REDUCING THE IMPACT OF ENVIRONMENTAL EMERGENCIES THROUGH EARLY WARNING AND PREPAREDNESS - THE CASE OF EL NIÑO-SOUTHERN OSCILLATION (ENSO)

INSMET | UNU

IMPACTS OF THE 1997-98 EL NIÑO EVENT IN CUBA

Edited by:

Lino Naranjo Diaz

Havana, Cuba
2000

MEMBERS OF THE TECHNICAL WORKING GROUP FOR THIS PROJECT

Lino Naranjo Diaz
Team Leader
Instituto de Meteorología de Cuba (INSMET)

Pedro Cárdenas Pérez
Contributor
Instituto de Meteorología de Cuba

Abel Centella Artola
Contributor
Instituto de Meteorología de Cuba

Oscar Solano Ojeda
Contributor
Instituto de Meteorología de Cuba

Yamila Rodriguez Eduarte
Contributor
Instituto de Meteorología de Cuba

Amparo Pérez Benítez
Contributor
Instituto de Meteorología de Cuba

CUBA

SETTING

1. What is the socioeconomic setting of your country? (Include a brief description of the government mechanisms for dealing with climate-related impacts: the ministries, task forces, and public safety mechanisms, etc.)

The Republic of Cuba is an independent state, located in the Meso-American Caribbean Sea and at the entrance of The Gulf of Mexico. Cuba is the biggest insular state in this basin and it is constituted by an archipelago of 110,860 km^2 in area, 105,599 km^2 of which corresponds to the main island (Cuba) which gives the name to the country; the rest includes the Island of Youth and 1600 other islands and keys (Figure 1.1). Cuba is very near the continental territory of the United States. It is separated only by a narrow stretch of water between the United States (to the north) and Mexico (to the west).

The Republic of Cuba is divided administratively into fourteen provinces and these, in turn, are divided into municipalities. These are the basic administrative units and there are a total of 168 in the country. Additionally, a special municipality is constituted by the Island of Youth, the second in importance in the archipelago. The most western Province of Cuba is Pinar del Rio that is bordered on the West by the Strait of Yucatan. The easternmost Province is Guantánamo whose shores are bathed by the waters of the "Paso de los Vientos" which separate Cuba and Haiti. The political and administrative capital of Cuba is Havana City, which, in turn, constitutes the smallest province in extension of the country.

Plains constitute 82% of Cuban territory. This landform constitutes the majority of fertile lands that support intense agricultural activity and makes up the main economic sector of the country. The agricultural area covers 3,701,459 ha, of which 2,606,136 are devoted to the permanent cultivation of sugar cane (the main crop with 1,800,000 ha), coffee, cocoa and citrus fruits. Almost 3,000,000 ha of the Cuban territory are covered by forests. 53.7% of the arable land is in the hands of the State, while the rest (46.3%) belongs to private owners.

Cuba possesses a potential of 38,139 km^3 of water per year, which means 1,293 km^3 for each inhabitant. However, this potential depends in large measure on aquifers, which are open to the sea and concentrated mainly in the western half of the country. This is why the Cuban government designed a wide hydraulic infrastructure that possesses nearly 223 important dams and over 800 micro-dams to protect. This would enable the people to use this resource more. Among the country's socioeconomic activities, agriculture is the higher water-consuming sector with 72%, followed by the population with 10% (Figure 1.2).

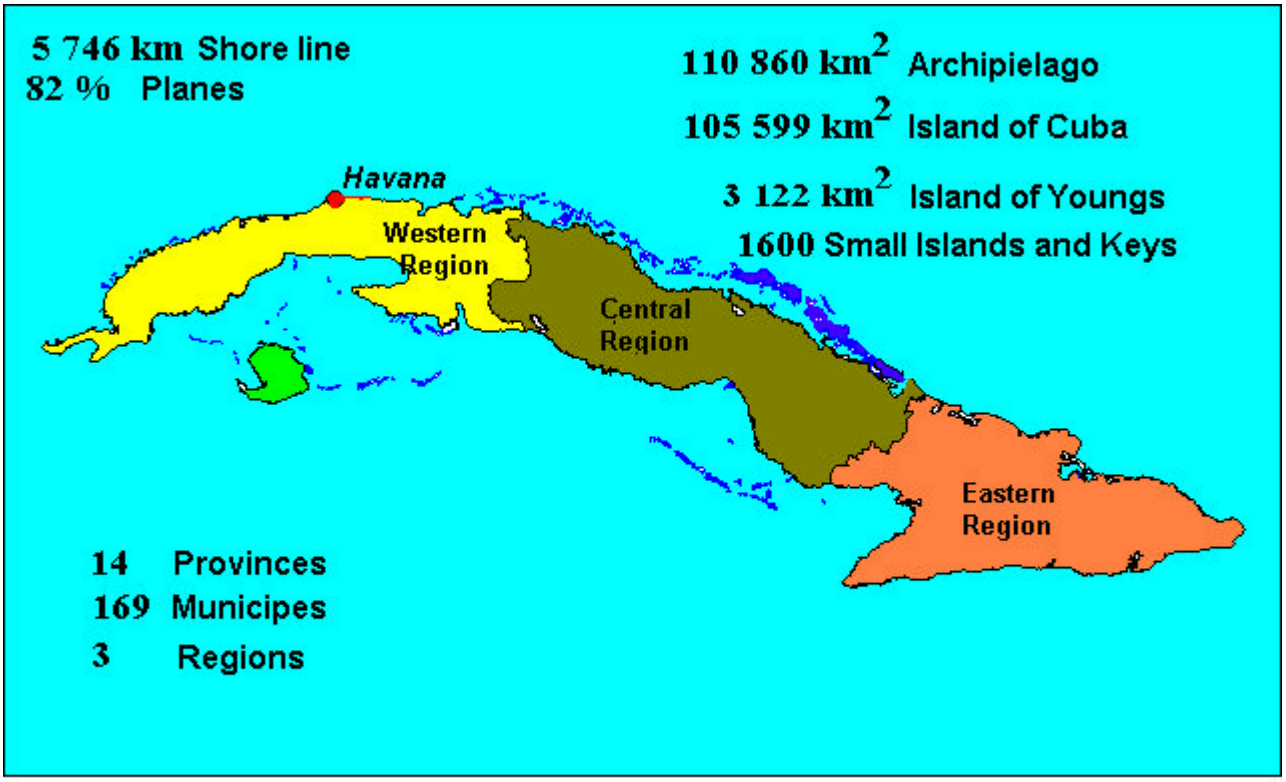


Figure 1.1. The Cuban Archipelago showing its main geographic features

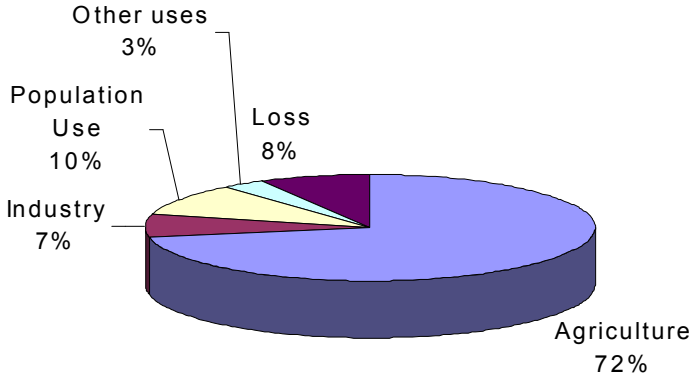


Figure 1.2. Use of water resources in Cuba

In 1997 the Cuban population was 11,093,152, which means a population density of 99.6 inhabitants per square kilometer. The rate of annual population growth is 4.9 per thousand inhabitants, with a mortality rate of 7.0 per one thousand inhabitants and a birthrate of 13.8 per thousand. The Cuban population has a high concentration index because 74.3% live in 570 human settlements, of which 55 are cities with a population of between 20,000 and 1 million inhabitants. Another important characteristic of the Cuban population is that, with the exception of the capital of Havana City (with more than 2 million inhabitants), 1 million Cubans live in coastal settlements with a high vulnerability to the impact of coastal floods caused by severe weather events.

The Gross Domestic Product[1] of Cuba has had important variations in the last few years. At the beginning of the decade of the 1990s, the Cuban economy, whose development was very much linked to the economies of the socialist countries of Eastern Europe, suffered a severe loss of revenue caused by the disintegration of the USSR (its main commercial partner) and the rest of the socialist bloc. This, along with the permanency of the conditions of the economic blockade imposed by the Government of the United States since 1960, caused a growth rate of only 0.5 % for the Gross Domestic Product. Beginning in 2000, an important transformation occurred that included a bigger opening to foreign investment and the quick development of tourism. Increments above 2% of growth were registered with a stable tendency of continued growth. Already in 1997, the earnings in the tourist sector were triple those obtained in 1993 and the figure of 1 million tourists was surpassed. This has not been reached since 1959, when the current social system of socialist orientation settled in Cuba.

The climatic characteristics of Cuba are conditioned by the location of the archipelago at the northern limit of the tropical area, and by other features like the elongated form of the main Island (Cuba) with 5,746 kms of coast. Its proximity to North America as well as the influence of important atmospheric and oceanic systems such as the trade winds and the Gulf Stream, respectively, also influence Cuba's climate.

The climate of Cuba can be considered tropical or tropical oceanic, characterized by a well-defined rainy season (occasionally called "wet season") with warm temperatures and a dry season where precipitation is scarce.

Cuba's rainy season runs from May through October and accounts for nearly 70% of the annual total rain. The dry season runs through the remaining months (from November until April) and it is in this season that Cuba is affected by weather events characteristic of extratropical latitudes. Among these events are cold fronts and continental cold air outbreaks, called "Nortes" that are mainly responsible for temperatures in this season becoming slightly cooler than one would expect for a tropical climate.

Cuba does not have volcanic activity. Seismic activity is relatively low level, and is concentrated almost exclusively in the southeastern portion of the country. Here earthquakes can occasionally produce damages of some importance. As a result of the

[1] Strictly speaking, this should be Gross Internal Product, which is calculated on a slightly different basis from Gross Domestic Product as defined in the UN System of National Accounts.

above-mentioned facts, it is possible to affirm that the main source of natural disasters in Cuba are meteorological events such as hurricanes that have the potential to cause severe damage to property, as well as loss of human lives. On the other hand, droughts and heavy precipitation are able to impact the agricultural sector and the country's water supplies. For that reason, the Cuban government allocates considerable resources to the establishment of efficient mechanisms for the prevention and mitigation of natural disasters. The National System of Civil Defense as well as the study and monitoring of climate-related impacts by means of the Climate Monitoring Service are the main ways to cope with these extreme events and their impacts.

THE REPUBLIC OF CUBA'S CIVIL DEFENSE SYSTEM

This system was created to cope with possible damages caused by disasters such as hurricanes, heavy rains and coastal flooding, and other problems such as disease outbreaks and epidemics, plagues and problems in agriculture that affect the population and the economy. This system pays fundamental attention to the population's protection and it acts based on the coordinated participation of all of the state's agencies, economic entities and social institutions.

The functional and structural organization of the System of Civil Defense of Cuba is based on the Law 75 of 1997 National Defense. It responds to the principles in line with recent worldwide tendencies on the subject. The main mission of the System of Civil Defense is to protect the population and the economy in case of disastrous events, as well as the consequences of the deterioration of the environment.

The highest level of command in this System is that of the President of the Council of State. The chain of command then passes through the Minister of the Revolutionary Armed Forces, with the National Headquarters of the Civil Defense being the main executive agency of the System. At the province level and in municipalities the presidents of the respective assemblies of *Poder Popular* (Popular Power) exercise the command that in turn directs the Civil Defense at those levels.

The "defense zones" are simpler structures spread throughout the whole country. They are comprised of human establishments and other areas of economic and social interest. This structure facilitates an immediate response for handling the emergencies and is carried out by previously trained voluntary personnel.

Planning and organization of the measures in the case of disasters begins in the community, in working centers, (i.e., factories, general labor centers, etc.) state entities, schools, etc. This work continues in the municipalities and the provinces and concludes at the national level. Nevertheless, their main force resides in the community and in the broad participation of the population. Plans of measures for all these levels exist for disasters according to the procedures established by Civil Defense Headquarters. This plan is based on the following aspects:

- The results of studies on vulnerability and risk.
- Measures of prevention, response and rehabilitation (by phases).
- Preparedness at all levels of society.
- Organization of the management.
- Organization and assurance of communications.
- General assurance actions.
- Cooperation measures.

The national experience in response to and confrontation with disasters demonstrates that the current functional and structural organization adapts appropriately to a wide spectrum of situations generated by natural hazards.

EXISTING WARNING SYSTEM

Cuba has a system of warning by phone that allows us to warn the population about the prediction or imminence of a climate-related disaster. This can be activated at the national level or by the provinces. It allows us to send any information on the subject to the governments of the provinces and municipalities. As for the public, the broadcasting systems are used as well as the network of national and territorial television. The main economic and social concerns under risk have direct television lines to the centers of management of the Civil Defense in the nearest towns.

As a complement, the national emergency network of the Federation of Radio Amateurs of Cuba is used, which also has possibilities for international communication.

Cuba integrates the worldwide network of the International Red Cross into its own system with respect to early warning of disasters. Likewise, Cuban air and marine vessels are incorporated into the system of emergency response, search and rescue.

The Institute of Meteorology of Cuba (InstMet) has established an extensive and permanent weather and climate monitoring system around the country. Plans and objective methods of prediction and warning exist in the case of meteorological problems. They are developed for different periods of time. In addition, by means of the Climate Center, the InstMet works intensively on climate monitoring in Cuba, which allows it to establish projections on its behavior from one to several months in advance. In fact, an integral system that acts as the first source of information about climatic variability and the extreme events exists (linked or not with the El Niño). Its general structure can be observed in Figure 1.3.

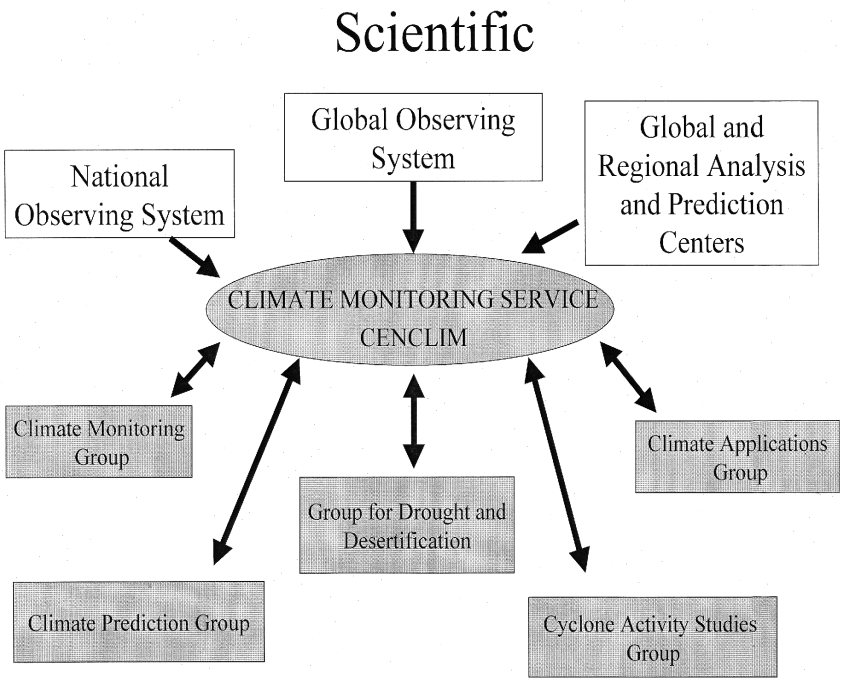


Figure 1.3 National Climate Monitoring System

The Climate Monitoring System generates three basic products:

- The Climate Monitoring Bulletin (current behavior of climate at the regional and national scales, monthly climatic predictions and monthly development of any El Niño event).
- Seasonal predictions, including El Niño forecasts.
- Special climate early warning (including the state of drought conditions and the possible evolution and impacts of the El Niño signal).

These systems, although they cannot be considered as optimum due to material and technical limitations in the country, allow us to understand appropriately the evolution of climate-related hazards and in most cases to take timely response measures.

2. What are the climate-related and other natural hazards affecting your country? (List them in order of concern.)

TROPICAL CYCLONES

The Cuban archipelago is located in one of the six-cyclogenic regions of the Earth. In this region approximately 11% of the total number of tropical cyclones (TC) are formed, a frequency surpassed only by the Australian and the North Pacific regions.

