Are the socio-economic impacts associated with Tropical Cyclones in Mexico exacerbated by local vulnerability and ENSO conditions?

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What is a tropical cyclone (TC)?

A tropical cyclone is a rotating, organized system of clouds and thunderstorms that originates over tropical or subtropical waters and has a closed low-level circulation. Tropical cyclones rotate counterclockwise in the Northern Hemisphere.

**Saffir-Simpson Scale**

- **Tropical Depression**: maximum sustained winds of 38 mph (33 knots) or less.
- **Tropical Storm**: maximum sustained winds of 39 to 73 mph (34 to 63 knots).
- **Hurricane**: maximum sustained winds of 74 mph (64 knots) or higher.
- **Major Hurricane**: maximum sustained winds of 111 mph (96 knots) or higher, corresponding to a Category 3, 4 or 5 on the Saffir-Simpson Scale.

https://www.nhc.noaa.gov/climo/
Category of tropical cyclones that have made landfall in Mexico during the 1980-2018 period
Mexico is affected by TCs every year

This map shows the tracks of all tropical cyclones in the 2020 Atlantic hurricane season. Last TC = Eta

TCs represent 86% of the annual cost of disasters in Mexico, and the main TC hazard is the extreme rainfall they produced (CENAPRED, 2019)
List of years when the ENSO phase was strong La Niña, neutral conditions, and strong El Niño from May to November during the 1981-2017 period.

| La Niña | Neutral | El Niño |
|---------|---------|---------|
| 1988    | 1981    | 2008    | 1982    |
| 1999    | 1983    | 1993    | 2012    | 1987    |
| 2010    | 1984    | 1996    | 2013    | 1997    |
|         | 1985    | 2001    | 2014    | 2015    |
| 1986    | 2003    |         | 2016    |         |
| 1989    | 2005    |         | 2017    |         |
| 1990    | 2006    |         |         |         |

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The Oceanic Niño Index (ONI) is computed on a three-monthly basis, so we averaged the values from May-June-July to September-October-November per year to define intense episodes of ENSO. Strong El Niño years are years whose anomaly average is equal or higher than +1.0°C, and Strong La Niña years are years whose average is lower or equal to -1.0°C. Twenty years are defined as neutral conditions (from -0.5°C to 0.5°C).
strong El Niño conditions

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Neutral conditions

strong La Niña conditions

An annual average of tropical cyclone density for: (a) strong El Niño years, (c) neutral years, (e) strong La Niña years, and anomalies of tropical cyclone density for: (b) strong El Niño years, (d) neutral years, (f) strong La Niña years during the 1981-2017 period.
Mean accumulated tropical cyclone rainfall (mm) for: (a) strong El Niño years, (d) neutral years, (g) strong La Niña years, mean number of days when tropical cyclones produced extreme precipitation for: (b) strong El Niño conditions, (e) neutral conditions, (h) strong La Niña years, and mean anomalies in tropical cyclone days for: (c) strong El Niño years, (f) neutral years, (i) strong La Niña years during the 1981-2017 period.

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Trends accumulated tropical cyclone rainfall and days when TCs produce extreme precipitation during the 1981-2017 period.

Trends in (a) accumulated tropical cyclone rainfall (mm/year), and (b) days when TCs produce extreme precipitation (days/year) during the 1981-2017 period. The dotted regions indicate a 5% significance level applying the t-test, and striped regions also indicate the same significance level but applying the Mann-Kendall test.
Mean costs of disasters in US million dollars reported by EM-DAT

Disasters during La Niña are the most expensive!

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Mean costs of disasters in US million dollars per administrative state unit reported by EM-DAT for: (a) strong El Niño years, (b) neutral years, and (c) strong La Niña years.
Disasters will be decreased if vulnerability is aimed to be reduced, even when the frequency and intensity of TCs increase in the future

Disaster impacts:
1980-1999 vs. 2000-2019

- Reported disasters: 1980-1999: 4,212, 2000-2019: 7,348
- Total deaths: 1980-1999: 1.19 million, 2000-2019: 1.23 million
- Total affected: 1980-1999: 3.25 billion, 2000-2019: 4.03 billion
- US$ Economic losses: 1980-1999: 1.63 trillion, 2000-2019: 2.97 trillion

UNDRR/CRED 2020
Conclusions

• TCs are critical phenomena that cause ~50% of the extreme precipitation events, mainly over shorelines of the Gulf of Mexico, Caribbean Sea, and Eastern Pacific basin.

• The south and northwest of Mexico have experienced an increase in TC rainfall and TC days.

• Under El Niño conditions, the northeastern and southwestern regions can experience disasters of up to 60 US million dollars. Under neutral conditions, more Mexican states can be affected by TCs when compared to the other ENSO phases, and disasters may occur over the northwest and south of Mexico. Under La Niña conditions, the eastern coast of Mexico undergoes economic losses of up to 100 US million dollars.

• Future early warning systems (EWSs) for TCs will be valuable if a multi-risk approach is considered. New EWSs should include several TC hazards (storm surges, high speed of the wind, translational speed, TC rainfall, and TC size) and social vulnerability at the same time.
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“At the heart of science is an essential balance between two seemingly contradictory attitudes—an openness to new ideas, no matter how bizarre or counterintuitive they may be, and the most ruthless skeptical scrutiny of all ideas, old and new. This is how deep truths are winnowed from deep nonsense”.

Carl Sagan, The Demon-Haunted World: Science as a Candle in the Dark (1997), 304

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