Investigating Effects of Climate Change on Volcanic Eruption Hazards and Associated Economic Impacts in the Cook Inlet, Alaska

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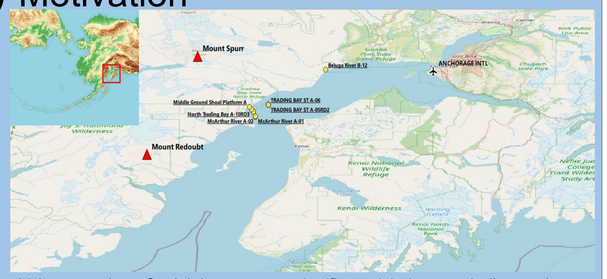
Research Question: In what ways do increased precipitation levels caused by climate change intensify volcanic hazards and their economic impacts such as greater risks of lahars and ash dispersal, aviation disruption, damage to oil infrastructure, and rising water demand?

1) Motivation



- Volcanoes along Cook Inlet present a significant risk due to ash dispersal, which can severely impact nearby oil infrastructure and Anchorage International Airport (ANC)

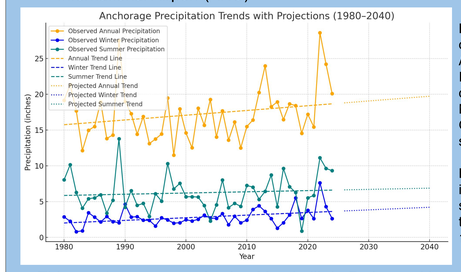


Fig. 1: (above) Location of volcanic systems near Anchorage, within Cook Inlet, including locations of oil wells and ANC. Made using QGIS; Opentopo imagerary; at a scale of 1:1,000,000

Fig. 2: (left) Shows the increase in annual and seasonal precipitation in the Anchorage area since 1980. (NWS & NOAA).

- This graph was created using Matplotlib in Python, with scatter plots for observed precipitation data and linear trend lines. The projections were calculated using (numpy.polyfit()) to show historical and future projections for annual, winter, and summer precipitation.
- Rain in anchorage is increasing at an annual rate of 0.07 inches per year. Winter precipitation is going up by 0.04 inches per year. Summer precipitation is increasing by 0.02 inches per year.
- Increasing annual and seasonal precipitation is important for heightened lahar activity and ash densification, which can amplify volcanic hazards and impacts.

3) Societal and Economic Impacts on Aviation and Infrastructure

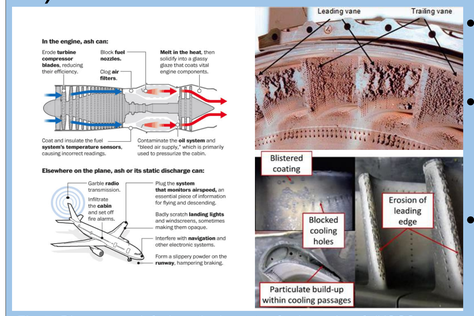


Fig. 7: Diagrams on left show the impacts of ash on aircraft (USGS, 2015). Images on right show an engine damaged by ash from Galunggung volcano on 24 June 1982 (Clarkson et al., 2016).

- Ash can severely damage jet engines by abrasion.
- Fine particulate matter poses health risks to those on board as it can pass through air filters.
- NoPac air route over Alaska currently traverses ~70,000+ people per day.

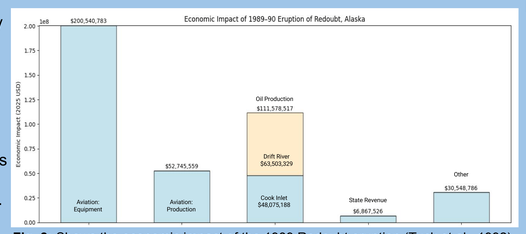


Fig. 8: Shows the economic impact of the 1989 Redoubt eruption (Tuck et al., 1992).

- KLM 867 quadruple engine failure accounts for majority of the aviation equipment damages.
- Recent eruption economic data not available to policymakers.
- Shows the potential impacts of ash fallout.

Currently Anchorage handles…

- Over 3.5 million metric tons of air freight annually, making it the 2nd busiest cargo airport in North America and 4th busiest in the world
- 140 cargo aircraft landings per day
- 3.4 million passenger enplanements.

Fig. 9: Made using the formula $h = \frac{Load}{(\rho)(g)}$ ρ= ash density (kg/m³) g = acceleration due to gravity (9.81 m/s²)

- Wet ash exerts far greater load for the same thickness compared to dry ash.
- During or after an eruption, increased precipitation can drastically increase roof collapse risk.

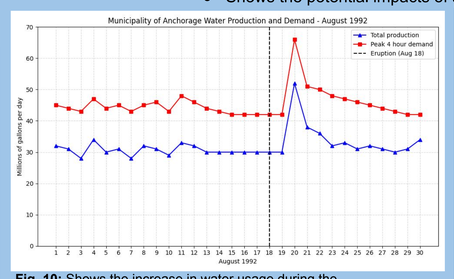


Fig. 10: Shows the increase in water usage during the 1992 Spurr eruption (AWWU, 2019; AWWU, 2024).

- Emergency water storage and backup systems are essential to maintain supply during sudden disruptions.
- The Anchorage Water and Wastewater Utility (AWWU) was aware of the risk in advance but failed to take action, showing a lack of preparedness.

