TRMM precipitation from extreme storms in South America: Bias and climatological contribution

Kristen L. Rasmussen, Robert A. Houze, Jr., Manuel D. Zuluaga, Megan Chaplin, Stella Lina Choi

★ *Department of Atmospheric Sciences, University of Washington, Seattle, WA* ★

AGU Poster H33E-1436; 11 Dec 2013

Introduction

- **TRMM satellite observations have led to the realization that intense deep convective storms just east of the Andes in subtropical South America are among the most intense anywhere in the world (Zipser et al. 2006)**

South American MCSs:

→ **~ 60% larger than those over the United States (Velasco and Fritsch 1987)**

→ **Larger precipitation areas than those over the United States or Africa (Durkee et al. 2009)**

→ **Highest frequency of large hail globally (Cecil and Blankenship 2012)**

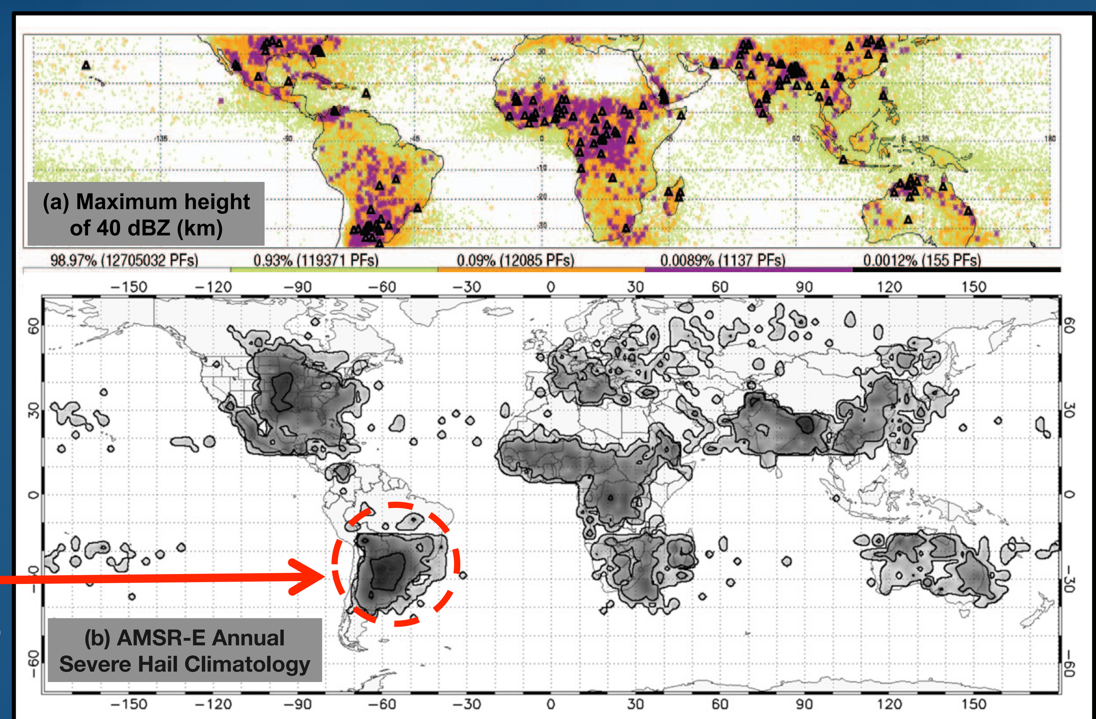
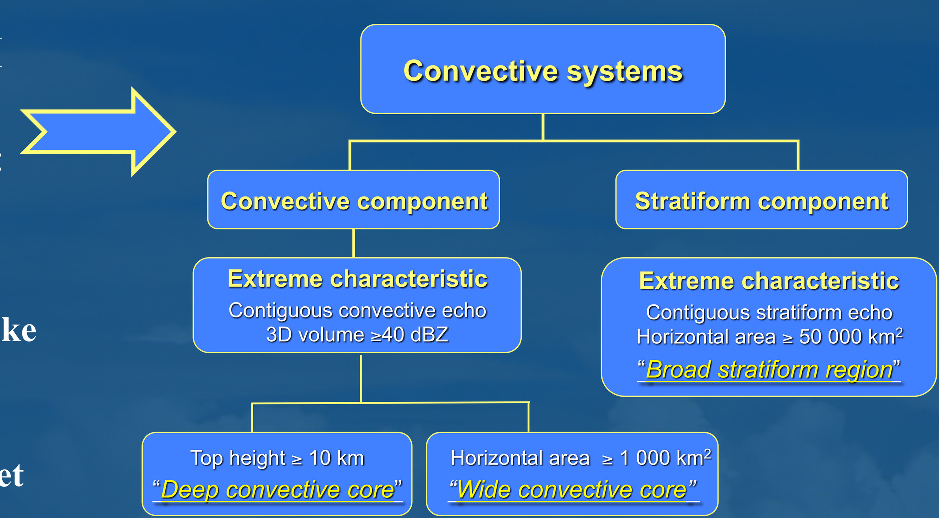


Figure 1. (a) Locations of intense convective events using the color code matching their rarity from Zipser et al. (2006). (b) AMSR-E annual severe hail (>1 in. diameter) climatology from Cecil and Blankenship (2012).

