Why do rainfall projections from GCMs and RCMs differ? A synoptic circulation method approach over southern Africa

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CLIMATE SYSTEM ANALYSIS GROUP CSAG

FRACTAL FUTURE RESILIENCE FOR AFRICAN CITIES AND LANDS

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- GCMs primary tools for climate information -spatial scale not appropriate for regional scale decision making
- Downscaling using RCMs - adds value and provide a better representation of the regional climate

However projections from RCMs and GCMs can differ, particularly in the case of rainfall
Long term changes in synoptic circulation events, especially on the daily time scale of weather events, remains weakly explored, yet offers a valuable additional source of information to assess the robustness and value of downscaled climate .

Research question

- Why does GCMs and RCMs projections differ? Can you relate it to circulation changes?

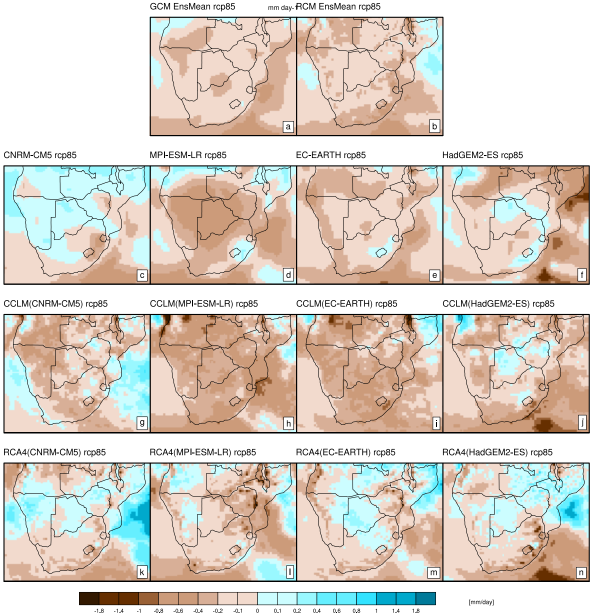


Figure : Changes in annual mean precipitation over 2098-2069 relative to 1976-2005 under RCP 8.5

Data

Model Data

4 CMIP5 GCMs, downscaled to 50km by RCA4 and CCLM4 RCM model

GCM CMIP5	Historical (1976-2005)	RCP 8.5 (2069-2098)
CNRM-CM5	✓	✓
EC-Earth	✓	✓
HadGEM2-ES	✓	✓
MPI-ESM-LR	✓	✓
ERA-Interim	(1981-2005)	

Application of SOM

- Synoptic pattern classification
- Frequency of occurrence of synoptic patterns

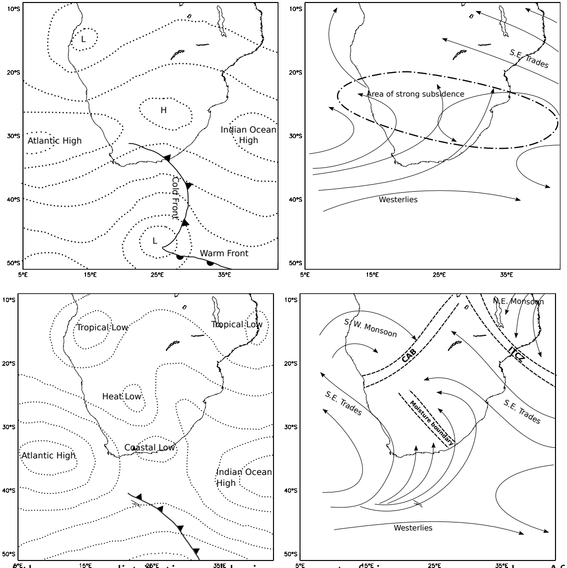


Figure : Features of the pressure distribution and basic movement of air masses over southern Africa during winter (top) and summer (bottom) (after Hurry 1982)

