# Seasonal forecasts
## presented by:



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**Seasonal Climate Forecasts**

Seasonal Forecast Worx

Latest Update:   14 April 2023

- The seasonal forecasts presented here by **Seasonal Forecast Worx** are based on forecast output of the coupled ocean-atmosphere models administered through the North American Multi-Model Ensemble (NMME) prediction experiment (http://www.cpc.ncep.noaa.gov/products/NMME/; Kirtman et al. 2014). NMME real-time seasonal forecast and hindcast (re-forecast) data are obtained from the data library (http://iridl.ldeo.columbia.edu/) of the International Research Institute for Climate and Society (IRI; http://iri.columbia.edu/).

- NMME forecasts are routinely produced and are statistically improved and tailored for southern Africa and for global sea-surface temperatures by employees and post-graduate students in the Department of Geography, Geoinformatics and Meteorology at the University of Pretoria (http://www.up.ac.za/en/geography-geoinformatics-and-meteorology/). Statistical post-processing is performed with the CPT software (http://iri.columbia.edu/our-expertise/climate/tools/cpt/).

- Why do we apply statistical methods to climate model forecasts?

  "…statistical correction methods treating individual locations (e.g. multiple regression or principal component regression) may be recommended for today's coupled climate model forecasts". (Barnston and Tippett, 2017).

- Why do we not use just a single model in our forecasts?

  "…multi-model forecasts outperform the single model forecasts…" (Landman and Beraki, 2012).


- For the <u>official</u> seasonal forecast for South Africa, visit the South African Weather Service website at http://www.weathersa.co.za/images/data/longrange/gfcsa/scw.pdf

**South African Weather Service**

# ENSO and Global SST Forecasts

# Prediction Method

- Forecasts for global sea-surface temperature (SST) fields are obtained through a combination of NMME models and a linear statistical model, that uses antecedent SST as a predictor (Landman et al. 2011). Forecasts for the Niño3.4 area (see insert) are derived from the global forecasts.

- SST forecasts from the NMME models are variance and bias corrected.

- Three-month Niño3.4 SST forecasts are produced for three categories:
  - **El Niño:** SST above the 75th percentile
  - **La Niña:** SST below the 25th percentile
  - **Neutral:** Neither El Niño nor La Niña
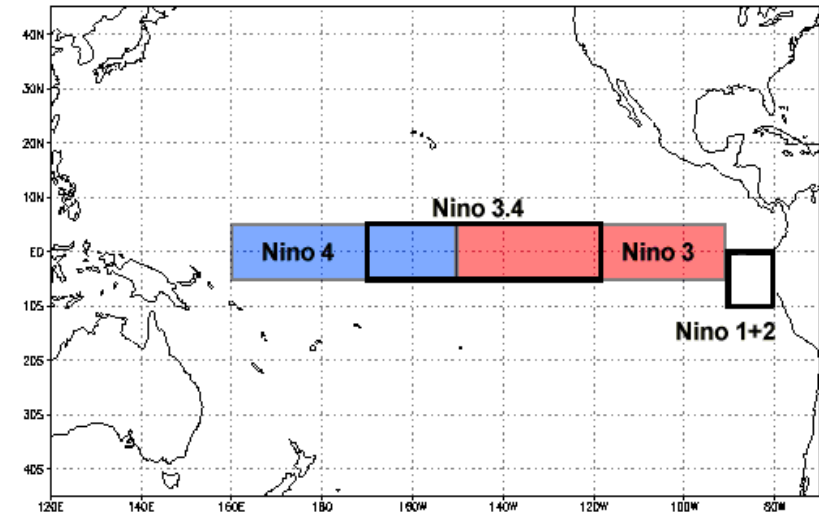
**CSiriMM Nino3.4 SST Forecast**
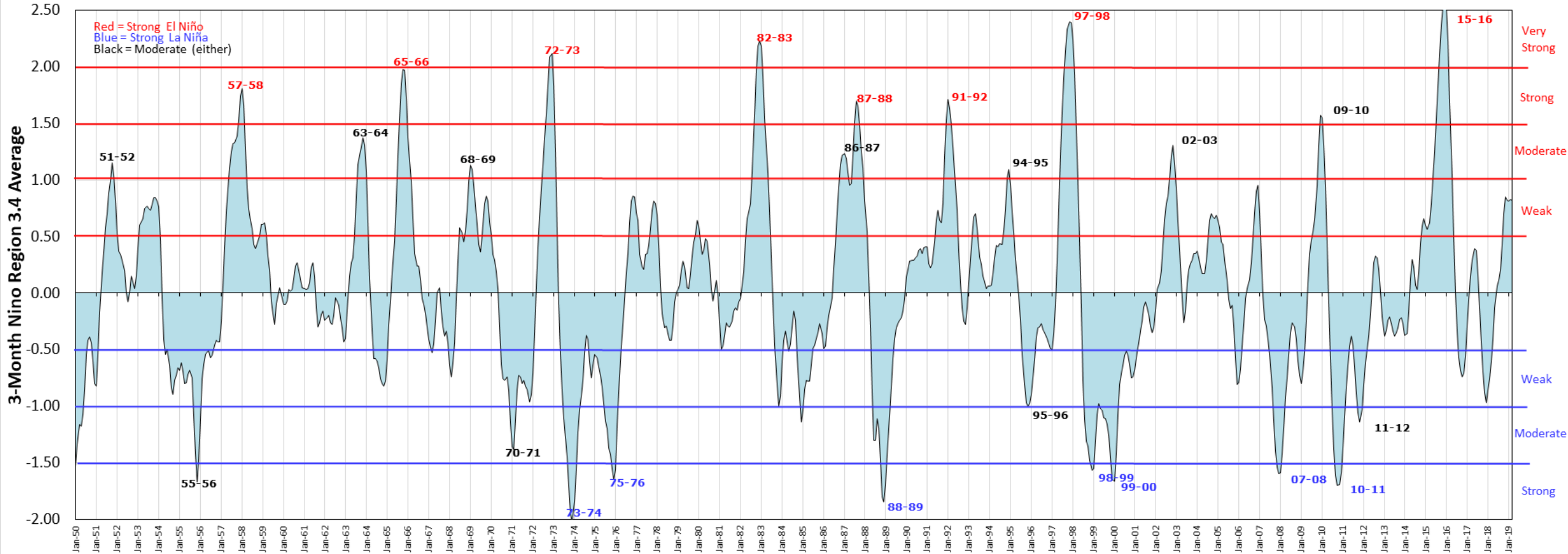**Issued on: 13-Apr-2023**
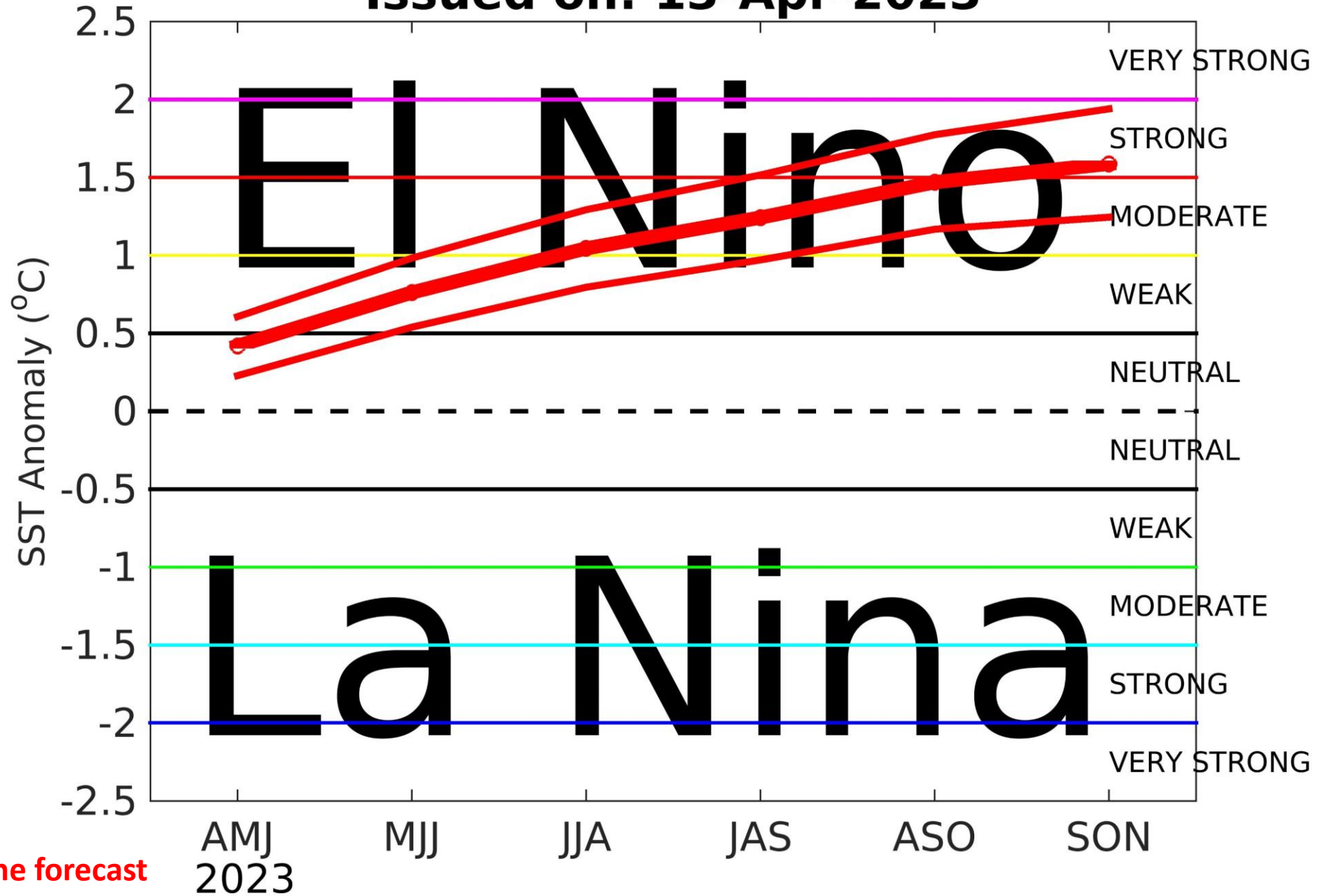
Middle red line: the forecast
Thin red lines: 25% confidence levels
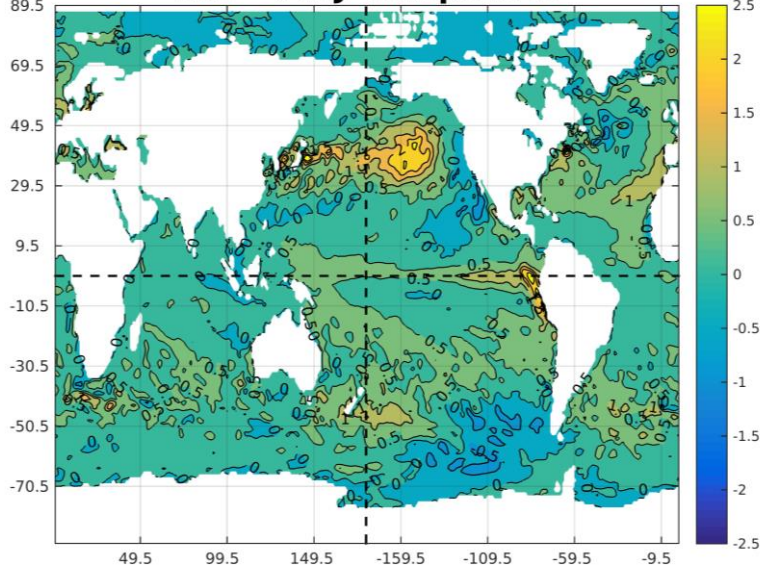
Oceanic Niño Index (ONI)

