VARIABILITY OF HAWAIIAN WINTER RAINFALL DURING LA NIÑA EVENTS SINCE 1956

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HRI (Hawaii Rainfall Index)

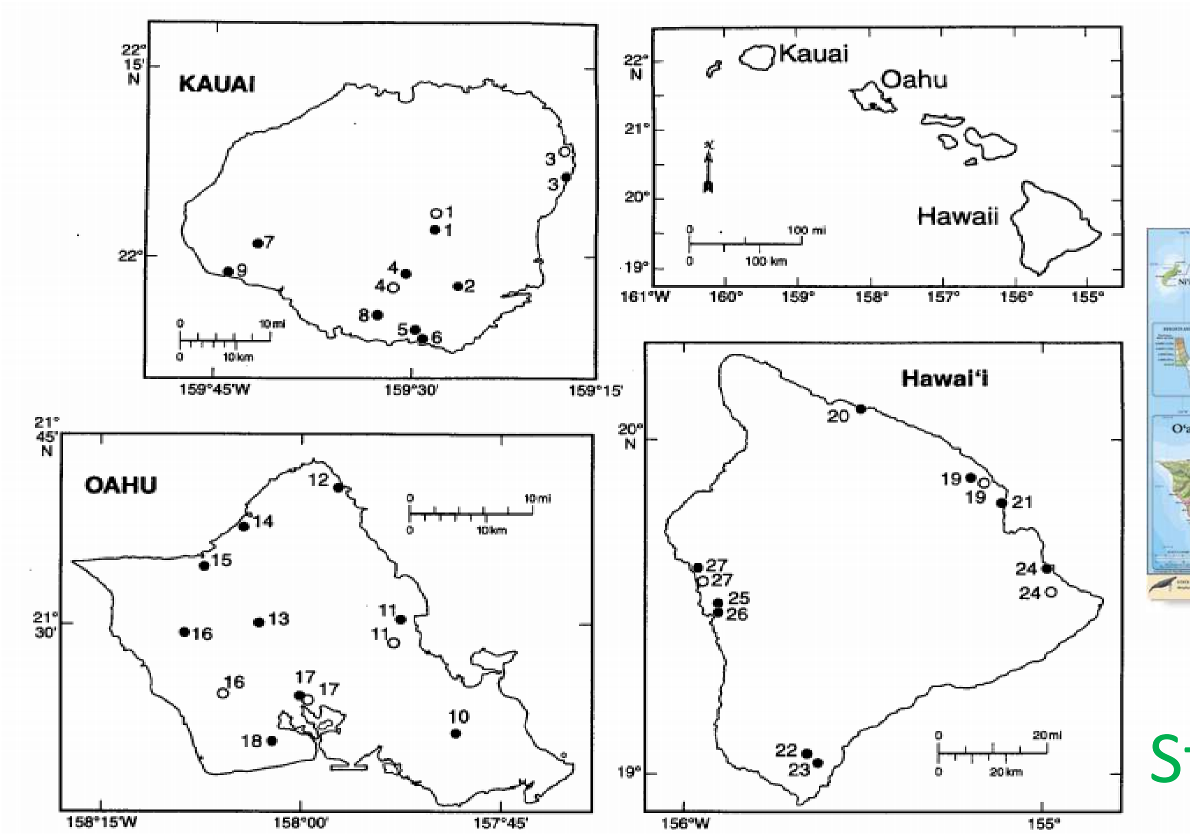
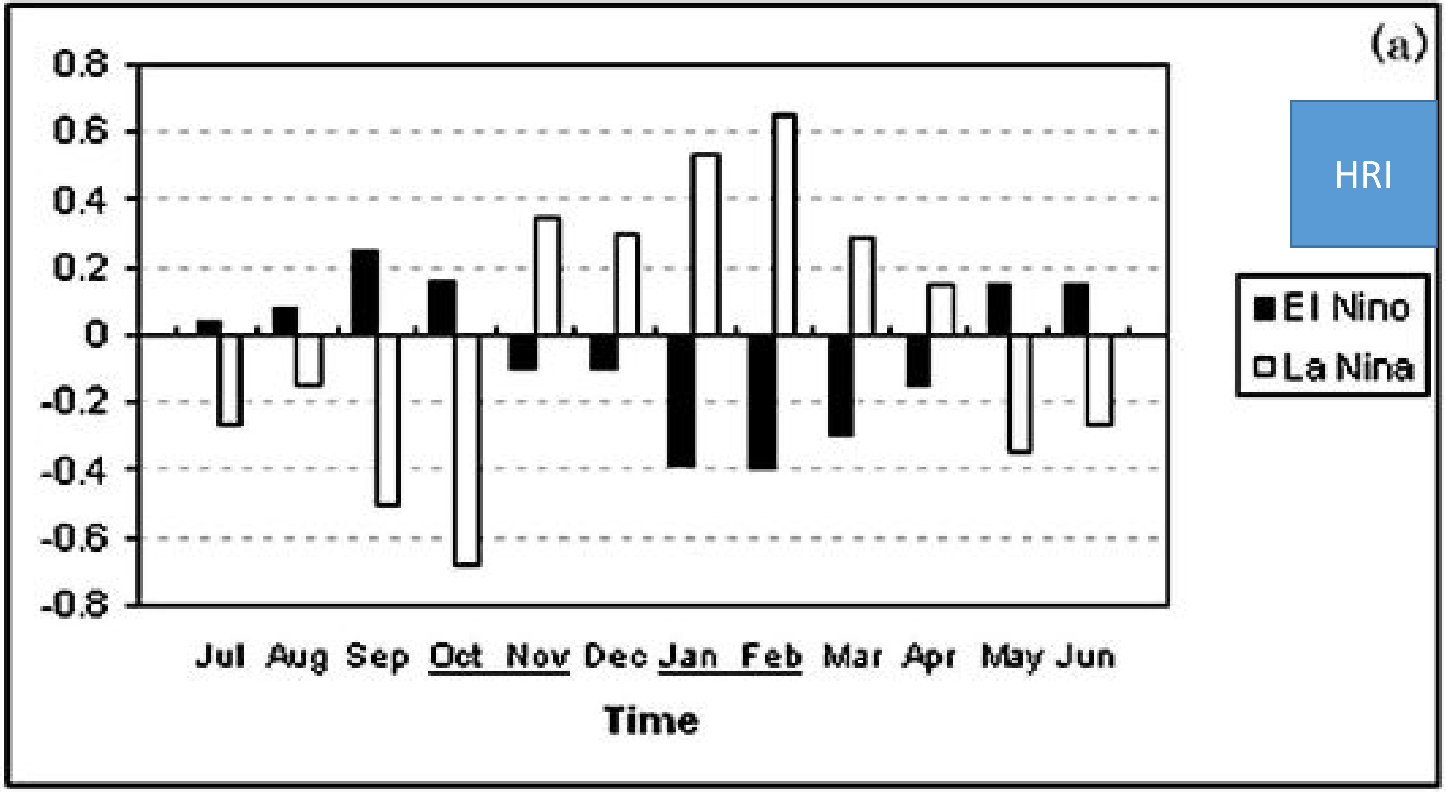


