

La Niña Came to Eden

Michael J. McPhaden and Christina Karamperidou

ABSTRACT: In July 1929, Dr Friedrich Ritter and Dore Strauch left their spouses and the turmoil of post–World War I Germany for the remote, uninhabited, and rugged volcanic island of Floreana in the Galapagos archipelago. Their dream was to live self-sufficiently in an idyllic tropical setting unspoiled by civilization. Wealthy yachters stopping at Floreana in the early 1930s reported on the couple’s pioneering enterprise to the outside world. The news created a sensation that subsequently attracted other settlers, including a mysterious Viennese faux baroness who quickly sowed discord on the island. Not all the participants in this drama survived though. A prolonged drought gripped the island from 1933 to 1935 leading to food shortages that ultimately claimed the life of Dr. Ritter, a vegetarian who unwittingly ate tainted chicken out of desperation. The bizarre intrigues and struggles to endure on Floreana were chronicled in Dore Strauch’s 1936 memoir *Satan Came to Eden* and a 2013 Hollywood documentary based on it. A story that has not been told is how an extended period of cold La Niña conditions in 1933–35 led to the drought that caused the food shortages. We use an atmospheric reanalysis and other data sources to describe these cold conditions and how they affected the human drama that unfolded on Floreana Island. The protracted La Niña impacted other parts of the globe and in particular was a major influence on development of the 1930s Dust Bowl in the southern plains of the United States.

KEYWORDS: ENSO; La Nina; Ocean circulation; Drought; Air-sea interaction

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In July 1929, Dr. Friedrich Ritter and his mistress Dore Strauch (Fig. 1) left their spouses and the turmoil of post–World War I Germany for the remote, uninhabited, and rugged volcanic island of Floreana in the Galapagos archipelago (Fig. 2). Disdainful of modern society that he viewed as overly materialistic and disillusioned by the economic, political, and cultural upheavals in the wake of the Great War, Ritter wanted to “flee the beaten paths of man, put aside all the irrelevant trappings of civilization, and seek a solitude where I could at last live wholly and completely in contemplation and communion with nature” (Ritter 1931a). In Dore Strauch he found a soulmate and together they meticulously planned to escape from their homeland for what they hoped would be a more fulfilling life in an idyllic setting.

They chose the Galapagos as their destination, inspired by the naturalist and explorer William Beebe’s best-selling book *Galapagos, World’s End* (Beebe 1924). Beebe’s account of the history, geology, flora, and fauna was comprehensive, richly illustrated, and filled with information of practical value. He noted for example that “January to April is the chief period when the rain falls,” an important detail when considering the cultivation of rain-fed crops, which Ritter and Strauch would depend on for their vegetarian diets. Geographically, the Galapagos appealed to Ritter and Strauch not only because of its isolation 600 miles to the west of Ecuador, but also because of its tropical climate. As Ritter noted, “I had decided that we must go to the tropics, because in my German home the winter extends through three quarters of the year and it rains during half of the summer . . . *I needed a climate as unchangeable as possible. The Galapagos Islands satisfied this condition perfectly* [italics added]” (Ritter 1931a).



Fig. 1. Friedrich Ritter and Dore Strauch in 1932 aboard the yacht *Valero III* owned by G. Allan Hancock, with Floreana Island in the background. From the Hancock Pacific-Galapagos Expeditions Smithsonian Institution Archives. Image SIA2011-1147.



Fig. 2. Map of the Galapagos Islands showing the Spanish and, in parentheses, English names of the islands. The inset shows the Galapagos in relation to South America.

Ritter and Strauch understood that they would face many challenges in uprooting their lives and relocating to a distant foreign land, but they were undaunted. Dr. Ritter was a disciple of the philosopher Friedrich Nietzsche and subscribed to Nietzsche's Übermensch theory that one could overcome any obstacle, no matter how extreme, by sheer force of willpower. So, with much effort in the face of extraordinary hardship, they established a rudimentary homestead in the wild and untamed interior of Floreana Island. They called their new home "Friedo," a combination of their given names and also an evocation of "Frieden," the German word for "peace."

Wealthy yachtsmen stopping at the Floreana Island in the early 1930s met and befriended Friedrich and Dore, reporting on their pioneering enterprise to the outside world. The news of this eccentric couple, going "entirely without clothes, like the original Adam and Eve in the first earthly paradise" (Ritter 1931b), created a sensation. To their dismay, the publicity subsequently attracted a small number of other settlers to the island whom they viewed as intruders on their private sanctuary in paradise. One of these was a mysterious gun-toting faux Viennese baroness, Eloise Wagner de Bousquet, and her two German lovers, Robert Philippson and Rudolf Lorenz. Her goal was to establish a hotel catering to wealthy American tourists, which she named "Hotel Paradiso." Arrogant, belligerent, and manipulative, the baroness acted as if she owned the island and from the start vexed Ritter, Strauch, and other new settlers to the point of open hostility. Strauch said of the baroness, "I felt as Eve must have felt on learning that the serpent was the Evil One" [Strauch (1936) 2014]. The bizarre intrigues, extraordinary adventures, and struggles to survive on the harsh and remote volcanic island were the inspiration for Dore Strauch's 1936 memoir *Satan Came to Eden* and a 2013 Hollywood documentary based on it entitled *The Galapagos Affair: Satan Came to Eden*.

Not all the participants in this drama survived the experience of colonizing Floreana Island though. A prolonged and devastating drought gripped the island from 1933 to 1935, laying

waste to Ritter and Strauch's vegetable garden. Native fruit trees withered and livestock died of thirst and starvation. As Dore said, "The spring, that was the source of life to Friedo, ceased to flow . . . the rains were months overdue . . . the island was strewn with the carcasses of those the drought had killed" [Strauch (1936) 2014].

In the midst of the drought, the baroness and Philippson disappeared and were never seen again. According to Strauch, they were murdered. Given the acrimony between the baroness and the other settlers, they were all suspects in the eyes of the Ecuadorian authorities—especially Lorenz who was jilted by the baroness when their relationship soured. Lorenz, eager to leave the island, sold off the belongings the baroness left behind at the Hotel Paradiso to the other settlers and used the funds to book passage on a small motor yacht that departed Floreana in July 1934 bound for nearby San Cristobal Island. However, Lorenz and the ship's captain, Trygve Nuggerud, never made it to San Cristobal; they were found dead four months later in November 1934 on desolate and uninhabited Marchena Island located 150 km to the north of Floreana. Their desiccated bodies lay on a beach where they had died of thirst.

Dr. Ritter would soon meet his end as well. Faced with a scarcity of food as the drought wore on, Ritter and Strauch, avowed vegetarians, ate tainted chicken out of desperation. Ritter perished in agonizing pain after only two days, on 24 November 1934, presumably from botulism (Treherne 1983). As he lay dying, he reportedly said "that it would be very funny indeed if he as a vegetarian was going to die of meat poisoning" (Wittmer 1989).

