

## Chapter 2

# The Tropical Cyclone Early Warning System of Cuba

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**Abstract** For more than 40 years, the Cuban Government has been investing material resources and human capital in the creation and improvement of its early warning system for tropical cyclones and other alert systems. As a result, the resolution of meteorological and hydrological monitoring systems has been strengthened through the acquisition of new equipment, the training of specialists and the development of working tools that improve understanding of the hazards. Plans have been refined and structures have been perfected to ensure their implementation along with the population's preparation, at national to local levels. An extensive network of radio and television stations, newspapers and other facilities has been established to ensure the rapid dissemination of alert messages. Recently, local access and distribution points for early warnings have also been set up in communities at greater risk. Associated with the local administration centers, these outlets contribute to ensuring the timely transmission of information for the reduction of municipal risk. In summary, Cuba's system has the following key components:

- The technological capabilities of the meteorological service to predict the occurrence of hazardous events and issue specialized warnings for the Civil Defense and a clear explanation of the current and future situation to the population at large.
- Ensuring the application of plans elaborated from modeled risk scenarios to advance preparations by institutions trained for their implementation and reinforced by a prepared population with an appropriate perception of the hazard. All of this facilitates rapid mobilization.
- A network that uses all available means, from advanced technology to people themselves, to ensure the rapid transmission of alert messages.

### 2.1 Overview

Cuba's island condition and geographic location in the path of most tropical cyclones that develop in the Atlantic basin and the Caribbean Sea make these hydrometeorological events the greatest hazard faced by the nation. At the same time, official United Nations reports indicate that Cuba is one of the less vulnerable countries in relation to these weather phenomena. This has resulted, to a large extent, from the fact that, for several years, Cuba has had an Early Warning System (EWS) in place, supported by numerous institutions including an efficient Meteorological Service with an extensive monitoring network of meteorological and hydrological stations and weather radars. The Early Warning System ensures continuous monitoring, timely warning and effective communication links between the monitoring systems and Civil Defense organs, from the national down to the local level. The dissemination of forecasts and warnings is underpinned by a secure communications system and by the involvement of all mass media, alternative resources, and the people. Plans have been designed for different situations on the basis of the most likely disaster scenarios. All existing resources are made available during these contingencies, ensuring that people are effectively protected against the different hazards that they may face where they live.

### **2.1.1 Background to the Establishment of EWS in Cuba**

In Cuba, a set of institutions is entrusted with the monitoring of all events threatening the country. They ensure surveillance against hydrometeorological events, droughts, forest fires, floods, earthquakes, epidemics, and animal and plant diseases. They also, systematically, keep the relevant state authorities informed, with the reporting frequency ranging from daily to monthly depending on the variables and phenomena involved. These institutions have branches in all provinces, with some having municipal representation, and supply data on the variables they measure to both national and territorial authorities. This surveillance network provides the basis for Cuba's Early Warning System and is part of its Civil Defense System.

Prior to 1995, tropical cyclone activity in the Atlantic, Gulf of Mexico and Caribbean Basin was relatively low. During the decade of the 80's, for example, only hurricane "Kate" hit Cuba, in 1985, and it was a weak storm. An active period began in 1995 and that year registered the second most active hurricane season of the 20th Century, with 1933 being in first place. Although Cuba itself was not affected by any hurricanes in 1995, neighboring countries were badly hit by some of them. In consequence, the Cuban National Meteorological Service identified a need to provide early alerts on tropical cyclones, to increase awareness and preparation time, rather than simply issuing information when a hurricane directly threatened the country. Early Warning Messages were, therefore, initiated in 1996, being added to the regular warnings system. The first Early Warning Message was issued on 14 October 1996, several days before hurricane "Lili" crossed over the central provinces of Cuba. Success was immediate and since that time Early Warnings have been developed and institutionalized so that, today, not only text information is provided but also graphs depicting probabilities. Moreover, continuous interaction takes place with the Civil Defense, the Central Government of the country and other interested organizations.

## **2.2 Governance and institutional Arrangements (National to Local Levels)**

### **2.2.1 Policy, institutional and legal Frameworks to Support Emergency Planning and Response**

Cuba has a broad legal framework that regulates the functioning of Early Warning Systems at all levels. Those laws and directives which provide guidance in this area are mentioned below:

- Law No. 75/94 (December 21, 1994) of National Defense establishes the main missions and measures of the Civil Defense System and the principles for its territorial and institutional organization.
- As a complementary document to Law 75, Decree-law No. 170/97 (May 8, 1997), on the Civil Defense system of measures, regulates the role and position of state agencies and organizations, economic entities and social institutions in the disaster reduction process; the organization and implementation of these measures to protect the people and the economy; the establishment of phases during the response and the funding for disaster reduction plans.
- Guideline No. 1/05 (June 20, 1995) of the Vice President of the National Defense Council<sup>15</sup> on the planning, organizing and preparing by the country for disaster situations, establishes the regulations for the disaster reduction process and the guidelines to organize response and recovery at all levels. This document provides for the supply of updated information by the surveillance and early warning systems and its contribution to the actions implemented during the response, as one of the most important elements within disaster reduction plans. It also stipulates that in case of tropical storms, "Early Warning notices will be issued prior to the establishment of the response phases, so that the necessary measures are taken in advance". According to this guideline, the National Staff of the Civil Defense is the agency in charge of ensuring the implementation of civil defense measures and the observance of international standards and agreements regarding the civilian population signed by Cuba. It is also responsible for coordinating with the Ministry of Foreign Investment and Economic Cooperation concerning international cooperation and aid programs in cases of disasters caused by natural hazards or other types of catastrophe. In addition, its powers and functions include organizing, coordinating and controlling the work of state agencies and organizations, economic entities and social institutions with a view to protecting the people and the economy, as well as acting as a national organizing platform for the system.
- Resolution No. 43/06 (August 8, 2006) of the Ministry of Science, Technology and the Environment establishes that the Environment Agency is the body that has the mandate to organize, lead and conduct hazard, vulnerability and disaster risk studies. There are other legal texts that complement this guiding document at all levels. These include: Law No. 81/97 (July 11, 1997) on the Environment, Law No. 41/83 (July 13, 1993) on Public Healthcare, Law No. 77/95

<sup>15</sup> National Defense Council is the highest level in the response structure of the country.

(September 5, 1995) on Foreign Investment and Law No.85/98 (July 21, 1998) on Forestry, as well as ministerial and local resolutions which address specific aspects relating to the functioning of the early warning system for tropical cyclones and other hydro-meteorological events.

- Resolution 106 /99 (December 6, 1999) of the Ministry of Science, Technology and Environment establishes the General Norms of Direction, Organization and Operation of the Institute of Meteorology (INSMET), subordinated to the Ministry of Science, Technology and the Environment (CITMA). This document describes the general structure of the Institute of Meteorology of Cuba as the National Meteorological Service with the main mission of “giving authorized, reliable and opportune meteorological and climatic information on the state and future behavior of the atmosphere. This information is aimed at protecting the security of human life and reducing losses of material goods from disasters of meteorological origin, contributing directly to the well-being of the community and sustainable socioeconomic development”. One of the functions of the Cuban Meteorological Service laid down in the Eleventh section of the document is to improve meteorological and climatic prediction, especially of phenomena that constitute hazards to human life, and to material goods and the national economy. Furthermore, this Resolution assigns to the Institute of Meteorology nation-wide responsibilities to issue through the Media, as the only authorized institution, meteorological and climatic information that may be required, especially warnings and forecasts of variables, processes and meteorological phenomena that constitute a hazard for human life, material goods, and the economy and for the development of the country. A somewhat similar role is defined for Provincial Meteorological Centers, as the only institutions authorized to disseminate and issue through the provincial Media meteorological and climatic information that may be required, particularly the warnings and forecasts of processes and meteorological phenomena that could constitute a hazard for human life, the loss of material goods, the economy and for the development of the county.

On a broader, overarching level, the Executive Committee of the Council of Ministers issued Ordinance Law No. 279/07 (March 19, 2007) “On General Principles, Organization, Preparation and Provisions of the Hydrometeorological System of Cuba for Exceptional Situations”. This Law lays down that the Hydrometeorological System for Exceptional Situations is the group of hydrological and meteorological entities deployed in the territory of the country that has as its main mission to obtain, analyze, evaluate, process and issue the necessary hydrological and meteorological information for the execution of protective measures directed at the mitigation of the effects of disasters caused by natural hazards.

### ***2.2.2 National to Local Emergency Planning and Related Linkages to EWS***

The success achieved by Cuba with warnings on the impact of tropical cyclones is based, to a great extent, on the response planning processes. These involve the following:

- Plans for disaster reduction are elaborated down to the lowest level of the administrative political division of the country and are updated every year between January and April.
- At each level, the necessary resources are earmarked to ensure the protection of people, their goods and the economic resources (transportation, foods, medical care, emergency electric generators for vital services, etc.), based on the degree of risk for each community. Shelters for evacuees are identified and certified along with houses that receive people for their protection during an emergency.
- The state and readiness of the system of communications is refined in each territory, through the employment of all local means.
- The resources existing in the reserves established in each territory are checked to ensure efficient and fast recovery action based on a rapid re-establishment of affected vital services. The supplies in the national reserve are also inventoried.
- With the participation of journalists and the national and local media, radio and television, and the social organizations, the communications networks required to keep the people informed are upgraded to ensure delivery of early warnings. These facilities include the existing television rooms in rural and mountainous communities that work with solar panels and dish satellite antennas.
- As part of this process, the authorities that lead the response actions upgrade their plans and inform the population about the changes made to those plans for their protection. These preparations culminate with “Exercise Meteor” that is carried out during one weekend in the month of May, just prior to the beginning of the hurricane season.
- In April of each year, journalists and leaders of the media (i.e. newspapers, television and radio stations) at all levels meet together in a Seminar to upgrade knowledge of their roles and to clarify the national and local strategy for the hurricane season. The National Forecast Center also participates in these Seminars.
- Specialists from the meteorological and hydrological services report on the state of their technical resources to address the hurricane season and hold meetings with the Civil Defense organs at all levels.