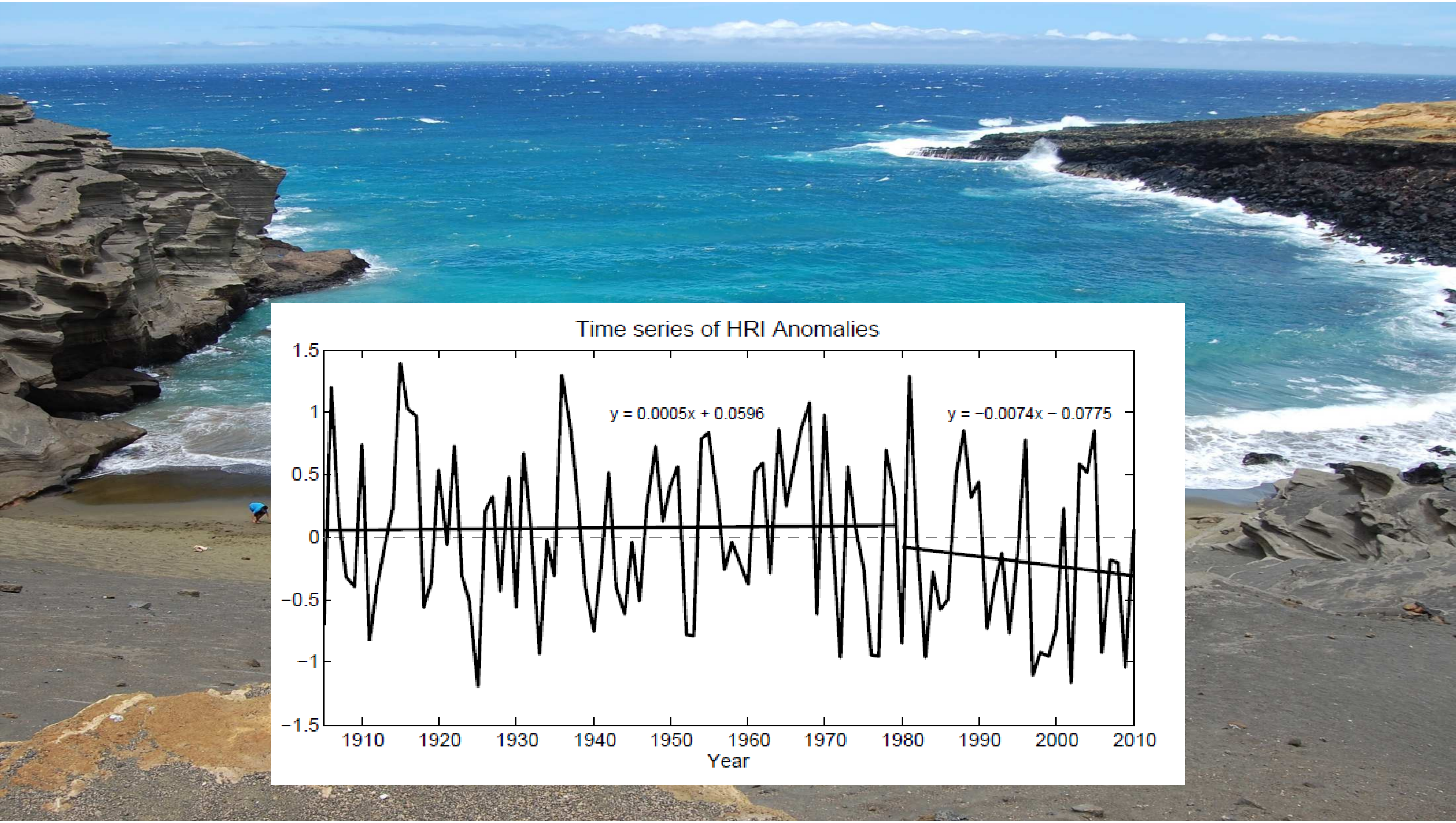
FIG. 1. Map of the major Hawaiian Islands and the locations of rainfall stations used in this study. Station numbers are the same as listed in Table 1. An open circle indicates a new station.

