Superstorm 93: A Case Scenario 12-15 March 1993.

The case scenario in the Cuban sector

--

Lino Naranjo Díaz
MeteoGalicia
University of Santiago de Compostela. Spain

Project supported by:
NCAR/Dir, NSF/ATM, NCAR/ESIG

2004

Superstorm 93: A Case Scenario 12-15 March 1993: The case scenario in the Cuban sector

Lino Naranjo Díaz
MeteoGalicia
University of Santiago de Compostela. Spain

Introduction

In March of 1993 I was working as a senior researcher at the Meteorological Office of the Cuban province of Matanzas (80 kilometres from Havana), sharing experiences with Dr. Arnaldo Alfonso, one of the most outstanding Cuban researchers in mesoscale meteorology. In the evening of the 12th I returned to my home very worried. For three days, we had been monitoring a possible development of a strong winter storm in the Gulf of Mexico. Dr. Alfonso was deeply aware that "something big was cooking in the Gulf" ever since the 10th, when information from numerical models received by radio fax began to raise this possibility. That afternoon, we were calling to the Institute of Meteorology in Havana trying to get information. We discussed with the meteorologist of the Prediction Department that the risk was high of a strong squall line for the early morning of Saturday. Finally, we decided to call some authorities of the local government to warn them about "possible bad weather conditions for Saturday morning." I remember that we were quite vague because we still had a high level of uncertainty. Maybe the only certain data that we had at that time was the skill of Dr. Alfonso.

During the night I spent much of the time watching the only two TV channels of the Cuban national broadcasting network. I was looking for the release of a warning or some "special note" from the National Meteorological Service, but this never happened. Only during the 11 pm coverage of the baseball game on Channel 2 did presenters comment that the Institute of Meteorology was indicating that a strong thunderstorms line was approaching the western tip of Cuba. Around midnight, a failure in electricity took place, producing an extensive blackout over the city of Havana. Green light flashes over the horizon were clearly visible from my windows toward the northwest, becoming more frequent and intense, and making it possible to observe that strong cumulonimbus clouds were approaching from this side. A few minutes later, winds began to blow furiously; rain became heavy with droplets beating against my windows like small hailstones. The storm lasted less than a half hour, and later a dead calm prevailed until morning. I realized that we were fortunate because our neighbourhood remained out of the most severe areas of the squall.

By Saturday morning, news from many places indicated that a very severe squall line had affected almost every place in western Cuba with extensive damages and some casualties. In the afternoon, intense coastal flooding along the north coast and mainly in Havana contributed to make everything worse. Everybody was surprised; no one remembered a disaster like this out of the

hurricane season, The media began to use the euphemism “Storm of the Century” to refer to what it had happened that day.

The Storm of the Century, or Superstorm ‘93, as it was later named, represented a real disaster for Cuban society, which was immersed in an unprecedented economic crisis. Its effects contributed to lowering the standard of living of the Cuban population to the lowest level known since 1959. On the other hand, the Superstorm changed the nation’s perceptions about risks and surprises in Cuban climate, and this contributed to an increase in the role of the Meteorological Service in society, to an improvement in Cuban early warning systems, and to the development of important research fields in the environmental sciences. Only a few years later in 1997, Dr. Alfonso died in an accident in Matanzas, leaving unfinished work on severe storms in Cuba. Maybe he was the one who had the closest idea about the actual magnitude of the approaching catastrophe on the afternoon of March 12, 1993.

Initial background

The climate of Cuba is considered tropical oceanic, with two well-defined seasons: A “Wet season” (from May to October) and a “Dry season” (from November to April). The influence of extratropical winter storms over Cuba is not unusual in the dry season. Consequently, in the western half of the island, this season is slightly cooler than can be expected from a tropical climate. The influence of the winter storms accounts for more than 70% of the rain in this season over western Cuba.

Most of these systems originate over the Gulf of Mexico and are young and weak when they affect Cuba. Occasionally, they can be associated with severe weather events that are capable of causing large-scale damage and casualties. For example, on December 26, 1940, a winter storm from the Gulf of Mexico produced the most intense tornado ever recorded in Cuba, killing 40 people in the town of Bejucal, near Havana.

On average, about twelve winter storms affect Cuba during a normal winter season. These systems originate either over the Gulf of Mexico or the southern part of the United States. Conditions related to a winter storm affecting Cuba follow a sequence characterized by the establishment of southerly winds in the approaching stage, before the frontal passage. Occasionally, southerly winds become strong and persistent and are called by the local population “Sur” or “Lent’s wind” due to the time of maximum frequency, March and April.

December 26, 1940	Tornado in Bejucal (Havana) the most intense registered in Cuba.
January 2, 1958	The most intense cold front in Cuba associated with hurricane force winds.
March 16. 1983	Tornado outbreak over Western Cuba
March 13, 1993	The most damaging squall lines registered in Cuba during the winter season.

