FAMINE EARLY WARNING SYSTEMS NETWORK

SMPG Tool User's Manual

Version 2.0 Plugin for QGIS

May 2025

FEWS NET provides tools to help mitigate or prevent humanitarian crises. The SMPG tool is a powerful user-friendly tool for seasonal monitoring. This manual is intended for users of the SMPG plugin for QGIS.

Contents

Introduction

The **Seasonal Monitoring and Probability Generator (SMPG)** tool is a powerful new resource designed to help users monitor the progression of the rainy season across various spatial units. These could include individual polygons, administrative regions, agricultural zones, watersheds, or custom-defined areas. The SMPG operates using either 5-day or 10-day total rainfall time series data for each polygon, enabling a detailed and comprehensive analysis of the evolution of the rainy season.

The tool provides a range of outputs, including numerical, graphical, and geographical products. It does this by comparing current rainfall data with long-term averages (LTA) and historical records from selected years, such as analog years. Additionally, the SMPG features an **Outlook Module** that simulates and calculates probabilities for the **End of Season (EOS)** by completing the season with historical data from user-selected years.

To ensure seamless integration into existing workflows, the SMPG is designed as a **plugin for QGIS**. It utilizes time series data extracted for each polygon, making it an intuitive addition to GIS-based monitoring and analysis systems.

The SMPG is directly aligned with **Step 4 of FEWS NET's agroclimatology assumption development process**, where it plays a critical role in monitoring the rainy season's development using available data. Below is a summary of the FEWS NET process and the SMPG's role within it:

1. **Understand the climatology for the area of concern well in advance of the Start of Season (SOS).**
2. **Evaluate current climate modes approximately three months before SOS and continue until the End of Season (EOS).**
3. **Interpret available forecasts starting about two months before SOS and continuing through EOS.**
4. **Incorporate monitoring data from remote sensing and other sources from SOS through EOS.**

By enabling detailed monitoring and probabilistic forecasting, the SMPG tool represents a significant advancement in seasonal rainfall monitoring, empowering users to make informed decisions for agriculture and food security, water resource management, disaster preparedness, energy, and public health. The SMPG tool is especially useful for statistical intra-seasonal forecasting, bridging the gap between weather forecasting and seasonal forecasting. This user friendly tool supports:

- Climate data analysis.
- The generation of climate information products in spatial resolutions that support decision making at the regional, national and district levels.
- The generation of regional tailored products, addressing regions of common climate characteristics.
- The generation of a range of probabilistic outlooks that support consensus-based outlooks by Regional Climate Outlook Forums.

Installation

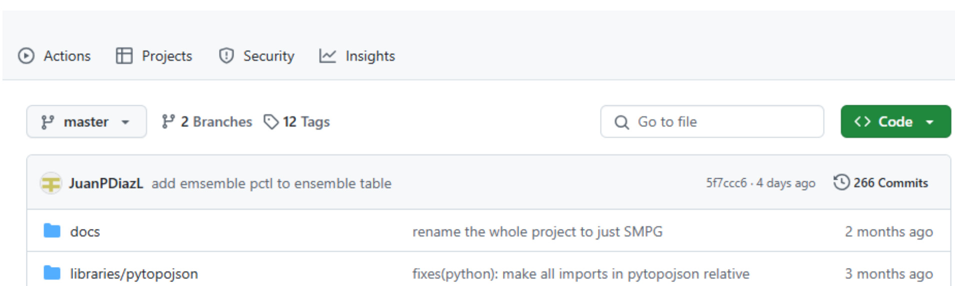
System Requirements

- Microsoft Windows Operating System (10 or later)
- QGIS 3.40

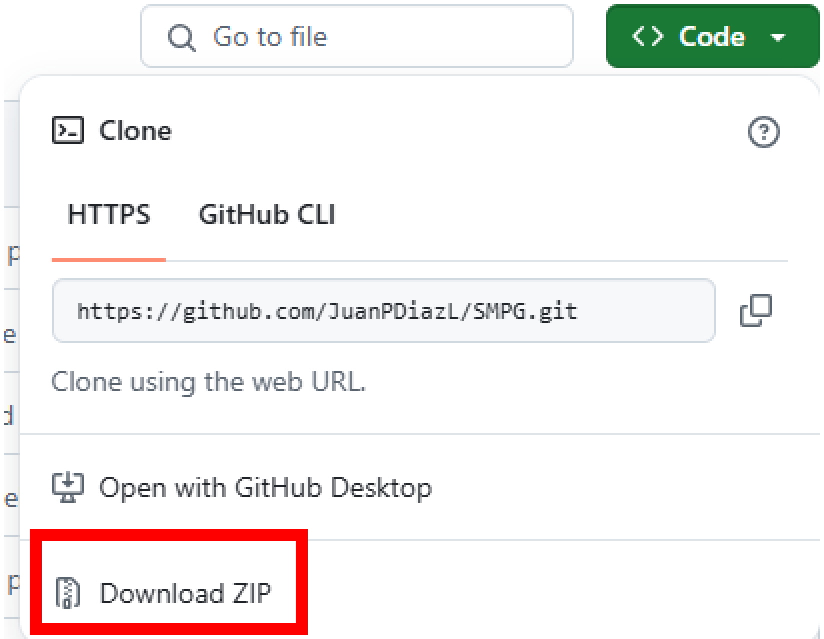
Installing the SMPG tool

New versions of the SMPG plugin are released periodically to address bugs, implement performance improvements, or add new features. Follow these steps to download and install the latest version of the SMPG plugin for QGIS:

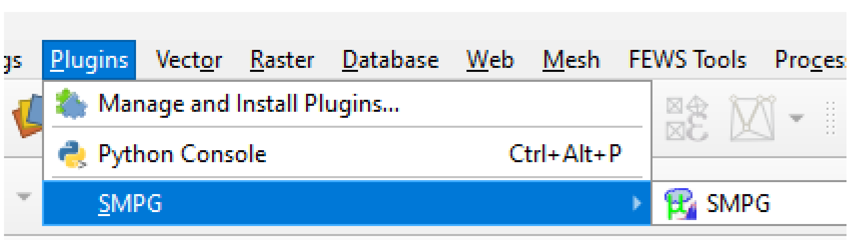
1. Open the SMPG GitHub page.



