

A storyline approach to select the CMIP6 model ensemble to be downscaled for the South America domain

Andressa Andrade Cardoso^{1,2}, Erika Coppola², Julia Mindlin^{3,4,5}, and
Theodore G. Shepherd^{6,7}

ICRC-CORDEX 2023, 25-29th September 2023

¹University of São Paulo, Institute of Astronomy, Geophysics and Atmospheric Sciences - IAG, Atmospheric Science department, Brazil

²The Abdus Salam International Centre for Theoretical Physics – ICTP, Earth System Physics department, Italy

³Departamento de Ciencias de la Atmósfera y los Océanos, Universidad de Buenos Aires, Buenos Aires, Argentina

⁶Department of Meteorology, University of Reading, Reading, UK

⁷Jülich Supercomputing Centre, Forschungszentrum Jülich, Jülich, Germany

MOTIVATION & GOALS

First research question



Selecting the best Global Climate Models (GCMs) in South American domain is needed to provide the initial and boundary conditions for the Regional Climate Model (RCM) downscaling.

Second research question



The physical process we want to study and which are the mechanisms that are relevant for it, or in a more general way which is the storyline of large-scale circulation we are interested in.

**A storyline approach to select the CMIP6 model ensemble to be downscaled for the South America domain
ICRC-CORDEX 2023, 25-29th September 2023**

MOTIVATION & GOALS

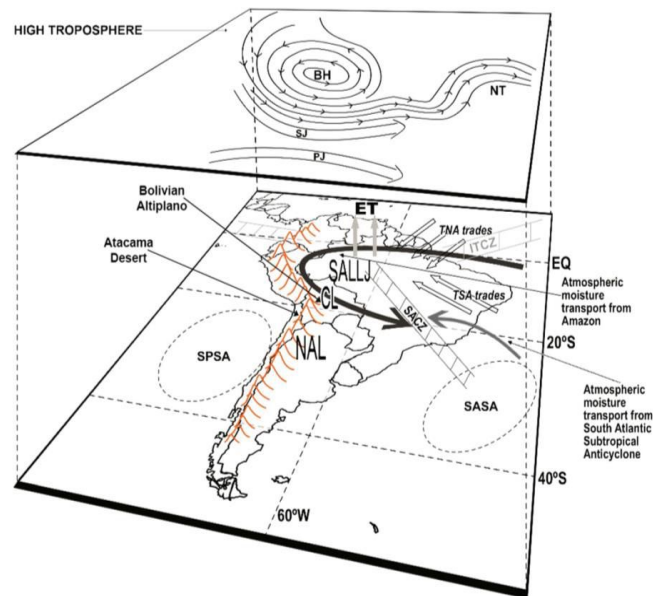
Large-scale Circulations



South America
Monsoon System
(SAM)



Extratropical
Cyclones (EC)



Source: Ferreira and Reboita (2022)

A storyline approach to select the CMIP6 model ensemble to be downscaled for the South America domain
ICRC-CORDEX 2023, 25-29th September 2023

