

# MTFC Scenario Quest 2023-24

Team Name	Team Tim Team
Team ID #	16418
Proposal Topic Title	Mitigating the Risk Associated with Volcanic Eruptions

## MTFC Scenario Quest Template Use Notes:

- Refer to the official MTFC Scenario Quest 2023-24 for the prompts for each of the 5 Missions.
- The use of this template is NOT required for MTFC Scenario Quest submissions. It is provided as an optional resource for teams to keep their Scenario Quest response organized. Teams who wish to use this template should make a copy in order to edit.
- The final version of the MTFC Scenario Quest should be downloaded as a PDF or Word document to submit on the ICS Dashboard. A single file will be submitted.
- Additional resources can be found on the Modeling the Future Challenge website:
  - The Actuarial Process Guide <https://www.mtfchallenge.org/the-actuarial-process/>
  - Data Sources <https://www.mtfchallenge.org/data-sources/>
  - Sample Project Topics for Proposal Ideas <https://www.mtfchallenge.org/example-projects/>
  - Video Resources <https://www.mtfchallenge.org/video-resources/>
- Please direct any questions to [challenge@mtfchallenge.org](mailto:challenge@mtfchallenge.org).

# Mission 1 Ski Resort Prompts

These prompts can be found on pages 11-12 of the Scenario Quest. Additional information on Data Identification and Analysis can be found on pages 11-22 of the [Actuarial Process Guide](#).

Responses:

- 1.1  
Ski equipment manufacturers, ski enthusiasts, and businesses surrounding ski resorts are at risk due to climate change and its effect on ski resorts. Ski equipment manufacturers and businesses in areas surrounding ski resorts depend on ski resorts for much of your business because ski resorts purchase large quantities of equipment to rent and resell, so when ski resorts lose profits and are forced to buy less equipment, the equipment manufacturers lose profits as well. Additionally, if the skiing conditions are worse, less people will be inclined to purchase new gear. Skiers and snowboarders are at risk because ski resorts being open for less of the year deprives them of an important pastime and can cause emotional loss. Finally, the businesses around ski resorts are at risk due to climate change because ski resorts attract a large amount of traffic to the area, so ski resorts being open for less of the year reduces the amount of business that other businesses in the area receive.
- 1.2  
The ski resorts are at risk of higher operation costs and losing several forms of business: ticket sales, hotel bookings, gear sales, food sales and event hosting. To assess these variables, quantifications can be made to count or the annual revenue per category as well as the annual operation expenses. When analyzed, these variables can show which sectors of the ski resort are impacted most severely, allowing for more educated solutions to be devised.
- 1.3  
One potential solution would be selling insurance for when snowfall is less than a certain expected value or when less people show up than expected value. This would protect ski resorts from bad years and give the ski resorts peace of mind. Another solution would be to reduce ticket prices during the beginning and end of the season to incentivize people to ski during those parts of the year. Then, people would be more inclined to purchase tickets regardless of the snow quality. Finally, rainwater could be saved throughout the year to facilitate greater artificial snow production when snowfall is insufficient.

## Mission 1 - Team Project Proposal Prompt

### Identify The Topic

The broad topic we plan to investigate is volcanoes, which is an important topic because volcanoes can pose a significant threat to many people's lives and property and people currently have no fool proof way to protect all their belongings and livelihood in the event of an eruption. It affects those who live or work near volcanoes. It is prevalent near tectonic plate boundaries, which closely ties this issue to the problem of earthquakes.

### Identify Potential Risks

Volcanoes pose risk to property owners, air traffic, businesses, and the public. Volcanoes create many dangers including those created by ash, pyroclastic flow, lava flow and forest fires created as a result. For those in areas surrounding a volcano, the best-case scenario would be when a volcano does not erupt whereas the worst-case scenario could be one of several possibilities but all result in total destruction of a home or business alongside air contamination that prevents airplanes from flying. Loss of life is the worst-case scenario on the human level.