Background

UW methodology to separate TRMM Precipitation Radar (PR) echoes into three storm types (Houze et al. 2007): *deep convective cores, wide convective cores, and broad stratiform regions*

- **South Asia: Houze et al. (2007), Romatschke et al. (2011a, b), Rasmussen et al. (2013)**
- **South America: Romatschke et al. (2010), Rasmussen and Houze (2011), Rasmussen et al. (2013)**



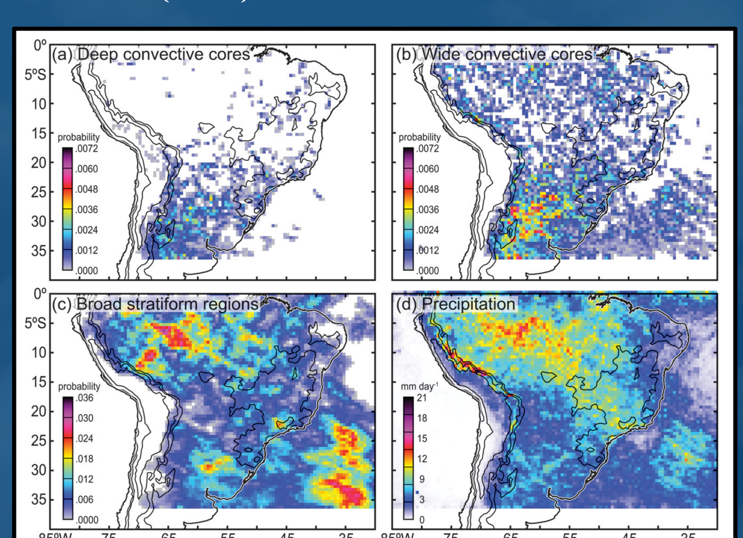


Figure 2. Locations of storm types in South America derived from TRMM PR data. From Romatschke and Houze (2010)

Storm evolution hypothesis :

- ***Deep convective cores* initiate along Andes foothills and secondary topographical features**
- **Convection grows upscale, develops *wide convective cores*, and moves eastward**
- **Decaying convective elements move farther eastward and develop *broad stratiform regions***

TRMM Precipitation Bias

- Our aim is understanding the rainfall from **extreme** convective storms globally
- TRMM PR rainfall algorithm underestimates precipitation from deep convection over land (Iguchi et al. 2009)

Need to mitigate this bias → Use a traditional Z-R method

- **Precipitation comparison using two methods:**
  - TRMM 2A25 near-surface rain from the V7 PR algorithm
  - Traditional Z-R technique using parameters defined for subtropical land regions

The deeper the convection, the greater the rain bias

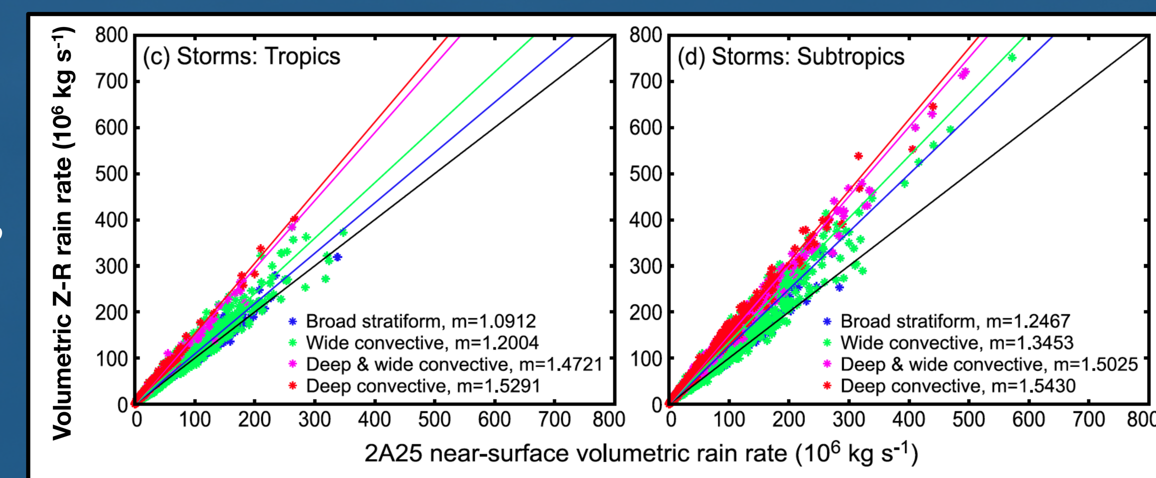


Figure 7. Volumetric rain rate comparisons for TRMM-identified storm types in (a) tropical and (b) subtropical South America.

