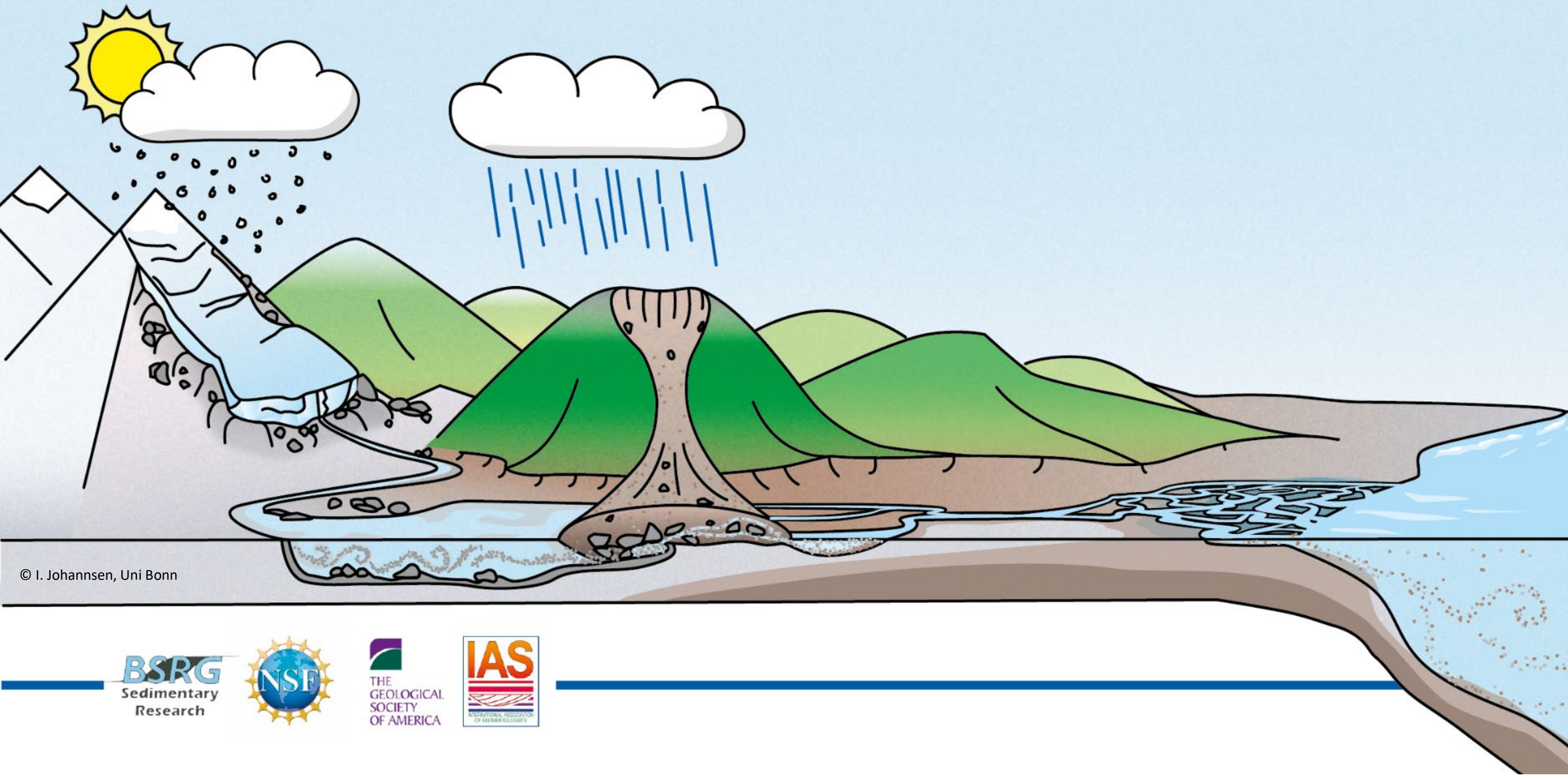
CLAST2019

Climatic controls on continental erosion and sediment transport

4 - 10 August 2019 Juneau, Alaska



BSRG Sedimentary Research

The Geological Society of America

IAS

Contents

Conference Conveners:
Tara N. Jonell, University of Queensland
Jan H. Blöthe, University of Bonn
Peter D. Clift, Louisiana State University

GSA Meeting Manager:
Becky Sundeen

Field Trip Leaders:
Cathy Connor, University of Alaska Southeast
Sonia Nagorski, University of Alaska Southeast
Eran Hood, University of Alaska Southeast

Venue and hotel information

Hotel and conference venue
The Baranof and Ramada hotels are located in the heart of Alaska's state capital within walking distance to the waterfront, restaurants, shopping, cruise ship docks, and government buildings.

