ERATOSTHENES Centre of Excellence (ECoE)

EXCELSIOR

ERATOSTHENES:
Excellence Research Centre for Earth Surveillance & Space-Based Monitoring of the Environment

1st virtual EXCELSIOR International Technical Workshop

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Measurement of Rainfall from Space-based Platforms

@excelsior2020eu

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ERATOSTHENES Centre of Excellence

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CONSORTIUM

Cyprus University of Technology · DLR · TROPOS Leibniz Institute for Tropospheric Research · DEC

- **The 21st is referred to by many as "the century of water."**

- **Water is an essential element of the Earth's environment and is indispensable for human existence but also for almost all economic activities.**

- **Many places in the World face problems directly related to water, such as droughts, water shortages and floods leading to deterioration of living standards even to loss of life, as a result of food shortages, epidemics, diseases, etc.**

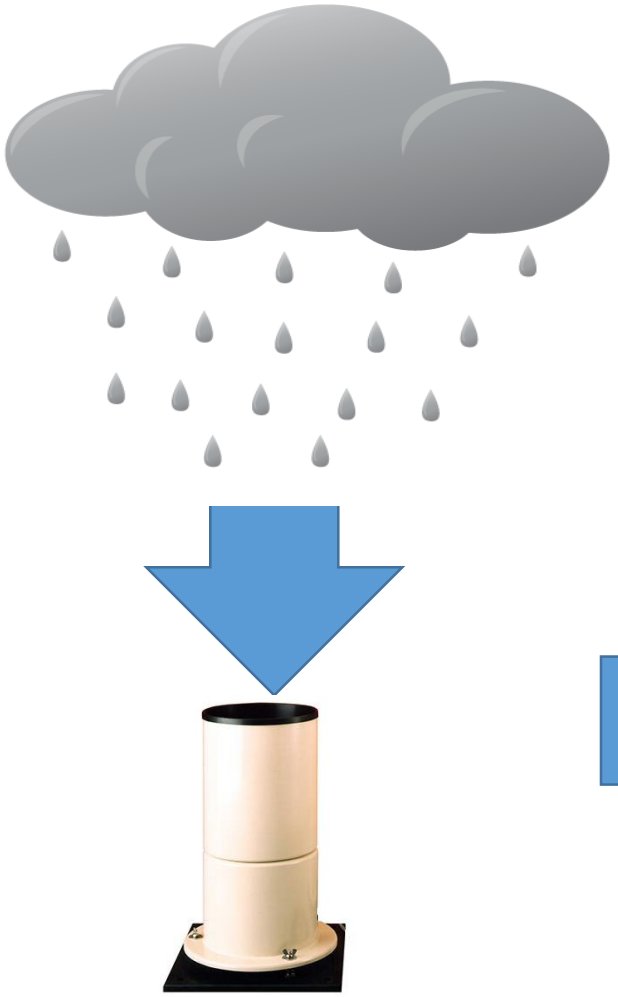
- **Rainfall is still the major input to water resources (with secondary contributions from other sources). In order to alleviate the above mentioned problems, we must be able to determine the rainfall distribution, as accurately as possible and to improve techniques for predicting it.**

Rainfall data are important for applications at different time-scales:

Short-term applications:	Medium-term applications:	Long-term applications:
• Weather forecasting • NWP model initialization • Water supply management • Flood control • Severe weather nowcasting • etc	• Rainfall annual and inter-seasonal variability • Agriculture • etc	• Climate change • Hydrological planning • etc

