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Evaluations and Perceptions of the Climate Change in the State of Veracruz (Mexico): An Overview

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1. Introduction

The State of Veracruz (Mexico) is a strip of continent oriented from North-Norwest to South-Southeast on the Gulf of Mexico slope, with a surface area of 72815 km^2, and 7.5 million inhabitants. Its latitudinal width ranges between 46 km and 156 km. The Pico de Orizaba mountain (5747 m altitude), is located in the middle of the State and it is part of the mountain range that crosses Mexico from West to East around the 19°N parallel. This complex orography causes a very large spatial variability of climates and geographical configurations over this coastal State (figure 1).

The State is crossed by several rivers. The more important are, in the north, by the Panuco, Tuxpan, Cazones, Tecolutla and the Nautla rivers; in the center of the State the Actopan, La Antigua, and the Jamapa river, and down the south, the Papaloapan and the Coatzacoalcos rivers. All together, they transport 25% of the surface water that crosses over Mexico. The State also has some important lakes, such as the Tamiahua (880 km^2, on the north coast), the Lagoon of Alvarado (62 km^2, center-south at delta of Papaloapan river) and the fresh water Catemaco lake (75 km^2, south coast). The State has more than 750 square kilometers of coasts in front of the Gulf of Mexico, as well as a flat surface formed by the continental coastal flatland to the north, and another from the center to the south-center, and at center full of mountainous surfaces that go up to 5200 meters of altitude in less than 200 kilometers of width (see table 1), all of which exposes it to frequent disastrous weather phenomena. In the semester around winter, there are cold fronts with winds blowing at over 70 km/h for 35 days a year in average. This provokes temperature declines of more than 10°C within 24 hours; and in the summer, due to tropical flow, sometimes in the form of a storm, flooding occurs on the lower parts of the State as well as landslides (Tejeda et al. 1989)

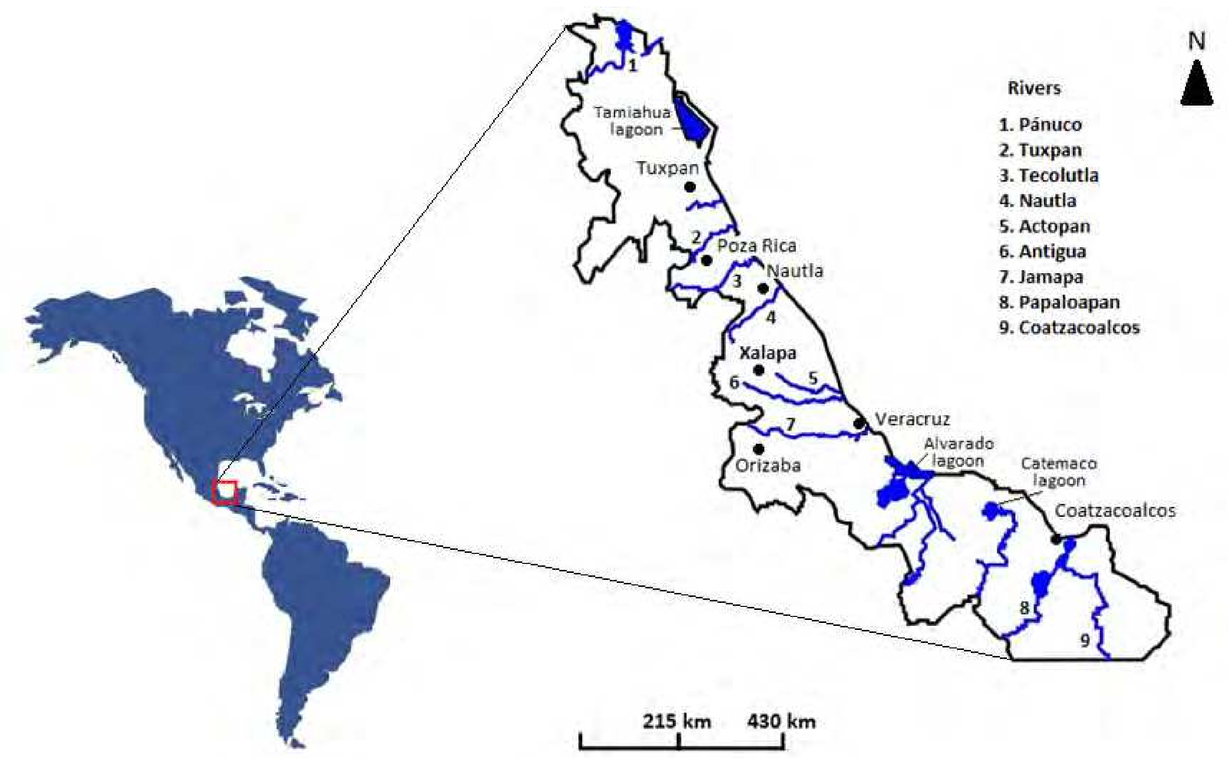


Fig. 1. Main rivers and human settlements of the State of Veracruz.

Altitude (m)	Area (km[2])	Percentage
0 to 200	52827	72.5
From 201 to 1000	13092	18.0
From 1001 to 2000	4988	6.9
From 2001 to 3000	1748	2.4
Over 3000	160	0.2

Table 1. Percentages of area corresponding to different altitude intervals for the State of Veracruz.

The years 2005 and 2010 have been especially upsetting. Four tropical storms affected the State in 2005, causing 1.5 million storm victims, 130 thousand affected houses, 170 road disruptions, but there were no human losses. Nevertheless, six years before, on October 1999, just one tropical storm, produced 200 thousand storm victims, 12 thousand affected houses, 20 road disruptions, and left 20 dead. The difference in deaths was because in 2005 a rudimentary but efficient early warning system was started.

2010 was a specially long and intense year regarding floods. For example, the city of Tlacotalpan (18.62°N, 95.66°W and 10 m above sea level), which is located on the riverside of the Papaloapan river -and considered cultural heritage of the humanity because of its XIX century architecture-, was flooded twice: the first time from August 28 to September 21 and the second time from September 28 to October 4. The level of the first flood was 2.7 meters above the river level and the second time 4 meters. Two hurricanes, Karl (September 17-18) and Mathew on the same month (September 26-27,) caused flooding on different parts of the State and losses for over five billion dollars - the State's budget in comparison is 7 billion dollars a year - and 20 deaths, but the for the entire State within the rainy season, there were 130 deaths accumulated in the year 2010.

In summary, the demographic growth –the State increased from 6.3 million inhabitants in 1990 to 7.6 million inhabitants in 2010–, the human settlements located in flood areas, and a policy lacking in preventive measures for disasters that only tends to emergencies, make this territory a laboratory for involuntary risks, increased by the ignorance of the patterns of atmospheric circulation at mesoscale and teleconnections as the main causes of climate variability, and of course adding the global warming.

And, by the way, Mexico emits approximately 2% of the world's green house effect gases. Of this percentage, because Veracruz produces oil, it emits 10%.

A first view of the complexity of this problem can be shown on the schematics of figure 2. What it expresses is that from an entirely atmospheric point of view (X axis) it is necessary to understand at least three moments: the meteorological moment, that allows for the realization of more or less accurate climate forecasts on a short term, the climate variability for the medium term (months) and the generation of climate change scenarios. And Y axis, the socio-environmental moment, requires a historical revision of the disasters and future

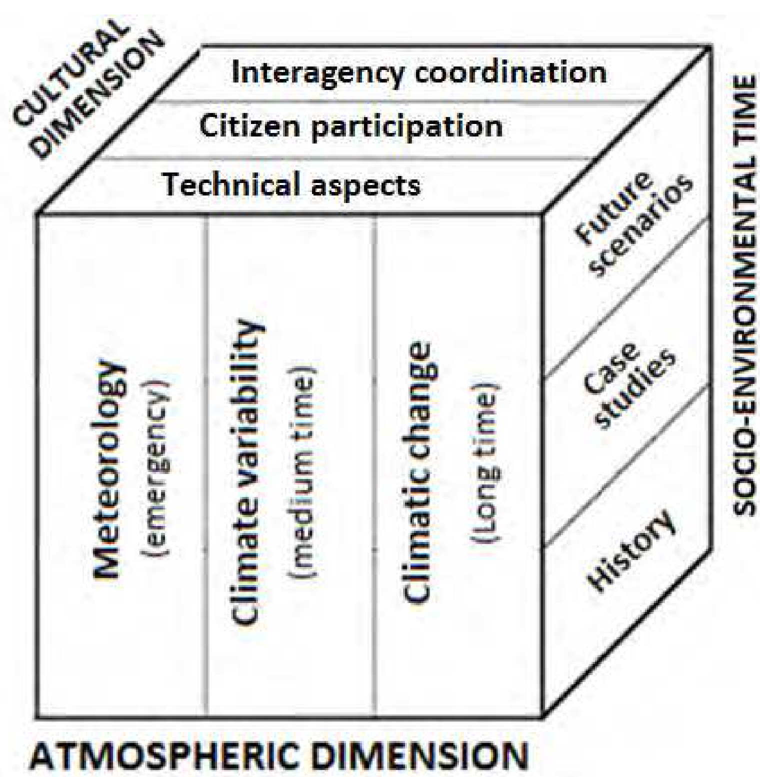


Fig. 2. Fundamental coordinates in the atmospheric, socio-environmental and cultural dimensions of the hydrometeorological phenomena.

projections, together with the study of special cases such as the ones mentioned in the years 1999, 2005 and 2010, for example.
Finally, what could be called the cultural dimension, must come from a solid technical knowledge regarding atmospheric aspects (climate and meteorological of a medium term), as well as the socio-environmental history, the most important cases and future projections. But this knowledge will be useless unless it corresponds to an inter-institutional coordination, which won't exist unless there is a highly participative society that forces the decision-makers to come into action.
This chapter will present a revision about the atmospheric teleconnections and their link to the local climate variability, as well as the evidence of the climate change and the tendencies of precipitation and temperature. Besides, some scenarios of the sea level rising will be commented on, plus the results of the perception of climate change poll in the two main urban centers in the State, and finally there will be a synopsis on an action plan to deal with the climate change.

