

Dear Reviewer,

Thank you very much for your highly constructive feedback. Below, we respond to your comments in blue italics. We hope these responses adequately address your efforts to improve the scientific rigor of our manuscript. We will provide our textural changes once all reviews are received.

An intriguing paper that describes how Ryukyuan classical music could play an important role in engaging Okinawans and those in the Okinawan diaspora in the geosciences and science education. I enjoyed listening to the examples of Nubui Kuduchi and Kudai Kuduchi; this is definitely a strength of this paper.

We thank you for listening to our recording and appreciating its contribution to our manuscript.

While this paper has the potential to contribute to scientific progress within the scope of Geoscience Communication, it fails to do so due to its lack of claim for significance (so *what?*) that is solidly grounded in the scholarly literature.

We hope our responses to your suggestions below will address our claim to significance by better situating ourselves in the Indigenous knowledge and science education literature, particularly in geoscience works. To summarize our edits:

- 1. We improve the organization of our manuscript. Mainly, we move the background information on the Okinawan people and diaspora from the Discussion to the Introduction sections. We also focus on historical discrimination and present activity in Okinawan culture to highlight why our work is important for geoscience communication. We then split up several long in-text citations to better explain the significance of each work.*
- 2. We better present the knowledge gap our work aims to cover, particularly that Indigenous music can be used to interpret geoscience topics and engage Indigenous communities. We highlight the gap in research on Ryukyuan classical music (Ryūkyū koten ongaku; RKO) regarding geoscience, which, to our best knowledge, has never been done before in English or Japanese literature.*
- 3. We expand on our methods section by splitting it into how we 1) performed our lyrical synopses in collaboration with Indigenous practitioners and 2) performed our literature review with a specific focus on observations of climate and volcanic systems. Due to this change, we include our Background/literature review as a result in our new Results section.*

From what is presented, the paper has the potential to contribute to (a) the literature on Indigenous Knowledge and how traditional music can help scientists better understand historical as well as more recent climatic and geological processes; and (b) the literature on how traditional music, especially those of marginalised communities, could be used to improve

engagement of these communities with science, and empower them. Unfortunately, the authors fail situate the article well within the scholarly literature. In fact, the literature review in the Introduction section is too superficial for the reader to get a good understanding of the literature. As for (a), it is unclear what the literature discusses on how traditional music can help scientists better understand historical as well as more recent climatic and geological processes.

We greatly appreciate your detailed, constructive criticism of our Introduction here.

To address (a), we rewrite lines 21-24 to explicitly state how the cited works have contributed to including Indigenous knowledge in studying climate science or geologic hazards, not necessarily music (e.g., sea-level rise, earthquakes, volcanoes). To situate our study in traditional music, we then cite the success of works that have used Indigenous performing and visual arts to scientifically analyze geologic and environmental phenomena (e.g., Hough, 2007; Ludwin et al., 2005; Swanson, 2008). Furthermore, we cite new literature that exemplifies how incorporating multiple ways of knowing (such as that recorded in Indigenous art) is beneficial for science by increasing research objectivity and creativity (Bang et al., 2018; Am. Acad. Arts Sci.; Intemann, 2009; Social Epistemology).

As for (b), four articles are cited as highlighting “previous works highlight how incorporating indigenous stewardship in Earth science courses can increase engagement by emphasizing the local, land-human interactions to which a learner has an ancestral connection” but we have no idea what these previous works have said on this topic. Thus, it is unclear to the reader how this paper contributes to the literature on (a) and (b).

We acknowledge the lack of background from the cited papers in this section. To accommodate point (b), we specifically introduce the sources of indigenous knowledge used by Chinn et al. (2014) and Gibson and Puniwai (2006) to increase geoscience engagement in Hawai‘i. We also describe the positive outcomes of including these multiple ways of knowing described in Alexiades et al. (2021). We then add Palmer et al. (2009; Journal of Geoscience Education), that utilized North American Indigenous art in an undergraduate course to showcase how art can increase geoscience engagement, similar to our work here.

