Assessing glacier changes in the Nanga Parbat region using a multitemporal photographic dataset

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This article presents a multitemporal photographic dataset from the Rupal Valley, south of Nanga Parbat in the northwestern Himalaya. The historical metric photographs were taken in 1934, 1958 and 1987 during scientific expeditions focusing on topographical mapping and glacier dynamics of the mountain massif. All photographs showing glacier aspects have been collected from archives and repeated from the same viewpoints during several surveys between 1992 and 2010. This dataset allows for a detailed visual assessment of glacier fluctuations, changes in snout positions, ice volumes, and debris cover over almost eighty years. It offers insights for a better understanding of glacier changes in this prominent Himalayan mountain region. The dataset supports a recently published article (Nüsser and Schmidt, 2021) with original archival material.

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**Specifications Table**

| Subject | Environmental Science  
| Global and Planetary Change |
| Specific subject area | Himalayan glacier changes; Repeat photography |
| Type of data | Images: photographs, TIFF files |
| How data were acquired | The original glass plates of the metric photographs from 1934, 1958 and 1987 (13 cm × 18 cm) were collected in the archive of the Institute for Photogrammetry and Cartography at the Technical University Munich. The glass plates were scanned at 600 dpi with a large format scanner (Epson Expression 10000XL with transparency unit) at Heidelberg University. Prints were used during fieldwork to return to the original viewpoints for repeat photography using a tripod and professional equipment (Nikon cameras and lenses). |
| Data format | Raw  
| Processed |
| Parameters for data collection | The repeat photographs have to be taken during weather conditions with minimum clouds and shadows during summer and autumn to minimize the influence of seasonal snow cover. |
| Description of data collection | All available historical photographs were evaluated and selected according to their quality and topical relevance. Prints of the selected photographs were taken to the field in order to identify the exact viewpoints. The camera was always mounted on a tripod for careful selection of the view angle and frame. |
| Data source location | Nanga Parbat, North-western Himalaya  
| Name of the Glaciers: Chungphare, Bizhin, Tap, Shaigiri, Rupal, Mazeno, Loiba  
| Region: Gilgit-Baltistan, District Astore, Rupal Valley  
| Country: Pakistan  
| Latitude and longitude for collected data: Latitude: 35.05°–35.15°N Longitude: 74.28°–74.43°E, Elevation of viewpoints of re-photographic surveys: 2940–5370 m a.s.l. |
| Data accessibility | The datasets described in this study are available from the Mendeley repository and can be accessed at:  
| Mendeley Data, V1, doi: 10.17632/sr5gzb9f9p.1  
| http://dx.doi.org/10.17632/sr5gzb9f9p.1  
| Related research article | Nüsser, M., Schmidt, S. (2021) Glacier changes on the Nanga Parbat 1856–2020: A multi-source retrospective analysis. Science of the Total Environment 785, 147,321. http://dx.doi.org/10.1016/j.scitotenv.2021.147321 |

**Value of the Data**

- The multi-temporal dataset contributes towards a more detailed understanding of glacier changes in the Nanga Parbat region, north-western Himalaya over a long observation period from 1934 to 2010. Due to the spatial proximity of the Nanga Parbat massif and the Karakoram region with its peculiar glacier behaviour this is useful for research on climate and environmental change.
- Glaciologists, climate and environmental change scientists and disaster risk planners.
- This dataset can be used for further scientific monitoring studies of Nanga Parbat glaciers and for modelling glacier behaviour in high relief areas. It provides possibilities for further repeat photography surveys and additional studies using high-resolution remote sensing data and unmanned aerial vehicles.

**1. Data Description**

This dataset contains multi-temporal glacier photography from the Rupal Valley, south of Nanga Parbat in the north-western Himalaya. It includes historical metric photographs with different Zeiss Phototheodolites from the years 1934, 1958, and 1987 and repeat photography taken
Table 1

Historical and repeat photographs.

| Year         | Photographer                  | Material                   | Camera, focal length                  |
|--------------|-------------------------------|----------------------------|---------------------------------------|
| 1934         | Richard Finsterwalder (RF),   | metric photographs\(^1\)   | Zeiss Phototheodolit TAF, 160.06 mm   |
|              | Walter Raechl (WR)            |                            | (RF) (Fig. 3, 4, 5, 7, 9, 10)         |
|              |                               |                            | 159.98 mm (WR) (Fig. 11, 13, 14)      |
| 1937         | Carl Troll (CT)               | photographs\(^2\)          | Zeiss Phototheodolit TAF 22,          |
| 1958         | Wilhelm Kick (WK)             | metric photographs\(^1\)   | 160.56 mm (Fig. 3, 4, 7, 8,          |
|              | Rüdiger Finsterwalder (RüF)   |                            |                                       |
| 1987         | Wilhelm Kick (WK), Rüdiger     | metric photographs\(^1\)   | Zeiss Phototheodolit TAF 92,          |
|              | Finsterwalder (RüF)           |                            | 159.85 mm (Fig. 4, 7), 162.23 mm     |
| 1992, 1993,  | Marcus Nüsser (MN)            | photographs\(^3\)          | Nikon F90 with zoom lenses            |
| 1994 /       |                               |                            | 35–70 mm (Fig. 6, 8, 9, 12, 14)       |
| 2010 /       | Marcus Nüsser (MN)            | photographs\(^3\)          | Nikon D300 S with zoom lenses         |
|              |                               |                            | 28–70 mm (Fig. 2, 3, 4, 5, 6, 7, 8, 9, |
|              |                               |                            | 10, 11, 12, 13, 14)                   |

