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ANNUAL REPORT 2016

KOREA METEOROLOGICAL ADMINISTRATION

Korea Meteorological Administration

ANNUAL REPORT 2016

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Message from the KMA Administrator

It is a great pleasure to publish the *2016 Annual Report of the Korea Meteorological Administration* (KMA), which reviews the KMA's achievements and performance from 2016.

From the meteorological perspective, the year of 2016 was full of a variety of dramatic and unprecedented events. An increasing frequency and intensity of weather extremes and natural disasters, including earthquakes, typhoons and abnormally warm weather, was observed. The average temperature of the globe rose to its highest level since records began in 1880.

In particular, a magnitude-5.8 earthquake (following a magnitude-5.1 quake), the strongest ever recorded on the Korean Peninsula, jolted the historic city of Gyeongju on September 12, 2016. The quake was so strong that it was felt in areas hundreds of kilometers from the city, and many Koreans trembled with fear as hundreds of aftershocks continued. In October, typhoon Chaba, the first to make landfall in the nation in four years, battered its southern areas such as Jeju Island, Busan and Ulsan, claiming lives and damaging many properties.

These events reminded the KMA of the significance of accurate weather forecasts and the prompt communication of earthquake information, and as a result, various measures have been implemented to improve its work process and system.

First of all, a special analyst system was introduced by short-term, mid-term, marine and Asian dust area to enhance forecast accuracy, and forecast experts were hired to improve our analytical capacity of high-impact weather events. In particular, we established Weather Extremes Research Centers within meteorology-related universities and research institutes to promote long-term and intensive research on heatwaves, Jangma (Korean summer monsoon) and other abnormal weather events.

In addition, a training system by level was designed to sharpen forecasters' expertise, and the Meteorological Human Resource Development Institute was newly established in 2017 to foster expert forecasters. In terms of earthquake response, we have upgraded the Earthquake Early Warning System by reducing the lead-time for the warning from 50 seconds to 15-25 seconds after the earthquake. The Earthquake and Volcano Bureau was expanded into the Earthquake and Volcano Center, thereby enhancing earthquake-related expertise and R&D functions.

Watching the Sky Friendly, Serving the People Faithfully

The KMA's main policy goal in 2016 was to move towards "impact-based forecasts." Under the drive to elevate current forecasts to a new level by incorporating socio-economic impacts, we have endeavored to build infrastructure and develop relevant technologies. As part of these efforts, a pilot alert service for typhoons and heatwaves was initiated in some regions. We have also developed a pilot Numerical Weather Prediction Model with our own technologies. This new concept of forecast service is expected to offer more accurate numerical predictions, thus contributing to the decision making of relevant institutions and the public.

In addition, the KMA is focusing on the fourth industrial revolution to prepare itself for the rapidly changing social environment and promote meteorological advancement. We strive to integrate IoT (Internet of Things), Big Data, drones, AI (Artificial Intelligence) and other cutting-edge science and technologies into the meteorological area.

To this end, the Advisory Group on AI Forecast kicked off to set weather and AI application tasks. In order to inform drivers of the risk of car accidents by weather condition, a production system for Road Weather Information has been built by applying IoT and other advanced IT technologies. Our endeavors do not stop here. An application service incorporating climate and weather Big Data is under development to predict agricultural production and provide information on fluctuations in fishery catches. Various weather observation technologies are also being developed such as using drones for precise atmospheric monitoring. These are small steps that will help shift the paradigm of the meteorological services.

The KMA is committed to investing in long-term research on weather extremes and incorporating cutting-edge technologies into the meteorological services for the future, thereby taking initiative in promoting the safety and living standards of the public.

I hope that many related agencies and people around the globe find this report useful. Thank you.

Administrator
Korea Meteorological Administration
Jaecheol Nam

Vision & Goals

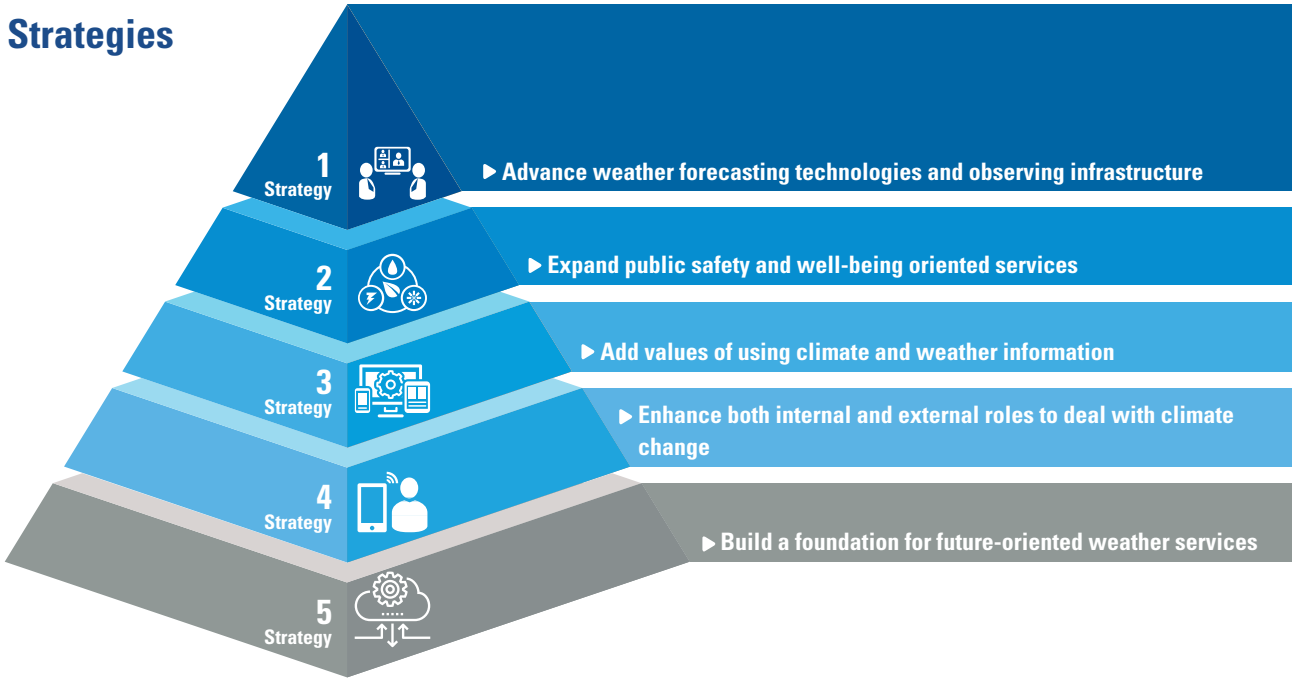
Vision

Satisfactory weather services via providing reliable information

Goals

- **Provide more accurate and prompt information**
- **Expand applications of climate and weather information, while creating added values**
- **Secure cutting-edge meteorological technologies as well as outstanding experts**

Strategies



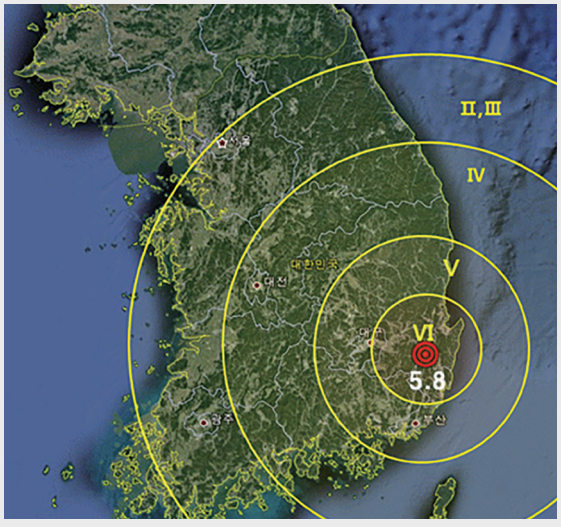
In 2016, the KMA focuses on elevating accuracy of weather forecasts, enhancing capacity to deal with High Impact Weather (HIW) events, strengthening monitoring and observing infrastructure for HIWs and earthquakes, spreading the value of the application of climate and weather information, supporting socio-economic decision-making process, and improving efficiency of the governance under the over-arching policy objective of '***Disaster Risk Reduction via Paradigm Shift towards Impact-based Forecast***'.

2016 NEWS HIGHLIGHTS

Record-breaking 5.8-magnitude earthquake

A magnitude 5.8 earthquake hit the city of Gyeongju, North Gyeongsang Province in Korea on 12 September 2016. This quake was the largest ever recorded in the country since the Korea Meteorological Administration (KMA) began monitoring seismic activities.

48 minutes later after the initial 5.1 foreshock was detected, a very strong earthquake of magnitude 5.8 occurred, which registered the maximum intensity level of 6 on the Korean seismic scale (in Gyeongju and Daegu). Even after the principle earthquake, a series of aftershocks were felt throughout the whole country including Seoul. As of 31 December 2016, 554 aftershocks continued to shake the country, rattling the nerves of people across the nation. The Gyeongju earthquake resulted in 23 injuries and some 9,000 incidents of property damage, such as cracks on the walls of historic and cultural buildings, causing an estimated more than 10 billion won in economic losses. The KMA sent a joint investigation team to the site to conduct a field investigation into the extent of the affected area and damage.



Epicenter of the Gyeongju earthquake

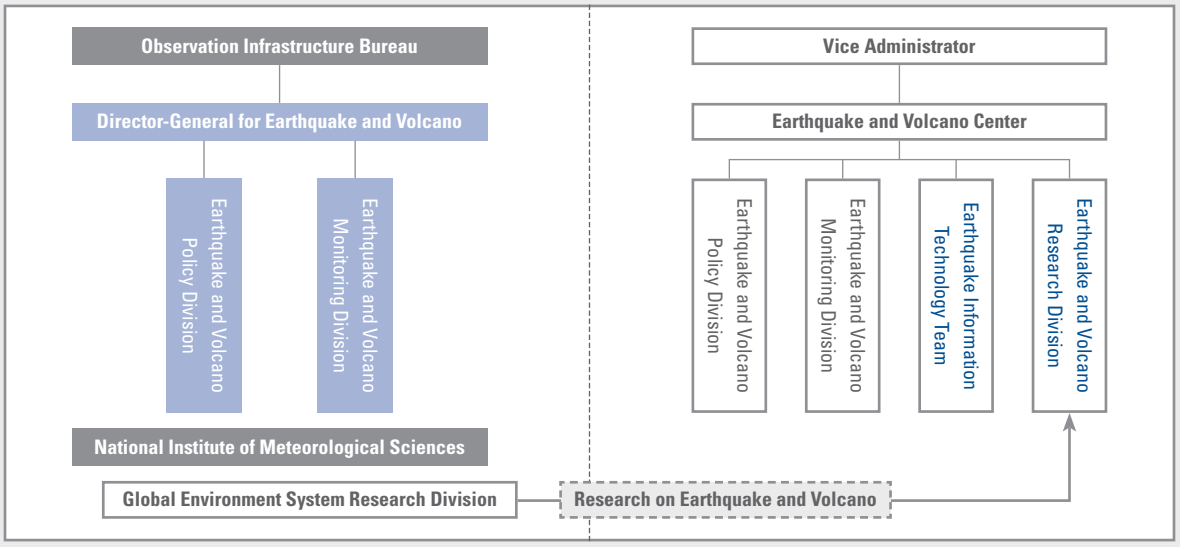
The earthquake damage in Gyeongju

Earthquake and Volcano Center established

After the strongest earthquake ever recorded in Korea, which struck the city of Gyeongju on 12 September 2016, the public's increasing concerns over potential earthquakes have led the government to come up with government-wide preparedness measures for earthquakes. To meet the needs of the public, the Korea Meteorological Administration transformed "Earthquake and Volcano Monitoring Bureau" into "Earthquake and Volcano Center" by increasing the number of subsidiary divisions from two to three with one team, and the number of personnel from 25 to 45, to ensure that it can better provide earthquake early warnings and promptly undertake emergency response actions.

