REPRESENTING THE PRESENT-DAY REGIONAL CLIMATE OVER SOUTHERN AFRICA IN A DOUBLE NESTED SYSTEM

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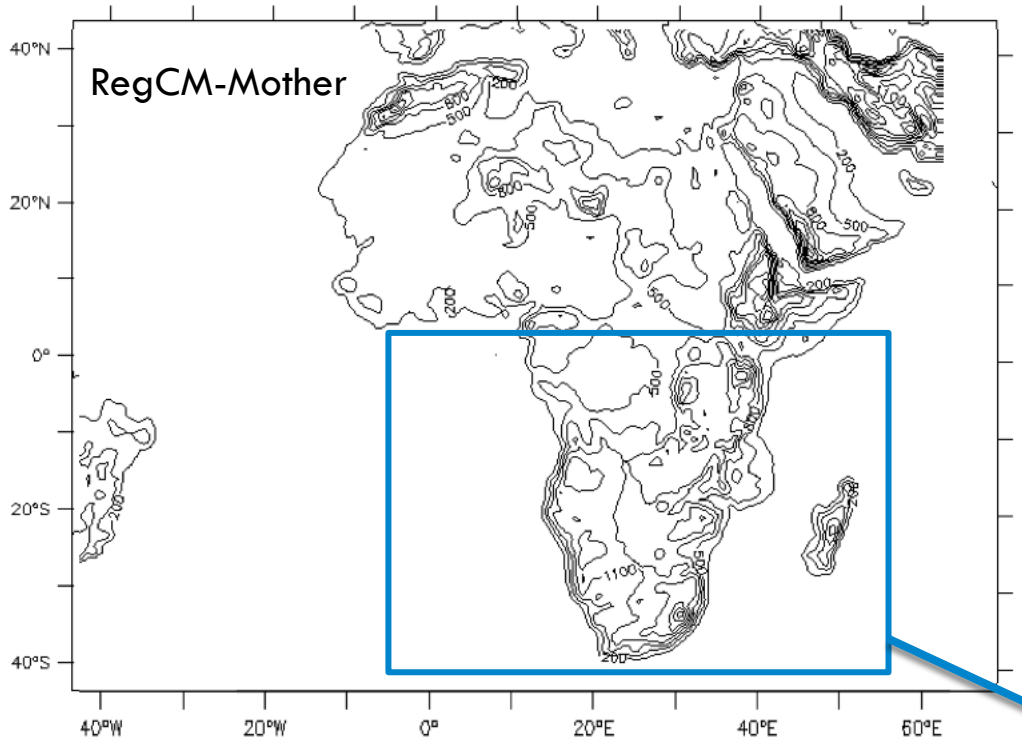
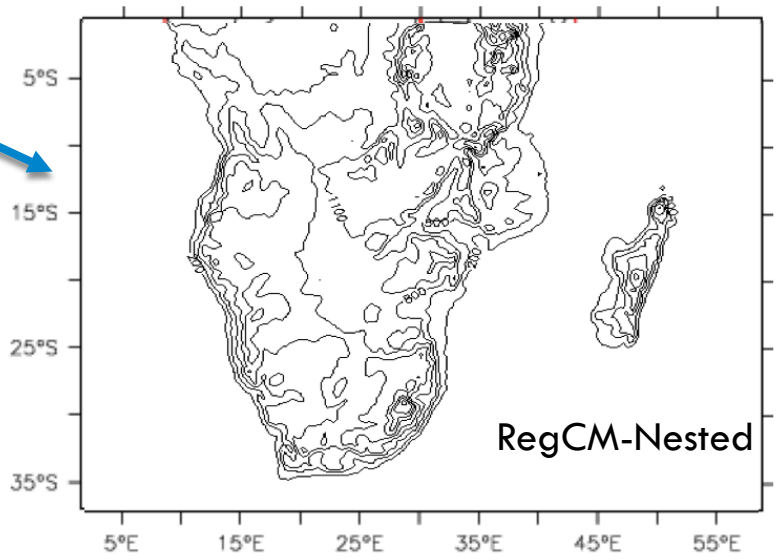
Introduction

- Southern Africa is bounded by the southern Atlantic and Indian Oceans, whose circulations have great influence on the region's climate.
- The region is characterized by highly complex topographical features due to the presence of mountain chains.
- These features are variable in spatial extension and are subject to rapid changes in the climate.
- By virtue of its position, the sub-continent experiences complicated climate variability.

Domains and topography





Four sets of experiments covering 10 years (1991-2000) each have been conducted over two domains in Africa and southern Africa.

