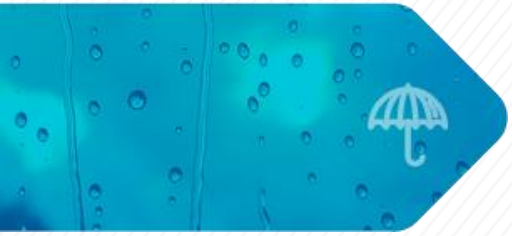
Introduction to Meteorology

35 Weather forecast and satellites

Introduction

Compared to the past, the accuracy of weather forecast has improved dramatically. This is because of the rapid development of numerical weather forecast and the increase in observation data. Especially, the remote sensing technology which provides detailed information on the atmosphere, ocean and land has played a significant role.
The Korea Meteorological Administration (KMA) is also using data provided by the geostationary satellite, Chollian Satellite.

Contents



1. Satellites and weather forecasts
2. Chollian satellite
3. Receiving and preprocessing system
4. COMS Meteorological Data Processing System (CMDPS)

Learning objectives

1. Describe the types and utilization of meteorological satellites.
2. Explain the Chollian satellite.
3. Describe the receiving and preprocessing system, and CMDPS.

Learning Activities

1. Satellites and weather forecasts

A satellite can be a weather station on Earth's orbit.

Weather satellites provide images of clouds. Because 70% of the Earth 's surface is covered by the ocean, there are many places where clouds cannot be observed from the ground.

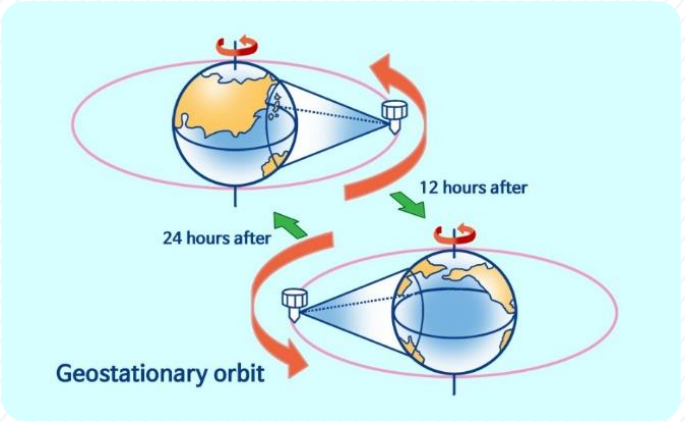
Before the era of meteorological satellites, it was hard to know anything until a severe storm or typhoon hit the coastal area. Now, weather satellites enable us to track typhoons accurately.

Learning Activities

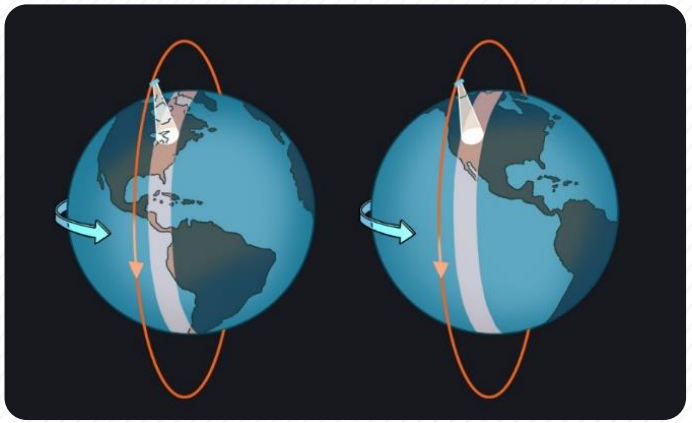
1. Satellites and weather forecasts

1) Types of meteorological satellites

There are two main types of meteorological satellites: a geostationary satellite and a polar-orbiting satellite.



※ Source: http://nmsc.kma.go.kr/html/homepage/ko/satellitelab/category_10.do



※ Source: http://www.scientificgamer.com/blog/wp-content/uploads/2012/02/polar.jpg

Geostationary satellites are rotating around the earth at a speed equal to the earth's rotation 36,000 km above the equator. Therefore, it is always appears to be stationary in the sky. In this manner, it is capable of monitoring a fixed region continuously for 24 hours a day. Most importantly, with its "real-time" data system, images can be sent out immediately.

Learning Activities

1. Satellites and weather forecasts

Fronts, movement of the clouds along with the storm, and the dissipation or development of the storm can be observed on the basis of the cloud satellite imagery, which is very useful for the weather forecast. Moreover, wind direction and speed in various vertical levels can be estimated with the images.

However, it is limited to monitoring a specific region.

