COMITE PERMANENT INTER-ETATS DE LUTTE CONTRE LA SECHERESSE DANS LE SAHEL
PERMANENT INTERSTATE COMMITTEE FOR DROUGHT CONTROL IN THE SAHEL
COMITÉ PERMANENTE INTER-ESTADOS DE LUTA CONTRA A SECA NO SAHEL
اللجنة الدائمة المشتركة لمحاربة التصحر في الساحل

Bénin | Burkina Faso | Cap Vert | Côte d'Ivoire | Gambie | Guinée | Guinée Bissau | Mali | Mauritanie | Niger | Sénégal | Tchad | Togo

Centre Régional AGRHYMET

Methodological guide for agro-hydro-climatological forecast for West Africa and the Sahel

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By

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I. Preamble

In West Africa and the Sahel in particular, socio-economic activities are highly dependent on the quality of the rainy seasons, due in particular to the high sensitivity of key sectors such as agriculture, water resources, energy and ecosystems to the agro-hydro-climatic parameters characterizing rainfall patterns. The most important of these parameters are cumulative seasonal rainfall amounts, onset and cessation dates of the rainy seasons, dry spell durations and extreme rainfall events. These vary greatly from year to year and from place to place, making it difficult to plan activities and investments on the eve of the rainy seasons. Faced with this situation, seasonal forecasting of these parameters is an effective means of reducing uncertainties in decision-making for better risk and disaster reduction and to take advantage of the expected configuration of the rainy season. It is within this framework that the AGRHYMET Regional Centre, ACMAD and the national meteorological and hydrological services of West African and Sahelian countries are developing, on the eve of each rainy season, consensual seasonal forecasts on cumulative rainfall, season onset dates, dry spell duration, season cessation dates and flows in the major river basins of the sub-region. To this end, two forecasting sessions are organized in the form of regional forums, followed by monthly updates:

1. *The seasonal forecast forum for the Sudanian and Sahelian zones (PRESASS);*
2. *The seasonal forecasting forum for the Gulf of Guinea Countries (PRESAGG).*

Each of these sessions have the active participation of experts from the countries that prepare the national forecasts and contribute to the development of the regional consensus forecasts. Each session is organized in two parts (the pre-forum and the forum) and includes three thematic groups for forecasting:

- *cumulative rainfall for the periods June-July-August and July-August-September (for PRESASS) and March-April-May and May-June-July (for PRESAGG) ;*
- *agrometeorological parameters such as season onset dates, dry spells durations at the beginning and towards the end of the rainy season, and season cessation dates;*
- *flows (runoffs) in the major river basins of the sub-region.*

The Pre-forum takes place over 3 to 4 days and within each group, it covers the following aspects:

- *Review on forecasting methods,*
- *Formatting, updating and preparation of the data of the parameters to be predicted,*
- *Calculating the predictands and formatting them in the CPT software compatible format,*
- *Downloading the observed or simulated by climate models predictors: sea surface temperatures (SST), winds at different altitude levels, precipitations, long wave radiation, etc. ;*
- *Searching for correlations between predictands and predictors and establishing forecasting models;*
- *Synthesis between the different groups for the refinement and consolidation of consensus forecasts, taking into account the forecasts of the major climate centers and the knowledge of climate experts in the sub-region ;*
- *Elaboration of advice and practical guidance to enable users (decision-makers, researchers, extension workers, farmers, herders, fishermen, NGOs, disaster risk reduction agencies, health services, populations, etc.) to minimize risks related to droughts, floods, diseases, phytosanitary attacks, and to better take advantage of the foreseen potential benefits of the rainy season.*

The forum is the formal framework for communicating and sharing the results of the seasonal forecasts produced. It is the forum where the final communiqué on the seasonal forecasts is made public before the national authorities of the organizing country and various regional actors: representatives of technical services, NGOs and disaster risk reduction agencies, etc.

In order to improve the organization of seasonal forecasts, the AGRHYMET Regional Centre (a regional institution that is in the process of becoming the Regional Climate Centre for West Africa and the Sahel) ensures, at the regional level, the coordination of forecasts with the technical and scientific support of ACMAD (an institution playing the role of Continental Climate Centre at the African level). At the national level, each country is requested to formalize within the NMHSs a team dedicated to forecasting with the appointment of a national focal point.

II. Detailed methodology for the elaboration of agro-hydro-climatic forecasts

2.1. Cumulative rainfall forecasts JJA and JAS

2.1.1. Organization of data

Two types of data are required: Predictands and predictors
Predictands are the data to be predicted. They are usually observed data from weather stations or satellite data considered as observed data.
Predictors are the data used to make the forecast. They are generally Sea Surface Temperatures (SST), data from seasonal climate prediction models (general circulation models) of the World Forecast Centers (WFCs) or WMO reference centers. Exemple: NOAA/NCEP/cfs, IRI/echam, etc.

2.1.2. Observational data/stations

- *Use the reference period 1981-2010*
- *Have a series of daily precipitation data for at least the period from 1981 to date ;*
- *Aggregate (calculate) the daily data into rainfall totals for the periods June-July-August (JJA) and July-August-September (JAS), e.g. rainfall totals from 1981-2019.*
- *Put the data in Excel format as follows:*

STN	Station_A	Station_B	Station_C	Station_D	Station_E	Station_-
LAT	14.23	14.75	10.48	12.5	13.55	-
LON	-0.87	0.85	16.55	-7.78	-7.45	-
1981	549.1	248.3	642.2	975.3	438.4	-
1982	643.2	325.5	457.8	801.9	533	-
						-
						-
2019	726.8	85.8	-999	1077.4	-999	-

Where -999 represents missing values

- *Convert the Excel files to the txt format (text, separator, space) ou csv (text, separator, comma)*

❑ **Data from global circulation models** *(ECHAM, CFS, CAM-CMC, GFDL, ECMWF, NMME, COPERNICUS, etc.).*

These data are downloadable from the sites of the different centers (example of IRI DataLibrary, or NCEP/CPC) in an appropriate format (here, the CPT format should be used, which is the tool to be used later):
On the NCEP site, there are formats ready to be downloaded and used by the CPT tool:

- https://ftp.cpc.ncep.noaa.gov/International/nmme/seasonal_nmme_forecast_in_cpt_format/
- https://ftp.cpc.ncep.noaa.gov/International/nmme/seasonal_nmme_hindcast_in_cpt_format/
- https://ftp.cpc.ncep.noaa.gov/International/nmme/monthly_nmme_forecast_in_cpt_format/

- https://ftp.cpc.ncep.noaa.gov/International/nmme/seasonal_nmme_hindcast_in_cpt_format/

On the IRI platform, one would have to go to the dataLibrary and download the data using the INGRID language developed for this purpose. Sample script: Downloading the U component of the JAS mean winds from the ECHAM model

```
expert
 SOURCES .IRI .FD .ECHAM5 .T42 .Forecast .ca_sst .ensemble24 .MONTHLY
.PressureLevel .v
  S ( Apri 1981) ( Apri  2020) RANGEEDGES
  S (Jul-Sep) seasonalAverage
  [M L]average
  X (60W) (20E) RANGEEDGES
   Y (00N) (40N) RANGEEDGES
   L (2.5) (4.5) RANGEEDGES
  P (925) VALUES

  S (T) renameGRID
   -999 setmissing_value
```

The arguments of S, X, Y, L and P can be modified to take into account the period (S), the spatial coverage (X and Y), the time step (L) and the pressure level (P).

From these sites several parameters used as predictors can be downloaded and used by the CPT Tool. These include, but are not limited to:

- *Winds at different altitudes*
- *Precipitable water*
- *Total Precipitation*
- *Long wave radiation*
- *Sea surface temperatures,*
- *etc.*

2.1.3 Review of the State of the Atmosphere and the Oceans

Here, the aim is to understand the current and future dynamics of the atmosphere and oceans through the atmospheric general circulation and ocean surface states.
Analysis of sea surface temperatures:

- *Pacific Ocean (ENSO) especially the NINO 3.4 box.*
  Positive temperature anomalies or warming in this part indicate El-NINO conditions that are generally characterized by rainfall deficits over the Sahel.
  Negative anomalies of temperatures or cooling on this part indicate LA-NINA conditions that are generally characterized by excess rainfall over the Sahel.

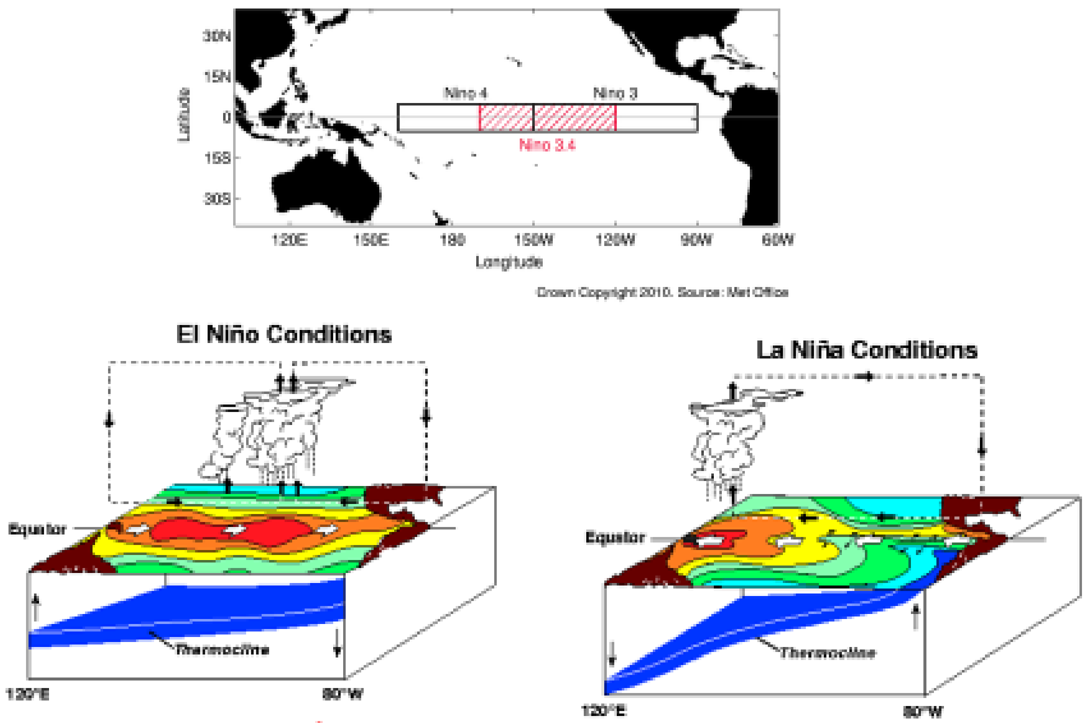
- *Atlantic Ocean: Gulf of Guinea*
  A cooling over the Gulf of Guinea leads to a fairly good penetration of the monsoon flow on the Sahelian strip.

