

**EUROPEAN SPACE AGENCY CONTRACT
REPORT**

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WASCIA – WATER STRESS AND CLIMATE INDICES FOR AFRICA

Associated documentation of processors/toolbox/
software – V1

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1 INTRODUCTION

1.1 *PURPOSE OF DOCUMENT*

This document is D9 deliverable for the ESA Water Stress and Climate Indices for Africa (**WaSCIA**) project. Principally, it contains the associated documentation of the processors. This is the first version of this document; the next version will be delivered at the end of the project and it will contain an updated version detailing the work done during the implementation phase. This document is not a User Handbook, as this will be D11.

The content of this document has been produced using the outputs of WP2.2.3 – Climate Indices Development, WP2.2.4 – Development of Threshold Warnings and WP2.2.6 – Validation & Testing.

D9 is for public distribution.

1.2 *CONTENTS OF DOCUMENT*

Following this introductory section, the document layout is as follows:

Section 2 presents the System Specifications. This is partitioned as:

Section 2.1 Cloud Environment

Section 2.2 Processing Workflows

Section 3 presents the System Documentation. This is partitioned as:

Section 3.1 Soil Moisture

Section 3.2 Climate Indices

Section 4 presents the Conclusions

1.3 REFERENCES

1.3.1 Applicable Documents

The following applicable documents are those referenced in the Contract or approved by the Agency. They are referenced in this document in the form [AD n.]:

AD	Title	Version / Date
AD 1.	Statement of Work - ESA Express Procurement [Plus] - [EXPRO+] - EO AFRICA - NATIONAL INCUBATORS EXPRO+	1.0 26/10/2021
AD 2.	KPT91865-AO11039-Proposal-EOAFRICA-R1r0.pdf	1.0 18/02/2022
AD 3.	WASCIA-KO-Minutes_1.0.pdf	1.0 07/10/2022

1.3.2 Reference Documents

The following reference documents are those referenced within this document. They are referenced in this document in the form [RD n.]. They are not applicable documents.

RD	Title / source	Version / Date
RD 1.	ESA Tiger initiative: looking after water in Africa [online] Available at: http://www.tiger.esa.int/	Accessed 30 Nov 2023
RD 2.	G. J. -P. Schumann et al., "An Online Platform for Fully-Automated EO Processing Workflows for Developers and End-Users Alike," 2021 IEEE International Geoscience and Remote Sensing Symposium IGARSS, 2021, pp. 8656-8659, doi: 10.1109/IGARSS47720.2021.9554498	2021
RD 3.	https://github.com/fadeoutsoftware/WASDI	Accessed 30 Nov 2023
RD 4.	https://www.mydewetra.org/	Accessed 30 Nov 2023
RD 5.	http://edrift.cimafoundation.org/DRF/	Accessed 30 Nov 2023
RD 6.	https://ghsl.jrc.ec.europa.eu/	Accessed 30 Nov 2023

1.4 ACRONYMS AND TERMS

The following acronyms and abbreviations have been used in this document.

Acronym / Term	Definition
C3S CDS	Copernicus Climate Change Services Climate Data Store
CCI	Climate Change Initiative
EO	Earth Observation
ESA	European Space Agency
PET	Potential Evapotranspiration
TEP	Thematic Exploitation Platforms
SEN	Senegal
WaSCIA	Water Stress and Climate Indices for Africa

2 SYSTEM SPECIFICATIONS

2.1 CLOUD ENVIRONMENT

Cloud computing is a revolutionary paradigm that has transformed the landscape of IT infrastructure and services. In this dynamic environment, computing resources such as servers, storage, databases, networking, software, and analytics are delivered over the internet on a pay-as-you-go basis. Unlike traditional on-premises models, cloud computing provides scalable and flexible solutions, allowing businesses to rapidly scale resources up or down based on demand. This transformative approach enhances agility, promotes collaboration, and reduces capital expenditures, enabling organisations to focus on innovation and strategic initiatives rather than managing complex hardware and software infrastructure. The cloud computing environment has become integral to modern business operations, fostering innovation, efficiency, and global connectivity.

EO and climate data are dramatically increasing in volume and complexity, just as the users of these data in the scientific community and the public are rapidly increasing in number. This increase in data volume is projected to grow even more over the next decade, which creates challenges for not only physical archiving and sharing of the data, but for ease of access, finding the right data, and how decision-ready information can be extracted from these data archives. Moreover, meeting the growing need for full exploitation of EO and climate assets, data access and usage across Africa has been impeded by technological limitations i.e. low-bandwidth and infrastructure bottlenecks that still persist across the continent.

Innovative EO-based solutions and the latest cloud computing technologies are recognised as important tools to overcome these challenges. Significant progress has been made in recent years regarding the development of more accessible EO and climate data archives and platforms that “bring the user to the data”, e.g. ESA Thematic Exploitation Platforms (TEP), ESA Climate Change Initiative (CCI) Portal and Copernicus Climate Change Services Climate Data Store (C3S CDS). At the same time, long term programs such as the TIGER initiative [RD 1] have been conducted by ESA to promote the use of EO for achieving the sustainable development goals by the African stakeholders and to help them overcome problems faced in the collection, analysis and use of geo-information by exploiting the advantages of space technology. However, there are still gaps when it comes to transferring knowledge and expertise to the African organisations and policy makers so they can fully exploit the resources and EO assets available through these programs.

WaSCIA is an innovative EO-based solution for climate and water stress monitoring at a national scale over Senegal based on Sentinel-3 satellite data and state-of-the-art

atmospheric reanalysis data from the fifth generation ECMWF atmospheric reanalysis (ERA5).

The system uses open source cutting edge information technology (cloud computing, geospatial data analysis platforms, etc.) as it has been deployed using an existing cloud-based platform, WASDI.

On the WASDI platform, we have developed two main WaSCIA applications, soil moisture processing and climate indicators processing. Alongside these we have also developed the threshold warning tool.

2.1.1 WASDI

The WASDI platform is made available for use in the WaSCIA project by “WASDI Sarl”, a Luxembourg registered company. A full description of the WASDI platform has been published in the scientific literature [RD 2] with source code made available on GitHub [RD 3]. WASDI has been used in several projects by researchers and EO experts, including CIMA foundation DEWETRA platform [RD 4], Earth Observations for Disaster Risk Financing program (eDRIFT [RD 5]) and European Commission’s Joint Research Centre Global Human Settlement Layer (GHSL [RD 6]).

WASDI provides a complete documentation centre:

[Wasdi Web Platform access and basic usage — WASDI documentation center documentation](#)

The most relevant content of this website for the project stakeholders is:

- Getting Started. Any new user needs to follow the set-up instructions in this section in order to have access to the WaSCIA applications and data.
- WASDI User Manual. Users should consult this manual to understand how to access WaSCIA data and to understand the concept on how WASDI works.

In addition, the project partners involved in the applications development, have access to the programming tutorials, also available in that website.

2.2 PROCESSING WORKFLOWS

2.2.1 Soil Moisture: HydroSENS-SWS

HydroSENS-SWS: HydroSENS-Soil Water Stress

The application including the Soil Moisture index, and the Evapotranspiration index are computed in two steps, and the application on WASDI is referred to as “HydroSENS-SWS”. The first step consists of processing the two indices and the second one consists of the

downscaling. To create an easy-to-use application, we decided to regroup the two components into one single application. This application is called `wascia_hydrosens_ws` and is deployed to run Soil Moisture and Evapotranspiration indices. Currently, only the first step has been deployed on WASDI.

