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CDEMA CARIBBEAN DISASTER EMERGENCY MANAGEMENT AGENCY
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STRENGTHENING EARLY WARNING SYSTEMS IN THE CARIBBEAN

DOMINICAN REPUBLIC

NUMERICAL FORECASTING

PRIOR KNOWLEDGE AND IDENTIFICATION OF RISK

MONITORING AND WARNING SYSTEMS

DISSEMINATION AND COMMUNICATION

RESPONSE CAPACITY

STRENGTHENING EARLY WARNING SYSTEMS IN THE CARIBBEAN DOMINICAN REPUBLIC

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This document covers humanitarian aid activities implemented through the project *Strengthening the integration of early warning systems for more effective disaster risk reduction, through knowledge and tools transfer.* The project is led by the United Nations Development Program (UNDP) in collaboration and coordination with the Caribbean Disaster Emergency Management Agency (CDEMA) and the International Federation of Red Cross and Red Crescent Societies (IFRC). Financial assistance was provided by the European Civil Protection and Humanitarian Aid Operations (ECHO).

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ACRONYMS

CDEMA » Caribbean Disaster Emergency Management Agency

COE » Centre of Emergency Operations

DIPECHO » Disaster Preparedness Program of the European Civil Protection and Humanitarian Aid Operations

DRR » Disaster Risk Reduction

ECHO » European Civil Protection and Humanitarian Aid Operations

EU » European Union

EWS » Early Warning System

GrADS » Grid Analysis and Display System

HIP » Humanitarian Implementation Plan

HVR » Hazard, Vulnerability, and Risk

ICT » Information and Communications Technology

IFRC » International Federation of Red Cross and Red Crescent Societies

INDRHI » National Institute of Water Resources

IN-MHEWS » International Network for Multi-Hazard Early Warning Systems

INSMET » Cuban Meteorological Institute

ONAMET » National Office of Meteorology

SIDS » Small Island Developing State

SisPI » Immediate Forecast System

SSC » South-South Cooperation

SVG » Saint Vincent and the Grenadines

SWAN » Simulating Waves Nearshore

UNDP » United National Development Program

WFP » World Food Programme

WRF » Weather Research Forecasting Model

1. INTRODUCTION

The Caribbean region is highly prone to natural hazards such as hurricanes, floods, volcanic and seismic activities, droughts and forest fires. The increasing impact of global climate change and the risk posed by a range of natural, environmental and technological hazards are among the Caribbean's most critical development problems. The past decades have been marked by an intensification of the impact of disasters, such as destruction of livelihoods and communities, as well as a setback in development gains.

Due to the high levels of vulnerability, there is a broad recognition of the need to strengthen capacity for preparedness, response, and recovery, and integrate risk reduction measures into development paths to create safe, resilient and sustainable communities and States in the Caribbean. As one component to reducing risk, the Caribbean Comprehensive Disaster Management (CDM) Strategy 2014 – 2024 prioritizes integrated, improved and expanded community early warning systems.[1] This focus is reinforced by the Sendai Framework for Action which calls for enhanced disaster preparedness.[2] Likewise, UNDP's Strategic Plan 2018 – 2021 aims to strengthen resilience to crisis and shocks and support countries with assessments, planning tools and mechanism so that gender-sensitive and risk-informed prevention and preparedness solutions are available to limit the impact of natural hazards.[3] Reducing risk and building resilience is a theme that cuts across the Sustainable Development Goals.

As identified in the ECHO Humanitarian Implementation Plan (HIP) 2017, preparation and response capacities in the Caribbean have improved. However, the need for further action to address preparedness capacities, reinforce Early Warning Systems (EWS) and foster exchanges between countries and linkages with regional institutions is crucial. The HIP specifically highlighted that "collaboration between countries on Early Warning Systems to exchange on good practices should be

1. Priority Area 4, Outcome 3, Regional CDM Strategy 2014 – 2024 https://www.cdema.org/cdm
2. Priority Area 4, Sendai Framework for Disaster Risk Reduction 2015 – 2030. https://www.unisdr.org/we/coordinate/sendai-framework
3. Outcome 3, Signature Solution 6, UNDP Strategic Plan 2018 – 2021 https://strategicplan.undp.org/

fostered" and stressed that the "compilation of DRR tools and processes endorsed at national and regional level, led by national systems in coordination with the CDEMA, EU Delegations and other development actors" are priority areas for action.

