

# SEASONAL PREDICTION FOR SOUTHERN AFRICA: MAXIMISING THE SKILL FROM FORECAST SYSTEMS

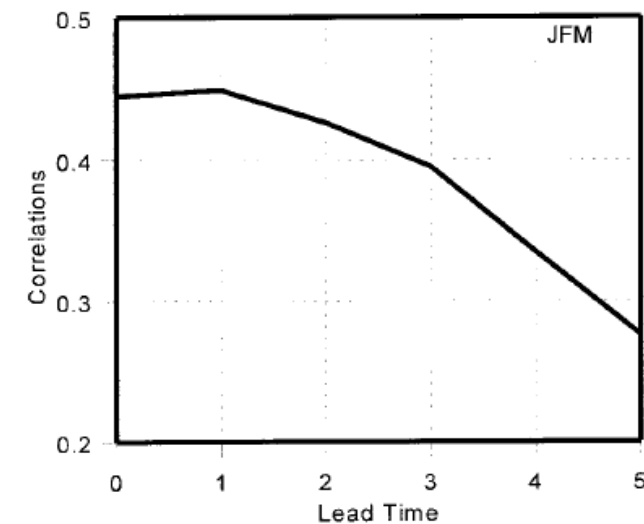
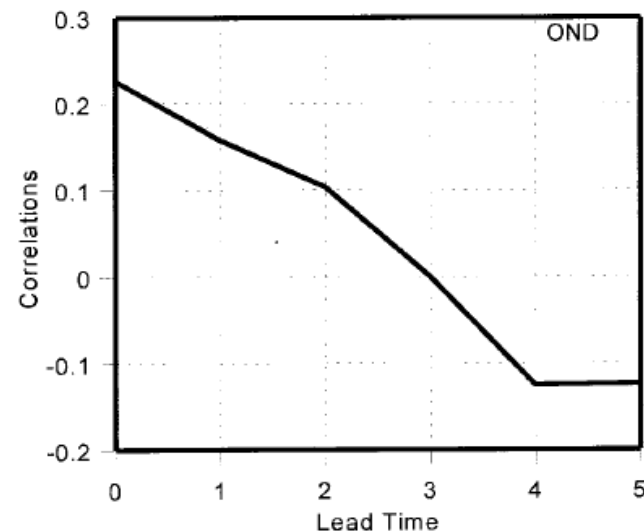
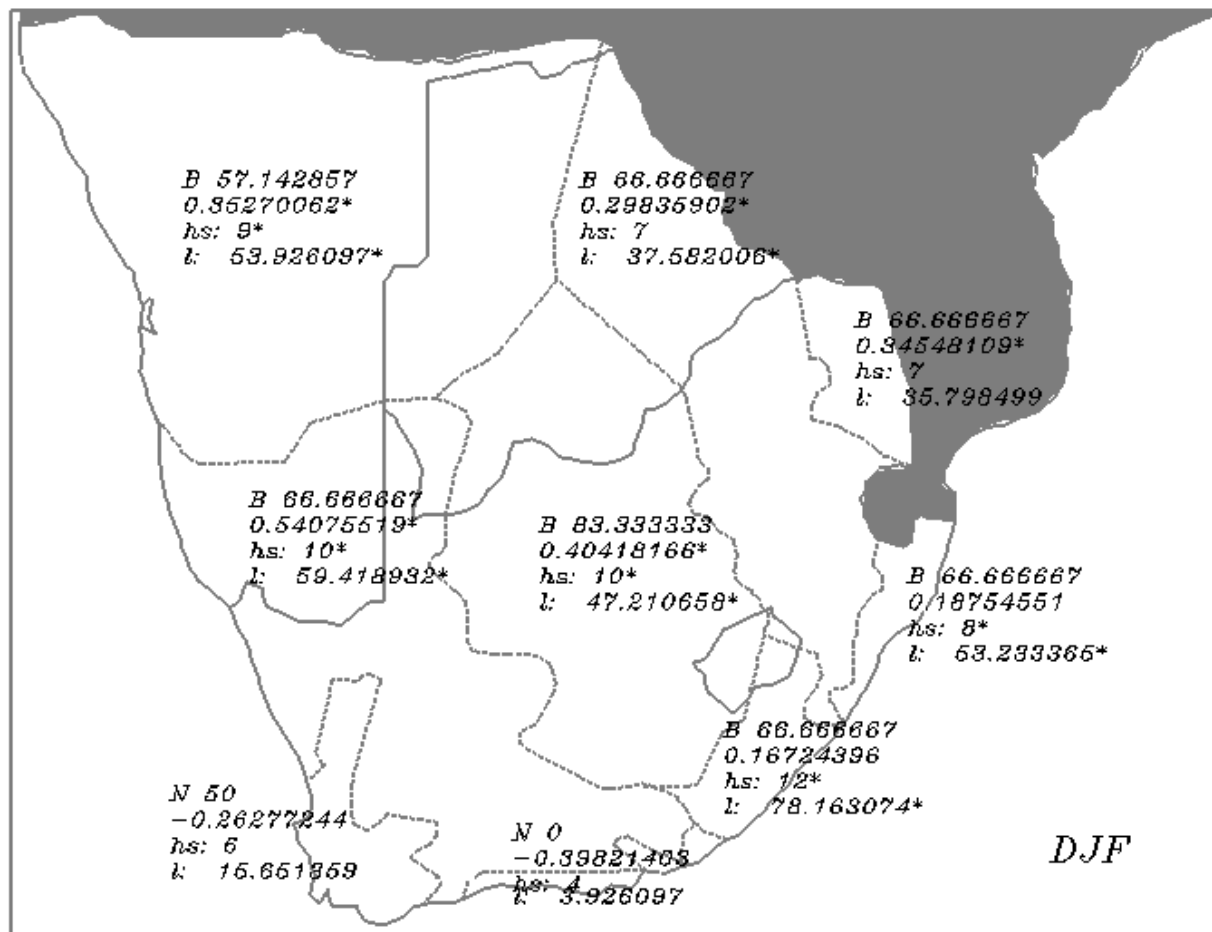
Willem A. Landman



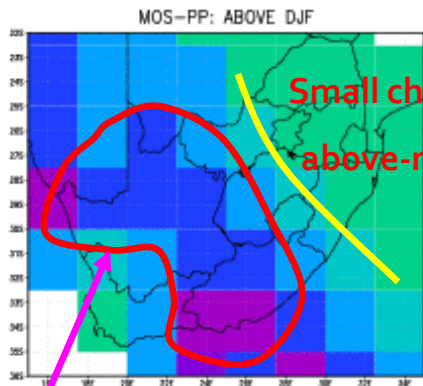
# The evolution of the science of seasonal forecasting in southern Africa

- ◆ Model/system development started in early 1990s – SAWS, UCT, UP, Wits (statistical forecast systems)
- ◆ South African Long-Lead Forecast Forum
- ◆ SARCOF started in 1997 – consensus through discussions
- ◆ Late 1990s – started to use AGCMs and post-processing
  - ◆ At SAWS (COLA T<sub>30</sub>, then ECHAM<sub>4.5</sub>)
  - ◆ At UCT (HadAM<sub>3P</sub>)
  - ◆ At UP (CSIRO-II/III, then CCAM)
  - ◆ At CSIR (CCAM – since 2009)
- ◆ Global Forecasting Centre for Southern Africa – 2003
- ◆ Objective multi-model forecast systems – 2008
- ◆ Coupled model considerations – 2010 onwards

# Deterministic statistical model (antecedent SST as predictor):

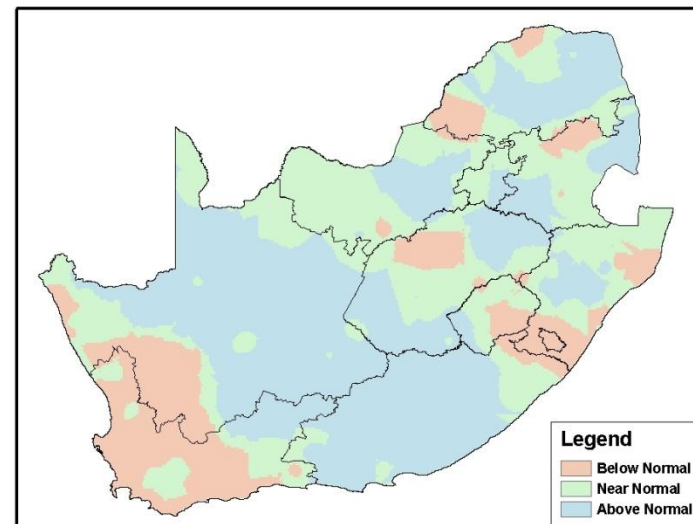


# DJF 2005/06 forecast made early December

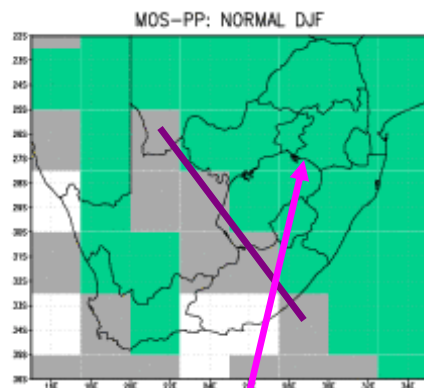


Small chance of above-normal

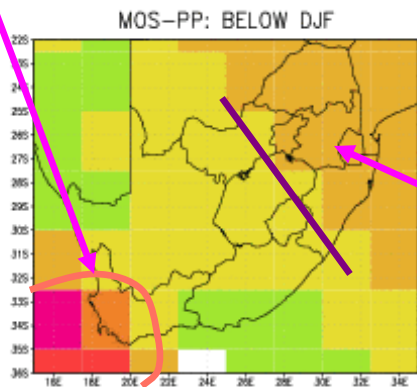
## Assessment of Rainfall for December 2005 to February 2006



Enhanced probabilities

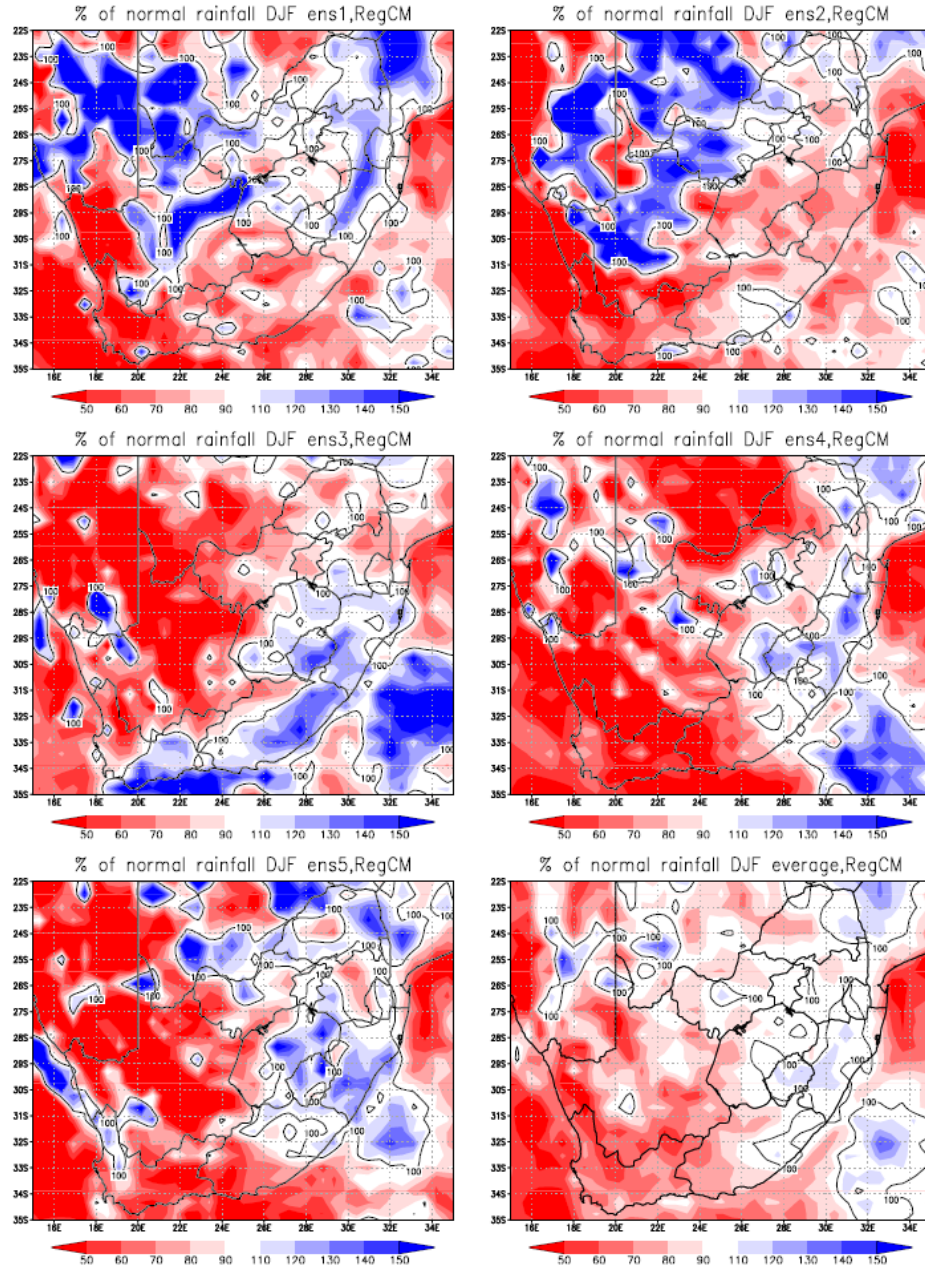


“Normal to below-normal” most likely



The MOS-PP-ECHAM4.5 system was successful in predicting enhanced probabilities of above-normal over the central-western parts and enhanced probabilities in below-normal over the south-western parts, but predicted only small probabilities of above-normal over the north-eastern parts

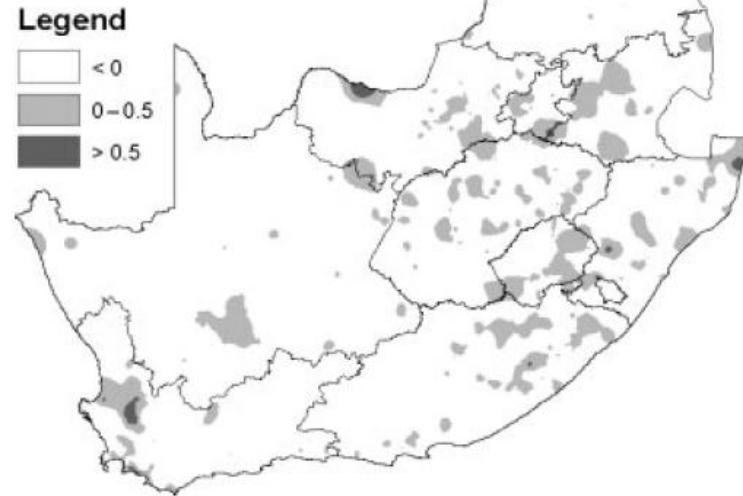
# DJF forecasts using RCM



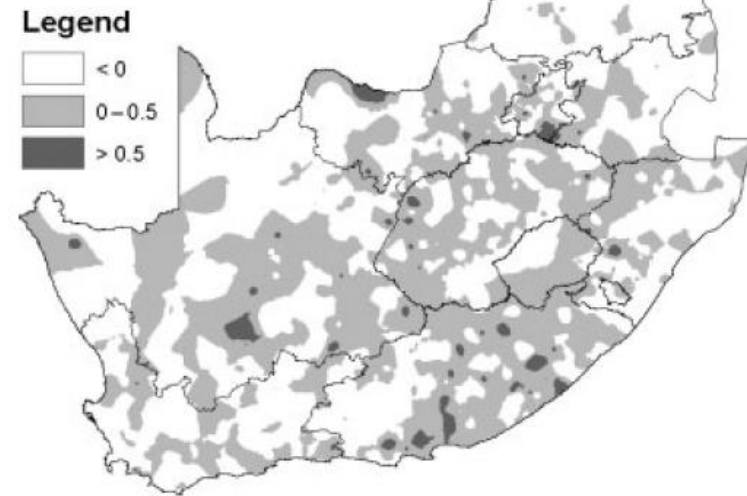
- ◆ **First ever** operational *regional climate model* forecast for southern Africa
- ◆ ECHAM4.5-RegCM3



