Statistical analysis of cyclone hazard for Guadeloupe, Lesser Antilles

Narcisse Zahibo [a,*], Efim Pelinovsky [b,c], Tatiana Talipova [b], Alexander Rabinovich [d], Andrey Kurkin [c], Irina Nikolkina [c]

[a] Département de Physique, Université des Antilles et de la Guyane, Pointe-à-Pitre, France
[b] Department of Nonlinear Processes in Geophysics, Institute of Applied Physics, Nizhny Novgorod, Russia
[c] Applied Mathematics Department, State Technical University, Nizhny Novgorod, Russia
[d] Institute of Oceanology, Moscow, Russia

Abstract

The statistical analysis of the tropical cyclone activity for Guadeloupe (Lesser Antilles, Caribbean Sea) is given. In total, 162 events are selected for period 1635–2000. The number of cyclones in different periods has a large variability. In average, the time interval about 100 years can be considered as stationary one to have the reliability assessment of cyclone hazard. The distribution functions and cumulative frequencies of the cyclones depending on the atmospheric pressure drop and wind speed are calculated. They are used to determine the return period for cyclones with given characteristics (category, atmospheric pressure, and wind speed). The data of the storm-induced surges in the coastal locations of Guadeloupe is collected. It is shown that the surge height increases with increase of the wind speed, but observed data have great dispersion. Numerical simulation of the long water waves induced by the hurricane "Lili" in 2002 is performed; surge heights in Guadeloupe exceed 10 cm.
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1. Introduction

Tropical cyclones are formed over the warm waters of the tropical oceans, mainly in the belt between 20° N and 20° S. In comparison with extra-tropical (continental) cyclones, tropical cyclones are characterized by much smaller size and much higher intensity, i.e. by much higher atmospheric pressure gradients and respective wind speeds (Murty, 1984). Tropical cyclones which sustain maximum wind speeds greater than 33 m/s are known as *typhoons* in the Pacific Ocean and as *hurricanes* in the Atlantic Ocean. Severe hurricanes have maximum wind speeds more than 100 m/s. In an average hurricane, the release of latent heat from the condensation of water vapor provides as much energy as the detonation of 400 20-megaton hydrogen bombs (Davis, 1993). The cyclones induce the storm surges and the evaluation of storm surge hazard for Canada and Bangladesh is actively discussed (Sharma and Murty, 1988; Danard et al., 2003; Rao et al., 2004).

Neumann and Hill (1976) and Neumann et al. (1978) gave detailed tracks and statistics of the tropical cyclones of the North Atlantic Ocean for the period

1871–1977. During this 107-year period, at least 850 tropical cyclones occurred in this region, mainly in the period from June to November (maximum number of these cyclones is related to the end of August–beginning of September). Each year on average, 10 tropical storms (on which 6 become hurricanes) develop over the Atlantic Ocean, Caribbean Sea, or Gulf of Mexico. Many of these remain in the ocean. The deadliest Atlantic tropical cyclones during 1492–1996 are described by Rappaport and Fernandez-Partagas (1997). Various data of tropical storms and hurricanes in the Atlantic can be found in sites (NTC; UNISYS; Hurricanecity) and in papers (Gray and Landsea, 1992; Gray et al., 1993; Gray et al., 1992; Landsea et al., 1992). Recently, Goldenberg et al. (2001) studied the major North Atlantic hurricanes for high and low activity periods, and found the average numbers of major hurricane per year 2.7, 1.5 and 3.8 for the 1944–1970, 1971–1994, 1995–2000 respectively.

Recently Pielke et al. (2003) discussed the hurricane vulnerability in Latin America and the Caribbean after catastrophic Hurricane Mitch killed more than 10,000 people and caused as much as $8.5 billion in damage in Honduras and Nicaragua. The fatalities and destruction caused by Hurricane Mitch were the greatest in at least several decades. The Caribbean Sea basin has a great history of natural disasters; for instance, the Great Hurricane in October 1780 killed about 22,000 people in the Lesser Antilles (Martinique, Barbados). Authors analyze the regional climatology of hurricanes in the Caribbean Sea and point out that hurricane frequency is not constant: in 1968–1991 it was less than in the previous period 1944–1967. Webster et al. (2005) examined the characteristics of tropical cyclones over the past 35 years and concluded that a large increase was seen in the number of hurricanes reaching categories 4 and 5 which has not been accompanied by an increase in the actual intensity of the most intense hurricanes: the maximum intensity remained remarkably static over the past 35 years; and claimed that the smallest percentage increase occurred in the North Atlantic Ocean.

The French West India situated in the Lesser Antilles has a huge experience with tropical cyclones. Tropical cyclones are a very important part of natural disasters and influence all components of life in the French West Indies (Yacou, 1999; Martin, 2002). Saffache et al. (2002, 2003) collected the descriptions of cyclone activity in Martinique and Guadeloupe. In particular, about 160 events occurred in Martinique and Guadeloupe during 1635–1999, and therefore, the mean return period for the cyclones in the French West India is 3–4 years. The very catastrophic cyclone of September 6, 1776 (its category is highest, 5 according to the Saffir–Simpson scale (Simpson, 1974)) killed more than 6000 people in Pointe-á-Pitre Bay (Guadeloupe). In September 17, 1989 the Hugo Hurricane slammed Guadeloupe (the wind speed reached 60 m/s), killing 5, injuring 80 and leaving 11,000 homeless (Duteil, 1999).
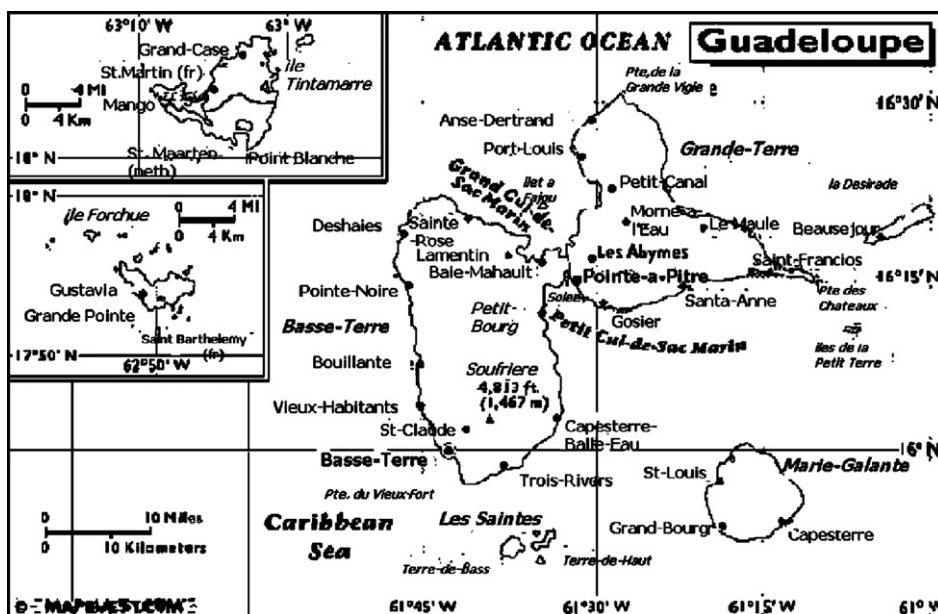

Fig. 1. Chart of the Guadeloupe Department.