



## **Impact of the hurricanes Gustav and Ike in the karst areas of the Viñales National Park, Cuba**

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Among the many natural hazards affecting the island of Cuba, the hydro-meteorological hazards include extreme rainstorms, tropical cyclones and hurricanes. At Cuba, as in the rest of the Caribbean Islands, the cyclonic period generally starts at the beginning of June and ends in late November; during this time period, hurricanes represent the most powerful expression of the tropical cyclones. As shown by historical data, the effects of hurricanes interest the whole island, with a particular focus at its western regions. Intensity of these events causes severe damage to the environment and the society. Hurricanes are classified into five categories according to the Saffir-Simpson Hurricane Scale, essentially on the basis of the velocity reached by the winds. In this scale, category I is the less intense, and V the highest.

In 2008, two strong hurricanes affected the province of Pinar del Rio, in western Cuba, during August and September, with a 10-days interval between the two events. Many effects were produced by the passage of the hurricanes, especially in the karst areas of the Viñales National Park. The first hurricane (named Gustavo) was registered on August 30, 2008. Classified as category IV, it hit the area with wind velocities over 250 km/h, gusts over 300 km/h, and a total rainfall of approximately 100 mm. The hurricane affected the southern slope of the area of mogotes, that is the isolated cone or tower left by intense development of karst processes in tropical climate conditions. The vegetation cover was strongly hit, and largely stripped away, thus exposing several situations of hazards in karst that were previously undetected. Local flooding was also recorded, generally in the lowest topographic areas, and with short duration, due to bedrock characteristics.

Ten days after Gustavo, the second hurricane (named Ike) affected the whole Cuba on September 9, 2008. Even though classified as category I, it caused severe damage to the man-made environment. Winds reached a velocity of 153 km/h, and were accompanied by a total amount of rainfall greater than 300 mm. Among the more remarkable effects, flooding in karst valleys and poljes has to be mentioned, the best examples being Valle de Viñales and Valle de San Vicente. The latter remained inundated for 15 days, due to the drainages located just at the foothills of the limestone ridges, without a well-defined stream and with the swallow holes often clogged by debris and trees. In the Valle de Viñales, on the other hand, the water was absorbed through the allochthonous water course that makes the karst system Palmarito-Novillo, and an estavelle that periodically is active at the footslope of Mogote de Tumbadero. This determined a much shorter permanence of the flooding conditions. The present contribution describes and examines the main impacts produced by the two hurricanes, and the following processes of recovering by the natural environment, with particular regard to the natural hydrologic regulation of the karst systems after these extreme meteorological events.