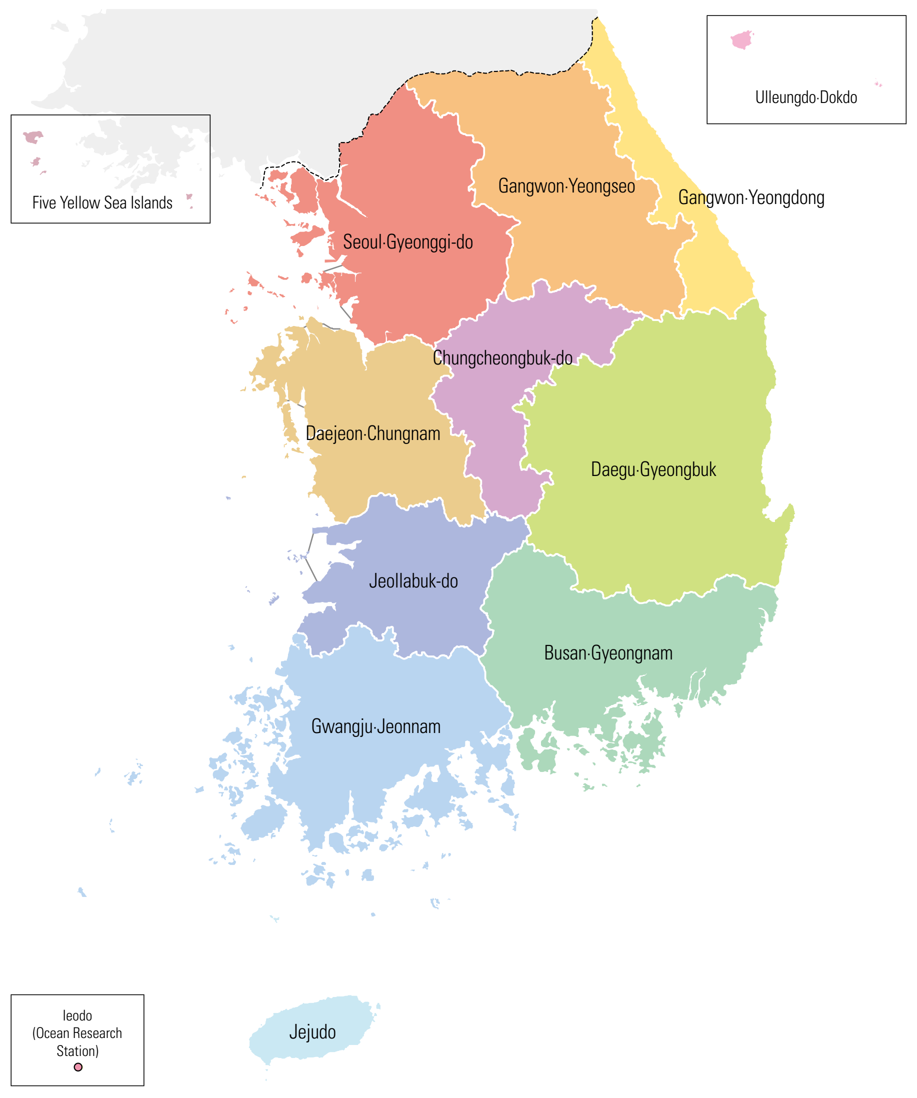
Meteorological Forecasting

Process of Meteorological Service Weather Forecasting

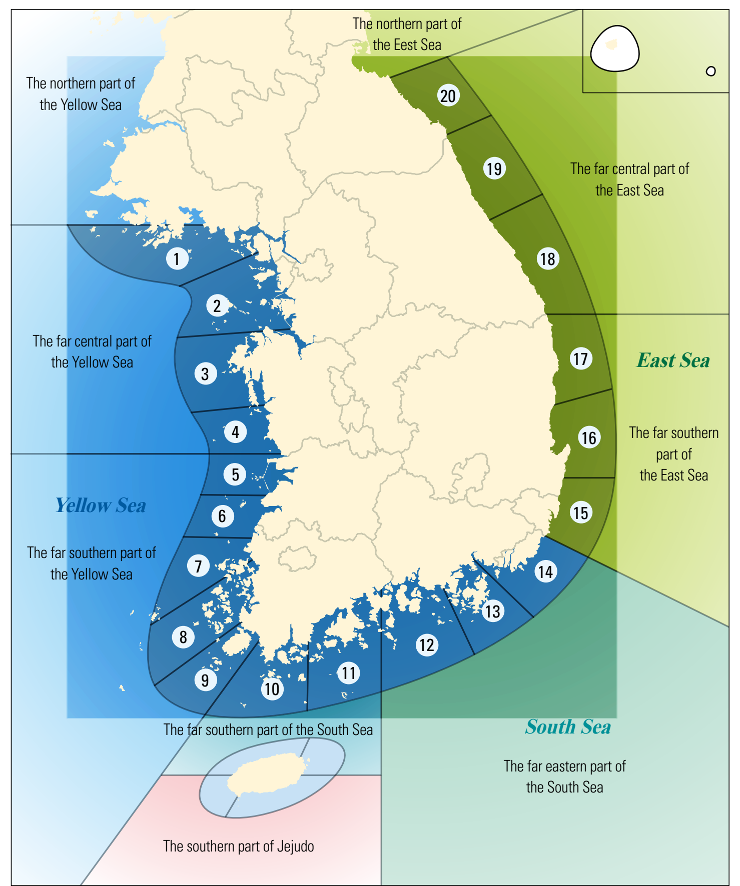


Korea Meteorological Administration (2016)

Terrestrial Weather Forecast Area Map



Marine Weather Forecast Area Map



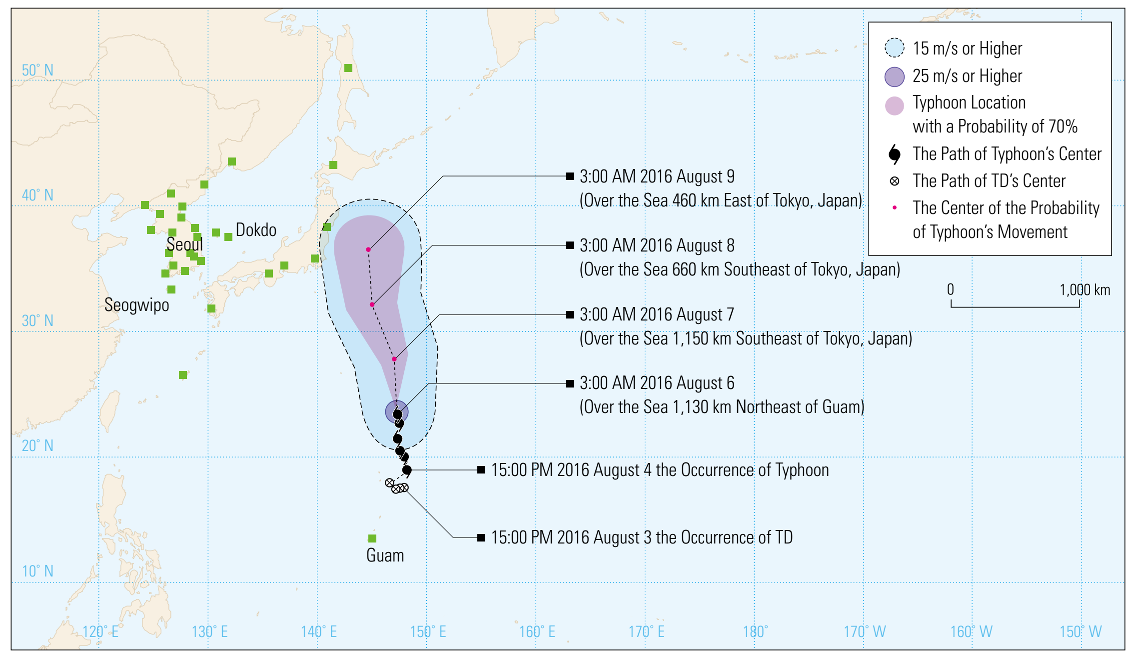
Coast of the Central Yellow Sea	① Northern Gyeonggi-do ② Southern Incheon/Gyeonggi-do	③ Northern Chungcheongnam-do ④ Southern Chungcheongnam-do
Coast of the Southern Yellow Sea	⑤ Northern Jeollabuk-do ⑥ Southern Jeollabuk-do ⑦ Northern Yellow Sea off Jeollanam-do	⑧ Central Yellow Sea off Jeollanam-do ⑨ Southern Yellow Sea off Jeollanam-do
Coast of the Western South Sea	⑩ Western South Sea off Jeollanam-do ⑪ Eastern South Sea off Jeollanam-do	
Coast of the Eastern South Sea	⑫ Western South Sea off Gyeongsangnam-do, Eastern Geoje ⑬ Central South Sea off Gyeongsangnam-do ⑭ Busan	
Coast of the Southern East Sea	⑮ Ulsan ⑯ Southern Gyeongsangbuk-do	⑰ Northern Gyeongsangbuk-do
Coast of the Central East Sea	⑱ Southern Gangwon-do ⑲ Central Gangwon-do	⑳ Northern Gangwon-do

Korea Meteorological Administration (2016)

National weather data are collected in a central server of supercomputers and shared with member nations of the World Meteorological Organization in real time. These data are assimilated for the production of various numerical models through the super computers. Then trained forecasters with expertise and experience examine current atmospheric conditions based on the observations, and analyze the numerical weather prediction models comprehensively. Finally, forecasters across the country consult and exchange opinions via videoconference to make to a final forecast decision. Area forecasts are provided on both a regional scale (12 overland areas and 14 marine areas) and local scale (about 3,500 towns).

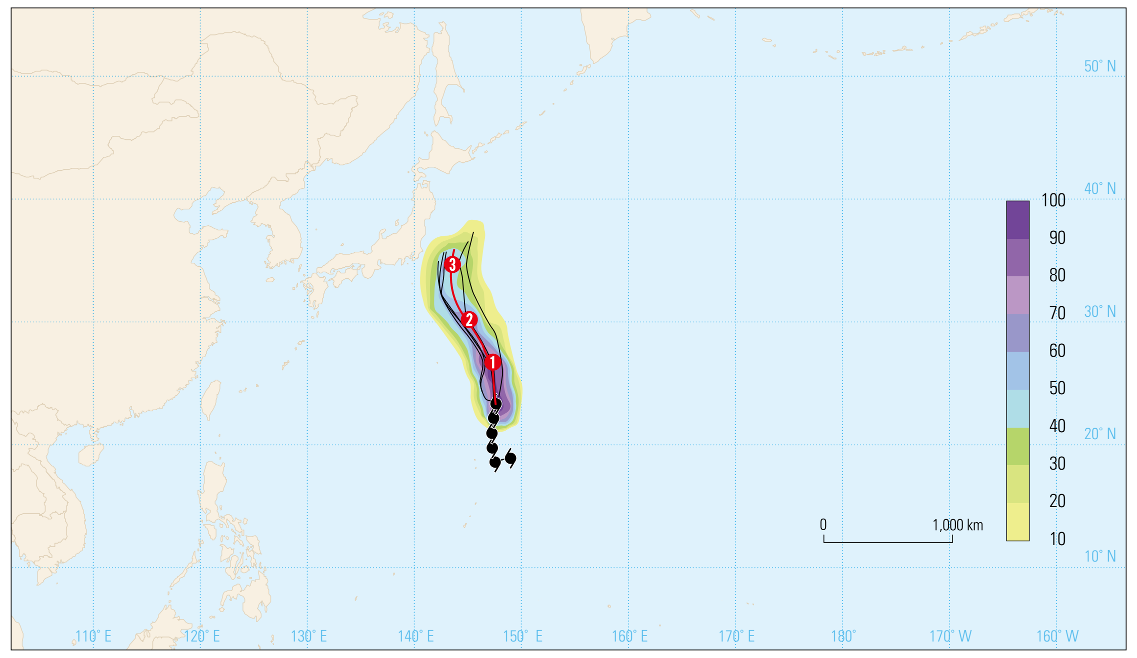
Special weather reports are issued as weather advisories for possible natural disasters. The report is issued as either a watch or a warning, depending on the risk level of the following 11 natural disasters: heavy rainfall, heavy snowfall, storm surge, tsunami, typhoon, strong winds, high seas, Asian dust, drought, cold surge, and heat wave. A preliminary weather advisory is issued ahead of a special weather report in order to help people to prepare for meteorological disasters.

Typhoon Forecast



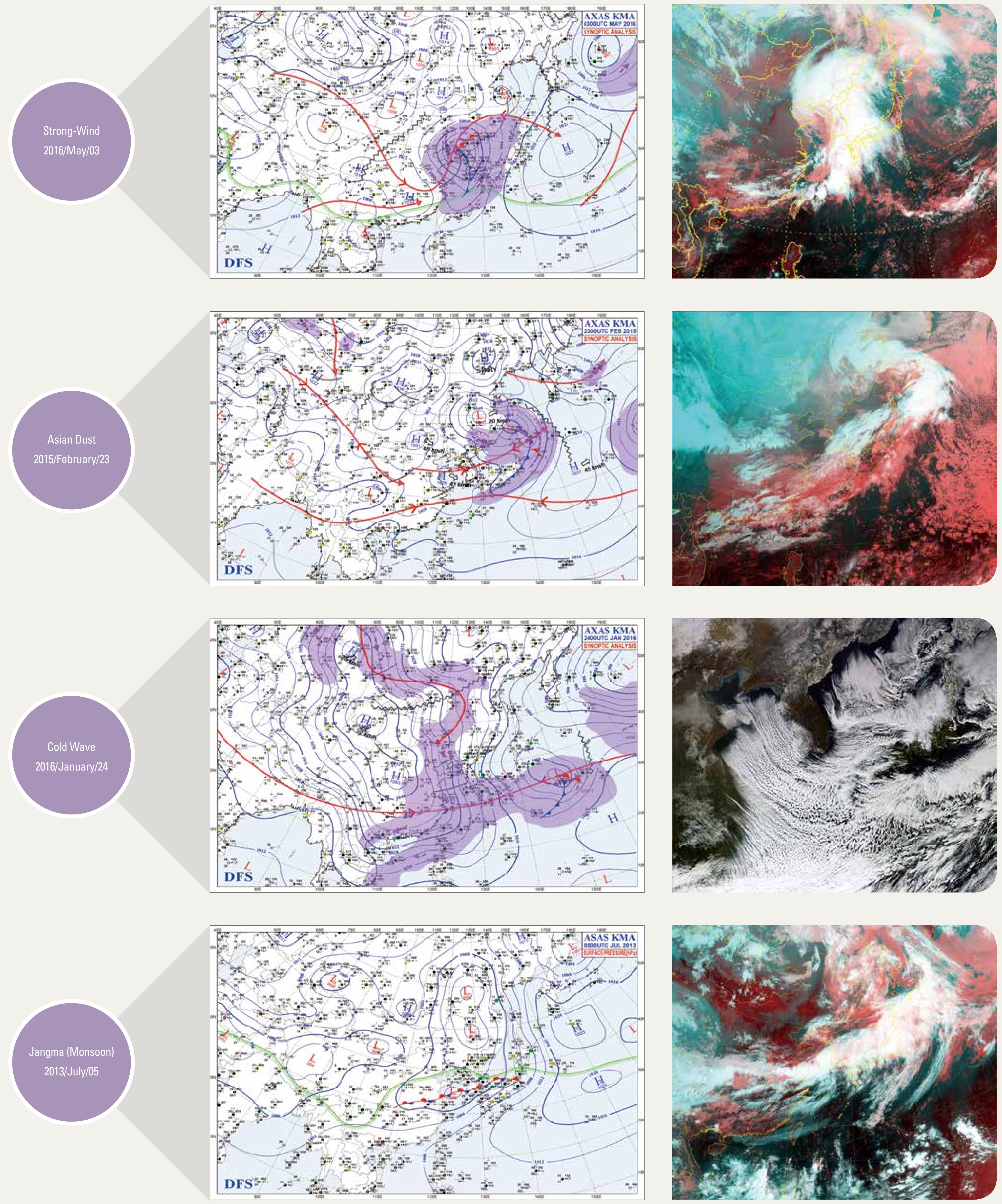
Korea Meteorological Administration (2016)

Typhoon Path Forecast



Korea Meteorological Administration (2016)

Surface Weather Chart and Chollian Satellite Image

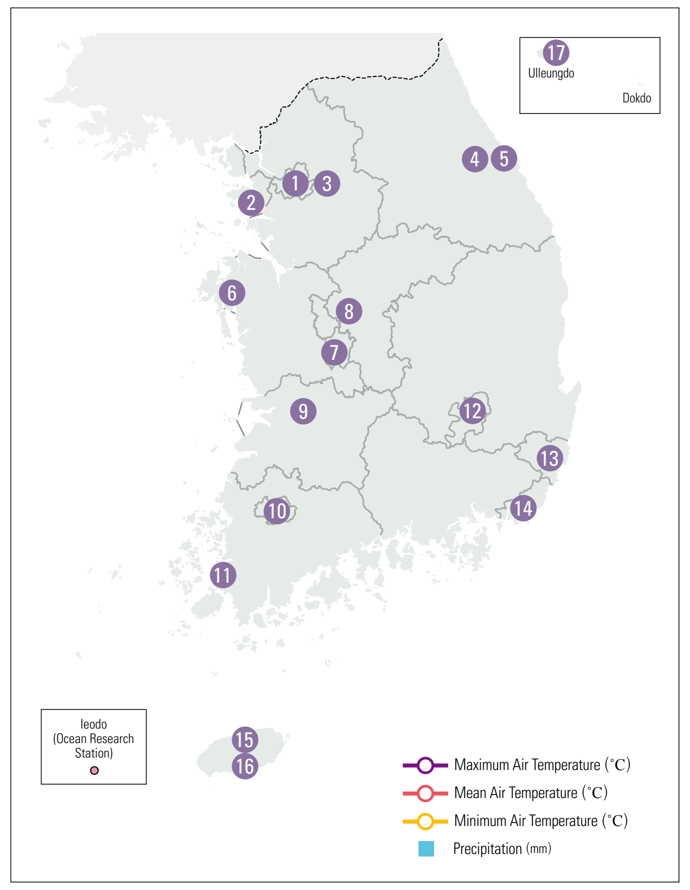


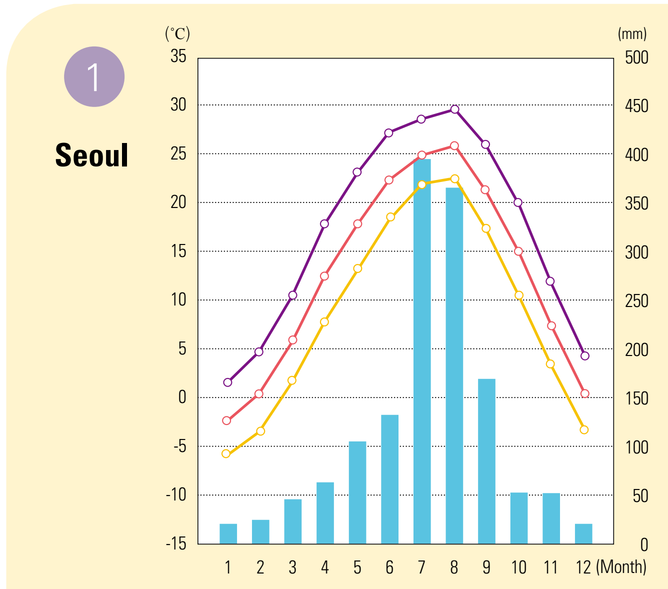
Korea Meteorological Administration (2016)

Weather maps produced in Korea are broadly divided into surface weather maps and upper-air weather maps. Surface weather map refers to a weather map analyzing atmospheric conditions, including distribution of sea-level pressure, surface temperature, wind direction and speed, weather, and type and height of clouds. In Korea, these weather maps are analyzed every 3 hours, and local weather maps are drawn at one-hour intervals for analysis of micro-scale weather.

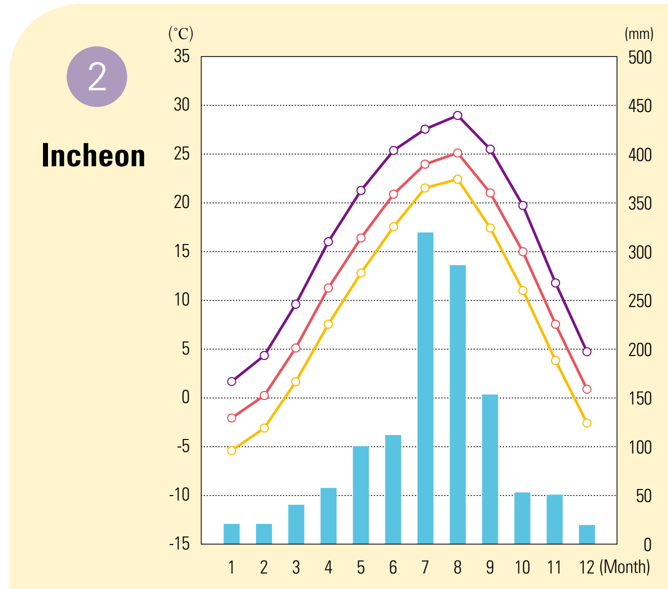
The upper-air weather map represents weather conditions in the upper atmosphere, including altitude of the isobaric surface, air temperature, wind speed, and humidity. In Korea, these weather maps are analyzed twice a day (at 9:00 and 21:00) at various levels: 925 hPa, 850 hPa, and 700 hPa for prediction of change in precipitation and air temperature in the lower atmosphere; 500 hPa for analysis of massive air flow in the middle atmosphere; 300 hPa (200 hPa in summer) for analysis of the jet stream around the boundary between the troposphere and the stratosphere; and 100 hPa for analysis of aircraft airflow.

Climate of South Korea

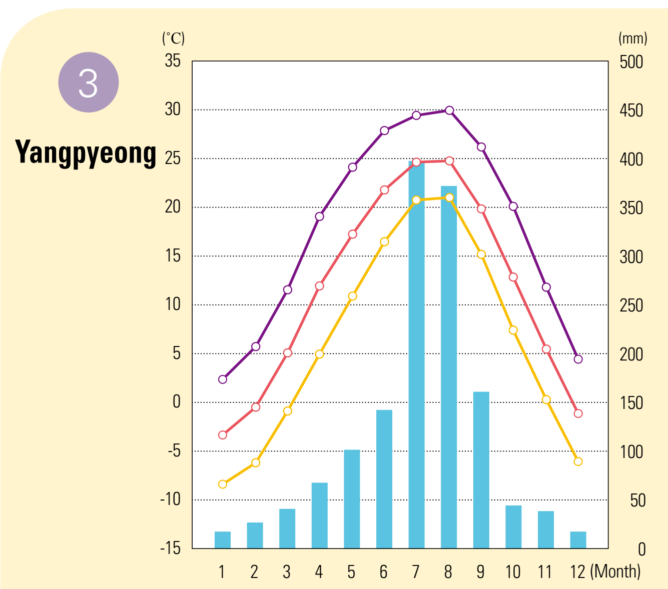




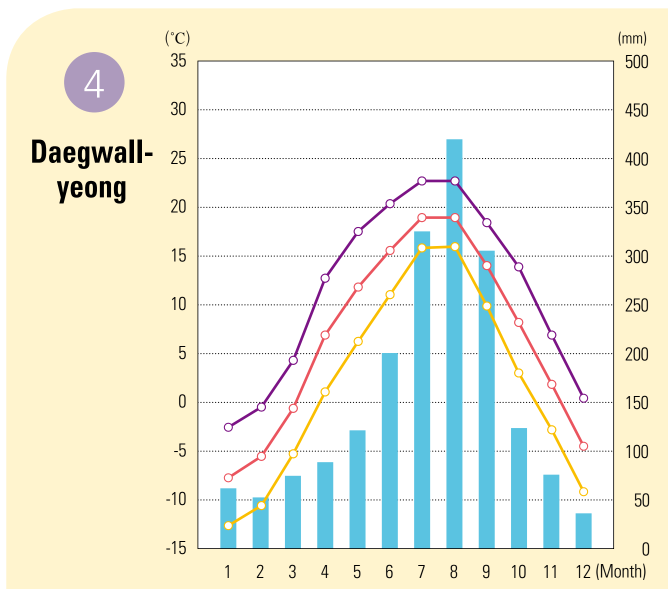
Seoul has an annual mean air temperature of 12.5˚C. The mean air temperature of the coldest month, January, is -2.4˚C, while that of the warmest month, August, is 25.7˚C, creating a wide annual mean air temperature range. In addition, Seoul receives 1,450.5 mm of precipitation annually. While summer precipitation (months of June, July, and August) is 892.1 mm (61% of the annual precipitation), winter precipitation (months of December, January, and February) is only 67.3 mm (5% of the annual precipitation).



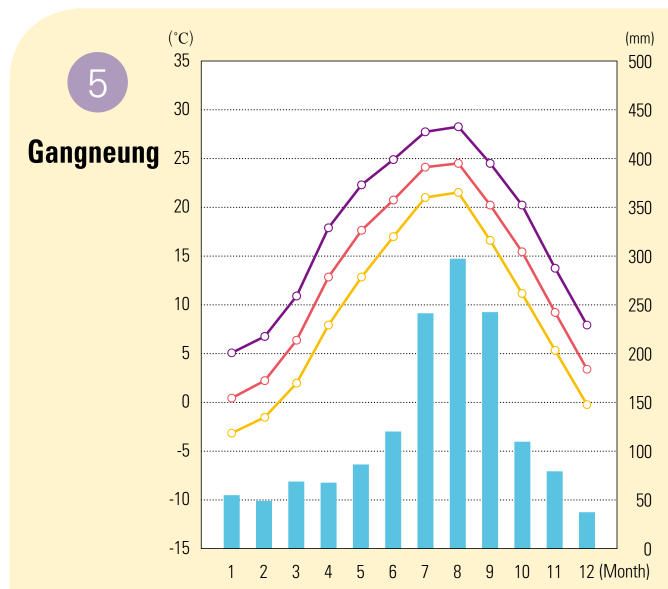
Incheon has an annual mean air temperature of 12.1˚C. Mean air temperatures in January and August are -2.1˚C and 25.2˚C, respectively, making a large annual mean air temperature range, 27.3˚C. Incheon receives relatively low precipitation (1,234.4 mm) annually. Incheon receives more precipitation in July than in August, epitomizing the monthly precipitation patterns of Korea. Summer precipitation (months of June, July, and August) is 717.4 mm, accounting for about 58% of the annual precipitation.



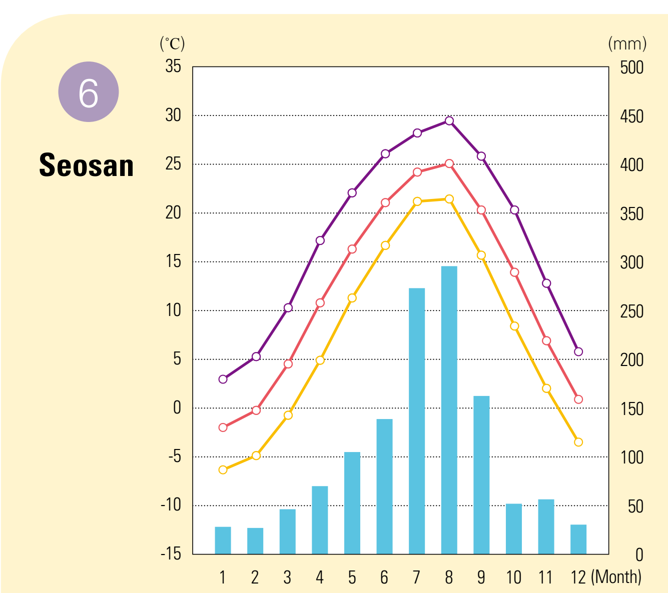
Yangpyeong has a larger annual mean temperature range (28.1˚C) because it is geographically located in a basin. The minimum temperature in winter drops as low as -8.5˚C. Annual mean temperature is 11.5˚C, which is lower than that of cities located at similar latitudes, such as Incheon and Seoul. The average temperature in January is -3.4˚C and that in August is 24.7˚C. Yangpyeong has an annual precipitation of 1,438.2 mm. Precipitation from June to August makes up 64% of the total amount, whereas that from December to February only accounts for 4%.



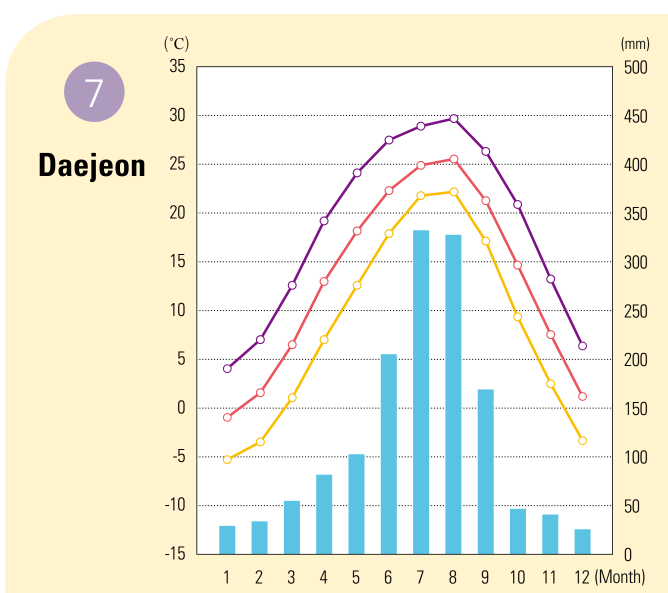
Daegwallyeong has the highest located weather station in Korea with an elevation of 773 m. Due to the elevation, the annual mean temperature (6.6˚C) is the lowest in Korea. Daegwallyeong also has the lowest monthly mean temperatures in January (-7.7˚C) and August (19.1˚C). In addition, there's no single month in the year with an average temperature higher than 20˚C. Daegwallyeong receives the highest annual precipitation (1,898.0 mm) due to the effect of the Taebaeksanmaek. Daegwallyeong has an August precipitation of 420.9 mm on average, which is 326.7 mm more than its average July precipitation.



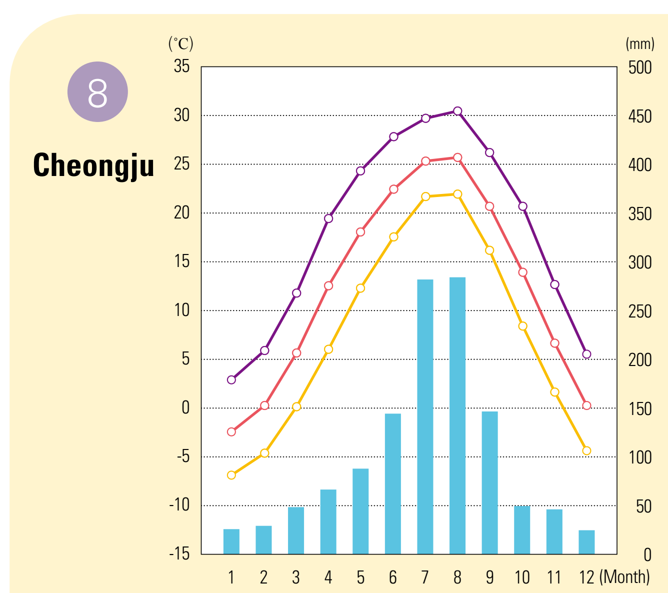
Since Gangneung is located on the eastern coast, its climate is largely influenced by the ocean. It has an annual mean air temperature of 13.1˚C, which is high, considering its latitude. Gangneung shows milder temperature than the western coastal regions at the same latitude because of the effects of the Taebaeksanmaek blocking the northwesterly in winter, and the warm current flowing in the East Sea. Gangneung has an annual precipitation of 1,464.5 mm with relatively heavy precipitation in winter and spring. The city receives more precipitation in August (298.9 mm) than in July. It receives its lowest monthly precipitation (38.3 mm) in December.



Since Seosan is located on the western coast of Korea, its climate is influenced by the ocean. It has an annual mean air temperature of 11.9˚C. Mean air temperatures in January and August are -2.0˚C and 25.1˚C, respectively, making Seosan's annual mean air temperature range, 27.1˚C. Annual precipitation in Seosan is 1,285.7 mm; 55% of it falls in summer (mostly in August; 295.9 mm), while only 17%, 21%, and 17% of it fall in spring, autumn, and winter, respectively.

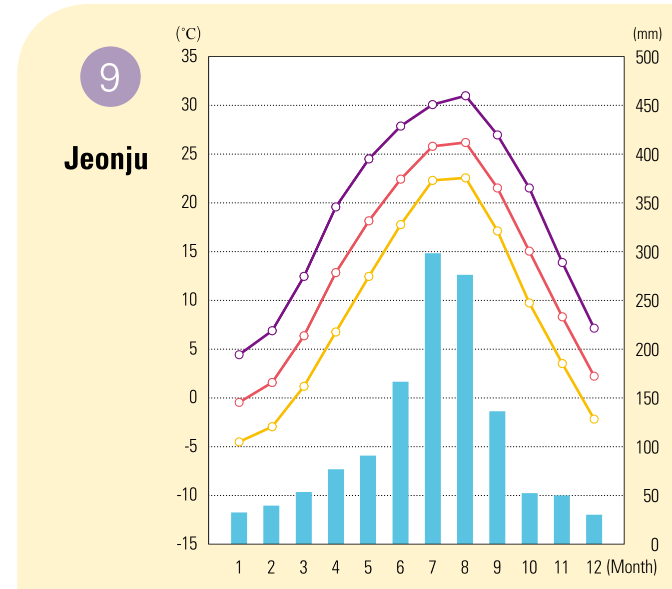


Because of its geographical location inland, Daejeon is characterized by a continental climate. Annual mean air temperature in Daejeon is 13.0˚C. The August mean air temperature is 25.6˚C, while January mean air temperature is -1.0˚C, having an annual mean temperature range of 26.6˚C. While the highest monthly air temperature (29.8˚C) in Daejeon is similar to that of surrounding regions, its lowest monthly air temperature (-5.4˚C) is 2 – 4˚C higher than its surroundings. Daejeon has an annual precipitation of 1,458.7 mm with about 60% of it falling in summer. Spring, autumn, and winter precipitation make up only 16%, 18%, and 6% of the annual precipitation, respectively.

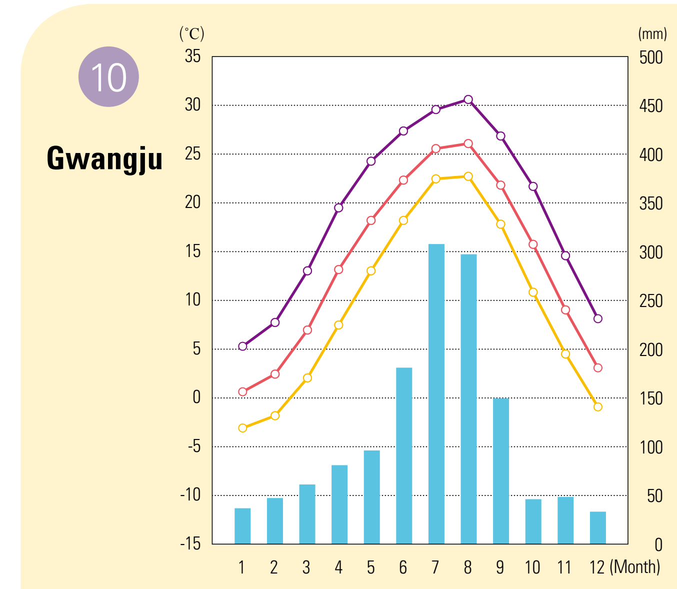


Cheongju, located in the central inland region of Korea, is characterized by a continental climate. Cheongju has an annual mean temperature of 12.5˚C with a wide annual mean temperature range (28.2˚C). This is because of the big difference in average temperature between the coldest month, January (-2.4˚C), and the warmest month, August (25.8˚C). Cheongju has an annual precipitation of 1,239.7 mm. Cheongju receives 58% of its annual precipitation in summer, while it receives 16% of its precipitation in spring, 20% in autumn, and 7% in winter.

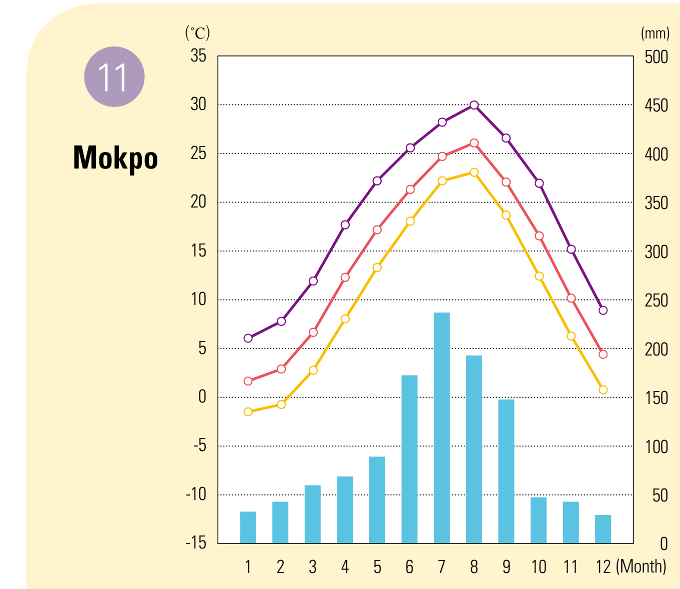
Korea Meteorological Administration (2011)



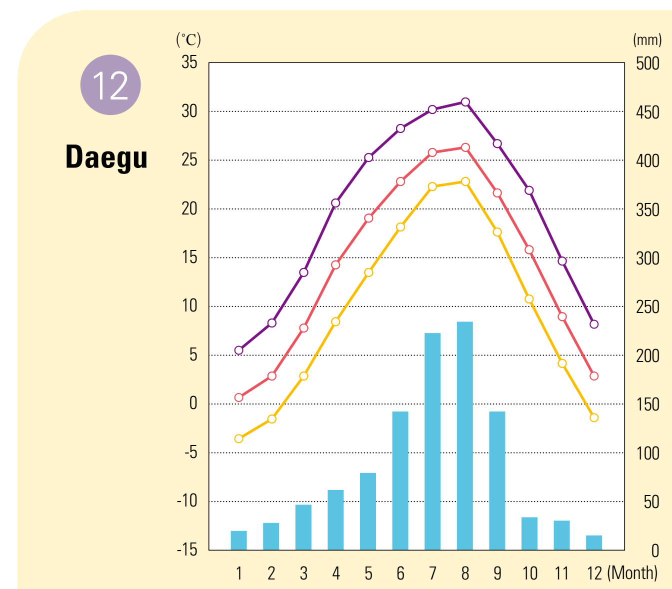
Jeonju, an inland city, shows an annual mean temperature of 13.3˚C, with the highest August mean air temperature (26.2˚C) in the Honam area along with Jeongeup. Jeonju has a January average temperature of -0.5˚C and annual temperature range of 26.7˚C. Annual precipitation for Jeonju is 1,313.1 mm. Summer precipitation makes up 57% of the annual total, whereas spring, autumn, and winter precipitation make up 17%, 18%, and 8%, respectively.



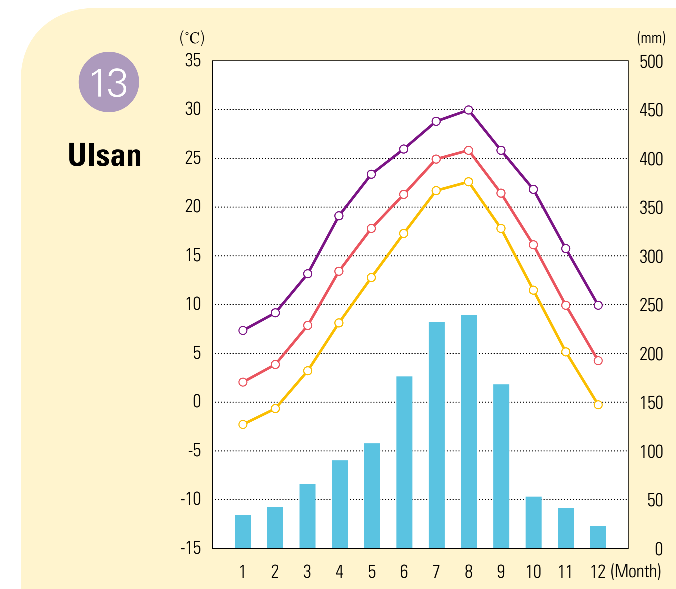
Gwangju, a southern inland city, has an annual mean temperature of 13.8˚C. Its August average temperature is 26.6˚C and its January average temperature is 0.6˚C, resulting in an annual mean temperature range of 25.6˚C. Gwangju is characterized by a continental climate with an annual temperature range that is larger than the surrounding regions (Mokpo, Goheung, and Haenam). Annual precipitation in Gwangju is 1,391.0 mm. While about 57% of the annual precipitation falls in summer, only 17%, 18%, and 8% fall in spring, autumn, and winter, respectively.



