Shashank Bhushan

More Hall, Room 201, Box 352700
Seattle, WA USA 98195
+1 206-788-7059
sbaglapl@uw.edu

Education

2023 **Ph.D. in Civil and Environmental Engineering with Data Science Option**, *University of Washington Seattle, USA*, *GPA- 3.89/4*,
Thesis:- *Using high-resolution imaging satellite constellations to understand glacier mass balance and dynamics in High-Mountain Asia*.
Committee:- Dr. David Shean (Chair), Dr. Michelle Koutnik (GSR), Dr. Jesicca Lundquist, Dr. Scott Henderson, Dr. David Rounce

2018 **5 Yr. Int. MSc. Tech. in Applied Geology**, *IIT(ISM) Dhanbad,India*, *GPA- 9.13/10*,
Thesis:- *Investigating mass budget and surface dynamics of Himalayan Glaciers*.
Advisor:- Dr. Tajdarul Syed

Professional Research Experience

Aug 2023 – present **Postdoctoral Scholar,** Department of Civil & Environmental Engineering, University of Washington, Seattle, USA.
Supervisor:- Dr. David Shean.

- *Develop an imaging susbsystem concept and associated software for future NASA Surface Topography and Vegetation (STV) mission (funded by NASA STV).*
- *Improve stereo processing and elevation retrieval accuracy for currently on-orbit satellite missions (funded by NASA STV).*
- *Develop new satellite observation techniques and enhance our ability to characterize changes in the Earth's Cryosphere and Hydrosphere (funded by NASA HiMAT-2).*
- *Contribute to defining limitations in current satellite missions and proposing accuracy requirements and needs for topography retrieval in future missions (funded by NASA STV).*
- *Develop interactive tutorials on Geodesy and photogrammetry processing using Github code space (funded by NASA OSTFL).*

Sep 2018 – June 2023 **Graduate Research Assistant,** Department of Civil and Environmental Engineering, University of Washington, Seattle, USA. Advisor:- Dr. David Shean.

- *Lead on successful NASA proposal for PhD fellowship.*
- *Major contributions to 4 NASA proposals (2 funded in full, 1 partially funded, 1 declined).*
- *Developed methods to resolve processes controlling surface mass balance of debris-covered glaciers using remotely sensed observations. (NASA FINESST, NASA HiMAT-2)*
- *Developed methods to compute and analyse glacier velocity time series estimates from Planet Cubesat derived high resolution optical imagery. (NASA FINESST, NASA HiMAT-2)*
- *Co-lead experiments (with UW CEE PhD student Michelle Hu) to determine controls (e.g., acquisition geometry, image resolution, processing choices) on stereo derived DEM accuracy. (NASA Stereo2SWE, NASA FINESST)*
- *Contributor to student led glacier velocity inter-comparison project. (NASA FINESST)*
- *Member of IGE Grenoble-UW team which contributed to the RAGMAC glacier mass balance inter-comparison experiment. (NASA FINESST)*
- *Lead UW efforts for geodetic analysis of Chamoli disaster in India. (NASA FINESST)*
- *Led efforts for development of photogrammetry/DEM generation workflows from Planet imagery (Skysat and PlanetScope) (NASA Commercial Data Buy, NASA Stereo2SWE, NASA FINESST)*
- *Developed and evaluated rigorous error estimates for regional scale geodetic glacier mass balance calculations. (NASA HiMAT/NASA FINESST)*
- *Assisted in implementing and testing of stereo workflow for high-resolution ($\sim$ 0.5 m) panoramic (optical bar) cameras on board declassified US spy satellites. (NASA AIST)*

Jun – Sep 2020 **Photogrammetry Intern,** Data Pipeline, Planet, San Francisco, USA.
Advisors:- Dr. Kelsey Jordahl, Antonio Martos.

- *Developed an automated, dockerized pipeline for DEM production from SkySat imagery on Google Cloud.*
- *Assisted in time-sensitive SkySat tasking.*
- *Led and assisted experiments involving photogrammetry with Planet data, participated in global reference DEM evaluation project for L3B orthorectified product generation.*

May – July 2017 **Research Intern,** Applied Physics Lab, University of Washington, Seattle, USA.
Advisors:-Dr. Anthony Arendt, Dr. David Shean.

