St. Anthony Falls Laboratory

Faculty, staff and student participants in the

46th Annual Fall Meeting of the American Geophysical Union

December 9-13, 2013

San Francisco, California

AGU FALL MEETING

San Francisco | 9–13 December 2013

St. Anthony Falls Laboratory. The St. Anthony Falls Laboratory (SAFL) is an interdisciplinary fluid mechanics research and educational facility of the College of Science and Engineering at the University of Minnesota. Located on Hennepin Island in the Mississippi River in the heart of Minneapolis, SAFL research explores science-based solutions to major societal challenges in energy, the environment and health. Learn more at www.safl.umn.edu.

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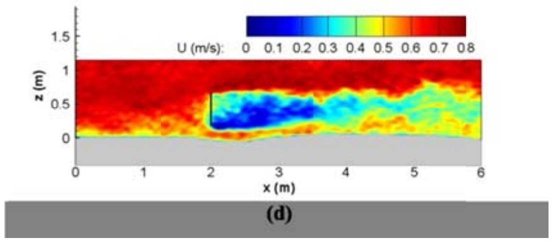
MONDAY, DECEMBER 9, 2013

Monday, December 9, 2013
Session OS13E. Marine Renewable Energy II
2:55 PM - 3:10 PM
3009 (Moscone West)

Numerical investigation of bed morphodynamics due to a hydrokinetic turbine (OS13E-06)

Xiaolei Yang (University of Minnesota); Ali Khosronejad (University of Minnesota); Fotis Sotiropoulos (University of Minnesota)

Marine and hydrokinetic (MHK) energy comprises an important source of clean and renewable energy. The beds of natural waterways are usually erodible. The hydrokinetic turbines affect the sediment transport, which, on the other hand, also influences the performance of hydrokinetic turbines. A powerful computational framework for simulating marine and hydrokinetic (MHK) turbine arrays mounted in complex river bathymetry with sediment transport has been developed and validated by our group. In this work we apply this method to simulate the turbulent flow over a hydrokinetic turbine mounted in an open channel with erodible bed. Preliminary results show qualitatively good agreement with the experiment. Detailed comparison with measurements and analysis of the simulation results will be presented in the conference.



Contours of the instantaneous streamwise velocity for flow past a hydrokinetic turbine mounted on an erodible bed.

TUESDAY, DECEMBER 10, 2013

Tuesday, December 10, 2013
Session H23I. Advances in Spatial Scaling of Hydrological and Biogeochemical Processes II
1:55 PM - 2:10 PM
3018 (Moscone West)

Quantifying the imprint of geologic controls on river network topology and scaling in hydrologic response *(Invited)* H23I-02

Mohammad Danesh Yazdi (University of Minnesota); Anthony Longjas (University of Minnesota); Stefano Zanardo (University of Minnesota); Efi Foufoula-Georgiou (University of Minnesota)

River network topology has been at the core of relating geomorphologic and hydrologic properties of landscapes, specifically in developing scaling frameworks of hydrologic fluxes. Recent studies have suggested that the topological structure of river networks might carry the signature of the underlying climatic and/or geologic controls of landscape evolution with implications for regionalization studies and network-based predictive frameworks of hydrologic response. In this study, the drainage networks of 12 sub-watersheds within the Minnesota River Basin (MRB), extracted from the National Hydrography Dataset (NHD), are analyzed in terms of statistical self-similarity in geomorphologic, topologic, and hydrologic attributes. The MRB offers a unique setting for studying fundamental processes of landscape evolution as its geologic history has left behind a still evolving landscape with propagating knickpoints, steep bluffs, strath terraces, and an impressive spatial heterogeneity in river network topology. Preliminary analysis of the MRB sub-watersheds reveals that they do not follow some of the statistical self-similarity relationships usually found in river networks such as the scaling of slopes and lengths with respect to stream order. In addition, the Tokunaga self-similarity analysis shows a wider variability of the higher-order branching parameter c ranging from 1.3 to 2.7, relative to the first-order branching parameter a, which ranges from 0.9 to 1.6. Also, as the Horton-Strahler order of the sub-watersheds increases, a different topology with more regular drainage patterns is observed with lower c values, revealing important connections between geology and network topology. We investigate the hypothesis that sub-watersheds with steeper and still actively incising channels exhibit a pronounced higher-order branching, reflected visually in highly “feathered” networks and quantitatively in higher values of the Tokunaga parameter c. The frequency of knickpoints, which are described as locations in a river where there is a sharp change in channel slope, is examined using high-resolution digital elevation models to provide a better understanding of the quantitative relationship between landscape geomorphic features, drainage patterns and scaling in hydrologic response.

TUESDAY, DECEMBER 10, 2013

Tuesday, December 10, 2013
Session H23N. The Flow Below: Defining, Quantifying, and Understanding Baseflow II
2:55 PM - 3:10 PM
3005 (Moscone West)

Sources of baseflow for the Minnehaha Creek Watershed, Minnesota, US (H23N-06)

John Little Nieber (University of Minnesota), Trisha L. Moore (University of Minnesota), John S. Gulliver (University of Minnesota), Joseph A. Magner (University of Minnesota), Linse B. Lahti (University of Minnesota)

Minnehaha Creek is among the most valued surface water features in the Minneapolis, MN metro area, with a waterfall as it enters the Minnehaha Creek park. Flow in Minnehaha Creek is heavily dependent on discharge from the stream's origin, Lake Minnetonka, the outlet of which is closed during drought periods to maintain water elevations in the lake resulting in low- (or no-) flow conditions in the creek. Stormwater runoff entering directly to the creek from the creek's largely urbanized watershed exacerbates extremes in flow conditions. Given the cultural and ecological value of this stream system, there is great interest in enhancing the cultural and ecosystem services provided by Minnehaha Creek through improvements in streamflow regime by reducing flashiness and sustaining increased low-flows. Determining the potential for achieving improvements in flow requires first that the current sources of water contributing to low-flows in the creek be identified and quantified. Work on this source identification has involved a number of different approaches, including analyses of the streamflow record using a hydrologic system model framework, examination of the Quaternary and bedrock geology of the region, estimation of groundwater-surface water exchange rates within the channel using hyporheic zone temperature surveys and flux meter measurements, and analyses of the stable isotopes of oxygen and hydrogen in samples of stream water, groundwater, and rainfall.

Analysis of baseflow recessions using the method of Brutsaert and Nieber (1977) indicates that only a small portion of the catchment, probably the riparian zone, contributes to baseflows. This result appears to be supported by the observation that the limestone/shale bedrock layer underlying the surficial aquifer has a non-zero permeability, and in a significant portion of the watershed the layer has been eroded away leaving the surficial aquifer 'bottomless' and highly susceptible to vertical (down) water loss. The analysis of the stable isotopes indicate that much of the low flow volume originates from surface storages including wetlands and small lakes within the watershed, with a small amount of the flow originating from groundwater seepage into the creek in the upper reaches of the creek. The temperature surveys and the seepage meter measurements along the main channel of the watershed show a trend that groundwater enters into the creek in the upper reaches, while the flux exchange is from the creek to groundwater in the lower reaches. The differences in flux direction between the upper and lower portions of the creek can be explained by three possible nonexclusive causes. First, the creek empties to the Mississippi River, and as the mouth of the creek is approached, the regional piezometric head drops significantly. Second, the lower end of the creek has a much larger portion of 'bottomless' surficial aquifer and therefore greater potential vertical loss of water. Third, the lower portion of the watershed is more developed and has major stormwater pipe infrastructure, a possible pathway for accelerating drainage of the surficial aquifer. To address the issue of low groundwater contribution to low-flows in the creek it is proposed to divert stormwater to key locations within the riparian zone along the creek, and to infiltrate that water and store it for slow release to the creek during non-rain periods.

WEDNESDAY, DECEMBER 11, 2013

Wednesday, December 11, 2013
EP31D. Connecting Natural Landscapes to Experimental and Numerical Models of Earth and Planetary Surface Evolution I
8:30 AM - 8:45 AM
2010 (Moscone West)

Validation of a Parcel-Based Reduced-Complexity Model for River Delta Formation *(Invited)* (EP31D-03)

Man Liang (University of Texas at Austin); Nathanael Geleynse (University of Texas at Austin); Paola Passalacqua (University of Texas at Austin); Douglas A. Edmonds (Indiana University at Bloomington); Wonsuck Kim (University of Texas at Austin); Vaughan R. Voller (University of Minnesota); Chris Paola (University of Minnesota)

Reduced-Complexity Models (RCMs) take an intuitive yet quantitative approach to represent processes with the goal of getting maximum return in emergent system-scale behavior with minimum investment in computational complexity. This approach is in contrast to reductionist models that aim at rigorously solving the governing equations of fluid flow and sediment transport. RCMs have had encouraging successes in modeling a variety of geomorphic systems, such as braided rivers, alluvial fans, and river deltas. Despite the fact that these models are not intended to resolve detailed flow structures, questions remain on how to interpret and validate the output of RCMs beyond qualitative behavior-based descriptions.

