El Niño Occurrences, Volcano Eruptions, and Teleconnections

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El Niño occurrences, volcanic eruptions, and extreme weather events were documented. The null hypothesis is that these variables are independent which makes the alternate hypothesis that these variables are dependent. A chi-squared analysis was used to analyze the data and indicates if the variables are independent or dependent. The dependent occurrences were then analyzed to see if regional weather events effected other regional weather patterns. The primary results show that there are certain time frames that the variables are dependent on an El Niño occurrence or volcanic eruption and that the weather occurrences can influence regional weather patterns.

INTRODUCTION

This study researches the relationship between El Niño occurrences, volcano eruptions, and extreme weather events. From those results, it is possible to analyze how these extreme weather events can influence other regional weather systems. There has been research and observations that when an El Niño occurs it effects weather patterns around the world. These effected regions can change weather patterns of neighboring regions. This is commonly known as teleconnections. The areas that were observed in this project were Europe, Atlantic Ocean, west Africa, Brazil, and India. In the Pacific Ocean, there is a cycle of the top water heating up and moving to the western coastal area so that cold water can be pulled up from the ocean, thus creating a cycle. El Niño occurs when the water in the Pacific Ocean is warmer than usual and does not move to the western coast as it should, which effects global rain patters, wind patterns, temperatures, and other weather events.

Literature

El Niño effects patterns of atmospheric pressure.[1] High pressure is associated with dry, sinking air while low pressure is associated with rising and unsettled weather.[1] During an El Niño, areas of higher than normal pressure are typically over southwestern Europe and western Africa.[1] At the same time, lower than normal pressures form in the southern U.S.[1]

The jet streams can also be effected.[1] During the process of an El Niño, the unusually warm body of water in the Pacific Ocean moves which also effects the movement of moist tropical air.[1] Both the polar front and subtropical jet streams are affected.[1] The jet streams flow around the earth in a continuous wave form stream where the location is influenced by high and low pressure.[1] Changes in El Niño strength and air pressure change the normal pattern of the jet streams.[1] The jet streams control the typical paths of weather-generated storms and other weather patterns.[1]

According to the National Oceanic and Atmospheric Administration (NOAA), an El Niño occurrence can trigger noticeable irregularities from the normal rainfall patterns around the globe.[2] An El Niño causes excess heating in the Pacific upper atmosphere which can change the strength of the Hadley circulation which in turn changes circulation patterns worldwide.[2] The Hadley circulation is the poleward movement of air in the upper atmosphere which sinks over the subtropics and return flow toward the equator.[2] A change in this circulation can change the position of the jet stream.[2] An El Niño usually leads to an elongated jet stream that can extend to North America which creates an above average occurrence of storms across the southern U.S.[2] Teleconnections are the global change in atmospheric circulation and subsequent ground-level climate impacts.[2] Patterns have emerged from climate simulations and historic observations.[2]

Figure 1 is a map from the NOAA which shows rainfall patterns from El Niño events.[2] As shown during an El Niño event, this map indicates that west Africa, India, and Brazil as dry–meaning drought.

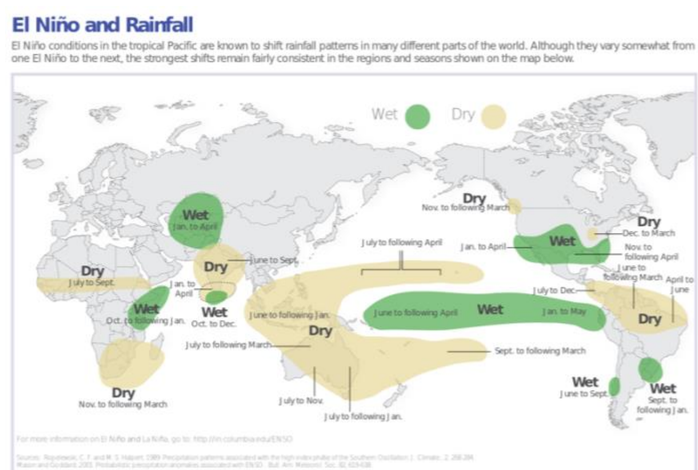

Figure 1. El Niño and Rainfall
Source: Barnston, Anthony. How ENSO Leads to a Cascade of Global Impacts.

An El Niño occurrence also influences the formation of hurricanes.[3] Because of the effected Hadley circulation, anomalous atmospheric conditions form where vertical wind shear over the Atlantic basin increases which suppresses hurricane activity.[3] An El Niño also increases atmospheric stability in the Atlantic basin.[3] A typical El Niño creates fewer hurricanes in the Atlantic Ocean.[3] In Figure 2, it is seen that the El Niño causes a lower number of hurricanes and activity in the Atlantic basin.[3]

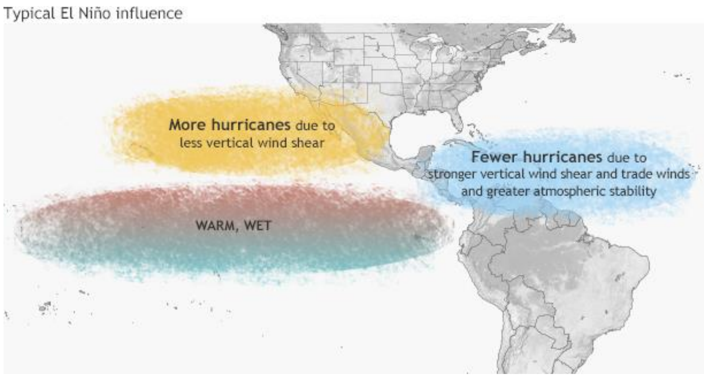

Figure 2. Typical El Niño Influence
Source: Becker, Emily. Impacts of El Niño and La Niña on the Hurricane Season.

According to the United States Geological Survey (USGS) volcanoes can impact the climate.[4] During major eruptions, volcanoes release huge amounts of volcanic gas and aerosol droplets into the stratosphere.[4] Volcanic gases like sulfur dioxide can cause global cooling while carbon dioxide has the potential to promote global warming.[4] Sulfur dioxide condenses in the stratosphere to form sulfate aerosols.[4] The aerosols increase the reflected radiation of the Sun back into space which cools the Earth's lower atmosphere.[4] While carbon dioxide from volcanic eruptions are released into the atmosphere, it is very small in comparison to human output.[4]

DATA AND METHODS

The data was collected by University of Florida Professor Emeritus Cesar Caviedes. Data from 1509 to 2000 was used for the analysis. Total El Niño, Normal El Niño, Major El Niño, and Volcanic Eruption occurrences were observed and compared to 12 other variables. These 12 variables are: Seca Brasa (drought) in Brazil, Drought in West Africa, Drought in India, Above Average Hurricanes, Below Average Hurricanes, Atlantic Storms, European Cold Winter, European Warm Winter, European Cold Summer, European Warm Summer, European Cold Year, and European Warm Year. The null hypothesis is that these variables are independent which makes the alternate hypothesis that these variables are dependent.

A chi-squared analysis uses the following calculations to find the probability value and is used to calculate statistical significance. Data was organized into a 2x2 contingency table where an El Niño or Volcanic Eruption did occur or did not occur and compared to a variable that did or did not occur.

A binary number system of 1 and 0 was used to indicate if an occurrence took place. The number 1 indicates an occurrence while 0 indicates no occurrence. This allowed for the creation of four numerical combinations where the an El Niño occurrence or Volcanic Eruption are the first number and the 12 variables are the second number: (1,1), (1,0), (0,1), (0,0). A chi-squared analysis was used to test for variable independence and dependence. The premise of the chi-squared analysis is that the probability of the actual event occurrence is compared to the probability of predicted events and if the difference is statistical significant then the test indicates a dependent relationship. Excel was used for all computations and data graph results.

Data samples were grouped into 50 years where a continuous sliding window was used. Meaning the results for year 1509 used data from 1509 to 1558 and results for year 1510 used data from 1510 to 1559. For each sample group the data was sorted into the four possible binary number categories and each category was added together. All years up to 1951 was calculated this way. The data sample of 50 years is used as the observed value. Expected frequency is calculated from this formula:

$$E_{ij} = \frac{R_i C_j}{n}$$

where R_i and C_j are observed counts for row i and column j, respectively.

The test statistic is calculated with the following equation:

$$X^2 = \sum_{i=1}^{r} \sum_{j=1}^{c} \frac{\left(O_{ij} - E_{ij}\right)^2}{E_{ij}}$$

where O_{ij} is the observed value and E_{ij} is the expected value.

The test statistic's probability is calculated and compared to the significance value. The significance value for all results is .1 (10%). This means that any test statistics with a probability value less than .1 was significant. This also means that the probability of rejecting the null hypothesis given that it is true is 10%. 48 graphs were created in total. The colored lines show where the results are significant for each year from the chi-squared test. It does not indicate the type of relationship between the variables.

The graphs created indicate when variables are dependent but the specific relationship is not specified by the chi-squared test. The odds ratio was used to examine the relationship between the variables where dependence was indicated by the chi-squared test. The odds ratio represents the odds that an outcome will occur given a certain event, compared to the odds of the outcome occurring in the absence of that event. The odds ratio equation is:

$$OR = \frac{a/c}{b/d} = \frac{a * d}{b * c}$$

where *a* = (1,1), *b* = (1,0), *c* = (0,1), *d* = (0,0) for each category.

Only years that showed significance were used to calculate the odds ratio where each binary value was calculated and then added into their respective category. The odds ratio compares the odds of a (1,1) occurrence to a (0,0) occurrence. An odds ratio above 1 means the relationship (1,1) have higher odds of occurring than a (0,0). A ratio below 1 means the relationship (0,0) have higher odds of occurring than a (1,1).