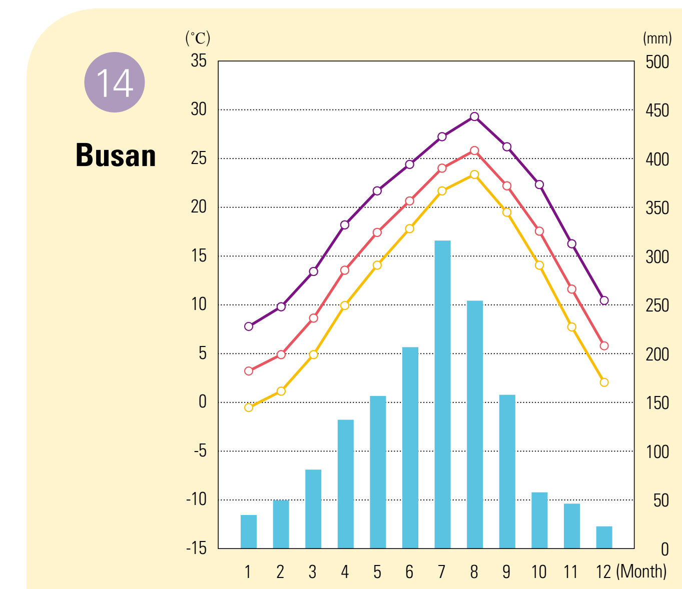
Mokpo has a relatively high annual mean air temperature of 13.9˚C. Due to the ocean effect, the January mean air temperature is 1.7˚C and there is no month with a mean air temperature below zero. The August mean air temperature is 26.1˚C and the annual mean air temperature range is 24.4˚C. Mokpo receives low annual precipitation (1,163.6 mm) relative to the rest of Korea, while more precipitation falls in July than in August. Summer precipitation accounts for about 52%, whereas spring, autumn, and winter precipitation only do for 19%, 20% and 9%, respectively.



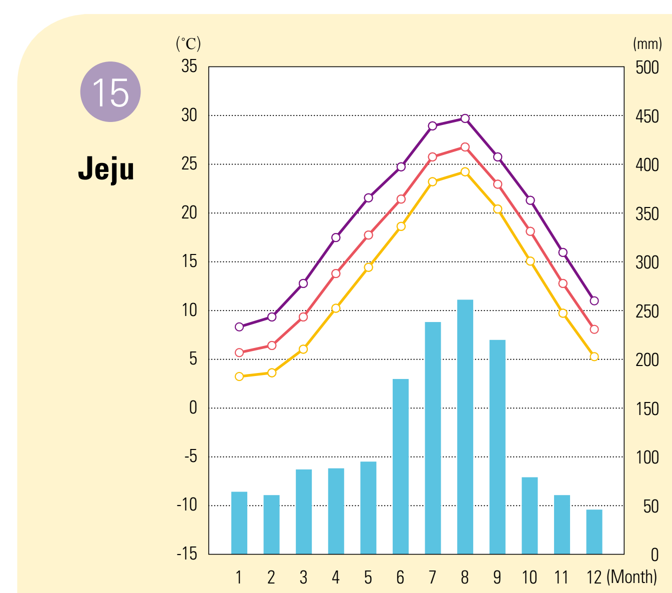
Daegu, a southeastern inland city, has a January mean air temperature of 0.6˚C and an August mean air temperature of 26.4˚C, resulting in an annual air temperature range of 25.8˚C. Daegu (31.0˚C) has one of the highest August mean air temperatures, along with Jeongeup, Miryang, and Jeonju, since an air current passes through the Taebaek and Sobaek Mountains and blows into the basin as dry air. Owing to its location on the leeward side, Daegu receives the 4th least amount of precipitation (1,064.4 mm) after Baengnyeongdo, Uiseong, and Yeongcheon.



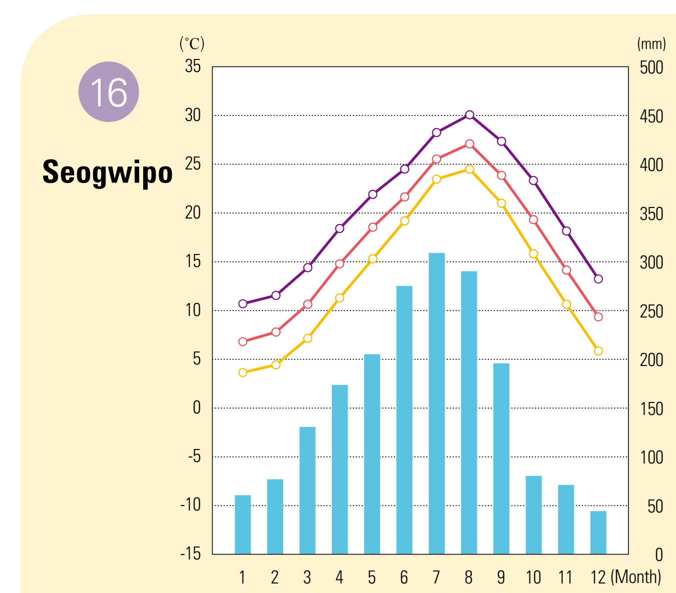
Ulsan, located on the southeastern coast, has an annual mean air temperature of 14.1˚C and an annual mean air temperature range of 23.9˚C. The range is smaller than regions located at the same latitude owing to the influence of the adjoining ocean. Ulsan has an annual precipitation of 1,277.1 mm. The average amounts in July (232.3 mm) and August (240.3 mm) are similar due to the effects of typhoons.



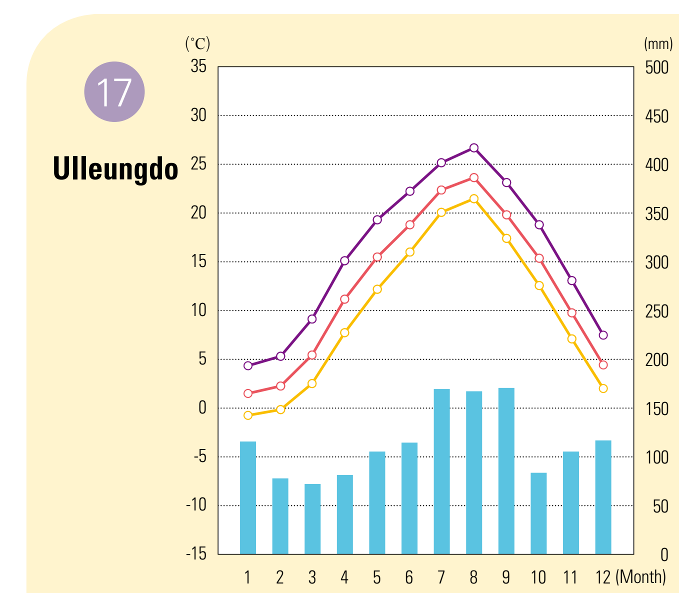
Busan, a low-latitude coastal city, has a high annual mean air temperature (14.7˚C) and a small annual mean air temperature range (22.7˚C). The city experiences relatively mild winters compared to the rest of the Korean Peninsula. For example, Gwangju, located at the same latitude, has a January mean air temperature 2.6˚C lower than Busan. Annual precipitation (1,519.1 mm) in Busan is high. Rainfall amount from March to May, totals 370.8 mm, which is the 6th largest amount after Geoje, Seogwipo, Seongsan, Namhae, and Tongyeong.



Jeju has the 2nd highest annual mean temperature (15.8˚C), with a relatively small annual mean temperature range of 21.1˚C. Also, Jeju is warm throughout the year because its monthly average temperature is no lower than 5˚C. Jeju has an annual precipitation of 1,497.6 mm. While summer precipitation makes up 46% of the total amount, spring, autumn, and winter precipitation only account for 18%, 24%, and 12%, respectively.



Seogwipo has the highest annual mean temperature (16.6˚C) in Korea. The annual mean temperature range in Seogwipo is only 20.3˚C. Seogwipo remains warm throughout the year because monthly mean temperatures are above 5˚C. Annual precipitation in Seogwipo is 1,923.0 mm, the 3rd highest after Geoje (2,007.3 mm) and Seongsan (1,966.8 mm). Seogwipo receives 46% of its annual precipitation in summer, while it receives 27% of its precipitation in spring, 18% in autumn, and 9% in winter.

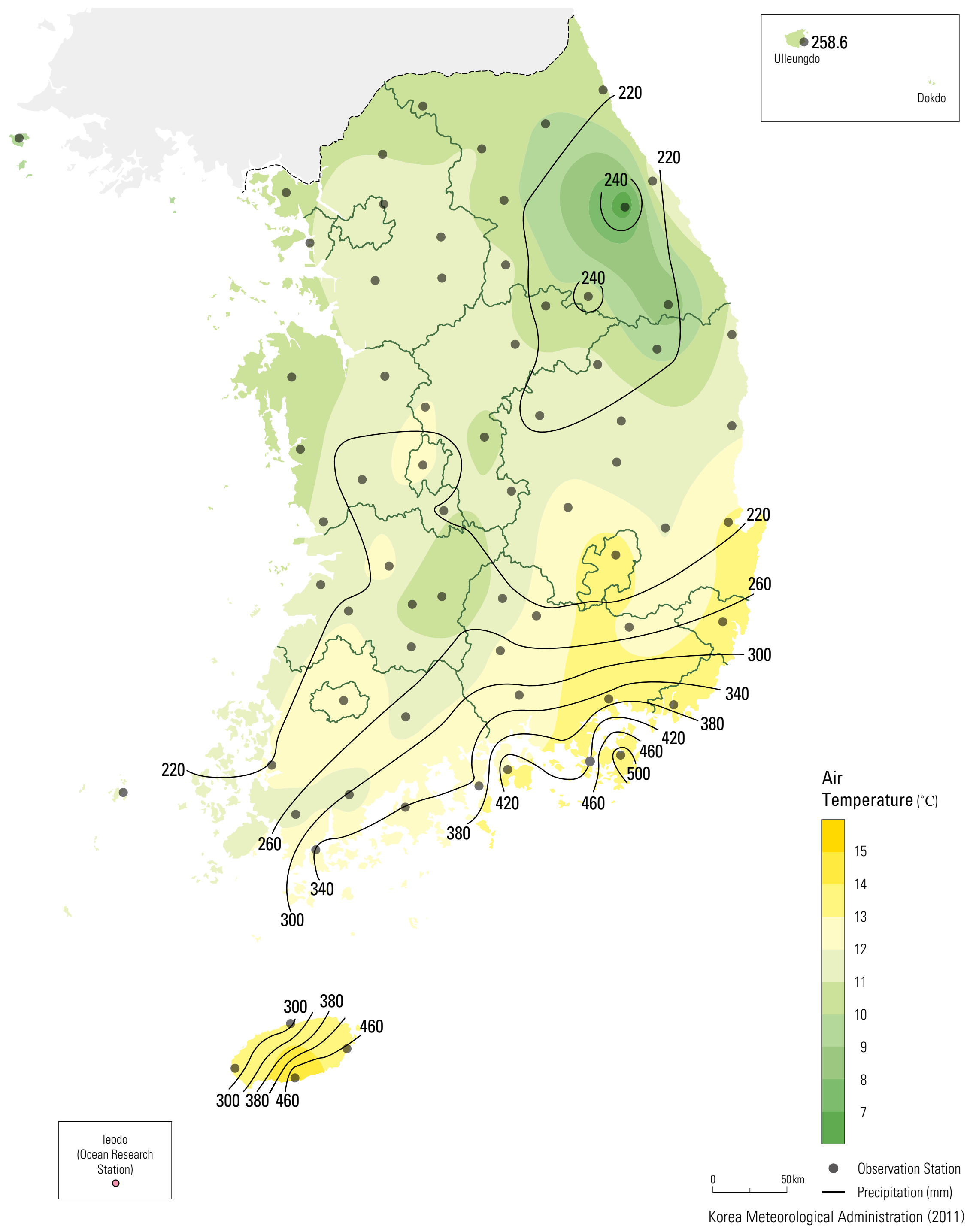


Ulleungdo is largely affected by the East Korea Warm Current. Monthly mean air temperatures in January and August are 1.4˚C and 23.6˚C, respectively, resulting in a small annual mean air temperature range of 22.2˚C. Also, Ulleungdo is characterized by a relatively mild climate compared to regions at the same latitude such as Seoul and Incheon. Ulleungdo has an annual precipitation of 1,383.4 mm. It is a region of abundant snowfall during winter, which accounts for 22% of its annual precipitation. There is no big difference in the mean annual total for each season: spring (19%), summer (33%), autumn (26%), and winter (22%).

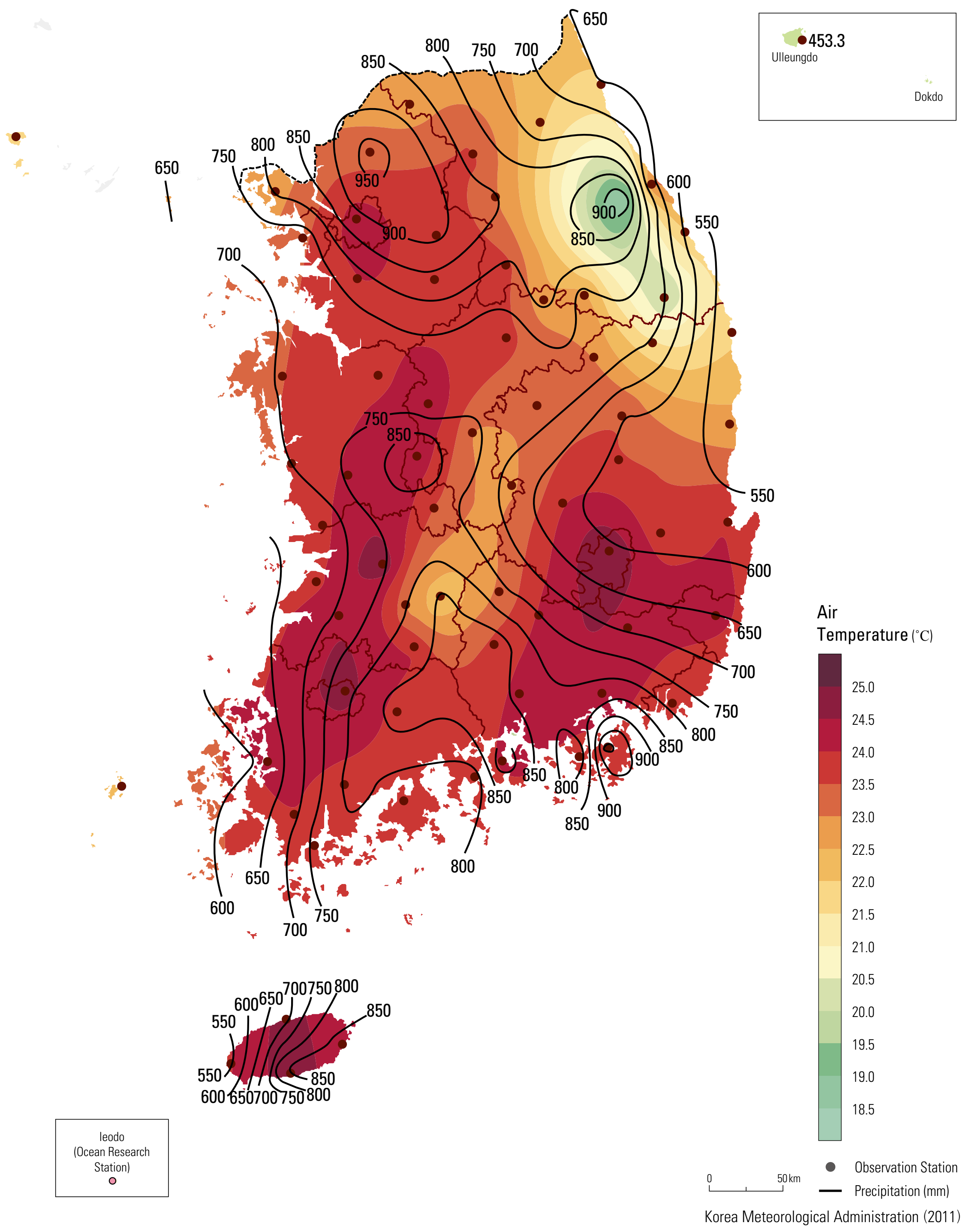
Korea Meteorological Administration (2011)

Climate Elements and Number of Days with Weather Phenomena

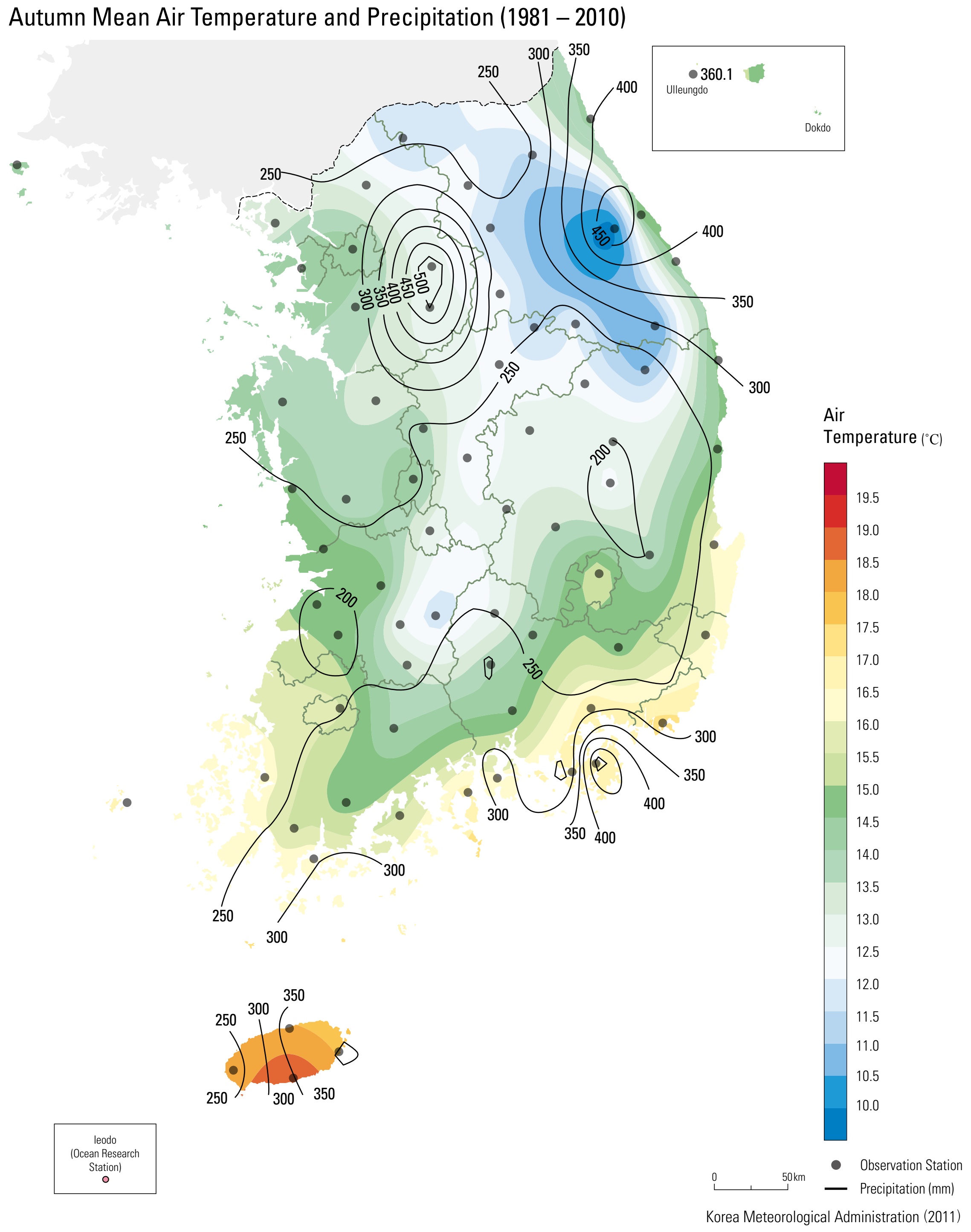
Spring Mean Air Temperature and Precipitation (1981 – 2010)



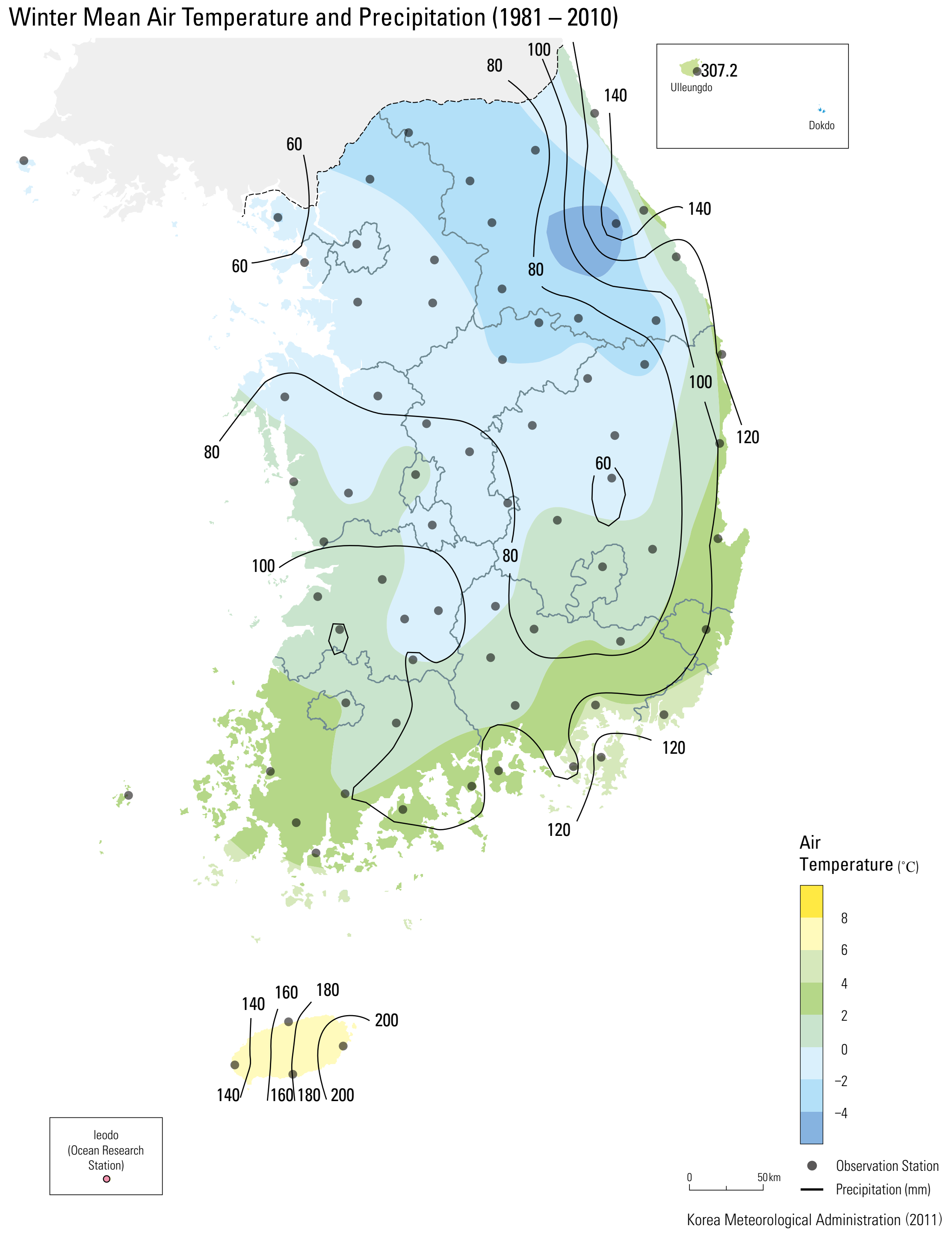
Summer Mean Air Temperature and Precipitation (1981 – 2010)



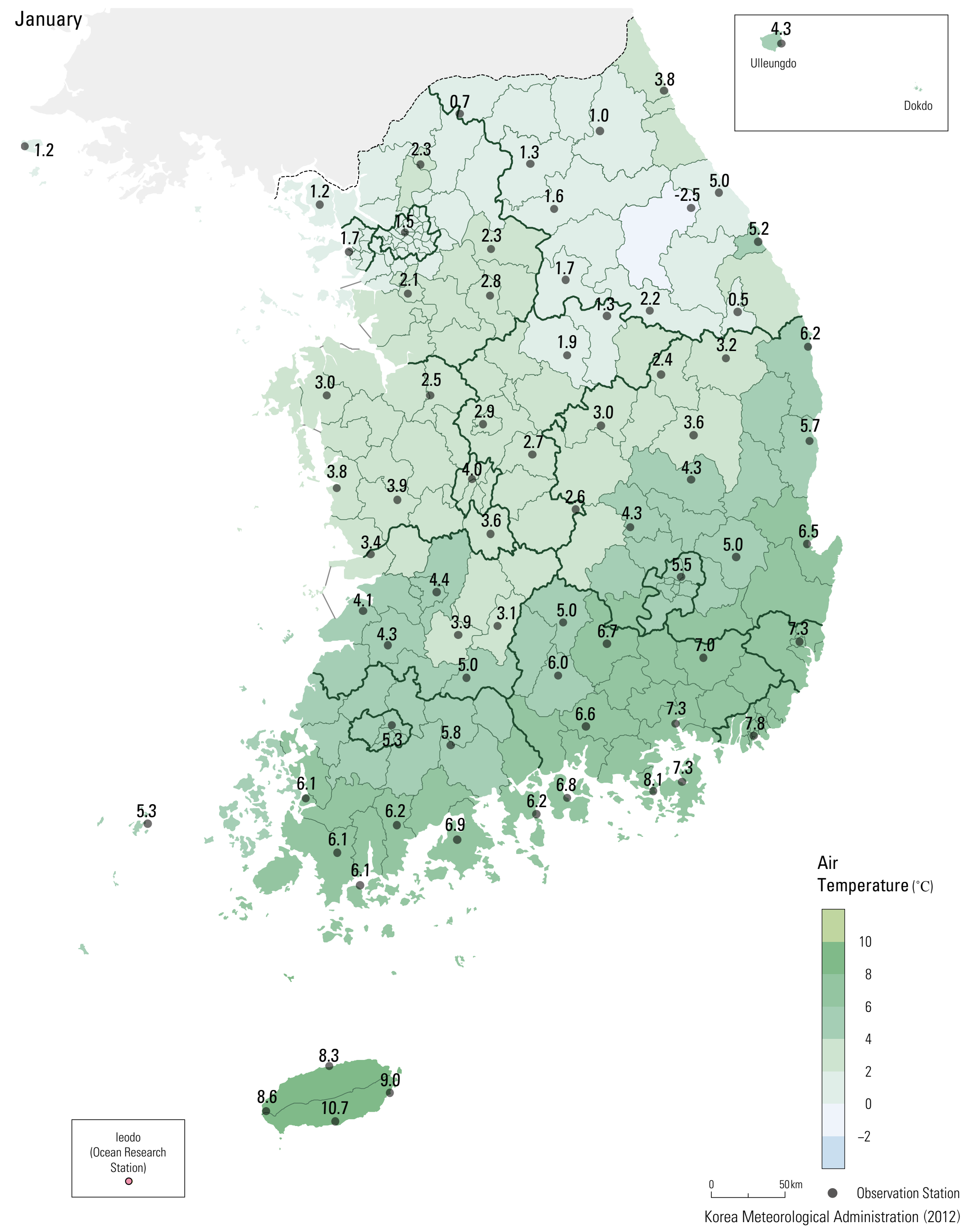
Autumn Mean Air Temperature and Precipitation (1981 – 2010)

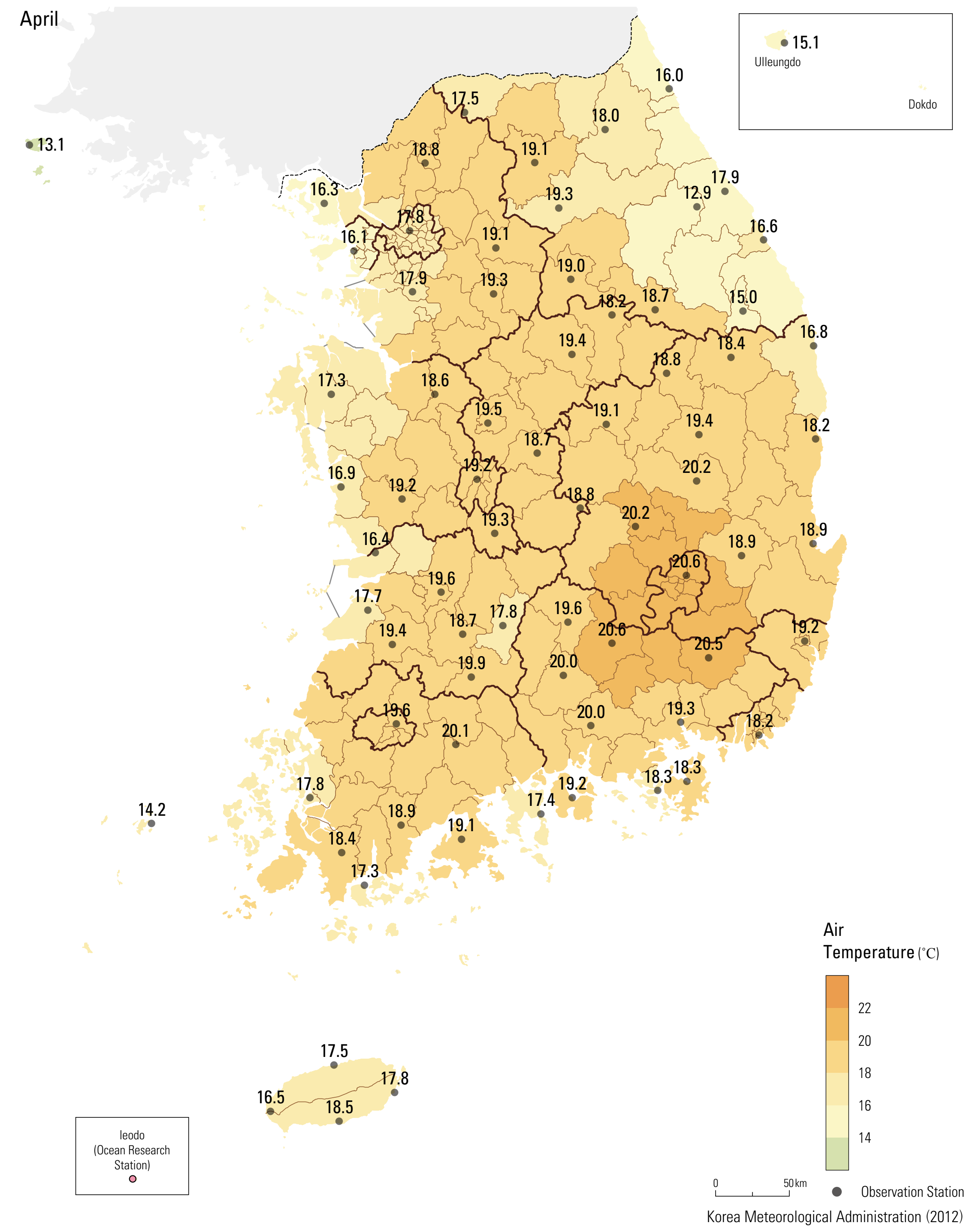


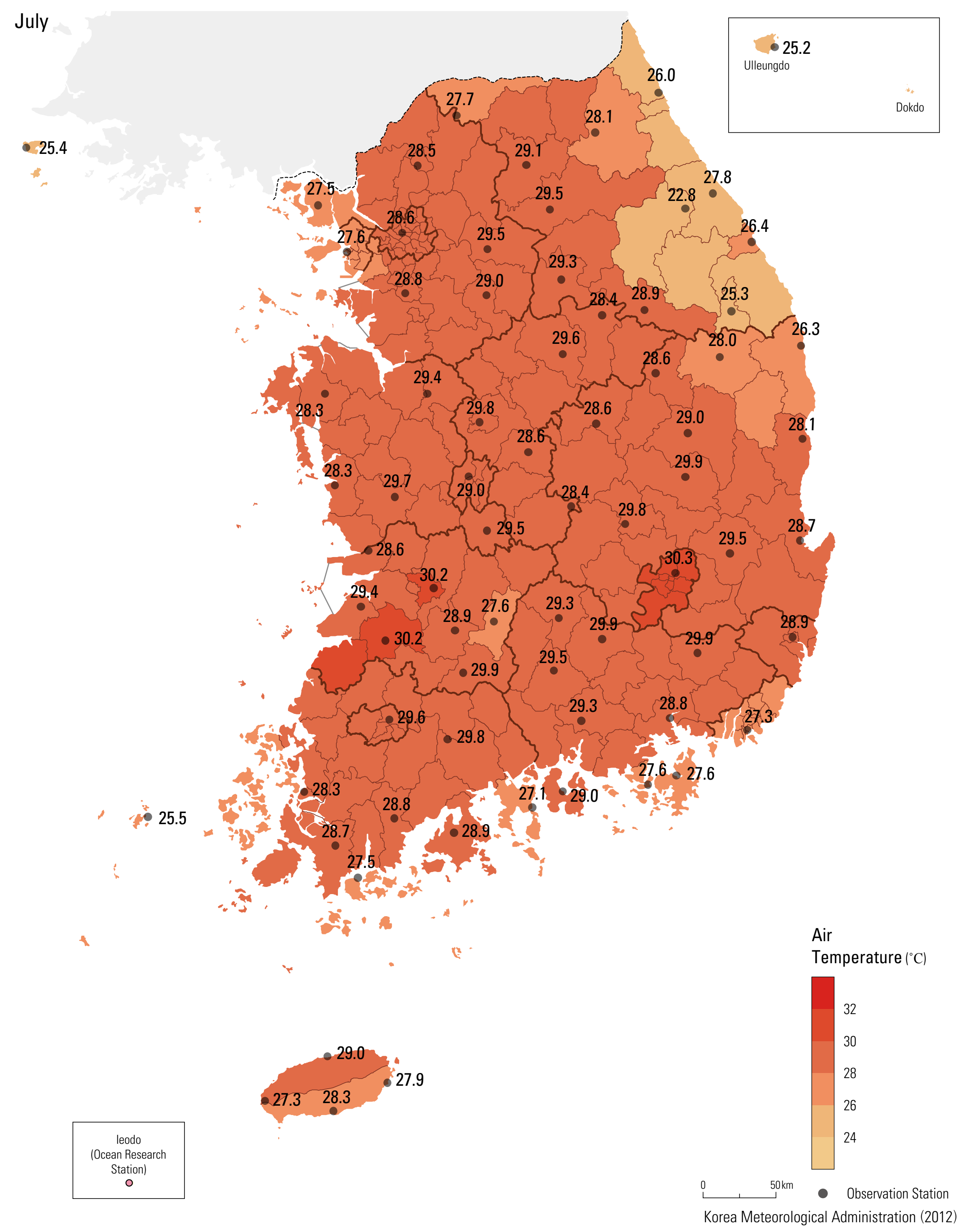
Winter Mean Air Temperature and Precipitation (1981 – 2010)

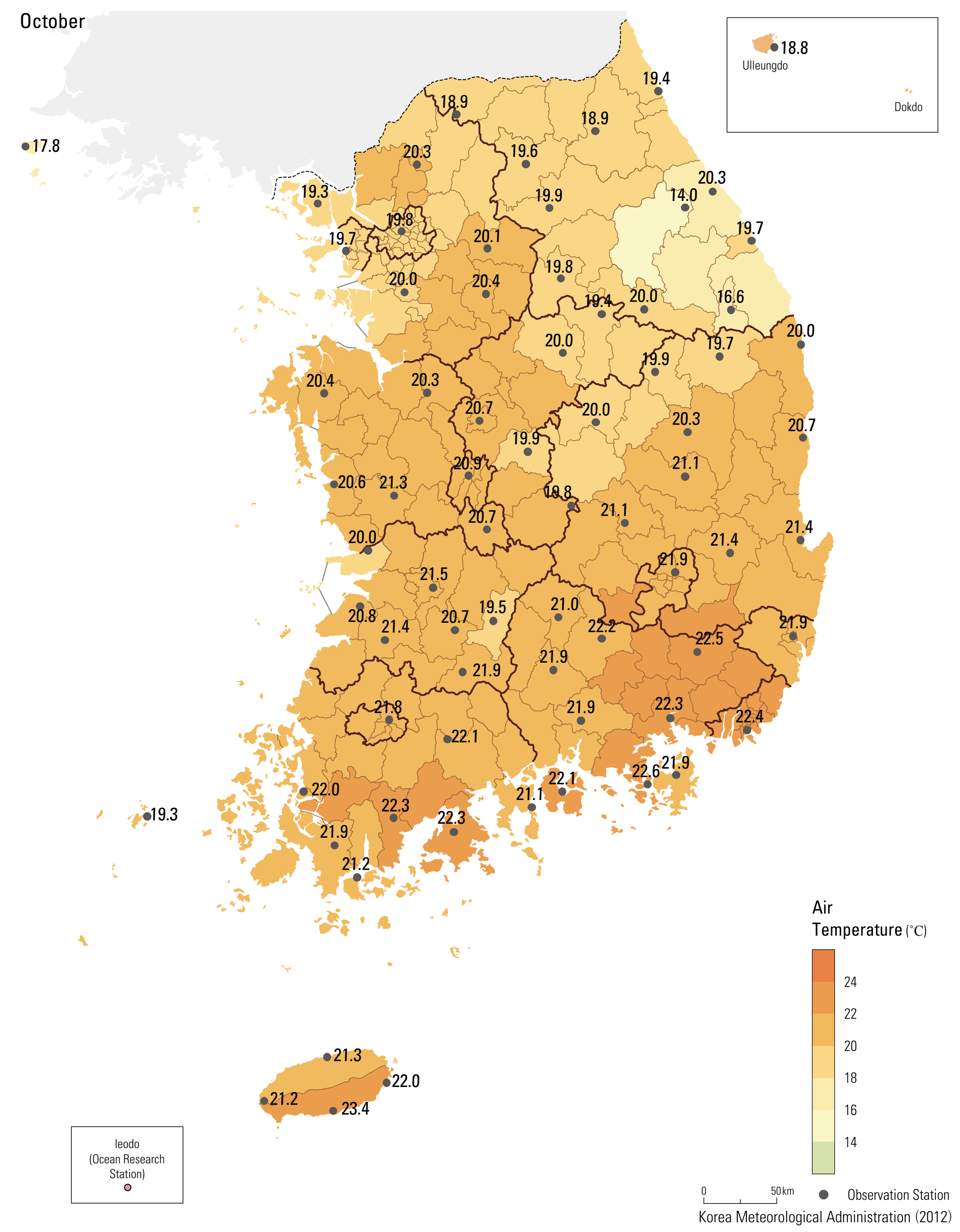


Mean Monthly Maximum Air Temperature (1981 – 2010) by Region (Si/Gun)