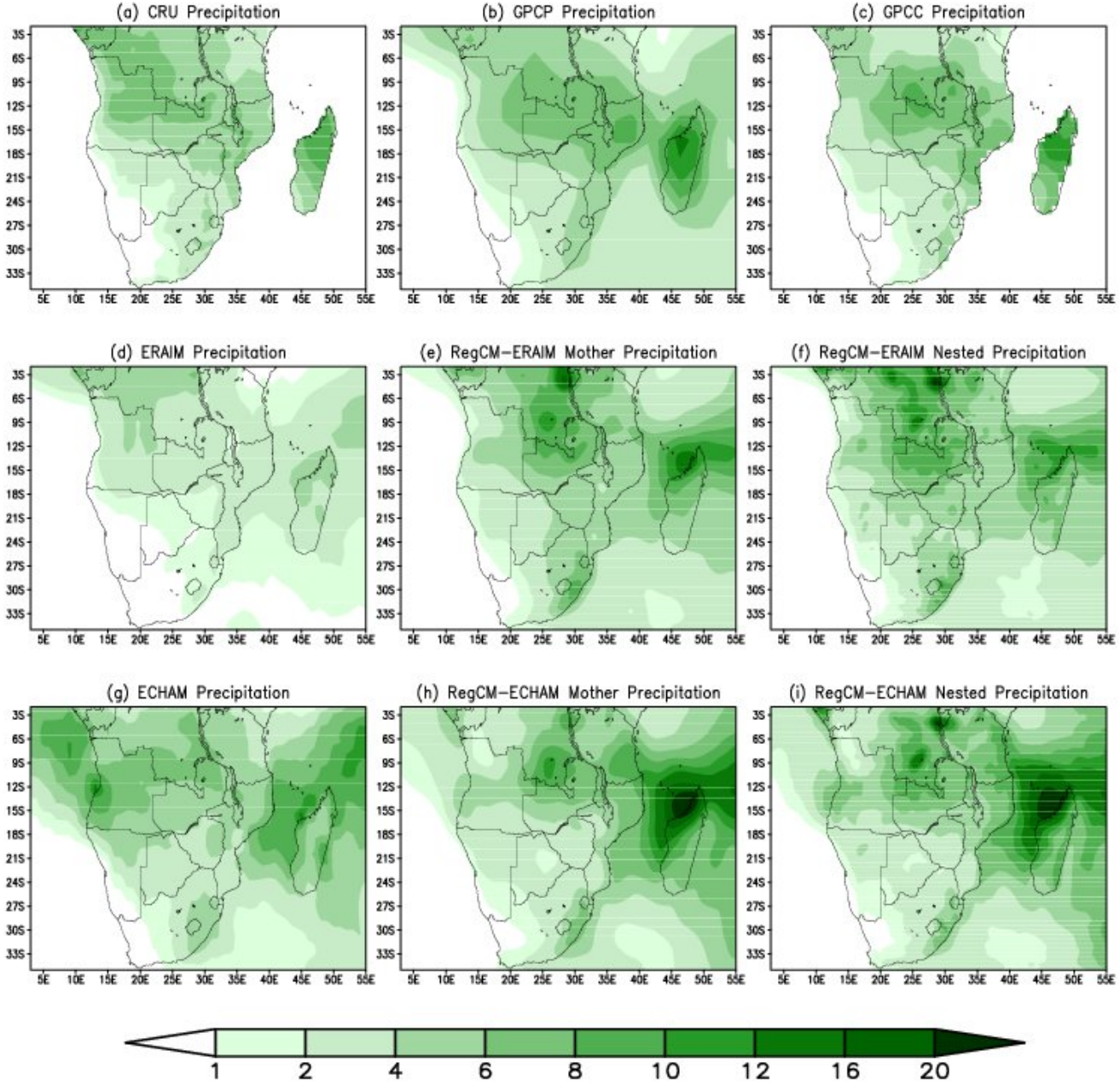
Experiments

- The first, African domain (RegCM-ERAIM Mother) is 50km resolution and used ERA-interim to drive the fields.
- The second experiment over southern Africa (RegCM-ERAIM Nested) used the RegCM-ERAIM Mother to evaluate the appropriate climate features in a nested simulation (25km).
- The third experiment (RegCM-ECHAM Mother) is 50km resolution and used ECHAM to drive the fields.
- The fourth (RegCM-ECHAM Nested) used RegCM-ECHAM Mother as a driving force for a nested simulation at 25km resolution.
- In these experiments, the initial and lateral boundary conditions for the RegCM4 simulation are obtained from the new ERA-Interim 0.75° x 0.75° gridded reanalysis (Simmons et al. 2007; Uppala et al., 2008).

Aim of this effort

- The aim of this effort is to present fine scale circulation details of the southern African climate and ultimately produce high resolution (25km) estimates of the present-day climate from ERAIM and ECHAM4.
- This requires quantifying the biases of RegCM4 itself when nested within reanalysis atmospheric boundary conditions and then nested again with the RegCM4 output to produce high resolution simulations.
- The later sets of simulations are required to differentiate between RegCM4 biases and those introduced through the GCM boundary forcings.
- Observational data (mainly CRU) were used to identify biases in precipitation from the low (50km) resolution simulation.