Among the severe weather events that affect Cuba, the TC occupies an important place. The causes that establish the importance of the TC are multiple and are not associated only with the direct impact that they cause. Their frequency and their links with other meteorological variables make them an unquestionable part of Cuba's climate.

The number of tropical hurricanes that affects Cuba annually is very variable, with totals that run from zero to 5 tropical storms (for the case of hurricanes from zero up to 4). Between 1900 and 1995 there were only 31 years when the country was not affected by a TC; 35 years with only one; 18 with two; 8 years with three; 2 years with 4; and the year 1933, 5 TCs affected the Cuban territory.

The TCs' appearance presents a clearly defined seasonality. The month of highest frequency is October, followed by September, August and November. It is interesting to note that the secondary maximum observed in June occurs at the beginning of the season. A similar behavior occurs in the case of hurricanes, most of which have originated in the Caribbean Sea (57%), while the remainder originated in oceanic areas (43%).

On average one tropical cyclone affects Cuba each year, while a hurricane affects Cuba once every two years, on average. The Western region is the most affected (see chart), while the Central region has been less affected. The impacts in the west can occur at any time throughout the entire hurricane season (June-November), even in May. Such is not the case in the rest of the country.

September and October are the major months of TC influence in all regions, with the exception of the central region where the major influence occurs in October. A distinctive feature of the eastern region is that it is more affected in November.

Table 2.1. Observed return period (in years) in Tropical Cyclones impacts in 3 Cuban regions.

REGION	TROP. CYCLONE	TROP. STORM	HURRICANE
Western	1.3	2.4	2.6
Central	3.0	5.6	6.3
Eastern	2.3	4.5	4.8

In the case of hurricanes, the western region is the most affected during the whole season (except for the maximum, which takes place in November in the eastern region) with an average of one hurricane every 1.9 years. In the western and central regions the most impacting month is October with averages of one hurricane each 7.3 and 15.8 years, respectively. In eastern Cuba the month of most impacts is September, with a hurricane frequency of once in 13.6 years.

DROUGHT

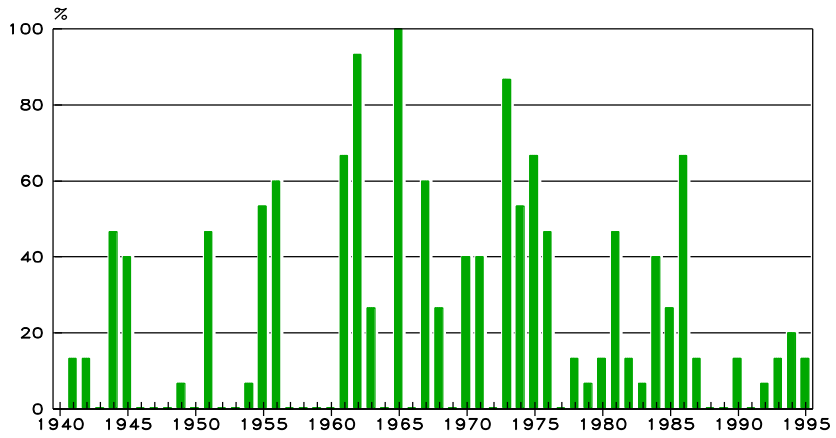
The complexity of the analysis of drought starts with its very definition. In fact a unique definition that satisfies all the interests does not exist. Nevertheless, the International Meteorological Vocabulary (O.M.M., Not. 182, 1992) defines drought as follows: "a period of abnormally dry meteorological conditions, sufficiently lingering so that the precipitation lack causes a serious hydrological imbalance." In the last decades, drought, as an extreme aspect of climatic variability, has increasingly affected parts of the planet, with dramatic impacts in numerous countries of Africa and Asia.

These climatic episodes in Cuba have also been on the increase in the last few decades, bringing very harmful consequences to agricultural production and the conservation of our soils, which tend to experience salinity and desertification in the coastal and semi-arid areas. Thus, the risk of drought in each region of the country is a very important factor to take into consideration for various socioeconomic activities. This should be a major consideration from the design to the planning stages to cope with these adverse events.

Studies about drought in Cuba (Lapinel, et. al. 1993), using 30 rainfall stations with long time series as reference and the analysis of climatological normals (1931-1960 and 1961-1990) for rainfalls, showed a decrease from the first to the second 30-year period by 10%, basically concentrated in the months of the rainy season. In the trimester June-August, the reduction was of 0.4 mm per day, which also corresponds with 10% of the norm for that trimester.

These results are compatible with those obtained for our region by Hulme et al., (1992), who referred to global changes of precipitation between these periods. A synthesized picture of years most affected by droughts in Cuba, during the 1941-1995 period, can be seen in Figure 2.1.

Figure 2.1 Annual percentage of provinces affected by drought



The case of increasing drought in Cuba seems to be representative of a variety of regional climate anomalies. The frequency of years with moderate and severe droughts was doubled in the second 30-year period in relation with the first, reducing the return period of this harmful phenomenon from 5 to 2.5 years, with a simultaneous increase of duration. The frequency of years with severe drought experienced a bigger increase between both periods, becoming from one to four times every 25 years.

The analysis of the 1971-1990 period (Lapinel, et. al., 1993) reflected important impacts to the south of the Province of Pinar del Rio, Havana, Sancti Spíritus and Guantánamo, as well as other specific parts of the country. The return period is two times every five years, and for the southeastern portion of Guantánamo, once every two years.

These drought events, if combined with high evaporation rates, can exhaust groundwater and decrease underground water reservoirs. The stresses that this causes for the vegetation are increased when occasionally droughts are interrupted by episodes of torrential rains. These processes cause intense soil erosion processes in grounds that lead to a poor vegetative cover and a high level of surface drainage capacity.

In Cuba, among other important meteorological and climatic events that occurred during the 1997-98 El Niño, (the most intense one in the 20th century), was the normal dry season (November to April), which was extremely rainy from November to March. Subsequently, starting from the month of April until June, an intense and geographically extensive short-term drought affected the whole country, in particular the central and eastern regions.

The first signs of this drought began at the end of the November-March period when, despite rainy conditions, some parts of the eastern region began to report significant rainfall deficit.

The low amount of accumulated rainfall in April over the whole country generated favorable conditions for the possible evolution of drought. May was very dry too, and this drought was already established mainly in the central and eastern regions.

At the end of June (also a dry month throughout the whole country) the state of the drought had become critical in most parts of the central and eastern regions. It became evident that the deficit of the April-May-June trimester was the most severe in Cuba, the central region and the S. Spíritus, Camagüey, Granma and Guantánamo provinces.

In July 1998 favorable rainfall conditions led to the climatological average in most of the country, favoring a gradual return to normal conditions from a meteorological point of view in August. Some parts of the central and eastern regions registered significant deficits with respect to their accumulated totals at the end of the April-August semester.

HEAVY PRECIPITATION

Among disastrous meteorological phenomena, heavy precipitation constitutes one of the most frequent in Cuba. Big floods and the damages caused by this phenomenon occurred in the remote past. Nevertheless, as Cuba develops and activities like the agriculture and urbanization continue to grow, rainy events become much more important because they increase the potential for societal and environmental damage.

In Cuba heavy precipitation (HP) is considered to have occurred if the rainfall accumulation is 100 mm or more at a single location within 24 hours. Their occurrence is strongly conditioned by a combination of atmospheric circulation, at different spatial scales, and physical-geographical factors in a region. For that reason, these events are associated with the occurrence of certain typical circulation patterns over Cuba. Alfonso and Florido (1992) described 12 basic circulation configurations linked to the HP, of which only two have mechanisms of certain tropical origin (tropical hurricanes and tropical waves). In the remaining ones, the mechanisms of interaction between tropical and extratropical patterns prevail. For their importance, the classic and quasistationary cold fronts and the tropical extension of high latitude waves should be noted.

During the 1965-1990 period, the HP occurred on an average of 85 days a year in the whole country. This frequency justifies the idea that this event is an element of the Climate of Cuba. The months with a greater frequency of heavy precipitation are June (western and central region), October (eastern region) and November in the northeast of Holguín and Guantánamo.

An interesting aspect is the occurrence of extreme values in the HP in the period 1977-1997. Although the exact comparison with the remote past is impossible because of notable differences in the observational networks, in some cases the magnitude of floods can be used for comparison. This way, for example, floods of the end of the 19th century described by Gutiérrez (1927) can be considered to have been of the same magnitude or higher than those observed in 1982 and 1988.

In fact, it seems clear that the extreme precipitation that occurred in the 1980s do not have an equal in the 20th century. It is important to point out that the increase of HP related with the classic cold fronts has produced a relative increase in big precipitation events in the dry season, starting from 1977.

Precipitation connected with the Mesoscale Convective Complex of June 1982 (Alfonso and Naranjo, 1989) and, of May 31 to June 2, 1988 (Fernández, 1988) can be considered extraordinary events because of the expansion of the affected area.

Related to ENSO, years under the influence of this event in the period 1965-1998 showed a notable increase in the number of days with HP, with an average of 110 days.

Strong ENSOs have heavy precipitation associated with extratropical lows in the Gulf of Mexico and a remarkable absence of HP due to tropical cyclones. Weaker ENSOs *show an increase of HP events because of slow moving cold fronts and tropical waves.*

SEVERE LOCAL STORMS

The intense and destructive thunderstorms are known in Cuba from its history. There is evidence that the aboriginal population first gave the name of hurricane to tropical cyclones and tornadoes produced by severe local storms (SLS). In general, these storm systems have a local character and the damages that take place are usually considerable only in relatively small areas, as their effects on the economy become more evident when they are analyzed as a group. Nevertheless, in some years their number is increased and their effects can be very significant throughout the country.

In Cuba, a thunderstorm is classified as an SLS, when one or several of the following phenomena are present (Alfonso, 1988):

- Tornadoes
- Wind gusts greater than 90 km/h.
- Hail
- Waterspouts

A day is registered as having an SLS when at least one SLS has been reported somewhere in the country. An SLS outbreak is said to have occurred when three or more storms have been reported in the same day. Starting from 1978, the Institute of Meteorology began a systematic study of SLS in Cuba. At the present time, a long chronology has been developed that picks up data from 1784 (Alfonso, 1994).

When the frequencies of SLS are analyzed by year, a small tendency toward an increase in the last 13 years can be observed. However, this tendency is not significant and it is likely to be linked to the remarkable improvement in detection systems. In this sense, the best presumption that we can make is that major trends did not exist in this period.

When conditions that favor the formation of SLS are analyzed, one finds clear different behaviors between El Niño and non-El Niño years. In particular, from February to mid-May, the frequency of occurrence of very intense pre-frontal squall lines is significantly higher in El Niño years.

Based on an analysis of 25 El Niño years, major SLS were not detected in only 4 of them, in particular devastating tornadoes. So, it can be assumed that in El Niño years the presence of episodes of extremely powerful examples should be expected. Table 2.2 lists some notable examples.

Table 2.2. Five of the most devastating severe weather events in the last 60 years for the winter season in Cuba

1. **December 26, 1940**	Tornado in Bejucal (Havana), one of the most intense registered in Cuba. Associated with a strong cyclogenesis over Lousiana in the USA.
2. **January 2, 1958**	The most intense cold front in Cuba. Associated with an Extratropical Cyclone deepening over the Gulf of Mexico.
3. **February 16, 1983**	Intense mesocyclone, in a squall line associated with an intense cyclone in the Gulf of Mexico.
4. **March 16, 1983**	Tornado outbreak over Western Cuba associated with the most intense extratropical cyclone affecting Cuba.
5. **March 13, 1993**	The most damaging Squall Line registered in Cuba during the winter; this was associated with the superstorm that hit the Eastern half of the United States.

If damages are compared for SLS throughout the years, a significant tendency can be observed toward more dangerous events with regard to their destructive capacity. Nevertheless, this conclusion should be taken with caution, because factors such as population growth, economic development and even the value of the currency in each historical period, make attribution difficult. Nevertheless, it seems to be a fact that the most numerous and the most destructive SLS outbreaks in the century in Cuba were linked to the years in the 1980s and the 1990s.

3.What was the level of scientific research in your country relating to El Niño?

Currently, The Institute of Meteorology of Cuba, through its National Center for Climate, possesses the leadership on scientific investigations related to El Niño and its impacts in Cuba. Besides this function, among others given by the Cuban State, the Center for Climate possesses a high level of scientific experience and a structure that favors and guarantees a continued capacity building process for the development of research.

The first two studies on the El Niño carried out in Cuba (Meulenert 1991, Cardenas and Pérez, 1991) were devoted to the evaluation of the impact of this event on the weather and climate in the country. In 1994 important advances in the study of the El Niño cycle occurred and a first operational method for the prediction of monthly precipitation and temperature explicitly included predictors linked to El Niño.

By the middle of the 1990s, the influence of ENSO on cyclonic activity in the Atlantic and the Caribbean was studied and a seasonal prediction method was developed that included ENSO information.

In 1995 another important step was taken in Cuba for the development of research related to ENSO. In that year, in the National Scientific Program "The Global Changes and the Evolution of the Cuban Environment", a 5-year project, was structured with ENSO as its central objective - its predictability, impacts and modulation effects on Cuba's Climate. Thus, we can conclude that at the time of the 1997-98 El Niño, scientific development in Cuba on El Niño was high, and allowed for efficient monitoring and prediction.

4. Identify and document (with citations, if possible) the historical interest, if any, in the country (popular, political, media, etc.) in El Niño before the onset of the forecast and/or impact of the 1997-98 event.

Cuban interest about El Niño underwent a major change in the 1990s, passing from being a mysterious and virtually unknown element for policy makers and the public, to become one of the main considerations when speaking about topics related to climate. It may be even better known than climate change.

In the first trimester of 1983 Cuba suffered the serious impact of severe meteorological phenomena (tornadoes, heavy rains, storm surges, etc). However, it is interesting that at that time, none of these events was linked with El Niño. The Granma Newspaper (the official organ of the Communist Party of Cuba) dedicated considerable space to report on the serious consequences of these phenomena that literally destroyed crops and disrupted numerous socioeconomic activities. The 1 March 1983 issue of Granma reported the losses in the tobacco sector, reflecting the view of the harvesters that something unusual was happening and requesting that meteorologists study these events more deeply. However, there was no link with what happened to El Niño.

The first reference in the media to El Niño and its effects in Cuba were made belatedly on 21 February 1987, when Granma published an article of journalist Orfilio “El Niño Return?” In this article he explained that, "The phenomenon that caused serious atmospheric disturbances 4 years ago [in 1983] is still an enigma for the scientists." The article also referred to the winter season 1982-83: "An unusual climatic disorder made its appearance in the World."

In the 1990s - due to the development of scientific research in this field, to the creation of the first climate monitoring system in the country and to the accumulated international experience - the interest of the state and the general population in El Niño increased. The finances granted to research projects increased and more intense work began on informing the public and the official media.

Soon after the 1994-95 event, interest intensified in an important way with respect to news coverage. On 22 January 1995 the newspaper Tribune of Havana published an article, "When La Niña was expected...An El Niño appears." A reporting style characterized by interviews with scientific personnel linked to El Niño began. The objective of this style was to clarify the issues and to inform the population. This approach continues to the present and has contributed in a decisive way to an improved perception about these events. The best example of this approach was an article published in Granma in January of 1997, ″The war of ENSO will be announced″ a few months before the onset of the 1997-98 El Niño

was predicted for the first time. This article summarized in a brilliant way the state of current scientific knowledge about El Niño and it contributed in an important way to prepare the population and policy makers for the event's impacts.

1997-98 EVENT

5. Trace the flow of information on the 1997-98 El Niño within your country, using the following guidelines:

a. When did the various agencies first hear about this developing El Niño?

From April 1997 it became evident for the researchers at the Climate Center of Cuba that an El Niño event was in progress. Already in March, information coming from the U. S. National Center for Environmental Prediction (NCEP) began to indicate this possibility (Climate Diagnostic Bulletin, April 1997). It reported that, "*the evolution of atmospheric and oceanic conditions during the past few months is consistent with the demise of cold episode conditions and with the possible onset of warm episode conditions*." Additionally, in the month of April, the prediction method developed in Cuba (an ENSO Index, IE), indicated an increase in this index until August. Consequently, an El Niño event was expected to "lock in" in that month. In May the Climate Center released an alert on the possible development of an El Niño event for the current year (1997).

b. From where did the information come?

As noted in the previous paragraph, two sources of information pointed out to the National Climate Center of the Institute of Meteorology of Cuba that an El Niño event was in progress between April and May of 1997. They were the following: the Climate Prediction Center of the U.S. NCEP, and the Climate Center of Cuba. The Climate Center assumed the responsibility, conferred by the Cuban State, of serving as the only official source of information and advice on the evolution of the El Niño event.

c. When did they first hear it would be a strong event? From whom?

