Workshop report: Training on IRI Climate Data Tools and developing a method for integrating climate data

Kigali, Rwanda

August 2017

Rija Faniriantsoa

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Abstract

For more than five years, the Rwanda Meteorological Agency (Météo Rwanda) and the International Research Institute for Climate and Society (IRI) have been working together to implement the IRI's Enhancing National Climate Services initiative (ENACTS) in Rwanda. The ENACTS initiative brings climate knowledge into national decision- making by improving availability, access and use of climate information. Météo Rwanda staff have received a number of trainings on the different aspects of generating the datasets and developing climate information products. However, the tools used to generate ENACTS datasets have been evolving through addition of several new features. As a result, it is necessary to revise the training and to expose the staff to the new version of the tools. On the other hand, Météo Rwanda has started operating a network of automatic weather stations (AWS) and a weather radar. The integration of these datasets to ENACTS datasets is very important to improve the quality of climate data in Rwanda. Thus, the current training activities had three major components: (1) make a full use of the IRI Climate Data Tools (CDT) to create and analyze ENACTS datasets; (2) develop quality control procedures and create scripts to integrate data from the AWS network into ENACTS datasets; and (3) create scripts to process and adjust the radar-based precipitation estimates with data from the AWS network and integrate the processed data into ENACTS datasets.

Keywords

Climate information services; Rwanda; Climate forecast; Climate data; Adaptation; ENACTS; Training

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Contents

Acronyms

AWS	Automatic Weather Stations
CDT	IRI Climate Data Tools
CIDD	Cartesian Interactive Data Display
ENACTS	Enhancing National Climate Services initiative
IRI	The International Research Institute for Climate and Society
JRA55	Japan 55 Years Re-analysis
MDV	Meteorological Data Volume
PICSA	Participatory Integrated Climate Services for Agriculture
QC	Quality Control
QPE	quantitative precipitation estimates
SOND	September-December rainy season
TAMSAT	Tropical Applications of Meteorology using SATellite data and ground-based observations
TITAN	Thunderstorm Identification Tracking Analysis and Nowcasting

Introduction

The Rwanda Meteorological Agency (Météo Rwanda), in collaboration with the International Research Institute for Climate and Society (IRI), has embarked on a unique multi-faceted initiative called Enhancing National Climate Services (ENACTS). The initiative aims to bring climate knowledge into national decision-making by improving availability, access and use of climate information. Availability of climate data is improved by combining quality controlled data from the national observation network, with satellite estimates for rainfall and elevation maps and reanalysis products for temperature. These new data sets have been used to develop information products that are available through Météo Rwanda's web page.

Météo Rwanda staff have received several trainings by IRI experts on the different aspects of generating the data sets and developing climate information products. However, due to the recent reorganization at Météo Rwanda, new staff have been hired. Thus, Météo Rwanda has requested refresher training for existing staff as well as training new staff. There have also been some new developments in methodology and tools. The purpose of the training was to provide the necessary basis use of the IRI Climate Data Tools (CDT) to generate and exploit ENACTS datasets.

Over a seven-day period, the participants had the opportunity to practice CDT and were able not only to generate the data sets, but also to make full use of these data through this tool to develop elaborated products. The training program (Appendix 2) had the following main components: 1) Introduction to CDT; 2) Data manipulation; 3) Data analysis; 4) Quality control; and 5) Merging data.

In order to enhance their meteorological observational network, Météo Rwanda has installed 41 automatic weather stations and 100 automatic rain gauges. The automatic stations provide regular and more objective measurements. In order to acquire and provide accurate data records, a quality control procedure is required. Thus, an automated quality control procedure was developed to ensure quality of the data and integration into ENACTS datasets.

Weather Radar offers weather forecasters, scientists and the public with an alternative means of measuring precipitation. Although its measurements are indirect, it remains the best alternative gauge measurements to capture the spatial variability of precipitation at high temporal and spatial resolutions. Thus, accurately measuring the amount of precipitation is becoming increasingly more important for the end-user's application. Thus, a computer program was developed to improve the existing radar precipitation field and to integrate the processed data to ENACTS datasets.

Training on IRI Climate Data Tools (CDT)

This training was designed to provide the participants with strong skills in utilizing CDT and manipulate ENACTS gridded datasets that can be used in technical reports. The training was divided into 5 sessions; the first three sessions were for all of the participants and focused on data processing and analysis. Sessions IV and V were designed to provide hands-on training on data quality control and generating ENACTS datasets, and were specifically for staff responsible for the operational production of ENACTS data. The following is a brief description of the five sessions.

Session I: Introduction to CDT

CDT[1] is an R-based software package with a set of modules accessible via a Graphical User Interface for data quality control, homogenization and analysis of climatological time series (mainly air temperature and precipitation). In addition, CDT offers an easy way to combine station data with satellite rainfall estimates products and reanalysis for temperature. Users have full control over each step of the process. This session trained the participants on how to install and configure CDT on their computers: acquisition and installation of all required software and cloning CDT from GitHub repository. This session also provided the participants with hands-on troubleshooting tips during installation. After CDT installation, an introduction to the main menu of CDT was presented. The session provided an overview of the various features of CDT.

[1] https://github.com/rijaf/CDT

Session II: Data manipulation

This session provided more practice on the different components of CDT data organization and acquisition so that participants are familiar with the following tasks:

- Convert stations data to CDT data format;
- Download and extract satellite rainfall estimates and reanalysis data; and
- Download auxiliary's data such as Digital Elevation Model and administrative boundaries.