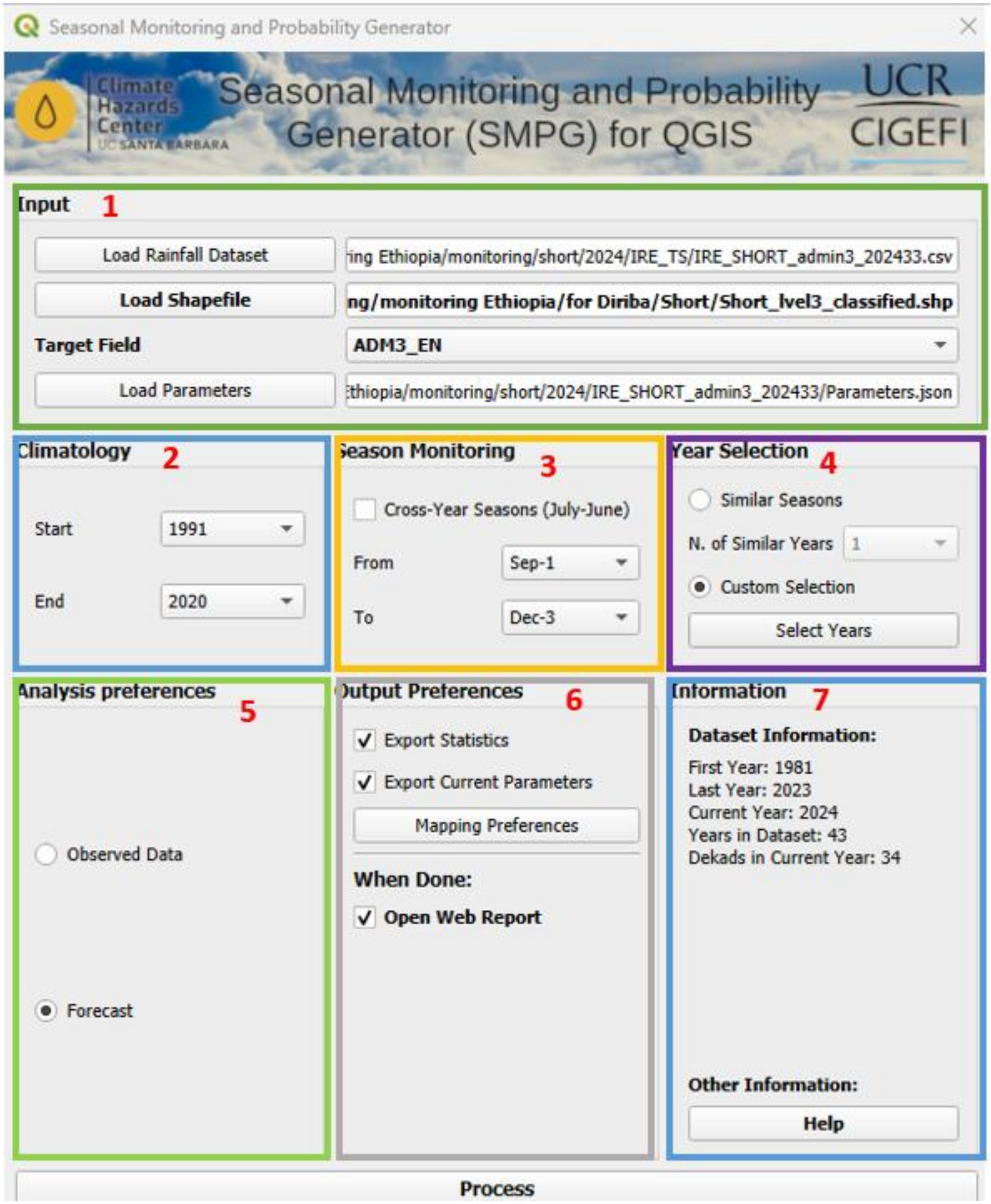
2. Click on the green **< > Code** dropdown button.
3. Click on **Download ZIP** to save the plugin files to your computer.



4. Open the QGIS application.
5. From the main toolbar, navigate to **Plugins** > **Manage and Install plugins.**
6. In the left-hand sidebar, select **Install from zip**.
7. Click the Browse button next to the ZIP file field and locate the ZIP file you downloaded from the GitHub page (named QSMPG-master.zip by default)
8. Click **Install Plugin**.
9. A popup message will appear, asking for confirmation to proceed with the installation. Click **Yes** to finalize the process.
10. Once the installation is complete, click **Close**.
11. Open the tool by navigating to **Plugins > SMPG** from the main toolbar.



12. The SMPG tool will launch, displaying an interface as shown in the image below.



Seasonal Monitoring and Probability Generator
Climate Hazards Center
UC SANTA BARBARA
Seasonal Monitoring and Probability Generator (SMPG) for QGIS
UCR
CIGEFI
Input
1
Load Rainfall Dataset
ing Ethiopia/monitoring/short/2024/IRE_TS/IRE_SHORT_admin3_202433.csv
Load Shapefile
ng/monitoring Ethiopia/for Diriba/Short/Short_lvel3_classified.shp
Target Field
ADM3_EN
Load Parameters
thiopia/monitoring/short/2024/IRE_SHORT_admin3_202433/Parameters.json
Climatology
2
Start
1991
End
2020
Season Monitoring
3
Cross-Year Seasons (July-June)
From
Sep-1
To
Dec-3
Year Selection
4
Similar Seasons
N. of Similar Years
1
Custom Selection
Select Years
Analysis preferences
5
Observed Data
Forecast
Output Preferences
6
Export Statistics
Export Current Parameters
Mapping Preferences
When Done:
Open Web Report
Information
7
Dataset Information:
First Year: 1981
Last Year: 2023
Current Year: 2024
Years in Dataset: 43
Dekads in Current Year: 34
Other Information:
Help
Process

The Interface Overview

The SMPG tool consists of **seven sections.**

1. Input Section

The **Input** section is where users provide the primary datasets required for processing. This section includes the following fields:

- **Time Series Table:** The user must upload a table containing either the 5-day or 10-day total rainfall time series data for each polygon. This table should be generated as an output from the **Extract Statistics** function of GeoCLIM.

