To measure the amount of rainfall, raingauge is used. There are two types of raingauge used by PAGASA. The 8-inch raingauge and the tipping bucket raingauge.

a. 8-inch Raingauge

An 8-inch raingauge (Fig. 8), so called because the inside diameter of the receiver is exactly 8 inches, is provided with a funnel that conducts rain into a cylindrical measuring tube. The volume of the receiver is 10 times the volume of the measuring tube. Therefore the actual depth of rainfall is increased ten times on being collected in the smaller measuring tube.

To measure the amount of rainfall accumulated in the measuring tube, a thin measuring stick with the magnified scale printed on its face is used. The precisely dimensioned measuring tube has a capacity of 2 inches (50.8 millimeters). Rainfall exceeding this amount spills into the overflow but can be easily measured by pouring it into the measuring tube for total rainfall. Used this way, the gauge has a total capacity of 20 inches.

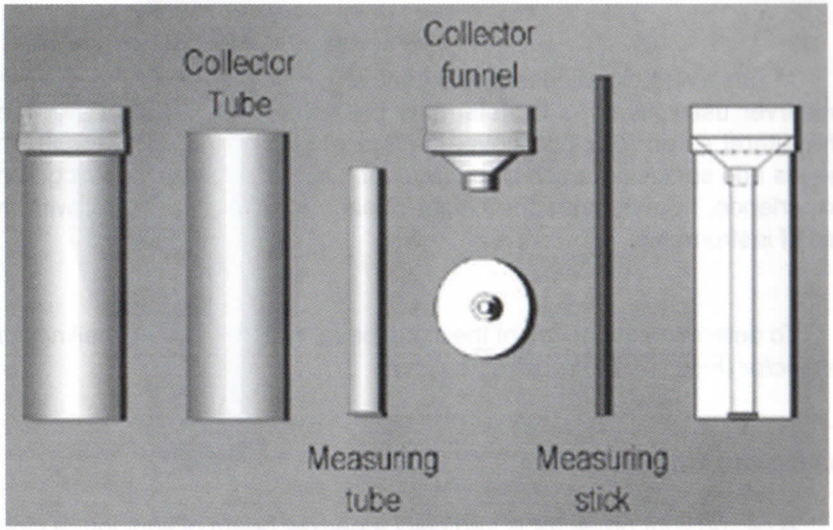
b. Tipping Bucket Raingauge

Another type of rainfall recording instrument is the tipping-bucket raingauge (Fig. 9). It is an upright cylindrical that has a funnel-shaped receiver. The precipitation collected by the receiver empties into one side of a “tipping bucket”, an inverted triangular contraption partitioned transversely at its center, and is pivoted about a horizontal axis. Once it is filled with rain, it tips, spilling out water and placing the other half of the bucket under the funnel. The tipping activates a mercury switch causing an electrical current to move the pen in the recorder. Each tipping is equal to one millimeter of rainfall.

CLOUDS

Clouds are either composed of water-droplets or ice-crystals dependent upon their altitude and temperature conditions.

In observing clouds, an accurate description of both type and size plays an important part in the analysis and forecasting of weather.