http://www.cpc.ncep.noaa.gov/products/analysis_monitoring/ensostuff/ensoyears.shtml
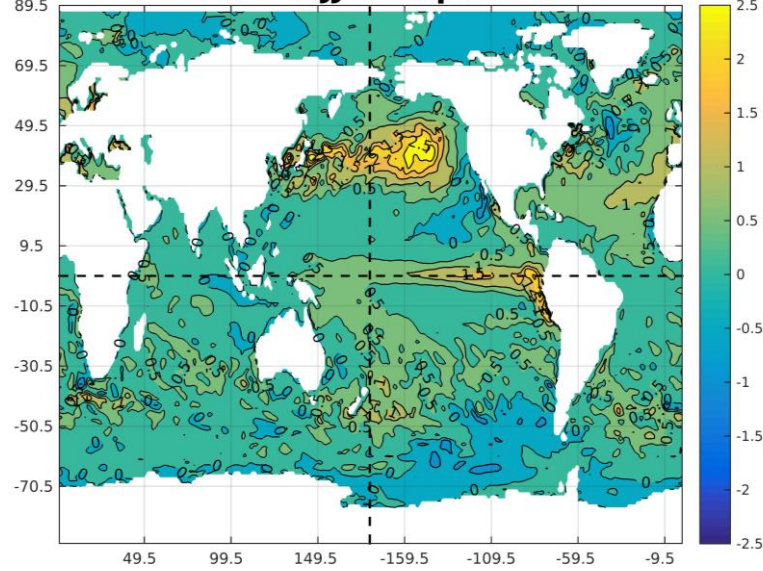
# SST anomalies (in °C, where blue is cooler and orange is warmer)

# Round-up: ENSO

- The UP model predicts a moderate to strong El Niño event towards the Austral summer



Historical Nino 3.4 Sea Surface Temperature Anomaly
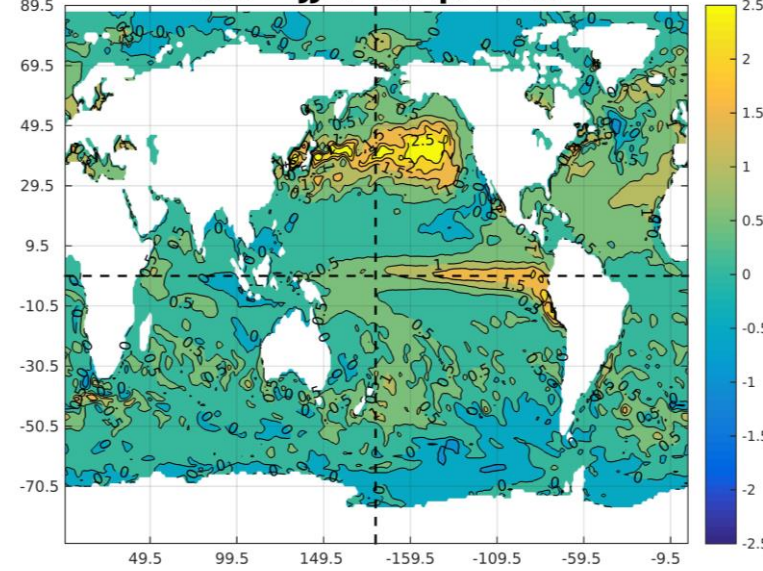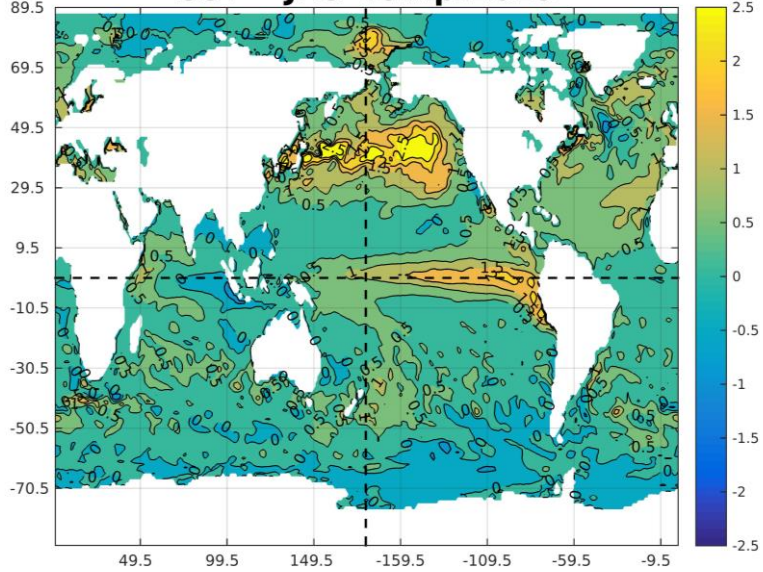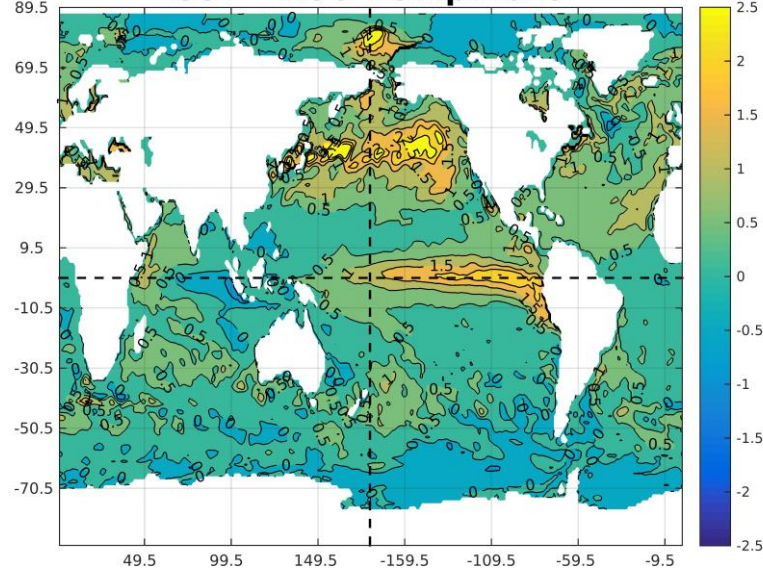


Model Predictions of ENSO from Mar 2023
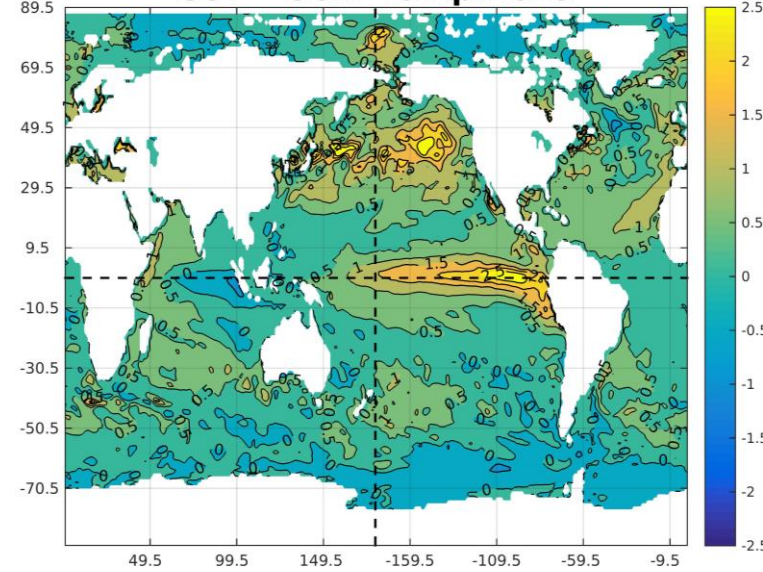
# Africa forecasts, south of 20°N

# Prediction Method

- Three-month seasons for seasonal rainfall totals and average maximum temperatures of NMME ensemble mean forecasts are interpolated to the Climatic Research Unit (CRU; Harris et al. 2014) grids (0.5°x0.5°), by correcting the mean and variance biases of the NMME forecasts. Probabilistic forecasts are subsequently produced from the error variance obtained from a 5-year-out cross-validation process (Troccoli et al. 2008). Forecasts cover a 6-month period.
- Forecasts are produced for three categories:
  - **Above:** Above-normal ("wet" rainfall totals / "hot" maximum temperatures higher than the 75th percentile of the climatological record)
  - **Below:** Below-normal ("dry" rainfall totals / "cool" maximum temperatures lower than the 25th percentile of the climatological record)
  - **Normal:** Near-normal ("average" season)
- Verification of forecast skill:
  - ROC Area (Below-Normal) – The forecast system's ability to discriminate dry or cool seasons from the rest of the seasons over a 23-year test period. ROC values should be higher than 0.5 for a forecast system to be considered skilful.
  - ROC Area (Above-Normal) – The forecast system's ability to discriminate wet or hot seasons from the rest of the seasons over a 23-year test period. ROC values should be higher than 0.5 for a forecast system to be considered skilful.
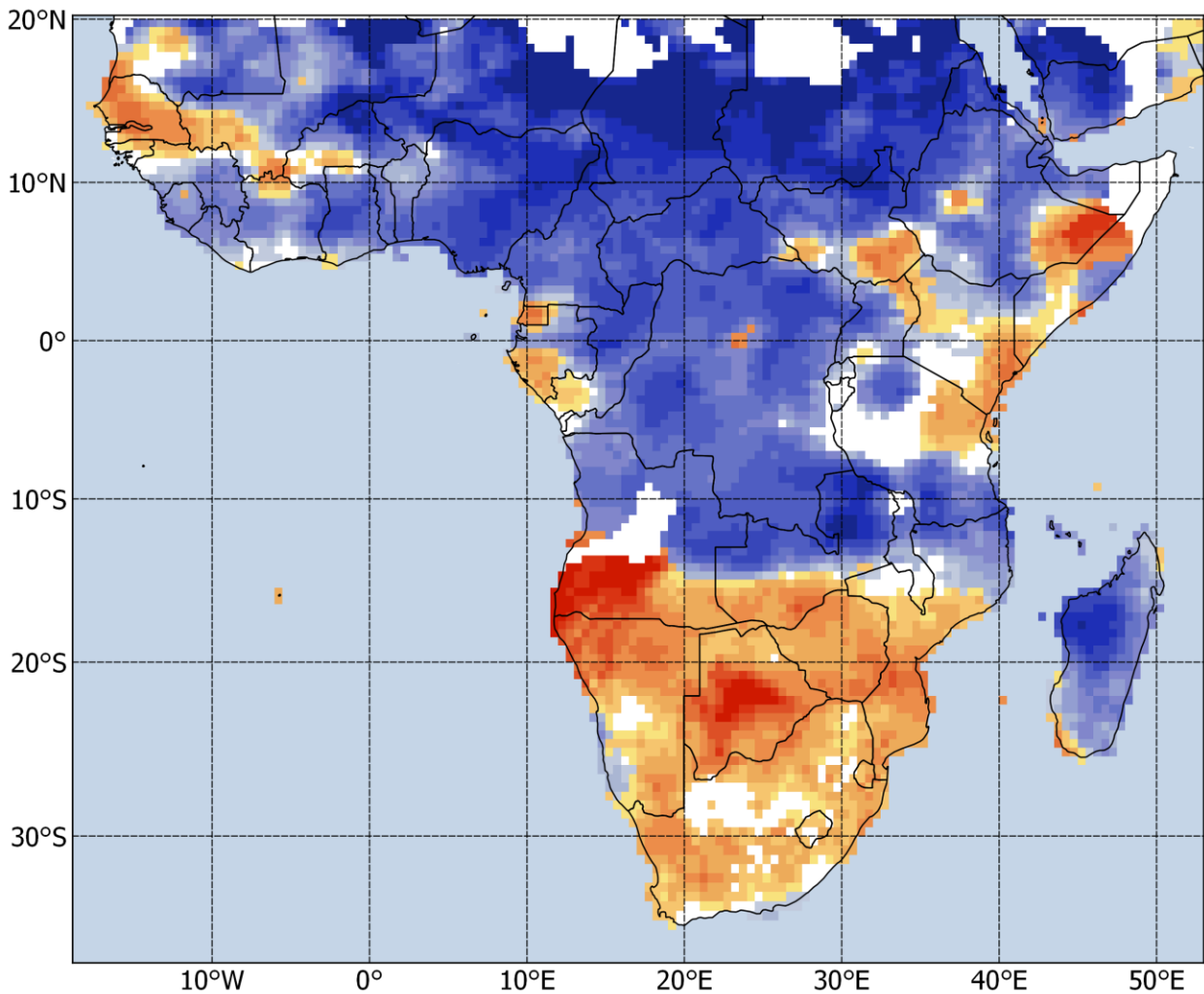
# Forecasts are probabilistic

Probabilistic forecasts can help users understand risks and opportunities (forewarned is forearmed) in order to make more informed decisions.