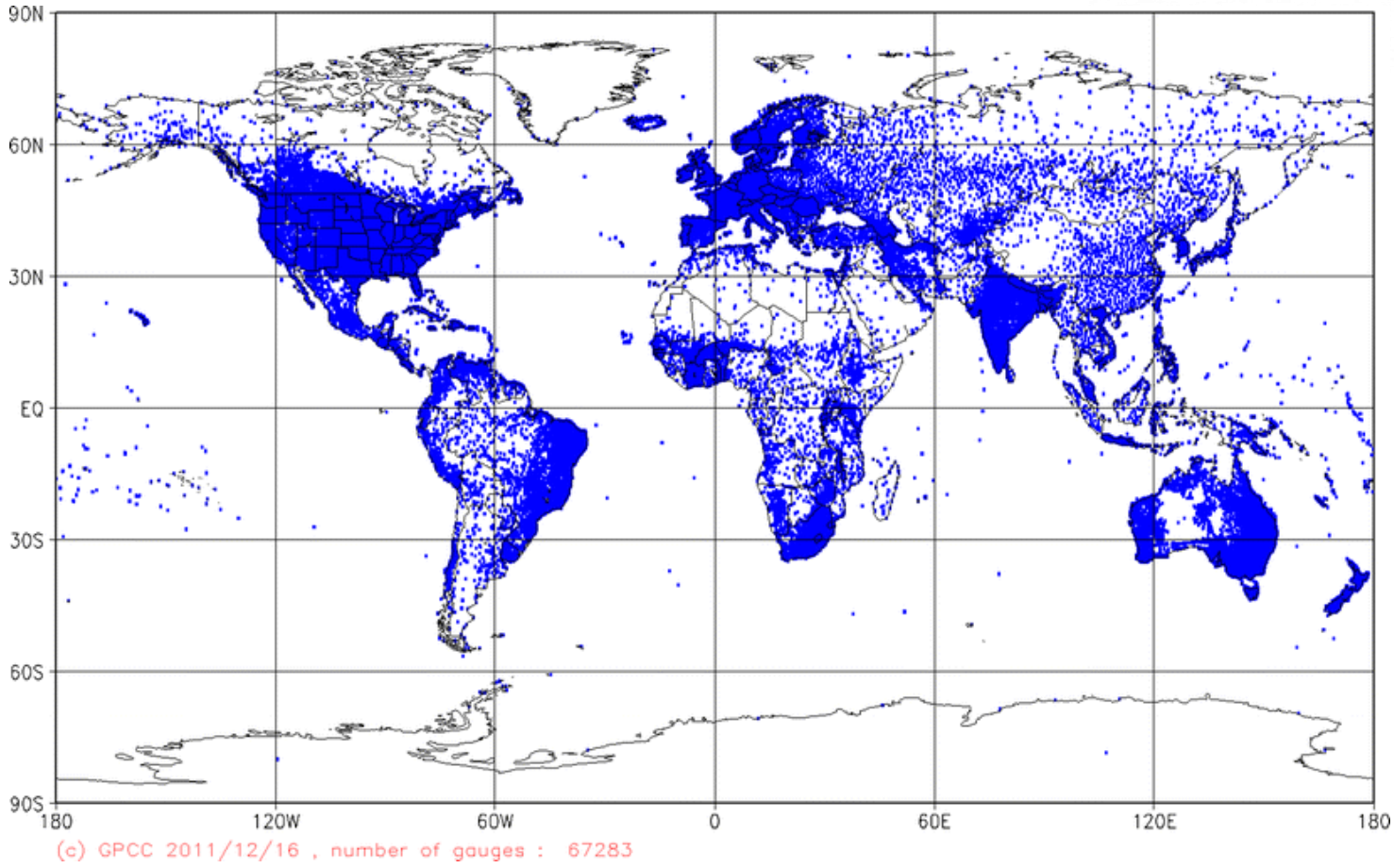
Traditionally Rainfall is measured *in situ* (at the ground) with rainfall measuring instruments: the raingauges.

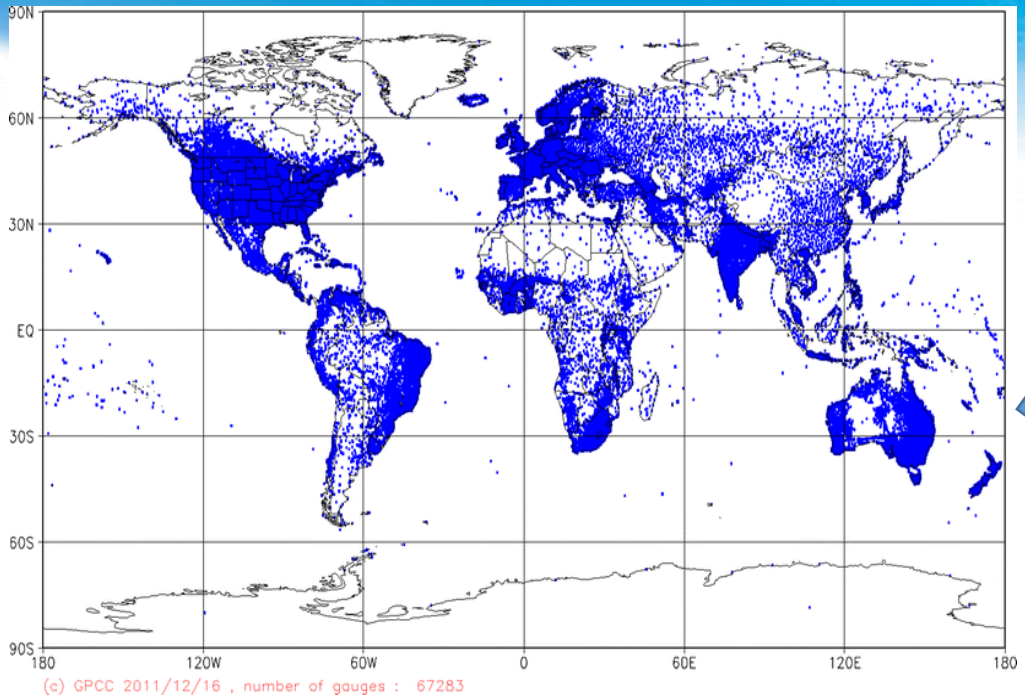
Raingauges are available in different shapes, materials and exposures



However, they all make use of the same principle: all raingauges collect rainfall falling on the surface of the Earth and measure the height of water collected in the gauge.