Parts of an 8-inch raingauge

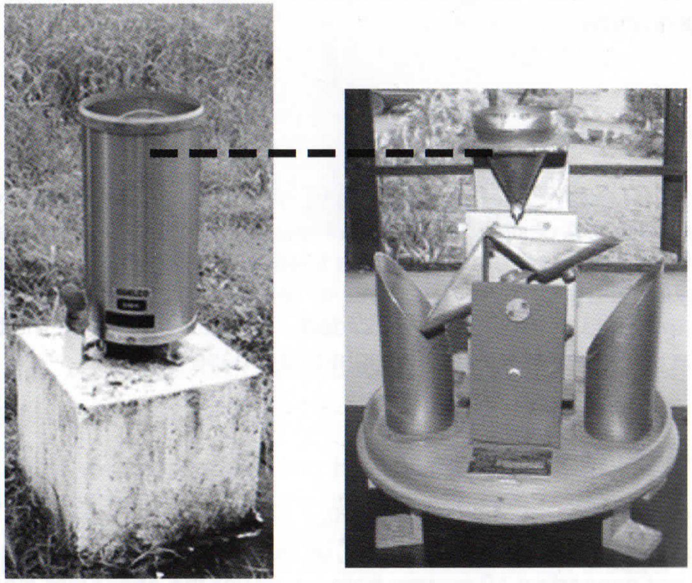


Fig. 9 Tipping Bucket Raingauge (and parts inside)

Thus, for this purpose an International Classification of clouds was prepared and adopted by most countries.

In observing cloudiness (the extent where clouds cover the sky), the observer uses his eyes to determine the presence of cloud layers and the lateral extent of cloud coverage. He must also be familiar with the genus and species of each cloud present. On the basis of knowledge and experience, he estimates the height of each layer or measure it with the aid of instruments.

To determine the height of the cloud base, PAGASA uses a ceiling *light projector* (Fig. 10) *and a ceiling balloon.*

a.) Ceiling Light Projector

A ceiling light projector is vertically a narrow beam of light into a cloud base. The height of the cloud base is determined by using a clinometer located at a known distance from the projector to measure the angle included by the illuminated spot on the cloud, the observer, and the projector. From trigonometry, the height of the cloud base is equal to the distance of the observer from the ceiling light projector multiplied by the tangent of the elevation angle.

b.) Ceiling Balloon

Another away of determining the height of the cloud base is by using a ceiling balloon. A ceiling balloon is a meteorological balloon whose rate of ascent has been predetermined. It is filled with gas lighter than air, usually hydrogen, and released. The time of release and the time the balloon disappears into the cloud are recorded. The time difference multiplied by the rate of ascent will give the height of the base cloud.

SPECIAL INSTRUMENTS

The instruments described earlier are tools for measuring weather elements prevailing at the "surface" or near the surface of the earth at a height not exceeding 10 meters from wherever the observers stands.

Fig. 10. Ceiling Light Projector

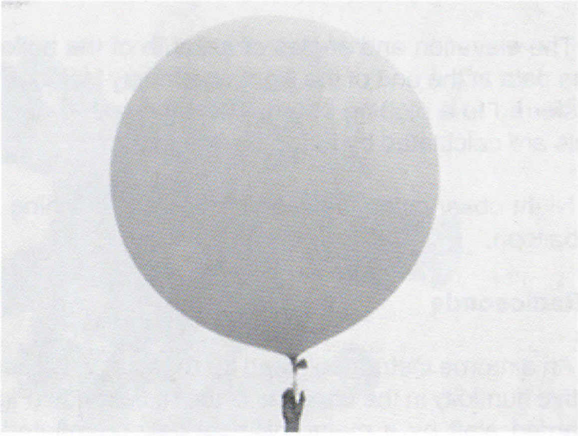


Fig. 10a. Ceiling Balloon

The art of weather forecasting however is never completed if the conditions of the air above us are not known. The weather forecaster needs to know the humidity, temperature, pressure, and speed direction at different levels of the atmosphere so that he could obtain a better picture of what the prevailing weather conditions are from the surface upwards.

These data are called Upper-Air Data. Most of the marked weather changes and the resulting effects on our daily lives occur at levels higher that what we observe or feel near the surface of the earth.

Some of the widely used instruments to obtain upper air data are as follows:

a. PIBAL/Theodolite = Pilot balloon
   Theodolite
b. Radiosonde;
c. Rawinsonde;
d. Rawin;
e. Wind-Finding Radar; and
f. Weather Surveillance Radar

a. Pilot Balloon/Theodolite

A pilot balloon (Fig. 11a) is a meteorological balloon that is filled with gas lighter than air. When the pilot balloon is used in conjunction with a theodolite it is used to determine the speed and direction of winds at different levels of the atmosphere. The theodolite (Fig. 10b) is similar to

The elevation and angles of azimuth of the balloon are recorded and these data at the end of the flight which may last for more than an hour are transferred to a plotting board. The wind speed and direction at selected levels are calculated by trigonometric methods.