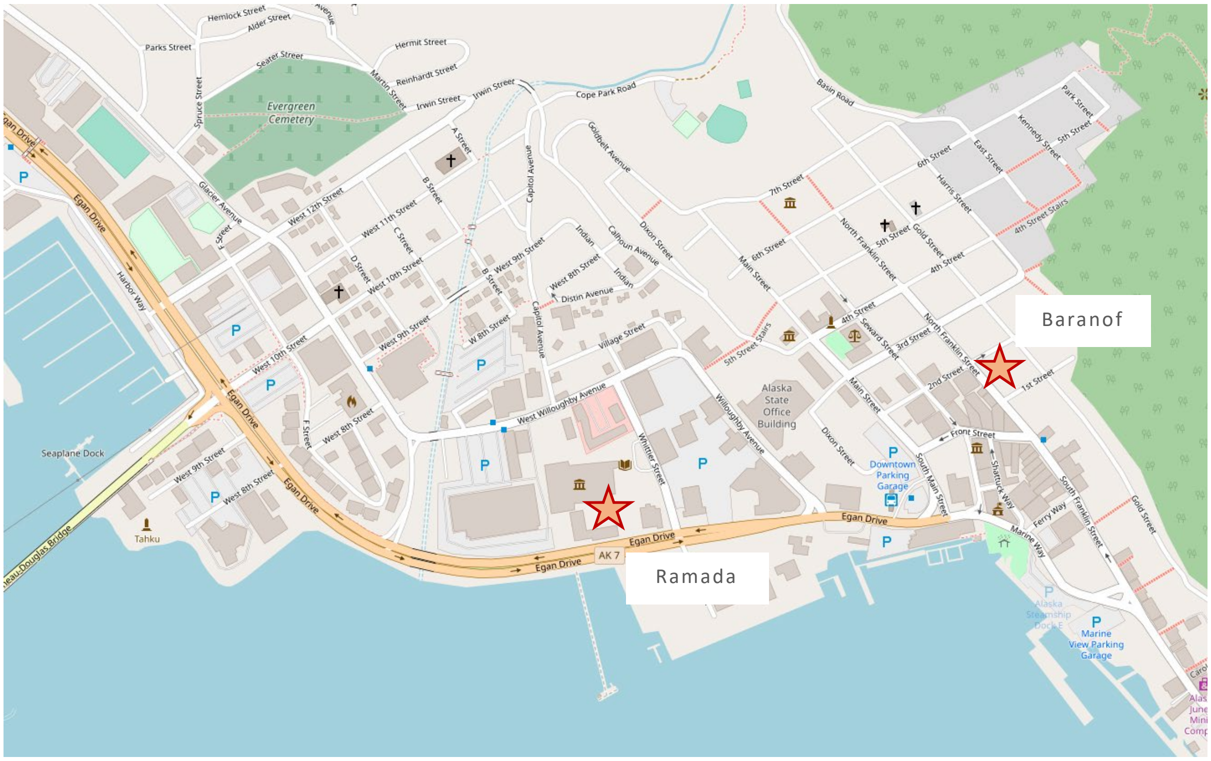
Baranof Hotel and conference venue (Treadwell meeting room)
127 N Franklin St
Juneau, AK 99801-1280, USA
Phone: +1-907-586-2660

Ramada by Wyndham
375 Whittier St
Juneau, AK 99801, USA
Phone: +1 907-586-3737

Directions from JNU airport to the city center:
Time: about 15 minutes
Distance: 8.3 mi/13.4 km
Head south on Shell Simmons Dr towards Yandukin Dr.
Turn right onto Yandukin Dr and continue for almost one mile (1.5 km).
Take a slight right onto Egan Dr. and continue for 7.3 mi/11.7 km.

Conference dinner
There will be catered dinner at the Eagle Beach State Recreation Area at the end of the first field trip on Wednesday (7 August) at around 6:00 pm. The coach bus will provide attendees a shuttle to the hotel after dinner.
Guests are allowed to attend the conference dinner if they purchase a dinner ticket ($50). There will be an option to purchase these tickets on the registration form. Per GSA Policy for field trips, guests will need to find their own transport to/from Eagle Beach.

