

# Volcano eruptions

L Blanc

2023-12-06



## **‘Ring of Fire’ Stratovolcano eruptions:**

The primary objective of this case study was to ascertain whether stratovolcanic activity in countries within the so-called ‘Ring of Fire’ has been affected by climate change. To address this inquiry, data relating to volcanic activity in the RoF region was obtained that covered the periods pre-and post-industrial revolution c. 1760 and was analysed for an increase or decrease in volcanic activity. Particular attention was paid to stratovolcanoes and Violent Explosion Index (VEI) number three. Although not the highest number on the VEI index, it represents a significantly dangerous level. Also, the information garnered will be used to try and develop a machine learning model capable of predicting where and when the most violent eruptions are likely to occur, which could be used as early warning data to help emergency services in given regions prepare in advance for significant eruption events.

The ‘Ring of Fire’ - a tectonic belt circumscribing the Pacific Ocean containing two-thirds of the world’s volcanoes. The countries forming the ROF are:

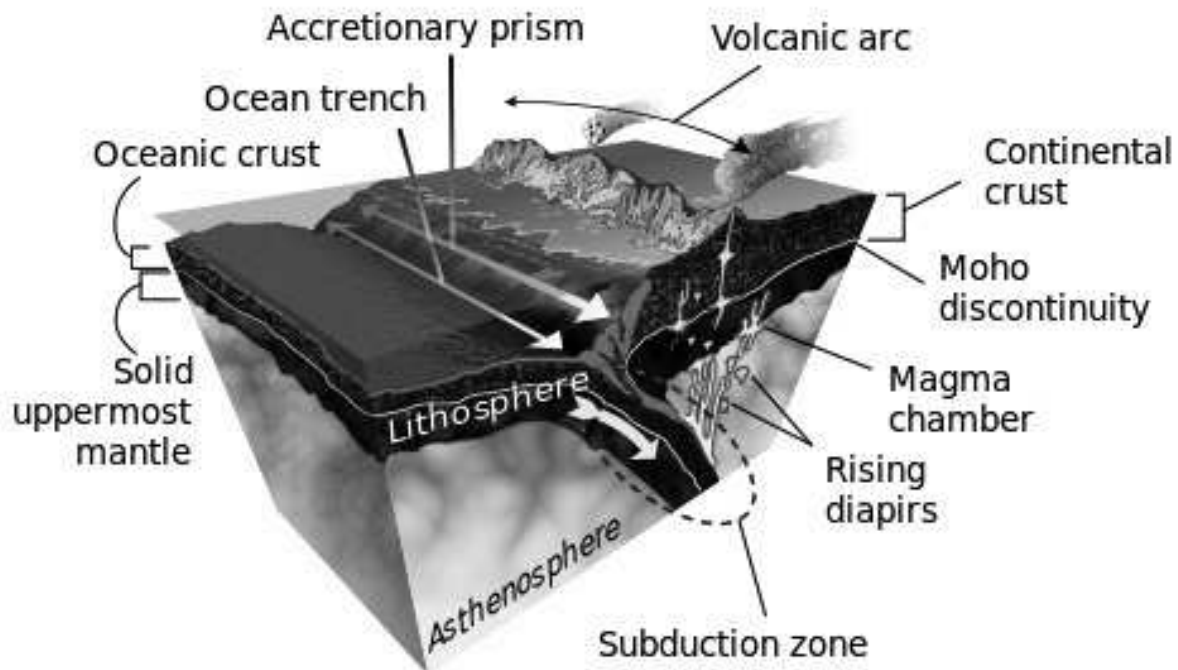
1. Indonesia
2. New Zealand
3. Papa New Guinea
4. Philippines
5. Japan

6. United States
7. Chile
8. Canada



Stratovolcano:

Stratovolcanoes form chains and clusters at subduction zones along plate tectonic boundaries and are the most common types of hazardous volcanoes. This is because of the pyroclastic flows (a fast-moving current of hot gas and volcanic matter) and lahars (volcanic mud flow) following explosive eruptions.



