CariCOF 2023 Wet/Hurricane Season - Seasonal Forecast Training Workshop
New Kingston, Jamaica

22nd - 23rd May 2023

WORKSHOP REPORT

The 2023 Wet/Hurricane Season pre-CariCOF forecasters' training was held on May 22nd and 23rd in New Kingston, Jamaica, ahead of the Forum held on May 24th and 25th. The CariCOF, including the training workshop, was organised by the Caribbean Institute for Meteorology and Hydrology (CIMH) and hosted by the Meteorological Service of Jamaica (MSJ).

The training workshop was facilitated by Dr. Cédric Van Meerbeeck, Dr. Teddy Allen and Ms. Janice Reid of the World Meteorological Organization (WMO) Caribbean Regional Climate Centre (Caribbean RCC) at the Caribbean Institute for Meteorology and Hydrology (CIMH), Romayne Robinson of the Geographic Information Systems (GIS) in Schools Education Programme (GISSEP) of Jamaica, Dr. Claudia Di Napoli of the University of Reading (UoR), Dr. Simon Mason of the International Research Institute for Climate and Society (IRI), and Dr. Shanna Combley and Ms. Cristina Recalde of the U.S. National Oceanic and Atmospheric Administration (NOAA).

The workshop was made possible through two Intra-ACP projects, namely the Enhancing Climate Resilience in CARIFORUM Countries as part of the Global Climate Change Alliance+ (GCCA+) programme and the ClimSA Caribbean project as part of the Climate Services and Applications Programme (ClimSA), both funded through the European Union. Further received financial support from the World Meteorological Organization (WMO) and the US National Oceanic and Atmospheric Administration. The agenda is found in **Appendix I**.

Day 1: Monday May 22nd, 2023 – Quantifying the relationship between extreme wet spell and flash flood occurrence

The workshop participants were warmly welcomed by the MSJ, while opening remarks were given by Mr. Trotman of the CIMH. After this, Dr. Van Meerbeeck of the CIMH provided a brief background to the work that spurred the sessions in this training workshop, followed by the workshop objectives and an overview of the workshop agenda.

The first technical session focused on wildfire weather monitoring and prediction. In this session, a presentation and demonstration was given by Dr. Van Meerbeeck on a new early warning information product for Caribbean countries for wildfire weather monitoring as part of the Caribbean RCC's operational monitoring and prediction activities. This development was made possible by bilateral discussions between the Global Wildfire Information System (GWIS) of the European Commission's Joint Research Centre in Ispra, Italy and the Caribbean RCC during the ClimSA JRC Climate Station Training Workshop in March 2023. The development

of such wildfire early warning products had been prioritised by the Caribbean RCC in view of abnormally strong fire weather activity during the peak of the 2022-23 Caribbean Dry Season, i.e. February/March.

The new monitoring products consist of country/territory-specific graphs that track the weekly Daily Severity Rating (i.e., a numeric rating of the difficulty of controlling fires as developed by the Canadian Forest Fire Weather Index (FWI) System) against its climatological seasonality, including the historical weekly average, minimum and maximum value.

These products, as well as other GWIS products were immediately put to the test during the 2023 Wet/Hurricane Season CariCOF training workshop for validation as several countries and territories in the Caribbean experienced wildfire weather and wildfires in April and May. NMHS participants were satisfied with the accuracy of the wildfire detection and fire weather monitoring products, upon validating their countries' situations.

Background information on these country/territory-specific fire weather monitoring products are found at https://rcc.cimh.edu.bb/caribbean-fire-weather-monitor/ .

The second presentation in this session focused on wildfire weather monitoring and prediction was made by Mr. Robinson, GISSEP. Mr. Robinson used to be attached to the MSJ when he spearheaded the development of sub-seasonal bushfire index tool for Jamaica, a collaboration forged between MSJ and the Jamaica Fire Brigade (JFB).

This tool utilises a so-called Bush Fire Index. This index combines data on soil type, which determines soil porosity as some soils hold heat and moisture better than others; vegetation, as the status of the vegetation of the area determines combustibility; rainfall, where increased water input into the soil and vegetation helps prevent the likelihood of combustion or a sustained burn; and temperature, as warmer temperatures coupled with dry conditions increase fire likelihood.

The Bush Fire Index can be calculated for the entire country for the upcoming two weeks using a set of ArcMap/ArcGIS tools. Validation and verification rely on a strong and active partnership between the operator of the tool and the fire management authority of the country (i.e., the JFB). Initial verification exercises showed promising skill of the forecast system. However, the products have not been operationalised to date, but could be in the future.

