**README**

**Introduction:**

*EqVolc* is a collection of MATLAB scripts for analysing statistical relationships between large earthquakes and volcanic eruptions. *EqVolc* was developed by Alex Jenkins at the University of Bristol, and any works using the *EqVolc* scripts should cite the following references:

* Jenkins, A. P., Biggs, J., Rust, A. C. & Rougier, J.C. (2021). ‘Decadal timescale correlations between global earthquake activity and volcanic eruption rates’ *Geophysical Research Letters* **48**(16), e2021GL093550.
* Jenkins, A. P., Rust, A. C. & Biggs, J. (2023). ‘The relationship between large earthquakes and volcanic eruptions: A global statistical study’ *Volcanica (submitted).*

*EqVolc* is designed to run using MATLAB R2018a on Windows; using other MATLAB versions or operating systems may result in bugs or errors. The scripts should run using MATLAB R2018a on Linux-based systems, although the user may need to alter line #11 of geteq.m from inpeqs{i,1}=datenum(inpeqs{i,1},'dd/mm/yyyy')to inpeqs{i,1}=x2mdate(inpeqs{i,1}), due to an issue with how dates are stored in .xlsx files between the two systems.

This readme is not a comprehensive guide for the scripts but aims to provide enough information so that the user is able to run the main scripts with little prior MATLAB knowledge. More detailed understanding of the scripts can be achieved by studying the scripts themselves, if the user is familiar with MATLAB, and from the papers referenced above. Users are also encouraged to modify the scripts to achieve their own needs. Bugs may be reported to Alex Jenkins ([alexander.jenkins@bristol.ac.uk](mailto:alexander.jenkins@bristol.ac.uk)), although no commitment is made to updating the scripts (but it would help if the user also provides a fix to any bugs they encounter!).

**Input earthquake and eruption catalogues:**

*EqVolc* takes earthquake and eruption records from well-known catalogues, principally the CMT earthquake catalogue (<https://www.globalcmt.org/>) and the GVP eruption catalogue (<https://volcano.si.edu/>). These catalogues are stored in the ‘eq databases’ and ‘volc databases’ directories.

Provided with the download of *EqVolc* is the file ‘gcmtall2.xlsx’, which contains the CMT earthquake catalogue from 1976 through 2020, modified to be in a suitable form for use by the *EqVolc* scripts. To update this file, the user will need to download the latest CMT earthquake catalogue as a text file from the CMT website (see ‘gcmtall.txt’ to see what this should look like). The user should then run the script ‘cmt2input.m’, specifying in the INPUT section the name of the new CMT catalogue text file and the desired name of the new earthquake input file for use in *EqVolc*. To use other earthquake catalogues, the user must write their own script to convert the catalogues into the form given in ‘gcmtall2.xlsx’ (note that only the first 5 columns of information in ‘gcmtall2.xlsx’ are strictly necessary; columns 6 and 7 are not used in the scripts, while the slip orientation in column 8 is optional, so these may be left blank (although do include the headers)).

Also provided with the download of *EqVolc* is the file ‘GVPall2.xls’, which contains the GVP eruption catalogue from 1960 through 2020. To update this file, the user will need to download the latest eruption catalogue as a .xls file from the GVP website. Currently, the .xls file downloaded from the GVP website can be used directly with the *EqVolc* scripts. However, some issues may prevent this file from working properly initially with the *EqVolc* scripts. Most notably, any recorded eruptions with a missing ‘VEI’, ‘start year’, ‘start month’, or ‘start day’ value will probably cause an error when a script is run. The easiest fix for this is to delete any eruptions before the desired start date of your analysis (this will remove many if not all of the problem eruptions) from the GVP eruption catalogue file, and replace any other missing values with a 0 (copy a 0 from another cell rather than simply typing 0 to ensure it is entered with the correct format). Start dates with a 0 will be treated as uncertain start date eruptions in any analysis.

Remember, to run the main scripts with different or updated databases than the ones provided with the download of *EqVolc*, the user must specify the new database names in the INPUT sections of the main scripts!

