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The January 2018 to September 2019 surge of Shisper Glacier, Pakistan, detected from remote sensing observations

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ABSTRACT

This study analysed the actively surging Shisper Glacier in the Karakoram region of Pakistan using earth observation data from Landsat 8 OLI and Planet images. Changes in the surface glacier velocity, supraglacial moraines and debris cover were assessed using Landsat 8 data at monthly time-steps from January 2018 to May 2019. High resolution data from Planet Labs was used to precisely detect the snout advance and ice-dammed lake expansion. Downstream cross-section profiles of the valley were generated using a moderate resolution digital elevation model to assess the inundation in the event of rapid ice-dammed lake drainage. Correlation Image Analysis Software working on the principle of normalized cross-correlation was used to generate time series monthly surface velocity profiles for Shisper Glacier. Manual digitization at 1:30000 scale was used to delineate supraglacial moraines and supraglacial debris cover. The glacier surface velocity profiles indicate that the ablation zone of the glacier continues to be in an active surge phase resulting in advance of the snout and expansion of the ice-dammed lake. Surface glacier velocities are as high as 48 m d^{-1}. Between 18 December 2018 and 8 May 2019, the glacier snout advanced at ~6 m d^{-1} with a total overall advance of 860 m. The lake formed due to damming of an outflow stream from Mochowar Glacier expanded to its maximum area (29.69 ha) in May 2019 before drainage started on 23 June 2019. Our estimates indicate that the peak discharge in case of rapid drainage could vary between 5033 $m^3 s^{-1}$ and 6167 $m^3 s^{-1}$ and potentially affect infrastructure downstream.

1. Introduction

Glacier surges are characterized by flow velocity variations where a glacier can advance very rapidly (10–100 times faster than normal) in a short time period (lasting few months to few years). This phenomenon has been reported from across the globe, for example, the Andes of Argentina, Alaska, High Mountain Asia (Karakoram and Pamir), Patagonia, Svalbard and Greenland (Hewitt, 1998; Sevestre and Benn, 2015; Yasuda and Furuya, 2015). Surge-type glaciers undergo a short-lived active phase characterized by high flow velocities, and a quiescent/stable phase that usually lasts for a decade or more (Meier and Post, 1969). Although glacier surges in the Karakoram remain poorly understood (Hewitt, 2005), velocities associated with surge-type glaciers increase by ~200% during the active phase (Hewitt, 1969; Jiskoot, 2011). However, studies indicate that the majority of the surge-type glaciers are often associated with 'feeder' tributaries and are 12–25 km long (Hewitt, 1969, 2007). Although the dynamics of mountain glaciers have been extensively used to extract climate signals (Oerlemans, 2005; Banerjee and Azam, 2016) the anomalous behaviour of surging glaciers makes drawing (paleo)climate inferences from such glaciers difficult.

Karakoram glacier surges can occur at any time of year (Quincey et al., 2015). While some surges build-up extremely fast, others tend to grow gradually over time often resulting in substantial advance of the glacier snout (Kick, 1958; Gardner and Hewitt, 1990). The glacier surges in Karakoram could be either triggered by changes in thermal regimes (Hewitt, 2007) or changes in subglacial hydrological regimes (Copland et al., 2011; Mayer et al., 2011). While some studies indicate that glacier surges in the Karakoram are triggered by an interplay of thermal and hydrological conditions (Quincey et al., 2015), others suggest that the glacier surges could be controlled by landscape topographic (Lovell et al., 2018) and geomorphic characteristics (Paul, 2019).

The active surge phase at times blocks the path of rivers resulting in the formation of ice-dammed lakes (Mason, 1935; Hewitt, 1969; Hewitt and Liu, 2010) and also threatening life and key infrastructure like roads and bridges (Richardson and Reynolds, 2000; Ding et al., 2018). For instance, Steiner et al. (2018) reported on the surge of Khurdopin Glacier (Lat: 36° 16′ 14″ N; Lon: 75° 28′ 40″ E) where an ice-dammed lake formed as a result of blockage of a tributary river, posing a threat to the communities and infrastructure downstream in case of an outburst.

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Recent flood hazards in Kashmir put into context with millennium-long historical and tree-ring records

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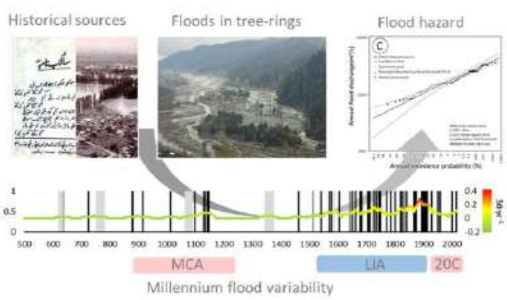
HIGHLIGHTS

- Kashmir has recently suffered extreme flood disasters
- Historical and tree-ring flood records show the occurrence of extreme floods events over last millennium
- The gained records contribute to a better flood-hazard assessment.
- This information is relevant for flood mitigation under the Indus Water Treaty.

GRAPHICAL ABSTRACT



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ABSTRACT

In September 2014, the Kashmir valley (north-west India) experienced a massive flood causing significant economic losses and fatalities. This disaster underlined the high vulnerability of the local population and raised questions regarding the resilience of Kashmiris to future floods. Although the magnitude of the 2014 flood has been considered unprecedented within the context of existing measurements, we argue that the short flow series may lead to spurious misinterpretation of the probability of such extreme events. Here we use a millennium-long record of past floods in Kashmir based on historical and tree-ring records to assess the probability of 2014-like flood events in the region. Our flood chronology (635 CE–nowadays) provides key insights into the recurrence of flood disasters and propels understanding of flood variability in this region over the last millennium, showing enhanced activity during the Little Ice Age. We find that high-impact floods have frequently disrupted the Kashmir valley in the past. Thus, the inclusion of historical records reveals large flood hazard levels in the region. The newly gained information also underlines the critical need to take immediate action in the region, so as

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Recession of Gya Glacier and the 2014 glacial lake outburst flood in the Trans-Himalayan region of Ladakh, India

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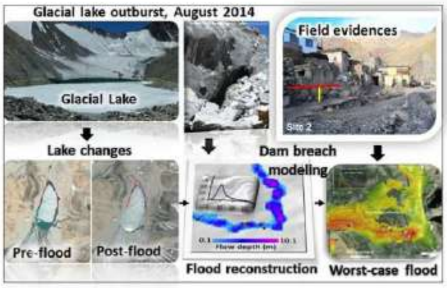
HIGHLIGHTS

- First comprehensive model-based reconstruction of the 2014 Gya GLOF
- Satellite data reveal a 45.6% loss in total glacier area from 1969 to 2019
- Field-based geomorphic indicators suggest piping failure led to 2014 GLOF event
- One-fourth of the lake waters drained out, inundating ~4 km^2 around Gya village
- A future worst-case GLOF could be 5.5 times larger than the 2014 event

GRAPHICAL ABSTRACT



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ABSTRACT

This study assessed spatiotemporal changes at Gya Glacier, the associated development of a proglacial lake, and reconstructed the 2014 outburst flood that struck Gya Village in the Trans-Himalayan region of Ladakh, India. This study analyzed and for the first time modeled a Glacial Lake Outburst Flood (GLOF) event in the Trans-Himalayan region of Ladakh. Glacier and glacial lakes changes were quantified using remote sensing data supplemented with field observations. Glacier ice-thickness and glacier-bed overdeepenings were modeled using a shear-stress based model, GlabTop (**Gla**cier-**b**ed **Top**ography). The reconstruction of the 2014 GLOF and the potential hazard assessment of Gya Lake were carried out using the hydrodynamic model HEC-RAS; results were validated against ground-collected data. Temporal evaluation of satellite data revealed a 45.6% loss in the total glacier area between 1969 and 2019. The earliest snow-free image available for the region shows that a proglacial lake existed as early as 1969 with an area of 3.06 ha. The lake has expanded to ~11 ha in 2019. Results from the GlabTop model suggest that the lake could grow further up to 12 ha in the future. Field-based geomorphic indicators suggest that the 2014 GLOF event resulted from a piping failure of the frontal moraine destroying numerous agricultural fields, some buildings, downstream infrastructure, and eroded natural channel embankments. The reconstruction of the event revealed that 25% of the lake waters drained out with a peak discharge of 470 m^{3}s^{-1}, inundating an area of ~4 km^2 around Gya Village. However, a complete breaching of the terminal moraine could result in an event that would be 5.5 times larger than the 2014 GLOF. Therefore, this study could be useful not only in planning disaster-resilient infrastructure around proglacial lake environments in the cold-arid Ladakh but also in framing mitigation plans to reduce risk for vulnerable downstream communities.