Eagle Beach State Recreation Area
The Tongass National Forest
28955 Glacier Hwy, Juneau, AK 99801, USA



Getting around Juneau

Although the hotel and conference venue are in shared facilities and all transport into the field and to the conference dinner are included, attendees will need to arrange transport to/from the Westmark Baranof Hotel. Downtown Juneau has a public bus service, is easily accessible by walking, and some roads in the city have been developed for cyclists. A bike path also extends parallel to the main highway and routes are available up to Mendenhall Glacier.

Public transport:
The local area government operates a bus service called Capital Transit. Single Adult fares are $2.00 cash but fare tokens and monthly passes can be purchased at several areas in Downtown Juneau. More information is available through their website and you can download their transit app at https://transitapp.com/ for routes and timetables.

Ride-hailing services:
Local taxis, Uber, and Lyft

Car and bike rental services:
There are many companies operating rental services from the Juneau International Airport, such as *Avis*, *Alamo*, *Budget*, and *Hertz*. Bikes are available from *Cycle Alaska* and *Play it Again Sports* in downtown Juneau.

Program overview

Time	Sunday	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday
7:00		Group Breakfast @ BW Baranof Treadwell Room		Group Breakfast @ BW Baranof Treadwell Room			
7:15							
7:30							
7:45							
8:00		Greetings, orientation, overview of meeting objectives; Introductions around		Field Trip: Source to Sink (Ice to Estuary in the Coast Mountains) Meet @ 7:45 am in BW Baranof Hotel Lobby			Field Trip: Tracy Arm Meet @ 7:30 am in BW Baranof Hotel Lobby
8:15							
8:30			Presenter Uploads		Presenter Uploads	Presenter Uploads	
8:45							
9:00		Christian France-Lanord	Daniella Rempe		Nicole Gasparini	Alexis Licht	
9:15							
9:30							
9:45		Kathie Marsaglia	Eran Hood		Brian Yanites	Yani Najman	
10:00							
10:15							
10:30		Coffee/tea and posters	Coffee/tea and posters		Coffee/tea and posters	Quick break, grab coffee	
10:45						Synthesis Keynote 1: Jane Willenbring Followed by group discussion	
11:00							
11:15		Glenn Sharman	Ken Ferrier		Sergio Andò		
11:30							
11:45							
12:00		Quick table discussions	Quick table discussions		Quick table discussions	Working Lunch? Discussion	
12:15							
12:30		Lunch and break; presenters load	Lunch and break; presenters load;		NSF: Justin Lawrence and Marguerite Toscano lunch; presenters load		
12:45							
13:00						Synthesis Keynote 2: Niels Hovius	
13:15							
13:30		Luca Malatesta	Sonia Nagorski		Kristen Cook		
13:45							
14:00							
14:15		Mitch D'Arcy	Eva Enkelmann		Elizabeth Cassel	Final breakouts; 5 biggest challenges in next five years? What do we need to move forward? Are there key areas that were identified? Discussion etc.	
14:30							
14:45							
15:00		Coffee/tea and posters	Coffee/tea and posters		Coffee/tea and posters		
15:15							
15:30		Assembly of focus groups: summary and challenges	Cathy Connor		Pedro Val		
15:45							
16:00							
16:15			Assembly of focus groups		Assembly of focus groups		
16:30						Last pop-ups? Final words , thoughts	
16:45							
17:00	Packet pick-up and Reception @ BW Baranof Treadwell Room						
17:15		Pop-ups for Day 1 posters (and related	Pop-ups for Day 1 posters (and related		Pop-ups (extras, or carryover discussion)		
17:30							
17:45		Posters and Refreshments	Posters and Refreshments		Posters and Refreshments	Refreshments/Farewell to some	
18:00							
18:15				Conference Dinner @ Eagle Beach SRA			
18:30							
18:45							
19:00							
19:15							
19:30							
19:45							
20:00							
20:15							
20:30							
20:45							
21:00							

Day 0: Sunday, August 4

Pre-Meeting

5:00–7:00 pm   Reception and Icebreaker

Day 1: Monday, August 5

Welcome address

8:00–9:00 am   Greetings, orientation, and overview of meeting objectives; Introduction of participants around the room

