At which scales can added value be expected in Regional Climate Models?

Silvina Solman
CIMA (CONICET-UBA) – DCAO (FCEyN-UBA)
Buenos Aires - Argentina

Second Workshop on Regional Climate Modelling and Extreme Events over South America
November 5-9, 2018, Saõ Paulo, Brazil

Motivation

- Are RCMs better compared with their driving GCMs in reproducing the behavior of precipitation over South America (SA) at different temporal scales?
  - Interannual
  - Intraseasonal
  - High-frequency (synoptic scale)
  - Statistics of daily rainfall
  - Extreme precipitation
- Do RCMs add value compared with the driving GCM? At which scales?

Solman and Blázquez (2018) submitted to Clim Dyn

Precipitation Data (1979-2005)

Observations:

- CPC-Unified (0.5ºx0.5º) monthly and daily

CORDEX/CMIP5 RCMs/GCMs:

- RCA4/ICHEC-EC-EARTH (1.1215ºx1.1215º)
- RCA4/MPI-M-MPI-ESM-LR (1.865ºx1.865º)
- REMO2009 /MPI-M-MPI-ESM-LR (1.865ºx1.865º)
- WRF3.4/CanESM2 (2.79º x 2.81º)

- CORDEX RCMs resolution is 0.44º x 0.44º

Methodology

- Analysis based on different temporal sales of precipitation behavior:
  - **Seasonal Means**
  - **Variability**
    - Filtering (Lanczos filter)
    - EOF analysis
  - **Extremes**
    - PDFs
    - Percentiles

Seasons: AMJJAS and ONDJFM

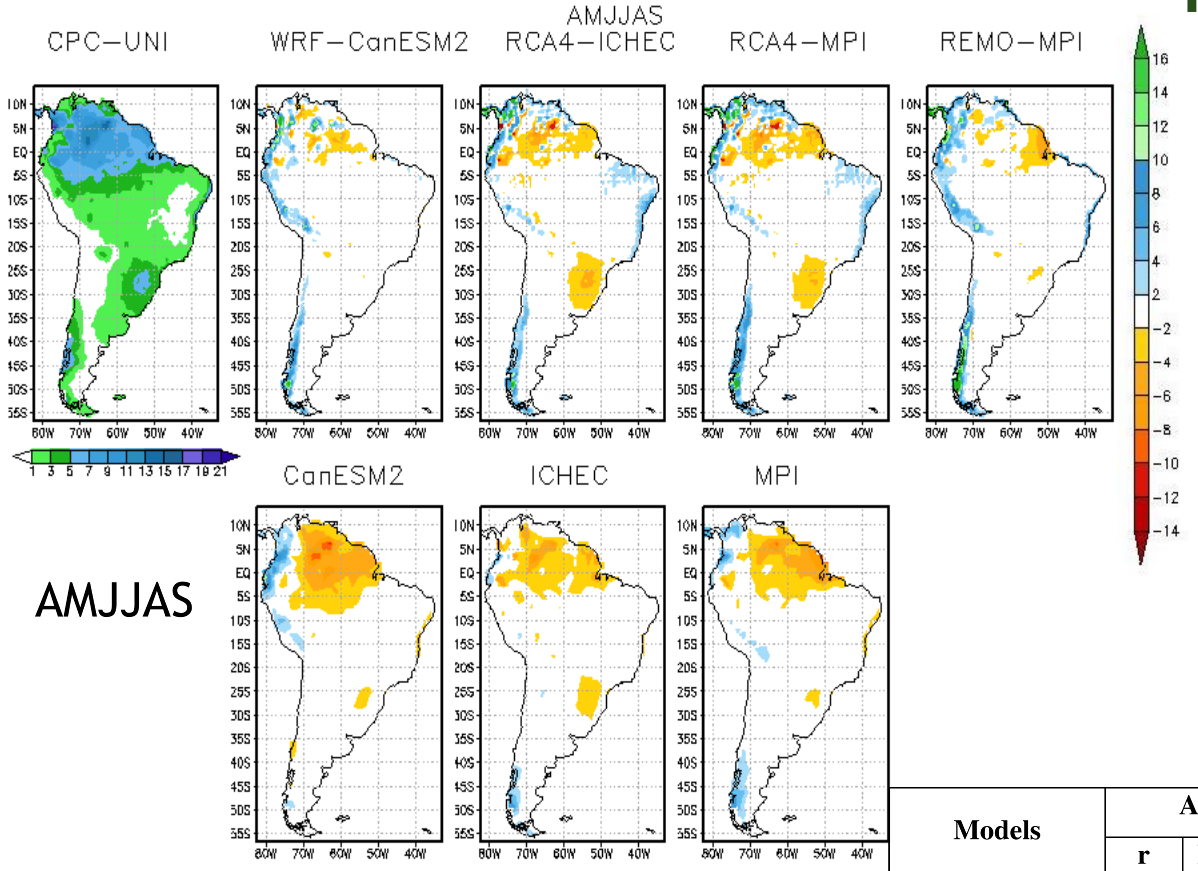
- Metrics
  - Pattern correlation
  - M-skill score $M = \frac{2}{\pi} arcsin\left(1 - \frac{MSE}{V_x + V_y + (G_x - G_y)^2}\right) x1000.$ (Watterson et al., 2014)

