CLIPSSA: High-Resolution Island Scale Climate Simulation for Improved Adaptation Strategies in the Southwest Pacific Region

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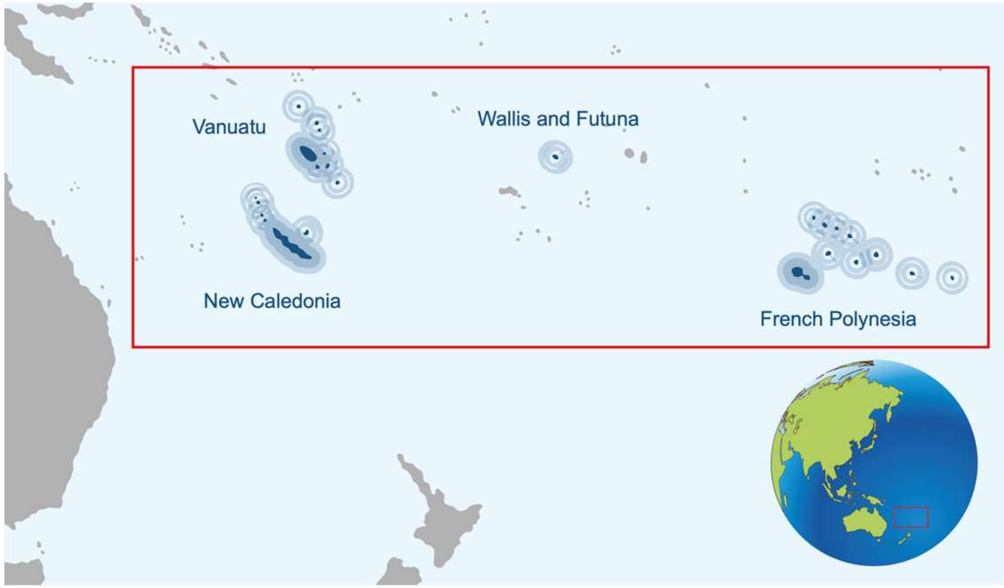
CLIPSSA

● CLIPSSA project: Pacific Climate Local Knowledge and Adaptation Strategies



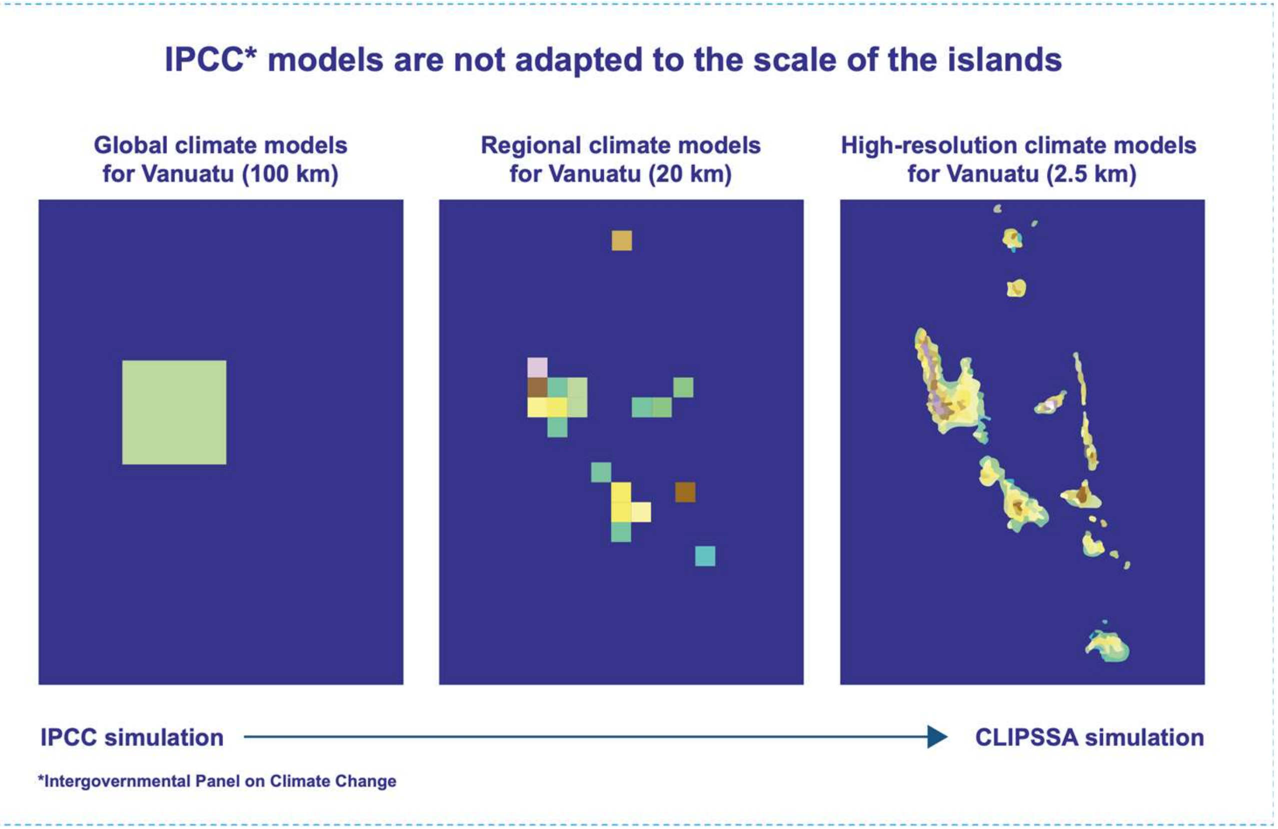
- ***CLIPSSA is a regional project that aims to develop new scientific data on the future climate of the South Pacific to analyse sectoral impacts and local knowledge and adaptation practices already existing in each territory***

- **Produce high-resolution climate simulations (20km grid cells) for the entire South Pacific.**
- Generate very high-resolution simulations (2.5 km grid cells) over selected region
- Update climate change data from IPCC models and national priorities for climate-impacted sectors.
- Develop databases to collect local knowledge and practices, forming "risk cultures" of island populations
- Analyze changes in knowledge transmission and valuable know-how for adaptation.
- Provide support for developing/updating climate adaptation strategies, leveraging local knowledge and promoting them among the population.