Source:

1 Collection of photogrammetric plates and maps from Nanga Parbat expeditions (Technical University Munich);
2 Leibniz-Institut für Länderkunde, Leipzig.
3 Own collection, HIMVID (Himalayan Visual Database), Heidelberg University.

Table 2

Camera locations of photographs used in this study.

| Glacier    | Viewpoint | Figure | Lat/Lon                      | Elevation [a.s.l.] |
|------------|-----------|--------|------------------------------|--------------------|
| Chunghare  | a         | Fig. 2 | 74°43′58.647″E 35°17′2.717″N  | 4301               |
| Chunghare  | b         | Fig. 3 | 74°43′32.766″E 35°13′45.121″N | 2940               |
| Chunghare  | c         | Fig. 4 | 74°42′59.404″E 35°13′58.414″N | 3032               |
| Bizhin     | d         | Fig. 5 | 74°39′4.283″E 35°12′48.994″N  | 4173               |
| Bizhin     | e         | Fig. 6 | 74°42′50.261″E 35°13′10.199″N  | 3479               |
| Bizhin     | f         | Fig. 7 | 74°38′43.23″E 35°12′16.939″N  | 3656               |
| Tap        | g         | Fig. 8 | 74°37′10.587″E 35°10′56.808″N  | 4099               |
| Shaigari   | h         | Fig. 9 | 74°37′15.126″E 35°10′36.853″N  | 4427               |
| Rupal      | i         | Fig. 10| 74°32′35.256″E 35°8′53.101″N   | 4564               |
| Rupal      | j         | Fig. 11| 74°31′13.033″E 35°10′22.966″N  | 4390               |
| Rupal      | k         | Fig. 12| 74°31′8.568″E 35°10′4.16″N     | 4087               |
| Mazeno     | l         | Fig. 13| 74°29′3.314″E 35°12′50.052″N   | 5370               |
| Loiba      | l         | Fig. 14| 74°29′3.314″E 35°12′50.052″N   | 5370               |

Source: Coordinates and altitudes according to GPS (Global Positioning System) readings during field survey 2010.

with a single-lens reflex camera (SLR) in small-screen size (35 mm) in the 1990s and a digital single-lens reflex camera (DSLR) with full-frame in 2010 (Table 1). All relevant historical glacier photographs taken during scientific expeditions have been collected from archives and repeated from the same viewpoints during several surveys. The set of multitemporal photography comprises 13 matched images from seven large valley glaciers to document their decadal changes. All camera positions (viewpoints) and view directions of re-photographic surveys are marked on a map (Fig. 1). The elevation of camera positions ranges between 2940 and 5370 m a.s.l. and their exact locations, including GPS (Global Positioning System) data, are listed in Table 2. While nine of these image pairs (Figs. 2, 5, 6, 8, 9, 10, 11, 13, 14) present larger parts of the glacier tongues as overviews, three image pairs (Figs. 4, 7, 12) show details of Chunghare, Bizhin and Rupal glacier surfaces and one (Fig. 3) shows changes of the Chunghare Glacier frontal position.

2. Experimental Design, Materials and Methods

Repeat photography is the practice of reoccupying the camera positions of earlier photographs and taking new pictures of the same scene. Thus, re-photographic surveys aim to
Fig. 1. Location of viewpoints in re-photographic surveys.

Fig. 2. This bi-temporal pair of matched photographs from 1937 to 2010 shows the major tributary glaciers of Chungphare Glacier with characteristic ogives. The viewpoint (a) is located on a spur at 4300 m a.s.l. and the cairn proves the identical position. The photograph from June 1934 shows more seasonal snow cover than the replicate taken in September 2010.
Fig. 3. This tri-temporal set of repeat photography shows the snout position of the Chungphare Glacier in June 1934, September 1958 and August 2010. The viewpoint (b) is located on the opposite slope at an altitude of 2940 m a.s.l. The lateral moraine and the ridges in the background can be used for orientation.
Fig. 4. This set of matched photographs shows the debris-covered surface of the Chungphare Glacier tongue in June 1934, September 1958, August 1977 and August 2010. The photographs are taken from the orographic right moraine crest at an altitude of 3030 m a.s.l. (viewpoint c). Orographic features in the background can be identified for orientation.

