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# The complex consequences of volcanic warnings: Trust, risk perception and experiences of businesses near Mount Zao following the 2015 unrest period

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## ABSTRACT

This paper reports results from a study of business owners carried out in 2016 in the region around Mount Zao, an active stratovolcano in Japan. In April 2015, Mount Zao experienced a period of unrest consistent with magma rising in the volcanic system. This led to alerts and public awareness campaigns, which provoked extensive media interest. This project used a survey and 12 semi-structured interviews to examine the opinions of business people on how the crisis was managed, and how it affected them. It also examined the perceptions of risk and the stories that were told about the potential eruption. Business owners who thought that an eruption would be harmful and that forecasting eruptions is difficult were more likely to be trusting. In general, respondents were very unaware of the risk from the volcano and the hazards that it could produce. The data also show that the impacts of disasters and even warning periods can cascade, much as hazards do: respondents noted that the crisis period effectively extended the time it has taken them to recover from the impact of the Tohoku earthquake in 2011, or brought them low just as they recovered. With increased vulnerability, the warning period at Zao exacerbated their situation, and this was not helped by a lack of scientific information and some perceived “rumours”. The paper suggests that public engagement via participatory strategies would be beneficial in reducing risk in this region, because it would enable stakeholders to own their risk and understand it.

## 1. Introduction

Mount Zao is a complex stratovolcano in northern Honshu, Japan (Fig. 1). It is historically one of Japan's most frequently active volcanoes (Table 1). It typically erupts basaltic to andesitic composition lavas, and has a long history of minor eruptive activity that is well documented [2]. However, the last activity was a minor event in 1940, so on the edge of living memory. The volcano is also a popular tourist attraction in Japan, particularly in winter, when its famous “snow monsters” make an appearance, and when the ski slopes are open. It is famous too for its hot springs (Onsen), which are frequented by visitors from the local area and other parts of Japan. The volcano is also at the boundary between two Japanese Prefectures, Miyagi and Yamagata, which means that there are different locally led approaches to risk reduction on the different sides of the volcano [5]. The volcano is also breached to the east side, such that the risk from hazardous flows is generally higher in Miyagi than in Yamagata [40].

In September 2014, scientists had detected ground deformation around Mount Zao, and in October, the crater lake Okama at the summit turned white. On 7th April 2015, an increase in seismicity was

detected, and led to a volcanic alert being issued in the Zao area on 13th April. The seismic activity continued for about a month, and the alert was discontinued by the Japanese Meteorological Agency on 16th June. These events took place in the shadow of the Ontake eruption on 27th September 2014, which had shocked Japan: the volcano exploded without warning and killed 63 people who were hiking near the summit. The Japan Times reported on 14th April:

With Ontake's eruption still fresh in people's minds, the latest warning quickly stoked fear in visitors, said a tourism association spokesman for the Zao ski and onsen resort.

“Okama is one of the key tourist spots in Zao,” he said, referring to the color-changing lake in Zao's crater, “but people think the resort is already dangerous to enter, just because it has the same name as the volcano.”

Many other media sources also made this link between the two volcanoes. Following the alert level, tourism decreased sharply in the region, leading both the Miyagi and Yamagata Prefectures to introduce discount schemes to encourage tourists to return [43]. The region is strongly dependent on tourism, both from within Japan and overseas

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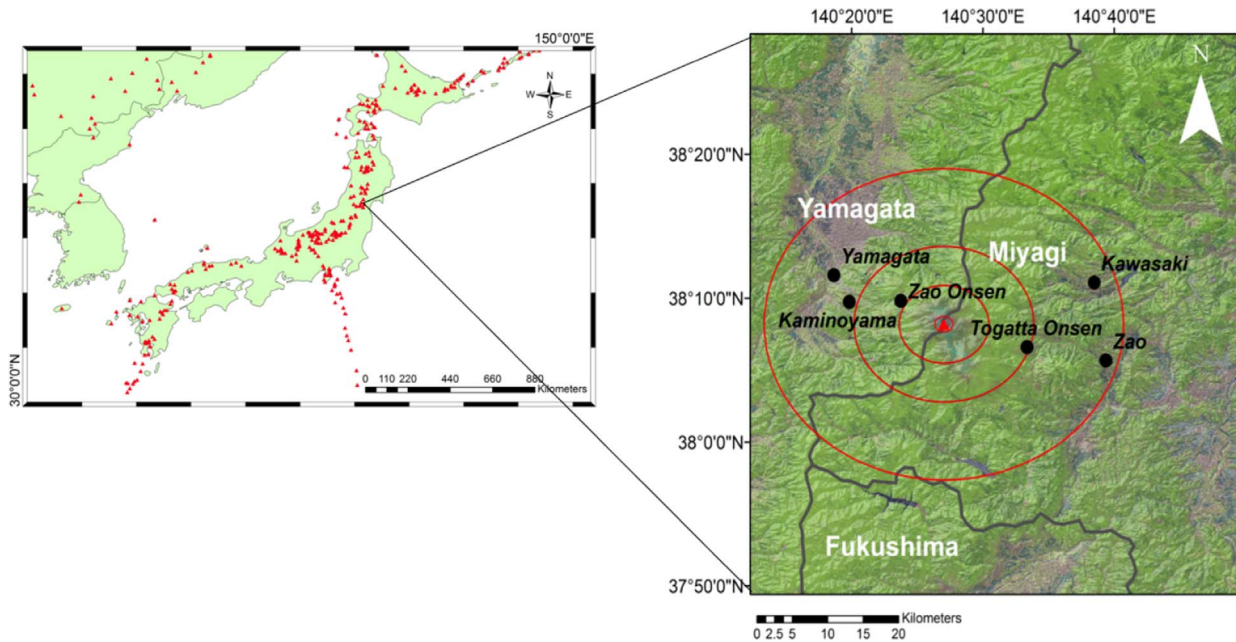