The seasonal rainfall and maximum temperature forecasts to follow are expressed in probabilities, shown as the % chance of the most likely outcome of 3 categories. The colour of the scale reflects the most likely category and the % shows the probability of that outcome. Only ONE of the ROC area skill assessment maps should be consulted, depending on the category shown on the forecast map (Above- or Below- Normal), and the higher the value, the more skilful the forecast for that pixel is. The probabilities shown are always less than 100% - so there is no absolute certainty that the less favoured outcome will not occur. For example, if the forecast claims a 75% of below-normal rainfall totals for a season (i.e. drought), it means that 1 out of 4 times it will **not** develop into a drought.
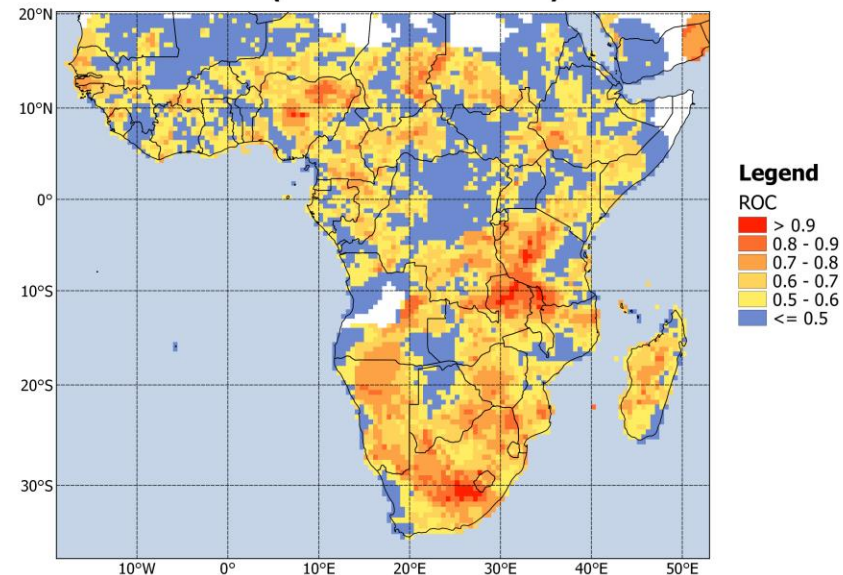
The nature of a probabilistic forecast implies that the less likely outcomes are always possible. In fact, for the probabilistic forecasts to be considered reliable, the less likely outcomes will and must occasionally occur.

Note: Probabilistic forecasts are considered reliable when the forecast probability is an accurate estimation of the relative frequency of the predicted outcome. In other words, forecasts are reliable if the observation falls within the category (Below-, Near- or Above- Normal) as frequently as the forecast implies
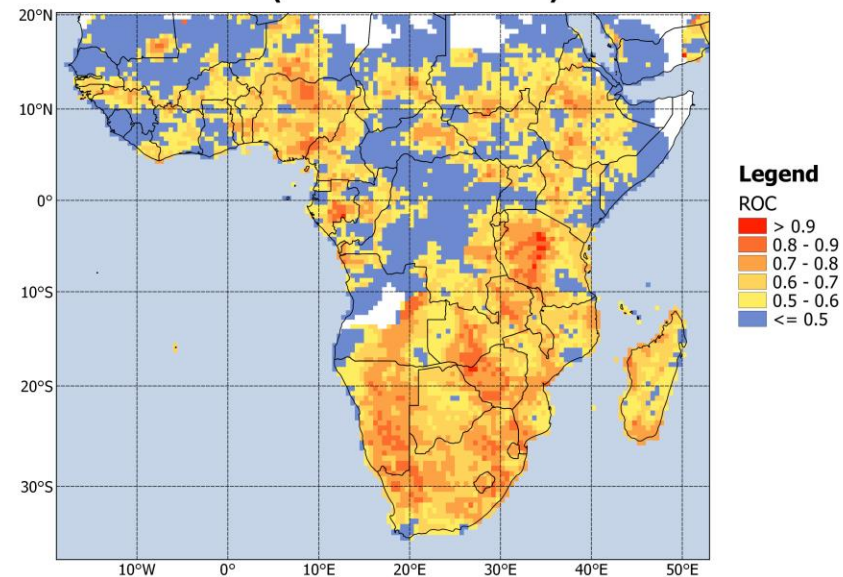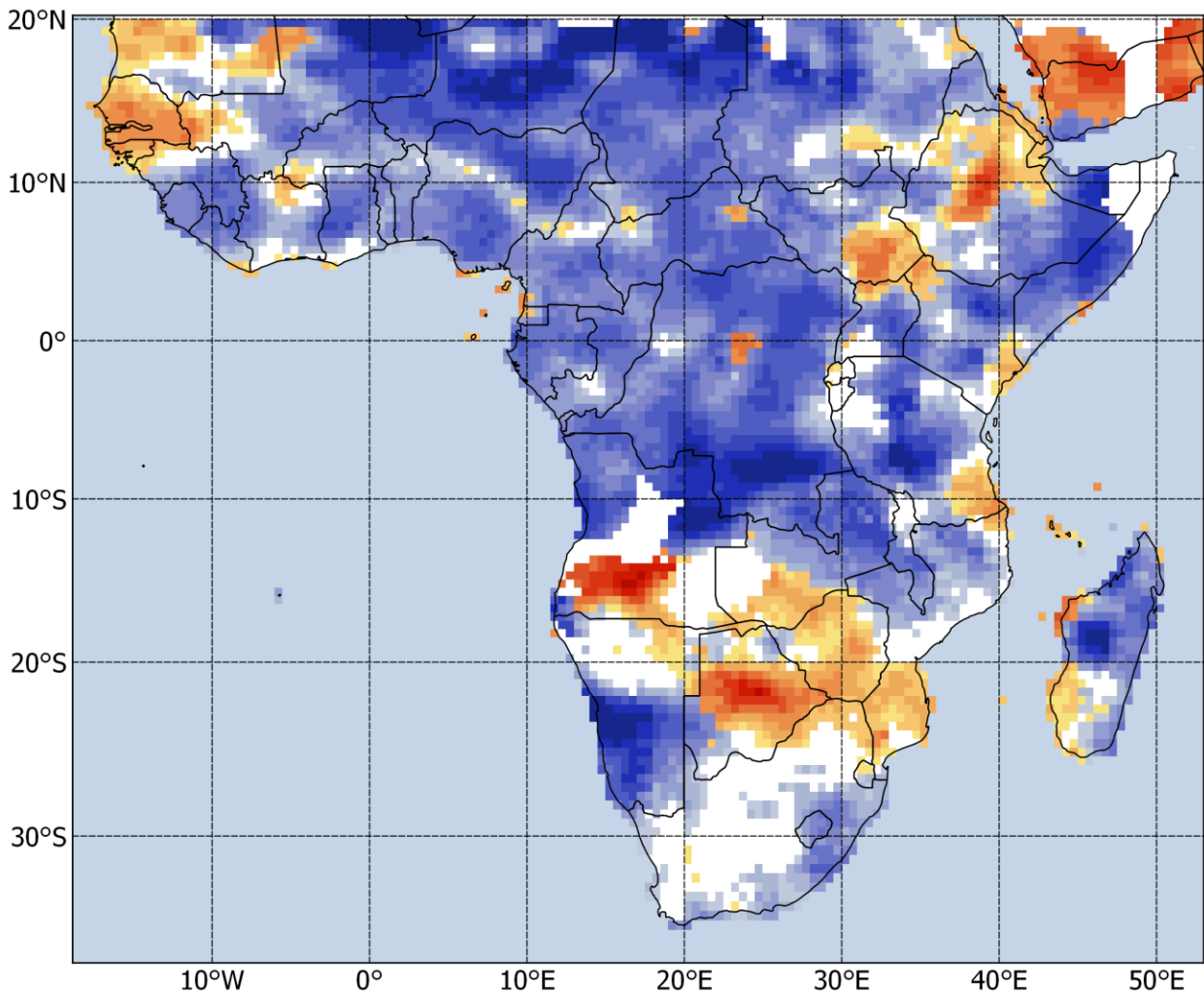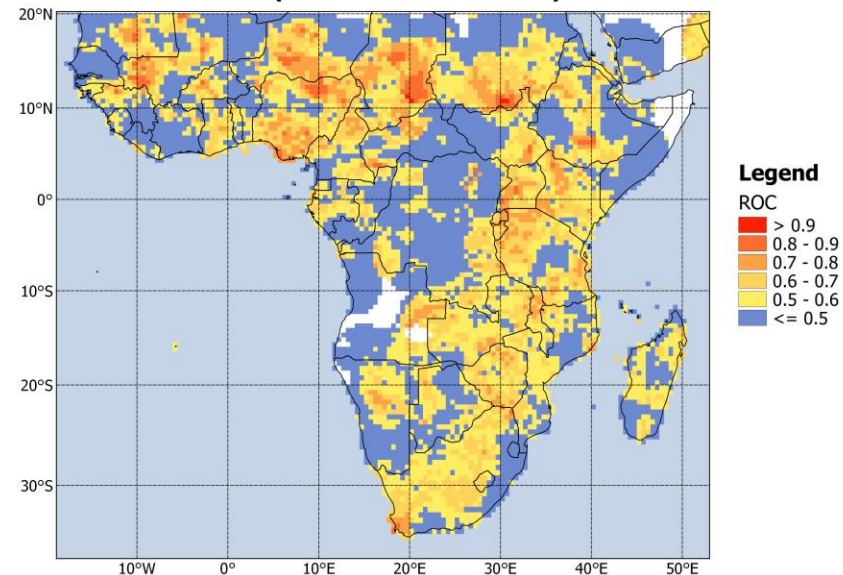
# AMJ 2023 Rainfall; ICs: Apr

## Legend

### Rainfall Prob

- >75
- 70-75
- 65-70
- 60-65
- 55-60    Above
- 50-55    Normal
- 45-50
- 40-45
- 35-40
- 35-40
- 40-45
- 45-50
- 50-55    Below
- 55-60    Normal
- 60-65
- 65-70
- 70-75
- >75

