

# Weather Radar Polarimetry

Text by Dr. Guifu Zhang

**Richard Ice**

WSR-88D Radar Operations Center

NEXRAD Technical Advisory  
Committee

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# Weather Radar Polarimetry

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- Relevant Texts on Meteorological Radar
- Sources
- Content
- Focus on Chapter 5
  - Estimators
  - Clutter Identification and Filtering
- For Further Investigation - Chapter 7
- Discussion

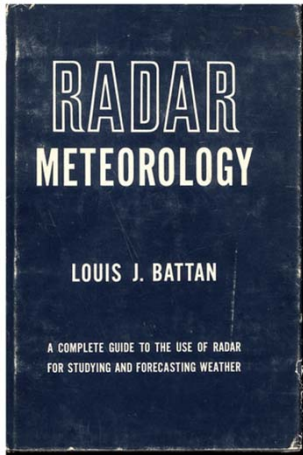
## Foreword by Doviak and Zrnic'

- “There are several texts describing the theory and application of weather radars including Doppler radars, but relatively few that focus on polarimetry”
- Based on Dr. Zhang’s course at OU offered by the School of Meteorology and the School of Electrical and Computer Engineering.
- “In Weather Radar Polarimetry Dr. Zhang takes a unique approach to teaching weather echo processing, polarimetric theory, and the application of theory to the interpretation of polarimetric weather radar observations.”

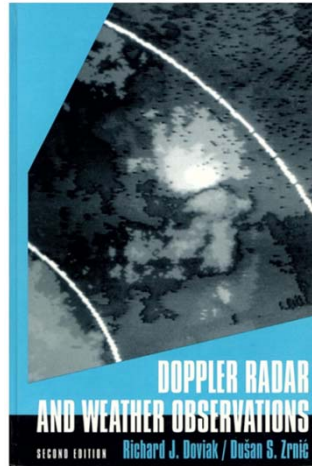
# Preface

- “...another set of measurements we can use to better study weather: polarimetric radar data (PRD).”
- “Although the technology of radar polarimetry has matured and PRD are available nationally and worldwide, radar polarimetry is still in its initial stages for operational use.”
- “...important to know principles of radar polarimetry and PRD estimation and ***improvement***, as well as information content, and ***error characterization***.”
- “...need for a textbook that meteorology students, scholars, and scientists can use to obtain this knowledge.”
- Supporting data and tools available
  - <http://weather.ou.edu/~guzhang/page/book.html>

