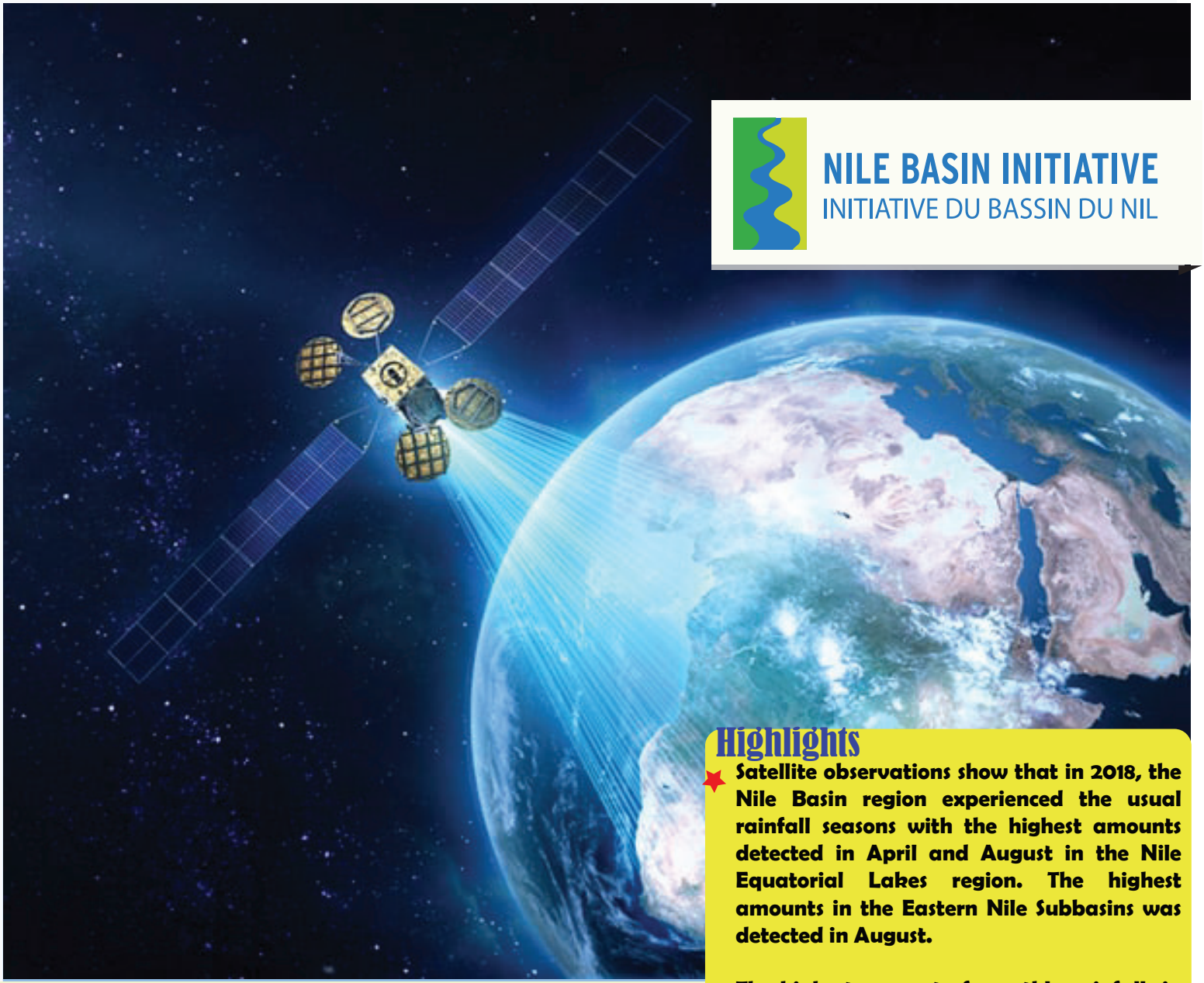

NILE BASIN INITIATIVE
INITIATIVE DU BASSIN DU NIL

October - December 2018
plus an annual analysis

MONITORING THE NILE BASIN USING SATELLITE OBSERVATIONS

A QUARTERLY BULLETIN

Highlights

- **Satellite observations show that in 2018, the Nile Basin region experienced the usual rainfall seasons with the highest amounts detected in April and August in the Nile Equatorial Lakes region. The highest amounts in the Eastern Nile Subbasins was detected in August.**
- **The highest amount of monthly rainfall in 2018 was 297mm and this was in the Lake Victoria Sub basin during the month of April while the lowest amount was 0.12mm in the White Nile Subbasin during the month of January.**
- **Rainfall excess maps (P-E) and soil moisture maps show high values starting from the month of March in the equatorial lakes region and in May for the eastern Nile region up to November. P-E gives an indication of available water in the basin.**
- **In 2018, water levels in Lake Victoria and Lake Tana were detected to be higher than the long term average.**
- **The Groundwater productivity map shows that there is potential for ground water resources to suppliment surface water use in many parts of the basin**

MONITORING THE NILE BASIN USING SATELLITE OBSERVATIONS

October - December 2018
Plus an annual analysis

The Nile Basin Initiative (NBI) is an intergovernmental partnership of ten Nile riparian countries that is seeking to manage and develop the common Nile water resources in a cooperative manner and promote regional peace and security.

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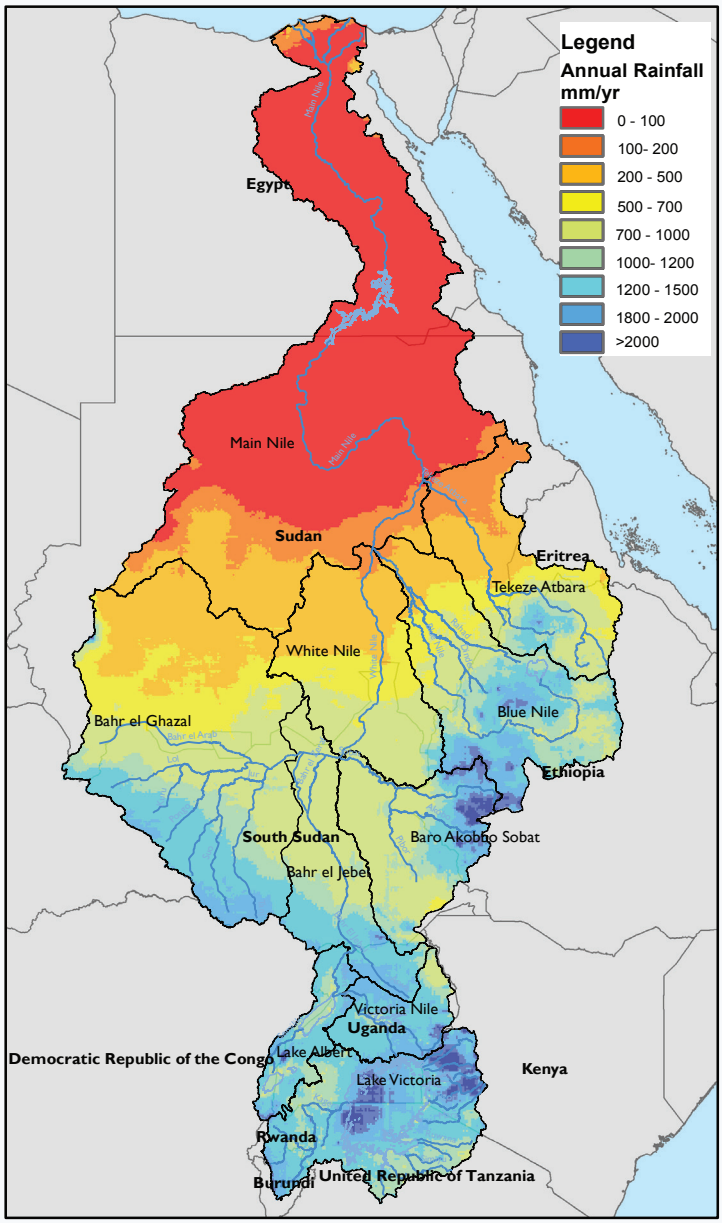
INTRODUCTION



Total Annual rainfall in the Nile Basin- 2018.

The River Nile Basin covers about 3,176,541 square kilometers, which represents about ten percent of Africa's land mass area. 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 experiences diverse climatic conditions which result in changes in seasonal and annual flows of the river. Monitoring of such processes is important for water resources management.

It was with this realization that the Nile Basin Initiative, according to its 10 year Strategy (2017-2027), aims at strengthening evidence-based transboundary water resources planning and management through improved monitoring of the Basin using satellite observations in addition to the proposed regional Hydrometeorological monitoring network.

The NBI therefore releases four quarterly bulletins for each year (January - March, April- June, July - September and October - December). The last quarter also incudes an annual anlysis.

These quarterly Basin Monitoring bulletins aim at providing a shared understanding of patterns of some of the water cycle components in this 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 in the 10 major sub-basins, and an analysis of Water levels in some lakes during 2018 from October to December. This last issue of the year provides an anlysis of all the rainfall seasons in the Nile basin and monthly totals in comparison to a 38 year long term average.

Rainfall in the Sub-basins of the Nile Basin has been estimated using CHIRPS v2.0. Climate Hazards Group Infra-Red Precipitation with Station data (CHIRPS) is a 30+ 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

A snapshot of Ground water resources has been included in this bulletin.