- *Atlantic Ocean: Senegalese and Mauritanian coasts:*

A warming over this zone generally leads to a good penetration of the monsoon on the coastal countries in the Sahel.

- *Indian Ocean*
  Temperature evolution over the Indian Ocean may indicate the initiation conditions (cyclogenesis) over East Africa of squall lines responsible for more than 80% of the Sahel rainfall.

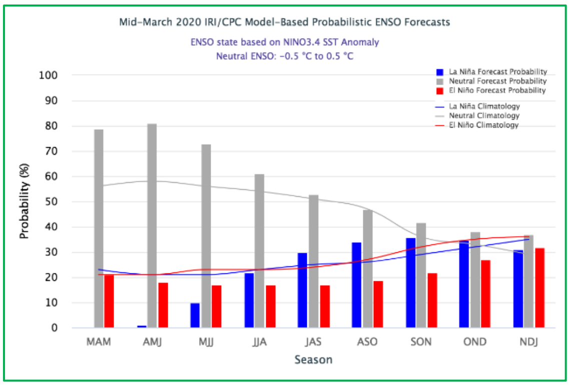
- *Mediterranean Sea*
  Prolonged warming in this part could lead to the Inter-Tropical Front being sucked up and maintained for a longer period of time over the northern Sahel countries, thus prolonging the rainy season.

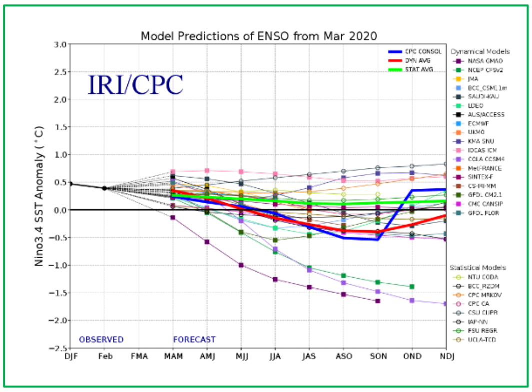


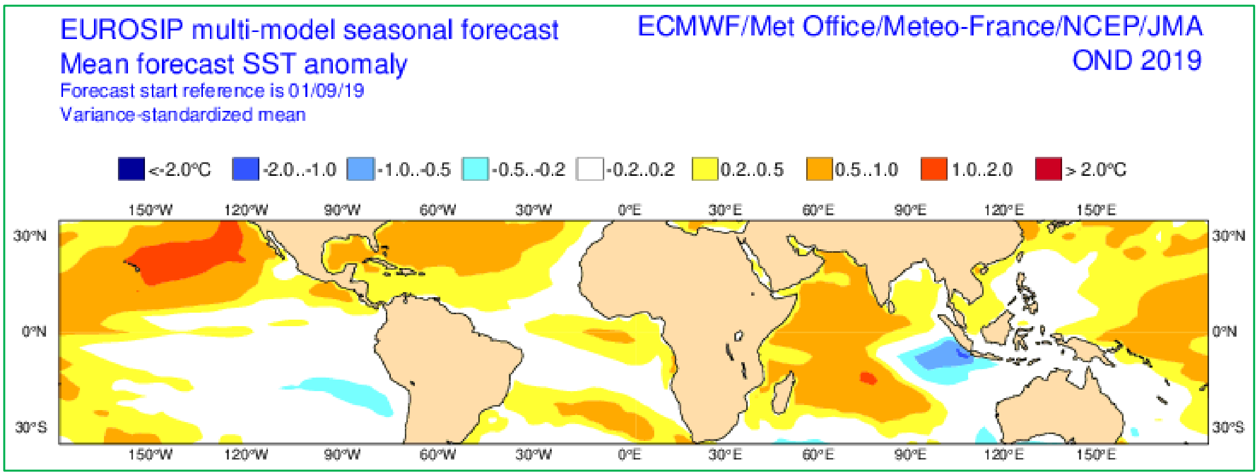
Sur le Pacifique le déplacement de la masse d'eau chaude d'Ouest en Est induit le deplacement des nuages precipitantes. (Niño et Niña)

- **Outlook for sea surface temperatures and precipitation**

Analysis of model predictions of future changes in sea surface conditions and precipitation outlook from world and reference centers.
Here, the aim is to provide an overview of global circulation model forecasts in terms of SST and precipitation outlooks for periods concerning e.g. JJA and JAS.

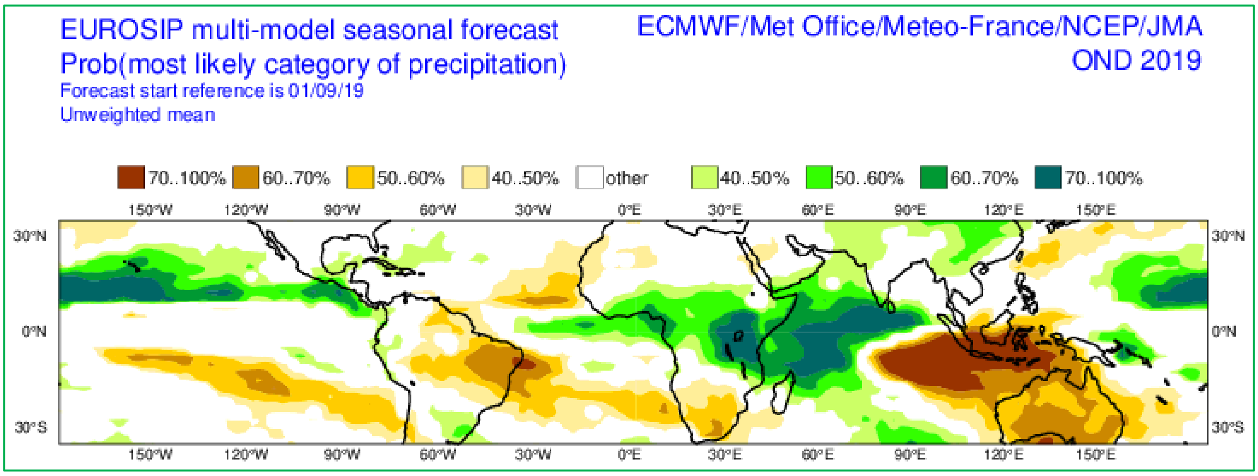






Exemple :

- https://www.cpc.ncep.noaa.gov/products/international/nmme/nmme_seasonal_body.html
- https://iri.columbia.edu/our-expertise/climate/enso/
- https://iri.columbia.edu/our-expertise/climate/forecasts/enso/current/?enso_tab=enso-sst_table
- https://www.wmolc.org/seasonPmmeUI/plot_PMME



Here are the links to some of the centers:

*ECMWF:*https://www.ecmwf.int/en/forecasts/charts/seasonal/?facets=Product%20group,Spatial%20maps

IRI: https://iri.columbia.edu/our-expertise/climate/forecasts/seasonal-climate-forecasts/

NMME: https://www.cpc.ncep.noaa.gov/products/international/nmme/nmme_seasonal_body.html

WMO : https://www.wmolc.org/seasonPmmeUI/plot_PMME

2.1.4. Forecast of cumulative rainfalls with the CPT tool

- **Choose the type of statistical analysis**

  For our case we use Canonical Correlation Analysis (CCA).

  In CPT, station data from JJA or JAS cumulative precipitation are used as predictands and model data are used as predictors.

  Column X= RR-CFS-hincast-JAS_1982-2010
  Column Y= Cumul JAS_1981-2019
  Column Z= RR-CFS-forcast-JAS_2020

  Where

  Column X= RR-CFS-hincast-forecast-JAS_1981-2020
  Column Y= Cumul JAS_1981-2019

- **Adjust the domain of X**

  For SSTs take either the tropical 30°N/30°S domain or any forcing zone deemed relevant.

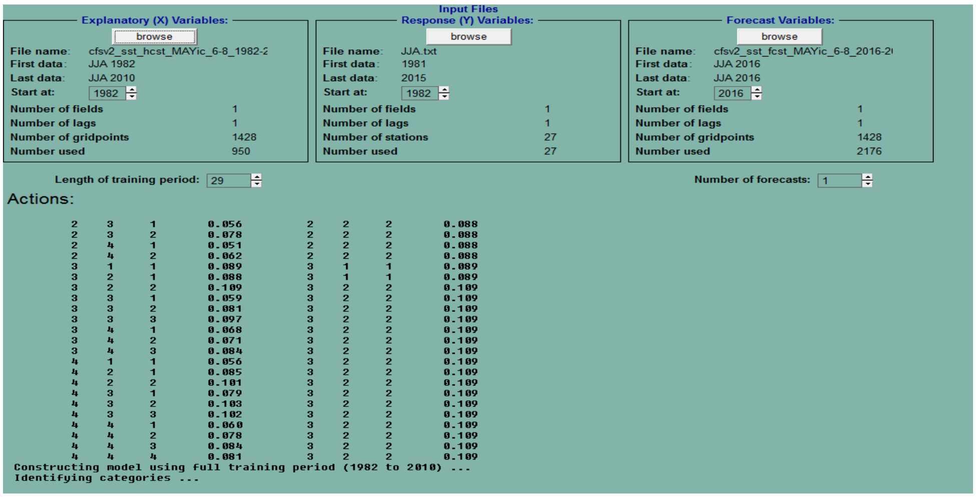
  For precipitations or winds, please limit yourself to the area concerned, e.g. ˆ0°W/30°E and 40°S/30°N

- **Choose the number of modes**

  Preferably a number from 5

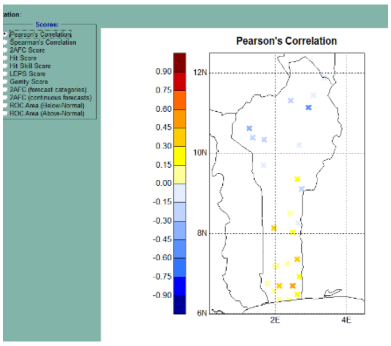
- **Start the simulation**

  Use cross-validation with a window of 3



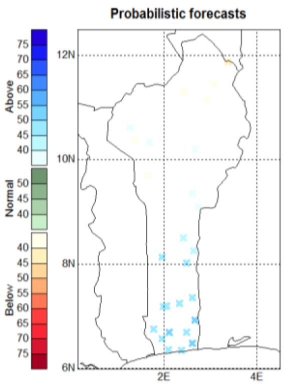
- ***Retrieve performance maps (Skill maps)***

- *Map of the Pearson Correlation which is the indicator of the performance of the constructed forecast model*