Eruption classification:

- Violent Explosive Index (VEI): 3
- Category: Severe
- Type: Vulcanian and Pelean

VEI	Description	Plume Height	Volume	Classification	How often	Example
0	non-explosive	< 100 m	1000s m <sup>3</sup>	Hawaiian	daily	Kilauea
1	gentle	100-1000 m	10,000s m <sup>3</sup>	Haw/Strombolian	daily	Stromboli
2	explosive	1-5 km	1,000,000s m <sup>3</sup>	Strom/Vulcanian	weekly	Galeras, 1992
3	severe	3-15 km	10,000,000s m <sup>3</sup>	Vulcanian	yearly	Ruiz, 1985
4	cataclysmic	10-25 km	100,000,000s m <sup>3</sup>	Vulc/Plinian	10's of years	Galunggung, 1982
5	paroxysmal	>25 km	1 km <sup>3</sup>	Plinian	100's of years	St. Helens, 1980
6	colossal	>25 km	10s km <sup>3</sup>	Plin/Ultra-Plinian	100's of years	Krakatau, 1883
7	super-colossal	>25 km	100s km <sup>3</sup>	Ultra-Plinian	1000's of years	Tambora, 1815
8	mega-colossal	>25 km	1,000s km <sup>3</sup>	Ultra-Plinian	10,000's of years	Yellowstone, 2 Ma

Dangerous active volcanoes:



Data set source:

<https://public.opendatasoft.com/explore/dataset/significant-volcanic-eruption-database/table/>

<https://ourworldindata.org/grapher/significant-volcanic-eruptions?tab=table>

<https://volcano.si.edu/>

<https://www.kaggle.com/datasets/joebeachcapital/volcano-eruptions>

The data was structured from reliable sources and cross-referenced to ensure integrity. The data provided detailed information such as dates, regions, countries, volcano types and names. These data points assisted in building a picture from which to search for patterns.

Data cleaning software:

- Excel
- SQL
- Python

Excel, SQL, and Python were utilised to correct spellings, duplications, data types, reorganise data structures, amalgamate, aggregate, and create new data sets.

Data visualization software:

- Tableau
- R studio

Analysis process:

Four sub-periods were selected from available information that covered the overall period of 11345 BCE-2023 CE. These were formatted into:

General periods: 1. 11345-1760 2. 1760-2023

Specific periods: 3. 1760-1900 4. 1900-2023

Each period was analyzed for data points in order to form a pattern from which observations could be deduced. Categorical and numerical data emerged that revealed relationships between variables.

Data sets:

```
library(readr)
X17_19_rof <- read_csv("C:/Users/44786/Desktop/VOL CASE STUDY DATA/data sets/17_19_rof.csv")

## Rows: 87 Columns: 3
## -- Column specification -----
## Delimiter: ","
## chr (2): country, volcano_type
## dbl (1): VEI
##
## i Use 'spec()' to retrieve the full column specification for this data.
## i Specify the column types or set 'show_col_types = FALSE' to quiet this message.

library(readr)
X19_23_rof <- read_csv("C:/Users/44786/Desktop/VOL CASE STUDY DATA/data sets/19_23_rof.csv")

## Rows: 34 Columns: 3
## -- Column specification -----
## Delimiter: ","
## chr (2): country, volcano_type
## dbl (1): VEI
##
## i Use 'spec()' to retrieve the full column specification for this data.
## i Specify the column types or set 'show_col_types = FALSE' to quiet this message.

library(readr)
X11_2023_era <- read_csv("C:/Users/44786/Desktop/VOL CASE STUDY DATA/data sets/11_2023_era.csv")

## Rows: 2 Columns: 4
## -- Column specification -----
## Delimiter: ","
## chr (1): era
## dbl (3): total_eruptions, stratovolcanic_eruptions, VEI_3
##
## i Use 'spec()' to retrieve the full column specification for this data.
## i Specify the column types or set 'show_col_types = FALSE' to quiet this message.

library(readr)
X17_23_c <- read_csv("C:/Users/44786/Desktop/VOL CASE STUDY DATA/data sets/17_23_c.csv")
```

```
## Rows: 120 Columns: 3
## -- Column specification -----
## Delimiter: ","
## chr (2): country, volcano_type
## dbl (1): VEI
##
## i Use 'spec()' to retrieve the full column specification for this data.
## i Specify the column types or set 'show_col_types = FALSE' to quiet this message.
```

Analytical findings:

The data was structured from reliable sources and cross-referenced to ensure integrity. The data provided detailed variables such as dates, regions, countries, volcano types, and names. These data points assisted in building a picture from which to search for patterns.

