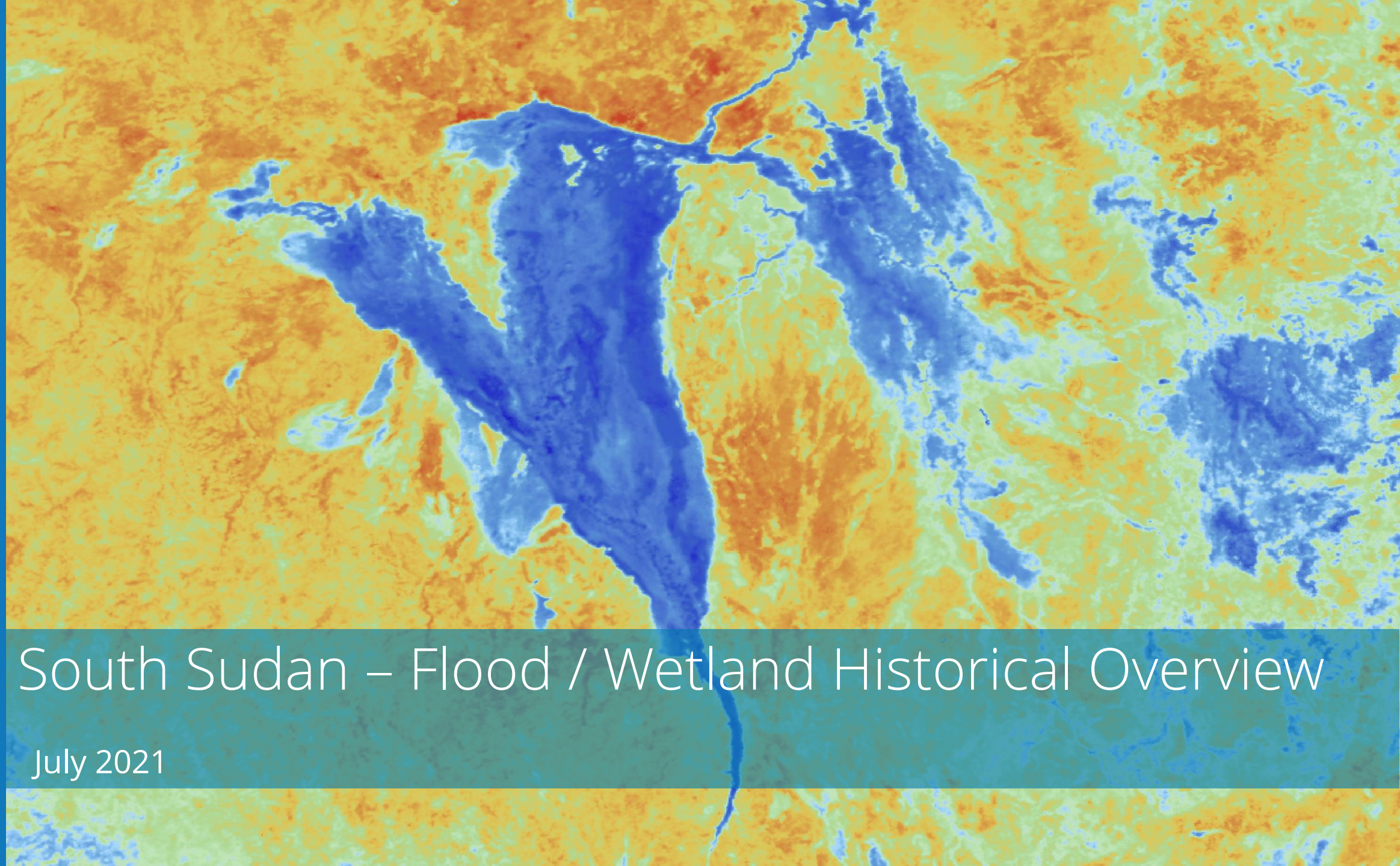
SAVING LIVES

CHANGING LIVES



South Sudan – Flood / Wetland Historical Overview

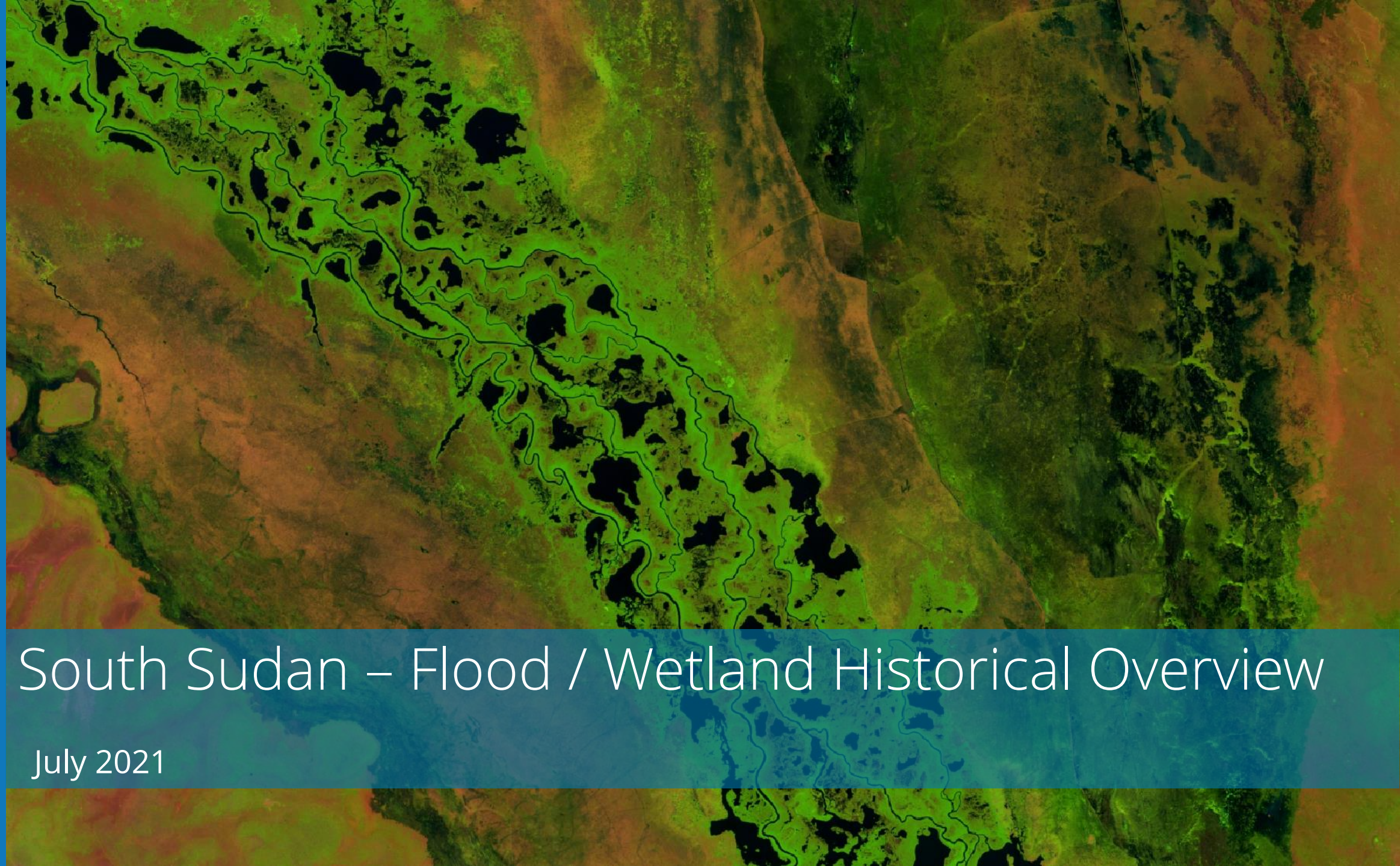
July 2021

WFP

World Food Programme

SAVING LIVES

CHANGING LIVES



South Sudan – Flood / Wetland Historical Overview

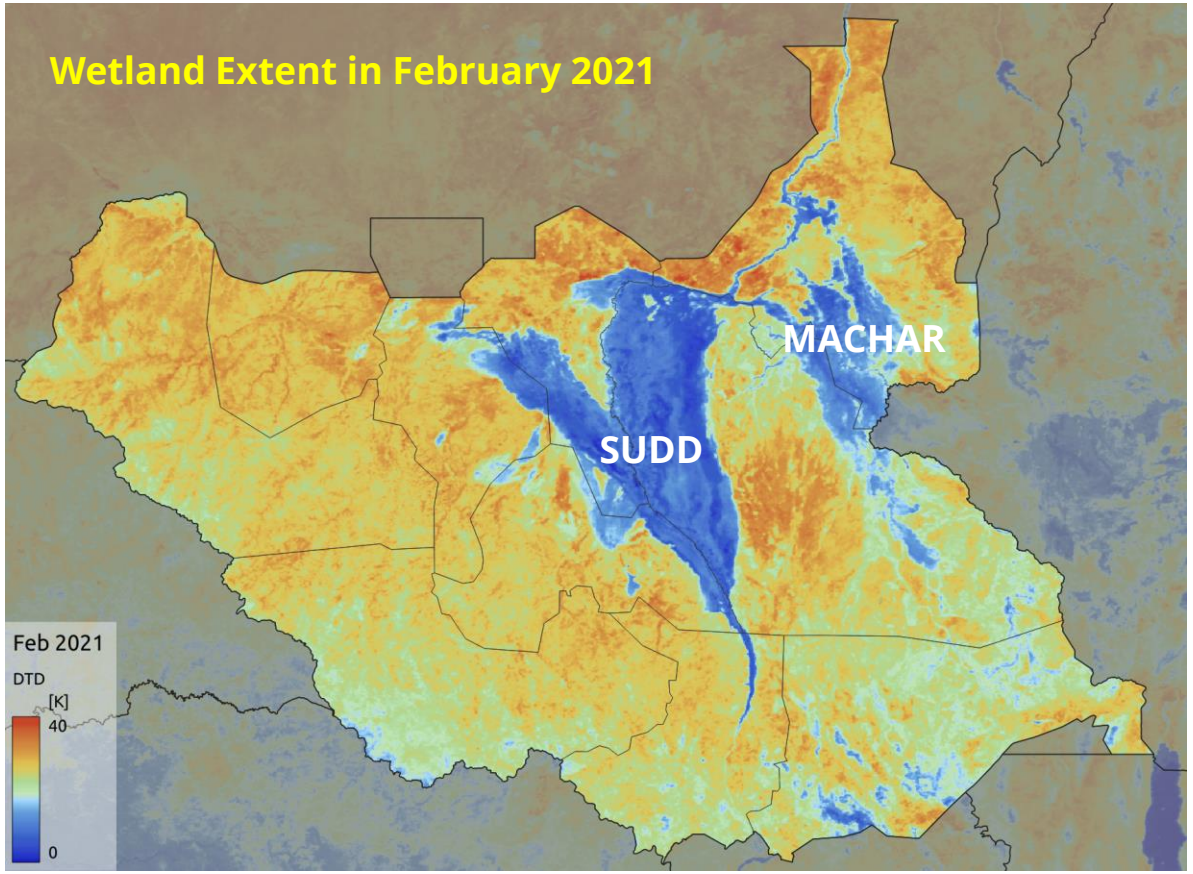
July 2021

WFP
World Food Programme

Summary

- Seasonal flooding of large wetlands is a feature of the South Sudan landscape and play a crucial role in the livelihoods of large numbers of South Sudanese people. Their seasonal extent is determined by both in country rainfall and inflows from the Nile and its tributaries.
- The record breaking floods of 2019-20 and 2020-21 in South Sudan and their impacts, raised the importance of placing these events in their historical context. For this purpose, thermal satellite imagery available from 2002 was analyzed to determine wetland extent in each flood season.
- A number of drivers are thought to contribute to the exceptional recent events: multi-year above average rainfall in the higher reaches of the Nile catchment, leading to record lake levels in Uganda and extreme river heights within South Sudan. This was accompanied by wetter than average conditions in the eastern regions of South Sudan in both 2019 and 2020.
- Satellite thermal data was analyzed to identify wetland status and to summarize seasonal flooding into a single image. This was done for each season in the 19 season record, allowing a time series of wetland extent at different persistence levels to be extracted.
- Results are presented for the two sub-basins, Sudd and Sobat. For both basins, the last two seasons were indeed when wetland extent was at its largest. The exceptional nature of these events is more marked for the Sobat than for the Sudd.
- While the three largest extents all occurred in the past six years (2020-21, 2019-20 and 2014-15), there isn't a well marked trend, at least in the sense of a smooth increase in wetland extent. Inter-annual variability can quite large, with historically low extents transitioning to high extents and vice-versa.
- Long range rainfall forecasts for the next five years (2021-2025) indicate that this period is likely to be wetter than average over the Nile basin – this may imply that historically large wetland extents may be here to stay.

Flooding and Wetlands in South Sudan



Extent of flooded / wetland areas in February 2021 revealed in darker blue shades in satellite derived thermal amplitude (daytime – nighttime) data. Dry bare soil in red, with shades in between for intermediate water content.

