HURRICANE WITH A HISTORY

Hawaiian Newspapers Illuminate an 1871 Storm

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How 114 years of Hawaiian-language newspapers starting in 1834 extend our knowledge of natural disasters into the nineteenth century and to precontact times.

On 9 August 1871 a major hurricane struck the islands of Hawaii and Maui and wrought widespread destruction from Hilo to Lahaina (Figs. 1 and 2). This paper presents a detective story of how Hawaiian-language newspapers proved instrumental in determining the extent and the severity of the hurricane damage and tracing the likely path of the storm. The existence of such a powerful hurricane, uncovered in the historical record, has significant consequences for assessing the hurricane risk faced by the people of Hawaii today. More broadly, the citizens of the Hawaiian Islands documented the impact of weather and climate on their lives and livelihoods through Hawaiian language newspapers and thereby left a fascinating and important archive for scientists and historians interested in understanding the history of climate patterns such as El Niño and La Niña and high-impact events such as hurricanes, droughts, and floods during the nineteenth and early twentieth centuries.

From 1834 to 1948 over 125,000 pages of Hawaiian language print were published in more than a hundred independent newspapers (Fig. 3). These newspapers became an intentional repository of knowledge, opinion, and historical progress as Hawaii moved through kingdom, constitutional monarchy, republic, and territory. This newspaper archive comprises more than a million typescript pages of text—the largest native-language cache in the Western Hemisphere, yet only a small fraction of that archive (~2% as of this writing) has been made available to the English-speaking world today.

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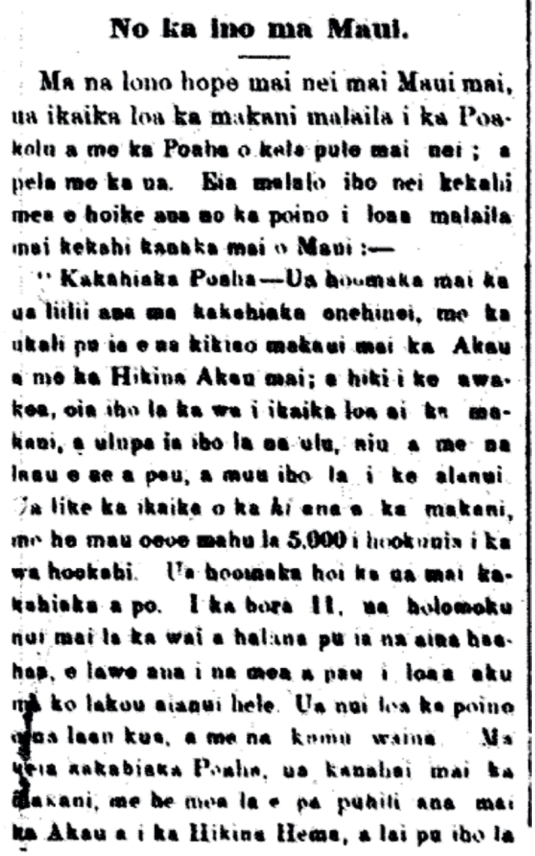
THE HAWAIIAN NEWSPAPER ENTERPRISE. This section briefly explores the history of Hawaiian-language newspapers to provide context for the meteorological analyses that follow. The reader can elect to skip to the “Back to the Hawaii hurricane of 1871” section to return to meteorological topics. How and why did the Hawaiian people generate such a large newspaper enterprise, eventually publishing over a hundred independent newspapers, so shortly after Christian missionaries first set foot in Hawaii? It



No ka ino ma Maui.

Ma na lono hope mai nei mai Maui mai, ua ikaika loa ka makani malaila i ka Poakolu a me ka Poaha o keia pule mai nei; a pela me ka ua. Eia malalo iho nei kekahi mea e hoike ana no ka poino i loaa malaila mai kekahi kanaka mai o Maui :—

" Kakahiaka Poaha—Ua hoomaka mai ka ua liilii ana ma kakahiaka onehinei, me ka ukali pu ia e na kikiao makani mai ka Akau a me ka Hikina Akau mai; a hiki i ke awakea, oia iho la ka wa i ikaika loa ai ka makani, a ulupa ia iho la na ulu, niu a me na laau e ae a pau, a moe iho la i ke alanui. Ua like ka ikaika o ka ki ana a ka makani, me he mau oeoe mahu la 5,000 i hookanis i ka wa hookahi. Ua hoomaka hoi ka ua mai kakahiaka a po. I ka hora 11, ua holomoku nui mai la ka wai a halana pu ia na aina haahaa, e lawe ana i na mea a pau i loaa aku ma ko lakou alanui hele. Ua nui loa ka poino o na laau koa, a me na kumu waina. Ma keia kakahiaka Poaha, ua kanahai mai ka makani, me he mea la e pa puhili ana mai ka Akau a i ka Hikina Hema, a lai pu iho la

"It started lightly raining from yesterday morning, followed by the gusting winds from the North and Northeast; until the early afternoon, when the wind became really strong, and all of the breadfruits, coconuts, and other plants were destroyed, broken in the roadway. The streaming of the wind was similar to 5000 steam whistles set off at one time. The rain continued from morning till night. At 11 'o clock, the waters rushed swiftly and the lowlands were flooded, sweeping everything that was in their paths. The damages were great concerning the koa trees and the grapevines. On Thursday, the wind lessened, and it seemed to be veering from the North towards the Southeast and it calmed down by 5 o'clock in the evening."