After a health break, the second session started with a presentation by Dr. Mason *cum quo* demonstration facilitated by Dr. Mason and Dr. Van Meerbeeck of new climate prediction functionality of the Climate Predictability Tool (CPT), which is now available in versions 17 and 18. The Enhancing Climate Resilience in CARIFORUM countries project included a consultancy taken on by the IRI, with Dr. Mason being the main consultant in his team. Ahead of the 2023 Wet/Hurricane Season CariCOF meetings, extensive CPT development efforts were executed under this project. Some of the main elements of the development of CPT 17 and 18 under the project are summarized in **Appendix II**.

In the presentation/demonstration included mostly hands-on examples of:

1. Regular seasonal rainfall total forecasting but highlighting the skill-masking option and the option to ignore negative skill when calculating the goodness index.
2. Storm-count forecasting, highlighting the use of Kendall's tau-c for the goodness index, and setting of absolute thresholds.

In the last session of the morning, Dr. Allen taught a refresher class on empirical orthogonal functions (EOFs), modes, the Goodness index of a hindcast model and forecast confidence within the context of statistically downscaled climate forecasts. His efforts were warranted by the perceived lack of in-depth analysis and understanding of climate hindcasts and forecasts in a majority of Caribbean NMHSs, who have become accustomed to highly automated climate forecast production using the CariCOF Outlook Generator (CAROGEN) tool developed and maintained by the Caribbean RCC.

After lunch, a (chronologically) regular part of the pre-CariCOF training workshops was facilitated by Dr. Allen with support from Dr. Van Meerbeeck, namely producing, presenting and consensus-building on the climate outlooks to be presented at the CariCOF Forum. Dr. Allen led the presentation and consensus-building of the CariCOF's 2022-23 Dry Season climate outlooks, including seasonal monitoring and forecasting information products, but also of global monitoring and forecasting products, such as seasonal forecasts from the WMO Global Producing Centres, the IRI, the Copernicus Climate Change Service and the Asia Pacific Climate Center. Among the presented CariCOF technical outlook products were the precipitation and temperature outlook maps, the drought outlook, the wet days and wet spells outlook, the dry spells outlook and the flash flood potential outlook.

Day 2: Tuesday May 23rd, 2023 – Sub-seasonal forecasting of extreme rainfall and dry spells

The second training workshop day reprised the CariCOF's ongoing work on developing sub-seasonal forecasting capabilities within Caribbean NMHSs and at the Caribbean RCC on extreme rainfall and dry spells. The day 2 sessions were facilitated by Dr. Mason, Dr. Van Meerbeeck and Ms. Janice Reid and kicked off with a refresher presentation on sub-seasonal predictability and predictions of rainfall extremes by Dr. Van Meerbeeck. This presentation compiled the knowledge and knowhow developed in previous years within the CariCOF context. The second presentation, made by Dr. Mason, was a general introduction to sub-seasonal forecasting. The focus was on the importance of the Madden-Julian Oscillation (MJO) and its monitoring, including the interpretation of Wheeler-Hendon diagrams, plus the availability of sub-seasonal model outputs. The termination of the SubX programme was noted, although the commitment of NOAA via the RA-IV Regional Climate Centre should guarantee long-term access to at least the NOAA model sub-seasonal forecasts.

After the first health break, much of the remainder of day to was spent on hands on exercises. These exercises were created to provide participants with experience in sub-seasonal forecasting using the CFSv2. During discussions between the Caribbean RCC and the IRI ahead of the CariCOF activities, it was decided to focus on forecasts initialised in October rather than attempting to make a real-time prediction because of predictability considerations.

14-day forecasts made during the sessions were for total rainfall, frequencies of exceeding 30 mm in one day, and numbers of dry days during weeks-2 to 3. To this end, ahead of the training workshop, Dr. Mason has set up separate experiments for start dates in each of the dekads in October, with generally improving predictability evident through the month. He had then written a bespoke program to calculate the corresponding sub-seasonal predictands from daily data. Furthermore, in initial preparatory work with CIMH, CHIRPS data were used for the predictands, but station-based data files were set-up for use in the Workshop.

The final session was a discussion on the way forward in CariCOF's work towards operational sub-seasonal forecasting. This included further CPT implementations, testing and hands-on exercises, as well as considerations on the resources needed to operationalise the production of such sub-seasonal forecasts. The major challenge was found to be the increased frequency of climate forecasting operations for sub-seasonal forecasting – i.e., at least once per week – as compared to seasonal forecasting – i.e., once per month. The inputs provided by workshop participants pointed to the need for integration of largely automated sub-seasonal forecast generation for the Caribbean within the next iteration of the CAROGEN.