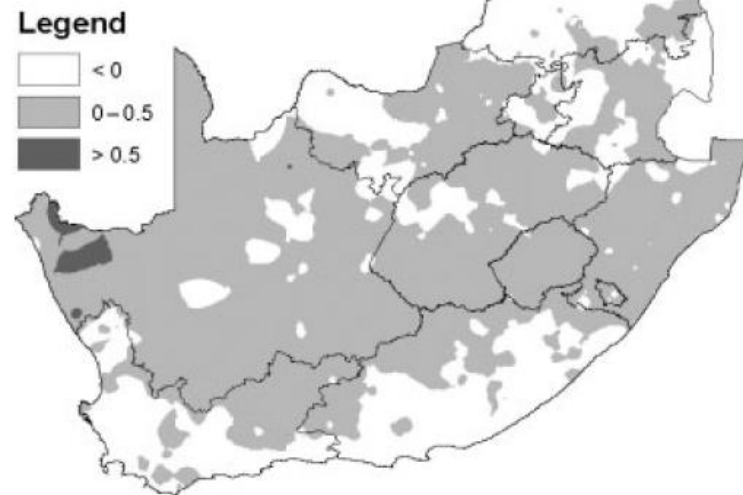
(a)

**RCM - MOS**

(b)

**RCM - SST**

(c)

**MOS - GCM**

(d)

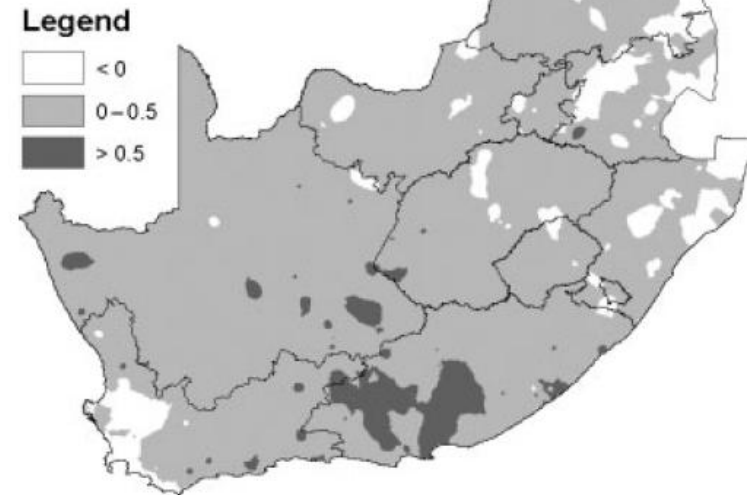
**MOS - SST**

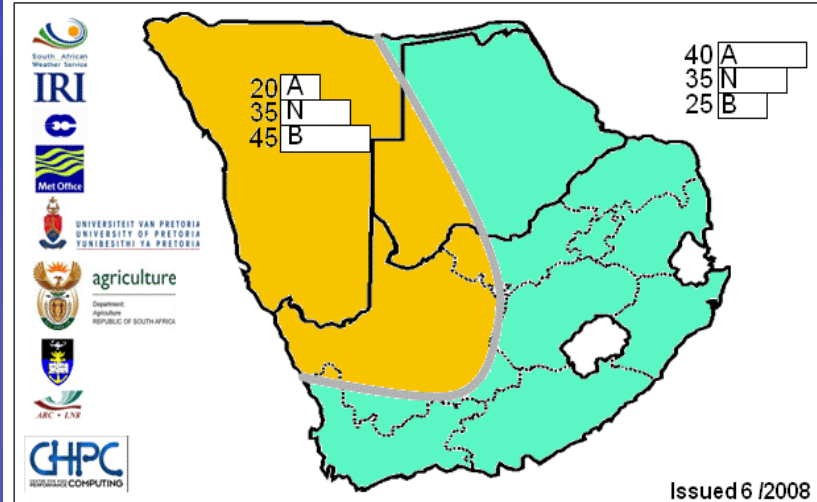
Figure 12. Correlation differences between the (a) ECHAM4.5-RegCM3 system and the ECHAM4.5-MOS system (24-member mean), the (b) ECHAM4.5-RegCM3 system and the baseline model (using SSTs to simulate rainfall), the (c) ECHAM4.5-MOS and the raw ECHAM4.5 systems (24-member mean), and the (d) ECHAM4.5-MOS (24-member mean) and the baseline system (using SSTs to simulate rainfall) over the 10-year test period. Negative values are masked out.

# Operational Forecast Skill

## From CONSENSUS discussions

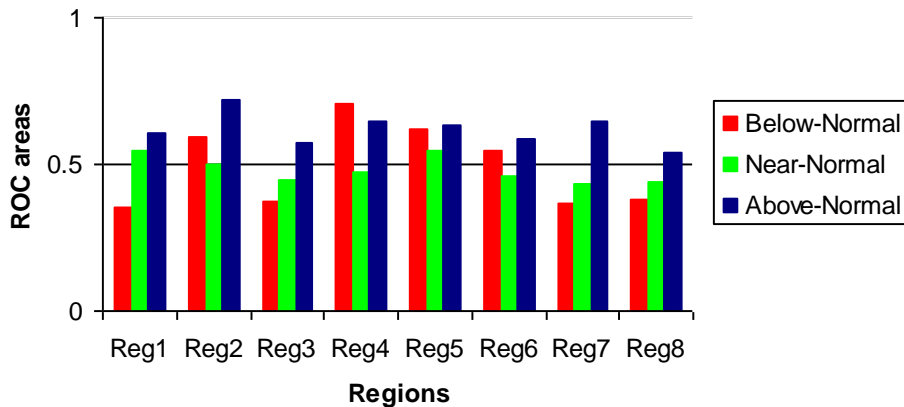
Verification over 7 years of consensus forecast production

Expected Total Rainfall for the period  
August-September-October 2008

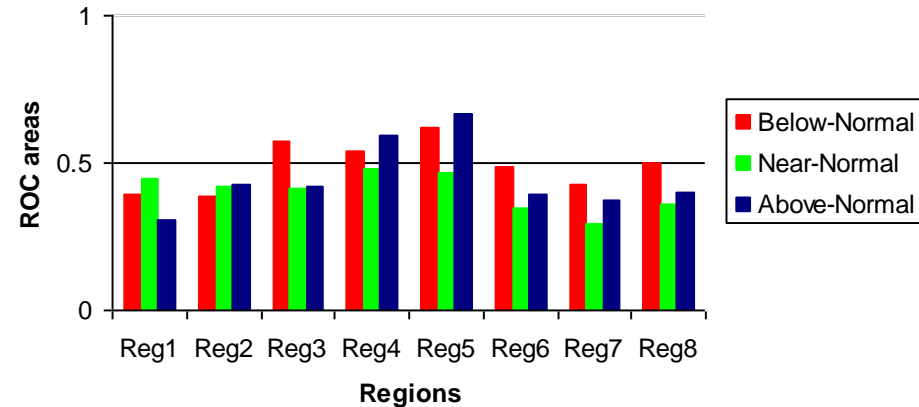


Please send comments to [longrange@weathersa.co.za](mailto:longrange@weathersa.co.za)

SON ROC analysis



DJF ROC analysis

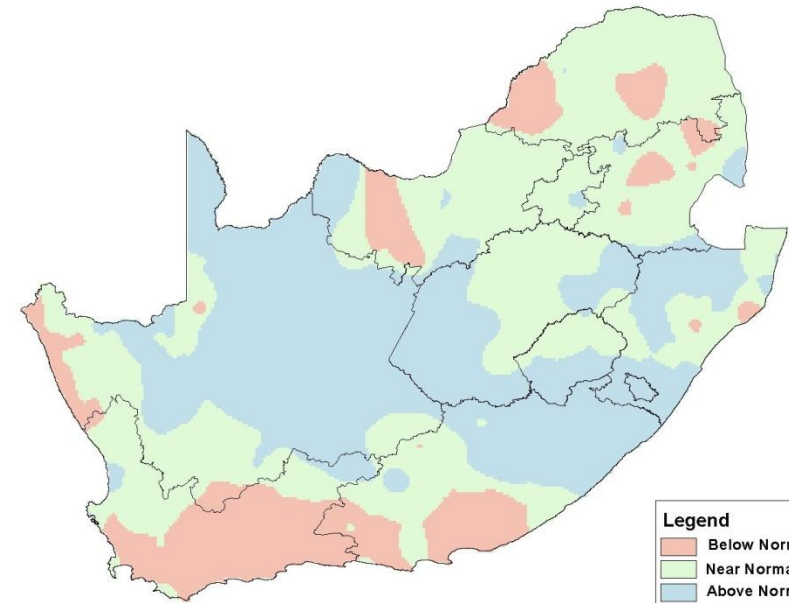
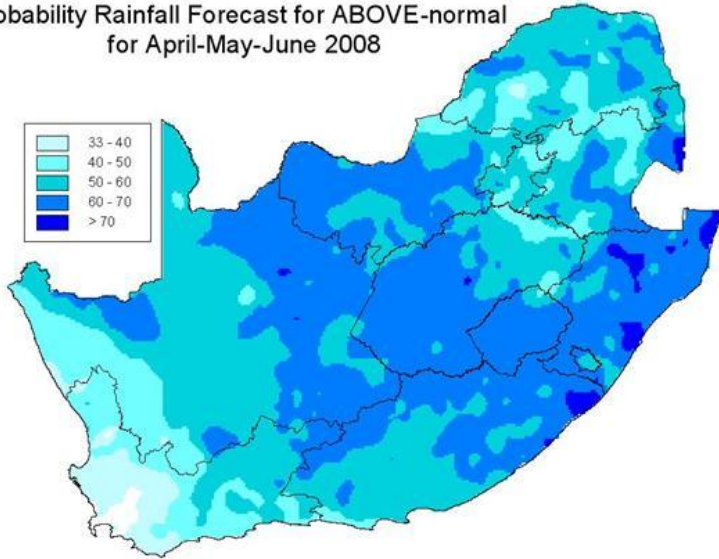
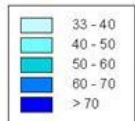


# New objective multi-model forecast

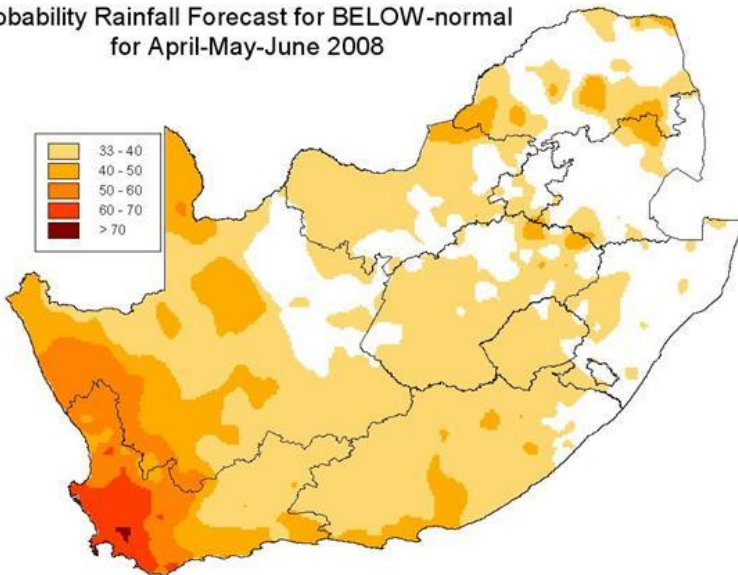
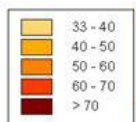
# Assessment of Rainfall for April to June 2008



Probability Rainfall Forecast for ABOVE-normal for April-May-June 2008

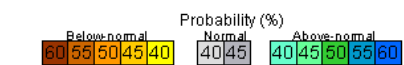
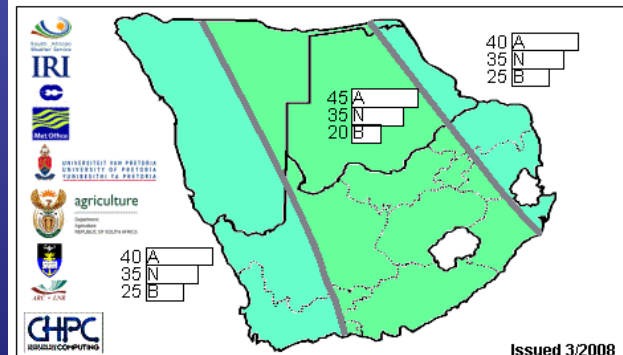


Probability Rainfall Forecast for BELOW-normal for April-May-June 2008



# Old subjective consensus forecast

Expected Total Rainfall for the period April-May-June 2008



Please send comments to [longrange@weathersa.co.za](mailto:longrange@weathersa.co.za)



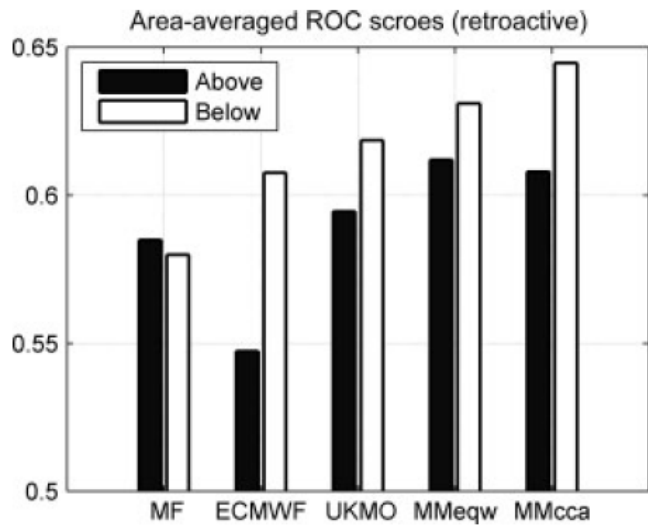


Figure 3. ROC scores, averaged over the southern African domain, for the above-normal and below-normal rainfall categories. Scores for the single models and for the two multi-models are shown.

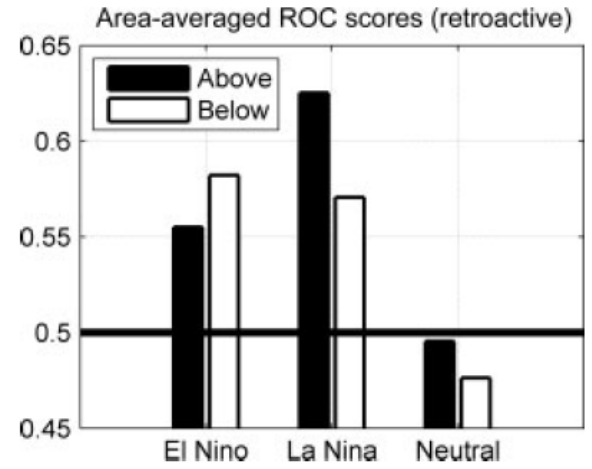


Figure 7. ROC scores, averaged over the southern African domain, for the above-normal and below-normal rainfall categories during El Niño, La Niña and neutral seasons. Scores for the MMcca multi-model are shown.