Fig. 1. Excerpt from the Hawaiian-language newspaper *Ke Au Okoa* published on 24 Aug 1871, with English translation.

may seem natural to credit the missionaries. However, the story of literacy in Hawaii is more nuanced; otherwise, rapid, widespread literacy and large numbers of newspapers would have arisen wherever missionaries went, and that is not the case.

The missionaries initially arrived in Kailua, Hawaii, on 30 March 1820, just after the passing in 1819 of Kamehameha I, the first monarch to unite the Hawaiian Islands. His son, Kamehameha II (Liholiho), debated with his royal council before allowing the missionaries to stay. The young king understood that the missionaries wanted to teach and that among their cargo they had a printing press. The king gave them permission to stay for one year, insisting that they first teach the aliʻi (royalty) to read and write. The missionaries agreed to the king's terms, and instruction in English began soon thereafter.

Included in the initial group of students was the second son of Kamehameha I, Kauikeaouli (Kamehameha III). After one year of English instruction several gifted Hawaiians learned to read and write in English well enough to teach their peers. The same process was used to put spoken Hawaiian into written form. First to be printed, in 1822, was an alphabet book and elementary reading primer in the Hawaiian language (ʻōlelo Hawaiʻi) (Fig. 4).

Contrary to popular supposition, missionaries did not generate the Hawaiian orthography. Rather it was a collaborative effort with literate Hawaiians of the time who deserve equal credit for that accomplishment (Laimana 2011). The innovation of Hawaiian orthography enabled a second innovation, Hawaiian-language printing, a technology that supported a transformative cultural shift across the archipelago to universal schooling and text literacy within a decade. These critical social innovations in knowledge conservation and transmission were adopted by the kingdom at a time of extremely rapid cultural change as Hawaii entered the global arena.

Literacy rates rose from near zero in 1820 to between 90% and 95% by midcentury. This astonishing and celebrated rise occurred in a single generation from the time the first book was printed. As the newly literate 12-year-old King Kamehameha III proudly declared when he came to the throne in 1825, "He aupuni palapala koʻu"—"Mine shall be a kingdom of literacy"

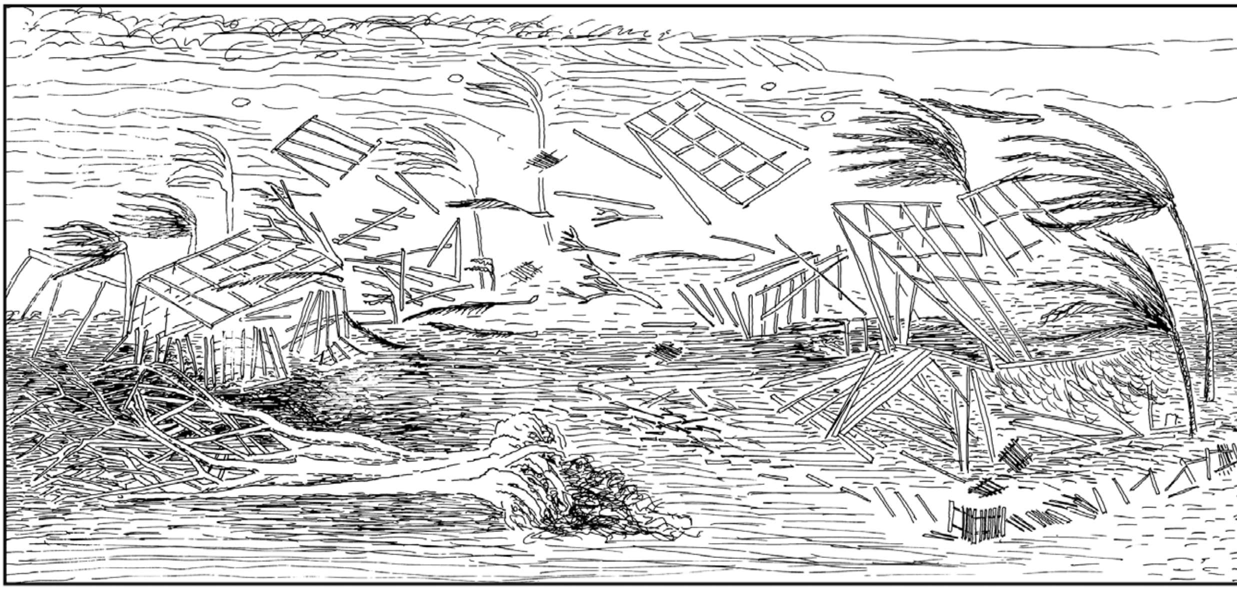


Fig. 2. Artist's rendering of the destruction and mayhem visited on a Hawaiian compound during the Hawaii hurricane of 1871.

(Fig. 5). His call for national literacy was strongly advocated by the aliʻi, and by 1831, the royal government financed all infrastructure costs for 1,103 schoolhouses and furnished them with teachers. There was a rapid national embrace of literacy, with over 60,000 spelling primers (pīʻāpā) in circulation in 1825. A year later, more than 1.5 million pages of text had been printed and distributed to a population of less than 200,000. By 1830, 400,000 books, tracts, or pamphlets had been printed, suggesting that most of the Hawaiian population old enough to read and write were actively doing so.

During this period, 182,000 Hawaiians lived in 1,103 districts on the eight major Hawaiian islands, and books and reading materials of every kind were in great demand. Hawaiian-language newspapers filled much of the demand for reading material, conveying current events in the wider world, commentary on events in the archipelago, and compilations of cultural knowledge that preceded western contact (Chapin 2000).