Table 1. The XX century most devastating severe weather events for the winter season in Cuba.

A frontal passage is normally characterized by the occurrence of rains and thunderstorm activity, which occasionally turn severe. After a frontal passage, the cold sector brings dry and cool northerly winds that sometimes become strong, causing coastal hazards in western Cuba.

Although severity associated with winter storms in Cuba does not follow a simple pattern, usually it is rather local and of short duration and only becomes significant to the media when they hit a big city.

In Cuban society, there is a traditional conceptual framing that relates severe weather only with hurricanes during the hurricane season. This perspective has prevailed among meteorologists for decades, delaying research efforts on the subject. Consequently, there had not been an impact assessment in Cuba on winter storms before the Big Storm of 1993. As a main consequence, Cuban society did not have a real awareness about risk in this matter, which made it highly vulnerable to future winter storms.

In addition to hurricanes, Cuba's preparedness plans are designed to include some key weather events such as strong winds, heavy rains, coastal flooding, and so forth. Predictability is crucial to define the scope of such plans. Coastal flooding conditions, for example, could be predicted 2 or 3 days in advance, making possible the establishment of anticipated action for protection of life and property.

Usually a fast-moving squall line can be predicted only a few hours ahead and actions in the plans are mainly focused only on mitigation. Under this condition, in case of an early prediction of a squall line, preparedness systems could remain "frozen" until risks become apparent and imminent.

1992-1993: hard years

In 1959, a communist revolutionary movement headed by Fidel Castro came to power in Cuba. Since then, Cuba in the Western Hemisphere became a close alley of the Soviet Union. In fact, in 1961 Cuba claimed be the first socialist country in America, beginning a long-lasting conflict with the United States, which in that year established an economic embargo against Cuba. Soon the Cuban economy shifted to become highly dependent on support from the European Socialist bloc.

Although much effort has been done to change the structure of the Cuban economy, it has remained mostly dependent on agriculture. In 1959, earlier agrarian reform in Cuba turned *latifundia* (huge farms with one owner) over to their workforces as cooperatives. In 1963, a law brought two-thirds of cultivated land directly under state control, creating the state farm system. Rural living standards and life expectancy improved greatly. But salaries were unrelated to yield. In the belief that "more state property means more Socialism," this system expanded. Compared to private farms, productivity of the state farms remained consistently lower.

In 1990, after a crisis hit the Soviet Union, there were major shortfalls in Soviet grain and oil deliveries to Cuba. By 1993, imports were half that of pre-1989 levels. Shortages of fuel and other inputs helped cut Cuban domestic output by some 35%. After a dismal 1992-93 sugar harvest, coupled with low prices, sugar revenue fell drastically. In mid-March 1993, the "Storm of the Century" caused $200 million of damage in the agrarian sector alone. People did not have enough to eat.

Within a few years, Cuba had lost its main living source. In only 2 years, goods imported fell from $8.14 billion to only $2.24 billion. Sugar production was suffering from a severe deficit in fertilizer, as well as other problems. Nickel prices dropped more than $1,000 per tonne, partly as a result of the surplus minerals former Socialist countries had that they were dumping onto the market from their reserves. It reduced the price of that raw material considerably. Shrimp prices dropped $1,600. Lobster prices dropped by more than $500. Practically all of Cuba's export prices fell precipitously.

When the Soviet Union and the Socialist bloc disappeared, highly favorable agreed-upon currencies also disappeared. Some agreements of this nature, however, remained in effect with China and Vietnam. However, the bulk of Cuban trade was with the European socialist countries and with the Soviet Union. Suddenly, the Cuban government had to pay for everything with foreign exchange, to the last cent. Cuba had to pay with the money it received from the sale of goods whose production had been reduced dramatically, and had also been negatively affected by the international economic crisis.

Every Cuban felt the effect of the economic crisis following the collapse of the Eastern Socialist bloc and the suspension of Socialist-bloc common market trade agreements. From 1990 to 1993, according to official statistics, the Cuban GNP fell by just under 35% and consumption plummeted (including such basics as food). The crisis affected not only living standards but social relations and political morale as well. In the aftermath of the economic crisis, Cuba faced a major challenge in its effort to achieve economic recovery and still preserve its revolutionary gains.

Regarding the climate, things could not be worse. Years 1992 and 1993 were highly unfavorable. In the second half of 1992, weather in Cuba was dry and a severe drought affected the western half of the country. However, the first 3 months of 1993, usually a dry period, became wet (over 160% of the normal rainfall fell in these months) introducing an additional stress to agriculture and food production.