MOTIVATION & GOALS

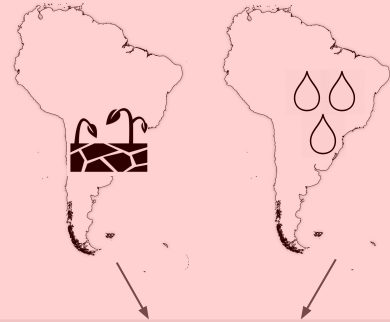
Present

South America
Monsoon

Extratropical
Cyclones

Evaluation of large-scale
performance

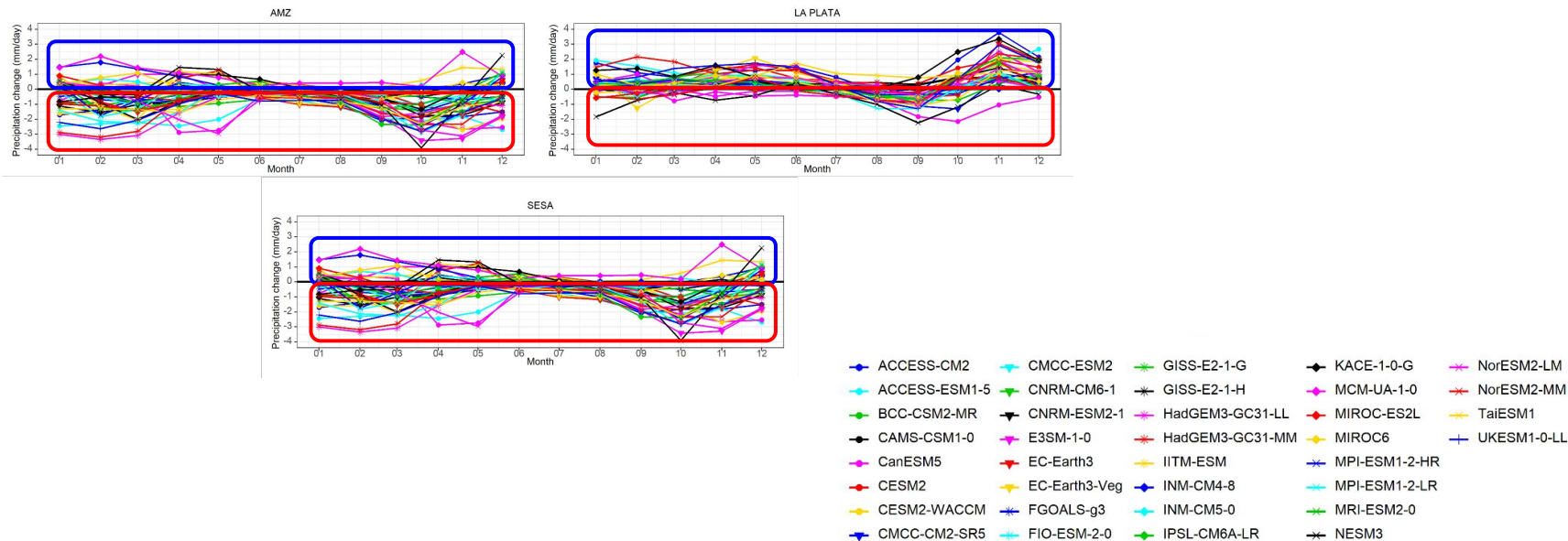
Future



Sampling response uncertainty

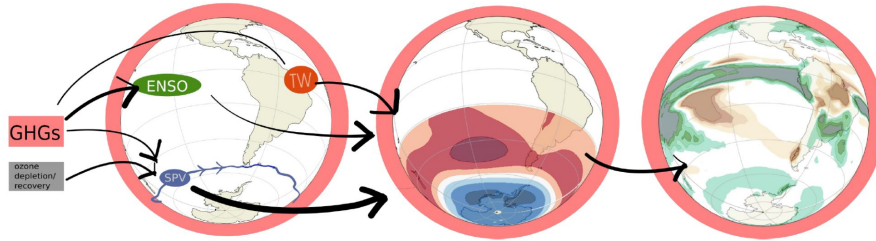
A storyline approach to select the CMIP6 model ensemble to be downscaled for the South America domain
ICRC-CORDEX 2023, 25-29th September 2023

MOTIVATION & GOALS



A storyline approach to select the CMIP6 model ensemble to be downscaled for the South America domain
 ICRC-CORDEX 2023, 25-29th September 2023

DATA & METHODOLOGY

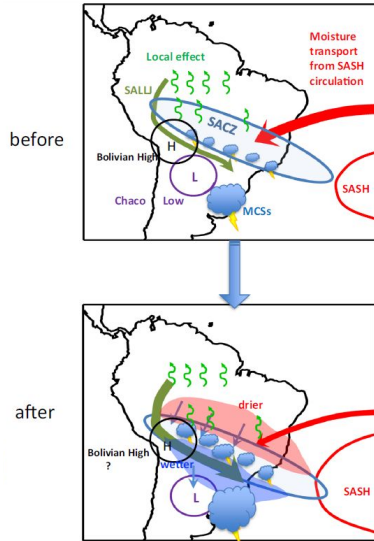


Future changes in extratropical circulation in the Southern Hemisphere

- **Stratospheric polar vortex** breakdown delay leads to poleward shift of Eddy Driven Jet.
- **Tropical Warming** leads to strengthening of the eddy driven jet
- **Warming patterns** in the ENSO region affect South America via planetary waves

A storyline approach to select the CMIP6 model ensemble to be downscaled for the South America domain
ICRC-CORDEX 2023, 25-29th September 2023

DATA & METHODOLOGY



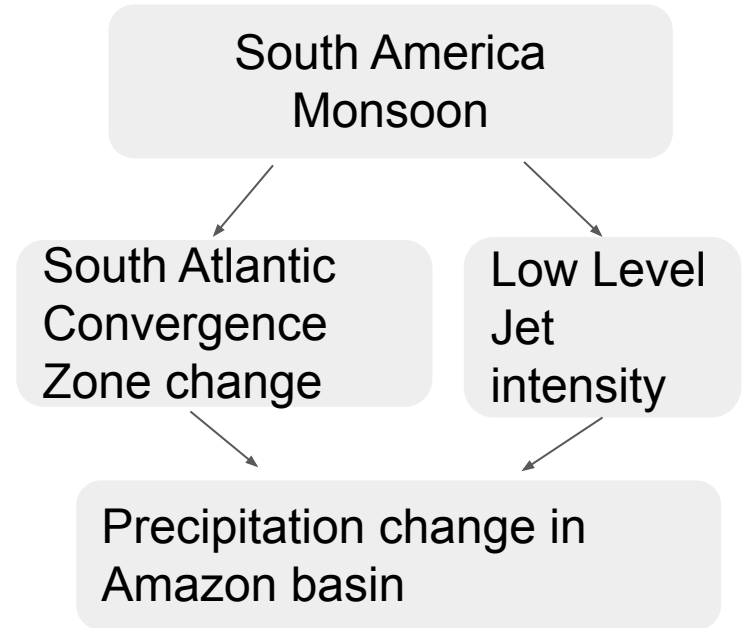
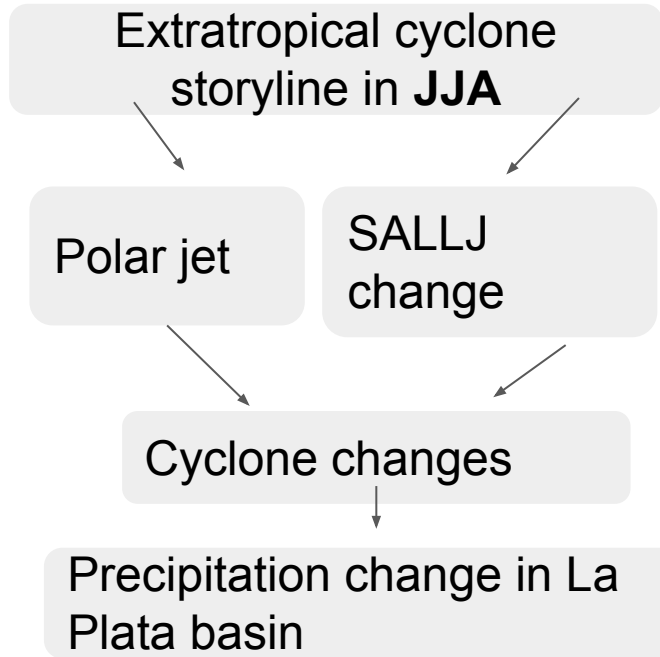
Pascale et al. (2019)

