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# 2018
# ANNUAL REPORT

KOREA METEOROLOGICAL ADMINISTRATION

Korea Meteorological Administration

2018

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KOREA METEOROLOGICAL ADMINISTRATION

# Contents

# Message from the KMA Administrator

## Watching the Sky Friendly,

## Serving the People Faithfully

It is a great pleasure to publish the 2018 Annual Report of the Korea Meteorological Administration (KMA), which reviews the KMA's achievements and performance from 2018.

From the meteorological perspective, the year of 2018 was full of a variety of dramatic and unprecedented events. First of all, climate change made it the hottest year on record in Korea. The mean temperature nationwide in August 2018 hit a record high of 27.3 degrees Celsius, which was 2.2 degrees Celsius above normal. Both the number of heat wave days and tropical nights in summer were the highest on record, at 31.4 days and 17.7 days, respectively, three times the normal of 9.8 days and 5.1 days. As the temperature of the Earth is expected to continue rising due to climate change, we are more likely to experience a scorching summer heat wave like that of 2018 more often. The KMA will always keep in mind the summer of 2018, and strive to minimize the impacts of heat waves by providing accurate forecasts and customized weather information for users.

Another extreme weather event in 2018 was climate change-induced heavy rain. The northern part of the Seoul metropolitan area received accumulated rainfall of 524 mm in August. Dobong district in Seoul and Jangbong Island in Incheon had rainfall of 496.5 mm and 485 mm, respectively. In particular, a narrow, 10 km-band of heavy rain affected Seoul and the northern part of Gyeonggi province. As each region across the country showed a big difference in the intensity and amount of rainfall, it made it difficult for the KMA to produce accurate forecasts.

In addition, the Korean peninsula was hit by Typhoon Soulik in August 2018, one of the strongest typhoon to ever hit Korea. This typhoon has become the most memorable typhoon to the KMA. It brought winds of up to 62 m/s in Jeju, the highest wind speed recorded since modern meteorological records began. It was also accompanied by heavy rainfall of 1,113 mm in Sajebi Hill at Halla Mountain in Jeju, and over 300 mm of rainfall in many parts of Jeju and South Jeolla province.

These events reminded the KMA of the significance of very short-range forecasting and close communication with related agencies and the public. One of the main duties of the KMA is to deliver information on rapidly-changing weather conditions to emergency management officers as well as the general public in prompt manner. To effectively carry out this duty, the KMA is using upgraded weather radars to enhance its forecasting and prediction technology, as well as improving the display of real-time weather information on its website, with a view to having a better communication with the public. Our endeavors do not stop here. Going forward, we will spare no effort to issue accurate and prompt very short-range forecasting, as well as medium and long-term perspective.

Furthermore, the KMA successfully launched its geostationary weather satellite, the GEO-KOMPSAT 2A (GK2A, Cheollian 2A), on December 5, 2018 at 5:37 a.m. The GEO-KOMPSAT 1 (COMS1, Cheollian 1), satellite launched in 2010 made Korea the 7th country to own an independent satellite. With the GK2A, Korea has become one of three countries worldwide to have a next-generation weather satellite. Having entered official services from July 2019, the GK2A uses the world's best meteorological payload system to deliver high-resolution color images every two minutes, with a resolution four times higher than the previous satellite. The new satellite is expected to greatly contribute to improving the KMA's forecasting capability, by increasing the accuracy of meteorological analysis and tracing the path of typhoons more accurately.

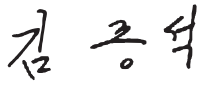
In 2018, the KMA started to fully tap into a meteorological research aircraft in November 2017 to carry out artificial rainfall experiments and preliminary observation of severe weather, as well as monitoring greenhouse gases. Going beyond observation and forecasting of weather conditions, the artificial rainfall technology will especially be a first step toward weather modification, which modifies weather to improve the lives of people, such as by securing water resources. The importance of weather modification technology will continue to increase to the future weather industry. The KMA will continue to focus on researching and investing in technology to become a leading agency in the field of weather modification.

Lastly, as a WMO member since 1956, the KMA has promoted close cooperation and exchange through real-time data sharing and communication among WMO members, with the goal of contributing to the advancement of meteorological science and technology. With a globally growing interest in meteorological research and technology, the KMA will exert the utmost to fulfill its duty as one of the leading countries in meteorological service and technology.

I hope that agencies and people around the world find this report useful. I take this opportunity to thank all our employees for their dedicated work on the publication of this report.

Thank you.

**Administrator**
**Korea Meteorological Administration**
**KIM Jongseok**



# Vision & Goals

**Become a leader in preparing for the future and ensuring public safety**

**Mission**

Offer prompt, accurate, and valuable weather services

**Vision**

Provide reliable weather information that meets the public's needs

**Goals**

- Increase speed and accuracy of weather forecasts
- Expand the application of weather & climate information to create added value
- Secure cutting-edge meteorological technologies and experts

**Strategies**

Advance weather forecasting technologies and observing infrastructure

Expand public safety and well-being oriented services

Add values of using climate and weather information

Enhance both internal and external roles to deal with climate change

Build a foundation for future-oriented weather services

# Overview of 2018

- 2018 NEWS Highlights
- 2018 Weather Patterns over Korea

# NEWS 1 GK2A, the World's Third Next-Generation Geostationary Meteorological Satellite, Launched Successfully

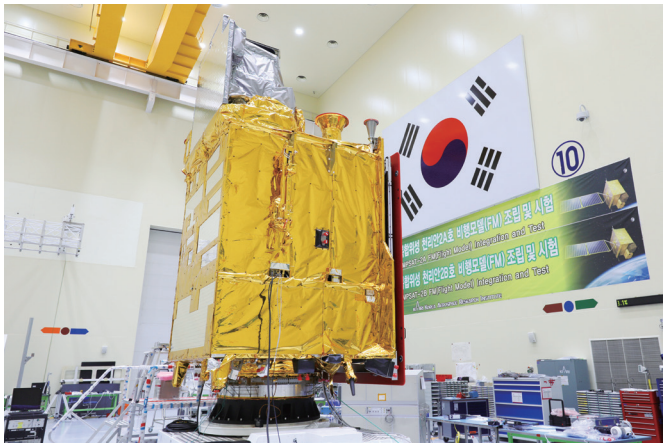
Korea's Cheollian 2A, a next-generation geostationary meteorological satellite, also known as GEO-KOMPSAT 2A or GK2A, was successfully launched from the Guiana Space Centre in French Guiana on December 5, 2018 at 5:37 a.m. KST. The GK2A was started to be developed since 2012 as a follow-up satellite to Korea's first geostationary satellite Cheollian 1, also called the Communication, Ocean and Meteorological Satellite (COMS). On December 21, the new multipurpose satellite was successfully stationed at an altitude of 36,000 km above the Earth's equator and at a longitude of 128.2°E.

The GK2A is the world's third next-generation geostationary satellite equipped with an Advanced Meteorological Imager (AMI), after the ones launched by Japan and America. Compared with its predecessor the COMS, it can provide images with much higher temporal and spatial resolution, especially true-color images. With the Korean Space wEather Monitor (KSEM), it can also observe space weather hazard phenomena.

The GK2A carried out an In-Orbit Test (IOT) to verify the performance and quality of its data. After the IOT, it started to provide images from July 2019. The GK2A's shorter observation cycle and more types of data are expected to greatly contribute to early detection of severe weather and climate change monitoring.

**» Comparison between COMS and GK2A**

| Features | COMS | GK2A |
|---|---|---|
| Components | Meteorological Imager, Geostationary Ocean Color Imager, Ka-band Communication Payload | Advanced Meteorological Imager, Korean Space wEather Monitor |
| Number of Channels | 5 _ Vis (1) / IR (4) | 16 _ Vis (4) / IR (12) |
| Spatial Resolution (km) | Vis (1 km) / IR (4 km) | Vis (0.5km, 1km) / IR (2 km) |
| Observation Cycle | Full Disk (3 hr), Korean peninsula (15 min) | Full Disk (10 min), Korean peninsula (2 min) |
| Number of Products | 16 (meteorological conditions) | 52 (meteorological conditions), 8 (space weather) |



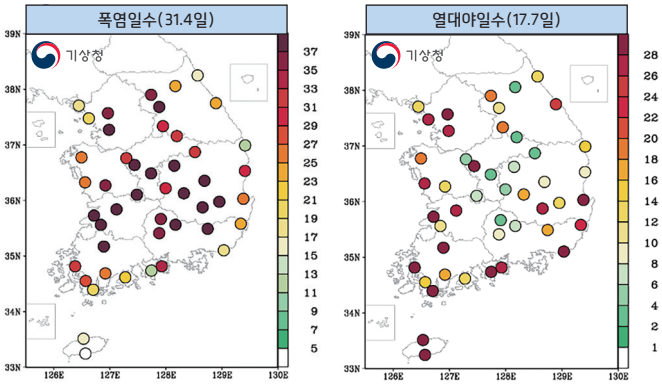
Before the launch of GK2A on Sept. 6, 2018

Launch of GK2A on Dec. 5, 2018

# NEWS 2 Record-Breaking Heat Wave in Korea

The average temperature nationwide in summer 2018 was recorded at 25.4 degrees Celsius, the highest ever since records began in 1973, due to a stronger-than-normal North Pacific High and Tibetan High. Many cities across the country saw the record-breaking maximum temperatures: 39.6°C for Seoul, 41.0°C for Hongcheon and 38.9°C for Jeonju. The country also witnessed the highest number of heat wave days (daily maximum temperature is at 33°C or higher) and tropical nights (overnight lows are at 25°C or higher) since 1973, at 31.4 and 17.7 days, respectively.

According to an analysis of the severe heat wave in 2018, the Korean peninsula was heated up by hot and humid air, as well as strong radiation under the clear sky conditions, when the strongly developed Tibetan High in the upper atmosphere and the North Pacific High in the mid-and low atmosphere expanded to the Korean peninsula. Many countries around the world also suffered from the record-setting heat waves. The Northern European countries experienced the warmest temperatures, which were 10°C higher than the previous years. The world's highest nighttime low temperature was recorded in Oman at 42.6°C, and an Algerian city within the Sahara desert reached the highest temperature in Africa at 51.3°C.




