Supporting Materials

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UNIVERSITY OF PLYMOUTH School of Geography, Earth and Environmental Sciences
SIGMA Eros-IsoGlas
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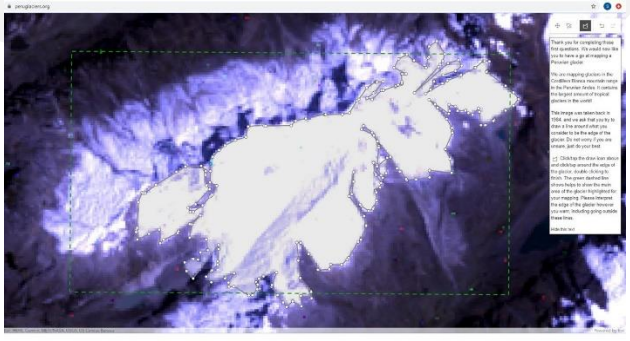
GlacierMap: a citizen science mapping tool for evaluating glacier change and contributing to climate literacy

What?

- GlacierMap is an interactive tool to engage the public, and specifically school students, in learning about glacier retreat and its impacts in regions such as Peru.
- Participants contribute to a database of glacier change, based on mapping of Landsat data (selected due to temporal range and availability) from 1984 and 2018.
- Mapping is conducted via the ArcGIS Online interface, embedded as a component within a larger workflow, and glaciers are chosen at random from a selection of 30.
- GlacierMap involves pre- and post-mapping surveys to gauge participant knowledge and concern around glacier change and downstream impacts, and what impact, if any, participation in the mapping exercise has on this.



Website design

Website and online mapping task designed by specialists in web development and GIS. Based on ArcGIS online interface so freely accessible.

Data collection

Data collection began in August 2020. Survey responses were collected until December 2020, but mapping will continue.

Analysis

Analysis of outputs from the survey and mapping, with focus on value for data generation (vs "expert" mapping) and as an educational tool.

GlacierMap v2

We plan to translate GlacierMap into Spanish for use in educational settings in Peru, and have already had interest from educators in Peru.

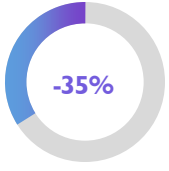
Why?

- The overall aim of GlacierMap is to generate a new database for glacier area change while increasing public awareness of mountain glacier retreat, changes to downstream freshwater contribution, and implications for water, food, and energy security.
- Glaciation is in the UK national curriculum, but is not taught at GCSE / A level in many schools who opt to teach coasts as an alternative. Improving understanding of glacier retreat and its impacts amongst school pupils, and creating a useful tool for teachers to help illustrate this global issue, is a key target output of this study.

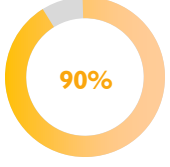
Where?

- GlacierMap is focussed on Peru's Cordillera Blanca mountain range.
- The range includes Peru's highest mountain, Huascaran (6768 m), and is the most glaciated in the tropics.
- Glacier melt provides here water for the 1.8 million people in the Rio Santa basin.

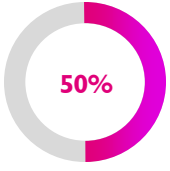
Change in glacier area in Cordillera Blanca over the last 40 years



Meltwater contribution to river discharge during drought



Energy generation from hydropower in Peru



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Information provided to participants on impacts after mapping task (also directed to https://sigmaperu.wordpress.com/impacts-of-glacier-retreat/)

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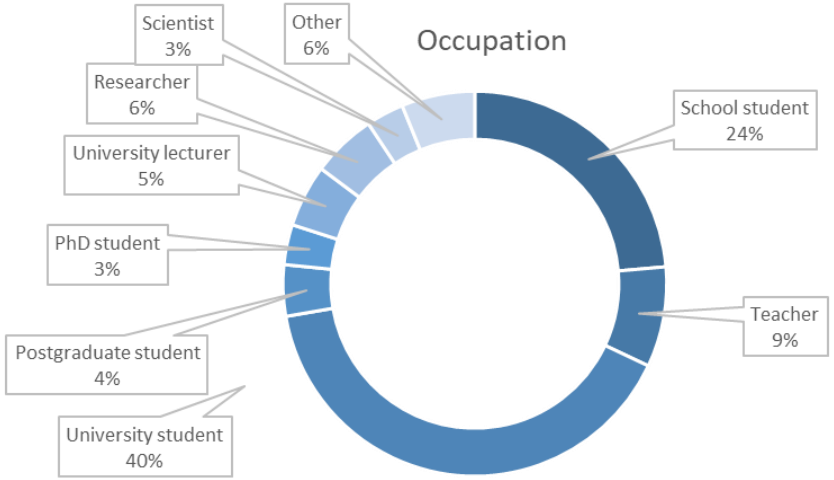
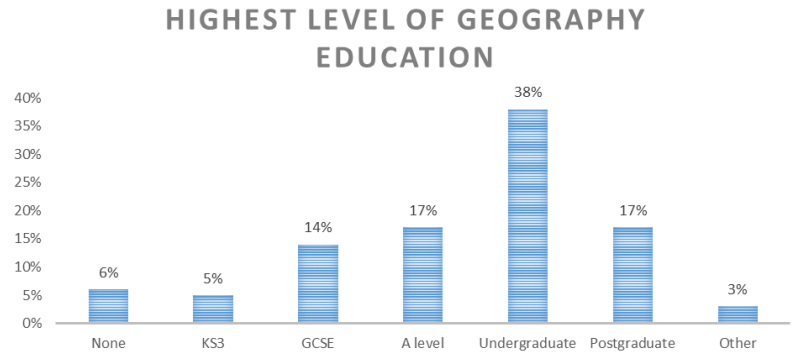
Demographic data from pre-mapping survey* (n = 537)

- Age: 19-21: 28%, 16-18: 24%
- Gender: 51% female, 46% male
- Occupation: 24% school students, 8% teachers, 40% undergraduate students
- Country of residence: 43% UK (n = 233), 19% Canada (n = 101), 11% USA (n = 58), 4% Switzerland, 4% Peru, 2% Germany, 2% India, 1% China, other
- Education: 30% had a postgraduate level of education and 86% had studied geography to some extent, including at GCSE (14%), A level (17%), undergraduate (38%) and/or in postgraduate education (17%)
- Glaciology experience: 40% had glaciology experience (n = 216), and 18% were "experts" (n = 96) (glaciology employment and/or postgraduate experience)
- Local experience: 85% of participants had not visited Peru

*data presented as analysed 3rd Dec 2020 (number of participants on 13th April 2021 = 614)