Fig. 1. Map showing the area around Mount Zao (red triangle). Red triangles on map of Japan are volcanoes from the LaMEVE database [8]. Red lines are at 1 km, 5 km, 10 km and 20 km, to illustrate the distances around the volcano. Zao Onsen is a major ski resort in Yamagata Prefecture; Togatta Onsen is a hot springs resort area in Miyagi. Imagery is Landsat 4–5 MSS, overlaid with an SRTM DEM. Grey lines show the boundaries between Prefectures (white text).

Table 1

Eruption history of Mt Zao. All activity noted here in stage 4 has been located at Okama lake, at the summit of Zaosan.  
Source: [2,40,59,61].

Stage	Dates	Eruption style	VEI (where known)
1	c. 1 Ma	Pyroclastics	
2	c. 300 ka	Lavas	
3	100–300 ka	Lavas	
4	30 ka to present	Pyroclastics, lavas	
4: historical activity since 1000	C12th–15th	Regular activity – tephra fall	Up to 3
	1620–1625	Regular activity – tephra fall	3
	1669–70	Tephra fall	3
	1694	Moderate eruption	2
	1794–6	Eruptive activity	2
	1804, 1806, 1809	Eruptive activity	2
	1821	Eruptive activity	2
	1830–33	Eruptions, tephra fall	2
	1867	Phreatic activity	2
	1873	Eruptive activity	1
	1894–7	Tephra fall	2
	1906	Small phreatic eruption	1
	1940	Tephra fall	1

[41].

A timeline of the disruption caused by the warning is provided in Fig. 2. This shows that the crisis was prolonged – the volcano remained restless from autumn 2014 until the time of the fieldwork for this project in 2016. During this time, the alert level was raised to 2 in April and lowered to 1 in June, but warnings continued to be issued into early 2016 due to periods of raised seismicity. More importantly, perhaps, no announcement was made that the crisis was over. During this period, volcanic hazard maps were revised repeatedly and an evacuation plan was announced almost a year after the initial alert (Fig. 2).

In this paper, we investigate the impact of this alert on local businesses, focussing in particular on the impacts, role of the media and the respondents’ perceptions of risk and uncertainty surrounding volcanic

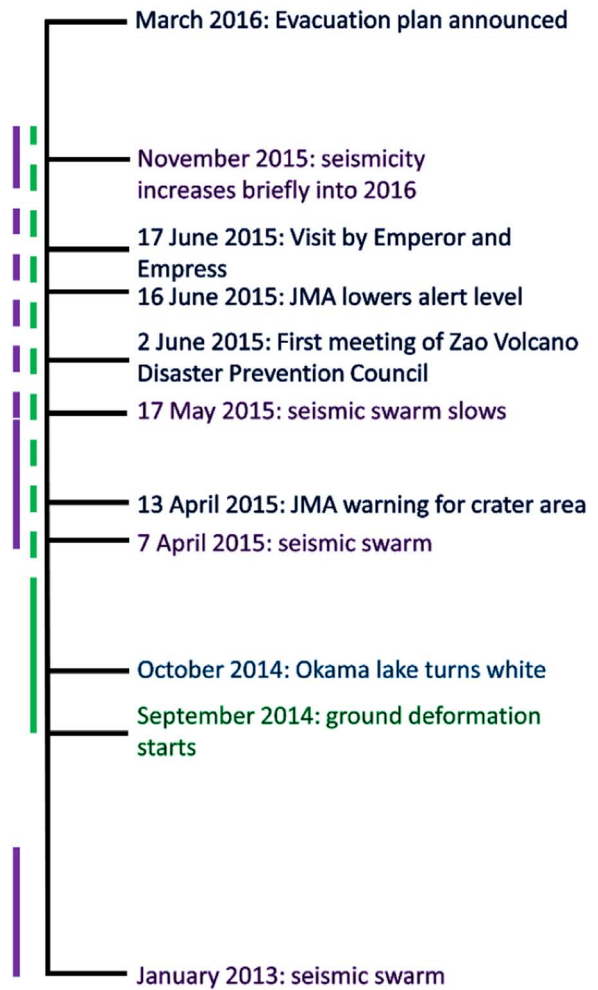


Fig. 2. Timeline of the volcanic crisis at Mount Zao. Seismic events are shown in purple and ground deformation in green. Social and warning information is dark blue.

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