Unusual rainfall in northern Africa signs of a changing climate?

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Over the past months, multiple news articles have been published on unusual rainfall events and patterns in northern Africa, specifically in the Sahel and Sahara regions. From beautiful photos of pristine blue lagoon-like ponds amidst red sand dunes to reports of devastating floods killing hundreds to thousands across the Sahel region, it is clear that the 2024 rain season in the Sahel region is an unusual one. Below, I will describe some of the specific events, the mechanisms behind the rain season in northern Africa and the likely effect climate change will have on it. Long story short, the 2024 rain season might be a sneak preview into the not-so-distant future.

Extreme rainfall events and its impact

To start with the latest, last week heavy rainfall in the southeastern Morocco desert gave spring to lakes between the desert sand dunes on places were no lakes have been seen for 30 to 50 years (see top picture, source: **Al Jazeera**). One month ago, a similar event happened in the same region when multiple widespread lakes became visible on NASA's satellite imagery (source: **NASA**). In the same event one month ago, the Sahara desert in south Libya – regarded as one of the driest places on Earth – received severe rainfall and thunderstorms, something that "has not occurred for at least 100 years" in that region (source: **ArabiaWeather**). But besides this being meteorologically very interesting and photographically stunning, the extreme rainfall that led to the formation of these lakes also killed more than 20 persons in Morocco and Algeria.

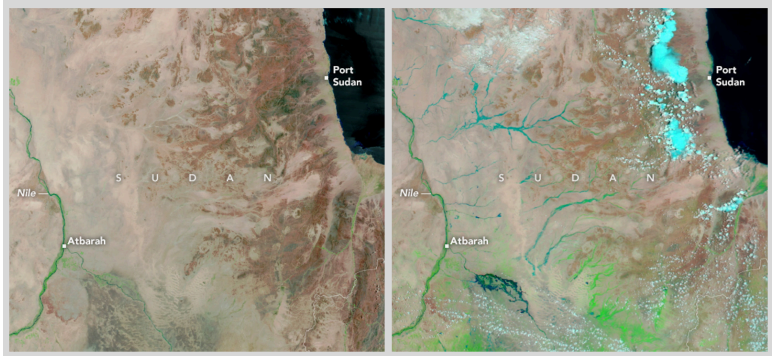

Figure 1 - MODIS satellite images of northeast Sudan prior to (left, 9 July 2024) and after (right, 31 August 2024) extreme rainfall events. Water (blue) and vegetation (green) are clearly seen in the August image. Source: NASA Earth Observatory.

Unfortunately, such casualties is a red threat through most news from these regions: anomalous extreme rainfall causes widespread flooding, leaving millions displaced, damaging large areas of cropland and claiming hundreds of victims across the Sahel region. In August, heavy rainfall hit northern Sudan – normally a dry region – resulting in a dam overflowing, and eventually collapsing, close to Port Sudan, killing at least 148 people (source: **The Guardian**). The two satellite images above (Figure 1) show the distinct formation of widespread lakes and rivers across eastern Sudan (source: **NASA**), similar to those in Morocco last week.

In the first half of September, a vast area across Chad, Niger, Nigeria, Burkina Faso and Mali received anomalous large amounts of rainfall during several weeks resulting in widespread flooding across those countries. In total, hundreds of people were reported killed and in Niger alone 1.1 million people were displaced (source: **France24**). According to FEWS (Famine Early Warning System), the wet conditions resulted in more than 2 million hectares of flooded cropland (source: **reliefweb**), an area similar in size to countries such as Rwanda or Slovenia. And just recently, the Logone river bordering Cameroon and Chad was reported to be at its highest level in 30 to 40 years, indicating potential new floods (source: **Reuters**).

The driver: African monsoon

Some meteorological background. The major driver behind the seasonal rains in Africa is the InterTropical Convergence Zone (ITCZ). This band of clouds and thunderstorms encircles the globe near the equator and moves up and down between 15°N and 15°S based on the position of the sun. In northern-hemisphere summer (Jun-Aug), it is positioned over the Sahel region, while in southern-hemisphere summer (Dec-Feb) it can be as south as Zimbabwe. Therefore, some areas near the equator receive a dual rain season, as the ITCZ passes over twice per year, while regions towards the fringes have only one distinct rain season, like in the Sahel.