Fig. 3. In Feb 1834, the first edition of *Ka Lama Hawaiʻi* was printed at Lahainaluna School on Maui, the first newspaper and first school west of the Rocky Mountains. Among other content, each weekly issue presented readers with stories and images of the great animals of the world.

THE ALPHABET.

VOWELS. Names.	SOUND. Ex. in Eng.	Ex. in Hawaii.
A a ....â	as in *father*,	la—sun.
E e ....a	— *tele*,	hemo—cast off.
I i ....e	— *marine*,	marie—quiet.
O o ....o	— *over*,	ono—sweet.
U u ....oo	—*rule*,	nui—large.

CONSONANTS.	Names.	CONSONANTS.	Names.
B b	be	N n	nu
D d	de	P p	pi
H h	he	R r	ro
K k	ke	T t	ti
L l	la	V v	vi
M m	mu	W w	we

The following are used in spelling foreign words:

F f	fe	S s	se
G g	ge	Y y	yi

1

Fig. 4. The first published book in 1822, the pīʻāpā, presented the Hawaiian-language alphabet and served as the first educational reading and writing lesson book.

Hawaiian newspapers allowed readers to respond to the writings of Hawaiian scholars, leading to academic discourse full of public opinion, challenges, additions, and disagreements. By the midnineteenth century, newspapers encouraged their readership to submit content for the papers. Combined with reports on weather, volcanic activity, and other observations of the natural world that underscore the importance of close observation in Hawaiian culture, Hawaiian newspapers served dual functions as repositories of ancestral knowledge and conveyors of the latest news and events.

In 1893, a cabal of wealthy locals backed by U.S. troops staged an overthrow of Queen Liliʻuokalani and Hawaii's monarchial government. The new regime passed a law in 1896 mandating English as the language of instruction in all schools that ensured the decline of oral and written Hawaiian. The last Hawaiian-language newspaper, *Ka Hoku o Hawaii*, ceased publication in 1948 owing to lack of readership, but over 114 years an estimated 125,000 pages written by native speakers created a massive repository of Hawaiian text (Nogelmeier 2010).

HAWAIIAN NEWSPAPERS AS A RESOURCE FOR SCIENCE AND CULTURE.

Newspapers in Europe and America, with some exceptions, typically conveyed business and daily news, while more serious scholarly work was reserved for books or journals. In contrast, Hawaiian-language newspapers were the center of both current affairs and academic discourse. Much of the intellectual production was a conscious effort to preserve oral traditions and conserve knowledge as foreign diseases and cultural change rapidly reduced the numbers of experts and elders who held this knowledge. Readers shared specific bodies of knowledge, such as the techniques of making nets, twine, or cloth from native plants or the names of the winds of a certain ahupuaʻa. Ahupuaʻa is a Hawaiian land division, usually extending from the uplands to the sea that facilitated sustainable agriculture and aquaculture. Scholars contributed epics of Hawaiian literature, such as that of the volcano goddess, Pele, who in her chant for her lover, Lohiʻau, names all of the winds of Kauaʻi to prove that she is not a stranger to the island. Another epic, *The Wind Gourd of Laʻamaomao* (*Ka Ipu Makani O Laʻamaomao*), weaves hundreds of wind names associated with each of the Hawaiian Islands throughout its narrative (Fig. 6). Epics served to map indigenous knowledge, recording locations, names, and characteristics of winds, rains, and other natural phenomena.

One of the coauthors of this paper has worked on several dynamic projects[1] to convert Hawaiian-language newspapers to word-searchable digital format and to open up this resource for general online access.[2] Puakea Nogelmeier's vision has helped to conserve Hawaiian language of the past and is opening a window on the historical record that has been long overlooked in Hawaii. Doak Cox, a Hawaii-born geoscientist at the University of Hawaiʻi at Mānoa (UHM), was among the first to examine Hawaiian newspapers with an eye

[1] Puakea Nogelmeier, School of Hawaiian Knowledge (Hawaiʻinuiākea), helped initiate Hoʻolaupaʻi (Generate Abundance), ʻIke Kūʻokoʻa (Liberating Knowledge), Awaiaulu (Unify), and the Institute for Hawaiian Language Research and Translation.

[2] Link for access to the Hawaiian-language newspaper database: www.papakilodatabase.com/main/main.php.

to expand historic and precontact records of geoscience events (Lao and Miller 2004). Recognizing the value of Hawaiian newspapers as sources of data for the day-to-day events of interest to Native Hawaiians, Thomas Schroeder, former director of the Joint Institute for Marine and Atmospheric Research (JIMAR) at UHM, provided funds to Nogelmeier and his graduate students to extend Cox's efforts. They produced a digital database of more than 4,000 articles related to meteorology and geology (Nee-Benham et al. 2012). Mark Merrifield, JIMAR's current director, and Dr. Businger have continued to support the effort to search Hawaiian-language newspapers for articles relating to geophysical events, including floods, droughts, high surf, storms, landslides, earthquakes, tsunamis, and volcanic eruptions. The goal of the ongoing work is to extend our understanding of geoscience back into historical, postcontact, and precontact times to project and prepare for future events.