2. Climate change and variability

The change over time of the atmospheric conditions is called climate variability, which has always existed as a product of the climate-ocean-continent interaction. In the process of understanding the climate at a regional scale (e.g.: the State of Veracruz) it is helpful to study the climate signals separately from the anthropogenic climate change.
Climate variability and change tests over the State will be presented to show that natural variability has a small relationship with atmospheric oscillations: El Niño-Southern Oscillation (ENSO), the Pacific Decadal Oscillation (PDO), the Arctic Oscillation (AO) and the North Atlantic Oscillation (NAO). Regional climate change signals were evaluated using the methodology proposed by the Expert Team on Climate Change Detection and Indexes (ETCCDI). The results show evidence of warmer conditions in recent years, with an increased frequency of hot days and a decrease on cool days. Although extreme precipitation indexes present non-significant changes on annual basis, a tendency of temporal concentration of rainfall was found.
The variability of precipitation in Mexico is in a good measure modulated by the El Niño/South Oscillation, ENSO (Seager et al., 2009). In the positive phase of El Niño phenomena, there are humid conditions during winter in all the Mexican territory, whereas during the summer, conditions are dry in the north and humid in the south. According to Magaña et al. (1998), winter rainfall intensifies during El Niño in the northwest and northeast of Mexico, but they decrease in the south. The El Niño winters are colder in almost all the country and the summers are warmer.

2.1 Data

In order to analyze the teleconnections between the atmospheric oscillations and the local precipitation variability, PDO index was used, which are available in the Washington University (http://jisao.washington.edu/pdo/PDO.latest); the optimum interpolated by Reynolds ocean surface temperatures and the index for the North Atlantic sea were obtained from the Unit of Investigation of the Climate of the United Kingdom (http://www.cru.uea.ac.uk/cru/data/nao.htm). The indexes of ENSO were obtained from the Hadley Center, also in the UK, through the British Centor of Atmospheric Data (http://badc.nerc.ac.uk/data/hadisst/). A common period was chosen for all the data between January of 1950 and December of 2001.

The daily data of maximum and minimum temperature and precipitation for the analysis of the changes in extreme climates were provided by the Mexican National Meteorological Service (2008) during the "Workshop on detection and indexes of climate change in the Mexican Republic", which was had on March 2009 in the city of Puebla, Mexico. Some series of data were updated with information provided by the *Organismo Cuenca Centro de la Comision Nacional del Agua*, and data by the observatory of the city of Veracruz were included.

The selection of these time series was made on the basis of the methodology proposed by the ETCCDI, using the RClimDex software as an auxiliary in the process of quality control, and the application of the information of the local climate in order to evaluate the extreme data marked as suspicious in the series. The sources consulted for the revision of the outliers and other mistakes were the printed meteorological bulletins, the climate dates for the main cold fronts, historical records of tropical storms, the directly registered observations on paper or the records from the previous and later days to the date analyzed.

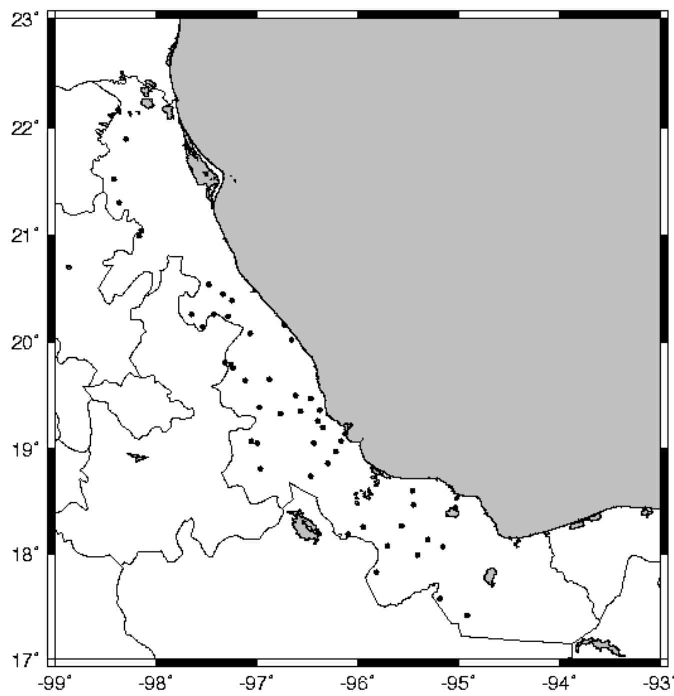
For each time series, a homogeneity test was performed with the software RHtesV2 developed by Wang and Yang (2007). It uses a regression in two phases in order to identify the changes of a median in the temperature data of the series of time intervals from each season.

From the quality control process and the homogeneity test, 50 series of precipitation and 30 of temperature were chosen because they were reasonably homogenous, they didn't have major mistakes, and they also had more than 90% of the data observed during the time period of 1963-2005. The climate stations cover geographically most of the State of Veracruz, with the exception of the northeast portion (21.0°-22.5°N y 97°-98°W) and the south of the State (17.0°-17.5°N y 94.0°- 95.0°W). See figure 3.

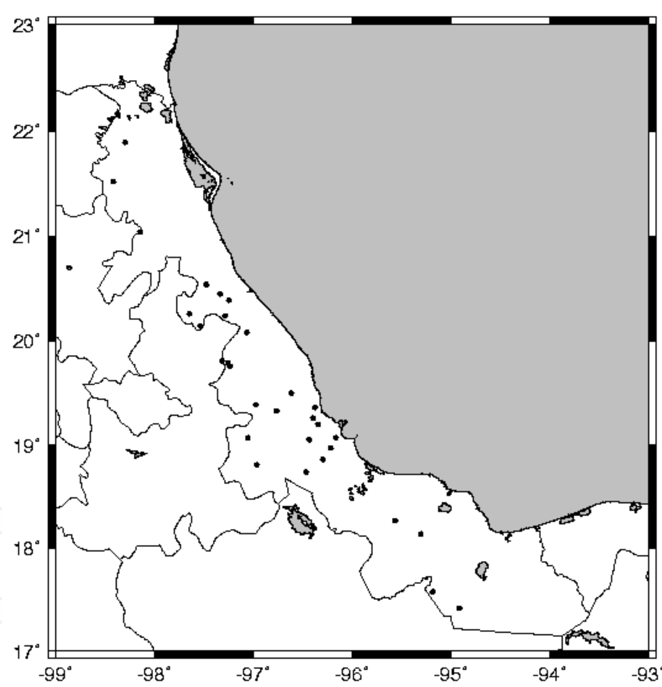
In summary, the State's series of maximum and minimum temperature were homogenized with the method used by Spaniard series (BRUNET et al., 2008), which are based on the Homogeneity Normal Standard test (SNHT; Alexanderson and Moberg, 1997), that detects the change points in the data, and establishes a pattern of correction, estimating the monthly adjustment of the series.

The series of time intervals allowed evaluating 24 climate change indexes proposed by the ETCCDI. The RClimDex software was applied for it. These indexes evaluate the diverse aspects of climate change such as intensity, frequency and duration of temperature and rainfall extreme events, duration of hot, cold, dry, gusts, maximum and minimum temperature during all the year, the number of very cold or very warm days, etcetera (Alexander et al., 2006). In this chapter important results will be shown, but for more details it is recommended that Torres-Alavez et al. (2010) be consulted.

The Gini index was used additionally in order to quantify the yearly variation in the concentration of rainfall (Martin-Vide, 2004) in 14 climate stations located in the State of Veracruz, which had continuous and good quality data from 1963 to 2005. This last index was compared to the simple index of daily intensity proposed by the ETCCDI, resulting in a quotient obtained by dividing the total annual rainfall between the number of days of rainfall.



a)



b)

Fig. 3. Geographical location of the climate stations used for the analysis of a) precipitation and b) temperature.

2.2 Correlations and trends

There were no important correlations found between the rainfall and the oscillation indexes. The only remarkable information was that the monthly accumulated rainfall reached its maximum correlation (0.14) with a ten month gap to the previous PDO.

When analyzing the relationships with the ENSO, it was found that the years in which El Niño happens are drier than those in which the conditions of La Niña present themselves, with a 0.05 statistical significance. The mid-summer drought (*canicula*) is the relative decrease of rainfall that occurs in the middle of the rainy season; its intensity is calculated as a deficit of the percentage of rainfall, relative to an ideal period with only a maximum of rainfall (Mosiño and García, 1966). It was found that approximately 16% can be explained as a relationship to the variations to the oscillations of the North Atlantic, while 9% can be explained as a relationship to ENSO.

When correlating the index of mid-summer drought with the annual medium of the indexes of the oscillations, it is concluded that El Niño (3.4) and the NAO of the Azores are the most highly correlated with respective values of 0.31 and 0.4 (the variation explained is of 9% and 16% respectively). In the case of the PDO and the AO, the correlation is imperceptible.

Regional series of maximum and minimum temperatures were generated for all the State, in which it is shown for both variables that there is a positive tendency starting from 1990 (figure 3). For the maximum temperature, the change in the linear tendency is 1.3°C along 1996-2005 decade, while the minimum temperature presents a change of 0.4 in the same period.

In the case of indexes for cold days, warm days and cold nights, the results agree with the results found by Vasquez-Aguirre et al., (2008). In many of the analyzed climate stations there is significant evidence of an increase in the happenings of hot spells (43% of the climate stations in figure 3a), and of the increase of the minimum extreme temperatures (50% of the climate stations in figure 3b).

The annual happenings of the hot spells (it is defined as when the hot temperature is over the 90 percentile for six consecutive days), as well as the minimum temperature show a significant increase in the entire region (figures 4a and 4b).

