ES14: Advances in Earth Surface Processes

Conveners: Jaclyn Cockburn[1], TBA

Co-chairs: Jaclyn Cockburn[1], and TBA

[1] Geography Dept., University of Guelph, Guelph, ON, N1G 2W1

[2] Phone: 519-824-4120 ext 53498, E-mail: jaclyn.cockburn@uoguelph.ca

Session Description

Earth Surface Processes are an important subdiscipline of geosciences. It addresses, past, present and future challenges within geosciences and includes the influence of human activities on the Earth's surface. We invite oral and poster contributions that focus on scientific results and/or their applications to exploring earth surface processes at regional, national and international scales and would be suitable for work that does not fit any approved specialist sessions.

Primary Affiliation: CGU / Earth Surface Processes / Geodesy / Hydrology / Solid Earth / Biogeosciences

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

SCHEDULE MAY BE SUBJECT TO CHANGE.

ORAL SESSION ES14

Chairs: J. Cockburn, J. Franssen **Room: GEOG 229**

Tuesday, May 30th

TIME	AUTHORS	TITLE
14:00	Brett Eaton, Lucy MacKenzie, and Matthias Jakob	Steady states and extreme floods: experiments on the dynamics of steep gravel bed streams
14:15	Anya Leenman*, Jon Tunnicliffe, and Gary Brierley	Deciphering historic change in tributary-junction fans in response to catchment-wide sedimentary disturbance
14:30	Collin Branton*, Derek T. Robinson, and Rebecca Rooney	Quantifying topographic roughness and spatial pattern at the landscape scale in the prairie pothole region of Alberta, Canada
14:45	Pamela E. Tetford*, Joseph R. Desloges, and Dimitri Nakassis	Assessing geomorphic processes and their potential relationship with archaeological artifact exposure – NE Peloponnese, Greece
15:00	Siobhan Whadcoat, Nick Rosser, Matthew Brain, Richard Hardy	Identifying potential failure zones in rock slopes based on spatial and temporal patterns that characterize rockfall evolution
15:15	Ronda Strauch*, Erkan Istanbulluoglu, and Sai Siddhartha Nudurupati	A regional model of landslide susceptibility using Landlab and macro-scale hydrologic simulations

POSTER SESSION ES14

Chairs: J. Cockburn, J. Franssen **Room: ESB Atrium**

Tuesday, May 30th

Poster No.	AUTHORS	TITLE
ES14-07	Marco G. Jorge*, Tracy A. Brennand, Jonathan E. Cripps	Canada's digital elevation
ES14-08	Antoine Prince*, Jan Franssen, and Jean-François Lapierre	Modelling of depth to bedrock and soil composition attributes at the catchment scale

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SUBMITTED ABSTRACTS

ES14-01 Steady states and extreme floods: experiments on the dynamics of steep gravel bed streams

Brett Eaton[1], Lucy MacKenzie[2], and Matthias Jakob[3]

[1] Geography Dept., University of British Columbia, Vancouver, BC, V6T 2P6
Phone: 604-822-2257 Fax: 604-822-6150, E-mail: brett.eaton@ubc.ca
[2] Geography Dept., University of British Columbia, Vancouver, BC, V6T 2P6
[3] BGC Engineering, 980 Howe St, Vancouver, BC, V6Z 0C8

Abstract
A series of stream table experiments were conducted to document the effects of extreme flood events on channel dynamics. Initial channels were established during a 6-hr period at bankfull flow (Q_{bf}), and then subject to 1-hr extreme floods ranging in size from $1.25Q_{bf}$ to $3.0Q_{bf}$, followed by a 2-hr recovery period at Q_{bf}. Prior to the extreme floods, the channels developed steady state channel morphologies and exhibited patterns of erosion and deposition consistent with the migration of channel bars and the occurrence of channel avulsions. During extreme events larger than $1.25Q_{bf}$, the floods caused extensive channel widening and widespread aggradation of the initial channel bed, despite the occurrence of substantial net degradation. Periods of lateral instability were associated with enhanced erosion and transport of the largest two size classes of the bed material, relative to periods of lateral stability. The extreme floods also modified the channel pattern, increasing the number of active anabranches and significantly modifying the mean width, depth and boundary shear stress. Following the extreme floods, the channels were wider and shallower for the same Q_{bf} than prior to the extreme floods, and the changes observed during the recovery period indicate that sediment deposition in small anabranches and vertical incision of the main channel combined to reestablish a dominantly single thread channel. The ability of large floods to dramatically widen a stream clearly indicates that the sequence of flows can create a historical legacy that strongly influences how a stream will respond to future events. [283 words]