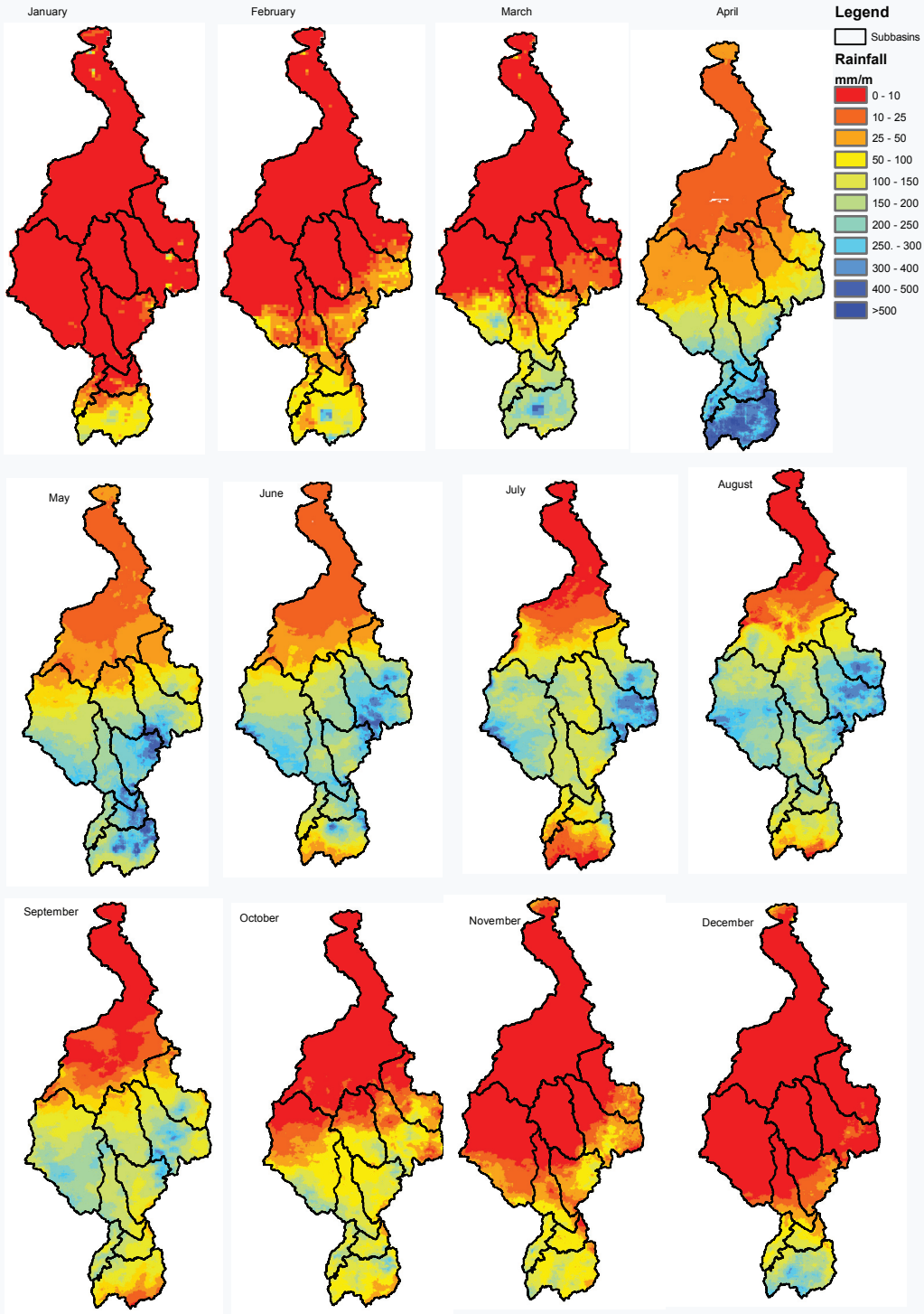
VARIABILITY OF RAINFALL IN THE NILE BASIN

Overall, Satellite rainfall estimates indicate a wide spatial and temporal rainfall variability in the basin. Minimum rainfall is seen in the arid areas in the northern part of the basin and the maximum rainfall estimates are observed in the equatorial lakes region in the areas around Lake Victoria and the Ethiopian Highlands.

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, Baro-Akobo-Sobat and Tekeze subbasins 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.

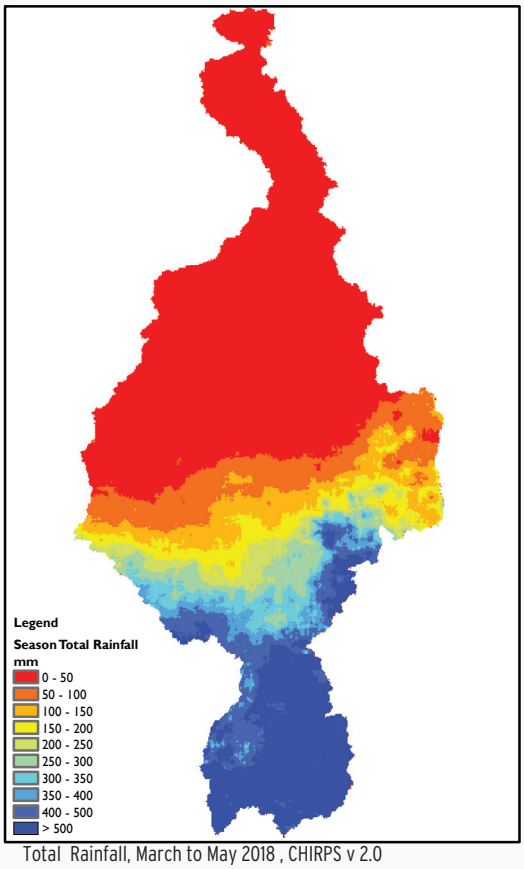
During 2018, rainfall distribution was detected in a similar pattern as seen in the maps below.

A full analysis for each of the sub basins is given in this quarterly bulletin

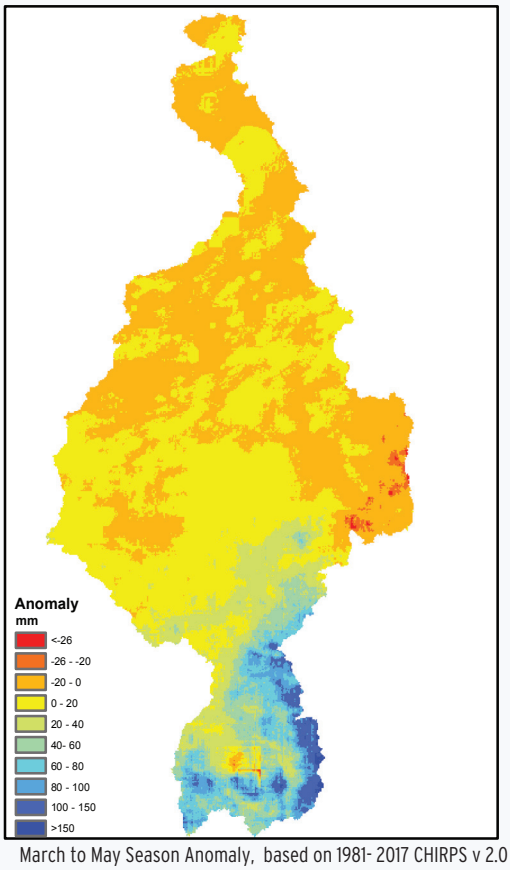


Monthly Rainfall (mm) January to December 2018 , CHIRPS v 2.0

SEASONAL RAINFALL IN THE NILE BASIN REGION



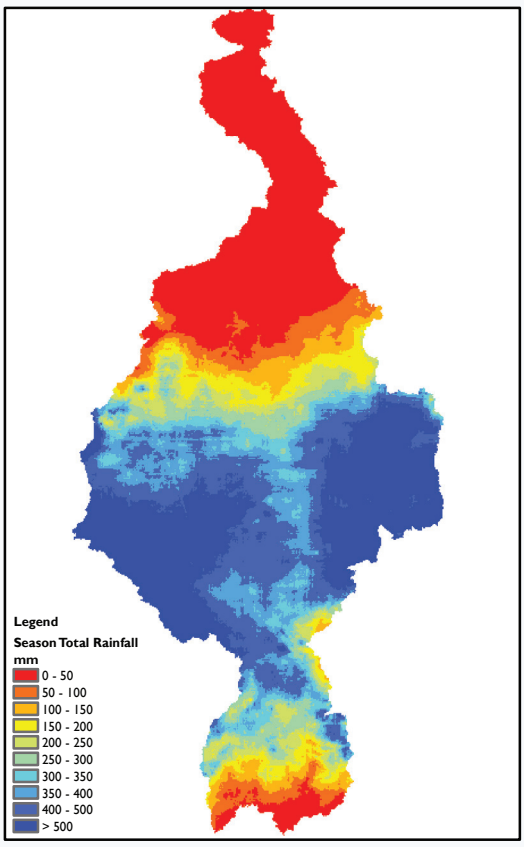
Total Rainfall, March to May 2018 , CHIRPS v 2.0



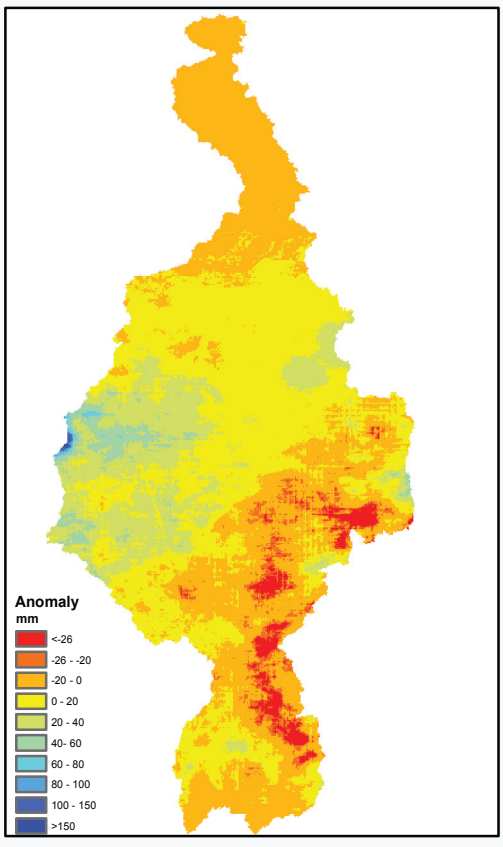
March to May Season Anomaly, based on 1981- 2017 CHIRPS v 2.0

Seasonality in the Nile basin is determined by the position of the Inter tropical convergence Zone (ITCZ) with moisture sources from the Indian and Atlantic oceans. The Nile Equatorial Lakes region experiences the first wet season of the year during March- April - May.

In 2018, during the MAM season, rainfall was detected in Nile equatorial lakes region, southern part of the Bahr el Ghazal, southern part of Bahr el Jebel and parts of the Baro Akobo Sobat subbasins which was higher than the long term average. especially in the Lake Victoria, Victoria Nile subbasin and parts of Baro Akobo Sobat
The Eastern Nile Subbasins are largely dry during this season.



Total Rainfall, July - September 2018, CHIRPS v 2.0

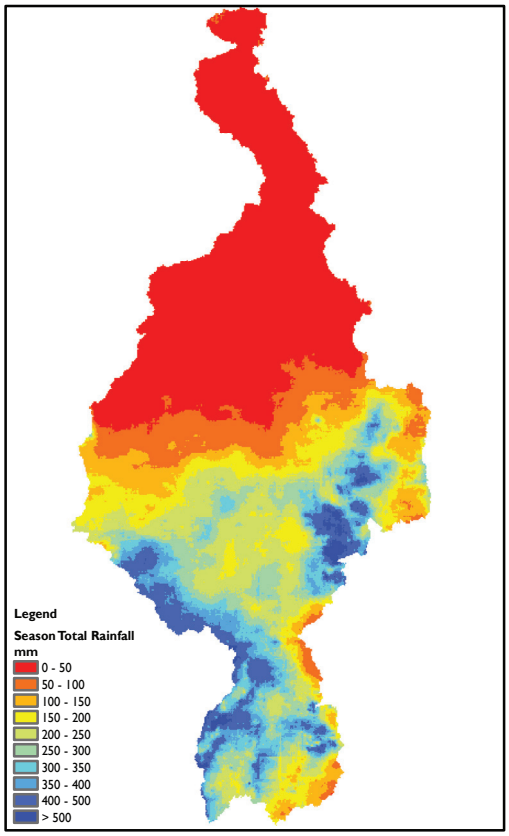


July - September Season Anomaly, based on 1981- 2017 CHIRPS v 2.0

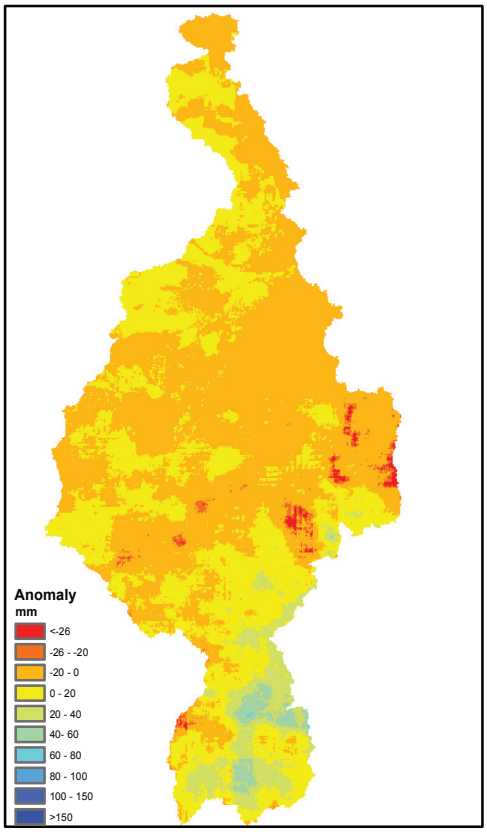
In 2018, during the July- August -September (JAS) season, highest rainfall amounts where detected during August in the Blue Nile Subbasin, Tekeze Atbara, Baro Akobo Sobat, White Nile, Bahr el Jebel and Bahr el Ghazal subbasins.