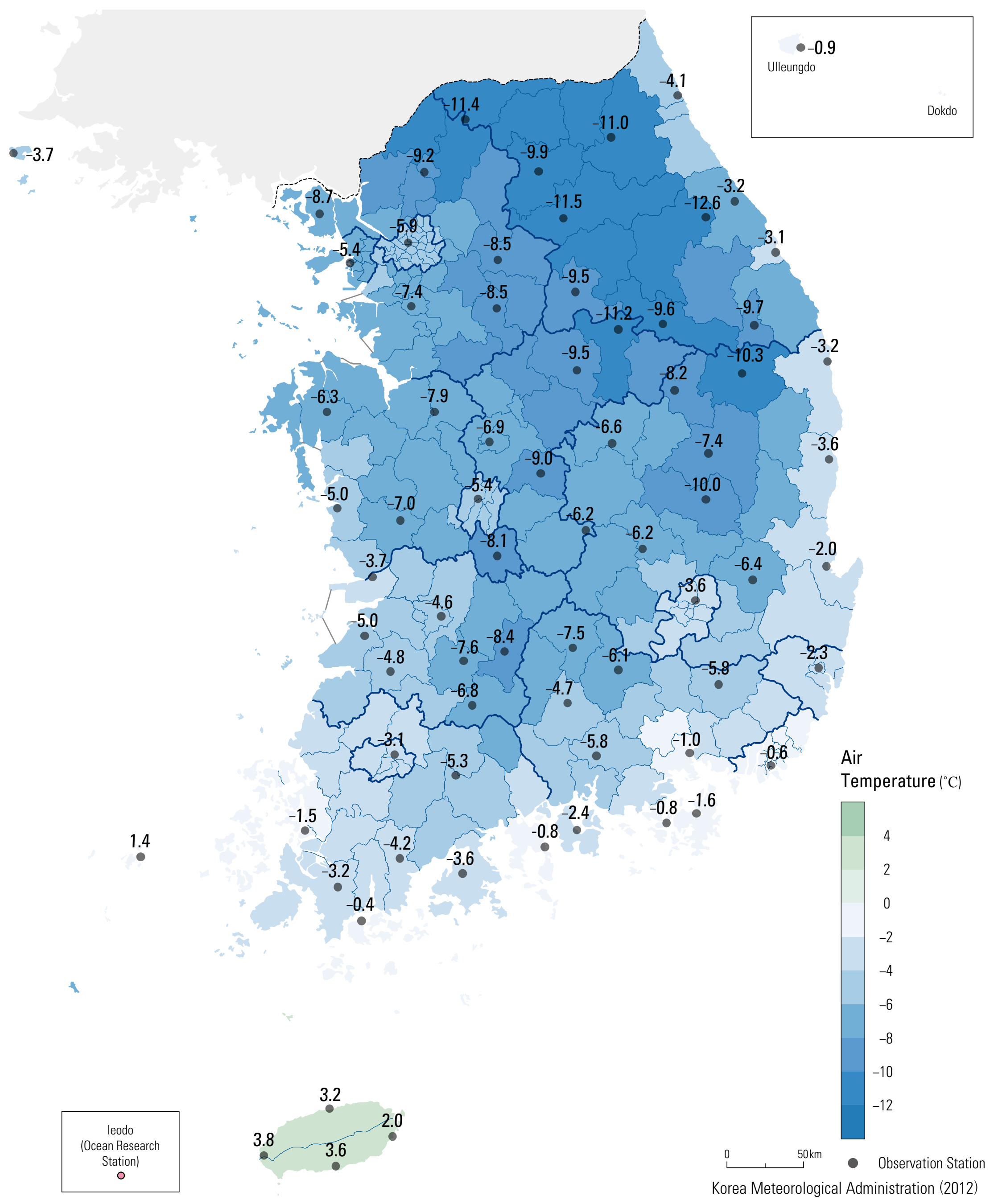




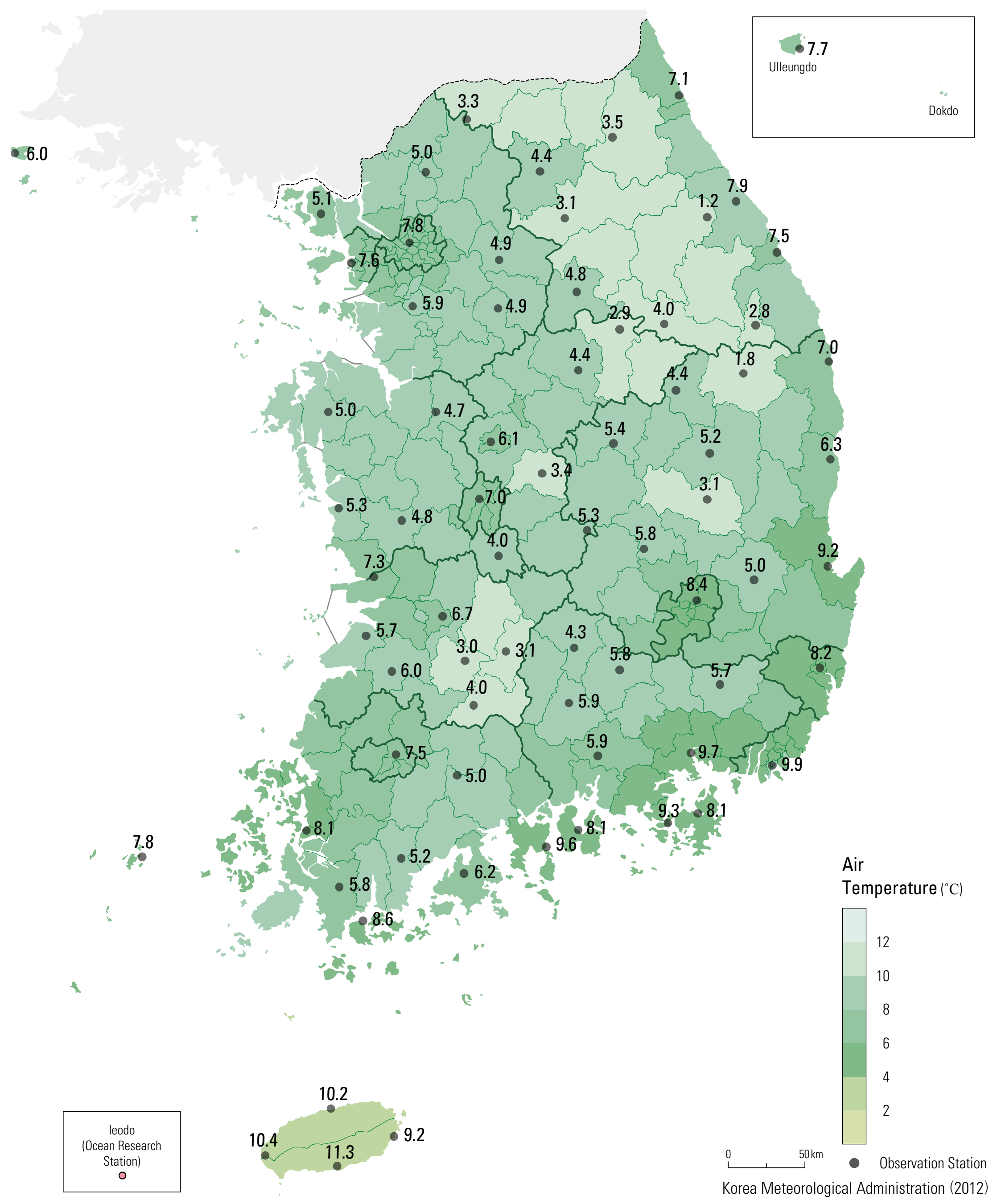


Mean Monthly Minimum Air Temperature (1981 – 2010) by Region (Si/Gun)

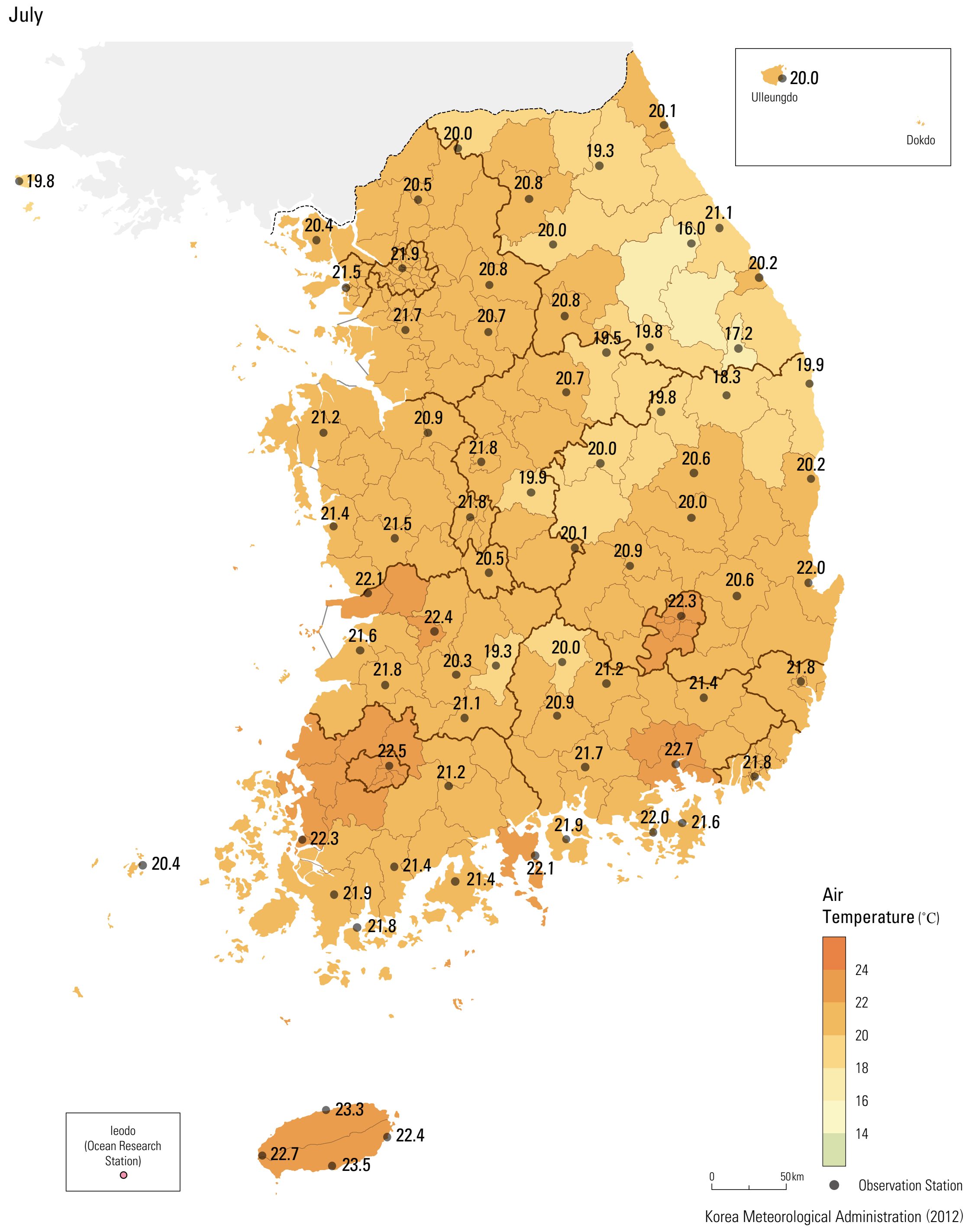
January



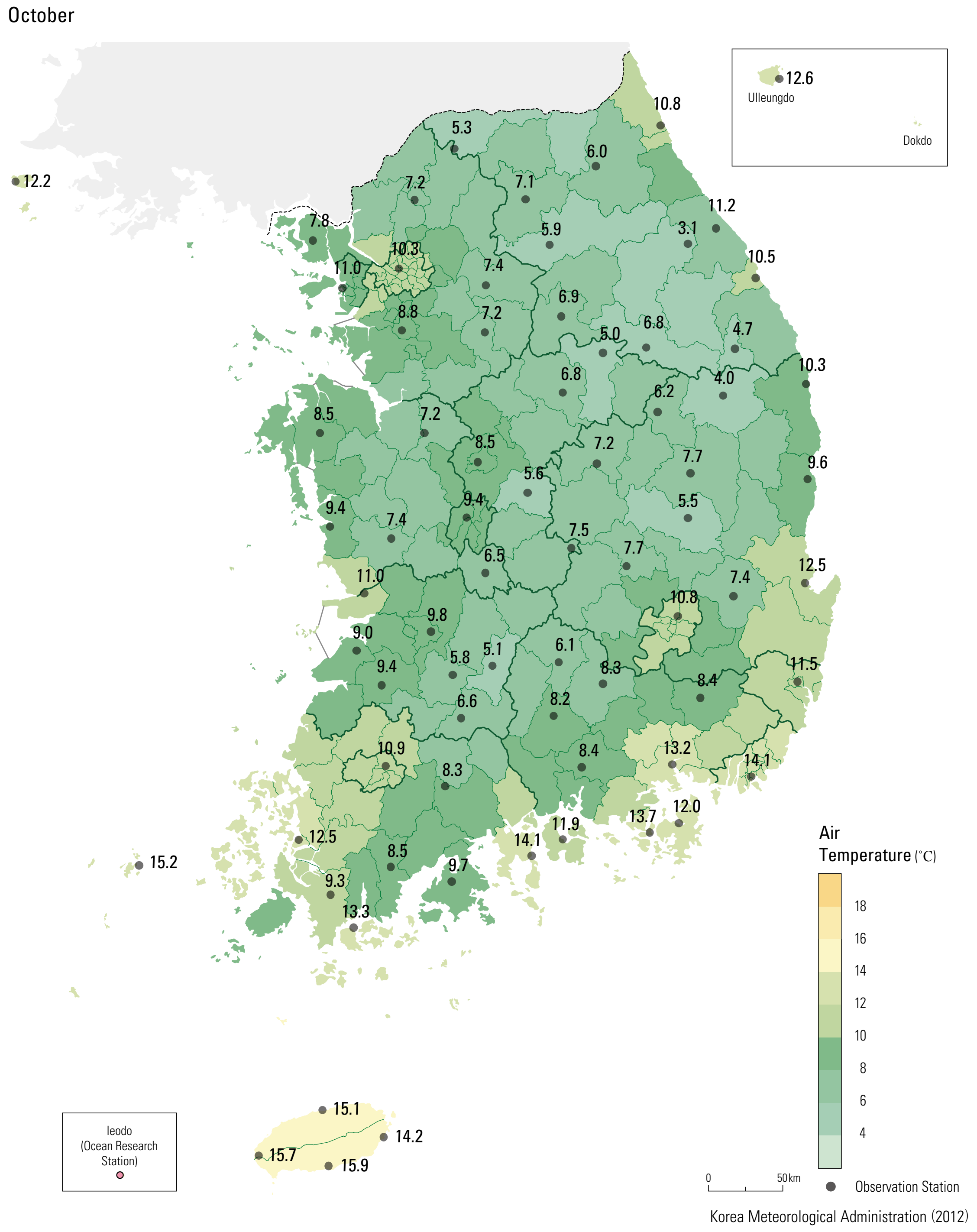
April



July

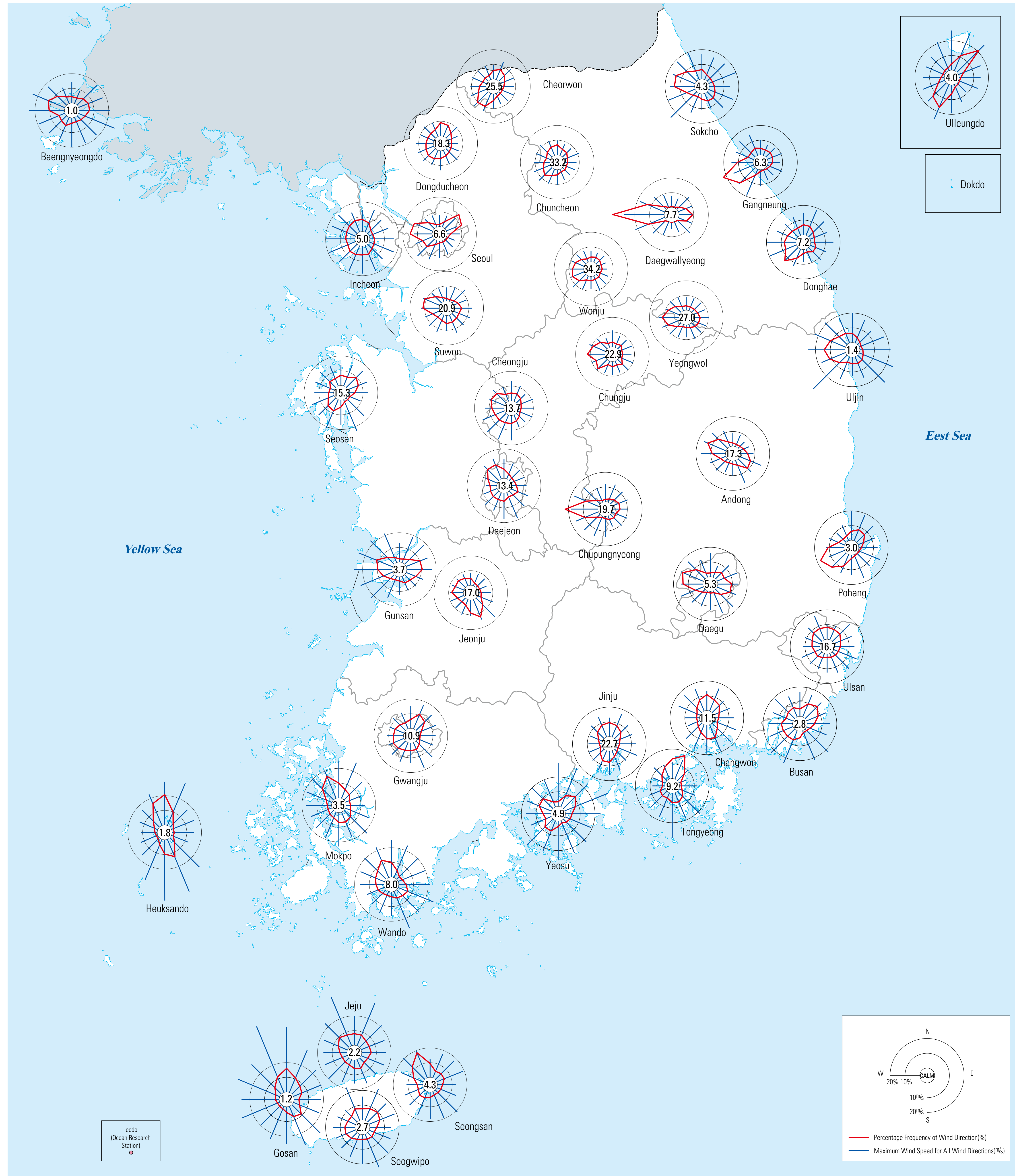


October



ATMOSPHERE AND HYDROSPHERE
Weather and Climate
Climate Elements and Number of Days with Weather Phenomena

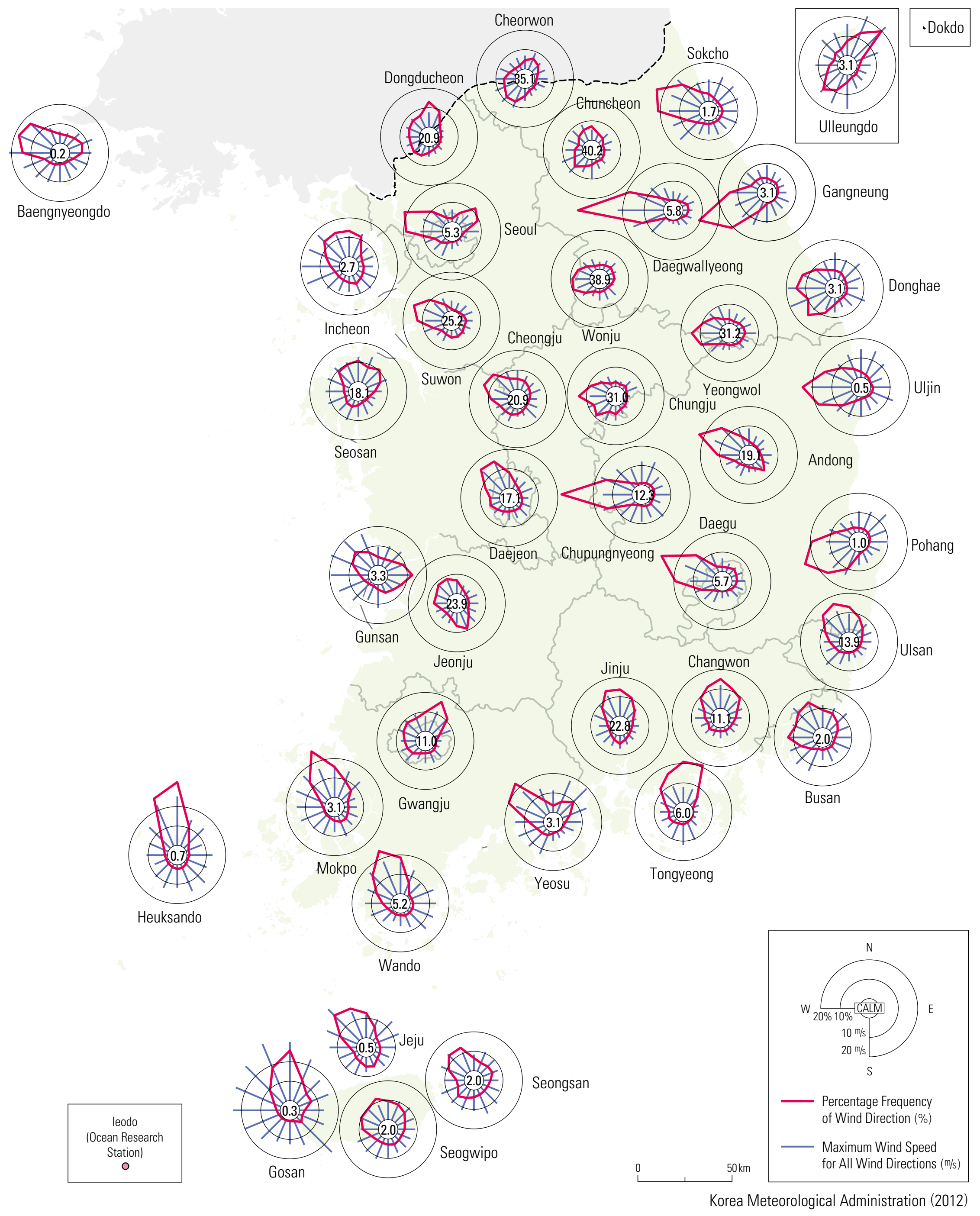
Annual Mean Wind Rose at Selected Stations (1981 – 2010)



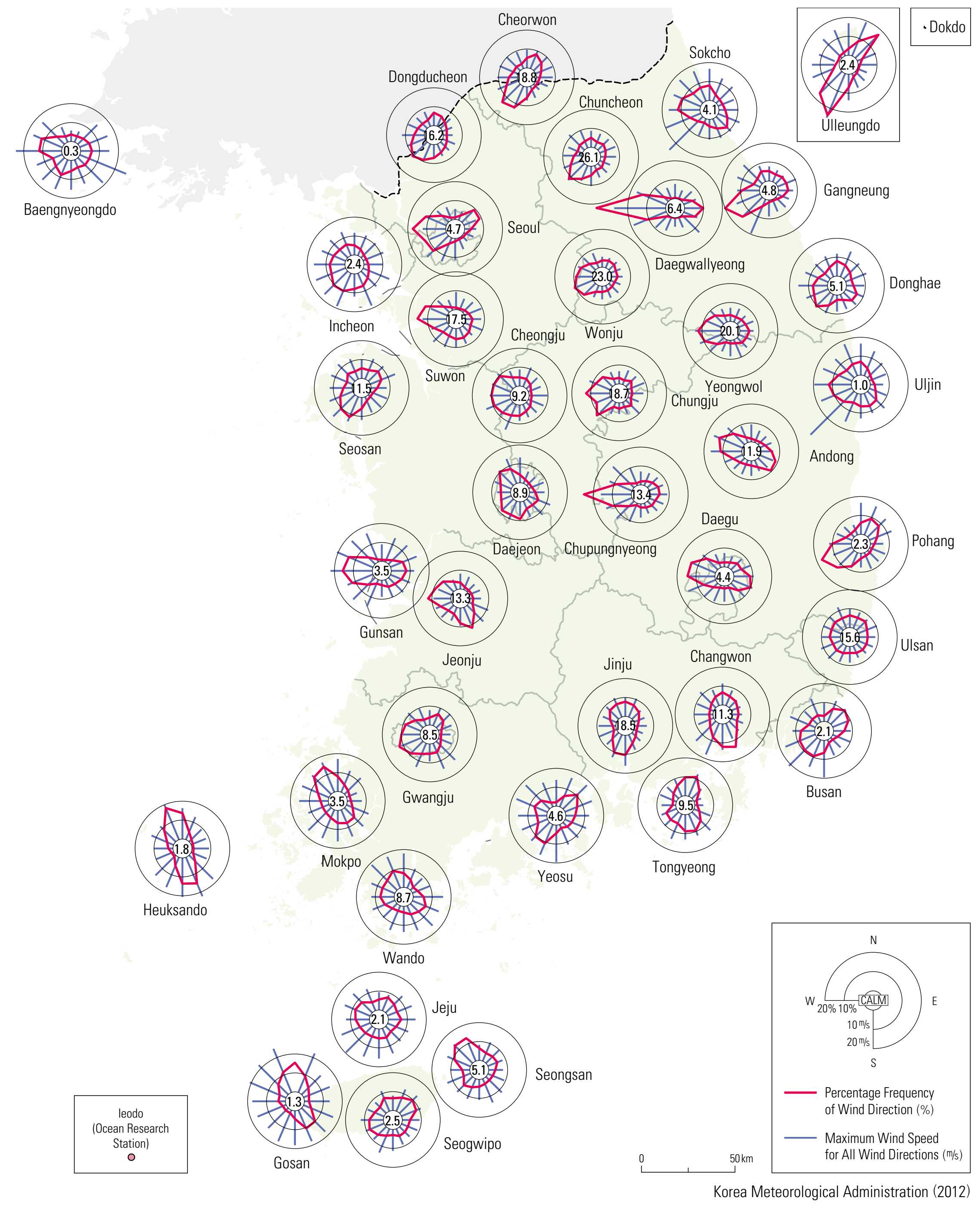
Korea Meteorological Administration (2012)

Korea, located in the mid-latitudes, is largely affected by the westerlies and the East Asian monsoon system. Thus, the northerly and the westerly are dominant during winter, especially in January, while the southwesterly, the southerly, and the southeasterly prevail in summer, especially in August. However, the wind direction in summer is not as prevalent as in winter. Although there is no prevailing wind in spring (April) and autumn (October), the northeasterly often blows into the east coast areas. However, the wind direction can vary on a local scale with the geographical location of weather stations and its surrounding topography. Wind speed is generally much greater in coastal areas than in inland areas. The highest daily maximum wind speed was recorded in Gosan (51.1 m/s) on September 12, 2013, and the highest daily maximum instantaneous wind speed was recorded in Sokcho (63.7 m/s) on October 23, 2006.

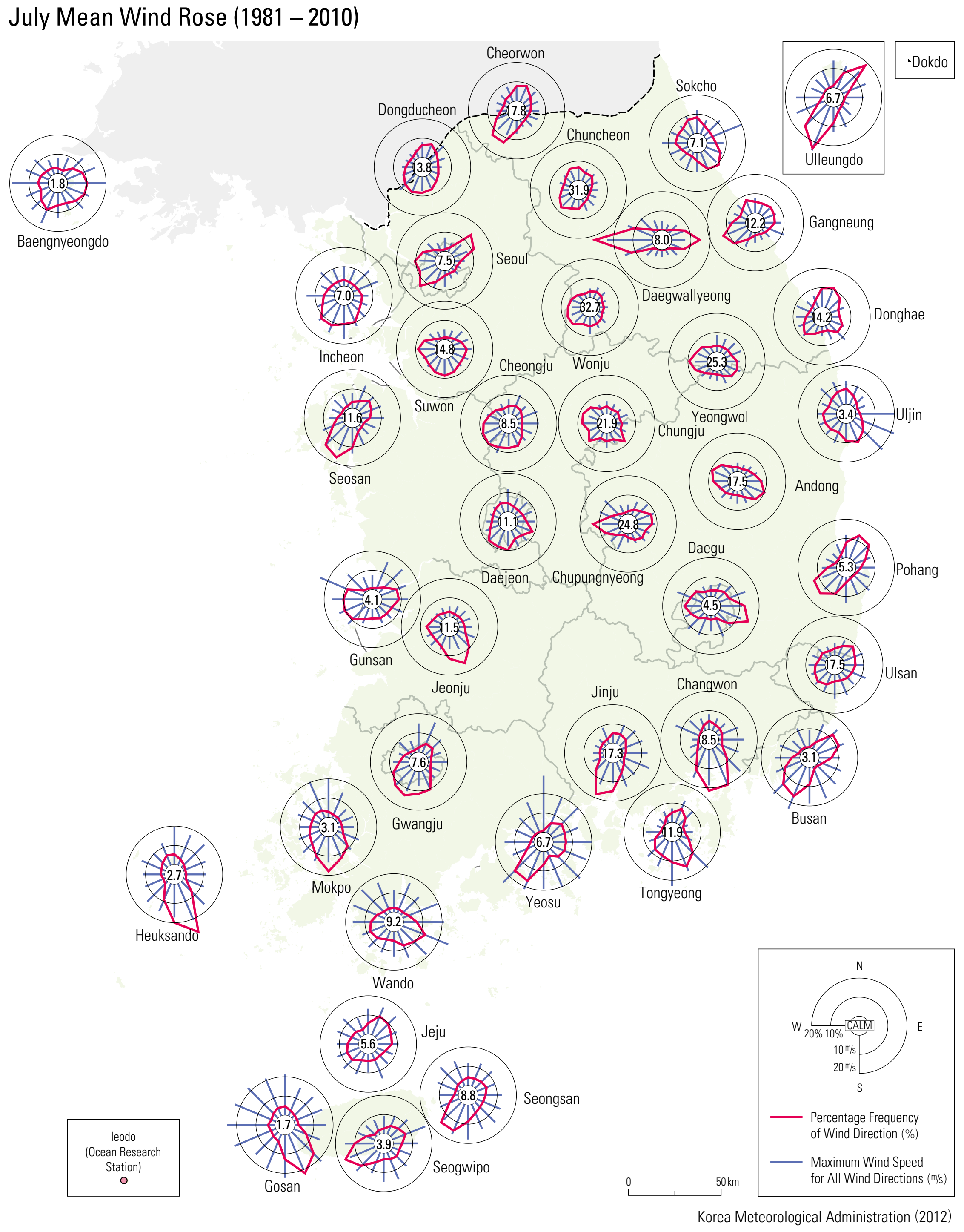
January Mean Wind Rose (1981 – 2010)



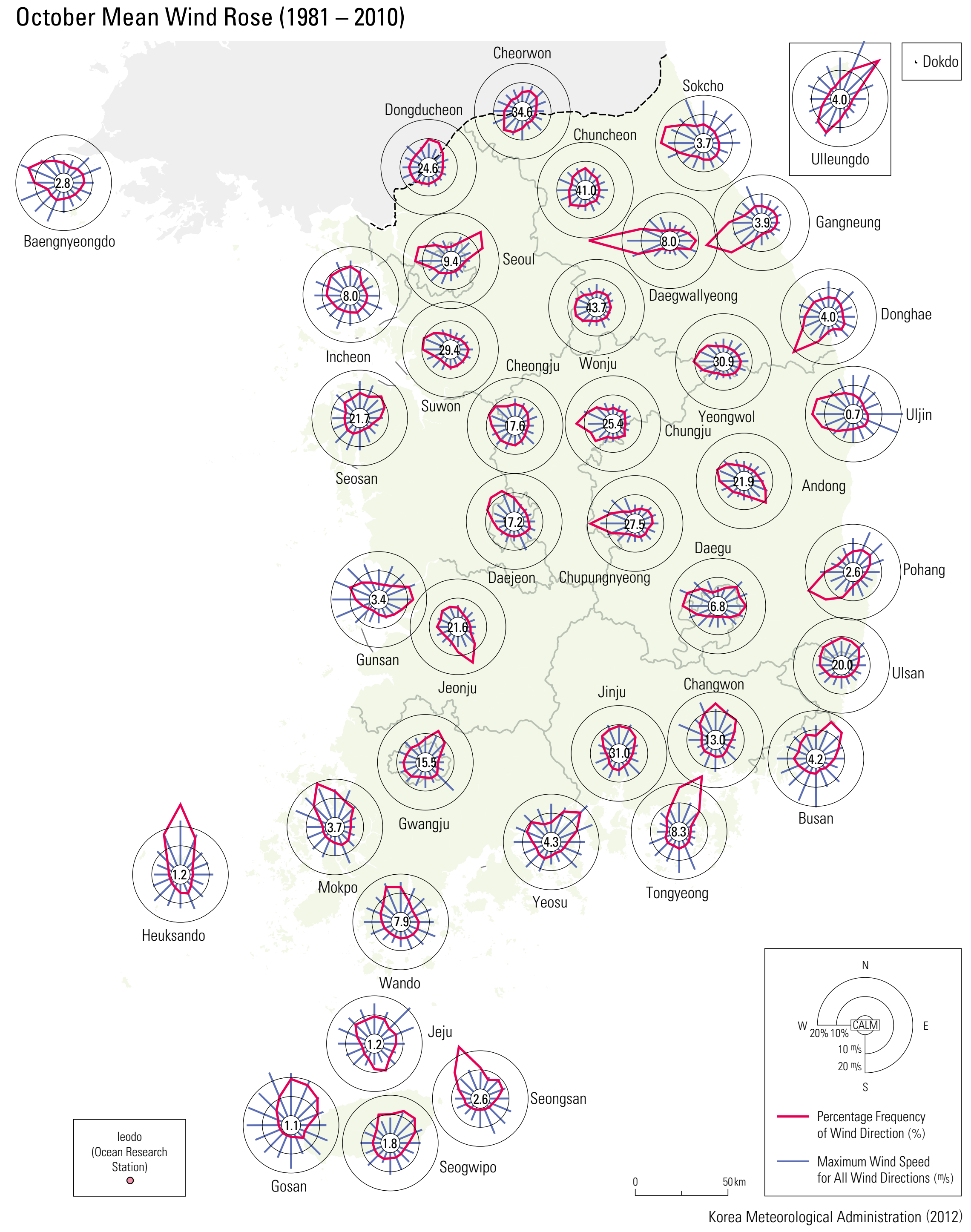
April Mean Wind Rose (1981 – 2010)



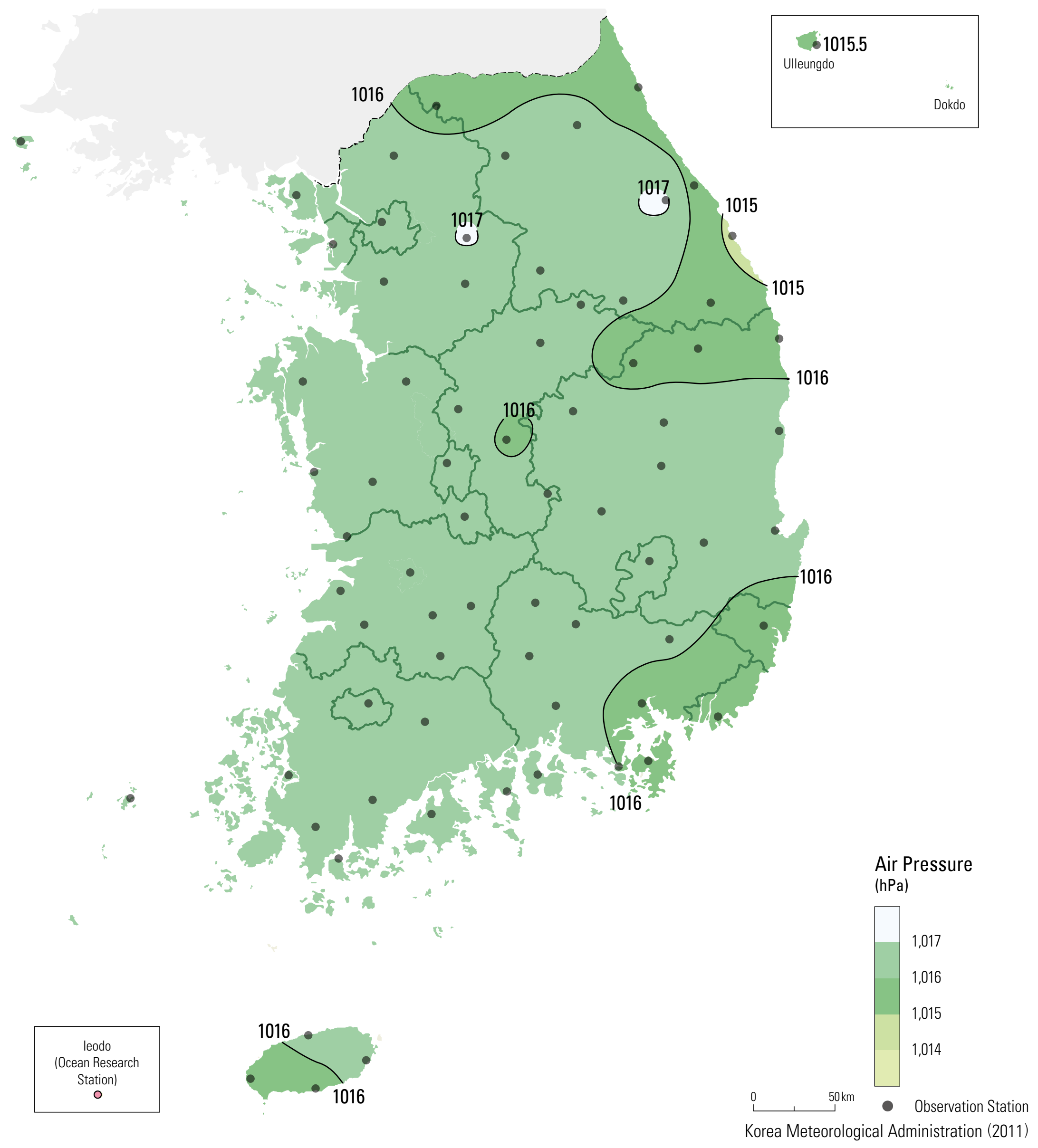
July Mean Wind Rose (1981 – 2010)



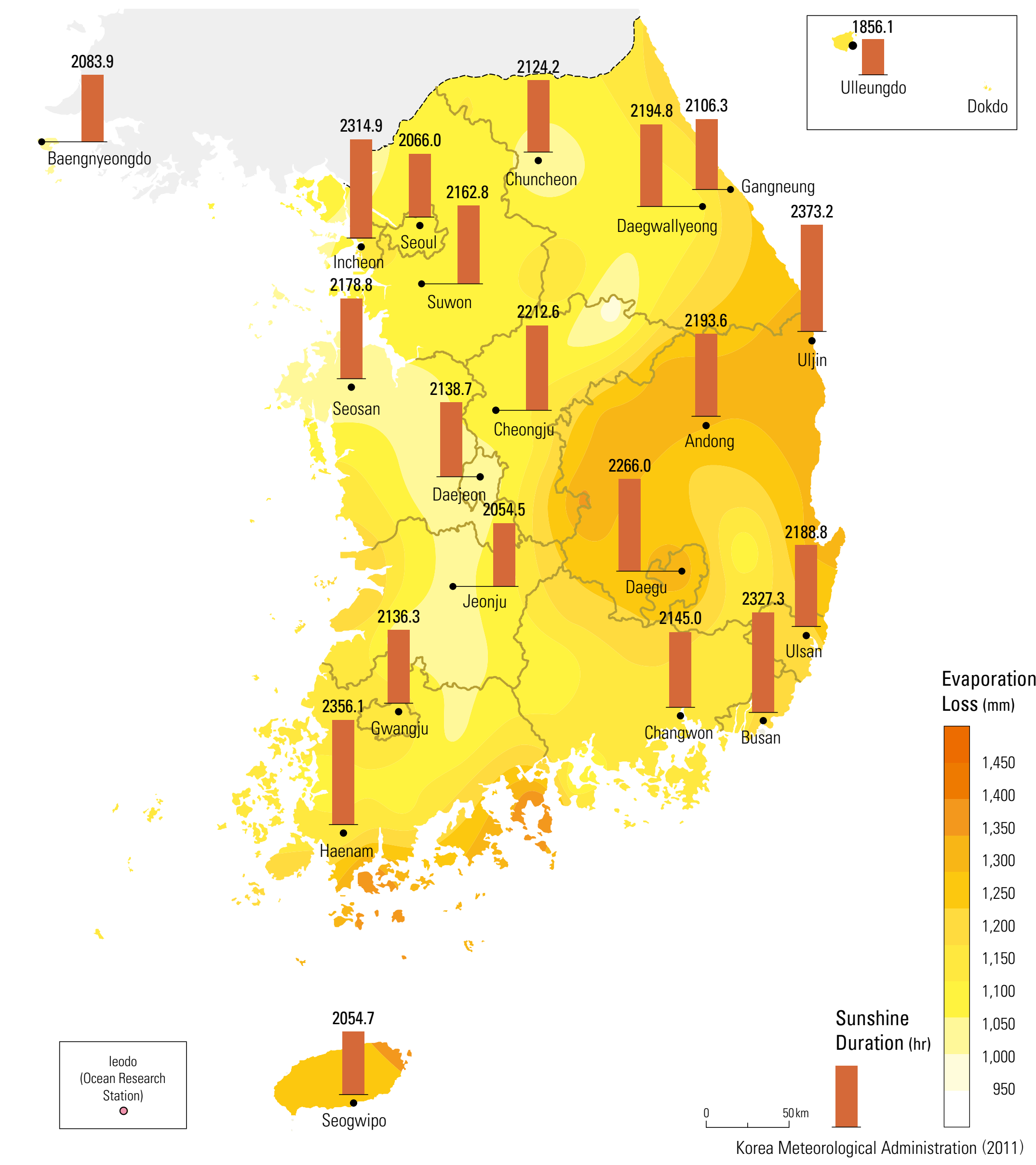
October Mean Wind Rose (1981 – 2010)