CLIPSSA objective

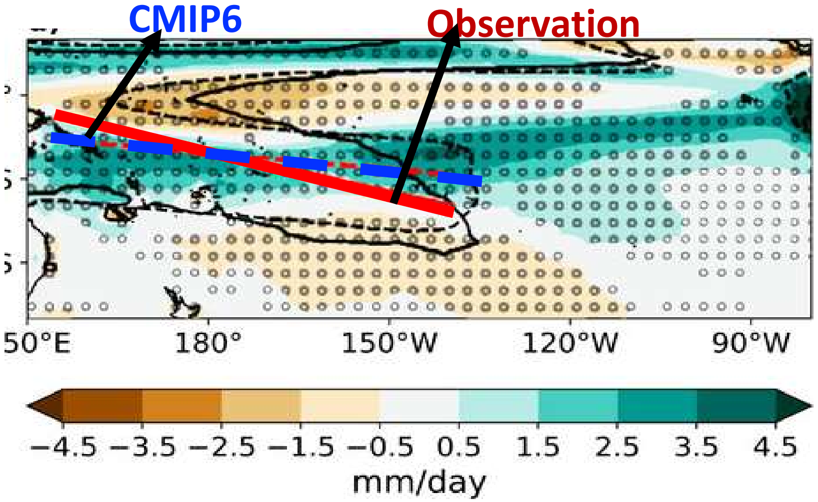
High resolution climate simulation for South Pacific region

- Better understanding of future climate extremes ; heat waves, precipitation, drought and cyclone activities
- Region : New Caledonia, Vanautu , Wallis and Futuna, and French Polynesia



IPCC* models are not adapted to the scale of the islands

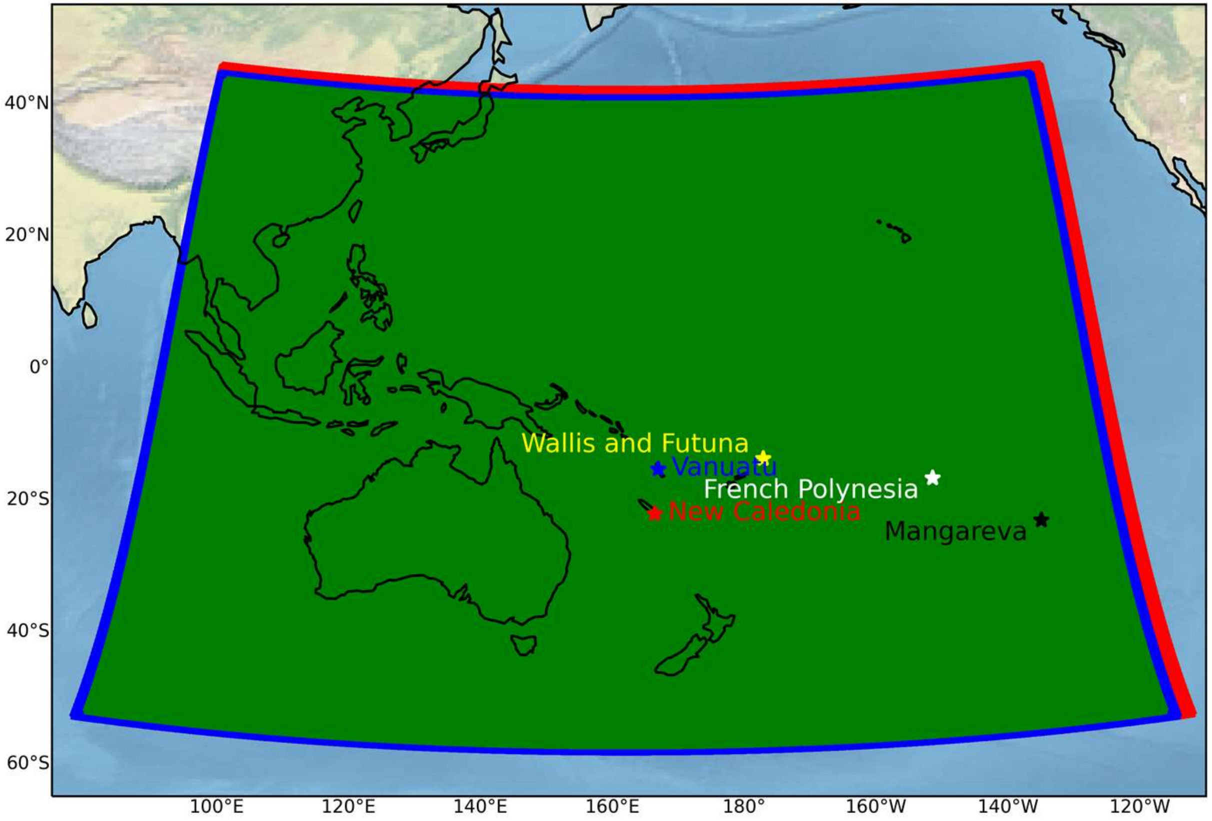
*Intergovernmental Panel on Climate Change



- Challenges : Create a better simulation using ALADIN with accurate positioning of South Pacific Convergence Zone (SPCZ) associated patterns

ALADIN Model

- ❑ Limited area and hydrostatic bi-spectral model based on the 37t1 cycle of ARPEGE climate model
- ❑ **ALADIN v632**
- ❑ Projection: Lambert conformal
- ❑ 91 vertical levels
- ❑ 789 x 637 points for the C+I area
- ❑ From 40N to 60S and 100E à 120W
- ❑ Projection: Lambert conformal
- ❑ **20km**
- ❑ **Historical period**: Forced by **ERA5** reanalysis