Night observation is accomplished by attaching a lit paper lantern to the balloon.

b.) Radiosonde

An airborne instrument used for measuring pressure, temperature and relative humidity in the upper air is the radiosonde (Fig. 11). The instrument is carried aloft by a meteorological balloon inflated with hydrogen. The radiosonde has a built-in high frequency transmitter that transmits data from the radiosonde meter and recorded on the ground by a specially designed radiosonde receiver.

Fig. 10a. Pilot Balloon

Fig. 10b. Theodolite

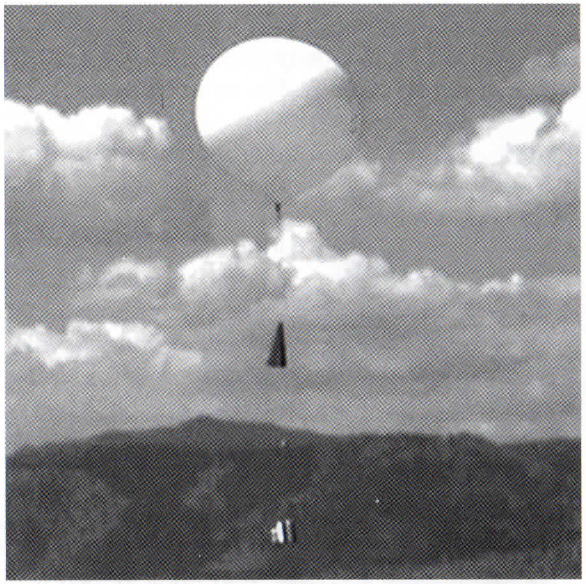


Fig. 12. Radiosonde attached to a Meteorological balloon

c.) Rawinsonde

A more sophisticated version of this instrument is the rawinsonde. The rawinsonde (Fig. 12) is an electronic device used for measuring wind velocity, pressure, temperature and humidity aloft. It is also attached to a balloon and as it rises through the atmosphere, it makes the required measurements.

The data gathered are then converted to radio signals which are received by a receiving set on the ground where they are decoded and evaluated.

d.) Rawin

Another special instrument is the Rawin which is short for Radar and Wind. It is an electronic device that measures pressure, temperature and humidity.

e.) Wind Finding Radar

Another instrument is the Wind Finding Radar (Fig. 13). It determines the speed and direction of winds aloft by means of radar echoes. A radar target is attached to a balloon and it is this target that is tracked by ground radar.

