



Photo courtesy of Chris Simpson.

Issue 4 | January 2014

# Scaling new heights ESD News

Welcome to the Geography and Environment, Earth Surface Dynamics research group newsletter. In this issue we have a range of interesting articles about the group highlighting cutting edge research, and a special feature on the STELAR-S2S team riding out the flood wave during Mekong fieldwork.

# News in brief

## Paul Carling

Over the past few months, Paul has given presentations at 8th Symposium on Rivers, Coast and Estuarine Morphodynamics (RCEM) in Santander, Spain, and at the 10th International Conference on Fluvial Sedimentology (ICFS) in Leeds, on Ground-penetrating Radar Interpretation of Giant Gravel Dunes. During the ICFS conference, Paul also led a successful fieldtrip to the Severn Estuary with 16 international delegates. In November 2013, Paul presented work at the IGCP 581-Evolution of Asian River Systems in Hanoi, Vietnam.

One of Paul's former PhD students, Luba Meshkova (now a visiting researcher), presented a joint paper with Paul on "The Quaternary Mekong River: terraces, sediments, climate and former river courses" at the highly respected 8th International Association of Geomorphologists conference in Paris. Whilst one of Paul's current PhD students, Akirat Abdulkad, presented a poster "The Dynamics of Cobble Dunes, Severn Estuary, UK" at the British Society of Geomorphology (BSG) meeting at the University of London, Royal Holloway. Akirat was successful in receiving sponsorship from the BSG to attend the meeting.

Paul has recently been awarded £15K by Nexen Inc, Canada, for a pilot project entitled 'Sedimentology of a tidally influenced river deposit: River Severn Estuary, UK'. Together with possible extra funding from the Faculty Enterprise Fund (£5K) towards aid the Nexen project, there is potential for future large grant bids to stem from this work. Additionally, Paul has also made an application for c. £7K to the University's NERC Pilot Impact Acceleration Account (result pending).

Over the past few months Paul has also been engaged with visiting researchers from across the globe. Louisson Besozzi and Pierre Duraton, Centre d'Enseignement et de Recherche de Paris, Élève à l'École des Arts et Métiers Paris Tech, Paris, France, spent 8 weeks with Paul processing data for work experience and English language development. In addition, Prof. Juergen Herget (University of Bonn, Germany) and Dr. John Jansen (University of Wollongong, Australia) visited Paul to discuss potential future collaborations. Meanwhile, Paul and Prof. Peter Atkinson visited University of Utrecht to discuss collaboration with Associate Prof Maarten Kleinhans. Whilst in the Netherlands, Paul was a member of a PhD viva panel at the University of Utrecht.

River Severn Estuary



Flooding on the Mekong

## Steve Darby

Steve oversaw the first two major fieldwork campaigns of the NERC funded STELAR-S2S ([www.stelar-s2s.org](http://www.stelar-s2s.org)) project during September, October and November. The fieldwork was a huge success, with the team on hand to document rapidly rising (~6m in less than 1 week) flood levels following heavy rainfall associated with the passage of Typhoon Usagi over the basin. The fieldwork campaign was aided by two UG students from Southampton - Eleanore Heasley and Amelia Pazkowski. The key achievements of this initial campaign have been to make the first estimates of bedload and suspended sediment flux on the peak of a major flood, and to document the efflux of sediment and water through floodplain splay complexes. A more detailed report of the STELAR-S2S project and fieldwork campaigns can be found later on in the newsletter.

Steve has appointed Dr. Arnold Jan (Arjan) Reesink as a new Post-Doctoral Research Assistant (PDRA) to aid Steve in his research projects over the coming three years. Arjan joins us from the University of Hull where he has been working on large river

systems and sediment-flow interactions. His expertise compliments the research currently being conducted in the research group and we look forward to welcoming him to the group in January 2014.

Steve welcomes Frances Dunn, a new PhD student (co-supervised by Steve Darby and Prof Robert Nicholls and funded through the Southampton Marie and Maritime Institute), who started in October 2013. Frances will be working on modelling the future fluxes of sediment being delivered by the world's large rivers to their receiving deltas.

