El Niño 2023 Summit Report

Communique: Update on the 2023/2024 El Niño development and retrospective for southern Africa

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1. Context.

1.1 Recap: What is ENSO (El Niño /La Niña)?

El Niño Southern Oscillation or ENSO is a term used to describe the naturally occurring dynamic ocean-atmosphere phases of a significant part of the Pacific Ocean. This dynamic state fluctuates over periods of months along a gradient where the two extreme states are known as El Niño versus La Niña. In essence, El Niño is characterized by warmer-than-average sea surface temperatures in the ocean adjacent to the south-central coast of the Americas, while La Niña is characterized by lower-than-average sea surface temperatures in that same region. ENSO is one of several such ocean-atmosphere "dipoles" that occur around the globe, but its magnitude is such that its state or phase (and intensity) along the gradient has a strong effect on global atmospheric circulation patterns and these are respectively associated with extreme climate events in various locations. For more information see here and here. Statistically, El Niño is associated with warmer and drier than average conditions in the summer rainfall region of South Africa, with the opposite (cooler, wetter than average) during the La Niña phase.

1.2 What's is (was) the 2023/2024 El Niño?

In early July 2023, the World Meteorological Organization officially declared the "onset of El Niño Conditions" – this was a moment (persistent sea surface threshold exceedance) that this year's ENSO phase or state was officially recognized as an El Niño. This was anticipated as early as March 2023 supported by both the observations data and climate models . The current status of this El Niño is provided below.

1.3 ECERA and the El Niño 2023 Summit.

On the 21st of June 2023, a team of experts were assembled under the auspices of the Extreme Climate Events Research Alliance (ECERA) association, in order to share information about the development of the El Niño in the 23/24 season, and to raise awareness of its potential for impact in southern Africa. This was because we have been heading out of a prolonged La Niña phase into this new El Niño phase and given the events of the 2015/16 El Niño and its impact on South Africa, it was deemed necessary to commence with this alert. The presentations and media related to that event can be found here. It was agreed at that meeting that regular updates would be issued during the build-up to and during the southern African summer season.

2. Developments since the WMO El Niño declaration in July.

2.1 The development of the 2023/4 El Niño.

Ongoing monitoring of the El Niño and a wide range of climate metrics have been conducted and data from this season's features relative to other years' seasons are now available. We have now passed the peak of this season, the metrics of the 2023 El Niño show that this season's event, while not as intense as the strongest such events of the past, was within the range of the top four such events recorded in the past. This is illustrated in figure 1 which provides an index of the Sea-Surface Temperature (SST) anomalies for the 8 most intense Los Niños on record.

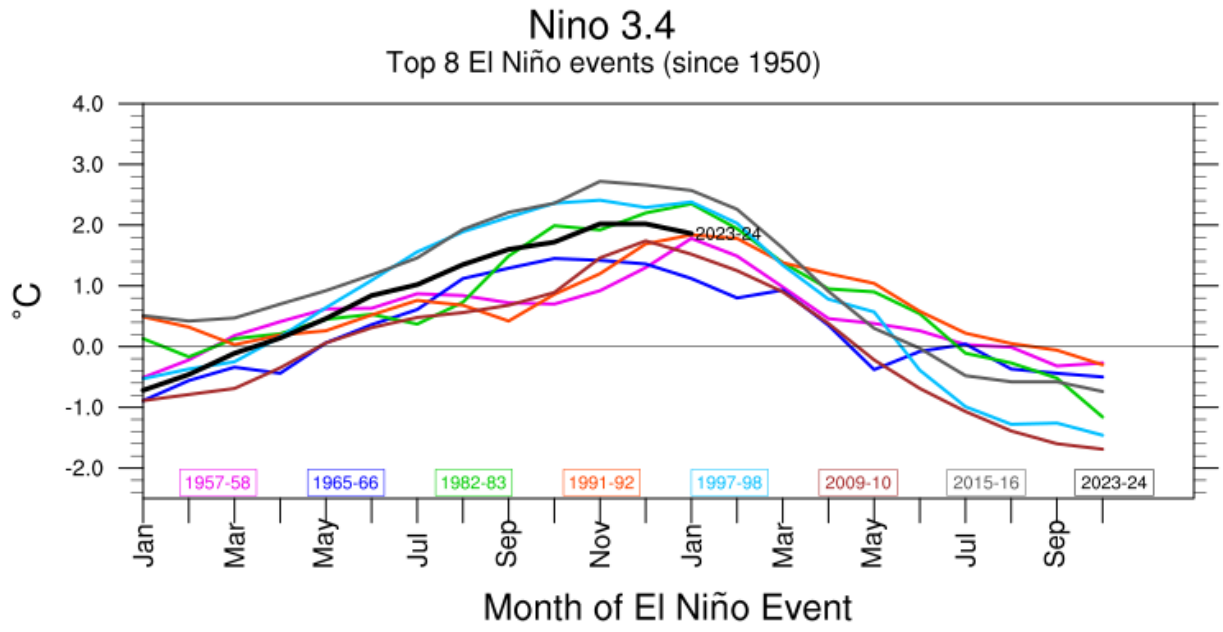


Figure 1: SST anomalies averaged over the NINO3.4 region 5°North-5°South;170-120°West. Calculated from the Monthly NOAA ERSST V5 (at NOAA/CPC). Sourced from NOAA PSL: Visit this website.