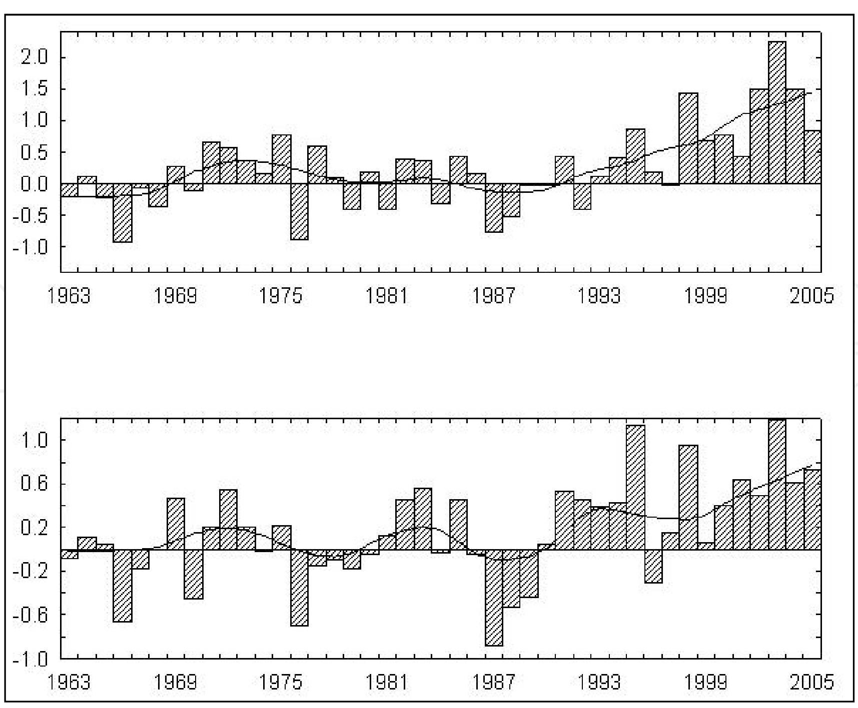


Fig. 4. Annual anomalies (1963-2005) of maximum temperatures (up) and minimum temperatures (below), of the base period 1963-1992 in °C.

Significant changes were observed in neither the total annual rainfall nor in the intense rainfall, although they were in the distribution of the time of rainfall, in which the number of consecutive humid days is reduced, while the dry spells show a slight increase (figure 5).

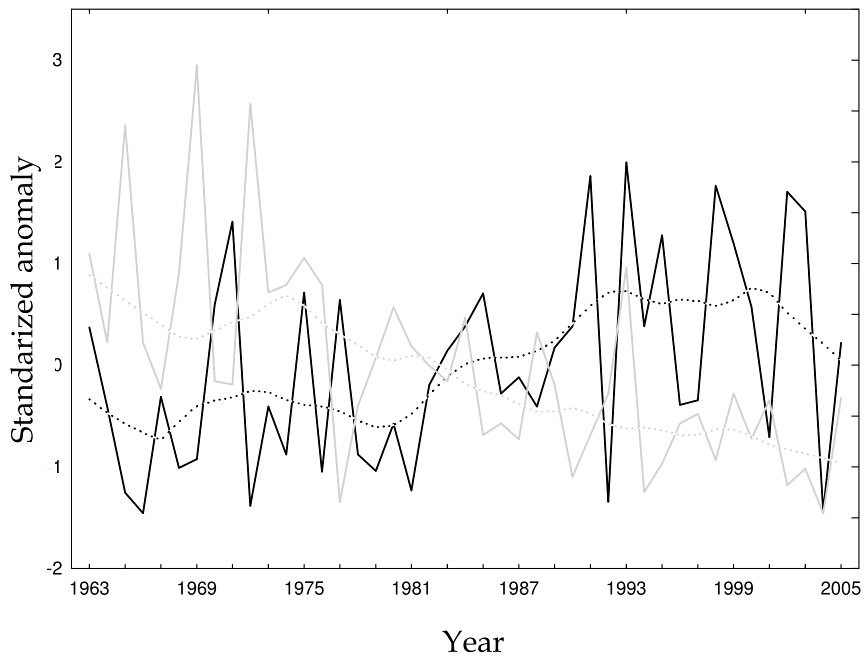


Fig. 5. Standard anomaly of consecutive humid days (continuous gray line) and dry consecutive days (continuous black line), both softened with a lowess (dotted lines).

The daily simple index (SDII) resulted in a cero tendency, due to both the rainfall and the number of decrease in rainfall days, while the Gini index showed a slight negative tendency (figure 6).

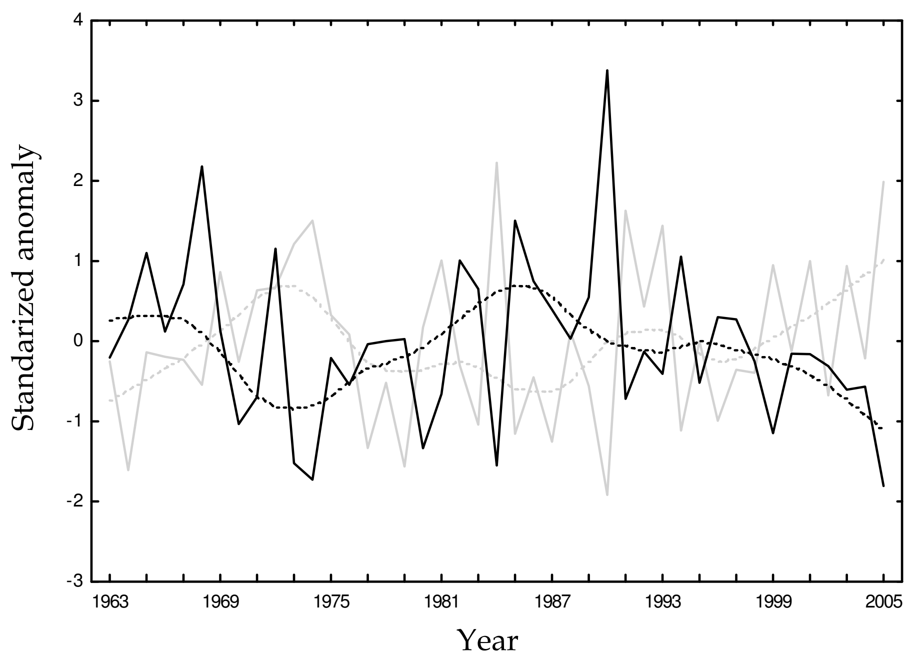


Fig. 6. Standard anomaly of the SDII (continuous gray line) and the Gini index (continuous black line), both softened by a lowess (dotted lines).

3. Sea level scenarios

On other side, climate change scenarios (temperature increases and rainfall modifications) for the rest of the century Veracruz State are similar to other tropical regions. The ocean level rise will be analyzed in order to prevent impacts on coastal towns and increase of the risk by flooding of rivers because 35% of the surface water of Mexico crosses through Veracruz State, mainly by five large enough rivers to flood 60% of land and towns with 3 millions of people.

The rise of the sea level represents a threat to the coastal settlements of Veracruz. The scenarios based on different numerical models indicate a sea level increase of 59 centimeters for 2100 (IPCC 4th Assessment Report, 2007) up until dozens of meters should Greenland's and the poles' ices melt. An exercise was performed calculating a scenario of a sea level increase from one to two meters for the coasts of Veracruz. 15 houses with 58 inhabitants would be permanently flooded. But what is more disturbing is the latent danger of a similar flood to the one that occurred in Louisiana, US with maximum registered rises of 8.5 meters with hurricane Katrina. This last situation, added to the two meters of the exercise performed in the climate change scenario (10-5 meters) shows a danger of flooding of 327 thousand houses (1.3 million people).

At the end of 2010 there was a State government change. The floods and the political campaigns for elections that year alongside with a propaganda overspending, left the government with a 3 billion dollar debt, with an annual budget of 7 billion dollars. Therefore the new government is pushing for an economic reactivation based mostly on beach tourism, which requires a minimal infrastructure investment.

Among the main touristic beaches of the State are Costa Esmeralda (figure 7), which is located 50 kilometers south of Poza Rica and north of Nautla; the Cazones, Tuxpan, and Tecolutla beaches are at the north of Costa Esmeralda; Palma Sola, La Mancha, and Lechugillas beaches are at center; Villa Rica and Mocambo beaches between Veracruz and Boca del Rio cities (Veracruz-BR, henceforth); Playa Escondida Beach at a side of Catemaco Lake and the zone of Coatzacoalcos city, among others. Next, some information will be presented to illustrate the potential vulnerability of the touristic zone. [1,2]

Even though these beaches cannot be considered to attract great numbers of tourism, they have an important infrastructure. For example, alongside Costa Esmeralda, there is an important hotel industry of categories ranging from 5 star hotels to economy, including camping sites as well as trailer-parks. The municipality of Tecolulta (22872 permanent inhabitants) had in December 2008 36 restaurants and one museum; 126 hotel businesses of which 89 are hotels, 25 are bed and breakfasts, 6 businesses are cabins and 6 trailer-parks, all of which have a total of 2164 hotel rooms, 248 house guest rooms and 114 cabins. Of the 126 hotels, one is a five star hotel, 11 are 4 star hotels, 27 are 3 star, 33 are two star, 13 are one star, and 41 have no category. Costa Esmeralda -located on the road that runs through Casitas, Monte Gordo, La Vigeta, Flores Magon and La Guadalupe towns, none of which is bigger than 3000 permanent inhabitants (figure 8)- count with 38 hotels that add up to more than 900 rooms.

