The Current Advances in the Science of Climate Forecasting and the Various Types and Methods that are Presently Used in Africa

Seasonal forecasting in Africa

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The scientific bases

Seasonal forecasting is based on some scientific principles, which are important to recall insofar as they are appreciably different from the scientific bases of the short- to medium- range forecasts.

In seasonal forecasting, one uses the adjustment property of the atmosphere to the evolutions of external forcing conditions, the latter partly controlling the atmospheric behavior at large scales.

More precisely, the evolutions of the conditions of oceanic and continental surfaces are often slow and predictable, these evolutions inferring a slow memory effect at the atmosphere whose evolution becomes partially predictable then.

The short- and medium- range numerical forecasts indicate to us that the predictability is limited in time to about fifteen days. The apparent paradox is directly related to the subjacent averaging operator used in seasonal forecasting.

The successive instantaneous states of the atmosphere have indeed a limited predictability (with about fifteen days) whereas the averaged state of the atmosphere, which is particularly sensitive to the conditions of oceanic and continental surfaces, shows more predictability at the extended ranges (cf. figure 1).

Thus, It is really the seasonal average state of the atmosphere which one will seek to forecast rather than the weather chronology during the season. Additionally, the space and time scales being very strongly connected in meteorology, such kind of forecast will correspond, in fact, to a forecast on large space scales (i.e. that of the averaged atmospheric circulation).

It is important to note that average circulation in the tropics is on one hand a major characteristic of the atmospheric variability and on the other hand strongly influenced by the large scale organized convection (notably the Hadley-Walker divergent circulation), the latter being strongly controlled by the evolutions of the conditions of oceanic and continental surfaces. That particularly explains why seasonal forecasting has enhanced scores and skills in the tropical areas compared to the mid-latitude regions.

External forcings

In addition to solar forcing, the principal source of energy for the climatic system, one distinguishes the continental from the oceanic forcings.

Currently, oceanic forcings are those which are used in seasonal forecasting. One finds there information from the sea surface temperatures particularly used in both coupled or forced numerical models but also in the majority of statistical models.

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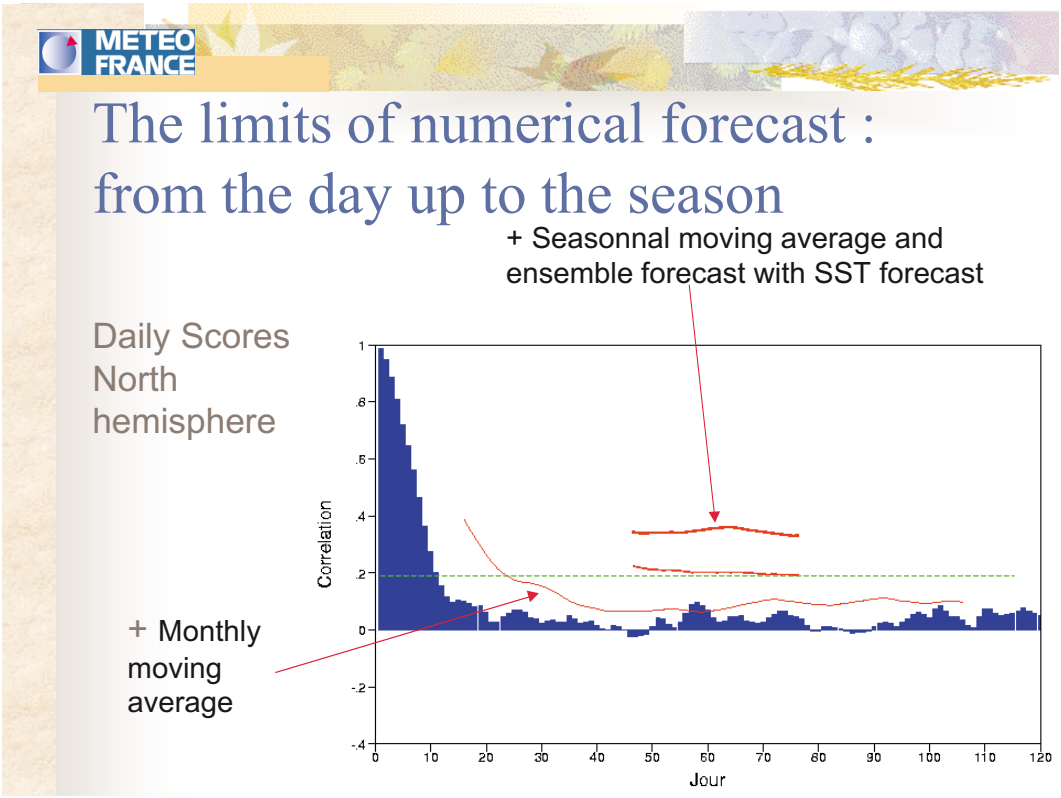


