THE SAN DIEGO HURRICANE OF 2 OCTOBER 1858

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The discovery of a hurricane that directly impacted San Diego, California, nearly 150 yr ago has implications for residents and risk managers in their planning for extreme events for the region.

Tropical cyclones forming in the eastern North Pacific Ocean are occasional visitors to the southwestern United States. By the time these systems travel far enough to the north to bring their associated moisture to the United States, the tropical cyclones have normally diminished below tropical storm strength over Mexico or over the colder waters of the California Current that flows southward along the California coast. Rain, sometimes locally excessive, is frequently observed in many areas of the southwestern United States when tropical cyclone remnants enter the region (Blake 1935; Smith 1986).

Four tropical cyclones have managed to bring tropical storm–force winds to the southwestern United States during the twentieth century: a tropical storm on 25 September 1939 in California, Hurricane Joanne on 6 October 1972 in Arizona, Hurricane Kathleen on 10 September 1976 in California and Arizona, and Hurricane Nora in September 1997 in Arizona. Only the 1939 tropical storm made a direct landfall in coastal California (Smith 1986), because the other three systems entered the United States after first making landfall in Mexico.

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The 1939 tropical storm caused $2 million in property damage in California, mostly to shipping, shore structures, power and communication lines, and crops. Ships in coastal waters of southern California reported southeast winds between 34 and 47 kt (Hurd 1939). However, no tropical cyclones are recorded or estimated to have made landfall in the southwestern United States as a hurricane, with maximum 1-min surface (10 m) winds of at least 64 kt. A list of the documented tropical cyclone remnants to affect the southwestern United States can be found in Smith (1986).

Extreme rain events in the southwestern United States and heavy rains are the most frequent effect of tropical cyclones in the region. High winds and coastal storm–surge and wave action are much less frequent. Smith (1986) states: "The occurrence of sustained winds of even hurricane intensity, 65 kn[ots], is extremely unlikely anywhere in the Southwest."

Recently, the first author discovered the existence of a hurricane at San Diego, California, on 2 October 1858 in newspaper accounts from California. This hurricane is perhaps not unknown to local historians of the area, but its existence has been unknown or apocryphal at best, to the meteorology community until now. The existence of this hurricane and its damaging effects on land are of interest to meteorologists interested in the unique alignment of atmospheric events that brought such a powerful storm so near to land. Property insurers, local governments, and others interested in risk assessment may well find a need to reconsider the risks for a hurricane strike in southern California.

In this paper, we present the newspaper accounts of the storm in southern California. To these reports we add the meteorological observations for the region made by the U.S. Army, U.S. Coast Survey, and private individuals to reconstruct the large-scale synoptic pattern. Damage reports are examined in respect to methods for estimating wind speed from poststorm surveys of the resulting damage caused by tropical cyclones and tornadoes. The merging of all data sources leaves no doubt as to the tropical origin of this storm.

Documentation of a northeast Pacific hurricane to impact San Diego parallels ongoing efforts to reanalyze the Atlantic basin hurricane database (Landsea et al. 2004a). This work seeks to go back in time and to revisit and revise, if necessary, the official tracks and intensities of tropical storms and hurricanes from 1851 to the present. Currently, alterations and additions have been made for the period of 1851–1910, as well as for 1992's Hurricane Andrew (Landsea et al. 2004b).

DATA SOURCES. Data sources include microfilm copies of daily weather observations made by the U.S. Army medical staff at the various army posts throughout the United States (Fleming 1989), microfilm copies of California newspapers, and original U.S. Coast survey notebooks. The U.S. Army and U.S. Coast Survey notebooks are kept at the U.S. National Archives in College Park, Maryland. Newspaper records are held by the U.S. Library of Congress Newspaper Library.

Newspaper accounts from the *Daily Alta California* (San Francisco) and the Los Angeles *Star* provide the

Fig. 1. Location of weather station data and other sites mentioned in newspaper accounts used in this study. All labeled sites are U.S. Army or Smithsonian Institution observers except for Visalia, San Luis Obispo, Santa Barbara, Los Angeles, and San Pedro. (The town of El Monte, immediately east of Los Angeles is not labeled.)

only surviving records. However, the *Daily Alta California* carried press items from other newspapers, including the *San Diego Herald,* providing crucial details on the storm.