Similarly, it is unclear from the brief mentions of the literature at the end of p.2 to the first paragraph on p.3, what has been written so far (if any) on the topic of Ryukyuan classical music and climatic/geological processes. Is this paper filling a gap in any literature? If so, what exactly are the gaps?

Thank you for pointing out this deficit in our manuscript. We now discuss the background behind current work that examines Ryukyuan indigenous knowledge on scarce island groundwater (Takahashi, 2022), regional fisheries (Toguchi et al., 2016), and coral reef geobiology (Toguchi and Nishime, 2013). We also explicitly state that there is a gap in researching Ryukyuan classical music in terms of geoscience engagement in both English and Japanese literature (to our best knowledge) despite Ryukyuan classical music being a very visible component of Okinawan culture today.

The methods is another section where scientific rigour could be improved; the methods are not described comprehensively. In particular, it would be good for the reader to know (1) what are the other versions/schools of Nubui Kuduchi and Kudai Kuduchi exist, why the version used for analysis in the paper was used (is it the “mainstream” version? Why was it not compared with other versions/schools?);

Thank you for this constructive comment towards improving our Methods section.

To address point (1), we now add sentences on why we opted to use the version of the songs here. As members of the mainstream Afuso Ryu school of Ryukyuan classical music, our lineage only covers the versions that we present here. However, J.Y. Uyeunten and K.A. Odo are also knowledgeable about the one other mainstream school called Nomura Ryu. The differences between schools are mainly in how the song is executed through singing and playing; there are only a few differences in lyrics, and the most relevant difference regarding volcanoes is already noted in the Results section. This overall similarity is likely because both schools diverged from the same lineage relatively recently in the 1800s. Gillan (2012) and new citation Garfias (1993; Asian Music) discuss how Afuso Ryu preserved the style of the original lineage while Nomura Ryu simplified the style to make the art more accessible. Therefore, we add sentences to explicitly discuss such version control, differences between versions, and why we use our version.

(2) a description of the Okinawan diaspora in general, and the diaspora in Hawai’i, ...

To address point (2), instead of in the Methods, we expand our newly added Introduction Section 1.1 (described in-depth in a later response) to describe the Okinawan community in Okinawa Prefecture, in the diaspora, and the differences between both groups. We then add a review on where diasporas are located, the number of immigrants, what kind of labor attracted them to go overseas, discrimination faced overseas, and the distinct Okinawan identity retained through 4+ generations, with a focus on the one in Hawai’i (e.g., population, affinity groups, cultural events).

... and what kind of differences would the reader need to be aware of, in terms of the Okinawans in Okinawa vs. the diaspora elsewhere (also related to (1) above, are there differences in Nubui Kuduchi and Kudai Kuduchi sung by Okinawans in Okinawa and those transmitted within the diasporas?);

We then add a review on the differences between Okinawans in Okinawa and abroad: the language and culture barrier after separation from Okinawa by 4+ generations. We also address how Ryukyuan classical music instructors in the diaspora are often trained in Okinawa or trained by instructors from Okinawa. This training ensures that the versions transmitted in the diaspora are the same as those sung in Okinawa Prefecture.

(3) more details on methodology used to “link” observations of climatic, geological, and environmental processes, as the authors refer to Swanson’s work. This may help the reader understand better how photos and images (Figures 2, 4) were used in the analysis.

To address point (3), we expand on and organize our Methods Section 2 into two subsections: 1) the Indigenous sources of lyrics and how we created our lyrical synopses and 2) the specifics of how we performed our literature review to find the concurrence between song and science.

In new Section 2.1, we include our background of Nubui and Kudai Kuduchi and the various sources of Ryukyuan indigenous knowledge and modern literature used to supplement our synopses. This is where we discuss the various permissions we obtained from Ryukyuan arts practitioners, how we collaborate between art and science practitioners to ensure rightful recognition of Ryukyuan sources, and why we base our interpretation off one version of both songs (i.e., the lyrics we are interpreting are very similar across the two main Ryukyuan classical music schools, described above).

