

PROCESS-BASED ASSESSMENT OF REGIONAL CLIMATE MODEL PROJECTIONS OVER SOUTHERN AFRICA

Rachel James, Richard Washington, and Richard Jones



Rationale

- Model projections used for adaptation
- Need to assess credibility
- Studying climatologies important but not sufficient
- Need direct investigation of mechanisms for change

→ As important for RCMs as GCMs

Application to West Africa



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RESEARCH ARTICLE

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Key Points:

- Circulation changes associated with modeled precipitation change are identified
- Modeled processes are similar for future change and historical variability
- Contrasts to variability in reanalyses bring these models' futures into question

Supporting Information:

- Figures S1–S9

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Process-based assessment of an ensemble of climate projections for West Africa

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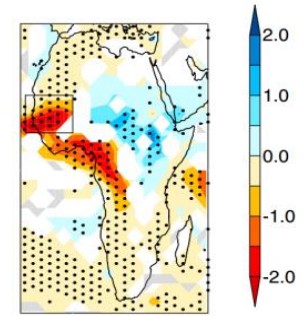
Abstract Determining the level of confidence in regional climate model projections could be very useful for designing climate change adaptation, particularly for vulnerable regions. The majority of previous research to evaluate models has been based on the mean state, but for confidence in projections the plausibility of the mechanisms for change is just as, if not more, important. In this study we demonstrate a methodology for process-based assessment of projections, whereby circulation changes accompanying future responses are examined and then compared to atmospheric dynamics during historical years in models and reanalyses. We apply this methodology to an ensemble of five global and regional model experiments and focus on West Africa, where these models project a strong drying trend. The analysis reveals that this drying is associated with anomalous subsidence in the upper atmosphere, and large warming of the Saharan heat low region, with potential feedback effects via the African easterly jet and West African monsoon. This mode occurs during dry years in the historical period, and dominates in the future experiments. However, the same mode is not found in dry years in reanalysis data, which casts doubt on the reasons for strong drying in these models. The regional models show a very similar response to their driving global models, and are therefore no more trustworthy in this case. This result underlines the importance of assessing model credibility on a case-by-case basis and

Framework applied in James et al. 2015 (JGR-A)

Examine future projections

*How do GCMs and
RCMs project
precipitation will
change in future?*

GCM
future



Framework applied in James et al. 2015 (JGR-A)

Examine future projections

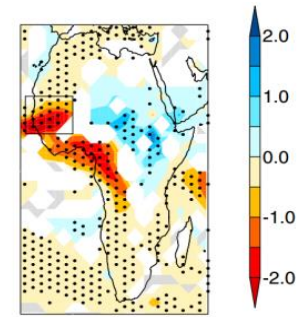


Analyse modelled circulation responses in future

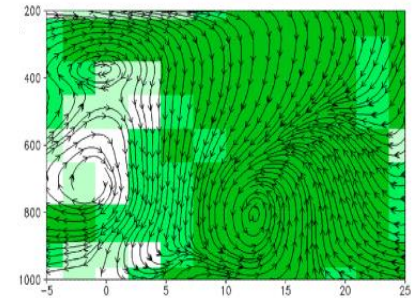
How do GCMs and RCMs project precipitation will change in future?

Is it possible to infer potential mechanisms for precipitation change?

GCM
future



GCM
future

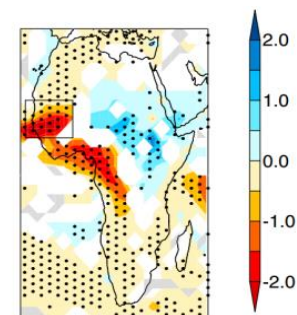


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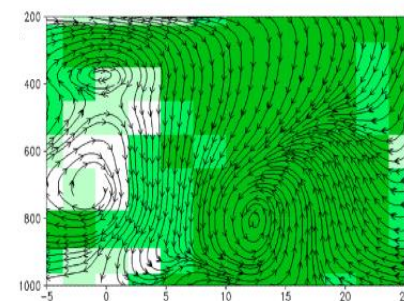
GCM
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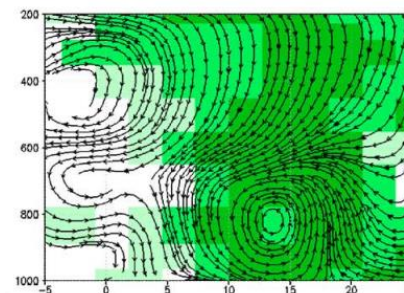
GCM
future



Investigate composites of historical wet and dry years

Are the drivers of change similar for future projections and interannual variability?