Nationwide map of the number of heat wave days and tropical nights in summer (Jun. to Aug.)

» Top 5 the number of heat wave days and tropical nights in summer (Jun. to Aug.)

| Rank | Year | Heat wave days | Year | Tropical nights |
|---|---|---|---|---|
| 1 | 2018 | 31.4 | 2018 | 17.7 |
| 2 | 1994 | 29.7 | 1994 | 17.4 |
| 3 | 2016 | 22.4 | 2013 | 15.8 |
| 4 | 2013 | 18.2 | 2010 | 12.0 |
| 5 | 1990 | 17.0 | 2017 | 10.8 |

# NEWS 3 Successful Weather Support for the Pyeongchang 2018 Winter Olympic Games

Given that most Winter Olympic competitions are held at outdoor mountain venues, it would not be an exaggeration to say that the key to success of the Winter Olympic Games is dependent on prompt accurate weather forecasting and responses. Thus, the Korea Meteorological Administration (KMA) started its preparations for the 2018 Winter Olympic weather support services as soon as Pyeongchang was announced as the host city of the 2018 Winter Olympic Games in July 2011. The KMA prepared its weather support services for the Games for seven years.

The KMA first installed meteorological equipment specialized in mountain weather observation to secure observation data in advance, as well as selecting and training weather forecasters dedicated to the Winter Olympic Games. In addition, it established Specialized Forecasting System and Smart Weather Support System to allow the Olympic staff and the public to easily access real-time weather information for Olympic competitions. During the Games, the KMA provided customized weather information for 16 venues, as well as dispatching its Weather Support Team consisted of professional KMA staff in weather services (36 for the Olympics, 20 for the Paralympics), to the Olympic sites to offer venue-specific weather forecasts. Furthermore, while all foreign media outlets expected a severe cold weather during the opening and closing ceremony, the KMA forecasted there would not be severe cold and heavy snow. The KMA not only perfectly carried out its duties for the Olympic weather support services, but also surprised the world with its accurate forecasts.

With the successful weather support services, the KMA received a lot of compliments from foreign and domestic Games organizers and related staff, as well as media. Jerry Ling, Director of Sport Services for PyeongChang Winter Olympics, sent the KMA a letter commending the KMA for its great service. Joseph Fitzgerald, FIS freestyle coordinator, showed his strong confidence and great respect for the KMA's forecasting by calling the weather forecasters weather masters.

The KMA gained valuable experience and asset through providing weather support services, such as professional Olympic forecasters and confidence in its weather forecasting. Based on this experience, it is now cooperating with the Chinese Meteorological Administration to give its know-how for the Winter Olympic weather services for the Beijing 2022 Winter Olympics. Additionally, the KMA published the *2018 PyeongChang Winter Olympics & Paralympics Weather Support White Paper* to make its experience and knowledge more widely used for other international sports events in the future.


PyeongChang Winter Olympic Weather Support Team


Smart Weather Supporting System

# NEWS 4 Atmospheric Research Aircraft, Successfully Performed Duties During Its First Year

The Korea Meteorological Administration introduced Korea's first atmospheric research aircraft in November 2017, with an aim of providing multi-dimensional data on the upper atmosphere of observational gaps to improve cutting-edge observation and experimental technology. In line with these aims, the aircraft is carrying out its duties, such as preceding observation of severe weather, greenhouse gas monitoring, environmental meteorological monitoring, and cloud physics observation and weather modification experiment. Since its official operation from November 2018, the aircraft has been used 106 times for 352 hours during the year, slightly exceeding the target (350 hours).

One of the most representative examples of using the research aircraft was observing meteorological conditions over the East Sea during the 2018 PyeongChang Winter Olympic Games, to help respond to severe weather in eastern Gangwon province. During the Games, 200 data sets from the aircraft were sent to forecasters for numerical weather prediction. In addition, the aircraft was used for the International Collaborative Experiments for Pyeongchang 2018 Olympic and Paralympic inter games (ICE-POP 2018) organized by the World Meteorological Organization, to provide observation data of the upper air. Furthermore, when strong typhoons, namely Prapiroon, Yagi, Soulik and Kong-rey, hit the Korean peninsula in 2018, it conducted observation of sea winds and atmospheric conditions to provide forecasters with observations.

It also participated in the 2018 National Radiological Emergency Exercise, organized by the Nuclear Safety and Security Commission and joined by the KMA, Ministry of National Defense, Korean National Police Agency and Busan Metropolitan Government, in order to observe aerial radiation in the environment. The observations were used and displayed by the System for Identifying Radiation in Environments Nationwide (SIREN), in collaboration with related domestic agencies, increasing the usability of the atmospheric research aircraft and its data.


The atmospheric research aircraft

The aircraft observing meteorological conditions

# NEWS 5 48th Session of the IPCC Held in Incheon, Korea

The 48th meeting of the Intergovernmental Panel on Climate Change (IPCC), which was convened in Incheon, Korea from October 1 to 6, adopted the Summary for Policymakers (SPM) of the Special Report on Global Warming of 1.5°C to provide scientific basis to the 2015 Paris Agreement, a new global pact to address climate change by countries around the world. At the meeting, 570 representatives from over 130 countries reviewed and agreed line by line to a 30-page SPM, the first part of the Special Report. The report shows the impacts of global warming of 1.5°C above pre-industrial levels and ways to limit warming to below 1.5°C by 2100.

The meeting was initially schedule to end on October 5. However, disagreement over a number of sentences among delegates from participating governments made them ended up working through the night for line-by-line approval. In the end, the entire meeting was over on October 6 at 4 p.m. When a chair struck the gavel to announce the adoption of the report, all the Co-Chairs of the IPCC Working Groups and government delegates celebrated the adoption by cheering and giving a standing ovation.

With the press conference on October 8, the adoption of the Special Report on Global Warming of 1.5°C was reported around the world. This news was reported by many Korean media outlets, serving as a good opportunity to raise the public's awareness of the gravity of global warming issue. Holding the meeting in Korea was also a chance to draw attention from the international community to Korea's willingness and interest in climate change response.


Opening ceremony on Oct. 1

Delegates at the 48th Session of the IPCC on Oct. 1


Korean delegation on Oct. 6


Working Group Co-Chairs celebrating the adoption of SPM on Oct. 6

# NEWS 6 Seoul Hit by Heaviest First Snowfall of 8.8 cm

Seoul saw a record 8.8 cm of first snow of the season on November 24, 2018, the heaviest level for the first snowfall in history since the Korea Meteorological Administration began recording snowfall in 1907. The surface temperature was 2 to 4 degree Celsius on November 23 at 4:10 a.m. It started to sleet at first, and then it turned into snow at 6:00 a.m., recording 2 to 11 cm of snowfall in most of the Seoul metropolitan area. The snow stopped one to two hours after clouds quickly moved northeast at 60 km/h.

According to an analysis by the KMA, a band of rain developed by a trough of low pressure over the West Sea was further developed as it was passing through the Gyeonggi Bay area. With a surface temperature of 0.3 degree Celsius for three hours, the band of rain turned into snow in a short period of time. The KMA issued a heavy snow warning for Incheon and the northwestern part of Gyeonggi province, and expanded the warning to most parts of the metropolitan area.

Analysis of the first snowfall days since 1907 showed that the first snow mostly fell as sleet. When the first snow fell, it mostly melted into rain and did not accumulated on the ground. However, as the temperature on the ground was around zero degrees Celsius, it could have fallen as either rain or snow, depending on a slight change in the temperature.

The unexpected heavy snow led to a number of traffic accidents and paralyzed the traffic for an hour in the central part of the country. Despite the sudden heavy snowfall, the KMA and local governments efficiently communicated in real time for the safety of the public. As the result of a joint effort, only 1.49 million KRW in property damage was reported with no casualties.

First snow in the Seoul weather station

» Top 5 Maximum Depth of Season's First Snow

| Year | Date of first snow | Depth (cm) |
|---|---|---|
| 2018 | November 24 | 8.8 |
| 1954 | December 13 | 6.6 |
| 1990 | December 1 | 4.5 |
| 1942 | November 8 | 4.3 |
| 2007 | November 19 | 1.5 |

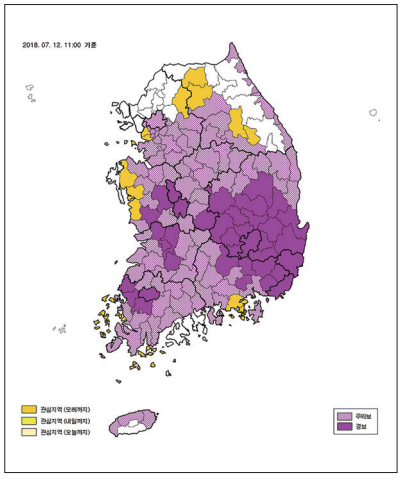
# NEWS 7 Trial Service of Impact-Based Heat Wave Forecasting Launched

The Korea Meteorological Administration issued impact-based heat wave forecasts as a trial service from June 1 to September 30, 2018 to effectively prevent worsening impacts of heat waves.