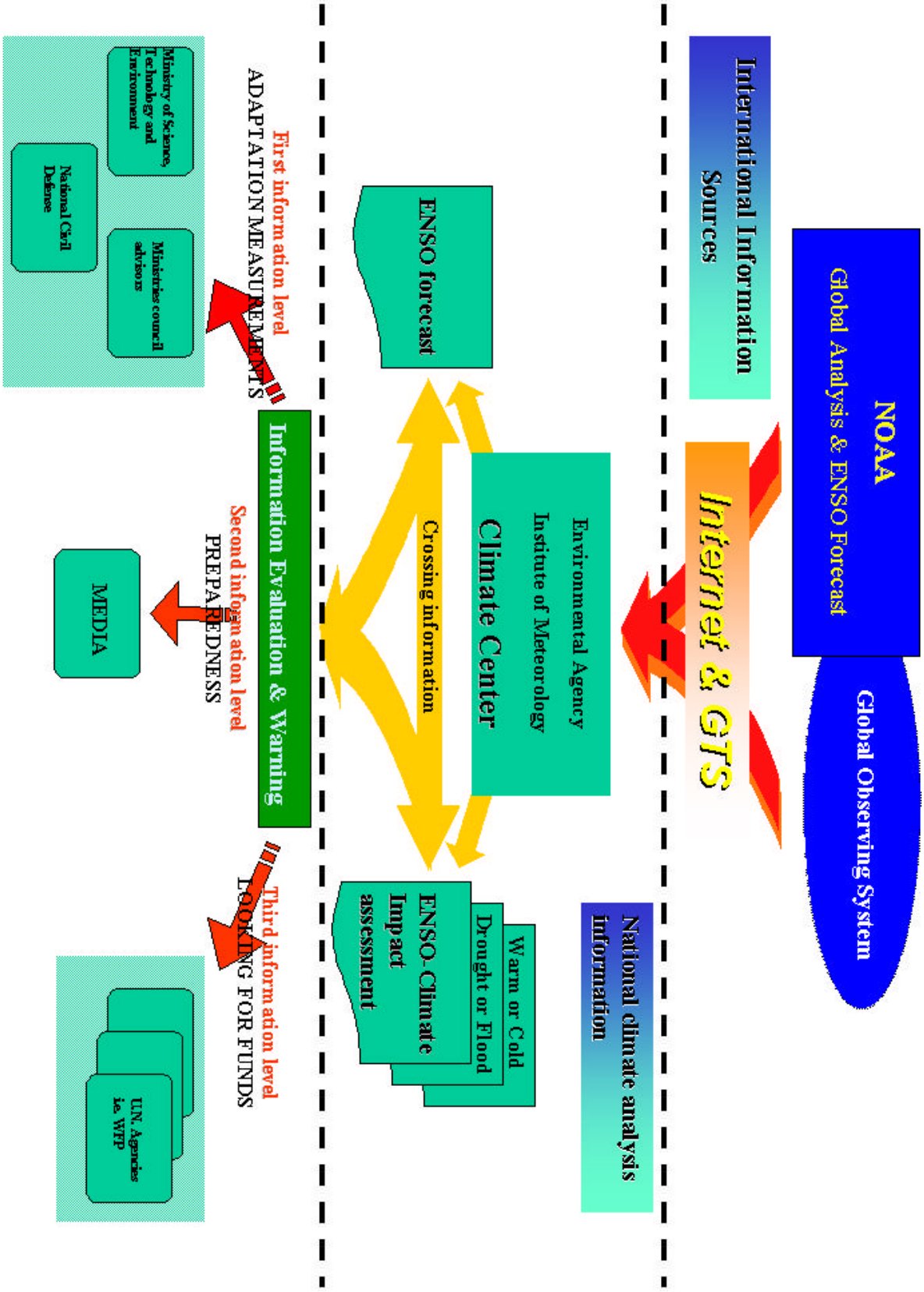
Starting with the first information about an El Niño, an operational monitoring system was developed. In June it became evident, after analyzing all the available information, that it would be a strong mature event. Consequently, this characteristic was noted in the Special Warning No. 2, which was released at the beginning of July. Besides, it was explicitly noted that the predicted values for El Niño were very high, indicating at the time that the second biggest event in the century, second only to the 1982-83 event, was in progress.

d. Which agencies first received the information?

Figure 5.1 shows a simplified diagram of the information flow during the 1997-98 El Niño event. As shown in the lower section, information, evaluations and alerts/warnings flowed toward three levels of information. A first level, composed of the Ministry of Science Technology and Environment, the advisors' team of the Council of Ministers of Cuba and the Civil Defense; the public media constituted a second level; and a third level existed,

which included the different agencies for international assistance. All the information generated during the monitoring activities and the prediction was sent to the first level before being sent to the remaining levels.

Figure 5.1 Information Flow Diagram during the 1997-98 El Niño Event



e. Were these the appropriate agencies to first receive the information?

The first level of information is an adequate initial step, because the entities that compose it have a very high responsibility in the development of the country's economic strategies. In turn, they constitute the source of information starting from which the other government agencies trace their policies of preparation. In the case of Civil Defense, as discussed previously, it has the maximum responsibility in the planning and execution of eventual protection measures before the onset of disasters.

f. How was the information obtained?

In Figure 5.1, the stages of obtaining of the information are presented in a schematic form. This figure illustrates how much of the international information on the evolution of the El Niño event was obtained by means of the Internet. This was the case for the climate predictions and evaluations coming from the U. S. National Oceanic and Atmospheric Administration (NOAA). Another key element in the monitoring activity was the information coming from the Global Information Systems (GTS).

At the national level, the main source of information was in the form of predictions and evaluations elaborated by the Institute of Meteorology.

g. How was the information transmitted?

Several ways: phone, e-mail and personal delivery were used for the transmission of information.

In September 1997, with the knowledge that this event could already be more intense than the 1982-83 El Niño (during which the city of the Havana was severely hit by coastal flooding and other severe impacts), direct contact was made with the government of this City and the Civil Defense. These entities had the objective of warning about the arrival of a winter with severe impacts. As a precautionary measure, Civil Defense (in this case), decided to activate the operational structure, which had been created in the summer throughout the whole country, in order to face climate-related eventualities during the hurricane season. As a result of this measure, a higher level of early responses was guaranteed in case of a wintertime emergency caused by El Niño.

An additional measure taken to increase the flow and exposure of El Niño information was the convening of scientific and educational conferences on El Niño in different societal and economic settings in the country. Among those are the following:

- Scientific personnel in the Institute of Meteorology, February 1997
- Council of Directives. The Ministry of Agriculture, May 1997
- Members of Cuban Meteorological Society (SOMETCUBA), August 1997
- Ministry of Planning and Finances, September 1997
- Council of Provincial Administration Ciudad Habana, October 1997
- Provincial Council of Defense Ciudad Habana, November 1997
- Investors. Popular Power Headquarters, Ciudad Habana, November 1997

- Director of the World Food Program in Cuba, 1997
- Directors of United Nations Agencies, October 1997
- Council of Defense of the Regla municipality (Havana), December 1997
- Civil Defense National Workshop on Natural Disasters, July 1997
- Meeting of the National Headquarters of the Civil Defense, October 1997

h. How did the media first report the developing El Niño?

The first reports of the 1997-98 El Niño event appeared in the middle of 1997 in news programs on the radio and on Cuban Television. First, these reports were made from news from the main international agencies about El Niño's impacts that were occurring in other countries, mainly in Peru and Ecuador. In the press, news about El Niño's development began to appear in September 1997. The first article in the press about this event appeared on 27 September 1997 in the newspaper Juventud Rebelde entitled, "The Bad Ghost of Climate." It was written by the Cuban journalist Yamila Rodríguez (Figure 5.2). This report, covering a complete page of the newspaper, presented a broad explanation of what El Niño is and its prospective impacts at international and national levels. This article presented an analysis of the worldwide losses registered during the 1982-83 event. It concluded by offering an optimistic image related to the possibilities that the international and Cuban scientific communities currently possess to predict the evolution and to prevent the impacts of the event in progress.

Many articles and news items related to the 1997-98 El Niño were also published in 1998. Between September 1997 and August 1998, seven articles were published on El Niño in the newspaper Juventud Rebelde and four were published in Granma.

i. How did the media cover the event over time? (Quote headlines, names of radio stations, TV programs, etc., with dates.)

Monitoring of El Niño 1997-98 by the Cuban press

The press in Cuba is composed of a total of three important newspapers with National circulation:
- Granma, an official organ of the Communist Party of Cuba
- Juventud Rebelde, official organ of the Communist Youth from Cuba
- Trabajadores, the Cuban workers' official organ

Likewise, in each province a newspaper exists as an official organ of the political institutions, making a total of fourteen provincial newspapers. There are also a certain number of newspapers specializing in different aspects of Cuban life (culture, sports, movies etc). Nevertheless, during the 1997-98 event, almost all of the articles about the subject were concentrated in the newspapers of national circulation. Granma, with the biggest circulation of news, and Juventud Rebelde, with more in-depth reports, were especially directed at preparing the population for El Niño's likely impacts.

These publication schedules of these papers are fundamentally the result of economic reasons. In 1997, because of the severe economic slowdown of the 1990s in Cuba, previously noted in this report, the circulation of Juventud Rebelde, Trabajadores and all the provincial papers became weekly. For this reason, it was impossible to publish in these journals daily news from around the world about the El Niño. However, Granma remained with daily circulation, and was the only one able to publish daily news about El Niño.

In the special case of the provincial newspapers, further resource limitations restricted the number of pages that could be printed, causing them to publish news and reports exclusively related to the life in and economy of each province.

How did the press report about the 1997-98 El Niño development?

The news on the 1997-98 El Niño development in the press began in September 1997 with the publishing of the previously noted article "The Bad Ghost of Climate" on 27 September 1997 in Juventud Rebelde.

Between September 1997 and August 1998, seven articles were published on El Niño in the newspaper Juventud Rebelde and four were published in Granma. In 1998 a larger number of reports and news items related to the 1997-98 El Niño were published. Among these publications, the following can be highlighted.

Reports

- "El Niño is already the strongest of the century." (Granma, December 1997).
- "El Niño isn't coming, it is already here." (Juventud Rebelde, January 1998).
- "The Boy of Tragedy." (Juventud Rebelde, February 1998)
- "Dry Ground." (Juventud Rebelde, July 1998)

Headlines of some news published in the press

- "Peru, the effects of El Niño destroyed 800 schools." (March 1998, Granma).
- "Victims of El Niño in Peru." (April 1998, Granma).
- "Floods in Italy." (May 1998, Juventud Rebelde).
- "Losses of 2,300 million dollars El Niño left in Ecuador." (June 1998, Granma).
- "El Niño hits the South of Ecuador." (November 1998, Granma).
- "Latin America continues to be affected by the El Niño phenomenon." (December 1998, Granma).

Starting from the second half of 1997, there was a general tendency in the Cuban press to increase the information about El Niño, in order to prepare the population for the upcoming winter. Traditionally in Cuba, wintertime is when one should expect El Niño's biggest impacts.

Given the number of informative reports in the press, written in the period from September 1997 to August 1998, the press in Cuba played a fundamental role in the creation of a more realistic perception among the public about what El Niño is, and what its impacts in Cuba might be.

Monitoring by Cuban Television

The Cuban Television is a government entity composed by two national channels (Cuba-vision and Television Rebelde) and a group of seven television centers with an exclusively provincial focus. The Television Rebelde channel is devoted in a prioritized way to the broadcasting of programs and news. However, at 8 o'clock at night, every night, both channels transmit the "National TV News", which constitutes the most important news on Cuban TV.

Based on this structure, already from the middle of the year 1997, the different news media began to report on news coming from international agencies about disasters caused by El Niño in other countries. In November 1997, journalist Adelfa Fiallo of Cuban TV presented a report of 20 minutes in length, divided into six chapters. The report not only contained a considerable amount of information about El Niño, but also included interviews with Cuban scientists who were studying this event. They clarified different aspects of the nature and magnitude of the expected impacts in Cuba. This material was presented during six days in a row by the National Cuban TV News. This commands the biggest television audience in the country, influencing in an important way the level of the public's information. Although this report can be considered as the only one made by Cuban Television on El Niño, it was not only the most complete one released by the media, but also was the most influential with regard to reaching the majority of the Cuban population during an El Niño event.

Monitoring by the Way of National Radio Broadcasts

The radio in Cuba includes a wide network of more than fourteen provincial radio stations and two national radio stations (Radio Rebelde and Radio Progreso) with broadcasts of a general character. Additionally, another informative radio station exists (Radio Reloj) and others specialize in transmissions for tourism, classical music, etc. The basic role of the radio stations during the 1997-98 El Niño was news coverage in radio programs about the most outstanding aspects relating to El Niño as reported by international news agencies. However, in 1997, before the beginning of the dry (or winter) season in Cuba, programs and interviews with scientists at the Climate Center provided information to the public, similar to the way done by television and the press. There were seven interviews, five transmitted by national radio stations (Radio Rebelde and Radio Reloj) and the remaining two by radio stations in the Western Province of Cuba, Pinar del Rio and Havana Province.

During 1998, the biggest volume of coverage on El Niño by the radio was centered on the effects of drought and the measures taken to mitigate its effects. This was developed almost exclusively through traditional radio news reports.

Figure 5.2 Front cover of the first report about El Niño 1997-98 published by the Cuban press

ENOS

El duende malo del clima

Inundaciones, sequías, calores extremos en las zonas más insospechadas del planeta son algunas de las consecuencias de El Niño. Cuba en mejores condiciones de enfrentar sus efectos

que existen excepciones como la de 1958, cuando hubo un invierno frío y lluvioso.

Además pueden ocurrir tormentas de granizos y vientos fuertes, y lluvias muy intensas en poco tiempo.

No obstante, en el verano también se sienten los efectos, ya que son más calientes de lo normal. En la presente temporada se rompieron varios records de temperatura máxima y el pasado agosto fue el más caliente de los últimos 35 años.

La actividad ciclónica —clásica del verano— también se afecta, porque disminuyen notablemente los organismos que se forman en el Atlántico y en el Caribe.

Desde hace varias décadas, los meteorólogos estudian estos impactos, pero no es hasta 1982-1983, cuando ocurrió el ENOS más intenso de este siglo, que se intensifican las investigaciones. En aquella oportunidad se produjeron pérdidas estimadas en más de 8 000 millones de dólares y más de 2 000 muertos, en varias regiones del mundo.

Aunque muy peligroso, el ENOS se puede pronosticar. Desde 1993-1994 comenzaron a aparecer en el mundo los primeros mode-

Source: Juventud Rebelde, 27 September, 1997

j. Was the 1997-98 El Niño compared with any previous events?

The Cuban media were not prolific when it came to comparisons of the 1997-98 event with previous events. In several journalistic articles and in the previously mentioned television reports, some references were made to the 1982-83 El Niño, but in almost all cases, it was

done to illustrate the potential effects and was not a true comparison.

The only report that made an explicit comparison between the events of 1982-83 and 1997-98 was published in Granma in December 1997 entitled, "ENSO is already the strongest in the Century," (written by journalist Orfilio Pelaez). In this article Peláez interviewed Dr. Pedro Cardenas from the Climate Center who presented meteorological information that made it possible to classify the 1997-98 El Niño as more intense than the 1982-83 event.

6. Before the mention of the 1997-98 El Niño, when was the previous mention of El Niño in the media?

The previous mention of El Niño prior to the 1997-98 event, occurred in January 1997, when Granma published the report, "The war of ENSO will be announced" (by journalist Orfilio Peláez). At the beginning of his report, he noted the following: "Absent from the climatological universe since 1995, the terrible ENSO event doesn't surprise us again with its unusual rains in the months of the dry season and with other weather anomalies." Based on this introduction, he reported on the capacity of Cuba's Climate Center to predict an El Niño some months in advance, as a consequence of the latest results. At the end of his report he pointed out that these results make Cuba one of the few nations in the world with its own methodology to predict the onset of the well-called "Diabolical Child of the Climate." A few weeks later this forecasting was dramatically tested by nature.

TELECONNECTIONS
(i.e., Expected Effects of El Niño)

7. What are the scientific views about the existence and the strength of El Niño Teleconnections to the country area?

The findings of studies such as those carried out by Rogers (1988), Aceituno (1988), and Naranjo (1994) agree in describing a more evident El Niño influence on winter circulation patterns in the Caribbean. This is similar to what takes place in the United States and is mainly the result of frequent intrusions in this season of the extra-tropical westerlies from the North American Continent.