Steve has, in collaboration with Prof Daniel Parsons (Hull) been awarded funding (\$92k) from the Mekong River Commission for a consultancy that aims to establish a baseline habitat survey at the locations of proposed dam sites on the Mekong River in Cambodia. The work involves the use of hydroacoustic sensors to map the bathymetry and surface composition of the river bed, and to generate estimates of bed material and suspended sediment flux.

### Jane Hart

Jane has appointed Dr. Andrew Turner as a new PDRA working on the GLACSWEB project. Jane chaired a session on “Environmental Sensor Networks and Informatics” at the American Geophysical Union meeting in San Francisco, USA, in December 2013.

### David Sear

David welcomes David Sutherland who has started his PhD co-supervised by, Joe Wheaton (Utah), Nick Bouwes (Utah) and Julian Leyland on large wood mobility - the PhD is jointly funded with Utah State University, USA.

David attended an invitation only event for Defra/EA focused on working with natural processes. The meeting was aimed at developing a national research strategy for the next 5 years with funding set at £2.5 Million pa. The project is currently at a very early stage, and more news shall be delivered as the project progresses.

### Julian Leyland

Julian and Gareth Roberts were successful with an EPSRC small equipment bid to purchase an Unmanned Aerial Vehicle (UAV). The UAV has subsequently been deployed by Alex Clayton and Tom Bishop in Iceland, and by Julian and Chris Hackney in Cambodia. Preliminary results show that the UAV has the potential to monitor geomorphic change over enhanced spatial and temporal scales, compared to existing surveying techniques. Find out how the UAV may be used in geomorphological research later on in the newsletter.

Julian and David Sear, along with Rebecca Hodge (Durham) were successful in their bid for NERC funding for their study “How does the development of particle scale structure control river scale morphology?” (£270k to Southampton). The project involves the application of field monitoring, flume experiments, CT scanning and numerical modelling to assess the 3D fluvial structure of river bed morphology. The team are hoping to appoint a PDRA to work on the project for 36 months.

In December, Julian attended a workshop in the Netherlands focussed on “Improving understanding of fluvial landscape development: exploring synergies between field-based and modelling approaches”. Attendance was by invitation only and brought together twenty researchers from the landscape modelling and field data communities with the aim of producing an agenda setting paper.

Julian welcomes a new PhD student, Greg Vasilopoulos, who started in September, working on “A generic model for quantifying boundary layer roughness in different fluid flows through the application of Terrestrial Laser Scanning (TLS) data”. The project is co-supervised by Jo Nield.

Along with colleagues in Psychology, Julian appointed a PDRA to the EPSRC human vision project. Alex Murry will be collecting and processing TLS data under the guidance of Julian to build a database of natural scene statistics. processes - developing a research strategy for the next 5 years with funding set at 2.5 Million pa. More on this as it develops - spring 2014.



Alex and Tom with the new UAV in Iceland.



The STELAR-S2S September crew (from left to right) back: Steve, Jim, Rolf, Chris, Rich. Front: Dan, Amelia, Eleanore

## STELAR-S2S team ride out flood wave during Mekong fieldwork.

In September and October Steve Darby, Julian Leyland and Chris Hackney joined partners from the universities of Exeter, Hull and Illinois and ventured out to the Mekong River, Cambodia, to undertake fieldwork as part of the NERC funded STELAR-S2S (Sediment Transport and Erosion in Large Alluvial Rivers – Source to Sink) project ([www.stelar-s2s.org](http://www.stelar-s2s.org)). STELAR-S2S aims to understand the relationship between climate and sediment flux on the world's largest rivers. Every year ~19 billion tonnes of sediment is transported by the world's largest rivers to their deltas, which are home to approximately 14% of the world's population. The majority of this sediment is transported and deposited during the annual monsoonal floods; the timing and magnitudes of which are being affected by climate change and human development in the form of hydropower installations; indeed the Mekong's delta is one of only three in the world to be classified by the IPCC as 'extremely vulnerable' to future

changes in climate. STELAR-S2S aims to provide the first quantification of the natural and human controls on sediment supply and deposition under changing climates.