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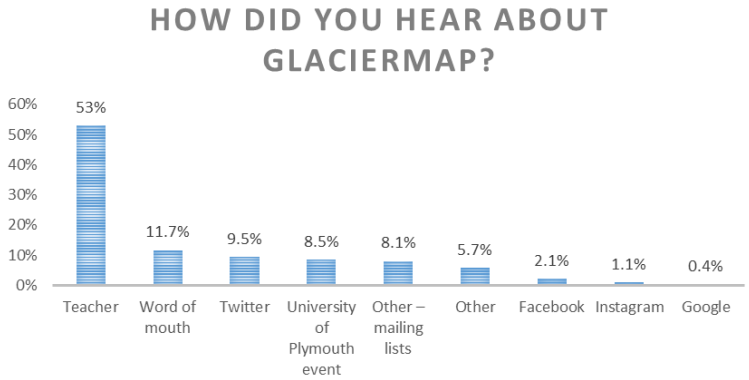
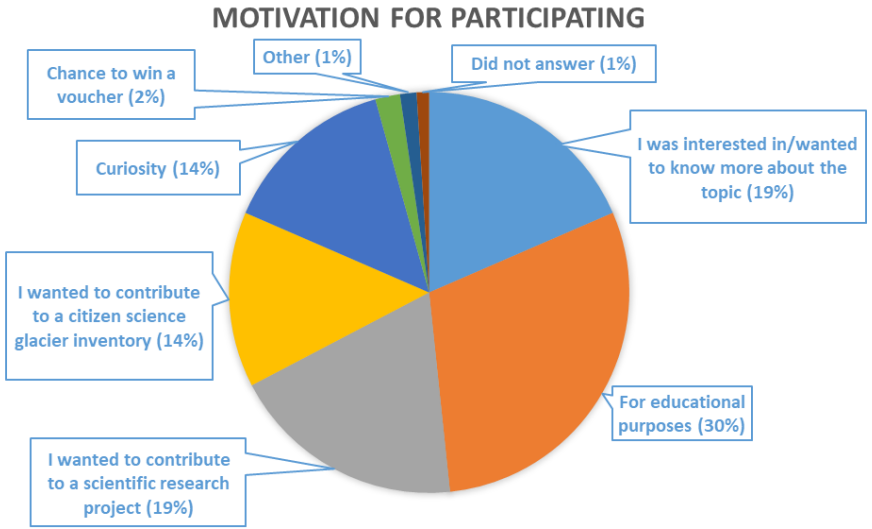
Participant recruitment and motivation





-> social media campaign and prize draw were not very significant in attracting participants

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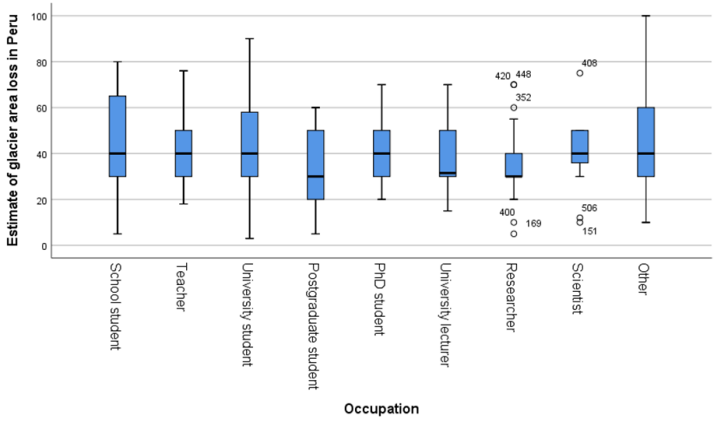
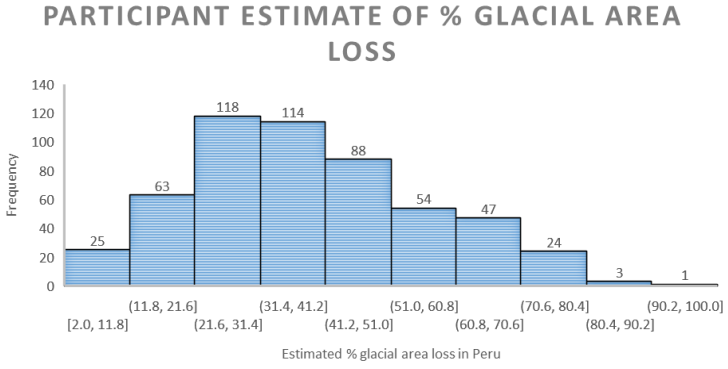
Participant awareness (pre-mapping survey)

- *"Q: Do you think glaciers are changing in the Peruvian mountains?"*
  - 98% yes
  - 2% no
- *"Q: How do you think glaciers are changing in the Peruvian mountains?"*
  - 98% shrinking (n = 512)
  - 2% growing (n = 13)
- *"Q: What percentage of glacial area do you think has been lost in Peru since 1980 (%)?"*
  - mean estimate 41% (correct answer ~30%)
  - min 2%, max 100%, st dev 18.5
  - general overestimation of % glacier area loss, but most within +/- 10% of true value





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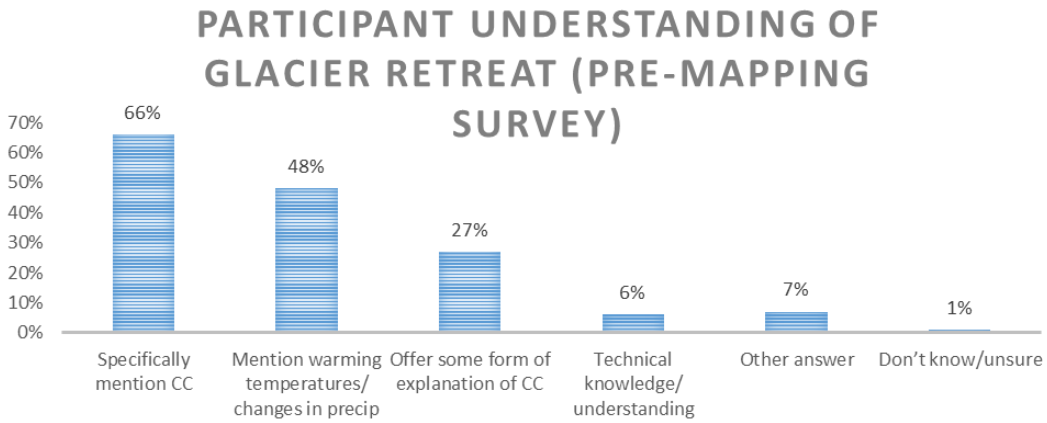
Coding of open-ended text around participant understanding



- *"Q: Why do you think the area covered by glaciers has changed / reduced in the Peruvian Andes since 1980?"*
  - 82% response rate to question
  - 66% of responses mentioned climate change / global warming
  - only four participants stated they did not know / were unsure why glaciers are retreating in Peru (1%). This suggests that a significant proportion of the GlacierMap participants were knowledgeable about CC and glacier retreat.
  - majority of those who demonstrated technical knowledge were either school students (n = 10, 36% of those who demonstrated technical knowledge) or university students (n = 8, 27% of those who demonstrated technical knowledge). This could be because they are used to being asked to provide a written explanation to their answers in assessments.

