Characterization of the thermodynamic environment of extreme precipitation events in southeastern South America

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1. Introduction

Southeastern South America (SESA) is characterized as one of the regions in the world with the highest frequency of occurrence of intense storms associated with deep convection, mainly during the spring and summer months (Zipser et al. 2006). These events induce extreme precipitation events and produce most of the warm season rainfall (Rasmussen et.al 2015) generating significant damage (floods, intense winds, hail) and have a high impact on economic and social activities.

Considering that the occurrence of extreme events in SESA is associated with the occurrence of certain thermodynamic patterns, **the objective of this study is to explore the ability of three regional climate models to reproduce the thermodynamic environment that triggers deep convection in SESA.**

3. Methods

- Selection of three extreme precipitation events based in the analysis of Bettolli et. al 2021 and Lavin-Gullon et al 2021. The events took place in February 2010 (case 1), January 2010 (case 2) and November 2009 (case 3 not shown). All three cases reached daily precipitation above 150 mm/day (Lavin-Gullon et al 2021).
- Identification of the spatial pattern of precipitation observed for each case study from the accumulated rainfall between 06-12 UTC on the day of the extreme event.
- Characterization of the thermodynamic environment from the analysis of the spatial distribution of the equivalent potential temperature at 850 hPa and the gradient between 700-850 hPa at 00 UTC on the day of the extreme event.

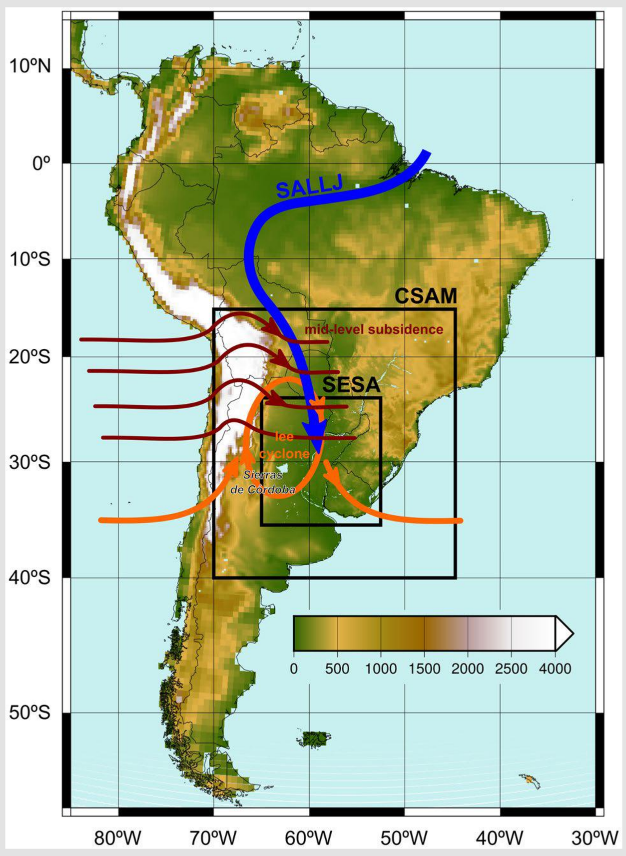
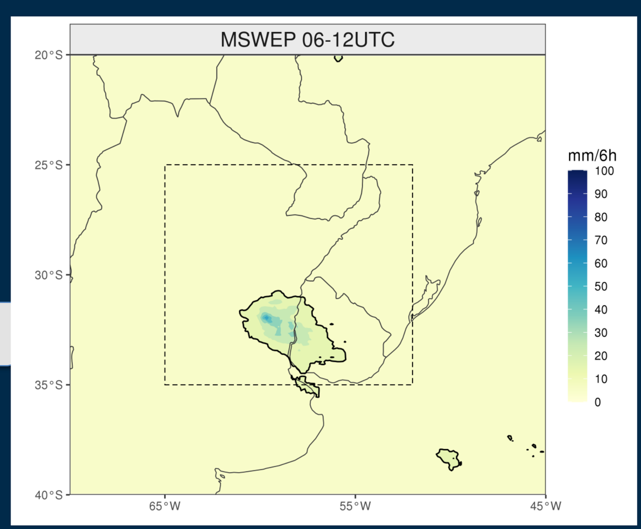


Figure 1: Analysis domains over central South America (CSAM) and Southeastern South America (SESA). A schematic depiction of the drivers of MCSs over SESA is also shown (adapted from Rasmussen and Houze 2016). Blue arrow represents the low-level jet, red arrows refer to mid-to-upper level flow and orange arrows represent the low level flow associated with the lee cyclone over Sierras de Córdoba. Figure extracted from Lavin-Gullon et al 2021.