The metropolitan area Veracruz-BR has an approximate population of 600 thousand inhabitants. The most important commercial port is found in the city of Veracruz (figure 8)

[1] Tecolutla, http://www.tecolutla.gob.mx/ (Accessed August 2010)
[2] Totonacapan, www.totonacapan.com.mx/ (Accessed August 2010)

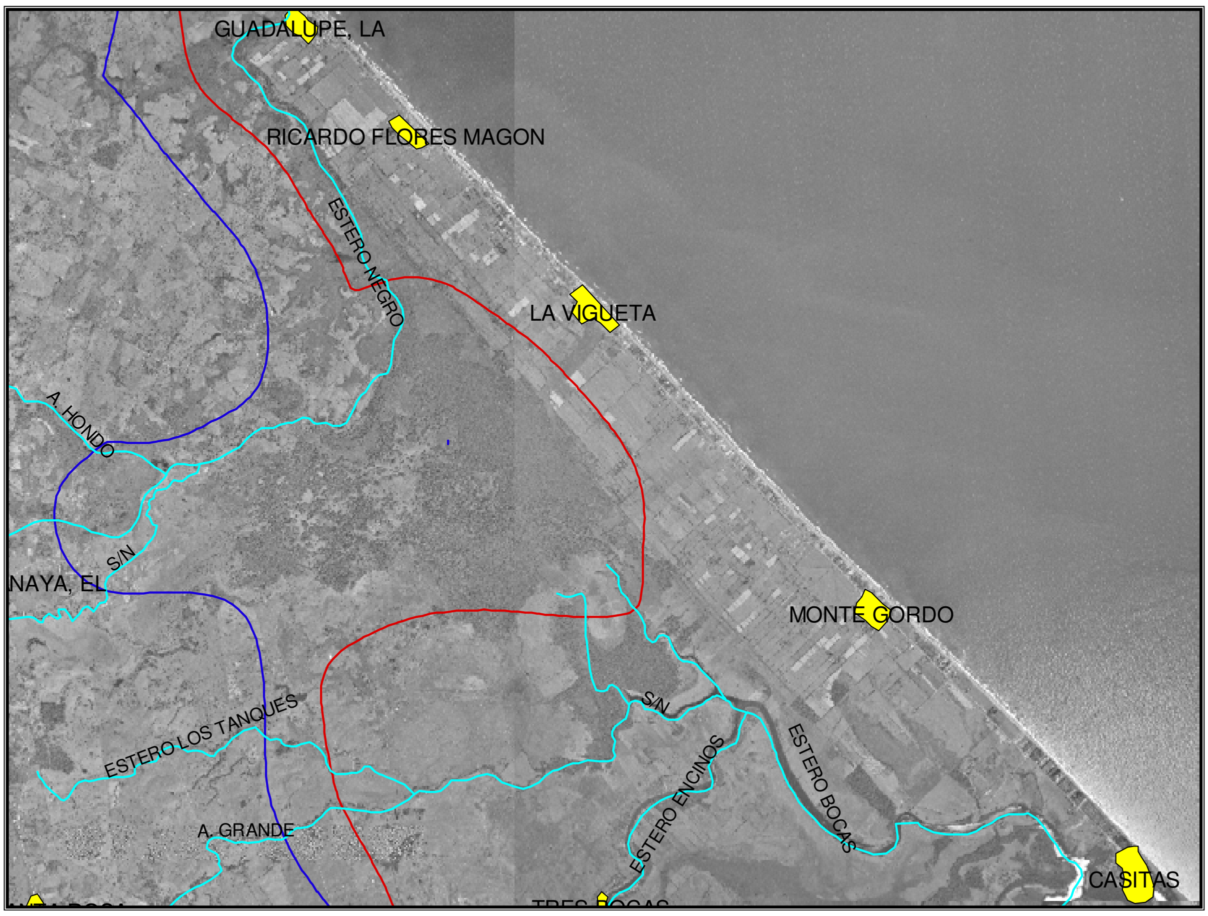


Fig. 7. The Zone of Costa Esmeralda, the red isoline is 7 meters above sealevel, the blue isoline is 11 meters above sea level, and the clear blue shows the rivers.

and the hotel infrastructure has 139 places of which 106 are hotels, 24 are motels, 6 are bed and breakfasts, there is an area of cabins and there are 3 suite complexes, all of which represent a total of 6037 rooms and/or hotel units. Of these, 5 are five stars hotels, 13 are two stars, 24 are three stars, 41 are two, and 14 don't have a category[3].

Regarding Boca del Rio (figure 9), its names comes from the shape of the Jamapa river when it flows into the Gulf of Mexico. The infrastructure of the hotel businesses is made up of 6 five star hotels, 23 four star hotels, 10 three star hotels, 15 two star hotels, 3 one star hotels and 5 without category, all of which give a total of 3215 rooms, plus bed and breakfasts and cabins; there are 10 suite complexes and a trailer-park. So, all the metropolitan area Veracruz-BR has an availability of approximately 10000 hotel rooms, that is, 17000 beds.

[3] State tourism information in www.inegi.org.mx/prod_serv/contenidos/espanol/biblioteca/Default.asp?accion=15&upc=702825159900 (Accessed August 2010)

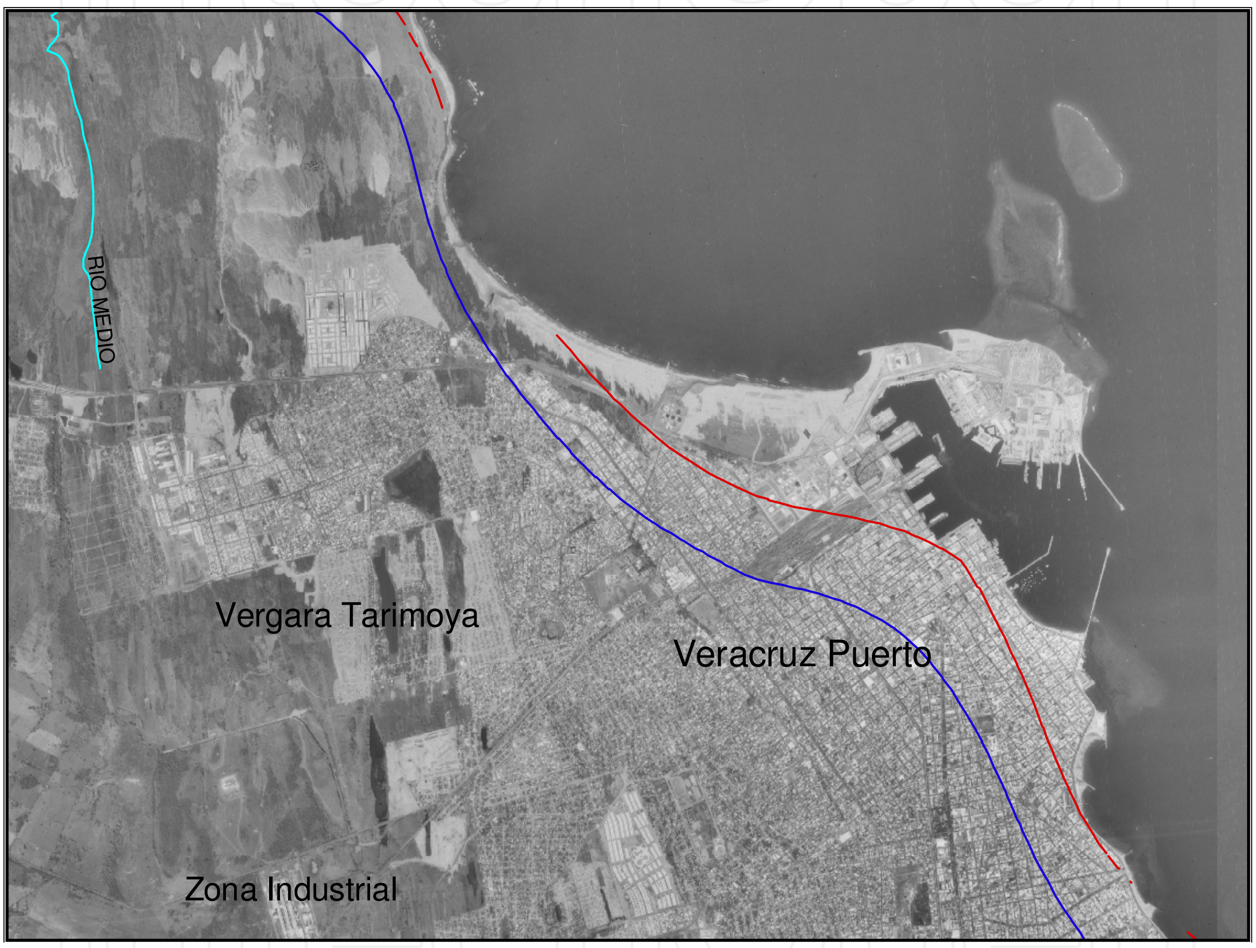


Fig. 8. The port of Veracruz, the red isoline is 7 meters above medium sealevel, the blue isoline is 11 meters and the light blue line shows the rivers.

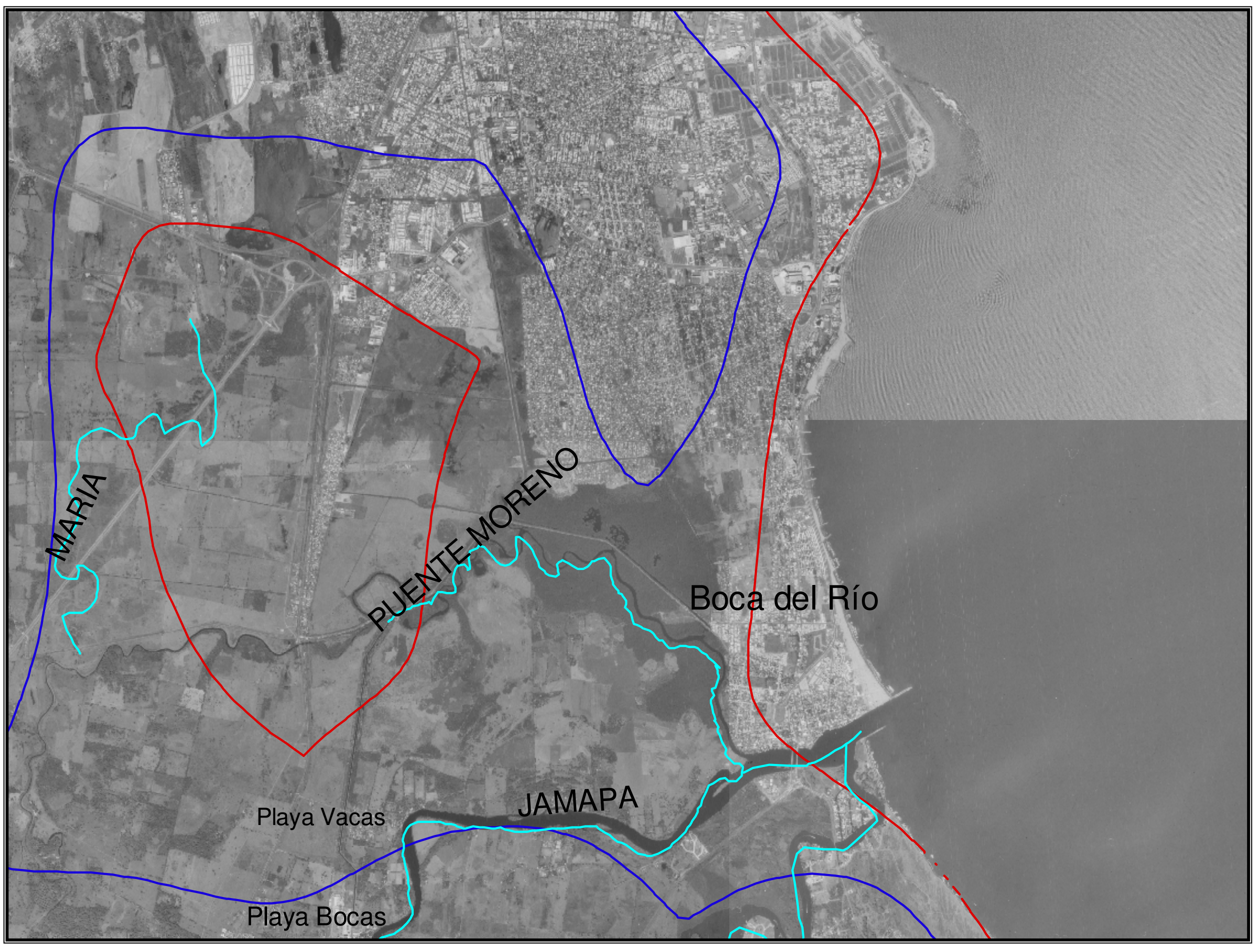


Fig. 9. Boca del Rio, the red isoline is 7 meters above medium sea level, the blue isoline is 11 meters and the light blue line shows the rivers.