GCM
dry -
wet

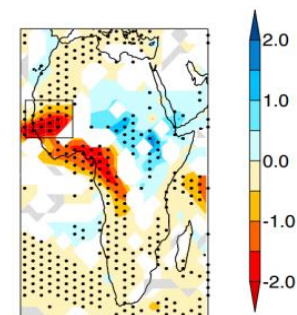


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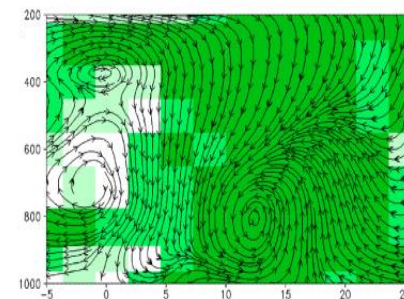
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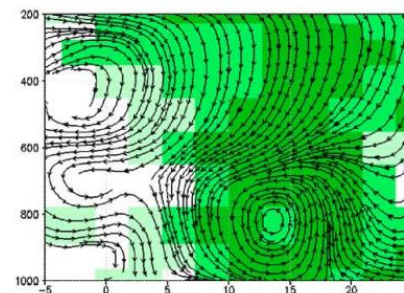
GCM
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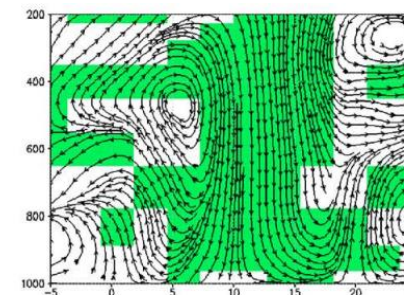
GCM
dry -
wet



Compare modelled composites to reanalysis

Are interannual circulation responses similar in models and reanalysis?

ERA-I
dry -
wet

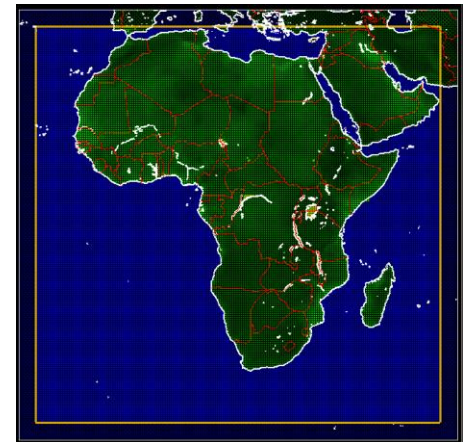


Focus on southern Africa

- How do GCMs and RCMs project precip will change in future?
- What circulation changes are associated with the precipitation projections?
 - What are the possible mechanisms for change?
 - Are they plausible/credible?

Data

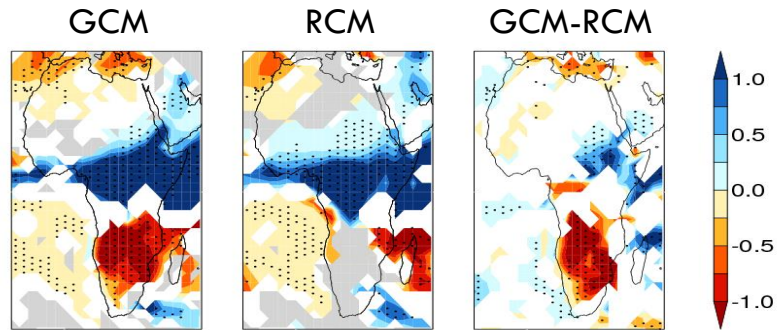
- Met Office Hadley Centre ensemble (Buontempo et al. 2014):
 - GCM: HadCM3
 - Five versions with perturbed physics
 - 1950-2100
 - SRESA1B
 - RCM: HadRM3P (PRECIS)
 - Five runs with five versions of GCM as boundary conditions
 - CORDEX Africa domain
 - 50km gridspace



Precipitation Projections

How do models project precip will change in future?