Standardized anomalies



El Niño (La Niña) occurs if 5-mo running mean of SST anomalies in Nino 3.4 region exceeds 0.4°C (-0.4°C) for at least 6 consecutive months

Chu, 1995, J. Climate; Chu and Chen, 2005, J. Climate

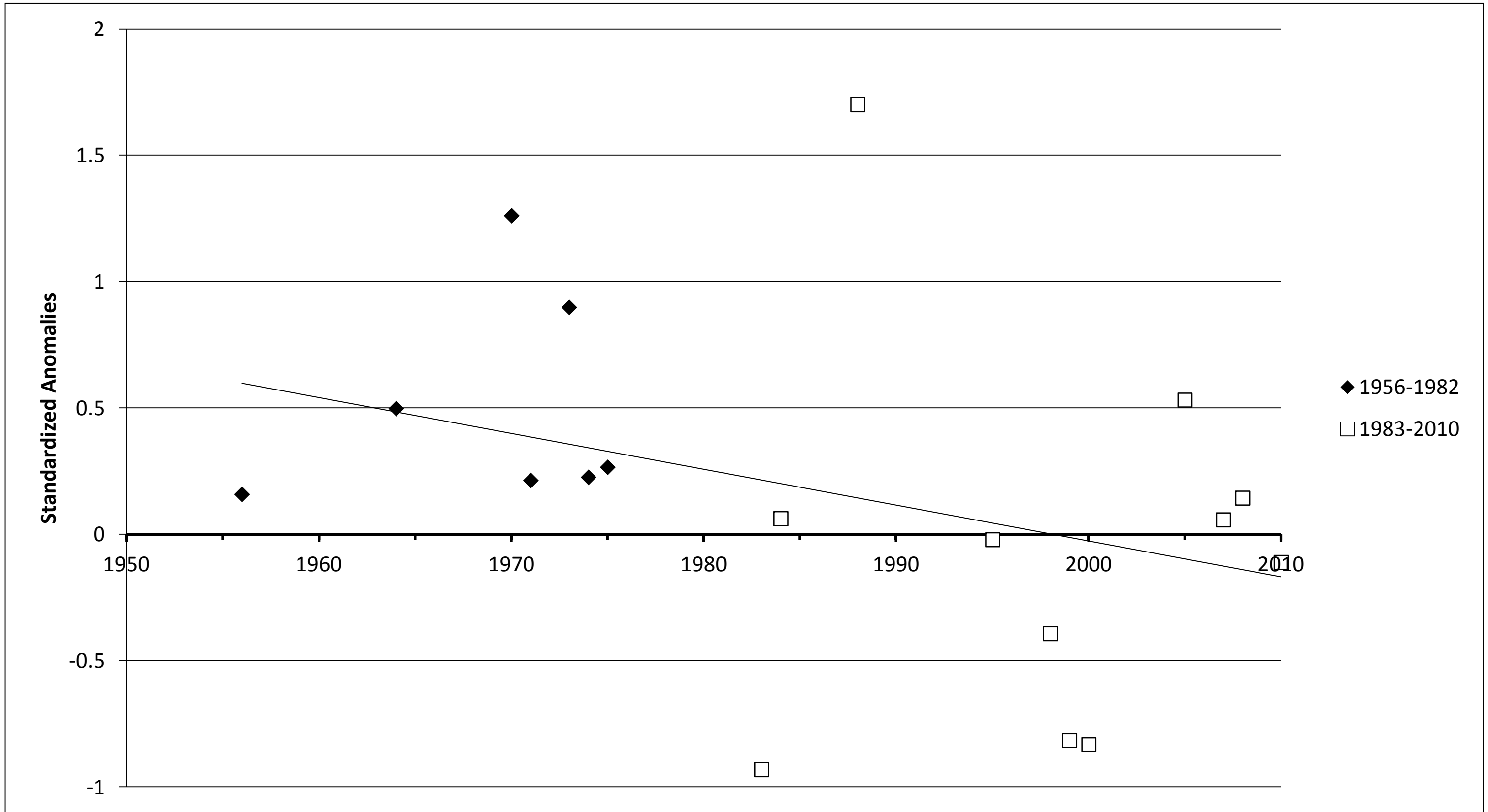

Time series of HRI Anomalies
y = 0.0005x + 0.0596
y = −0.0074x − 0.0775
1.5
1
0.5
0
−0.5
−1
−1.5
1910
1920
1930
1940
1950
1960
1970
1980
1990
2000
2010
Year