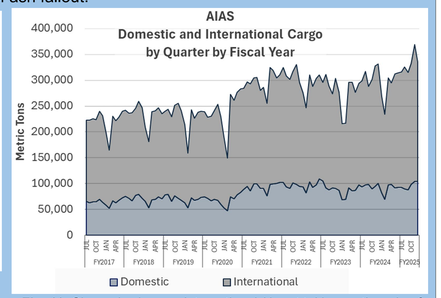


Fig. 11: Shows Anchorage International Airport taking on the role of international cargo hub (Spear & Lindseth, 2025).

- A total of $2.3 billion in economic impact (Spear, 2025).
- Each hour shut down would cost >$262,557.
- 51% of cargo flown from Asia to North America (McKinley, 2023).

4) Policy Recommendations

National Volcano Early Warning and Monitoring System (NVEWS) is a program enacted in 2019 to increase monitoring and early warning at very high risk volcanoes. Through targeted funding it has increased monitoring at volcanoes like Redoubt. Early warning is critical to preparedness and response, but the original act only authorized funding to the end of FY23 (supplemental since then).

Policy provides funding and outlays priorities (like early warning and monitoring). Effective policy is critical for resiliency and emergency management. Current policymaking is laggard and chaotic at the federal level.

Policy recommendations:

- Congress should reauthorize the NVEWS and appropriate at least $75 million over the next decade. Sen. Murkowski is in the early stages of sponsoring legislation to do so. Individual preparedness must be stressed at the community/state level.
- USGS must update their 2018 National Volcanic Threat Assessment. "[It] helps prioritize U.S. volcanoes for research, hazard assessment, emergency planning, and volcano monitoring" (AVO 2018).
- A standardized format for economic impact assessments related to volcanic eruptions must be established, adopted, and deployed for future eruptions.
- Stop DOGEing scientists. Examples include the AVO building lease and credit card limits.

Fig. 12: Depicts our current President ignoring climate change (Riddell, 2025).

2) Volcanic Hazards in Alaska

Spurr 1952 and 1992 **Redoubt 1989 and 2009**

Scanning Electron Photomicrographs of Volcanic Ash

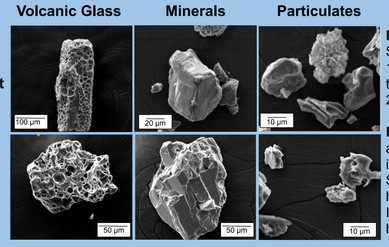


Fig. 3: (Above) August 18, 1992 Spurr eruption (left; McGimsey 1992). Redoubt eruption seen in the background (right; Sadler 2009).

Fig. 4: (Left) These images were acquired using secondary electron imaging on an FEI Quanta 200 Scanning Electron Microscope housed in the Advanced Instrumentation Laboratory (AIL) here at UAF.

- Volcanic glass is important because it can melt, resolidify, and encase jet engines.
- Minerals in ash can vary in hardness and cause abrasion.
- Fine particulate matter can enter the lungs and pose serious health risk.

Volcanic Ash Fallout

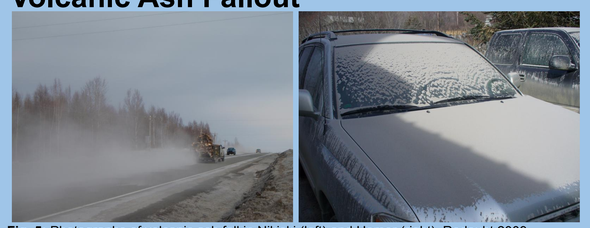


Fig. 5: Photographs of volcanic ash fall in Nikiski (left) and Homer (right), Redoubt 2009.

- Resuspension prolongs hazards of ash, damaging vehicles.
- Resuspended ash can reduce air quality and visibility, and damaging vehicles by clogging air filters, scratching paint, and wearing down engine components while driving.

Lahars/Pyroclastic Flows

Fig. 6: Drift River Oil Terminal (Johnson n.d.)

- Drift River was inundated by lahars during the 1989 and 2009 Redoubt eruptions.
- Drift River Oil Terminal has been decommissioned and an aging natural gas pipeline was repurposed for oil transport across the Cook Inlet, which is still vulnerable against damage from lahars.

5) Concluding Remarks

- Emergency policymakers must minimize inconsistencies in information.
  - MOA sharing information to "use water sparingly" and also advising "dampen ash in yard and streets to reduce resuspension," in the same pamphlet.
  - MOA advising "Use a dust mask or hold a damp cloth over your face to assist in breathing." when USGS states that "Wetting materials does not improve the ability of masks or cloth to filter volcanic ash."
- The economic impacts of volcanic events can be severe when there is no policy in place to ensure financial and public preparedness, especially as the government continues to target essential agencies like AVO, which exist to protect Alaska's economy and communities. Strengthening individual and community preparedness is crucial to reducing long-term costs and ensuring resilience.
- It's time to acknowledge the reality of climate change and its intensifying effects on natural hazards; volcanic activity included. As the climate continues to shift, the risks associated with these events grow, making it all the more critical to invest in monitoring and preparedness.
- Moving forward, it will be crucial to establish consistent monitoring protocols focused on economic impacts, providing a reliable framework for assessing damage across eruptions where comparable data is currently lacking.

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