November



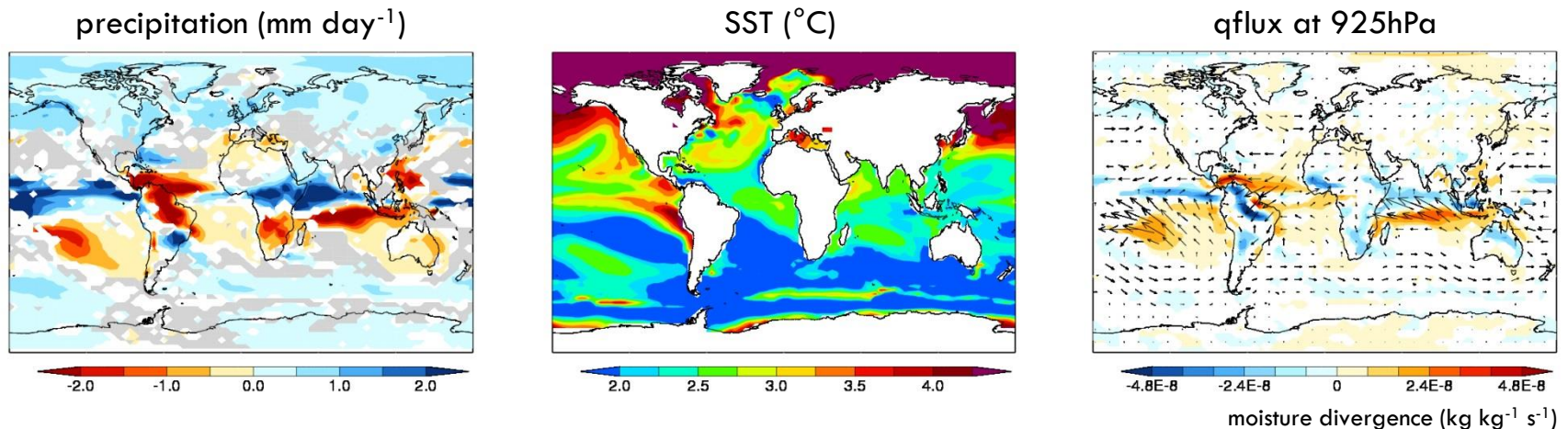
January

All projections are anomalies, 2079-2098 relative to 1980–1999

Investigating drivers of change

What circulation changes are associated with the precipitation projections?

