

Sensitivity of convective precipitation to warming in the extratropical Andes

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viCPCMW

Buenos Aires city, 2022 Sep. 7-9th

Convection-Permitting Climate
Modeling Workshop

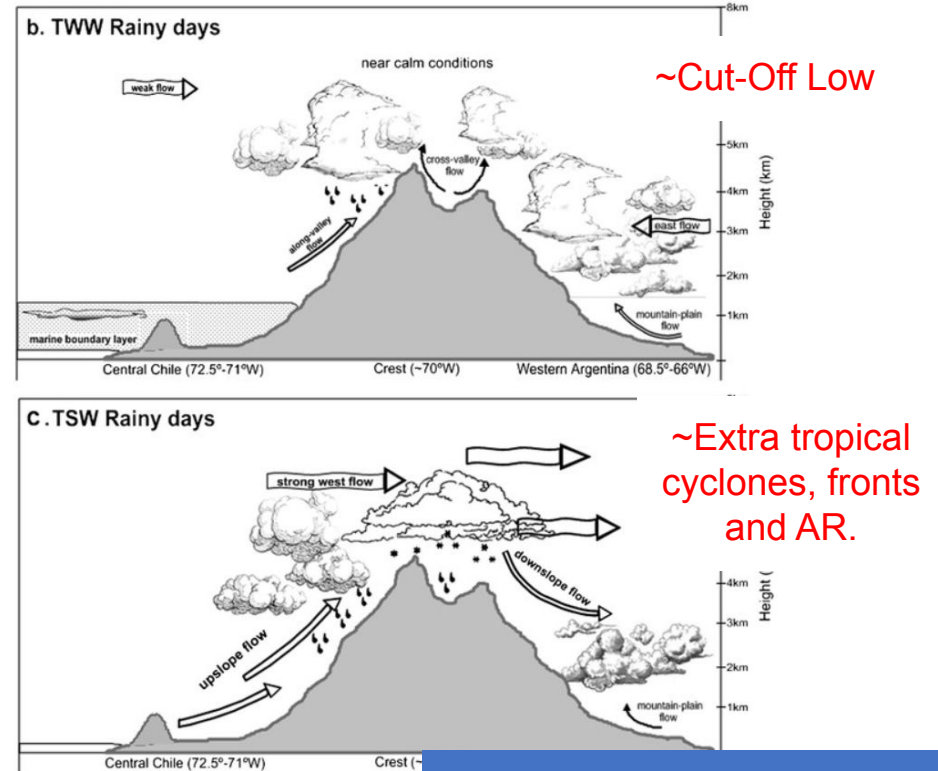
Agenda

- Summer precipitation events in central Andes
- Case studies and Methodology
- Configuration of WRF Convection-Permitting simulations
- Preliminary results
 - Pseudo Global Warming Approach
 - Precipitation sensitivities
- Discussion and concluding remarks

1. Summer precipitation events in the Andes

Western Andes (Chile)

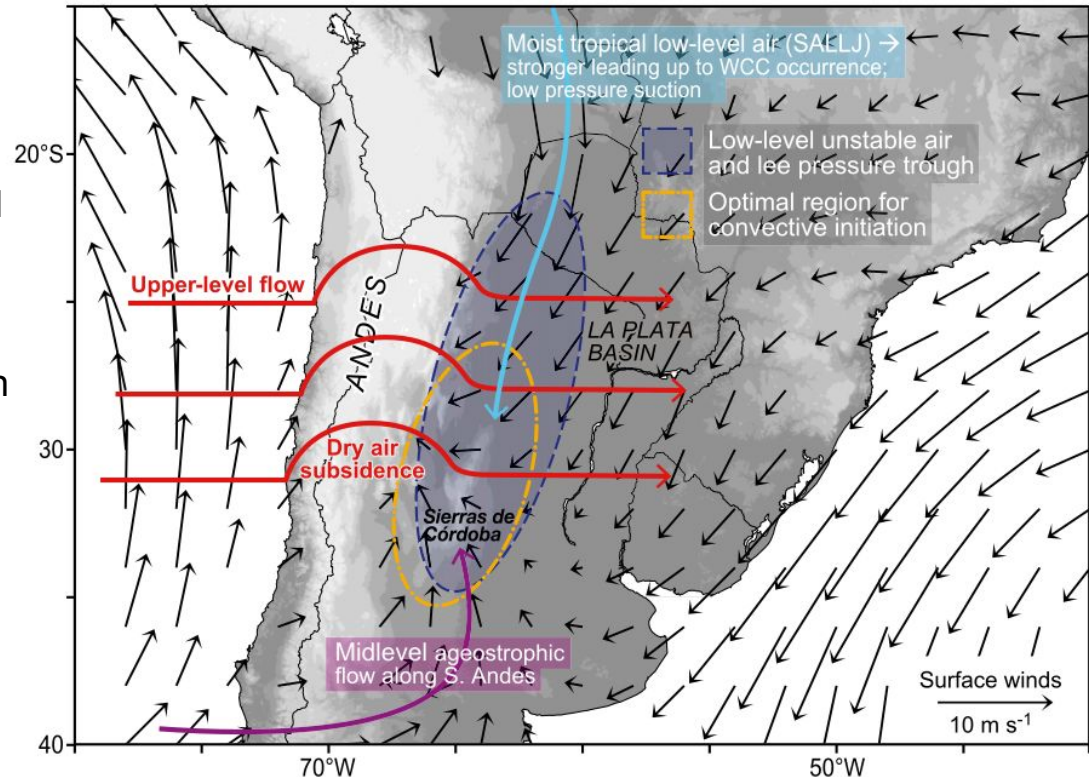
- Summer precipitation events in Chile aren't deeply studied because of their relative low contribution to annual precipitation.
- Nevertheless, due to the high temperatures and summer instability, these kind of events present potentially dangerous conditions favoring floods and landslides.