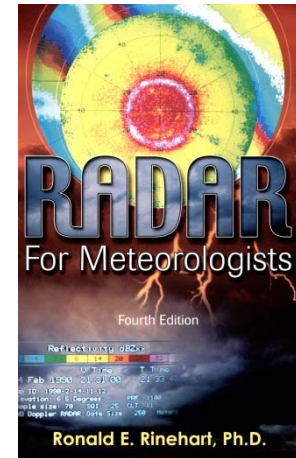
## Texts on Meteorological Radar Theory



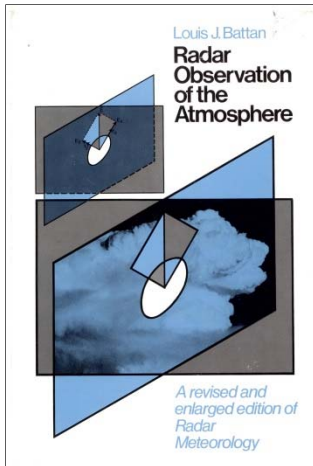
1959



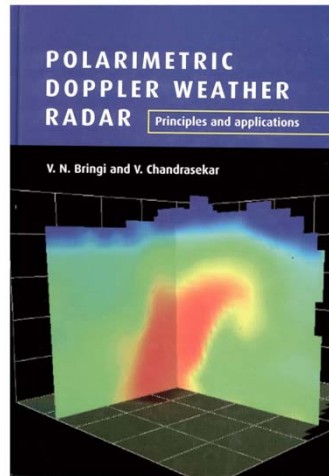
1993



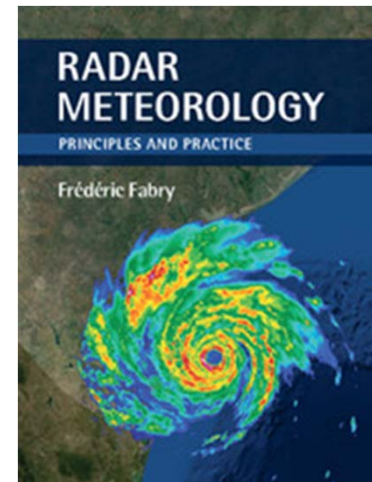
2004



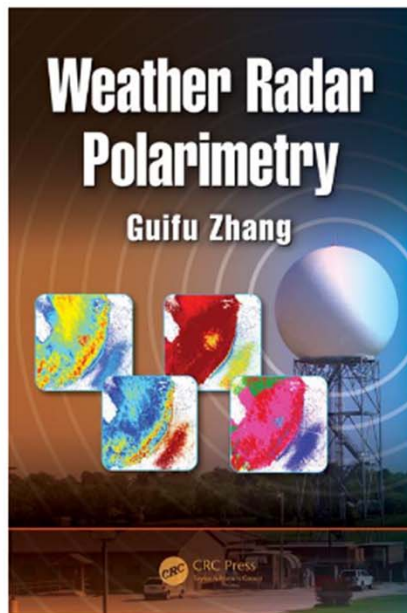
1973



2001



2015