- *Utilised high resolution WorldView/GeoEye and Cartosat-1 DEMs to produce elevation change and mass budget estimates for glaciers in Sikkim Himalayas as a part of the NASA High-Mountain Asia Project.*
- *Mapped glacial lakes in the region and computed multi-annual surface velocities for glaciers in the region.*
- *During this internship, I started learning Python coding and gained familiarity with open-source data science and geospatial libraries.*

May – July 2015 & 2016 **Summer Intern,** Divecha Center for Climate Change, Indian Institute of Science, Bangalore, India
Advisor:-Dr. Anil Kulkarni.

- *Performed a case study to estimate glacier mass budget and surface velocity of Gangotri Glacier using DEM differencing and optical image feature tracking techniques respectively.*
- *We inverted for Gangotri Glacier's ice thickness using the derived surface velocity and DEM slope maps. The ice thickness data was utilised to map bed overdeepenings, which could serve as sites for future glacier lakes as the glacier retreats.*
- *The internship in 2015 served as my first introduction to remote sensing and glaciology. I learnt techniques to map glaciers from optical imagery. I also learnt to operate COSSI-CORR software for deriving glacier velocity from repeat optical imagery.*

Achievements/Awards

AAG 2022 Grove Karl Gilbert Award for Excellence in Geomorphological Research by American Association of Geographers. Recognition for Shugar et al. (2021) Science paper on Chamoli disaster.

NASA Future Investigators in NASA Earth and Space Science and Technology [NASA FINESST (2019-2022)].

UW Top 1% Merit-Graduate/Fee Exempt Waiver by the University of Washington Graduate School (2019-2022).

AGU AGU Student Travel Grant to attend the 2017 AGU Fall Meeting, AGU Student Endowment Fund.

S N Bose Fellowship Awarded the prestigious SN Bose Fellowship by the Indo-US Science and Technology Forum to conduct research at the University of Washington, Seattle during the summer of 2017.

AAPG AAPG L. Austin Weeks Undergraduate Grant recipient for the academic years 2016 and 2017.

EAGE Travel Grant to attend the 78th EAGE Conference and Exhibition, EAGE Student Fund.

INSPIRE Recipient of Scholarship for Higher Education (SHE)-INSPIRE from DST, Govt. of India (2013-2018).

IAS SRFP Summer Research Fellowship, Indian Academy of Sciences, 2015.

IIT JEE Advanced Top 1 percentile out of 1.5 million students in Joint Entrance Exam, Advanced 2013.

Peer Reviewed Journal Articles

Sep 2023 Zheng W., **Bhushan S.**, Van Wyk de Vries M., Kochtitzky W., Shean D., Copland L., Dow C. and Pérez F. ***"GLAcier Feature Tracking testkit (GLAFT): A statistically- and physically-based framework for evaluating glacier velocity products derived from satellite image feature tracking"*** The Cryosphere (***accepted***) `https://doi.org/10.5194/tc-2023-38`.

Apr 2023 Scheick J., Leong W.J., Bisson K., Arendt A., **Bhushan S**., Fair Z. and 11 others, ***"icepyx: querying, obtaining, analyzing, and manipulating ICESat-2 datasets"*** in the Journal of Open Source Software. `https://doi.org/10.21105/joss.04912`.

Dec 2022 Knuth F., Shean D., **Bhushan S.**, Schwat E., Alexandrov O., McNeil C., Dehecq A., Florentine C. and O'Neel S., ***"Historical Structure from Motion (HSfM): Automated processing of historical aerial photographs for long-term geodetic change analysis"*** in Remote Sensing of Environment. `https://doi.org/10.1016/j.rse.2022.113379`.

Oct 2022 M.V.W. de Vries, **S. Bhushan**, M. Jacquemart, C. Deschamps-Berger, E. Berthier, S. Gascoin, D.H. Shugar, D. Shean and A. Kääb ***"Pre-collapse motion of the February 2021 Chamoli rock-ice avalanche, Indian Himalaya"*** in Natural Hazards and Earth System Sciences. `https://doi.org/10.5194/nhess-22-3309-2022`.

Jun 2021 D.H. Shugar, M. Jacquemart, D. Shean, **S. Bhushan**, K. Upadhyay, A. Sattar, et al. ***"A massive rock and ice avalanche caused the 2021 disaster at Chamoli, Indian Himalaya"*** in Science. `https://doi.org/10.1126/science.abh4455`.