4. Results

Case 1 : 20th February 2010

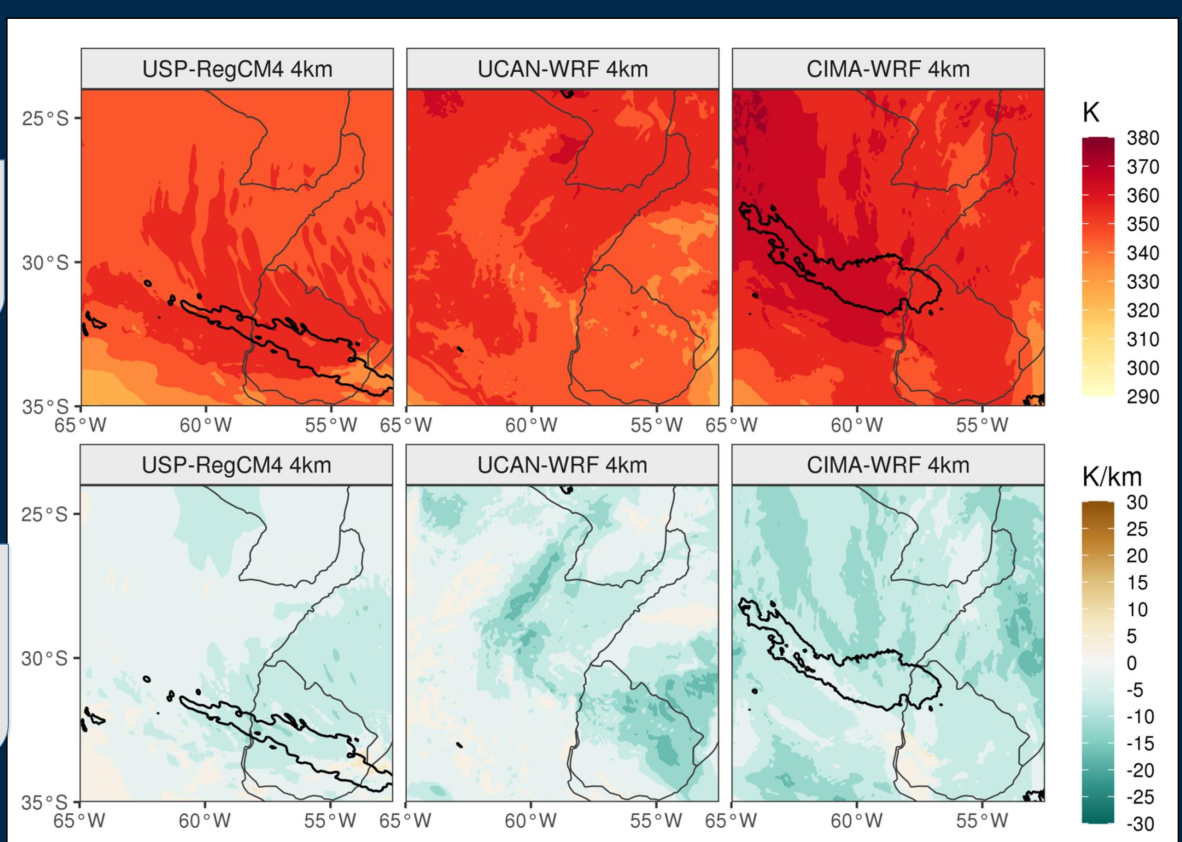
Accumulated 6-hourly precipitation



Acumulated 6-hourly precipitation in shaded. Black contour represents 10 mm.