Each of these *in situ* rainfall measurements are taken individual locations, with about 70000 such collecting and measuring points around the World.





If you gather all of the World's rain gauges currently in use in one place they would cover an area only about the size of two basketball courts !!!

This is an unacceptably low coverage for the entire Earth's surface, if you wish to have a wide view of what is happening to all the water falling from the sky !!!

Other *in situ* (ground based) instruments for measuring rainfall include a small group of **disdrometers**. However, even the global-wise coverage by such instruments is far from satisfactory.

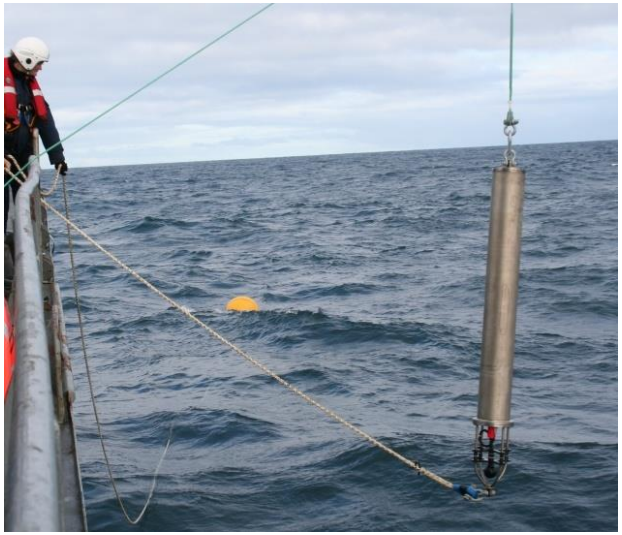
e.g., JOSS-WALDVOGEL disdrometer

Optical Parsivel disdrometer

To complete the picture of available instruments for *in situ* measurements of precipitation, it is worth mentioning ground-based weather radars….

….2 DVD Distrometers….

….and hydrophones.



However, you can't have a rain gauge or any of the sensors everywhere that rain can fall. Therefore, collecting global precipitation data from the ground is an impossible task (deserts, oceanic surfaces, polar regions are very poorly covered).

You need to put the measuring platform much higher, ideally in space.

In the past few decades, satellite precipitation measurement (estimation) has gone through, basically, two phases.

Satellite Platforms:

A. Passive Microwave (MW) sensors

- Initially, passive microwave techniques for the derivation of rain rates were used.

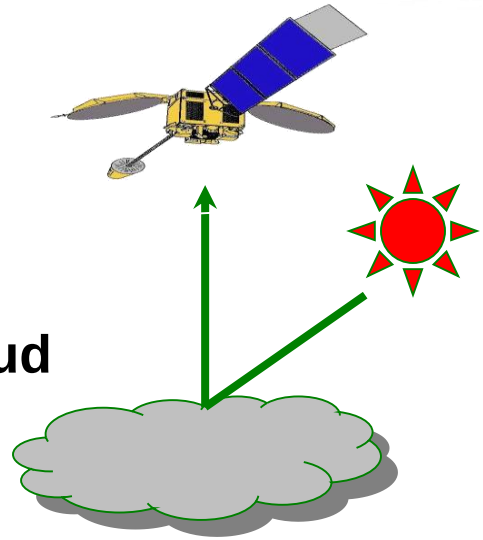
Satellite Missions with Microwave Measurements

DMSP - SSM/I, SSM/T, SSM/T-2
NOAA(17&18) – AMSU-A/AMSU-B
AQUA – AMSR-E
IRS-P4/Oceansat-1 – MSMR
ADEOS-II – AMSR
NPOESS – CMIS

The basic principle is: Rainfall at the Earth's surface is related to cloud properties observed from space (in the visible or infrared)

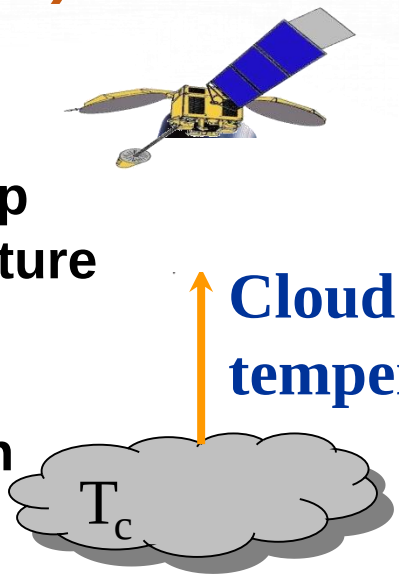
VIS

reflected (visible) sunlight from cloud



IR

cloud top temperature from emitted radiation



VIS/IR radiometers measure cloud-top properties. These properties are "translated" into rain rates using algorithms combining cloud properties, e.g., as above.