Depending on various climatic variables, such as sea surface temperatures across the globe, El Nino (ENSO), atmospheric oscillations (e.g. MJO), and land use changes, the timing, strength, and duration of the rain season varies from year to year. The influence and impact of these variables is not fully understood, making it difficult to monitor and forecast the rain season correctly. A more detailed description of the African rain season, its variability, and how we forecast it at **Weather Impact** was written a while ago by my former colleague **Fiona van der Burgt**, please find it here: **Forecasting the start of the rain season**. At the moment, Weather Impact develops and tests an operational algorithm to monitor and forecast the status of the rain season for Ghana on a daily basis: see **our website**. When sufficiently evaluated, this will be scaled to other countries across the Sahel and Africa.

Indicated by the recent events described above, the current rain season in the Sahel is stronger in most of the region and extended much more northward than its climatological average. In mid-September, it extended 1.5°-3.0° latitude more northerly than normal (source: **NOAA/CPC**), corresponding to roughly 150-300 km. And although that does not sound extreme on continental scales, it is for sure significant given that annual average rainfall in the Sahel decreases with more than 100 mm per 100km northward. For example, the rainfall difference between northern Ghana and northern Burkina Faso is ca. 600 mm/yr over a distance of less than 500 km. One way to look at rainfall anomalies is using SPI, the standard precipitation index, a measure for how (ab)normal rainfall over a past period, usually 30, 60, or 90 days, has been. In Figure 2 below (**source**), it is very clear that over the past 2 months the entire Sahara and Sahel regions have been much wetter (blue colours), while the areas south of it, such as

the coastal areas of West-Africa (Ghana, Cote d'Ivoire), have been slightly drier than normal (yellow/red colours). The latter is the logical effect of the ITCZ rain band moving more northerly thereby leaving other regions with less rain than normal.

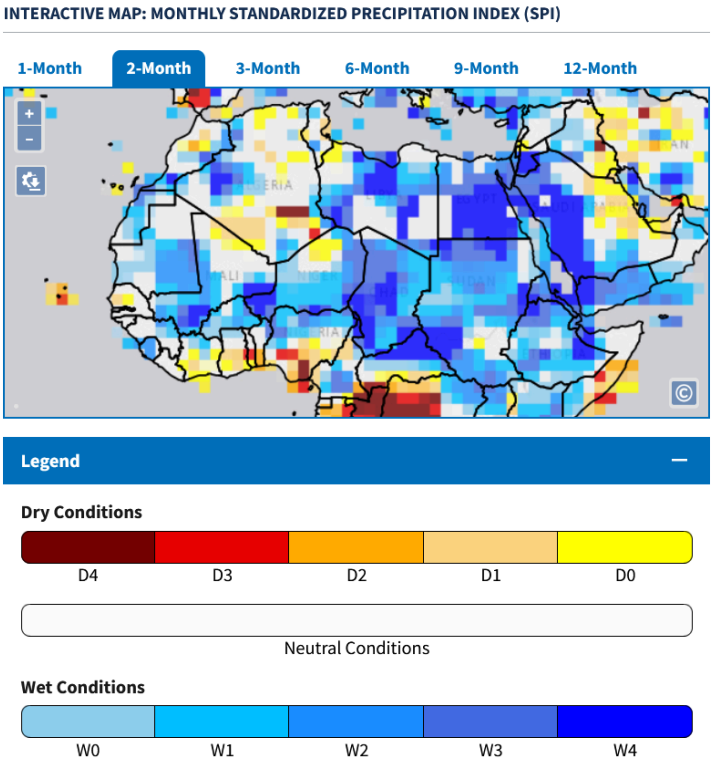

Figure 2 - Standard Precipitation Index (SPI) of northern Africa on 9 October 2024 showing the observed rainfall anomaly over the past 2 months. Colours indicate wetter/drier conditions than normal. Source: GPCC, screenshot of NIDIS drought website.