A story that has not been told, and the subject of this article, is the role that climate variability, and in particular, La Niña,¹ played in the Galapagos Affair. We will show, using reconstructed sea surface temperatures (SSTs), the Twentieth Century Reanalysis (Compo et al. 2011), and other data sources, that an extended period of cold La Niña conditions existed during 1933–35 in the tropical Pacific. La Niña is associated with stronger-than-normal trade winds, unusually cold SSTs, and exceptionally dry atmospheric conditions in the eastern equatorial Pacific (McPhaden et al. 2021a). Around the Galapagos in particular, the rains fail in the normal wet season from January to April during La Niña events because the inter-tropical convergence zone (ITCZ), a rainband situated on average north of the equator where the northeast and southeast trade winds collide, does not migrate southward as part of its normal seasonal cycle (Mitchell and Wallace 1992). This seasonal migration is mediated by underlying SSTs which are warmest along the equator early in the calendar year—except during La Niña when enhanced upwelling of cold thermocline water cools the surface enough to fend off the ITCZ.

¹ La Niña is Spanish for "the girl" and is used to describe the cold phase of the El Niño–Southern Oscillation (ENSO) cycle. Its counterpart, El Niño, which means "the boy" in reference to the Christ child, refers to the warm phase of the ENSO cycle.

It is not surprising that contemporary accounts from this period make no mention of La Niña as a cause of the drought since it was only decades later that Bjerknes (1966, 1969) provided the modern conceptual framework for understanding the nature of year-to-year climate variations originating in the Pacific basin. Prior to Bjerknes, El Niño was thought to be a local oceanic warming mainly confined to the coastal zone of Ecuador and Peru (Adamson 2019). He showed instead that El Niño affected the entire Pacific basin, arising through a reinforcing feedback loop between the atmosphere and ocean that involved weakening trade winds and warming equatorial SSTs (now referred to as the "Bjerknes feedback"). Weakening trade winds were linked to variations in the Southern Oscillation, a fluctuation in surface air pressure between the Eastern and Western Hemispheres first described by Sir Gilbert Walker in the early twentieth century (Walker 1924; Walker and Bliss 1932). Rasmusson and Wallace (1983) introduced the term El Niño–Southern Oscillation (ENSO) to underscore this coupling between the ocean and the atmosphere in the context of 1982/83 El Niño which, as the strongest El Niño of the twentieth century up to that time, wrought havoc on weather systems around the globe (Canby 1984). It was soon realized though that unusually cold SSTs in the equatorial Pacific could

have devastating climatic impacts comparable to those of warm anomalies, as highlighted by the extreme drought that affected the U.S. Midwest in the summer of 1988 (Trenberth et al. 1988). The cold phase of ENSO was subsequently dubbed “La Niña” (Philander 1990).

With the hindsight of research advances over the past 60 years, we will now revisit the Galapagos Affair to describe the environmental conditions the settlers experienced in the early 1930s. Contrary to Ritter’s mistaken assumption, the climate of the Galapagos Islands is not perfectly constant from one year to the next and the variations that occur have significant consequences. We will see how the ENSO cycle, especially the La Niña conditions that prevailed in 1933–35, influenced the human drama that unfolded on Floreana Island.

Data and methods

The data sources used in this study include fields from version 3 of the Twentieth Century Reanalysis (20CR; Compo et al. 2011), which is based on a global atmosphere–land weather forecast model that assimilates only surface air pressure, with SST and sea ice concentrations as a first-guess lower boundary condition. The 20CR uses an ensemble Kalman filter for data assimilation to produce an ensemble of 56 analyses at 6-hourly intervals on a 1° latitude $\times$ 1° longitude grid from January 1836 to December 2015. We present ensemble means of these analyses to describe ENSO variability in the Pacific as it relates to the Galapagos Affair. We will also comment on the ensemble spread, which provides a measure of uncertainty in the 20CR.

The SST product used as a first-guess boundary condition in the reanalysis is the Hadley Centre Global Sea Ice and Sea Surface Temperature (HadISST; Rayner et al. 2003). It consists of monthly averages on a 1° latitude $\times$ 1° longitude grid from 1871 to the present derived from optimal interpolation of available ship and buoy data. HadISST is similar to, but not exactly equal to, the SST output of the 20CR because of the ensemble Kalman filtering methodology used in the reanalysis. To help characterize SST variability and its uncertainty, we also make use of the Extended Reconstructed Sea Surface Temperature, version 5 (ERSSTv5; Huang et al. 2017), which is a monthly SST product on a 2° latitude $\times$ 2° longitude grid available from 1854 to the present. Monthly anomalies for the reanalysis and the SST products were computed relative to a contemporaneous 30-yr (1921–50) climatology encompassing the 1930s. Using a climatology appropriate to the current era (e.g., 1991–2020) to compute year-to-year anomalies in the 1930s would alias long-term warming trends related to climate change into the analyses, biasing representation of earlier climate variability.

We also use monthly average rainfall data for Seba, Indonesia (10.5°S , 121.9°E), from October 1918 to December 1975 and Guayaquil, Ecuador (2.2°S , 79.9°W), from January 1915 to December 2000 obtained from the NOAA National Climatic Data Center (NCDC) Global Historical Climatology Network (GHCN). Guayaquil, 1,000 km to the east of the Galapagos, is the closest station we could find to Floreana with data going back at least to the 1930s. As with other datasets, we computed rainfall anomalies relative to a 1921–50 climatology.

Finally, we use data from the Global Precipitation Climatology Project (GPCP) version 2.3 (Adler et al. 2018) to help characterize rainfall variability in the vicinity of the Galapagos in the current era. These data are monthly values on a 2.5° latitude $\times$ 2.5° longitude grid based on the analysis of rain gauge and satellite estimates from 1979 to the present.

For indices of ENSO cycle variability, we compute areal average SST anomalies in the Niño-1+2 (0° – 10°S , 80° – 90°W), Niño-3 (5°N – 5°S , 90° – 150°W), Niño-3.4 (5°N – 5°S , 120° – 170°W), and Niño-4 (5°N – 5°S , 150°W – 160°E) regions (Fig. 3). These regions capture variability close to the South American coast (Niño-1+2), in the eastern Pacific equatorial cold tongue (Niño-3), and in the western Pacific warm pool (Niño-4). The Niño-3.4 region overlaps with the Niño-3 and Niño-4 and is most highly correlated with remote global climate impacts related to ENSO (Barnston et al. 1997).

