Seasonal forecasting: Basis, approaches in West Africa, limits and prospects




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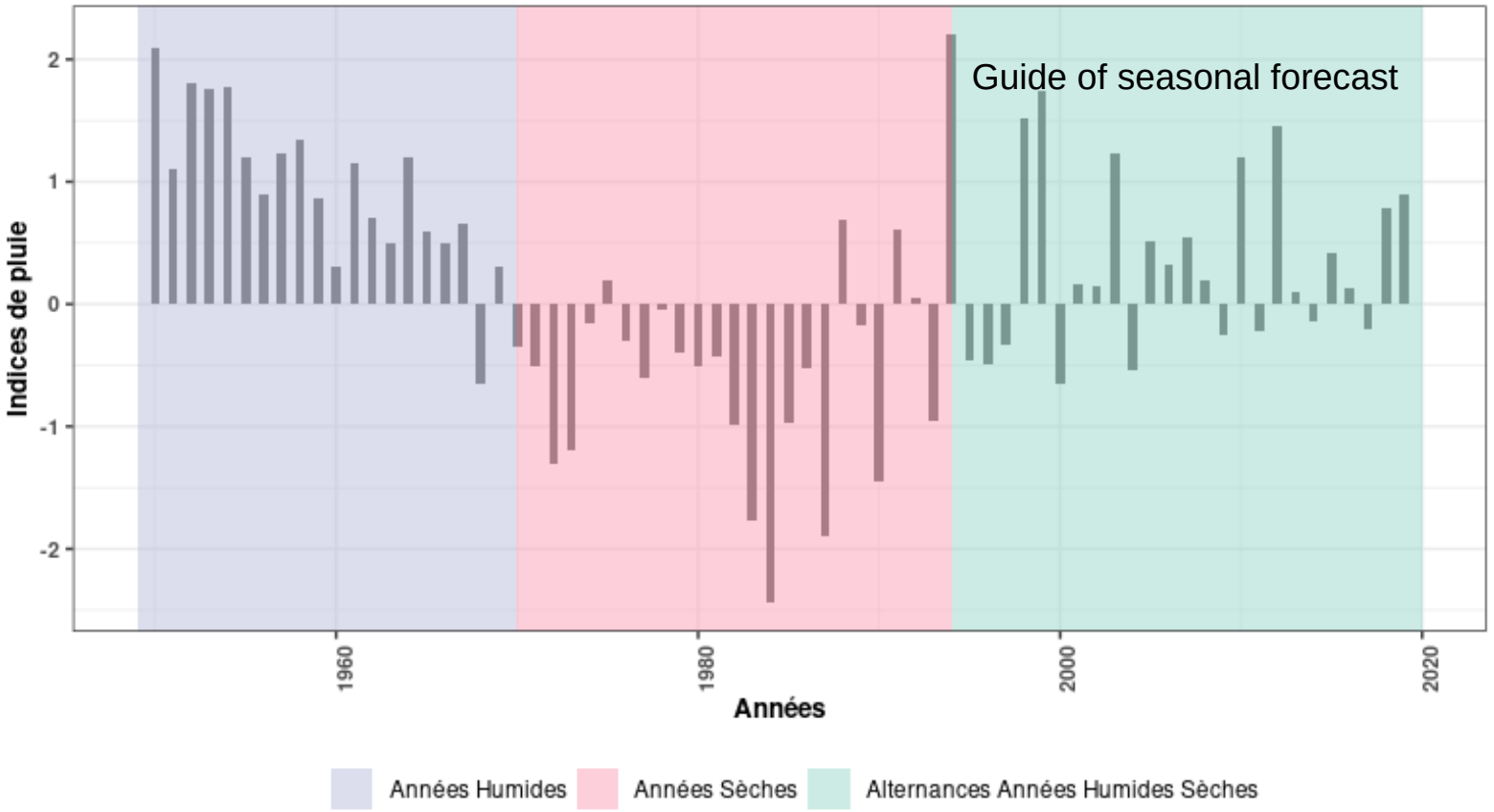
Background



Celle-ci se traduit également :

- le démarrage tardif et une fin précoce;
- les pauses pluviométriques longues en cours de saison,
- la recrudescence d'extrême,

This also translates as:

- **late onset and early end; l**
- **Long rainfall pause during the season,**
- **an increase in extremes, ...**

Background

Les conséquences de cette variabilité sont catastrophiques pour la plupart des secteurs d'activités…

The consequences of this variability are catastrophic for most economic sectors...

