

## Future cloud and precipitation observation mission

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The Tropical Rainfall Measuring Mission (TRMM) is Japan-US joint satellite mission that equips world first spaceborne precipitation radar (PR) as well as microwave imager (TMI) and has been producing very valuable precipitation data more than eleven years. This long term precipitation record from TRMM made it possible to provide not only the precise global precipitation amount but also improve the understanding the mesoscale tropical and sub-tropical weather system revolutionary. For example, diurnal cycles of rainfall is revealed by several studies using PR data both land and ocean. It is worth to note that the mesoscale climatology developed from PR data is used to evaluate the global cloud-resolving model such as NICAM. The follow-on mission of TRMM, which is called the global precipitation measuring (GPM) mission, is planned to start in 2014. GPM mission is consist of Core satellite which equips dual frequency (14 GHz and 35 GHz, the former is same frequency as TRMM/PR) radar to improve the estimation accuracy of rainfall and to observe the light rain and snowfall and constellation satellites which equip microwave radiometer to gain the sampling of precipitation. On the other hand, satellite cloud remote sensing started with optical sensors to estimate the effective radius of cloud and so on. In 2006, NASA's CloudSat satellite was launched to observe the cloud structure using 95-GHz cloud radar. CloudSat has been providing the vertical structure of clouds and even light rain and enables us to see the cloud and precipitation properties at the same time. In Japan, spaceborne cloud radar similar to the CloudSat but upgraded in terms of sensitivity, long life time and the additional Doppler capability is being developed for EarthCARE mission which is JAPNA-ESA joint program aiming to reveal the aerosol-cloud processes to realize more precise Earth radiation budget estimation using cloud radar and lidar.

Beyond the GPM and the EarthCARE targeting 2018, post-GPM mission is discussed under the GPM science team. First, scientific paradigm toward 2018 and beyond in discussed. For example, global water circulation and impact of global warming to the rainfall are recognized as very important study theme. In addition, long term accurate global rainfall record by spaceborne radar is also recognized as important. The importance of comprehensive and frequent of extreme events, especially for typhoons and hurricanes is pointed out. Based on these scientific requirements, sensor requirements are discussed and concluded the needs of both the cloud radar and the precipitation radar with Doppler measurement capability and wind measurements by Doppler Lidar. Alternative approach to the wind measurement is multiple satellites concept (e.g. train satellites) to see the development process of cloud-precipitation system by observing in a short time intervals. In the sensor requirement study phase, development item of the sensors are also summarized (e.g. pulse compression radar, scanning W-band radar). Base on the sensor requirements, several missions are proposed. For example, multiple satellite system is one of the solutions to fulfill the scientific requirements and the typhoon observation from geostationary orbit (it is recognized as the mission more than 10 years from now). With the help of JAXA's system engineering group, preliminary mission feasibility study was also performed. Based on these studies, detailed sensor study and trade-off will be done.