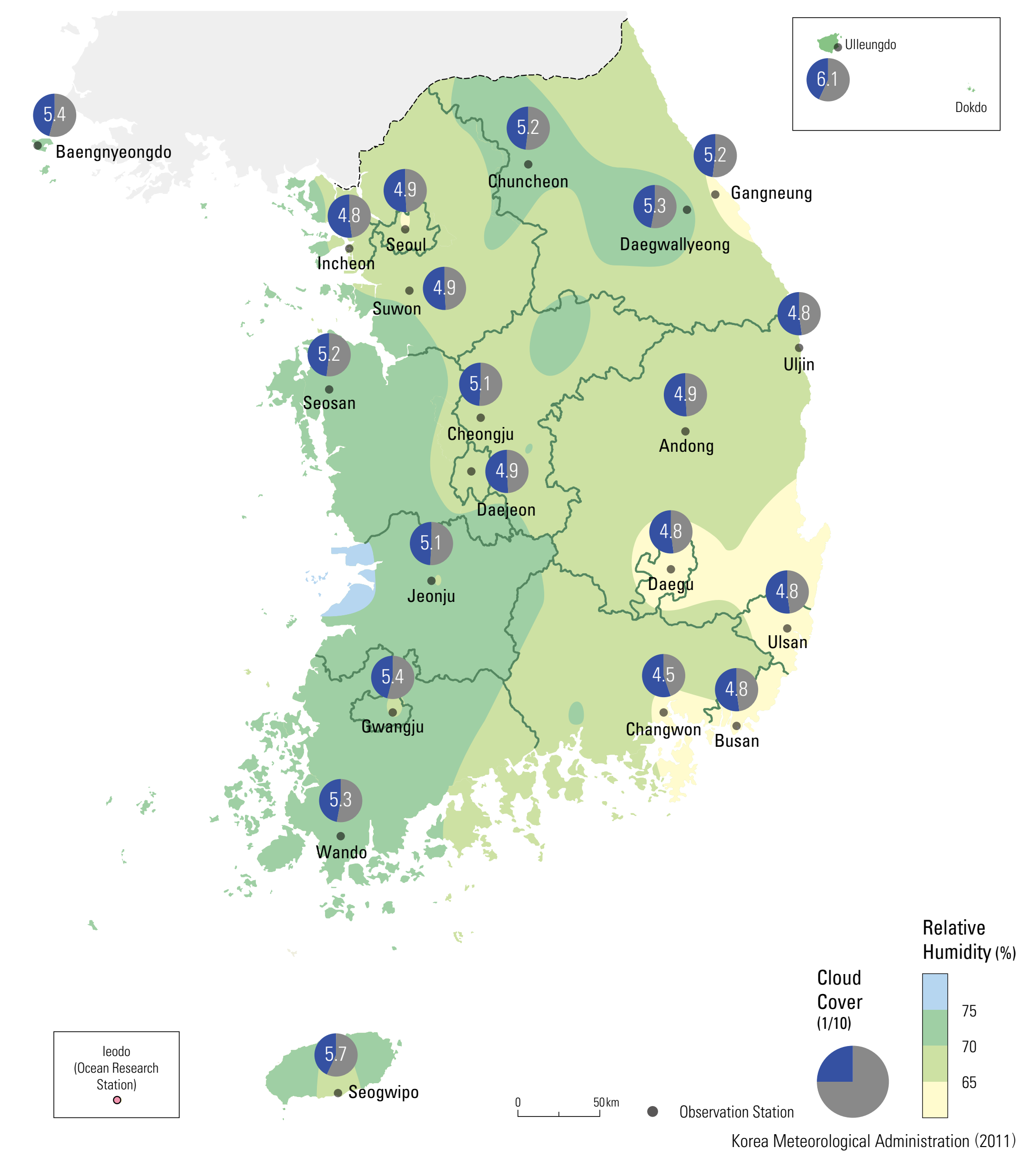
Annual Mean Sea-Level Pressure (1981 – 2010)



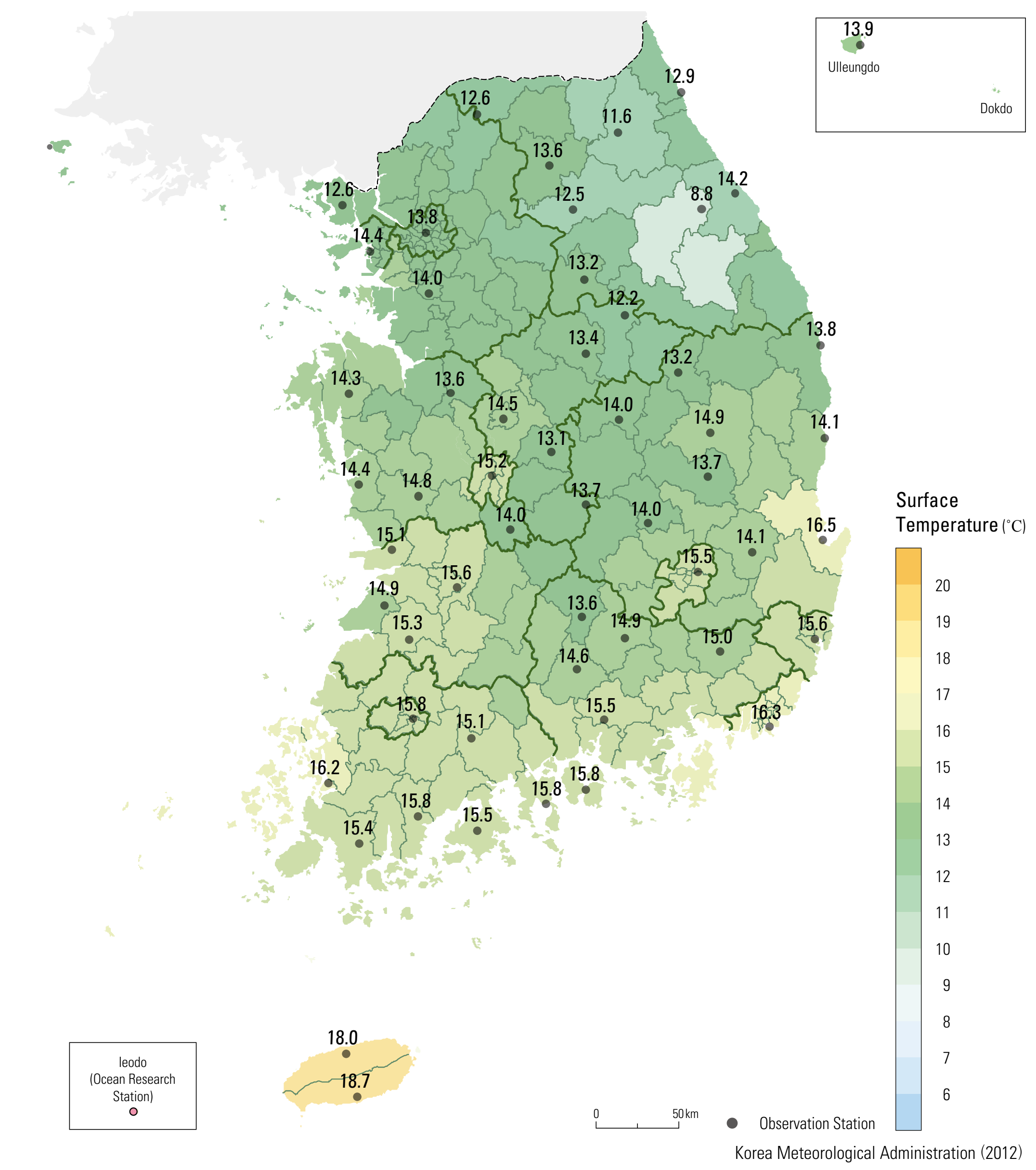
Annual Sunshine Duration and Annual Mean Amount of Evaporation (1981 – 2010)



Annual Mean Cloud Cover and Relative Humidity (1981 – 2010)



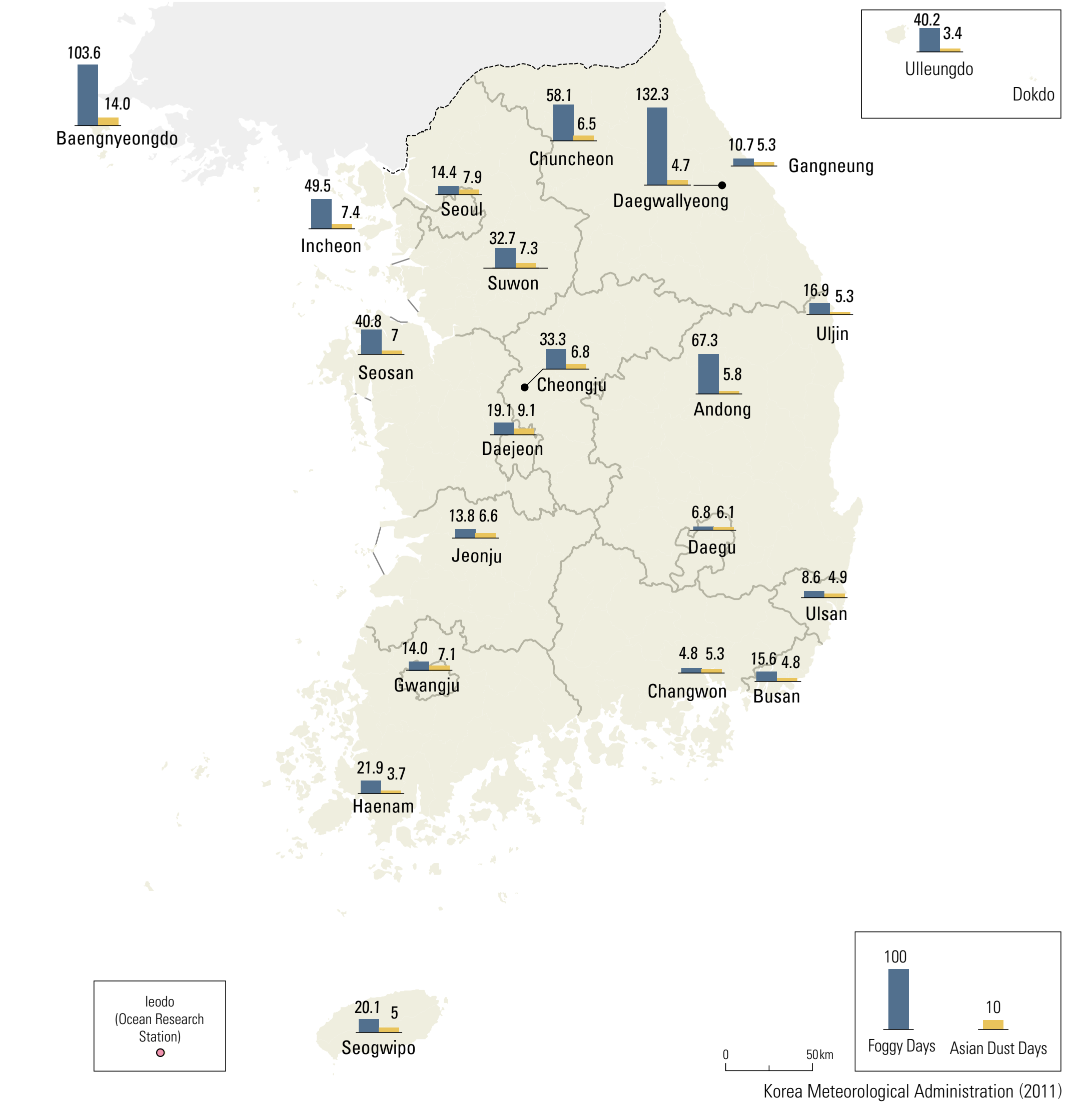
Annual Mean Surface Temperature (1981 – 2010) by Region (Si/Gun)



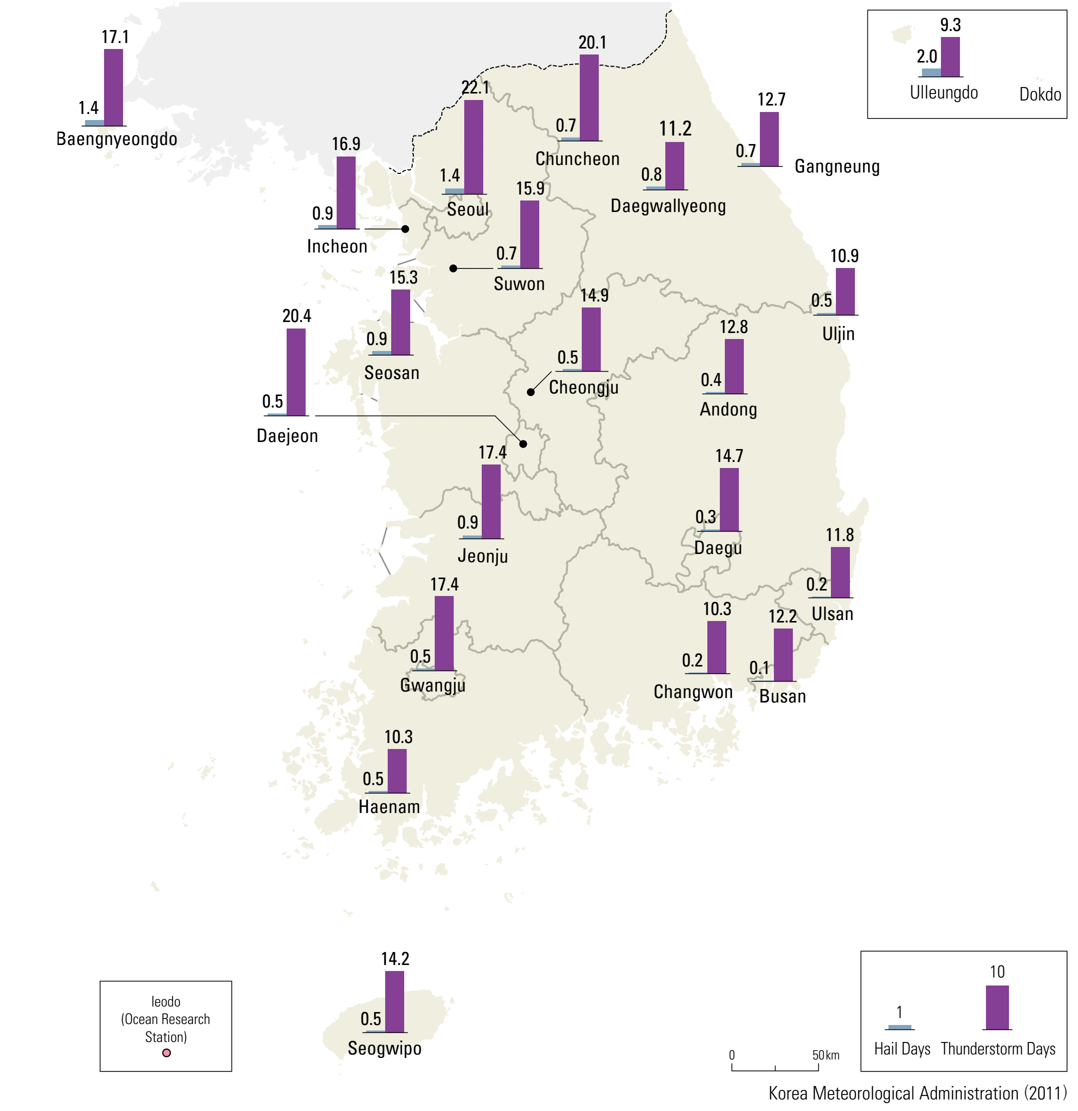
The annual mean sunshine duration is short in island areas such as Seogwipo (2,054.7 hrs), Ulleungdo (1,856.1 hrs), and Baengnyeongdo (2,083.9 hrs). On the other hand, the annual mean sunshine duration is long in the Yeongnam inland areas, the southeastern coastal areas, and the southernmost parts of the Taebaeksanmaek. Uljin (2,373.2 hrs) has the longest annual mean sunshine duration, followed by Haenam (2,356.1 hrs), Busan (2,372.3 hrs), Daegu (2,260.0 hrs), and Andong (2,193.6 hrs). In terms of amount of evaporation loss, Yeosu (1377.6 mm) has the largest while Ganghwa (956.8 mm) has the lowest.

Annual mean cloud cover in Korea varies from 45% to 61%. Gosan, Jeju, and Ulleungdo have the highest cloud cover with 61%. Seongsan, Imsil, and Suncheon also have a high cloud cover. Changwon and Ganghwa have the lowest cloud cover at 45%, followed by Tongyeong, Mungyeong, Yeosu, and Pohang. Annual mean relative humidity varies from 61.4 to 77.4%. The highest relative humidity appears in Heuksando (77.4%). Buan, Gunsan, Gosan, and Ulleungdo also have high relative humidity. The lowest relative humidity appears in Gangneung (61.4%), followed by Daegu, Pohang, Geoje, and Changwon.

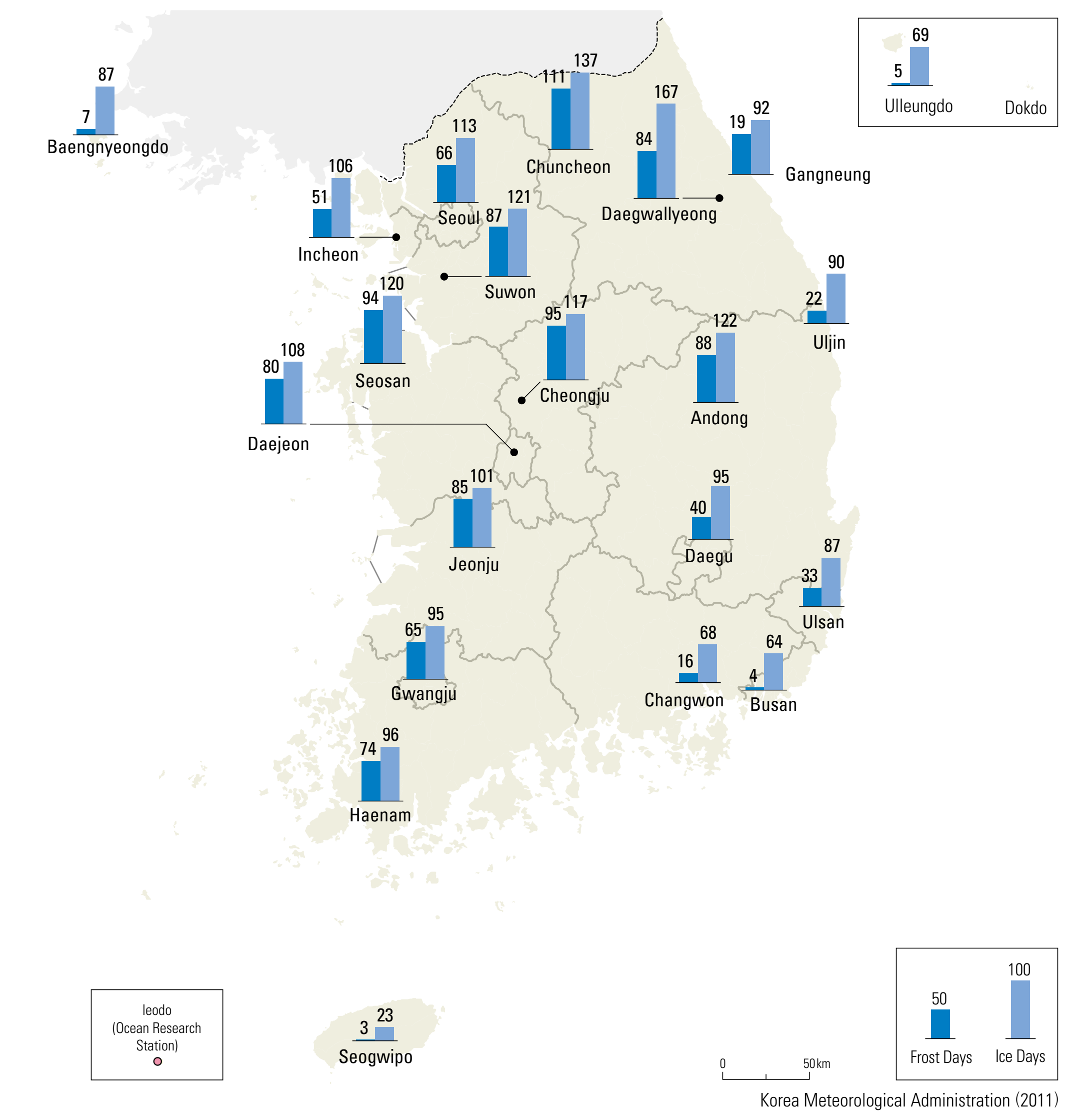
Annual Mean Number of Foggy Days and Asian Dust Days (1981 – 2010)



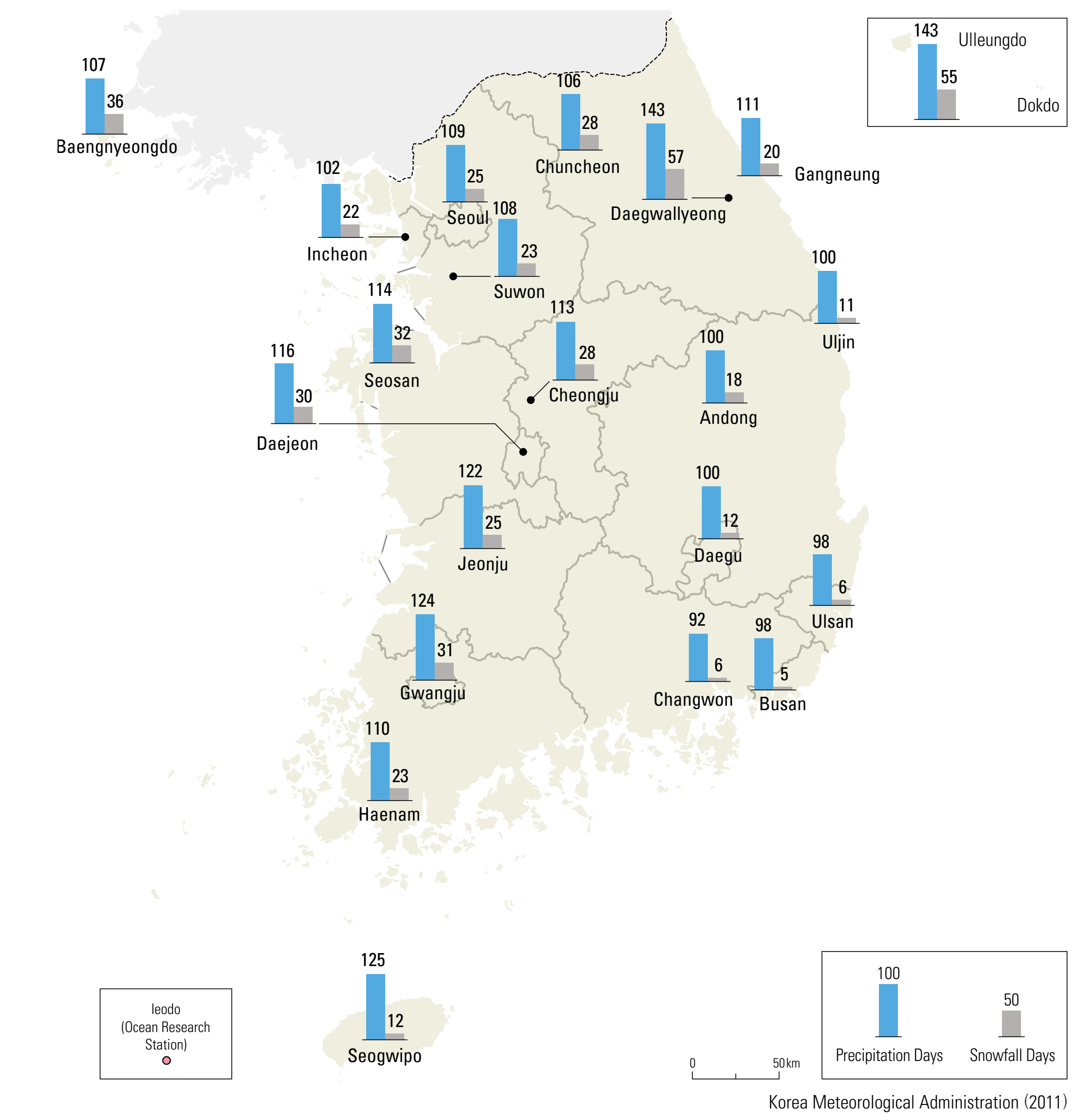
Annual Mean Number of Hail Days and Thunderstorm Days (1981 – 2010)



Annual Mean Number of Frost Days and Ice Days (1981 – 2010)



Annual Mean Number of Precipitation Days and Snowfall Days (1981 – 2010)



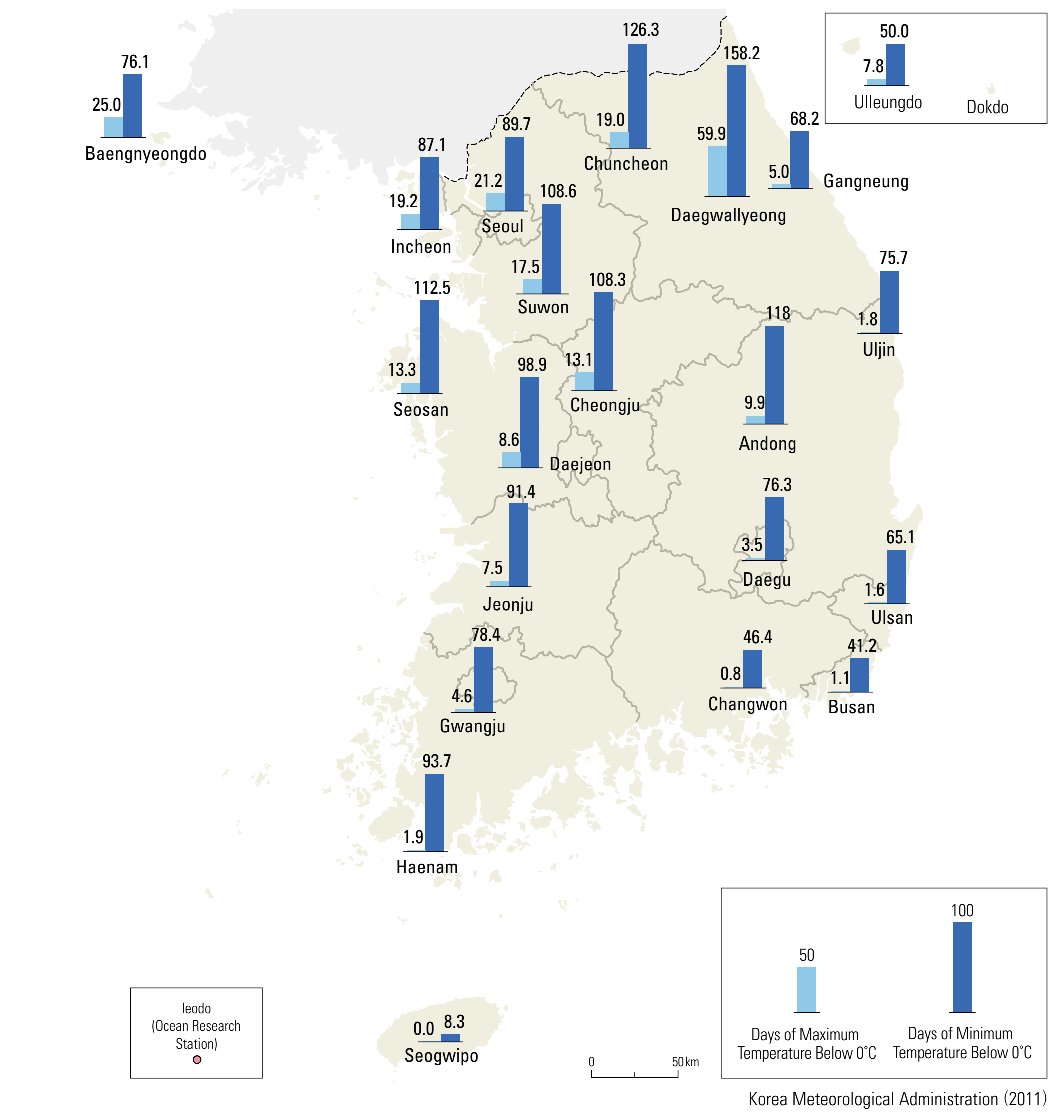
Daegwallyeong experiences the highest annual mean number of days with fog (132.3 days) due to high altitude. On average, the eastern coast has more foggy days than the western coast. Low numbers of fog day are found in Changwon (4.8 days), Daegu (6.8 days), and so forth. The annual mean number of Asian dust days varies from 3.4 to 14 days. The number of Asian dust days decreases from the west coast to the east coast because the dust moves along with the westerlies. Baengnyeongdo has the most number of days (14 days) while Ulleungdo has the fewest (3.4 days).

The greatest annual mean number of days with hail occurs in Ulleungdo (2 days). Baengnyeongdo and Seoul (1.4 days) show the second greatest number of hail days. The maximum annual mean number of thunders occurs in Seoul (22.1 days), followed by Daejeon (20.4 days) and Chuncheon (20.1 days). It decreases from the west coast to the east coast. Ulleungdo has the lowest number of thunder days (9.3 days).

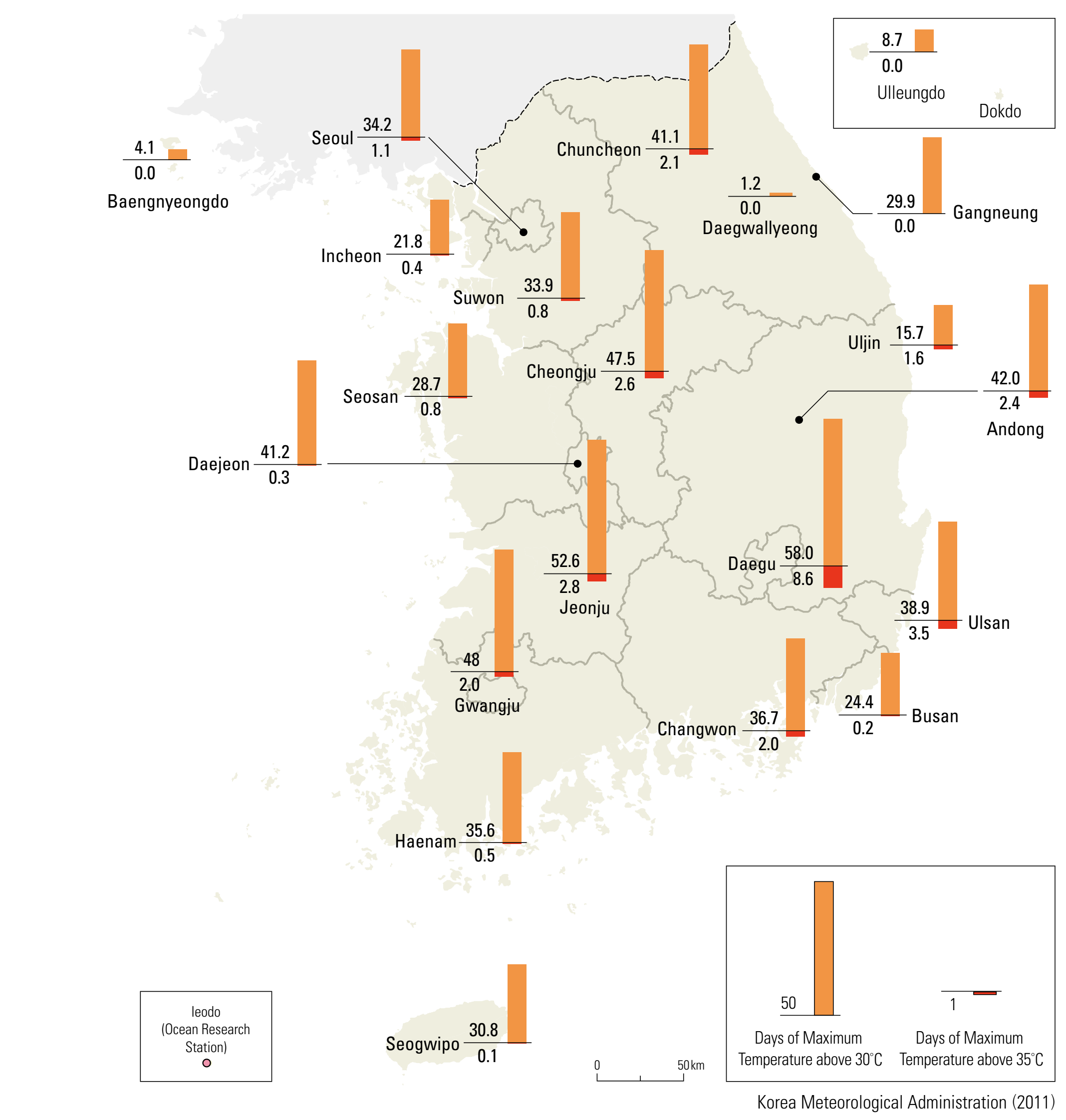
The greatest annual mean number of days with frost occurs in Chuncheon (111 days), followed by Cheongju (95 days) and Seosan (94 days). The areas on the east coast experience more frost days than those of the west coast. For instance, Gangneung (19 days) has 32 frost days fewer than Incheon (51 days), and Uljin (22 days) has 72 frost days fewer than Seosan (94 days). The largest annual mean number of days with ice occurs in Daegwallyeong (167 days). The annual mean number of ice days varies from 23 to 167 days, with the number of days decreasing from north to south. There is a relatively small difference in the annual mean number of ice days and frost days between the western coastal areas and the eastern coastal areas.

The annual mean number of days with daily precipitation over 0.1 mm in the central region is about 110 days. Daegwallyeong and Ulleungdo (143 days) have about 30 more precipitation days than the average for the central region. The annual mean number of precipitation days in the south is about 110 days, which is similar to the number of days in the central region. There is a big difference in the annual mean number of snowfall days between the central (30 days) and the southern region (14 days). Due to its high elevation, the highest number of snowfall days occurs in Daegwallyeong (57 days), which is 37 days more than that of cities adjacent to it, Gangneung (20 days). Also, Ulleungdo experiences many snowfall days owing to effects of the northeasterly.

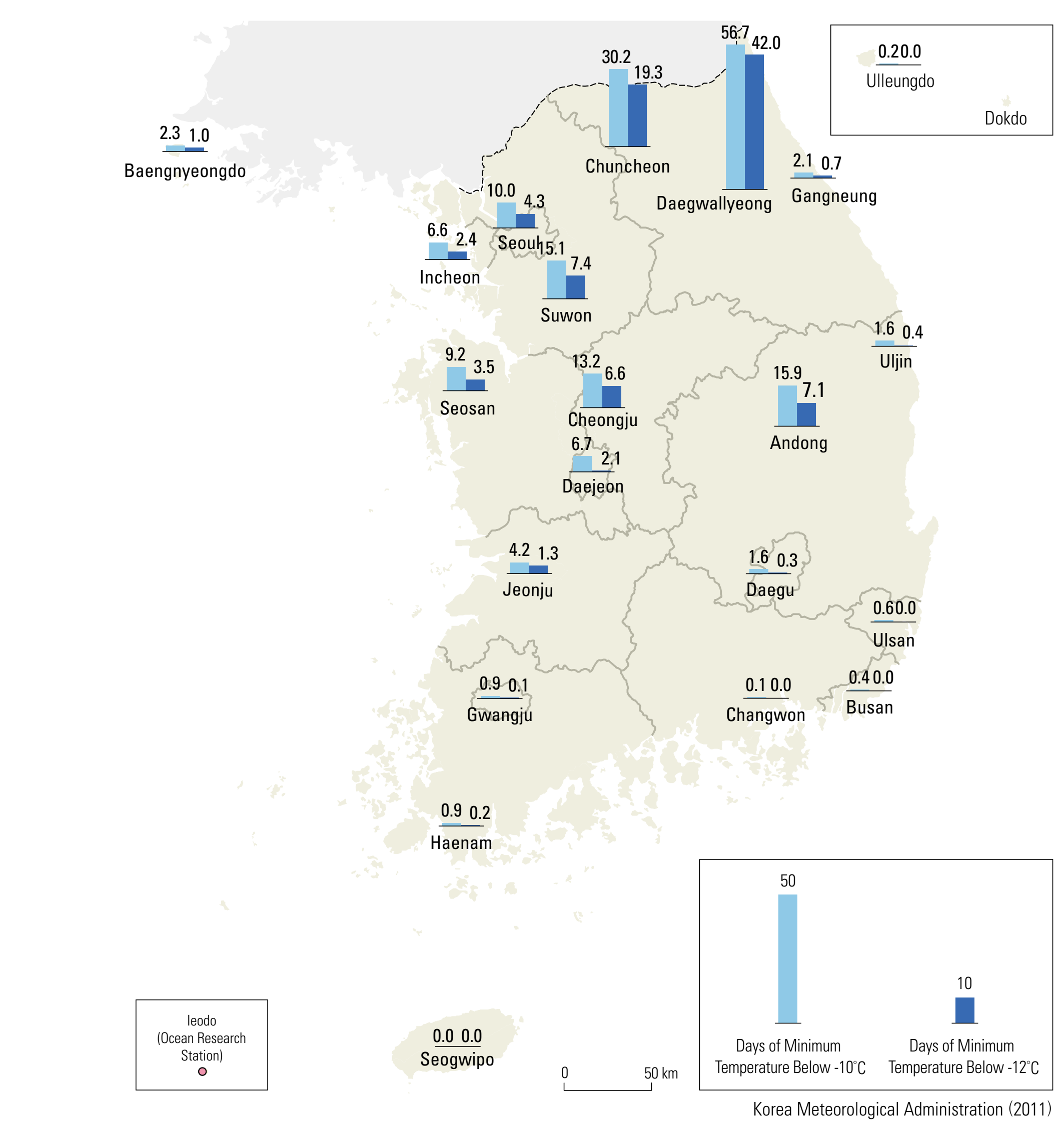
Annual Mean Number of Days with Daily Maximum and Minimum Temperature below 0˚C (1981 – 2010)



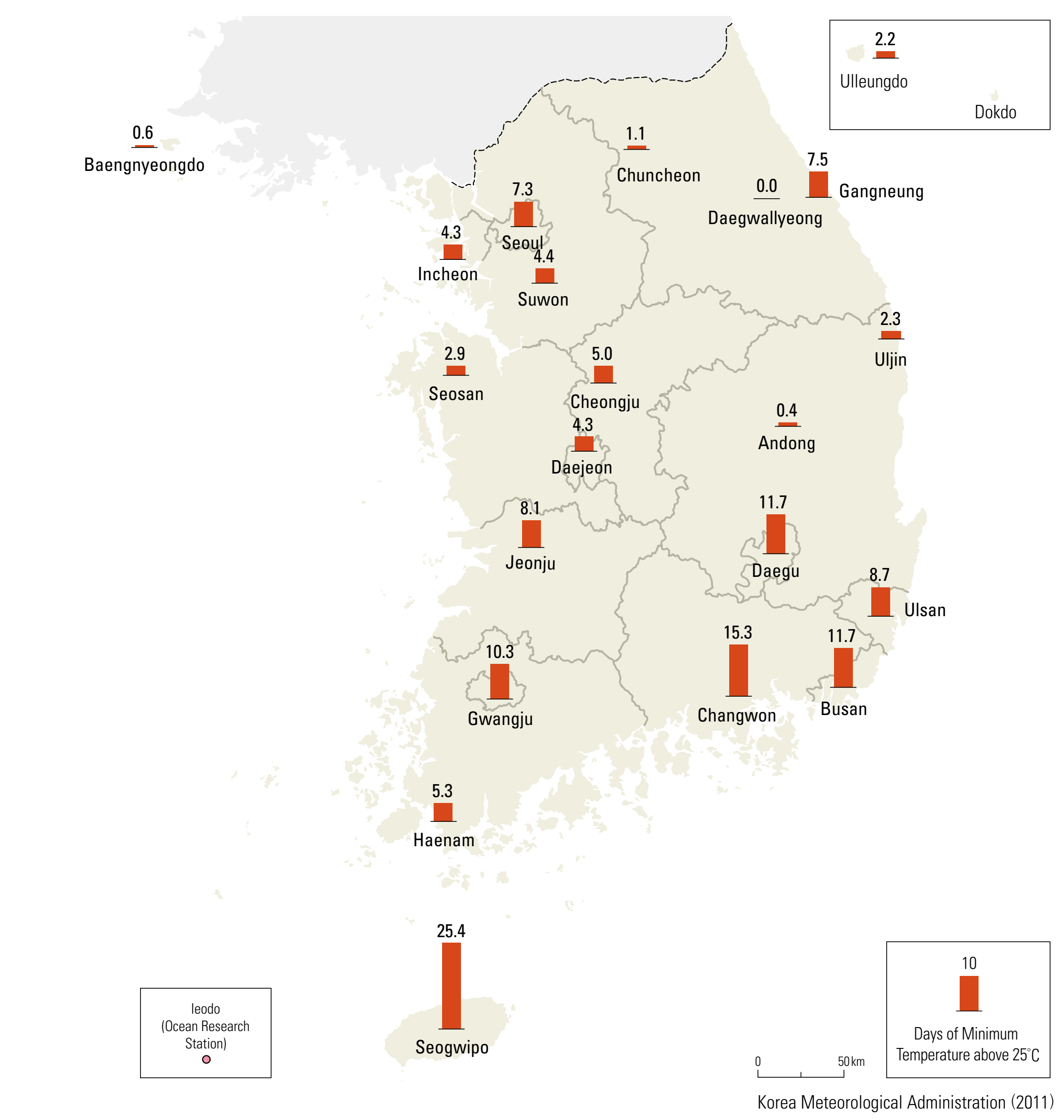
Annual Mean Number of Days with Daily Maximum Temperature above 30˚C and above 35˚C (1981 – 2010)



Annual Mean Number of Days with a Minimum Temperature below -10˚C and -12˚C (1981 – 2010)



Annual Mean Number of Days with a Daily Minimum Temperature above 25˚C (1981 – 2010)



The annual mean number of days with daily maximum and minimum temperatures below 0˚C is greater in inland areas than in coastal areas, and increases with latitude. Daegwallyeong (59.9 days) has the the most number of days with a maximum temperature below 0˚C, while Seogwipo (0.0 days) has the fewest. Daegwallyeong (158.2 days) also has the maximum number of days with a minimum temperature below 0˚C, while Seogwipo (8.3 days) has the fewest.