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Guifu Zhang

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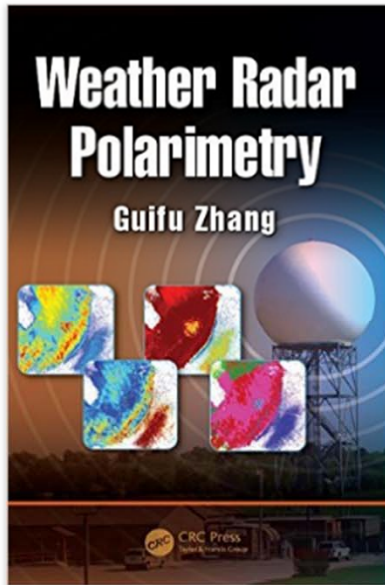
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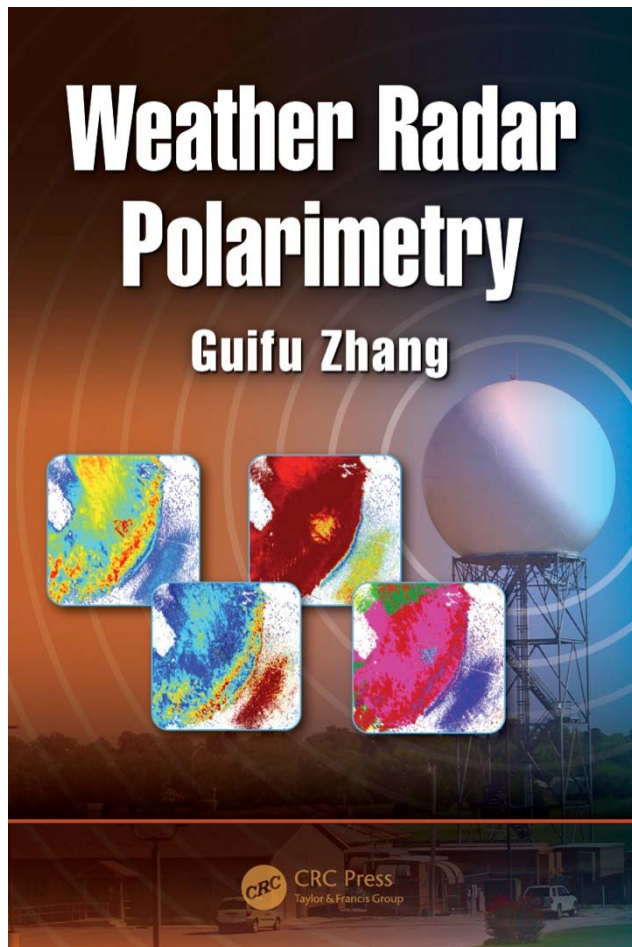
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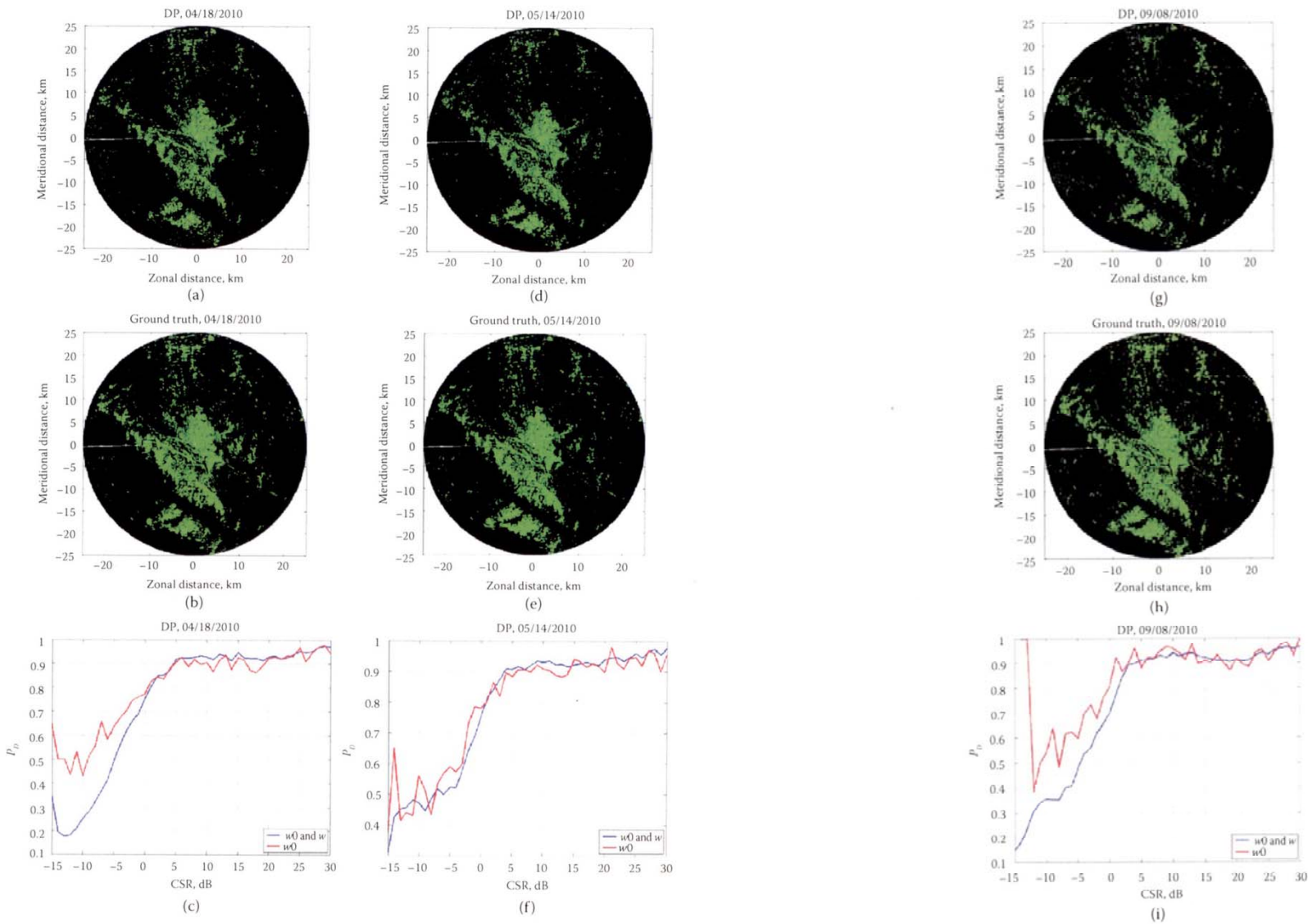


