The Dynamics of Co-behaviour of climate processes relevant to Southern Africa

[1]Kwesi A. Quagraine*, [1]Bruce Hewitson, [1]Chris Jack, [1]Izidine Pinto, [1]Chris Lennard, [2]Grigory Nikulin

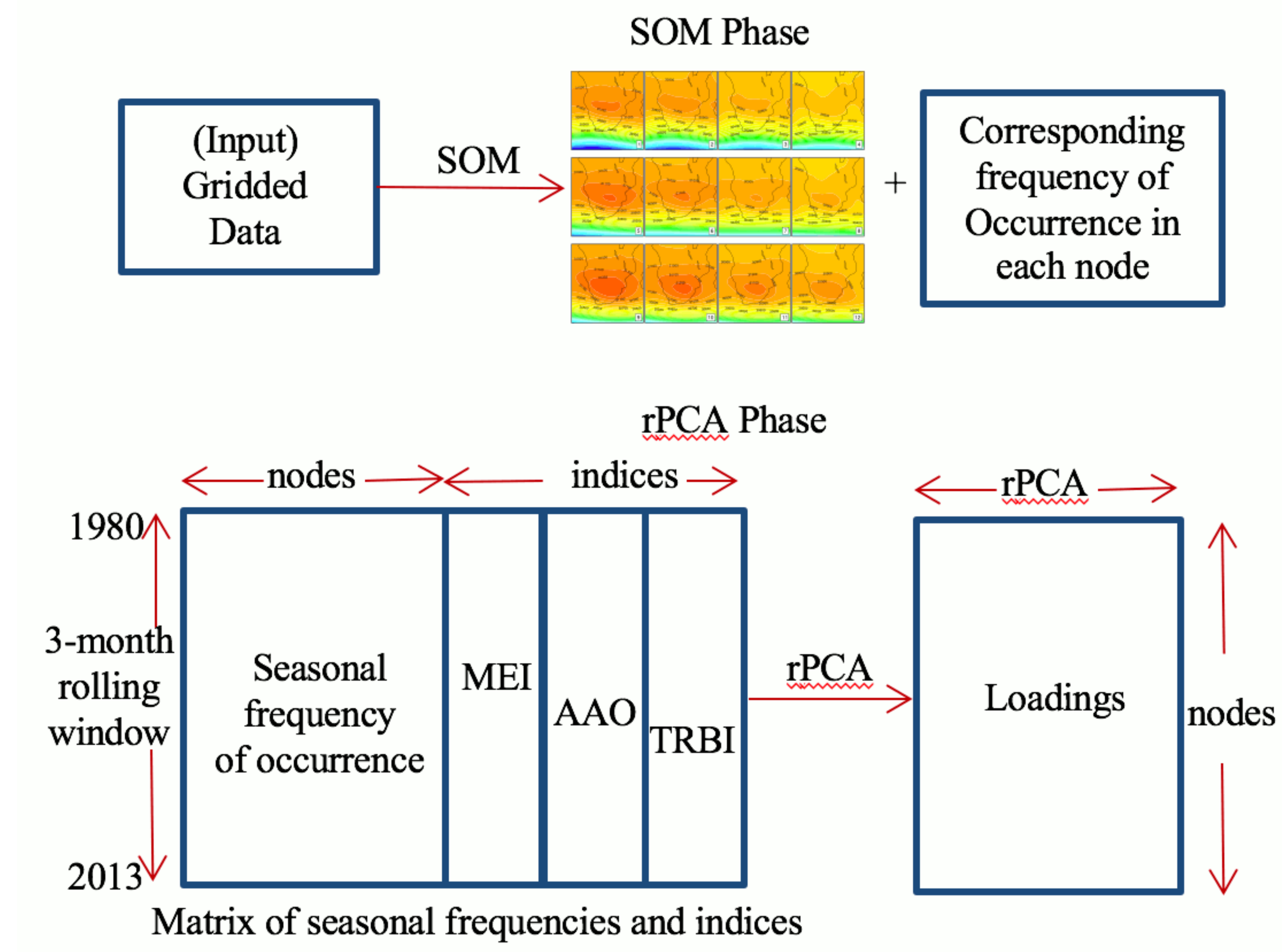
[1]Climate Systems Analysis Group, University of Cape Town, South Africa
[2]Rossby Centre, Sveriges Meteorologiska och Hydrologiska Institut (SMHI), Sweden
(contact: **kwesi@csag.uct.ac.za**)