CLIPSSA: Better extreme events in downscaled models

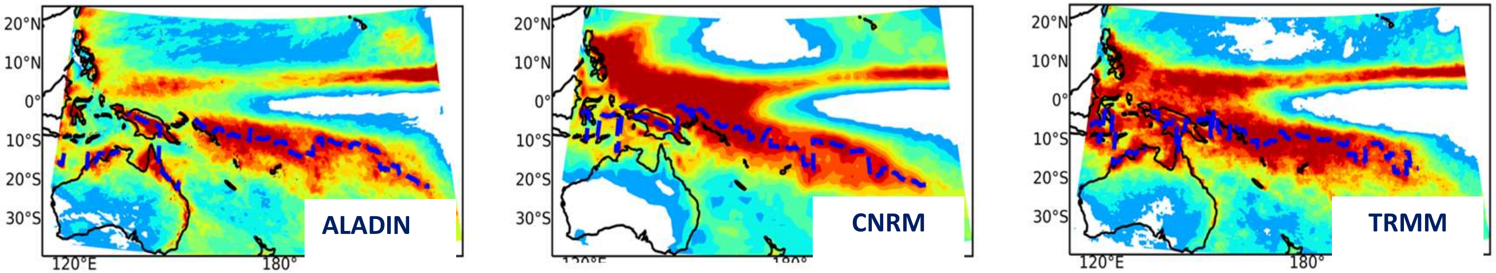


***Fig**: Annual rainfall (shaded) and position of SPCZ (blue line)*

ALADIN simulate the SPCZ and rainfall better than CNRM global model

ALADIN simulate the tropical cyclones better than ERA5 (forcing model) in terms of frequency, and intensity

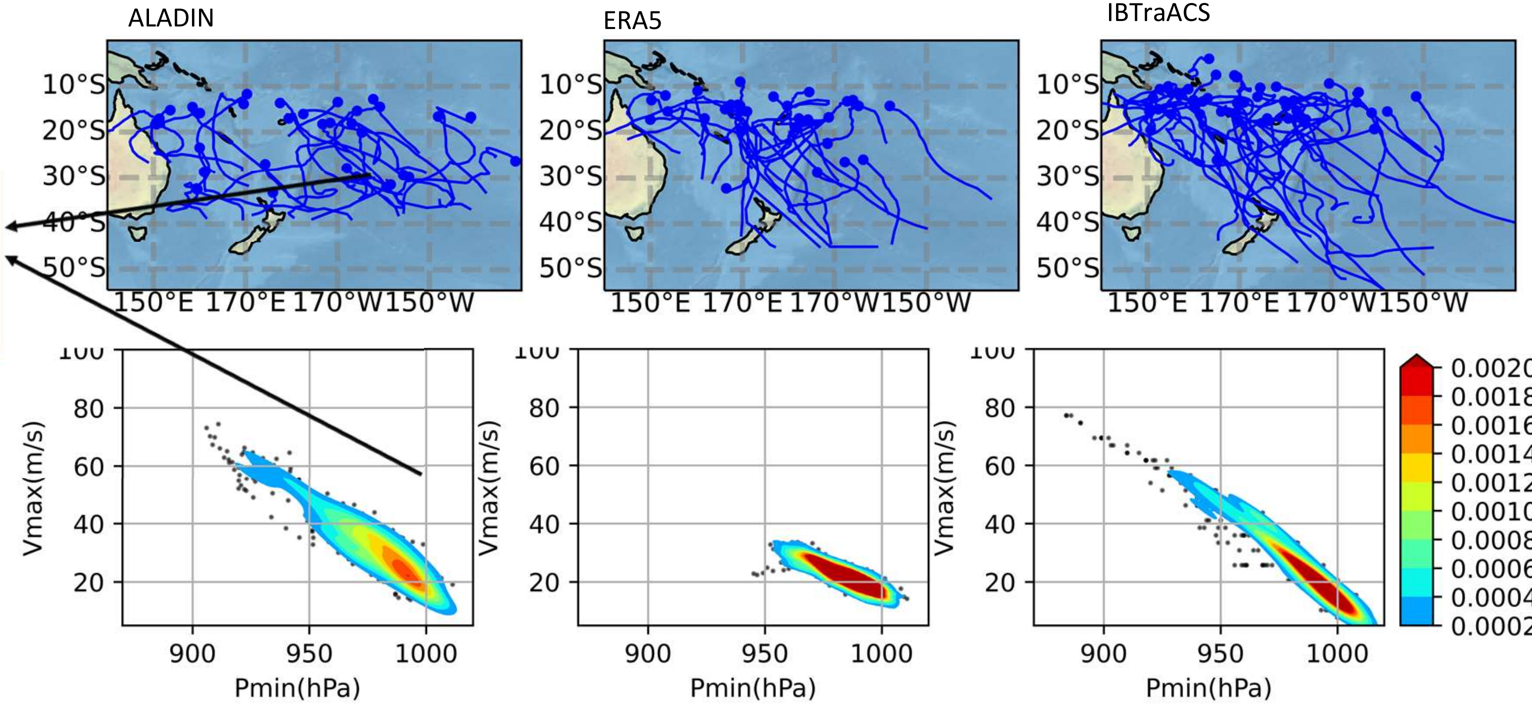
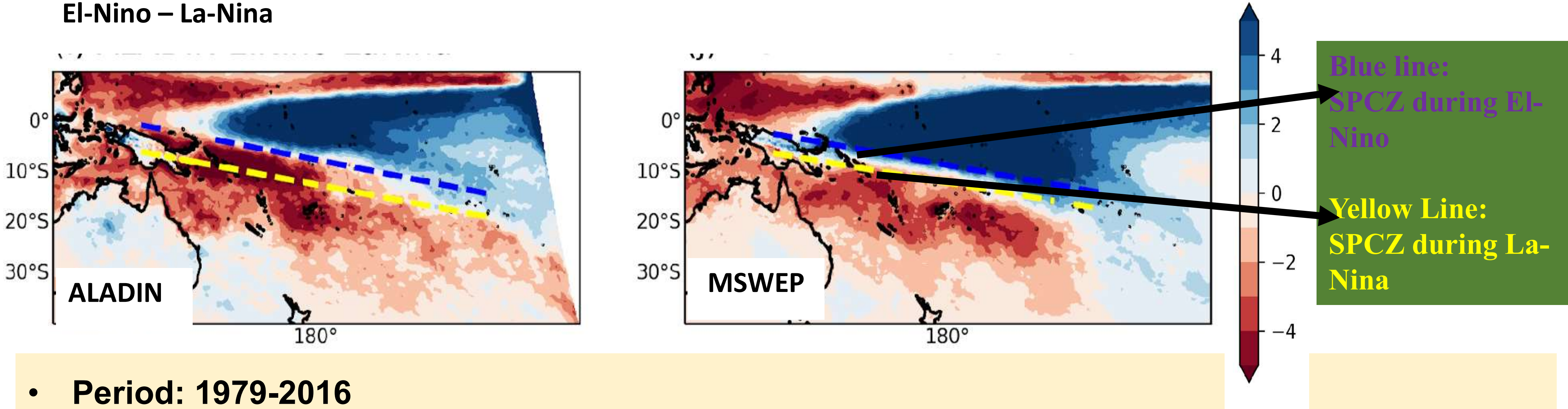