For a typical winter following El Niño's onset, westerlies in the upper air are expanded toward the south and a branch of the subtropical jet stream carries energy from the cloud clusters over the Pacific Ocean to the Gulf of Mexico and the southeast of the United States. As a general rule, this situation favors the formation of extratropical cyclones in the Gulf of Mexico, increasing the frequency of frontal events that especially affect the Greater Antilles and part of Central America, and influence a relative increase in the winter rainfall on these zones during El Niño years.

Although ten winter cyclones develop on average each season in the Gulf of Mexico, there were twenty-six cyclones in the 1982-83 winter associated with one of the most intense El Niños in the 20th century (Hsu, 1993).

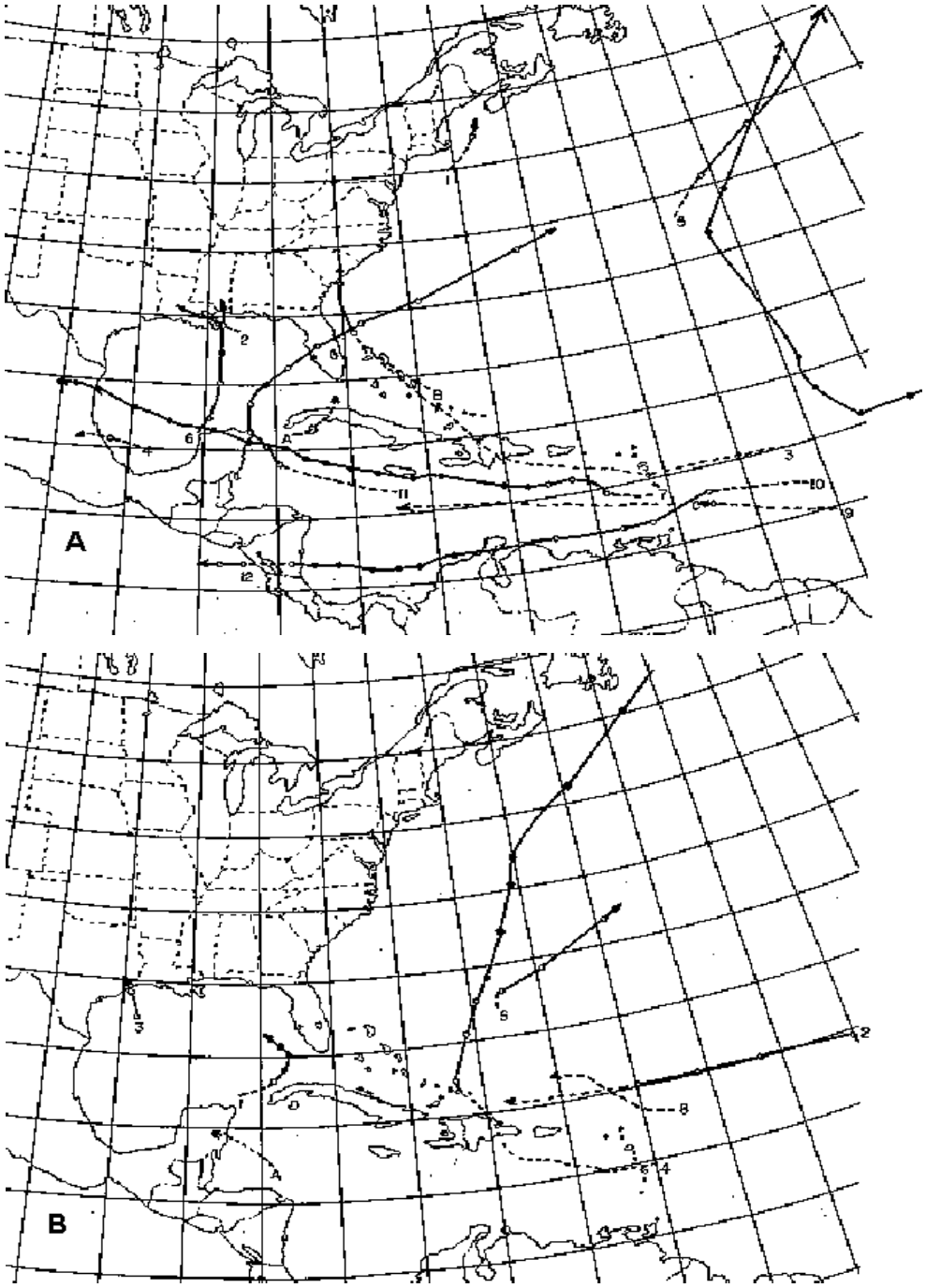
In Cuba, the influence of the El Niño becomes more evident and important in the second half of winter. In fact, the biggest natural disasters in this season are associated with extra tropical cyclone systems formed under El Niño conditions.

In the rest of the Caribbean, the presence of expanded westerlies is a typical characteristic of winter circulation under El Niño conditions. This is reflected in a tendency toward a predominance of negative anomalies of surface pressure over the whole area throughout this season.

In summer the interrelationship between the atmospheric circulation over the Caribbean region and El Niño becomes less evident. At 200 the hPa level, Arkins (1982), studying the El Niño events of 1969, 1972 and 1976, identified the presence of increased westerlies (or weakened easterlies) in summer all over the Caribbean and the tropical Atlantic belt. Gray (1984) verified this when he found significant differences of 200 hPa zonal winds between El Niño years and non-El Niño years in the vertical profiles of four meteorological stations of the Caribbean with a larger sample.

In general, no significant relations have been found in surface circulation. However, as a result of the changes in the upper air, an increase of the vertical wind shear during El Niño years should be expected. This established a possible connection between El Niño events and tropical hurricane activity in the Atlantic, an issue of crucial importance for the entire Caribbean area.

Figure 7.1A and B (See text)



The Atlantic Hurricanes and the El Niño

Gray (1984) suggested the existence of significant relationships between the anomalies of sea surface temperatures in the equatorial Pacific Ocean and tropical cyclone activity in the Atlantic. He found a tendency toward the reduction of this activity in El Niño years. The cyclone activity in the Atlantic during the El Niño event of 1982 (Figure 7.1A) is compared to that of the year 1988, during a La Niña event (Figure 7.1B).

In analyzing the climatology of intense hurricanes (maximum sustained winds of more than 50 m/sec) between 1950 and 1990, Gray (1992) found a clear decrease in these cyclonic systems during El Niño years. According to Landsea (1993), 83% of intense hurricanes reported in this zone have a "pure" tropical origin through the development and intensification of waves in the easterlies. Consequently, Gray's finding suggests that the anomalies imposed on the summer circulation in the Atlantic during an El Niño tend to reduce the efficiency of the tropical formation mechanisms through an increase in wind shear below 20ºN (Hess and Elsner 1995). It follows from this that, during El Niño years, there is to be expected a decrease in the number of tropical cyclones that intensify to the category of hurricane in or next to the Caribbean Basin, while during a La Niña (cold) event an increase in the number of hurricanes is also to be expected.

Ballester and González (1995) studied the relationships of cyclone activity and the presence of moderate and strong El Niño events in the 1966-94 period and found significant relationships that not only confirmed Gray's previous results but also shed new information on the subject. The fact that the onset of a moderate to strong El Niño reduces the number as well as intensity of cyclones appearing in the North Atlantic was confirmed. Likewise, this reduction was evident also in the Gulf of Mexico and the Caribbean Sea, studied separately.

In studying the duration of the cyclone season, the existence of significant differences between El Niño years and non-El Niño years was shown. It was found that, during El Niño events, the cyclone season finishes earlier.

Although the study and characterization of the influence of El Niño on atmospheric circulation mechanisms in the Caribbean is still open to scientific research and many vital aspects in this field are still to be established, it is evident that the disorders of the global circulation associated with El Niño have a significant impact in our region. The increase of winter storms with the damage aftermath, and the alteration of the rainfall regime in the zone as a result of anomalies in the circulation patterns, have captured the attention of both specialists and non-specialists in the region about the need to know more about El Niño events and their consequences.

Recent studies linking the ENSO to tropical cyclone activity, their intensity, duration and characteristics are of the greatest importance for this region, which is so heavily threatened and adversely affected by these devastating systems.

8. If known, what were the climate-related anomalies and impacts in your country of the 1982-83 event?

In terms of disasters, the 1982-83 event was the most severe ever experienced by Cuba. In the winter of 1982-83 a record number of twenty-six extratropical cyclones developed on the Gulf of Mexico (Hsu, 1993), some in very low latitude. These brought rains that surpassed the expected historical means by three to five times in almost the whole country. They caused the winter to be the wettest and rainiest in the last fifty years. However, rain was not the most adverse meteorological factor. Other events of unusual intensity and frequency also plagued Cuban territory. In March 1983, southerly winds with hurricane force caused enormous damage in the western region of Cuba. On the 18th of March, the biggest tornado outbreak in Cuba up to now, was reported with a total of seven (7) and with winds estimated in 300 km/h. These tornadoes were associated to an intense squall line generated just ahead of a low-pressure system over the Gulf of Mexico.

However, maybe the most well known event associated with the 1982-83 El Niño was the intense seawater intrusion (surge) that took place on March 17. It flooded extensive urban areas of the City of the Havana (capital of Cuba with nearly 2 million inhabitants), producing very severe damage to the city's infrastructure. An intense extratropical low pressure system in a very low latitude produced waves in the Gulf of Mexico between 4 and 5 meters and even higher that, combined with other factors, caused the deepest and most devastating penetration of sea water that has plagued Havana since the great hurricane of 1926.

The damages were considerable throughout the country. The official press reflected unprecedented losses until that moment. More than 40,000 acres of tobacco were completely destroyed, 65% of the whole tomato crop was severely damaged, while the potato damages amounted to more than 120,000 metric tonnes lost, or one-fourth of that year's crop.

The strong winds demolished more than one and a half million banana trees with an estimated production loss of 50,000 metric tonnes. Many varieties of vegetable crops were destroyed. The sugar cane was strongly damaged by the strong winds, resulting in a considerable reduction of the yields.

El Niño's impacts in other social sectors were also considerable. The state began to assign, urgently, funds and emergency resources for the repair of houses. For this a system of credits was created for the purchase of materials with discounts up to 50% of the nominal value, in order to stimulate quickly the repair of damages in such a sensitive sector.

There were also damages in the health sector. Although major epidemic outbreaks were not reported, because of the intense efforts of the Cuban health system, increases were detected in the incidence of non-contagious illnesses such as bronchial asthma, associated to the stress caused by the severe weather conditions.

9. What were the 1997-98 climate-related physical and social impacts of the 1997-98 El Niño in your country? (Include agriculture, health, water, migration, etc.)

As discussed previously, El Niño impacts present a clear and differentiated influence on the Cuban dry season (from November to April). El Niño's influence on the rainy season or on summer seems to be more complex and less clear, with the exception of its impact on cyclone activity. In this section the impacts of El Niño on the Cuban meteorological conditions are discussed. Its impacts can be divided into three stages: the rainy 1997 season, the 1997-98 dry season, and the short drought in the summer of 1998.

Anomalies in the Rainy Season May to October 1997

In the 1997 rainy season very remarkable maximum temperatures were reached, especially in August and September, where new records were reached at several stations. In August and September records of high minimum temperatures were also reached in Cuba, with extremely warm conditions. Regarding monthly means, new records for Cuba and for its three regions were reached (Table 9.1). The spatial distribution of rain was very irregular, with rainfall accumulation in different areas of below 75% and 50% of the historical averages in this semester. For the Eastern region the situation was worse than for the other regions, although almost none escaped this impact.

For October the rain deficit was much more widespread (Fig. 9.2), where most parts of the country had monthly precipitations accumulate below 50% of their normals. The irregularity of the distribution of the rain was linked to the greatly diminished cyclone activity. Only seven tropical cyclones were formed then, none of which affected Cuba.

Table 9.1. Significant values of monthly mean and minimum temperatures in Cuba and its three regions. Day of occurrence and values (in parenthesis) are given. A shaded cell means a record.

	Mean Temperature			
DATE	**CUBA**	**WEST**	**CENT**	**EAST**
May-97	1-97(27.3)	2-97(27.4)	1-97(27.0)	
Jun-97		5-97(27.6)		
Jul-97	2-97(28.4)	1-97(28.4	5-97(27.7)	4-97(29.3)
Ago-97	3-97(28.3)	2-97(28.4)	4-97(27.8)	
Sep-97	5-97(27.8)		5-97(27.3)	4-97(29.2)
Oct-97				
Nov-97	2-97(26.1)	2-97(25.8)		3-97(27.6)
Dec-97				
Jan-98				
	Mean Minimum Temperature			
DATE	**CUBA**	**WEST**	**CENT**	**EAST**
May-97	1-97(26.0)	1-97(23.3)	1-97(22.1)	
Jun-97	2-97(23.9)	2-97(24.0)		4-97(25.4)
Jul-97	2-97(24.3)	1-97(24.3)		5-97(26.0)
Aug-97	1-97(24.2)	1-97(24.4)	2-97(23.1)	
Sep-97	1-97(24.0)	3-97(23.8)	2-97(22.9)	1-97(25.7)
Oct-97				4(97(24.8)
Nov-97	2-97(22.7)	1-97(21.4)	5(97(21.4)	3-97(24.5)
Dec-97	4-97(20.5)	3-97(20.3)		
Jan-98				

Anomalies of the 1997-98 November-April Semester

The anomalies of the daily mean and minimum temperatures in the months of this period presented a shift toward higher values, especially the minimum temperature that reached very high values. A new record of high minimum temperature for the Western region was reached in November.

The remaining regions were very near to their records for this and other months. Figure 9.3 presents the behavior of the mean minimum temperature from May 1997 to June 1998.

The totals of rainfall accumulation in the November-March period in Cuba and in each of the three regions were well above the norm (see Figure 9.4). If the total accumulations only in these four months were analyzed, it would seem that this would be profitable for many economic sectors. However, the characteristics of the rains (short-lived episodes, but with great intensity) actually made them not only unprofitable, but also harmful for many activities. As a consequence of the influence of extratropical lows, the occurrence nationwide of strong winds, intense rains, lightning activity and other dangerous meteorological phenomena occurred. In the following box the most significant events from November 1997 until the end of March 1998 are shown.

The most significant weather events (November 1997 to the end of March 1998)

DATE (dd/mm/yy)	***EVENTS***
13/11/97	*November record for strong southerly winds (called Sures) in Western Cuba.*
12/97	*Record frequency of "Sures" for December.*
3/12/97	*Rainy Cold front in Eastern Cuba. Holguín registered 400 mm in 24 hours.*
2/2/98	*Strong extratropical cyclone over the Gulf of Mexico. Wind gusts over 114 km/h in Havana. Heavy rains, strong winds and coastal flooding.*
15/2/98	*Strong extratropical cyclone over the Gulf of Mexico. Wind gusts over 116 km/h. Coastal flooding in Western Cuba.*
22/3/98	*Quasi-stationary Cold Front over Eastern Cuba. Heavy rains in Santiago de Cuba and Guantánamo provinces.*

Short Period Drought of April-June 1998

Starting in April 1998, an intense drought lasted during the April-June period, causing the most significant rainfall deficit since 1941 for this period.

The first symptoms of this drought began to appear at the end of the November-March period, when, despite high precipitation nationwide, some parts of the Eastern region began to show significant deficits. Already during April, scarce rains were registered throughout the country, and there was an appearance across large areas of drought conditions. This event was a national drought, which settled in May, with major rainfall deficits in all of

Cuba, but mainly in the Central and Eastern regions. When June (one of the traditionally rainy months in Cuba) registered a considerable precipitation deficit, the drought became critical and was one of the most severe reported in history (Figures 9.5).

The drought in Cuba was very severe, especially in the Eastern region. The percentages regarding the historical averages at the end of June, considered the month when this El Niño event ended, was for Cuba 56%, for the Western region, 64%, 52% for the Central region and 51% for the Eastern area. Although the month of July had more favorable rains, the April-July period still showed a major deficit. In the eastern part of the country the rains generally were restricted to coastal areas. This caused an especially difficult situation for that region by disrupting water supplies for human consumption in some major cities.

The Guantánamo province registered less rain, with only 27% of the long-term average. In the towns of Imías, Maisí and San Antonio, semi-desertic areas located in the south of this province, 62,000 people had to be supplied with water by means of water trucks. The region's agriculture was practically devastated.