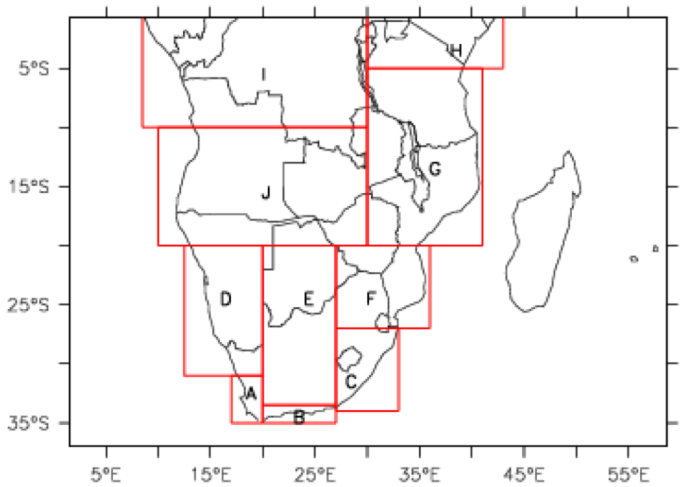
Simulated rainfall patterns

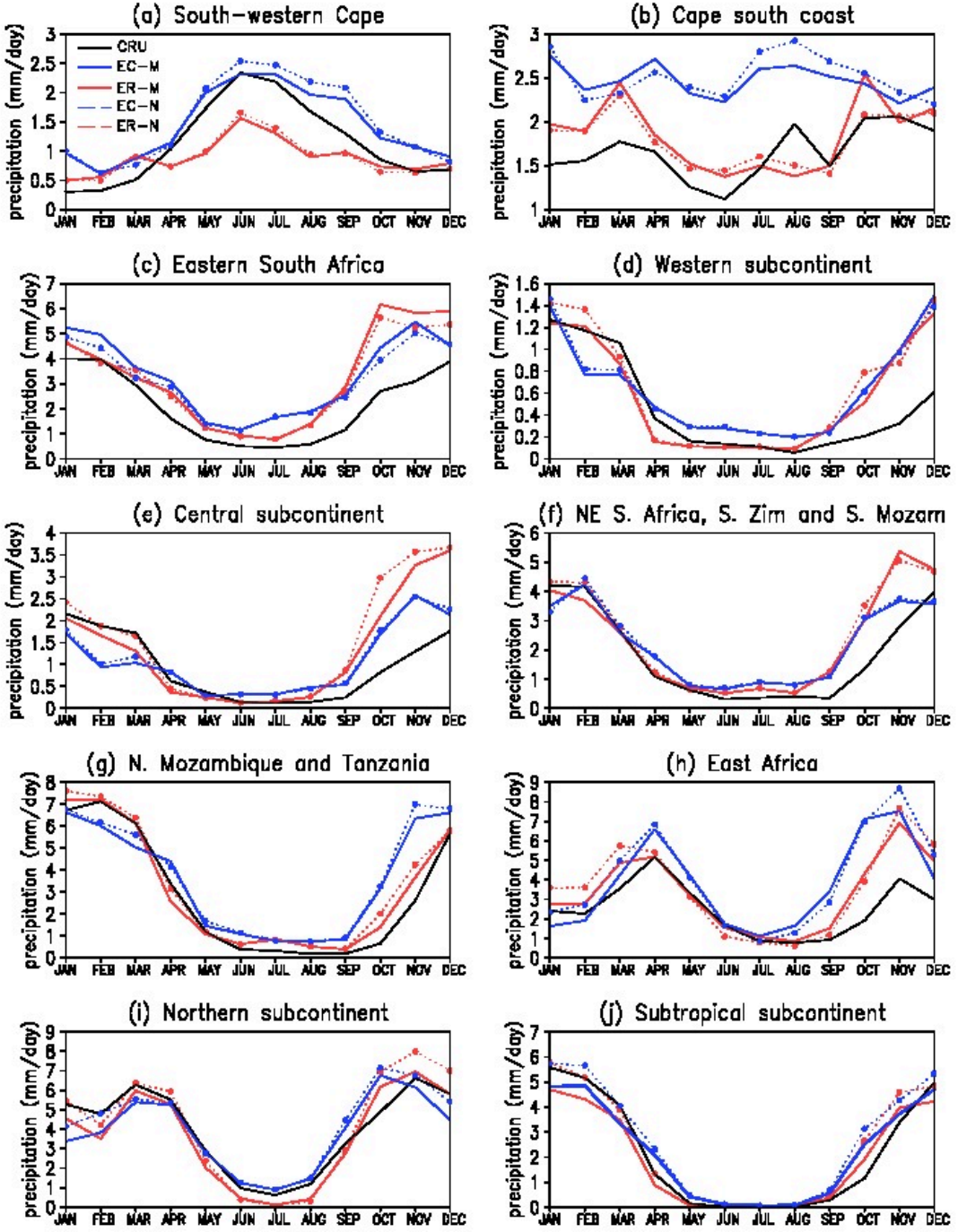


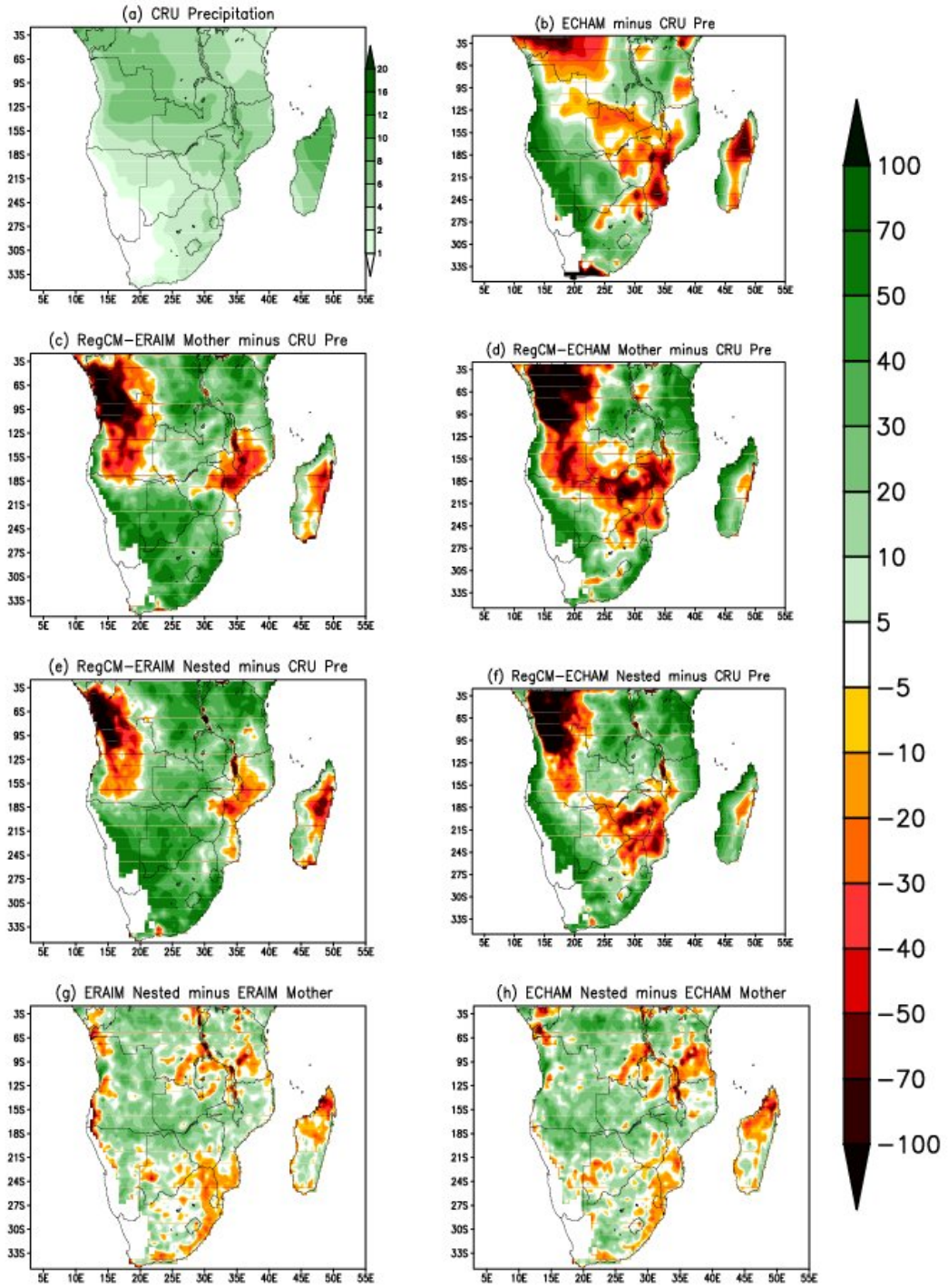
- Rainfall increases non-uniformly towards the equator with two maxima located at the Congo basin and Madagascar
- The ECHAM driven rainfall exhibits similar patterns as obs but shows some disagreements in amounts.
- The nested rainfall patterns are similar to the mother rainfall patterns but stronger.