Once the database of translated articles relating to geophysical events became available in 2010, the late Dr. Isabella Aiona Abbott, a Native Hawaiian scientist familiar with Puakea Nogelmeier's project, met with Pauline Chinn and Nogelmeier to explore the synergy of using the new online resource in secondary education. Chinn and Nogelmeier collaborated with Thomas Schroeder, Steven Businger, and Scott Rowland of the School of Earth Science and Technology to create Kahua Aʻo, A Learning Foundation, which uses Hawaiian-language newspaper articles in place- and culture-based geoscience education and curriculum development (Chinn et al. 2014). With support from the National Science Foundation, Kahua Aʻo has developed a series of Earth science, technology, engineering, and mathematics (STEM) lessons with activities[3] that teachers find particularly relevant to their Native Hawaiian and culturally diverse students.

Fig. 5. King Kamehameha III (Kauikeaouli) (1813–54), king from 1825 to 1854.

Historical reports of droughts and floods and the ENSO cycle. Hawaii is located relatively close to the center of action of ENSO;[4] therefore, its effects are strongly felt here (Chu and Chen 2005). While planning a Kahua Aʻo lesson exploring the ENSO phenomenon, we wondered if nineteenth-century Hawaiian-language newspaper articles could provide insight into the occurrence of droughts and floods in Hawaii and their relation to ENSO, long before this phenomenon was known to western science. Dr. Businger and student Kelly Lance collected references to droughts, floods, and heavy rains in Hawaiian language newspapers and compared the results to a 30-yr record of El Niño and La Niña events in the nineteenth century. This record of events has been reconstructed using proxy datasets, such as tree rings and ice cores in areas outside of Hawaii but known to be sensitive to ENSO cycles (McGregor et al. 2010).

The number of articles from 1869 to 1900 reporting on droughts and floods in the Oahu newspaper *Ka Nupepa Kuokoa* were tallied. The number of articles was normalized by the number of *Kuokoa* issues published per month so that it more accurately reflected differences in weather rather than changes in the number of newspapers issued (Fig. 7). The analysis shows that the normalized number of droughts per month during El Niño years is 0.536, whereas during La Niña years it is 0.157. The normalized number of heavy rains per month is 0.305 during El Niño years and 1.1 during La Niña years. These results are statistically significant (Student's *t* test) and suggest that

[3] Access to the Kahua Aʻo STEM lessons is available at http://manoa.hawaii.edu/kahuaao/index.html.

[4] El Niño–Southern Oscillation (ENSO) is an atmospheric circulation change caused by irregular, periodic anomalies in sea surface temperatures (SSTs) over the equatorial Pacific Ocean that has nearly global impact (Rasmusson and Carpenter 1982). Warm anomalies in the equatorial central Pacific are referred to as El Niño, whereas cold anomalies are called La Niña, representing the two extremes in the ENSO cycle.

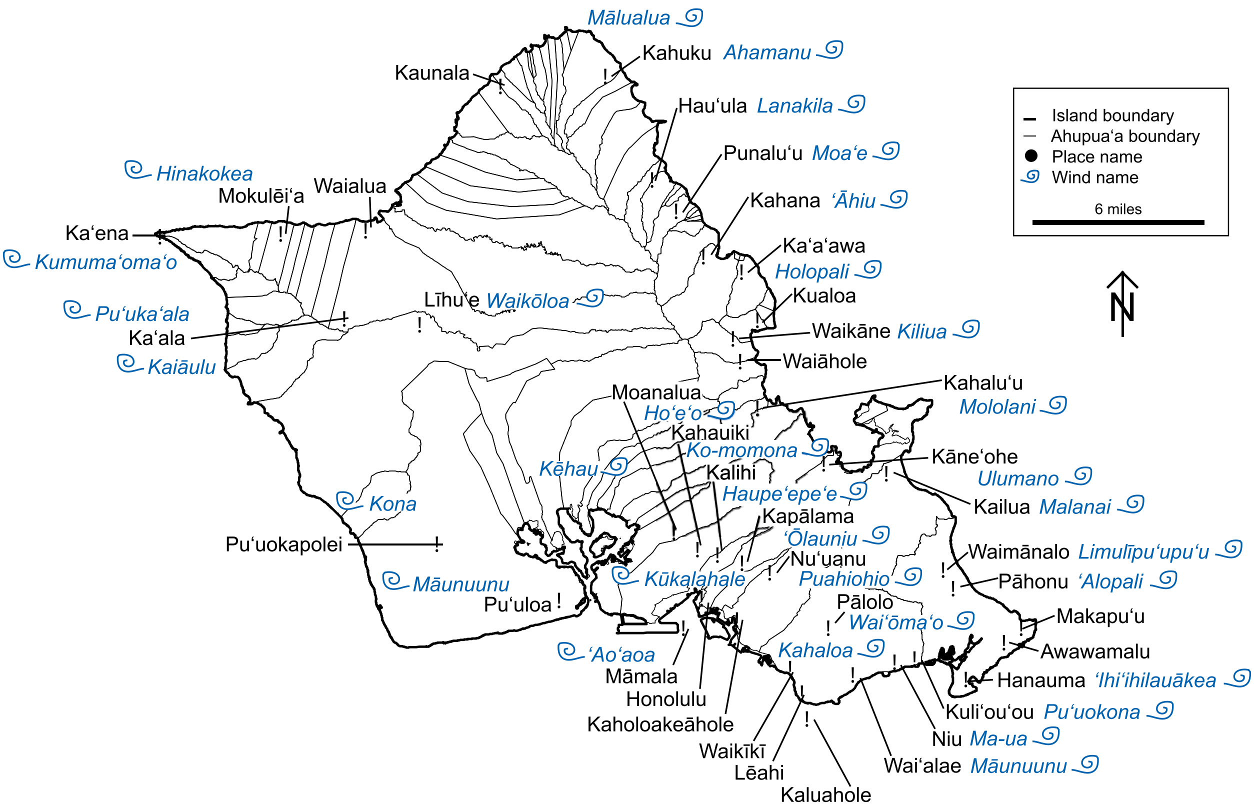


Fig. 6. Wind map of Oahu from *The Wind Gourd of Laʻamaomao*, adapted from Nakuina (1902).