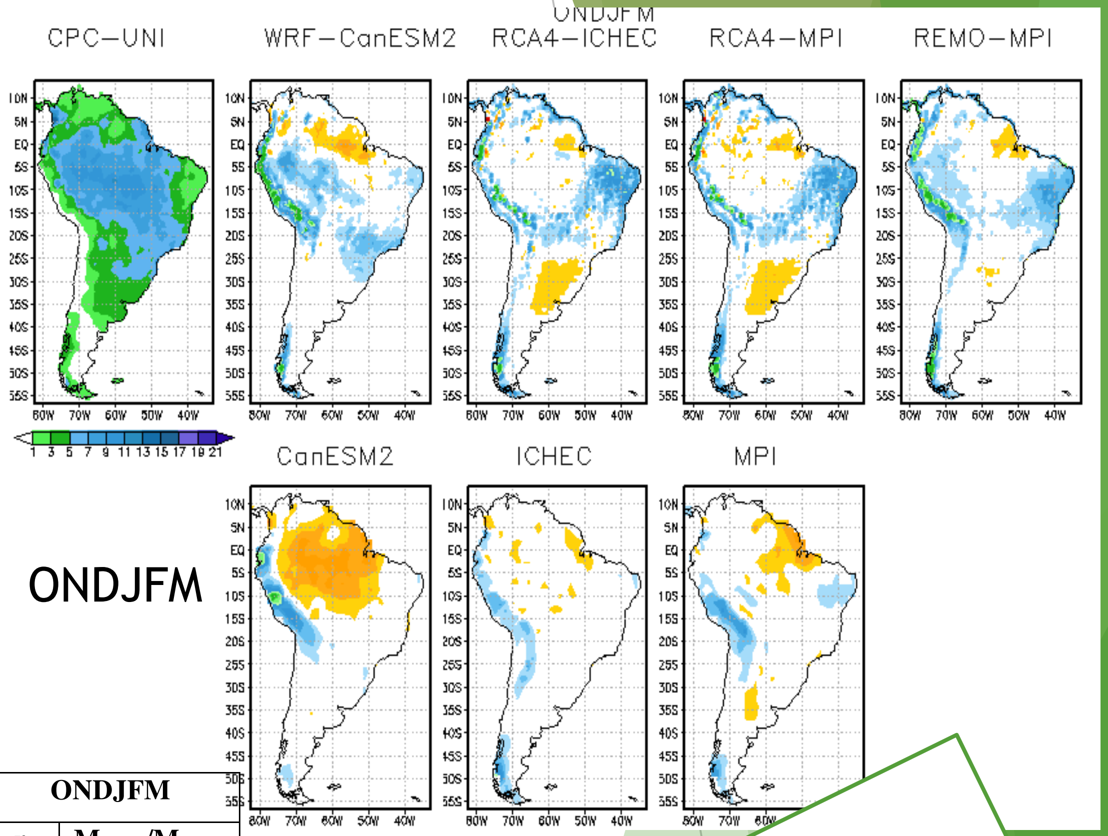
Spatial variance (V_x, V_y); Spatial mean (G_x, G_y)