Future changes

- Poleward shift of **monsoon's precipitation** over SAM → weakening of northerly winds and drying of the low-mid levels in tropical atlantic ocean.
- Southward shift of the **South Atlantic Convergence Zone**
- Strengthening of the **South American Low Level Jet**

A storyline approach to select the CMIP6 model ensemble to be downscaled for the South America domain
ICRC-CORDEX 2023, 25-29th September 2023

DATA & METHODOLOGY



A storyline approach to select the CMIP6 model ensemble to be downscaled for the South America domain
ICRC-CORDEX 2023, 25-29th September 2023

DATA & METHODOLOGY

Monsoon



1. Spatial correlation for precipitation in the Hovmoller field
2. Spatial correlation for precipitation in DJF for each region
3. Temporal correlation for precipitation in the annual cycle for each region

Monsoon
and
cyclones



4. Spatial correlation for psl features for DJF
5. Spatial correlation at low levels features (wind speed) for DJF
6. Spatial correlation at upper levels features (wind speed) for DJF

Cyclones

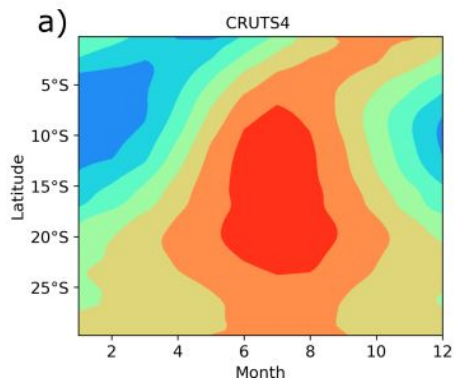


7. Spatial correlation for psl features for JJA
8. Spatial correlation at low levels features (wind speed) for JJA
9. Spatial correlation at upper levels features (wind speed) for JJA

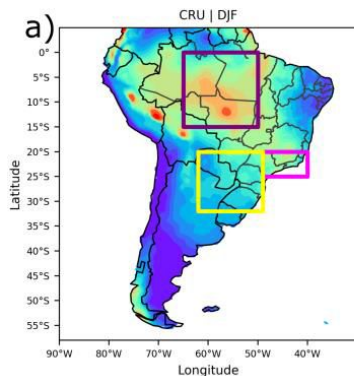
DATA & METHODOLOGY

Monsoon

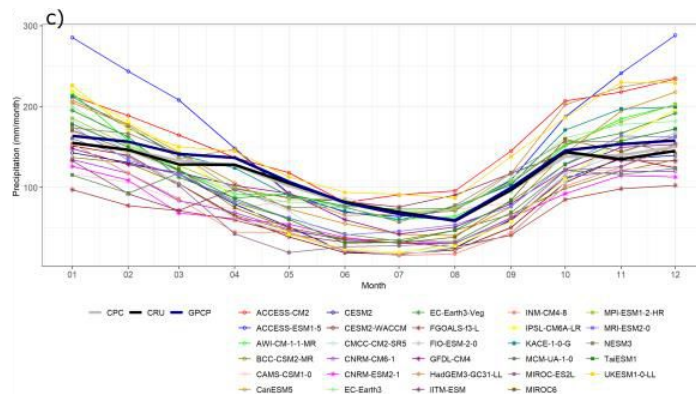
- Spatial correlation for precipitation in the Hovmoller field
- Spatial correlation for precipitation in DJF for each region
- Temporal correlation for precipitation in the annual cycle for each region



Index 1



Index 2



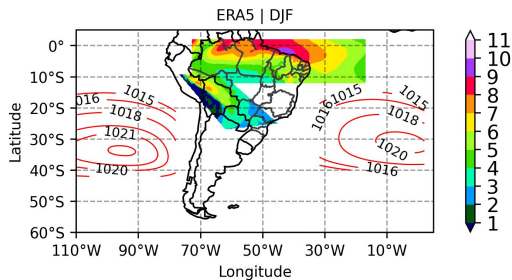
Index 3

DATA & METHODOLOGY

Monsoon
and
cyclones

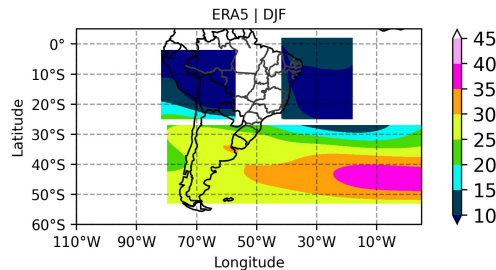
4. Spatial correlation for psl features for DJF
5. Spatial correlation at low levels features (wind speed) for DJF
6. Spatial correlation at upper levels features (wind speed) for DJF