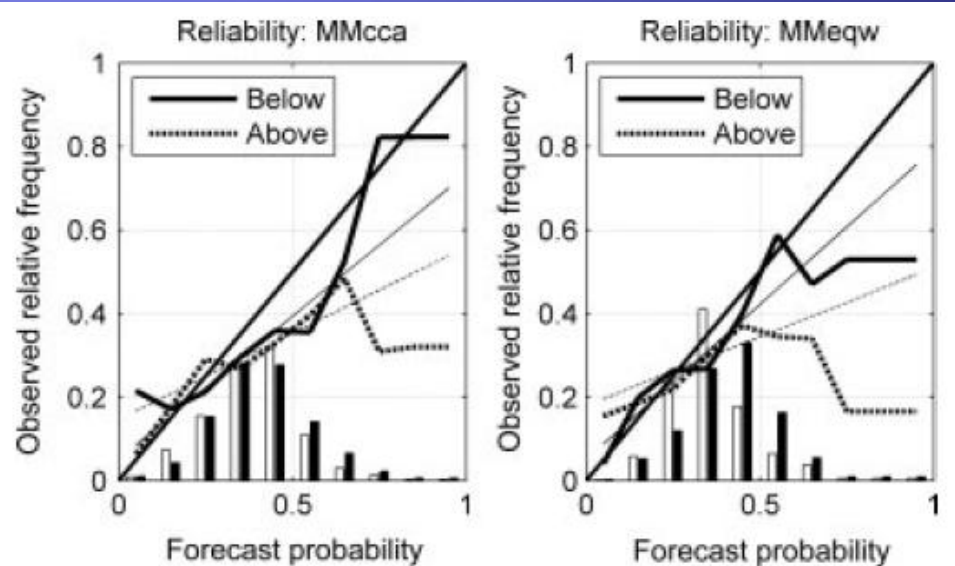
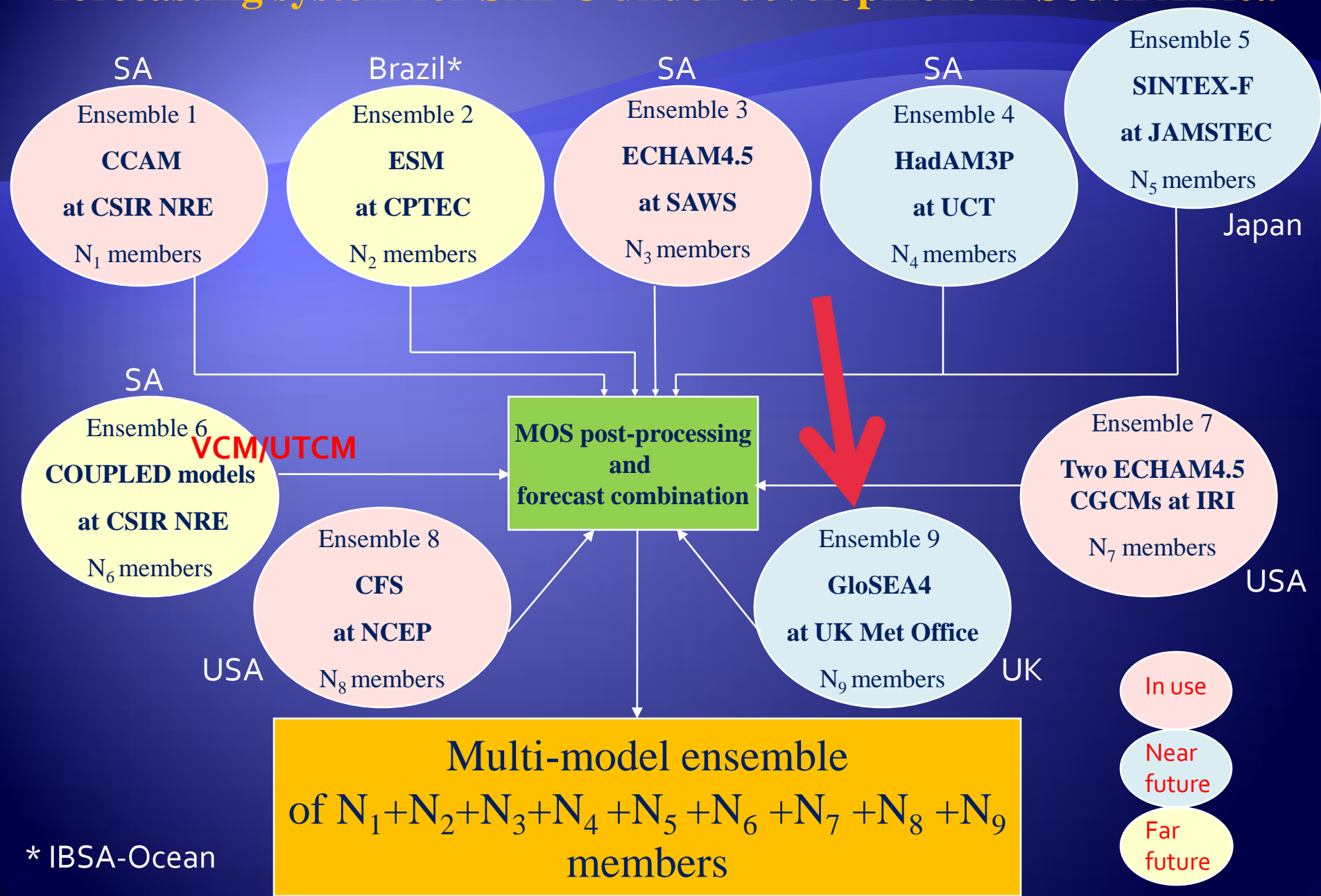
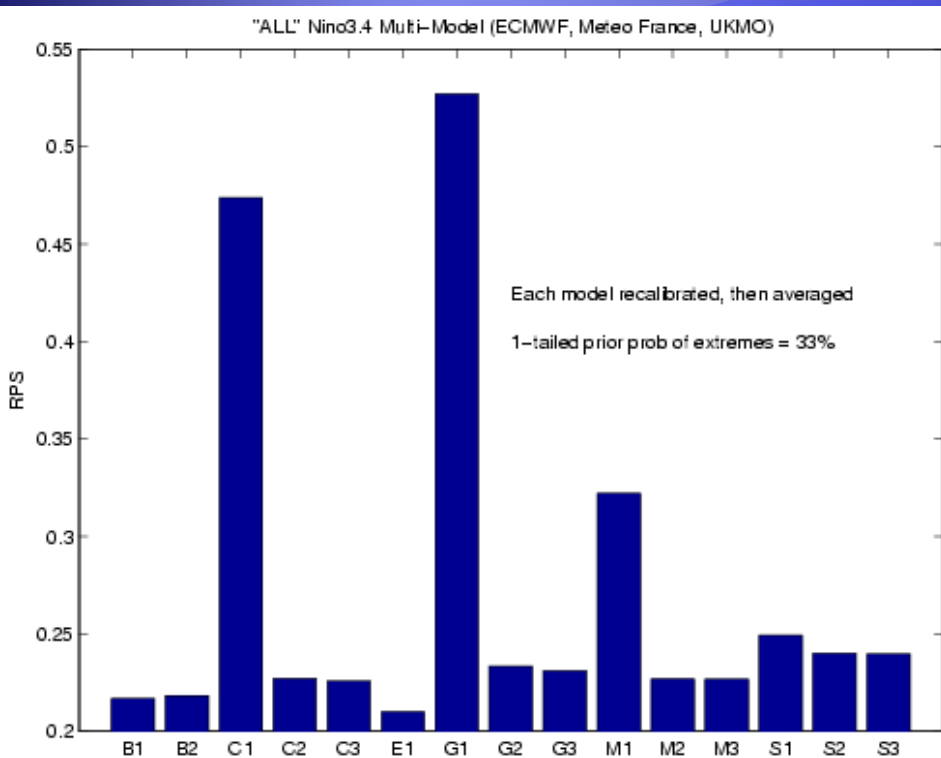


Figure 6. As in Figure 5, but for the two multi-models.

# The multi-model seasonal rainfall and surface temperature forecasting system for SADC under development in South Africa



# Some MM Combination Schemes



- ♦ Bayesian optimal weighting (B1)
  - ♦ Bayesian sequential optimal weighting (B2)
  - ♦ Canonical variate analysis
    - ♦ using members (C1)
    - ♦ using PCs (C2)
    - ♦ using moments (C3)
  - ♦ Equal weighting (E1)
  - ♦ Generalized linear model
    - ♦ using members (G1)
    - ♦ using PCs (G2)
    - ♦ using moments (G3)
  - ♦ Multiple linear regression
    - ♦ using members (M1)
    - ♦ using PCs (M2)
    - ♦ using moments (M3)
  - ♦ Stepwise regression
    - ♦ using members (S1)
    - ♦ using PCs (S2)
    - ♦ using moments (S3)
1. Models recalibrated and combined at the same time
  2. Each model recalibrated, then averaged

long-range forecasts for  
southern Africa

Global Forecasting Centre for Southern Africa



**ToR 1:** To facilitate cooperation between the centres within southern Africa that run an operational global scale long-range forecasting (LRF - from 30 days up to 2 years) system

**ToR 2:** To produce global forecasts from dynamical forecasting systems

**ToR 3:** To establish a web based environment for non commercial product dissemination

**ToR 4:** The consortium will be managed by a committee

**ToR 5:** To compile archived hindcasts

UCT: HadAM3P

SAWS: ECHAM4.5 (AGCM and CGCM)

CSIR: CCAM, VCM, UTCM

**ToR 6:** To apply standard verification tools

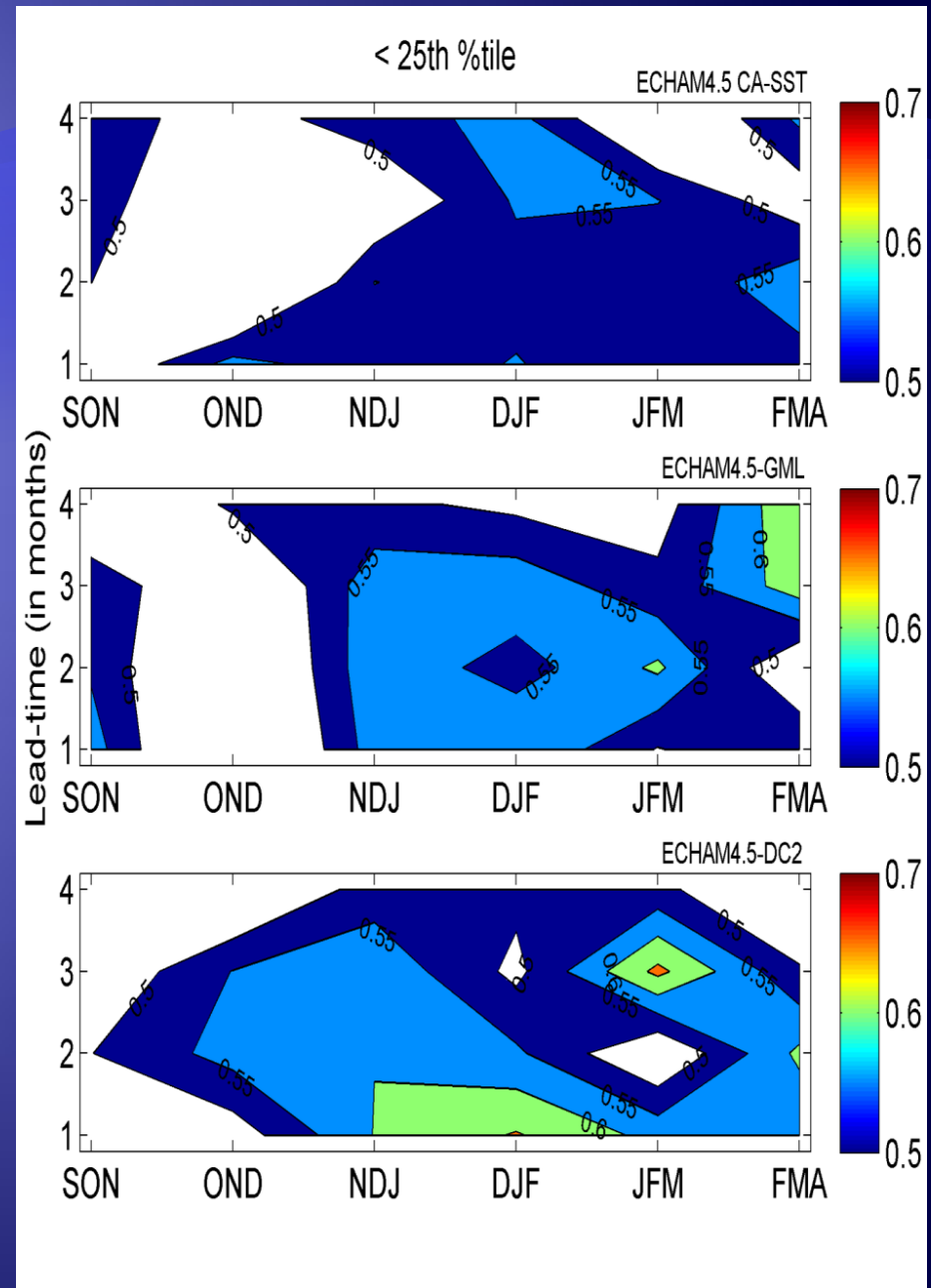
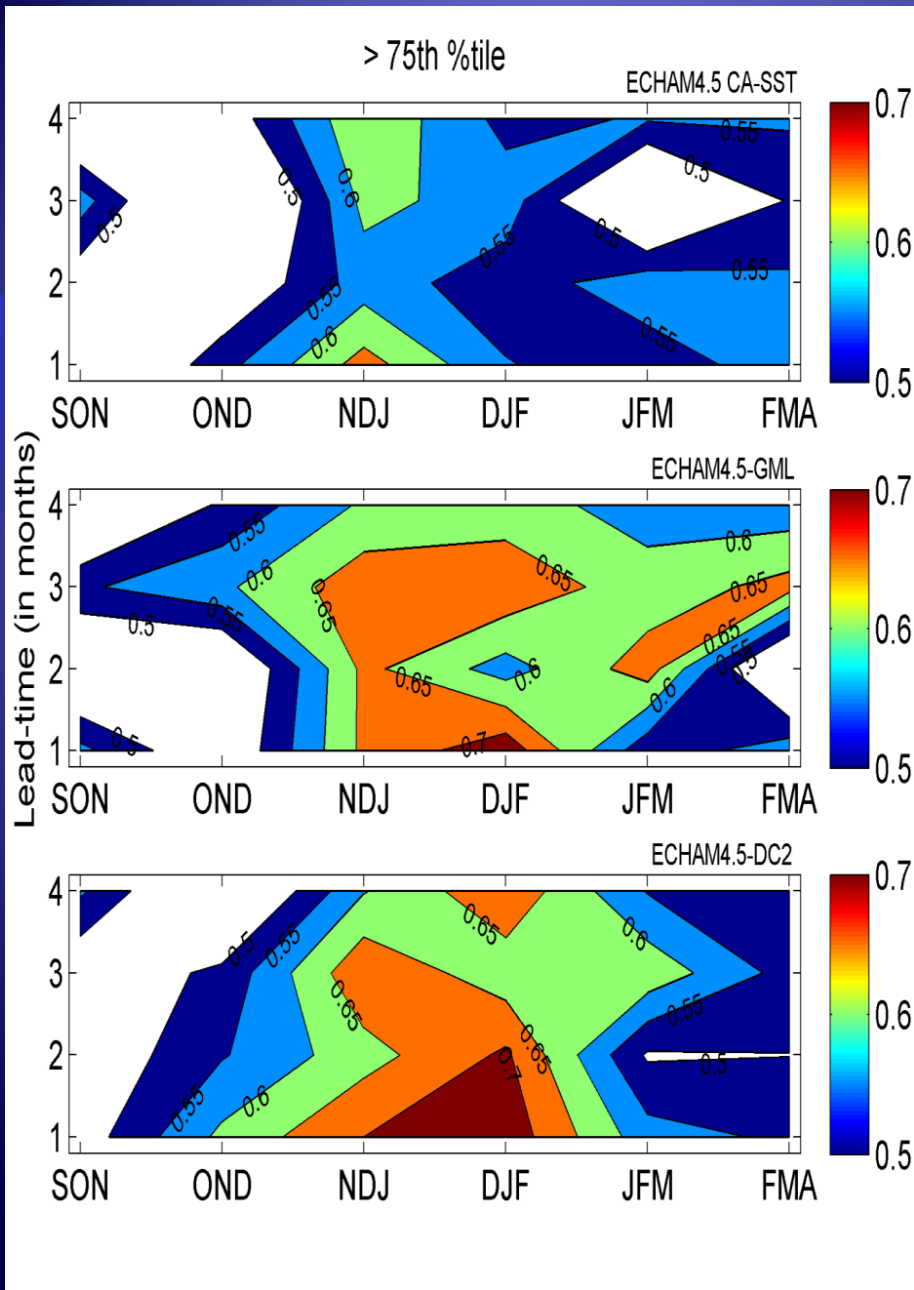
**ToR 7:** To assist in training and capacity building for LRF

“ToshioGeorge”  
(multi-node machine)

