Exploration with Passive Microwave Radiometers at JPL: Past, Present and Future

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Microwave radiometers measure natural thermal emission in the microwave portion of the electromagnetic spectrum, with most instruments operating in the range from 0.3-200 GHz. These instruments provide information on thermodynamic and constituent make-up of an observed volume. The Jet Propulsion Laboratory has been developing microwave radiometers since the early 1960s. The first microwave radiometer developed at JPL was for the Mariner 2 spacecraft, which explored the planet Venus in December of 1962. This radiometer, which operated at 16 and 22 GHz, allowed scientists to peer beneath the thick clouds to reveal that Venus has a hot surface. Subsequent to this, JPL led the development of many microwave radiometers for Earth science. The first radiometer developed by JPL for Earth science was the Scanning Multi-Channel Microwave Radiometer (SMMR), which flew on the Nimbus-7 satellite from October 1978 to December 1987. The SMMR instrument led to many advances in the field of microwave radiometry and it is recognized that the start of the passive microwave sea ice climate data record begins with its data. After SMMR, the Microwave Scanning Unit (MSU) and the Microwave Limb Sounder (MLS) were developed. MSU was the predecessor to the cross-track sounding instruments currently flown by NOAA that have been shown to have the most significant impact on weather forecast accuracy, among all data sources assimilated into the weather models. In 1992 the Topex/Poseidon ocean altimetry satellite was launched to measure sea surface topography using a radar altimeter, which included the Topex Microwave Radiometer (TMR) to correct for the propagation delay of the radar signal through the troposphere due of water vapor. This led to a family of altimeter radiometers that were developed from the late 1990s to present for the Jason series missions, with each successive generation improving upon the last. These advancements in radiometer technology enabled the development of the Juno Microwave Radiometer (MWR) system which is currently exploring the inner-depths of Jupiter's thick atmosphere and the Compact Ocean Wind Vector Radiometer (COWVR) system which provides measurements of the speed and direction of the wind over the surface of Earth's oceans. COWVR is an example of a new generation of small-satellite radiometer which could play an important role in the future Earth observation system. Other yet smaller systems under development include TEMPEST system which is intended to measure precipitation development with a tandem of 6U CubeSat systems. This talk will highlight the developments of the past and how they relate to on-going and future research in microwave radiometry at JPL. Along the way, key science resulting from the various instruments will be presented, ranging from the first ever time-continuous thermodynamic observations of a rapidly intensifying hurricane on Earth to observations enabling the understanding the deep circulation within Jupiter. Finally, prospects for the future of radiometry will be presented focusing on emerging technology trends and what small-satellite systems could mean for observing the Earth system like never before.