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water

MDPI

Article

Linking the Recent Glacier Retreat and Depleting Streamflow Patterns with Land System Changes in Kashmir Himalaya, India

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check for updates

Abstract: This study reports the changes in glacier extent and streamflow similar to many Himalayan studies, but takes the unusual step of also linking these to downstream land use changes in Kashmir Valley. This study assessed changes in the area, snout, and equilibrium line altitude (ELA) of four parts of the Kolahoi Glacier using earth observation data from 1962 to 2018. Changes in the discharge of the two streams flowing out from Kolahoi Glacier into the Jhelum basin were also assessed between 1972 and 2018. Additionally, satellite data was used to track the downstream land system changes concerning agriculture, orchards, and built-up areas between 1980 and 2018. This analysis suggested a cumulative deglaciation of 23.6% at a rate of 0.42% per year from 1962 to 2018. The snout of two larger glaciers, G1 and G2, retreated at a rate of 18.3 m a^{-1} and 16.4 m a^{-1}, respectively, from 1962 to 2018, although the rate of recession accelerated after 2000. Our analysis also suggested the upward shift of ELA by ≈120 m. The streamflows measured at five sites showed statistically significant depleting trends that have been a factor in forcing extensive land system changes downstream. Although the area under agriculture in Lidder watershed shrunk by 39%, there was a massive expansion of 176% and 476% in orchards and built-up areas, respectively, from 1980 to 2018. The conversion of irrigation-intensive agriculture lands (rice paddy) to less water-intensive orchards is attributed to economic considerations and depleting streamflow.

Keywords: remote sensing; glacier dynamics; land system changes; streamflows; Kashmir Himalaya

1. Introduction

Himalayan glaciers are in a continuous state of retreat since the 19th century in response to climatic change and anthropogenic activities [1–3] except in the Karakoram region where glaciers have been reported to be in a stable phase [4–6]. The ever increasing temperatures have resulted in the faster melting of cryosphere reserves in the region [7,8]. Although most of the studies consider climate to be the main controlling factor in glacier recession [9–11], many studies identify the influence of topography [12–14] and debris cover on glacier retreat [15,16]. The warming trends over the region have not only accelerated the glacier melt [17–19] but have also changed the form of precipitation [20,21] that has resulted in persistently negative glacier mass balances in the region [22,23].

The glacier recession in the Himalayan arc has not only impacted the streamflows but also resulted in the formation of proglacial lakes [24,25], which could be potential sites for occurrence of glacial lake outburst floods. Compared to other regions of high-mountain Asia, the glaciers in the Kashmir region are retreating at an accelerated pace [26]. The shrinking of the Himalayan cryosphere has been linked

Collaborative paper of Dr. Irfan Rashid with Prof. Markus Stoffel, University of Geneva, Switzerland [https://c-cia.ch/team-members/markus-stoffel/] and Sonam Lotus, India Meteorological Department [https://www.moes.gov.in/sites/default/files/Sonum_Lotus_0_0.pdf] published in Sustainability [**IF-3.3**]

sustainability

MDPI

Article

Impacts of Erratic Snowfall on Apple Orchards in Kashmir Valley, India

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Abstract: Kashmir Valley has been witnessing erratic snowfall events in recent autumns which severely impacted apple orchards and harvests. Here, we combine remotely sensed data and field observations to map snowfall distribution and snow depths during the recent snowfall events in November 2018 and November 2019. Besides, we used ERA-5 reanalysis climate datasets to investigate the causes of these erratic snowfall events, pointing to an early arrival of Western Disturbances (WD) to the area. Analysis of these untimely snowfall episodes indicates that snow depths varied from 5–122 cm and 31–152 cm during the 2018 and 2019 snowfall events, respectively. In turn, satellite data analysis reveals that the apple orchards cover roughly 9.8% (1329 km^2) of the entire surface of Kashmir Valley, out of which 32.6% were mildly to severely damaged by snow. The areas in South Kashmir suffered the most from the untimely snowfall with an area affected estimated to ~264 km^2, followed by North Kashmir (~151 km^2) and Central Kashmir (18 km^2). The snowfall caused substantial harvest losses in orchards ranging from 4–50% with an average of ~35%. The geopotential analysis from the ERA-5 dataset provides insights into the synoptic weather patterns leading to the snowfall events and point to a trough in the high-troposphere (200 mb), along with a col at lower levels (850 mb) over the Kashmir Valley from November 2–5, 2018. The lower levels (850 mb) experienced intense cyclonic circulation which favored advection of moisture from the Arabian Sea during the November 6–7, 2019, snowfall event. The large economic losses related to early arrival of WD led to a virtual grounding of the horticultural sector in 2018 and 2019. Therefore, more baseline research is critically needed along with a comprehensive evaluation of the suitability of horticulture as an economically viable sector that is being promoted over the Kashmir region, also under climate change.

Keywords: snowfall variability; western disturbances; erratic snow precipitation; Kashmir Himalaya; horticulture

1. Introduction

The Himalayan region constitutes one of the most vulnerable areas as it suffers from extreme weather events under present climate conditions and also in light of climate projections [1]. Over the

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Science

RESEARCH ARTICLES

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A massive rock and ice avalanche caused the 2021 disaster at Chamoli, Indian Himalaya

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On 7 Feb 2021, a catastrophic mass flow descended the Ronti Gad, Rishiganga, and Dhauliganga valleys in Chamoli, Uttarakhand, India, causing widespread devastation and severely damaging two hydropower projects. Over 200 people were killed or are missing. Our analysis of satellite imagery, seismic records, numerical model results, and eyewitness videos reveals that ~27x10^6 m^3 of rock and glacier ice collapsed from the steep north face of Ronti Peak. The rock and ice avalanche rapidly transformed into an extraordinarily large and mobile debris flow that transported boulders >20 m in diameter, and scoured the valley walls up to 220 m above the valley floor. The intersection of the hazard cascade with downvalley infrastructure resulted in a disaster, which highlights key questions about adequate monitoring and sustainable development in the Himalaya as well as other remote, high-mountain environments.

Steep slopes, high topographic relief, and seismic activity make mountain regions prone to extremely destructive mass movements [for example, (*1*)]. The sensitivity of glaciers and permafrost to climate changes is exacerbating these hazards [for example, (*2–7*)]. Hazard cascades, where an initial event causes a downstream chain reaction [for example, (*8*)], can

Collaborative paper between University of Kashmir and Dr. B. K. Sahoo, BARC Mumbai [https://scholar.google.com/citations?user=BuZe8ZYAAAAJ&hl=en] published in Environmental Geochemistry and Health [**IF-3.2**]

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ORIGINAL PAPER

Dose estimation of radioactivity in groundwater of Srinagar City, Northwest Himalaya, employing fluorimetric and scintillation techniques

Salik Nazir · Shakeel Simnani · B. K. Sahoo · Irfan Rashid · Sajad Masood

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Abstract The research is a maiden study aimed to assess the radioactivity in groundwater of Srinagar City using uranium and radon as proxies. In this study, 60 water samples were collected from various water sources that include bore wells, hand pumps and lakes of Srinagar City. Among them, 45 samples were taken from groundwater with depths ranging from 6 to − 126 m and the rest of the 15 samples were collected from surface sources like lakes, rivers and tap water. A gamma radiation survey of the area was carried out prior to collection of water samples, using a gamma radiation detector. A scintillation-based detector was utilized to measure radon, while as LED fluorimetry was employed to assess uranium in water samples. The average uranium concentration was found to be 2.63 $\mu g\ L^{-1}$ with a maximum value of 15.28 $\mu g\ L^{-1}$ which is less than the globally accepted permissible level of 30 $\mu g\ L^{-1}$. ^{222}Radon concentration varied from 0.2 to 38.5 Bq L^{-1} with an average value of 8.9 Bq L^{-1}. The radon concentration in 19 groundwater samples (32% of total sites) exceeded the permissible limits of 11 Bq L^{-1} set by USEPA. This information could be of vital importance to health professionals in Kashmir who are researching on the incidence of lung cancers in the region given the fact that radon is the second leading cause of lung cancers after smoking worldwide.

Keywords Groundwater quality · Srinagar City · ^{222}Rn detection · Uranium activity

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Introduction

Among the natural contaminants to drinking water, there are some radioactive elements such as uranium and radon, the activity concentrations of which depend upon the geological, physical and chemical nature of the aquifer (Jobbágy et al. 2010; Porcelli 2003). Uranium is a naturally occurring radioactive element, which decays to radon through the radioactive decay of radium. Uranium can be found in different types of rocks such as granites, dark shales, sandstones apart from other sedimentary rocks that contain phosphate, and metamorphic rocks derived from these rocks (Bottrell 1993; Carvalho et al. 2007; Gundersen et al. 2016; Lawrence et al. 1991; Tayyeb et al. 1998).

Collaborative paper between University of Kashmirm and Dr. B. K. Sahoo, BARC Mumbai [https://scholar.google.com/citations?user=BuZe8ZYAAAAJ&hl=en] and SKIMS, Kashmir published in Journal of Radioanalytical & Nuclear Chemistry [**IF-1.5**]

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Radon mapping in groundwater and indoor environs of Budgam, Jammu and Kashmir

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Abstract

Radiation exposure, an inescapable share of our everyday life, primarily arises from terrestrial or cosmic sources. A small fragment of the total dose is also contributed by our own bodies. Humans receive an average radiation of 2.4 mSv y^{-1} as natural background radiation. In the present study, an attempt to quantify groundwater radon-222 and indoor radon, thoron and their progeny was made using both active as well as passive techniques. Solid state nuclear track detectors (LR-115 type-II films) were employed for long-term passive measurements while as scintillation based radon monitor was used for active short-term measurements.