RESULTS

El Niño and Dependent Variable Occurrences (Figures 3A to 3L)

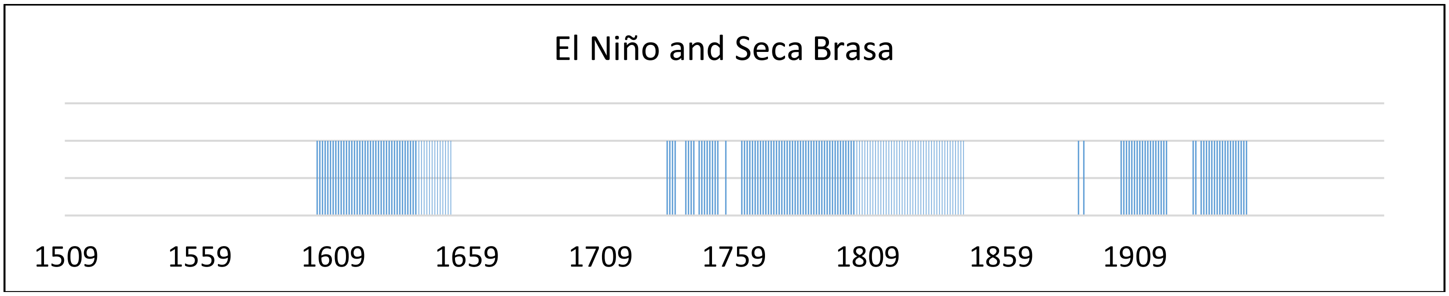

Figure 3A. El Niño and Seca Brasa

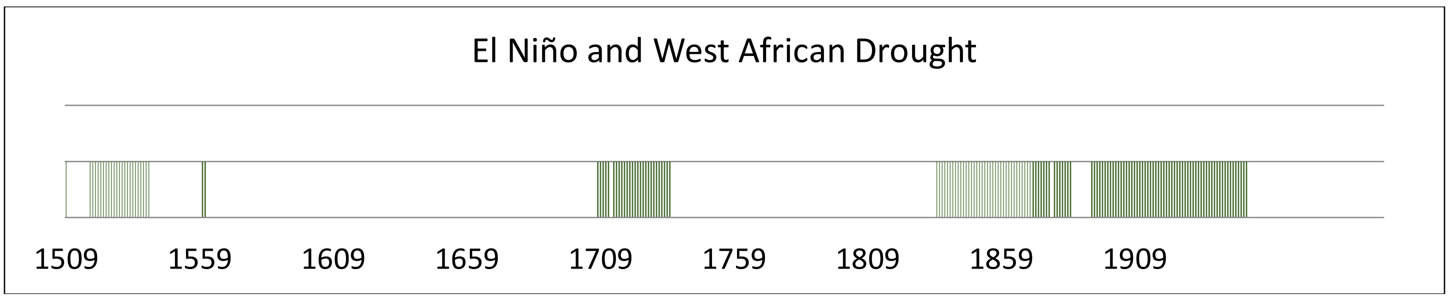

Figure 3B. El Niño and West African Drought

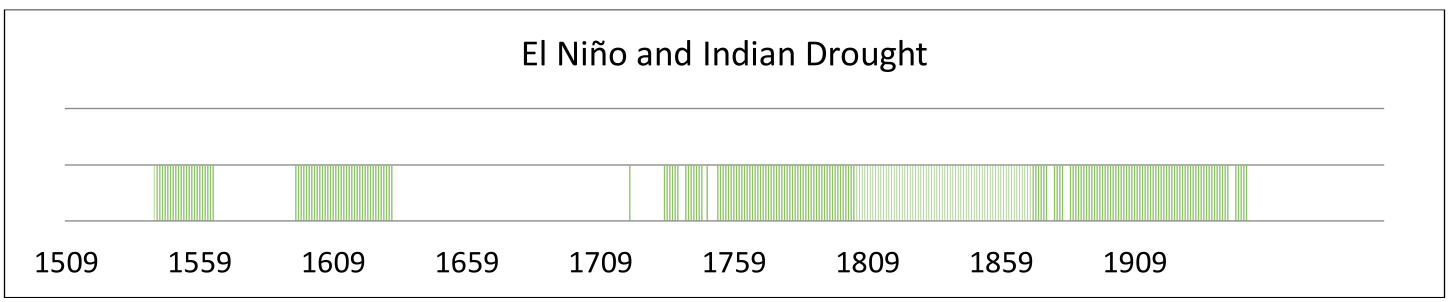

Figure 3C. El Niño and India Drought

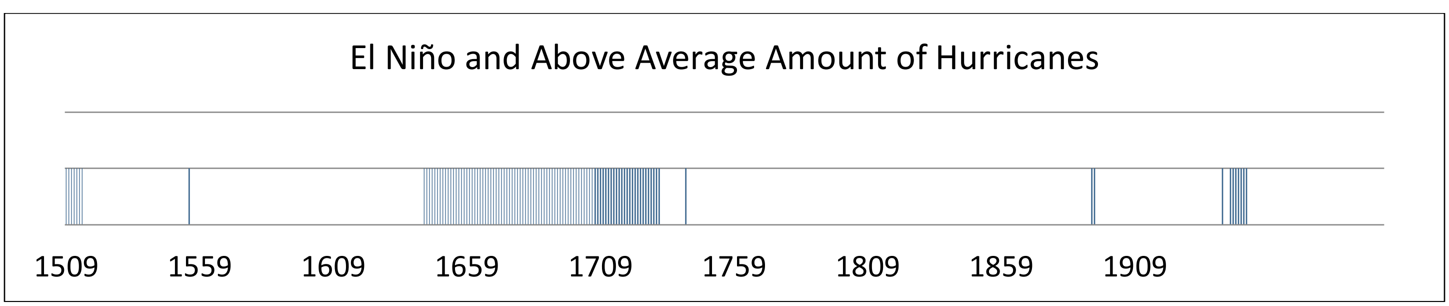

Figure 3D. El Niño and Above Average Amount of Hurricanes

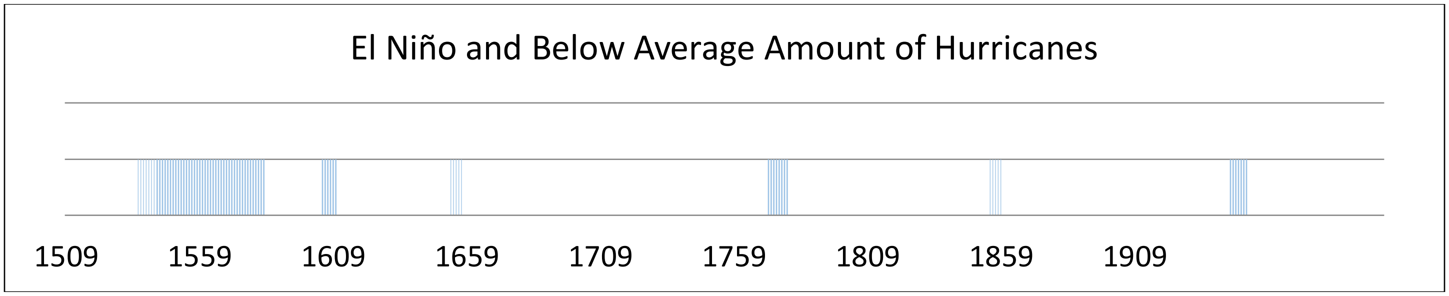

Figure 3E. El Niño and Below Average Amount of Hurricanes

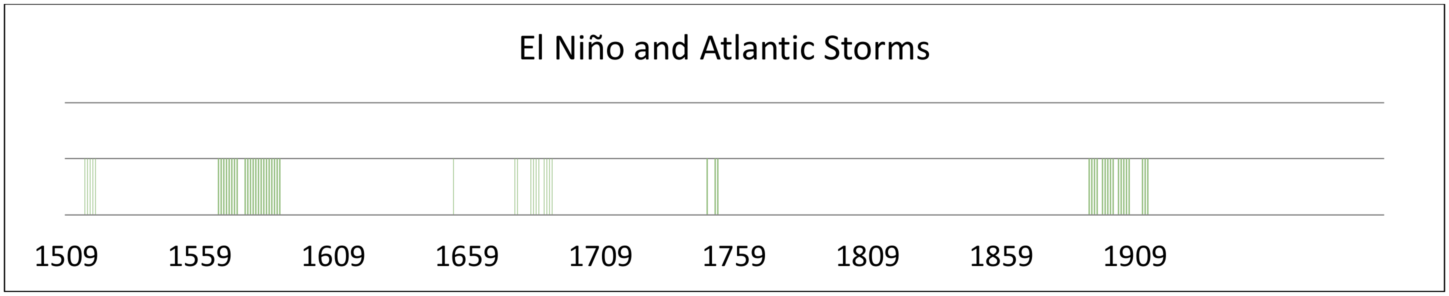

Figure 3F. El Niño and Atlantic Storms

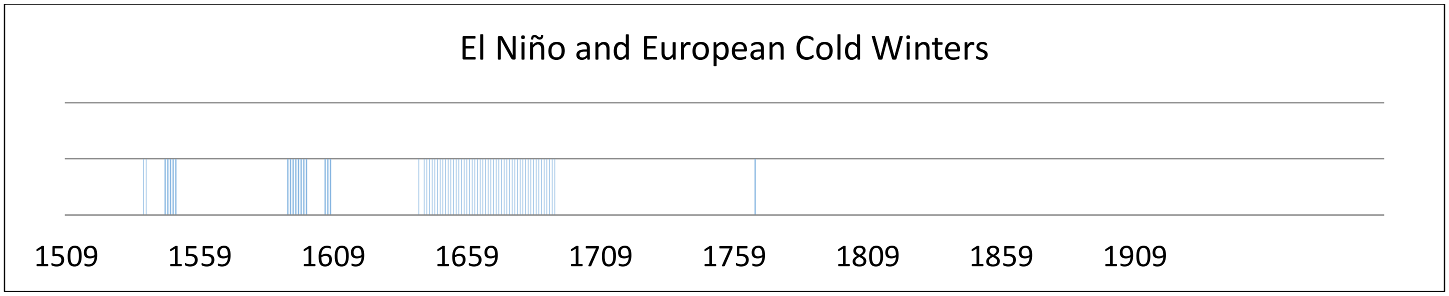

Figure 3G. El Niño and European Cold Winters

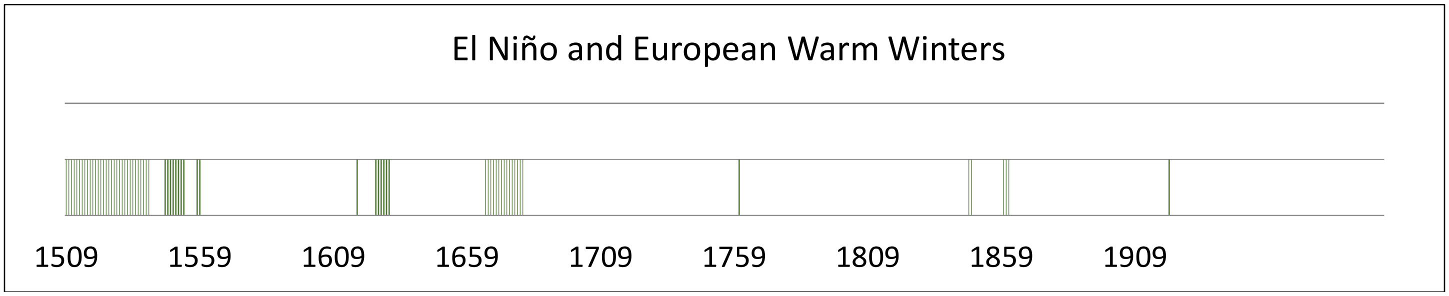

Figure 3H. El Niño and European Warm Winters

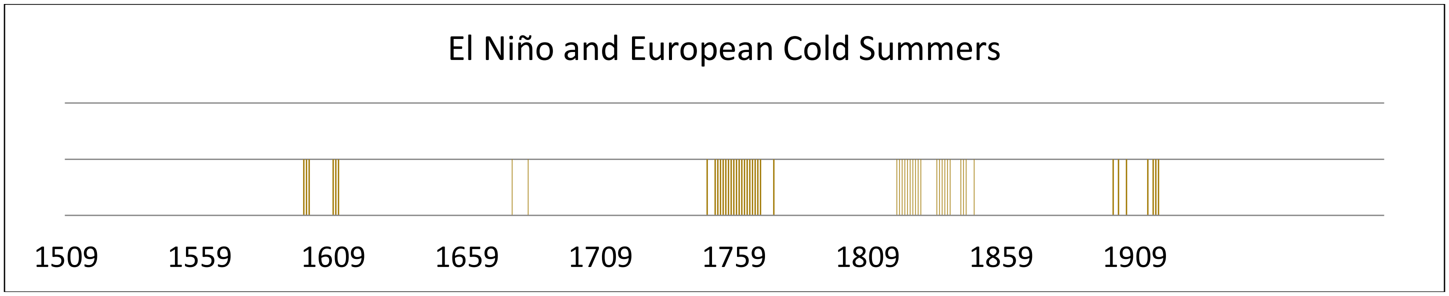