2.2 Global Sea Surface Temperatures (SSTs).

The most recent observations of global average SSTs present a different picture, with new records of global sea-surface temperatures well above those previously recorded. The figure below, adapted from Climateanalyzer.org provides a perspective showing the data from 1983 (near the start of the data series), 2013 (to demonstrate the decadal warming trend), 2016 (which was an El Niño year, evident from the early very high SSTs), 2022 which was a La Niña year (i.e. cooler eastern Pacific, yet a relatively high record) and 2023 which shows the record high SSTs. So far in 2024 we are seeing SSTs never before recorded (see figure 2).

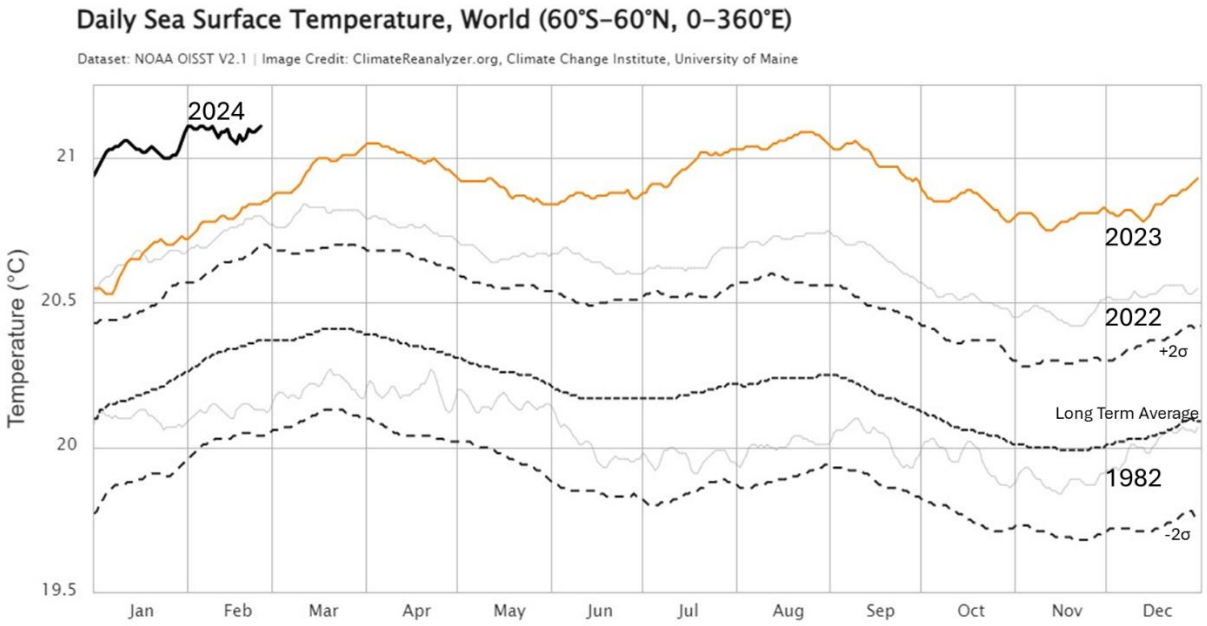


Figure 2: Global average SSTs for selected years showing relative changes and trends. Adapted from Climateanalyzer.org. The bimodal distribution of these data are related to a range of seasonal physical processes.

2.3 Global Atmospheric Temperatures.

Global average air temperatures have also broken records in 2023 and so far in 2024. Most significantly is the fact that the warmest day ever recorded (on average) occurred on the 6th of July 2023, and July and September 2023 are the warmest month ever documented. Figure 3, below, shows long term global average temperature (with 2 standard deviations to show the variability), includes the 1984 plot for reference, and which was a relatively average year, 2016 which was an El Niño year. The inferences from this data are that atmospheric temperatures are rising steadily and even cooler than average SSTs do not offset this trend and that this year's El Niño, in concert with the warming oceans (as evidenced from the SSTs above), are combining to deliver record levels of atmospheric warming.

3. Model projections for the austral seasons.

We re-iterate here that the southern African climate is sensitive to the ENSO signal, but that this is a statistical relationship that is modulated by several phenomena. Hence, in general, the El Niño phase of ENSO is associated with drier and warmer than average summers in the summer rainfall region, and the La Niña phase, which is associated with wetter and cooler summers in the summer rainfall region. The degree of this departure from normal is not always associated with the strength of the ENSO signal. While this season's El Niño is now waning, early signs of a La Niña are appearing in the seasonal forecast models (figure 4). While it is early to conclude confidently, these are signs that a climate mode change to neutral or La Niña conditions are developing.