Jan 2021 **S. Bhushan,** D.E. Shean, O Alexandrov, S. Henderson ***"Automated digital elevation model (DEM) generation from very-high-resolution Planet SkySat triplet stereo and video imagery"*** in ISPRS Journal of Photogrammetry and Remote Sensing. `https://doi.org/10.1016/j.isprsjprs.2020.12.012`.

Jan 2020 D.E. Shean, **S. Bhushan**, P. Montesano, D.R. Rounce, A.A. Arendt and B. Osmanoglu ***"A systematic, regional assessment of High-mountain Asia glacier mass balance"*** in Frontiers in Earth Sciences `https://doi.org/10.3389/feart.2019.00363`.

Jun 2018 **S. Bhushan,** T.H. Syed, A.A. Arendt, A.V. Kulkarni and D. Sinha, ***"Assessing controls on mass budget and surface velocity variations of glaciers in Western Himalaya"*** in Scientific Reports `https://doi.org/10.1038/s41598-018-27014-y`.

Dec 2017 **S. Bhushan,** T.H. Syed, A.V. Kulkarni, P. Gantayat and V.Agarwal, ***"Quantifying Changes in the Gangotri Glacier of Central Himalaya: Evidence for Increasing Mass Loss and Decreasing Velocity"*** in IEEE Journal of Selected Topics in Applied Earth Observations and Remote Sensing (JSTARS) `https://doi.org/10.1109/JSTARS.2017.2771215`.

Articles under-review

Sep 2023 **Bhushan, S.,** Shean, D., Hu, J.M. Gulliet G. and Rounce D. ***"Seasonal and annual surface mass balance for debris-covered glaciers in High-Mountain Asia from flow-corrected satellite stereo DEM time series"*** submitted to Journal of Glaciology.

Aug 2023 Hu, J. M., Shean, D., and **Bhushan S.**. ***"Six consecutive seasons of high-resolution mountain snow depth maps from satellite stereo imagery"*** submitted to AGU Geophysical Research Letters .

Articles under-preparation

Nov 2023 **Bhushan, S.,** Shean, D., Henderson, S. and Price, S. ***"Seasonal to monthly glacier velocity estimation from PlanetScope Dove Classic constellation"*** being prepared for submission to IEEE JSTARS.

Dec 2023 Hu, J. M., **Bhushan S.** and Shean D. ***"Evaluating the effect of stereo acquisition geometry, image resolution and photogrammetry processing parameters on DEM accuracy"*** being prepared for submission to ISPRS Journal of Photogrammetry and Remote Sensing.

Synergistic Activities

Teaching I have developed and delivered the following two guest lectures.
- *"Introduction to Photogrammetry"* for undergraduate level CEE 347: GeoSurveying course at University of Washington.
- *"Photogrammetry from commercial satellite imagery and application to Earth Surveying"* for graduate level CEN 612: Advanced Digital Image Processing course at Indian Institute of Technology Roorkee.

Educational Tutorials I am currently developing several image processing and photogrammetry tutorials. In the past, I developed these two tutorials .
- *"3D reconstruction of urban areas from satellite imagery"* as part of undergraduate level summer school at IIT Roorkee.
- *"Open-source, executable tutorial on stereo processing of ASTER stereo imagery using ASP tools"* (`https://github.com/uw-cryo/asp-binder-demo`)

Review Services Reviewed nine journal articles submitted to Journal of Glaciology, Water Resource Research, Remote Sensing, Geophysical Research Letters, ISPRS Journal of Photogrammetry and Remote Sensing, and Polar Science.

Mentorship Continually provide technical science guidance and academic career advice to students from several Indian and US institutes.

Leadership Roles Served as team lead and data science lead for multiple projects at University of Washington eScience Hackweeks. Served as Data Science Helper for the 2023 ICESat-2 Hackweek. At IIT (ISM) Dhanbad, I served as General Secretary of American Association of Petroleum Geologists student chapter, where I led the organisation activities of student-led pan-India AAPG Annual Meet 2017.

Science Outreach Media interviews on Chamoli disaster at print and digital outlets (e.g., Deccan Herald, Temblor News, CBC Canada) . Volunteer at the annual Science days at the Seattle Pacific Science Center. Upcoming Instagram page on earth system observation from satellite imagery.