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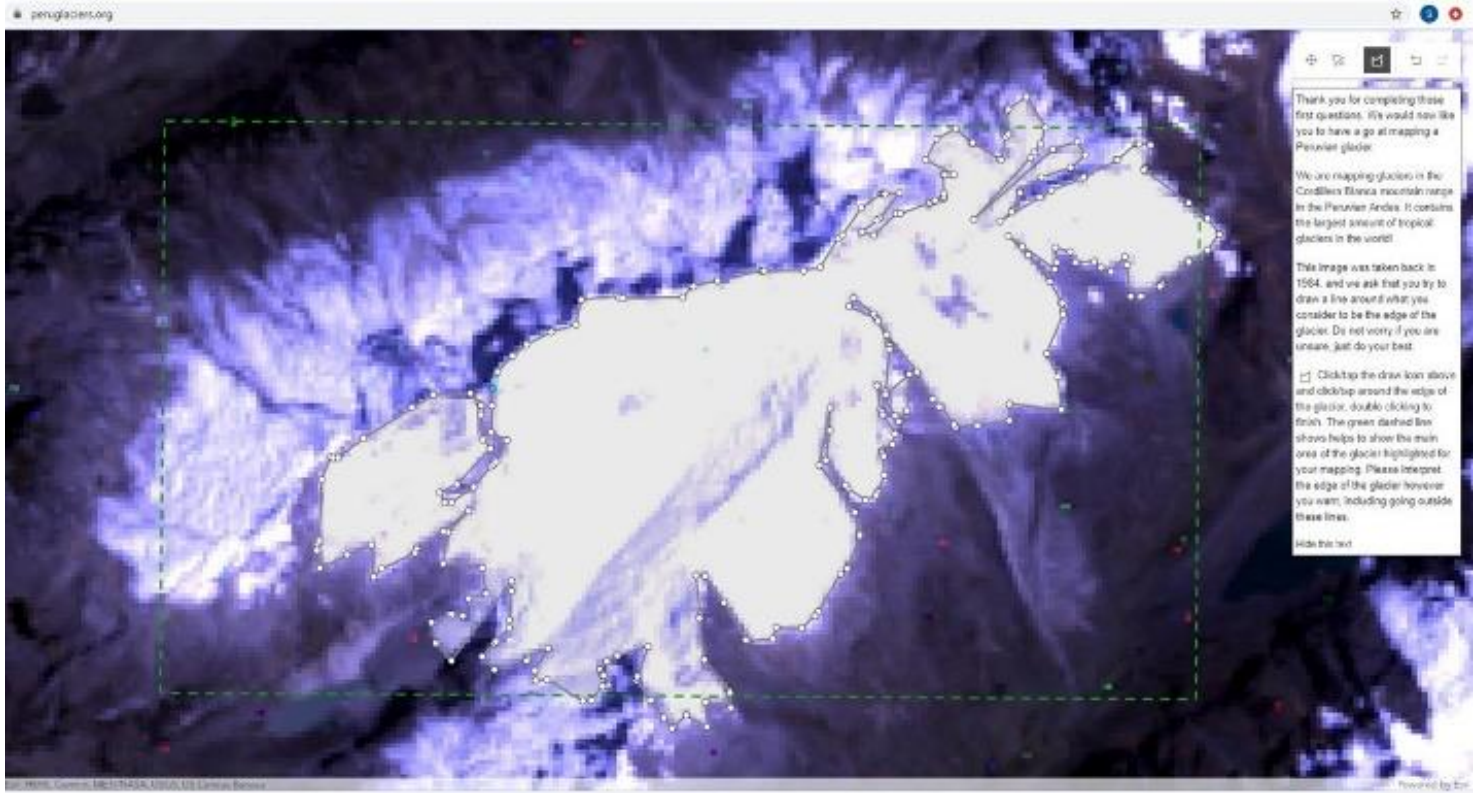
The mapping task: ArcGIS online interactive mapping platform – randomly selected glacier, mapping of outline for 1984 and 2018



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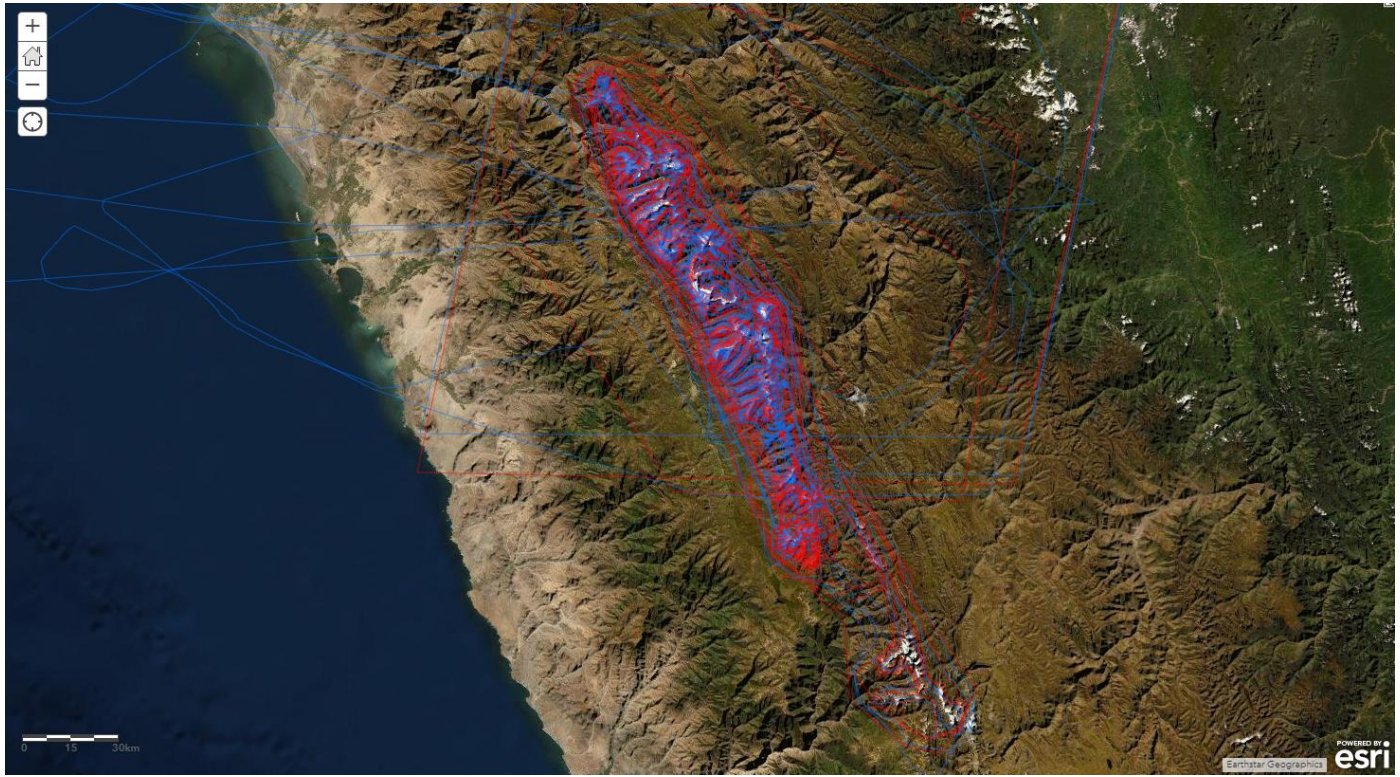
Total mapping contributions for 1984 (red) and 2018 (blue); n = 1069



-> considerable variation in the scale / accuracy of features mapped by participants!