Keywords Indoor ^{222}Rn · Indoor ^{220}Rn · Groundwater · SSNTDs · Lung-cancer · Budgam

Introduction

Inhalation dose due to radon (^{222}Rn), thoron and their decay products is the major contributor (~50%) to the total background radiation dose to the populace. It is considered as the second most leading cause of lung cancer next to smoking [1, 2]. Radon (^{222}Rn) and thoron (^{220}Rn) are naturally occurring radioactive gases which are continuously produced in rocks and soil grains due to the radioactive decay of ^{226}Ra and ^{224}Ra, respectively. These gases migrate from rocks and soil grains to environment by two fundamental processes. The first being the *emanation* and the second is *exhalation* from the matrix through different transport processes [3, 4]. In emanation, the radon atoms escape from the solid mineral grains to the air-filled pores while as in exhalation, the radon gas is transported from air-filled pores to the atmosphere. Radon transport in soil pores is mainly governed by two processes-*diffusion* (brought out by concentration gradient) and *advection* (brought out by pressure driven flow of radon gas from the soil) [4, 5]. Depending upon the geological formation of the rock and its radioactivity content, the exhalation rate of radon from ground may vary from place to place [6]. Radon tends to accumulate in closed domains like indoor areas of dwellings, office buildings and caves. This accumulation is attributed to poor ventilation indoors in comparison to outdoors [7]. Since radon, thoron and their decay products in residential buildings contribute significantly to the total dose to populace, epidemiological investigation and monitoring of radon related lung cancer in residential buildings have received significant attention among researchers globally [8–14]. The reliability of epidemiological investigation is largely dependent upon the accuracy of inhalation dose data in studied dwellings, for which the method of measurement and dose estimation procedure should be extremely unwavering. Radon (^{222}Rn/^{220}Rn) being a gas, is easily removed from the respiratory tract during exhalation while as the decay products, being solid particles, are

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2022

Multi-institutional collaborative paper between Dr. Adam Emmer, University of Graz, Austria [https://profiles.ucalgary.ca/daniel-shugar] and 32 other instituters including University of Kashmir published in Natural Hazards and Earth System Science [**IF-4.2**]

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Natural Hazards and Earth System Sciences
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EGU

Progress and challenges in glacial lake outburst flood research (2017–2021): a research community perspective

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SPECIAL ISSUE ARTICLE

WILEY

Deciphering the source contribution of organic matter accumulation in an urban wetland ecosystem

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Abstract

A better understanding of the organic matter (OM) dynamics is a key to successful wetland management. We established the radiocarbon chronology (^{14}C) and vertical distribution of nitrogen (N), phosphorus (P), OM, and carbon to nitrogen ratio (C/N) in the sediment core retrieved from the Anchar Wetland, Kashmir Himalaya. The accelerator mass spectrometer (AMS) assisted ^{14}C dating of the sediment core showed ^{14}C age reversals related to occasional disturbances. The vertical distribution of various fractions revealed increased concentrations of organic carbon (OC), OM, and nutrients (N and P) in the upper part of the sediment core, largely related to increased anthropogenic inputs from the catchment areas during recent decades. Further, the low to high C/N ratio (1.3–36.4) suggests a combination of both the autochthonous and allochthonous inputs as the major contributors of OM to the wetland ecosystem. The linear regression model showed significant ($p < 0.05$) positive and negative relationships among various analyzed parameters. Principal component analysis (PCA) resulted in three principal components (PCs) accounting for a cumulative variance of 83.6%. The PCA suggests that the primary production, human activities such as extraction of Lotus stems (*Nadru*) and fishing, and terrestrial inputs (sewage disposal and fertilizer runoff) are the major factors controlling the distribution of organic fractions and nutrients. This study provides important insights into the sources and distribution of sedimentary OM and nutrients crucial for assessing the risks of pollution and for adopting the socially, politically, and scientifically robust strategies for the management of wetlands.

KEYWORDS
^{14}C dating, Anchar Wetland, C/N ratio, organic matter, wetlands

1 | INTRODUCTION

Sediments in wetlands act as an important archive of past environmental conditions (Hensel et al., 2021). Wetland sediments can offer a comprehensive picture of change to a large extent over a long period. Sediments are accumulated as autochthonous and allochthonous materials comprising soil particles, minerals, OM, air, water, and living biota (Adesuyi et al., 2016; Semeniuk & Semeniuk, 2004). Sediments are a natural medium that support the growth of aquatic plants, enhance biological productivity, and help in the cycling of nutrients (Cardoso et al., 2019; Kiani et al., 2021). Due to their dynamic nature and characteristics, sediments are essential components of wetland biogeochemistry, resulting in various biogeochemical transformations and reactions (de Vicente, 2021). Wetland sediments play a vital role by acting as natural buffers and reservoir pools by cycling and sequestering large amounts of atmospheric carbon dioxide (Avelar

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CSIRO PUBLISHING

SPECIAL ISSUE | RESEARCH PAPER
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Environmental Chemistry

Aerosol variability and glacial chemistry over the western Himalayas

Irfan Rashid[A,*], Imtiyaz Ahmad Bhat[A], Nadeem Ahmad Najar[A], Shichang Kang[B], Faisal Zahoor Jan[A], Shahid Ahmad Dar[C], Sami Ullah Bhat[C], Syed Danish Rafiq Kashani[A] and Waseem Rasool[A]

Environmental context. While it is known that aerosol deposition causes exacerbated melt of the glaciers, information about aerosol variability and deposition in the glaciated environments in the western Himalayas is still lacking. We analysed the aerosol variability, modelled the potential aerosol sources and assessed physicochemical characteristics of glacier ice in the region. This information could be foundational for initiating studies on aerosol impacts on the glacier melt besides climate change.

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ABSTRACT

Rationale. There is increasing scientific evidence of aerosol deposition triggering glacier melting but very little understanding about the spatiotemporal variability of aerosols over the Indian Himalayas. The current study is a maiden effort to ascertain the aerosol variability in glacial environments of the Indian Himalayas. Aerosol sources were modelled and physicochemical characteristics of glacial ice were evaluated to draw firsthand insights into the light-absorbing impurities over three glaciers. **Methodology.** Aerosol variability over four decades was analysed using MERRA-2 data (Modern-Era Retrospective analysis for Research and Applications) over five different topographically distinct mountain ranges of the western Himalayas. Information about nine physicochemical variables was analysed over the ablation zone of glaciers in the region. HYSPLIT model was used to track the air mass sources at a weekly time-step from December 2020 to November 2021 over the selected glaciers. **Results and discussion.** MERRA-2 data analyses indicate increasing trends in surface dust, columnar dust and black carbon. The highest columnar dust concentration was found in Pir Panjal Mountain Range (PP: 125 648 $\mu g\ m^{-2}$) followed by the Greater Himalayan Mountain Range of Kashmir (GH: 64 384 $\mu g\ m^{-2}$), Karakoram (KA: 47 574 $\mu g\ m^{-2}$), Ladakh (LA: 45 861 $\mu g\ m^{-2}$) and Zanskar (ZA: 38 416 $\mu g\ m^{-2}$), however, the black carbon indicated a PP > GH > LA > KA > ZA trend. HYSPLIT trajectories indicate that the contribution of global sources is highest (65%) followed by local (21%) and regional (14%) sources. Ice chemistry analysis revealed a higher concentration of total solid particles (830 $mg\ L^{-1}$) and sulfates (14.33 $mg\ L^{-1}$) indicative of the contribution from anthropogenic footprint and lithology. **Conclusion.** The research underpins the need for establishing long-term aerosol observatories and a detailed hydrochemical assessment for precisely ascertaining the black carbon and allied constituents to unravel their contribution to glacier melt in the north-western Himalayas.

Keywords: aerosol deposition, black carbon, dust, glacier melt, HYSPLIT model, physicochemical characterisation, reanalysis data, western Himalayas.

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Introduction

Solid particles and liquid droplets suspended in the air, collectively known as aerosols, can impact our environment significantly in many ways (Mhawish *et al.* 2018) that include climate (Koch *et al.* 2009; Mahowald *et al.* 2011), radiation budget (Haywood and Shine 1995; Lauer *et al.* 2007), snow and glaciers (Ramanathan *et al.* 2001; Xu *et al.* 2009; Kang *et al.* 2020; Sarangi *et al.* 2020) and human health (Landrigan 2017; Kinney 2018; Balakrishnan *et al.* 2019). Aerosols in the atmosphere originate from natural sources as well as anthropogenic activities (Seinfeld *et al.* 1998). The natural sources include wind-

2023:

Collaborative paper between Prof. RAAJ Ramsankaran, IIT Bombay and Dr. Irfan Rashid, University of Kashmir published in Journal of Earth System Science [**IF-1.3**]

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Kayak-based low-cost hydrographic surveying system: A demonstration in high altitude proglacial lake associated with Drang Drung Glacier, Zanskar Himalaya

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This study aims to demonstrate the capability of a low-cost echosounder for measuring the depths of high-altitude glacial lakes. A pilot survey was conducted in a shallow glacial lake associated with the Drang Drung glacier located in the Zanskar region of Ladakh, India. A bathymetric survey was carried out using Airmar P66 echosounder mounted on the inflatable Sea Eagle 380x Explorer kayak. From over 5000 data points, the maximum depth of glacial lake comes out to be 3.85 m with a mean depth of around 1.91 m. Depth estimates from the low-cost echosounder were in close agreement with manual measurements carried out at selected locations. The individual data points recorded by the echosounder were used to create 2D and 3D maps resulting in an estimation of the volume of water present in the glacial lake. Based on the collected points, the total volume of water present in the glacial lake comes out to be 0.18×10^6 m^3. To ensure the correctness and to check the consistency in the performance of low-cost echosounder in different environments, bathymetric surveys were conducted at three different water bodies. The depth estimates at all three different test sites obtained from the instrument showed accurate results. The obtained results signify that a low-cost and simple hydrographic surveying system such as the one adopted in this study provides reliable bathymetric measurements and is suitable for water volume estimation in logistically demanding highly altitude glacial lakes.