more droughts and fewer heavy rains accompany El Niño events. In contrast, there are fewer droughts and more heavy rain events during La Niña years. This finding is consistent with the relationship between ENSO and Hawaiian rainfall described in the peer-reviewed literature (e.g., Chu and Chen 2005). In addition, it is significant that El Niño events with the most drought references (the years 1868, 1877, and 1888 in Fig. 7) were all years that were categorized as "very strong" events in the El Niño proxy reconstructed by Gergis and Fowler (2009).

BACK TO THE HAWAII HURRICANE OF 1871. To provide some context regarding the importance of the 1871 hurricane in risk analysis, a short review of recent hurricane impact in Hawaii may be useful. On 11 September 1992 Hurricane Iniki scored a direct hit on the island of Kauaʻi. Over a period of only 3 hours, the category 4 hurricane (on the Saffir–Simpson hurricane wind scale; Simpson 1974) caused damage equivalent to the total general fund budget of the state of Hawaii at that time and wiped out the historical profits of the Hawaii homeowners insurance industry. Economic impacts were felt even a decade after the event. There is much the public can do at modest cost to mitigate the damage in advance of hurricanes (hurricane clips to keep the roof from blowing off, storm shutters to protect windows, etc.). Insurance risk models begin projecting property losses as winds hit 40 miles per hour (mph; 1 mph = 0.45 $m\ s^{-1}$). However, a major obstacle to overcome is public complacency. It had been over a century since a major hurricane struck the islands of Hawaii or Maui, and the historical record was largely unknown to government and the public, so the general assumption was that especially Hawaii was "immune."

On 9 August 1871 a category 3 hurricane struck both islands, Hawaii and Maui, leaving tornado-like destruction in its wake. While only minimal reference was extant in English sources (Shaw 1981), and a check of twentieth-century reanalysis data (e.g., Truchelut and Hart 2011) did not reveal any hint of the system, the JIMAR database brought to light that this event was well documented in the Hawaiian newspapers,[5] which allowed the track and intensity of the storm as it crossed the islands to be well estimated (Fig. 8). Although there have been previous notable efforts to analyze the historical record of tropical cyclones (e.g., McAdie et al. 2009), to the best of the authors' knowledge this analysis is the first to rely

[5] The 17 Hawaiian-language newspaper articles referenced in the development of this paper are available here: ftp://ftp.soest.hawaii.edu/businger/outgoing/Hawaiian_Newspaper_Articles.

on a written record from an indigenous population. Hawaiian newspaper articles include the following accounts from eyewitnesses. On the island of Hawaii, the hurricane first struck the Hāmākua coast and Waipiʻo valley. The following is from a reader's letter from Waipiʻo dated 16 August 1871:

> At about 7 or 8 AM it commenced to blow and it lasted for about an hour and a half, blowing right up the valley. There were 28 houses blown clean away and many more partially destroyed. There is hardly a tree or bush of any kind standing in the valley (*Pacific Commercial Advertiser* on 19 August 1871).

An eyewitness from Kohala on Hawaii Island wrote the following:

> The greatest fury was say from 9 to 9:30 or 9:45, torrents of rain came with it. The district is swept as with the besom of destruction. About 150 houses were blown down. A mango tree was snapped as a pipe stem, just above the surface of the ground. Old solid Kukui trees, which had stood the storms of a score of years were torn up and pitched about like chaff. Dr. Wright's mill and sugarhouse, the trash and manager's residence, were all strewn over the ground (*Ke Au Okoa* on 24 August 1871).

On Maui, newspaper reports document that Hāna, Wailuku, and Lahaina were particularly hard-hit. A writer in Hāna described the storm:

> Then the strong, fierce presence of the wind and rain finally came, and the simple Hawaiian houses and the wooden houses of the residents here in Hāna were knocked down. They were overturned and moved by the strength of that which hears not when spoken to (*Ka Nupepa Kuokoa* on 26 August 1871).

In Wailuku the bridge was destroyed: "the bridge turned like a ship overturned by the carpenters, and it was like a mast-less ship on an unlucky sail" (*Ka Nupepa Kuokoa* on 19 August 1871). From Lahaina came the following report:

> It commenced lightly on Tuesday night, with a gentle breeze, up to daylight on Wednesday, when the rain began to pour in proportion, from the westward, veering round to all points, becoming a perfect hurricane, thrashing and crashing among the trees and shrubbery, while the streams and fishponds overflowed and the land was flooded (*Pacific Commercial Advertiser* on 19 August 1871).