# Chapter 5 - Radar Measurements and Improvement of Data Quality

- 5.1 The Polarimetric Weather Radar System and Equation
- 5.2 Regular Estimation of Polarimetric Radar Variables
- 5.3 Multilag Correlation Estimators
- 5.4 Clutter Detection
- 5.5 Clutter Mitigation
- 5.6 Spectrum-Time Estimation and Processing

# Chapter 5 - Radar Measurements and Improvement of Data Quality

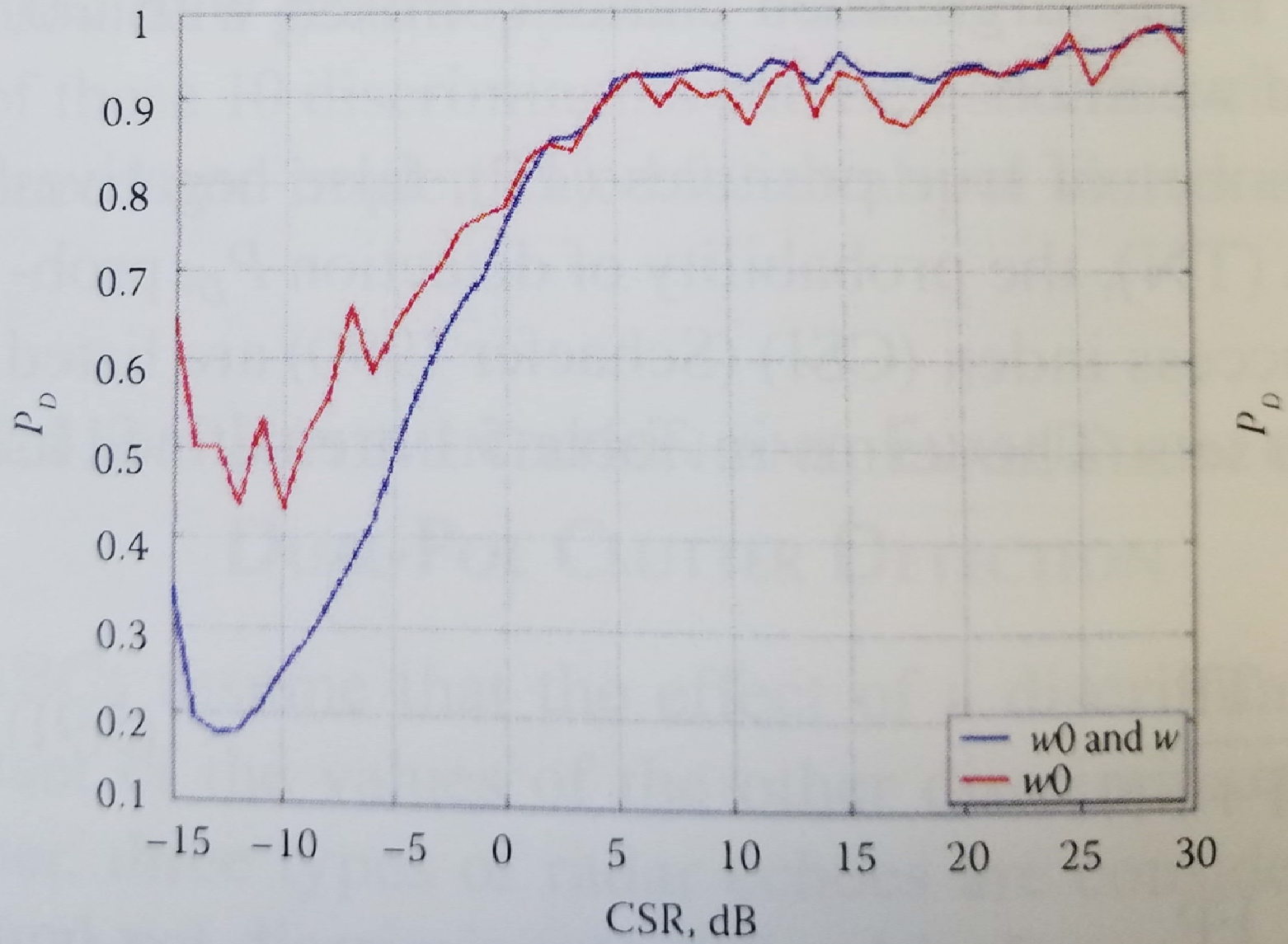
- Multilag Correlation Estimators
  - Reduce effects of noise component
  - Two-Lag Estimator
  - Three Lag Estimator
- Clutter Detection
  - Power Ratio Discriminant - “cousin” of CMD’s CPA
  - Dual Polarization Discriminants
  - Dual Scan Discriminant
  - Dual-pol Dual-Scan Discriminants (DPDS)
  - Simple Bayesian Classifier (SBC)
- Let’s look at Figure 11



**FIGURE 5.11** SBC-DP clutter maps (a, d, g) compared with the ground truth (b, e, h) for the three testing data.  $P_D$  as a function of CSR (dB) is shown in (c, f, i) for the three testing data. The blue line represents the performance of the SBC-DP in detecting ground clutter in the presence of both  $w$  and  $w_0$ , whereas the red line represents the performance in the presence of only  $w_0$ . (Continued)