3.1 Sea level scenario

By using the topographical information of the National Geophysical Data Center (NGDC) and the National Oceanic and Atmospheric Administration (NOAA), a global elevation model (ETOPO 1[4]) was applied to a grid of one minute latitude by one of longitude for the topography as well as for the bathymetry. It was interpolated using the Kriging geo-statistic method, which is appropriate when a spatially correlated distance or directional tendency of the data is known. This is frequently used in soil science and geology.

[4] ETOPO, http://www.ngdc.noaa.gov/mgg/global/global.html (Accessed August 2010)

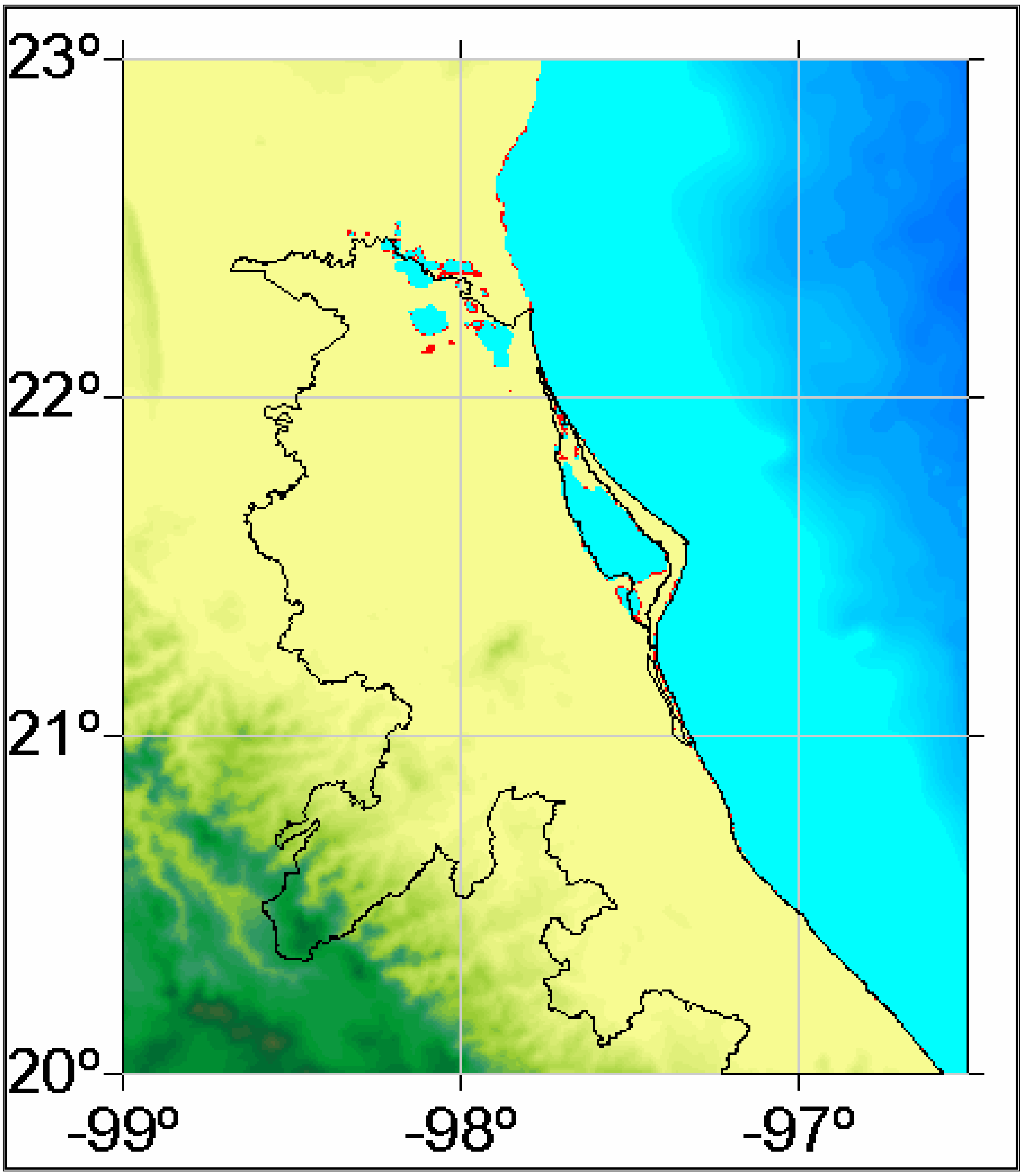


Fig. 10. The areas in red are those that would be flooded when the sea level increases one meter.

The coastal territories will be exposed to impacts due to the increase in the sea level, but mostly because of the higher exposure to extreme meteorological phenomena which will have the higher sea level as a platform to go deeper into mainland, settlements and infrastructure.
A scenario of sea level a rise for the State of Veracruz was calculated by one meter (figure 10) and by two meters (figure 11). The zones the most danger of being flooded were located,

according to information from the National Institute of Statistics and Geography (INEGI[5]) stored in an IRIS hard drive version 4 of the year 2005 (IRIS V 4.0.1)

3.2 Potential risks

The data from INEGI 2005 shows seven settlements in danger of permanent flooding by the two meter sea level increase, because of global warming (figure 11). With a total of 76 inhabitants and 22 houses, these towns are called, Playa Palma Sola, Punta Delgada, Burgos, Playa Miranda, Puente Casitas, El Cristo and Rancho Los Cerritos (table 2). In figures 10 and 11, the red spots that are further south, go into the mouth of river Papaloapan; the population living in that strip of land within two meters over sea level is scarce, but the potential risks increase when considering a storm surge. Of course, if the risk of the extreme case of nine meters is considered, the red spot increases much more (figure 12).

Settlement	Local government	Latitude (°N)	Longitude (°W)	Altitude (masl)	Population (thousands)
Playa Palma Sola	Alto Lucero	19.8	96.4	2	11
Punta Delgada	Alto Lucero	19.9	96.5	2	5
Burbos	La Antigua	19.5	96.3	0	5
Playa Miranda	La Antigua	19.4	96.3	2	25
Puente Casitas	San Rafael	20.2	96.8	2	7
El Cristo	Tecolutla	20.5	97.0	0	20
Rancho los Cerritos	Tuxpan	20.9	97.3	1	3
					76

Table 2. Settlements in potential danger due to 2 m sea level increase (INEGI 2005).

It must be taken into consideration that the biggest danger of flooding in the coastal zones of Veracruz is for the effect of a storm surge, especially by tropical storms and hurricanes. Up until now, in the Gulf of Mexico coast the biggest flooding was caused by Katrina, a level 3 hurricane that by entering Buras, Louisiana on the 29th of August of 2005, into the Mississippi delta, it raised the sea level to 8.5 meters; and Camille, a level 5 hurricane that upon entry to the Bay of Saint Louis on the 17th of August of 1969, also into the Mississippi delta, it generated a 7.5 high tide.

The settlements in danger of flooding by storm surge or hurricane are found at a height of less than 8.5 meters. If 2 meters of sea level are added, the danger zone at the end of the 21st century is of 10.5 meters or less above sea level. In figure 13, the level curves for 9, 10, and 11 meters show the vulnerability of the river basins for the rivers, Panuco, Papaloapan and Coatzacoalcos. In the case of the coastal flooding of 11 meters, the number of people in

[5] www.inegi.org.mx

danger is 1.3 million with 327000 houses, because this includes the metropolitan area Veracruz-BR.