No forecast

## ROC Area (Above-Normal): AMJ Rainfall

### Legend
ROC
- > 0.9
- 0.8 - 0.9
- 0.7 - 0.8
- 0.6 - 0.7
- 0.5 - 0.6
- <= 0.5

## ROC Area (Below-Normal): AMJ Rainfall

### Legend
ROC
- > 0.9
- 0.8 - 0.9
- 0.7 - 0.8
- 0.6 - 0.7
- 0.5 - 0.6
- <= 0.5

MJJ 2023 Rainfall; ICs: Apr

Legend

Rainfall Prob

| | |
|---|---|
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| 70-75 | |
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| 55-60 | Above |
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| 40-45 | |
| 35-40 | |
| 35-40 | |
| 40-45 | |
| 45-50 | |
| 50-55 | Below |
| 55-60 | Normal |
| 60-65 | |
| 65-70 | |
| 70-75 | |
| >75 | |

No forecast

ROC Area (Above-Normal): MJJ Rainfall

Legend
ROC

| | |
|---|---|
| | > 0.9 |
| | 0.8 - 0.9 |
| | 0.7 - 0.8 |
| | 0.6 - 0.7 |
| | 0.5 - 0.6 |
| | <= 0.5 |

ROC Area (Below-Normal): MJJ Rainfall
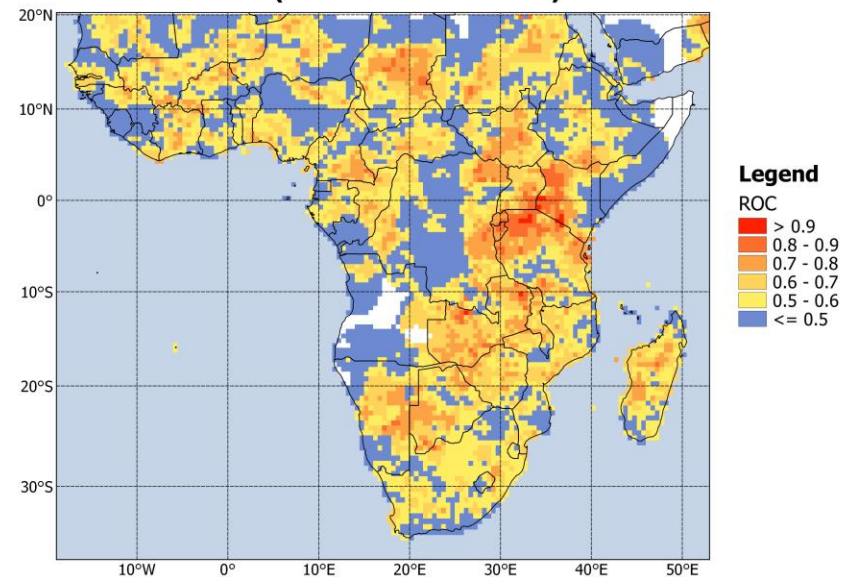
Legend
ROC

| | |
|---|---|
| | > 0.9 |
| | 0.8 - 0.9 |
| | 0.7 - 0.8 |
| | 0.6 - 0.7 |
| | 0.5 - 0.6 |
| | <= 0.5 |

JJA 2023 Rainfall; ICs: Apr

Legend

Rainfall Prob

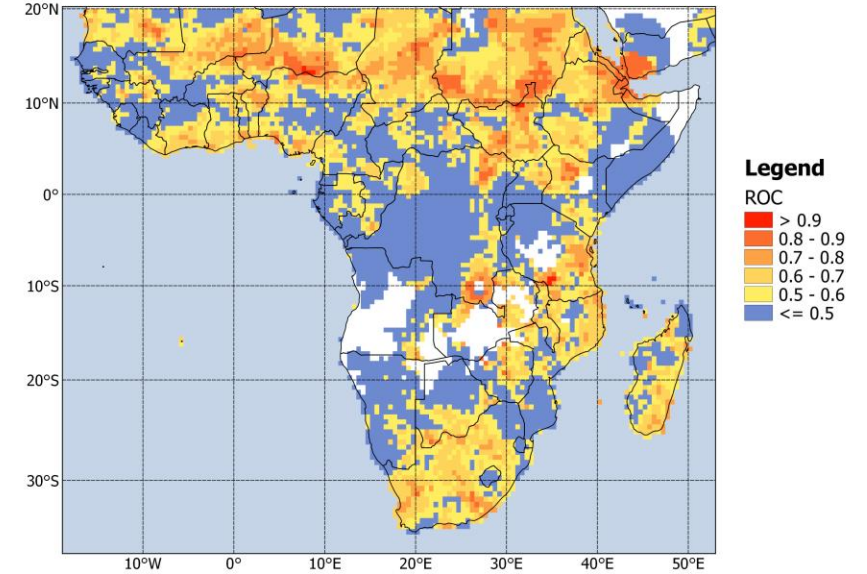| | |
|---|---|
| >75 | |
| 70-75 | |
| 65-70 | |
| 60-65 | |
| 55-60 | Above |
| 50-55 | Normal |
| 45-50 | |
| 40-45 | |
| 35-40 | |
| 35-40 | |
| 40-45 | |
| 45-50 | |
| 50-55 | Below |
| 55-60 | Normal |
| 60-65 | |
| 65-70 | |
| 70-75 | |
| >75 | |
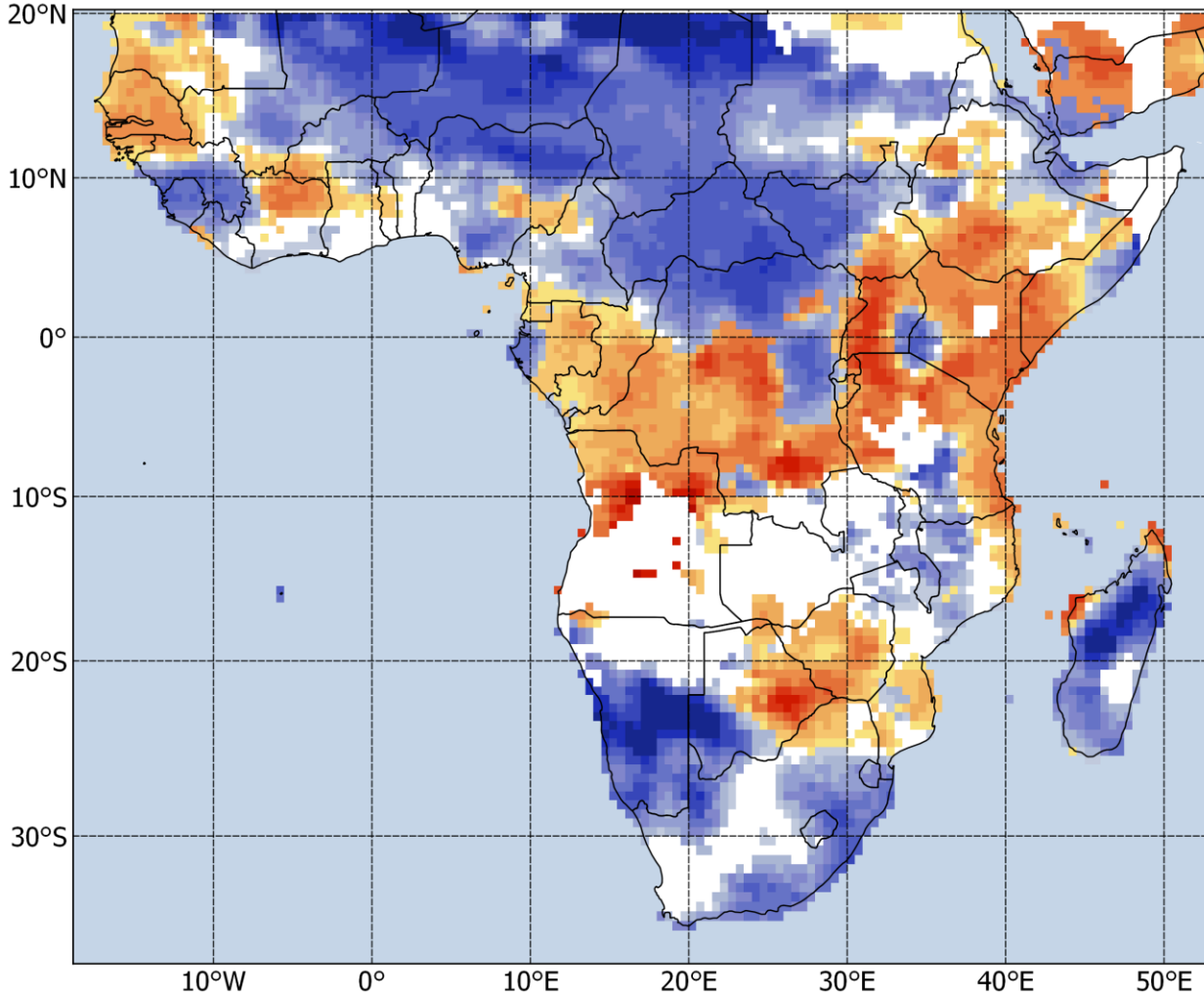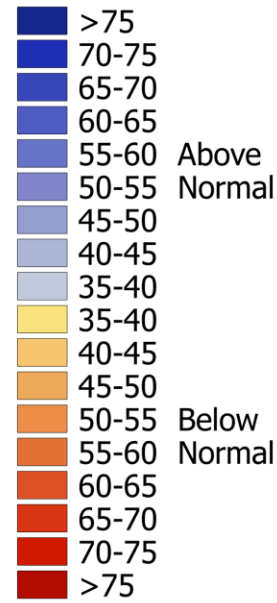
No forecast

ROC Area (Above-Normal): JJA Rainfall

Legend
ROC

| | |
|---|---|
| > 0.9 | |
| 0.8 - 0.9 | |
| 0.7 - 0.8 | |
| 0.6 - 0.7 | |
| 0.5 - 0.6 | |
| <= 0.5 | |
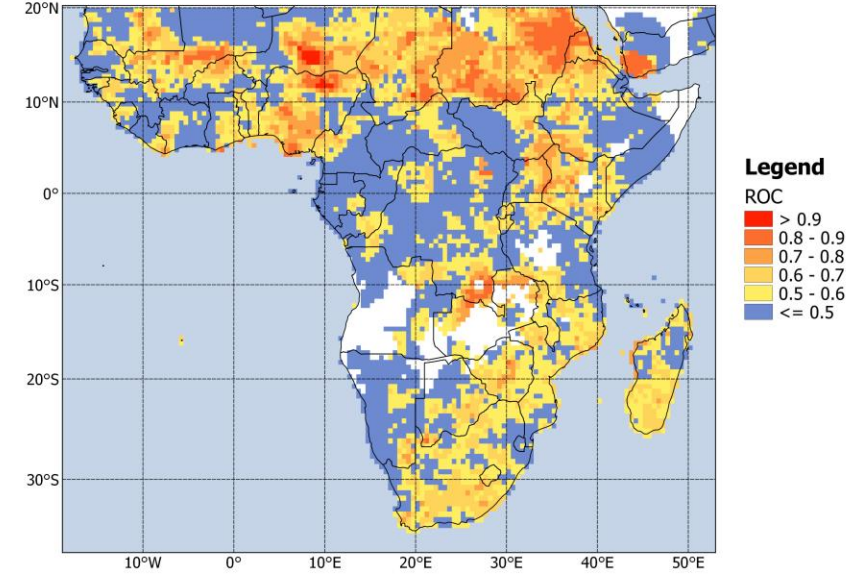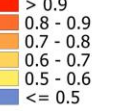
ROC Area (Below-Normal): JJA Rainfall

