Introduction

Mexico has terrain features that determine the spatial distribution of air temperature, low-level winds, and precipitation. During the warm season, low to mid-level easterly flow and tropical cyclones (TCs) play a significant role among the weather systems that originate from the western Atlantic or the eastern Pacific basins to bring significant moisture and convective activity. While most TCs develop over open ocean some of them move close to the continent to provide periods of strong winds and heavy rainfall. Eventually, their presence over land may cause property damage as well as loss of human lives. In this study, the best-track dataset compiled by the United States National Hurricane Center (NHC, http://www.nhc.noaa.gov), a disaster database (EM-DAT, http://www.emdat.be), and reports from meteorological stations are used to identify the impact from landfalling TCs.

The Sierra Madre Occidental and Sierra Madre del Sur are the most relevant terrain features. The landfall distribution of TCs that moved onshore through the Pacific coastline from 1970-2010. The highest landfall frequencies are in 1) Baja California Sur, 2) Sinaloa and 3) Oaxaca. Guerrero is ranked in seventh place.

Main results from 1970-2010

- Because of the population density and the human development index, upon TC landfall, there are major differences between impacts from tracks over southern (Oaxaca or Guerrero) versus those moving in northern (in particular, the Baja California peninsula) Mexico.
- Baja California Sur is the state that received most of the long-term impacts due to heavy rainfall. Tropical cyclone Liza, in September of 1976, was the worst landfall event which caused 600 deaths in a single community.
- Knowledge of TC motion, wind intensity, and total rainfall accumulations are useful parameters that go along with the occurrence of property damage and loss of lives. However, our results suggest that there is a lack of a well-defined relationship between TC intensity at landfall and population impact.
- The majority of the top 10 TC-related disasters occurred during El Niño events, followed by neutral conditions. Considering top TC-related extreme rainfall events, El Niño and neutral conditions are more favorable for extreme events inducing to disasters than La Niña as also suggested by Guerrero (Cavazos 2015).

Next, there is a brief description of some case studies with strong impact in Mexico from the 1970-2010 period and from the most recent seasons.

Pauline (October 1997)

Late in the season, this TC affected inhabitants in Oaxaca and Guerrero; this is considered the worst TC-related disaster experienced in the entire west coast of Mexico since 1951.

A representation of three-day rainfall accumulations from Pauline, based on the standard rain-gauge network, shown in Figure a. Accumulations reveal a distinct area around the TC track and north of the coast, in the Sierra Madre del Sur. Heavy precipitation depicts a pattern consistent with the large area of deep convection from geostationary satellite (not shown). The maximum came from a site located 25 km away from the coastline, in the eastern Guerrero foothills, and a couple of additional stations with 300-400 mm accumulations are located around Acapulco. Inspection of daily records reveals that up to 360 mm were collected on October 9 (Fig. b). Stations, within 25 km from Acapulco, reported totals between 200-345 mm and some of them resulted in new records of daily and monthly rainfall since 1972. Within the impact area, Guerrero had 27 out of the 160 available stations setting new records of daily rainfall, while only 17 (out of 105) stations set new records in Oaxaca and none in Michoacán. To provide a long-term perspective, Figure c shows a time series of Acapulco’s monthly accumulations.

Manuel (September 2013)

According to EM-DAT, the TC was associated with 105,000 affected people and 189 killed. This was, mainly, due to heavy rainfall, flash flooding and mudslides over several states in southern Mexico and a secondary landfall in southern Sinaloa. Manuel made a first landfall as tropical storm, experienced slow motion and caused isolated maximal above 500 mm. One station in the Guerrero foothills recorded 315 mm during a single 24-hour period.

While Manuel developed off the Pacific coast, hurricane Ingrid was also active in the southwestern Gulf of Mexico (Cavazos 2015). It is likely that the combination of these hurricanes became a unique situation that provided moist flow and heavy rainfall, especially in the mountainous locations of central and southern Mexico. According to the NHC, Manuel was the first eastern Pacific TC to make landfall in the mainland, to redevelop over water in the southern Gulf of California, and go on to become a (category-one) hurricane, since their records began in 1949.