In addition to precipitation anomalies, temperatures also registered major anomalies. May was characterized with values very near to those reported in 1997, when the warmest May since1951 was recorded. In June record values of maximum temperatures were reported in many parts of Cuba, making it one of the warmest Junes on record.

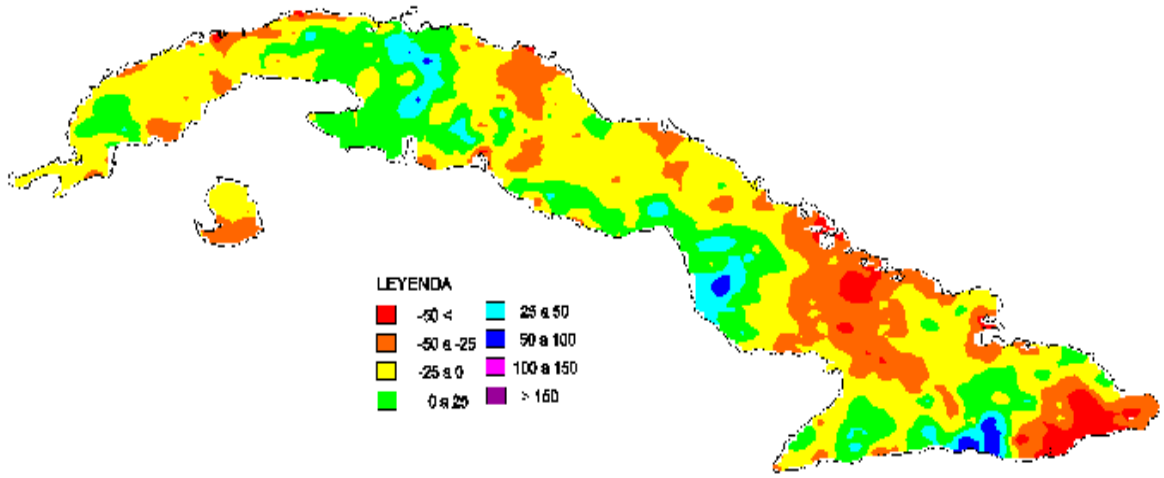


Figure.9.1 Rainfall Anomalies in % related to long-term averages for the May/97 to October/98 period

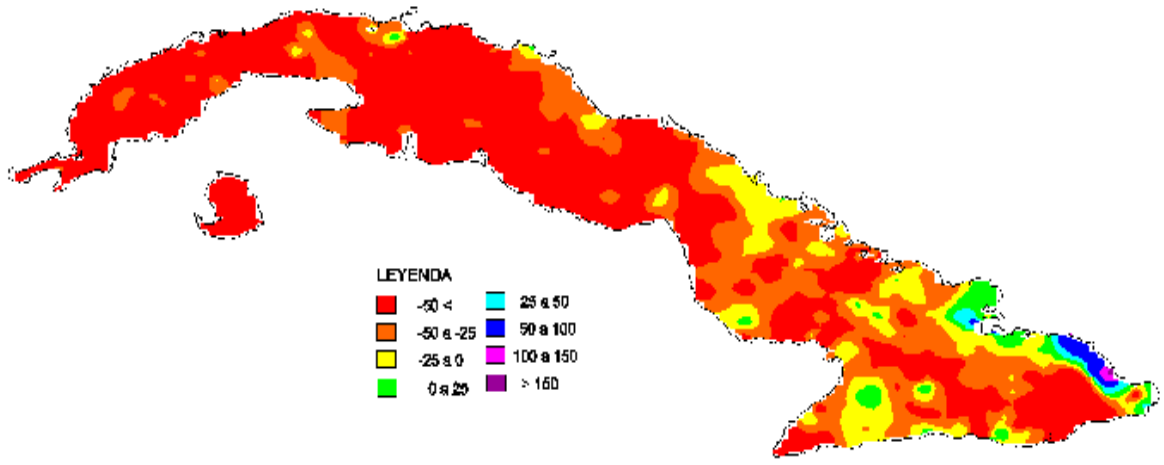


Figure 9.2 Rainfall Anomalies in % related to long-term averages for October 1998

Figure. 9.3. Mean Minimum temperatures anomalies in Cuba.

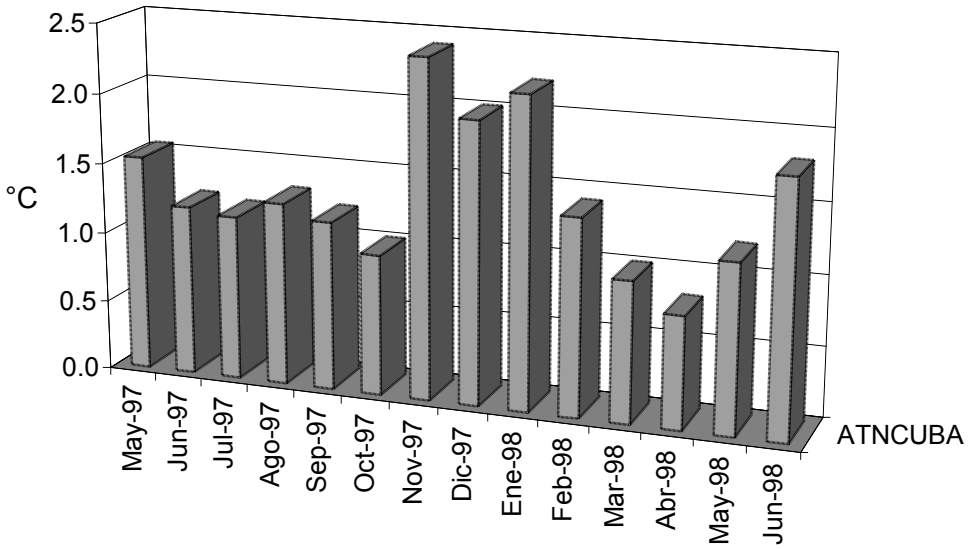
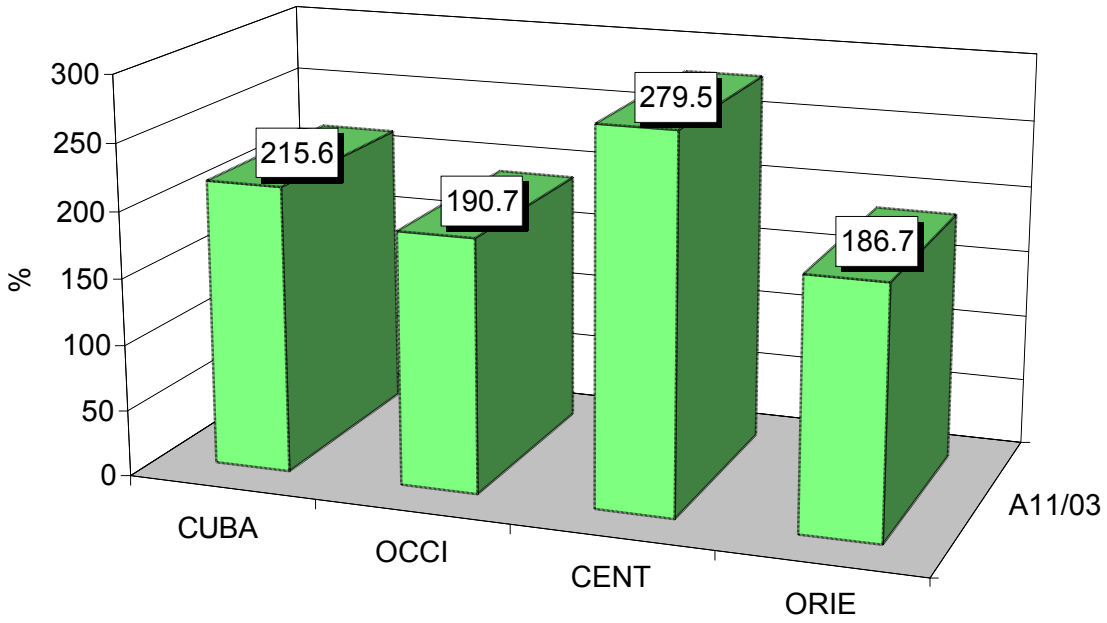


Fig. 9.4. Percentage related to long term normals, for rainfall for November 1997 to March 1998.



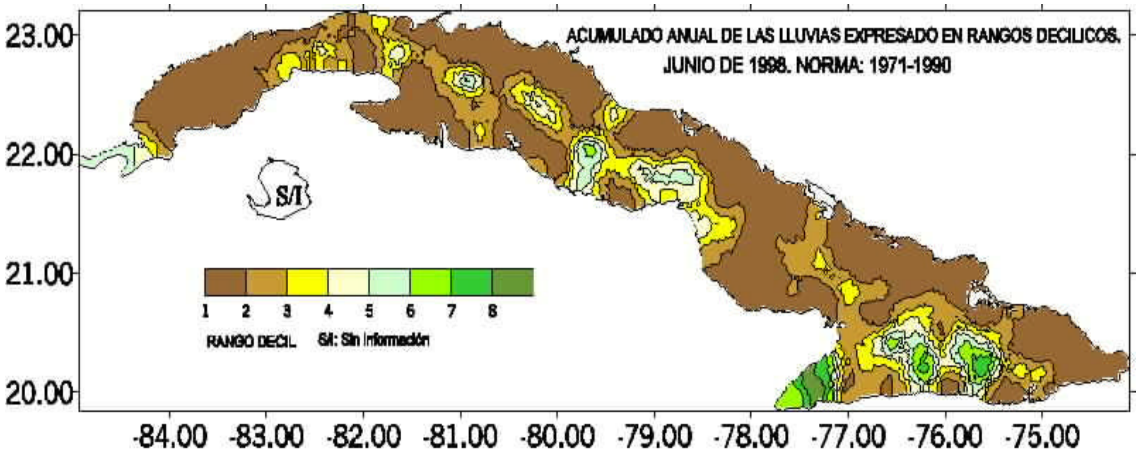


Figure 9.5. Annuals rainfall amount in June 1998 in relation to the 1971-1990 period in decile intervals. Brown areas indicate extreme drought condition. (From National Climate Center, Cuba.)

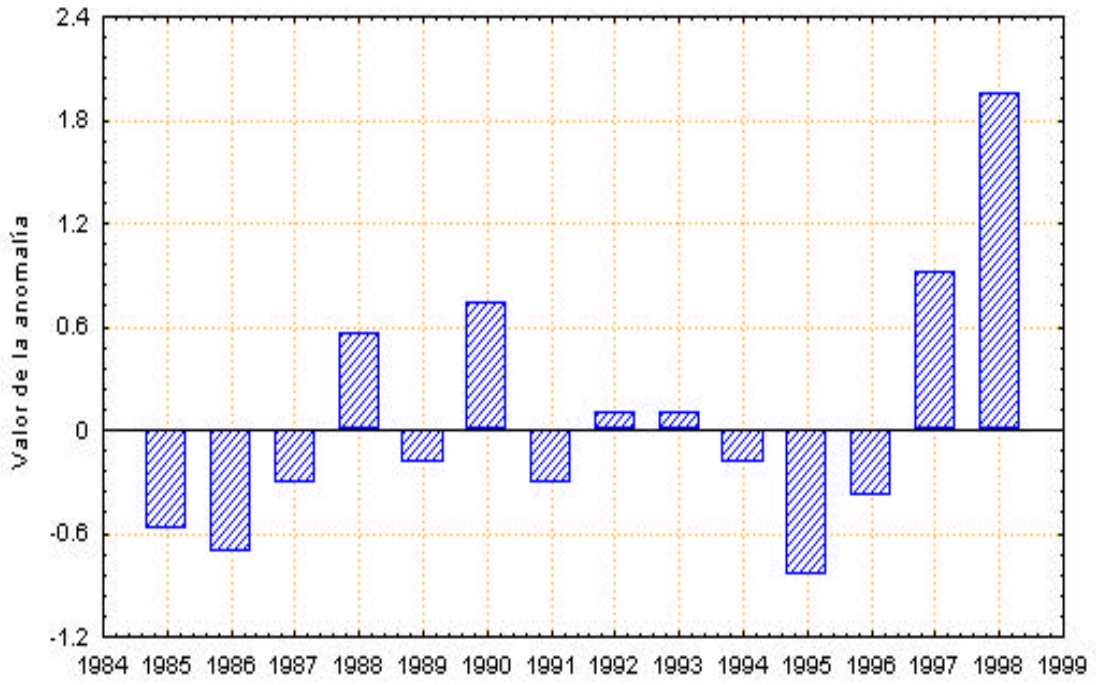


Figure 9.6. ARI occurrence in Havana City for June.

SOCIOECONOMIC IMPACTS OF THE CLIMATIC ANOMALIES ASSOCIATED WITH El NIÑO 1997-98.

The socioeconomic activities in any country whose economy has a major agricultural component depend largely on the behavior of climate. In the case of Cuba other sectors such as fishing and tourism are also very vulnerable.

Population concentrations in coastal areas in most countries are constantly growing, along with all type of supporting infrastructure. The societal vulnerability to events like coastal floods has increased. In Cuba, since an event of that type is predicted, impacts on the economy begin with evacuations and the creation of marginal living conditions for those who have been evacuated. Measures to protect the infrastructure are very expensive and increase if a flood actually occurs. Taking preventive measures for other events, like heavy rains, are also costly.

An example of the consequences of changes in regional climatic conditions linked to El Niño would be sugar production, the country's primary crop. Sugar cane requires abundant rainfall during its vegetative stage (the months of summer) but low temperatures and little precipitation, in winter, when it is necessary to increase the sucrose concentration in the juices and to guarantee high yields. Besides diminishing the yields, rainfall in the wintertime also affects the harvesting activities that are carried out at this time of year. This way, little rain in summer and a warm and rainy winter negatively impacts the normal development of the sugar cane production.

IMPACT ON AGRICULTURE AND CATTLE GRAZING

Sugar Cane

Because of the warnings about the possible onset of an El Niño event released by the Climate Center, Cuba's Ministry of Sugar decided to advance the harvesting to diminish the impacts of an expected increase of rainfall during the normal period of dryness (November-April). In spite of this, there was a rainfall deficit, which reduced the yields. This resulted because the moisture stored in the soil was not favorable for sucrose buildup in the shafts.

The short drought in 1998 resulted in the loss of 8,000 ha. of "spring cane" (cane which is sowed from May to July) in the five eastern provinces of Gramna, Las Tunas and Guantánamo the sugar cane losses were more than 700,000 metric tonnes.

A qualitative evaluation of the agrometeorological conditions for the agricultural yield of sugar cane, regarding some optimum value, is shown in the following table. It illustrates how the combination of the observed anomalies in the dry season and the summer drought were able to cause important negative impacts in all Cuban Provinces.

Province	**January- April**	**May - June**
Pinar del Río	*Favorable*	*Very unfavorable*
La Habana	*Favorable*	*Very unfavorable*
Matanzas	*Slightly favorable*	*Not favorable*
Villa Clara	*Satisfactory*	*Very unfavorable*
Cienfuegos	*Slightly favorable*	*Very unfavorable*
Sancti Spiritus	*Favorable*	*Very unfavorable*
Ciego de Avila	*Satisfactory*	*Very unfavorable*
Camagüey	*Satisfactory*	*Very unfavorable*
Las Tunas	*Slightly favorable*	*Very unfavorable*
Holguín	*Satisfactory*	*Very unfavorable*
Granma	*Poco favorable*	*Very unfavorable*
Santiago de Cuba	*Favorable*	*Very unfavorable*
Guantánamo	*Slightly favorable*	*Very unfavorable*

Tubers and Vegetables

Potatoes, which constitute an important element in Cuban nutrition, were adversely affected by rain in this period. Losses were estimated at more than 18,077 metric tonnes and damaged about 940 hectares of potato fields, in spite of measures taken to improve the drainage of the fields.

High humidity, heavy winds and hailstorms reported in some towns, caused adverse impacts on plantations. In some parts of the country there were outbreaks of Phytophtora and of other bacterial species. This led to additional losses of the order of 59,521 metric tonnes of the tuber, mainly in Havana Province.

Banana plantations were severely hit by strong winds that damaged or demolished over 6,710 ha. in the western provinces. In addition, the droughts during the rainy season caused additional reductions in the yields in the eastern provinces, affecting nearly 40,000 ha. This caused an estimated loss of 166,000 metric tonnes.

The occurrence of abnormally warm and humid winds in the winter season (November-January) affected tomato flowering. In fact, a decrease in overall vegetable production was recorded, sparked by a decrease in the early production (winter 1997-98) of tomatoes, cabbage and cucumber. Tomato losses were more than 14,000 metric tonnes.

