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Hydrological assessment of TRMM rainfall data over Yangtze River Basin

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Abstract: High-quality rainfall information is critical for accurate simulation of runoff and water cycle processes on the land surface. In situ monitoring of rainfall has a very limited utility at the regional and global scale because of the high temporal and spatial variability of rainfall. As a step toward overcoming this problem, microwave remote sensing observations can be used to retrieve the temporal and spatial rainfall coverage because of their global availability and frequency of measurement. This paper addresses the question of whether remote sensing rainfall estimates over a catchment can be used for water balance computations in the distributed hydrological model. The TRMM 3B42V6 rainfall product was introduced into the hydrological cycle simulation of the Yangtze River Basin in South China. A tool was developed to interpolate the rain gauge observations at the same temporal and spatial resolution as the TRMM data and then evaluate the precision of TRMM 3B42V6 data from 1998 to 2006. It shows that the TRMM 3B42V6 rainfall product was reliable and had good precision in application to the Yangtze River Basin. The TRMM 3B42V6 data slightly overestimated rainfall during the wet season and underestimated rainfall during the dry season in the Yangtze River Basin. Results suggest that the TRMM 3B42V6 rainfall product can be used as an alternative data source for large-scale distributed hydrological models.

Key words: *Tropical Rainfall Measuring Mission (TRMM); satellite rainfall product; hydrological simulation; distributed hydrological model; Yangtze River Basin*

1 Introduction

Precipitation is the only way for water to enter the land phase of the hydrological cycle, a critical part of the atmospheric cycle and water cycle. It is important for hydrologists to

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understand the temporal and spatial distribution of the amount, rate, duration, and quality of precipitation (Browning 1990; Dingman 2002). As an input to a hydrological model, the accurate measurement of rainfall is an essential foundation for hydrological cycle research (Yu 2008). Because the temporal and spatial distribution of rainfall is uneven, it is difficult to determine how much rain actually falls across the earth, but this is the information we need if we want to be able to predict weather conditions, floods, and droughts. At present, there are three resources used to estimate rainfall: rain gauge stations, ground-based rainfall radar, and satellite remote sensing devices. In situ monitoring of rainfall is accurate and reliable, but is usually limited in its usefulness at the regional and global scale because of the high temporal and spatial variability of rainfall. The areal rainfall estimated by rain gauges exhibits a great deal of uncertainty where the rain gauge network is sparse (Collischonn et al. 2008). Thus, this method is not practical for most ocean and undeveloped land areas. Ground-based radar can be used to estimate the spatial distribution of instantaneous rainfall rates in clouds, which can be electronically integrated to provide estimates of total rainfall for any time period. The observation from the ground-based radar can reflect the temporal and spatial distribution of rainfall, while the area covered by the ground-based radar is limited and there is no perfect radar network for many regions. With the rapid development of remote sensing observation techniques in recent years, microwave remote sensing observations are appropriate for retrieving the temporal and spatial rainfall coverage because of their global availability and frequency of measurement. Various satellite rainfall products with different temporal and spatial resolutions are available (Arkin and Ardanuy 1989; Petty 1995; Xie and Arkin 1996; Todd et al. 2001; Boi et al. 2004; Brown 2006). Satellites have biases and random errors that are caused by factors such as the sampling frequency, the non-uniform field of view of sensors, and the uncertainties of the rain retrieval algorithms (Kummerow 1998; Anagnostou et al. 1999; Chang and Chiu 1999).

The Tropical Rainfall Measuring Mission (TRMM) is a joint mission of the U.S. National Aeronautics and Space Administration (NASA) and the Japan Aerospace Exploration Agency (JAXA). It is the first mission dedicated to measuring tropical and subtropical rainfall (Simpson et al. 1988; Kummerow et al. 1998). The data from TRMM can be used to find the location of rain as well as the rainfall intensity. TRMM was launched in November 1997, with an altitude of 350 km, which rose to 403 km in August 2001. It has a good coverage area, ranging from latitudes 50°S to 50°N, and a high temporal (3 h) and spatial (0.25° × 0.25°) resolution. TRMM carries a rainfall radar (PR), TRMM microwave imager (TMI), visible and infrared scanner (VIRS), lightning imaging sensor (LIS), and cloud and earth radiant energy system (CERES). The PR, VIRS, and LIS are the main instruments for rainfall retrieval (Kummerow et al. 1998; Cho and Chun 2008). One thing that should be mentioned is that the PR, which can provide three-dimensional rainfall distribution in an unprecedented way, may provide more accurate rainfall data than any previous space-borne sensor. The TRMM rainfall