Annual Cycle of monthly precipitation averaged over 10 different sub-regions of the subcontinent.

This helps to point out regional features in the rainfall annual cycle. The simulations agree with CRU observation in most regions in the overall pattern but with varying disagreements in the amount and peak of rainfall.





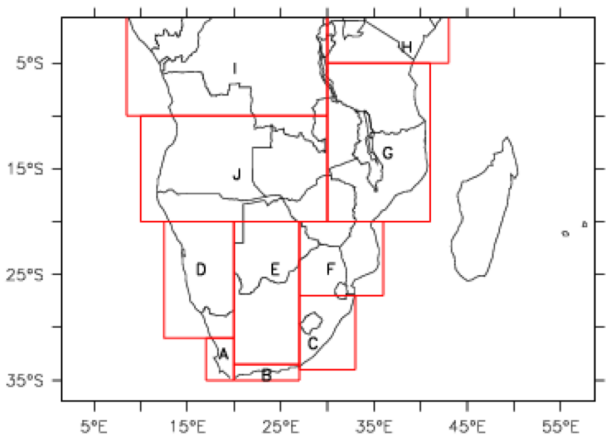


Differences in mean JJA rainfall from RegCM4 mother and nested simulations compared with CRU. Units are expressed in percentages of CRU values.

The nested simulations do not exhibit as much differences as compared with the mother simulations. The main difference seen here are over the high elevations, over the south eastern part, north western part, north of Madagascar, and central part of the subcontinent.

Biases in simulated rainfall patterns: Mean Bias

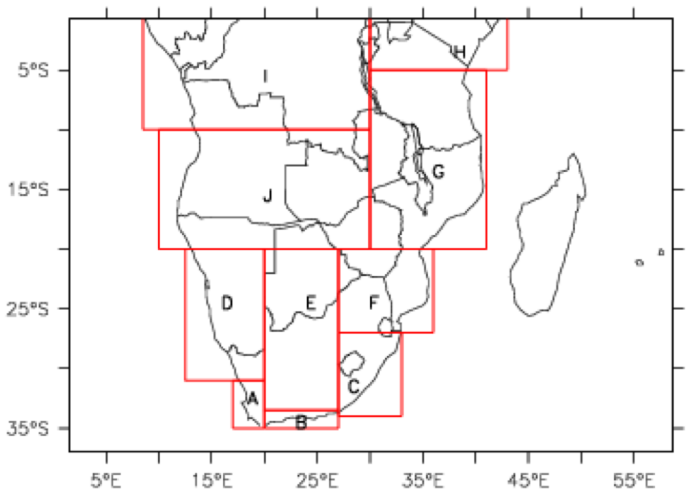
	MB (%)			
Region	ERAIM-Mo	ERAIM-Ne	ECHAM-Mo	ECHAM-Ne
A	-24.87	-25.55	30.80	37.39
B	19.06	14.24	**81.97**	**86.63**
C	**115.7**	**100.1**	**120.2**	**98.26**
D	11.52	17.50	17.89	18.27
E	38.78	**58.28**	13.65	17.41
F	49.92	**60.84**	35.54	40.52
G	21.84	35.68	**68.77**	**79.56**
H	**83.44**	**105.1**	**127.7**	**155.7**
I	-34.14	15.15	-20.07	16.18
J	-17.77	22.66	9.7	47.74



