**Appendix 1**

**TERMS OF REFERENCE**

**CONSULTANCY FOR THE WEATHER RESEARCH AND FORECASTING MODEL TRAINING**

1. **INTRODUCTION**

Meteorological services globally are being challenged by an increasing number of hydro-meteorological and climate related disasters. The socio-economic losses form these disasters are in the order of billions of United States dollars, and loss of life in the hundreds to thousands depending on the regions impacted. The magnitude of the losses from these events is driving the call for improved integrated early warning systems that address fundamental questions such as (a) where will the event occur? (b) what will be the nature of the event? (c) what is the expected start time and duration of the event? and (d) what are the expected impacts and losses from the event?

Key to addressing the questions posed above is the hydro-meteorological forecast. Within the last two decades, hydro-meteorological forecasts have undergone significant improvements that have improved their accuracy. It is now an industry expectation to produce accurate hydro-meteorological forecasts 72-96 hours in advance. Central to this improvement are significant advancements in numerical weather prediction models, advances in computing platforms and decreasing computational costs.

Within the Caribbean, the Caribbean Institute for Meteorology and Hydrology (CIMH) has been playing a critical role in deploying numerical weather prediction models to improve hydro-meteorological forecasts at national and regional levels. Starting in 2006, the CIMH first deployed operationally the MM5 numerical weather prediction model across the Caribbean region at 18 kilometre (km) and 54 km resolutions. The benefits of this implementation to regional forecasting was significant especially for tracking and predicting fairly large scale weather systems. In 2008, the CIMH added the Weather Research and Forecasting (WRF) Model also running at 18km and 54km resolutions into its modeling platform. This inclusion allowed inter-model comparisons to be performed by hydro-meteorological forecasters to further improvements in weather forecasts issued by National Meteorological and Hydrological Services (NMHSs) in the Caribbean.

The 18 km and 54 km resolution model outputs were particularly suited to regional level forecasting but were too coarse to capture local weather features at the watershed scale for most island states in the Caribbean. In 2010, immediately following the Haiti earthquake, the CIMH deployed a 4 km resolution model local to Haiti using the WRF ARW platform. The goal of the implementation was to predict severe hydro-meteorological events at the watershed level as part of an early warning system that may adversely impact search, rescue and recovery efforts. Outputs from the platform were incorporated into the planning activities of many organisations operating in Haiti including the International Red Cross and Red Crescent Societies.

In 2011, building on the experience of Haiti, the CIMH introduced twice daily 4km 48 hour WRF ARW region-wide simulations which allowed NMHSs to track rainfall in their areas of responsibility at the watershed level. Since 2011, run times for the WRF-based simulations have decreased from approximately 20 hours to approximately 4 hours as new computational hardware has been acquired. Improvements in computational efficiency coupled with the decreasing cost of computational platforms is providing a compelling case for NMHSs in the Caribbean to consider running their own sub 4 km local area numerical weather prediction models. Indeed, the Belize National Weather Service currently runs a 5 km resolution version of WRF over Belize. Other NMHSs have indicated a desire to follow this trend but using CIMH outputs to drive their local forecast models.

To facilitate countries with their numerical weather prediction ambitions, the CIMH as the World Meteorological Organisation (WMO) Regional Training Centre for the Caribbean is obligated to provide them with the required level of training needed to successfully integrate numerical weather prediction into their forecasts through (a) in-class trading in the Senior Level Meteorology Technicians' course; and (b) an online continuing professional development course focused on teaching NMHSs forecasters how to integrate numerical weather predictions into forecasts. This proposal seeks to advance this process by providing NMHSs with the requisite skills to use the WRF to build their own local area numerical weather prediction models.

1. **The Caribbean Institute for Meteorology and Hydrology (CIMH)**

The CIMH is an institution of the Caribbean Community and the technical organ of the Caribbean Meteorological Organisation (CMO). The mandate of the CIMH is to assist in improving and developing the meteorological and hydrological services as well as, providing the awareness of the benefits of meteorology and hydrology for the economic well-being of the 16 CMO Member States. This is achieved through training, research, investigations, and the provision of related specialised services and advice.