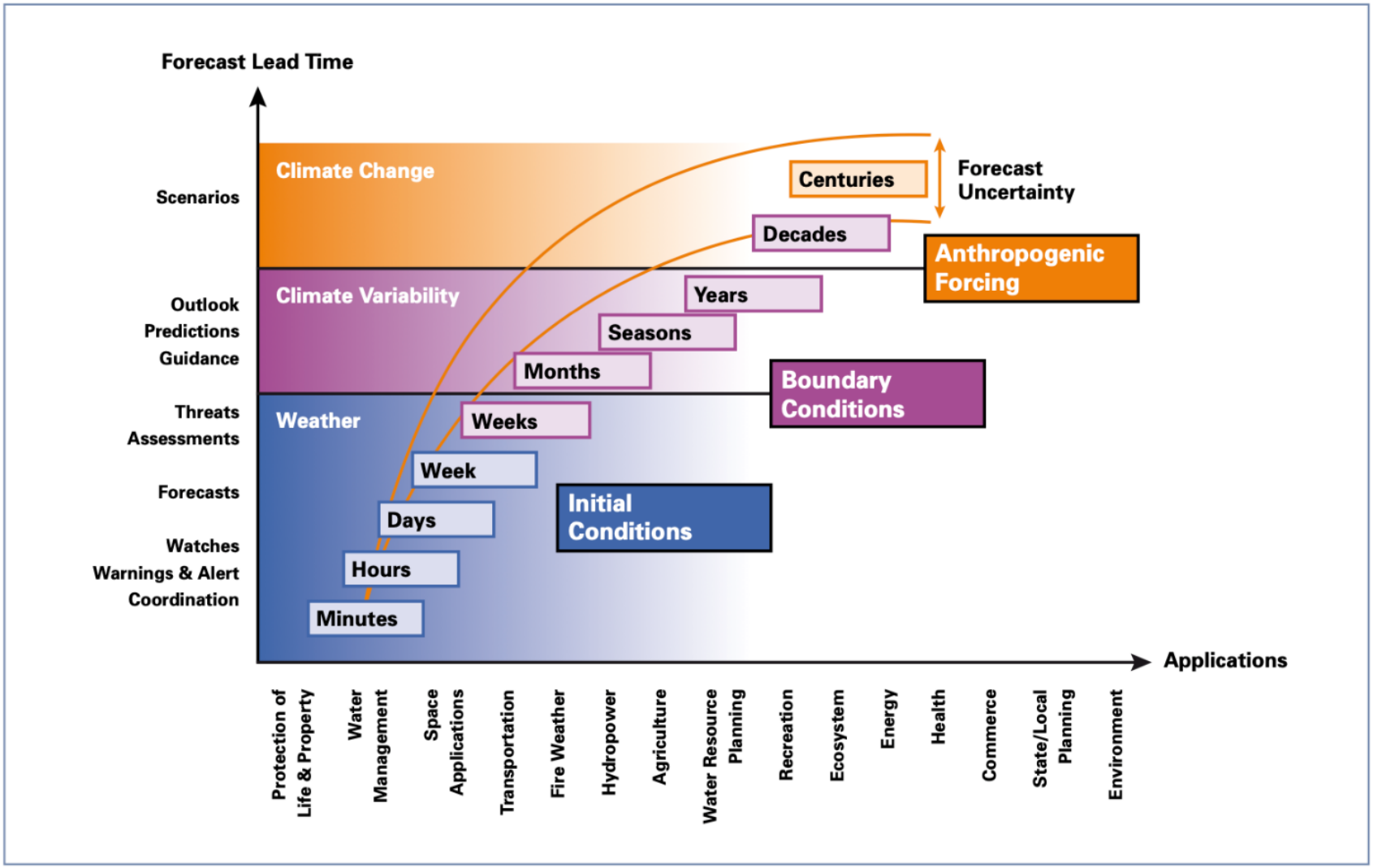
La prévision saisonnière est l'une des meilleures stratégies d'adaptation à cette variabilité pluviométrique observée…

Seasonal forecasting is one of the best adaptation strategies to cope with this observed rainfall variability...

Elles permettent de faire des choix à la fois pour minimiser le risque de conditions climatiques dangereuses et pour tirer parti des conditions climatiques favorables.

It enables making choices both to minimize the risk of hazardous weather conditions and to take advantage of favorable weather conditions.

Background



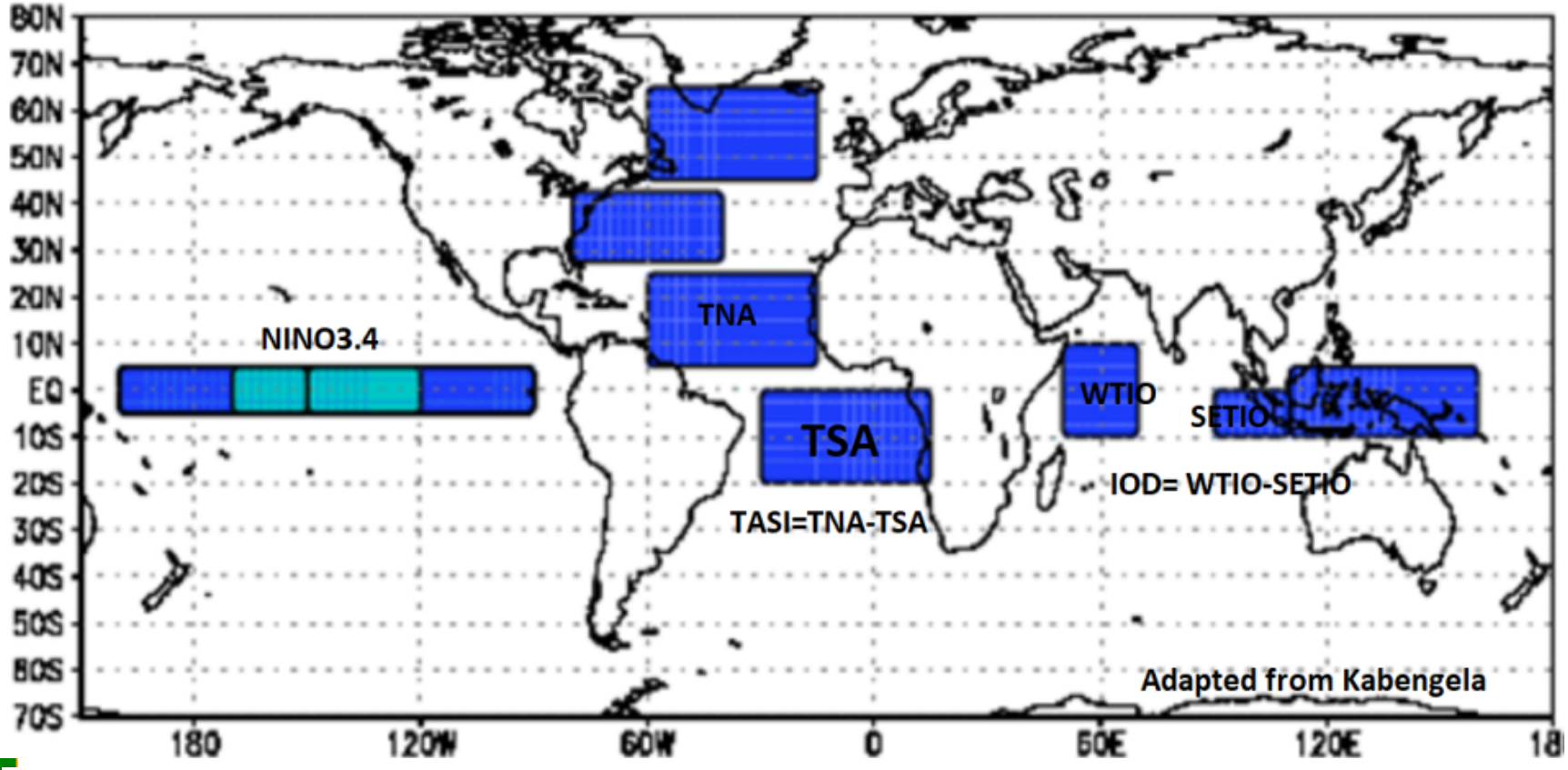
Scientifics fundations for seasonal forecasts

Seasonal (climatic) forecasts are based not only on the interactions between components of the climate system but also on the behavior of certain components at different temporal scales.