Presentation type: Oral Presentation

ES14-02 Deciphering historic change in tributary-junction fans in response to catchment-wide sedimentary disturbance

Anya Leenman[1*], Jon Tunnicliffe[2], and Gary Brierley[2]

[1] Geography Dept., University of British Columbia, Vancouver, BC, V6T 1Z1
Phone: 778-233-2446, E-mail: anyaleenman@gmail.com
[2] School of Environment, University of Auckland, Auckland, New Zealand

Abstract
Alluvial fans at tributary junctions mediate sediment transfer through river networks, particularly where disturbance response rates differ in the trunk stream and tributaries. In New Zealand's East Cape region, colonial deforestation has combined with weak sandstone and mudstone lithology, high rainfall, uplift, and steep topography to produce a landscape with some of the highest erosion rates and sediment yields on earth. We investigated how tributary-junction alluvial fans in this region responded to severe erosion following deforestation, and during extreme storms such as Cyclone Bola in 1988. Five tributary-junction fans were examined for the period 1939-2016. In response to major sediment loading, fan areas increased by up to 130,000 m^2, fans aggraded by up to 12 m, and prograded by up to 170 m. Fan sediment storage ranged from 15,000 to 1,500,000 m^3. The major influences on fan response were climate, land cover, tributary-catchment connectivity, and most importantly, the nature of fan interaction with the main stem channel at seasonal and decadal scales. The interaction between a fan and the trunk stream controls its ability to buffer the trunk from changes in the tributary. Although previous studies proposed relations between fan morphometry and tributary characteristics, we demonstrate that fan morphometry varies considerably at decadal, annual or even monthly timescales. Such studies could therefore benefit by examining regional histories of sedimentary disturbance. [217 words]

Presentation type: Oral Presentation

ES14-03 Quantifying topographic roughness and spatial pattern at the landscape scale in the prairie pothole region of Alberta, Canada

Collin Branton[1*], Derek T. Robinson[1], and Rebecca Rooney[2]

[1] Geography Dept., University of Waterloo, Waterloo, ON, N2L 3G1
Phone: 519-503-5798, E-mail: cebranto@uwaterloo.ca
[2] Biology Dept., University of Waterloo, Waterloo, ON, N2L 3G1

Abstract

The importance of topographic variation on understanding natural phenomena is the central tenet of digital terrain analysis and geomorphometry. While topographic variation is typically quantified for individual study sites, it is rarely quantified at landscape to regional scales and the spatial pattern of the topographic variation has largely been ignored. The presented research develops a methodology to calculate and compare the topographic variation, measured using six different terrain roughness metrics, of a large number of wetland landscapes spanning three natural regions and a gradient of human disturbance in Alberta, Canada. Our analysis of topographic variation corroborate expectations that 1) landscapes in the boreal natural region are statistically different than those in the parkland or grassland natural regions and 2) that landscapes with a low proportion of human disturbance (0-20 %) have a topographic variation statistically different from more disturbed landscapes.

To quantify the spatial pattern of topography, discrete landforms were classified for each landscape using literature-derived classification rules and their pattern quantified using landscape metrics. The topographic characteristics of the landforms were quantified by summarizing terrain metrics by landform class and the distribution of landforms and their associated terrain metric values within the study landscapes were compared across different natural regions and a gradient of human disturbance.

The presented methodology and quantified wetland landscapes provide a continuum of reference conditions that characterize topographic variation and pattern across a gradient of human disturbance. These conditions can be used to guide reclamation planning and closure permitting by industry and energy regulators seeking objective measures to meet social and policy requirements to ensure landscapes are self-sustaining and mimic the ecological and hydrological functions found in reference landscapes. [274]

Presentation type: Oral Presentation

ES14-04 Assessing Geomorphic Processes and their Potential Relationship with Archaeological Artifact Exposure – NE Peloponnese, Greece

Pamela E. Tetford[1*], Joseph R. Desloges[2], and Dimitri Nakassis[3]

[1] Department of Geography, University of Toronto, Toronto, ON, M5S 3B1
Phone: 416-723-9698, E-mail: pam.tetford@mail.utoronto.ca
[2] Department of Earth Sciences, University of Toronto, Toronto, ON, M5S 3B1
[3] Department of Classics, University of Colorado, Boulder, CO, 80309