**ToR 8:** To actively pursue the development and improvement of global scale LRF techniques

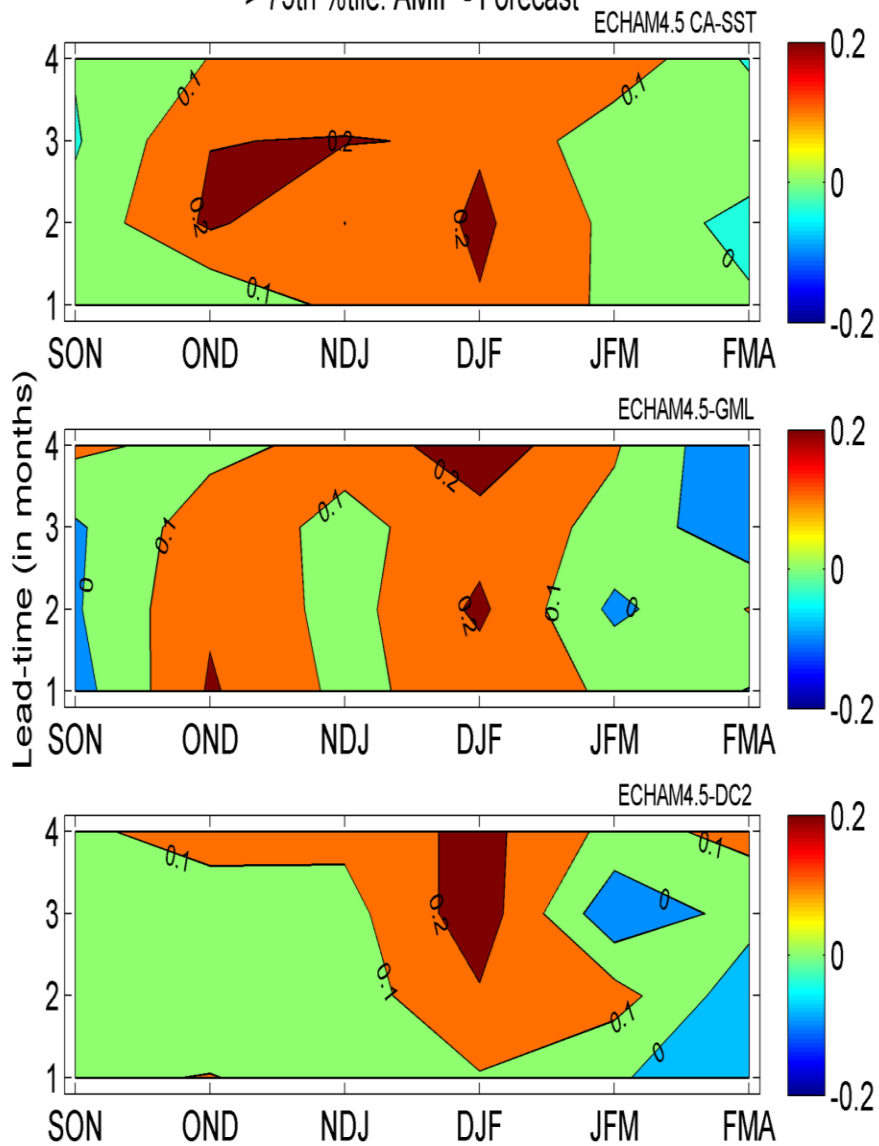


# ROC Scores: Coupled vs. 2-tiered systems

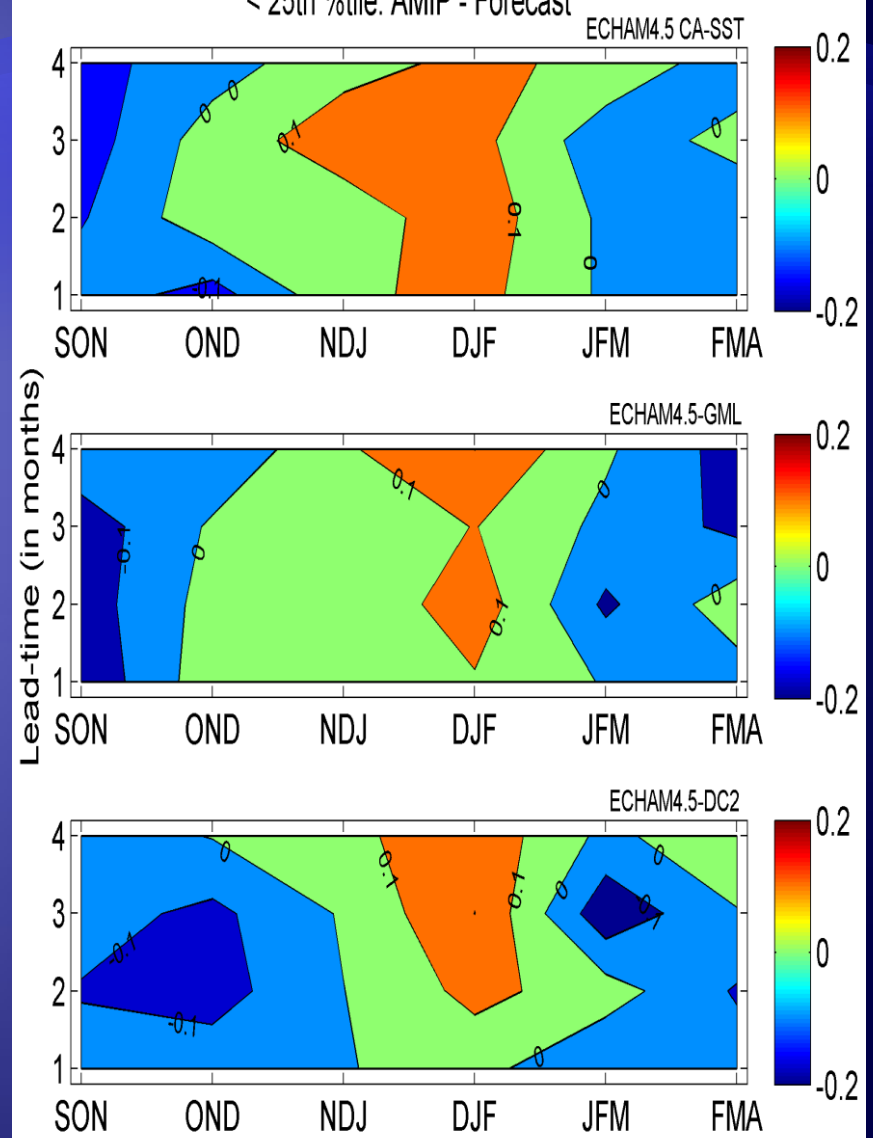


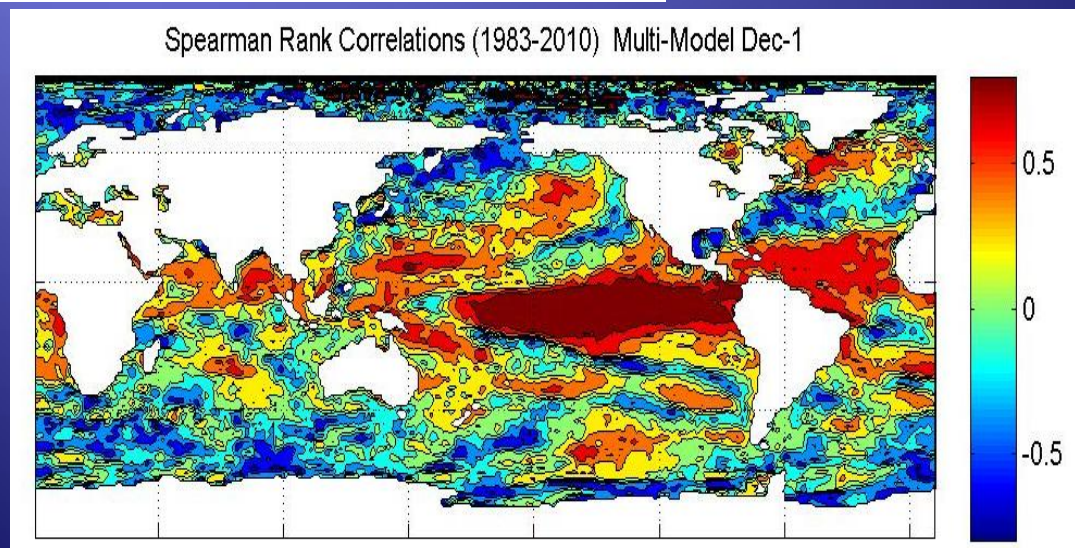
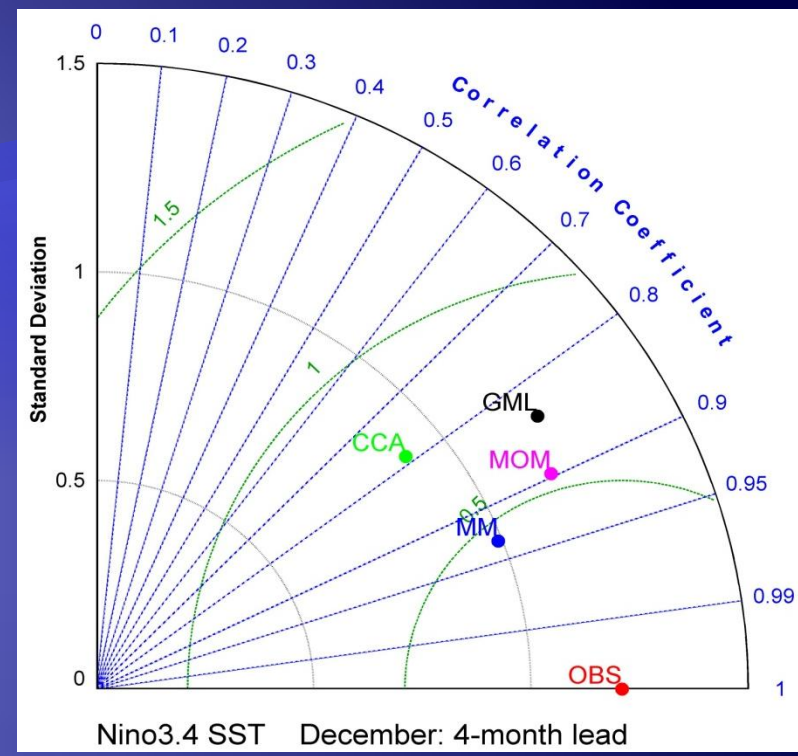
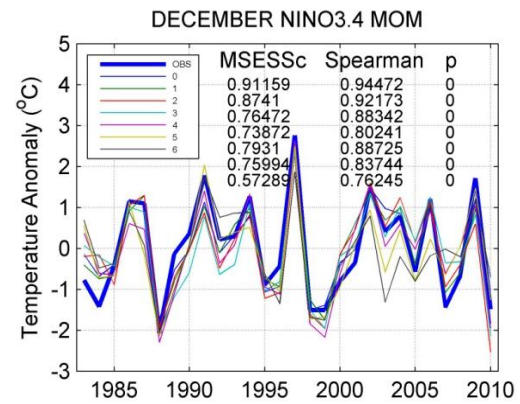
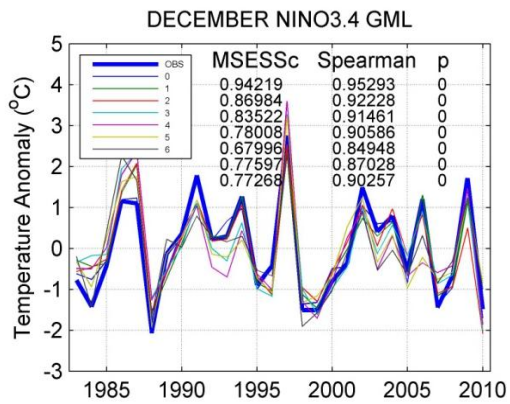
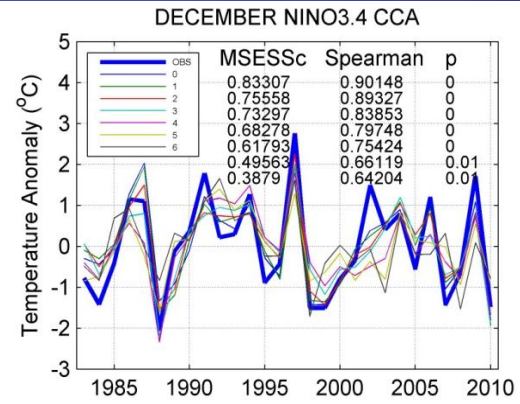
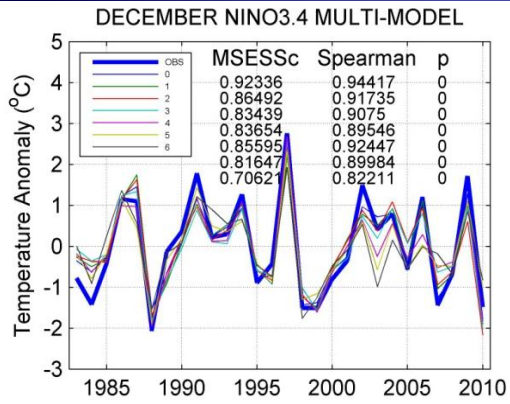
# ROC differences

> 75th %tile: AMIP - Forecast



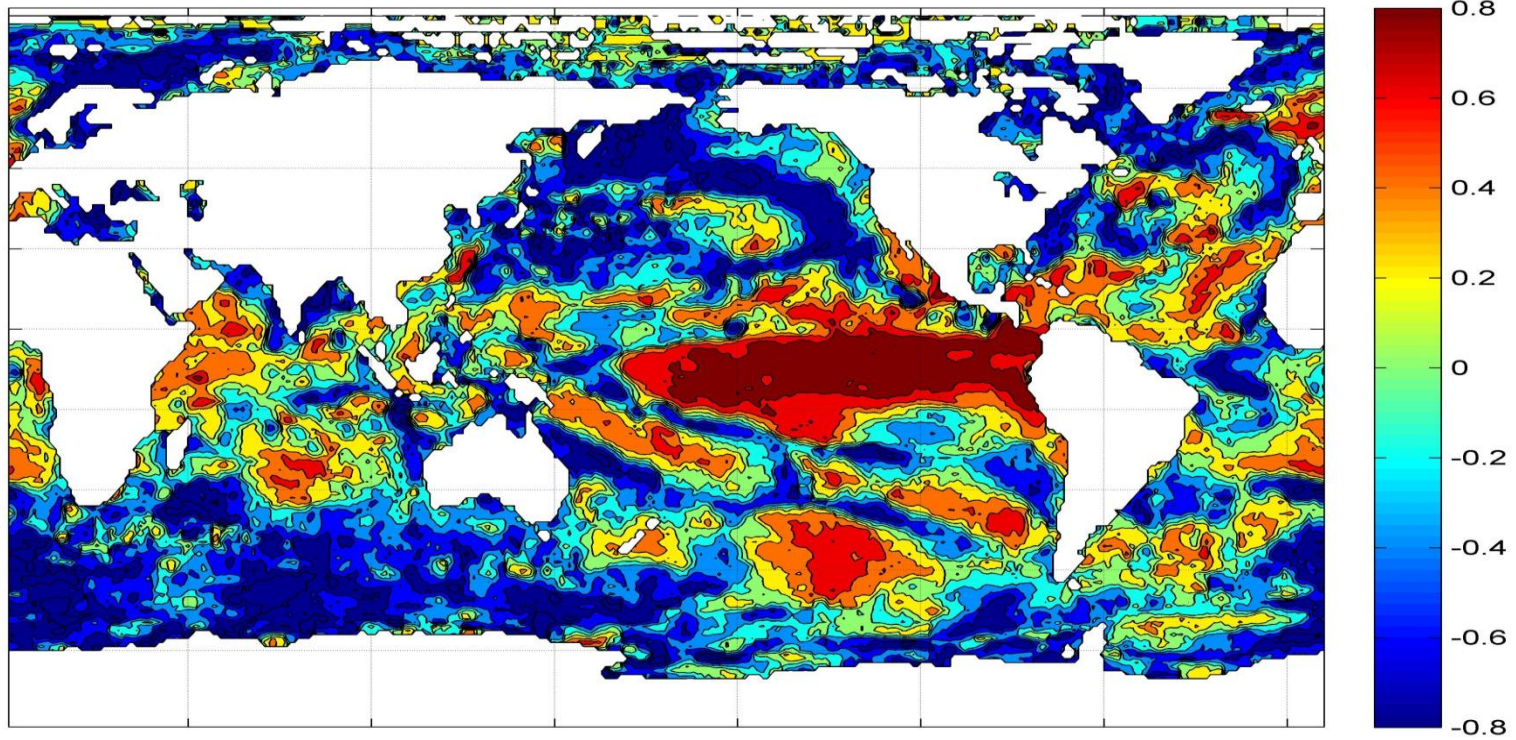
< 25th %tile: AMIP - Forecast



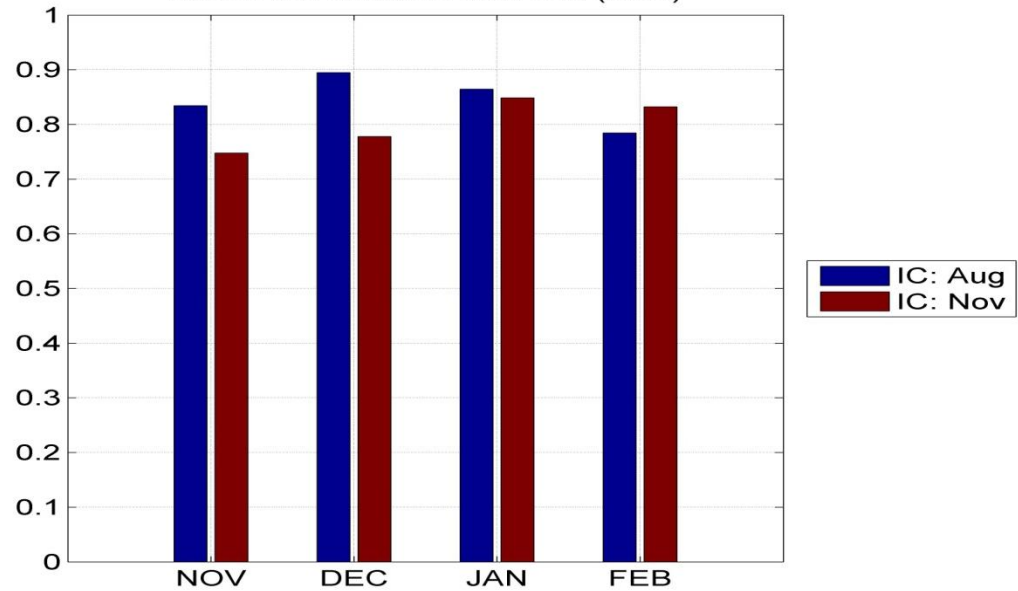




Spearman Correlations (1996-2009) HadGEM3; DEC SST, Nov IC



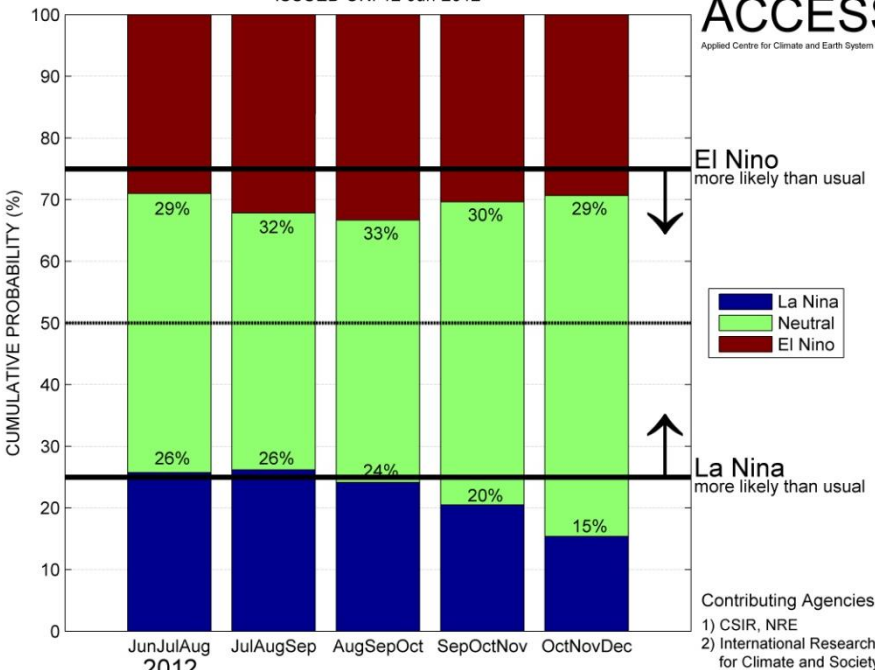
HadGEM3 Nino3.4: MSE SS (Clim)