- **Shapefile:** The user must also upload the shapefile that was used to extract the rainfall data. This ensures the tool correctly maps the time series data to its corresponding polygons.

- **Unique Identifier Field:** Specify the field within the shapefile that uniquely identifies each polygon. This field ensures that the tool associates the correct time series data with each spatial unit.

- **Load parameters** (.json): After completing all the required parameters for running the SMPG tool, users can save these settings for future use. This feature enables the tool to automatically load previously saved parameters, streamlining subsequent runs and ensuring consistency in the analysis. Users can revisit saved configurations to replicate workflows without manually re-entering inputs.

2. Climatology

In the **Climatology** section, users define the period that will be used to calculate the climatology or long-term mean (LTM), which serves as the baseline for identifying deviations from typical seasonal rainfall patterns. The selected period serves as the baseline for computing the following:

- **Anomalies:**
  Deviations from the long-term mean, indicating whether current rainfall amounts are above or below average.

- **Percent Anomalies:**
  The percentage difference between current rainfall and the climatological baseline.

3. Season Monitoring

In the **Season Monitoring** section, users define the start and end of the rainy season to be monitored:

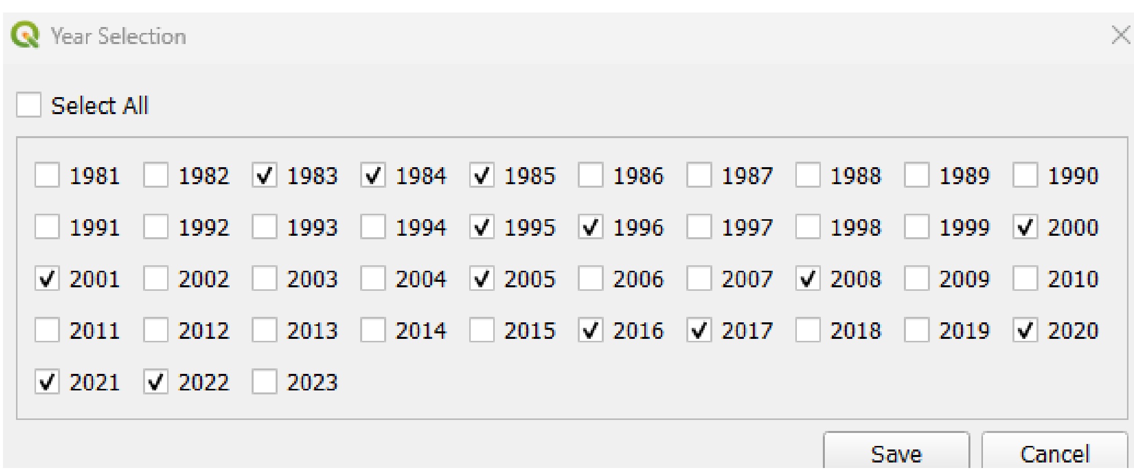
- **Start of the Season (SOS):**
  Specify the average start period for the season. It is recommended to include 2–3 periods prior to the expected SOS to allow the tool to identify early starts.

- **End of the Season (EOS):**
  Specify the expected end date for the season. This parameter enables the tool to make projections for the remainder of the season.

- **Cross-Year Season (e.g., July–June):**
  For seasons that span across two calendar years, users should select the **Cross-Year Season** option. When this box is checked, the tool reconfigures the period selection interface, allowing users to accurately define the start and end dates for cross-year seasons.

4. Year Selection

The **Year Selection** section allows the users to choose historical years to be used for completing the season from the current period to the End of Season (EOS). This process generates possible scenarios by combining the current season's observed data (from the Start of Season, or SOS, to the current period) with historical data from each of the selected years. By using these historical patterns, the tool provides a range of potential outcomes for the remainder of the season, offering valuable insights for scenario planning and decision-making. The figure below shows a set of analog years selected.



5. Analysis Preferences

In this section, users define the configuration of the analysis, determining whether it includes forecast data or relies solely on observed data:

- **Forecast Inclusion:**
  The SMPG identifies the next-dekad forecast as the last column in the input table. When selected, the tool incorporates this forecast data into the analysis to provide extended scenarios and additional insights.

- **Observed Data Only:**
  If forecasts are excluded, the analysis will be based solely on observed data up to the current period. When this box is selected, the tool assumes there is no forecast.

6. Output Preferences

In this section, users select the types of outputs generated by the tool. These options include the following:

➢ **Statistics Tables (Optional):**
Detailed tables containing all statistical results from the analysis, providing comprehensive numerical insights.

➢ **Save Run Parameters:**
Users can save the parameters configured for the current analysis into a file. These saved parameters can be retrieved in **Section 1 (Input)** for consistent replication in future runs.

➢ **Output Maps:**
By selecting **Mapping Preferences**, users can configure various map outputs, including:

  - **C.Dk./LTA Pct.:**
    Depicts the percent of the long-term average (LTA) for the accumulated precipitation from the Start of Season (SOS) up to the current period (current dekad: C.Dk.).

  - **C.Dk. + Forecast/LTA Pct.:**
    Depicts the percent of average for the accumulated precipitation from the Start of Season (SOS) up to the current period, including the forecast.

- **Current Season Pctl.:**
  Shows the percentile rank of the accumulated precipitation from the SOS up to the current period, based on historical data.

- **Ensemble Med. Pctl.:**
  Depicts the percentile rank of the median value of all possible outcomes at the End of Season (EOS). The ensemble is created using historical data from selected years (from **Section 4**) to simulate a range of potential outcomes.

- **Ensemble Med./LTA Pct.:**
  Displays the percent of average for the EOS median value of all possible outcomes compared against the long-term average (LTA).

- **Tercile Probabilities:**
  This map displays the probability of the season's outcome falling into one of three categories:

  - **Below Normal:** Below the 33rd percentile of the historical distribution.
  - **Normal:** Between the 33rd and 67th percentiles.
  - **Above Normal:** Above the 67th percentile of the historical distribution.

- **Analysis Plots (Web Reports):**
  Automatically generated visual summaries of the analysis results, designed for web-based reporting. When the box is selected, the reports open automatically.