### Identify Risk Mitigation Strategies

Potential risk mitigation strategies include evacuation, regulations on landscaping (lawns and bushes farther from house in case they catch on fire), insurance, conscious building placement (away from volcanoes, out of the way of possible lava flow), tungsten or titanium house stilts, places for lava to flow safely away from the population, and evacuation plans for families and communities is important, so they are aware of where to go and possible alternative routes. As for building design, preventing contact with lava flow and the effects of fires is crucial for protection of the house. Airlines cannot protect themselves from ash filled air and can only mitigate risk via the closure of airspaces. House stilts are not popular as they are incredibly expensive and have questionable effectiveness. Places for lava and flowing rock to flow through, avoiding populations is incredibly important when mitigating property damage and loss of life. Evacuation routes further prevent the loss of life and advanced fore-warning further contributes to this goal.

## Mission 2 Ski Resort Prompts

These prompts can be found on pages 18-19 of the Scenario Quest. Additional information on Data Identification and Analysis can be found on pages 23-29 of the [Actuarial Process Guide](#).

Responses:

- 2.1
  - What are the effects of climate change on ski resorts?
  - What is the Data on the effectiveness of climate change prevention tactics for ski resorts?
  - What areas of the ski resort are affected in different ways because of climate change?
  - How can the risks presented by climate change be mitigated to maximize ski resort profits?
- 2.2
  - Data defining historical climate conditions and their effect on snowfall and data forecasting future climate conditions (projecting and describing the severity of future trends) will be necessary to model climate trends and relate them to potential losses (snow loss/ticket loss/shortened season length/et cetera). Data describing the severity of potential outcomes (climate change) will be essential to predicting climate impacts on ski resorts. Historical data of business for the given climate could also be used to model how much money the ski resort would make in a given year.
- 2.3
  - How accurate/how important the data is can be identified through data sample size and data types. The most important data types for the model would include historical and projection-based data. These data types would allow for the model to view what previous conditions made for what profit, to project what future conditions would make in terms of profit. Graphs and charts are especially useful because they allow for visualization of data and get a better understanding of the data points. It is very difficult to view hundreds or thousands of data points and quickly understand trends and distributions, that is why visual representations such as histograms, bar charts, box plots and pie charts are so important. Although, a model can only be as good as the data that it interprets. If the dataset is not big enough/is from a biased source, the model will likely be inaccurate. It is important to use a big dataset to make for a more accurate model.

## Mission 2 - Team Project Proposal Prompt

- 2 - Project Proposal
  - Some questions that need data to be able to answer: How much money do certain properties cost as they relate to location? How close is too close to a volcano? How much damage does a volcano really do and how can it be stopped? These questions can be answered with datasets from credible governmental sources such as Nasa, the British Geological Survey, the United States Geological Survey and the National Geophysical Data Center. These sources are incredibly reliable and will give us data on average home prices for those near volcanoes, maps of volcanic regions to see what areas are at the greatest risk, and dangers of a volcano with quantities as well as examples with the effectiveness of various volcano prevention techniques. The perfect dataset will provide data regarding past eruptions and probabilities of future eruptions. This way we can calculate the odds of a severe eruption happening in the future.

## Mission 3 Ski Resort Prompts

These prompts can be found on pages 24-26 of the Scenario Quest. Additional information on Data Identification and Analysis can be found on pages 30-31 of the [Actuarial Process Guide](#).

Responses:

- 3.1

<https://dspace.mit.edu/bitstream/handle/1721.1/42018/226339450-MIT.pdf?sequence=2>  
<https://www.tandfonline.com/doi/full/10.1080/13658816.2014.933481>  
<https://www.mdpi.com/2071-1050/12/24/10617>

The mathematical models that were found mostly addressed the vulnerability that certain ski resorts would have from climate change. Methods that were used include agent-based models, Vector Autoregressive models, and various charts. These models often include flowcharts to represent the models. These models are helpful because they show different ways to tackle these problems.

- 3.2

- 3.2.1 - There is a 70% chance of typical snowfall, a 20% chance of light snowfall, and a 10% chance of heavy snowfall.

- 3.2.2

	Light	Typical	Heavy	Total
Alpine Arena	450.5	786.14	1116	752.00
Mountain Meadows	482.5	885.93	945	811.15
White Haven	504.75	798.5	645	724.40

Light snowfalls lead to dramatically reduced profits.