Figure 1: Scores of the Arpège-Climate model used in SST forced mode for Geopotential Height at 500hPa over North Hemisphere. In blue daily scores, in red scores of moving average values for month and 3-month time scales.

This information coming from the oceanic surface allows us to get reasonable forecasts up until a range of 4 months. If one hopes to go beyond this range, one must necessarily use information coming from the coupled dynamic of the Ocean-Atmosphere system, notably including the sub-surface information. That is what is achieved with Ocean-Atmosphere coupled models. The most known of these forcings, without contestation, is related to the ENSO forcing and its planetary consequences. But a very important point to be underlined and which is illustrated in figure 2 is that the effects of La Niña forcing are often non-symmetric of those of El Niño forcing.

In seasonal forecasting, this fact will be expressed, in practical form and depending on the year, by a different confidence level into the forecast in relationship with the kind of oceanic forcing influencing the considered year and region.

Oceanic forcings are not alone to confer a slow memory effect in the atmosphere; here one can also find continental forcings, even if, at this stage, they are less used than the former. In this point of view, one has to quote the soil moisture content which contributes to the low-frequency variability of the atmosphere (20-60 days) or the snow cover which was extensively studied in the frame of the Indian and South-East Asian monsoons. Finally, surface property variations, notably (but not only) related to vegetation condition variations, are also able to influence the average circulation (through for instance the surface albedo and its variations).

Continental forcings are not actually and directly used mainly for observational problems. For instance, it is extremely difficult to get a “soil moisture" product in an operational way with a reasonably good quality.