Characteristics of Superstorm 93 in the Cuban sector

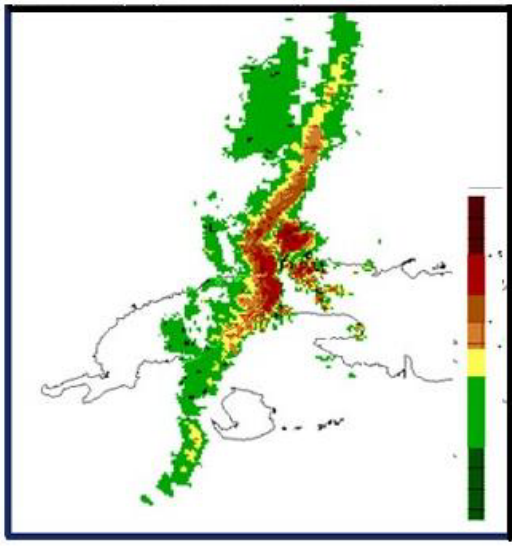
On March 13,1993, a very strong winter storm hit a broad area of the United States and Cuba, causing considerable damage and casualties. In Cuba, the total number of fatalities was relatively low (10), but economic losses amounted to more than US$1 billion. A significant portion of these losses were caused by a prefrontal squall line with severe weather that swept the whole country, bringing straight-line winds clocked at over 200 km/h and hail to the western

provinces. Rains over 100 mm in 24 hours fell over the eastern provinces. Although the observed severe phenomena were not the most intense ever recorded in Cuba, the extent of the area affected by significant phenomena was greater than that of any other severe prefrontal squall lines reported in Cuba.

A strong polar outbreak over the central United States brought on sustained surface pressure increases in that area on March 11 and 12. At the same time, an extratropical low-pressure center began to develop over Mexico. At 7.00 pm EST March 11, the low started to move east along a quasi-stationary front that had remained over the northern part of the Gulf of Mexico during the preceding 48 hours. An increase in the contrast between cold continental air and maritime air from the Atlantic Ocean covering the Gulf of Mexico south of the quasi-stationary front was clearly observable. By 6.00 pm EST March 11, the continental high-pressure center had reached a value of 1031 hPa over Kansas. Meanwhile, the low-pressure center had moved into the Gulf and was located near 25.0N, 93.0W and had a surface pressure of 1004 hPa at its center.

The low-pressure center deepened rapidly, and at 7.00 pm EST on March 12, it was located near 29.0N and 89.0W with a central pressure of 991 hPa. The associated cold front was already strong and well defined, extending from the low's center down to the Isthmus of Tehuantepec. During the following hours, the low-pressure center continued to deepen and to move east-northeastward. Winds continued to increase at the surface until the squall line arrived. Thermal analyses indicated strong baroclinity associated to an intrusion of warm and humid air into Florida and the eastern portion of the Gulf of Mexico. No data were received from radiosonde stations in Central America and the Caribbean Sea (except from San Juan, Puerto Rico) at 7.00 pm EST March 12.

Observational evidence obtained from severe squall line forecasting in Cuba suggests that most of the time, squall lines develop in the Gulf of Mexico; they extend south only to about 25.0N latitude as they traverse the northwest and central Gulf. As they reach the eastern Gulf, squall lines typically expand rapidly southward over the southeast Gulf and western Cuba. The satellite picture showed a very rapid building to the south of the squall line over the eastern Yucatán Peninsula.

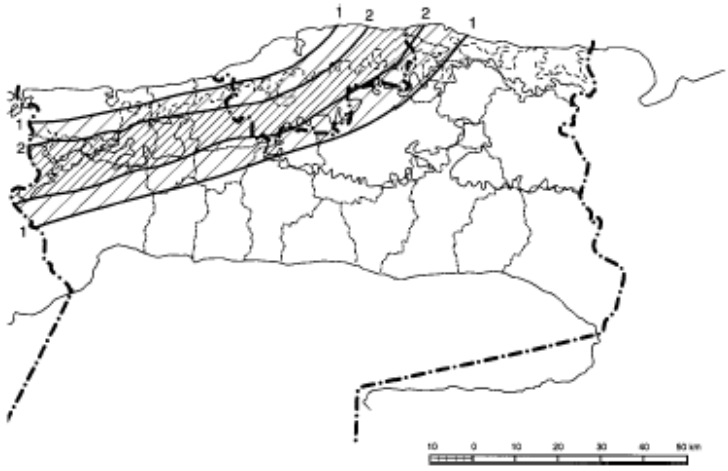


Severe squall line as was viewed by the Havana radar during the early morning of March 13.

The synoptic environment was highly favorable for the development of very deep convection and of related severe weather on the eastern side of the Gulf of Mexico at 7.00 pm EST 12 March 1993. This included most of the classical elements associated with severe weather development common to mid-latitudes during winter or spring. However,

because of the latitude, the available humidity in the lowest layer was higher than usual for the time of year, and the air was considerably unstable ahead of the squall line.