Timed to coincide with the peak of the annual flood, the September fieldtrip started smoothly. However, after about day four the rains came, and once the rain started, it fell so heavily that the near-zero visibility meant it was no longer safe to navigate on the Mekong River, so all work ceased. For about a week and a half after that point the team were at the mercy of the annual monsoon and Typhoon Usagi which made landfall in the northern part of the Mekong catchment adding more water to an



The storm clouds gathering over the Mekong

already swollen river. Little did they know that they were soon to be caught up in one of the Mekong's largest floods (by peak discharge). At its peak, the discharge measured exceeded 60000 cumecs. By comparison the largest flood recorded on the River Severn in the UK is 533 cumecs.

Aided by two Royal Geographical Society funded Fieldwork Apprentices, Eleanore Heasley (Southampton) and Richard Campion (Hull) and third year physical geography undergraduate student Amelia Pazskowski (Southampton), the team collected high-resolution bathymetric data of the river and detailed measurements of the near-bank flow structure, revealing complex patterns of behaviour previously unidentified in large rivers. When combined, these data sets will enable the team to say, in detail, how large rivers behave

close to their banks and how floods act to control the processes occurring within these large river systems.

By the time the team returned to the Mekong at the end of October, to conduct repeat surveys, the nature of the river had dramatically changed. Water levels had dropped by 7 meters and the debris which had made navigation and surveying difficult a month before had all but disappeared. This time around, the maximum discharge measured was 24000 cumecs, less than half that observed on the previous campaign. These marked changes only a few weeks apart made it apparent how much of an impact Typhoon Usagi had had upon the system, and enforced how lucky the team had been to have captured such a significant event.

Setting up the dGPS basestation



The data collected over the two fieldwork campaigns will be used to inform numerical models of large river behaviour in order to elucidate the response of large rivers to climatic variability and anthropogenic influences on hydrological regimes. In a region which is currently undergoing substantial hydropower development,

coupled with the pressures of a changing climate, the outputs from the STELAR-S2S project promise to be both timely and significant.

For more information on the STELAR-S2S project, visit [www.stelar-s2s.org](http://www.stelar-s2s.org) or follow us on Twitter @Stelar\_s2s.

Flooding affects local communities along the Mekong



## ESD research makes EGU news

Research conducted by Dr. Jo Nield, Prof. Steve Darby and Dr. Julian Leyland in Iceland has featured in the European Geophysical Union *Imaggeo on Mondays* feature on 16 December 2013. *Imaggeo on Mondays* is a look at the EGU's image repository, with selected images being chosen every week to highlight the research undertaken in European Universities, and the stunning natural landscapes the research is conducted within.

This image was taken by Jo en route to the supermarket during a fieldwork campaign in 2011 following the Grímsvötn eruption. The eruption covered the surface of the glacier in a spatially variable layer of volcanic tephra. Jo and her team used terrestrial laser scanning to study the impact on nearby Svínafellsjökull soon after the eruption with funding from the Royal Society – by

“Fjallsjökull after the 2011 Grímsvötn eruption” by Joanna Nield, distributed by the EGU under a Creative Commons licence.

taking daily surface measurements the team have shown that shortly after an eruption, ice melt rates could be reduced by as much as 59% compared to clean ice model predictions.

When ash covers an ice surface, it changes the rate that snow and ice is lost from the glacier (the ablation rate). Dark coloured ash will reduce the albedo (reflectiveness) of the surface, causing it to absorb more heat. This causes an increase in melt rates for thin debris layers, but thick layers of ash insulate the ice and reduce melt. On top of this, complex feedbacks between debris cover, meltwater and surface shape redistribute ash and change surface roughness – which also influences ablation rates. It is important to understand these ash-ice interactions as well as feedbacks between the surface and atmosphere to better quantify the impact of volcanic eruptions in glaciated landscapes.