Fig. 12. Rawinsonde Antenna

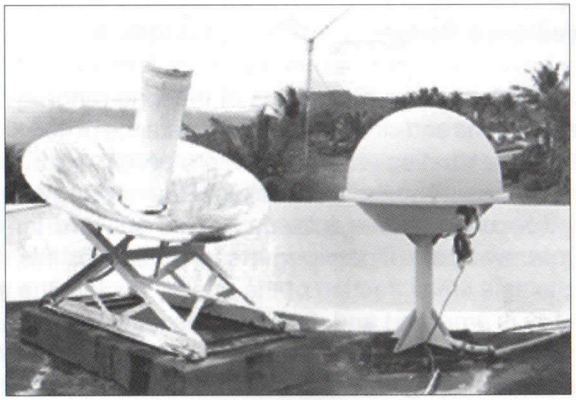


Fig. 13. Wind Finding Radar Antenna

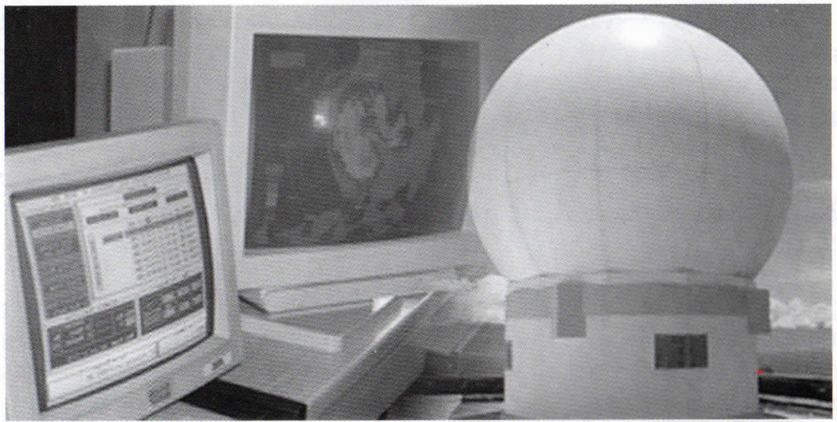


Fig. 14. Weather Surveillance Radar

The bearing and time of interval of the echoes is evaluated by a receiver.

f.) Weather Surveillance Radar

A weather surveillance radar (Fig. 14) is of the long range type which detects and tracks typhoons and clouds masses at distance of 400 kilometers or less. This radar has a rotating antenna disk preferably mounted on top of a building free from any physical obstruction. Radio energy emitted by the transmitter and focused by the antenna shoots outward through the atmosphere in a narrow beam. The cloud mass, whenever it is part of a typhoon or not, reflects a small fraction of the energy back to the antenna. This reflected energy is amplified and displayed visually on a radar scope. The distance or slant range of the target from the radar is determined through the elapsed time to signal is transmitted and then received as an echo. Its direction is determined by the direction at which the focused beam is pointing at an instant the echo is received.

WEATHER SATELLITE Modern Tool for Weather Analysis

Polar-Orbiting Satellites

The National Oceanic and Atmospheric Administration (NOAA) satellite system consists of satellites in polar orbit at 833 and 870 km. above the earth's surface. Each satellite transmits data from a circular area of the earth's surface with diameter of 2,800 kms. Inboth satellites, one of the sensors is the Advance Very High Resolution Radiometer (AVHRR) which is sensitive to visible near infrared and infrared radiation. This instrument is used for measuring cloud distribution and for determining temperature of radiating surface (clouds or surface).

Another sensor is the TIROS Operational Vertical Sounder (TOVS) system which is used to calculate the temperature profiles from the surface to 10 mb, water vapor content at three levels of the atmosphere and total ozone content.

Geo-stationary Meteorological Satellite

The most valuable feature of Geostationary Meteorological Satellites (GMS) is that they can globally observe atmospheric phenomena uniformly, including overlying areas in sea, desert and mountain regions where weather observation is difficult.

The GMS of Japan is a spin stabilized satellite that is placed in geosynchronous orbit about the equator and 140 degree longitude.

The GMS provides a real time digital cloud image (Stretched-VISSR) broadcast to the users, which are the Medium Scale Data Utilization Station (MSDUS). The S-VISSR data can be processed not only by a high grade computer system but also by an ordinary personal computer system.

PAGASA has both the GMS AVHRR, the NOAA polar orbiting satellite ground receiving facility. Both are located in Diliman, Quezon City.

Satellite data coming from both the orbital and geo-stationary satellites are used for monitoring the development of severe weather systems, locating tropical cyclones centers, determining the cyclone's present intensity and future movement and weather forecasting.

Fig. 15a. Geostationary Meteorological Satelite Antenna

MODIS

MODIS (Moderate Resolution Imaging Spectroradiometer) is a key instrument aboard the Terra (EOS AM) and Aqua (EOS PM) satellites. Terra's orbit around the Earth is timed so that it passes from north to south over the equator in the morning, while Aqua passes south to north over the equator in the afternoon. Terra MODIS and Aqua MODIS are viewing the entire Earth's surface every 1 to 2 days, acquiring data in 36 spectral bands or groups of wavelengths.