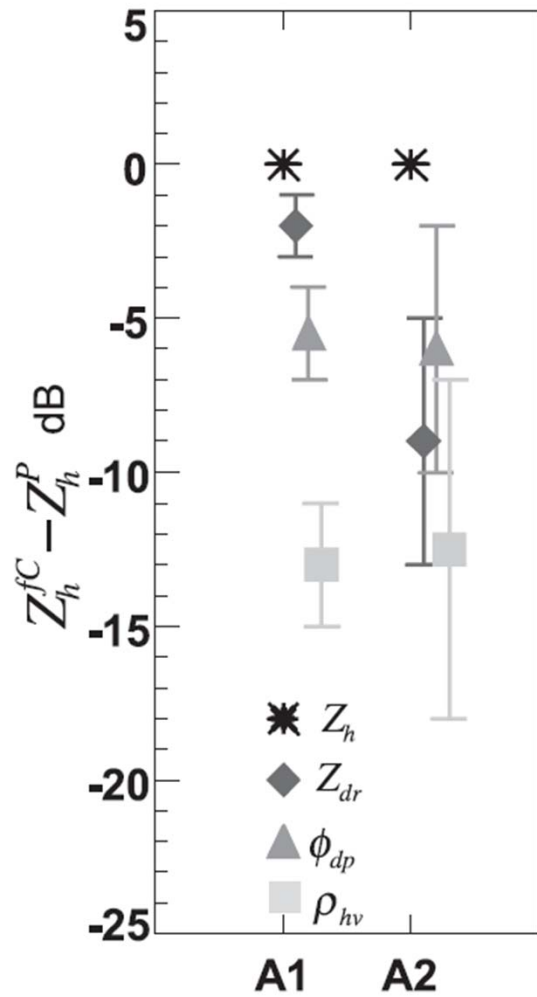
**FIGURE 5.11 (Continued)** SBC-DP clutter maps (a, d, g) compared with the ground truth (b, e, h) for the three testing data.  $P_D$  as a function of CSR (dB) is shown in (c, f, i) for the three testing data. The blue line represents the performance of the SBC-DP in detecting ground clutter in the presence of both  $w$  and  $w_0$ , whereas the red line represents the performance in the presence of only  $w_0$ .

DP, 04/18/2010

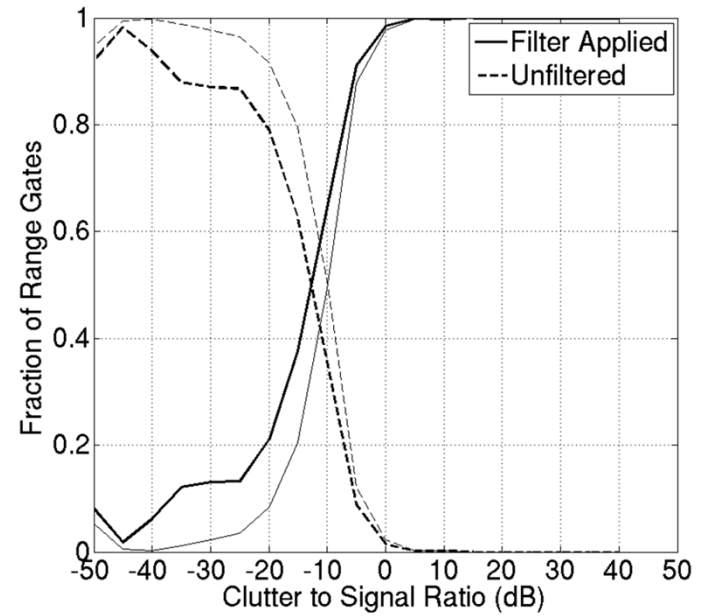


(c)

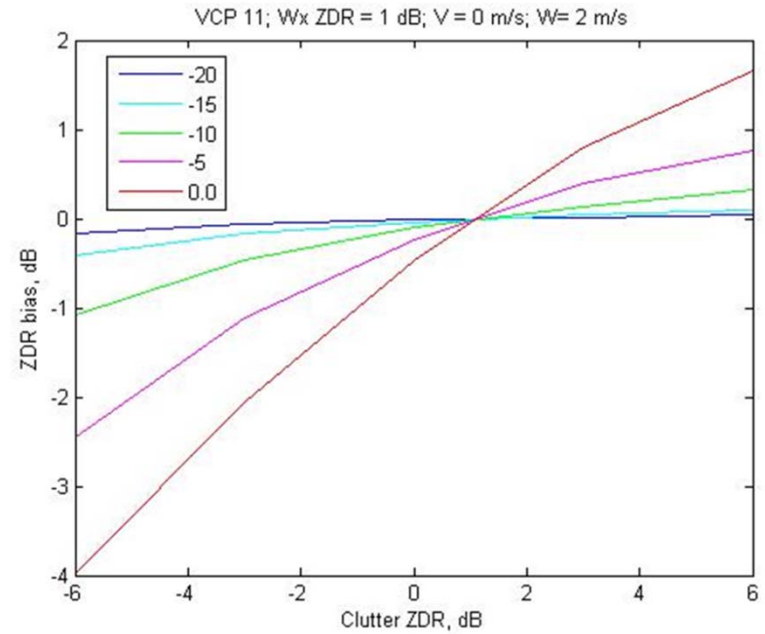
# Detecting and Removing Clutter is Critical for Polarimetric Variable Quality