By the standards of the twenty-first century Global Climate Observing System (<https://gcoss.wmo.int/>), data in the tropical Pacific during the 1930s were relatively sparse and mostly limited to in situ surface measurements along a few heavily traveled shipping routes (e.g., Deser et al. 2010). Thus, SST analyses and atmospheric reanalyses from this era will not be as accurate as during later periods when data were more abundant, like for example during the satellite era for Earth observations that began around 1980. However, we have confidence in the patterns of variability that we observe for a variety of reasons. First, there is general agreement between the three different SST products in the character of early 1930s ENSO variability, with differences between the products typically a few tenths of a °C (Fig. 3b and Fig. S1 in the online supplemental material; <https://doi.org/10.1175/BAMS-D-21-0343.2>), which smaller than the 0.5°C threshold for detection ENSO events. The only exception is in the Niño-1+2 region where differences at times can approach 1°C (Fig. 3b). Second, the SST ensemble spread from the 56 members of the 20CR dataset in the tropical Pacific during the 1930s is generally also less than 0.5°C, which is again below the threshold typically used

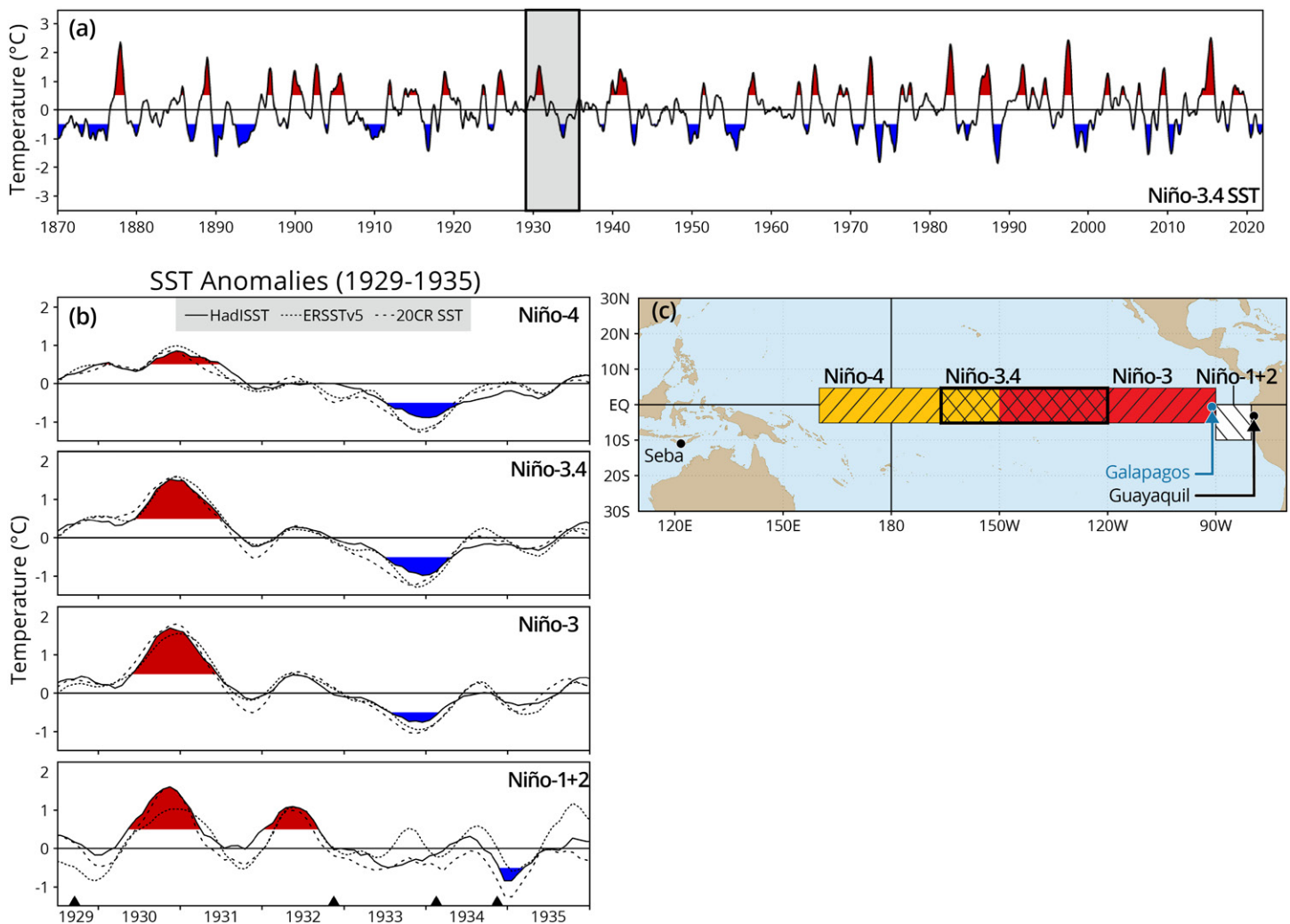


Fig. 3. (a) Monthly Niño-3.4 SST time series for 1871–2022 based on HadISST. Red peaks (Niño-3.4 $\geq 0.5^{\circ}\text{C}$) indicate El Niño events and blue troughs (Niño-3.4 $\leq -0.5^{\circ}\text{C}$) indicate La Niña events. The period 1929–35 is highlighted. (b) SST anomalies in different Niño index regions for July 1929–December 1935 for three different datasets: HadISST (with color shading to indicate periods when SSTs exceed $\pm 0.5^{\circ}\text{C}$), 20CR (long-dashed line), and ERSSTv5 (short-dashed line). Monthly anomalies in (a) and (b) are calculated relative to a 1921–50 climatology then smoothed with a 5-month running mean. The Niño regions in (b) are defined in (c), which also shows the locations of the Galapagos Islands, Guayaquil, Ecuador, and Seba, Indonesia. Rainfall data from the latter two sites are presented in Fig. 6. Markers on the lower time axis of the Niño-1+2 time series in (b) indicate when Friedrich Ritter and Dore Strauch arrived on Floreana (September 1929), when the baroness arrived (November 1932), when Dore Strauch first mentioned that drought had set in (February 1934), and when Rudolf Lorenz was found dead and Friedrich Ritter died (November 1934).

for El Niño and La Niña detection. Reanalysis wind and rainfall fields are more uncertain than SST because they are not directly constrained by observations. However, as we shall see below, the relationships among 20CR fields is consistent with our current understanding of ENSO dynamics. Also, Compo et al. (2011) show that indices of year-to-year variability in the Pacific Walker circulation are consistent between the 20CR and those based on other analysis products, some going back to 1900. Surface wind stresses based on the 20CR have been used to force an ocean general circulation model to simulate ENSO SST variations of the early twentieth century, including El Niños and La Niñas of 1930s, with a high degree of fidelity (Giese et al. 2010).

A further indicator of 20CR reliability is the high correlation between 20CR rainfall variations at Seba and Guayaquil and those measured independently from station data. For 86 wet season (December–May) rainfall totals at Guayaquil over the period 1915–2000 and 47 wet season (November–April) rainfall totals at Seba over 1919–75, the cross correlations are 0.57 and 0.46, respectively, between station data and 2° latitude $\times$ 2° longitude 20CR estimates around the stations. These correlations are statistically different from zero with greater than 99% confidence. Thus, despite uncertainties inherent in analysis products that are based on limited data constraints, we are confident in the essential character of 1930s ENSO cycle variations described in this study.