The Cuban Meteorological Service is an active participant in the preparation and planning procedures of the Early Warning System (EWS). Its fundamental function is to raise awareness among the people and the institutions of the country by providing information on what is a hurricane; the various hazardous phenomena associated with it; the various risks to be faced and how to avoid them; how the warnings system is organized; and how to interpret warning messages. The Meteorological Service also participates in the preparation phase for the nationwide exercise "Meteor" that is organized annually by the Civil Defense prior to the hurricane season. Meteorologists also participate through frequent delivery of talks to provincial and local Governments, Civil Defense bodies and journalists on hurricanes and the predicted behavior of the next hurricane season. These activities are covered by radio and the television and serve to prepare the population for the upcoming hurricane season. Coordination plans and communications links between the Meteorological Service and the Civil Defense are also updated, in order to place the system in a state of complete readiness prior to the start of the hurricane season.

The Cuban Civil Defense is organized throughout the national territory on the basis of the country's political-administrative divisions and State structure. Its activity is supported by the use of the human and material resources available in government agencies and organizations, economic entities and social institutions, i.e. the organized forces of society. The President of the Council of State heads the Civil Defense System, through the Minister of the Revolutionary Armed Forces. In this capacity, the Minister is supported by the National Staff of the Civil Defense which is the lead agency in this System. The presidents of local governments are, correspondingly, the heads of the Civil Defense in their territories. In carrying out this responsibility, they have the support of the local professional Civil Defense entities which, along with state organization at all levels, coordinate, organize and plan the periodic assessment of risks associated with each event, the disaster reduction measures, the people's preparedness, the dissemination of information regarding actions to take and the behavior to be observed during different situations. They also control the implementation of protective measures for the different segments of the population, their property and the economy. Similarly, the top authorities of the central state administration and those of social institutions and entities are the heads of the Civil Defense for these bodies and are responsible for the implementation of the measures contained in the approved disaster reduction plans in their respective areas. Those individuals at the heads of ministries, industries, companies, education centers, hospitals, banks, cooperatives, stores, workshops and other production, service or research centers are also the heads of the Civil Defense in their respective institutions. They are in charge of planning, organizing and implementing Civil Defense measures which are mandatory for all institutions.

Political and mass organizations at all levels play an important role in the implementation of Civil Defense measures because of their autonomy and characteristics. These organizations have always actively participated in evacuation, rescue operations, and citizen's orientation and information in the event of disasters. At the People's Councils<sup>16</sup>, the lowest government representation, measures are implemented to respond to and recover from disasters in accordance with the disaster reduction plans for each municipality. Disaster reduction plans are drafted for every territory and for all economic entities. These plans include an assessment of the risks at every location and are updated yearly using the data provided by the entities regarding the vulnerability parameters established by the methodology. The plans include measures to mitigate vulnerability and preparedness, response and recovery actions. They are prepared according to the instructions provided by the entities' higher government level and the decisions adopted by the local governments.

Disaster Reduction Plans that are prepared at each territorial level as well as within each organization and ministry, start from an updated assessment of the difference in risk between each location. This is defined on the basis of the magnitude of the hazard associated with each meteorological event and the vulnerabilities identified at that level. Starting from the update and appropriate zoning of the risk, actions for mitigation of vulnerabilities are established for that year, taking into account the available material and financial resources and prioritizing the most risky areas. Taking into account the level of risk at each location, measures for the protection of the population and economic resources are refined and appropriate response actions are planned to address each event, including actions needed to ensure a rapid and efficient recovery. The national organisms and ministries update the guidance for their entities, which also refine their plans on the basis of the risks associated with the territory where they are located, taking into account the specific guidance from their ministry or organism.

The Cuban Meteorological Service is engaged from the very beginning in the process of planning an Early Warning. The Meteorological Service issues the first early warning signal by means of a document entitled "Early Warning Message" that is sent to the Civil Defense and the Central Government when a meteorological situation is seen by the Service as being potentially dangerous for the country during the upcoming 120 hours. This "Early Warning Message" is issued in clear language that is understandable to non-meteorological personnel. It enables them to appreciate the uncertainties associated with a meteorological process that may or could happen and affect the country within a relatively long time frame of 120 hours. This type of information is transmitted through the media to the population in order to ensure an increasing level of concern while, at the same time, not creating immediate alarm. The precise purpose of these "Early Warning Messages" is to inform the Civil Defense, the High Authorities of the Country, and the population in general, in a timely manner, that it is necessary to monitor the meteorological situation over the coming days so that if a hazardous meteorological system develops they will be ready to take the required preventive measures.

<sup>16</sup> People's Councils are constituted in cities, towns, neighbourhoods and rural areas.

### 2.2.3 Organizational Structure for Implementing the Plans

The Early Warning System for tropical cyclones includes the following elements:

- An effective meteorological and hydrological surveillance system with appropriate human and material resources to ensure permanent monitoring and timely warning, both at the national and local levels.
- Effective communication between meteorological and hydrological surveillance systems and Civil Defense institutions, both at the national and local levels.
- An effective network for transmitting information, supported by secure communications systems.
- The use of all of the mass media to disseminate warning notices, including radio, television, newspapers, along with alternative means and people, both at the national and local levels.
- Plans designed for different situations, on the basis of likely disaster scenarios, and supported by all resources available in each territory, in order to ensure the effective protection of people under different levels of risk.

Figure 2.1 maps the EWS organizational structure at national and provincial to local levels, identifying ministries, disaster risk management agencies and authorities, other technical agencies, media and non-governmental organizations (NGOs).

In the context of risk management and the handling of disaster hazards, the Early Warning System (EWS) plays an important role in reducing human and material losses in Cuba. The EWS is considered a major Civil Defense asset and is systematically used and strengthened. The Cuban EWS takes advantage of the existing socio-economic structure, the strength of the institutions, and the levels of organization and education of both the authorities and the general population, among other aspects that assist its functioning. In general terms, the main participants in the Cuban EWS are:

- The central surveillance entities responsible for monitoring the hazards along with their territorial branches responsible for this work at regional and local levels. The central surveillance entity for meteorological systems is the National Forecast Center of the Institute of Meteorology (National Meteorological Service).
- The authorities entrusted with the provision and dissemination of disaster related information at the different levels and with implementing the relevant protective measures, advised by officials and experts of the Civil Defense. These authorities are the top officials at provincial and municipal levels (Governors or Presidents of the Provincial Government; Mayors or Presidents of the Municipal Government).
- The media and mass and social organizations at the local level which help to disseminate information. These include local media, newspapers, radio and television stations that exist in all the provinces and most of the municipalities in the country. The mass and social organizations that participate in the dissemination of the information in urban and rural areas, respectively, are the associations of neighbors known as the Committees for the Defense of the Revolution (CDR) that bring together residents and exists in all neighborhoods of the country, and the National Association of Small Farmers (ANAP).
- The people who are well organized and prepared. These are, fundamentally, people of the mass and social organizations that have been trained to disseminate alert messages in communities far from the main cities and towns. They also include the people in charge of the operational sites for early warning located in key places with difficult access, who are prepared to measure rainfall and river levels and flows. These latter individuals possess means of communication enabling them to rapidly inform their respective risk management centre located at the municipal government site.