Havana radar indicated that the squall line consisted of a line-echo with a series of bow echoes, indicating strong winds. These echoes were very persistent and intense. The two bow echoes that affected western Cuba and the Isle of Youth retained their comma shape and identity during the entire 5 hours that they were observed by Havana radar. The echoes reached heights up to 16.3 km during the period of maximum intensity over the westernmost provinces of Cuba.



Damage swath over Havana during the squall passage. Dashed area indicates winds ranging F2 scale in a Fujita scale for tornado intensity, about 200 km/h .(From Alfonso and Naranjo, 1996. Weather and Forecastingt, Vol 11, number 3. pp 89-102)

A detailed assessment of damage patterns displayed by trees and different types of construction allow us to define over Havana a swath 10–20 km wide where maximum estimated gusts ranged up to 215 Km/h. This damage occurred between 1.30 am and 4.00 am EST March 13.

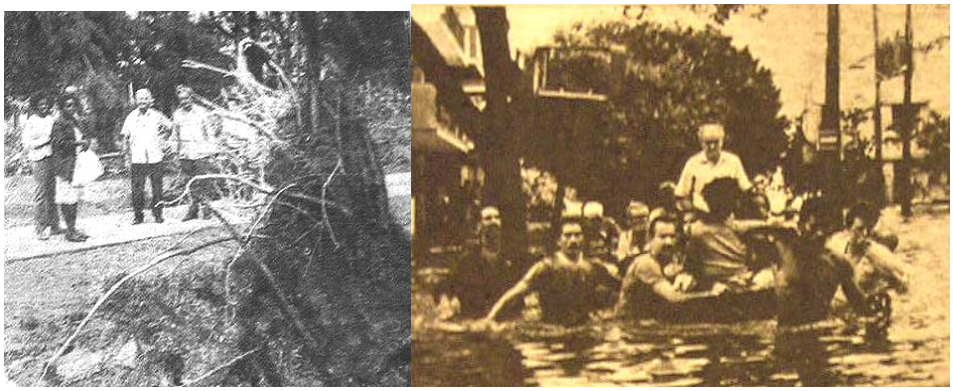
In the afternoon of March 13, the cloud band associated with the storm reached the eastern provinces of Cuba, with this low's movement producing heavy rains in eastern Cuba. In many places rainfall exceeded 100 mm in a few hours. At this time, strong northwesterly winds were producing waves up to 8 meters in the Central Gulf of Mexico. Rough seas, more than 3 meters high, battered the northern coast of Cuba, producing severe coastal flooding in Havana and other coastal settlements, which occurred from mid-morning of Saturday, March 13. The coastal flooding of March 13 was one of the four biggest events of this kind registered in the twentieth century. In fact, considering the combination of the severe squall line, heavy rainfall and coastal flooding, this meteorological event could be considered the worst in more than 100 years. That is why the term "Storm of the Century" was widely accepted by all levels of Cuban society.

Finally, it is remarkable that the air mass following the storm was very cold, producing a significant drop in temperatures in the early morning of March 14.

Values between 7 and 8 degrees Centigrade were recorded in central Cuba, which is remarkable for the month of March.

Superstorm: What it did in Cuba

Damages in Cuba were severe and extensive. Losses, as calculated by the Cuban government, exceeded a billion US dollars; 10 people lost their lives and many were injured to some degree. These casualties represented a very high cost in human lives for a country proud of its protective measures against disasters, mainly when they occurred during the hurricane season.



There are very few photos about the Superstorm effects published in the Cuban press. In the left side picture, a big tree brought down by the wind in Havana and in the right side a rescue in a flooded street of Vedado, Havana City.

Practically all of the Cuban territory was affected in some way by severe events associated with this Superstorm. Strong winds from the severe squall line were responsible for much of the damage reported in the western half of Cuba, while heavy rains seem to have been the main cause of the damages in the eastern half of the country. Coastal areas of the north coasts of Pinar del Rio and Havana provinces were severely affected by floods caused by sea water surges. Havana City was particularly affected by severe flooding in its coastal neighborhoods. Buildings and almost all the infrastructure of the Havana coastal area were damaged to some degree. Some Havana hotels and the United States Interest Office were isolated by the water, and occupants had to be evacuated.

On Sunday morning, March 14, the local newspaper in Havana published a preliminary report about damages only within the city, including 3 deaths and 55 injured.