The second half of this session focused on time series aggregation. It also explored the different ways that CDT aggregate stations or gridded NetCDF data. This session included several exercises where the participants calculated the monthly or seasonal amount of rainfall, the monthly and seasonal average temperature and the number of days above or below a given threshold. A practical exercise on operational applications was also carried out: computing the coldest, hottest, driest and wettest month or season, the frequency of a frost day or tropical night.

Session III: Data analysis

This session was designed to provide the participants with in-depth knowledge on the main components of CDT's data analysis and familiarity with the different features. The session started with the extraction of gridded ENACTS data over a defined geometry support (points, rectangle, polygons), then aggregated the data to other time step or compute climatologies, anomalies or standardized anomalies. The output can be exported to different formats used by different software such as the IRI Climate Predictability Tool (CPT).

This session also trained the participants on how to generate a historical climate data and graphs which can be used by the Participatory Integrated Climate Services for Agriculture (PICSA) approach[2]. An overview of the computing of the historical onset and cessation of the rainy season was presented. Definitions were presented: on the onset of September-December (SOND) rainy season and how to set the different

[2] http://www.walker.ac.uk/projects/participatory-integrated-climate-services-for-agriculture-picsa/

criterions depending on the geographic/climatological region, the rainy season and the definition in the context of agriculture.

Having been introduced to the method used to calculate the onset and cessation of the rainy season, the participants began to work with the data. The exercises allowed the participants to navigate through the different options of CDT and get familiar with the creation and interpretation of graphs and maps that would be useful for PICSA. Below are some examples of the several graphs and maps that participants could generate and interpret during the exercises (Figures 1-7).

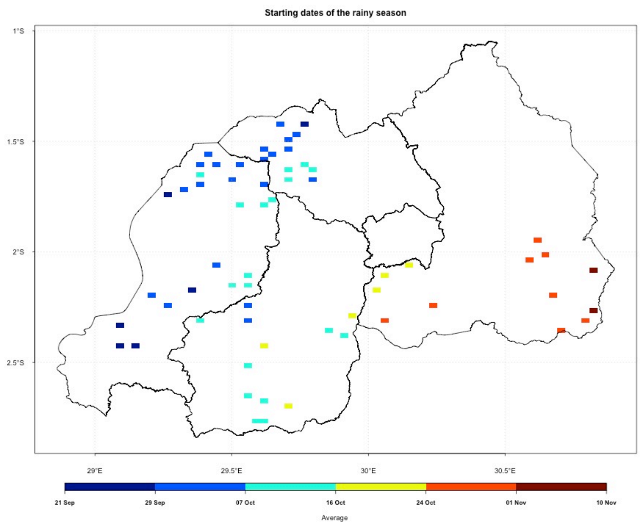

Figure 1: Average onset date of the SOND rainy season for a few locations for the period 1981-2016

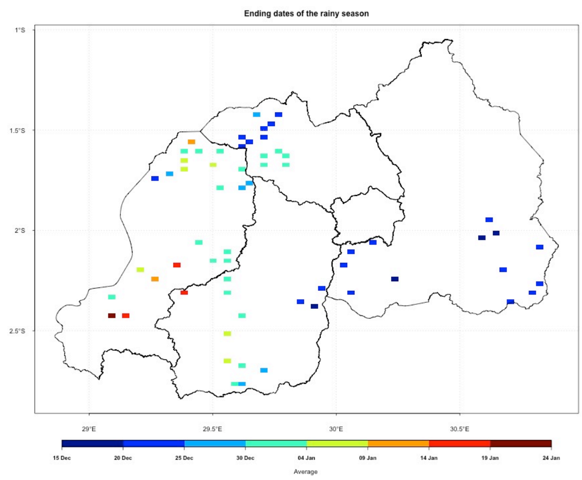

Figure 2: Average cessation date of the SOND rainy season for a few locations for the period 1981-2016

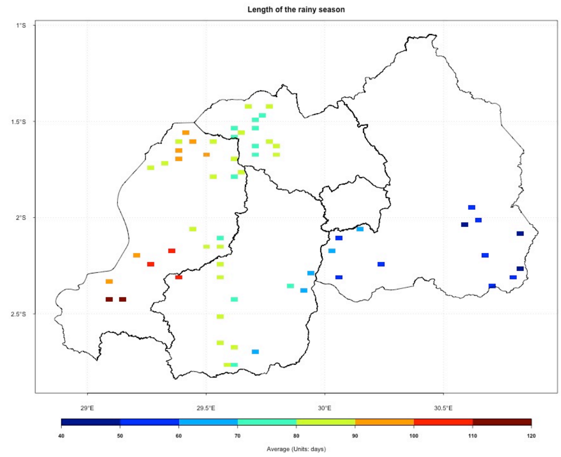

Figure 3: Average duration of the SOND rainy season from a few locations for the period 1981-2016