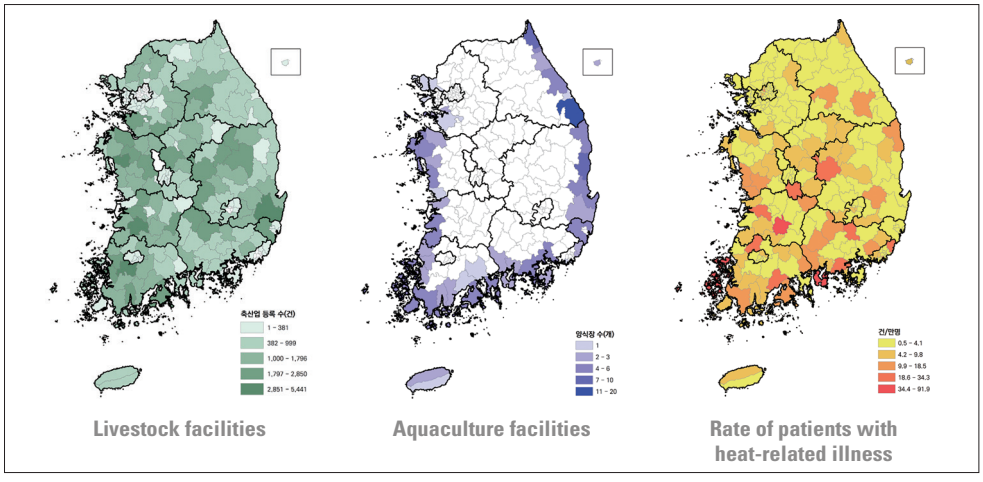
The existing heat wave forecasts were provided in the form of a heat wave advisory or warning. The new impact-based heat wave forecasts were, however, issued by region and sector, with four risk levels (Aware, Alert, Warning, Severe Warning) by considering the comprehensive impacts of heat wave. The impact-based heat wave forecasting focused on offering the public practical information to help them respond to heat waves more properly and effectively. The information included the impacts of heat wave and desirable actions to take depending on the risk level, as well as impacts on different sectors, including health, fisheries, agriculture, manufacturing, livestock, and energy, based on regional environmental characteristics and past heat wave damage.

Depending on the heat wave risk level, the impact-based heat wave forecasts were provided to related agencies and emergency management officers at local governments through special weather statements and warning bulletins as well as text messages. The general public were also able to access the forecasts and information both on the KMA mobile website (m.kma.go.kr) and on its weather forecasting website (www.weather.go.kr).

The trial service of impact-based heat wave forecasting held significance because it was the first of its kind in Korea, which was linked with operational weather forecasting, as well as being as a service developed to give actual assistance to emergency management agencies in their response to the impacts of heat wave and related disasters.



Status of nationwide heat wave




Heat wave risk map

# 2018 Weather Patterns over Korea

During the year 2018, while the temperature remained below zero at the beginning of the year due to strong cold weather, seasonal temperature variations were significant, with the temperature hitting daily highs due to a prolonged heat wave. The Jangma (Korean monsoon system) in 2018 was the second shortest since 1973, and two typhoons (Soulik, Kong-rey) landed on the Korean Peninsula consecutively.

The highest temperature between 23 January and 13 February was 0.6°C (deviation of -4.5°C), which was the lowest since 1973, as cold air in the upper atmosphere continued to flow into the peninsula from late January to early February. The national mean temperature between December 2017 and February 2018 was –0.8°C, which was lower than the 30 year-average (0.1 to 1.1°C). During this period, 631 patients suffered from cold-related illness (including 11 deaths) due to severe cold wave, recording the highest number of patients with the illness since 2011 when the monitoring system started to operate.

The mean temperature in spring was 8.1°C (normal of 5.5 to 6.3°C), the third highest since 1973. The spring season also had the third highest amount of precipitation, as warm and humid southerly wind frequently flowed into the country. However, the temperature changed significantly due to a significant drop in temperature temporarily affected by a continental anticyclone three to four times. The mean, highest and lowest temperatures in March hit a record high since 1973, and the precipitation was 110.7 mm (96.1%ile of the normal).

The Jangma ended early because the Tibetan high pressure has intensified compared to the normal, warming the upper atmosphere around the Korean Peninsula and significantly expanding the North Pacific high pressure to the northwest since late June. The Jangma season in 2018 (June 19–July 11) was the second shortest since 1973 and the national average precipitation was 283.0 mm, less than the normal precipitation of 356.1 mm.

After the Jangma, the mean temperature during the summer months (June to August) was recorded at 25.4°C (normal of 23.6°C), which was the highest since 1973, and the daily maximum and minimum temperatures were the second highest since 1973 because the Tibetan high pressure and North Pacific high pressure were unusually strongly developed. As heat waves swept through the country, the country saw 31.4 days of heat wave (normal of 9.8 days) and 17.7 days of tropical nights (normal of 5.1 days), a record-breaking number of heat wave days since 1973.

In particular, the daily maximum temperature reached 41.0°C in Hongcheon on August 1, which was the highest temperature since the KMA officially began recording observation data. The extreme highest temperature of 39.6°C was recorded in Seoul in 111 years since October 1, 1907. The excessive heat around the Korean Peninsula resulted in 4,526 patients with heat-related illnesses, a record high number since 2011 when the monitoring system started operation. And the peak power demand recorded at 92,478W on July 24, the highest ever.

The mean temperature during the fall season (September to November) was 13.8°C, similar to that of the normal (14.1°C), but the temperature in October was lower than the normal temperature because cold air masses continued to move into the country as air pressure system was slowly moving between east and west and an upper air trough was located near the Korean Peninsula. The amount of precipitation was 351.2 mm, larger than the normal of 193.3-314.0 mm, as the rainfall in October was higher than that of the normal due to Typhoon Kong-rey.

In 2018, five typhoons affected Korea (normal of 3.1 typhoons) and two of them (Soulik, Kong-rey) landed in

Korea. Typhoon Soulik (August 22-24) landed near Mokpo via the western sea of Jeju Island and passed through North Chungcheong province and southern Gangwon province, causing 41.4 billion won in property damage due to flooding caused by torrential rain. In addition, the low sea temperature was maintained until August 30, as a typhoon stayed in the western sea of Jeju Island for more than 30 hours, bringing the temperature in the southwestern sea of Jeju down by up to 7°C. Typhoon Kong-rey (October 5-6) headed north near Jeju Island and landed in Tongyeong before passing near Pohang and moving off the peninsula towards the East Sea. As a result, the nationwide precipitation in October recorded the highest since 1973.

# KEY ACTIVITIES OF 2018

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

# Forecast

## Operations of Numerical Weather Prediction System

The NWP system of the Korea Meteorological Administration (KMA) consists of Global Data Assimilation and Prediction System (GDAPS), Ensemble Prediction System for Global (EPSG), Regional Data Assimilation and Prediction System (RDAPS), Local Data Assimilation and Prediction System (LDAPS), Limited area Ensemble prediction System (LENS), Korea Local Analysis and Prediction System (KLAPS), Very short range Data Assimilation and Prediction System (VDAPS), and several application systems such as for marine meteorology, Asian Dust, and statistics.

The KMA uses the Unified Model (UM) as its operational model since it adopted the model from the UK Met Office in 2010, and updates it to the latest version once or more every year.

There were improvements in five main areas of the model during 2018: (1) global model—improvement in resolution (17km→10km), application of 10km resolution global model and updating to the latest version (UM10.2→UM10.8); (2) global data assimilation—version improvement and introduction of the latest background error covariance; (3) local data assimilation—addition of satellite data from GNSS and AMSUB; (4) local model—predictions from expanded areas in East Asia including fixed and variable grids; (5) local ensemble model—increase in resolution (3km→2.2km) and application of a physical process in the mid-latitudes.

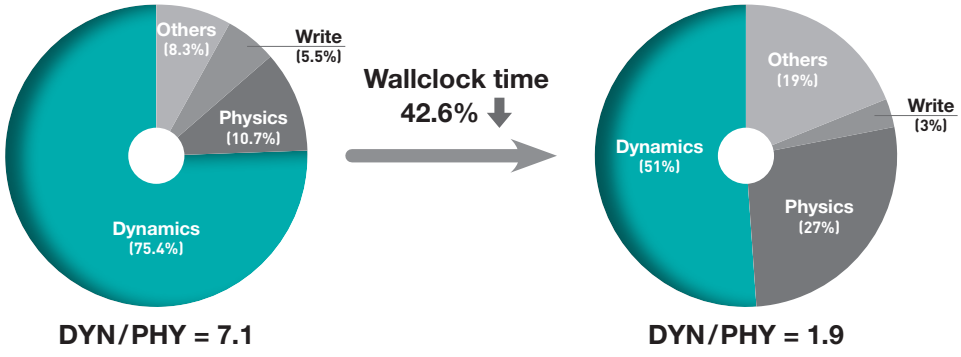
## Status of Korean Numerical Weather Prediction (NWP) Model Development

The year of 2018 was the second year of the third stage of Korean NWP model development, focusing on the development and improvement of testing prediction system for better computational efficiency, predictive performance and stability optimization.

The testing prediction system was updated to version 3.1 in February 2018 and to version 3.2 in July, producing near real-time forecasts. In particular, a high-resolution parallel prediction system was established and started to be operated this year. To this end, the model was stabilized and upgraded. The status of a Korean NWP model is shown in Table below.

In the field of dynamic core development, a new calculation grid system was

introduced and the lower-order basis functions were improved to increase the efficiency of the calculation. The result was a 42.6% reduction in calculation time compared to the previous one, and the ratio of dynamic core to physical process calculation was reduced from about 7.1 times to about 1.9 times. As part of the upgrading of high-resolution dynamic core, the semi-Lagrangian advection method was applied to reduce noise for the accuracy improvement. The improvement in statistical performance was confirmed by using an adaptive viscosity coefficient depending on the balance of the governing equation.