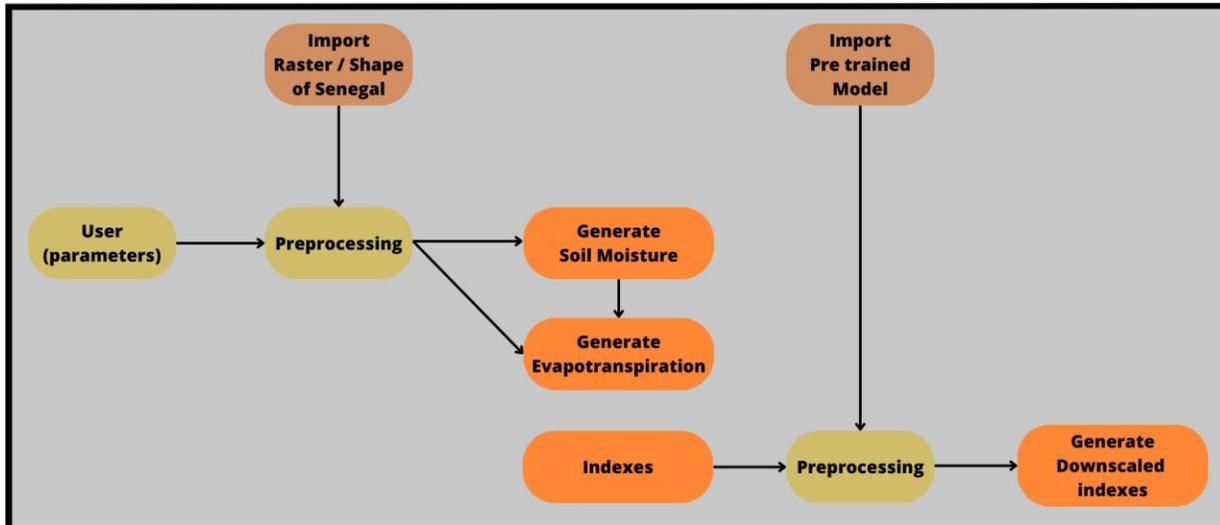


Figure 2-1: Workflow diagram of the application in WASDI

Figure 2-1 illustrates the workflow, using Sentinel 3 and Sentinel 2 data. However, we only have access to the data originating from Sentinel 3A, as Sentinel 3B data are faulty. Regarding the Sentinel 2 images the code will only work with data originating from the level MSIL2A of the S2A and S2B. At the current stage, the user needs to download this product into his workspace before launching the application. Soon the user will be free of this task and will only need to choose some parameters (date, cloud coverage, area, downscaled, downscaled with or without using a pretrained model, etc.). Regarding the area of use case, the user will be limited by a bounding box around the Senegal, and will have the opportunity to draw or place a rectangle in the area of interest in order to proceed to the downscaling.

In addition, the users will also be able to choose if the data should be processed one by one, producing individual outputs, Figure 2-4, or if the data should be processed all together, producing one single output, representing the mean values of the time series.

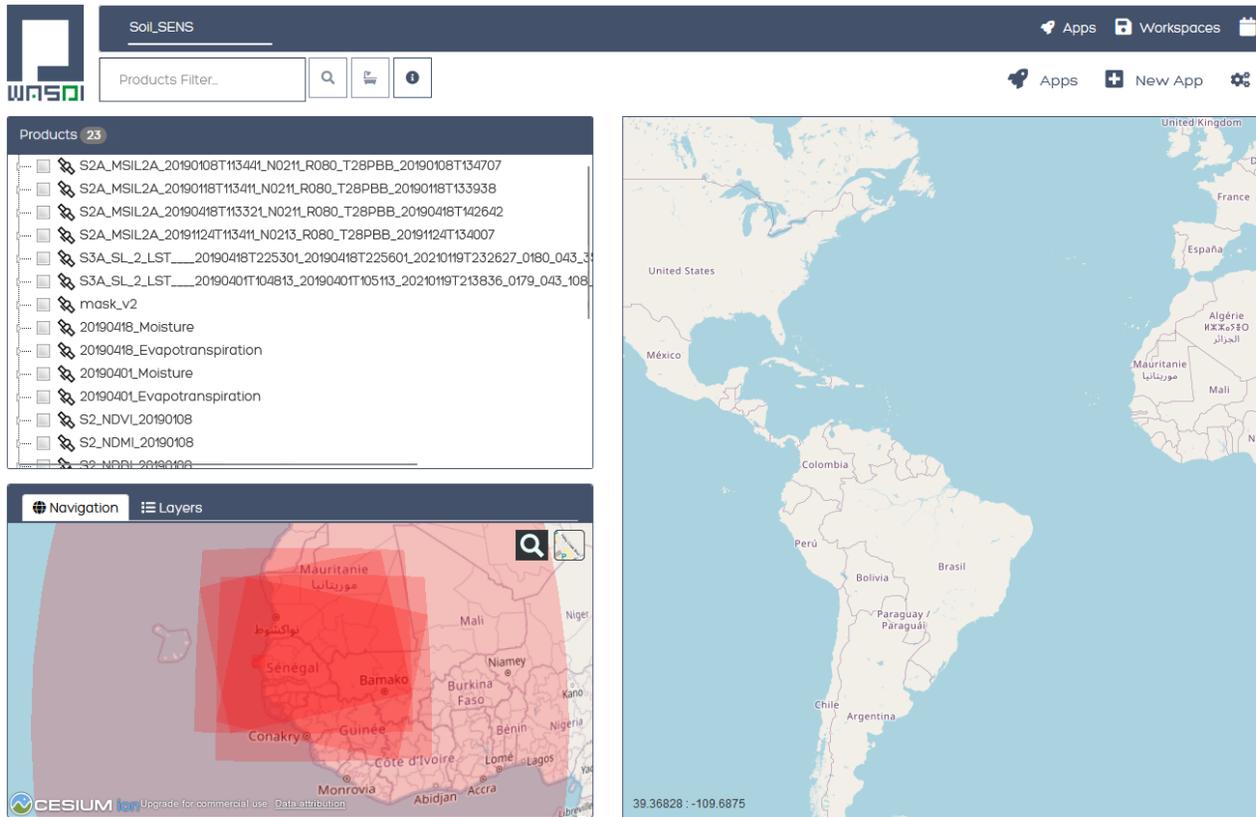


Figure 2-2: Presentation of the workspace and the index

The necessary files (As described in the workflow) are available on a workspace called “HydroSENS” and need to be imported by the user. To do so the files need to be downloaded before launching the application. The first file to import is a raster defining the shape of the country, to erase all the data that could corrupt the output. The second one is the pretrained model, which will be re-trained every 2 or 3 months. In the near future, one of the objectives is to make this process fully automated.

Finally, to have a user-friendly workspace, only the final index will be displayed. However, the user will have the possibility to get the S2 index by customizing the variables (Figure 2-4). For the more experienced users, and depending on the progress made by the WASDI developers on the Jupiter Notebook, we will work on giving them access to further functionalities, such as graphs to help them understand the disparities between the Surface Temperature and the Vegetation and study their correlation.