Figure 3I. El Niño and European Cold Summers

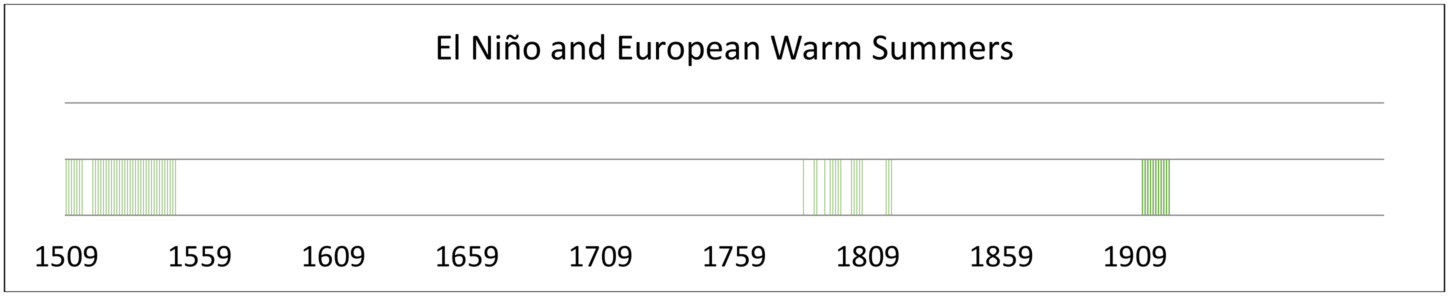

Figure 3J. El Niño and European Warm Summers

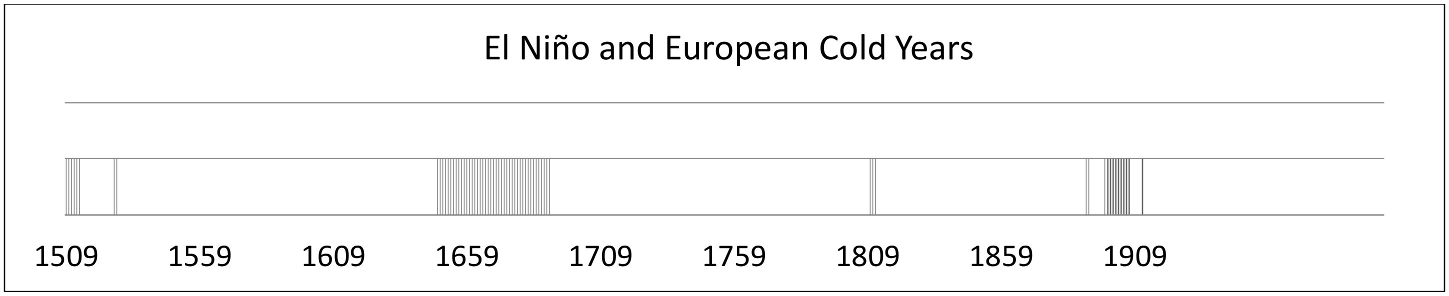

Figure 3K. El Niño and European Cold Years

Figure 3L. El Niño and European Warm Years

El Niño Odds Ratios:

Seca Brasa	1904-1951: OR > 1
West African Drought	1904-1951: OR > 1
Indian Drought	1733-1951: OR > 1
Above Average Amount of Hurricanes	1649-1729: OR > 1
Below Average Amount of Hurricanes	1536-1583: OR = 0
Atlantic Storms	1566-1583: OR = 0
European Cold Winters	1641-1692: OR < 1
European Warm Winters	1509-1553: OR > 1
European Cold Summers	1752-1769: OR > 1
European Warm Summers	1509-1550: OR > 1
European Cold Years	1649-1700: OR > 1
European Warm Years	1509-1553: OR > 1

Table 1. El Niño Odds Ratio

Normal El Niño and Dependent Variable Occurrences (Figures: 4A to 4L)