On top of the two existing divisions — Earthquake and Volcano Policy Division responsible for developing basic policies on earthquake, tsunami, and volcano service, and Earthquake and Volcano Monitoring Division focusing on monitoring, analysis, and notification of earthquakes —one division and team were newly established under this new center: Earthquake and Volcano Research Division for further research including on local magnitude scale, and Earthquake Information Technology Team in charge of earthquake-related technologies, such as for Cell Broadcast Service (CBS), earthquake monitoring network, and earthquake early warning system.

With the increase in personnel and capacity, the KMA, as the sole government agency responsible for coordinating national earthquake services, has strengthened its independence and expertise. This is expected to lead to more systematic and comprehensive earthquake preparedness, contributing to protecting people's life and property from earthquakes and reducing people's anxiety about potential disasters.

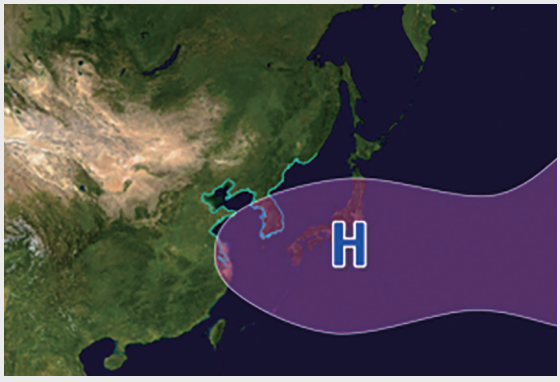


Organizational change of Earthquake and Volcano Center

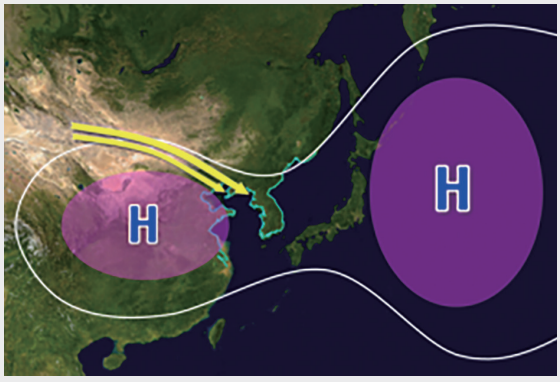
Unprecedented heat wave in 2016

The year 2016 was the hottest year on record since 1973 as the average annual temperature was 1.1℃ above normal (12.5℃). In particular, the high-temperature event from late July to late August, which is traditionally considered the hottest period of the year, resulted in a continued heat wave and tropical night phenomena.

∗The number of heat wave days in summer of 2016 : 22.4 days (the normal of 9.8 days)
The number of tropical nights in summer of 2016: 10.8 days (the normal of 5.1 days)



Typical pressure system around the Korean Peninsula in August



Pressure system around the Korean Peninsula in August

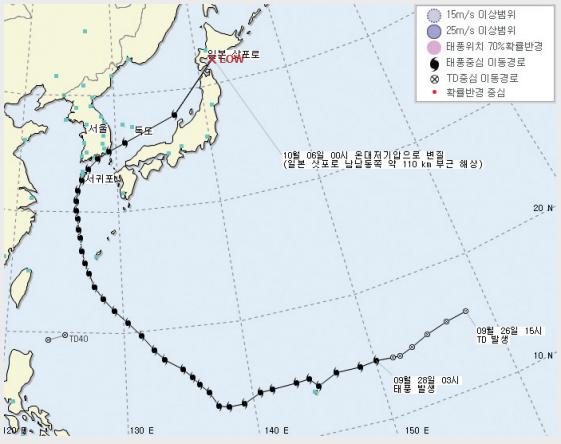
The stronger than normal ridge of the North Pacific high-pressure system over the East coast of Japan blocked the movement of air, from the west to east (blocking effect). This effect allowed both hot and dry air moving in from China and the air heated up by solar radiation to remain in the sky over the Korean Peninsula. Such an unprecedented event significantly lowered the forecast accuracy, resulting in a failure to meet the expectations of the public. An analysis has found out three reasons that made it difficult for the KMA to forecast the heat wave in 2016: 1) unprecedented pattern of air movement (stagnant air flow by the blocking effect and the most extreme heat wave in 150 years), 2) a decrease in predictability of numerical weather prediction models, and 3) limitations of forecasters in calibrating the forecast results from the NWP models. To address these issues for more accurate prediction, the KMA has developed a short-, mid- and long-term comprehensive plan to improve the accuracy of precipitation forecast during the monsoon season and the mid-range forecast. Specifically, the short-term plan includes the implementation of a professional forecast analyst system, the improvement of forecasters' capacity, and the enhancement of communication with the media and the public. The mid-and long-term plan mainly focuses on establishing a center for extreme weather events, implementing an operational Korean NWP model, supplementing areas that lack observations with more observation data, and introducing a system that enables forecasters to work in the forecasting field in the long term.

Chaba, the strongest typhoon that struck Korea in October

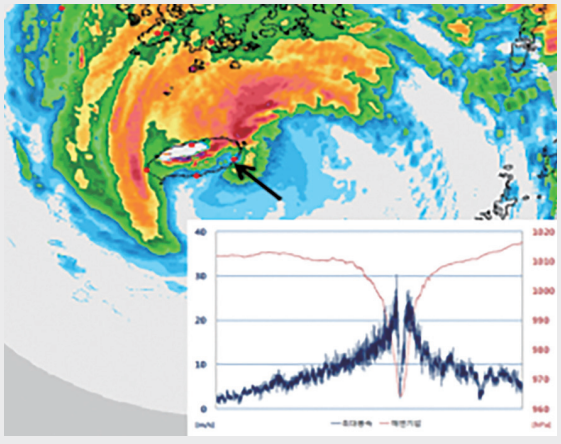
South Korea was hit hard by typhoon Chaba, which was developed about 590 km east of Guam on 28 September 2016. Chaba brought a spell of heavy rain and strong winds on the Korean Peninsula as it was passing over Jeju Island, Geoje Island, and the southern part of Busan. The typhoon unleashed 659.5 mm of rain on the mountainous regions in Jeju and 100 to 300 mm of rain on the southern and other regions of Jeju Island. The National Typhoon Center was also hit by over 290 mm of heavy rainfall. Also, strong winds of 49 m/s and the maximum instantaneous wind speed of 56.5 m/s were observed at Gosan in Jeju Island.

Typhoon Chaba was the strongest typhoon ever recorded that struck the Korean Peninsula in October. Before Chaba's arrival, typhoon Seth in 1994 was the first typhoon that hit the Peninsula in October since 1980. But the central pressure of Seth was about 975 hPa when it landed on the south coast of Korea, which was less stronger than that of Chaba (970 hPa recorded nearby Geoje Island). Chaba moved toward the Peninsula along the edge of a stronger than normal ridge of North Pacific high pressure, and it started to affect Korea while passing through the southern waters of Jeju Island.

Even though it was out of the ordinary for a major typhoon to hit the country in October, Chaba caused a lot of damage in Jeju and other southern parts of the Peninsula. The typhoon left seven dead and three missing, with 215 billion Korean won worth of economic damage due to power outages, flooding, and structural damage.



The track of Typhoon Chaba



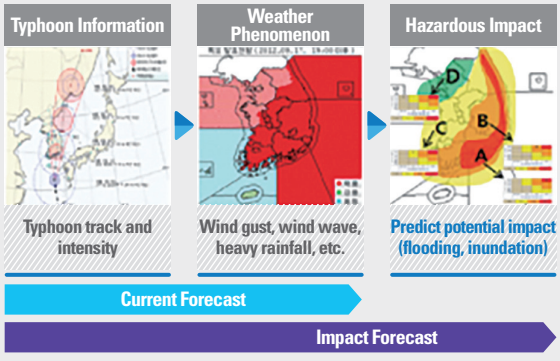
Radar image and changes in wind speed and pressure of Chaba on 5 October at 04:50

Basic plan and prototype of impact forecast implemented

The same meteorological conditions can result in different impacts, depending on time and place. As traditional weather forecasts have only contained meteorological phenomena, they have failed to inform users of different impacts as a result of the expected weather, which can help them effectively respond when any disaster is predicted. For better response planning and preparation, the Korea Meteorological Administration set its policy direction for 2016 as "shifting to impact forecast to mitigate meteorological disaster risks." As a first step toward this goal, the KMA created a Task Force (TF) team dedicated to the implementation of impact forecast.

The TF team first established a basic plan with aim of fully implementing impact forecast by 2020. The plan consists of four strategies: 1) to establish a big data-based system for meteorological impact analysis and support, 2) to develop technologies to produce impact forecasts, 3) to promote understanding of impact forecast and collaboration with related organizations, and 4) to build impact forecast service and assessment system. It also has run a prototype of typhoon impact forecast service dedicated to Jeju Island, to test related technologies and collaboration with other disaster and emergency management organizations. In addition, the team generated and provided 24 impact weather forecasts for four typhoons that affected the Korean Peninsula, in order to support a decision-making of local governments in their implementation of disaster response and recovery activities. Each regional office of the KMA operated a prototype of impact forecast service tailored to major severe weather conditions in each region. As a result, the prototype service was found to contribute to reducing meteorological disasters in those regions, and a great number of users showed positive responses to the user satisfaction survey.

