Assessment of homogeneous groups climatology simulated by RCMs-CP over southeastern South America

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Introduction

Climate models with **coarse horizontal resolution** use cumulus convection **parameterization schemes** to solve deep moist **convection**

Uncertainties in simulations and projections

Alternative: to use **high resolution non-hydrostatic models** to **explicitly solve convection** (convection permitting models - CPM)

Before performing long climate simulation (and projection) with **CPM**, we need to know if it **aggregates relevant information** in reproducing **local aspects of climate**.

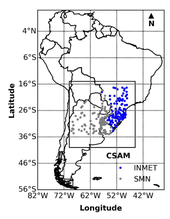
As part of the **CORDEX-Flagship Pilot Studies over southeastern South America - SESA -** (Bettolli et al., 2021), our **objectives** are:

to evaluate convection permitting RCMs simulations over SESA from **RegCM4, RegCM5, WRF-UCAN, WRF-NCAR;**

to assess simulated and observed homogeneous clusters of the annual cycles of precipitation.

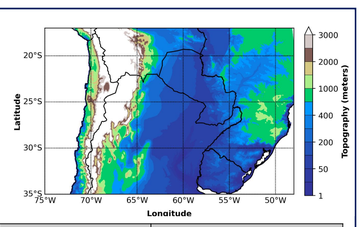
Data

Validation data: **ERA5 reanalysis**
Local stations from **Brazil (InMet), Argentina, Paraguay and Uruguay (SMN):** precipitation
Only from InMet: air temperature, wind at 10 m
Period: June-2018 to May-2021



Simulations

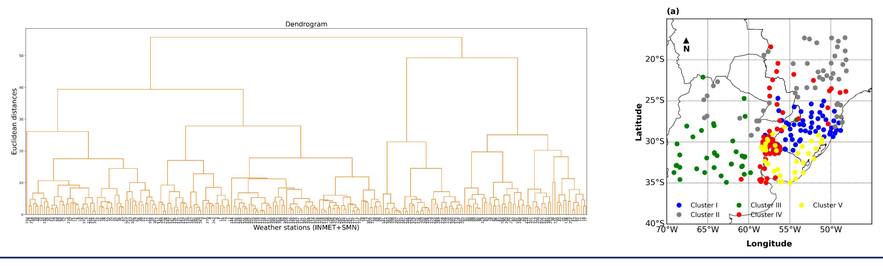
Initial and lateral boundary conditions: ERA5 (SST - ERA5)
Horizontal resolution: ~ 4 km
*WRF-NCAR: longer simulation (2000-2020) over all **South America domain**



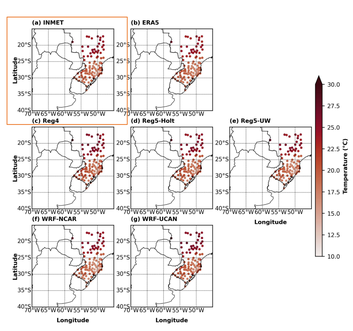
Simulation Period: Jun/2018 to May/2021 (3 years)		Radiation	PBL	Land-surface	Shallow convection
Experiment	**Cloud Microphysics**				
RegCM4 USP (Reg4)	Nogherotto et al.	RRTM	Holtslag	CLM4.5	none
RegCM5 ICTP (Reg5-Holt)	Nogherotto et al.	RRTM	Holtslag	CLM4.5	none
RegCM5 ICTP (Reg5-UW)	Nogherotto et al.	RRTM	UW-PBL	CLM4.5	none
WRF-NCAR*	Thompson Aerosol-Aware	RRTMG	YSU	NOAH-MP	GRIMS
WRF-UCAN	Thompson Aerosol-Aware	RRTMG	NOAH-MP	NOAH-MP	GRIMS

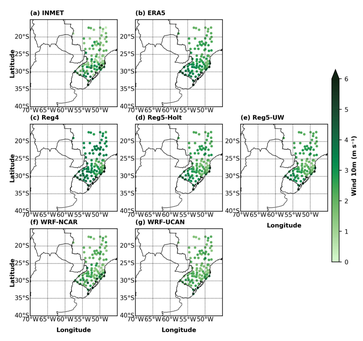
Homogeneous cluster

Annual cycles of precipitation in each station are used to define 5 homogeneous groups (Figure)