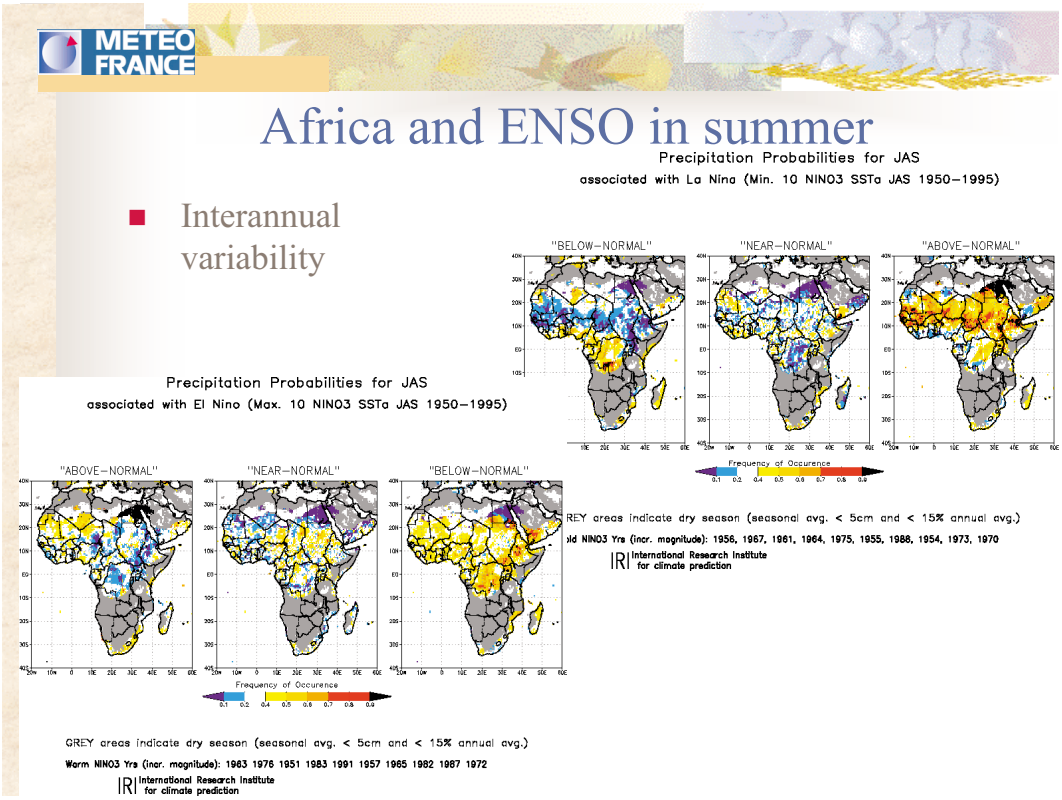


Figure 2: Frequency of «Dry», «Normal», «Wet» rainfall classes observed for the July-August-September period during respectively the 10 strongest Niña (top and right panel) and the 10 strongest Niño (bottom and left panel) – from IRI.

The Regional Climate Outlook Forums

The Regional Outlook Climate Forums in Africa were boosted in the context of the 97-98 El Niño and with the support of the WMO CLIPS Project, particularly because of the media coverage of this event and because of its follow-up by the big numerical forecast centers all around the world. Consequently, these fora raised to a wide collaboration between different organizations and Seasonal Forecasting Producing Centers where one can find not only the DMCs, ACMAD but also NOAA, IRI and the ECMWF.

These Fora are built on an organization where one can find different aspects such as training as well as technical aspects related to the forecast; the organization is composed of:

- The Preforum: typically a few weeks duration (4 to 6). Here, one collects key information for the forecast of the next rainy season and notably the SSTs which are used as predictors in statistical models. Thanks to these models, one can build the national forecasts (i.e. for each country in the considered region). Then, an important part of the preforum is devoted to training activities to the benefit of climate forecasters and also to the benefit of seasonal forecasting users in relationship with the tackled topics in the fora;
- The Forum: its duration is typically over a few days (maximum 1 week). Here, one presents the last available information on the climate system and its evolution. Obviously, specific presentations and discussions are given on different topics of interest like for instance Climate Forecasting, Agriculture, Health and Climate or Hydrology. Then the most important part of the forum is devoted to the elaboration of the consensual forecast which allow to get regional bulletin and products about the

quality of the next rainy season or of water resources availability (run-off of the main river basins);

- The dissemination: it is done by the NMHS at a national level, including the country and user adaptations of the regional products. One has to highlight that, even if the methods and channels used for dissemination are very different from one country to another, a national forum exists in a lot of them;

- The forecast update: The seasonal forecasting process is not a punctual exercise that has to be done once a year at a specific time but must be rather viewed as a continual process which has to be regularly adapted to the last available information. This update is particularly important to allow the adaptation of the corresponding decisions and advice. This update, notably for SST, is done on a monthly basis at the country level which can retrieve this information, most of the time, using Internet or E-mail facilities;

- The evaluation of the forecasts: It is currently acknowledged that the evaluation process is entirely included in the forecast process itself. One has to distinguish 2 evaluation levels; the first one is the technical level which is dealing with the quality of the forecast while the second one is the user level which is dealing with the use of the forecast, its interest and value from a user's point of view. From now, one can consider that the first evaluation is regularly done while the second one must yet be organized and performed on a regular basis.

Finally, one has to underline that, the seasonal forecasting processes have been in existence for some years already, and they were evaluated on one hand by a global point of view in 2000 (Pretoria – 16-20 October 2000) and on the other hand for more specific aspects (SARCOF – October 2001 / PRESAO – June 2002).