Here we present a validation of the newly developed RCM for river delta formation with channel dynamics (Liang, 2013). The model uses a parcel-based "weighted-random-walk" method that resolves the formation of river deltas at the scale of channel dynamics (e.g., avulsions and bifurcations). The main focus of this validation work is the flow routing model component. A set of synthetic test cases were designed to compare hydrodynamic results from the RCM and Delft3D, including flow in a straight channel, around a bump, and flow partitioning at a single bifurcation. Output results, such as water surface slope and flow field, are also compared to field observations collected at Wax Lake Delta. Additionally, we investigate channel avulsion cycles and flow path selection in an alluvial fan with differential styles of subsidence and compare model results to laboratory experiments, as a preliminary effort in pairing up numerical and experimental models to understand channel organization at process scale. Strengths and weaknesses of the RCM are discussed and potential candidates for model application identified.

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Wednesday, December 11, 2013 EP32A. Biophysical Interactions in Rivers: Restoration and Management II 11:35 AM - 11:50 AM 2003 (Moscone West)	**Coupling Ecology and River Dynamics using a Simplified Interaction Model** (EP32A-06) Anthony Longjas (University of Minnesota); Jonathan A. Czuba (University of Minnesota); Jon Schwenk (University of Minnesota); Mohammad Danesh Yazdi (University of Minnesota); Amy Hansen (University of Minnesota); Efi Foufoula-Georgiou (University of Minnesota) Quantifying how changes in streamflow and sediment affect riverine life is an important component of river basin management and stream restoration efforts, especially under human and climate-induced changes affecting many basins around the world. In the Midwestern US, drastic changes in mussel populations have been witnessed over the past decade begging quantitative understanding of cause and effect and attribution of these changes to the concurrent changes in streamflow and sediment loads to the rivers. Previous empirical analyses have attempted to explore mussel abundance with habitat associations and bulk hydrologic and geomorphic attributes as predictors but results showed relatively weak relationships and low predictive power. In this work, we developed a process-based model that incorporates water-sediment-mussel interactions using functional relationships and predicts the long-term trends of suspended-sediment, chlorophyll-a and mussel population using a daily streamflow record. We applied the model to the Minnesota River Basin, which has experienced significant changes in precipitation and runoff, increased sediment delivery, and decreasing mussel populations. Our model captures the general dynamics of the system and provides a better predictor of mussel populations than predictions based on geomorphic (e.g. upstream drainage area, slope) and hydraulic variables (e.g. 2-year recurrence interval peak streamflow, depth, width, cross sectional area, velocity, and Froude number) alone. To highlight the utility of our model, we tested possible scenarios that illustrate (1) how climate and land-use change may undermine the resilience of mussel populations and (2) how management efforts can allow mussel populations to recover.
Wednesday, December 11, 2013 EP32B. Connecting Natural Landscapes to Experimental and Numerical Models of Earth and Planetary Surface Evolution II 10:20 AM - 10:35 AM 2010 (Moscone West)	**A backwards-in-time Lagrangian framework for extraction of meander bend dynamics: use in meander classification, process diagnostics, and model comparison** (EP32B-01) Jon Schwenk (University of Minnesota); Stefano Lanzoni (Università di Padova); Efi Foufoula-Georgiou (University of Minnesota) Physically based river meander migration models have grown in popularity and complexity since the pioneering work of Ikeda, Parker, and Saswe in 1981. Numerical meander models have proven valuable for understanding river meander dynamics by providing highly resolved temporal and spatial series of physiographic and morphodynamic properties that are difficult or impossible to observe from real meandering rivers. Analyses of such model outputs typically focus on either reachwide (e.g. sinuosity) or pointwise (e.g. local migration rates) measures. We propose here a framework that bridges the gap between holistic and reductionist approaches to river meandering. This research introduces a new method for identifying and tracking individual meanders ("atoms") from cutoff to inception. An atom is a river reach that evolves in time and eventually intersects itself to become an oxbow lake. Typically individual meander extractions use inflection points to demarcate meander end-points, but automated inflection detection is susceptible to spurious flexes along the centerline. We propose a different approach based on tracking cutoff nodes backwards in time thereby avoiding detection problems and making an atom's dynamics easily accessible. A classification scheme is developed that separates extracted atoms into three types of increasing complexity. Type I atoms are simple, single-loop meander bends; type II atoms contain complex, single-loop bends; and type III atoms consist of compound or multiple meanders. The distinct dynamic behavior of each atom type is explored through individual and ensemble dynamics, e.g. average growth rate, average migration rate, or statistics of local curvature series. Analyses reveal new insights that relate process and form and explore the effect of local versus non-local influences on meander growth. The utilized river migration model represents the most basic physical processes that drive river migration—i.e., channel cutoff and channel migration/elongation due to curvature and bed topography—while leaving heterogeneities of bank erodibility, vegetation, climate, anthropogenic forcings, etc. unaccounted. Moreover, it relies on a linearized description of the flow field which does not account for resonance. Nevertheless, the proposed methodological approach objectively characterizes the dynamics of different planforms, and hence provides a framework for future comparisons between models involving different and more refined flow field descriptions.

Wednesday, December 11, 2013
EP33D. Deltas: A Multi-trillion Dollar Global Problem II
1:40 PM - 1:55 PM
2005 (Moscone West)

Ganges-Brahmaputra Delta: Balance of Subsidence, Sea level and Sedimentation in a Tectonically-Active Delta ***(Invited)*** **(**EP33D-01)

Michael S. Steckler (Lamont-Doherty Earth Observatory); Steven L. Goodbred (Vanderbilt University); Syed H. Akhter (Dhaka University); Leonardo Seeber (Lamont-Doherty Earth Observatory); Meredith D. Reitz (Lamont-Doherty Earth Observatory); Chris Paola (University of Minnesota); Scott L. Nooner (University of North Carolina); Scott DeWolf (University of California San Diego); Eleanor K. Ferguson (Lamont-Doherty Earth Observatory); Jonathan Gale (Lamont-Doherty Earth Observatory); Saddam Hossain (Dhaka University); Michael Howe (Lamont-Doherty Earth Observatory); Won-Young Kim (Lamont-Doherty Earth Observatory); Cecilia M. McHugh (and Lamont-Doherty Earth Observatory); Dhiman R. Mondal; Andrew L. Petter (University of Minnesota); Jennifer Pickering (Vanderbilt University); Ryan Sincavage (Vanderbilt University); Lauren A. Williams (Vanderbilt University); Carol Wilson (Vanderbilt University); Mark A. Zumberge (University of California San Diego)

Bangladesh is vulnerable to a host of short and long-term natural hazards – widespread seasonal flooding, river erosion and channel avulsions, permanent land loss from sea level rise, natural groundwater arsenic, recurrent cyclones, landslides and huge earthquakes. These hazards derive from active fluvial processes related to the growth of the delta and the tectonics at the India-Burma-Tibet plate junctions. The Ganges and Brahmaputra rivers drain 3/4 of the Himalayas and carry ~1 GT/y of sediment, 6-8% of the total world flux. In Bangladesh, these two great rivers combine with the Meghna River to form the Ganges-Brahmaputra-Meghna Delta (GBMD). The seasonality of the rivers' water and sediment discharge is a major influence causing widespread flooding during the summer monsoon. The mass of the water is so great that it causes 5-6 cm of seasonal elastic deformation of the delta discerned by our GPS data. Over the longer-term, the rivers are also dynamic. Two centuries ago, the Brahmaputra River avulsed westward up to 100 km and has since captured other rivers. The primary mouth of the Ganges has shifted 100s of km eastward from the Hooghly River over the last 400y, finally joining the Brahmaputra in the 19th century. These avulsions are influenced by the tectonics of the delta. On the east side of Bangladesh, the >16 km thick GBMD is being overridden by the Burma Arc where the attempted subduction of such a thick sediment pile has created a huge accretionary prism. The foldbelt is up to 250-km wide and its front is buried beneath the delta. The main Himalayan thrust front is <100 km north, but adjacent to the GBMD is the Shillong Massif, a 300-km long, 2-km high block of uplifted Indian basement that is overthrusting and depressing GBMD sediments to the south. The overthrusting Shillong Massif may represent a forward jump of the Himalayan front to a new plate boundary. This area ruptured in a ~M8 1897 earthquake. Subsidence from the tectonics and differential loading also influences the river patterns and avulsion rates of the delta. We are beginning to unravel these interactions through sampling and numerical modeling. One advantage for geologic research in Bangladesh is that the rapid sediment accumulation preserves a detailed structural and stratigraphic archive. We have been tapping into these records using the combination of a local, low-cost drilling method, resistivity imaging and MCS seismics, while GPS, seismology and other geophysical methods are helping to unravel GBMD dynamics. Five transects of >130 wells are illuminating the Holocene shifts of the Brahmaputra River and subsidence patterns. Very high resolution MCS seismics on the rivers shows deformation by subsidence and compaction. Resistivity is further mapping surfaces warped by the anticlinal folds. GPS geodesy is quantifying the rates of overthrusting and differential subsidence across the delta. Optical fiber strain meters installed in well nests are constraining sediment compaction rates. Seismology is imaging the tectonics in and around Bangladesh, while structural geology maps the tectonic deformation exposed on the margins of the delta. Numerical modeling is beginning to integrate all these results. I will present an overview of the GBMD and our growing research into the dynamics of the delta. A comprehensive view of these processes and their interaction is critical for understanding human impact and the future evolution of the delta.