Introduction and Objectives

- Climate features interact to govern regional climates of the world. Most regions have experienced unpredictable climates and other prevalent extreme events due to variability and change occurring as a result of these interactions.
- A wide variety of atmospheric and oceanic interactions strongly influences the regional climate of Southern Africa; e.g. Antarctic Oscillation (AAO), El-Niño Southern Oscillation (ENSO), Tropical Temperate Trough (TTT), and Inter-tropical Convergence Zone (ITCZ).
- Co-behaviour is a concept used here and is interpreted as an interaction between at least two or more climate features leading to their influence on the weather and climate for any given region.
- **This work aims to develop a methodological approach to examine co-behaviour leading to the understanding of the response of the existing interplay across climate features.**
- Our approach is to apply a combination of peer-reviewed methods; Self-Organizing Maps (SOM) and Principal Component Analysis (PCA) to examine co-behaviour.

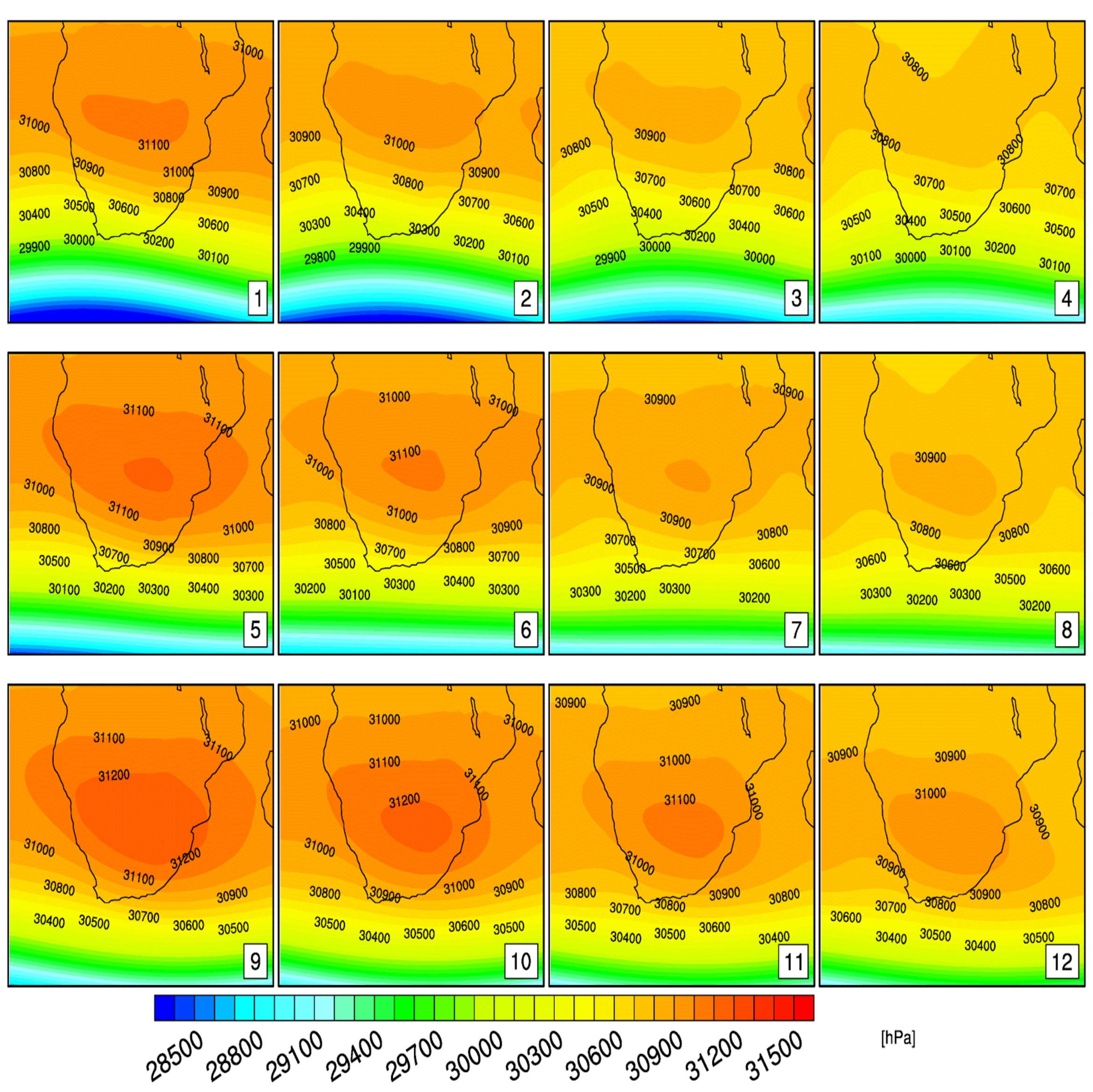
Data and Methods

