

Introduction.- Among the ocean basins of the world, the Eastern North Pacific (ENP) is characterized by the largest number of tropical cyclones (TCs) produced per unit area (Blake, 2008). Every year, these cyclones affect the Mexican Pacific coasts, being an important source of freshwater for the region but also with the potential of being catastrophic for the population.

A statistical review of the TCs that made landfall over the Mexican Pacific coasts during the period 1970-2009, for which reliable records of TC tracks and intensity exist based upon high-quality satellite images, is presented. The analysis includes the monthly, seasonal, intraseasonal and interannual variability of TC landfalls, along with their spatial variation and type of TC trajectory.

The genesis location of landfalling TCs is located east of 117.5°W, along a band roughly parallel to the coast, and the largest number is generated between 10°-16°N and 93°-103°W (Fig. 1).

Data.- The National Hurricane Center best track database for the ENP (HURDAT, www.nhc.noaa.gov) is used for the analysis. Geopotential height and wind data from the NCEP/NCAR Reanalysis 1 (www.esrl.noaa.gov/psd) are used to calculate mean and anomaly patterns for different types of TC trajectories.

Table 1. Monthly distribution, annual average, and percentage of TC landfalls over the Mexican Pacific coasts during 1970-2009 according to the maximum intensity reached.

Month	TS	C1	C2	C3	C4	C5	Total	%
May	1	1	2	0	0	0	4	4.1
June	7	4	3	0	0	0	14	14.3
July	2	0	2	1	0	0	5	5.1
August	3	3	1	2	0	0	9	9.2
September	11	8	6	3	7	0	35	35.7
October	4	3	6	5	9	2	29	29.6
November	1	0	1	0	0	0	2	2.0
TOTAL	29	19	21	11	16	2	98	
Annual Average	0.73	0.48	0.53	0.28	0.40	0.05	2.45	
% occurrence	29.6	19.4	21.4	11.2	16.3	2.0		

Table 2. Number of TC landfalls by State and category (see Fig. for location). BCN=Baja California Norte; BCS=Baja California Sur; SIN=Sinaloa; NAY=Nayarit; JAL=Jalisco; SON=Sonora; MICH=Michoacan; GRO=Guerrero; OAX=Oaxaca; CHIS=Chiapas.

State	TS	C1	C2	C3	C4	C5	Total	%
BCN	0	0	1	0	0	0	1	1.0
BCS	7	5	5	6	8	0	31	31.6
SON	0	1	0	0	0	0	1	1.0
SIN	6	3	6	3	4	1	23	23.5
NAY	0	0	0	1	0	1	2	2.0
JAL	1	3	3	0	0	0	7	7.1
COL	2	1	0	1	0	0	4	4.1
MICH	2	0	4	0	2	0	8	8.2
GRO	2	5	1	0	1	0	9	9.2
OAX	8	1	1	0	1	0	11	11.2
CHIS	1	0	0	0	0	0	1	1.0

Table 3. Total number of TC landfalls by State and month.

State/ Month	MAY	JUN	JUL	AUG	SEP	OCT	NOV	TOTAL
BC	0	0	0	0	0	1	0	1
BCS	0	0	1	7	17	6	0	31
SON	0	0	0	0	1	0	0	1
SIN	0	1	0	1	8	13	0	23
NAY	0	0	0	0	0	2	0	2
JAL	1	0	2	1	1	2	0	7
COL	1	1	1	0	0	1	0	4
MICH	1	3	0	0	2	2	0	8
GRO	1	5	0	0	2	1	0	9
OAX	0	3	1	0	4	1	2	11
CHIS	0	1	0	0	0	0	0	1

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Table 4. TC intensity classification according to the ENSO conditions (based on the ONI) that were present at the time of landfall. W=Weak, M=Moderate, S=Strong, N=Neutral.

	TS	C1	C2	C 3	C4	C5	Total
ENW	1	1	2	1	4	0	9
ENM	1	1	2	0	1	1	6
ENS	2	1	4	0	3	1	11
LNW	1	1	1	1	0	0	4
LNM	4	4	2	2	0	0	12
LNS	6	2	2	1	0	0	11
Ν	14	9	8	6	8	0	45
TOTAL	29	19	21	11	16	2	98

According to the Ocean Niño Index (ONI), 45 landfalls occurred in months with neutral conditions; 27 in months affected by La Niña (LN), and 26 by El Niño (EN) (Table 4). Although the total number of landfalls occurring when EN conditions were present is not statistically different from that when LN conditions were present, it can be seen that there is a significant difference regarding the intensity reached by the landfalling TCs, showing that stronger cyclones occurred when EN conditions were present.

Tropical cyclone landfall probabilities and track analysis for the Eastern North Pacific: 1970-2009

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Space-time variability of landing TCs.-The Mexican Pacific state with the largest number of TC hits in the period is Baja California Sur (BCS) with 31.6%, followed by Sinaloa (SIN) with 23.5% (Table 2). Even though the state of Sonora has just one direct TC hit, a considerable number of TCs crosses the Baja California Peninsula reaching the coasts of Sonora (SON) and Sinaloa (see Fig. 2).

The spatial distribution of landfalls has a notable variability along the season; in May-July most of the TCs hit in the center and southeastern states, Jalisco (JAL), Colima (COL), Michoacan (MICH), Guerrero (GRO), Oaxaca (OAX), and Chiapas (CHIS), with 21 up to 23 landings. On the other hand, in the period of August-October most of the landings occurred in the central and northwestern states, BCN, BCS, SON, SIN, NAY, and JAL, with 60 up to 73, but 13 made landing in the southeastern states. November is different since the two observed landings occurred in $50N \frac{24 H}{10}$ OAX (Table 3).

TC track variability.- TC trajectories are different depending on the largescale weather patterns (REFS), some of them follow a northward or northwestward displacement (Type 2) and others recurve to the north or 50N 00 HOUR northeast (Type 1). September and October are characterized by the large number of Type 1 tracks, i.e., those with an initial W-NW displacement and eventually recurving N-NE (Fig. 10N