Hence, the Caribbean RCC took on the recommendations provided and confirmed that CAROGEN version 2 would be developed to include the latest version of CPT so as to ensure that the necessary statistical tools and functionality for sub-seasonal forecasting and for the forecasting of weather-within-season, as well as an expansion of forecast products are prioritised.

APPENDIX I – Training Workshop Agenda

Day 1: Monday May 22nd, 2023 – Quantifying the relationship between extreme wet spell and flash flood occurrence

09:00 – 09:20   Opening and welcome remarks (Met Service of Jamaica, CIMH)

09:20 – 09:30   Workshop objectives (Cedric Van Meerbeeck, CIMH)

09:30 – 10:15   Fire weather monitoring – a new early warning information product for Caribbean countries (Cedric Van Meerbeeck, CIMH); Jamaica brush fire index product Romayne Robinson, GISSEP)

10:15 – 10:30   *Break*

10:30 – 11:30   CPT versions 17 & 18 – updates and hands-on (Simon Mason, IRI and Cedric Van Meerbeeck, CIMH)

11:30 – 12:15   EOFs? Modes? Goodness index? Forecast confidence? How does it work? (Teddy Allen, CIMH)

12:15 – 13:30   *Lunch (provided)*

13:30 – 15:00   Preparing the 2023 Wet/Hurricane Season climate outlooks (Teddy Allen and Cedric Van Meerbeeck, CIMH)

15:00 – 15:15   *Break*

15:15 – 16:00   Preparing the 2023 Wet/Hurricane Season climate outlooks (Teddy Allen and Cedric Van Meerbeeck, CIMH)

Day 2: Tuesday May 23rd, 2023 – Sub-seasonal forecasting of extreme rainfall and dry spells

09:00 – 10:15   Sub-seasonal predictability and predictions (Cedric Van Meerbeeck - extreme rainfall and dry spells, CIMH; Simon Mason - global forecast products, including Wheeler-Hendon diagrams)

10:15 – 10:30   *Break*

10:30 – 12:15   Predictors and predictands for sub-seasonal forecasts of extreme rainfall and dry spells (Simon Mason, IRI; Cédric Van Meerbeeck, CIMH)

12:15 – 13:30   *Lunch (provided)*

13:30 – 15:00   Producing a sub-seasonal forecast for extreme rainfall and dry spells – hands-on

15:00 – 15:15   *Break*

15:00 – 15:45   Discussion on way forward in CariCOF's work towards operational sub-seasonal forecasting

15:45 – 16:00   Closing Remarks (Adrian Trotman, CIMH)

END OF WORKSHOP

Learning objectives for training workshop day 2 - sub-seasonal forecasting:
1. Learn the format of predictor files and predictand files for weeks 2-3 forecasts as opposed to seasonal forecasts.
2. Learn to use CPT 18 to make a simple retroactive rainfall forecast for weeks 2-3.
3. Learn to use CPT 18 to use GCM model forecast ensemble members to predict the probability of
   a) any day in weeks 2-3 exceeding 30mm across Caribbean stations
   b) a 7-day dry spell in weeks 2-3 across Caribbean stations

APPENDIX II. CPT Developments (by Dr. Simon Mason, IRI)

In preparation for both meetings, extensive work was performed on CPT versions 17 and 18 to ensure that both seasonal and sub-seasonal forecasts could be produced without any problems, and some new features were introduced to facilitate the production of the forecasts. A hands-on presentation on the first day of the Training Workshop was given to introduce the new features of CPT 17 and 18 that are of importance in the CariCOF process. Some of these features had been implemented for a while and even introduced before, but had not been previously utilised by the participants, or were insufficiently familiar and required reiteration. Hands on experiments were specifically designed to provide practice with the following already-implemented features:
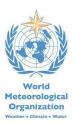
1. Skill-masking – to force CPT to issue climatological forecasts when the cross-validated skill level is below a user-specified threshold.
2. Ignore negative skill when calculating the goodness index – to enable CPT to optimise the model only for locations where there is positive skill.
3. Use of Generalised Linear Models (GLMs) for non-normally distributed predictands – with the primary focus in this Workshop on forecasting counts. An explanation of the different link function options associated with GLMs was provided.