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WEDNESDAY, DECEMBER 11, 2013	Wednesday, December 11, 2013 EP34B. Deltas: A Multi-trillion Dollar Global Problem III 4:00 PM - 4:15 PM 2005 (Moscone West)	**DELTAS: A new Global Delta Sustainability Initiative *(Invited)*** (EP34B-01) Efi Foufoula-Georgiou (University of Minnesota) Deltas are economic and environmental hotspots, food baskets for many nations, home to a large part of the world population, and hosts of exceptional biodiversity and rich ecosystems. Deltas, being at the land–water interface, are international, regional, and local transport hubs, thus providing the basis for intense economic activities. Yet, deltas are deteriorating at an alarming rate as "victims" of human actions (e.g. water and sediment reduction due to upstream basin development), climatic impacts (e.g. sea level rise and flooding from rivers and intense tropical storms), and local exploration (e.g. sand or aggregates, groundwater and hydrocarbon extraction). Although many efforts exist on individual deltas around the world, a comprehensive global delta sustainability initiative that promotes awareness, science integration, data and knowledge sharing, and development of decision support tools for an effective dialogue between scientists, managers and policy makers is lacking. Recently, the international scientific community proposed to establish the International Year of Deltas (IYD) to serve as the beginning of such a Global Delta Sustainability Initiative. The IYD was proposed as a year to: (1) increase awareness and attention to the value and vulnerability of deltas worldwide; (2) promote and enhance international and regional cooperation at the scientific, policy, and stakeholder level; and (3) serve as a launching pad for a 10-year committed effort to understand deltas as complex socio-ecological systems and ensure preparedness in protecting and restoring them in a rapidly changing environment. In this talk, the vision for such an international coordinated effort on delta sustainability will be presented as developed by a large number of international experts and recently funded through the Belmont Forum International Opportunities Fund. Participating countries include: U.S., France, Germany, U.K., India, Japan, Netherlands, Norway, Brazil, Bangladesh, Vietnam, and Canada. Key components of the DELTAS Sustainability Initiative are: integrated research on deltas as coupled socio-ecological systems undergoing change (Delta-SRES), a global delta data depository (Delta-DAT), a suite of open access delta risk assessment and decision support modeling tools (Delta-RADS), and the coordinated demonstration of these activities in deltas around the world (Delta-ACT).
THURSDAY, DECEMBER 12, 2013	Thursday, December 12, 2013 ED41E. Effective Strategies for Undergraduate Research Experiences I 8:00 AM - 8:15 AM 3007 (Moscone West)	**What Went Wrong (and Right) in my Research for Undergraduates Program this Summer** (ED41E-01) Diana M. Dalbotten (University of Minnesota); Emily M. Geraghty Ward (Rocky Mountain College); Antony R. Berthelote (Salish Kootenai College); Emi Ito (University of Minnesota); Amy Myrbo (University of Minnesota); Christa Drake (University of Minnesota); Thomas Howes (Fond du Lac Band of Lake Superior Chippewa); Phillip Woods (University of Minnesota) The Research Experience for Undergraduates Site on Sustainable Land and Water Resources (NSF GEO-055346) is a complicated affair (like many REUs) with research teams on site on two different Native American reservations (the Fond du Lac Band of Lake Superior Chippewa Reservation, Minnesota, and the Flathead Indian Reservation of the Confederated Salish and Kootenai Tribes, Montana), mentors from 2 universities and 2 reservations, and diverse participants from across the country. Students are diverse in ethnicity, academic majors, institution type, age, and life situation, with many nontraditional students as participants. While this all adds up to an interesting and exciting program, it is not without challenges. Herein the program directors discuss some of the particular challenges faced this summer, feedback the outside evaluation specialist received from participants and mentors, and ways the program's mentor team might respond in the future. This discussion will include a look at how systemic changes to an REU can lead to positive change, including a review of the recruiting and application process, communication between and among mentors and participants, the team structure of the REU, and supports in place to lead to participant success. Also included will be a discussion of how the relationship between the Native American reservations and the academic institutions was developed and how we continue to evolve based on annual feedback from all participants.
	Thursday, December 12, 2013 EP43E. Exploring the Interplay Between Solid Earth Tectonics and Surface Processes From Mountains to the Sea II 2:55 PM - 3:10 PM 2003 (Moscone West)	**River avulsions in the presence of tectonic tilting, and the Ganges-Brahmaputra Delta** (EP43E-06) Meredith D. Reitz (Columbia University); Michael S. Steckler (Columbia University); Chris Paola (University of Minnesota); Steven L. Goodbred (Vanderbilt University); Andrew L. Petter (University of Minnesota); Jennifer Pickering (Vanderbilt University); Lauren A. Williams (Vanderbilt University) In Bangladesh, the set of active rivers of the Ganges-Brahmaputra Delta overlie a landscape that is being continually modified by tectonics. The response of rivers to a surface being altered by tectonic tilting or other causes of spatially variable subsidence is generally understood to be a preferred path direction toward regions of higher subsidence. Quantifying the magnitude of the effect of variable subsidence on the timescale and path direction of channel avulsion remains, however, an open question. Recent experimental work has suggested an equilibrium-slope explanation for the timescale and conditions for avulsion, which provides a way forward on understanding how varied subsidence conditions would affect the avulsion process. Here we adapt this model for avulsion to the context of variable subsidence, developing a new framework to quantify its effect on channel avulsions. We find that variable subsidence results in two effects: differing timescales between avulsions on different parts of the delta, and differing frequencies of avulsion to these locations. Regions of higher subsidence both draw avulsions more frequently, and result in longer channel residence times in these locations. We also describe the effect of incision or aggradation due to sea level changes within this framework: incisional events lengthen avulsion timescales everywhere on the delta, while periods of sea-level rise drive the timescales back

toward their minimum values. Finally, we apply this theory to the Ganges-Brahmaputra Delta, where we use a map of regional variable subsidence that we derived from GPS and published stratigraphic data, to predict the variation in avulsion timescale and frequency for the Brahmaputra River due to this variable subsidence. We make estimates for two different tectonic history interpretations, and for the cases with or without the estimated incision from the most recent sea-level fall. Comparison between our predictions and our stratigraphy-derived estimates of avulsion timescale shows encouraging consistency. The work presented here represents the first quantitative, general framework for the influence of variable tectonics or subsidence on large-scale nodal avulsion timescale and path direction.

THURSDAY, DECEMBER 12, 2013

Thursday, December 12, 2013
EP44B. From Grains to Landscapes: Understanding the Links Between Surface Topography, Fluid Mechanics, and Sediment Transport II [SWIRL_CU]
5:00 PM - 5:15 PM
2005 (Moscone West)

Particle-Scale Controls on Entrainment and Deposition due to Debris Flows (EP44B-05)

Kimberly M. Hill (University of Minnesota); Laura Maki (University of Minnesota); Roland Kaitna (University of Natural Resources and Life Sciences)

When a debris flow – a large flow of boulders, gravels, sands, and mud – course down mountains, it can entrain materials many times the initial mass of the debris flow. The material is deposited at lower slopes. The amount of material they entrain and deposit can influence both the potential damage they do to habitat and communities in their paths and the landscape along the way. There is little quantitative understanding of the controls of entrainment and deposition along a debris flow path. We present experiments in a novel laboratory flume developed at the University of Minnesota to study particle-scale controls on entrainment and deposition due to debris flows. We control particle size distribution and water content in the flow itself and in an erodible bed over which the mixture flows, independently. Particle velocities, pore pressures, and local particle size distributions can be monitored, as can total erosion and deposition. Here, we first demonstrate how subtle differences in the bed structure or “fabric” induced by the bed preparation can have dramatic differences on the entrainment rate of bed particles by the flowing mixture. Then we demonstrate the dependence of entrainment on particle size distribution in the flow and in the bed itself as it varies with angle of inclination of the bed. In all cases, we find that the erosion increases (or at lower angles, deposition decreases) with increasing angle of inclination of the bed. When the particles in the flow are uniform and the same size as those in the bed, we find the dependence of erosion on angle of inclination is linear. We find that single-sized systems exhibit more erosion and less deposition under the same conditions as their mixed counterparts. When the flow has a larger or smaller average particle size than that in the bed, the dependence of erosion on angle is somewhat more complicated. We model the variability by considering granular temperature in the flow, average stress on the bed, and the fabric of the bed itself, and validate the model using high speed particle tracking measurements.

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Friday, December 13, 2013
EP51D. Source to Sink: Earth-Surface-Process Connections From Mountains to Margins II
9:00 AM - 9:15 AM
2005 (Moscone West)

Sink to source: The effects of offshore dynamics on upstream processes (EP51D-05)

Antoinette Abeyta (University of Minnesota); Chris Paola (University of Minnesota); John B. Swenson (University of Minnesota, Duluth)

Often, when we model fluvial sedimentation on large space and timescales, we focus on local controls (e.g. sediment and water supply), as well as the effects of relative sea level change. Shoreline often provides a boundary condition, which implies that offshore processes are merely acting as a passive sink for sediment accumulation. However, over long time scales, coastal rivers are strongly coupled to offshore and slope transport systems via the clinoform geometries typical of prograding sedimentary bodies. Here, we adopt a “sink to source” view of sediment mass balance on coastal-plain rivers. We identify a variety of effects by which offshore processes influence the state of coastal rivers. For example, the toe of the clinoform represents a critical point that controls net deposition upstream of itself. Mechanisms that increase sediment transport at the toe or along the foreset reduce sedimentation in the fluvial system, reducing the shoreline progradation rate and increasing sedimentation in more distal regions. Results from two experimental studies give examples of how the dynamics of the offshore can control fluvial bypass and progradation. First, results of a 1D flume study show that progradation over pre-existing basin topography combined with overpassing turbidity currents can “unlock” the clinoform toe, reducing sedimentation in the fluvial system and directing sediment to more distal offshore regions. Second, a 3D study using cohesive sediment that produces complex foreset dynamics, such as mass failure, shows that such failures are expressed in the topset, through land loss, shoreline retreat, and upstream-migrating erosion. These are just two examples of how dynamics in the offshore can influence fluvial sedimentation with no change in upstream supply or base level.

