RETRIEVAL OF LATENT HEATING FROM TRMM MEASUREMENTS

BY W.-K. TAO, E. A. SMITH, R. F. ADLER, Z. S. HADDAD, A. Y. HOU, T. IGUCHI, R. KAKAR, T. N. KRISHNAMURTI, C. D. KUMMEROW, S. LANG, R. MENEGHINI, K. NAKAMURA, T. NAKAZAWA, K. OKAMOTO, W. S. OLSON, S. SATOH, S. SHIGE, J. SIMPSON, Y. TAKAYABU, G. J. TRIPOLI, AND S. YANG

TRMM-based latent heating products—not long ago considered out of our technological reach—are beginning to contribute to global modeling, but the necessary retrieval algorithms produce varying results and will require further research.

Precipitation, in driving the global hydrological cycle, strongly influences the behavior of the Earth's weather and climate systems and is central to their variability. Two-thirds of the global rainfall occurs over the Tropics,[1] which leads to its profound effect on the general circulation of the atmosphere. This is because its energetic equivalent, latent heating (LH), is the tropical convective heat engine's primary fuel source as originally emphasized by Riehl and Malkus (1958). At low latitudes, LH stemming from extended bands of rainfall modulates large-scale zonal and meridional circulations and their consequent mass overturnings (e.g., Hartmann et al. 1984; Hack and Schubert 1990). Also, LH is the principal energy source in the creation, growth, vertical structure, and propagation of long-lived tropical

[1] The Tropics are liberally taken as the area bounded by the 25°N–25°S latitude zone.

AFFILIATIONS: TAO, SMITH, ADLER, HOU, MENEGHINI, AND SIMPSON—Laboratory for Atmospheres, NASA Goddard Space Flight Center, Greenbelt, Maryland; HADDAD—NASA Jet Propulsion Laboratory–California Institute of Technology, Pasadena, California; IGUCHI AND SATOH—National Institute of Information and Communications Technology, Tokyo, Japan; KAKAR—NASA Headquarters, Washington, DC; KRISHNAMURTI—Department of Meteorology, The Florida State University, Tallahassee, Florida; KUMMEROW—Department of Atmospheric Science, Colorado State University, Fort Collins, Colorado; LANG—Science Systems and Applications, Inc., Greenbelt, Maryland; NAKAMURA—Hydrospheric Atmospheric Research Center, Nagoya University, Nagoya, Japan; NAKAZAWA—Japan Meteorological Agency, Meteorological Research Institute, Tsukuba, Japan; OKAMOTO AND SHIGE—Department of Aerospace Engineering, Osaka Prefecture University, Sakai, Osaka, Japan; OLSON—UMBC Joint Center for Earth Systems Technology, Baltimore, Maryland; TAKAYABU—Center for Climate System Research, University of Tokyo, Tokyo, Japan; TRIPOLI—Department of Atmospheric and Oceanic Sciences, University of Wisconsin—Madison, Madison, Wisconsin; YANG—School of Computational Sciences, George Mason University, Fairfax, Virginia
CORRESPONDING AUTHOR: Dr. Wei-Kuo Tao, NASA Goddard Space Flight Center, Code 613.1, Greenbelt, MD 20771
E-mail: tao@agnes.gsfc.nasa.gov