The following plots show an increase in eruptions in stravalcanoes with VEIs of 3 between 11345 BCE and 2023 in the ROF region.

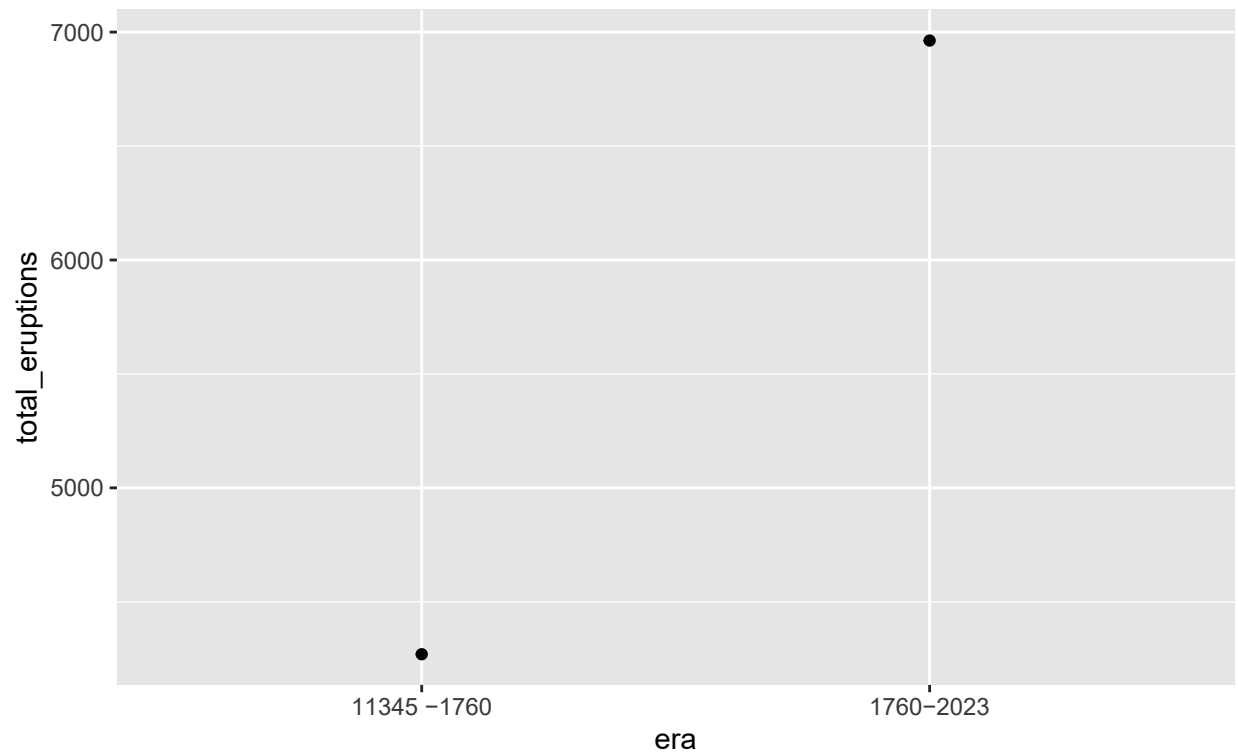
```
library(ggplot2)
library(tidyverse)
```

```
## -- Attaching core tidyverse packages ----- tidyverse 2.0.0 --
## v dplyr      1.1.4      v stringr  1.5.0
## v forcats    1.0.0      v tibble  3.2.1
## v lubridate  1.9.3      v tidyr   1.3.0
## v purrr      1.0.2
## -- Conflicts ----- tidyverse_conflicts() --
## x dplyr::filter() masks stats::filter()
## x dplyr::lag()    masks stats::lag()
## i Use the conflicted package (<http://conflicted.r-lib.org/>) to force all conflicts to become errors
```

```
ggplot(data = X11_2023_era) + geom_point(mapping = aes(x =era,y =total_eruptions)) + labs(title = "Volc
```

