Skill and economic benefits of dynamical downscaling of ECMWF ENSEMBLE seasonal forecast over southern Africa with RegCM4

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Motivation
ECMWF Sys 3 Ensemble data and RegCM set up
Perfect boundary condition run
ECMWF ENSEMBLE forcing runs
Summary

Outline

1. Motivation
2. ECMWF Sys 3 Ensemble data and RegCM set up
3. Perfect boundary condition run
4. ECMWF ENSEMBLE forcing runs
5. Summary

Motivation

- Limited area models(eg. MM5, WRF, RegCM,...) have been used for downscaling short range weather forecasts and/or climate change studies

- *for example RegCM has been extensively validated on various domain for its ability to have an "added" value compared to the global climate models*

- There is a growing demand from impact models for a detailed (localized) seasonal forecasts
- Dynamical downscaling with RegCM3 resulted in little gain over parts of the horn of Africa partly because the ECMWF driving GCM (29r2) has a wrong ENSO teleconnection signal over the Indian ocean
- Given the improvements in the driving GCMs, is there a prospect for dynamical downscaling?

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ECMWF ensemble hindcasts from 31r1

- Resolution : $1.125^0 \times 1.125^0$ in horizontal and 62L in vertical
- Hindcast period: 1991-2001
- 9 member ensembles
- addressing forecast uncertainty
- *uncertainty in initial condition: Perturbed initial conditions*
- *model error: Perturbed physics*
- Two start dates (May and November): here we used the Nov 1^{st} start for Malawi domain
- 6 month hindcasts starting from November 1^{st}

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Model setup and experimental design

- Resolution : 25km (288x200) in horizontal and 18 levels in the vertical
- Convection scheme: Grell over land and Emanuel over the ocean
- Two experiments were carried out with:
  - 'Perfect' boundary conditions
  - seasonal hindcasts boundary conditions
- For the 'perfect' boundary simulation:
  - ERA-Interim re-analysis,OI-weekly SST
  - simulation period: Jan 1990 to May 2002
- For hindcasts simulation
  - The 9 ECMWF ensemble members from 31r1 cycle are downscaled independently
  - simulation period: Nov 1^{st} to May 1^{st} every year between 1991 and 2002

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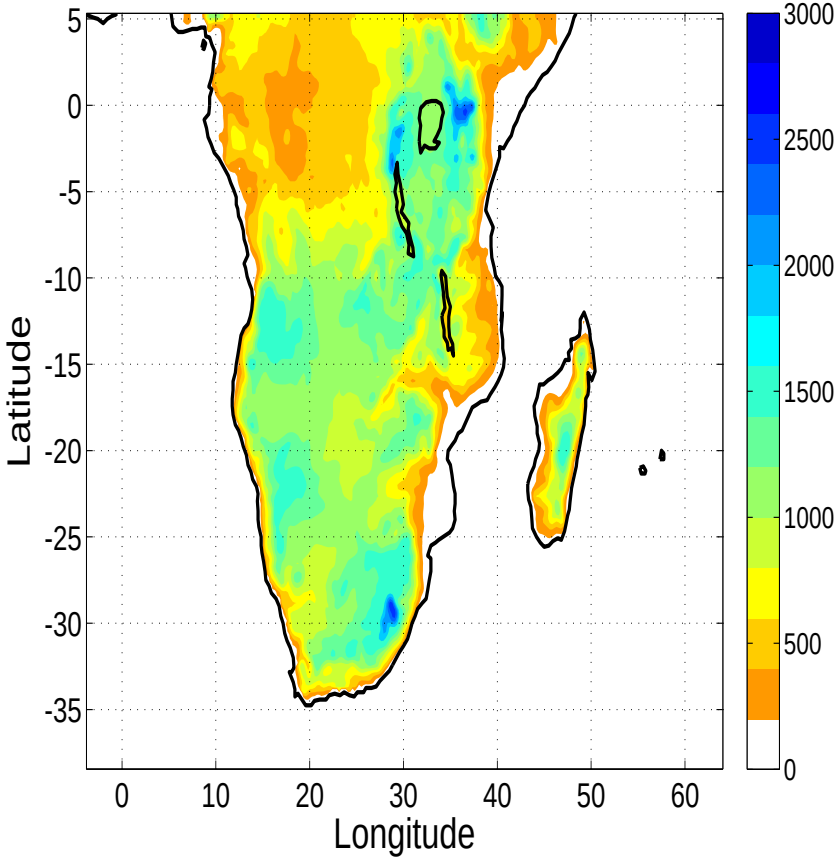
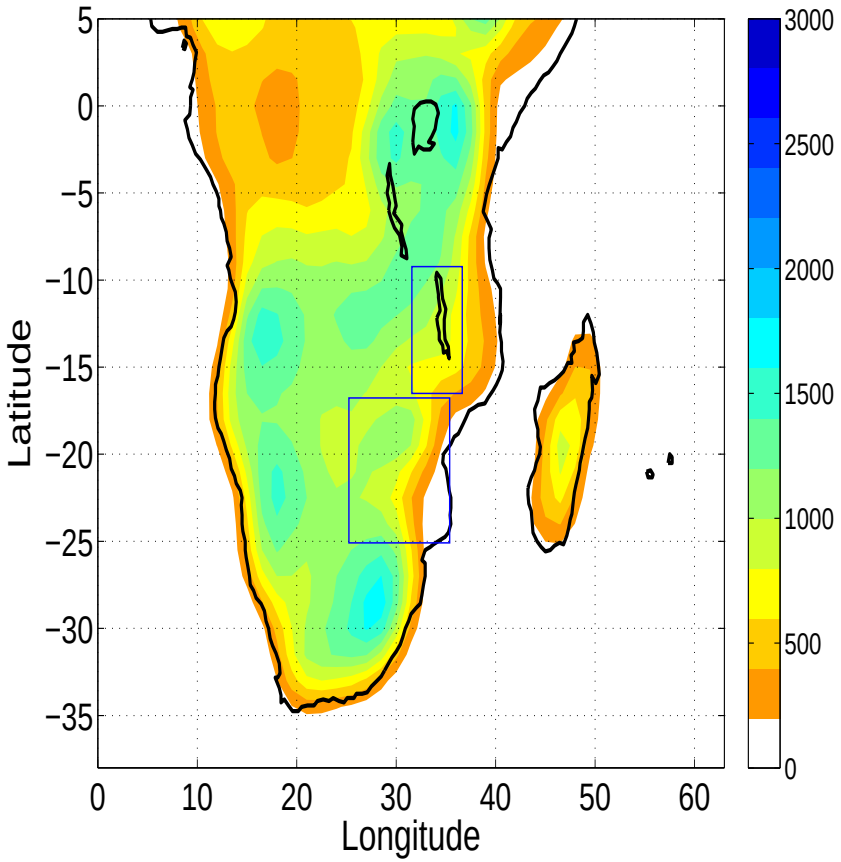
Model domain and Topography