Friday, December 13, 2013
EP52A. Influence of Climate and Climate Variability on Landscape Form and Function I
12:05 PM - 12:20 PM
2003 (Moscone West)

Landscape re-organization under changing climatic forcing (EP52A-08)

Arvind Singh (University of Minnesota); Liam Reinhardt (University of Exeter); Efi Foufoula-Georgiou (University of Minnesota)

Understanding how landscapes respond to changes in climate in terms of macro-scale (relief) and micro-scale (drainage network structure) re-organization is an issue of timely interest in view of climatic trends in many regions of the world. Although several studies have addressed the large-scale response, studies that focus on the smaller-scale drainage pattern re-organization and quantification of landscape vulnerability to the timing, magnitude, and frequency of the changing forcing are lacking. The reason is the absence of data for such an analysis. To that goal, a series of controlled laboratory experiments were conducted at the St. Anthony Falls laboratory of the University of Minnesota to study the effect of space-time variable and changing precipitation

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patterns on landscape evolution at the short and long-time scales. High resolution digital elevation models (DEM) both in space and time along with the instantaneous sediment transport rates were measured for a range of rainfall patterns and uplift rates. These experiments were designed to create an evolving and self-organized drainage network by the growth and propagation of erosional instabilities in response to external forcing, such as, tectonic uplift and rainfall dynamics. Results from our study show distinct signatures of extreme climatic fluctuations on the statistics of topographical features which are evident in widening and deepening of channels, change in drainage patterns within a basin and change in the probabilistic structure of hot-spots of change contributing to mass-wasting events, such as, landslides and debris flows. Understanding and quantifying these signatures is important as the underlying processes developing these landscapes exhibit complex dynamics and nonlinear behavior to the timing, frequency, and magnitude of the changing forcing, which needs to be understood for predicting landscape vulnerability to future climatic change.

Friday, December 13, 2013
EP53E. Numerical Modeling of River Fluxes Under Changing Environmental Conditions II
2:55 PM - 3:10 PM
2003 (Moscone West)

Vulnerability assessment to flux amplification in river basins: a dynamic network approach and impact decomposition (EP53E-06)

Jonathan A. Czuba (University of Minnesota); Efi Foufoula-Georgiou (University of Minnesota)

Long-term prediction of basin environmental response becomes highly uncertain using physically-based distributed models, particularly for the sedimentological response for sand and gravel, with time scales ranging from tens to thousands of years. Yet, such predictions are needed as changes in one part of a basin now might adversely affect other parts of the basin in many years to come. In this work we propose a simplified prediction framework which takes advantage of network topology, channel characteristics, and transport-process dynamics to perform a process-based scaling of the network width function to a time-response function (travel-time distribution). The framework is generalized in a way that can account for the transport dynamics of different fluxes (i.e., streamflow, sediment, nutrients, biological material, etc.) through a dynamically connected network of pathways representing various geomorphic states (i.e., hillslope, fluvial, pond/wetland, subsurface, pipe, etc.). The framework explores how river fluxes are structured by time delays on a dynamically connected network, and offers the possibility to identify hot spots or vulnerable areas/times of disturbance that can lead to synchronization and downstream amplification of the flux. We have developed the process-scaling formulation for transport of mud, sand, and gravel and applied the methodology to the Minnesota River Basin. We have identified two peaks in the sedimentological response (sedimentograph) for sand which we have attributed to specific areas of the basin and suggest that there is a resonant frequency of sediment supply where the disturbance of one area followed by the disturbance of another area after a certain period of time, results in amplification of the effects of sediment inputs which would be otherwise difficult to predict. Thus, identifying an important vulnerability of the Minnesota River Basin to spatial and temporal structuring of sediment inputs, aids in understanding how current and future management decisions will be superimposed on the evolving landscape as it responds to past disturbances. The developed framework can incorporate time-varying storage and release functions and current efforts are being made toward this end, but confidence in its implementation is limited by data availability. Furthermore, we will present a comparative assessment of the complexity of the framework versus its predictive capability in light of data limitations.

Friday, December 13, 2013
A54B. Atmospheric Boundary Layer Processes and Turbulence IV (cosponsored by AMS)
4:00 PM - 4:15 PM
3004 (Moscone West)

On structural similarity in wall turbulence organization under weak thermal effects: from the wind tunnel to the atmospheric surface layer *(Invited)* (A54B-01)

Michele Guala (University of Minnesota)

Reproducing the different thermal stability regimes of the atmospheric boundary layer (ABL) in wind tunnel experiments requires accurate control of the free stream air and wall temperatures and a test section long enough to ensure the establishment of fully developed conditions. Such requirements are met in the SAFL atmospheric wind tunnel, with some limitations on the achievable range of z/L, confined between the weakly stratified and weakly convective boundary layers. A number of statistical checks based on Reynolds, Monin–Obukhov similarities, Kolmogorov small scale universality, temperature and velocity variance balance equations, are available to assess the quality of the measurements, flow and estimate of the scaling parameters. However, limited work has been devoted to the comparison of the spatio-temporal structure of turbulent flows from the laboratory to the field scale. Specifically, the vertical extent, scaling and statistical relevance of different structural types pose some scalability issues and deserve further investigation. PIV and triple wire measurements from the SAFL Wind Tunnel will be presented and compared with measurements in the atmospheric surface layer. Particular care is devoted to the contributions of large and very-large scale motions to the momentum and heat fluxes, and to their role in near-surface processes and wind energy.

POSTER SESSIONS

MONDAY, NOVEMBER 9, 2013

Monday, December 9, 2013
A13G. Weather-Driven Renewable Energy II Posters (cosponsored by AMS)
1:40 PM - 6:00 PM
Hall A-C (Moscone South)

An analytical canopy-type model for wind farm-atmosphere interaction (A13G-0312)

Corey D. Markfort (École Polytechnique Fédérale de Lausanne); Wei Zhang (University of Minnesota); Fernando Porte-Agel (École Polytechnique Fédérale de Lausanne)

We present a new model for the interactions between large-scale wind farms and the atmospheric boundary layer (ABL) based on similarity to canopy flows. Wind farms capture momentum from the atmospheric boundary layer both at the leading edge and from above. Based on our recent findings that turbulent flow in and above wind farms is similar to canopy-type flows, we examine this further with an analytical model that can predict the development length of the wind farm flow as well as vertical momentum absorption. Within the region of flow development, momentum is advected into the wind farm and wake turbulence draws excess momentum in from between turbines. This is characterized by large dispersive fluxes of momentum. Once the flow within the farm is developed, the area-averaged velocity profile exhibits an inflection point, characteristic of canopy-type flows. The inflected velocity profile is associated with the presence of a dominant characteristic turbulence scale, which may be responsible for a significant portion of the vertical momentum flux. Prediction of this scale is useful for determining the amount of available power for harvesting. The new model is tested with results from wind tunnel experiments, which characterize the turbulent flow in and above model wind farms. The model is useful for representing wind farms in meteorological and wind resource assessment models, for optimizing wind turbine spacing and layout, and for assessing the impacts of wind farms on nearby wind resources and the environment.

TUESDAY, DECEMBER 10, 2013

Tuesday, December 10, 2013
H21D. Anomalous Transport: Experimental and Mathematical Studies Posters
8:00 AM - 12:20 PM
Hall A-C (Moscone South)

Anomalous diffusion for bed load transport with a physically-based model (H21D-1083)

Niannian Fan (Tsinghua University); Arvind Singh (University of Minnesota); Efi Foufoula-Georgiou (University of Minnesota); Baosheng Wu (Tsinghua University)

Diffusion of bed load particles shows both normal and anomalous behavior for different spatial-temporal scales. Understanding and quantifying these different types of diffusion is important not only for the development of theoretical models of particle transport but also for practical purposes, e.g., river management. Here we extend a recently proposed physically-based model of particle transport by Fan et al. [2013] to further develop an Episodic Langevin equation (ELE) for individual particle motion which reproduces the episodic movement (start and stop) of sediment particles. Using the proposed ELE we simulate particle movements for a large number of uniform size particles, incorporating different probability distribution functions (PDFs) of particle waiting time. For exponential PDFs of waiting times, particles reveal ballistic motion in short time scales and turn to normal diffusion at long time scales. The PDF of simulated particle travel distances also shows a change in its shape from exponential to Gamma to Gaussian with a change in timescale implying different diffusion scaling regimes. For power-law PDF (with power - μ) of waiting times, the asymptotic behavior of particles at long time scales reveals both super-diffusion and sub-diffusion, however, only very heavy tailed waiting times (i.e. $1.0 < \mu < 1.5$) could result in sub-diffusion. We suggest that the contrast between our results and previous studies (for e.g., studies based on fractional advection-diffusion models of thin/heavy tailed particle hops and waiting times) results could be due the assumption in those studies that the hops are achieved instantaneously, but in reality, particles achieve their hops within finite times (as we simulate here) instead of instantaneously, even if the hop times are much shorter than waiting times. In summary, this study stresses on the need to rethink the alternative models to the previous models, such as, fractional advection-diffusion equations, for studying the anomalous diffusion of bed load particles. The implications of these results for modeling sediment transport are discussed.