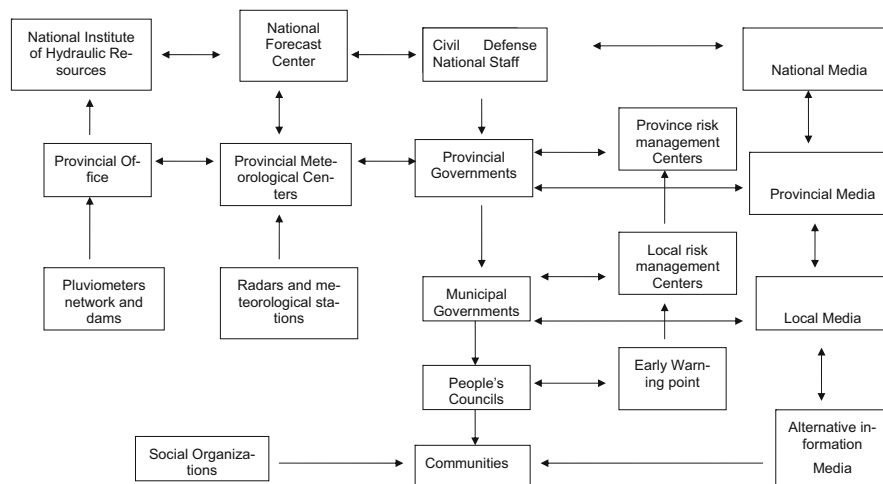


Fig. 2.1. The functional structure of the early warning system in Cuba

The EWS for tropical cyclones is a well-structured, coherent, nation-wide system that works closely with the Institute of Meteorology's National Forecast Center and the National Staff of the Civil Defense. These two organizations exchange and analyze information, allowing authorities to take the necessary measures and establish the relevant phases. At the national level, the exchange of information between the National Forecast Center of the Institute of Meteorology and the National Staff of the Civil Defense facilitates decisions on the phasing of the response for threatened territories, which presupposes a certain time frame for the adoption of measures in those places. The more effectively the Early Warning System works, the greater the opportunity it provides for provinces and municipalities to react, enabling them to protect the lives of people and economic resources exposed to different levels of risk. Whenever a province receives an early warning message, or notice of the establishment of one of the phases of the response, the authorities begin immediately to undertake the measures for that phase, outlined in the plan for disaster reduction, taking into account the characteristics of the threatening event, the level of risk to people and the exposed economic resources. In this decision-making process, a similar exchange to that at the national level, also takes place within the province. This engages the authorities and the meteorological service of that province in determining the magnitude of the impact of winds, rains and storm surge in the territory, building on the guidance that is received from the National Meteorological Service. Having completed this assessment, the planned protection measures, developed during the preparations for each possible scenario, begin to be implemented, making this a fast and efficient process.

Starting from the information provided by the Forecast Center of the Institute of Meteorology, the National Staff of the Civil Defense analyzes the initial situation. A note from the Civil Defense can be transmitted to provide an early warning to the governments of the threatened territories. The exchange of information between the Forecast Center and the National Staff of the Civil Defense continues while the hazard threat remains over any portion of the country. Response action in Cuba is organized into three phases or stages – the “Informative”, “Alert” and “Alarm” phases. The protection measures to be undertaken in each phase are planned for each event. The early warning system functions according to the phase that has been established, taking into account the fact that as the hurricane comes closer to Cuban territory, the ways of disseminating the messages also change. The establishment of each phase is approved by the Central Government, having been proposed by the National Staff of the Civil Defense following consideration of the recommendations provided by the National Meteorological Service, along with other factors. Similarly, the meteorological and hydrological services in each province interact with the authorities and are responsible for keeping both them and the provincial population informed through all available means of communication.

There are three levels of local government in Cuba, namely, province, municipality and people's council. These three levels of government each have a President and a structure that facilitates the organization of the government's administration. The National Forecast Center (Meteorological Service) interacts with the Government at National level. The Provincial Meteorological Centers interact with the government at provincial, municipal and people's council levels, offering information and advice during the different Civil Defense phases. The Institute of Meteorology (Meteorological Service of Cuba) interfaces directly with the Central Government, the National Civil Defense, the National Media, the Provincial Meteorological Centers and the National Institute of Hydraulic Resources, through the National Forecast Center. The provincial meteorological centers provide information on their territory to the provincial and municipal governments, the Civil Defense at that level, the provincial and municipal media and the provincial delegations of the National Institute of Hydraulic Resources. The system is, moreover, a two-way system as the National Forecast Center also receives information from those entities.

The key stakeholders of the National Meteorological Service (NMS) include not only the Civil Defense, the Government, and the various media, at national, provincial and municipal levels, but also the National Institute of Hydraulic Resources, the Civil Aviation Weather Office and different ministries such as the Ministry of Agriculture, the Ministry of the Sugar Industry and the Ministry of Construction. These stakeholders receive meteorological Early Warnings and Warnings as a special service through computer links and e-mail. Once a message has been received by them, the stakeholders speak by phone with meteorologists to receive more detailed information that may be useful in their respective fields. Each of these stakeholders has its own means of transmitting this information down to their lowest level of its activity and receiving feedback.

#### ***2.2.4 Institutional Capacities and Concept of Operations (Coordination and Operational Collaboration)***

The exchange of information between the Institute of Meteorology's National Forecast Center and the National Staff of the Civil Defense is regulated by a Memorandum of Understanding that provides for the monitoring of tropical cyclones as described above. The Operational Plan of the National Forecast Center outlines all the technical procedures required to ensure

the implementation of this agreement, including the frequency of reports and their content. The different stakeholders mentioned earlier receive the information and then contact meteorologists directly to obtain additional details that can help in their decision making process (e.g. forecast wind speeds associated with the hurricane could exceed thresholds for an agriculture cropping activity). Such consultations with meteorologists are made by phone, though written advice may sometimes also be required depending on the information needed and its implications for the decision making process. This is a standard procedure of the Meteorological Service in dealing with these special users. Following the occurrence of a storm, substantial information is also requested to assess the damage and document claims to insurance.

Provincial Meteorological Centers fulfill a role similar to the National Forecast Center except that they relate to provincial and municipal governments, Civil Defense and local users including people's councils. In practice, the Provincial Meteorological Centers represent the Institute of Meteorology at the provincial level, though only the National Forecast Center can issue Early Warnings and Warnings in the event of large scale weather systems such as hurricanes. In such circumstances, the Provincial Centers serve as advisors in assessing the local impact that the hurricane may have in a specific province. Where severe local storms or other rapidly developing local weather features are concerned, however, a Provincial Meteorological Center can issue its own local warning to local authorities, while merely informing and receiving advice from the National Forecast Center.

The roles of the National Staff of the Civil Defense in relation to drafting the early warning reports, the operation of the mass media, and activities undertaken by local authorities to ensure that the warning messages reach the entire population and that necessary measures be taken, are defined in additional documents issued at each level and included in the disaster reduction plan. Acting in accordance with Guideline No. 1 of the Vice-president of the National Defense Council, the heads of all state organisms and local authorities issue resolutions and instructions to regulate the functions assigned to their respective agencies and entities, within the general framework of the Early Warning System and the execution of other activities within the disaster reduction process. The Chief of the National Staff of the Civil Defense, the Minister of the Institute of Hydraulic Resources and the Minister of Radio and Television have issued corresponding instructions in this regard. Local authorities also issue guidance and directions to subordinate levels, specifying the functions to be carried out by these different structures in relation, for example, to the transmission of alert messages down to the level of people's councils; to reports that should be provided by the early warning access and distribution points; and to the maintenance of the flow of information. A large number of additional documents on this topic also exist but will not be summarized here.

Following the response to an event, an analysis is undertaken into how effectively the Early Warning System worked. Measures are taken to strengthen the system based on the experience gained in dealing with the event, thereby ensuring the refinement of procedures. The operation of the EWS is also assessed during the yearly "METEOR" drill that lasts for two days and involves all structures from the national to the local levels. In addition, the system is reviewed prior to the beginning of each hurricane season to ensure that everything is in place. "Exercise Meteor" is held annually during a weekend in May, prior to the beginning of the upcoming Hurricane Season. During the first day of this drill (Saturday), general preparations and all planned response and recovery measures are reviewed and exercised, at all levels of the country (nation, province, municipality, people's council, community and entities). On the second day (Sunday), practical activities such as evacuation and protective measures are carried out with the population and the forces that participate in the response. The Meteorological Service prepares a set of simulated warnings to be disseminated by all communications links that also serve to test the system. In addition, the Meteorological Service plays a role in increasing public awareness by reviewing the main characteristics of hurricanes, the warning service, and the correct interpretation of warnings, and by providing an overview of the coming season. These talks are presented at the commencement of the exercise (on Saturday) at provincial and municipal levels and this activity receives coverage by national, provincial and municipal media.

The Cuban Meteorological Service plays an active lead role in all aspects of the Early Warning process, as well as in the development and implementation of coordination and cooperation with stakeholders. Of top priority are the relationships with the Government and the Civil Defense at national, provincial and municipal levels that have been established in national legislation (see Sect. 2.2.1) and a Memorandum of Understanding (MOU) with the media and the National Institute of Hydraulic Resources (NIHR). Cooperative activities also exist with other entities, however, mainly concerning the enhancement of knowledge on hazardous weather phenomena and increasing awareness prior to a new hurricane season. The MOUs with the media and NIHR and the MOU with the Civil Aviation Weather Office are the only specific agreements of this type. However, the National Forecast Center's Operational Manual details the services to be provided to ministries and other important organizations as well as how the information for them should be transmitted and feedback obtained. The National Forecast Center produces a wide range of detailed information for these special interests, such as forecast winds, storm surge, rainfall, etc for specific locations.

The Cuban Committee of the Red Cross Society is another important stakeholder. The Society has several detachments that participate, at the community level, in the preparation of the population and operational groups that take part in rescue and salvage during the response stage, along with other territorial forces. Although no formal MOU exists between the National Meteorological Service (NMS) and the Cuban Committee of the Red Cross Society, both organizations participate

jointly in workshops, seminars and training sessions. The Cuban Red Cross also receives operationally detailed information from the National Forecast Center so that they can update their contingency plans for specific areas in the event of threat. Their contingency plans do not mention these informal agreements because the information to be received from the National Forecast Center is normally delivered as part of the Operational Plan of the Meteorological Service and is included in this Plan. Since Cuba has chosen to use the MOU process as its basis for documentation of operations and coordination, the Meteorological Service would, however, like to see a statement as to the role the NMS plays included in the development of any overarching MOU regarding EWS operations. The NMS takes part in the planning and implementation process, participating in seminars, meetings and training sessions with the Cuban Society of the Red Cross and other stakeholders, such as the Latin American Center for Disaster Medicine (CLAMED) which has implemented a Masters Degree course on Disasters in which some of the professors are specialists from the NMC.

