Advancing the Use of Satellite Rainfall Datasets for Flood Prediction in Ungauged Basins: The Role of Scale, Hydrologic Process Controls and the Global Precipitation Measurement Mission

Faisal Hossain and Nitin Katiyar

Department of Civil and Environmental Engineering, Tennessee Technological University

1 Introduction

Floods account for about 15% of the total death toll related to natural disasters, wherein typically more than 10 million lives are either displaced or lost each year internationally (Hossain, 2006). Rainfall is the primary determinant of floods and its intimate interaction with the landform (i.e., topography, vegetation and channel network) magnified by highly wet antecedent conditions leads to catastrophic flooding in medium (i.e., $1000 \sim 5000\,\text{km}^2$) and large (i.e., $>5000\,\text{km}^2$) river basins. Furthermore, floods are more destructive over tropical river basins that lack adequate surface stations necessary for real-time rainfall monitoring – i.e., the ungauged river basins (Hossain and Katiyar, 2006) (see Figure 1, left panel).

However, flood prediction is becoming ever more challenging in these medium-to-large river basins due to the systematic decline of in situ rainfall networks world-wide. The gradual erosion of these conventional rainfall data sources has lately been recognized as a major concern for advancing hydrologic monitoring, especially in basins that are ungauged or already sparsely instrumented (Stokstad, 1999; Shikhlomanov et al., 2002). As a collective response, the hydrologic community has recently established partnerships for the development of space-borne missions for cost-effective, yet global, hydrologic measurements. The most pertinent example in the context of flood prediction is the Global Precipitation Measurement (GPM) mission for global monitoring of rainfall (Smith et al., 2007). Hence, there is no doubt that the hydrologic community as a whole will gradually become dependent on GPM for a substantial part of its rainfall data needs for hydrologic research and operational monitoring.

F. Hossain and N. Katiyar: *Advancing the Use of Satellite Rainfall Datasets for Flood Prediction in Ungauged Basins: The Role of Scale, Hydrologic Process Controls and the Global Precipitation Measurement Mission*, Studies in Computational Intelligence (SCI) **79**, 163–181 (2008)
www.springerlink.com

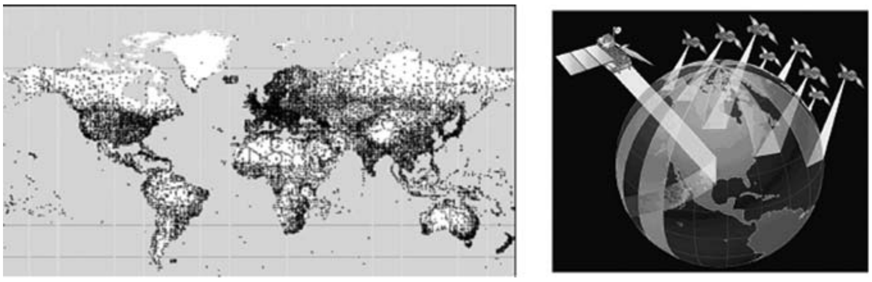

Fig. 1. Left panel – global distribution of in-situ rainfall gages showing the sparse and unevenness in the underdeveloped world (source: http://www.cpc.noaa.gov). Right Panel – Constellation of anticipated GPM satellites. The larger satellite on the left represents the core with a radar on board, while the rest carry polar orbiting PMW sensors (source: http://gpm.gsfc.nasa.gov).

GPM now beckons hydrologists as an opportunity to improve flood prediction capability in ungauged basins. However, before the potential of GPM can be realized, there are a number of hydrologic issues that must be addressed. Our success in leveraging the GPM to improve flood prediction will depend largely on the recognition of these issues and the feedback provided by hydrologists on the assessment of satellite rainfall data to the satellite data producing community (Hossain and Lettenmaier, 2006). The purpose of this chapter is to articulate these hydrologic issues that require further research and highlight the recent progress made in understanding them in the hope that satellite rainfall data can be used in hydrologic models more effectively in future.

2 Overview of Satellite Rainfall Remote Sensing and GPM

The heritage of GPM originated two decades ago when Infrared (IR) radiometers on geostationary satellites were launched to provide high resolution measurement (Griffith et al., 1978). While geostationary IR sensors have substantial advantages in that they provide essentially continuous observations, a major limitation is that the quantity being sensed, cloud top temperature, is not directly related to precipitation (Huffman et al., 2001). Subsequently, space-borne passive microwave (PMW) radiometers evolved as a more dependable alternative (in terms of accuracy) a decade later. PMW sensors work on the principle that naturally emitted radiation in the microwave frequencies greater than 20 GHz is dictated by the composition of atmospheric hydrometeors. PMW sensors are considered more accurate under most conditions for precipitation estimation over land than their IR counterparts.