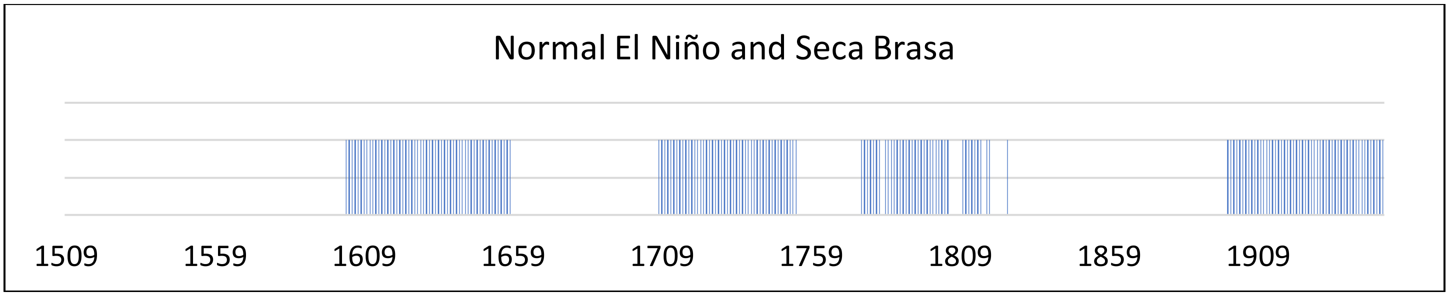

Figure 4A. Normal El Niño and Seca Brasa

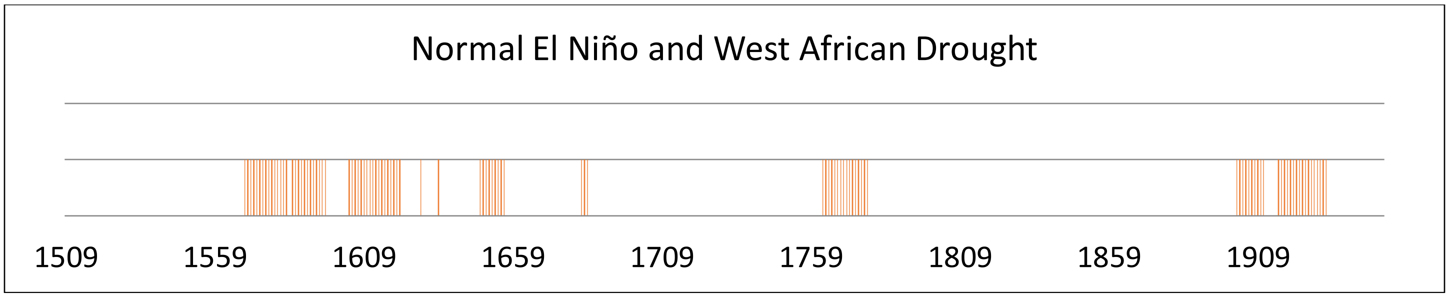

Figure 4B. Normal El Niño and West African Drought

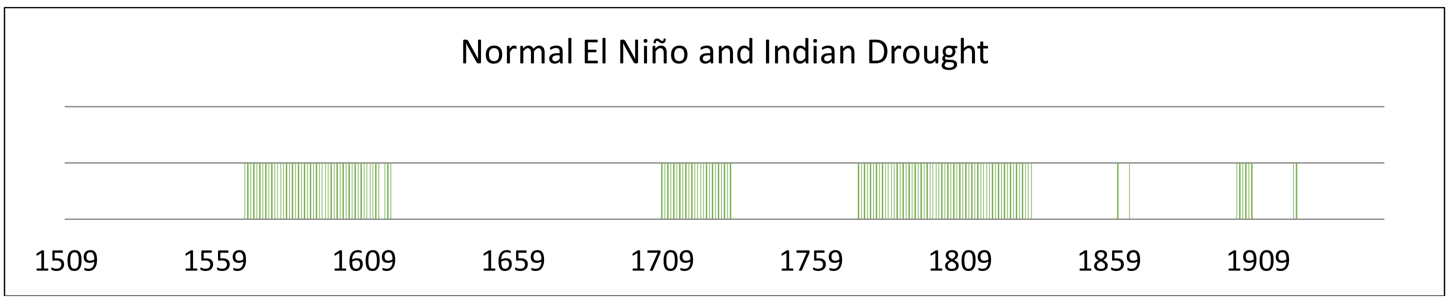

Figure 4C. Normal El Niño and Indian Drought

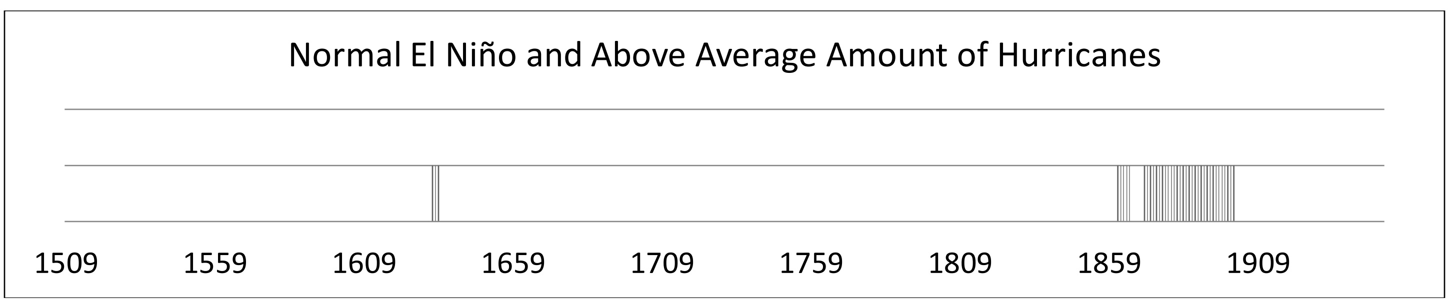

Figure 4D. Normal El Niño and Above Average Amount of Hurricanes

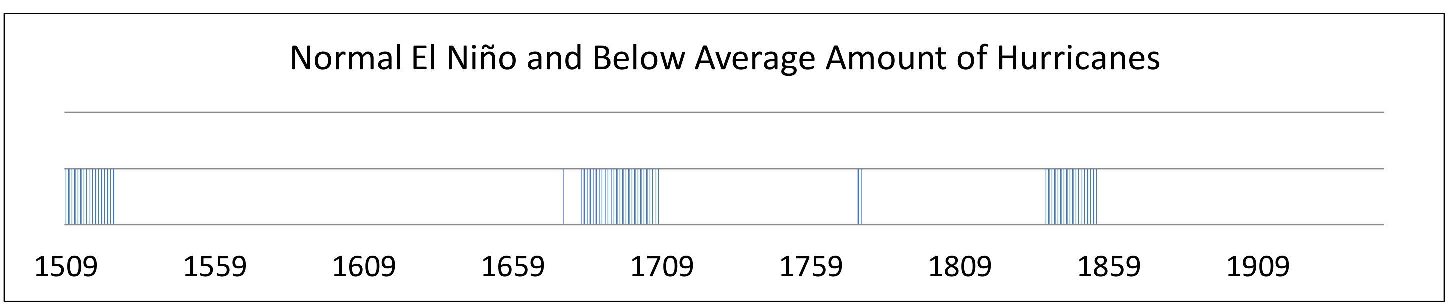

Figure 4E. Normal El Niño and Below Average Amount of Hurricanes

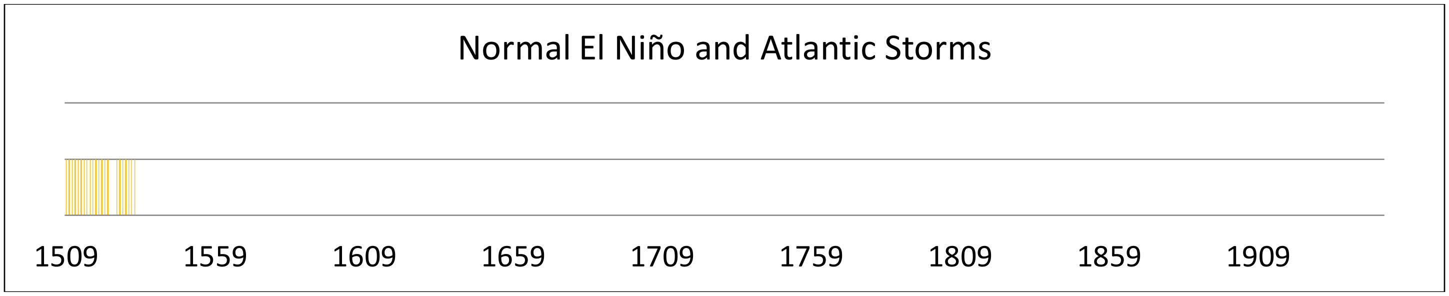

Figure 4F. Normal El Niño and Atlantic Storms

Figure 4G. Normal El Niño and European Cold Winters

Figure 4H. Normal El Niño and European Warm Winters

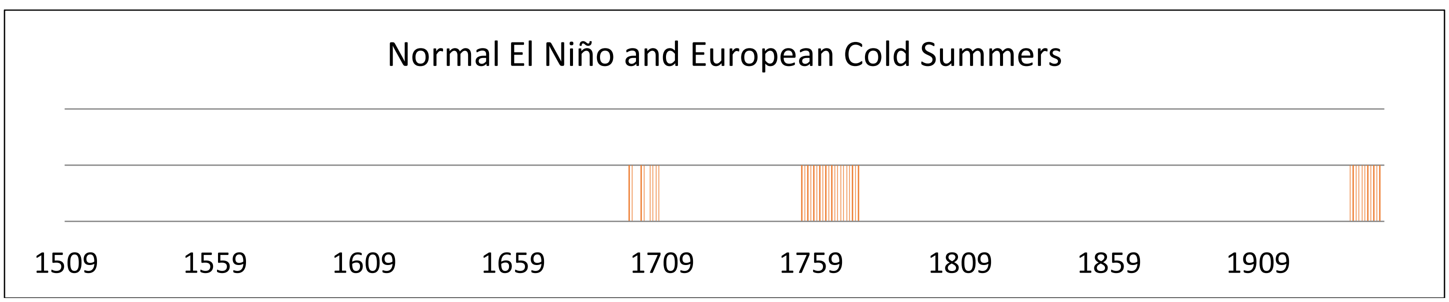

Figure 4I. Normal El Niño and European Cold Summers

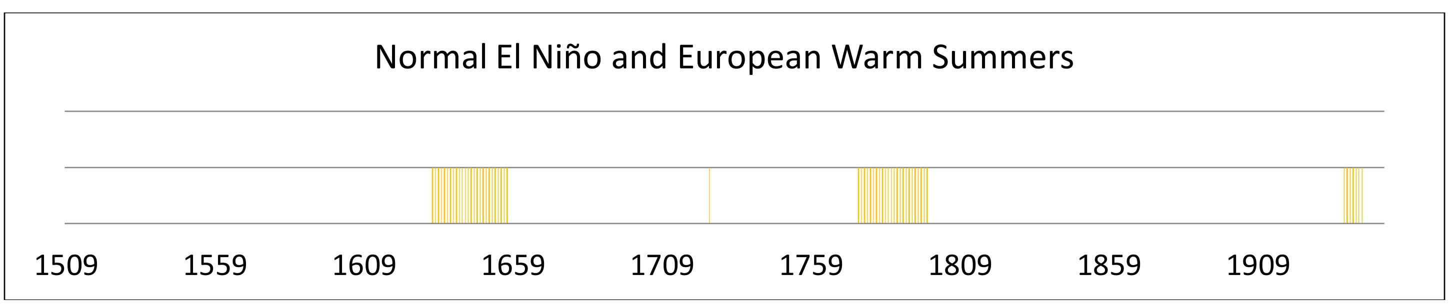

Figure 4J. Normal El Niño and European Warm Summers

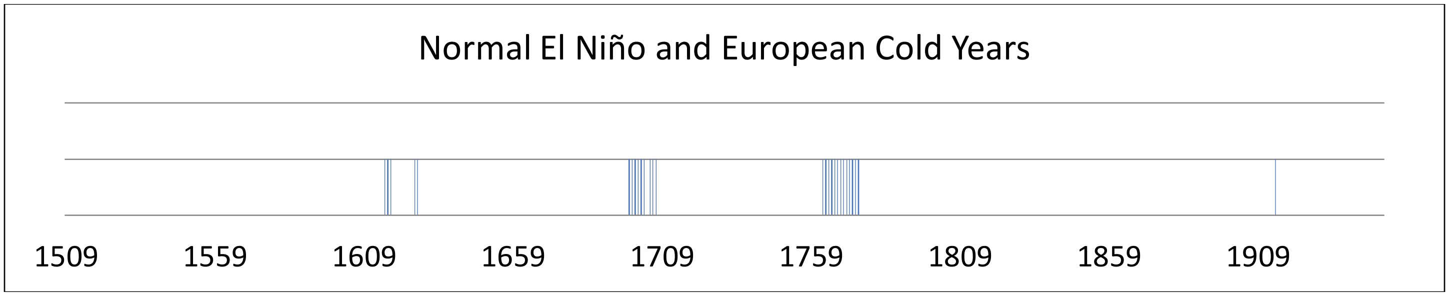

Figure 4K. Normal El Niño and European Cold Years

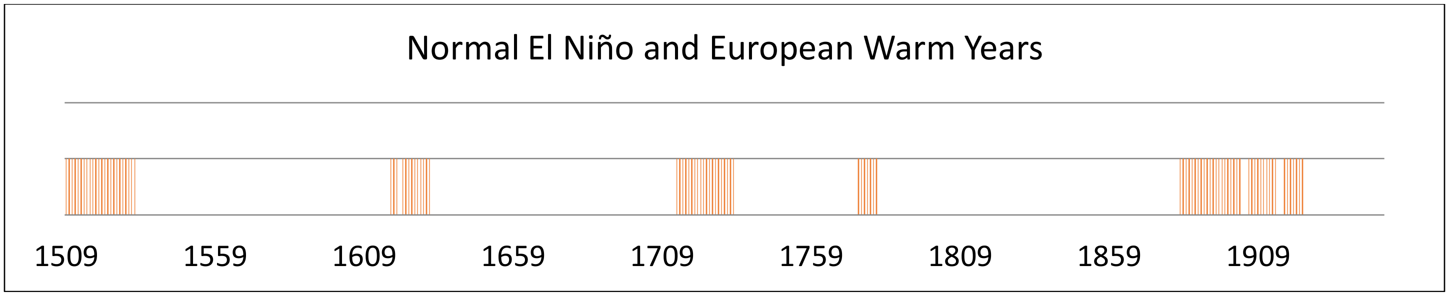

Figure 4L. Normal El Niño and European Warm Years

Normal El Niño Odds Ratios:

Seca Brasa	1603-1658: OR > 1, 1708-1754: OR > 1, 1776-1819: OR > 1, 1899-1951: OR > 1
West African Drought	1569-1621: OR > 1, 1902-1931: OR > 1
Indian Drought	1569-1618: OR > 1, 1775-1833: OR > 1
Above Average Amount of Hurricanes	1871-1901: OR = 0
Below Average Amount of Hurricanes	1509-1525: OR > 1, 1682-1708: OR > 1
Atlantic Storms	1509-1523: OR = 0
European Cold Winters	1863-1888: OR = 0
European Warm Winters	1509-1532: OR > 1, 1603-1631: OR > 1, 1866-1930: OR > 1
European Cold Summers	1756-1775: OR > 1
European Warm Summers	1632-1657: OR > 1, 1775-1798: OR = 0
European Cold Years	1698-1707: OR = 0, 1763-1775: OR > 1
European Warm Years	1509-1532: OR > 1

Table 2. Normal El Niño Odds Ratios

Major El Niño and Dependent Variable Occurrences (Figures 5A to 5L)

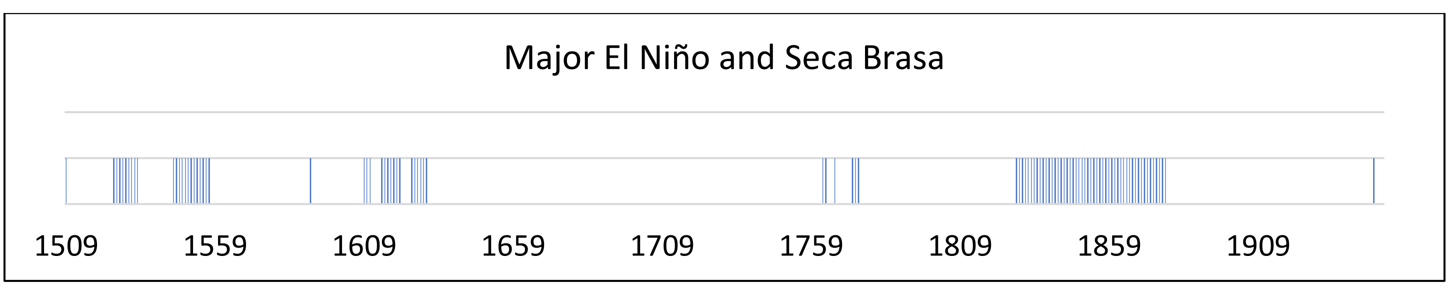

Figure 5A. Major El Niño and Seca Brasa

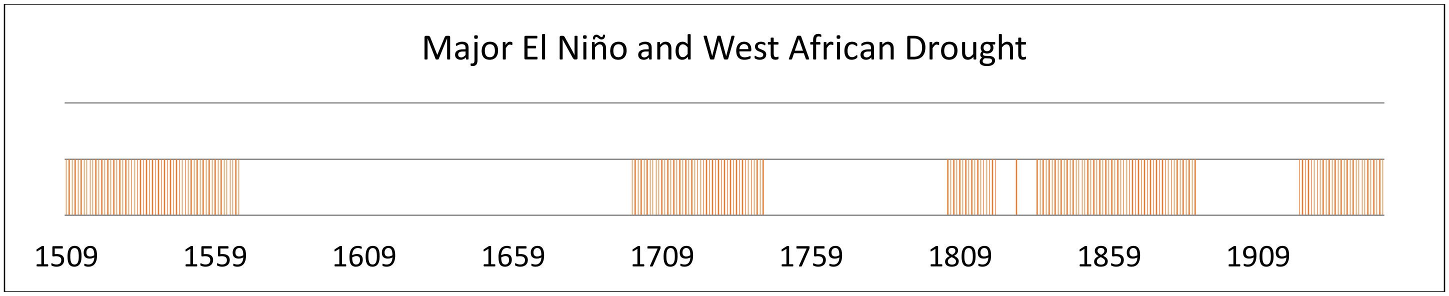

Figure 5B. Major El Niño and West African Drought

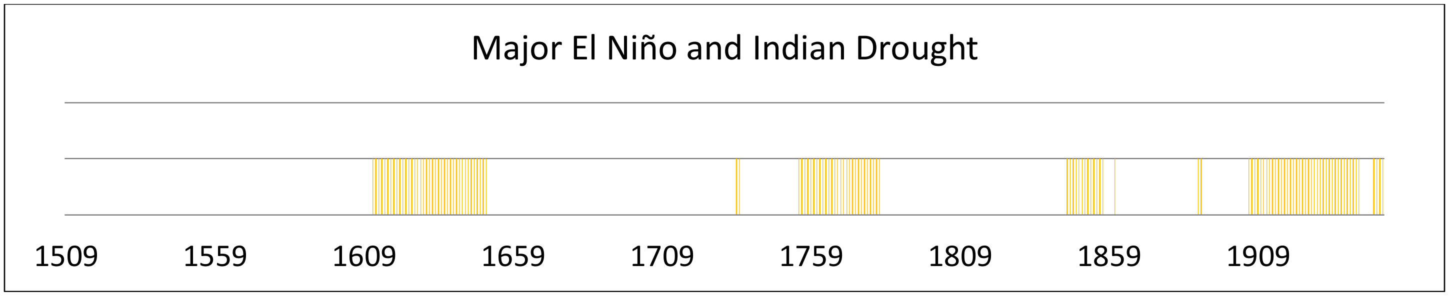

Figure 5C. Major El Niño and Indian Drought

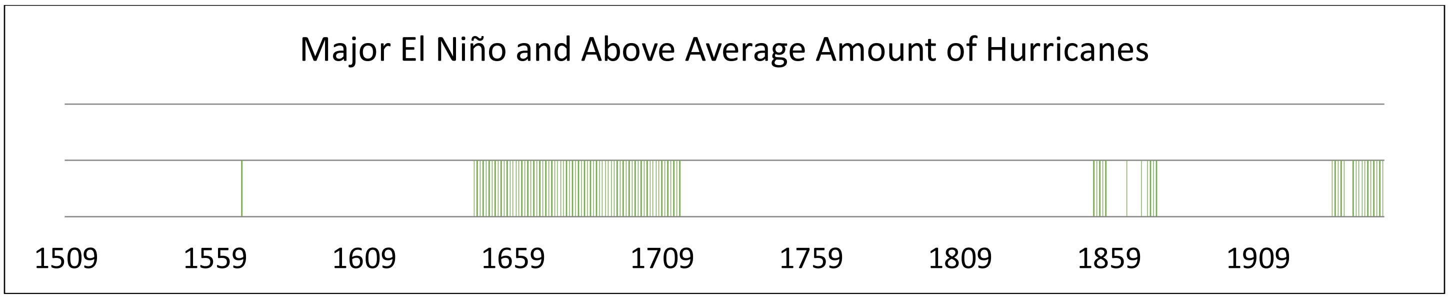

Figure 5D. Major El Niño and Above Average Amount of Hurricanes

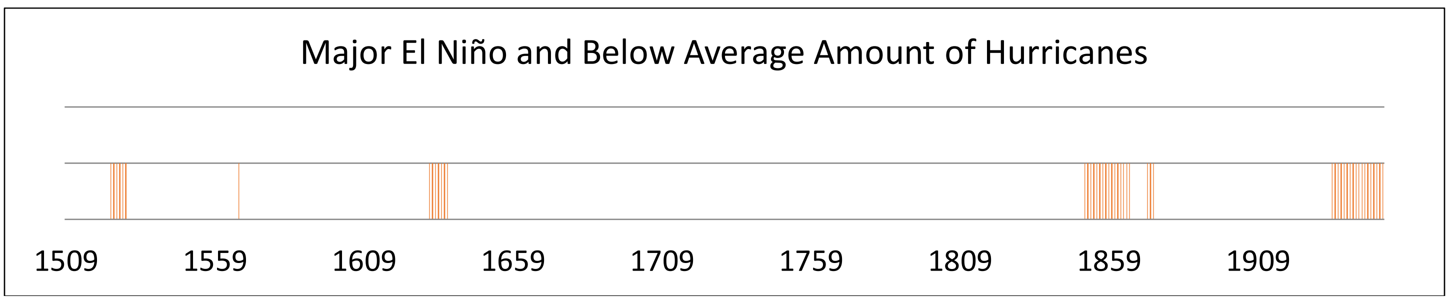

Figure 5E. Major El Niño and Below Average Amount of Hurricanes

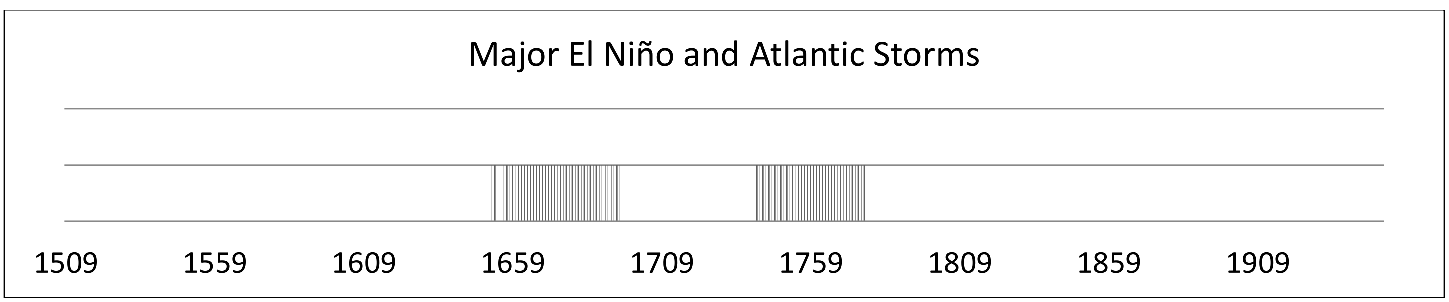

Figure 5F. Major El Niño and Atlantic Storms