1. Summer precipitation events in the Andes

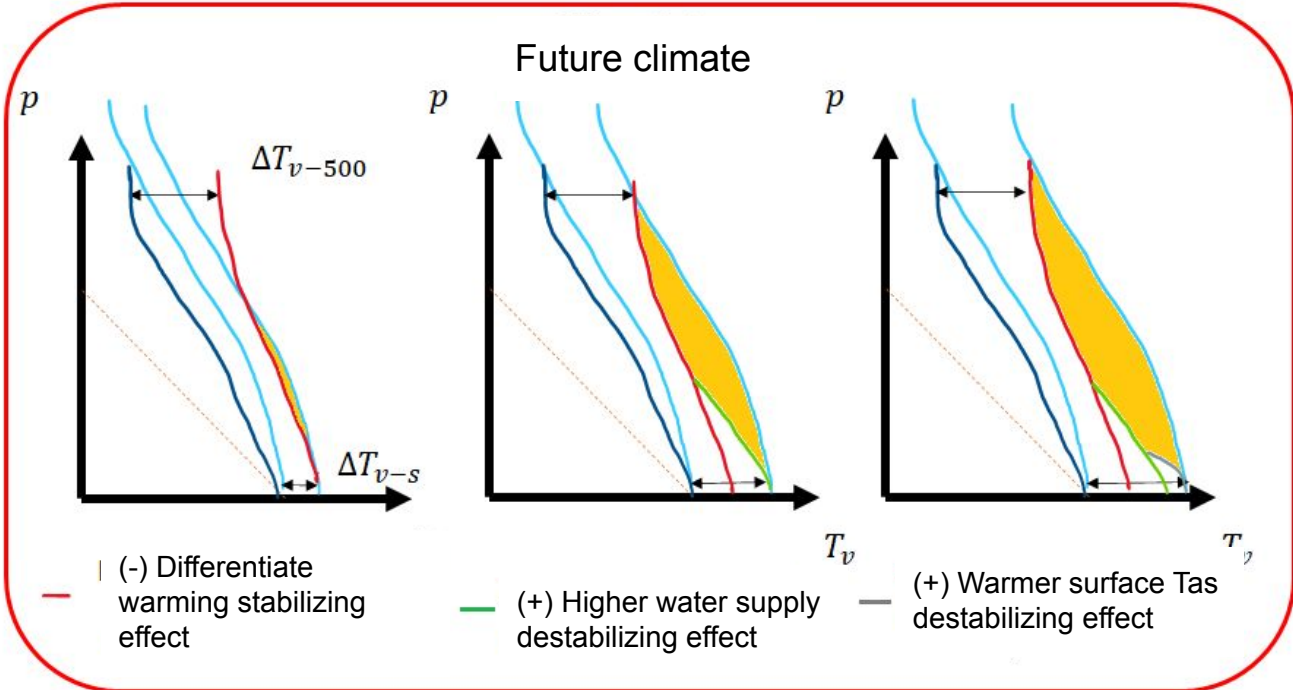
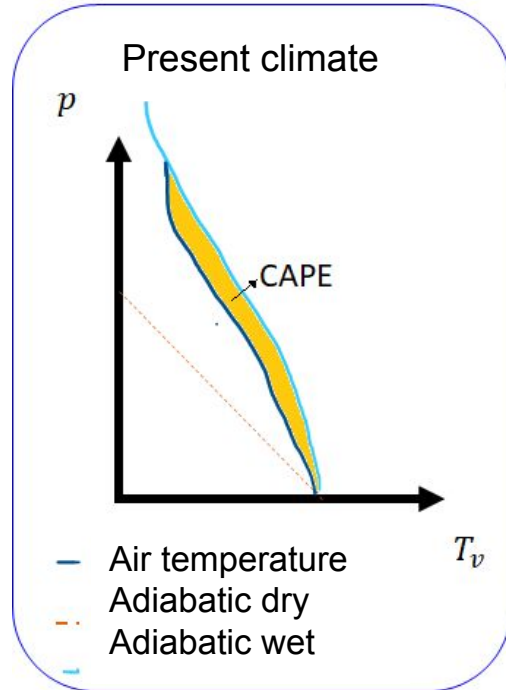
Eastern Andes (Argentina)

- The condition of eastern Andes are remarkably different from western Andes, due to the low-level circulation and convergence as well as high instability.
- In Argentina, deep convection is a key process in extreme precipitation events and is the main source of precipitation, and has been extensively studied.

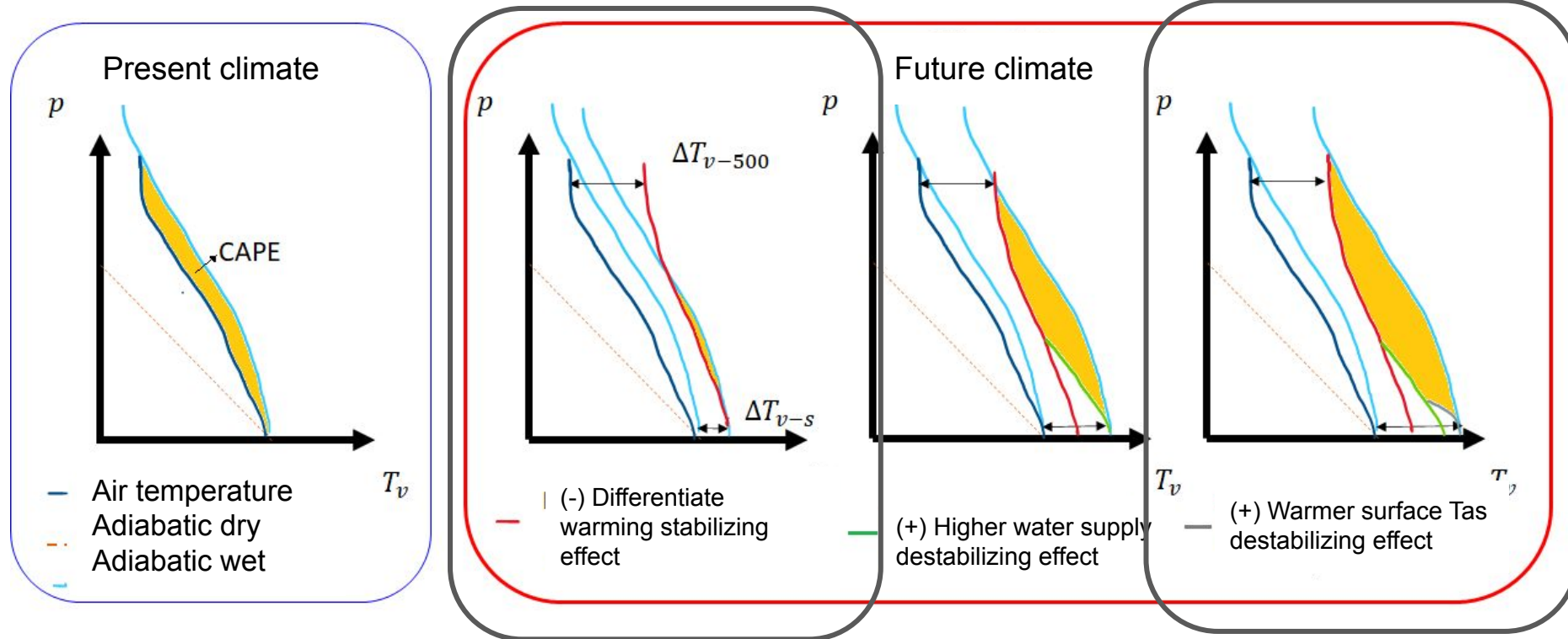


Rasmussen and
Houze Jr. (2016)

Why temperature sensitivity?



