VOLCANO AND ENSO PUNCTUATION OF NORTH AMERICAN TEMPERATURE: REGRESSION TOWARD THE MEAN

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Abstract

Contrary to popular media and urban mythology the global warming we have experienced since the Little Ice Age is likely finished. A review of 10 temperature time series from US cities ranging from the hottest in Death Valley, CA, to possible the most isolated and remote at Key West, FL, show rebound from the Little Ice Age (which ended in the Alps by 1840) by 1870. The United States reached temperatures like modern temperatures (1950 – 2000) by about 1870, then declined precipitously principally caused by Krakatoa, and a series of other violent eruptions. Nine of these time series started when instrumental measurement was in its infancy and the world was cooled by volcanic dust and sulphate spewed into the atmosphere and distributed by the jet streams. These ten cities represent a sample of the millions of temperature measurements used in climate models. The average annual temperatures are useful because they account for seasonal fluctuations. In addition, time series from these cities are punctuated by El Nino Southern Oscillation (ENSO).

As should be expected, temperature at each city reacted differently to differing events. Several cities measured the effects of Krakatoa in 1883 while only Death Valley, CA and Berkeley CA sensed the minor new volcano Paricutin in Michoacán, Mexico. The Key West time series shows rapid rebound from the Little Ice Age as do Albany, NY, Harrisburg, PA, and Chicago. IL long before the petroleum-industrial revolution got into full swing. Recording at most sites started during a volcanic induced temperature minimum thus giving an impression of global warming to which industrial carbon dioxide is persuasively held responsible. Carbon dioxide, however, cannot be proven responsible for these temperatures. These and likely subsequent temperatures could be the result of regression to the normal equilibrium temperatures of the earth (for now). If one were to remove the volcanic punctuation and El Nino Southern Oscillation (ENSO) input many would display very little alarming warming from 1815 to 2000. This review illustrates the weakness of linear regression as a measure of change. If there is a systemic reason for the global warming hypothesis, it is an anthropogenic error in both origin and termination. ENSO compliments and confirms the validity of NOAA temperature data. Temperatures since 2000 during the current hiatus are not available because NOAA has closed the public website.

Introduction

Weather and climate are complex multiple input-output, multiple loop dynamic three-dimensional systems with a fourth dimension – father time – with his finger on the scale. Understanding climate is as if one were given a chocolate and vanilla marble cake and asked to reverse engineer it in an hour. Understand - the weather forecast best-before-date might be one week or less.

The author is a geologist and let it be known, geologists often tread where no man has ever gone and, moreover, geological science is a juggling act more complex than the weather with animals that become minerals, plants that turn to mud, 3,800 named minerals (of which I can identify fewer than 10), thousands of chemical compounds, unknown subsurface fluids, geophysics, deep time, organic and planetary evolution and a host of other mysterious and daunting unknowns. Despite the machine age of isotopes, microchips, vast libraries, and 200 years of common knowledge, the multiple working hypothesis is still the best tool in a geologist kit and skepticism is still the best attitude.

The Data

There is no way of knowing how the National Oceanographic and Atmospheric Administration (NOAA) annual temperature time series were arrived at except to assume that, as is usual in early weather stations, 365 pairs of daily high and low temperatures were probably recorded and averaged to produce an annual temperature for the calendar year. Today's weather stations likely average 24 measurements each day.

These ten charts were downloaded from a NOAA website in the early 2000s to illustrate a presentation for a global warming debate at a local university. It was my intention to update the charts to the current time (2019) to evaluate the possibility of a hiatus in global warming. The site is no longer supported. NOAA now charges a large fee for hard copy from Key West. I declined their data and used the time series in this report.

We are aware in our thought experiment that this small sample size extrapolates to the millions of daily temperature measurement taken during the instrumental age around the world. These parameters, old or new, have their limitations; the foremost limitation is the problem of the regionalized variable; a value is only valid where and when it is recorded. Their limitations cannot and must not be extrapolated without caution and context. Volcanic eruptions and ENSO are reliable historical data, however, and have had global consequences.