ENSO variations in the early 1930s

ENSO variability over the past 150 years as characterized by the Niño-3.4 SST index (Fig. 3a) shows warm El Niño and cold La Niña events recurring with a periodicity of roughly 2–7 years. The three strong El Niños of the past 40 years (1982/83, 1997/98, and 2015/16) stand out and the current 2020–22 La Niña is seen right at the end of the record. Early-twentieth-century El Niños that have been discussed in the literature, such as in 1918/19 (Giese et al. 2010) and 1925/26 (Takahashi and Martínez 2017), are also evident. The 1877/78 El Niño, by some accounts as strong as any that have occurred since (Davis 2001; Aceituno et al. 2009), is notable near the start of the time series.

Our focus is the first half decade of the 1930s (Fig. 3b) for which significant year-to-year variability is evident. Noteworthy in the Niño-3.4 record is an El Niño in 1930/31 and a La Niña in 1933/34. These warm and cold episodes are basin scale in their zonal extent as evident from their signatures in the Niño regions to the east and to the west of Niño-3.4. These events, with peak Niño-3.4 anomaly magnitudes between 1° and 1.5°C , would be considered “moderate” strength by conventional ENSO definitions today (Trenberth 2021) though it is possible that the magnitudes were somewhat stronger given the data limitations of the time (e.g., Giese et al. 2010). Both the 1930/31 El Niño and the 1933/34 La Niña are evident in independent coral oxygen isotopic records from Maiana Atoll (1°N , 173°E) near the international date line (Urban et al. 2000) and from Fanning (4°N , 160°W) and Palmyra Atolls (6°N , 162°W) in the central equatorial Pacific (Sanchez et al. 2020).

Additional significant SST anomalies in the Niño-1+2 region appear in 1932 (warm) and 1934/35 (cold). The warm 1932 SST anomalies represent a “coastal El Niño” (Takahashi and Martínez 2017; Echevin et al. 2018; Hu et al. 2019) whose impacts are generally confined to the far eastern Pacific. The 1934/35 cold anomalies in the Niño-1+2 region diminish farther to the west in contrast to the cold SST anomalies in 1933/34 that weaken toward the east (Fig. 3b and Fig. S1). The three products disagree on whether unusually cold conditions prevailed in the Niño-1+2 region in early 1934, but they otherwise agree in all the major warm and cold features during this period.

In her memoir, Dore Strauch observed that in early 1934 “the drought began towards the end of February,” which is in the middle of the normal wet season in the Galapagos. The cause of this drought was the 1933/34 La Niña (Fig. 3b). The rainfall deficit as it relates to

SST and atmospheric circulation anomalies in the boreal winter (January–March) of 1934 is evident in the Twentieth Century Reanalysis (Fig. 4). One can see cold SST anomalies stretching along the equator all the way from the coast of South America to 150°E, with peak cold anomalies more than 1.0°C below normal (Fig. 4a). Surface easterly winds are unusually strong between 150°E and 140°W (Fig. 4b) consistent with the Bjerknes feedback in which intensified trade winds and cold SST anomalies reinforce one another. Anomalous cold SSTs east of 140°W along the equator coincide with local trade winds that are unusually weak; these SSTs are remotely forced by the trade winds farther to the west via the generation of eastward-propagating upwelling favorable equatorial Kelvin waves (McPhaden et al. 2021a).

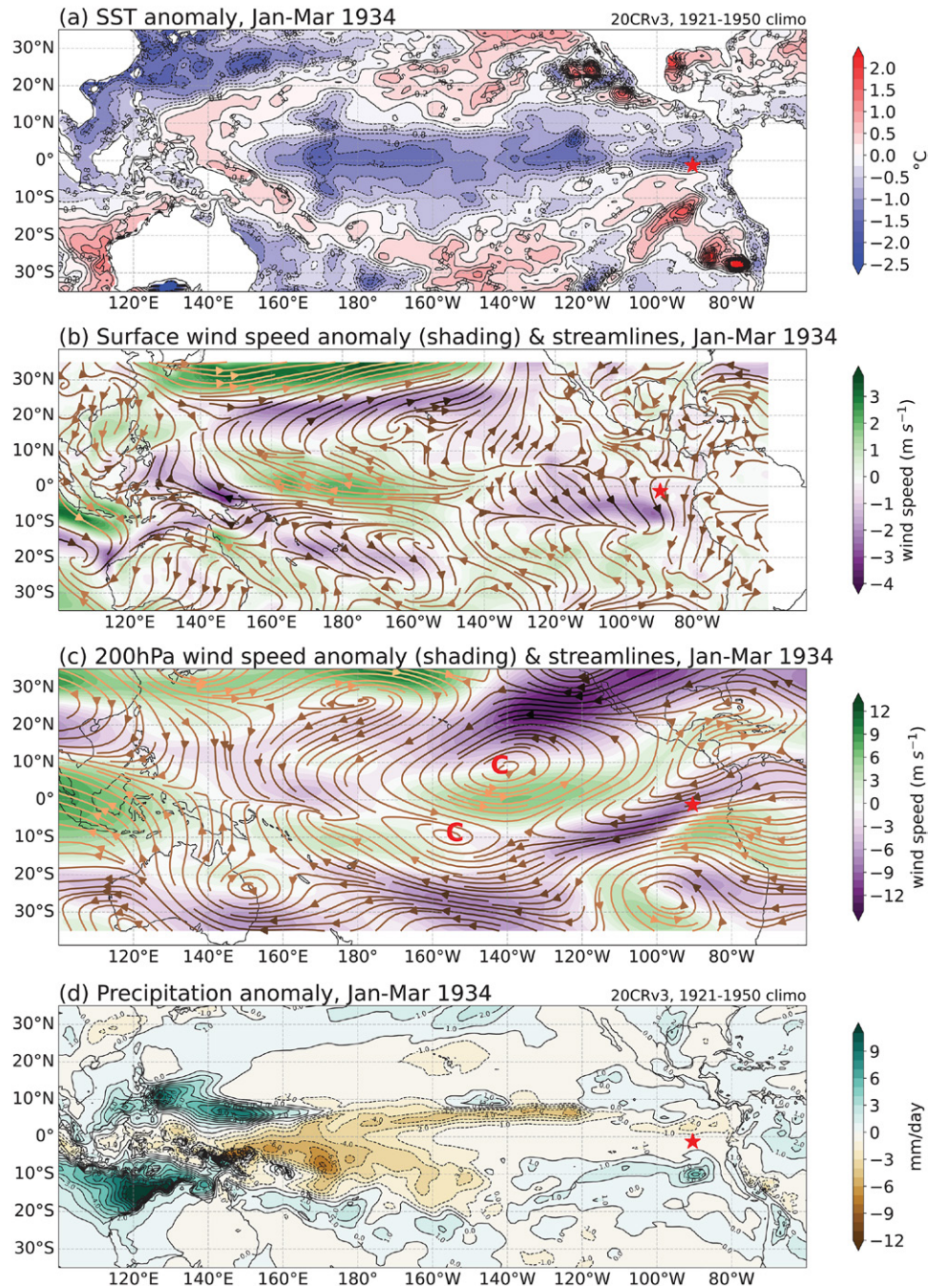


Fig. 4. Seasonal average anomalies in the Pacific basin in January–March 1934 based on the Twentieth Century Reanalysis for (a) SST (°C), (b) surface wind speed (shading; m s^{-1}) and streamlines, (c) wind speed (shading; m s^{-1}) and streamlines at 200 hPa in the upper atmosphere, and (d) rain rate (mm day^{-1}). In (c), two stationary cycles flanking the westerly wind anomalies along the equator are labeled with the letter C. All anomalies are calculated relative to a 1921–50 climatology. The location of Floreana is indicated by the red star.