Examples of VIS/IR rainfall estimates

VIS reflectivity

Brighter (thicker clouds) => heavier rainfall
Dark => no rain

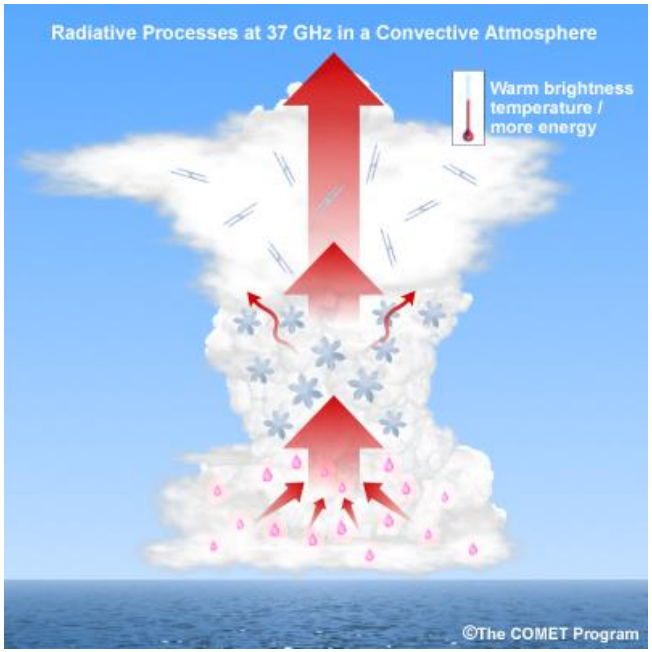
IR brightness temperature

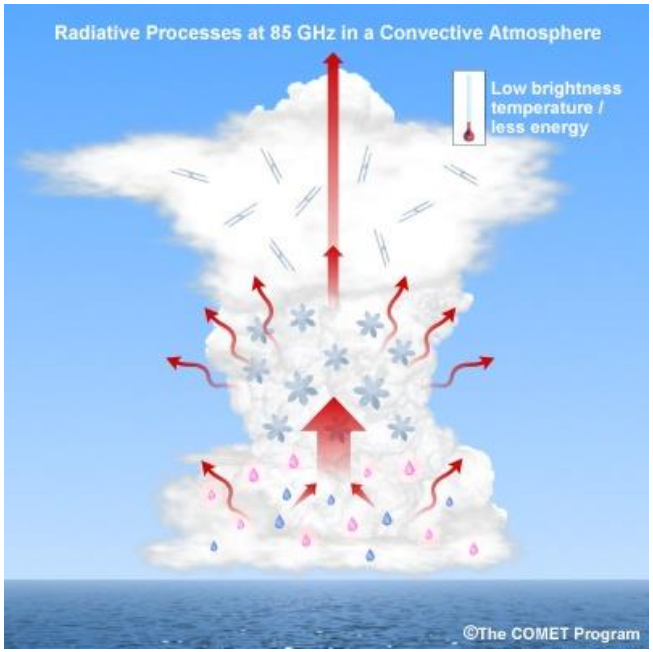
Colder (deeper clouds) => heavier rainfall
Warm => no rain

NIR brightness temperature

$|T_{NIR}-T_{IR}|$~0 (large drops or ice) => rain more likely
$|T_{NIR}-T_{IR}|$>0 (small water drops) => no rain

The basic principle is: rainfall at the surface is related to microwave emission from rain drops (low frequency channels) and microwave scattering from ice (high frequency channels):





Microwave emissions are "translated" into precipitation using algorithms combining cloud properties, e.g., as above.

Examples of microwave emissions

Low frequency (emission) channels - ocean only

Warm => many raindrops, heavy rain
Cool => no rain

High frequency (scattering) channels

Cold => scattering from large ice particles, heavy rain
Warm => no rain

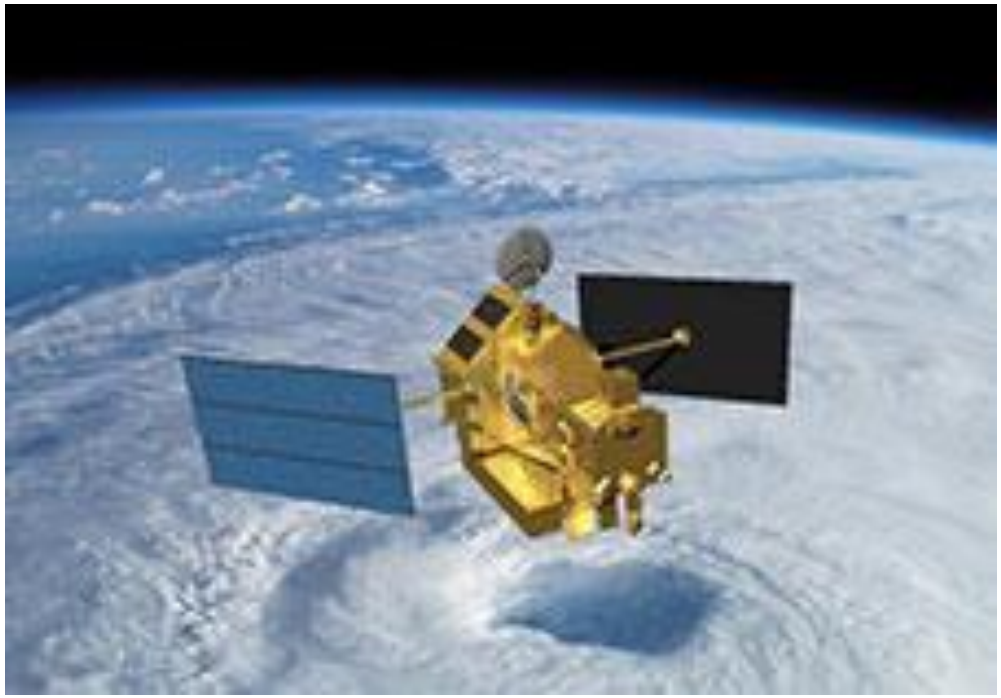
Satellite Platforms:

B. Active Microwave sensors

A major breakthrough in the satellite technology and precipitation science for measuring rainfall from space was TRMM (Tropical Rainfall Measuring Mission).

In this satellite mission, NASA (USA) worked with JAXA (Japan) to measure tropical and subtropical rainfall.

Tropical Rainfall Measuring Mission (TRMM)



A successful NASA – JAXA joint mission for measuring precipitation with the first space-borne precipitation radar, collecting tropical and subtropical precipitation data from 1997 until 2015.

Instruments aboard the TRMM

Precipitation Radar (PR).

The Precipitation Radar was the first space-borne instrument designed to provide three-dimensional maps of storm structure. The PR operated at 13.8 GHz and measured the 3-D rainfall distribution over land and ocean surfaces.

TRMM Microwave Imager (TMI).

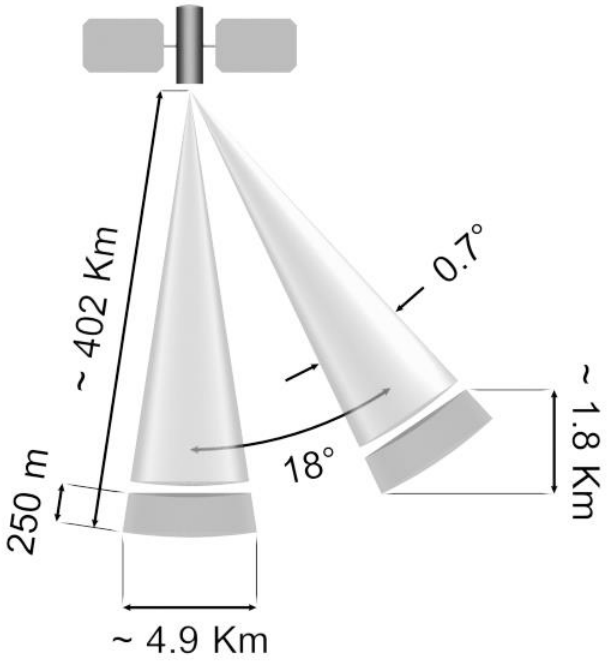
The TRMM Microwave Imager (TMI) was a passive microwave sensor designed to provide quantitative rainfall information over a wide swath under the TRMM satellite.

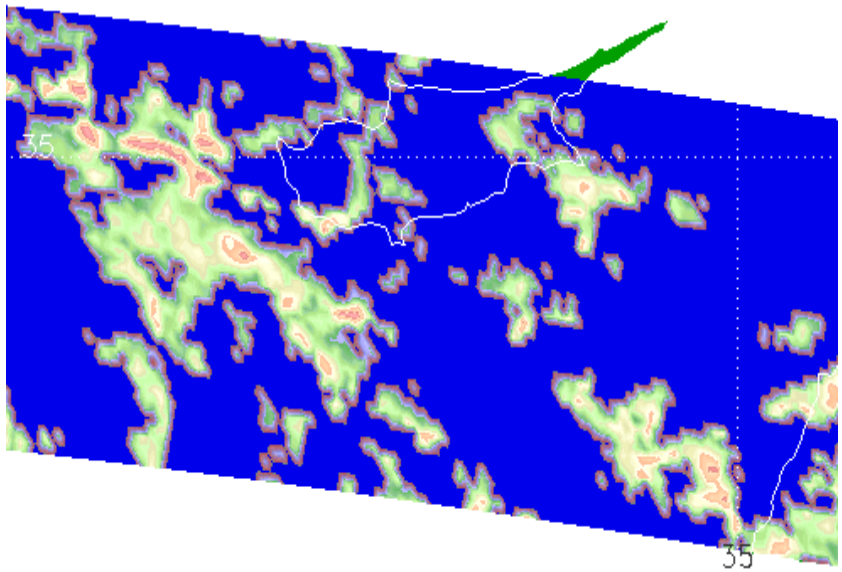
Clouds and the Earth's Radiant Energy Sensor (CERES).

Lightning Imaging Sensor (LIS).