An important element to add here is that historical back-processing is important to stakeholders. In this respect, MODIS (and Landsat) satellite data could provide an excellent complementary source to the Sentinel-3 mission data by providing a longer historical record of essential climate variables, particularly for land surface temperature (LST) and vegetation indices (VIs) as used in the simple triangle method employed in

WaSCIA. MODIS has been operational since 2002, providing over 20 years of continuous data, while Sentinel-3 was launched in 2016, offering a shorter but more recent data record. This combination of long-term and recent data allows for more comprehensive and robust climate risk assessments and studies of interannual and long-term variability in Earth's climate change impacts.

However, historical back-processing would very likely require additional resources, both in terms of time and budget, and therefore it is suggested to look at this element towards the end of the project.

2.2.2 Climate Indices

The climate indices workflow has two main components: the pre-processor and the processor.

2.2.2.1 Pre-processor

The pre-processor for the climate indices is needed in order to prepare the required input data. The pre-processing is done by two different applications:

- ***wascia_preprocessor_era5-land_data***, which runs the pre-processing for the temperature and precipitation data. This application opens the previous pre-processed data file and checks the date of most recent data it contains. It then checks in WASDI if any more recent ERA5-Land data is available (ERA5-Land data is available in WASDI 100 days behind the current date) and downloads any new ERA5-Land data. The application resamples the new ERA-5-Land data from hourly to daily data and crops the dataset extent to the area of Senegal. This new data is then appended to the pre-processed data files.
- The output pre-processed data files are:
 - Daily mean temperature (t2m): *t2m_daily_ERA5-Land_SEN_total*
 - Daily maximum temperature (tasmax): *tasmax_daily_ERA5-Land_SEN_total*
 - Daily minimum temperature (tasmin): *tasmin_daily_ERA5-Land_SEN_total*
 - Daily total precipitation (tp): *tp_daily_ERA5-Land_SEN_total*.

Figure 2-5 shows the workflow diagram. This data pre-processing step is expected to be run automatically, although at the moment it needs to be run manually. Once the scheduling of applications is implemented in WASDI, this process will be scheduled to be run once a week to automatically update the pre-processed data files with newly available ERA5-Land data.

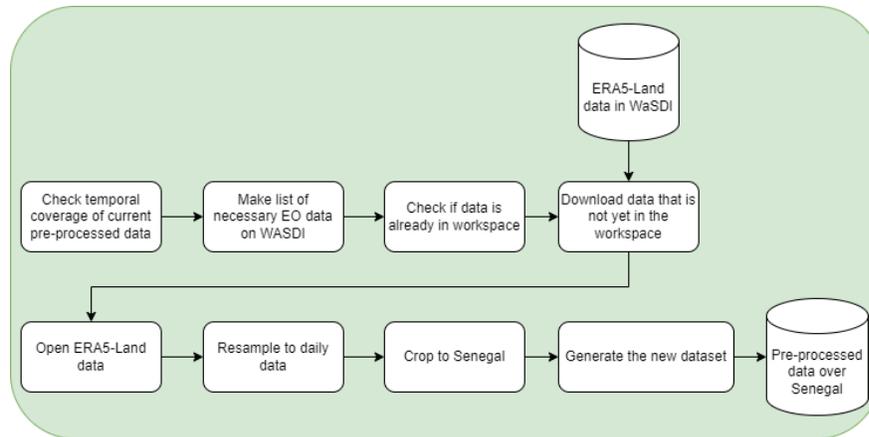


Figure 2-3: Workflow diagram of the climate indices pre-processor

- **wascia_preprocessor_pet_data**, which runs the pre-processing for the PET data. This application opens the previous pre-processed data and updates it with the most recent PET data available in WaSCIA PET Data Store. The PET data is updated every January with the latest year data. This application updates the file *pet_daily_ERA5-Land_SEN_total**, see Figure 2-6.

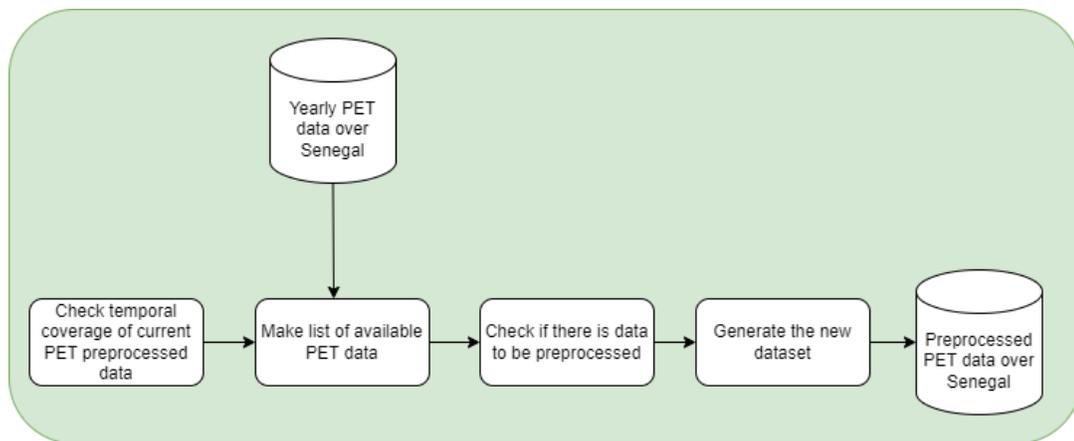


Figure 2-4: Workflow diagram of the climate indices PET data pre-processor

As mentioned above, WaSDI works in workspaces. For running the pre-processor applications, two project workspaces are considered:

- **WaSCIA PET Data Store**, this workspace stores the PET data cropped over Senegal, which is ingested by the **wascia_preprocessor_pet_data** application. See Figure 2-5.

- **WaSCIA Pre-processed Data Senegal**, this workspace stores the pre-processed data which is the input for the climate indicators processor. The applications **wascia_preprocessor_era5-land_data** and **wascia_preprocessor_pet_data** belong to this workspace, so they can only be run from this workspace. See Figure 2-6.

At the moment, these two workspaces are only accessible by Telespazio UK. During the implementation phase, the accessibility will be also shared with whoever will play the role of administrator of the service. As this workspace contains the input data for the climate indicators which is also used by the threshold warning tool, it is recommended to limit its accessibility to avoid potential damage to the input datasets.