Effect of climate change

The obvious question that arises with all weather extremes nowadays is: is this related to climate change? The answer to that is not simple and I do not pretend to know at this point. Hopefully, the experts of World Weather Attribution might be able to say something about this at the end of the season. However, the pattern of a northward shift of the African rain season is an effect of a warming climate that is simulated by CMIP6 climate models. When looking at the well-known IPCC figure with forecasted change in climate average precipitation on global scale (Figure 3 below), it is one of the things that stands out: a large green area over the Sahel and Sahara, which extends over the Middle East and India as well. Other clear signals are, for example, a much drier Mediterranean region, wetter polar regions, and drier southern Africa. Of course, more rain in one place means less rain in others...

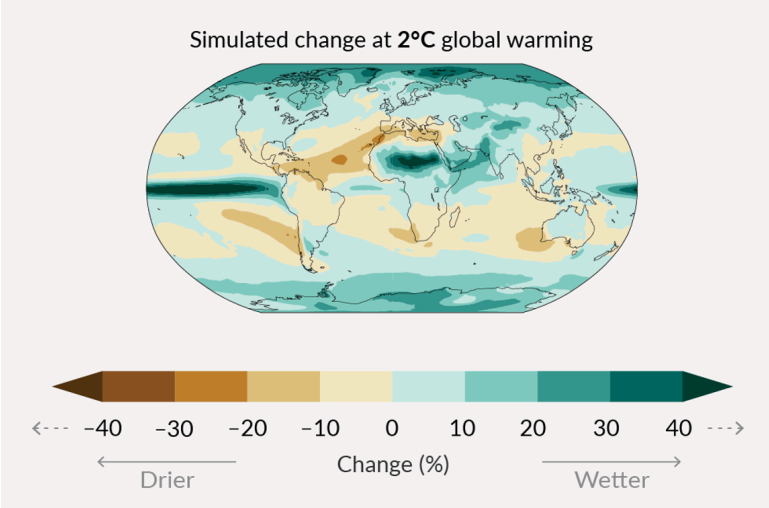

Figure 3 - Simulated change in future precipitation (in %) for +2°C global warming, where blue/green is wetter and yellow/brown is drier than historical climate. Figure adapted using Figure SPM.5c from IPCC, 2021.

It appears that a major driver of changes in the Sahel rainfall patterns are the sea surface temperatures surrounding North Africa, the north Atlantic Ocean and specifically the Mediterranean Sea (Park et al., 2016, Schwebe and Levermann, 2022). Due to warmer seas, the existing atmospheric circulation changes and one posed hypothesis is that a warmer Mediterranean Sea leads to a northward shift of the Sahara Heat Low pressure system, thereby intensifying northward flow over the Sahel – basically generating space for the rain season to move further north (Monerie et al., 2023). With the Mediterranean Sea temperatures at a record high in 2024 (source: **France24**), this seems a plausible explanation. And although n=1 in this case, the resemblance between the IPCC simulated figure and observed SPI values (Figures 2 & 3) is striking.

Nevertheless, the climate is warming rapidly – and will continue to do so for some decades – with the oceans and Mediterranean Sea following, making it likely that this year's anomalous rainfall pattern over northern Africa might be a sneak peak into the future. And since climate change is here and now already occurring, this future might be not so distant. I hear people thinking: well that is a good thing, right, more rain in the Sahel makes more land suited for agriculture in an area renown for its droughts and famines? Yes, this is true, on the long term. With a more northward rainfall pattern, the northern Sahel will likely become greener and more livable with time. However, the way towards there might be littered with floods and disasters like this year. The current semi-arid land is not capable of handling heavy rainfalls, leading to water that quickly runs off into rivers that are also not made for such rainfall amounts, nor human-made nor nature-made. So if the African rain season will shift more northerly bringing more rain to the Sahel, substantial climate adaptation measures are essential during the next decades to guide this well.

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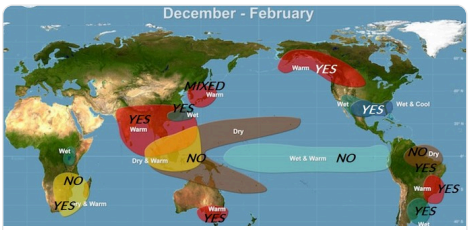

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