Why temperature sensitivity?



2. Case studies

January 28-31th, 2021

February 24-25th, 2017

ARGENTINA

Fuertes tormentas en Córdoba: Consecuencias que ha tenido el temporal

Tras más de una semana con altas temperaturas, llegó una fuerte tormenta con ráfagas de viento y abundante caída de agua. Cómo seguirá el tiempo.

As.com

Actualizado a 31 de enero de 2021 11:01 ART



AS Argentina (2021)

Sistema frontal: Los impactantes registros de aluviones que está dejando el fenómeno climático en el centro y sur del país

Por: El Desconcierto | Publicado: 31.01.2021



Ruta 127 cortada por un alud en el Cajón del Maipo (Foto: Agencia Uno)

El Desconcierto (2021)

Lluvias, granizo y cortes de luz en la Ciudad tras otra jornada de calor sofocante

También se vieron afectados puntos de la provincia de Buenos Aires

22 de Febrero de 2017



Tres muertos y 19 desaparecidos por aluviones en regiones centro y norte del país

por EFE | 27 febrero, 2017

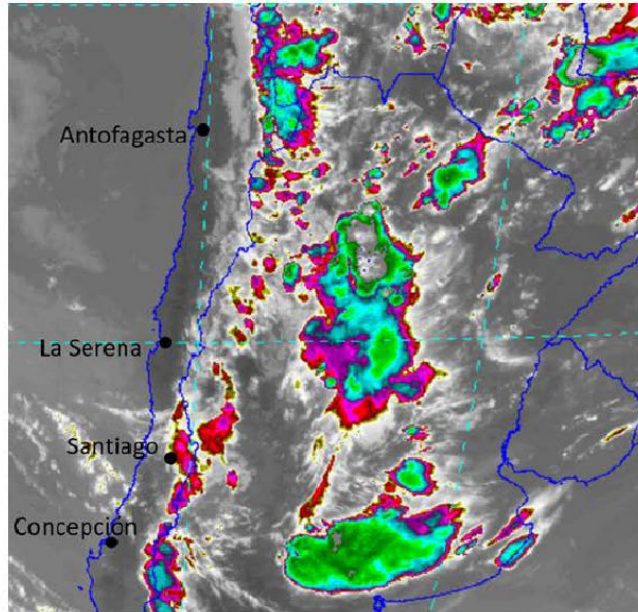


Infobae (2017)

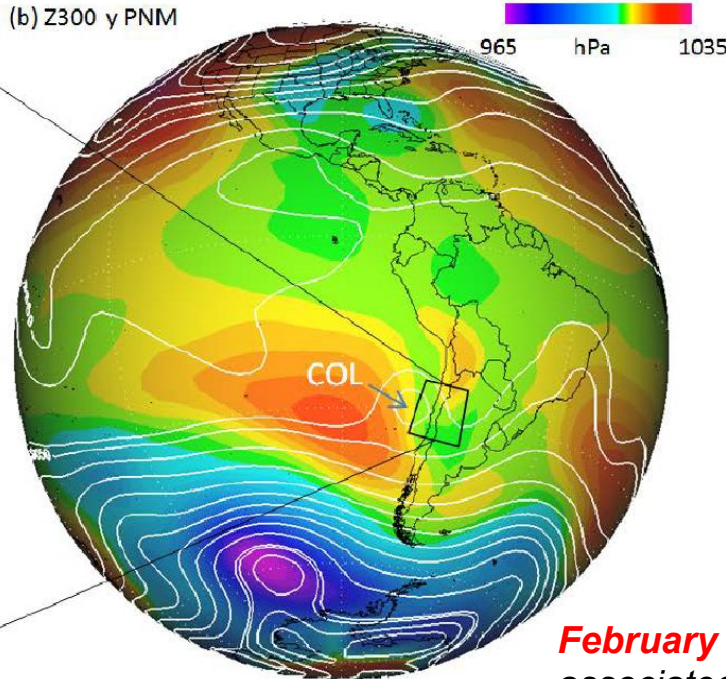
El Mostrador (2017)

February 2017 event

(a) GOES IR



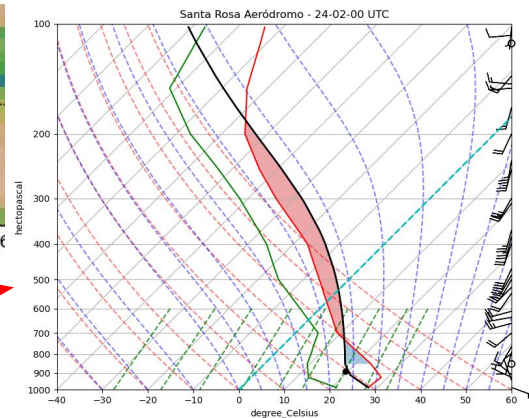
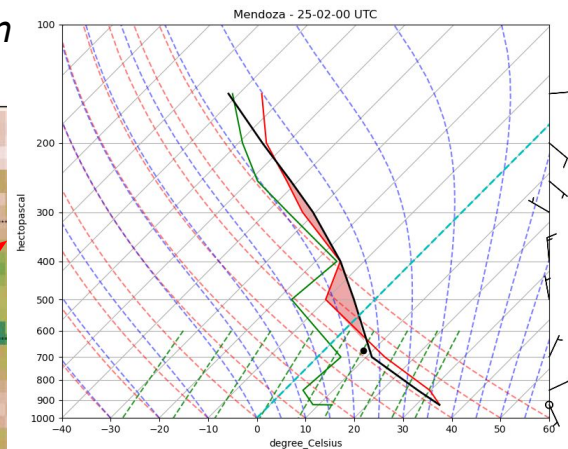
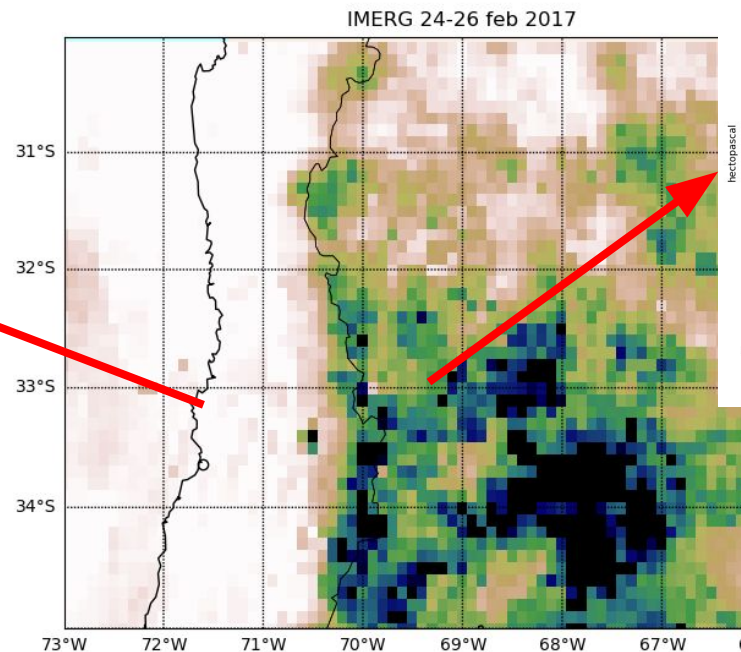
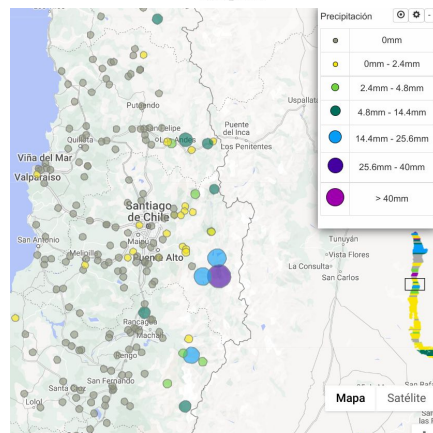
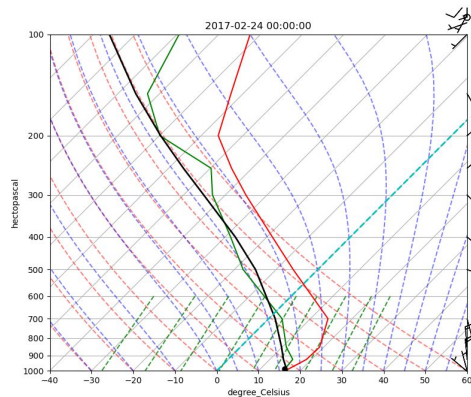
(b) Z300 y PNM