Guard and Lander (1999) developed a scale relating tropical cyclone wind speed to resulting damage to structures and vegetation. Their work was undertaken on the island of Guam, which is no stranger to strong typhoons and, like Hawaii, has some terrain. For a category 3 typhoon, with sustained winds of between 111 and 129 mph, Guard and Lander (1999) provide the following description regarding damage to vegetation: "Major damage to shrubbery and trees; up to 50% of palm fronds bent or blown off; numerous ripe and many green coconuts blown off coconut palms; crowns blown off of a few palm trees; up to 10% of coconut palms blown down. Some large trees {palm trees [*Cocos nucifera* (1)], breadfruit [*Artocarpus spp.* (9)], monkeypod [*Samanea saman* (7)], mango [*Mangifera indica* (9)], acacia [*Acacia spp.* (8)], and Australian pines [*Casuarina spp.* (5)]} blown down when the ground becomes saturated; 30%–50% defoliation of many trees and shrubs; up to 70% defoliation of tangantangan [*Leucaena spp.* (4)]. Some very exposed panax [*Polyscias spp.* (11)], tangantangan [*Leucaena spp.* (4)], and oleander [*Nerium oleander* (11)] bent over. Overall damage can be classified as extensive." In addition, for a category 4 typhoon they state the following: "Extensive damage to non-concrete roofs; complete failure of many roof structures, window frames and doors, especially unprotected, non-reinforced ones; many well-built wooden and metal structures severely damaged or destroyed." A study of the strength of the building stock in 1871 is beyond the scope of this paper, but the newspaper accounts suggest that the damage caused by the storm to traditional Hawaiian homes was greater than would be expected for more sturdy New England–style wooden homes.

Hawaiian-language newspaper accounts quoted above and other accounts[6] not quoted in this paper suggest damage to vegetation and structures from a category 3 or perhaps a category 4 hurricane impacting Hawaii in August of 1871. The Saffir–Simpson hurricane wind scale was developed over Florida, where terrain effects are minimal (Simpson 1974). Wind accelerations because of terrain were well documented on Kauai following Hurricane Iniki (NOAA 1993), and similar terrain acceleration of the winds occur on Hawaii and Maui islands (Chambers 2008). Therefore, we are choosing the more conservative category 3 designation for the 1871 hurricane.

[6] All of the Hawaiian-language newspaper articles and the excerpt on the 1871 hurricane from Shaw (1981) that were used in this paper are available at the following FTP link: ftp://ftp.soest.hawaii.edu/businger/outgoing/Hawaiian_Newspaper_Articles.

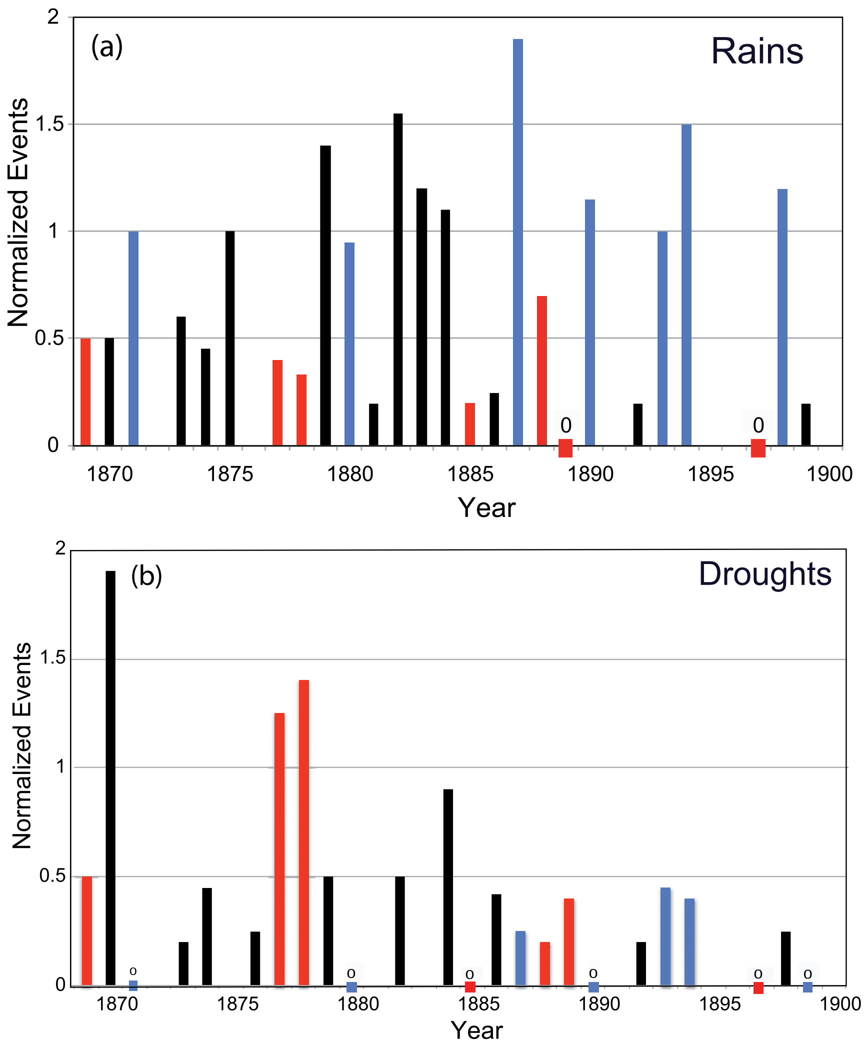


Fig. 7. Histograms of the number of Hawaiian-language newspaper reports of (a) heavy rain and (b) drought events between 1869 and 1900 normalized by the number of *Ka Nupepa Kuokoa* issues published per month. Red bars indicate El Niño, blue La Niña, and black neutral. Years based on the ENSO proxy of McGregor et al. (2010).

observations that the 1871 hurricane was a compact storm, similar to Iniki. Iniki caused devastating winds on Kauai but very little impact in Honolulu, save for sultry weather and an enhanced south swell that caused some coastal damage on the Waiʻanae coast of Oahu (NOAA 1993). The track and small core of the 1871 hurricane help explain in part why Kohala and Lahaina experienced extensive damage, whereas Kona only received a steady rain and Honolulu reported no damaging winds or rains from the close passage of a tropical cyclone. Reports published in Honolulu during the time of the 1871 hurricane's passage noted sultry weather with relatively light winds. Such conditions are consistent with a small storm tracking just north of Oahu. It is also reasonable to suggest that the storm was weakening as a result of both terrain disruptions of the storm's circulation by Maui and the Island of Hawaii and possibly moving into unfavorable environmental wind shear, which is the climatological norm in the vicinity of Hawaii (Kodama and Businger 1998).