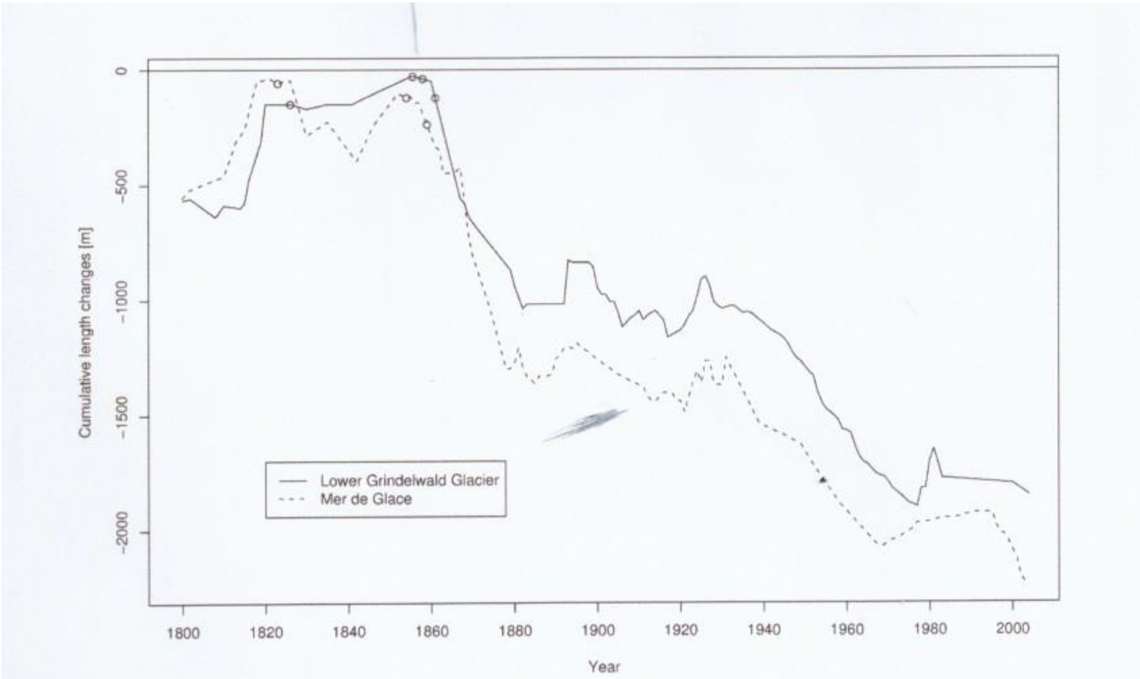
DISCUSSION

Volcanic eruptions expel molten lava, bombs and ash as well as numerous gasses that impact the atmosphere. Most of the coarser particles fall out within a few hours or days after an eruption. The smallest particles of dust are injected into the stratosphere and can travel worldwide. Tiny glass ash particles are so light that they can drift in the stratosphere for months, blocking sunlight and causing cooling over large areas of the planet. The very fine ash particles ejected into the air from volcanoes cool the planet by shading incoming solar radiation (Robock, 2000).

Erupting volcanoes emit sulfur dioxide. Sulfur dioxide is more effective than ash particles at cooling. The sulfur dioxide in the stratosphere combines with water to form sulfuric acid ionized droplets or aerosols. The sulfuric acid makes a haze that reflects incoming solar radiation, causing cooling at the Earth’s surface. The aerosols can stay in the stratosphere moved around by jet stream winds causing significant global cooling. Eventually, the droplets grow large enough to nucleate raindrops (Marsh and Svensmark, 2000, Svensmark et al, 2017

Obvious volcanic effects are local but can be more widely distributed as gases, and ash get into the atmosphere. Eruptions at mid or high latitudes tend to only impact their hemisphere, but eruptions in the tropics can influence the climate in both northern and southern hemispheres.

The cooling effect is said to have lasted for 5 years after Krakatoa erupted - from 1883 to 1888. Examination of these charts, However, shows that, e.g., Krakatoa did not add to the cooling effect from earlier eruptions of Cosaguina in 1835 and Askja in 1875. The temperature charts all show rapid rebound to equilibrium temperature for the region affected in a year or two at most.



Two major Alpine glaciers (Grindelwald and Mere de Glace) began wasting away about 1860 marking the regression toward normal modern temperatures (for now) before the serious volcanic era from 1883 to 1918 (Zumbühl et al, 2008).

Fourteen major volcanic eruptions, however, were recorded between 1883 and 1918 (Robock, 2000, and this essay). Some erupted for days or weeks and some were cataclysmic and shorter. The sum of all these eruptions from Krakatoa onward effected temperatures early in the instrumental age. Judging from wasting glaciers in the Alps, abrupt retreat began about 1860).

CONCLUSIONS

1) Four of these time series (Albany, Harrisburg, Chicago and Key West) show recovery to the range of today's temperatures by 1870 before the eruption of Askja in 1875. The temperature rebounded very quickly after the Little Ice Age in the northern hemisphere.
2) Volcanic eruptions and unrelated huge swings shown from ENSO largely rule global temperature. Volcanic history and the El Nino Southern Oscillation (ENSO) trump all other increments of temperature that may be hidden in the lists.
3) The sum of the eruptions from Krakatoa (1883) to Katla (1918) and Cerro Azul (1932) was a cold start for climate models.

4) It is beyond doubt that academic and bureau climate models use data that was gathered when volcanic activity had depressed global temperature. The cluster from Krakatoa to Katla (1883 -1918) were global.
5) Modern events, Mount Saint Helens and Pinatubo, moreover, were a fraction of the event intensity of the late 19th and early 20th centuries eruptions.
6) The demise of frequent violent volcanos has allowed the planet to regress toward a norm (for now).
7) Teasing out a signal for carbon dioxide is probably not possible. In any case, if one were able to remove volcanic input, the linear regression would be slight and not alarming.
8) Linear regression is not a definitive proof or even a supportive of the cause and effect of the carbon dioxide hypothesis for anthropogenic global warming.
9) The 22-year solar cycle also has input because solar minima are shown to be rainy periods and solar maxima can be warm sunny periods (Manns, 2017).
10) A characteristic of temperature measurements is that the values are regionalized variables and always relate as much or more to local conditions as to distal events. Three linear regression charts fall from warmer to cooler: Newnan GA, Albany NY, and Harrisburg PA. This is not easily explained by a claim that the local weather station source was moved to a new location because that would yield an abrupt shift (though there are incremental steps that might suggest such movement).