Legend
ROC

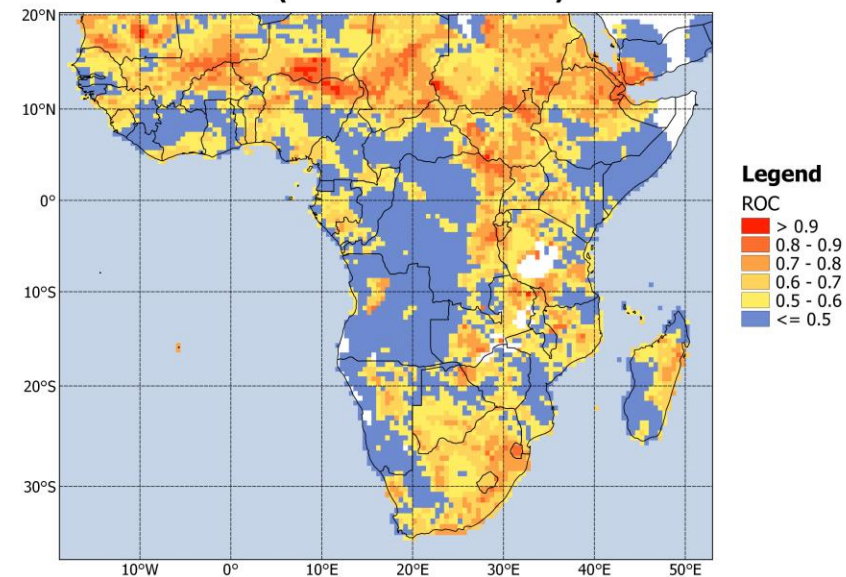| | |
|---|---|
| > 0.9 | |
| 0.8 - 0.9 | |
| 0.7 - 0.8 | |
| 0.6 - 0.7 | |
| 0.5 - 0.6 | |
| <= 0.5 | |

JAS 2023 Rainfall; ICs: Apr

Legend

Rainfall Prob

>75
70-75
65-70
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45-50
40-45
35-40
35-40
40-45
45-50
50-55  Below
55-60  Normal
60-65
65-70
70-75
>75

No forecast
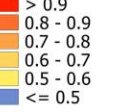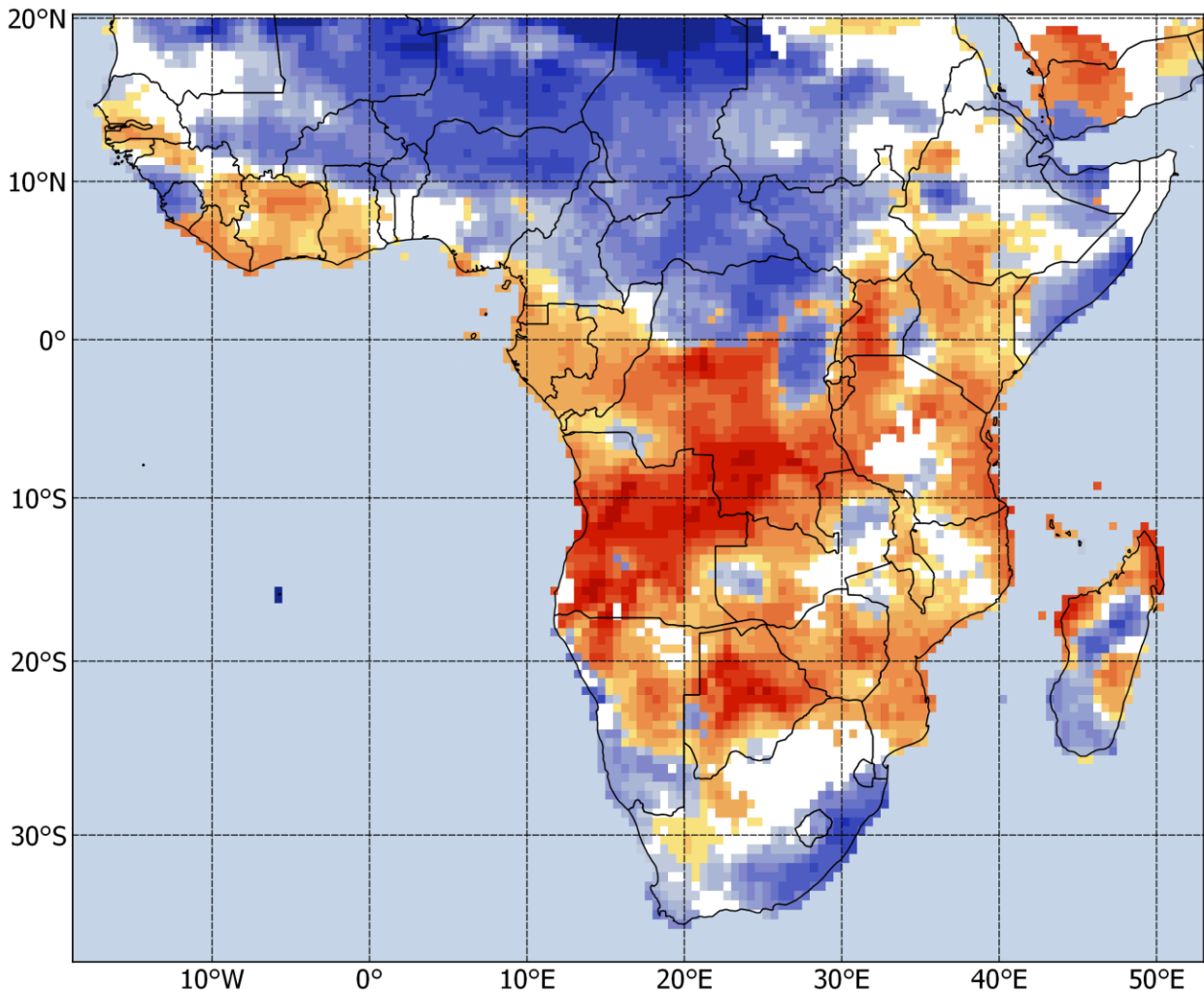
ROC Area (Above-Normal): JAS Rainfall

Legend
ROC

> 0.9
0.8 - 0.9
0.7 - 0.8
0.6 - 0.7
0.5 - 0.6
<= 0.5
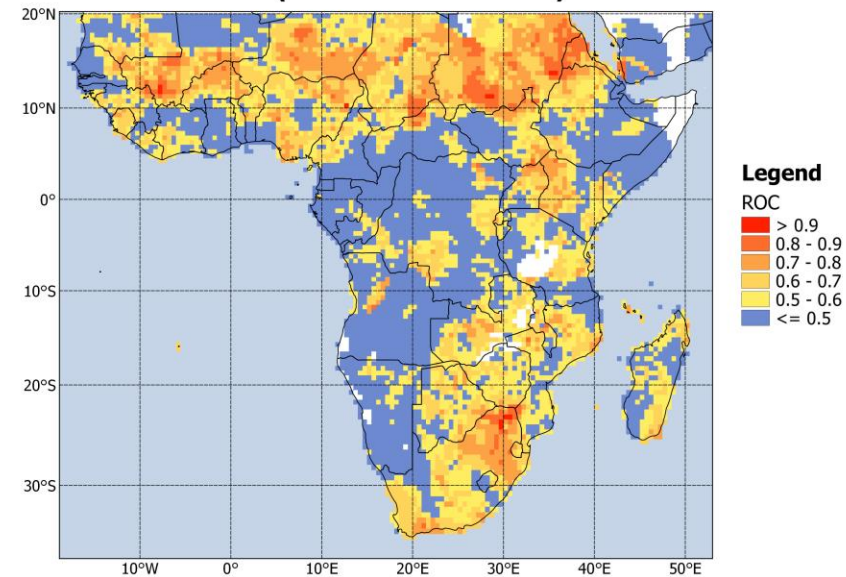
ROC Area (Below-Normal): JAS Rainfall

Legend
ROC

> 0.9
0.8 - 0.9
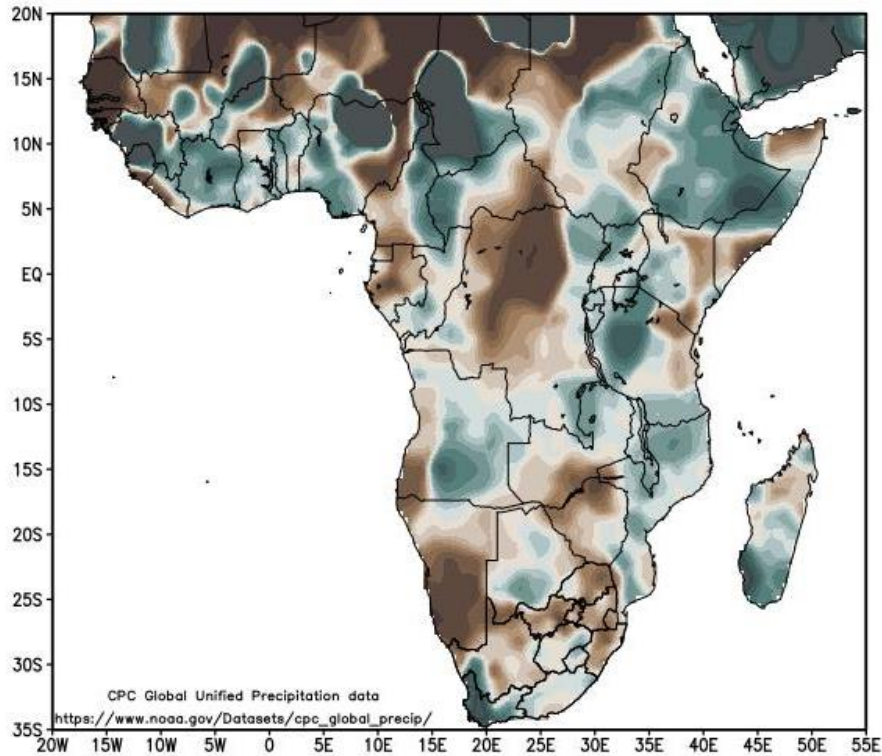0.7 - 0.8
0.6 - 0.7
0.5 - 0.6
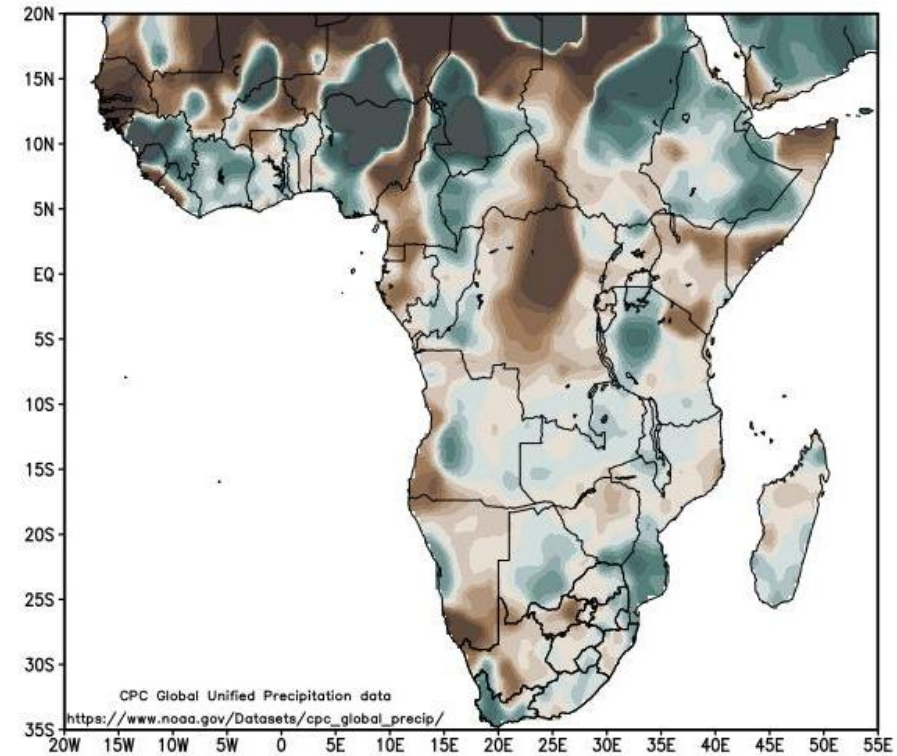<= 0.5