Compared to the long term average, parts of the Blue Nile,parts of baro Akobo Sobat, Victoria Nile and Barl el Jebel recieved slightly less rainfall during the JAS season while the northern parts of the Bahr el Ghazal subbasin recieved more rainfall during the JAS season compared to the long term average as seen in the anomaly maps.

SEASONAL RAINFALL IN THE NILE BASIN REGION



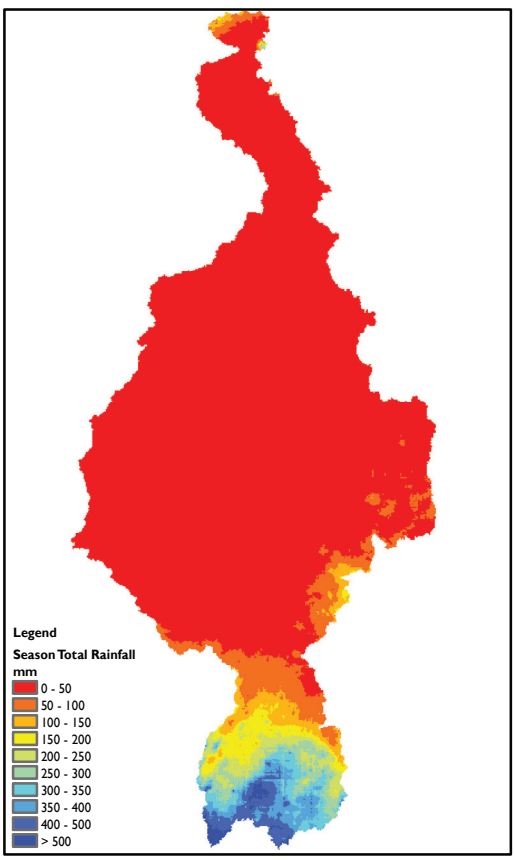
Total Rainfall, Sept - Nov 2018, CHIRPS v 2.0



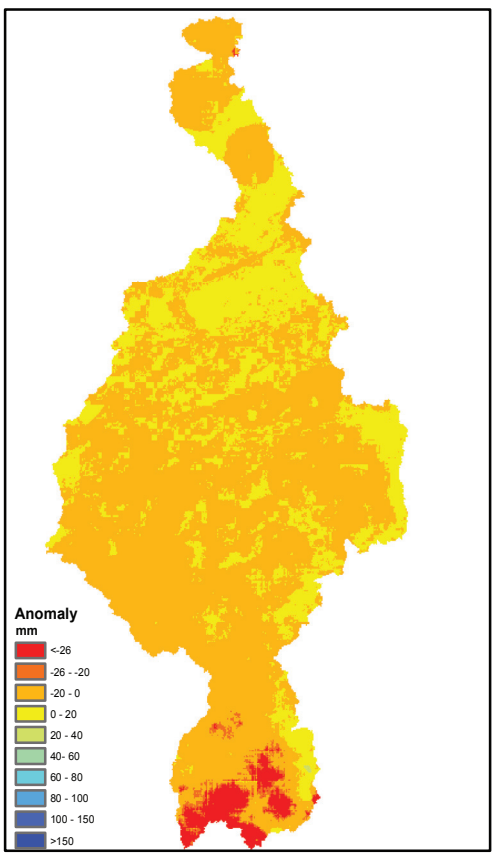
Sep - Nov Season Anomaly, based on 1981- 2017 CHIRPS v 2.0

In 2018, during the September - November (SON) season, highest rainfall amounts where detected in the southern parts of the Blue Nile, parts of Tekeze Atbara, parts of Baro Akobo Sobat, parts of White Nile and also in the western part of Bahr el Ghazal subbasin., Lake Albert subbasin, Victoria Nile subbasin and northern parts of the Lake Victoria subbasin.

Compared to the long term average, Most parts of the Nile basin recieved less rainfall apart from the Victoria Nile subbasin and parts of the Lake Victoria basin as seen in the season anomaly maps



Total Rainfall, Dec- Feb 2018, CHIRPS v 2.0



Dec - Feb Season Anomaly, based on 1981 - 2017 CHIRPS v 2.0

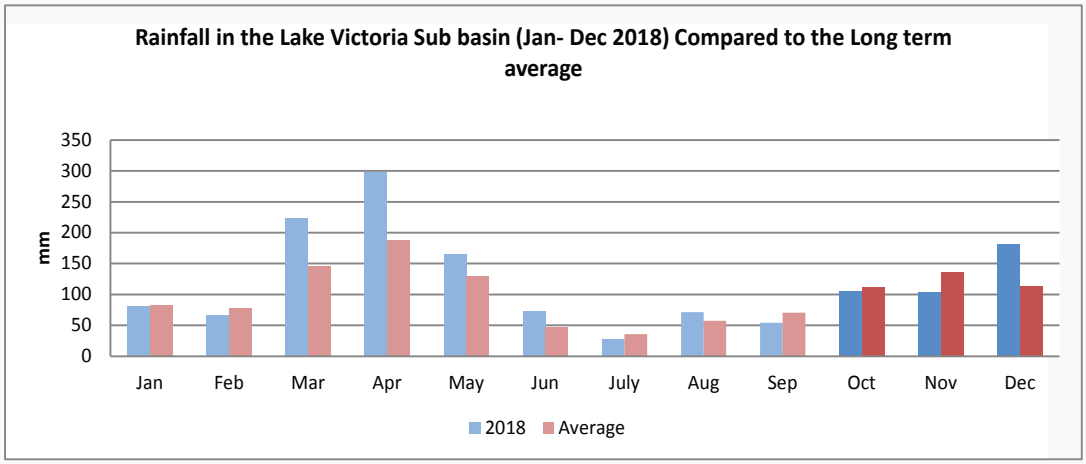
In 2018, most parts of the basin were very dry with very little amounts of rainfall detected in the Lake Victoria basin, Lake Albert subbasin, Victoria Nile subbsain and parts of the Baro Akobo Sobat.

Compared to the long term average, Most parts of the Nile basin recieved less rainfall with parts of the Lake Victoria basin seen to be more drier as shown in the season anomaly maps. However, there was more rainfall in the month of December in the Lake Victoria subbasin.

RAINFALL OVER LAKE VICTORIA SUBBASIN

The Lake Victoria subbasin normally experiences a bimodal rainfall pattern with two rain seasons MAM and SOND. In 2018, a similar pattern of increasing rainfall is seen in March, April, May, October, November and December with the usual dry season between June July and August. The second wet season recieved less rainfall compared to the long term average. January and February were dry months as well. Highest amount of rainfall was detected in April which was higher than the long term average by 58% as shown in the chart below.

For the October to December quarter, the lake Victoria subbasin recieved highest rainfall in December of 181mm which was 60% higher than the long term average while there was less rainfall detected in October and November compared to the long term average.

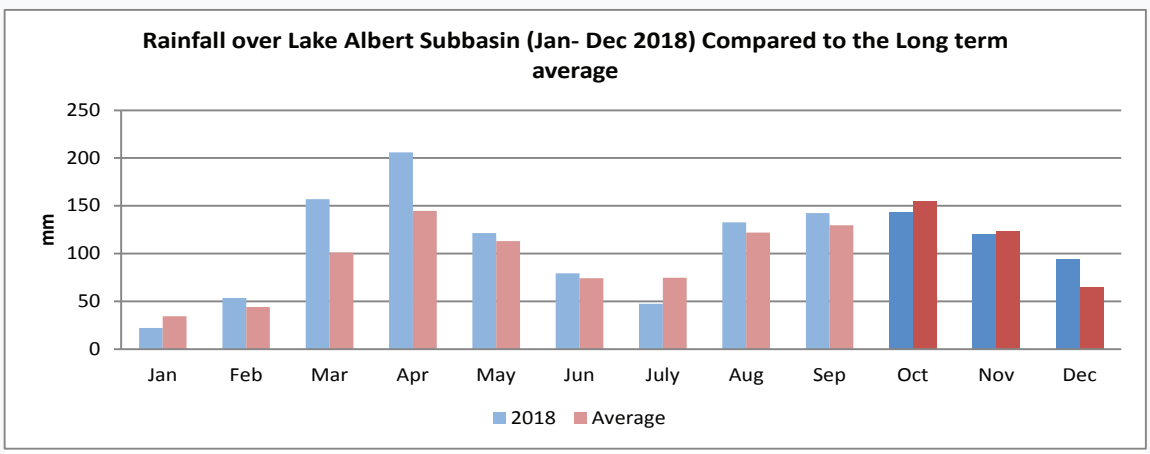


Month	%Change
Jan	-1
Feb	-14
Mar	53
Apr	58
May	27
Jun	54
July	-22
Aug	24
Sep	-23
Oct	-6
Nov	-24
Dec	60

RAINFALL OVER LAKE ALBERT SUBBASIN

Lake Albert subbasin normally experiences a bimodal rainfall with two rain seasons in MAM and SOND. In 2018, a similar pattern with increasing rainfall during March, April, May and in August, September, October and November was observed. Highest rainfall was recorded during April of 205 mm which was 42% above the long term average while the lowest amount was 47mm which was less than the long term average by 37% as shown in the chart below.

For the October to December quarter, the Lake Albert subbasin recieved highest rainfall in October of 143mm which was slighly less than the long term average. However, there was more rainfall detected in December compared to the long term average.