The slightly weaker-than-normal trade winds in the eastern Pacific during this time are a feature common to La Niña events at their peak (Abellan and McGregor 2016). This weakening results from a combination of two effects. One is a surface wind divergence related to anomalous descending air masses over the unusually cold water of the eastern Pacific that results from a westward shift in the Walker circulation (see below); the other is the stabilization of the surface boundary layer over the cold water limiting the turbulent downward transfer of wind momentum from the free atmosphere aloft (Wallace et al. 1989).

Upper-level (200 hPa) winds exhibit intensified westerlies in the central equatorial Pacific flanked by two stationary cyclones (Fig. 4c). Together with the surface wind anomalies, these upper-level wind anomalies represent an intensification and westward shift of the Walker circulation along the Pacific equator. This westward shift is also evident in the rain-rate anomalies (Fig. 4d), which show a dry zone in the central Pacific and a wet zone in the western Pacific. This pattern indicates a westward displacement of the ascending branch of the Walker circulation, which is characterized by deep convection and heavy rainfall over the western Pacific warm pool.

Of particular note for this study is the anomalous dry zone that straddles, and extends north of, the equator in the far eastern Pacific encompassing the longitude of the Galapagos Islands. This feature reflects a northward shift of the ITCZ away from its normal location close to the equator because of the underlying unusually cold equatorial SSTs. It is this northward shift in the ITCZ that was the proximate cause for the rains to fail in the Galapagos as recorded in Dore Strauch's memoir.

The temporal evolution of ENSO conditions along the equator during the first half of the 1930s shows in more detail the relation between SST, zonal winds and rainfall variability (Fig. 5). A brief period of warming occurred in late 1929–early 1930 in the central Pacific between 160°W and

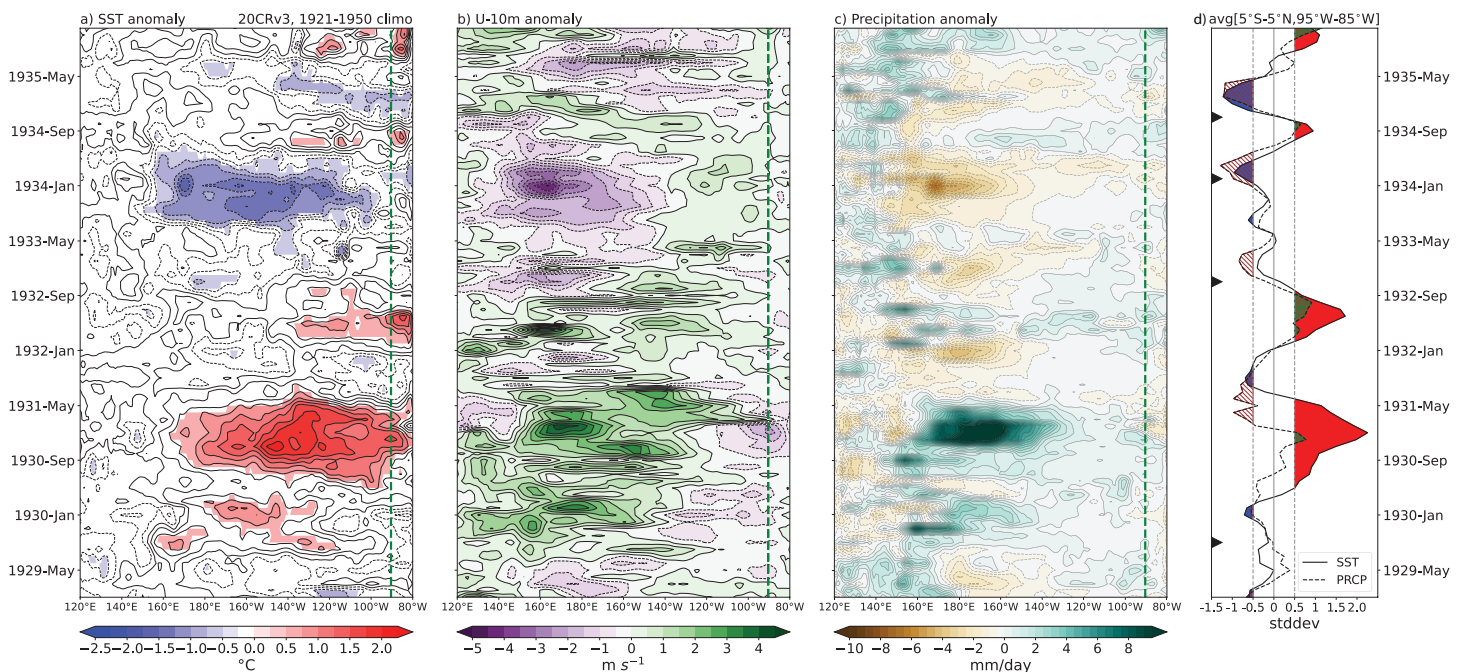


Fig. 5. Monthly average anomalies between 5°N and 5°S based on the Twentieth Century Reanalysis for 1929–35. Anomalies are calculated relative to a 1921–50 climatology. (a) SST (°C), (b) zonal wind speed (m s^{-1}), and (c) rain rate (mm day^{-1}). Dashed contours indicate negative anomalies and the green dashed line indicates the longitude of Floreana. In (a), shading is only shown from anomalies greater or less than 0.5° and –0.5°C. (d) Standardized SST and precipitation anomalies averaged in a 5°S–5°N, 95°–85°W box encompassing the Galapagos Islands. The standardized anomalies are divided by their respective standard deviations over the period 1921–50 (0.61°C for SST and 0.78 mm day^{-1} for precipitation) and then smoothed with a 3-month running mean. Anomalies in (d) greater in magnitude than 0.5 standard deviation are color coded and hatched to emphasize extrema. Markers on the time axis in (d) indicate the same events as described in Fig. 3b.

the date line associated with a weakening of the trade winds, enhanced central Pacific rainfall and reduced rainfall in the western Pacific. These are El Niño–like conditions, but they did not last long enough over a wide-enough region with sufficient amplitude to qualify as an El Niño by conventional definitions. However, the following year’s anomalous warming that developed in mid-1930 in the central and eastern Pacific became a significant El Niño. This warming was associated with weakening trade winds farther to the west (Fig. 5b), unusually dry conditions in the far western Pacific and heavy rainfall in the central and eastern Pacific, including at the longitude of the Galapagos (Fig. 5c). The El Niño weakened in early 1931 and by midyear the event was over. Warming developed again in early 1932, but it was limited to 80°–140°W and lasted only a few months. This coastal El Niño (seen also in Fig. 3b) was linked to weakened trade winds to the west and enhanced precipitation at the longitude of the Galapagos (Figs. 5c,d).

