Interannual Variability of Near-Coastal Eastern Pacific Tropical Cyclones

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Introduction:

Pacific tropical cyclones are a significant factor in the summer precipitation regime across southwestern North America. The necessary climatic ingredients for such storms: warm ocean temperatures, modest shear, and incipient disturbances to facilitate cyclogenesis are generally present in the northeastern tropical Pacific during the warm season. Consideration of tropical cyclone activity should therefore be part of more general efforts to improve seasonal prediction of summer rainfall in the North American monsoon region.

Here we describe the interannual variability of tropical storm counts in the eastern North Pacific Ocean. Although individual storms are inherently unpredictable months in advance, it is possible that the aggregate monthly/seasonal storm activity may be predictable. Slow fluctuations of the ocean provide the physical basis for such potential predictability, so we examine the statistics of tropical storm counts for possible modulation by ENSO and decadal oceanic modes of variability.

A companion poster by Ritchie et al. describes the number and synoptic settings of tropical storm remnants that reach the Southwest United States.

Data:

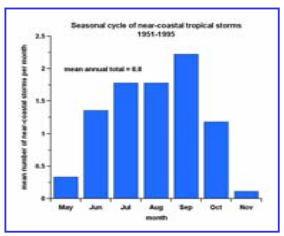
1) Lewis (2003) reconstructed the tracks of tropical storms, including disturbances of depression and cyclone strength, in the northeastern Pacific Ocean since 1921. His census was based on examination of individual storm track data from a variety of U.S. and Mexican data sources. The present study is based on the subset of storms that tracked near the west coast of North America, defined as the region east of 110°W and north of 15°N. The number of such storms each month during the May-November storm season is used as an index of tropical storm activity. The seasonal-interannual variability of near-coastal tropical storm counts is the focus of this study.

2) Monthly near-coastal storm counts are compared with the monthly Niño3 SST index, obtained from the NOAA Climate Prediction Center. Niño3 is the monthly mean near-equatorial SST averaged between 5°S-5°N latitude and 150°W-90°W longitude. Niño3 was chosen to represent ENSO variability for this study, rather than other ENSO indices based on equatorial regions farther west, because Niño3 describes SST directly south of the Mexican coast affected by near-coastal storms.

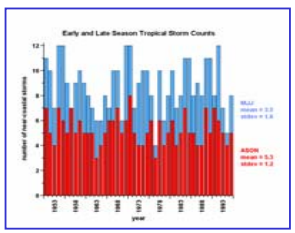
3) To complement and confirm previous results, we will examine the covariability of near-coastal tropical storm counts with the seasonal anomalies of rainfall in subregions of the North American Monsoon domain defined by Gutzler (2004). These subregions were derived from an EOF analysis of summertime interannual rainfall variability across southwest North America.

Interannual fluctuations in the number of tropical storms affecting the west coast of North America are shown to be correlated with ENSO and Pacific decadal variability, during the early months of the tropical storm season.

Seasonal Cycle and Interannual Variability of Eastern Pacific (EP) Near-Coastal Tropical Storms



Average number of near-coastal storms per month along the Pacific coast of North America during the seven-month tropical storm season, as determined by Lewis (2003). The period of record used to derive these statistics is 1951-1995.



Time series of near-coastal tropical storm counts along the Pacific coast of North America. The blue bars on top represent the "Early" phase of the season, defined here as May-Jul (denoted MJJ). Red bars represent the "Late" phase of the storm season, defined here as Aug-Nov (denoted ASON).

Note that the interannual variability of MJJ storm counts is greater than the variability of ASON storm counts, despite the larger mean number of storms in the later months.

Seasonal anomalies in the number of storms in MJJ are not correlated with the number of storms in the subsequent ASON season the same year.

More tropical storms affect the Pacific coast in May-July (MJJ) during La Niña years (when equatorial Pacific Ocean SST is anomalously cold) than during El Niño years.

The difference between La Niña and El Niño years was especially pronounced during the mid-20th Century epoch when cold equatorial ocean temperatures were enhanced, associated with Pacific decadal variability.

Near-coastal tropical storm counts are significantly correlated with summer seasonal rainfall anomalies in the southern part of the North American monsoon domain, as has been shown in previous studies (e.g. Englehart and Douglas 2001).