Changes in Wall Clock Time by Key Components of Korean NWP model

**» Forecasting System of Korean NWP Model**

| Type | Forecasting System |
|---|---|
| Horizontal Resolution | Approx. 12km |
| No. of Grids | 3,110,402 in horizontal direction |
| Vertical Resolution/Top layer | 91 layers / 0.01hPa, Approx. 80 km |
| Time Step | 20 secs |
| Data Assimilation | Hybrid-4DEnVar |
| Cycle/DA window/cutoff | 6-hour cycle 6 hours (±3 hours) DA window Cutoff time: 2 hours 40 minutes (00, 12 UTC early observation) |
| Observation data | Surface (Synop, METAR, Ship, Buoy), Sonde (TEMP, PILOT, Windprofiler, Drop-Sonde), Aircraft (AMDAR, AIREP), GPS-RO, AMSU-A, MHS, ATMS, IASI, CrIS, AMV, ScatWind, TCBogus, SSMIS, Saphir |

### » Operations of NWP System at KMA (As of December 2018)

| | | Horizontal Resolution (Vertical Layers) | No. of Operations / Day | Duration of Prediction | Objective |
|---|---|---|---|---|---|
| Global (GDPS) | Global Forecasting System (UM N1280 L70) | 10km (70) | 4 times | 12 days, 87 hours | Global weather prediction, Digital forecast, Weekly forecast |
| Regional (RDPS) | Regional Forecasting System (UM 12km L70) | 12km (70) | 4 times | 87 hours | Weather forecast for Asia Digital forecast |
| Local (LDPS) | Local forecasting System (UM 1.5km L70) | 1.5km (70) | 4 times | 36 hours | Weather forecast for the Korean Peninsula |
| Wave | Global Wave Model (GWW3) | Approx. 55km | 2 times | 12 days | Target: global wave<br>Application: digital and mid-range ocean forecast |
| | Regional Wave Model (RWW3) | Approx. 8km | 2 times | 87 hours | Target: wave in East Asia<br>Application: digital ocean forecast |
| | Local Coastal Wave Model (CWW3) | Approx. 1km | 2 times | 72 hours | Target: Daejeon, Gwangju, Busan, Gangwon, and Jeju Regional Office of Meteorology<br>Application: Digital and local coastal ocean forecast |
| | Ensemble Regional Wave Model (EWW3) | Approx. 8km | 2 times | 87 hours | Target: Wave in Asia<br>Application: digital ocean forecast |
| Storm Surge | Regional Storm Surge Model (RTSM) | Approx. 8km | 2 times | 87 hours | Application: storm surge in East Asia |
| | Local Coastal Storm Surge Model (CTSM) | Approx. 1km | 2 times | 72 hours | Target: Daejeon, Gwangju, Busan, Gangwon, and Jeju Regional Office of Meteorology<br>Application: local coastal storm surge |
| Asian Dust / Haze | Asian Dust Aerosol Model (ADAM2) | 25km (47) | 4 times | 72 hours | Application: prediction of Asian Dust |
| | Asian Dust and Haze Model (ADAM3) | 25km (49) | 4 times | 72 hours | Application: haze prediction |
| Ensemble (EPSG) | Global Ensemble Prediction System (EPSG UM N400 L70 M49) | 32km (70) | 2 times | 12 days | Target: global weather prediction<br>Application: weekly forecast |
| Local Area (LENS) | Limited Area Ensemble Prediction System (LENS UM 2.2km L70 M13) | 2.2km (70) | 2 times | 72 hours | Target: weather forecast for the Korean Peninsula<br>Application: severe weather prediction |
| Very Short-range | Very Short-range Background Analysis (KL15) | 15km (22) | 8 times | - | Target: East Asia<br>Application: generation of background fields for very short-range model |
| | Very Short-range Background Prediction (KLBG) | 15km (40)<br>5km (40) | 4 times | 30 hours | |
| | Very Short-range Analysis (KL05) | 5km (22) | 24 times | - | Target: Korean Peninsula<br>Application: three-dimensional analysis / prediction |
| | Very Short-range Prediction (KLFS) | 5km (40) | 24 times | 12 hours | |
| | Very Short-range Prediction System (VDPS) (UM 1.5km L70) | 1.5km(70) | 24 times | 12 hours | Weather forecast for the Korean Peninsula |

# Observation

## Weather Observation Standardization

The KMA has been carrying out a project since 2007 to standardize weather observations across the country by improving the observing environment and avoiding duplicated installations of the same equipment, and thereby to increase the accuracy of the observation data as well as its collaborative applications. The KMA provides technical support and training and workshops for 27 public agencies conducting observations to help them install and operate observation facilities, as well as reinforcing the competence of their staff involved in observations. In addition, the KMA assists the agencies to diagnose their level of standardization and comply with related laws and regulations.

To secure and maintain the best suitable observing environment of the observation facilities, the KMA reduced the share of observing equipment installed on buildings' rooftops from 9.6% at the end of 2015 to 6.1% at the end of 2018.

Several meetings were held in 2018 to carry out observation standardization policies, such as Weather Observation Standardization Committee (twice) and Weather Observation Standardization Working Committee (twice).

The KMA also formed a Help Desk Team staffed with 26 members to support the interested agencies in standardizing their observations and improving the value of observation data for joint data use. In 2018, in particular, it provided technical support to improve the linkage between weather observation data, review the equipment installation environment and increase a data collection rate, resulting in the average collection rate reaching as high as 96.5% in 2018. Moreover, it had consultations with other observing agencies on evaluating observing environment and installation conditions before they install, replace or transfer observing equipment, in order to avoid duplication in equipment installation and support them in creating the optimized environment.

## Operations of COMS and Data Service

Since April 1, 2011 the National Meteorological Satellite Center (NMSC) has provided satellite images and a variety of analysis images through real-time broadcasting service for Asia and the Pacific, and real-time data service through landline networks for related agencies such as military, broadcasters, and disaster prevention institutions. The NMSC offers these data through various routes including website, web system of the intranet, and WMO's Data Collection or Production Centres (DCPC). It exerts its efforts to improve the quality of the service by conducting and assessing statistical results of the service and a satisfaction survey every year.

**» Current Satellite Data Service by COMS**

| Route | | Service |
|---|---|---|
| 1 | Satellite Broadcasting by COMS (xRIT) | 21 receivers (Domestic: 16, Overseas: 5)<br>- Overseas: weather services of Sri Lanka, Philippines (2), Laos, space technology agency of Thailand<br>- Domestic: Air Force, Navy, National Institute of Fisheries Science, National Science Museum, Seoul Emergency Operations Center, National Disaster Management Research Institute, and related governmental agencies |
| 2 | Website (http://nmsc.kma.go.kr) | No. of subscribers: 655 in total (Internet: 432, Intranet: 223)<br>Amount of request and download data in 2018: 14,457 times, 1,642GB |
| 3 | Partner agencies (Real-time FTP provided) | Domestic: 19 agencies (via ICT division of the KMA)<br>- Air Force, Army, Navy, Ministry of Public Safety and Security, National Institute of Environmental Research, broadcasters (KBS, MBC, SBS), etc.<br>Overseas: 3 institution<br>- Hong Kong Observatory, University of Wisconsin, and University of Colorado |
| 4 | Off-line | Amount of document: 38 times<br>Amount of data provided: Approx. 97.8 TB<br>- Requested by academia, research institutes, industries, etc. |

## Successful launch of Geo-KOMPSAT-2A

The Geo-KOMPSAT-2A was successfully launched on December 5, 2018 in Guiana Space Center, which will succeed the COMS (Communication, Ocean and Meteorological Satellite) meteorological mission. The Geo-KOMPSAT-2A has much better capabilities in terms of observation performance with AMI(Advanced Meteorological Imager). The number of channels of AMI will be increased from 5 to 16 and the number of meteorological products from 16 to 52, respectively. Its ability of full disk scanning of every 10 minutes will enhance the disaster monitoring over the Asia-Pacific region.

The Geo-KOMPSAT-2A also has space weather sensors, KSEM (Korea Space wEather Monitor) which includes particle detectors, magnetometer, charging monitor. The official operation and data service of Geo-KOMPSAT-2A will be started in July 2019.

# Climate

## Integrated Climate Change Monitoring Information

The World Meteorological Organization is going ahead with the establishment of integrated information system on factors resulting in climate change while setting up a new Global Atmosphere Watch (GAW) Implementation Plan (2016-2023). Domestically, the need for more comprehensive climate change monitoring of the Korean Peninsula and the globe was raised for better understanding of climate change at the national level.

To shift gears from global atmosphere watch to an integrated climate change monitoring system, the KMA established Integrated Climate Change Monitoring Information Service Plan (2017-2021) for monitoring the causes, results and impacts of climate change, and developed a service roadmap based on the trends of climate change monitoring at home and abroad and the status of related service in different countries.

Since 2018 the KMA's climate information portal site (http://www.climate.go.kr) started providing information about 15 variables by adding seven new variables: nitrous oxide, chloro fluoro carbons, sulfur hexafluoride, surface radiation balance, ultraviolet rays, wind direction and wind speed, and sea surface temperature. The portal site also offers climatological significance and long-term impacts of each variable on the peninsula and related data analysis. Furthermore, the website gives users guidance on how to take advantage of the information to improve users' understanding and access to the provided contents.

## Meteorological Drought Forecasting Service

Droughts are categorized as meteorological drought which occurs due to lack of rainfall in certain areas; agricultural drought which affects crop production; and drought for living and industrial water where water from dams or reservoirs becomes scarce.

Although droughts originate mostly from meteorological droughts, it is very difficult to monitor and predict droughts based on a single data source because different types of droughts could occur sporadically depending on local characteristics and climatic conditions in a region. Therefore, the KMA produces various meteorological drought indices to monitor droughts, as well as providing them for drought related governmental agencies and the general public through KMA's website and the Hydrometeorological Drought Information System (http://hydro.kma.go.kr).

In 2018, a legal basis for meteorological drought forecast for the general public was provided to proactively and systematically respond to regional drought disasters. From April, meteorological drought forecasting service has started as a pilot service for related agencies and local governments responsible for water management. In November the upgraded meteorological drought forecasting service was launched for the general public.

## Extension of Weather Drought Analysis Information

Since there are different types of droughts, the KMA provides various meteorological drought analysis information along with meteorological drought forecast. It also implemented a detailed drought analysis system that can identify precipitation characteristics in case of drought, by utilizing real-time precipitation observation data by periods and regions, to produce various types of drought information. The information includes the required amount of precipitation to relieve drought conditions, the number of drought days, GIS map-based drought information by administrative district and basin, drought index time series, precipitation information, and water storage rate of reservoirs and dams, and others.