Two major wetland areas can be seen: The Sudd marshes in the centre of the country and the Machar marshes along the Sobat in southern Upper Nile.

Seasonal flooding of large wetlands, their expansion and retreat is a feature of the South Sudan landscape. Wetlands play a crucial role in the livelihoods of large numbers of South Sudanese people. In South Sudan two major wetland systems can be identified: the Sudd marshes along the White Nile and the Machar marshes along the Sobat river.

Their seasonal extent is determined by both in country rainfall and inflows from the Nile and its tributaries. It usually reaches a maximum towards the end of the rainfall season and its seasonal minimum towards the end of the dry season. Problems arise when their seasonal extent is either too small or too large.

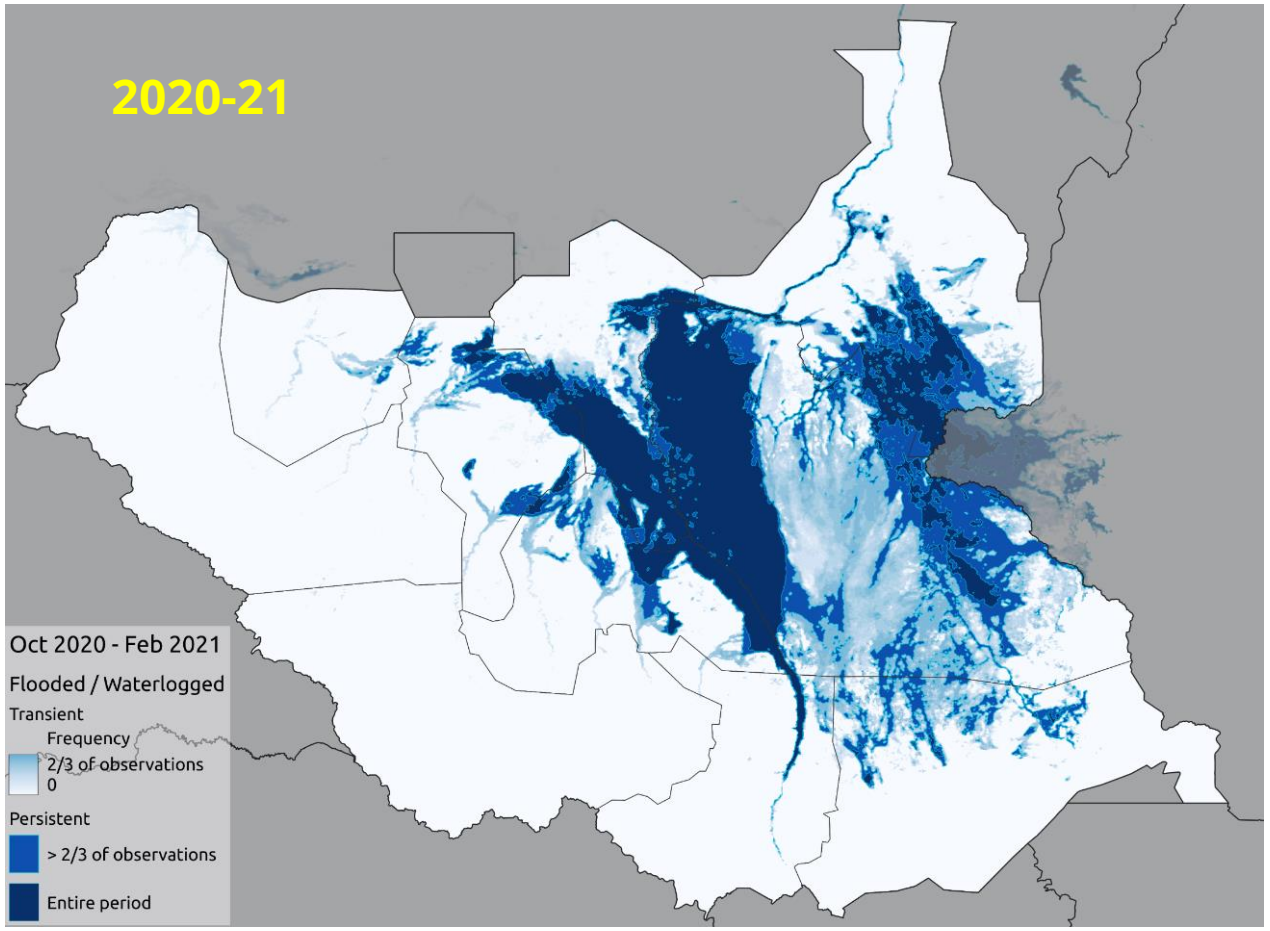
This report does not address the more conventional localized flooding. It focuses instead on an analysis of what might be better designated as wetland status. Most areas affected by the large scale floods of 2019-20 and 2020-21, were not submerged under standing water, but were turned into a mixed landscape of waterlogged soil, patches of open water, water under vegetation canopy, patches of drier higher ground.

We designate this mixed landscape as wetland – while not meeting the narrow definition of a flooded landscape, wetland status nevertheless prevents populations from practicing their livelihoods by making agriculture impossible, dry season pastures unusable, promoting livestock disease transmission, preventing seasonal livestock movements and leading to population displacement.

Exceptionally in 2019-20 and 2020-21, many areas turned into wetland remained so throughout the dry season, preventing return of populations and planting activities.

This report provides an overview of the drivers for the current record wetland extent and places the recent events in its historical context.

Wetland Extent Mapping: Methodology



Wetland status is detected by analyzing thermal imagery from the MODIS/AQUA satellite platform. Specifically, wetlands are detected by analysis of diurnal thermal amplitude (difference between day and night temperatures): dry surfaces exhibit high thermal amplitude, in contrast with wet or flooded surfaces.

Wetland extent is a very dynamic phenomenon, as it varies along the season as a function of changes in rainfall and river levels. The challenge is to convey in a map both the extent and the regularity of the wetland status.

Wetland status is detected using thermal satellite imagery, as the presence of water leads to significant cooling compared with dry ground. Thermal imagery is analyzed with a period from October to February as most seasonal changes occur from the later stages of the rainfall season onwards.

Within this period, we count the proportion of observations that are classified as wetland. This enables the identification of areas which are permanent wetland from those where wetland status is transitory.

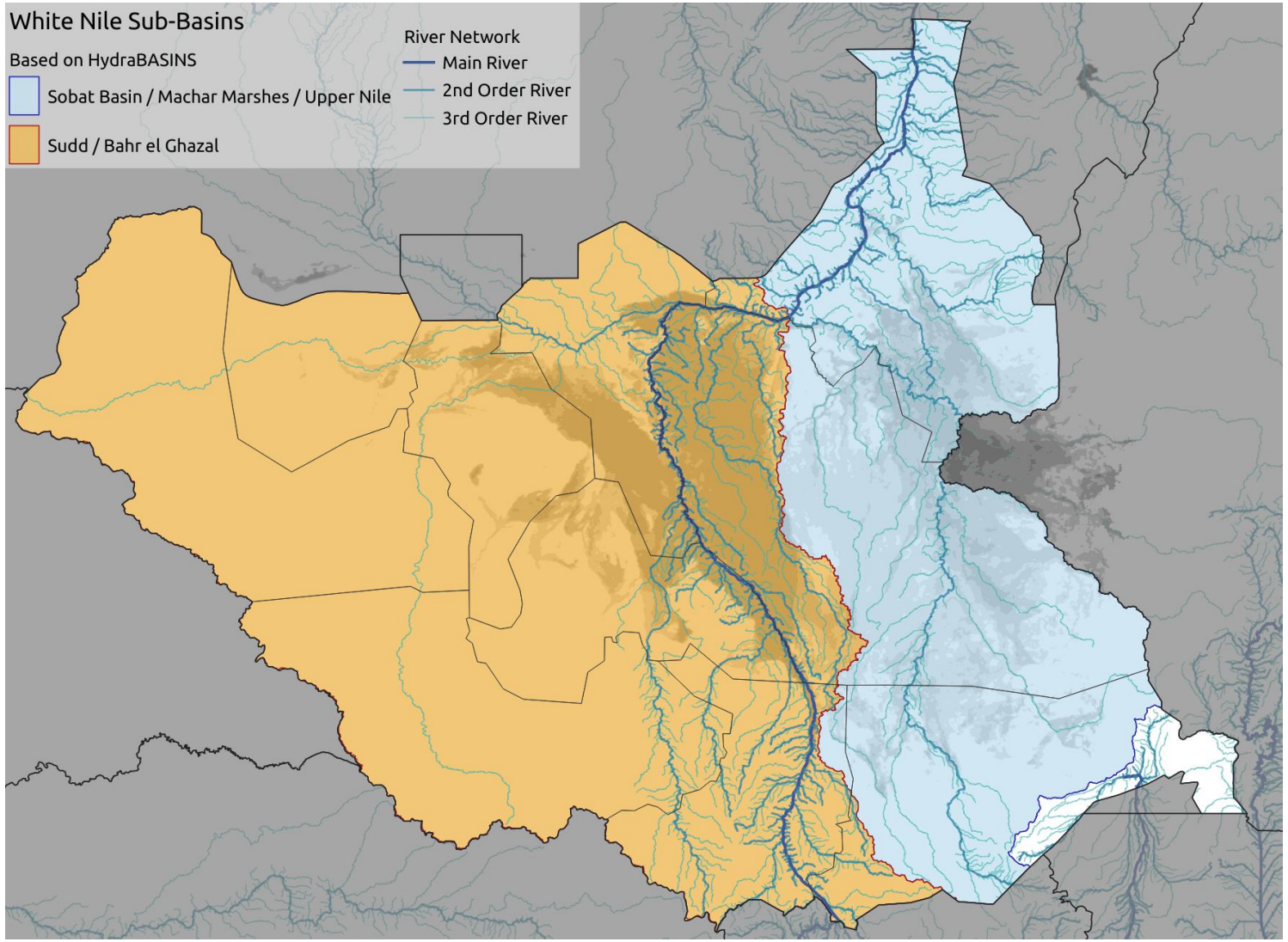
This results in a single synthetic map for each October-February period. An example for 2020-21 is shown on the map to the left.

Three classes were defined: **Permanent**, wetland during the whole period (darkest blue); **Persistent**, wetland during more than two thirds of the period (blue); **Transient**, wetland during less than two thirds of the observations (light blue fading to white).

The example shown left, clearly identifies for 2020-21 the large extent of permanent wetland along the Sudd, persistent wetland in the Machar marshes and along the Ethiopia border and an area of transient wetland in the middle of these two systems.

This data is available since 2002, allowing a nearly 20 year long time series of wetland extent to be analysed (see further ahead).

River Basins in South Sudan



South Sudan has two main sub-basins of the (White) Nile river each with its own large wetland systems.

The Sobat sub-basin occupies most of East Equatoria, Jonglei and nearly all Upper Niles state. This sub-basin includes mostly transitory wetland systems along the Pibor river and the Machar marshes in southern Upper Nile .

The Sudd / Bahr-el-Ghazal sub-basin is larger and includes the rest of the country. This is dominated by the Sudd marshes, which occupy the centre of the country. The central part of these are permanent wetlands.

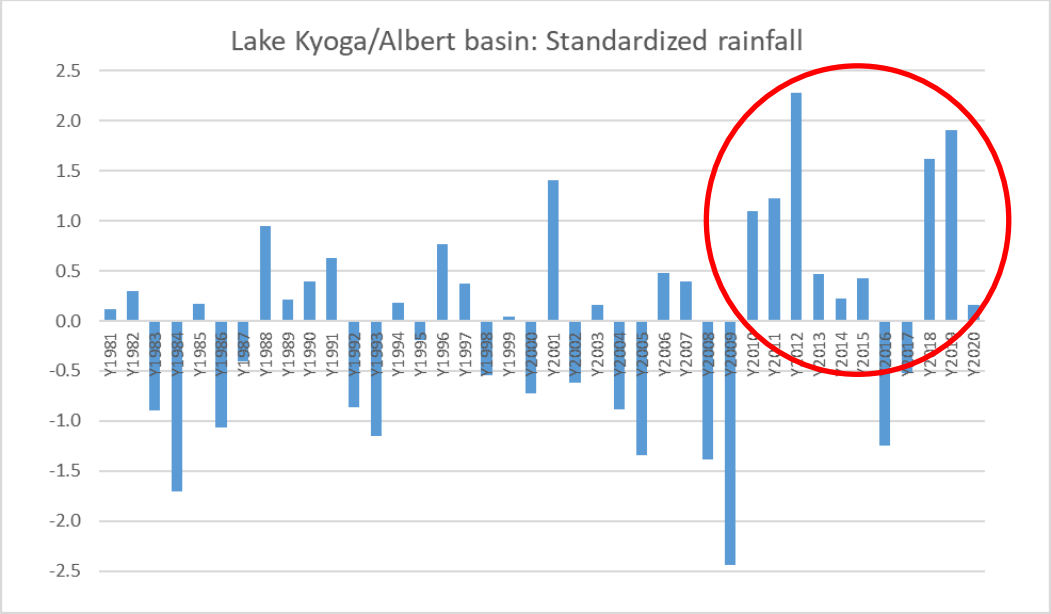
Dark shades in the map show the extent of the record flooding/wetland extent from late 2019 to early 2021.