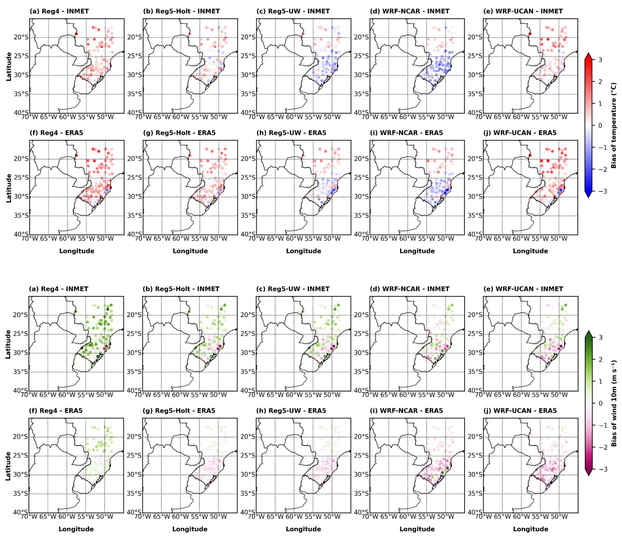


Air temperature and 10-m winds: Means and biases





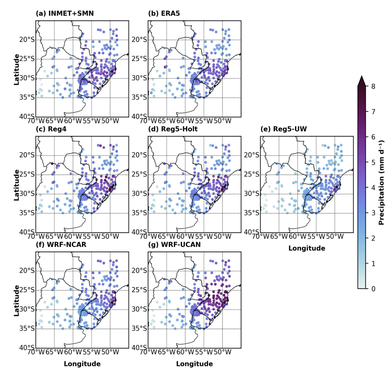
Observed (stations and ERA5) spatial patterns of **air temperature and 10 m winds** are very well reproduced by all simulations.



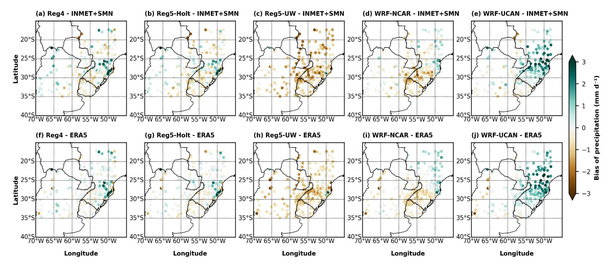
Ai temperature biases (positive or negative) are in general small (± 1.0 ºC) .
Reg4, Reg5-Holt and WRF-UCAN: warm biases predominate in most of the domain;
Reg5-UW, WRF-NCAR: warn bias in north and cold biases in south sectors.

10-m wind biases are greater in module when simulations are compared with the local stations; **Reg4 -** positive biases predominates.
Reg5-UW/Holt, WRF-UCAN, WRF-NCAR: winds underestimation to the south and overestimation to the north of domain.

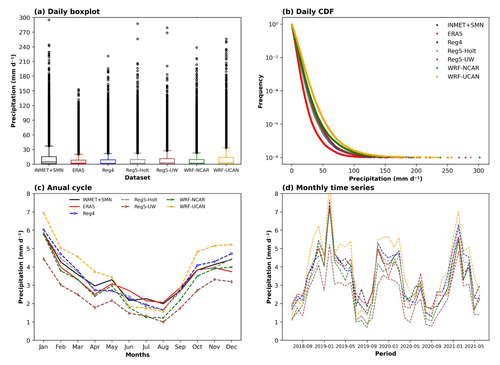
Rainfall: Daily and annual cycle



All simulations captures the observed locations of weaker (center-west Argentina and Brazil) and stronger (south Brazil) rainfall



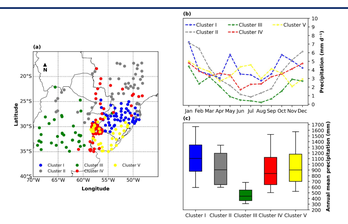
WRF-UCAN: overestimation; **Reg-UW:** underestimation of rainfall;
WRF-NCAR: negative to the south and positive to the north;
Reg4/Reg5-Holt: mix of positive/negative biases; greater overestimation near steeper mountains in south Brazil



