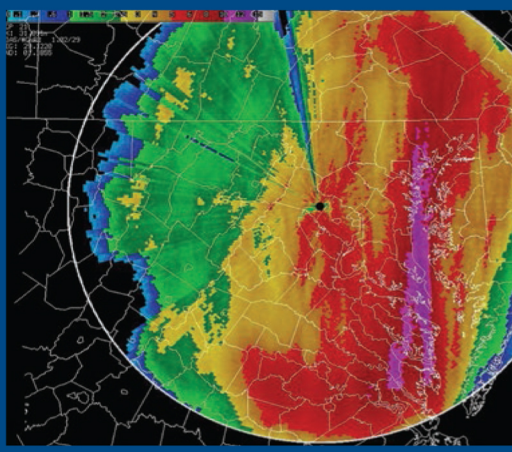
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Radar Rainfall Data Estimation and Use





Surface Water Hydrology
Technical Committee

Edited by
Chandra S. Pathak, Ph.D., P.E., D.WRE
Ramesh S. V. Teegavarapu, Ph.D., P.E.

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Prepared by the
Radar Rainfall Data and Application Task Committee of the
Surface Water Hydrology Technical Committee of the
Watershed Council of the Environmental and Water Resources
Institute of the American Society of Civil Engineers

Edited by
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PREFACE

This manual on radar rainfall data estimation was developed as one of the several tasks that was undertaken by the Radar Rainfall Data and Application Task Committee, under the Surface Water Hydrology Technical Committee within the Watershed Council of Environmental and Water Resources Institute's (EWRI), American Society of Civil Engineers (ASCE).

This manual was developed primarily for use by the practicing water resources engineers in the industry. This manual has nine chapters and their titles and authors are shown as follows.

Chapter 1: Radar Rainfall Estimation, Chandra S. Pathak (US Army Corps of Engineers);

Chapter 2: Radar Rainfall Data: Temporal and Spatial Characteristics, Chandra S. Pathak (US Army Corps of Engineers) and David C. Curtis (WEST Consultants);

Chapter 3: Radar Rainfall Data Processing, David Kitzmiller (National Weather Service);

Chapter 4: Evaluation and Improvement of Radar Rainfall Data, Ramesh S.V. Teegavarapu (Florida Atlantic University);

Chapter 5: Use of Radar Rainfall Data in Hydrologic Modeling, David C. Curtis (WEST Consultants);

Chapter 6: Examples in Radar Rainfall Data, Analyses, and Applications, Chandra S. Pathak (US Army Corps of Engineers);

Chapter 7: Advanced Topic: Framework for Bias Analysis of Radar Data, Ramesh S.V. Teegavarapu (Florida Atlantic University);

Chapter 8: Advanced Topic: Rain-Gauge Rainfall Data Augmentation and Radar Rainfall Data Analysis, Ramesh S.V. Teegavarapu (Florida Atlantic University);

Chapter 9: Advanced Topic: Design of Rainfall Monitoring Networks, Ramesh S.V. Teegavarapu (Florida Atlantic University).

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The authors wish to thank the following individuals for their reviews of this manual: Dr. Scott Huebner, P.E. (South Florida Water Management District); Mr. Michael DelCharco, P.E. (Taylor Engineering, Inc.); Mr. David Preusch, P.E. (WSP USA and formerly with WEST Consultants, Inc.); Dr. Thomas Evans (US Army Corps of Engineers); and Dr. Daniel Wright (University of Wisconsin—Madison and formerly with Princeton University).

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CHAPTER 1
RADAR RAINFALL ESTIMATION

1.1 INTRODUCTION

Radar-derived rainfall estimation is clearly one of the most significant recent advances in hydrologic engineering and practice. There is a trade-off in hydrologic modeling between using rainfall data collected by rain gauges and those collected by radar. Rain gauges provide point values of rainfall depth and intensity, but they are not cost-effective in providing information about the spatial distribution of rainfall. Although rain gauges might suffice for widespread rain events, a gauge network can miss localized convective rainfall events altogether. Radar-derived rainfall data provide a density of measurements that are not obtainable by rain gauges alone. Combining these two sensor systems produces better rainfall estimates that more accurately characterize rainfall over a watershed. Using rain-gauge–adjusted radar rainfall data, hydrologists have more information about rainfall rates at high resolution in space and time over large areas. Understanding radar rainfall estimation and estimation errors within a hydrologic modeling context have important advantages.

The *Journal of Hydrologic Engineering* has been publishing technical articles on radar rainfall since 1996. Through April 2013, it has published more than 150 technical papers, case studies, and technical notes on this subject. In February 2013, the *Journal of Hydrologic Engineering* published a special issue on "Radar Rainfall Data Analyses and Applications." This publication includes the most significant advances in hydrologic engineering practice on the subject. This special issue (Pathak 2013) has 17 technical papers grouped into four categories: (a) two papers are of radar rainfall data development methods, (b) six papers are on radar rainfall data improvement and validation, (c) four papers are on application of radar rainfall data, and (d) five

papers are on case studies. The reader is also directed to the special issue on radar rainfall and operational hydrology (Pathak et al. 2017) and a special issue on hydrologic applications of weather radar (Seo et al. 2015) for a compendium of papers on different issues ranging from radar estimation to applications for operational hydrology.

This manual is intended to provide a flexible framework within which both government agencies and private consulting firms can develop radar rainfall data sets and analyze them according to their varied goals and resources. The guidelines herein are not intended to provide a complete manual of all procedures available for estimating radar rainfall data and data analyses. The basic philosophy and principles are described in sufficient detail to promote a reasonable degree of consistency and uniformity among data developers and users to perform various tasks within the hydrologic engineering field.

We, the editors and the authors, sincerely hope that this manual on the topic of radar rainfall data analyses and applications is useful to researchers and practicing engineers alike as this discipline of hydrologic engineering progresses in the future. This manual was developed as a part of several tasks that were undertaken by the Radar Rainfall Data and Application Task Committee, under the Surface Water Hydrology Technical Committee within the Watershed Council of the Environmental and Water Resources Institute (EWRI) of ASCE.

1.2 BACKGROUND

1.2.1 Traditional Rainfall Estimation

Traditionally, rainfall has been and is measured by rain gauges—devices that record rainfall entering the gauge orifice. Gauge diameters generally range from 1 to 12 in. (2.54 to 30.48 cm) in diameter. Even the largest diameter gauge (12 in. or 30.48 cm) measures rainfall over only a tiny portion of a watershed (0.0000000282 mi^2 or 0.0000000730 km^2). With a relatively dense network density of one gauge per 10 mi^2 (26 km^2), rainfall is only measured in parts per billion.

Hydrologically, rainfall estimates at tiny points are not particularly valuable. By themselves, rain-gauge measurements represent very little volume. What is really needed are rainfall estimates over an entire watershed to accurately determine watershed volumetric inflow. To estimate rainfall over an area from point rain-gauge data, engineers and hydrologists use a variety of interpolation techniques to compute a rainfall "surface" over a watershed. The rainfall surface is then integrated over the watershed area during each time step to estimate the volumetric rate of inflow (Figure 1-1).