Abstract
The complex interactions between topography, climate and human activity shape a landscape, conditioning archaeological deposits and making sediment deposits from surface erosion and fluvial transport important archives. Consequently, there is a potential relationship between the rate and intensity of geomorphic processes and surface artifact distribution. Mediterranean regions, with climate variability and a long history of anthropogenic occupation, are particularly vulnerable to soil erosion and subsequent sediment redistribution. This study examines surface soil stability and stream energy of the 243 km^2 Inachos River watershed in the northeast Peloponnese, Greece. This mountainous, semi-arid Mediterranean region has an extensive history of human activity accelerating surface soil losses. Soil loss and stream energy are each quantified for the watershed by applying the Unit Stream Power Erosion Deposition (USPED) method to the Revised Universal Soil Loss Equation (RUSLE) and the specific stream power approach to the main river channel. These are used as indicators of the spatial variability in geomorphic activity. Results indicate an average potential soil loss of 15.0 t ha^{-1} a^{-1}, ranging from nil in low gradient environments to 4287 t ha^{-1} a^{-1} in steep mountainous regions. Slope-length and rainfall erosivity are the primary factors explaining soil loss. High specific stream power in the upper watershed exceeds 17,100 W m^{-2} resulting in the mobilization of sediment into channelized debris flows. The spatially variable estimates of soil loss and stream power are compared to surface artifact finds of the 30 km^2 intensive fieldwalk survey of the Western Argolid Regional Project (WARP). A statistically significant relationship is identified between surface erosion rates and artifact density, with the lowest artifact densities associated with the highest rates of soil loss. Preferential topography for occupation suggests this is an associative rather than causative relationship. Accurate reconstruction of human settlement history is enabled through knowledgeable interpretation of artifact distribution. [300 words]

Presentation type: Oral Presentation

ES14-05 Identifying potential failure zones in rock slopes based on spatial and temporal patterns that characterize rockfall evolution

Siobhan Whadcoat[1], Nick Rosser[2], Matthew Brain[2], Richard Hardy[2]

[1] Department of Earth, Ocean and Atmospheric Sciences, University of British Columbia, 2020-2207 Main Mall, Vancouver, BC, V6T 1Z4
Phone: 604-827-3864, E-mail: swhadcoat@gmail.com
[2] Department of Geography, Durham University, Durham, UK, DH1 3LE

Abstract
Rock slope monitoring at the local scale ($10^1 – 10^2$ m^2), via remote and direct methods, is often used to identify areas of deformation, opening of discontinuities, and the locations of previous failures. Recent advances in monitoring technology have provided a higher spatial and temporal resolution in monitoring capabilities, allowing detection of pre-failure deformation and precursors that indicate areas of potential future failure. At a larger scale ($\geq 10^3$ m^2), where monitoring of rock slopes is often infrequent and at a coarser spatial resolution, areas of potential failure are commonly identified based on environmental, geological and morphological characteristics. Various statistical and modelling based approaches are used to determine which controls are the most important rockfall predictors. Here, we present the spatial and temporal distribution of rockfalls from high resolution field monitoring data, and identify patterns that characterize rockfall evolution, considering the applicability of these findings for larger rock slopes. Terrestrial laser scans of coastal cliffs in North Yorkshire (UK) were collected monthly over two years. Results show observations of rockfalls that are indicative of a progressive failure mechanism, demonstrated via observations of directionality in rockfall propagation across the cliff face; and evidence that rockfalls cluster significantly at a range of scales. The findings demonstrate that variability exists beyond what can be explained solely by geological and environmental variability. A moving kernel window is used to examine the distribution of rockfalls identified over different spatial areas and shows that an area measuring 63% of the total cliff face provides an adequate representation of the rockfalls across the entire cliff face. The patterns and behavior identified are considered for their applicability to other rock slopes; for use in numerical modelling of rock slope failure; and for highlighting areas of potential failure in rock slopes at a larger scale. [297 words]

Presentation type: Oral Presentation

ES14-06 A regional model of landslide susceptibility using Landlab and macro-scale hydrologic simulations

Ronda Strauch[1*], Erkan Istanbulluoglu[1], and Sai Siddhartha Nudurupati[1]

[1] Dept. of Civil and Environmental Engineering, University of Washington, Seattle, WA 98195
Phone: 425-445-7934 E-mail: rstrauch@uw.edu

Abstract
Landslides are key landscape processes shaping steep terrain, yet remain elusive to predict. Physically-based numerical models of hillslope stability provide a path forward, but are challenging to parameterize and apply at regional scales, where field investigation is often unfeasible. We employ the newly developed Landlab platform, an open-source, Python-based earth systems modeling environment, to deploy a numerical model of hillslope stability. An infinite-slope limited-equilibrium landslide model predicts spatial and temporal probability of failure over large regions driven by groundwater recharge derived from the Variable Infiltration Capacity (VIC) model, a distributed macro-scale hydrology model. Uncertainties in local soil conditions, such as soil properties, are addressed through Monte Carlo simulations of the factor-of-safety stability index. Predictions are further refined by an optional geomorphic soil depth evolution model that estimates distributed soil depth with greater spatial variability than conventional soil survey map units. The coupled hydro-geomorphic model advances the characterization of the landslide probability without detailed data collection, and captures more of the uncertainty intrinsic in regional landslide assessments. We demonstrate the model in North Cascade National Park Complex, a rugged terrain with nearly 2,700 m (9,000 ft) of vertical relief, covering 2,757 km2 (1,064 mi2) in northern Washington State, U.S.A. The results will aid resource management decision-making in current and future climatic and landscape conditions. [213 words]

