The highest amounts of rainfall during July - September 2021 were detected in the Blue Nile Subbasin. High rainfall was generally recorded in Tekeze Atbara, Baro Akobo Sobat, Bahr el Jebel, and Bahr el Ghazal, subbasins.

Satellite observations detected highest amounts of ET in the Bahr el Jebel subbasin around the sudd and Baro Akobo Sobat subbasin. The highest evaporation over the large lakes was over Lake Naser during July and August.

Height variation charts show a sharp rise of water levels in Lake Tana. Lakes heights in the Equatorial region are observed to show high water levels compared to long term average.

Nile-SEC added for the first time the surface water dynamics in the Nile Basin.
The River Nile Basin covers about 3,176,541 square kilometers, which represents about ten percent of Africa’s land mass area. The river presents an array of opportunities for a sustainable future. This can only be realized if riparian countries can jointly plan, manage and develop the shared resources in a coordinated manner. Since time immemorial, the river plays a central role in human settlement and in the development of a rich diversity of cultures and livelihoods. The basin includes world class environmental assets such as River Nile being the longest river in the world, Lake Victoria being the second largest fresh water lake by surface area; and the Sudd wetlands in South Sudan being one of the largest in Africa.

The Nile basin region is a land of increasing population and rapidly changing land use patterns; changes that have profound local, regional and global environmental significance. In addition, the region experiences diverse climatic conditions which result in changes in seasonal and annual flows of the river. Monitoring of such processes is a pre-requisite to sound water resources management.

It was with this realization that the Nile Basin countries established the all-inclusive Nile Basin Initiative (NBI) on February 22, 1999 with the shared vision objective: ‘To achieve sustainable social economic development through the equitable utilization of, and benefit from, the common Nile Basin water resources.

According to its 10 year Strategy (2017-2027), NBI aims at strengthening evidence-based transboundary water resources planning and management through improved monitoring of the Basin using satellite observations.

The NBI in collaboration with its member states has designed a regional Hydro Meteorological monitoring system to enhance basin monitoring. In addition, use of satellite data has been identified as one way of supplementing the existing monitoring system.

This Basin Monitoring bulletin aims at providing a shared understanding of patterns of some of the water cycle components in our changing environment based on satellite data. Estimates of water cycle parameters provide insights on available opportunities for water use, water conservation and thereby enhance water use efficiencies.

This issue provides an analysis of Rainfall, Actual Evapotranspiration, and Runoff in the 10 major sub-basins compare to the long term average of 1981-2020, and an analysis of Water levels in some large lakes during 2021 as compared to the long term average of 1992-2020.
Rainfall in the Sub-basins of the Nile Basin has been estimated using CHIRPS v2.0. Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) is a 40+ year quasi-global rainfall dataset. Spanning 50°S-50°N (and all longitudes), starting in 1981 to near-present, CHIRPS incorporates 0.05° resolution satellite imagery with in-situ station data to create gridded rainfall time series for trend analysis and seasonal drought monitoring. By combining high resolution (0.05°) rainfall mean fields with current satellite-derived rainfall estimates, the Climate Hazards Group InfraRed Precipitation with Stations (CHIRPS) estimates provide daily, pentadal (5-day), decadal (10-day), and monthly precipitation fields suitable for crop monitoring and drought monitoring.

Monthly distribution of rainfall over the basin is characterized by monomodal rainfall patterns (June-July-August (JJA)) in the Ethiopian plateau especially in the Blue Nile and Tekeze sub basins and bimodal rainfall pattern (March-April- May (MAM) and September- October- November (SON) in the equatorial lakes region especially in the Lake Victoria, Lake Albert, Victoria Nile sub-basins. Overall, monthly rainfall estimates within the year indicate wide spatial and temporal rainfall variability in the basin. Minimum rainfall is normally seen in the arid areas in the northern part of the basin and the maximum rainfall estimates are normally observed in the equatorial lakes region in the areas around Lake Victoria and the Ethiopian Highlands.

During July to September 2021, the Nile Basin received rainfall in the Eastern Nile region especially in the Blue Nile and Tekeze Atbara sub-basins in July and August. In the Equatorial Lakes region the amount of rainfall is recorded was less significant. A full analysis of how much rainfall was detected in each subbasin is given in this bulletin. The map below gives an indication of how rainfall was distributed over the reporting period.