Morning Session: From Source to Sink: Tracing Erosional Signals

9:00–9:45 am   Christian France-Lanord: *Himalayan erosion from +5000 to -5000m*

9:45–10:30 am   Kathleen Marsaglia: *Chasing bits and pieces of New Zealand from source to sink: sand provenance studies in New Zealand sedimentary systems*

10:30–11:15 am   Coffee/tea and posters

11:15–12:00 pm   Glenn R. Sharman: *Differentiation of tectonic and climatic drivers using sediment supply and provenance*

12:00–12:30 pm   Quick group discussion among tables

Session description: Understanding the transport of eroded sedimentary particles from bedrock sources to their final depocenter is critical if we are to use sedimentary sequences to reconstruct uplift and erosion of mountain chains and assess the impact of climate events on landscape evolution. Temporary storage and subsequent reworking of sediments from valleys and floodplains have the potential to dilute or completely erase erosional signals produced by subsequent erosion of bedrock. Large drainage systems with extensive floodplains are particularly susceptible to this process. Changes in climate have the potential to both accelerate erosion and increase the volume of material fluxed downstream, yet increased flux can often result in deposition of material that then can be stored and reworked at a later time. In this session we consider both the causes and limits to sediment buffering and consider classic examples from a number of different geologic settings to better understand how these processes can be recognized in sedimentary sequences from source-to-sink worldwide.

Lunch break

12:30–1:30 pm	Lunch will be provided

Afternoon Session: Beyond the mainstream: continental deposits and erosion outside fluvial systems

1:30–2:15 pm	Luca Malatesta: *Stadial-interstadial sediment flux variations captured in alluvial piedmonts of the Tian Shan*
2:15–3:00 pm	Mitch D'Arcy: *Alluvial fans as sensitive recorders of past hydroclimate*

Session Description: Sedimentary budgets often rely on records made from and adjacent to river systems, but many continental sediments are first generated and stored outside of floodplains. Alpine environments are commonly associated with powerful glacial erosion, although the first stage of mechanical erosion and chemical weathering often occurs before contact with glacial ice. The importance of cold-weather periglacial effects on bedrock and the first sediments are typically overlooked, and it is only recently that these processes have been found to be fundamental in generating sediments and denuding mountains. After generation but before introduction to rivers and the ocean, continental sediments can be periodically stored for long times in dry, closed-system environments. Many of these accumulated sediment masses are sensitive to environmental change and can offer long-term climate-erosion records in the form of lake or loess records. Some of these sediment reservoirs, such as dune fields and alluvial fans, have less well-constrained climate-erosion relationships and are further susceptible to substantial reworking and buffering of erosional signals carried through fluvial systems.

3:00–3:30 pm	Coffee/tea and posters
5:00–5:30 pm	Assembly of focus groups; day summary and outstanding challenges
5:30–6:00 pm	Pop-ups for first half of Monday/Tuesday posters:

Jan H. Blöthe	Donovan Dennis
Mathieu Cartigny	Xiaoni Hu
Hon Chim Chiu	Tara N. Jonell
Peter D. Clift	

6:00–7:00 pm	Posters and refreshments

Day 2: Tuesday, August 6

Morning Session: Cycles, Thresholds, and Feedbacks: The Evolving Atmosphere and Biosphere

9:00–9:45 am	Daniella Rempe: *Probing the fractured bedrock in Earth's Critical Zone*
9:45–10:30 am	Eran Hood: *Glacier loss impacts riverine sediment and organic carbon transport to the ocean*
10:30–11:15 am	Coffee/tea and posters
11:15–12:00 pm	Ken L. Ferrier: *Sea-level responses to rapid erosion and deposition of sediment*
12:00–12:30 pm	Quick group discussion among tables

Session Description: Continental environmental conditions shape the distribution and development of vegetation and fauna across any given drainage system. Vegetation can pivotally influence both rates of initial erosion and chemical weathering, can promote or inhibit slope stability, and dictate the storage and release of sediment stored in floodplains. The nature of the biosphere can directly control the transport of material from source to sink, yet its role has been traditionally overlooked by the geologic community. The evolution of any drainage system immediately impacts the biosphere through its expansion or reduction in size, leading to eco-geomorphological consequences, evolutionary pressure, and possible change in transport of nutrients downstream. Here we also reflect on the sources, transfer, and recycling of organic material from the continent into the ocean. Key to this conversation should be discussion of the balance between liberated organic material from ancient deposits, the burial of organic matter, and how this cycle influences atmospheric CO_2 concentrations and global temperatures. In this session we seek to discuss how the biosphere affects erosion, transport and sedimentation across drainage systems, and how these changes may be assessed within preserved sediments using traditional and/or nontraditional isotopic, geochemical, and fossil evidence.