**Major Volcanic Eruptions from 1835 to 2000;
numbered for NOAA time series.**

1) 1835: Cosigüina, Nicaragua – In 1835, Cosigüina produced the largest historical eruption in Nicaragua. Ash from the eruption has been found in Mexico, Costa Rica, and Jamaica. The eruption caused a decrease in the average land temperature of Earth of about 0.75ºC.

2) 1875: Askja Volcano, Iceland – The Askja eruption was followed by a noticeable dip in the temperature. The ashfall poisoned the land and killed livestock. Ash was wind-blown to Norway, Sweden, Germany and Poland. It triggered a substantial wave of emigration from Iceland.

3) 1883: Krakatoa, Netherlands Antilles (Indonesia) – The eruption produced the loudest sound ever heard in recorded history and was heard 4,800 km away. It caused a 5-year volcanic winter. More than 36,000 died from the eruption or the tsunamis caused by land and sea slides. **Anak Krakatoa** erupted violently in 2018.

4) 1886: Okataina [aka Tarawera], N.Z. – In Auckland the sound of the eruption and the flashing sky was thought by some to be an attack by Russian warships. Approximately 2 cubic kilometres of ash erupted, more than Mount St. Helens ejected in 1980.

5) 1897: Mount Mayon, Philippines – Mayon's longest uninterrupted eruption occurred on June 23, 1897 and lasted for seven days. Eleven kilometers eastward, the village of Bacacay was buried beneath 15 m of lava. Ash was carried as far as 160 kilometres from the event, which killed more than 400 people.

6) 1902: Mount Pelée, French Department of Martinique, Lesser Antilles – The island arc of the Caribbean. The eruption killed about 30,000 people.

7) 1902: Santa Maria, Guatemala – The eruption in 1902 was one of the three largest eruptions of the 20th century, after the 1912 Novarupta and 1991 Mount Pinatubo eruptions. It is also one of the five biggest eruptions of the past 200 (and most likely 300) years.

8) 1907: Ksudach, Kamchatka, Russia - The last eruption of Ksudach was the largest ever recorded in Kamchatka. The eruption in 1907 sent ash which was transported by the jet stream made North America east of the Rockies unseasonably cold.

9) 1912: Novarupta, Katmai Peninsula, Alaska – The 1912 eruption that formed Novarupta was the largest to occur during the 20th century. The 60-hour-long eruption expelled 13 to 15 km^3 of ash, thirty times as much as the 1980 eruption of Mount St. Helens.

10) 1913: Volcán de Colima, Mexico – Colima which has erupted more than 40 times since 1576 is one of the most active volcanos in Mexico and in North America. One of the largest eruptions was in 1913.

11) 1914: Sakurajima, Japan – AKA Cherry Blossom Island is the most active volcano in Japan. Formerly an island, it is now a peninsula, in Kagoshima Prefecture, Kyushu, Japan. The lava flows of the 1914 eruption connected it to the mainland.

12) 1916 – 1918: Tungurahua, **Ecuador** – Tungurahua in the Central Andes erupted every 80 to 100 years. The major eruptions have been in 1773, 1886 and 1916–1918.

13) 1918: Katla, Iceland – The last major eruption started on 12 October 1918 and lasted for 24 days. The 1918 eruption extended the southern coast by 5 km.

14) 1932: Cerro Azul, Chile – Cerro Azul is responsible for several of South America's largest recorded eruptions, in 1846 and 1932.

15) 1939-1941 Santorini, Greece – **(**Vougioukalakis, 2005**).** Not as destructive, however, as the eruption 3.600 years ago that buried the Minoan civilization.

16) 1943-1952: Paricutin, Michoacán, Mexico - A new volcano that began as a cinder cone in a cornfield**.**

17) 1955: Bezymianny, Kamchatka, Russia – Bezymianny volcano had been considered extinct until activity starting in 1955 culminating in a dramatic eruption on 30 March 1956.

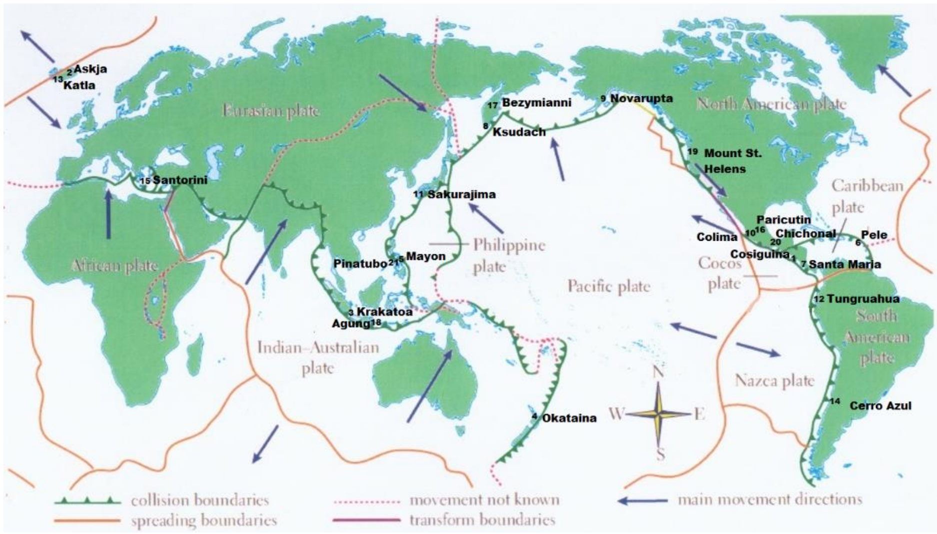
18) 1963: Mount Agung, Bali, Indonesia – The eruption of 1963 was one of the largest and most devastating eruptions in Indonesia's history.