## Volcano eruptions per era

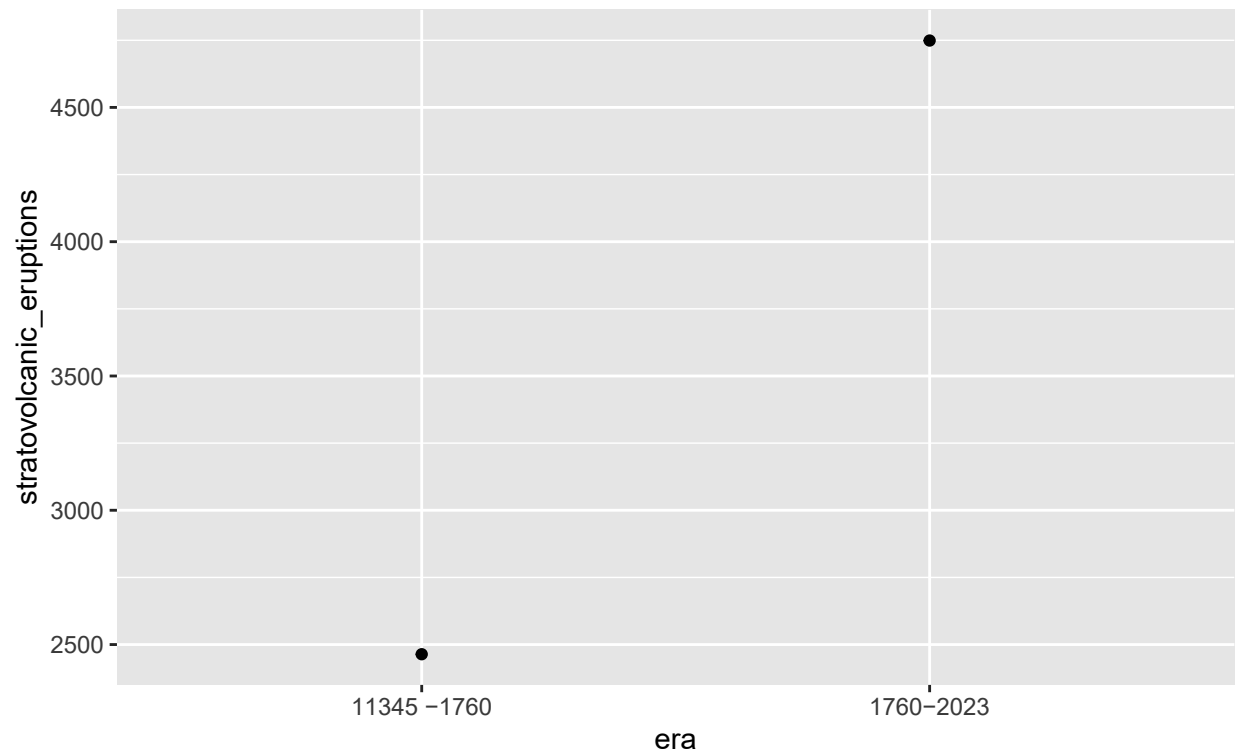
63.06 increase in eruptions



```
library(ggplot2)
library(tidyverse)
ggplot(data = X11_2023_era) + geom_point(mapping = aes(x =era,y =stratovolcanic_eruptions)) + labs(title = "Volcano eruptions per era")
```