The period 1933–35 was characterized by unusually cold and dry conditions along the equator, punctuated by two pronounced cooling events in late 1933–early 1934 and late 1934–early 1935. The first of these was the basin-scale La Niña event evident in Fig. 3 while the second, with stronger cooling in the Niño-1+2 region extended only to 140°W (Fig. 3b and Fig. S1). Both were associated with intensified trade winds (Fig. 5b) and rainfall deficits in the central and eastern Pacific. The rainfall deficits at the longitude of the Galapagos were most pronounced during the normal wet season of January–April and, though the settlers had experienced previous periods of anomalously low rainfall, none were drier than early 1934 and 1935 (Fig. 5d). In general, we found 20CR monthly SST and rainfall anomalies to be highly correlated in the 10° latitude × 10° longitude box around near the Galapagos, with a coefficient of 0.71 over the entire period of the reanalysis (Fig. S2). The same calculation using GPCP rainfall and HadISST (ERSSTv5) for the period 1979–2021 resulted in a correlation of 0.72 (0.73) attesting to the robustness of this relationship.

Dore Strauch reported in her memoir sometime in mid-1933 as La Niña conditions were developing, that “the fertility of the soil had not maintained itself into a third year, and all our fruit and vegetables were coming up either very poorly or not at all.” She had recognized, through the consequences it had for her garden, the contrast between the relatively wet conditions the settlers experienced during the El Niño events of 1930/31 and 1932, and the beginning of what would become a long dry spell associated with La Niña conditions in 1933–35. In this context, the apparent disagreement between the two cold extrema near the Galapagos during 1933–35 (Fig. 5d) and only a single obviously cool period in the Niño-1+2 region for the same period can be reconciled considering that Niño-1+2 extends to 10°S along the South American coast. This region is characterized by strong SST gradients in both latitude and longitude, so it is not always representative of conditions along the equator near the Galapagos.

Data from observing stations at opposite ends of the basin reflect the ENSO rainfall variations evident in the Twentieth Century Reanalysis (Fig. 6). Significant positive rainfall anomalies occur at Guayaquil in late 1930 during the basin-scale El Niño and in early 1932 during the coastal El Niño (Fig. 6a). There is also a significant rainfall deficit at Guayaquil in early 1935 associated with the strong cooling episode in the eastern equatorial Pacific (Figs. 3b, 5a, and Fig. S1). Rainfall is near normal in 1934 though, in contrast to the dry conditions that Strauch reported in the Galapagos at that time. This difference may result from the fact that Guayaquil is a 1,000 km to the east of the Galapagos. Rainfall and SST are highly correlated in the coastal zone of Ecuador and Peru (Takahashi and Martínez 2017) and coastal SST anomalies were relatively weak in early 1934 compared to those farther west along the equator (Figs. 3b and 5a). Also, rainfall is characterized by significant intraseasonal variability and synoptic conditions that may have been different at the two locations, leading to a deviation of the regional signals from the expected large-scale ENSO signals (e.g., drying for La Niña conditions). For example, Kiefer and Karamperidou (2019) showed that during some La Niña events, the Guayaquil region can counterintuitively receive high accumulated

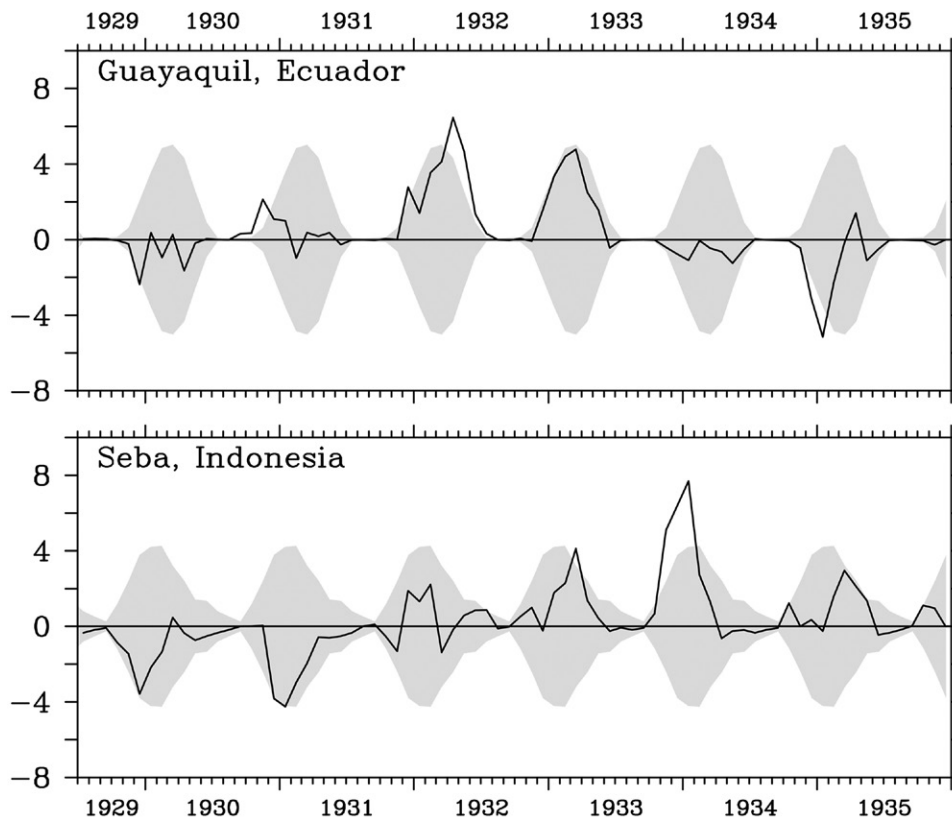


Fig. 6. Monthly average rain-rate anomalies (mm day^{-1}) smoothed with a 3-month running mean at (a) Guayaquil, Ecuador (2.2°S , 79.9°W), and (b) Seba, Indonesia (10.5°S , 121.9°E), for July 1929–December 1935. As a measure of statistical significance, shading indicates one standard deviation for interannual anomalies around the mean seasonal cycle based on a 1921–50 climatology.

precipitation amounts owing to regional circulation processes in the tropical Andes affected by remote processes apart from the eastern Pacific (Vuille et al. 2000; Lavado-Casimiro and Espinoza 2014).