MULTI-MODEL PROBABILISTIC ENSO FORECASTS (NINO3.4 SST)  
ISSUED ON: 12-Jun-2012

**ACCESS**  
Applied Centre for Climate and Earth System Science

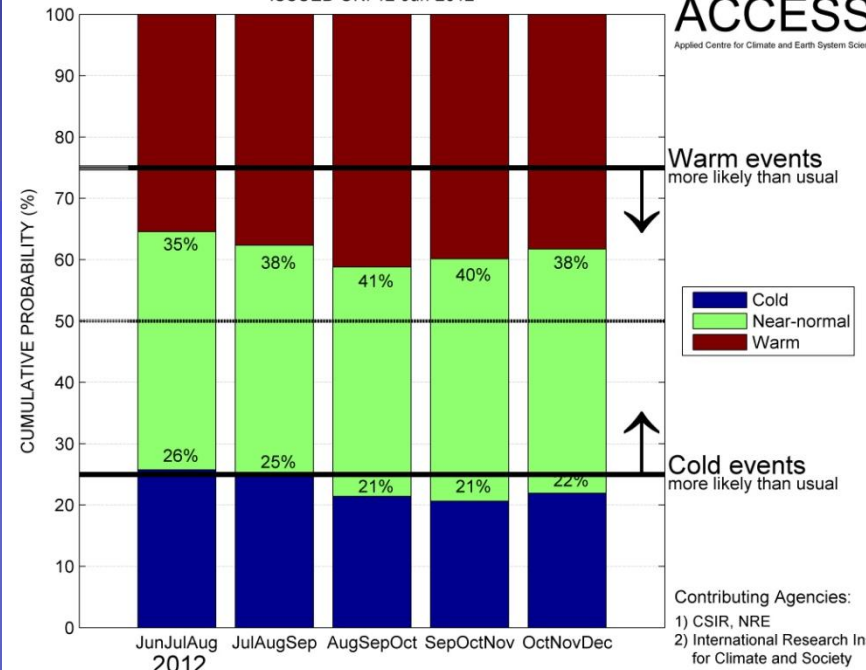


Contributing Agencies:  
 1) CSIR, NRE  
 2) International Research Institute for Climate and Society

To find out how ENSO may affect the rainfall over southern Africa during the months ahead, please refer to the forecasts for SADC:  
[http://rava.qsens.net/themes/climate\\_template/](http://rava.qsens.net/themes/climate_template/)

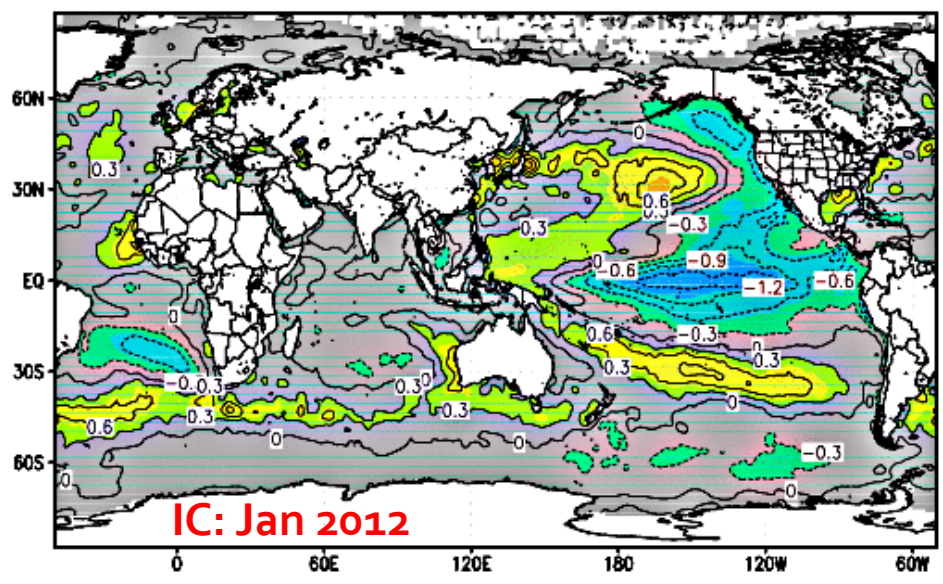
MULTI-MODEL PROBABILISTIC INDIAN OCEAN SST FORECAST (5°S-20°S; 55°E-80°E)  
ISSUED ON: 12-Jun-2012

**ACCESS**  
Applied Centre for Climate and Earth System Science



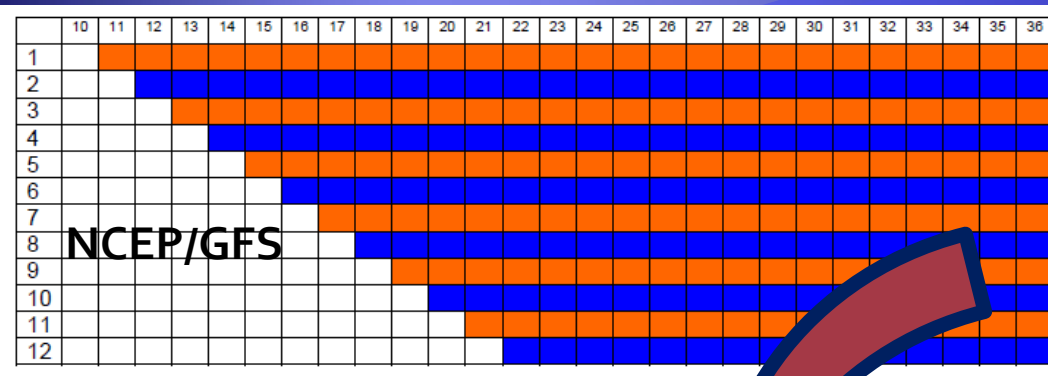
Contributing Agencies:  
 1) CSIR, NRE  
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**FEBRUARY-MARCH-APRIL 2012**

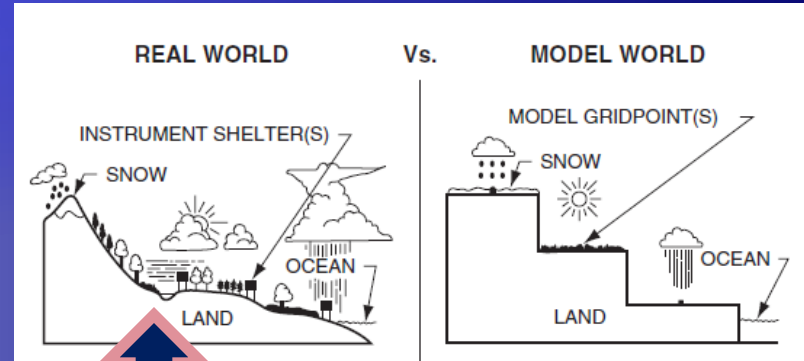


# New operational approach

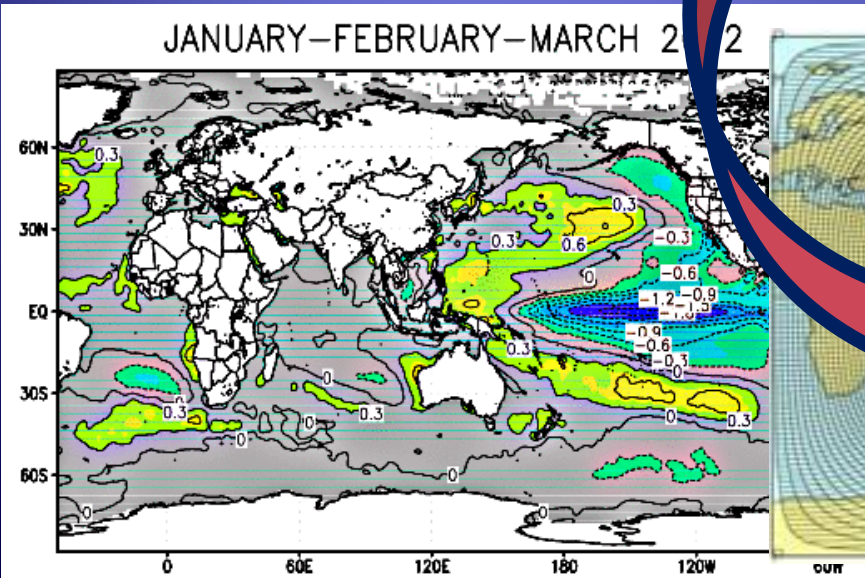
## Atmospheric Initial Conditions



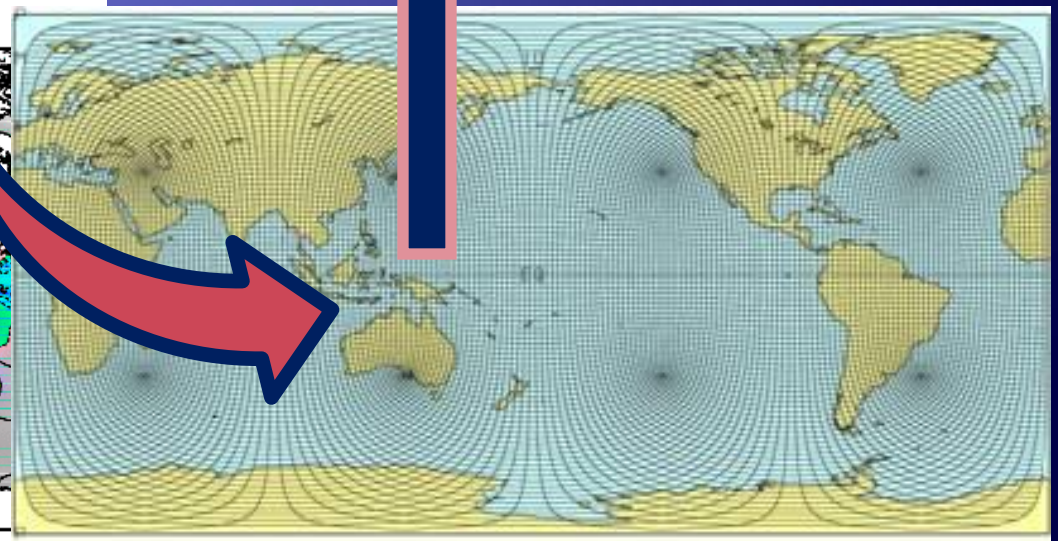
## Model Output Statistics



## SST Boundary Conditions

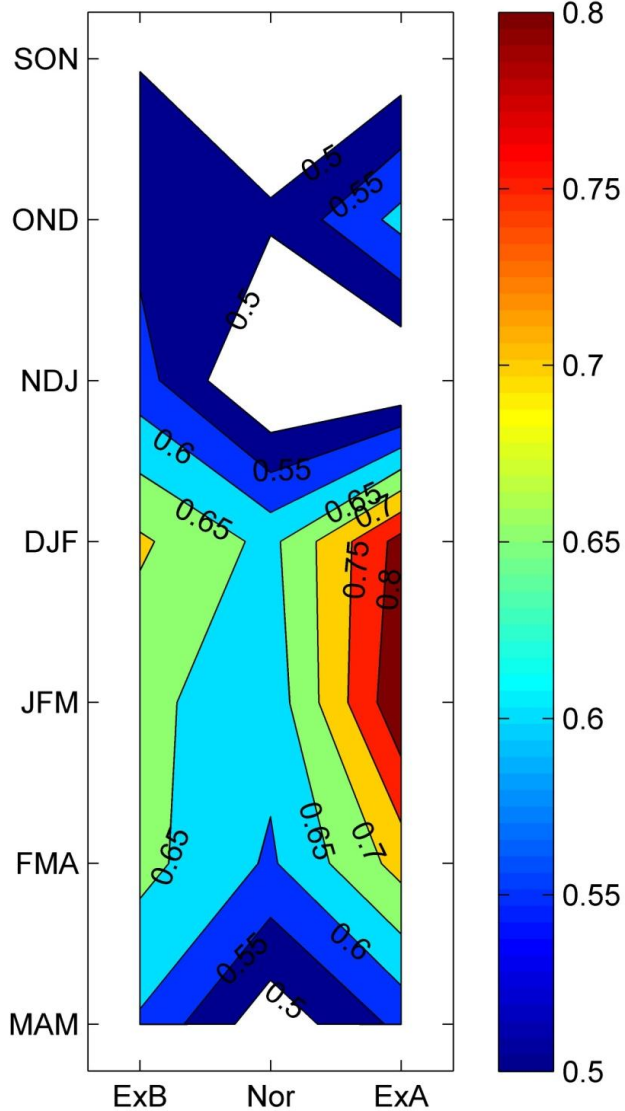


Resolution ~100km

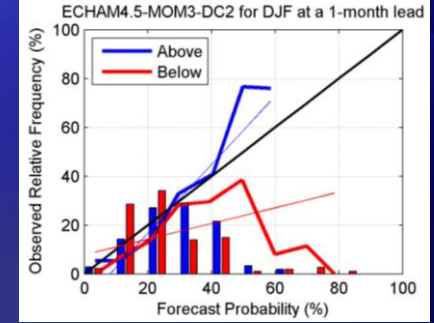
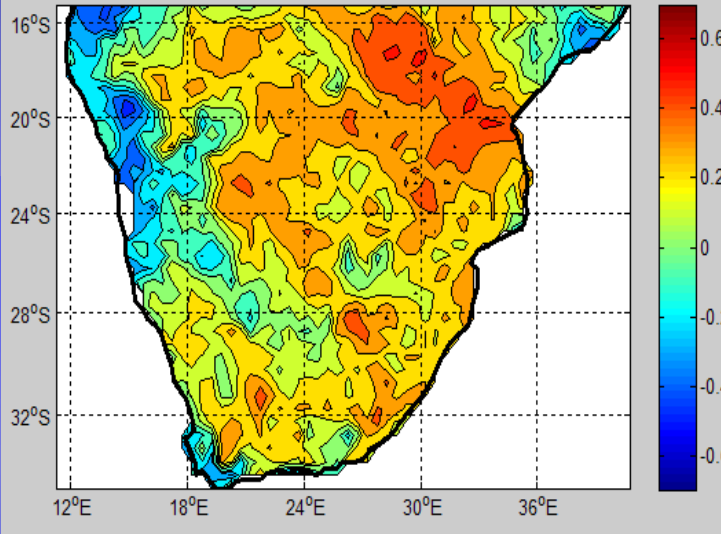