- We use **3 climate feature indices relevant to southern Africa**; AAO, TRBI and MEI, 700-hpa ERA-Interim geopotential height, Climatic Research Unit (CRU v4.01) Temperature data and Climate Hazards Group Infra-Red Precipitation with Station (CHIRPS) data over the region (5 ^{0}E – 45 ^{0}E and 10 ^{0}S - 35 ^{0}S).
- 700-hpa ERA-Interim geopotential height is used as an input to the SOM to objectively classify circulation patterns over the region while also obtaining the frequency of occurrence for each SOM node
- A varimax rotated PCA is applied to a matrix of seasonal frequency of occurrence and climate indices to ascertain the influence of each climate feature and obtain correlations on each SOM node
- As a means of verification of co-behaviour, we examine the potential influence it may have on regional precipitation and temperature
- A schematic of the implementation of peer-reviewed methods.



Results

- For the SOM mapping of 700-hpa geopotential height, the region is dominated by a range of high and low pressure systems.



MEI=0.10 AAO=-0.06 TRBI=0.07 (**30%**)

0.87	0.74	0.16	-0.46
0.83	0.23	-0.53	-0.66
0.62	-0.17	-0.76	-0.71

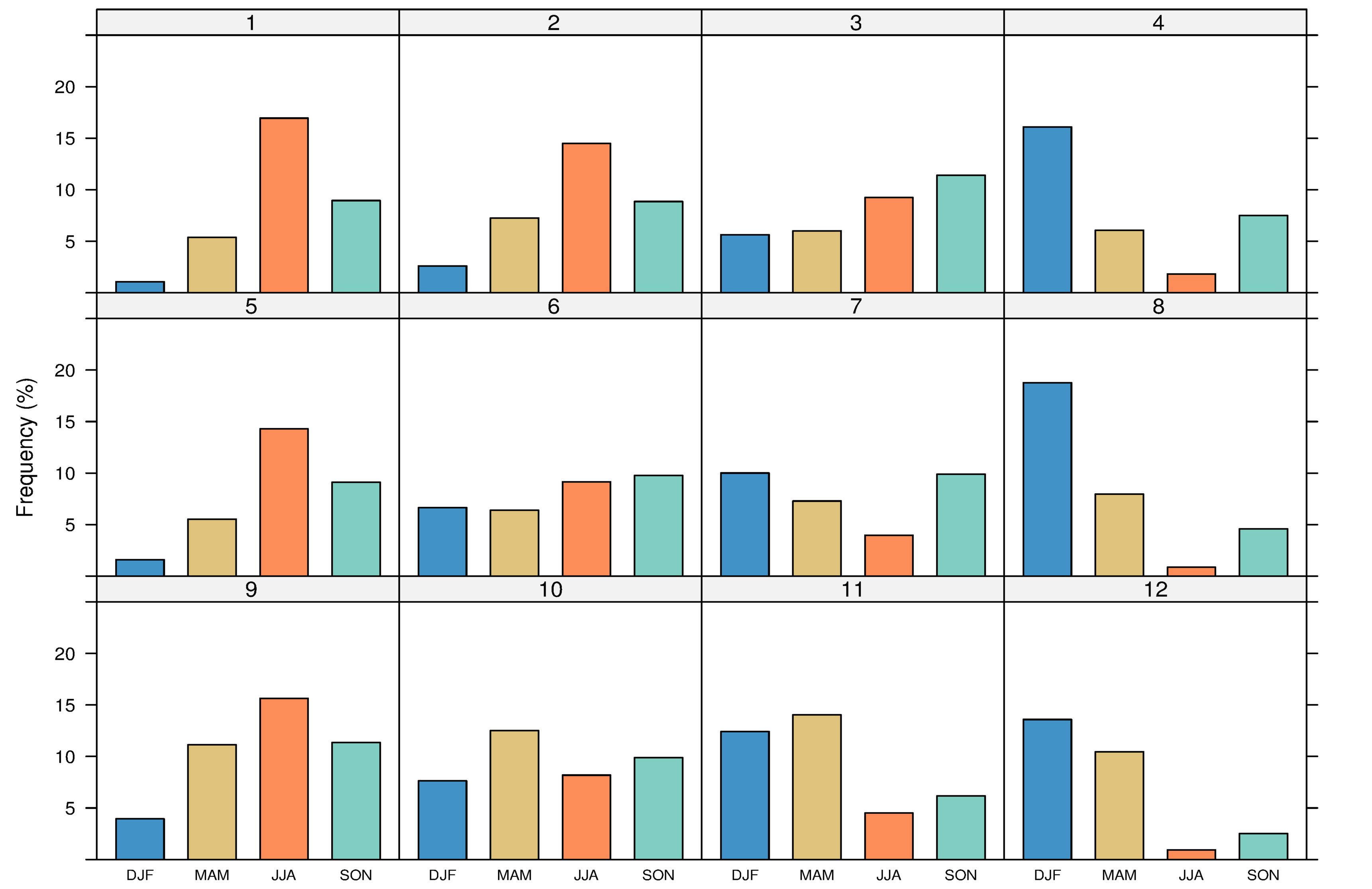
MEI=0.72 AAO=-0.09 TRBI=-0.32 (**19.8%**)