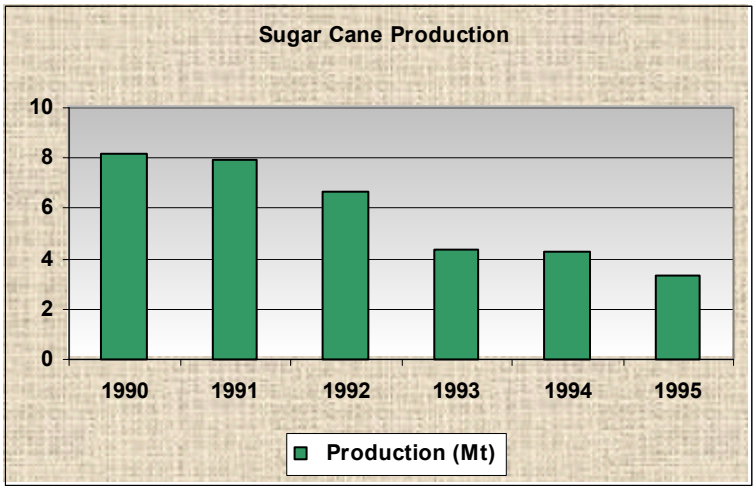
On March 19, the magazine “Bohemia” published the most complete report to appear in the Cuban press about the Superstorm. More than 30,000 houses and more than 2,500 economic establishments and other social facilities were damaged or destroyed. Almost all sugar factories in Cuba from Pinar del Rio to Ciego de Avila had to stop temporarily in the middle of the sugar harvest season. Many of the banana plantations were swept away by Superstorm’s hurricane-force winds. From Pinar del Rios through Matanzas, almost 1.5

million plants were destroyed and the harvest was almost a complete loss. Other cultures such as citrus, beans, tomatoes, etc., were also severely affected. Many livestock facilities were destroyed, and more than 600 cattle and more than 24 000 poultry died.

Hundreds of electric power-line posts were brought down and broken like toothpicks by the wind**.** As a consequence, extensive and long lasting power cuts and blackout were produced affecting other basic supplies such as water, gas and telephone.

Tobacco losses were extremely high because much of the overall Cuban production is concentrated in the western half of the country. Much of the highest quality Cuban tobacco harvested in the winter campaign was practically destroyed by the winds and the heavy rains.

Sugar production, the main economic activity in Cuba, was especially impacted, because the Superstorm's impacts put additional stress on an industry severely affected by an economic crisis. Although there is no exact information about the matter, because usually this kind of information has been considered strategic by the Cuban government, some official estimations suggested a reduction of almost 2 million tonnes of sugar in relation to what the government had hoped to produce in 1993. A significant part of these losses could legitimately be associated with the Superstorm's effect in terms of damages to plantations, industrial facilities, and the untimely interruption of the harvesting process. Damages to the plantations had a negative impact in the following year because of the inadequate preparation of the sugar cane fields for the 1994 sugar cane harvest, which turned out to be as low as the 1993 harvest.



Sugar cane production in millions of Tons (from FAO)

On July 26, President Castro, in his speech marking the fortieth anniversary of the assault on the Moncada Garrison in 1953, made the following remarks regarding the Superstorm (Storm of the Century).

> *The first half of 1993, from a climatic point of view, was really hellish. The so-called Storm of the Century swept through the island, from one end to the other, during a season that is not a storm or hurricane season. … The*

storm of the century had already affected us for an estimated $1 billion. It swept away a sizable portion of the tobacco harvest, the plantain farms, and other crops. It caused considerable damage to homes and industrial, agricultural, and social facilities. That compounded the situation even more.

Response to the forecast

In 1993, the Cuban Meteorological Service did not have full access to operational prediction models from the US National Weather Service. Only the National Meteorological Center's Nested Grid Model (NGM) forecasts for 24 to 48 hours were available by open radio fax broadcast from the US Navy. On the afternoon of March 10, in an internal operational document called "Weather General State" (WGS), there was a first reference about what the NGM dynamical model was predicting regarding the future of a storm:

NGM models for the next 48 hours suggest the development of a "Golfiana" low pressure center in the west side of the Gulf of Mexico with high humidity and strong vertical movements over this area. This development will bring a cold front over the Western half of Cuba over next Saturday.

The use of the term "Golfiana" to describe this future development indicates that the Cuban meteorology team in charge got some warning about a possible risk because, among Cuban weathermen, this name is used to describe a fast-developing low-pressure system formed in the southwest Gulf of Mexico in the early springtime. It is usually associated with strong southerly winds and severe weather events in the western half of Cuba. However, no action was taken to warn the public, media or the government. There were reasons for this behavior: Information was considered uncertain because there was no experience with NGM model performance, and other information sources were not available. Additionally, in 1993 and aside from hurricanes, there was no early warning structure in place for facing severe weather events in Cuba. As a consequence, any early warning 48 hours ahead could be misunderstood or simply neglected by official agencies. A measure of this uncertainty was reflected by the next day (March 11), when little attention was given to the possible development of a Gulf cyclone.

On the morning of March 12, evidence that a strong cyclogenesis was under way in the Gulf of Mexico became clear. A WGS released in the early morning analyzed the observed synoptic pattern, characterized by a strong polar outbreak in the southern United States and the fast development of a low-pressure system over the Gulf of Mexico. Again, regarding the NGM output, the WGS stated:

NGM model is insisting on the development of a "Golfiana" type low pressure system over the Gulf of Mexico, North of Campeche where there is a maximum vorticity center.