At the opposite end of the Pacific, Seba, Indonesia, shows marginal rainfall deficits associated with the weak 1929/30 warming event and again during the 1930/31 El Niño (Fig. 6b). A period of unusually wet conditions followed in 1933–35, punctuated by exceptionally high rainfall in late 1933–early 1934 associated with the 1933/34 La Niña. These rainfall variations, like those at Guayaquil, are consistent with the ENSO time-scale variations evident in the 20CR.

It is not unusual for cold La Niña conditions to extend over two successive years in the tropical Pacific (Wu et al. 2019), sometimes referred to as “double dip” La Niñas (Zheng et al. 2015). Such an event is currently underway in 2020–22 [Fig. 3a; see also Fang et al. (2023) and Hasan et al. (2022)]. While 1933/34 and 1934/35 do not formally qualify as a basin-scale double-dip La Niña according to the Niño-3.4 index, double-dip cold conditions prevailed in the vicinity of the Galapagos during 1933–35, accompanied by significant and prolonged rainfall deficits (Fig. 5d) that had dramatic impacts on the lives of the Galapagos settlers.

Perspectives

In retrospect, Ritter’s mistaken notion that the climate was “constant” in the Galapagos poorly prepared him and Strauch for the year-to-year climate variations due to ENSO that they encountered on Floreana. Their impressions of the local climate were strongly influenced by William Beebe’s 1924 book *Galapagos, World’s End* that described the seasonal cycle of rainfall but not its interannual variations. This book was a travelogue based on a scientific expedition to the Galapagos in 1923 sponsored by the New York Zoological Society. The expedition lasted only 20 days during which the scientific party spent only 100 h in total on land. Beebe was so

fascinated by the Galapagos though that he convinced the New York Zoological Society to sponsor a second expedition to the Galapagos on the 280-ft-long (85 m) research vessel *Arcturus* in February–April 1925. On this expedition he recounted (Beebe 1926), “to our surprise, we found that there was absolutely no trace of the Humboldt Current about the Galapagos. The inexplicable absence of this great, cold, Antarctic current was more than made up for by the presence of equally unexpected natural conditions.” What he had discovered, although he did not identify it as such at the time, were unusually warm El Niño SSTs and related disruptions in ocean circulation in the far eastern Pacific. More than 90 years later, Takahashi and Martínez (2017) described the 1925 El Niño using historical data, some of them collected on the *Arcturus* expedition, noting that “the 1925 El Niño event was the third strongest in the twentieth century according to its impacts in the far-eastern Pacific associated with severe rainfall and flooding in coastal northern Peru and Ecuador in February–April 1925.” They went on to say that “ship data indicate an abrupt onset of strong northerly winds across the equator and strengthening of the intertropical convergence zone . . . south of the equator.” Though Ritter and Strauch had been inspired by Beebe’s 1924 publication *Galapagos, World’s End*, there is no evidence to suggest that they were familiar with Beebe’s 1926 account of the Galapagos, *The Arcturus Adventure*, and its implications for the climate variations they would encounter on Floreana.

Cold SSTs near the equator in the eastern Pacific result in large part from equatorial upwelling, which transports cold water from deeper depths to the surface layer (Wyrski 1981; Jakoboski et al. 2020). Upwelled water is also rich in nutrients that support a diverse and vibrant marine ecosystem in the eastern Pacific, especially around the Galapagos islands (e.g., Karnauskas et al. 2015). There is no evidence that Ritter and Strauch had ever augmented their diet with protein from the sea even though a short-lived commercial fishing operation had been established on the island soon after they arrived. Thus, it was ironic that Ritter, a vegetarian, had poisoned himself by eating tainted meat because, as Strauch noted in late 1934, “the long drought had ruined our season’s crops.” Had they learned how to fish, he might have survived.

ENSO extremes have opposing effects on the productivity of marine and terrestrial ecosystems in Galapagos (Weiner 1994). During strong El Niños for example, terrestrial ecosystems on the Galapagos thrive because the abundance of rainfall causes greening of the landscape. Conversely, upwelling of cold, nutrient-rich water is greatly reduced in the eastern Pacific, leading to a reduction in primary productivity (i.e., carbon fixation by phytoplankton) that adversely affects all higher trophic levels of the marine food web (e.g., Barber and Chavez 1983; Canby 1984). Thus, the ocean may temporarily become a biological desert while land ecosystems flourish. The opposite happens during La Niña: a lack of rainfall can decimate land ecosystems while the marine environment teems with life because of enhanced upwelling of cold nutrient-rich water. The dramatic changes in ocean primary productivity that underpin broadscale marine ecosystem changes between warm El Niño events and cold La Niña events in the eastern Pacific can be seen from space via satellite ocean-color measurements, as, for example, during the 1997/98 El Niño and the 1998/99 La Niña (Chavez et al. 1999; Turk et al. 2001). Although we lack the data to assess the health of the Galapagos marine ecosystem during the La Niña events of the early 1930s, the presence of cool unusually cool SSTs clearly indicates vigorous upwelling, implying a rich abundance of fish that could have alleviated the food shortage brought about by drought and crop failure on Floreana then.

Environmental conditions also provide a context to understand how Lorenz and Nuggerud ended up on Marchena Island, 150 km to the north of Floreana, in November 1934. They left Floreana in July 1934 bound for Santa Cruz Island to drop off another passenger before heading on to San Cristobal Island, where Lorenz intended to book passage to Guayaquil. They successfully made it to Santa Cruz, but not to San Cristobal. Wittmer (1989) speculated that

somewhere on the passage between Santa Cruz and San Cristobal, the engine on Nuggerud's old motorboat failed and they were blown off course by the prevailing winds and currents.

Oftentimes during double-dip La Niñas, there is a rebound toward normal during the boreal summer in the interval between the first and second cold extremes (Okumura and Deser 2010). A similar rebound happened during the boreal summer of 1934 in the eastern Pacific between the cold extremes of 1933/34 and 1934/35 (Figs. 3b and 5). The trade winds are normally strong from the south-southeast in the vicinity of the Galapagos at this time of year (Fig. 7a) and the Twentieth Century Reanalysis suggests they may have been even stronger than normal during July–November 1934 (Fig. 7b). Both surface winds and surface currents, which are essentially downwind very near the equator where the Coriolis force is vanishingly small, would have pushed Lorenz and Nuggerud northwest toward Marchena Island. Unfortunately for them, there were no sources of freshwater where they eventually landed.

