(WIP) Glaciation in Grand Teton National Park: Little Ice Age to 2021

Authors

- **Elizaebth Case**
  [0000-0002-8169-0343](#) · [elizabethcase](#) · [elizabeth_case](#)
  Department of Earth and Environmental Sciences, Columbia University; Lamont-Doherty Earth Observatory · Funded by Grant XXXXXXXX

- **Jonny Kingslake**
  [0000-0002-6854-8422](#) · [jkingslake](#)
  Department of Earth and Environmental Sciences, Columbia University; Lamont-Doherty Earth Observatory

- **Daniel McGrath**
  [0000-0002-9462-6842](#) · [danielmcgrathCSU](#)
  Department of Geosciences, Colorado State University

- **Simeon Caskey**

  Physical Science Branch Chief, Grand Teton National Park

Abstract

Glaciers are responsible for some of the Teton Range's most iconic features, and remain important for both visitor recreation and as integral components of the alpine ecosystem. Much work remains to be done to document glacial change in the Teton range over the course of the last two centuries, from the end of the Little Ice Age (LIA) to the present day. Here we present: the first database of LIA glacial geology in the Teton Range, a series of remotely sensed change in aerial and volume extent from 1955-present day extended from Reynolds 2011 and Edmunds et al. 2012 [1], in situ data of Middle Teton surface elevation change and velocity from National Park Service-led efforts, preliminary GPR results from the first campaign in May 2021, and a slab model estimating ice thickness and volume across the range. These observations will help inform efforts to understand the future of ice in the Tetons as well as the Greater Yellowstone Ecosystem, from impacts on the alpine ecosystem to changing natural hazards for visitors.

Test edit - JK

Another edit, this time its on my local machine in a branch of the original repo (i.e. not a forked version). I made the branch in the github website.

Introduction.{page_break_before}

The Teton Range's iconic landscape of jagged peaks and classic U-shaped valleys has been carved out of stone by glaciers over many thousands of years. The range is the defining feature of Grand Teton National Park, which lies just south of Yellowstone in the north-western corner of Wyoming. This study investigates the de-glaciation of the 11 named glaciers in the park from the Little Ice Age to 2021.

1. Little Ice Age While most of the sculptural work was completed over the last two ice ages ==cite==, the Little Ice Age (1300-1850), a period of cooling in the northern hemisphere, left its mark on the landscape. Terminal and lateral moraines delineate the park's remaining glaciers, which subsist on and in north and east facing walls and valleys scattered throughout the park.

2. Glacial change 1950-present day

- natural climate cycle
- anthropogenic influences
- climate vs topography

3. Distinguishing

Relevance - impact

Making a change to see how it shows up on contributor repo Adding some more text to practice pulling to contributor repo. now what happens if i create an conflict.

Little Ice Age Glacier Identification

Little Ice Age moraines were digitized primarily from 2014 LiDAR imagery ==cite== with a hillshade applied (QGIS). These data were corroborated and augmented by ==year== National Agricultural Inventory Program (NAIP) aerial imagery and ==add data refs==. We follow the methods outlined in Martin-Mikle 2019 [2], delimiting the LIA location and size of glaciers from the presence of a terminal

moraine, the presence of lateral moraines, and a size requirement of 0.01 km^2. ==add note about trimlines, etc==

> The criteria used for identifying the former size and location of glaciers were (1) the presence of a terminal moraine; (2) the presence of lateral moraines; and (3) whether the identified glacier area exceeded 0.01 km2. A potential glacier was not omitted if it failed to meet both of the first two criteria (i.e., a LIA glacier that terminated at a cliff with well-defined lateral moraines but no discernible terminal moraine). [[**martin-mikleGlacierRecessionLittle2019?**]]

We used GLARE [3] to... VOLTA[4], which employs an augmented slab model, was used to remove ice to determine full extent... corroborated by comparing ice thickness between glaciers that have completely disappeared and those that remain...

Change in Aerial Extent

Digital Elevation Model timeseries

Digital Elevation Models were generated using

In-Situ Data

Surface Elevation Surveys

Ablation Stake Surveys

Seasonal timelapse imagery

Ground-penetrating radar

Ice-slab model to generate approximate ice thicknesses

Results

Conclusions

References

1. **Glacier Variability (1967-2006) in the Teton Range, Wyoming, United States1**
   Jake Edmunds, Glenn Tootle, Greg Kerr, Ramesh Sivanpillai, Larry Pochop
   JAWRA Journal of the American Water Resources Association (2011-10-21)
   https://doi.org/bxswd8
   DOI: 10.1111/j.1752-1688.2011.00607.x

2. **Glacier recession since the Little Ice Age: Implications for water storage in a Rocky Mountain landscape**
   Chelsea J Martin-Mikle, Daniel B Fagre
   Arctic, Antarctic, and Alpine Research (2019-01-01) https://doi.org/gpksp4
   DOI: 10.1080/15230430.2019.1634443