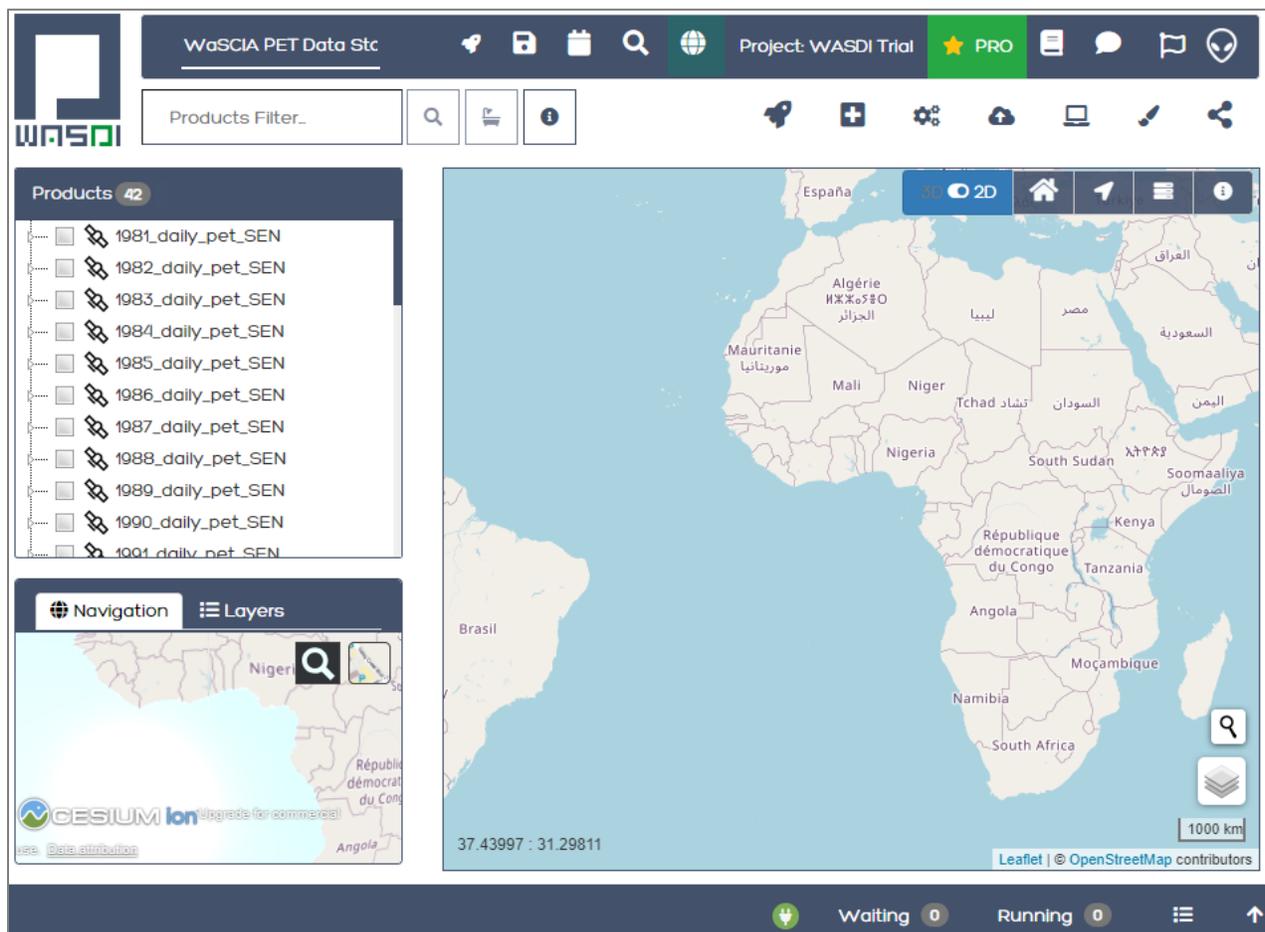


Figure 2-5: WaSCIA PET Data Store workspace.

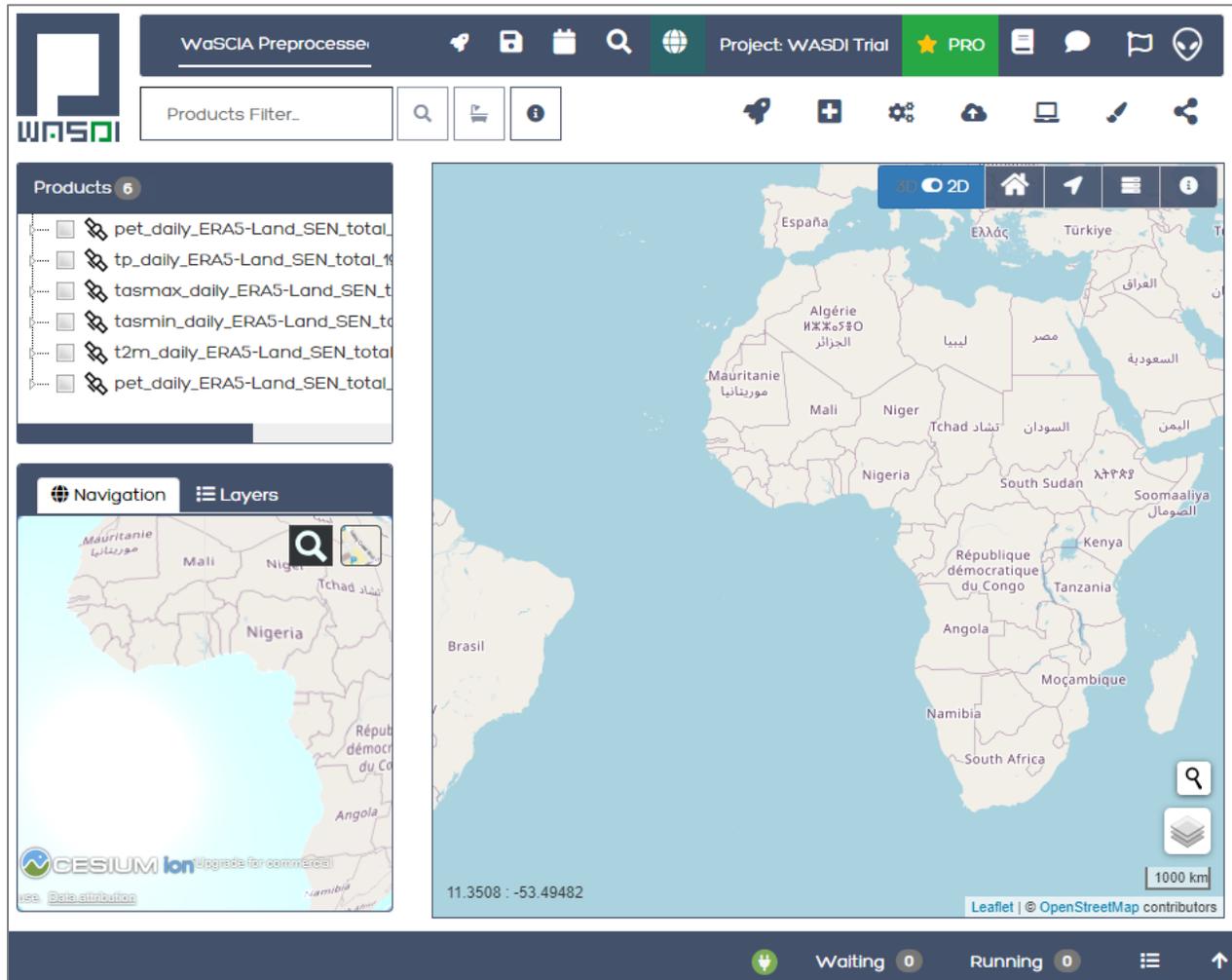


Figure 2-6: WaSCIA Pre-processed Data Senegal workspace.

2.2.2.2 Processor

The processor is the application that calculates the climate indices. This application is named **wascia_processor_climate_indicators** and is publicly accessible to any WASDI user. Figure 2-7 shows the application in WASDI marketplace.

To run the application, the user will enter their personal workspace and load the processor application. The user will then need to select the climate index of interest from a dropdown menu, before running the application, see Figure 2-8.



Figure 2-7: WaSCIA application for climate indices processing in WASDI marketplace.