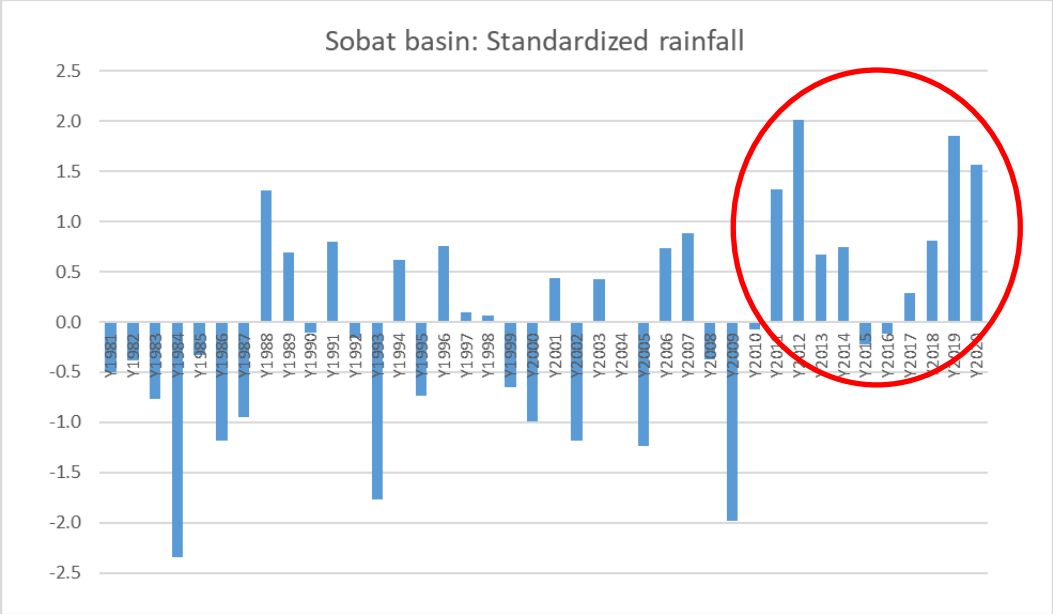
The historical variations of flooding/wetland in these sub-basins is different and is addressed separately.

Drivers of Flooding: Nile Upper Catchment Rainfall

The higher areas of the Nile catchment (Lake Victoria, Lake Albert / Kyoga and Sobat basins), are going through a multi-year wetter than usual phase since 2010. Four or five of the six wettest years in a 40-year record have taken place during this period. 2018 and 2019 in particular, were some of the wettest on record, with extremely intense rainfall.

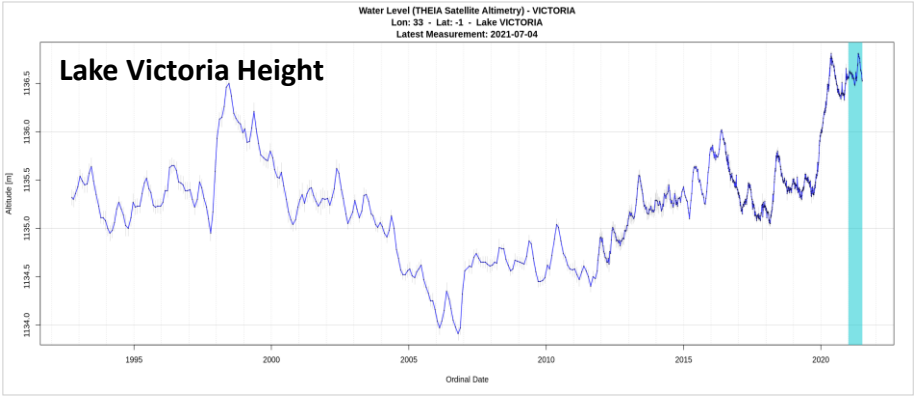
This wet period might remain in place for longer according to short range climate projections and is in agreement with expected patterns from climate projections (see ahead).

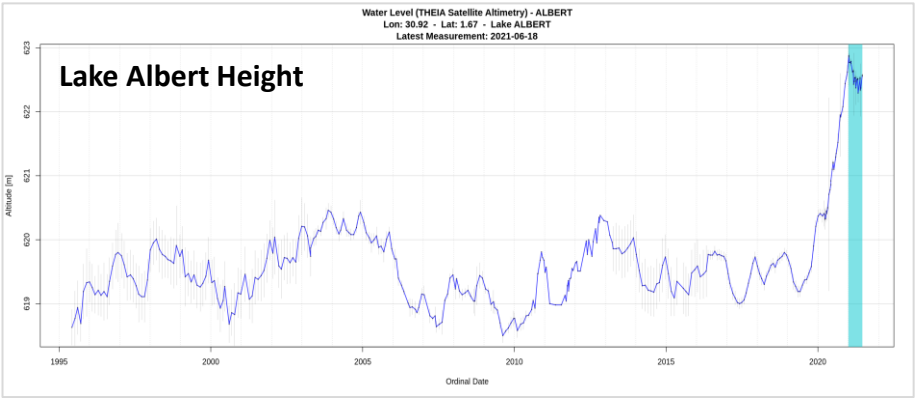


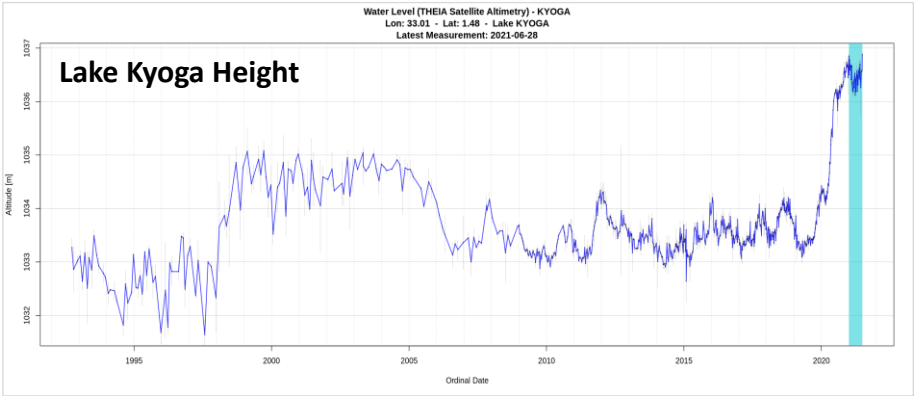


Annual rainfall in the Lake Kyoga/Albert basin in Uganda (above) and the Sobat basin in Ethiopia (below) from 1981 to 2020.
Rainfall is expressed in standard deviations off the 40 year mean. Values above +1 or below -1 would be expected to occur once every six years on average. Note how the +1 value has been consistently exceeded since 2010

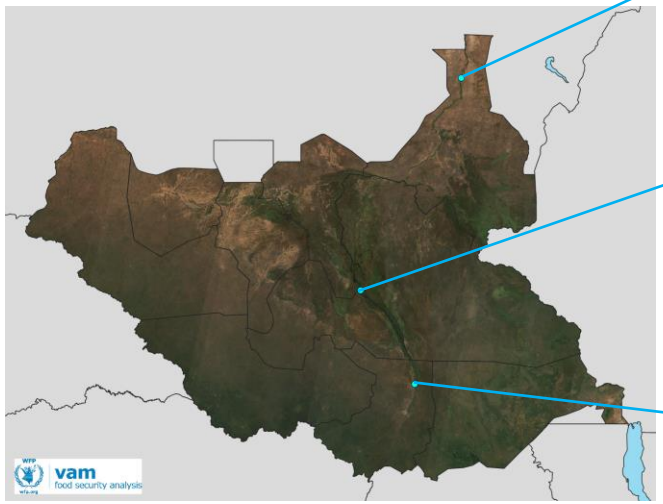
Drivers of Flooding: Lake Water Height and River Levels

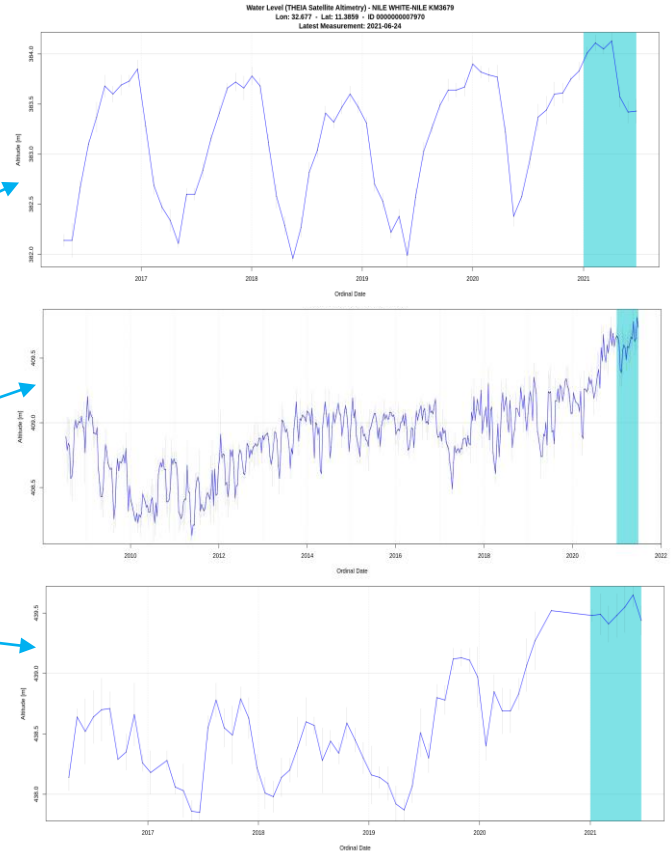






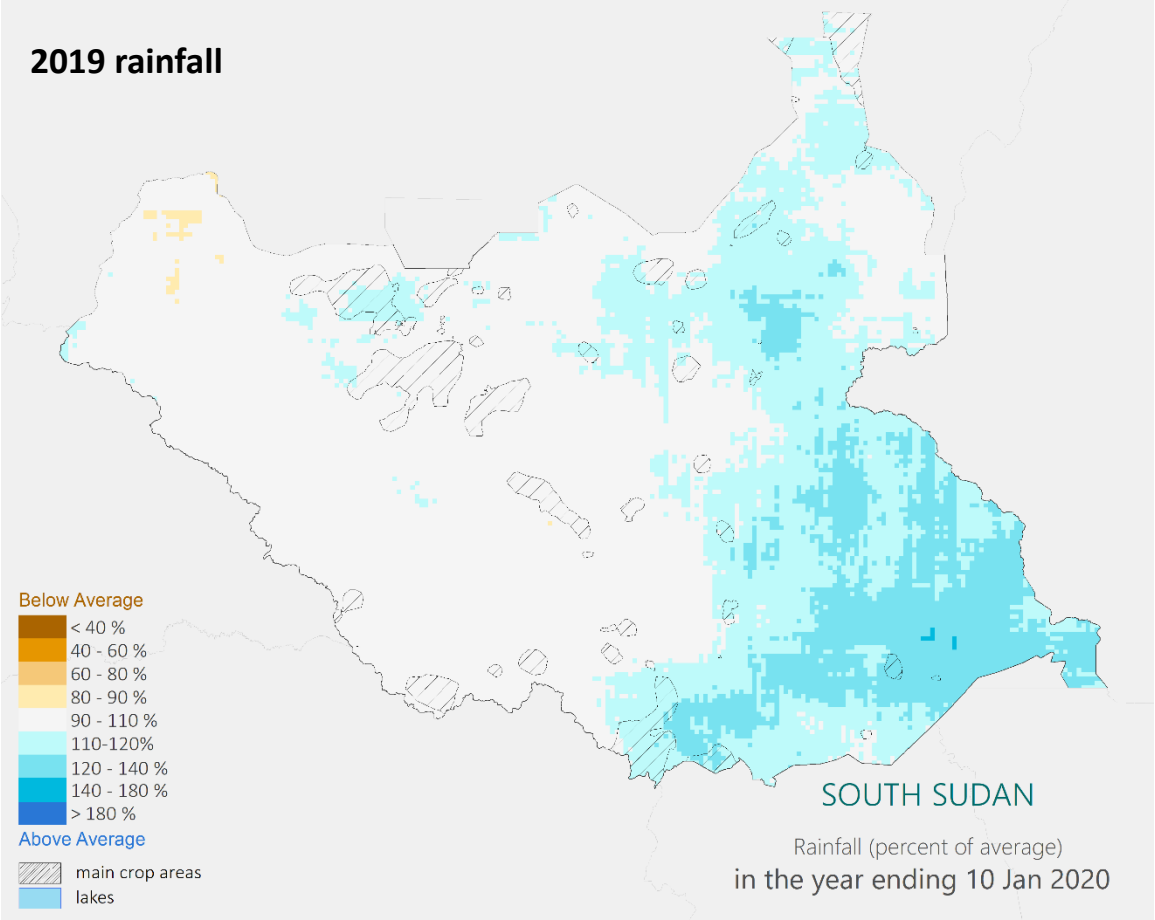
As a result, water levels at Lakes Victoria, Albert and Kyoga reached and remained at record heights since mid-2020, even if more recent rainfall has been closer to normal. This excess water has increased Nile flows into South Sudan and will drive an enhanced flood risk there months down the line.