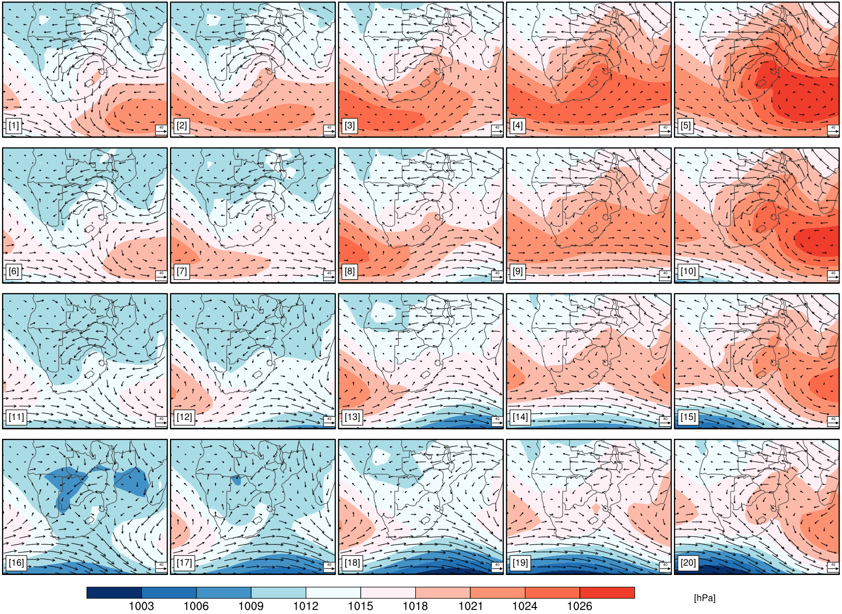
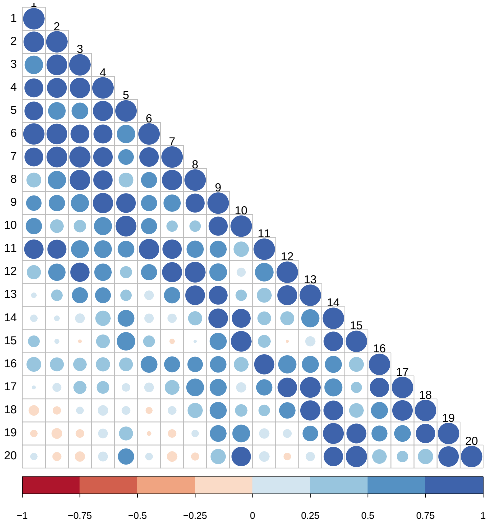


Figure : The 5x4 master SOM of SLP. The *reds* indicate high pressure and the *blues* lower pressure. Vectors represent moisture transport [units: g kg-1 m s-1] composite associated with each node from ERAINT.

Figure :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−0.75
−0.5
−0.25
0
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0.5
0.75
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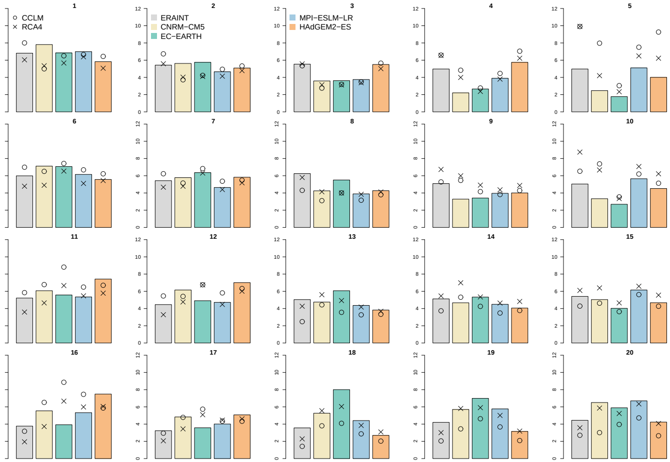
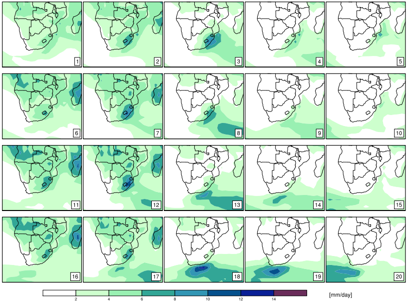
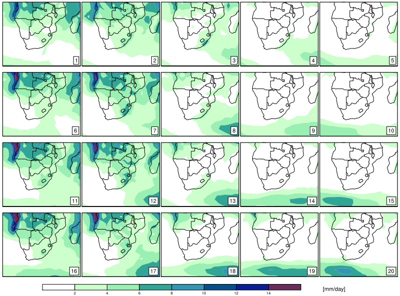