Focus: GCMs in November

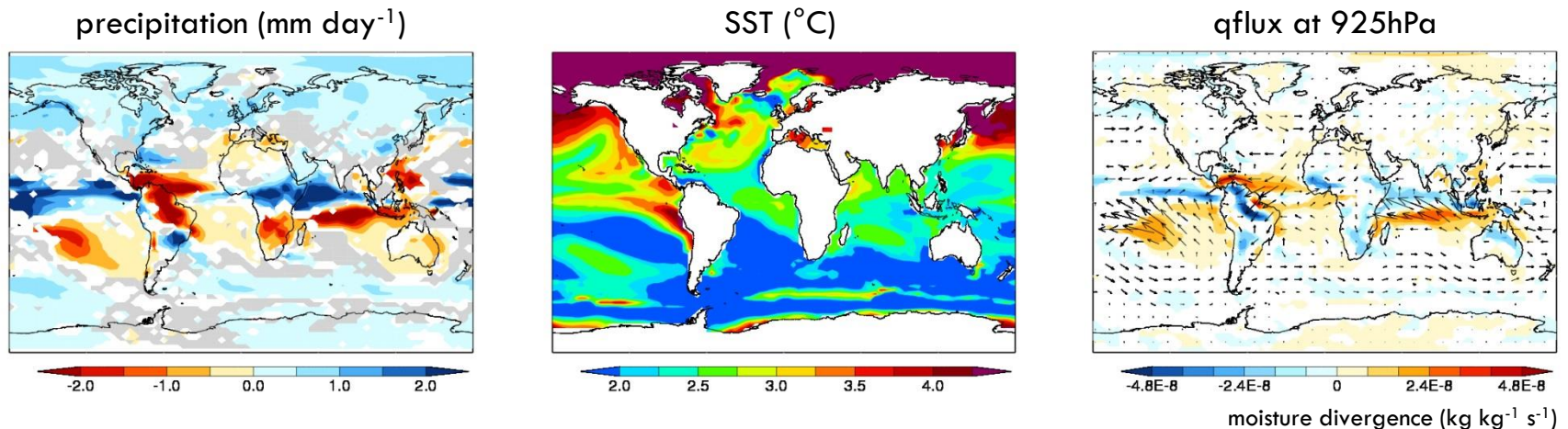


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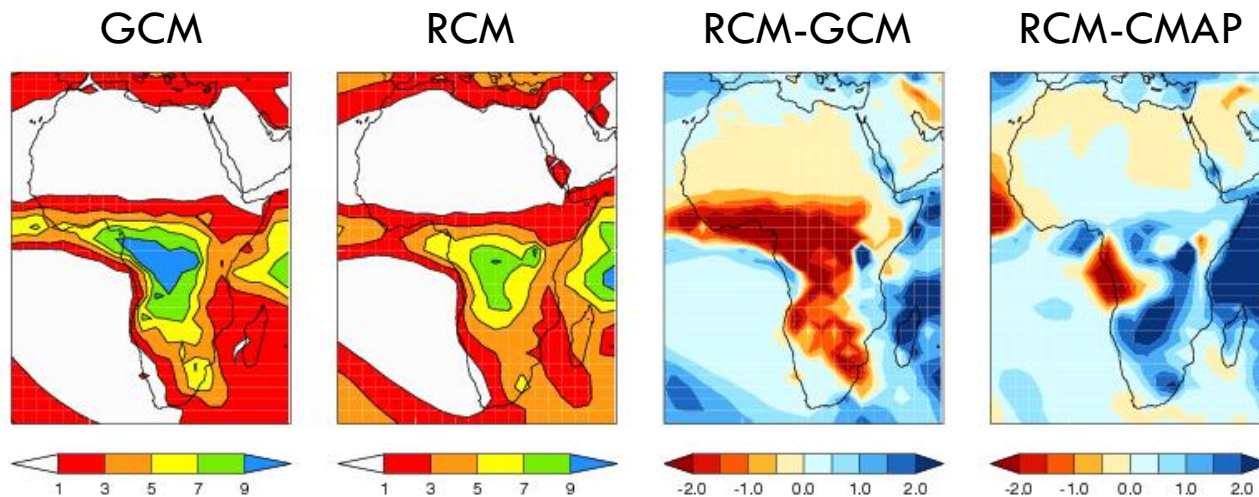


Possible delay in seasonal cycle of SSTs and migration of tropical precipitation

see also Biasutti and Sobel (2009)

Investigating GCM/RCM contrast

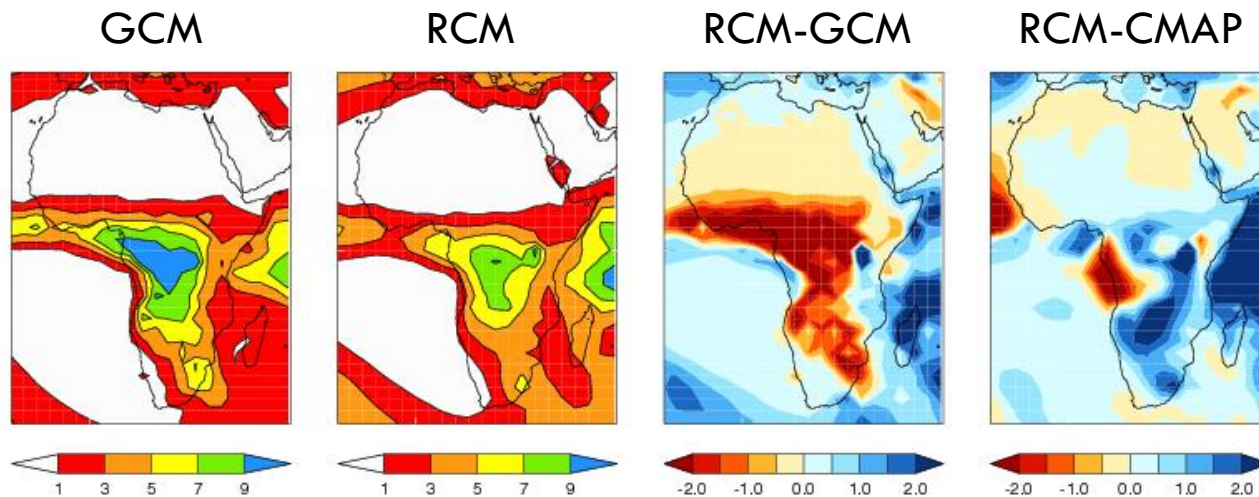
If GCM is drying due to a global delay in the seasonal migration of precipitation, why is there no change in RCM?