In new Section 2.2, we provide more details on our literature review to find the correspondence or “links” we found between lyrics and the literature. Here, we describe the methodology of Swanson (2008), namely utilizing one source of a Hawaiian oral history/chant/dance, of which there may be many versions, to compare with contemporary scientific literature. We note that this situation is similar to ours, where there is more than one version of both songs, but the meanings are fundamentally the same. We summarize that Swanson (2008) finds correspondence between Western and Indigenous ways of knowing.

What is written in sections 4.2-4.3 show that the lyrics and historical records concur; how was this information analysed to lead to the discussion in section 5.1?

In Section 2.2, we then describe how we applied the framework of Swanson (2008) and focused on a literature review that specifically aims to find 1) similarities or differences between observations in Nubui/Kudai Kuduchi and modern literature (e.g., concurring monsoonal winds and volcanic activity) and 2) how the climate and volcanism described in song and science can affect humans today (e.g., impacts of climate change on typhoons, air pollution from volcanic activity). Discussion Section 4.1 (previous Section 5.1) thus relates to addressing point 1) and how the concurrence between Ryukyuan observations in song and modern instrumented science can lead to interesting and novel scientific inferences. Section 4.2 (previous Section 5.2) will relate to addressing point 2) by using these scientific links to connect environmental science issues in Okinawa with students through place-based learning.

Following these changes, we reorganize the Results Section 3, where 1) the literature review constitutes a separate “result” followed by 2) the correspondence in climate or volcanic

processes that we propose are found in song and science. Thus, the literature review work does not precede the methods that describe how and why the literature review was done.

Moreover, we add another figure showing a diagram of how specific verses are related to literature in our review. We cite reordered Figures 1, 3 (originally Figure 4), and 4 (originally Figure 2) to emphasize how the observable phenomena or visitable sites in those figures are related to each link.