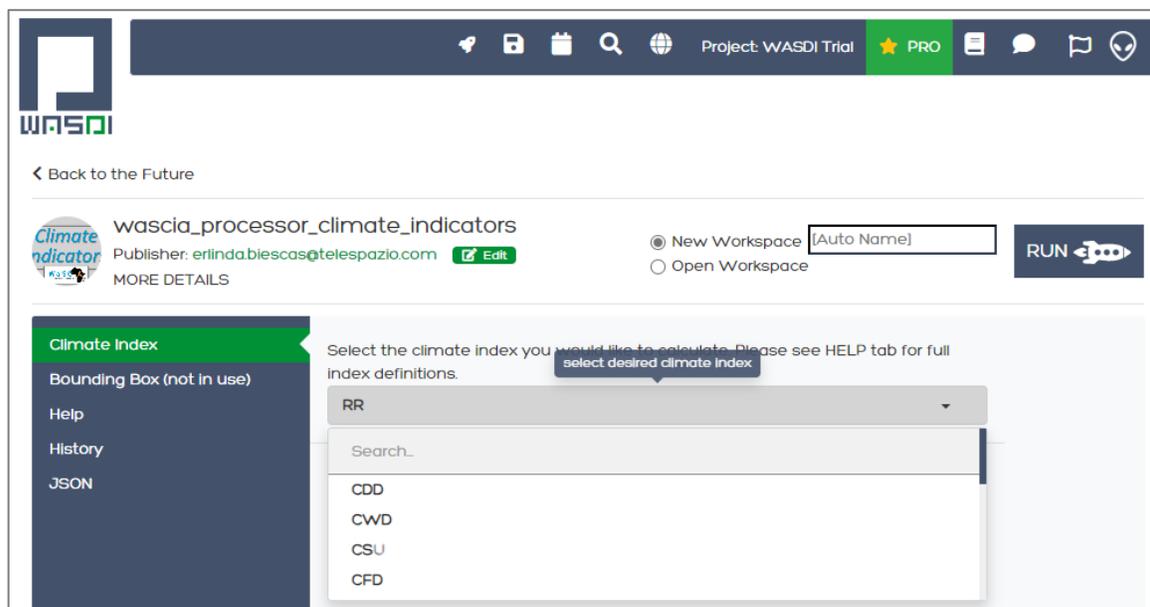


Figure 2-8: WaSCIA application for climate indices processing run in WASDI.

When the application is run, the processor follows the workflow below, also outlined in Figure 2-9.

- From within their personal workspace, the user will load the processor application and select the climate index of interest.
- The processor accesses the required pre-processed data file(s) from the **WaSCIA Pre-processed Data Senegal** workspace. The processor has permission to download the latest pre-processed data file from this restricted workspace even though the user does not have specific access to this workspace.
- The appropriate function is run to generate the climate index of interest.
- The climate index is saved as a netcdf data file to the user's personal workspace.

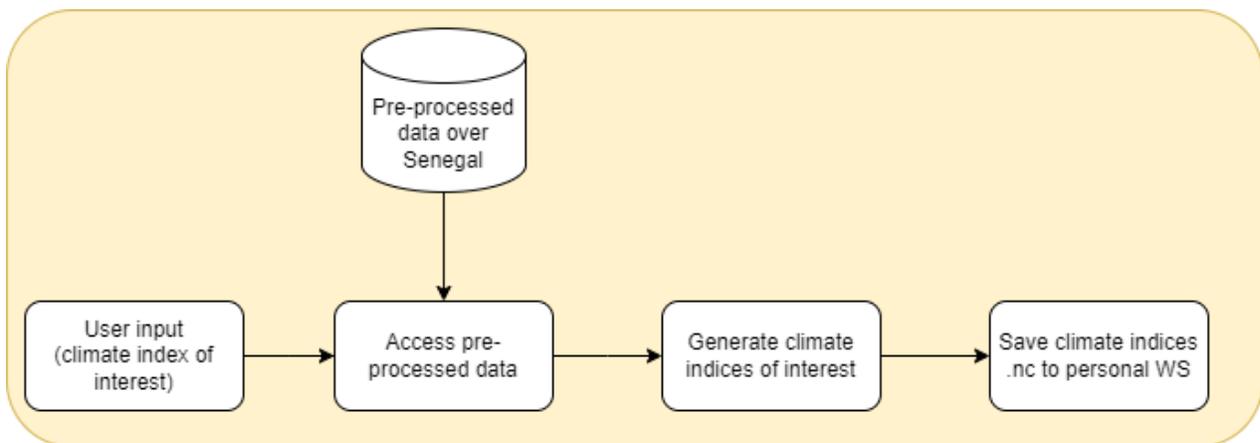


Figure 2-9: Climate indices processing workflow.

2.3 DATA ANALYSIS TOOLS

2.3.1 Jupyter Notebooks

We have developed a suite of Jupyter Notebooks which sit alongside the generated climate indices and soil moisture products and enable users to easily interact with the data and extract valuable insights. These interactive tools are designed to help the users understand the data and aim to support effective decision-making.

These notebooks have been developed in the Jupyter environment, which is a highly versatile and interactive solution that empowers non-technical users to interact with complex data. Some of the benefits of Jupyter notebooks are outline below:

- **Interactive Jupyter Environment:** The Jupyter Notebook environment is accessible through a web-based interface that is user-friendly and intuitive. The interface is designed with non-technical users in mind, featuring a simple and visually appealing layout. Users can easily navigate the tool without requiring extensive technical expertise.
- **Data Integration:** The notebooks seamlessly integrate all climate indices available on the platform. The data products are regularly updated to provide near real-time information. As the Jupyter Notebook environment is integrated in WASDI, it ensures easy access to the climate indices detailed in the section above.
- **Interactive Visualisation:** The tool offers interactive visualisations that allow users to plot historical time series data of climate indices. Users can easily switch between different indices and time periods for analysis.
- **Customisable:** Users can customise the Jupyter notebooks to display the specific climate indices and soil moisture products relevant to their agricultural region and crop of interest.
- **Data Export and Reporting:** Users have the option to export data and generate reports directly from the Jupyter environment. These reports can be used for documentation, sharing insights with stakeholders, or future reference.

The Jupyter notebooks will be made available to users to download from the WaSCIA project website. After this, users will need to upload them into their own WASDI workspace in order to use them.

2.3.2 Climate Indices Simple Plotting Functions

This notebook is called ***WaSCIA Climate Indices Simple Plotting*** and has been prepared to demonstrate some simple plotting of the WaSCIA climate indices. The notebook is designed to sit alongside the user's WASDI workspace. After running the climate indices application (***wascia_processor_climate_indicators***) and generating the climate indices of interest, the notebook will read these output data files directly from the user's workspace.