X: obs

Y: model

Seasonal mean precipitation bias



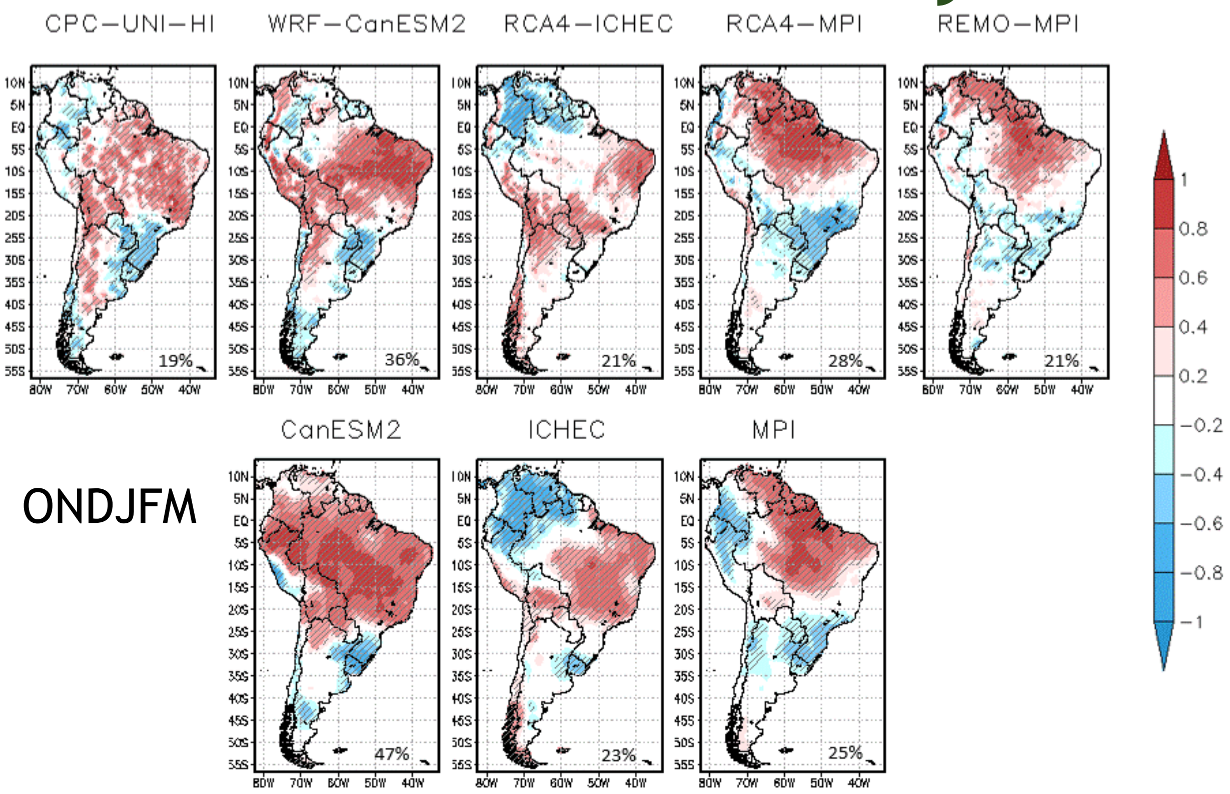


Models	AMJJAS		ONDJFM	
	r	M_{RCM}/M_{GCM}	r	M_{RCM}/M_{GCM}
WRF-CanESM2	**0.76**	1.70	**0.55**	2.10
RCA4-ICHEC	**0.59**	0.21	**0.55**	0.63
RCA4-MPI	**0.54**	0.86	**0.48**	0.66
REMO-MPI	**0.63**	1.00	**0.56**	0.67
CanESM2	0.56		0.24	
ICHEC	0.78		0.76	
MPI	0.66		0.65	