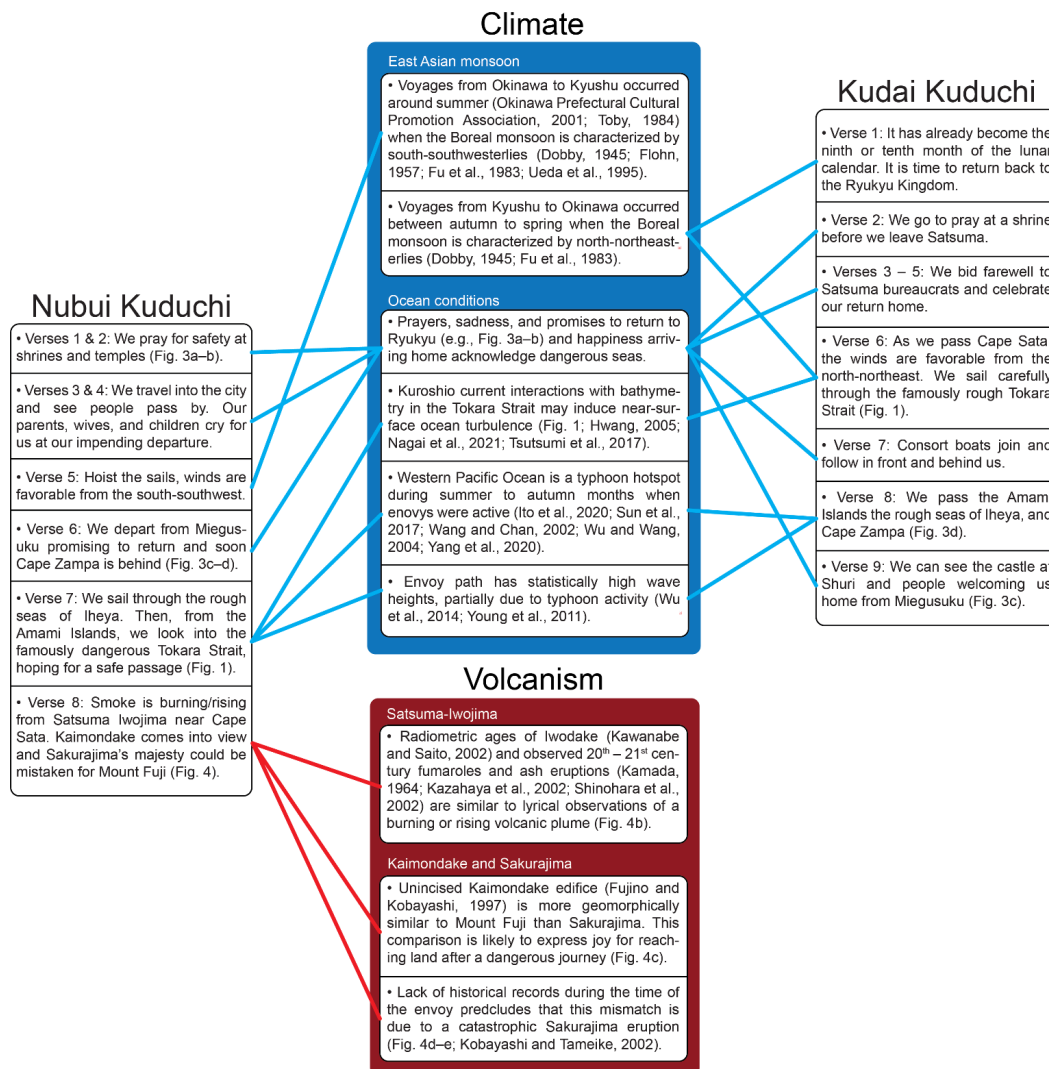


Figure #: Summarized 18th-century verses of Nubui Kuduchi (left) and Kudai Kuduchi (right) linked with 20th-21st-century scientific observations and literature on climate and volcanism (center). Climate and volcanism are divided into specific phenomena or locations that are likely sung about in both songs. Some verses or observations may discuss oceanic conditions (Fig. 1), landmarks (Fig. 3), and volcanic landforms (Fig. 4) that are observable or visitable in the 21st century.

Sections 5.2 and 5.3 appear to be literature review sections, much of which could be brought to the Introduction section to show us the gaps (or, what this paper builds on) in the literature. Once again, the authors would need to include more details so the reader can get a better understanding of the literature on the topic.

Thank you for pointing out this needed reorganization. We have moved much of the original Discussion sections to the Introduction to highlight the gaps and demand for our work in Ryukyuan indigenous knowledge. We also expand upon our discussion of the Ryukyu Kingdom, Ryukyu colonization and discrimination, the Okinawan diaspora, Ryukyuan classical music, and the environmental themes likely recorded in Ryukyuan classical music that could be useful for geoscience engagement.

In Section 1, we move up the previous work in Ryukyuan Indigenous knowledge and geoscience (i.e., moved the second paragraph in the original Section 5.2 and citations Takahashi, 2022; Toguchi et al., 2016; Toguchi and Nishime, 2013) and the gap in utilizing Ryukyuan classical music in geoscience, as discussed in a previous response.

In the new Section 1.1, we provide more details on the Ryukyu Kingdom, its conquest and annexation by Japan, assimilation policies implemented by Japan, and post-World War II history that led to revitalization efforts of Ryukyuan culture (i.e., moved much of the original Section 5.3 on Empowering Okinawan Communities to the Introduction).

Then, we include more details on the Okinawan diaspora as highly active and distinct from the Japanese diaspora. This Okinawan diaspora is another audience for the work done here due to historical discrimination and a demand to reconnect with their Okinawan heritage.

We also provide more details on Ryukyuan classical music. Specifically, we include how Ryukyuan classical music is still relevant in Okinawa today due to the support of classical music schools, instructors, and organizations, as well as prefectural government support.

I also recommend that the authors state the argument of the article clearly in the introduction. Currently, the first time the argument appears (after the abstract) is at the end of the methods section. It would be helpful for the reader to see this earlier.

Thank you for pointing this out. We will more clearly state the argument of our paper in the Introduction.

Once again, the fact that the authors have experiences and expertise as Ryukyu classical musicians makes this paper particularly appealing. Once the scientific rigour is strengthened, the paper could make an important contribution to scientific progress within the scope of Geoscience Communication.

Thank you again for your helpful and constructive feedback for improving the scientific rigor of our manuscript.