Fruit

Fruit trees were mainly affected by strong winds. The winds caused damages in flowering and detachment of citric, mango and other fruits. Based on a study carried out by the World Food Program in Cuba (1998), the losses in tubers, vegetables and fruit are summarized in Table (9.2).

Coffee and Cocoa Production

The main areas of coffee and cocoa cultivation are located in the mountainous areas of the central and eastern regions of Cuba. Cocoa production is concentrated almost exclusively in the mountainous areas of the eastern tip of Cuba. In general, the rain conditions in the first part of the 1997-98 winter did not affect to any great extent the cultivations of coffee and cocoa, except in December when rains in the central region accelerated the maturation of the coffee grains.

Table 9.2 Losses in metric tonnes (second column) and U.S. dollars (third column) for some crops during the 1997-98 El Niño event. (Based on the World Food Program Report 1998).

CULTURE	LOSSES IN METRIC TONNES.	ECONOMICAL IMPACT. (MILLIONS DOLLARS)
Potato	77598.2	16.8
Banana	137994.4	25.0
Tomato	14248.3	5.0
Cabbage	6954.0	0.5
Cucumber	942.0	0.1
Mango	29898.8	4.6
Avocado	5519.7	2.2
Strawberry	22.9	0.1
Beans	4369.8	5.3
TOTAL	205548.7	59.6

During the months of January and February of 1998, humid conditions accelerated the flowering of the coffee; however, the instability of the rainfall regime in the rest of the dry period caused, in many cases, the loss of flowering with major negative impacts. In the case of the cocoa, drought conditions in February and intense rains at the end of March in the crop area impacted negatively, causing very low production.

Additionally in this mountainous cultivation, the intense rains caused collapses and ground slips that affected the infrastructure of warehouses, elaboration plants and communications.

Cattle Grazing

Summer drought also affected milk production, the losses of which (only in the eastern provinces) surpassed 20 million liters during the summer of 1997. Nearly 13,000 animals died from malnutrition in the state sector. It was necessary to evacuate more than 25,000 cattle to safer places, in addition to having to feed another 225,000 by different methods.

With regard to poultry, the record high temperatures increased the heat stress in barnyard fowl, affecting the yields.

Tobacco

The magnitude of the rain in the November 1997 to March 1998 period, which is fundamental in the development of the tobacco plant, was very unfavorable for the growth and productivity of this crop mainly in the tobacco areas of Havana, Villaclara and Sancti Spíritus provinces. During this period, the rains were above normal. Up to January 31, 1998, the loss of 3,350 hectares had been reported because of this. Additionally, the temperature régime was unfavorable when temperature anomalies of greater than 1.5^{o} Celsius were observed. High temperatures negatively impacted the maturation of the tobacco leaves. Furthermore, the strong warm southerly winds that occurred between November 1997 and January 1998 negatively affected the youngest plantations.

Weather conditions in this period were favorable for the outbreak and propagation of plagues and diseases (in particular, Blue Mold), which increased because of an inadequate use of the natural fungicide in the affected areas. Due to the increase of grasses, because of the rains, harmful insect populations grew sharply. In the most important varieties reductions in tobacco yields were reported for more than 100 kg/ha.

The 1997-98 El Niño Event and its Effects Upon Human Health

The human health sector is a major state priority in Cuba. The health sector was unified in the decade of 1960, when by a decision of the Cuban government, a unique sanitary system under state control was developed; it was universal and free. In the following three decades health conditions in Cuba varied significantly with the application of health programs and a policy directed toward the control and prevention of infectious illnesses. For example, through the Program of Immunizations, several illnesses have been eliminated and/or controlled, while the influence of others in the morbi-mortality frame of the country were reduced. From the 1960s a System of Statistical Registration of Illnesses was introduced. The statistical departments of the different units compiled the registrations of medical consultations; and they consolidated this information weekly, which flows to a network from the municipality levels, provinces and the nation. This constitutes the information source of the System of Epidemic Surveillance of Infectious Illnesses.

Of the number of notifications that took place, acute respiratory infections (ARI) and acute diarrheic illnesses (ADI) are two of the most epidemic-prone in Cuba. They had respective infection rates in 1997 of about 43,905 and 8,996 per 100,000 inhabitants. In 1997 cases of poliomyelitis, diphtheria, tosferine, measles, rubella, mumps, and neonatal tetanus were not reported. The infectious illnesses of the central nervous system (NCS), bacterial meningitis (rate of 9.12) and viral meningitis (rate of 26.4) showed relatively low rates.

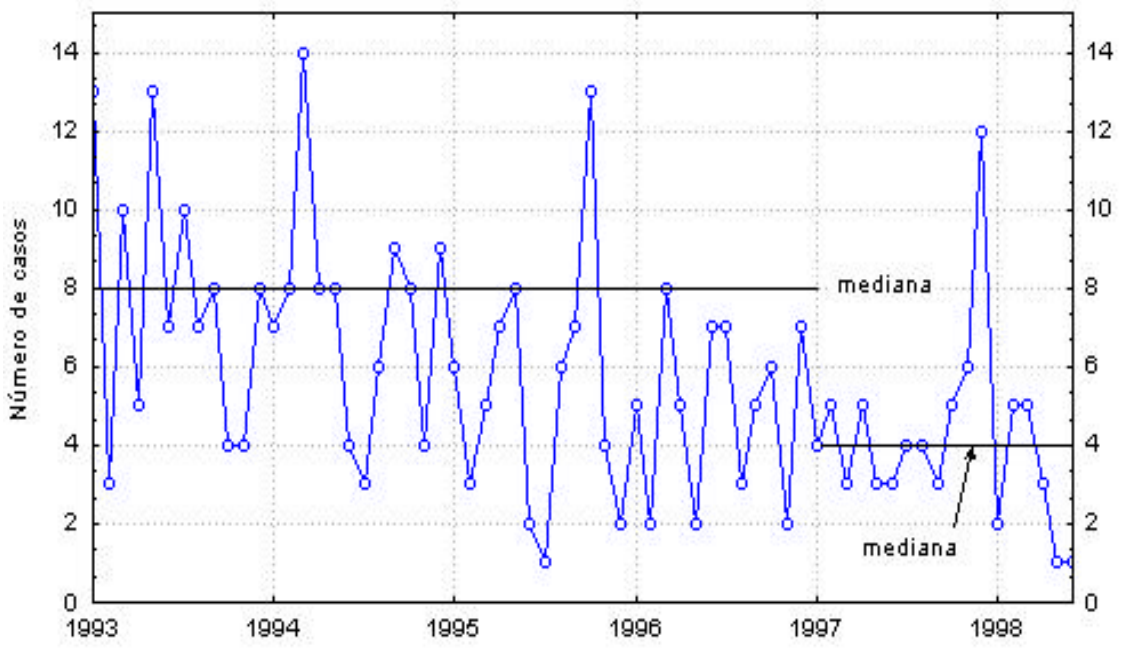


Figure 9.7 Cases of Meningitis Menigococcica between 1993 y 1998

Regarding Bronchial Asthma (BA) its prevalence is of 8.58% in the urban areas, 7.5% in the rural areas and 8.2% for the total Cuban population.

Another important aspect of the BA is that it is responsible for 13.6% of all the emergencies in the hospitals; in the case of the children the rate is 6.8%. This illness is not only a problem in Cuba but in developed countries as well. The number of consultations varies from 20-40% of the total of all the consultations given in pediatric hospitals.

From the analysis obtained through cooperative studies carried out between the Cuban Ministry of Public Health and the Climate Center, the cases of the BA and of ADI dropped during the 1997-98 event. For the former, that could be explained by the presence of a warmer and less contrasting winter, while for the latter it was due to the occurrence of a humid winter and a delay in the onset of the rainy season (caused by the onset of the summer drought).

Regarding ARI, the values with the most significant anomalies, occurred in June 1998 (Figure 9.5). This anomaly coincided with the existence of markedly warm and dry conditions during this month. The increase in the number of cases caused by climate anomalies in June 1998 for ARI in Havana City cost 6 million pesos above that which had been planned, because there were 23,242 more cases than expected.

An analysis is presented in Table 9.3 showing that the effect of the impact of the 1997-98 El Niño caused an increase in costs of about 48% with regard to a normal month's behavior, as was the case in June 1996.

Table 9.3a Economic Effects of the Impact on ARI cases during the 1997-98 El Niño

ITEMS	IN 1996	IN 1998
Cases reported (number)	488	720
Cost (in US$)	166,500	245,656
Cases Increase	232	
Increase in costs	79,156	
Percentage increase in costs	47.54 %	

In the case of the menigococcic illness and according to Ortiz (1998), there is evidence that during an El Niño the number of cases of this illness increases to significant levels. In November and December 1997 the threshold of 10 cases in Cuba was surpassed (4 is considered the normal value) for this illness.

Impacts on Fishing

El Niño not only affects fishing as a result of extreme events, but also because of its effects on different marine populations. These changes can last well beyond the time period of the event, constituting a long-term impact, which is very difficult to quantify.

Lobster, one of the main marine species marketed in Cuba, registered a decrease of population due to the bad weather. Losses were about $9 million US dollars. The catches of other marine species such as shrimp were reduced due to the increase of bad weather during the winter.

Fishing activities in fresh water are basically concentrated in dams and reservoirs. Climate anomalies (abundant rains in winter and an intense drought in summer) affected water storage and water levels with resulting impacts on some commercial fish species. In February 1998 the losses in this sector reached nearly one million US dollars.

Direct Effects on the Population and Housing

The direct impacts of the 1997-98 El Niño on the population and on housing occurred almost solely during the dry season in winter (November 1997-April 1998). Damages were associated with severe meteorological anomalies. These anomalies, although they were not extreme (as were those observed during the 1982-83 winter), caused damages and losses of comparable magnitude.

A total of 12 of Cuba's 14 provinces suffered the direct impact of the 4 most important severe events. Nearly 20,000 people suffered some kind of property damage, and more than 12,000 were evacuated.

From 22 to 23 March 1998, a cold front brought heavy rains over the eastern provinces. Precipitation was 400% above the historical average. For transportation and evacuation of people, losses amounted to 5 million US dollars. In all cases the National System of Civil Defense activated its measures. This avoided the loss of lives but, at the same time, considerable damage to housing was reported. This is summarized in Table 9.4.

Table 9.4 Impact over housing and losses due to evacuations (in U.S. dollars) because of severe weather events in the 1997-98 winter.

DAMAGED HOUSES	EVACUATED PEOPLE	LIVING EXPENSES FOR EVACUATED PEOPLE	TRANSPORTATION EXPENSES FOR EVACUEES	TOTAL EXPENSES
4,305	12,025	$ 19,752, 660	$ 120,250	$ 19,872,910

10. What is the reliability of those attributions?

The current level of development of research in Cuba on ENSO's extremes and their impacts allows one to assume that many of these attributions of impacts to El Niño has an acceptable margin of confidence. It seems clear, starting from works carried out by Cardenas and Naranjo (1995) and Naranjo and Centella (1997), that the increase in precipitation in winter is a frequent effect in El Niño years. This is based not only on statistical analyses, but also by observing the structure of the circulation patterns in the region surrounding Cuba. In this case, the expansion of the westerlies toward the south not only favors an increase in the precipitation in this period but also an increase in the possibility of occurrence of severe weather conditions. Nevertheless, in the case of the intense summer drought of 1998, considerations about a reliable attribution are more complex.

In an analysis of the last 24 years (Lapinel Braulio, personal communication) 7 droughts of long duration involving more than two consecutive seasons were reviewed. In 16 Cuban towns, a direct association was not identified with the El Niño event. Besides, 21 droughts of shorter duration (6 or less months in duration) were evaluated; in 9 cases a linkage to El Niño was confirmed. However, 4 were very doubtful and 8 were not associated with any of these events.

From a statistical point of view, the existence of an El Niño signal linked to the occurrence of droughts in Cuba, the remarkable and uncommon characteristics of the 1997-98 El Niño, leave a wide opening for speculation. It seems reasonable to think that, *if this event began earlier in the year than many other events (including the 1982-83 event) and it reached its maturity stage in a different period, then its effect on the regional and global circulation would take place in different climatological circumstances.* Consequently, its impact on regional climate had to be different. In addition, as Cardenas and Naranjo (1998) have outlined, other factors are able to affect El Niño's effects in Cuba. One of those factors, the Quasi-Biennial Oscillation in the tropical stratosphere, tends to cause, in its west phase, negative precipitation anomalies during summer. During the onset and development of 1997-98 El Niño, this was the existing condition in the low stratosphere over the tropical belt. Therefore, it was logical for precipitation to be below the historical mean values during the summer. This consideration was noted in Special Warning No.2 about El Niño. Nevertheless, it was not possible to evaluate the real magnitude of these anomalies. In fact, an exhaustive evaluation of factors linking 1997-98 El Niño and the intense summer drought of 1998 is extremely complex and a topic awaiting clarification. The temperature anomalies that occurred during the Cuban winter period suggest that there is a decrease in

the frequency of invasions of cold air coming from the continent. On the other hand, the increase in the cloud cover tends to reduce the radiative cooling process at night, one of the main causes of low morning temperatures in the Cuban winter. This also favors the positive anomalies in temperatures.

During the summer, when rain plays a role of softenin g the intense heat, drought conditions can cause remarkable increases in temperatures, mainly during early afternoon when daily maximum values are recorded. However, it is important to highlight that temperatures in Cuba have shown an important warming tre nd during the last couple of decades (Centella et.al. 1997). This process seems to be linked to the broader scale global warming described in the second report of the Intergovernmental Panel on Climate Change (IPCC, 1995). In the last 50 years the monthly mean minimum temperatures in Cuba have risen by 1.7 degrees Celsius - a considerable warming rate. To determine just how much of the increment registered during 1997 and 1998, could be reliably attributed to El Niño, and how much to the secular warming tre nd or low frequency oscillations is an open task for further research.

RESPONSES

11. Were any government reports or statements issued before the impacts of the 1997-98 El Niño appeared?

A previous and clear response of the Cuban state before the imminence of the appearance of the event did exist, though reports or previous declarations at the government level regarding El Niño impacts in 1997-98 were not issued to the public through the official press organs. The first response had, as its main objective, to provide a good level of information and to create an atmosphere favorable to future response measures to possible disasters. This can be answered in two parts. On one hand the government's Institute of Meteorology, in charge of monitoring ENSO, began to issue special warnings on El Niño in June 1997, with a monthly frequency. These warnings were not only limited to a discussion of the development and prediction of the event and its evolution, but also included a section on the possible implications for Cuba's climate. This became a guide to the possible and most immediate consequences to expect in Cuba, because of El Niño. These warnings were first sent to the First Level of Information, noted earlier. Secondly, when it became undoubtedly clear that an exceptionally strong event was developing and therefore, a winter season with possible severe events and adverse effects on the population was approaching, the media began, in September, to publish reports to keep the population informed and prepared. Details about the role that the media played in the 1997-98 El Niño were presented earlier.

12. Were any reports issued after the impacts appeared?

During the 1982-83 event (in March 23), the Official Organ of the Communist Party of Cuba, the newspaper Granma published, by means of an editorial, an official government declaration entitled "The natural phenomena that have affected us and the necessity to fight resolutely to face the loss". This document made an analysis of what was happening, including the damages, the recuperative measures taken, and calling on the people to fight resolutely in the recovery phase. However, during the 1997-98 event, information of that type was not issued. A fundamental factor sheds light on the difference. As discussed previously, the 1982-83 event not only yielded more severe events, but rather its impacts literally took the country by surprise. In addition, a clear knowledge about what was happening did not exist. Consequently, the mechanisms of prevention and response were under strong pressure to act. Many economic activities and social services were very much affected. In addition, the public had a strong feeling of insecurity and surprise for what to them seemed to be an important change in Cuba's climate. To cope with this situation, a government declaration was indispensable. It provided information and outlined the main features for a national response strategy.

During the 1997-98 event previous warnings had been issued with enough lead-time before the impacts. Furthermore, the level of knowledge about El Niño in Cuba had also been substantially increased. This allowed for the developing of a systematic monitoring and information network that contributed to a high level of preparedness in society. This was very different from what happened in the 1982-83 event. However, even a higher level of

preparedness did not avoid El Niño's severe impacts on the Cuban economy. These impacts were all the more severe because of the economic contraction in Cuba, called the "Sp ecial Period." One of the main priorities was the search for funds and material support from international institutions in order to alleviate the difficult economic conditions created by El Niño.