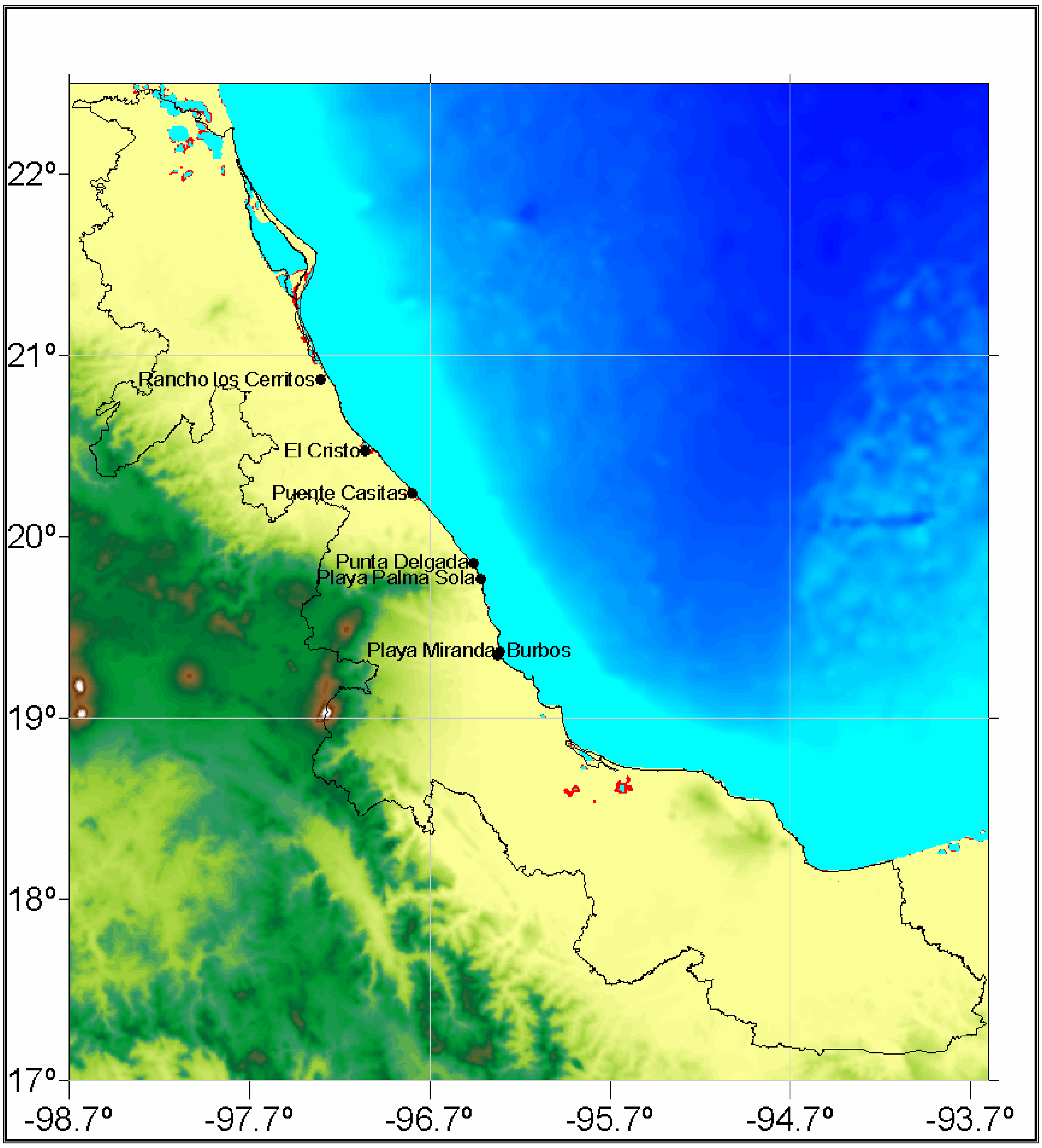


Fig. 11. The zones in red are at two meters or less above sea level. The black dots indicate the settlements that are located two meters or less below the sea level.

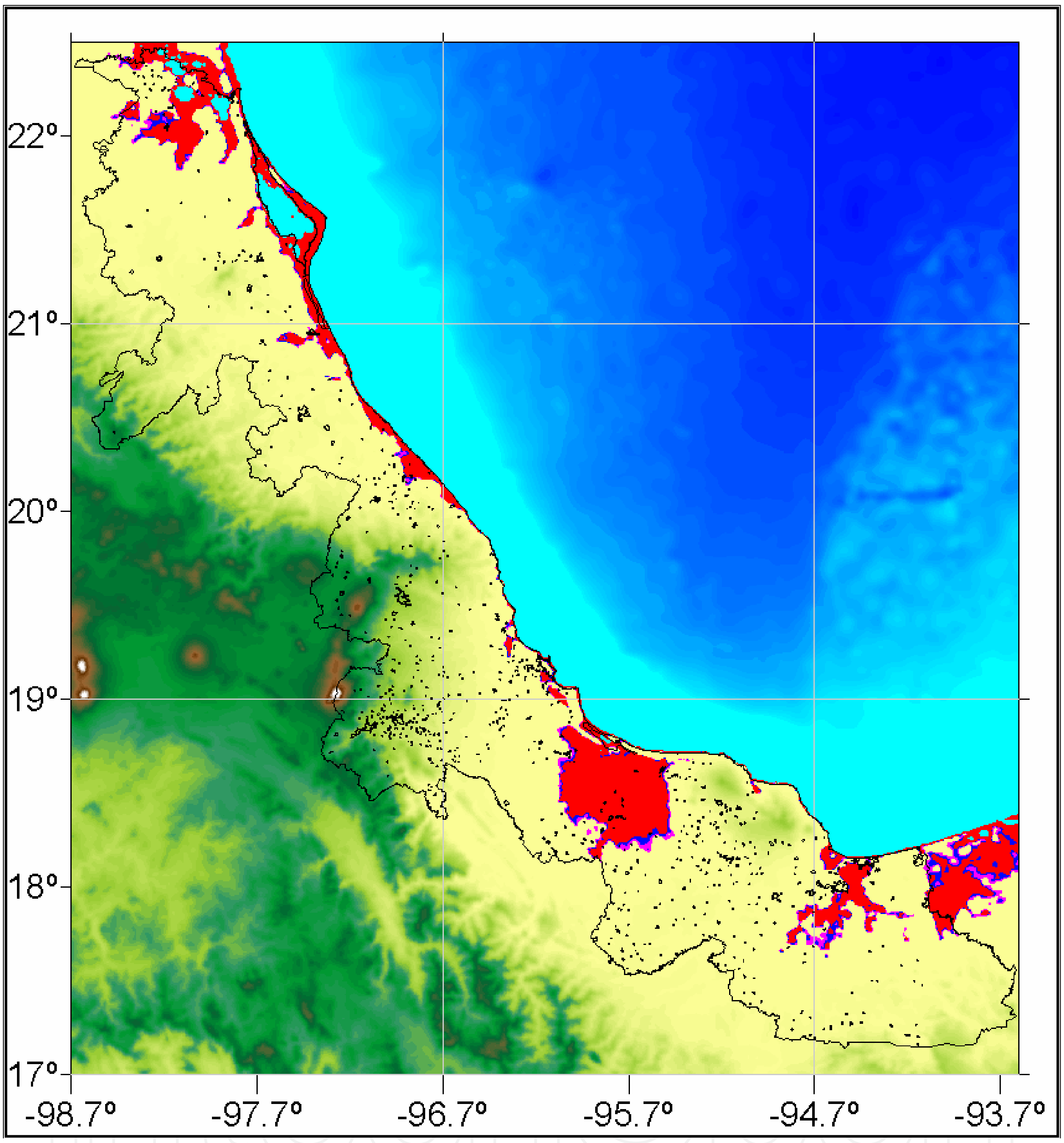


Fig. 12. The zones with a high level over the average sea level of less than 9 meters are in red. The blue zone is the 9-10 meters and the magenta is the 10-11 meters.

4. Climate change perception

The perception of climate change in the urban population is confused, according to polls applied during November 2010 in the capital of the State (Xalapa, altitude 1300 m) and the important marine port of Veracruz City, which total 1.1 million inhabitants.

The study of the public perception of the climate changes has developed significantly in the last two decades (Immerwaher, 1999; Bord, *et al.*, 1998, Brechin, 2003, Leiserowitz, 2006). It has been possible to establish some recurring trends in different studied contexts (Lorenzoni

and Pidgeon, 2006), such as the existence of a high concern for environmental issues and climate change, although climate change is considered less important than other personal and social problems (Dunlap *et al*., 1993; Bord *et al*., 1998; Immerwahr, 1999; Brechin, 2003; Norton y Leaman, 2004). Leiserowitz (2006) expressed about the American public, "despite the high concern about climate change, it is not perceived as an urgent challenge that can involve changes in its priorities and spending habits, but a problem that can be resolved by other actors." Stoll-Kleeman *et al*. (2001) have highlighted the difficulties of understanding that climate change poses to the public, due to the nature of the problem; and other studies State that the perception of climate change is a problem without solution (Immerwahr, 1999; Norton y Leaman, 2004), whose origin are very general issues such as human greed, which turn feelings into a lack of effectiveness of personal action. Thus, the combination of high concern with low awareness and personal effectiveness can lead to frustration and disinterest in the citizen (Immerwhar, 1999), as it will be seen with the populations surveyed in the conurbations of Xalapa (19.51°N, 96.9°W and 1400 masl), capital of the State of Veracruz, and Veracruz-BR (19.16°N, 96.14°W y 20 masl).
On the other hand, the study of images that people associated with climate change shows little connection with everyday life (Leiserowitz, 2005). Most people tend to associate climate change with distant phenomena such as the melting of icecaps, increases in temperature or different environmental problems, but it is rarely associated with aspects of everyday life.
Under these assumptions, the perceptions and attitudes of people in major urban centers are analyzed (Xalapa y Veracruz-BR; with 500 thousand and 600 thousand inhabitants) as not being expert of climate change; perceived risk, associated images, and self-efficacy to cope with climate change, among perceptions. Citizens play an important double role in climate change (Moser, 2006). On the first place, as actors involved in politics of climate change, because they can mobilize themselves to reach government policies, and in second place, individuals are resource consumers, for which reason they can initiate changes in the behaviors –favorable—to the reduction of them as well as adapting to change.

4.1 The pool

The survey was aimed at people over 18 living in both conurbations. To know the number of people to be interviewed, the methodology of the simple random sampling design for estimating a proportion was used. For the calculation of each sample, an error of 4% was considered and a 95% confidence level in the estimation of a dichotomized proportion. The calculated sample for the Veracruz-BR conurbation was 394, and for Xalapa, 384 questionnaires.
The sample was distributed in different Basic Geostatistics Areas (AGEB'S) of the cities into very high /high, medium and low/very low degrees of marginalization. For the location of the field researchers (IC) in the AGEB'S, maps were made with the program IRIS-SCINCE for each IC. The pool was conducted in electronic tablets-minimizing transcription errors-on November 13 and 14 of 2010, with trained IC in the areas of public opinion, statistics, and in the management and transfer of computer files.
The composition of the sample by gender was 54% women and 46% men in Xalapa, against 52% and 48% in Veracruz-BR. The age of the population shown in Xalapa was 43% between 18 and 34 years, 48% from 35 to 64, and 9% for over 65 (in Veracruz-BR the percentages were 40%, 48% y 12%). In the first city, schooling is divided into thirds between 1) primary and

secondary, 2) high school and 3) undergraduate and graduate school, while for Veracruz-BR it was divided into 28%, 36% and 21% with 5% non-response. Housewives, students and self-employed, each had with 20% in Xalapa, while employees have accumulated 34% and 6% unemployed. In Veracruz-BR proportions were covered by 22% housewives, 10% students, 22% of self-employed, 34% of employed and 12 unemployed.
It can see there are a variety of ages, education and occupations that allow us to infer that the survey responses are approximately valid for the respective cities.