Circulation differences between MJJ seasons with the most (6) and fewest (0 or 1) storms suggest that ENSO-related, off-equatorial anomalies affect the tracks of tropical storms. Although modest in magnitude, these differences may be potentially predictable.

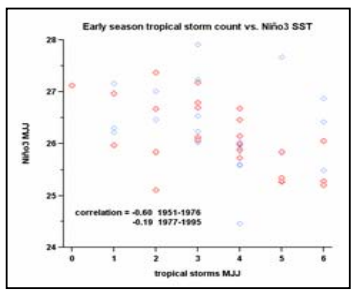
References:

Englehart, P.J., and A.V. Douglas, 2001: The role of eastern North Pacific tropical storms in the rainfall climatology of western Mexico. *Int. J. Climatology*, **21**, 1357-1370.

Gutzler, D.S., 2004: An index of interannual precipitation variability in the core of the North American monsoon region. *J. Climate*, **17**, 4473-4480.

Lewis, M.D., 2003: A comprehensive revision of eastern North Pacific tropical cyclone tracks, 1921-1966. M.S. thesis, Dept. of Atmospheric Sciences, Creighton University, 81 pp. + appendices.

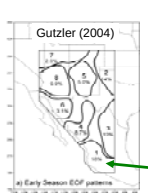
Near-Coastal Tropical Storms, ENSO / PDO, and Continental Precipitation

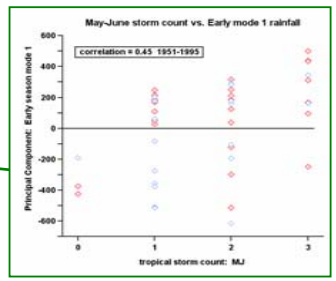


Scatter plot of the annual numbers of near-coastal storms in MJJ vs. contemporaneous Niño3 SST. Data points for 1951-1976 are red crosses; blue diamonds are for years between 1977 and 1995, after the decadal shift to warmer temperatures in the tropical Pacific.

Correlation for the entire period of record is -0.50.

Niño3 is not significantly correlated with tropical storm counts from the later months of the storm season.

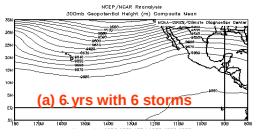


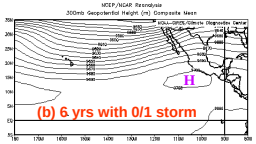


Scatter plot of the annual number of near-coastal storms in May-June vs. principal component of rainfall in coastal states of western Mexico. The rainfall index is derived from an EOF analysis of interannual variability of southwest North American rainfall from May 15-Jul 3 (the "Early" monsoon season defined by Gutzler 2004). Data points for 1951-1976 are red crosses; blue diamonds are for years between 1977 and 1995.

Correlation for the entire period of record is 0.45; this value does not change significantly in association with the 1977 decadal shift.

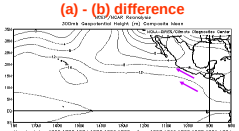
300 hPa heights for MJJ seasons with (a) 6 storms (b) 0 or 1 storm





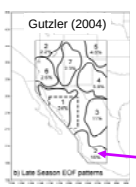
[composites generated using the NOAA/CDC online analysis facility]

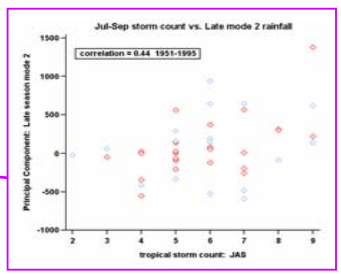
(a) - (b) difference



MJJ seasons with the most near-coastal storms have a stronger along-shore steering flow near the average location of cyclogenesis, near 10°N, 100°W. The High center at 15°N in (b) helps steer tropical storms into the Pacific, away from the coast.

The easterly lower tropospheric flow at 10°N in the far eastern Pacific (not shown) is weaker in the composite for MJJ years with 6 storms compared to the 0/1 storm composite, also consistent with more tracks directed toward the northeast (onto the continent).





Scatter plot of the annual number of near-coastal storms in Jul-Sep vs. principal component of rainfall in coastal states of western Mexico (as above, but for the "Late" monsoon season defined by Gutzler 2004). Data points for 1951-1976 years are red crosses; blue diamonds are for years between 1977 and 1995.

Correlation for the entire period of record is 0.44; this value does not change significantly in association with the 1977 PDO shift.