Scientific Aspects and Applications of the Tropical Rainfall Measuring Mission and its Follow-On Mission

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Solar heating of the Earth occurs mostly in the tropics, much of which is covered by ocean. Oceanic surface currents, such as the Atlantic Gulf Stream and the Pacific Kuroshio current, transport some of that heat away from the tropics to influence the climate at mid-latitudes. Oceans store heat in the summer and release it during the remainder of the year, so that oceanic heat moderates land temperatures, especially at mid-latitudes. When ocean surface currents fluctuate, as occurs during El Niño events, the climatic effects can be disastrous and widespread. The amount and rate of heat transferred between the Earth and atmosphere is determined by both conduction, which contributes about 2/3 of the total incident solar energy, and by evaporation which accounts for the remaining third. Water vapor, having absorbed heat from the evaporative process, can be transported far from the site of its origin.

Upon cooling, when moisture laden air is saturated and the vapor that it contained condenses, rain is produced and the heat that was originally used to evaporate the water from the Earth's surface is released into the atmosphere. The rate of energy release for each mm/hour of rainfall is three times as great as the solar energy (~350 Watts/m2) that falls on the same surface area. Thus the precipitation process concentrates heat that was used to evaporate moisture from large expanses of the tropics by factors of ten to a hundred into those regions where rain occurs. While solar heating of the atmosphere takes place mainly at the surface, the heat released by condensation occurs at high altitudes where it has a greater impact on the atmosphere's large scale circulation. Averaged over the entire Earth the heating released by precipitation is about five times greater than that produced by variations in surface heating.

Unfortunately, due to inaccessibility of tropical oceans, measurements of the global distribution of rainfall at the Earth's surface had uncertainties of the order of 50% and the global distribution of vertical profiles of precipitation was far less well determined. The need to understand tropical precipitation and our lack of existing accurate measurments have led to the development of the Tropical Rainfall Measuring Mission (TRMM).

The Tropical Rainfall Measuring Mission (TRMM), a joint project between the United States and Japan, and the first spacecraft designed to monitor rain over the tropics, was successfully launched from Tanegashima, Japan, on November 27, 1997. TRMM provides the first spaceborne rain radar, along with a 5-channel SSM/I-like passive microwave imager (TMI), an AVHRR-like visible-infrared radiometer (VIRS), a lightning sensor and a cloud sensor, to measure the vertical distribution of precipitation over the tropics in a band between ± 35_ in latitude. The specific science issues that TRMM will address includes:

1.frequency distributions of rainfall intensity and areal coverage;
2.the partitioning of rainfall into convective and stratiform categories;

3.the vertical distribution of hydrometeors (including the structure and intensity of the stratiform region bright band); and

4.variation of the timing of heaviest rainfall - particularly nocturnal intensification of large mesoscale convective systems over the oceans, and diurnal intensification of orographically and sea-breezed forced systems over land.

In this paper, we will discuss the scientific aspects and the applications of the TRMM and its Follow-On Mission. We will also present some of the early measurements obtained by TRMM.