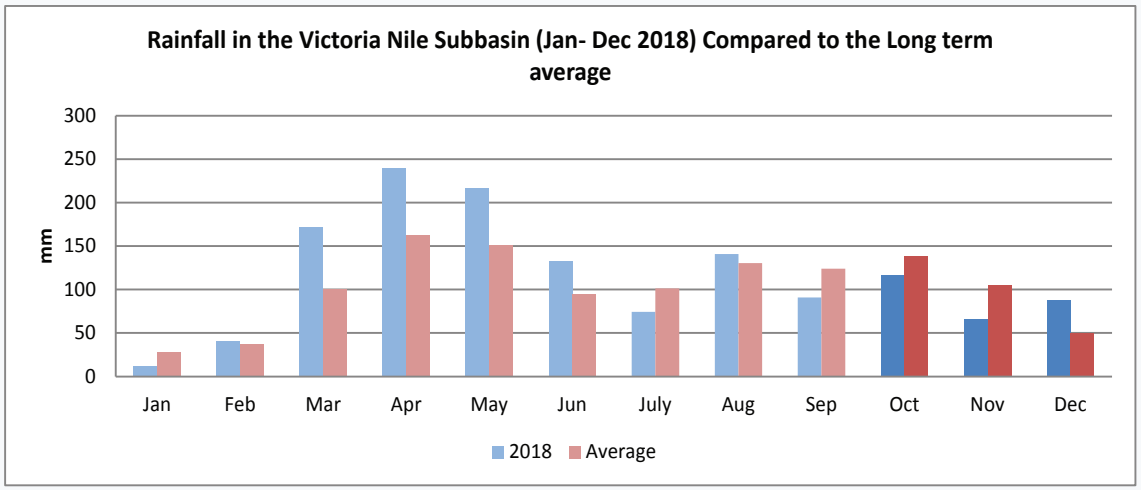


Month	%Change
Jan	-36
Feb	21
Mar	55
Apr	42
May	8
Jun	7
July	-37
Aug	9
Sep	10
Oct	-7
Nov	-3
Dec	45

RAINFALL OVER VICTORIA NILE SUBBASIN

The Victoria Nile subbasin normally experiences bimodal rainfall seasons of MAM and SOND like the other Nile Lakes Equatorial sub basins. In 2018, the same pattern with increasing rainfall in March, April, May an October November and December was observed. Highest rainfall was observed during April of 240mm higher than the long term average by 48% while the lowest amount was 11mm during the month of January which was less than the long term average by 60% as shown in the chart below.

For the October to December quarter, the Victoria Nile subbasin recieved more rainfall in October of 116mm which was less than the longterm average. Both October and November recieved less than the long term average while December recieved 77% more than the long term average.

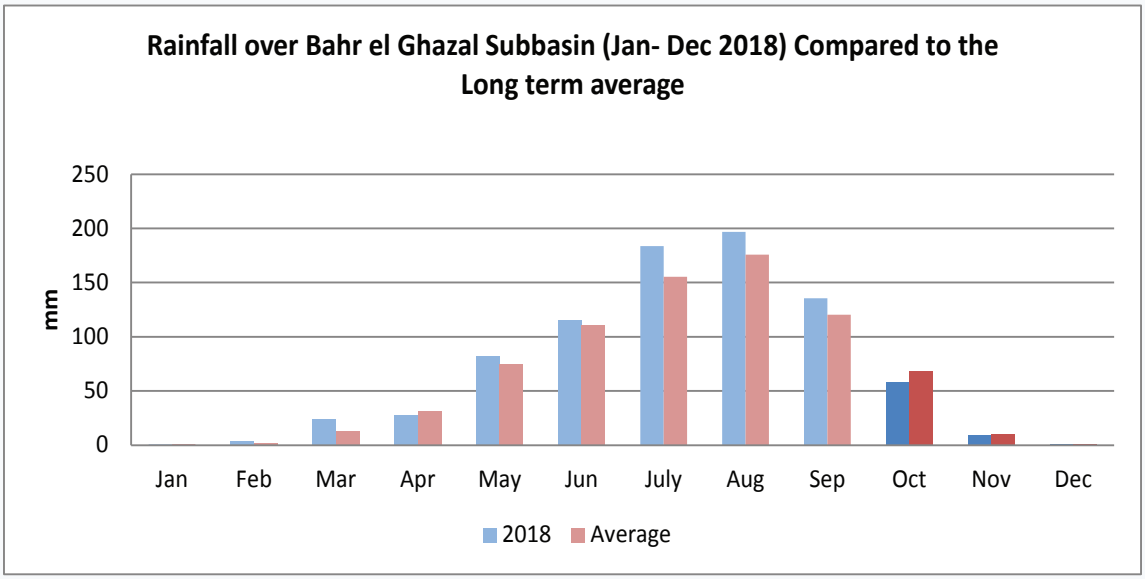


Month	%Change
Jan	-60
Feb	11
Mar	72
Apr	48
May	43
Jun	40
July	-27
Aug	8
Sep	-27
Oct	-16
Nov	-37
Dec	77

RAINFALL OVER BAHR EL GHAZAL SUBBASIN

Bahr el Ghazal sub-basin experiences a monomodal rainfall pattern. However, the northern part of the basin which lies in Sudan is dryer than the southern part of the basin in South Sudan. In 2018, there is a similar pattern with a gradual increase from May to September with the highest amount observed in August of 196mm which was higher than the long term average by 11% while the lowest was 0.6mm during the month of January which was less than the long term average by 35% as shown in the chart below.

For the October to December quarter, the Bahr el Ghazal subbasin recieved highest rainfall in October of 58mm which was at the end of the wet season and was less than the long term average by 14%.

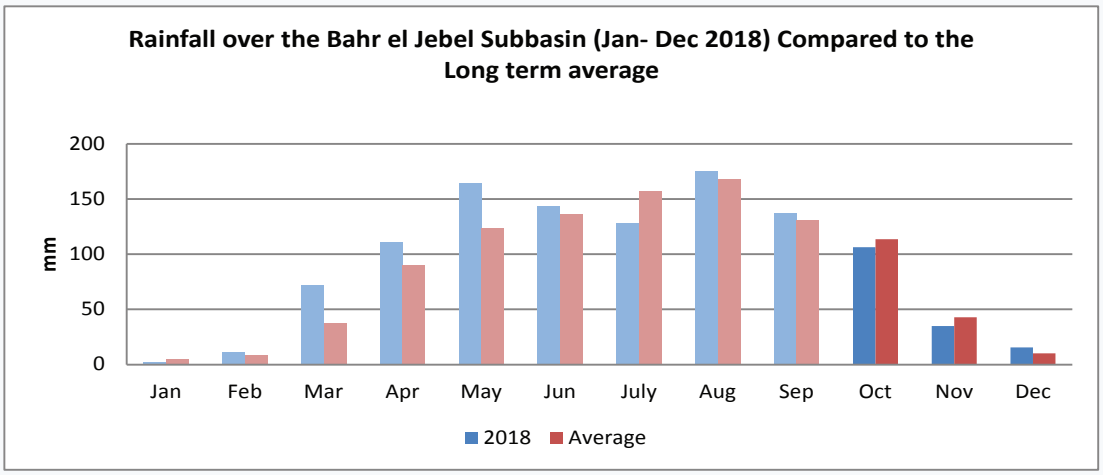


Month	%Change
Jan	-35
Feb	82
Mar	95
Apr	-12
May	10
Jun	4
July	18
Aug	12
Sep	13
Oct	-14
Nov	-9
Dec	36

RAINFALL OVER BAHR EL JEBEL SUBBASIN

Bahr el Jebel sub-basin experiences a monomodal rainfall pattern. Monthly estimated rainfall in 2018 shows a gradual increase with the highest record in August of 175mm, slightly higher than the long term average while lowest amount was in January . Generally, the first months of the year recieved more rainfall as compared to the long term average as shown in the chart below.

For the October to December quarter, the Bahr el Jebel subbasin like the other eastern Nile subbasins was at the end of the wet season therefore highest rainfall was recieved during October of 106mm and less during November and December.

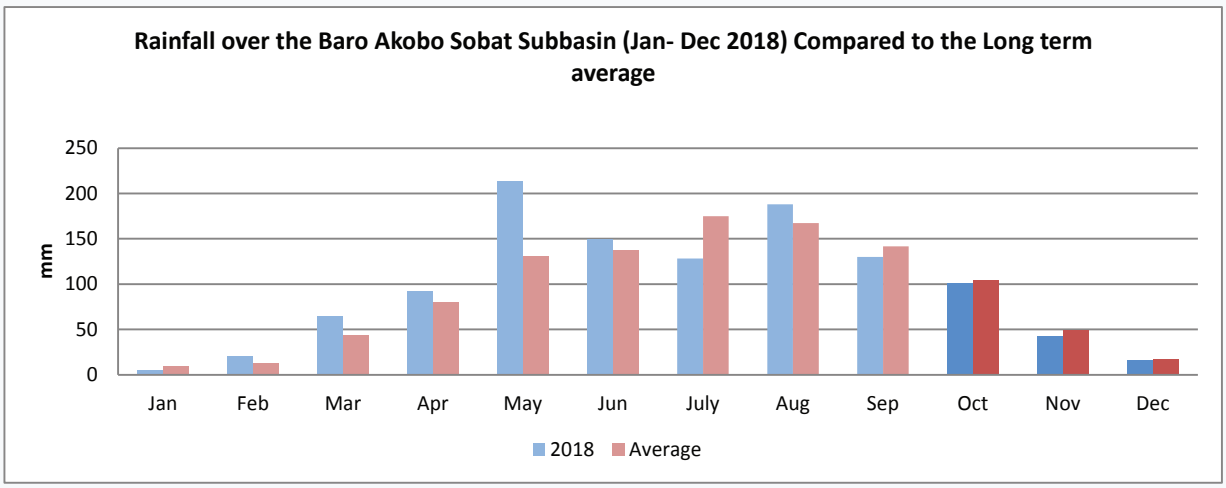


Month	%Change
Jan	-56
Feb	35
Mar	92
Apr	23
May	33
Jun	5
July	-18
Aug	4
Sep	5
Oct	-6
Nov	-18
Dec	53

RAINFALL OVER BARO AKOBO SOBAT SUBBASIN

The Baro Akobo Sobat subbasin like the other eastern Nile subbasins normally experiences a monomodal wet season between May – October. 2018 shows a similar pattern with the highest rainfall estimated in May of 210 mm which was higher than them average by 63% as shown in the chart below.

For the October to December quarter, the Baro Akobo Sobat recieved more rainfall in October of 100mm as the wet season was coming to an end. There was less rainfall detected in all the three months compared to the long term average.