Tuesday, December 10, 2013
H21D. Anomalous Transport: Experimental and Mathematical Studies Posters
8:00 AM - 12:20 PM
Hall A-C (Moscone South)

Does Model Development Ahead of Data Collection Have Merit? A Case for Advancing Non-Local Fluvial Transport Theories (H21D-1084)

Vaughan R. Voller (University of Minnesota); Fede Falcini (Consiglio Nazionale delle Ricerche); Efi Foufoula-Georgiou (University of Minnesota); Vamsi Ganti (Cal Tech); Chris Paola (University of Minnesota); Kimberly M. Hill (University of Minnesota); John B. Swenson (University of Minnesota, Duluth); Anthony Longjas (University of Minnesota)

The purpose of this work is to suggest how experiments might be constructed to provide data to test recently proposed phenomenological non-local model of depositional transport; formulated on the basis of morphological arguments but with limited data.

A sound methodology for developing models of geological systems is to first collect significant data and then carefully identify an appropriate model form and parameters. An alternative approach is to construct what might be referred to as a phenomenological model, where limited observation of the system is used to suggest an appropriate mathematical form that matches the critical nature of the physical system behavior.

By their nature, phenomenological models are often developed within a fairly narrow range of observations. In this way, interesting findings can occur when the models are modified and exercised across wider physical domains, in particular in domains where there is an absence of hard data to corroborate or invalidate the model predictions. Although this approach might be frown on my some, it is important to recognize the stellar and proven track record of phenomenological models, which despite the original scarcity of data, often pave the way to new perspectives and important findings. The poster child example is the Higgs boson. In the early 60's manipulation of the quantum field equations revealed a critical inconsistency related to the masses of fundamental particles that could only be mathematically resolved by assuming that they operated within a field that would exert drag; this conjecture took almost fifty years and the vast experimental operation of the Large Hadron Collider to physically confirm.

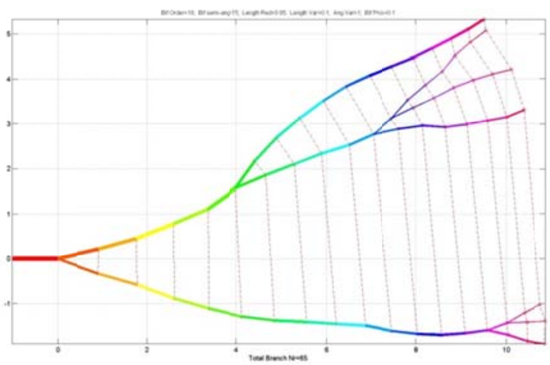
In this work we examine a current phenomenological model used to describe non-local transport in fluvial sediment domains. This model has its genesis in attempting to describe the shapes of hill slope profiles, while acknowledging the fact that two points of the landscape with the same local slope are not always associated with the same sediment flux. The key innovation then is to model the sediment flux at a point in terms of an upstream weighted sum of fluvial slopes or other geomorphological attributes of the system. In the hill-slope context, the downstream flow of information in this non-local formalism is well supported by fundamental observations of the distribution of downstream particle transport distances. However, when the same model is applied in the context of depositional systems it appears to be inconsistent with profiles of depositional surfaces. In particular, the model predicts fluvial profiles with curvature signs opposite to those observed in nature. When a simple mathematical manipulation is made, where the flux at a point is expressed as a downstream weighting of fluvial slopes, however, predictions with the correct form are recovered. At this time, no specific mechanism or clear corroborating data have been identified that would explain this downstream control. Does this mean we should ignore this result or would it be better to use it as a motivation to seek out hypotheses tests that would confirm or invalidate the current suggested models of downstream non-local transport? A series of innovative experiments that address the collection of experimental evidence for downstream control in fluvial transport are described.

Wednesday, December 11, 2013
EP33A. Connecting Natural Landscapes to Experimental and Numerical Models of Earth and Planetary Surface Evolution III Posters
1:40 PM - 6:00 PM
Hall A-C (Moscone South)

From Fractal Trees to Deltaic Networks (EP33A-0857)

Dan Cazanacli (University of Minnesota); Matthew A. Wolinsky (Shell Technology Center); Zoltan Sylvester (Shell Technology Center); Alessandro Cantelli (Shell Technology Center); Chris Paola (University of Minnesota)

Geometric networks that capture many aspects of natural deltas can be constructed from simple concepts from graph theory and normal probability distributions. Fractal trees with symmetrical geometries are the result of replicating two simple geometric elements, line segments whose lengths decrease and bifurcation angles that are commonly held constant. Branches could also have a thickness, which in the case of natural distributary systems is the equivalent of channel width. In river- or wave-dominated natural deltas, the channel width is a function of discharge. When normal variations around the mean values for length, bifurcating angles, and discharge are applied, along with either pruning of “clashing” branches or merging (equivalent to channel confluence), fractal trees start resembling natural deltaic networks, except that the resulting channels are unnaturally straight. Introducing a bifurcation probability fewer, naturally curved channels are obtained. If there is no bifurcation, the direction of each new segment depends on the direction the previous segment upstream (correlated random walk) and, to a lesser extent, on a general direction of growth (directional bias). When bifurcation occurs, the resulting two directions also depend on the bifurcation angle and the discharge split proportions, with the dominant branch following the direction of the upstream parent channel closely. The bifurcation probability controls the channel density and, in conjunction with the variability of the directional angles, the overall curvature of the channels. The growth of the network in effect is associated with net delta progradation. The overall shape and shape evolution of the delta depend mainly on the bifurcation angle average size and angle variability coupled with the degree of dominant direction dependency (bias). The proposed algorithm demonstrates how, based on only a few simple rules, a wide variety of channel networks resembling natural deltas, can be replicated.



Network Example

Wednesday, December 11, 2013
EP33A. Connecting Natural Landscapes to Experimental and Numerical Models of Earth and Planetary Surface Evolution III Posters
1:40 PM - 6:00 PM
Hall A-C (Moscone South)

Particle entrainment in dry and saturated granular flow experiments (EP33A-0875)

Roland Kaitna (University of Natural Resources and Life Sciences); Laura Maki (University of Minnesota); Kimberly M. Hill (University of Minnesota)

Geophysical flows like rock avalanches and debris flows often gain volume and thereby destructive potential by entraining loose sediment along the flow path. The mechanisms of sediment entrainment are not yet well understood. The presence and amount of fluid in the bed and in the flow are expected to play a key role in the dynamics and erosion of grains. To gain insight of the role fluid plays in particle scale dynamics controlling particle entrainment a small scale experimental facility has been developed at the University of Minnesota. Material with varying water content is released from a head gate and flows over a rigid bed followed by an erodible section. The water content in the erodible layer is adjustable and variations of fluid pressure are registered by pressure transducers at the base of the erodible as well as the non-erodible section. Other measured parameters include flow depth, velocity profile and net erosion or deposition. In this contribution we describe the effect of variations of inclination and fluid content on the bulk erosion/deposition behavior of simple mixtures of spherical glass beads and water. We compare dry granular flows over a dry bed, dry granular flows over a saturated bed, and saturated grain-fluid flows over a saturated bed. First results highlight the importance of slope angle on erosion efficiency. The presence of pore fluid in the bed shifts the transition between erosional and depositional flows to a lower flume inclination. Future experiments shall also include natural sediment mixtures.

Wednesday, December 11, 2013
EP33A. Connecting Natural Landscapes to Experimental and Numerical Models of Earth and Planetary Surface Evolution III Posters
1:40 PM - 6:00 PM
Hall A-C (Moscone South)

The Influence of Laboratory-Generated Tides on Experimental Deltas (EP33A-0876)

Sarah E. Baumgardner (University of Minnesota); Antoinette Abeyta (University of Minnesota); Dan Cazanacli (University of Minnesota); Chris Paola (University of Minnesota)

Due to their ecological and economic importance, deltas are widely studied but the controls on the processes that create and shape them are incompletely understood. The most prominent downstream control on a delta is the input of basinal energy from (wind-driven) waves and tides. Studies of the response of field-scale deltas to changing basinal energy conditions are limited by their large size and long response time. Laboratory-generated deltas allow control over upstream inputs (sediment and water) and base level, and enable the generation of a high-resolution record of topography and planform morphology of the deposit throughout the experiment.
We include the effects of tides by imposing cyclic changes in base level with a period that is long compared to ordinary gravity waves but short compared to time scales of morphologic evolution; here we used periods of < 120 seconds, and amplitudes of <2.5 cm. These fluctuations led to the development of sinuous, headward cutting channels. Preliminary analysis of overhead imagery suggests that the addition of tides to the experimental deltas changed the grain-size distribution on the topset, increased channel occupancy times, and altered the size and frequency of mouth bars, point bars and mid-channel bars. The mechanisms of these changes were found to differ between cohesive and non-cohesive deltas: in non-cohesive deltas, tides interrupted channel backfilling, suppressing avulsion, while in cohesive deltas, tides generated knickpoints, which led to channel deepening. These results suggest that basinal energy can affect deltaic processes far upstream of the coastline.
We introduce waves to the system through the use of a generator; this generator produces waves with a single, user-defined period (here, ~1-2 seconds) and amplitude (2-3 cm) . The orientation of the incoming wave crests is set by the position of the generator. The addition of wave energy led to rapid shoreline retreat and straightening and the formation and migration of shore parallel barrier bars similar to what is observed in wave-influenced field-scale systems. Analysis of overhead imagery shows that wave transport of sediment occurs over a much shorter timescale than tidally-driven transport, leads to the formation of a continuous, coarse berm parallel to the shoreline and plays a major role in determining the configuration of channel mouths.