19) 1980: Mount St. Helens, Washington, USA – was the most deadly and economically destructive volcanic eruption in the modern history of the United States. Ashes reached Montana. The blast of the volcano was heard 700 miles away.

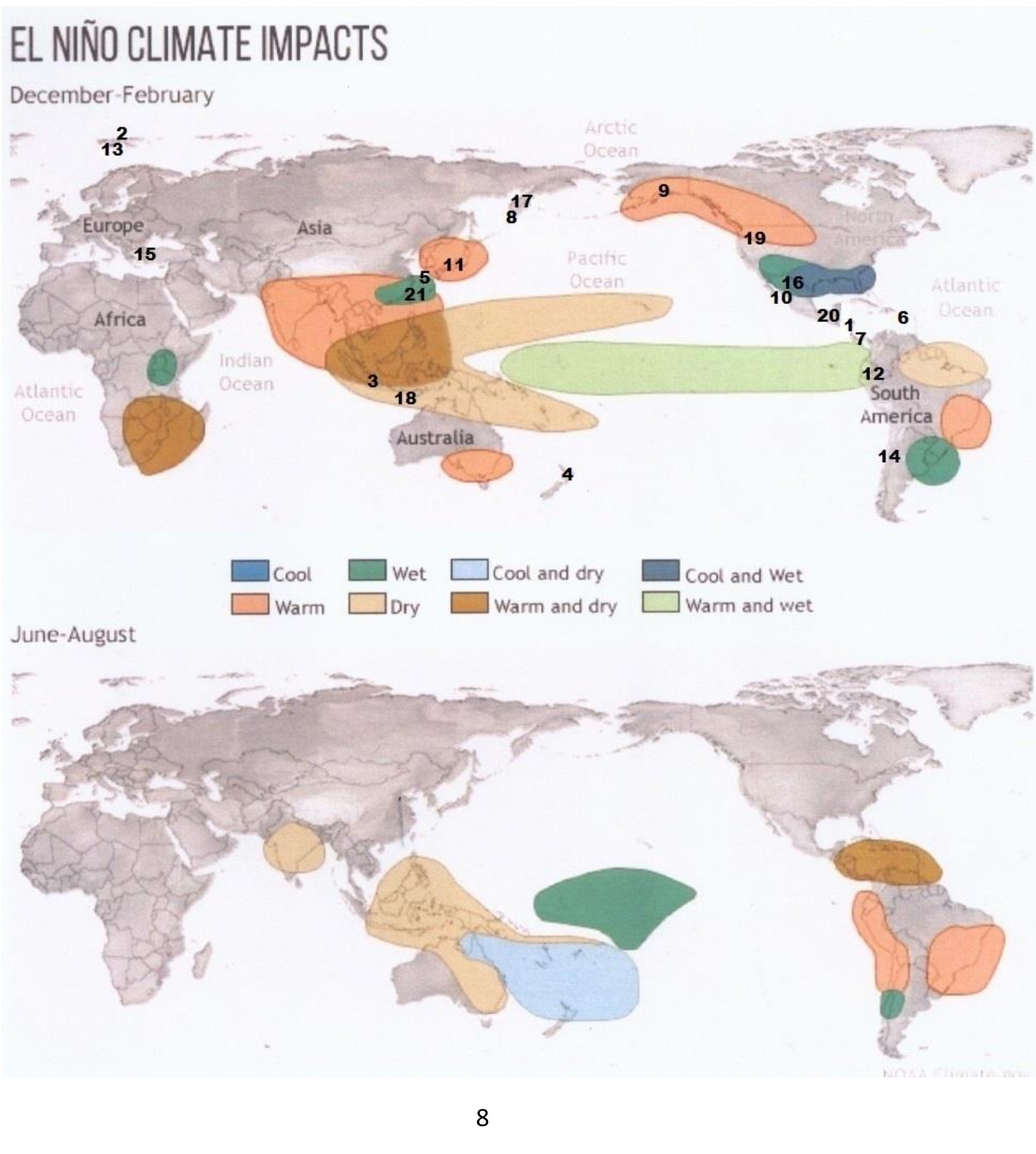
20) 1982: Chichonal [El Chichón], Chiapas, Mexico, killed between 1,700 and 2,300 people, and made more than 20,000 people homeless. No cooling was seen in the first year after the El Chichón eruption, because the El Niño produced large compensating warming (Robock, 2000).

21) 1991: Mount Pinatubo, Philippines – Global Temperatures fell 0.6ºC.