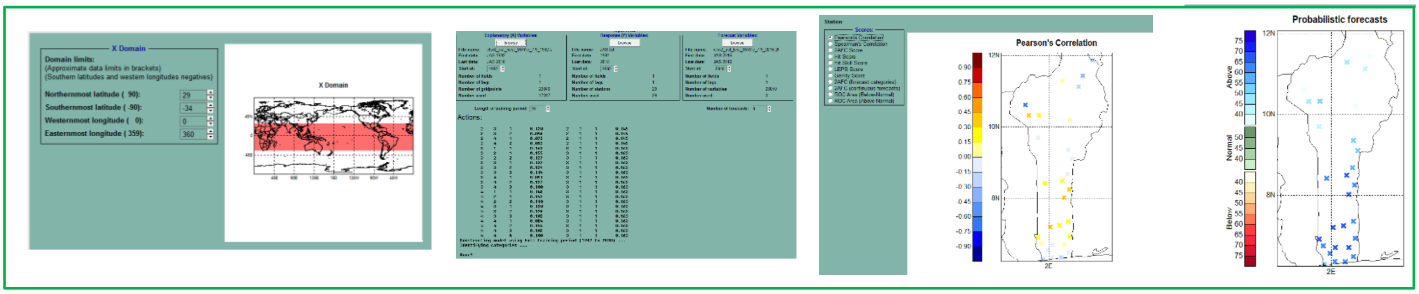
  - *One could look at the ROC maps to see the forecasts by category, the contingency table, and the modes.*
  - *Etc*

- ***Retrieve the forecast map***



- ➢ **Try with different data from different Production Centers** *for a much more robust multi-model approach.*

- ➢ **Do the same for JAS forecasts**



- ➢ **National Consensus Forecast**

For the consensus forecast, try to see:

- *the global trend of the world production centers with the model skills for the period concerned*
- *forecasts of ensemble models (NMME, COPERNICUS) with the skills of the models for the period concerned*
- *Atmospheric and oceanic dynamics*
- *The forecasts made with the CPT and the skills of the models*

All these elements are brought together to reach a consensus that focuses on the current and future dynamics of the general circulation of the atmosphere and oceans.

2.1.5. Regional consensus forecast

This approach provides a data set that better captures the patterns of rainfall variability in conjunction with those of the predictors. With the CCA approach that is chosen, this regional method offers greater forecast robustness. Therefore, it is strongly encouraged to put the data together.

- ➢ *Centralize cumulative rainfall data (e.g. JJA cumulative rainfall, JAS cumulative rainfall).*
- ➢ *Gather data in a single Excel file in CPT format*
- ➢ *Convert to a text (txt) file*
- ➢ *Use CPT to make the forecast (same procedure as for countries)*

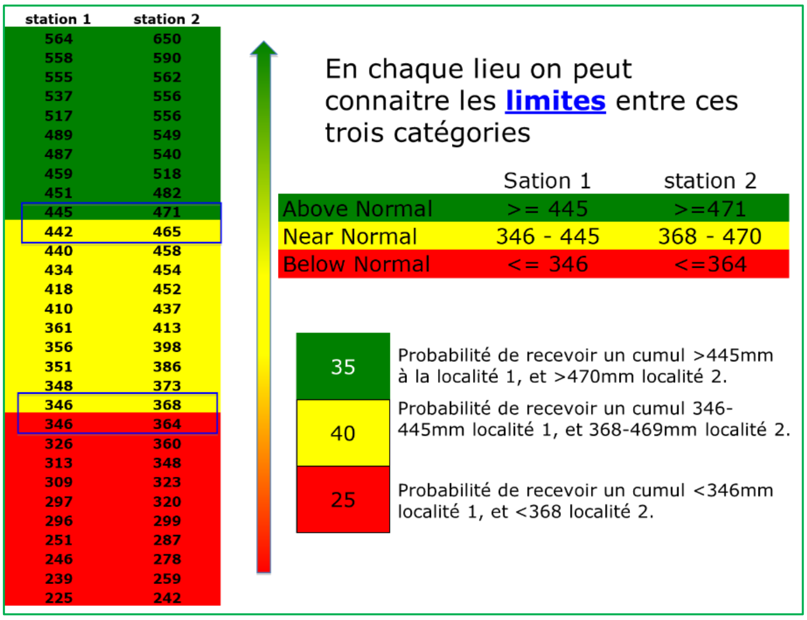
- *In the consensus, take into account forecasts from countries, global production centres with expertise in the region, and trends in sea surface temperature conditions.*

2.1.6. Probabilities on the occurrence of forecasts

Finally, percentages are allocated to each category according to the evidence from the various analyses used and according to the skills and results obtained by the CPT.

The results are compared to the average established over the reference period 1981-2010. The prediction concerns the probability of occurrence of one of the three categories: normal (average), above normal (wet) and below normal (dry). The categories are defined from the observed data for each station by taking the boundaries between one-third (1/3) of the data in descending order.

Below is an example of the distribution of the figures (percentages)



2.2 Agrometeorological forecasts

2.2.1. Preparation of rainfall data

In order to develop forecasts of season onset dates, dry spells duration and season cessation dates, historical daily data of observed rainfall over the period 1981 to the most recent year for which data are available are required.

The data should be processed and put into a format that can be used by the INSTAT+ software downloadable from the Statistical Services Centre, University of Reading, UK, http://www.reading.ac.uk/SSC/software/instat/instat.html or now R-INSTAT downloadable from http://r-instat.org/Download.html. A demonstration on the use of R-INSTAT is available on YouTube: https://www.youtube.com/watch?v=BsJ_SY9bzB8. It is with these open access tools *that seasonal (for season onset and cessation dates) and intra-seasonal (for dry spell durations) values are calculated year by year and stored station by station for a given country or at a sub-regional scale. Those who are familiar with programming can also develop scripts to automate the calculations of the various parameters on the number of stations for which data are available.*

In all cases, the different agrometeorological parameters are calculated with these tools and from historical daily rainfall data, based on well-defined and specific criteria for each parameter and according to the agro-ecological zones of the sub-region. In INSTAT+ all dates must be in Julian days (see Table 5).

2.2.2. Importing Data into INSTAT+

First create a climate data file in INSTAT+ by doing:

Climatic => Manage => New Worksheet

Give a file name (example: Niamey) and click on OK.

To import data into INTSAT+, do the following

Climatic => Manage => Import Daily Data

If the data is in CLICOM format, check the corresponding box, indicate the path where the file to be imported is located (you can browse your disk using the Browse button) and click on OK.

If the data is in another text or Excel format, make sure that it follows the list format, i.e., the rows represent records (days) and the columns represent fields (years). See the file below for an example of a daily rainfall file.

1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0

*Note that **in INSTAT+, the year always has 366 days**. For non-leap years where the month of February does not have 29 days, **the value 9988 is assigned to that date**. **For actual missing data, the code is 9999.***

Convert your Excel files to the 1997-2003 (.xls) format.*

Do File => Open Worksheet,

Choose the appropriate format in the Type field

Retrieve the file you want to import on your disk and click OK.

2.2.3. Calculation of rainy season onset dates

Criteria used:

a) *For Sahelian countries with a monomodal regime: **date after 15 MARCH**, from which a cumulative rainfall of **at least 20 mm** is recorded for **01 to 03 consecutive days** and without **a dry spell exceeding 20 days** during the **following 30 days**.*
b) *For stations located north of the 400 mm isohyet, **take 15 mm recorded from 1 May for 01 to 03 consecutive days**, without a dry spell exceeding **20 days during the following 30 days.***
c) *For the northern parts of the coastal countries of the Gulf of Guinea, in the areas with monomodal regime (North, Latitude above 8°N): The rainy season starts **from 15 MARCH, when at least 20 mm** of rainfall is recorded in 01 to 03 consecutive days without **dry spells of more than 10 days within the following 30 days.***
d) *For the southern parts of Gulf of Guinea countries with bimodal regime (South, Latitude below 8°N): in this part there are two rainy seasons: Long and short. For the onset of the long season, the same criterion as the northern zones is adopted: i.e. **at least 20 mm of rainfall recorded in 01 to 03 consecutive days** starting from **1st FEBRUARY**, with no dry episodes of more than **10 days in the following 30 days**. As for the short rainy season, it starts when, **from 15 AUGUST, more than 10 mm of rain is recorded in 3 consecutive days.***

In INSTAT+ the start date of the season is calculated as follows: case of Sahelian countries

Do Climatic => Events => Start of the Rains

Check the First box

Select the years for which you want to perform the calculations.

Click on the Calendar button in front of the Earliest possible day box and choose January as the first month on the worksheet and May 1st (= day 122) as the date from which you want to start the calculations.

Keep the threshold 0.85mm of useful rain (Threshold for rain)

Take three (3) successive days to reach the required threshold

Tick the Total rainfall box and give the value 20 mm.

Check the Dry spell box and enter the values for 20 days and 30 days respectively in the not exceeding and in the next boxes and click OK.

The results of the calculations are displayed in Days of Year (see Appendix 1: Example 140 = 19 May) in the column named stdy1 starting with the first year to the last. You can rename this column by directly typing Start

2.2.4. Calculation of rainy season cessation dates

a) *For Sahelian countries with a monomodal regime: date **after 1 September (15 September for West Mali (West of the latitude of Bamako), Senegal, Mauritania, Gambia; Guinea Bissau),** when a soil capable of holding **70 mm of available water is** completely exhausted by a **daily evapotranspiration of 5 mm**.*
b) *For the coastal countries of the Gulf of Guinea:*

*In the northern areas of these countries, the end of the season is observed when, from **1 October, soil capable of holding 70 mm** of available water is completely exhausted by a **daily evapotranspiration of 4 mm**.*

*In the southern zones, the same criteria as in the northern zones are used, except that the calculations are triggered **from 1 July for the main season**.*
*As for the end of the short season, calculations are triggered **from October 15**.*

In INSTAT+ the cessation date of the season is calculated as follows:

Case of Sahelian countries

- *Do Climatic => Events => Water Balance*
- *Select the years for which you want to perform the calculations.*
- *Check the First box*
- *Enter the values 70 mm and 5 mm respectively in the Capacity and Evaporation boxes.*
- *Click on the Calendar button in front of the Earliest possible day box and choose January as the first month on the worksheet and September 1 (= day 245) as the start date for the calculations.*
- *Tick the box <= in front of Water Balance to give the value 0 mm.*
- *Click on OK*

The results of the calculations are displayed in Days of the Year (see Appendix 1: Example 258 = 14 September) in the next column of your worksheet. You can name this column End

In order to better visualize to which year the values displayed in the Start and End columns correspond, it is useful to create a year column. This is done in INSTAT+ as follows

- *Do Manage => Data => Regular Sequence*
- *Check the Sequence box*
- *Enter the year of departure in the From box (example 1951)*
- *Enter the end year in the To box (example 2010)*
- *Enter 1 in the In steps of box to increment by one year each time, and Click OK.*

You can name the new column Year

2.2.5. Calculation of maximum dry spell durations

***Definition**: There are several ways to calculate dry spell durations in INSTAT+. The one we use here corresponds to the unconditional dry spell definition, which allows to have the maximum dry spell duration (number of consecutive days without rain (P <= 0.85 mm) from a given date and for a given duration).*

a) Early season dry spells

This is the longest number of consecutive dry days during the 50 days after the season onset date.