Why rainfall in Hawaii has decreased since the early 1980s?

- 50 stations with complete rainfall records for 1956-2010
- NWS-Honolulu Office
- Oceanic Nino Index (ONI) –

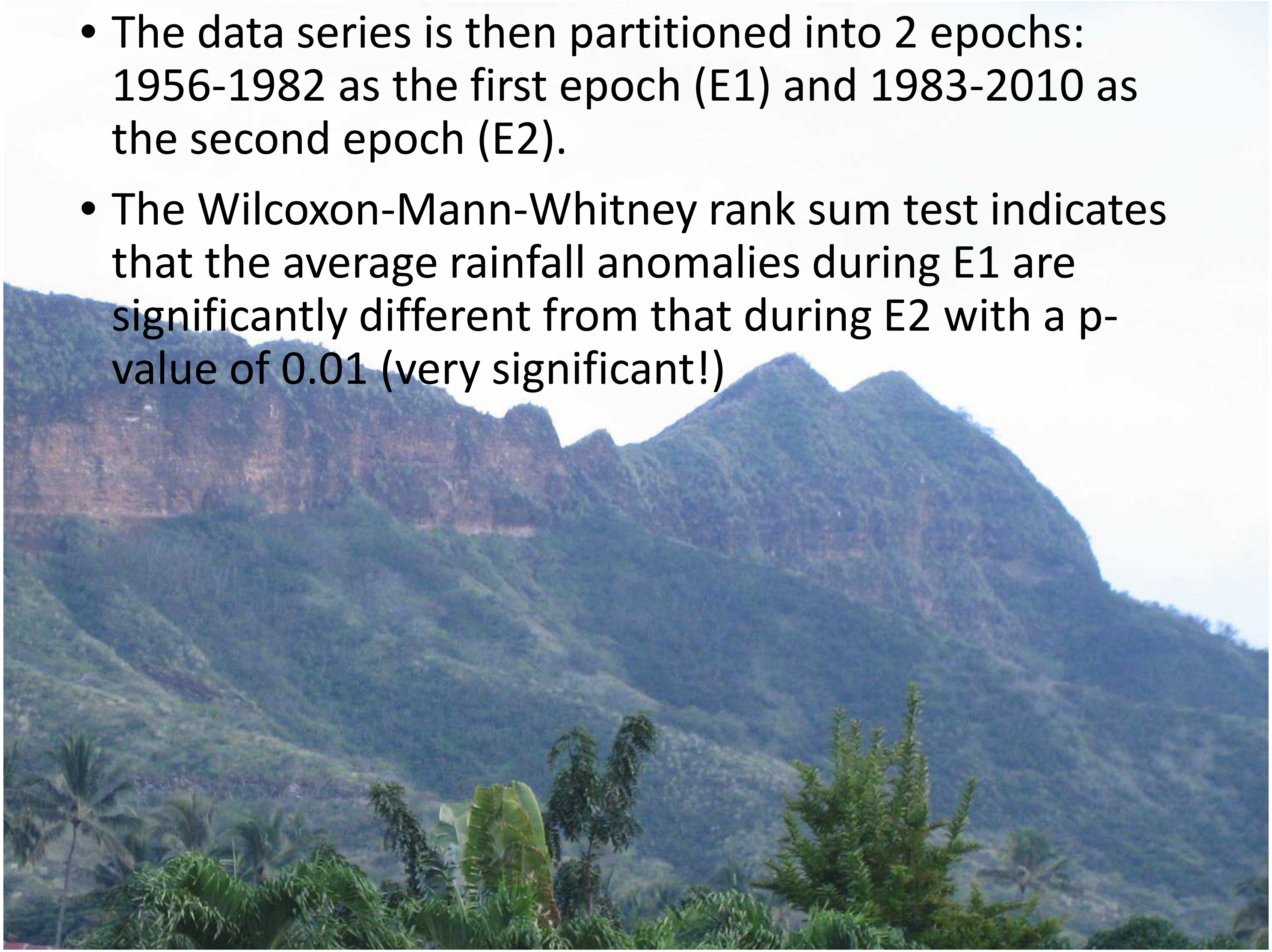
  NOAA/Climate Prediction Center
- El Nino (La Nina) event: 3-mo running mean of SSTs in the Nino3.4 region greater (less) than 0.5C (-0.5C) for five consecutive, overlapping seasons (e.g., JFM, FMA,…)
- NCEP/NCAR reanalysis 1 for circulation study