Finally, as events surrounding the Galapagos Affair were unfolding, another tragedy of monumental proportions was playing out a few thousand miles away: the 1930s Dust Bowl of the American Great Plains. This was one of the worst environmental disasters ever experienced in the United States, a catastrophe exacerbated by the economic distress of the Great Depression. It was a time of tremendous social upheaval and hardship, as told poignantly in literature, movies, and photographs (e.g., Egan 2006). The Galapagos Affair and the Dust Bowl were not just contemporaneous historical events though: the same extended cold La Niña conditions that factored so prominently into the lives of the Galapagos settlers was also responsible for the drought that contributed to the development of the Dust Bowl (Schubert et al. 2004). Either near-neutral or unusually cold conditions persisted in the tropical Pacific for most of the 1930s, culminating in another basin-scale La Niña in 1938/39 (Fig. 3a). Multiyear La Niña periods in the tropical Pacific can lead to severe persistent drought over the United States (Okumura et al. 2017) and Cook et al. (2007) observed, “numerical experiments indicate the dominating importance of . . . cool ‘La Niña-like’ SSTs in the eastern tropical Pacific region . . . in determining how much precipitation falls over large parts of North America.” Cook et al. (2014) moreover identified 1934 as the worst drought year of the past millennium in the United States, the same year that La Niña–induced drought helped to unravel so many well-laid plans on Floreana. So, while our story has focused on the fates of a few individuals struggling to survive on a remote island in the Galapagos archipelago, their life histories were inextricably

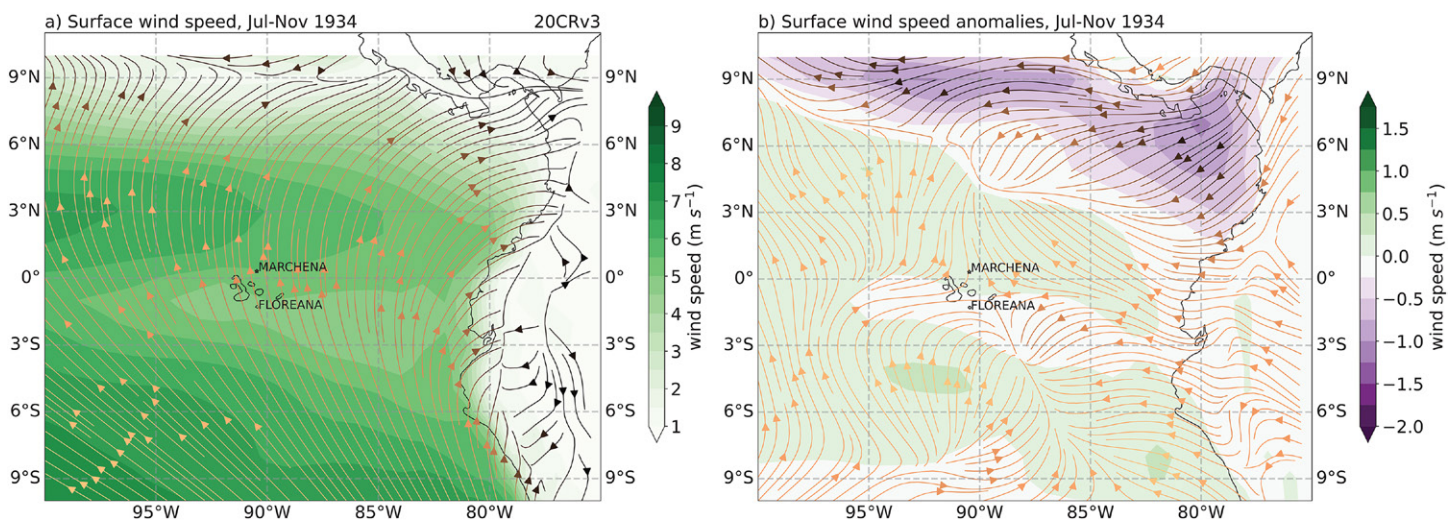


Fig. 7. (a) Average surface wind speed (shading; m s^{-1}) and streamlines in the vicinity of the Galapagos for July–November 1934 based on the Twentieth Century Reanalysis. (b) Anomalies calculated relative to a 1921–50 climatology. The locations of Floreana and Marchena Islands are indicated. The anomalous northward shift in position of the ITCZ can be seen in (b) with reduced wind speeds to the north of the zero streamline and enhanced wind speeds to the south.

linked by cold equatorial Pacific Ocean temperatures to the millions who experienced privation resulting from the Great Plains Dust Bowl.

Summary

The principal players in this saga are long gone and the documentary record is incomplete, so there are many questions that will likely remain forever unanswered about the Galapagos Affair. What ultimately happened, for example, to the baroness and Philippon? How precisely did Lorenz and Nuggerud end up on Marchena Island? Why did Ritter die of food poisoning but not Strauch, when both had eaten spoiled chicken?

There are some conclusions we can draw with confidence though. According to Dore Strauch, Satan came to Eden in the form of the baroness, but we now also know that La Niña came to Eden in the form of drought. This was a double whammy for Ritter and Strauch. They had outlasted the baroness, but sheer force of will could not defeat the drought that would eventually lead to Ritter's demise. In short, Nietzsche's *Übermensch* was no match for nature's "little girl."

Had Ritter and Strauch understood the vagaries of climate, they may have been better able to adapt to its vicissitudes. They naively expected the Galapagos climate to be unvarying from one year to the next. Thanks to a half century of research on ENSO dynamics, we have the benefit of knowing better. In their ignorance though, Ritter and Strauch were not well prepared to deal with the severe 1934 drought. They made a fatal mistake by eating spoiled meat when there were alternative sources of nourishment from the sea around them.

The Dust Bowl and the Galapagos Affair were connected by a common physical driver in the form of unusually cold SSTs over a prolonged period of time in the tropical Pacific. ENSO variations, though not the only force at work in shaping these events, was essential to their development. The tragedies that ensued were on vastly different scales, but they both illustrate in their own ways how environmental change can affect the human condition.

The global reach and strength of its impacts ensure that ENSO will continue to affect the course of human events in the future, as it has done in the past, though precisely how is a matter of considerable debate. The background climate of Earth is warming (IPCC 2021), which will likely lead to changes in ENSO properties, dynamics, and teleconnections (McPhaden et al. 2021b). Climate models suggest that, in response to anthropogenic greenhouse gas forcing, SST (Cai et al. 2018) and rainfall variability (Ying et al. 2022) will increase in the tropical Pacific, extreme ENSO events will double in frequency by the end of the twenty-first century (Cai et al. 2021), and the strength and structure of far-field ENSO teleconnections may be altered (Yeh et al. 2018; Taschetto et al. 2021). Much more research is needed to gain confidence in these projected future ENSO changes and the processes that account for them though (Luo et al. 2017; Heede et al. 2020; Karamperidou et al. 2021). The stakes are high: as the Galapagos Affair highlights, reliable environmental intelligence can be a matter of life or death in the face of risk and uncertainty.

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Data availability statement. All data used in this study are publicly available. The HadISST can be downloaded from the Met Office (www.metoffice.gov.uk/hadobs/hadisst/). The Twentieth Century Reanalysis and GPCP data are available from the NOAA Physical Sciences Laboratory (<https://psl.noaa.gov/>). ERSSTv5 and Seba and Guayaquil rainfall data can be downloaded from the National Centers for Environmental Information (www.ncei.noaa.gov/).

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