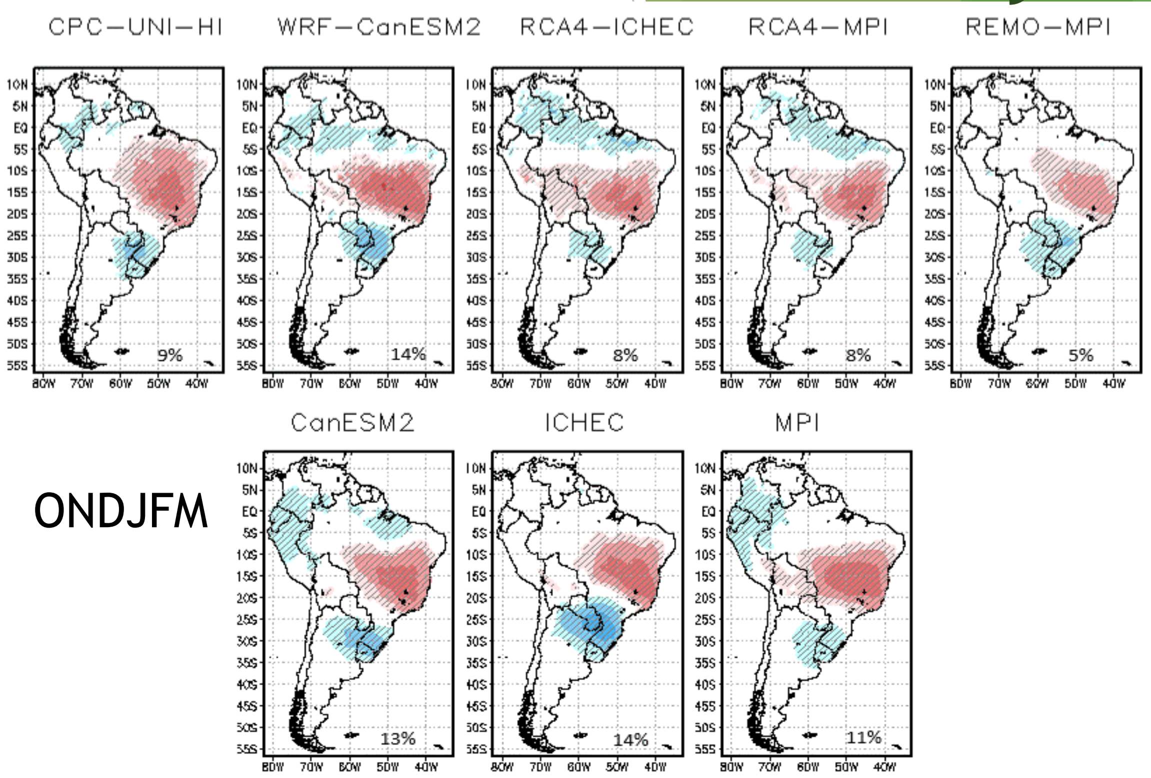
Lack of added value from RCMs in capturing the mean precipitation features may be due to the dominant control of the large-scale circulation on the precipitation climatology.

RCMs do not systematically improve driving GCMs

Interannual variability



Intraseasonal variability



Correlation between PC 1st EOF and precipitation anomalies

Dominant control of variability driven by GCMs

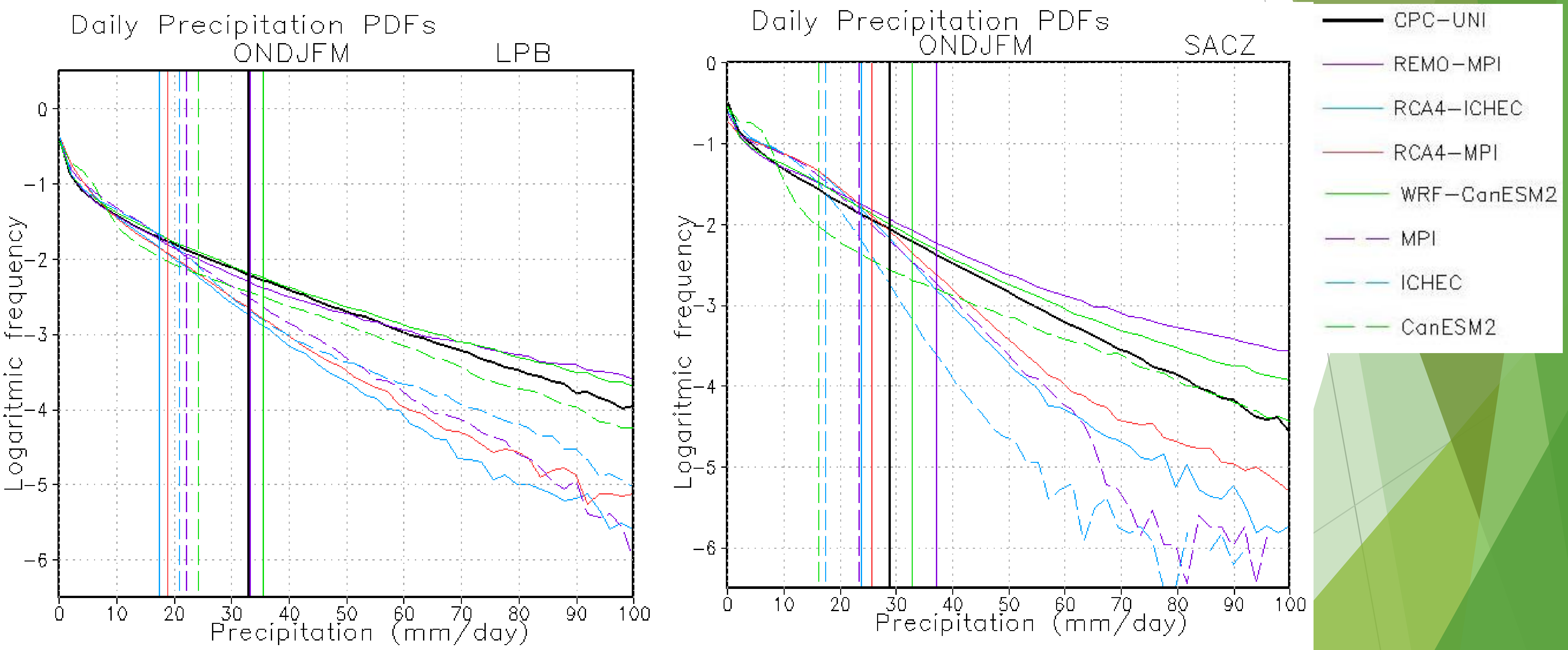
RCMs do not systematically improve driving GCMs