- Lithosphere : . . .
- Cryosphere : . . .
- l'hydrosphere : . .
-

The identification of statistically significant global climate teleconnections associated with ocean surface anomalies has enabled the use of corresponding parameters, along with other climatic factors, to predict seasonal climate
(Losada et al., 2012; Vizy, 2002), (Rowell, 2001), (Fontaine et al., 2010; Rowell, 2003), (Bader & Latif, 2003; Palmer, 1986)

Scientifics fundations for seasonal forecasts



- Océan pacifique équatorial : Chaud=El Nino / Froid =La Nina $\Longrightarrow$ Sahel et zone soudanienne : sec/humide,
- Atlantique équatorial sud : chaud/froid $\Longrightarrow$ Golfe de guinée : humide/sec et Sahel et zone soudanienne : sec/humide,
- l'atlantique nord-ouest aurait une influence contraire à celle de l'atlantique équatorial sud sur les régions sahéliennes et soudaniennes.

Main seasonal forecasts methods
Dynamical methods

Dynamic methods represent the complex processes of the climate system and their interactions.

14 centres ont été désignés par l'OMM pour systématiquement produire ces prévisions à l'echelle du Globe `https://wmolc.org/`

- Approches systémiques deux niveaux
- approches systémiques 1 niveau

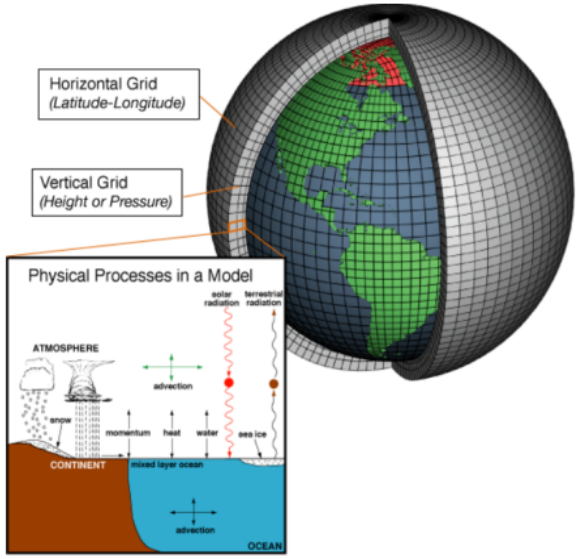
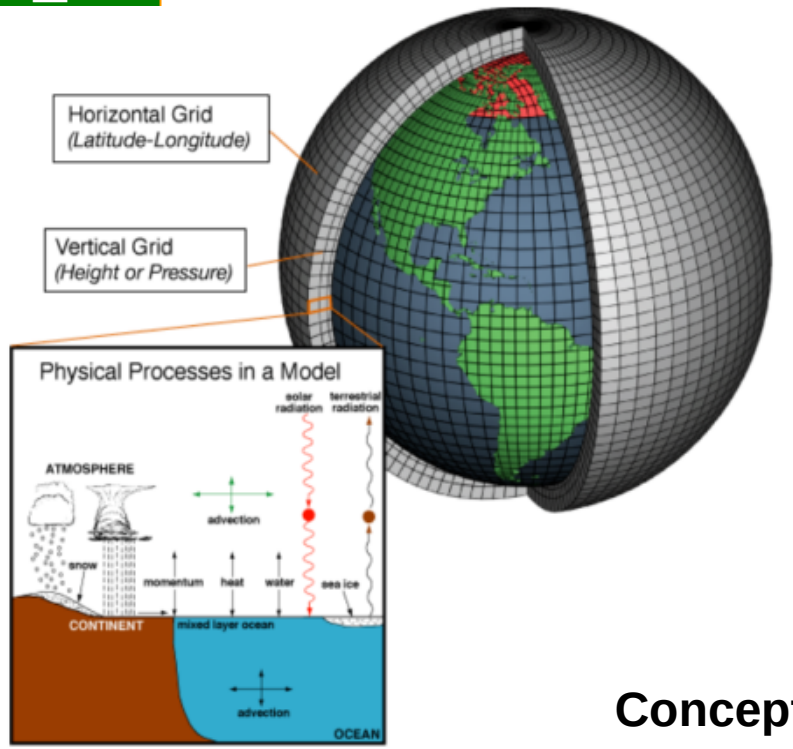


Figure – schema discretization
(source : NOAA)

Concepts

Dynamical approach



Hindcast (JAS)	Forecast (JAS)
Member_1....Member_n	Member_1….Member_n
1991 ….1991	2023…..2023
…. …..	
…. …..	
2022…..2022	

Concepts of leadtime and initialization

Hindcasts are forecasts of past climate states (WMO, 2020).

They are produced using the same methods as those used for forecasts of future states.

They are used to assess the quality of forecasts, but also to calibrate them.

Main seasonal forecasts methods
Dynamical methods

Pros of dynamical methods

- Forecast unprecedented climatic situations ... (situations that have not been observed in the past),

- No assumptions of stationarity,

- Provide daily data series...

Cons of dynamical methods

- required substantial computing resources (limits their use in NHMS)

- precipitation simulated … is often biased in relation to observations.

- Low resolution lose on the information (due to high computational).