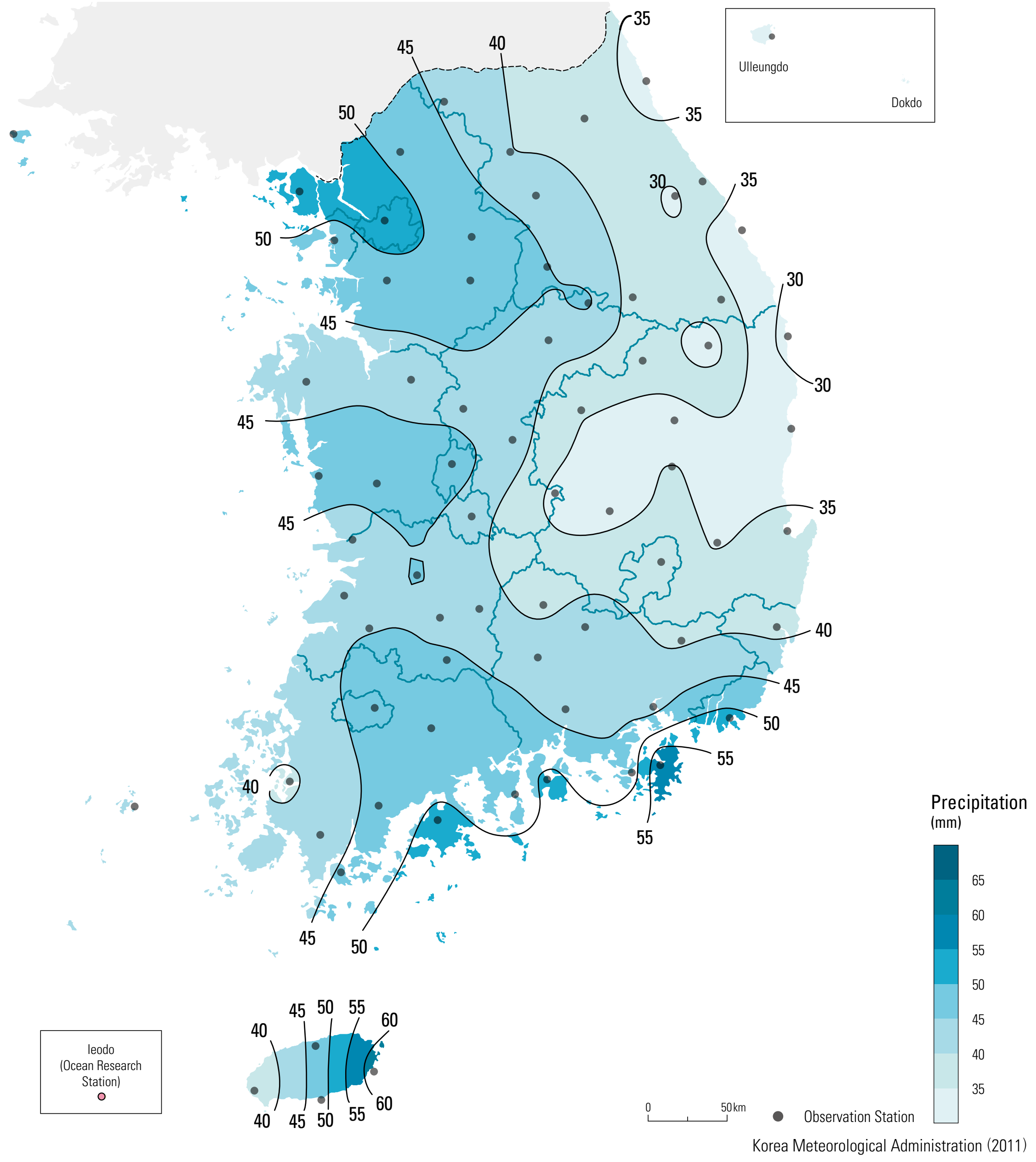
The annual mean number of days with a maximum temperature above 30˚C increases from coastal areas to inland areas. Daegu (58.0 days) experiences the greatest number of days with a maximum temperature over 30˚C, followed by Jeonju (52.6 days), while Daegwallyeong (1.2 days) experiences the fewest. Daegu (8.6 days) also has the most number of days with a maximum temperature over 35˚C, while Daegwallyeong, Gangneung, Baengnyeongdo, and Ulleungdo (0.0 days) have the fewest.

The annual mean number of days with a minimum temperature below -10˚C and -12˚C decreases from north to south, but increases from coastal areas to inland areas, as well as with altitude. The maximum number of days with a daily minimum temperature below -10˚C occurs in Daegwallyeong (56.7 days) while the fewest number of days is found in Seogwipo (0.0 days). The most number of days with a daily minimum temperature below -12˚C occurs in Daegwallyeong (42.0 days) while the fewest number of days is found in Changwon, Ulleungdo, Busan, Ulsan, and Seogwipo (0.0 days).

The daily minimum temperature above 25˚C usually occurs from July to September. Seogwipo (25.4 days) has the most number of days with a minimum temperature above 25˚C while Daegwallyeong (0.0 days) has the fewest, followed by Andong (0.4 days) and Baengnyeongdo (0.6 days).

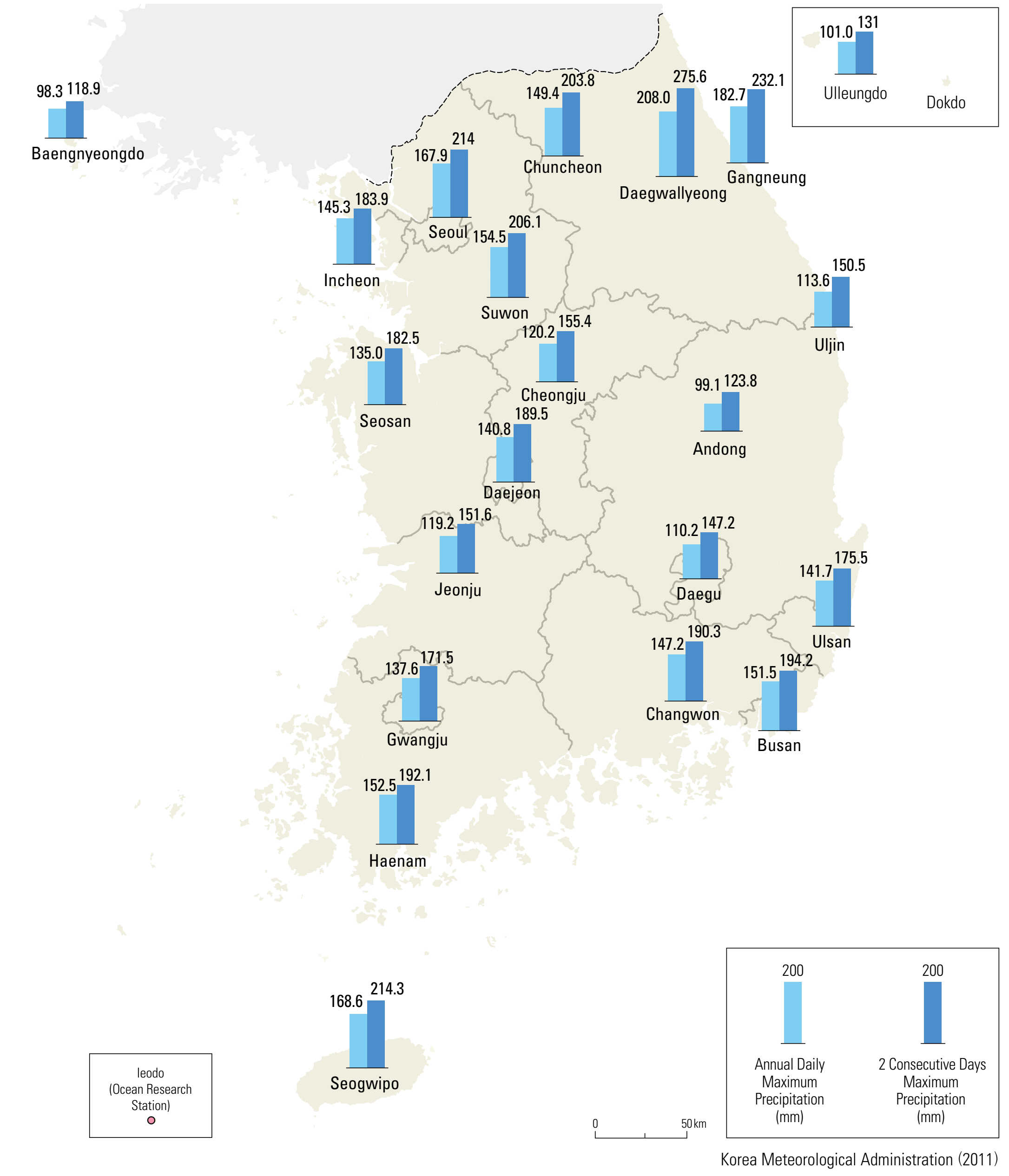
Extreme Climate Events

1-Hour Maximum Precipitation (1981 – 2010)



Korea Meteorological Administration (2011)

Annual Daily and 2-Day Consecutive Maximum Precipitation (1981 – 2010)



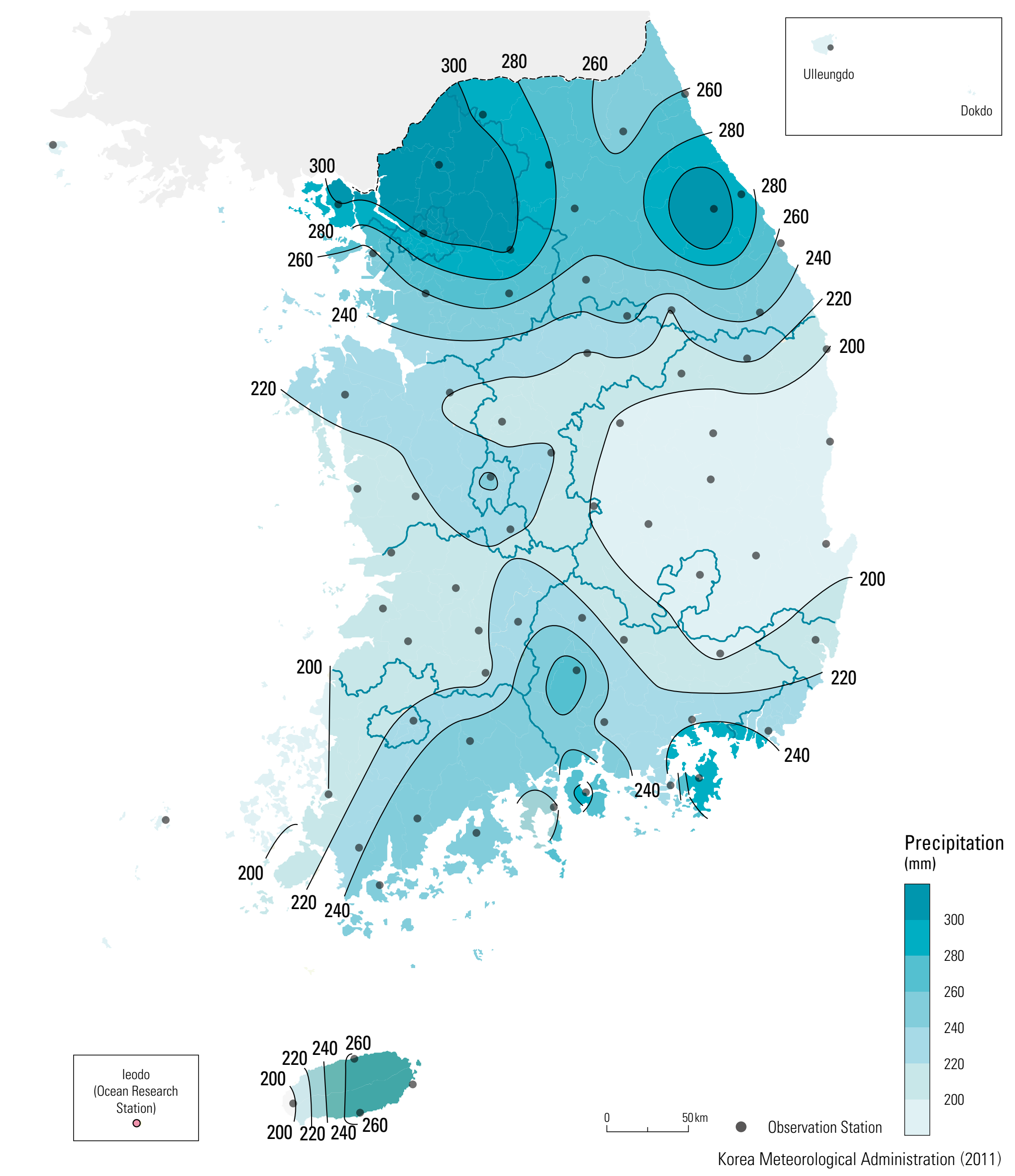
Korea Meteorological Administration (2011)

The highest 1-hour maximum precipitation on record was measured in Suncheon (145.0 mm) on July 31, 1998. This is attributed to localized heavy rain resulting from a strong ascending air current formed by the combination of the North Pacific High and low pressure associated with the southerly on the windward side of Jirisan. The second highest 1-hour maximum precipitation was recorded in Ganghwa (123.5 mm) on August 6, 1998.

The highest maximum daily precipitation on record occurred in Gangneung (870.5 mm) on August 31, 2002 in the aftermath of Typhoon Rusa, followed by Daegwallyeong (712.5 mm) on the same day, Jangheung (547.4 mm) on September 2, 1981 in the aftermath of Typhoon Agnes, and Pohang (516.4 mm) on September 30, 1998 due to Typhoon Yanni.

The maximum consecutive 2-day and 5-day precipitation are used as extreme climate indices, representing intensity of precipitation. They are high in Daegwallyeong, Yeongdong region, the southern region including Jejudo, and north Gyeonggi-do, while they are low in Gyeongsangbuk-do, including Daegu.

Annual 5–Day Consecutive Maximum Precipitation (1981 – 2010)

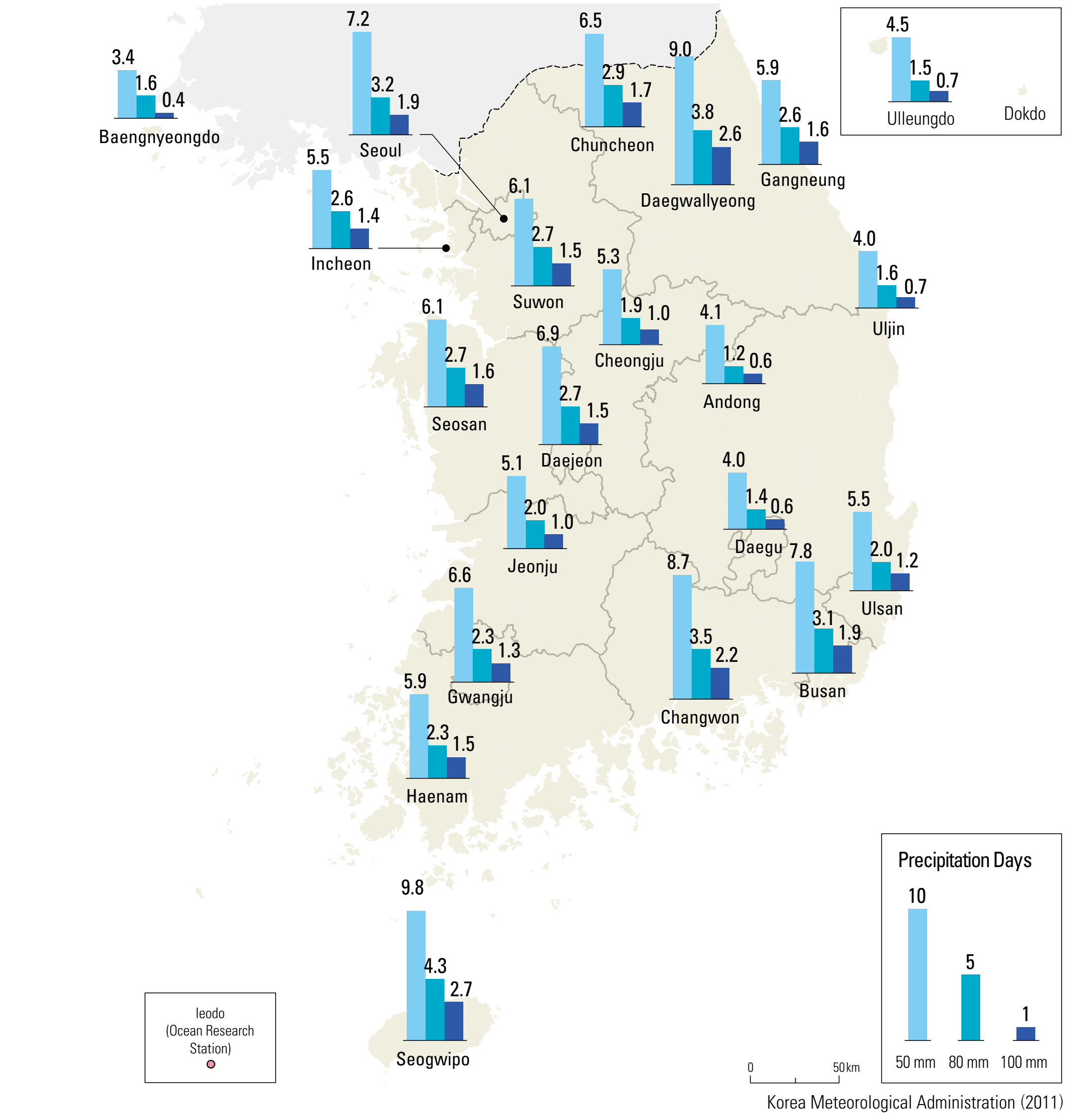


Korea Meteorological Administration (2011)

Extreme Climate Events	Rank	Location	Date (yyyy/mm/dd)	Value
Maximum Daily Precipitation (mm)	1	Gangneung	2002/08/31	870.5
	2	Daegwallyeong	2002/08/31	712.5
	3	Jangheung	1981/09/02	547.4
	4	Buyeo	1987/07/22	517.6
	5	Pohang	1998/09/30	516.4
1-Hour Maximum Precipitation (mm)	1	Juam	1998/07/31	145.0
	2	Gangwha	1998/08/06	123.5
	3	Seoul	1942/08/05	118.6
	4	Buyeo	1999/09/10	116.0
		Seoul	1964/09/13	116.0
Amount of Snowfall at One Time (cm)	1	Ulleungdo	1955/01/20	150.9
	2	Ulleungdo	1967/02/12	118.4
	3	Ulleungdo	1954/01/25	94.1
	4	Daegwallyeong	1992/01/31	92.0
	5	Daegwallyeong	198702/03	90.3
Snow Accumulation (cm)	1	Ulleungdo	1962/01/31	293.6
	2	Ulleungdo	1962/01/30	291.6
	3	Ulleungdo	1962/01/28	290.1
	4	Ulleungdo	1962/01/27	288.9
	5	Ulleungdo	1962/02/01	287.9

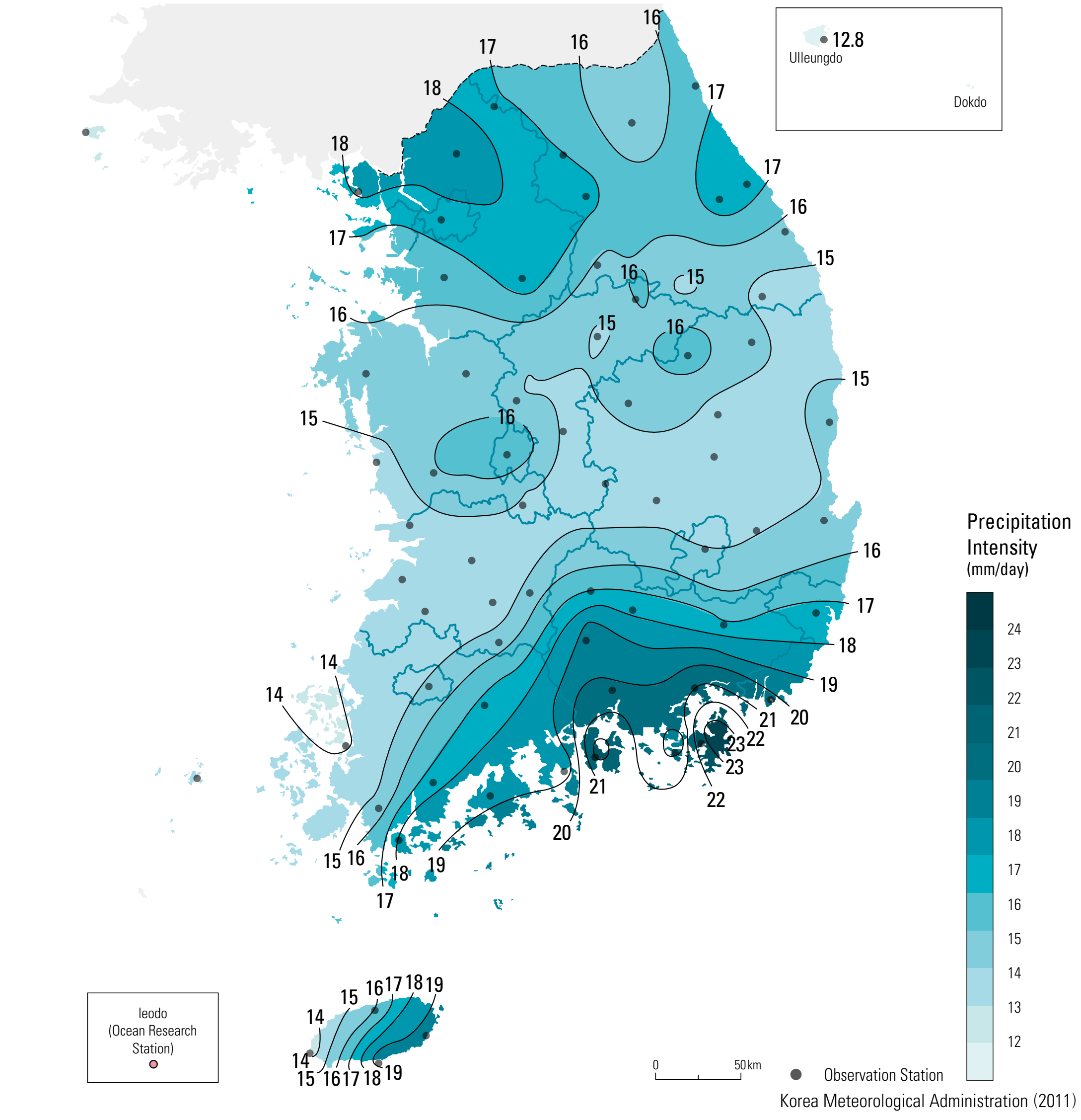
Korea Meteorological Administration (2011)

Annual Mean Numbers of Days with Daily Precipitation above 50 mm, 80 mm and 100 mm (1981 – 2010)



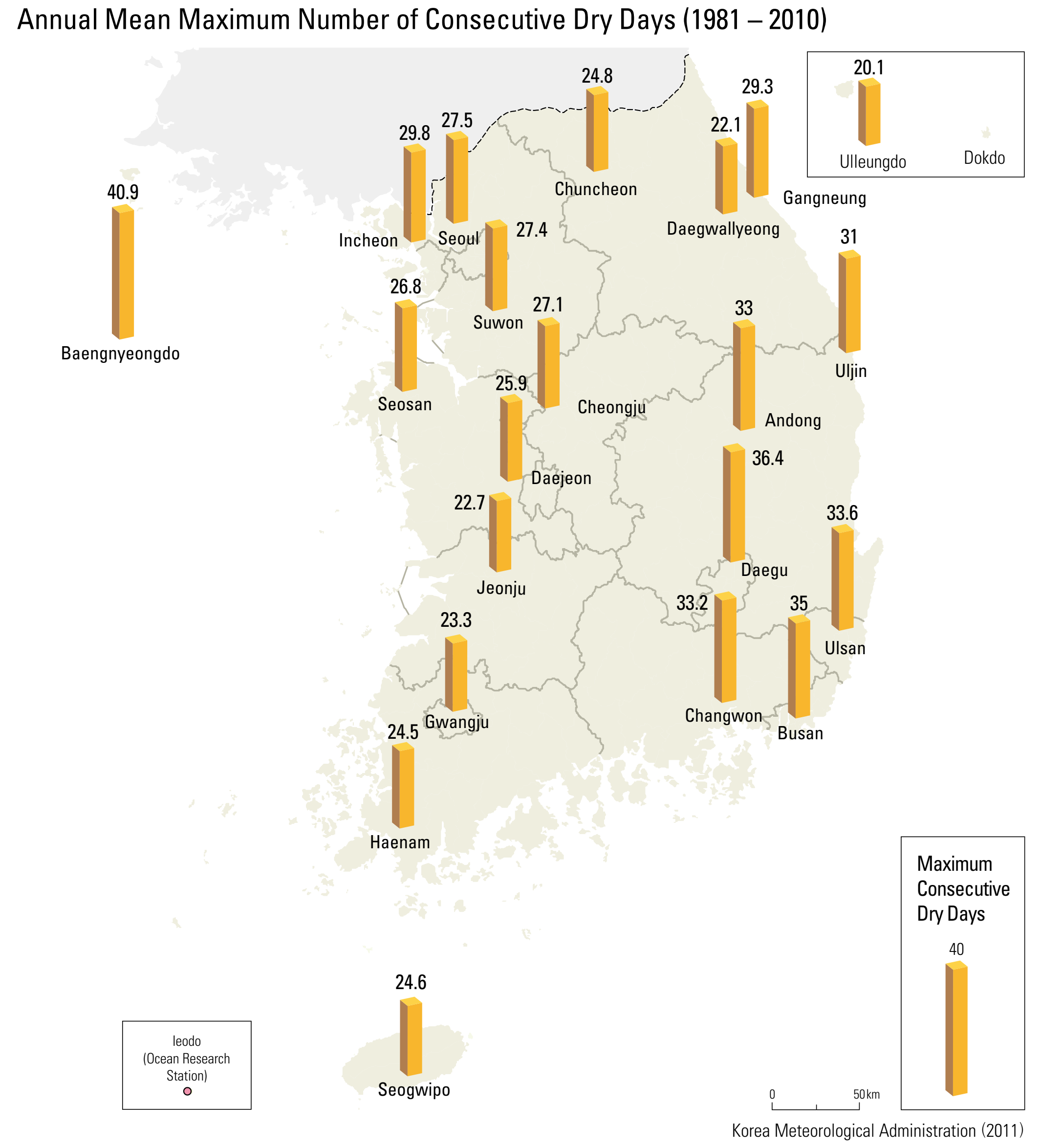
Korea Meteorological Administration (2011)

Annual Precipitation Intensity (1981 – 2010)



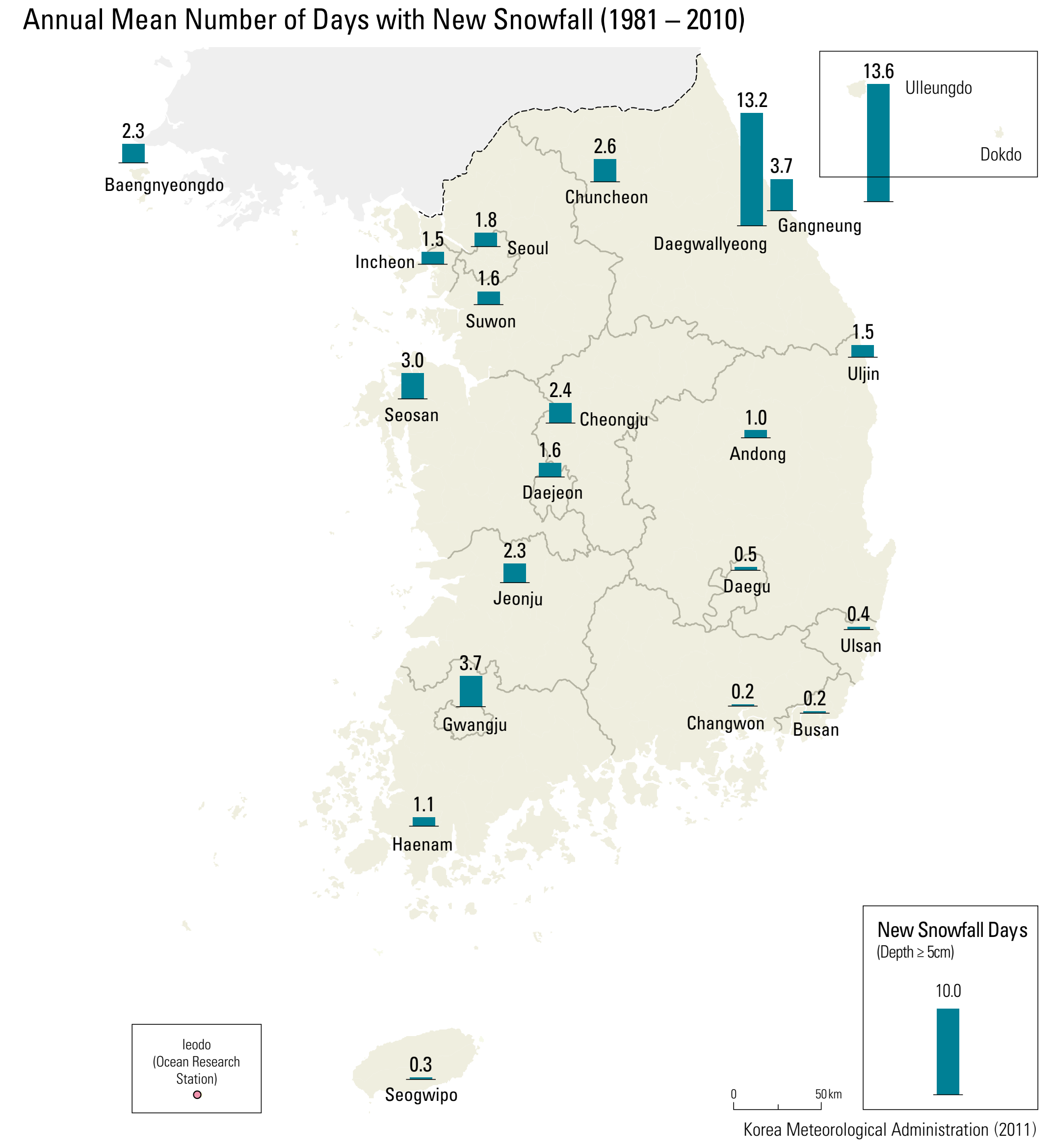
Korea Meteorological Administration (2011)

Annual Mean Maximum Number of Consecutive Dry Days (1981 – 2010)



Korea Meteorological Administration (2011)

Annual Mean Number of Days with New Snowfall (1981 – 2010)



Korea Meteorological Administration (2011)

The annual mean number of days with daily precipitation greater than 50 mm is largest in Seogwipo (9.8 days), while Baengnyeongdo (3.4 days) has the fewest. Seogwipo (4.3 days) also has the largest annual mean number of days with daily precipitation exceeding 80 mm. Andong (1.2 days) has the fewest days, followed by Daegu (1.4 days) and Ulleungdo (1.5 days). The annual mean number of days with daily precipitation greater than 100 mm is largest in Seogwipo (2.7 days), followed by Daegwallyeong (2.6 days) and Changwon (2.2 days).

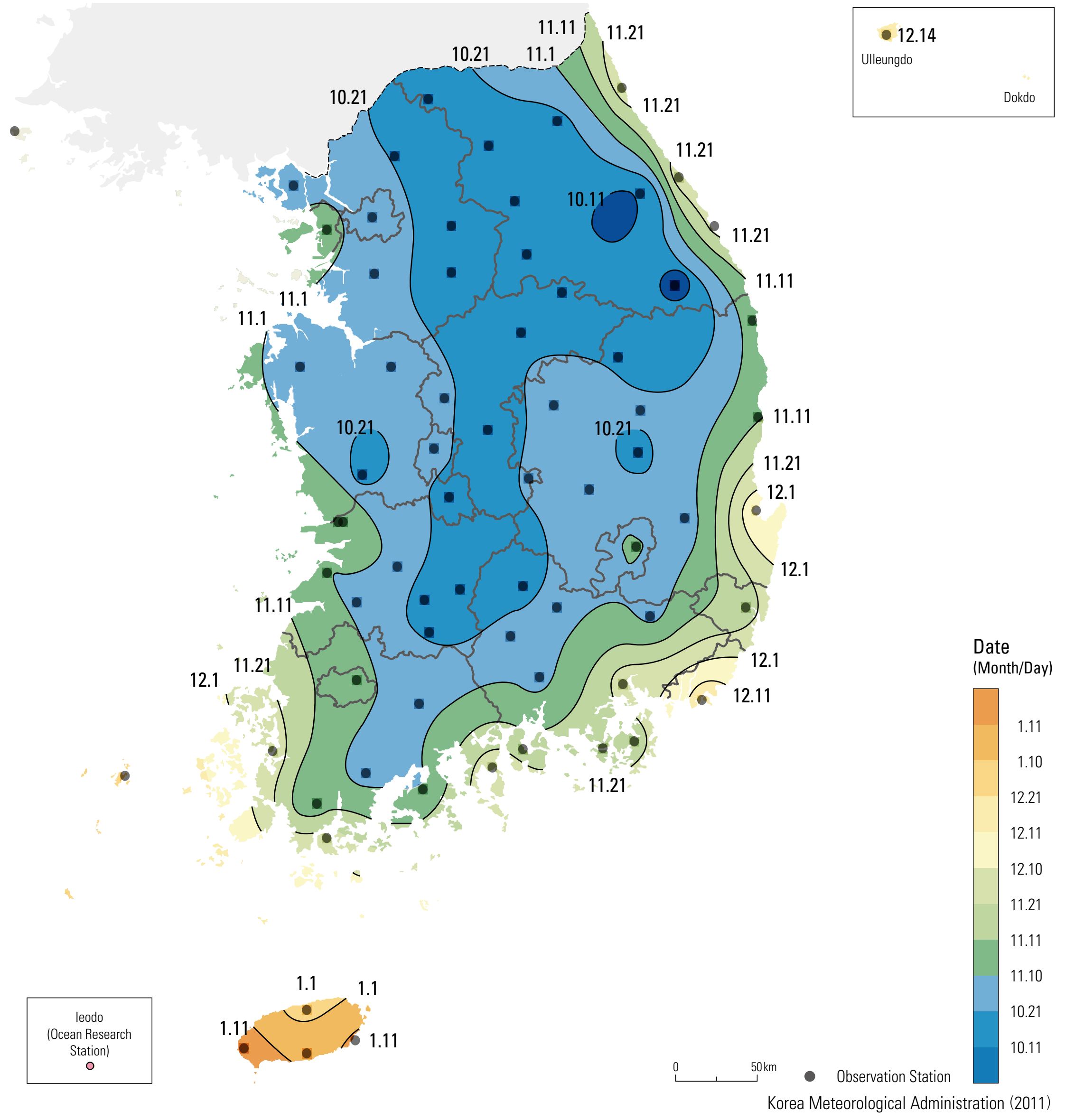
Annual precipitation intensity is a climate index, calculated by dividing annual precipitation by annual mean number of precipitation days. The precipitation intensity appears relatively strong in the southern region including Jejudo and northern part of Gyeonggi-do. For instance, the southern coastal region has a precipitation intensity greater than of 20 mm/day in general. Whereas, the precipitation intensity appears relatively weak in the inland areas of Gyeongsangbuk-do, the western coastal areas of both Joellanam-do and Jeollabuk-do, and Ulleungdo.

Annual mean maximum number of consecutive dry days (with daily precipitation below 1.0 mm) is a climate index indicating the severity of dryness. The annual mean maximum number of consecutive dry days is small in Jejudo, Daegwallyeong, and Jeollabuk-do, while the number is large in inland and eastern coastal areas of Gyeongsangbuk-do. Baengnyeongdo (40.9 days) has the longest average stretch of consecutive dry days, followed by Daegu (36.4 days), whereas Ulleungdo (20.1 days) has the shortest average stretch of consecutive dry days, followed by Daegwallyeong (22.1 days) and Jeonju (22.7 days).