Equivalent potential temperature at 850 hPa (4 km)

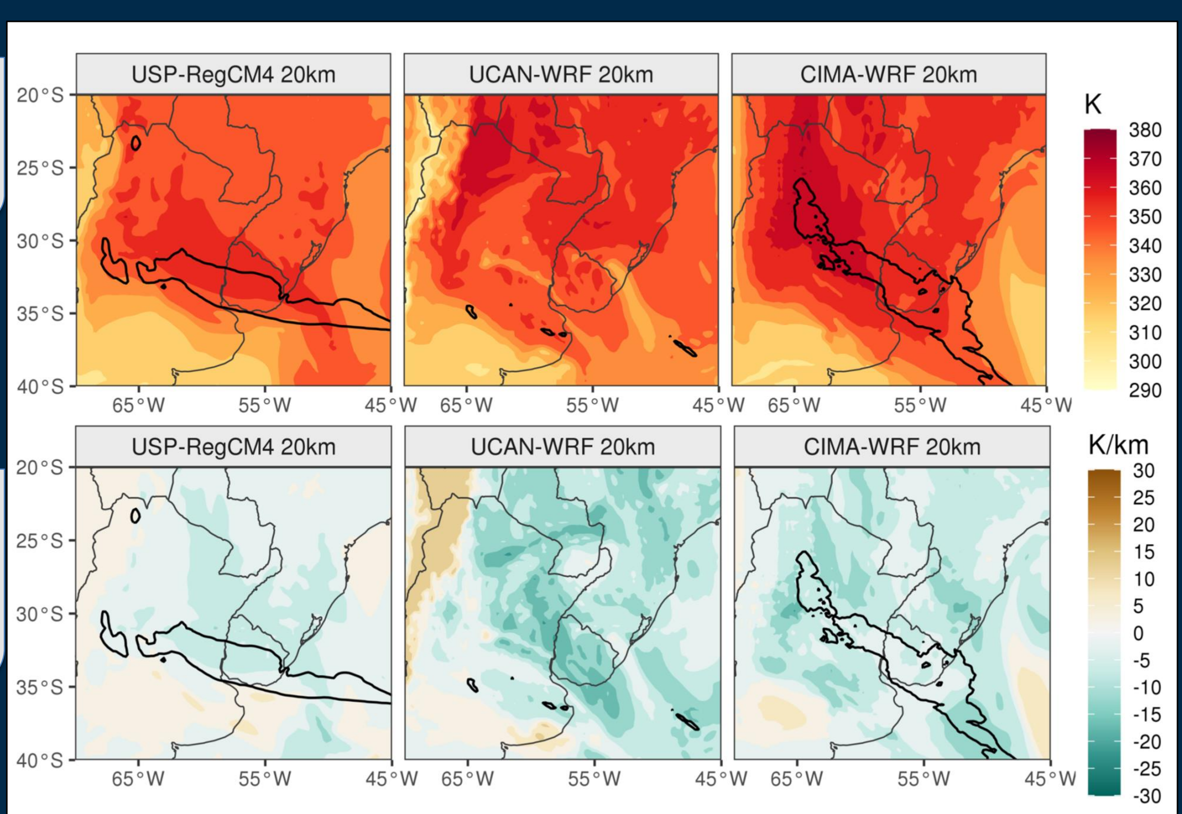
Equivalent potential temperature gradient between 700-850 hPa (4 km)



Equivalent potential temperature at 850 hPa (top) and equivalent potential temperature gradient between 700-850 hPa (bottom) in shaded. Precipitation simulated by the model in contours (black contour represents 10 mm).

Equivalent potential temperature at 850 hPa (20 km)

Equivalent potential temperature gradient between 700-850 hPa (20 km)



Equivalent potential temperature at 850 hPa (top) and equivalent potential temperature gradient between 700-850 hPa (bottom) in shaded. Precipitation simulated by the model in contours (black contour represents 5 mm).

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2. Data

- Simulations of three models:

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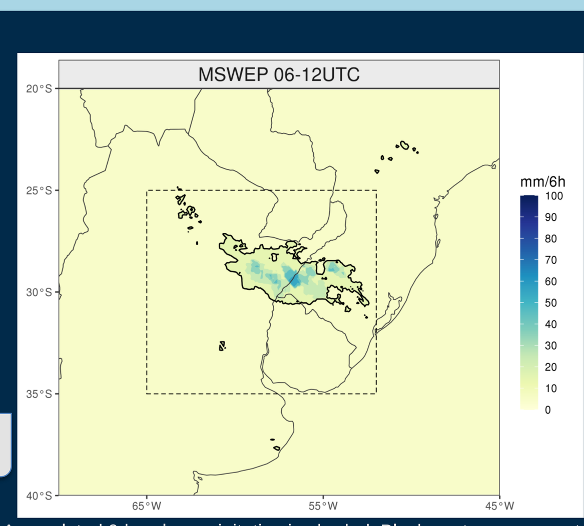
belonging to the Flagship Pilot Study in southeastern South America (FPS-SESA) for two spatial resolutions, 4 (Convection Permitting Regional climate model) and 20 km (Bettolli et. al 2021 and Lavin-Gullon et al 2021). A high-resolution (4 km) convection permitting domain centered over La Plata basin (SESA) was nested into a coarser resolution (20 km) domain over central South America (CSAM) (Lavin-Gullon et al 2021). These domains cover the respective common analysis domains (Fig. 1).