The KMA will continue to conduct test services to identify and solve potential problems, as well as pushing forward government-wide cooperation for more effective responses to meteorological disasters. Plus, it will make its best effort to further develop a fundamental technology for the full implementation of impact forecast by 2020.



Comparison between existing forecast and impact forecast

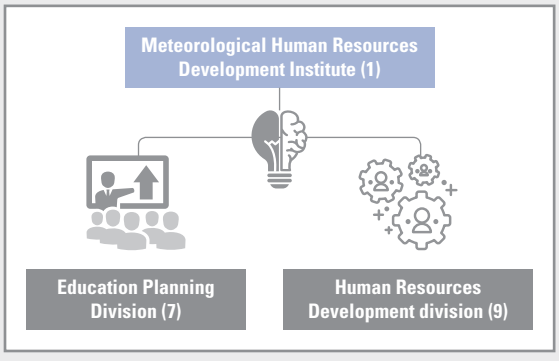
Joint meeting for impact forecast in Jeju

Meteorological Human Resources Development Institute opened

After 18 years since the Meteorological Education Training Institute was closed down in 1999, the Korea Meteorological Administration has newly established an independent educational organization, the Meteorological Human Resources Development Institute (MHRDI), to lay a foundation for advanced education and training in the fields of meteorology. With the expansion of the existing Human Resources Development division to two divisions with 17 staff members, the institute has taken its first step toward advanced meteorological education.

The KMA has been facing demands, internally and externally, for reforming the educational system to develop better meteorological professionals. With an increase in the frequency of severe weather events and disasters caused by climate change and after the strong earthquake struck the city of Gyeongju last year, the public has recognized Korea is not safe from earthquakes and disasters anymore. This has led to a significantly growing demand for disaster response education and training from both the public and organizations related to disaster and emergency management.

To meet these needs, the institute is committed to strengthening student-tailored education to nurture future professionals by considering their career path and jobs, as well as increasing educational programs on meteorological disasters for the general public and those working in the fields of meteorology. In particular, by securing full-time instructors, the MHRDI will enhance its professionalism in education on 10 professional fields[1] and publicly open the KMA's e-learning contents to help promote meteorological education not only for the KMA itself but other organizations. In addition, as the KMA was designated as the WMO RTC Korea in 2015, the institute will continue to reflect feedback on the effectiveness of education and training for those from the foreign NMHSs, to better fulfill its role as a regional training center.



Organizational chart

Signboard hanging ceremony of the Meteorological Human Resources Development Institute

1) forecast, numerical weather prediction, satellite, radar, earthquake, climate, typhoon, aviation meteorology, hydrological meteorology, marine meteorology

Meteorological Science Museum to be established in major regions

The Korea Meteorological Administration has run Daegu Meteorological Science Museum since 2014 to spread and promote the culture of science, meteorology, and climate in the nation. It plans to operate meteorological science museums in a total of four regions including Daegu, which are tailored to the characteristics of respective regions.

Jeonbuk Meteorological Science Museum in North Jeolla province will open in 2017 after the pre-opening operations in 2016. The KMA also plans to build the museum in the city of Miryang and Chungju with the aim of opening by 2019.

Meteorological Science Museum is mainly comprised of experience-focused exhibitions that facilitate understanding of fundamentals of meteorological science and general exhibitions about how to respond to disasters. Each museum will also have special exhibitions showing the characteristics of its own region. In addition, it is designed to help visitors learn about the basics of meteorology and climate change, as well as attracting their interests in meteorological science. Furthermore, the museum will be used as an educational venue for the public to learn about how to prevent damage from severe weather events and earthquakes and to help children and young students experience their future careers in the fields of meteorology.

Daegu Meteorological Science Museum

Jeonbuk Meteorological Science Museum

Weather and Climate Big Data Analysis Platform has opened to the public for free

In June 2016, the Korea Meteorological Administration has fully opened its Weather and Climate Big Data Analysis Platform to make weather and climate big data widely used and to create added values of big data fusion service. To establish the platform, the KMA used the latest cutting-edge information and communication technology (ICT), such as cloud computing and big data processing technology, to make it easier for users to analyze large volumes of meteorological data whenever and wherever they are.

Using this platform, users can employ various types of resources and data required for big data analysis, such as computing resources (analysis server, data storage), data analysis software (Hadoop, R), data of observations, forecasts, and numerical models, and climate statistics. Also, they will be provided with basic guidance on how to utilize weather and climate data and big data analysis cases for beginners who have no experience in using the big data. Anyone can use this platform for free if you sign up on the Weather and Climate Big Data Platform website (http://big.kma.go.kr) and apply for a permit to use the platform.

The public opening of this platform is expected to lay a foundation to promote opening and sharing government-owned data under the Government 3.0 plan, create an ecosystem for weather service industry, and realize business ideas of startups and those who want to start a business.

Website of Weather and Climate Big Data Platform

"Integrated Forecasting and Warning System for Asian Dust & Fine Dust Particles" established

The Korea Meteorological Administration (KMA) and the Ministry of Environment (ME) have laid out a plan for integrated forecasting and warning system for Asian Dust and fine dust particles.

Under this new system, when Asian Dust and fine dust particles occur simultaneously, the KMA and the ME jointly produce forecasts after consultations. First, the KMA and the National Institute of Environmental Research (NIER), a subsidiary organization of the ME, provide Asian Dust information and fine dust particle information, respectively, that are required for forecasting. Then based on these information, two organizations have consultations prior to issuing a forecast; the NIER releases an integrated forecast after incorporating the Asian Dust forecast information into fine dust particle forecast. The KMA provides information for weather forecast reports on whether Asian Dust is expected to be present.

The existing four stages of Asian Dust special report system and fine dust particle warning system (fine dust advisory – fine dust warning – Asian Dust advisory – Asian Dust warning) will be consolidated into three stages (fine dust advisory – fine dust warning – Asian Dust warning). In other words, the existing Asian Dust advisory is incorporated into fine dust warning; Asian Dust warning, the same as before, will be issued when an average concentration of fine dust particles per hour (PM 10) of more than 800 ㎍/㎥ is expected to last more than two hours.

Criteria for Asian Dust special weather report and fine dust warning (implemented on January 13, 2017)

(Unit : ㎍/㎥)

Existing	New
- Fine dust particle: Advisory (150) ⟶ Warning (300) - Asian Dust: Advisory (400) ⟶ Warning (800)	- Fine dust advisory (150) ⟶ Fine dust warning (300) ⟶ Asian Dust warning (800)

KEY ACTIVITIES OF 2016

- Forecast
- Observation
- Climate
- Meteorological Industry
- Information & Telecommunication
- International Cooperation
- International Education and Training

Key Activities of 2016

Forecast

Operations of the Advanced Forecasting System

Since 2010, the KMA has carried out a project to establish the Advanced Forecasting System with the aim of modernizing the whole forecasting process, ranging from monitoring to analysis, decision-making, production, and dissemination. In 2016, the focus was to make the developed systems more efficient. The 5 themes for the focus included 1) Sharing and Application with the associated agency, 2) Smart Forecasting System, 3) Scientifically advanced forecasting technology, 4) Training system for forecasters, and 5) User-oriented service. To create a foundation for Impact-based Forecasting, a new paradigm for forecasting, the KMA improved its existing forecasting system, while transferring to web-based forecasting system in 2016. It plans to develop the system more intelligent and lighter to provide more prompt weather information in the near future.

Operations of NWP

The NWP system of the KMA consists of the Global Data Assimilation and Prediction System (GDAPS), the Ensemble Prediction System for Global (EPSG), the Regional Data Assimilation and Prediction System (RDAPS), the Local Data Assimilation and Prediction System (LDAPS), the Limited area ENsemble prediction System (LENS), the Korea Local Analysis and Prediction System (KLAPS) and several application systems for such as marine meteorology, sand and dust storms, and statistics.

The major areas improved during 2016 contained (1) the operations of high-resolution (N768) based NWP system, (2) the operations of improved wave prediction system, (3) the operations of local forecasting system that expanded to East Asia, (4) the development of very short range NWP to support the Pyeongchang Winter Olympic Games, and (5) the improvement of data transmission and dissemination system. In particular, with the completion of the installation of

the 4th Supercomputer, the operational NWP system was moved for more stable production and provision of its forecasts.

Total 18 NWP models are run approximately 100 times a day, while producing about 9.0 TB of data with over 150,000 pages of maps.

Operations of NWP system at KMA (As of December 2016)

Models			Horizontal Resolution (Vertical Layers)	No. of Operations/Day	Duration of Prediction
Global (GDPS)	Global Forecasting System (UM N768 L70)		17km (70)	4 times	12 days 87 hours
Region (RDPS)	Regional Forecasting System (UM 12km L70)		12km (70)	4 times	87 hours
Local (LDPS)	Local Forecasting System (UM 1.5km L70)		1.5km (70)	4 times	36 hours
Wave	Global Wave Model (GWW3)		Approx. 50km	2 times	12 days
	Regional Wave Model (RWW3)		Approx. 8km	2 times	87 hours
	Local Coastal Wave Model (CWW3)		Approx. 1km	2 times	72 hours
Storm Surge	Regional Storm Surge Model (RTSM)		Approx. 8km	2 times	87 hours
	Local Coastal Storm Surge Model (CTSM)		Approx. 1km	2 times	72 hours
Yellow Dust/Haze	Yellow Dust Short-term Prediction Model (ADAM2)		25km (47)	4 times	72 hours
	Haze Prediction Model (ADAM3)		25km (47)	4 times	72 hours
Ensemble (EPSG)	Global Ensemble Prediction System (EPSG UM N400 L70 M49)		32km (70)	2 times	12 days
Local Area (LENS)	Limited Area Ensemble Prediction System (LENS UM 3km L70 M13)		3km (70)	2 times72 hours	
Statistics Model	Gloabl UM	Mid-term Temperature (MOS)	Major spots	2 times	11.5 days
	Regional UM	3 hrs/Highest/Lowest Temp. Type/Probability of Precipitation, Sky condition, New snow, Humidity, Wind (MOS)	Major spots	2 times	87 hours
Very Short-range	Very Short-range Background Analysis (KL15)		15km (22)	8 times	-
	Very Short-range Background Prediction (KLBG)		15km(40) 5km(40)	4 times	30 hours
	Very Short-range Analysis (KL05)		5km (22)	24 times	-
	Very Short-range Prediction (KLFS)		5km (40)	24 times	12 hours

Observation

Weather Observation Standardization

Since 2007, the KMA has been carrying out a project to standardize the weather observation across the country by improving the observing environment and avoiding duplicated installations of the same equipments and thereby to increase the accuracy of the observation data as well as its collaborative applications. Through training and workshops, the KMA supports the 27 public agencies which conduct observations, so that they can diagnose their level of standardization and comply the related laws and regulations.