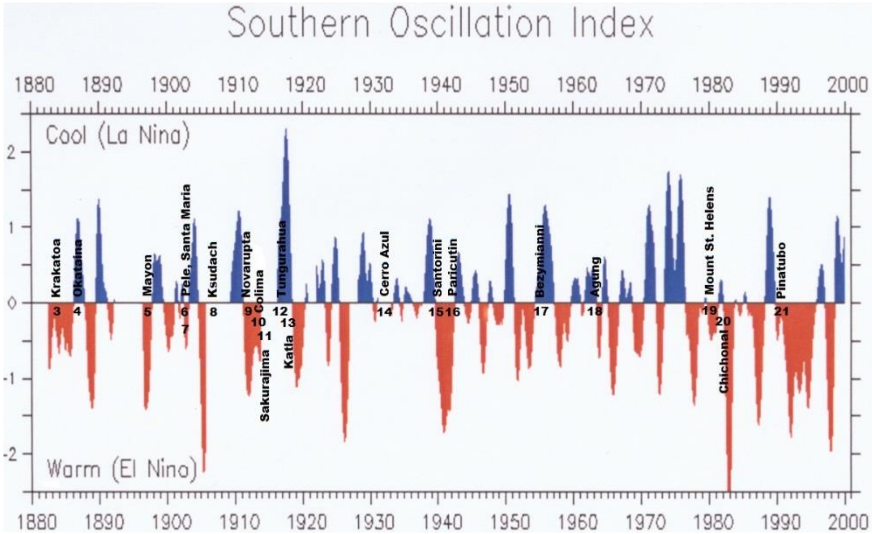
It is quite interesting to visit each volcano on Google Earth.



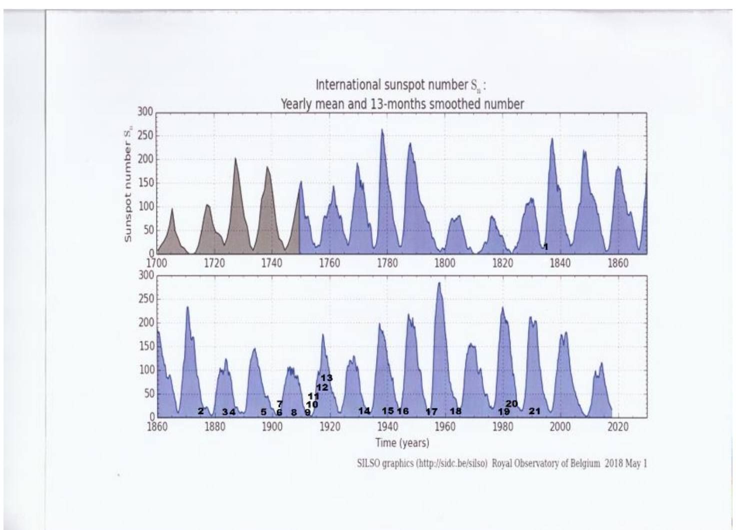
2 Askja
13 Katla
Eurasian plate
15 Santorini
African plate
17 Bezymianni
8 Ksudach
9 Novarupta
North American plate
19 Mount St. Helens
11 Sakurajima
Philippine plate
Pinatubo 21 5 Mayon
3 Krakatoa
Agung 18
Indian–Australian plate
Pacific plate
4 Okataina
Colima 10 16 Paricutin
Chichonal
20 Cosiguina
1
6 Pele
7 Santa Maria
Caribbean plate
Cocos plate
12 Tungruahua
South American plate
Nazca plate
14 Cerro Azul
N
W
E
S
collision boundaries
spreading boundaries
movement not known
transform boundaries
main movement directions



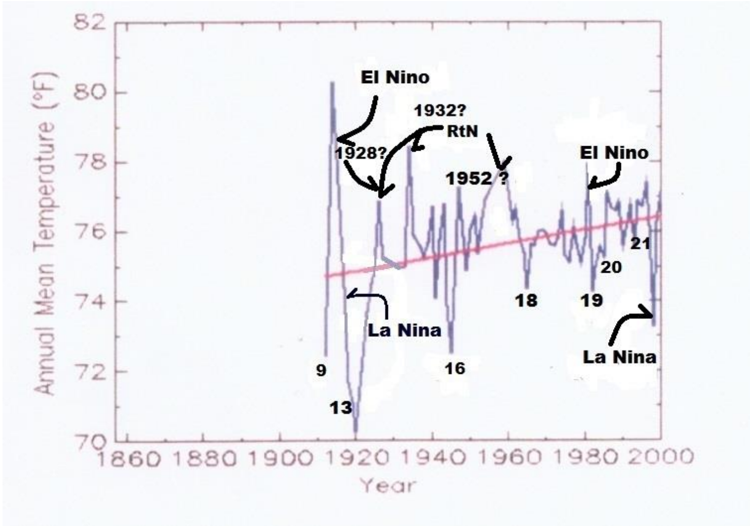
EL NIÑO CLIMATE IMPACTS
December-February
Arctic Ocean
Europe
Asia
Africa
Indian Ocean
Atlantic Ocean
Pacific Ocean
North America
Atlantic Ocean
South America
Australia
2
13
17
8
9
19
15
11
5
21
16
10
20
1
6
7
12
3
18
14
4
Cool
Warm
Wet
Dry
Cool and dry
Warm and dry
Cool and Wet
Warm and wet
June-August



El Nino- Southern Oscillation (ENSO) plot with volcanic eruptions plotted for reference. There is no intention to suggest any correlation.

