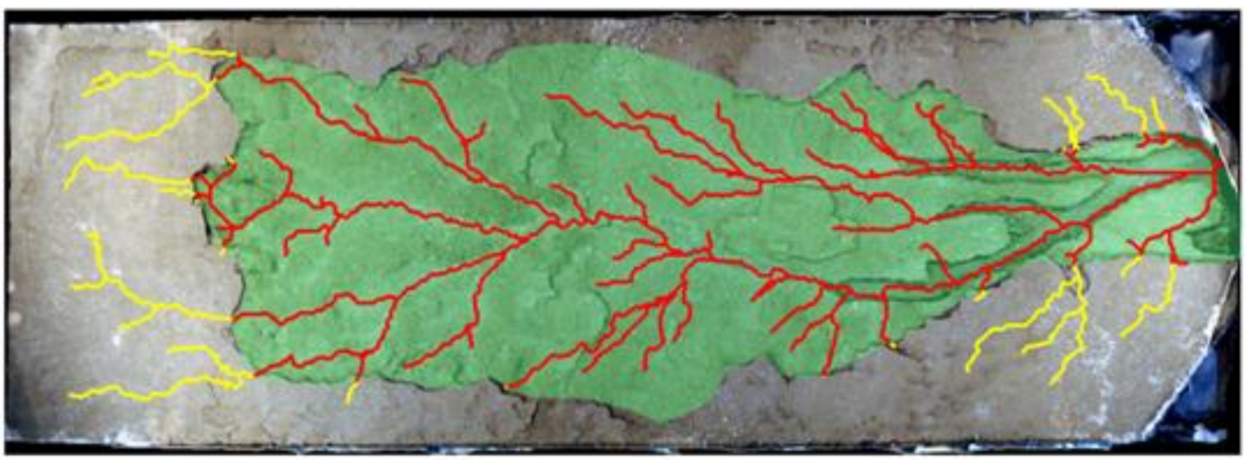
Laboratory Experiments in Geomorphology

46th Annual Binghamton Geomorphology Symposium

September 18 to 20, 2015
University at Buffalo

FINAL PROGRAM



Organized by:

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Introduction

The study of geomorphic systems—the analysis of the processes that shape the Earth's surface and their associated landforms—has been dominated by field research endeavors (Bennett et al., 2015). This field tradition of geomorphic research can be traced back to the world's early explorers, which provided the impetus for physiographic mapping and the necessary context to consider landscape origin and evolution (Church, 2013). The focus on field geomorphic research also is logical because geomorphologists can conduct research activities at the exact locations where processes operate and landforms are created (McKenna Neuman et al., 2013).

Yet field research is not the only methodological approach available to the geomorphic research community. A second approach is numerical modeling. Here, modeling is broadly defined to include empirical and statistical approaches to quantify geomorphic phenomena, analytical approaches to define or extend governing equations, and numerical models of varying complexity to simulate and heuristically investigate geomorphic systems. A third methodological approach available to the geomorphic research community is physical modeling and experimentation using laboratory facilities. Here, physical modeling is broadly defined to include scaled models based on similarity principles, analogue models based on similarity in form and/or composition, and single-purpose facilities designed to explore a specific geomorphic phenomenon. Experimental investigation has been part of geomorphology for many decades, although few treatises or seminal papers report on the design and use of laboratory experiments and facilities in geomorphology.

The annual Binghamton Geomorphology Symposium (BGS) is one of the most recognizable geoscience meetings worldwide. For nearly 50 years, the symposium series has addressed a wide range of scientific and socially relevant topics in geomorphology, engaging a multitude of geoscientists (Sawyer et al., 2014).

Three primary drivers exist for hosting a symposium entitled "Laboratory Experiments in Geomorphology." First, no BGS symposium has focused on the topic of laboratory experiments, in spite of enormous activity and recent re-engagement and expansion in this area. Second, few treatises currently are available to the geomorphic community that provide detailed information about the design, construction, and execution of laboratory experiments and how these facilities can be used for transformative research. Third, the importance of experimental facilities in research on Earth surface processes was recently highlighted by the National Research Council (2010). This report noted that experimental research can be used to develop, test, and validate geomorphic transport laws as well as examine the emergence of organized landscapes.

The 46th Binghamton Geomorphology Symposium seeks to bring together leading experts and emerging scientists actively engaged in experimental geomorphic research. Geomorphic research has been greatly enhanced and transformed by laboratory experiments and the future of geomorphic research depends on the continued complementarity and successful melding of the three approaches to geomorphic research: field work, numerical modeling, and laboratory experimentation.

Symposium Organization and Support

The symposium was organized by Sean J. Bennett, University at Buffalo, Peter Ashmore, University of Western Ontario, and Cheryl McKenna Neuman, University of Trent. The organizers invited the following individuals to serve on the Scientific Committee for the symposium: Les Hasbargen, State University of New York-Oneonta, Leslie Hsu, Lamont-Doherty Earth Observatory, and Brandon McElroy, University of Wyoming.

Financial support for the symposium was kindly provided by the National Science Foundation. Logistic support for the symposium was kindly provided by the National Center for Geographic Information and Analysis, the Office of Special Events, and Three Pillars Catering, University at Buffalo.

Venue

The symposium will be held at the Center for Tomorrow, on the North Campus of the University at Buffalo (Figure 1). The Center for Tomorrow features over 4,500 square feet of space to comfortably accommodate from 10 to 300 guests. As the University's sole facility dedicated to conference and banquet support, this year-round, multi-purpose building will be divided into tailored meeting spaces, speaker venues, and poster displays, plus it has a comfortable, private boardroom. All meals, presentations, and posters scheduled for Saturday, Sept. 19 and Sunday, Sept. 20, will be at this facility. There is ample parking directly in front of the center.

Travel from the Airport

Many of the motels near the campus offer shuttle service to and from the airport. The invitees will be staying at the DoubleTree by Hilton-Buffalo/Amherst, 10 Flint Road. Once an attendee arrives to Buffalo, they may call the motel at 716-689-4414, and the motel shuttle will be dispatched. Alternatively, participants could take a taxi from the airport to their motel. For example, the Airport Taxi Service, which would have taxis waiting outside of baggage claim, would charge approximately $35 for a one-way fare to the North Campus of the University at Buffalo.

Registration Fees, Amenities, and Graduate Student Support

The fees for the symposium are as follows: $150 for students and $250 for professionals. This fee includes printed materials, breakfast and lunch on Saturday and Sunday, dinner Saturday night, and all coffee breaks.

Funds are available to partially support the participation of graduate students. These funds, and any residuals from the symposium, will be dispensed after all expenditures are resolved.

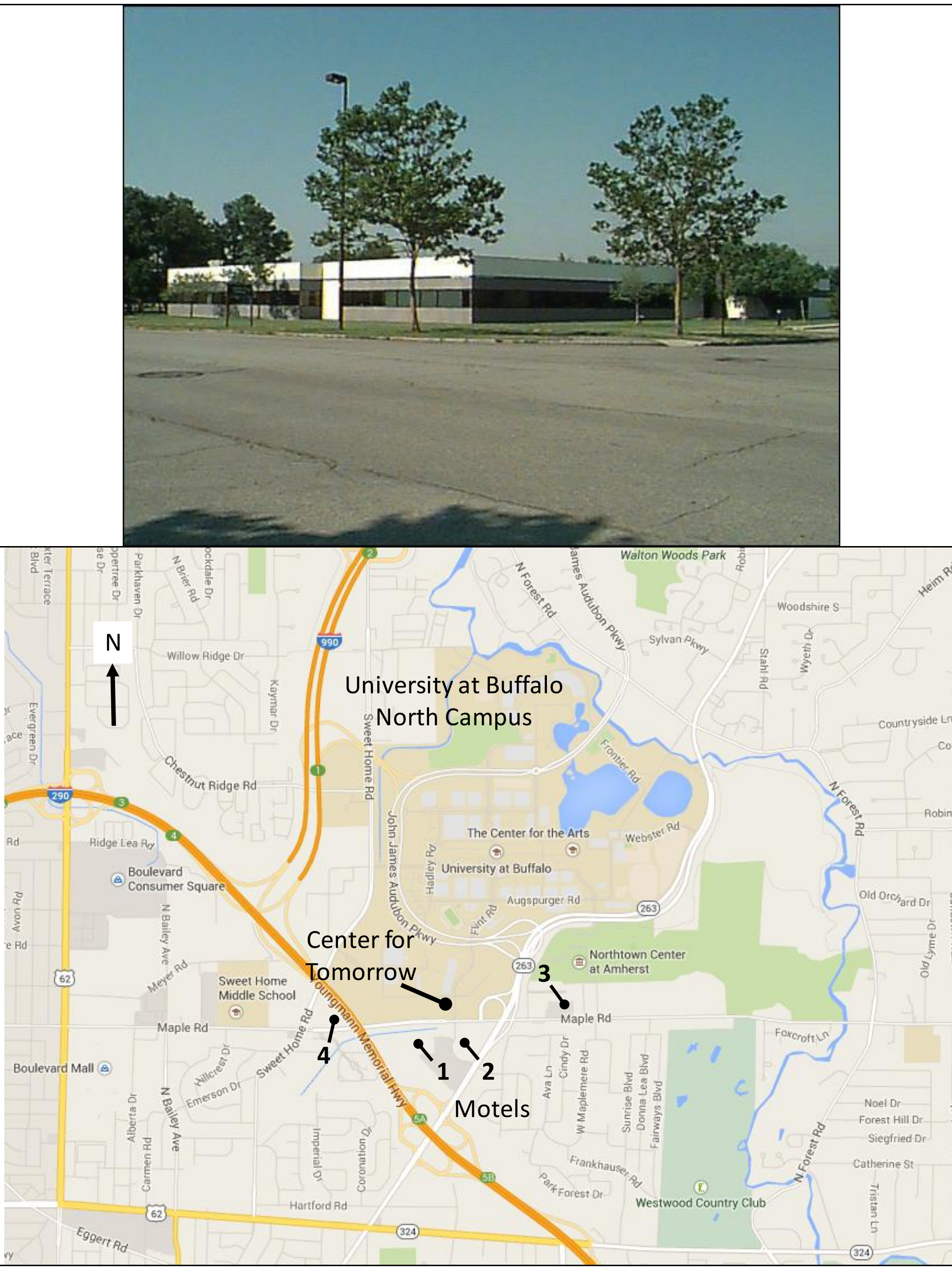

Figure 1: The Center for Tomorrow, venue for the symposium, showing a photograph of the facility (above) and a map location (below). The numbered locations identify nearby motel: (1) DoubleTree by Hilton-Buffalo/Amherst, 10 Flint Road, (2) Comfort Inn University, 1 Flint Road, (3) Residence Inn—Buffalo/Amherst, 100 Maple Road, and (4) Motel 6—Buffalo/Amherst, 4400 Maple Road.

Tour of Experimental Facilities

Given the focus of the current symposium, the co-organizers have arranged a pre-meeting fieldtrip comprised of a tour and hands-on demonstration of the experimental facilities at the University at Buffalo. The university has three (3) fully-functional and diverse laboratories to examine Earth surface processes. These facilities include: (a) the Wilkeson Hydraulics Laboratory, with a tilting recirculating flume, a mixing box, an impinging jet apparatus, a particle image velocimetry (PIV) system, and a wide array of additional equipment; (b) the Statler Geomorphology Laboratory, with a large flume for soil erosion and stream channel studies, an overland flow flume, and a stream corridor flume, all with rainfall simulators, photogrammetry systems, and other devices; and (c) the Jarvis Hydraulics Laboratory, comprised of several recirculating flumes and a rotating room with a scaled-model of Lake Ontario. The location of these laboratories and photographs of select experimental facilities are provided in Figure 2.

The guided tour and hands-on demonstration will run on Friday, September 18, from 12:00 to 17:00 at the onsite experimental facilities. At each location, graduate students and faculty will be on-hand to describe the experiment and to demonstrate the facility and data collection. The tour will begin by assembling outside of the Center for Tomorrow at 12:00 (Figure 2). The participants will be subdivided into groups and transported around campus using shuttles and guided to the facilities. Convenience stops will be provided. All participants will be returned to the Center for Tomorrow no later than 17:00.

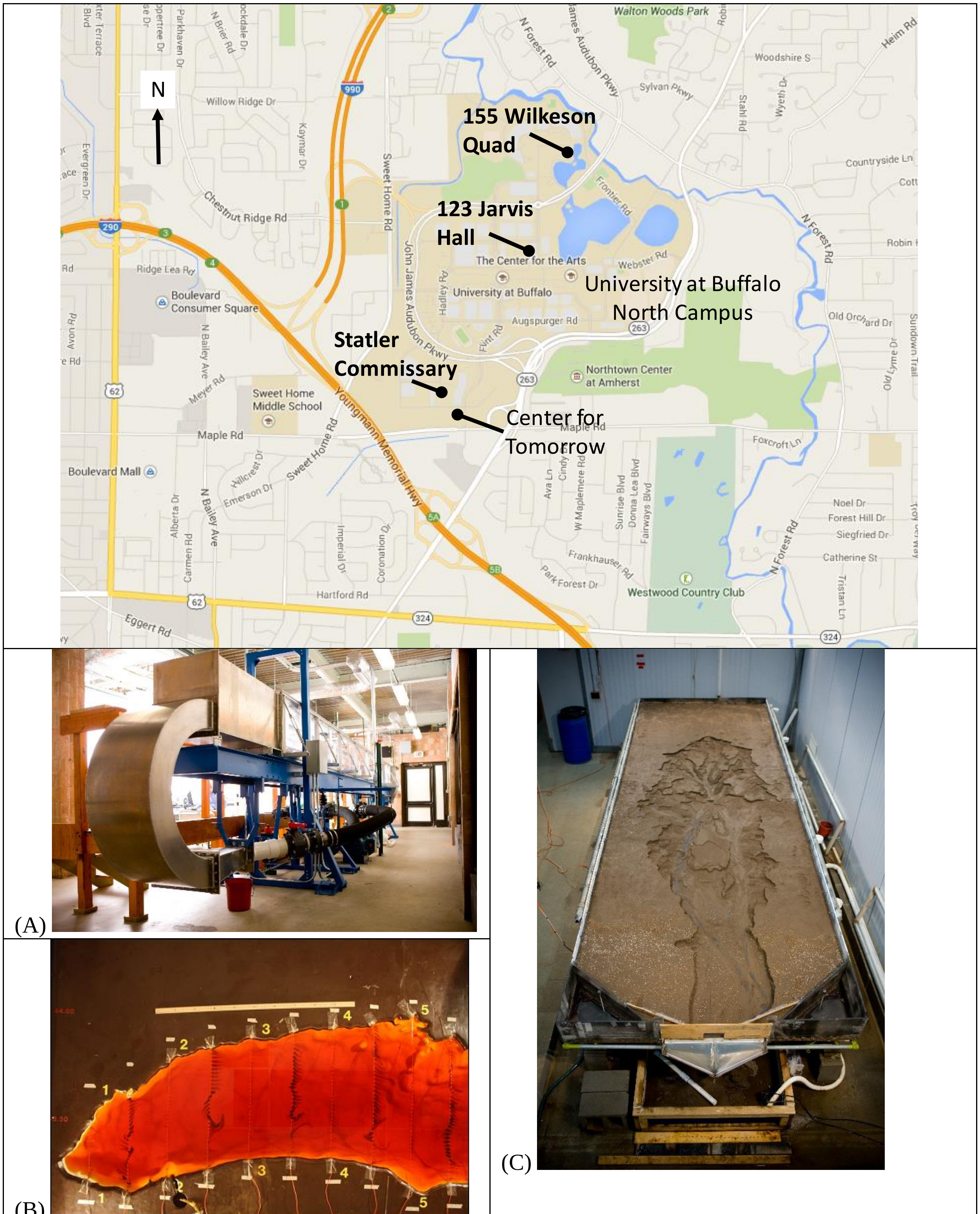

Figure 2: Map locations for the laboratory tour, with photographs showing the facilities in (A) 155 Wilkeson Quad, (B) 120 Jarvis Hall, and (C) Statler Commissary.

Program

There are many geomorphic themes that can be examined through experimentation. Owing to the short duration of the symposium, and to the single-session venue, the co-organizers identified eight (8) topics that could be represented at the symposium, which span a wide range of environments and scales. These topics are as follows: (1) granular flows and hillslopes; (2) fluvial processes; (3) aeolian processes; (4) coastal and marine processes; (5) glacial and periglacial geomorphology; (6) landscape and planetary processes; (7) biophysical and ecogeomorphic processes; and (8) large-scale facility development and data management. This is not an exclusive inventory, but it helped frame the list of potential contributors.

Using these themes, the co-organizers assembled a long list of potential speakers, which was then whittled down in size. To accomplish this, the co-organizers were motivated to achieve strong diversity within the program. This was done on the basis of gender, geography, career stage, and perspective. In every case, the co-organizers were able to secure positive commitments from the top candidates in each thematic area. Some changes were required to the program due to conflicts in scheduling.

List of Speakers and Program Itinerary

Below are tables detailing each day's list of speakers, activities, presentations, and social events.

<u>Friday, September 18, 2015</u>

Time		Activity
12:00	17:00	Guided tour and demonstration of experimental facilities at the University at Buffalo. Assemble at the Center for Tomorrow.

Friday night: Dinner on one's own.