Open-source software and Data Products

Mar 2023 Shean D., and **Bhushan S.** *"dshean/vmap: v1.1.0 Compatibility updates (v1.1.0)"* on Zenodo. `https://doi.org/10.5281/zenodo.7730146`.

Oct 2022 Alexandrov O., McMichael S., Broxton M., and 21 others including **Bhushan S.** *"NeoGeography-Toolkit/StereoPipeline: 2022-10-24-daily-build (2022-10-24-daily-build)."* on Zenodo. `https://doi.org/10.5281/zenodo.7243717`.

Apr 2022 Pestana S., **Bhushan S.** and Carter J. *"spestana/goes-ortho: Initial release (v0.1)"* on Zenodo. `https://doi.org/10.5281/zenodo.3600013`.

Nov 2021 Shean D., **Bhushan S.**, Lilien D., Knuth F., Schwat E., Meyer J., Sharp M. and Hu J.M. *"dshean/demcoreg: v1.1.0 (v1.1.0)"* on Zenodo. `https://doi.org/10.5281/zenodo.5733347`.

Feb 2021 **Bhushan S.,** and Shean D., *"Chamoli Disaster Pre-event 2-m DEM Composite: September 2015 (Version 1.0) [Data set]"* on Zenodo. `http://doi.org/10.5281/zenodo.4554647`.

Feb 2021 Shean D., and **Bhushan S.**, Berthier E., Deschamps-Berger C., Gascoin S., and Knuth F., *"Chamoli Disaster Post-event 2-m DEM Composite (February 10-11, 2021) and Difference Map (Version 1.0) [Data set]"* on Zenodo. `http://doi.org/10.5281/zenodo.4558692`.

Feb 2021 Shean D., and **Bhushan S.**, *"Chamoli Disaster Post-event DEM (2021-02-11 WorldView-2 Cross-track Stereo) and Preliminary DEM Difference Map (Version 1) [Data set]"* on Zenodo. `http://doi.org/10.5281/zenodo.4539740`.

Jan 2021 **Bhushan S.,** Shean D., Alexandrov O., and Henderson S., *"uw-cryo/skysat_stereo: Zenodo doi revision updates (0.2)"* on Zenodo. `https://doi.org/10.5281/zenodo.4422248`.

Jan 2020 **Bhushan S.,** *"ShashankBice/raster_geostatistics:"* on Zenodo. `https://doi.org/10.5281/zenodo.4422248`.

Recent Abstracts in International Conferences

2022

- **Bhushan S.**, Shean D., Hu J.M., Rounce D., and Gulliet G., ***"High resolution estimates of surface mass loss over debris-covered glaciers in High-Mountain Asia from VHR stereo satellite imagery"*** at AGU Fall Meeting, Chicago.
- Hu, J.M. Hu, Shean D. and **Bhushan S.** ***"Satellite Stereo Snow Depth Retrievals over Complex Terrain"*** at AGU Fall Meeting, Chicago.
- **Bhushan S.**, Shean D., Rounce D., Hu J.M., and Gulliet G., ***"High resolution observations of surface mass loss over debris-covered glaciers in Nepal Himalaya"*** at NorthWest Glaciologists Meeting at Moscow, Idaho.

2021

- **S. Bhushan** , D.E. Shean, S. Henderson and M. Hu. "Using repeat, high resolution satellite imagery to constrain surface melting and seasonal glacier dynamics in High Mountain Asia" at AGU Fall Meeting, New Orleans.
- M. Hu, **S. Bhushan** and D. Shean, 2021. "Very-high-resolution satellite stereo processing improvements offer more accurate snow depth maps and SWE estimates" at AGU Fall Meeting, New Orleans.
- W. Zheng, **S. Bhushan**, M.V.W. de Vries, W. Kochtitzky and D.E. Shean. "Gftt: an open-source tool for evaluating remotely sensed glacier velocity products".
- F. Knuth, D.E. Shean, E. Schwat and **S. Bhushan**. "70 years of high-resolution glacier surface elevation records derived from historical aerial photography across Western North America" at AGU Fall Meeting, New Orleans.
- ***Invited talk***: **S. Bhushan** and D. Shean. "Planet SkySat Stereo: 4D surveys of Planet Earth" at Planet Explore Conference.
- M.V.W. de Vries, **S. Bhushan**, D. Shean, E. Berthier, C. Deschamps-Berger, S. Gascoin, M. Jacquemart, A. Kääb, and D. Shugar. "Resolving pre-collapse slope motion at the February 2021 Chamoli rock-ice avalanche via feature tracking of optical satellite imagery" at EGU General Assembly, Vienna.