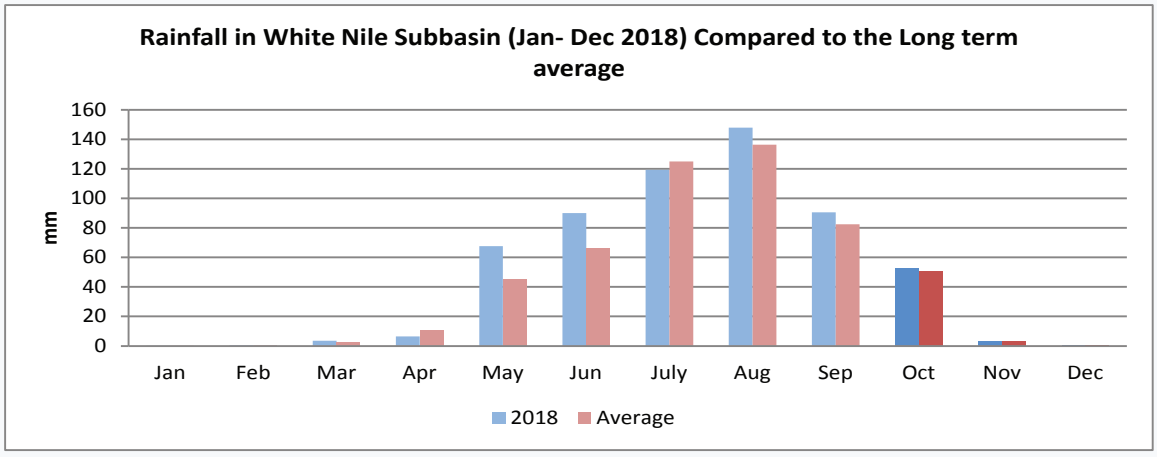


Month	%Change
Jan	-53
Feb	55
Mar	47
Apr	16
May	64
Jun	9
July	-27
Aug	12
Sep	-8
Oct	-4
Nov	-14
Dec	-10

RAINFALL OVER WHITE NILE SUBBASIN

Rainfall in the White Nile normally reduces gradually northward with a monomodal pattern from May to October. A similar pattern was observed in 2018 with increasing rainfall in May to October with the highest amounts observed in August more than the long term average by 8% while December, January and February were generally dry as shown in the chart below. This subbasin recieved the lowest amount of rainfall in the basin.

For the October to December quarter, the White Nile subbasin like the other eastern Nile subbasins was coming to the end of the dry season therefore highest rainfall of 52mm was detected in October with almost no rainfall in November and December.

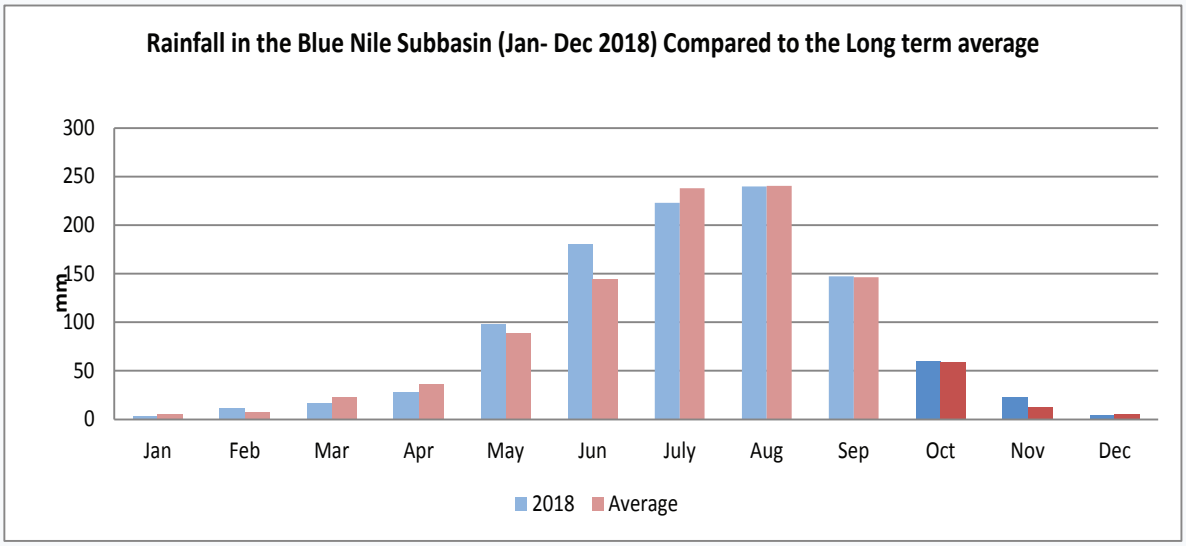


Month	%Change
Jan	-15
Feb	37
Mar	37
Apr	-38
May	49
Jun	37
July	-4
Aug	8
Sep	10
Oct	5
Nov	-6
Dec	30

RAINFALL OVER BLUE NILE SUBBASIN

The Blue Nile Subbasin normally experieinces monomodal rainfall from May to October. In 2018, a similar pattern is observed with the highest amount of 240mm in August while the lowest was during December, Janaury, February during the dry season. The Blue Nile sub-basin recieved the highest amount of rainfall in the eastern Nile region in 2018.

For the October to December quarter, the Blue Nile like the other eastern Nile subbasins was coming to the end of the wet season therefore highest amount of rainfall in this quarter was detected in October of 60mm.

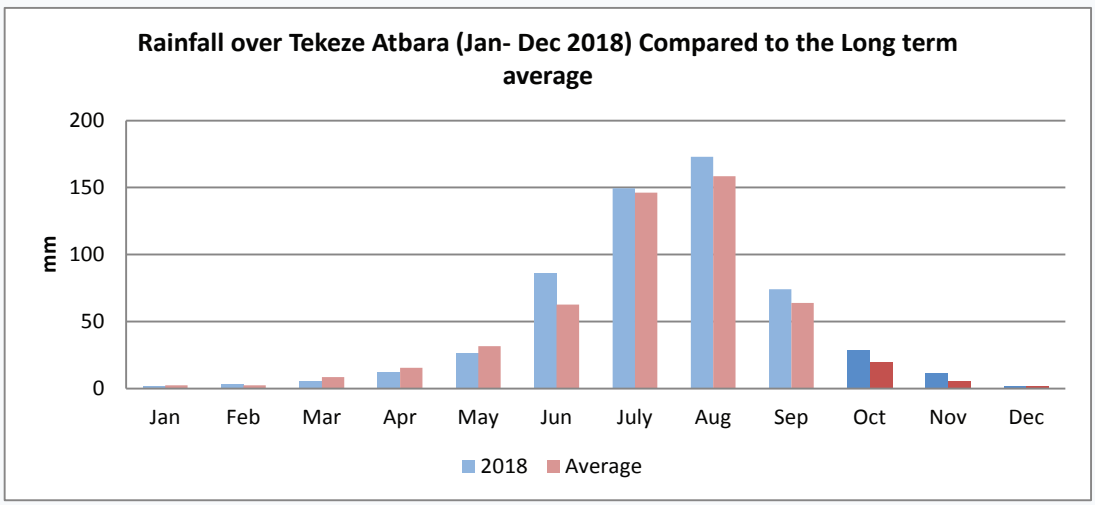


Month	%Change
Jan	-29
Feb	51
Mar	-28
Apr	-22
May	11
Jun	24
July	-6
Aug	0
Sep	0
Oct	2
Nov	85
Dec	-21

RAINFALL OVER TEKEZE ATBARA SUBBASIN

The Tekeze Atbara subbasin normally experiences monomodal rain. Monthly rainfall shows an increase from May to September with the highest record in August of 172mm which is higher than the long term average by 9% while the lowest amount was between December to March during the dry season.

For the October to December quarter, the Tekeze Atbara subbasin like the other eastern Nile subbasins was coming to the end of the rain season therefore heighest rainfall of 28mm was detected in October and very little rainfall detected in November and December .

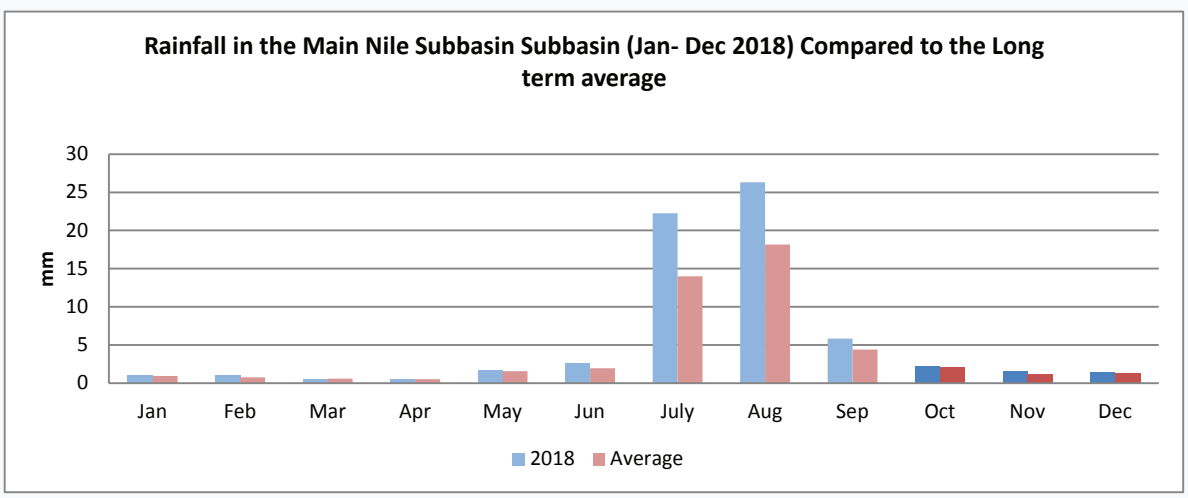


Month	%Change
Jan	-20
Feb	23
Mar	-36
Apr	-18
May	-16
Jun	38
July	2
Aug	9
Sep	16
Oct	43
Nov	113
Dec	-16

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. The Delta region which is close to the Mediterranean Sea exhibits more rainfall.

The October to December quarter was largely dry.