In INSTAT+ dry spells are calculated as follows:

- *Do Climatic => Events => Spells*
- *Select the years for which you want to perform the calculations.*
- *Check the Unconditional box*

- *Keeping the 0.85mm rainfall threshold useful (Range for spell)*

Check the "relative" box -- select the "start date", in the "Calculated dates" column (dry spell calculations will be performed from this season onset date) -- in the "Initial days" box enter "1" (i.e. calculations start from day 1 following the season onset date). In the "length of period" box, specify the length of the period over which you want to calculate the dry runs (50 in this case).

b) End-of-season dry spells

The calculation of the longest dry spells towards the end of the season, i.e. over the period taking into account the critical phases of heading-flowering and crop maturation, can be done for example from the 50th day after the calculated season onset dates (SOD+50) to the average season cessation date at a given station. For this purpose, the following calculation is made:

- *the length of the season for all years (LS),*
- *the average length of the rainy season at the LS_Avg station),*
- *50 days are subtracted from the average length of the season (LS_Average 50),*
- *dry spells are calculated over the remaining period of the average length of the season (LS_Average 50), starting from season onset date +50 Days (Relative to SOD+50)*

The results of the calculations, representing the maximum number of consecutive dry days in the specified period, are displayed in the following columns of your worksheet. You can name these columns to indicate the start periods for the calculations.

2.2.6. Organization of data from INSTAT+ in CPT format

The season onset dates, dry spells durations and season cessation dates calculated (year by year, station by station and country by country) using INSTAT+ must be compiled into separate files in the format used by CPT. In the file format, the first column is reserved for vertically arranged years (e.g. 1981-2019). The following columns must contain (one column for each station) the values of the calculated parameters (onset dates, dry spell durations or cessation dates). Each data column should have the name of the station in question "in Column Heading, first line" and the geographical coordinates of the station (Latitude in the second line and longitude in the third line). Missing data are always replaced by "-999". The tables below show models for organizing the data before importing them into CPT

Table 1: Sample file for calculated season onset dates

STN	Abomey	ADJOHOUN	APLAHOUE	BANTE	BOHICON	BONOU	BOPA	COTONOU	DASSA	DOGBO	GRAND-POPC	KETOU	LONKLY
LAT	7.18	6.70	6.94	8.42	7.17	6.90	6.38	6.36	7.75	6.80	6.28	7.36	7.13
LON	1.99	2.50	1.67	1.88	2.07	2.46	2.44	2.43	2.17	1.78	1.82	2.61	1.67
1981	95	122	142	93	97	84	110	72	117	149	123	70	69
1982	107	77	121	101	46	99	121	107	99	56	99	93	107
1983	91	131	93	136	91	100	136	136	92	93	136	91	91
1984	97	72	68	99	112	68	94	113	121	47	109	112	68
1985	92	92	95	91	96	68	-999	96	122	56	75	92	94
1986	92	139	105	78	49	68	115	115	78	58	101	118	68
1987	74	57	138	78	46	79	67	69	70	47	57	138	67
1988	104	97	67	86	63	110	114	113	79	86	85	104	67
1989	-999	66	65	108	109	72	70	95	72	-999	72	70	95
1990	92	92	90	-999	90	92	-999	92	90	92	93	92	90
1991	-999	75	75	93	74	92	58	77	75	58	93	92	75
1992	96	125	128	-999	99	86	78	87	97	-999	125	128	96
1993	110	110	91	-999	49	116	110	110	109	59	110	110	110
1994	96	119	93	93	94	61	114	59	86	94	49	109	94
1995	66	43	67	93	66	-999	61	107	119	61	68	103	-999
1996	46	73	-999	59	102	33	96	88	-999	44	96	-999	59
1997	82	73	61	112	82	83	73	73	118	82	121	-999	73
1998	93	93	113	117	113	103	83	125	103	89	110	155	88
1999	54	47	70	122	46	46	105	47	95	47	49	101	70
2000	107	79	106	85	107	101	122	79	121	-999	138	106	106
2001	88	94	82	92	88	109	109	94	73	102	109	88	-999
2002	88	97	88	88	67	84	97	98	97	98	132	71	67
2003	97	102	94	110	94	103	94	97	96	83	79	132	92
2004	132	87	132	117	109	79	80	97	108	113	77	106	92
2005	52	69	63	159	56	-999	68	74	105	61	57	109	63
2006	66	61	61	61	67	-999	76	115	107	67	120	64	48
2007	88	132	70	89	122	120	131	141	114	79	120	132	-999
2008	113	109	91	115	114	-999	123	107	147	93	108	151	72
2009	106	88	95	78	56	-999	106	88	108	45	-999	106	-999
2010	112	100	44	96	92	81	75	108	117	44	100	44	-999
2011	41	41	49	-999	41	59	94	94	135	41	142	-999	-999
2012	135	107	49	92	132	89	129	36	98	100	-999	84	59
2013	116	120	116	92	116	32	-999	76	108	116	-999	-999	84
2014	83	51	65	97	58	70	75	83	-999	99	83	65	-999
2015	75	81	44	191	75	-999	80	69	-999	77	48	77	65
2016	59	73	73	73	68	82	68	68	-999	68	67	73	60
2017	106	125	94	106	150	63	97	69	83	94	125	74	65
2018	97	123	56	118	56	89	49	77	-999	56	-999	120	124
2019	133	38	61	-999	66	-999	96	39	125	97	-999	-999	81

Table 2: Sample file for the longest dry spells observed at the beginning of the season

STN	ABOMEY	ADJOHOUN	APLAHOUE	BANTE	BOHICON	BONOU	BOPA	COTONOU	DASSA	DOGBO	GRAND-POPC	KETOU	
LAT	7.2	6.70	6.94	8.42	7.17	6.90	6.38	6.36	7.75	6.80	6.28	7.36	
LON	1.99	2.50	1.67	1.88	2.07	2.46	2.44	2.43	2.17	1.78	1.82	2.61	
1981	9	6	4	10	9	7	6	12	9	8	8	13	
1982	8	10	7	5	9	9	7	5	6	12	7	10	
1983	8	9	8	14	7	8	9	10	6	7	12	8	
1984	8	17	6	8	8	11	19	7	7	12	8	4	
1985	5	9	5	10	8	12	-999	6	8	7	13	8	
1986	13	8	13	10	8	12	6	9	8	8	10	7	
1987	24	11	8	16	13	14	10	13	26	9	26	9	
1988	8	8	10	10	13	7	5	8	10	9	-999	8	
1989	-999	12	13	11	9	14	12	10	4	-999	12	13	
1990	11	7	10	-999	9	8	-999	7	6	8	-999	6	
1991	-999	7	9	7	9	7	10	14	10	7	6	7	
1992	7	12	7	-999	8	17	12	7	7	-999	7	8	
1993	11	4	8	-999	13	-999	5	4	9	7	4	7	
1994	9	6	11	8	11	12	9	12	8	8	16	12	
1995	9	17	10	9	6	-999	12	7	-999	14	12	15	
1996	10	8	-999	11	9	9	5	7	-999	8	7	-999	
1997	6	8	10	10	7	10	9	8	7	8	6	-999	
1998	6	8	8	9	7	13	5	5	6	8	12	8	
1999	8	8	10	9	6	9	10	18	9	17	21	6	
2000	5	8	9	8	7	10	7	7	6	-999	9	8	
2001	9	10	10	10	7	9	6	6	14	7	6	9	
2002	6	10	6	5	6	13	8	8	6	8	5	8	
2003	14	9	10	7	14	8	9	9	13	11	9	5	
2004	6	13	9	9	7	-999	10	6	10	7	8	7	
2005	13	14	10	8	10	-999	7	7	8	13	13	8	
2006	9	7	12	15	9	-999	10	7	10	9	8	10	
2007	11	6	8	5	8	12	7	5	5	19	6	13	
2008	5	9	6	8	5	-999	4	7	6	7	5	5	
2009	12	9	8	9	10	-999	9	-999	22	20	-999	9	
2010	10	7	10	7	9	8	10	8	10	10	7	22	
2011	13	22	11	-999	13	11	7	10	5	11	7	-999	
2012	8	9	23	8	6	-999	4	11	13	-999	-999	7	
2013	5	7	7	7	7	13	-999	10	18	-999	-999	8	
2014	8	9	10	11	8	6	11	9	-999	-999	-999	10	
2015	11	10	20	9	11	-999	19	10	-999	17	9	11	
2016	18	12	8	12	13	7	12	11	-999	8	12	21	
2017	9	4	6	18	11	10	10	10	18	8	5	8	
2018	9	10	8	10	7	13	9	11	-999	7	-999	9	
2019	4	9	13	-999	8	-999	12	7	8	13	-999	-999	

Table 3: Sample file for the longest dry spells observed towards the end of the season