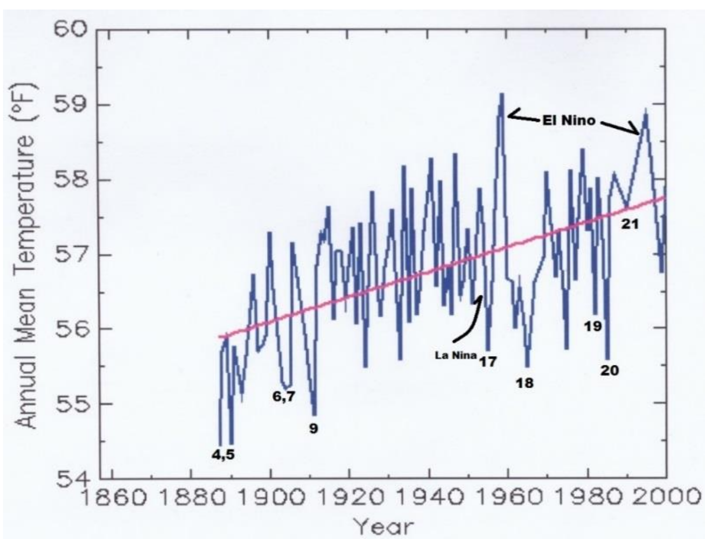


Solar Cycle plot (sunspots) with numbered volcanic eruptions cited in this essay. There is no intention to suggest any correlation, however, the additive effect of a solar minimum to the cluster of eruptions may have contributed to the freezing of Niagara Falls in 1912 (Manns, 2017).



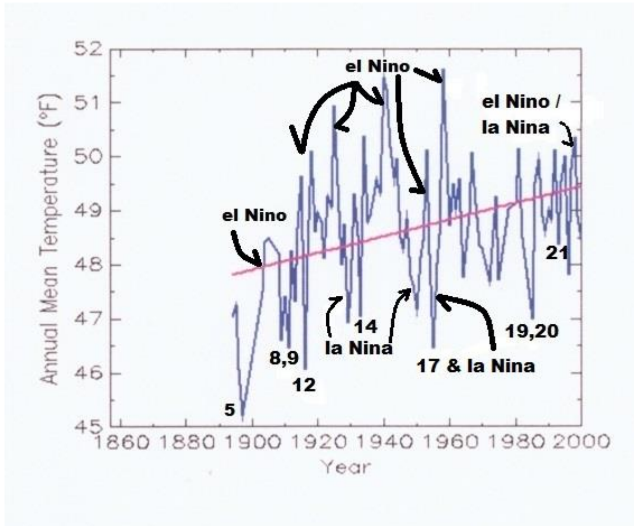
1: **Death Valley, CA**

The Death Valley CA temperature time series starts from a cool period following the eruption of Novarupta on the Katmai Peninsula of Alaska (Valley of 10,000 Smokes) and Katla, Iceland in 1918 which bracket wide fluctuations caused by an ENSO couplet which preceded 9 to 13. Five more downward temperature spikes (16-21) correspond to volcanic eruptions of record – a function of activity, prevailing winds and distance from Death Valley; compare Agung on distant Bali with proximal Mt. St. Helens. The more dominant spikes are from ENSO events. Three hotter spikes at 1928, 1932, and 1952 are unexplained and designated as possibly regression toward the norm (RtN); more research of climate records from Death Valley is warranted.



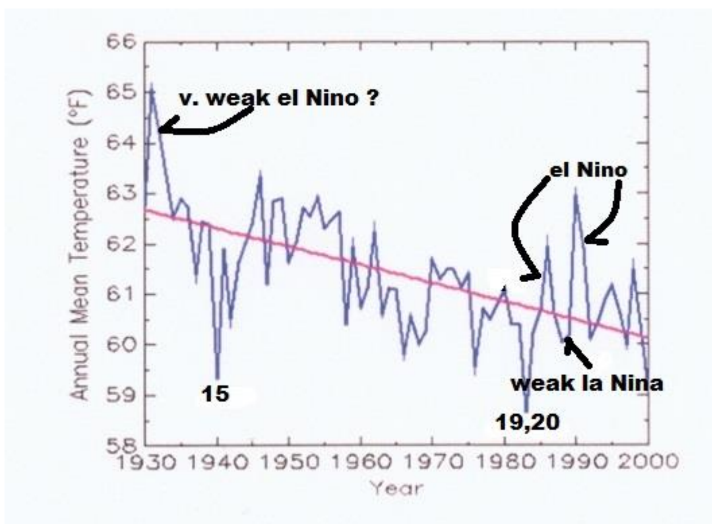
2: BERKELEY, CA

Instrumental records at Berkeley began during a cold spell following the eruption of Krakatoa in 1883. Eruptions of Okataina, NZ (4) and Mt. Mayon (5) in the Philippines and Mt Pele and Santa Maria (6,7) are clearly shown as is Katmai (9) in Alaska. It is interesting to speculate about the slope of the regression following 1920 and the importance of ENSO.