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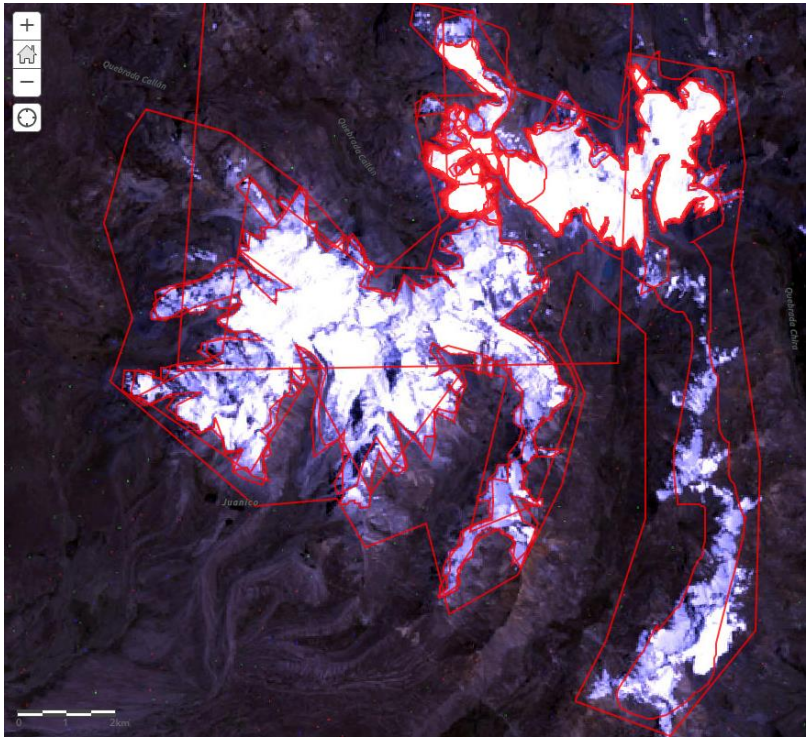
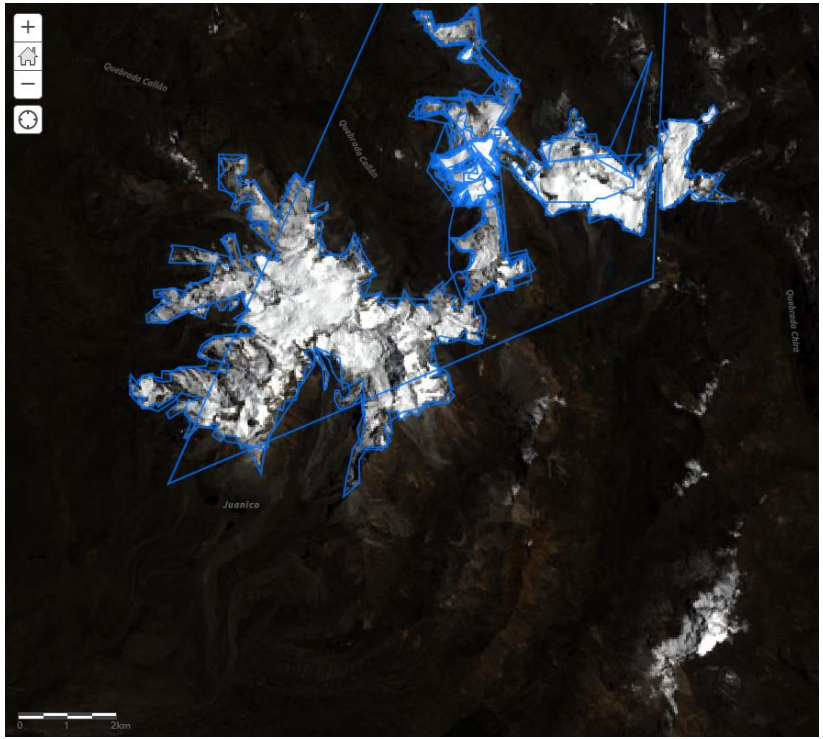
Mapping contributions for glacier 5 for 1984 (red) and 2018 (blue) – base maps Landsat 1984 and 2018





-> reduction in "glacier" area visible in mapping, but some difficulties interpreting snow vs glacier cover

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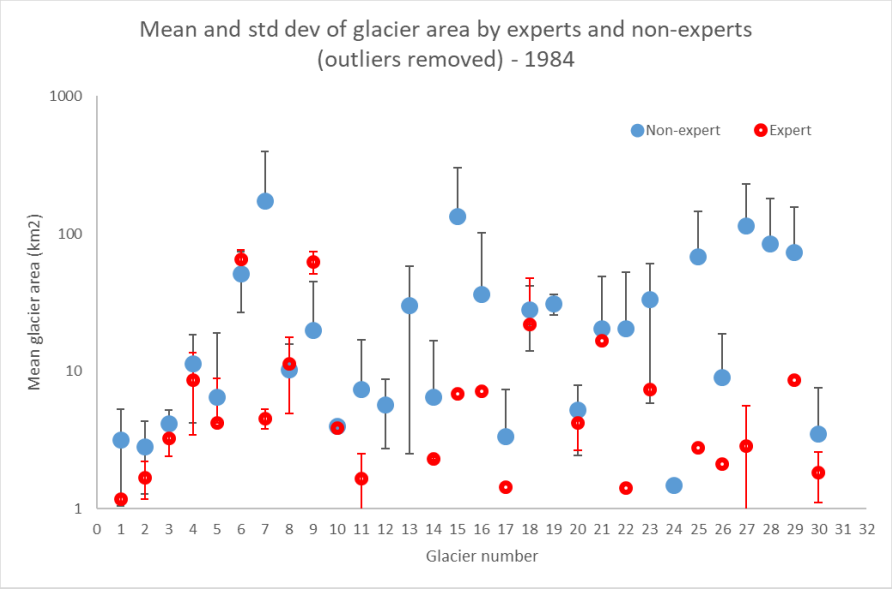
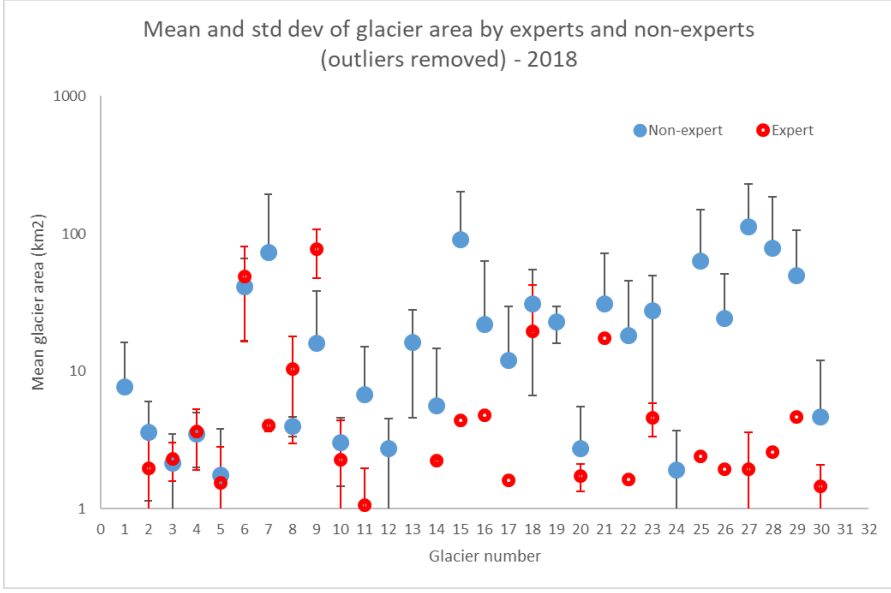
Mapping data – mean glacier area mapped by experts and non-experts