The bold figures have more than 50% biases

Biases in simulated rainfall patterns: PCC

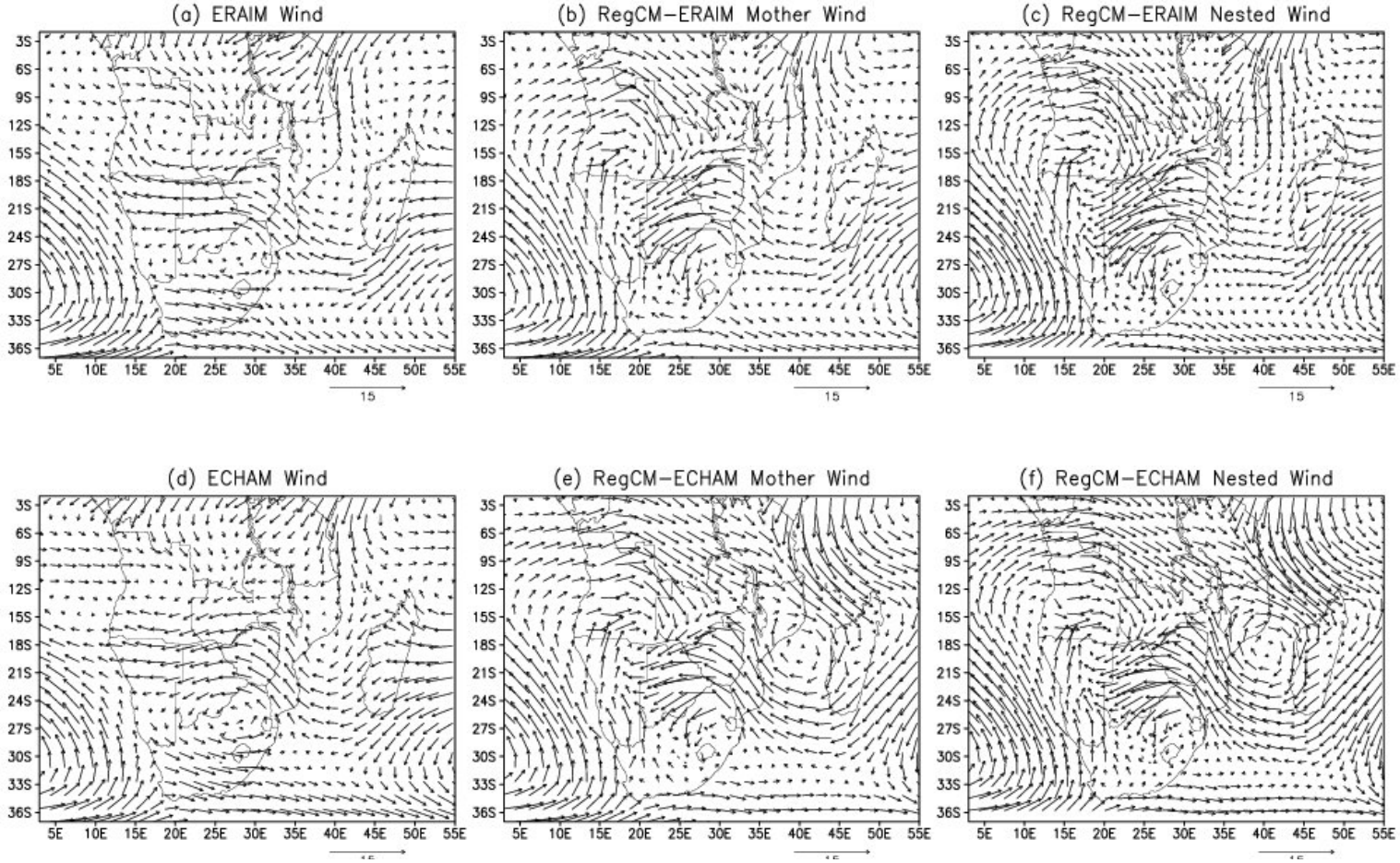
Region	PCC			
	ERAIM-Mo	ERAIM-Ne	ECHAM-Mo	ECHAM-Ne
A	0.70954	0.601727	0.699105	0.674924
B	**0.46045**	**0.32977**	**0.427485**	**0.357968**
C	**0.15944**	**0.303432**	**0.201859**	**0.239224**
D	0.841513	0.900527	0.710261	0.765318
E	0.676464	0.722545	0.571512	0.529585
F	0.73366	0.782381	0.686019	0.571888
G	**0.309863**	**0.352117**	**0.263835**	**0.129794**
H	**0.497703**	**0.460139**	**0.493178**	**0.453675**
I	**0.297349**	**0.221053**	**0.259895**	**0.131636**
J	0.752387	0.783513	**0.470169**	**0.436973**



The bold figures have less than 0.5 PCC values.