# Meteorological Industry

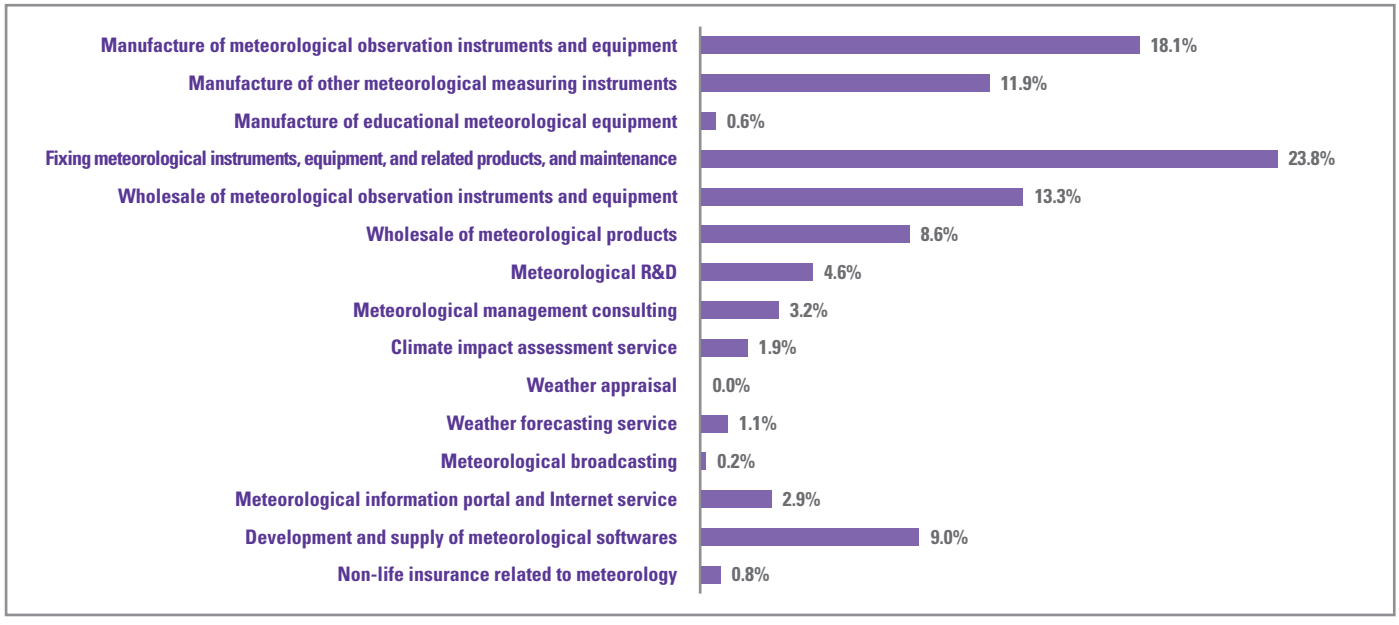
## Meteorological Industry in Korea

The Korea Meteorological Administration focuses on discovering and promoting cases of using meteorological information in an effective and efficient manner to mitigate weather and climate risks and create economic values. It also provides supports for the opening and growth of meteorological businesses providing various services with meteorological information, to increase the market and demand of meteorological services and enhance the capability of service suppliers.

With the advent of the fourth industrial revolution era, IoT (Internet of Things) sensor-based high-resolution weather observation system, artificial neural network or AI-based forecasting technologies have developed. And discussions over developing weather service fused with these new technologies are actively underway.

## Number of Meteorological Businesses

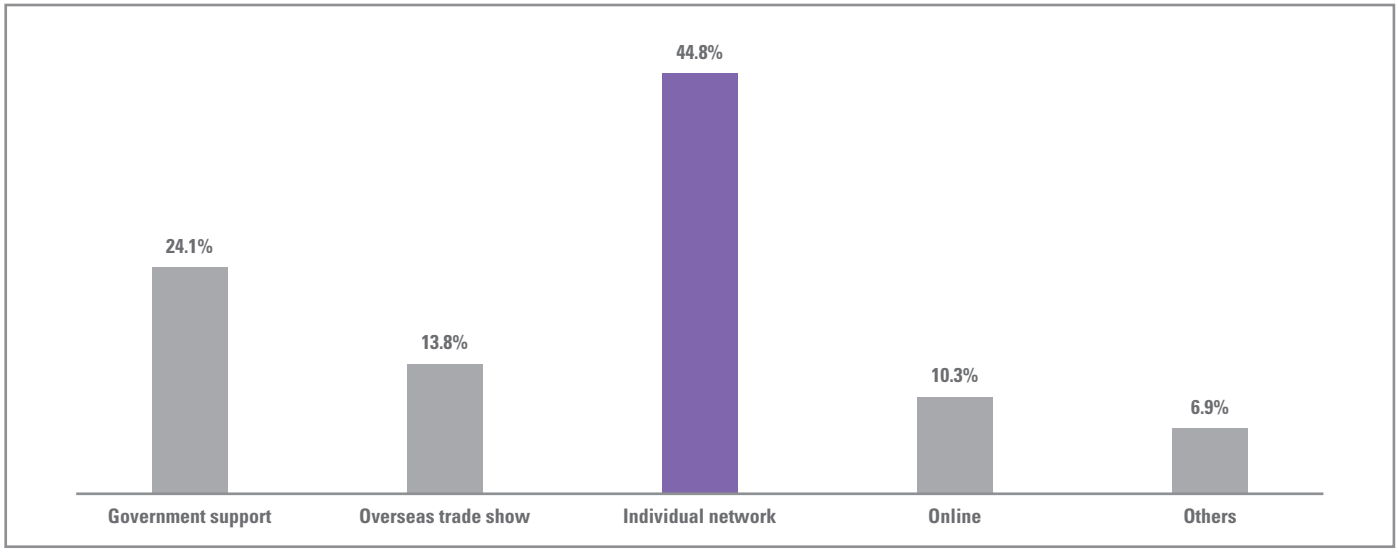
A survey showed that there are 630 meteorological enterprises across the country (as of December 2017), which fall into the definition and category (15 subcategories) of meteorological industry. One of the most representative types of business were fixing meteorological instruments, equipment and related products, and maintenance (23.8%), followed by manufacturing meteorological observation instruments and equipment (18.1%) and wholesale of meteorological observation instruments and equipment (13.3%).




Breakdown of Meteorological Industry in Korea (2017)

## Import and Export in the Korean Meteorological Industry

The total values of imports and exports in the meteorological industry recorded at KRW 30.513 billion won and 10.89 billion won, respectively. Breaking down by business type, wholesale of meteorological products represented the largest share in terms of export, followed by manufacturing other meteorological measuring instruments. On the other hand, wholesale of meteorological observation instruments and equipment accounted for the biggest share in terms of import, followed by whole sale of meteorological products. The main channels for export was individual network (44.8%), governmental support (24.1%), and overseas trade show (13.7%).




**Breakadown of Export Channels in the Meteorological Industry (2017)**

## Weather Industry Promotion Act

Even though demands for meteorological information from different industrial sectors have been growing and getting more specific, the size of the meteorological industry and market was smaller as compared to other industries. To invigorate the industry and market, the KMA enacted Weather Industry Promotion Act in 2009 which contains the provisions to support and foster the industry to lay a foundation for the growth of the weather industry in Korea and enhance its competitiveness.

## New Steps to Promote Meteorological Appraisal Market

The KMA gave a definition of weather appraisal business in 2009, and adopted a license test for weather appraisers in 2012 to foster qualified professional weather appraisers. Also, it inserted a new provision in the Enforcement Decree of the Weather Industry Promotion Act with regard to the range of weather appraisal business in 2016, and then it enacted a Public Notice on Weather Appraisal Business Procedures in 2017.

In addition, as part of follow-up measures, the KMA developed a standard manual for weather appraisal to offer standards and examples and facilitate the business.

## Technology transfer to Meteorological Businesses

The KMA has transferred its own meteorological technology to private weather enterprises to help strengthen their capability and technology. The transfer which began in 2005 includes software specialized in generating user-specific weather information, improvement reports, operational manual, etc.

Eighty eight types of meteorological technology were transferred to 51 meteorological businesses (423 times) from 2005 to 2018, contributing to the vitalization of the weather industry. In 2018, eight kinds of technology (16 times) were transferred to six businesses. Among them, newly transferred technologies in 2018 were eight: Real-time wind information production based on local forecasting model in Seoul metropolitan area; weather data quality inspection; measurement method of stereoscopic observation with fixed and rotating imaging devices; development technology of microwave radiometer for weather observation; technology for adding radiosonde supplementary sensor; methods for providing meteorological information on the flight path; application technology of weather services supporting the plum industry; frost prediction for crops in Jeju Island.

**» Transfer of meteorological technology to private weather businesses**

| Year | '05 | '06 | '07 | '08 | '09 | '10 | '11 | '12 | '13 | '14 | '15 | '16 | '17 | '18 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of cases | 12 | 48 | 7 | 4 | 4 | 11 | 24 | 24 | 45 | 51 | 99 | 59 | 19 | 16 | 423 |
| Number of types | 2 | 10 | 2 | 3 | 4 | 8 | 3 (6) | 3 (6) | 5 (10) | 6 (18) | 10 (22) | 15 (11) | 9 (2) | 8 | 88 |
| Number of businesses | 6 | 4 (6) | (4) | (3) | 1 (1) | 2 (1) | 4 (4) | 3 (4) | 7 (4) | 6 (8) | 6 (7) | 5 (8) | 1 (6) | 6 (2) | 51 |