Wednesday, December 11, 2013
EP33A. Connecting Natural Landscapes to Experimental and Numerical Models of Earth and Planetary Surface Evolution III Posters
1:40 PM - 6:00 PM
Hall A-C (Moscone South)

Experiments Evaluating the Interaction between Deformable Substrates and Prograding Clinoforms (EP33A-0879)

Emily S. Chatmas (University of Saint Thomas); Brady Foreman (University of Minnesota); Antoinette Abeyta (University of Minnesota); Chris Paola (University of Minnesota)

Passive margins often contain salt and mobile shale layers that act as deformable substrates underlying coastal sediments. By understanding the interaction between deformable substrates and migrating clinoforms in simplified, experimental settings, we hope to clarify their fundamental behavior in natural deltaic settings. Substrate deformation occurs by a number of processes and can result in rugose ocean floor bathymetry which can locally trap sediment. In our experiments, we focus on how differential sediment loading on two substrates of different rheologies (Newtonian versus Bingham) affects aspects of clinoform deposition. We are particularly interested in the effects of the progradation rate and substrate rheology on the locus of clinoform deposition over time as the substrate and delta interact.

Our experimental setup uses a rectangular flume that is 230 cm long, 8 cm wide and 30 cm tall. The materials we used for the mobile shale experiments involved a mixture of kaolinite and water which provide a Bingham rheology, and the sediment was a quartz sand and coal mixture. For a Newtonian rheology we used corn syrup as a deformable substrate, capturing the Newtonian rheology of subsurface salt, and the sediment consisted of a mixture of equal volumes of walnut shells and kaolinite clay. For each experiment we systematically changed sediment feed rate and substrate thickness. Deformation styles differ qualitatively between Bingham (kaolinite/mobile shale) and Newtonian (corn syrup/salt) experiments. In mobile-shale (Bingham) experiments, a bulge forms at the toe of the clinoform and the clinoform eventually overtops this bulge, creating alternating thick and thin stratigraphic accumulations down depositional dip. For the salt (Newtonian) experiments, deformation occurs behind the clinoform foreset in the form of diapirs. Preliminary results show minimal impacts on shoreline progradation rate as the delta loads mobile shale substrates. This suggests that the deformation shortens the available accommodation depth and changes in the partitioning of sediment in the topset and toeset of the clinoform. Shoreline progradation rate for the salt substrates varies with time showing a constant long term rate with periods of slowed advance. This suggests that the sediment is sinking into the substrate, creating space. The clinoform has to fill the vertical space before moving laterally rate is periodically stifled due to a major slope failure on the foreset, potentially in response to diapirism below the topset of the clinoform.

POSTER SESSIONS

WEDNESDAY, DECEMBER 11, 2013

Wednesday, December 11, 2013 EP33B. Exploring the Interplay Between Solid Earth Tectonics and Surface Processes From Mountains to the Sea I Posters 1:40 PM - 6:00 PM Hall A-C (Moscone South)	**Effects of basin subsidence on experimental delta sedimentation patterns and surface morphology** (EP33B-0886) Jordan Carey (Augustana College); Antoinette Abeyta (University of Minnesota); Chris Paola (University of Minnesota); Brady Foreman (University of Minnesota) Tectonic subsidence has long been recognized as an important factor affecting surficial patterns of delta morphology. However, the link between subsidence and its manifestation in surface morphology is still unclear. Alluvial systems actively undergoing subsidence have an uncanny ability to fill in the newly created space. In other words, the rate at which sediment is deposited is adjusted to the rate of subsidence, on average. Here we present an analysis of two experiments conducted using the Experimental EarthScape (XES) basin. The XES basin allows for the study of sedimentological and geomorphological characteristics under controlled conditions of sediment/water supply, base level, and subsidence rate and geometry. Subsidence is created by the removal of gravel below the system through 108 independently controlled hexagonal cells. The basin consisted of an area of ~17 m^2 (5.72 m x 2.98 m). For this study, we observed depositional expansion structures, avulsion patterns, and depositional bar formation in response to two varying types of subsidence; XES-02 experienced passive margin style subsidence, while XES-10 underwent foreland style subsidence, both of which had temporally constant subsidence. Water-to-sediment supply varied slightly in each experiment; XES-02 was 50:1, while XES-10 was 43:1. Flow in the experiments alternated between channelized flow and sheet flow. Depositional events in the system primarily occurred via two features; through point bars and expansion structures, both of which are related to avulsion characteristics. Expansion structures are defined as regions transitioning from channelized flow to sheet flow. Differential subsidence geometries appear to have a significant effect on the frequency and spatial distribution of expansion structures across the system. XES-02 expansion structures occurred most often (22.5%) between linear distances of 0.76 m – 1.00 m from the sediment source. XES-10 expansion structures were found most frequently (22.6%) between linear distances of 1.76 m – 2.00 m. In both experiments, the largest expansion structures formed between 0.5 m and 1.0 m away from the sediment source. The larger expansion structures tend to be a starting phase for channel avulsion. Sheet flow of the expansion structure would appear to retreat towards the sediment source, subsequent bifurcations would occur, and new channels would emerge. From these channels, new expansion structures formed and the cycle would repeat. During channelized flow, we saw an increase in bar formation compared when compared to sheet flow. We show that, experimentally, varying types of subsidence geometries express themselves differently at the surface and an understanding of surface process can provide insight to subsidence geometry.

Wednesday, December 11, 2013
EP33B. Exploring the Interplay Between Solid Earth Tectonics and Surface Processes From Mountains to the Sea I Posters
1:40 PM - 6:00 PM
Hall A-C (Moscone South)

The Brahmaputra delta and its merger into an accretion wedge in advance of the progressive suturing between India and Asia (EP33B-0892)

Leonardo Seeber (Lamont-Doherty Earth Observatory); Eleanor K. Ferguson (Lamont-Doherty Earth Observatory); Syed H. Akhter (Dhaka University); Michael S. Steckler (Lamont-Doherty Earth Observatory); Dhiman R. Mondal (Queens College); Jonathan Gale (Lamont-Doherty Earth Observatory); Cecilia M. McHugh (Queens College); Chris Paola (University of Minnesota); Steven L. Goodbred (Vanderbilt University)

The Tsangpo-Brahmaputra River is coupled with the progressive suturing of continental India with continental Asia. Since the Eocene onset of this ongoing collision, the delta of this river has advanced along the Indian margin in front of the suture. As the collision lifts the suture above sea level, progradation has kept the delta ahead of it, at sea level. The delta itself is confined between the still passive Indian continental margin and the advancing subduction boundary. Within this transition zone, the accretion prismof the active margin advanced progressively onto the delta and transformed it from a subsiding sediment sink to a rising and folding sediment source. The faster the accretionary prism grows, the faster the delta progrades to find new accommodation space; on the other hand, the prism advances faster upstream of the delta front where it finds more sediment to accrete. The strong mutual dependency of these processes represents a delicately balanced feedback between tectonics and sedimentation. The shape of the margin of India before and after the birth of the Dauki-Shillong structure modulates this interaction. We highlight this coupling between tectonics and sedimentation by examining structure and stratigraphy in the active foldbelt close to the current delta in Bangladesh and eastern India using field and published subsurface data. Insights include: 1) The shift of the Dauki boundary from a passive margin to a south-verging blind-thrust front is marked by a Quaternary foredeep. Foredeep growth buried along its axis formerly breached and eroded anticlines. Progressive growth of the buried Dauki fault has exposed this unconformity along the northern flank of the foredeep. 2) The rise and northward tilt of the Shillong/Dauki thrust-anticline during Quaternary is probably the cause of the Brahmaputra River avulsing from east of the massif to north and west of it. The Naga collision and the differential growth of the foldbelt south of the Dauki Fault predate the rise of the massif and the avulsion. 3) The foldbelt widens forming a 'promontory' into the active delta, about 100 km north of the coastline. The outer few anticlines have low amplitudes and no or partial surface expressions, yet they root below several km of sediment. Fault-bend models also require much more shortening than the folding can account for. These properties suggest substantial layer-parallel shortening ahead of the folding. 4) Rhythmic sandstone-shale beds characterize a particularly competent part of the stratigraphy of eroding anticlines in different parts of the foldbelt. We interpret them as seasonal facies changes in foreset sequences of the delta. The position of these ridge-forming beds would thus mark the southwestward advance of the delta preceding the folds and can be used to guide research into the role of structure and stratigraphy in the severe landslide hazard affecting development in the foldbelt (e.g., Aizawl, Mizoram State).