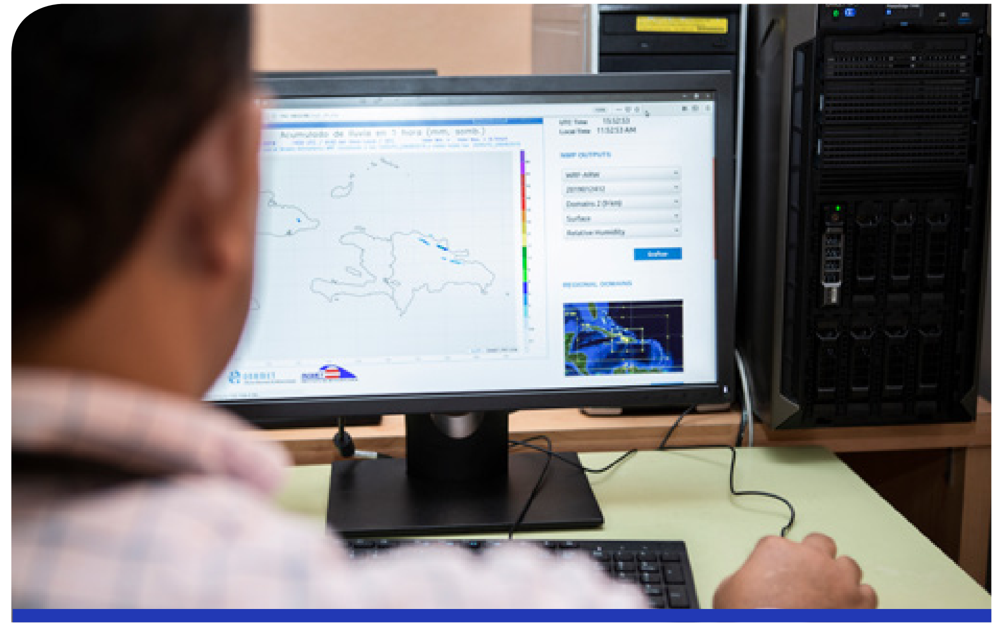
Thus, Antigua and Barbuda, Dominica, Dominican Republic, Saint Lucia and Saint Vincent and the Grenadines (SVG) set out to improve their Early Warning Systems (EWS) through an 18-month project financed by European Civil Protection and Humanitarian Aid Operations (ECHO). The *"Strengthen Integrated Early Warning Systems for more effective disaster risk reduction in the Caribbean through knowledge and tool transfer"* project sought to strengthen EWS components and close priority gaps at a national level, contributing to the integration of national and community EWS, and addressing sustainability and national ownership of EWS.

The country level actions were supported by UNDP, International Federation of the Red Cross and Red Crescent Societies (IFRC), and the Caribbean Disaster Emergency Management Agency (CDEMA), who embraced a partnership approach and helped reinforce the efforts to realize a more integrated EWS and enhance disaster risk reduction at the regional, national and community level.

The project also aimed to increase access to tools and knowledge of EWS at a regional, national and regional level, through development of, improvement to, and translation of models, methodologies and toolkits to distinct contexts. Emphasis was put on knowledge transfer and exchange, allowing actors to leverage the expertise that exists in the Caribbean to reduce disaster risk and foster stronger linkages between countries exposed to the similar risks.

This case study details the South-South Cooperation (SSC) process and activities between the Dominican Republic and Cuba. Based on the EWS Checklist analysis and the Gap Report, the Dominican Republic identified flash flooding and improved monitoring of basins as a specific gap that could benefit from Cuban expertise. Cuban institutions and specialists prepared packages and trainings on the management of flash flooding through numerical forecasting and supported institutions in the Dominican Republic in implementing a pilot project that addressed identified deficiencies in the early warning system. This document provides a systematization of the results, lessons, processes and tools used in the process of transferring knowledge and capacity between the Dominican Republic and Cuba.

This document is intended to be read together with, and complemented by, the *Strengthening Early Warning Systems in the Caribbean* and *Strengthening Early Warning Systems in the Caribbean: South-South Cooperation* documents.



2. CONTEXT

The Dominican Republic, a small island developing state (SIDS), is exposed to multiple recurring hazards, the majority of which are linked to weather-related events, such as hurricanes, storms, floods, fires, droughts and epidemics. According to the Global Climate Risk Index published by Germanwatch, the country ranks 12th for the period 1998 – 2017, as one of the most affected nations by climatic events. The 2017 hurricane season was one of the most intense seasons in the last decades for Dominican Republic. Irma and María hurricanes affected 9% of agricultural production, one million people resulted without drinking water, 24,000 people were displaced and 38 communities isolated. In 2016, floods affected nearly 1.8 million people in the Dominican Republic.[4] These losses made the Dominican Republic realize the need to strengthen local forecasting systems to mitigate future similar events.

4. Guha-Sapir D, Hoyois P, Wallemacq P, Below, R. 2017 *Annual Disaster Statistical Review 2016: The* Numbers and Trends. Brussels: CRED; pg. 33

3. DEMAND & OFFER

3.1 The Demand

Initial Identification of Needs: In the case of the Dominican Republic, first contact with Cuba in the framework of this initiative corresponded with the MHEWS Checklist roll out. The National Validation workshop, the MHEWS Gap Report, and the Roadmap had yet to be realized. The definition of the needs was therefore based on the preliminary findings of the Checklist and the discussions held during the Cuban scoping mission.

