# Technical Assistance to the Republic of Seychelles for the GCCA Seychelles Global Climate Change Alliance+

*Component A*

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**Seasonal forecasting with SEAFORDS tool training workshop**
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Implemented by a consortium led by:

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## List of acronyms

| | |
|---|---|
| **CA** | Composite Analysis |
| **CCA** | Canonical Correlation Analysis |
| **ECMWF** | European Center for Medium Range Weather Forecast |
| **ENSO** | El Nino Southern Oscillation |
| **EOF** | Empirical Orthogonal Function |
| **GCM** | Global Climate Model |
| **GPCP** | Global Precipitation Climatology Project |
| **IOD** | Indian Ocean Dipole |
| **NCEP** | National Centers for Environmental Prediction (USA) |
| **NOAA** | National Oceanic and Atmospheric Administration (USA) |
| **PCA** | Principal Component Analysis |
| **PMER** | "*Pression au niveau de la Mer*" Mean Sea Level Pressure (MSLP) |
| **PV200** | "*Potentiel de Vitesse*" Velocity Potential at 200hPa |
| **RR** | Rainfall accumulation |
| **SPI** | Standardized Precipitation Index |
| **SST** | Sea Surface Temperature |
| **SWIOCOF** | SouthWest Indian Ocean Climate Outlook Forum |
| **TCWV** | Total Column Water Vapour |
| **Uxxx** | Zonal wind at xxx level (850hPa, 200hPa) |
| **Vxxx** | Meridian wind at xxx level (850hPa) |

The annual running quarters from January-February-March to December-January-February are referred to as their acronyms: **JFM** , **FMA**, ... to **DJF**.

## Foreword

This manual focuses on the use of the Seafords toolbox developed by Meteo France Réunion in the context of climate analysis and statistical downscaling for seasonal forecast purposes over the Seychelles.

The content is mainly a synthesis of the practice sessions of a training that took place in the University of Seychelles (Mahé - Grande Anse) from 12th to 16th Nov. and from 3rd to 7th Dec. 2018. This training was facilitated by experts from Météo France Réunion. It was supported by the Global Climate Change Alliance + project and was locally organized by the Seychelles Meteorological Authority with the contribution of the University of Seychelles.

# 1 CLIMATE ANALYSIS AND SEASONAL PREDICTABILITY

## 1.1 large-scale variability

The large-scale phenomenon that may have an impact on the climate over Seychelles are associated to oceanic features. The heat content and distribution in the Pacific and Indian Oceans are the main drivers that may influence the Seychelles climate through coupling with the atmosphere. The El Nino Southern Oscillation (ENSO) and the Indian Ocean Dipole (IOD) are examined hereafter.

The analysis presented have been produced with the Seafords toolbox, which implementation process is described in appendix. The large-scale data is given by the ERA-Interim reanalysis from ECMWF for the 1979-2017 period.

**ENSO**

The ENSO is a non-periodic feature of the Pacific Ocean that involves oceanic and atmospheric mechanisms. Significant impacts in the tropical belt are expected when ENSO is in positive (El Nino events) or negative (La Nina events) phase.

The primary signal is observed on the Sea Surface Temperature (SST). Processing a Principal Component Analysis (PCA) for the December to February quarter, allows to identify the most significant patterns that explain the variability of this parameter. The first EOF shows the well-known pattern in the Pacific Ocean (fig. 1). Given the sign of the EOF, a positive ENSO is associated to a negative value of the principal component. From the evolution of this variable, the positive and negative phases can be identified: (pos: 2015, 2009, 1997, 1991, 1982 / neg : 2010, 2007, 1999, 1998, 1988). This result may be compared to the record of the Oceanic Nino Index provided by the NOAA (fig. 3).

The direct impact of the SST anomaly on the atmosphere is the water vapour content. The result of a PCA on the Total Column Water Vapour (TCWV) shows that the dominant mode explaining the variability of this parameter (fig. 2) is highly linked to the SST oscillation.

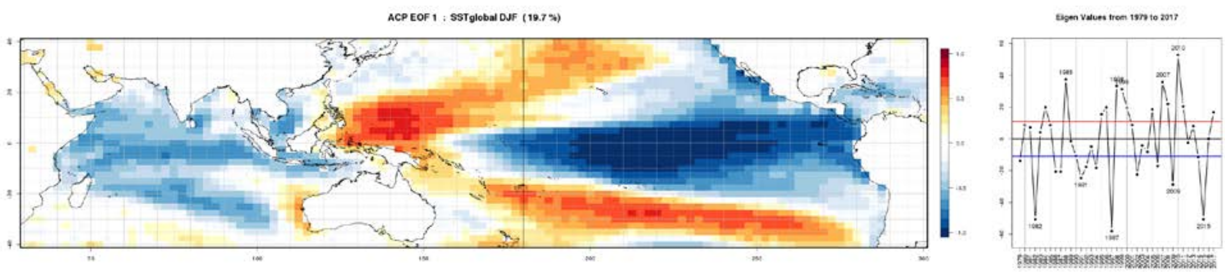



*figure 1: PCA of **SST** in DJF - EOF 1 and principal component history*

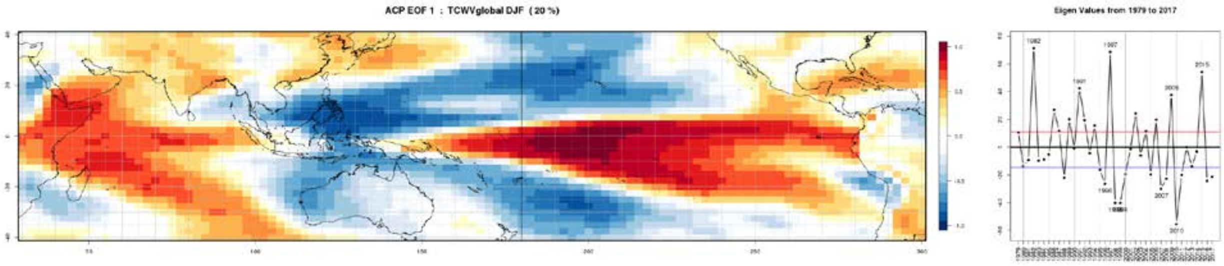



*figure 2: PCA of **TCWV** in DJF - EOF 1 and principal component history*

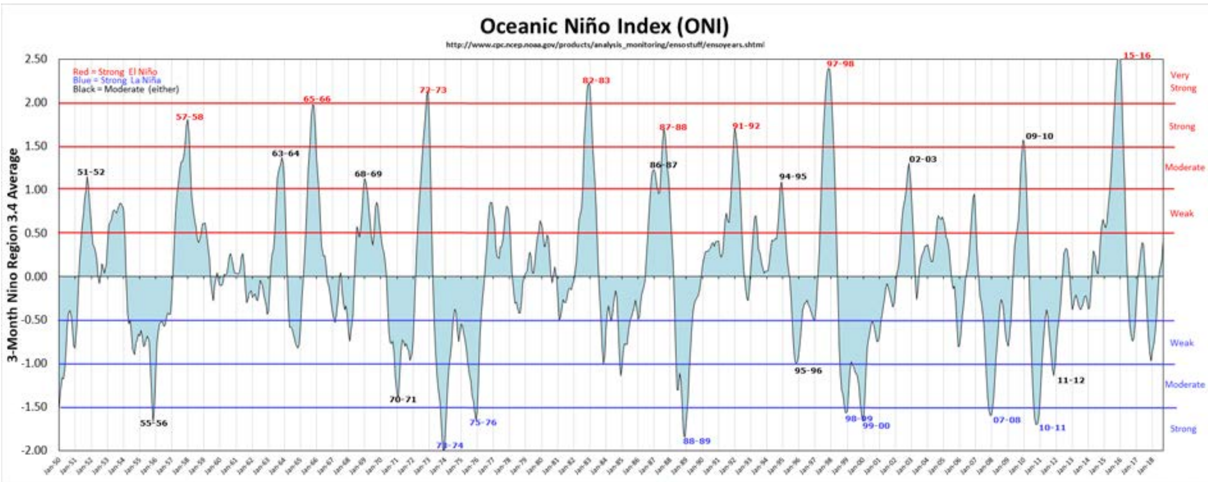
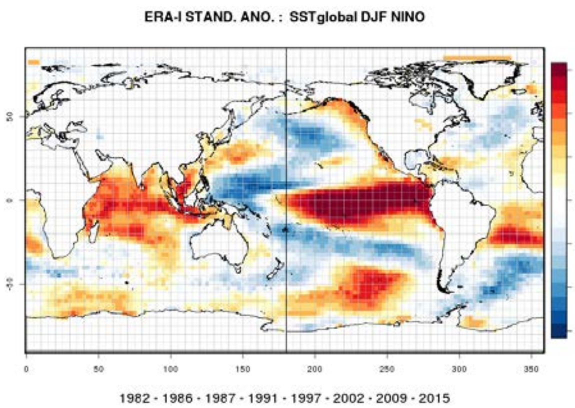
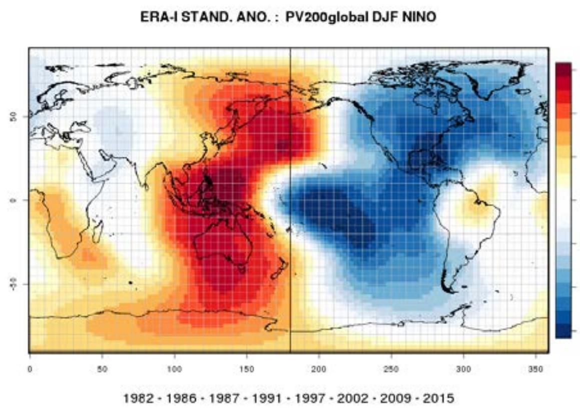



*figure 3: ONI history (NOAA/NCEP)*

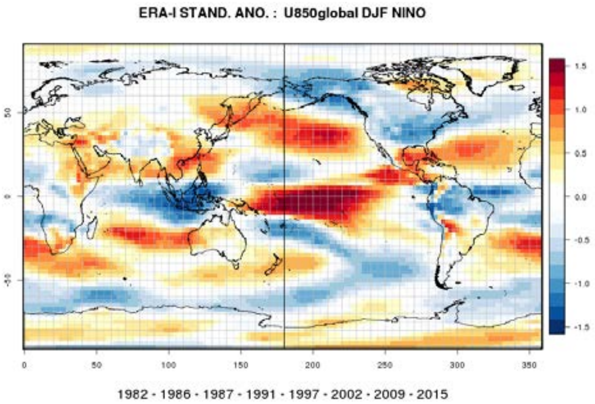
The atmospheric feedback to the SST anomaly may be assessed by making composite maps. Figure 4 displays the result of such a Composite Analysis (CA) for years corresponding to the most significant positive ENSO events (El Nino) at the moment of the year when the peak anomaly is observed (DJF). Beside the typical SST pattern, the examined atmospheric parameters are the velocity potential at 200hPa (PV200), the zonal wind at 850hPa (U850) and the zonal wind at 200hPa (U200). Around the equator these anomalies reflect the modification of the Walker circulation that determines the precipitation patterns.



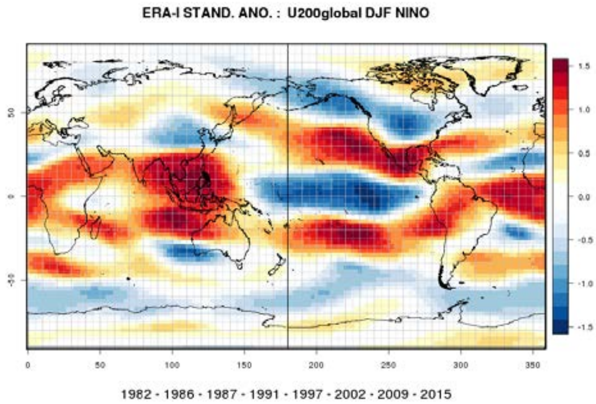

*CA **SST** in DJF for NINO years*




*CA **PV200** in DJF for NINO years*




*CA **U850** in DJF for NINO years*




*CA **U200** in DJF for NINO years*

*figure 4: Composite Analysis for anomalies of large-scale parameters (from top left to bottom right : Sea Surface Temperature, Velocity potential at 200hPa, Zonal wind at 850hPa, Zonal wind at 200hPa) in DJF for NINO years.*
*Each year refers to the first month of the quarter i.e. December*

The specific impact of El Nino over the Indian Ocean may be assessed by a Composite Analysis of the precipitation field for this region. The GPCP (Global Precipitation Climatology Project - NOAA) rainfall estimate is used to provide a gridded dataset. Figure 5 shows the composite map of this variable for the Nino years, during the DJF quarter. If a clear signature is observed over the African continent and over some parts of the Indian Ocean, little impact is noticed on the Seychelles for this quarter. Indeed, the largest impacts for the main islands (Mahé and Praslin) are detected during the ASO and MAM quarters. Positive rainfall anomalies are then observed as showed on the figure 6. This suggests that the El Nino events have more influence on the length of the rainy season than on the intensity of its core period.

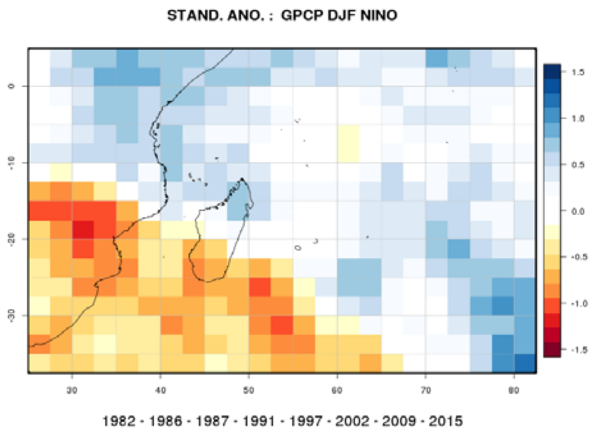
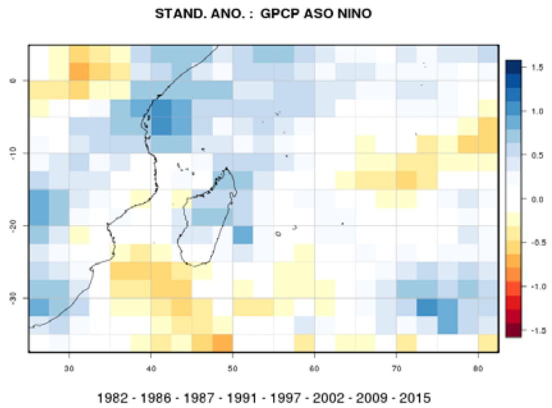
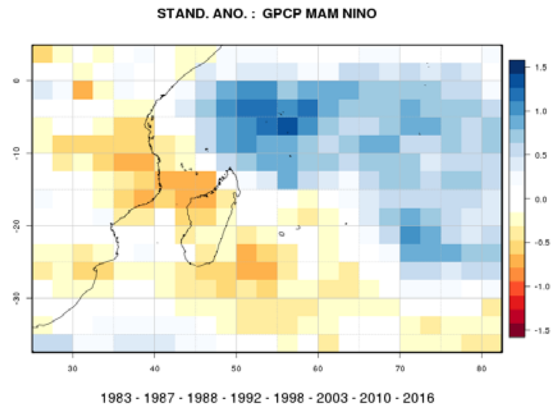



*figure 5: Composite Analysis for GPCP rainfall estimate anomaly in DJF for NINO events*

The impact of negative ENSO events (La Nina) are assessed in a similar way. Figure 7 can be compared to figure 4 except for the selection of years corresponding in this case to the most significant negative ENSO events (La Nina). The SST field exhibits the well-known cold pattern in the Pacific Ocean which is associated to the atmospheric response including enhanced convection over the oceanic continent.