Wind speed at 850 hPa and
mean pressure level



Index 4 and 5

Wind speed at 200 hPa



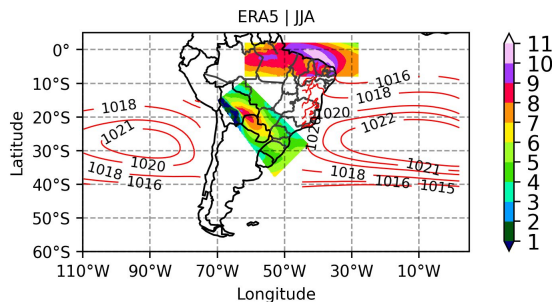
Index 6

DATA & METHODOLOGY

Cyclones

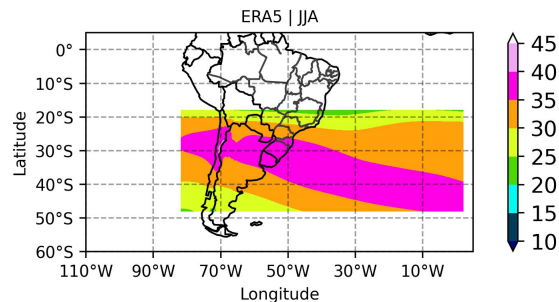
7. Spatial correlation for psl features for JJA
8. Spatial correlation at low levels features (wind speed) for JJA
9. Spatial correlation at upper levels features (wind speed) for JJA

Wind speed at 850 hPa and mean pressure level



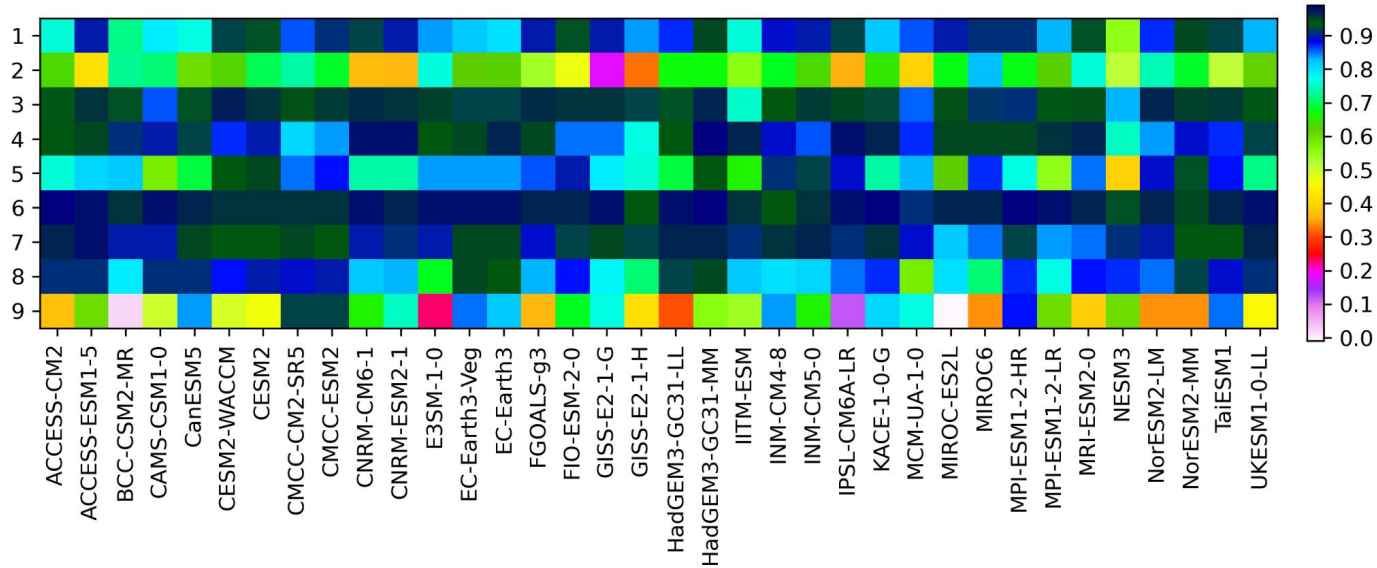
Index 4 and 5

Wind speed at 200 hPa



Index 6

RESULTS



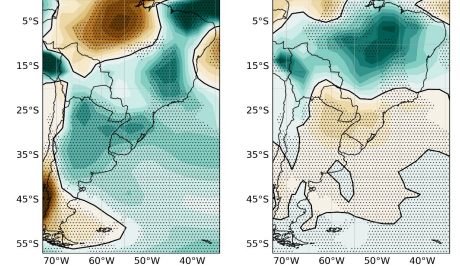
A storyline approach to select the CMIP6 model ensemble to be downscaled for the South America domain
ICRC-CORDEX 2023, 25-29th September 2023

RESULTS

Main drivers
response for SAMS
in Amazon basin

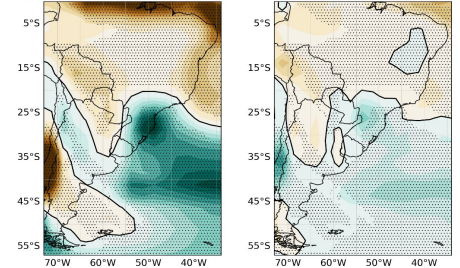
Main drivers
response for EC in
La Plata basin