These data will improve our understanding of global dynamics and processes occurring on the land, in the oceans and in the lower atmosphere. MODIS is playing a vital role in the development of validated, global, interactive Earth system models able to predict global change accurately enough to assist policy makers in making sound decisions concerning the protection of our environment.

The qualitative and quantitative estimates and display of atmospheric parameters and a few oceanographic elements from newly acquired NOAA HRPT Receiving Systems of PAGASA enables the agency to monitor, forecast and predict weather and climate and issue early warning of associated hazards.

MODIS also provides finer horizontal-scale atmospheric vapor gradient estimates which is a valuable input in weather forecasting. Data derived from the system used to monitor flood inundation areas. Acquisition of this new technology strengthens PAGASA farm weather forecasting using data from the multi-spectral band imaging instrument.

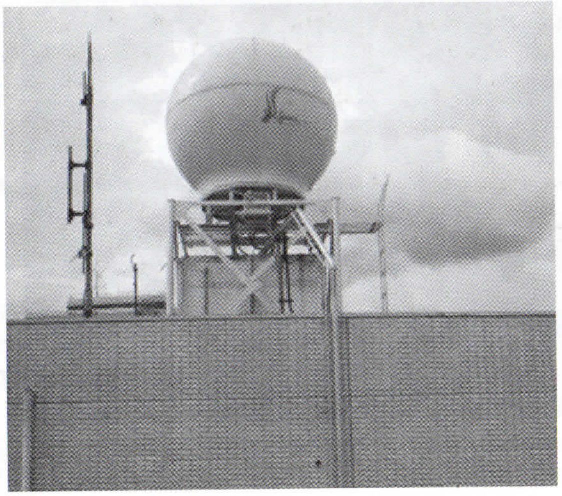


Fig. 16. MODIS Satellite Reciever

Multi-functional Transport Satellite (MTSAT)

To improve meteorological services over a wide field of activity (such as weather forecasts, natural-disaster countermeasures and securing safe transportation), the MTSAT series replaced the GMS series that had been in operation since 1977. It has taken over the role of the GMS series, covering East Asia and the Western Pacific region from 140 degrees east above the equator.

It also provides information to 27 countries and territories in the region, including imagery for monitoring the distribution/motion of clouds, sea surface temperatures, and distribution of water vapor.

The MTSAT series carries a new imager with a new infrared channel (IR4) in addition to the four channels (VIS, IR1, IR2 and IR3) of the GMS-5. Its imagery is more effective than GMS-5 imagery in detecting low-level cloud/fog and estimating sea surface temperatures at night and has enhanced brightness levels, enabling a whole new level of image imagery.

By further computation of cloud imagery, data obtained by MTSAT's observations can be used to calculate wind data for numerical weather prediction; make nephanalysis charts and analyze the distribution of cloud amounts according to area.

The Imager scans the earth by moving an internal scan mirror in an east-west and north-south direction. The light reflected by the mirror is converted into a beam and channeled through a system of lenses and filters and is separated into one visible and four infrared channels.

The beam intensities are converted to electric signals by visible and infrared detectors and these signals are transmitted to the Meteorological Satellite Center's Command and Data Acquisition Station (CDAS).

PAGASA's weather forecasting has significantly improved with the availability of high resolution satellite imageries both from the MTSAT and MODIS installed at the Weather and Flood Forecasting Center (WFFC) Building in Quezon City. A redundant Meteorological Satellite High Resolution Imaging (MTSAT-HRIT) was also installed at Cebu PAGASA Complex Station.