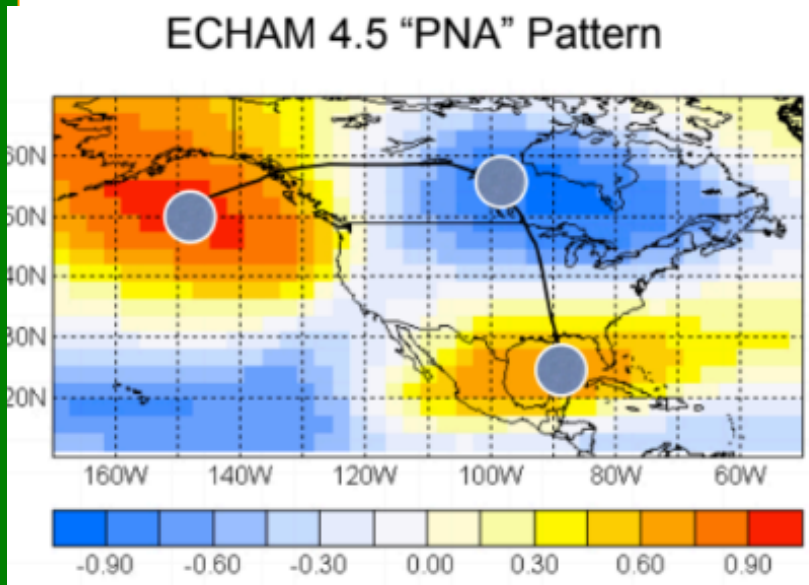
Main seasonal forecasts methods
Dynamical methods

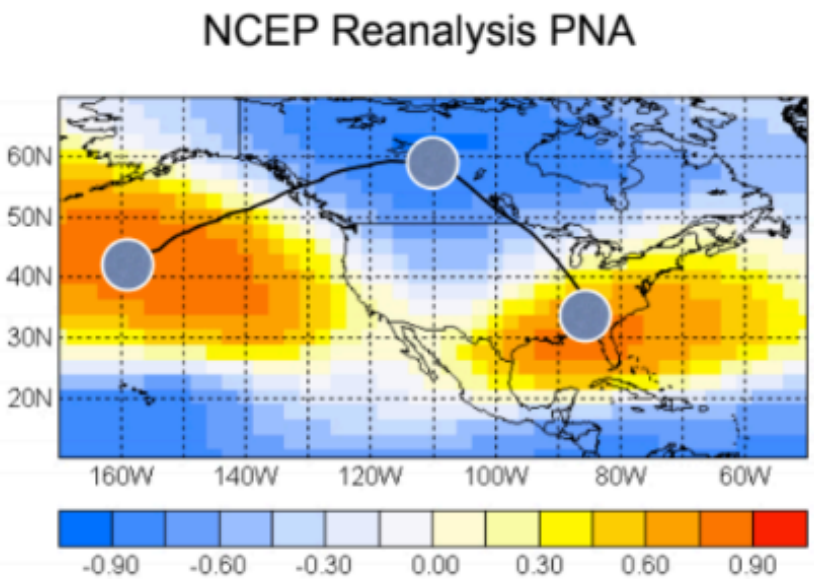
Pros of dynamical methods :

- Used to forecast unprecedented climatic situations
- do not rely on assumptions of stationarity
- provide daily data series

Cons of dynamical methods :

- required substantial computing resources (limits their use in NHMS)
- precipitation simulated … is often biased in relation to observations.
- do not reproduce the observed characteristics of climatic variables (spatial and temporal structure,...)





Credit to Andrew Robertson

Main seasonal forecasts methods
Statistical methods

Statistical methods use statistical models to predict future climatic conditions.

These models are based on statistical relationships among different climatic variables (predictors) and the variable to be predicted (predictand).

Statistical methods do not establish causality, nor do they explain the mechanisms of the relationship between predictands and predictors.

Main seasonal forecasts methods
Statistical methods

Statistical Approaches are used to predict the relationship between observed predictors (current conditions) and predictands (future conditions), using the time lag between predictors and predictands.

Predictors
(observed NINO3.4-SST-MJJ)

1991

....

....

2022

2023

Predictand
(Preciptation for JAS)

1991

....

2022

$$\hat{Y}_{2023} = \hat{f}(X)_{2023}$$

Main seasonal forecasts methods
Statistical methods

Pros of Statistical methods

- they require few computer resources and are easy to implement,

- they are directly based on the observation data.

Cons of statistical methods

- Assume the stationarity of phenomena, which is being questioned by climate change,

- assume linear relationships between parameters, which is rarely the case with natural phenomena,

- Finally, these are so-called black-box methods, which do not allow information on physical processes to be explicitly taken into account

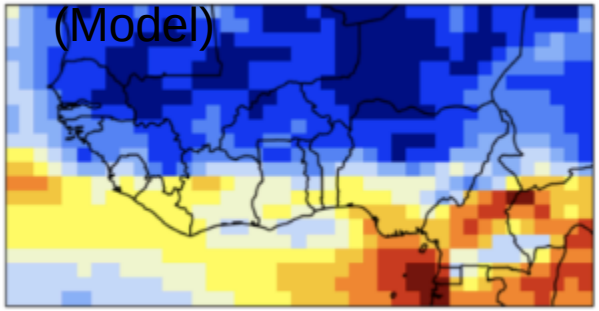
Main seasonal forecasts methods
Statistico-Dynamical methods

- **Hybrid (statistico-dynamical)**

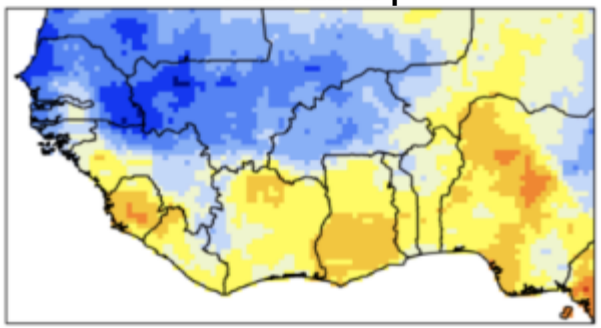
Hybrid methods derive from the combination of dynamic and statistical methods, drawing on the advantages of each of these approaches.