The well-described timing of changes in wind speed and direction and the swath of greatest destruction in the Hawaiian-language accounts allowed us to reconstruct the path of the core of the 1871 Hawaii hurricane (Fig. 8). For example, when a hurricane approaches from the east, the winds first increase from the north and northeast, and then as the storm passes the winds become southeasterly, as was observed in Lahaina, Maui, in the translation provided in Fig. 1. The motion of the core of the storm, as inferred from the observations, indicates that the storm was traveling at a rate of ~25–30 mph, with the strongest winds on the right side of the track causing devastation first in Waipiʻo and then followed in succession by Kohala, Hāna, and Lahaina (Fig. 8). One can also surmise from the

A major hurricane in the tropics generally propagates no faster than 20 mph. A propagation speed of 30 mph and a track turning northerly in time (Fig. 8) suggests that the 1871 hurricane was under the influence of increasing steering flow that was turning more southerly with time as an associated upper-level trough approached from the west. Such conditions also attended Hurricane Iniki, which made a sweeping northward turn to make landfall on Kauai while traveling northward at ~30 mph. Sadler (1976) documented that a tropical upper-tropospheric trough (TUTT) can provide favorable upper-level venting for tropical cyclones that can strengthen mature hurricanes or maintain their strength under the dissipating

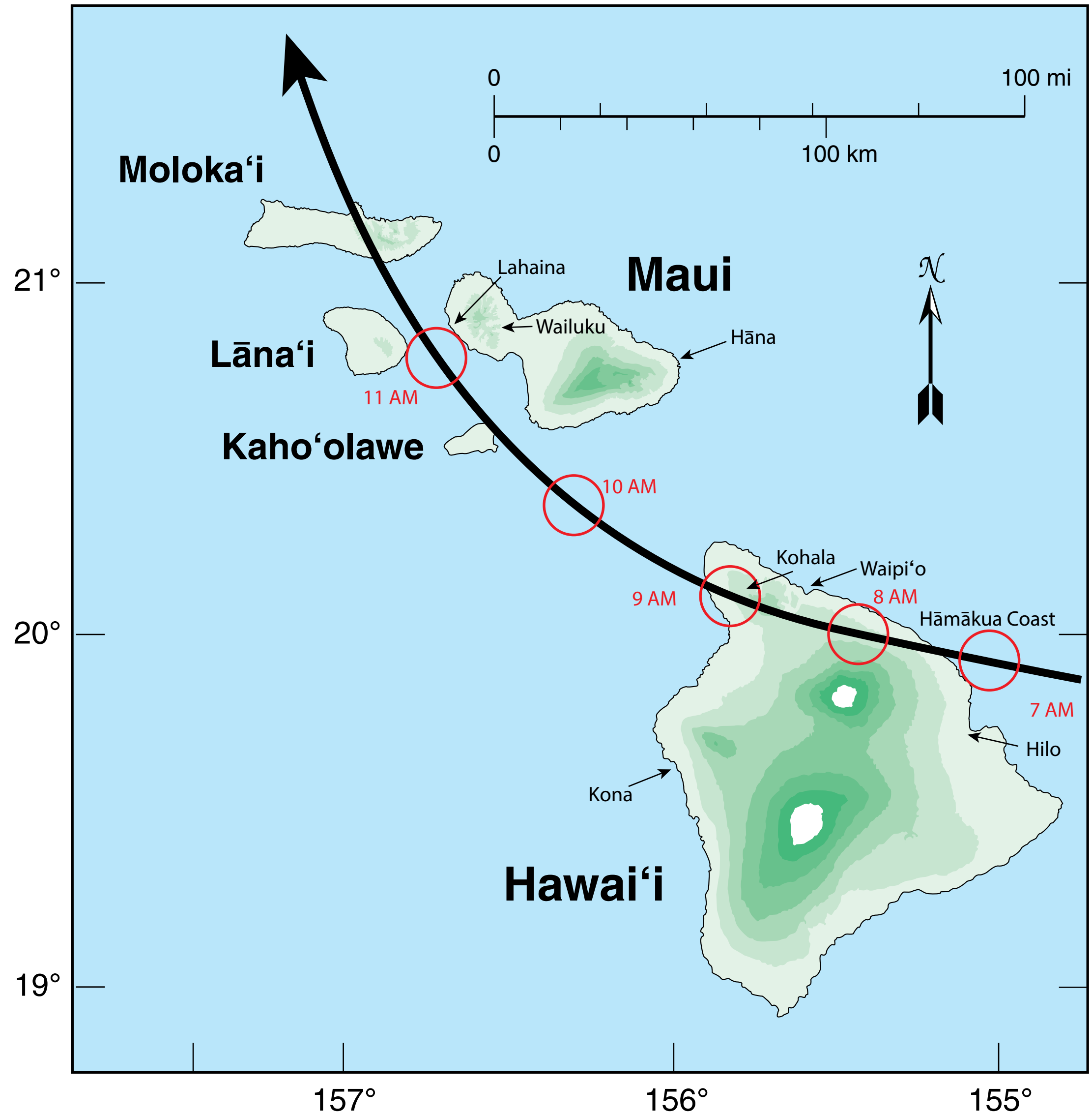


Fig. 8. Map showing the reconstructed track of the Hawaii hurricane across the eastern islands of Hawaii and Maui on 9 Aug 1871. Labeled red circles indicate the approximate time and location of the core of the storm. Green shading shows terrain altitude every 2,000 ft (610 m).

influence of cooler water, such as is climatologically observed to the west of the island of Hawaii.