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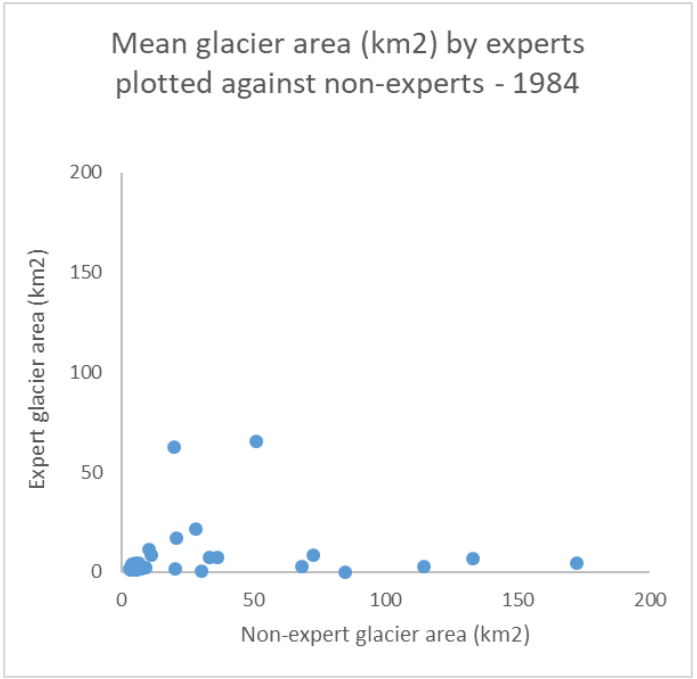

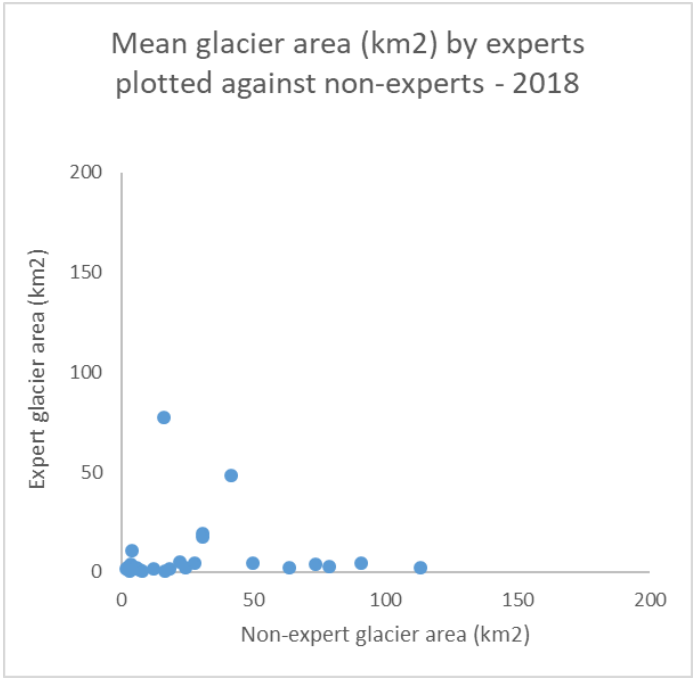

-> larger spread of glacier area for non-experts, likely due to lack of experience in interpreting satellite imagery

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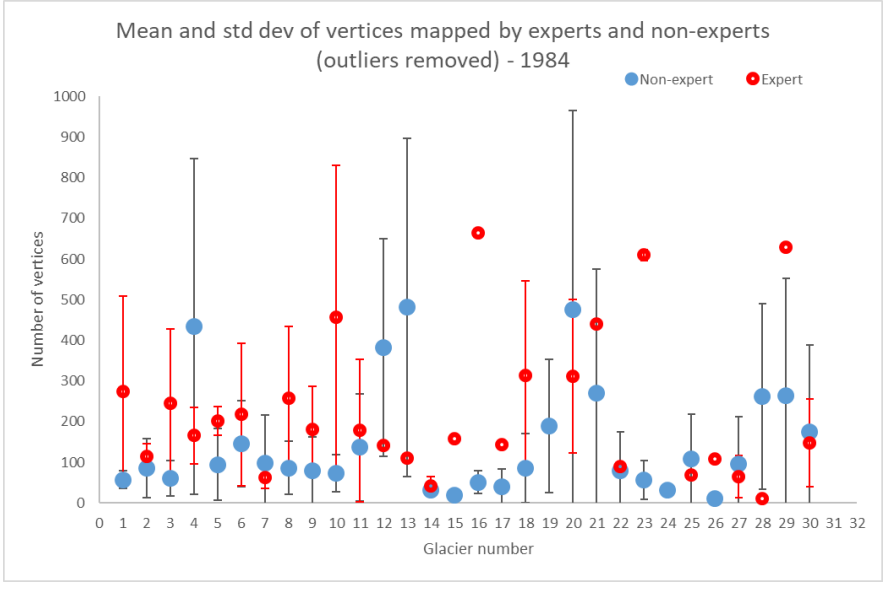
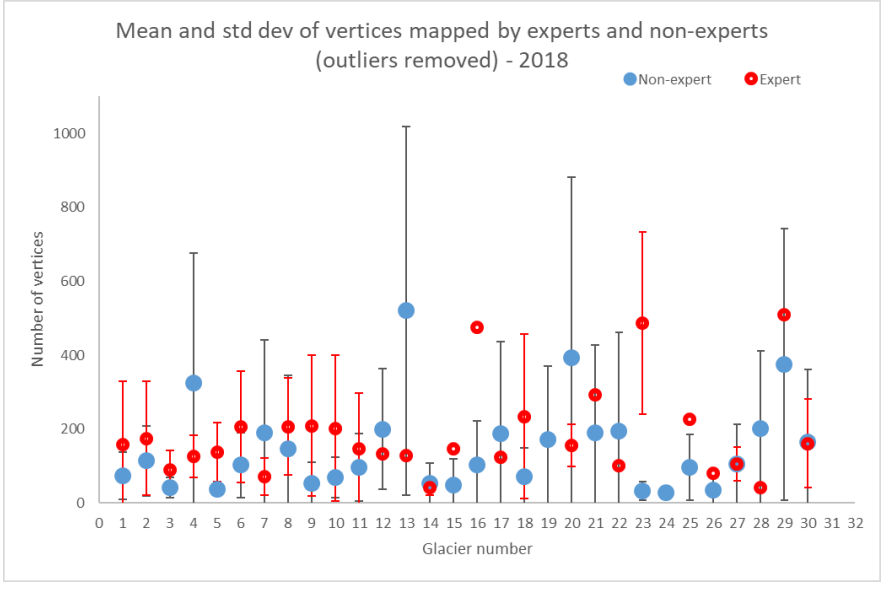
Mapping data – number of vertices mapped by experts and non-experts