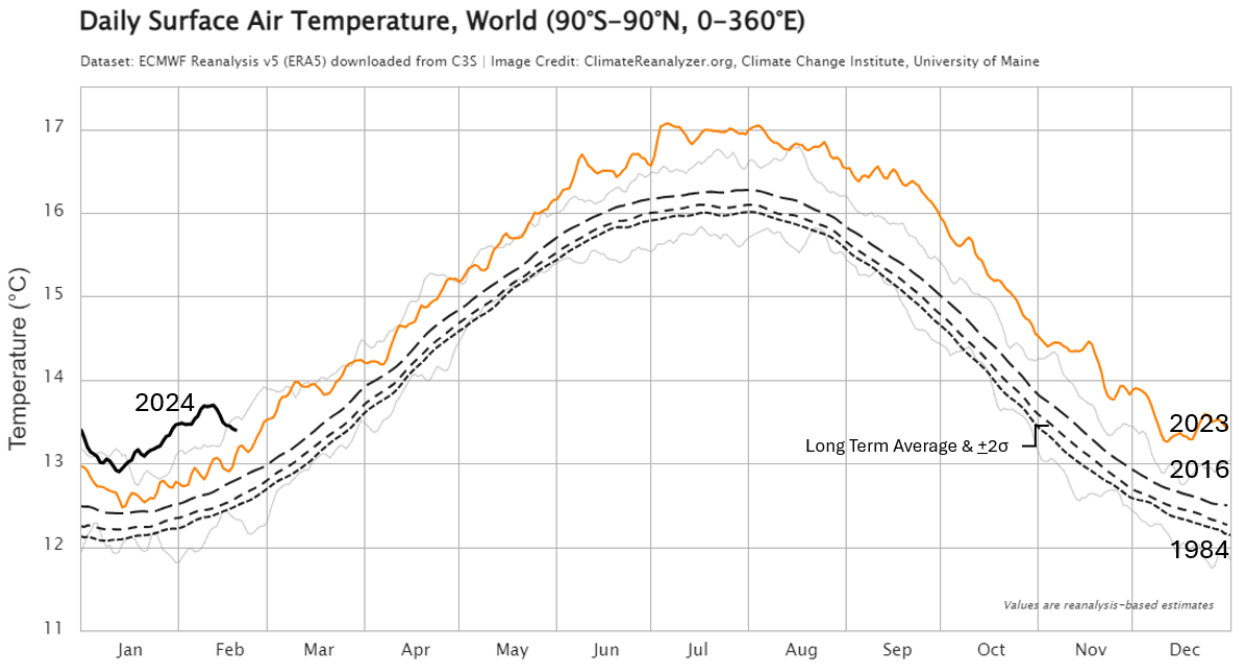


Figure 3: Global average daily surface temperatures for selected years showing relative changes and trends. Adapted from Climateanalyzer.org. The shape of the curve is driven by the fact that there is more land in the Northern Hemisphere whose summer months are June, July and August.

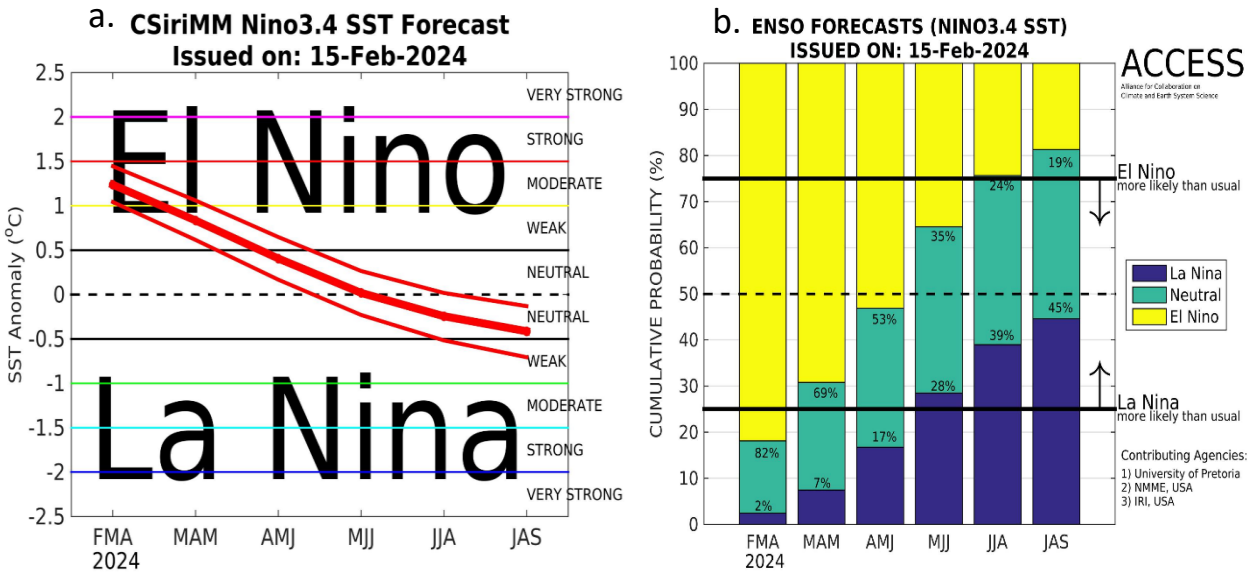


Figure 4: University of Pretoria ENSO forecast model projects for ENSO outlook in 2024. The model shows SST anomalies cooling toward the boreal summer months and tending to La Nina like conditions with the probability index (b) reflecting these conditions. Credit Professor Willem Landman (https://www.facebook.com/ForecastProf).

4. How severe was the 2023/24 El Niño?

In retrospect, El Niño did display some of the typical features of impact on our climate with a somewhat drier rainy season and much warmer summer season relative to the long-term average. The manifestation of this was not as severe as similar events in the past and due to the previous years' good rain (La Niña years), there was sufficient water storage to offset any impact of the drying. Nevertheless, there was a discernable impact on dam levels during this period.

Rainfall.

Rainfall as a percentage of long-term average was cumulatively lower for the NDJF period (fig.5). This is typical of El Niño patterns. The departure is not as severe as in some other previous Los Niños and the region did experience patches of good rainfall within the summer period.