POSTER SESSIONS

WEDNESDAY, DECEMBER 11, 2013

Wednesday, December 11, 2013
EP33B. Exploring the Interplay Between Solid Earth Tectonics and Surface Processes From Mountains to the Sea I Posters
1:40 PM - 6:00 PM
Hall A-C (Moscone South)

A comprehensive view of Late Quaternary fluvial sediments and stratal architecture in a tectonically active basin: Influence of eustasy, climate, and tectonics on the Bengal Basin and Brahmaputra River system (EP33B-0893)

Ryan Sincavage (Vanderbilt University); Steven L. Goodbred (Vanderbilt University); Lauren A. Williams (Vanderbilt University); Jennifer Pickering (Vanderbilt University); Carol Wilson (Vanderbilt University); Michael S. Steckler (Lamont-Doherty Earth Observatory); Leonardo Seeber (Lamont-Doherty Earth Observatory); Meredith D. Reitz (Lamont-Doherty Earth Observatory); Saddam Hossain (University of Dhaka); Syed H. Akhter (University of Dhaka); Dhiman R. Mondal (CUNY Queens College); Chris Paola (University of Minnesota)

More than 130 closely-spaced (~3-5 km) boreholes have been drilled along five transects in the upper Bengal Basin, providing the first detailed record of the stratigraphic architecture and provenance of the entire Late Quaternary fluviodeltaic sedimentary succession of the Ganges-Brahmaputra-Meghna Delta (GBMD). This effort is part of BanglaPIRE, an interdisciplinary, multi-institutional research effort aimed at unraveling the history and mechanisms of river-tectonic-basin interactions in the GBMD and Bengal basin, around which three tectonic plates converge. Following the Younger-Dryas, the onset of a strong summer monsoon coincident with continued eustatic sea-level rise initiated construction of the modern delta and rapid development of a thick (up to 80 m) succession of fluvial and deltaic sediments. These deposits illustrate several (3-4) avulsions and asymmetric occupations of the Brahmaputra River in the tectonically active Sylhet Basin. We hypothesize that the longer occupation periods (10^3 years) may be classified as major river avulsions driven by autogenic fluvial processes, whereas shorter occupation periods (10^2 years) reflect minor distributive events that may have been initiated by allogenic forcing via floods or earthquakes. Subsidence rates in Sylhet Basin, driven by an active foredeep, are relatively high (~5 mm/yr); however, the Brahmaputra River does not regularly migrate towards this side of the delta. Annual widespread flooding of Sylhet Basin may negate the potential topographic attraction for the system to be steered in this direction. Furthermore, a gentle westward topographic tilt of the active thrust front of the Tripura fold belt appears to have forced lateral steering of the Brahmaputra River and initiated erosion of a bench-cut terrace into an adjacent Pleistocene landform. Tectonic effects over longer timescales (10^3 years) are revealed by the presence of sediment with a unique provenance at the core of regional anticlines, which suggest a strong link between the basinward advance of the tectonic deformation front and re-organization of the fluvial channel network within the GBMD. These observations and other evidence for river-tectonic-basin interactions will provide fundamental insights into the coupling between sedimentation and tectonics in one of the world’s most densely populated regions.

POSTER SESSIONS

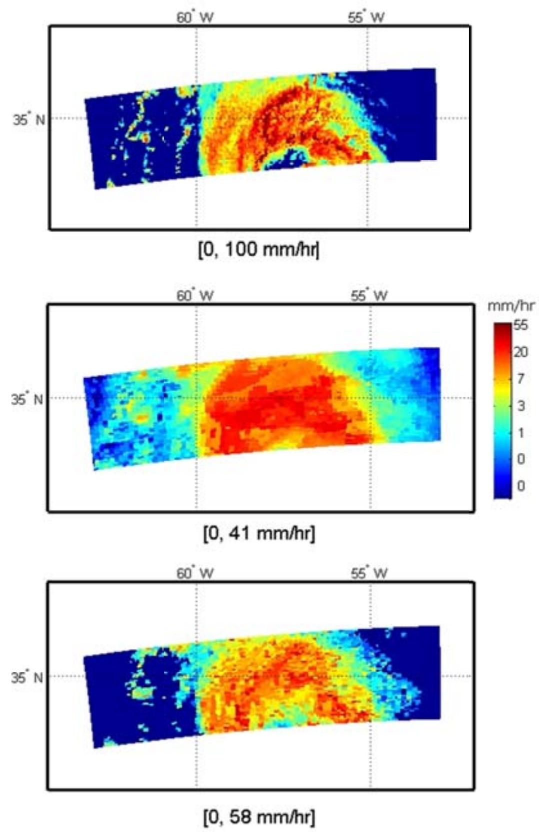
WEDNESDAY, DECEMBER 11, 2013

Wednesday, December 11, 2013
H33E. Global Precipitation Measurement, Validation, and Applications III Posters
1:40 PM - 6:00 PM
Hall A-C (Moscone South)

Passive microwave rainfall retrieval: A mathematical approach via sparse learning (H33E-1408)

Mohammad Ebtehaj (University of Minnesota); Gilad Lerman (University of Minnesota); Efi Foufoula-Georgiou (University of Minnesota)

Detection and estimation of surface rainfall from spaceborne radiometric imaging is a challenging problem. The main challenges arise due to the nonlinear relationship of surface rainfall with its microwave multispectral signatures, the presence of noise, insufficient spatial resolution in observations, and the mixture of the earth surface and atmospheric radiations. A mathematical approach is presented for the detection and retrieval of surface rainfall from radiometric observations via supervised learning. In other words, we use a priori known libraries of high-resolution rainfall observations (e.g., obtained by an active radar) and their coincident spectral signatures (i.e., obtained by a radiometer) to design a mathematical model for rainfall retrieval. This model views the rainfall retrieval as a nonlinear inverse problem and relies on sparsity-promoting Bayesian inversion techniques. In this approach, we assume that small neighborhoods of the rainfall fields and their spectral signatures live on manifolds with similar local geometry and encode those neighborhoods in two joint libraries, the so-called rainfall and spectral dictionaries. We model rainfall passive microwave images by sparse linear combinations of the atoms of the spectral dictionary and then use the same representation coefficients to retrieve surface rain rates from the corresponding rainfall dictionary. The proposed methodology is examined by the use of spectral and rainfall dictionaries provided by the microwave imager (TMI) and precipitation radar (PR), aboard the Tropical Rainfall Measuring Mission (TRMM) satellite. Pros and cons of the presented approach are studied by extensive comparisons with the current operational rainfall algorithm of the TRMM satellite. Future extensions are also highlighted for potential application in the era of the Global Precipitation Measurement (GPM) mission.



Comparing the retrieved rain rates for Hurricane Danielle 08/29/2010 (UTC 09:48:00). (Top panel) PR-2A25 surface rain rates in [mm/hr], (middle panel) TMI-2A12 and (bottom panel) sparse precipitation retrieval (SPaR) rainfall retrieved rain rates.

Thursday, December 12, 2013
A43A. Atmospheric Boundary Layer Processes and Turbulence I Posters (cosponsored by AMS)
1:40 PM - 6:00 PM
Hall A-C (Moscone South)

Canopy-wake dynamics: the failure of the constant flux layer (A43A-0219)

Heinz G. Stefan (University of Minnesota); Corey D. Markfort (École Polytechnique Fédérale de Lausanne); Fernando Porte-Agel (École Polytechnique Fédérale de Lausanne)

The atmospheric boundary layer adjustment at the abrupt transition from a canopy (forest) to a flat surface (land or water) was investigated in a wind tunnel experiment. Detailed measurements examining the effect of canopy turbulence on flow separation, reduced surface shear stress and wake recovery are compared to data for the classical case of a solid backward-facing step. Results provide new insights into the data interpretation for flux estimation by eddy-covariance and flux gradient methods and for the assessment of surface boundary conditions in turbulence models of the atmospheric boundary layer in complex landscapes and over water bodies affected by canopy wakes. The wind tunnel results indicate that the wake of a forest canopy strongly affects surface momentum flux within a distance of 35 - 100 times the step or canopy height, and mean turbulence quantities require distances of at least 100 times the canopy height to adjust to the new surface. The near-surface mixing length in the wake exhibits characteristic length scales of canopy flows at the canopy edge, of the flow separation in the near wake and adjusts to surface layer scaling in the far wake. Components of the momentum budget are examined individually to determine the impact of the wake. The results demonstrate why a constant flux layer does not form until far downwind in the wake. An empirical model for surface shear stress distribution from a forest to a clearing or lake is proposed.