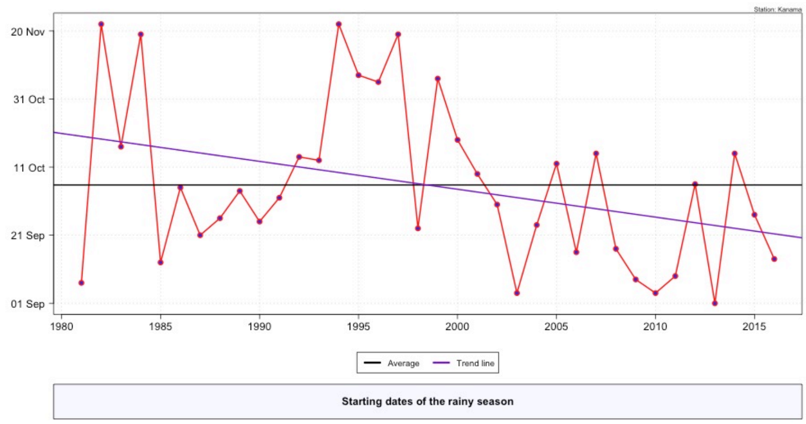

Figure 4: Onset date time series graph of the SOND rainy season for Kanama

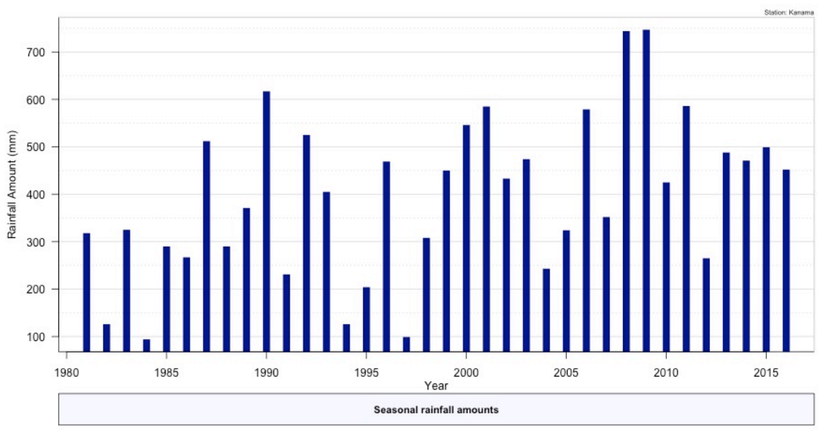

Figure 5: Seasonal rainfall amounts during the SOND rainy season defined by the onset and cessation date for Kanama

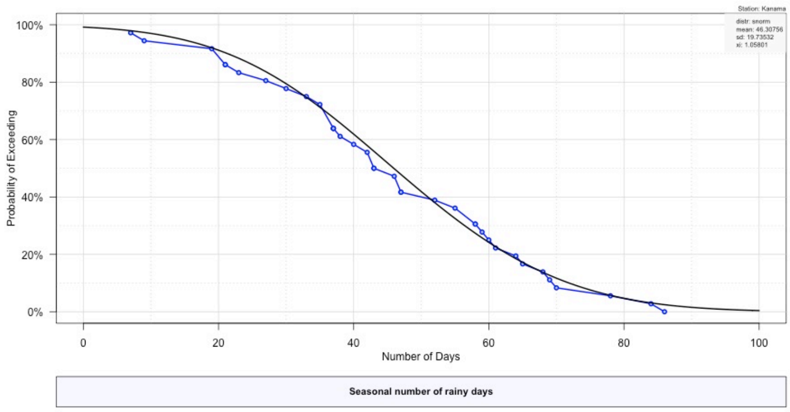

Figure 6: Seasonal number of rainy days probability of exceedance for Kanama (SOND season defined by the onset and cessation date)

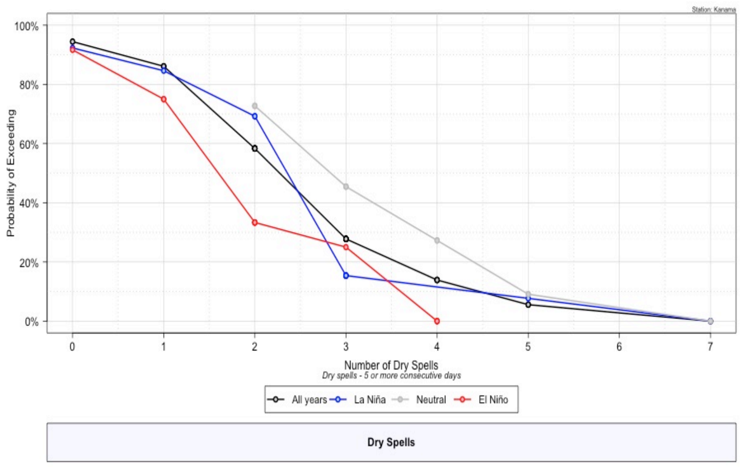

Figure 7: Seasonal number of dry spells (5 or more consecutive dry days) probability of exceedance for each ENSO phase at Kanama (SOND season defined by the onset and cessation date)

This session also included exercises with the CDT menu where the participants were invited to calculate the climate extremes indices defined by the ETCCDI (Expert Team on Climate Change Detection and Indices)[3]. The session also included a practical exercise on a climatological analysis. This exercise allowed participants to calculate totals, averages, medians, trends, anomalies and other functions for a given period of time.

[3] http://www.climdex.org/indices.html

Session IV: Quality control

This session trained Météo Rwanda’s staff on how to conduct a quality control of rainfall and temperature time series with CDT. The importance of using quality controlled was emphasized. Inaccurate data can cause many problems for users when creating reliable climate information products. The participants were introduced to the different types and sources of error that could be found in the climate datasets, including:

- Change or malfunction of sensor/instrument
- Change in the environment around the station, in the station location, or in the time of observation
- Data entry errors and typos, or change of units
- Mixture of data with decimal points and data not yet converted to decimal points
- Confusion between variables, e.g. minimum temperature instead of maximum temperature
- Confusion between missing and actual values, e.g. missing value set to zero
- Files format conversion

The training mainly focused on practical work on Météo Rwanda's own data. Most of this was done outside the training hours because there was not enough time to do it as part of the regular training.