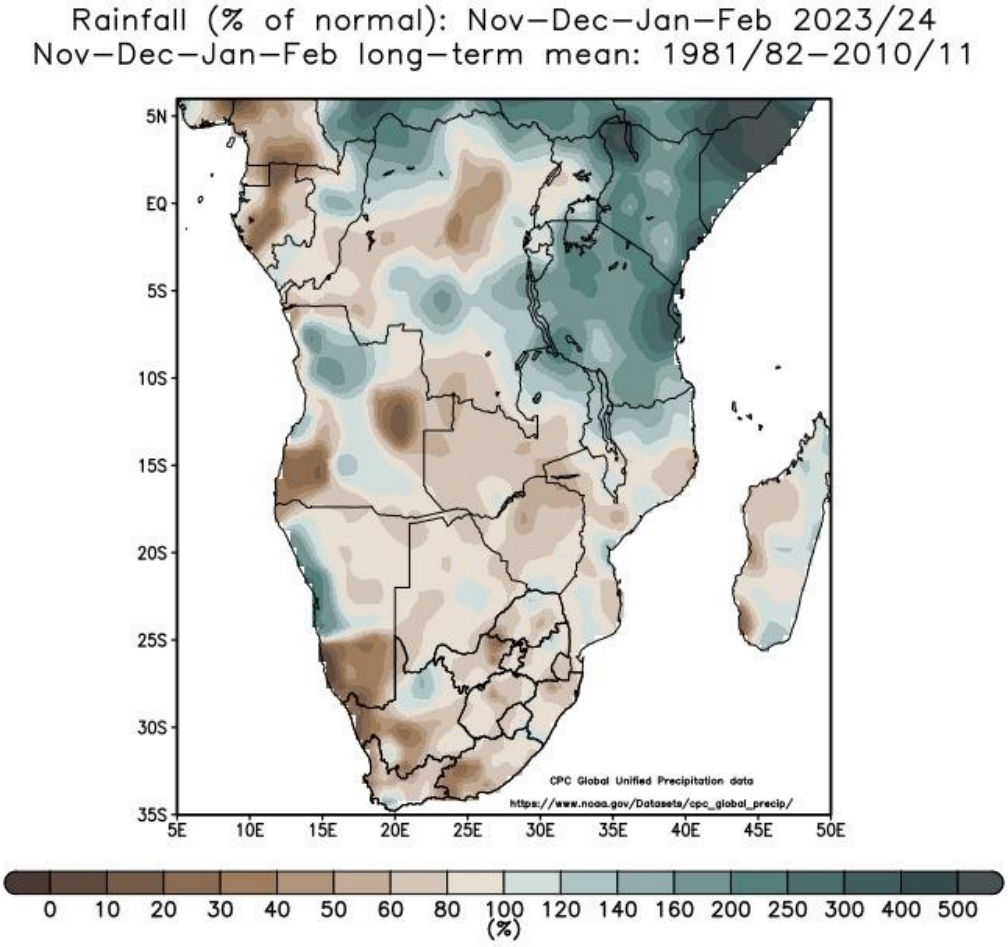
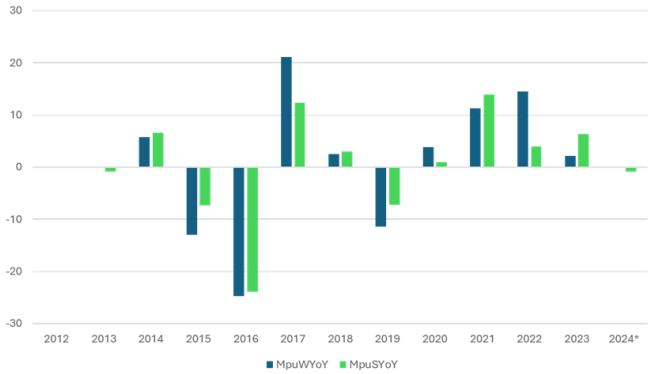


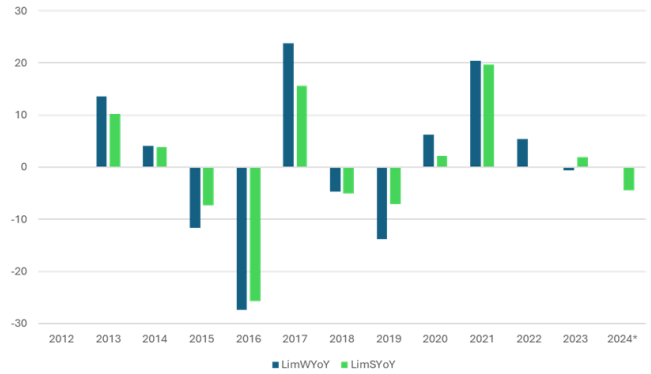
Figure 5. Composite distribution of the rainfall anomaly for the of the summer season. Supplied by Dr Christien Engelbrecht, SAWS.

Dam levels.

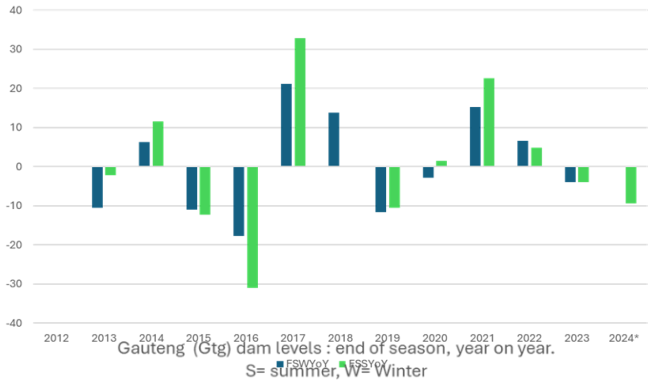
Mpumalanga (Mpu) dam levels : end of season, year on year.
S= summer, W= Winter