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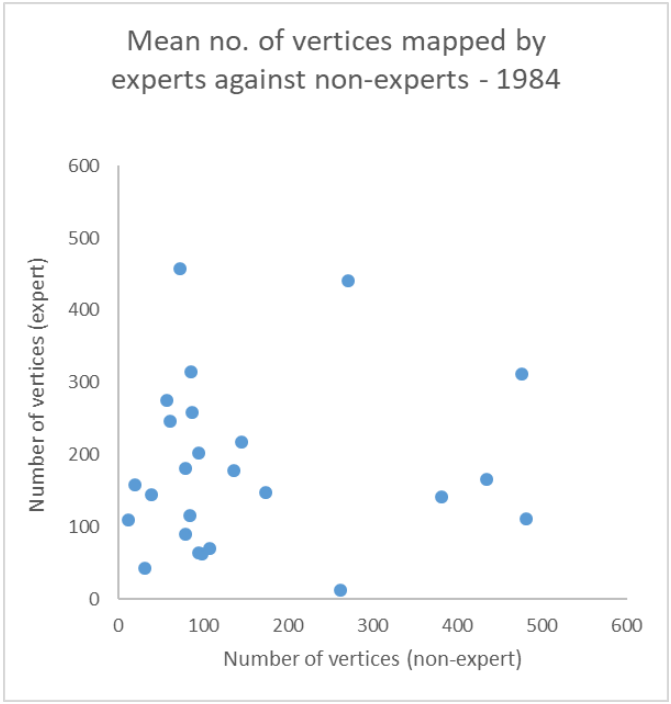

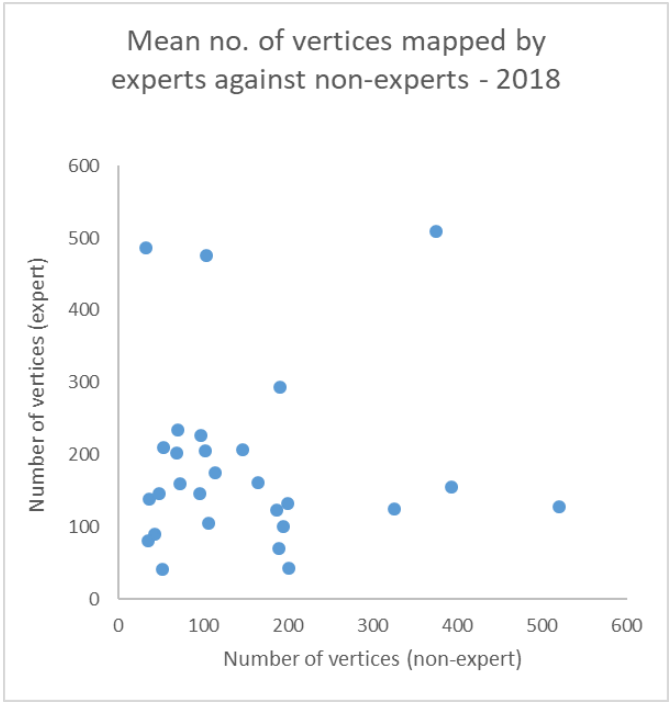

-> slight tendency for experts to map in a more detailed fashion, especially for the first mapping exercise (1984)

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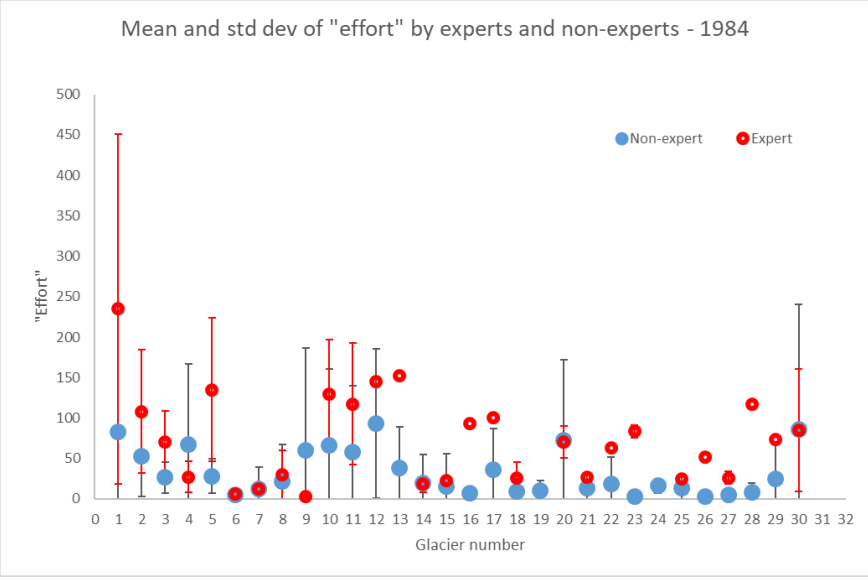
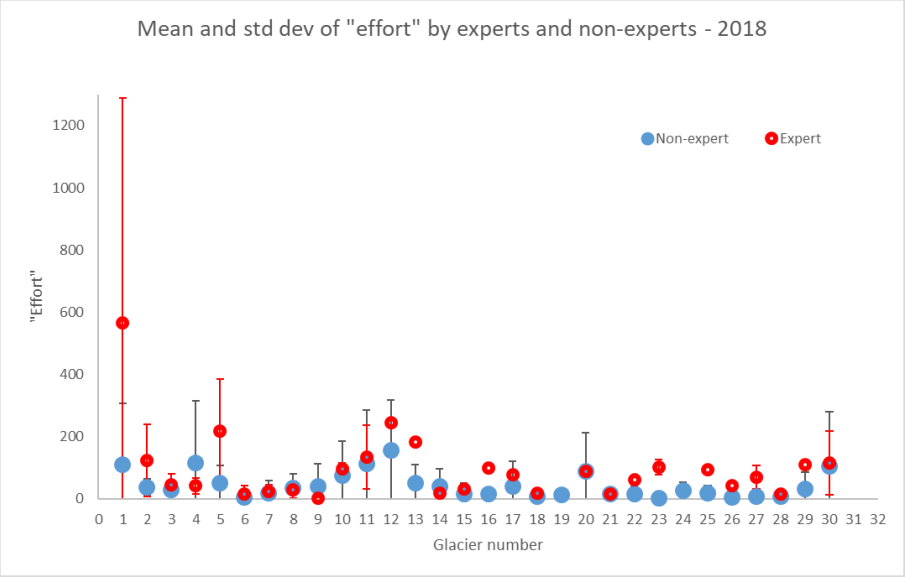
Mapping data – "effort" by experts and non-experts (where effort = vertices / area)