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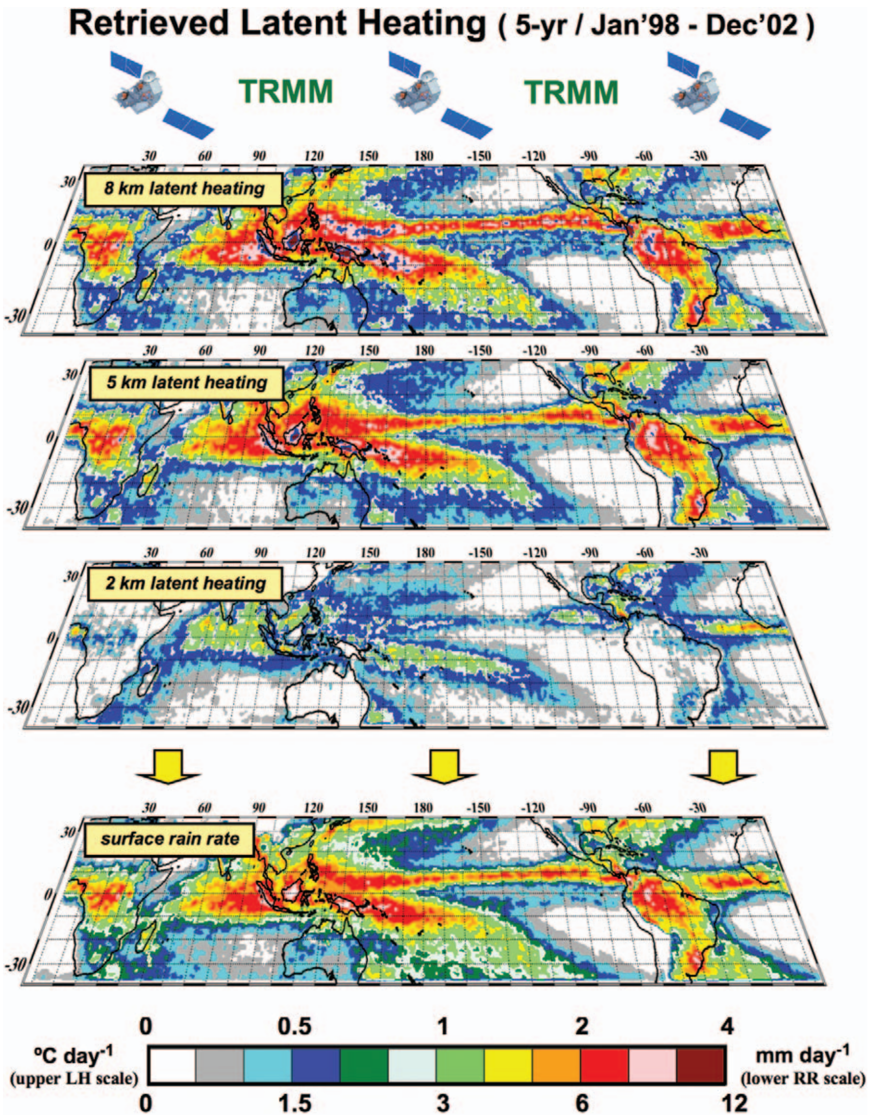

Fig. 1. (upper three panels) Five-year mean Q_l heating rates at 8, 5, and 2 km AGL (upper 3 panels) along with (bottom) surface rain rates over global Tropics determined by GSFC CSH algorithm applied to 1998–2002 PR measurements acquired from the TRMM satellite.

waves (e.g., Puri 1987; Lau and Chan 1988). Moreover, the distinct vertical distribution properties of convective and stratiform LH profiles help influence climatic outcomes via their tight control on large-scale circulations (Lau and Peng 1987; Nakazawa 1988; Sui and Lau 1988; Emanuel et al. 1994; Yanai et al. 2000; Sumi and Nakazawa 2002; Schumacher et al. 2004).

The purpose of this paper is to describe how LH profiles are being derived from satellite precipitation rate retrievals, focusing on those being made with Tropical Rainfall Measuring Mission (TRMM) satellite measurements. As an example, Fig. 1 provides an illustration of averaged patterns of LH determined from five years of TRMM measurements (1998–2002), mapped at three vertical levels (2, 5, and 8 km), along with the associated averaged surface rain-rate map (this diagram is discussed in detail in "Temporal and spatial averages").

The TRMM satellite is the centerpiece of a joint rainfall mission between the American and Japanese space agencies, the National Aeronautics and Space Administration (NASA) and the Japan Aerospace Exploration Agency [(JAXA); formerly the National Space Development Agency of Japan (NASDA)], providing the first high-quality rainfall and space–time structures of LH over the global Tropics and subtropics (see Simpson et al. 1996). The TRMM observatory was launched in November 1997, in a 350-km orbit inclined 35° to the Earth's equatorial plane (in August 2001, the orbit was boosted to ~400 km to preserve fuel by reducing atmospheric drag). The main rain instruments are JAXA's Ku-band Precipitation Radar (PR) and NASA's nine-channel TRMM Microwave Imager (TMI).

Studies of latent heat estimation from satellites date back to the first spaceborne passive microwave (PMW) rain radiometer [see, e.g., a study by Adler and Rodgers (1977) concerning total column LH within tropical cyclones]. Latent heating is that portion of diabatic heating that is either released or absorbed within the atmosphere as a result of the phase changes of water (i.e., from gas to liquid, liquid to solid, gas to solid, and their reverse processes). The related terms are condensation–evaporation, freezing–melting, and deposition–sublimation. Latent heating is dominated by phase changes between water vapor and small liquid or frozen cloud-sized particles. These processes are not directly detectable with current remote sensing or in situ instruments, which explains why the retrieval schemes to be discussed depend heavily on some type of cloud-resolving model (CRM).