![Monthly Rainfall (mm) July - September 2021 CHIRPS v 2.0](https://earlywarning.usgs.gov/fews/datadownloads/Global/CHIRPS%202.0)
Rainfall over Lake Victoria subbasin

The Lake Victoria subbasin normally experiences a bimodal rainfall pattern with two rain seasons MAM and SOND. During July to September 2021, the basin was experiencing a dry season after the end of the MAM rain season. A slight decrease in rainfall is detected in July by 19.2%, and a slight increase in August by 9.06% and in September by 22.86% compared to the long term average of 1981-2020.

![Rainfall in the Lake Victoria Subbasin (July - Sep 2021) Compared to the Long term average](chart)

Rainfall over Lake Albert subbasin

Lake Albert subbasin normally experiences a bimodal rainfall pattern with two rain seasons in MAM and SOND. Highest rainfall during July, August, and September was detected in September with almost similar values as the long term average. In July a reduction of 20.2% was recorded as compared to the long term average and in August a reduction by 8.9% compared to the long term average of 1981-2020 was recorded as shown in the chart below.

![Rainfall over Lake Albert Subbasin (July - Sep 2021) Compared to the Long term average](chart)
Rainfall over Victoria Nile Subbasin

The Victoria Nile subbasin, like the other Nile Lakes Equatorial sub basins, normally experiences bimodal rainfall seasons of MAM and SON with June to August and January and February as the dry months. Rainfall was detected during this season, with the highest amount recorded in September by 13.3% higher than the long term average. The month of July experienced less rainfall compared to the long term average by 29.2%. August experienced less rainfall by 9.3% as compared to the long term average of 1981-2020 as shown in the chart below.

Rainfall over Bahr el Ghazal Subbasin

Bahr el Ghazal normally experiences a monomodal rainfall pattern during May to October. During the reporting period, the subbasin received more rainfall during July as compared to the long term average. The highest amount of rainfall was recorded in August 2021 and was less than the longterm average by 15.1%. Increasing rainfall was detected during July by 8.3% and September was almost similar compared to the long term average of 1981-2020 as shown in the chart below.
Rainfall over Bahr el Jebel Subbasin

Bahr el Jebel subbasin normally experiences a monomodal rainfall pattern that is registered between May and October. In July to August 2021 the subbasin was experiencing a drier season compared to the long term average. The highest recorded rainfall was in September by 14.8% above the long term average. In July there was a decrease in rainfall by 7.9% and decrease of 18.6% in August as compared to the long term average of 1981-2020.

Rainfall over Baro Akobo Sobat Subbasin

The Baro Akobo Sobat subbasin normally experiences a monomodal wet season between May to October. During July to September 2021, highest amounts were detected in September and this was more than the long term average by 25.6 % as shown in the chart below. Almost similar rainfall was recorded in July compared to the long term average. In August there was a decrease in rainfall by 11.6% as compared to the long term average of 1981-2020.
Rainfall over White Nile Subbasin

The White Nile subbasin normally experiences a monomodal pattern from May to October. This subbasin covers parts of north-eastern South Sudan, a small part of south western Ethiopia and the south part of Sudan. Rainfall gets reduced downstream the basin. During July to September 2021, highest rainfall was detected in August and higher by 3.5% than the long term average. July and September recorded more rainfall by 8.1% and 5.3% respectively compared to the long term average of 1981-2020 as shown in the chart below.

Rainfall over Blue Nile Subbasin

The Blue Nile Subbasin is shared between Sudan and Ethiopia and experiences monomodal rainfall from May to October. As you move downstream into Sudan, the amounts recorded diminishes almost registering rainfall only in the wet season and nothing in the remaining part of the year but with the same rainfall pattern. During July to September 2021, highest rainfall was detected in July and was higher than the long term average by 14.9%. During the wet season, rainfall recorded in August was more than the long term average by 4.2% and that in September was higher than the long term average of 1981-2020 by 4.9% as shown in the chart below.
Rainfall over Tekeze Atbara Subbasin

The Tekeze Atbara subbasin is shared by Ethiopia and Sudan and normally experiences a monomodal rainfall pattern with the wet season normally experienced between June and September. During July to September 2021, the subbasin experienced rainfall higher than the previous quarter. Rainfall was recorded highest during July and higher than the long term average by 19.5%. In August, rainfall was higher than the long term average by 2.6% and in September the rainfall was higher than the long term average by 31.7% compared to the long term average of 1981-2020 respectively.