0.09	0.09	-0.23	-0.70
0.27	0.48	-0.06	-0.58
0.56	0.81	0.25	-0.34

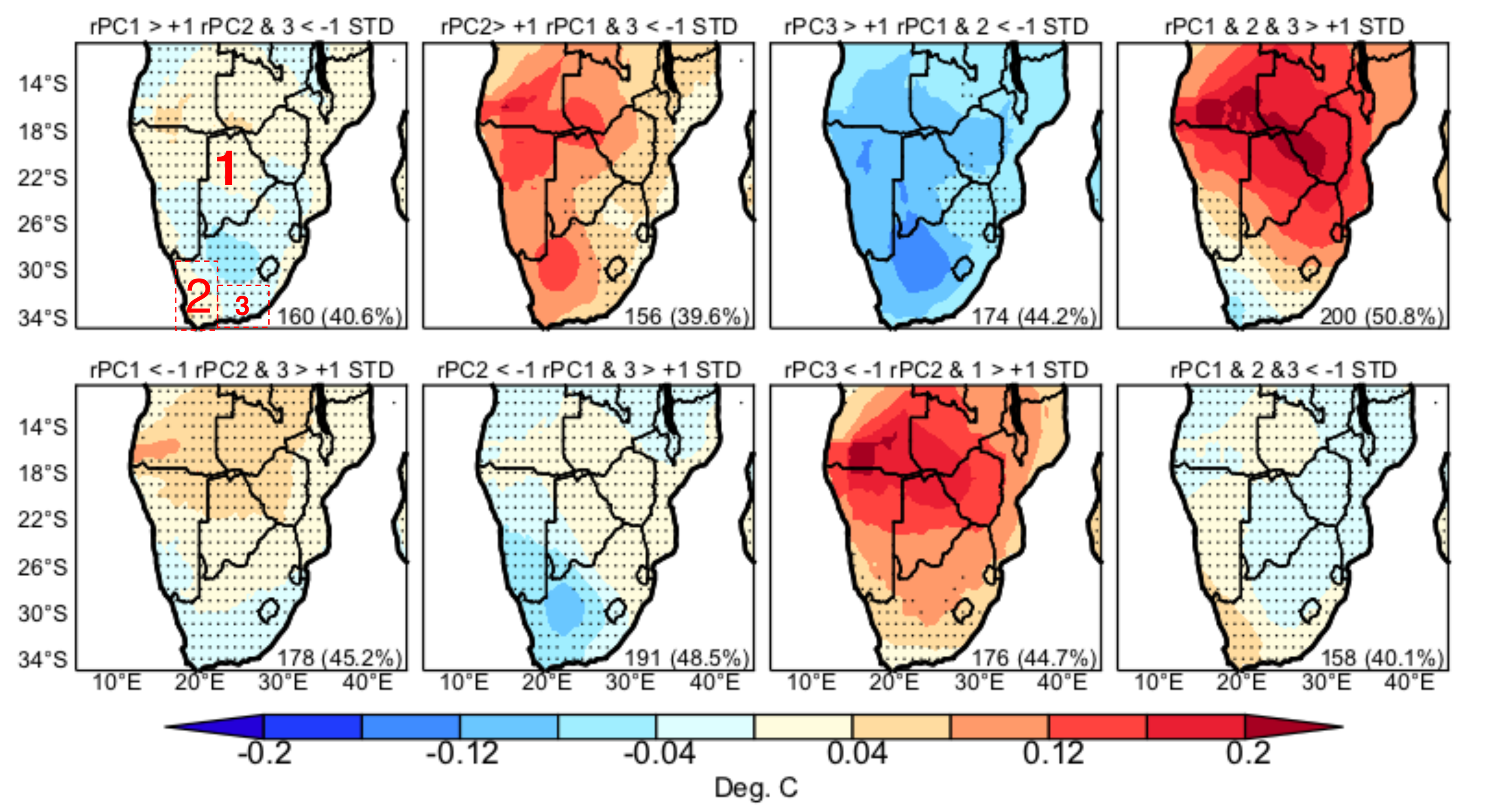
MEI=0.04 AAO=-0.43 TRBI=0.22 (**12.6%**)