Figure : Frequency (%) of occurrence that map to each SOM node shown in fig. 3 for the period 1989-2005

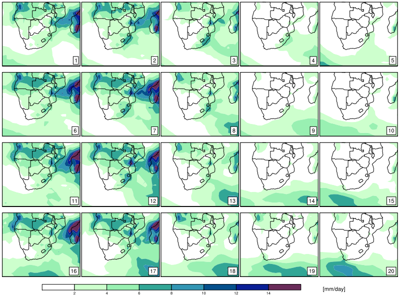
CNRM-CM5



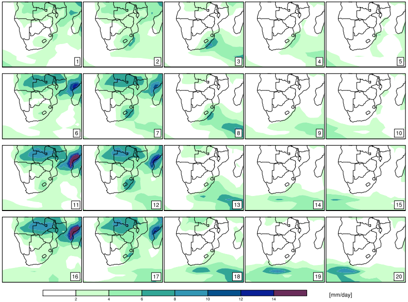
CCLM(CNRM-CM5)



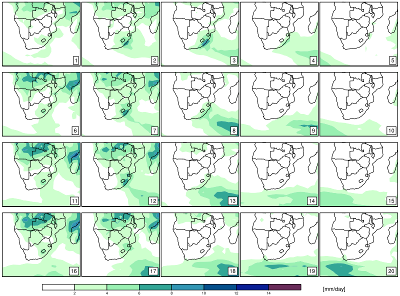
RCA(CNRM-CM5)



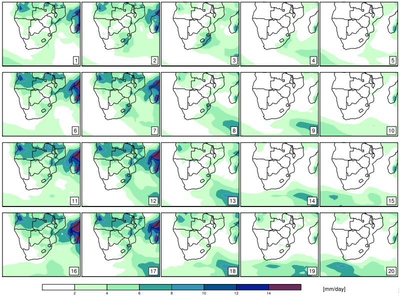
HadGEM2-ES



CCLM(HadGEM2-ES)



RCA(HadGEM2-ES)



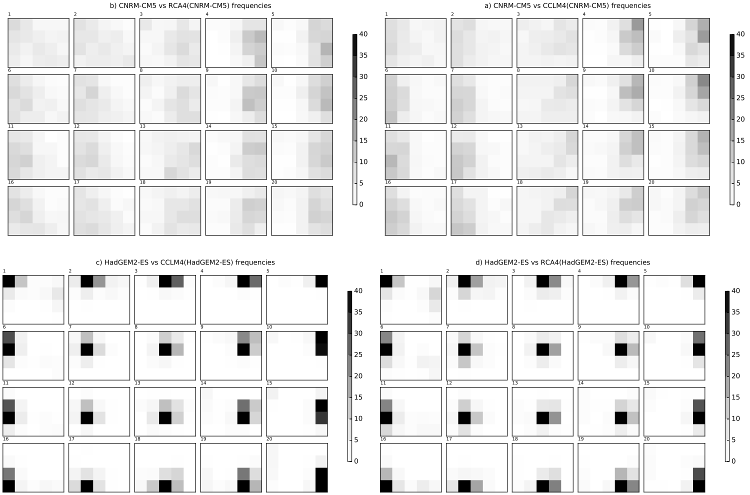


Figure : Frequency (%) distribution of RCMs nodes occurrence corresponding to each GCM node occurrence (agreement maps)