RegCM



ECMWF



RegCM has a better realistic surface features due to its high resolution.

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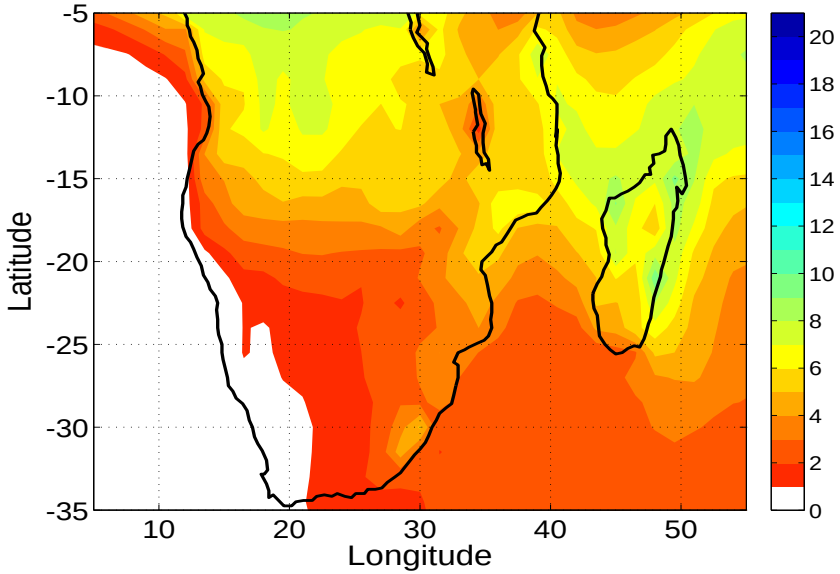
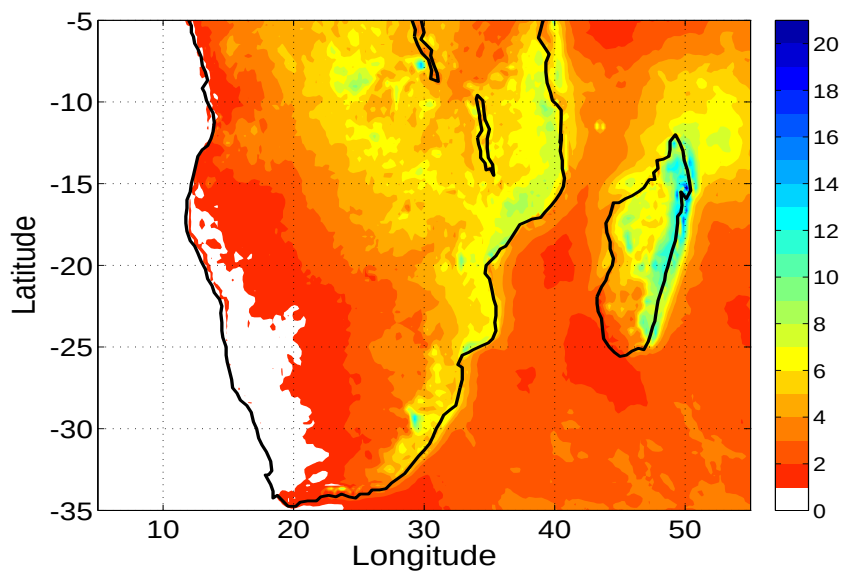
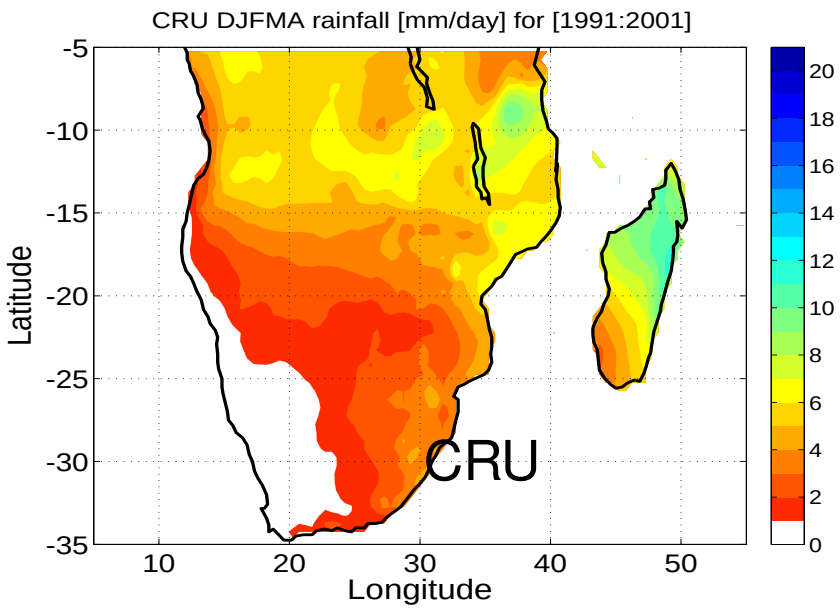
Perfect boundary run: DJFMA Climatology