Survey notebooks of the U.S. Coast Survey were consulted, but no data for October 1858 were found. Likewise, a check of Comprehensive Ocean–Atmosphere Data Set (COADS) marine data (Woodruff et al. 1987) from the region did not provide any information on the hurricane's origin or subsequent track. Figure 1 depicts a map of the western United States and the location of U.S. Army, and other locations where daily weather observations are available for October 1858.

METHODS. We compiled all available weather data and produced thrice-daily weather maps (0700, 1400, and 2100 LT) for each day from 1 to 3 October 1858. The shipping news from the newspapers and COADS did not provide data with ship positions (newspapers) or data in the region (COADS) so that the analysis is based on land observations only. Data from Mexico are not available except in the southern reaches of the country at Mirador (near Vera Cruz on the Gulf of Mexico coast). Barometric pressure data for Sacramento (38°35′N, 121°28′W), San Francisco (37°48′N, 122°25′W), and New San Diego (32°41′N, 117°13′W) were adjusted for elevation, instrument temperature, and standard gravity (List 1951). These readings should be considered reliable only with a ±2–4 mb uncertainty because metadata are not complete or independently confirmed.[1] Wind-force estimates, based upon visual observations at U.S. Army posts, were made according to a scale included in the printed form used for recording daily weather observations (Table 1). Some caution is required in interpreting these values with reference to modern values. Because the modern definition of wind speed in the United States is based on instrumental 1-min averages, and the methods used in the mid-nineteenth century are unknown, the values cannot be considered equivalent. Additionally, accurate reference frames for wind calibration were not generally available in the mid-nineteenth century. As late as 1890, the highest standard velocity for calibration was 35 mph by whirling machine (Ferguson and Covert 1924). The low frequency of hurricane-force winds also makes it difficult to subjectively estimate wind speed without the aid of instruments.

Table 1. The wind-force scale in use by the U.S. Army (adopted from Smithsonian Institution practices) in 1858. Note the absence of calm winds as a separate category.

1. Very light breeze	2 mph (2 kt)
2. Gentle breeze	4 mph (3 kt)
3. Fresh breeze	12 mph (10 kt)
4. Strong wind	25 mph (22 kt)
5. High wind	35 mph (30 kt)
6. Gale	45 mph (39 kt)
7. Strong gale	60 mph (52 kt)
8. Violent gale	75 mph (65 kt)
9. Hurricane	90 mph (78 kt)
10. Most violent hurricane	100 mph (87 kt)

We use the Saffir–Simpson hurricane scale of wind speed (Saffir 1973; Simpson 1974) and the Fujita scale (Fujita 1971) to equate typical destructive effects of high wind speeds on land to independently estimate the wind speed at San Diego. These estimates take into consideration modifications of Fujita's original system used in more recent research of hurricane damage (Boose et al. 2001). Other weather elements, such as temperature, are given as recorded but, because the temperature readings were made in nonstandard exposures (Chenoweth 1993), there is a potential for a warm bias in daytime temperatures due to radiation reaching unscreened thermometers. At night, these biases are smaller unless artificial heat reaches the instrument.

The general absence of pressure data, and the varied topography of the western United States, makes the daily weather map analysis incomplete but the best possible from available sources. We follow principles of airmass continuity used in modern synoptic surface analysis in the mapping of the weather reports (Carlson 1991).

NEWSPAPER ACCOUNTS. The *San Diego Herald,* as reported in the *Daily Alta California* (13 October 1858), reported

[1] List (1951) is used for the reduction of the mercury column to standard temperature (16.7°C). The attached thermometer readings were from 18° to 27°C, which gives a range of corrections between −3.3 and −4.7 mb. The correction for standard gravity for the latitude of San Diego is between −0.7 and −1.0 mb. These two adjustments overwhelm the positive correction of +0.3 mb for the stated sea level elevation of the station. Because we do not have confirmation if this is the ground or barometer cistern elevation above sea level, along with no information on instrument errors and other basic metadata, we assume a minimum uncertainty of ±2–4 mb in the derived values.