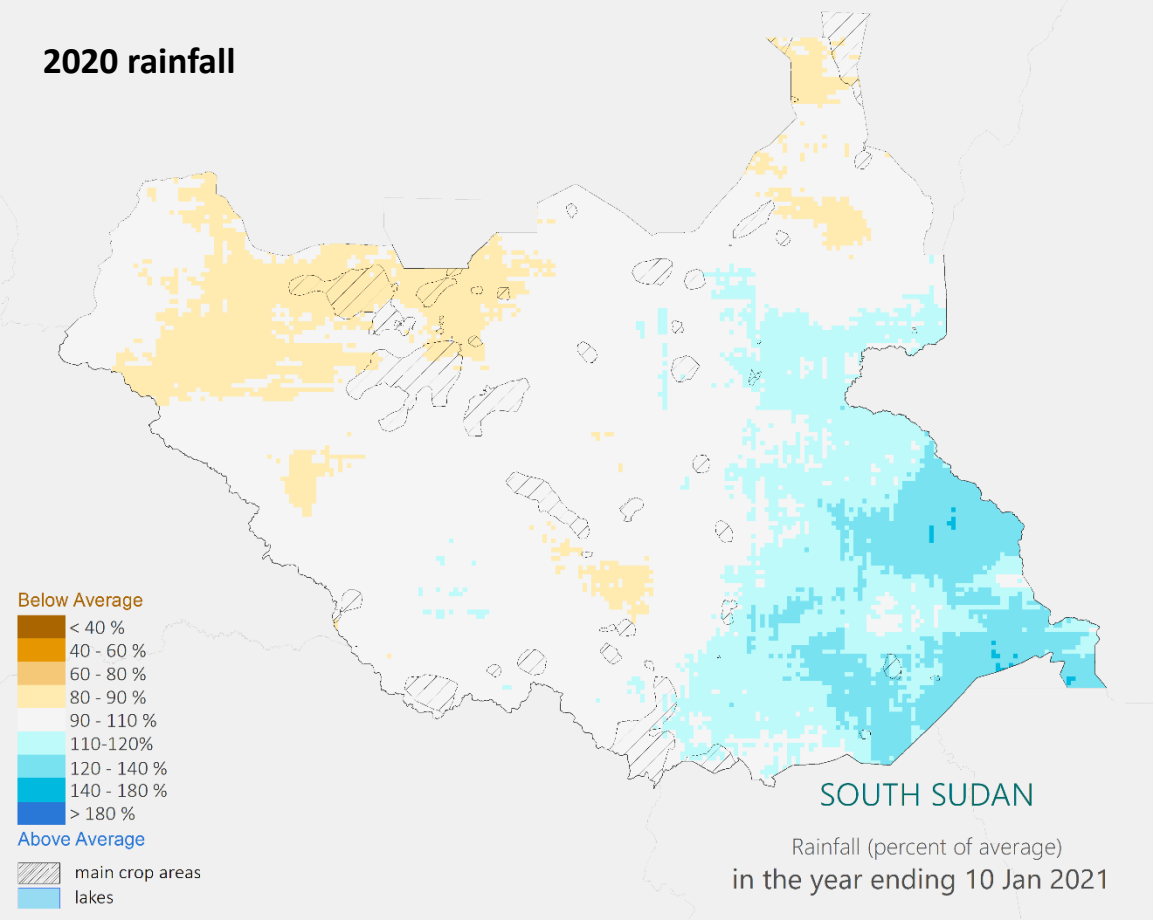




Satellite altimetry data shows that water levels along the main White Nile have remained at record levels at all times of the season since late 2019, sometimes with much less evident seasonal minima. The Baro and Sobat river levels are also very elevated.

Drivers of Flooding: In-country rainfall



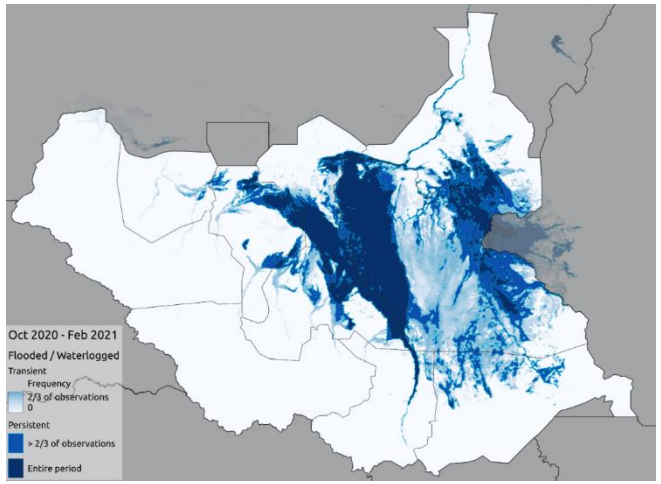


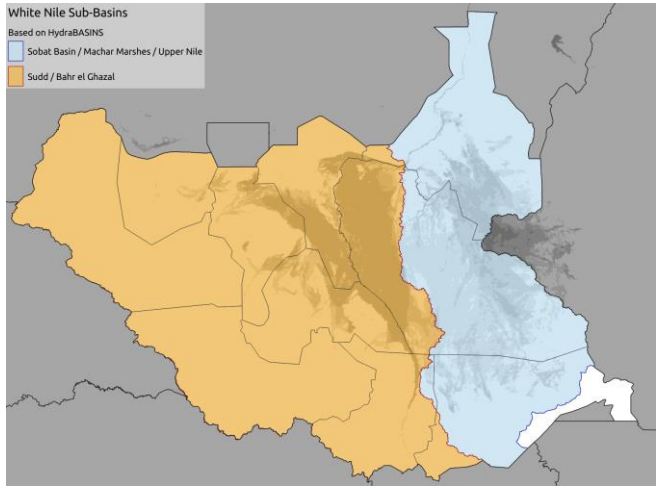
Annual rainfall for South Sudan in 2019 (left) and 2020 (right) as a propotion of the long term average. Blue (orange) shades for wetter (drier) than average conditions.

For the past two years in a row, rainfall has been above average in the eastern regions of South Sudan, with large areas receiving about 30% more than usual. These wetter than average conditions are also a major contributor to the wetland extent in these regions, but their impact seems to be more transient than the flooding driven by large scale excess catchment rainfall and enhanced river levels

Historical Wetland Extent

Wetland Extent Assessment: Method





Wetland extent is computed from the synthetic seasonal images derived from thermal imagery.

The extent is derived separately for the Sudd and the Sobat sub-basins and for each wetland duration class:

- Permanent Wetland (full duration),
- Persistent Wetland (over 2/3 of the period)
- Transient Wetland (between 1/3 and 2/3 of the period)

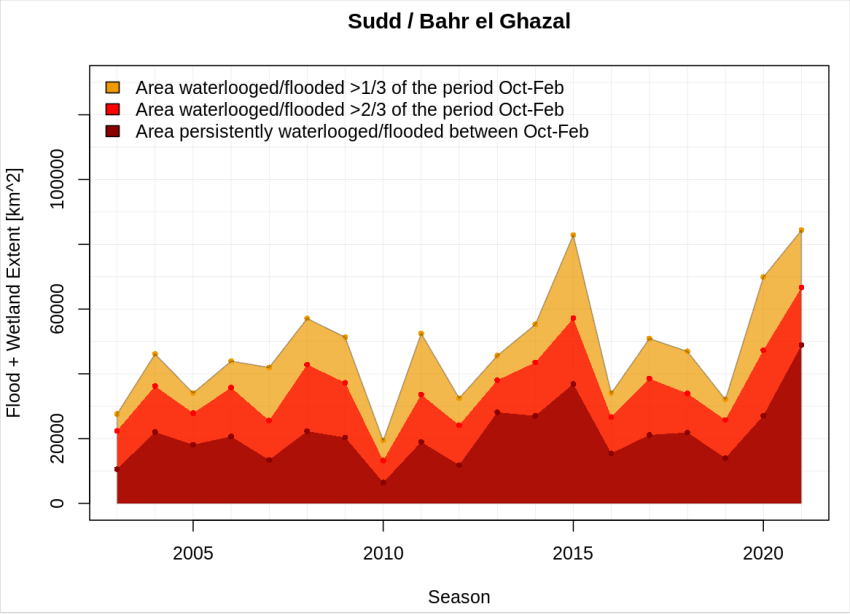
The total countrywide extent (both sub-basins) is also derived

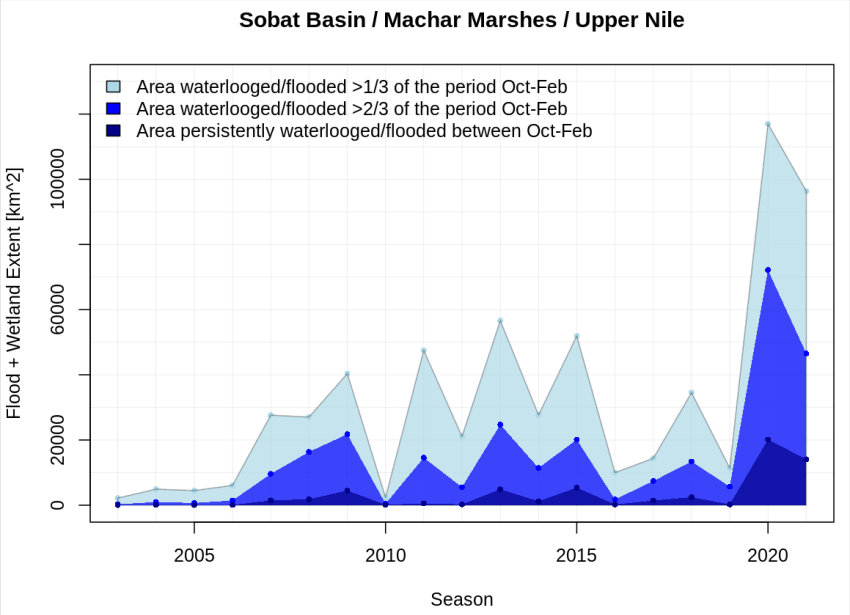
These wetland extents are derived for all the October-February periods since 2002-03 to 2020-21 and plotted as time series (see next slide).

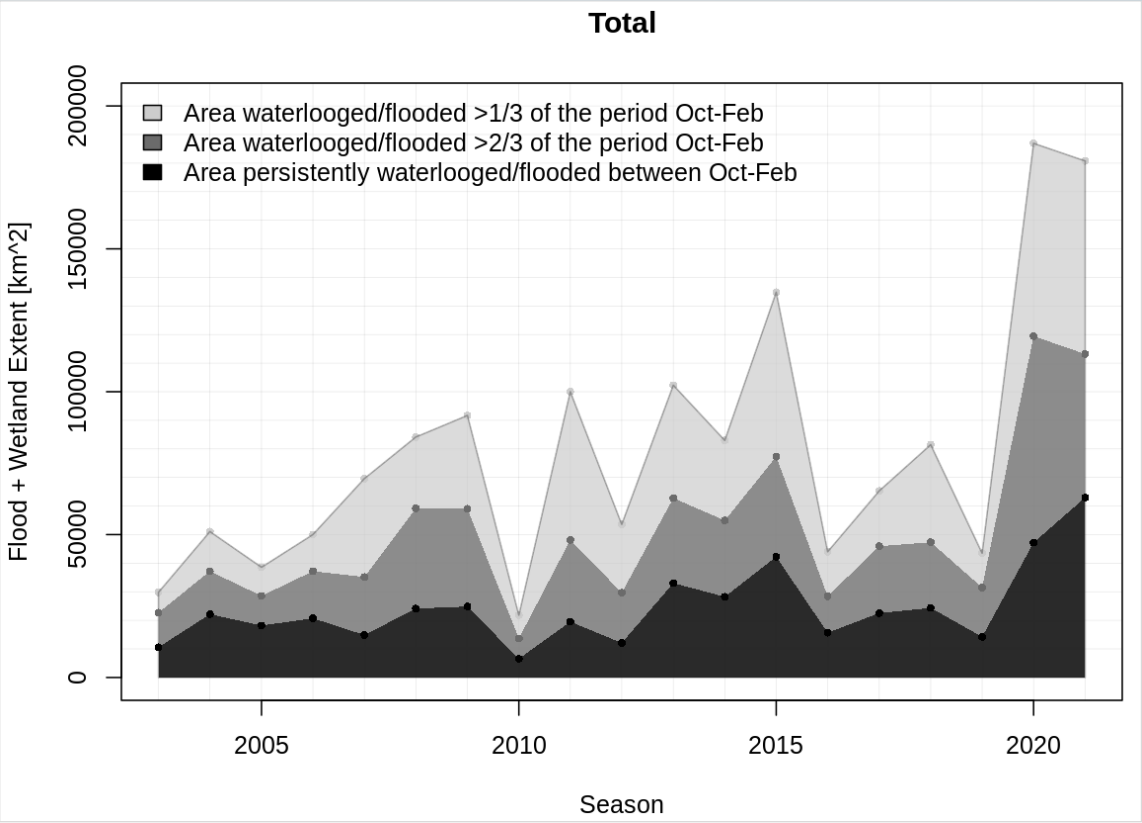
The historical maps are presented next, first with some summaries (long term average, extremes and sharp transitions) and then the full complement of yearly maps.