7. Information

This section details key attributes of the input dataset, including the starting/ending years, the number of periods in the current year, and other relevant parameters.

Preparing the data to run the SMPG

Having completed the interface overview, we now turn to data preparation. The first step involves preparing the shapefile containing the polygons to be analyzed. This step is a one-time process, as the same shapefile will be reused whenever the tool is run. Once the shapefile is ready, the focus shifts to preparing a table with rainfall data corresponding to each polygon.

Step 1: Setting up the Polygon shapefile

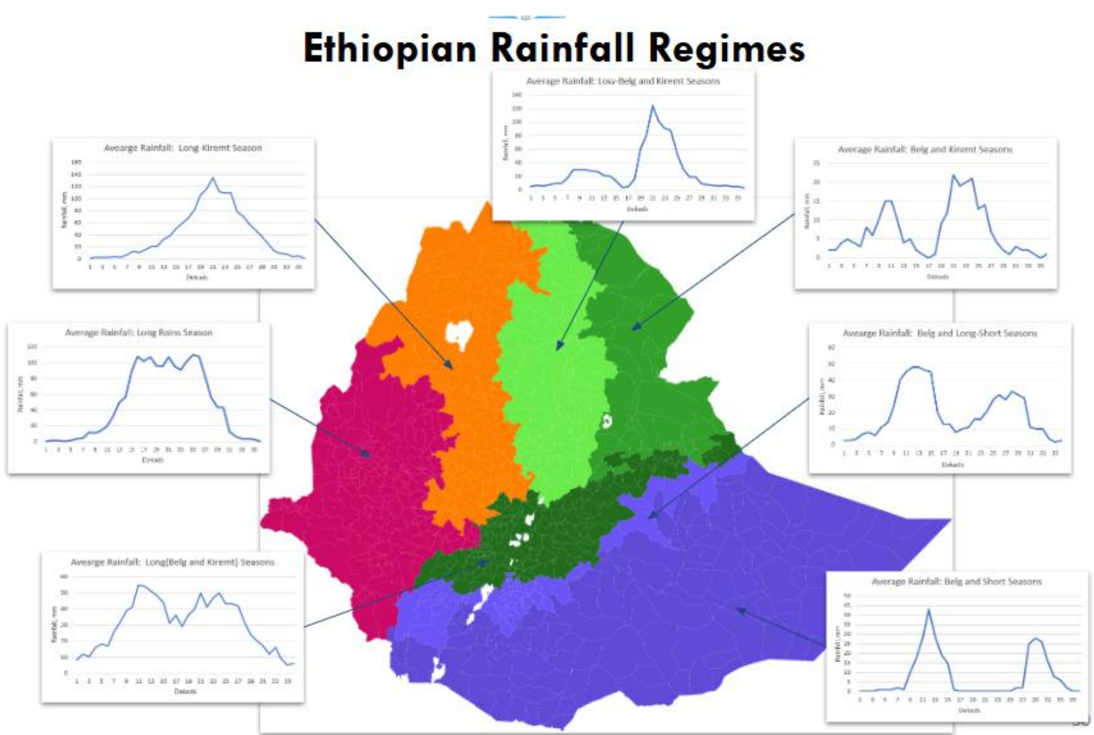
1. **Select a Suitable Shapefile**: Choose a shapefile representing the region to be analyzed. This could include administrative units, watersheds, customized areas or any other relevant boundaries.

2. **Ensure Unique Identifiers**: Verify that each polygon in the shapefile has a unique identifier. Address any issues where multiple polygons share the same ID (e.g., islands belonging to the same district) by assigning distinct IDs.

3. **Eliminate Duplicates**: Remove or dissolve overlapping polygons (e.g., polygons within other polygons) to prevent redundancy and ensure accurate analysis.

4. **Group Polygons by Rainfall Characteristics** *(Optional)*: In regions with multiple rainy seasons, consider grouping polygons based on the characteristics of their rainfall patterns. Create a separate shapefile for each group of polygons to streamline workflows and maintain consistency when extracting rainfall data.

Example: Below is a characterization of Ethiopia's rainy seasons. Each color represents a set of polygons sharing similar rainfall patterns. The large areas are made by classifying level3 administrative units (municipalities).



Step 2: Preparation of the input data table

To use the tool, a table containing rainfall data (5- or 10-day totals) for each polygon is required. This table should include historical data up to the current period and, if available, forecasts for the upcoming period. Data can be sourced from publicly available datasets like CHIRPS or customized datasets. Below are the instructions for users working with 10 day totals CHIRPS data. These steps can be adapted for customized data sources.

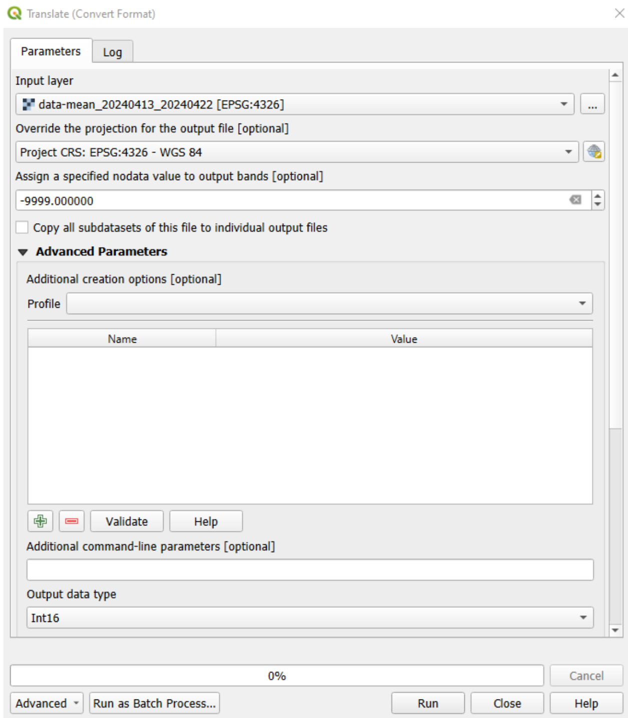
Instructions for CHIRPS Users

1. **Download Historical Data**
   Access the CHIRPS final dataset for historical periods from the following link:
   CHIRPS Final Dataset
   Ensure you collect data covering the required time frame.