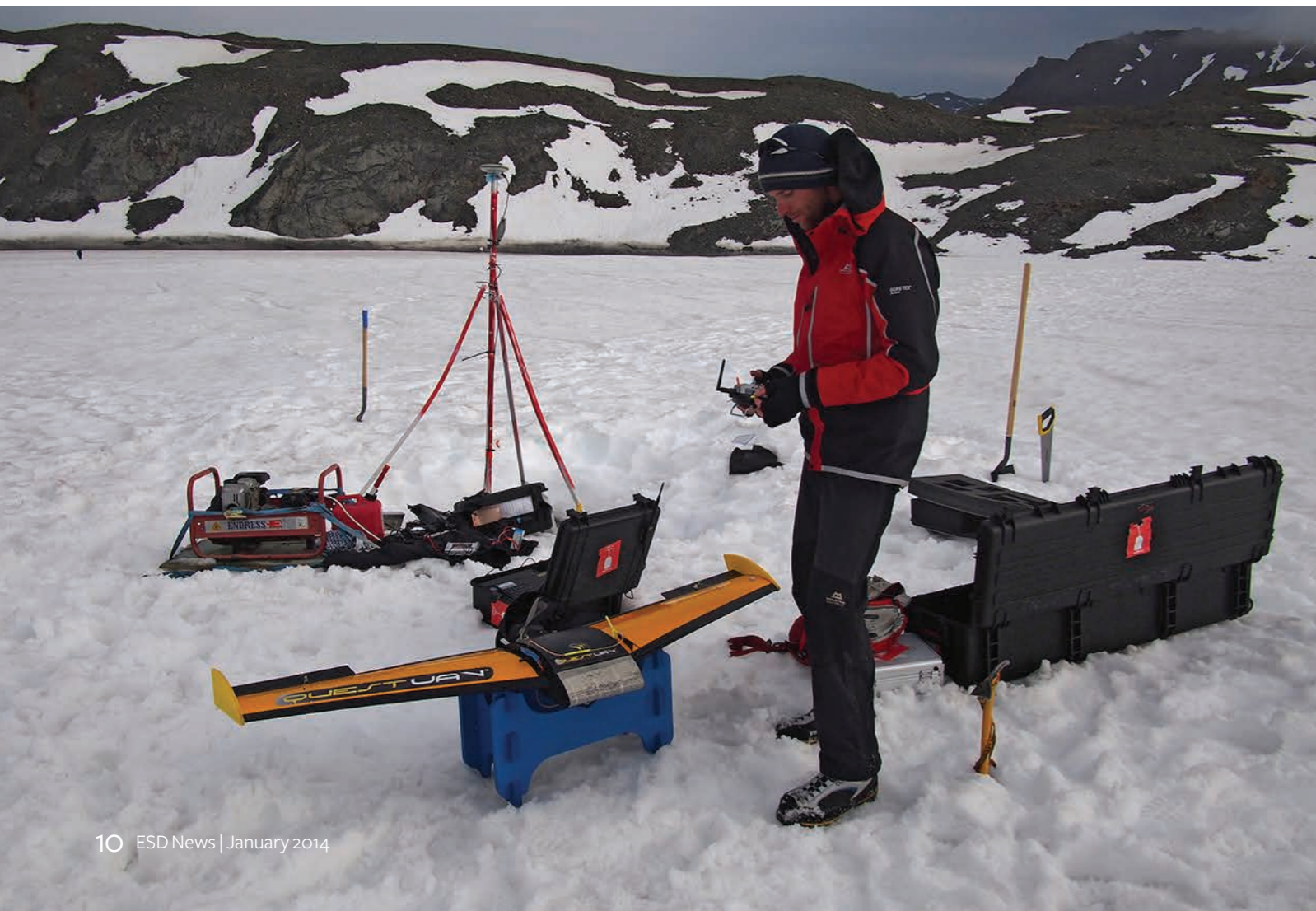
## Blue skies research: capturing geomorphology from the air

One of the major developments in geographical research over the past few years has been the advent of remotely operated aerial photography. Previously the domain of private survey companies with access to light aircraft, or major satellite platforms, now-a-days cheaper options exist allowing the user to survey when and where they like (within any legal restrictions, obviously!). At Southampton, we have a light weight, small unmanned aerial vehicle (UAV), a QuestUAV 200, which allows us to get aerial photography, and, using some impressive software, covert these images into digital terrain models. Having such an ability has opened up many research opportunities.

One project making the most of the UAV's potential is Glacsweb. PhD student, and ESD member Alex Clayton recently deployed the UAV over the Skalafellsjökull glacier in Iceland to better understand how the glacier moves. "If we know more about how glaciers move now, it will help us understand how they're going to move later this century in a warmer climate," he explains. "The models also tell us about the effects of climate change, we estimate this glacier is losing up to four metres of ice a year from its surface." The Glacsweb project also collects data from probes sunk under the surface of the glacier which can be combined with aerial photographs to provide a unique data set with which to better understand glacial movement and response to climate change.