Lunch break

12:30–1:30 pm	Lunch will be provided

Afternoon Session: From Ice to the Ocean

1:30–2:15 pm	Sonia A. Nagorski: *Mercury export from glaciated and non-glaciated watersheds of southeast Alaska, as influenced by bedrock geology, landcover, and atmospheric deposition*
2:15–3:00 pm	Eva Enkelmann: *Tectonics and Surface Process Interaction at the Yakutat-North American collision zone*

Session description: Ice, although encompassing only a modest area of our modern planet, has critically affected erosion both at high altitude and latitudes, as well as climate in low latitudes over the Cenozoic and in the deeper geologic past. Glaciation is argued to be a primary control limiting the height of mountains due to the efficiency with which glaciers erode and thereby supply large volumes of sediment to drainage basins. In turn, powerful glacial erosion may control exhumation patterns across mountain belts over long periods of geologic time. Yet, it is not always true that the most efficient erosion occurs during times when climatic conditions promote glacial maxima. We further reflect on the transport of glacially-derived sediment to the deep oceans, either directly through glacial transport to sea level, or via fluvial systems or further aided by oceanic currents. Understanding the impact that climate change has on erosion and transport systems directly or indirectly by glaciation is the focus of this morning's presentations.

3:00–3:30 pm	Coffee/tea
3:30–4:15 pm	Cathy Connor: *Southeast Alaska (SEAK)--A Bedrock History of Climate-Controlled Erosion and Contributions to Terrestrial and Deep Ocean Depocenters from Paleozoic to Present*
4:15–5:30 pm	Assembly of focus groups; day summary and outstanding challenges
5:30–6:00 pm	Pop-ups for second half of Monday/Tuesday posters:

Yuting Li	Jessica Raff
Claire Masteller	Stefanie Tofelde
Anthony Maue	Peng Zhou
Alexander Neely	

6:00–7:00 pm	Posters and refreshments

Day 3: Wednesday, August 7

Field excursion through Coast Mountains from Source-to-Sink (led by Drs. Cathy Connor, Sonia Nagorski, Eran Hood; U. Alaska-Southeast)

8:00–6:00 pm Field Trip

Please assemble at 7:45 am in the Baranof Hotel lobby.

Packed lunches, snacks, and drinks will be provided. You are more than welcome to bring your own food in addition to what is provided.

This is a one-day field trip through the Neogene of the Juneau region that is structured in a way for attendees to travel from the glaciated Coast Mountains to fjordal marine sinks and, in doing so, touch upon some of the dominant erosional and transport processes discussed during the meeting. This region of southeast Alaska is similar in setting to the beautiful Glacier Bay National Park to the west. Set within the Coast Mountains, Juneau features the Juneau Ice Field (including Mendenhall and Taku glaciers), abundant fjordland landscapes, uplifted glaciomarine sediments, ongoing glacial isostatic adjustment, fault-controlled fluvial morphology, and a rich history of gold mining and salmon fishing. Many topics covered in Day 2 (Cycles, thresholds, and feedbacks and From Ice to the Oceans) will set the foundations for this trip on Day 3.

Field trip attendees will be provided with packed lunches, water, and snacks throughout the day. We do not foresee any trouble with weather in terms of driving and/or walking at this time of year. However, several sites will require some walking off road without paths, where individuals with limited mobility may require extra assistance.

This field excursion will begin at the Mendenhall Glacier Visitor Center. After a short hike to the main Photo Point Trail overlook, attendees will have an introduction over the local glacial geomorphology and landmarks, progressing into climatic controls on Juneau Ice Field glaciation especially since the Last Glacial Maximum (LGM), to the mid-Holocene (Glague et al., 2009), the Little Ice Age (LIA; late 1700s), and into modern day conditions (Motyka et al., 2003). Topics here range from glacier and ice sheet contributions to local sea level, to sediment production and subglacial erosion (adjacent Taku Glacier - Motyka et al. (2006)), and oceanographic controls on sediment distribution in fjords (i.e., Syvitski, 1989). From here, attendees will travel south to Douglas Island to discuss the historic (now reclaimed) Treadwell Gold Mine at Treadwell Historic Park for Coast Mountain panoramas and to learn about the bedrock geology carved and eroded by glaciers. Overviews of Mesozoic-Cenozoic tectonic growth, primary geologic bedrock units, and the Gastineau Fault-Coast Shear Zone (i.e., Gehrels et al., 2000; Gehrels et al., 2009). Briefly, we will touch on Eocene gold mineralization along the Juneau Gold Belt and its historic role in the economy of Juneau (Miller et al., 2000).