4.2 Opinions of the citizens

According to the survey the most worrying problems were insecurity and drug trafficking (21% in Xalapa, Veracruz 18%), poverty (19% and 22% respectively), education and health (18% and 13%), unemployment (17% and 24%) and several others were about 16% for both cities. Climate change was noted in fifth place with 10% of the priorities in Xalapa and 6% in Veracruz-BR.
With regard to the opinion of the environmental problems that require further attention, water scarcity, water pollution, air pollution and climate change, each has a 15% in Xalapa, followed by the depletion of natural resources with 11% and the rest (29%) in many others.
In Veracruz-BR, air pollution is the biggest with 22% on concerns of respondents, followed by water pollution (15%), scarcity of water (12%), depletion of natural resources (11%), several other (34%) and climate change only reached 6%.
In Xalapa 85% agree that there is climate change, 9% do not and 6% do not know. In Veracruz-BR percentages are different, 73%, 23% and 4%. However, only 68% of respondents in Xalapa agree that climate change is already happening in the city (but it is 75% in Veracruz), which will occur over a period of one to ten years estimated at 16% in Xalapa 11% in Veracruz-BR, and that no claims will occur on 16% and 14% respectively. But there is near unanimity in both cities in terms of climate change affecting the family, community and country (80% to 85%) and that it will affect future generations (92%).
The main impacts identified in Veracruz-BR, are the recent floods (which occurred one month before the implementation of the survey), with 38%, higher temperatures by 20% and extreme atmospheric phenomena by 17%. In Xalapa these percentages are very different: 14%, 14% and 27%. Take into account that the annual average temperature in Vercruz-BR is 25°C (average relative humidity of 78%, with 120 rainy days/year totaling 1500 mm of precipitation) and for Xalapa it is 19°C (humidity on average 70%, 170 days and 1500 mm of rainfall per year).
What are the causes of climate change? Both in Xalapa and Veracruz-BR 75% of respondents pointed to air pollution, greenhouse gases, fossil fuel use and livestock, that is, more or less the causes identified by the experts, but 25% accused the ozone hole, the use of sprays and toxic waste. 6% at both sites defines climate change as the deterioration of the ozone layer and 7% didn't define it in Veracruz-BR and 2% did not in Xalapa.
Of course it is expected that about 90% of respondents agree that urgent measures and plans to face the phenomenon are needed, and they themselves say they are willing to change their habits to mitigate it. 44% in both surveys view that the sector that must take greater measures is the citizenry, the government is reported by 33% in Xalapa and 40% in Veracruz-BR, while corporate responsibilities are assigned by 23 % in the first and 16% in the second city.
The responses of the type of transport used by respondents do not reflect environmental awareness, but on the other hand the socio-economic, climatic and the urban circumstances,

do (Xalapa is warm Veracruz-BR is hot). In both cities, 60% use public transport; 26% and 37% own a car, in Xalapa and Veracruz, while in the first 14% say they favor walking and bike use, and only 3% Veracruz.

The television is the main source of information about the phenomenon in both Xalapa and Veracruz-BR (56% and 61%), followed by internet (13% in both), radio (9% and 13% respectively), newspapers (8% in both), family and friends reported by 8% and 3%, while the school only 6% and 2% in Xalapa and Veracruz-BR.

5. Concluding remarks and the Veracruz program for climate change

The variability of rainfall in the State of Veracruz is significantly modulated by the ENSO. During the years of El Niño, drier conditions prevail over the years than those of La Niña. The influence of the PDO is presented with a time lag of 10 months, but it has a very small relative influence of ENSO. For its part, the AO and NAO oscillations do not show a significant impact on the weather of the region.

The analyzed climate change indices corroborate the evidence of trend to warmer conditions in recent years in the State, an increased frequency of hot days and decrease in cool days. In precipitation no significant changes are seen, both in the annual rate as in the occurrence of extreme events, but a temporary increase in the concentration of this variable is noticed in most of the State.

Like other coastal cities in the world threatened by rising sea levels, measures to increase the resilience of the population and infrastructure in areas at risk should be taken, as well as the handling of financial security to adapt the building regulations housing to new changes in climate and extreme weather events. Modernizing water systems in these cities is imperative. Any amount of budget allocated to these adjustments will reduce the amounts paid, for example, by insurance companies in Cancun, Hurricane Gilbert, 1200 million in 1988 and 1781 million dollars to Hurricane Wilma in 2005 (AMIS, 2005).

Clearly the social concern about unemployment and public safety, together with environmental issues, seem to be in public awareness, positioning the environment as an immediate social problem directly related to the quality and life expectancy for each a citizen.

97% of the population indicates the need for a national, regional, State or municipal government to help tackle climate change, marking the importance of dissemination of plans and programs established and newly created at different levels of influence to strengthen the role of government as the institution capable and suitable for channeling citizen demands and strengthening its role in the solutions to the problem of climate change.

93% of respondents expressed their willingness to organize themselves to contribute to the mitigation of the causes and adapting to climate change impacts, individually and collectively. Now, only the approval and launch of the Veracruz Program for Climate Change (PVCC) is needed, as well as its immediate sector and massive spread throughout the population to start an organized united front to face this global phenomenon.

As it can be seen, in the State of Veracruz manifests the global warming trends of the accumulation of greenhouse gases; because of its particular geography, the State is susceptible to climate variability, which is not fully explained, together with its topography and coastal settlements, making it very vulnerable to the same variability and thus to climate change. Additionally, the population-at least in urban areas of Xalapa and Veracruz-BR-there is a perception that it favors the gradual implementation of a program to address climate change, which must necessarily go through a review of other social, environmental, and public policy issues, more or less following the scheme of figure 2.

Despite the fact that the State of Veracruz is one of the first Mexican states with a program and a law on climate change, and a Climate Change and Environment Ministry at the year 2010, polls show that public policies are perceived as unclear or non-existent. The Universidad Veracruzana in 2009 gave the State government the PVCC, which was developed by about eighty scholars who produced the technical and scientific bases contained in the eBook *Estudios para un Programa Veracruzano ante el Cambio Climático* (Tejeda-Martínez, 2009; Universidad Veracruzana, British Embassy, INE, 2009), which was the basis for the drafting of this section.

Among the basic considerations of the PVCC, it is estimated that the scenarios will show increases of the sea level up to 60 cm to 2 m coupled with storm surges.

In addition, climate change lead to an increase in water demand with the increasing temperature, which all together with the reduced rainfall, this induces saline intrusion in the groundwater of the coastal plains, which, in turn, generates most likely a decrease in the availability of water to meet future needs. This century the water storage is expected to decrease from 10 to 20% in irrigated agricultural areas, industrial areas and most densely populated centers.

In terms of biodiversity, in Veracruz there is virtually all vegetation types described for Mexico which shows the richness and complexity of the State. Just to mention it, the rich flora includes 7482 species of angiosperms and gymnosperms, which puts it in third place after the states of Oaxaca and Chiapas (Rzedowski, 1993). As for fauna, there has been the presence of 188 species of terrestrial mammals, over 660 species of birds, 85 species of amphibians and 209 reptiles (Challenger, 1998).

The biological wealth of Veracruz is at serious risk, since more than 72% of the State's area has been heavily transformed for agricultural and urban uses. If plant species are lost, this would affect significantly the provision of goods and services. This is the case of edible plants that are the native food support for local populations and which are widely used. Another is the availability of products that contribute financial support and are a means of maintaining rural populations (the herbalist vernacular, for example).

As in the case of plant species, Veracruz is considered one of the states with the highest diversity of fauna. The effects of global climate change can cause, in addition to the extinction of species and depletion of the distribution areas already discussed, conditions that favor the establishment of animal species in areas where they were not found before, the expansion of their distribution area and the creation of an enabling environment to increase their numbers, which unfortunately could occur with species considered harmful to humans, as is the case of insects that transmit pathogens that cause diseases (dengue, malaria, Chagas disease, etc.).

From the point of view of the economy, the PVCC considers that, if droughts occur in the north and floods in the southern State, the rural population could lose between 12 and 35% of income per capita by mid 21^{st} century, which would exacerbate the crisis in rural areas.

As for the energy requirements of the population to cool buildings, this is expected to increase as the temperature increases. The average increases most significant user-compared to late last century, will occur in coastal areas: 10, 20 and 43%, corresponding to the decades of 2020, 2050 and 2080. This increase will tend to diminish in the villages located in

Scope	Objetives to…
1. Monitoring and knowledge generation	• provide the State of Veracruz with a proper legal and institutional framework to tackle climate change • substantially improve the knowledge about the effects of climate change and climate variability in the State of Veracruz • contribute to the creation of human capital in mitigating GHG emissions and climate change adaptation
2. Environmental protection system	• establish mechanisms and actions that promote the reduction of electricity consumption and to mitigate GHG emissions • contribute to the mitigation of GHG emissions through proper management of waste • reduce the GHG emissions generated by the transport sector • promote adaptation and mitigation measures aimed at conservation of biodiversity, as part of a strategy to tackle climate change • reduce the fragility of forest ecosystems (forests, forests and wetlands, among others) and increase their biomass and productivity, to assist in mitigating GHG emissions • reduce the effect of climate change on the development of pests and invasive species in production systems and natural • use wild life species that have traditional uses as part of a strategy to tackle climate change • reduce the pollution of major rivers and water bodies • forecast, in a timely manner, the increased flows and water levels in flood-prone areas, on one hand, and drought, on the other. • improve the efficiency of water utilities as a strategy to address the water shortage due to climate change • protect the Veracruz coast from the effects of climate change • monitor and to protect coastal aquifers to provide saline intrusion caused by over-exploitation of aquifers or by the sea level rise
3. Health and welfare	• reduce risk of the tourism, industrial and port sectors from the effects of climate change, chiefly from the sea level rise • reduce the effects of the climate change on the cattle sector • reduce the effects of the climate change on fishery • reduce the effects of the climate change on agriculture • increase the potential of the productive coffee systems as a measure of mitigation • reduce the negative effects of the climate change (the decrease in the thermal comfort and the hidric phenomena risks) on houses and buildings • implement a strategy for educational communication and government coordination in order to give viability to mitigation actions and climate change adaptation • consider the gender perspective in the development and implementation of adaptation actions to climate change and GHG emissions mitigation • strengthen the adaptive capacity of economic and geographically groups vulnerable to the impacts of climate change

Annex 1. Veracruz Program for Climate Change. Objectives

mountainous regions, but for the population of the coastal region, considering the overall population and temperature, could be expected to reach 25% by 2020, 91% by 2050 and 111% by 2080, while for the State of Veracruz as a whole it would be 35, 127 and 155% for the same periods. All this even considered the heat produced by urban heat islands, which should be incorporated in the cases of the cities that approach or exceed one million inhabitants. For its part, the effects of heat waves on the population of the hot zones will lead to more and more clearly the increased risk in death for people with heart and circulatory problems.