***Fig**: Top panel: Tropical cyclone Track (line) and genesis (dot) Bottom Panel: Intensity diagram, Pressure minimum versus the maximum velocity.*

Rainfall during ENSO phases

El-Nino – La-Nina



Blue line: SPCZ during El-Nino

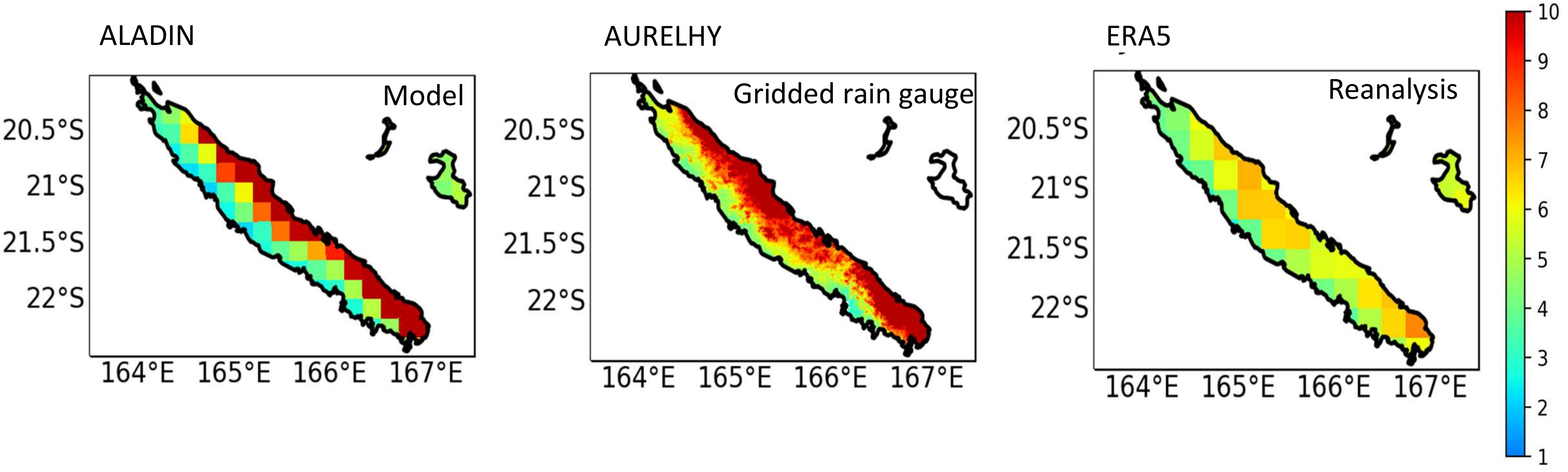
Yellow Line: SPCZ during La-Nina

- **Period: 1979-2016**
- **During El-Nino, the SPCZ shifted towards the equator, with more precipitation in the central Pacific region and less in the southwest Pacific region.**
- **The opposite is true during La-Nina.**
- **ALADIN captures interannual variability in terms of ENSO.**

La-Nina = [1984, 1985, 1989, 1996, 1999, 2000, 2001, 2006, 2008, 2009, 2011, 2012]
El-Nino = [1983, 1987, 1988, 1992, 1995, 1998, 2003, 2005, 2007, 2010, 2015, 2016]

Rainfall in Island scale (New Caledonia)

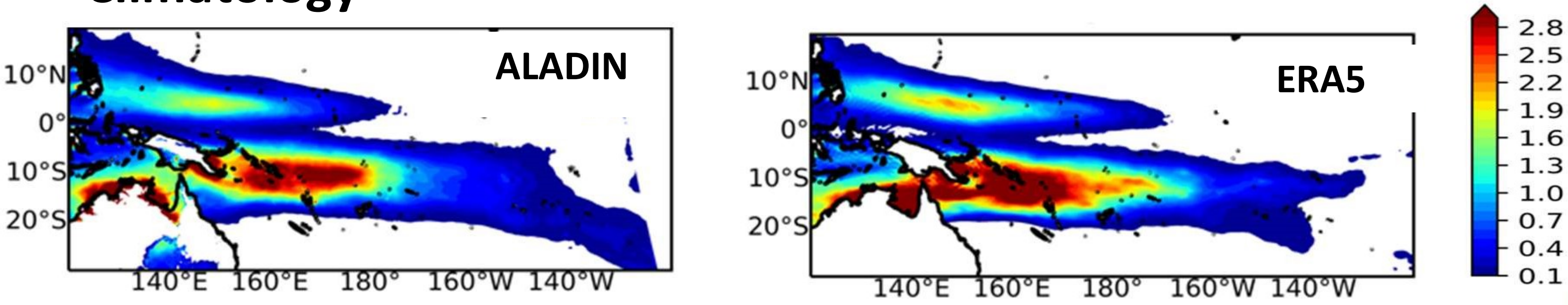
Summer (DJF)