In Africa for the RCOFs one finds 4 main areas of activity (cf. Map 1); these regions being homogeneous in relationship with the main characteristics of the rainy season:

- West Africa: where 5 PRESAO forums were held on an annual base. Initially, this zone joined West Africa and countries from the Guinean Gulf but recently, the latter joined the PRESAC forum;

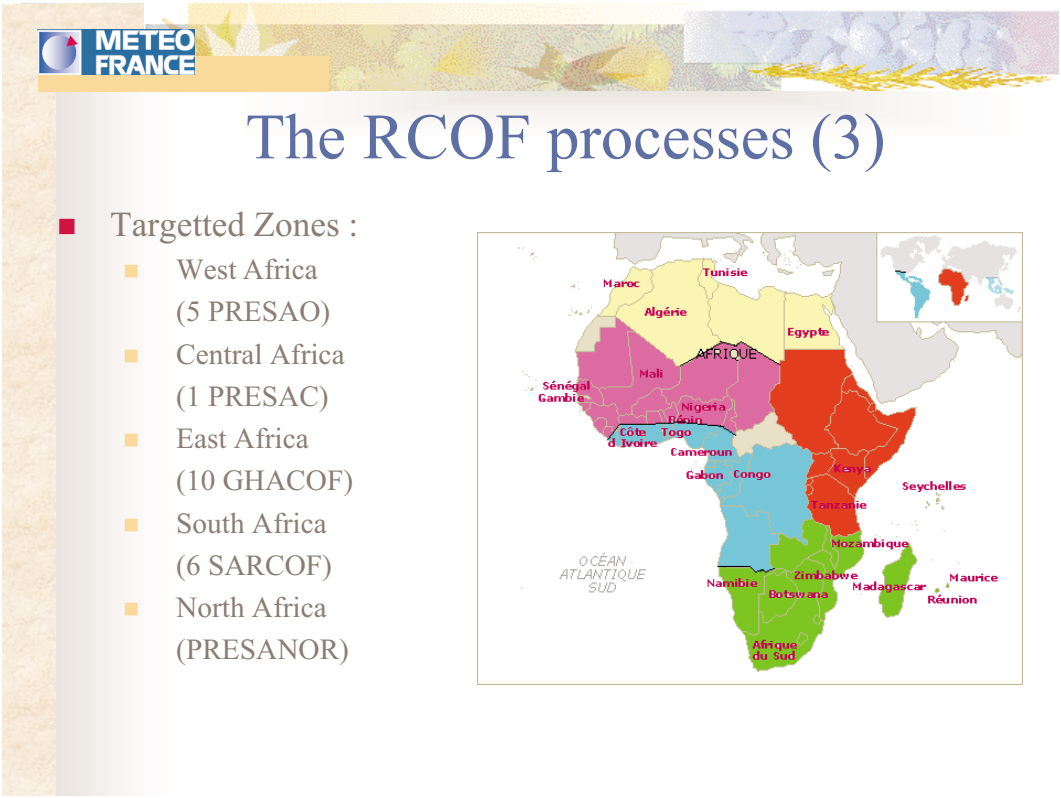
- Central Africa: This region consists of countries showing 2 rainy seasons along the costal area of the Guinean Gulf. The first PRESAC was held in August 2002 in Brazzaville.

One has to point out a preliminary forum, namely PRESANOR, devoted to regions of North Africa and along the Mediterranean Basin. This should be the lead to other PRESANOR forums and consensual regional products for the considered regions.

The country's forecast method

As already noted, the method is mainly based on the use of information coming from the SSTs. Without exhaustiveness of the used predictors (cf. introductive and ENSO presentations), one can recall that the key oceanic zones which influence the rainfall over Africa are found in the Pacific (notably Niño 3 and 3.4 boxes), the Atlantic (including the Atlantic dipole), the Guinean Gulf or the Indian Ocean (notably the equatorial part).

The statistical model is a Multiple Regression one calibrated between the SST predictors and the standardized rainfall anomalies. Each country is divided into homogeneous zones in a predictors' correlation sense (fig.3).



Map 1: Schematically representation of concerned zones by the RCOFs.

- East Africa: Taking into account the 2 rainy seasons in regions of the Great Horn of Africa, the forum is held twice a year. One had already 10 GHACOF;

- South Africa: Region where 6 SARCOF were taking place.