February 2017 event was associated to a **Cut-Off Low** event (western Andes), and surface convergence in the eastern Andes.

February 24-25th, 2017

February 2017 event produced moderate intense precipitation in the WA, and intense precipitation in EA.

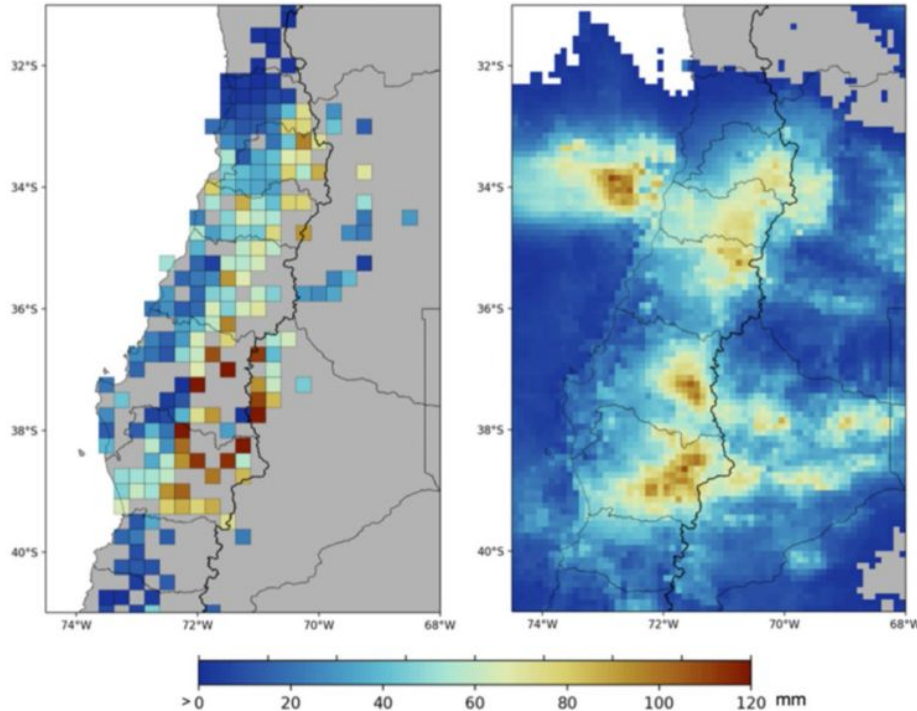


In Western Andes, there was no evidence of CAPE
High CAPE in eastern Andes.

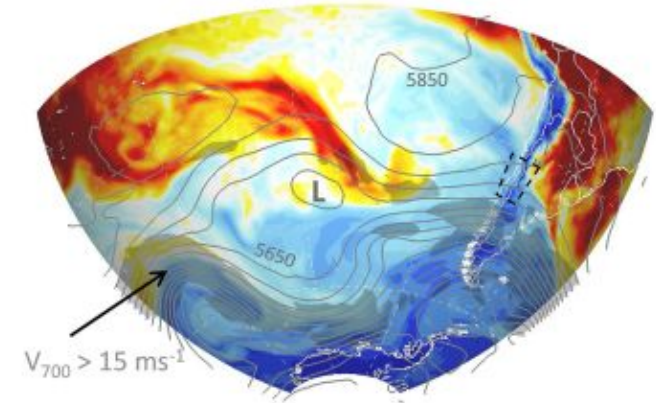
January 28-31th, 2021 event

(a) Gridded precipitation
accumulation (average)