Scoping Mission: During April 3rd and 4th of 2018, two Cuban experts, the Head of Compatibilization of the Disaster Risk Reduction (DRR) Department of Cuban Civil Defence, and the National Coordinator of Hazard, Vulnerability, and Risk (HVR) Studies, carried out a scoping mission to assess the Dominican EWS and analyse potential areas of collaboration between the two islands. They were later joined by Cuban officials from the Ministry of Science, Technology and Environment and the Ministry of Foreign Trade and Investment. On day one of the scoping mission, several meetings were facilitated by UNDP with Dominican institutions, including the Centre for Emergency Operations (COE), the Dominican Red Cross, the National Office of Meteorology (ONAMET), the National Institute of Water Resources (INDRHI), Civil Defence, Ministry of Agriculture, Ministry of Health, Ministry of Public Works and Communication, Geological National Service, National Office for Seismic Evaluation and Infrastructural Vulnerability, and the Dominican Institute of Telecommunications, among others. On the second day, the Cuban team participated in the "Regional Exchange of Experiences for Disaster Risk Reduction" held in the city of Juan Dolio, where the Cuban EWS Toolkit and the response to Hurricane Irma were presented.

The diagnostic side of the mission included the following elements of ***assessment*** and possible ***areas of collaboration***:

a) Presentation on South-South Cooperation Solution Packages approach, where the overall process of the project was explained, and an overview of the main steps for the design and facilitation of knowledge transfers was provided.

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b) Review of the preliminary findings of the EWS Checklist, which included: 1) gaps in the generation and analysis of vulnerabilities and risk maps and scenarios for vulnerable regions and groups; 2) needed improvements in the forecast and warning services, including the quality and reliability of forecasts, as well as having alternate systems to face potential failures; 3) needed incorporation of a measuring mechanism on the perception and reaction of the population to warnings; 4) improvement in the assignation of budget allocations to EWS plans, and 5) improvement of their multi-hazard approach.

c) Additional issues were identified, including: 1) the community-level capacity to communicate with EWS institutions, particularly regarding the triggering of response actions at community level after an alert; 2) the communication, dissemination and interaction of alerts for people with disabilities (for other types of disability in addition to the already established system including sign language), for senior citizens and differentiated by gender.

d) In terms of the most critical hazards, emphasis was placed on flash flooding and the need for improved monitoring of basins.

e) A critical equipment gap was highlighted in regard to the lack of functioning radars for hydrometeorological monitoring and forecasting, including a damaged radar in Punta Cana, and the need for alternate methods not requiring the use of radars.

f) From a specific institutional capacity perspective, the lack of radar meant a gap in the real-time monitoring and forecasting capacity of ONAMET, who also reported low server capacity to process more data, as well as low resolution forecast models. This in turn limited COE's capacity to activate its emergency protocols and alerts.

Solutions Packages: Based on the scoping mission findings, the Cuban SSC Expert Committee prepared and delivered a Solution Package to the Dominican representative of the COE, during the 10th International Congress on Disasters held in Cuba in July 2018.

The Solutions Package for Dominican Republic contained three options of offered support:

1) Volunteer River Observation

2) Hazard, Vulnerability and Risk (HVR) Studies

3) Management of Flash Flooding Without the Use of Radar through Numerical Forecasting

Selecting a Priority Action & Preparing the Proposal: The Solution Package was received and discussed among the national actors; a determination was made to select the 'Management of Flash Floods Without the Use of Radars' option, based on the level of priority, as well as funds and timeframe available. In this context, the Dominican Republic prepared a specific proposal for this solution and submitted it to the Project Coordination Team, where it was approved for $ USD 19,825.

Identification of Leading Recipient Organization and Team: Once the priority action was selected, ONAMET was designated as the leading recipient organization, given its mandate for meteorological forecasting; COE and INDRHI, who emit the alerts and generate hydro and pluviometric bulletins respectively, were included as key coordinating parties. A consultant was commissioned to support the implementation and to document the process.

Implementing Partner: UNDP was the implementing partner who supported these activities. Its role was three-fold. One was to facilitate all exchanges between Cuba and the Dominican Republic. The second was to ensure that tools, training and methods used by the offering country were properly adapted to the context, time available and language of the recipient countries. Third, it supported all equipment purchases.