3. **GlaRe, a GIS tool to reconstruct the 3D surface of palaeoglaciers**
   Ramón Pellitero, Brice R Rea, Matteo Spagnolo, Jostein Bakke, Susan Ivy-Ochs, Craig R Frew, Philip Hughes, Adriano Ribolini, Sven Lukas, Hans Renssen
   Computers & Geosciences (2016-09) https://doi.org/f827s2
   DOI: 10.1016/j.cageo.2016.06.008

4. **Automated modelling of spatially-distributed glacier ice thickness and volume**
   William HM James, Jonathan L Carrivick
   Computers & Geosciences (2016-07) https://doi.org/f8rdwd
   DOI: 10.1016/j.cageo.2016.04.007

5. **Sci-Hub provides access to nearly all scholarly literature**
   Daniel S Himmelstein, Ariel Rodriguez Romero, Jacob G Levernier, Thomas Anthony Munro, Stephen Reid McLaughlin, Bastian Greshake Tzovaras, Casey S Greene
   eLife (2018-03-01) https://doi.org/ckcj
   DOI: 10.7554/elife.32822 · PMID: 29424689 · PMCID: PMC5832410

6. **Reproducibility of computational workflows is automated using continuous analysis**
   Brett K Beaulieu-Jones, Casey S Greene
   Nature biotechnology (2017-04) https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6103790/
   DOI: 10.1038/nbt.3780 · PMID: 28288103 · PMCID: PMC6103790

7. **Bitcoin for the biological literature.**
   Douglas Heaven
   Nature (2019-02) https://www.ncbi.nlm.nih.gov/pubmed/30718888
   DOI: 10.1038/d41586-019-00447-9 · PMID: 30718888

8. **Plan S: Accelerating the transition to full and immediate Open Access to scientific publications**
   cOAlition S
   (2018-09-04) https://www.wikidata.org/wiki/Q56458321

9. **Open access**
   Peter Suber
   MIT Press (2012)
   ISBN: 9780262517638

10. **Open collaborative writing with Manubot**
    Daniel S Himmelstein, Vincent Rubinetti, David R Slochower, Dongbo Hu, Venkat S Malladi, Casey S Greene, Anthony Gitter

Manubot (2020-05-25) https://greenelab.github.io/meta-review/

11. **Opportunities and obstacles for deep learning in biology and medicine**
Travers Ching, Daniel S Himmelstein, Brett K Beaulieu-Jones, Alexandr A Kalinin, Brian T Do, Gregory P Way, Enrico Ferrero, Paul-Michael Agapow, Michael Zietz, Michael M Hoffman, … Casey S Greene
Journal of The Royal Society Interface (2018-04) https://doi.org/gddkhn
DOI: 10.1098/rsif.2017.0387 · PMID: 29618526 · PMCID: PMC5938574

12. **Open collaborative writing with Manubot**
Daniel S Himmelstein, Vincent Rubinetti, David R Slochower, Dongbo Hu, Venkat S Malladi, Casey S Greene, Anthony Gitter
PLOS Computational Biology (2019-06-24) https://doi.org/c7np
DOI: 10.1371/journal.pcbi.1007128 · PMID: 31233491 · PMCID: PMC6611653

This manuscript is a template (aka "rootstock") for Manubot, a tool for writing scholarly manuscripts. Use this template as a starting point for your manuscript.

The rest of this document is a full list of formatting elements/features supported by Manubot. Compare the input (`.md` files in the `/content` directory) to the output you see below.

Basic formatting

Bold text

Semi-bold text

<div align="center">Centered text</div>

<div align="right">Right-aligned text</div>

Italic text

Combined *italics and **bold***

~~Strikethrough~~

1. Ordered list item
2. Ordered list item
   a. Sub-item
   b. Sub-item
      i. Sub-sub-item
3. Ordered list item
   a. Sub-item

- List item
- List item
- List item

subscript: H_2O is a liquid

superscript: 2^{10} is 1024.

[unicode superscripts](#)^{0123456789}

[unicode subscripts](#)$_{0123456789}$

A long paragraph of text. Lorem ipsum dolor sit amet, consectetur adipiscing elit, sed do eiusmod tempor incididunt ut labore et dolore magna aliqua. Ut enim ad minim veniam, quis nostrud exercitation ullamco laboris nisi ut aliquip ex ea commodo consequat. Duis aute irure dolor in reprehenderit in voluptate velit esse cillum dolore eu fugiat nulla pariatur. Excepteur sint occaecat cupidatat non proident, sunt in culpa qui officia deserunt mollit anim id est laborum.

Putting each sentence on its own line has numerous benefits with regard to [editing](#) and [version control](#).

Line break without starting a new paragraph by putting
two spaces at end of line.

Document organization

Document section headings:

Heading 1

Heading 2

Heading 3

Heading 4

Heading 5

Heading 6

A heading centered on its own printed page

Horizontal rule:

`Heading 1`'s are recommended to be reserved for the title of the manuscript.