2020

- **S. Bhushan**, D.E. Shean, K. Jordahl, A. Martos, O. Alexandrov, S. Henderson and J. Kington. "Automated DEM generation and scientific applications of Planet SkySat triplet stereo and video imagery". AGU Fall Meeting, Online Program.
- F.A. Knuth, D.E. Shean, O. Alexandrov and **S. Bhushan**. "Historical Structure From Motion (HSfM): Automated Generation of High-Resolution DEMs and Geodetic Glacier Mass-Balance Measurements from Historical Aerial Photography". AGU Fall Meeting, Online Program.
- D.E. Shean, J.M Hu, **S. Bhushan**, O. Alexandrov, C. Heimstra, S. Henderson and J. Lundquist. "Stereo2SWE: Snow depth and snow-covered area from commercial stereo satellite imagery". AGU Fall Meeting, Online Program.

2019

- **S. Bhushan**, D.E. Shean, O. Alexandrov and S. Henderson. "Quantifying changes in dynamic Cryosphere using high resolution imagery: Automated tools for sensor correction, DEM generation and glacier velocity" at AGU Fall Meeting, San Francisco.
- D.E. Shean, **S. Bhushan**, J.M Hu, O. Alexandrov, S. Henderson, J. Mayer, J. Lundquist and C. Heimstra. "Snow depth from sub-meter stereo satellite imagery" at AGU Fall Meeting, San Francisco.
- F.A. Knuth, D.E. Shean, O. Alexandrov and **S. Bhushan**. "Historical Structure From Motion: Automated production of high-resolution DEMs from historical imagery for quantitative analysis of glacier and geomorphological change" at AGU Fall Meeting, San Francisco.

2017

- **S. Bhushan**, D.E. Shean, U.K. Haritashya, A.A. Arendt, T.H. Syed and L. Setiawan. "Analysis of High Resolution Satellite imagery to assess Glacier Mass Balance and Lake Hazards in Sikkim Himalayas" at AGU Fall Meeting, New Orleans.
- **S. Bhushan**, T.H. Syed and A.V. Kulkarni, "Contemporary Mass Budget Analysis of Gangotri Glacier" at National Conference on Himalayan Glaciology, Bangalore, India.

2016

- **S. Bhushan** and T.H. Syed, "Mapping of Potential Lake Sites in Gangotri Glacier", 53rd Annual Convention, Indian Geophysical Union (IGU), Dhanbad, India.
- **S. Bhushan**, T.H. Syed and H. Gupta, "Ice Thickness and Volume Estimates of Drang Drung Glacier using remote sensing", 78th EAGE Annual Conference, Vienna, Austria.
- **S. Bhushan**, H. Gupta and T.H. Syed, "Velocity Estimates of Siachen Glacier: Trends over the last 15 Years", 10th SPIE Asia Pacific Remote Sensing Symposium, New Delhi, India.

Scientific Workshops and Training

June 2021	SnowEx Hackweek organised by eScience Insititute, University of Washington
June 2019, June 2020, August 2023	IceSAT-2 Hackweek organised by eScience Insititute, University of Washington
Sep 2018, Sep 2019	GeoHackWeek organised by eScience Insititute, University of Washington
June 2015	Training on Glaciers and Remote Sensing, IISc, Bangalore and University of Iceland

Technical Skills, Memberships

Coding	Python, Bash scripting, versed in High Performance Computing environments
Open Source	NASA Ames Stereo Pipeline, COLMAP, OpenSfM, GDAL, OGR, GSLIB, OpenCV, QGIS, Linux, Latex
Proprietary Software	ArcGIS 10.2, Rolta Geomatica 15, Pix4D Mapper, ENVI 4.5, MS Office, Adobe Illustrator
Membership	AGU,ASPRS and IACS Working Group on Debris-covered glaciers
Github Profile	`https://github.com/ShashankBice`
Google Scholar	`https://scholar.google.com/citations?user=_4_TcXcAAAAJ&hl=en`