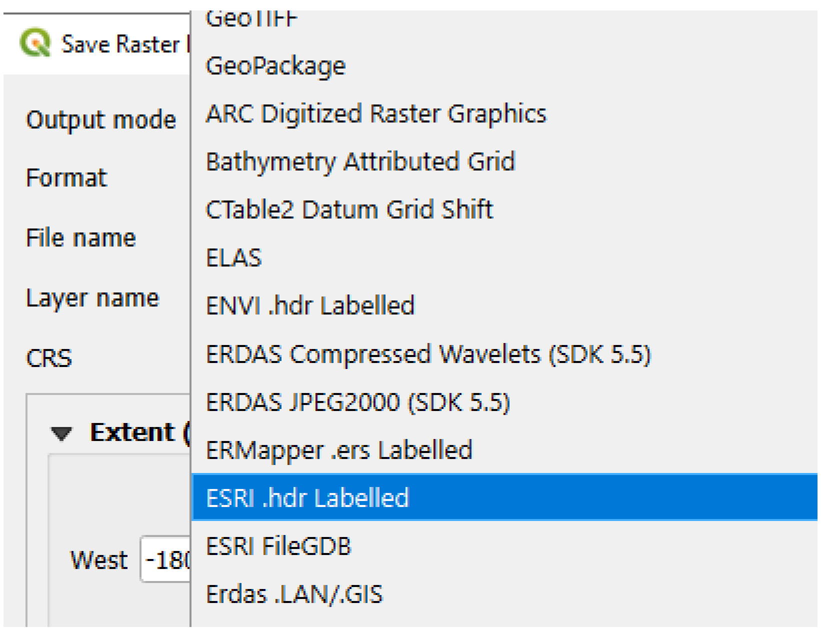
2. **Download Preliminary Data**
   For the most recent dekads, download the CHIRPS-prelim data from this link:
   CHIRPS-Prelim Dataset
   CHIRPS-Prelim provides rapid estimates of rainfall and incorporates readily available in situ observations from sources such as the Global Telecommunications System (GTS), Global Summary of the Day (GSOD) and Global Historical Climatology Network (GHCN). Additional sources cover Mexico, Costa Rica, Germany, Kenya, Colombia, Republic of Korea, South America, Guatemala and Chile. This dataset is updated two days after the end of a pentad on the 2nd, 7th, 12th, 17th, 22nd, and 27th of the month.

3. **Download Forecast Data**
   Download forecast from the link below, available in GeoTIFF and .BIL formats. Process the .bil as described below.
   https://data.chc.ucsb.edu/products/EWX/data/forecasts/CHIRPS-GEFS_precip_v12/10day/precip_mean/
   a. For .bil users:

i. Use the **Translate** function in QGIS and save the **Output data type**



ii. On the **Save Raster Convert** screen, select *ESRI. hdr Labelled*. See figure below.



iii. Save forecast as the last dekad in the time series.
To include the forecast data as the final entry in the time series:

iv. Rename the files for consistency:
Rename the forecast files to ensure they clearly represent the last period in the sequence. This step is essential to maintain chronological order in the time series and avoid confusion during processing.

v. Verify Integration:
Confirm that the renamed forecast files match the expected naming convention and fit seamlessly as the last dekad in the dataset. This ensures the forecast data is correctly recognized during subsequent analysis.

By following the above steps, the forecast data are effectively incorporated as the final entry, completing the time series.

4. Blend Local Station Data with CHIRPS (if applicable, otherwise go to the next point)
Where local station data is available, blend it with CHIRPS data for enhanced accuracy.
5. Extract Spatial Averages Using GeoCLIM
Use GeoCLIM's *Extract Statistics* function to calculate the spatial average rainfall for each polygon in the shapefile prepared in **Step 1**. Follow these guidelines:
   a. **First-Time Users**: Extract the complete historical time series, including all available CHIRPS final, preliminary, and forecast data.
   b. **Operational Users**: Update the time series table with the latest final, preliminary, and forecast data as new information becomes available.

Example of Output table

The table below presents the format of the finalized time series produced at the conclusion of this process. Column A identifies unique polygons representing distinct geographical areas, while the subsequent columns provide rainfall data covering historical, preliminary, and forecast periods.

historical final-CHIRPS (blue) + prelim-CHIRPS (orange) + forecast (pink)

A	B	C	BGM	BGN	BGO	BGP	BGQ	BGR	BGS	BGT	BGU
Feature	v2p0chirps198101	v2p0chirps198102	v2p0chirps202	v2p0chirps202	v2p0chirps202	v2p0chirps202	v2p0chirps202	v2p0chirps202403	2p0chirps202404	v2p0chirps202405	2p0chirps202406
Qala-e-Kah	12	10	1	2	1	3	3	4	2	4	12
Pusht Rod	14	9	0	2	1	3	3	4	3	4	13
Shib Koh	9	9	0	1	1	3	3	3	1	2	10

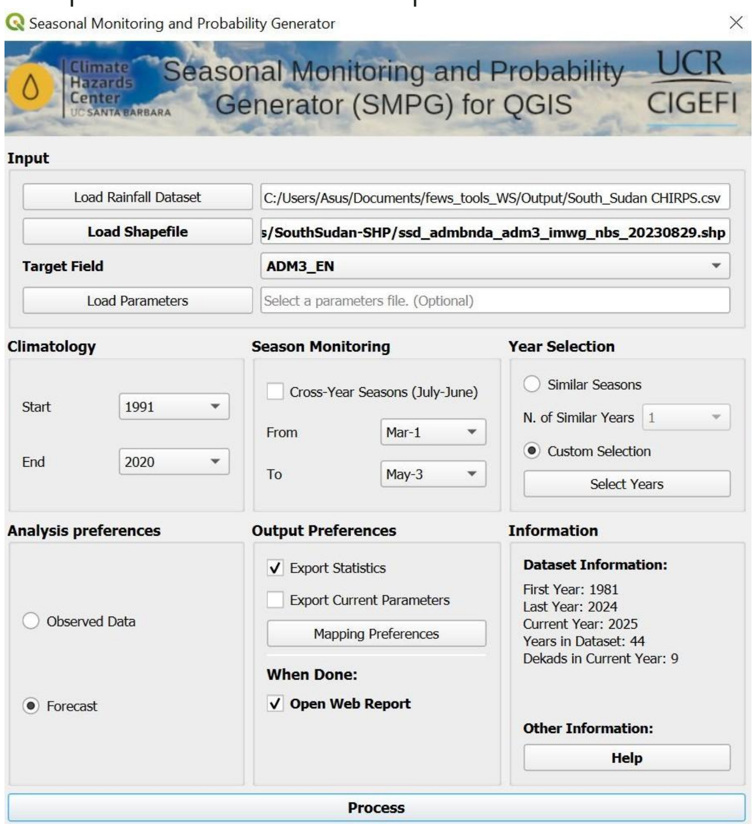
- **Column A**: Lists the unique polygon identifiers (e.g., administrative units IDs). Make sure there are no duplicates.
- **Columns B to end**: Contain rainfall data for each time step in the series.
   - **Blue Box**: CHIRPS-final data from the earliest available period (e.g., 1981 dekad 01) to the most recent final data (e.g., 2024 dekad 03).