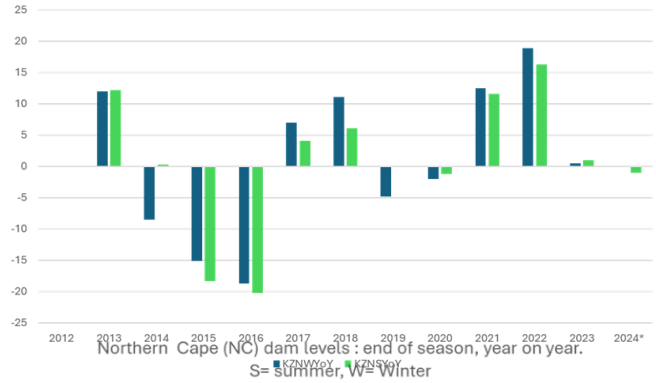
Limpopo (Lim)dam levels : end of season, year on year.
S= summer, W= Winter



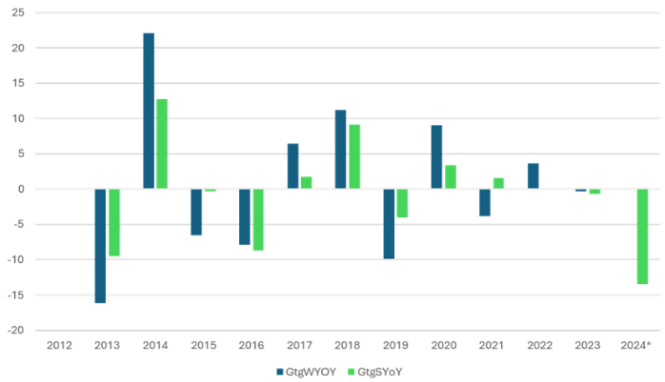
Free State (FS) dam levels : end of season, year on year.
S= summer, W= Winter



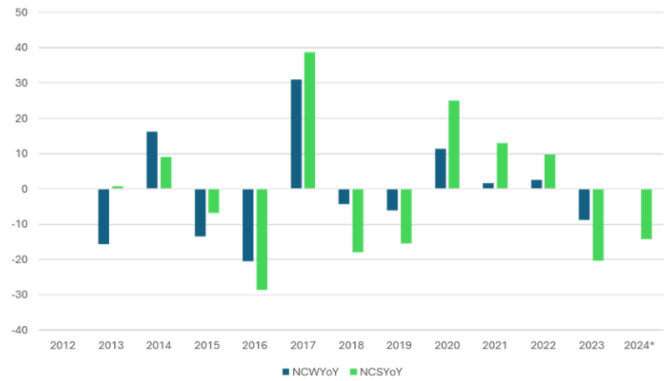
Kwazulu- Natal (KZN) dam levels : end of season, year on year.
S= summer, W= Winter



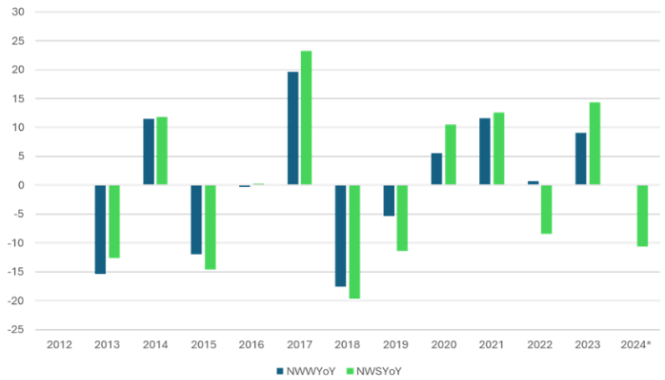
Gauteng (Gtg) dam levels : end of season, year on year.
S= summer, W= Winter



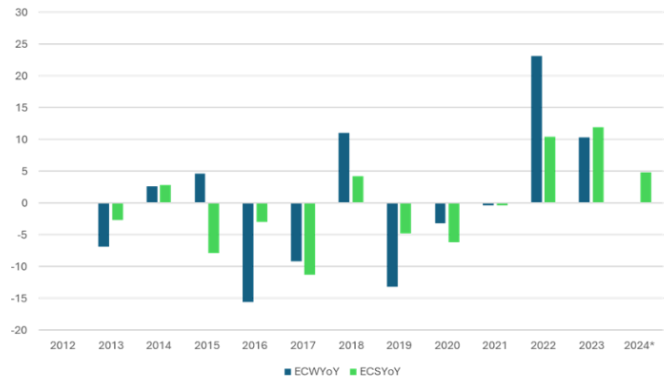
Northern Cape (NC) dam levels : end of season, year on year.
S= summer, W= Winter