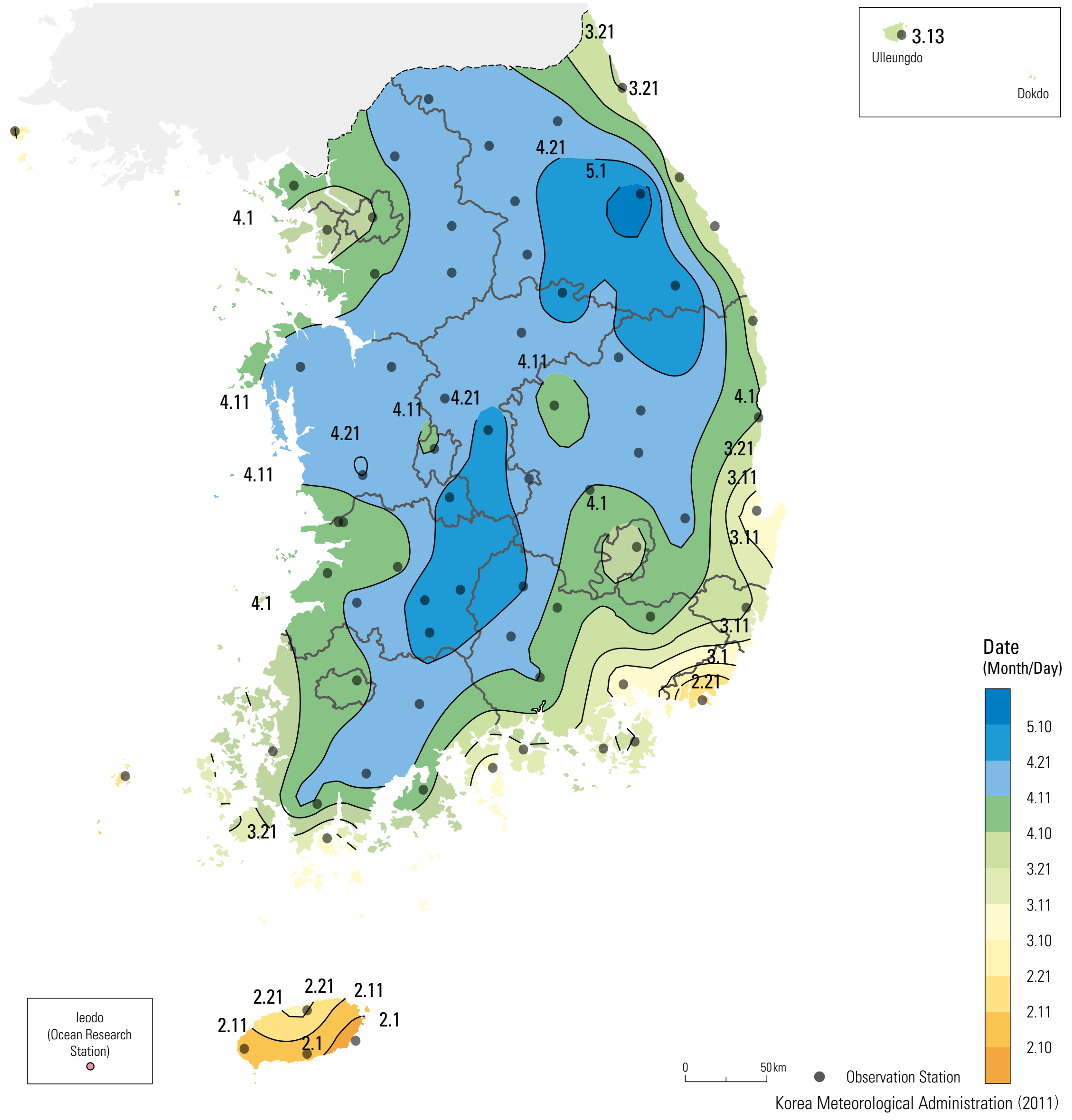
The annual mean number of days with new snowfall (depth of snowfall ≥ 5 cm) varies from 0.2 to 13.6 days across regions. Ulleungdo (13.6 days) has the largest annual mean number of days with new snowfall due to effects of the northwest monsoon and northeasterly, followed by Daegwallyeong (13.2 days), which is located at a high elevation. In Gangneung (3.7 days) and Gwangju (3.7 days), the annual number of days with new snowfall is lower than 4 days. Busan (0.2 days) and Changwon (0.2 days) have the fewest annual mean number of days with new snowfall, followed by Seogwipo (0.3 days), Ulsan (0.4 days) and Daegu (0.5 days).

First and Last Days of Seasonal Climatic Events

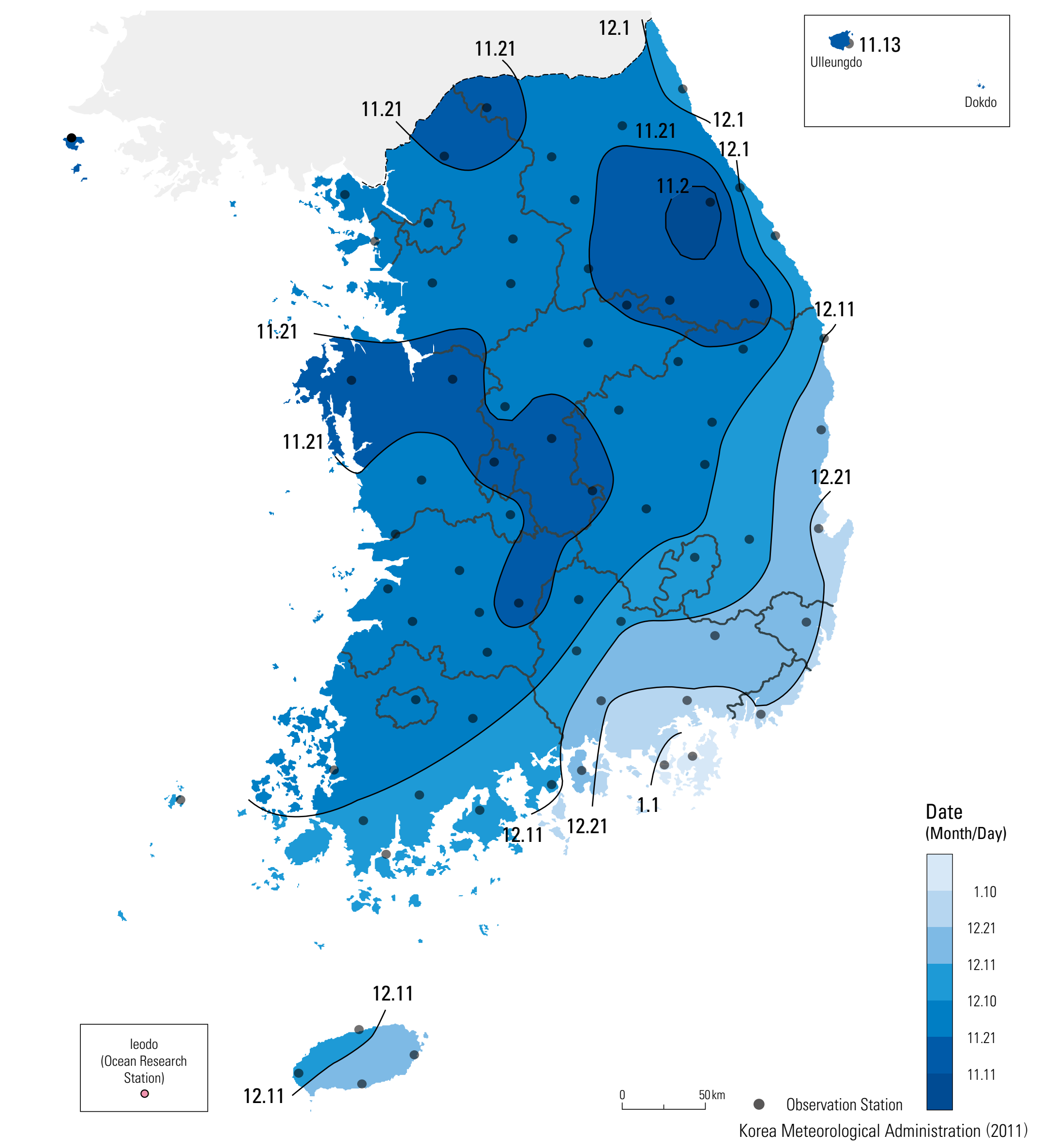
Mean First Day with Frost (1981 – 2010)



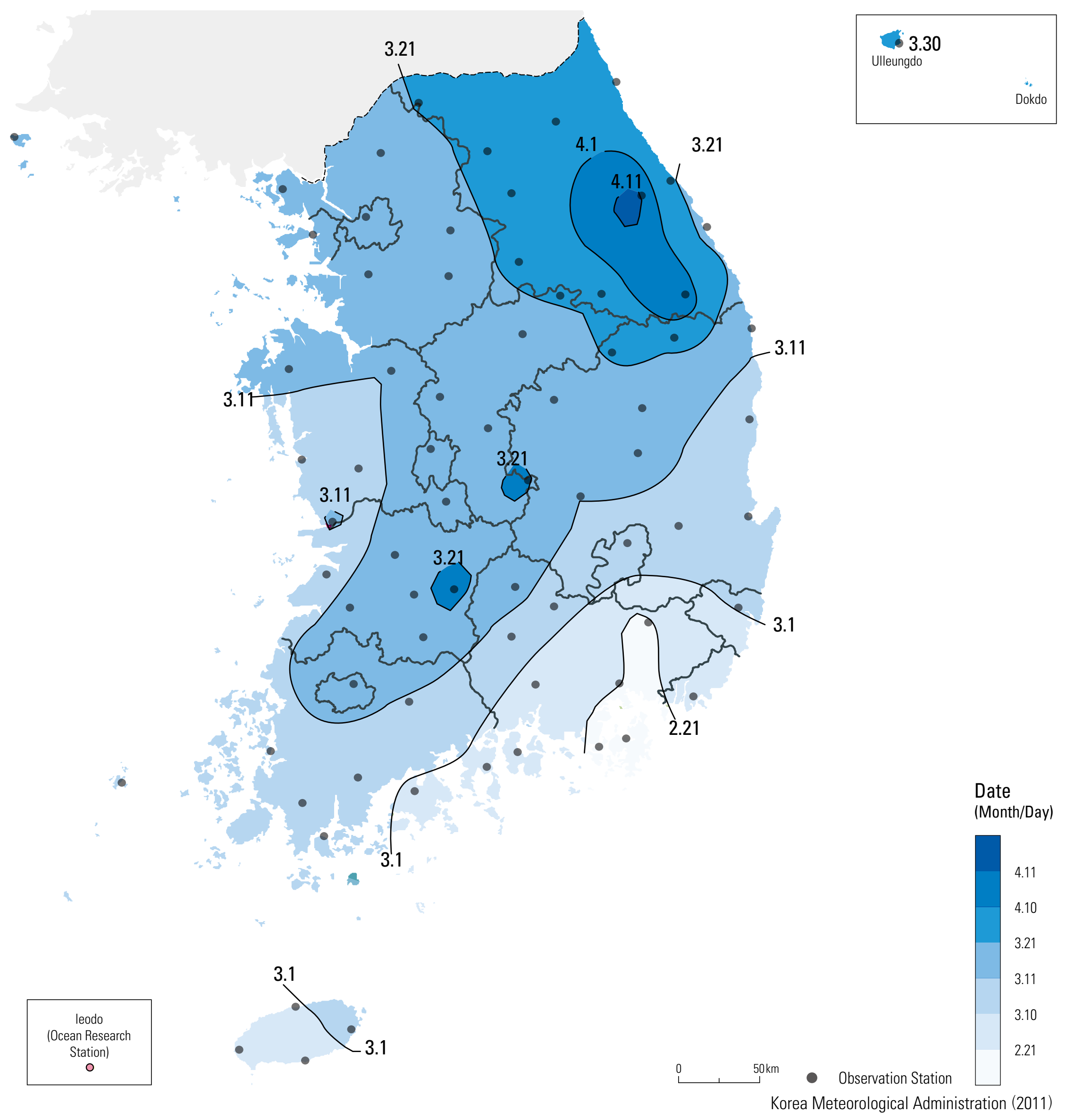
Mean Last Day with Frost (1981 – 2010)



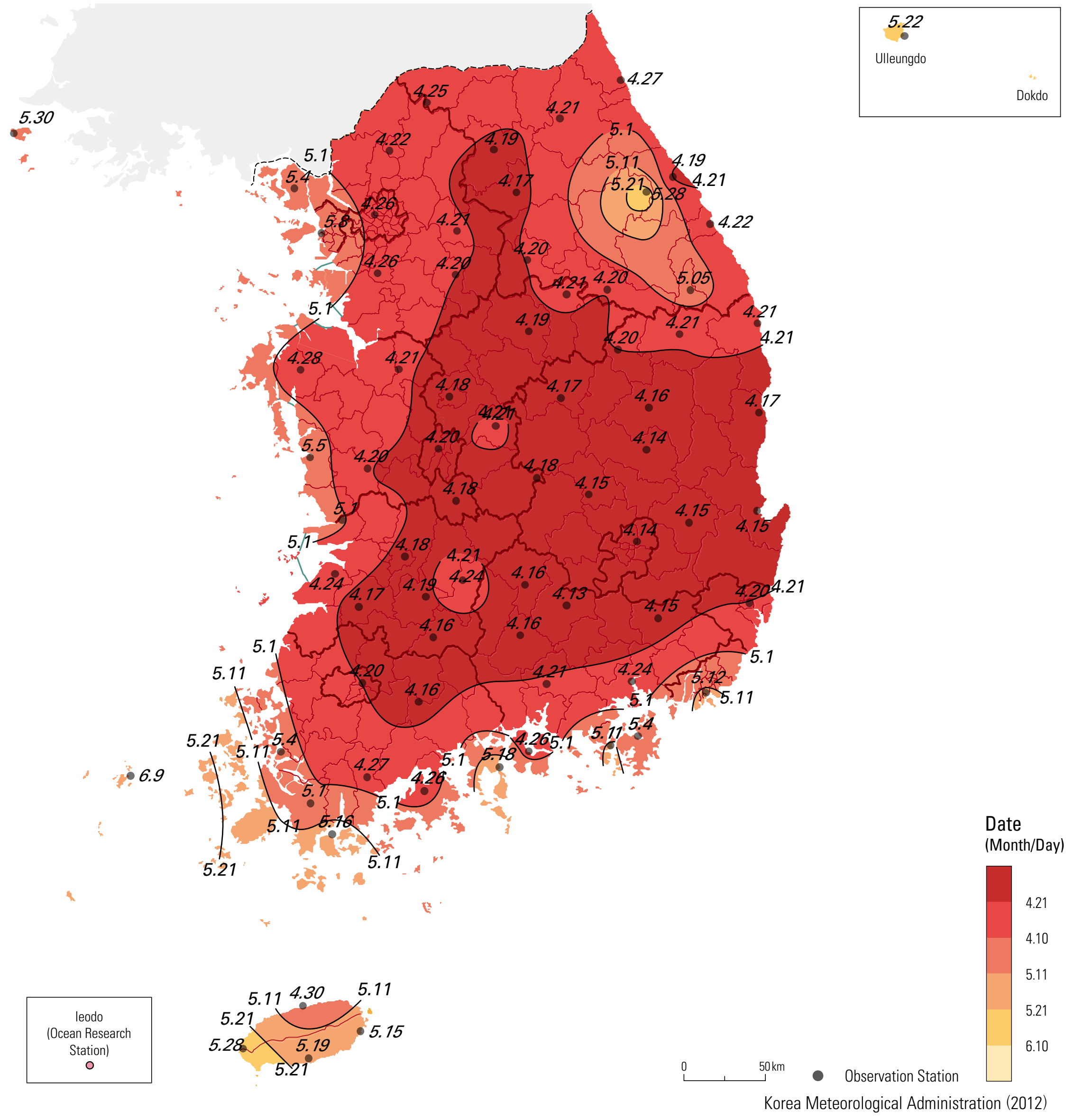
Mean First Day with Snowfall (1981 – 2010)



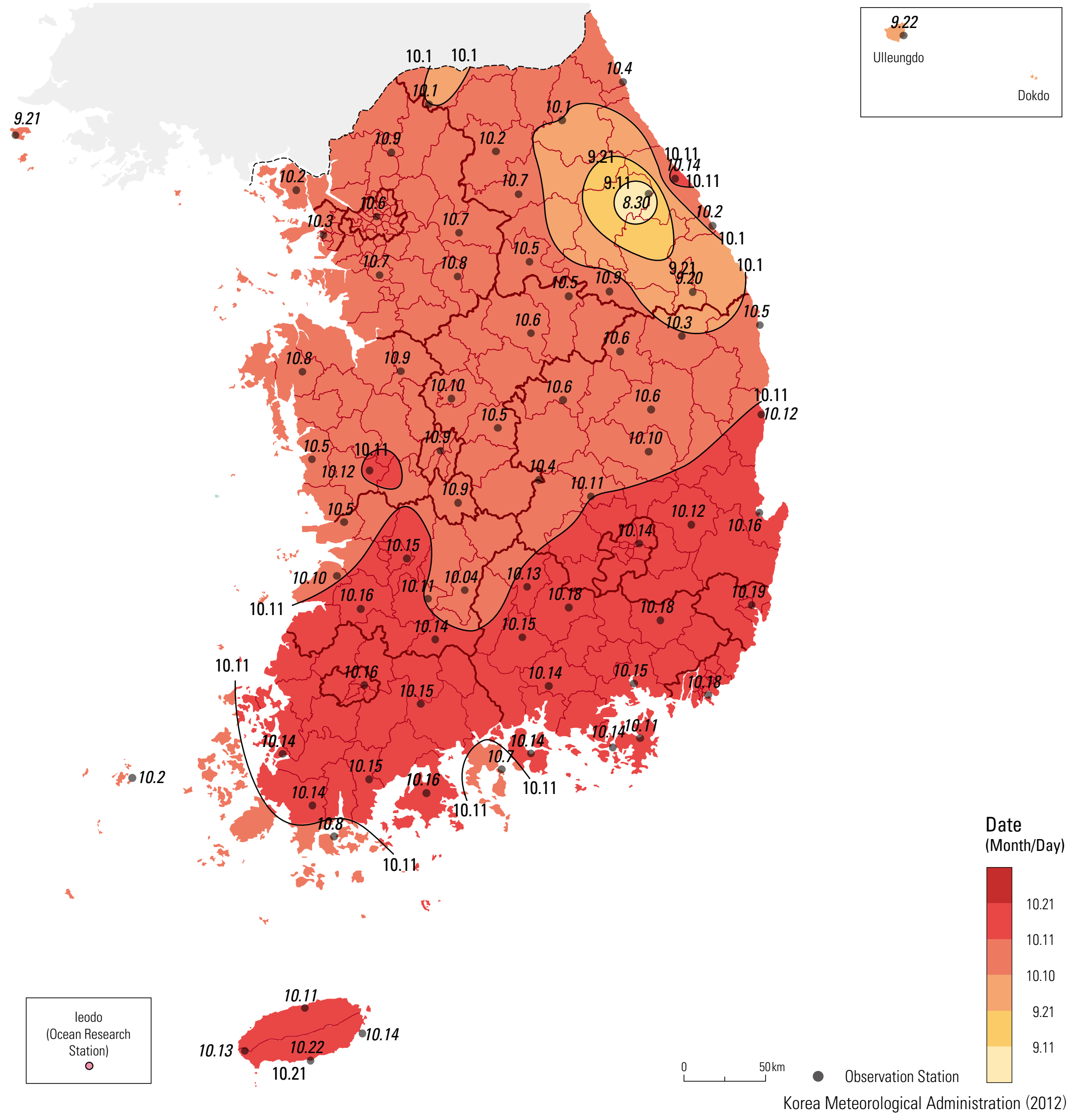
Mean Last Day with Snowfall (1981 – 2010)



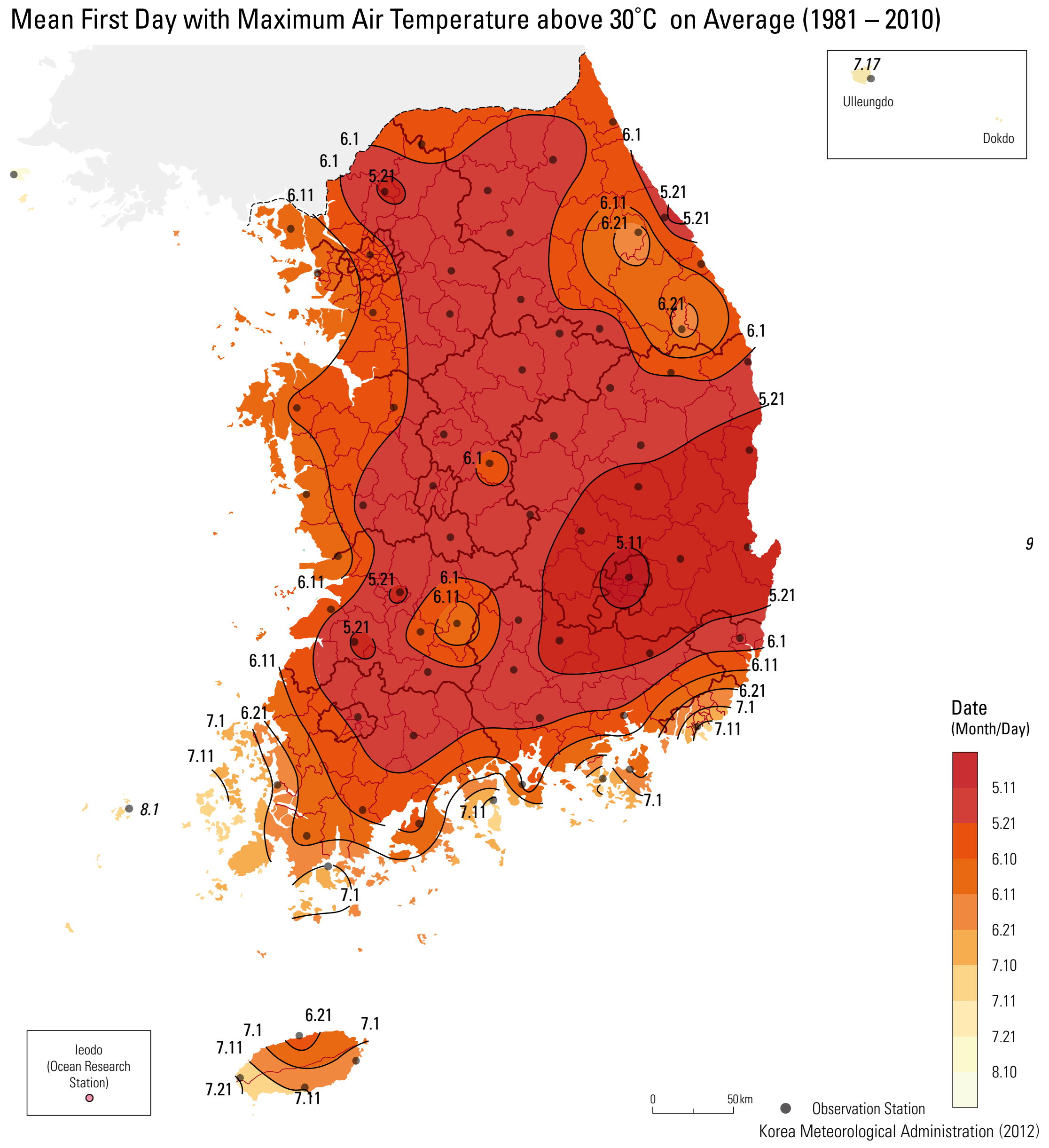
Mean First Day with Maximum Air Temperature above 25˚C on Average (1981 – 2010)



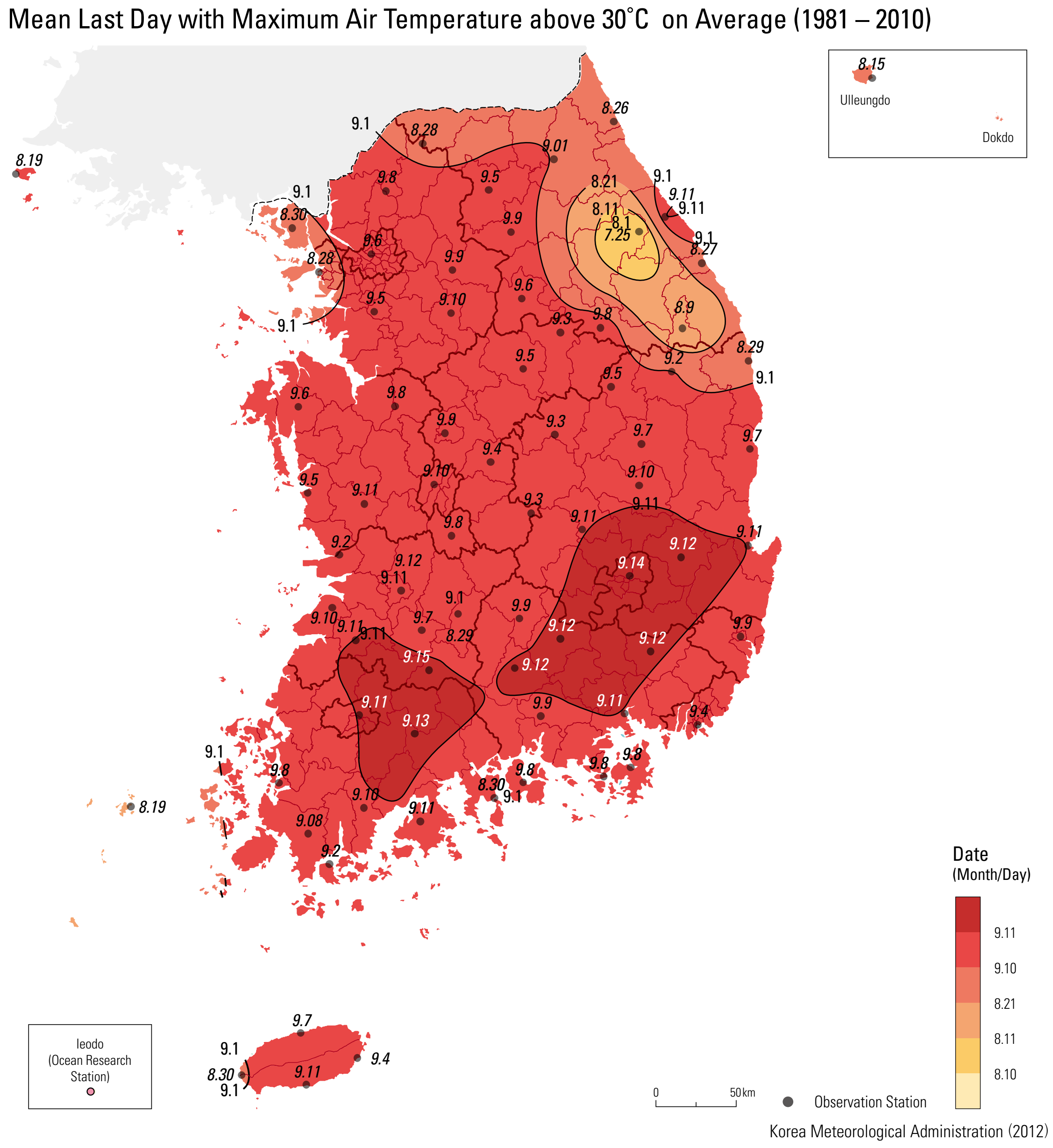
Mean Last Day with Maximum Air Temperature above 25˚C on Average (1981 – 2010)



Mean First Day with Maximum Air Temperature above 30˚C on Average (1981 – 2010)



Mean Last Day with Maximum Air Temperature above 30˚C on Average (1981 – 2010)



The first frost of the season occurs during October in most parts of the Korean Peninsula. However, some parts of the coastal areas and the southern region experience frost between November and December, with Jejudo, the last, in January. The last frost occurs during April in most places. In general, the later the frost begins, the earlier the frost stops forming. For instance, the earliest days with the last frost occurs around January 27 in Seongsan, followed by Seogwipo (February 2), Gosan (February 5), and Busan (February 8). The latest frost occurs in Daegwallyeong around May 9, followed by Bonghwa, Jangsu, and Taebaek (April 30).

The first snow of the season falls around November on average in most parts of the Korean Peninsula. On average, the first snowfall occurs in Daegwallyeong (November 2), followed by Taebaek (November 11), Ulleungdo (November 13), and Baengnyeongdo (November 16). The latest first snow occurs in Geoje (January 9), followed by other southern regions, Tongyeong (January 3), Pohang (December 23), and Changwon (December 22). In most areas, the last snow of the season is seen around March. The earliest days with last snow falls in Geoje (February 16), followed by Miryang (February 19), Tongyeong (February 21), and Changwon (February 22). While, Daegwallyeong experiences snow until April 17 on average.

The first day with maximum air temperature above 25˚C occurs on average around April. The maximum air temperature rises to over 25˚C first in Hapcheon (April 13), followed by Daegu and Uiseong (April 14). The latest first maximum air temperature greater than 25˚C occurs in Heuksando (June 9) on average. It increases with proximity to inland areas while it decreases with elevation.

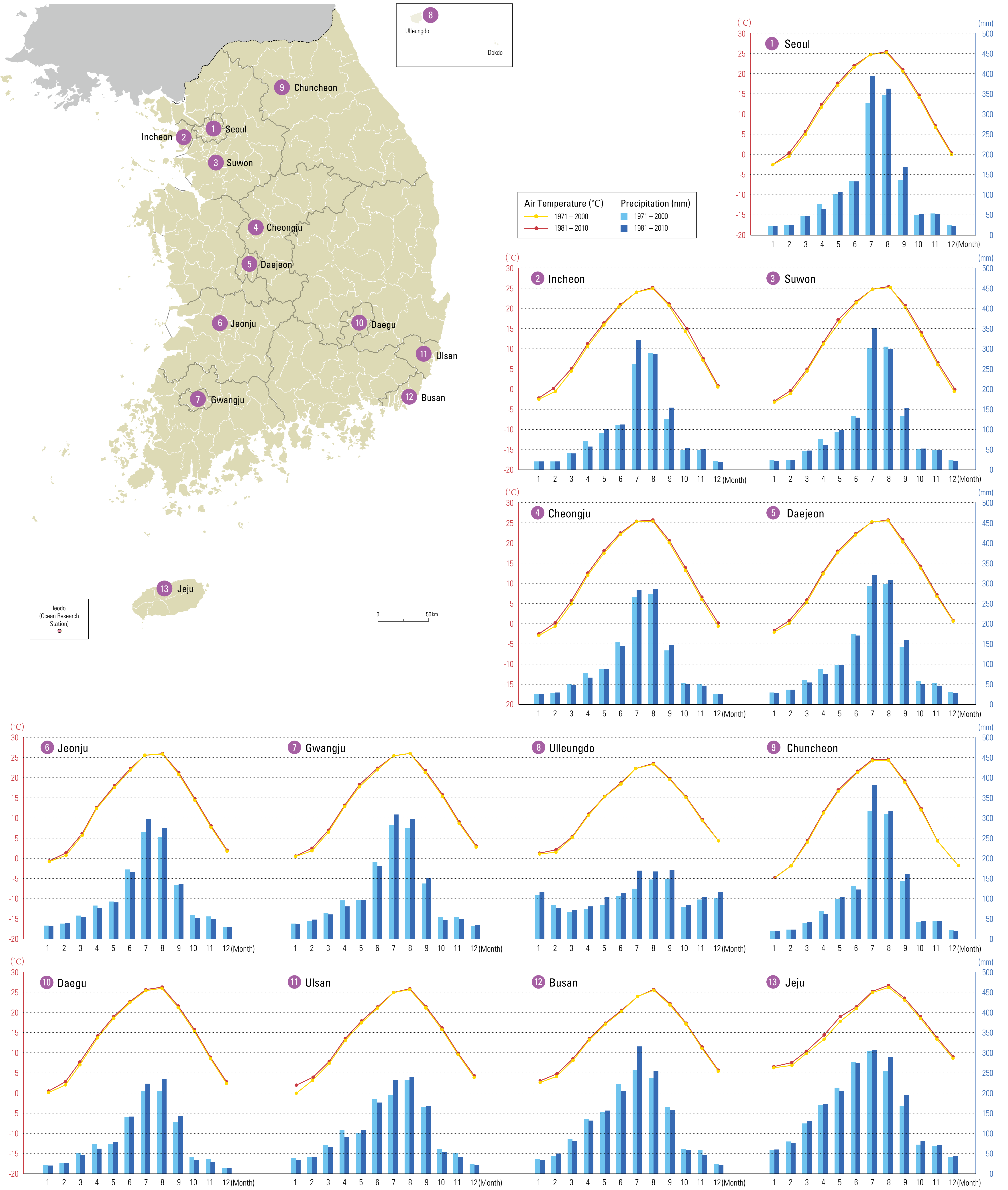
The last date of maximum air temperature above 25˚C is around October on average. Daegwallyeong (August 30) experiences the earliest last date of maximum air temperature above 25˚C, followed by Taebaek (September 20). On the other hand, Seogwipo (October 22) experiences the latest date with maximum air temperature above 25˚C, followed by Ulsan (October 19). The last date of maximum air temperature above 25˚C generally comes earlier with increasing latitude and elevation.

The regional difference in the first date with maximum temperature exceeding 30˚C is higher than that in the first date with maximum air temperature above 25˚C. Daegu (May 9) experiences it the earliest, followed by Pohang (May 12), the southern inland areas such as Yeongcheon and Yeongdeok (May 14), and the eastern coastal areas. The latest mean first date with maximum air temperature greater than 30˚C occurs in Baengnyeondo (August 2), followed by the southern coastal areas such as Heuksando (August 1), Seongsan (July 22), and Yeosu (July 20). The mean first date of maximum air temperature above 30˚C is earlier in coastal areas than in inland areas.

The last date of maximum air temperature above 30˚C occurs around September in most areas. The earliest last date occurs in Daegwallyeong (July 25), followed by Taebaek (August 9) and Ulleungdo (August 15). The latest date for a maximum air temperature greater than 30˚C occurs in Namwon (September 15), followed by the southern inland areas such as Daegu (September 14) and Suncheon (September 13).

Climate Change

Changes in Climographs at Selected Stations



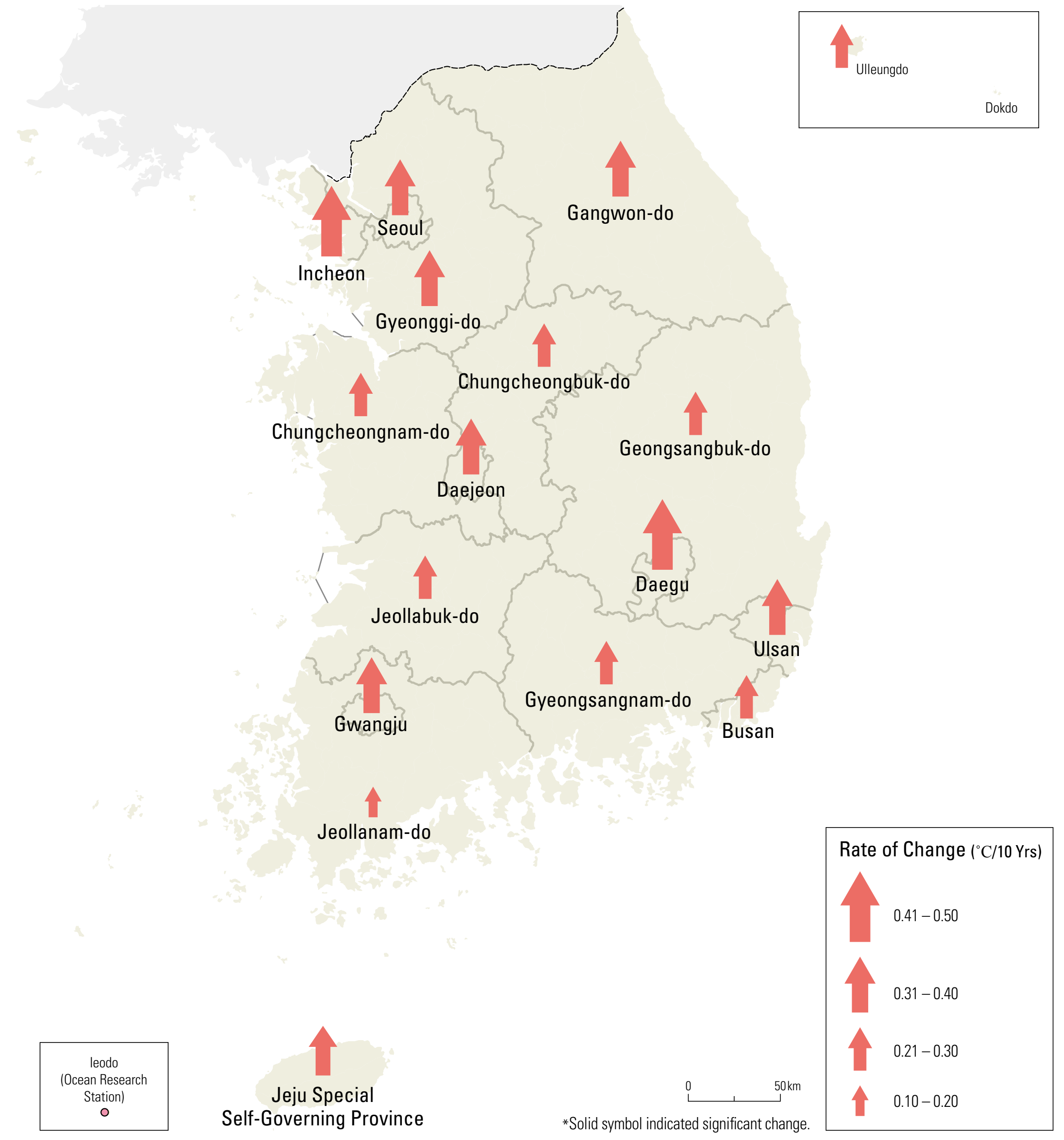
Korea Meteorological Administration (2011)

There has been an increasing trend in temperature over the past 30 years. According to the climographs, average monthly temperature of recent 30 years (1981 – 2010) are greater than the past 30 years (1971 – 2000), except for July.

The annual precipitation of the Korean Peninsula experienced a slight increase by around 50 mm on average in the last 30 years (1981 – 2010). The annual precipitation recorded at 13 observation stations increased by about 3.9% on average than the past, while Ulleungdo experienced an 11% increase in precipitation. In most areas, summer precipitation has increased, while spring and autumn precipitation have decreased.