About 11 o'clock A.M. of Saturday, 2d instant, a terrific gale sprung up from the S.S.E. and continued with perfect fury until about 5 P.M., when it somewhat abated, and rain commenced to fall. It blew with such violence, and the air was filled with such dense clouds of dust, that it was impossible to see across the Plaza, and it was with the greatest difficulty that pedestrians could walk the streets. The damage to property was considerable; houses were unroofed and blown down, trees uprooted, and fences destroyed. It is said to have been the severest gale ever witnessed in San Diego.

The schooner *Plutus,* Capt. Vernon, dragged her anchor and went ashore on the beach.
The schooner *Lovely Flora* was also blown high and dry on the beach.
The schooner *X. L.* on the ways, repairing, was blown over and somewhat injured.
The *Clarissa Andrews* and *Teresa* rode out the gale without damage.

So fearful was the gale at Point Loma, the Lighthouse Keeper, Capt. Keating, was obliged to leave at 12 o'clock, M., fearing the tower would fall. No damage, however, was done. The roof of the house of Don Mattias Moreno was blown off, and carried some distance into a neighboring corral, but fortunately no damage was done to the inmates or the furniture of the house.

The portico of the Kiln House, on the south side, was torn down, the roof stripped of its rine covering and the house otherwise materially damaged. Pieces of the heavy roofing were blown several hundred yards away from the building.

The windmill, recently constructed by Mr. Geo. P. Tolman, on Mission Point, was almost entirely demolished, nothing remaining but the shaft and one of the fans. Mr. Tolman's loss is considerable.

The house of Andrew Kriss, on the flat, was completely destroyed. Great damage was also done to the fences and walls of different enclosures in town.

The next day, the *Daily Alta California*'s (14 October 1858) own correspondent in San Diego filed the following report:

One of the most terrific and violent hurricanes that has ever been noticed by the inhabitants of our quiet city, visited us on Saturday the 2d inst., at daylight; the appearance of weather was ominous, and portended a sudden change of some extraordinary character; about 7 1-2 o'clock, A.M., we had a slight shower of rain with the wind from S.S.E. Soon after this I am informed by the gentlemanly keeper of the tide gauge in this place, (who has a very fine and sensitive barometer, furnished him by the government, through those who have charge of the tidal observations), that the barometer went almost immediately down several degrees lower than has ever been known in this vicinity. From this time until 11 1-2 o'clock, A.M., the wind gradually increased, and the whole heavens seemed closing in with bank upon bank of dark, heavy, ominous-looking clouds, fleeting pretty close down to the ground, before the increasing gale. About the time above mentioned several very heavy gusts of wind came driving madly along, completely filling the whole atmosphere with thick and impenetrable clouds of dust and sand, so much so, that one who was in the street could no more see around him than if he was surrounded by an Egyptian darkness; this continued for a considerable length of time, the violence of the wind still increasing, until about one o'clock, when it came along in a perfect hurricane, tearing down houses and everything that was in its way. Roofs of houses, trees, fences, &c., &c., filled the air in all directions, doing a large amount of damage, in and about the city, and its immediate vicinity. From this time until dark a continuance of the above was experienced, interspersed now and then by a crash of some house, tree, fence, or something of the kind; with the sun the wind went down; during the night we had a considerable fall of rain, which made a very pleasant change. The streets, alleys, and roads, from a distance as far as yet heard from, were swept as clean as if a thousand brooms had been laboriously employed for months. The scenes of the next day were unpleasant to witness; persons were standing here and there in groups, discussing and relating the effects of the storm, and the private injuries or losses sustained by them.

The next location to feel the effects of the (diminishing) hurricane was San Pedro (33°43´N, 118°17´W), the port for Los Angeles (34°02´N, 118°14´W). According to the *Los Angeles Star* (9 October 1858),

The rains of the beginning of this week were unaccompanied with heavy winds here, but at San Pedro a regular south-easter came up, doing considerable injury to the small craft anchored in the Bay. We are sorry to say, that Mr. Banning's famous yacht

> "Medora" suffered from the envious winds and waves, whose swiftest course she had frequently outrun. Laying quietly at anchor, they rose in their might against her, drove her from her moorings on to the beach, where they prevailed against her and broke her up, scattering her fragments on the shore. A large barge was also broken up; another, having dragged its anchor a considerable distance, was brought by the anchor fastening against a rock. The wharf at San Pedro was very much injured, a large part of the flooring having been carried away by the violence of the sea.
>
> A large quantity of lumber stored on the beach was floated off by the high tide and the violence of the storm.
>
> The storm of Saturday and Sunday last (October 2 and 3), we understand, was not general. It did not extend far up the coast. It was unknown at San Luis Obispo [35°17´N 120°40´W] and scarcely felt at Santa Barbara [34°28´N 119°51´W].