The typical workflow for quality control with CDT is as follows:

- Stations geographical coordinates verification
- False zeros for daily rainfall, which is the case where missing values are set to zero.
- Outliers detection for rainfall and temperatures:
  - Internal consistency check
  - Temporal outliers check
  - Spatial outliers check
- Reporting suspicious values and correcting errors:
  - Problems might be identified but more difficult to correct.

- Throwing out valid extreme values can cause errors as easily as keeping erroneous extreme values.
- Undetected observation errors are always possible even using objective methods.
- The biggest problem is usually the lack of accessible metadata.

Session V: Merging data

This session provided more practice on combining stations t data with gridded datasets using CDT. The workflow used to merge stations measurement data with satellite rainfall estimates is as follows:

- Use the data from 1981 to 2016 (station and satellite) to calculate a gridded climatological bias factor for each day (days 1 to 365) or dekad (dekads 1 to 36).
- Apply the bias correction to satellite rainfall estimates time series from 1981 to present.
- Merge the bias corrected rainfall satellite estimates with the stations data for each time step.

Fig. 8 compares station data with satellite, the bias corrected satellite and combined station-satellite products.

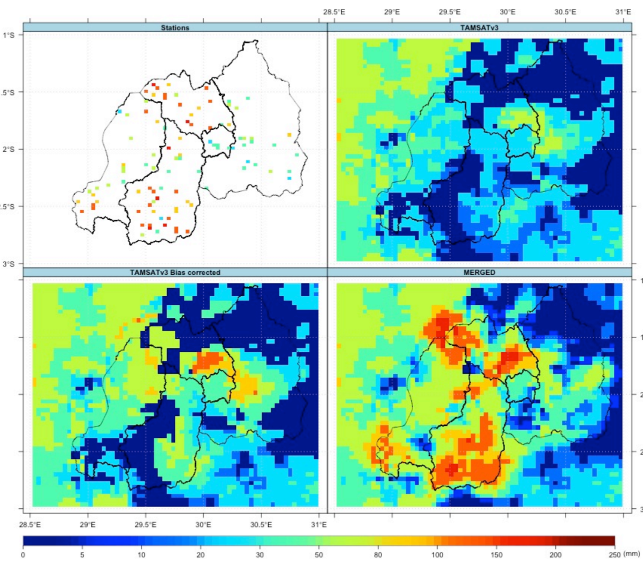

Figure 8: Comparisons of station observation (top left), TAMSATv3 (top right), TAMSATv3 bias corrected (bottom left) and combined product (bottom right) for the 1st dekad of May 1987.

As there are no satellite temperature estimates going back 30 years, reanalysis data are used as a proxy. Reanalysis products are climate data generated by systematically combining climate observations (analyses) with climate model forecasts using data assimilation schemes and climate models. The Japanese 55-year Reanalysis (JRA55)[4] is used to generate a gridded temperature time series for the period 1961-2016. This product has a coarse spatial resolution of about 50km. Thus, the reanalysis data are downscaled to 5km spatial resolution using station observations and elevation maps.

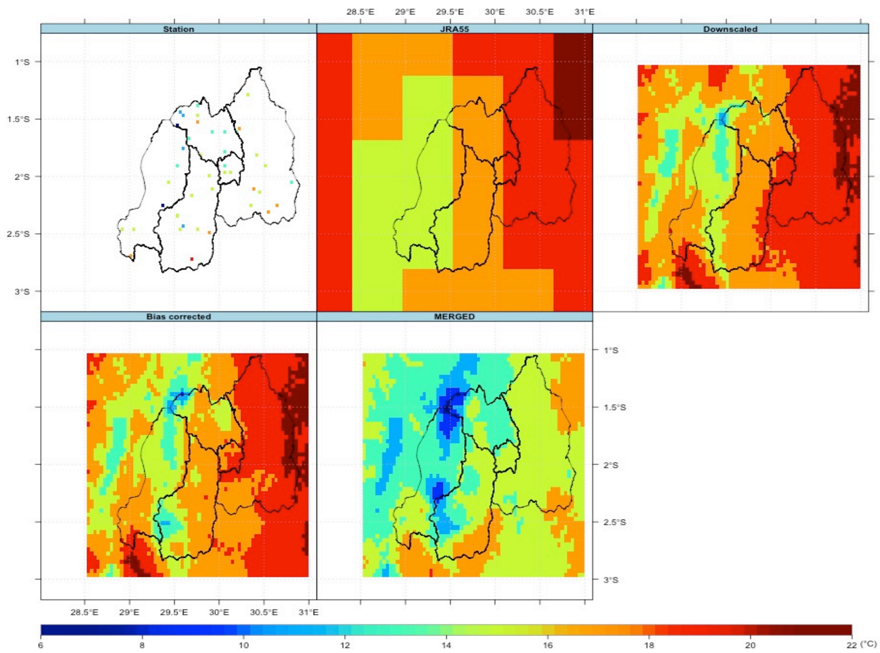

Figure 9: Comparisons of station observation (top left), JRA55 reanalysis (top center), downscaled JRA55 (top right), bias corrected data (bottom left) and combined product of minimum temperature (bottom center) for the 3rd dekad of February 2015.

The workflow used to generate gridded temperature time series by combining stations measurement data with reanalysis is as follows:

- Calculate the coefficients for the downscaling using the elevation and the station temperature data.
- Downscale reanalysis data from 50km to 4km resolution for the period 1961-2016 using the coefficients estimated above.