Predictors are selected using a stepwise process. Then, from a regression giving a quantitative forecast, one transforms this forecast into a qualitative forecast by comparing the forecasted value to the terciles of the climate rainfall anomaly distribution. If the forecast is below the lower tercile, one forecasts «Below Norma » conditions (or «Dry» conditions), «Above Normal» conditions (or «Wet» conditions) when the forecast is above the upper tercile and «Normal» conditions between the two terciles. Models are evaluated using a cross-validation procedure and using contingency tables “Observation” versus “Forecast” for the 3 previous categories. If a model shows a too low level of performances (Score and Skill – cf. verification) consequently, the forecast provided is the Climatological Forecast.

Finally, the probability provided with the categorical forecast comes from the contingency tables used in the evaluation of the statistical model.

The consensual forecast

The goal of this step is to take into account the national forecasts in drawing a forecast at the regional scale. For that, the climate forecasters merge all the national forecasts. Then, one tries to take into account the complementary information provided notably by numerical models, the last known or presumed evolutions of the climate system or the climate knowledge coming from international experts. All these components allow to build regional forecasted products (cf. figure 4) for each of the previous regions already presented (AO, AC, GH, SA), the forecast being expressed under its probabilistic formulation for each of the categories previously quoted («Dry», «Normal»,«Wet»). One has to highlight that the provided probability

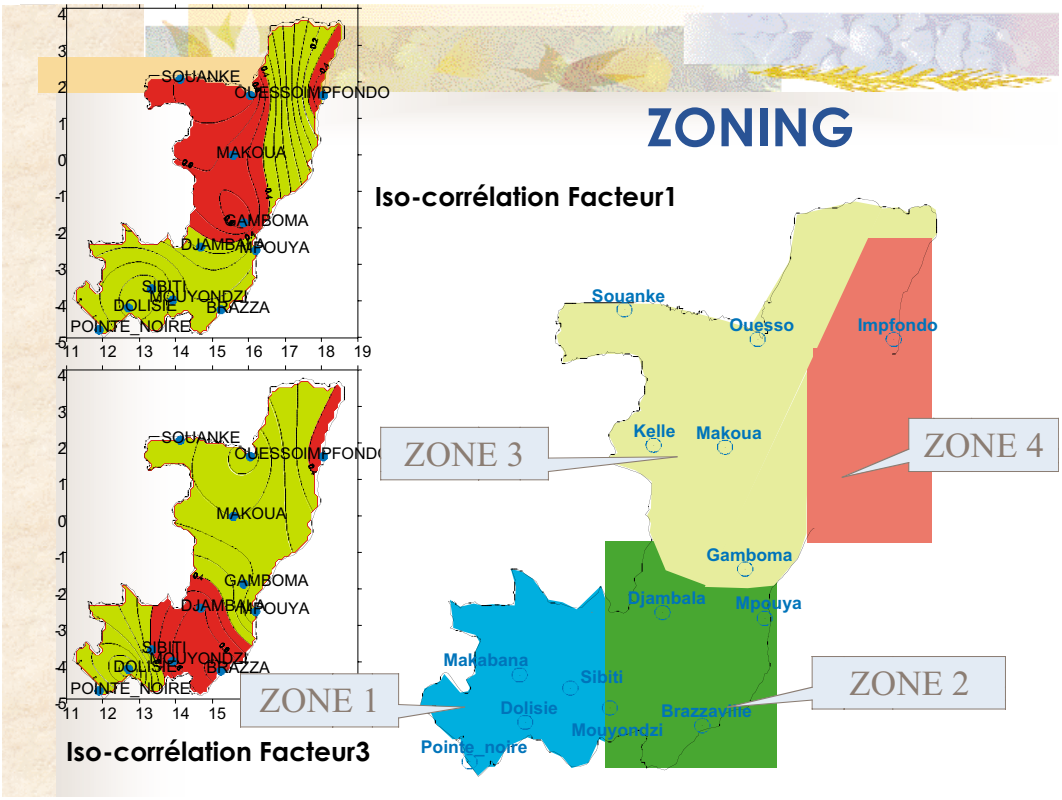


Figure 3: Zoning performed by Congo Brazzaville for the calibration of the national statistical models. On the left, one finds the iso-correlation maps between rainfall and predictors. One can notice the good correspondence between these maps and the proposed zones. Here, only the first three zones will give a useable model.

is based on one hand on the performances of the statistical models and on the other hand, and more subjectively, on the confidence in the climate evolutions for the next.