North West (NW) dam levels : end of season, year on year.
S= summer, W= Winter



Eastern Cape (EC) dam levels : end of season, year on year.
S= summer, W= Winter



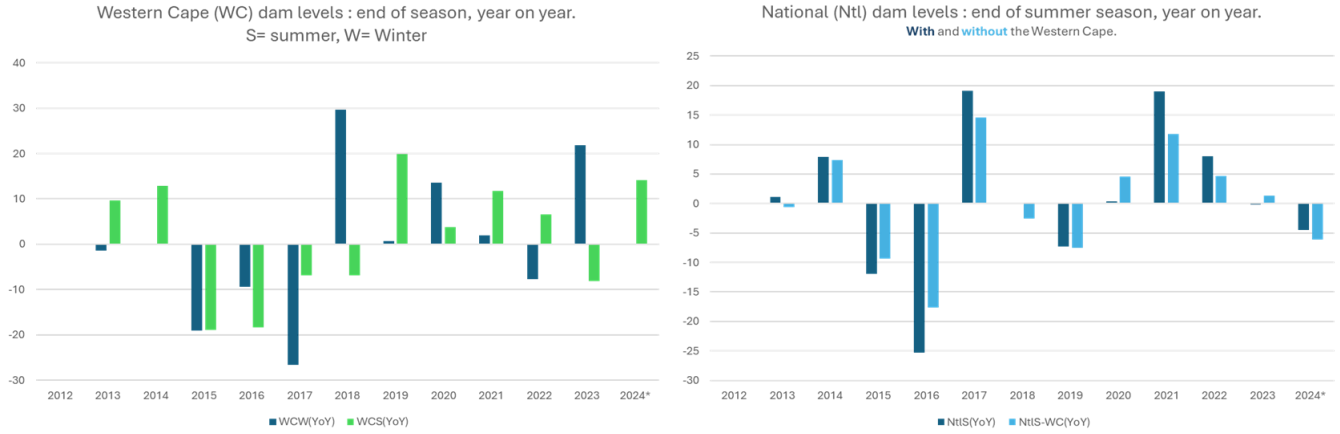


*Figure 6 comprises 10 panels, one for each province and one for the national average across provinces (with the Western Cape included and excluded). The values are the percentage difference, year-on-year, in dam level % fullness, measured on the last day of March (summer season) or September (winter season) to date. *2024 data extends to the end of February.*

Here we consider how the 2023/24 El Niño impacted water security in the country. Dam levels provide an integrated assessment of water inflow and outflow, and given that water use patterns are relatively consistent, the rainfall will have a greater influence on % standing capacity. Here we assume that, at the end of a rainy season, dams are relatively fuller due to greater inflow, and relatively emptier due to lower inflow during any given drier season.

Figure 6. compares the difference in % capacity of the dams by province for all provinces between 2013 and 2024 (up to end of February 2024). The values represent the percentage change in dam levels by province, year-on-year for that season (summer or winter) taken as the % of capacity at the end of the season either September for winter (compared to the last September) or March (compared to the last March) for summer, except for 2024 where the data set extends up to the end of February (compared to the end of March 2023).

What is evident in these data is:

- The 2015/16 El Niño is clear in the seasonal comparisons for all provinces,
- 2015 and 2016 were relatively “emptier years”, and the 2015/2016 El Niño was preceded by a drier than average year,
- The La Niña years (2021-2023), albeit that this manifested differently in the respective provinces, generally resulted in fuller dam levels at the end of the seasons,
- The distinct pattern of the Western Cape where the “Day Zero Drought” persisted between 2015 and 2018 and the very wet winter of 2023 having replenished dam levels,
- The effect of the 2023/24 El Niño is evident in the summer rainfall provinces, with almost all provinces (bar the Western Cape and the Eastern Cape) showing emptier dams at the end of this summer season, relative to that at end of summer in 2023.
- As a whole the country’s dams, excluding the Western Cape which has winter rainfall), are ~6% emptier at the end of February 2024, than they were at the end of summer in 2023. (~4% emptier if the Western Cape is included).

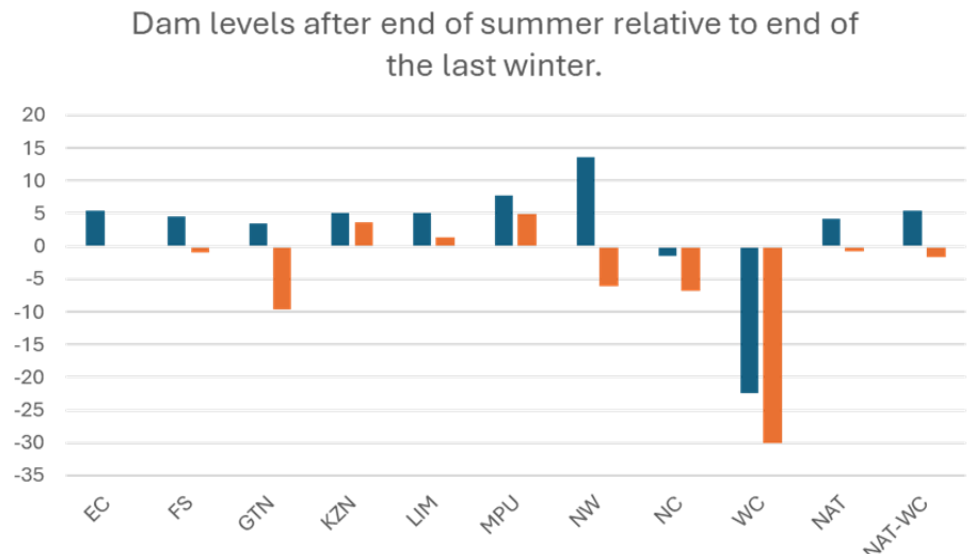


Figure 7. Relative difference in dam levels, by province, end of summer compared to the end of the last winter, for 2023 and 2024.

Figure 7 shows relative dam fullness during summer for 2023 (La Niña year) versus 2024 (this last El Niño season). The values are calculated by subtracting the % fullness at the end of the winter season, from that at the end of the summer season. A positive value means that the dams were fuller at the end of the summer than the end of the winter/ beginning of summer (which is anticipated for summer rainfall areas), and a negative value means the dams were emptier than that of the beginning of the season. The results show that for all provinces (bar the Western Cape and the Northern Cape) dam levels increased during the summer of 2022/23 whereas in several provinces the lower levels of summer rainfall in 2023/2024, resulted in either a lower positive dam levels (than in 2023) or a negative dam levels, relative to that at the start of the rainy season. The Western Cape differs due to its rainy winter season and hence one expects lower levels of the dams after the summer relative to the winter.

In summary then, while the country had healthy water reserves from the good rain received in the preceding La Niña years, the El Niño of this season (23/24) was associated with a measurable negative effect on the state of the countries stored water reserves. The impact of this was offset by the healthy reserve and that the season was not exceedingly dry (as in previous events), and in fact rain did fall consistently throughout the period.