[4] http://jra.kishou.go.jp/JRA-55/index_en.html#about

- Use the data from 1961 to 2010 (station and downscaled data) to calculate a gridded climatological bias factor for each day (days 1 to 365) or dekad (dekads 1 to 36).
- Apply the bias correction to the downscaled data from 1981 to 2016.
- Merge the bias corrected data with the stations data for each time step.

All the steps listed are shown in Fig. 9.

Integrating AWS data into ENACTS datasets

So far, Rwanda's ENACTS datasets have been produced using manual meteorological stations network. During the last 4 years, Météo Rwanda has developed and operates a network of automatic weather stations (AWS) across Rwanda. A major advantage offered by the AWS network is that it has the ability to gather and disseminate greater quantities of data at more frequent intervals than a conventional meteorological station network. Thus, the main objective of this work was to maximize the use of these data, and integrate it into ENACTS datasets.

The AWS network

At present, Météo Rwanda operates a network of 141 AWS providing real-time data at 10 minute intervals. The network is composed of 41 automatic weather stations recording meteorological parameters such as pressure, temperature, relative humidity, wind speed and direction, radiation and precipitation, and 100 automatic rain gauge stations. Fig. 10 shows the geographical distribution of the 141 stations. The blue asterisks in the figure represent the location of the automatic rain gauges while the red crosses are the locations of the AWS. The network covers the totality of the Rwanda territory with a more or less homogeneous geographic distribution in some places.

In the quasi-totality of the stations, data are recorded at 10 minute intervals, and they are transferred to a server at Météo Rwanda office, dedicated to exploitation and archiving. There are two servers used to manage the data. The data from 119 stations are stored in a LSI LASTEM GIDAS database, which is a Microsoft SQL Server compatible database for storage of data acquired and elaborated through the instruments. A viewer program allows the user to make a query, re-process, extract and display the data stored using Microsoft SQL Server Gidas. Apart from the direct measurements of the main meteorological parameters, additional information is provided, such as wind rose data and daily minima and maxima of all parameters.

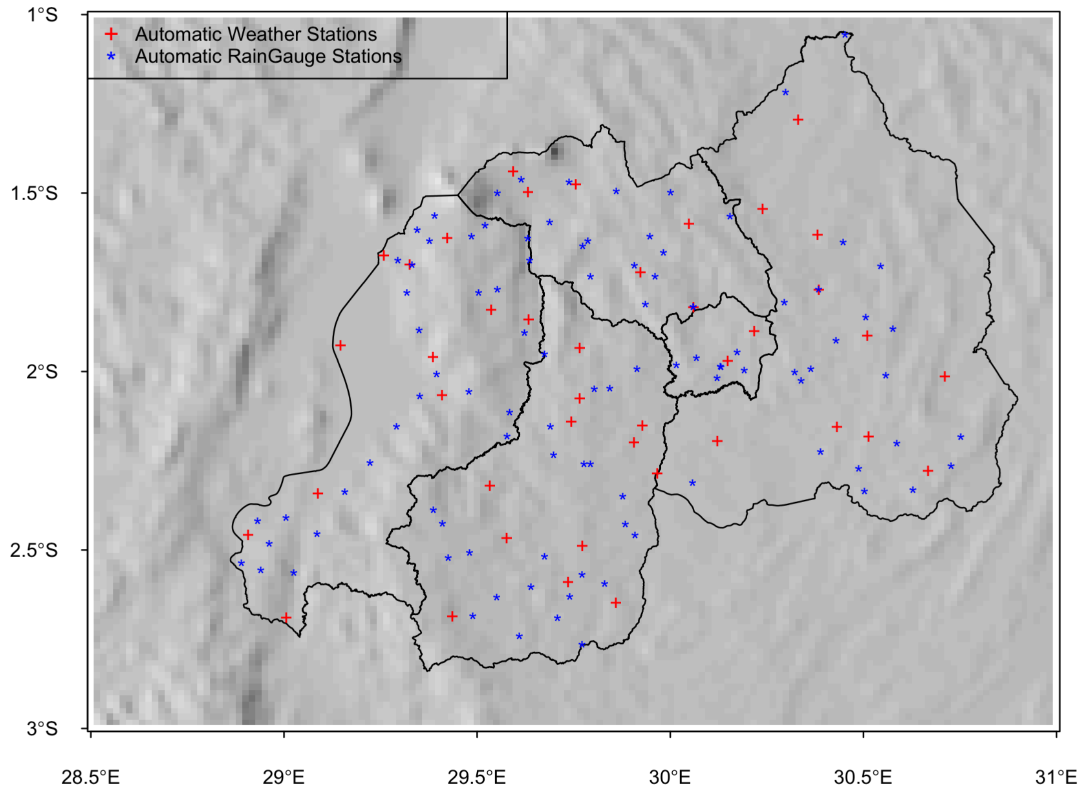

Figure 10: Geographical distribution of the AWS network over Rwanda

The data from the other 22 stations use a Linux MySQL database. Those stations have a dedicated webpage which provides the most recent measurements, diagrams of measured parameters for a selected period, and some basic statistical information.

The two servers have a different program to processed the data. The elaborated data are sent to an FTP server.

Data processing

All of the data from the AWS were already subject to a basic quality control. It is a Quality Control (QC) performed on the raw data (signal measurements) inside the AWS system, which eliminates the technical devices errors, including sensors, measurement errors (systematic or random), errors inherent in measurement procedures and methods. However, the basic quality control procedures do not remove the erroneous values from the AWS data completely; there are still some errors undetectable by the AWS QC system. Thus, those data need to be extensively quality controlled before being used.