<u>Saturday, September 19, 2015, Center for Tomorrow</u>

Time		Activity/Presentation
7:30	8:30	Registration, poster session, continental breakfast
8:30	8:45	Welcome and Introduction
8:45	9:30	**Gerard Govers** [KEYNOTE], Full scale experiments in geomorphology: Have they a future?
		Theme: Granular Flows and Hillslope Processes
9:30	10:00	**David J. Furbish**, Meshing experimental insights with views of sediment transport on hillslopes involving long timescales: Tweaking the autocatalytic worldview of hillslope geomorphology
10:00	10:20	Break and poster session
10:20	10:50	**Richard M. Iverson**, Scaling and design of landslide and debris-flow experiments
		Theme: Fluvial Processes
10:50	11:20	**Michael P. Lamb**, New insights into the mechanics of fluvial bedrock erosion through flume experiments and theory
11:20	11:50	**Elowyn M. Yager**, Taking the river inside: Fundamental advances from laboratory experiments in measuring and understanding bedload transport processes
11:50	14:00	Lunch, meetings, and poster session
14:00	14:30	**Maarten G. Kleinhans**, Swiftness of morphodynamics in Lilliput-to-Giant-sized rivers and deltas
		Theme: Aeolian Processes
14:30	15:00	**Keld R. Rasmussen**, Laboratory studies of aeolian and sediment transport processes on planetary surfaces

15:00	15:20	Break and poster session
		Theme: Coastal and marine processes
15:20	15:50	**Heidi Nepf**, Vegetation-flow Interaction: connecting lab experiments to field observation and landscape modeling
15:50	16:20	**Jeff Peakall**, Submarine channel flow processes and deposits: a process-product perspective
		Theme: Glacial processes
16:20	16:50	**Neal R. Iverson**, Experiments on the dynamics and sedimentary products of glacier slip
16:50	18:00	Refreshments and poster session
19:00	22:00	Banquet

<u>Sunday, September 20, 2015, Center for Tomorrow</u>

Time		**Activity/Presentation**
7:30	8:30	Registration, poster session, continental breakfast
8:30	8:45	Announcements
8:45	9:30	**Chris Paola** [KEYNOTE], Effects of waves, tides, and cohesive sediment on deltas at experimental scales
		Theme: Landscape and planetary processes
9:30	10:00	**Lucy E. Clarke**, Experimental alluvial fans: advances in understanding of fan dynamics and processes
10:00	10:20	Break and poster session
10:20	10:50	**Fabien Graveleau**, Experimental modelling of tectonics-erosion-sedimentation interactions in compressional, extensional, and strike-slip settings
		Theme: Biophysical and ecogeomorphic processes
10:50	11:20	**Joseph Atkinson**, Physical and numerical modeling of lake hydrodynamics
11:20	11:50	**Joanna C. Curran**, Real time measurements of sediment transport and bed morphology during channel altering flow and sediment transport events
11:50	13:30	Lunch, meetings, and poster session
		Theme: Large-scale facility development and data management
13:30	14:00	**Alison Graettinger**, Large-scale outdoor facility for geohazard experiments with results from recent explosive cratering experiments
14:00	14:30	**Luke Pangle**, The Landscape Evolution Observatory: a large-scale controllable infrastructure to study coupled Earth-surface processes
14:30	15:00	**Leslie Hsu & Brandon McElroy**, Data management, sharing, and reuse in experimental geomorphology: challenges, strategies, and scientific opportunities
15:00		Closing Remarks: **E. Bruce Pitman**, Dean, College of Arts and Sciences

Dissemination of the Results
The primary outlet for disseminating the results of the symposium is publication of papers prepared by the invitees in a special issue of the journal *Geomorphology*. All invited speakers were afforded the opportunity to submit a paper to this special issue.

The special issue in the journal *Geomorphology* was published September 1, 2015, and it is Volume 244, Pages 1-204, edited by Sean J. Bennett, Peter Ashmore and Cheryl McKenna Neuman. Below is a list of all papers appearing in this issue, written and submitted in support for the symposium.

Transformative geomorphic research using laboratory experimentation, by Sean J. Bennett, Peter Ashmore, Cheryl McKenna Neuman. pp. 1-8,

Scaling and design of landslide and debris-flow experiments, by Richard M. Iverson, pp. 9-20.
Taking the river inside: Fundamental advances from laboratory experiments in measuring and understanding bedload transport processes, by E.M. Yager, M. Kenworthy, and A. Monsalve, pp. 21-32.
New insights into the mechanics of fluvial bedrock erosion through flume experiments and theory, by Michael P. Lamb, Noah J. Finnegan, Joel S. Scheingross, and Leonard S. Sklar, pp. 33-55.
Swiftness of biomorphodynamics in Lilliput- to Giant-sized rivers and deltas, by Maarten G. Kleinhans, Christian Braudrick, Wout M. van Dijk, Wietse I. van de Lageweg, Roy Teske, and Mijke van Oorschot, pp. 56-73.
Laboratory studies of aeolian sediment transport processes on planetary surfaces, by Keld R. Rasmussen, Alexandre Valance, and Jonathan Merrison, pp. 74-94.
Submarine channel flow processes and deposits: A process-product perspective, by Jeff Peakall and Esther J. Sumner, pp. 95-120.
Experiments on the dynamics and sedimentary products of glacier slip, by Neal R. Iverson and Lucas K. Zoet pp. 121-134.
Experimental alluvial fans: Advances in understanding of fan dynamics and processes, by Lucy E. Clarke, pp. 135-145.
Experimental modelling of tectonics–erosion–sedimentation interactions in compressional, extensional, and strike–slip settings, by Fabien Graveleau, Vincent Strak, Stéphane Dominguez, Jacques Malavieille, Marina Chatton, Isabelle Manighetti, and Carole Petit, pp. 146-168.
Real time measurements of sediment transport and bed morphology during channel altering flow and sediment transport events, by Joanna Crowe Curran, Kevin A. Waters, and Kristen M. Cannatelli, pp. 169-179.
Data management, sharing, and reuse in experimental geomorphology: Challenges, strategies, and scientific opportunities, by Leslie Hsu, Raleigh L. Martin, Brandon McElroy, Kimberly Litwin-Miller, and Wonsuck Kim, pp. 180-189.
The Landscape Evolution Observatory: A large-scale controllable infrastructure to study coupled Earth-surface processes, by Luke A. Pangle, Stephen B. DeLong, Nate Abramson, John Adams, Greg A. Barron-Gafford, David D. Breshears, Paul D. Brooks, Jon Chorover, William E. Dietrich, Katerina Dontsova, Matej Durcik, Javier Espeleta, T.P.A. Ferre, Regis Ferriere, Whitney Henderson, Edward A. Hunt, Travis E. Huxman, David Millar, Brendan Murphy, Guo-Yue Niu, Mitch Pavao-Zuckerman, Jon D. Pelletier, Craig Rasmussen, Joaquin Ruiz, Scott Saleska, Marcel Schaap, Michael Sibayan, Peter A. Troch, Markus Tuller, Joost van Haren, and Xubin Zeng, pp. 190-203.

References Cited

Bennett, S.J., P. Ashmore, and C. McKenna Neuman, 2015, Transformative geomorphic research using laboratory experimentation, Geomorphology, 244, 1-8.
Church, M., 2013, Refocusing geomorphology: Field work in four acts, Geomorphology, 200, 184-192.
McKenna Neuman, C., P. Ashmore, and S.J. Bennett, 2013, Laboratory and experimental geomorphology: Examples from fluvial and aeolian systems, in J. Shroder (Editor in Chief), A.R. Orme and D. Sack (Eds.), Treatise on Geomorphology, Academic Press, San Diego, vol. 1, The Foundations of Geomorphology, pp. 325-348.
National Research Council, 2010, Landscapes on the Edge: New Horizons for Research on Earth's Surface. Committee on Challenges and Opportunities in Earth Surface Resources, Board on Earth Sciences and Resources, Division on Earth and Life Studies, The National Academies Press, Washington, D.C., 180 pp.

Acknowledgements

The symposium was financially supported by NSF. We thank the National Center for Geographic Information and Analysis, University at Buffalo, for logistical support. We also would like to thank the referees who provided reviews of the papers submitted in support of the symposium.

Poster Session

Abstracts were solicited from students, faculty, and professional for presentation during the meeting as posters. There was no limit or expectations on poster submissions, except that the presenter must be registered for the symposium. Moreover, each abstract could be up to pages in length and include figures, where appropriate. Posters should be no larger than 4-ft wide and 3-ft high with a landscape orientation. Posters will be setup by Saturday morning, Sept. 19, and they will be accessible during all breaks and meals.

All poster abstracts have been listed and numbered alphabetically, and all poster boards and/or areas where posters will be displayed also will be numbered accordingly. The abstracts for all posters are provided below.

1. Revealing the dynamics of flow around complex geomorphology: an approach using refractive index matching

Jim Best [1,2]*, Julio Barros[3], Gianluca Blois[4], Ken Christensen[4], Taehoon Kim[4], and Derek Lichtner[1]

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[2]Departments of Geography and GIS, Mechanical Science and Engineering and Ven Te Chow Hydrosystems Laboratory, University of Illinois at Urbana-Champaign, Champaign, IL 61820
[3]Department of Mechanical Engineering, United States Naval Academy, Annapolis, Maryland.
[4]Departments of Aerospace and Mechanical Engineering and Civil and Environmental Engineering and Earth Sciences, University of Notre Dame, IN 46556
*Presenter

Quantifying flow near the surface of, and around, complex geomorphologic topography has been an experimental challenge for many decades, with the fluid dynamics near three-dimensional topography, or flow that is hidden from direct view, often being difficult, if not impossible, to measure. We have addressed this issue by adopting an experimental approach in which the refractive index of the experimental model is matched to that of the fluid, thus rendering the model invisible and suitable for measurements using laser-based techniques such as PIV. Here, we describe the technique, the flumes constructed for permitting a wide range of geophysical flow experiments, and highlight the challenges and possibilities offered using refractive-index matching (RIM).

Our approach has been the combined use of acrylic for the laboratory models and sodium iodide (NaI) as the working fluid: at the correct concentration (~63% by weight) and temperature, the NaI possesses the same refractive index (n_f ~ 1.49) as the acrylic and thus complex models become invisible. The NaI solution has a specific gravity of ~1.8 and its kinematic viscosity (ν_{NaI} = 1.1–1.5 10^{-6} m^2s^{-1}) is only 10-15% greater than that of water, thus permitting experiments to be run at high flow Reynolds numbers.

The NaI is used within a small prototype tunnel that has enabled a wide array of experiments, and also served as the test facility for construction of larger facilities. The test section of the prototype flume is constructed of clear acrylic, is 2.50 m long and possesses a constant cross-section of 0.1125 × 0.1125 m. The slope of the test section is adjustable from 0 to +2%. While the floor and sidewalls are fixed, the ceiling is removable to provide full access to the interior of the tunnel for maintenance and installation of flow models. The removable cover is sealed with an EPDM gasket and secured with stainless steel fasteners to handle a slight positive (5 psi) pressure. This capability allows generation of free-surface flows by filling the test section only partially with the working fluid and introducing nitrogen gas (N_2) into the overlying space under a slight positive pressure. The use of N_2 avoids the risk of discoloration of the salt solution, which occurs by I^{3-} ions formed by simultaneous exposure to oxygen and visible light. The NaI solution is chemically unstable in the simultaneous presence of oxygen and light. This chemical instability results in two problems: high corrosion and, above all, optical degradation. The NaI was stabilized by removal of the dissolved oxygen using a dedicated deoxygenation processor. The deoxygenation procedure consisted of exposing the solution to cycles of deep vacuum (-29.9" Hg) followed by nitrogen pressurization (5-10 psi). By increasing the partial pressure of the nitrogen component, the partial pressure of the oxygen in turn decreases. The RIM flume is equipped with two fiberglass-reinforced centrifugal pumps that deliver a combined discharge in the range 0.016 – 1 m^3s^{-1}. Due to energy transferred by the pumps to the working fluid, temperature control of the system using a thermocouple is critical, not only for fine-tuning the RI of the fluid, but also for maintaining a constant fluid temperature over long periods of time to enable long duration experiments. Additional details on the technique and facility are given in Blois et al. (2012, 2014).

Here, we demonstrate the capabilities of this technique, including flow over and within a porous block, flow over and within a gravel river bed surrogate using acrylic spheres (Figure 1), and flow associated with interacting barchan dunes. Each experimental program has allowed unique measurements to be conducted in regions of flow inaccessible using other experimental approaches.

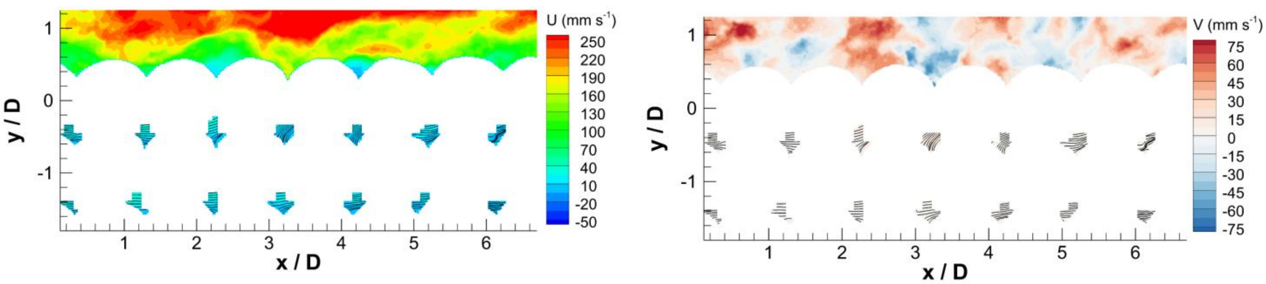

Figure 1. Examples of instantaneous realizations of flow above, and within, a flat gravel bed comprising 1.27cm diameter acrylic spheres in a cubic packing arrangement. Flow left to right. Left: Streamwise velocity, U, and Right: Vertical velocity, V. The downstream, x, and vertical, y, dimensions are normalized by the sphere diameter, D. Streamlines are also plotted within the pore spaces. Note the ability of RIM to resolve flow both very near to the bed surface, as well as in the pore spaces. This technique thus allows investigation of flow across this interface, and how turbulence is modulated in both the near-bed and hyporheic flow zones.

References

Blois, G., J.L. Best, K.T. Christensen, R.J. Hardy and G.H. Sambrook Smith, 2013. Coherent flow structures in the pore spaces of permeable beds underlying a unidirectional turbulent boundary layer: a review and some new experimental results, In: *Coherent Flows at Earth's Surface*, (Eds Vendetti, J.G., Best, J.L., Church, M. and Hardy, R.J.), 43-62, Wiley Blackwell.

Blois, G., K. T. Christensen, J.L. Best, G. Elliott, J. Austin, M. Garcia, M. Bragg, J.C. Dutton and B. Fouke, 2012. A Versatile Refractive-Index-Matched Flow Facility for Studies of Complex Flow Systems Across Scientific Disciplines. *50th American Institute of Aeronautics and Astronautics (AIAA) Aerospace Sciences Meeting, Nashville, TN, AIAA Paper* 2012-0736, January 2012. doi: 10.2514/6.2012-736.

2. Controls on lateral erosion of an active uplift by antecedent streams: an experimental study

N. Aaron Bufe[1]*, Chris Paola[2], and Douglas W. Burbank[1]

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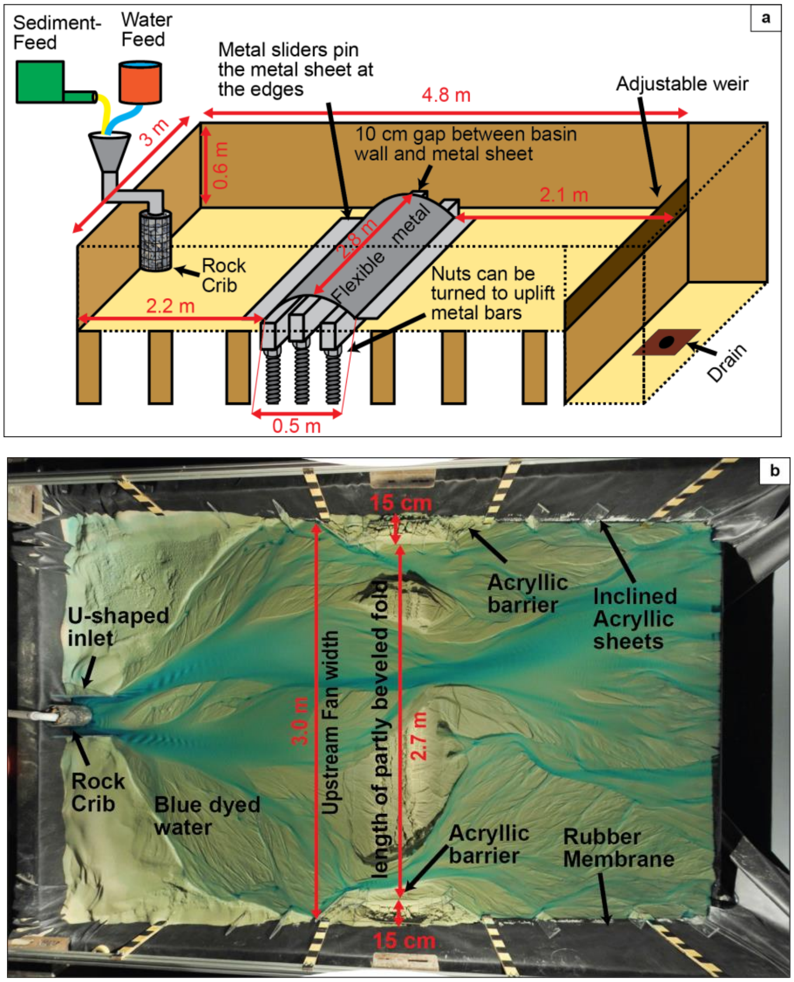

Figure 1: Experimental Setup. A) Sketch of the basin and the uplift mechanism. B) Head down photograph of the final stages of Run 3 (c.f. Figure 2).

The controls on the partitioning of incision and lateral erosion of rivers are still poorly understood. We present an analogue model of a growing anticline perpendicular to antecedent streams on an alluvial fan. This experiment is inspired by an example of laterally extensive beveling of actively uplifting detachment anticlines in the foreland of the Tian Shan. A wooden box with dimensions of 3x5x0.6 m with a 50-cm-wide slot across the center of the basin (Fig. 1) was built at St Anthony Falls Laboratory, Minneapolis. Inset into the central slot are three metal beams that can be raised to fold a flexible metal sheet. The basin is filled with well sorted coarse sand and has a fixed base level controlled by a weir on the downstream side. Sediment and water are fed from a single inlet on the upstream side and rapidly organize into a channelized alluvial fan that encounters an actively growing fold. Six experiments were performed varying uplift rate and sediment influx (Fig. 2). Overhead photographs and high-resolution topographic scans were analyzed to extract the channel mobility and the beveled area of the fault. Our results suggest that the width of a beveled platform across a fold is controlled by a competition between uplift rate and channel mobility and that order of magnitude changes in the ratio of these parameters are necessary to explain significant variations in the width of beveled valleys (Fig. 3). Furthermore, the width of the upstream alluvial fan is critical in setting the beveled area (Fig. 3). We note that only a limited number of parameters could be explored and that the dependence of lateral erosion on rock strength and water flux remains untested. Moreover, an unknown length scale has to be introduced to obtain a non-dimensional parameter controlling the beveled area. It is possible that this length scale is linked to the dimension of the water flux, such as the depth of flow, but more experiments are necessary to test this hypothesis.