3.2 The Offer – Numerical Forecasting for Flash Flooding

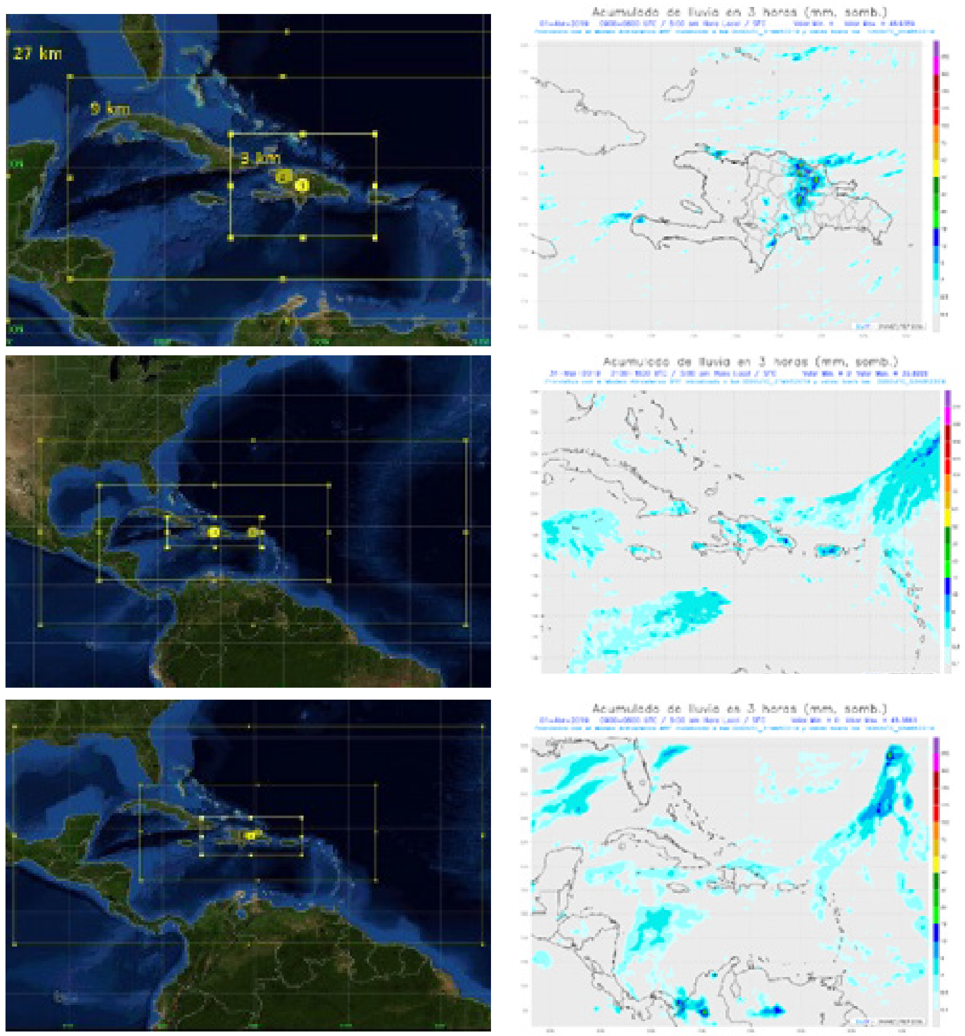
Following Hurricane Sandy in 2012, UNDP supported the development of the Immediate Forecast System (SisPI) in Cuba, in light of the capacity gaps for more precise, smaller-scale forecasting that were observed. Over the years, SisPI has been a key tool in strengthening Cuba's EWS. Its success led to the replication of the tool in Haiti, Panama, and now the Dominican Republic.

The Weather Research Forecasting Model (WRF), which is the free and open software SisPI is based on, has been developed and refined since the 1990's in a collaborative partnership between the National Centre for Atmospheric Research, the National Oceanic and Atmospheric Administration, the Air Force Weather Agency, the Naval Research Laboratory, the University of Oklahoma, and the Federal Aviation Administration in the United States. Its effectiveness has led the WRF to be in operational use in National Centres for Environmental Prediction and other national meteorological centres, as well as in real-time forecasting configurations at laboratories, universities, and private companies in over 160 countries around the world.

The WRF Model is an atmospheric modelling system designed for both meteorological research and numerical weather prediction for operational forecasting applications. It offers a range of options for atmospheric processes, can run on a variety of computing platforms, and can be used in a broad range of applications across scales ranging from tens of meters to thousands of kilometres. For researchers, WRF can produce simulations based on actual atmospheric conditions or on idealized conditions. This model can predict the evolution of all kinds of meteorological variables: temperature, wind, humidity, cloud conditions, vorticity, rainfall, and pressure, etc. Based on these variables, it can forecast large-scale phenomena, such as hurricanes and cold fronts, and small-scale processes like electric storms.

SisPI, a system based on the WRF, generates *immediate* and short-term numerical forecasting for meteorological processes at *synoptic and meso-level scale*, with the purpose of improving meteorological forecasts and decision-making. Its purpose is to generate a short-term forecast of meteorological events at a local scale with specific geographic regions (e.g. coasts, basins) for more effective decision-making, warnings and tailored information, in contrast to macro scale information with less resolution and precision.

In simplified terms, the WRF is the modelling operating system and software infrastructure, and SisPI is an application that has designed and tested a series of configurations, operative scripts, and numerical modelling formulas to generate specific types of meteorological products and graphic outputs, such as rainfall accumulation predictions, pressure at sea level, temperature, and estimated trajectory and wind force of simulated hurricanes, among others. The SisPI can use data from meteorological stations and other on-surface observation stations, wind measuring towers, satellites, radars, and buoys, etc. In other words, SisPI has customized the WRF to the needs of countries and has proven to be a useful tool in the Caribbean region.