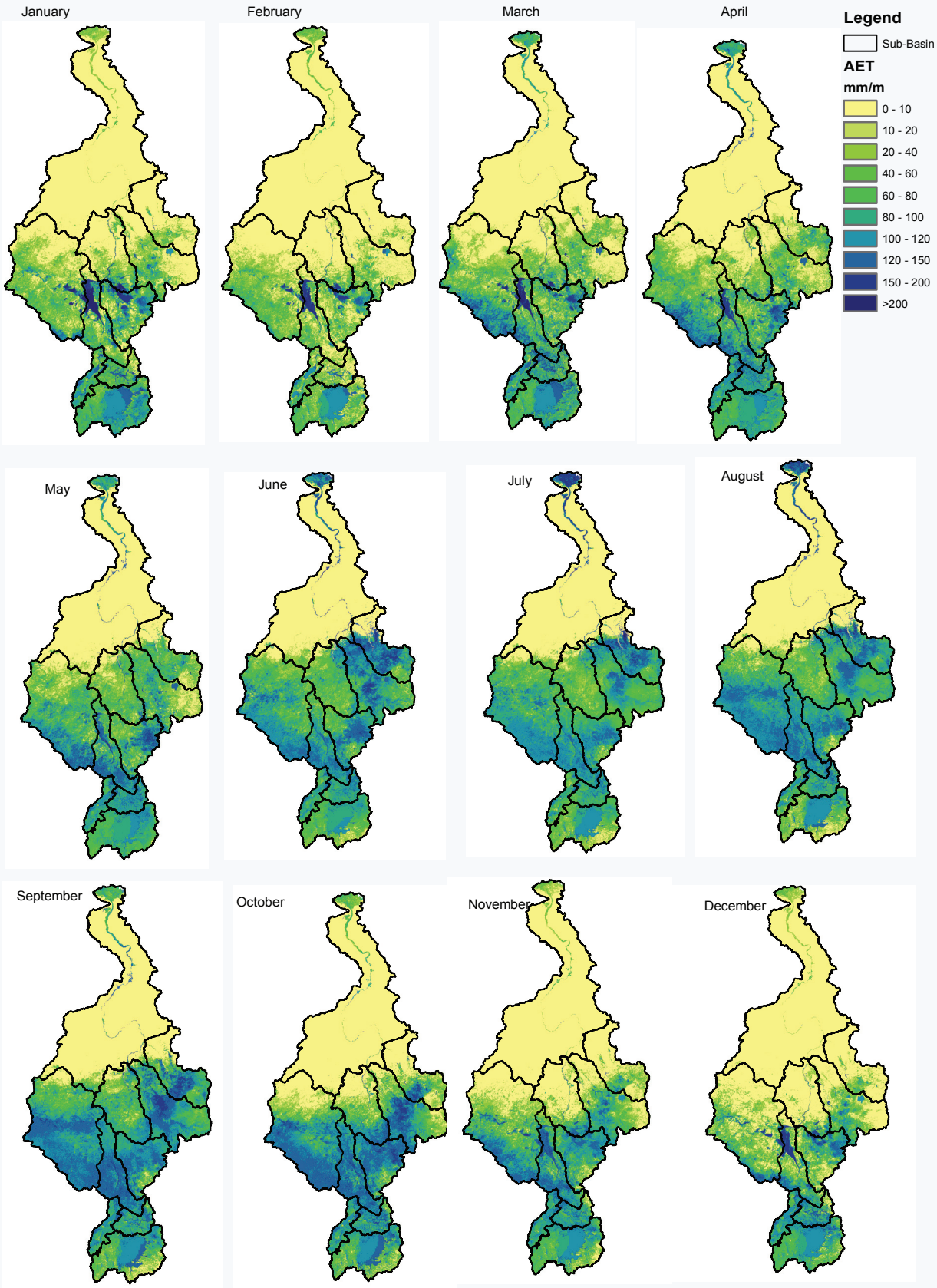


Month	%Change
Jan	12
Feb	34
Mar	-4
Apr	1
May	9
Jun	37
July	59
Aug	45
Sep	33
Oct	13
Nov	37
Dec	11

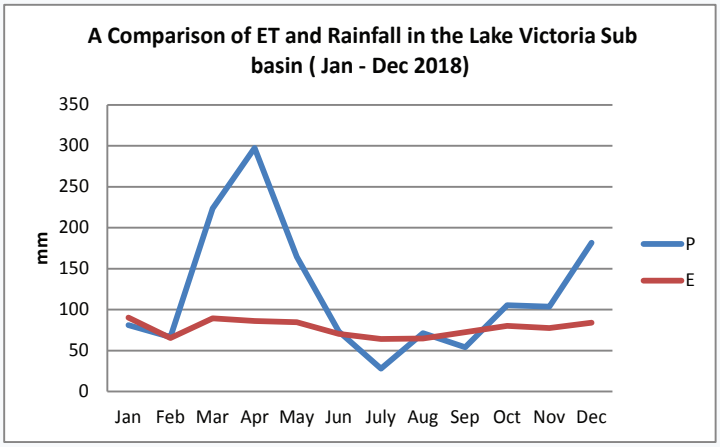
ACTUAL EVAPOTRANSPIRATION OVER THE NILE BASIN

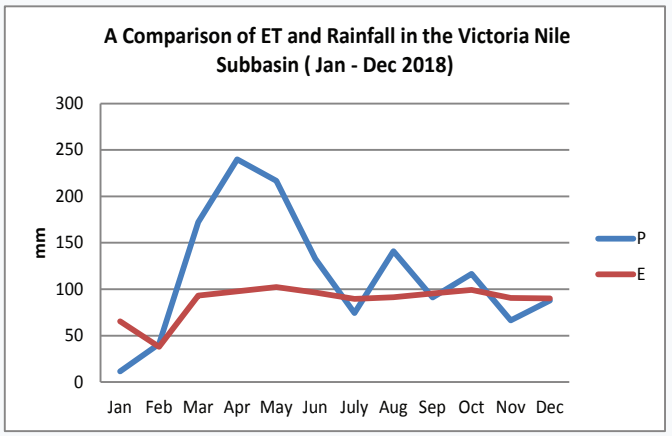
Actual Evapotranspiration is a major component of the water balance of the Nile basin. Monitoring monthly AET is based on data from FEWSNET early warning and drought monitoring data portal for January to December 2018 and the analysis is shown below.

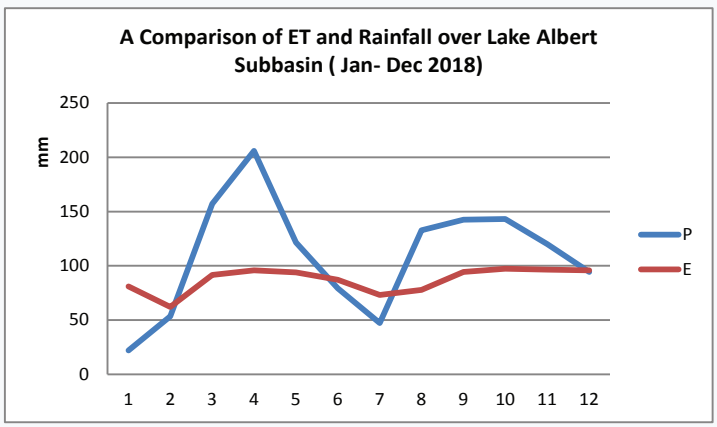
Monthly Actual Evapotranspiration over the Nile Basin January to December 2018

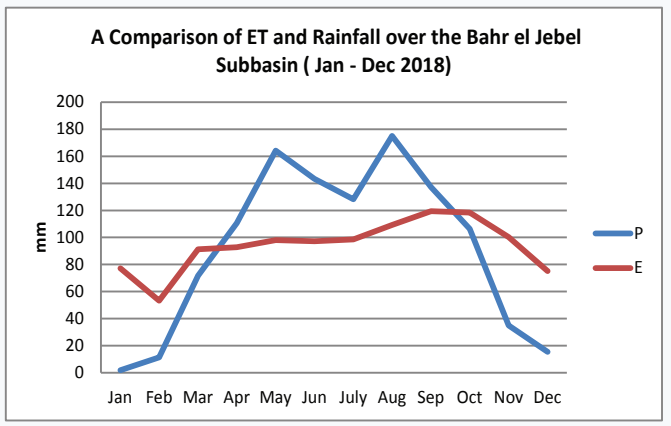


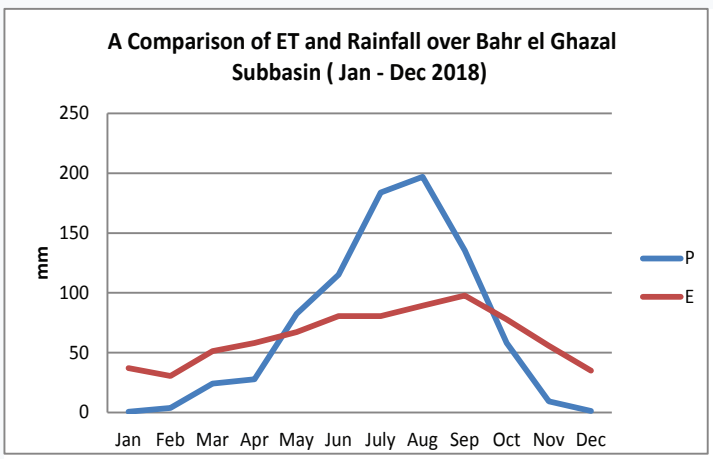
Estimation of Monthly Actual Evapotranspiration January to December 2018