The implementation of hybrid approaches can be analyzed from two angles: Calibration and bias correction

CFVS2 Precipitation (Model)

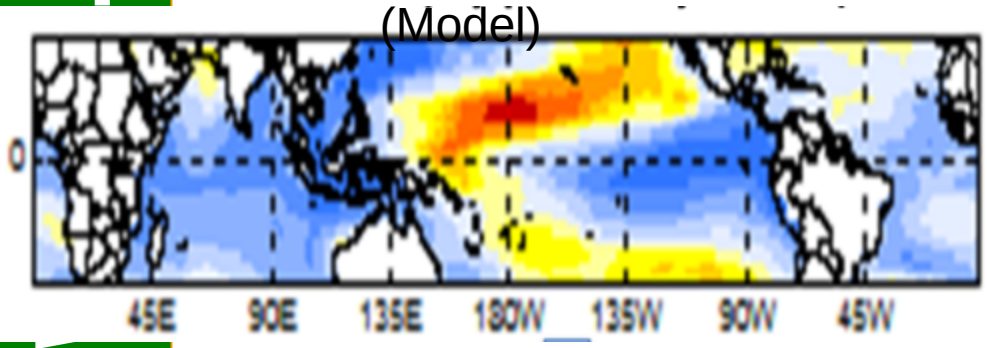


CHIRPS Precipitation

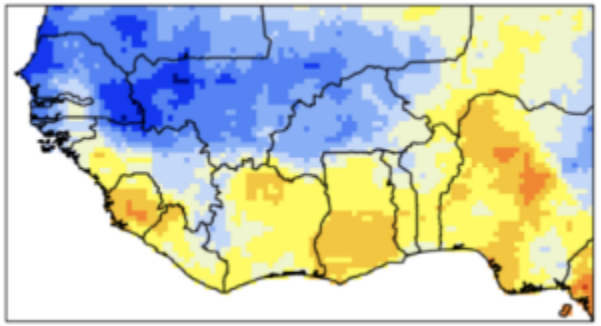


$$\hat{Y} = \hat{f}(X)$$

CFVS2 SST (Model)



CHIRPS Precipitation



Main seasonal forecasts methods
Statistico-Dynamical methods

X (from climate models)	Y (from Observation)
Hindcast (Predictor)	Observation (Predictant)
1991	1991
….	….
….	….
2020	2020
Build the model : $Y = f(X)$	
Forecast (Predictor)	
X_{2025}	$Y_{2025} = f(X_{2025})$

Main seasonal forecasts methods
Statistico-Dynamical methods

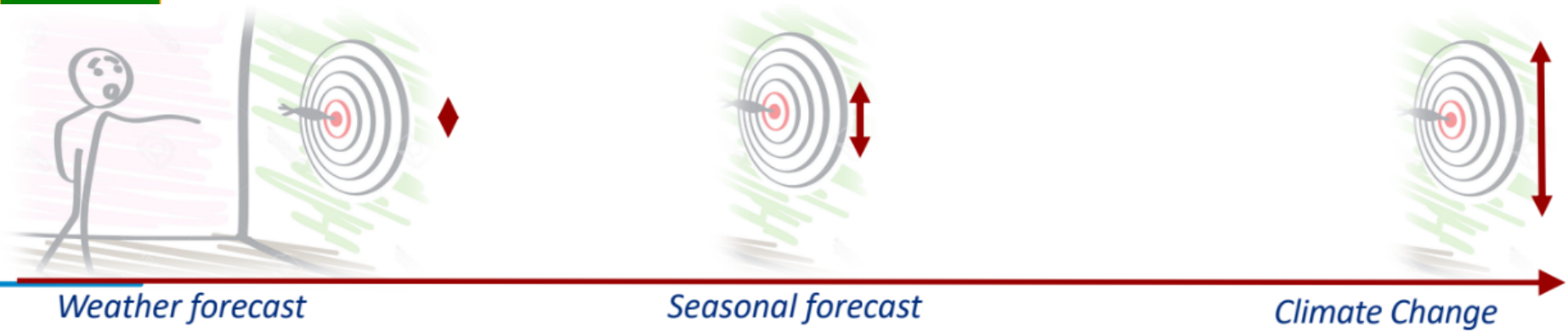
Advantages :
Mixed methods have the advantage of dynamic methods while correcting model biases.

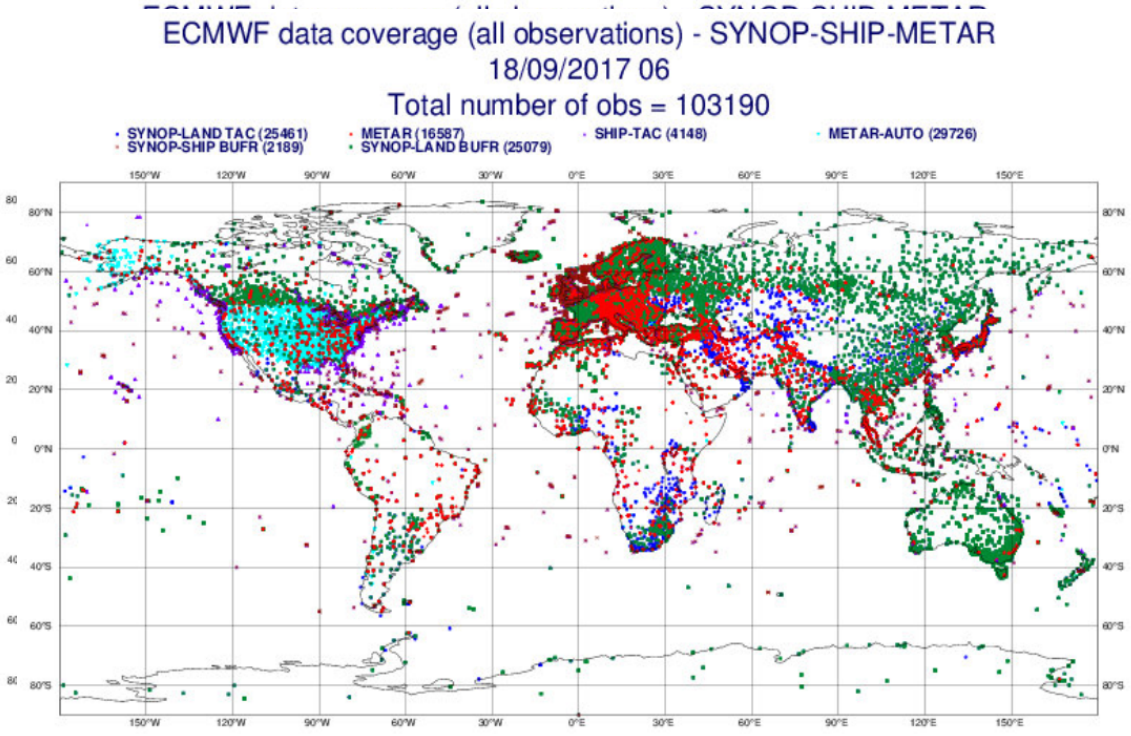
advantage of statistical methods (simple and inexpensive)