Attendees will continue around North Douglas Island to visit '9-mile' field site and Outer Point to see the uplifted coastal marine terraces composed of the Gastineau Channel Formation and enjoy lunch. These Late Pleistocene-Early Holocene glaciomarine sediments form a bathrub ring of fjordal deposits seen around Juneau and other areas of southeastern Alaska (Powell and Cooper, 2002). Southeast Alaska has experienced significant loss of ice following late Neogene warming at the end of LGM and, in particular, immediately following the LIA. Uplift, predominantly through glacial isostatic adjustment (but with some tectonic contribution) has produced about 350 m of vertical uplift following the LGM. Considerable loss of ice after the LIA has produced some of the fastest ongoing glacial isostatic adjustment observed anywhere in the world at ~3 cm/yr (Larsen et al., 2005; Larsen et al., 2007; Elliot et al., 2010). Sites on Douglas Island will include a visit to Fish Creek to discuss fault- and salmonid-controls on fluvial morphology into geologic time (e.g., Fremier et al., 2018).

Continuing from here, sites along Montana Creek valley and Auke Bay area would provide some of the best exposures of the Gastineau Formation hosting marine fossils, and exposures of uplifted nearshore environments (salt wetlands and salt chucks). From there, the trip will move along the Coast Shear Zone and Lynn Canal, the deepest fjord in western North America. We will see excellent bedrock exposures along the road and overlooks to Juneau Icefield nunataks, which offer time to talk about cold-weather weathering processes (Day 2). The trip will continue up to Peterson Creek near Echo Cove, with examples of uplifted terraces and tidal inlets that will welcome deeper discussion into the feedbacks between landscape, glaciation, and biology. The impacts of vegetation succession after deglaciation in context to the area around Juneau is a natural topic, given the amount of study of the temperate rainforest in the region and how it affects slope stability (Glacier Bay; Klaar et al., 2015). This will segue into how deglaciation lends to development of a variety of different erosion processes, glacial lakes, and transition into fluvial transport systems (Montana Creek). In particular, glacial lake outburst flood occurrence, stochastic processes, and their geologic signatures would fit well into the conversation, with an introduction by co-leader Dr. Hood on the Suicide Basin Outburst Flood Project and hazards to downtown Juneau (i.e., Jacobs et al., 2016; see outreach video at https://www.youtube.com/watch?time_continue=40&v=i1tz_cGLuko).

The field trip will end at Eagle Beach State Recreation Area, where sediments exit their mountain source regions into the Lynn Canal as a fluvio-deltaic system. This last site invites discussion on controls of sediment lag times (Cowan et al., 2010), sediment flux, and ties with global geochemical cycles (i.e., Smith et al., 2015).

6:00 pm–sunset Conference BBQ at Eagle Beach State Recreation Area, Juneau

Conference Dinner: BBQ dinner would be included for all attendees from ~6:00–7:00 pm to sunset. Field trip attendees will arrive here at end of their field trip, with other participants (not attending field trip, but with guest tickets) arriving by personal transport in early evening. Coach would provide evening back to downtown Juneau for safety of attendees.

Day 4: Thursday, August 8

Morning Session: Moving forward: innovations in data sharing, visualization, and modelling to understand landscapes and climate

9:00–9:45 am	Nicole M. Gasparini: *Climate and Landscape Evolution Models: What we have learned? What are the opportunities?*
9:45–10:30 am	Brian Yanites: *Linking weather and climate impacts on landscape evolution with numerical and natural experiments*
10:30–11:15 am	Coffee/tea and posters
11:15–12:00 pm	Sergio Andò: *High resolution Raman Spectroscopy studies of silty-turbidites*

Session Description: Advances in our understanding of erosion and sediment transport can proceed as a result of improved concepts, the study of suitable case studies, and through numerical modelling, yet further insight can be gained by application of improved and novel methods to existing study areas. Some of these methods are analytical, such as improved dating of continental sequences (e.g., cosmogenic isotopes or luminescence dating) that now allow high-resolution correlations to be made between climate histories and erosional products. Precise application of these methods have further benefited from recent research outlining gaps and biases within them. Alternatively, progress has been made through the compilation of large remote-sensing data sets, such as LIDAR or satellite precipitation records, that provide unprecedented opportunities for detailed correlation of geologic features, long-term rainfall, ice, or the nature of vegetation cover and how these have changed through time. Open-access databases either summarizing existing geochemical and geophysical data sets or compiling analytical tools are further recognized as crucial to our ability to integrate contrasting independent proxy records used to understand the impact of climate change on continental environments and erosion.