# Round-up: Rainfall south of 15°S

- The late autumn / early winter season rainfall is expected to be mostly below-normal over the entire region
- Parts of the summer rainfall area may expect winter rain
- Above-normal rainfall is expected over the winter rainfall region during early spring
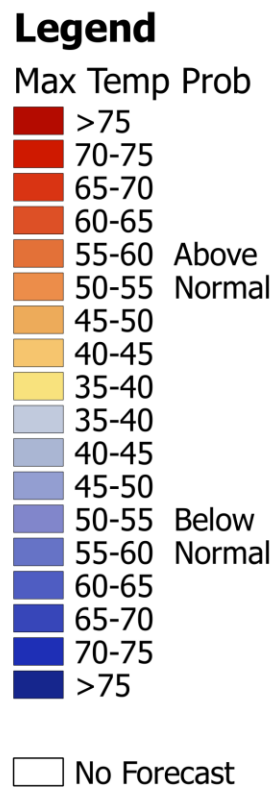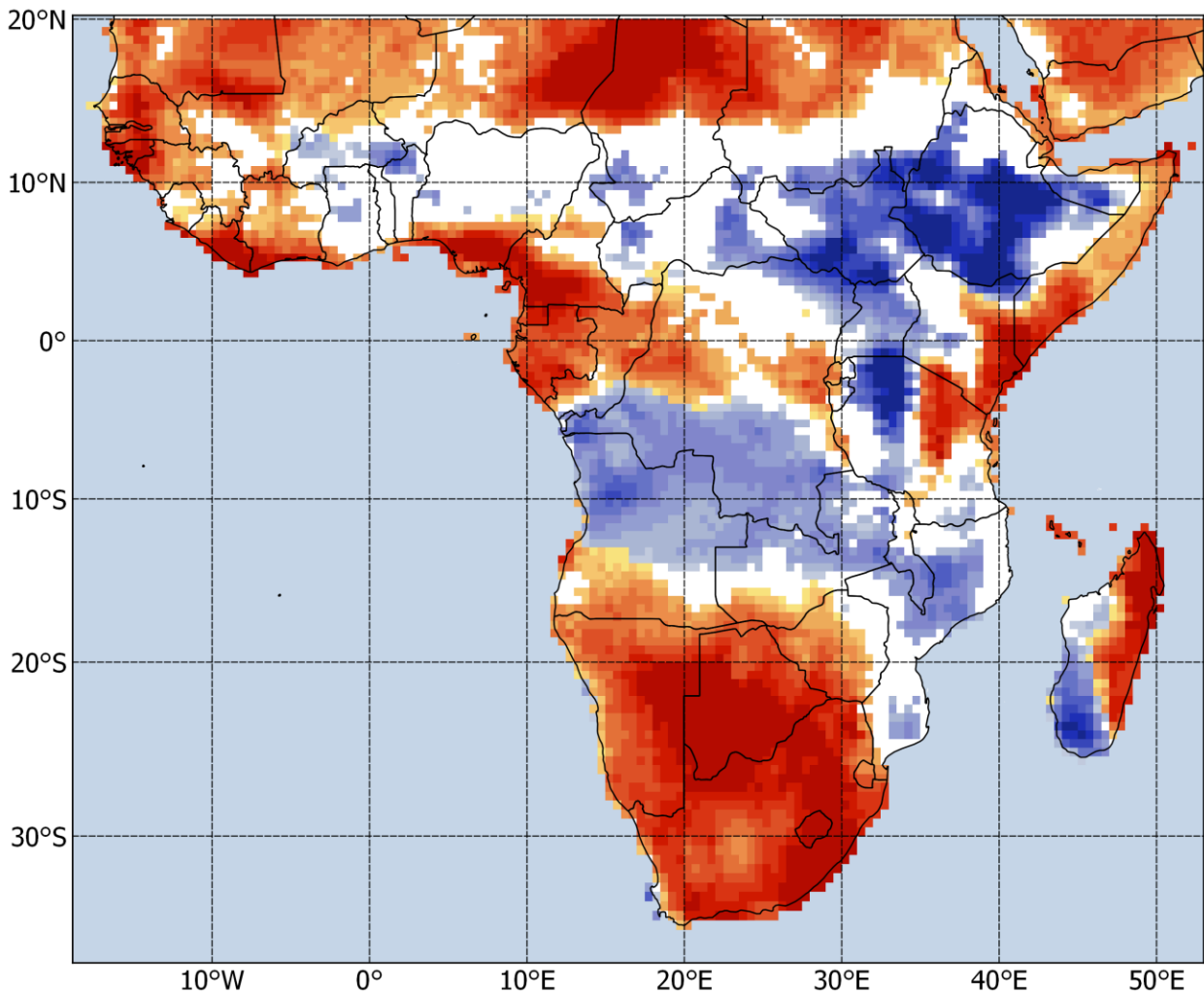
# Observed Rainfall



Recorded rainfall for March and the January-February-March season show below-normal rainfall over the brown areas and above-normal rainfall over the green areas
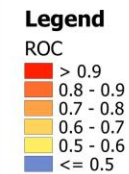
Maps prepared by Dr. Christien Engelbrecht

AMJ 2023 Max Temp; ICs: Apr

Legend

Max Temp Prob

| | |
|---|---|
| >75 | |
| 70-75 | |
| 65-70 | |
| 60-65 | |
| 55-60 | Above |
| 50-55 | Normal |
| 45-50 | |
| 40-45 | |
| 35-40 | |
| 35-40 | |
| 40-45 | |
| 45-50 | |
| 50-55 | Below |
| 55-60 | Normal |
| 60-65 | |
| 65-70 | |
| 70-75 | |
| >75 | |

No Forecast

ROC Area (Above-Normal): AMJ Max Temp

Legend
ROC

| | |
|---|---|
| > 0.9 | |
| 0.8 - 0.9 | |
| 0.7 - 0.8 | |
| 0.6 - 0.7 | |
| 0.5 - 0.6 | |
| <= 0.5 | |
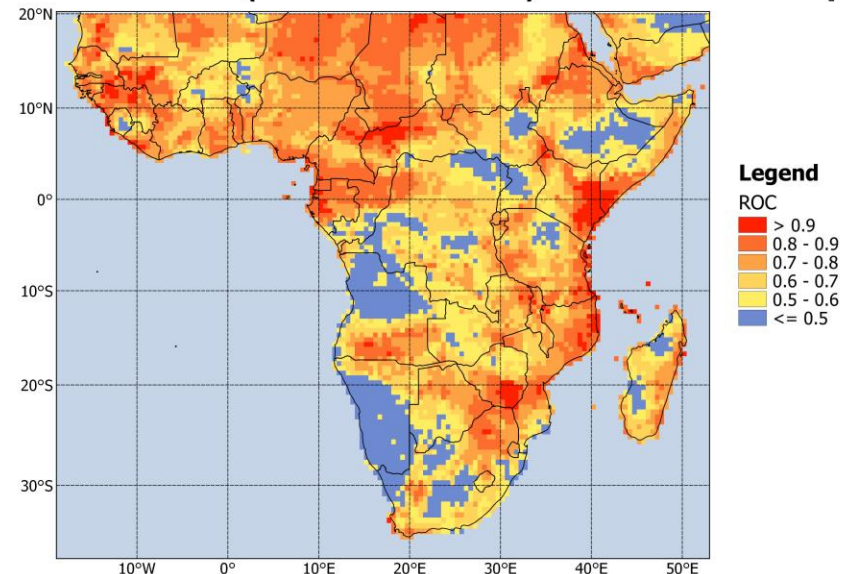
ROC Area (Below-Normal): AMJ Max Temp

Legend
ROC

| | |
|---|---|
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MJJ 2023 Max Temp; ICs: Apr