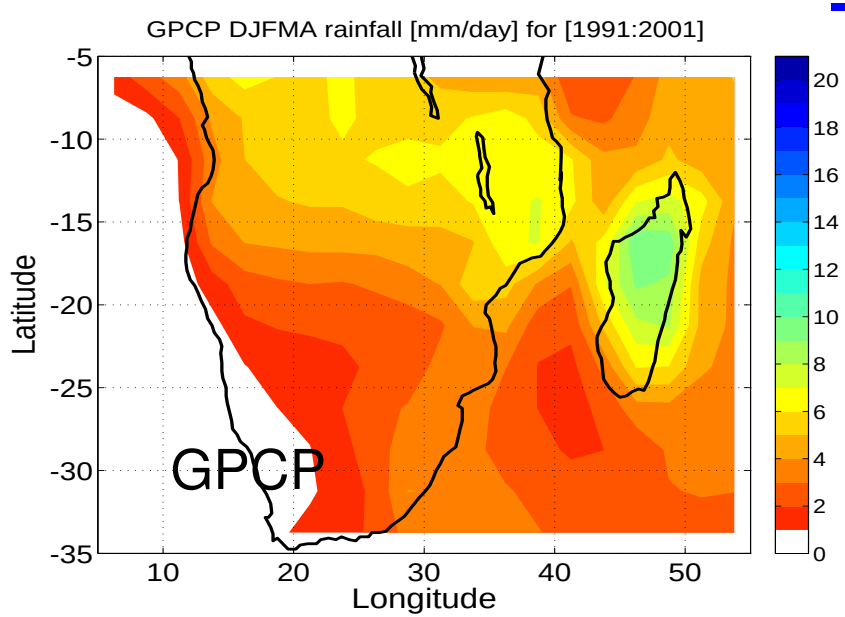
ERA-Interim



RegCM4







The ERA-interim wet bias over the Congo is reduced in RegCM4

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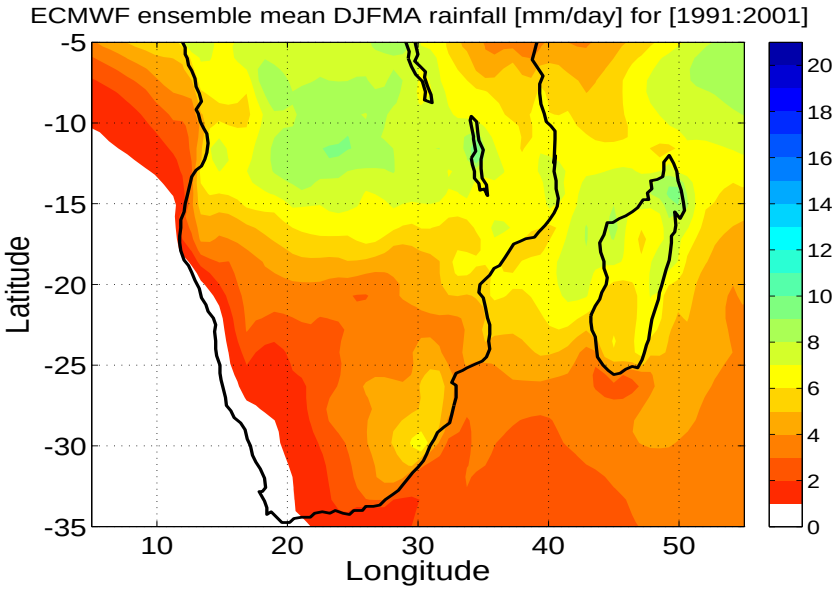
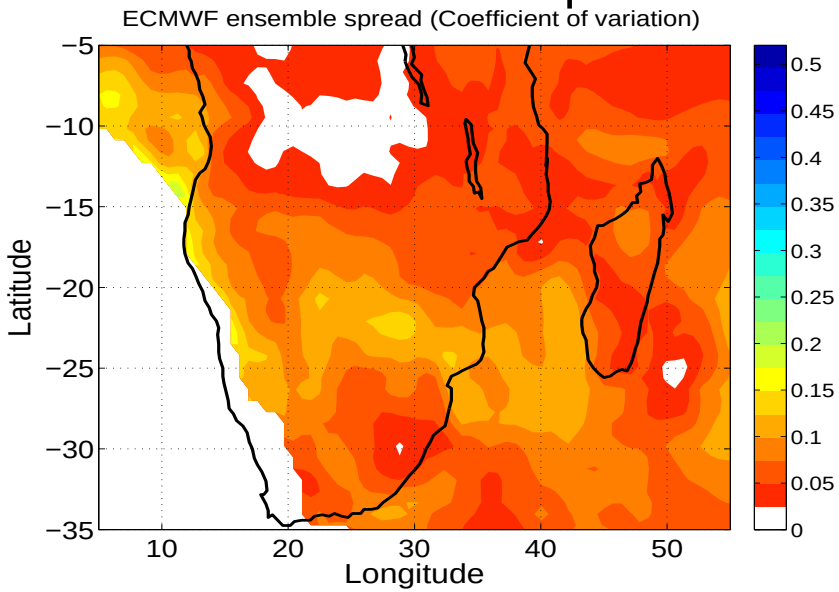
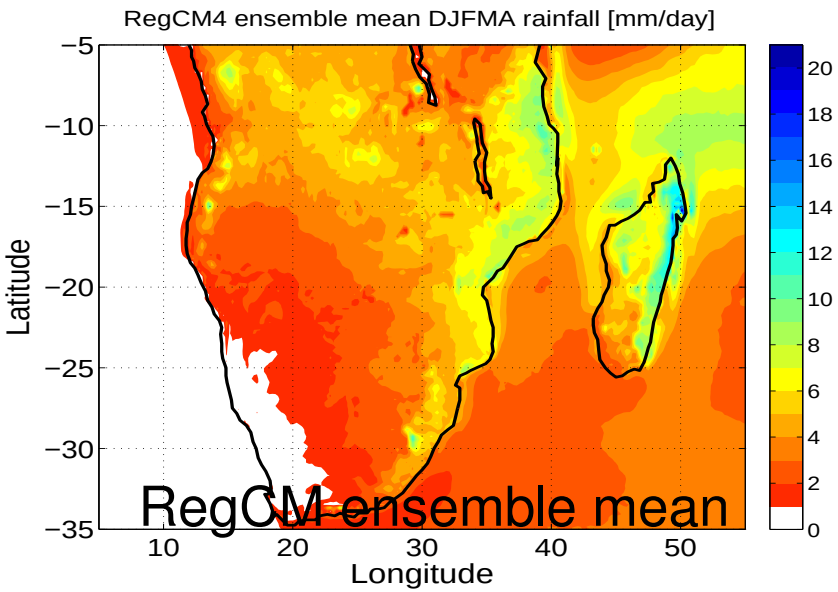