Presentation type: Oral Presentation

ES14-07 Canada's digital elevation

Marco G. Jorge[1,a,*], Tracy A. Brennand[1], Jonathan E. Cripps[1]

[1] Geography Dept., Simon Fraser University, Burnaby, BC, V5A 1S6
[a] Phone: 778-782-3823, E-mail: mjorge@sfu.ca

Abstract
Digital representations of Earth's surface topography are fundamental in Earth Sciences and geoengineering, such as for geophysical inversions, geomorphological mapping, natural hazard susceptibility assessments, and estimations of sediment volume and provenance. For the majority of Canada, the 1 arc-second (ca. 30m) AW3D30 and SRTM DSMs, and the Canadian CDEM, comprise the best freely, publicly available digital elevation data. The CDEM (DTM) is mostly based on data inventoried at 1:50,000 scale and has a spatial resolution of 0.75 arc seconds at best, but most frequently lower (>20m cell-size). The AW3D30, released in 2016 by the Japanese space agency, is created by down-sampling of a 5m spatial resolution model and is generally substantially superior to the CDEM. The SRTM is limited to latitudes <60º. Provincial governments have developed and are in the process of acquiring higher resolution DEMs (≤5m) for considerable areas, but, based on our experience in British Columbia, access to those or their data sources by academics is still limited. New Brunswick is an exception; the province has made freely available a LiDAR DEM of the whole province. Two notable new products are the 0.4 arc seconds TanDEM-X global DSM by the German space agency and Airbus, and the 2 to 8m pan-Arctic DSM by a consortium of U.S.A. institutions. The TanDEM-X is available for non-profit research at reduced cost and the Arctic DSM, which is not yet completed, will be free. This presentation compares the specifications and the geomorphological merits of the range of digital elevation data available seamlessly for large portions or the whole of the Canadian territory. Using provincial geodetic network benchmarks, we compute and compare the accuracy and precision of the different DEMs in British Columbia's Interior Plateau. [293 words]

Presentation type: Poster

ES14-08 Modelling of depth to bedrock and soil composition attributes at the catchment scale

Antoine Prince[1*], Jan Franssen[1], and Jean-François Lapierre[2]

[1] Geography Dept., Université de Montréal, Montréal, QC, H2V 2B8
2 Biology Sciences Dept., Université de Montréal, Montréal, QC, H2V 2S9
Phone: (514)-781-4743, E-mail: antoine.prince@umontreal.ca

Abstract
Detailed mapping of subsurface characteristics at broad spatial scales is one of the fundamental challenges in geoscience. Depth to bedrock (DTB) and soil composition attributes (SCA) (e.g. hydraulic conductivity, grain-size) are critical to our understanding of hydrologic and geomorphic processes. DTB and SCA are controlling factors in the movement and storage of shallow groundwater, and the mapping of these attributes across catchments should prove useful in determining sediment source areas. DTB and SCA are defined by weathering, erosion and deposition processes that are controlled in part by surface and subsurface hydrologic dynamics, which in humid regions are closely related to topographic and landscape metrics. Methods used to model and predict DTB and SCA at broad scales include: (i) simple interpolation models based on point-scale measures; (ii) physically-based soil evolution models; and (iii) empirico-statistical models consisting of a multiple linear regression analysis used to correlate punctual measures to landscape topographic attributes (e.g. Earth curvature, slope, upslope accumulated area). Previous research suggests that this latter method can be used to obtained detailed DTB maps based on several key geomorphometric attributes of a terrain. Here, we present our methodology for testing geostatistical modeling approaches for obtaining detailed maps of DTB and SCA within nested sub-catchments of a Precambrian shield watershed. Local measurements of DTB and SCA will be obtained with intrusive (e.g. coring, probing) and non-intrusive (e.g. electrical resistivity surveys) methods. These measures will then be related to landscape topographic attributes obtained from terrain analysis of a high-resolution (i.e., sub-meter) LiDAR digital elevation model. This research will contribute to a broader integrated study of hydrogeomorphic and hydroecologic processes in Precambrian shield headwater catchments. [270 words]

Presentation type: Poster