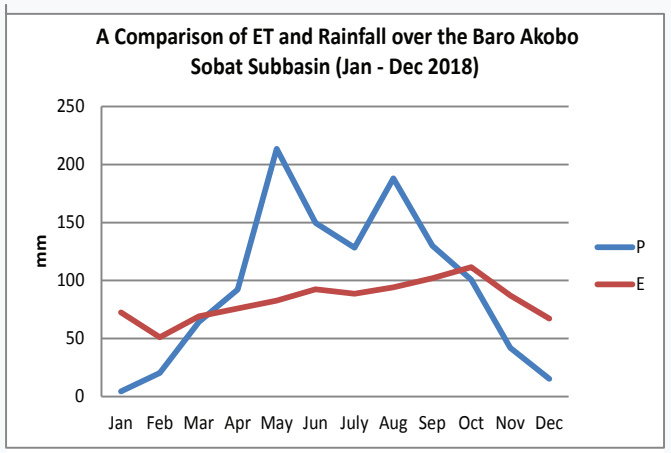


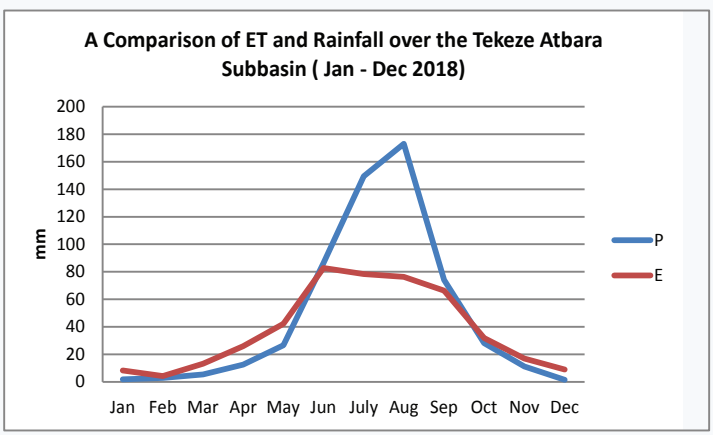


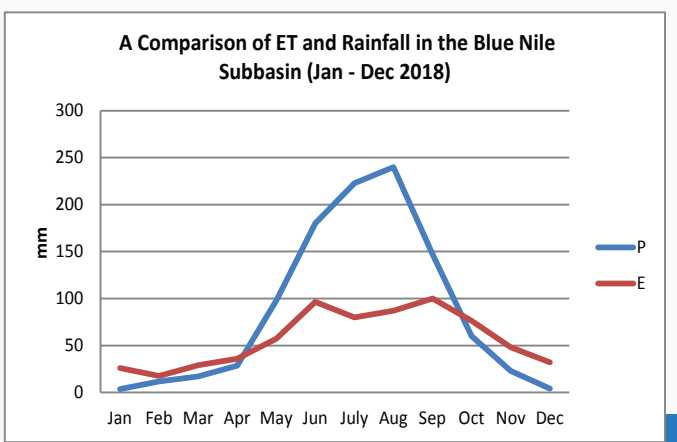




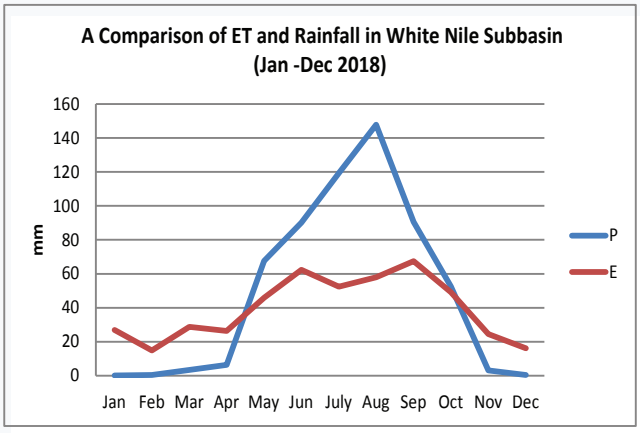


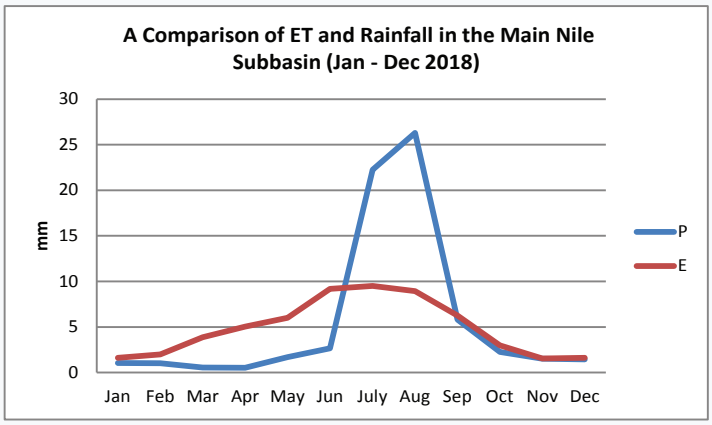






Estimation of Monthly Actual Evapotranspiration January to December 2018

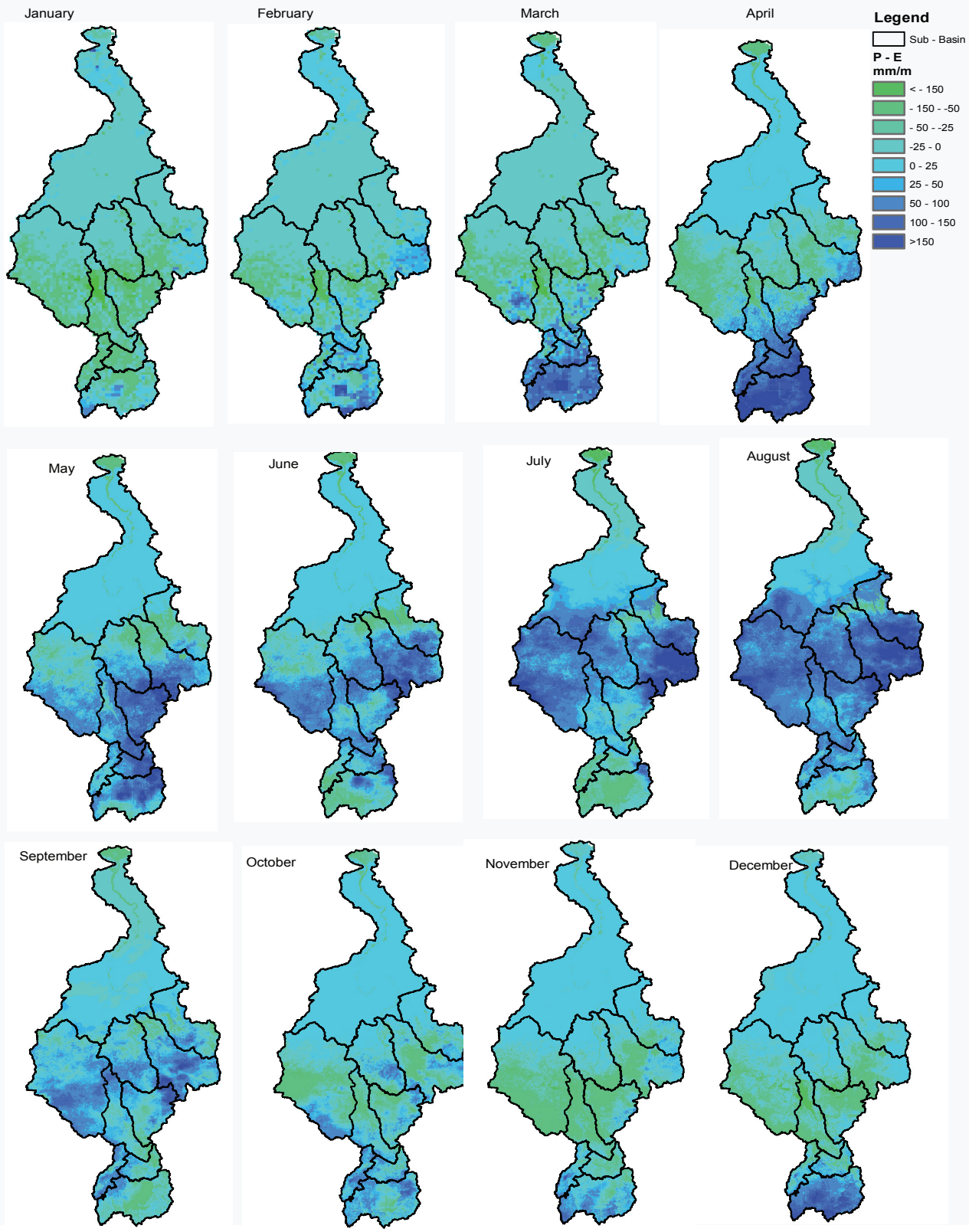




Runoff Potential

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.

In 2018, there is rainfall excess observed starting in the month of March in the Equatorial lakes region which extends to the Eastern Nile region in May to September similar to the wet season pattern.



Water levels in major lakes in the River Nile Basin region basing on Satellite Altimetry

The River Nile and Lakes with in the Nile Basin region are extremely sensitive to changes in rainfall with variations impacting lake levels and river discharges.

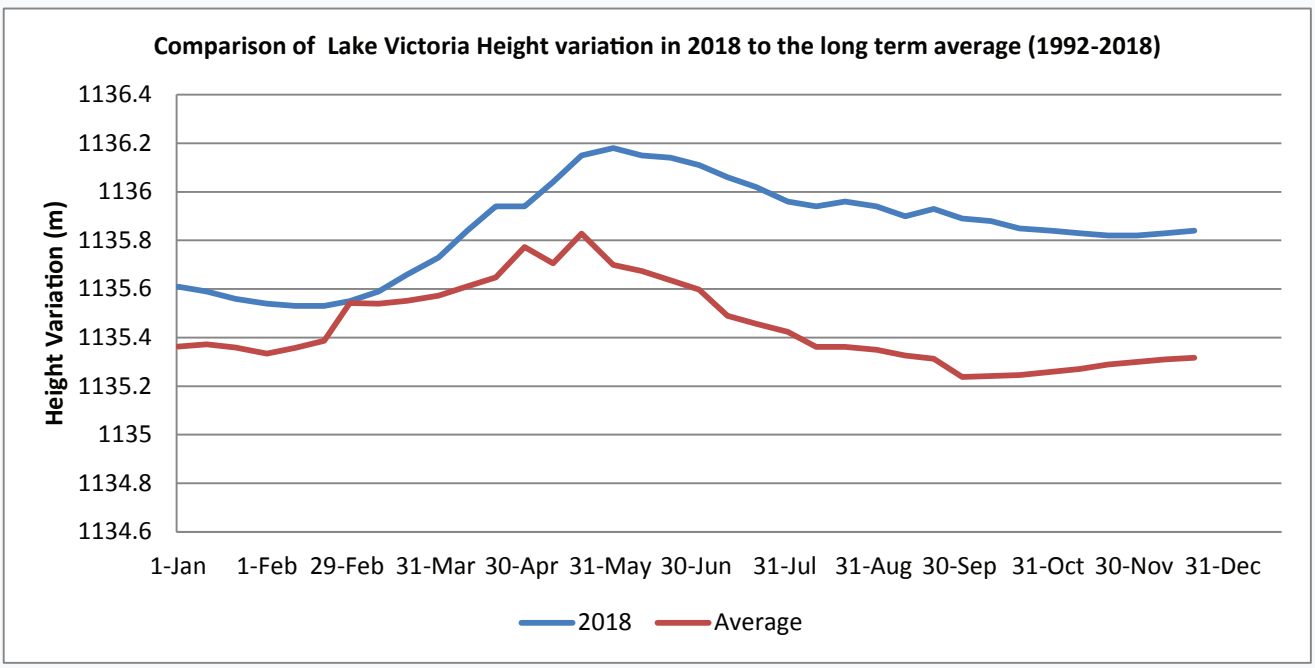
The major lakes in the Nile basin system are Lake Victoria, Lake Kyoga, Lake Albert, Lake Tana, Lake Edward, and Lake Nasser. Numerous tributary rivers flow into the upper lakes and it is essential to monitor these differences in water levels.

Relative lake height variations have been computed from TOPEX/POSEIDON (T/P), Jason-1 and Jason-2/OSTM altimetry with respect to a 9 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 Levels

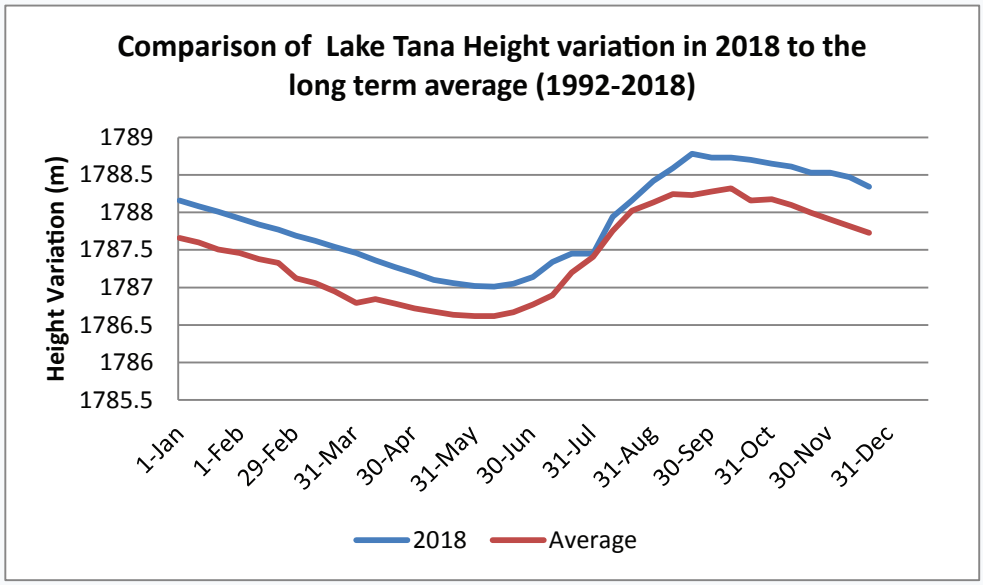
TPJOJ.2.3 : Data Processing Version ID
314 Victoria_1 : Lake database id number and name
-0.670 33.546 : Latitude and longitude (degrees East) of lake mid-point
-1.335 -0.019 : Latitude range of pass traversing lake at which data is accepted