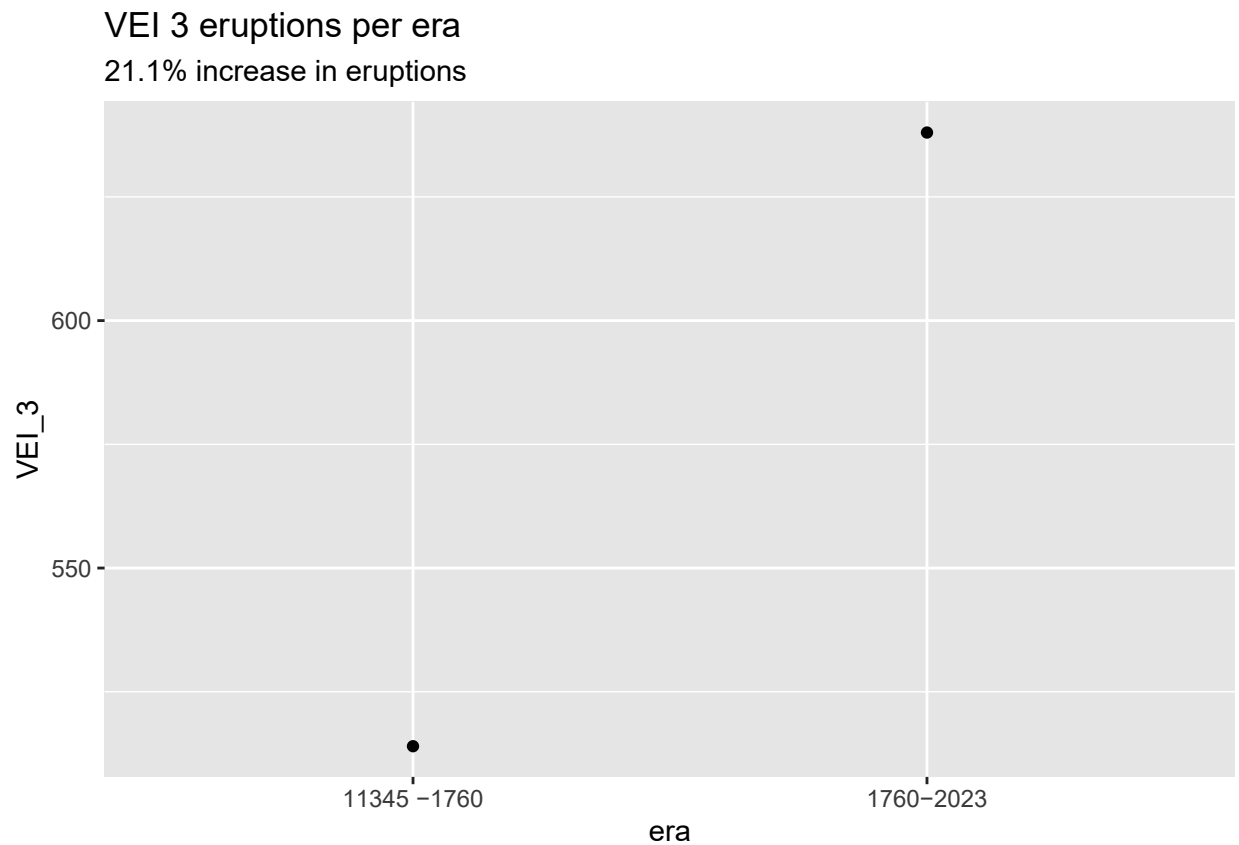
## Stratovolcano eruptions per era

92.73% increase in eruptions



```
library(ggplot2)
library(tidyverse)
ggplot(data = X11_2023_era) + geom_point(mapping = aes(x =era,y =VEI_3)) + labs(title = "VEI 3 eruptions")
```