Between January and June 1998, five Cuban entities, The I nstitute of Meteorology, The Ministry of the Agriculture, The Ministry of Fisheries, Civil Defense and The Institute of Physical Planning, in coordination with the World Food Program issued a report entitled "Preparedness Program for the Effects of the El Niño Phenomenon in Cuba". This report assessed the appropriate bases for the development of a sustained program of food security in areas of high risk, to mitigate the societal effects of impacts, and to identify measures and rehabilitation actions. Up to now, this report constitutes the most complete report on the 1997-98 El Niño impacts. It also served as a basis for the establishment of an important assistance plan developed by the World Food Program in Cuba.

13. What were the major responses to the event?

Measures of General Character

At the end of the 1997 summer, based on the predictions issued by the Institute of Meteorology regarding the intensification of the El Niño event, and on the information received from different countries in the region, The National Civil Defense System sent the presidents of the provincial assemblies of the Popular Power **a** communication alerting them about the situation. The communication addressed a group of measures according to the plans developed for responding to extreme meteorological situations.

At the same time, the National Headquarters of Civil Defense sent to the organisms of the Central Administration of the State a communication alerting them to the same situation, indicating that pertinent preventive measu res should be adopted in order to reduce the expected impacts in each sphere of responsibility.

The System of Civil Defense paid constant attention to the information issued by the Institute of Meteorology taking the exceptional measure of maintaining for the winter the systems of prevention that were created during the hurricane season for dealing with possible disasters.

Based on guidelines from the System of Civil Defense, the different sectors and spheres of the economies and of social life developed specific plans of specific preventive measures. With regard to fishing, for example, the main measures were related to the protection of production facilities, mainly to guarantee the movement of ships toward a safe place, if necessary.

Measures in the A gricultural Sector

From April 1997 the agrometeorological service of the InstMet warned farmers about the possible onset of El Niño, keeping the agricultural sector systematically informed on the

expected variations in the local weather and climate. Their information included evaluations of the possible impacts on cultivation and harvest. Information was also provided about the possible impacts of agricultural drought and of favorable conditions for forest fires and grassland fires. They also suggested the use of measures to mitigate the adverse effects. For example, where the occurrence of agricultural drought was expected, it was suggested that the farmers take the following measures:

- To save and efficiently use water, in addition to using appropriate phytotechnical measures that tend to provide better use of rainfall and conserve soil moisture, such as soil management according to expected climatic conditions and weed elimination.

- To pursue cautious measures in areas of forests and vegetation undergoing severe water supply stress.

- To avoid planting seedlings or developing plantations on unirrigated lands, unless it is recommended to do so.

- To keep informed about the development of the agricultural drought.

On the other hand, the Ministry of Agricultur e, keeping in mind the predictions of InstMet, formulated indicators and measures for the country's companies and agricultural entities. Among these were plans to protect people, animals, plantations and material facilities from El Niño's impacts . Noteworthy are the following:

- To carry out the Civil Defense measures in the event of heavy rains, seawater intrusion, etc.

- To plan, on the basis of previous experience, possible impacts on companies and institutions located in at -risk areas, and to determine me asures and actions needed to protect the personnel required to implement these actions.

- To carry out the cleaning and maintenance of channels and existent drainage works in agricultural areas.

- To anticipate the necessary works to assure the drainage of the fields.

- To clean and repair the channels and retaining walls of micro -dams in the agriculture and to maintain ready the security systems.

- To identify places for the evacuation of cattle (for feed, water, veterinary attendance and protection).

- To create conditions for the undertaking of these measures and by taking into account the unique characteristics of each company, institution or sector following the first warning of the onset extreme events associated with El Niño.

Agricultural locations of Cuba were not all exposed to the same degree of severity. In spite of this and in view of the fact that it was not possible to identify in advance the at-risk areas in specific sectors, they took some additional general measures.

One of the most significant measures was adopted by the Ministry of Sugar, because the seasonal predictions anticipated an increase of the rains during the dry season. This time of the year is usually considered as the normal period for sugar cane milling, and for this reason the forecast anticipated rainfall at the beginning of the 1997-98 sugar harvest.

The years 1997 and 1998 coincided with a period when the Cuban sugar industry was trying to overcome the deep crisis that it had been immersed in since the early 1990s. In that period, the collapse of the socialist bloc and the economic blockade imposed by the United States caused a considerable drop in sugar production. This way the Secretary of the Council of State of the Republic, highest level of the government in the country, requested from the Institute of Meteorology seasonal predictions of rain to support the management strategy for the massive seeding of sugar cane in the agricultural campaign of spring 1998. Due to this solicitude, they started to elaborate agrometeorological predictions of water reserves of the soil for the seeding of this cultivation under unirrigated land conditions. These results influenced, in a fundamental way, the decision taken by the Ministry of Sugar of postponing the massive seedings of cane of the spring campaign in those regions where the prediction of water reserve indicated possible unfavorable conditions.

In the tobacco crop, due to the expected conditions of abnormally high rain accumulated in the winter and the possibility of high temperatures in this same epoch, it was decided to increase the phito-sanitary vigilance to avoid the appearance and development of plagues and illnesses in a time that coincides, just as with sugar cane, with the crop season.

Once the appearance became known of agricultural drought and the prediction of its possible intensification in the eastern region of Cuba, the Administration of Cattle Raising in the Ministry of Agriculture decided on the evacuation of a great number of cattle to lower areas of elevation: primarily, rice fields, where better conditions of food supplies for cattle could be guaranteed. In those locations where there was no way to move the animals, the measures were taken to deliver water to the animals by means of tanker trucks (more than 225,000 cattle stayed under these conditions during the short drought in 1998). In those places where it was possible to neither move the cattle nor provide water, animals with signs of malnutrition were slaughtered.

The agrometeorological information from the Institute of Meteorology was sent to the forest guards systematically. It indicated when favorable fire conditions in grasslands, and within other natural vegetation and forested areas, were present. Based on this information forest guards intensified their protective measures in the most vulnerable areas.

Nevertheless, the previous examples of measures adopted by some agricultural sub-sectors were applied with effectiveness, although not in all cases. In a general sense, the Cuban agricultural community does not yet have an appropriate "culture about El Niño," nor does it know how best to use climate predictions. Occasionally, not enough resources are

assigned to carry out certain preventive measures, because they imply the need for big investments to prevent or mitigate El Niño's impact on agriculture.

14. Identify (with citations, if possible) the extent of national research (in the last 20 years) in your country on the following:

a. El Niño
b. Climate-related hazards

a. El Niño

The first two scientific results in Cuba focused on El Niño and their impacts over the national territory were obtained in an independent way in 1991. In this year Cuban researchers Angel Maulenert, of the Institute of Meteorology, on one hand (Maulenert, 1991) and Pedro Cardenas and María E. Pérez, of the Meteorological Center of Villaclara (Cardenas and Pérez, 1991), on the other, carried out evaluations of El Niño's impacts on weather and climate in Cuba. In the former case, El Niño's influence on the activity of winter storms affecting Cuba was described and some characteristics of the anomalies of the circulation in the surroundings of Cuba associated with these events were delineated. In the latter case, for the first time, El Niño's impacts on the Cuban rainfall régime (basically on the central provinces of Cuba) were quantified. Already in 1994, after almost 3 years without a significant output on El Niño, a considerable increase in research related in some way to El Niño began to appear. In this year, Naranjo (1994) analyzed with more detail than carried out previously. He analyzed the changes observed in atmospheric circulation in the Caribbean under El Niño conditions and evaluated them using circulation indices. Similarly, Cardenas, Centella and Naranjo (1994) put into operation, at the Institute of Meteorology, a prediction method for monthly precipitation and temperature that explicitly included predictors linked to El Niño.

In the following year a study carried out by Ballester and Gonzalez (1995) established ENSO's influence on the cyclone activity of the Atlantic and Caribbean. They also established a prediction method for cyclone activity, which was elaborated by season with ENSO taken into account. This method was operational in the Climate Monitoring Service of the Institute of Meteorology.

In 1995 an important step was taken in Cuba in the development of research related to El Niño. A 5-year project containing as its central objectives the study of the ENSO cycle, its predictability, impacts and modulation of Cuba's climate, was built into the National Scientific Program on "Global Changes and the Evolution of the Cuban Environment". Of the main achievements of this project, the following are noted:

- A deeper knowledge of the ENSO cycle's impacts on the climate of Cuba was obtained.

- Monitoring and evaluation techniques of impacts were improved by defining a new "ENSO Index", based on transformations made to the indices traditionally used to characterize an ENSO extreme event (Cardenas and Naranjo, 1997) .

- It was demonstrated that other forcing elements of the climate variability, such as the Quasibiennal Oscillation in the tropical stratosphere, were able to modulate effects of El Niño impacts (Cardenas and Naranjo, 1997).

- An official chronology of El Niño events was defined.

- A first method of prediction of El Niño's onset was developed based on the index IE.

- An improved system of prediction for precipitation and monthly temperature by several months in advance was developed (Cardenas and Naranjo, 1997).

- The first operational system in the Climate Center of Cuba for monitoring and predicting ENSO extremes was developed.

In January 1996, a scientific workshop about El Niño and Extreme Events in the Caribbean region was organized in Havana, Cuba. It was organized by NCAR and UNEP. It constituted an important summary of research, not only carried out about El Niño in Cuba, but also carried out in several nations of the Caribbean region.

Starting from 1997, the framing of research carried out in Cuba related to El Niño began to be more focused toward socioeconomic impacts. A general summary on the impact of the El Niño on some economic sectors in Cuba (Naranjo, 1997) was presented at an ENSO colloquium at NCAR (Boulder, Colorado). Ortiz and others (1999) attempted to demonstrate that El Niño is able to exert a significant impact on some non-transmittable illnesses in the country.

Based on conclusions reached by El Niño researchers in Cuba, in 1999 a new national 5-year project was developed and was financed by the Environment Agency, for an ENSO Warning System and for predictions about its impact on climate. A national El Niño-related program for education and mitigation of the adverse effects on food production, the handling of water resources and human health was being created. Among their goals were the following:

- Implement an El Niño warning system, including the prediction of its evolution.

- Predict human illnesses, influenced by El Niño in Cuba, such as bronchial asthma and acute respiratory diseases.

- Search for and apply technical advances for economic evaluation of impacts.

- Develop an educational program on El Niño.

b. Climate-related Hazards

One of the natural disasters that has received major consideration in scientific research in Cuba is the tropical cyclone. Research that includes a wide range of studies has been undertaken in the past 20 years. In studies on the climatology of these systems, the works of Portela et.al. (1985) and of Rodriguez (1985) established very complete chronologies and statistical analyses. Studies developed by Ortiz (1994) focused on trajectory.

The impacts of tropical hurricanes in Cuba have been evaluated by various researchers such as Portela (1985); Rodríguez (1985); Pérez Suárez et.al. (1991); García and Beauballe t (1992) and Limia and Paz (1994).

In the last 5 years a marked interest has been developed regarding the role of tropical cyclones in the inter-annual variability of Cuba's climate (Pérez Suárez et. al., 1994); Quesada et.al. (1998) and of the seasonal predictions (Ballester and González 1995).

The tropical cyclone track prediction methods are currently in operative use and were developed by A. García and M. Limia, and P. Gresko. Called the Cynematic Method (CNMT). It is based on climatology and persis tence, and the trajectory is obtained by using stepwise regression screening as predictors of the current position of the cyclone and of its preceding movement (speed and acceleration) among other factors.

A method similar to CLIPER (Knaff and Landsea, 1 997) was developed in Cuba by Dr. P. Gresko, but with the difference that it only uses linear combinations of predictors and the curvature characteristic for the precedent trajectory.

In fact, Cuba is one of the Western Hemisphere countries with major sci entific research about these dangerous systems.

Various and significant research in Cuba has been undertaken on the rainfall régime, its fluctuations, cyclicity, etc. that are key objects of concern. Among those that can be mentioned are Trúsov (1967), Gagua (1976), Kissin et al. (1983) and Trúsov et al. (1983).

Research related to certain atmospheric processes or meteorological synoptic-scale patterns, as conditioning factors in the occurrence of rain in Cuba have been carried out by, among others, Howell (1953), Burlutski (1973), Watered (1977 and 1983), Novo (1978), Lapinel (1989), Suárez et. al., (1989) and Fernández (1992).

Cardenas (1991), established an important relationship between El Niño and rainfall anomalies in Cuba, based on the behavior of solar activity. He also developed valuable work on a profile of the statistical and physical -statistical prediction of rainfall totals in seasonal periods and on an annual basis.

The meteorological conditions that prevailed in Cuba that gave rise to serio us droughts that affected the country in 1981 to 1986, were analyzed by García, et al., (1991).

Recently, Lapinel et al. (1993) developed a National Drought Surveillance System and studied the period 1931-1990 in Cuba. They demonstrated that in the second half of this period, the frequency of droughts doubled and their degree of severity increased, noticing a drop of 10 to 30% of normal precipitation.

There have been only a few studies on severe local storms that cause tornado outbreaks, hail and strong w inds. There had been a general feeling among the national researchers (up to 1967) that severe weather phenomena were not so important. However, studies carried out in the 1970s by Alfonso and Pérez (1975) and Boytel (1972), among others, began to change this view. In 1985, Rivero published the first synoptic climatology of these events and Alfonso (1981) provided important insights into the conditions that generate severe local storms in Cuba. Already in 1994, Alfonso (1994) published the book entitled, "Climatology of Cuba's Severe Storms; A Chronology" in which he included for the first time, detailed information about severe storm impacts on society, including estimates of victims and damages.

15. Is there a national plan to respond to disasters?

A national plan exists in Cuba for the handling of a range of possible disasters. It constitutes plans for handling emergencies. They are the legal instruments that allow the governments of each region to execute in an effective and organized way, measures directed to protect the population and the economy before the onset of disasters.

The plans constitute the main documents for the preparation, prevention, mitigation and control measures to be undertaken before and after the onset of severe meteorological phenomena.

The plans were developed according to a particular methodology, but modified to take into account the characteristics of each region.

All the documents spelled out in this plan are saved in a portfolio at the Civil Defense Headquarters at different levels.

16. Is El Niño explicitly considered to be a disaster in your country?

El Niño events are not explicitly considered as a disaster in the national plans for preparation against disasters. This is because the Cuban System of Civil Defense is essentially built to deal with specific meteorological and climatological emergencies. These could be intense rains, droughts, coastal floods, strong winds, etc., without having to keep in mind the extreme event's origin or atmospheric system to which it is associated. The only exception to this rule, perhaps, is the tropical cyclone, which is the only meteorological system that is explicitly considered a disaster in preparation plans. This is due to the fact that it is historically considered as the mo st dangerous natural hazard in

Cuba.

It should be kept in mind that El Niño can cause important positive impacts, as is the case with the reduction of tropical cyclone activity in the Atlantic. Thus, this fact may logically contribute to a view that this event should not be considered explicitly as a disaster. However, the popular perception about El Niño associates it with those natural disasters that it occasionally spawns and personalizes as one event (usually the most devastating one). This popular perception about El Niño, although influenced by associating it with tropical cyclones, demonstrates that, in spite of the effort carried out in recent years, deficiencies still exist in Cuba's effective educational activities about El Niño.

17. Identify (with citations, if possible) any international research about the impacts of El Niño events on your country.

At the present time, international research specifically dealing with El Niño impacts in Cuba does not exist. It has been the exclusive domain of Cuban researchers. However, because of Cuba's geographical location, near to the United States and the Caribbean Basin, several research activities abroad have reflected in a marginal way this matter. Some studies, such as those carried out by Rogers (1988), and Aceituno (1988) traced important considerations regarding El Niño impacts in the Caribbean region that yielded important information about Cuba. In a similar way, Giannini et al. (1998) carried out a study on the influence of the El Niño on the interannual variability of rainfall in the Caribbean. They concluded that the dry season coinciding with the mature stage of an El Niño event is more humid than average in the northwest section of the Basin, i.e., Yucatan, the Caribbean coast of Honduras and Cuba. This is consistent with the results obtained by Cuban researchers. Additionally, research for the United States such as that case of O´Brian (1997) was very useful in defining coherent structures of possible impacts in the areas surrounding Cub a.

FORECASTING BY ANALOGY

(i.e. Using Recent Historical Examples to Plan Ahead)

18. If a perfect forecast had been available as early as October 1996 (knowing what is now known about the actual impact), what could have been done differently? (Do not take into consideration at this time any restrictions on possible actions).

a. About Information Flow?

This point is most important in Cuba's prevention plans for facing possible disasters, because the effectiveness of the whole System depends on it. There are not likely to be changes in the flow of information stemming from an earlier prediction of El Niño. It is possible, however, to suppose that there would be variations in the interactions among the elements dealing with El Niño events.

b. About Preparing for the Forecast Impacts?