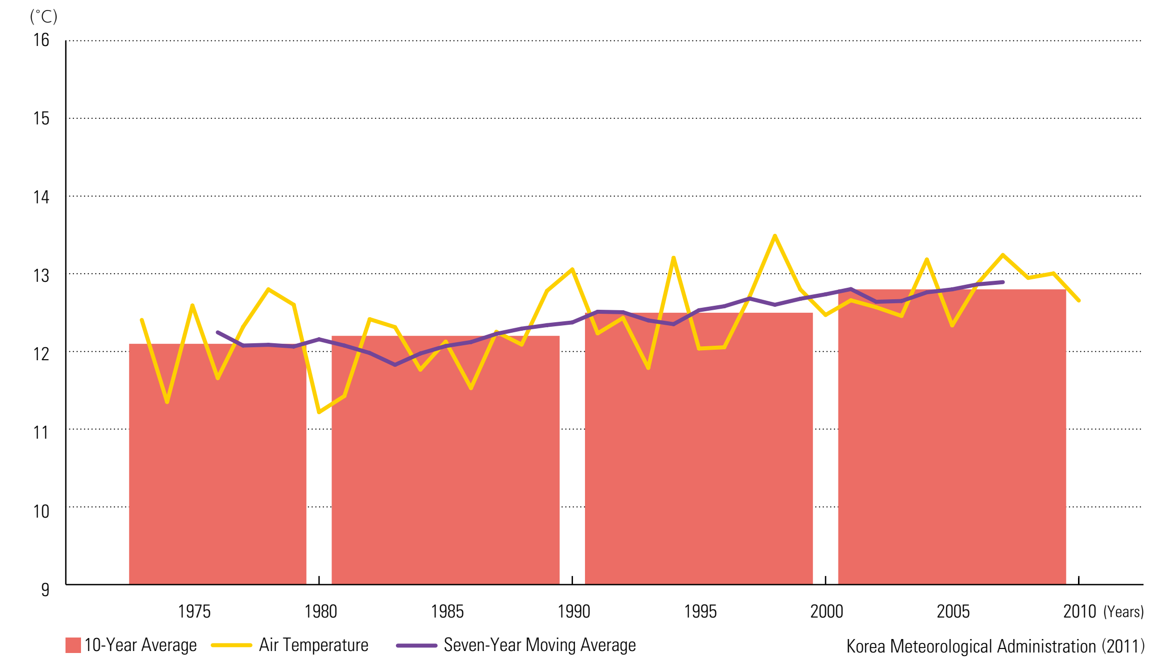
ATMOSPHERE AND HYDROSPHERE

Rate of Change in Annual Mean Air Temperature (1973 – 2010)



Korea Meteorological Administration (2011)

Change in Annual Mean Air Temperature (1973 – 2010)



Korea Meteorological Administration (2011)

Rate of Change in Annual and Seasonal Mean Air Temperature (1973 – 2010)

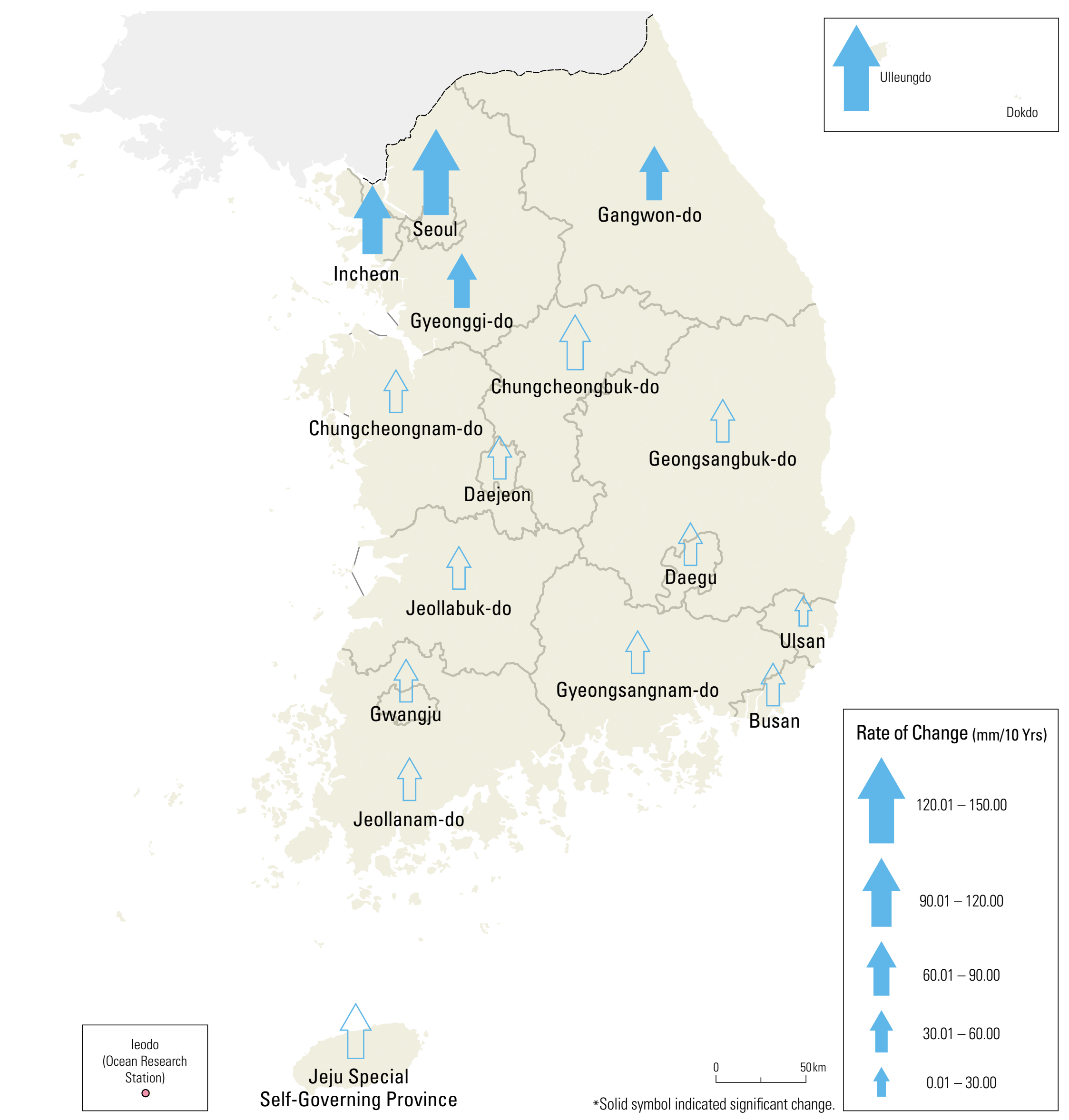
Unit (°C/10 yrs)

Classification	Annual	Spring	Summer	Autumn	Winter
Mean Temperature	0.27**	0.24**	0.1	0.31**	0.53*
Maximum Temperature	0.27**	0.26 **	0.08	0.29*	0.51*
Minimum Temeperature	0.30**	0.25*	0.18	0.38**	0.52*

*Significant at α=0.05 / **Significant at α=0.01

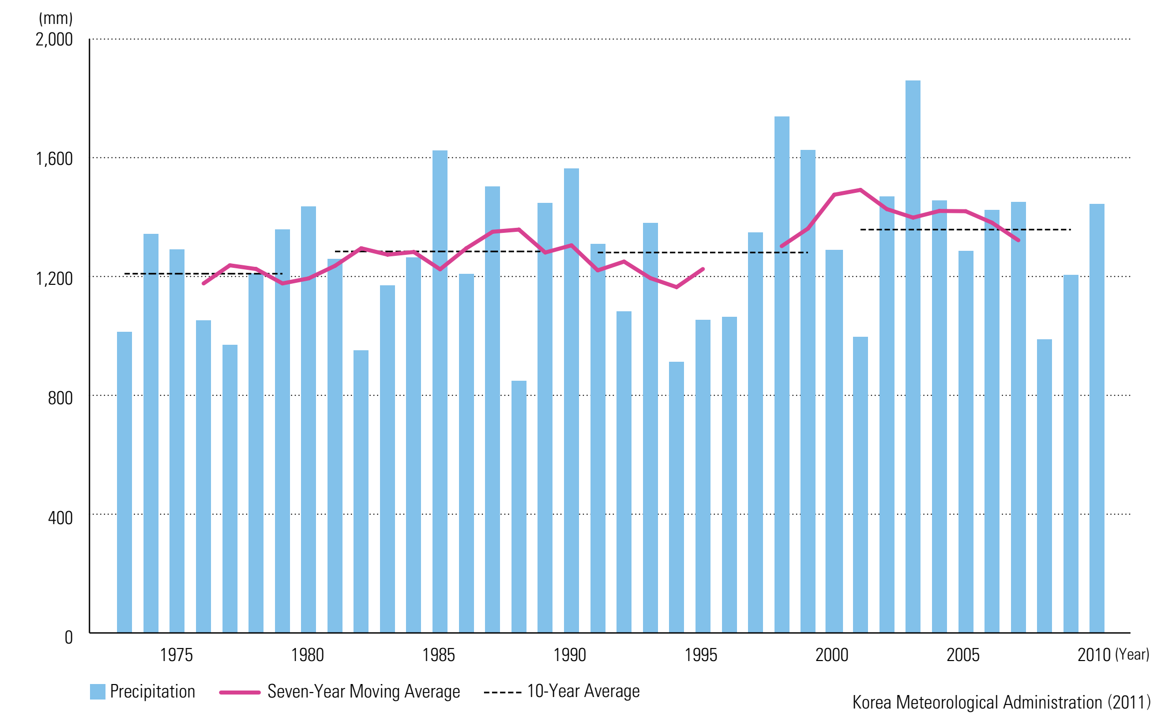
Korea Meteorological Administration (2011)

Rate of Change in Annual Mean Precipitation (1973 – 2010)



Korea Meteorological Administration (2011)

Change in Annual Mean Precipitation (1973 – 2010)



Korea Meteorological Administration (2011)

Rate of Change in Annual and Seasonal Mean Precipitation (1973 – 2010)

Unit (mm / 10 yrs)

Classification	Annual	Spring	Summer	Autumn	Winter
Precipitation	55.45	-5.75	55.20 *	6.89	0.15

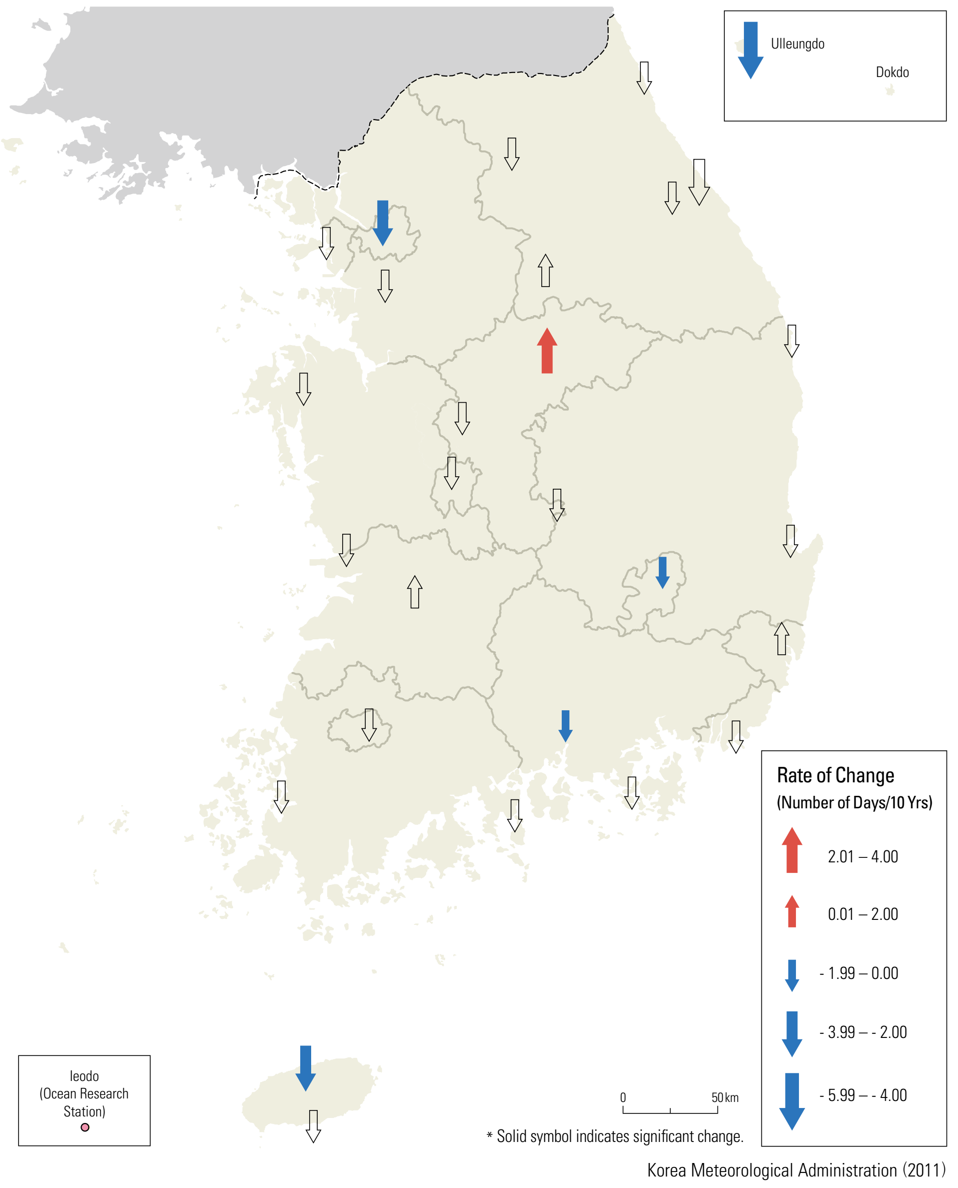
*Significant at α=0.05 / **Significant at α=0.01

Korea Meteorological Administration (2011)

The rate of change in annual mean temperature, 0.27°C/10 yrs, clearly shows a warming trend in Korea. On average, all the areas except Mungyeong have experienced a rise in annual mean temperature between 0.09°C and 0.57°C for every 10 years. Cheongju and Suwon have experienced the greatest increase in temperature for the most recent 10 year period. Also, the annual mean temperature increases at a greater rate in metropolitan areas than the national average rate of change. The highest rate of change in annual mean temperature occurs in Daegu and Incheon (0.46°C/10 yrs). Winters (0.53°C/10 yrs) have experienced the greatest increase in air temperature, while summers (0.1°C/10 yrs) have experienced the lowest temperature increase.

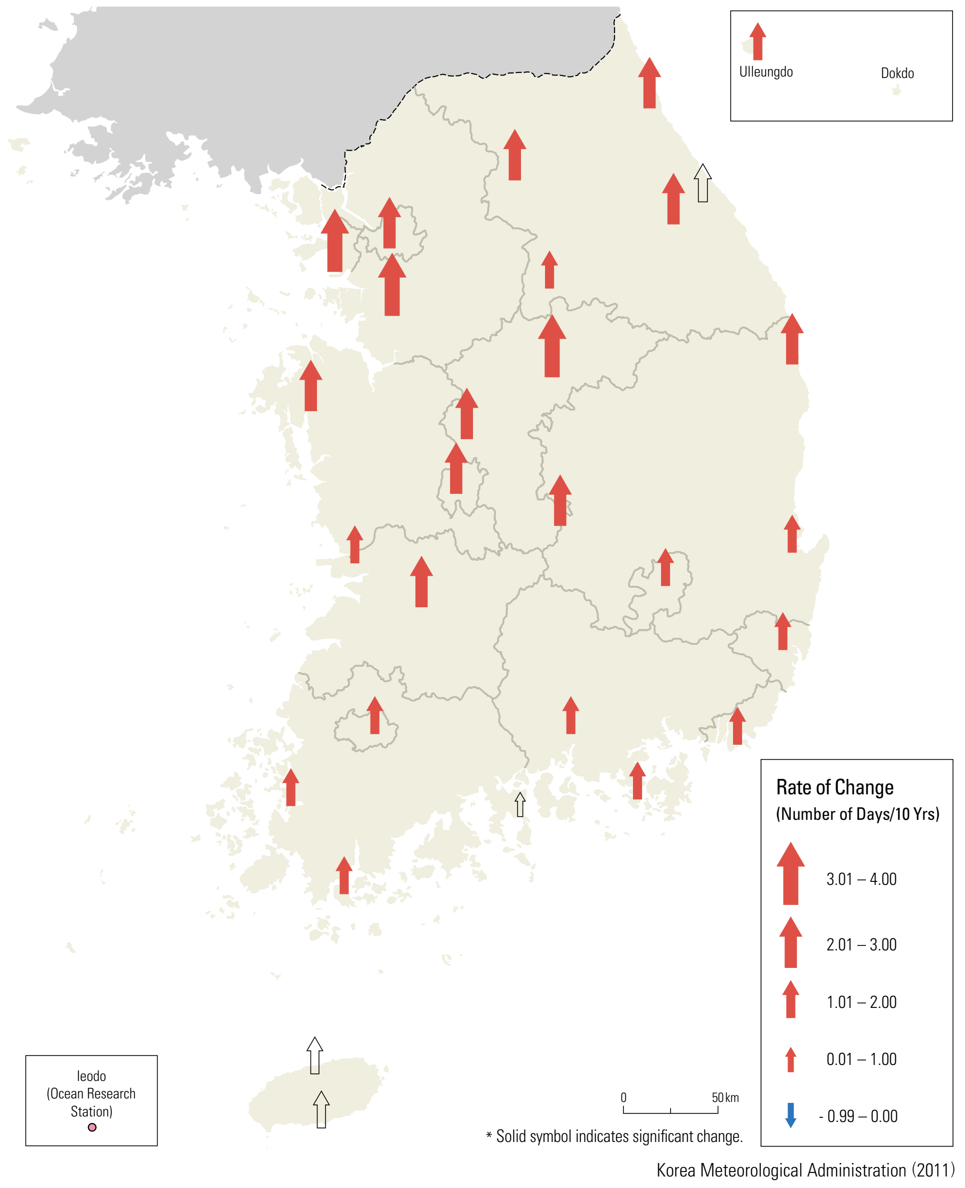
The rate of change in annual precipitation, 55.45 mm/10 yrs, represents an increasing trend in most areas. Seoul has seen the biggest increasing rate of precipitation at 147.16 mm/10 yrs, while Goheung has experienced a changing rate at -18.95 mm/10 yrs. Throughout all seasons, the summer has the highest rate of change 55.2mm/10yrs, and this trend is analogous to that of annual precipitation. However, the rate of change in annual precipitation is quite low throughout the year except the summer. Also, the concentration ratio of precipitation in the summer has increased as a response to reduced rainfall in other seasons across large parts of the Peninsula.

Rate of Change in Annual Average Number of Snowfall Days (1973 – 2010)



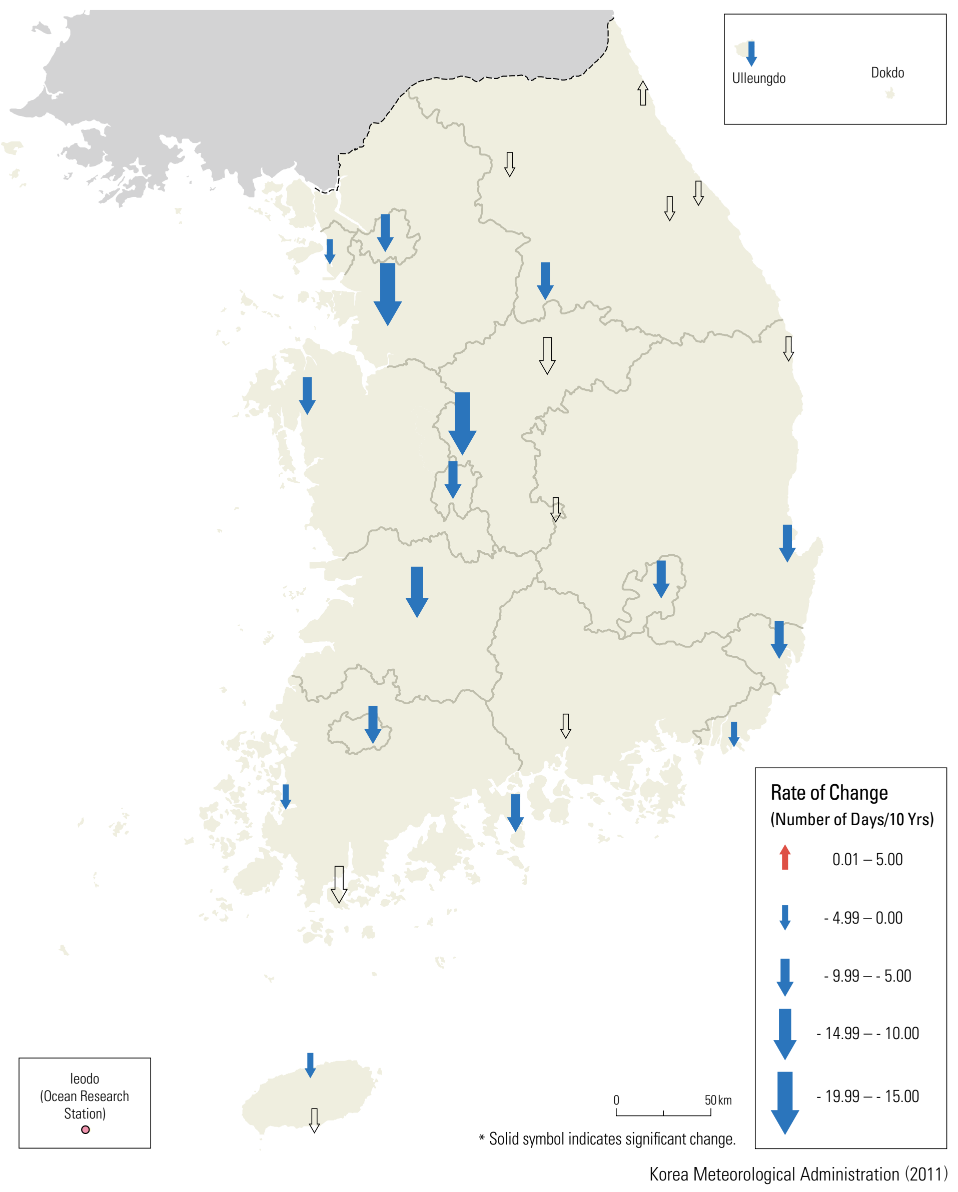
Korea Meteorological Administration (2011)

Rate of Change in Annual Average Number of Asian Dust Days (1973 – 2010)



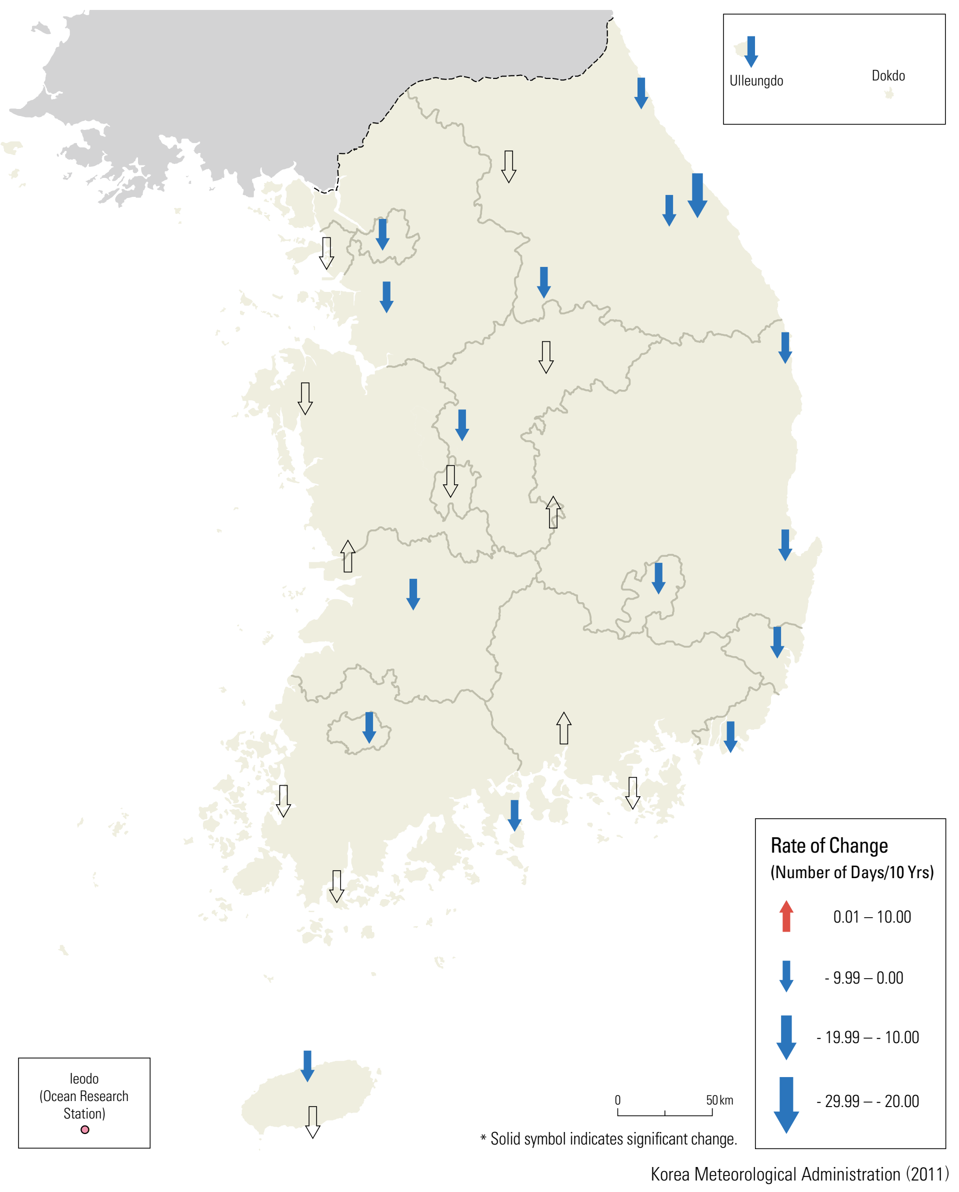
Korea Meteorological Administration (2011)

Rate of Change in Annual Average Number of Frost Days (1973 – 2010)



Korea Meteorological Administration (2011)

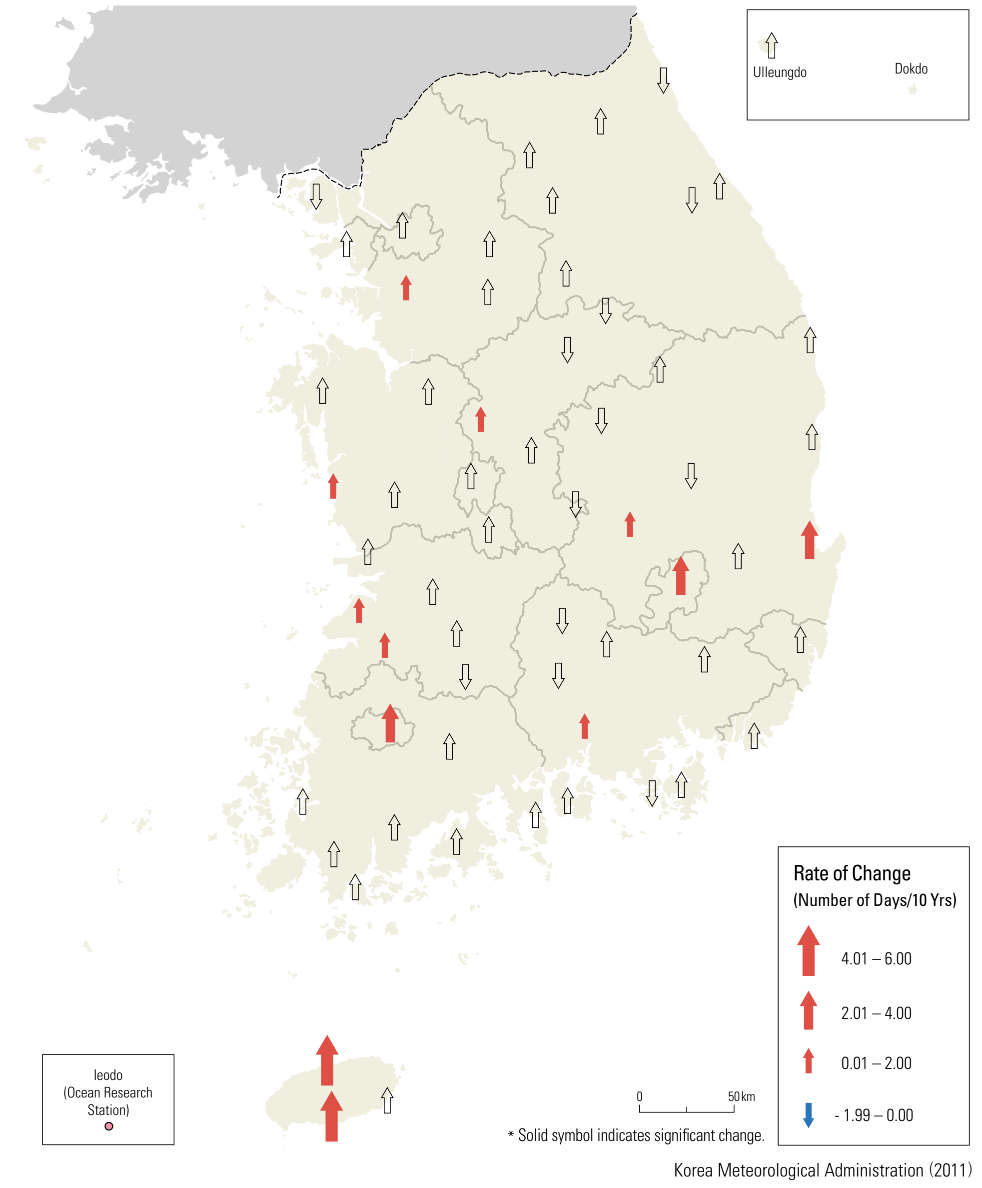
Rage of Change in Annual Average Number of Ice Days (1973 – 2010)



Korea Meteorological Administration (2011)

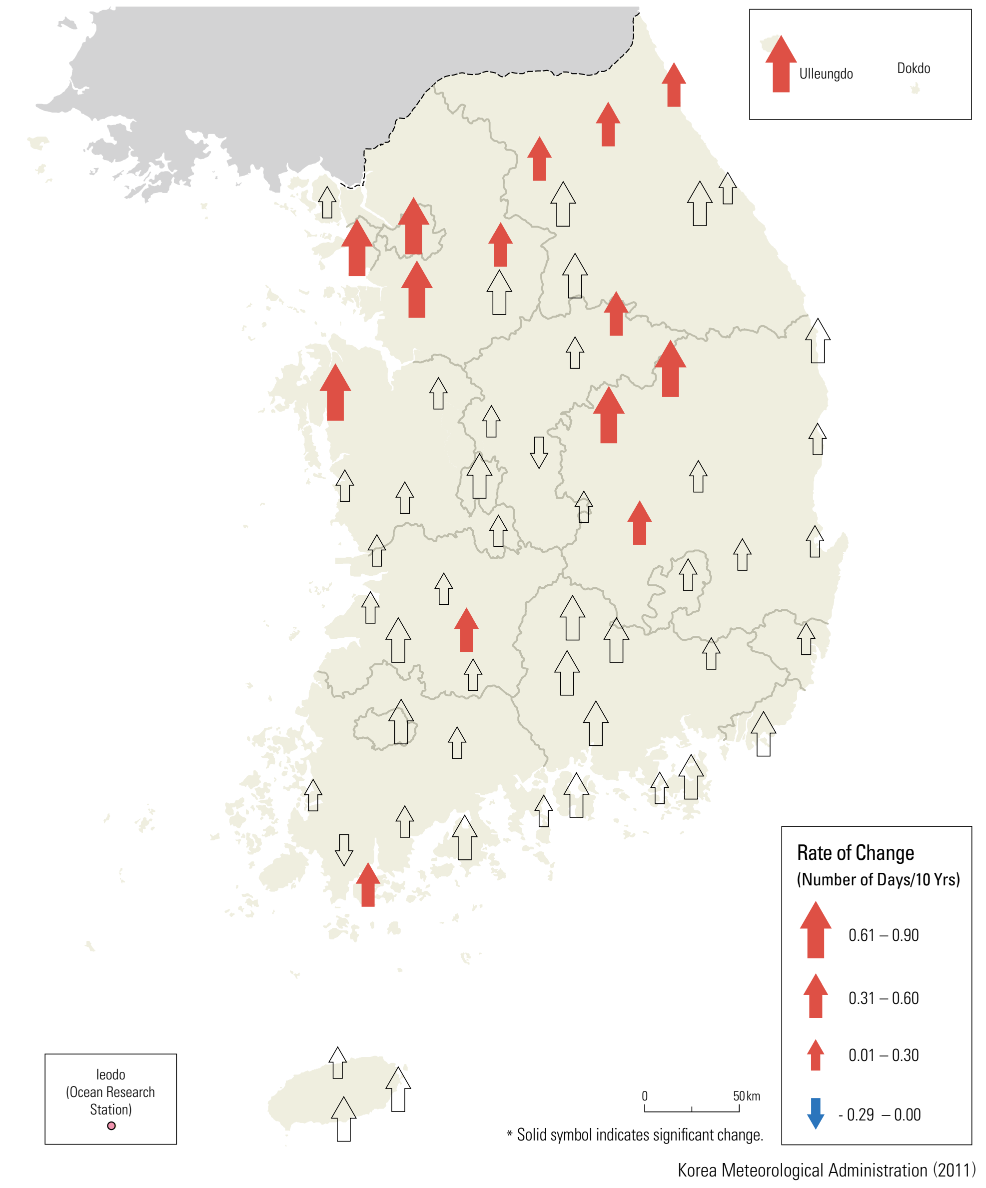
The rate of change in the annual average number of snowfall days is not statistically significant in most areas. The increasing trend for the annual average number of Asian dust days is prominent in Korea, especially in the western coastal region and the central region. The annual average number of frost days has diminished in all areas, with the greatest decrease in Suwon (-18 days/10 yrs), followed by Cheongju (-16 days/10 yrs). The annual average number of ice days is decreasing due to the increase of the annual mean temperature. For instance, Gangneung has the highest decreasing rate of -12.57 days/10 yrs. Suwon, Cheongju, and Yeoju also have experienced sharp decreasing trends.

Rate of Change in Number of Days with Daily Minimum Air Temperature above 25˚C (1973 – 2010)



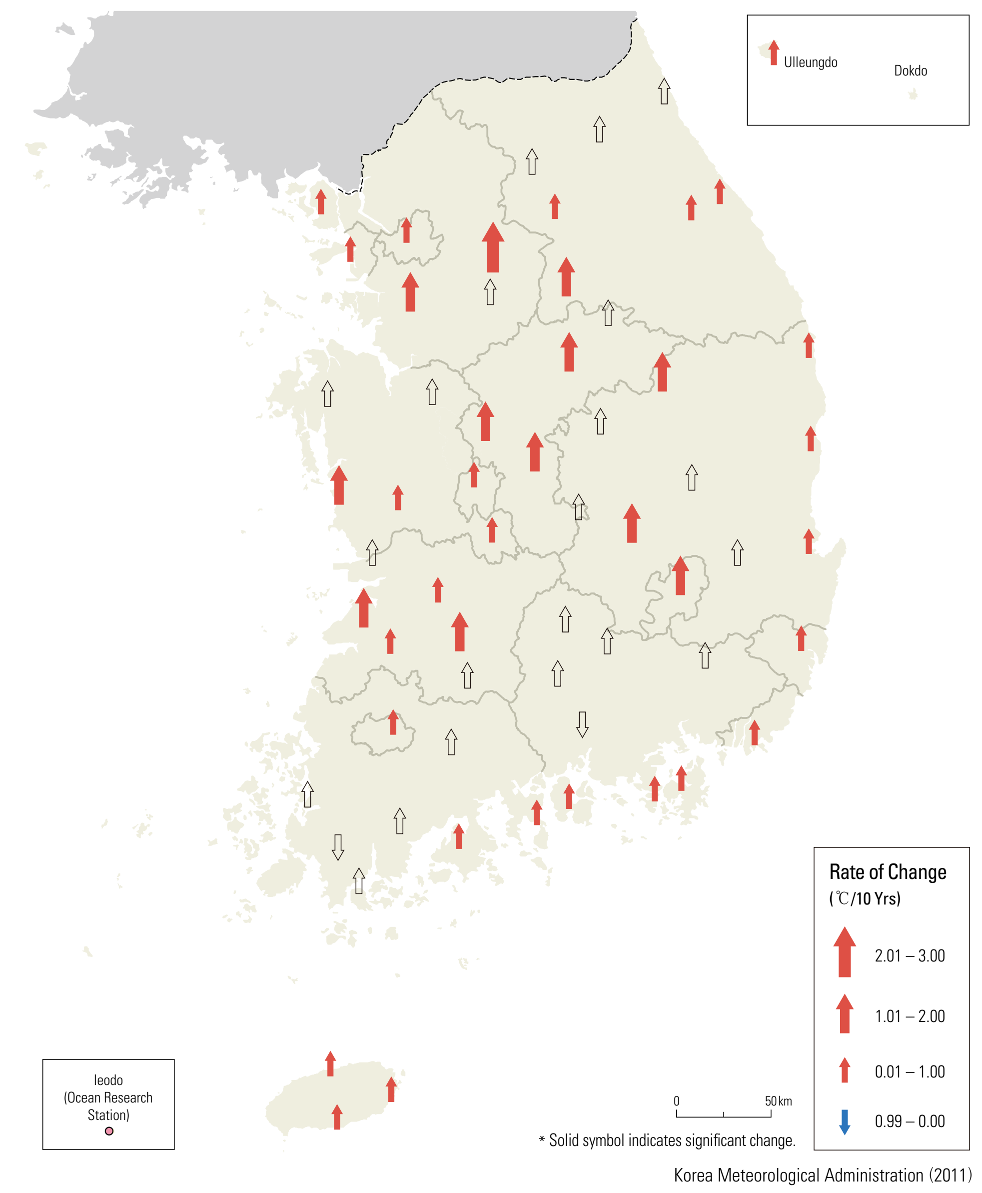
Korea Meteorological Administration (2011)

Rate of Change in Annual Mean Number of Days with Daily Precipitation above 80 mm (1973 – 2010)



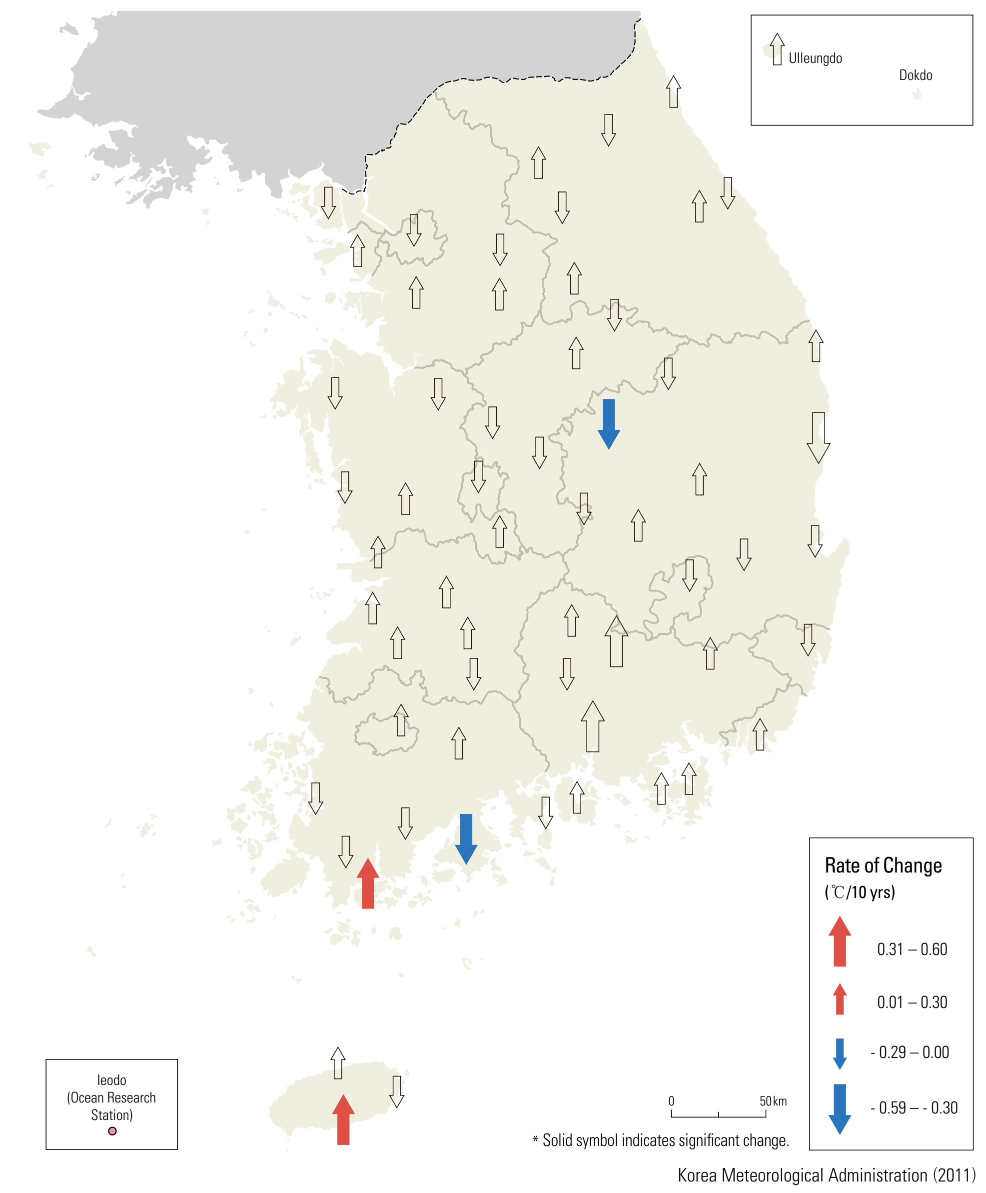
Korea Meteorological Administration (2011)

Rate of Change in the 1st Percentile Minimum Air Temperature (1973 – 2010)



Korea Meteorological Administration (2011)

Rate of Change in the 99th Percentile Maximum Air Temperature (1973 – 2010)



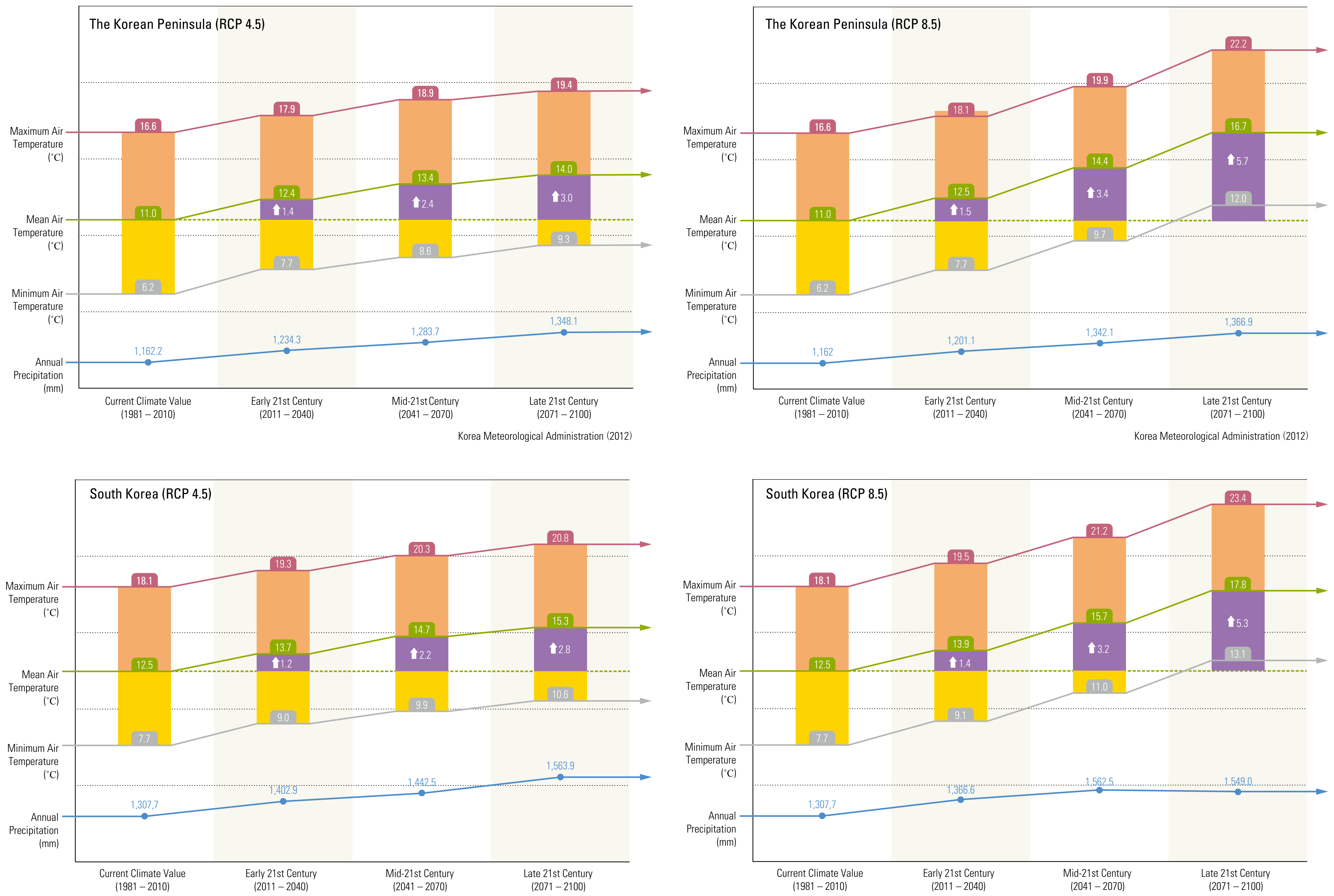
Korea Meteorological Administration (2011)

The number of days with daily minimum temperature greater than 25˚C shows a statistically significant increase at 12 observation stations including Seoqwipo, Jeju, Pohang, Daegu, and Gwangju.