STN	ABOMEY	ADJOHOUN	APLAHOUE	BANTE	BOHICON	BONOU	BOPA	COTONOU	DASSA	DOGBO
LAT	7.2	6.70	6.94	8.42	7.17	6.90	6.38	6.36	7.75	6.80
LON	1.99	2.50	1.67	1.88	2.07	2.46	2.44	2.43	2.17	1.78
1981	8	14	15	9	13	12	13	7	6	20
1982	31	6	28	17	11	46	19	26	10	10
1983	21	34	24	10	23	21	43	40	15	21
1984	6	7	8	10	8	7	12	22	11	10
1985	7	12	15	6	10	8	-999	10	7	7
1986	9	28	18	10	8	19	-999	35	7	16
1987	8	12	5	9	24	13	18	9	30	14
1988	9	15	13	8	8	17	20	24	8	-999
1989	-999	5	7	4	8	6	9	10	8	-999
1990	7	11	8	-999	8	-999	-999	17	6	-999
1991	-999	9	10	8	15	-999	8	7	6	7
1992	10	11	-999	-999	12	20	-999	9	14	-999
1993	25	23	30	-999	13	21	26	27	19	-999
1994	20	25	10	5	14	17	18	10	23	12
1995	12	17	8	7	5	-999	11	9	-999	-999
1996	10	6	-999	11	7	10	13	7	-999	9
1997	8	9	10	12	9	11	4	7	10	-999
1998	12	7	-999	8	19	-999	-999	22	6	14
1999	15	10	10	5	10	11	10	8	6	10
2000	14	10	-999	9	11	13	17	8	-999	-999
2001	12	11	-999	10	12	10	12	8	8	-999
2002	5	12	-999	8	12	12	7	7	15	-999
2003	9	20	11	4	14	-999	12	13	9	10
2004	16	9	12	7	12	-999	14	13	9	17
2005	11	14	-999	16	9	-999	9	8	16	15
2006	5	8	9	10	8	-999	7	9	17	9
2007	12	8	10	10	7	18	8	14	12	-999
2008	7	7	-999	13	7	-999	26	13	16	-999
2009	16	11	-999	9	9	-999	13	8	13	-999
2010	14	23	-999	10	13	13	6	24	11	-999
2011	18	9	8	-999	15	-999	12	9	19	-999
2012	-999	15	12	12	10	-999	20	28	13	9
2013	25	25	23	12	20	9	22	10	17	34
2014	11	10	7	12	9	12	8	9	-999	9
2015	11	11	29	53	11	-999	8	8	-999	14
2016	18	21	10	43	13	16	11	11	-999	13
2017	13	10	11	8	15	16	9	10	21	11
2018	22	10	12	12	12	66	11	10	-999	14
2019	20	16	15	-999	9	-999	12	12	10	18

Table 4: Sample file for calculated season cessation dates

STN	ARIBINDA	BAGASSI	BAGUERA	BAM	BANFORA	BANI	BARABOUL	BARSALOG	BATIE	BEREBA	BEREGADC	BETARE
LAT	14.23	11.75	10.53	13.33	10.62	13.72	14.22	13.42	9.88	11.62	10.75	11.43
LON	-0.87	-3.3	-5.42	-1.5	-4.77	-0.17	-1.85	-1.07	-2.92	-3.68	-4.73	-1.37
1981	251	272	277	270	287	256	272	276	285	277	286	267
1982	250	260	279	258	292	258	256	260	279	263	292	272
1983	270	280	276	250	248	248	255	248	280	286	265	282
1984	263	280	304	268	296	272	245	256	295	300	297	246
1985	263	281	294	263	290	249	249	261	287	284	291	286
1986	265	284	285	276	287	247	245	256	292	291	289	280
1987	285	289	263	258	269	245	246	246	302	264	295	294
1988	269	279	292	280	291	268	258	272	288	275	291	283
1989	260	291	293	275	296	258	256	264	300	286	291	296
1990	246	280	292	248	280	256	245	253	283	281	280	252
1991	259	266	277	266	269	259	246	276	274	262	269	270
1992	259	284	278	267	280	264	269	264	280	281	287	288
1993	252	289	280	268	282	249	247	259	305	274	289	289
1994	265	310	311	301	313	-999	248	286	313	274	313	293
1995	261	249	305	266	291	257	249	254	302	249	294	284
1996	246	301	293	280	291	271	280	282	297	296	290	301
1997	258	281	301	283	300	268	261	249	287	286	293	262
1998	247	288	298	254	285	258	246	254	251	290	292	286
1999	263	280	303	274	301	-999	270	272	297	299	305	298
2000	254	258	300	271	291	-999	245	273	298	256	293	266
2001	252	258	288	284	294	-999	250	247	291	287	293	298
2002	248	-999	305	260	296	-999	264	264	289	272	286	290
2003	271	-999	306	277	289	273	282	273	298	293	294	294
2004	247	265	283	265	302	251	253	272	285	266	269	289
2005	263	-999	294	269	282	253	257	269	296	292	277	281
2006	273	-999	308	252	306	262	251	270	309	314	308	297
2007	258	-999	291	268	276	246	264	266	283	270	276	266
2008	265	-999	302	264	300	247	252	283	295	269	293	298
2009	277	282	326	256	285	251	247	270	294	286	281	280
2010	252	290	302	252	298	272	273	288	305	298	294	296

Table 5: Days of Year (Julian Days)

	Jan	Fev	Mar	Avr	Mai	Juin	Juill	Aout	Sept	Oct	Nov	Déc
1	1	32	61	92	122	153	183	214	245	275	305	336
2	2	33	62	93	123	154	184	215	246	276	306	337
3	3	34	63	94	124	155	185	216	247	277	307	338
4	4	35	64	95	125	156	186	217	248	278	308	339
5	5	36	65	96	126	157	187	218	249	279	309	340
6	6	37	66	97	127	158	188	219	250	280	310	341
7	7	38	67	98	128	159	189	220	251	281	311	342
8	8	39	68	99	129	160	190	221	252	282	312	343
9	9	40	69	100	130	161	191	222	253	283	313	344
10	10	41	70	101	131	162	192	223	254	284	314	345
11	11	42	71	102	132	163	193	224	255	285	315	346
12	12	43	72	103	133	164	194	225	256	286	316	347
13	13	44	73	104	134	165	195	226	257	287	317	348
14	14	45	74	105	135	166	196	227	258	288	318	349
15	15	46	75	106	136	167	197	228	259	289	319	350
16	16	47	76	107	137	168	198	229	260	290	320	351
17	17	48	77	108	138	169	199	230	261	291	321	352
18	18	49	78	109	139	170	200	231	262	292	322	353
19	19	50	79	110	140	171	201	232	263	293	323	354
20	20	51	80	111	141	172	202	233	264	294	324	355
21	21	52	81	112	142	173	203	234	265	295	325	356
22	22	53	82	113	143	174	204	235	266	296	326	357
23	23	54	83	114	144	175	205	236	267	297	327	358
24	24	55	84	115	145	176	206	237	268	298	328	359
25	25	56	85	116	146	177	207	238	269	299	329	360
26	26	57	86	117	147	178	208	239	270	300	330	361
27	27	58	87	118	148	179	209	240	271	301	331	362
28	28	59	88	119	149	180	210	241	272	302	332	363
29	29	60	89	120	150	181	211	242	273	303	333	364
30	30		90	121	151	182	212	243	274	304	334	365
31	31		91		152		213	244		305		366

2.2.7. Preparing the Predictors

The predictors used are the same as those used for cumulative rainfall and runoff forecasts in large river basins. They are outputs from global circulation models (ECHAM, CFS, CAM-CMC, GFDL, ECMWF, NMME, COPERNICUS, etc.) that can be downloaded online from various sites including IRI DataLibrary or NCEP/CPC. Monthly forecast data are used to forecast the characteristics of the season. It is best to download it in CPT format, directly from the NCEP website:

- *https://ftp.cpc.ncep.noaa.gov/International/nmme/monthly_nmme_forecast_in_cpt_format/*
- *https://ftp.cpc.ncep.noaa.gov/International/nmme/seasonal_nmme_hindcast_in_cpt_format/*

In the IRI DataLibrary, the data can be downloaded in the INGRID language developed for this purpose. Example of a script to download the U component of the monthly winds initiated in April for different lead times (L from 0.5 to 7.5 for example), from the ECHAM model:

```
expert
SOURCES .IRI .FD .ECHAM5 .T42 .Forecast .ca_sst .ensemble24 .MONTHLY .PressureLevel .u
S ( Apri 1981) ( Apri  2020) RANGEEDGES
X (60W) (20E) RANGEEDGES
Y (00N) (40N) RANGEEDGES
L (0.5) (0.5) RANGEEDGES
P (925) VALUES
[M L]average
S (T) renameGRID
T 12 STEP
-999 setmissing_value
```

The arguments of S, X, Y, L and P can be modified to take into account the period (S), the spatial coverage (X and Y), the time step (L) and the pressure level (P).

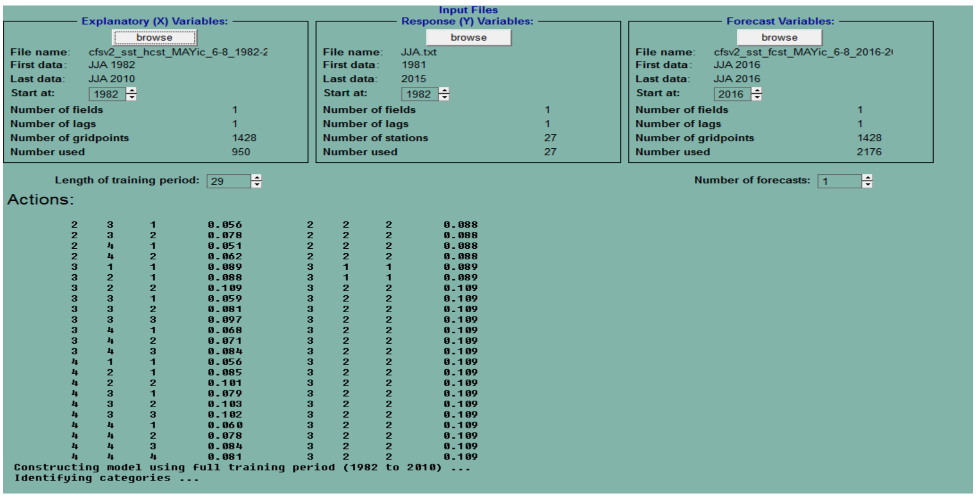
*From these sites several parameters (serving as predictors) can be downloaded and used in the CPT tool, to search for correlations (from cause to effect) with the parameters to be predicted (season start dates, dry sequences, season end dates, etc.). As already presented above, these include: **Winds at different altitude levels; Precipitable Water, Total Surface Precipitation, Long Wave Radiation and Ocean Surface Temperatures.***

2.2.8. Predicting onset dates, dry spell durations and cessation dates with the CPT tool

Once the season onset dates, dry spell durations and season cessation dates have been calculated and checked (correcting outliers), each data file (initially in Excel) must be converted into a .txt (text, separator, space) or csv (text, separator, comma) file before being imported into CPT, for the preparation of the forecasts on a case-by-case basis (the principle is always the same).