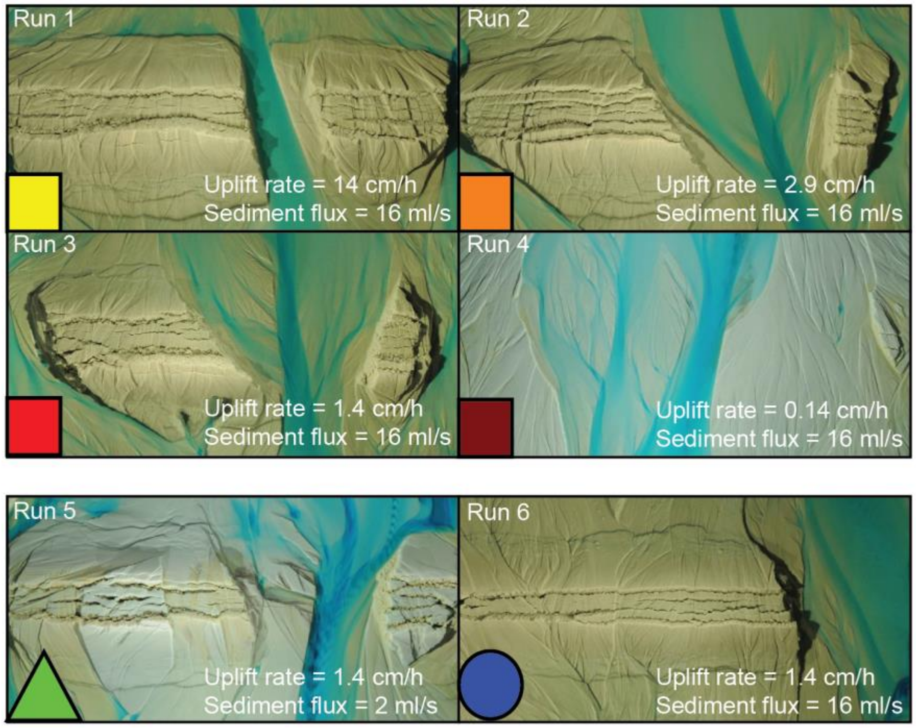

Figure 2: Images of the fold shape in the final stages of all experiments. The colored geometric shapes mark the color scheme adopted in Figure 3.

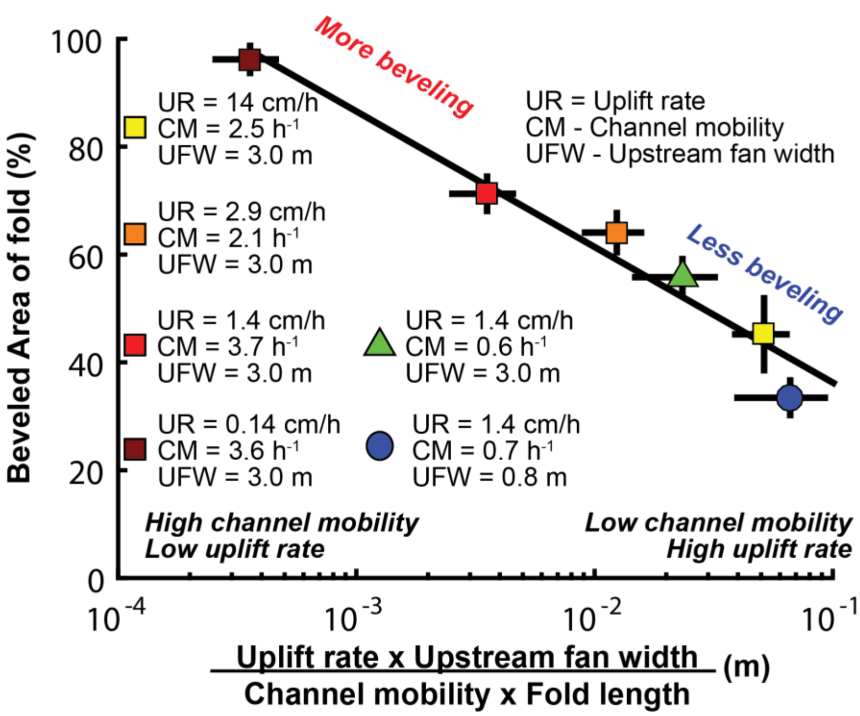

Figure 3: The beveled area of the fold as a function of uplift rate and channel mobility. The ratio is normalized by the upstream fan width in order to account for the upstream boundary condition.

3. Double diffusive sedimentation in sediment laden interflows

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*Presenter

When a sediment-laden river enters into a stratified lake or the coastal ocean, it is of great interest to know how fast the sediment settles from the resulting surface or sub-surface intrusion, as the settling rate then largely determines the spatial scale of sediment deposition on the lake bed or ocean floor. Although the sediment-laden intrusion can be stable with respect to density, a double diffusive instability may arise due to the diffusion of salt being much faster than the Brownian diffusion of sediment [1]. Such instability results in the “sediment fingering” transport phenomena: a double diffusive sedimentation associated with vertical sediment concentration and salt gradient. Sediment fingering is governed by similar mechanism as salt fingering, but there is a paucity of solid experimental or theoretical descriptions of the process, which motivates the present study.

Our new quantitative experimental investigation of double diffusive sedimentation makes direct measurements of different flow characteristics associated with such sedimentation process. A series of experiments are used to make the first direct velocity measurements of sediment fingering convection using a high resolution Nortek Acoustic Doppler Velocimeter (ADV) to measure turbulent convection above and below the density interface. Previous experiments on sediment fingering estimate the velocities of the sediment fingers using series of photos. They showed that the velocities for these fingers could be an order of magnitude higher than the Stokes settling velocity of the particles [1, 2, 3, 4, 5, 6]. However these visual methods could only measure mean velocities, and were limited to the lower optically clear layer. Our new experiments will also be compared to the results with the recent DNS numerical simulations [7, 8].

The new experimental results quantitatively confirm that the velocity of the sediment fingers in the lower layer are always larger than their Stokes settling velocity, in some cases by several orders of magnitudes. Our measurements also show an asymmetry in the turbulent velocity between the upper and lower convective layers. This suggests that sediment fingering is acting in concert with the mean settling velocity, so that the velocity of the convection in the upper layer is much smaller than the velocity of sediment fingers.

In addition to these quantitative results on when double diffusive sedimentation occurs, we will also present preliminary experimental results that document how the spatial scale of sedimentation changes between situations when double diffusive effects are important, and the case where sedimentation is slow and dominated by the settling velocity.

References

[1] J. D. Parsons and M. H. Garcia, Enhanced sediment scavenging due to double-diffusive convection. Journal of Sedimentary Research, Vol. 70, No. 1, pp. 47-52 (2000).
[2] C. F. Chen, Particle flux through sediment fingers. Deep-Sea Research, Vol. 44, No. 9-10, pp. 1645-1654 (1997).
[3] T. Green, The importance of double diffusion to the settling of suspended material. Sedimentology, Vol. 34, pp. 319-331 (1987).
[4] D. C. J. D. Hoyal, M. I. Bursik and J. F. Atkinson, The influence of diffusive convection on sedimentation from buoyant plumes. Marine Geology, Vol. 159, pp. 205-220 (1999a).

[5] D. C. J. D. Hoyal, M. I. Bursik and J. F. Atkinson, Settling-driven convection: A mechanism of sedimentation from stratified fluids. Journal of Geophysical Research, Vol. 104, No. C4, pp. 7953-7966 (1999b).
[6] J. D. Parsons, J. W. M. Bush and J. P. M. Syvitsky, Hyperpycnal plume formation from riverine outflows with small sediment concentrations. Sedimentology, Vol. 48, pp. 465-478 (2001).
[7] P. Burns and E., Meiburg, Sediment-laden fresh water above salt water: linear stability analysis. Journal of Fluid Mechanics, Vol. 691, pp. 279-314 (2012).
[8] P. Burns and E. Meiburg, Sediment-laden fresh water above salt water: non linear stability analysis. Journal of Fluid Mechanics, Vol. 762, pp. 156-195 (2015).

4. Physical modeling of the feedbacks between invasive Reed Canarygrass (*Phalaris arundinacea)*, hydraulics, and bed form evolution

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This study examines the effects of the invasive riparian ecosystem engineer *Phalaris arundinacea*, or Reed Canarygrass (RCG), on riverbed form evolution and subsequent feedback cycles. The linkage between the interdependent processes in riparian biological communities and fluvial geomorphology works to alter the aquatic landscape as described in the biogeomorphology concept[1]. It is found that many riparian vegetation species act as ecosystem engineers by creating pioneer landforms that impact channel morphology[2]. This alteration of the river's physical landscape results in accelerated reach scale morphological changes such as an increase in flow velocity, alterations to the Manning's roughness[3] and an increase in the availability for riparian colonization sites. In the case of *P. arundinacea*, propagation results primarily from rhizome shoots, floating rhizome mats and seed dispersal in a wide range of ecological conditions[4]. With the highest germination rates in saturated soils[5], RCG can easily spread in many aquatic habitats, including rivers where the plant can form mid-channel patches. This research will investigate the invasive Reed Canarygrass' control of fluvial landform development by quantifying the change in bed form topography as a result of changing depths of submergence in a hydraulic flume. Using Froude similitude, vegetation is scaled to flume channel geometry using depth as characteristic length. Through the implementation of a physical model, feedbacks associated with bed form evolution that further link biological and physical processes will be explored. A primary hypothesized feedback is as depth of submersion increases and plant becomes fully deflected, *P. arundinacea* decreasingly contributes to bed form development in the low velocity wake region, which leads to a decreased surface for further colonization behind the patch. A second possible feedback of the bedform expansion includes the narrowing of the river channel and increased lateral velocities[6], maintaining a transport mechanism for further downstream rhizome and seed dispersal but also limiting patch expansion laterally. The results of the proposed research will ultimately contribute to the fundamental understanding of the linkage between fluvial geomorphology and vegetation, as well as the management of invasive species.

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[1]D. Corenblit et al., "Feedbacks between Geomorphology and Biota Controlling Earth Surface Processes and Landforms: A Review of Foundation Concepts and Current Understandings," *Earth-Science Reviews* 106, no. 3–4 (June 2011): 307–31, doi:10.1016/j.earscirev.2011.03.002.

[2]A.M. Gurnell, W. Bertoldi, and D. Corenblit, "Changing River Channels: The Roles of Hydrological Processes, Plants and Pioneer Fluvial Landforms in Humid Temperate, Mixed Load, Gravel Bed Rivers," *Earth-Science Reviews* 111, no. 1–2 (February 2012): 129–41, doi:10.1016/j.earscirev.2011.11.005.

[3]M. Luhar and H.M. Nepf, "From the Blade Scale to the Reach Scale: A Characterization of Aquatic Vegetative Drag," *Advances in Water Resources*, 35th Year Anniversary Issue, 51 (January 2013): 305–16, doi:10.1016/j.advwatres.2012.02.002.

[4]S. Lavergne and J. Molofsky, "Reed Canary Grass (*Phalaris Arundinacea*) as a Biological Model in the Study of Plant Invasions," *Critical Reviews in Plant Sciences* 23, no. 5 (September 2004): 415–29, doi:10.1080/07352680490505934.

[5]H. Coops and G. Van Der Velde, "Seed Dispersal, Germination and Seedling Growth of Six Helophyte Species in Relation to Water-Level Zonation," *Freshwater Biology* 34, no. 1 (August 1, 1995): 13–20, doi:10.1111/j.1365-2427.1995.tb00418.x.

[6]E.M. Follett and H.M. Nepf, "Sediment Patterns near a Model Patch of Reedy Emergent Vegetation," *Geomorphology* 179 (December 15, 2012): 141–51, doi:10.1016/j.geomorph.2012.08.006.

5. Physical-scale river models for evaluating responses of experimental river corridors to engineered log jams

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Engineered log jams (ELJs) provide multifunctional benefits to degraded stream corridors, protecting infrastructure while simultaneously creating aquatic habitat and enhancing the aesthetic qualities of degraded streams. However, limited data on the hydraulic and morphodynamic impacts of differing ELJ design-types and multi-structure deployment configurations is available to inform stream restoration design. To address this gap we conducted a two-part experimental campaign using fixed- and movable-bed depth-distorted Froude-scaled physical river constructs of the Big Sioux River, SD, to evaluate in-stream hydraulic and morphodynamic effects for two ELJ types (ELJ-1 and ELJ-2) deployed in single- and multi-structure configurations each composed of a single ELJ type only.

Model ELJs were created to reflect the dimensions of timber available near the prototype and scaled according to the width-scaling ratio prototype:model; ELJ-1, is a bi-level two- to three-tiered crib style structure installed perpendicular to flow, and ELJ-2 is a three-tiered spur-style structure of uniform height installed at approximately 45° to flow. Drag force acting on an ELJ was measured at a single instrumented structure mounted pendant to flow in the fixed-bed experiments, and varied with differing structure geometry, flow penetration, and angle-to-flow, resulting in drag coefficients of 2.43 and 1.27 for ELJ-1 and ELJ-2 respectively. In two- and three-ELJ configurations, a decrease in drag force acting on the downstream instrumented ELJ was observed when structures were deployed upstream. As the deployment spacing interval between structures increased, the drag force acting on the downstream structure remained low. Drag force measured at the most-downstream structure in three-ELJ configurations deployed at an interval, x, was similar to the drag force incident upon a downstream two-ELJ configurations deployed at an interval of 2x, indicating that ELJs downstream of the leading structure were shielded from flow within that structure's wake. Following this, the morphodynamic response of the movable-bed channel to single- and multi-structure ELJ configurations was then investigated, and also found to vary in response to ELJ type and configuration. A greater area of bed- and bank-adjustment developed in response to ELJ-1 versus ELJ-2 for all configurations examined, with significantly-less opposite-bank erosion resulting from the installation of ELJ-2 compared to ELJ-1. Channel response was amplified when multi-structure configurations of ELJs were deployed at shorter spacing intervals, indicating enhanced redirection of flow away from the protected near-bank at the expense of increased opposite-bank erosion. At the maximum interval evaluated, the downstream ELJ-1 remained in the wake of the upstream structure, causing no downstream morphodynamic response, but this result was not observed for ELJ-2. Results of both experimental campaigns agree that ELJ-1 more-effectively redirects flow than ELJ2, but that it also poses a greater-risk of opposite-bank erosion for similar gains in potential habitat area. Outcomes of this investigation are intended to guide the deployment of ELJs in a prototype river, demonstrating the relevance of physical-scale river modeling to evaluate and improve stream restoration designs.

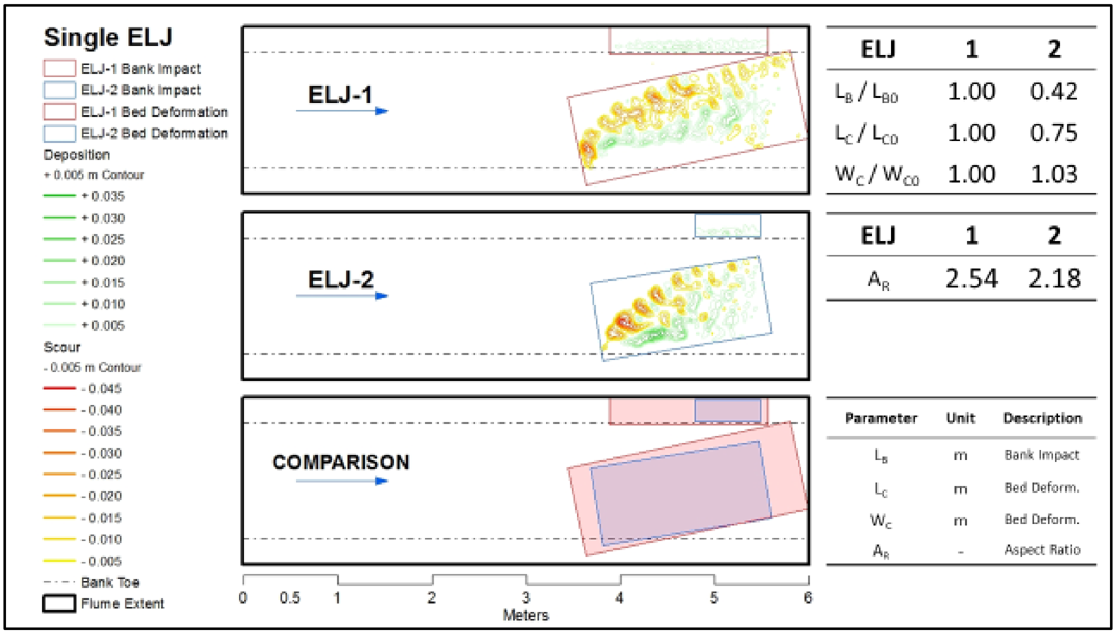

Figure 1. Comparison of channel morphodynamic response to single-structure configurations for ELJ-1 and ELJ-2. While the extent of channel bed-adjustment is similar for both structures, the zone of opposite-bank impact is less extensive for ELJ-2 versus ELJ-1. This indicates that each structure generates similar gains in potential habitat area, but that ELJ-2 does so with less-extensive negative impact to the opposite bank, suggesting ELJ-2 as a more-desirable alternative to ELJ-1 in sensitive stream restoration scenarios.

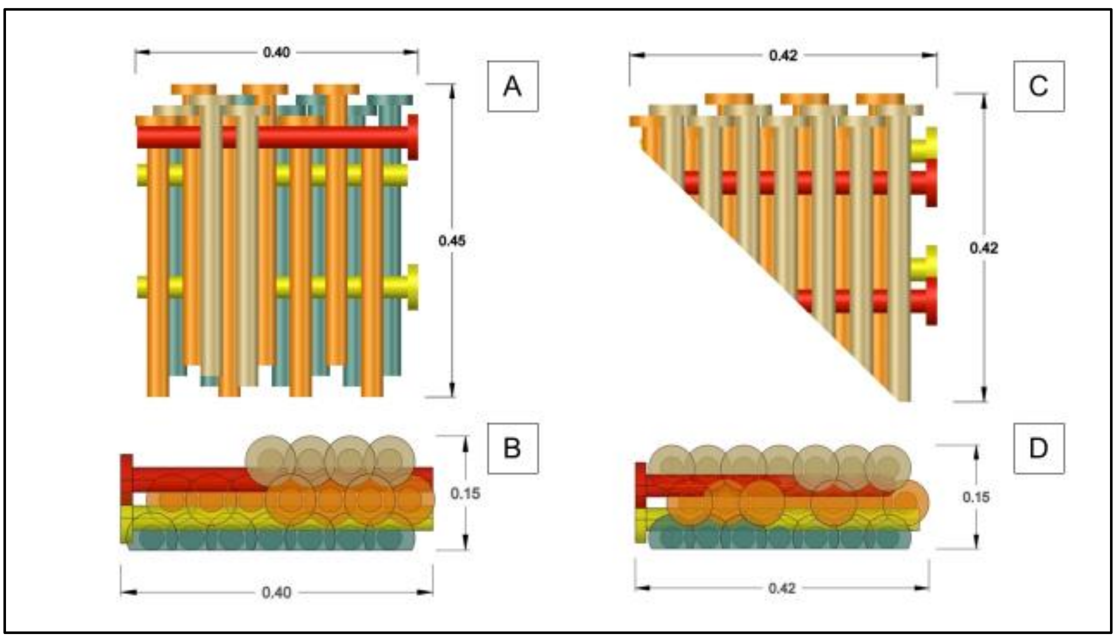

Figure 2. Engineered log jams for stream restoration. ELJ-1 top (A) and face (B); ELJ-2 top (C) and face (D). Design credit: Andrew Brooks.

