Convective initiation in the vicinity of the subtropical Andes

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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)
  - → Hot spot of deep convection (Zipser et al. 2006)
  - → Larger precipitation areas than those over the United States or Africa (Durkee et al. 2009)
  - → Largest number of severe hailstorms globally (Cecil and Blankenship 2012)

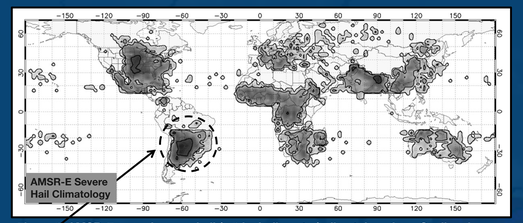
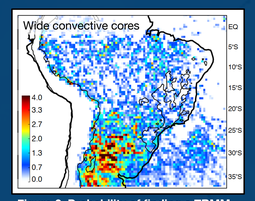


Figure 1. AMSR-E annual severe hail (>1 inch diameter) climatology from Cecil and Blankenship (2012).

Background

UW methodology to separate TRMM Precipitation Radar (PR) echoes into wide convective cores (Houze et al. 2007)

Wide convective cores are defined as contiguous 40 dBZ echo that extends over 1,000 km^2



Wide convective cores are numerous in subtropical South America

Figure 2. Probability of finding a TRMM-identified wide convective core in the austral summer (DJF).

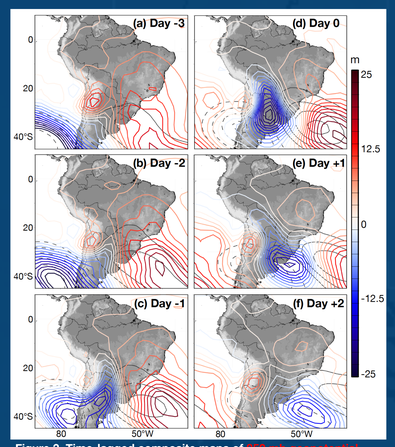


Figure 3. Time-lagged composite maps of 850 mb geopotential height anomalies on days when TRMM-identified wide convective cores were located in subtropical South America.

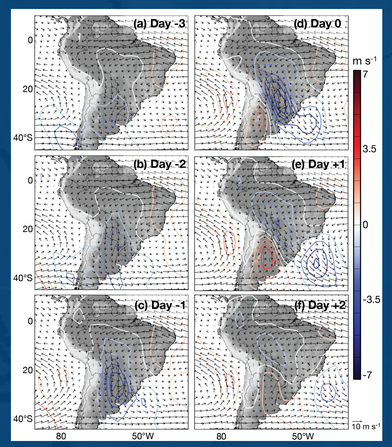


Figure 4. Time-lagged composite maps of 850 mb meridional wind anomalies on days when TRMM-identified wide convective cores were located in subtropical South America.

Convective initiation in South America

- **WRF modeling study to investigate the the patterns observed by the TRMM PR → convective storms initiating on the immediate foothills of the Andes**
- **Terrain modification experiments allow for testing of the importance of terrain in convective initiation in subtropical South America.**

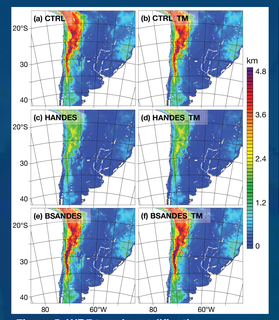


Figure 5. WRF terrain modification experiments.

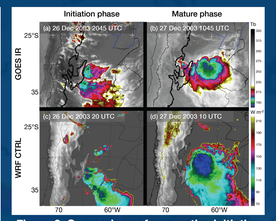


Figure 6. Comparison of convective initiation stage and mature stage between the WRF model CTRL run and GOES IR data.

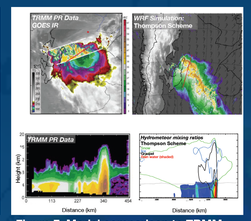


Figure 7. Model comparison to TRMM PR data.