- Accumulated precipitation data every three hours of the base: Multi-Source Weighted-Ensemble Precipitation **(MSWEP)**

4. Results

Case 2: 19th January 2010

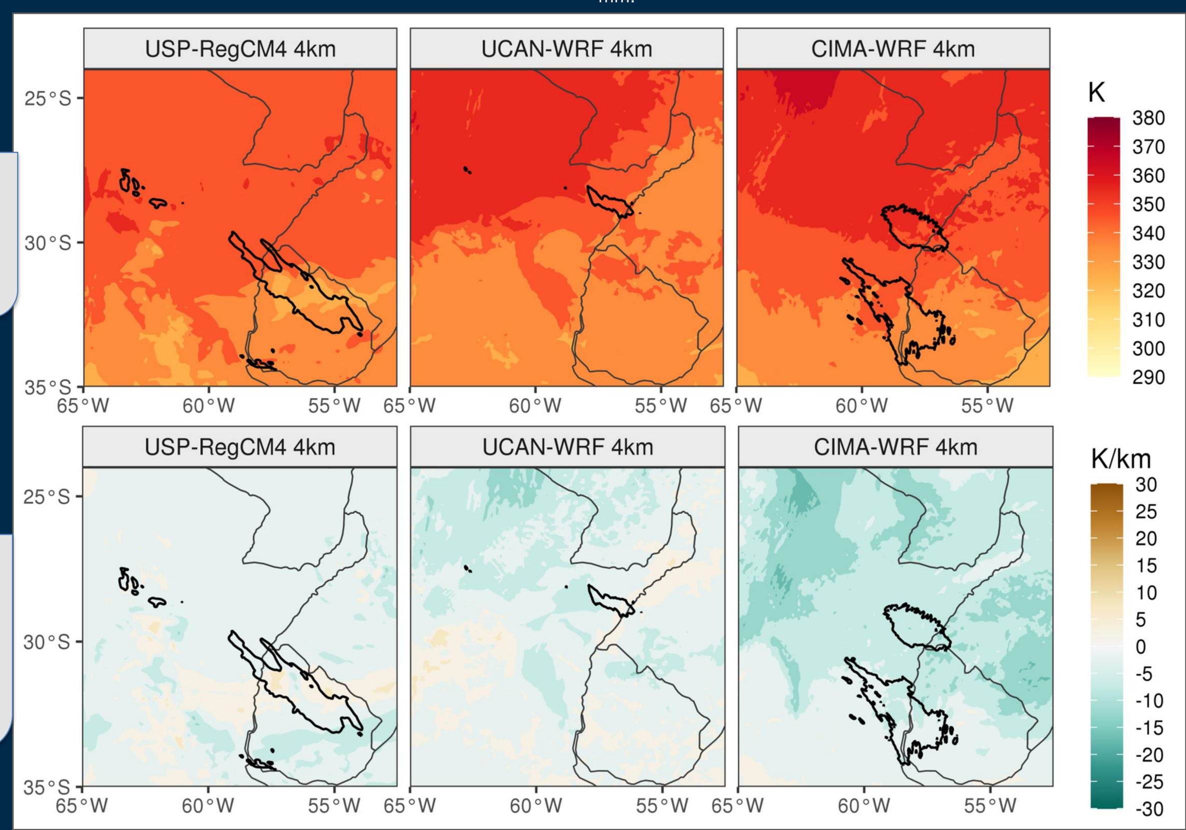
Accumulated 6-hourly precipitation



Acumulated 6-hourly precipitation in shaded. Black contour represents 10 mm.