(a) South American Low Level Jet (b) South Atlantic Convergence Zone



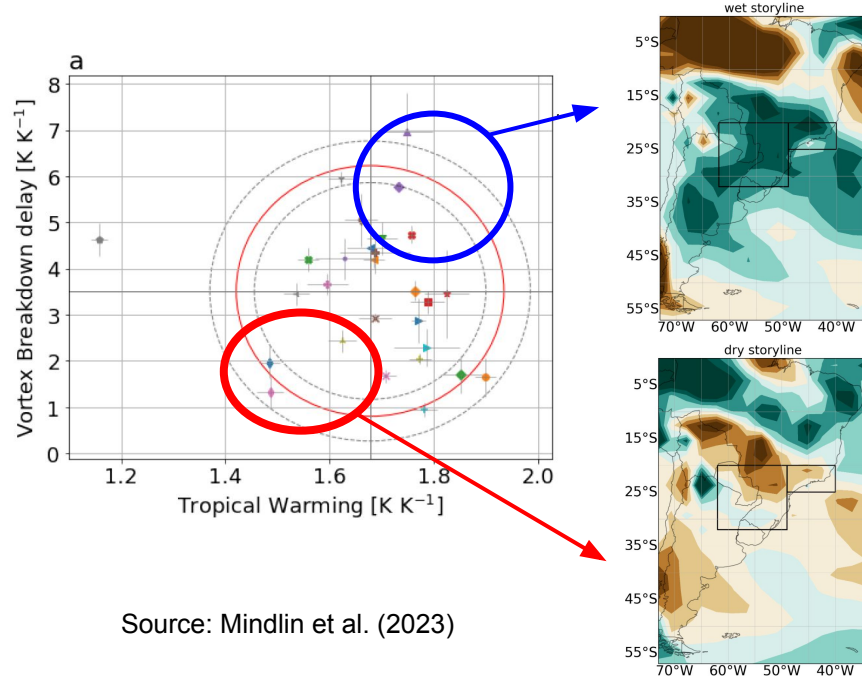
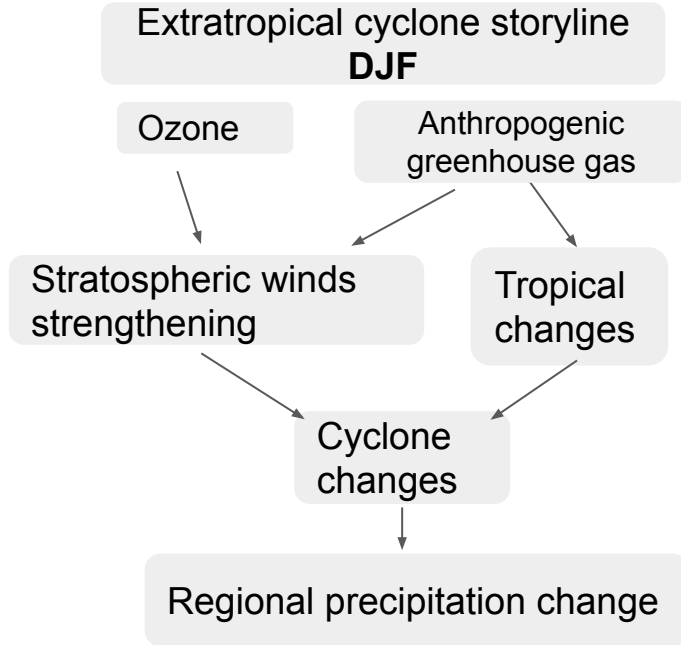
(a) South American Low Level Jet