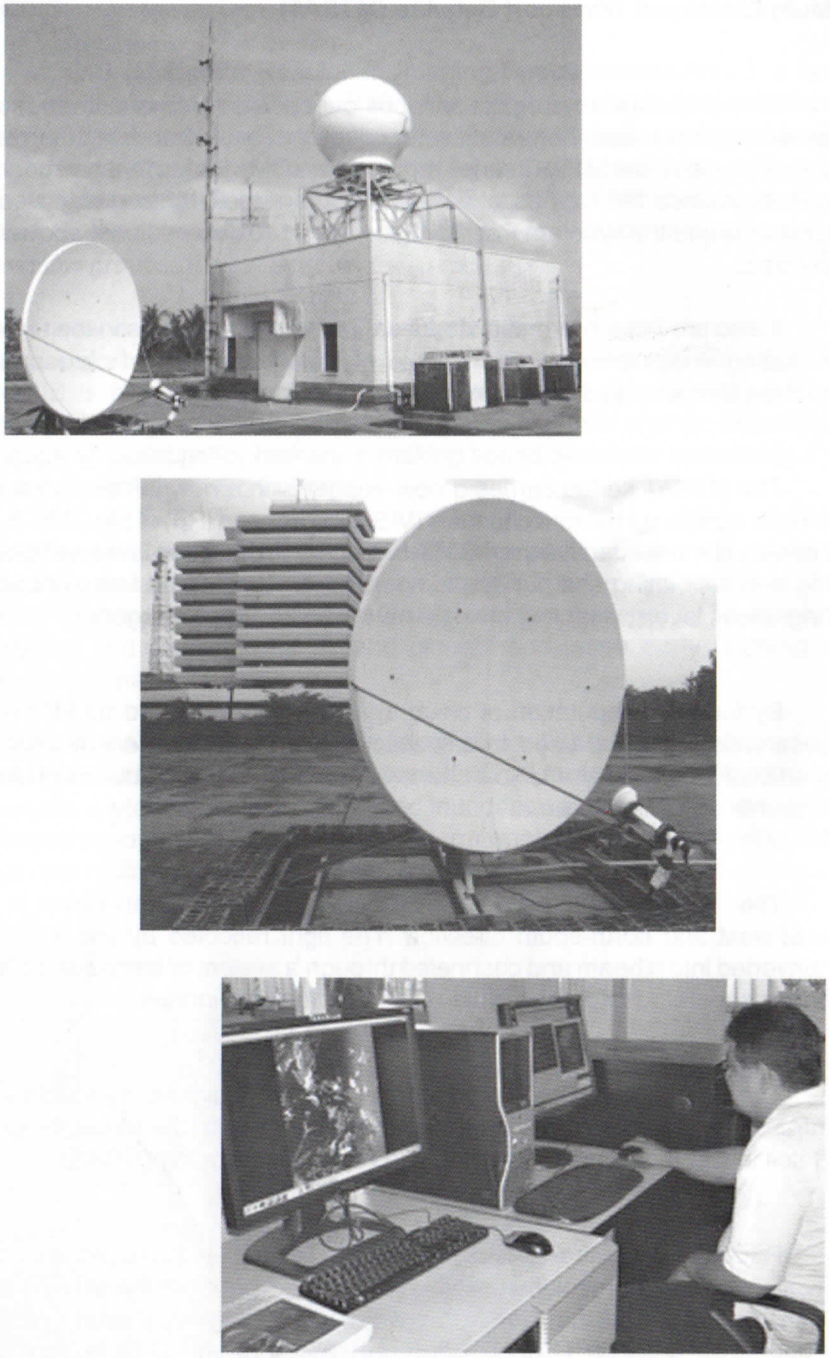


Fig. 17. MTSAT Satellite Receiver Facility

"tracking the sky... helping the country"

Department of Science and Technology
PHILIPPINE ATMOSPHERIC, GEOPHYSICAL AND
ASTRONOMICAL SERVICES ADMINISTRATION

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