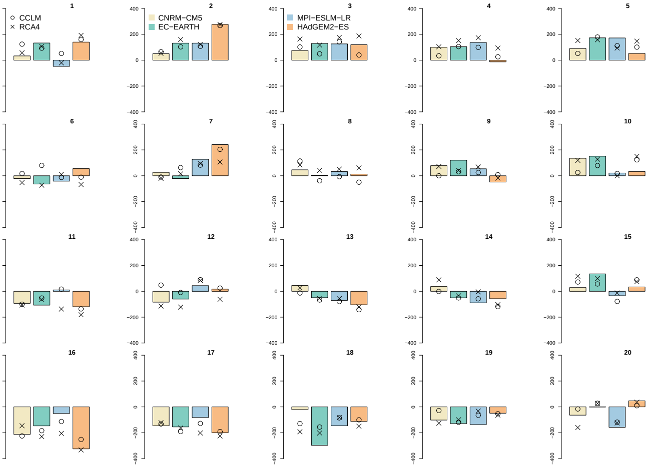


Figure : Projected changes in the frequency of occurrence that map to each SOM node shown in fig. 3 over the period 2069-2098 relative to 1976-2005 under RCP8.5.

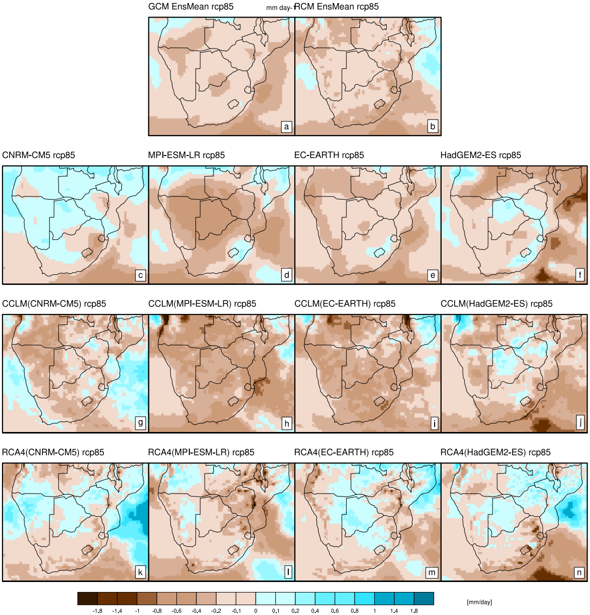


Figure : Changes in annual mean precipitation over 2098-2069 relative to 1976-2005 under RCP 8.5

Main messages

From two RCMs (COSMO-CLM and RCA4) that downscaled four GCMs (MPI-ESM-LR, HadGEM2-ES, CNRM- CM5, and EC-EARTH)

- increase in the occurrence of the oceanic high-pressure systems, a more dominant high-pressure circulation poleward of the continent and
- decreased occurrence of patterns of continental lows and mid-latitude lows, ie,
- the synoptic states that reduce precipitation are projected to increase, while synoptic states that enhance precipitation are projected to decrease over time.

Main messages

- Since the atmospheric circulation is relatively well simulated in both RCMs and GCMs (i.e, the RCM and GCM are in phase regarding to circulation patterns!), the differences in the projected precipitation is due to the representation of local subgrid-scale parameterized processes, such as convection and/or the representation of coastlines
- i.e, the climate change signal can be a local response dynamic rather than circulation dynamic.

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RESEARCH ARTICLE

Process-based model evaluation and projections over southern Africa from Coordinated Regional Climate Downscaling Experiment and Coupled Model Intercomparison Project Phase 5 models

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Decision-scale relevant climate information on climate change is needed to inform policy and decision making but often involves high uncertainty. To enhance confidence in interpreting regional climate projections, it is important to understand the underlying physical processes driving the change. This study explores a methodology to investigate climate change as a function of changes in frequency of synoptic circulation. The approach examines how dynamically downscaled future climate from two regional climate models (RCMs) from the Coordinated Regional Climate Downscaling Experiment (CORDEX), driven with four general circulation models (GCMs), can give rise to surface climate changes that differ from those of the driving GCMs. The study focuses on changes in precipitation and the circulation processes driving the projected changes from the regional climate simulations. Despite uncertainty in future projections, the RCMs and GCMs both show decreases in precipitation over most of southern Africa and suggest a reduction (increase) in the frequency of circulation patterns associated with precipitation (no precipitation) over the region. However, some contradictions are seen in the centre of the domain for some ensemble members. This study shows that some of this disagreement in precipitation projections between GCMs and RCMs is due to the inconsistencies in the physical parameterizations of precipitation processes rather than inconsistences in regional-scale circulation patterns.

Acknowledgements