Conclusions on the Regional Climate Outlook Forums (RCOFs)

Currently there are well-established bases which are undoubtedly accepted and from which one should be able to build a better future. This operating way is now quite well-known and under control despite some improvements which could and should be addressed in order to secure the sustainability of these forums. In the suggestion list for the future, one can highlight:

- To assure the sustainability of the existing forums (Financial, human and material resources);
- To consolidate and improve actual products and methods (statistical models, new predictors, merging of information coming from different models, …);
- To demonstrate the interest and the value of seasonal forecasting products from a user point of view (notably through national pilot projects);
- To create new user oriented products (notably in term of onset and end of the rainy season, dry spell, downscaling, …);
- To promote the sharing of experiences and ideas (by strengthening exchanges through networking organization – may be with the support of Clips Focal Points);
- To strengthen the communication with users (including the transformation of forecasts in terms of users' actions) particularly using multidisciplinary groups (both way communication) and with the support of training activities.

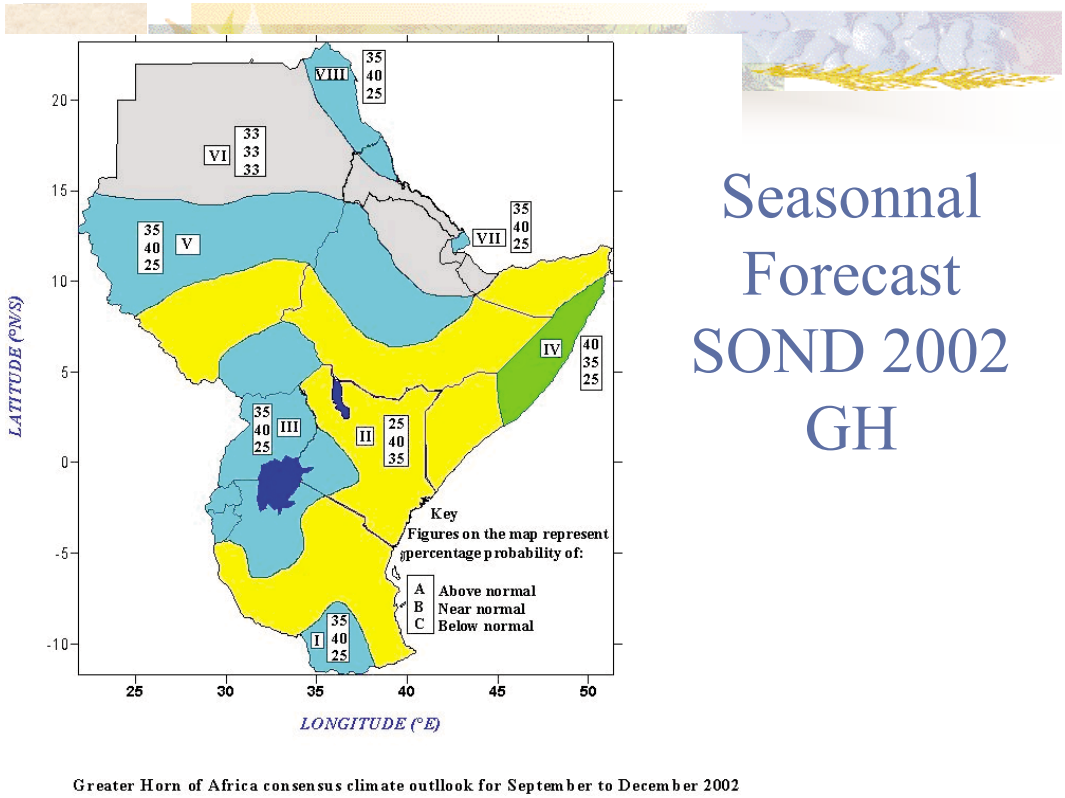


Figure 4: Prévision consensuelle sur la qualité de la saison SOND 2002 des pluies établie pour la région «Afrique de l'Est» au cours du 10ième GHACOF.