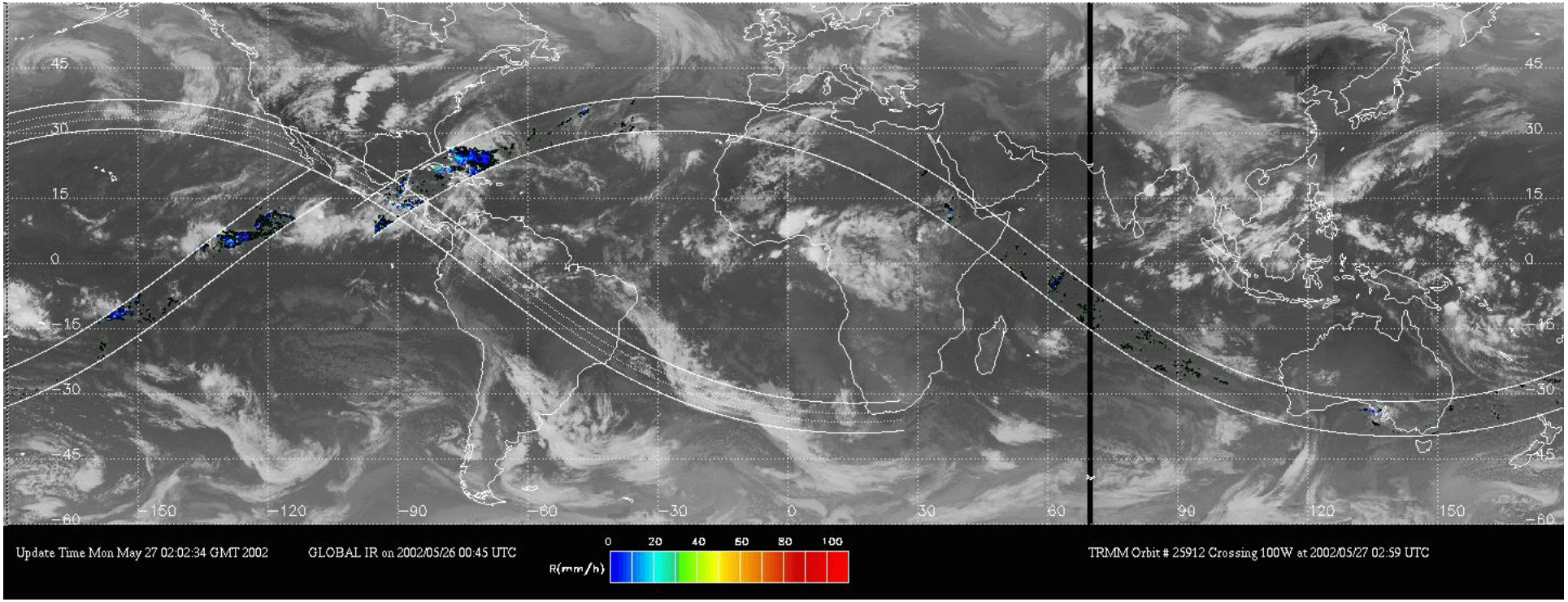
The Lightning Imaging Sensor was a small, highly sophisticated instrument that detects and locates lightning over the tropical region of the globe