* ( ): the number of overlapped technologies transferred in the past

# Earthquake

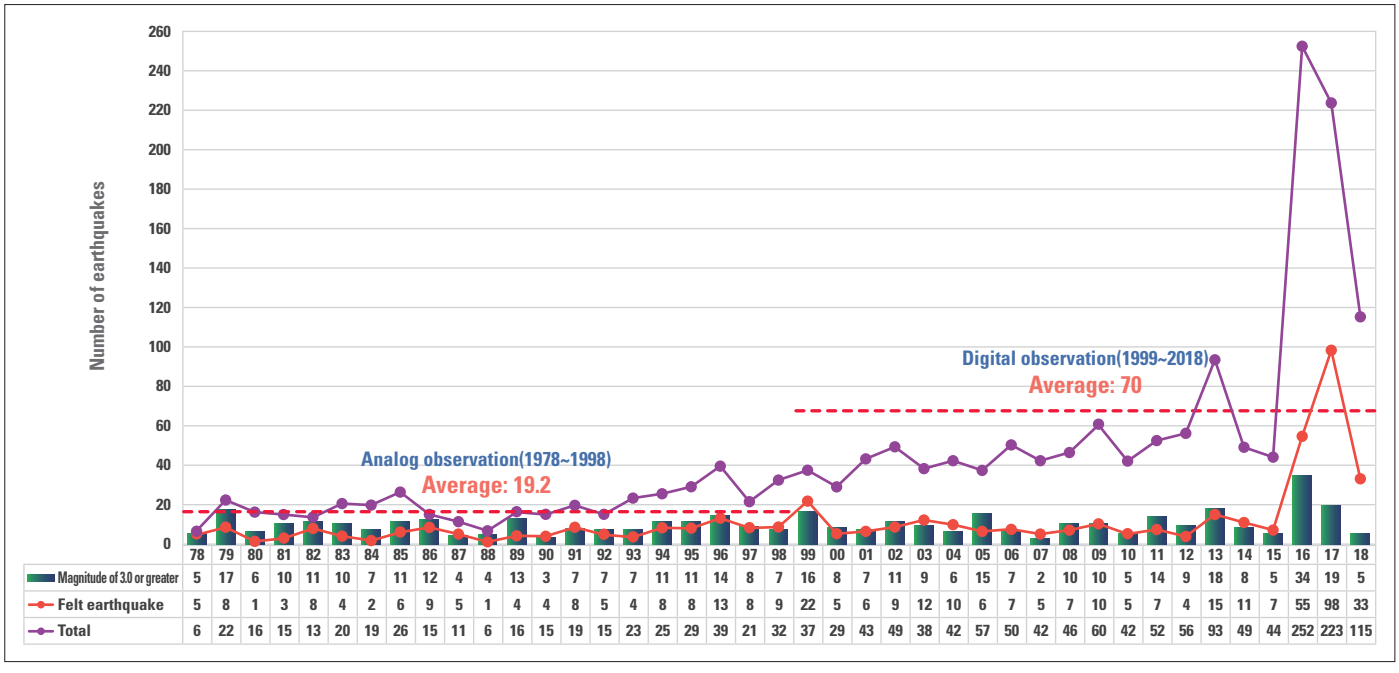
## Earthquakes in Korea

In 2018, a total of 115 earthquakes with the magnitude of 2.0 or greater were detected, showing less frequent than in 2016 (252) and 2017 (223), but greater than the annual average number of 67.6 between 1999 and 2017. This was the third largest number of earthquakes since Korea officially began recording seismic data.

On February 11, 2018, a magnitude 4.6 aftershock of the 2017 Pohang earthquake hit the city of Pohang. The epicenter of this earthquake was located 4.6 km southwest away from the mainshock and the depth was 14 kilometers. It was the largest earthquake in 2018. The maximum intensity of 4 was detected in Ulsan City and North Gyeongsang province, intensity 3 in Daegu City and South Gyeongsang province, and intensity 2 in Busan City and North Chungcheong and North Jeolla provinces.

Earthquakes with the magnitude of 3.0 or greater occurred five times in 2018, which was half of the annual average of 10 times, while felt earthquakes took place 33 times, the third highest number of earthquakes per year.

In 2018, 64 earthquakes struck inland areas and 51 earthquakes hit the waters off the Korean Peninsula. Daegu City and Gyeongsang province experienced 35 earthquakes, the largest number of inland earthquakes, and the West Sea had 20 earthquakes.

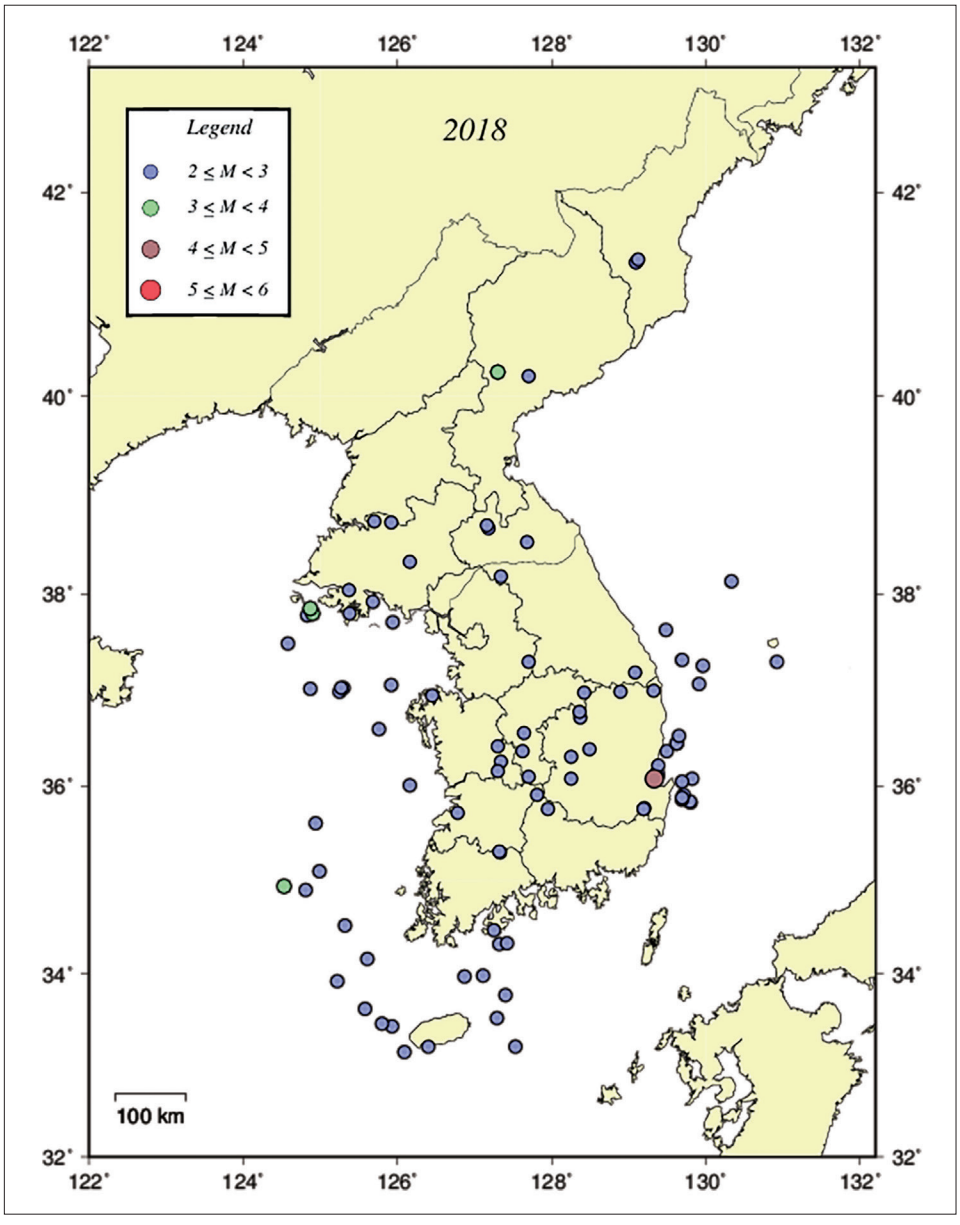



| | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Magnitude of 3.0 or greater | 5 | 17 | 6 | 10 | 11 | 10 | 7 | 11 | 12 | 4 | 4 | 13 | 3 | 7 | 7 | 7 | 11 | 11 | 14 | 8 | 7 | 16 | 8 | 7 | 11 | 9 | 6 | 15 | 7 | 2 | 10 | 10 | 5 | 14 | 9 | 18 | 8 | 5 | 34 | 19 | 5 |
| Felt earthquake | 5 | 8 | 1 | 3 | 8 | 4 | 2 | 6 | 9 | 5 | 1 | 4 | 4 | 8 | 5 | 4 | 8 | 8 | 13 | 8 | 9 | 22 | 5 | 6 | 9 | 12 | 10 | 6 | 7 | 5 | 7 | 10 | 5 | 7 | 4 | 15 | 11 | 7 | 55 | 98 | 33 |
| Total | 6 | 22 | 16 | 15 | 13 | 20 | 19 | 26 | 15 | 11 | 6 | 16 | 15 | 19 | 15 | 23 | 25 | 29 | 39 | 21 | 32 | 37 | 29 | 43 | 49 | 38 | 42 | 57 | 50 | 42 | 46 | 60 | 42 | 52 | 56 | 93 | 49 | 44 | 252 | 223 | 115 |

Number of Earthquakes Each Year (1978-2018)

**» Number of Earthquakes in 2018: 115 (felt earthquakes: 33)**

| Magnitude | 2.0≤$M_L$<3.0 | 3.0≤$M_L$<4.0 | 4.0≤$M_L$<5.0 | $M_L$≥5.0 | Total |
|---|---|---|---|---|---|
| Unfelt+felt earthquake | 110 | 4 | 1 | 0 | 115 |
| Felt earthquake | 30 | 2 | 1 | 0 | 33 |




Earthquake Epicenter in 2018

## Improvement in Earthquake Early Warning Service Time

As the Act on Observations and Warnings for Earthquakes, Tsunami, and Volcanoes was enacted from 2015, the Earthquake Early Warning Service set a target to provide the earthquake information within 50 seconds after detecting the event. Since then the KMA gradually improved its Earthquake Early Warning (EEW) system, resulting in that the EEW service time was shortened from 26 to 27 seconds at the time of the Gyeongju earthquake on September 12 in 2016 (magnitude of 5.8), and to 29 seconds when an earthquake occurred in Pohang in 2017.

Until now, the KMA had issued earthquake warnings based on the accurate data gained from repeated information analysis for stable EEW service. However, the KMA decided to further improve the EEW system to meet the people's demand for faster EEW service after the 2017 Pohang earthquake.