Complementing the geostationary satellites, polar orbiting satellites are in close proximity to the Earth meridian. Each time the Earth revolves around the sun, polar orbiting satellites pass over north and south poles. As the earth under the satellite rotates to the east, the satellite is able to cover the entire earth by monitoring the western region which it passed in the previous step. The polar orbiting satellites have many advantages. First of all, clouds under the satellite can be observed directly. Also, polar orbiting satellites provide high-resolution images. Because the polar orbiting satellite is at an altitude of 850 km, which is much lower than geostationary satellites, it provides detailed images of storms and cloud systems.

Learning Activities

1. Satellites and weather forecasts

2) Utilization of meteorological satellites

As sensors continue to evolve, the use of meteorological satellites has been diversified.

※ Source: https://en.wikipedia.org/wiki/TIROS-1

※ Source: https://en.wikipedia.org/wiki/GOES_12

Satellites, such as the TIROS I, launched on April 1, 1960, took a cloud image with a television camera. Nowadays, a radiometer that can detect the radiant energy emitted from the top of the clouds is used. Next-generation satellites provide cloud images and vertical profiles of temperature and humidity.

Learning Activities

1. Satellites and weather forecasts

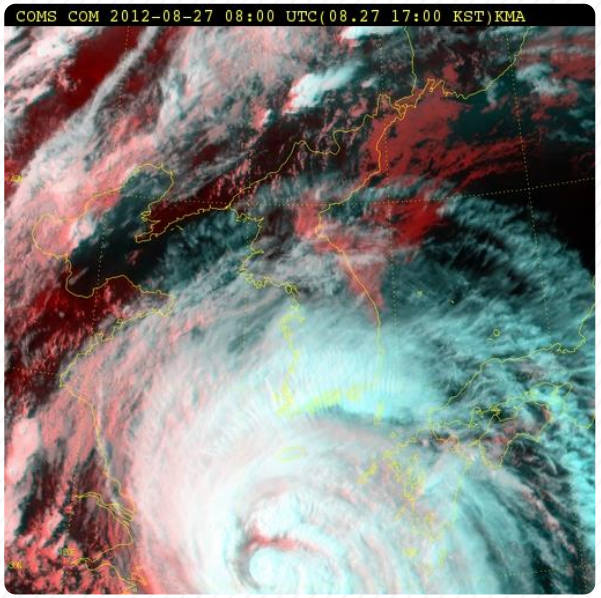
Modern satellites provide a particular type of advanced radio meter satellite image called an imager. Another type of special radiometer, called a sounder, offers a more precise temperature and humidity vertical profile than before. Recent satellites can operate independently of imager and sounder.

How do forecasters determine the weather forecast? First, they use the information about the thickness and height of the cloud from the satellite images. The thicker the cloud, the greater the reflectivity of sunlight from the cloud top, so one can estimate the thickness of the cloud with the reflectivity.

However, since the height of the cloud does not significantly affect the reflectivity, it is impossible to estimate the height simply by using visible rays. The infrared images can be used. Because it does not depend on the visible portion of the light spectrum, it provides a better image of the cloud.

Learning Activities

1. Satellites and weather forecasts



※ Source: Chollian satellite image of typhoon Bolaven, Aug-27, 2012

Then how can we interpret an infrared image? Because hotter objects radiate more energy than colder objects, infrared images can be artificially processed to appear darker in higher temperature regions. Because the top of low-cloud is warmer than the upper part of high-cloud, low and high clouds can be classified with infrared images.

Learning Activities

2. Chollian satellite

Chollian satellite was made by a joint project that started in 2003 by the KMA (Korea Meteorological Administration), MEST (Ministry of Education, Science & Technology), MLTM (Ministry of Land, Transport and Maritime Affairs), and KCC (Korea Communications Commission) in accordance with the mid- and long-term National Space Development Plan. It was launched successfully from the Guiana Space Center, Kourou in French Guiana, South America on June 27, 2010.

The Chollian satellite is Korea's first geostationary multi-purpose satellite which is stationed at an altitude of 36,000 km above the Earth's equator and a longitude of 128.2°E performing the duties of meteorological and ocean observations and communications services

The main missions are: continuous monitoring of imagery and extracting of meteorological products, early detection of severe weather phenomena, and monitoring of climate change and atmospheric environment.

The operation of meteorological satellite made intensive monitoring of weather conditions possible through observing over the Korean peninsula eight times per hour. Also, in the case of extreme weather, it is feasible to adjust the observation areas and times independently around the Korean peninsula. Also, it has been able to produce 16 types of meteorological products and data needed to support numerical forecasting through its own data processing system.