6. Hydrodynamics of impinging jets and the assessment of soil erodibility

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Analysis and prediction of soil and water management problems require accurate assessment of the erodibility of cohesive sediment. The Jet Erosion Test (JET) has been developed to quantify the erodibility of soil and other cohesive sediments based on theory derived for circular impinging jets. The JET is now an ASTM standard used commonly around the world, yet the physical characteristics of the impingement jet in the apparatus have not been evaluated in detail. A recent study by the authors demonstrated that a confined environment produces variations in jet properties, in comparison with impinging jet theory. Here, we report on detailed measurements of shear stress in the JET apparatus acting on a flat plate representing a soil surface to be tested. The flow field was quantified at high temporal and spatial resolution with 2D particle image velocimetry. Results show that (1) applied surface shear stress is significantly larger than that predicted by impinging jet theory and assumed by JET methodology (Fig. 1), and (2) the wall jet characteristics are asymmetric within the apparatus. These results provide the basis for understanding the erosion process in the JET. This study should improve confidence in employing the JET for determining the erodibility of cohesive sediments in field applications.

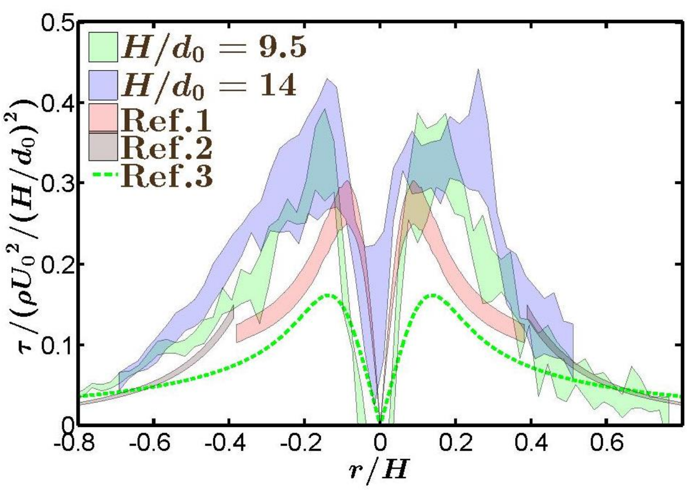

Figure 1. Scaled wall shear stress for two cases of JET experiment, with H/d_0 of 9.5 and 14 where H and d_0 are respectively impingement height and nozzle diameter, is compared to the distributions in the literature for unconfined conditions (Ref. 1: Phares et al. 2000, Ref. 2: Poreh et al. 1967, and Ref. 3: Beltaos and Rajaratnam 1974).

7. Small is beautiful: miniature landform generation and monitoring

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This poster provides a summary of landform experiments conducted over the past 18 years by the author, and presents a website where all of the data from the experiments is available online. The overarching goal is to provide fellow experimentalists with examples of landforms generated under a range of conditions in sufficient detail that comparisons can be made between labs and landforms. In addition, very small basins (microbasins) will be presented which could be used as a basis for exploration by students in the classroom. Very small experiments have the significant advantages of low cost and minimal effort in moving sediment around while still capturing interesting erosional and depositional behavior and forms. Landforms of ~1 m^2 in areal extent can easily contain 100s of kg of sediment, which requires some effort to move into the basin and to dispose of. Landforms of 0.01 m^2 can still exhibit fundamental aspects of stream behavior, and develop third order drainage basins. With readily available digital cameras and structure-from-motion software, monitoring and measuring landforms of this scale has never been easier. Surface elevations can be determined at sub mm vertical resolution with multiple photos from a point and shoot camera. 3D object models are becoming common, and so is the software to render and visualize point clouds. GIS software can read in these object files, and perform standard elevation operations (slope maps, topographic profiles and contouring, drainage network delineation, etc). Photographs can be stored freely online, and numerous photographic apps are available to create timelapse movies, and link these into digital media (web documents, websites, presentations, etc.). Thus, the technology to support studies of experimental landforms has never been as potent, user-friendly or as affordable as the present day. Numerous examples of landforms and object models will be provided, and the steps to generate such models and develop monitoring tools will be provided.

Figure 1 Miniature basin, 15x20 cm.

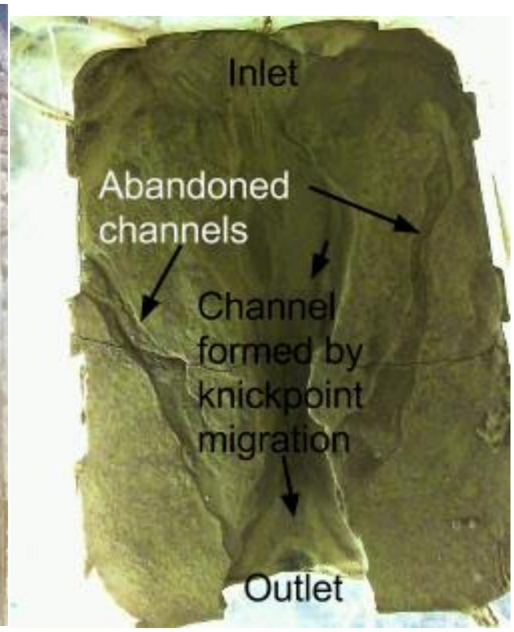

Figure 2. Photo of active and abandoned channels.

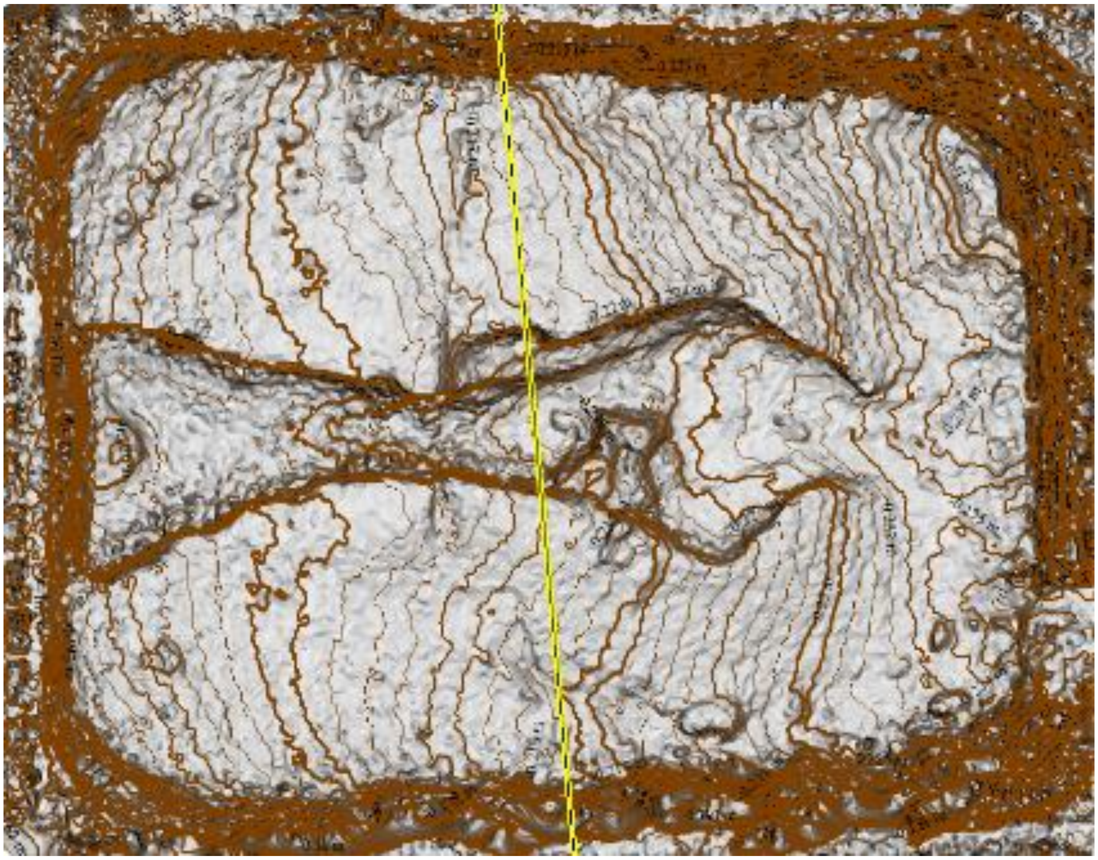

Figure 3. Shaded relief geotiff with 1 mm contours and a profile drawn across the main channel in GIS, showing the scale of relief (the canyon is ~1 cm deep and 1-2 cm wide; see profile below). Basin is 15x20 cm.

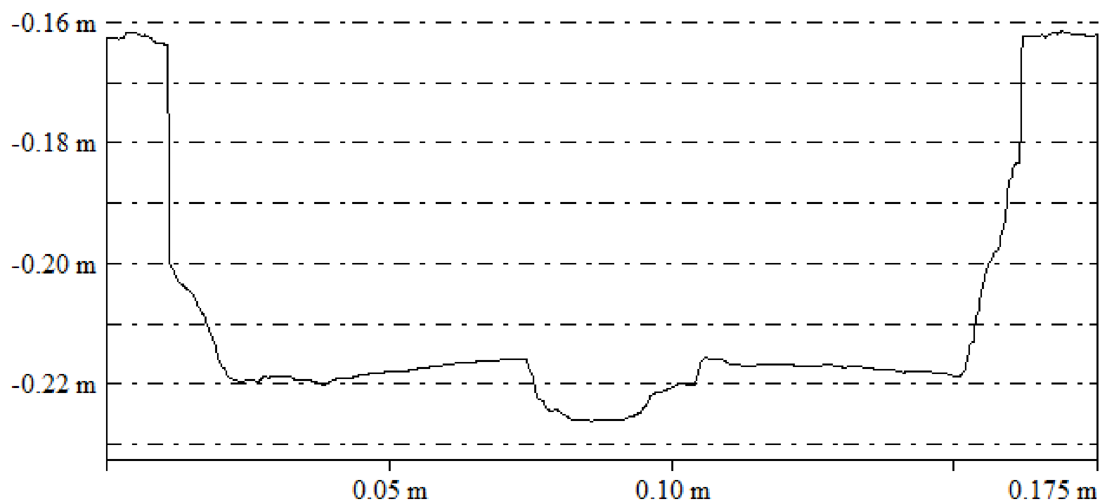

Figure 4. Topographic profile across elevation model of miniature landform (Figure 3; left side of profile is on the bottom of Figure 3), showing inset terrace and scale of measurable relief.

8. Nature's contribution to foredune development on developed shorelines

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The space available to provide a source of wind-blown sand and growth of coastal foredunes is often restricted on developed coasts. Natural dunes are self-regulating and achieve widths, heights and cross shore positions in accordance with natural cycles of beach change and delivery of wind-blown sand. Dunes on a developed coast are often fixed in position by sand fences, beach cleaning activities, buildings and support infrastructure. Infrastructure can truncate dunes and cause them to be variable in width, height, length and continuity along and across shore. Restrictions in space and time on developed coasts place increased importance on supplementing natural processes through active human efforts.

A field investigation was conducted on the developed shoreline of New Jersey, USA to assess the importance of sediment delivery to the foredune by natural processes. The dune (Figure 1) is in an enclave set back from the line of houses adjacent to it and was selected to represent the kind of environment that occurs when space between private developments is set aside as a conservation area. A dune was bulldozed onto the landward portion of the backshore to prevent overwash of a road. Prevailing winds at the site are from the northwest and west, but northeasterly storm winds are most influential in delivery of sediment from beach to dune. The setback at the site partially shelters the dune from the northeasterly winds.

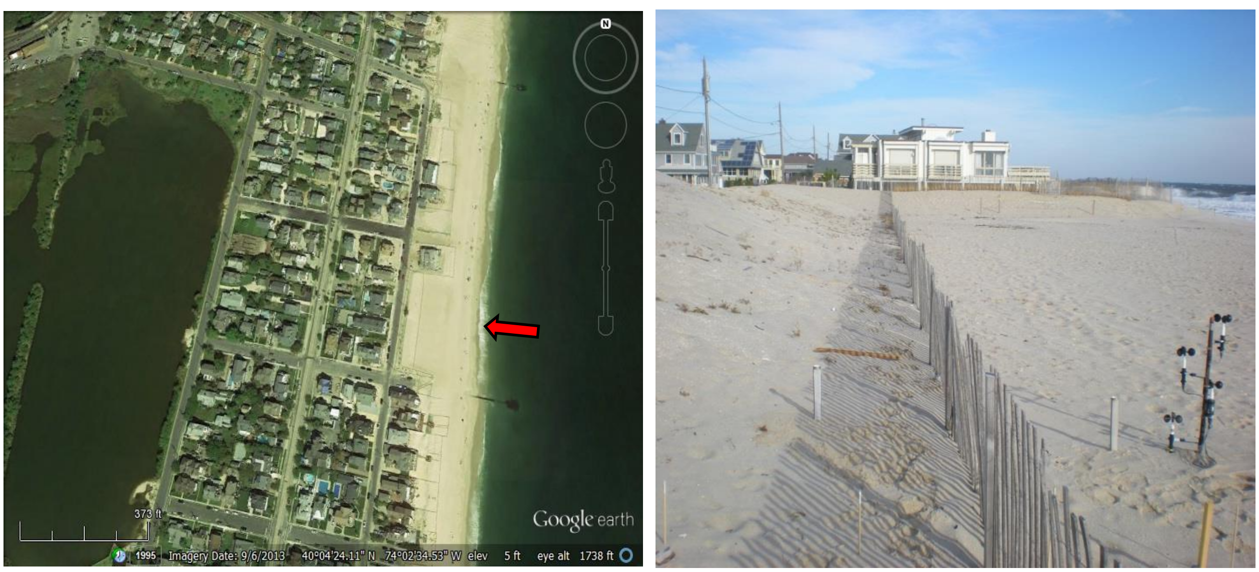

Figure 1. Study site.

Wind speeds were monitored at 0.25 m increments at four elevations at locations on the beach berm crest, the backshore just seaward of a fence at the due toe (Figure 1b) and the dune crest, where a recording wind vane was placed at 2.65 m elevation. Sediment in transport was measured using vertical cylindrical traps. Surface sediments were gathered to determine grain size and moisture. The sediments are predominately moderately well sorted to well sorted medium to coarse sand.

Sediment transport was measured on 3 days of offshore winds and one day of longshore winds. Regional wind speeds were strong during offshore winds, but residential development reduced local wind speeds and sediment transport. Rates on the exposed berm crest were no greater than 1.62 kg m^{-1} hr^{-1} across fetch distances of up to 66 m associated with an average wind speed of 6 m s^{-1} at 1 m elevation. Rates of transport during the longshore winds were as high as 21.32 kg m^{-1} hr^{-1} on the active berm, associated with average wind speed of 8 m s^{-1} at 1 m elevation. Rates here and on the mid backshore were two orders of magnitude greater than on the dune crest and dune toe.

The beach/dune system is transport-limited due to human development. Longshore sediment transport can be an important input to coastal foredunes, but enclaves created by structures on the backshore can decrease potential for transport of sediment from backshore to foredune. Management actions in these enclaves likely require other actions, such as artificial fill and bulldozing, to construct and maintain dunes to overcome vulnerability to storms.

9. The effect of a solid boundary on homogeneous isotropic turbulence: an experimental investigation

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In the surf and swash zones of beaches, turbulence levels produced by breaking waves substantially exceed those generated via mean boundary shear alone, producing bottom boundary layers that differ greatly from classic near-wall turbulence characterizations. The resulting sediment suspension is significantly greater than what would occur solely from mean bed shear. To identify the contribution of turbulence to such sediment suspension, experiments are conducted in a facility designed to generate homogeneous isotropic turbulence absent mean shear via a randomly actuated synthetic jet array. Experiments are performed above both a smooth solid boundary and a sediment boundary of narrowly graded sand (D_{50} = 260 μm). Acoustic Doppler velocimetry and particle image velocimetry measurement techniques are used to characterize the near-boundary flows with statistical metrics such as turbulence intensities, turbulent kinetic energy, temporal and spatial spectra, and integral length scales. We compare various methods of computing dissipation rates and evaluate the assumptions of isotropy that are typically invoked. Furthermore, we consider Eulerian frequency spectra to improve dissipation estimates from single-point velocity measurements. Surprisingly, we observe the formation of sediment ripple patterns, a result that points to a link between turbulence absent mean shear and ripples. We hypothesize that the ripples scale with the integral length scale of the turbulence. Analogous to altering the driving algorithm of an active grid to change the integral length scale (Mydlarski & Warhaft, JFM 1996), our investigations examine the effect of altering jet firing parameters on the integral length scale and resulting sediment dynamics. We conclude with thoughts on the use of the dissipation rate to parameterize the bed stress in the absence of mean shear where traditional friction velocity methods struggle to fully capture the local stresses and energy present in turbulence.

10. Experimental study of scour hole formation by impinging jets for soil erosion assessment

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Soil erosion and soil degradation are critical concerns worldwide. Developing comprehensive techniques to assess soil erodibility is in direct response to this need for quantifying this important characteristic. Many factors have been found to impact soil erodibility including soil texture, unit weight, water content, percentage of clay, clay mineralogy, and etc. Soil erosion rate is commonly estimated by the excess shear stress, the amount of shear stress acting on a soil surface in excess of critical shear stress (τ_c), and conditioned by the erodibility coefficient (K_d). The Submerged Jet Erosion Test (JET) is a widely used technique to measure the critical shear stress and erodibility coefficient based upon the impinging jet theory. Recent studies by the authors [1, 2], however, have shown that there are inconsistencies in the hydrodynamics of impinging jet reported in literature. It has been shown that the result of JET is highly dependent on boundary conditions and jet hydrodynamics. Therefore, this study seeks to investigate the effects of each of these parameters on the soil erodibility coefficient and critical shear stress. Initially, we will use one type of soil and intend to record the resulting scour depth as a function of time for several impinging heights and nozzle velocities. The main objective of this study is to improve the use of impinging jets and to ensure that the variable test conditions do not affect the results obtained. The soil specimens will be compacted inside a mold, 15×15×20 cm in size, following the steps available in the current ASTM standard for the JET. The scour hole depth and its rate of formation beneath the impinging jet will be quantified using photogrammetry. Photos will be taken at different time spans from the beginning of the JET test until the equilibrium conditions. Then, the available JET methods developed in the literature will be revised according to the results to make them consistent and independent of the test conditions in field. Lastly, these JET experiment results will be compared to other methods currently available for soil erosion assessment, including the SEDFlume.