ECMWF forcing runs: mean and spread

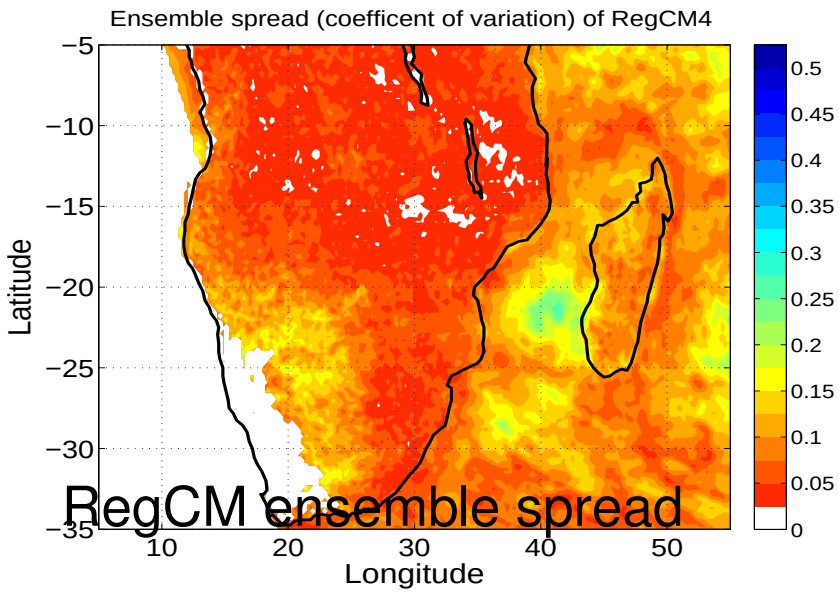
ECMWF ensemble mean



ECMWF ensemble spread







less spread over land than over the ocean

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Mean Climate (DJFMA) : Biases compared to CRU