(b) Precipitation accumulation
from IMERG Final Run



(a) 12Z 26 Jan 2021

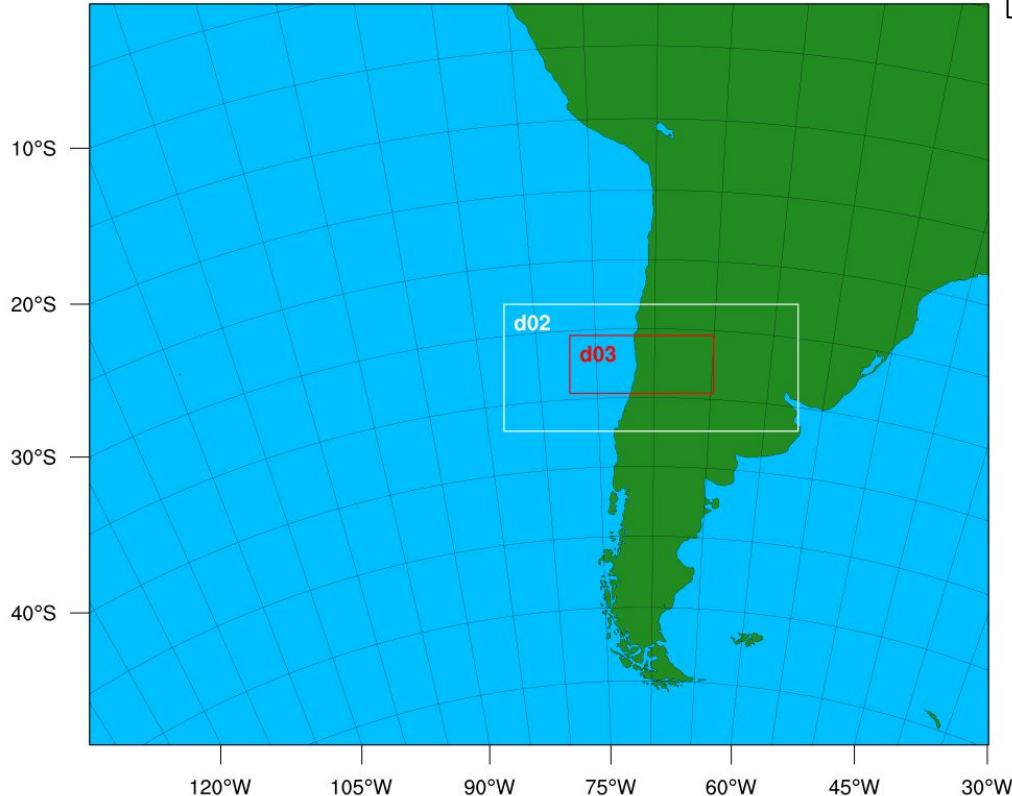


January 2021 produced strong
precipitation in both sides of the Andes,
associated to a Zonal Atmospheric River.

3. Methodology and mode configuration

Advanced Weather Research and Forecasting Model (WRF) at CP scale (d03)

- 3 nested domains (27 km, 9 km, 3 km), 61 η lev.
- Nodes: 60210, 30475, 53066
- CI & CB: GFS
- 2 day warm up



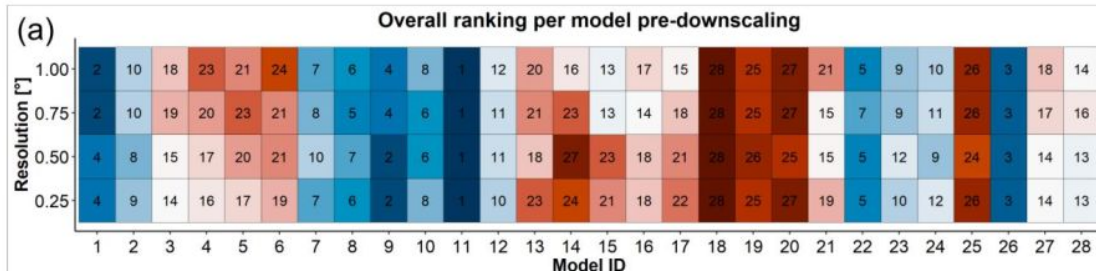
Physics	Scheme
Surface layer option	5: MYNN 2.5 level TKE
boundary-layer option	5: MYNN 2.5 level TKE
Land Surface option	4: Noah-MP land-surface model
Microphysics	6: WSM 6-class graupel
Longwave radiation	1: RRTM
Shorthwave radiation	1: Dudhia scheme

3. Pseudo Global Warming

$$\text{PWG} = \text{WRF3k} + \Delta \text{CMIP6}_{\text{GCM}}$$

$\Delta \text{CMIP6}_{\text{GCM}}$: Mean change of selected CMIP6 GCMs on
SST and **air temperature (Ta)**

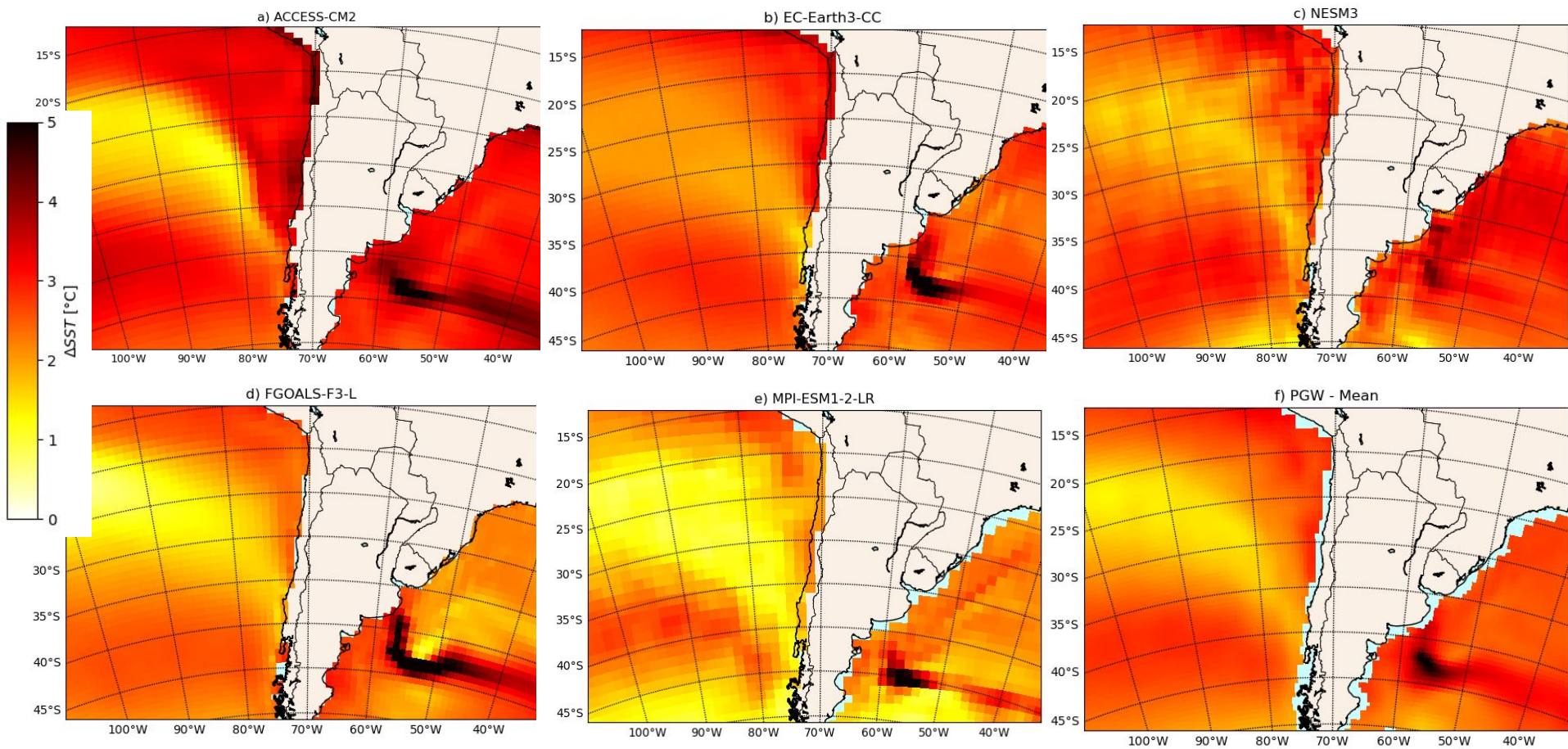
Selected models based on **past performance of Pr, Tx and Tn** over continental Chile