Again, no actions were taken at this time. Public forecasts released to the media only warned about a cold front affecting western Cuba in the afternoon of the 13th with “cloudiness and heavy showers” in this region.

Since then, the fast development of the event overcame the technological capacity of the Cuban Meteorological Service for monitoring the event and preventing its impacts. This capacity remained at minimum levels, almost critically low, due to the economic crisis and the American embargo. Communication channels with the World Data Center in Washington had been suffering from a substantial reduction in previous months, and during the morning and afternoon of March 12, data from the Gulf area were not accessible. Satellite picture availability was restricted to low-resolution images, and were only available after 6:40 pm on this day, only a few hours before the first impact of the squall line over the western tip of Cuba. In spite of these difficulties, the meteorological staff in charge of operational weather prediction, based on the information available, and on the previous knowledge acquired in Cuba regarding prefrontal squall line formation and displacement over the Gulf of Mexico, issued a special warning on the possible occurrence of the squall line at 8.00 pm on March 12.

This information was urgently released to Civil Defense, and to the radio and TV stations. There was no response. Finally, TV acceded to transmit a warning that a severe squall line was coming, but it was only transmitted in the early morning news after the Midnight Saturday Movie program. As a result, only a few people heard the warning and, besides, it was too late. Less than one hour later, everybody was “surprised” by the unusual thunder activity and very strong winds.

Explanations about why there was no reaction to the warning in a society with a high capacity of mobilization, and proud of its preparedness systems, became complex because of many aspects. The superstorm was unique; it was an extreme event with a very low probability of occurrence and, as a consequence, there was no experience with coping mechanisms for such an event. As was acknowledged in a governmental report prepared after the event, there was a lack of methodology to establish warning systems similar to those for hurricanes. In fact, the “system” did not work because there was no system. Additionally, it is important to clarify that the Cuban media are fully controlled by the government; consequently, they are not able to take individual actions about information, mainly when the supposed action is in order to mobilize people. The warning released by the Meteorological Service on the night of March 12 was an example. Media were not able to give it an adequate priority because they did not have orders to do so from any level of the government. Instead, information was handled as normal, because on a Friday night nobody wants to hear about bad news from the weather service.

Response to impacts

12 hours later, confusion among people, politics, and the government remained high. However, all protective measures for mitigation were activated urgently,

and all resources including military facilities were put to the task of saving people, cultivation, and property. The government began to use the media as if a real attack from an enemy had occurred. Headlines or news about damages and recuperative efforts used terms such as “war against nature” or “treason from nature” became very common. Even Castro, reviewing the damage south of Havana exclaimed, “this is almost treason.” This kind of informative handling proved to be very effective. It was looking for a mobilizing effect for the population to carry out recovery measures as soon as possible. Besides, it was trying to emphasize that damages were caused by an extraordinary event, despite government good will.

Some days later, the Central Committee of the Communist Party, headed by President Castro, developed a meeting with the head of the Cuban Meteorological Service and managers from the main economic sectors. Three important agreements to improve the protective capacity of the nation against severe weather events were taken:

1. To increase the forecast capacity of the Cuban Meteorological Service by increasing its technological facilities and improving relationship between the researcher and the operational meteorologist. For the first time, a link between El Niño and severe weather in Cuba was acknowledged.

2. To improve the early warning system to the population and civil defense, including education to create societal awareness for a number of meteorological events different from hurricane that are able to produce severe weather. This agreement meant a redefinition of the media role: since then the Cuban Meteorological Service was able to release its warnings more freely. Although with some restrictions, the service was permitted to assign priorities for its warnings to the media. Besides, relationships between the Cuban Meteorological Service and Civil Defense became closer, because the government established a stronger control over it.

3. To develop measures to increase protection of coastal settlements, mainly in Havana City. This, implicated an ambitious long-term plan for reconstruction and the creation of protective facilities along the Havana shore. The Havana City local government, Civil Defense, and the Cuban Academy of Sciences were designated to coordinate this effort, although later many institutions contributed with resources and technical capacity.

In the international field, Cuba tried to get aid, although the environment was very unfavorable. In the United States, groups like Pastors for Peace challenged the American embargo, arguing that it is "immoral and illegal to starve people for political purposes." Pastors for Peace organized a "friendshipment," a ninety-truck convoy that collected food, clothing, and medical supplies in Canada and 120 US cities for delivery in Cuba.

In Canada, individuals, church groups, and even some provincial governments sent emergency food and medical supplies to Cuba. Federal agencies such as the Canadian International Development Agency (CIDA) needed special

permission from the Secretary of State for External Affairs to finally approve the food aid shipment in early August.