- **Model captures spatial and seasonal structure better than reanalysis**

Tropical cyclones: Genesis Potential Index

Climatology



- **Period: 1979-2016**
- **Cyclone conductive over southwest for La-Nina and northeast for El-Nino**

El-Nino – La-Nina

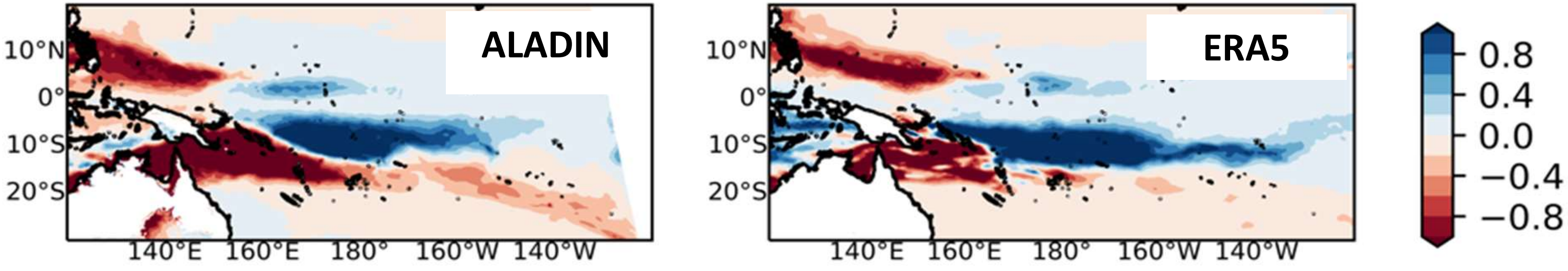
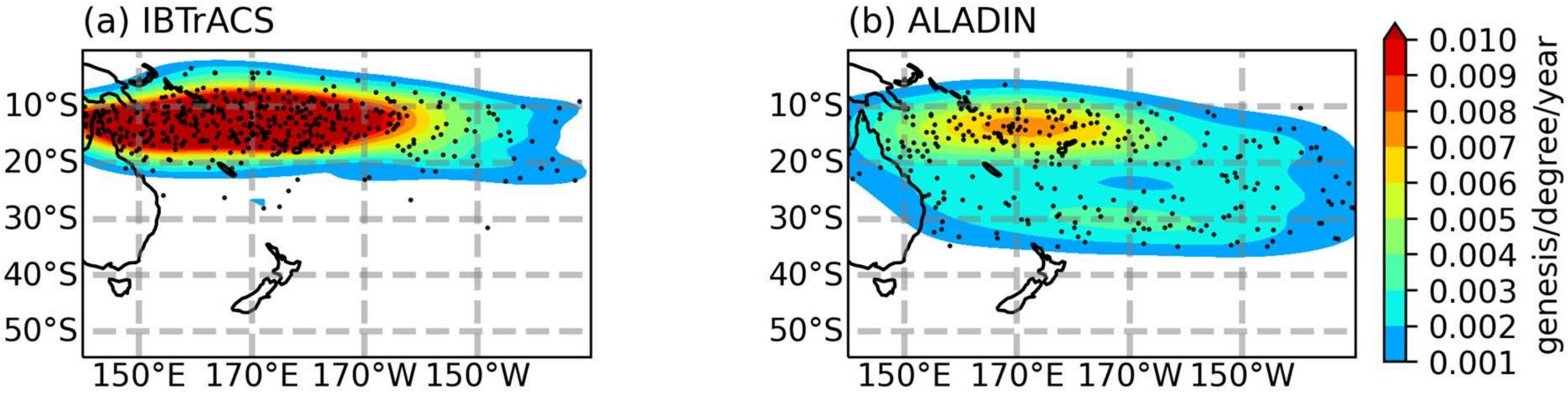


Fig: GPI in ALADIN model and observation (ERA5).

$$GPI = \left(\frac{H}{50}\right)^3 \times |10^5\eta|^{\frac{3}{2}} \times (1+0.1V_{shear})^{-2} \times \left(\frac{V_{pot}}{70}\right)^3$$

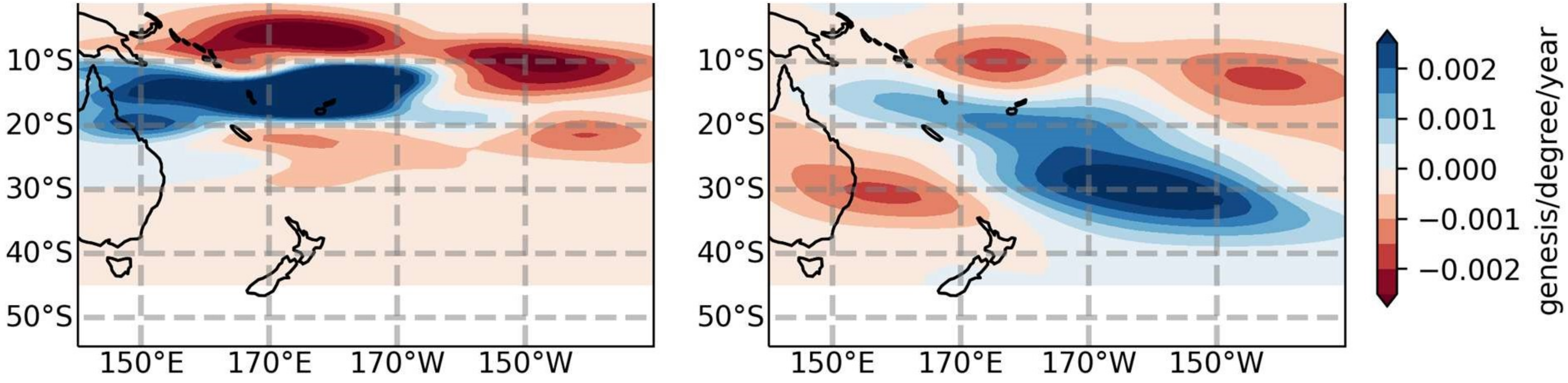
Trend in Tropical cyclones

Genesis Density, Climatology of tropical cyclones



- The model captures the trend of southward displacement in places of genesis.