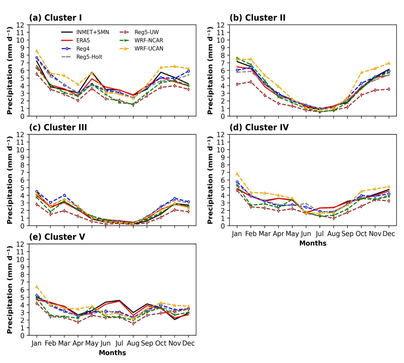
Annual cycle:
- simulations reproduces the phase and amplitude of the observed (stations);
- Minimum in April and peak in May → better reproduced by Reg5-UW and WRF-NCAR.

Average daily rainfall for all station points: Simulations have a better representation of the stations statistics (median, interqual range and outliers) and PDFs than ERA5.

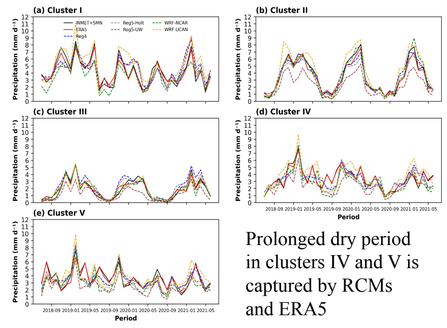
Clusters analysis of rainfall and interannual variability



The five clusters were separated using only station data;
5 clusters have different annual cycles and total amounts of rainfall.

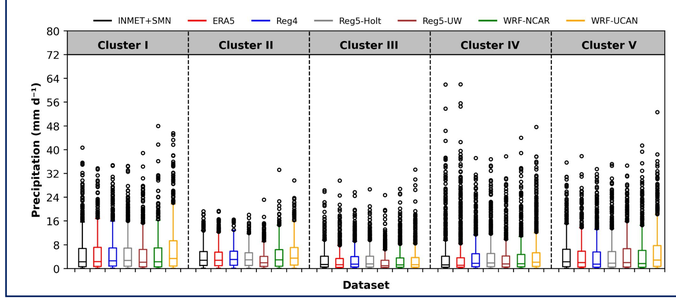


Annual cycle:
- Simulations captures very well the phase and amplitude of the observed annual cycles in most clusters, except in cluster V;
- ERA5 is able to show the 5 clusters annual cycles in greater agreement with local stations, including the V.



Prolonged dry period in clusters IV and V is captured by RCMs and ERA5

- RCMs captures better the time evolution of monthly rainfall in the clusters I, II and III;
- RCMs discrepancies in relation to the stations are greater in the clusters IV and V;
- ERA5 have great ability in reproducing both the phase and amplitude of interannual and seasonal variabilities showed by stations.



Most of simulations (except WRF-UCAN in clusters I, II and IV) the medians, interquartile ranges, and outliers (except cluster IV) in greater agreement with station data than ERA5.

Conclusions

A **3 years (Jun/2018 to May/2021) RCM-CP** simulations for SESA were analysed.
RCMs vs ERA5 vs local stations
- RCMs mean spatial pattern of rainfall, air temperature and 10-m winds are similar to the observed ones (local stations and ERA5);
- RCMs biases are smaller compared to ERA5 than local stations
- RCMs reproduces better the daily rainfall statistics for all stations than ERA5.

Cluster analysis:
- **RCMs** reproduces the annual cycle, interannual variability and frequency distributions of daily rainfall in **great agreement with the observations.**

RCM simulations x ERA5 (added value)
- daily rainfall statistics is better reproduced by RCMs than ERA5;
- ERA5 is better to reproduces the monthly rainfall climatology (annual cycle and monthly time series) in all clusters → a) good news to study interannual variability using ERA5; b) to help us with the missing monthly data in the stations (very common problem in South America).

Overall: RCMs-CP results are encouraging, as previous simulations for SESA did not perform well in terms of annual cycle and interannual variability.

References

Bettolli, M.L., Solman, S.A., da Rocha, R.P. *et al.* The CORDEX Flagship Pilot Study in southeastern South America: a comparative study of statistical and dynamical downscaling models in simulating daily extreme precipitation events. *Clim Dyn* 56, 1589–1608 (2021). https://doi.org/10.1007/s00382-020-05549-z

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