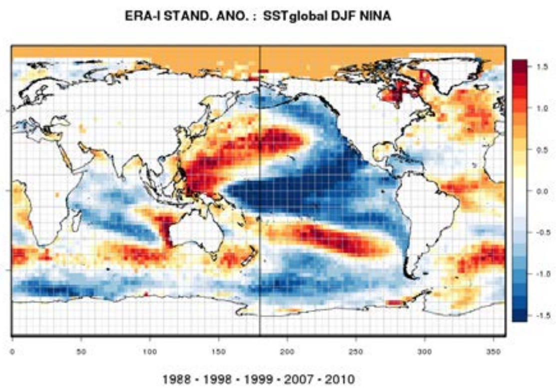



CA **GPCP** in ASO for NINO years

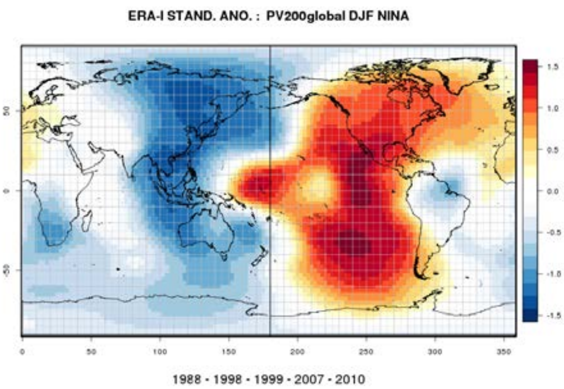



CA **GPCP** in MAM for NINO years

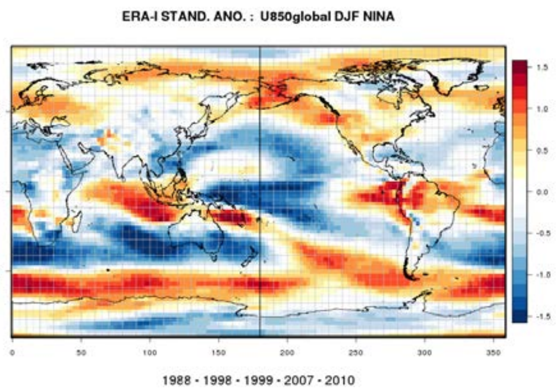
*figure 6: Composite Analysis for GPCP rainfall estimate for NINO events*



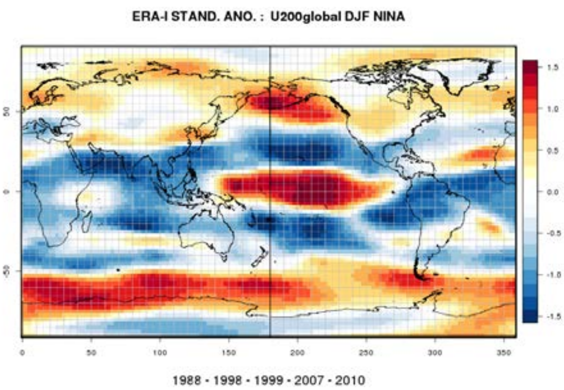

CA **SST** in DJF for NINA years




CA **PV200** in DJF for NINA years




CA **U850** in DJF for NINA years




CA **U200** in DJF for NINA years

*figure 7: Composite Analysis for anomalies of large-scale parameters (from top left to bottom right : Sea Surface Temperature, Velocity potential at 200hPa, Zonal wind at 850hPa, Zonal wind at 200hPa) in DJF for NINA years*

Over the Indian Ocean, the composite map of the GPCP data for La Nina events during the DJF quarter (fig. 8) exhibits inverse patterns compared to those observed during El Nino events. Again the impact over Seychelles is small at that moment of the year, but more significant negative rainfall anomalies are observed in OND and MAM quarters (fig. 9).

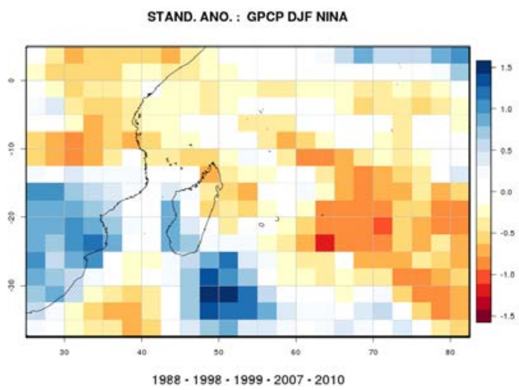
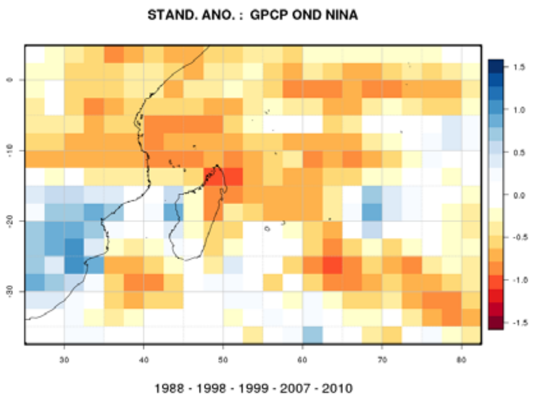
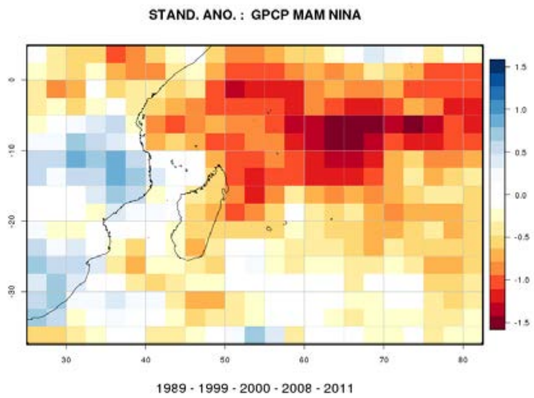



*figure 8: Composite Analysis for GPCP rainfall estimate anomaly in DJF for NINA event*




*CA **GPCP** in ASO for NINA years*




*CA **GPCP** in MAM for NINA years*

*figure 9: Composite Analysis for GPCP rainfall estimate for NINA event*

**IOD**

The Indian Ocean climate has also its specific modes of variability. A Principal Component Analysis performed on the SST for the JJA quarter displays a first mode that is related to the warming of the Indian Ocean and a second mode which shows an east-west dipole pattern near the equatorial part of the basin (fig. 10). The latter is representative of the Indian Ocean Dipole (IOD) which positive phase shows negative SST anomalies in the eastern side of the basin and positive anomalies in the western side.

The time series of the principal component exhibits significant positive (1982, 1994, 2011, 2012, 2015) and negative values (1992, 1996, 1998, 2005, 2016) which match quite well with the extremes of the IOD index curve displayed in figure 12. Unlike the ENSO the IOD oscillation generally reaches a peak in the course of the year and shows a near neutral state during the DJF quarter.

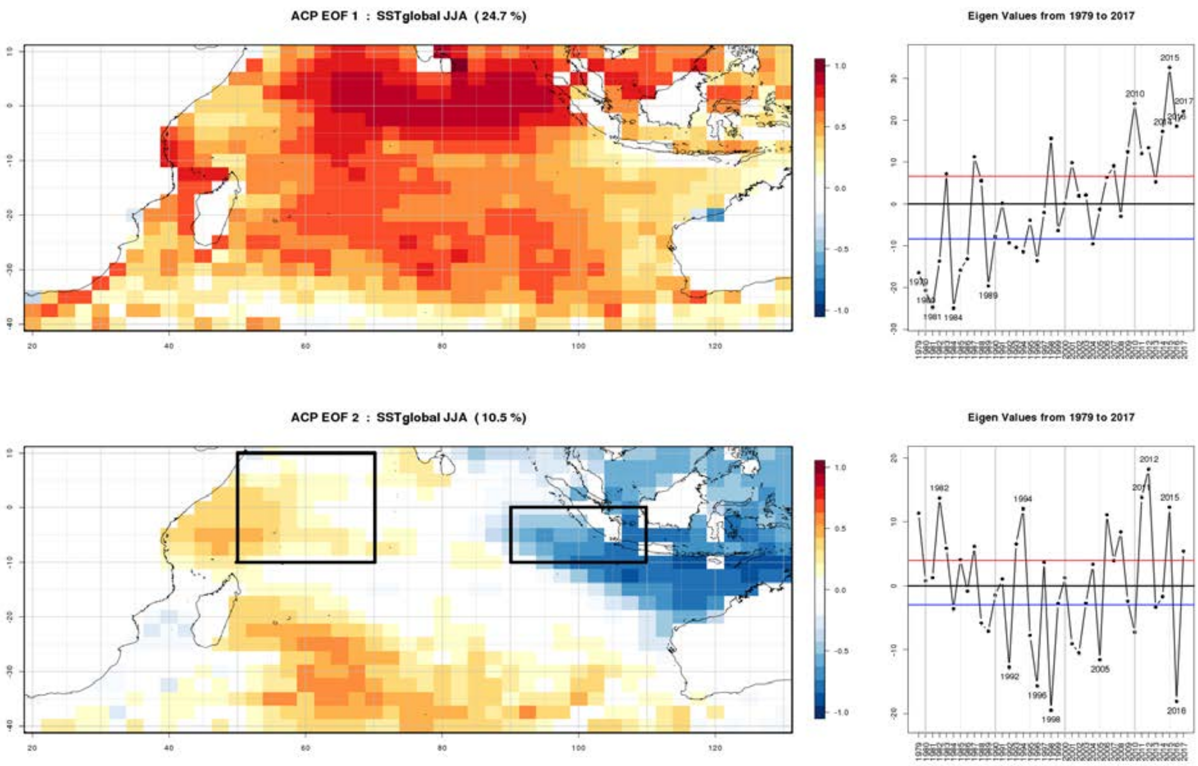



*figure 10: PCA of **SST** in JJA - EOF 1 (top) and EOF 2 (bottom) and principal component history*
*[The east and west boxes show the areas over which the SST is averaged to compute the IOD index]*

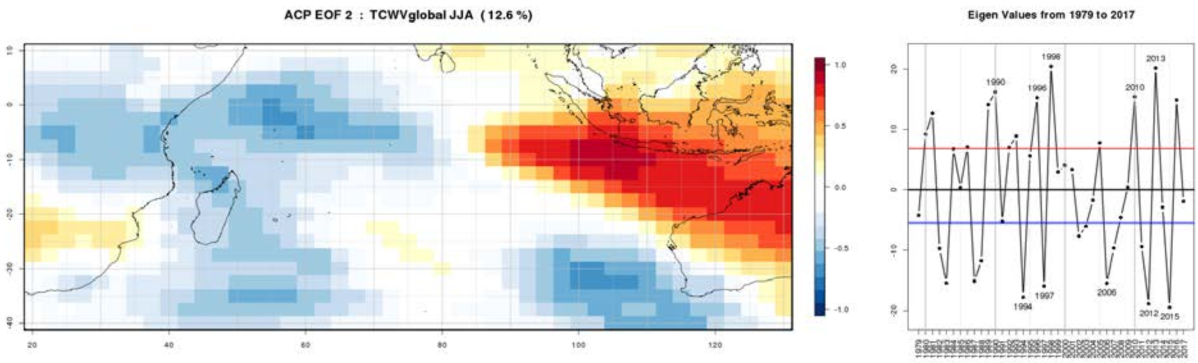



*figure 11: PCA of **TCWV** in JJA - EOF 2 and principal component history*

To examine the atmospheric variability, a Principal Component Analysis is conducted with the precipitable water variable (Total Column Water Vapour).

This analysis shows a second mode which pattern is similar to the SST one (fig. 11). The time evolution of the principal component bears positive and negative peaks which are coherent with the identified phases of the IOD. Indeed, a warm (resp. cold) ocean is associated to more (resp. less) evaporation and then positive (resp. negative) atmospheric humidity anomalies.

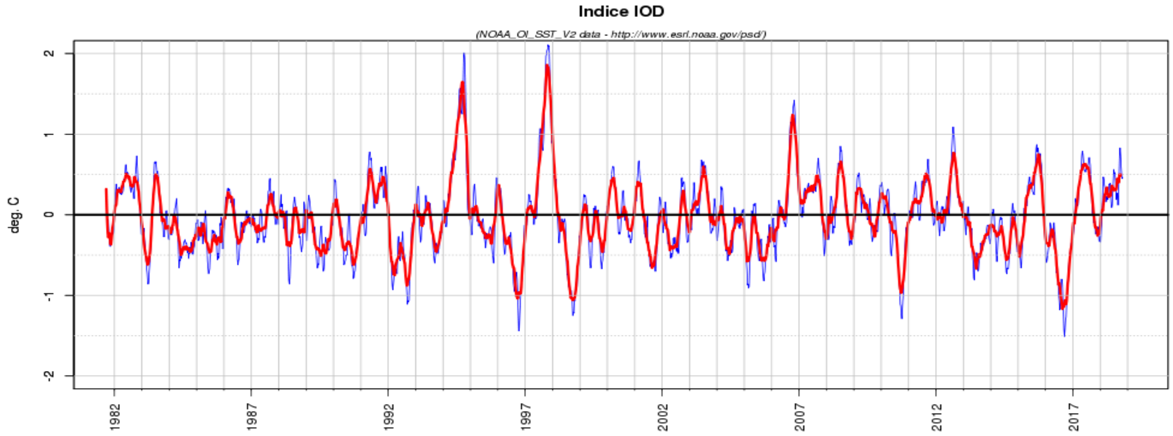
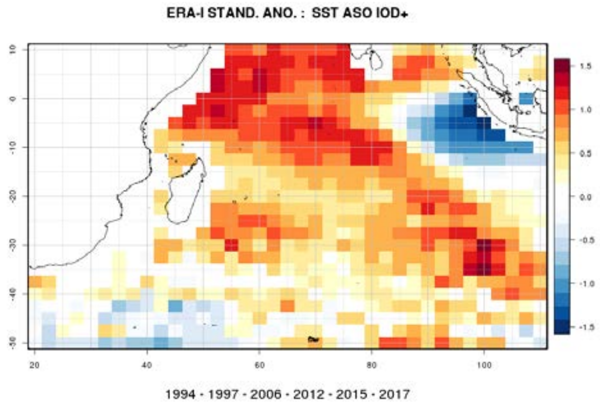
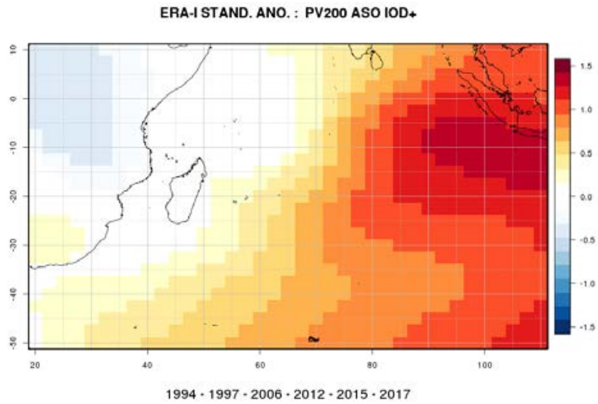



*figure 12: IOD index history (Météo France Réunion from NOAA OISSTv2 data)*

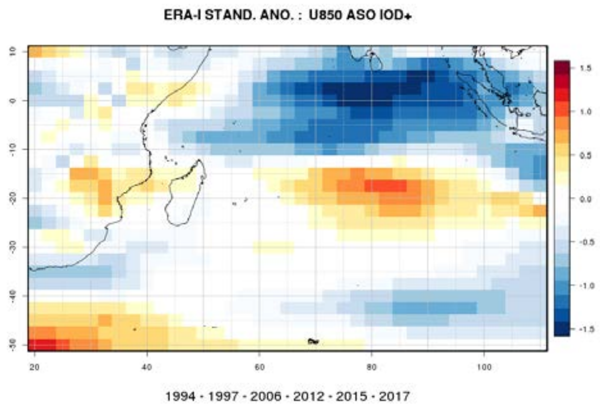
The Composite Analysis showed on figure 13 presents the SST anomaly during the ASO quarter for IOD positive phase years. The atmospheric feedback displays the characteristics of a zonal cell with easterly winds at low levels (850hPa) and westerlies at upper levels (200hPa).