SisPI Scales and Modelling results on different scales

WRF & SisPi

PRODUCTS IT OFFERS:

- Meteorological studies
- Real-time numerical weather prediction
- Idealized simulations
- Data assimilation
- Earth system model coupling
- WRF Model training and educational support with workshops and tutorials each year, and a worldwide community of over 39,000 users

SCOPE:

- The WRF model serves a wide range of meteorological applications across scales from tens of meters to thousands of kilometres. It is configured to cover the entire globe at a three-dimensional scale of 27x27 km horizontally and 22 vertical levels and can include over 164 hydro-thermodynamic variables and indicators on a temporal scale of 24 up to 144 hours.
- With the SisPI configuration, three simulation domains can be generated at three resolution scales: 3, 9 and 27 km. It can provide forecasting down to a 3 km spatial resolution scale during a period of up to 36 hours. It can also forecast other meteorological phenomena at a 9 and 27 km scale for periods of up to 72 hours. The forecasts update four times a day at 0000, 0600, 1200 and 1800 UTC.
- Applied to the region, it can cover the Caribbean Sea, the Gulf of Mexico, part of the Atlantic and the Pacific coast along Central America.

PRODUCTS IT OFFERS:

- Ubuntu-Linux operating system
- Grid Analysis and Display System (GrADS) interactive desktop tool for the access, manipulation, and visualization of the data
- At least 2 servers (Server 1 with 2 network connections for the internet and for the internal network, Server 2 with 1 network connection to connect with the Server 1) with at the very least 24 processors, a minimum of 32 Gb of RAM, and a hard drive above 1TB. It is recommended that greater capacity servers, hard drives and greater memory be installed to be able to process more data without congesting the system, diminishing calculation time, and increasing the temporal range of forecasts.

4. TRANSFER & ADAPTATION

The transfer combined different methods, including training, direct technical assistance in installing and testing the new systems and delivery of products, and remote assistance and troubleshooting. It is noteworthy, that in this case, some of the activities were implemented and co-financed as an inter-agency collaboration between UNDP and the World Food Programme (WFP), who is also supporting EWS on the island.

For this initiative, the adaptation process happened in a dynamic on-going manner during the implementation of the transfer, allowing the training and the provision of technical assistance to be adjusted and tailored to the needs of the country.

The transfer was carried in three main stages:

Stage 1 - Training: The first mission to the Dominican Republic was carried out by two meteorological forecast specialists from the Centre of Atmospheric Physics of the Cuban Meteorological Institute (INSMET) as part of a two-week long training for ONAMET, COE and INDRHI personnel, held between the 5th and 16th of November 2018. The first week was dedicated to an introduction to numerical modelling of the weather and the WRF system. The second week was focused on the SisPI system, its modelling domains, and practical application sessions where simulations were run using three studies cases relevant to the Dominican Republic: Hurricane Maria, Tropical Storm Beryl, and a trough that provoked intense rains in May of 2018. During the training, discussions were held regarding the specific meteorological products of interest to the Dominican Republic, so the SisPI system could be adequately configured during the installation phase of the transfer.

Stage 2 - Guided Visit and Adaptation Needs: From the 19th to the 23rd of November 2018, Dominican forecast specialists and ICT personnel from ONAMET, COE and INDRHI went to Cuba to observe INSMET's forecast system at work. They met with INSMET units - Centre for Forecasting, the Centre of Atmospheric Physics, Centre of Marine Meteorology, and Provincial Meteorological Centre of Havana, Artemisa and Mayabeque - and with the Risk Management Group of the Ministry of Science, Technology, and the Environment. They received information on

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CONTENT OF TRAINING

Stage 1

1. Introduction to numerical modeling

- Introduction to numerical modeling of the weather
- The role of Numerical Modeling in Monitoring for EWS
- The Cuban National Meteorological System
- Experience and Results in the use of SisPI in Haiti and Panama
- Modeling Atmospheric Processes: primitive equations, dynamic cores of the models
- Modeling by Stages:
  - Initialization: setting initial conditions and objectives
  - Data Assimilation
  - Physical Parameters
  - Visualization and Post-Processing