- **Orange Box**: CHIRPS-prelim data for the latest dekads (e.g., dekad 04 and dekad 05).
- **Pink Box**: Forecast data for the upcoming dekad (e.g., dekad 06).

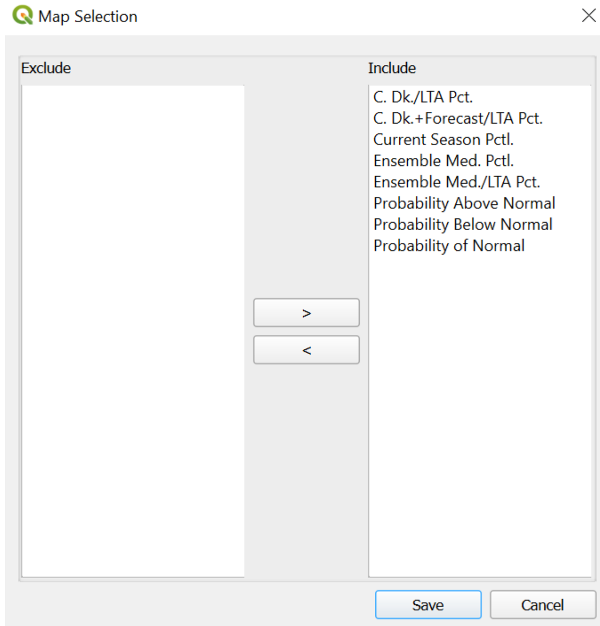
Running the SMPG

Once you have the shapefile, and organized the data in the correct format

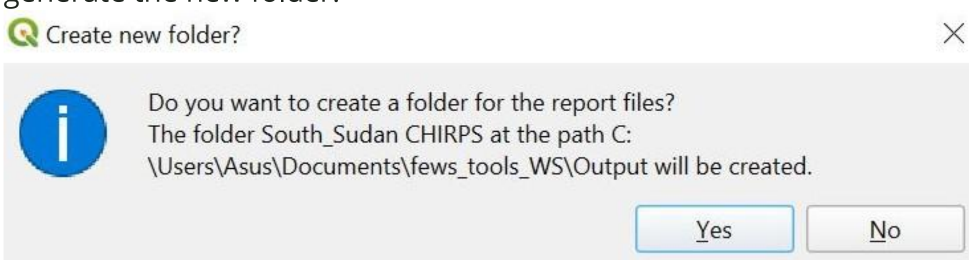
- Complete the form. See example below:



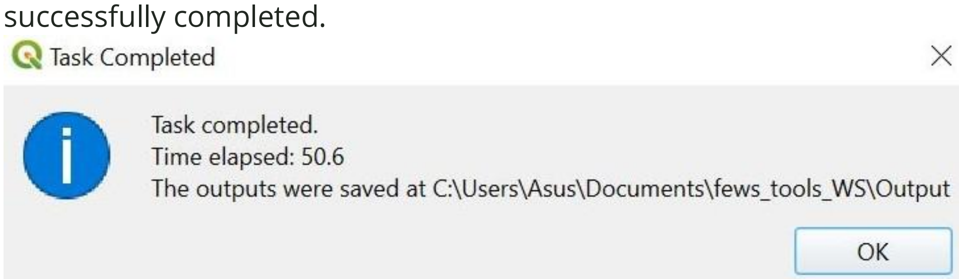
13. Click on the Mapping preferences bottom to select the maps to be generated.



- Execute the tool by clicking on the process bottom.
- Select the folder where to save the results.
- The SMPG tool will generate a folder containing all the results. By default, this folder will be named after the input table unless you choose a different name. Navigate to the folder where you want to save the results. Click yes to generate the new folder.



- A confirmation message will appear, indicating that the task has been successfully completed.



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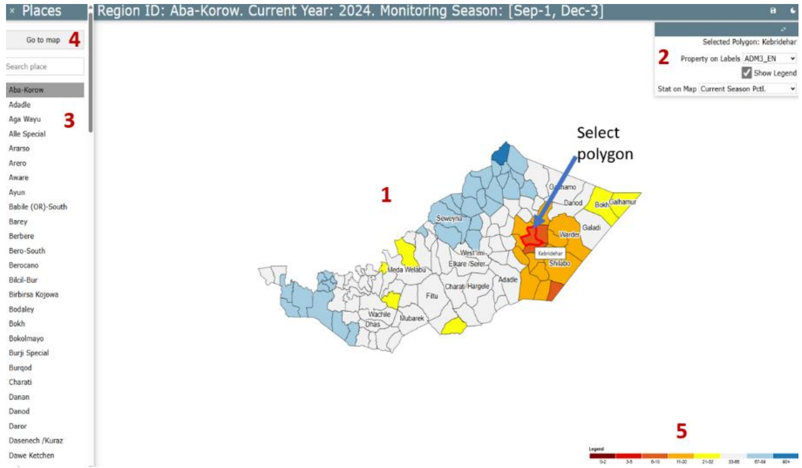
- At the same time, a new browser window opens (see figure below). This window displays the web-based report.