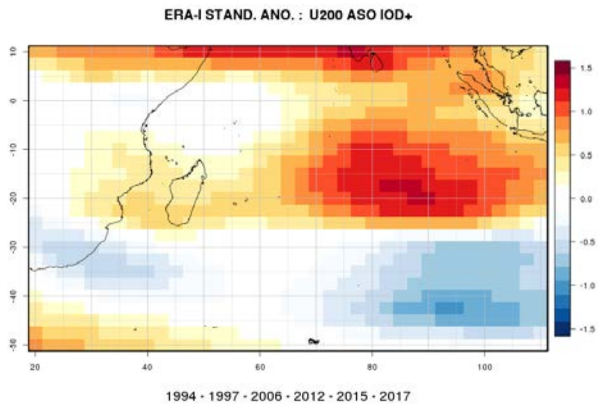

*CA **SST** in ASO for IOD+ years*




*CA **PV200** in ASO for IOD+ years*



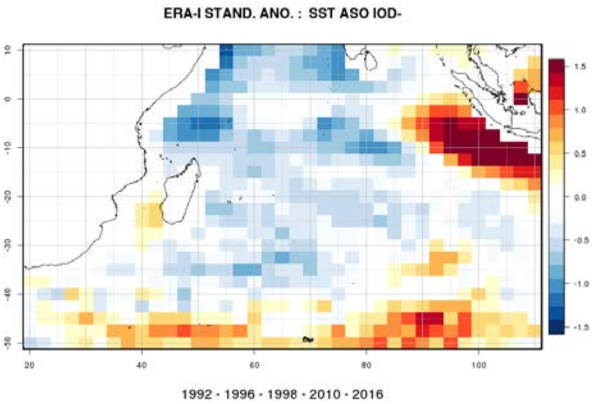

*CA **U850** in ASO for IOD+ years*



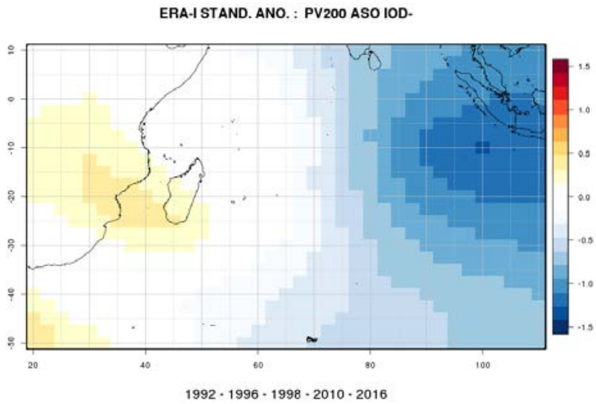

*CA **U200** in ASO for IOD+ years*

*figure 13: Composite Analysis for large-scale parameters in ASO for positive phase of IOD years*

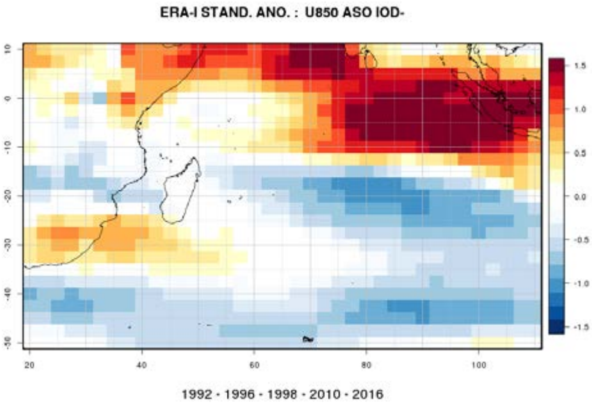
The situation for the negative phase of the IOD shows an inverse circulation anomaly as displayed on the CA maps of the figure 14.



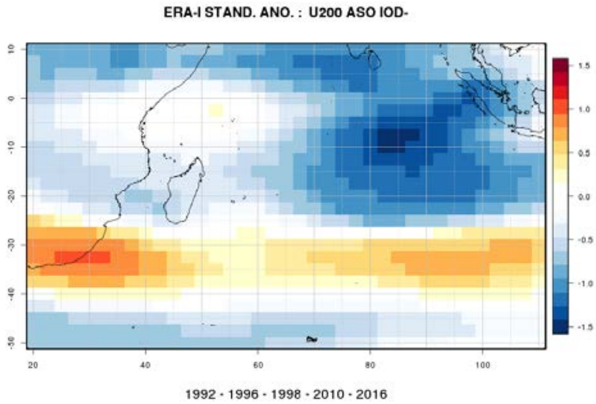

*CA **SST** in ASO for IOD- years*




*CA **PV200** in ASO for IOD- years*

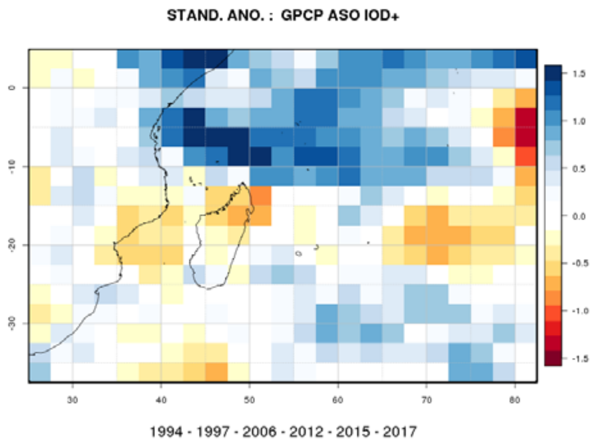



*CA **U850** in ASO for IOD- years*

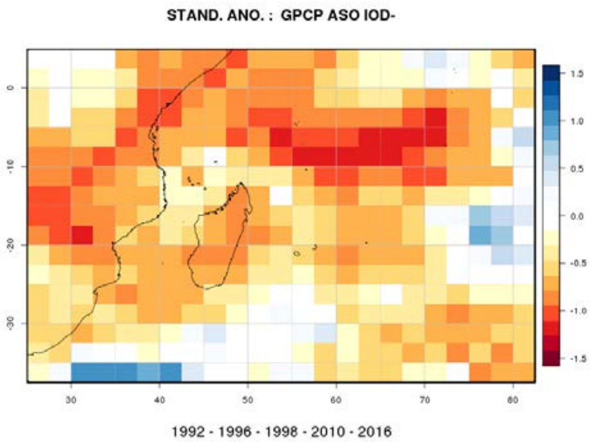



*CA **U200** in ASO for IOD- years*

*figure 14: Composite Analysis for large-scale parameters anomalies in ASO for negative phase of IOD years*




*CA **GPCP** in ASO for IOD+ years*




*CA **GPCP** in ASO for IOD- years*

*figure 15: Composite Analysis for GPCP rainfall estimate for years corresponding to the two phases of IOD*

The consequences in terms of rainfall are detailed by the CA maps of the GPCP field for the corresponding quarter and for the two phases of the IOD. Figure 15 shows that a positive (resp. negative) IOD is associated to a positive (resp. negative) anomaly of rainfall over the Seychelles region.

## 1.2 Impact over Seychelles

The daily rainfall data over the main island of Seychelles (Mahé and Praslin) is available for 14 stations listed in table 1. From this data, several variables are derived using the `Indices.R` application of the Seafords toolbox. The RRTOT variables containing the quarterly rainfall accumulation for each station will be used as the basic dataset.

When examining the deviations from an average situation, the use of the Standardized Precipitation Index (SPI) is a convenient parameter that allows to compare the rainfall balance from different locations which may be associated to various climatic constraints. As an example, figure 16 shows the statistical distributions of DJF rainfall for two stations of the island of Mahé (Intl. Airport (altitude circ. 5.m) and Rochon (altitude circ. 250.m)) and the same data projected on a standardized normal distribution. The application CalculSPI.R of the Seafords toolbox allows to compute the SPI data from a rainfall time series.

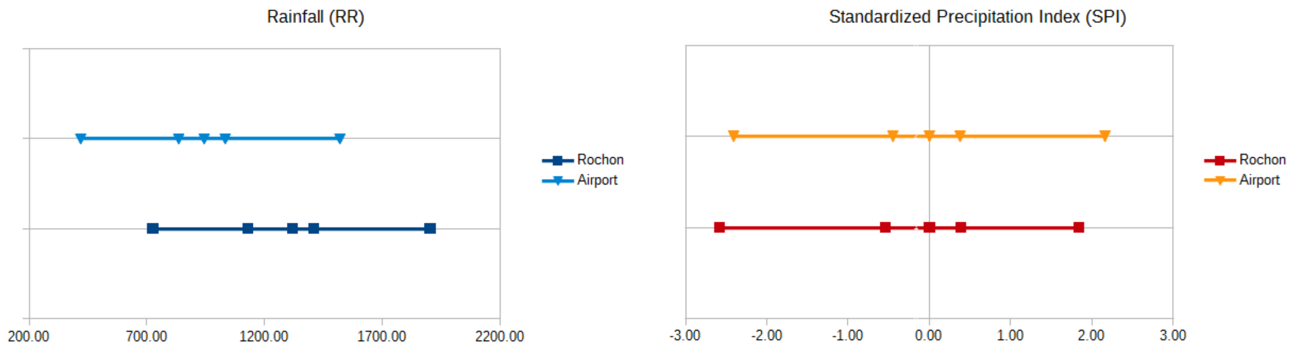
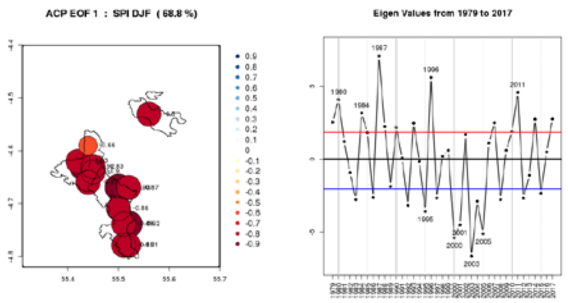
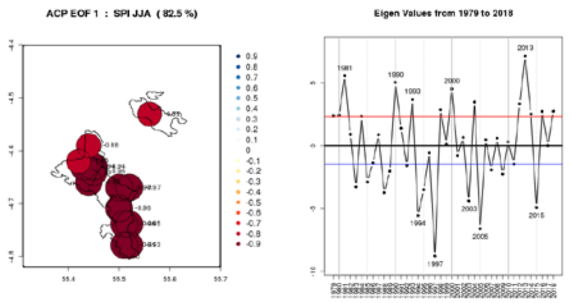



*figure 16: Distribution of precipitations expressed in terms of rainfall data (RR in mm) and Standardized Precipitation Index (SPI) - The plotted values for each distribution are: Min, Tercile 1, Average, Tercile 2 and Max. - Examples are taken from the Airport station and the Rochon station.*

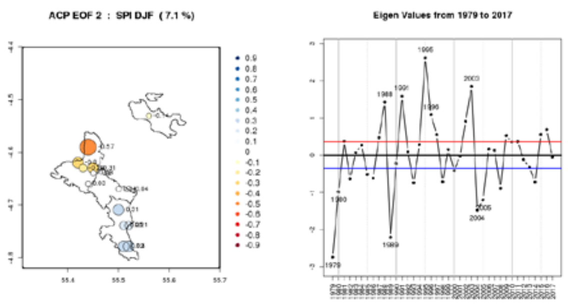
In order to reduce the noise induced by a relatively large number of stations compared to the extent of the area of interest, a zoning of the territory has been made. This also allows to highlight the main differences of the rainfall regimes that may be explained by the large-scale climatic forcing.



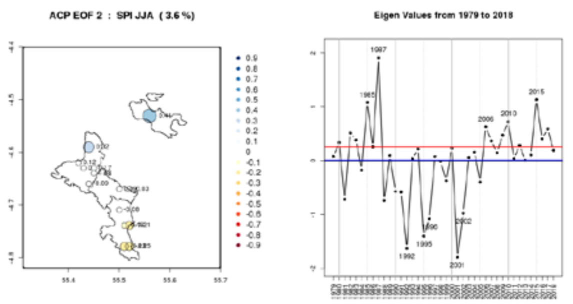

PCA of ***SPI*** in DJF - EOF 1 and principal component history



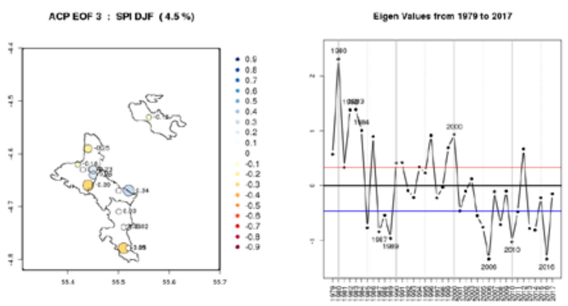

PCA of ***SPI*** in JJA - EOF 1 and principal component history



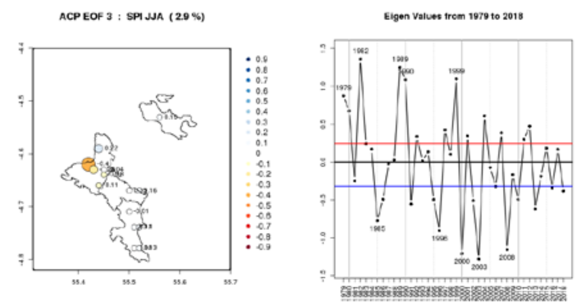

PCA of ***SPI*** in DJF - EOF 2 and principal component history




PCA of ***SPI*** in JJA - EOF 2 and principal component history




PCA of ***SPI*** in DJF - EOF 3 and principal component history




PCA of ***SPI*** in JJA - EOF 3 and principal component history

*figure 17: Principal Components Analysis for SPI data in Mahé and Praslin in DJF and JJA quarters - The three first components are displayed - On these local maps the island of Praslin has been represented closer of Mahé than it really is.*

A Principal Component Analysis of the SPI dataset is performed for the DJF and JJA quarters. The first three modes are displayed on figure 17. The most important variability mode is quite homogeneous for the two quarters. This result suggests that the impact of the variations of climatic conditions are mainly similar over the territory. Nevertheless the two following modes show some different patterns that allow to distinguish between three zones in addition to the Praslin island which is considered itself as one zone.