Genesis Density, trend of tropical cyclones Epochal Difference (2002-2016) - (1983-1997)



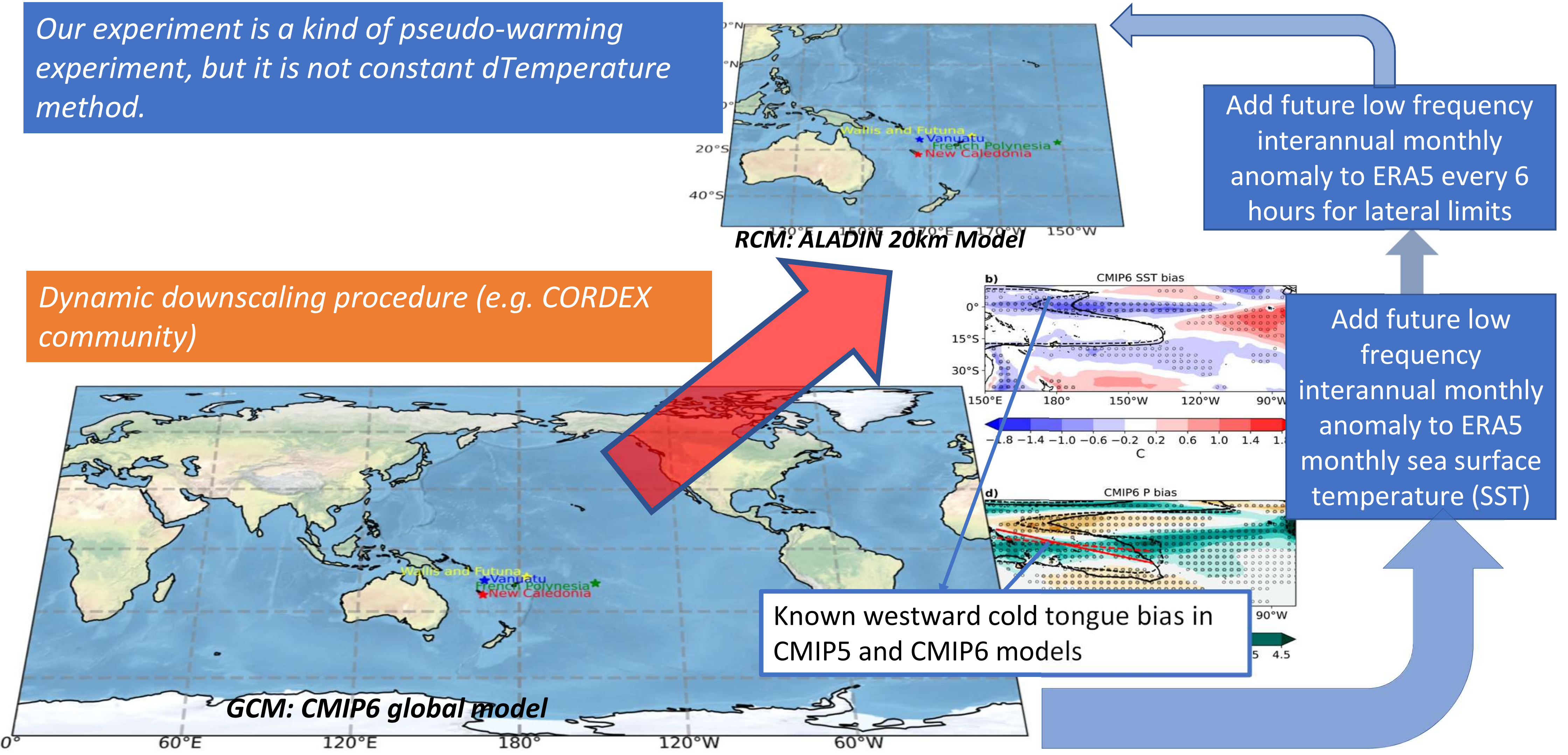
Conclusion

- ALADIN gives a good representation of climatological and interannual variability in the South-West Pacific, making it a valuable tool for CLIPSSA's downscaling strategies.

CLIPSSA : Downscaling strategy

Our experiment is a kind of pseudo-warming experiment, but it is not constant dTemperature method.

Dynamic downscaling procedure (e.g. CORDEX community)



RCM: ALADIN 20km Model

Add future low frequency interannual monthly anomaly to ERA5 every 6 hours for lateral limits