Summary of RCM vs GCM performance

	MODELS	AMJJAS			ONDJFM		
		STD r	M_{RCM}/M_{GCM}	EOF r	STD r	M_{RCM}/M_{GCM}	EOF r
IA	WRF-CanESM2	**0.46**	1.09	0.28	**0.26**	1.14	**0.58**
	RCA4-ICHEC	0.33	1.79	**0.36**	**0.22**	1.88	**0.26**
	RCA4-MPI	**0.34**	0.86	0.30	**0.25**	0.87	**0.31**
	REMO-MPI	**0.46**	1.64	**0.05**	**0.35**	1.53	**0.23**
	CanESM2	0.54		0.31	0.30		0.49
	ICHEC	0.32		0.16	0.27		0.47
	MPI	0.55		0.31	0.44		0.49
IS	WRF-CanESM2	**0.63**	2.22	**0.70**	**0.46**	1.50	**0.80**
	RCA4-ICHEC	**0.35**	1.25	**0.22**	**0.40**	1.30	**0.68**
	RCA4-MPI	**0.38**	0.66	**0.06**	**0.36**	0.68	**0.67**
	REMO-MPI	**0.57**	0.98	**0.72**	**0.57**	0.84	**0.76**
	CanESM2	0.45		0.61	0.41		0.78
	ICHEC	0.50		0.45	0.52		0.85
	MPI	0.67		0.76	0.63		0.85
SI	WRF-CanESM2	**0.69**	2.59	**0.82**	**0.41**	1.67	**0.82**
	RCA4-ICHEC	**0.35**	1.10	**0.32**	**0.35**	0.88	**0.75**
	RCA4-MPI	**0.38**	0.70	**0.26**	**0.28**	0.34	**0.68**
	REMO-MPI	**0.65**	1.76	**0.68**	**0.59**	0.84	**0.74**
	CanESM2	0.45		0.47	0.35		0.58
	ICHEC	0.48		0.51	0.51		0.70
	MPI	0.61		0.80	0.67		0.70

- Only WRF RCM overperforms ist driving GCM
- The improvement is more evident as long as the higher is the frequency