### ***2.2.5 Key Factors considered for Sustainability of different Components of Early Warning Systems with a Multi-Hazard Approach***

The development, maintenance, sustainability and strengthening of early warning systems is ensured by means of the allocation of the necessary resources at two levels – institutional and territorial. In Cuba, there are regulations issued by the Ministry of Economy and Planning and the Ministry of Finance and Prices that allow national organizations and local governments to plan the allocation of resources for disaster reduction, as well as those needed for the operation of the early warning systems. In the specific case of the EWS for tropical cyclones, the Ministry of Science, Technology and the Environment plans and receives resources for the maintenance and development of the National Weather Service. Correspondingly, the Ministry of Informatics and Communications and the Cuban Institute of Radio and Television are responsible for the investments that ensure the proper functioning of TV and radio stations at the national, provincial and municipal levels. This is also the case for newspapers. By law, local governments have at their disposal all the resources needed to undertake the protection measures during the response phase that begins the moment they receive the Early Warning Notice. The Cuban Meteorological Service receives funding for all its activities from the State, through the Central Government and the National Budget that is approved by Law every year by the National People's Power Assembly (National Assembly or Parliament). All required funds for the operation of Provincial Meteorological Centers and for the maintenance of radars and weather stations are also included in the National budget allotted to the Institute of Meteorology.

Development of EWS has a number of financial costs associated with it. These include long-term, on-going, investments in the four components of the early warning systems, including:

- Observing, monitoring and forecasting of hazards;
- The development of risk information and inclusion of risk information in the warning messages;
- Communications systems for dissemination of warnings to the authorities and the population at risk, and
- Emergency preparedness and response planning at the community level (training, emergency planning and drills), with support from provincial and national governments.

Furthermore, operations of the EWS during a potential event have many costs including the coordination, cost of preparedness prior to an event, evacuations, etc. In addition, there are other human resource and training requirements for the development and maintenance of these systems over time. As in any other Cuban institution, the budget for the coming year begins to be discussed at the Meteorological Service from April to June of the previous year. A proposed budget is presented in July each year. The proposed NMS budget is included in the overall budget of the Ministry of Science, Technology and Environment and forms part of the National budget proposal. The National State Budget is approved by the People's Power National Assembly (Parliament) during its December session. Budget allocations are then made at the Ministry level with the National Meteorological Service subsequently receiving its own budget along with responsibility for its implementation. The NMS obtains all funding requirements for the fiscal year in its State Budget through this process. The human resources needed for the maintenance of the Service are obtained each year from the University, taking into account assessments of requirements from the preceding three years and the progress that students have made in practical work at the NMS during three years prior to graduation. There is currently no methodology developed for cost-benefit assessments although an overall assessment of damage is made by local, provincial and national governments, with the aid of the Civil Defense and the insurance sector.

## 2.3 Utilization of Risk Information in Emergency Planning and Warnings

### 2.3.1 *Organizational Responsibilities and Arrangements for the Development of Risk Information*

Fulfilling a mandate under Guideline No. 1 of the Vice-president of the National Defense Council, the Environment Agency of the Ministry of Science, Technology and the Environment has been assigned the responsibility, under Resolution No. 43 of August 8, 2006 of that ministry, to organize, lead and conduct hazard, vulnerability and disaster risk studies. In carrying out these tasks, the Environment Agency can draw upon the nation's scientific potential and is assisted by other organizations of the central government administration. This agency has a group of specialists that have elaborated the methodology to assess the risk using vulnerability indicators which are determined in each municipality. These facilitate monitoring the reduction of major vulnerabilities. Guideline No. 1 and the Resolution No. 43 constitute the legal mandate for this agency to create the group of specialists that elaborated the methodology for risk assessment in each municipality and to prepare the specialists in each territory. At the local level, groups of specialists are being created from municipal organizations such as Physical Planning, Statistics, Water Resources, Public Health, Agriculture, Construction, Housing, Project Enterprises and others, under the supervision of the local office of the Ministry of Science, Technology and the Environment. This risk assessment program is undertaken in coordination with the National Staff of the Civil Defense.

Using a guide drafted by the National Staff of the Civil Defense for carrying out the risk studies, the Environment Agency, assisted by a group of experts from different scientific institutions, has compiled a methodology for risk assessment that considers the impact of the rain, the wind and the sea. This methodology has already been applied in the municipalities exposed to greatest hazard. The local office of the Ministry of Science, Technology and the Environment in each province coordinates with the other organizations in the territory to obtain the necessary data to determine the risk. Among the organizations involved are the territorial divisions of Housing, Physical Planning, Statistics, Water Resources, Public Health, Education and others. The findings are all stored in a database, supported by a Geographic Information System (GIS), which is updated as actions are implemented to reduce vulnerabilities. The methodology allows the local governments to determine the risk periodically so that its reduction can be monitored. This necessitates that the specialists from each organization update the information related to each indicator of vulnerability.

As regulated by law, the Meteorological Service of Cuba is the only entity in the country that issues meteorological information on dangerous phenomena. Its researchers and technicians participate in hazard, vulnerability and risk studies that are undertaken by multidisciplinary technical groups in the Agency of the Environment, a component of the Ministry of Science, Technology and Environment (CITMA) that has the national mandate for such studies. The participation of the NMS in these studies relates, mainly, to investigations of hazards and to numerical simulation of storm surge and winds performed for vulnerability and risk studies.

### 2.3.2 *Hazard Assessment, Quantification and Mapping (National to Local)*

Hydrometeorological events, specifically tropical cyclones, pose the greatest hazard for Cuba. During the past 158 years, Cuba has been affected by 205 cyclones for an average of 1.2924 annually. There is a 60 percent probability that a tropical cyclone will strike Cuba in any one year. The corresponding probability is 71.3 percent that a tropical cyclone will affect Cuba without the eye making landfall on the island. The probability of a major hurricane striking Cuba is only 13.3 percent annually while the corresponding figure for a hurricane coming close to Cuba increases to 17.3 percent. On average, therefore, a major hurricane passes over Cuba every 7.5 seasons and one comes close to Cuban territory every 5.8 seasons.

In Cuba, October is the most hazardous month in terms of the frequency and the intensity of tropical cyclones, followed by August and September with hazard probabilities that are quite similar. Overall, 97.3 percent of the tropical cyclones that have hit Cuba have done so within this season. All tropical cyclones that have affected the country during October have made landfall from the south coast and most of these have been formed in the central and western zones of the Caribbean Sea. In October 1963, Hurricane Flora affected the eastern region of the country for 5 days, with heavy rains unleashing great floods in the basin of Cauto River. Over one thousand people died and the economy and environment were seriously damaged. Addressing the causes for the disaster, then Prime Minister Fidel Castro outlined steps that should be taken to begin building reservoirs, canals and other water works, regulate flows and to prevent floods from occurring in future. This policy was rapidly implemented all over the country that today boasts 239 water dams, hundreds of kilometers of canals and other works. All of these facilities are monitored daily in relation to their operating standards and also receive ap-

appropriate technical maintenance. In October 2007, the combination of a long spell of rain plus intense precipitation associated with the passage of tropical storm Noel resulted in the accumulation of a volume of water similar to that of 1963 in the same areas. This time, however, the water works built during previous years and the prompt and organized action of the population and the authorities prevented the loss of human life.

The Cuban Meteorological Service (NMS) participates in studies of hazards, contributing data, processing and analysis and obtaining, as final output, hazard maps for different hazardous weather systems or weather elements. Several weather systems and elements have been addressed in this way, including hurricane storm surge maps and maps of strong winds, coastal flooding and floods due to intense rains. There are also return period maps and maps that try to take into account the effect of climate change, for future planning purposes. These studies are already in a very advanced stage but have not yet been completed for the whole country. More specifically, the maps for coastal flooding and hurricane storm surge have been completed for all Cuban coastal areas and an electronic Atlas has been created for rapid consultation. The NMS also plays an important role in national post-storm impact analysis, jointly with the Government and the Civil Defense. Here, the main contribution of the NMS is in the assessment of impacts in the areas affected by winds, rains, rain flooding, storm surge, coastal flooding and other aspects of the storm, as well as in the evaluation of the forecasts that were made. This impact assessment of the meteorological factors and the damage that they caused are very important inputs for updating hazard maps and related information.

### ***2.3.3 Assessment of Vulnerabilities and Exposure (National to Local)***

Starting from the studies carried out on the hazards of rains, the state of the sea and winds in hydrometeorological events that threaten the country, a group of national level specialists developed a methodology to determine the associated risk of each of these events. This methodology establishes indicators of vulnerability such as the technical condition of buildings, the drainage situation, the level of people's exposure in flood areas, etc. This enables multidisciplinary groups that have been created in each municipality with the participation of all the involved organisms to estimate the reduction of risk that constitutes the basis for annual updating of disaster reduction plans. All information related to the update of the databases for each vulnerability indicator and the determination of the risk for each area is carefully stored at the risk management centers in each municipality and is supported by a Geographic Information System (GIS). The results of the update of the risk levels in each people's council of the municipality are relayed to the provincial and national levels. This annual analysis enables the weakest aspects of the risk assessment to be determined and these are then corrected for next period. The communities with greater exposure to the hazards generally coincide with those at greater risk because they also concentrate the main vulnerabilities. Consequently, these places require more detailed planning of response actions and are, therefore, prioritized, generally being the first ones to be protected with the available resources in the territory.