Similarly, STELAR-S2S (a NERC funded project seeking to understand the controls on sediment erosion and deposition within large alluvial rivers) has deployed the UAV over the floodplains of the Mekong in Cambodia. As part of the project,

Alex preparing the UAV on the Skalafellsjökull glacier, Iceland



Preparing the UAV for deployment in Cambodia.

STELAR-S2S requires high resolution aerial imagery to inform detailed studies of bank erosion and to fully comprehend the role the annual monsoonal floods play in floodplain sedimentation. This October, the STELAR-S2S team took the UAV out to Cambodia in order to photograph a series of splay complexes; sedimentary deposits formed when the main river breaches its natural levee and deposits sediment across the floodplain. A series of surveys were flown over these complexes and the resulting data has allowed the team to gather elevation data at a resolution previously infeasible given the time constraints the project was operating within. This data is going to feed into models which will enable the STELAR-S2S team to understand the flow dynamics over

these complexes; the first time this sort of analysis has been conducted on natural splay complexes. This important research would simply not have been possible without the use of a UAV.

It is generally agreed that UAVs have a large role to play in the future of geomorphological surveying. Their durability, cost effectiveness and rapid surveying time all make for a highly useful and powerful tool. Having only recently begun to use our UAV in earnest, we are slowly realising just how useful this tool may be, and already new research avenues have opened up as a result of a better understanding of its capabilities. As for the future of airborne photogrammetry, the sky's the limit...

# In the jungles of the South Pacific: A quest for Holocene climate in lake muds.

**In July 2013 an interdisciplinary research team from Geography & Environment travelled to the remote jungles of Samoa and New Caledonia to unpack the story locked in the sediments of freshwater lakes. This story, a record of climate and environmental change, is largely untold for this part of the world, despite the south Pacific having one of the largest climate systems on earth. The research now forms the focus of a NERC PhD studentship taken up by Jon Hassall (ex RHUL MSc) who accompanied David Sear and Pete Langdon on the expedition.**

Long, undisturbed lake sediment archives from the south Pacific are extremely rare. However, where they have been studied (eastern Pacific), researchers have demonstrated that they contain high resolution environmental records, notably in the Galapagos and Rapa Nui. Lake Lanoto'o in Samoa, and the lake systems in New Caledonia are unique in providing a location that spans the SPTCZ (South Pacific Tropical Convergence Zone), and is central to regions of tropical cyclone formation and large scale climate variability

(ENSO, SPTCZ). The lakes have the potential to deliver a long (10<sup>3</sup> – 10<sup>6</sup> yr), high resolution record of climate and environmental change. This is vital, since it is only by understanding climate variability (for example precipitation, cyclone frequency and temperature from lake sediment archives) at decadal or annual resolution over long timescales that we can significantly improve our understanding of the links between the larger scale atmospheric and ocean processes represented in global climate models and smaller scale weather systems (cyclones). Furthermore, high resolution records have the potential to enable us to understand how these climate and weather systems create variability in precipitation and temperature. In turn such a record would help our understanding of the role of climate and environmental change in driving the observed changes in island ecosystems and human colonisation of the south Pacific.

**Read more at:** <http://esdsoton.wordpress.com/2013/10/07/in-the-jungles-of-the-south-pacific-a-quest-for-holocene-climate-in-the-lake-muds-part-1-samoa/>