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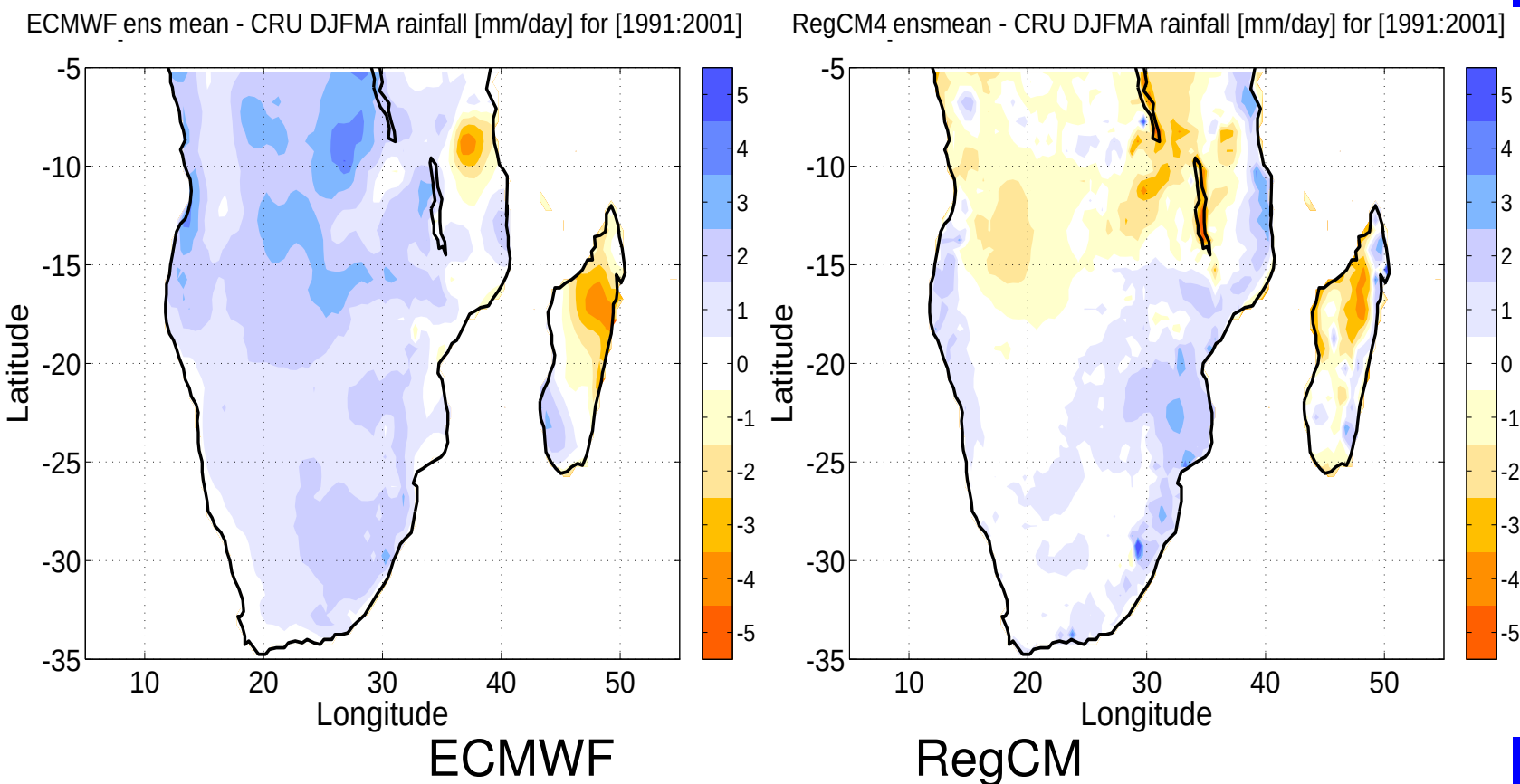
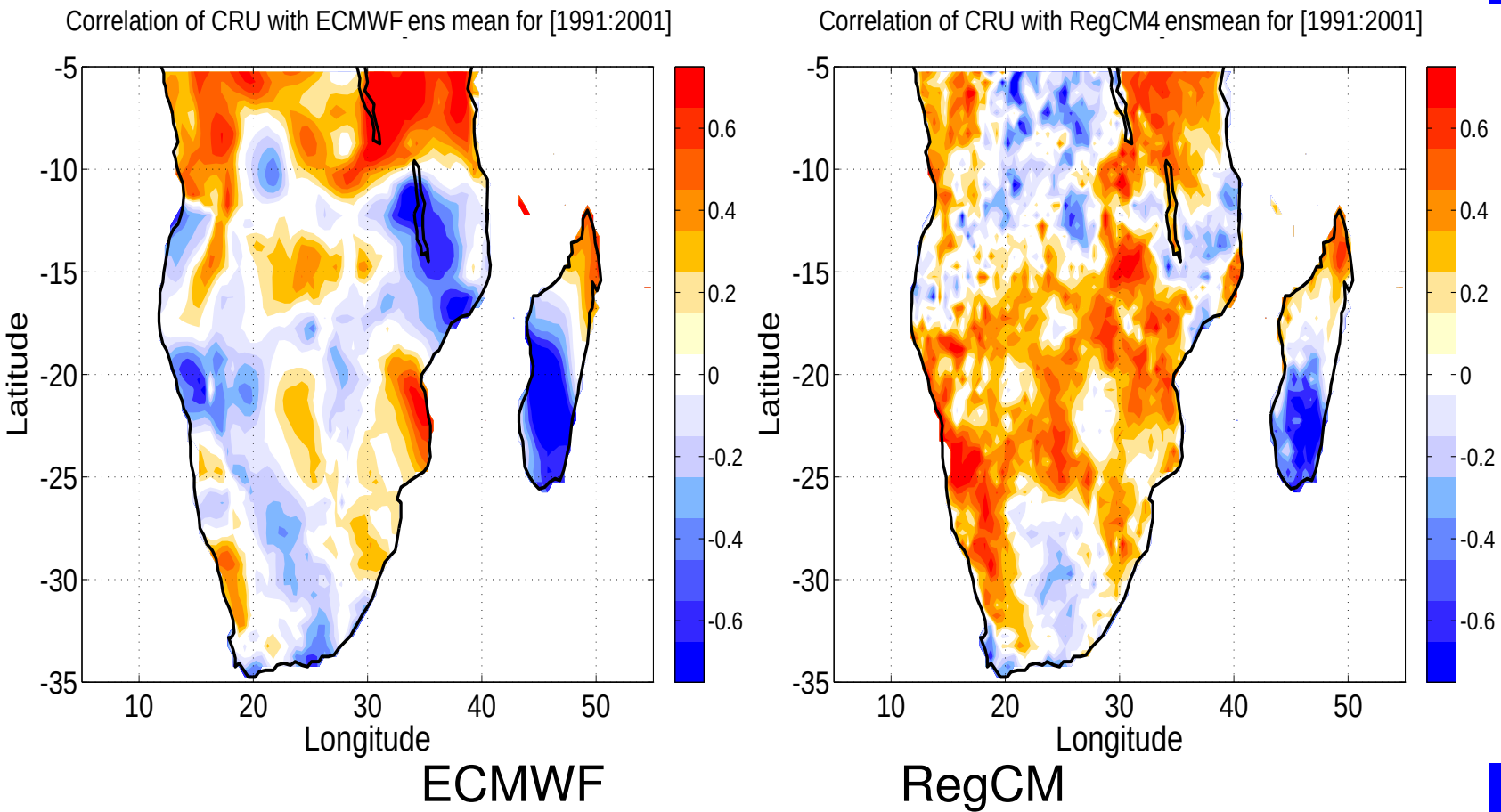