The Environment Agency creates the groups of specialists that elaborate the methodology for risk assessment in each municipality and trains specialists in each territory. At the local level, groups of specialists from municipal organizations such as Physical Planning, Statistics, Water Resources, Public Health, Agriculture, Construction, Housing, Project Enterprises and others are created under the supervision of the local office of the Ministry of Science, Technology and the Environment. The risk assessment program is undertaken in coordination with the National Staff of the Civil Defense. Using a guide on the conduct of the risk studies drafted by the General Staff of the Civil Defense, and assisted by a group of experts from different scientific institutions, the Environment Agency put together a methodology for risk assessment that considers the impact of the rain, the wind and the sea. This methodology has already been applied in the municipalities exposed to greater hazard. The methodology allows for the local governments to periodically determine the risk so that its reduction can be monitored. This requires that the specialists from each organization update the information related to each indicator of vulnerability. The vulnerabilities associated with the destructive effects of hurricanes and other hydro-meteorological events are assessed (winds, storm surge, coastal flooding, rains, etc.) While these are, according to historical data, the most frequently recurrent events, vulnerability indicators have also been determined for drought, forest fires and earthquakes.

The Environment Agency has the mandate to produce hazard, vulnerability and risk maps for each municipality. The designed vulnerability indicators consider the special needs and the economic and social development of each municipality and their communities to assess the risk to each area. The social achievements of the Cuban Revolution – which wiped out illiteracy and promoted education, provided free health care, built roads connecting the most remote places, guaranteed electricity to more than the 95 percent of the homes, and facilitated women's involvement and participation – have progressively led to a reduction in the population's vulnerability to the impacts of hurricanes and other weather events. Today, the main elements of vulnerability to hurricanes relate to the technical state and the construction methodology of

houses, mainly in the eastern region where more than 240 coastal settlements still exist and a large number of houses are adjacent to rivers or in the path of spillways. The Cuban Meteorological Service also participates in vulnerability and risk assessment studies with data, processing, analysis and the prediction of local hazards and by providing advice for these studies as well as to local authorities.

#### ***2.3.4 Storage and Accessibility of Disaster and National Hazard Risk Information***

The National Meteorological Service has the responsibility of gathering all the relevant basic information on meteorological systems as well as on each of the hazardous weather elements such as hurricanes, intense rains, storm surge, coastal flooding, severe local storms and their associated phenomena (lightning, tornados, strong winds), cold fronts, and strong winds not associated to the meteorological systems already mentioned. The assessment of risks, the conscious and progressive reduction of associated vulnerabilities and the monitoring of their reduction is a mandate of the Cuban state that the government at its different levels is required to implement. With financial assistance from agencies of the United Nations and some non-governmental organizations, Cuba has undertaken a new initiative aimed at facilitating this effort by establishing Risk Management Centers in the most vulnerable municipalities in the country. These Centers are located within the head offices of municipal governments and allow local authorities to keep a record of all hazard and vulnerability studies that have been completed, the main indicators of vulnerability in the territory and all information needed to monitor risk reduction. Additional centers exist at the provincial capitals where the data provided by the municipalities is assembled. The General Staff of the Civil Defense is developing an Intranet that will allow access to all of this information, thus creating a large database with controlled access.

There are three or more Early Warning Points associated with each Early Warning Center from which people can be warned of a hazard or the strike of a new meteorological event. These are, generally, located in remote places with difficult access. Local Inhabitants are trained to operate and maintain these facilities and they are given means of communication and power generators that allow for uninterrupted monitoring of local meteorological situations. Presently, there are 40 Early Warning Centers in operation, seven in the provincial capitals and 33 in the municipalities, along with 129 Early Warning Points. An additional 25 Early Warning Centers and 195 Early Warning Points are being planned. The Risk Management Center also takes part in the response, providing advice to local authorities and making available the data on risks that they store and those data that they receive from the early warning points, thus assisting in the decision-making process. In addition, these data are used to produce hazard maps and underpin the drafting of norms and regulations regarding the use of the land for construction.

The Cuban Meteorological Service has the responsibility of archiving, processing and quality controlling all of the primary meteorological data. It is also responsible for conducting post storm studies, identifying the preferred tracks of tropical cyclones, as well as their impacts, updating and preserving records of hazardous weather, such as tropical cyclones, storm surge, coastal flooding, cold fronts, strong winds, severe local storms and tornados, publishing the results and providing all the available information to the user community.

#### ***2.3.5 Development and Utilization of Hazard/Risk Information to support Emergency Planning and Warnings***

The value of the risk associated with each event is distributed within each people's council. This permits planning the resources for the reduction of vulnerabilities, prioritizing those places at higher risk. In areas with higher probability that the impact of an event will become a disaster, the response and recovery measures are given more detailed attention and greater priority, including the transmission of the warnings on the evolution of any danger. As a general rule, Early Warning Points are situated in these locations to ensure greater effectiveness in the dissemination of the information. The Cuban Meteorological Service has an advisory role during the development and use of the risk information in the planning and warnings stages. Information on risk is incorporated in the warnings, mainly in direct radio and TV broadcasts by meteorologists (e.g. the risk that a certain coastal area may experience a hurricane storm surge and that area should be evacuated). The inclusion of information on risk in meteorological warnings is not mandated by the government, however, though it assists Civil Defense in the mobilization of the people to be evacuated in the threatened region.

## 2.4 Hazard Monitoring, Forecasting, and Mandates for Warning Development

### 2.4.1 *Organizational Responsibilities for Monitoring, Forecasting and Development of Hazard Warnings*

The National Meteorological Service has the sole mandate to issue meteorological warnings for hazards 1–3, 5–10, and 11 in Table 2.1. More specifically, this includes providing all scientific information on the hazard, including its forecast behavior, communicating the information on the hazard to the public and promoting awareness of the fact that it is a threatening meteorological situation for a certain region of the country. The National Forecast Center supplies the basic information to the National Staff of the Civil Defense, following previous coordination with Civil Defense including a discussion on the different aspects of the hazardous situation. The National Staff of the Civil Defense then issue a warning note for the threatened area stating that, in view of the information from the NMS, there is the need to take all protective measures. The hazards listed above are considered Type II hazards. Note that hazards numbers 2–9, and 10 are usually associated with hurricanes although some of them may often occur individually in other weather systems. Where hazards 4 and 9 listed above are concerned, the National Forecast Center provides information that can be used by the National Institute of Hydraulic Resources to assess the probability of river flooding and by the Forest Keeper Body to assess the probability of forest fires. These hazards are classified as Type III from the NFC point of view. Hazard 12 is of primary concern to the Cuban National Center for Seismologic Research, which plays the same role in relation to seismologic hazards as does the National Forecast Center in the case of hydrometeorological hazards.

While the Cuban Meteorological Service has, from the scientific and operational perspectives, the organizational responsibility for monitoring, forecasting and developing the hazard warning and communicating it to the public, the National Civil Defense is responsible for the development of the warning in terms of the mobilization of all national and local resources, including all logistics for protective measures and evacuations. There is, however, a genuine partnership in the sense that the Cuban National Meteorological Service and the National Civil Defense act as part of a single national system in which all efforts are combined for the protection of life and material resources. Consequently, we consider that what we really have is a combination of Type I and Type II hazards.

**Table 2.1** Major hazards that affect Cuba

Hazard	National Agency for Mandate	Type of the Hazard
1. Thunderstorm or lightning	NFC, EMNDC	II
2. Tropical cyclone	NFC, EMNDC	II
3. Flash flood	NFC, EMNDC	II
4. River flooding	EMNDC, NIHR, NFC	III
5. Strong winds	NFC, EMNDC	II
6. Landslide or mudslide	NFC, EMNDC	II
7. Tornado (rotational high winds)	NFC, EMNDC	II
8. Coastal flooding	NFC, EMNDC	II
9. Forest or wild land fire	EMNDC, GB, NFC	III
10. Storm surge	NFC, EMNDC	II
11. Drought	NFC, EMNDC	II
12. Earthquakes	EMNDC, CNIS	I

(NFC = National Forecast Center (National Meteorological Service); EMNDC = National Staff Civil Defense; FKB = Forest Keeper Body; CNIS = National Center for Seismologic Research (National Seismologic Service); NIHR = National Institute of Hydraulic Resources)

### 2.4.2 *Organizational Collaboration and Coordination for Monitoring, Forecasting and Development of Hazard Warnings*

The Cuban Meteorological Service has several coordination mechanisms with the Government and the National Civil Defense. These include very frequent operational meetings while the threat of any hazardous meteorological system such as a hurricane exists, coordination by direct voice line and by computer networks. The operational meetings take place at either the National Forecast Center or at the headquarters of the National Staff of the Civil Defense, since both institutions are located about 50 meters apart. The monitoring of meteorological observations is carried out by the National Meteorological Service using a network of 68 first order meteorological stations, 30 automatic stations, 8 meteorological radars