Gateño et al. (in prep). *An approach to rank global climate models for regional studies based on past performance.*

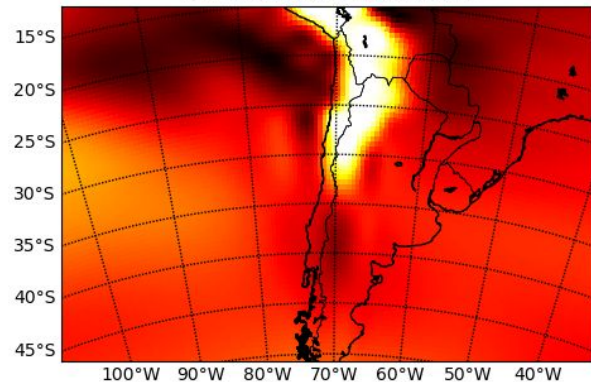
Overall ranking	GCM	Lon / Lat resolution
1	EC Earth3 CC (Europe)	1.87° x 1.24°
2	ACCES.CM2 (Australia)	0.70° x 0.69°
3	NESM3 (China)	1.87° x 1.86°
4	MPI-ESM1.2.L R (Germany)	1.87° x 1.86°
5	FGOALS.f3-L (China)	1.24° x 1.0°

$\Delta \text{SST}_{\text{DJF}}$ (2070-2100) - (1980-2014) SSP5-8.5

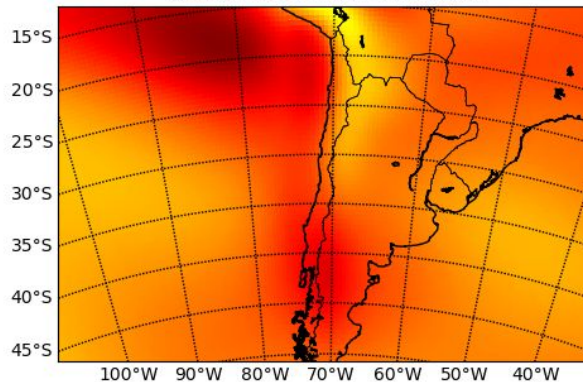


$\Delta T_{a_{DJF}}$ (2070-2100) - (1980-2014) SSP5-8.5 850 hPa

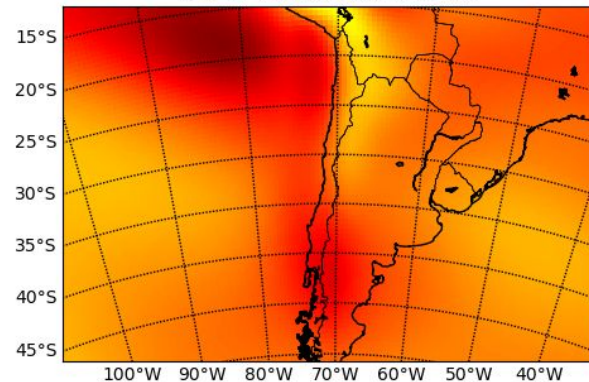
a) ΔT_a ACCESS-CM2 850hPa



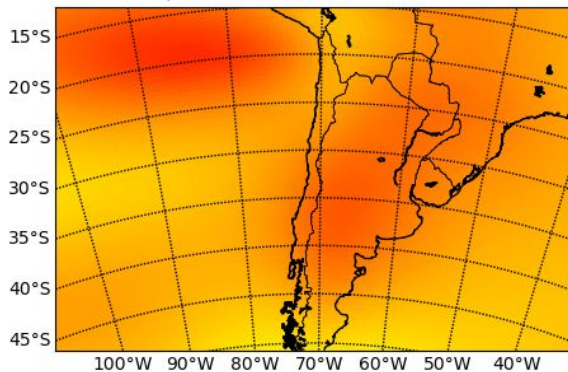