**Main scripts usage:**

The main scripts (.m files) to be accessed in MATLAB by the user are located in the main *EqVolc* directory:

* RatesCalc.m – Generates time-series of annual earthquake and eruption rates. Also has functionality to generate randomised Monte Carlo simulations of annual earthquake and eruption activity. Creates an output .mat file which can be used in ‘RatesPlot.m’ to visually plot the time-series.
* RatesPlot.m – Plots time-series of annual earthquake and eruption rates calculated in ‘RatesCalc.m’ and calculates the Spearman cross-correlation between the earthquake and eruption time-series. Also has functionality to determine the significance of observed correlations through using randomised Monte Carlo simulations.
* EruptionTriggering.m – Calculates the number of eruptions before and after large earthquakes within a specified distance and time period, as well as background eruption rates. Also has functionality to generate randomised Monte Carlo simulations of eruption rates associated with large earthquakes. Creates an output .mat file which can be used in the ‘PlotTriggering.m’ functions to visually plot the eruption rates associated with large earthquakes.
* PlotTriggering.m – Plots volcanic eruption rates associated with nearby large earthquakes calculated in ‘EruptionTriggering.m’. The plots show eruption rates calculated across all selected earthquakes, both in terms of the rate change from after relative to before the earthquakes, and the before and after rates relative to the baseline rates. Also has functionality to determine the significance of observed eruption rates relative to randomised Monte Carlo simulations. This script is for one set of input parameters only across multiple time periods.
* PlotTriggering2.m – Same as ‘PlotTriggering.m’, but this script compares multiple sets of input parameters (e.g. depth, Mw, slip orientation).
* PlotTriggering3.m – Further investigates the characteristics of individual earthquakes associated with given volcanic eruption rates relative to baseline eruption rates, using the .mat file output from ‘EruptionTriggering.m’. The generated plots show the proportion of individual earthquakes with given relative eruption rates, subdivided by earthquake characteristics (depth, slip orientation). Also has functionality to determine the significance of observed proportions of earthquakes with given relative eruption rates relative to randomised Monte Carlo simulations. This script is for one set of input parameters and one time period only.

Each main script first has a basic description of what it does, followed by a section titled ‘INPUT’. The INPUT section contains a list of input parameters to be defined by the user. These parameters have commented descriptions next to them (green text following the %), so that the user can understand what each input parameter does. The input parameters can be changed by changing the value to the right hand side of the equals sign. If it is not immediately obvious what a certain parameter does, try experimenting with the value and observing what happens.

In the input section, the user must also define the ‘home directory’ (home\_dir) for the function- this is the path to where the *EqVolc* folder is located on the users system.

Before running the scripts, the user must also change their MATLAB path to the home directory. To do this, click on the ‘Home’ tab, then select ‘Set Path’, then select ‘Add with Subfolders’, and finally navigate to and select the *EqVolc* directory. When ready to run the scripts, select the ‘editor’ tab at the top of MATLAB, then select ‘run’.

Note that the scripts ‘RatesCalc.m’ and ‘EruptionTriggering.m’ use the input earthquake and eruption catalogues to calculate the relationships between earthquakes and eruptions, which are stored in .mat files saved to the ‘outputs’ folder. The scripts ‘RatesPlot.m’, ‘PlotTriggering.m’, ‘PlotTriggering2.m’ and ‘PlotTriggering3.m’ then access these output .mat files to perform further calculations and visually plot the results. Some example .mat output files are included in the download of *EqVolc* and are pre-entered into the relevant main scripts to provide ready-to-run examples:

* rates\_test.mat – Time-series of annual earthquake and eruption rates calculated using the default parameters in ‘RatesCalc.m’ (default catalogues, Mw≥7, VEI≥2, multiple eruptions, certain start year eruptions, 1000 MC simulations with completely randomised dates).
* ET\_test\_Xtime.mat – Eruption rates associated with nearby large earthquakes calculated using the default parameters in ‘EruptionTriggering.m’ and a range of time periods (default catalogues, Mw≥7, VEI≥2, <750 km between earthquakes and eruptions, multiple eruptions, only certain start date eruptions, 1000 MC simulations with permutated eruption dates).
* ET\_test\_Xtime\_noMC.mat – Same as ‘ET\_test\_Xtime.mat’, but without any randomised Monte Carlo simulations.
* ET\_test\_Xtime\_shallow.mat - Same as ‘ET\_test\_Xtime.mat’, but only including earthquakes with a centroid depth of <70 km.

Additionally, ‘RatesCalc’.m’ is set-up so as to produce the ‘rates\_test.mat’ output file, while ‘EruptionTriggering.m’ is set up to produce the ‘ET\_test\_1year.mat’ output file.