November precipitation climatologies 1980–1999 (mm day⁻¹)

Investigating GCM/RCM contrast

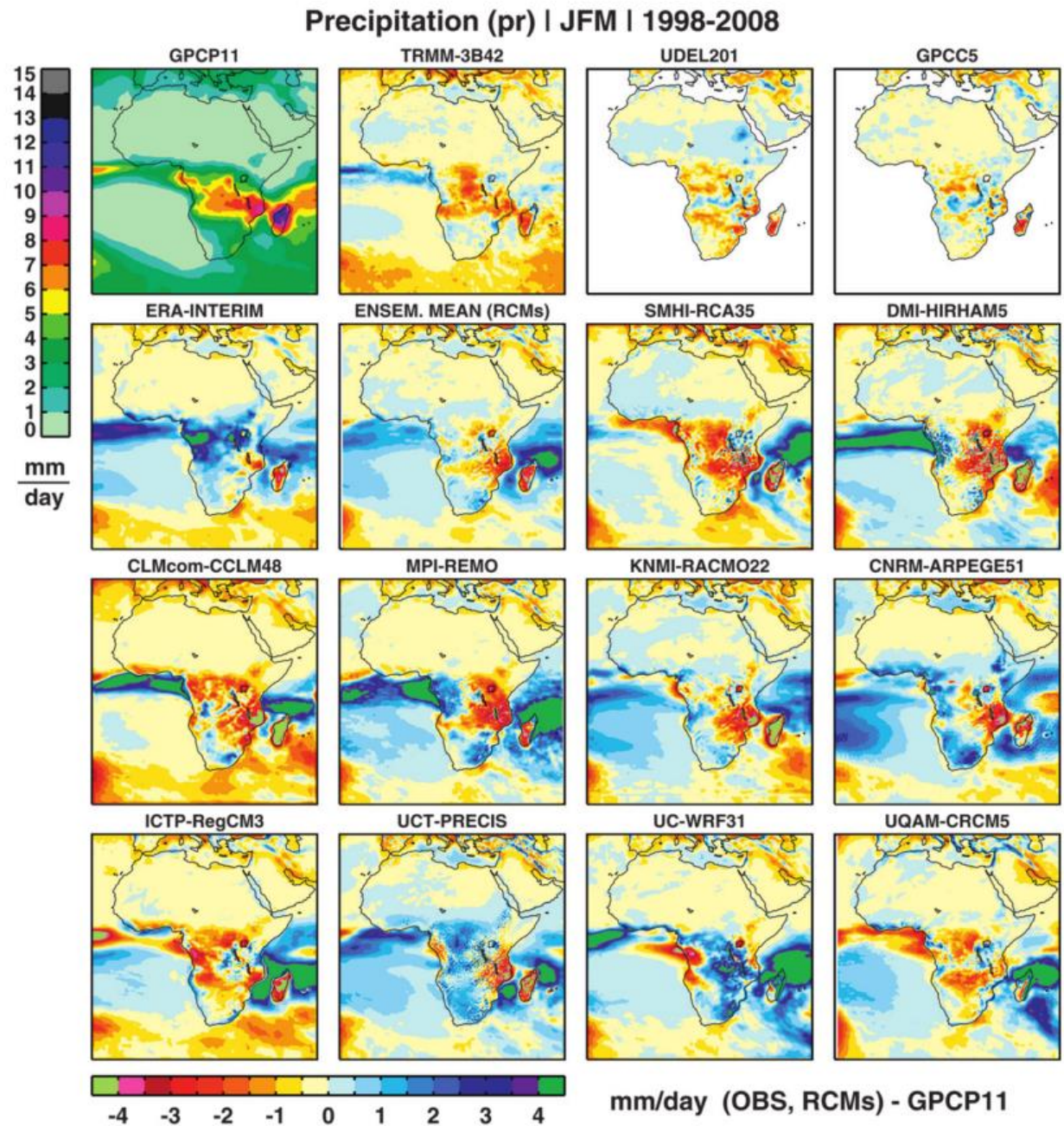
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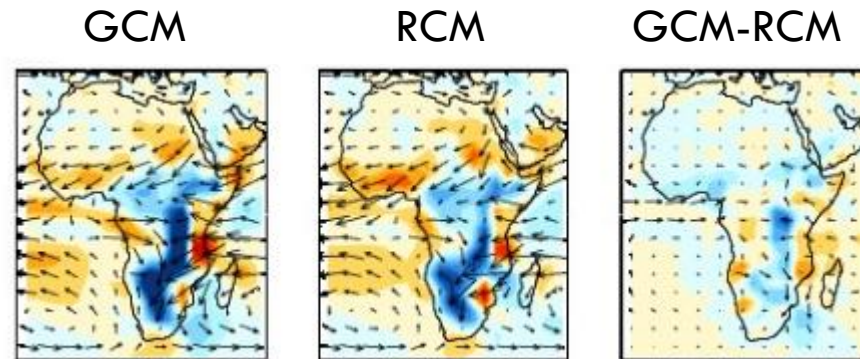
November precipitation climatologies 1980–1999 (mm day⁻¹)