Standardized rainfall anomalies during wet season (NDJFMA). La Niña events during epoch 1 (1956-1982) and epoch 2 (1983-2010) are marked by black diamonds and white squares, respectively. Note the drying trend indicated by the straight line.



Based on Pettitt-Mann-Whitney change-point test, the most likely shift occurs in 1983 (p-value = 0.06)

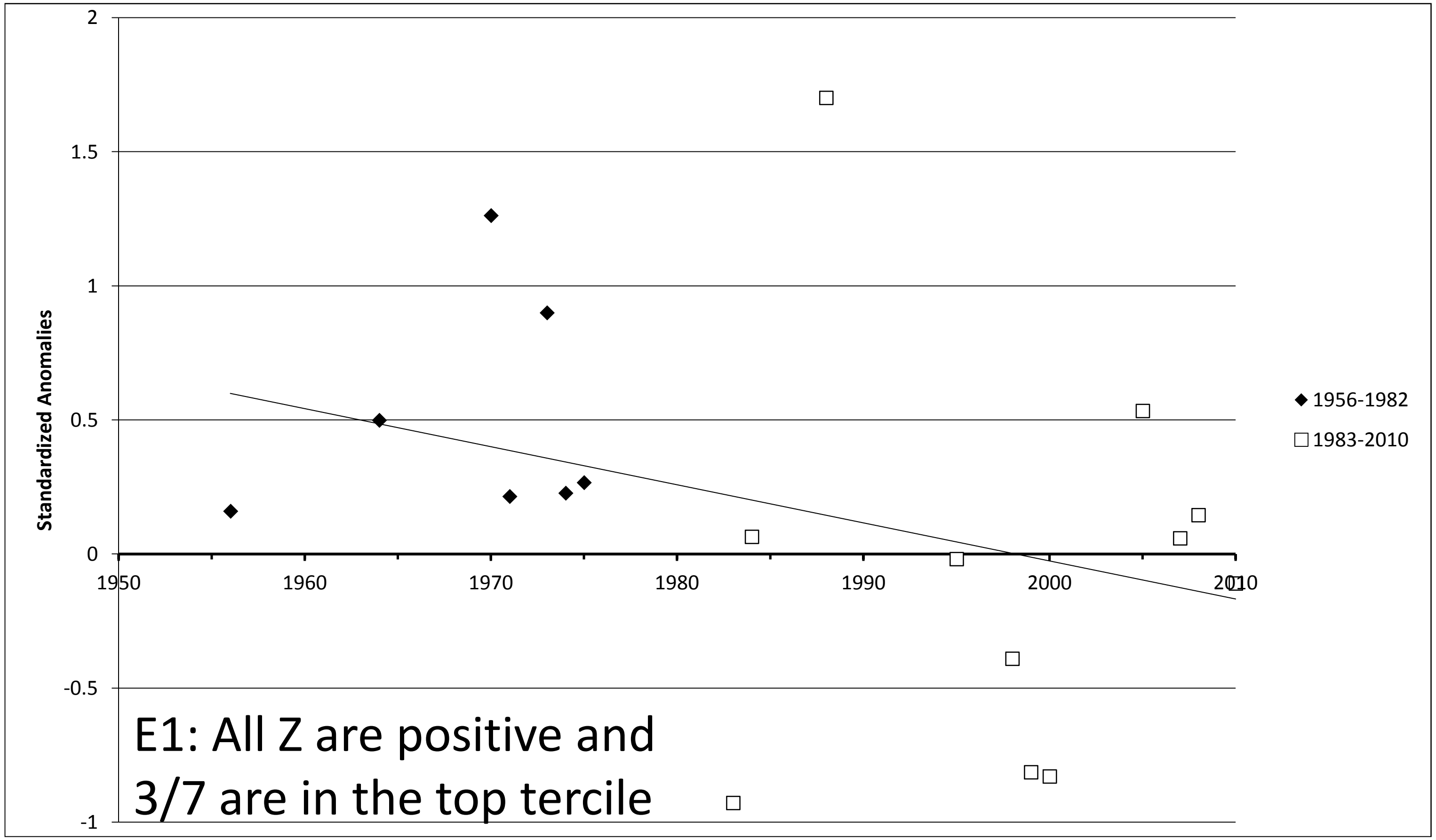
- The data series is then partitioned into 2 epochs: 1956-1982 as the first epoch (E1) and 1983-2010 as the second epoch (E2).
- The Wilcoxon-Mann-Whitney rank sum test indicates that the average rainfall anomalies during E1 are significantly different from that during E2 with a p-value of 0.01 (very significant!)