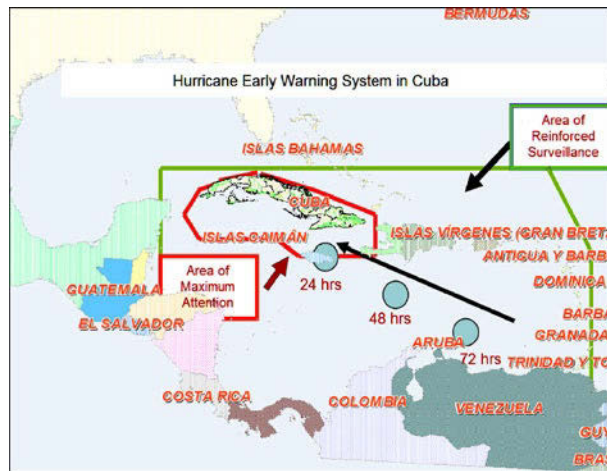
(providing coverage of the whole country) and a meteorological satellite receiving station. All meteorological information is in digital format and is relayed via computer networks that link all Provincial Meteorological Centers and meteorological stations with the National Forecast Center. Forecasts and warnings are distributed to the end users by electronic means. In addition, these products are posted on a web site (<http://www.insmet.cu>) and are made available to the public through a toll-free meteorological telephone service. Live broadcasts by meteorologists are also transmitted directly from the National Forecast Center on radio and national TV stations.

## 2.5 Development of timely authoritative, recognizable, and understandable Warnings

### 2.5.1 *Warning Message Development Cycle*

The Early Warning System for tropical hurricanes is organized and functions in the following sequential manner.

1. The Institute of Meteorology's National Forecast Center continuously monitors the formation and development of tropical cyclones and tropical waves from their genesis off the West African coast through their travel across the Atlantic towards the Caribbean. Within the framework of the WMO RA IV Hurricane Committee, international cooperation is maintained with several countries in the area, including with the United States National Hurricane Center, which is also a WMO Regional Specialized Center for Tropical Cyclones in WMO's Regional Association IV (RA IV). It has been established that no tropical cyclone that has passed outside the area South of latitude 24° N and limited by meridians 60° W and 89° W has affected Cuba. Consequently, any tropical cyclone that enters or is formed in this region (known as the "Area of Reinforced Surveillance" (Fig. 2.2) is closely monitored, even if it is merely a tropical wave with some potential to develop. An agreement exists with the National Forecast Center that, in such cases, the Center produces Early Warning Notices for use by the General Staff of the Civil Defense, sometimes as early as 120 hours before the system may strike Cuban territory. Such a Notice includes an assessment of the tropical system's future development. It is not intended for public broadcast but simply for hazard assessment. At the same time, however, public information will include some indication that the situation should be carefully monitored by everyone.
2. The National Staff of the Civil Defense evaluates the warning and issues a Notice to the governments of threatened provinces and to state organizations whose resources might be affected (e.g. ministries of Agriculture, Tourism, Information and Communications, and others). This Notice is not relayed to the national press due to the uncertainty that still exists regarding the developing system's track and organization. In their weather reports, however, TV channels do begin to refer to the fact that a weather system is likely to become a cyclone and is being watched.
3. The governments of threatened provinces which have received the Early Warning Notice begin to take the measures outlined in their disaster reduction plans to address the anticipated hazard, based on the risk level of each community. Working with the local meteorological and hydrological services, they assess the consequences of the possible impact of rains, waves and winds associated with the tropical event. The necessary logistics for these protection measures are identified but no resources are mobilized at this stage.
4. As the tropical cyclone continues to approach Cuba, the Meteorology Institute's Forecast Center increases the number of warnings, describing in detail the system's future trajectory and organization and the expected impact of the rains, waves and winds.
5. When it is anticipated that the tropical cyclone could affect the island territory within the following 72 hours, the phases foreseen in the response stage (Informative Phase (72 hours), Alert Phase (48 hours), and Alarm Phase (24 hours)) are announced by means of Bulletins issued by the Civil Defense National Staff and broadcast over national and local radio and television.
6. Building on the Forecast Center's assessment of the likely behavior of the rains associated with the tropical cyclone, the provinces' meteorological centers evaluate the probable local impact of the precipitation and forward this information to the hydrological service in the territory. In turn, the hydrological service estimates the potential for floods, based on the water resources situation (i.e. the water levels in reservoirs, canalization and drainage conditions, the degree of soil saturation, and the hydrological condition of rivers). When the rains begin to affect the territory, the local network of rain gauges records precipitation each hour and likely flood areas are mapped and reported to the local governments to confirm that the protective measures being taken are the correct ones under the circumstances.
7. A similar assessment of the likely impact of winds and waves is conducted, taking into consideration the structural vulnerabilities of housing, economic facilities and coastal settlements, each of which receive protection in accordance with their level of exposure and risk.
8. When the tropical cyclone is no longer a hazard for the country, the Recovery Stage is declared. At this stage, the restoration of damaged infrastructure and services commences, in accordance with territorial and national plans.



**Fig. 2.2** Areas of Reinforced Surveillance and of Maximum Attention in the Hurricane Early Warning System in Cuba

The Program of Social Communication for disaster reduction provides the main guidance for the operation of the mass media during all stages of the disaster reduction cycle, including the conduct of surveys among the population regarding the reception and interpretation of the Early Warning message, immediately following the impact of each event. The methodical nature of this process has facilitated perfecting the content of EW messages and the mechanisms for their delivery to ensure that the whole population, including people who live in remote places, receive the EW messages in a timely and appropriate manner. During the process of updating plans previously outlined, checking is carried out to confirm whether corrective actions were included.

In Cuba, two approaches are taken to defining the threshold for warning readiness. One depends on space and the other on time:

### The Space Approach

The space variable defines two areas around the country that determine the actions of Early Warning. Their boundaries were established on basis of a study of historical tracks dating back to 1851 that was undertaken by the Institute of Meteorology to determine the probabilities of hurricanes affecting Cuba. Two areas have been agreed upon – one for “reinforced surveillance” and one for “maximum attention” (Fig. 2.2). The first area is defined by meridians 60° W and 89° W, and for the parallel 24° N. The National Forecast Center of the Institute of Meteorology carefully monitors any tropical cyclone (including tropical waves with some possibilities for development) that is formed in or enters this area, whenever it represents a potential hazard for Cuba. This special monitoring lasts until the cyclone either leaves the area or the conditions for its development have disappeared. This makes possible the issue of an Early Warning, with an assessment of the future development of the system, although a reasonable amount of uncertainty may exist in the analysis. This Early Warning can be issued by the National Forecast Center from 120 to 72 hours before the tropical cyclone begins affecting any part of Cuban national territory. Response actions are modulated by several factors in addition to the storm strength threshold. In addition to the strength thresholds of the meteorological system, the degree of risk of a particular location is taken into account with other factors including the degree of isolation of the given location or difficulty in access to it and whether the beginning of the evacuation operation, as calculated from the already mentioned time variable, is going to be at night. In the latter circumstance, evacuation is scheduled to commence and be completed during daylight and never during the night. A modulation of the response is made in each these situations which are the subject of further studies. The other area, that of a “maximum awareness”, is limited by an imaginary line located 200 kilometers off the Cuban coast line. All tropical cyclones that arrive at any point on this line can begin to affect the country in a 24-hour time frame. Consequently, the moment that the tropical cyclone being monitored penetrates into or makes a tangential approach to the limits of this area, protective measures should be rushed to completion in threatened territories within the 24-hour time frame corresponding to the alarm phase.

### The Time Approach

The time approach specifies time-based stages of Early Warning, taking into account the space analysis outlined above. It is characterized by a step response with the levels of response being established on the basis of the time until the first effects of the tropical cyclone are expected to be felt in the threatened territory. Under this approach, the “Informative

Phase” commences 72 hours prior the onset of any destructive effects of the hurricane in Cuban territory; the “Alert Phase” commences 48 hours in advance of such impacts; and the “Alarm Phase” commences 24 hours prior to such effects being felt. Each Phase determines a set of actions to be executed to protect the population. These actions are defined in relation to the level of risk for each location and the strength and main features of the tropical cyclone (tropical storm, minor hurricane or major hurricane) as forecast by the National Forecast Center of the Institute of Meteorology. The specific Phases for each territory are established by the Civil Defense taking into account the future track and intensity of the tropical cyclone and the risk level of each area.

As explained previously, the tropical cyclone warnings issued by the National Forecast Center and the informative notes issued by the National Staff of the Civil Defense are relayed by the communication links to local authorities who disseminate the information through the mechanisms already mentioned. The meteorological information is broadcast live by meteorologists through TV channels and radio stations to the whole country. After that, the Civil Defense informative notes are delivered carrying the information and recommendations for the protection of lives and material goods. Both types of information have previously been coordinated between the National Forecast Center and the National Staff of the Civil Defense. The National Forecast Center interacts frequently with the National Staff of the Civil Defense. Both organizations are physically located some 50 meters apart, have high speed computer links, dedicated telephone lines and a special folder in a dedicated local network for all information to be shared. The two organizations discuss the performance of the watch, forecast and warning process immediately after a hurricane has affected the country to search for weaknesses and improve the mechanism for the next threat.