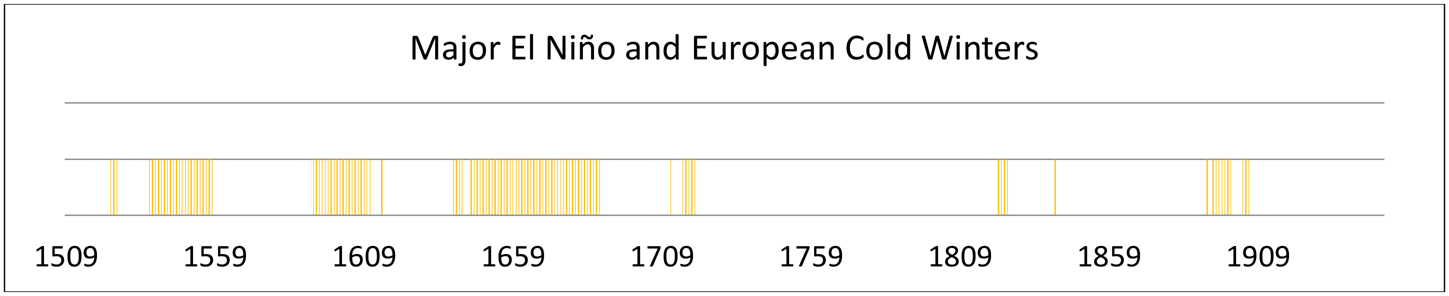

Figure 5G. Major El Niño and European Cold Winters

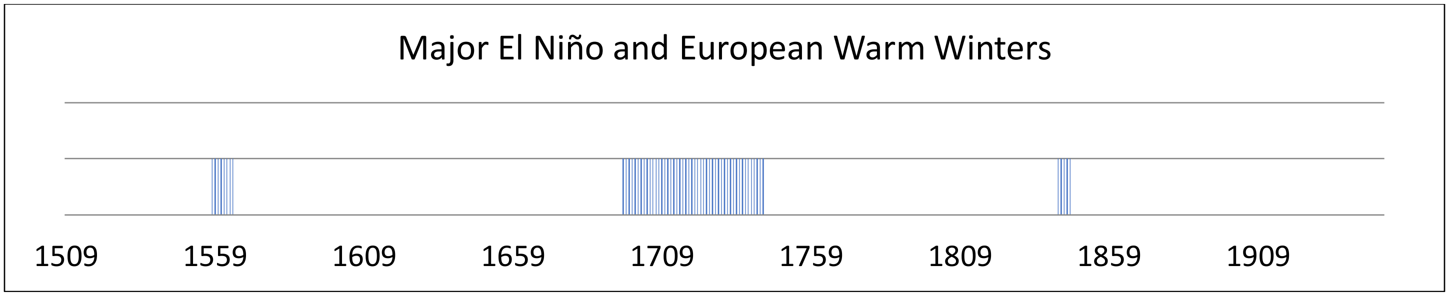

Figure 5H. Major El Niño and European Warm Winters

Figure 5I. Major El Niño and European Cold Summers

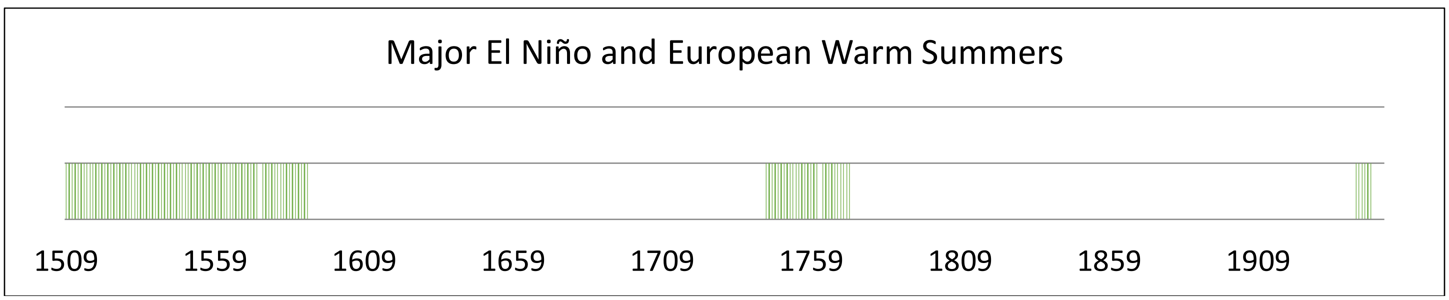

Figure 5J. Major El Niño and European Warm Summers

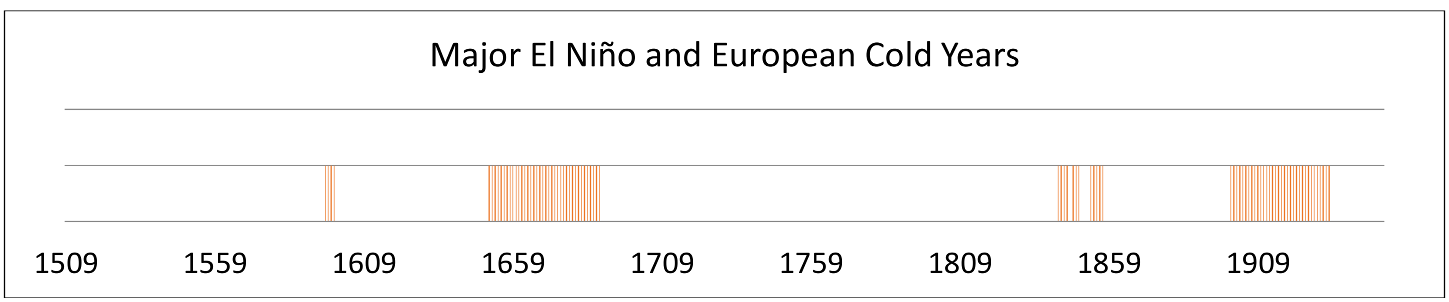

Figure 5K. Major El Niño and European Cold Years

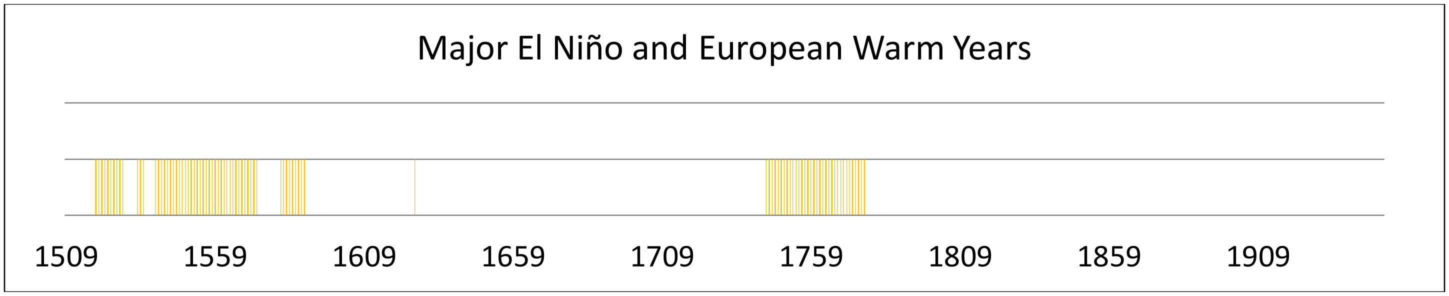

Figure 5L. Major El Niño and European Warm Years

Major El Niño Odds Ratios:

Seca Brasa	1828-1878: OR > 1
West African Drought	1509-1567: OR > 1, 1699-1743: OR > 1, 1835-1888: OR > 1
Indian Drought	1755-1782: OR > 1
Above Average Amount of Hurricanes	1646-1715: OR > 1, 1934-1951: OR > 1
Below Average Amount of Hurricanes	1934-1951: OR = 0
Atlantic Storms	1652-1695: OR > 1, 1741-1777: OR > 1
European Cold Winters	1639-1688: OR > 1
European Warm Winters	1696-1743: OR > 1
European Cold Summers	1646-1678: OR = 0, 1817-1864: OR > 1, 1901-1932: OR > 1
European Warm Summers	1509-1590: OR > 1, 1744-1772: OR > 1
European Cold Years	1651-1688: OR > 1, 1842-1857: OR > 1, 1900-1933: OR > 1
European Warm Years	1519-1573: OR > 1, 1744-1777: OR > 1

Table 3. Major El Niño Odds Ratios

Volcano Eruption and Dependent Variable Occurrences (Figure 6A to 6L)

