



Painting by René Magritte (1898-1967): Hegel Vacation of 1958.

Pluviometry: Historical and Technician Aspects

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rain is without a doubt the atmospheric phenomenon that more interferes with our daily one. Either in the pleasure aspect, either in the economic aspect, mainly in Brazil whose energy matrix is based at hydro power which depends primordially on rain the regimen, either in the social aspect, because in periods very rainy riverine and suburb populations at great cities suffer with floods, diseases boom, fall of hillsides; in periods of drought, families who depend on subsistence agriculture suffer with food scarcity. Brazil with its "continental" area presents immense climatic diversity, which reflects at space and temporal distribution of the precipitation. To mention, the Northeast region of Brazil, in coastland the annual volume arrives to 1,600mm or more that, whereas at inland the annual only arrives 400 mm or lesser, similar to other regions semi-arid of the world like Sahel, northeast of Africa and parts of India.

Pluviometry, from latin "*pluvia = rain + metria = measurement*", is about the process or measurement technique of the precipitation, either this liquid or solid. Treating to solid precipitations (snow, hailstorm or hail) the measurement is made after ice fusion.

The instrument used to quantify precipitation that arrives to surface is known as rain gauge, udometer or pluviograph. The measure unit of the precipitation is millimeter, that is, one millimeter of rain is equal to 1 liter per 1m² by convention.

The precipitated volume is normally express for the water layer thickness that it would form on a horizontal surface, plain and impermeable, with a area of 1m²:

$$1 \frac{\text{litro}}{\text{m}^2} = 1 \frac{\text{dcm}^3}{100\text{dcm}^2} = 0,1\text{cm} = 1\text{mm}$$

BRIEF HISTORY

Measurers of Surface

The origin of the first rain register is uncertain and the literature that deals of subject is scarce. Thus, we go to deal of the historical aspects with some exceptions how much dates and names, mainly when will be dealt with previous subjects to modern age, that is, previous to XV Century.

At *Aristotle* documents (340 B.C.), more specifically in his book of natural philosophy "*Meteorologica*", certainly presented topics such as clouds, mist, rain, snow, etc, but did not mention the measurement of precipitation.

In the ancient times, man depended upon atmospheric conditions of rain and drought because they were farmers and hunters. Aristotle's ideas were almost unchallenged for nearly 2000 years. The



beginning of Meteorology as a true science in the Western World did not come about until around the end of the 16th century. However, some research indicates that around 100 A.D., rain gauges were being used around Palestine to measure rainfall for agricultural purposes.

According to some authors to be credited to a king in Korea called King *Munjong* (son of King *Sejong* and fourth king at *Joseon* Dynasty) who reigned from 1418 to 1450, the development of the earliest quantitative rain gauge whose intention was to perfect agricultural techniques and to provide adequate food to his vassals. The gauge was invented in the fourth month of 1441 according to records while *Munjong* made measuring rainfall at the palace and perceived that instead of digging into the soil to check rain levels, it would be better to use a standardized container that stood on a pillar to measure the rainfall. These containers were sent a rain gauge to every village, and they were used as an official tool to measure the farmer's potential harvest. As also were used these measurements to determine what the farmer's land taxes should be.

The rain gauge invented by *Christopher Wren* in Europe around 1661, used the standard of weight, or sometimes volume of the liquid precipitation. It is necessary to remember, however, that the metric system as we know it did not exist then. The instrument idealized by *Wren* is still used in many of the automated electronic gauges today.

His device is endowed with a container divided in two symmetrical compartments in relation to the cross wind axis that supports it (similar to the next figure). When one of the compartments fills, the container tumbles by side and water flows, while other compartment starts to full. When emptying one of the compartments, a mechanism that made punctures in a paper ribbon was set in motion. The number of punctures was proportional to the amount of accumulated rain



Rain Gauge with tipping bucket structure.

At past, the most of the regions of the World if not in all, the rain gauge networks had been developed of aleatoric form. In England, from 1860 to 1861 the systematic work of rain observation by *G. J. Symons* had beginning, with about 500 stations distributed by about 300,000 kilometers squared, where is today the Ireland Republic. Due to the personal effort of Mr. Symons, until his death in 1900, the number of stations increased for about 3,500.

In 1866, the Reverend T.E. *Crallan* began observing rainfall catches with gauges of uniform openings, but composed of different materials. These were also spread over different areas and elevations to see how the effect of elevation and wind direction changed the readings. The results were that they needed more testing until 1890. Some of the conclusions of that study are listed below:

- Materials: The material of the gauge is important. It must be a smooth surface that is durable in all weather conditions. Ebonite was recommended, but copper was found to be much less expensive with very little change in results.
- Size of Opening: Different openings were carefully examined and experiments conducted using gauges with various sized openings all being the same height above the ground. It was found that the gauges between 4 and 24 inches were very close in readings, so the five inch gauge was most practical.
- Altitude: It was found that the more altitude a gauge had, the less rain was captured. Wind was the variable that caused this discrepancy.

Among his discoveries, *Mr. Symons* also observed that wind had a dramatic affect on the amount of rain collected at various altitudes above the ground. His studies actually gave the basis of modern day standardization of rain gauges.

The conclusions were:

1	A five inch copper gauge was most practical.
2	A standard height of the rim of the gauge should be one foot.
3	Gauges must be level; a change in slope should be avoided.
4	Sheltering influences, such as trees and buildings should be avoided for precise measurements.