In achieving its mandate, the CIMH has established an affiliation with the UWI where its primary responsibility is the delivery of the Bachelor of Science Programme in Meteorology in the Faculty of Pure and Applied Sciences. The CIMH is also recognised by the World Meteorological Organisation (WMO) as: (i) the WMO regional training centre in the Caribbean for meteorology and hydrology and related disciplines; (ii) a regional instrument centre for the Caribbean; (iii) centre of excellence in satellite meteorology training; and (iv) the WMO regional climate centre (in demonstration phase) for the Caribbean.

In addition, the CIMH is a repository for the climate data from CMO Member States. The institute is also an important Caribbean Centre for research and development related to meteorology, hydrology, agro-meteorology and climate in the Caribbean. It is active in such areas of hydrological risk impacts forecasting and agricultural risks forecasting and has had strong collaborations with other regional institutions, national organisations in CMO Member States and the international community.

***Expanding Weather and Climate Forecasting and Innovative Product and Service Development and Delivery in the Caribbean* Project**

The CIMH is implementing the 2-year ACP-EU-CDB NDRM in CARIFORUM Countries funded ***Expanding Weather and Climate Forecasting and Innovative Product and Service Development and Delivery in the Caribbean* Project**. This project outcome is expected to increase predictive capacity of national and regional institutions for weather and climate forecasting. The project component 1 is to build regional capacity to implement the Weather Research and Forecasting (WRF) Modeling Platform at the national level to support operational hydro-meteorological forecasting.

1. **CONSULTANCY AIM AND OBJECTIVES**

The overall objective of this assignment is to build regional capacity to implement the WRF Modeling Platform at the national level to support operational hydro-meteorological forecasting. It is expected that operationalisation of the Platform will improve the accuracy of national hydro-meteorological forecasts.

It is also expected that persons trained under this effort will be able to use the WRF Platform to re-analyse historical weather systems to better understand their genesis and impacts to strengthen national level early warning processes and impacts forecasting efforts.

1. **SCOPE OF WORK**

Within the framework of the Expanded Weather and Climate Forecasting *and Innovative Product and Service Development and Delivery in the Caribbean* Project in the Caribbean Project, the scope of work is to provide training to persons to operationalise the WRF platform at the national levels. It is expected that attendees will be taught:

1. the basis of numerical weather prediction systems including the underlying equations and assumptions;
2. the basics of the WRF Modeling Platform with introductions to WRF-Chemistry Model, WRF-Hydrology Model etc.;
3. how to install either WRF-Advanced Research WRF and/or WRF-Non-hydrostatic Mesoscale Model Modeling Platforms, associated core software including Network Common Data Form and Open-Message Passage Interface and post-processing software;
4. how to run the WRF system – data download, data preprocessing, execution of the WRF Platform and post-processing of the model outputs;
5. how to select appropriate model parameterization schemes through calibration activities; and
6. how to interpret model outputs.
7. **CONSULTANT DELIVERABLES AND INDICATIVE SCHEDULE**

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| 1. | An Inception Report (inclusive of work plan, minimum requirements for students to take part in the course, certification for course participants, hardware and software requirements for the course) |
| 2. | A Training syllabus |
| 3. | A Training Manual and the delivery of training to selected participants |
| 4. | A Training Report |

1. **QUALIFICATIONS**

The Consultant is required to have recognised credentials (with strong preference being given to candidates with MSc and PhD degrees) in either Meteorology, Physics and/or Applied Mathematics. Candidates with degrees in other related fields will be given consideration based on their experience. In addition, the Consultant must have:

1. more than ten years of experience delivering training in area of atmosphere modeling and the application of numerical models to hydro-meteorological and impacts forecasting;
2. at least five years experience implementing WRF Platforms;
3. awareness of the challenges associated with hydro-meteorological and impacts forecasting on Small Island Developing States (SIDS); and
4. experience working with developing countries and in particular SIDS.
5. **DURATION**

The contract is expected to be completed within 4 months.