**Legend**

Max Temp Prob

| >75 |
| 70-75 |
| 65-70 |
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| 45-50 |
| 50-55 | Below |
| 55-60 | Normal |
| 60-65 |
| 65-70 |
| 70-75 |
| >75 |
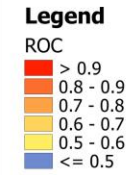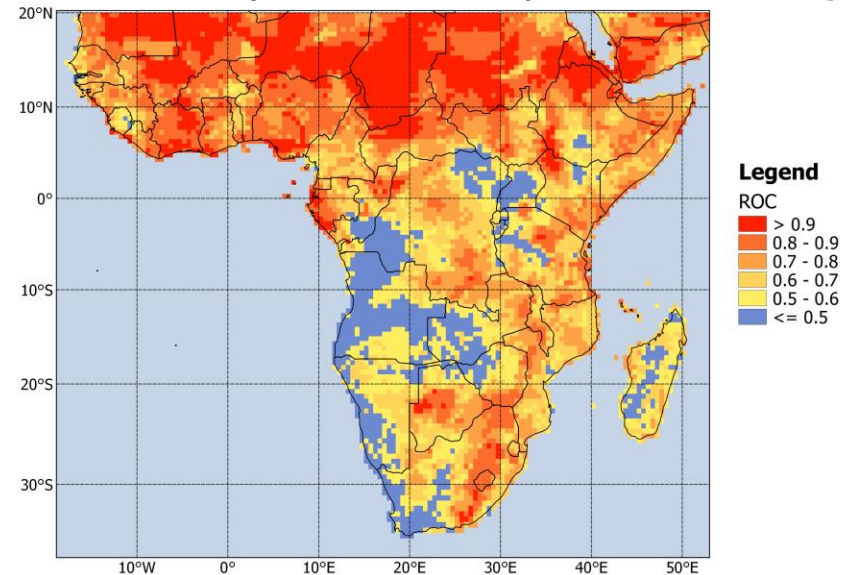
No Forecast
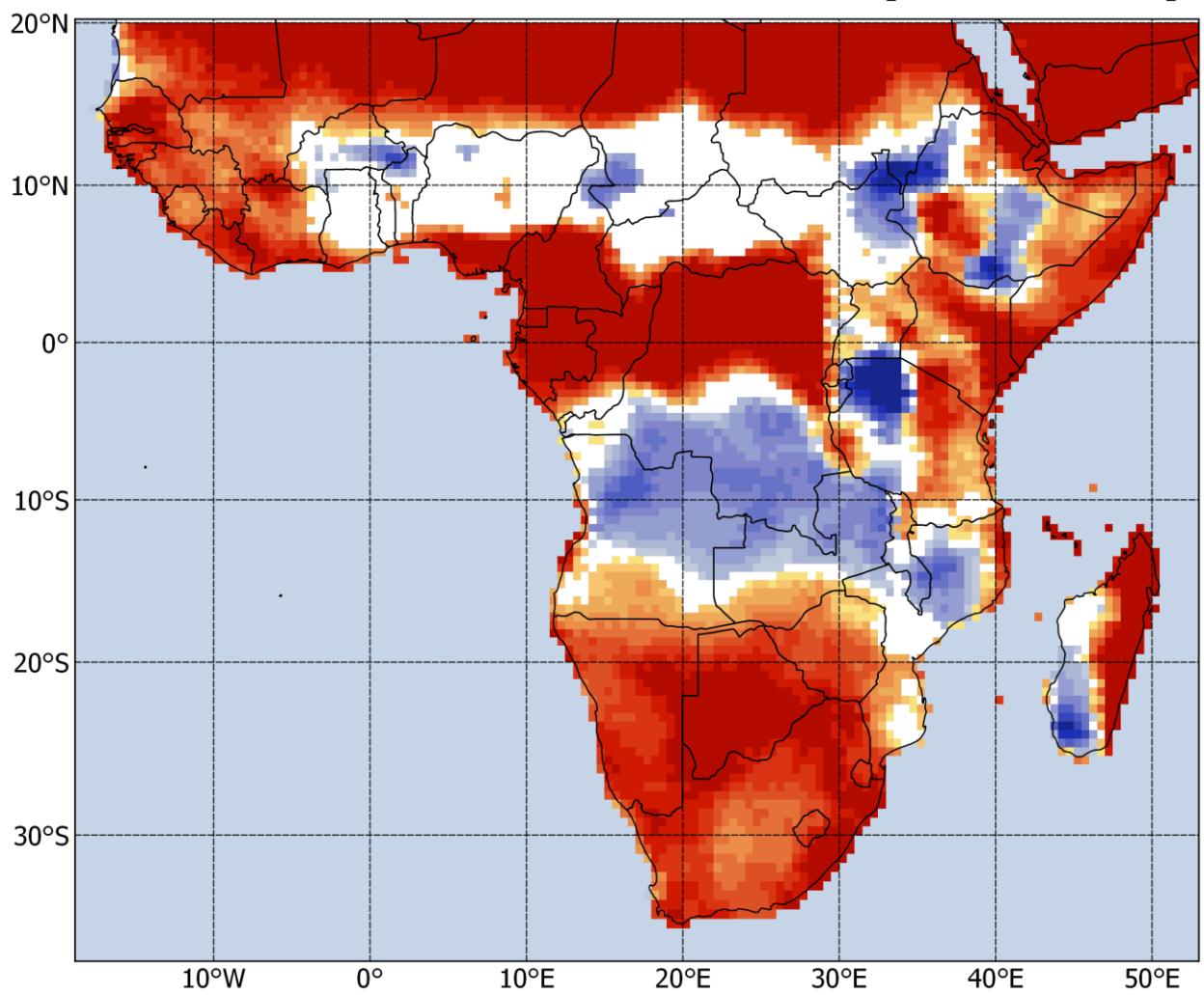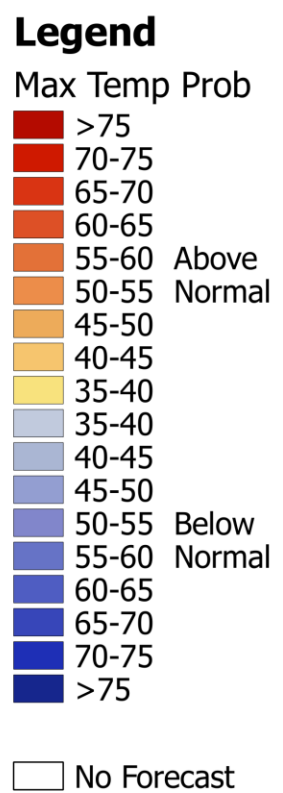
ROC Area (Above-Normal): MJJ Max Temp
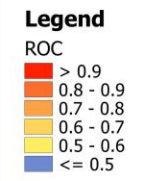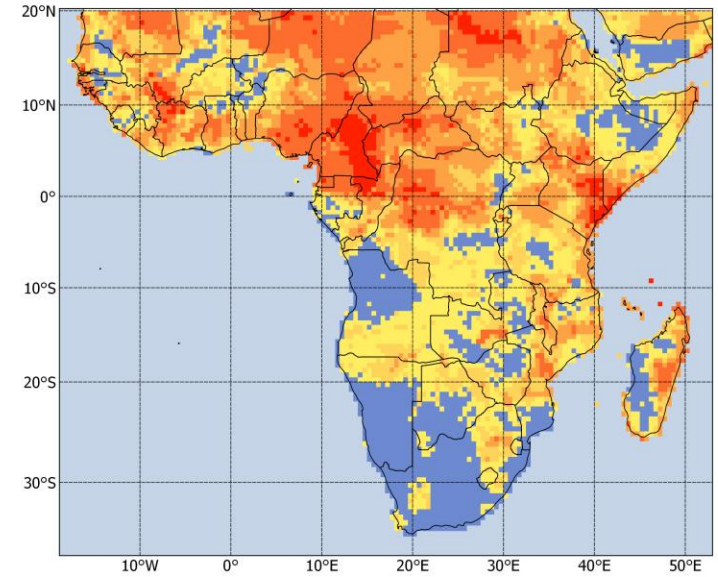
ROC Area (Below-Normal): MJJ Max Temp

**Legend**

ROC

| > 0.9 |
| 0.8 - 0.9 |
| 0.7 - 0.8 |
| 0.6 - 0.7 |
| 0.5 - 0.6 |
| <= 0.5 |

**Legend**

ROC

| > 0.9 |
| 0.8 - 0.9 |
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JJA 2023 Max Temp; ICs: Apr

**Legend**

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| 45-50 | |
| 50-55 | Below |
| 55-60 | Normal |
| 60-65 | |
| 65-70 | |
| 70-75 | |
| >75 | |
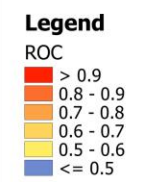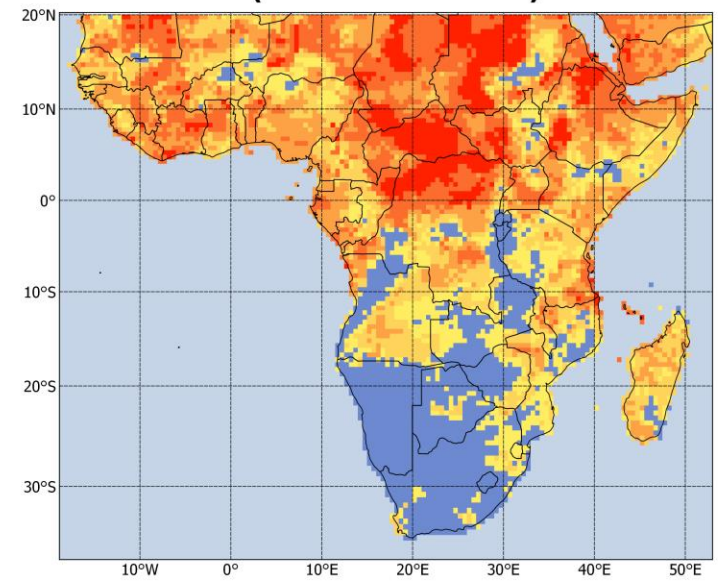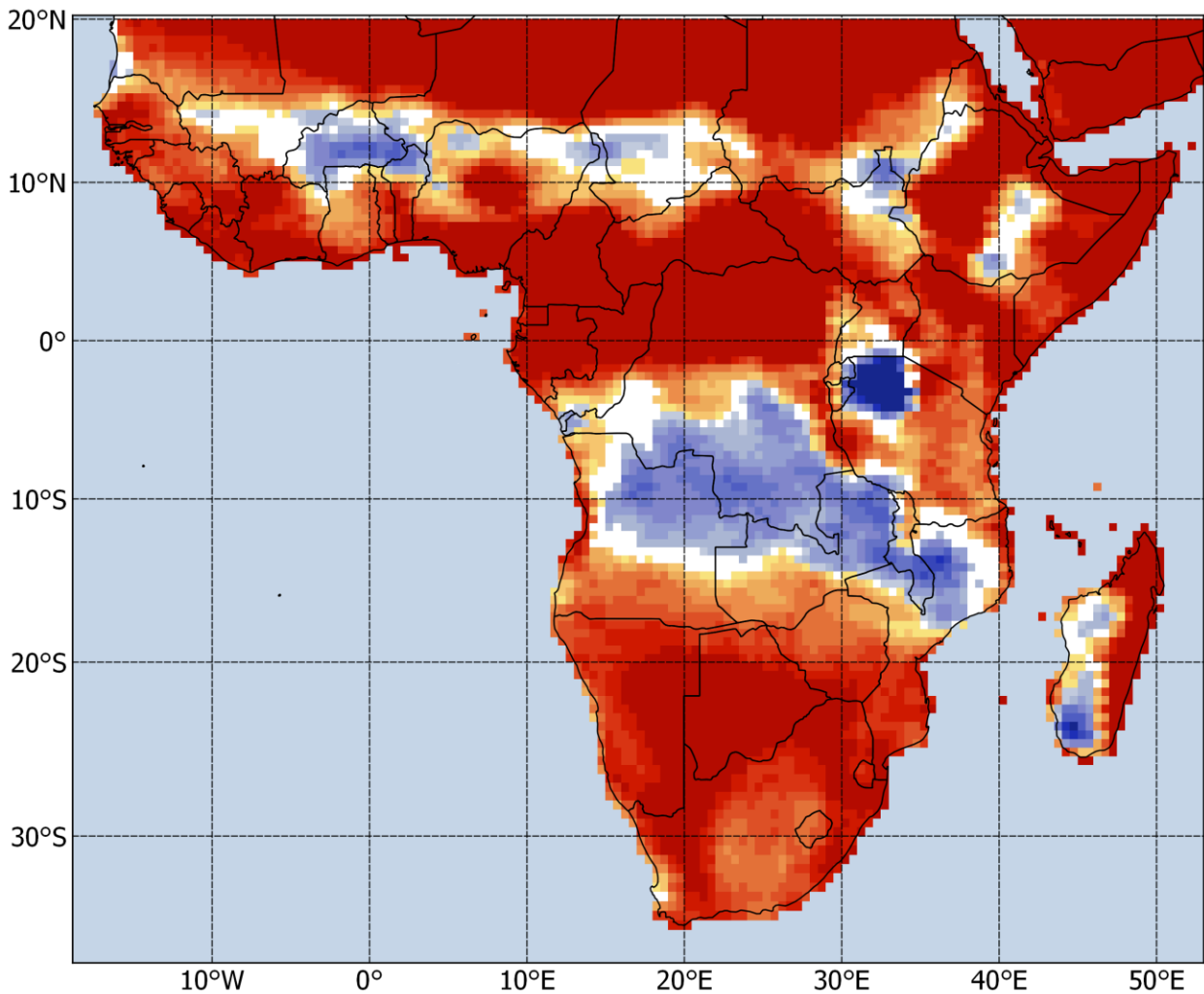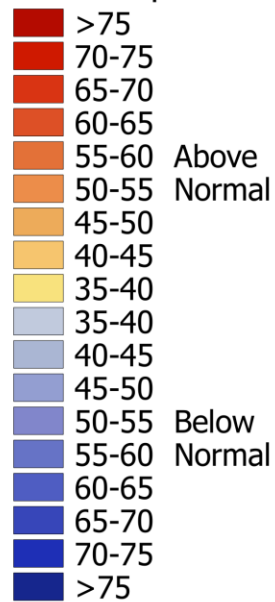
No Forecast