To obtain and maintain the best suitable observing environment, the KMA secured additional land through land purchase, free leasehold, and allowance to use government owned properties to build standardized observing sites, while upgrading 540 among 585 sites to the highest level of standardization at the end of 2016 (92.3%).

In 2016, several meetings such as 'Weather Observation Standardization Committee' and 'Weather Observation Standardization Working Committee' were held to come up with more reasonable collaborative frameworks.

The KMA formed a Help Desk consisting of 26 staff members to instruct technologies related to observation standardization and to promote the utilization of the joint application system. In particular, it analyzed and solved the problems with telecommunication system and data processing to collect more data from other observing agencies including municipal governments in 2016 and achieved the data collection rate as high as 93.6%.

Current operations of COMS and data service

The National Meterological Satellite Center (NMSC) of the KMA launched the first-ever Korean geostationary satellite, Cheollian – 1 (Communication Ocean and Meteorological Satellite, COMS) on 27 June 2010 and has been successfully fulfilling its mission of weather observation for the last 6 years with the aim of providing stable satellite data service to both of the international and domestic users. The success rate of the operations of COMS in terms of completing its missions in 2016 showed as high as 99.7% (Goal: 99%).

Since 1 April 2011, the NMSC has provided basic satellite images and a variety of analysis images through various routes such as the regular broadcasting service for about 2.2 billion people from approximately 30 countries in Asia and the Pacific, a real-time data services for the related agencies, the web-site, the web system of the intranet, and WMO's Data Collection or Production Centre (DCPC). It exerts its efforts to improve the quality of the service via conducting and assessing the statistical result of the service and the survey every year.

Current Data Service by COMS

Route		Service
1	Satellite Broadcasting by Cheollian	• About 41 receivers (Internal: 14, External: 27) - External: US Air Force (Guam, Okinawa), Vietnam Air Force, Weather Services of Sri Lanka, Taiwan, Japan, Lao, Philippines, Australia and Thailand, and several universities - Domestic: Air Force, Navy, and related governmental agencies
2	Web-site (http://nmsc.kma.go.kr)	• No. of Subscriber: Total 1,111 (Internet: 948, Intranet: 163) - No. of visitors to the web-site in 2016: 61,264 • Downloaded data in 2016: Approx. 1.7 TB
3	Partner Agencies (Real-time FTP provided)	• Domestic: 19 Agencies (Via ICT Division of the KMA) - Air Force, Navy, National Institute of Environmental Research, KBS, MBC, SBS, etc. • Foreign: 3 partners - HKO, University of Wisconsin, and University of Colorado
4	Joint Testbed - ETRI	• Himawari-8 data provided to support the development of algorithm for the follow-up satellite: About 60 TB
5	Off-line	• Data provided: About 34 TB - Requested by academia, research institutes, industries, etc.

Climate

Intergovernmental Panel on Climate Change (IPCC)

As a focal point for the IPCC of the Republic of Korea, the Korea Meteorological Administration plays a key role in coordinating international and domestic cooperation relevant to IPCC activities, and it attends the IPCC plenary which is held an average of twice a year to review and make key decisions of the IPCC with government representatives around the world.

To expand South Korea's contribution to the Sixth IPCC Assessment Report (AR6), the KMA recommended Korean specialists from government agencies, academia, and other relevant fields, to the IPCC. As a result, five experts were selected to participate in scoping the IPCC special report: one expert for a Special Report on Global Warming of 1.5℃ (Prof. Tae-Yong Jung, Yonsei University), two experts for a Methodology Report on the 2019 Refinement of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (Jong-Su Yim, National Institute of Forest Science; Jung-Hun Woo, Konkuk University), and two experts for a Special Report on the Ocean and Cryosphere in a Changing Climate (So-Min Cheong, University of Kansas; Suk-Hee Lee, Korea Marine Environment Management Corporation).

Also, the KMA organized the IPCC Expert Forum to promote information sharing among experts and make preparations for the IPCC plenary meeting. At the forum which was held twice in 2016, experts exchanged their reviews and thoughts about the expanded scope of the main products of the Sixth Assessment Report — Special Report on Global Warming of 1.5℃ and Methodology Report on the 2019 Refinement of the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The forum provided domestic IPCC experts with an opportunity to review and discuss related issues, and draw more attention to the IPCC from the public.

In addition, the KMA has continued to contribute to the IPCC community through its contribution to the IPCC Trust Fund since 2006. The following shows the status of the KMA's contributions to the Fund.

The status of the KMA's contributions to the IPCC Trust Fund

(Unit : CHF)

Year	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Contribu-tions	36,600	36,600	47,400	32,760	113,706	110,769	114,348 (USD)	121,314	127,116	122,441	126,075

Report on 2016 Abnormal Climate in 2016

The KMA jointly working with the Office for Government Policy Coordination has published a *Report on Abnormal Climate in 2016* on 16 January 2017, with the participation of 21 relevant agencies. This report deals with unusual climate phenomena in 2016 and their impacts on different sectors as well as its response plan for the future.

Over the course of 2016 the Republic of Korea witnessed a variety of extreme weather and climate events, such as heat wave, tropical night, typhoon, heavy rain, and cold wave. In particular, it recorded the highest average temperature since 1973 at 12.5℃, which was 1.1℃ warmer than normal. A heat wave warning was even issued in May; with continued warm days with high temperatures from late July to August, Korea experienced 22.4 consecutive days of heat wave and 10.8 days of tropical nights. Among others, Typhoon Chaba that occurred in October brought heavy rain in Jeju Island and the southern part of the Korean Peninsula, resulting in that several parts of the country had their maximum daily precipitation in October. Typhoon Chaba was recorded as the most strongest typhoon ever to hit the Korean Peninsula in October.

Such extreme unusual weather and climate events caused damage to different sectors, such as agriculture, marine fisheries, industrial energy, and land and transport. Unusually high temperature in spring and heat wave in summer especially had great impacts on these sectors. For instance, heat wave and drought withered crops and killed livestock; abnormally high sea temperatures, 7 to 8℃ higher than normal, killed a great number of farmed marine species in some parts of the coastal and bay areas.

With a substantial increase in the frequency of abnormal climate events and consequent economic damage, the KMA will strengthen collaboration with other government agencies to reduce the damage and to properly respond to ever-worsening climate impacts.

Global Framework for Climate Services (GFCS)

The KMA has made contributions to the GFCS Trust Fund since 2013 to contribute to strengthening global climate services. Through its contribution to the Fund, the KMA, along with the WMO, participates in and provides assistance to the GFCS activities to reinforce national climate prediction system and capacity building projects in East African countries, such as Rwanda, Uganda, Djibouti, and Burundi.

In addition, the KMA focuses on research on climate service for healthcare sector to adopt the latest global trends in climate services, and it has also published a best practice report in Korean regarding the application of climate services to sectors such as agriculture, disaster, water resources, healthcare in order to promote and increase understanding of values of weather and climate information services.

The status of annual contributions to the GFCS Trust Fund

(Unit : CHF)

Year	2013	2014	2015	2016
Contributions	126,369	132,305	127,136	131,363
Beneficiary country	Rwanda	Uganda	Djibouti	Burundi

Climate Change Scenarios

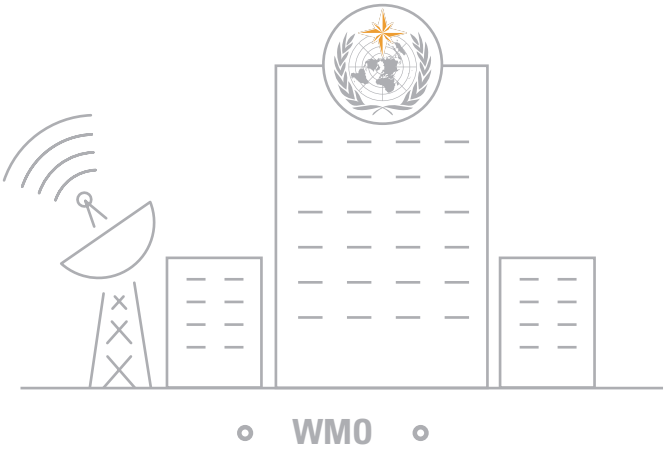
The KMA produces and provides climate change scenarios and applied information to assist the development of climate change policies, including national climate change adaptation policy and related research. For users convenience, the KMA also offers scenarios at different resolutions via its climate information web portal (http://www.climate.go.kr). This portal site offers various types of scenarios based on Representative Concentration Pathways (RCP), including global scenarios (135 km), scenarios for the Korean Peninsula (12.5 km), downscaled scenarios for South Korea (1 km), extreme climate indices, information by administrative district, and applied information for different sectors. In 2016 alone, the website provided 180 users with 583 information. It has shown that information especially about water management, climate monitoring and prediction was used the most by academia and industries.

To support local government's development of action plans for climate change adaptation, the KMA has produced a 2016 climate change analysis report for 63 local governments. The KMA therefore has successfully continued to provide the report for all local governments since 2012.

WMO World Calibration Center for SF_6

Recognizing the importance of monitoring sulfur hexafluoride (SF6), the WMO Global Atmosphere Watch (GAW) programme has started its monitoring since the late 1990s. In line with this, the Anmyeondo climate change observatory in Korea has begun its observation and monitoring of SF6 since 2007. The KMA hosted the WMO/GAW World Calibration Center for SF6 in 2011 and signed a MoU with the WMO in October 2012. As of 2016, 53 observatories in 19 countries are monitoring SF6. The Anmyeondo observatory is the sole station in East Asia that makes consecutive observations permanently.

The World Calibration Center for SF6 has five main duties: 1) to assist in making the SF measurements traceable to primary standards by the Central Calibration Laboratory for SF6 of NOAA; 2) to develop quality control procedures to support the quality assurance of SF6 measurements and ensure the traceability of these measurements to the corresponding WMO reference; 3) to maintain a laboratory that produces standard gas traceable to the WMO reference and transfer the standard gas; 4) by using the standard gas, to perform regular calibrations for the WMO/GAW stations and inter-comparison of the results of RRTs; 5) to provide training on data quality control and monitoring technology for WMO/GAW stations.