The bias is greater for storms with deeper echo tops and with significant mixed phase hydrometeors (Rasmussen et al. 2013)

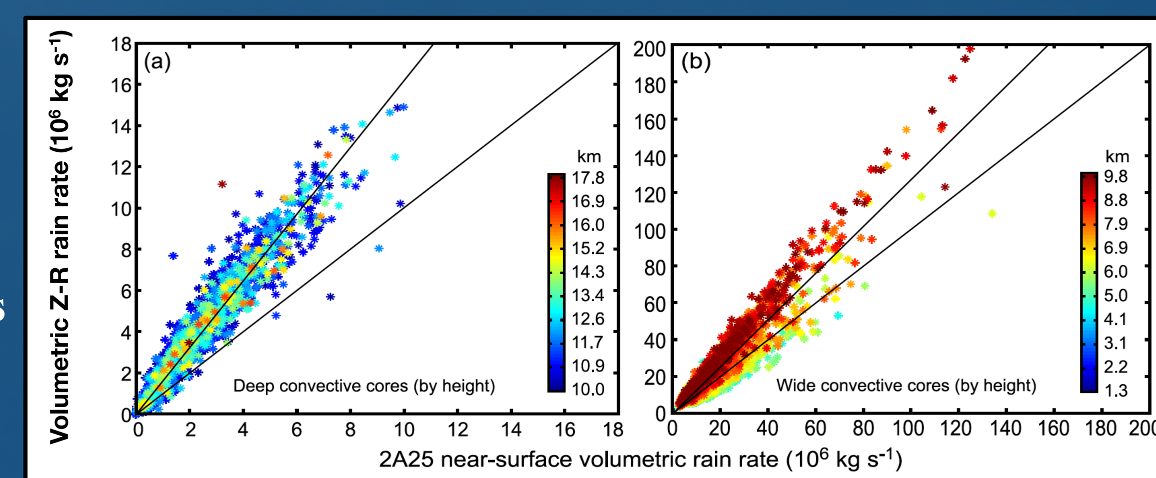
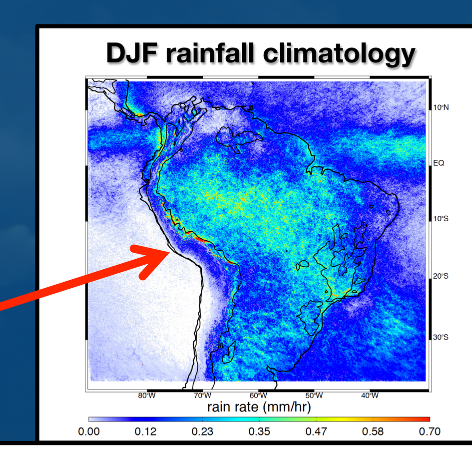


Figure 8. Volumetric rain rate comparisons for TRMM-identified storms shaded by the altitude of the 40 dBZ echo. (a) Deep convective cores and (b) wide convective cores

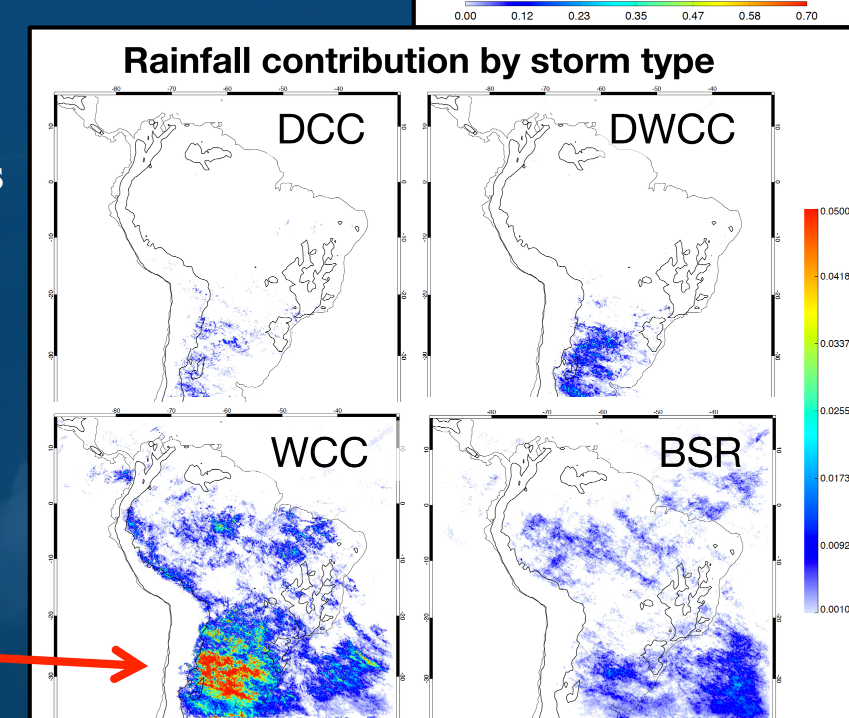
★ Significant implications for TRMM PR precipitation estimation and hydrological applications over land ★