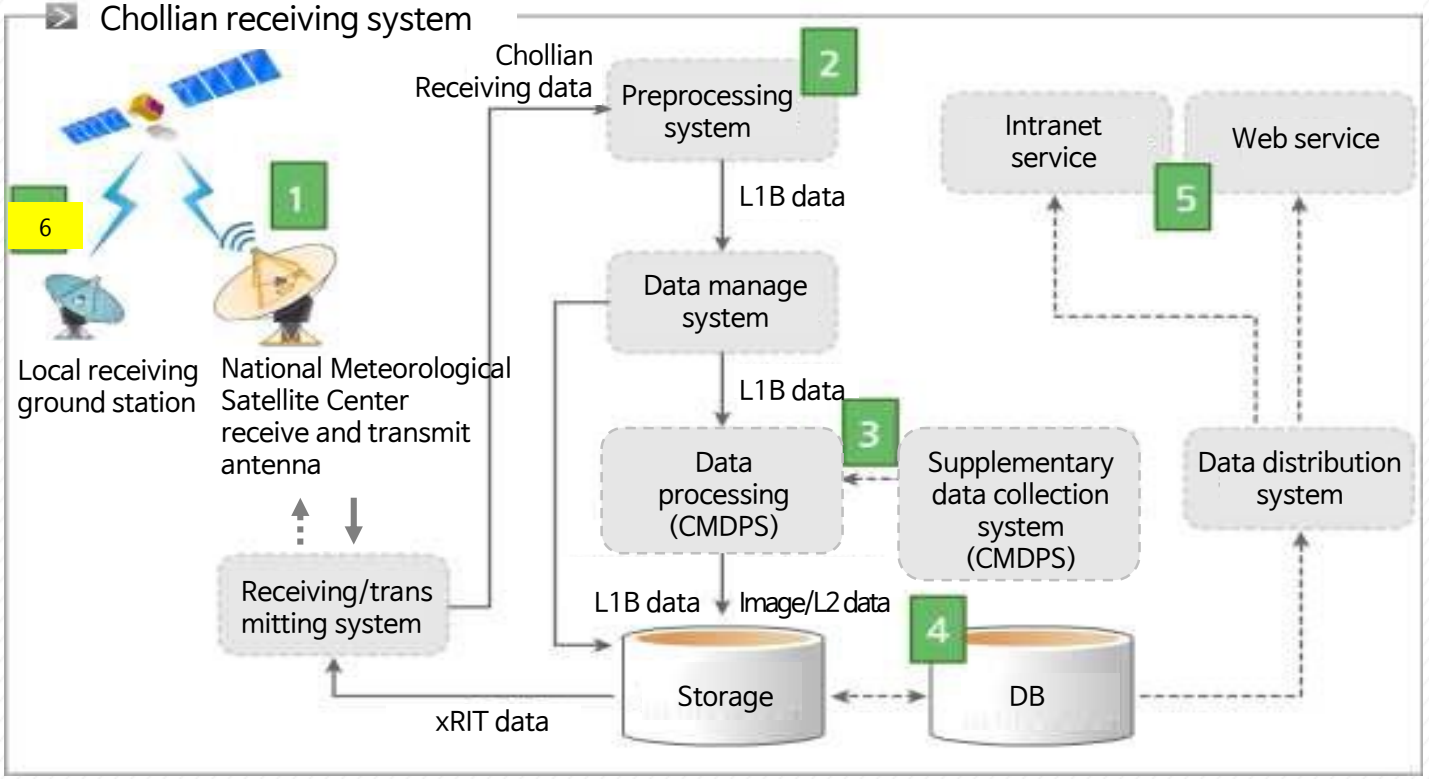
Learning Activities

3. Receiving and preprocessing system

1) Satellite data receiving system

Local ground stations receive satellite data and provide the data that users need. A ground station is responsible for receiving, processing, and providing data. The presented figure shows the ground station of Chollian satellite data.

Once the ground station receives the satellite data, it goes through a preprocessing process. The pre-processed data are stored in the database and distributed to the intranet or the web.



※ Source: National Meteorological Satellite Center, 2011

Learning Activities

3. Receiving and preprocessing system

For satellite data to be used in conjunction with other observations or numerical model data, it is necessary to extract the meteorological variables (such as temperature, wind, precipitation, etc) from the preprocessing such as radiometric calibration or geometric correction and radiance observed from the satellite. These processes are performed by the ground stations.

Learning Activities

3. Receiving and preprocessing system

2) Preprocessing

Meteorological satellites, such as Chollian, measure the solar radiation reflected by the Earth or longwave radiation emitted from the Earth through a telescope. However, the telescope is restricted to measure the visible channel within 1 km and infrared radiation within about 4 km of diameter.

Also, the performance of the sensor is not constant. Furthermore, the energy reaching the satellite sensor includes the cosmic radiation and noise emitted by the device itself.

The satellites depart from the specified position or deviate from the original position because of the effects of other objects, gravity, and the solar wind.

In the case of Chollian, because it is located 36,000 kilometers above the equator, slight changes in satellite position can cause errors of up to several tens of kilometers. To derive accurate weather variables, satellite data and the location must be accurate.