`Heading 2`'s are recommended for broad sections such as *Abstract*, *Methods*, *Conclusion*, etc.

`Heading 3`'s and `Heading 4`'s are recommended for sub-sections.

Links

Bare URL link: https://manubot.org

Long link with lots of words and stuff and junk and bleep and blah and stuff and other stuff and more stuff yeah

Link with text

Link with hover text

Link by reference

Citations

Citation by DOI [5].

Citation by PubMed Central ID [6].

Citation by PubMed ID [7].

Citation by Wikidata ID [8].

Citation by ISBN [9].

Citation by URL [10].

Citation by alias [11].

Multiple citations can be put inside the same set of brackets [5,9,11]. Manubot plugins provide easier, more convenient visualization of and navigation between citations [6,7,11,12].

Citation tags (i.e. aliases) can be defined in their own paragraphs using Markdown's reference link syntax:

Referencing figures, tables, equations

Figure 1

Figure 2

Quotes and code

> Quoted text

> Quoted block of text
>
> Two roads diverged in a wood, and I—
> I took the one less traveled by,
> And that has made all the difference.

Code `in the middle` of normal text, aka `inline code`.

Code block with Python syntax highlighting:

```python
from manubot.cite.doi import expand_short_doi

def test_expand_short_doi():
    doi = expand_short_doi("10/c3bp")
    # a string too long to fit within page:
    assert doi == "10.25313/2524-2695-2018-3-vliyanie-enhansera-copia-i-
        insulyatora-gypsy-na-sintez-ernk-modifikatsii-hromatina-i-
        svyazyvanie-insulyatornyh-belkov-vtransfetsirovannyh-geneticheskih-
        konstruktsiyah"
```

Code block with no syntax highlighting:

```
Exporting HTML manuscript
Exporting DOCX manuscript
Exporting PDF manuscript
```

Figures

Figure 1: A square image at actual size and with a bottom caption. Loaded from the latest version of image on GitHub.

Figure 2: An image too wide to fit within page at full size. Loaded from a specific (hashed) version of the image on GitHub.

Figure 3: A tall image with a specified height. Loaded from a specific (hashed) version of the image on GitHub.

Figure 4: A vector `.svg` image loaded from GitHub. The parameter `sanitize=true` is necessary to properly load SVGs hosted via GitHub URLs. White background specified to serve as a backdrop for transparent sections of the image.

Tables

Table 1: A table with a top caption and specified relative column widths.

Bowling Scores	Jane	John	Alice	Bob
Game 1	150	187	210	105
Game 2	98	202	197	102
Game 3	123	180	238	134

Table 2: A table too wide to fit within page.

	Digits 1-33	Digits 34-66	Digits 67-99	Ref.
pi	3.14159265358979323 846264338327950	28841971693993751 0582097494459230	78164062862089986 2803482534211706	`piday.org`
e	2.71828182845904523 536028747135266	24977572470936999 5957496696762772	40766303535475945 7138217852516642	`nasa.gov`

Table 3: A table with merged cells using the `attributes` plugin.

	Colors	
Size	Text Color	Background Color
big	blue	orange
small	black	white

Equations

A LaTeX equation:

$$\int_0^\infty e^{-x^2} dx = \frac{\sqrt{\pi}}{2} \tag{1}$$

An equation too long to fit within page:

$$x = a + b + c + d + e + f + g + h + i + j + k + l + m + n + o + p + q + r + s + t \\ + u + v + w + x + y + z + 1 + 2 + 3 + 4 + 5 + 6 + 7 + 8 + 9 \tag{2}$$

Special

⚠ **WARNING** *The following features are only supported and intended for* `.html` *and* `.pdf` *exports. Journals are not likely to support them, and they may not display correctly when converted to other formats such as* `.docx` *.*

[LINK STYLED AS A BUTTON]

Adding arbitrary HTML attributes to an element using Pandoc's attribute syntax:

> Manubot Manubot Manubot Manubot Manubot. Manubot Manubot Manubot Manubot. Manubot Manubot Manubot. Manubot Manubot. Manubot.

Adding arbitrary HTML attributes to an element with the Manubot `attributes` plugin (more flexible than Pandoc's method in terms of which elements you can add attributes to):

> Manubot Manubot Manubot Manubot Manubot. Manubot Manubot Manubot Manubot. Manubot Manubot Manubot. Manubot Manubot. Manubot.

Available background colors for text, images, code, banners, etc:

white `lightgrey` `grey` `darkgrey` `black` `lightred` `lightyellow` `lightgreen` `lightblue` `lightpurple` `red` `orange` `yellow` `green` `blue` `purple`

Using the Font Awesome icon set:

✔ ? ★ 🔔 ✖ •••

> 🏫 **Light Grey Banner**
> useful for *general information* - manubot.org

> ℹ️ **Blue Banner**
> useful for *important information* - manubot.org

> 🚫 **Light Red Banner**
> useful for *warnings* - manubot.org