Limits :
depend on the ability of the models to represent the relationship between the climate in West Africa and the factors influencing it

require the management of a large volume of data from dynamic models

Forecast uncertainties and probabilistic format in WAS





Conditions at the departure point

Conditions along its trajectory

the simplifications inherent in the various models used in the forecasting process, whether statistical or dynamic

Uncertainty about changes in factors influencing the climate system

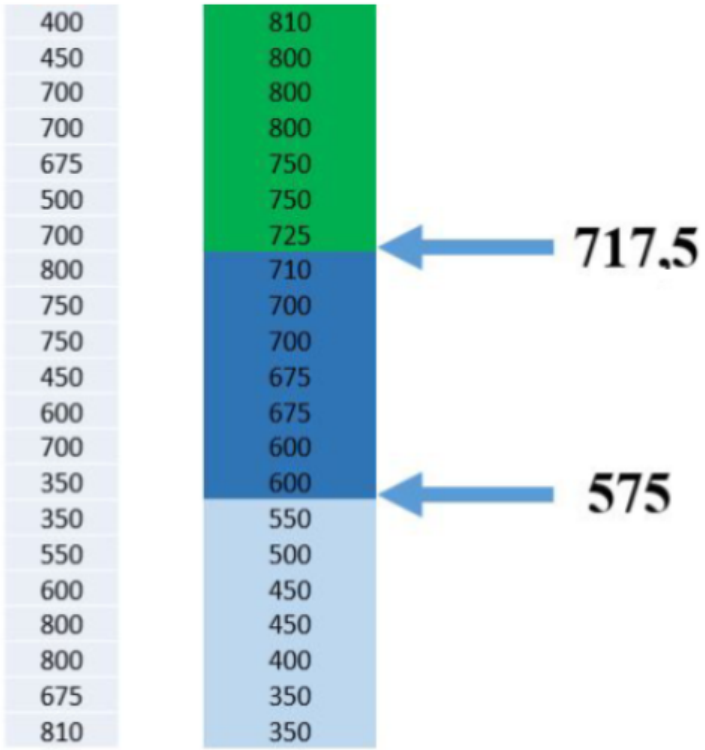
Forecast uncertainties and probabilistic format

The notion of reference period is important in seasonal forecast, as it is used to determine the statistical characteristics of the reference climate.

Reference climate is then compared to predict one to taking account uncertainty

The reference period is generally defined as the last 30 years, in line with WMO recommendations.