- RegCM is able to reduce most of the biases of the ECMWF GCM

Inter-annual variability (DJFMA): ensemble mean correlation with CRU



- RegCM improves the DJFMA (1 to 5 months lead time) mean correlation over most part of southern Africa compared to the driving GCM but still not good enough over Malawi

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Seasonal hindcasts run: Probabilistic

Remark

- *ensemble hindcasts are first converted to tercile probabilistic forecasts by fitting the ensembles with a Gaussian distribution and integrate the pdf between the pre-determined tercile thresholds.*
- *As the hindcasts from ECMWF and RegCM4 have different tercile threshold values compared to CRU, all datasets are first standardized prior to dressing*
- *Ranked Probability Skill Score (RPSS) and Relative Operational Characteristics Score (ROCS) are used to assess the skill of the probabilistic hindcasts where relative value is used to assess the economic benefits of the forecasts compared to climatology.*

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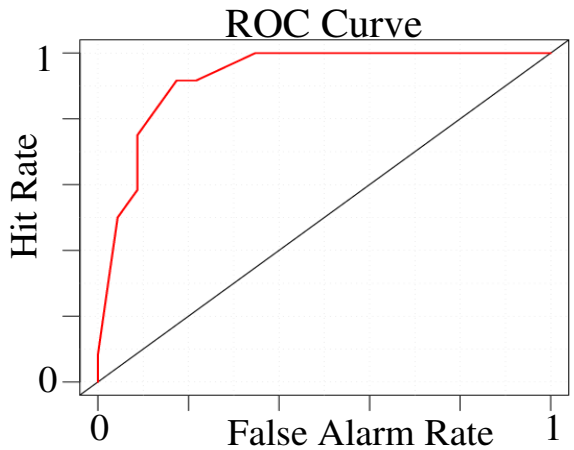
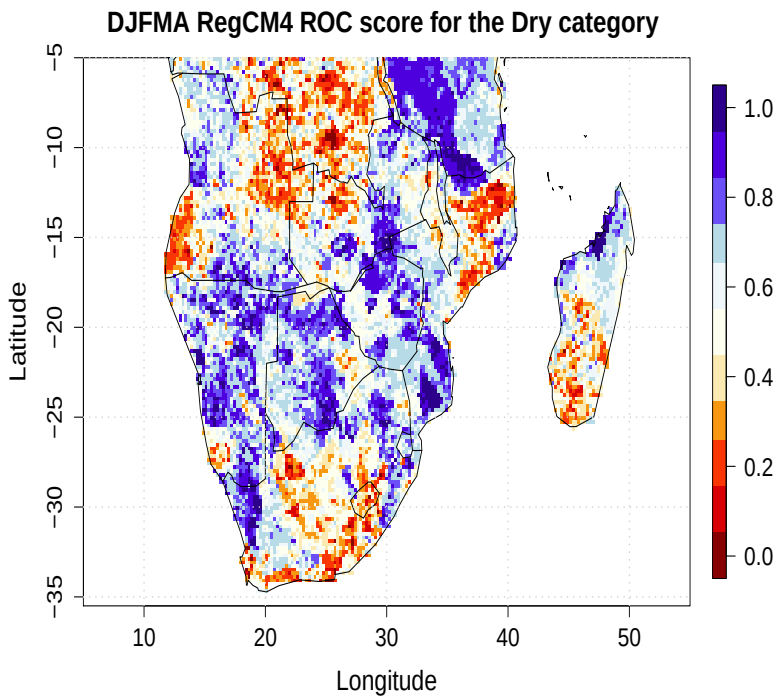
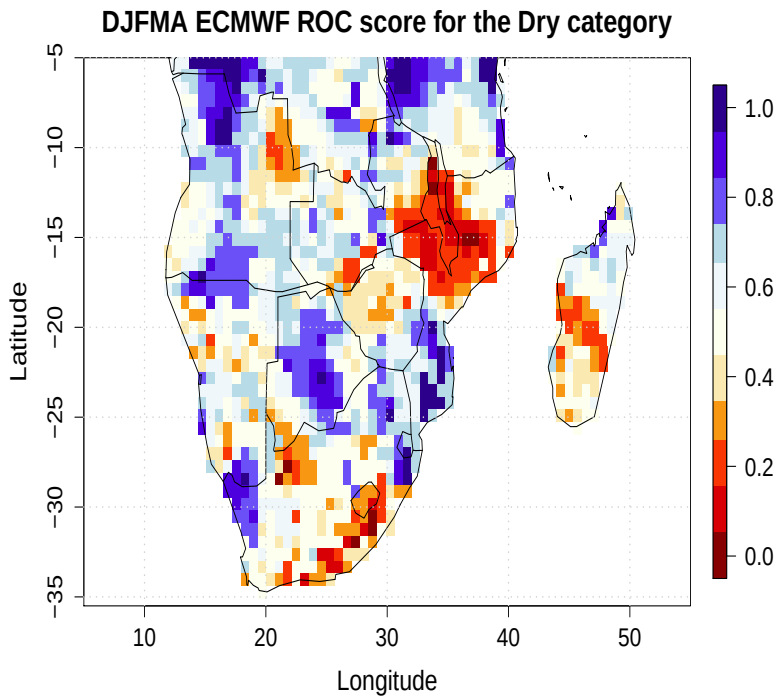
Relative Operating Characteristics Score: ROCS