Turbulent flow over a surface-mounted 2-D block in thermally-stratified boundary layers (A43A-0221)

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Turbulent boundary-layer flows over complex topography have been of great interest in the atmospheric sciences and wind engineering communities. The geometry of the topography, surface characteristics and atmospheric thermal stability play important roles in determining momentum and scalar flux distribution. Studies of turbulent flow over simplified topography, such as 2-D or 3-D blocks and 2-D or 3-D sinusoidal hills, conducted under neutrally stratified boundary-layer conditions have provided insightful information of fluid dynamics. However, atmospheric thermal stability has rarely been incorporated into laboratory simulations, in particular, wind-tunnel experiments. Extension of such studies in thermally-stratified wind tunnels will fill this gap and advance our understanding of the underlying physics of flow over complex topography. Additionally, experimental data are useful for the development of new parameterizations for surface fluxes and validation of numerical models such as Large-Eddy Simulation (LES). A series of experiments involving neutral and thermally-stratified boundary-layer flows over a surface-mounted 2-D block, conducted at the Saint Anthony Falls Laboratory boundary-layer wind tunnel, will be presented. The 2-D block, with a width to height ratio of 2:1, occupied the lowest 25% of the turbulent boundary layer. Thermal stratification of the boundary layer was achieved by independently controlling the temperature of both the airflow, the test section floor and block surfaces. Measurements using high-resolution PIV, x-wire/cold-wire anemometry, thermal-couples and surface heat flux sensors were made to identify and quantify the turbulent flow properties, including the size of the recirculation zone, coherent vortex structures and the subsequent boundary layer recovery. Emphasis will be put on addressing thermal stability effects on momentum and scalar flux distribution.

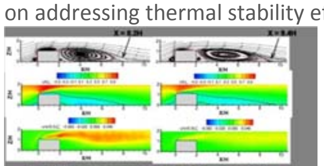

Figure 1: Turbulent flow over a surface-mounted 2-D block in neutral (left) and stable boundary layers (right)

Friday, December 13, 2013
H51I. Hydrologic Data Assimilation IV Posters
8:00 AM - 12:20 PM
Hall A-C (Moscone South)

Coping with model uncertainty in data assimilation using optimal mass transport (H51I-1313)

Lipeng Ning (University of Minnesota); Francesca P. Carli (University of Minnesota); Mohammad Ebtehaj (University of Minnesota); Efi Foufoula-Georgiou (University of Minnesota); Tryphon Georgiou (University of Minnesota)

Most data assimilation methods address the problem of optimally combining model predictions with observations in the presence of zero-mean Gaussian random errors. However, in many hydro-meteorological applications uncertainty in model parameters and/or model structure often result in systematic errors (bias). Examples include the prediction of precipitation or land surface fluxes at the wrong location and/or timing due to a drift in the model, unknown initial conditions, or non-additive error amplification. Existing bias-aware data assimilation methods require characterization of the bias in terms of a well-defined set of parameters or removal of bias, which is not always feasible. Here we present a new variational data assimilation framework to cope with model bias in a non-parametric fashion via an appropriate “regularization” of the state evolution dynamics. In the context of weak-constraint 4D-VAR, our method can be seen as enforcing a minimum nonlinear distance (regularization or correction) in the evolution of the state so as to reconcile measurements with errors in the model dynamics. While a quadratic functional is typically sufficient to quantify errors in measurements, errors in state evolution is most naturally quantified by a transportation metric (Wasserstein metric) originating in the theory of Optimal Mass Transport (OMT). The proposed framework allows the use of additional regularization functionals, such as the L1-norm regularization of the state in an appropriately chosen domain, as recently introduced by the authors for states that exhibit sparsity and non-Gaussian priors, such as precipitation and soil moisture. We demonstrate the performance of the proposed method using as an example the 1-D and 2-D advection diffusion equation with systematic errors in the velocity and diffusivity parameters. Extension to real world data assimilation settings is currently under way.

Friday, December 13, 2013
OS51B. Ocean Sciences General Contributions VII Posters
8:00 AM - 12:20 PM
Hall A-C (Moscone South)

Numerical study of turbulence under progressive surface wave (OS51B-1671)

Xin Guo (University of Minnesota); Lian Shen (University of Minnesota)

To study the dynamics of the interaction between surface waves and turbulence in the upper ocean, we simulate turbulent flows under a progressive wave. The governing equations are the Navier-Stokes equations subject to fully nonlinear free-surface kinematic and dynamic boundary conditions. The surface wave is dynamically maintained by applying a gentle pressure at the free surface. Instantaneous turbulence field under the distortion of surface waves is illustrated. The periodic and accumulative effect of the surface wave on turbulence is analyzed in both wave Eulerian and Lagrangian frames. In the Eulerian frame, turbulence statistics become strongly wave-phase dependent. The distortion of both free surface and surface waves on turbulence is found important. The budget of the Reynolds normal stresses is analyzed to understand the effect of surface wave on turbulence kinetic energy. Turbulence vortices are stretched, compressed, and turned periodically. The distribution of Reynolds shear stresses is affected by the blockage effect of the free surface and the inclination of the turbulence vortices. In the Lagrangian frame, the net energy transfer from wave to turbulence is quantified in terms of Reynolds shear stresses and surface wave properties. The model and time scale of the wave dissipation due to wave-turbulence interaction are also discussed. Vertical turbulence vortices are tilted towards the wave propagation direction due to the accumulative effect of Stokes drift velocity and the correlation between the wave strain rate and turbulence vorticity. This finding provides insights to the mechanism of the generation of initial Langmuir cells.

Friday, December 13, 2013
EP53A. Earth and Planetary Surface Processes General Contributions Posters
1:40 PM - 6:00 PM
Hall A-C (Moscone South)

Experiments evaluating subsidence generated within a subaqueous deformable substrate due to varying differential sediment loading patterns (EP53A-0772)

Brady Foreman (University of Minnesota); Emily S. Chatmas (St. Thomas University); Antoinette Abeyta (University of Minnesota); Chris Paola (University of Minnesota)

The intraslope areas of many passive margins display a complex bathymetry of topographic depressions and crests that form series of minibasins. These minibasins are linked to the deformation of subsurface salt layers and act as localized sediment traps. Many mechanisms have been proposed for the initiation of minibasins, including tectonic forces (both extensional and contractional), regional gravitational sliding, density inversion between salt layers and overburden, and differential sediment loading. Regardless of initiation mechanism, it is widely recognized that synkinematic deposition plays a active role in determining subsidence patterns and sediment routing within and among the minibasins. We undertook a series of simplified 1-D and 2-D experiments 1) to evaluate the feasibility of developing a series of well-defined minibasins created exclusively by differential sediment loading and 2) to quantitatively determine the effects of substrate thickness, density contrast, and sedimentation rate on the resultant subsidence pattern. We also present an initial non-dimensionalized formulation of the problem that relates density contrasts, clinoform thickness, substrate thickness, progradation rate, and viscosity of the deformable substrate.

Two sets of experiments were performed. The first set (1-D) vertically loaded a subaqueous corn syrup substrate (capturing the rheology of subsurface salt as a Newtonian fluid) with walnut sand. The second set (2-D) of experiments prograded a walnut sediment clinoform across a corn syrup substrate. We systematically varied sedimentation rate, substrate thickness, and, in the case of the prograding clinoform, base level. In no cases did we successfully reproduce a series of minibasins similar to those observed in natural settings. Instead the substrate was simply displaced laterally as sediment was deposited, forming a single depression. High sedimentation rates tended to produce wider zones of subsidence, however, if given sufficient time subsidence tended towards a similar overall geometry for both slow and fast sedimentation rates. This occurred as long as a sufficiently thick substrate was maintained. In our experiments, this was a ratio greater than 1:4 of substrate-to-clinoform thickness. When the substrate is insufficiently thick, weld structures formed as the overlying sediments were deposited onto the base of the flume. These structures appear similar to salt welds in natural systems. We also noted small zones of enhanced subsidence below the toeset and foreset of the prograding clinoform as sediment was deposited. These minor features are approximately one tenth the size of the overall basin formed in the substrate, and locally trap additional sediment during progradation. These are potentially related to infrequent grain flow events. Overall our experiments suggest that sediment differential loading is an insufficient mechanism in isolation to produce series of minibasins, but that the loading does significantly affect the initial geometry and rate of subsidence within these basins.

Friday, December 13, 2013
OS53B. Sediment Transport by Turbidity Currents: Simulation and Observation II Posters (cosponsored by IAS)
1:40 PM - 6:00 PM
Hall A-C (Moscone South)

Large-eddy simulation of coupled turbulence, free surface, and sand wave evolution in an open channel (OS53B-1696)

Ali Khosronejad (University of Minnesota); Fotis Sotiropoulos (University of Minnesota)

We develop and validate a coupled 3D numerical model for carrying out three-phase large-eddy simulations of turbulence, free-surface, and sand waves-bed morphodynamics under live bed conditions. We employ the Fluid-Structure Interaction Curvilinear Immersed Boundary (FSI-CURVIB) method of Khosronejad et al. (Adv. in Water Res., 2011). The LES is implemented in the context of the CURVIB method using wall modeling (Kang and Sotiropoulos, Adv. in Water Res., 2011). Free-surface motion is simulated by coupling the CURVIB method with a two-phase level set approach as in Kang and Sotiropoulos (Adv. in Water Res., 2012). The mobile channel bed is discretized with an unstructured triangular grid and treated as the sharp-interface immersed boundary embedded in a background curvilinear mesh. Transport of bed load and suspended load sediments are combined in the non-equilibrium form of the Exner-Poyla for the bed surface elevation, which evolves due to the spatio-temporally varying bed shear stress field induced by the turbulent flow. Simulations are carried out for the rectangular flume experiments of Venditti et al. (2005). It is shown that the model can accurately capture sand-wave initiation, growth, and migration processes observed in the experiment. The simulated bed-forms are found to have amplitude and wave length scales of ~5 cm and ~30 cm, respectively. The effects of free-surface on bed-form dynamics is also quantified by comparing the three-phase simulation results with two-phase simulations using a fixed rigid-lid as the water surface.