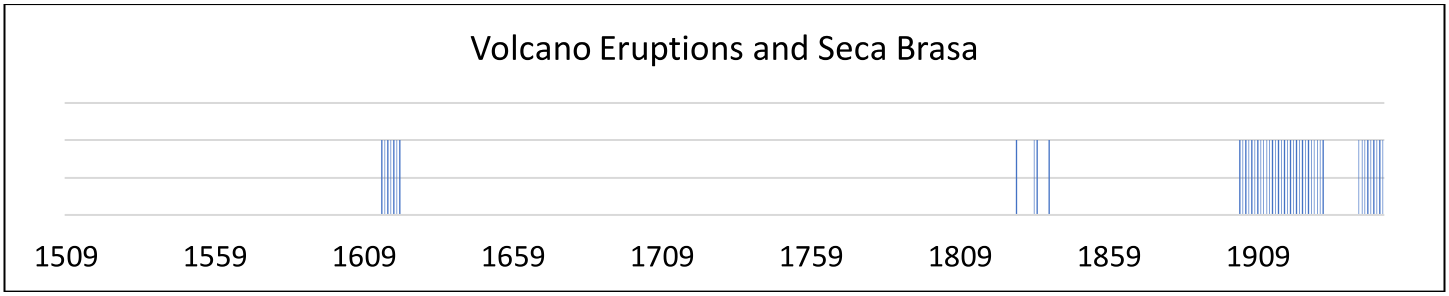

Figure 6A. Volcano Eruptions and Seca Brasa

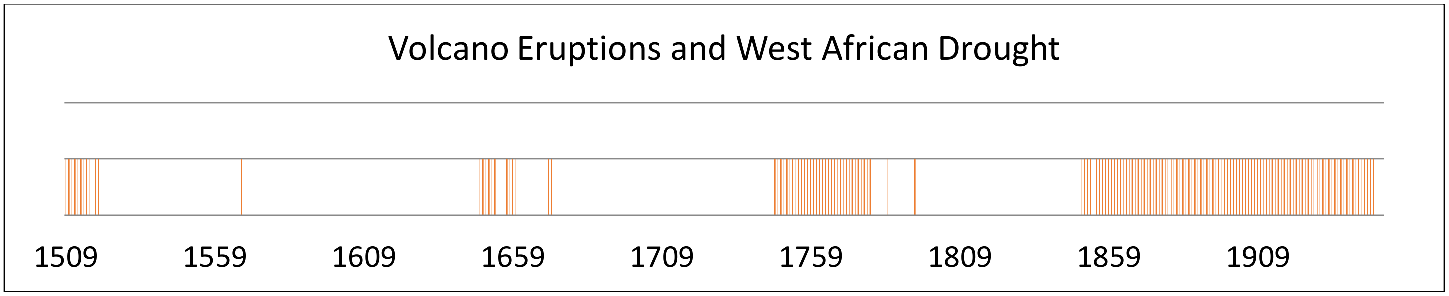

Figure 6B. Volcano Eruptions and West African Drought

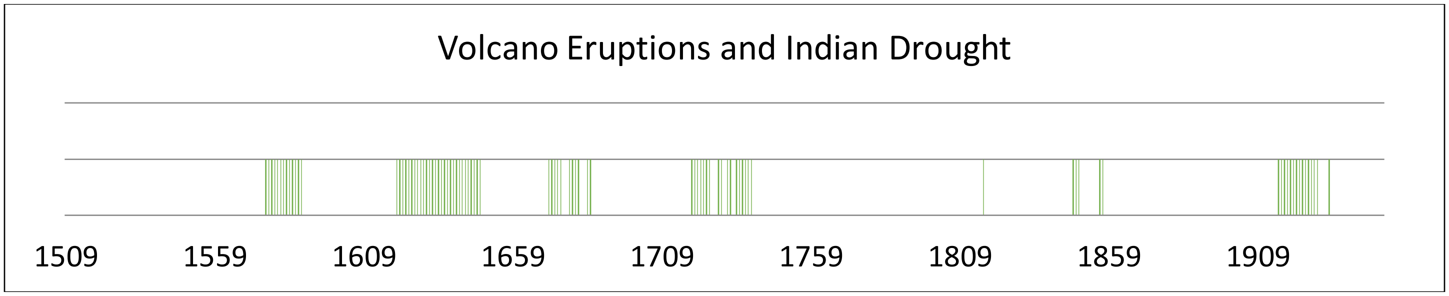

Figure 6C. Volcano Eruptions and Indian Drought

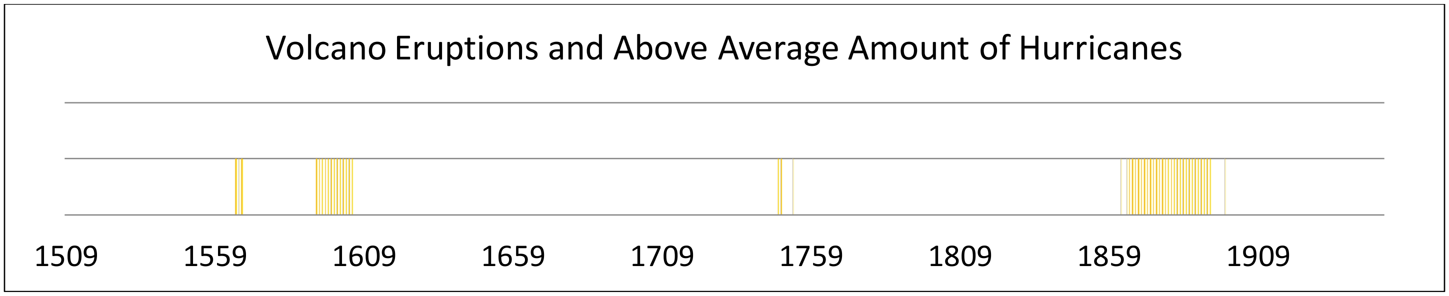

Figure 6D. Volcano Eruptions and Above Average Amount of Hurricanes

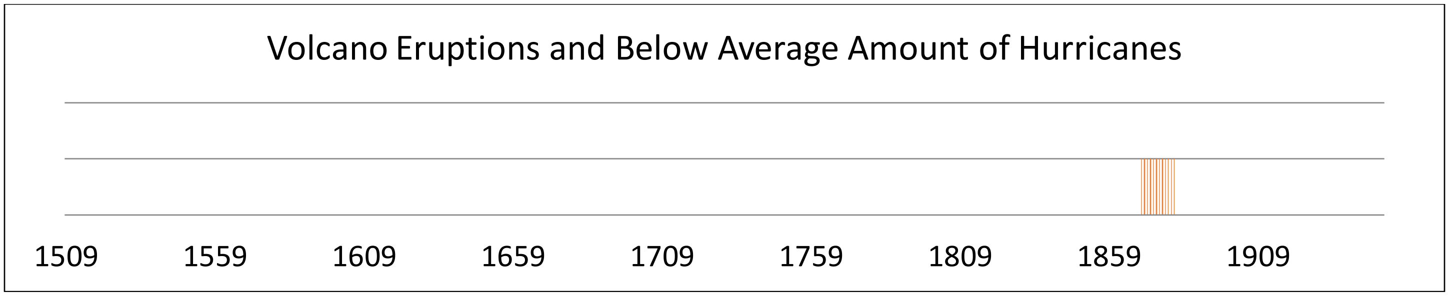

Figure 6E. Volcano Eruptions and Below Average Amount of Hurricanes

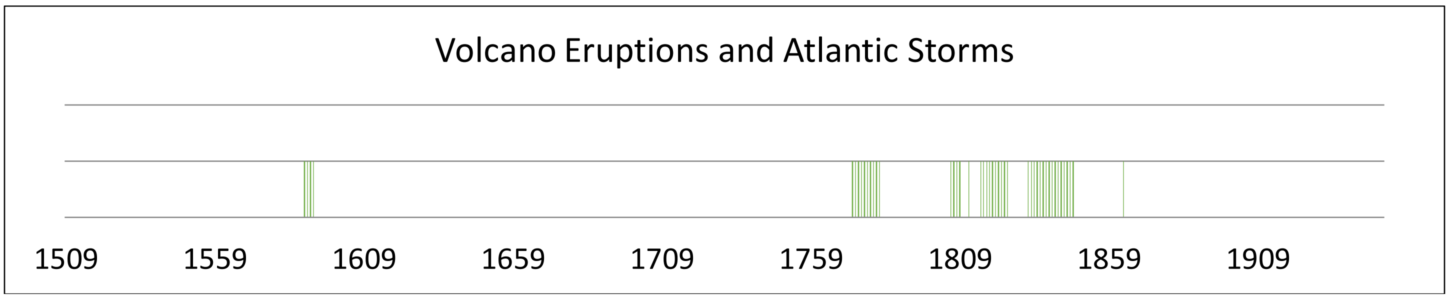

Figure 6F. Volcano Eruptions and Atlantic Storms

Figure 6G. Volcano Eruptions and European Cold Winters

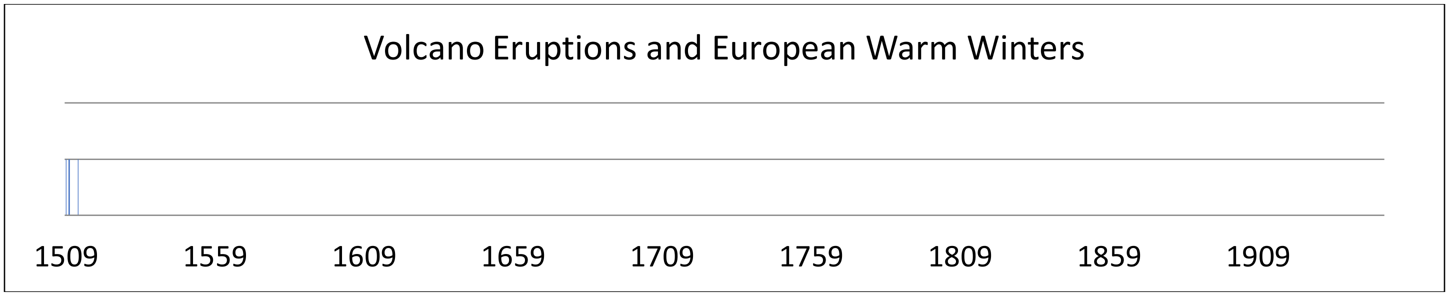

Figure 6H. Volcano Eruptions and European Warm Winters

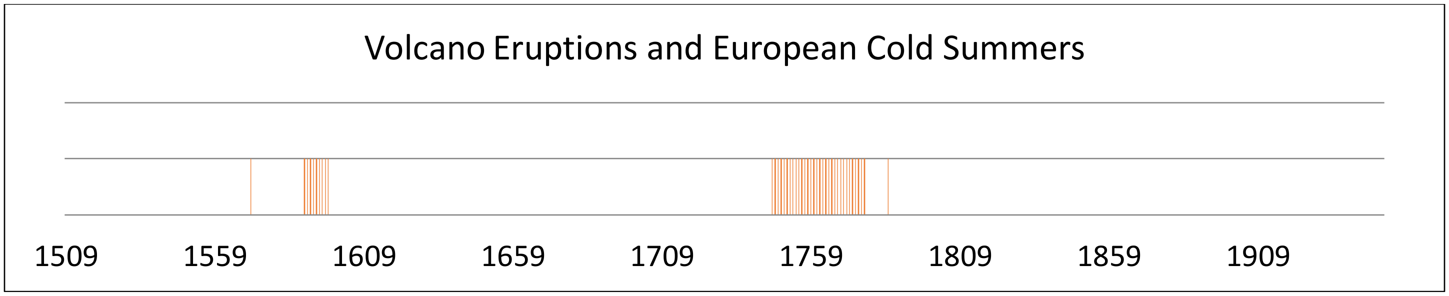

Figure 6I. Volcano Eruptions and European Cold Summers

Figure 6J. Volcano Eruptions and European Warm Summers

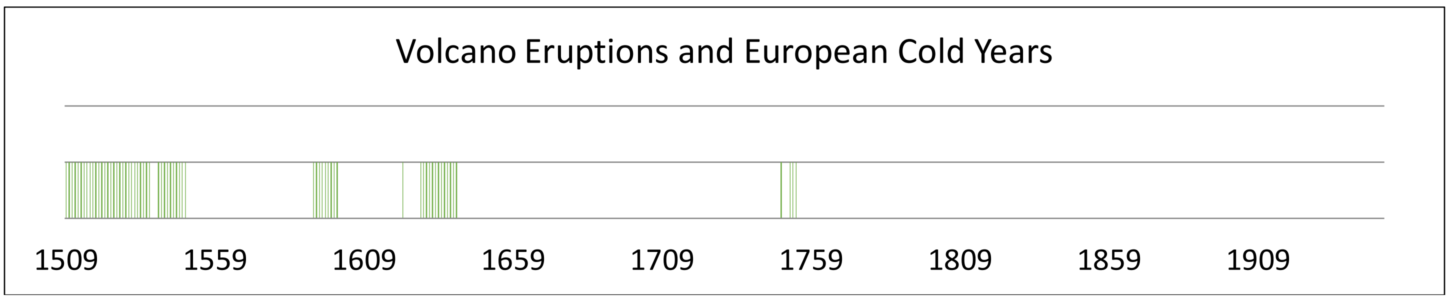

Figure 6K. Volcano Eruptions and European Cold Years

Figure 6L. Volcano Eruptions and European Warm Years.