In a follow-up item, the *Star* (16 October 1858) reported

> The late rains caused very little damage, we have been informed, to the new cutting on the San Fernando hill. A part of the embankment washed off a little, of course, but a hundred dollars will defray the cost of restoring it. The other portions have been improved by the rain.
>
> We understand that Banning's clipper yacht, the famous "Medora", was not utterly demolished by the late storm and that he intends to have it repaired.

At Los Angeles itself, heavy rain was a problem. The *Star* noted (16 October 1858)

> On Saturday morning last, about two o'clock, rain commenced falling, and shortly after became a perfect pour down, continuing all day and night, not clearing off till after daylight on Sunday morning. Such a heavy rain has not been experienced here since last Christmas. The earth soon became thoroughly saturated, and the water poured down from the hill sides, flooding the streets.
>
> Considerable inconvenience was experienced, and some damages sustained, from leaky roofs. Many were roused from their beds by the intrusive shower, and as the visit was rather prolonged, rooms were flooded and the occupants turned out.
>
> We perceive, in various parts of the town, marks of the effects of the storm. The adobe walls have suffered a good deal—some having, fallen down, and others so much injured as to necessitate removal.
>
> The embankment lately erected by the city for the new canal, was so much injured as to prevent the water flowing in the canal.
>
> It was feared that great damage had been sustained by the grape crop, but we are glad to say that the rain caused no injury in this respect
>
> The copious rains will prove most beneficial to the country at large, as farmers will commence ploughing, and be enabled to get in their grain crops in due season—a circumstance which has not occurred for several years.
>
> Already the beneficial effects of the rain are observable everywhere. Indeed, before the clouds had ceased yielding their fructifying showers, the earth, under their genial influence, began to develop its vegetating powers, and now the hills and plains are covered by a carpet of beautiful green.

The *Los Angeles Vineyard* report, carried in the *Daily Alta California* (22 October 1858), reported additional details from the region:

> The storm commenced in Los Angeles at 3 o'clock A.M., on the 2d, and continued with slight intermission for twenty-four hours. At this place there was but little wind during the storm, although in all directions, at only a short distance from the city, the rain was preceded or accompanied with fresh gales.
>
> At the Monte [possibly El Monte, located east of Los Angeles at 34°04´N 118°03´W] the gale was severe, prostrating corn and trees.
>
> At Visalia [36°08´N 119°14´W] about 200 miles N.W. from here, it commenced raining about 3 o'clock A.M., of the 2d, and continued until about 4 P.M., with but little wind. At the Tejon [34°55´N 118°53´W or 34°48´N 118°52´W] the rain continued on the 3d till evening. The quantity of water which fell was unusually great, being estimated by those who had opportunities of judging pretty correctly, at seven inches.
>
> The thermometer had ranged remarkably high at this place for a fortnight previously, frequently going

above 100 in the shade. The nights also were uncommonly warm, the thermometer seldom falling below 70, and for a number of nights remained at 78. Throughout the storm the thermometer was from 75 to 80. Within the past twenty-seven years, which we have been conversant with this locality, there has been no storm, which afforded so much water so early in the autumn. It is worthy of notice that though the wind was blowing a gale at San Diego during this storm, yet the rain did not commence till 5 P.M. on the 2d, whereas the rain began at Los Angeles at 3 A.M. of the same day.

The asymmetric structure to the rainfall may be indicative of a vertically sheared tropical cyclone (with more precipitation found on the downshear side of the system (Rogers et al. 2003) and/or influences of the significant topographical features (and possible downslope drying) on the tropical cyclone.