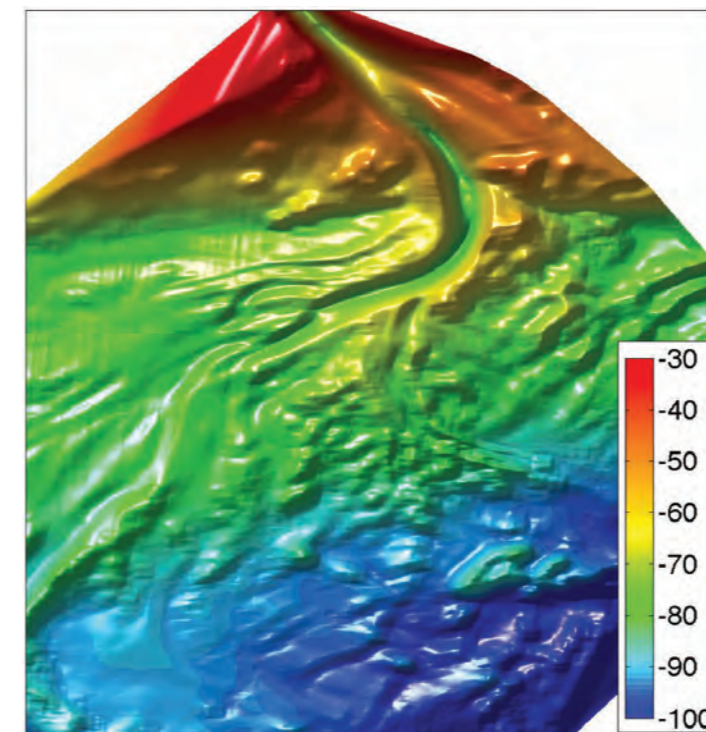
# A million miles from rivers? Radical new ESD paper identifies the key controls on secondary flow 'reversals' in submarine density currents.

**ESD members Dr. Rob Dorrell and Prof. Steve Darby have, in collaboration with colleagues at the Universities of Leeds and Hull and at NOCS, have just published an important new paper in the prestigious Journal of Geophysical Research – Oceans. The new research details how secondary flow structures (often called helical**

**flows) in meandering submarine channels can be completely different from their fluvial counterparts.**

Meandering submarine channel systems, created by density driven flows or turbidity currents, form some of the largest sedimentary deposits

on the planet. However, the morphological and sedimentological evolution of these systems is poorly understood. One of the key controls on the evolution of meander morphology is the sense of orientation of cross-channel flow. Such cross-channel flow arises in meandering flows primarily as a result of the action of the centrifugal force. In rivers this tends to push water towards the outer bank, super-elevating the water surface there and creating an opposing transverse pressure gradient. Imbalances in the magnitude of the pressure gradient and centrifugal forces through the water column create the helical flows observed in many rivers, where the sense of the helical circulation is such that the near-bed flow is typically orientated towards the inner bank. This circulation has a fundamental role in shaping patterns of scour near outer banks and deposition on inner-bank point bars.



Meandering submarine channel, South West Black Sea, bed depth below the sea increases from red to blue.

In recent years there has been a very hot debate about whether secondary flow structures in submarine channels are 'river-like' or 'river-reversed' in their sense of orientation. Previous experimental and theoretical studies have tackled this problem by generalizing fluvial theory

with various conflicting results. The current "consensus" is that both circulations are possible, but that 'river-reversed' flows are most likely confined to specific areas of submarine channel systems, such as the deep, steep, canyons that dissect the continental shelf.

However, the new paper proposes a radical new theory that highlights the unique role of super-elevation and 'overspill' in submarine systems. In river systems it is, over a relatively wide range of conditions, reasonable to assume that net cross-channel transport of material is negligible. In the new theoretical treatment, our team show that these net cross channel material fluxes exert the key control on the near-bed direction of cross channel flow – for cases where the material fluxes are not negligible the secondary flow structure is much more likely to be 'reversed'. With reference to experimental and field data the team showed that such cases are likely to be common, arising primarily from the enhanced flow super-elevation and resulting 'overspill' that is frequently seen in density currents.

Previous studies have suggested that secondary flow reversal is likely to be common mostly within the proximal regions of submarine canyon-fan systems and is unlikely in the more distal regions. However, the new paper has shown that 'river-reversed' flows are likely to be induced where flow super-elevation and overspill generates strong, outer bank oriented, radial fluxes as is likely the case even in the distal parts of submarine canyon-fan systems. Given that the direction of the near-bed radial flow is known to have a strong influence on sediment transport processes within meander bends, this research has significant implications in the context of seeking to understand facies patterns and bend topography within submarine channel systems.

The paper is now available through Wiley's website, with the full citation at: <http://onlinelibrary.wiley.com/doi/10.1002/jgrc.20277/abstract>

# From Iceland to Botswana – examining complex surface terrain

Research funded by the Royal Society, the Natural Environment Research Council and the Worldwide Universities Network is exploring estimating aerodynamic roughness using surface terrain measurements of sandur (glacial outwash plains) in Iceland and salt pans (dry lakes) in Botswana.