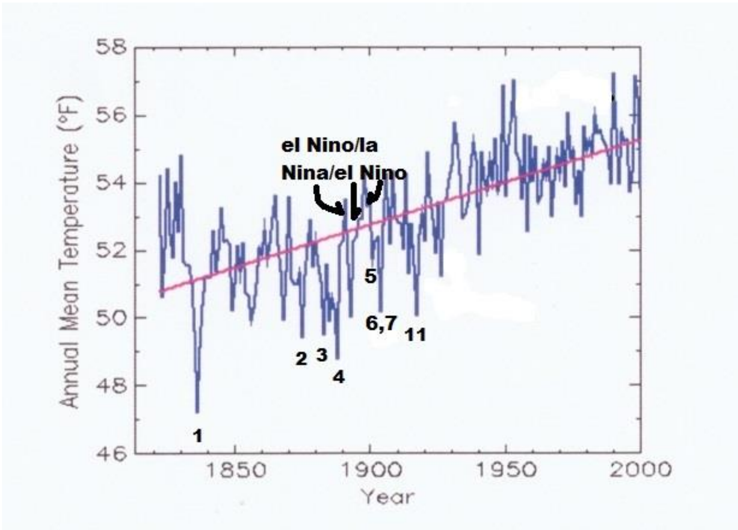
3: **BLAIN, WA**

The downward spike at 5 likely corresponds to the eruption of Mount Mayon in the Philippines in 1897. Several ENSO pairs were recorded at Blain. Both Mt St Helens (19) and Chichonal (20) appear as does Pinatubo (21). The linear regression would likely yield a relatively flat slope were it not for a cold start.



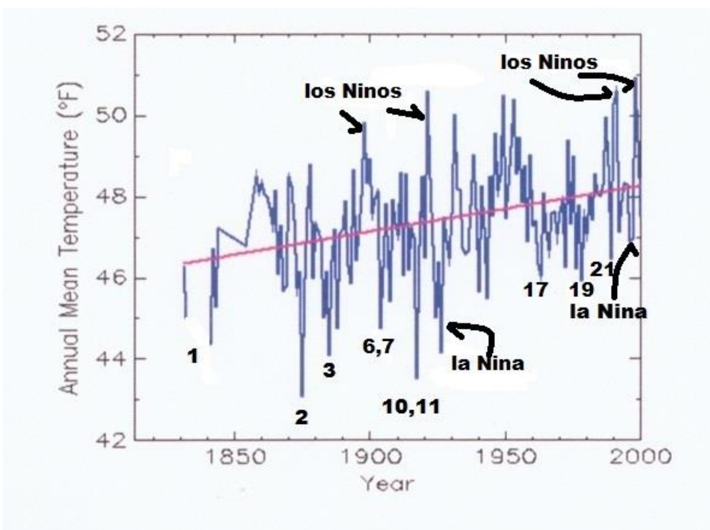
4: NEWNAN, GA

Newnan temperatures are recorded at an airstrip on a plateau about 60 km southwest of Atlanta. The airport is on a hill 20 - 30 metres above the surrounding countryside. The linear regression is negative for no obvious reason. The first downward spike is tentatively attributed to the volcano Santorini (15) in the Aegean Sea. Mount St. Helens (19) and Chichonal (20) are combined as a single downward cool spike. More local weather records are needed to investigate the Newnan site.



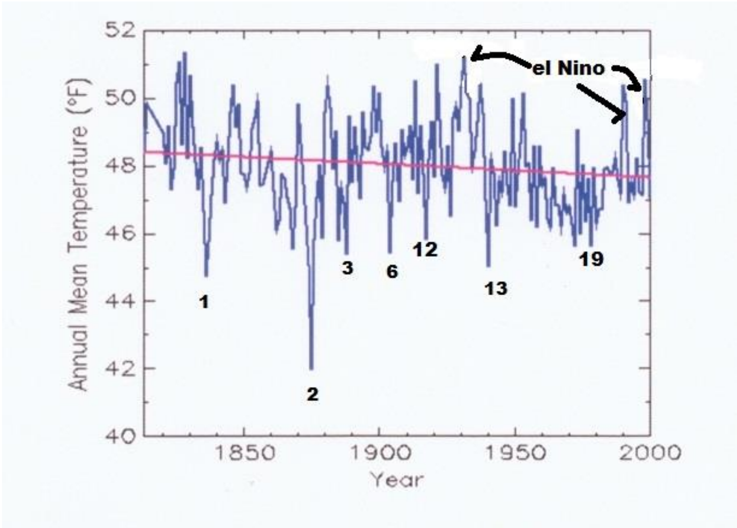
5: NEW YORK, NY

New York City began recording temperatures about 1820, NY was affected by the oldest of the record, Cosaguina, Nicaragua in 1835. This eruption is said to have caused a decrease of average land temperature of 0.75 C. In NYC that reported as an annual decrease of 5 F. The other 19th century eruptions and early 20th century eruption effects are shown from Askja, Iceland (2) to Sakurajima, Japan (11). Younger time series is not interpreted. It would be safe to say that the urban heat umbrella controlled the time series from 1940s onwards. The linear regression plotted begins in a colder climate caused by volcanic eruptions. Even the ENSO is blurred since the 1940s