Keywords. Bathymetry survey; glacial lakes; low-cost echosounder; fishfinder; Drang Drung glacier.

1. Introduction

Bathymetric measurement of water bodies provides important information about the erosion rate, sedimentation rate, deposition of pollutants, and important morphological changes in rivers or lakes (Arseni *et al.* 2019). The bathymetric light detection and ranging (LIDAR) scanning technology is the most preferred method for data collection of depth measurements but does not provide accurate results

Supplementary material pertaining to this article is available on the *Journal of Earth System Science* website (http://www.ias.ac.in/Journals/Journal_of_Earth_System_Science).

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Environ Monit Assess (2023) 195:1139
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RESEARCH

Check for updates

Quantifying the landscape changes within and outside the Dachigam National Park, Kashmir Himalaya, India using observations and models

Sheikh Aneaus · Irfan Rashid · Prashant K. Srivastava · Samina Amin Charoo

Received: 23 May 2023 / Accepted: 3 August 2023 / Published online: 4 September 2023

Abstract Protected areas are the cornerstone of biodiversity and serve as a haven for biodiversity conservation. However, due to immense anthropic pressures and ongoing changes in climate, the protected reserves are under immense threat. Human interference through land system changes is a major precusor of fragmentation of landscapes resulting in the decline of Himalayan biodiversity. In this context, this research assessed land use land cover changes (LULCCs) and fragmentation within and outside the Dachigam National Park (DNP) using remote sensing data, GIS-based models and ground truth over the past 55 years (1965–2020). Landscape Fragmentation Tool (LFT) helped to compute edge effect, patchiness, perforation and core areas. The Land Change Modeller (LCM) of IDRISI TerrSet was used for simulating the future LULC for the years 2030, 2050, 2700 and 2100. The analysis of LULCCs showed that built-up and aquatic vegetation expanded by 326% and 174%, respectively in the vicinity of the DNP. The area under agriculture, scrub and pasture decreased primarily due to intensified land use activities. Within the DNP, the area under forest cover declined by 7%. A substantial decrease was observed in the core zone both within (39%) and outside (30%) the DNP indicative of fragmentation of natural habitats. LCM analysis projected 10% increase in the built-up extents besides forests, shrublands and pastures. This knowledge generated in this study shall form an important baseline for understanding and characterising the human-wildlife relationship, initiating long-term ecological research (LTER) on naturally vegetated and aquatic ecosystems (primarily Dal Lake) of the region.

Keywords Remote sensing · LULCC · Landscape fragmentation · LULC projections · Himalaya

Highlights
- LULCCs over six decades linked with fragmentation in the western Himalaya.
- Aquatic vegetation, built-up, forest and shrubland are projected to decrease in the vicinity of conservation reserve.
- Alpine pasture and exposed rock are projected to decrease within the conservation reserve.
- Fragmentation has implications on biodiversity richness, human-wildlife conflicts and earth surface processes.
- This baseline knowledge is useful for habitat modelling, human-wildlife relationships and climate impact studies.

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Collaborative paper between Dr. Argha Banerjee, IISER Pune, Dr. Chandan Sarangi, IIT Madras, Dr. Irfan Rashid, University of Kashmir, and Dr. Saurabh Vijay, IIT Roorkee published in Geophysical Research Letters [**IF-4.6**]

AGU ADVANCING EARTH AND SPACE SCIENCES

Geophysical Research Letters

RESEARCH LETTER

10.1029/2023GL104942

A Scaling Relation for Cryoconite Holes

Argha Banerjee[1,2], Chandan Sarangi[3], Irfan Rashid[4], Saurabh Vijay[5], Nadeem Ahmad Najar[4], and Amit Singh Chandel[3]

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Key Points:

- Effects of shortwave radiation on cryoconite holes modeled in three dimensions
- Under steady clear-sky conditions, cryoconite holes deepen up to a steady depth which scales with radius
- This depth-diameter scaling yields estimates of cryoconite-hole contribution to glacier mass balance

Supporting Information:

Supporting Information may be found in the online version of this article.

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Citation:

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Abstract Tiny cryoconite holes are commonly found on glacier surfaces. Despite a long history of research on them, their influence on glacier-scale mass balance and runoff are not well understood. We model the absorption of solar radiation at the bottom of cylindrical cryoconite holes, incorporating the three-dimensional geometry. The simulated holes achieve a limiting steady-state depth, where the daily melt rate at the bottom of the holes matches that at the glacier surface. This implies a feedback loop restricting the excess ice melt due to the presence of dark supraglacial impurities. The modeled steady-state depth scales approximately linearly with the radius, consistent with in situ observations at several glaciers across the world. Given the areal coverage and radius distribution of cryoconite holes on a glacier, this scaling yields first-order estimates of their melt contribution.

Plain Language Summary Dark particles deposited on glacier surfaces absorb more solar radiation than the surrounding ice, and melt into the surface to create approximately cylindrical holes with a layer of dark "cryoconite" substance at their bottom. Such cryoconite holes are commonly seen on glacier surfaces all over the world. These holes continue to deepen, reducing the exposure of the dark cryoconite to solar radiation, and eventually leading to a steady-state depth. We combine modeling and in situ observations to show that the steady depth is approximately proportional to the radius of the hole. This simple geometric property proves useful in estimating the net contribution of all the cryoconite holes present on a glacier to its mass balance and runoff. Our estimates suggest that these holes efficiently negate the melt-enhancing effects of the dark impurities on glacier surface.

1. Introduction

Cryoconite holes are ubiquitous on glacier surfaces across the globe (Cook, Edwards, et al., 2016; MacDonell & Fitzsimons, 2008). These approximately cylindrical melt holes form due to a higher absorption of incident solar radiation by the dark "cryoconite" substance trapped at their bottom. These holes are typically a few centimeters to a few tens of centimeters in radius, but larger holes are also observed (Fountain et al., 2004). It was argued that collectively cryoconite holes may contribute significantly to the glacier energy and mass balance, and to glacier runoff (Cook, Edwards, et al., 2016). These holes harbor cold-resistant microscopic lifeforms, and may be important for the carbon budget of glaciers (e.g., Chandler et al., 2015). However, a quantitative understanding of the glacier-scale collective effects of the tiny cryoconite holes, which are not resolved by coarse-scale glacier models (Cook, Edwards, et al., 2016), remains an open problem. This scale gap continues to obscure glacier-scale effects of cryoconite holes, despite a more than 150 years long history of research (Cook, Edwards, et al., 2016).

Theoretical consideration indicates that under stable, sunny weather conditions cryoconite holes deepen up to a steady-state depth (Fountain et al., 2004). This deepening due to a higher absorption of solar radiation at the dark (low-albedo) cryoconite disk, buries the cryoconite deeper into ice and away from the surface, causing a decline in the solar energy absorbed. This negative feedback ultimately stabilizes a steady-state hole geometry (Wharton et al., 1985), where the brighter ice surface and the darker bottom of the cryoconite hole both melt at the same rate. There are field observations that support this idea (Fountain et al., 2008). In contrast, higher turbulent heat fluxes on cloudy days may cause relatively higher melt at the surface, reducing the hole depth. This can cause the hole to collapse, spreading the cryoconite material on surrounding ice and enhancing melt (e.g., Takeuchi et al., 2018). Several additional factors complicate the evolution of cryoconite holes, for example, the cross-sectional geometry and its evolution, the presence of meltwater in them (Fountain et al., 2008; Podgorny & Grenfell, 1996), meltwater advecting heat in

Collaborative paper between Dr. Argha Banerjee, IISER Pune, Dr. Irfan Rashid, University of Kashmir, Dr. Jakob Steiner, ICIMOD Nepal/University of Graz, Austria and Dr. Saurabh Vijay, IIT Roorkee published in Natural Hazards [**IF-3.3]**

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ORIGINAL PAPER

Assessing potential risk of glacier avalanches to hydropower infrastructure in the Himalayan region

Sourav Laha[1,2] · Ulfat Majeed[3] · Argha Banerjee[2] · Irfan Rashid[3] · Jakob Steiner[4,5] · Saurabh Vijay[6]

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Abstract

A number of recent flash floods and debris flows, which were triggered by glacier avalanches from relatively small but steep hanging glaciers have exposed the vulnerability of infrastructures and livelihoods in the high Himalaya. As of now, there are no methods to identify potentially dangerous hanging glaciers in a catchment, and to assess the associated risk to any infrastructure. In this study, we propose a simple physics-based, probabilistic method to provide a first-order solution to this problem. It is based on considering a large number of hypothetical glacier avalanches and associated flood events within a numerically-efficient Monte-Carlo framework. We assign probability weights to the chain of events involved in any flood reaching a given dam location. To assess the relative risk, we test the method in three Himalayan catchments, including two where glacier avalanche events have been reported in the recent past. The proposed method is based on a series of simplifying assumptions regarding the initiation and propagation of the events, necessitated by the complexity of the processes involved and a lack of data in these remote environments. Our method performs reasonably well in two of the studied Himalayan catchments, while limitations in the performance of the method are apparent in one of the studied catchments. A better understanding of the underlying processes may help with more accurate parameterisations of the weights assigned to the chain of events. The presented method may be considered a starting point to quantify the risk posed by increasingly unstable ice on high and steep slopes to hydropower infrastructures in the Himalayan catchments.