- Area under ROC curve (ROCA)
- Compares against a random forecast
- A skillful forecast $\rightarrow$ ROCA > 0.5







RegCM4 has an added value

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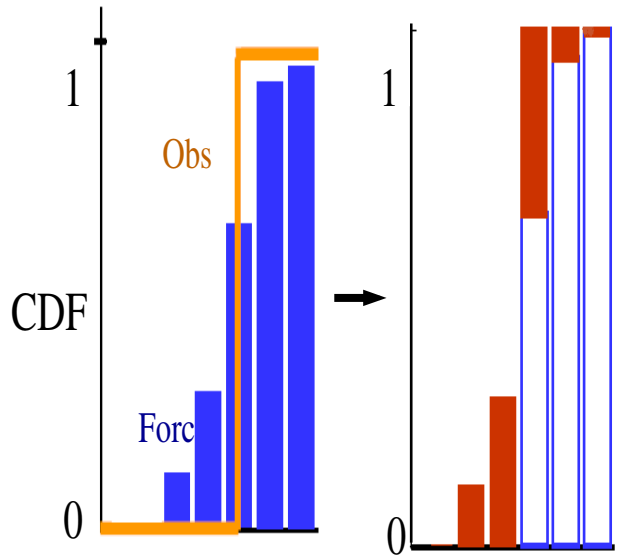
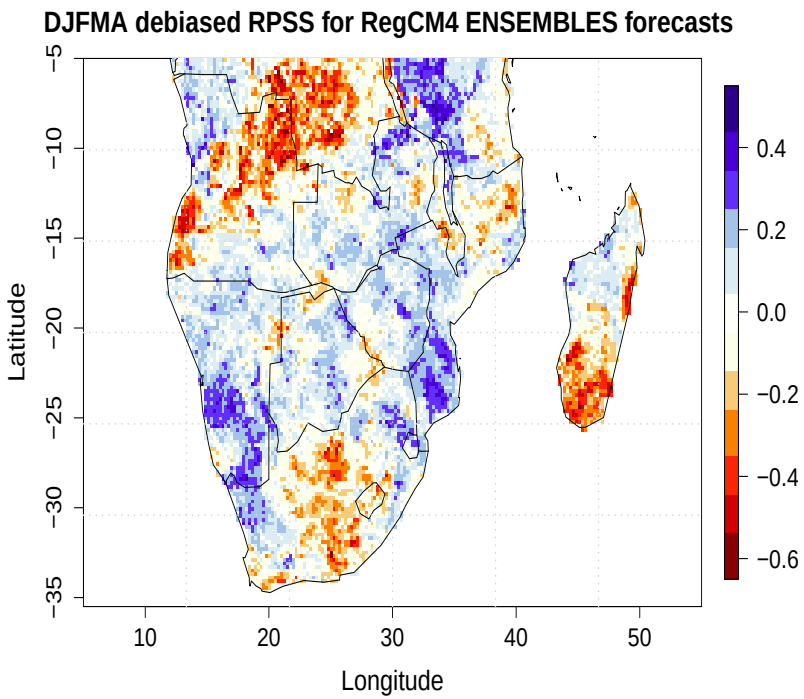
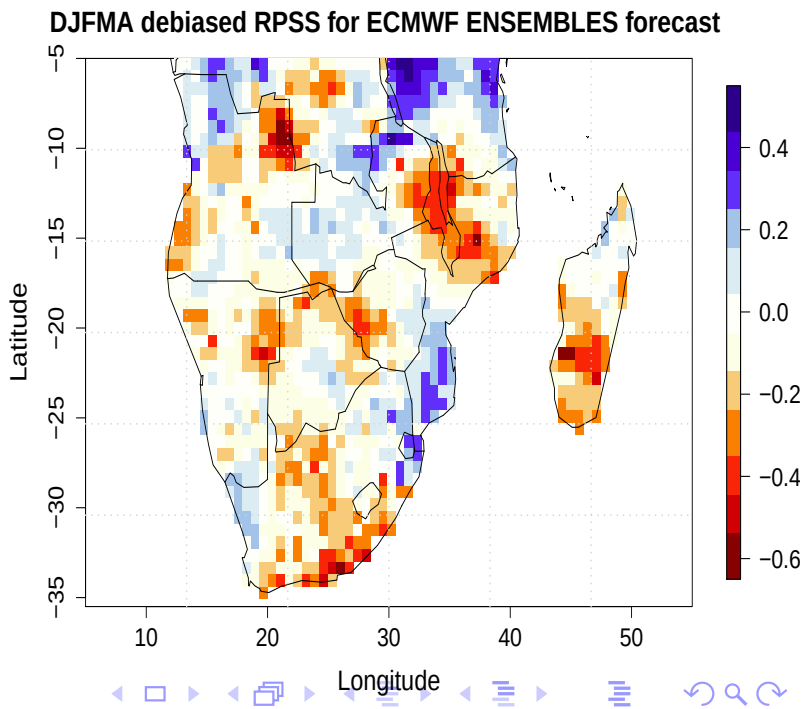
Ranked Probability Skill Score: RPSS