Table 1 shows the distribution of the 14 stations over the identified zones.

| Station | Lat | Lon | Zone |
|---|---|---|---|
| Anse-Forbans | -4.78 | 55.52 | SOUTH |
| Anse-Royale Police station | -4.74 | 55 .52 | SOUTH |
| Anse-Royale PUC waterwork | -4.74 | 55.51 | SOUTH |
| Belombre | -4.62 | 55.42 | NORTH |
| Bon Espoir | -4.71 | 55.50 | SOUTH |
| Cascade PUC waterwork | -4.67 | 55.50 | CENTRAL |
| Hermitage PUC waterwork | -4.63 | 55.45 | NORTH |
| La Gogue PUC waterwork | -4.59 | 55.44 | NORTH |
| Le Niol PUC waterwork | -4.63 | 55.43 | NORTH |
| Praslin airstrip | -4.53 | 55.56 | PRASLIN |
| Quatre bornes Police station | -4.78 | 55.51 | SOUTH |
| Rochon PUC waterwork | -4.64 | 55.45 | NORTH |
| Intl. Airport | -4.67 | 55.52 | CENTRAL |
| Tea factory Morne blanc | -4.66 | 55.44 | NORTH |

*table 1: Stations of Mahé and Praslin*

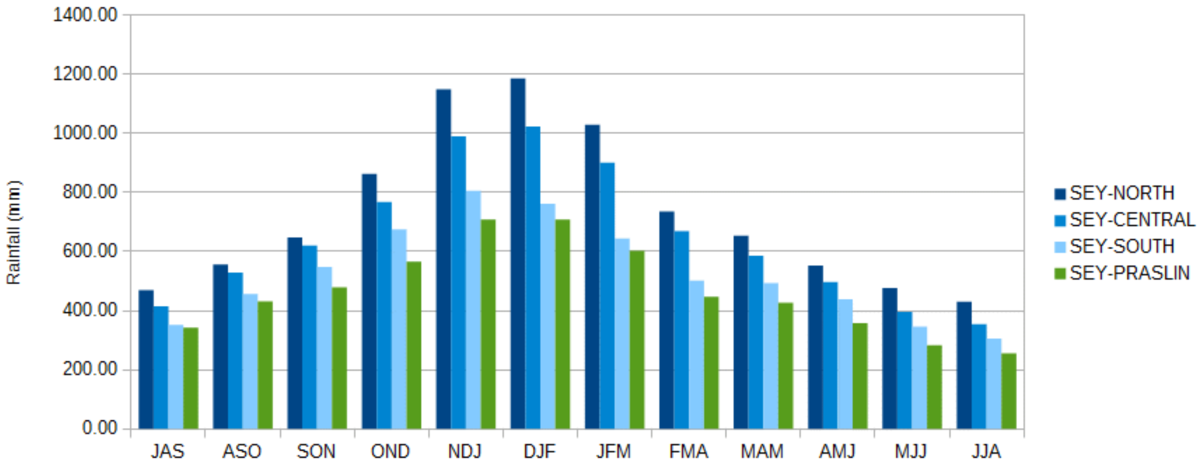



*figure 18: Annual cycle of quarterly rainfall (mm) for the 4 zones (RR4Z) of Mahé-Praslin*

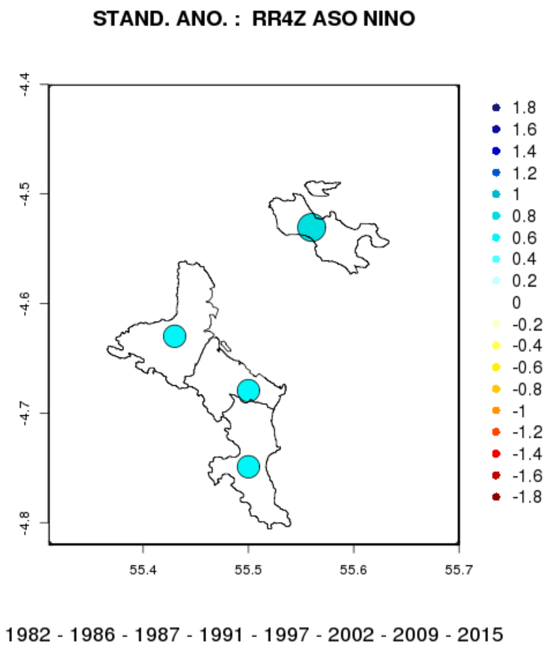
A composite time serie (RR4Z) is computed from the average data of the stations included in each zone. Figure 18 shows the annual cycle of the quarterly accumulated rainfall for the four zones. A gradient from north to south is highlighted. Some details related to the distribution of these quarterly series are given in table 2 that contains the first and second terciles for each running quarter. These values are used to distinguish between "above normal" situations (above the second tercile), "normal" situations (between the first and the second tercile) and "below normal" situations (below the first tercile).

| | JAS | ASO | SON | OND | NDJ | DJF | JFM | FMA | MAM | AMJ | MJJ | JJA |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **SEY-NORTH** | 345.0<br>490.0 | 416.0<br>597.5 | 546.3<br>685.0 | 707.2<br>1034.4 | 992.9<br>1253.3 | 1016.6<br>1307.2 | 916.8<br>1122.2 | 612.7<br>842.8 | 561.2<br>707.9 | 439.8<br>651.3 | 368.9<br>537.2 | 276.2<br>448.2 |
| **SEY-CENTRAL** | 318.5<br>490.7 | 373.6<br>600.4 | 485.0<br>648.5 | 652.0<br>905.7 | 823.9<br>1162.2 | 910.2<br>1120.9 | 828.7<br>975.3 | 541.4<br>766.3 | 480.5<br>650.1 | 387.2<br>543.2 | 266.8<br>433.4 | 227.6<br>383.6 |
| **SEY-SOUTH** | 267.2<br>392.9 | 317.9<br>487.3 | 437.4<br>565.6 | 591.9<br>771.2 | 701.0<br>891.7 | 687.8<br>840.4 | 584.4<br>692.1 | 411.1<br>580.8 | 429.0<br>528.6 | 342.0<br>470.8 | 241.9<br>387.9 | 195.1<br>339.7 |
| **PRASLIN** | 220.4<br>388.2 | 274.0<br>454.5 | 330.5<br>495.4 | 479.2<br>625.8 | 590.6<br>767.4 | 549.8<br>814.0 | 490.5<br>671.9 | 392.9<br>500.9 | 346.7<br>497.0 | 262.8<br>415.7 | 219.8<br>325.8 | 155.8<br>320.9 |

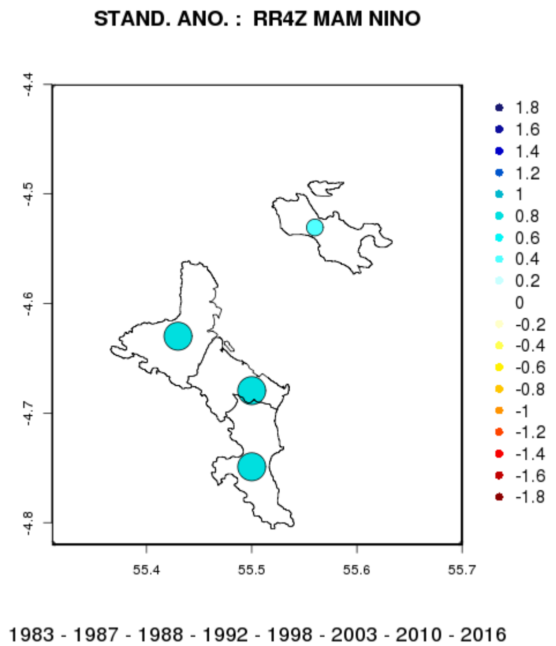
*table 2: Terciles (mm) for the composite quarterly rainfall series related to the 4 zones (Mahé+Praslin)*

In what follows, the quarterly rainfall data for the four zones and the derived SPI parameter (SPI4Z), are used to account for the precipitation variations.

The impact of ENSO and IOD events on the Seychelles are illustrated by the Composite Analysis. From the previous regional scale analysis, using GPCP, it was shown that the influence of ENSO is mainly noticed at the beginning and at the end of the rainy season, whether in its positive or negative phase. Figure 19 (for El Nino) and 20 (for La Nina) show the impact of these events on the Seychelles rainfall records. As expected, the positive anomalies (during El Nino) and negative anomalies (during La Nina) are observed.

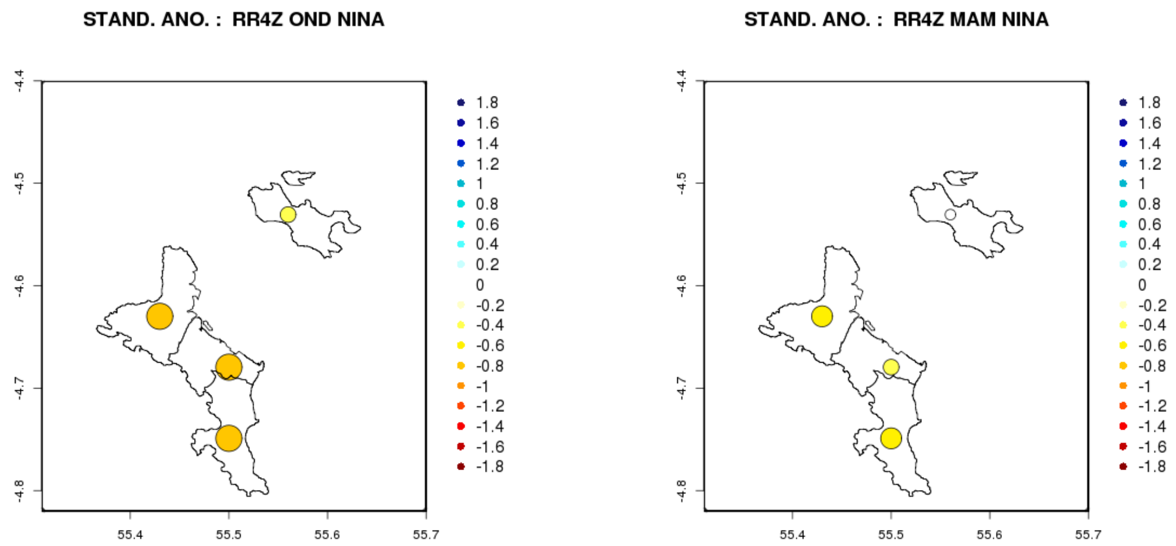



*CA **RR** in ASO for NINO years*




*CA **RR** in MAM for NINO years*

*figure 19: Composite Analysis for rainfall over Seychelles for NINO events*




1988 - 1998 - 1999 - 2007 - 2010

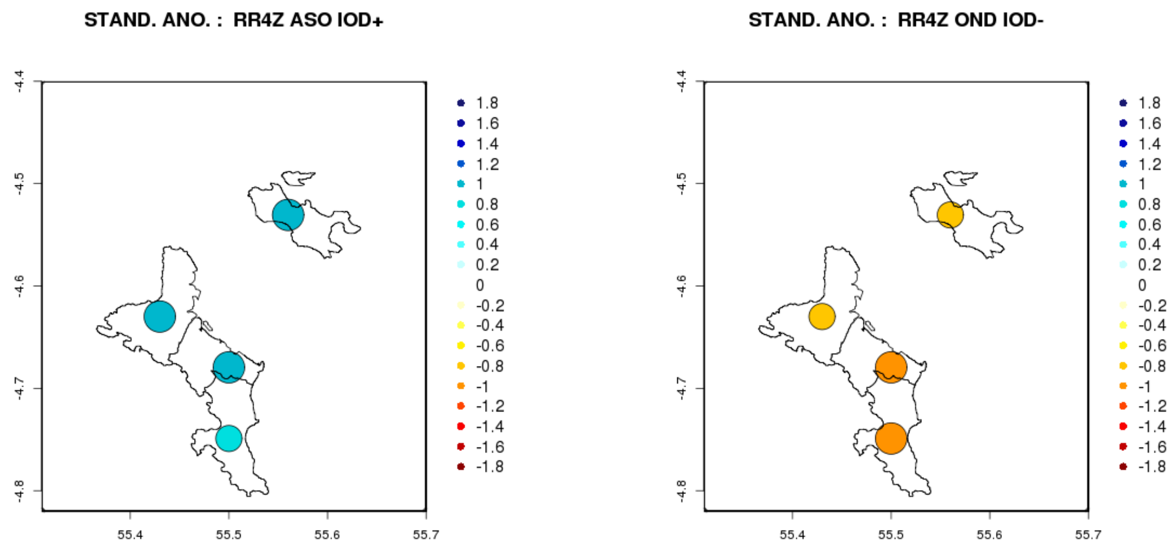
*CA **RR** in OND for NINA years*

1989 - 1999 - 2000 - 2008 - 2011

*CA **RR** in MAM for NINA years*

*figure 20: Composite Analysis for rainfall over Seychelles for NINA events*

The regional scale analysis also showed that the IOD positive and negative phases have significant impact over the Seychelles area. Using the observed data the Composite Analysis brings out that the quarters ASO (during positive IOD) and OND (during negative IOD) are those for which greatest impacts are obtained (fig. 21).




1994 - 1997 - 2006 - 2012 - 2015 - 2017

*CA **RR** in ASO for IOD+ years*

1992 - 1996 - 1998 - 2010 - 2016

*CA **RR** in OND for IOD- years*

*figure 21: Composite Analysis for rainfall over Seychelles for years corresponding to the two phases of IOD*

## 1.3 Seasonal predictability

The previous analysis showed that the climate of the Seychelles is influenced by large-scale drivers which are associated to coupled ocean-atmosphere quasi-periodic patterns. The time scale on which these features evolve allow to expect some predictability for the seasonal climate.

The implementation of seasonal forecast at local scale is based on the one hand on the large-scale predictions provided by Global Climate Models (GCM) and on the other hand on statistical adaptation model aiming at downscaling these predictions to the observation locations.
The statistical model implemented in the Seafords toolbox is mainly based on Canonical Correlations Analysis (CCA). This method allows identification of the best statistical links between two sets of variables between which a regression function may then be adjusted. In the present case the CC Analysis is performed between a large-scale variable (e.g. gridded SST) and a local variable (e.g. Seychelles-zone SPI). The computation process is detailed in appendix.

Figure 22 displays the first mode of the CCA between the SST field provided by ERA-Interim reanalysis and the SPI data of the four zones of Mahé-Praslin for the SON quarter. The correlation map between the first large-scale canonical variable and the SST (left panel in fig. 22) shows a pattern which can be interpreted as the IOD signal. The correlation between the local scale canonical variable and the SPI data (right panel in fig. 22) is high and roughly homogeneous over the area. The third chart shows the time series of both large-scale and local scale canonical variables. The high correlation between them allows to build a regression relationship linking the large-scale GCM information with the local scale data.

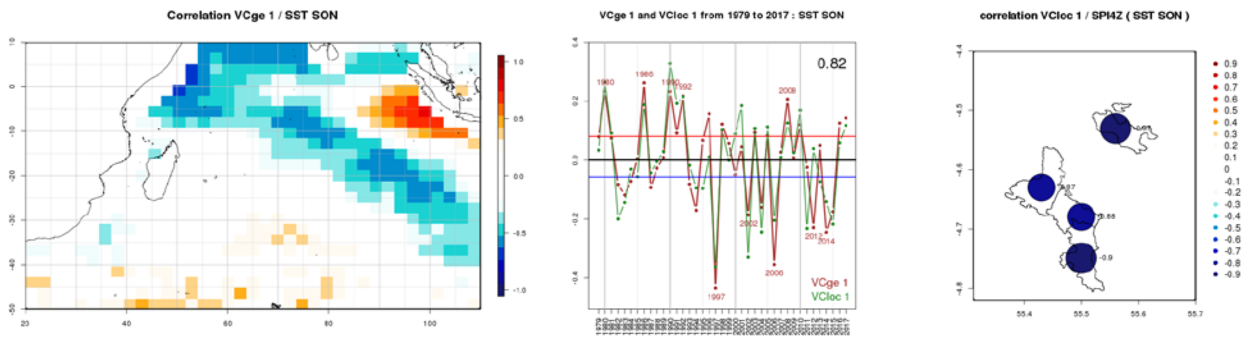



*figure 22: Canonical Correlation Analysis between SST over SWIO region and SPI over the Seychelles 4 zones - SON - mode 1*

The model performance can be measured by the correlation coefficient between the observed precipitation (RRTOT or SPI) data and the simulated one. This information illustrates the strength of the statistical link between the large-scale information and the local observations and can be interpreted as a climatological predictability score for the Seychelles.