Keywords Hanging glaciers · Glacier avalanche · Risk assessment · Himalaya

1 Introduction

Gravity-driven catastrophic mass flows involving rock-debris, snow, ice, and/or water are common in high-relief, steep, glacierised mountains (Evans and Delaney 2021) like the Himalaya. While phenomena like landslides (Vaidya et al. 2019), glacial lake outburst floods (Nie et al. 2021; Zheng et al. 2021), and snow/ice avalanches (Mehta et al. 2011; McClung 2016; Acharya et al. 2023) have received significant scientific attention in recent years, only a few studies have looked into glacier avalanches and associated mechanisms

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REVIEW ARTICLE

Recent Indian studies in Himalayan cryosphere

Rasik Ravindra[1] · Anil V. Kulkarni[2] · A. P. Dimri[3] · Kalachand Sain[4] · Milap C. Sharma[5] · Argha Banerjee[6] · Parmanand Sharma[1] · Thamban Meloth[1] · Irfan Rashid[7] · N. C. Pant[1,8]

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Abstract

Cryosphere all over the globe is thawing, be it the Arctic, Antarctic, Greenland or Himalaya. Studies have predicted that loss in the glacier mass over the Upper Indus Basin in Kashmir Himalaya would amount to 47 to 67% (Romshoo in 7th conference of Science and Geopolitics of Arctic and Antarctic, 2023). A similar trend prevails in the Bhaga basin of the Upper Chenab, where glaciers in size classes < 0.5 km^2 and 0.5^{-1} km^2 show a higher relative loss of 25% (0.5% $year^{-1}$) and 13% (0.3% $year^{-1}$) respectively (Das et al. in Quat Sci Rev 316:108258; J Mt Sci 20:299–324, 2023). The loss in Eastern Himalaya (Sikkim) has been reported to range from 20 to 30% (Debnath in 7th conference of Science and Geopolitics of Arctic and Antarctic, 2023). On the basis of the compiled records of snout fluctuations of 285 glaciers and two regional means spanning 17 decades from the 1850s, it has been deduced that most of the Himalayan glaciers are retreating, and the retreat rates have accelerated in the past few decades, but the observed tendencies are not regionally uniform (Kulkarni et al. in Water Security 14(6557):100101; J Indian Soc Remote Sensing 49(8):1951–1963, 2021). The excessive ice mass loss has resulted in the formation and/or expansion of glacial melt water lakes posing a threat of Glacial Lake Outburst Flow (GLOF). The results of the studies on the response of climatic variability over the state of cryosphere, the role of debris on the melting of glaciers, changes in the winter precipitation pattern and consequent impact on the hydrological cycle, water availability and state of permafrost over Himalaya have also been a focus of studies, including developing models (Banerjee et al. in Geophys Res Lett 49:096989, 2020), in contemporary publications, enriching the data on the fundamental aspects of glacial processes that are of great societal relevance.

Keywords Retreating glaciers · Glacial late outburst flow · Debris control · Mitigation measures

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Introduction

The Himalayan range, which extends over ~ 2400 km, constitutes the largest concentration of snow and ice after the two Polar Regions and is highly sensitive to the ongoing climate changes. The region feeds three major river basins namely: the Indus, the Ganga and the Brahmaputra Basins (Fig. 1) which in turn support a population of more than a billion people. Though there has been a large interest in studying the climatic variability over different parts of the cryospheric domain of the Himalaya, there still exists a wide gap in ground-based data as also the uncertainty in data on most aspects (Azam et al. 2021) such as the highly heterogeneous behaviour of glacial melting (Hugonnet et al. 2021). There is a negative balance in the eastern Himalaya, a relatively less negative mass balance in the western Himalaya and a in the Karakoram these are in balasnce. (Amir et al. 2018). Similarly, the estimates of snow cover and rainfall are also highly

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- Collaborative paper of Prof. Shakil Ahmad Romshoo with Prof. Yoshihide Wada, International Institute for Applied Systems Analysis, Schlossplatz 1, 2361 Laxenburg, Austria [https://iiasa.ac.at/], published in One Earth

[**IF-14.944**]

One Earth

Perspective

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Co-designing Indus Water-Energy-Land Futures

Yoshihide Wada,[1,*] Adriano Vinca,[1] Simon Parkinson,[1] Barbara A. Willaarts,[1] Piotr Magnuszewski,[1] Junko Mochizuki,[1] Beatriz Mayor,[1] Yaoping Wang,[1] Peter Burek,[1] Edward Byers,[1] Keywan Riahi,[1] Volker Krey,[1] Simon Langan,[1] Michiel van Dijk,[1] David Grey,[2] Astrid Hillers,[3] Robert Novak,[4] Abhijit Mukherjee,[5] Anindya Bhattacharya,[6] Saurabh Bhardwaj,[7] Shakil Ahmad Romshoo,[8] Simi Thambi,[9] Abubakr Muhammad,[10] Ansir Ilyas,[10] Asif Khan,[10] Bakhshal Khan Lashari,[11] Rasool Bux Mahar,[11] Rasul Ghulam,[12] Afreen Siddiqi,[13] James Wescoat,[14] Nithiyanandam Yogeswara,[15] Ather Ashraf,[16] Balwinder Singh Sidhu,[17] Jiang Tong,[18] and the rest of the ISWEL Indus Basin Team

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The Indus River Basin covers an area of around 1 million square kilometers and connects four countries: Afghanistan, China, India, and Pakistan. More than 300 million people depend to some extent on the basin's water, yet a growing population, increasing food and energy demands, climate change, and shifting monsoon patterns are exerting increasing pressure. Under these pressures, a "business as usual" (BAU) approach is no longer sustainable, and decision makers and wider stakeholders are calling for more integrated and inclusive development pathways that are in line with achieving the UN Sustainable Development Goals. Here, we propose an integrated nexus modeling framework co-designed with regional stakeholders from the four riparian countries of the Indus River Basin and discuss challenges and opportunities for developing transformation pathways for the basin's future.

Introduction

The mid-21st century will see the global population increase from 7.7 billion in 2019 to 8.5–10 billion in 2050.[1,2] Scientific evidence increasingly indicates that humanity has already reached or even exceeded the carrying capacity of several of the Earth's ecosystems[3] and that future populations will face a range of climatic hazards, including notable global "hotspots" exposed to varying levels of risks.[4–6] The magnitudes of such risks are critically dependent on regional adaptive capacity to prepare for and manage changing risks.[7] Growing needs for food, energy, and water will only exacerbate existing socio-economic challenges.[8–10] The world's poorest and most vulnerable are disproportionately exposed to climate change[11,12] and hydro-climatic variability.[13–17]

Improving and sustaining human welfare is not an easy task, particularly in regions expected to see continued population and economic growth in the future. Looking ahead to 2050, 50% more food production will be required globally (a larger increase is expected in developing countries[18,19]), and electricity generation is expected to double as we achieve universal access to energy.[20] With increasing energy and food demands on top of population growth, water demands will also rise by more than 50%, particularly in developing countries.[17,21] Greater land, energy, and water resource demands pose growing concerns given that such resource pressures have historically acted as conflict multipliers and have occasionally lead to social unrest. Transboundary river basins have often been at the center of such conflicts.[22] Given these alarming projections, a "business as usual" (BAU) development pathway is no longer seen as acceptable. Decision makers and wider stakeholders are increasingly calling for new, more integrated, and inclusive development pathways that avoid dangerous interference with the local environment and global planetary boundaries. These urgent calls are also embodied in global policy frameworks such as the United Nations' 17 Sustainable Development Goals (SDGs).