Daily precipitation statistics



Extreme precipitation

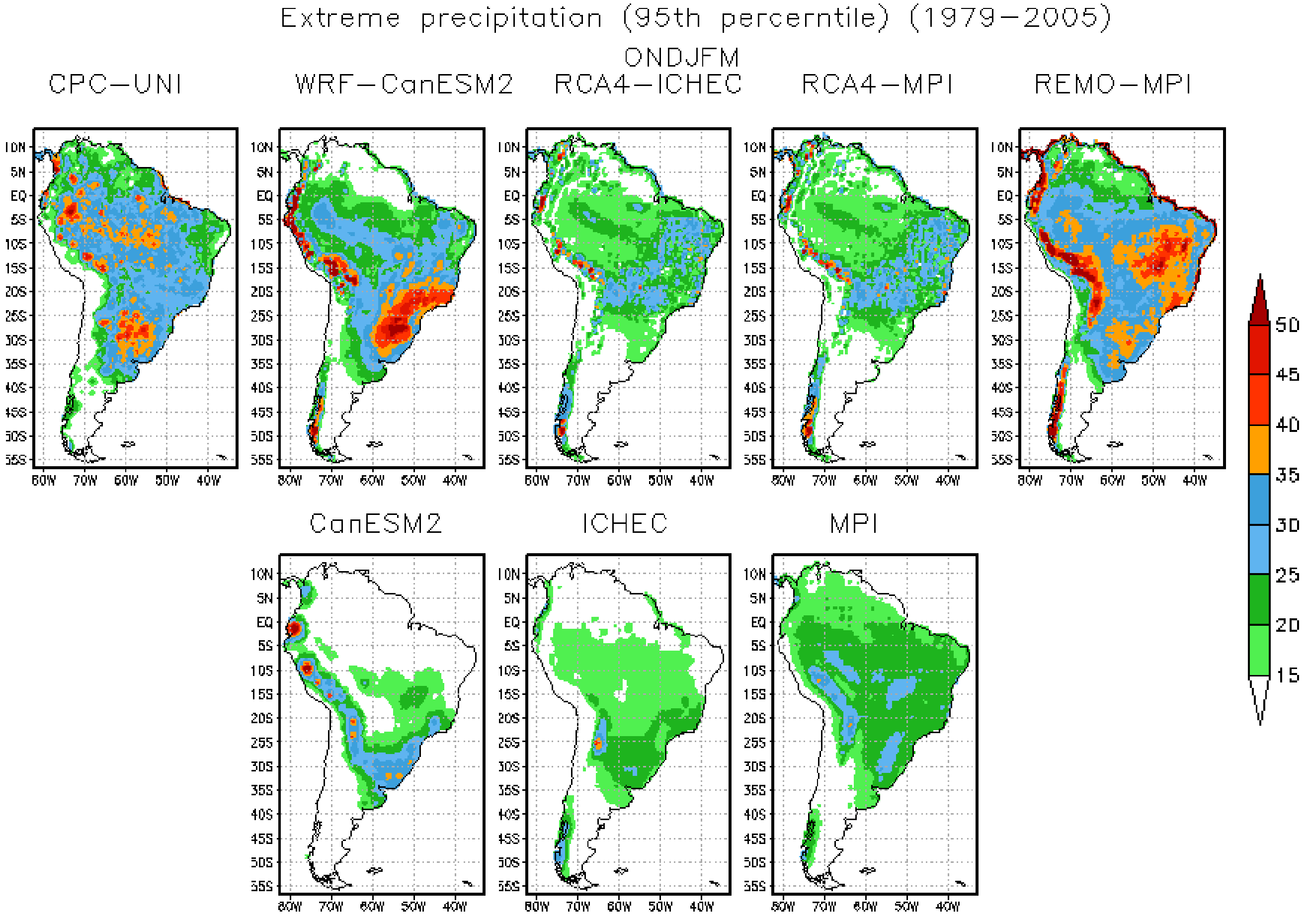


Figure 8: Extreme precipitation (95th percentile) for the period 1979-2005 for ONDJFM. Units are mm/day.

MODELS	Extreme precipitation for ONDJFM			
	95th percentile		Contribution to seasonal rainfall	
	r	M_{RCM}/M_{GCM}	r	M_{RCM}/M_{GCM}
WRF-CanESM2	**0.41**	2.86	**0.44**	1.59
RCA4-ICHEC	**0.34**	0.92	**0.41**	0.90
RCA4-MPI	**0.30**	0.52	0.41	0.90
REMO-MPI	**0.47**	1.02	0.41	1.75
CanESM2	0.27		0.26	
ICHEC	0.61		0.56	
MPI	0.64		0.41	

- Improvement of RCMs compared with GCMs in reproducing extremes
- Models with strong biases do not add value to their driving GCMs at any scale
- Resolution is still low for RCMs to capture topographic forcings inducing a systematic improvement in model performance

Challenges for CORDEX-SAM

- Model improvements, particularly on the land-surface schemes
- Increasing resolution for the CORDEX – SAM domain (22 km)
- Increasing the ensemble size
- Availability of reliable datasets of high-quality observations covering the whole South American continent
- Regional phenomena and smaller domains deserving higher resolution (convective- permitting) - FPS SAM

Thank you!