In order to shorten the EEW service time, the KMA developed a method to perform intensive observation of seismic waves at stations in areas where earthquakes occurred, and to identify and compare seismic waves with magnitude 5.0 or greater from the beginning of seismic analysis.

As a result of a test application of this method to the Gyeongju earthquake and Pohang earthquake, it was verified that whether to send an earthquake warning text message or Cell Broadcasting Service (CBS) can be determined within 6 to 8 seconds after an earthquake was detected. In the future, the EEW service is expected to be provided within 7 to 25 seconds from the first seismic detection. However, this method only can be applied to earthquakes in inland areas with high-density seismic station network. Unlike inland areas, as coastal areas have insufficient seismic stations, offshore earthquakes should be analyzed and updated over a given period of time, as previously done.

# Information & Telecommunication

The Global Telecommunication System (GTS) is a global network established in the 1960s for the transmission of meteorological data between WMO members and International Organizations. 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.

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

In June 2012, the GISC Seoul was designated as one of 15 GISCs. The GISC Seoul, which has come into full operation in March 2013, is responsible for operating three DCPCs (DCPC WAMIS, DCPC LC-LRFMME, DCPC NMSC) and one NC (http://gisc.kma.go.kr). In accordance with the WIS manual, the GISC Seoul manages the metadata of the three DCPCs and exchanges a total of 655 metadata with other 14 GISCs under the WIS community.

In addition, jointly working with the UK, France, Australia, the U.S., Finland, India and ECMWF, the KMA, as a permanent member has participated in the OpenWIS, an international non-profit organization in the development of business strategies with open source-based software developers. Thereby, the KMA was recognized for its work in establishing government agencies-led business models for open software, contributing to the WMO community.

For the stable operation of the GISC Seoul, the OpenWIS, operating software for WIS center, was upgraded to the latest version (v3.13.1 to 3.14.8). The newly established Real-time Monitoring System of Global Meteorological Data enables us to get statistical information on the routes and types of data acquired by the GISC Seoul. Moreover, the KMA launched the TDCF Conversion Service, which offers text files from TDCF (Table Driven Codes Form), in the GISC Seoul Portal in order to improve end users' utilization of the data.


Main Page of GISC Seoul Portal Site (http://gisc.kma.go.kr)

# International Cooperation

## Multilateral Cooperation

In 2018 the KMA not only actively participated in various meetings including WMO Executive Council and Technical Commissions, but also strengthened its position and role as a member of the WMO Executive Council by hosting the 17th Session of Commission for Agricultural Meteorology (CAgM-17) in the Republic of Korea.

As a member of the EC, the KMA was represented at various important technical meetings such as the 17th session of the Commission for Climatology (CCl-17) held in Geneva, Switzerland, and the 17th session of the Commission for Instruments and Methods of Observation (CIMO-17) held in Amsterdam Convention, Netherlands to play a leading role.

As part of efforts to nurture international professionals, the KMA has also run a training course for Korean undergraduate and graduate students for the past five years. In 2018 it selected competent students and dispatched them to relevant international organizations, including WMO, Typhoon Committee (TC), Asian Disaster Preparedness Center (ADPC), International Centre for Water Hazard and Risk Management (ICHARM), United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), and Food and Agriculture Organization of the United Nations (FAO).


The 17th Session of the Commission for Agricultural Meteorology (CAgM-17)

## Intergovernmental Panel on Climate Change (IPCC)

As a focal point for the IPCC of the Republic of Korea, the KMA plays a key role in coordinating international and domestic cooperation relevant to IPCC activities. The KMA attended an IPCC plenary, which was held twice in 2018 and made key decisions of the IPCC with government representatives around the world. The 47th Session held in Paris, April celebrated its 30th anniversary of the establishment of the IPCC, and decided to form a task group for coordinating the IPCC's assessment cycle.

The 48th Session in October was held in Incheon, Korea, jointly organized by the KMA and Incheon Metropolitan City. At the session, a Special Report on Global Warming 1.5°C that the United Nations Framework Convention on Climate Change (UNFCCC) requested to the IPCC was finally approved to provide scientific grounds for the Paris Agreement. On the occasion of the IPCC Session held in Korea, various Korean media outlets reported the Session and climate change issues, raising the public's interest and understanding of climate change and serving as an opportunity to strengthen the ability to respond to Framework Convention on Climate Change between countries.

A total of 11 Koreans were selected as the authors of the Working Group (WGI, II, and III) Report for the Sixth Assessment Report (AR6), which will be published between 2021 and 2022. This number of Korean authors has increased from two for the AR4 and seven for the AR5.

## Global Framework for Climate Services (GFCS)

The KMA has been actively participating in the GFCS since the establishment of the GFCS. Since 2013 it has made financial contributions to the GFCS Trust Fund every year.

In doing so, the KMA has supported a prediction system and capacity building in East African countries to improve their climate services. In particular, in 2018 the KMA operated a training course "Capacity Building for Climate Services in Asia" in cooperation with the GFCS and the Meteorological Human Resources Development Institute of the KMA, contributing to the improvement of climate service capabilities in developing countries.

## Bilateral Cooperation

The KMA strategically engages in bilateral cooperation with several countries around the world to respond to rapidly changing weather and climate issues and pursue partnership and cooperation with the international meteorological community. Since a bilateral cooperation relationship began with China in 1994, it has signed a bilateral agreement with 18 countries and five international organizations up until 2018.

Throughout the year 2018, the KMA has also conducted bilateral cooperative activities in various areas. The KMA, the Korea Aerospace Research Institute (KARI), and the Centre National d'Etudes Spatiales (CNES) signed a letter of intent to cooperate in building aerospace monitoring stations to support responses to climate change. In 2018, of many partner countries, it had regular bilateral meetings with Vietnam (5th meeting), Mongolia (8th), China (11th for earthquake), Indonesia (4th) and the United States (6th) to examine the progress in the implementation of activities agreed at the previous meetings and discuss exchanges of technology and experts in the future.

## Development Cooperation

**Modernization of Forecasting and Warning System for Natural Disaster in Myanmar (2017-2019)**

The KMA established a master plan for modernizing national weather services in Myanmar from 2015 to 2016. As a follow-up to the plan, meteorological disaster mitigation by automating weather observations in Myanmar was selected as a top priority project. This project aims to install automatic observation system at 40 weather stations across Myanmar and build an observation data monitoring system at the main office of the Department of Meteorology and Hydrology of Myanmar, by the Korea Meteorological Institute (KMI), an implementing agency of the KMA.

**Installation of Automatic Weather System (AWS) in Mongolia (2017-2019)**

By the request of Mongolia, the KMI, sponsored by the KMA, initiated this project to modernize surface observation system by installing automatic weather system (AWS) at 32 manual weather stations in the vicinity of the capital of Mongolia. Automatic weather observation equipment was installed at 11 weather stations in Ulaanbaatar and Tau regions in 2017, as well as at weather stations in Volgang and Arhangai regions in 2018.

**Climate Data Rescue Project in Uzbekistan, Phase I (2013-2018)**

With the sponsorship of the KMA, the WMO has conducted Climate Data Rescue Project for Uzbekistan since 2013 which aims at transforming the climate data in paper format into image files. As of April 2018, it completed the transformation of 6.5 million pieces of paper.

This project is expected to provide valuable digital climate data that can be actively utilized as a basic data for global climate change prediction.

**Coastal Inundation Forecasting Demonstration Project-Fiji (2016-2019)**

The WMO plans to implement the next phase of this project based on the road map derived from the phase I of the project which has been sponsored by the KMA. As for the 2018 project, a coastal inundation forecasting model for wave, storm surge, and river inundation was developed, and an interim report briefing session was held in Nadi, Fiji in November 2018.

## Cooperation between Two Koreas

The KMA has made continuous efforts to establish the foundation for actual inter-Korean meteorological cooperation as inter-Korean relations have improved and cooperation was revitalized. In order to prepare for and redefine the inter-Korean meteorological cooperation, the Inter-Korean Meteorological Cooperation Planning Team was expanded and reorganized into an Inter-Korean Meteorological Cooperation Promotion Team and an advisory committee meeting composed of external experts was held in November. In addition, the KMA conducted research projects, such as Research on Mid-and Long-term Strategies for Inter-Korean Meteorological Cooperation, and Study on Inter-Korean R&D Cooperation Plan in the field of Meteorology and Earthquake, to develop strategies for promoting inter-Korean meteorological cooperation.

The KMA has accumulated meteorological technologies to acquire information about North Korea by analyzing the past and future climate, data and forecasts. The KMA released 2017 Annual Weather Report of North Korea in 2018 using quality-controlled data of North Korea, which were collected through the WMO's GTS. Also, short- and medium-range forecasts have been produced for main regions in North Korea,

just as have been done in South Korea. Additionally, an analysis of meteorological characteristics (average temperature, precipitation) in North Korea has been provided to the KMA website on a monthly basis.

To be well prepared for the possible eruption of the Baekdu Mountain in North Korea, the KMA has been monitoring the eruption precursors with satellites, as well as analyzing earthquakes in North Korea. The KMA also uses short term radar data to observe the precipitation of the Imjin River and the Bukhan River Basin, and produces forecasting data for users.

# International Training and Education

## International Training Course for Improving Weather Services in WMO Member Countries

The KMA was designated as a WMO Regional Training Center (RTC) in June 2015. Since then, it has been focusing on enhancing the capacity of meteorologists and meteorological technicians in member countries for their respective public weather services, aviation, marine and hydrological forecasting, and climate services, as well as promoting collaboration to establish the WMO Global Campus and educational cooperation system for the Asian region.

In 2018 the RTC-Korea operated a variety of training courses, such as weather radar operation and data utilization, and weather forecasting for foreign experts, to share meteorological technologies and know-how with a budget allocated to Official Development Assistance (ODA). "The Weather Forecasting for Operational Meteorologist Course" was provided for seven officials from six countries for three weeks from April 2 to 20, and "Program for High-Level Officials" was for five officials from five countries for one week from April 16 to 20.

In addition, the RTC-Korea joined a global capacity building program offered by the Korea International Cooperation Agency (KOICA) to provide training courses on weather forecasting and satellite data application using Information and Communication Technologies (ICT).