The impact of climate change on human settlements should be assessed as part of at least the change in water availability and climatic factors affecting people's bio-comfort, and threats of spreading diseases.

The government budget deficit the State already mentioned, doesn't allow for any further actions that would be clearly mitigation and adaptation to climate change. In the last five years the State government founded the Center for Climate Studies, the Ministry of Environment and Climate Change, and in September 2010 approved a State law on climate change, 70% stated in the objectives that PVCC are listed in Annex 1.

In short, the requirement is of a shift budget of 60 million dollars a year, but which must be supported by a clear government policy, which hasn't happened so far. However, the repeated occurrence of disastrous weather phenomena, the gradual rise of sea level change and the sudden storm surge, and a perception among the population ever more clearly that the phenomenon could be harm society, all this might make the government plan schemes considering climate change and other aspects as shown in figure 2, such as the outline of a strategy for disaster reduction.

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7. References

Alexander, L.V., Zhang, X., Peterson, T.C., Caesar, J., Gleason, B., Klein Tank, A.M.G., Haylock, M., Vazquez-Aguirre, J.L. y et al, (2006). "Global observed changes in daily climate extremes of temperature and precipitation." Journal of Geophysical Research, 111, D05109, doi:10.1029/2005JD006290.

Alexandersson H. y Moberg A. (1997). *Homogenization of Swedish temperature data. Part I: homogeneity test for linear trends*. International Journal of Climatology, pp. 17: 25-34.

AMIS, (2005).- Asociación Mexicana de Instituciones de Seguros. http://www.amis.org.mx/amis/index.html (Accessed January 2011).

Brunet, M., O. Saladié, P. Jones, J. Sigró, E. Aguilar, A. Moberg, D.Lister, A. Walther, C. Almarza. (2008). *A case study/guidance on the development of long-term daily adjusted temperature datasets*. WCDMP No. 66 – WMO/TD-No.1425.

Bord, R., Fisher, A., y O'Connor, R. (1998) "Public perceptions of global warming:United States and international perspectives". *Climate Research*, v.11, pp. 75-84

Brechin, S. R. (2003) Comparative Public Opinion and Knowledge on Global Climatic Change and the Kyoto Protocol: The U.S. versus the World? International Journal of Sociology and Social Policy, v. 23, n. 10.

Challenger, A. 1998. Utilización y conservación de los ecosistemas terrestres de México: pasado, presente y futuro. CONABIO, Instituto de Biología UNAM, Agrupación Sierra Madre S.C. México. 847 pp.

Dunlap. R.E.; Gallup G.H.; Gallup A.M. (1993). Health of the planet. George H. Gallup International Institute, Princeton, NJ.

Immerwahr, J. (1999) Waiting for a Signal: Public Attitudes toward Global Warming, the Environment and Geophysical Research. A report from Public Agenda. www.agua.org. (Accessed August 2010).

IPCC, (2007): Summary for Policymakers. In: Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change [Solomon, S.; Qin, D.; Manning, M.; Chen, Z.; Marquis, M.; Averyt, K.B.; Tignor, M.; Miller, H.L. (Eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA. http://www.ipcc.ch/ipccreports/assessments-reports.htm. (Accessed August 2010).

IRIS Versión 4.0 Demo, (2005). Información Referenciada geoespacialmente Integrada en un Sistema, Navegante Geoestadístico, Instituto Nacional de Estadística Geografía e Informática, DR. 2006.

Jevrejeva, S., J.C. Moore, A. Grinsted and P.L. Woodworth. (2008). Recent global sea level acceleration started over 200 years ago? Geophysical Research Letters, 35, L08715, doi:10.1029/2008GL033611.

Kellstedt, P., Zahran, S. y Vedlitz, A. (2008) Personal Efficacy, the Information Environment, and Attitudes Toward Global Warming and Climate Change in the United States. *Risk Analysis* 28, 1.

Leiserowitz, A. (2005) American Risk Perceptions: Is Climate Change Dangerous? *Risk Analysis* 25, n. 6.

Leiserowitz, A. (2006) Climate Change Risk Perception and Policy Preferences: The Role of Affect, Imagery, and Values. *Climatic Change* 77, 1-2.

Lorenzoni, I.; Pidgeon, N. (2006) Public views on climate change: European and USA perspectives. *Climatic Change* 77, pp. 73–95.

Magaña, V. J. L. Pérez y C. Conde. (1998) *El fenómeno de El Niño y la Oscilación del Sur y sus impactos en México*. Revista Ciencias. Julio-septiembre 51. pp. 14-18.

Martín-Vide, J. (2004): Spatial distribution of daily precipitation concentration index in Peninsular Spain. International Journal of Climatology, 24, pp. 959-971.

Mosiño A. P. and E. García, (1966). *Evaluación de la sequía intraestival en la República Mexicana.* Conferencia Regional Latinoamericana, Unión Geográfica Internacional, 3, pp. 500 – 516. Ciudad de México, 9 – 15 de agosto.

Moser, S. (2006) Communicating Climate Change- Motivating Civic Action: An Opportunity for Democratic Renewal? Woodrow Wilson International Center for Scholars. Canada Institute.

Norton, A; Leaman, J. (2004) The Day After Tomorrow: Public Opinion on Climate Change. MORI Social Research Institute. [en línea] <http://www.mori.com/pubinfo/jl/the-day-after-tomorrow.shtml>

Rahmstorf, S. (2007), Response to Comments on "A semi-empirical approach to projecting future sea-level rise". Science, Vol. 317.

Rzedowski*, J. 1993. Diversity and origins of phanerogamic flora of Mexico. En: T.P., Ramamoorthy, R. Bye, A. Lot y J. Fa (Eds.) Biological diversity of Mexico origins and distribution. Oxford University Press, New York. pp.129-144.*

Seager,R., M. Ting, M. Davis, M. Ca Ne, N. Naik, J. Nakamura, C. Li, E. Cook, D. W. Stahle, (2009): *Mexican drought: an observational modeling and tree ring study of variability and climate change*. Atmósfera, Vol. 22, Núm. 1. 2009. pp. 1 – 13.

Stoll-Kleeman, S.; O'Riordan, T.; Jaeger, C. (2001). The psychology of denial concerning climate mitigation measures: evidence from Swiss focus groups. Global Environmental Change 11, i. 2.

Tejeda-Martínez, A., F. Acevedo y E. Jáuregui (1989). *Atlas climático del estado de Veracruz*, Universidad Veracruzana, México, p.

Tejeda-Martínez, A. (coord.), 2009. *Estudios para un Programa Veracruzano ante el Cambio Climático,* Universidad Veracruzana, Instituto Nacional de Ecología, Embajada Británica en México, Centro de Ciencias de la Atmósfera de la UNAM, Instituto de Ecología A. C. y Gobierno del Estado de Veracruz [http://www.instrumentacionelectronica.net/cienciasatmosfericas/].

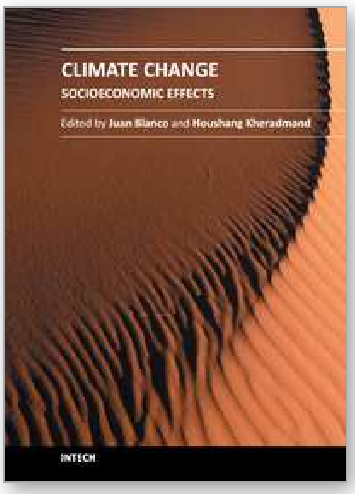
Torres-Alavez, J.A., A. Tejeda Martínez, J. L. Vázquez Aguirre, M. Brunet, P. Hernández Ávila, A. Ruiz Barradas (2010). Índices de cambio climático y análisis de variabilidad en el estado de Veracruz, México, en *Ciudad, clima y ecosistemas* (F. Fernández-García, E. Galán-Gallego y R. Cañada-Torrecilla, editores). Asociación Española de Climatología: 295-304.

Universidad Veracruzana, Instituto Nacional de Ecología, Embajada Británica en México, Centro de Ciencias de la Atmósfera de la UNAM, Instituto de Ecología A.C. y Gobierno del Estado de Veracruz, 2009. *Programa Veracruzano ante el Cambio Climático.*[http://www.instrumentacionelectronica.net/cienciasatmosfericas/]. (Accessed May 2011).

Vázquez-Aguirre, J.L., Brunet M., Jones P. D. (2008). Cambios observados en los extremos climáticos de temperatura y precipitación en el estado de Veracruz, México a partir de datos diarios. VI Congreso Internacional de la Asociación Española de Climatología.

Vázquez-Aguirre, J.L., Brunet M., Jones P. D. (2008). Cambios observados en los extremos climáticos de temperatura y precipitación en el estado de Veracruz, México a partir de datos diarios. En *Cambio climático regional y sus impactos.* J. Sigró-Rodríguez, M. Brunet-India Y E. Aguilar-Anfrons (compiladores), VI Congreso Internacional de la Asociación Española de Climatología. 823 P.: 447-456.

Wang, X. L. y F. Yang. (2007). RhtestV2. User Manual, disponible on-line en: http://cccma.seos.uvic.ca/ETCCDI/software.shtml



Climate Change - Socioeconomic Effects
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This book shows some of the socio-economic impacts of climate change according to different estimates of the current or estimated global warming. A series of scientific and experimental research projects explore the impacts of climate change and browse the techniques to evaluate the related impacts. These 23 chapters provide a good overview of the different changes impacts that already have been detected in several regions of the world. They are part of an introduction to the researches being done around the globe in connection with this topic. However, climate change is not just an academic issue important only to scientists and environmentalists; it also has direct implications on various ecosystems and technologies.

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