Conformal-Cubic Atmospheric Model

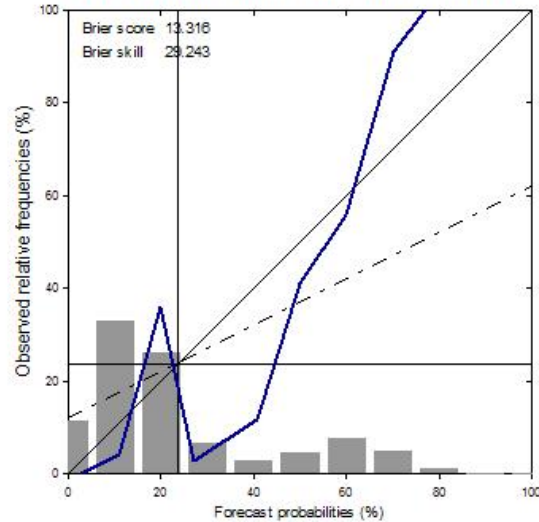
Limpopo Rainfall Simulation Skill (ROC)



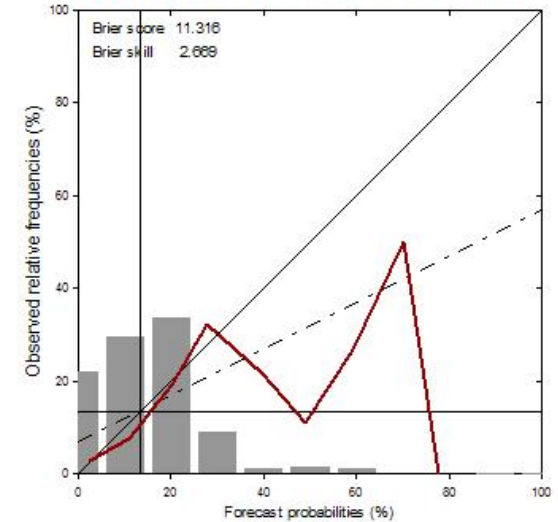
Kendalls Tau: DJF 1979/80 to 2002/03



Limpopo Pcp: DJF Extremely Above (>85th %-tile)



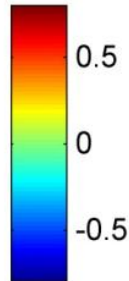
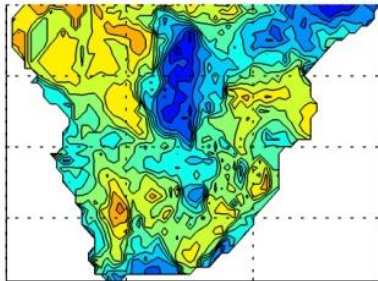
Limpopo Pcp: DJF Extremely Below (<15th %-tile)



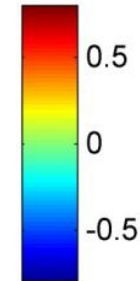
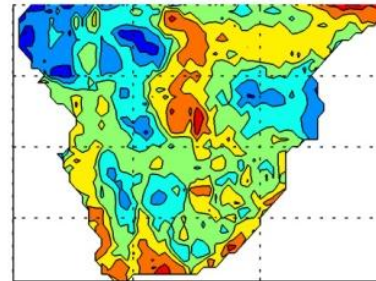


# Cross-validation: DJF (Nov) (3-year-out)

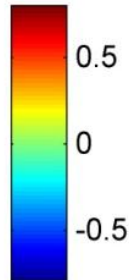
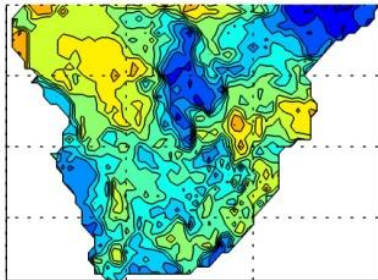
Kendalls tau: MOS 850 hPa



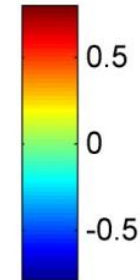
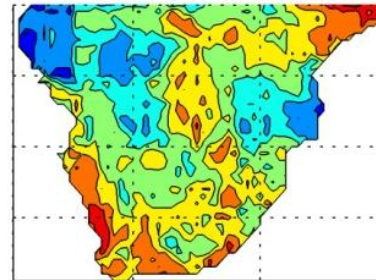
Differences: Raw - MOS 850



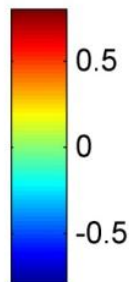
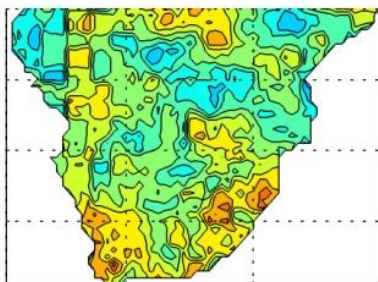
Kendalls tau: MOS Precip



Differences: Raw - MOS Precip



Kendalls tau: Raw Precip



HadGEM3 CV Verification

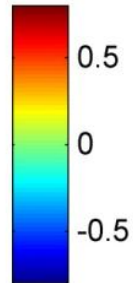
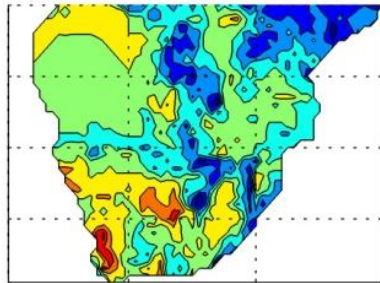
DJF IC:nov



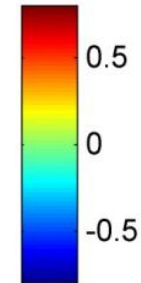
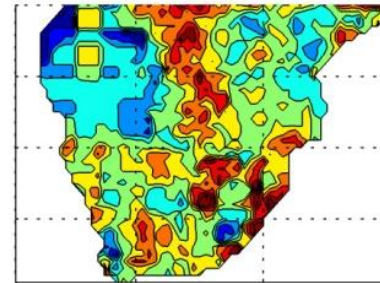
# Retro-active: DJF (Nov)

## (2003-2009)

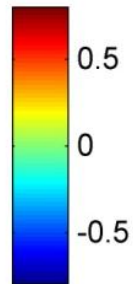
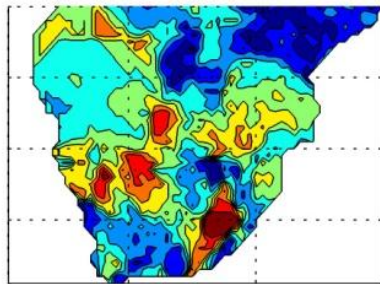
Kendalls tau: MOS 850 hPa



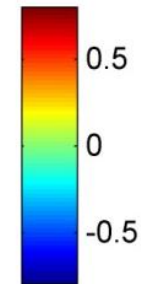
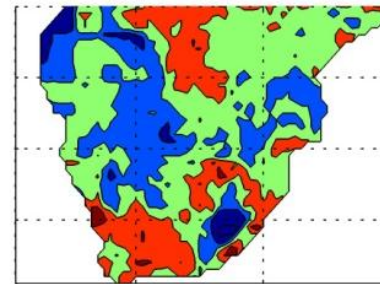
Differences: Raw - MOS 850



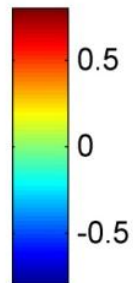
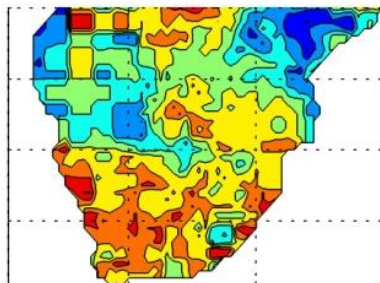
Kendalls tau: MOS Precip



Differences: Raw - MOS Precip



Kendalls tau: Raw Precip

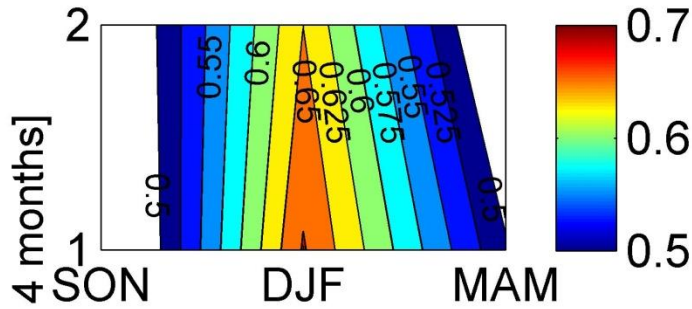


HadGEM3 Retro Verification

DJF IC:nov

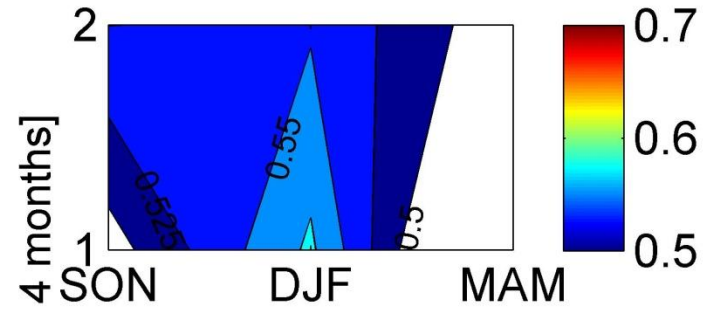
> 67th %tile

HadGEM3 850 hPa MOS

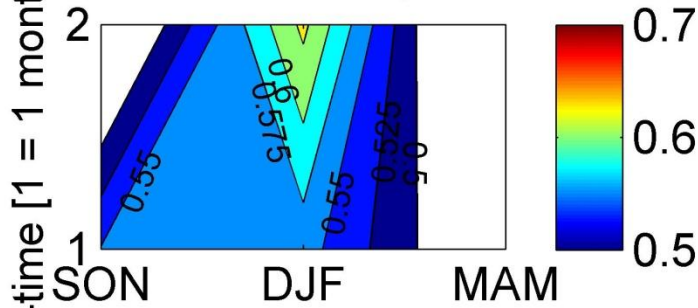


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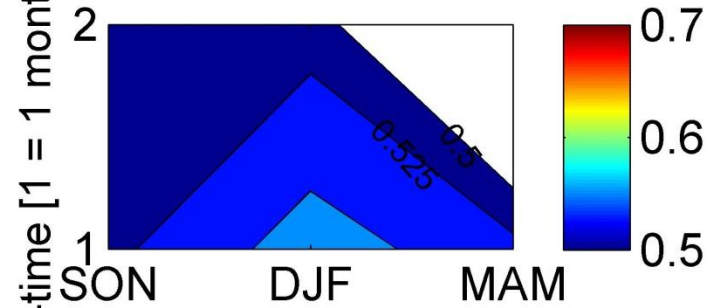
HadGEM3 850 hPa MOS