The workflow used to process the AWS data before used to generate ENACTS datasets is as follows:

- Download 10-min AWS data from FTP servers every hour.
- Apply a first QC to the 10-min data for each meteorological variable during the elapsed one hour in order to detect and flag data of questionable quality. The erroneous data detected in this QC level are recorded to a log file, and are replaced by a missing value and not used in further data processing. This QC procedures check for:
    - conformance to the operational range of each sensor;
    - exceedance of predefined extreme values for each variable;
    - suspiciously persistent values;
    - internal consistency;
- Aggregate 10-min data to hourly, a minimum number of 10-min data is required to compute the hourly data (5 for precipitation and 4 for the other variables). If minimum number is not present, then the value is replaced by missing.
- Apply a second QC to the hourly data. A spatial check is performed, the value of the target station is compared with the closest stations observations by taking into account the elevation and relief. The suspicious data detected in this QC are saved to a log files, and replaced by a missing value and not used in further data processing.
- Aggregate hourly data to daily, as the case of hourly data a minimum number of hourly data is required to compute the daily data (23 for precipitation and 18 for the other variables).
- Apply a third QC to the daily data. A spatial and temporal check are performed.

All the processed and quality controlled data are saved to a disk. The hourly precipitation will be used to adjust the radar-based rainfall estimate. The daily data will be used in combination with data from the conventional meteorological station network to produce ENACTS datasets.

All procedures used to process the data should be fully automated by using a task scheduler and an appropriate configuration on the computer to be used to run the scripts. The data acquisition from the FTP servers, QC for 10-min, hourly aggregation and QC will be executed every hour, while the daily aggregation and QC will be executed daily. Unfortunately, there was not enough time, so the configuration of the computer to run the scripts has not been fully tested and the procedures are not yet completely automated.

Development of an applications to produce specific data formats, summaries, and charts from the output data should also be added to help Météo Rwanda to compute weekly, dekadal, and monthly climate summaries and bulletin. It is highly recommended that Météo Rwanda establish a well-documented metadata information for all AWS. All information about the operation of the stations must be meticulously noted. These metadata include:

- Detailed description of each station related to the location, coordinates and ID;
- Detailed description of the dates of regular maintenance, problems encountered, and the calibration of sensors; and
- Reporting of dates of sensor replacements, due to failure or ageing.

Integrating Radar data into ENACTS datasets

Météo Rwanda has weather radar, which is mainly used by forecasters to track the evolution of storm systems over time and monitor severe weather events. Following the storm/event, the weather radar data are then stored and are no longer used. Weather radars give quantitative precipitation estimates (QPE) over large areas with high spatial and temporal resolutions not achieved by conventional rain gauge networks. Therefore, the integration of these data into ENACTS datasets is highly relevant for later analysis and applications.

The radar is an ARC C250P C-band polarimetric doppler weather operated by Météo Rwanda located at the latitude 02°09'29.07" S, longitude 30°06'44.43" E and altitude 1616 m (Fig. 11). Every 5 minutes, the radar performs 11 azimuthal scans of 360° around a vertical axis at beam elevation angles of 0.5°, 1.5°, 2.5°, 3.5°, 4.5°, 6.0°, 8.0°, 11.0°, 15.0°, 22.0° and 32.0° with maximum range 250 km. More technical specifications about the radar can be found on Advanced Radar Company's website[5].

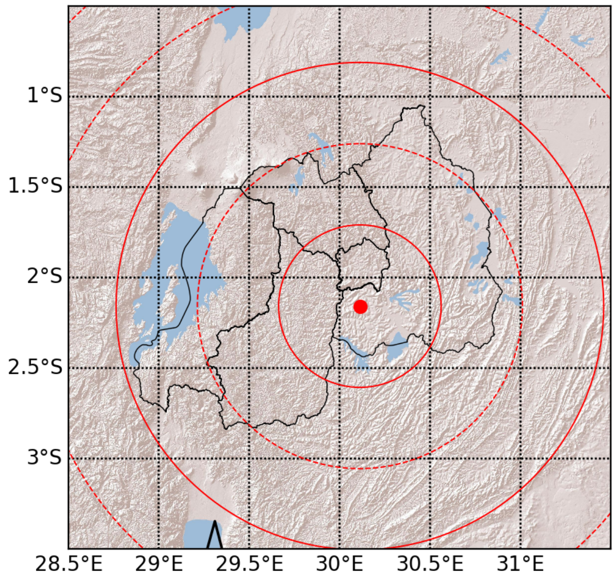

Figure 11: Location of the weather radar, with the red circles represent the rings of range with a spacing of 50 km

The data from the radar are archived in a data format called Meteorological Data Volume (MDV), and the software to process and display the data is Thunderstorm Identification Tracking Analysis and Nowcasting (TITAN)/Cartesian Interactive Data Display (CIDD) developed by the National Center for Atmospheric Research (NCAR).

TITAN Precipitation estimation

To compute the precipitation rate, the TITAN configuration installed in Rwanda currently uses the Marshall-Palmer relationship $Z = a R^b$, where Z is the reflectivity

[5] http://advancedradarcompany.com/products/arc-c250p/

factor and R is rainfall intensity. The coefficients are set as a = 200, b = 1.6 in the current configuration.