This constitutes one of the most difficult aspects to evaluate. Some officials in the Ministry of Agriculture answered this question in a surprising way, "If I would know 6 months in advance that an El Niño event would affect us, then...I would take my vacation early in order to face its impacts more rested." This answer, apart from expressing the proverbial Cuban sense of humor, also reflects a very important viewpoint, at least in this important economic sector. Essentially, the most important measures to be taken would be the same; only more time would be available to apply them. This, logically, would impact in a very favorable way the results to obtain by the protection and/or prevention measures, because not only the existing mechanisms would have more time to respond, but also it would be possible to educate and inform the people more efficiently.

This response seems to be the same for most of the economic and social sectors. However, if we assumed that is correct, the attribution of the short period 1998 drought as an impact of the ENSO 1997-98, and if we consider that this effect was predictable in October 1996, some of the measures for handling water resources in the different sectors would have been different. If the preventive measures taken by the different sectors are analyzed, it can be seen that they were based mainly on preventing possible impacts of a dry season more humid than normal. In fact, the measures taken to face the drought, although many were taken in advance, were taken as a reaction to an event that could be foreseen with relatively little lead-time following a rainy winter.

19. Which are the realistic obstacles that could have been avoided, had these theoretical actions taken place?

In Cuba, two main obstacles can be considered as obstacles to the taking of measures with a lot of lead-time for the impacts of El Niño. The first is related to the level of knowledge that we have on the impacts, and the second is related to different times of resp onse that many sectors need in order to prepare for the possible impacts.

With regard to the first case, existing knowledge about El Niño still has a wide margin of uncertainty, despite the fact that Cuban research on El Niño is at a relatively high level . Many research results, such as the case of the increase of precipitation in winter, although conclusive, are of a statistical teleconnections nature and their physical bases are still not well explained. Others are not so clear, like is the case of El Niño's impacts on the rainy season. Each El Niño is different, which makes it difficult for the general public to understand. This makes preventing the impacts a very difficult task, which negatively influences the following:

- It reduces the efficiency of the prevention system, which is designed according to previously established outlines. To maintain its effectiveness, the prevention system assumes a "typical condition" that often tends to estimate the real impacts inappropriately.

- It influences negativel y the state of the preparation of society, since it affects the credibility of predictions and the level of general knowledge. For this reason, socioeconomic sectors show some resistance to taking measures. This, therefore, diminishes the effectiveness of the country's responses.

A second obstacle resides in the question about the capacity of certain levels of society and economy to make better responses when forecasts are released with varying lead -times. Although it is certain that inside the so -called "top decision-making level" of the economy of our country, many measures of a strategic nature can be taken many months in advance, it is not realistic to think that smaller entities, subjected to the daily tensions of a subsistence economy, can think about effective preventive measures some weeks in advance.

20. What can be added to the national plans against disasters, particularly concerning El Niño?

Previously, in Point 16, the reasons why El Niño is not considered a disaster in our country were explained. However, these reasons do not deny the possibility that considerations about El Niño can be included within the national plans against disasters. In fact, according to the results of research on the matter, it seems clear that in El Niño years, an important number of severe events become more probable (e.g., severe local storms and the adverse effects of extratropical lows in winter). These reasons, regardless of the present levels of current scientific uncertainties, establish a clear distinction t hat should not be ignored by

our national plans against disasters. The experience of the 1997 -98 event demonstrates this, when some special measures were taken in addition to the established traditional plans.

It is a real possibility that as the knowled ge about El Niño and its impacts in Cuba continue to deepen, and the national monitoring service establishes more reliable climatic forecasts, El Niño and the anomalies it spawns will become explicitly included in the plans of prevention in a similar way, as currently happens with the disasters caused by tropical hurricanes.

21. Identify the strengths and weaknesses in the way that the country responds to the climatic anomalies related to El Niño.

To carry out a conclusive analysis about the strengths and weaknesses in the way that Cuba faces climatic anomalies related to El Niño is a highly complex activity.

With the independence to take many elements into account, to establish an objective analysis, any conclusion would likely be hindered, because o f a "natural" resistance of the different sectors of society to accept "what was wrong" in decision-making or in the measures pursued under their responsibility. Nevertheless, in spite of this, and based on that discussed in this report, it is possible to trace the main general characteristics of this topic in Cuba.

The main achievements or virtues of the Cuban system of response to the impacts of the climatic anomalies start from the existence of a solid and centralized structure, along with wide participation of all levels of society. The fact that the National System of Civil Defense is inserted inside the general plans for the defense of the country assures that there will be a high level of response and readiness of resources.

If a single aspect had t o stand out to describe the main virtues of the Cuban response system, it would be the fact that it puts as its main priority the preservation of human life ahead of the costs of the investment of important material resources.

Another positive aspect, worthy of highlighting, is the close connection of the of decision makers with the centers in charge of monitoring services. This was executed through a flow of information that guarantees the exchange among the different levels of decision -making.

The fact that the State assigns to a unique institution the responsibility for Climate Monitoring is also one of the strengths of the Cuban system. This guarantees unity of approach and concentration of the scientific efforts toward the main concern(s). The role that the media played in achieving a clearer popular perception about El Niño also constitutes an aspect to be highlighted. In general, sensationalism was avoided and education of the public was achieved in an atmosphere of tranquility and security that helped government and agencies to execute the preparedness plans and responses.

However, the system also presented important weaknesses. Popular perception, along with misinformation disseminated from some agencies about what El Niño is, still remains incomplete and, in some cases, erroneous. This is because, in spite of efforts, an education

system geared to educate the public on El Niño does not yet exist. In general, the great majority of educational courses for professionals do not contemplate subjects related to climate. That means that future decision makers from the different economic sectors will not possess solid information that would allow them to use the information emanating from the centers of monitoring and forecasting in a really efficient wa y. In the scientific field, a clear certainty has still not been achieved with regard to attribution of impacts, while the climatic forecasts, fundamental to the whole System, are still not able to reflect information certain enough for users with all thei r required needs. The language used is not always able to transmit useful information. And, prediction does not always cover the information expectations of the decision makers who are more interested in obtaining evaluations of possible impacts on specifi c socioeconomic activities than on climatic variables whose consequences are very difficult to estimate.

22. Did the 1997-98 El Niño have any influence on your country's response to the forecast in early 1998 of an expected La Niña event?

The 1997-98 El Niño influenced in an important way the level of preparedness of and responses to the 1998-2000 La Niña. Both events were very close in time, causing the long lasting 1997-98 droughts to spread into the 1998-99 winter. This had severe consequences for the stressed Cuban economy. However, this coincidence contributed considerably to a more effective response to La Niña's impacts, because experiences gained by coping with El Niño made better preparedness activities possible.

Experience based on El Niño wa s crucial to the development of monitoring and the establishment of information mechanisms. Warning systems established during El Niño were maintained and adapted to the new circumstances.

In many cases the response infrastructure created during the El Ni ño event could be adapted and quickly used, increasing considerably the country's response efficiency. In fact, both decision makers and the population had better knowledge before this La Niña than before the onset of the1997-98 El Niño.

If the 1998 La Niña could be considered the most monitored cold event by Cuban scientists and by the popular media, it would mainly be due to one important fact: Cuban Society had just faced the most dangerous phase of the ENSO cycle in Cuba, the 1997-98

El Niño.

References

Aceituno, P. (1988): On the functioning of the Southern Oscillation in the South American Sector. Part I. Surface climate, Mon Wea Rev, 116, 505-524.

Alfonso A. (1988): Climatología de las tormentas locales severas de Cuba y fundamentos para su pronóstico. Tesis para optar por el grado científico de Doctor en Ciencias Geográficas. Matanzas, 183 pp.

------- (1994): Climatología de las tormentas locales severas. Cronología. Editorial Academia. La Habana, 168 pp.

-------, A. Florido (1992): Las grandes precipitaciones en Cuba, aspectos fundamentales. 3 er Congreso de Desastres, La Habana.

-------, L. Naranjo (1989): Análisis de las lluvias torrenciales del 18 -19 de junio de 1982 en la región occidental de Cuba. Rev. Cub. Met.

Arkin, P.A. (1982): The relationship between interannual variability in the 200 mb tropical wind field and the Southern Oscillation. Mon Wea Rev, 110, 1393-1404.

Ballester, M., González, C. y Pérez, R. (1995): Variabilidad de la ciclogénesis tropical en el Atlántico Norte. Informe Final del Resultado 415.511. Instituto de Meteorología, CITMA. 88 pp.

Burlutski, R (1973): Los procesos sinópticos que influyen sobre las precipitaciones en Cuba. Ed. Hidrometeoizdat, Leningrado, GGO, trudi No. 101 (en ruso)

Cagua A. S. Zasembo y A Izquierdo (1976): Sobre el nuevo mapa isoyético (3ra versión). Rev. Voluntad Hidráulica., 13(37).

Cardenas P, and M. Perez(1991): Eventos El Niño NO y anomalías de las lluvias en Cuba. Technical Report. Instituto de Meteorología, Havana Cuba. 24 pp.

---------- **and L. Naranjo** (1996): Impacto y modulación de los efectos El Niño NO sobre elementos climáticos en Cuba. Technical Report. Instituto de Meteorología Cuba. 15 pp.

Centella, A.; L. Naranjo, L. Paz, (Editores, 1996): Variaciones y Cambios del C lima de Cuba. Instituto de Meteorología, Centro Nacional del Clima. La Habana, 59 pp.

Cioffi, D y Rego J.S. (1983): Cusas principales de las lluvias en Cuba y contribución relativa a las variaciones totales para áreas y período de tiempo determinados. Cen tro de Documentación del Instituto de Meteorología, Casablanca, La Habana.

Fernández A. (1988): Precipitaciones torrenciales del 1 -2 de junio de 1988 en la provincia de Cienfuegos. Oficina Provincial del Instituto de Meteorología, Cienfuegos.

---------- (1992): Tipos sinópticos del período poco lluvioso y las precipitaciones ligeras. Revista Cubana de Meteorología. 5 (12). pp 35-39.

García A. y Beauballet P. (1992): Sistema de información estadística sobre ciclones tropicales, Trabajos del 1er. Congreso Iberoamericano de Meteorología Tropical, Tomo I, 299-302.

García, O. (1991). Causas sinópticas de la sequía que afectó a Cuba desde 1981 a 1986.). Revista Cubana de meteorología, Vol. 4 No. 1, 1991.

Gray, W. (1984): Atlantic seasonal hur ricane frequency. Part I: EL Niño and 30 mb quasi-biennial oscillation influence. Mon. Wea. Rev., 112, 1649-1668.

Gutiérrez M. (1927): Génesis y evolución del huracán del 20 de octubre de 1926 y catálogo de ciclones de la Isla de Cuba. 1865 -1926. Imp. A. Dorrbecker, La Habana, 52 pp.

Hess, J.C; J.B, Elsner and N.E. La Seur (1995): Improving seasonal hurricane predictions for the Atlantic Basin. Wea Forecasting, 10. 425-432.

Howell, W. C. (1953): Un estudio de las precipitaciones en la parte central de Cu ba. Journal of Meteorology. 10, No. 4. Pp 270-278.

Hsu, S.A. (1993): The Gulf of México. A Breading Ground for winterstorms. Mariners Weather Log. Spring 1993. 4-7.

Hulme, M., R. Marsh, and P. D. Jones (1992): Global Changes in a humidity index between 1931-60 and 1961-90. Clim. Res. , 2:1-22.

IPCC (1995): Climate Change. The IPCC Scientific Assessment. Edit. J. T. Houghton, G.J. Jenkins y J. J. Epheraums. Cambridge University Press, Cambridge.

Kissin, I., E semionov y A izquierdo (1968): Ciclicidad de las preciitaciones, el escurrimiento y su sincronismo en el territorio de Cuba. Instituto Nacional de Recursos Hidraúlicos, Publicación especial,6, 1 -191.

Knaff, J. A. and C.W. Landsea (1997): An El Niño -Southern Oscillation CLImatology and PERsistence (CLIPER) Forecasting Scheme. Weather and Forecasting , 12, 633-652.

Lapinel B. (1988): La circulación atmosférica y las características espacio temporales de las lluvias en Cuba. Tesis por opción del grado de Doctor en Ciencias Geográficas. Centro de Documentación, Instituto de Meteorología, Casablanca La Habana.

---------- (1993). Sistema Nacional de Vigilancia de la Sequía: Análisis del período 1931 - 1990. Reporte Científico. Programa de Cambio Global y Evolución del Medio Ambiente Cubano.

----------., R.E. Rivero y V. Cutié (1993):"La Sequía en Cuba: Análisis del período 1931 - 1990" . Informe científico-técnico. Centro Meteorológico Territorial, Camagüey, 40 pp.

Landsea, C.W. (1993): A climatology of Intense (or Major) Atlantic Hurricanes. Mon Wea Rev, 121. 1703-1713.

Limia, M. (1976) : Climatología y estadística de los ciclones tropicales en Cuba. UDICT, INSMET, CITMA. 15 pp.

Limia M. y L. Paz. (1994): Los Ciclones Tropicales. En *El Clima de Cuba* (Ed. Academia, La Habana): 121 - 128.

Meulenert A. R. (1991): Efectos del evento El Niño-Oscilación del Sur sobre le estado del tiempo en Cuba. Technical Report, Forecast Department Instituto de Meteorología, Havana Cuba . 23 pp.

Naranjo, D.L. (1994): Uso de los índices de circulación para la cara cterización de las condiciones atmosféricas en las inmediaciones de Cuba. Reporte de Investigación. Grupo Nac. de Pronóstico a Largo Plazo. Inst. de Meteorol. 50

---------- y A. Centella. (1997): Variaciones interanuales de los campos meteorológicos sob re el Caribe y el Golfo de México. Parte I: Presión a nivel medio del mar y altura en 500 hPa.Reporte Científico Instituto de Meteorología, Cuba. 20 pp.

Naranjo, D.L., (1997): Impacts of El Niño on Cuba. Contribution to " A systems approach to El Niño ", A Colloquium on El Niño -Southern Oscillation (El Niño): Atmospheric, Oceanic, Societal, Environmental and Policy Perspectives. Held at NCAR, Boulder Colorado, 20 July.

Novo,R. (1978): El Clima. Tesis por la opción del grado de Doctor en Ciencias geográf icas. Universidad de La Habana, Cuba.

OMM (1992) Vocabulario Meteorológico Internacional. OMM/No 182.

Ortiz, **R**. (1994): Trayectorias de los ciclones tropicales del Atlántico. (Inédito). Instituto de Meteorología. 76 pp.

Ortíz, P. (1997): Modelos para la simulación del comportamiento semanal del asma bronquial (AB) y de infecciones respiratorias agudas (IRA) y su pronóstico a través de series de tiempo. Memorias del 8vo Congreso Internacional de Biomatemática Panamá, 97. Imprenta de la Universidad de Pa namá. 240-249.

Ortíz, P. (1998) Models for setteng up a biometeorological Warning System over a Populated Area in Havana. Book Urban Ecology. Springer-Verlang. Alemania. 87 -91

Pérez Suarez, R., Ballester, M., González, C. y Salas, I. (1991): Cambios Cli máticos y Ciclones Tropicales. I Taller sobre Cambios Climáticos y sus consecuencias. (Inédito). Instituto de Meteorología. La Habana. 10 pp.

Portela, M. (1985): Algunas cuestiones de la climatología de los ciclones tropicales en Cuba. Resúmenes del II Simposium Internacional. Lab. Conj. Cuba - URSS de Meteorología Tropical (traducción al español). La Habana. (Ed. Hidromet., Leningrado): 112 - 119.

Programa Mundial de Alimentos (1998) : Programa de preparación a los efectos del fenómeno El Niño en Cuba. Instituto de Planificación Física, La Habana. 76 pp.

Rodríguez, **M** (1985): Clima. En *Nuevo Atlas Nacional de Cuba* (Instituto de Geografía, ACC, La Habana - Madrid) VI.2.1 - VI.2.2.

Rogers, J.C. (1988): Precipitation variability over the Caribbean and T ropical Americas Associated with the Southern Oscillation. J. Climate, 1. 172-182.

Suarez et. al. (1989): Anticiclón Subtropical del Atlántico Norte. Su relación con las precipitaciones y flujos de vapor de agua en Cuba. Revista Cubana de Meteorlogía. 2 (1), pp 50-53.

Trúsov I.I., A. Izquierdo y L. R. Díaz (1983.): Características espaciales y temporales de las Precipitaciones en Cuba. , Editorial Academia. 150 pp.