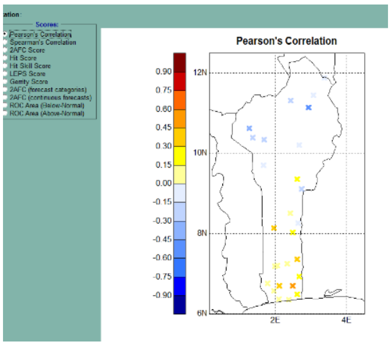
In CPT:

3. *Import data (Example SOD (season onset dates) as predictands and model data as predictors.*
   - *Column X= cfsv2_precip_hcst_Apr_3_1982-2010*
   - *Columbn Y= SOD_1981-2019*
   - *Column Z= cfsv2_precip_fcst_Apr_3_2020*
   - *Where*
   - *Column X= CFS-hincast-forecast_Apr_3_1982-2020*
   - *Column Y= SOD_1981-2019*
4. *Choose the type of statistical analysis => Canonical Correlation Analysis (CCA)*
5. *Adjust the domain of X*
   - *For SSTs take either the tropical 30°N/30°S domain or any forcing zone deemed relevant.*
   - *For precipitations or winds, limited to the area concerned, e.g. 20°W/30°E and 0°N/30°N*
6. *Choose the number of modes*
   - *Preferably a number starting at 5*
7. *Start the simulation*
   - *Use cross-validation*



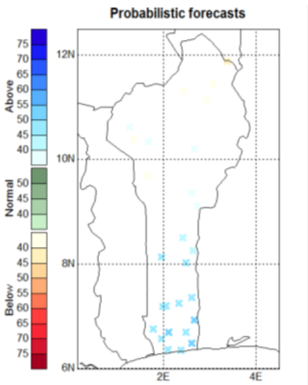
8. Retrieve performance maps (Skill maps)

- *Map of the Pearson Correlation which is the indicator of the performance of the constructed forecast model*



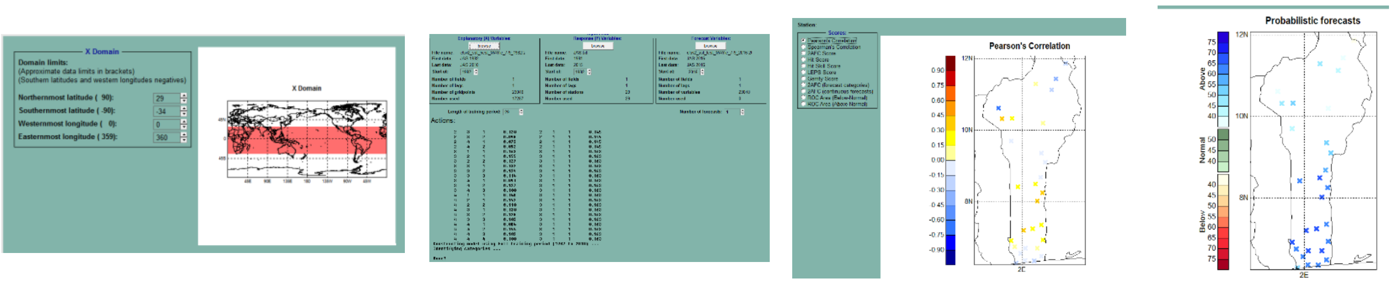
  - *One could look at the ROC maps to see the forecasts by category, the contingency table, and the modes.*
  - *Etc*

9. Retrieve the forecast map



10. **Try with different data from different Production Centers** *for a much more robust multi-model approach.*

11. Do the same for dry spell durations and season cessation dates



12. National Consensus Forecast

For the consensus forecast, try to see:

- *Atmospheric and oceanic dynamics*
- *The forecasts made with the CPT and the skills of the models*

All these elements are brought together to reach a consensus that focuses on the current and future dynamics of the general circulation of the atmosphere and oceans.

13. Regional consensus forecast

This approach provides a data set that better captures the patterns of rainfall variability in conjunction with those of the predictors. With the CCA approach that is chosen, this regional method offers greater forecast robustness. Therefore, it is strongly encouraged to put the data together.

- *Centralize data on onset dates, dry spell durations and season cessation dates.*
- *Gather data in a single Excel file in CPT format*
- *Convert to a text (txt) file*
- *Use CPT to make the forecast (same procedure as for countries)*
- *In the consensus, take into account forecasts from countries, global production centres with expertise in the region, and trends in sea surface temperature conditions.*

14. Probabilities on the occurrence of forecasts

Finally, percentages are allocated to each category according to the evidence from the various analyses used and according to the skills and results obtained by the CPT.

The results are compared to the average established over the reference period 1981-2010. The prediction concerns the probability of occurrence of one of the three categories: normal (average), above normal (late, longer) and below normal (early, shorter). The categories are defined from the observed data for each station by taking the boundaries between one-third (1/3) of the data in descending order.

See below the corresponding legends to apply to the different agrometeorological parameters of the season

	Season Onset Dates	Season Cessation Dates	Dry spell durations after Onset	Dry spell durations toward the end
LEGEND **S** **Supérieur à la normale** **N** **Normale** **I** **Inférieur à la normale**	**LEGENDE** **T** **Tardive** **N** **Normale** **P** **Précoce**	**LEGENDE** **T** **Tardive** **N** **Normale** **P** **Précoce**	**LEGEND** **L** **Longue** **N** **Normale** **C** **Courte**	**LEGEND** **L** **Longue** **N** **Normale** **C** **Courte**

2.3. Hydrological forecasting

2.3.1. Definition of the forecasting network

The basic hydrometric data used for the preparation of the forecasts are the river flows at the main stations of the basins concerned. Figures 1 & 2 present the hydrometric networks used for seasonal forecasts in the Gulf of Guinea countries and the Sahelian and Sudanian zones of CILSS/ECOWAS member countries.

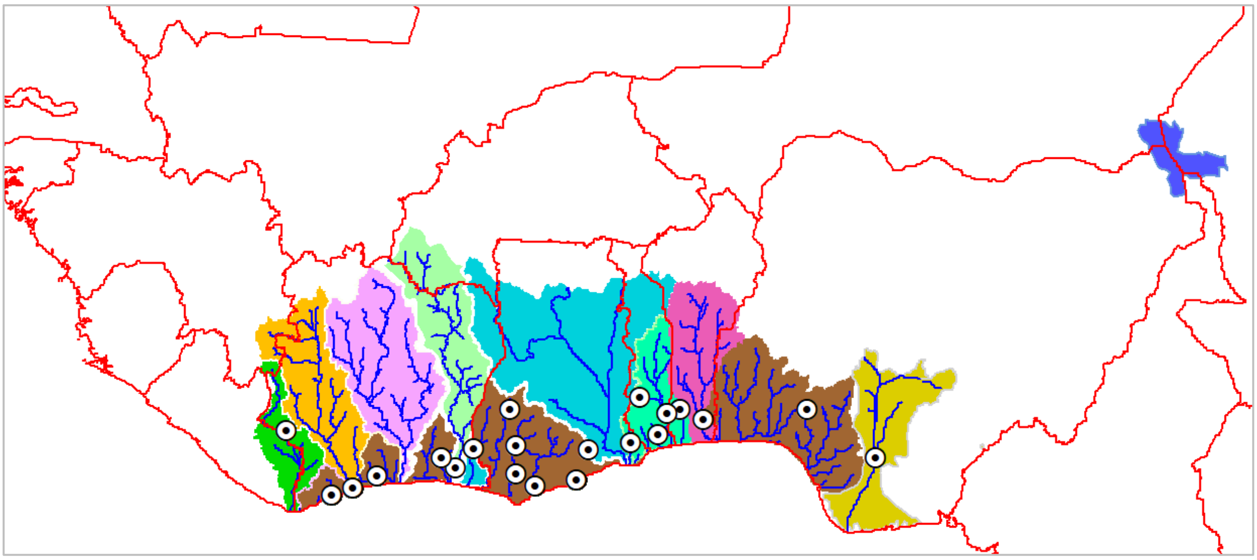


Figure 1: Hydrometric Network for Seasonal Forecasts in the Gulf of Guinea Countries (PRESAGG)

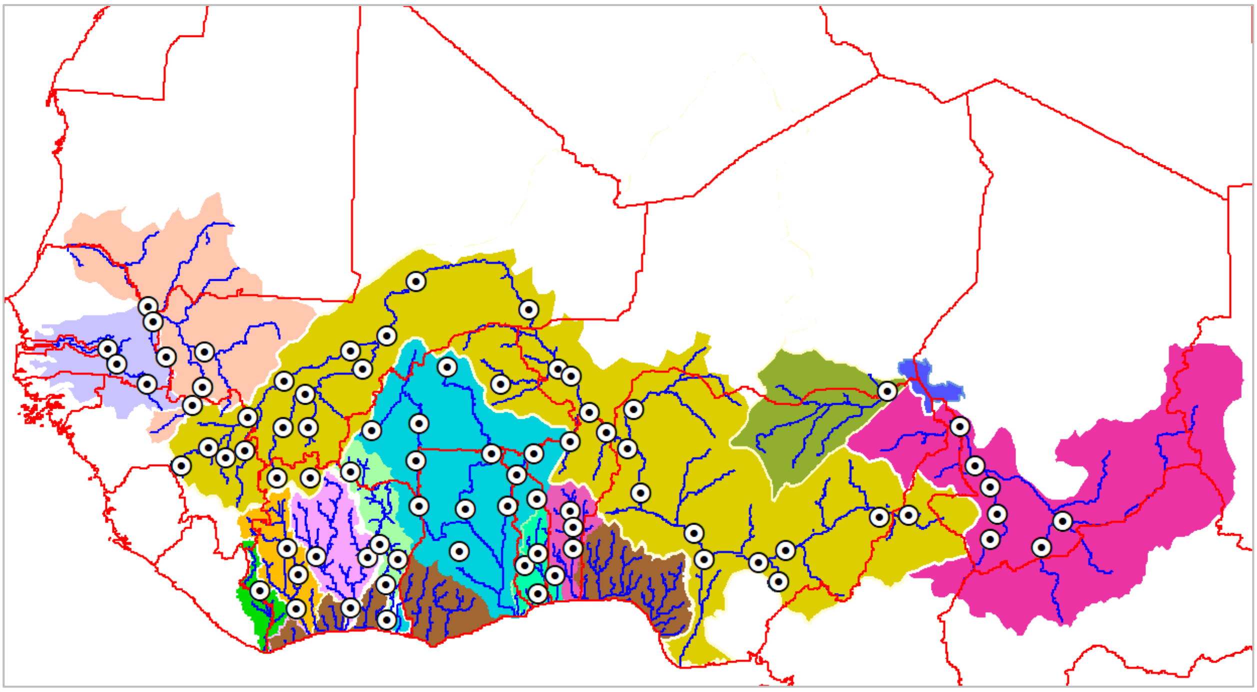


Figure 2: Hydrometric network for seasonal forecasts in the Sahelian and Sudanian zones (PRESASS)

2.3.2. Definition and calculation of predictands

For the implementation of the seasonal hydrological forecast, the JAS period (July-August-September) is not predicted a priori, as is the case for climate forecasts, but rather the average flow over the high-water period (Figure 3). This variable is called the predictand.