- Rainfall trend for El Niño years is downward and trend for Neutral years (not fallen into El Niño and La Niña groups) is upward, but none of them are statistically significant
- Downward trend in HRI since the early 1980s appears to be caused mainly by decreasing rainfall during La Nina events

- Rainfall anomalies in La Nina years are categorized as either drier than normal (Z<-0.43), wetter than normal (Z>0.43), or near normal (between -0.43 and +0.43), where Z is the standardized rainfall anomalies.
- This tercile categorization (i.e., top, middle, bottom) has been commonly used in operational centers.

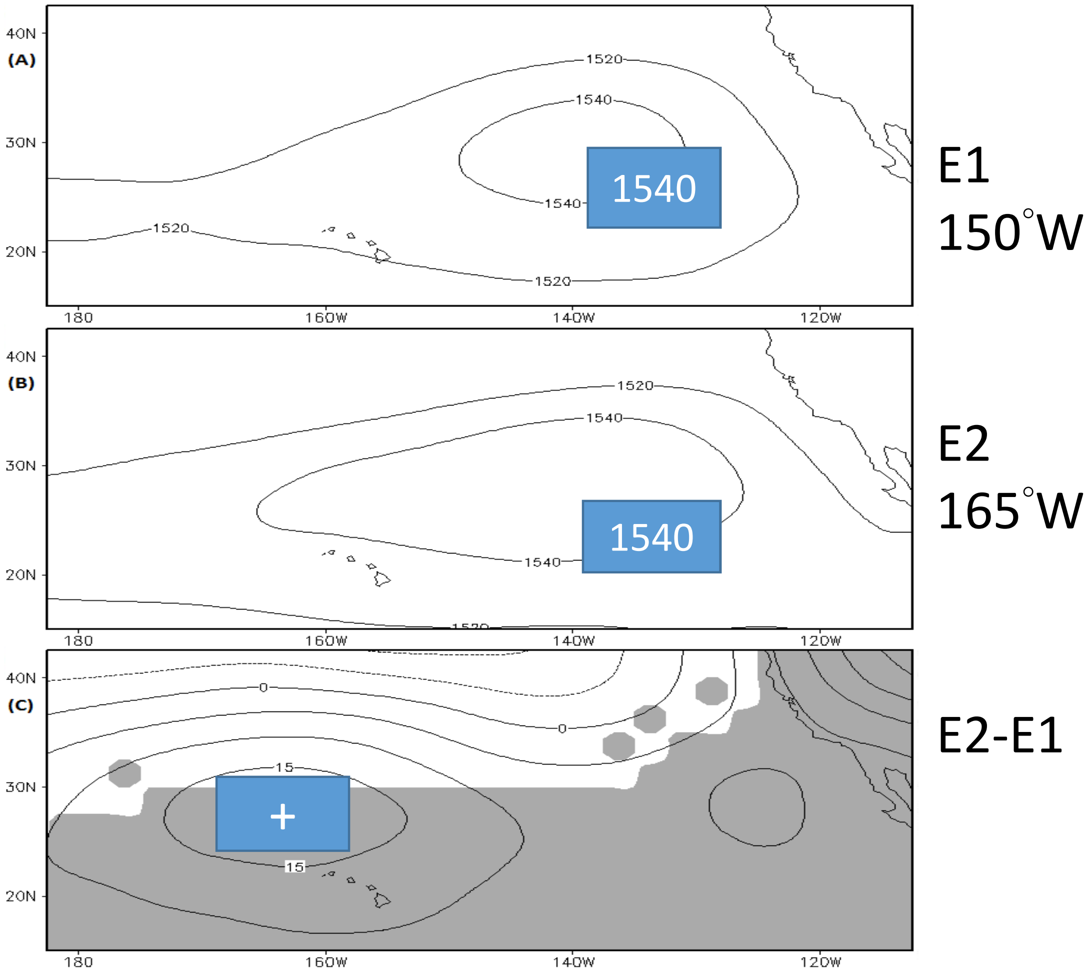
Time series of standardized rainfall anomalies. La Niña events during epoch 1 (1956-1982) and epoch 2 (1983-2010) are marked by black diamonds and white squares, respectively.



