Environmental Controls on the Vertical Structure of Tropical Orographic Precipitation

Kimberly A. Reed and Stephen W. Nesbitt

Department of Atmospheric Sciences, School of Earth, Society, and Environment, University of Illinois at Urbana-Champaign

Introduction

This study seeks to investigate the vertical structure of tropical orographic precipitation using dynamic and thermodynamic variables that are known to influence precipitation mode and structure in regions of complex terrain where ground-based precipitation observations are limited or non-existent.

An understanding of the environmental controls behind the vertical structure of orographic precipitation will allow for an investigation into the role of the vertical structure on biases in orographic precipitation retrievals from spaceborne precipitation sensors.

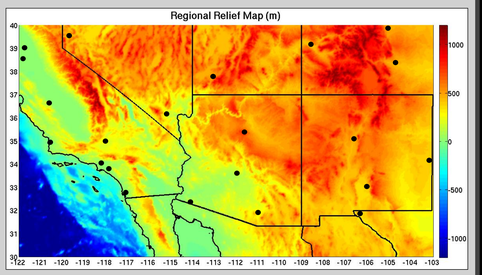
Data and Methods

Nine years (2002-2010) of warm season (JJA) dynamic, thermodynamic, and precipitation data were used to analyze the biases between spaceborne precipitation retrievals and ground-based observations in the complex terrain of the southern Rocky Mountains.

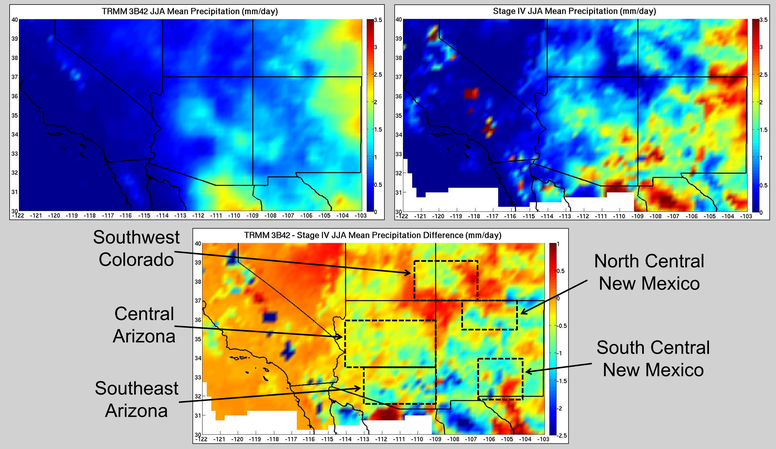
NCEP/EMC Stage IV hourly observational precipitation data composed of multiple sensors including ground-based radar precipitation estimates and rain gauge measurements were averaged into 3-hour time steps and regridded to 0.25° x 0.25° horizontal resolution to match the resolution of the spaceborne TRMM Multi-Satellite Precipitation Analysis (TMPA) 3B42 precipitation data set.

TRMM 3B42 and Stage IV mean rain rates were compared to identify subset regions in the complex terrain where large precipitation biases were present. The diurnal cycle and the probability density function of these regions were investigated to try to determine the source of the biases.