2. Introduction to the WRF Model

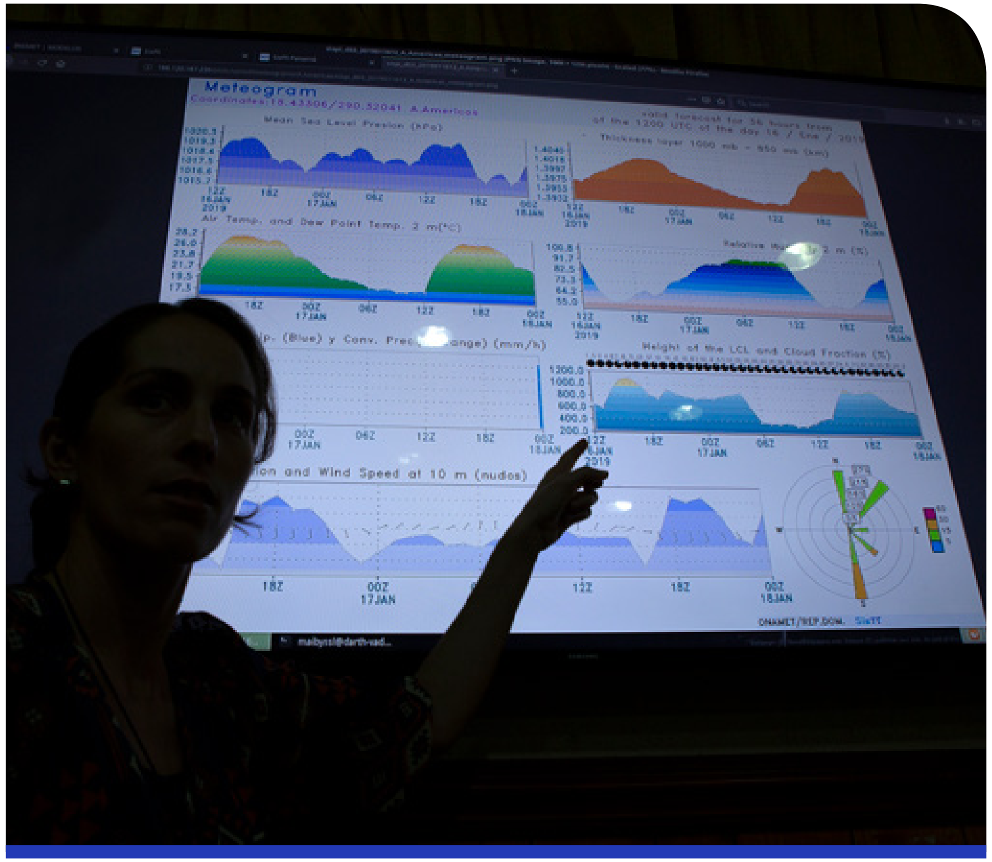
- Description and Specifications
- WRF-related specialty systems (WRF-Fire, WRF-ROMS-SWAN, WRF-Hydro, etc.)
- Visualization Tools to post-process WRF outputs: ARWpost, GrADS, NCL, Python.
- The Generation of Modeling Domains
- Designing Experiments with WRF
- Good Practices for the Design of WRF Experiments

3. Practical Training at River Sites

- Description
- Design of Experiments for La Hispaniola
- Selection of study cases and generating proposed domain
- Methods to Verify Numerical Predictions
- Running Selected Study Cases on SisPI and interactive practice with the system
- Web Page needed for SisPI
- SisPI Modeling Products
- Identification of new products for the Dominican Republic

monitoring and forecasting procedures for extreme hydro-meteorological events, as well as an orientation to each team in terms of their roles in generating specialized meteorological products tailored for the energy, transport, water management and agriculture sectors. SisPi is the primary tool for producing forecasts with relevant variables to the sector, including rainfall, direction and velocity of the wind, temperature, relative humidity, and cloud cover. Discussions were held on how to adapt these tools to the needs of the Dominican Republic and the technical requirements for installation and use of WRF and SisPI.

Based on this information, the rest of the initiative was planned, the needed equipment identified, the procurement process initiated, and the additional training and technical assistance determined.



CONTENT OF TRAINING AND TECHNICAL ASSISTANCE

Stage 3

Summary:

- Inspection of the equipment purchased
- Preparation and transfer of the SisPI Installation and Use Manual
- Installation and installation training of the server, operating system, compilers, visualization tools, WRF and SisPI
- Configuration of the SisPI scripts and adaptation to the requested modeling products by the country
- Operational tests, detection of errors and correction
- Training and implementation of the new modeling products
- Presentation and review od the new modeling products
- Preparation and design of the Dominican SisPI Web Page

Stage 3 – Installation, Technical Assistance and Learning-while-Doing Training: The third stage took place between the 14th and 25th of January 2019 in the Dominican Republic, with a two-week mission led by two Cuban meteorology specialists from the Centre for Atmospheric Physics of INSMET. The objective of this training was two-fold: to install the equipment, system and software, and to train staff in its application.

Technical assistance was provided to ONAMET, COE, and INDHRI staff, particularly directed at the ICT computer technicians and some of the meteorologists, to install the equipment and systems (server, operative system, the WRF and SisPI software and scripts), carry out an operational test of the system, and teach local staff the step-by-step set-up, using the *SisPI Installation Manual*. The equipment and systems were installed at ONAMET.

The second objective saw a group of meteorologists trained on the use of the newly installed system, focusing on the six meteorological graphic outputs that the Dominican Republic had identified as priority (meteograms, Hovmöller diagrams, etc.), including hydrological rainfall accumulates in specific vulnerable provinces and basins requested by INDRHI. The group worked with the Cuban team to configure the outputs and set up a SisPI *Dominican Republic Web Page* where the information can be viewed live. Meteorologists and other specialists from ONAMET, INDRHI, and COE were the trainees. The training was characterized by a learning-by-doing approach, which promoted greater absorption of knowledge through practical application, as well as direct involvement of the users in developing and setting up their own system.