(b) Polar Jet



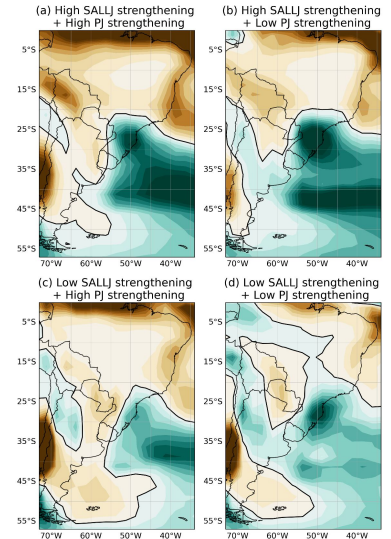
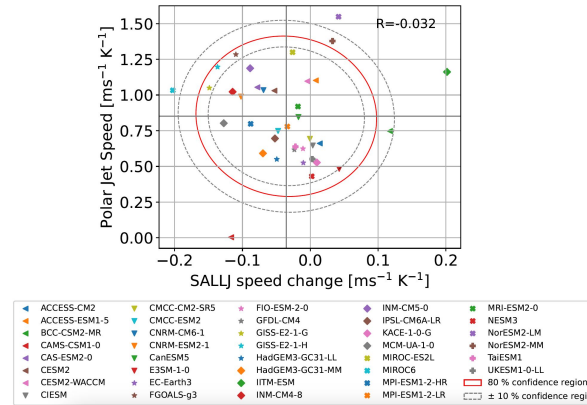
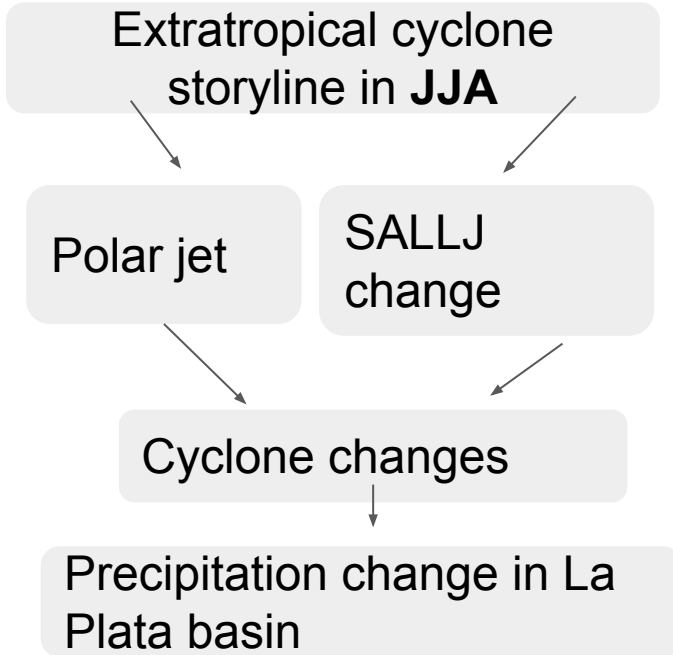
A storyline approach to select the CMIP6 model ensemble to be downscaled for the South America domain
ICRC-CORDEX 2023, 25-29th September 2023

RESULTS



A storyline approach to select the CMIP6 model ensemble to be downscaled for the South America domain
ICRC-CORDEX 2023, 25-29th September 2023

RESULTS



A storyline approach to select the CMIP6 model ensemble to be downscaled for the South America domain
ICRC-CORDEX 2023, 25-29th September 2023

RESULTS

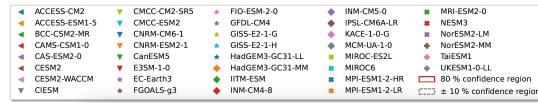
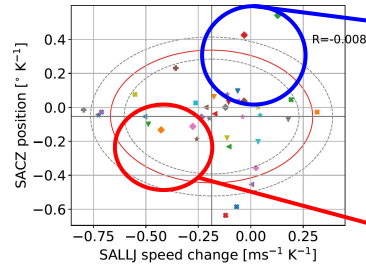
South America
Monsoon storyline **DJF**

South Atlantic
Convergence
Zone change

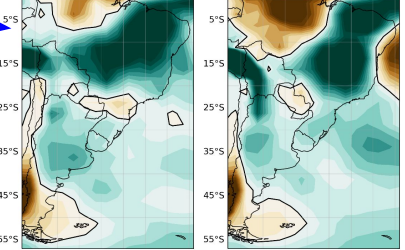
Low Level
Jet
intensity

Cyclone changes

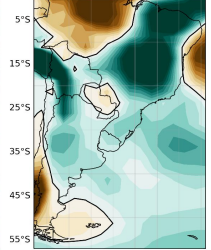
Precipitation change in Amazon basin



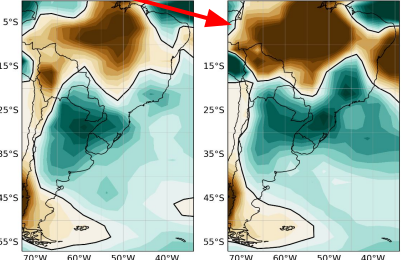
(a) High SALLJ strengthening
+ Large SACZ shift



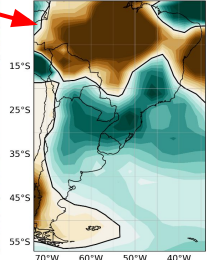
(b) High SALLJ strengthening
+ Small SACZ shift