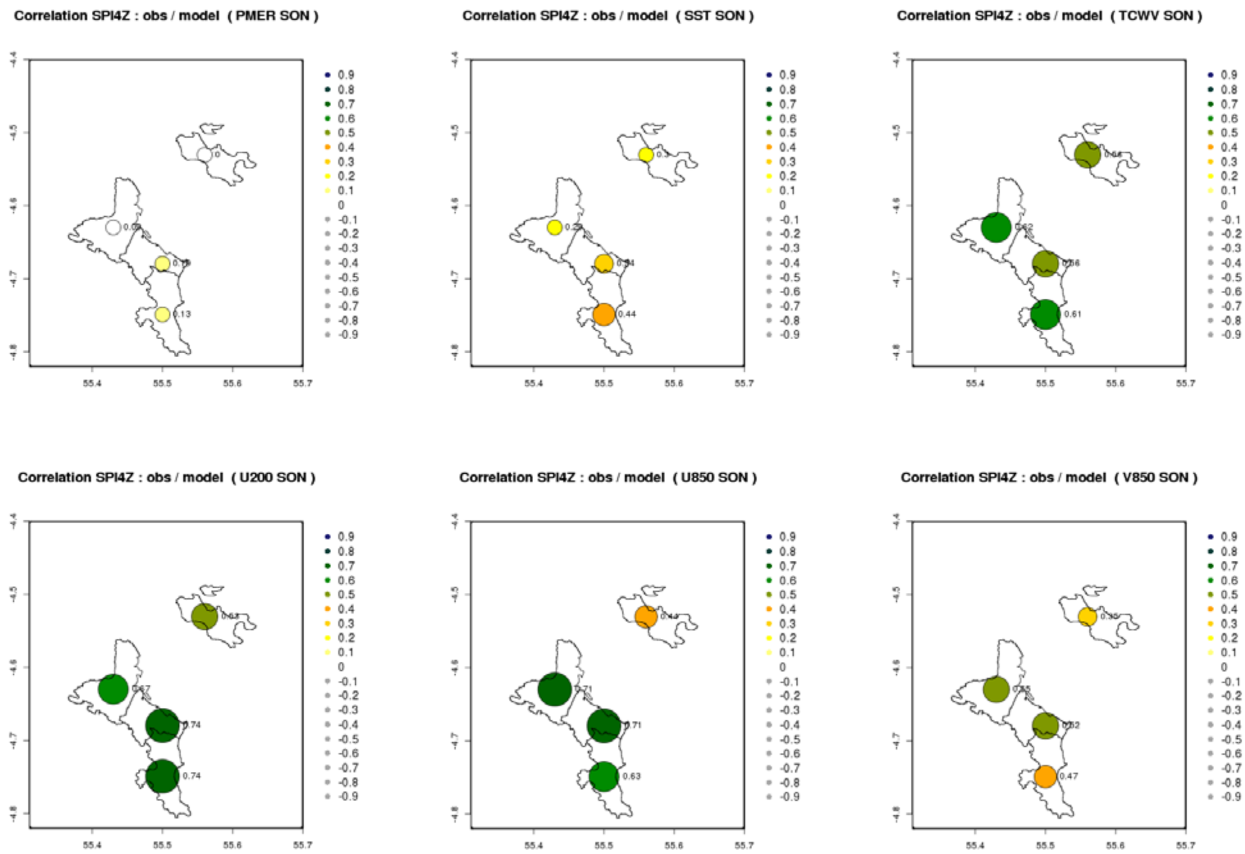



*figure 23: Correlation between observed and simulated SPI over Seychelles in SON with different large-scale predictors (from top left to bottom right :MSLP, SST, TCWV, U200, U850, V850)*

Figure 23 displays the correlation maps for the statistical models built between the different large-scale parameters and the local SPI for the SON quarter. The highest values are found when using TCWV, U200 and U850 large-scale variables as predictors. The predictability score also varies depending on the moment of the year. Figure 24 displays the correlation maps for the statistical model using TCWV as predictor for the 12 running quarters. It turns out that there is very low predictability for DJF, JFM and AMJ quarters, while the best predictability is obtained from the July to December period, which includes the onset of the rainy season.

The same process may be implemented with another type of local data. The GPCP data may be used as predictand. In that case, the model performs a statistical adaptation of the large-scale parameters to produce a simulated precipitation field over a grid covering the Southwest Indian Ocean region. Correlation maps are also produced to assess the model skill.

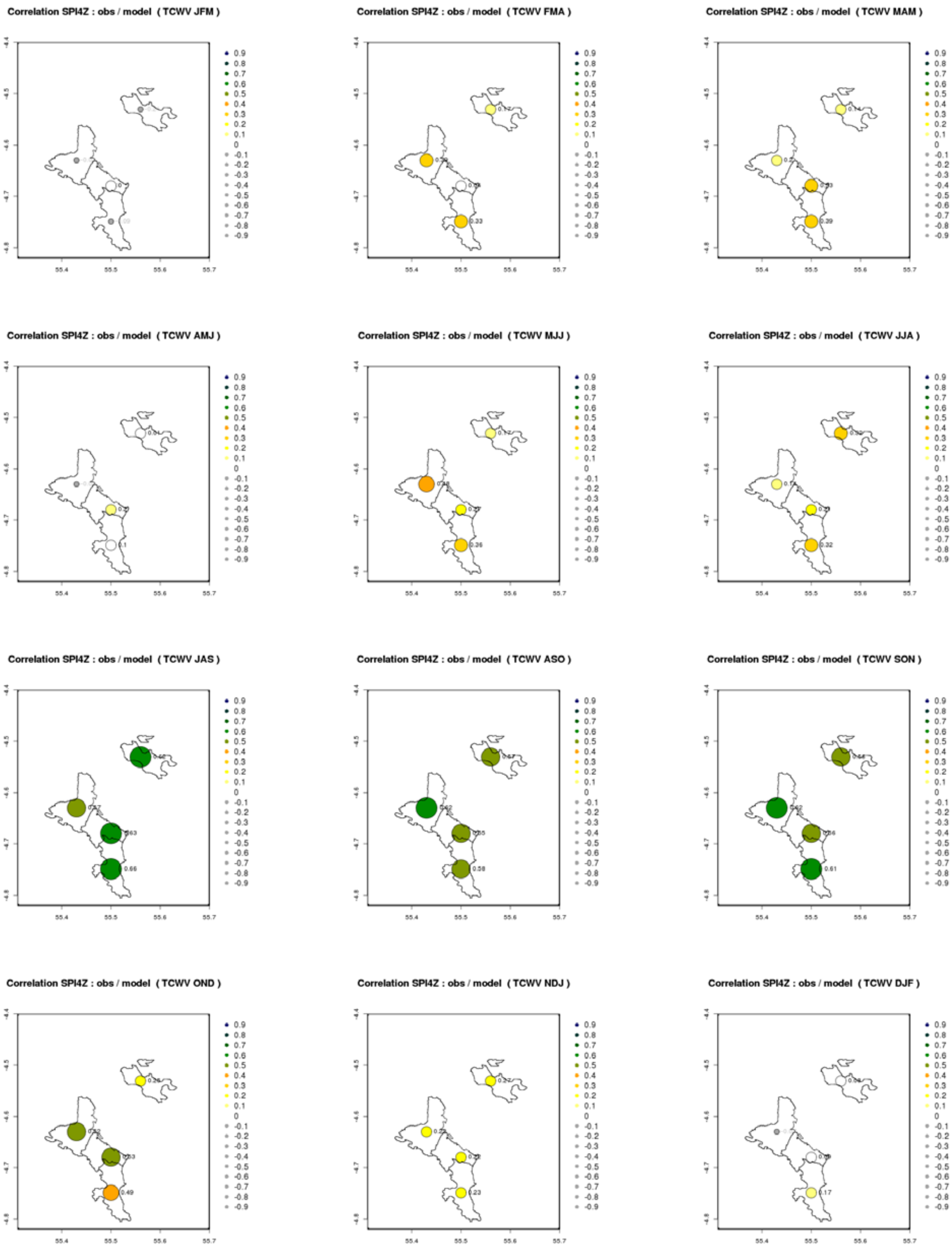



*figure 24: Correlation between observed and simulated SPI over Seychelles - large-scale predictor: TCWV for 12 quarters (JFM to DJF)*

Figure 25 shows the correlation maps between observed (GPCP) and computed rainfall field using the TCWV large-scale variable as predictor and for the DJF and JFM quarters. If the local downscaling process prove to have no skill for these periods, the regional adaptation shows significant correlation values. This result allows the production of some information over Seychelles for these quarters even if not at local scale.

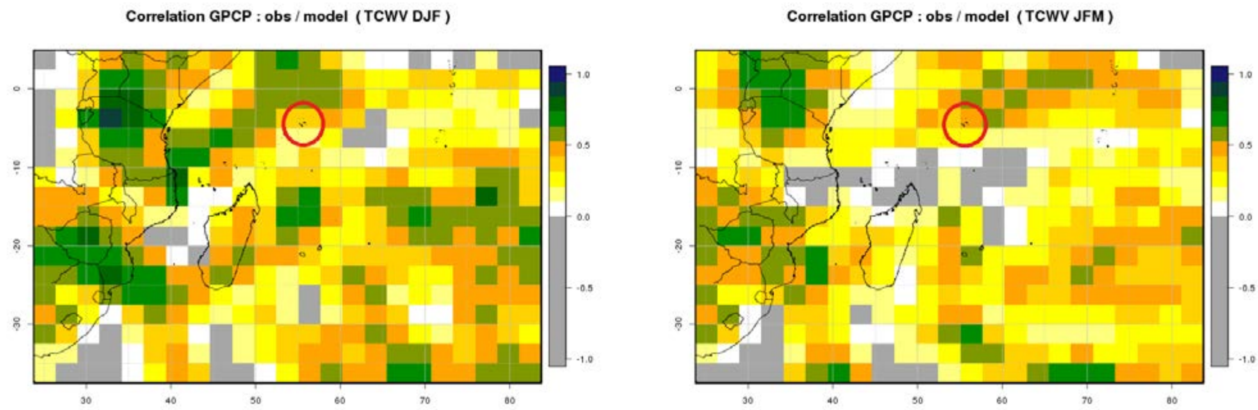



*figure 25: Correlation between observed (GPCP) and simulated rainfall field over the Southwest Indian Ocean with the large-scale predictor TCWV for DJF and JFM quarters*

# 2 PERFORMING THE CURRENT SEASONAL FORECAST

This section describes the process to follow in order to produce a seasonal forecast of rainfall over the Seychelles on a regular basis using the Seafords toolbox.

Like any statistical process, the CC Analysis and the regression model benefit from the length of the time series used as input data. Then a first step is to make sure that the climatology of the local data (rainfall records on stations) and the large-scale data (ERA-Interim reanalysis) are up to date. This should be done once a year.

Regarding the seasonal forecast itself, the final product is the result of an expertise taking into account three aspects of the seasonal climate : The large-scale monitoring of the main drivers, the output of the Seafords statistical model at local and/or regional scale and the knowledge of the local climate.

## 2.1 Annual updates

The basic dataset that is needed consists of daily rainfall records over the selected stations. These data should be in one file in csv format :

```
StationId,Station_Name,Lat,Lon,Elev,Year,Month,Day,PRECIP
16,Anse Royale Waterwork PUC,-4.74,55.51,,1979,8,1,0
16,Anse Royale Waterwork PUC,-4.74,55.51,,1979,8,2,0
16,Anse Royale Waterwork PUC,-4.74,55.51,,1979,8,3,8
16,Anse Royale Waterwork PUC,-4.74,55.51,,1979,8,4,12.3
16,Anse Royale Waterwork PUC,-4.74,55.51,,1979,8,5,0
16,Anse Royale Waterwork PUC,-4.74,55.51,,1979,8,6,1.2
16,Anse Royale Waterwork PUC,-4.74,55.51,,1979,8,7,1.1
...
81,Praslin Airstrip (Amitie),-4.60,55.56,,2017,12,24,0
81,Praslin Airstrip (Amitie),-4.60,55.56,,2017,12,25,2.5
81,Praslin Airstrip (Amitie),-4.60,55.56,,2017,12,26,10.4
81,Praslin Airstrip (Amitie),-4.60,55.56,,2017,12,27,0.5
81,Praslin Airstrip (Amitie),-4.60,55.56,,2017,12,28,4.5
81,Praslin Airstrip (Amitie),-4.60,55.56,,2017,12,29,20.4
81,Praslin Airstrip (Amitie),-4.60,55.56,,2017,12,30,10.5
81,Praslin Airstrip (Amitie),-4.60,55.56,,2017,12,31,2.4
```

This file, placed in the `DATA_SEY` folder of the main Seafords directory, has to be processed with the `Indices.R` script located in the `TOOLS` folder. The quaterly accumulated rainfall data is found in the `DATA_SEY/RRTOT` folder.

The composites quarterly series for each zone are computed with the `script_RR4Z.sh` Linux shell script. The files are found in the `DATA_SEY/RR4Z` folder.
The SPI series are derived from the zonal composite rainfall series using the `CalculSPI.R` script located in the `TOOLS` folder. The output files are in the `DATA_SEY/SPI4Z` folder.

The ERA-Interim dataset is maintained up to date by Météo France Réunion. The files are made available through the SWIOCOF portal :

## 2.2 Synthesis of large-scale drivers

The large-scale climatic patterns that may influence the Seychelles region are subject to monitoring and forecasting by Global Producing Centers. The analysis of these elements gives an assessment of the activity of the climate drivers and hence an idea of the contextual predictability. Indeed, the climatic response over the Seychelles is stronger and therefore the seasonal trend is more predictable, when the drivers like ENSO or IOD are in an active phase.
A synthetic information on the status of the ENSO can be found on the Australian Met Service:

A history and the present value of the Oceanic Nino Index is available from NOAA:

This service also provides a global SST monitoring (fig. 26) that is available on this site:

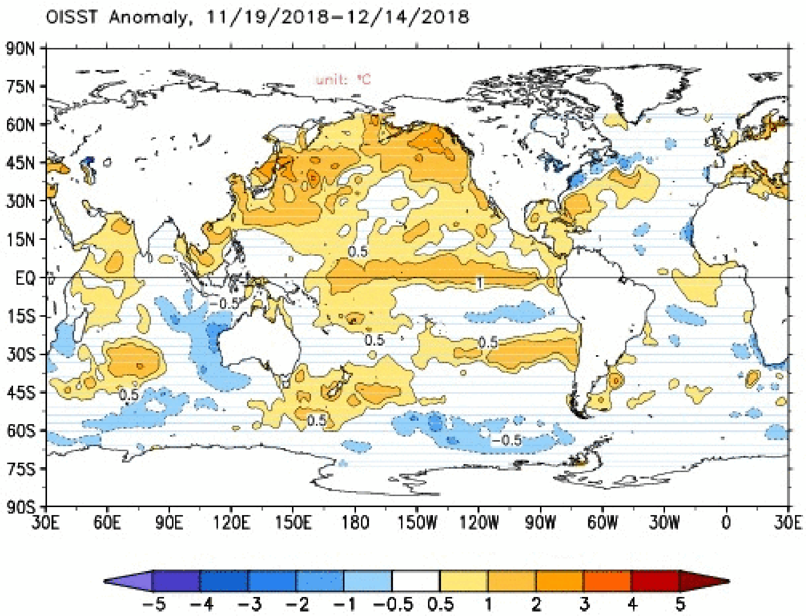



*figure 26: Example of SST anomaly over a 30 days period given by the NOAA/NCEP GODAS system*

From the OISST data and the ECMWF seasonal forecasts, Météo France Réunion performs a monitoring of the South West Indian Ocean SST including the IOD index (fig. 27). The figures are available on the SWIOCOF portal.

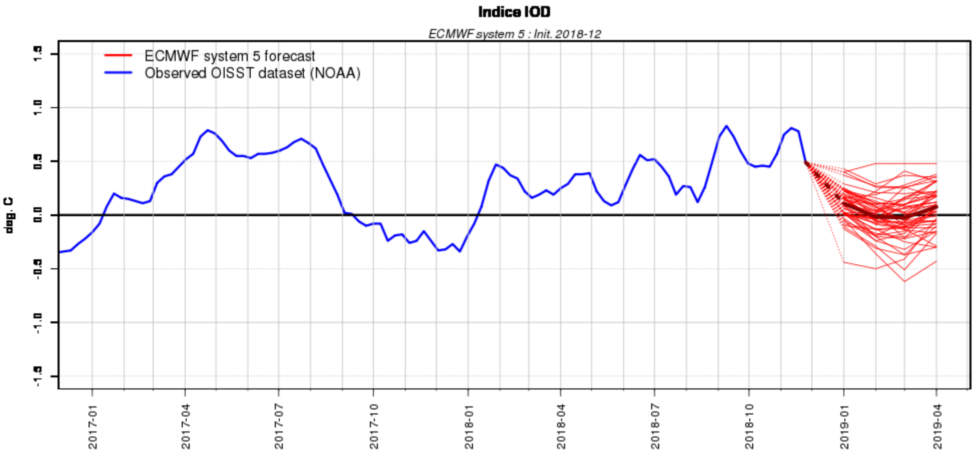



*figure 27: Example of IOD index observed and forcasted by the ECMWF model.*
*Chart provided by Météo France Réunion*

An outlook of the seasonal forecasts produced by European centers at global scale can be found on the Copernicus portal :

As an example, figure 28 displays the forecast plume for the Nino 3.4 SST anomaly.