12:00–12:30 pm	Quick group discussion among tables

Lunch break

12:30–1:30 pm	Lunch will be provided
	NSF updates by Justin Lawrence and Marguerite Toscano

Afternoon Session: Closing the gap - emergent tools and techniques for integrating earth surface process and solid earth datasets across different timescales

1:30–2:15 pm	Kristen Cook: *A river in the face of extremes – sediment generation and transport in the Bhote Koshi River valley, central Nepal*
2:15–3:00 pm	Elizabeth Cassel: *The evolution of Cordilleran topography: Records of surface uplift and the onset of orogenic collapse*
3:00–3:30 pm	Coffee/tea
3:30–4:15 pm	Pedro Val: *Asymmetry of the Andes orogen, geometry of the subducting Nazca slab, and topographic trends across rain shadows*

Session description: Numerical models are an essential component in any understanding of how landscapes respond to climate change. Although models need to be ground-truthed with high quality observational data, numerical models allow us to make predictions about the controls on erosion and stratigraphic development. Furthermore, they allow scientists to arrive at conclusions that might not be intuitive. Modelling further permits us to understand the sensitivity of the climate and earth surface system with regard to the various processes that act upon it and the interactions that can occur between them. In this session we examine recent climate models, especially those designed over longer time scales than is normal for atmospheric scientists. We shall also explore how different numerical models can be used make predictions about the formation of drainage basins and the physical and chemical weathered products derived from those basins over both millennial and million-year timescales.

4:15–5:30 pm	Assembly of focus groups; day summary and outstanding challenges
5:30–6:00 pm	Pop-ups for all Thursday and Friday posters:

Michal Ben-Israel	Adam Forte
Nicola Brilli	Karl Lang
Julia Carr	Udita Mukherjee
Anna Clinger	Veronica Prush
Ian Delaney	Duna Roda-Boluda
Kalli Dubois	Kelly Thomson

6:00–7:00 pm	Posters and refreshments

Day 5: Friday, August 9

Morning Session: History matters: Reconciling Tectonic, Climate, and Erosion Histories

9:00–9:45 am	Alexis Licht: *Tibetan-Himalayan uplift, Asian monsoons, and global cooling: chicken, egg, or omelette*
9:45–10:30 am	Yani Najman: *Climatic and Tectonic controls on the Bengal Fan sediment archive*

Session Description: Over long periods of geologic time tectonic forces and sea-level are the primary mechanisms that influence sediment generation, transport, and distribution. Disentangling tectonic effects from climate is a common problem for many sedimentary geologists if they are working over timescales longer than a typical glacial cycle (~100 ka). Tectonic forces drive rock uplift that causes incision and an increase inn erosion and rate of sediment delivery to the basin. Uplift disrupts topography, encourages drainage evolution and migration, and divergence of sediments into different basins as uplift proceeds. Rock uplift produces surface elevation that impacts atmospheric circulation patterns, while the opening and closure of oceanic gateways has long been recognized to affect the redistribution of heat from the tropics to the high latitudes. This session opens the conversation on how tectonic forces induce erosion independently of, in association with, and potentially as a consequence of climatic change over geologic time.

The second part of this session will further outline some of most provocative unanswered questions in the field (hopefully already informally discussed at the meeting) and contemporary challenges by two speakers giving keynote synthesis talks. These speakers will provide the last necessary foundations to provoke discussion that, together with the scientific organizing committee, will commence a group synthesis on the last day of the meeting. Each talk will have a wide group discussion followed by focus group break-outs.