Equivalent potential temperature at 850 hPa (4 km)

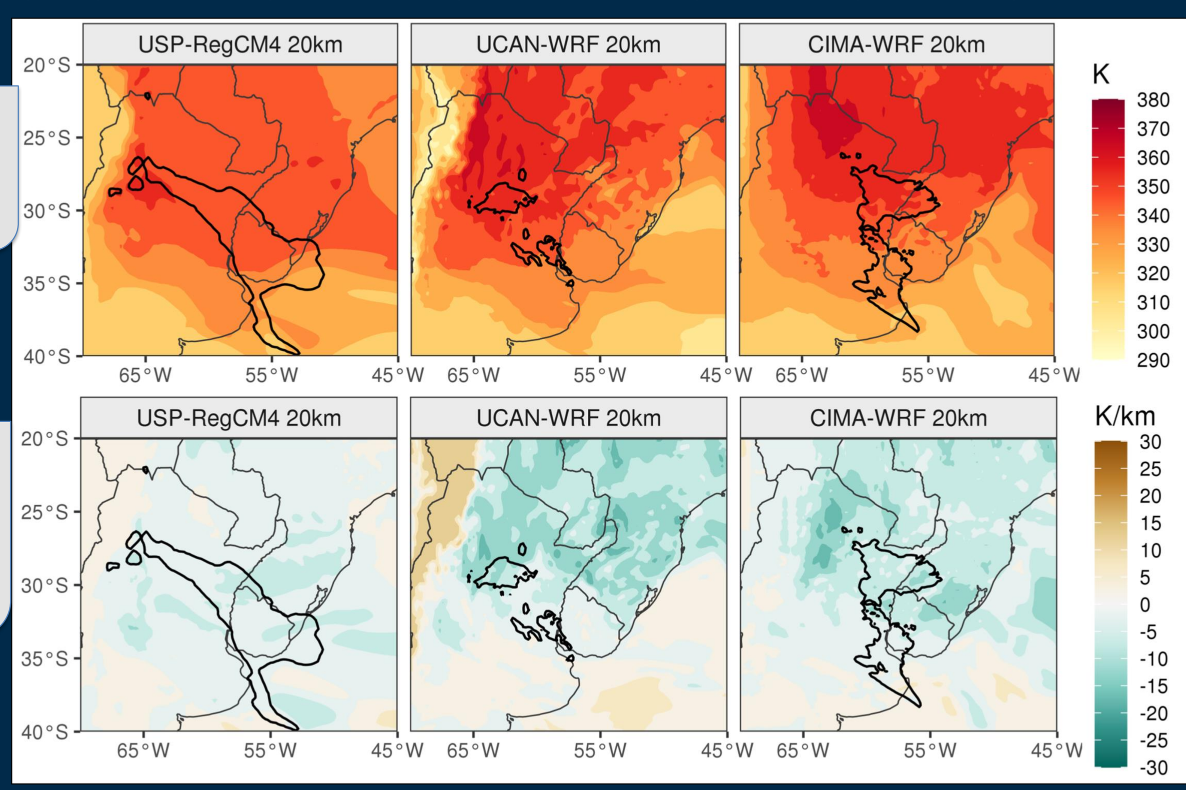
Equivalent potential temperature gradient between 700-850 hPa (4 km)



Equivalent potential temperature at 850 hPa (top) and equivalent potential temperature gradient between 700-850 hPa (bottom) in shaded. Precipitation simulated by the model in contours (black contour represents 10 mm).

Equivalent potential temperature at 850 hPa (20 km)

Equivalent potential temperature gradient between 700-850 hPa (20 km)



Equivalent potential temperature at 850 hPa (top) and equivalent potential temperature gradient between 700-850 hPa (bottom) in shaded. Precipitation simulated by the model in contours (black contour represents 5 mm).

5. Conclusions

- In general, the regions with the highest instability (largest negative values of the equivalent potential temperature gradient) coincided with the regions where precipitation was simulated.
- Moreover, it is observed that in the regions where the equivalent potential temperature in 850 hPa was higher, the models simulated the precipitation.
- Case 1 showed higher values of equivalent potential temperature at 850 hPa compared to the case 2. It should be noted that the WRF-CIMA model presented the highest values and this is highlighted in the 4 km resolution.
- No great differences were found between the circulation simulated by the models with a resolution of 20 km and 4 km.

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