Rainfall over Main Nile Subbasin

The Main Nile subbasin experiences the driest climate over the entire Nile Basin with very little rainfall amounts recorded mainly in July and August. During July to September 2021, rainfall was recorded highest during July and above the long term average by 68.1%. In August rainfall was almost similar compared to the long term average of 1981-2020 and in September the rainfall was almost around 5 mm.
Seasonality in the Nile basin region is determined by the position of the Inter tropical convergence Zone (ITCZ) with moisture sources from the Indian and Atlantic oceans. The Nile Basin normally experiences the SON, MAM, JJA seasons. The Nile equatorial lakes region normally experiences rainfall during the MAM and SON season. This analysis indicates that subbasins in the Eastern Nile experienced heavy rainfall during the reporting period. However, there was a slight increase in some subbasins and a slight decrease in others as compared to the long term average as shown in the previous section.

Seasonal Rainfall (mm) July-Sept 2021 CHIRPS v 2.0
Actual Evapotranspiration is a major component of the water balance of the Nile Basin. Monitoring monthly AET is based on data from FEWSNET early warning and drought monitoring data portal for the months July to September 2021 as shown in the maps below. A comparison of Rainfall to Evapotranspiration is also shown for each subbasin in the charts below.

**Monthly Actual Evapotranspiration over the Nile Basin July to September 2021**

**Comparison of Monthly Actual Evapotranspiration to Rainfall in the Nile Subbasins**

During computation of actual evapotranspiration estimates over the subbasins, Evaporation over the lake surfaces has not been considered.
Comparison of Monthly Actual Evapotranspiration to Rainfall in the Nile Subbasins

A Comparison of ET and Rainfall in the Lake Victoria Subbasin (July - Sep 2021)

A Comparison of ET and Rainfall in the Victoria Nile Subbasin (July - Sep 2021)

A Comparison of ET and Rainfall over Lake Albert Subbasin (July - Sep 2021)

A Comparison of ET and Rainfall over the Bahr el Jebel Subbasin (July - Sep 2021)

A Comparison of ET and Rainfall over Bahr el Ghazal Subbasin (July - Sep 2021)

A Comparison of ET and Rainfall over the Baro Akobo Sobat Subbasin (July - Sep 2021)

A Comparison of ET and Rainfall over the Tekeze Atbara Subbasin (July - Sep 2021)

A Comparison of ET and Rainfall in the Blue Nile Subbasin (July - Sep 2021)
Evaporation over major lakes in the Nile Basin

Evaporation (mm) over Lake Tana (July - Sep 2021)

Evaporation (mm) over Lake Nasser (July - Sep 2021)

Evaporation (mm) over Lake Victoria (July - Sep 2021)

Evaporation (mm) over Lake Edward (July - Sep 2021)

Evaporation (mm) over Lake Albert (July - Sep 2021)
Runoff is estimated as total precipitation less the losses caused by evapotranspiration (loss to the atmosphere from soil surfaces and plant leaves). Rainwater that is not evaporated or stored in the soil eventually runs off the surface and finds its way into rivers, streams, and lakes or recharges ground water. The difference of P-ET gives an indication of such beneficial or non-beneficial losses. This serves to identify, locate or delimit regions that suffer from a deficit of available water, a condition that can severely affect the effective use of the land for such activities as agriculture or stock-farming.

During July to September 2021, there is rainfall excess observed in parts of the Eastern Nile regions especially in Blue Nile, Tekeze Atbara, and Baro Akobo Sobat where rainfall is mostly recorded to be over 200mm. In the White Nile, rainfall excess is observed in the Albert and White Nile subbasins. Other subbasins generally recorded low runoff attributed to low amounts of rainfall during the reporting period.
The River Nile and Lakes with in the Nile Basin region are sensitive to changes in rainfall with variations impacting lake levels and river discharges.