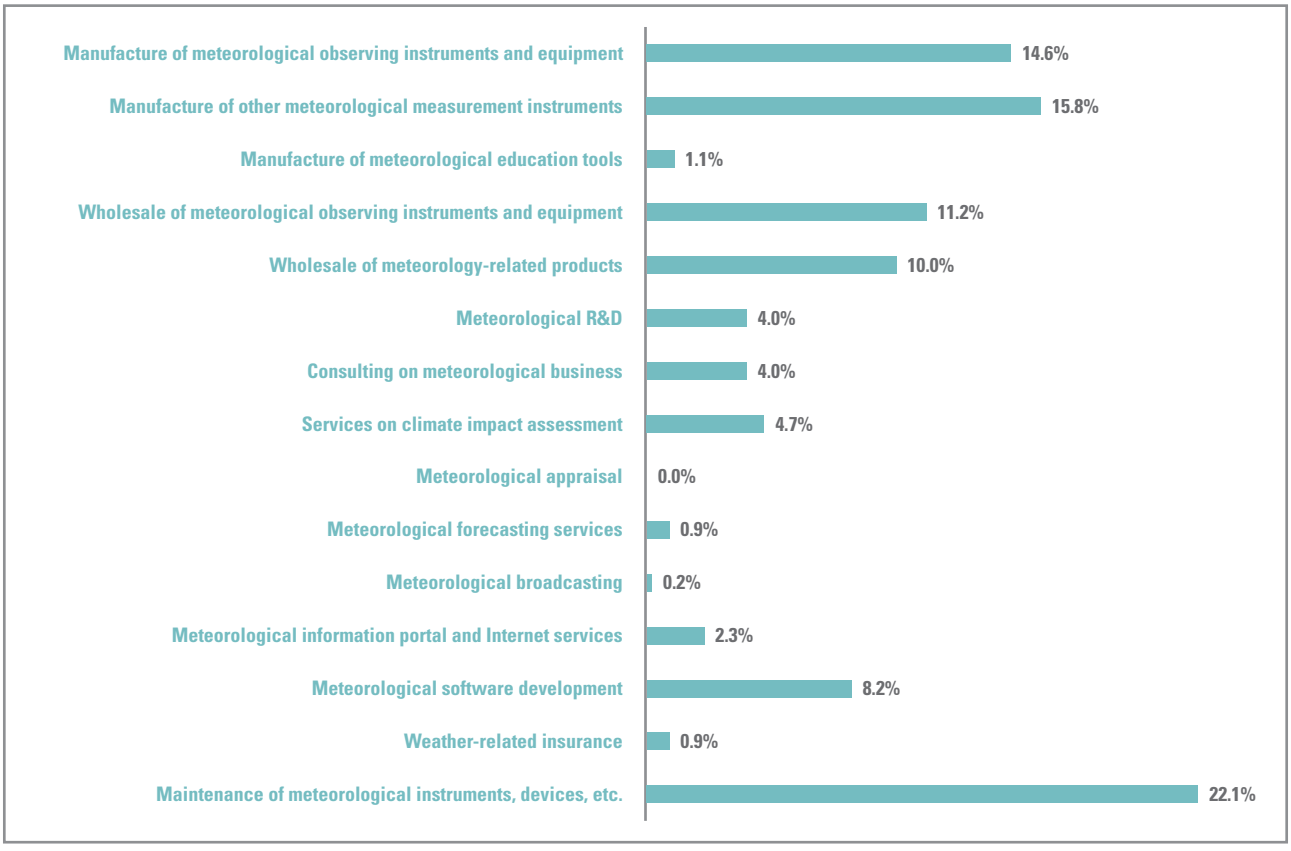


Meteorological Industry

The State of Domestic Meteorological Industry

1.1. Number of meteorological businesses

A survey has shown that there are 570 meteorological enterprises across the nation which fall into the category (15 subcategories) of meteorological industry. The industry includes different types of business, such as fixing meteorological instruments, equipment and related products and maintenance, which accounted for 22.1 percent of the industry; manufacture of other meteorological measuring instruments business (15.8%); manufacture of meteorological observation instruments and equipment business (14.6%).



Share of each business type in the meteorological industry

1.2. Revenues of meteorological industry

As of December 2015, total revenue for the meteorological industry stood at 371.9 billion won to 650 million won for each enterprise.

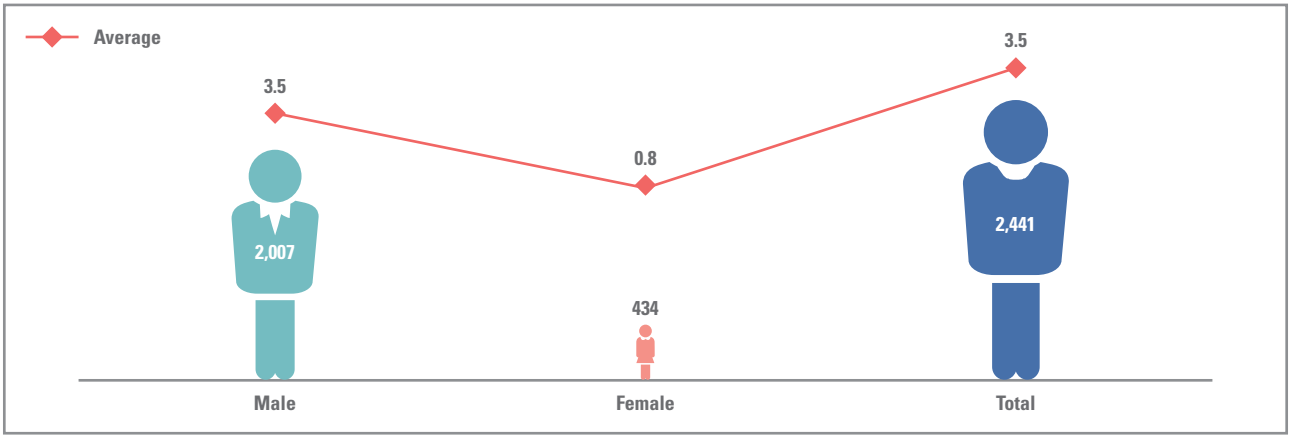
Total revenue by business type was: 131 billion won (35.2 %) in the manufacture of meteorological instruments, equipment, and related products, 54.4 billion won (14.6 %) in the wholesale of meteorological instruments and equipment, 25.1 billion won (6.8 %) in the technical service, 33.1 billion won (8.9 %) in the meteorological broadcasting and information service, and 128.4 billion won (34.5 %) in the other meteorological services.

Number of meteorological enterprises and their revenues

Type	No. of enterprises		Revenues	
	Total	Share (%)	Total (₩ million)	Share (%)
Total	570	100.0	371,908	100.0
Manufacture of meteorological instruments, equipment, and related products	179	31.4	130,953	35.2
Manufacture of meteorological observation instruments and equipment	83	14.6	70,127	18.9
Manufacture of other meteorological measuring instruments	90	15.8	59,097	15.9
Manufacture of educational meteorological equipment	6	1.1	1,729	0.5
Wholesale of meteorological instruments, equipment, and related products	121	21.2	54,351	14.6
Wholesale of meteorological observation instruments and equipment	64	11.2	27,868	7.5
Wholesale of meteorological products	57	10.0	26,483	7.1
Meteorological technical service	78	13.7	25,131	6.8
Meteorological R&D	23	4.0	7,706	2.1
Meteorological management consulting	23	4.0	13,157	3.5
Climate impact assessment service	27	4.7	1,860	0.5
Weather appraisal	-	-	3	0.0
Weather forecasting service	5	0.9	2,405	0.6
Meteorological broadcasting and information service	61	10.7	33,093	8.9
Meteorological broadcasting	1	0.2	1,782	0.5
Meteorological information portal and Internet service	13	2.3	8,204	2.2
Development and supply of meteorological softwares	47	8.2	23,107	6.2
Other meteorological services	131	23.0	128,380	34.5
Non-life insurance related to meteorology	5	0.9	103,465	27.8
Fixing meteorological instruments, equipment, and related products, and maintenance	126	22.1	24,915	6.7

1.3. Number of full-time employees in the meteorological industry

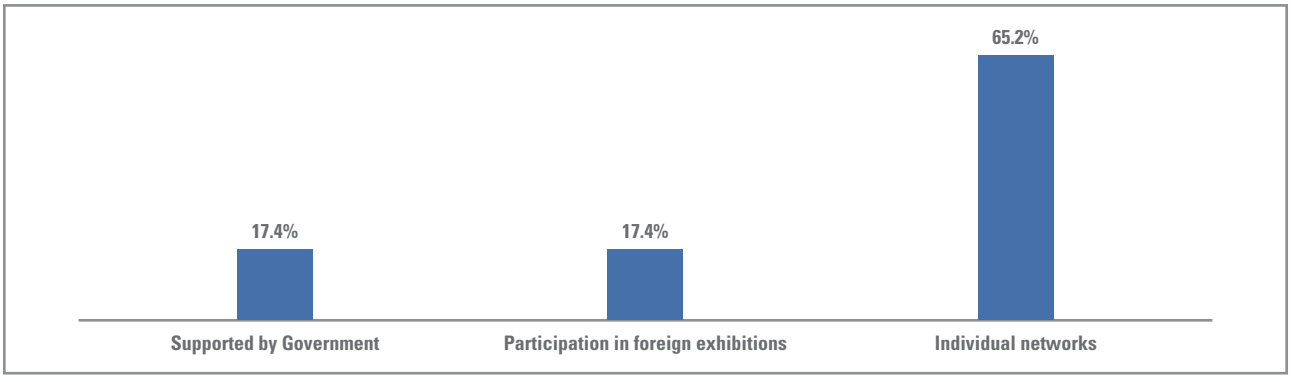
Total number of full-time employees in the meteorological industry was 2,441, an average of 4.3 per enterprise. By gender, the number of male and female full-time employees was 2,007 (82.2%) and 434 (17.8%), respectively.



Number of full-time employees in the meteorological industry

1.4. The state of imports and exports in the meteorological industry

The total values of imports and exports in the meteorological industry recorded at 39.2 billion and 11.8 billion won, respectively. Breaking down by business type, manufacture of other meteorological measuring instruments had the highest share in exports, followed by manufacture of meteorological measuring instruments and equipment; wholesale of meteorological observation instruments and equipment showed the highest share in imports, followed by manufacture of meteorological observation instruments and equipment.