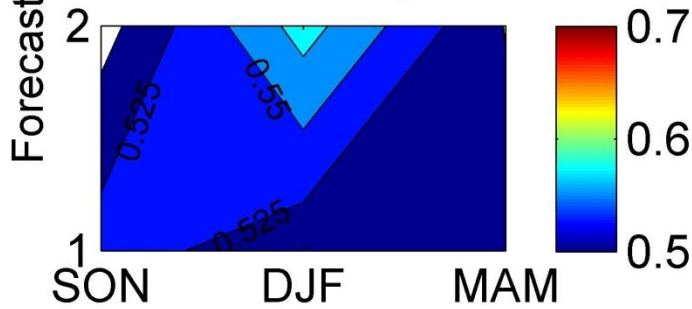
HadGEM3 Precip MOS



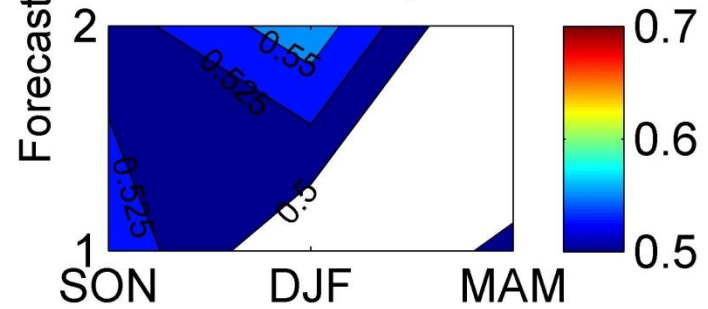
HadGEM3 Precip MOS



HadGEM3 Precip RAW

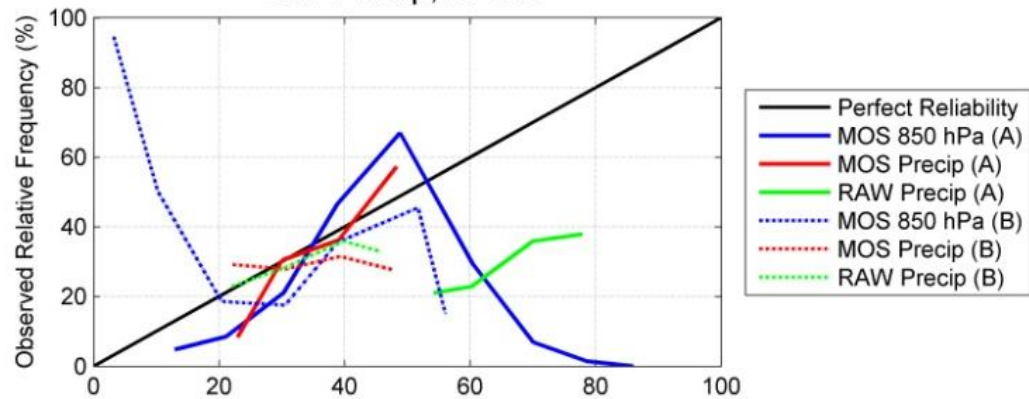


HadGEM3 Precip RAW

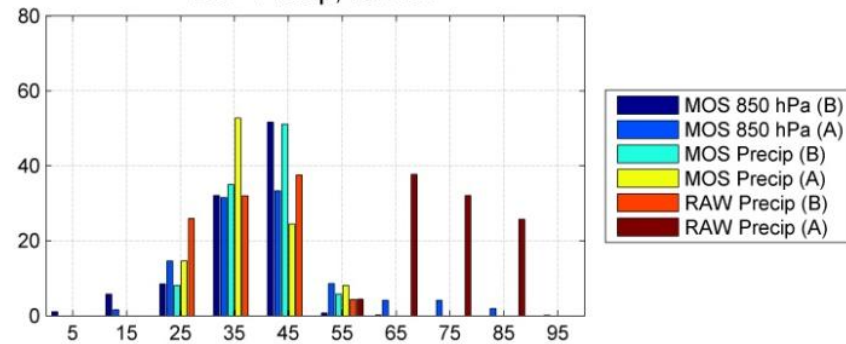


# DJF reliability (retro-active)

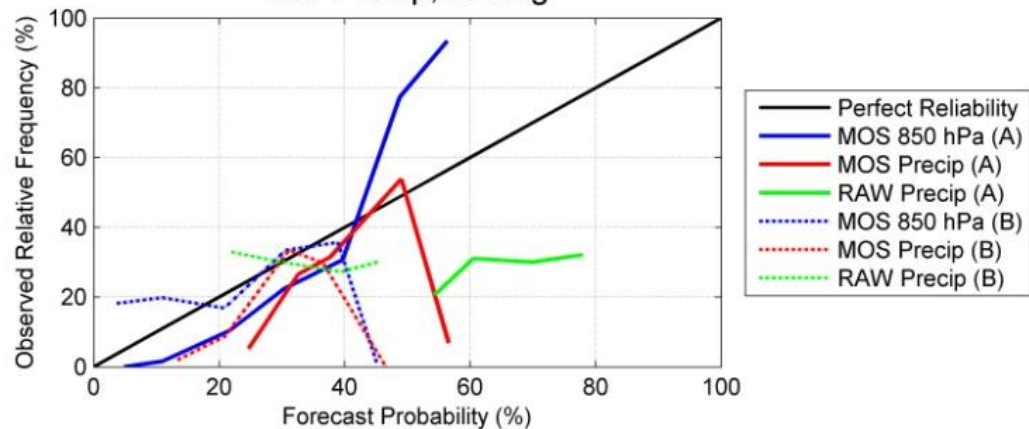
DJF Precip; IC Nov



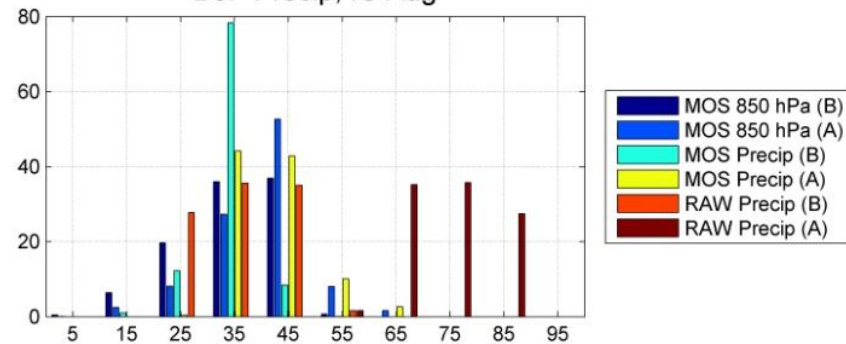
DJF Precip; IC Nov



DJF Precip; IC Aug

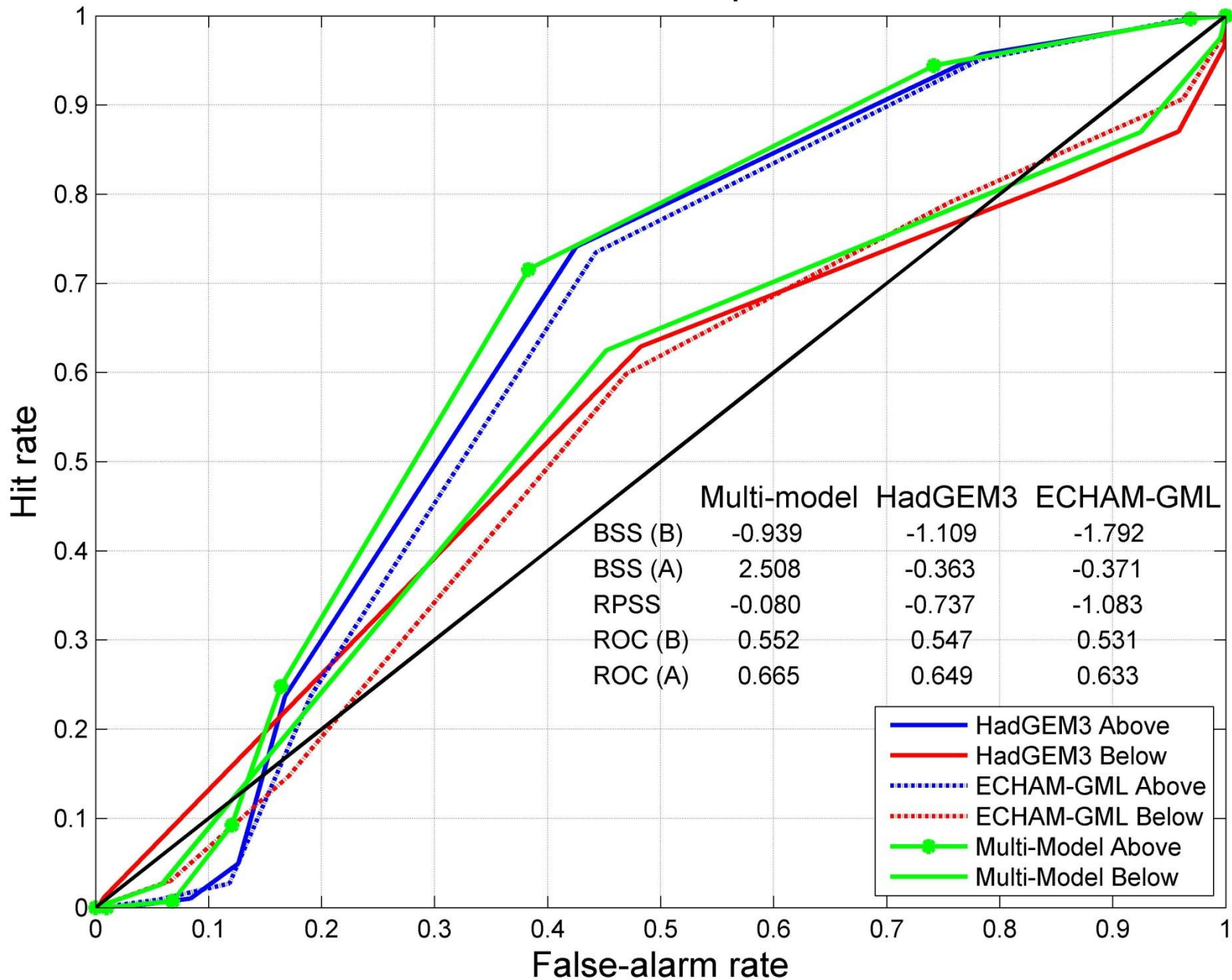


DJF Precip; IC Aug



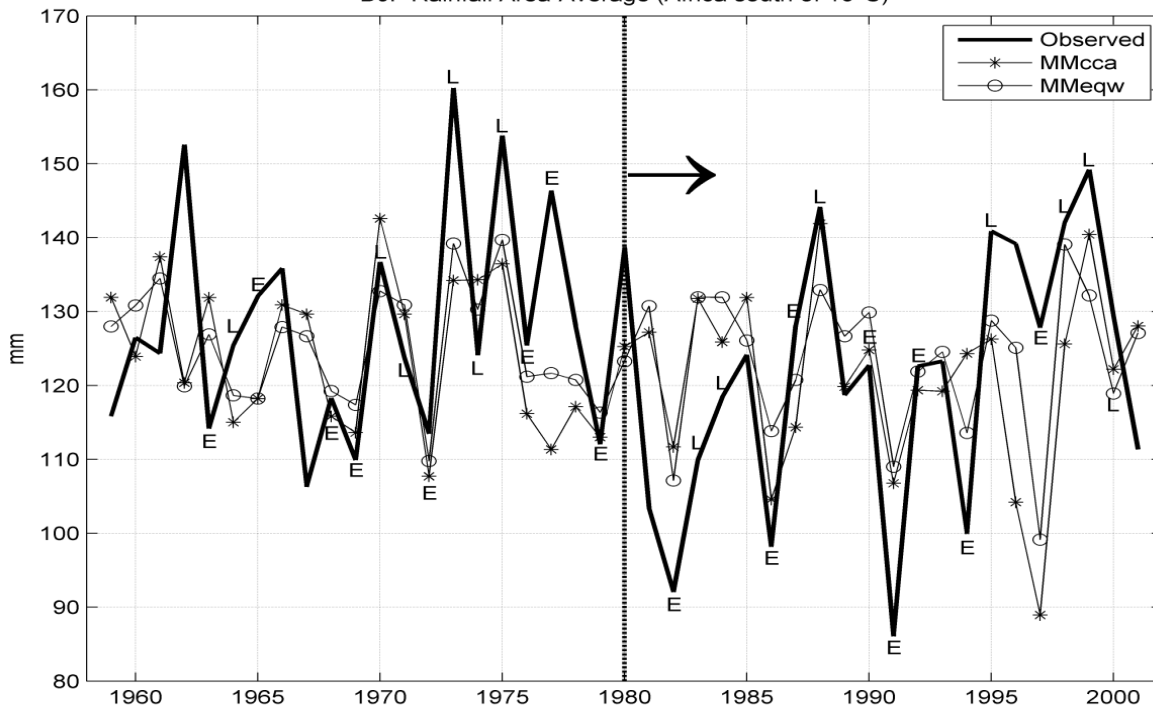


# ROC: DJF Precip IC Nov

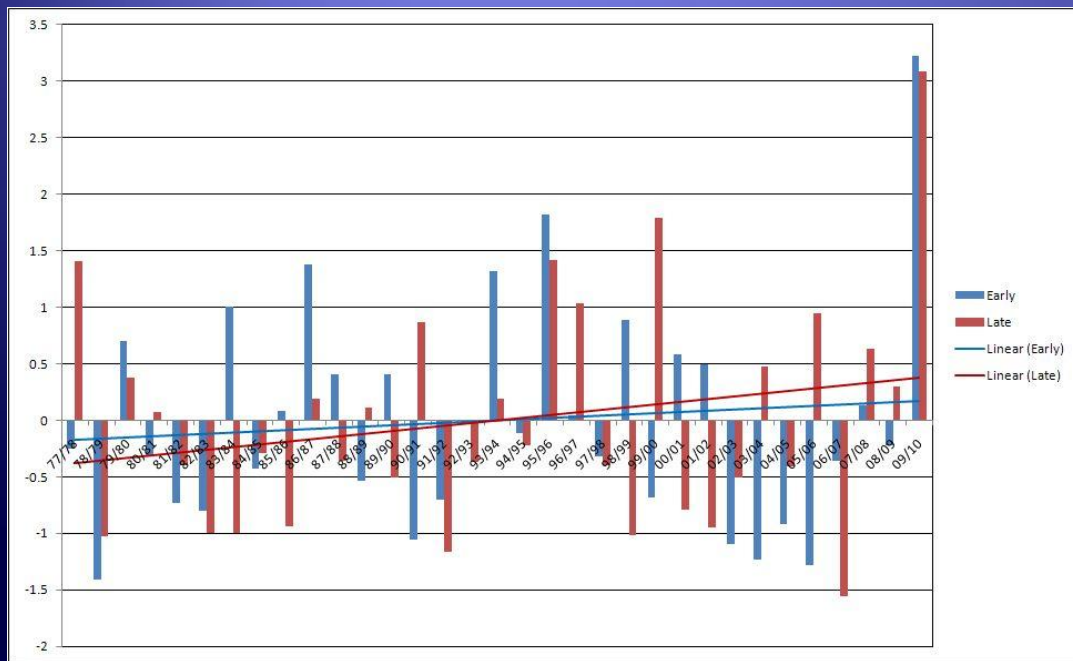
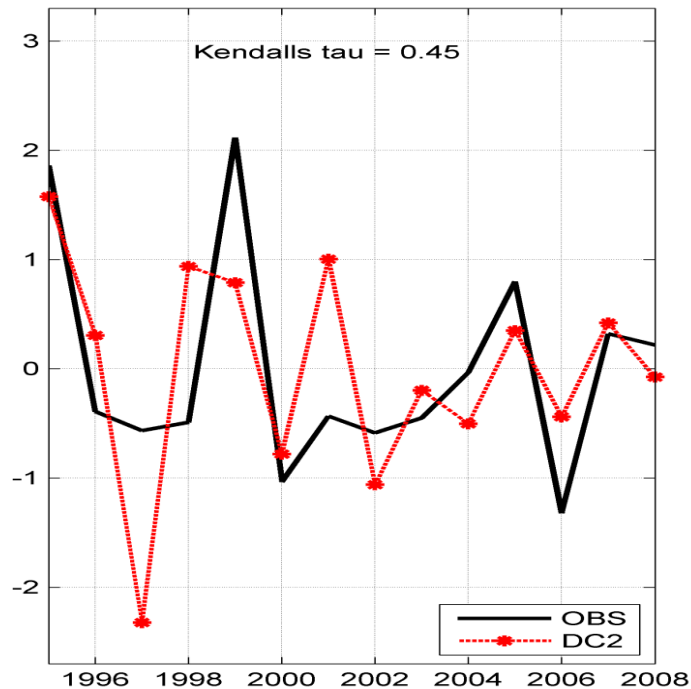




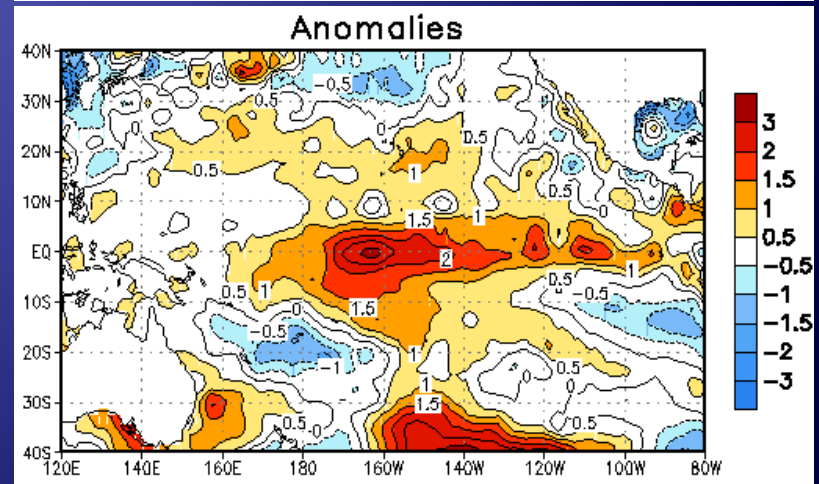
DJF Rainfall Area-Average (Africa south of 10°S)



December-January-February

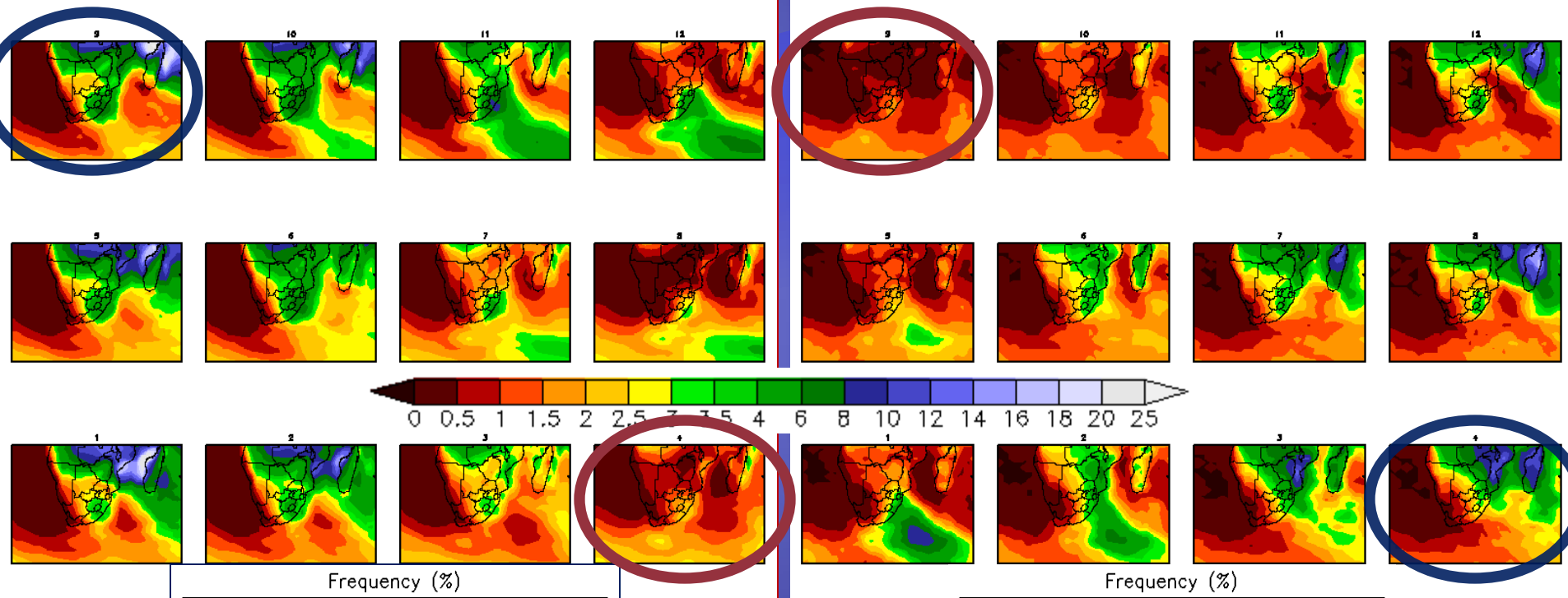


Sea Surface Temperatures (deg C) for Week centered on 06 JAN 2010



# SOM

(HadGEM3 daily data, IC: Aug, 1 member)



Frequency (%)

8.99	5.03	6.20	11.15
3.53	7.46	3.02	12.25
9.50	6.05	7.42	19.40

Christien  
Engelbrecht

Frequency (%)

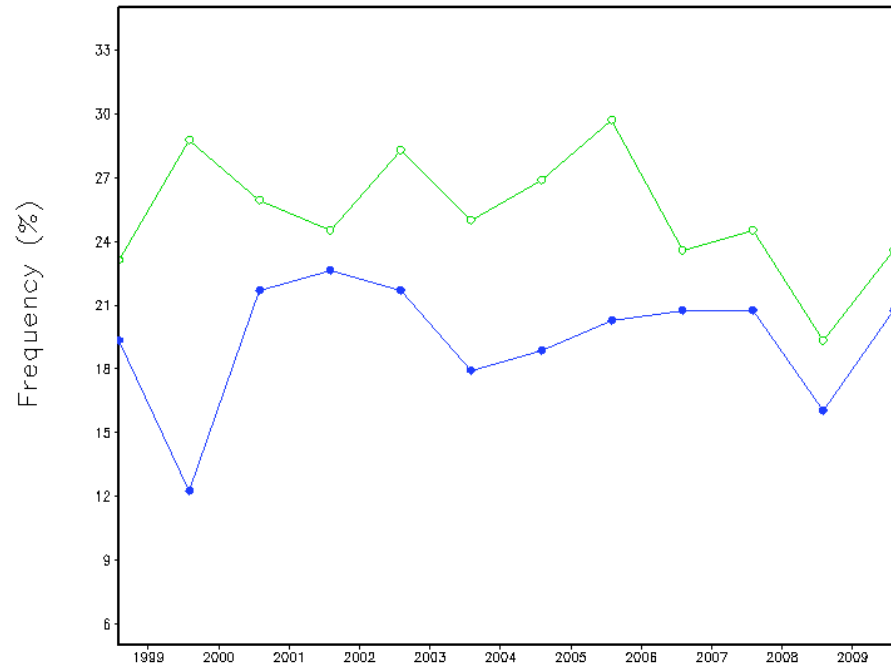
25.25	8.48	10.09	7.22
7.77	5.06	3.30	7.18
10.17	3.06	8.56	3.85