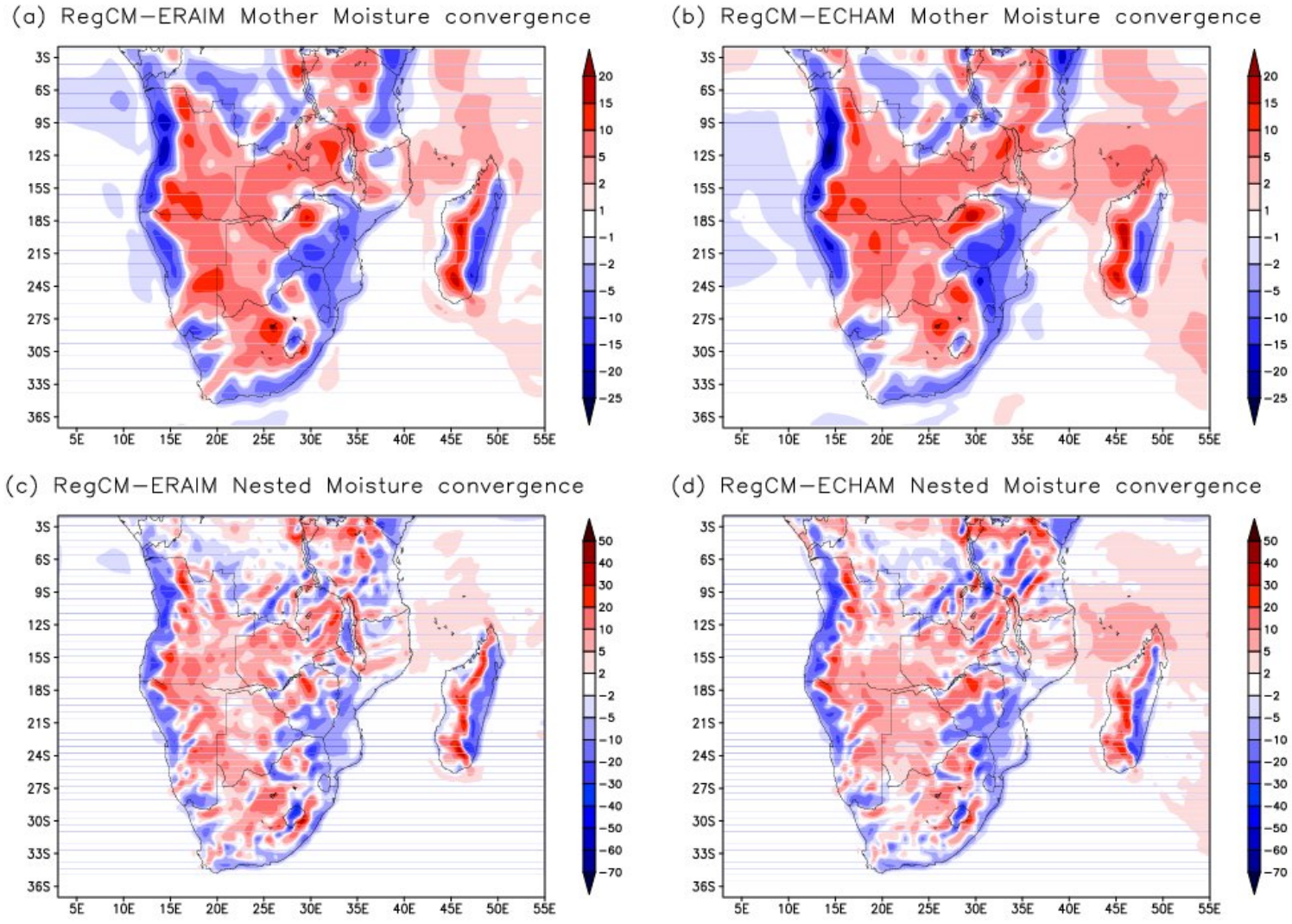
Mean JJA wind fields (m/s) at 850hPa showing the monsoon of southern Africa RegCM4 mother and nested simulations compared with ERAIM and ECHAM driving fields.

This circulation is more intense in the nested than the mother and mother is more intense than the driving fields.



The RegCM4 is characterized by stronger vertical velocities (Sylla *et al* 2012) mainly due to improved resolution of smaller scale features of the dynamics (e.g. storms) and also its interaction with topography.

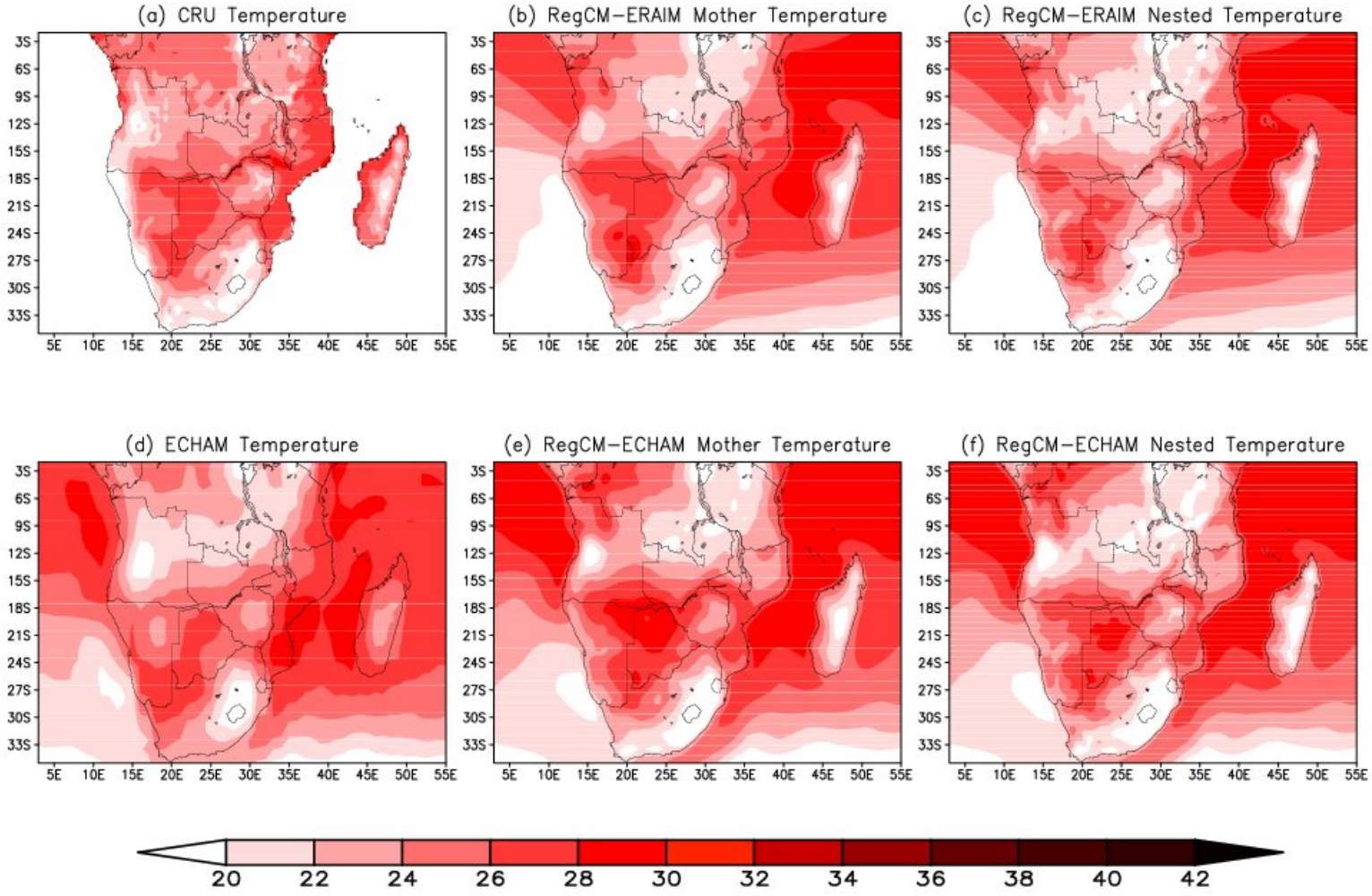
Moisture convergence at 850hPa from RegCM4 mother and nested simulations.