Export channels in the meteorological industry

Values of imports and exports in the meteorological industry

Segment	Values of exports		Values of imports	
	Number of exports	Total (₩ million)	Number of imports	Total (₩ million)
Total	24	11,755	37	39,203
Manufacture of meteorological instruments, equipment, and related product	14	7,150	16	8,493
Manufacture of meteorological observation instruments and equipment	4	2,542	9	5,702
Manufacture of other meteorological measuring instruments	10	4,608	7	2,791
Manufacture of educational meteorological equipment	-	-	-	-
Wholesale of meteorological instruments, equipment, and related products	4	3,047	15	27,602
Wholesale of meteorological observation instruments and equipment	2	515	8	25,102
Wholesale of meteorological products	2	2,532	7	2,500
Meteorological technical service	1	15	1	6
Meteorological R&D	-	-	-	-
Meteorological management consulting	-	-	1	6
Climate impact assessment service	-	-	-	-
Weather appraisal	-	-	-	-
Weather forecasting service	1	15	-	-
Meteorological broadcasting and information service	5	1,543	-	-
Meteorological broadcasting	-	-	-	-
Meteorological information portal and Internet service	1	5	-	-
Development and supply of meteorological software	4	1,538	-	-
Other meteorological services	-	-	5	3,102
Non-life insurance related to meteorology	-	-	-	-
Fixing meteorological instruments, equipment, and related products, and maintenance	-	-	5	3,102

Information & Telecommunication

The Global Telecommunication System (GTS) is a global network established in the 1960s for the transmission of meteorological data between WMO member countries. The GTS plays a key role in acquiring global meteorological data which is integral to the generation of weather charts and operation of numerical weather prediction models.

With the termination of the frame relay network services —a telecommunication method of the GTS — and the introduction of the Met Office Unified Model (UM) — the KMA's numerical prediction system — the KMA has recognized the need to acquire a large volume of meteorological data. To address this issue and adapt to the new telecommunication environment, the KMA terminated the frame relay service with the Japanese Meteorological Agency on 24 March 2009 and upgraded the GTS by establishing a dedicated international telecommunication circuit and increased its speed to 128 Kbps, thus contributing to obtaining a huge volume of meteorological data to improve the accuracy of numerical weather predictions. The way of transmitting and receiving data with the Chinese Meteorological Agency was also changed from using Sockets to File Transfer Protocol.

Also, the KMA has joined the Regional Meteorological Data Communication Network (RMDCN) since December 2009, which is the WMO community's core network (the speed was increased from 2 Mbps to 4 Mbps in 2014), to prepare for the transition to the WMO Information System (WIS).

In accordance with the 12th bilateral cooperation agreement between KMA and CMA, the KMA terminated the international frame relay service on 30 November 2015; with the JMA, the data communication method has changed from using Sockets to FTP with the discontinuation of the dedicated international circuit on 31 January 2016. As a result, the KMA has begun to exchange global meteorological data via the RMDCN (4 Mpbs) from 1 February 2016. The KMA currently exchanges data with other meteorological agencies through the RMDCN, including JMA, CMA, Met Office, DWD, Roshydromet, and Meteo France.

As the existing GTS showed its limitations in exchanging and accessing a large volume of (numerical model, satellite) meteorological data, the WMO carried out developing a new version of WMO WIS from 2003, which can supplement the previous telecommunication system. The WMO WIS not only has the existing functions of the GTS, but also provides Discovery, Access and Retrieval (DAR) service. Also, it consists of Global Information System Centre (GISC), Data

Collection or Production Centre (DCPC), and National Centre (NC).

The KMA joined the SIMDAT (vGISC Pilot: virtual test of GISC) project early on, which has been conducted in Europe. In 2006 it expressed its willingness to host the DCPC, and then again in 2008 it actively showed its desire to host GISC and three DCPCs. Hence, the KMA became one of candidate countries for GISC in November 2010. In addition, jointly working with the UK and France, the KMA has participated in the development of core software "OpenWIS" for the WIS center since early 2010 (Currently, the development is also joined by Australia and America). With the completion of the first stage of the OpenWIS software development in 2012, the KMA has obtained core technology required for operating the GISC. As a result, the GISC Seoul was designated as one of 15 WMO GISCs in June 2012, and the GISC Seoul has come into full operation in March 2013.

The KMA, as a co-director, has continued to participate in the OpenWIS, a non-profit organization aiming to developing the software that was organized by UK, France, Australia, America, Finland, and Korea. The KMA hosted the 2016 OpenWIS annual meeting in Seoul from 7-11 March 2016 to offer an opportunity to set up business strategies with open source-based software developers. By hosting this meeting, the KMA was recognized for its work in establishing government agencies-led business models for open software, thereby contributing to the WMO community.

The GISC Seoul (http://gisc.kma.go.kr) is responsible for operating three DCPCs (DCPC WAMIS, DCPC LC-LRFMME, DCPC NMSC) and one NC. Through the NC Seoul, GISC Seoul registers and controls about 30 types of metadata of the data produced by the KMA, and also it has started to provide Geographic Information System (GIS) service which links domestic observation data to geographic information.

GISC Seoul homepage (http://gisc.kma.go.kr)

International Cooperation

Multilateral Cooperation

As the atmospheric system including weather, climate and water related environmental phenomenon does not stop at the borders, international cooperation among National Meteorological and Hydrological Services at the global level is essential to address such issues. Thus, the KMA conducts a variety of multilateral cooperation activities with several related international organizations, mainly with the World Meteorological Organization (WMO) which provides a necessary framework in coordinating the activities among its Members, while seeking capacity development of developing and least developed countries for the co-prosperity of the human-being in the era of climate change.

Active roles played by the KMA to contribute to the activities/programmes/projects of the WMO continued in the year of 2016, including participating in the 68th Session of the Executive Council (EC) of the WMO held in the Headquarters of the WMO, Geneva, Switzerland from 15 to 24 June 2016. Dr. Yunhwa KO, an EC member who also served as the Administrator of the KMA with 5 advisers attended the Session to discuss critical agenda items such as WMO's strategic and operating plans, budget, governance, public-private partnership, etc.

As a member of the EC, the KMA was represented at various important technical meetings such as the 16th Session of the Commission for Basic Systems (CBS) held in Guangzhou, China, and the 15th Session of the Commission for Hydrology (CHy) held in Rome, Italy to play a leading role. The Korean government sent total 12 delegates and 11 delegates to the Sessions of the two technical commissions of the WMO, respectively.

The KMA also ran a training course targeted for Korean undergraduate and graduate students and those young and talented students selected from this course were dispatched to relevant international organizations, including WMO, TC, ADPC, ICHARM, and UNESCAP in 2016. This is part of KMA's efforts to nurture Korean young scientists by providing opportunities to build their expertise in the international context.

The scale of assessment of the proportional contributions of the Republic of Korea to WMO in 2016 was 2.01%, which made the country the 13th largest financial contributor to the Organization among total 191 members. The table below shows the proportional contributions made by the Republic of Korea during the recent 5 years.

ROK's Proportional Contributions to WMO (2012-2016)

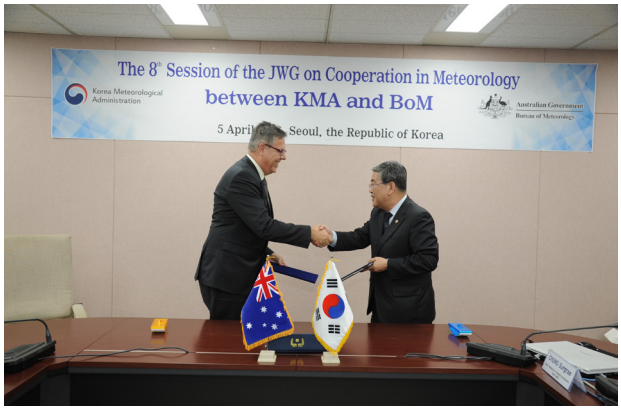
(Unit : CHF)

Year	2012	2013	2014	2015	2016
Scale of Assessment (%)	1,455,075 (2.23)	1,455,075 (2.23)	1,278,900 (1.96)	1,278,900 (1.96)	1,338,262 (2.01)

In addition, the Republic of Korea offered financial assistance to several trust funds in 2016, including WMO VCP ($30,000), ESCAP/WMO Typhoon Committee Trust Fund ($12,000), WMO AMDAR Trust Fund, ($4,000), IOC Tsunami Programme ($1,000), GEO Trust Fund (CHF 72,637) and GFCS Trust Fund (CHF 130,180).

Bilateral Cooperation

The KMA's bilateral cooperation in 2016 was conducted in a variety of meteorological areas. It renewed the bilateral agreements with NOAA and EUMETSAT for the next 5 years, while discussed issues on human and technical exchanges with Australia, Mongolia, USA, Vietnam, and Indonesia via regular bilateral meetings.



The 8th Bilateral Meeting between KMA and BoM

The 5th Bilateral Meeting between KMA and NOAA

The 7th Bilateral Meeting between KMA and NAMEM

The 8th Bilateral Meeting between KMA and BMKG

Observing the orientation of yellow dust in Dornogov

Development Cooperation

Modernization of Forecasting and Warning System for Natural Disaster in Vietnam (2014~2016)

The KMA completed the project to modernize the disaster monitoring system for 25 meterological stations and 25 hydrological stations in the northeast area of Vietnam in 2016, which is expected to contribute to reducing damages caused by weather disasters by shortening the data collection time as well as improving the reliability of observing data, and thereby increasing the accuracy and lead-time of forecasts and warnings.

Establishment of Master Plan for the Advancement of National Meteorological System in Myanmar (2015~2016)

The KMA established the master plan to modernize the national weather services of Myanmar, ranging from observation, forecast, telecommunication, governance, and legal system from 2015. It also plans to conduct a trial project to implement the master plan for 3 years from 2017.

Climate Data Rescue Project in Uzbekistan (2013-2017)

Under the cooperation with the WMO, the KMA has conducted the Climate Data Rescue Project for Uzbekistan which transforms the climate data in paper format into image files while assessing the quality as well as building index DB and management system. The wrap-up evaluation is planned to be done in Uzbekistan when the project is completed.

Modernization of Aviation Meteorological services in Mongolia (2014~2017)

The modernization project for aeronautical meteorological services of Mongolia has been carried out by the WMO with the sponsorship of the KMA since 2014. The WMO and the Korea Meteorological Institute signed on the Letter of Agreement in February 2016 and conducted the site investigation in May 2016.

Enhancing Weather and Climate Service through Severe Weather Forecast Demonstration Project (SWFDP) implementation in Western Africa (2015-2016)

The KMA provided support to the 1st phase of the Severe Weather Forecast Demonstration Project (SWFDP) which contained the establishment of the implementation plan of the severe weather forecasting in West Africa and the cooperative network. Regarding this, the workshop to build the implementation plan and capacity was held in November 2015, while the web-site for the project was developed in 2016.

Coastal Inundation Forecasting Demonstration Project-Fiji, Phase 2-4 (2016-2019)

Based on the Road-map of the Coastal Inundation Forecasting Demonstration Project for Fiji conducted by KOICA from 2012 to 2013, the KMA Plans to carry out the development of coastal inundation forecasting model (wave, storm surge, river inundation, etc.), installation of associated equipment (buoys), production of manuals, training and education from 2016 to 2019. The KMA-WMO-Fiji Meteorological Service had the kick-off meeting in August, 2016. WMO signed on the Letter of Agreement with the South Pacific Community (SPC) on the issues related to the purchase of marine observation equipment and the development of a marine model in February 2016.