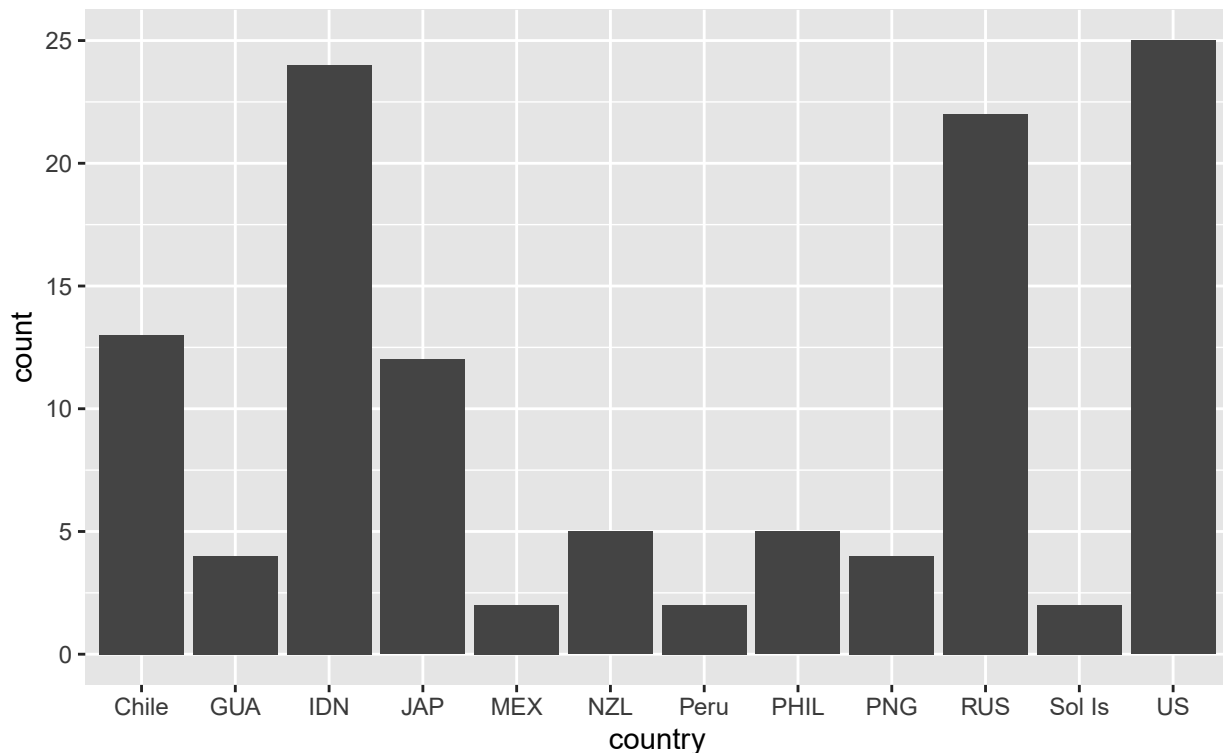


The final plots show the volcanic eruptions and VEIs of 3 in the countries forming the ROF between 1760 and 2023.

```
library(ggplot2)
library(tidyverse)
ggplot(data = X17_23_c) + geom_bar(mapping = aes(x=country)) + labs(title = "1760 - 23 eruptions by co
```

## 1760 – 23 eruptions by country

Bars also represent stratovolcano and VEI 3 totals



### Conclusion:

The data shows that there has been a significant increase in the volcanic activity of stratovolcanoes with an VEI of 3 within countries that form the Ring of Fire in the Pacific Ocean since the pre-industrial era. The question is whether this increase in volcanic eruptions can be attributed to anthropogenic climate change. It has been posited by some sections of the scientific community that any appearance of an increase in volcanic activity is the result of more eruptions being reported due to technological advances in communication. However, recent scientific research implies that climate change has a direct impact on the frequency, and two prominent triggers are melting glaciers and rising sea levels. Glaciers cool the temperature of lava flows underground, and once the glacier starts melting, the lava temperature rises, causing eruptions. The rises in sea level around volcanoes increase pressure on their sides, squeezing the lava into activity. Other triggers are aquifer depletion caused by high temperatures and mountain erosion caused by high water levels that weaken the structure of the mountain and its ability to contain an eruption. At what point during the post-industrial era have these effects been initiated? This has not been studied, and although advances in communication have improved the reporting of volcanic activity, this alone cannot account for the significant increase. It is highly likely that human-caused climate change also contributes to this increase in volcanic eruptions over the past 250 years.

### Other Sources:

[https://en.wikipedia.org/wiki/Types\\_of\\_volcanic\\_eruptions](https://en.wikipedia.org/wiki/Types_of_volcanic_eruptions)

[https://www.volcanodiscovery.com/erupting\\_volcanoes.html](https://www.volcanodiscovery.com/erupting_volcanoes.html)

‘How Will Climate Change Impact Volcanic Eruptions\_’ - [www.forbes](http://www.forbes.com)

Waking the Giant: How a Changing Climate Triggers Earthquakes, Tsunamis and Volcanoes. Bill McGuire, professor emeritus in geophysical and climate hazards, UCL.

How climate change might trigger more earthquakes and volcanic eruptions <https://phys.org/news/2023-08-climate-triggerearthquakes-volcanic-eruptions.html>

‘Get Ready for More Volcanic Eruptions as the Planet Warms I Scientific American’ - [www.scientificamerican](http://www.scientificamerican.com)

Climate Change Causes Increased Volcanism I Live Science’ - [www.livescience](http://www.livescience.com)