**ROC Area (Above-Normal): JJA Max Temp**

Legend
ROC
> 0.9
0.8 - 0.9
0.7 - 0.8
0.6 - 0.7
0.5 - 0.6
<= 0.5
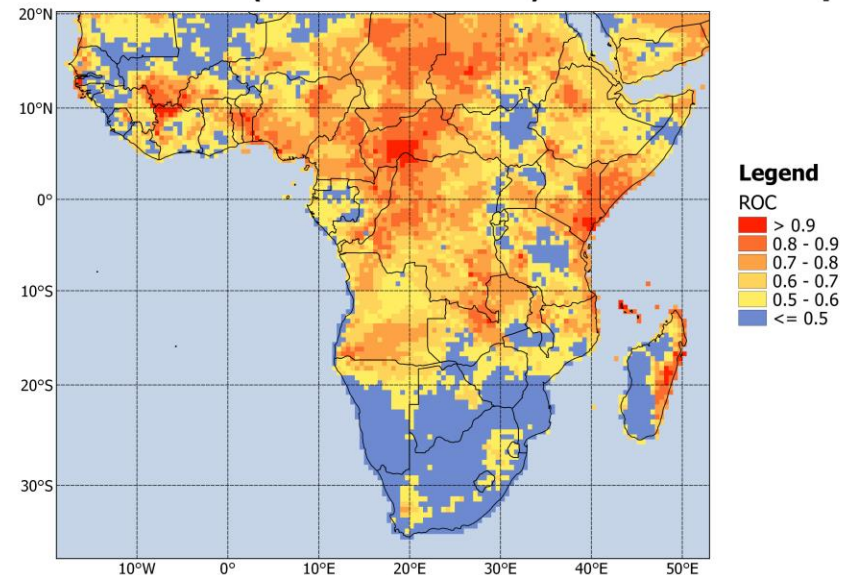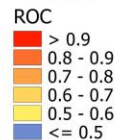
**ROC Area (Below-Normal): JJA Max Temp**

Legend
ROC
> 0.9
0.8 - 0.9
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0.5 - 0.6
<= 0.5

**JAS 2023 Max Temp; ICs: Apr**

Legend

Max Temp Prob

| | |
|---|---|
| >75 | |
| 70-75 | |
| 65-70 | |
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| 40-45 | |
| 35-40 | |
| 35-40 | |
| 40-45 | |
| 45-50 | |
| 50-55 | Below |
| 55-60 | Normal |
| 60-65 | |
| 65-70 | |
| 70-75 | |
| >75 | |

No Forecast
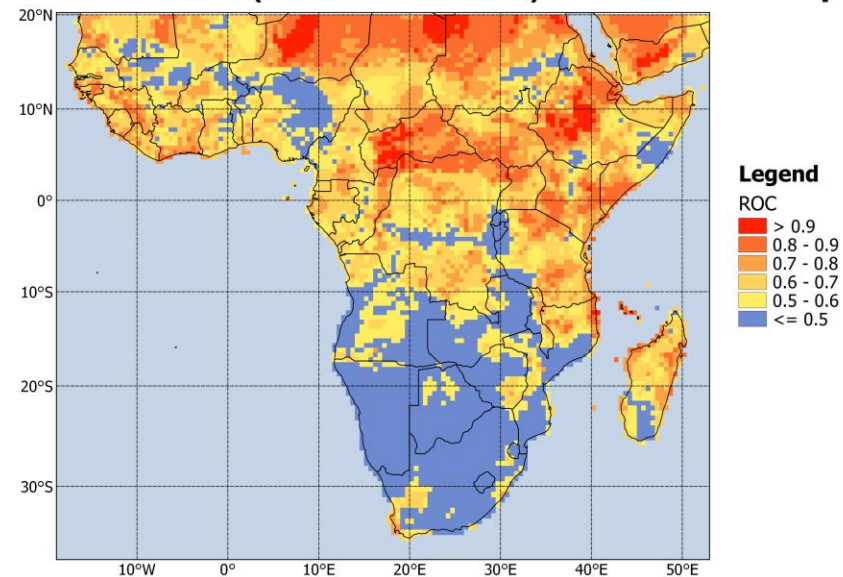
**ROC Area (Above-Normal): JAS Max Temp**

Legend
ROC

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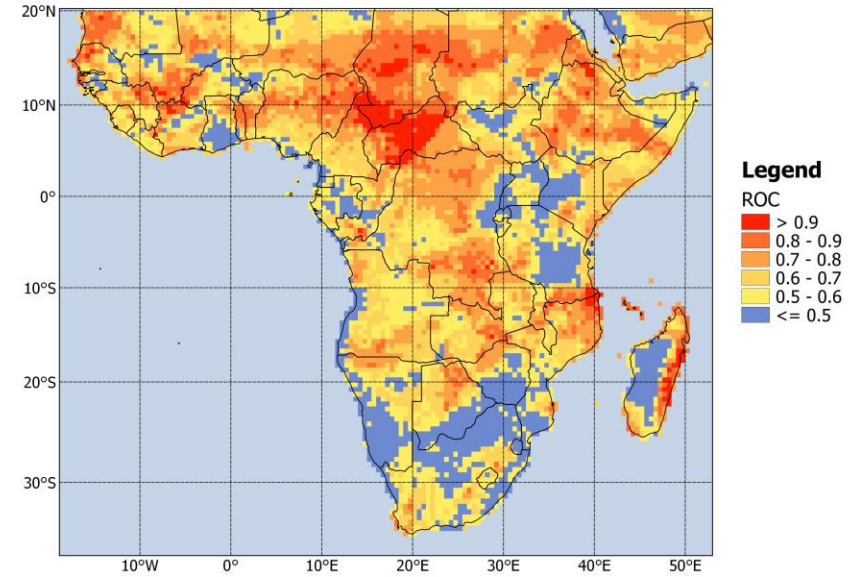
**ROC Area (Below-Normal): JAS Max Temp**

Legend
ROC

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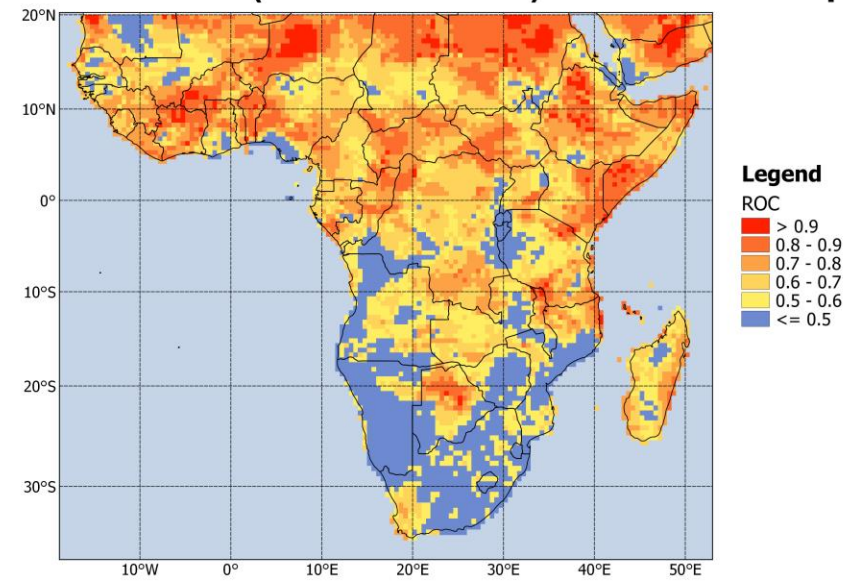
# Round-up: South of 15°S Max Temp

- Enhanced likelihood of warmer than normal maximum temperatures over the entire region is expected during the forecast period

**References**

- Barnston, A.G. and Tippett, M.K., 2017: Do statistical pattern corrections improve seasonal climate predictions in the North American Multimodel Ensemble models? Journal of Climate, 30: 8335-8355. doi: 10.1175/JCLI-D-17-0054.1
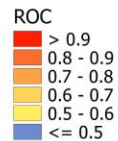
- Harris, I., Jones, P. D., Osborn, T. J., and Lister, D. H., 2014: Updated high-resolution grids of monthly climatic observations - the CRU TS3.10 Dataset. International Journal of Climatology, 34: 623-642. doi: 10.1002/joc.3711

- Kirtman, B. P. and Co-authors 2014: The North American Multimodel Ensemble: Phase-1 seasonal-to-interannual prediction; Phase-2 toward developing intraseasonal prediction. Bulletin of the American Meteorological Society. 95, 585–601. doi: http://dx.doi.org/10.1175/BAMS-D-12-00050.1

- Landman, W.A., and Beraki, A., 2012: Multi-model forecast skill for midsummer rainfall over southern Africa. International Journal of Climatology, 32: 303-314. doi: 10.1002/joc.2273.

- Landman, W.A., Archer, E. and Tadross, M., 2016: Decision-relevant information on seasonal time scales – the case of a farm in northern Namibia. Conference Proceedings of the 32nd Annual Conference of the South African Society for Atmospheric Science, Cape Town, 31 October to 1 November 2016, pp 69-72. ISBN 978-0-620-72974-1.

- Landman, W.A., Archer, E. and Tadross, M. (2019): How costly are poor seasonal forecasts? Peer reviewed abstracts, 35th Annual conference of the South African Society for Atmospheric Science, Vanderbijlpark, 8 to 9 October 2019, pp 60-63. ISBN 978-0-6398442-0-6.

- Landman, W.A., Archer, E.R.M and Tadross, M.A (2020a). Citizen science for the prediction of climate extremes in South Africa and Namibia. Frontiers in Climate, 2:5, doi: 10.3389/fclim.2020.00005

- Landman, W.A., DeWitt, D., and Lee, D.-E., 2011: The high-resolution global SST forecast set of the CSIR. Conference Proceedings of the 27th Annual Conference of South African Society for Atmospheric Sciences, 22-23 September 2011, Hartbeespoort, North-West Province, South Africa. ISBN 978-0-620-50849-0

- Landman, W.A., Sweijd, N., Masedi, N. Minakawa, N. (2020b). The development and prudent application of climate-based forecasts of seasonal malaria in the Limpopo province in South Africa. Environmental Development, 35, 100522, doi: 10.1016/j.envdev.2020.100522.

- Landman, W.A., DeWitt, D. Lee, D.-E., Beraki, A. and Lötter, D., 2012: Seasonal rainfall prediction skill over South Africa: 1- vs. 2-tiered forecasting systems. Weather and Forecasting, 27: 489-501. DOI: 10.1175/WAF-D-11-00078.1

- Muchuru, S., Landman, W.A. and DeWitt, D., 2016: Prediction of inflows into Lake Kariba using a combination of physical and empirical models. International Journal of Climatology, 36: 2570–2581, DOI: 10.1002/joc.4513.

- Troccoli, A., Harrison, M., Anderson, D.L.T. and Mason, S.J., 2008: Seasonal Climate: Forecasting and Managing Risk. NATO Science Series on Earth and Environmental Sciences, Vol. 82, Springer, 467 pp.

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The forecast is produced by Prof Willem Landman of the University of Pretoria, South Africa, and issued on or around the 15th of each month. Please feel free to contact me at WALandman1981@gmail.com

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Disclaimer: The author has compiled this forecast guidance as a service to users for application in appropriate sectors, but cannot be held responsible for inaccuracies contained therein

# Student participation in forecast system development



**Stephanie Hinze,  BSc (Honours)(Meteorology):**
Statistical downscaling using large and high-resolution data sets, forecast displays for SADC rainfall and maximum temperatures, forecast verification



**Surprise Mhlongo,  BSc (Honours)(Meteorology):**
Improving on SST forecast system through pattern correction, correlation vs covariance approaches, forecast output combination (multi-model approaches), mean and bias correction, and correct for skill

**Shepherd Muchuru, PhD (Meteorology):**
Statistical modelling to relate large-scale features to seasonal inflows into Lake Kariba in southern Africa. Two predictions systems: 1) using antecedent seasonal rainfall totals over the upper Zambezi catchment as predictor in a baseline model, and 2) using predicted low-level atmospheric circulation of a coupled ocean–atmosphere general circulation model as predictor.



**Pearl Gosiame, BSc (Honours)(Meteorology):**
Development of hydro-climate predictions models for dam levels and downstream flows of the Vaal Dam. Predictors considered include historical rainfall over the catchment, SST and output from global climate models.

**Idani Mandiwana, BSc (Honours) (Meteorology):**
Seasonal rainfall forecast verification of real-time forecasts produced by SFW over the 5-year period from 2018 to 2022. Area is SADC south of 17° South.