References

[1] Ghaneeizad, S. M., Karamigolbaghi, M., Atkinson, J. F., & Bennett, S. J. (2015). Hydrodynamics of confined impinging jets and the assessment of soil erodibility. *World Environmental and Water Resources Congress*, 1742-1751.

[2] Ghaneeizad, S. M., Atkinson, J. F., & Bennett, S. J. (2014). Effect of flow confinement on the hydrodynamics of circular impinging jets: implications for erosion assessment. *Environmental Fluid Mechanics*, 15 (1), 1-25.

11. Sedimentation on salt substrate: new opportunities in sediment experiment with polymer layer

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Subsidence resulting from differential sediment loading on a mobile substrate (e.g., salt) causes two-way interaction between sedimentation and subsidence, resulting in unique morphology and stratigraphy. This interaction occurs in various depositional environments, e.g. intraslope minibasins, terminal fans, clinoforms/deltas, and aeolian dunes. Polydimethylsiloxane (PDMS), a proxy for salt has been extensively used for salt tectonics and structural studies, and now brings a new opportunity to investigate the dynamic interaction between sedimentation and subsidence in laboratory experiments. The polymer has a viscosity of 2.5e4 Pa-s and behaves as a linear viscous fluid that is ideal for modeling the dynamics of wet salt deformation. The Morphodynamics and Quantitative Stratigraphy Research Group at the University of Texas, Austin recently conducted a series of experiments that develop self-organizing deltas/clinoforms/terminal fans, dunes, and minibasins on top of a PDMS layer. We present a synthesis of current experimental results and discuss new opportunities and challenges for the experimentalist community in sediment experiments with mobile substrate. The initial experimental results show the effects of 1) salt thickness that strongly controls subsidence rate, 2) intermittent sediment transport that changes depth and width of the deposit, 3) a ratio of progradation to subsidence that determines planform shape and size of the deposit, and 4) spacing between depositional bodies that modifies subsidence rate of individual deposit bodies. New experiments will aid to understand complex interplay between sediment and salt tectonics and produce new models to interpret morphology and the sedimentary record in natural systems.

12. Experiments of submarine braided channels driven by density currents

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*Presenter

We report laboratory experiments on submarine braided channels driven by saline underflows (ρ_{in} = 1.2 g/ml). The experiments include 6 different experimental runs. Each run is subdivided into 20 experimental stages (a stage every 5 min). In the experiment, the unconfined saline currents were released onto an inclined plastic bed with the slope ranges from 4 to 6 degrees. Upstream, sediment supply is held constant (about 0.7 ml/s). The ratio of sediment to water supply (*Qs/Qw*) varies from 0.02 to 0.05. With video cameras and laser light sheet, we use digital image processing to construct high resolution digital elevation models (DEMs) and color orthophotos of each experimental stage. With the orthophotos (recorded every 5 sec), we measured braiding intensity (BI) and the ratio of active braiding intensity (ABI) to total braiding intensity (TBI). Results point out submarine braided turbidites behave similarly to braided rivers. ABI of the braided turbidites increases when inflow discharge increases and reaches a stabilized value of each steady discharge. The ratio of active to total intensity (ABI/TBI) of the case of three different inflow discharges (13.6, 27.0 and 30.1 ml/sec) all converge to 0.5. The results suggest that the morphology of braided turbidites reaches a dynamic steady state. We therefore may quantify submarine braided channels by using the approaches for analyzing braided rivers. Our preliminary results show potential for future experimental studies on submarine braided channels. It is our hope that our results can stimulate new questions and motivate more future research.

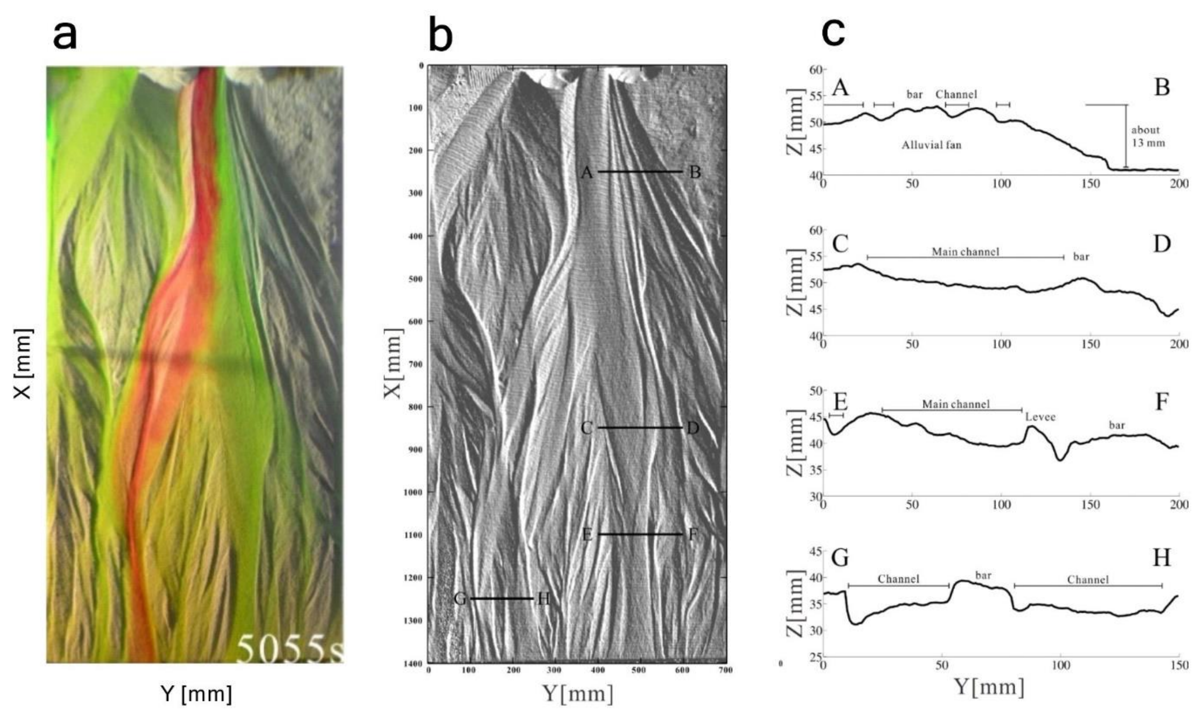

Figure 1. Measured morphology of submarine braided channels of Run 30. (A) Calibrated color orthophoto. (B) Hillshaded DEM. (C) Measured cross sections, with locations in (B).

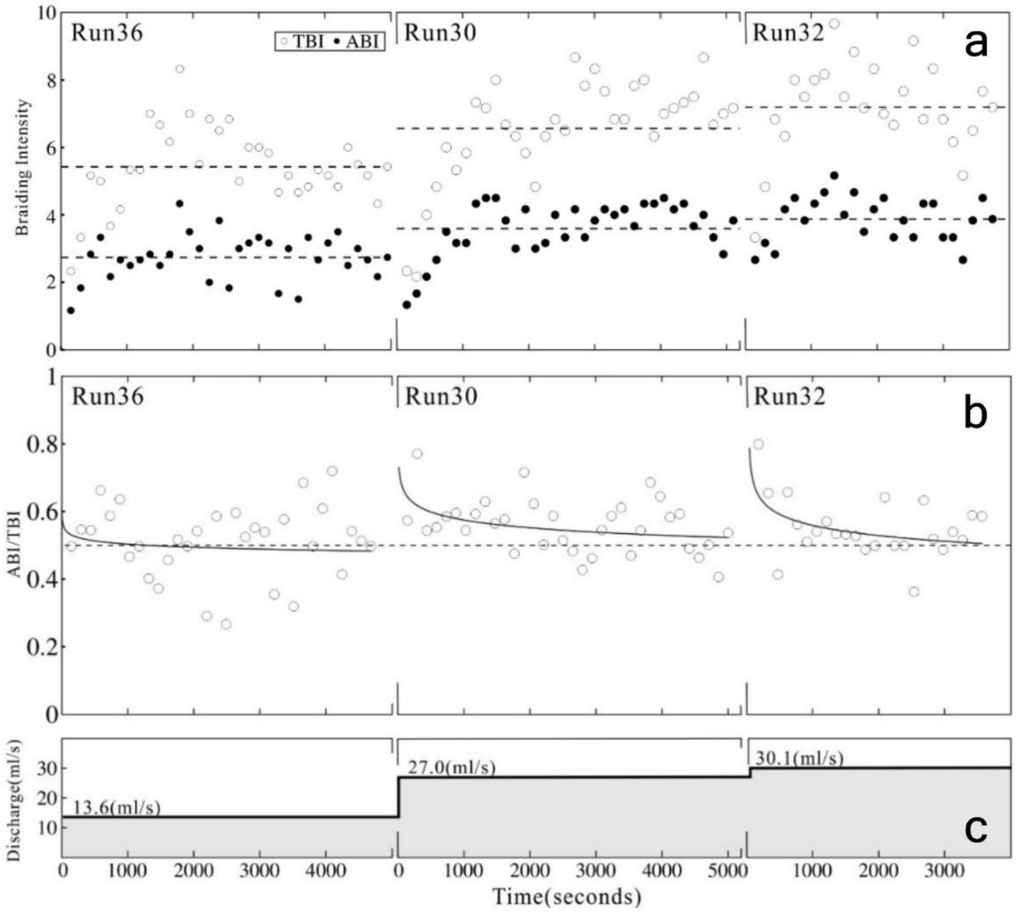

Figure 2. Braiding intensity of the braided turbidites with increasing inflow discharges.

13. Spatiotemporal structure and covariance of bedload motion and near-bed fluid velocity over bedforms: laboratory experiments downstream of a backward-facing step

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*Presenter

Despite numerous experimental and numerical studies investigating transport over ripples and dunes in rivers, the spatiotemporal details of the pattern of transport over bedforms remain largely unknown. Here we report turbulence-resolving, simultaneous measurements of bedload motion and near-bed fluid velocity downstream of a backward facing step in a laboratory flume. Details are compared to Nelson et al.'s (1995) results and Schmeeckle's (2014) coupled large eddy simulation and distinct element simulation (LES-DEM) of the same geometry.

Two synchronized high-speed video cameras simultaneously observed bedload motion and the motion of neutrally buoyant particles in a laser light sheet 6 mm above the bed at 250 frames/s downstream of a 3.8 cm backward-facing step. Particle imaging velocimetry algorithms were applied to the laser sheet images to obtain two-dimensional field of two-dimensional vectors while manual particle tracking techniques were applied to the video images of the bed. As expected, the experiments exhibit a strong positive correlation between sediment flux and near-bed fluid velocity. Sediment flux increases monotonically downstream of flow reattachment. The effect of flow separation on the pattern of sediment flux is explored by comparing experimentally observed sediment transport to sediment transport modeled as a function of boundary shear stress using a Meyer-Peter Müller type equation. Modeled sediment transport underestimates observed sediment transport near flow reattachment (~0-100 cm downstream of the backstep, Figure 1). This region of underestimated transport corresponds to an increase in the variance of near-bed vertical fluid velocity. Localized, intermittent, high-magnitude transport events are more apparent near flow reattachment than farther downstream. Often, these high-magnitude events are seen to have significant cross-stream particle velocities. In addition, downstream and cross-stream sediment transport events are of comparable magnitudes near reattachment. In contrast, farther downstream of the zone of underestimated transport, cross-stream transport events are small compared to downstream transport. The pattern of intermittent, high-magnitude cross- and downstream transport events near flow reattachment is consistent with the existence permeable "splat events", wherein a volume of fluid moves toward and impinges on the bed. The substantial effects of splat events on transport over bedforms cannot be modeled using simple bedload transport equations and must be included in future models of bedform evolution.

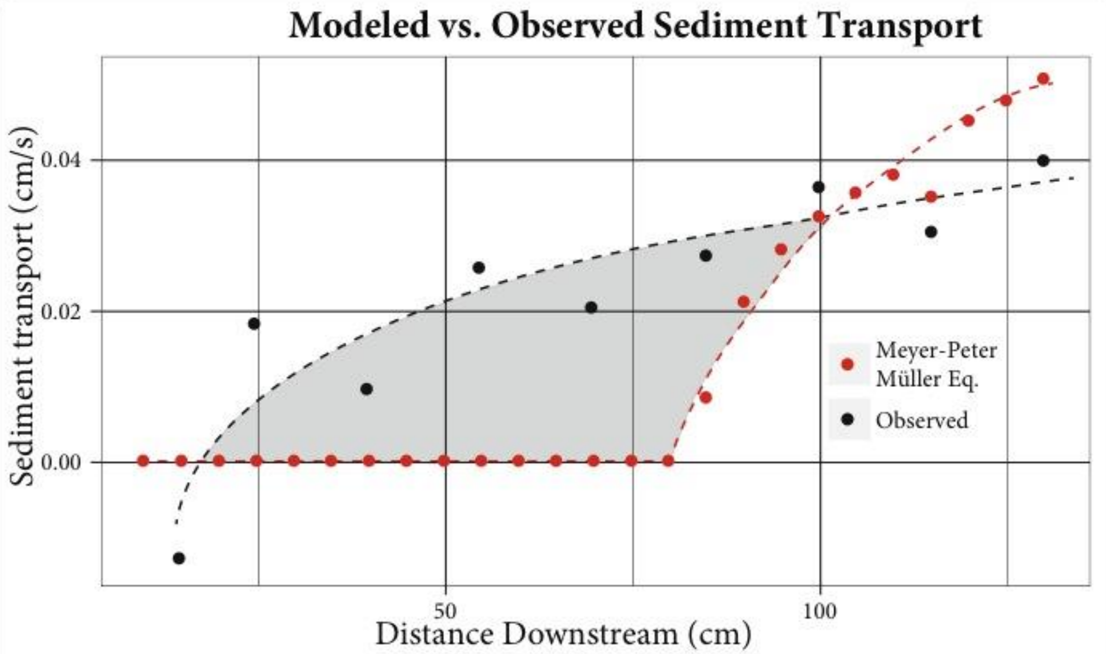

Figure 1. Modeled sediment transport (using the Meyer-Peter Müller Equation) compared to observed sediment transport. Modeled transport underestimates observed sediment transport until approximately 100 cm downstream of the backward-facing step (grey shaded area). Splat events play a key role in sediment entrainment in the zone in which sediment transport is underestimated by the model.

14. Collaborative science in geomorphology

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*Presenter

Collaborative science allows us to conduct complex interdisciplinary research impossible for a single investigator. Specifically, in the field of experimental geomorphology, where currently more sophisticated techniques are being developed to make high-resolution measurements and observations, collaborations aid in providing access to state-of-the-art facilities and equipment. The Sediment Experimentalist Network (SEN) is part of the NSF-funded EarthCube initiative that aims to use modern technological advances to make data collection and sharing more accessible. Over the past few years, SEN has organized several community experiments that have physically and virtually brought together scientists to conduct cutting-edge science. SEN is fostering further experimental collaboration by assembling a network of laboratory facilities, called "collaboraties", that are equipped with the necessary resources to conduct collaborative science. Collaborative experiments have potential to add to experiments in at least two major ways. First, experiments could be run in parallel rather than in series allowing for expedited results. Second, comparisons of experiments among institutions could allow for quantification of uncertainties not associated directly with experimental variables. For laboratories that are interested in joining the SEN Collaboraty Network, we will provide equipment and training for live broadcasting experiments, assistance in implementing data standards and workflow documentation, and a database website for posting data for public access and future use, satisfying funding and publication agencies requirements to make data available. SEN can help your laboratory take advantage of all the benefits of collaborative science.

15. Evaluation of three topographic factors in hillslope erosion process using terrestrial laser scanner and GIS: a case study in Loudoun, Tennessee

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*Presenter

Erosion on hillslopes is a complex process governed by natural and human factors, including geology and soil characteristics, rainfall, vegetation, land use, management practices, and topography. During the process, rills and gullies emerge and develop as channels to transport sediment. The location and morphological characteristics of the rills and gullies are reflected in topography, and the change in topography can be associated with surface erosion process in the next phase by changing the flow direction, flow accumulation, and consequently stream power. Hence, understanding the relationship between localized topography, rill/gully network change, and sediment movement is of significance in studying hillslope surface dynamics. The role topographic factor plays in the process has been carefully examined, and the Universal Soil Loss Equation and its derivatives have used different representations and calculation methods in soil loss monitoring and prediction. However, with the advent of fine-resolution digital elevation models (DEMs), whether these previous topographic factors still have satisfactory performance is to be tested. In this research, we used a terrestrial laser scanner to generate two 1-cm DEMs of the same study area at a 3-month interval. We investigated the micro-topographic change by comparing two different DEMs, and calculated three different topographic factors using the first DEM. Based on the assumption that the surface process during the 3-month period is relevant to the first phase DEM, we did a raster-based linear regression between the elevation change and the three topographic factors respectively. We found that among the three topographic factors, the one introduced by Bohner and Selige in 2006 showed the best performance.

16. Laboratory experimentation at University of British Columbia: facilities and research directions

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*Presenters

The new BioGeoMorphic eXperimental Laboratory (BGMX Lab) at the University of British Columbia is a state of the art laboratory containing a broad and complimentary set of facilities (Figure 1). BGMX Lab offers students, faculty and visiting scholars the opportunity to address a variety of river-related research questions and interests. The lab currently houses two systems for conducting experiments on stream dynamics. The first is the Adjustable-Boundary Experimental System (A-BES), which has a 12 m long by 1.5 m wide working surface designed for conducting reach-scale experiments on channel planform dynamics. This model, which can be set up to conduct work on floodplain slopes ranging from 0 to 5%, is useful for studying both channel and floodplain morphodynamics and is currently being used to investigate spatial-temporal patterns of erosion during flood events. The second is the Mountain Channel Hydraulics System (MCHS), built around a large 18 m long glass-walled flume with a capacity to accommodate bed slopes ranging from 0 to 10%. This model is best suited to study fluvial processes at near prototype scales, operating over relatively short time-scales. MCHS is currently being used to investigate the formation and maintenance of riffle-pool sequences. Work is ongoing on a third system built around a 10 m long flume that can model bed slopes up to 20%, which like the MCHS, will be used to study short-term fluvial morphodynamics. All of the experimental systems offer a full suite of measurement capabilities, primarily run using LabView®. Both ABES and MCHS are equipped with laser profiling systems that generate high resolution digital elevation models of the bed surface. Overhead cameras are used to construct composite, minimally distorted images of the stream channels, and record movies of experimental conditions. In the MCHS, flow field and at-a-point velocity are measured with an array of measurement devices. Pitot tube arrays are used to simultaneously measure at-a-point velocities across a wide area of flume bed, and Acoustic Doppler Current Profilers are used to measure the vertical velocity structure of experimental flows. Another innovative feature of the BGMX lab is the light table used to monitor sediment flux from MCHS at a frequency of 1 Hz for grain sizes as small as 0.5 mm. The combination of the two modelling approaches exemplified by A-BES and MCHS allow researchers to investigate both long-term and short-term channel dynamics or a range of spatial scales, making BGMX Lab an ideal facility for the study of gravel bed streams.