A number of plotting functions have been developed to generate a range of common timeseries and heatmap plots as follows:

- a) A timeseries plot of the mean data values for the whole of Senegal (user inputs: start and end dates)
- b) A timeseries plot of the maximum data values for the whole of Senegal (user inputs: start and end dates)
- c) A timeseries plot of the minimum data values for the whole of Senegal (user inputs: start and end dates)
- d) A timeseries plot of the data values for a specific location (user inputs: start and end dates, latitude and longitude)

- e) A heatmap plot of Senegal, plotting the mean data values for a selected time period (user inputs: start and end dates)
- f) A heatmap plot of Senegal, plotting the maximum data values for a selected time period (user inputs: start and end dates)
- g) A heatmap plot of Senegal, plotting the minimum data values for a selected time period (user inputs: start and end dates)
- h) A heatmap plot of Senegal, plotting the data values for a specific date (user inputs: date/ week/ month/ year)

While not all the plots will be relevant for all of the indices, these plots are intended as examples and we encourage the users to select the most appropriate plot for their purpose and/or adapt the code as necessary. Figure 2-10, Figure 2-11, Figure 2-12 and Figure 2-13 illustrate the tool.

WaSCIA Climate Indices - Simply Plotting Functions

This Jupyter Notebook has been prepared to demonstrate some simple plotting of the WaSCIA Climate Indices.

PLEASE NOTE: Before using this Jupyter Notebook you need to generate the climate indices of interest by running the 'WaSCIA Processor Climate Indices' application in WASDI from your personal workspace. Once the processing is complete and the netcdf outputs are available in your personal workspace, come here to use the plotting functions.

STEP 1: Installing required libraries

When using this notebook for the first time, uncomment this cell and run it to install the required libraries. After the first time you can comment this section for ease.

```
#!pip install xarray ...
```

STEP 2: Importing required libraries

Run this cell to import the required libraries and log in to WASDI.

User input needed: when prompted input your WASDI username and password.

```
import xarray as xr ...
```

STEP 3: Select your climate index

User input needed: specify below the name of the climate index you wish to plot.

The climate indices available and their temporal resolution are:

- CDD = Maximum number of Consecutive Dry Days (Yearly)
- CWD = Maximum number of Consecutive Wet Days (Yearly)
- CSU = Maximum number of Consecutive Summer Days (Yearly)
- CFD = Maximum number of Consecutive Frost Days (Yearly)
- SPEI = Standardised Precipitation Evapotranspiration Index (Monthly)
- RR = Precipitation Sum (Weekly)
- R1mm = Wet Days (Weekly)
- R10mm = Heavy Precipitation Days (Weekly)
- R20mm = Very Heavy Precipitation Days (Weekly)
- WW = Warm and Wet Days (Weekly)
- WSDI = Warm Spell Duration Index (Yearly)
- CSDI = Cold Spell Duration Index (Yearly)

Figure 2-10: WaSCIA Jupyter Notebook with plotting functions (1/4)

The image shows a Jupyter Notebook interface with the following content:

STEP 4: Load the climate index data array

This section loads the input data arrays and climate indices arrays from your personal workspace.

User input needed: specify below the filename of the climate index array you wish to plot.

```
Climate_index_file = "SEN_DTR_tempRes-W_1981-01-01_2023-08-19.nc" #user input needed here ...
```

```
# when opening the climate indices arrays 'decode' is needed to prevent xarray from automatically convert ...
```

STEP 5: Explore the climate index data array (optional)

The following commands are useful if you wish to explore the climate index data array

```
ClimateIndexArray.coords # this prints out the coordinates of the climate index array ...
```

```
#ClimateIndexArray.attrs # this prints out the attributes of the climate index array ...
```

```
#ClimateIndexArray.values # this prints out all the data values of the climate index array ...
```

STEP 6: Example Plotting Functions

The following sections include example plotting functions for climate indices. Not all plots will be relevant for all indices, you will need to choose the most appropriate in each case.

Timeseries plots

The code below plots the selected climate index for the specified time period. The plot options are:

- A) To plot the mean values for the whole of Senegal (inputs needed: start and end dates)
- B) To plot the maximum values for the whole of Senegal (inputs needed: start and end dates)
- C) To plot the minimum values for the whole of Senegal (inputs needed: start and end dates)
- D) To plot data values for a selected location (inputs needed: start and end dates, latitude and longitude)

Plot A

To plot the mean values for the whole of Senegal (**user inputs needed: start and end dates**)

```
## Plot A ...
```

Figure 2-11: WaSCIA Jupyter Notebook with plotting functions (2/4)

The screenshot shows a Jupyter Notebook interface with the following content:

- Plot B**: To plot the maximum values for the whole of Senegal (**user inputs needed: start and end dates**)
Code cell: `## Plot B ...`
- Plot C**: To plot the minimum values for the whole of Senegal (**user inputs needed: start and end dates**)
Code cell: `## Plot C ...`
- Plot D**: To plot data values for a selected location (**user inputs needed: start and end dates, latitude and longitude**)
Code cell: `## Plot D ...`
- Map plots of Senegal**: The code below plots the selected climate index for the whole of Senegal for a given time period. The plot options are:
 - E) To plot the mean values for a selected time period (inputs needed: start and end dates)
 - F) To plot the maximum values for a selected time period (inputs needed: start and end dates)
 - G) To plot the minimum values for a selected time period (inputs needed: start and end dates)
 - H) To plot the climate index values for an individual date (inputs needed: date/ week/ month/ year)
- Plot E**: To plot the mean data values for a selected time period (**user inputs needed: start and end dates**)
Code cell: `## Plot E ...`
- Plot F**: To plot the maximum values for a selected time period (**user inputs needed: start and end dates**)
Code cell: `## Plot F ...`

Figure 2-12: WaSCIA Jupyter Notebook with plotting functions (3/4)

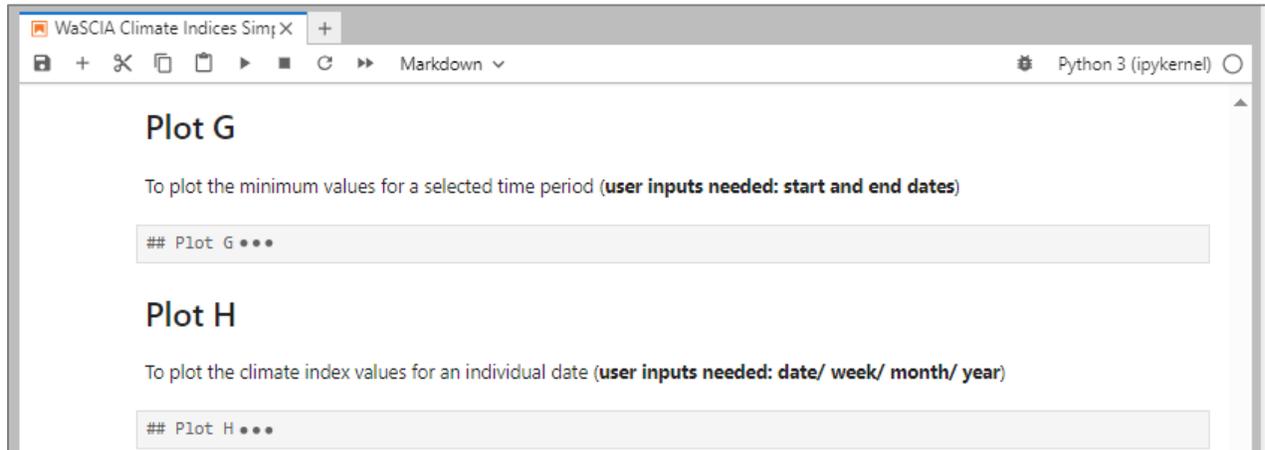


Figure 2-13: WaSCIA Jupyter Notebook with plotting functions (4/4)

2.3.3 Threshold Warning Tool

This notebook is called **WaSCIA Threshold Warning Tool** and has been prepared to enable users to compare the climatology and the in-season time-series of a selected climate index. The notebook is designed to sit alongside the user's WASDI workspace. After running the climate indices application (**wascia_processor_climate_indicators**) and generating the climate indices of interest, the notebook will read these output data files directly from the user's workspace.