Clutter are non-meteorological echoes. They are caused by the radar beam hitting objects on the earth's surface or in the air. Clutter causes a problem for precipitation accumulation calculations because a single clutter point will give a large amount of false precipitation value when the clutter reflectivity is converted into precipitation rate and integrated over time. Thus, clutter must be removed before computing the precipitation rate. TITAN standard clutter removal technique consists of computing a clutter map from a number of MDV volumes containing "clear air" data, a sample of 30 to 40 volumes are used to create the map. The median reflectivity values for these clear-air scans are computed then stored as a clutter map in MDV format. The clutter map is used to remove clutter from radar volumes. Only reflectivity which exceeds the median value by a specified amount (typically 3 or 5 dB) will be retained. Fig. 12 shows the steps for clutter removal.

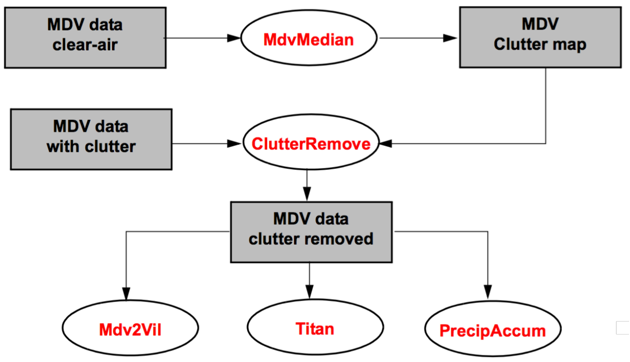

Figure 12: TITAN standard clutter removal technique diagram. Source: ARC TITAN System Manual

TITAN has a specific application, PrecipAccum, to compute precipitation rate and the accumulated precipitation by integrating the rate over time. Fig. 13 shows the diagram using PrecipAccum. A single-scan rate is computing first, then a running accumulation totals for 1-hour, 3-hour, and 24-hour products are performed.

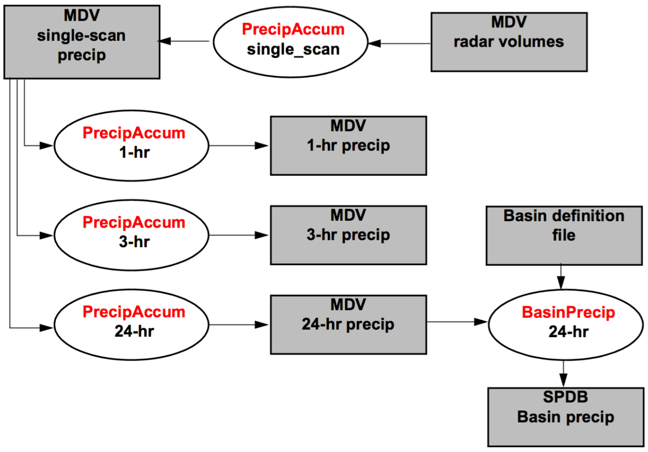

Figure 13: TITAN precipitation estimation application. Source: ARC TITAN System Manual

TITAN configuration installed at Météo Rwanda computes a single-scan depth, a 1-hour and 24-hour running accumulation totals precipitation. A 2-dimensional MDV file with the surface precipitation estimates in millimetres of rain is produced by the application. The precipitation values can be extracted and adjusted with surface gauge observations.

Adjustment of radar-based precipitation accumulations

Adjustment normally refers to using rain gauge observations on the ground to correct for errors in the radar-based precipitation estimation. The advantage with rain gauge measurements is their ability to directly measure the precipitation on the ground. It is often regarded as the true precipitation for a particular point of measurement. However, as rain gauge measurements are point observations, this limits their ability to capture the spatial variability of precipitation. It is difficult to interpolate or extrapolate rain gauge data in any accuracy or significant detail. At shorter time scales and distances the accuracy of the measurement are also dependent on rainfall type. Therefore, the radar-based rainfall estimates are extracted at rain gauge locations.

The general idea is to quantify the error of the radar-based rainfall estimate at the rain gauge locations. A mixed error model is used to adjust the raw radar rainfall estimates. This model assumes that the error to be heterogeneous in space and have both a multiplicative and an additive error term. The mixed error model is defined as:

$$R\_gauge = R\_radar * (1 + delta) + epsilon$$

R_gauge is the amount of rain from the rain gauges and *R_radar* is the amount of rain for the corresponding radar pixel. *delta* and *epsilon* have to be assumed to be independent and normally distributed. This implementation is based on a Least Squares estimation of *delta* and *epsilon* for each rain gauge location. *delta* and *epsilon* are then interpolated to the radar grid data and used to correct the radar rainfall estimates. The advantage of this approach is that *epsilon* dominates the adjustment for small deviations between radar and gauge while *delta* dominates in case of large deviations.

The hourly rainfall accumulations data from AWS network (Fig. 10) and the hourly accumulations from TITAN outputs are used to compute the coefficients *delta* and *epsilon* of the error model. Fig. 14 shows the results of the adjustment process. The automatic rain gauges have been extensively quality controlled. However, there may be some problematic measurement still as it is difficult to account for all the associated errors with the datasets. The estimated rainfall data from radar already show similarity with the rain gauges.