From a five day boat journey to the midnight sun of Iceland, to the vast expanse of a white, salty moonscape in the wilds of African Botswana, a sandur and a salt pan may seem like an unlikely coupling however, their complex, small scale roughness, relative flatness, lack of vegetation and large fetch make them the ideal experimental surfaces to develop empirical estimations of aerodynamic roughness from terrestrial laser scanner (TLS) datasets. More importantly, sandur and salt pans are also both potential dust emission sources, and so improving our understanding of surface-atmosphere interactions over surfaces in these areas is vital.

In a new paper just out in *Journal of Geophysical Research - Atmospheres*, Dr Jo Nield, together with colleagues from Oxford (Giles Wiggs, James King, David Thomas, Richard Washington), Southampton (Julian Leyland, Steve Darby, Larisa Vircavs), Liverpool (Richard Chiverrell), Cape Town (Frank Eckardt) and Sheffield (Robert Bryant) investigated 20 surfaces with element heights ranging from 1 to 199mm during four field campaigns. Co-located anemometer towers at each location measured actual aerodynamic roughness to compare to a myriad of surface metrics derived from TLS datasets.

Using cluster analysis height, shape, spacing

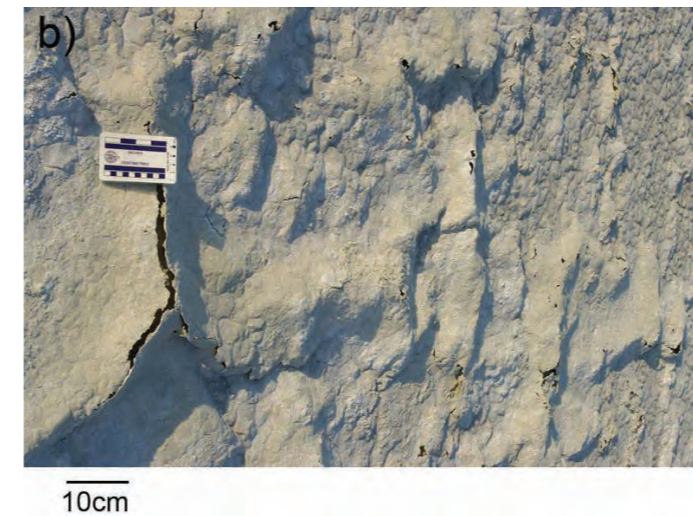
and variability metric groups were compared to decipher which best estimated aerodynamic roughness. When height metrics were employed, it was found that over 90% of the variability was explained and height is a better predictor than both shape and spacing.



The laser scanner on a Botswanan salt pan

This finding is in juxtaposition to wind erosion models that assume the spacing of larger-scale isolated roughness elements is most important in determining aerodynamic roughness. The study recognizes that when small-scale surface roughness is accurately quantified (with millimetre accuracy using TLS), height is most significant for estimating aerodynamic roughness, irrespective of comparator metric choice. This has very significant implications for the development of aerodynamic roughness predictors which are fundamental to the efficiency of wind erosion models, and, particularly, dust emission schemes in climate models.

The visuals below show (a) irregular salt pan, (b) regular, polygonal salt pan, and (c) sandur surface patterns measured using the TLS.



This research was undertaken thanks to many collaborative hours in the field with the Iceland data collection funded by the **Royal Society** and the Botswana work part of **DO4Models**, a much larger NERC funded project, with some travel support from the **Worldwide Universities Network**.

## Geography and Environment to host the British Society for Geomorphology annual conference

Southampton University has won the rights to host the BSG Annual Conference in 2015.

The meeting will be organised by members of Geography's Earth Surface Dynamics Research Group and will be held at the University in September 2015. The BSG conference is a major milestone in the geomorphological calendar and attracts scientists from the UK and overseas, offering an opportunity for scientists to discuss the latest developments and advances in geomorphic research.

More details on the conference logistics and abstract submission will be posted in due course. Southampton last hosted the conference in 2005 and we look forward to a similarly engaging meeting.



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