Volcano Eruptions Odds Ratios:

Seca Brasa	1903-1951: OR > 1
West African Drought	1747-1779: OR > 1, 1850-1948: OR > 1, 1903-1948: OR > 1
Indian Drought	1620-1648: OR > 1, 1916-1929: OR > 1
Above Average Amount of Hurricanes	1593-1605: OR > 1, 1863-1893: OR > 1
Below Average Amount of Hurricanes	1870-1881: OR > 1
Atlantic Storms	1832-1847: OR > 1
European Cold Winters	1613-1620: OR > 1
European Warm Winters	N/A
European Cold Summers	1746-1777: OR > 1
European Warm Summers	N/A
European Cold Years	1509-1549: OR = 0, 1592-1600: OR > 1, 1628-1640: OR > 1
European Warm Years	N/A

Table 4. Volcano Eruptions Odds Ratios

DISCUSSION

From the odds ratio, it can be examined if there were any commonalities between other variables during the same time periods. The limitations to the odds ratio are the number of years being too small for an accurate ratio. The odds ratio cannot be compared to other ratios because of the different sample sizes. The numbers used for the odds ratio were the years shown significant, not the 50-year sample numbers used for the chi-squared calculation. When variables have an odds ratio above 1 and in the same time frame, it can be suggested that the occurrence of the variables are related to each other.

The charts were ordered in the best possible way to analyze possible connections between variables. The areas in the Atlantic, hurricane formation and European weather systems are connected to each other. The Brazilian drought and west African droughts are also believed to be connected. India's weather system is in its own region since other variables in the Pacific area were not examined.

Figure 3 shows Total El Niño occurrences with the 12 variables and its respective odds ratio table indicates possible relationships between variables. Figures 3A and 3B both had an odds ratio of above 1 during the years 1904-1951, indicating that the Seca Brasa and Drought in Africa could influence each other. Figure 3D, Total El Niño Occurrences and Above Average Amount of Hurricanes had an odds ratio above 1 during the years 1649-1729. What is also interesting about these results is that both events occurred or did not occur at the same time which is unusual for an 80-year period. This indicates a strong correlation of El Niño occurrences with Above Average Amount of Hurricanes. Figure 3E has an odds ratio of 0 during the years 1536-1583. Figure 3F during the years 1566-1583 has an odds ratio of 0 as well. While the odds ratio of Figure 3E and Figure 3F are not the exact same time frame, it is highly suggestable that there is a relationship between no Atlantic storms, Below Average Amount of Hurricane occurrences, and no El Niño occurrences. Figure 3H during the years 1509 to 1553 and Figure 3J during the years 1509 to 1550 both have an odds ratio above 1 which is suggestive that European Warm Winters and European Warm Summers are connected by El Niño occurrences. Figure 3L had an odds ratio above 1 during the years 1509 to 1553. It is also notable that Figure 3H and Figure 3J also had an odds ratio above 1 during the same period indicating that European Warm Winters and European Warm Summers are related to European Warm Years which have higher odds of occurring when an El Niño event happens.

Figure 4 examines Normal El Niño occurrences with the 12 variables with odds ratios that can indicate possible relationships between variables. Figure 4A during the years 1603 to 1658, 1708 to 1754, 1776 to 1819, and 1899 to 1951 had an odds ratio above 1 meaning there are high odds of a normal El Niño and Seca Brasa occurrence. In Figure 4B from the years 1569 to 1621 and 1902 to 1932 the odds ratio is above 1 indicating that there are high odds of a normal El Niño and drought in western Africa occurring together. Figure 4C has an odds ratio above 1 for the years 1569 to 1618 and 1775 to 1833 indicating that normal El Niño and drought in India have high odds of occurring. In Figure 4D, Above Average Amount of Hurricanes, during the years 1871 to 1901 the odds ratio was 0. Within the time frame of 1863 to 1888, Figure 4G also had an odds ratio of 0 which suggests that a non-occurrence of Above Average Hurricane and European Cold Winter were related to each other during that time. From 1509 to 1532, 1603 to 1631, and 1866 to 1930 Figure 4H, European Warm Winters, has an odds ratio above 1. From 1756 to 1775, European Cold Summers, Figure 4I has an odds ratio above 1. Figure 4K, European Cold Years, during the years 1763 to 1775 has an odds ratio of above 1. Figure 4I and Figure 4K both had an odds ratio above 1 during the same time indicating that during an El Niño occurrence, European Cold Summers and European Cold Years are related. For European Warm Year,

Figure 4L, has an odds ratio above 1 during the years 1509-1532, 1618 to 1631, and 1883 to 1924. It is seen that European Warm Winter and European Warm Year, Figure 4H and Figure 4L, both have an odds ratio above 1 during the years 1509 to 1532 indicating a possible relationship.

Figure 5 examines Major El Niño occurrences with the 12 variables with odds ratios that can indicate possible relationships between variables. Figure 5A, Seca Brasa, during the years 1828 to 1878 had an odds ratio above 1. During the years 1509 to 1567 and 1835 to 1888, drought in western Africa, had an odds ratio above 1. While Seca Brasa and drought in western Africa have an odds ratio above 1 with different time frames (1828 to 1878 and 1835 to 1888) it is still possible that these two variables have a relationship during the time that they overlap. Figure 5D, during the years 1646 to 1715 and 1934 to 1951 have an odds ratio above 1 indicating that Major El Niño and Above Average Amount of Hurricanes have high odds of occurring. Below Average Amount of Hurricanes, Figure 5E, has an odds ratio of 0 during the years 1934 to 1951 which supports the odds ratio of above 1 for Figure 5D. During 1652 to 1695 and 1741 to 1777, the odds ratio for Atlantic Storms, Figure 5F, is above 1. With an odds ratio above 1 it also indicates that Atlantic Storm events and Above Average Amount of Hurricanes could be related during the years 1652 to 1695. During the years 1639 to 1688, Figure 5G, European Cold Winters has an odds ratio above 1 meaning that the variables Atlantic Storms, Above Average Amount of Hurricanes and European Cold Winters could be related during their overlapping time frame. Figure 5H, European Warm Winters, from 1696 to 1743 has an odds ratio above 1 which can indicate that this variable is related to Drought in Africa during 1699 to 1743. Figure 5I, European Cold Summer, during the years 1646 to 1678 has an odds ratio of 0 while years 1817 to 1864 and 1901 to 1932 have an odds ratio above 1. In the 1835 to 1864 time frame the odds ratio for Drought in Africa is also above 1 indicating that a Major El Niño, Drought in Africa, and European Cold Summer have a related occurrence. Figure 5J, European Warm Summers, had odds ratios above 1 for the years 1509 to 1590 and 1744 to 1772. From 1509 to 1567, Drought in Africa had an odds ratio above 1 indicating that it's occurrence could be related to European Warm Summers. For Figure 5K, European Cold Years, the odds ratio is above 1 for the years 1651 to 1688, 1842 to 1857, and 1900 to 1933. These years are all in the similar range to the European Cold Summers, which also had odds ratios above 1, indicating that European Cold Summers and European Cold Years are related. Figure 5L, European Warm Years, has an odds ratio above 1 during the years 1519 to 1573 and 1744 to 1777. During the same time periods, European Warm Summers had an odds ratio above 1 indicating a possible relationship between European Warm Summers and European Warm Years.

Figure 6 examines Volcanic Eruption occurrences with the 12 variables with odds ratios that can indicate possible relationships between variables. Computing the odds ratios for Volcanic Eruptions was more challenging due to the very small sample sizes. Figure 6A, during the years 1903 to 1951, has an odds ratio above 1 indicating that the Volcanic Eruption and Seca Brasa have higher odds of occurring together during that time. Drought in Africa, Figure 6B, has odds ratio above 1 for the years 1747 to 1779 and 1850 to 1948. Both Seca Brasa and Drought in Africa have an odds ratio above 1 during the same years indicating that the drought in Brazil and western Africa could be related. Figure 6D, Above Average Amount of Hurricanes, has an odds ratio above 1 during the years 1593 to 1605 and 1863 to 1893. During the same time frame Drought in Africa also had an odds ratio above 1 and this indicates that Above Average Amount of Hurricanes and Drought in Africa could possibly be related during this time. European Cold Winter, Figure 6G, has an odds ratio above 1 during the years 1613 to 1620. For Figure 6I, European Cold Summer, the odds ratio for the years 1746 to 1777 is above 1 indicating that European Cold Summer and Drought in Africa could possibly be related during this time. European Cold Year, Figure 6K, has an odds ratio of 0 during the years 1509 to 1549 indicating that during this time Volcanic Eruptions and European Cold Years did not occur at the same time.

CONCLUSION

El Niño and Volcanic Eruption occurrences are believed to cause unusual weather events to their local respective weather system. The idea of teleconnections supports the belief that the effects of El Niño events and volcanoes are beyond just local weather patterns and can extend to regional and global patterns. Brazil, Western Africa, Atlantic Ocean, and Europe are all regionally located in the same area and it can be hypothesized that regional weather patterns will affect other regional and global patterns. The observation of these regional areas is important because Europe and the Atlantic Ocean are less observed because El Niño occurrences happen in the Pacific Ocean. The chi-squared test indicates significance of these events occurring or not occurring at the same time. The odds ratio is the ratio between the occurrence of an event with the odds of the event not occurring. Odds ratios above 1 indicate that an event of (1,1) occurring is higher than (0,0). When variables have an odds ratio above 1 and in the same time frame, it can be suggested that the occurrence of the variables are related to each other.

All chi-squared results that were significant indicated that the variable is dependent on the original event. Most had an odds ratio above 1 indicating that there is a correlation between an El Niño or Volcanic Eruption event and the observed variable. Some odds ratios were 0 indicating that an El Niño or Volcanic Eruption event did not occur and the observed variable also did not occur meaning that the observed time showed that the variable was dependent and the non-occurrence was significant. These results are important because it supports the idea that El

Niño events and Volcanic Eruptions can cause unusual regional and global weather patterns through teleconnections. The results for an El Niño also show historic patterns which can be compared to modern patterns which may be different due to climate change. These results can be used to predict possible changes when climate change effects El Niño events and particle dispersion for Volcanic Eruptions and its effect on teleconnections.

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