Temperatures

This summer season has been notably warmer than the long-term average in terms of both minimum temperature, maximum temperature and number of heat wave days. It is apparent in figure 8 that November and February were months that experienced the highest number of heat waves in excess of the average number, and that these were located in the central, northeast and north of the country whereas in January these occurred more in the southwest.

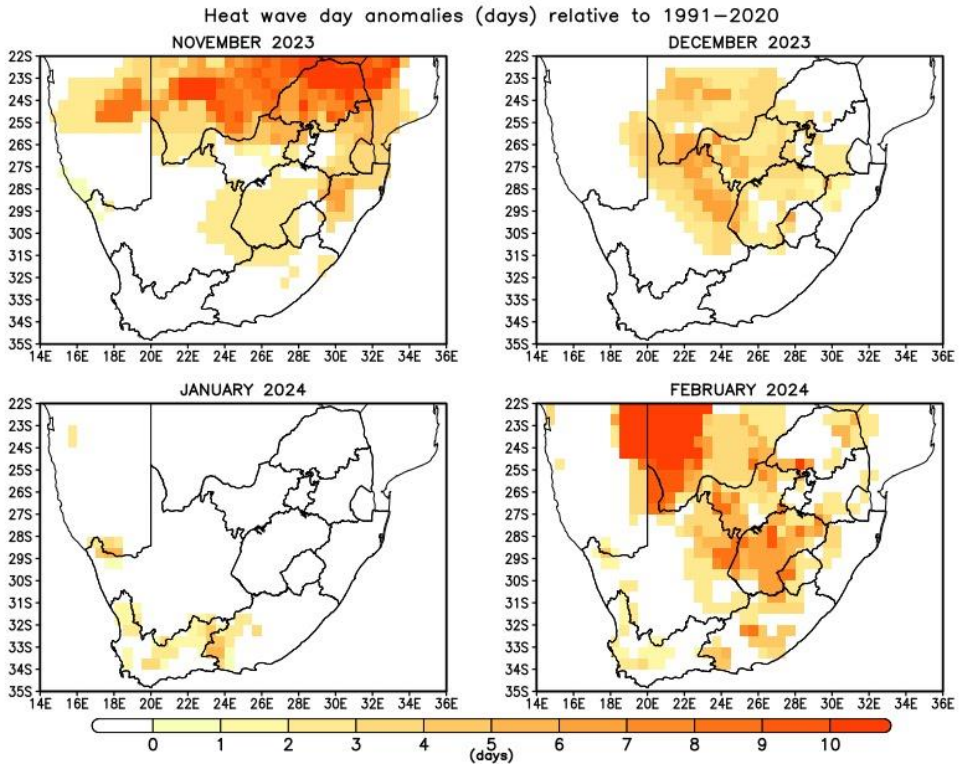


Figure 8: Heat-waves-days distribution, in time and space, as the number of days in excess of the long-term average number of heat waves days.

*F*igure 9 gives the minimum and maximum temperature anomalies for the NDJ part of the season. Interestingly the minimum temperatures were less anomalous than the maximum temperatures.