E1: All Z are positive and 3/7 are in the top tercile (wetter than normal)

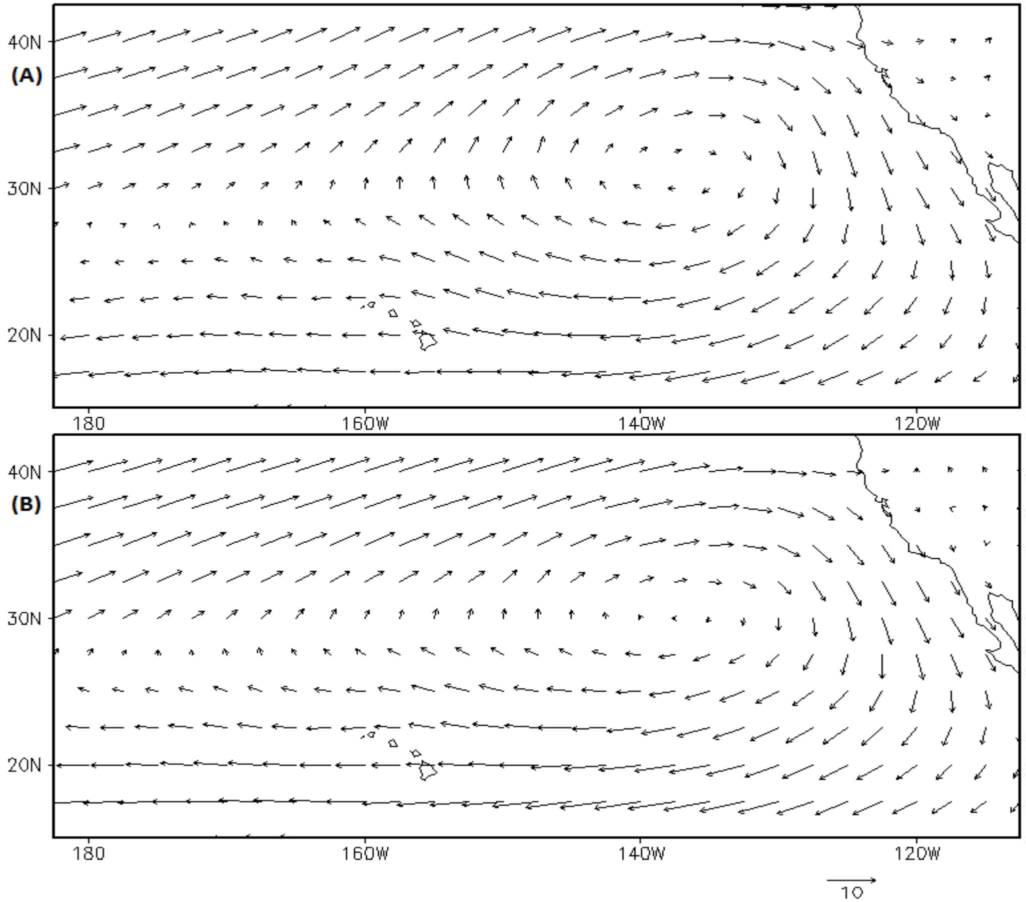
E2: only 2/11 are in the top tercile; 5 are negative

Seasonal mean geopotential height (m) in lower troposphere (850 hPa) during La Niña wet seasons. In (c), the grey shaded area is where the null hypothesis was rejected at the 5% level. Solid (dashed) contours denote positive (negative) value.



Seasonal mean wind (ms^{-1}) at 925 hPa during La Niña wet seasons. (a) Epoch 1 (1956-1982). (b) Epoch 2 (1983-2010).