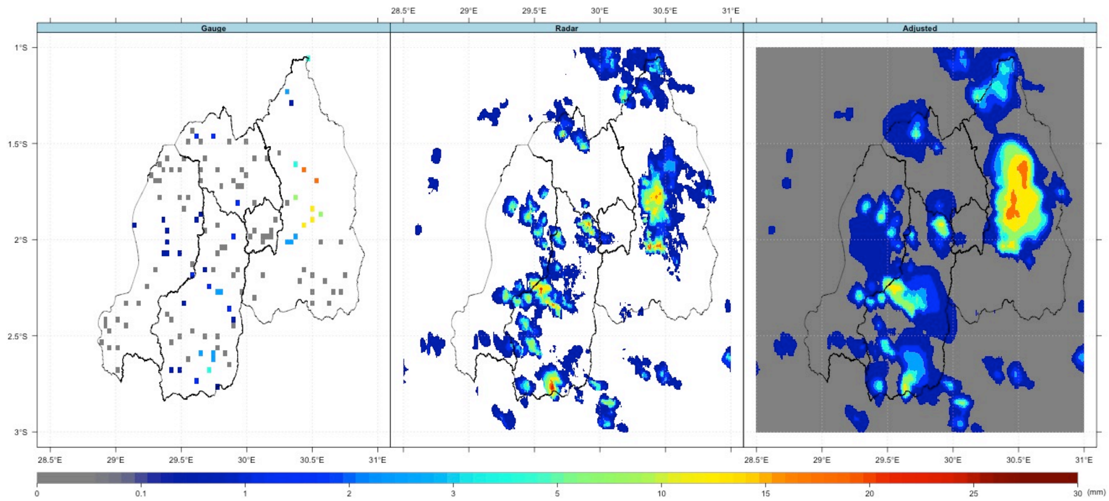

Figure 14: Hourly rainfall depths for 2017-09-28 16:00 at local time. Results are shown for the automatics rain gauges (left), radar radar-based rainfall estimation, and the adjusted rainfall.

As is in the case of AWS, all radar data processing should be automated. In addition, development of specific data formats and maps should be developed to help Météo Rwanda make the best use of their radar.

Conclusions and future work

The training activity built Météo Rwanda's capacity to take full advantage of ENACTS datasets. The first part of training allowed Météo Rwanda's Staff to make full use of their data with CDT, while the second part trained the staff to generate, maintain and update ENACTS datasets. An automated quality control procedures was implemented in order to ensure the accuracy of Météo Rwanda's AWS network, and a data processing scripts was developed to integrate these data into ENACTS datasets. Part of the work done at Météo Rwanda included the creation of scripts to process the radar-based precipitation estimation and the adjustment of these data with quality-controlled data from the AWS network. Further development is needed to improve the robustness of the procedures currently being implemented and to evaluate the outputs. Development of an application to produce specific data formats, summaries and charts from the output data should be added to help Météo Rwanda to compute a daily, weekly, dekadal, and monthly climate summaries and bulletins.

Appendix 1: Training Agenda

Week	Training title	Date	Training objectives
1	Training on updated CDT	Monday, August 14, 2017	• Meet with the participants • Software installation • Introduction to IRI Climate Data Tools (CDT) main menu
		Tuesday, August 15, 2017	• Data organization • CDT data manipulation and conversion • Time series aggregation
		Wednesday, August 16, 2017	• Time series aggregation (continue) • Data extraction
		Thursday, August 17, 2017	• Climate extremes indices calculations • Climatological analysis • Generate PICSA climate data and graphs
		Friday, August 18, 2017	• Quality control Rainfall • Quality control Temperature
2	Merging data	Monday, August 21, 2017	• A review of merging data • Merge Rainfall data • Operational updates of dekadal rainfall data
		Tuesday, August 22, 2017	• Downscaling reanalysis • Merge temperature data
	Incorporation of AWS data into ENACTS datasets	Wednesday, August 23, 2017	• System and server overview • Review of all available AWS data at Météo Rwanda • Implement a Verification and Quality control procedures and scripts • Create scripts to format AWS data to CDT • Create batch scripts for tasks scheduling and automation
		Thursday, August 24, 2017	
		Friday, August 25, 2017	
3	Incorporation of AWS data into ENACTS datasets	Monday August 28, 2017	• Continue above activities
	Incorporation of radar data into ENACTS datasets	Tuesday, August 29, 2017	• Review of all available radar data at Météo Rwanda • Writing scripts for processing radar data and adjusting radar rainfall estimates with rain gauge observations
		Wednesday, August 30, 2017	
		Thursday, August 31, 2017	
		Friday, September 1, 2017	

Appendix 2: Participant List

Name	Title	Institute	Gender
Amos Uwizeye	Data Quality Control	Météo Rwanda	M
Ernest Bagambiki	System Administrator	Météo Rwanda	M
Fidèle Maniraguha	Senior Radar and Remote Sensing Eng	Météo Rwanda	M
Joyce K Rusaro	Meteorological App Officer	Météo Rwanda	F
Felix Mucyo	Observations Supervisor	Météo Rwanda	M
Jacqueline Uwimbabazi	Meteorological App Officer	Météo Rwanda	F
Peace Bamurange	Meteorological App Officer	Météo Rwanda	F
Vedaste Iyakaremye	Observations Processing Officer	Météo Rwanda	M
Godfrey Musafiri	Meteorological App Officer	Météo Rwanda	M
Emmanuel Rukundo	Observations Supervisor	Météo Rwanda	M
Serge H. Senyana	Meteorological App Officer	Météo Rwanda	M
Clarrisse Mukazarukundo	Observations Officer	Météo Rwanda	F
Hervé Murenzi	Observations Officer	Météo Rwanda	M
Joseph Ndakize Sabaziga	Forecasting Officer	Météo Rwanda	M
Floribert Vuguziga	Senior Meteorological App Officer	Météo Rwanda	M
Rija Faniriantsoa	Trainer	IRI	M