May be partly explained by climatological differences, including large wet bias in Indian Ocean in RCM

Indian Ocean bias
shared by other
RCMs

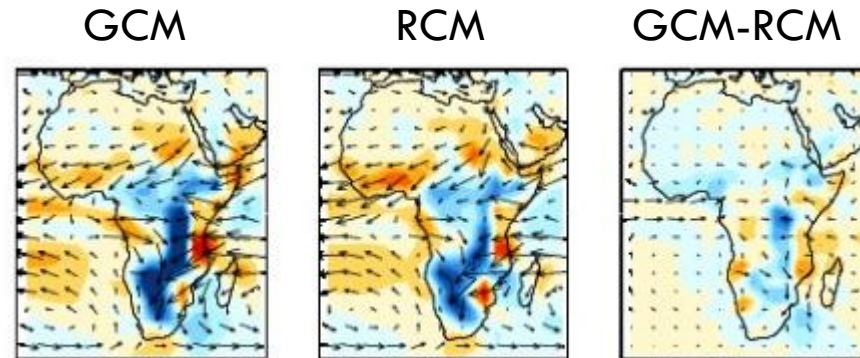


Investigating RCM bias



November qflux climatologies at 850hPa 1980–1999
with moisture divergence ($\text{kg kg}^{-1} \text{s}^{-1}$)

Investigating RCM bias



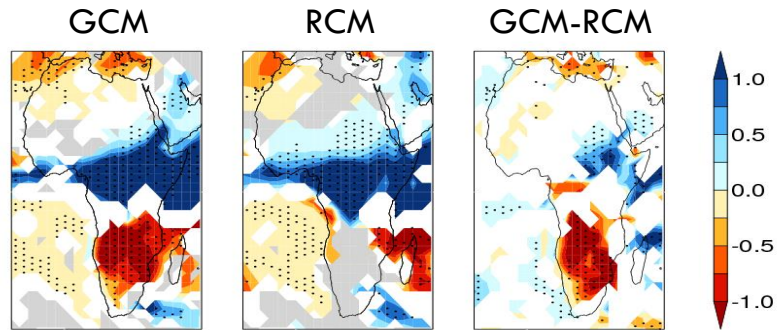
November qflux climatologies at 850hPa 1980–1999
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GCM also has more moisture convergence over southern Africa

Precipitation Projections

How do models project precip will change in future?