Lower troposphere

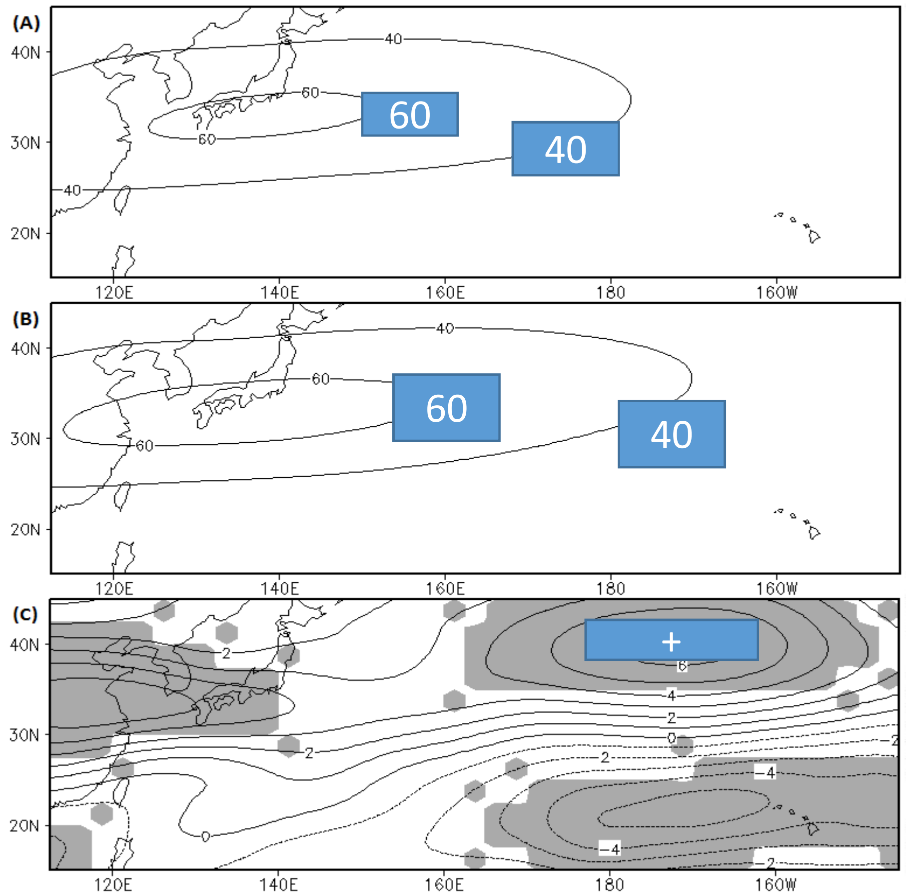


E1

E2

Seasonal mean zonal wind (ms^{-1}) at 200 hPa during the La Niña wet seasons. The grey shaded area is where the null hypothesis of the rank sum test was rejected at the 5% level. Solid (dashed) contours in (c) denote westerly (easterly) direction.

Upper troposphere



E1
178W

E2
170W

E2-E1

18.5°-22.5°N
159.5°-154.5°W

Chu, Nash, and Porter, 1993, J. Climate

La Niña Wet Seasons	Midlatitude Fronts	Kona Lows	Upper-level Lows	Rainfall Anomaly
1956	15	3	2	0.16
1964	18	5	2	0.50
1970	11	6	8	1.26
1971	9	10	3	0.21
1973	17	5	7	0.90
1974	9	4	6	0.23
1975	14	5	6	0.27
1983	11	2	1	-0.93
1984	13	5	4	0.06
1988	14	3	2	1.70
1995	12	4	3	-0.02
1998	8	1	4	-0.39
1999	6	1	4	-0.81
2000	10	1	2	-0.83
2005	8	4	6	0.53
2007	12	3	6	0.06
2008	8	5	5	-0.11
2010	10	4	7	0.14
E1 AVG	13.3	5.4	4.9	0.50
E2 AVG	10.2	3.0	4.0	-0.05
(E2 – E1)	-3.1	-2.4	-0.9	-0.55
E2/E1	0.77 (23%↓)	0.56 (44%↓)	0.82 (18%↓)	-

Summary

- Historically, Hawaii experienced low rainfall during El Nino events and abundant rainfall during La Nina events.
- A drying trend in Hawaii rainfall during La Nina years is evident. A change-point analysis determined that the shift occurs in 1983, forming 2 epochs (1956-1982 and 1983-2010).
- Tropical SSTs and circulation features in the North Pacific (e.g., Trenberth and Hurrell, 1994) have concurrently changed, thus possibly causing changes in La Nina year rainfall.
- The strengthening, and westward shifting of the eastern North Pacific subtropical high, coupled with the eastward elongation of the subtropical jet stream, are two main influences.

- Moisture transport analysis shows a reduction of moisture flux convergence in the Hawaii region during the second epoch. Changes in the circulation terms (i.e., dynamic effect) are found to be the primary driving force for the difference in moisture convergence surrounding Hawaii from E1 to E2.
- Additionally, a storm track analysis found fewer Kona lows and midlatitude fronts in the vicinity of Hawaii over the last 60 years. Decrease in these kinds of rain-bearing systems contributes mainly to a decline in La Nina rainfall since 1983.

O’Conner, Chu, Hsu, and Kodama, 2015, J. Climate