The notebook has the following functionality:

- **Climatology Generation:** For the selected climate index, the notebook will calculate the climatology of that index, using historical data from the baseline period 1981 to 2010. This climatology can be used as a reference to understand how the climate index typically varies throughout the year.
- **Threshold Definition:** Non-technical users can define threshold values for climate indices levels directly within the Jupyter environment, by investigating the climatology plots. This process is user-friendly and doesn't require coding skills. Users can visualise their defined thresholds, enabling them to assess whether current in-season values are above or below the thresholds. This information is presented graphically for easy interpretation.
- **Decision Support:** The tool provides actionable recommendations and guidelines based on threshold violations.

Figure 2-14 and Figure 2-15 show the tool in Jupyter Notebook. The scripts are divided in steps, so the user can easily identify where the inputs are needed.

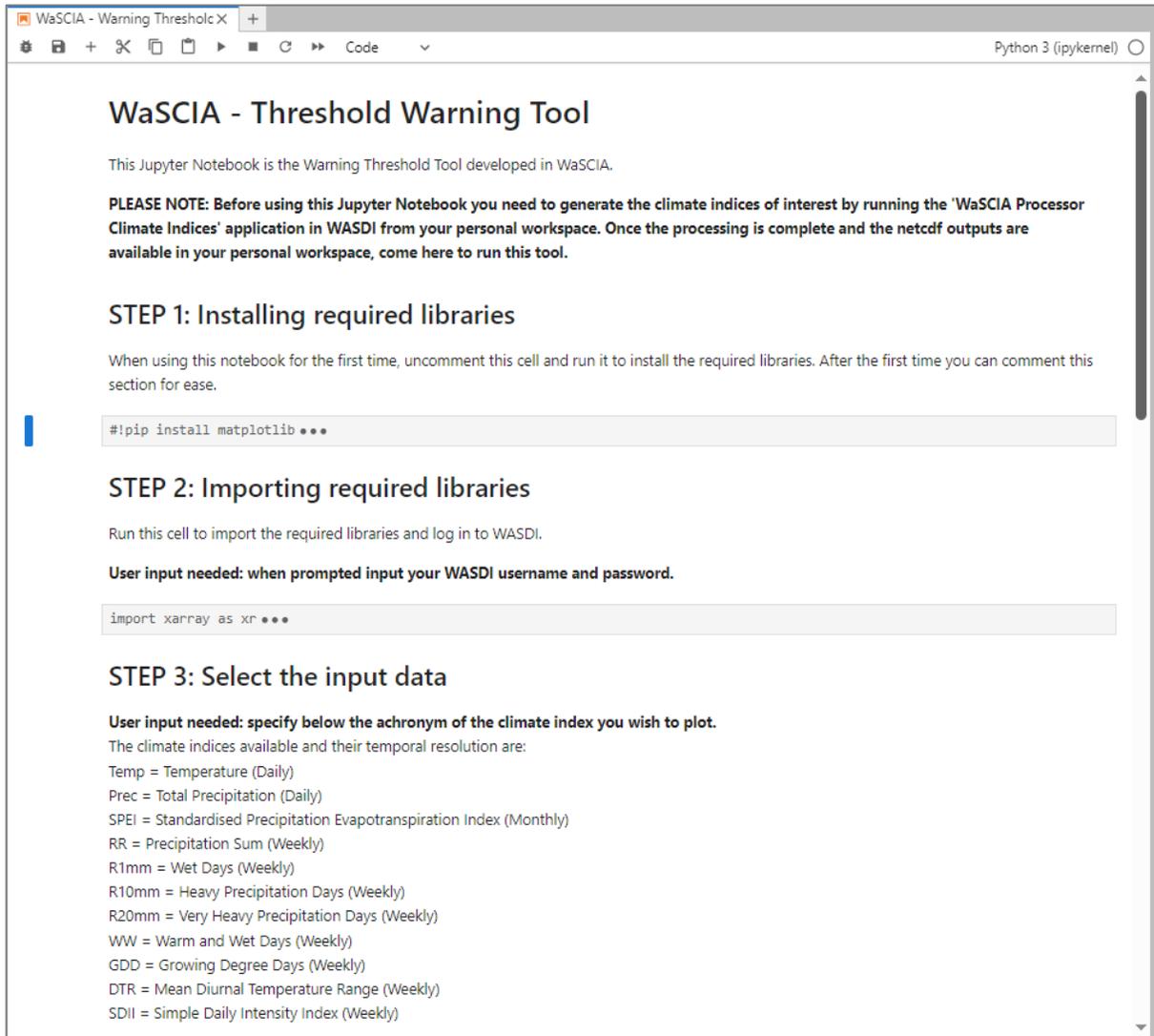


Figure 2-14: WaSCIA thresholds warning tool, steps 1, 2 and 3.

```
User input needed: Period of analysis.

# Starting date for the analysis ...

User input needed: Threshold type and values. Valid values: 'Percentile', 'Absolute Value' or 'Standard Deviation'
If threshold_type is 'Percentile' or 'Absolute Value' both a minimum and a maximum values are needed

threshold_type = 'Percentile' ...

STEP 4: Definition of functions required for the Warning Thresholds

Please, do not modify the code in this step.

##### Plotting function ##### ...

##### Plotting Description function ##### ...

##### Statistics function ##### ...

STEP 5: Calculating parameters from the inputs

This section loads the input data arrays and climate indices arrays from your personal workspace and creates all the parameters needed to run the plotting functions.

##### Calculating parameters from the inputs ##### ...

STEP 6: Run the Warning Thresholds

TsThresholdMin, TsThresholdMax = set_stats(refTs, threshold_type, refTsRolling, temp_res, threshold_value_min, threshold_val ...

...
```

Figure 2-15: WaSCIA thresholds warning tool, steps 4, 5 and 6.

2.4 CLOUD-ENVIRONMENT INTEGRATION

This section is a manual for the integration/deploy the processors on an existing operational platform environment by third parties. It will be completed during the following months, when the integration activities are carried out.

3 SYSTEM DOCUMENTATION

3.1 HYDROSENS-SWS

The HydroSENS-SWS (soil water stress) system has two main components: the application processor, including soil moisture, evaporation, and (optional) downscaling using Sentinel-2 indices. Figure 3-1 shows the workflow for this system.