Lake Tana Water Levels

TPJOJ.2.3 : Data Processing Version ID
402 Tana : Lake database id number and name
12.117 37.404 : Latitude and longitude (degrees East) of lake mid-point
11.950 12.199 : Latitude range of pass traversing lake at which data is accepted

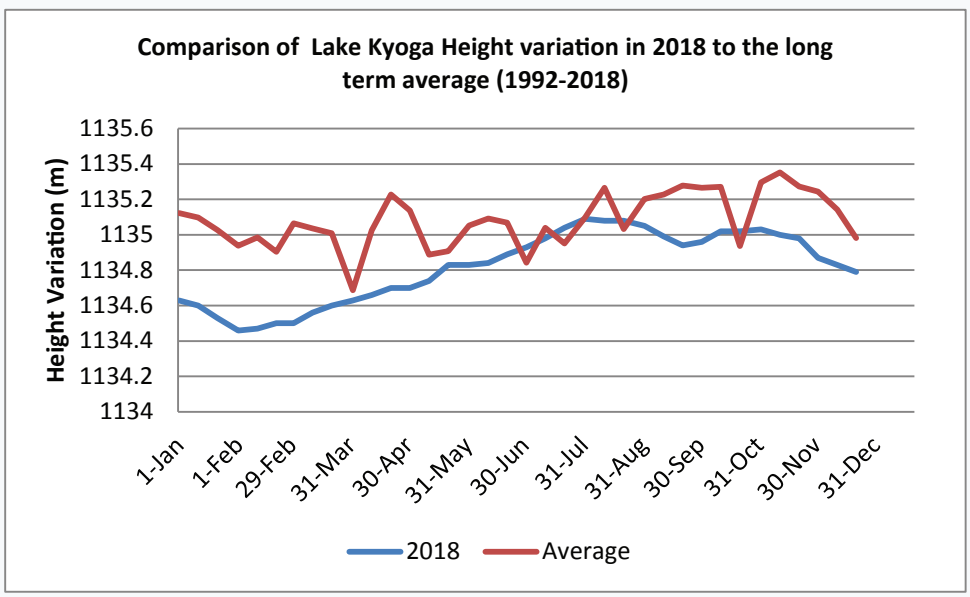
The level of Lake Tana in Ethiopia, fluctuates annually and seasonally following the patterns of changes in precipitation. With a mean depth of 8 only meters, the alternating dry and rainy seasons result in an average difference of 1.5 to 2 meters between the lowest (May-June) and highest (October-November) lake levels.



Lake Kyoga water levels

TPJOJ.2.3 : Data Processing Version ID
398 Kyoga : Lake database id number and name
1.488 32.777 : Latitude and longitude (degrees East) of lake mid-point
1.418 1.551 : Latitude range of pass traversing lake at which data is accepted

Lake Kyoga is a large shallow lake located in central Uganda north of Lake Victoria. The lake has fingerlike 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.

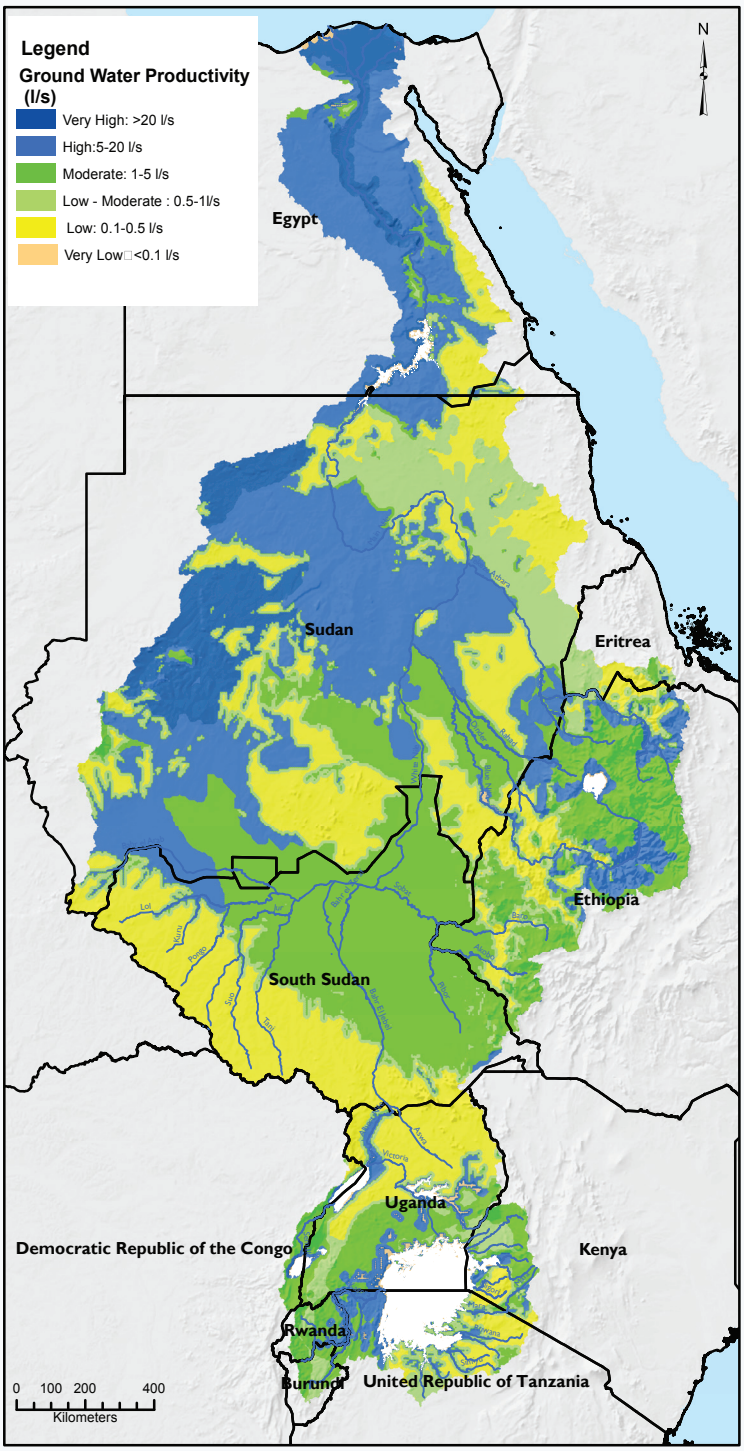


Ground Water Resources In the Nile Basin Region

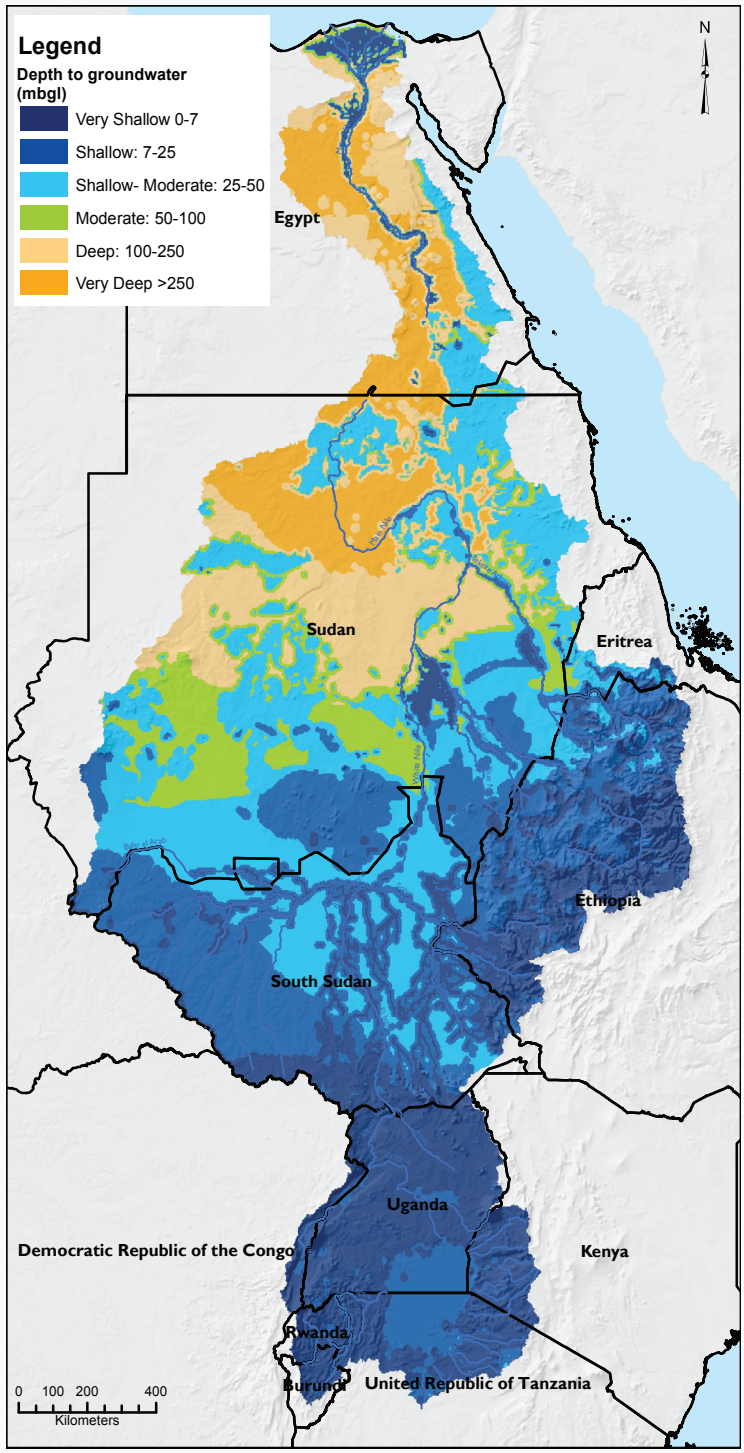
Groundwater resources in the Nile basin are considered as a potential asset that can contribute to climate resilience to droughts as a supplement to surface waters. The importance is reflected in the significant populations that are dependent on groundwater in many parts of the basin.

There are 12 transboundary aquifers identied in the Nile Basin, the largest being the Nubian Sandstone aquifer system covering an area of about 567,344 square Kms. Surface water and groundwater interaction has been confirmed in parts of the basin and this requires more investigation and monitoring.

Ground water productivity and Depth to groundwater maps are shown below.



Ground Water Productivity



Depth to Ground Water

IMPLICATION FOR WATER RESOURCES MANAGEMENT

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.
The process entails water resources availability assessment, water demands estimates, and a suite of planning options and alternatives for the entire river basin. Environmental, social, economic and other dimensions have to be appropriately considered. Hydro-meteorological monitoring systems are the most accurate source of real-time data and information. However, due to the fact that – for many technical, economic, and institutional reasons – 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 sub-basin, 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.

The detected variations in the distribution of rainfall during the different seasons of the year in different parts of the basin provide an opportunity for inter-basin agricultural trade to meet food deficiets in parts of the Nile Basin experiencing drought conditions.
Also, variation of evapo-transpiration rates with in the basin presents an opportunity for wise allocation of water conservation projects and increased storage in the basin.

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

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#NileCooperation; #NileBasin; #OneNile

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