(c) Low SALLJ strengthening
+ Large SACZ shift

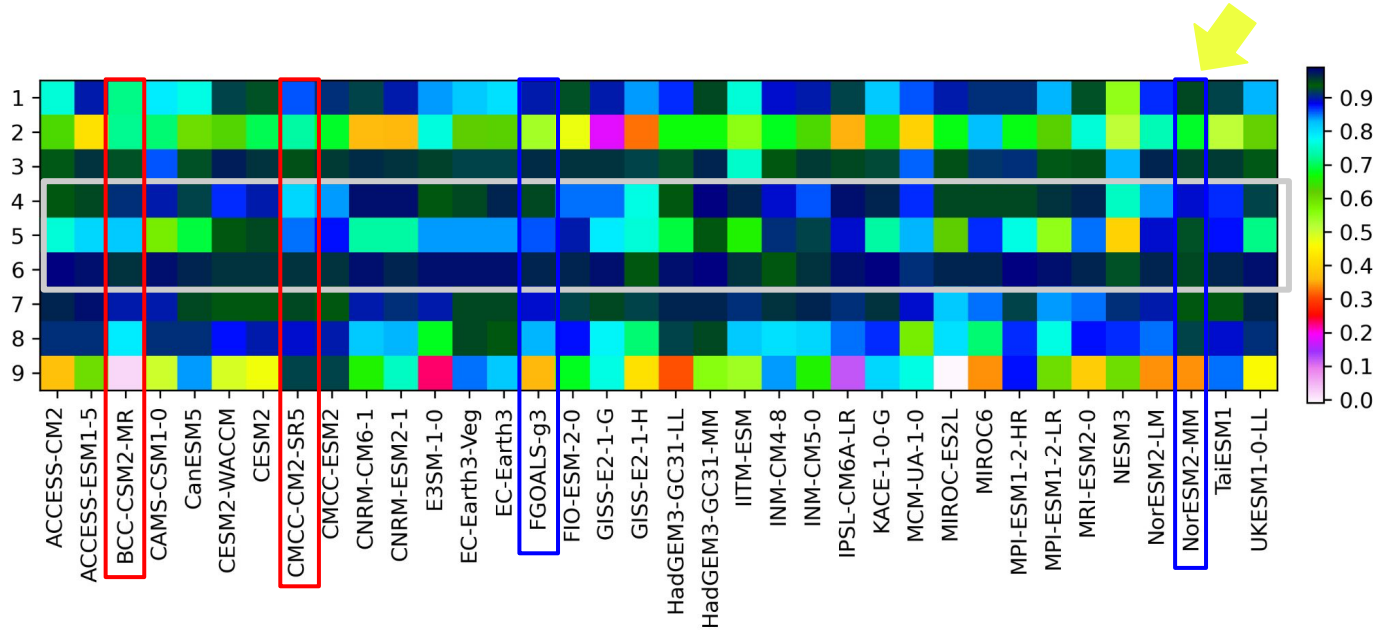


(d) Low SALLJ strengthening
+ Small SACZ shift



A storyline approach to select the CMIP6 model ensemble to be downscaled for the South America domain
ICRC-CORDEX 2023, 25-29th September 2023

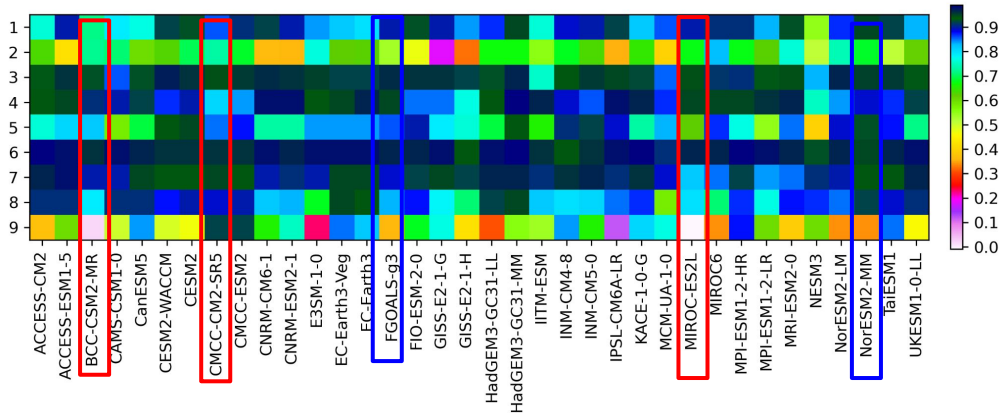
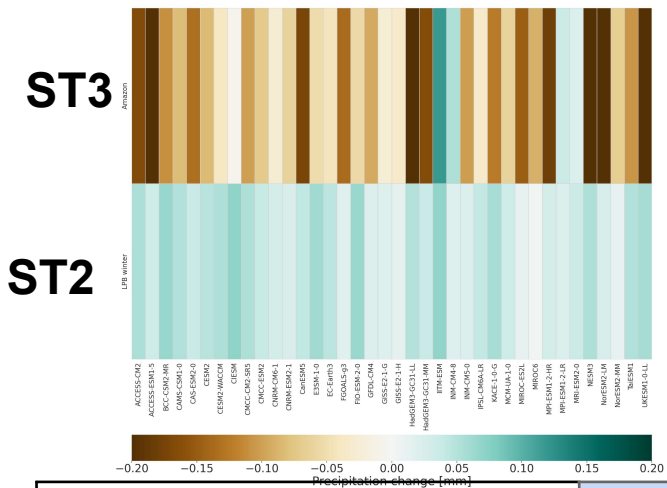
RESULTS