Fig. 5. Repeat photography shows the glacier tongue of the Bizhin Glacier in June 1934 and September 2010. The photographs are taken from a slope above the lateral moraine at 4175 m a.s.l. (photo location d) and show the upper Rupal Valley.

produce a set of matched images from viewpoints identical to the earlier ones. Depending on the availability and quality of historical photographic material, comparative image interpretation between original photographs and replicates can be used for change detection. The dataset from the Rupal Valley combines glacier photographs taken during expeditions to Nanga Parbat with matched photographs for multi-temporal comparisons and monitoring (Table 1) [1].

It allows for detailed visual assessments of glacier fluctuations, changes in glacier snout positions, ice volumes, and debris cover since 1934 and can serve as a baseline for further studies in this prominent Himalayan mountain region. The dataset provides reference data for a recently published article [1] with original archival material and replicated glacier photography.
Fig. 6. Matched photographs show the glacier mouth of Bizhin Glacier in October 1992 and September 2010. The viewpoint (e) is located on the Rupal Ridge at 3400 m a.s.l.

The original glass plates of the metric photographs from 1934, 1958 and 1987 (13 cm × 18 cm) were collected in the archive of the Institute for Photogrammetry and Cartography at the Technical University, Munich and scanned at 600 dpi with a large format scanner (Epson Expression 10000XL with transparency unit). In addition, the original small-screen size images from 1937 and the slides taken with an analogue Nikon camera from the 1990s (2.4 × 3.6 cm) were scanned at 4000 dpi with a film scanner (Nikon Super CoolScan 5000 ED). Suitable images were selected according to their quality and topical relevance for repeat photography. Prints of these selected photographs were used to identify and replicate exact viewpoints during several re-photographic surveys between 1992 and 2010. Wherever possible, additional information such as coordinates and altitudes of viewpoints were collected from archival sources and publications [2,3]. For the sake of precision in repeat photography, the camera was mounted on a tripod to ensure careful selection of the view angle and frame. During several field surveys it was possible to repeat a set of historical photographs for comparative visual interpretation. This method has been used for assessing changes on individual glaciers in the Nanga Parbat region [4–6] and across different mountain regions [7–10].
Fig. 7. This set of matched photographs show the debris-covered surface of the Bizhin Glacier tongue in June 1934, September 1958, September 1977 and August 2010. The photographs are taken from the orographic left moraine crest at an altitude of 3660 m a.s.l. (photo location f). Orographic features and individual juniper trees in the background can be identified for orientation.

Fig. 8. These photographs show the Tap glacier, a pedestal glacier with a proglacial lake, dammed by the terminal moraine. While the photographs from September 1958 and September 1987 show this glacier from different viewpoints, the photographs from July 1993 and August 2010 are taken from the same viewpoint (g) at 4100 m a.s.l.
Fig. 9. These photographs show the debris-covered Shaigiri glacier. While the photographs from June 1934 and September 1987 show this glacier from different viewpoints, the photographs from July 1993 and August 2010 are taken from the same viewpoint (h) at 4430 m a.s.l.

Fig. 10. This set of matched photographs shows the upper Rupal Glacier with debris-covered and clean ice parts taken from a viewpoint at 4560 m a.s.l. (photo location i). The photographs from June 1934 show more seasonal snow cover than the replicates taken in August 2010.
Fig. 11. This set of matched photographs shows the upper Rupal Glacier with debris-covered and clean ice parts taken from a viewpoint at 4390 m a.s.l. (photo location j). Laila Peak (left) and Toshain Peak (right) are visible in the background. The photographs from June 1934 show more seasonal snow cover than the replicates taken in August 2010.
Fig. 12. This set of matched photographs from July 1994 and August 2010 shows the upper Rupal Glacier and a tributary cirque glacier to the South from a viewpoint at 4085 m a.s.l. (photo location k).
Fig. 13. This set of matched photographs from July 1994 and August 2010 shows the upper Mazeno Glacier and mountains of southwestern Rupal Valley from viewpoint I located on the Mazeno Pass (5370 m a.s.l.).
Fig. 14. This tri-temporal set of matched photographs shows the upper part of Loiba glacier in June 1934, July 1994 and August 2010. The viewpoint (l) is located on the Mazeno Pass (5370 m a.s.l.).
Ethics Statement

Not applicable.

CRediT Author Statement

Marcus Nüsser: Conceptualization, Methodology, Repeat photography, Data curation, Writing - original draft, Funding acquisition; Susanne Schmidt: Visualization, Investigation, Writing - reviewing & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have or could be perceived to have influenced the work reported in this article.

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