The primary new features that were developed for the CariCOF 2023 Wet/Hurricane Season – Seasonal Forecast Training Workshop include:

1. The inclusion of a new goodness index, Kendall's tau-c, that is specifically designed for situations in which the predictand data contain ties (as is commonly the case with counts, such as, storm counts, or numbers of extreme rainfall events). Kendall's tau (and other rank correlations), which is used as the default goodness index in CPT, no longer ranges between -1 and 1 if there are ties in the data, and so the goodness index will look artificially low, and may not result in selecting the optimal model. The new index was introduced to the workshop participants, and was found to improve the goodness index in seasonal (e.g., hurricane counts) and sub-seasonal (e.g., days exceeding 30 mm) contexts.
2. An option to customise the Y-axis on graphs and colour-scale on maps by setting the number of tick-mark intervals on the graph / colours in the colour-scale. Although this option was implemented as part of the project deliverables to improve customisation of the graphics, it was not introduced at the Workshop because its application is intended primarily for SPI forecasting, which was not a primary focus.
3. Automatic recognition of when the normal category is undefined. If absolute thresholds are set to be identical for the above- and below-normal categories, or if probabilistic thresholds are defined so that the normal category has a 0% probability, CPT now presents forecasts in a two-category format. This

feature was added because of some confusion that was expressed when interpreting output for forecasts of the risk of at least one extreme wet day.

4. New-look versions of the Help pages that are easier to navigate and search, and are available online (https://cpthelp.iri.columbia.edu/) as well as built in to the software itself.

Corrections to CPT version 17 include:

1. Prevented possible fatal errors when running logistic regression. This problem arose when a cross-validated sub-sample contained either all 0s or all 1s.
2. Start-at date labels for sub-seasonal data were sometimes incorrect.
3. Resolved some occasional issues with the climatological period.
4. CPT was adjusting some settings set by the user in Options, including the standardisation option.
5. Some workarounds were implemented for a bug in the compiler that is used to build the Windows version of CPT. The bug was reported to the compiler manufacturer, and a fix has purportedly been implemented for the next release.
6. Resolved some occasional fatal errors when producing graphics
7. Improved some sub-seasonal graphics.
8. A complete list of the corrections is available in the revisions.txt file that is supplied with CPT, and which is available online at: https://iri.columbia.edu/cpt/releasenotes/ (revisions for versions 17.7.7 onwards).

Extensive testing was performed in collaboration with CIMH in the weeks and days leading up to the 2023 Wet/Hurricane Season CariCOF Training Workshop, and immediately prior to the Training Workshop beta versions of CPT 17.8.5 and CPT 18.1.1 were made available. For the most part, CPT worked without incident throughout the workshop, but a few participants experienced some difficulties in opening input files into CPT. Some of these participants were able to get a newly released 64-bit version of the software to work, but all of the software did not work on a couple of the laptops. It is unclear why; some simpler experiments did work successfully on these machines. One participant noted that the colour-scale is sometimes missing on some of the maps in version 18, and that for some screen resolutions outputs involving three maps do not always fit on the screen. Both problems were fixed during the workshop, and the revisions were released publicly as version 18.1.2 (https://doi.org/10.7916/39fx-at72) after the Training Workshop, and during the CariCOF itself. Version 17.8.5 was released publicly at the same time (https://doi.org/10.7916/t103-ra35).

Preliminary work to download sub-seasonal data from within CPT and to calculate sub-seasonal predictands from daily data has been completed. But these functionalities were not ready for use at the Training Workshop. To enable the download of data from the IRI data library without the need for coding by CPT users, CPT has a download configuration file that was redesigned for CPT version 18. The new configuration file has a simpler structure, making it easier to add, update, and subtract data files and dataset parameters, and the

code to construct the URL for downloading data has been modified to simplify the implementation of the sub-seasonal download. A batch script was adapted from one that was written for the Strengthening Disaster and Climate Resilience in the Eastern and Southern Caribbean (SDCR) project to download CFSv2 hindcasts for the Training Workshop (see following section). (Upon request, the script has been made available to a participant.) It should not be difficult to convert the bash script to work within CPT.

For the calculation of climate indicator or index-based (sub-)seasonal predictands, work has commenced on CPT 18.2 to allow the calculation of seasonal predictands from daily data. Version 18.2 now enables a daily Y file to be opened when the X file is monthly or seasonal. The seasonal calculation per se is not yet implemented, although most of the code required is already functioning for calculating seasonal predictands from monthly input data. The extension to the use of daily input data should not be difficult, nor should the further extension to the use of sub-seasonal predictands.