landscape response in the high mountains

Conveners: Dan H. Shugar[1], Jeffrey S. Kargel[2], Marten Geertsema[3]

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Session Description
Glacial thinning and retreat drives the destabilization of mountain systems, often resulting in catastrophic geomorphic processes and sediment cascades that can impact people and infrastructure downstream. Glacier debuttressing can lead to landslides and rock avalanches, thawing permafrost can destabilize slopes, and proglacial lakes can drain. The frequency of many of these geohazards seems to be increasing globally, suggesting a link to climate change. This session highlights studies that address issues of landscape change in high mountains that lead to geohazards. We welcome modeling, remote sensing, field, or theoretical studies, and from anywhere in the world.

Primary Affiliation: Earth Surface Processes

NOTE: THIS DOCUMENT CONTAINS INFORMATION FOR ALL SESSION SUB-SECTIONS. PRESENTER ABSTRACTS ARE FOUND AT THE END OF THE DOCUMENT.

SCHEDULE IS SUBJECT TO CHANGE.

ORAL SESSION ES02a

Chairs: D. Shugar, J, Kargel, M. Geertsema **Room: GEOG 229**

Wednesday, May 31st

TIME	AUTHORS	TITLE
11:00	Rebecca Hudson*, Vidyavathy Renganathan, Alexander Braun and Georgia Fotopoulos	High Resolution TerraSAR-X Data for the Detection of Rockfalls in Canada
11:15	G.W.K. Moore, Paolo Cristofanelli, Paolo Bonasoni, Gian Pietro Verza, J.L. Semple	In-situ observations of the April 2014 Mount Everest Avalanche
11:30	John J. Clague, Andreas von Poschinger, and Nancy C. Calhoun	Cataclysmic events in the upper Rhine River valley, Switzerland, during one hour in the early Holocene
11:45	Daniel H. Shugar, Peter J. Haeussler, Colin P. Stark, …	Preliminary findings from the seismologically detected Taan Fiord landslide and tsunami of 17 October 2015
12:00	Tim Giles	The Pinaus Lake Earthflow
12:15	Marten Geertsema, Gabriel Wolken, Anja Dufresne, Panya Lipovsky and Colin Stark	Ice/rock avalanches in Glacier Bay National Park, Alaska

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SUBMITTED ABSTRACTS

ES02-01 High Resolution TerraSAR-X Data for the Detection of Rockfalls in Canada

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Abstract
A new workflow is presented which utilizes high resolution synthetic aperture radar (SAR) data differencing for the detection of rockfalls in a critical transportation corridor in western Canada. Rockfalls account for 22% of all damage to railway lines in Canada which has led to extensive detection and monitoring campaigns. White Canyon is an area located 5 km northeast of Lytton, British Columbia and has seen a high rate of rockfalls close to the railway lines that operate at the base of the slope. Thirty scenes of single polarization (HH) staring spotlight mode TerraSAR-X data, with a resolution of up to 25 cm and a repeat period of 11 days, were collected over a two year period in the area of interest. These scenes were radiometrically calibrated and geometrically corrected using the SRTM 30m digital elevation model (DEM). High-resolution SAR observations with small swath size (TerraSAR-X staring spotlight with a scene size of 4 by 3 km) result in low coherence. Hence, current change detection techniques such as interferometry, which uses the phase difference, cannot be utilized as effectively. This becomes increasingly true for dynamic natural landscapes. The proposed workflow incorporates the differences between the intensity of the pixel values for each successive scene pair and classifies the image based on the source. The pixel locations attributed to rockfalls were compared to known rockfall events determined from independent in-situ and airborne monitoring techniques, including terrestrial and airborne LiDAR, photogrammetry and gigapixel imagery. While these methods are able to provide high spatial resolution, they have a very low temporal resolution. Ultimately, the proposed workflow provides an alternative space-based technique with high temporal resolution and potentially high spatial resolution depending on the rockfall characteristics in a region. [284 Words]