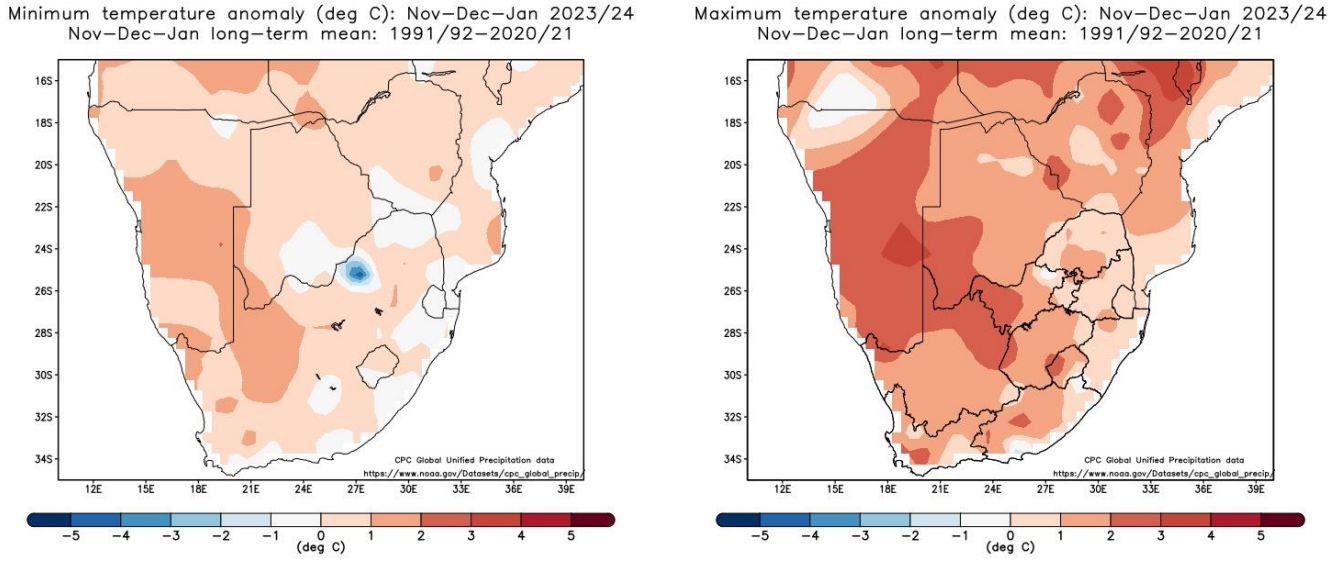


Figure 9: Composite minimum and maximum temperature anomaly for NDJ 2023/2024

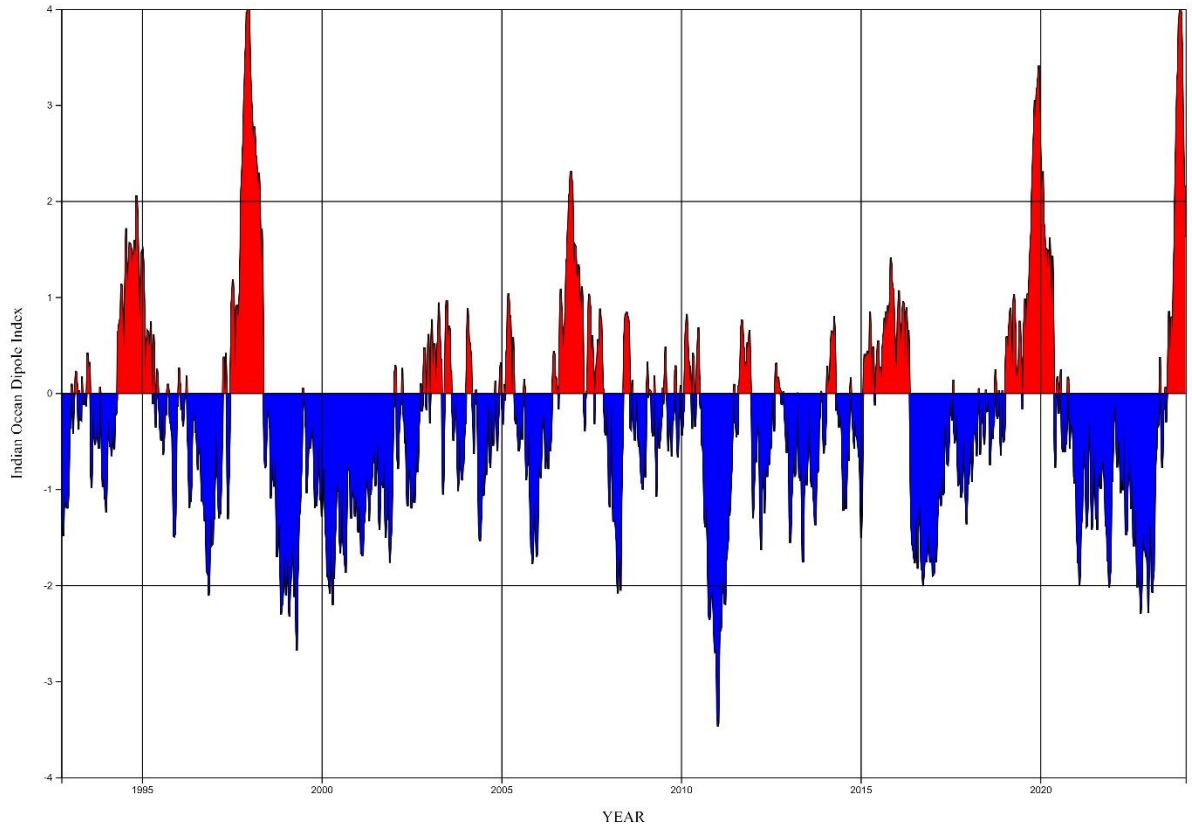
Crop production estimates

These hot and dry conditions over large parts of the interior since mid-January, and still continuing into March, are having a significant negative impact on summer crop production. According to the the latest estimate by the National Crop Estimates Committee was issued on the 28th of February. National production for Maize was estimated at ~13% less than last year and expected production of soybeans saw a ~23% reduction relative to 2023. A subsequent continuation of hot and dry conditions are leading to further reductions in the size of the expected crop. Regionally, grain crops in Zambia and Zimbabwe were also hit hard by hot and dry conditions. The regional effect of the El Niño related drought, will likely impact food security and the grains trade in the region.

In summary then, the 2023 El Niño is associated with typical El Niño conditions, namely warmer and drier than the long-term average. In terms of rainfall the impact seems to have been mild to moderate. In terms of temperature, the impact is not assessed here.

4. Indian Ocean Dipole considerations.

Similar to the El Nino, the Indian Ocean Dipole (IOD) is an area of the Indian Ocean that oscillates between phases of differing regions of warmer or cooler SSTs, in the eastern and western regions of the Indian ocean respectively. This system affects tropical circulation patterns in the Indian ocean rim and, in addition, has an effect on weather patterns in Southern Africa. It is less well studied relative to ENSO and its interaction with ENSO is also less well understood. The IOD has also peaked since our last report and is still in its positive phase.



6. Take home message.

- The 2023/204 El Nino was one of the top 5 strongest on record.
- The region experiences a moderately drier year in the summer rainfall region of South Africa, the impact of which was offset by previous wet seasons.
- Overall dam levels are around ~6% emptier than they were this time last year.
- Crop production estimates in the region are lower in 2024 than they were in the last season.
- Heat levels were significantly higher than the long-term average.
- Conditions are moderating and early signs of a La Nina season are appearing in the forecast models.

7. So what now and what next?

- It is clear that Climate Change is manifesting in new climate and weather records and extreme events and that this is no longer to be regarded as a future threat – it is here and now.
- We will consult with experts in various fields to understand the system dynamics that explain the evolution of ENSO impacts in Southern Africa as well as model uncertainty and report accordingly when later model runs have been completed.
- The ECERA team will continue to monitor both the international scientific reporting and local climate observations and monitor the dynamics and signals of ENSO events in the future.

For further information please contact Dr Neville Sweijd (nsweijd@access.ac.za).
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