Establishment of Communication, Ocean, and Meteorological Satellite (COMS) Analysis System in the Philippines (2013-2016)

KOICA completed the establishment of analysis and receiving system of COMS for the Philippines in 2016, while conducting a training course as well as dispatching experts to enhance the capacity to use satellite data.

Establishment of Early Warning and Monitoring System for Drought and Flooding in Ethiopia (2014-2017)

Since 2014, KOICA has carried out the project to build weather observation and early warning system to mitigate disaster risk in Ethiopia, which focuses on the installation of AWSs near River Awash, real-time data collection and distribution system, monitoring and prediction system for flood early warning, and the capacity building. The Korea Meteorological Institute serves as the implementing agency for this project.

International Education and Training

After the KMA was designated as a WMO Regional Training Center (RTC) in June 2015 at the 17th Session of the World Meteorological Congress, it signed a MoU with the WMO to better cooperate for the global meteorological training and education in June 2016. They shared a consensus on the need to build the capacity of meteorologists as well as meteorological technicians in Members for their public weather service, aviation, marine, and hydrological forecasting, and climate services, while agreed to collaborate to establish the WMO Global Campus.

MoU Signing Ceremony on RTC-Seoul

The KMA provided training courses on radar data application and forecasting for foreign experts to transfer its meteorological technologies and know-how using its own budget allocated for Official Development Assistance.

The training program for Weather Radar Data Application was conducted for 3 weeks from 18 April to 6 May for 9 trainees from 8 countries such as Senegal, Nepal, Thailand, Samoa, and Jamaica. The course focused on the application of the radar data, ranging from the interpretation of data from the perspective of meteorological observation to the input data for numerical models.

The training course for the foreign forecasters was conducted for 3 weeks from 10 to 30 July for 11 trainees from 11 countries, including Mongolia, Madagascar, and Micronesia. The course introduced KMA's policy, system, and service for the advanced weather forecasting, while offering educational programs together to increase the prediction capability for severe weather events and thereby to reduce disaster risk of the developing countries. The major subjects included NWP, impact-based forcasting, meteorological satellite, weather radar analysis, and response

to HIWs. Meanwhile, the students had a chance to visit KMA's related agencies, industrial facilities and to experience Korean traditional culture.

It also provided training courses on satellite data application and weather forecasting using Information and Communication Technologies (ICT) through participating in the 2016 global capacity building program offered by the Korea International Cooperation Agency (KOICA).

The course to improve weather forecasting using ICT was conducted for 3 weeks from 28 September to 12 October for 18 trainees from 10 countries, including Nigeria, Bhutan, and Jordan. The objective of this course was to nurture ICT professionals and to enhance the capability on NWP models and thereby to improve weather services of beneficiaries. The topics for the program consisted of basic ICT such as Linux, network, and security as well as COMIS, NWP program languages and library, etc.

The Satellite Data Application course was conducted for 4 weeks from 10 October to 2 November for 22 government officials from 14 countries from the Asia and Pacific region. The course covered the policy of satellite Cheollian and Cheollian-2A (to be launched in 2018), interpretation of satellite data, and analysis of major severe weather events.

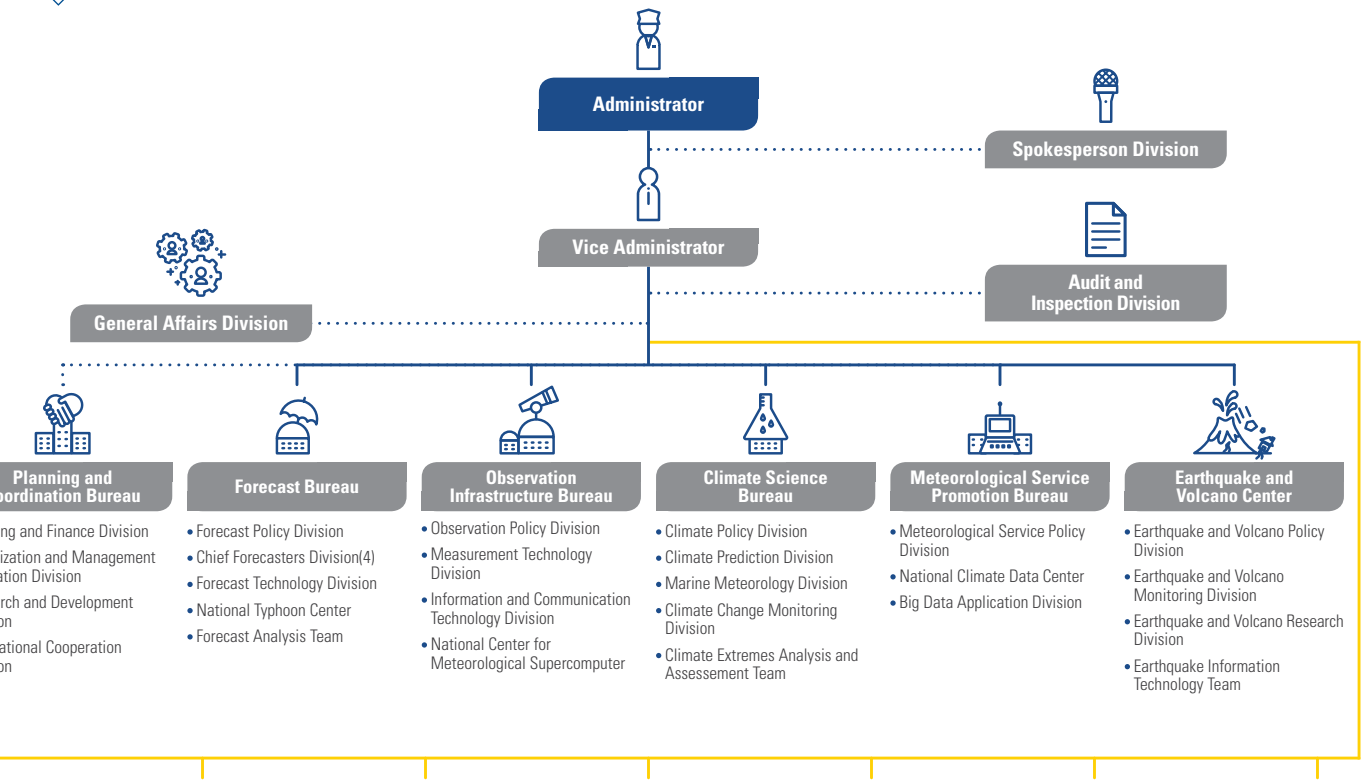
Sponsored by KOICA project, the KMA signed a MoU with the Hankuk University of Foreign Studies to provide master degree in atmospheric sciences as part of RTC-Korea program. It plans to nurture about 30 master degree students from developing countries by 2018. The KMA has been supporting the students by designating mentors depending on the topics of their dissertations.

APPENDIX

- Organizational Chart
- Human Resources
- Budget
- 2016 Weather patterns over Korea

Organizational Chart

(As of 1 January 2017)



Number of staff members

(As of 31 December 2016)

Category	HQ	NIMS	Regional Offices			NMSC	WRC	AMO			Total
			Main (6)	Branch (3)	Station (7)			Main	Office (5)	Station (2)	
Quota	389	155	391	146	49	48	41	53	53	8	1,333
Current	390	153	381	145	47	47	41	53	53	8	1,318

Human Resources

In Korea, there are 7 universities that provide a full range of undergraduate and postgraduate courses in Meteorology and Atmospheric Sciences (Seoul National University, Yonsei University, Gangneung-Wonju University, Kyungpook National University, Pusan National University, Pukyong National University, and Kongju National University). While many experts are nurtured in each faculty, those with the degree of meteorology and its related fields such as oceanography, environmental science, and earth science are consistently increasing in the KMA.

To mitigate the damage caused by abnormal weather disasters which the whole globe is facing now, the demand for a variety of specialized meteorological services is increasingly on the rise. To meet this ever-growing needs, the KMA hired outstanding and experienced personnel through competitive special recruitment, while additionally employing Grade 7 and 9 public officials in meteorological position to fill more working-level workforce. Breaking down the newly employed into their tertiary academic background, 5 with Ph. D, 2 with master, and 1 with bachelor degree were hired through the competitive special recruitment, while 36 (all with bachelor degree) and 10 (Master: 2, Bachelor: 8) joined the Administration through the KMA's open recruitment for Grade 9 and 7 public officials, respectively. As of the end of 2016, there are total 479 incumbents who hold advanced postgraduate degree (Ph.D: 121, Master: 358), which accounts for 33% of the total number of staff members of the KMA.

Number of qualified workforce (As of 31 December 2016)

Category	Degree	YEAR										
		Total	2016	2015	2014	2013	2012	2011	2010	2009	2008	2007
Special Recruitment	Ph. D	43	5	5	3	4	4	1	5	4	0	12
	Master	71	3	7	7	6	9	5	4	6	1	23
	Bachelor	23	6	1	5		4	2	2	0	1	2
	Sub-total	137	14	13	15	10	17	8	11	10	2	37
Open Recruitment		396	45	54	39	38	46	39	30	2	45	58
Total		533	59	67	54	48	63	47	41	12	47	95

Number of qualified workforce in each grade (As of 31 December 2016)

Grade	Ph. D	Master	Bachelor	Diploma or lower	Total
High-ranking officers	7	8	-	-	15
Grade 3~4	36	26	18	7	87
Grade 5	55	88	74	22	239
Grade 6~9	23	235	684	144	1,086
Facility Management	-	1	6	29	36
Total	121	358	782	202	1,463

Budget

The KMA's budget in 2016 was all complied into general accounts. The revenue showed KRW 5,771 million, increased by KRW 2,259 million or 64.3% from that of 2015, while the expenditure was KRW 402,086 million, increased by KRW 16,397 million or 4.3%, compared to the previous year.

The expenditure can be divided into labor costs (KRW 87,072 million, increased by KRW 5,299 million or 6.5% YoY), basic expenses (KRW 18,740 million, increased by KRW 319 million or 1.7% YoY), and major project costs (KRW 296,274 million, increased by KRW 10,779. million or 3.8% YoY). Of the total, these classified costs account for 21.7%, 4.7% and 73.7%, respectively.

The major project expenses consisted of general projects (KRW 82,929 million, 28.5%), R&D (KRW 153,255 million, 52.6%) and IT (KRW 55,226 million, 18.9%). Meanwhile, the budget for constructing new office buildings were transferred from the general accounts to the National Property Management Fund under the auspicious of Ministry of Strategy & Finance (MOSF) from 2012, drawing up KRW 7,311 million for Metropolitan Regional Office as well as Choonchun, Baekryeongdo, and Hongsung weather stations.