Presentation type: Oral Presentation

ES02-02 In-situ observations of the April 2014 Mount Everest Avalanche

G.W.K. Moore[1], Paolo Cristofanelli[2], Paolo Bonasoni[2],
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Abstract
Instrumental records indicate a warming of approximately 0.8°C has occurred in the Mount Everest region since the 1980s that has resulted in a 100-300m rise in the height at which the ground is permanently frozen as well as a retreat and thinning of Everest's glaciers. For some time, there have been concerns that this warming and the resultant changes in the region's glaciers may be increasing the risks for travellers to Mount Everest as well as the indigenous populations who support them. On April 18 2014, an avalanche caused by the collapse of a large serac swept down Mount Everest's Khumbu Ice Fall resulting in the deaths of 16 Sherpa. Although satellite imagery has been used to estimate the size of the serac, in-situ data on the avalanche itself has not been available. Here we show that this event coincided with an approximate 15min long wind, thermal and moisture anomaly that was observed at the Nepal Climate Observatory-Pyramid situated 10 km from Mount Everest. We argue that this anomaly was associated with the avalanche and thereby provides some information on its scale and duration as well as a potential mechanism to monitor future events in this remote and data sparse region. [201 words]

Presentation type: Oral Presentation

ES02-03 Cataclysmic events in the upper Rhine River valley, Switzerland, during one hour in the early Holocene

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Abstract

The Flims rockslide, which happened about 9400 years ago in the eastern Swiss Alps, is the largest postglacial terrestrial landslide in Europe. The landslide and the huge secondary mass flow it induced completely changed the floor and lower slopes of the Vorderrhein valley over a distance of several tens of kilometres, probably in one hour or less. The landslide began with the sudden detachment of 10-12 km^3 of Jurassic and Cretaceous limestone from the north wall of the Vorderrhein valley. The detached rock mass rapidly fragmented as it accelerated and then struck the Rhein valley floor and the opposing valley wall. Tongues of debris traveled up and down the Vorderrhein. The impact liquefied approximately 1 km^3 of valley-fill sediments, mainly fluvial and deltaic gravel and sand. The liquefied sediment moved as a slurry – the Bonaduz gravel – tens of kilometres downvalley from the impact site, carrying huge fragments of rockslide debris that became stranded on the valley floor, forming hills termed 'tumas'. Part of the flow was deflected by a cross-valley barrier and flowed 16 km up the Hinterrhein valley (the main tributary of the Vorderrhein), carrying tumas with it. Bonaduz gravel is >65 m thick and fines upward from massive sandy cobble gravel at its base to silty sand at its top. Sedimentologic and geomorphic evidence indicates that the liquefied sediment was transported as a hyperconcentated flow, possibly above a basal carpet of coarse diamictic sediment that behaved as a debris flow. The large amount of water involved in the Bonaduz flow indicates that at least part of the Flims rockslide entered a former lake in Vorderrhein valley. The rockslide debris impounded the Vorderrhein and formed Lake Illanz, which persisted for decades or longer before the dam was breached in series of outburst floods. These floods further changed the valley floor below the downstream limit of the landslide. Today, Vorderrhein flows in a spectacular 8-km-long gorge incised up to 400 m in Flims rockslide debris; the river has yet to reach the base of the debris sheet.

Presentation type: Oral Presentation

ES02-04 Preliminary findings from the seismologically detected Taan Fiord landslide and tsunami of 17 October 2015

Daniel H. Shugar[1], Peter J. Haeussler[2], Colin P. Stark[3], Sean P.S. Gulick[4], Breanyn MacInnes[5], Robert Weiss[6], Bretwood Higman[7], Chris Larsen[8], Colin Bloom[5], Eric Bilderback[9], Doug M. Bonno[1], Anja Dufresne[10], Goran Ekstrom[3], Marten Geertsema[11], Lucia Gualtieri[3], Bruce Jaffe[12], Michele Koppes[13], Keith Labay[2], Mike Loso[14], Patrick Lynett[15], Naoma McCall[4], Bruce M. Richmond[12], Bobby Reece[16], Jeremy Venditti[17], Maureen Walton[12], Mike Willis[18], Haley Williams[13]