- (1) A map based on the input shapefile

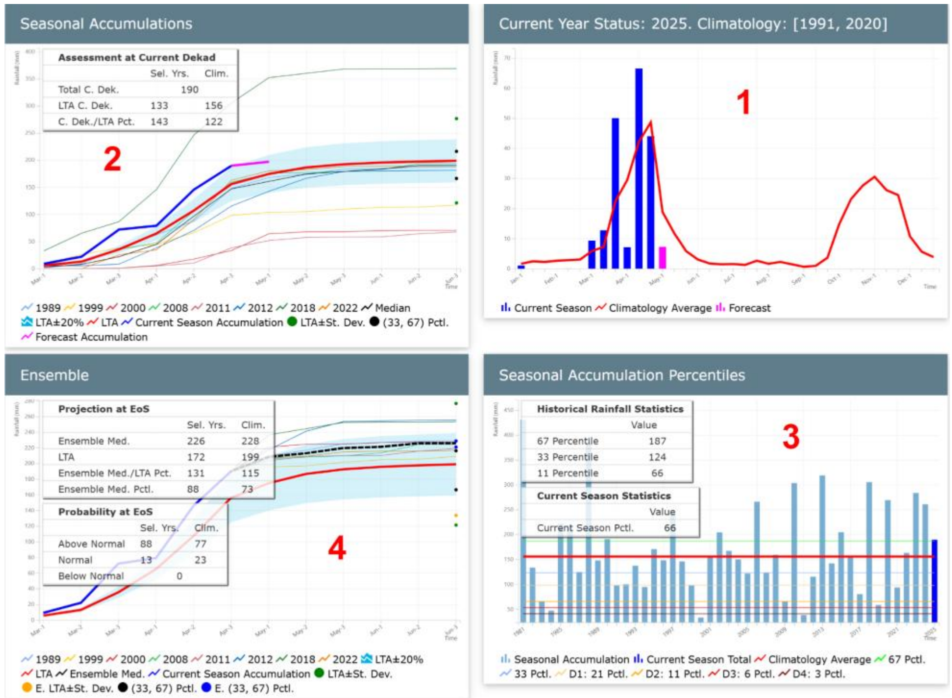
- (2) This section allows you to select an attribute to identify the polygons, such as name or ID, note that if the text for an attribute is too large for the polygon, it may not be displayed. Also, the ***Stat on Map*** field allows you to choose which map to display. The pull-down menu lists the maps selected during the SMPG execution. The legend updates dynamically based on the selected map.

- (3) Displays the list of polygons.

- (4) Returns to the main map window.

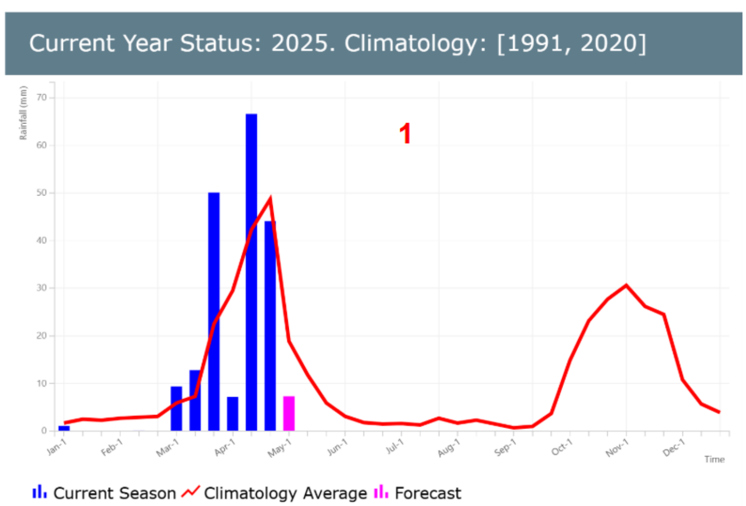
- (5) Displays the map legend for reference.

When you hover over a polygon on the map, its outline turns red, and its name appears in the upper right window. Clicking on a polygon displays four plots that show the current conditions for that specific region. See the four plots below.



The plots contain statistical results and a graph that describes the current season.

Plot 1: Current Rainfall Status (current year) Climatology [1991, 2020]



This plot compares current dekadal rainfall (blue bars) with the long-term average (red line) over the course of the current year, plus the forecast for the following dekad (pink).

- **Blue bars** represent the observed rainfall for the current year.

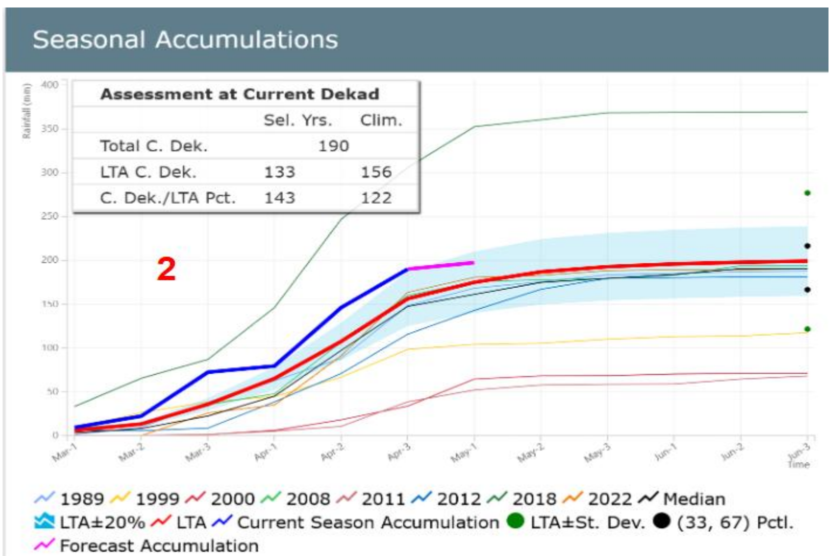
- **Red line** represents the **climatological average** over the selected historical period.
- **Pink bar** highlights the forecasted dekad.

 The statistics table includes:

- **LTA (Long-Term Average):** The historical average rainfall for the selected season.
- **Standard Deviation:** A measure of variability in historical rainfall.