Since 1871, only two strong hurricanes have made landfall in Hawaii. Therefore, it is hard to generalize about the expected behavior of such storms. Hurricane climatology shows that hurricanes are rare in the central Pacific in the vicinity of Hawaii, in part because of unfavorable wind shear over the area and in part because monsoon-trough conditions conducive to cyclogenesis are absent in the central tropical North Pacific. Moreover, Hawaii presents a rather small target. Monte Carlo hurricane track simulations based on the historic hurricane track record and undertaken for the hurricane insurance industry show that the island of Hawaii is actually the most likely island in the state to be impacted by a landfalling hurricane on an easterly track.

The observational evidence is convincing that the 1871 hurricane approached from the east or southeast, impacting Waipi'o, Kohala, Hāna, and then Lahaina. No other track explains the damage that was reported. If the track were from the south, the Kona coast would have been heavily impacted by wind, but there were only reports of heavy rain in Kona. If the storm had crossed directly over the highest peaks of Maunaloa or Maunakea, the storm would not have produced the levels of damage reported on Maui (see Chambers 2008). Hurricane Iselle threatened the island of Hawaii as a hurricane and made landfall on the Puna coast of the island of Hawaii in August of

2014 as a weakening tropical storm. The large volcanoes significantly disrupted its circulation so that it was barely a tropical depression as it passed westward following the encounter. However, the more northerly track of the 1871 hurricane would have allowed it to skirt the north side of Maunakea, with part of its circulation remaining over water and the rest tracking over the lower Kohala range.

No one living in Hawaii today witnessed the destruction visited on the islands of Hawaii and Maui in the 1870s. As a result of this long absence of hurricane impacts, a number of myths have arisen such as "the volcanoes protect us," "only Kauai gets hit," or "there is no Hawaiian word for hurricane." This last is not a surprise because words such as hurricane and typhoon arise from local words for the winds observed. It is noteworthy that David Malo (1843, unpublished manuscript) defined five different levels of the kona winds. We also note that there is no Hawaiian word for tsunami.

These misconceptions led a state senator from the island of Hawaii to repeatedly introduce legislation to eliminate hurricane insurance and reduce building code requirements for that island. In addition, politicians from Hawaii and Maui submitted legislation that would have required that all natural hazard risk analyses in Hawaii be limited to 1881 and later. This cutoff date would have eliminated the Hawaii hurricane of 1871, the Wood Valley earthquake of 1868, and the 1880 Maunaloa lava flow that entered Hilo. It is important to note that there would be much greater destruction if a storm of similar intensity and track were to occur today. Fortunately, the Hawaiian-language newspaper articles written by citizens who would not consider themselves geologists or meteorologists provide a body of credible, eyewitness evidence to inform public policy and impede such uninformed efforts.

SUMMARY AND DISCUSSION. The Hawaiian newspaper accounts enlighten us unequivocally that a hurricane on the right track with the right steering flow will pass directly over portions of the islands of Hawaii and Maui, as if the high volcanoes are just an obstacle course, leaving a wake of destruction as it did in 1871. Tropical Storm Iselle brought considerable damage to the Puna district of the island of Hawaii in 2014, confirming the point that the volcanic mountains do not protect the island from direct impact by tropical storms (Chambers 2008). It is a fact that there is a real threat of hurricane landfall for all the islands of Hawaii, including Oahu. Access to a digital archive of Hawaiian newspaper articles has helped us to better define that threat. The digital archive has also provided evidence that the frequency of floods and droughts in Hawaii responded to nineteenth-century ENSO cycles much as they do today.

Although this article has largely focused on the occurrence of hurricanes, droughts, and floods in Hawaii in the 1800s, it illustrates the far-reaching potential of the Hawaiian newspaper archive for research, education, and policy. Other natural disasters such as volcanic eruptions, lava flows, earthquakes, and tsunamis are currently being explored, and the results will likely provide more fascinating insights. Researchers and educators are studying the impacts of introduced plants and animals on island ecosystems and changes in cultural and economic practices through the writings of nineteenth-century Hawaiian citizens. The frequency of snow reported on the upper slopes of Maunaloa, Maunakea, and Haleakalā in the 1800s can be investigated as a proxy for global warming.

The Hawaiian-language newspaper archive is now fully digitized and publicly available through the Office of Hawaiian Affairs *Papakilo Database* (www.papakilodatabase.com), and translated articles, along with links to other repository resources, are available through the University of Hawai'i's system-wide Institute of Hawaiian Language Research and Translation (http://ihlrt.seagrant.soest.hawaii.edu/). These resources enable anyone to explore a range of questions to gain historical data and unique Hawaiian perspectives relevant to many fields. As the work of translation progresses, the fraction of Hawaiian newspapers readily accessible to researchers steadily grows.

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