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On 17 October 2015, the Global CMT Project seismically detected an unusually large landslide in the St Elias Mountains of southern Alaska. Satellite images revealed a landslide in Taan Fiord, only 3 km from the inferred location, that it had entered the ocean, and generated significant tsunami runup. A tsunami was observed at the closest two tide gauges—145 and 345 km away by sea. A single-force inversion model calculated a slide mass of 100-150 billion kg. In summer 2016, teams of scientists documented physical aspects of the landslide, tsunami, and deposits. Data include lidar and SfM topography, swath bathymetry, tsunami runup, and seismic profiles. Tsunami runup reached a maximum of 192 m directly across from the landslide. The rest of the 17-km-long fjord has a trimline that tapers gradually to 15 m at its mouth. Comparison of high-resolution DEM elevations show a landslide volume of ~56 million m^3, equivalent to a mass of ~132 billion kg, a value remarkably similar to the seismologically estimated value. Approximately 93% of the slide volume entered the fjord, which explains why it was so efficient at generating a tsunami. Landslide blocks are imaged on the fjord bottom up to 2.5 km from where the landslide entered the fiord. However, the seismic profiles show blocks likely extending to a distance of 3 km and fjord-bottom deformation extending to 6 km. These features are hidden by post-landslide suspended sediment deposition. Some landslide debris was

deposited as a 2-4 m thick blanket on the toe of the Tyndall Glacier, which has caused accelerated terminus failure. The overall setting of this landslide and subsequent tsunami is related to retreat of the Tyndall Glacier and debuttressing of the fjord walls. These studies highlight the robustness of rapid seismological detection and characterization of landslides even in remote regions. [299 words]

Presentation type: Oral Presentation

ES02-05 The Pinaus Lake Earthflow

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Abstract
The Pinaus Lake earthflow is located approximately 60 km southeast of Kamloops, British Columbia in the rolling uplands of the dissected Thompson Plateau. As can clearly be seen on LiDAR imagery, this earthflow is a reactivation of a much larger post-glacial landslide. The post-glacial landslide entered Pinaus Lake and the deposits isolated a small lake, Lady King Lake, to the west of the main Pinaus Lake basin. The recent active earthflow is 750 m long and over 200 m wide, a surface area of around 15 hectares, with an estimated volume of 1.0 million m3. The upper headscarp area is defined by two strong bedrock-cored ridges which diverge downslope. Local bedrock is identified as the Eocene Kamloops Group, Dewdrop Flats Formation trachyandesite flows with interflow breccias. The earthflow is defined by lateral faults which have displacements of up to 5 m. Slump blocks are generally perpendicular to slope and may be the result of de-buttressing of the slope by road and trail construction. Three drill holes completed with a rotary auger drill reached 6.1, 9.1 and 10.4 m depth before encountering relatively competent bedrock. Survey posts installed in late 2013 have been re-measured several times and results indicate movement is occurring at 1-3 mm per day. The upper, steeper and more confined sections of the flow are moving at over 2 mm per day; the gentler and wider areas lower down are moving $\leq$ 1 mm per day. There are no surface flows of water and only minimal water was observed during the drilling program. Groundwater reaching the weaker tuffaceous beds within the trachyandesite bedrock is believed to be the cause of the instability. These tuffaceous beds are typically higher in clay minerals which are susceptible to movement when soil pore water pressures are increased.

Presentation type: Oral Presentation

ES02-06 Ice/rock avalanches in Glacier Bay National Park, Alaska

Marten Geertsema[1*], Gabriel Wolken[2], Anja Dufresne[3], Panya Lipovsky[4] and Colin Stark[5]

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Abstract
Ice/rock avalanches are on the increase in Glacier Bay National Park and Preserve in southeastern Alaska. Between June 2012 and July 2016, four ice/rock avalanches with travel distances greater than 6 km occurred in the park. Numerous smaller rock falls and slides occurred as well. Landslides at Mt. Lituya, Mt. La Perouse, Mt. Wilbur, and Lamplugh Glacier traveled some 9, 7, 6, and 10 km over glaciers, respectively. Proximity of the landslides to the Fairweather Fault suggests tectonic stresses may have conditioned the rock slopes for failure. Both glacial debuttressing and permafrost degradation likely play a role in slope destabilization within the park, resulting in a landscape level response to climate warming. The landslides all initiated above 2000 m asl, in zones of cold permafrost, and involved hanging glaciers. If these landslides are indeed linked to ice loss and warming-induced permafrost degradation, climate projections would suggest more ice/rock avalanches can be expected in the decades to come.

Presentation type: Oral presentation