17. Experiments on simplified pool and riffle structures in flumes: what have we learned?

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Pools and riffles are a common sedimentary bedform in gravel-bed rivers and a frequent template for stream restoration, yet researchers agree on surprisingly little about how they work. Sediment queueing mechanisms, size sorting, lateral concentration of flow, near-bed velocity reversal, and turbulence have all been invoked to explain how they maintain their depth while allowing sediment throughput. To investigate these forms in more detail, a laboratory experimental plan was pursued to study key aspects of their hydrodynamics in a controlled setting. In particular, we were interested in whether the hydraulic phenomena that had been observed in field settings could be induced and controlled with a simplified 2D version of the form. The hypothesis was that many of the phenomena are the by-products of convective deceleration and acceleration. It was also our hypothesis that some of the phenomena would be likely to create a positive feedback loop with bed morphology, while others could be controlled via negative feedback. The objective of this poster is to highlight some of the key results, step back and discuss the overall implications, and clearly define the limits of what we learned as a means of spurring new research. The experiments were completed in two different experimental channels located at the University of Ottawa and the University of Illinois at Urbana-Champaign. In both flumes, pools and riffles were constructed as constant width rises and drops of the bed so that they formed 2D bedforms. The Ottawa flume is 1.5 m wide with a flat slope and we ran the experiment with a 0.25 m deep riffle section and a 0.50 m pool section. The bed was rough (D_{50} = 1.0 cm) and the side walls were tar-covered cinder blocks. A single pool was constructed as a negative relief bedform. The Illinois flume is 0.60 m wide with a variable slope and we ran with a 0.06 m deep riffle sections and 0.12 m pool sections at a slope of 0.001 m/m. The bed was smooth polyvinyl-chloride (PVC) plastic and the walls were smooth fiberglass and plexiglass. A number of runs were completed to assess the effect of Reynolds number with constant depth (Ottawa) and channel width and bedform length with constant depth and velocity (Illinois). Measurements were made with Nortek Vectrino velocimeters at Ottawa and with Metflow ultrasonic Doppler velocity profilers (UDVPs). Measurements were made at high frequencies to allow for analysis of mean and turbulent flow properties.

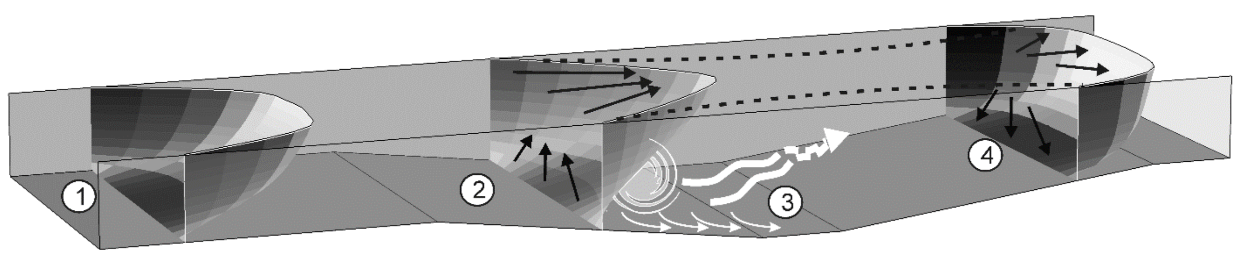

Figure 1. Model of hydrodynamic processes in a straight pool and riffle (MacVicar and Rennie, 2012).

The model we have elaborated shows that uniform flow (at point (1) in Figure 1) is perturbed by the increasing depth in the pool (2) that leads to convective flow deceleration. Convective flow deceleration results in increased turbulence production away from the bed that advects towards the bed as powerful coherent structures. In the middle of the pool (3) highly turbulent fluid coalesces and advects away from the bed and banks where it gradually loses energy. Lateral flow concentration is also observed in the pool. In the tail of the pool (4), convective flow acceleration results in the occurrence of high velocities very near to the channel bed.

Some of the observed hydrodynamics have interesting implications for flow and sediment transport in natural pools and riffles. For instance, shear stress varies significantly depending on which method is applied. Turbulence levels and the total shear stress estimated using the boundary characteristics method tend to peak in the pool (Figure 2) where the mean shear stress reaches a minimum value. Other flow features such as the lateral concentration of flow and high near bed velocities in the pool tail could be considered analogous to observed phenomena in field studies but do not appear to increase shear stress in the pool. Perhaps most interestingly, the recovery lengths of certain flow parameters related to turbulence tend to match with observed geophysical scales of pools and riffles. Turbulence and the mechanisms by which it could lead to a positive feedback effect on pool scour appear to be central to understanding pool-riffle dynamics.

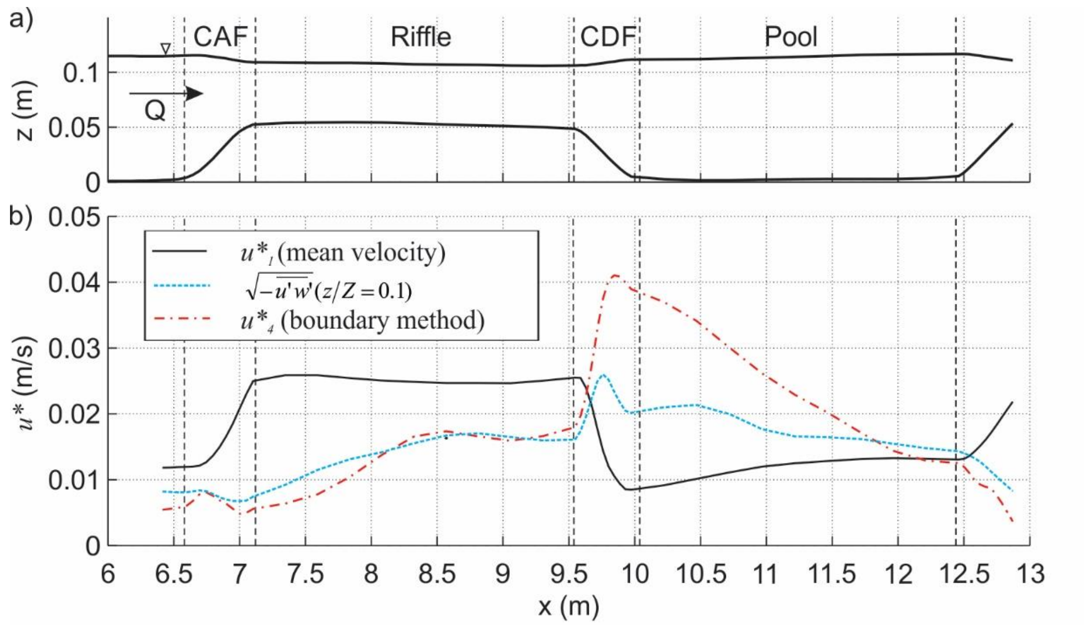

Figure 2. Shear velocity (u* = √(τ/ρ)) calculated using the mean velocity, Reynolds turbulent stress (√(u'w')) and the boundary characteristics methods through a straight riffle pool (MacVicar and Obach, 2015).

Additional research is necessary because of the extremely simplified nature of the modelled pool and riffle, the lack of mobile sediment on the bed, and the steady flow used in the experiments. Despite these limitations, this set of relatively simple experiments is interesting because it was able to reproduce many of the phenomena observed in field examples of pools and riffles. The key going forward will be to see how mobile sediment, a more realistic morphology and a peaked flow hydrograph will alter the model developed as a result of these studies.

18. Simulating the influence of living vegetation and large wood on river morphology

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Living vegetation and large wood are widely recognized as primary drivers of river morphodynamics. Physical modelling represents an opportunity to investigate vegetation/wood/flow interactions occurring in large rivers under safe, controlled, repeatable laboratory conditions. In this study, we investigated the joint effects of vegetation and wood on channel pattern evolution and we explored large wood dispersal in spatially complex fluvial systems. Laboratory simulations were performed at the Total Environmental Simulator of the University of Hull (UK). The flume was divided into three parallel channels (1.7 m wide, 10 m long) and filled with uniform sand. Self-organised, fully mobile braided networks were subject to a series of cycles of flooding, wood input, and vegetation growth. Model runs were performed under identical flow conditions with and without vegetation and with different wood supply rates.

Cylindrical dowels with and without cross-shaped root wads were used to simulate large wood. Dowel size was selected to ensure ‘large’ river conditions (low piece length/channel width and piece diameter/channel depth ratios) that are typical of temperate braided rivers. Alfalfa seedlings used to reproduce living vegetation stabilised the sediments through root reinforcement and interacted with flow and transported logs. Sequences of vertical images were used to monitor the evolution of channel configuration over time, vegetation establishment and erosion, and wood deposition and resuspension. Flume runs reproduced typical forms and processes that have been observed in the field, from scattered logs in unvegetated, dynamic braided channels to large wood jams associated with river bars and bends in vegetated, stable, single-thread rivers.

Results show that the inclusion of vegetation in the experiments changes both channel pattern and wood dynamics. Vegetated banks reduce lateral erosion and the number of active channels (Figure 1). Limited channel mobility promotes the formation of a small number of large, stable wood jams, where logs continue to accumulate during subsequent floods. The joint effect of living vegetation and high wood supply can cause a shift from a braided morphology to a single-thread channel. In contrast, large wood deposits in unvegetated networks are rapidly removed because of the intense reworking of the braidplain and therefore have a limited impact on channel morphology.

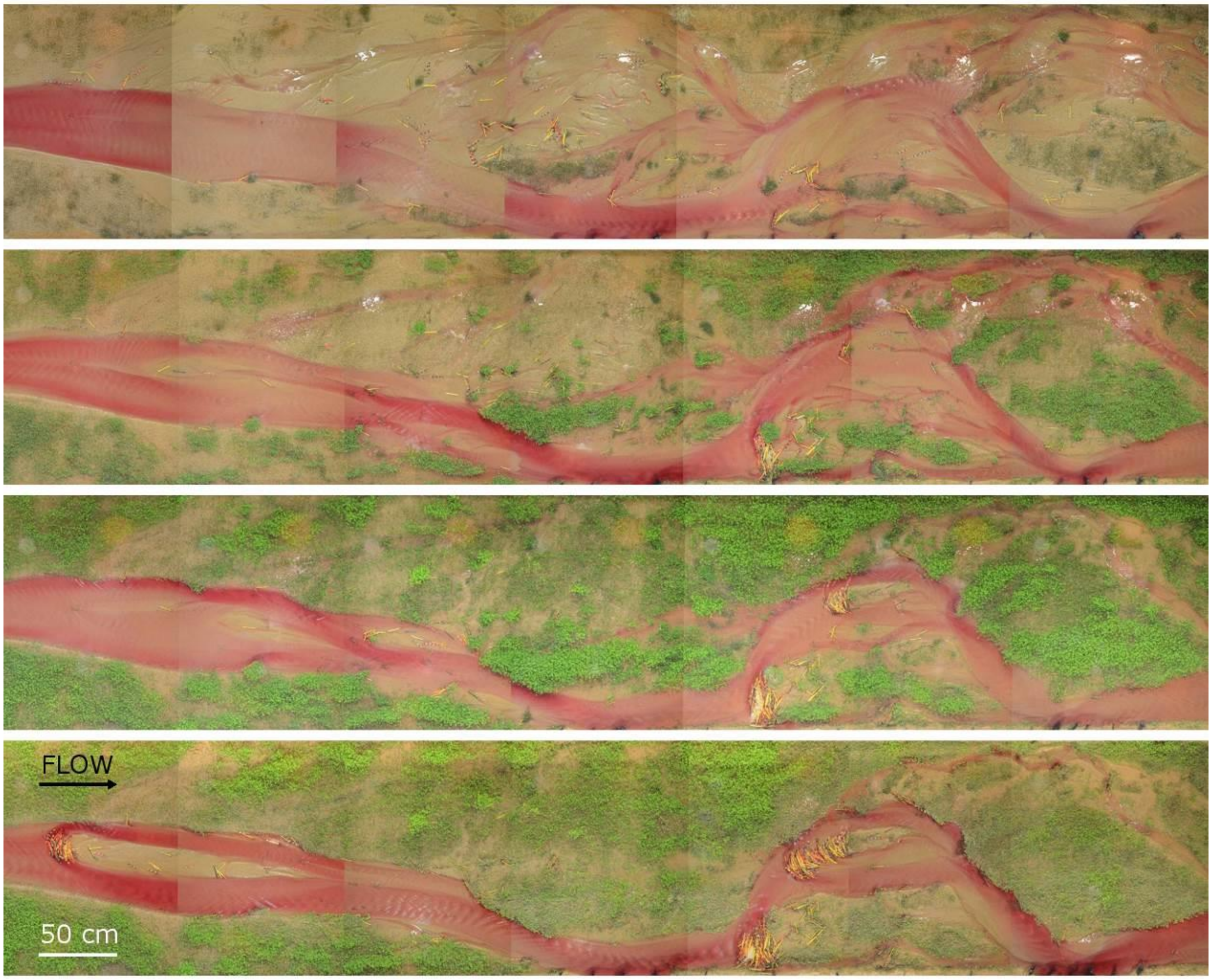

Figure 1. Evolution of a braided network over time (top to bottom) during four cycles of flooding, wood input and vegetation growth.

19. Experimental data management to achieve scientific goals: Case study of aeolian sediment transport fieldwork

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Sharp disagreements among models and experiments (both field and laboratory) limit our ability to predict fluxes of aeolian (wind-blown) sediment on Earth and other planetary bodies. Aeolian saltation (the characteristic hopping of aeolian sediment) is inherently stochastic, both in the nature of turbulent winds and in the interactions among particles. Comparisons of sediment flux to fluid shear stress therefore depend strongly on methods and scales of defining and measuring physical quantities. Recognizing these difficulties, I have led a series of field experiments to understand the origins and nature of stochastic aeolian saltation. While primarily motivated by scientific goals, this work also depends on careful documentation of data collection and analysis methods. Methodological decisions – e.g., how to calibrate values from saltation sensors, how to perform averaging for turbulence statistics, and how to fit vertical profiles of wind velocity and saltation flux – can all be strongly determinative of scientific interpretations of stochastic, scale-dependent processes.

Here, I present several novel experimental findings from our field experiments that demonstrate the importance of methodology: (1) Saltation flux displays no significant lag relative to horizontal wind velocity; (2) Characteristic height of the saltation layer remains constant with changes in shear velocity; and (3) During saltation, the vertical profile of mean horizontal wind velocity is steeper than expected from the Reynolds stress. In addition to presenting these research findings, I also offer a working example of how to organize raw data, metadata, and computer scripts toward the goal of total reproducibility. My approach utilizes both existing tools (e.g., Github code repositories) and resources in development as part of the EarthCube program (e.g., Sediment Experimentalists Network Knowledge Base). Based on my experiences, I consider prospects for ongoing efforts to define metadata standards and encourage publication of experimental datasets.

20. Investigating turbulent flow characteristics within a mixing box

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Most flows occurring in the nature are turbulent. Some fundamental characteristics of turbulent flow, however, remain unclear. The purpose of this research is to investigate the characteristics of turbulent flow in confined experimental conditions using a standard mixing box. The mixing box is a small box equipped with an aluminum grid situated near the bottom of the box. The grid is connected to an external electrical motor that can oscillate at different speeds. The oscillation of the grid produces a turbulent flow with zero-mean shear flow in the box, but with secondary currents. Two of the important turbulent characteristics that we intend to investigate are turbulent kinetic energy (TKE) and the magnitude of secondary flow velocities (U). To quantify these turbulent features, turbulent and secondary current velocities are measured by particle image velocimetry (PIV). To obtain 3-D patterns of turbulent kinetic energy and secondary currents in the box, velocities are measured in seven parallel planes on one side of the box. Since the box and flow are symmetric, the TKE and U patterns are each similar in both sides of the box. Results show that the magnitude of secondary flow velocity is a maximum in the plane near the center of the box, and it decreases toward the walls of the box. In addition, U is close to zero in planes located near the wall. TKE is shown to be a maximum in the planes located between the box center and the walls. This suggests that the most variation in flow velocity takes place at this middle position. Similar to U, TKE is close to zero in planes near the wall. Lastly, secondary flows are upward in planes closer to the box center, while these flows are oriented downward in planes near the wall. The largest circulation takes place in the plane located in between the rod and the wall. This information is somewhat counter to the accepted notions that turbulence within mixing boxes is spatially uniform a given height above the grid, and that secondary circulation is negligible or absent.

21. A new upgraded experimental facility for studying landscape dynamics: principles and first results

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*Presenter

After pioneer development of the Rainfall Erosion Facility at the Colorado State University by Stanley Schumm in the 1980's, the experimental modeling of landscapes has been extensively developed in the late 1990's at the San Anthony Falls Laboratory (Hasbargen and Paola, 2000) and in France at the University of Rennes (Crave et al., 2000). These setups have been used to study the geometry and internal dynamics of steady-state landscapes (Hasbargen and Paola, 2000, 2003; Bigi et al., 2006; Bonnet and Crave, 2006; Reinhardt and Ellis, 2015; Sweeney et al., 2015), the effect of tectonic uplift (Lague et al., 2003; Turowski et al., 2006) and rainfall (Bonnet and Crave, 2003; Bonnet, 2009; Singh et al., 2015) as well as interactions between landscape erosion and foothill deposition (Babault et al., 2005, 2007; Rohais et al., 2012).

In France, the facility initially developed in Rennes has been recently reinstalled in Toulouse, in 2015. Major upgrades of the facility have been done at the occasion of this resettlement, with the objective to improve automation in the application of the tectonic and climatic forcings as well as in the acquisition of the topographic data, at a higher frequency compared to the previous used digitization system. These upgrades will be presented and discussed in the first part of this presentation. Among its main specificities, the facility developed in France allows to produce temporal (Bonnet ad Crave, 2003) as well as spatial (Bonnet, 2009) variations of precipitations, this latter being fundamental for driving landscape instabilities. The new facility allows to produce cyclic variations in rainfall with different user-controlled frequencies and amplitudes. In this presentation we will also present first results of an experimental program designed for investigating the landscape response to cyclic variation of climate.