Extents in the charts can be crossed checked with the extent maps provided for each season (October-February period).

Wetland Extent Assessment: Inter-annual changes







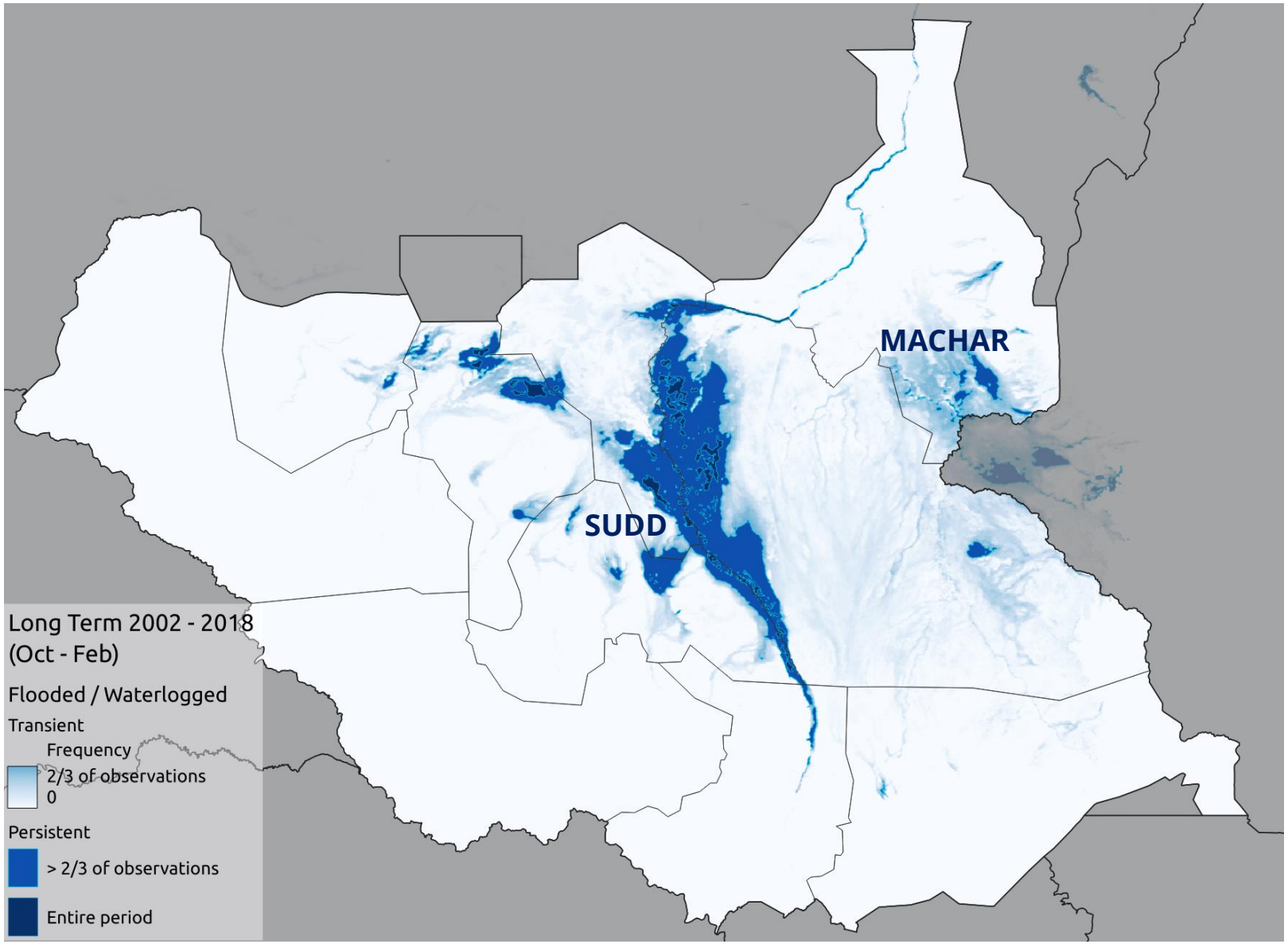
The wetland extent charts for the Sudd and Sobat are shown left above and below. We see that, for the two systems, the last two seasons register the largest extents since 2002. For the Sudd marshes, the difference is more pronounced for the Permanent and Persistent wetland extent. Only the season of 2014-15 comes close.

For the Sobat, the exceptional nature of the last two seasons is far more pronounced at all three levels of wetland duration.

The combined extent chart (above) reinforces these features, highlighting the large contribution of the Sobat system to the record breaking extent of the last two years.

There is an apparent trend that arises from the extreme values of the past two years but it is not known whether extents will decrease after this peak or remain around this level – see slide 16 for a possible outlook.

Wetland Extent Assessment: Long Term Average



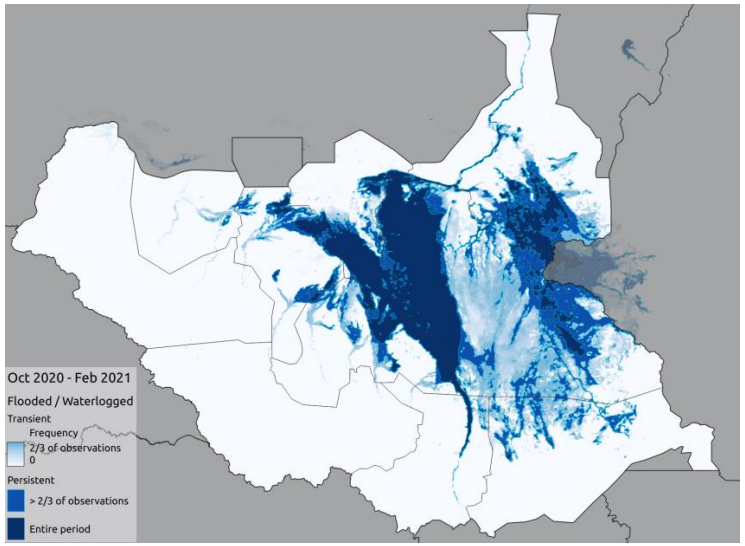
The long term cumulative of all wetland status observations shows clearly the areas more prone to wetland status. All areas with near permanent wetland status are well individuated.

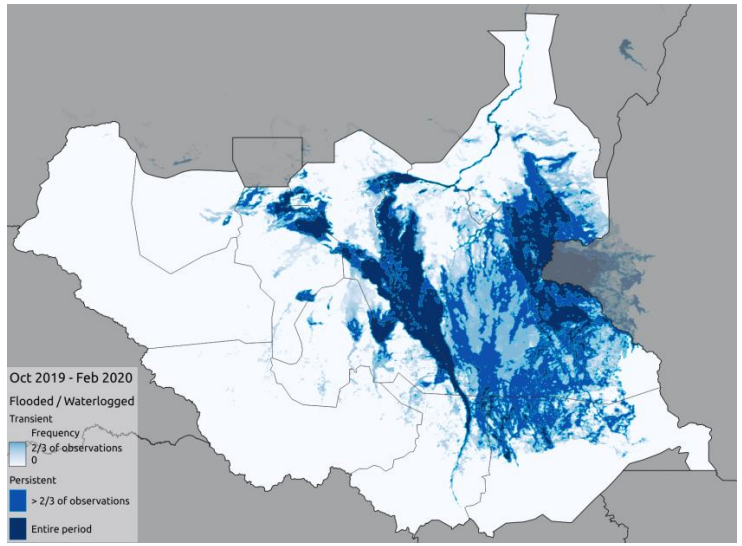
The large Sudd marshes are clearly far more permanent than the Machar marshes in southern Upper Nile – these are more dependent on exceptional rainfall years.

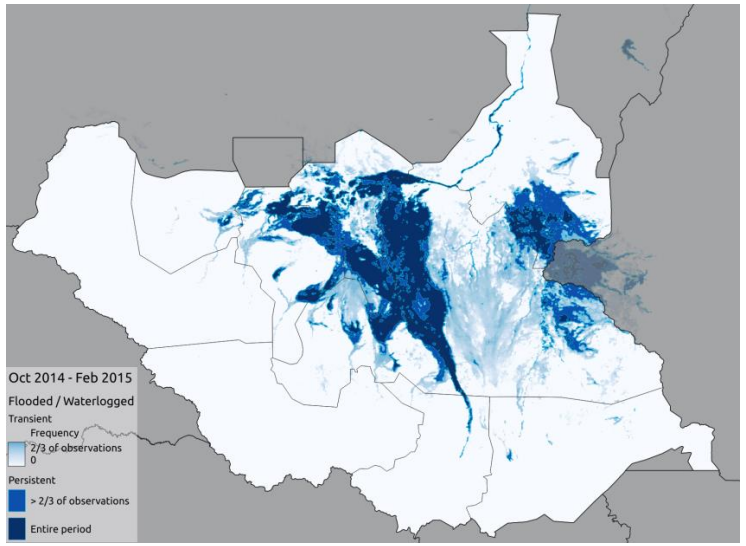
Other areas which go into wetland status only occasionally and for short periods are also well visible.

Individual season wetland extent maps are presented in the last section of this slide deck, slide 17 onwards.

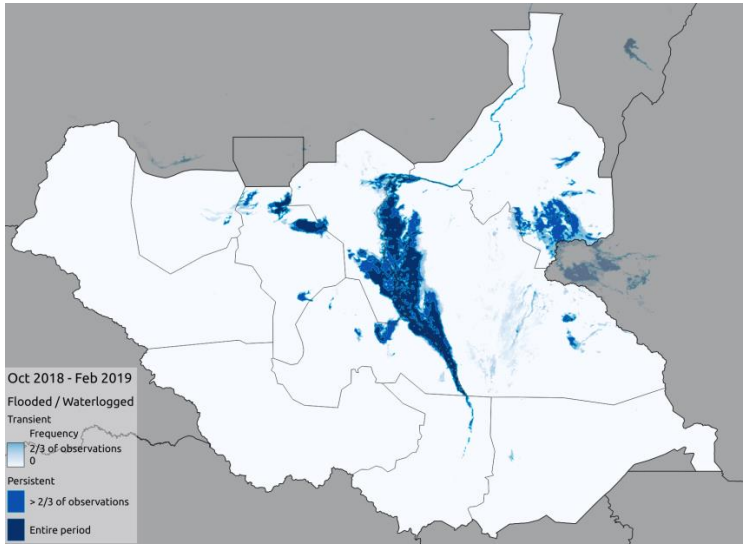
Wetland Extent Assessment: Extremes

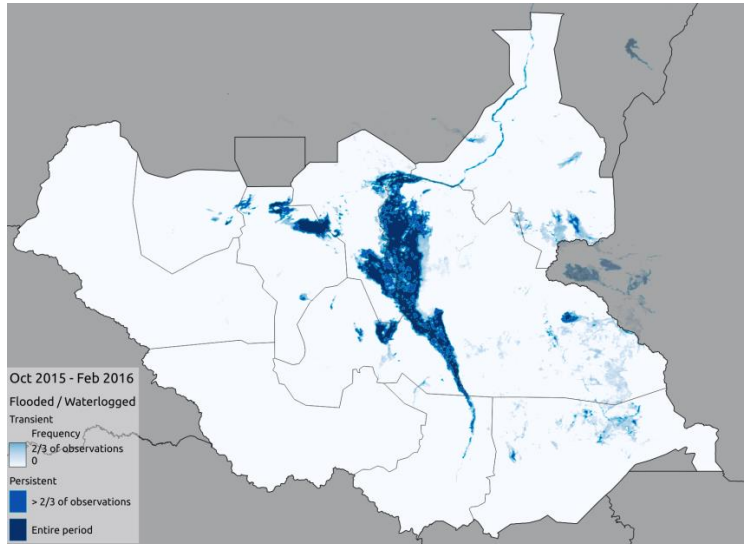


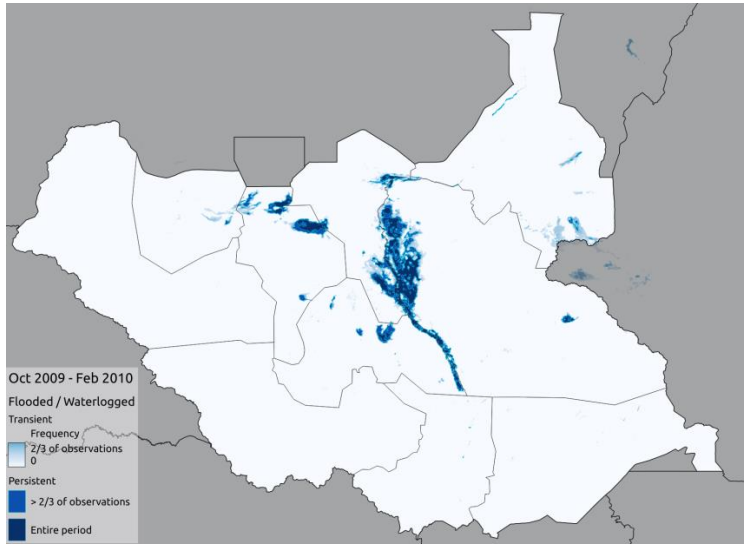




The three largest wetland extents in South Sudan in decreasing order of size: 2020-21 (left), 2019-20 (middle) and 2014-15 (right)