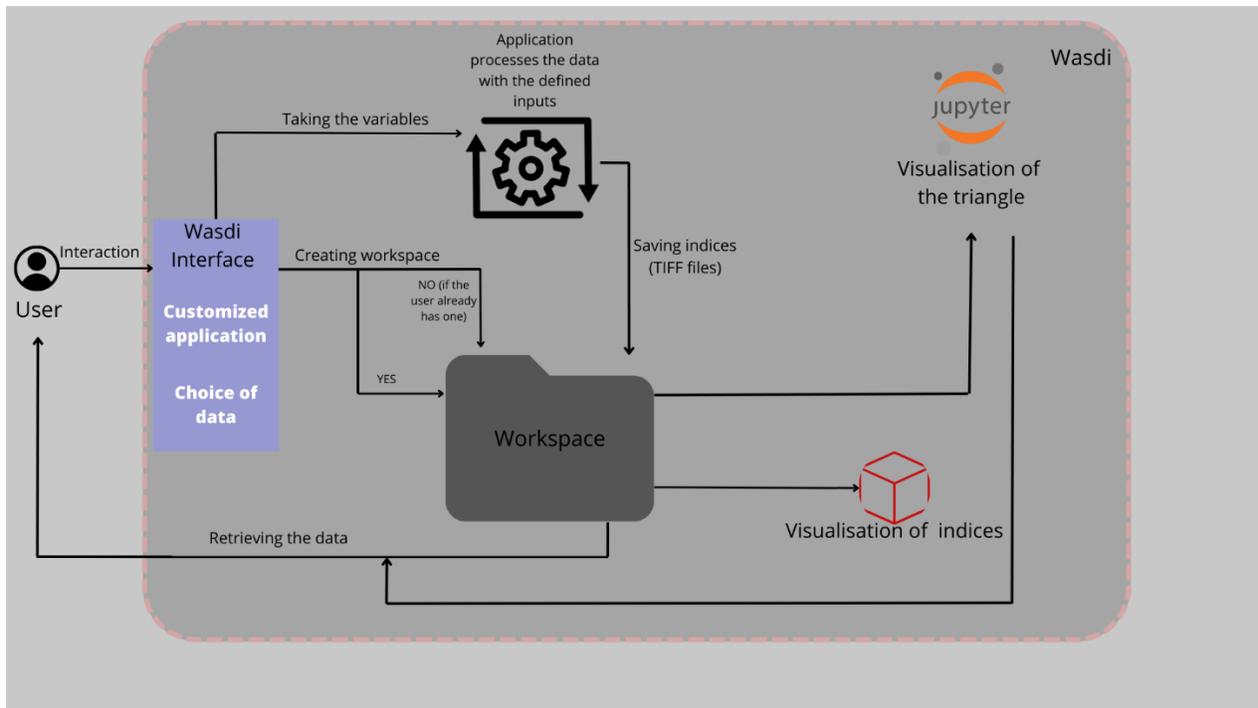


Figure 3-1: The processor workflow diagram of the HydroSENS-SWS application in WASDI

3.2 CLIMATE INDICES

The climate indices system has two main components: the pre-processor and the processor. Figure 3-2 shows the workflow for this system. This diagram includes also the threshold warning tool, which is described in section 2.3.

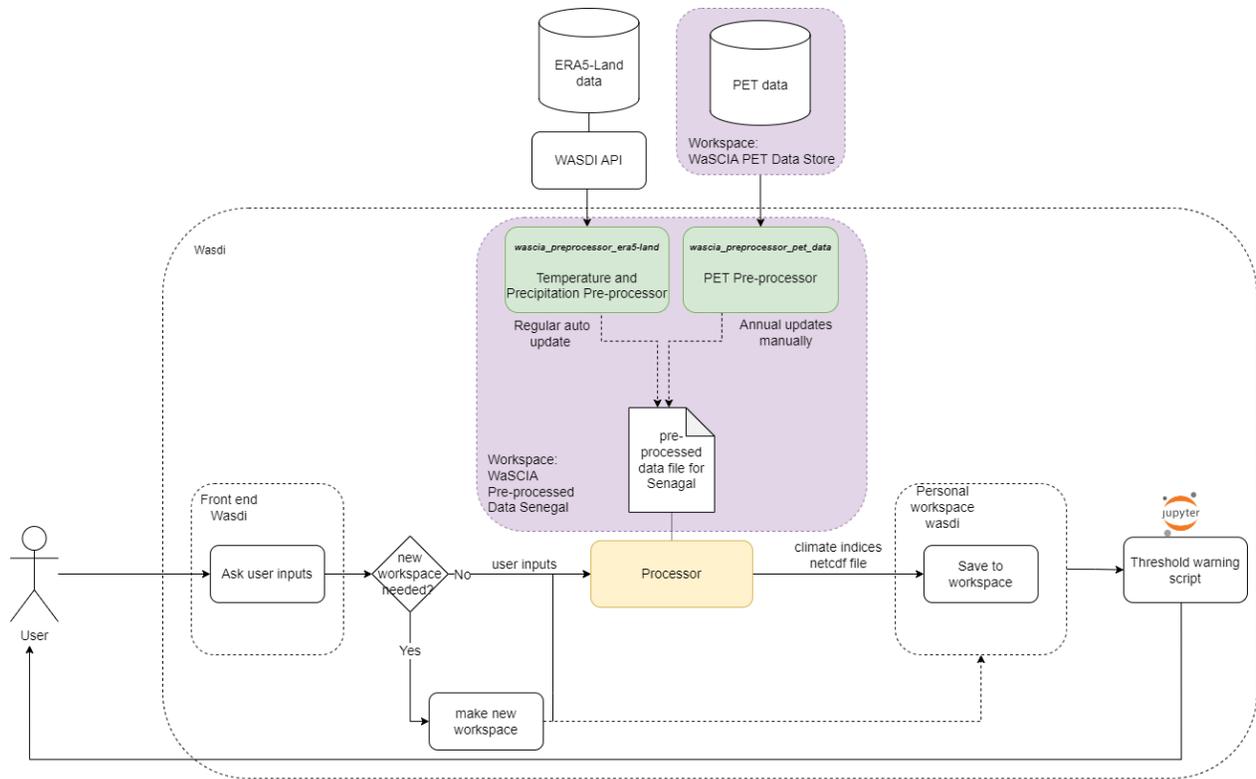


Figure 3-2: Diagram of the climate indices pre-processor and processor.

4 INSTALLATION GUIDE

Currently no installation is needed, as the system works in the WASDI website cloud environment. In case the process implementation involves in a desktop based service, this section will be updated.

5 CONCLUSIONS

The system developed in WaSCIA is a set of processors deployed in WASDI, a powerful cloud-based platform optimised for the exploitation of EO data.

WaSCIA system is divided into three main modules:

- **HydroSENS-SWS:** The soil water stress application computes a soil moisture index and evaporative losses from Sentinel-3 and uses Sentinel-2 indices to downscale employing a random forest ML algorithm. The user can run this process on the WASDI cloud computing environment selecting an area of interest. The results can be visualised using Jupyter Notebook for plotting time series average trends over the area for Soil Moisture (SM) and Evaporative Water Loss (EWL). These averages are taken from a weekly average image composite that can be optionally downscaled to 20 m and visualised on the WASDI interface.
- **Climate Indices Application:** The objective of this module is to deliver a set of climate indices over Senegal. This goal can be easily achieved by the user by running an application in WASDI. However, behind this simple application, other processes have been implemented in order to be able to provide the data needed.
- **Threshold Warning Tool:** This tool aims to help in the decision-making process allowing the analysis of the climate indices mentioned above. Jupyter Notebook, which is integrated into WASDI, is used to generate plots of the climate indices that can be tailored to the user needs. In addition, the tool provides a description of the plot to help identify the main characteristics. In the future, the tool will also provide a suggestion on actions to be performed given the results analysed.

During the following months, the project will be focused on the platform integration and the system deployment, and this document will be updated with that information.

[End of Document]