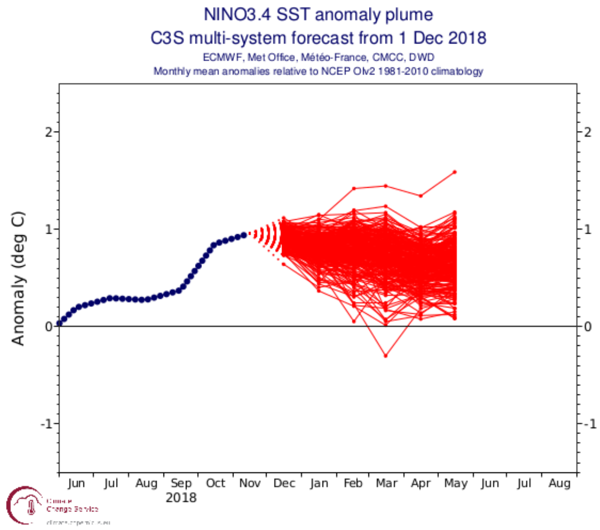



*figure 28: Example of  NINO 3.4 box SST anomaly: observed and forecasted plume*
*(Copernicus portal)*

## 2.3 Seafords downscaling process

The GCM forecasts are updated monthly on the SWIOCOF portal. These forecasts consist of an ensemble simulation of the large-scale variables including around 50 members. Each member is processed by the downscaling model which output is made of a statistical synthesis in the form of likelihood of each tercile for the four zones.

The files should be downloaded in the `FORECAST_DATA` folder of the main Seafords directory. The statistical model itself is processed in the `BIN` folder using the `Seasonal_Outlook.R` script and the results are found in the `OUTPUT` folder.

With the updated data, the Seafords statistical model may be run for the coming quarters associated to lead time 1 and 2. Lead time 3 is available, but is generally associated to poor skill and hence is seldom used. The model is used in Perfect Prognosis mode, meaning that the GCM forecast is supposed to reproduce "perfectly" the large-scale features that may be observed in the reanalysis (ERA-Interim) used for building the model parameters. In practice this is not the case so the predictability scores presented in part 1 should be considered as maximum values.

The model should be run first to provide a regional outlook with the GPCP dataset as predictand and then to downscale the forecast at local scale with the SPI4Z dataset as predictand.
From the previous section, namely the figures 23 and 24, it was shown that the predictability score varies with the predictor and the quarter. Depending on the moment of the year, the local predictability may not be sufficient to produce a reliable forecast at local scale. In that case, the regional outlook may be used to derive useful information for the Seychelles global area.

Actually the statistical model output is a synthesis of the individual models outputs associated to each large-scale predictor. Each individual model output is weighted by the corresponding score to produce the synthesis.

The **first example** is about the 2016 OND quarter. Figures 3 and 12 show that ENSO was in a weak Nina state when the IOD was in a quite strong negative phase. As a consequence a negative impact over Seychelles could be expected.

Figure 29A-B shows the output of the statistical model using SST as predictor. During the learning phase the canonical modes are computed highlighting the links between the large-scale predictor and the local rainfall data. The first two modes are displayed in figure 29A. The large-scale canonical variables are associated to east-west dipole in the SST anomaly field and the local scale canonical variables are negatively correlated to the local data. The OND 2016 ensemble forecast of SST anomaly leads to corresponding canonical variables which are also shown in figure 29A. The two variables have significant positive values. This result means that the large-scale east-west dipole is actually active (IOD is in a strong negative phase) and the consequence on the local scale rainfall is a negative anomaly (due to negative correlation). The GCM average forecast for SST and the forecast map for the rainfall distribution over Seychelles are in figure 29B.

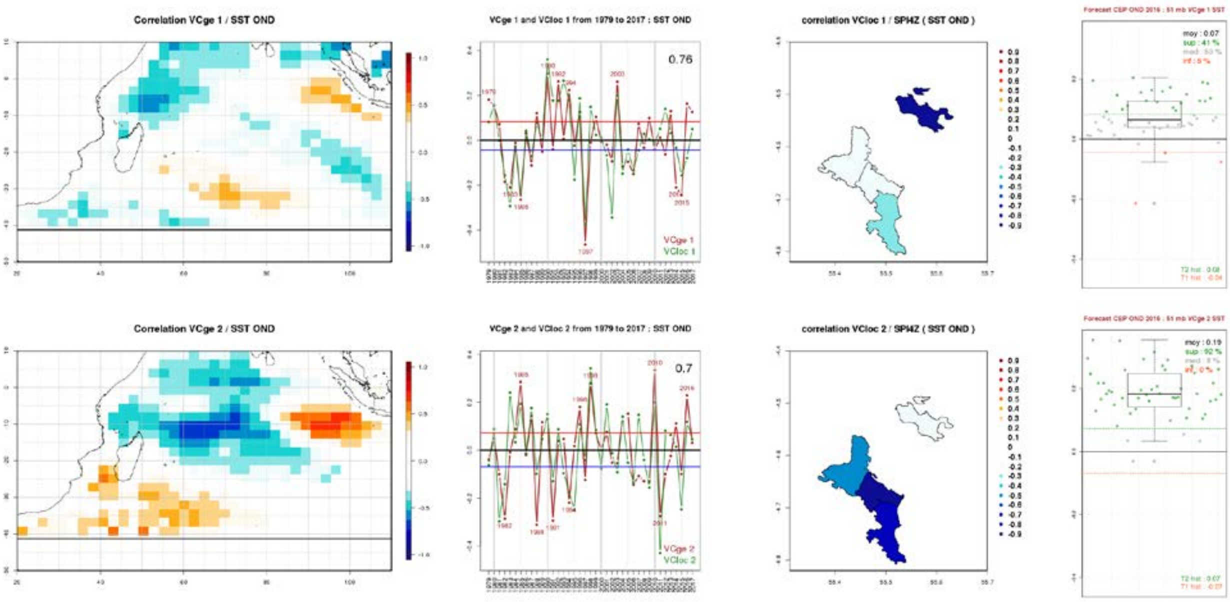



*figure 29A: Left: First two modes of CC Analysis of SST and local SPI showing correlation above 0.7 - OND quarter*
*Right: Forecast of the first two large-scale Canonical variables for OND 2016 lead time 1*

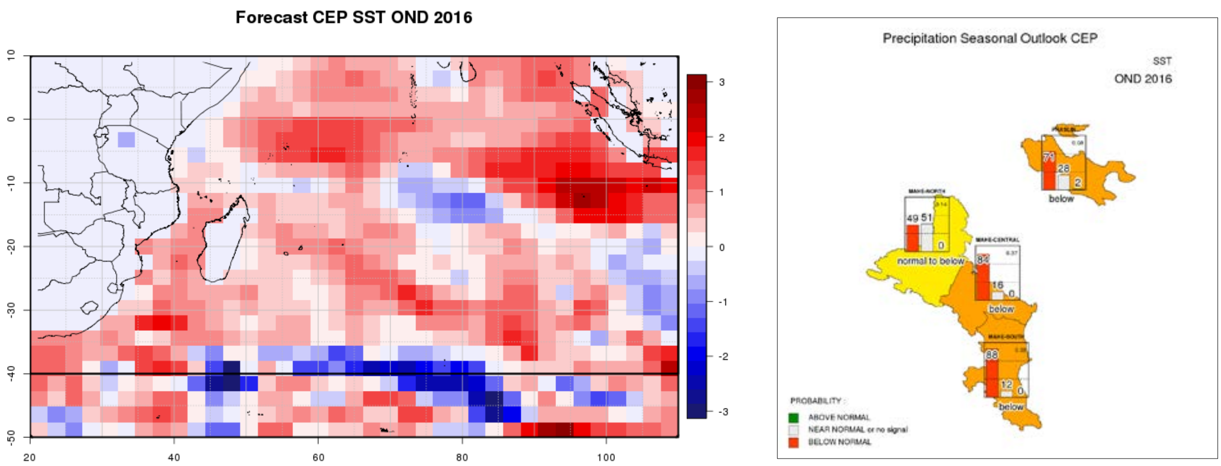



*figure 29B: Left: Forecast of SST anomaly for OND 2016 lead time 1*
*Right: Rainfall anomaly forecast for OND 2016 with SST as predictor expressed in terms of probabilities for the three terciles of the distribution.*

When another predictor is used the local forecast may be quite different since the statistical models are independent. However, the stronger the climate drivers, the more coherent is their impact on the regional climate. In the OND 2016 case, the results of the statistical model with U850 as predictor are more neutral than the SST ones. The model output is displayed in figure 30A-B with the same presentation as with the SST. The forecast produces an ensemble for the first large-scale canonical variable which is distributed around zero (fig. 30A). Hence the final forecast shown in the figure 30B exhibits a situation that has a more "normal" distribution than in the previous case.

The synthesis forecast takes into account the results from 5 predictors (SST, TCWV, U850, V850, U200). The final map displayed in figure 31 shows a normal scenario for Praslin and the northern zone of Mahé and a normal to below scenario for the other part of the main island. Considering the observed situation presented in figure 32, this forecast proves to be quite realistic.

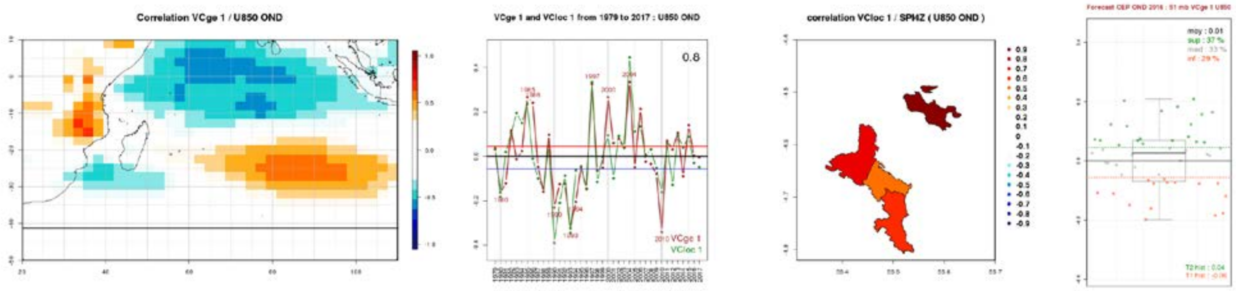



*figure 30A: Left: First mode of CC Analysis of U850 and local SPI showing correlation above 0.7 - OND quarter*
*Right: Forecast of the first large-scale Canonical variable for OND 2016 lead time 1*

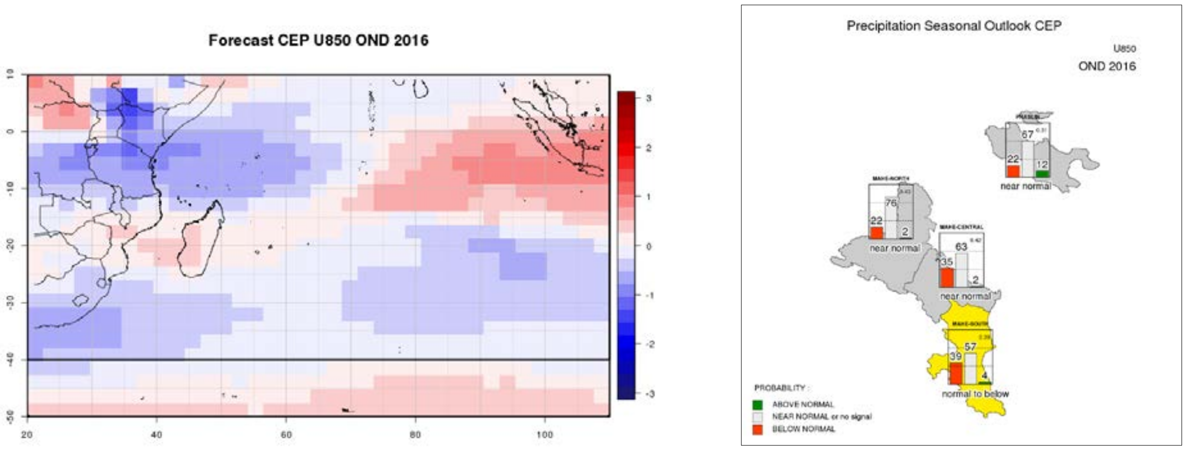



*figure 30B: Left: Forecast of U850 anomaly for OND 2016 lead time 1*
*Right: Rainfall anomaly forecast for OND 2016 with U850 as predictor expressed in terms of probabilities for the three terciles of the distribution.*

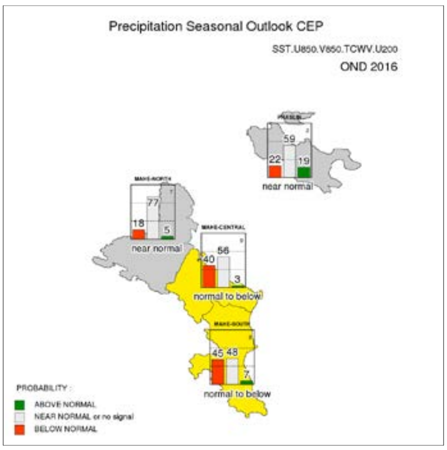



*figure 31: Synthesis precipitation forecast for OND 2016 from September 2016*

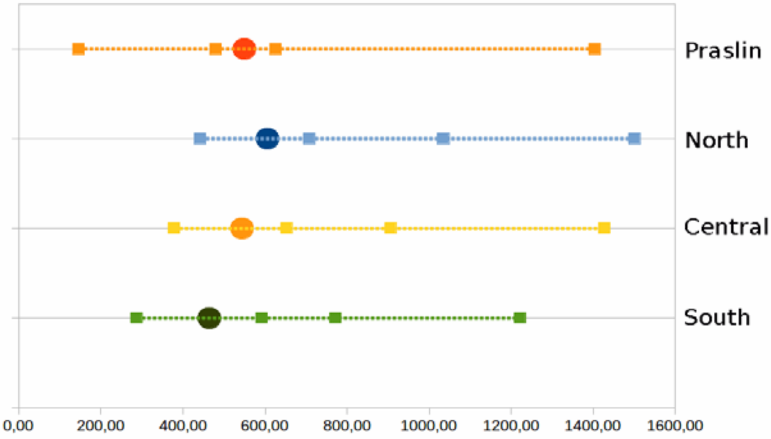
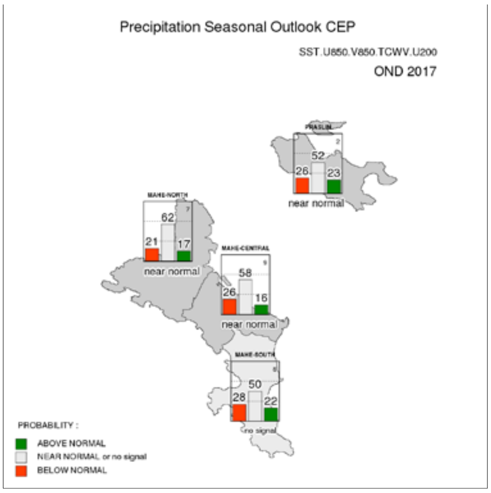



*figure 32: Rainfall observations for OND 2016 (plain circles) compared to the climatological distribution splitted in three terciles*

The **second example** is related to the 2017 OND quarter. At that time the ENSO and the IOD were both in a weak negative phase suggesting a weak impact over the Seychelles. The forecasts are performed with lead time 1 (from September 2017) and lead time 2 (from August 2017) using the ECMWF forecasts with SST, TCWV, U200, U850, V850 large-scale variables as predictors. In this case the climatological information (CC Analysis, correlation scores) is the same as in the first example. But in 2017 the weakness of the drivers (ENSO and IOD) is such that the regional climate response expressed in terms of canonical variables is roughly neutral.