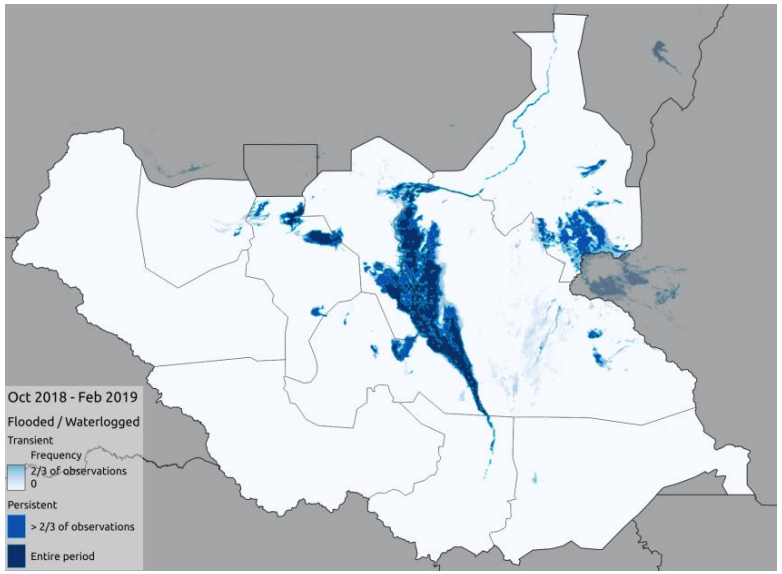


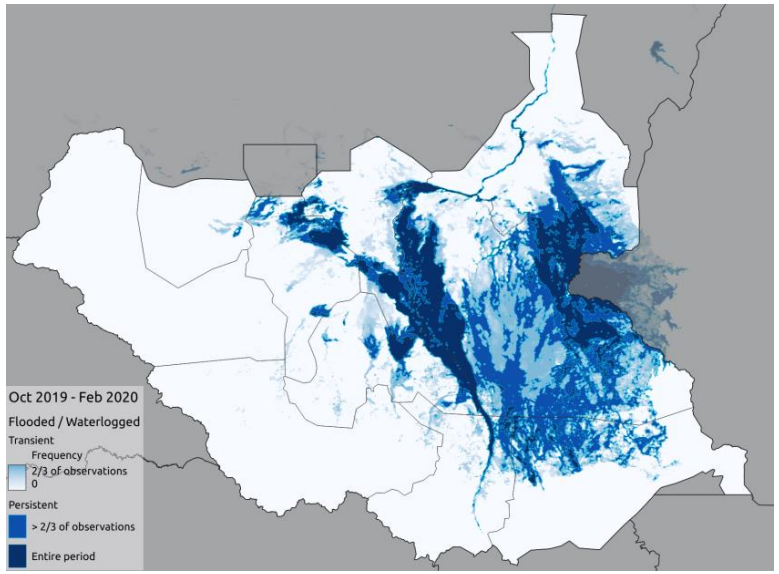




The three smallest wetland extents in South Sudan in decreasing order of size : 2018-19 (left), 2015-16 (middle) and 2009-08 (right)

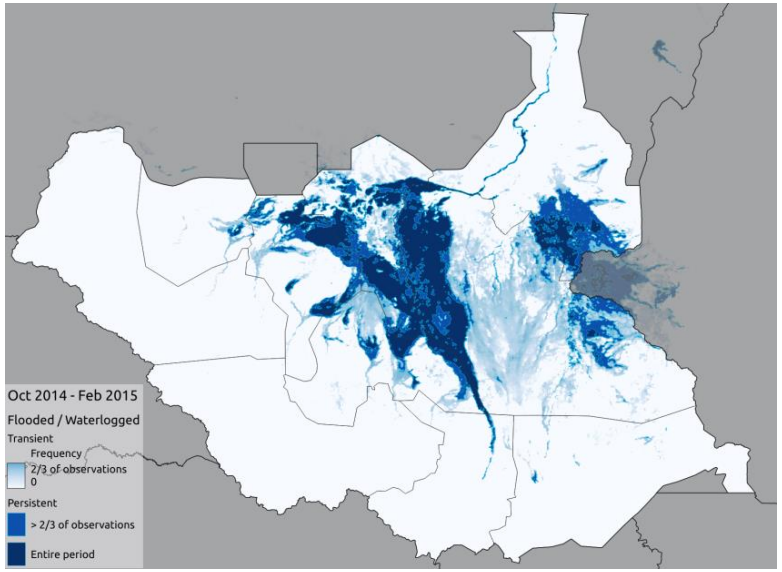
Wetland Extent Assessment: Sharp Year on Year Transitions

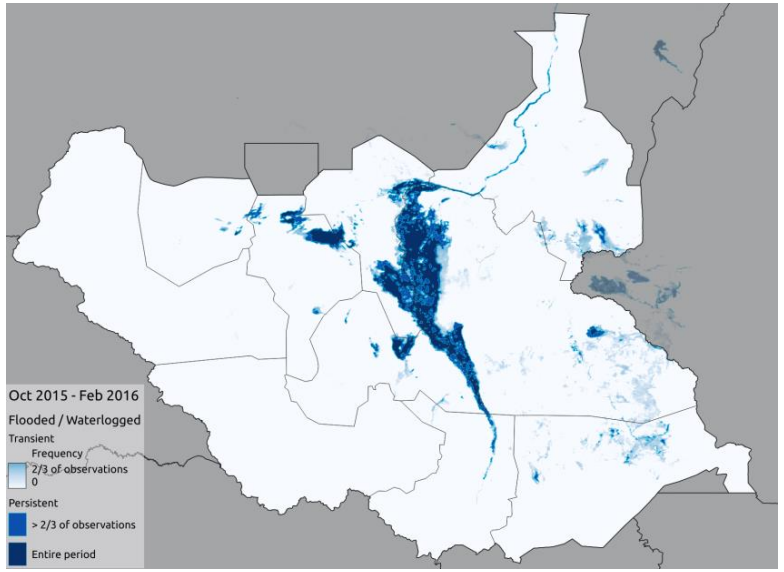




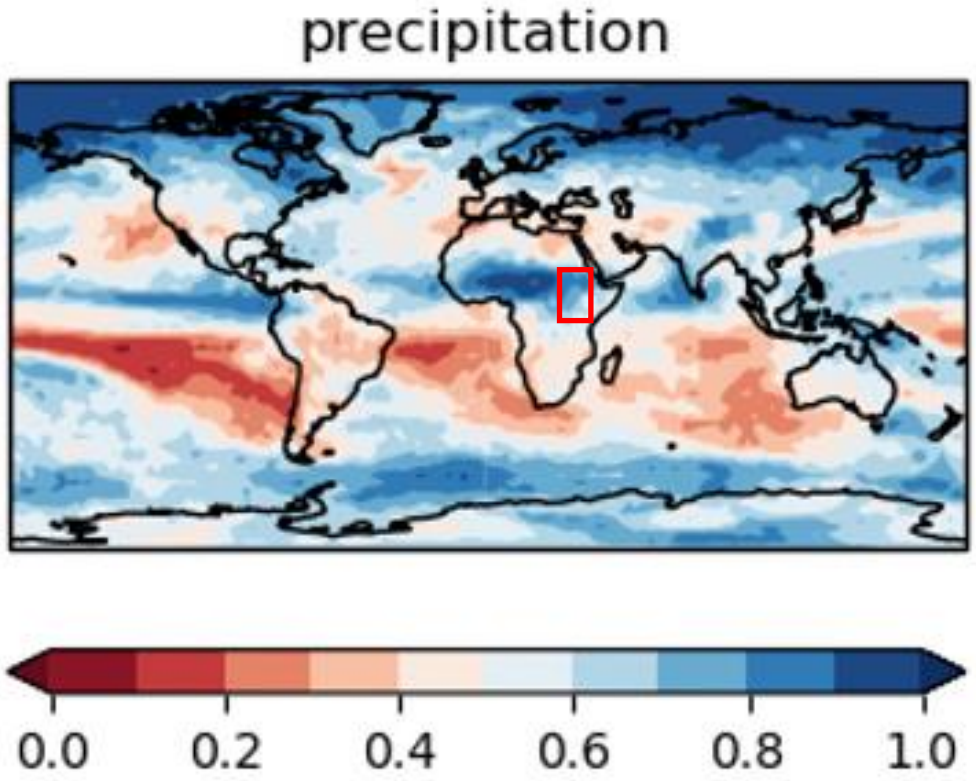
Sharp inter-annual transitions can be seen in the historical record, both from low to high (as in 2018-19 to 2019-20) or from high to low extents (as in 2014-15 to 2015-16.

Although changes in annual rainfall were behind these inter-annual changes, the question now is if the increased Nile flows, and the large soil moisture reservoirs that have built up in the past two years will offset a reduced contribution from possible lower rainfall amounts.





Wetland Extent Assessment: Long Term Outlook



The Global Annual to Decadal Climate Update, led by the UK's Met Office, is a joint international effort that provides a climate outlook for the next five years, updated annually.

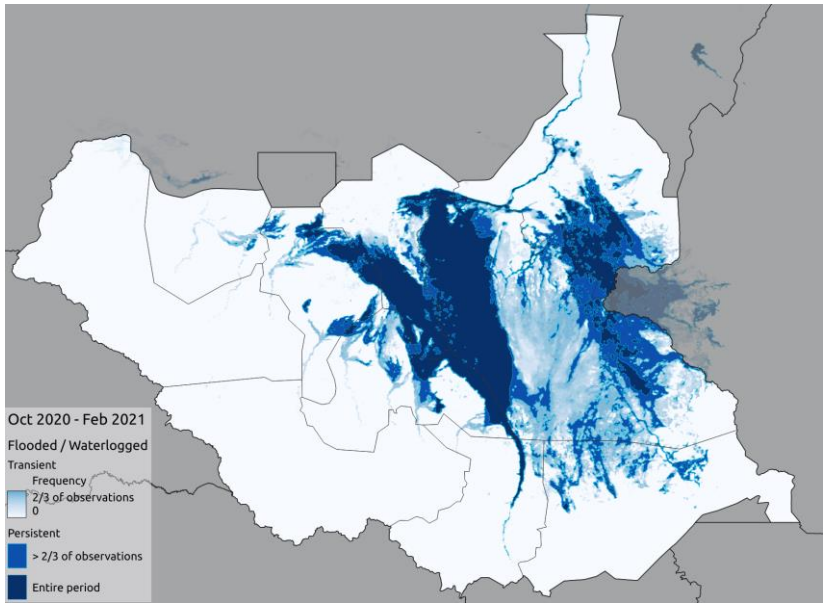
The latest forecasts cover the period 2021-2025. The map left shows the probability that the **next five** years will be characterized by above average rainfall.

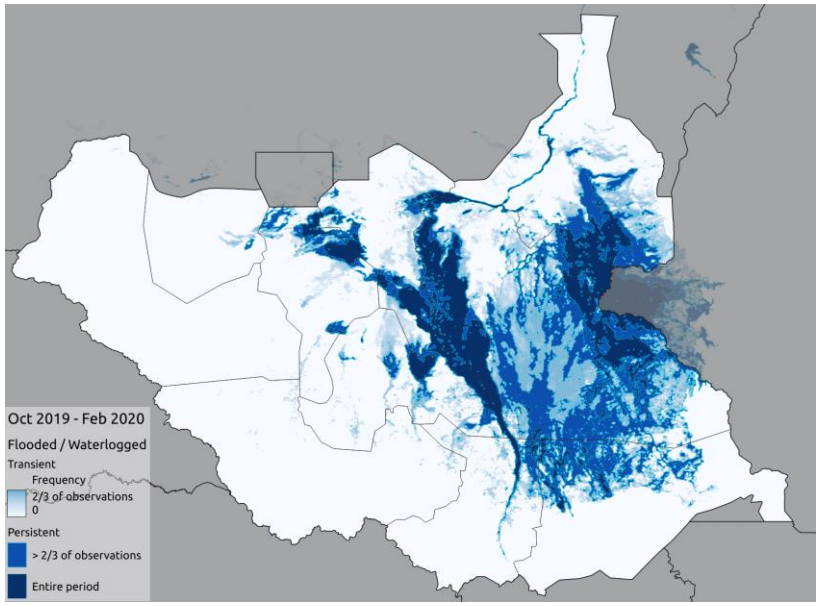
We see that expectations for the Nile basin are indeed of a period of wetter than average conditions. Although interannual variability around this forecast trend will be the major driver for food availability, enhanced rainfall over a sustained period is likely to lead to the maintenance or increase of elevated lake levels and river heights.