b) ΔT_a EC-EARTH3-CC 850hPa



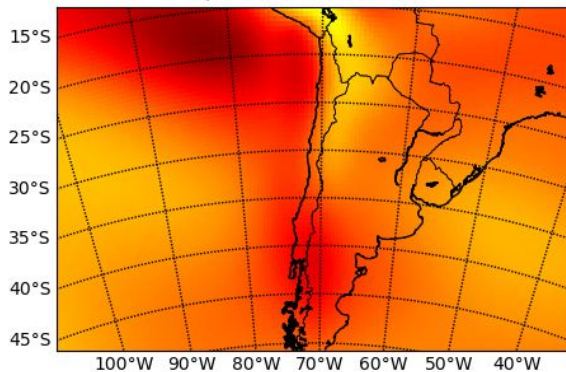
c) ΔT_a FGOALS-F3-L 850hPa



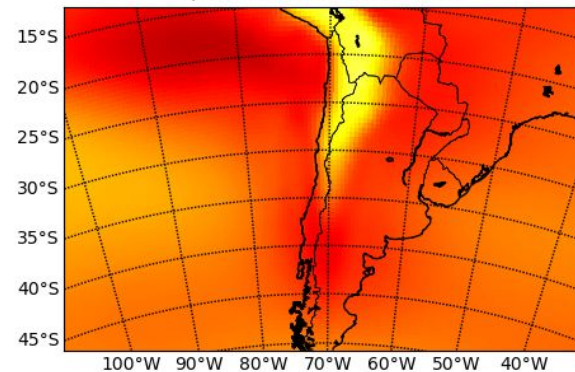
d) ΔT_a MPI-ESM1-2-LR 850hPa



e) ΔT_a NESM3 850hPa

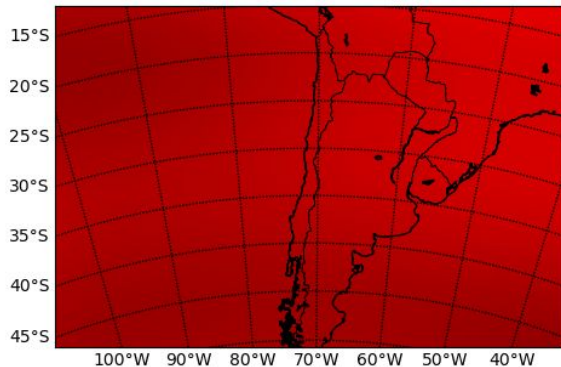


f) ΔT_a GCM Mean 850hPa

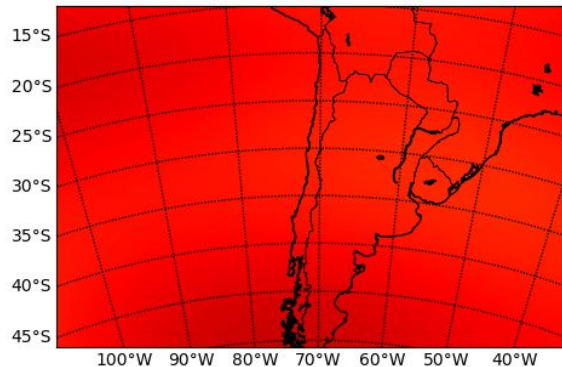


$\Delta T_{a_{DJF}}$ (2070-2100) - (1980-2014) SSP5-8.5 500 hPa

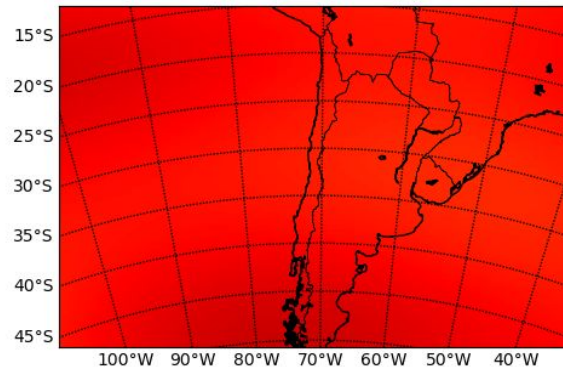
a) ΔT_a ACCESS-CM2 500hPa



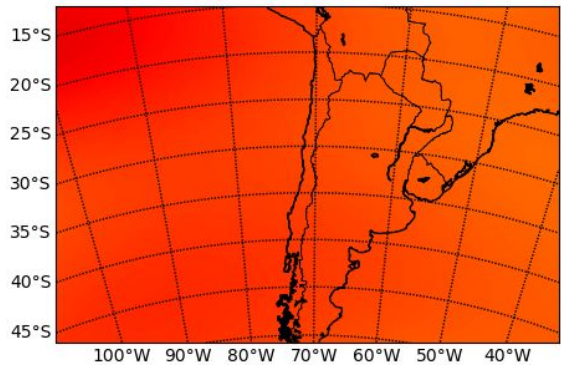
b) ΔT_a EC-EARTH3-CC500hPa



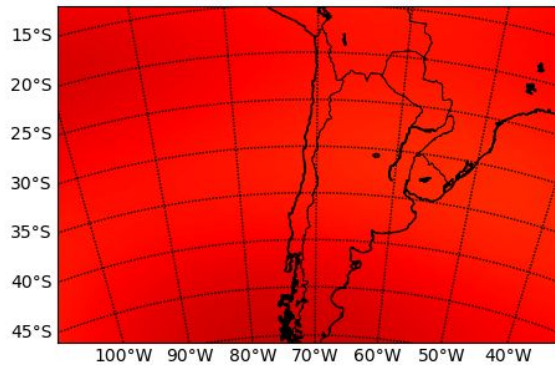
c) ΔT_a FGOALS-F3-L 500hPa



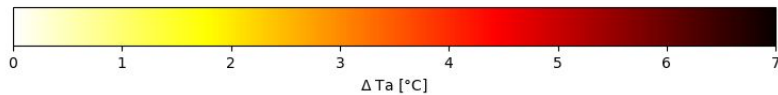
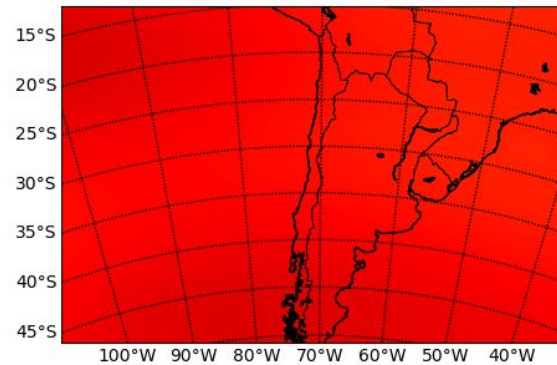
d) ΔT_a MPI-ESM1-2-LR 500hPa