Figure 33 displays the synthesis forecast map for these two lead time. This result is a combination of the individual forecasts obtained with each predictor separately. The analysis conducted in Part 1 showed that the skills of the model were quite good for this period of the year. This information is recalled as a score in the upper right corner of each plot. It may be considered as a representative of a "climatological" predictability when the strength of the large-scale drivers may be related to a "contextual" predictability.



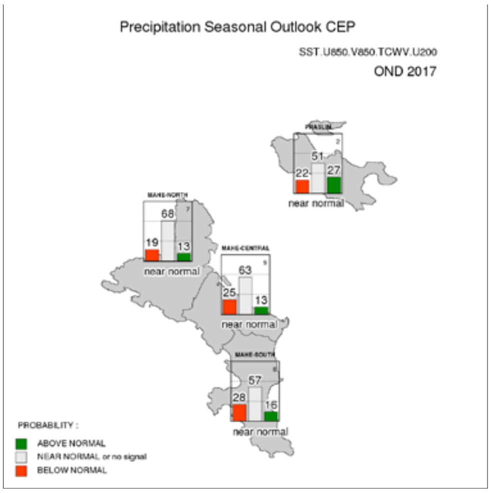




*figure 33: Synthesis precipitation forecasts*
*Left: OND 2017 forecast from September 2017 - lead time 1*
*Right: OND 2017 forecast from August 2017 - lead time 2*

However, despite the low "contextual" predictability, it turns out that the observations are mainly located in the normal tercile as shown in figure 34. Nevertheless the model fails to predict the slight negative bias noted on the observations.

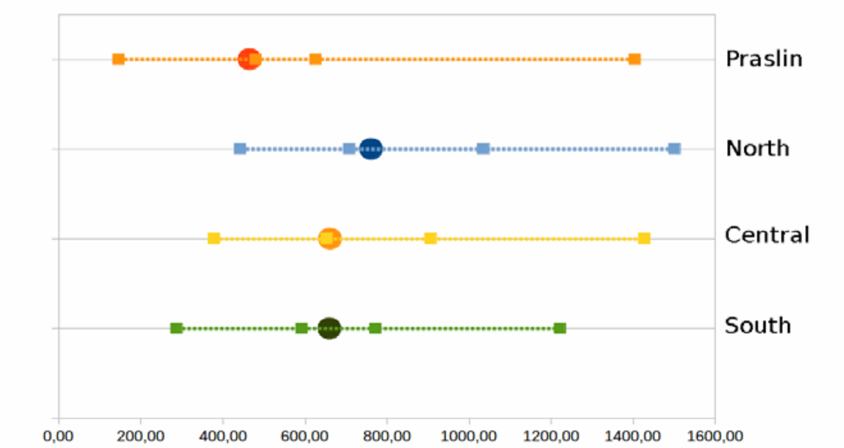



*figure 34: Rainfall observations for OND 2017 (plain circles) compared to the climatological distribution splitted in three terciles*

The **third example** is for the 2017 DJF quarter. The large-scale situation is the same as for the previous example. For that period we expect a poor skill for the downscaling model. The synthesis map obtained from the November forecast with lead time 1 is presented in figure 35 (left panel). If the computation delivered an output, the associated score is so low that no confidence should be awarded to this result especially since the large-scale drivers forcing is weak.

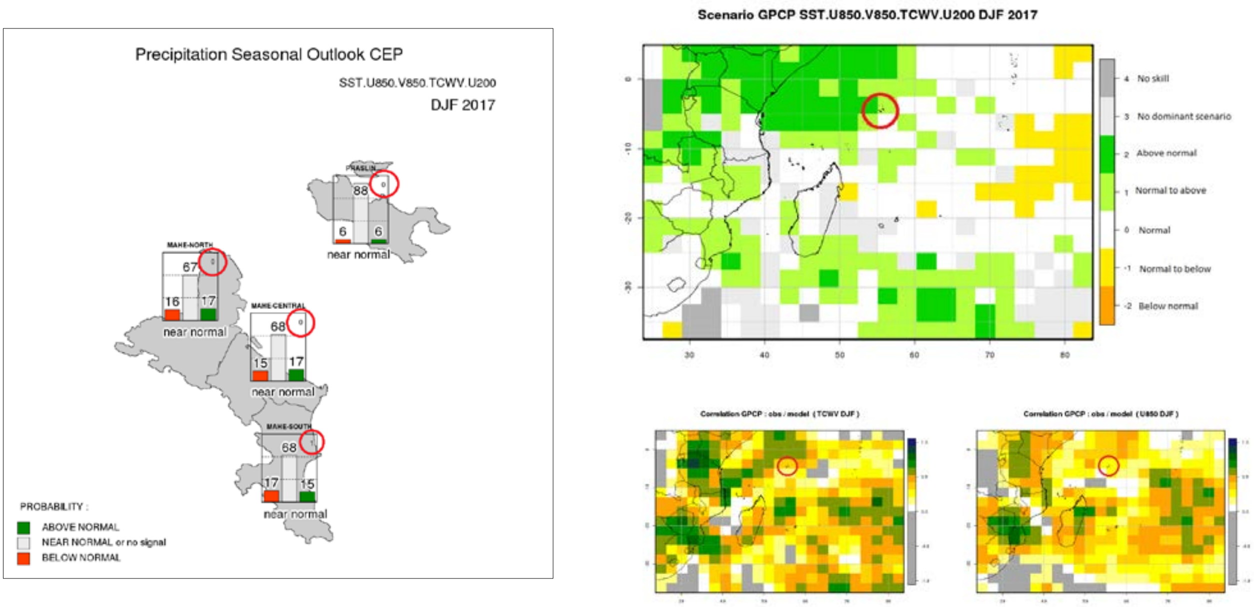



*figure 35: Precipitation forecasts for DJF 2017 from november 2017 - lead time 1*
*LEFT : Synthesis map for downscaled forecast at local scale - note the low skill score (red)*
*RIGHT : TOP: Synthesis map for regional forecast (colors according to the dominant terciles)*
*BOTTOM : Correlation maps for the TCWV and U850 models.*

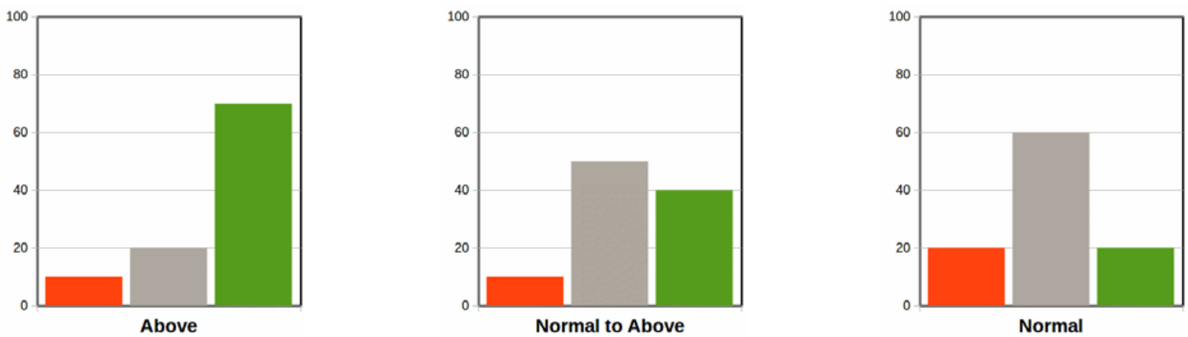
However, for this quarter the statistical model, with GPCP data as predictant, is associated to some skill. The predicted scenario is shown in figure 35 (right panel) along with the correlation maps for the TCWV and U850 models. This result offers a possibility to issue a general "normal to above" trend for the Seychelles even if not at local scale.

In this example the records negated the forecasts since a negative anomaly was observed for the Seychelles as seen in the figure 36.


*figure 36: Rainfall observations for DJF 2017 (plain circles) compared to the climatological distribution splitted in three terciles*

## 2.4 Making of the final map

The final forecast to be issued is the result of a consensus between the numerical results produced by the Seafords statistical model and the expertise of the operator. The knowledge of local climatology and the indications regarding the activity of the main climate large-scale drivers should consolidate or amend the conclusions drawn from numerical outputs. The information to produce is a map showing the scenarios adopted for the four zones. Each scenario is associated to probability values of the three terciles. Figure 37 displays some examples. Each probability should be expressed as multiples of ten since more precise values would be unrealistic considering the method uncertainties.



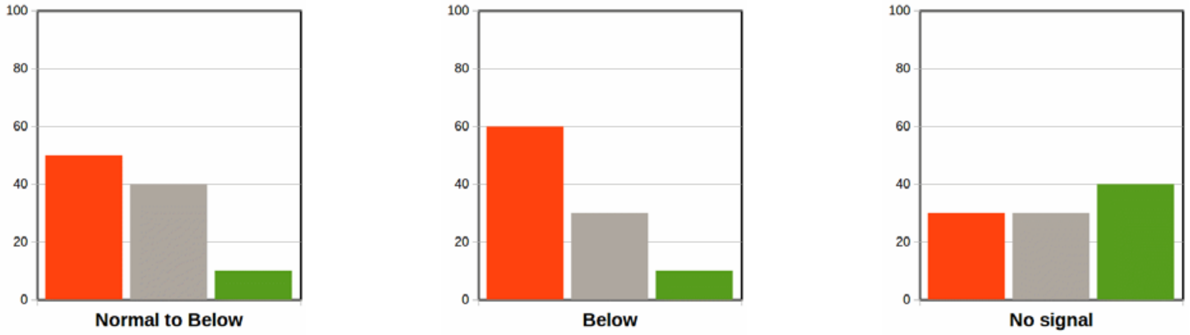


*figure 37: Examples of the 6 possible scenarios with associated probabilities for the three terciles*

The `final_forecast_map.R` script in the `BIN` folder produces the map showing the adopted scenarios. The examples of the OND 2016 and 2017 forecast cases are shown in figure 38. The OND 2016 numerical forecast (fig. 31) shows a different scenario for the northern zone of Mahé. This result should be questioned based on local expertise.
The climatology of the OND quarter shows that the observations in the northern zone are seldom in a different tercile than the other zones (4 cases in 39 years - last case in 2002).
Therefore a reasonable decision could be to amend the forecast so as to display an uniform signal over the main island. Nevertheless this is still a question for the local experts to debate about. The chosen option leads to the final map displayed in figure 38.

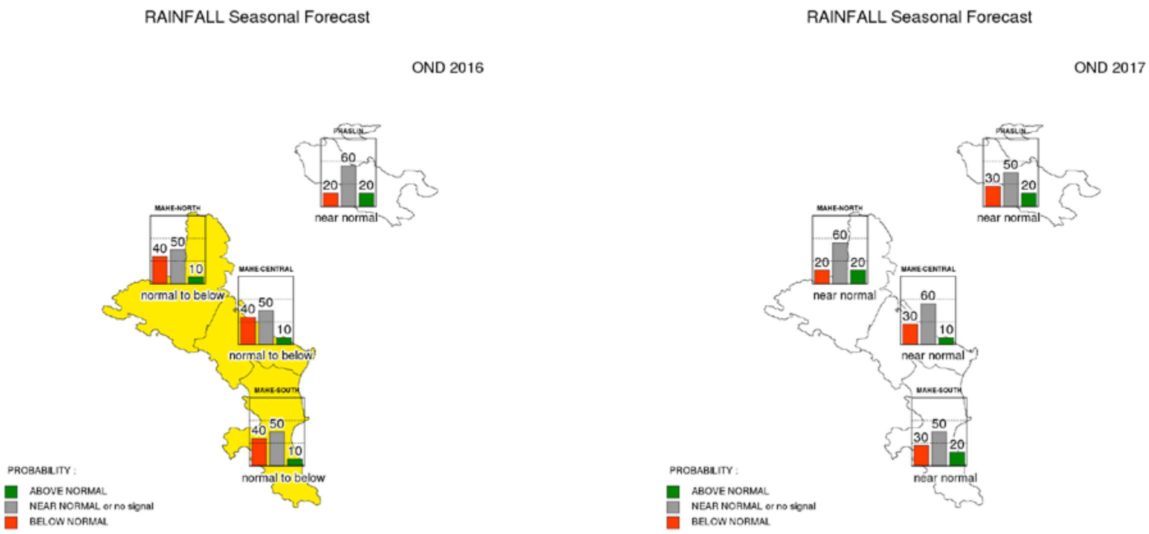


*figure 38: Examples of final forecast map for OND 2016 (Left) and OND 2017 (Right)*

This illustration as well as the synthesis of the general situation describing the state of the climate drivers relevant for the Seychelles should be included in the seasonal forecast bulletin. Some additional comments for specific end-users may be added according to the known sensitivity of these sectors to seasonal climate variability.

# 3 APPENDIX : THE SEAFORDS TOOLBOX

This appendix gives a quick description of the Seafords facilities that have been used for the climate analysis and the downscaling of seasonal forecasts. A more comprehensive users guide can be found in the "Seafords instructions" manual.

## 3.1 Installation

The Seafords toolbox has been developed by Météo France in the Indian Ocean (Saint-Denis, Réunion). The version of the software described herein is v2.2. It consists of a set of programs coded in ***R*** language. A user-friendly tool to run ***R*** scripts is the free software ***RStudio*** however the use of that tool is not mandatory to run Seafords. (/). The minimum required version of ***R*** is ***R V3.4.x*** (). Some extra modules (***R*** packages) have to be installed:

```
CircStats
dtw
fields
gsw
maps
oce
png
proxy
spam
TeachingDemos
verification
```

From the archive file, the main directory (hereafter : `[SEAFORDS]`) may be installed anywhere as per the user convenience. The software is Windows and Linux compatible.

The main directory `[SEAFORDS]` contains the following folders:

`BIN` : CC Analysis and downscaling tool + final map tool
`DATA_SEY` : Local observation data + derived indexes
`ERA-I_DATA` : Reanalysis data (large-scale predictors - Perfect Prognosis mode)
`FORECAST_DATA` : Forecast data (GCM forecasts)
`HINDCAST_CEP_lt1[2][3]_DATA` : GCM(ECMWF) climatology ( large-scale predictors - Model Output Statistics mode)
`OUTPUT` : Results from CC Analysis and downscaling model
`TOOLS` : PCA, CA, YA and indexes tools
`SHP` : Mapping data
`SRC` : Source code

## 3.2 Local data

The basic local data needed by Seafords are time series of seasonal accumulation of rainfall. The files are stored in the `[SEAFORDS]/DATA_SEY/RRTOT` folder. The following excerpt of the `SEY_RRTOT_ASO.txt` file shows the format of these data:

```
STN    Anse-Forbans Anse-Royale-Police-Station...
LAT    -4.78  -4.74  ...
LON    55.52  55.52  ...
1979   193.2  237    ...
...
2017   277.5  220.7  ...
```

These files may be used by the different tools within Seafords. In practice, the time series of seasonal rainfall accumulation are computed from daily observations records. The file containing the daily series should be in a CSV format, with the following organization:

```
StationId,Station_Name,Lat,Lon,Elev,Year,Month,Day,PRECIP
16,Anse Royale Waterwork PUC,-4.74,55.51,,1979,8,1,0
16,Anse Royale Waterwork PUC,-4.74,55.51,,1979,8,2,0
...
16,Anse Royale Waterwork PUC,-4.74,55.51,,2018,9,28,0
16,Anse Royale Waterwork PUC,-4.74,55.51,,2018,9,29,0
16,Anse Royale Waterwork PUC,-4.74,55.51,,2018,9,30,0
...
81,Praslin Airstrip (Amitie),-4.60,55.56,,1979,1,1,6
81,Praslin Airstrip (Amitie),-4.60,55.56,,1979,1,2,1
81,Praslin Airstrip (Amitie),-4.60,55.56,,1979,1,3,0
...
81,Praslin Airstrip (Amitie),-4.60,55.56,,2018,9,28,0
81,Praslin Airstrip (Amitie),-4.60,55.56,,2018,9,29,0
81,Praslin Airstrip (Amitie),-4.60,55.56,,2018,9,30,0
```

Then, the `Indices.R` script has to be executed ("sourced" in ***R*** language) to create different quarterly indices, including the `RRTOT` dataset. This script is contained in the `[SEAFORDS]/TOOLS` folder. It is set up by a configuration file named `config_Indices.R`. which also contains the description of each index). The name and path of the daily data file has to be filled in.