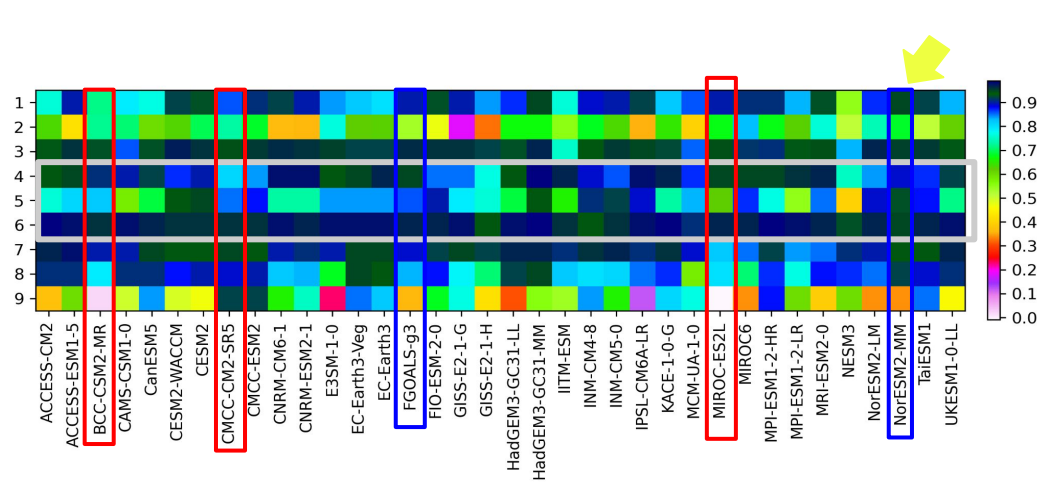
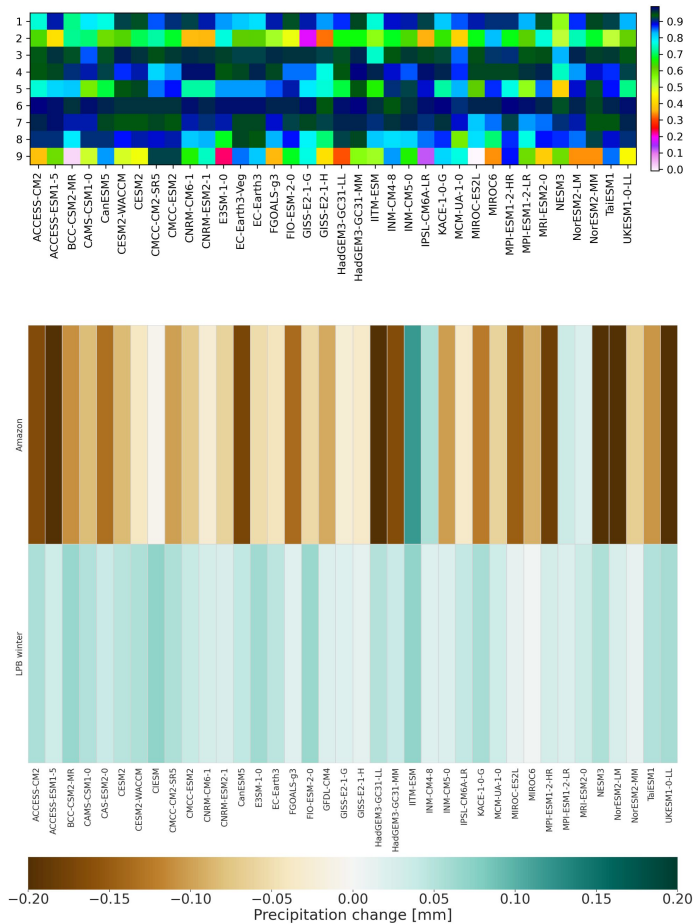
A storyline approach to select the CMIP6 model ensemble to be downscaled for the South America domain
ICRC-CORDEX 2023, 25-29th September 2023

SUMMARY

ST1



Storylines	Wet	Dry
ST1 (SESA -DJF)	NorESM2-MM	CMCC-CM2-SR5
ST2 (LP - JJA)	NorESM2-MM, CMCC-CM2-SR5	
ST3 (AMZ - DJF)	MRI-ESM2	NorESM2-MM, CMCC-CM2-SR5



1. Spatial correlation for precipitation in the Hovmoller field
2. Spatial correlation for precipitation in DJF for each region
3. Temporal correlation for precipitation in the annual cycle for each region

4. Spatial correlation for psl features for DJF
5. Spatial correlation at low levels features (wind speed) for DJF
6. Spatial correlation at upper levels features (wind speed) for DJF

7. Spatial correlation for psl features for JJA
8. Spatial correlation at low levels features (wind speed) for JJA
9. Spatial correlation at upper levels features (wind speed) for JJA

SUMMARY & CONCLUSION

- Storylines have been shown to be a useful tool to select the CMIP6 GCMs for dynamical downscaling;
- Storylines can answer one specific research question or a set of correlated questions
- It is important to consider who are the stakeholders that will use the downscaled product and which are the climatic impact-drivers that are relevant for their needs

THANK YOU

Questions?

For more information

Email: andressa.cardoso@iag.usp.br, aandrade@ictp.it,
julia.mindlin@cima.fcen.uba.ar

A storyline approach to select the CMIP6 model ensemble to be downscaled for the South America domain
ICRC-CORDEX 2023, 25-29th September 2023

REFERENCES

Ferreira GWS, Reboita MS. (2022). A New Look into the South America Precipitation Regimes: Observation and Forecast. *Atmosphere*; 13(6):873. <https://doi.org/10.3390/atmos13060873>

Mindlin, J., Shepherd, T.G., Vera, C.S. *et al.* Storyline description of Southern Hemisphere midlatitude circulation and precipitation response to greenhouse gas forcing. *Clim Dyn* 54, 4399–4421 (2020). <https://doi.org/10.1007/s00382-020-05234-1>

Mindlin, J., Vera, C.S., Shepherd, T.G., *et al.* (2023). Plausible drying and wetting scenarios for summer rainfall in Southeastern South America. *Journal of Climate*.

Pascale, S., Carvalho, L.M.V., Adams, D.K. *et al.* Current and Future Variations of the Monsoons of the Americas in a Warming Climate. *Curr Clim Change Rep* 5, 125–144 (2019). <https://doi.org/10.1007/s40641-019-00135-w>

**A storyline approach to select the CMIP6 model ensemble to be downscaled for the South America domain
ICRC-CORDEX 2023, 25-29th September 2023**