The Indus River Basin (hereafter referred to as the Indus) covers an area of around 1 million square kilometers and connects four countries: Afghanistan, China, India, and Pakistan. It is home to more than 300 million people, who depend upon

- Collaborative paper of Prof. Shakil Ahmad Romshoo with Gopalaswami Raghavan, Retired Advanced Systems and Technology Analyst, Formerly with DPSU, Government of India, Hyderabad, India[(17) Raghavan Gopalaswami (researchgate.net)], published in Open Journal of Earthquake Research [**IF-0.83**]

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Environmental Infrasound and Its Impact on Public Health in the Kashmir Region

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Abstract

In earlier published studies it was shown that an anomalous degree of human physiological ailments and a psychology of sustained anger and violence exist in highly populated countries located on boundaries of colliding Tectonic Plates in three continents at Latitude 34° north. The Valley of Kashmir in Northern India is also located exactly on this latitude, hence chosen for detailed experimental verification of this phenomenon. This region also suffers from chronic public health hazards. Infrasound is very low frequency acoustic wave with frequencies ranging from 0.01 Hz to 20 Hz. It emanates from earthquakes, geological Faults, colliding tectonic plates and atmospheric wind turbulence. Hearing protections like ear muffs and ear plugs offer little protection. One single earthquake can cause multiple infrasound sources in a region. It is shown how regional geomorphology in the Kashmir Valley enhances and sustains this phenomenon. Both the percentage of population with hearing disabilities; and casualties due to social violence increase or decrease in proportion to frequency of earthquakes. Infrasound is shown to be the causal linkage. Public health hazards due to environmental infrasound closely resemble public health hazards actually being suffered by the population in Kashmir as established by formal and extensive medical investigations. Hence a Field Study was carried out to locate and record infrasound emissions in ten locations near 34°N latitude in Kashmir Valley. An analytical technique was developed to integrate infrasound spectrum in specific locations with public health hazards. It was discovered that infrasound recorded in South Kashmir around 34°N latitude at the locations of highest amplitude lies in proximity of Active Faults from earthquake ruptures; and in proximity to a large field of past earthquakes that took place in 2006-2012. A comprehensive public health security system needs to be set up very urgently. Tech-

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- Collaborative paper of Prof. Shakil Ahmad Romshoo with Dr. T.K. Ramkumar, Sci.Engr-'SF' and Dr. V. Yesubabu, Sci.Engr-'SE', National Atmospheric Research Laboratory

India, [National Atmospheric Research Laboratory (narl.gov.in)] published in Atmospheic Chemistry and Physics [**IF-7.197**]

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Atmospheric Chemistry and Physics
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EGU

Analyses of temperature and precipitation in the Indian Jammu and Kashmir region for the 1980–2016 period: implications for remote influence and extreme events

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Abstract. The local weather and climate of the Himalayas are sensitive and interlinked with global-scale changes in climate, as the hydrology of this region is mainly governed by snow and glaciers. There are clear and strong indicators of climate change reported for the Himalayas, particularly the Jammu and Kashmir region situated in the western Himalayas. In this study, using observational data, detailed characteristics of long- and short-term as well as localized variations in temperature and precipitation are analyzed for these six meteorological stations, namely, Gulmarg, Pahalgam, Kokarnag, Qazigund, Kupwara and Srinagar during 1980–2016. All of these stations are located in Jammu and Kashmir, India. In addition to analysis of stations observations, we also utilized the dynamical downscaled simulations of WRF model and ERA-Interim (ERA-I) data for the study period. The annual and seasonal temperature and precipitation changes were analyzed by carrying out Mann–Kendall, linear regression, cumulative deviation and Student's t statistical tests. The results show an increase of 0.8 °C in average annual temperature over 37 years (from 1980 to 2016) with higher increase in maximum temperature (0.97 °C) compared to minimum temperature (0.76 °C). Analyses of annual mean temperature at all the stations reveal that the high-altitude stations of Pahalgam (1.13 °C) and Gulmarg (1.04 °C) exhibit a steep increase and statistically significant trends. The overall precipitation and temperature patterns in the valley show significant decreases and increases in the annual rainfall and temperature respectively. Seasonal analyses show significant increasing trends in the winter and spring temperatures at all stations, with prominent decreases in spring precipitation. In the present study, the observed long-term trends in temperature (°C $year^{-1}$) and precipitation (mm $year^{-1}$) along with their respective standard errors during 1980–2016 are as follows: (i) 0.05 (0.01) and −16.7 (6.3) for Gulmarg, (ii) 0.04 (0.01) and −6.6 (2.9) for Srinagar, (iii) 0.04 (0.01) and −0.69 (4.79) for Kokarnag, (iv) 0.04 (0.01) and −0.13 (3.95) for Pahalgam, (v) 0.034 (0.01) and −5.5 (3.6) for Kupwara, and (vi) 0.01 (0.01) and −7.96 (4.5) for Qazigund. The present study also reveals that variation in temperature and precipitation during winter (December–March) has a close association with the North Atlantic Oscillation (NAO). Further, the observed temperature data (monthly averaged data for 1980–2016) at all the stations show a good correlation of 0.86 with the results of WRF and therefore the model downscaled simulations are considered a valid scientific tool for the studies of climate change in this region. Though the correlation between WRF model and observed precipitation is significantly strong, the WRF model significantly underestimates the rainfall amount, which necessitates the need for the sensitivity study of the model using the various microphysical parameterization schemes. The potential vorticities in the upper troposphere are obtained from ERA-I over the Jammu and Kashmir region and indicate that the extreme weather event of September 2014 occurred due to breaking of intense atmospheric Rossby wave activity over Kashmir. As the wave could transport a large amount of water vapor from both the Bay of Bengal and Arabian Sea and dump them over the Kashmir region through wave breaking, it probably resulted in the historical devastating flooding of the whole Kashmir

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- Collaborative paper of Prof. Shakil Ahmad Romshoo with Dr. Majid Farooq, Scientist at J&K Climate Change Centre [http://www.jkdears.com/], Prof. Rohitashw Kumar**,** Associate Dean and Professor at Sher-e-Kashmir University of Agricultural Sciences and

Technology of Kashmir [https://skuastkashmir.irins.org/profile/228792], Dr. Gowhar Meraj, JSPS International Researcher at The University of Tokyo [Dr Gowhar Meraj - The Global Academy] published in *Proceedings* 2019 [**IF-**]

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Article

An Integrated Geoinformatics and Hydrological Modelling-Based Approach for Effective Flood Management in the Jhelum Basin, NW Himalaya †

Gowhar Meraj [1,2,*], Tanzeel Khan [3], Shakil A. Romshoo [4], Majid Farooq [1,2], Kumar Rohitashw [3] and Bashir Ahmad Sheikh [2]

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Published: 15 November 2018

Abstract: In the present study, using static land system parameters, such as geomorphology, land cover, and relief, we calculated the water yield potential (RP) of all the watersheds of the Jhelum basin (Kashmir Valley) using the analytical hierarchy process (AHP) based watershed evaluation model (AHP-WEM). The results revealed that among the 24 watersheds of the Jhelum basin, the Vishav watershed, with the highest RP, is the fastest water yielding catchment of the Jhelum basin followed by Bringi, Lidder, Kuthar, Sind, Madhumati, Rembiara, Sukhnag, Dal, Wular-II, Romshi, Sandran, Ferozpur, Viji-Dhakil, Ningal, Lower Jhelum, Pohru, Arin, Doodganga, Arapal, Anchar, Wular-I, Gundar, and Garzan in the case of a same intensity storm event. The results were validated with the mean annual peak discharge values of the watersheds and a strong positive correlation of 0.71 was found. Further, for the forecasting of the floods in the watersheds that had a small lag time, such as in the case of Vishaw, Bringi, and Lidder, we evaluated the performance of the HEC-GeoHMS hydrological model to simulate stream discharge during storm events. It was observed that the model performs well for August-September period with a strong positive correlation (0.94) between the observed and simulated discharge and hence could be used as a flood forecasting model for this period in the region.

Keywords: HEC-GeoHMS; AHP-WEM model; water yield potential; water yield; basin lag time; GIS

- Collaborative paper of Prof. Shakil Ahmad Romshoo with Dr. Anoop Mishra, SCIENTIST at India Meteorological Department, New Delhi, India [linkedin.com/in/dr-anoop-kumar-mishra-65919759], Dr. Mohammd Rafiq, Natural Resource Management Specialist at Ministry of Environment Forest & Climate Change (MoEF&CC), [**https://moef.gov.in/**] published in Journal of Mountain Science 2019 [**IF-2.371**]

Modelling Chorabari Lake outburst flood, Kedarnath, India

January 2019 · Journal of Mountain Science 16(1):64-74
DOI: 10.1007/s11629-018-4972-8

Mohammd Rafiq · Shakil Ahmad Romshoo · Anoop Mishra · Faizan Jalal

Abstract

In this study, the Glacier Lake Outburst Flood (GLOF) that occurred over Kedarnath in June 2013 was modeled using integrated observations from the field and Remote Sensing (RS). The lake breach parameters such as area, depth, breach, and height have been estimated from the field observations and Remote Sensing (RS) data. A number of modelling approaches, including Snow Melt Runoff Model (SRM), Modified Single Flow model (MSF), Watershed Management System (WMS), Simplified Dam Breach Model (SMPDBK) and BREACH were used to model the GLOF. Estimations from SRM produced a runoff of about 22.7 m 3 during 16-17, June 2013 over Chorabari Lake. Bathymetry data reported that the lake got filled to its maximum capacity (3822.7 m 3) due to excess discharge. Hydrograph obtained from the BREACH model revealed a peak discharge of about 1699 m 3/s during an intense water flow episode that lasted for 10-15 minutes on 17 th June 2013. Excess discharge from heavy rainfall and snowmelt into the lake increased its hydrostatic pressure and the lake breached cataclysmically.