The National Forecast Center has an operational cycle for issuing warnings. This 6-hour cycle begins with the reception of all relevant data from the WMO Global Telecommunications System (GTS) and Cuban weather station network, meteorological radars, satellite imagery and reconnaissance aircraft, as well as numerical model guidance on hurricane track and intensity from Cuban and foreign forecast models. Meteorologists meet two hours prior to the issuance time to discuss all data and forecasts models, to identify the hurricane’s position, strength, direction and speed of movement for the advisory issuance time. A draft of the advisory is written one hour before the issuance of the warning message. A half an hour prior to being issued, the text is discussed among meteorologists, including the Director of the Forecast Center who takes the final decision and makes any necessary changes. The Director then meets with the National Staff of the Civil Defense to discuss the results and coordinate the dissemination of the warning, which is delivered to users exactly at the issue time. Meteorologists then go “on air” on national television and radio with latest updates on the hurricane. This procedure is repeated every 6 hours when a hurricane is in the area of reinforced surveillance.

In addition to hurricane forecasts and warnings, the National Forecast Center issues different products such as specialized forecasts for ships and coastal interests, special services to agriculture, tourism, insurance companies, telecommunication companies, etc. All of these products are regarded as special information to address individual requirements of a special group of users. Meteorologists at the National Forecast Center have a plan for training each year that includes seminars, conferences, discussion of past cases, post graduate education, etc. The study of past cases is very important because the group chosen for that task has to discuss what happened and to assess whether the decisions that were made in an actual situation could have been better. The experience and knowledge of forecasters is being increased every year. Meteorologists also take part in meetings with stakeholders to increase their knowledge and perception of meteorological limitations so that they are able to interpret correctly any future warning information.

### ***2.5.2 Warning Message Improvement Cycle***

The operation of the Early Warning System is reviewed following each meteorological event, including its effectiveness during the response. The efficacy of the information transmitted is assessed by means of surveys conducted among the affected population. The Cuban Meteorological Service participates in this post-storm process. A review is undertaken of the whole forecast process and the hurricane “best track” is assessed after every storm. A critical review takes place jointly with the Civil Defense so that experience can be documented and taken into account during the next hurricane threat. This assists in improving the effectiveness of the forecast and warning processes as well as the procedures for Early Warnings and Warnings.

## **2.6 Warning Dissemination Mechanisms**

The issue of Early Warning messages by the National Forecast Center commences 120 hours in advance of a possible impact and these are repeated every 24 hours. When a hurricane penetrates inside the area of surveillance in the Caribbean

Sea, updated warnings are then issued every 12 hours. In situations where the hurricane presents a potential threat to Cuban territory within 72 hours or less, warnings are issued every 6 hours. Finally, when the hurricane is very near to the territory of the country, warnings are issued every 3 hours or more frequently.

Radio and television are very important tools for warnings. The country has more than a television set per household and the TV signal reaches 98% of the national territory and almost all of the population. Widespread awareness and interest is generated through frequent live broadcasts by meteorologists, direct from the National Forecast Center that explain, in simple and plain language, the overall meteorological situation including an analysis of the uncertainties and different probabilities that are seen at that time.

Several entities participate in the issuance and distribution process for the Early Warning messages:

- The National Forecast Center of the Institute of Meteorology issues Early Warnings and Warnings on tropical cyclones for the National Staff of the Civil Defense, the Central Government and the public as well, with meteorologists presenting the meteorological information through national and local radio and TV.
- The National Staff of the Civil Defense issues Informative Notes with guidance and recommendations for actions to ensure the protection of lives and material goods. These are distributed to all levels of government as well as to both national and local radio and TV.
- Both national and local television channels and radio stations transmit special broadcasts on a 24-hourly basis. These include reports, interviews with specialists and authorities, information on the evolution of the hurricane and on the protective measures being adopted in each location, along with guidance on measures that should be completed. Commencing 48 hours before the forecast strike of any hurricane, National radio and TV install a remote unit facility at the National Forecast Center and a TV set is activated at the National Staff of the Civil Defense for the same purpose.
- The International Press Center disseminates information for the foreign press agencies and coordinates interviews with forecasters and specialists.
- All information is public and is delivered to end-users by the Meteorological Service, with the exception of some very technical and detailed, model-based, information on rainfall intensity, winds or storm surge that is delivered to the National Civil Defense.

## **2.7 Emergency Preparedness and Response Activities (National to Local)**

### ***2.7.1 Disaster Preparedness and Response Planning and Emergency Response Activation***

In Cuba, Disaster Reduction Plans are drafted at all levels from the very basic people's council to the provincial governments and from local to national economic entities and organizations, based on an assessment of the risk at each level. The disaster reduction plans are updated every year based on risk assessments that take into account the vulnerabilities that have been reduced during the period. The results of this updating process are made public in each community as part of preparedness measures prior to the hurricane season. The National Forecast Center participates in the preparation of the preparatory work for the next Hurricane Season. This includes the preparation of the nationwide "Exercise Meteor" carried out every year by the Civil Defense during the month of May, just prior to the hurricane season. In preparation for the beginning of the upcoming hurricane season, joint training and combined work sessions are undertaken on a nation-wide scale with the involvement of the personnel of the Meteorological Service, the Civil Defense National Staff and journalists from different national and provincial media.

### ***2.7.2 Community Response Capacities***

Community preparedness is planned and organized by the Civil Defense in every municipality with the assistance of the local social and mass organizations. The Cuban Red Cross and other non-governmental entities also participate. The population's awareness and skills are put to the test every year during the Civil Defense exercise "Meteor". Experiences derived from the strike of a tropical hurricane are constantly analyzed in each community, locality, and province and at the national level, which facilitates improving the existing plans. Personnel from the Provincial Meteorological Centers meet with authorities and people in their communities, providing advice on the warnings issued by the National Forecast Center and tailoring this information to take account of local conditions and vulnerabilities.

### 2.7.3 *Public Awareness and Education*

In Cuba, citizen preparedness for disaster situations extends from the highest authorities to the people in their work places, schools and communities. It is aimed at making each participant capable of organizing or carrying out the planned actions according to their responsibility. It is also aimed at making them aware of the risk to which they may be exposed and the measures they must take to protect their lives and their property. Preparedness at the level of the different sectors of society is supported by the legal framework in place for the work of the Civil Defense. Every year, the chief of the National Staff of the Civil Defense issues a new set of Methodological and Organizational Instructions for Preparedness by means of a Resolution. This outlines the ways in which preparedness is to be undertaken by each sector, which rules and procedures to follow, what control to exercise, and other relevant information. The Civil Defense circulates this Resolution to the heads of national institutions and to Civil Defense in the provinces (i.e. provincial government presidents). These individuals use the information to draft their own specific directives and guidance, adapted to their assessment of risks, preparedness priorities and local characteristics.

Civil Defense preparedness is pursued through exercises, drills, training, practical activities and demonstrations, workshops, courses, lectures, and events. Special mention should be made of the yearly, two-day long METEORO (Meteor) National Exercise for Disaster Case Actions, referred to earlier. Usually conducted during a weekend in May, this Exercise assists authorities and the population at large to prepare for disaster situations. It is also used to test the warning, communication and information systems and check the logistics needed for the different protective measures such as the evacuation of people, goods, and economic resources, the vulnerability mitigation actions. The Exercise receives extensive coverage by all communication media (television, radio, newspapers, etc) regarding aspects that the population ought to know for every territory. In addition, authorities and officials at the different levels receive training and the readiness of operation centers and specialized forces is also reviewed (i.e. fire fighters, Red Cross groups, rescue teams, doctors and paramedics, military detachments and construction brigades, etc.). A subject dealing with Civil Defense topics is taught in the national school system during 3rd and 5th grades of elementary education and 8th grade in junior high, complemented by extracurricular activities. Theoretical-practical classes are taught in senior high schools both as part of the curriculum and in extracurricular lessons. During higher education, all career programs include a subject on Civil Defense, in addition to other subjects dealing with related issues. In short, the preparation system for disaster reduction in Cuba is comprehensive, systematic and planned. Furthermore, it is constantly perfected through systematic analysis of its advances and deficiencies with a view to creating a disaster reduction culture that results in fewer and fewer human lives being lost and in reduced damage to the national economy.

A Communication Program for Disaster Situations has been designed for use by the media that contains general guidelines aimed at making the messages and reports more preparedness effective. Every year, mass media staff members attend updating training courses on disaster reduction that contribute to improving their work. Media managers and journalists from different television and radio stations and the newspapers attend the national workshop. Later, the same course is taught at the provincial level with the participation of provincial and municipal media. During the response and recovery phases, all the resources in the territory are used to keep the people informed and oriented. TV and radio units are set up and connected to power plants or solar panels; mobile and fixed public address systems are installed; the radio ham network is activated and radios with multiple sources of power supply are distributed. Furthermore, people to people information transfer also assists through the participation of grassroots organizations, social workers and local leaders. All of this is possible because there are television and radio stations at the municipal and community levels. There is one TV set in each school classroom and there are also VCR players and computers in all schools in the country. In addition, there are public television halls in remote communities. These facilities and initiatives contribute to the effectiveness of Cuba's Early Warning System by facilitating the dissemination of information to the people in a rapid, understandable and reliable way.