TOOLBOX

- SisPI Installation and Use Manual
- Dominican SisPI Live Web Portal
- WRF User Guide
- SisPI Introductory Training Presentation
- Cuban SisPI Model Report
- Systematization of the Cuban-Dominican WRF & SisPI Transfer Report

5. RESULTS

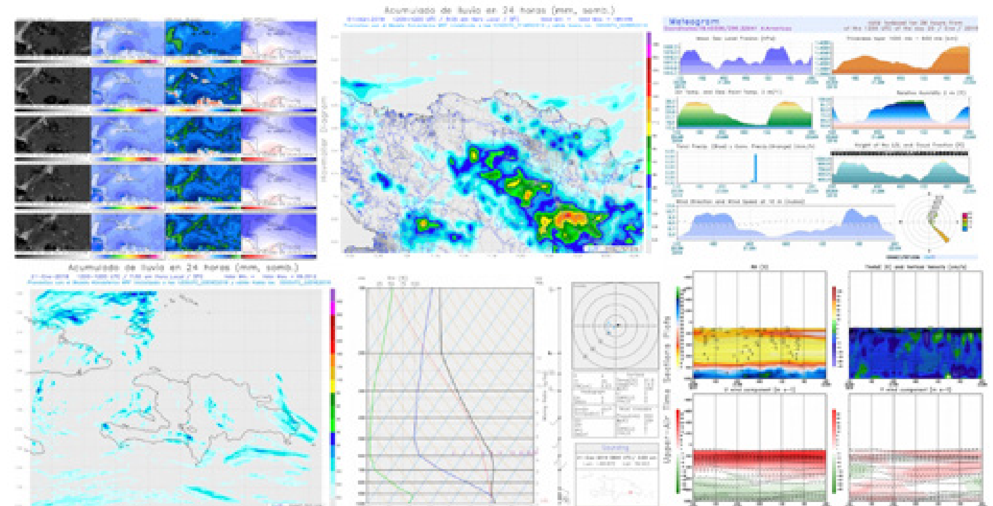
- The Dominican Republic meteorological sector has a fully operational WRF & SisPI system established and in use, generating forecasts four times a day at 3, 9 and 27 km resolution, up to 36 to 72-hour periods respectively, for the following products:
  - Hövmoller Diagram
  - Vertical Profiles and Time Variation
  - Aerological Diagrams for nine cities (Americas, Arroyo Barril, Barahona, Catey, Higuero, La Romana, Puerto Plata, Punta Cana, Santiago)
  - Meteograms
  - Rainfall Accumulates every 24, 48, and 72 hours
  - Rainfall Accumulates by hydrographic basin/province

- A Dominican SisPI live Web Page

- A SisPI Installation and Use Manual

- 17 forecast and ICT staff trained in installation, maintenance and use of WRF and SisPI

- The Dominican Republic ONAMET reinforced with equipment (two new servers, one hard drive)



Rainfall Accumulates 24hs
Hövmoller Diagram
Aerological Diagram
Rainfall by Basin
Vertical Profiles
Meteograms

6. SUSTAINABILITY

The institutions in the Dominican Republic have identified a series of elements that have or will have an impact on the sustainability of their newly acquired capacities:

- ***Ownership and Usefulness:*** The direct involvement of the staff in installing and creating the meteorological products, and the fact that these products responded to the expressed information needs of the sector, has ensured a high degree of national ownership and use of the system and its meteorological outputs in the day-to-day work of the institutions.

- ***Cost-effectiveness and Investment:*** Given that the WRF, SisPI, and all other visualization tools used are open source, including the updates, upkeeping the modelling system is financially sustainable. In terms of the infrastructural hardware costs, ONAMET is currently analysing budget options to increase its server, fibre optics and memory capacity, to process more data more efficiently and for longer forecasting periods. In the longer term, energy input will be addressed by acquiring a generator and inverters as backup systems during power failures.

- ***Remote Continued Assistance and Regional Networking:*** To assist the country with any failure in the system, a remote access to the server was habilitated to allow the Cuban team to troubleshoot remotely. A Whatsapp Group was also created between SisPI users and developers across the region to allow them to network, share experience and solve problems encountered. The group includes specialists from Cuba, Haiti, Panama, and the Dominican Republic, and is considered a valuable tool and method of assistance to ensure the continued use and improvement of the system.

- ***Expansion of the Dominican SisPI:*** There is an expressed interest to expand the SisPI to other areas, such as marine hydrometeorology forecast (waves, currents, etc.), as well as a desire to train more personnel from the different institutions and expand their modelling and simulation capacities. Training ONAMET staff in advanced WRF & SisPI configuration would harness the capacities developed with the new system.