The annual average of days with daily precipitation exceeding 80 mm in the central region shows a statistically significant increase. The biggest increase has been occurred in Seoul with 0.84 days/10 yrs. Incheon, Suwon, Yeongju, Mungyeong and Ulleungdo also have experienced a large increase in the annual average of days with daily precipitation amount ≥ 80 mm.

The rate of change in the 1st percentile minimum temperature generally varies largely from -0.99˚C/10 yrs to 3.00˚C/10 yrs. The increasing trend in the 1st percentile minimum temperature is statistically significant at 38 observation stations including Yangpyeong, Wonju, and Cheongju. The western coastal areas and the central region have shown larger increase in temperature than the southern region. For example, the 1st percentile minimum temperature in Yangpyeong shows the greatest increasing trend of 2.01˚C/10 yrs. The rate of change in the 99th percentile maximum temperature is not statistically significant in most areas.

Projection of the 21st Century Air Temperature and Precipitation over the Korean Peninsula under RCP Scenarios



Korea Meteorological Administration (2012)

The annual mean temperature of the Korean Peninsula is expected to rise steadily throughout the 21st century. In the Representative Concentration Pathways (RCP) 4.5 scenario, the increasing trend projected from the current mean temperature (11˚C) in the early 21st century is similar to that in the RCP 8.5 scenario. However, the increasing rate is expected to slow down during the mid-21st century. The annual mean temperature in the late 21st century is projected to be 14.0˚C in the RCP 4.5 scenario, corresponding to the current average temperature in the southeastern coastal region.

According to the RCP 8.5 scenario, the magnitude of the increase in annual mean temperature gets greater after the early 21st century. The annual mean temperature in the late 21st century is projected to be 16.7˚C, corresponding to the current average temperature in the southernmost tip of Jejudo.

The annual mean maximum and minimum temperatures, are expected to increase constantly. According to the RCP 4.5 scenario, the increasing rates of the maximum and minimum temperatures are projected to decrease during the mid after-21st century. Since the magnitude of the increase in the daily maximum temperature is smaller than that in the daily minimum temperature, the daily temperature range is projected to decrease gradually. According to the RCP 8.5 scenario, the increasing trends for the maximum and minimum temperatures accelerate toward the late 21st century.

The annual precipitation for the Korean Peninsula is projected to rise until the late 21st century. The RCP 4.5 scenario expects the annual precipitation in the late 21st century to be 1,348.1 mm, while the RCP 8.5 scenario predicts it to be 1,366.9 mm.

The annual mean temperature in South Korea is projected to continue to increase along with the increasing trend for annual mean temperature of the entire Peninsula. According to the RCP 4.5 scenario, the increasing trend in the early 21st century will have a rate similar to that of the RCP 8.5 scenario, but it will slow down over time. The annual mean temperature in the late 21st century is predicted to be 15.3˚C, corresponding to the current value of Jejudo. According to the RCP 8.5 scenario, the increasing trend for temperature accelerates from the mid-21st century to the late 21st century. In the scenario, the annual mean temperature in the late 21st century is projected to be 17.8˚C, which exceeds the current annual mean temperature of Seogwipo (16.6˚C). The annual mean maximum and minimum temperatures are also expected to increase steadily until the late 21st century. In the late 21st century, the increasing trend for the minimum temperature is slightly greater than that for the maximum temperature in the same period, according to the RCP 4.5 and RCP 8.5 scenarios.

Annual mean precipitation in South Korea in the late 21st century projected in the RCP 4.5 and RCP 8.5 scenarios are 1,563.9 mm and 1,549.0 mm, respectively, which correspond to the current mean amount for the southern coastal region of the Peninsula. Although the RCP 4.5 scenario shows a greater increasing rate in the annual mean precipitation during the early 21st century than the RCP 8.5 scenario, the increasing trend for precipitation appears to be low in the beginning of the mid-21st century. However, during the mid-21st century, the magnitude of the increase in annual mean precipitation gets greater once again, resulting in the average amounts predicted in the RCP 4.5 exceeding those predicted in the RCP 8.5 scenario.

Based on the RCP 8.5 scenario, the early 21st century begins with a small increase in annual mean precipitation. Then, the annual mean precipitation appears to increase largely right after the early 21st century. However, the increasing trend for precipitation slightly decreases during the mid-21st century.

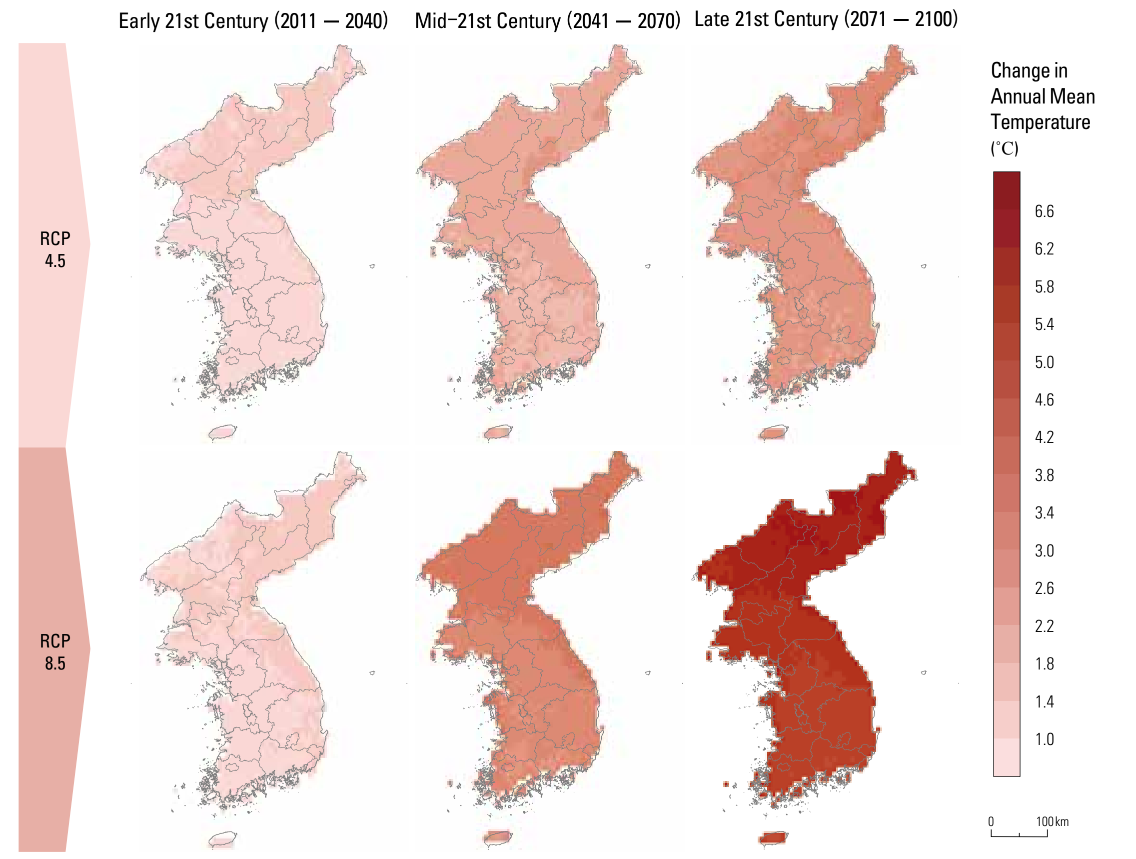
According to the Trewartha climate classification, the southern coast of the Korean Peninsula, including Jejudo, is classified as a humid subtropical climate region. As global warming accelerates, the boundary of the subtropical climate region is projected to move gradually to the north. According to the RCP 4.5 scenario, in the late 21st century, Jeollanam-do, Jeollabuk-do, the west coast of Chungcheongnam-do, the west coast of Gyeonggi-do, and Gyeongsangnam-do are expected to belong to subtropical climate regions, while the RCP 8.5 scenario predicts most of South Korea except the mountainous region to be classified as subtropical climate regions in the late 21st century.

The annual mean number of tropical nights grows, which is attributable to the increasing trend for air temperature over the Korean Peninsula along with global warming. According to the RCP 4.5 and 8.5 scenarios, the annual mean number of tropical nights in the late 21st century is expected to increase substantially. In the RCP 4.5 scenario, the annual mean number of tropical nights increases far more in South Korea than in North Korea from the mid-21st century to the late 21st century. However, according to the RCP 8.5 scenario, most areas of the Peninsula except some major mountainous regions with high elevation will have a much greater annual number of tropical nights than today in the late 21st century. Afterward, as climate change becomes more intensified, it is anticipated that areas with tropical nights expand to the high mountainous regions.

According to the RCP 4.5 and 8.5 scenarios, the annual mean number of heat wave days over the Peninsula starts to increase in the lowlands. In the RCP 4.5 scenario, the Korean Peninsula is unlikely to see a large increase in the annual mean number of heat wave days, while in the RCP 8.5 scenario, the increasing trend for heat wave days is likely to accelerate. The number of heavy precipitation days is projected to increase in most parts of the Korean Peninsula with wide variations depending on time, region and scenario.

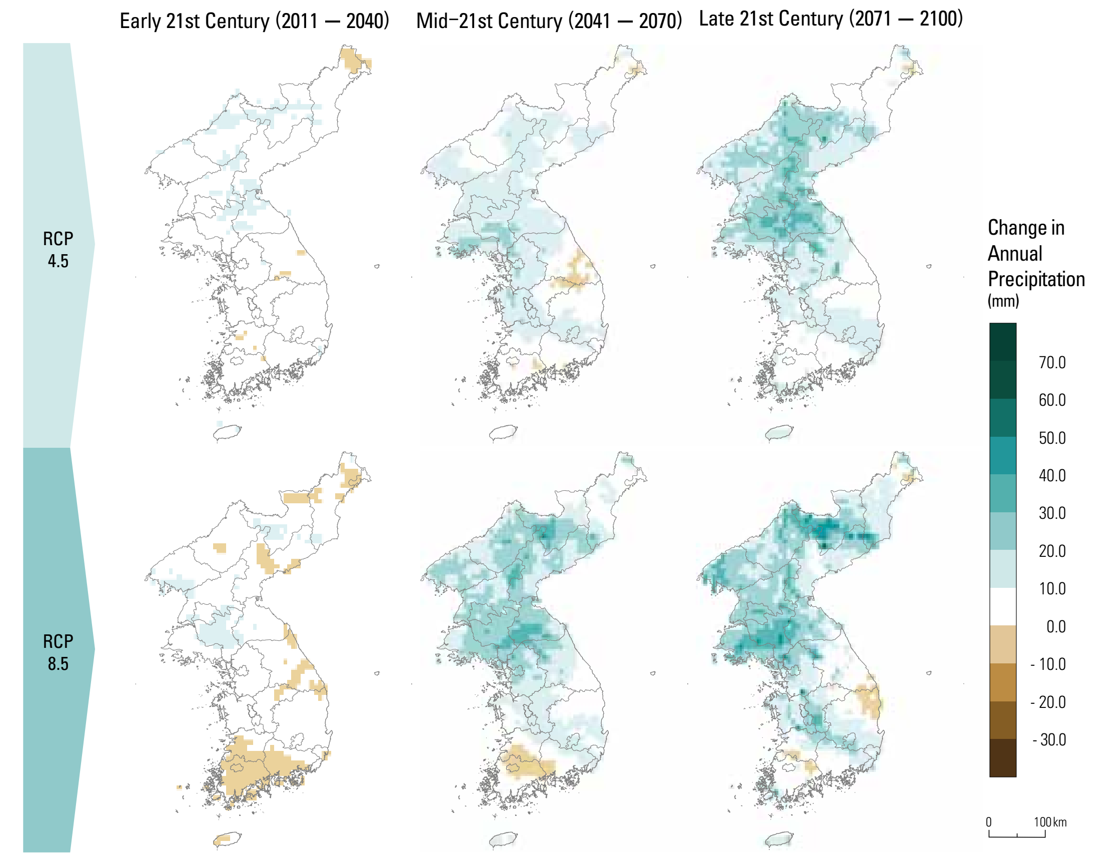
ATMOSPHERE AND HYDROSPHERE
Weather and Climate
Climate Change

Projection of Air Temperature over the Korean Peninsula under RCP 4.5/8.5 Scenario



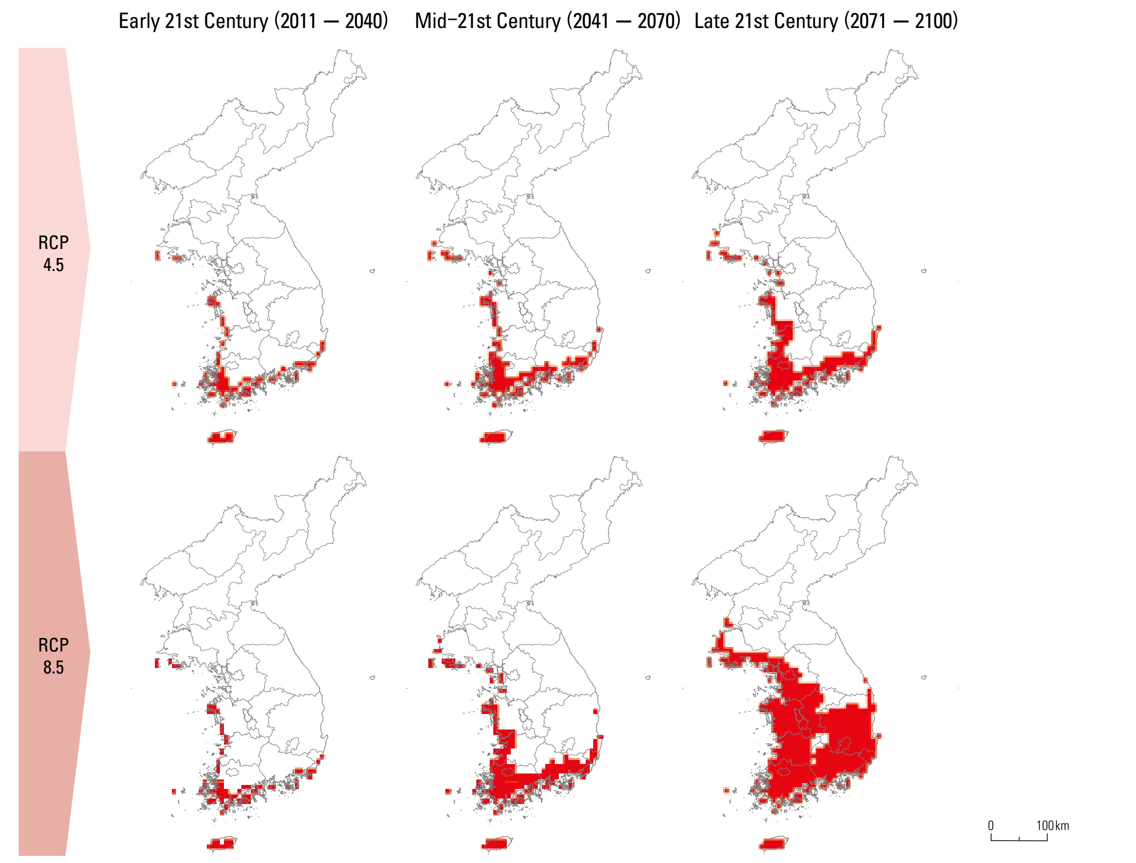
Korea Meteorological Administration (2012)

Projection of Precipitation over the Korean Peninsula under RCP 4.5/8.5 Scenario



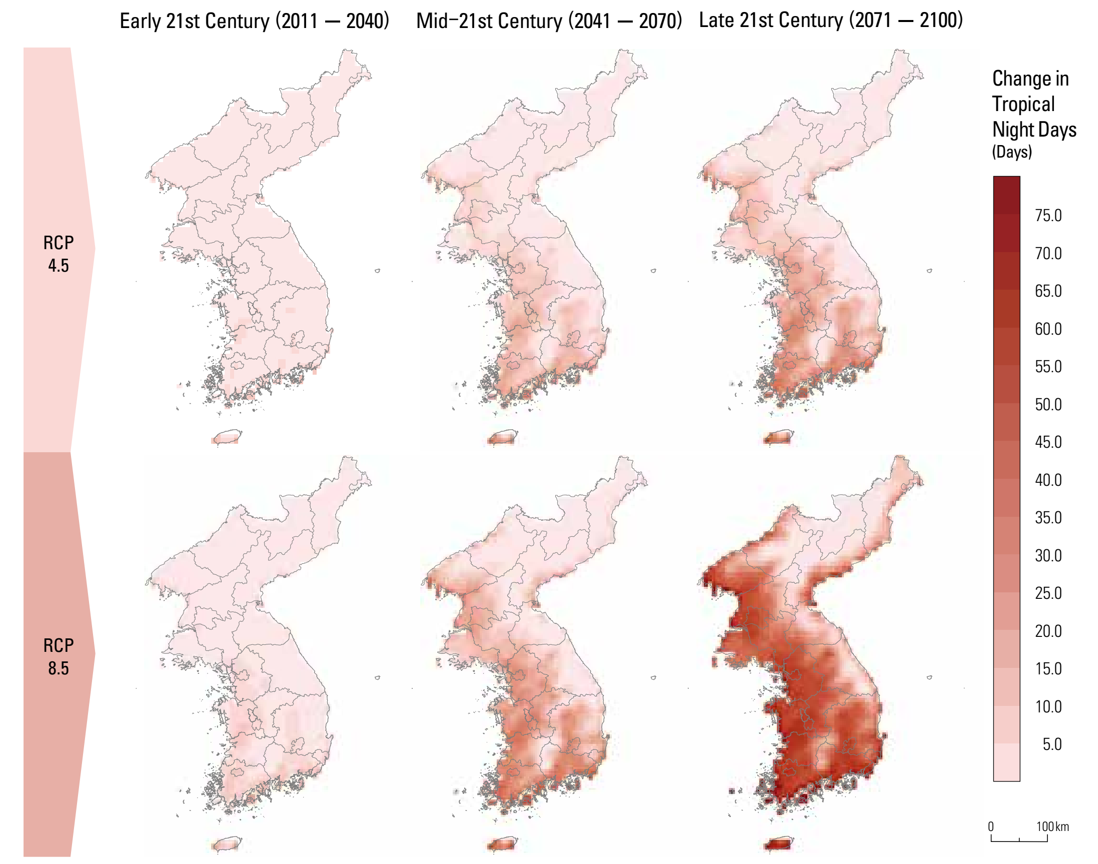
Korea Meteorological Administration (2012)

Projection of Subtropical Regions over the Korean Peninsula under RCP 4.5/8.5 Scenario



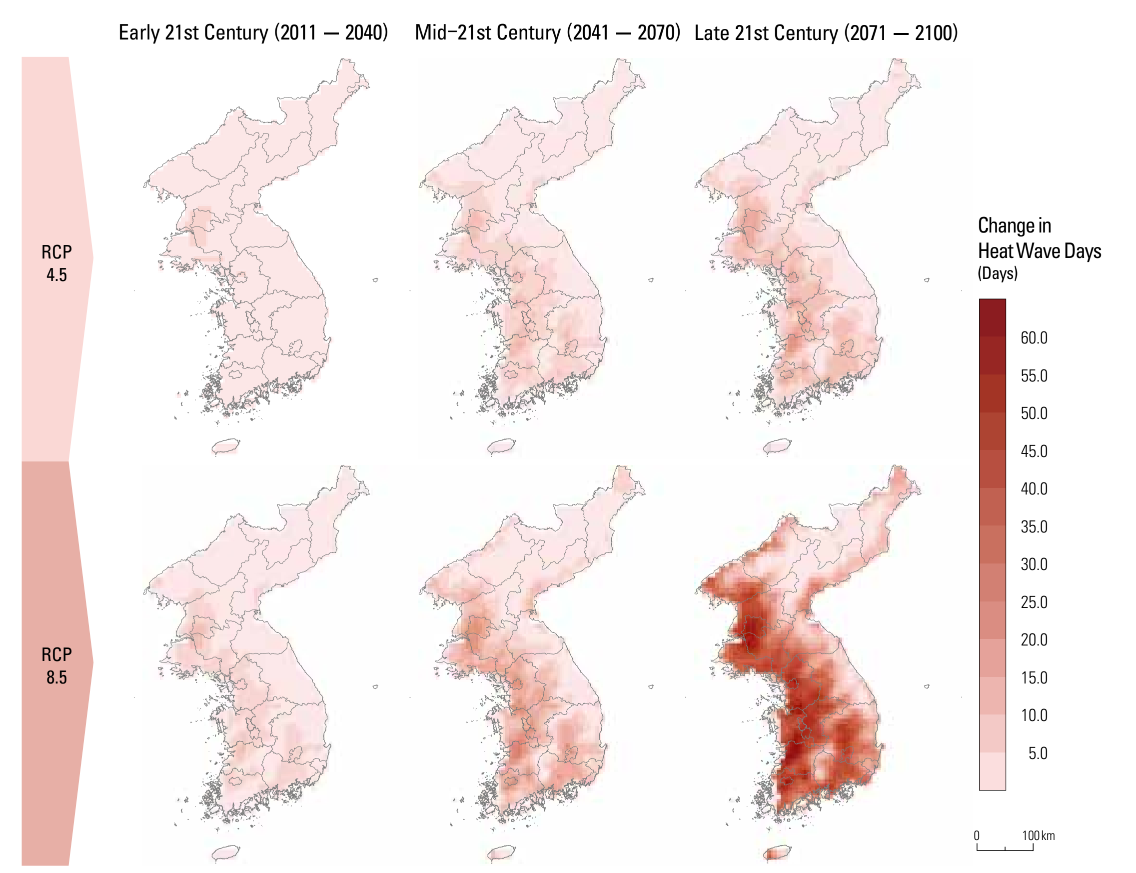
Korea Meteorological Administration (2012)

Projection of Number of Tropical Nights over the Korean Peninsula under RCP 4.5/8.5 Scenario



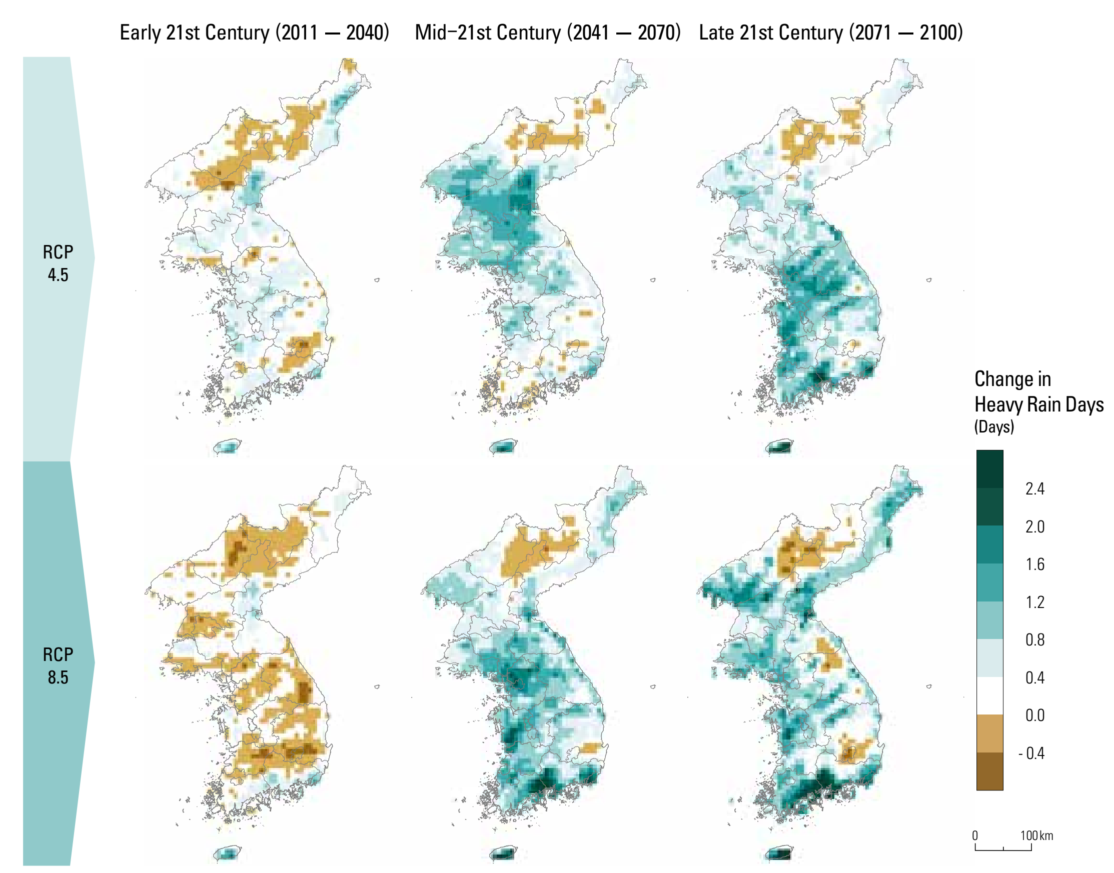
Korea Meteorological Administration (2012)

Projection of Number of Heat Wave Days over the Korean Peninsula under RCP 4.5/8.5 Scenario



Korea Meteorological Administration (2012)

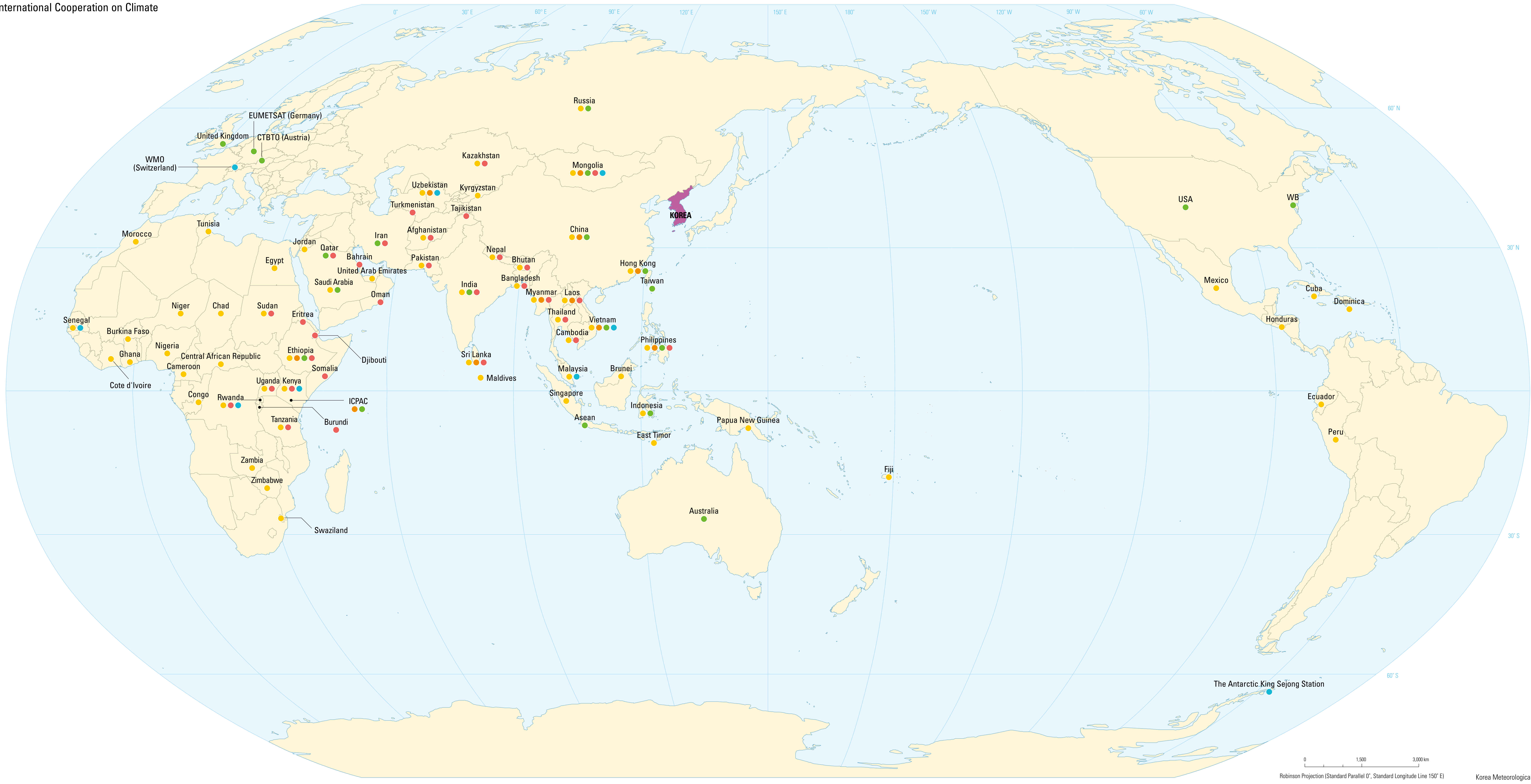
Projection of Number of Heavy Precipitation Days over the Korean Peninsula under RCP 4.5/8.5 Scenario



Korea Meteorological Administration (2012)

International Cooperation

International Cooperation on Climate



Robinson Projection (Standard Parallel 0°, Standard Longitude Line 150° E)

Korea Meteorological Administration (2015)

Infrastructure Support Program for Developing Countries

- The Construction of Korea-China Joint Observation Network (2003 – 2008)
- The Construction of Sri Lanka Meteorological Administration PC Cluster Numerical Forecasting System (2005)
- The Construction of the Philippines' Disaster Prevention Early Warning System
- The Modernization of Mongolian Meteorological Administration Climate Data Restoration and Management (2008 – 2009)
- The Establishment of East Africa Region Climate Center (East Africa Climate Prediction Application Center 2009 – 2012)
- The Construction of Vietnam Typhoon Analysis and Forecast System (2010-2012)
- The Construction of Sri Lanka Satellite Data Reception System (2010 – 2012)
- The Modernization of Vietnam Meteorological Disaster Monitoring System (2014 – 2016)
- The Establishment of Myanmar Meteorological Advancement Master Plan (2015 – 2016)

Educational Training Program for Developing Countries

- Foreigner Forecaster Course (1998 –)
- Korea ASEAN Training Workshop (2002 – 2001)
- Meteorological Service Enhancement Course using Information Communication Technology (ICT) (2006 –)
- Climate Prediction Experts Ability Cultivation Course (2006 – 2008)
- Numerical Forecast Training (2007 –)
- COMS Satellite Data Analysis Training Course (2007 –)
- Africa Disaster Management Ability Cultivation Course (2009 – 2012)
- Korea-China Asian Dust Joint Observation Network Operator Education (2010 –)
- Weather Radar Operation and Data Utility Course (2012 –)

Memorandum of Understanding (MOU) Signing

- As of August 2016, MOU signed with 17 countries and five international agencies.
- Numerical Forecasting, Experts Exchange, Education Enhancement, Earthquake, Asian Dust, Satellite, and so forth.

Numerical Forecasting Data Support

- The Atmospheric Pressure 500 hPa geopotential height field, 200 hPa isotach, and so forth. Forecast Weather Chart
- 30 Countries/358 Cities Prediction Data for Air Temperature, Wind, and Precipitation

Overseas Dispatch

- Switzerland WMO Asia Southwestern Pacific Region Office
- King Sejong Station, Antarctica
- Qatar Meteorological Administration
- Meteorological Advisor Dispatch: Kenya, Mongolia, Vietnam, Malaysia, Senegal, Uzbekistan, Rwanda

Korea carries out multilateral cooperation through international organizations including the World Meteorological Organization (WMO). WMO is one of UN agencies specialized in the meteorological field, with international authority over issues regarding atmospheric flow, the interaction between atmosphere and ocean, and climate-hydrology. After the foundation of the WMO in 1950, its membership has grown to a total of 191 countries, including Korea, joined as the 68th country in 1956.

The Korea Meteorological Administration (KMA) has been keeping its status as an executive council member of the WMO since 2007. The executive council is a core executive agency of the WMO, taking charge of supervising main policies such as the coordination of scientific technology and budget allocation. It is composed of head administrators from 37 member countries. The election of KMA's head administrator as an executive council member at the 17th World Meteorological Congress, in Geneva, Switzerland, 2015 was a great achievement for Korea as it raised the nation's status to a third term executive council member country. This could not have been possible without Korea's participation based on its foreign policy of trust into diverse international activities in meteorological field, headed by the WMO. As of 2016, the percentage of Korea's financial contribution to the WMO is 2.01%, which ranks Korea as 13th among member countries. The KMA is expected to strengthen its contribution as a part of leading international meteorological community group.

Also, the KMA was officially designated as a WMO Regional Training Center (RTC) at the 17th World Meteorological Congress due to its international reputation for outstanding performance on education-training sections. Since then, the KMA is equipped with enhanced system, enabling Korea to share its long-accumulated expertise, technology, experience, and so forth. with other members of the WMO. With the system, the KMA is planning to make specialized educational courses in accordance with the WMO education policy to lay a foundation for RTC operation base.

Another noticeable accomplishment is the election of the first Korean chairman of the IPCC (Intergovernmental Panel on Climate Change), having unparalleled authority over global climate change negotiations. IPCC is an agency established jointly by the WMO and the United Nations Environment Programme (UNEP) in 1988 to handle climate change issues. The election of a Korean chairman of the IPCC in 2015 demonstrates the nation's international renown for coping with climate change. The KMA continues to fortify its position and influence in the international meteorological community by actively participating in international activities and training domestic experts.

In 1994, a memorandum of understanding (MOU) on bilateral cooperation in the field of meteorology between the KMA and the China Meteorological Administration (CMA) was made. Since then, MOUs on bilateral cooperation in meteorology were made with the Australian Bureau of Meteorology in 1996, the Russian Federal Service for Hydrometeorology and Environment Monitoring in 1999, and the U.S. National Weather Service in 2000. Also, MOUs with Qatar and Saudi Arabia were made respectively in 2013 and 2015, not only extending KMA's meteorological cooperation with the Middle East countries but also paving the way for expanding Korean meteorological industry around the world. As a result, up until 2016, a total of 17 countries and 5 international agencies have made agreements on bilateral cooperation with the KMA.

The KMA has been keeping strong reciprocal relationship with its partners by opening bilateral cooperation convention in 2 – 3 year cycles, operating working groups, dispatching experts, and so on. In addition, the KMA is promoting cooperation with developed countries, including the US and the UK, to acquire state-of-the-art technologies such as next generation meteorological satellite technology, the introduction of UM model, operation technology, and so forth. Moreover, the KMA is promoting the construction of cooperation system with developing countries such as Vietnam and Mongolia with ODA program and capacity development program operation as the central figures.

The capacity of ODA began to develop since 1998 through educational programs of the KMA and KOICA. Since then, there have been training courses such as weather forecast training course for meteorological trainees of about 700 from 69 countries. These courses contribute greatly to the development of capability in predicting meteorological disasters in developing countries by cultivating staffs for meteorological administrations with abilities to utilize radar, acquire advanced technique of weather forecast, and understand and utilize numerical forecasting.

Building the capacity of ODA began in 2003 in cooperation with the KOICA and WMO. So far, about 20 programs including modernizing the Mongolian aviation weather, constructing the early warning system to mitigate the disasters in the Philippines, advancing the Vietnamese meteorological disaster monitoring system, and establishing a master plan for the advancement in meteorological technology of Myanmar have been completed. Supporting developing countries in their effort to advance in meteorological technology through the installation of large-scale system helps promote domestic meteorological technology. This has contributed to an increase in export of Korea's meteorological brands and domestic meteorological enterprises.

World Friend Senior Expert Dispatch Program, conducted by the Ministry of Science, ICT and Future Planning and carried out by the National IT Industry Promotion Agency, is a program dispatching senior experts to developing countries to support and provide advice regarding meteorological technology. Teams of meteorological advisors have been sent 19 times to countries such as Vietnam, Mongolia, Kenya, Uzbekistan, and so forth from 2010 to 2016. With their efforts, the KMA was able to identify demand in meteorological technology in those countries and has consolidated its international status.