International institutions as the World Food Program,the UN FAO, and the European Union through its Humanitarian Aid Office (ECHO) sent important aid, mainly food, and as financial support for reconstructing housing and social facilities.

In a general sense, response to the impact was as usual: quick and efficient in terms of recovery actions. The Cuban government had taken care to keep its defensive capacity high. Inclusive, it had been reinforced since 1991 by introducing the concept of an “All people´s war” – a strategic concept for national defense that links all societal stages and economic facilities to a unique defensive system in which everyone is an element of the system and no one remains outside of it. Such a system gives the government a considerably high capacity to react to mobilize people for recovery works, and for the handling of resources. However, actions would not only be reactive, but proactive as well, looking to the future. The Cuban government realized that climate surprises had to be considered in its overall strategy to overcome its economic crisis. The Meteorological Service and other institutions devoted to disaster mitigation were substantially improved through the following year. Besides, some economic sectors began to ask about climate and future climate scenarios, in order to minimize risk and to establish their development plans.

Implications for climate change

From the five most devastating meteorological events in the winter season in Cuba between 1940 and 1995, two of them occurred in 1983, and one (the Superstorm) occurred in 1993. Three major winter extreme events in 10 years and abnormally quiet hurricane seasons during these years became very suspicious to meteorologists. Initially, the idea of a possible “meteorological war” generated by the United States was considered at first. However, research developed by the Cuban Meteorological Service and other institutions indicated that anomalies were closely related to changes in the frequency and impact modes of the ENSO phenomenon. A possible indication of climate change impacts in Cuba began to be accepted.

From 1995 many institutions began to consider scenarios with a more rainy and stormy winter season, and not just a drier summer. Agricultural research institutions began to find out about varieties of plant types with higher resistance to new climatic conditions. Early warning plans were improved and readapted to a new scenario, to make possible a more efficient response to a wide range of severe climate- and weather-related events.

The superstorm in the Cuban Newspapers

Ahora el combate es contra la naturaleza

El actual invierno transcurre bajo los efectos de El Niño

Tormenta invernal

TRAICION ANONIMA DE LA NATURALEZA

Las pérdidas no han sido pocas, pero la respuesta está siendo la requerida

Los trabajadores agropecuarios

SALVARON LO POSIBLE

El énfasis está en recuperar todo lo posible

¡HAGAN TODO LO QUE PUEDAN!

Estudian fenómenos atmosféricos varias instituciones del país

Empresa tabacalera Lázaro Peña

Salvar hasta la última hoja

Ante la adversidad...

Multiplicamos el esfuerzo

Se multiplica el esfuerzo ante la adversidad climática

Extraordinario esfuerzo para recobrar lo dañado

Cuban media, controlled by the government ,gave to the superstorm an unusual full coverage. Terms as "treason from nature", "fighting against nature" were extensively used looking for the societal mobilization. For a first time, a weather disaster was related with El Niño event.

However, criteria on the matter were not at all conclusive. In a report to the Government about the Superstorm, officials from the Cuban Meteorological Service established that:

> *There is consensus among the international scientific community, that since 1988, anomalous extreme climate events have been observed into a natural scenario of climate variability. Currently there is a great uncertainty about the degree of influence on extreme events of a human-induced climate change.*

Experience and the measures taken regarding Superstorm '93 were crucial in preparing the Cuban society to face the 1997-98 El Niño event. Based on this experience, during the winter-spring seasons 1997-1998, the System of Civil Defense paid constant attention to the information issued by the Meteorological Service, taking the exceptional measure of maintaining for the winter the system of prevention that was created for the hurricane season to deal with possible disasters. Additionally, different sectors and spheres of the economy and social life developed specific preventive measures, including the request for specific meteorological predictions to support the management strategy for massive seeding of sugar cane in the agricultural campaign in the spring of 1998. However, this time the severity that was expected did not occur.

By the end of the 1990s, it was evident that final conclusions about trends in Cuban climate were still unclear. The term "climate variability" became more popular.