- $RPS = \frac{1}{K-1}[\sum_{i=1}^{K}(CDF_{forc,i} - CDF_{obs,i})^2]$
- $RPSS_D = 1 - \frac{RPS_{forc}}{(RPS_{clim} + RPS_{clim} * \frac{1}{M})}$
- A skillful forecast $\rightarrow$ $RPSS_D > 0$







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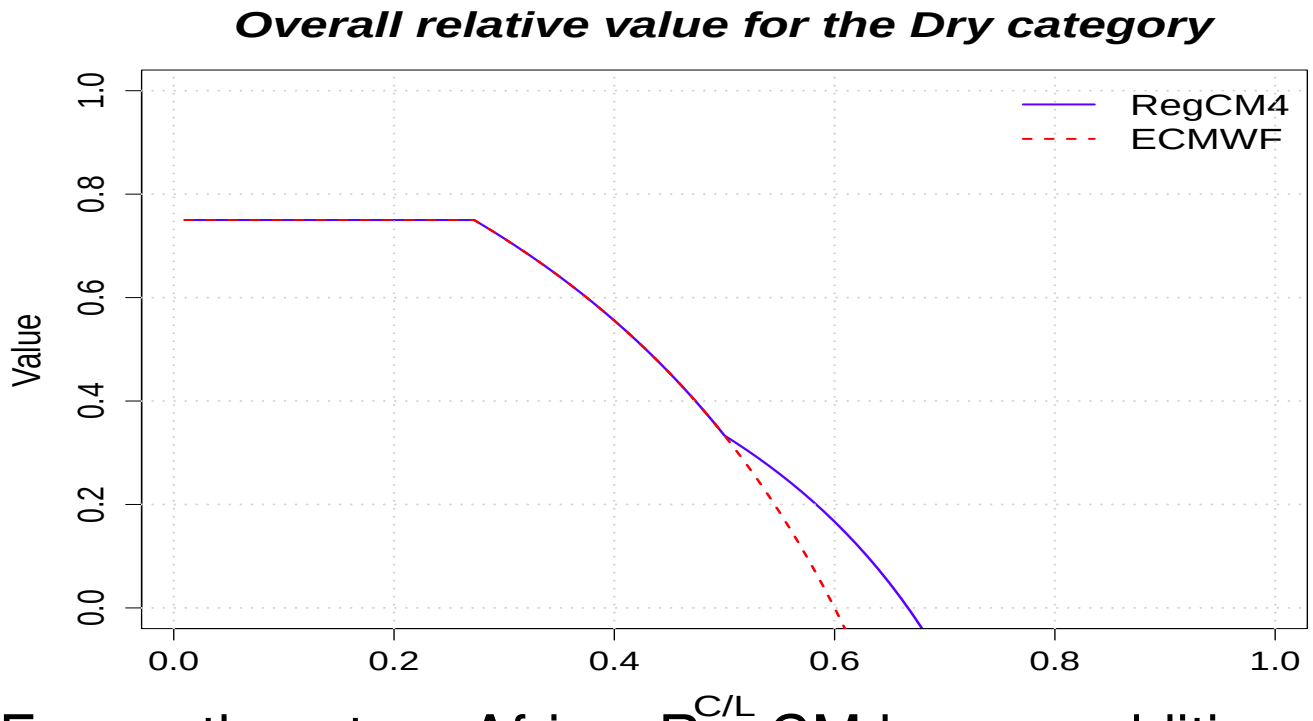
Relative value (V) /cost-loss ratio:

- It shows over what range of cost-loss (cl) ratio a forecast can provide a value
- relative value (V) of a forecast is a measure of reduction in expenses due to a forecast compared expenses occurred using climatology forecast



- For southeastern Africa, RegCM has an additional value for users with cost loss ration between 0.5 and 0.65.

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Conclusions

- *RegCM4 reproduced the mean and the variability of the seasonal climate over the southern Africa when forced by ERA-interim*
- *In most part of the domain RegCM4 reduced the bias and improved the interannual variability of ECMWF ensemble seasonal hindcast*
- *The improvement could be also because of the improvement in the ECMWF GCM hindcast itself*
- *For QWeCI- target region (Malawi) the skill is generally low but ECMWF is worst*
- *RegCM4 is generally better than ECMWF both in terms of skill and economic benefits over the southern Africa especially over the eastern coastal area*

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