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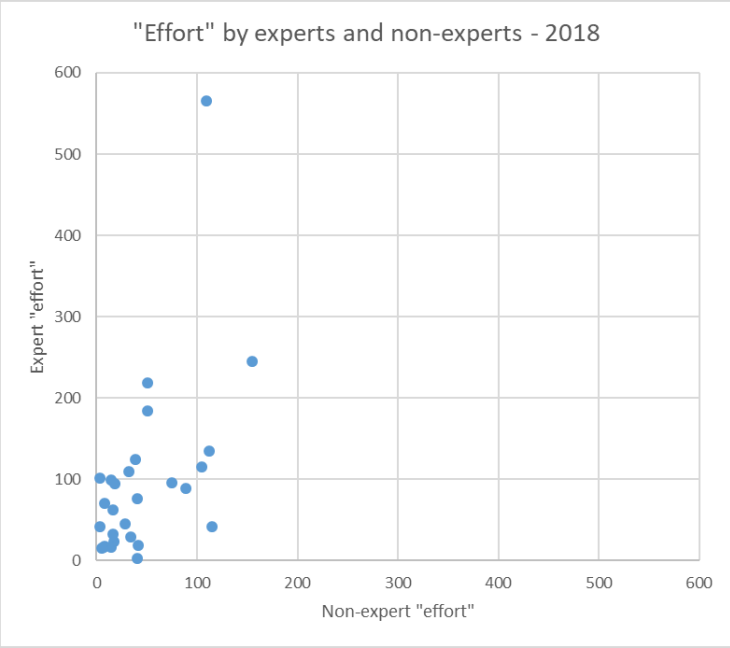

-> More effort from experts, especially for 1984 (fatigue for task second time round??)

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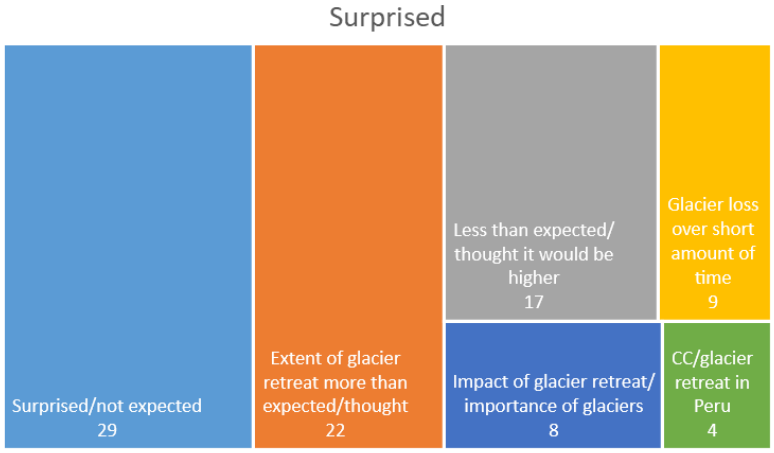
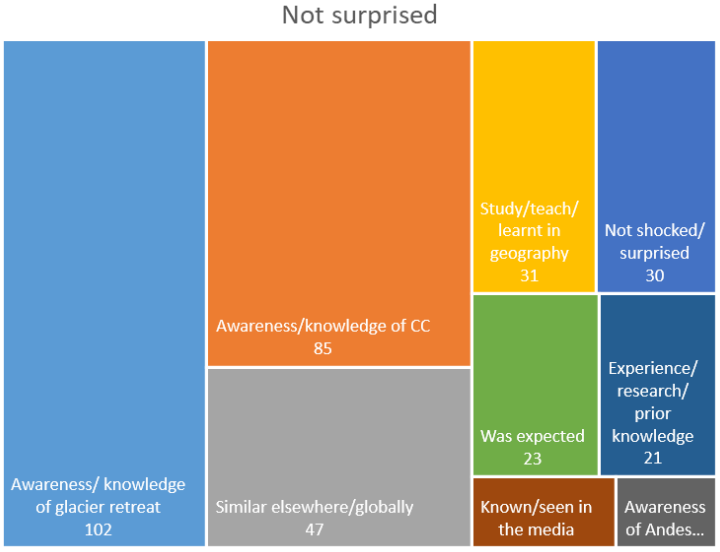
Were participants surprised by change in glacier area cover?

-> 27% of participants were surprised that glaciers in the Cordillera Blanca have lost ~30% of their area since 1980, while 68.5 % were not surprised. Themes from coding of participant responses in open text outlined below:





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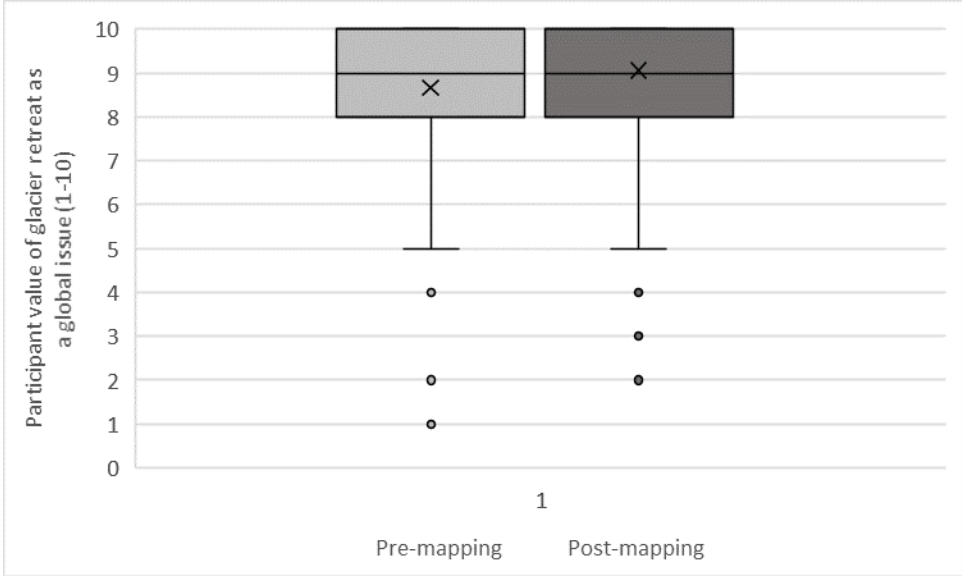
Did participants' perception change?

-> participants were asked before and after the mapping task: *"On a scale of 1-10 (1 being not very serious, 10 being very serious), how would you rate glacial change as a global issue?"*

- Pre-mapping average = 8.7
- Post-mapping average = 9.1
- Despite the existing awareness and initial high perception of glacier retreat as an issue amongst participants, we did see a slight increase in how serious participants thought glacier retreat was after conducting the mapping exercise and being provided with information on glacier retreat impacts in Peru.