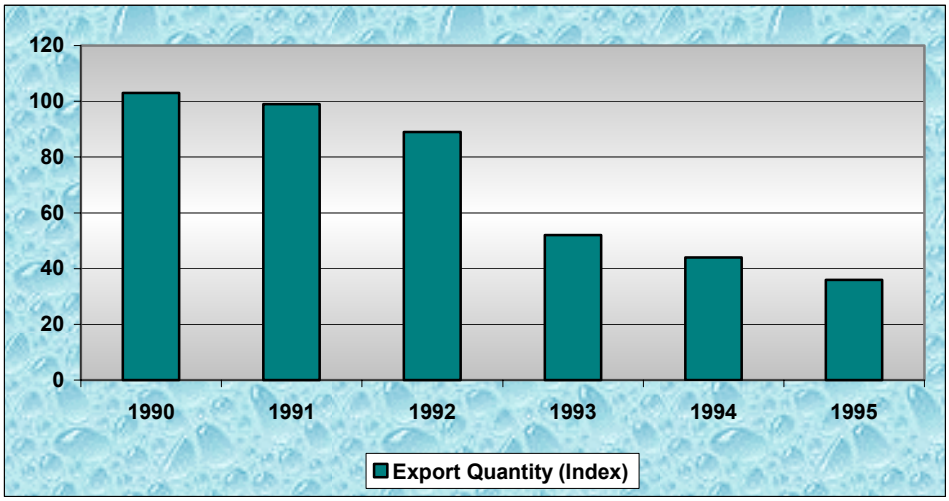
Superstorm '93 had a direct influence on the development of a strong societal awareness about climate change, climate variability, and the change in perceptions about their possible impacts and risks. Since March 1993, many efforts were devoted to the study of Cuban climate. El Niño and its influence, as well as weather events such as tornadoes or squall lines, became as popular as the season's named hurricanes**.**

Other implications

The Superstorm of March 1993 hit Cuba when the country was undergoing severe economic and societal crises. Its impact swept away much of the government's hopes to ameliorate severe food and energy shortages, increasing the risk of hunger and possibly famine. However, evaluating the socioeconomic history of Cuba after March 13, 1993, trying to isolate superstorm effects among multiple causes derived from the current international scenario, and the evolution of the Cuban social system, is a very complex task. Superstorm '93 did not create the crisis but evidently was a significant factor in making a bad situation worse.

In April a severe neuropathy, which had appeared in Cuba at the end of 1992, reached epidemic proportions and, during 1993, affected more than 50,000

people. Although official reports indicated that the illness outbreak was due to different causes, it was acknowledged that there was a close relationship with inadequate nourishment that created a lack of the B complex vitamin in the human body. Evidently, the epidemic was a dramatic effect of the food shortages within the Cuban population.



Losses in Cuban exporting capacity in agricultural products after 1993 (from FAO)

Damage to cultivation not only destroyed the harvest in 1993, but winds, hail, and floods severely affected seeds, soils and infrastructures, negatively handicapping many of the agricultural modes of production. In the years following, the Cuban economy was in the position of having to recover.

Concluding remarks

The Superstorm of March 13, 1993 in the Cuban sector constituted one of the most significant wintertime extreme events ever recorded in Cuba. The combination of severe thunderstorms with hail and hurricane-force winds embedded in the squall line, heavy frontal rains and coastal flooding due to strong northwesterly winds gave it unique characteristics. In fact, reports about similar severe winter storms are, at least, very scarce in Cuban historical records.

The uniqueness of this event could be considered as the main reason why the response level was so low prior to the event. There was not enough historical experience to create a societal awareness about the risk of a “Superstorm.” Ten years before, in 1983, two severe squall lines affected western Cuba, but they were single events and although they produced severe damage, it was limited to relatively small areas. Consequently, if a perfect and totally reliable forecast had been issued in advance of Superstorm ‘93, a quick and adequate response would not have been assured because there had been no previous experience. If a hurricane-season response methodology had been applied, it would likely have failed because, among other causes, the squall line moved along the

Cuban territory at a mean speed of about 90 km/h, almost five times the mean rate of movement of a hurricane.

Another aspect to take into account is the nature and predictive characteristics of severe events. Coastal flooding events associated with a winter storm can be estimated mainly by using the synoptic-scale surface wind patterns of the storm. In this fashion, they can be predicted at least two to three days in advance, making possible the establishment of anticipatory actions. However, a fast-moving squall line associated with the same storm is a mesoscale system that can be predicted only a few hours in advance, limiting possible responses. Sometimes, only mitigation efforts within damaged areas are possible.

Based on this rationale and considering in retrospect that the NGM prediction on March 10 was reliable, they could have served to create the worry that "something big" would happen in the following days. However, in no way could it indicate that a hurricane-force squall would affect Havana in the early morning hours of Saturday, March 13. There was too much of a margin of uncertainty in terms of predictability. This does not mean that "nothing more could have been done." Evidently "warning signals" from the NGM, along with other evidence could have promoted further monitoring actions, forcing a closer relationship between Civil Defense, the Meteorological Service, and TV. Radio broadcast media could have played a more active role. However, Cuba was under a severe societal and economic crisis that undoubtedly was a conditioning factor for all responses.

Acknowledgments

To write this paper became a real challenge. A lot of scarce information had to be gathered from unexpected places. I want to thank to Dr. Mario Carnesoltas who provided me with useful information. I am very much indebted to Gisell Aguilar for her assistance, support and patience, sharing with me many hours of intense work. Thanks also to D. Jan Stewart for her useful review. This paper was prepared under Contract SO4-44160 from UCAR.