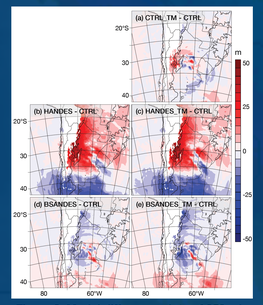


Figure 8. Model difference plots of 850 mb geopotential height.

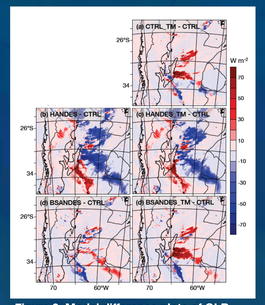


Figure 9. Model difference plots of OLR (w m^{-2}) in an early stage of the model run showing convective initiation.

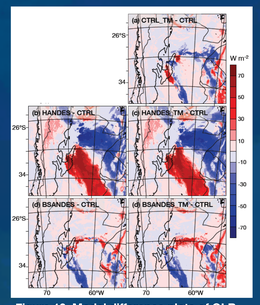


Figure 10. Model difference plots of OLR (w m^{-2}) at a mature stage of the model run showing the displacement of the storm.

Meridional wind pertubations from T=0

Run	700 hPa LLJ (V)	850 hPa LLJ (V)	950 hPa LLJ (V)	LLJ meridional V (sfc. to 600 hPa)
CTRL	-4.0	-2.7	-1.7	-2.4
CTRL_TM	-3.7	-2.7	-1.6	-2.3
HANDES	**-2.4**	**1.0**	**1.3**	**-0.3**
HANDES_TM	**-2.3**	**1.0**	**1.2**	**-0.3**
BSANDES	-4.4	-3.6	-2.5	-3.0
BSANDES_TM	-4.4	-3.7	-2.6	-3.1

- **Decreasing the height of the Andes decreases the magnitude of the low pressure in the lee, providing less suction and a weaker SALLJ**
- **Reducing and increasing the height of the Andes has the inverse effect indicating a clear relationship between the storms and the terrain in South America**

★ The Andes mountains are crucial in initiating intense convective storms in subtropical South America ★

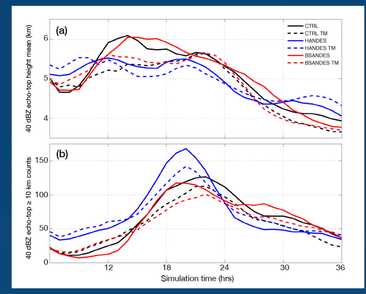


Figure 11. Time series of (a) 40 dBZ echo top height mean and (b) 40 dBZ echo top > 10 km counts.

- **Removing the Sierras de Cordoba mountains resulted in larger echo-top means in the larger Andes runs**
- **However, the HANDES runs produced more 40 dBZ echo tops > 10 km than the other runs (also seen in Figure 10)**
- **Reducing the Andes enabled a weaker capping inversion, more convective initiation, but an overall weaker storm**
  - **Convective instability distributed over more convective entities**

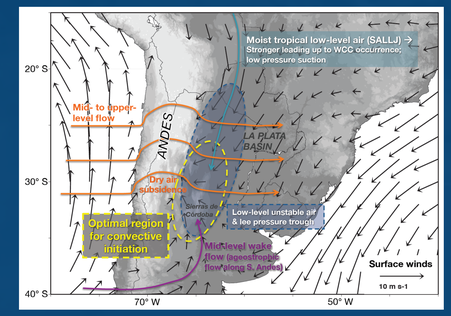


Figure 12. Conceptual model of convective initiation in South America.

Conclusions

- **Wide convective cores are correlated with strong signatures of lee cyclogenesis and SALLJ from suction effects**
- **Reducing and increasing the height of the Andes has an inverse effect, indicating the clear relationship between convective storms and orography in this region**
- **Reducing the Andes provided for a weaker lee pressure pattern and LLJ that resulted in enhanced convective initiation, but overall weaker storms**
- **The Sierras de Cordoba mountains play a secondary role in focusing convective initiation but the main terrain control is the altitude and large extent of the Andes**

Acknowledgements

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