The Cuban Meteorological Service plays an important role in public awareness and educational activities. Hundred of conferences and talks are offered each year in work places, factories and in social organizations of different types. Several times a day, meteorologists present weather information through radio and national, provincial and municipal television stations across the whole national territory. In these presentations, they frequently explain different meteorological phenomena that occur in Cuba or other parts of the world, so that the population acquires more and more knowledge and awareness about weather. Through the educational channels of Cuban TV, short courses of 30 lessons each have also been presented by meteorologists on themes such as general meteorology and hurricanes. During hurricane season, meteorologists have also participated in brief spot broadcasts (only some seconds long) transmitted between regular program changes on television and radio, in order to raise awareness of hazardous weather elements, particularly hurricanes.

## 2.8 Development of Warnings and related Products and Services for Disaster Risk Management

The key users in Cuba's Tropical Cyclone Warning System are the Government (National, province, local), the Civil Defense System and the media (as an interface with the population). The main process which the NMS uses to understand users' needs and requirements for information, products and services is the input provided by major users in the form of reports and suggestions. These act as reliable feedback mechanisms that the NMS utilizes to develop requirements and specifications for NMS products and services jointly with users. Several assessment meetings are held between the NMS and the Civil Defense after every hurricane strike to review all operational work, forecasts and interactions between the two institutions, as well as the actions taken by the Civil Defense. They also include the joint work with the media. New requirements and specifications normally arise from these meetings and are taken into consideration in planning for future events. The main challenges in working with users relate to lack of knowledge by middle and low level Civil Defense officials and general journalists who are not directly linked with the NMS. The NMS attempts to overcome these challenges through the provision of out-of-season and pre-hurricane season training. Users' satisfaction with NMS products and services is assessed through inputs provided by users on their perceptions of positive and negative aspects and their degree of satisfaction with the services. These inputs are normally obtained through opinion polls and letters from users and are always given appropriate consideration.

## 2.9 Improvement of overall operational Framework of the EWS

The feedback mechanism that the NMS has been utilizing is direct dialogue with users, particularly special users such as the government and Civil Defense and others such as Ministries, the media, etc. Sometimes written suggestions are also received. All suggestions are taken into consideration and they help to improve the forecast and warning service. Congratulatory messages are received from many people and organizations after each hurricane impact as forecasts and warnings are generally successful.

## 2.10 Examples of previous Events where the operational EWS Led to Improvements in Emergency Preparedness and Prevention

An active period for tropical cyclones in the Atlantic, Caribbean and Gulf of Mexico area began in 1995. As illustrated in Table 2.2, Cuba experienced strikes from 17 tropical cyclones of different intensities during the subsequent 14 years, namely 6 tropical storms and 11 hurricanes. Five of the latter were minor hurricanes and 6 were major hurricanes. Over these 14 years, Cuba had 41 (direct and indirect) casualties from tropical cyclones or an average of 3 casualties per year.

The 2008 hurricane season was one of great activity for Cuba with two tropical storms and three hurricanes striking the country. Two major hurricanes during that year, "Gustav" and "Ike", resulted in extensive damage and, in the case of "Ike", some loss of life while tropical storm "Noel" also caused extensive flooding.

Early warning and preparedness saved lives during Hurricane "Gustav".

*Category 4 hurricane "Gustav" struck Cuba in 2008. Warnings were issued several days before the hurricane's arrival and people were well prepared. Though great damage was caused by the hurricane, not a single life was lost.*

- The strongest hurricane to hit Cuba during 2008, and also the strongest in the period since 1995, was Category 4 major hurricane "Gustav" that struck the Isle of Youth and the province of Pinar del Rio with winds of near Category 5 strength. The highest recorded wind speed was a gust of 340 km/h measured at the weather station of Paso Real de San Diego (WMO 78317). The National Forecast Center issued Early Warnings several days before the hurricane's arrival and Watches and Warnings were issued 72 hours prior to the hurricane's landfall. The increase in hurricane intensity, due to the high heat content in the Caribbean Sea, was well forecast. Meteorologists explained the main features of this deadly hurricane along with the track and intensity forecasts. People were well prepared and the Civil Defense performed superbly. Material losses were great but not a single life was lost.

**Table 2.2** Tropical Cyclones that hit Cuba during the period 1995–2008

Name	Year	Saffir-Simpson Category	Casualties
Lili	1996	H2	0
Georges	1998	H1	6
Irene	1999	TT	2
Michelle	2001	H4	5
Isidore	2002	H1	0
Lili	2002	H2	1
Charley	2004	H3	4
Ivan	2004	H5	0
Dennis	2005	H4	16
Alberto	2006	TT	0
Ernesto	2006	TT	0
Noel	2007	TT	0
Fay	2008	TT	0
Hanna	2008	TT	0
Gustav	2008	H4	0
Ike	2008	H4	7
Paloma	2008	H2	0
<b>TOTAL 1995 – 2008 (14 years)</b>		<b>TT = 6 H1, H2 = 5 H3, H4, H5 = 6</b>	<b>42/14 = 3</b>

TT = Tropical Storm; H1, H2 = Minor Hurricane (Hurricane Category 1, 2; H3, H4, H5 = Major Hurricane (Hurricane Category. 3, 4, 5))

Hurricane “Ike” underlined the importance of training people how to react in the face of hazards.

*Cuba was struck by Category 4 hurricane “Ike” a few days after “Gustav”. While timely early warnings were issued there were 7 deaths associated with “Ike”. The fact that most of these fatalities resulted from inappropriate actions by the victims reinforced the need for even greater efforts to advise people how to react in the face of warnings of hazards.*

- A few days later, Category 4 major hurricane “Ike” arrived. This hurricane differed in that it affected the whole country. The Early Warning and the Watch and Warning process was a very good one. Everything was done to warn people to be prepared for another deadly hurricane. This was the first Category 4 hurricane to make landfall in the provinces of Holguin and Las Tunas. It subsequently continued to the west to affect the whole country and make landfall again in the area previously hit by hurricane “Gustav” a few days before. There were 7 deaths associated with “Ike”, the majority of them provoked by negligence on the part of the victims and, in some instances, not directly related to the hurricane. The lesson here is that even greater efforts must be made to warn people not to do things that individuals in affected areas or areas under some type of warning are not supposed to do.

Evacuation in response to warnings of heavy rainfall prevented fatalities during floods caused by Tropical Storm “Noel”.

*Accurate warnings of intense rains accompanying Tropical Storm “Noel” enabled evacuations of people to be carried out before flooding occurred. No one was killed during the event though there were substantial losses to agriculture and economy.*

- Tropical storm “Noel” during the same year resulted in substantial flooding and related damage in Cuba, highlighting that even tropical depressions that do not reach hurricane strength can present a major threat to life and property. Tropical Storm “Noel” had only light winds in its center. Some 300 kilometers to the East, however, huge bands of rain were forming. The warning issued in this case was for intense rains that were forecast to hit Eastern Cuba. Meteorologists

explained in great detail that rain was the danger and that the location of the center of the tropical storm was not important. They stressed that the critical feature was the intense heavy rain that was going to arrive well after the center of the tropical storm had crossed Eastern Cuba. Rainfall totals in 24 hours were between 200 and 300 mm over that area. Since the soil was already saturated from heavy rainfall during the previous month, large areas were completely flooded. A massive evacuation was undertaken well before flooding occurred, however, and no one was killed during the event though there were large losses to agriculture and economy.

## **2.11 Overall Lessons learned and Future Steps for Improving NMHS Contribution in EWS Particularly Focusing on institutional Coordination and Cooperation**

Hurricane “Lili” threatened Central and Western Cuba in 1996 when an increase in hurricane activity was taking place in the Atlantic, Caribbean and Gulf of Mexico. The Cuban NMS issued an Early Warning Message for the first time ever and it was successful. At that time, however, the NMS was not prepared to face a hurricane such as “Lili” as the computer and telecommunications infrastructure was still inadequate. Consequently, short wave radio contact was lost with all stations after their huge antennae collapsed one by one. Only by chance, was the NMS able to say that Hurricane “Lili” was making landfall at 11 am on October 18, 1996. Fortunately, everything went well with the forecast after that.

Following Hurricane “Lili”, the Cuban NMS reviewed all procedures for transmitting weather data and warnings and the NMS received funding to upgrade and modernize the communications system. This facilitated a modernization of the Meteorological Service that still is underway, though the main actions have been completed several years ago. Radars have been automated, a computer network has been established and many technological improvements have been made, resulting in the modern National Forecast Center that we have today.

### **List of Acronyms**

ANAP	National Association of Small Farmers
CDR	Committees for the Defence of the Revolution
CITMA	Ministry of Science, Technology and the Environment
CLAMED	Latin American Center for Disaster Medicine
CNIS	National Center for Seismologic Research (National Seismologic Service)
EMNDC	National Staff Civil Defense
FKB	Forest Keeper Body
GIS	Geographic Information System
GTS	(WMO) Global Telecommunications System
INSMET	Institute of Meteorology
MOU	Memorandum of Understanding
NFC	National Forecast Center
NIHR	National Institute of Hydraulic Resources
NMC	National Meteorological Center
NMS	National Meteorological Service
NGO	Non-Governmental Organization
RA IV	WMO Regional Association IV
VCR	Video Cassette Recorder
WMO	World Meteorological Organization

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