References

Babault, J., Bonnet, S., Van den Driessche, J., and Crave, A., 2005. Influence of piedmont sedimentation on erosion dynamics of an uplifting landscape: an experimental study. *Geology*, 33, 301-304.

Babault, J., Bonnet, S., Van den Driessche, J., and Crave, A. 2007. High elevation of low-relief surfaces in mountain belts: does it equate to post-orogenic surface uplift ? , *Terra Nova,* 19, 272-277.

Bigi, A., Hasbargen, L.E., Montanari, A., and Paola, C., 2006. Knickpoints and hillslope failures: interactions in a steady state experimental landscape. In: Willett, S.D., Hovius, N., Brandon, M.T., Fisher, D.M. (Eds.), Tectonics, Climate, and Landscape Evolution: Penrose Conference Series Special Paper. Geological Society of America, pp. 295–307.

Bonnet, S., and Crave, A., 2003. Landscape response to climate change: insights from experimental modeling and implications for tectonic vs. climatic uplift of topography, *Geology*, 31,123-126.

Bonnet, S., and Crave, A., 2006. Macroscale dynamics of experimental reliefs. In: Buiter, S.J. H. & Schreurs, G. (eds), Analogue and numerical modelling of crustal-scale processes, *J. Geol Soc. London Spec. Publ.*, 253, 327-339.

Bonnet, S., 2009. Shrinking and splitting of drainage basins in orogenic landscapes from migration of the main drainage divide. *Nature Geosci.*, 2, 766–771.

Crave, A., et al., 2000. Analogue modelling of relief dynamics. *Physics and Chemistry of the Earth, Part A: Solid Earth and Geodesy* 25 (6–7), 549–553.

Hasbargen, L.E., and Paola, C., 2000. Landscape instability in an experimental drainage basin. *Geology* 28 (12), 1067–1070.

Hasbargen, L.E., and Paola, C., 2003. How predictable is local erosion rate in erosional landscapes? In: Wilcock, P.R., Iverson, R.M. (Eds.), Prediction in Geomorphology. Geophysical Monograph. American Geophysical Union, Washington, D.C., pp. 231–240.
Lague, D., Crave, A., and Davy, P., 2003. Laboratory experiments simulating the geomorphic response to tectonic uplift. *Journal of Geophysical Research* 108 (B1). doi:10.1029/ 2002JB001785.
Reinhardt, L., and M. A. Ellis, 2015. The emergence of topographic steady state in a perpetually dynamic self-organized critical landscape, *Water Resour. Res.*, 51, doi:10.1002/2014WR016223.
Rohais, S., Bonnet, S. and Eschard, R., 2012. Sedimentary record of tectonic and climatic erosional perturbations in experimental coupled catchment-fan system. *Basin Research*, 24, 198-212.
Singh, A., Reinhardt, L., and Foufoula-Georgiou, E., 2015. Landscape reorganization under changing climatic forcing: Results from an experimental landscape, *Water Resour. Res*., 51, 4320–4337, doi:10.1002/2015WR017161.
Sweeney, K.E., Roering, J.J., and Ellis, C., 2015. Experimental evidences for hillslope control of landscape scale. *Science*, 349, 5, 51-53.
Turowski, J.M., Lague, D., Crave, A., and Hovius, N., 2006. Experimental channel response to tectonic uplift. *Journal of Geophysical Research* 111 (F03008). doi:10.1029/2005JF000306

22. A wind tunnel study of 2.5D particle saltation using EPAS PTV

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Wind tunnels provide geomorphologists with a highly effective tool for studying the physics of wind erosion and the environmental factors that govern saltation and dust emission. Data obtained from such work is required for the parameterization and validation of numerical models of aeolian transport. At the particle scale, experiments carried out in such facilities represent a 1:1 replication of nature with suitable calibration of the properties of the boundary layer flow (e.g., friction velocity, aerodynamic roughness length and turbulence intensity/wind gusting). Saltation, the ballistic movement of particles along the bed surface, underlies the creation and modification of a wide array of aeolian bedforms, both depositional (e.g., ripples) and erosional (e.g., flutes). While such bedforms are inherently three dimensional (3D) in nature, the study of saltation dynamics at the grain scale has historically been limited to two dimensions (2D). This paper describes a series of Particle Tracking Velocimetry (PTV) experiments conducted in the Trent University Environmental Wind Tunnel in which 2.5D steady state saltation was studied using an automated processing algorithm (EPAS PTV) that was created specifically for this application. By incrementing the spanwise angle of the PTV light plane from 0^{o} to 60^{o} in 5^{o} segments, a composite data set was obtained that represents a more realistic representation of the saltation cloud as compared to traditional approaches in which only a single wind aligned 'slice' has been examined.

The EPAS algorithm is capable of automating PTV trajectory identification with an accuracy of 99.9%, as verified through both manual processing of the particle images and via LDA (Laser Doppler Anemometry). Particle trajectories can be identified within one grain diameter of the surface, and range in length from 5 'frames' to full trajectories that include both ejection and impact (see Fig. 1). Analysis of the trajectory data obtained in the present study suggests that less than $1/8^{th}$ of all grains are aligned with the direction of the mean airflow through the tunnel, while approximately 95% of all grains sampled were travelling within 45^{o} of the longitudinal axis. An increasing spanwise alignment of the particle trajectory was found to systematically decrease the horizontal component of particle velocity, while increasing the angle of the trajectory segments sampled. This observation supports the theory that as the spanwise angle increases, an increasing proportion of the cloud of particles moving over the bed surface consists of low speed reptators. Indeed at spanwise angles $\geq 45°$ all particles appear to move in reptation, but on the whole, they constitute less than 5% of the trajectories sampled over the entire range of angles investigated. Measurements such as these, obtained through laboratory wind tunnel simulation, are important for the parameterization of emerging 3D saltation models, as well as for the interpretation of particle-scale processes underlying the development of small scale aeolian bedforms.

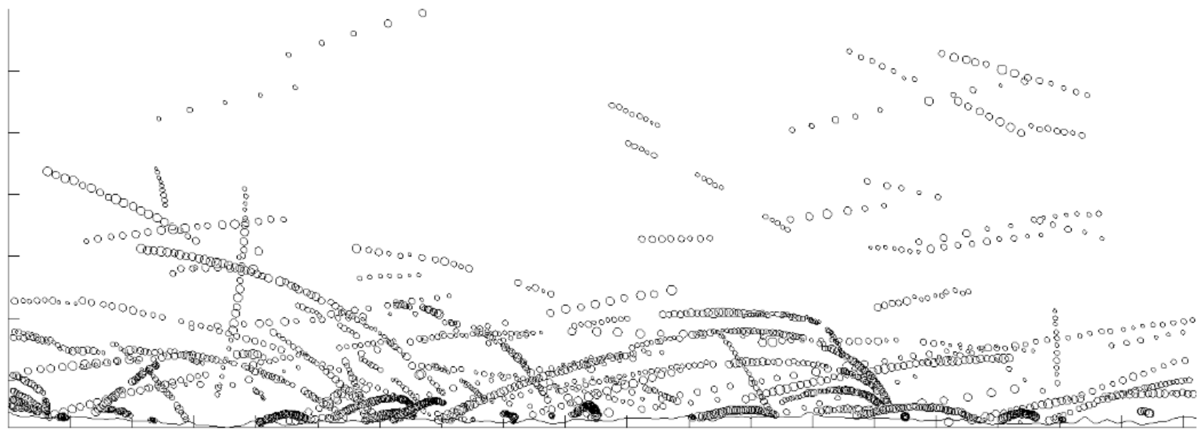

Figure 1. Sample of 250 sand particle trajectory segments captured in 0.25 s using the EPAS PTV system. Freestream velocity was 8 ms^{-1}. Interval between tick marks is 5 mm.

23. The use of magnetic resonance imaging to examine the 3D structure of gravel river beds

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[4]Scottish Water, Glasgow, UK
*Presenter

The characterization of surface and sub-surface sedimentology has long been of interest to gravel-bed river researchers. The determination of surface structure is important as it exerts control over bed roughness, near-bed hydraulics and particle entrainment. Similarly, interpretation of the sub-surface structure and flow is critical in the analysis of bed permeability, the fate of pollutants and maintaining healthy hyporheic ecology. Traditionally, extracted core samples, photogrammetry and laser displacement have been used to investigate evolution of bed surface composition and particle arrangement. However, to truly understand sediment structure inherently requires description of both the surface and sub-surface; 3D MRI scanning has the potential to address this (Figure 1).

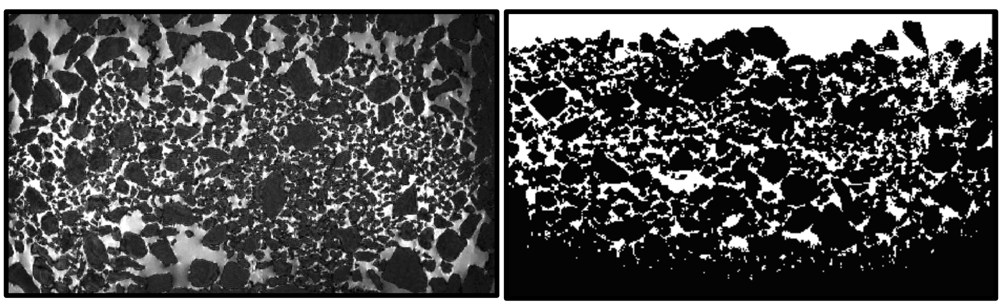

Figure 1. Example MRI scans; the first is a horizontal view of the bed surface, the second a vertical view through the same image

Two examples are discussed. The first compares estimates of surface topography generated using traditional 2.5D laser scanning with those derived from 3D MRI. Figure 2 shows DEMs generated from both technologies; although both have similar minimum elevations the DEM generated from the MRI has lower maximum and standard deviation values. The difference is due to either a) settlement after re-freezing of the MRI sample or distortions of the MRI surface interface making grain delineation difficult. This has implications for successfully using MRI to describe surface structure.

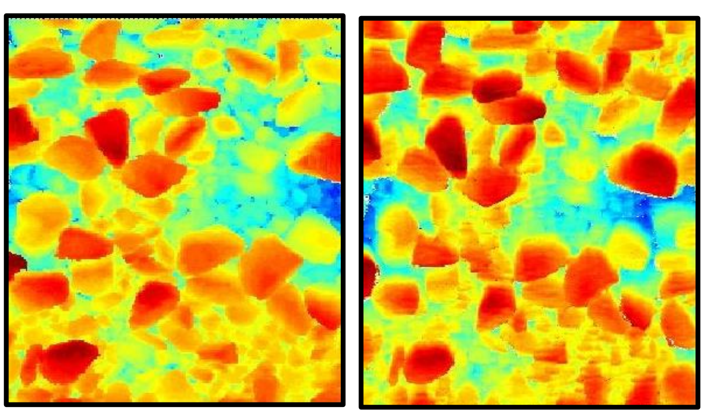

Figure 2. DEMs of the bed surface from the MRI (left hand image, resolution of 300μm) and laser (right hand image, resolution100μm) respectively. Red denotes areas of high relief, blue denotes areas of low relief. Flow is from top to bottom of the image.

The second pertains to defining the surface - sub surface transition in gravel beds. There are numerous definitions of where the surface subsurface transaction occurs, primarily relating active layer depth and porosity. When using surface based laser scanning the surface subsurface transition is deemed to occur at the bottom of the active layer, taken to be the lowest measured elevation where porosity tends to zero. However it is clear that sediment beds will still be porous below this value and hence the surface subsurface transition can be can be better estimated by using 3D MRI scanning. Comparison between porosity estimates generated from laser (red lines) and MRI (blue lines) highlights this discrepancy, showing a clear divergence in the vertical porosity profile. This has obvious implications for defining the depth at which the surface- subsurface transition occurs at (Figure 3).

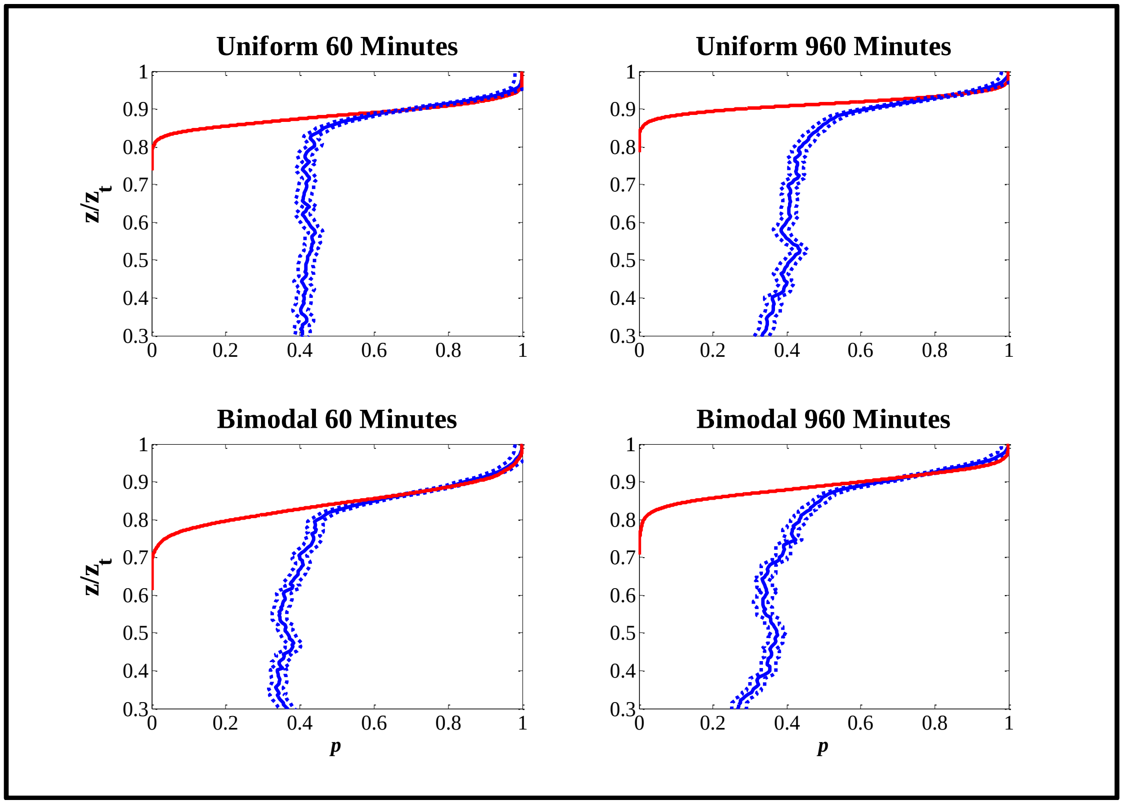

Figure 3: Vertical porosity profiles for uniform and bimodal beds (after 60 and 960 minutes of water working) given in terms of relative elevations, z/z_t. Laser-derived data is shown in red. MRI data in blue, including maximum uncertainty (dotted lines) of ±0.02. MRI profiles are truncated 30% above the base of the sample. Raw data are used to produce each profile; no smoothing algorithm is employed.

24. Using thermal imaging to measure coherent flow structures at the water-air interface

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*Presenter

Turbulent mixing processes in open channels affect the exchange of momentum, heat, nutrients, pollutants and control gaseous exchanges. The initiation of turbulent flow structures occurs at the sediment boundary where roller vortices generated over bed morphology evolve into horseshoe vortices. Ultimately these vortices rise upwards where they can be detected at the water surface - air interface as turbulent boils or 'kolks'. Such structures disrupt the net heat loss to the atmosphere and hence generate temperature variability at the water surface (Chickadel *et al*., 2010). This temperature variability can be measured using thermal cameras trained on the water surface. Herein, two proof-of-concept examples are discussed using thermal cameras to capture turbulent energy dissipation in laboratory experiments.

Firstly, the eruption of turbulent kolks, produced by a fixed bed of dunes, was measured using a thermal camera orientated parallel to the water surface (Figure 1). The thermal camera had a field of view of 0.65 by 0.50m and measured at 50 Hz. Particle Imaging Velocimetry (PIV) was simultaneously used to measure the streamwise development of flow structures from the dune bed to the free surface. This simultaneous measurement facilitated the description of the processes involved in generating these turbulent flow structures and their subsequent morphology and interaction with the free surface.

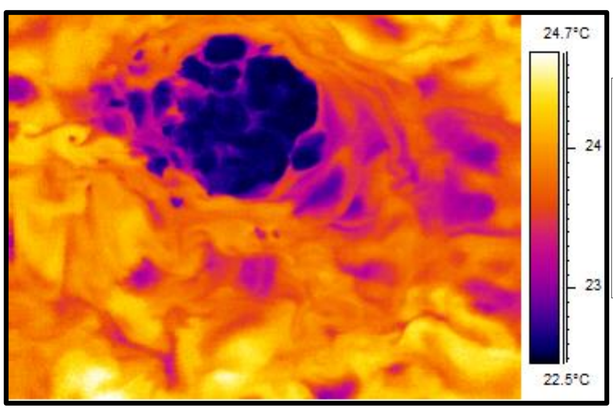

Figure 1. Example of a thermal image captured of the free surface. Purple denotes areas of cooler temperatures whilst yellow denotes areas of warmer temperatures. The turbulent boil is observed as the area of intense purple coloring at the center top of the

The second example pertains to understanding the temporal development of alluvial dunes in response to a simulated hydrograph. The spatio-temporal development of a mobile dune bed surface topography was captured using an array of ultrasonic sensors with three-dimensional flow measured using a vertical stack of Acoustic Doppler Velocimeters. The relationship between the bed surface development and the production of turbulent kolks at the water surface was captured by the thermal camera.

Results in both cases reveal the intricate linkages between the generation of macro-turbulent structures at the bed and their subsequent evolution and interaction with the leeside flow separation zone shear layer in producing complex patterns of 3D vortex interactions with the free surface. There is potential to use these results to examine the validity of past models of vortex interaction with the free surface.

