Mainshock-Aftershock Clustering in Volcanic Regions

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Earthquakes break their general Poissonean behavior through two types of seismic bursts: swarms and mainshock-aftershock sequences. The former is commonly thought to dominate in volcanic and geothermal regions, but aftershock production, including within swarms, is not well studied in volcanic regions. Here we compare mainshock-aftershock clustering in active volcanic regions in Japan to nearby nonvolcanic regions. We find that aftershock production is similar in both areas by two separate metrics: (1) Both volcanic and nonvolcanic regions have similar proportions of areas that cluster into mainshock-aftershock sequences. (2) Volcanic areas with mainshock-aftershock sequences have aftershock productivity at least as high as nonvolcanic regions. We also find that volcano-tectonic events that are precursors to an eruption are more common at volcanoes without mainshock-aftershock clusters than at volcanoes with well-defined mainshock-aftershock clusters. This last finding hints at a strategy to identify volcanic systems where cataloged earthquakes are good predictors of behavior.

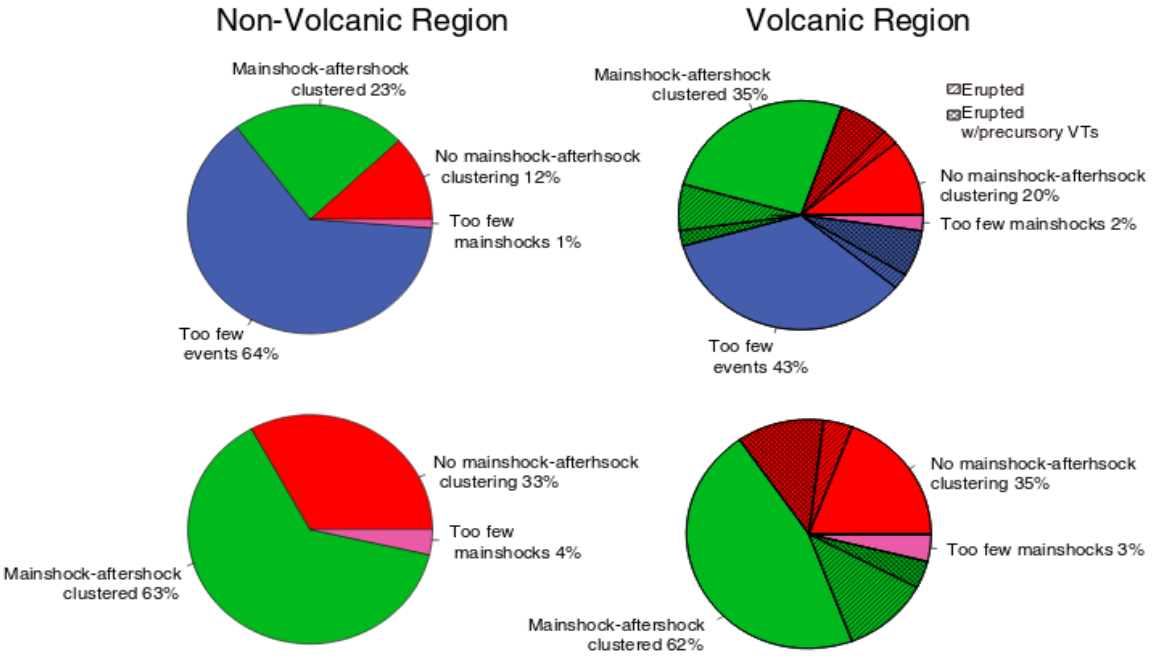

Fig. 1. Pie chart compiling the results of the (right) 46 volcanic regions and (left) all of the nodes of the nonvolcanic region. All categories are included in the upper row, and the domain is limited to the measureable categories in the bottom row. Blue: areas with insufficient seismicity (<1,000 earthquakes) to study clustering. This category is omitted in the bottom row. Green: areas that show mainshock-aftershock clustering; red: areas that have sufficient total seismicity and identified mainshocks to examine clustering but failed the time-shuffling test; magenta: areas with fewer than 3 identified mainshocks. The hatch slices represent the percentage of volcanoes that have had an eruption since 1998, and the crosshatch areas are the portion of eruptive volcanoes that showed signs of precursory volcano-tectonic events prior to the start of the eruption.