INSTRUMENTAL OBSERVATIONS. The weather journal kept by the U.S. Army hospital steward, James Mulholland, at New San Diego, provides instrumental data and other observations that support the newspaper accounts. The instrumental observations are included in Table 2. The rapid fall and subsequent rise of the barometer are indicative of a tropical cyclone. The corrected sea level pressure of 29.36 in. (994 mb), along with a southeast wind of force 8 (75 mph in the U.S. Army wind-force scale) at 1400 LT on 2 October, indicate that the hurricane center was nearly due west (~32.5°N, 117.3°W) of San Diego. The continuance of southeast winds until a shift to southwest on 3 October indicates that the hurricane remained offshore and tracked toward the northwest. A peripheral pressure of 994 mb from within a tropical cyclone (but not at the center of lowest pressure) suggests maximum 1-min surface winds of at least 58 kt from a subtropical latitude pressure–wind relationship (Landsea et al. 2004a). This is consistent with visual estimates of hurricane-force winds from the observed at the fort in San Diego. We do not attempt to estimate winds from the gradient pressure because the needed time resolution of pressure data (at least hourly) is not available. Figure 2, taken from a sequence of nine maps (not shown), shows the 1400 LT weather map for 2 October, depicting the hurricane just offshore of San Diego.

Observations obtained from the available U.S. Army posts and Smithsonian Institution observers in the western United States allow for a reconstruction of the synoptic conditions before, during and after the hurricane's impact along the coast. The second half of September 1858 featured persistent Santa Ana winds indicating a ridge of high pressure over the western United States. This ridge began to weaken and retreat at the beginning of October. A cold front passed through the northern parts of California on 1 October. This cold front penetrated as far south as the southern Central Valley. Heavy rains began to fall in the Fresno and Visalia regions on the night of 1–2 October. The *San Francisco Daily Evening Bulletin* (14 October 1858) reported flooding in the region that caused damage to mining interests. The rains did not extend as far north as the Merced River. The rains did reach Santa Barbara where it rained from an early hour on

Table 2. Weather conditions observed at the New San Diego fort on 1–3 Oct 1858. [Note that the 29.50 in. raw barometer reading shown below converted to the 29.36 in. (994 mb) described in the text after adjusting for elevation, instrument temperature, and standard gravity (List 1951).]

	Day/local time								
Weather element	1/0700	1/1400	1/2100	2/0700	2/1400	2/2100	3/0700	3/1400	3/2100
Air temperature	70	82	74	67	74	70	64	73	67
Wind direction	East	Southeast	Southeast	Southeast	Southeast	Southeast	Southeast	Southwest	Southwest
Wind force	1	3	2	3	8	5	2	4	3
Barometer	30.05	30.02	30.01	29.91	29.50	29.79	30.04	30.07	30.10
Barometer temperature	70	81	70	66	74	70	64	72	67
State of sky	Fair	Cloudy	Cloudy	Cloudy	Cloudy	Cloudy	Cloudy	Cloudy	Cloudy

Additional notes: Rain began 1700 LT 2 Oct and ended an unknown time later that night.
Weather remarks for 2 Oct: A great storm, causing the air to be filled with dense clouds of dust, some of the houses were unroofed and blown down, trees uprooted, and fences destroyed.

the morning of 2 October and continued for more than 24 h [*Santa Barbara Gazette,* quoted in the *Daily Alta California* (13 October 1858)]. An area of low pressure apparently formed as a wave on the initial cold front over Nevada and late on 2 October another low pressure area passed over northern California (and probably merged with the Nevada low the next day). The lowest pressures of the month were recorded at both Sacramento and San Francisco on the evening of 2 October. By this time, the remnants of the hurricane were near Los Angeles and moving in a north or northwest direction, indicating that the shortwave trough and its associated low pressure center did not penetrate far enough south to engage the hurricane. The continued presence of light westerly winds at Fort Tejon indicates that the wind field associated with the hurricane did not reach this far north, and this is also indicated by the continuing presence of southeast winds near Los Angeles. The center most likely moved to the northwest, away from San Diego, and weakened, passing near Santa Catalina Island and dissipating. Another possible reason for the hurricane's turn back to the northwest is that as the system decayed over cooler water it may have been steered more by the lower-tropospheric mean flow and that the upper trough's influence was minimized. The estimated portion of the track of the hurricane is indicated in Fig. 2 as best can be reconstructed from available land observations.