# SOM

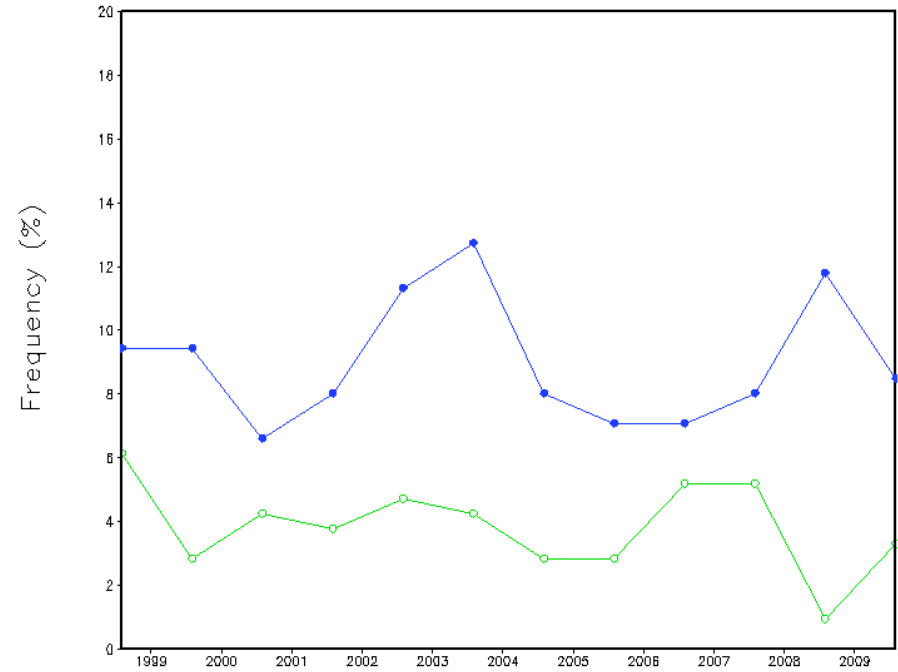
Dry

Wet

TRMM HadGem



TRMM HadGem



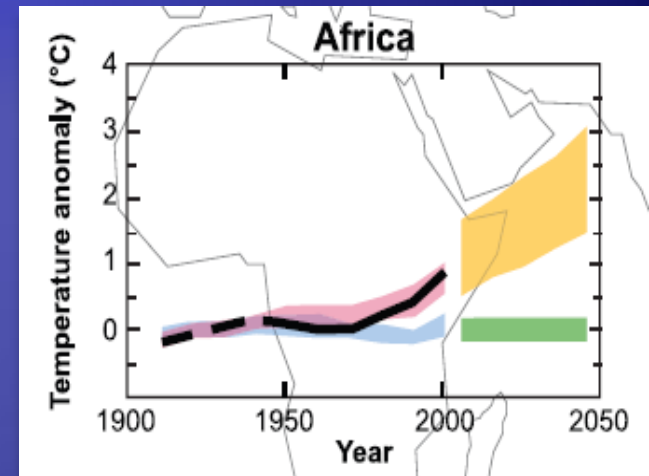
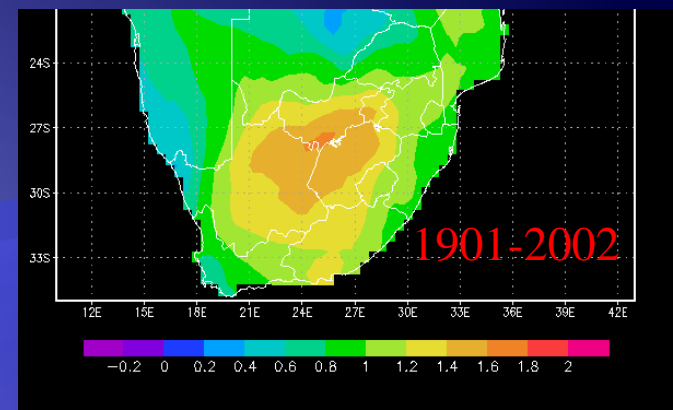
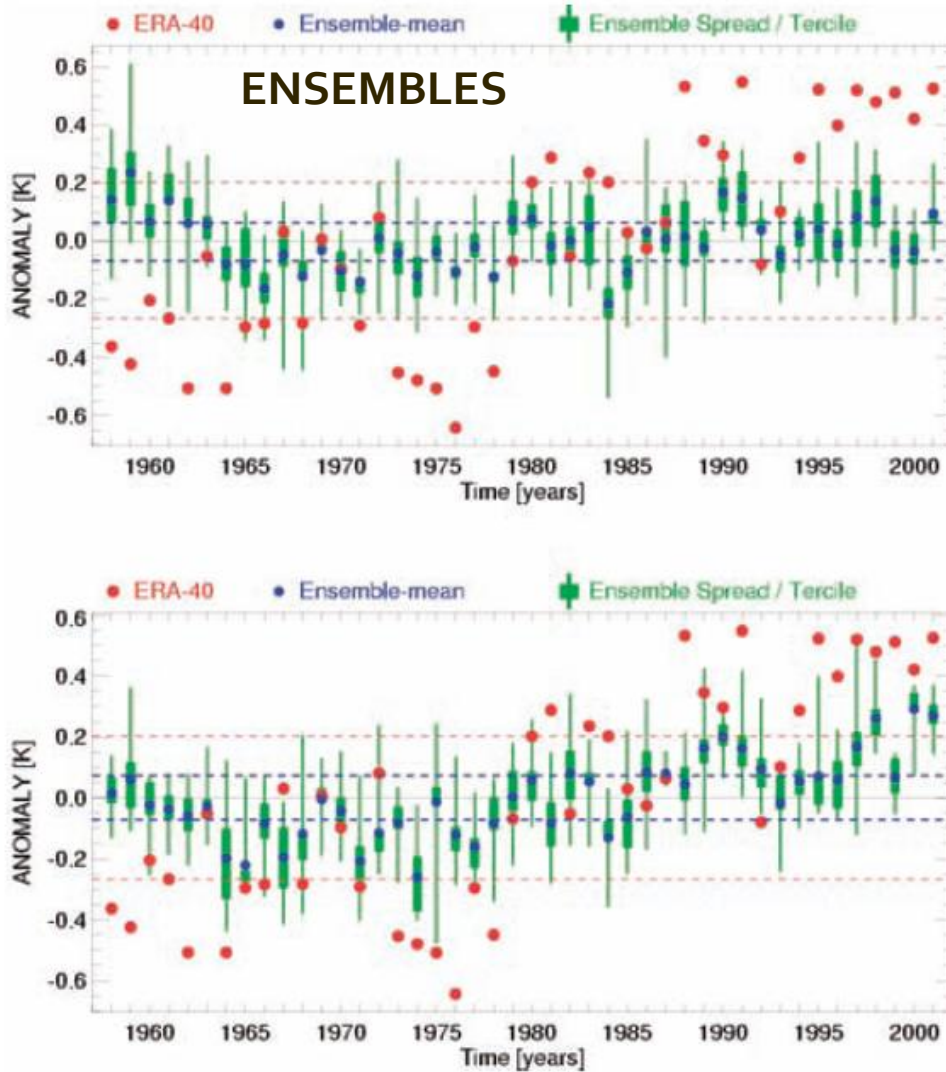


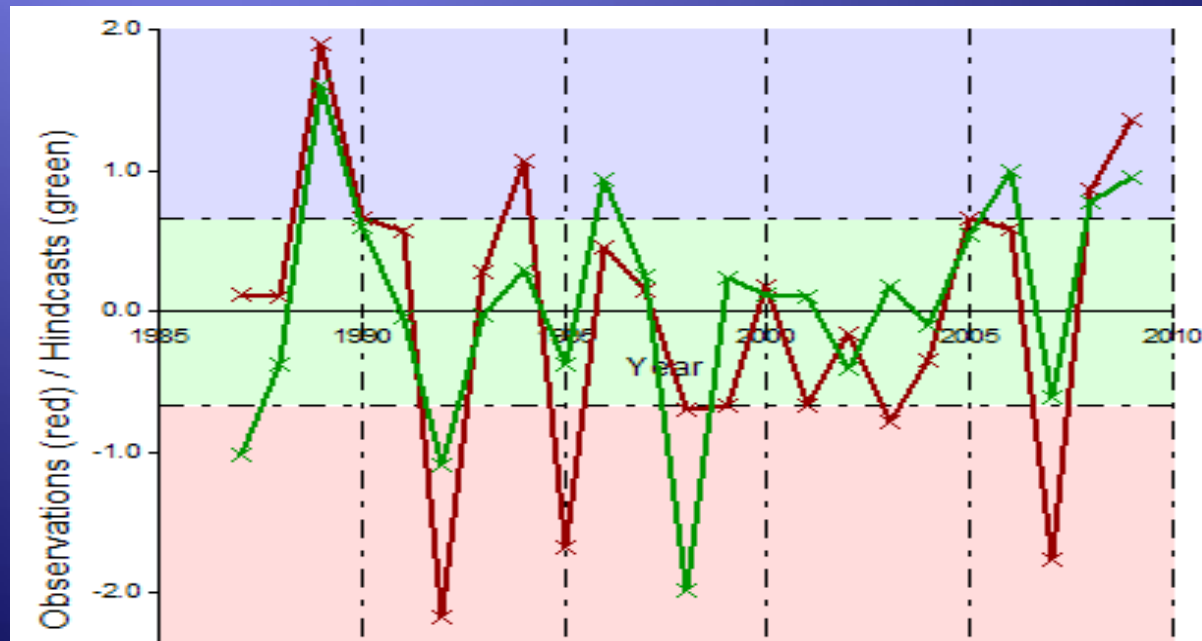
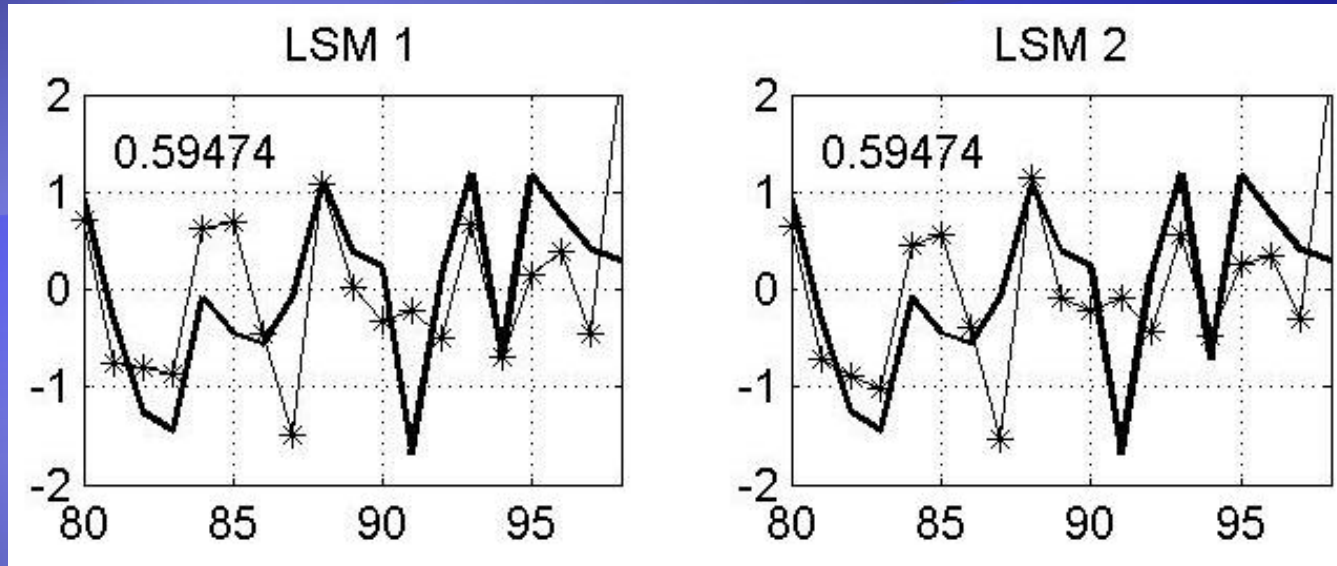
Figure 7.17: ECMWF 3-month lead time hindcasts of global 2 m temperature for August–October without (upper panel) and with (lower panel) time-varying anthropogenic greenhouse gases (GHG). In the upper panel the correlation between the ensemble mean and the observations is only 0.29, whereas this increases to 0.68 with variable GHGs, indicating that including variable greenhouse gas concentrations improves the seasonal forecast/hindcast skill of global mean surface air temperature (after Doblas-Reyes et al., 2006).

Strong anthropogenically forced warming trends have been observed over southern Africa and are projected to continue to rise, consequently justifying the investigation into how the annual update of greenhouse gas (GHG) concentrations in a global model may affect seasonal forecast performance over the region

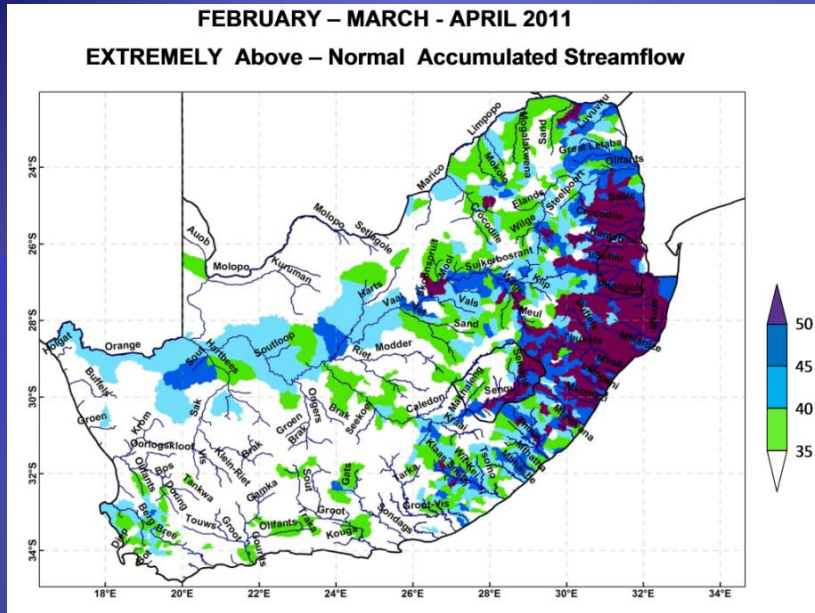


# Applications Modelling

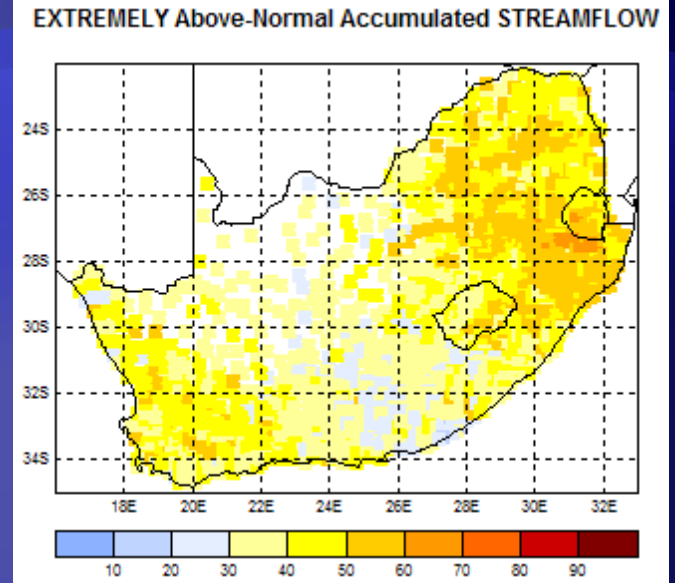
Simulated crop production for growing season



# Applications Modelling



DJF 1999/2000  
flooding;  
ECHAM4.5-  
MOM3-DC2  
fully coupled  
model forecast  
late October  
1999



# To summarize

- ◆ From empirical to physical
- ◆ MOS > RCM
- ◆ Objective combination > subjective consensus
- ◆ CGCMs have great potential
- ◆ AGCMs should continue to be optimized
- ◆ Downscaling and verification important components of forecast system
- ◆ System improvement still continuing, including applications model development
- ◆ South African modellers need international partners such as the UK Met Office!