Plot 2. Season accumulation

Displays cumulative rainfall across selected years, with the current season highlighted.



The **Assessment at current dekad** (CD) table contains the following rows:

I. **Total C. Dek.**: the accumulation from the start of season (defined in the tool) to current dekad - this calculation uses only the current-season values.
II. **LTA C. Dek.**: the accumulation of the long-term average from the SOS to current dekad. In the image above, this is the accumulation of the bold red line from the 1st of March to the 3rd dekad of June.
III. **C. Dek./LTA Pct.:** the percent of average for the accumulated precipitation from the Start of Season (SOS) up to the current period.

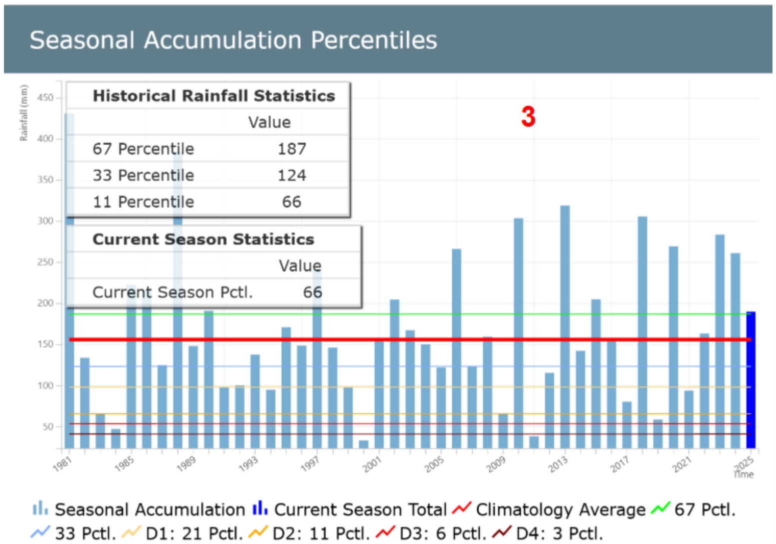
Another feature of the plot visualization includes **reference markers** on the right margin that help interpret the seasonal rainfall distribution:

- The **lower black circle** indicates the **33rd percentile**, representing a lower bound of what's considered a typical range for the climatological period.
- The **upper black circle** marks the **67th percentile**, serving as the upper bound of the typical range.

- The green circles represent the average +- a standard deviation.

Plot 3. Seasonal Rainfall Accumulation up to Current Dekad plot

Shows current cumulative rainfall (blue bar) compared to historical rainfall statistics such as the median and percentiles.

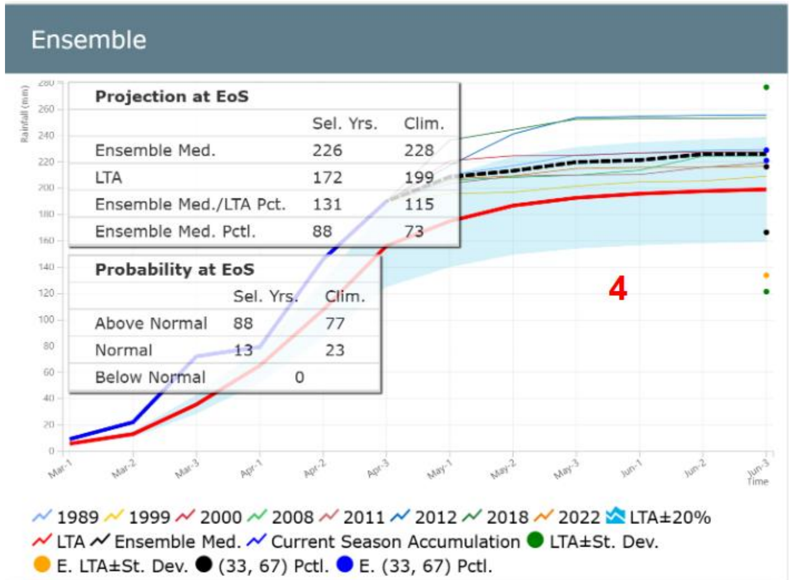


This plot includes the following lines:

- LTM-CD (red line): the average accumulation, using the climatological period defined
- 10 pct (yellow line): 10th percentile using the climatological period defined
- 33 pct (blue line): 33rd percentile using the climatological period defined
- 67 pct (green line): 67th percentile using the climatological period defined

Plot 4. Ensemble plot

The SMPG tool uses historical data from selected analog years to simulate the remainder of the current season, generating a range of possible scenarios. Based on these simulations, the SMPG calculates the probability of the season ending above-normal, normal, or below-normal. By determining the median of all scenarios, the tool identifies the most likely outcome for the season's end. The percentile rank of this most likely scenario indicates whether the season is expected to end above-normal (>67th percentile), normal (33rd-67th percentile), or below-normal (<33rd percentile).



This Ensemble plot illustrates the range of possible scenarios derived by using data from each of the selected years to complete the current season. The dotted line represents the median scenario or the most likely outcome.

Two tables are included with the Ensemble plot:

Projection at EoS (upper table)
This table describes the outlook at the end of the season. The table includes the following rows:

- **Ensemble Med**: the median of all the scenarios at the end of the season.
- **LTA**: the average at the end of the season calculated using the climatological period selected.
- **Ensemble Med./LTA Pct**.:the percent of the most likely scenario (dotted line) with respect to the long term average (red line) at the end of the season.
- **Ensemble Med. Pctl.**: the percent of the most likely scenario at the end of the season

Probability at EOS (lower table)
This table shows the probability of the season ending below normal (<33rd percentile), normal (between the 33rd and 67th percentiles) or above (>67th percentile) normal. The calculation is done by counting the number of scenarios in each range and dividing it by the total number of scenarios.

Acknowledgements

The SMPG was originally developed, in Excel, by Diego Pedreros based on previous work done by Greg Husak, with the support of Chris Funk, Greg Husak, Eric Alfaro, Hugo Hidalgo, and James Verdin. The Excel version was then programmed in Python by Jeaustin Andrey Sirias Chacón with the financial support from Hugo Hidalgo and Eric Alfaro from the Universidad de Costa Rica CIGEFI, UCT.