Terciles



Forecast uncertainties and probabilistic format
Dynamical case

Hindcast (JAS)	Forecast (JAS)
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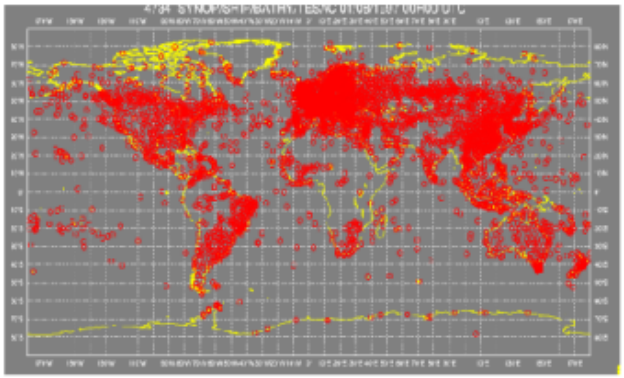
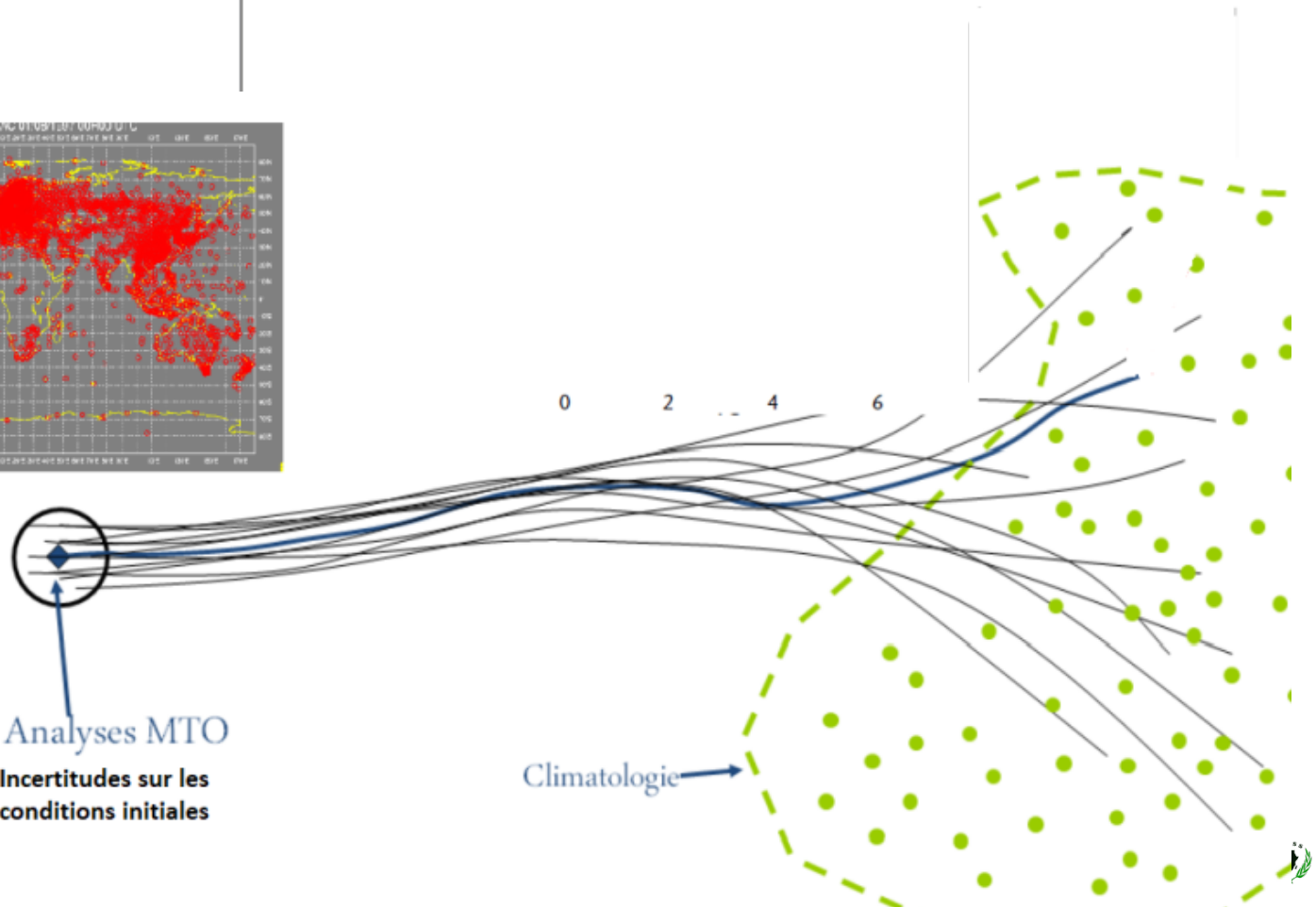
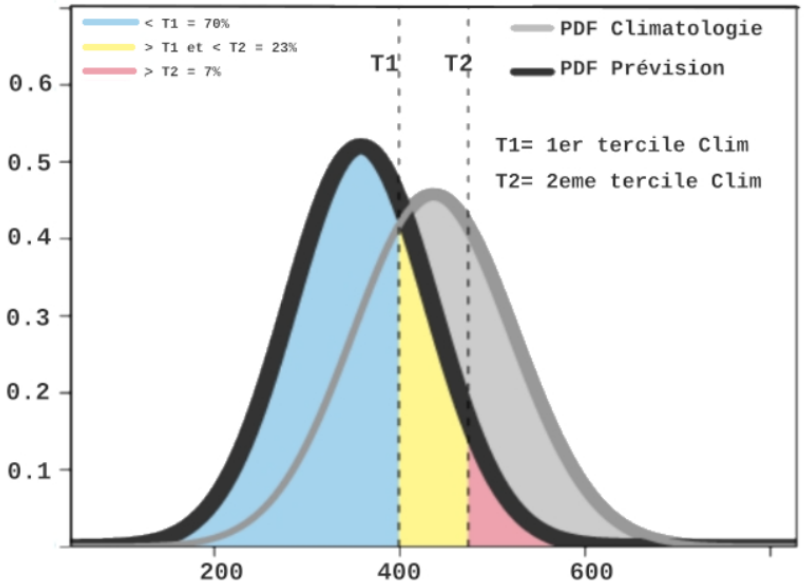
2022.....2022	





Forecast uncertainties and probabilistic format: in Statistical and hybrid seasonal forecast

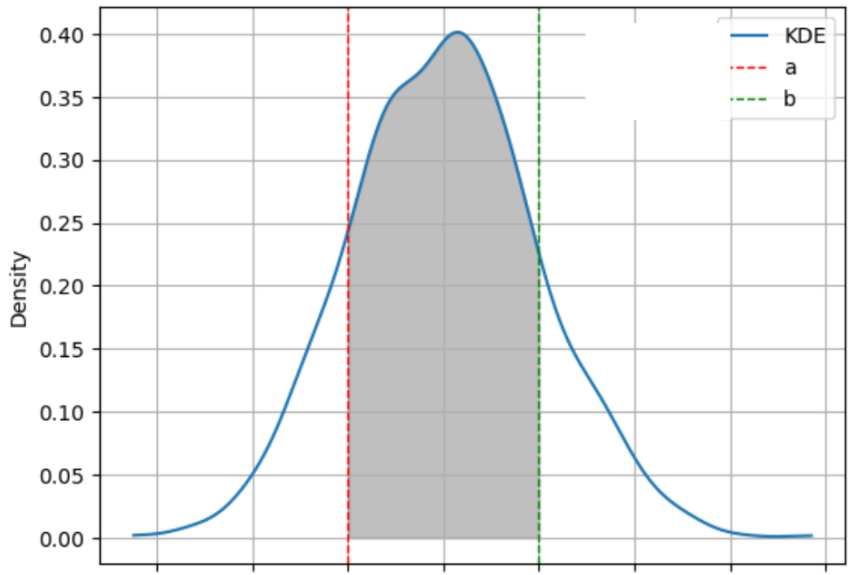
1981	Predict 1981	Omit 1982 – 1983	Training period							
1982	Omit 1981	Predict 1982	Omit 1983 – 1984	Training period						
1983	Omit 1981 – 1982		Predict 1983	Omit 1984 – 1985	Training period					
1984	Training period	Omit 1982 – 1983		Omit 1984	Omit 1985 – 1986	Training period				
1985	Training period		Omit 1983 – 1984		Predict 1985	Omit 1986 – 1987				
...										
2009	Omit 1981	Training period		Omit 2007 – 2008		Predict 2009	Omit 2010			
2010	Omit 1981 – 1982		Training period		Omit 2008 – 2009		Predict 2010			