Additionally and focusing on verification and uncertainty in seasonal forecasting, one can underline some more specific points such as:

- The verification process is an important part of the forecast process itself;
- The verification of the use and the impact of seasonal forecasts must be achieved;
- The users' feedback toward climate forecasters must be improved;
- Reliable and relevant data-base for verification purposes must be prepared and available;
- The fundamental probabilistic formulation of seasonal forecasts must be considered;
- Promoting the transformation of the probabilistic forecast to the benefit of users in more readable and comprehensive terms must be encouraged (transformations in terms of risks, or scenarios or specific user's actions and associated probabilities, …).

Other products

One has to underline that seasonal forecasting products are now widely disseminated all around the world, so one can access to many other products in addition to those directly coming from the forums. Although not exhaustive, one can see in the following, a brief description of the complementary products that one can get in and out of Africa:

- The numerical products: coming from the big numerical forecasting centres in the world (cf. figure 5). One can quote, as example, the ECMWF, IRI, the JMA, the NCEP, MF or the UKMO. Generally, one distinguishes 2 different parts in the forecast:

  (1) The model forecasts themselves, which are compared to the model climatology (pointing out the major role of the retrospective forecast experiment) and consequently which are presented as indices without unity;

(2) The adaptation of the model forecast indices to the local properties of observations (using a recalibration) which is presented as a forecasted anomaly.

Typically, it's the indices which can be used in multi-model approaches. The recalibration to the observation obviously depends on the used «observed» dataset.

- The statistical products: generally prepared out of Africa, one can highlight (again as examples) the African Desk products or those prepared by the UKMO. Some complementary products are created sometimes with a poor success despite operational application opportunities. Among these products one can quote the forecast of the onset and the end of the rainy season for West Africa (Omotosho method) which has not been operationally implemented apparently for some problems of predictors' availability. As a first approach of time downscaling, one can notice the forecasts of the intraseasonal evolution of the rainy season both directly from numerical models (Céron & Guérémy for West Africa) or from hybrid methods (Mainguy, Céron & Guérémy for the long rain season in Kenya). Finally, one has to also quote here the 10-days and monthly outlook bulletins notably available through the DMCs or ACMAD; they generally allow to adapt seasonal forecasts, associated impacts and advices at shorter scales.

Some references

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Numerical products

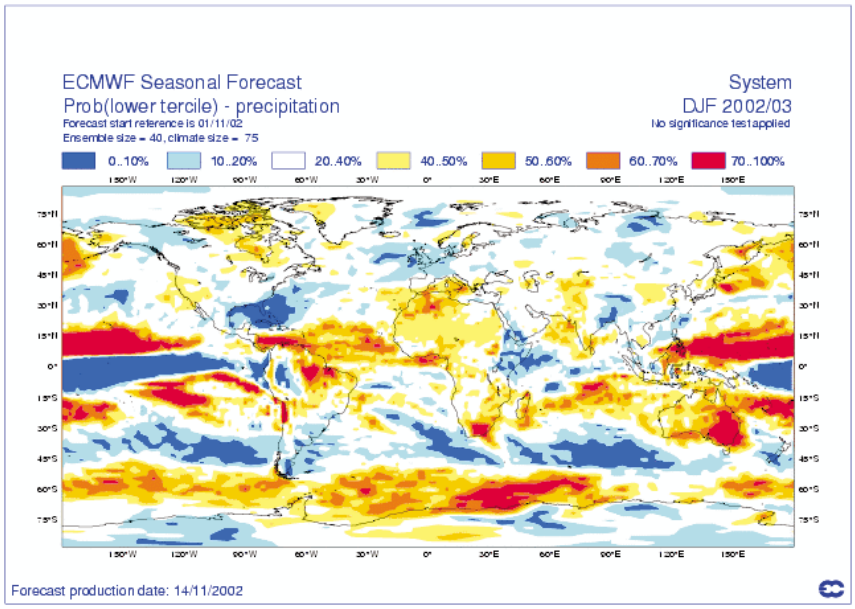

Figure 5: Exemple de produit numérique probabiliste produit mensuellement par le système de prévision d'ensemble du CEPMMT. A noter qu'il s'agit ici d'un modèle couplé Océan/Atmosphère et des probabilités associées à la catégorie «Sèche».