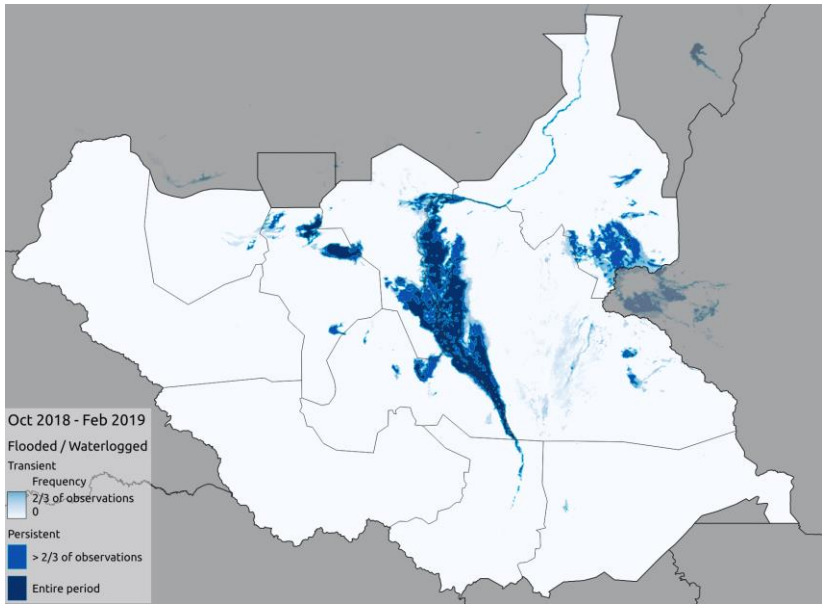
As such, should this forecast verify, South Sudan may see record wetland extents being maintained or exceeded in the next few years.

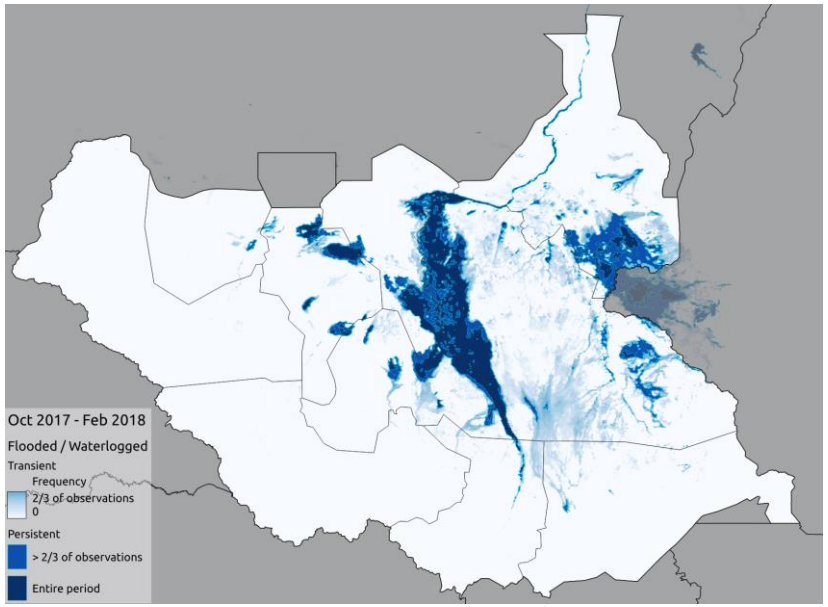
Historical Wetland Maps

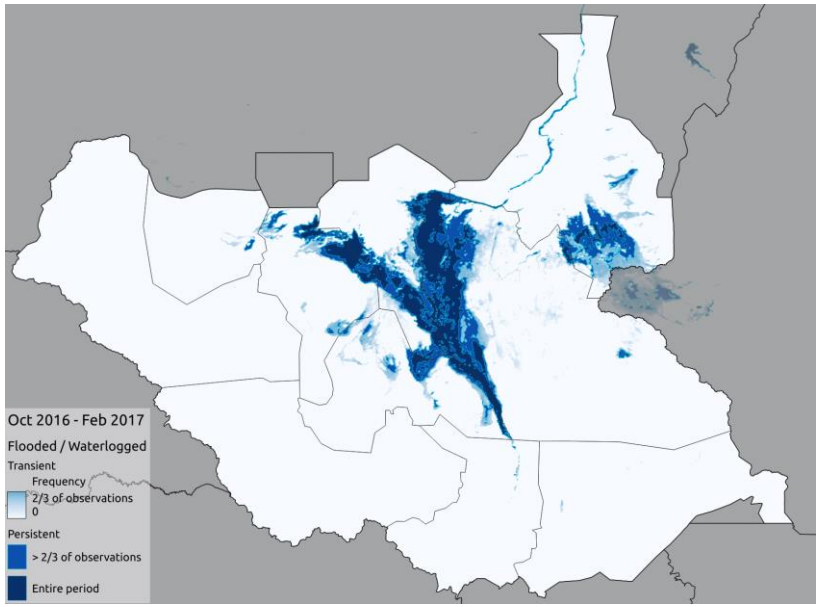
Wetland Extent Assessment: Seasonal Maps

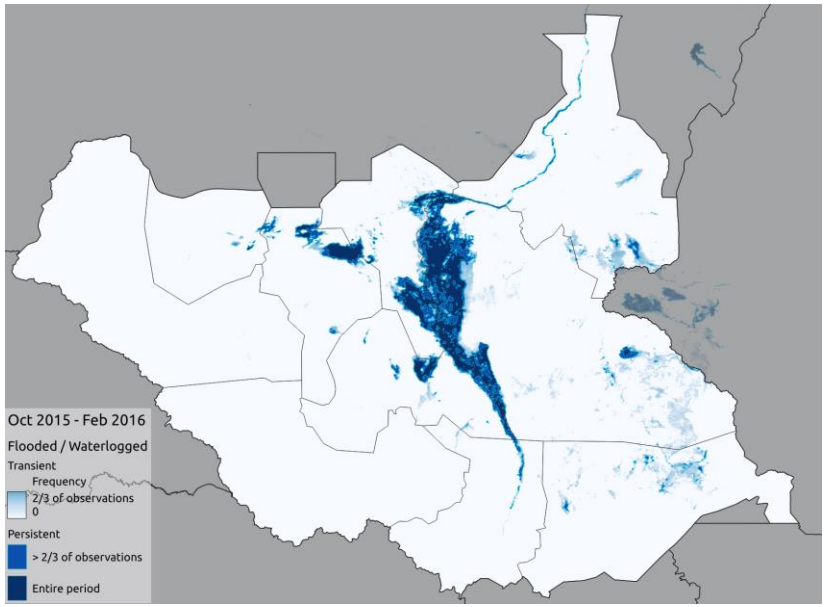




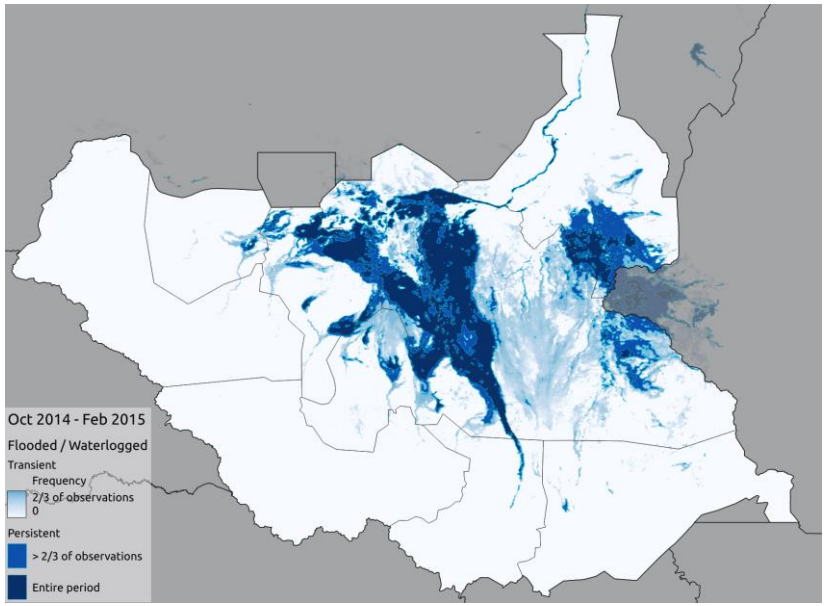


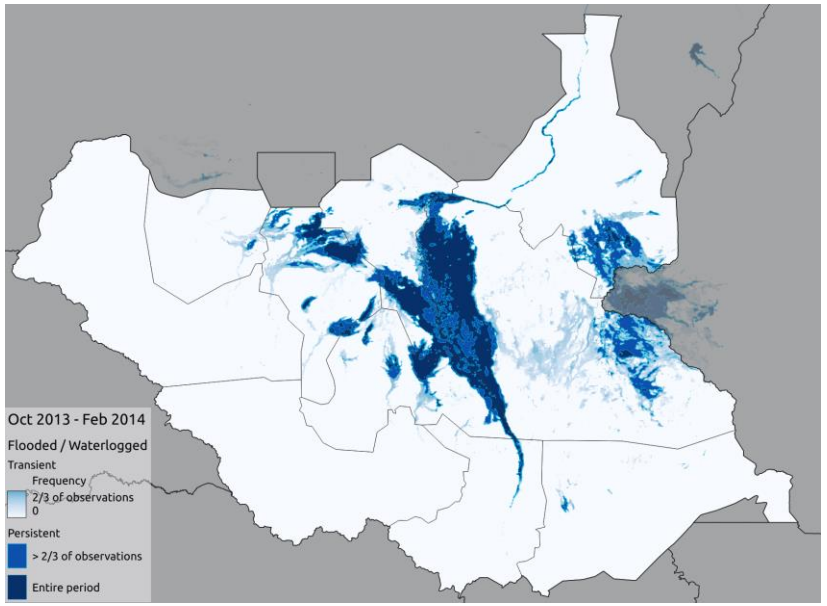


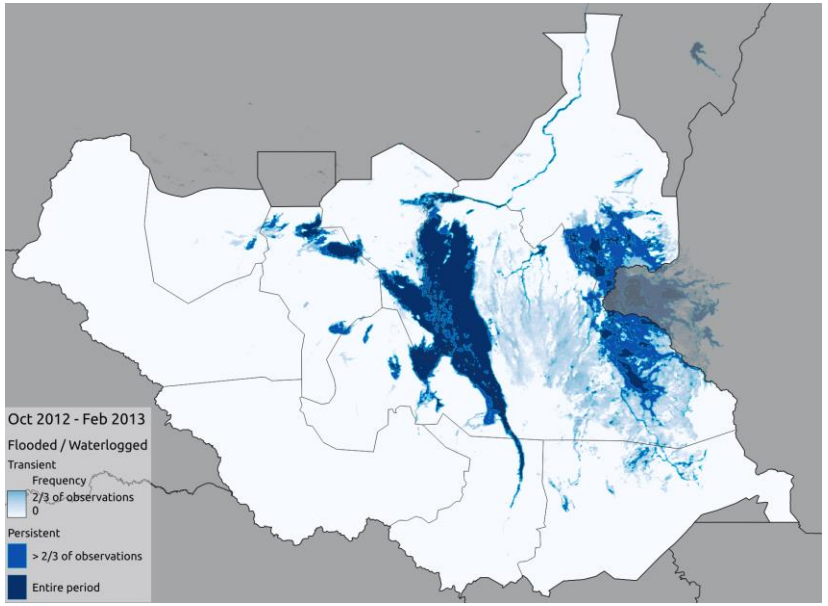


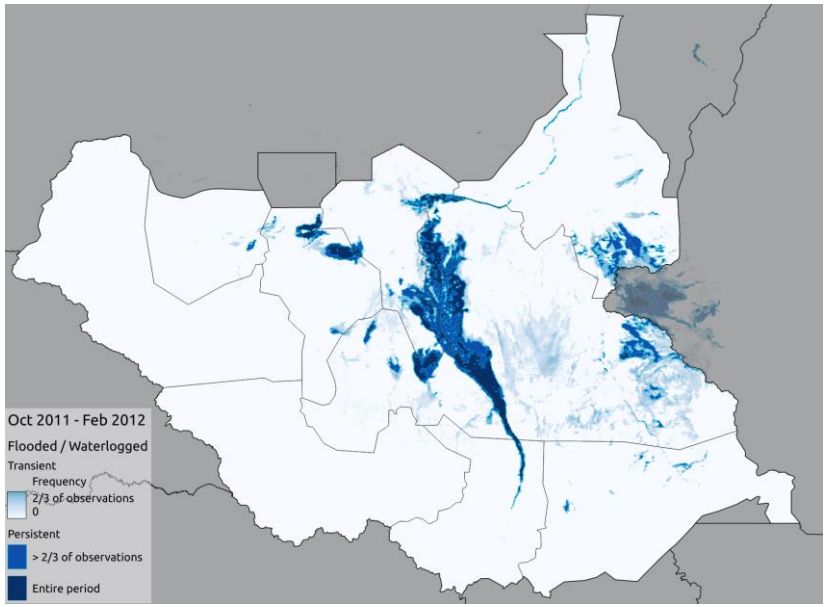


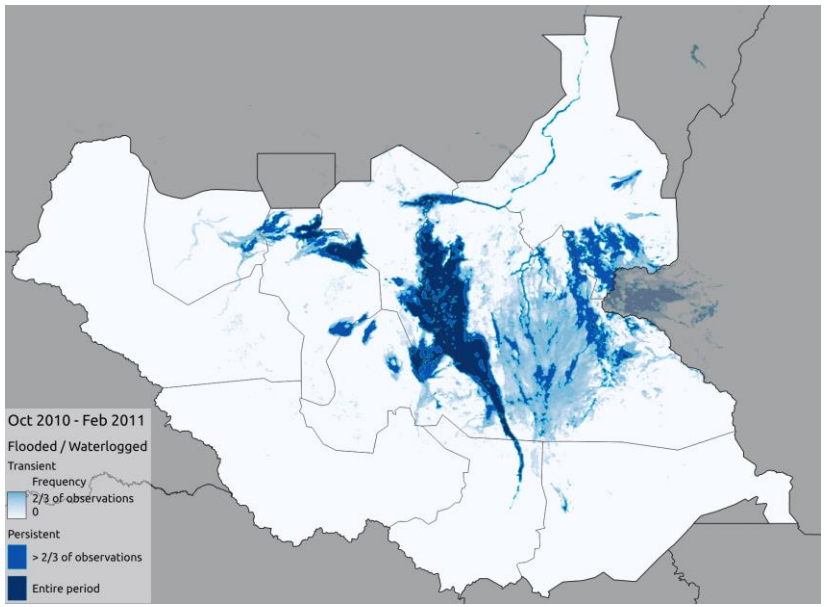
Wetland Extent Assessment: Seasonal Maps