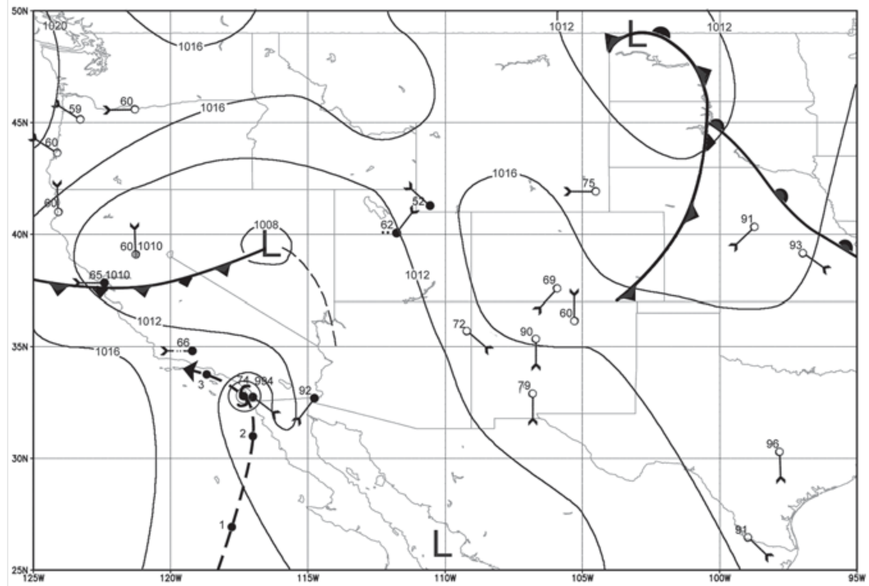

Fig. 2. Weather map for 1400 LT 2 Oct 1858 when the hurricane was probably at its nearest approach to San Diego. Because of apparent inconsistent adherence to the recommended wind force scales by many of the U.S. Army weather observers, the estimated wind speeds were omitted. The thick dashed line indicates the likely track of the hurricane with approximately 1200 UTC positions shown.

WINDS IMPLIED BY DAMAGE REPORTS. The damage reports are consistent with a category-1 hurricane (Saffir 1973; Simpson 1974) and F1 and F2 Fujita scale damage (Fujita 1971). The San Diego tide data remain unlocated. Damage reports do not explicitly mention a storm surge (except at San Pedro), although ships were driven ashore. The complete destruction of many homes and the blowing down of trees is consistent with F1/F2 damage, indicating winds of 50–68 kt. The wind speed estimate at 1400 LT in the New San Diego weather record of 75 mph is consistent with the press reports in both magnitude and timing. The period of high winds, approximately from 1300 to 1700 LT, is unusual for this region and likely to cause destruction if building practices were based on an expectation of no such violent winds. The construction material of the damaged and destroyed homes is not given. However, the rine roof of the Kiln House, mentioned in the *Herald*'s account, suggests a well-constructed building. Following Boose et al. (2001), we assign F1 damage to the blowing down of trees and F2 damage to the many homes and buildings that were unroofed and destroyed. We assume that the more substantial buildings were only unroofed, and weaker structures completely destroyed. The F2 damage was probably done by the higher gusts during the hurricane, accompanied with structural weakening due to the 4 h of high winds. The account of ships being driven ashore, the visually estimated winds, and structural damages from winds are all consistent with a category-1 hurricane impact in San Diego.

Damage was widespread but not quantified into a dollar amount in the newspaper accounts, though San Diego was a small settlement at the time; the countywide population in 1860 was only 4325. Today, the population in San Diego County is over 2.9 million. By way of a comparison, the 1939 tropical storm at Long Beach on 25 September produced $2 million in damage at that time. Adjusted for inflation, population in the region (9.5 million in the 2000 U.S. Census versus only 2.8 million in 1940) and wealth (Pielke and Landsea 1998), the 1939 storm would cause roughly $200 million in damages in 2004.