The major lakes in the Nile basin system are Lake Victoria, Lake Kyoga, Lake Albert, Lake Tana, Lake Edward, and Lake Nasser. Numerous tributary rivers flow into the upper lakes and it is essential to monitor these differences in water levels. Water levels for Lakes Victoria, Tana and Kyoga are presented below.

Relative lake height variations have been computed from TOPEX/POSEIDON (T/P), Jason-1 and Jason-2/OSTM altimetry with respect to a 29 year mean level derived from T/P altimeter observations for some of the lakes in the Nile Basin. The height variation time series has been smoothed with a median type filter to eliminate outliers and reduce high frequency noise.

Data source is USDA/NASA/SGT/UMD

Lake Victoria Water Level

The level of Lake Victoria fluctuates annually and seasonally following the patterns of changes in precipitation. The alternating dry and rainy seasons in the equatorial region subbasins result in difference lake levels compared to the term average of 1992-2020. During July to September, the water level is seen to decline but higher than the long term average by about of 1.2 to 1.55 meters.
The level of Lake Tana in Ethiopia, fluctuates annually and seasonally following the patterns of changes in precipitation. With a mean depth of only 9.7 meters, the alternating dry and rainy seasons result in an average difference of about 1.0 to 2.95 meters between the lowest (May-June) and highest (September) lake levels. During July to September, the water level is seen to rise sharply and generally higher than he long term average of 1992-2020 by 0.6 to 0.8 m.

Lake Kyoga is a large shallow lake located in central Uganda north of Lake Victoria. The lake has finger-like extensions with a surface of 1,720 sq. km at an elevation of about 1033m above sea level. Its average depth reaches 3 m, its maximum depth is 5.7 m. During July to September, the lake levels are seen to fluctuate with a slight rise in July and a decline in September. The lake height is seen to be higher by about 2.5 metres as compared to the long term average of 1992-2020.
Surface water transition in the Nile Basin has been derived from Global Surface Water (GSW) dataset developed by Joint Research Center (JRC). JRC developed GSW from Landsat imageries of Landsat 5, 7 and 8 from 1984-2020. In the Nile Basin 81.2% of the surface water remains permanent in the last 37 years and 3.8% of the surface water is new permanent surface water. The occurrence of the new permanent surface water could be from the new dams construction and irrigation schemes development as seen from the below figure.

Source: EC JRC/Google 
River basin management is a complex task. It involves several inter-dependent courses and processes. Sound transboundary water resources planning requires reliable data and information on the system features, characteristics and status. While the expertise of the professional water resources planners is essential, solid understanding of the system and governing phenomena plays an equally important role. This underscores the high importance of existing comprehensive data and information within the context of river basin management.

The process entails water resources availability assessment, water demands estimates, and a suite of planning options and alternatives for the entire river basin. Hydro-meteorological monitoring systems are the most accurate source of real-time data and information. However, due to the fact that parts of the Nile Basin are not sufficiently covered by hydromet networks, earth observations represent a viable source of information that well inform basin water resources planning and development.

Monitoring the Nile Basin using satellite observation provides key information on water availability and spatial and temporal distribution of rainfall over the Nile basin can be therefore determined. Seasonality in the Nile basin region, long-term variation for each subbasin, and actual evapotranspiration could thus be estimated. Water levels in major lakes wetlands extent, and soil moisture as well as some water quality parameters can be defined.

Satellite observations detected an increase in rainfall for subbasins in the Eastern Nile region in the reporting period especially in the Blue Nile, Tekeze Atbara, Baro Akobo Sobat, Bahr el Ghazel and Bahr el Jebel compared to the long term average and this indicates an increase in total amounts of water available upstream of the Nile basin. This presents a good opportunity for higher crop yields in the agriculture sector, higher hydro-power production for the energy sector.

The Nile Basin Initiative continues to collect, analyse and share remotely sensed data and information on Nile Basin hydrology to identify such opportunities for enhanced water use efficiencies and regional integration and cooperation.