7. LESSONS AND RECOMMENDATIONS

LESSONS LEARNED	RECOMMENDATIONS
The combination of efforts and funds between UNDP and WFP to support the Dominican Republic forecasting capacities allowed the initiative to have a greater scope and results. The fluid coordination between the UNDP and WFP Country Offices, Cuba, and the recipient institutions in the Dominican Republic was a key factor of its overall success and allowed for detailed planning and organization of the different activities on an on-going basis.	*Inter-Agency Coordination:* Seek collaboration between existing agencies and partners to maximize technical assistance and funding. Use inter-agency coordination groups as platforms for identifying common areas of support and coordination of actions.
The well-established inter-institutional coordination protocol between ONAMET, INDRHI, and COE allowed the recipient country to determine the consolidated demand, coordinate the definition and implementation of the transfer, and ensure there was a common understanding of the expected objectives and results from its inception.	*SSC Coordination:* Maximize existing inter-institutional coordination mechanisms in recipient countries to coordinate, review and implement relevant transfer and cooperation, allowing for broader ownership, more evenly distributed responsibilities and reflection in sector-wide plans and efforts. Map member entities of existing groups and commissions under a COE type mechanism.
Combining training with technical assistance in the set-up and installation of the equipment and software, and using a learning-by-doing approach, was a critical factor of success. It ensured that all systems were in place, tested, and operational by the end of the transfer, and that local technical staff learned how to do it. Also, being able to train using the newly established system and designing/configuring new products as part of the training increased the potential for future expansion of the system outputs. The Dominican forecasters learned how to use the system as well as how to design new modelling output.	*Systematic Utilization:* Emphasize greater engagement with national and regional scientific and research centres and universities to expand the use of the recently installed system in hydro-meteorological research, forecasting and simulating.
The length of the training was also critical for success; adequate time allowed for fuller and more effective absorption of the material and the practice exercises to test the acquired knowledge.	*Training Duration:* Schedule more than one training session for training initiatives focused on numerical modelling and mapping; at a minimum, the training should last two weeks to ensure transfer of skills.
Given that the technological gap with Cuba is significant, there is a possibility that the recommended hardware specifications might be lower tech than the technological level of recipient institutions; if the budget allows, the equipment can be upgraded.	*Addressing Technological Gaps:* Conduct more precise analysis of the computational hardware, to ensure the equipment purchased provides sufficient data processing and storage capacity. Involve ICT and other engineers with expertise in the institution's equipment when analysing and making decisions about hardware.

LESSONS LEARNED	RECOMMENDATIONS
The Solutions Package/Priority Action proposal formats were not the most useful, practical tool to guide the planning and implementation of the initiative.	*Solutions Packages and Call of Proposals:* Implement a more user-friendly, results-based management approach and format, where results, baselines, indicators and targets are reviewed for quality control and measurability, and where clear responsibilities, timelines, and budgets are reserved for monitoring documentation of the experience, and preparation of a final report. Carry out a knowledge survey among trainees beforehand and post-transfer to measure the acquired capacities.
The adaptation of the SisPI manual for the Dominican Republic and the configuration of meteorological products based on the specific needs of the recipient country was key to its degree of ownership, usefulness and context-specific developed capacity.	*Knowledge Adaptation:* Adapt offered knowledge to the local context and needs of the recipient country. Incorporate this as a core element of all Solution Packages, with an outline of how the proposed methods and mechanisms will be revised and adapted substantively before and during the transfer.
Despite the length of the trainings, securing the commitment of the institutions to nominate trainees and ensure staff participation throughout the entire process increased the effectiveness of the transfer.	*Institutional Commitment:* Engage decision-makers to secure a high level of commitment.
Including a systematization of the process as part of the implementation of the initiative guaranteed that the process was being well documented, that lessons were being generated and that the country would have a basis for sharing and replicating the experience.	*Systematization:* Include the systematization and documentation of the practice as a planned function in the SSC workplan. Provide a standard format and systematization guidelines to all SSC initiatives, and budget together with M&E functions.

8. CONCLUSION

Together with Antigua and Barbuda, Saint Lucia, Dominica, and SVG, the Dominican Republic has advanced in policy making for early warning systems, through analysis of gaps and planning a roadmap forward. This process has reinforced countries' understanding and identification of the strengths and gaps in their early warning systems, the standards for people-centred multi-hazard systems, and promoted commitment to addressing potential risks and threats with prioritized actions plans.

These efforts were supported by Cuban technical assistance, leveraging tested tools and methods, and promoting engagement between countries sharing similar context and exposure to hazards. In the Dominican Republic, the training and application of numerical forecasting for improved monitoring of basins and flash flooding aimed to strengthen EWS Pillar Two – Monitoring and Warning System. This experience provides solid lessons and recommendations for planning and implementing future knowledge transfers to the Dominican Republic or other islands. It also lays the foundation for providing authorities and decision-makers with the risk analysis tools necessary to provide effective and integrated early warning to other communities.

This systematization aims to make a fruitful contribution to the region's knowledge on early warning systems and to global knowledge on South-South Cooperation practices.