2020:

- Collaborative paper of Prof. Shakil Ahmad Romshoo with Dr. Gowhar Meraj, JSPS International Researcher at The University of Tokyo [Dr Gowhar Meraj - The Global Academy] published in Environmental Monitoring and Assessment [**IF-3.307**]

Environ Monit Assess (2020) 192: 597
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Satellite-observed glacier recession in the Kashmir Himalaya, India, from 1980 to 2018

Shakil Ahmad Romshoo · Midhat Fayaz · Gowhar Meraj · I. M. Bahuguna

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Abstract The study, first of its kind in the Kashmir Valley, uses a time series of satellite data (1980–2018) to determine the glacier health, which is critical for sustaining the perenniality of the rivers originating from the area. The role of topography, morphology and climate on the observed glacier recession was investigated. In total, 147 glaciers were mapped from 1980 image; ~ 72% of the glaciers have area ≤ 3 km^2 and a majority of them (123) are having size < 1 km^2. The glaciers have reduced from 101.73 ± 16.79 km^2 in 1980 to 72.41 ± 4.7 km^2 in 2018 showing a recession of 29.32 ± 12.09 km^2 during the period (28.82%). The observed glacier loss is higher (0.77 ± 0.31 km^2 a^{-1}) compared with the other Himalayan regions. The results indicated that there is strong influence of altitude, aspect, slope and climate on glacier recession. The glaciers with area ≤ 1 km^2 have receded significantly more (41.20 ± 6.20%) than the larger glaciers > 3 km^2 in area (15.97 ± 5.13%). The glaciers situated between 4200 and 4400 m altitudes have receded more (~ 55 ± 5.01%) than those situated at altitudes > 4800 m (~ 19 ± 6.9%). Furthermore, the glaciers with steep slope (> 25) have witnessed lower recession (0.25 ± 0.15 km^2 a^{-1}) compared to the glaciers with gentle slope (0.51 ± 0.22 km^2 a^{-1}). The south-facing glaciers showed higher recession (~ 38%) compared with the north-facing glaciers (~ 27%). The findings suggest that the increase in temperature and decline in winter solid precipitation have resulted in the glacier recession with the consequent depletion of the streamflows, which, if continued in the future, would adversely affect the economy in the region.

Keywords Glacier recession · Remote sensing · Topographic parameters · Western Himalaya

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Introduction

Observed fluctuations of the mountain glaciers are regarded as the most reliable indicator of climate change (IPCC 2013), growing and wasting in response to the observed changes in temperature and precipitation (Oerlemans and Reichert 2000). Investigating the glacier fluctuations can reveal several aspects of climate change particularly in the Himalayas where there is a paucity of hydro-meteorological observatories (Mir et al. 2014; Karimi et al. 2014; Murtaza and Romshoo 2017). Glaciers in the high mountain Himalayas act as the natural reservoir of waters for the downstream regions (Gardner et al. 2013) and have tremendous socioeconomic and scientific importance (Romshoo 2012). The Kashmir Himalayan glaciers are vital source to the headwaters of the Indus basin and support irrigation, tourism, hydropower generation and other domestic uses of water (Dar et al. 2014; Muslim et al. 2015; Kaser et al. 2010). It has been reported that there is a significant increase in the annual T_{max} and T_{min} (Bhutiyani

- Collaborative paper of Prof. Shakil Ahmad Romshoo with Kln Sastry, Rtd. Scientist at Space Applications Centre SAC-ISRO, [linkedin.com/in/mr-k-l-n-sastry-aa17a543], Manish Parmar, Senior Scientist Space Applications Centre, ISRO [Space Applications Centre (SAC) (isro.gov.in)] published in Applied Geography [**IF-4.732**]

Integration of social, economic and environmental factors in GIS for land degradation vulnerability assessment in the Pir Panjal Himalaya, Kashmir, India

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Shakil Ahmad Romshoo · Muzamil Amin · Kln Sastry · Manish Parmar

Abstract

Land degradation assessment is imperative for developing a mitigation plan to minimize the adverse impacts associated with land degradation. The study involves the integration of various social, economic and environmental indices for identifying the land degradation vulnerable areas in the Pir Panjal Himalaya, Kashmir, India. Analysis of the land use and land cover from the satellite data revealed that ~47% of the area is devoid of any vegetal cover. Slope index revealed that ~40% of the study area is precipitous with slope >30%. The land utilization index indicated that ~51% of the area is over-utilized. Integration of all the environmental indices in GIS environment yielded the Natural Resource Prioritization Index which revealed that ~41% of the area needs attention for land degradation mitigation on top priority. Integration of all the socioeconomic indices yielded the SocioEconomic Priority Zones which revealed that ~35% of the area needs attention for the socioeconomic upliftment on priority for combating the land degradation in the study area. Land Degradation Vulnerability Index (LDVI) model was developed in GIS environment based on the unique combination of various natural resource and socioeconomic priority zones using the weighted index approach to assess the cumulative impact of social, economic and environmental factors on land degradation. The model analyses revealed that ~48% of the study area (~603 Km 2) shows high to very high LDVI values alluding to its high vulnerability to different forms of land degradation. The approach developed in this research for the integration of various ca... Read more

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Vihar University Jaipur, India [linkedin.com/in/dr-suraj-kumar-singh-479bb1264], Dr. Shruti Kanga Associate Professor, Central University of Punjab[**https://cup.edu.in/dr_shruti_kanga.php**], Prof. Mahendra Singh Nathawat, Professor of Geography (School of Sciences) at Indira Gandhi National Open University (IGNOU) [linkedin.com/in/mahendra-singh-nathawat-27b7b718], Dr. Gowhar Meraj, JSPS International Researcher at The University of Tokyo [Dr Gowhar Meraj - The Global Academy] published in Environment, Development and Sustainability [**IF-4.080]**

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CASE STUDY

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Coronavirus pandemic versus temperature in the context of Indian subcontinent: a preliminary statistical analysis

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Abstract

The novel coronavirus (COVID-19) has unleashed havoc across different countries and was declared a pandemic by the World Health Organization. Since certain evidences indicate a direct relationship of various viruses with the weather (temperature in particular), the same is being speculated about COVID-19; however, it is still under investigation as the pandemic is advancing the world over. In this study, we tried to analyze the spread of COVID-19 in the Indian subcontinent with respect to the local temperature regimes from March 9, 2020, to May 27, 2020. To establish the relation between COVID-19 and temperature in India, three different ecogeographical regions having significant temperature differences were taken into consideration for the analysis. We observed that except Maharashtra, Rajasthan and Kashmir showed a significantly positive correlation between the number of COVID-19 cases and the temperature during the period of study. The evidences based on the results presented in this research lead us to believe that the increasing temperature is beneficial to the COVID-19 spread, and the cases are going to rise further with the increasing temperature over India. We, therefore, conclude that the existing data, though limited, suggest that the spread of COVID-19 in India is not explained by the variation of temperature alone and is most likely driven by a host of other factors related to epidemiology, socioeconomics and other climatic factors. Based on the results, it is suggested that temperature should not be considered as a yardstick for planning intervention strategies for controlling the COVID-19 pandemic.

Keywords COVID-19 · Temperature · India · Kashmir · Remote sensing · SPSS-IBM · Correlation

1 Introduction

World Health Organization (WHO), on March 11, 2020, declared COVID-19 as a pandemic (WHO 2020). The novel coronavirus (2019-nCoV) disease first appeared in Wuhan city of China and laid down its global footprints since 2019 as a result of its highly

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- Collaborative paper of Prof. Shakil Ahmad Romshoo with Prof Gufran Beig, Chair Professor @ NIAS (IISc) and Founder Project Director, SAFAR [http://safar.tropmet.res.in] published in Science of the Total Environment [**IF-10.753**]

Particulate pollution over an urban Himalayan site: Temporal variability, impact of meteorology and potential source regions

August 2021 · The Science of The Total Environme... 799(149364)
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Lab: G. Beig's Lab

Shakil Ahmad Romshoo · Mudasir Bhat · G. Beig

Abstract

Five-year (2013–2017) particulate matter (PM) data observed at an urban site, Srinagar, Kashmir Himalaya, India was used to examine the temporal variability, meteorological impacts and potential source regions of PM. The daily mean PM10 and PM2.5 concentration was 135 ± 112 µg/m3 and 87 ± 93 µg/m3 respectively with significant intra- and inter-daily variation. The annual PM10 and PM2.5 concentration was 2.0–3.2 and 1.7–2.8 times higher than the annual Indian National Ambient Air Quality Standards (PM10 = 60 µg/m3 and PM2.5 = 40 µg/m3). PM concentration shows a bimodal diurnal pattern with morning and evening peaks, which coincide with the increased anthropogenic activity and shallow planetary boundary layer (PBL). The combined effect of the low temperature, low wind speed, shallow and stable PBL and geomorphic setup of Kashmir valley leads to the accumulation of particulate pollution during autumn and winter and the converse meteorological conditions leads to dispersion, dilution and deposition during spring and summer. High precipitation rate (>15 mm/day) removes the coarse particles (PM10) more efficiently than fine particles (PM2.5), while as the moderate to high humid conditions (55–95%) leads to the accumulation and growth of more PM. It was observed that ~80% of the air masses arriving at the site during spring, autumn and winter are westerlies. Source contribution analysis revealed that highly potential source regions of PM at the site are neighboring Pakistan, Afghanistan, parts of Iran and Trans-Gangetic Plains, which could contribute high concentration of the P ... Read more

- Collaborative paper of Prof. Shakil Ahmad Romshoo with Prof Gufran Beig, Chair Professor @ NIAS (IISc) and Founder Project Director,