A pronounced moisture convergence is seen in the nested than in the mother from both ECHAM and ERAIM.

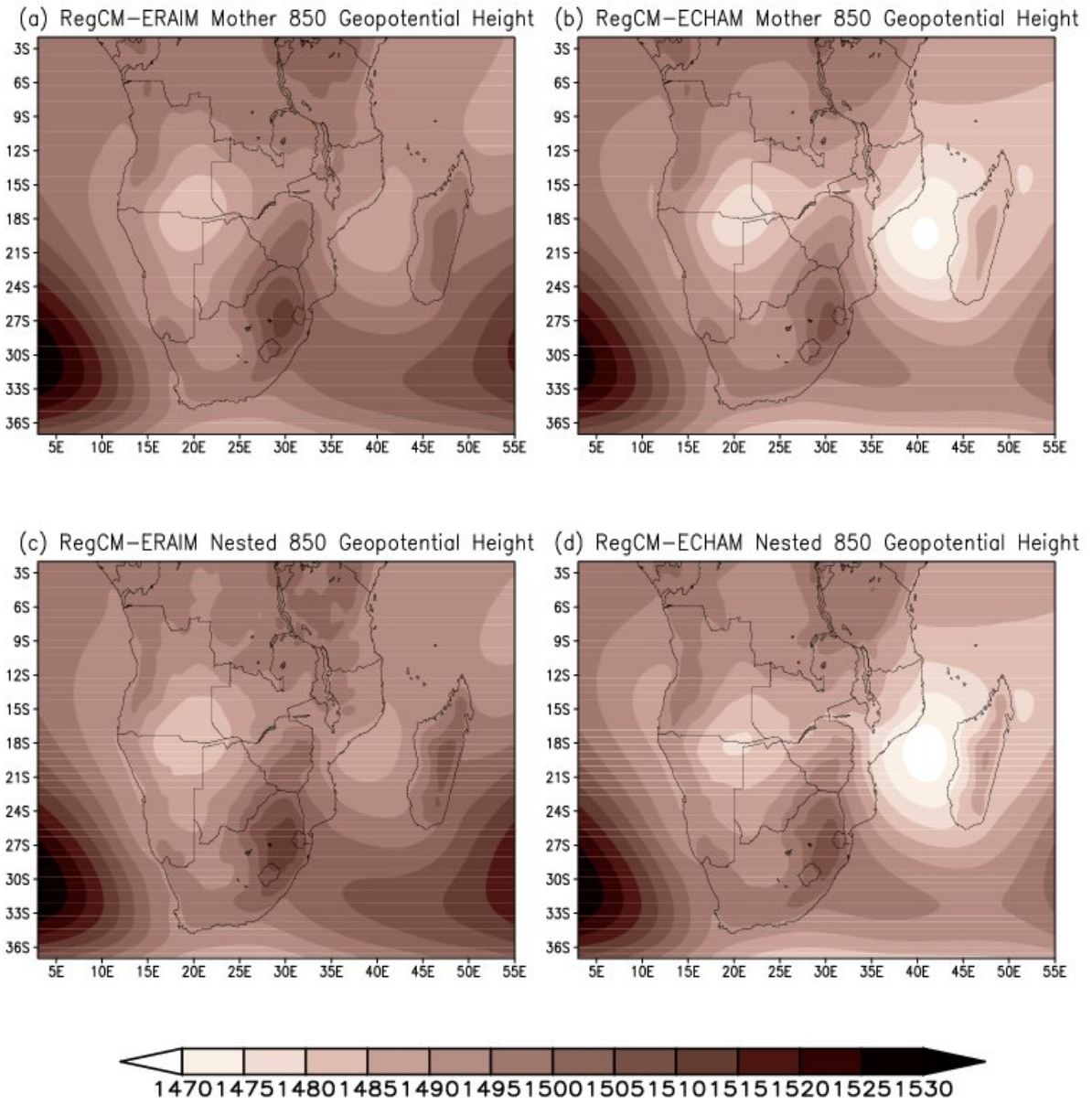
Mean temperature (degree Celsius) from RegCM4 mother and nested simulations compared with CRU observation and ECHAM driving field.