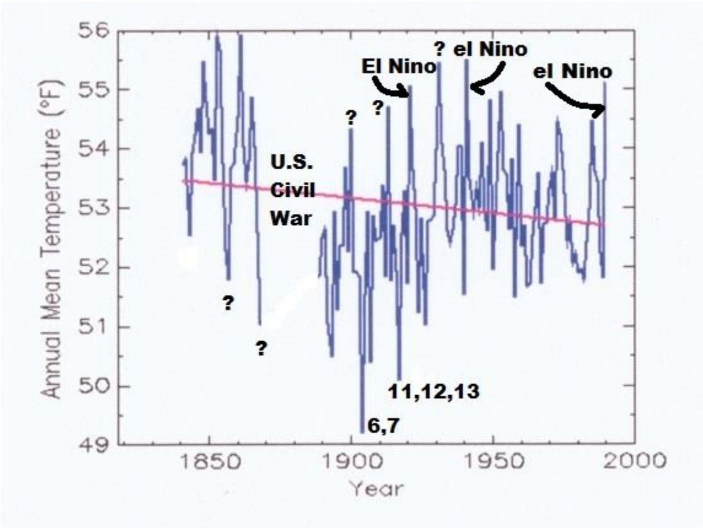
6: Buffalo, NY

Buffalo New York from about 1830 probably shows the effect of Cosiguina (1835) but one can't be certain. It is a strong likelihood that the linear regression line (red) is affected by eruption and la Nina cooling and el Nino heat events.



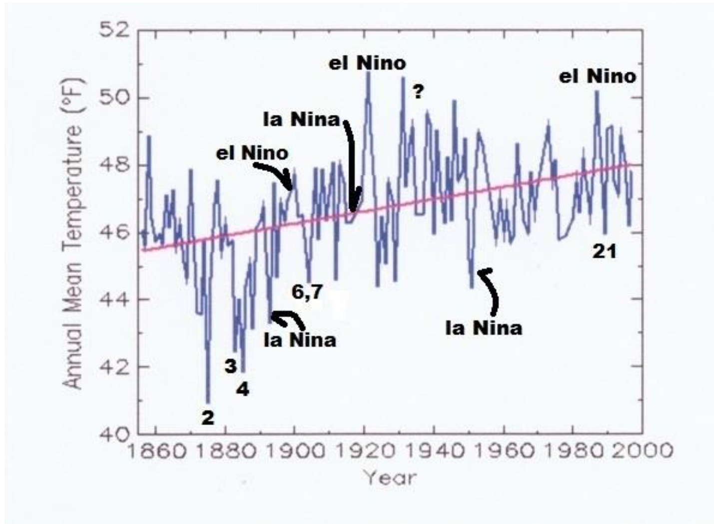
7: Albany, NY

In contrast to New York City, Albany NY displays slight falling of the linear regression curve from 18 1815 to 2000 whereas New York City is a poster child for the heat umbrella effect. Cosaguina, Nicaragua (1), Askja, Iceland (2), Katla Iceland (13) and others can be precisely identified; the Krakatoa (3) effect while less than the others, is still easily identified. Pinatubo is not identifiable.



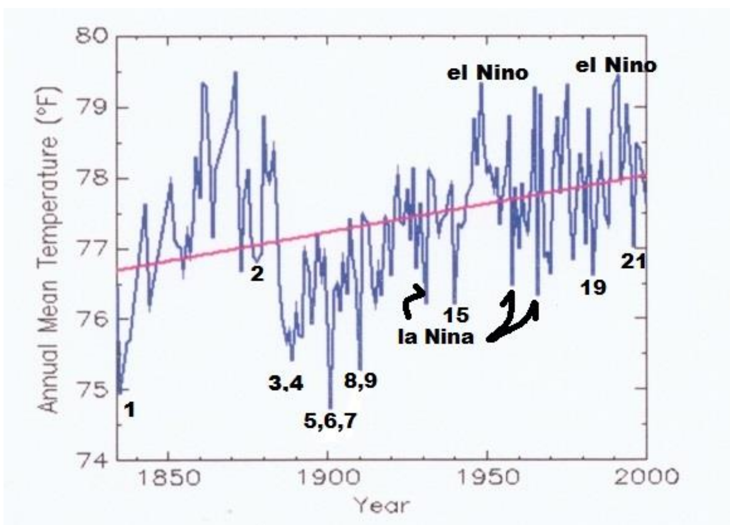
8: Harrisburg, PA

At Harrisburg, several extreme spikes prior to the 1860 and the U.S. Civil War and afterward are questionable. There is also a step in the 1930s that might indicate movement of the weather station. However, despite these shortcomings, five eruptions are visible as are several el Nino events. Several spikes cannot be explained and suggest an erratically monitored weather station at those times.



9: CHICAGO, IL

The instrumental record for Chicago Il began in 1855. The first major volcanic event recorded was Askja, Iceland (2) which erupted in 1875



10: Key West, FL

Key West, FL, in many ways may be the most interesting of all the 10 time series plots. It is the most remote site of all excepting, some would argue, Death Valley, CA. As a long-standing U.S. Naval base, it was manned with 'naval discipline' from the start. It records the mixture of air temperature over the Gulf of Mexico and the Gulf Stream as it exits the Gulf of Mexico, but it sits in the easterlies far from the industrial United States. Key West provides a homogenized sample of air undiluted by any possible heat island. Not only does it show Cosaguina in 1835, but 11 serious eruptions, and 5 ENSO events, many, in common with the other 9 cities examined in this essay,

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