Explain on the board

Forecast uncertainties and probabilistic format

1981	Predict 1981	Omit 1982 – 1983	Training period							
1982	Omit 1981	Predict 1982	Omit 1983 – 1984	Training period						
1983	Omit 1981 – 1982		Predict 1983	Omit 1984 – 1985	Training period					
1984	Training period	Omit 1982 – 1983		Omit 1984	Omit 1985 – 1986	Training period				
1985	Training period		Omit 1983 – 1984		Predict 1985	Omit 1986 – 1987				
…										
2009	Omit 1981	Training period		Omit 2007 – 2008			Predict 2009	Omit 2010		
2010	Omit 1981 – 1982		Training period		Omit 2008 – 2009			Predict 2010		



Explain on the board

$$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$$

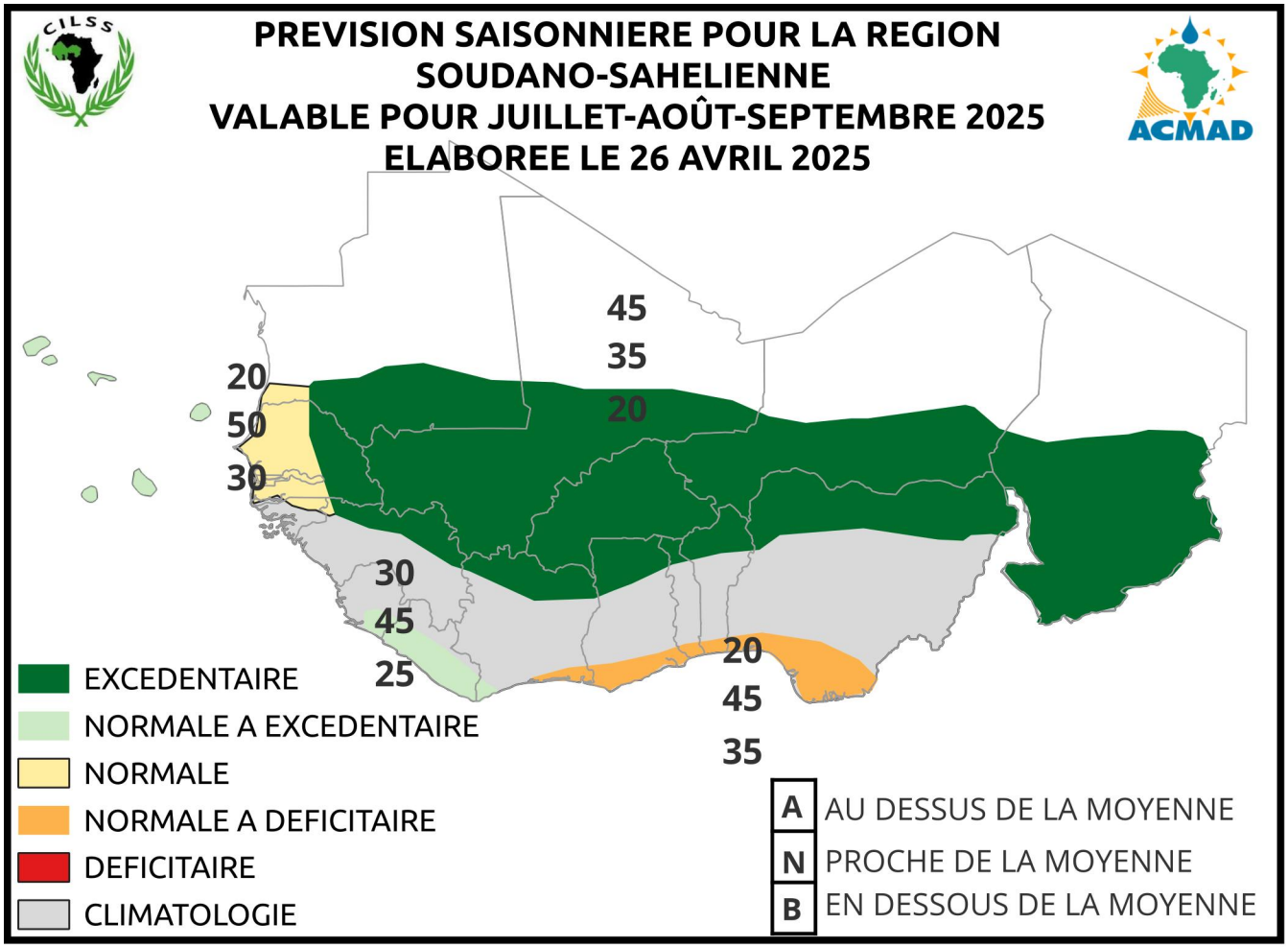
Current West Africa seasonal forecasting system: Consensual Seasonal Forecasting

First, global climate model outputs are rigorously analyzed:
- West African Monsoon (WAM) drivers,
- including sea surface temperatures (SST),
- surface and upper-level winds,
- and surface pressure

Second, statistical techniques such as Canonical Correlation Analysis, Principal Component Regression, or Multiple Linear Regression are employed

Third, subjective or manual techniques, leveraging the expertise of climatologists from NMHS,

Current West Africa seasonal forecasting system: Consensual Seasonal Forecasting



Current West Africa seasonal forecasting system

Objectives approaches : Shift to objectives seasonal forecasts

Objective Seasonal Outlooks (OSO) are defined as a set of traceable, reproducible, and well-documented steps that allow the evaluation of forecast quality (WMO 2020).

The objective approach is good, but it requires a solid knowledge production and effective utilization of tools within this approach.

PyCPT