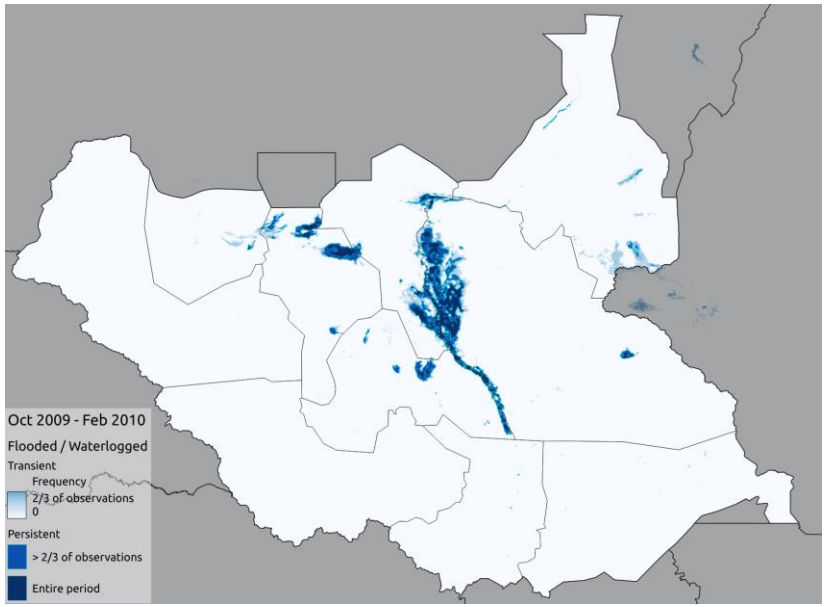




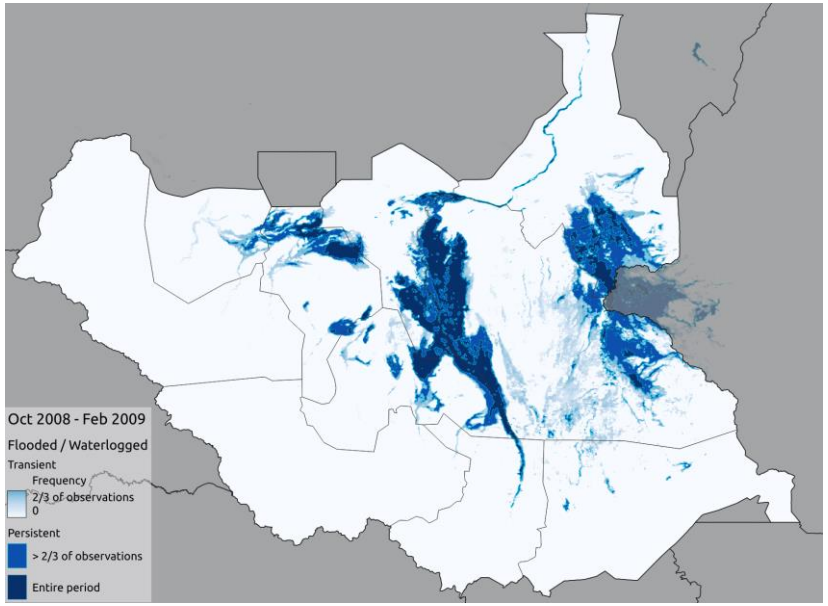


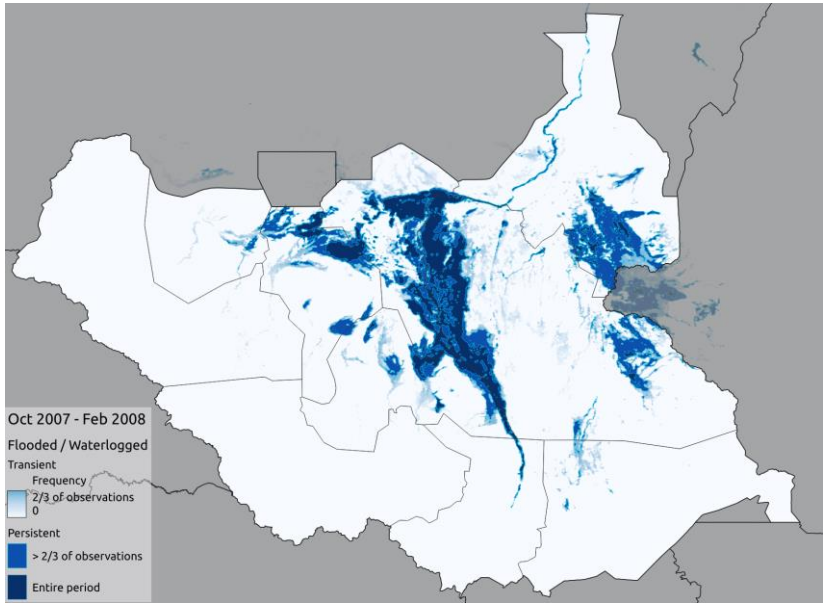


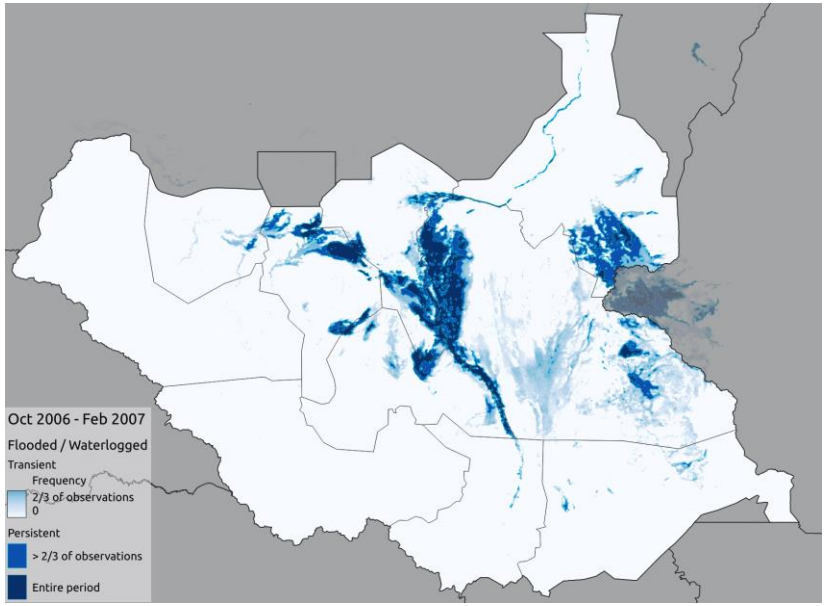


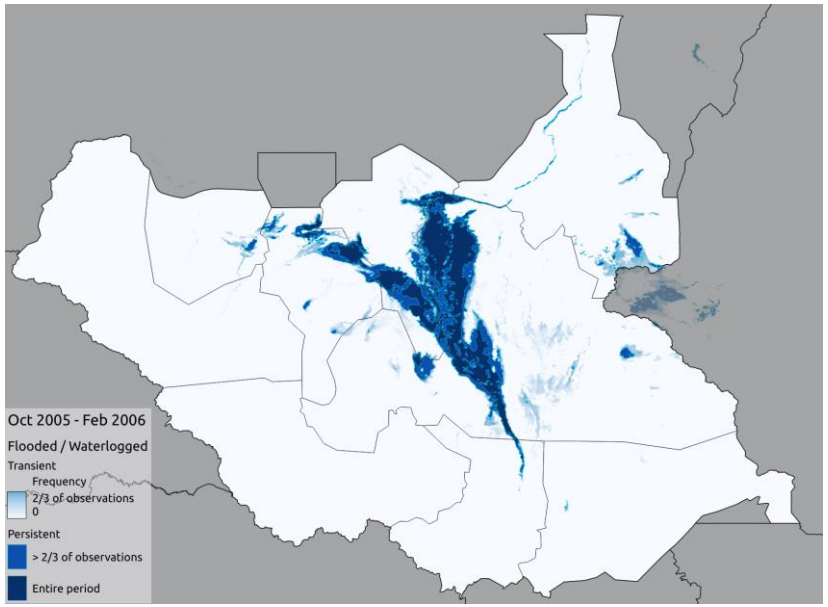


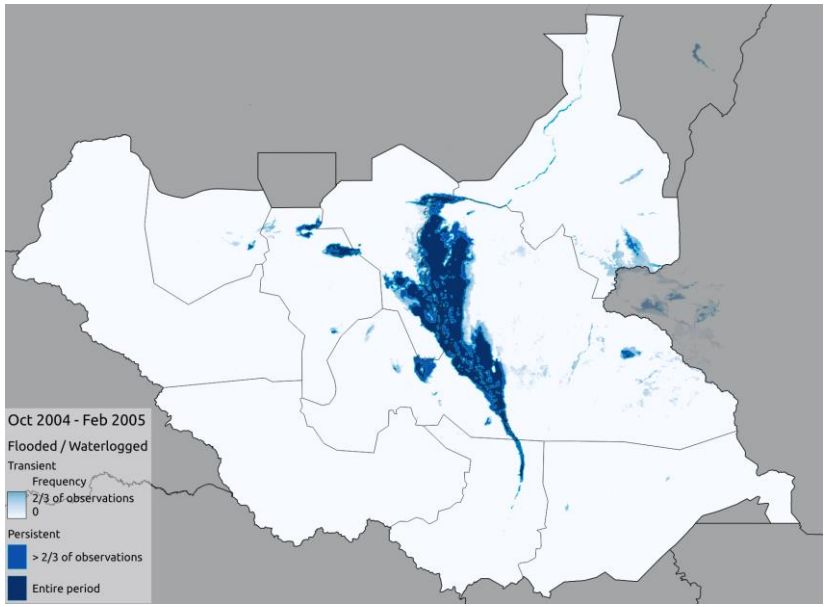
Wetland Extent Assessment: Seasonal Maps

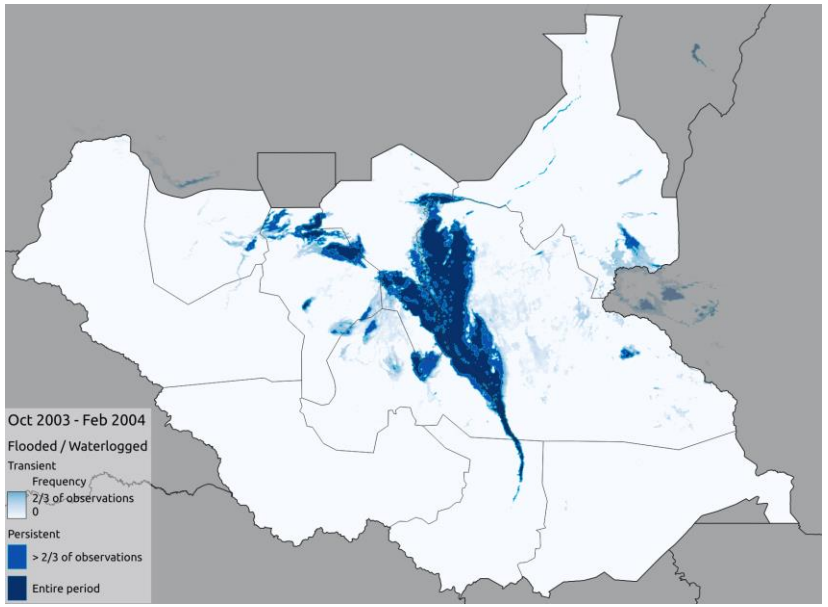












The End