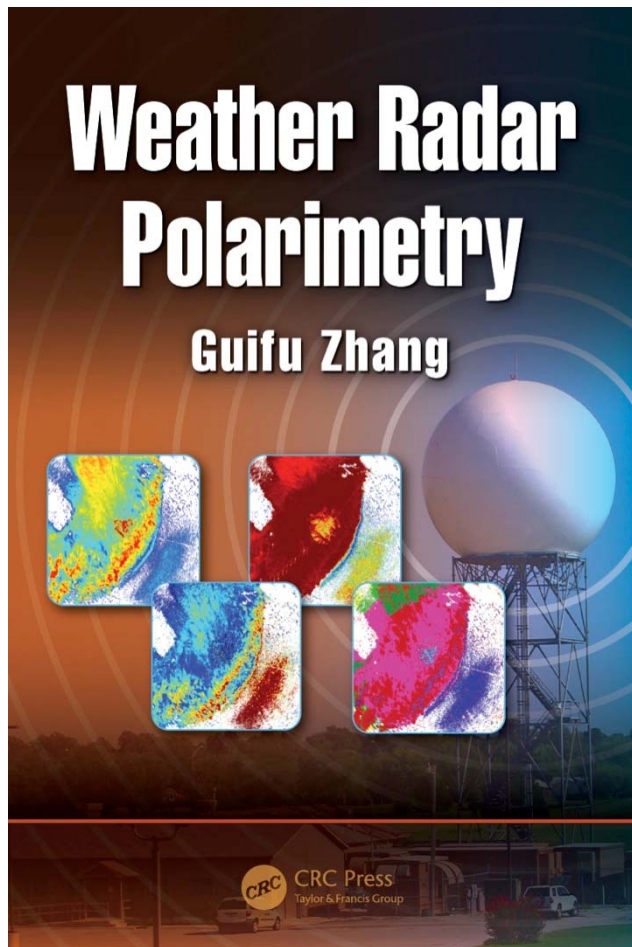


Friedrich, Germann and Tabary, 2009



Ellis and Hubbert, 2011





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# Chapter 7 - Advanced Methods and Optimal Retrievals

- 7.1 Simultaneous Attenuation Correction and DSD Retrieval
- 7.2 Statistical Retrieval of Rain DSDs
- 7.3 Variational Retrieval
- 7.4 Optimal Retrieval Through DA (*data assimilation*)

## For Further Study

- Lei, et al “Multilag Correlation Estimators for Polarimetric Radar Measurements in the Presence of Noise”, *Journal of Atmospheric and Oceanic Technology*, **29**, June 2012. (referenced)
- Ivic, “A Technique to Improve Copolar Correlation Coefficient Estimation”, *IEEE Transactions on Geoscience and Remote Sensing*, **54**, October 2016.
- Li, et al, “A New Approach to Detect Ground Clutter Mixed with Weather Signals”, *IEEE Transactions on Geoscience and Remote Sensing*, **51**, April 2013. (referenced)
- Li, et al, “Scan-to-Scan Correlation of Weather Radar Signals to Identify ground Clutter”, *IEEE Geoscience and Remote Sensing Letters*, **10**, July 2013. (referenced)
- Friedrich, et al “Influence of Ground Clutter Contamination on Polarimetric Radar Parameters”, *Journal of Atmospheric and Oceanic Technology*, **26**, February 2009.



# Discussion

- Dr. Zhang presents some concepts potentially useful to the NEXRAD program
  - Multilag estimators for other than CC
  - Clutter identification
  - Clutter ID performance evaluation
- Further investigation could be beneficial
  - DPDS, BGMAP - CMD, GMAP, CLEAN-AP
  - Look at Chapter 7 - Retrievals
- Future TAC presentation?
- Coordinate with NEXRAD Data Quality Team
- Radar Operations Center Engineering Change Proposal Team (ECP 0708) may want to investigate.