The process of minimizing the problem mentioned above is required, which is called preprocessing. First, Level 1 data is derived by geometric correction and by removing the influence of the noise included in the original data. Then, Level 2 data (meteorological variables) is derived with physical formulas.

Learning Activities

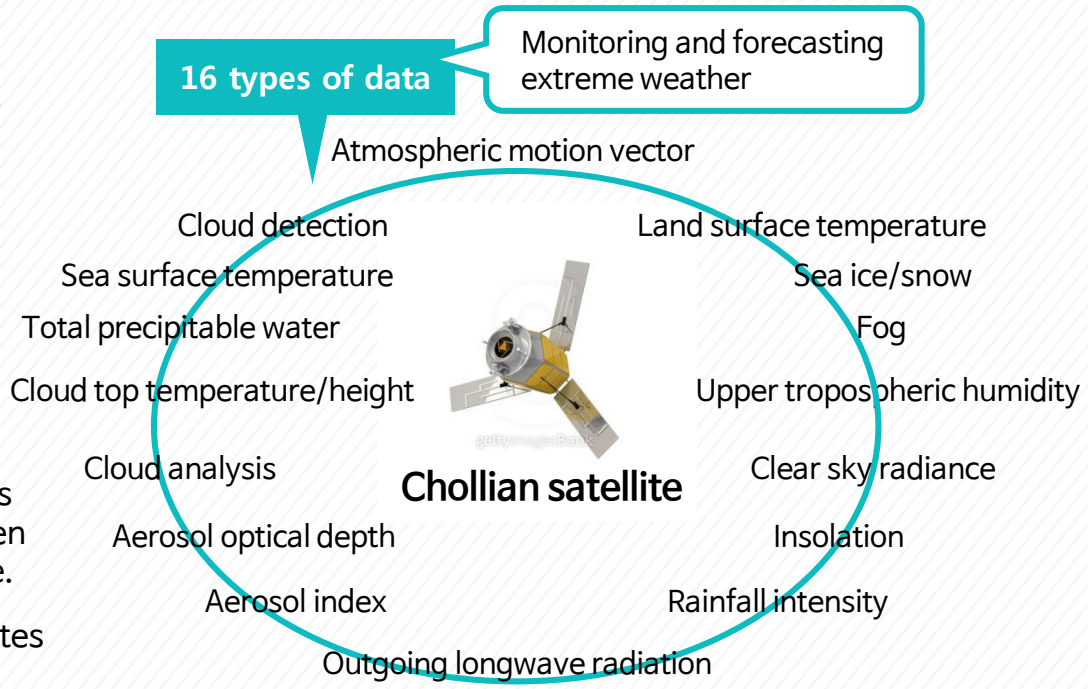
4. Meteorological Data Processing System (CMDPS)

The ultimate goal of satellite operation is to detect, understand, and predict various weather phenomena. To this end, a system that automatically calculates weather variables from Level-1B data by objective methods is required.

Since 2003, Korea has developed a COMS Meteorological Data Processing System (CMDPS).

Let's look at the process of calculating the meteorological component by CMDPS. The cloud detection algorithm is applied to the Level-1B data to determine cloudiness for each pixel. In clear pixels, it is possible to derive variables that can be calculated when there is no cloud, such as the sea surface temperature.

The advantage of CMDPS is that the algorithm calculates 16 types of analysis data (figure below) in real time. This meteorological information contributes to the accuracy of the forecasting model as well as monitoring the extreme weather. It is also used for analyzing and forecasting climate variability.



※ Source: National Meteorological Satellite Center, 2011

Summary

1. Satellites and weather forecasts

Types of meteorological satellites

- Geostationary satellite: Continuous monitoring of the atmospheric conditions above a specific region.
- Polar-orbiting satellite
  - Close parallel with the Earth meridian
  - Each time the Earth revolves around the sun, polar orbiting satellites pass over north and south poles.
  - As the earth under the satellite rotates to the east, the satellite is able to cover the entire earth by monitoring the western region which it passed in the previous step.

Forecasters use the information about the thickness and height of the cloud from the satellite images.

Summary

2. Chollian satellite

- On June 27, 2010, a successful launch of the Korean first geostationary satellite Chollian . Became operational on April 2011.
- The main missions
  1) Continuous monitoring of imagery and extracting of meteorological products using a high-resolution multi-channel.
  2) Early detection of severe weather phenomena such as typhoons, heavy rain, and dust
  3) Analysis of climate change via sea surface temperature and cloud data.

Forecasters use the information about the thickness and height of the cloud from the satellite images.

Summary

3. Receiving and preprocessing system

- Produce Level-1B data through radiometric calibration or geometric correction.

Summary

4. Meteorological Data Processing System (CMDPS)

- 16 types of meteorological data are calculated by the algorithm in real time from the preprocessed data (Level-1B) and then distributed to the users.