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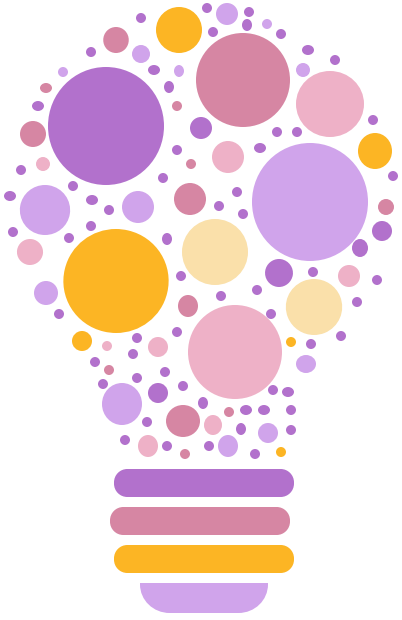
Feedback – 65% of comments were positive, 37% involved suggestions for improvement, 18% included negative feedback

"I liked the fact you could practice drawing out the shapes multiple times. I learnt that the water from the glaciers is used for many more reasons than I first thought. I found the fact that anyone can contribute the most interesting, as it allows people to lend a hand, even in the smallest way." (GCSE student)

"I really liked how we could see our two maps afterwards - it was a striking visual that helped me to appreciate the extent of glacial retreat. The diagram explaining the effects of this retreat was also very clear and easy to understand. I felt like I collected the data myself - which was really fun and exciting!" (GCSE student)

"I really liked the question that you asked before and after with how the loss of glaciers affected the locals as I did not realise the first time that it related to power and electrical energy." (GCSE student)

"I was previously unaware of how large the glacial mass loss in Peru actually was, it was fascinating to learn that. This was a very interesting and fun task." (GCSE student)



"I liked how I could actually contribute to research myself and see first hand from mapping the images that the glaciers are retreating. I also liked the diagram at the end with information as I find it interesting to find out more about the impacts of glacial retreat." (GCSE student)

"Really good idea to map like this - would like to use it as an activity in a lesson too!" (Teacher)

"Simple mapping task - raising awareness of impacts of climate change. I liked it." (Teacher)

"I think the resources were very clear and interesting. I love the duo-coding with images and words (impacts slides) as this is great for visual learners. I think maybe showing a slide with an example of a digitised glacier would help with accuracy if I was using this with pupils." (Teacher)

"I really liked this. I am a High School teacher and plan to do this with my Senior Geography class later in the month, so wanted to have a go first to see how it worked. Really looking forward to it - great for their Glaciated Landscapes understanding as well as consequences of climate change & greater understanding of hydrological cycle (and causes of regional inequality too). Thank you!" (Teacher)

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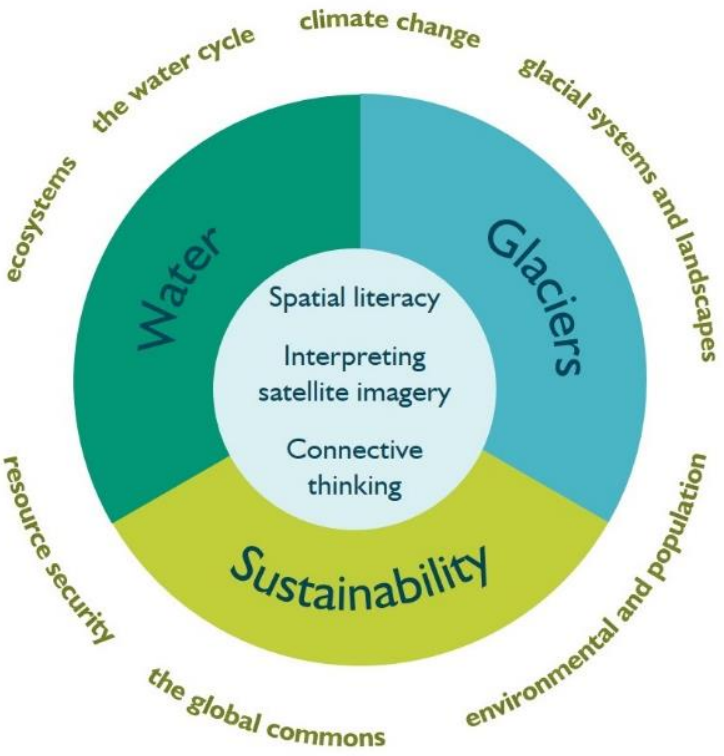
Benefits for teaching and learning



- Opportunity for inquiry-based learning through participation in interactive mapping, developing both spatial literacy and skills in interpretation of remotely-sensed imagery
- Students can develop their understanding of systems and environment-society interactions through engagement with materials provided in GlacierMap to promote improved understanding of downstream impacts of glacier change
- Provides an opportunity to situate glaciology in the curriculum within a current, challenge-facing context, promoting connective thinking.
- Discussions with students stimulated from the GlacierMap resource could include:
  - The importance of glaciers worldwide;
  - The importance of glacier meltwater for water, food and energy security for different users, at different times and on different geographical scales;
  - The importance of glaciers for local communities, both from a water resource and a spiritual/sense of place perspective;
  - Physical feedbacks with regards to climate change and glacier retreat;
  - Climate change mitigation and adaptation strategies for communities such as those in the Peruvian Andes - for example, Pre-Incan traditional adaptations such as canals, locally known as "amunas", and the importance of low-tech, low-cost options;
  - The concept of climate justice for nations and communities who have much lower contributions to global greenhouse emissions.

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GlacierMap: a citizen science mapping tool for evaluating glacier change and contributing to climate literacy

Challenges

- Important to gauge prior knowledge to create a baseline from which to evaluate educational impact, however measuring impact can be difficult where participants have good prior subject knowledge.
- We found it was most challenging to engage groups with no interest in the topic (as is often the case for science communication).
- Some mapping contributions may have been deliberately inaccurate, this means that quality checks by researchers are required.
- Involvement of minors in citizen science activities can be challenging due to ethical concerns. Where participant demographic details are collected for research purposes, this creates challenges around gaining participant and parental/guardian consent, particularly with online research.

Opportunities

- Many teachers have said they will use GlacierMap as an in-class activity and that they liked the resource.
- We were surprised to learn that there was also a lot of interest in GlacierMap from academics who would like to use it as an activity for higher education.
- We did not expect there to be as much international interest in GlacierMap! One participant offered to help translate GlacierMap into Spanish for roll-out in Peru, and we will now be redesigning the online platform with this in mind.
- Use of virtual resources such as GlacierMap provides opportunity to diversify the type of case studies used in teaching, while also acting as a vehicle for subject-specific training around spatial and climate literacy.

Lessons for Citizen Science?

- Consider how best to design your citizen science if you expect it to have an international reach (in terms of vocabulary used, possible interpretation of wording etc).
- Allowing citizen scientists to see that they have made a tangible contribution to research is really important. GlacierMap allows participants to review their mapping and compare mapping from different time periods, allowing for both interactive learning and an immediate sense of involvement.
- Don't underestimate the time it takes to create a participant-friendly accessible project! Carefully consider the clarity of instructions / training provided to participants as getting this wrong could mean no useable data.
- Be mindful of who the target participants are with regards to the complexity of the task(s).

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