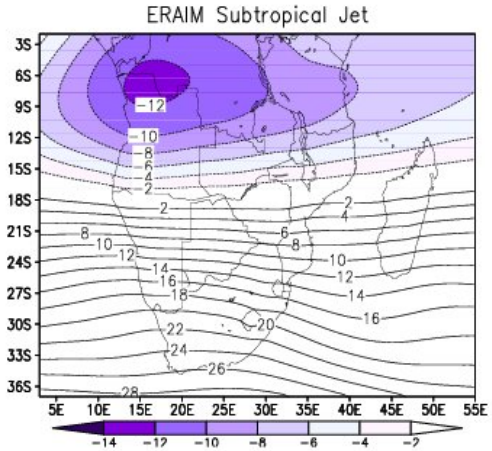
Consistent results with the moisture advection near the equator

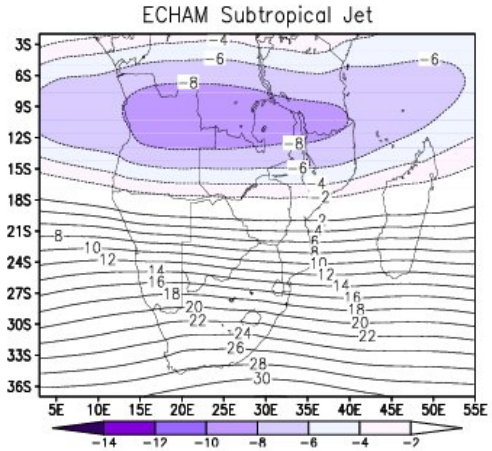


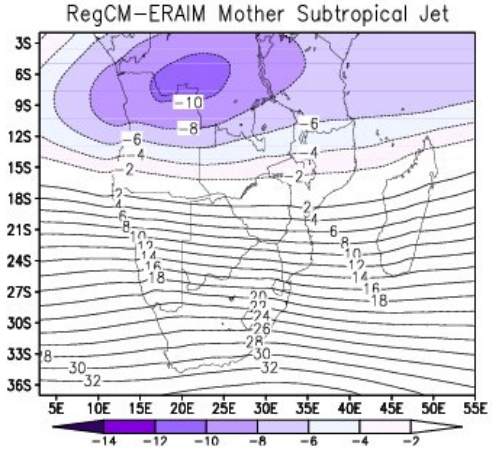
Geopotential height from RegCM4 mother and nested simulations.

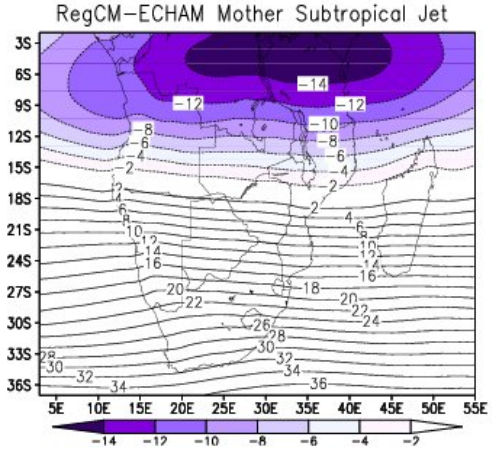
The more intense high geopotential height simulated by ERAIM-Mother and ECHAM-Mother suggest a more clearing weather over the eastern highlands while the more intense low especially in ECHAM-Mother suggests storms.

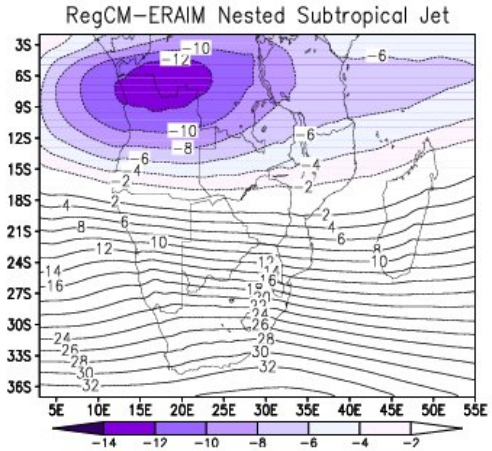


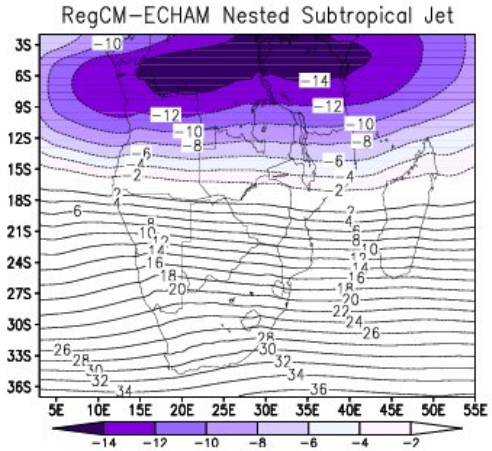












Vertical structure of zonal wind measured in m/s average between 5E and 55E showing the subtropical jet stream.

The jet is stronger with speed of about 35m/s in the mother and nested than their respective driving fields. This indicates that more moisture is transported in the simulations which will have implication on their rainfall over the southern Africa.

Conclusion

- The nested simulation, which is at a high resolution of 25km, captures the circulation features that implicate the summer rainfall of southern Africa better than the low resolution simulation at 50km.
- The nested simulations do better in capturing the observed distribution of daily rainfall than the mother simulations.
- This is due to improved resolution of the complex topography and coastline of the South Eastern Cape in the RegCM4.

Conclusion

- We show that when used in a double nested configuration, RegCM4 is capable of providing finer scale features in the spatial distribution of rainfall over southern Africa than its driving fields.
- For the circulation features that modulate rainfall over the southern Africa, the double nested RegCM4 simulation has a better representation.
- Not much difference was demonstrated by the high resolution relative to the low in the representation of the rainfall annual cycles over different sub-regions.

Thank You