With the type of destruction observed in 1939 from a tropical storm, the potential for even greater losses today in a landfalling hurricane like the 1858 event is higher because tropical cyclone damage tends to increase exponentially with wind speed. Today, if a category-1 hurricane made a direct landfall in either San Diego or Los Angeles, damage from such a storm would likely be on the order of a few to several hundred million dollars.

CONCLUSIONS. The only tropical cyclone known to produce estimated hurricane-force winds on the California coast affected San Diego on 2 October 1858. Wind damage was largely confined to coastal areas but heavy rains were felt inland and produced some flooding. The path of the storm exposed the entire coastline from San Diego north to the Long Beach area to estimated tropical storm–force winds. This path has more destructive potential than the 1939 tropical storm that struck a much more limited section of the coastline.

The wind speeds and pressure data for the 1858 hurricane in San Diego are impressive when compared with the official records for the city. From 1871 to 2002, the maximum 1-min wind speed is 49 kt from the southeast on 29 January 1980. The lowest sea level pressure on record at San Diego is 995 mb, measured in March 1983. However, these were from wintertime extratropical storm systems. During the May–November Northeast Pacific hurricane season, the highest 1-min winds ever measured in San Diego were 41 kt on 25 September 1939 (during the Long Beach tropical storm) and the lowest pressure was 1000 mb in November 1919 and September 1927. Thus, having sustained category-1 hurricane winds (~70 kt) and 994-mb pressure are unprecedented in San Diego. No evidence exists suggesting comparable or stronger winds in U.S. Army records dating back to 1849. The *Daily Alta California* (14 October 1858) description of "one of the most terrific and violent hurricanes ever noted" might be taken as evidence of another undiscovered hurricane. However, the memories of persons are unreliable and extratropical storms may be included in this assessment. Also, another newspaper account did describe the storm as the worst in San Diego history.

The risk of a hurricane in southern California is now documented to be real. Smith (1986) doubted the likelihood of such an event but mentioned that if it happened it would require several oceanic and atmospheric features. "The southern California coast south of Point Conception could conceivably experience a minimal hurricane if SSTs rose to about 24°C in the Pacific from Baja California west to 120°W and north to about 33°N and the hurricane moved onshore fast enough to avoid weakening. . . ." Our analysis suggests two possible scenarios. In the first, a mid- to upper-level anticyclone probably steered the hurricane to the north and northwest and that the deep trough and embedded cold front to the north did not penetrate far enough south to carry it inland. The second involves a greater steering by the lower-tropospheric mean flow, with minimal impact by the upper-level trough. In either event, the hurricane drifted to the northwest and filled over the waters of southern California.

Many years with tropical cyclone remnants reaching the southwest United States are El Niño years (Kimberlain 1999). During these years SSTs rise along the western coast of Mexico and the United States, thus, allowing tropical cyclones heading toward the region to maintain intensity longer than usual. Corals from the tropical Pacific indicate that 1858 was a warmer year than either 1857 or 1859 (Cole et al. 2002), but there is no firm historical documentation of an El Niño event that year (Ortleib 2000).

As we completed the first version of this article, the Atlantic basin's first documented tropical storm in the month of April formed south of Bermuda. As the paper was being edited for final submission, Brazil was struck by the first documented South Atlantic hurricane in recorded history. These are yet additional reminders that if we wait long enough, or dig deep enough in archives, that more surprises are in store to challenge our assumptions about the frequency, seasonality, and location of tropical cyclones. The implication of this current work is that a hurricane has directly impacted southern California in recorded history and, under the right circumstances, will again hit the region. One recent system had the potential to duplicate the track and impact of the 1858 hurricane. Hurricane Linda of 1997, during a strong El Niño event was forecast by the National Hurricane Center for a couple of advisories to make landfall near San Diego as a minimal hurricane or strong tropical storm (Lawrence 1999). Fortunately, this storm weakened and turned back to the open Pacific Ocean without impacting land. Residents, business owners, the insurance industry, local emergency managers and decision makers and Federal Emergency Management Association (FEMA) should take note of the meteorological curiosity of the 1858 San Diego hurricane and not be surprised when such an event occurs again to threaten lives and causes hundreds of millions of dollars in damage.

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