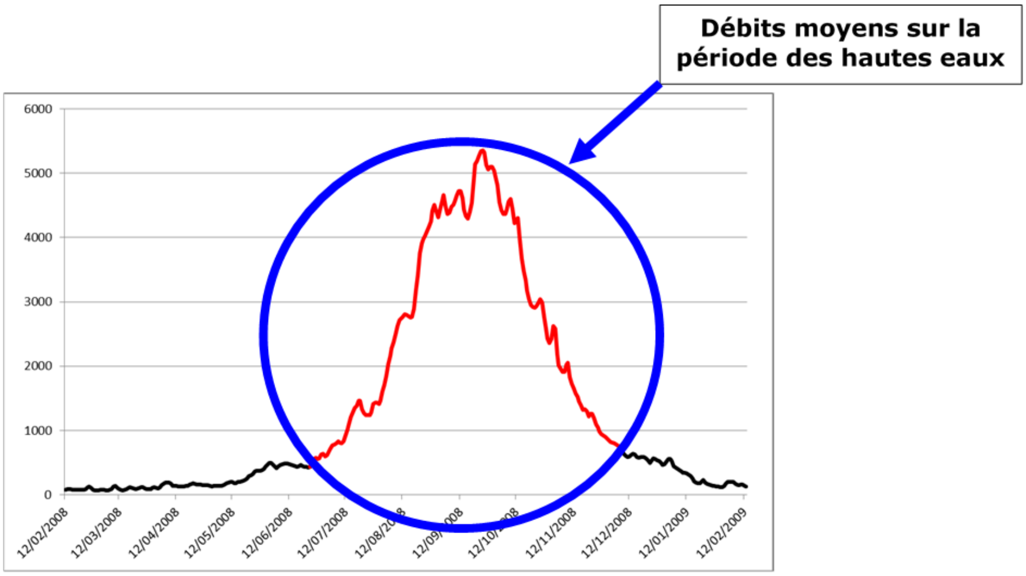


Figure 3: Period of high waters with expected modules over the season

This period differs from one watershed to another (Figure 4).

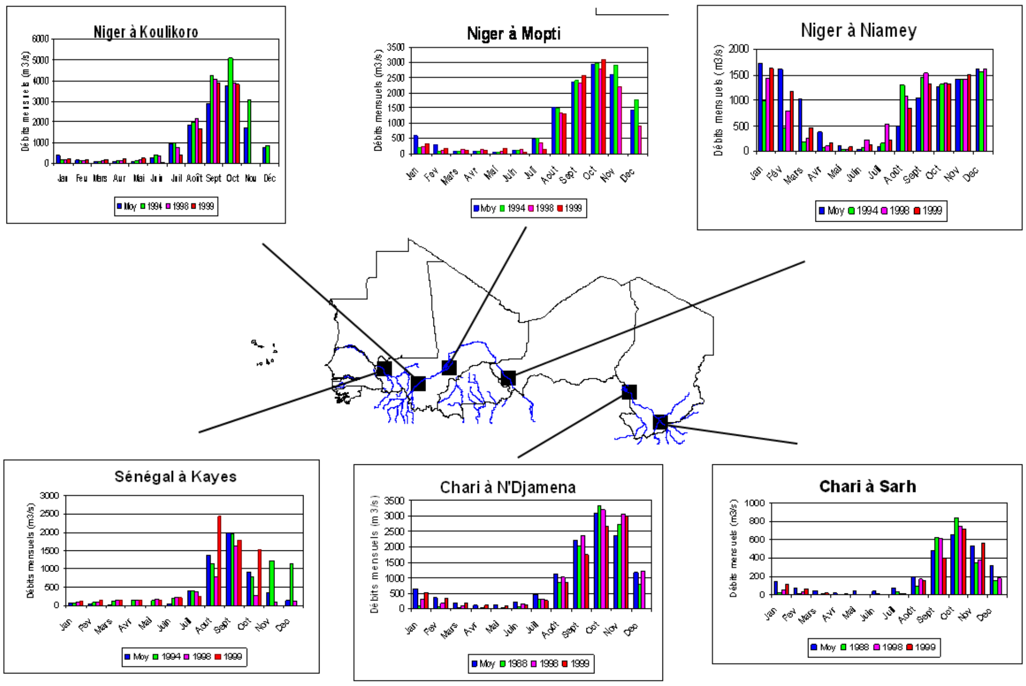


Figure 4: Period of high waters in some sub-basins

2.3.3. Putting data into CPT format

For each station and over the entire length of the series, the average annual flow over the high-water period is calculated. In hydrology, the analysis is done station by station. In other words, one file is prepared for each station. To be read by CPT, the data must be in a format consisting of two columns. The first column is for the years and the second column contains the corresponding mean flows. There are two variants of the CPT format. If the station is geo-referenced, the first three rows of the file contain respectively the station name (coded by STN), the latitude (LAT) and the longitude (LONG). On the other hand, if the coordinates of the station are not available, the header of the file consists of a single row containing the station name coded by NAME (Tables 1a & 1b).

Table 1: Input Data Formats (predictands) for CPT

(a)

*Kidira - Notepad

File Edit Format View Help

STN	Kidira
LAT	14.45
LONG	-12.217
1951	241.1
1952	222.4
1953	132.7
1954	266.2
1955	273.2
1956	257.1
1957	235.5
1958	218.4
1959	218.9
1960	150
1961	246.9
1962	218.6

(b)

*Kidira - Notepad

File Edit Format View Help

NAME	Kidira
1951	241.1
1952	222.4
1953	132.7
1954	266.2
1955	273.2
1956	257.1
1957	235.5
1958	218.4
1959	218.9
1960	150
1961	246.9
1962	218.6
1963	157.3
1964	271.5

2.3.4. Making current year forecasts with CPT

The Climate Predictability Tool (CPT) developed by the IRI (International Research Institute) is the forecasting tool used for the elaboration of flow forecasts through the statistical relationships between basin flows over the high water period on the one hand, and sea surface temperatures, winds and forecasted precipitations, on the other.
The CPT software allows the use of the following statistical forecasting methods: multiple linear regression (LRM), principal component analysis (PCA), canonical analysis (CCA).

a. Using the CPT software
The inputs of the CPT software are, on the one hand, explanatory variables (or predictors) consisting of either sea surface temperatures (SST), winds or predicted precipitations, and, on the other hand, the explained variable (predictand).
When the explanatory variable(s) is in the form of one value per year, the "Multiple Linear Regression" module is used. On the other hand, when the explanatory variable is in the form of grid points per year, the "Principal Component Regression" module is used.
After having loaded the different variables in the two corresponding windows, the year of the regression start, the size of the series and the parameter of the cross-validation of the regression models are specified. The third window is dedicated to forecasting. In the "option" menu, some settings are made, such as the code for missing values, the reference period, the performance criterion, the number of modes, etc.

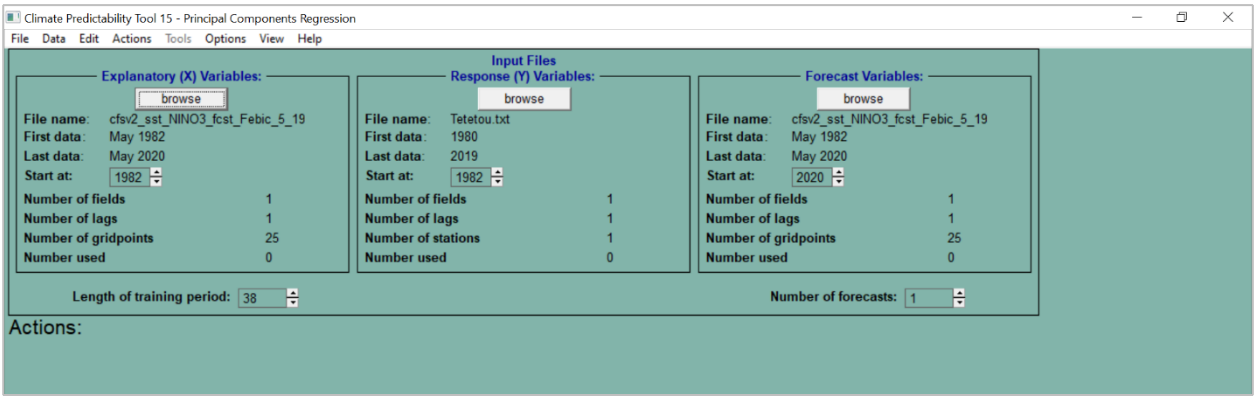


Figure 5: CPT environment (data entry box)

b. Predictor Selection
To make hydrological forecasts, a number of predictors are used whose strong relationship with flows in the sub-region has been proven by scientific studies. These are sea surface temperatures, wind and precipitation forecasts. For SSTs, the temperatures relative to the ocean areas shown in the figure below are generally used; these are:

- *NINO3: third component of the Pacific Ocean, between 10°N-10°S and 90°W-150°W,*
- *Atl NW: North-West Atlantic, between 20°N-40°N and 10°W-30°W,*
- *EOF3: third component of the long-term variability of global ocean surface temperature,*
- *Guinea Gulf: the Gulf of Guinea,*
- *Indian Ocean.*

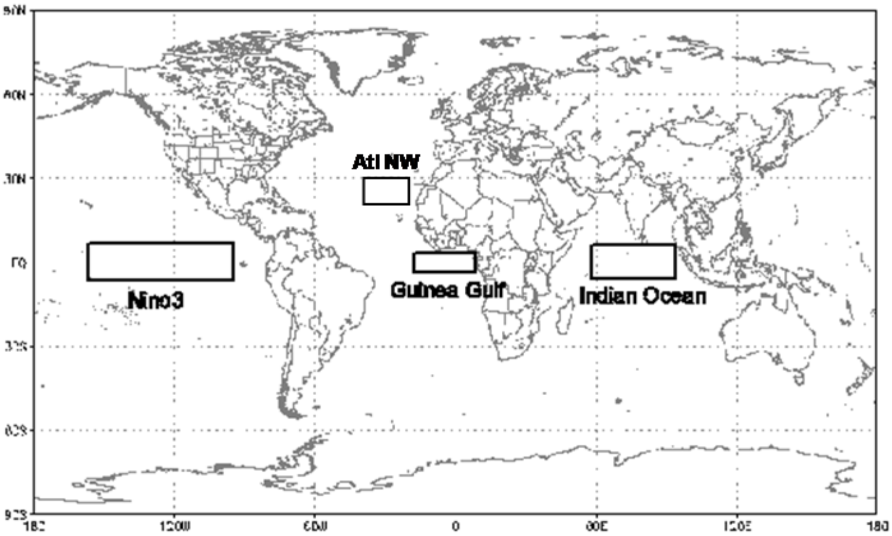


Figure 6: Ocean areas used

c. Forecast results

The CPT software allows the construction of a multiple linear regression model based on the relationship between the predictor used and the mean high water flows in a given sub-basin, following the principle of cross-validation.