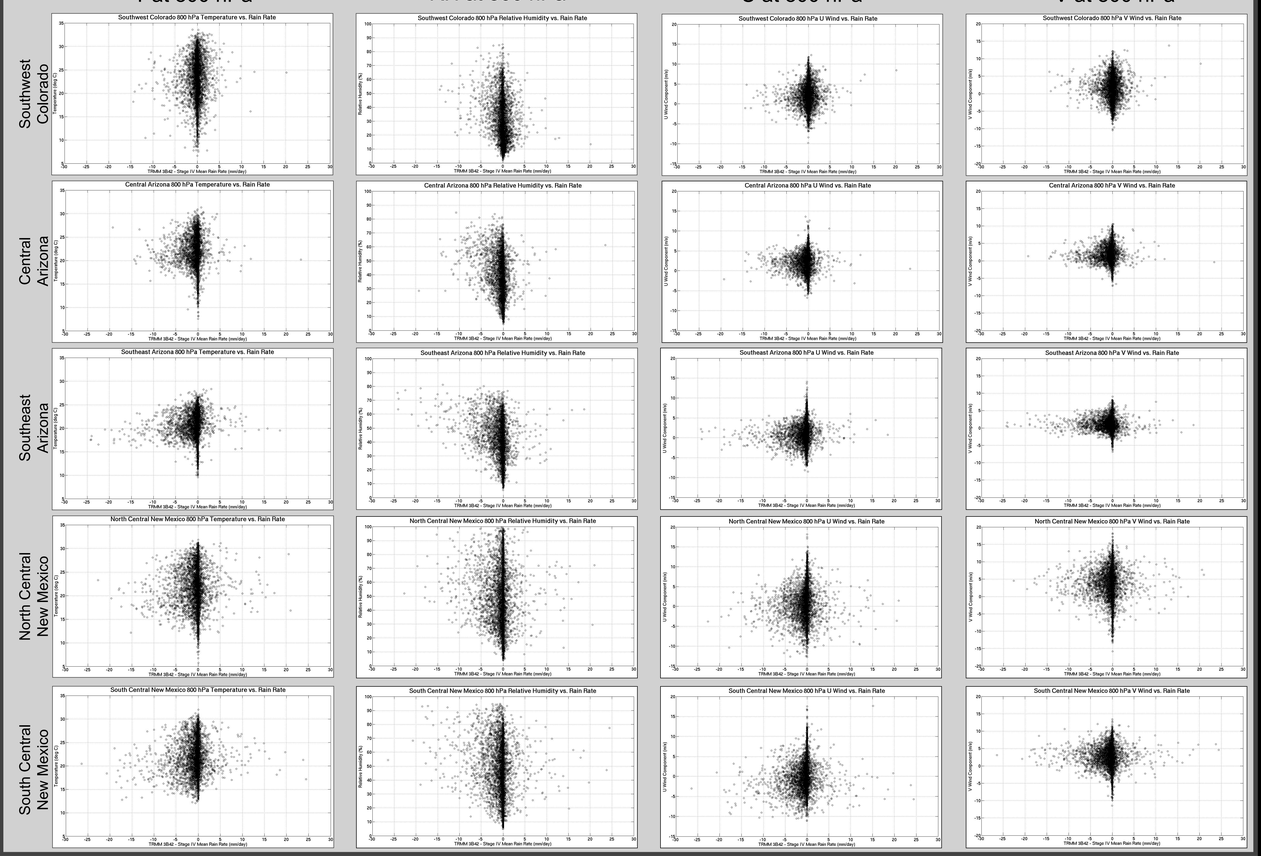
The subset regions were further analyzed using dynamic and thermodynamic variables including temperature, relative humidity, and u and v wind components from the NASA Modern Era-Retrospective Analysis for Research and Applications (MERRA) data set to investigate the impacts of the environmental controls on the retrieval biases.



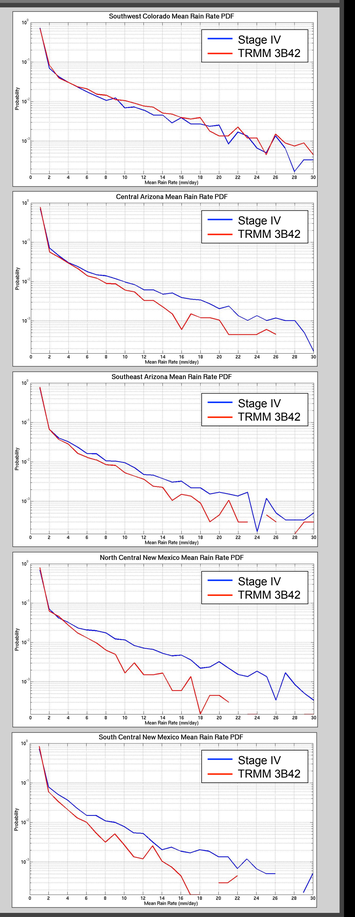
TRMM 3B42 vs. Stage IV Regions of Focus



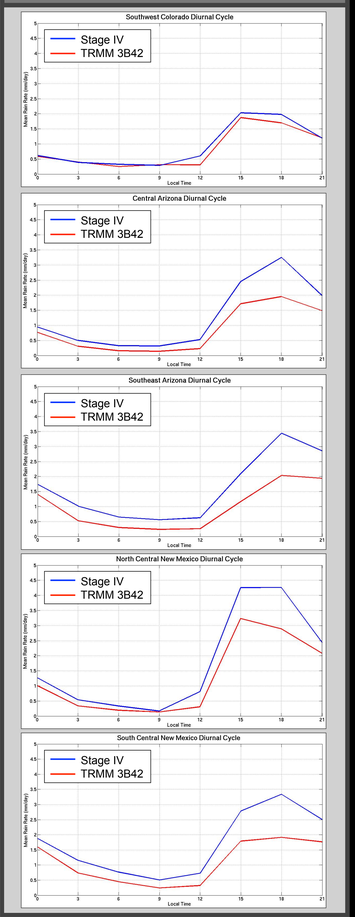
Environmental Controls vs. TRMM 3B42 - Stage IV Mean Rain Rate



PDFs



Diurnal Cycle



Conclusions

- There is relatively good agreement in the location of the precipitation between the TRMM 3B42 spaceborne retrievals and the Stage IV observations.
- The Stage IV data generally have greater rain rates in Arizona and New Mexico, while the TRMM 3B42 data show higher rain rates in Colorado and Utah.
- All of the subset regions show the greatest bias in rain rate occurring at the time of peak precipitation in the diurnal cycle, which is consistent with the PDFs which show that the biases in rain rate increase significantly as the rain rate increases.
- Temperature and relative humidity seem to play a role in the rain rate biases in some regions, while having less of an impact in other regions.
- Both the u and v wind components seems to have an important role in the rain rate biases in all regions with TRMM 3B42 retrievals significantly underestimating when wind speeds range between 0-5 m/s.

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