2015 Expenditure Budget for each Program

(Unit : KRW million, %)

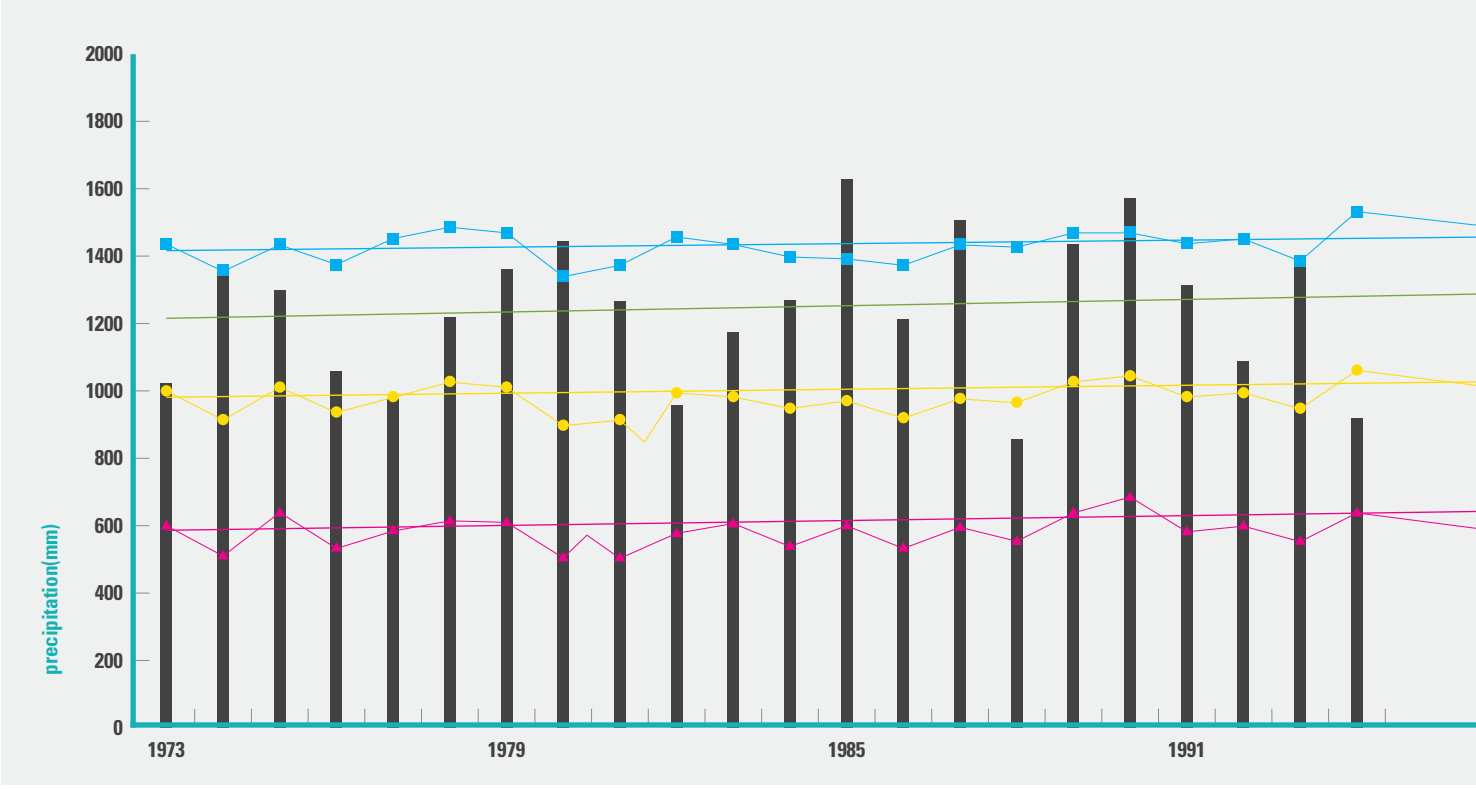
Program Classification	2015 Budget (A)	2016 Budget (B)	Up(△)Down (B-A)	Up(△)Down(%) (B-A/A)
Total	385,689	402,086	16,397	4.3%
1. Weather forecast	17,577	17,696	119	0.7%
2. Weather observation	80,810	75,815	△4,995	△6.2%
3. Climate change sciences	26,683	26,090	△593	△2.2%
4. Weather service promotion	13,652	15,738	2,086	15.3%
5. Meteorological research	121,974	133,895	11,921	9.8%
6. Performance-based agency operations	13,334	13,407	73	0.5%
7. International Cooperation, Education and Training, and Public Relations	7,993	8,749	756	9.5%
8. Administrative support	103,666	110,696	7,030	6.8%

2016 Weather patterns over Korea

The annual mean temperature in 2016 was 13.6℃ with the mean maximum and minimum temperatures showing 18.9℃ and 9.0℃, respectively. Those figures were higher by 1.1℃, 0.8℃, and 1.3℃ than those in the normal year. The annual and the mean minimum temperatures had ranked the highest figures since 1973, while the mean maximum temperature had ranked the third highest. The annual mean precipitation was 1272.5 mm which accounted for 97.4% compared to the normal, while the number of days with precipitation was 109.4 days, showing 5.9 days more than the normal value.

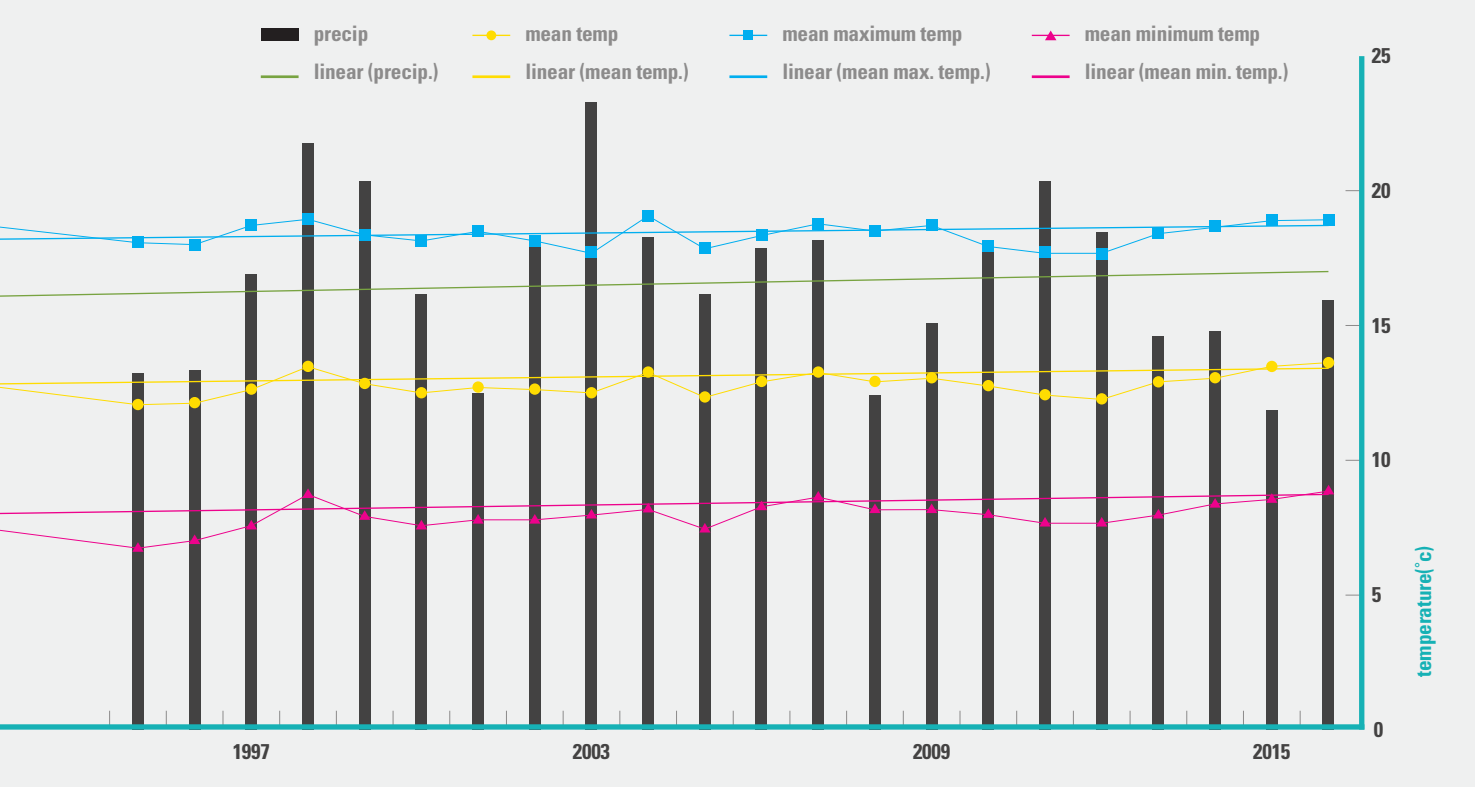
In case of the city of Seoul, the annual mean, mean maximum, and mean minimum temperatures were 13.6℃, 18.5℃, and 9.4℃, respectively, which were higher by 1.1℃, 1.5℃, and 0.8℃ than the average. The annual mean and mean maximum temperature of the city was the second highest figure since 1908 with the fifth highest record for the annual mean minimum temperature. The amount of annual precipitation was 991.7mm (68.4% of average), while the number of days with precipitation was 109, showing 0.1 less day compared to the normal.

Mean temperature, mean maximum temperature, mean minimum temperature, and mean precipitation (1973-2016)



The Jangma (Korean monsoon system) period of 2016 lasted for 37 days in the middle part of the country (24 June~30 July, longer than the normal), 29 days in southern area (18 June~16 July, shorter than the normal), and 29 days in Jeju (18 June~16 July, shorter than the normal). The precipitation during the period showed 398.2 mm, 347.4 mm and 283.8 mm in the middle, southern and Jeju, respectively. The average precipitation across the country during the Jangma season for the last 30 years (1981~2010) showed 356.1 mm with the number of days with precipitation of 17.1, whereas that of 2016 showed 332.1 mm with the 16.1 days.

When considering the long-term trend, it can be said that the annual mean temperatures of Seoul and the country as a whole have consistently increased. In particular, the annual mean minimum temperatures show relatively higher rise than the annual mean maximum temperature changes. The annual mean minimum temperature of Seoul during 2000s showed 9.1℃, warmer by 3.1℃ than that of 1920s.



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