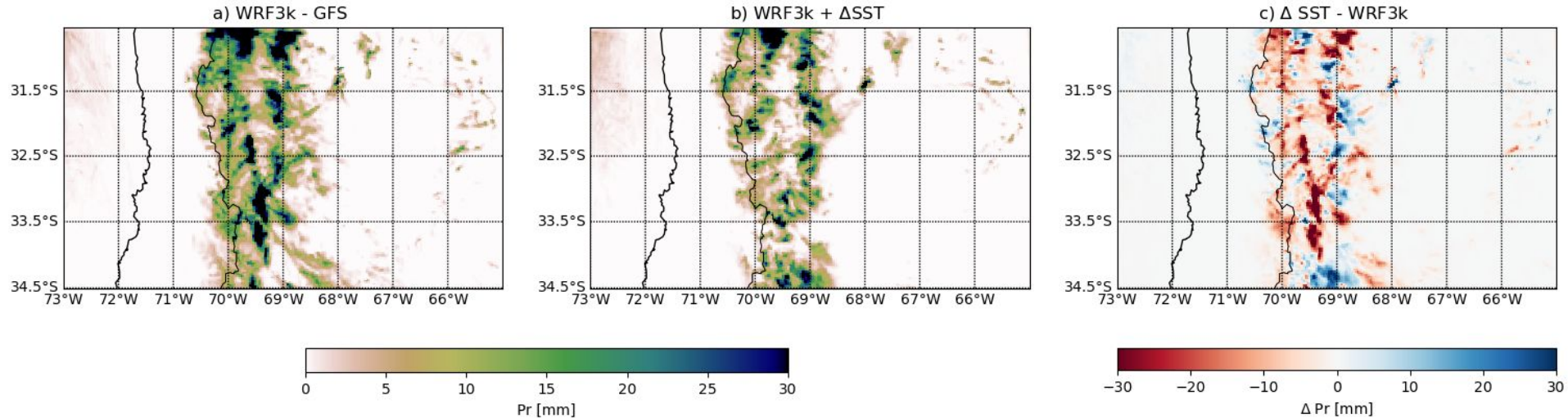
e) ΔT_a NESM3 500hPa



f) ΔT_a GCM Mean 500hPa



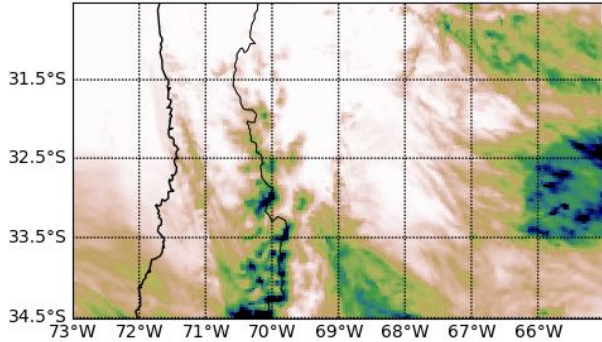
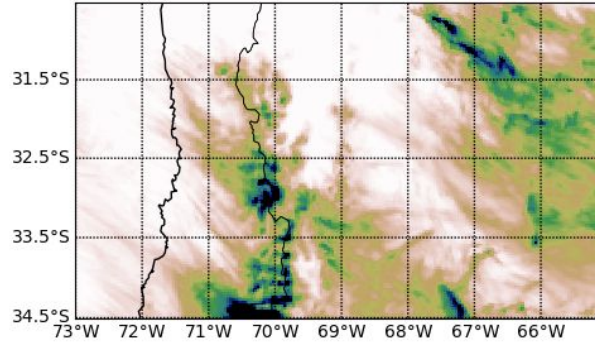
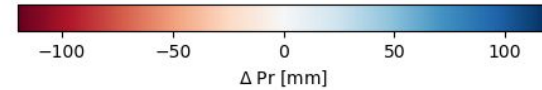
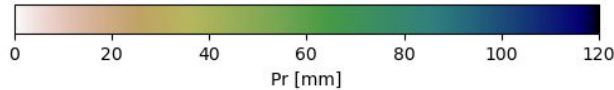
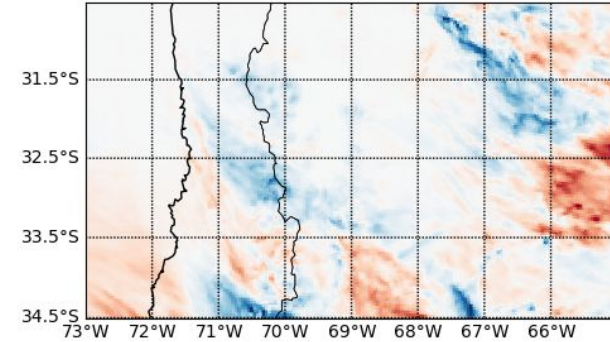
4. February 2017 - SST sensitivity



Warmer conditions in SST in the case of the COL event translates into **dryer conditions** in **western Andes**.
Eastern Andes presented **more intense precipitation** impacting **smaller surfaces**.

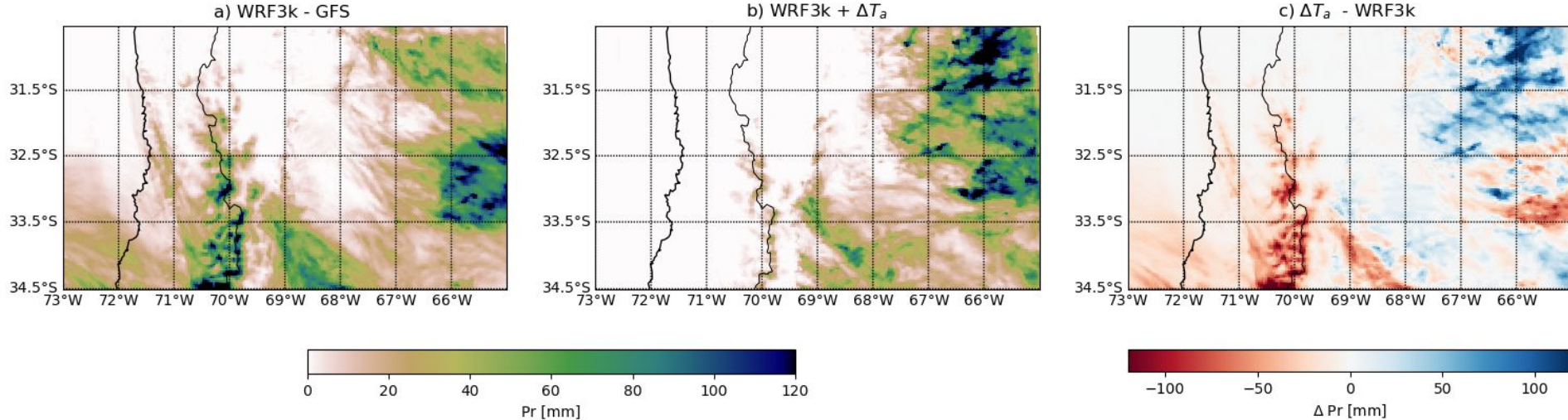
4. January 2021 - SST sensitivity

a) WRF3k - GFS

b) WRF3k + Δ SSTc) Δ SST - WRF3k

Warmer conditions in SST may contribute to (expected)
thermodynamic enhancement in precipitation (Clausius-Clapeyron)

4. January 2021 - **T_a** sensitivity



Warmer conditions in higher levels may impact the efficiency of precipitation because their impact on ***atmospheric instability***, in ***both sides of the Andes***.

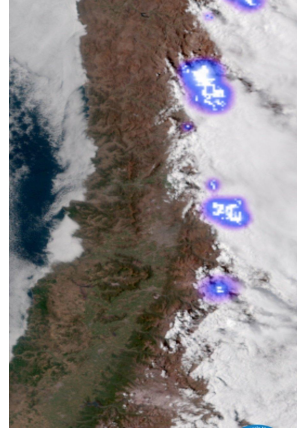
Discussion and conclusions

- **Warmer SST conditions** may be dependant on the dominant process of precipitation mechanism. **↓Pr for COL** and **↑Pr for the AR**.
- **Air temperature**, due to stability intensification may translate into **less precipitation** associated to the AR.
- **Dynamics, thermodynamics** and **moisture source** must be deeper analyzed to disentangle the role of warming conditions in the precipitation process in the extratropical Andes.

Thank you!



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Acknowledgements

- Powered@NLHPC: This research was partially supported by the supercomputing infrastructure of the NLHPC (ECM-02)
- VI Convection Permitting Climate Modeling Workshop organization for their funding support.
- Center for Climate and Resilience Research (CR2, CONICYT/FONDAP/15110009), Advanced Mining Technology Center (ANID-PIA Project AFB180004.). Universidad de Chile. ANID Doctoral Grant 21192178