- 3.2.3

Expected profit	
Alpine Arena	752
Mountain Meadows	811.15
White Haven	724.4

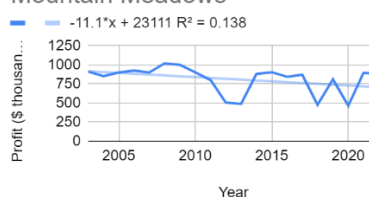
- 3.3

- 3.3.1

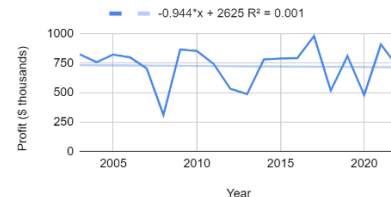
Alpine Arena



Mountain Meadows



White Haven



- Mountain Meadows has a riskier profit projection. This is because the slope of the projection line is the most negative. Interestingly, the data for Mountain Meadows also had the best correlation (the most optimal  $R^2$  value).
    - Assumptions

- Typical vs. Heavy vs. Light snow pertains to the volume of the snow, not the moisture/weight.
- The season length is the same for each location.
- If the snowfall is heavy, it will be heavy all year. The annual snowfall is constant.

## Mission 3 - Team Project Proposal Prompt

- 3 - Project Proposal

- <https://www.rdworltonline.com/using-math-to-predict-volcanic-eruptions/>
- <https://www.sciencedaily.com/releases/2017/06/170628095817.htm>
- [https://www.researchgate.net/publication/325908749\\_Mathematical\\_Modelling\\_of\\_Volcanic\\_Activity](https://www.researchgate.net/publication/325908749_Mathematical_Modelling_of_Volcanic_Activity) - The result of this study is several Mathematical models of gravity distribution fluctuations that coincide with pre-eruptive volcanic activity.
- <https://nap.nationalacademies.org/read/24650/chapter/2>
- <https://www.nature.com/articles/s41598-019-50675-2>

Journal articles modeling volcanic activity were a prevalent and useful source of information about our topic. Some things that were beyond our understanding were some of the origins of the physics based equations. Some search terms we used for searching for things were words pertaining to volcanoes like volcano eruption, lava, and magma, along with the search term “math model” so our results would yield mathematical models. The most effective model that we found for volcanoes appeared to be using similar physics equations and methods to make the data fit to our equations. This research has contributed to an increase in our understanding level regarding the modeling of volcanic activity. Mathematical modeling techniques included data assimilation inspired by meteorological models, and physics equations to model liquid flow and help us effectively model volcanic eruptions. We hope for our mathematical model to be able to identify the risks quantifiably and visually, such dangers include property damage, loss of life, and displacement of people.

## Mission 4 Ski Resort Prompts

These prompts can be found on pages 31-32 of the Scenario Quest. Additional information on Data Identification and Analysis can be found on pages 32-33 of the [Actuarial Process Guide](#).

Responses:

- 4.1  
There are no significant outliers in the atypical snowfall years of mountain meadows. There are only two heavy snowfall years, so neither could be considered an outlier. For light snowfall years, all three data points are relatively similar.
- 4.2
  - 4.2.1
    - 3.2.1 provides insight into the frequency of different events. This is because it does not provide anything about what is lost, but how often a certain event happens. These frequencies allow us to calculate the overall impact of different snowfalls.
  - 4.2.2
    - 3.2.2 doesn't show the frequency that the ski mountains lose, but it does show the severity of the loss of the mountains based on the type of snow for that year. When paired with these types of snow you could get the losses of the ski mountain.
  - 4.2.3
    - The loss for mountain meadows can be computed using the difference from the average profit. When the resort has lower than average profits in a given year, it can be considered to have lost money compared to their usual profits, and when it has higher than average profits, it can be considered to have gained money.

### Mission 4 - Team Project Proposal Prompt

- 4 - Project Proposal

There are two main types of risk mitigation strategies when it comes to volcanoes: those that reduce loss of life and those that reduce property damage. The loss of life risk mitigation strategies include evacuation plans, warning systems, air filtration systems and closing air spaces. The property damage mitigation strategies include intelligent building placement and landslide causeways. Evacuation plans and warning systems go hand in hand to get people to safety prior to facing the challenges of a volcano whereas air filtration systems and air space closings occur in response to the aftermath/results of an eruption. These systems reduce medical expenses associated with an eruption. Air space closings can also be attributed to property damage just as intelligent building placement and landslide prevention systems reduce the probability of properties being damaged during an eruption. Financially the latter solutions are higher in significance.