MEASUREMENT FOR REMOTE SENSING

The precipitation is an atmospheric phenomenon that presents large variability space-temporal. The pluviometric network is not capable still to cover all regions, mainly deserts and of difficult access places, that is, represents an enormous technological and economic effort to acquire and to keep a dense superficial pluviometric stations network and radars, sufficient to cover extensive areas of the globe especially at Tropic regions. Beyond the oceans that are not covered by this type of instrument.

From 1960s decade the first meteorological satellites had been launched allowing the monitoring of the cloudiness on extensive areas in the globe terrestrial. Diverse applications had been developed for the use of the data obtained by these satellites, between them, techniques for precipitation estimate that allow to get rain space-temporal distribution about extensive areas, included on oceans.

The precipitation estimate via remote sensing is based on techniques that use active and passive sensors. The active sensors irradiate energy on targets and measure the amount of backward spread energy for them. The backward spread energy is proportional to the diameter to sixth potency of the hydrometeor distribution illuminated by radar beams. These sensors are known normally as meteorological radars.

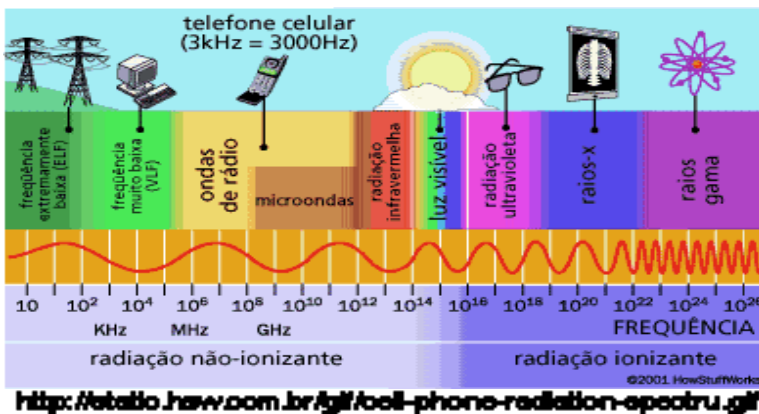
The passive sensors measure energy emitted by Earth-Atmosphere system which is absorbed or spread during its propagation at the atmosphere. As that this energy propagates, interacts with ambient (gases, aerosols and hydrometeors) that is used to infer different properties of the targets, for example: water vapor, ice, precipitation or concentration of gases and particulate material.

The earliest methods utilized visible frequency rang, and later came the use of the infrared range and currently it comes using of microwaves frequencies.

At visible, the radiation observed is the rate between incident energy and reflected one. In this way, it is observed to reflectivity of clouds and surface. The methods of precipitation estimate in the visible one relate to with cloud area of the certain reflectivity and texture with precipitation area. Researcher E. C. BARRET (1970) was pioneer at the development of a method of estimate of the monthly precipitation using visible spectrum, known as cloud indicator. This method defines different precipitation taxes for each type of cloud, being based on a cloud classification and calculating the covering fraction.

The infrared spectrum of the atmospheric window is proportional to temperature of the target to fourth potency, being able to be used to define the convection depth, beyond to allow estimate the precipitation at night. In 1979, P. A. ARKIN developed the estimate precipitation method known as *GOES Precipitation Index (GPI)*. This technique is based on the high correlation between cloud fraction with temperatures less than 235K (~-38°C) and rain area observed via radar in regions of 2.5° x 2.5° throughout the month.

The simultaneous images availability at visible and infrared spectrum, led to the development of the bi-spectral technique. In this method, the clouds which are shining in visible images are more probable to precipitate of what darkest, clouds with low temperatures of brightness in the infrared images, present peak higher of what hot clouds. Soon, the combination of the two canals was used to define rules and to identify clouds that present greater probability to precipitate, that is, cold and shining clouds.



Electromagnetic Spectrum.



The use of the microwaves frequency in the estimate of precipitation was given at the end of 1970s decade from release of the defense satellites data of the United States. The advantage of this canal is that in this frequency range the electromagnetic radiation interacts with hydrometeors, thus allowing one better description of the vertical structure of the precipitation, a time that as much the visible how much infrared observes only characteristic of the cloud top. On the other hand, measured in microwaves is restricted to the orbit satellites low (polar or equatorial), that is, to some measures per day.

At 1990s perceived that these techniques of estimate of precipitation would be better represented from coupling of measures of wind and relative humidity.

In 1998, the researcher *GILBERTO VICENTE* (NASA/GSFC) developed the method *The Operational GOES Infrared Rainfall Estimation Technique that operationally functions in the National Environmental Satellite Data and Information Service (NESDIS) of the National Oceanic and Atmospheric Administration* (NOAA).

In this technique, the information of wind, precipitable water and relative humidity gotten by numerical forecast model *ETA* (NCEP/NOAA) are incorporated to define rain probabilities and increase or reduction of precipitation modifying the relations between temperature of brightness and precipitation rate. This method was adapted and put in operation by CPTEC/INPE for precipitation estimates in the South America.

In November 1997, satellite *TRMM* (*Tropical Rainfall Measuring Mission*) was launched, and since then had a "revolution" at the knowledge of the precipitation. The satellite was equipped with microwaves sensors of SSMI, and one meteorological radar.

Project TRMM put in real time estimates of precipitation made by models as well as by first meteorological radar in the space. These estimates, in real time, are relatively necessary. On oceanic regions are gotten better resulted, and on continent still an error of the order of -20% is observed.

Due to success of the TRMM, it is tried from Global Precipitation Measurement program (GPM) to extend to the TRMM experience for estimates of global precipitation to each 3 hours.

In this program, GPM visualizes the use of 8 satellites of polar orbit that loading instruments of type SSMI and a satellite mother "similar" to the TRMM. In this way, the satellite mother will be used to calibrate algorithms of precipitation estimates.

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