25. Characterization of the active width of gravel-bed braided rivers using structure-from-motion photogrammetry

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*Presenter

Gravel-bed braided river morpho-dynamics is strongly tied to spatially and temporally variable bedload transport associated with bar dynamics, local scour-deposition and channel pattern instabilities. Consequently, bedload transport in these rivers is difficult to measure by conventional methods but may be measured and predicted using morphological (inverse) methods based on mapping rates of morphological change over time. Previous research has shown that a relatively small area of the channel actively transports sediment at given time, known as the active width. This active width seems to be controlled by hydraulic and morphological parameters in a predictable way such that its measurement could contribute to reach-averaged bedload measurement and prediction. This research aims to characterize the active width over a range of river morphologies and investigate its relationship with braided river morphology, stream power and bedload transport rate. Experimental control of channel pattern and stream power is achieved in a 20m x 3m river modeling flume with adjustable discharge (0.7-2.5l/s) and slope (1-2%) via Froude-scaling (~1:30) of the particle size distribution from a gravel-bed river with erodible sediment. Measurement of bed topography, volumetric transport rates and the morphological active width are achieved with high resolution DEMs of the channel topography. Digital imagery is acquired from 2 convergent cameras mounted on a movable trolley above the flume and Agisoft Photoscan SfM software is used to create DEMs with a vertical resolution of ± 3mm. Successive DEMs are subtracted to create a DEM of difference (DoD) allowing for the quantification of the active width as well as volumes of erosion and deposition. In each test run, the bedload transport rate is measured in sediment traps at the downstream end of the model which can be directly compared with morphological transport rates derived from DoD processing. Preliminary results have shown that the active width, dimensionless stream power and bedload transport are spatially and temporally variable even under constant initial slope and discharge. By characterizing these relationships this research will contribute to our understanding of gravel-bed river morpho-dynamics.

26. The relative importance of channel and vegetation temporal and spatial scales in maintaining a distributary channel network in the lab

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Natural deltas are incredibly complex systems that are controlled by a large number of variables. Here we attempt to determine the effects of vegetation on delta dynamics by conducting laboratory experiments using alfalfa (*Medicago sativa*) as a proxy for delta vegetation. Experiments were conducted with a 20% flood intermittency and a sediment mixture of sand- and clay-sized particles. In the early stages of the experiments, the imposed fluctuations in discharge led to clear pulses in shoreline progradation. As vegetation cover increased over time, shoreline progradation pulses became more damped, resulting in more constant shoreline growth. The pattern of vegetation cover, rather than the overall amount of cover, was more important in setting the timing of this switch to constant growth; patchier vegetation allowed for more channelization and therefore periods of rapid shoreline growth, while more uniform vegetation resulted in a faster transition to constant shoreline growth. Large deltas with relatively low vegetation cover had bifurcations that were maintained throughout several flow cycles. These deltas looked most qualitatively similar to natural deltas (Figure 1). Once vegetation cover increased, smaller channels were more easily annealed and channel distributary networks were less likely to persist over time. We therefore conclude that there is an important competition between the time and space scales of channelization and vegetation establishment that determines the point at which vegetation can help to both create and maintain a distributary channel network. Quantitative comparisons between experimental and natural deltas are still needed to determine the similarities and differences between the lab and nature.

Figure 1. An example of channelization during a vegetated experiment, showing a variety of channel scales and bifurcation around vegetated islands.

27. Hydrodynamic impacts of freshwater mussels: measurement of turbulence generation in a laboratory flume

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Hydrodynamics of aquatic ecosystems encompass both the physical interaction between flow and organisms, as well as ecologically relevant mass-transfer-uptake processes. As benthic filter feeders, mussels contribute to near bed flow hydrodynamics in two ways. First, mussel shells act as a physical roughness feature at the water-sediment interface, and second, mussel-filtering activity generates mass and momentum transfer processes with the surrounding water. Here, we look at turbulence generation due to mussel filtering activity in a laboratory flume. To control the experimental inputs, we used mussel shells (*Lampsilis siliquoidea*) with a model siphon pair connected to a peristaltic pump to enable variable filtration rates. We used three filtration rates representing a range of naturally occurring filtration ability. For each filtration rate, we introduced a range of ambient flow velocities in the flume and characterized the hydrodynamic flow conditions using two-dimensional particle image velocimetry. We are in the process of analyzing the results and will estimate the effect of filtering on downstream turbulence for each filter and flow scenario. These results will be used to make conclusions on how the filtering activity of mussels contribute to near-bed hydrodynamics and how this information can provide insight to nutrient mixing and feeding efficiency within mussel beds.

28. Infiltration response of Arctic soils impacted by volcanic ash, Iceland 2015

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*Presenter

Volcanic eruptions are a common occurrence in Iceland, which is often referred to as the land of ice and fire. In 2010, Eyjafjallajökull erupted spewing much fine ash into the atmosphere and over much of southern Iceland. In 2011, Grímsvötn erupted and coarse ash fell over southeastern Iceland. Expectations are that Katla (Myrdalsjökull) will erupt soon. Once settled, this ash is not easily removed from the environment, it often becomes incorporated into the vegetation, can augment stream bed levels and modifies slope infiltration patterns and runoff long after the initial eruption has occurred. The impact of volcanic ash on arctic landscapes (slopes and wetlands) is the focus of a broader study but here we evaluate the infiltration response of near-surface arctic soils impacted by volcanic ash using a simple field apparatus (see Fig. 1). The study site was located in a small upland catchment (63.6°N, 19.4°W) near the Fimmvorduhals Pass which separates Eyjafjallajökull from Myrdalsjökull.

Figure 1. Experimental field set-up of infiltration experiment, June, 2015. Each plot is 537 cm^2 and infiltrating water can be stored in the soil matrix, runoff or freely drain into a measuring vessel. Surficial materials are typical of the study slope. Left to right is: Moss, Ash Blasted Moss, Grass (no Ash), and a mix of Rock, Grass+Ash blasted Moss. The set-up can adjust for aspect and slope angle. Note a Theta soil moisture meter monitors volumetric soil moisture in the Ash plot.

The experimental apparatus was operated under an initial rainfall intensity of 45 mm/min. Preliminary results indicate that infiltration is highest for terrain types in the following order: Mixed Rocky+Grass+Moss > Grass > Moss > Ash Blasted Moss > Ash. More than 50% of the water drained through the Mixed Rocky+Grass+Moss plot, while the Ash plot retained about 90% of the infiltrating water in its matrix. These micro-plot results confirm initial infiltration studies using double ring infiltrometers, and provide an approach to evaluate the spatial pattern of infiltration, soil moisture storage and runoff in a remote study site.

29. Experimental evidence for hillslope control of landscape scale

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Theoretical models for landscape evolution suggest that the spacing of ridges and valleys in eroding landscapes is set by the efficiency of hillslope transport relative to channel incision. Specifically, these models predict that drainage density should vary with the landscape Péclet number, which is proportional to the ratio of hillslope diffusivity *D* and the stream power constant *K*. This theory implies that climate can affect landscape scale by modulating both diffusive processes that sculpt convex hillslopes and advective processes that carve concave valleys. However, the link between the relative dominance of hillslope and valley transport processes and landscape scale is difficult to demonstrate in natural settings due to the slow and episodic nature of erosion. Here, we present results from a series of laboratory experiments that systematically vary the landscape Peclet number by changing the relative dominance of hillslope transport. Our experimental apparatus, the St. Anthony Falls eXperimental Landscape Model, consists of a 0.5 m x 0.5 m test flume filled with crystalline silica (D_{50} = 30μ) mixed with water, a high-resolution laser scanner to measure topography, and load cells to measure sediment flux. Baselevel lowering is simulated by dropping two motorized weirs. During each run, we alternated between: (1) advective transport induced by a series of misting nozzles, where drops are not large enough to disturb sediment on impact, and (2) diffusive rainsplash transport driven by a constant head drip tray. Using established models for hillslope transport, we demonstrate that the % drip transport is a robust proxy for hillslope transport efficiency in our experiments. We use the steady-state topography of our experiments to independently calculate *D* and *K* and measure drainage density. Our results confirm theoretical predictions that landscape Péclet number is correlated with drainage density (Figure 1). Robust linkages between transport processes and topography, such as those we present, are an important component of interpreting a wide range of geomorphic forms, including planetary surfaces, paleolandscapes, and sedimentary deposits.

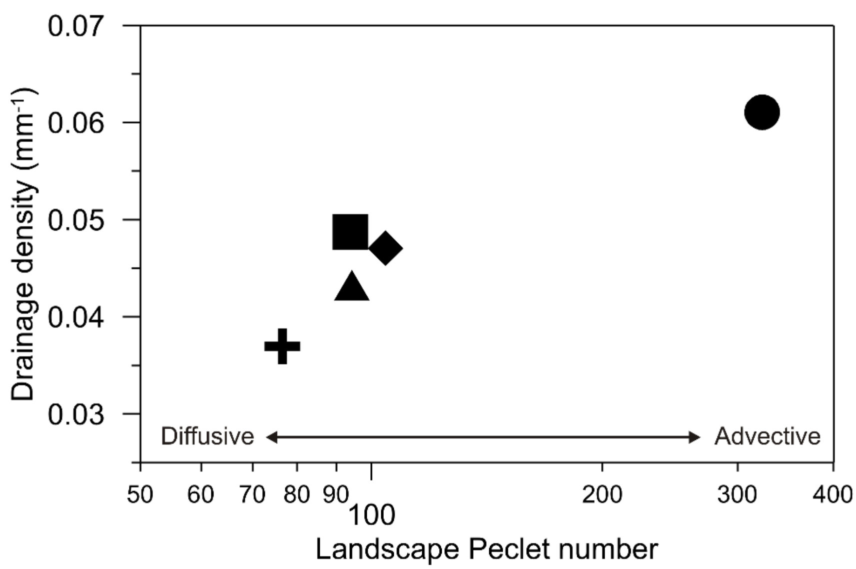

Figure 1. Effect of landscape Péclet number on landscape scale. Landscape Péclet number for each experiment (circle, 0% drip; square, 18% drip; diamond, 33% drip; triangle, 66% drip; plus sign, 100% drip) versus drainage density of GeoNet-derived drainage networks.

30. Reorganizing landscape under changing climatic forcing

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*Presenter

Understanding reorganization of an evolving landscape under changing climatic forcing is important to assess the response of landscapes to external perturbations. However, real landscape observations for long-term analysis are limited. To tackle this problem we have utilized a high resolution controlled laboratory experiment conducted at the St. Anthony Falls laboratory at the University of Minnesota. Elevation data were collected at temporal resolution of 5 mins and spatial resolution of 0.5 mm as the landscape approached steady state (constant uplift and precipitation rate) and in the transient state (under the same uplift and 5x precipitation rate). Recent results by Singh et al. (2015) revealed rapid topographic re-organization under a five-fold precipitation increase with the fluvial regime expanding into the previously debris dominated regime, widening channels, and accelerated erosion happening at hillslope scales. The focus of the present study is to better understand the initiation of the observed reorganization. For this purpose, we have performed a connectivity and clustering analysis of the erosional and depositional events, showing strikingly different spatial patterns of landscape evolution under steady-state (SS) and transient-state (TS), even when the time under SS is renormalized to match the total volume of eroded and deposited sediment in TS. Our preliminary results suggest a regime shift in the transport behavior of the fluvial system at intermediate scales from supply-limited to transport-limited.

References

Singh, A., L. Reinhardt, and E. Foufoula-Georgiou (2015), Landscape reorganization under changing climatic forcing: Results from an experimental landscape, *Water Resour. Res.*, 51, doi:10.1002/2015WR017161.

31. Swimming capacity of emerald shiner minnows (*Notropis atherinoides*) from the Upper Niagara River

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Along the Upper Niagara River, near the outlet from Lake Erie, structures such as the international Peace Bridge and Broderick Park seawall have augmented the flow of the river, increasing water velocity to an extent that may negatively impact wildlife, specifically emerald shiner minnows (*Notropis atherinoides)*. The emerald shiner minnow (ESM) is prey to many fish and migratory birds, and is considered to be a keystone species for the area's ecosystem. If the increased water velocity has created an unnatural hydrodynamic barrier to fish migration upstream, the ESM population may be impacted. As part of the effort to ascertain whether this is the case, we are conducting swimming capacity and endurance trials to quantify the swimming ability of the ESM. The fish are placed into a swim tunnel (Figure 1), which is inside a recirculating hydraulic flume. The ESMs are acclimated to the water, then the water flow is gradually increased to the target velocity. Once the target velocity is reached, the fish is monitored for 60 min or until swimming failure occurs. If the ESM fails, it is given a recovery period and then retried at that speed. Water parameters including temperature, dissolved oxygen, pH, and conductivity are recorded. Post-trial, the physical measurements of each fish are taken including total length, standard length, fork length, upper caudal lobe length, and body weight. A high-resolution is taken for archival purposes. Each velocity tested has a sample size of 10 fish. Due to the varying degree of fish health and age, a range of trial times has been observed at each of the velocities run to date. As shown in Figure 2, there have not yet been any fish that have exceeded a flow velocity of 60 cm/s, with most failing near the 1:30 min mark. Currently, all fish that have been run are treated as data points, without omission of trials that may have failed due to stress or disease. As such, any conclusions that are drawn from this data are not final. The Upper Niagara River typically has mean flow velocities from 1 to 2 m/s. Based on the preliminary data and observations, the individual swimming capacity of the ESM would not be able to navigate upstream under these hydraulic conditions. Future work will evaluate the effect of schooling behavior to overcome higher velocities, and to quantify the fluid dynamics of both individual and schooling swimming behaviors.

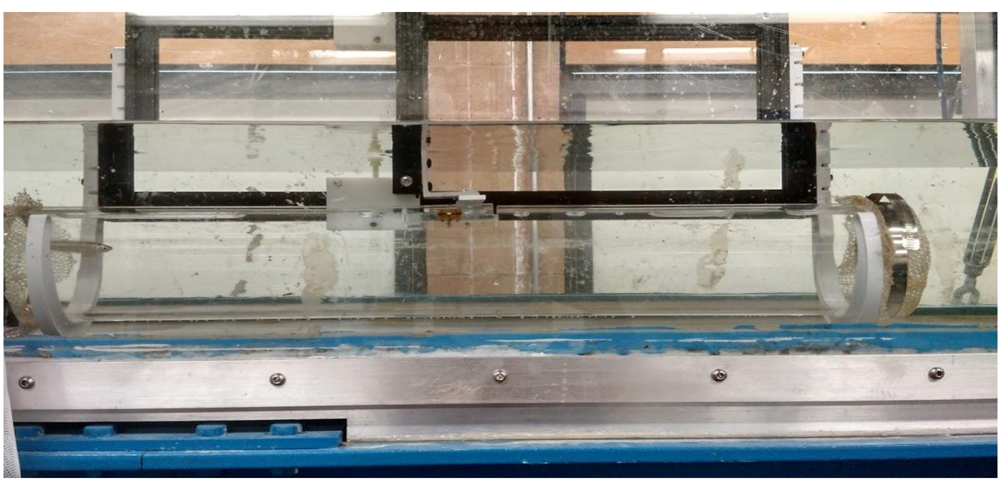

Figure 1. Swim tunnel placed into a recirculating flume. Flow is left to right. Note the EMS in the left-hand side of the tunnel.

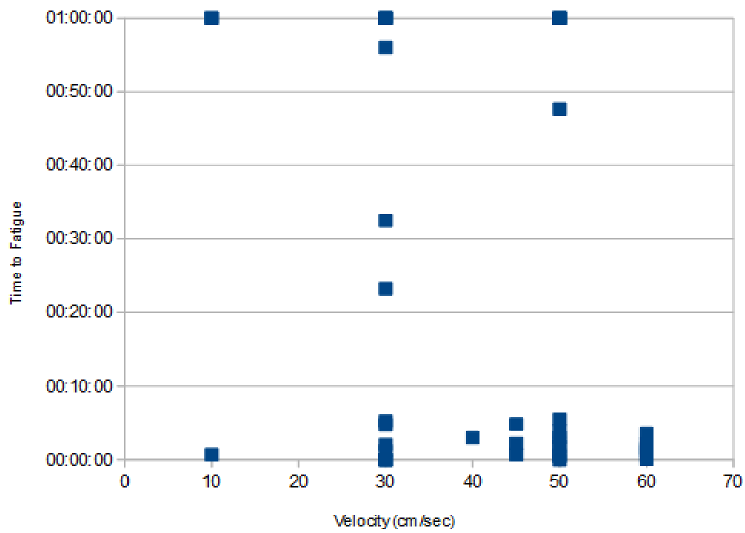

Figure 2. Preliminary data for time to fatigue for emerald shiner minnow.

32. Onset of sediment transport in vegetated channels

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The existence of aquatic vegetation alters the incipient velocity of sediment transport due to its impact on the bed shear stress and turbulence production. This study proposes a new model to estimate the bed shear stress in both vegetated and bare channels. The model, which is supported by measurements in a laboratory channel, indicates that for both bare and vegetated channels, within a viscous sublayer at the bed, the viscous stress decreases linearly with increasing distance from the bed, resulting in a parabolic velocity profile at the bed. For bare channels, the model describes the velocity profile in the overlap region of the Law of the Wall. For emergent canopies of sufficient density (frontal area per unit canopy volume $a \geq 4.3m^{-1}$), the thickness of the linear-stress layer is set by the stem diameter (d), leading to a simple estimate for bed shear stress, $u_* = \max(\sqrt{C_f}U, 2\sqrt{\nu U/d})$. The turbulence ($TKE$) induced by vegetation has been quantified by previous studies. The relationship between incipient sediment motion, bed stress (u_*), and TKE has been explored using laboratory studies. The sand motion was recorded using a camera. By subtracting the pixel intensity of subsequent images, moving sands were identified using Labview module IMAQ Find Circles.

33. The harmony of data-model interaction in landscape evolution modeling, an example from the Shale Hills CZO of central Pennsylvania

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A 0.08 km^2 first order catchment (Shale Hills Critical Zone Observatory, PA) installed hundreds of sensors and equipment for bedrock weathering, regolith movement, soil moisture, soil temperature, soil water flow path, solar radiation, plant growth, evaporation, surface water flow, sediment load, snow, etc. Previously, these data, plus the remote sensed data, only support a particular aspect of research. However, the increasing cooperation among different disciplines requires a higher level of collaboration among interdisciplinary observations and measurements.

With the support of multi-spatial and temporal scale data for model parametrization, calibration and validation, this study utilizes a 3D hydrologic-morphodynamic model (LE-PIHM) which links bedrock, soil, surface and subsurface water flow, plant, energy, and seasonal climate to explore the possible factors that causes the topographic asymmetry of the Shale Hills CZO. The simulated results show obvious spatial variations of solar insolation, infiltration and groundwater flow which affects overland flow, freeze-thaw events, bedrock weathering, and morphodynamic feedbacks on both hillslopes. Especially, the solar insolation is the major factor that affects evaporation and freeze-thaw frequency, thereby causing the asymmetric sediment diffusivity by freeze-thaw process on the hillslopes. The simulated diffusion flux indicates that the measurement overestimates the difference of sediment transport efficiency between the two hillslopes. The critical transition of diffusion flux by model simulation shows the limitation of current observations and measurements, and highlights the locations where additional measurement or observation should be conducted in order to better understand the landscape evolution in watershed scale.