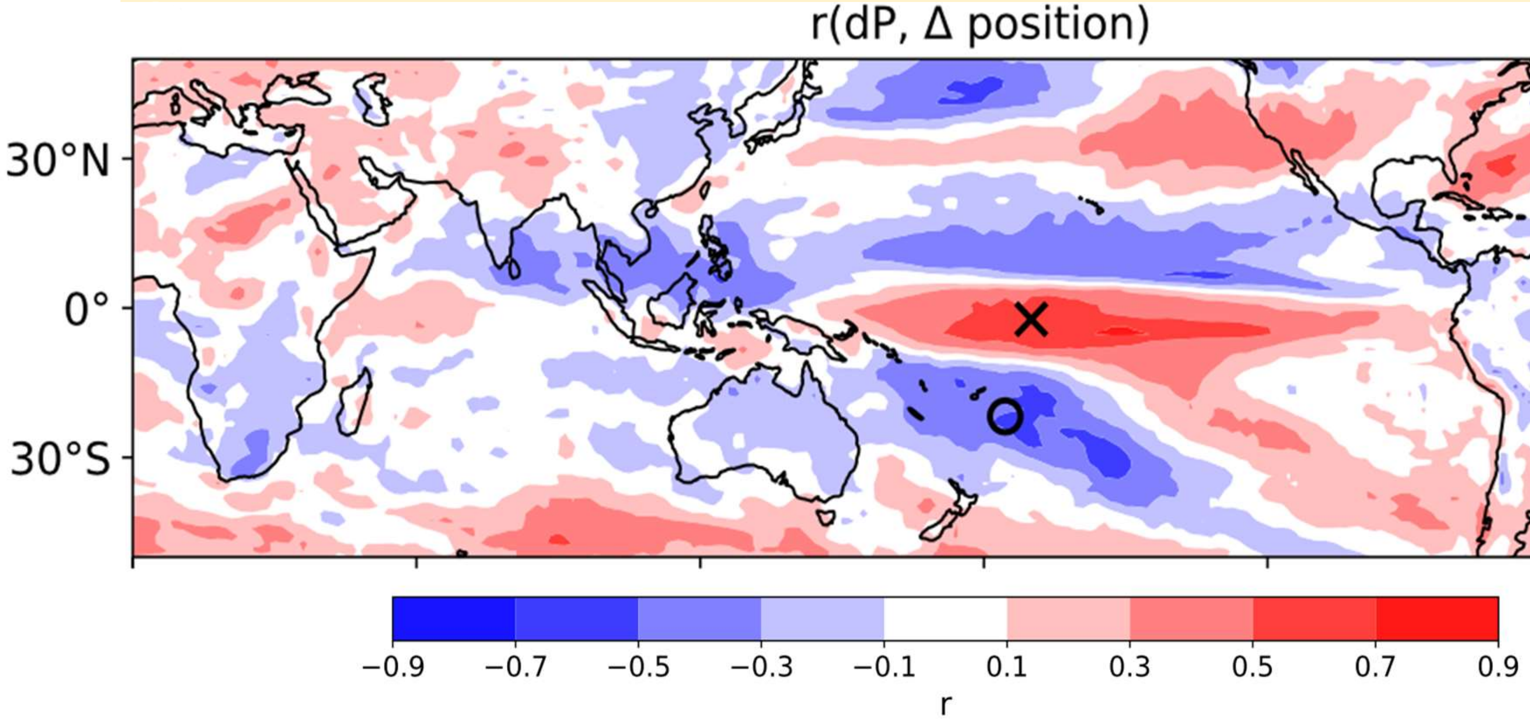
Add future low frequency interannual monthly anomaly to ERA5 monthly sea surface temperature (SST)

Known westward cold tongue bias in CMIP5 and CMIP6 models

GCM: CMIP6 global model

Projection: SPCZ and precipitation projections

Relationship between the future position of the SPCZ and precipitation in the South Pacific



Narsey et al 2022

- **Climate models with northward (southward) shift of the SPCZ creating a dry (wet) southwest Pacific in future projections**