TRMM overpass over Cyprus



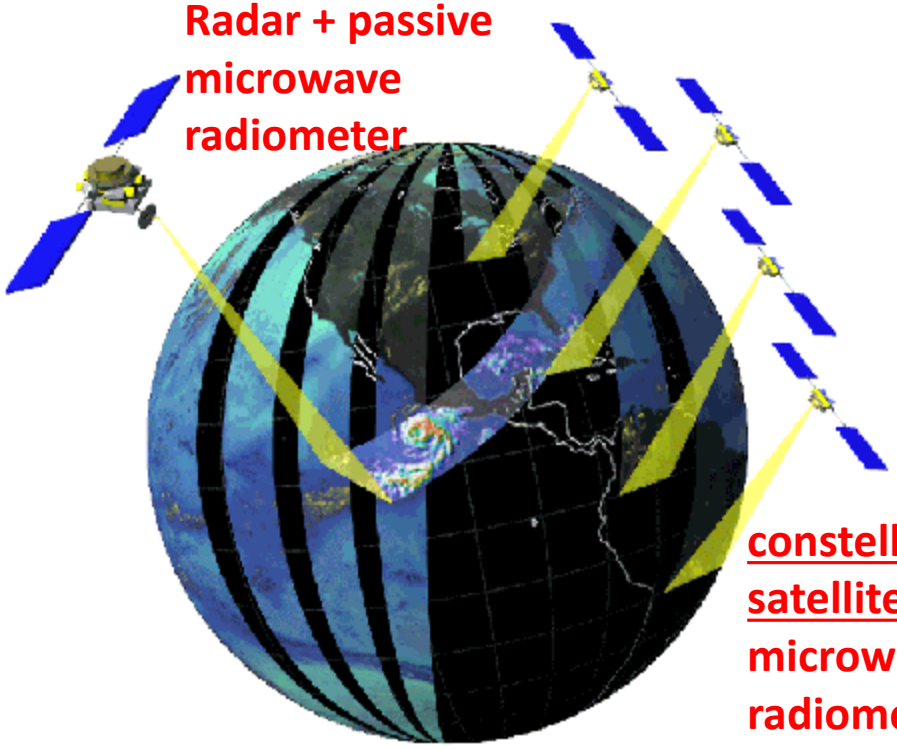


Tropical Rain Measuring Mission (TRMM) completed in 2015

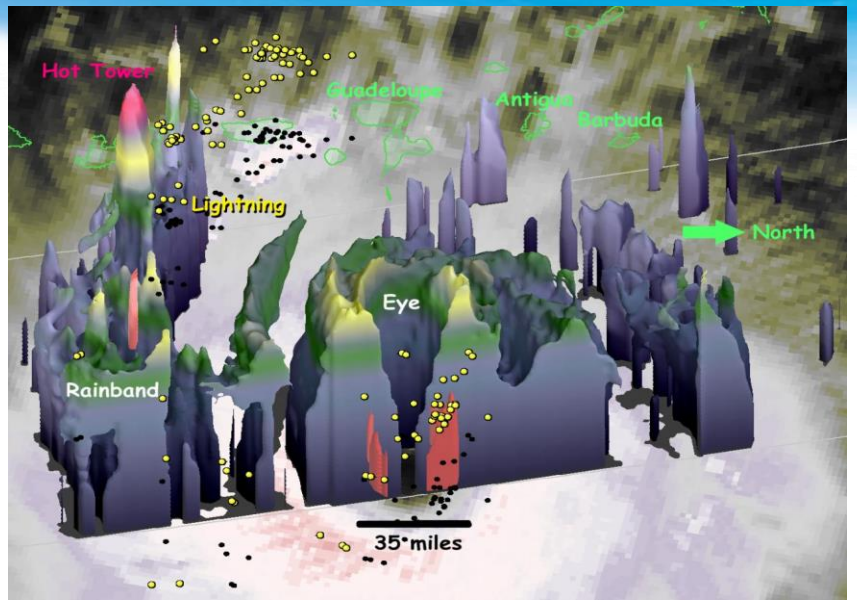


"Instantaneous" rain rate

Global Precipitation Measurement Mission (GPM) launched in February 2014



GPM's was built on the notable success of TRMM. In addition, to NASA and JAXA, the project embraces a consortium of international space agencies, including France's CNES, the Indian Space Research Organization (ISRO), the USA's NOAA, EUMETSAT, and others.



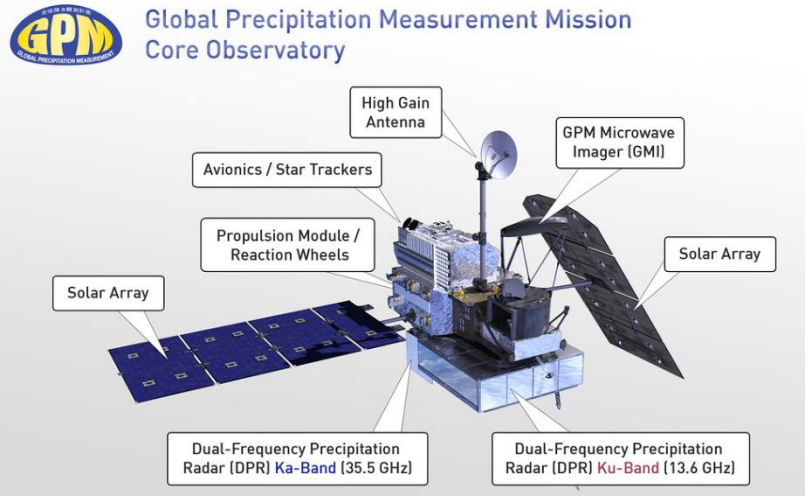
The GPM Mission consists of:

- a GPM Core Observatory satellite (below) at the core of the GPM is a platform built and launched by NASA and JAXA; it provides a new calibration standard for the rest of the satellite constellation;
- a constellation of spacecrafts from other agencies and missions.

Instruments aboard the GPM Core satellite:

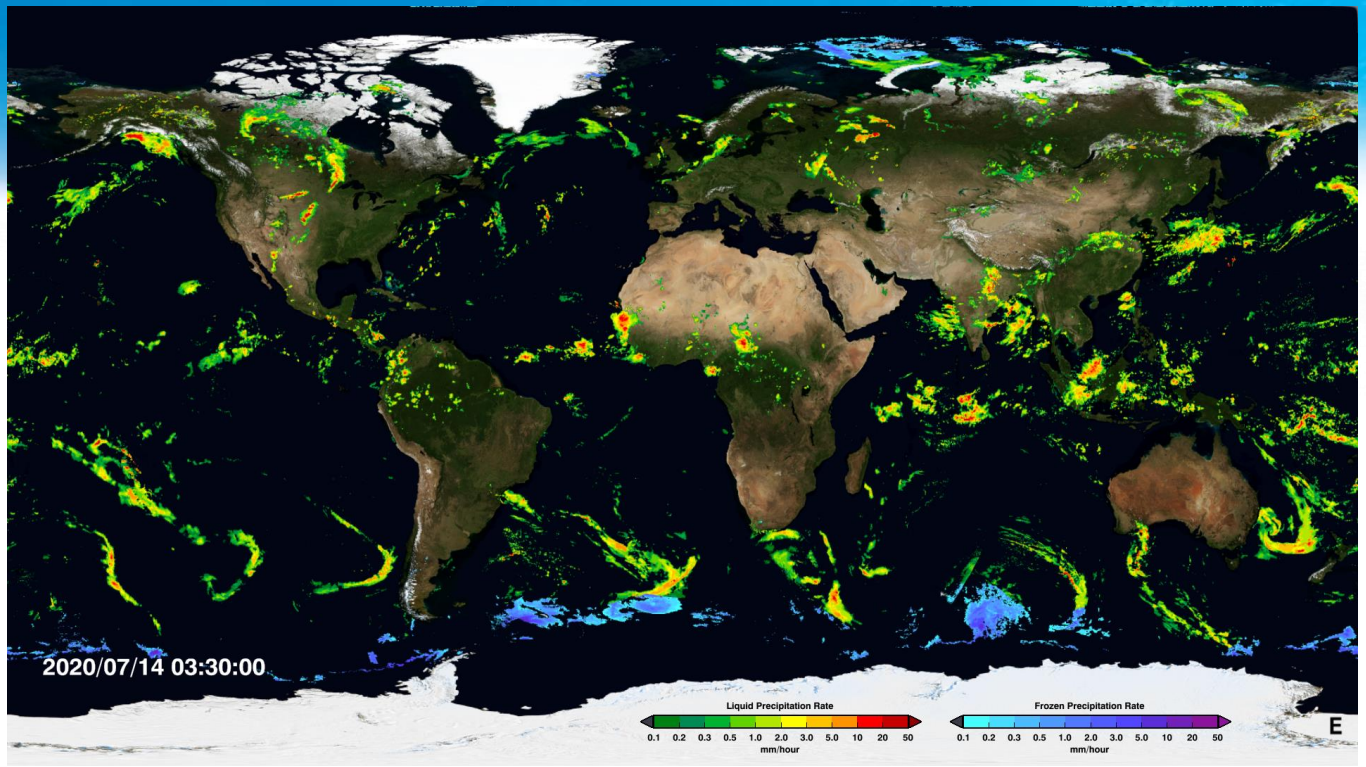
- Dual-Frequency Precipitation Radar (DPR): a spaceborne radar, providing three-dimensional maps of storm structure (above): a Ku-band radar and a Ka-band radar;

- GMI: GPM Microwave Imager



Although Tropical Rain Measuring Mission (TRMM) was terminated in 2015, currently, NASA is working on merging TRMM and GPM data into a single compatible data set (IMERG).

The IMERG dataset now includes TRMM-era data going back to June 2000. When completed, this unified satellite (and from other sources) precipitation database will comprise data from 1997 till to-day becoming a unique Global dataset with the highest spatial and temporal resolution, covering the needs of several applications.



Latest Half-hour of Earth's Precipitation (Yesterday's global view)

The Integrated Multi-satellitE Retrievals for GPM (IMERG) product combines precipitation observations using infrared and microwave sensors from a constellation of partner satellites, united by the GPM Core Observatory, to provide (near real-time) half-hourly precipitation estimates at 10km resolution for the entire globe.

Web page: https://pmm.nasa.gov/gpm/imerg-global-image

Ground Validation of Satellite data

Validation of the GPM data is an important aspect of the incorporation of such data into operationally useful applications, such as hydrology etc.

Cyprus is in an ideal position to contribute to GPM Ground Validation.

Participation of Cyprus to this effort will be pursued with a network of two X-band ground radars, around 40 automatic rain gauges, three disdrometers and around 140 daily reporting raingauges.

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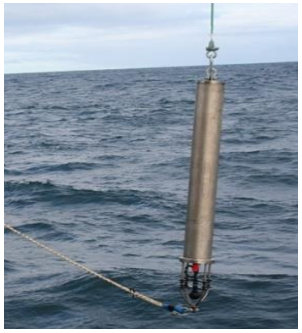
For a more comprehensive global view of Rainfall: Use all available platforms!

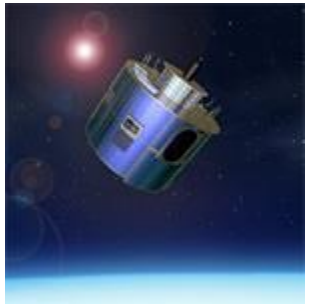
Ground radars

Hydrophones



Raingauges

Disdrometers



Geostationary satellites

Space borne Microwave radiometers

Space borne weather radars

THANK YOU FOR YOUR ATTENTION

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