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Measurement and Modelling of Particulate Pollution over Kashmir Himalaya, India

Mudasir Ahmad Bhat · Shakil Ahmad Romshoo · Gufran Beig

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Abstract Ground and satellite measurements of particulate pollution play an important role in determining the particulate pollutant-Aerosol Optical Depth (AOD) relationship. The daily observed PM_{10} and $PM_{2.5}$ concentration varied from 11–757 μg/m^3 and 8–630 μg/m^3 with the mean concentrations of 137 ± 119 μg/m^3 and 86 ± 90 μg/m^3, respectively. The long-term mean annual PM_{10} and $PM_{2.5}$ levels are several times higher than the WHO permissible limits. The 1377 satellite-derived AOD observations from the Moderate Resolution Imaging Spectrometer, ground-based particulate matter (PM) and meteorological observations from 2013–2017 were analysed to develop two-variate linear model (TVM) (AOD versus PM_{10} or $PM_{2.5}$) and multi-variate regression models (MVMs) (AOD + meteorological parameters versus PM_{10} or $PM_{2.5}$) for estimation of the ground level PM_{10} and $PM_{2.5}$ in the Kashmir Himalaya, India. The model evaluation showed that the PM prediction estimates are significant at 99% confidence level for all the models. The TVM predicts daily PM_{10} concentration better than $PM_{2.5}$ explaining 82% and 74% variance in the observed data, respectively. By adding meteorological data to the regression analysis, there is an improvement of 5% and 11% in R^2 for PM_{10} and $PM_{2.5}$ estimates which inter alia reduced the RMSE by 11.8% and 20.47%, respectively. Estimation of the particulate pollution, utilising satellite-based AOD, observed PM and meteorology, would encourage satellite-based air quality monitoring in the data-scarce Himalaya. However, it is suggested that more studies are required to improve the operational prediction of PM pollution by incorporating satellite observations of other pollutants, and processes in the model using advanced approaches.

Keywords MODIS · Aerosol optical depth · Meteorology · PM_{10} · $PM_{2.5}$ · Himalaya

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1 Introduction

Particulate pollution is reported as one of the major health risks all over the globe as most of the world's population lives in the areas with unhealthy concentration of particulate matter (HEI, 2019; Kumar et al., 2019). Developing countries constitute about 80% of the global population and particulate pollution accounts for about 90% of the premature deaths and nonfatal diseases each year in these countries (WHO, 2016). In 2017, 92% of the world's population lived in areas that exceeded the WHO limits for PM (HEI, 2019). In the developing world, a huge amount of particulate matter is emitted from different sources like vehicle emissions, coal-burning, power plants, industrial emissions, biomass burning and many other human and natural sources which leads to the higher exposure level of the populace to the particulate pollution (Gurjar et al., 2010;

- Collaborative paper of Prof. Shakil Ahmad Romshoo with Pankaj Kumar, Scientist F at National Geochronology Facility, IUAC Delhi [Kumar Pankaj | Inter-University Accelerator Centre (IUAC)], published in Geoscience Frontiers [**IF-7.483**]

Paleo-glacial reconstruction of the Thajwas Glacier in the Kashmir Himalaya using Be cosmogenic radionuclide dating

July 2022 · Geoscience Frontiers
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Lab: Pankaj Kumar's Lab

Omar Jaan Paul · Shakil Ahmad Romshoo · Reyaz Ahmad Dar · Show all 6 authors · Sundeep Chopra

Abstract

Quantitative glacial chronologies of past glaciations are sparse in the Himalaya, and mostly absent in the Kashmir Himalaya. We used cosmogenic 10Be exposure dating, and geomorphological mapping to reconstruct glacial advances of the Thajwas Glacier (TG) in the Great Himalayan Range of the Kashmir Himalaya. From 10Be exposure dating of ten moraine boulders, four glacial stages with ages ~20.77 ± 2.28 Ka, ~11.46 ±1.69 Ka, ~9.12 ±1.39 Ka and ~4.19 ±0.78 Ka, were identified. The reconstructed cosmogenic radionuclide ages confirmed the global Last Glacial Maximum (gLGM), Younger Dryas, Early Holocene, and Neoglaciation episodes. As per area and volume change analyses, the TG has lost 51.1 km2 of its area and a volume of 2.64 km3 during the last 20.77± 2.28 Ka. Overall, the results suggested that the TG has lost 64% of area and 73% of volume from the Last glacial maximum to Neoglaciation and about 85.74% and 87.67% of s area and volume, respectively, from Neoglaciation to the present day. The equilibrium line altitude of the TG fluctuated from 4238 m a.s.l present to 3365 m a.s.l during the gLGM (20.77± 2.28 Ka). The significant cooling induced by a drop in mean ambient temperature resulted in a positive mass balance of the TG during the gLGM. Subsequently the melting accelerated due to the continuing rise of the global ambient temperature. Paleo-glacial history reconstruction of the Kashmir Himalaya, with its specific geomorphic and climatic environment, would help close the knowledge gap about the chronology of past regional glacial episodes.

- Collaborative paper of Prof. Shakil Ahmad Romshoo with I. M. Bahuguna, Space Application Centre, Ahmedabad, [], published in Cold Region Science and Technology [**IF-4.427**]

Article

Explaining the differential response of glaciers across different mountain ranges in the north-western Himalaya, India

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DOI: 10.1016/j.coldregions.2022.103515
Lab: Himalayan Cryospheric Research Lab

Shakil Ahmad Romshoo · Tariq Abdullah · Irfan Rashid · I. M. Bahuguna

Abstract

The study investigated a group of 65 glaciers, selected from different mountain ranges in the north-western Himalaya, India to understand and explain their status and response to the changing climate, surface topography and glacier morphology. Two-date Landsat satellite images (1990 and 2014), ICESat altimetry data, HMA DEM and SRTM DEM were used to estimate the changes in glacier area, snout position, Equilibrium Line Altitude (ELA), glacier thickness and volume. The total area of the glaciers under consideration across the five ranges shrunk from 1106 ± 33.6 km^2 in 1990 to 1073 ± 24.6 km^2 in 2014 with the consequent reduction in the glacier volume from 219 ± 6.66 km^3 in 1990 to 211 ± 4.85 km^3 in 2014, a loss of 5.9 ± 0.09 Gt during 24-year observation period. Upward shift in ELA, ranging from 18 ± 17 m to 64 ± 17 m, was observed during the o period. The glaciers across the study area are losing thickness in the range of −0.59 ± 0.22–1.18 ± 0.40 m a^{-1}. The study revealed that the glaciers situated at altitudes <4500 m have witnessed higher glacier area loss (8.25 ± 1.3%) compared to those situated at altitudes >6000 m (2.72 ± 0.92%). The influence of size on glacier loss is indicated by the higher glacier shrinkage observed for the glaciers <3 km^2 in size (6.75 ± 1.63%) compared to the lower shrinkage of 2.17 ± 1.12% observed for the large-size glaciers (>30 km^2). Significant differences in the glacier response were observed across the five ranges due to the unique topographic and climatic setting endemic to a particular mountain range.

- Collaborative paper of Prof. Shakil Ahmad Romshoo with Prof Gufran Beig, Chair Professor @ NIAS (IISc) and Founder Project Director, SAFAR [http://safar.tropmet.res.in] published in Environmental Pollution [**IF-9.988**]

Characteristics, source apportionment and long-range transport of black carbon at a high-altitude urban centre in the Kashmir valley, North-western Himalaya

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Lab: G. Beig's Lab

Mudasir Bhat · Shakil Ahmad Romshoo · G. Beig

Abstract

Six years of data (2012–2017) at an urban site-Srinagar in the Northwest Himalaya were used to investigate temporal variability, meteorological influences, source apportionment and potential source regions of BC. The daily BC concentration varies from 0.56 to 40.16 μg/m³ with an inter-annual variation of 4.20–7.04 μg/m³ and is higher than majority of the Himalayan urban locations. High mean annual BC concentration (6.06 μg/m³) is attributed to the high BC observations during winter (8.60 μg/m³) and autumn (8.31 μg/m³) with a major contribution from Nov (13.88 μg/m³) to Dec (13.4 μg/m³). A considerable inter-month and inter-seasonal BC variability was observed owing to the large changes in synoptic meteorology. Low BC concentrations were observed in spring and summer (3.14 μg/m³ and 3.21 μg/m³), corresponding to high minimum temperatures (6.6 °C and 15.7 °C), wind speed (2.4 and 1.6 m/s), ventilation coefficient (2262 and 2616 m²/s), precipitation (316.7 mm and 173.3 mm) and low relative humidity (68% and 62%). However, during late autumn and winter, frequent temperature inversions, shallow PBL (173–1042 m), stagnant and dry weather conditions cause BC to accumulate in the valley. Through the observation period, two predominant diurnal BC peaks were observed at ~9:00 h (7.75 μg/m³) and ~21:00 h (6.67 μg/m³). Morning peak concentration in autumn (11.28 μg/m³) is ~2–2.5 times greater than spring (4.32 μg/m³) and summer (5.23 μg/m³), owing to the emission source peaks and diurnal boundary layer height. Diurnal BC concentration during autumn and winter is 65% and 60% ... Read more