November



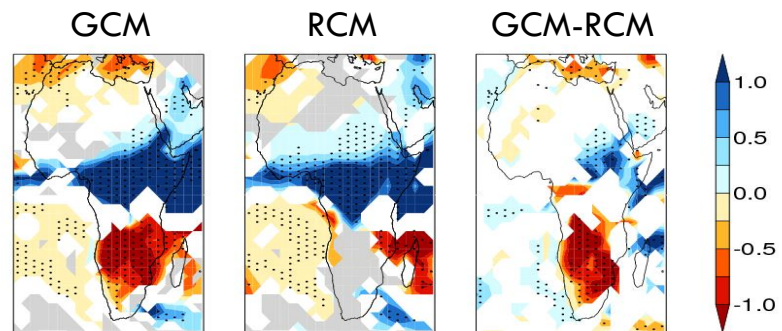
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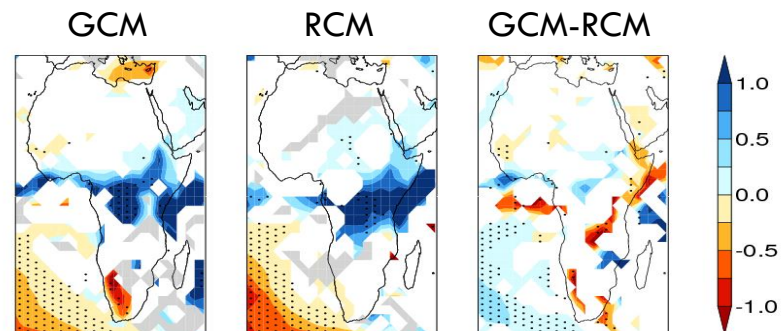
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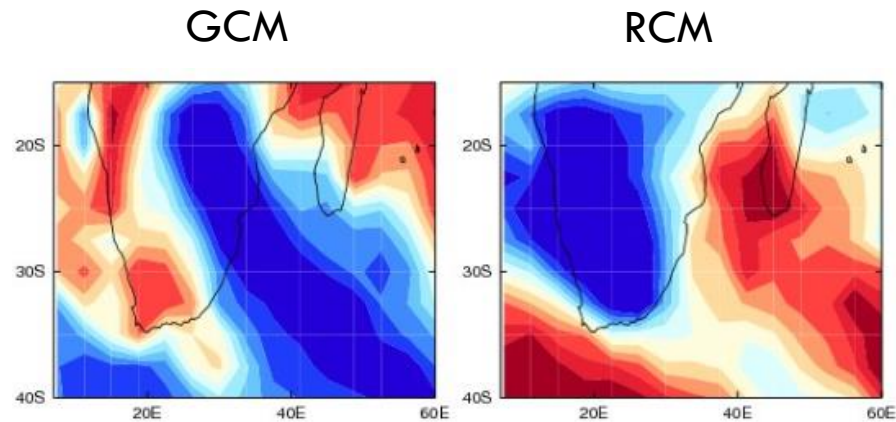
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Investigating modes of variability

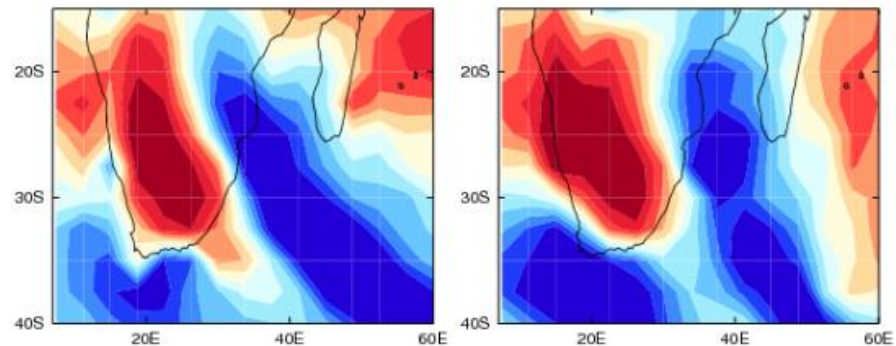
Example EOFs from two models in the ensemble (all “EOF1”)

Calculated for January, 1950-1999

Model 1



Model 2



Conclusions: southern Africa

- Contrasting precipitation projections in GCMs and RCMs
- Process based investigation can help to understand mechanisms of change
 - In November possible shift in tropical convection in GCMs
 - In January investigating possible change in TTTs
- Need further work to investigate these to better understand credibility

Lessons for regional climate change research

- Initial results suggest CORDEX Africa domain has potential problems for southern Africa:
 - Wet Bias over Indian Ocean
 - Truncation of TTTs
- Highlights importance of assessing projections on a case by case basis
 - but can we develop a standard framework for this?

Thank you! Any questions?

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Conclusions: West Africa

- Important difference in magnitude of GCM and RCM projections
- But character of response very consistent
- Both GCMs and RCMs show distinct circulation mode during 20th century dry years, and this dominates in response to global warming
- This mode is not found in reanalysis
- Findings cast doubt on strong drying of West Sahel
- RCM no more trustworthy than GCM in this case

→ Need for assessment of modelled signals before they are used to provide data for decision-making