Trashcano: Developing a quantitative teaching tool to understand ballistics accelerated by explosive volcanic explosions

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Almost all explosive eruptions eject clasts on ballistic trajectories. These projectiles of volcanic rock and magma may fall several kilometres away from the vent location. Understanding how to track and model projectile velocity, trajectory, impact location and impact speed can be important components of a volcanologist's toolbox. However, it is uncommon for students learning about volcanic processes at any level, to have the opportunity to participate in a ballistic monitoring campaign in the field. Simple outdoor experiments can be useful to convey concepts of volcanic processes in an exciting way. Beyond the fun aspects, these experiments can be expanded to provide an opportunity to engage with the physics of projectile flight and help promote mathematical learning within the Earth Sciences. We present a quantitative framework required to interpret ballistic trajectories using common tools appealing to many students (e.g. smart phones) and the outdoor experiment known commonly as "trashcano". From this, we provide some suggested student exercises that explore the same problems associated with actual ballistic monitoring at active volcanoes. Finally, we expand on the components of volcanic ballistics that are not captured by experiments such as this and discuss how such limitations are also learning opportunities.