-0.03	0.29	0.77	-0.01
-0.20	0.50	0.57	-0.30
-0.30	0.07	-0.21	-0.36

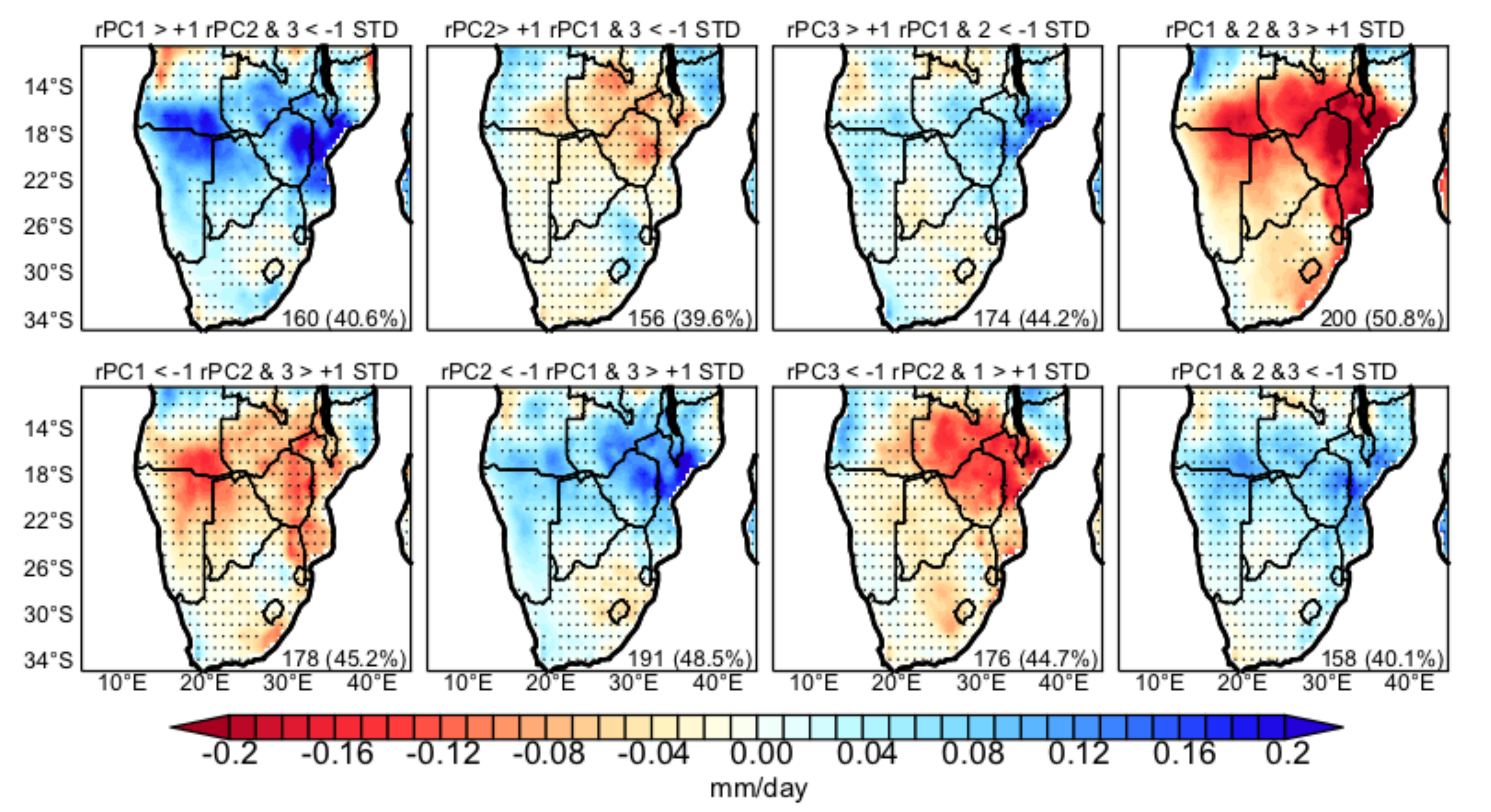
- The leftmost part of the SOM, nodes 1-2-5-9, passing mid-latitude cyclones cause frontal rains over the south-western cape of South Africa by forcing warm air to rise underneath the cool dense air which precipitates over the south-western cape.
- Semi permanent subtropical high migrates south due to continental heating allowing warm air masses to bring in humid air over the interior leading to rainfall in the region in nodes 4-7-8-12.
- First 3 rotated PCA (hereafter, rPC) were retained by Rule-N test. We find rPC1 accounts for natural variability while rPC2 shows ENSO dominance with rPC3 exhibiting AAO dominance.



- Here, seasonal variation of the frequency of occurrence (%) is mapped to each SOM node
- Dry summer states (typically winter season) are aligned to the left of the SOM archetype while wet summer states (typically summer season) are located to the right.



- A positive mode rPC2 + negative mode rPC1 and rPC3 identifies a longitudinal warming increment from the east to west with a statistically significant warming to the west and over regions 1, 2 and 3.
- A positive mode rPC3 + a negative mode rPC1 and rPC2 show regions 1, 2 and 3 are cold and significantly significant to the west.
- A positive rPC1 + rPC2 + rPC3 shows a statistically significant warming in region 1.



- A negative mode rPC2 + positive mode rPC1 and rPC3 shows a statistically significant peak wetness over parts of regions 1 and 2.
- A positive mode rPC3 + negative mode rPC2 and rPC3 influences a statistically significant wetness in region 2 while regions 1 and 3 are insignificant.
- A positive mode rPC1 + rPC2 + rPC3 shows peak dryness in region 1 and is significant.

Summary

- A methodology to understand the dynamics of co-behaviour is developed.
- A typical co-behaviour of La-Niña with positive mode AAO increases the intensity of precipitation over regions 1 and 2 and is statistically significant.
- A negative mode AAO reduces El-Niño influence in the east of region 1 although not significant, however, west of regions 1 and 2 are significantly warm under this co-behaviour.

Acknowledgements. This work was funded by Future Resilience for African CiTies and Lands (FRACTAL) project, which is part of Future Climate for Africa (FCFA) program funded by UK's Department of International Development and NERC. The first author is grateful to the University of Cape Town for funding assistance .and African Climate and Development Initiative (ACDI) of UCT, Tyndall Centre for Climate Change and Climatic Research Unit (CRU) under the Newton PhD Partnering Scheme funded by Research Councils UK (RCUK) and the National Research Foundation (NRF) of South Africa.