As part of an MOU with Hankuk University of Foreign Studies, which was signed in August 2018, the KMA provided "On-site Training Course for International Graduate Students" in atmospheric sciences for developing countries under the sponsorship of KOICA.

Following the conclusion of the agreement between KMA and WMO GFCS, "Capacity Building for Climate Services Program" was provided to help developing countries establish and operate national climate service systems, and "Weather Climate Data Processing and Restoration Course" was offered as part of KMA-ASEAN cooperation agreement.

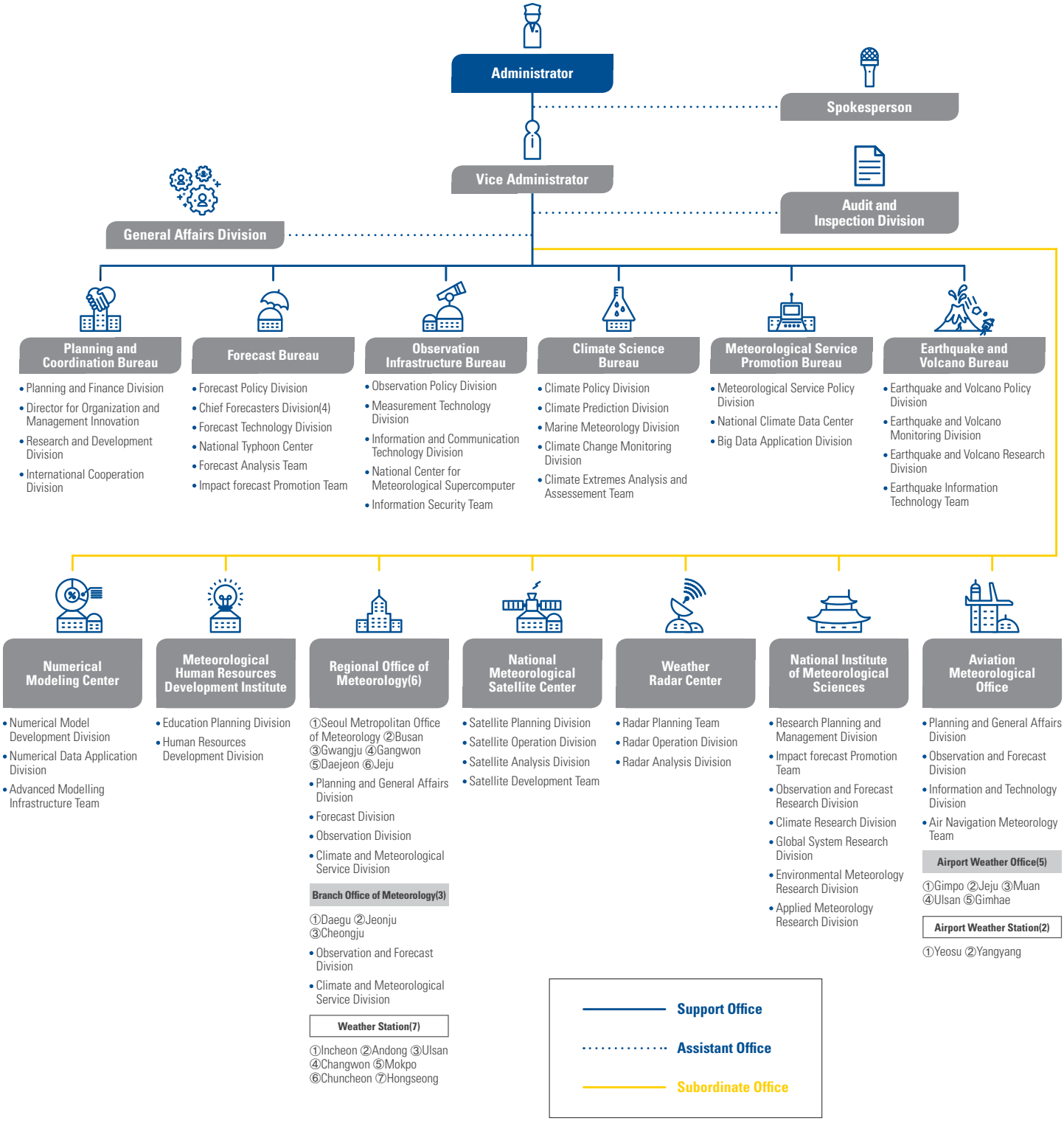
**» RTC-Korea Education Program in 2018**

| Training Title | Duration | Participants | Training Title | Duration | Participants |
|---|---|---|---|---|---|
| Weather Forecasting for Operational Meteorologist | 3 weeks | 7 persons | On-Site Training Course for International Graduate Students | 3 weeks | 15 persons |
| Program for High-level Officials | 1 week | 5 persons | ICT for meteorological services | 3 weeks | 11 persons |
| Weather Radar Utilization for Meteorological Services | 3 weeks | 13 persons | Improvement of Meteorological Satellite Data Analysis and Application Capacity | 4 weeks | 16 persons |
| Capacity Building for Climate Services Program | 3 weeks | 17 persons | Weather Climate Data Processing and Restoration | 5 days | 7 persons |
| | | | | | 91 |

# APPENDIX

- Organizational Chart
- Staffing
- Budget

# Organizational Chart (as of 31 December 2018)



# Staffing

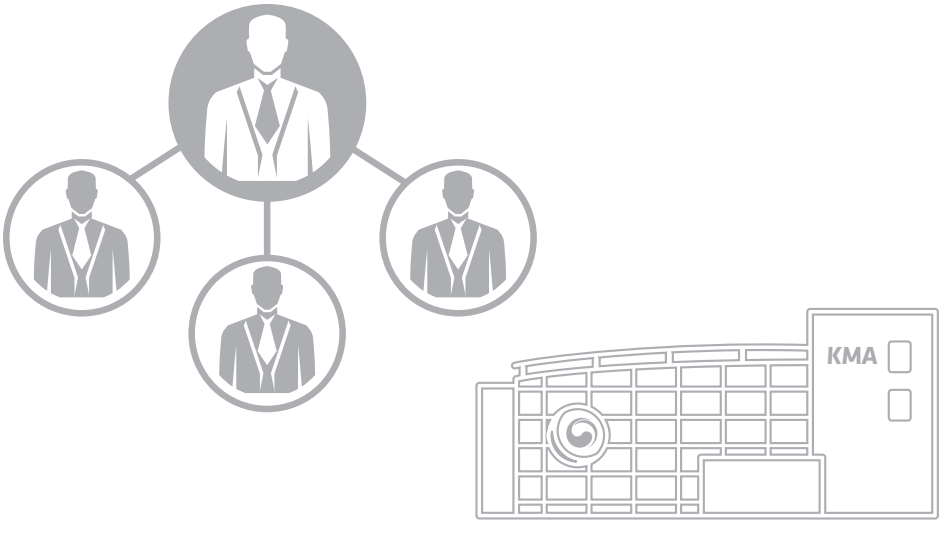
## Number of staff members

**(As of 31 December 2018)**

| Category | HQ | Regional Offices | | | NMC | MHRDI | NMSC | WRC | NIMS | AMO | | | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Main (6) | Branch (3) | Station (7) | | | | | | Main | Office (5) | Station (2) | |
| Quota | 402 | 357 | 133 | 37 | 52 | 17 | 51 | 42 | 111 | 57 | 50 | 8 | 1,317 |
| Current | 429 | 362 | 136 | 40 | 49 | 17 | 50 | 44 | 110 | 57 | 50 | 8 | 1,352 |

## Human Resources

| Degree | Ph. D | Master | Bachelor | Diploma or lower | Total |
|---|---|---|---|---|---|
| Number of qualified workforce | 120 | 340 | 720 | 172 | 1,352 |



# Budget

The KMA's budget in 2018 was all complied into general accounts. The revenue was amounted to KRW 9,219 million, increased by KRW 2,332 million or 33.9%, while the expenditure was KRW 397,899 million, increased by KRW 12,623 million or 3.3% compared to the previous year.

The expenditure can be divided into labor costs (KRW 96,140 million, increased by KRW 5,398 million or 5.9% YoY), basic expenses (KRW 18,699 million, decreased by KRW 41million or -0.2% YoY), and major project costs (KRW 283,060 million, increased by KRW 7,266 million or 2.6% YoY). Of the total, these classified costs accounted for 24.2%, 4.7% and 71.1%, respectively.

The major project expenses consisted of general projects (KRW 98,675 million, 34.9%), R&D (KRW 122,564 million, 43.3%), IT (KRW 56,786 million, 20.1%) and ODA (KRW 5,035 million, 1.8%). Meanwhile, the budget for constructing new office buildings were transferred from the general accounts to the National Property Management Fund under the auspicious of the Ministry of Strategy & Finance (MOSF) from 2012, drawing up KRW 2,898 million for the Busan, Metropolitan Regional Office, Baekryeongdo weather stations.

## 2018 Expenditure Budget for each Program

**(unit: KRW million, %)**

| Program Classification | 2017 Budget (A) | 2018 Budget (B) | Up/Down(△) (B-A) | Up/Down(△)(%) (B-A/A*100) |
|---|---|---|---|---|
| Total | 385,276 | 397,899 | 12,623 | 3.3 |
| 1. Weather forecast | 8,669 | 8,063 | Δ606 | Δ7.0 |
| 2. Weather observation | 86,023 | 85,733 | Δ290 | Δ0.3 |
| 3. Climate change sciences | 27,491 | 26,591 | Δ900 | Δ3.3 |
| 4. Weather service promotion | 15,505 | 15,132 | Δ373 | Δ2.4 |
| 5. Meteorological research | 92,120 | 96,670 | 4,550 | 4.9 |
| 6. Performance-based agency operations | 40,948 | 41,586 | 638 | 1.6 |
| 7. International Cooperation, Education and Training, and Public Relations | 8,698 | 9,526 | 828 | 9.5 |
| 8. Administrative support | 105,822 | 114,598 | 8,776 | 8.3 |

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