*Example : Configuration file config_Indices.R*

```
# Configuration pour le calcul d'indices OMM (Indices.R)

# country
country = "SEY"

# seasons
saison_list = c("JFM","FMA","MAM","AMJ","MJJ","JJA","JAS","ASO","SON","OND","NDJ","DJF")

# WMO indices
indice_list = c("RRTOT","R20mm","CWD","CDD")

# Daily data file  (.csv  separe par des virgules)
ficin = "../DATA_SEY/Daily_RRQ_SEY_1979-2018_coupe.csv"
```

This process may be used for the annual update.

## 3.3 Climate analysis tools

The `[SEAFORDS]/TOOLS` folder contains the scripts used to implement the different statistical analysis tools which results are found in the `[SEAFORDS]/TOOLS/OUTPUT` folder. Each script is set up with a corresponding configuration file. The examples hereafter show the main lines of these configuration files.

**Principal Components Analysis**

The PCA is implemented with the `ACP.R` script. This tool may process PCA for local and/or large-scale parameters for one or several quarters.

The configuration file is: `config_ACP.R`

*Example 1: PCA of SST over the Indian and Pacific Oceans - Used to create figure 1*

```
# CONFIGURATION FOR Principal Component Analysis

# list of parameters ("SST","PMER","U850","V850","U200","TCWV","PV200global", "SSTglobal")
  param_list = c("SSTglobal")

        # domaine choisi plus petit que le domaine initial :
        # LIMITES si le champ global est choisi a l'interieur de (-90, 90, 0, 357.5) : on peut mettre
des longitudes negatives (comme -90 90 -80 80) mais les contours des pays ne seront pas traces entre -
80 et 0
        # LIMITES si le champ Ocean Indien est choisi a l'interieur de (-50, 10, 20, 110)
         domaine_choisi = c(-50,50,30, 300)

# RR, TM
  param_loc_list=c()

# Choice of the season
  season_list = c("DJF")

# Choice of the data set (ERA-I or ERSST)
  hindcast = "ERA-I"
```

*Example 2: PCA of rainfall data over the Seychelles area - Used to create figure 17*

```
# CONFIGURATION FOR Principal Component Analysis

# list of parameters ("SST","PMER","U850","V850","U200","TCWV","PV200global", "SSTglobal")
  param_list = c()

        # domaine choisi plus petit que le domaine initial :
        # LIMITES si le champ global est choisi a l'interieur de (-90, 90, 0, 357.5) : on peut mettre
des longitudes negatives (comme -90 90 -80 80) mais les contours des pays ne seront pas traces entre -
80 et 0
        # LIMITES si le champ Ocean Indien est choisi a l'interieur de (-50, 10, 20, 110)
         domaine_choisi = c(-50,10, 20, 110)

# RR, TM
  param_loc_list=c("RRTOT","SPI")

# Choice of the season
 season_list=c("JFM","FMA","MAM","AMJ","MJJ","JJA","JAS","ASO","SON","OND","NDJ","DJF")
```

**Composites Analysis**

The CA is implemented with the `Composites.R` script. This tool may process CA for local and/or large-scale parameters for one or several quarters. The principle of such an analysis is to compute

average fields for selected years. The configuration file proposes a list of years for different events like ENSO and IOD. These lists may be modified or completed if necessary.
The configuration file is: `config_Composites.R`

*Example 1: CA of global SST and local rainfall for Nino years - Used to create figures 4 and 19*
```
# CONFIGURATION FOR COMPOSITE ANALYSIS

listName = "NINO"
yearList = c("1982","1986","1987","1991","1997","2002","2009","2015")

# list of parameters
param_list=c("SSTglobal","U850global","U200global","TCWVglobal","V850global","PV200global")

# GPCP, RR, TM
param_loc_list=c("RR4Z","SPI4Z")

# Choice of the season
season_list=c("JFM","FMA","MAM","AMJ","MJJ","JJA","JAS","ASO","SON","OND","NDJ","DJF")
```

### Yearly Analysis

The YA is implemented with the `YearlyAnalysis.R` script. This tool produces a map of the selected parameter (local or large-scale) for a list of quarters and a list of years. This allows to explore the variability of the parameter over a given period. It helps to verify the consistency of a Composite map which gives only an average.
The configuration file is: `config_yearlyAnalysis.R`

*Example 1: YA of local rainfall for all running quarters*
```
# CONFIGURATION FOR YEARLY ANALYSIS

# list of large-scale parameters
param_list=c()

# list of local parameters ("RR","SPI_7ZONES","GPCP","ARC2MAD",""NBRR10",...)
param_loc_list=c("RR4Z")


# years
#yearList <- "all"     # exemples : c(1985,1990)   ou   "all"
 yearList <- c(1992,1996,1998,2010,2016)

# Choice of the season
 saison_list=c("JFM","FMA","MAM","AMJ","MJJ","JJA","JAS","ASO","SON","OND","NDJ","DJF")
```

## 3.4 Statistical downscaling tool

The statistical model implemented in the Seafords toolbox is based on Canonical Correlation Analysis. This process is preconditioned by PC Analysis of the local variable (predictand) and the large-scale variable (predictor) in order to reduce the number of variables and ensure their independency. The Analysis allows to adjust a regression function to build a linkage between the large-scale information and the local one.

During the learning phase illustrated in figure A, the model parameters are derived from the climatological time series of both large-scale variables (from Reanalysis in case of Perfect prognosis mode) and local variables (rainfall or SPI for the stations or zones).

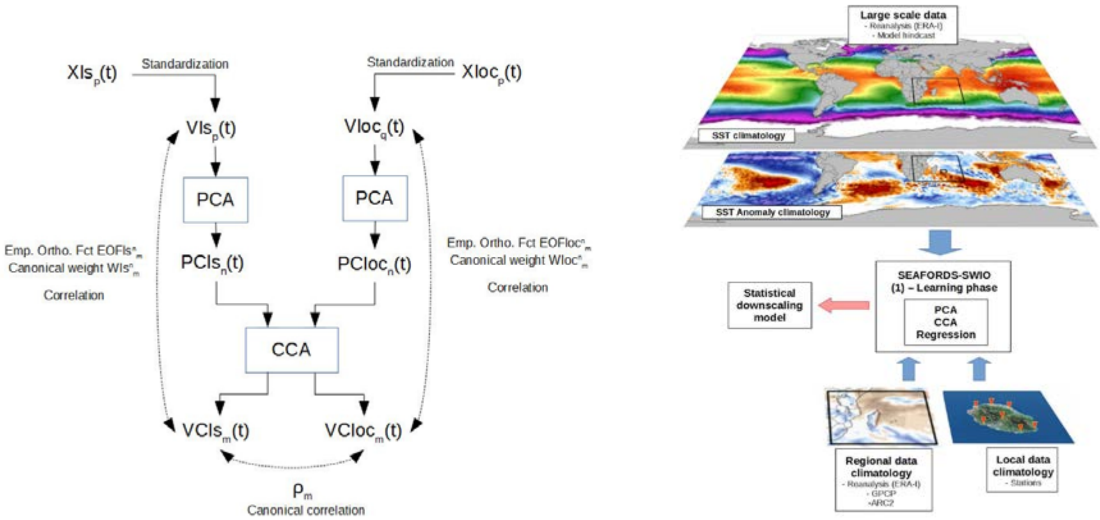


*Figure A: Learning phase of the Seafords statistical model*

The forecasts issued by the GCM are then downscaled using the model. This process is illustrated in figure B.

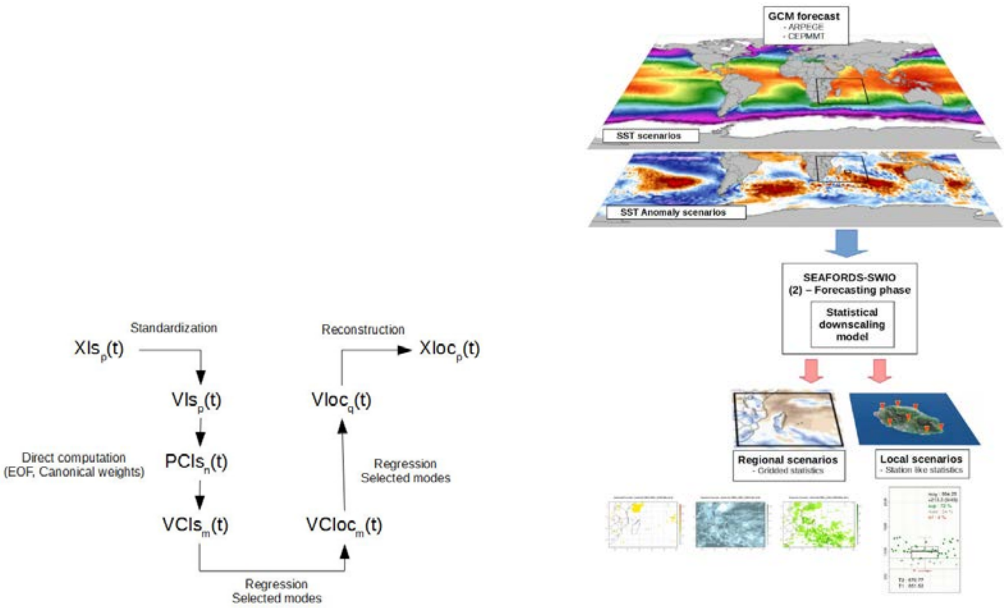


*Figure B: Forecast phase of the Seafords statistical model*

The statistical model is implemented by the `Seasonal_Outlook.R` script in the `[SEAFORDS]/BIN` folder. The configuration file is: `config.model.R`. It contains the parameters defining the context of the run. An option is to use the script to process the learning phase only. This allows to analyze the linkages between the large-scale parameters and the local (RRTOT/SPI) or regional (GPCP) variables including the predictability issue.

*Example 1 : Parameters for processing the learning phase only - Used to create the figures 22, 23, 24*

```
####################################################
#  CONFIGURATION DU MODELE DE DESCENTE D'ECHELLE  #
####################################################

# Enter large scale parameter
# SST, PMER (MSLP), U850 (850hPa zonal wind), V850 (850hPa meridian wind), U200 (200hPa zonal wind),
TCWV (Total column water vapour)
 parametres_a_traiter = c("SST","PMER","U850","V850","TCWV","U200")

# Enter forecast model (ARPS5, CEP)
# CEP (ECMWF), ARPS5 (ARPEGE)
 modele_prevision = "CEP"

# Enter Forecast Period (Season, Year)
 saison = "JFM"    #### period : 3 months (OND, NDJ...)
 annee = ""        #### year : >>>> NO VALUE IS FOR LEARNING PHASE PROCESSING ONLY
 leadtime = 1      #### 1, 2 ou 3

# Choix du jeu d'apprentissage (grande echelle)
# ERA-I (Perfect Prediction PP), HINDCAST (Model Output Statistics MOS)
 hindcast = "ERA-I"

# Enter local parameter
# station data : RR, SPI (the file must be placed in the fold DATA_country/RR, ...)
 param_loc = "SPI4Z"

# Enter if local data are gridded data or station data
 param_loc_type = "station"   # "station" or "gridded"

# Enter kind of data : zone or stations
 by.zone = "no" # "yes" (colored polygons) or "no" (colored points at station locations)

# Enter country choice
 country = "SEY"
```

*Example 2 : Parameters for processing the downscaling of the OND 2017 forecast over Seychelles - Used to create the figure 29*
*Learning phase parameters outlined in yellow - Forecasting parameters outlined in red*

```
####################################################
#  CONFIGURATION DU MODELE DE DESCENTE D'ECHELLE  #
####################################################

# Enter large scale parameter
# SST, PMER (MSLP), U850 (850hPa zonal wind), V850 (850hPa meridian wind), U200 (200hPa zonal wind),
TCWV (Total column water vapour)
 parametres_a_traiter = c("SST","U850","V850","TCWV","U200")

# Enter forecast model (ARPS5, CEP)
# CEP (ECMWF), ARPS5 (ARPEGE)
 modele_prevision = "CEP"

# Enter Forecast Period (Season, Year)
 saison = "OND"    #### period : 3 months (OND, NDJ...)
 annee = 2017        #### year : (exemple NDJ 2016 : it is N 2016, D 2016, J 2017)
 leadtime = 1      #### 1, 2 ou 3

# Choix du jeu d'apprentissage (grande echelle)
# ERA-I (Perfect Prediction PP), HINDCAST (Model Output Statistics MOS)
 hindcast = "ERA-I"
```

```
# Enter local parameter
# station data : RR, SPI (the file must be placed in the fold DATA_country/RR, ...)
 param_loc = "SPI4Z"

# Enter if local data are gridded data or station data
 param_loc_type = "station"   # "station" or "gridded"

# Enter kind of data : zone or stations
 by.zone = "yes" # "yes" (colored polygons) or "no" (colored points at station locations)

# Enter country choice
 country = "SEY"
```

*Example 3: Parameters for processing statistical adaptation of regional rainfall for the DJF 2017 forecast - Used to create the figure 30 Learning phase parameters outlined in yellow - Forecasting parameters outlined in red*

```
###################################################
#  CONFIGURATION DU MODELE DE DESCENTE D'ECHELLE  #
###################################################

# Enter large scale parameter
# SST, PMER (MSLP), U850 (850hPa zonal wind), V850 (850hPa meridian wind), U200 (200hPa zonal wind),
TCWV (Total column water vapour)
 parametres_a_traiter = c("SST","U850","V850","TCWV","U200")

# Enter forecast model (ARPS5, CEP)
# CEP (ECMWF), ARPS5 (ARPEGE)
 modele_prevision = "CEP"

# Enter Forecast Period (Season, Year)
 saison = "DJF"    #### period : 3 months (OND, NDJ...)
 annee = 2017        #### year : (exemple NDJ 2016 : it is N 2016, D 2016, J 2017)
 leadtime = 1      #### 1, 2 ou 3

# Choix du jeu d'apprentissage (grande echelle)
# ERA-I (Perfect Prediction PP), HINDCAST (Model Output Statistics MOS)
 hindcast = "ERA-I"

# Enter local parameter
# station data : RR, SPI (the file must be placed in the fold DATA_country/RR, ...)
 param_loc = "GPCP"

# Enter if local data are gridded data or station data
 param_loc_type = "gridded"   # "station" or "gridded"

# Enter kind of data : zone or stations
 by.zone = "no" # "yes" (colored polygons) or "no" (colored points at station locations)

# Enter country choice
 country = "SWIO"
```

### 3.5 Final map

The final map is made by using the `final_forecast_map.R` script. The configuration file contains the values of the terciles for each zone : `config.forecast-SEY.R`

*Example 1 : Configuration file used to create the figure 32.*

```
##################
#  FORECAST DATA #
##################

 saison <- "OND"
 annee <- 2017

# Probablities for terciles pour chaque zone (Prob. BELOW,NORMAL,ABOVE)
# Check the sum is 100 !!!!

 Proba_SEY_N <- c(20,60,20)     # zone N
 Proba_SEY_P <- c(30,50,20)     # zone Praslin
 Proba_SEY_C <- c(30,60,10)     # zone C
 Proba_SEY_S <- c(30,50,20)     # zone S
```