It is from these models that the character of the current year is predicted through the value of the predictand.

The forecast results are presented for each basin as classes of high, medium and low runoff relative to the mean runoff over the reference period (Figure 7).

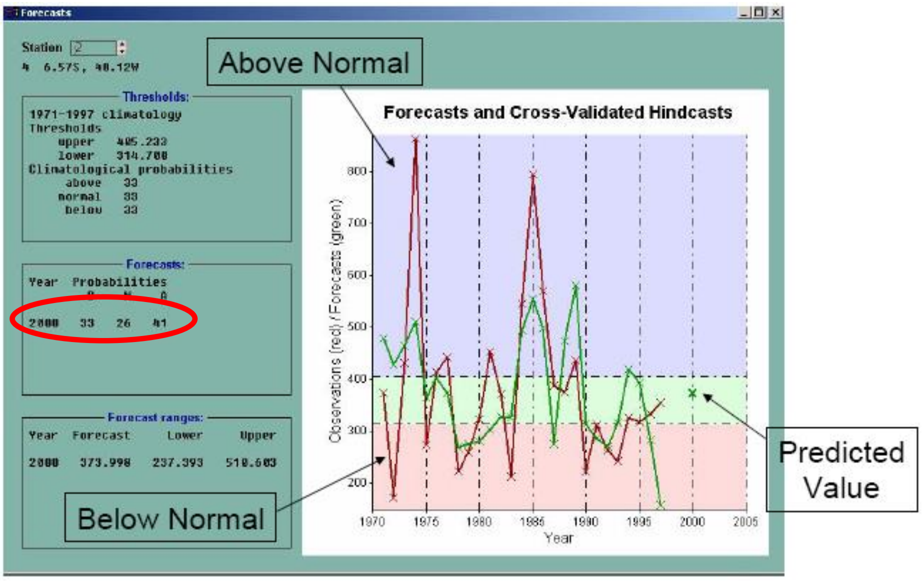


Figure 7: Forecast results as probability classes

d. Skill Map

As output, CPT provides a prediction model (MLR, PCA, CCA) for the prediction of the climatic or hydrological variable depending on the predictand used as input. Each forecast model is accompanied by assessment parameters that provide information on the level of confidence of *the forecast. The most important of these confidence parameters are the multiple correlation coefficient, the skill and the p-value. A model is good when its multiple correlation coefficient and skill are strong (close to 1) and its p-value is close to zero.*

The Skill map is very important during the forecast consolidation phase, especially in the case of singular situations or contrasts (divergent forecasts) between different forecasts in the same sub-basin.

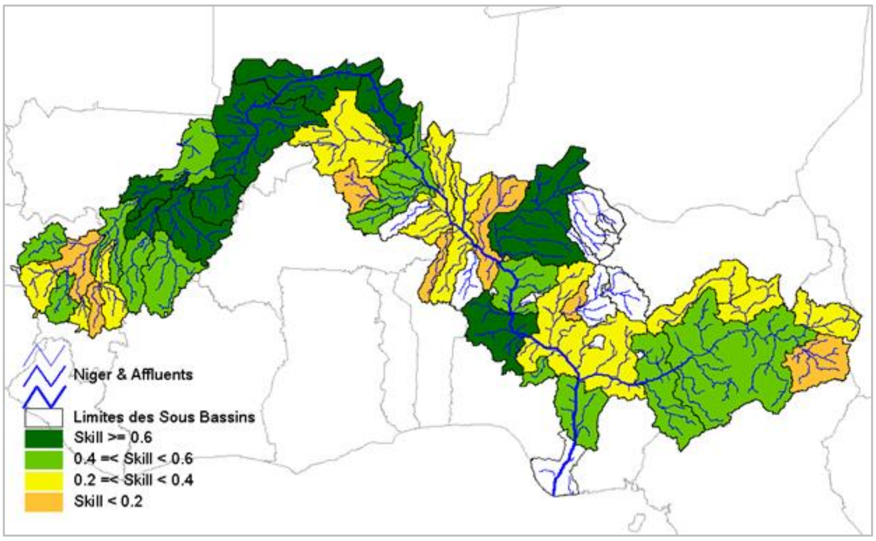
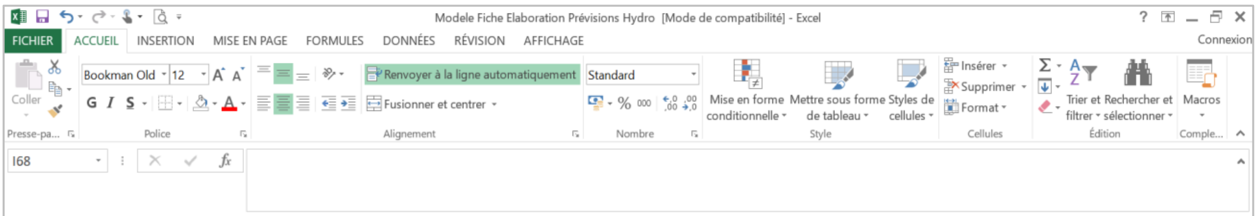


Figure 8: Example of forecasting models best Skill map

e. Forecast Development Sheet

At the end of the different forecasts, using the set of predictors for which the experts have agreed, the detailed results are listed in a table whose model is shown in the figure below.

Each participant presents the results obtained on all the stations used, including skill values, correlation coefficients and corresponding p-values.



	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S
1	Pays / Organisme de bassins	Nom_Station	Paramètres	PREDICTEURS															
2		--------		ACP															
3		Période		SST_Observed_Mars_1982-2018			SST_Observed_Avril_1982-2018			SST_AMJ_CCSM4-Glob_1982-2018			SST_AMJ_CFS2-Glob_1982-2018			SST_AMJ_CMC4-Glob_1982-2018			SST_AM Glob_19
64			G. Index		0.343						0.205			0.241					C
65		Lokoja	R		0.431						0.226			0.363					0.
66		--------	P-VALUE		0.02						0.112			0.02					0.
67			Résultat	B	N	A				B	N	A	B	N	A	B	N	A	B
68				17	32	51				16	27	56	13	27	60				11
69			G. Index		-0.222			0.05			-0.28			0.08					0.
70		Makurdi	R					0.13						0.06					0.
71		--------	P-VALUE					0.24						0.36					0.
72			Résultat	B	N	A				B	N	A	B	N	A	B	N	A	B
73							22	30	49				15	23	61				18
74			G. Index		0.152			0.15			0.087			0.174					0.
75		Kainji	R		0.256			0.31			0.09			0.242					0.
76		--------	P-VALUE		0.104			0.06			0.35			0.126					0.
77			Résultat	B	N	A	B	N	A	B	N	A	B	N	A	B	N	A	B
78	Nigeria			19	24	57	27	27	46	22	23	56	14	15	70				16
79			G. Index		0.046						0.046			0.03					-0.
80		Jebba	R		-0.02						-0.02			-0.02					

Figure 9: Forecast Summary Sheet

2.3.5. Making consensus hydrological forecasts

This step consists of making an overall analysis of all available forecasts. The aim is to harmonize the forecasts produced with the CPT software on the one hand, and those with the SST and rainfall forecasts produced by the global models, while keeping a critical eye on the trend in the evolution of the main predictors; in particular the SST in the ocean basins influencing the climate of the West African sub-region and the Sahel. These include the North Atlantic, Gulf of Guinea, Indian Ocean, Mediterranean and Equatorial Pacific. In this consensual analysis, the understanding of the rain-flow relationship over the basin plays an important role.

Based on the individual forecasts carried out at the scale of the sub-basins, these are harmonized over the whole basin. The skills map allows us to decide on certain singular cases: when, for adjacent basins, the forecasts are contradictory, preference is given to the forecast with the highest skill and/or low p-value.

Thus, the forecast map, drown with the help of GIS tools, presents for each basin, probability boxes indicating the chances of having for the coming rainy season, rivers flows higher, equivalent or lower than the averages calculated over the reference period (figure 10).

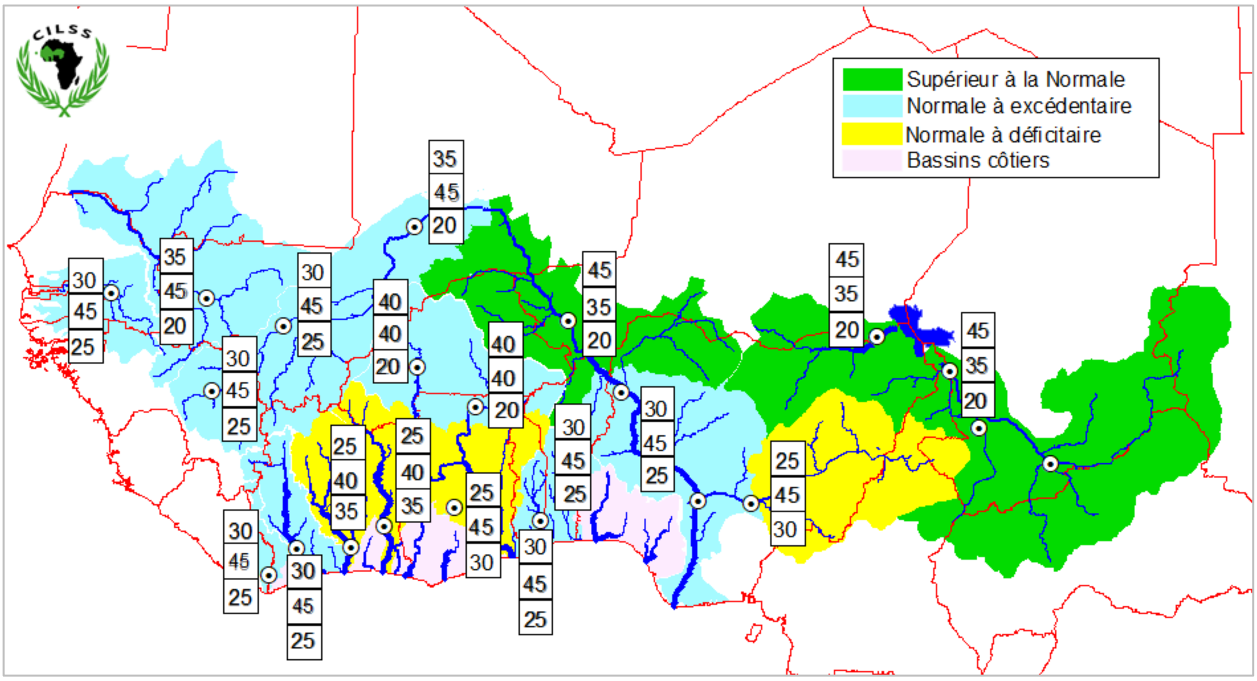


Figure 10: Flow Forecast Map for the Season