If no interventions are made, people who live near volcanoes can be subjected to dramatic financial loss as a result of injuries and property damage. The goal of a risk mitigation strategy is either to reduce damage (human or property) that comes as a result of a volcanic eruption. Risk mitigation strategies aim to lessen the burden of a volcanic eruption on those who live or operate business near volcanoes.

## Mission 5 Ski Resort Prompts

These prompts can be found on pages 36-38 of the Scenario Quest. Additional information on Data Identification and Analysis can be found on pages 34-35 of the [Actuarial Process Guide](#).

Responses:

- 5.1

The profit projection for the future years of Mountain Meadows suggests a lowered profit. If they do not intervene and change something, it is likely that their future profits will go down.

- 5.2

Behavior changes: Mountain Meadows can offer reimbursements to season pass holders when the season is shorter than expected and reduce ticket prices at the beginning and end of the season to incentivize people to come despite reductions in snowfall. This could potentially cost the resort money if it isn't successful in significantly increasing ticket sales since each ticket sale will generate less revenue. It also requires additional man-hours to calculate how much customers should be reimbursed by or how much ticket prices should be reduced based on snowfall or temperature data, and it also requires the creation of a streamlined system for keeping track of customer data and automating reimbursements.

Modifying Outcomes: Mountain Meadows can begin promoting other attractions such as hiking, mountain biking, and dirt biking trails, ziplines, or gravity-powered roller to continue accruing profit during the off-season. Another solution would be collecting and storing rainwater throughout the year to save money and produce greater volumes of snow at the beginning and end of the season. Some potential drawbacks are the cost to build and maintain new attractions, reimburse customers, and construct rainwater collection and storage infrastructure. Furthermore, the effectiveness of these measures is difficult to predict, as it is highly dependent on public opinion and the nature of the specific ski mountain (factors such as height and steepness).

Insurance: If profits don't reach a certain projected value, then Mountain meadows will be compensated. The insurance company could also be less direct by compensating Mountain meadows for lack of snowfall, or lower quality snowfall. They could meet somewhere in the middle by compensating them for not reaching a customer quota.

- 5.3

While the average profits are predicted to be lower, the standard deviation will nearly halve. This means that there will be less risk of straying too far outside of the mean estimated value and in reality, it will be a better idea to get the insurance policy.

	Average profit	probability
light	552.5	0.2
heavy	915	0.1
typical	855.9	0.7
	Average Profits	STDev
	801.15	132.3380817



## Mission 5 - Team Project Proposal Prompt

- 5 - Project Proposal
  - Recommendation Differences Between Mitigation Strategies”
    - The 3 risk mitigation strategies include behavior change, insurance, and modifying outcomes. The risk mitigation strategies we have identified in our project include those that reduce loss of life and property damage. The loss of life risk mitigation strategies include evacuation plans, warning systems, air filtration systems and closing air spaces. The property damage mitigation strategies include intelligent building placement and landslide causeways. The risk mitigation strategy the team labeled as more important is intelligent building placement. Using geography (topological maps), and volcano history, the risk can be assessed based on the location of the property. Based on this risk, the weight of all other risk mitigation strategies can be assessed on a normalized scale and prioritized accordingly.
  - Considering new problems introduced by the risk mitigation strategies:
    - A possible issue from the strategy of evacuation is that property may still be destroyed even if no life is lost. For adding protections to stop lava flow, there will still be smoke damage to property. Lastly, even with large landslide deterrent systems, a volcanic eruption of a high magnitude may still overpower them. No strategy is perfect, and no strategy is all encompassing, but when put together will offer significant protection for those at risk of a volcanic eruption.
  - Goals for situation improvement
    - We aim to mitigate the damage/loss of life resulting from volcanic eruptions and lava flow. The methods that reduce lava flow/landslides limit property damage, thus contributing to our objective. Closing airports and stopping air-traffic in affected airspaces will reduce the wear and tear/damage that ash filled air takes out on airplanes. On the other hand, evacuation with substantial forewarning would be able to limit the threat to human health. Additionally, effective air filtration systems will reduce the quantity of ash particles that enter the human body, reducing the health toll volcanic eruptions take out on people and pets.