Selection of CMIP6 models

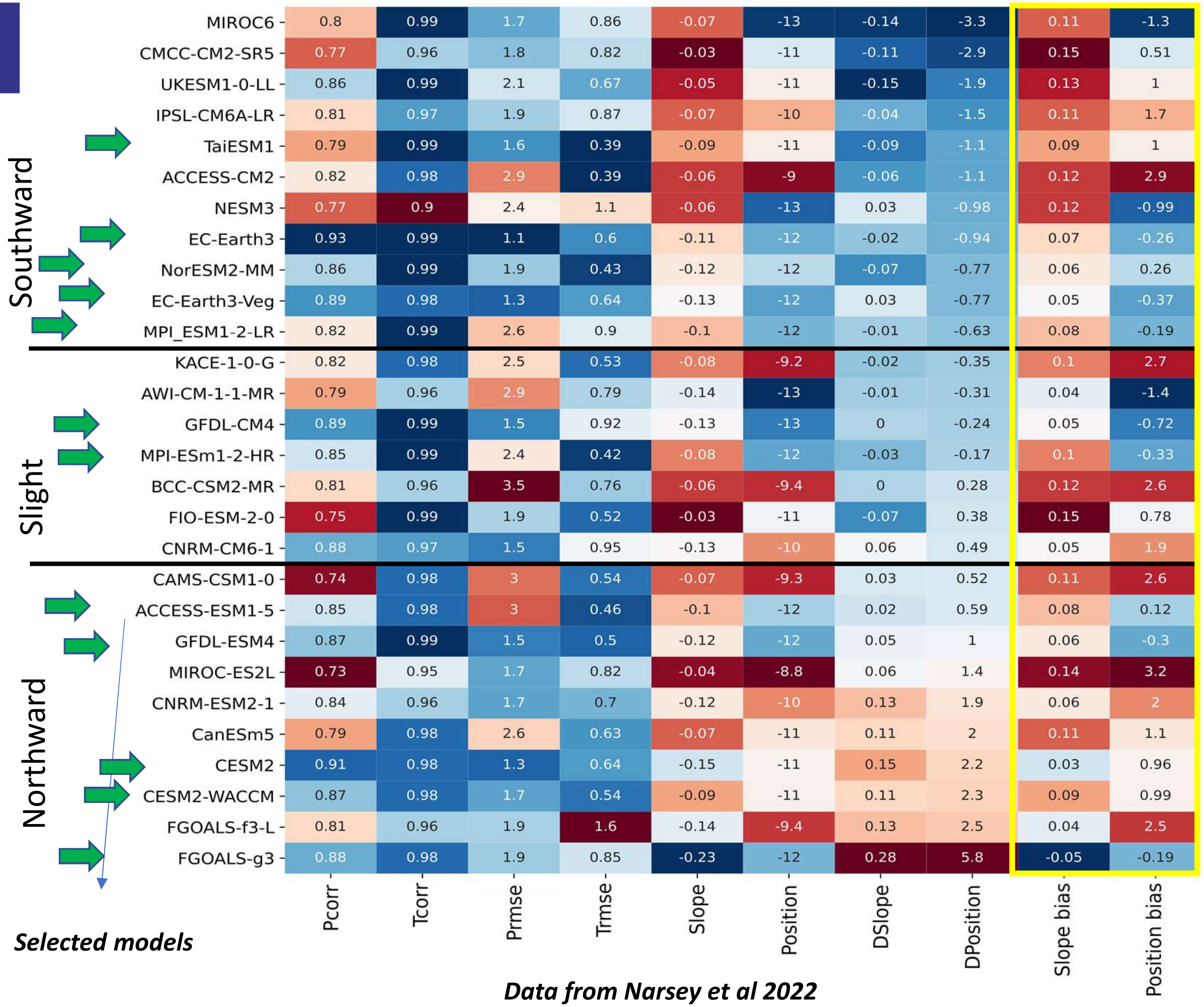
➡
Pos. Bias ≤ ±1 &
Slope Bias ≤ ±0.1

Model subset with :

1) SPCZ moving northwards

2) SPCZ moving southwards

3) Slight displacement of SPCZ



		Pcorr	Tcorr	Prmse	Trmse	Slope	Position	DSlope	DPosition	Slope bias	Position bias
Southward	MIROC6	0.8	0.99	1.7	0.86	-0.07	-13	-0.14	-3.3	0.11	-1.3
	CMCC-CM2-SR5	0.77	0.96	1.8	0.82	-0.03	-11	-0.11	-2.9	0.15	0.51
	UKESM1-0-LL	0.86	0.99	2.1	0.67	-0.05	-11	-0.15	-1.9	0.13	1
	IPSL-CM6A-LR	0.81	0.97	1.9	0.87	-0.07	-10	-0.04	-1.5	0.11	1.7
	TaiESM1	0.79	0.99	1.6	0.39	-0.09	-11	-0.09	-1.1	0.09	1
	ACCESS-CM2	0.82	0.98	2.9	0.39	-0.06	-9	-0.06	-1.1	0.12	2.9
	NESM3	0.77	0.9	2.4	1.1	-0.06	-13	0.03	-0.98	0.12	-0.99
	EC-Earth3	0.93	0.99	1.1	0.6	-0.11	-12	-0.02	-0.94	0.07	-0.26
	NorESM2-MM	0.86	0.99	1.9	0.43	-0.12	-12	-0.07	-0.77	0.06	0.26
	EC-Earth3-Veg	0.89	0.98	1.3	0.64	-0.13	-12	0.03	-0.77	0.05	-0.37
	MPI_ESM1-2-LR	0.82	0.99	2.6	0.9	-0.1	-12	-0.01	-0.63	0.08	-0.19
Slight	KACE-1-0-G	0.82	0.98	2.5	0.53	-0.08	-9.2	-0.02	-0.35	0.1	2.7
	AWI-CM-1-1-MR	0.79	0.96	2.9	0.79	-0.14	-13	-0.01	-0.31	0.04	-1.4
	GFDL-CM4	0.89	0.99	1.5	0.92	-0.13	-13	0	-0.24	0.05	-0.72
	MPI-ESm1-2-HR	0.85	0.99	2.4	0.42	-0.08	-12	-0.03	-0.17	0.1	-0.33
	BCC-CSM2-MR	0.81	0.96	3.5	0.76	-0.06	-9.4	0	0.28	0.12	2.6
	FIO-ESM-2-0	0.75	0.99	1.9	0.52	-0.03	-11	-0.07	0.38	0.15	0.78
	CNRM-CM6-1	0.88	0.97	1.5	0.95	-0.13	-10	0.06	0.49	0.05	1.9
Northward	CAMS-CSM1-0	0.74	0.98	3	0.54	-0.07	-9.3	0.03	0.52	0.11	2.6
	ACCESS-ESM1-5	0.85	0.98	3	0.46	-0.1	-12	0.02	0.59	0.08	0.12
	GFDL-ESM4	0.87	0.99	1.5	0.5	-0.12	-12	0.05	1	0.06	-0.3
	MIROC-ES2L	0.73	0.95	1.7	0.82	-0.04	-8.8	0.06	1.4	0.14	3.2
	CNRM-ESM2-1	0.84	0.96	1.7	0.7	-0.12	-10	0.13	1.9	0.06	2
	CanESm5	0.79	0.98	2.6	0.63	-0.07	-11	0.11	2	0.11	1.1
	CESM2	0.91	0.98	1.3	0.64	-0.15	-11	0.15	2.2	0.03	0.96
	CESM2-WACCM	0.87	0.98	1.7	0.54	-0.09	-11	0.11	2.3	0.09	0.99
	FGOALS-f3-L	0.81	0.96	1.9	1.6	-0.14	-9.4	0.13	2.5	0.04	2.5
	FGOALS-g3	0.88	0.98	1.9	0.85	-0.23	-12	0.28	5.8	-0.05	-0.19

Selected models

Data from Narsey et al 2022

Strategy

- Historical simulation from 1960 to 2020 using ERA5
- Future projection using the "Pseudo global warming" anomaly for the period 2020-2080 for different scenarios.
  - Use of the ensemble mean of the CMIP6 models with **a reasonable position and slope of the SPCZ** in the historical simulation.
  - Use of the ensemble mean of CMIP6 models with a future **northward shift of the SPCZ.**
  - Use of the mean of the members of the CMIP6 model set with a future **southward shift of the SPCZ.**
  - Using the average of the members of the CMIP6 model set with **a slight future shift of the SPCZ**

Thank you