Climatological Rainfall Contribution

- **A quantitative approach is employed to investigate the role of the most extreme precipitating systems on the hydrological cycle in South America**
- **Hotspots of total precipitation along the tropical Andes foothills tend to be from non-extreme echoes**



- **Subtropical S. America experiences frequent mesoscale convective systems (MCSs)**
- **TRMM-identified storms approximate the MCS lifecycle**
- ***Profound influence of MCSs on the precipitation climatology is clear***



★ Precipitation from mesoscale convective systems dominates the relative contribution to the total rain ★

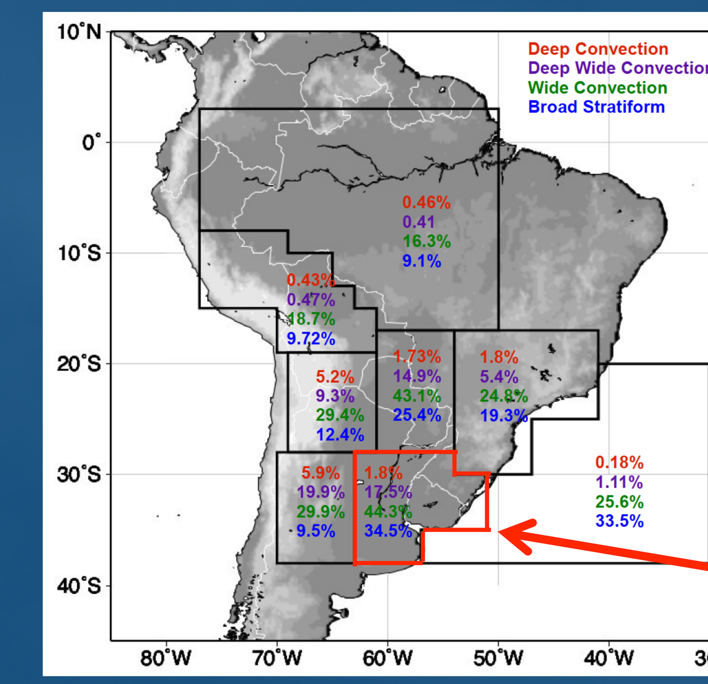


Figure 10. The rainfall contribution from each storm type (indicated by color) to the total precipitation in each region, expressed as a percentage.

- **Notably low extreme convective rain contributions in the tropics**
- **Clear orographic influence of the Andes on the precipitation distribution in the subtropics → modulates MCS lifecycle**

For the La Plata Basin (red region):

→ **Contribution of convective categories to the total warm season rainfall: ~ 60%**

→ **Including BSR precipitation, all extreme echo types contribute ~ 95% of the total warm season rainfall in the La Plata Basin**

Climatological rain contribution in the tropics and subtropics of S. America

	Tropics (%)	Subtropics (%)
Deep Conv.	0.6820	1.6150
Deep/Wide Conv.	1.2894	17.6728
Wide Conv.	15.7854	33.7034
Broad Stratiform	9.6918	30.4742

- **Overall, the tropics receive more rain than the subtropics**
- **HOWEVER, the climatological contribution from extreme storms identified by TRMM is significantly larger in the subtropics!**

★ Precipitation from extreme storms plays a crucial role in the hydrological cycle of the La Plata Basin ★

Conclusions

- **Precipitation estimates from storms with significant mixed phase hydrometeors are similarly affected by assumptions in the TRMM PR V7 algorithm in both the tropics and subtropics over land**
- **Regions that experience the most climatological rainfall are not collocated with regions of the largest rain contribution from extreme storms**
- **Amazon precipitation is affected by smaller non-extreme echoes**
- **Extreme MCSs dominate the precipitation in subtropical South America → ~ 95% of the total rain in the La Plata Basin!**

Acknowledgements

This research was supported by:
National Aeronautics and Space Administration Grants NNX10AH70G and NNX11AL65H
National Science Foundation Grants ATM-0820586 and AGS-1144105