10:30–11:00 am	Coffee/tea and posters
11:00–12:15 am	Synthesis Keynote I by Jane K. Willenbring: *Not Feeling the Buzz: Tectonics - Not Climate - Limits Heights of Mountains*

Synthesis Goals: The last day of the meeting is designed to encourage discussion of the major questions that pervaded the presentations and personal discussions earlier during the meeting. Although each session will feature formal discussion, attendees will converge into focus groups daily to summarize these questions and concerns. At the end of the week, each focus group will target the most concerning issues that need be addressed and how it may be best to amend the lack of data or modelling. Together, between wide and small-group discussion, we will formulate practical ways in which progress can be made in the next five to ten years within our sub-disciplines and as a whole. Ideally, these discussions will touch upon the ways by which the community can bridge gaps in our methods, monitoring, data network, communication, and outreach. The scientific committee, and interested attendees, will compile the major conference proceedings as a short article in GSA Today or similar venue. If numerous attendees display an interest in the proceedings, we will formulate tangible action plans for a GSA Special Paper collection.

Lunch break

12:15–1:15 pm	Working lunch with discussions

Afternoon Session: Reconciling Tectonic, Climate, and Erosion Histories (Continued)

1:15–2:30 pm	Synthesis Keynote II by Niels Hovius: *Seismic and meteorological drivers of sediment production*
2:30-3:00 pm	Coffee/tea and posters
3:00–5:00 pm	Final breakouts; great challenges in the next years?
5:00–6:00 pm	Pop-ups, final remarks, small group discussions, acknowledgements and farewell to some
6:00–7:00 pm	Posters and refreshments; tear down

Day 6: Saturday, August 10

Optional field trip to Tracy Arm, Juneau, Alaska

8:00 am–6:00 pm Field trip

Please assemble at 7:30 am in the Baranof Hotel lobby. We will walk as a group to Downtown Juneau port to board the Adventure Bound boat.

Made-to-order sandwiches and snacks are available for purchase on the boat. You are welcome to pack and bring your own food.

Leaving early in the morning, this field trip by high-speed catamaran lead by a Day 3 field trip leader would primarily involve a geologic tour through the structure and evolution of the Coastal Shear Zone. Given that the boat will be most likely run by an independent company also hosting tourists not in attendance of the meeting, there are no formal geologic stops. Along the way, notable views around some of the deepest fjordland in North America will incite casual discussion about fjord formation and sedimentation dynamics. Tours to Tracy Arm typically culminate in front-row seats to the twin Sawyer glaciers to observe ice-calving. Calving and iceberg formation, a somewhat poorly quantified process at least in the geologic community, would invite discussion on their importance to glacial dynamics and maritime glacier sediment distribution to oceans among field trip attendees. Trips to Tracy Arm usually depart early in the morning, and depending on fjord ice conditions, return to port around 6 pm.

List of participants

First Name	Last Name	Affiliation	Email
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Niels	Hovius	GFZ Potsdam, Germany	hovius@gfz-potsdam.de
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Tara	Jonell	University of Queensland, Australia	t.jonell@uq.edu.au
Karl	Lang	City University of New York, USA	karl.lang@qc.cuny.edu
Justin	Lawrence	National Science Foundation, USA	jlawrenc@nsf.gov
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Alexis	Licht	University of Washington, USA	licht@uw.edu
Luca	Malatesta	University of Lausanne, Switzerland	luca.malatesta@unil.ch
Kathleen	Marsaglia	California State University-Northridge, USA	kathie.marsaglia@csun.edu
Claire	Mastellar	Washington University St. Louis, USA / GFZ Potsdam	cmasteller@epsc.wustl.edu
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Abstracts (orals)

Monday, August 5 (Day 1)

Himalayan erosion from +5000 to -5000m

Christian France-Lanord

Centre National de la Recherche Scientifique, France

The Himalayan basin fosters the most active erosion system of the planet. The interplay between tectonic and climate allows to maintain the extreme elevation of the range, and to trigger monsoonal circulation and intense rainfall over the South flank of the range. It also acts over the long term on the carbon cycle through organic carbon burial and silicate weathering. Glacier, landslide, incision, river transport all generate an export of 1 to 2 billion tons/yr from the Himalayan slopes to the Gangetic floodplain, Bengal delta, and ultimately the Bengal Fan. The IODP Expedition 354 in the Bengal fan in 2015 generated a unique comprehensive record of Himalayan erosion over the Neogene and Quaternary. The Bengal fan is predominantly composed of detrital turbiditic sediments originating from Himalayan rivers, and transported through the delta and shelf canyon, supplying turbidity currents loaded with a wide spectrum of grain sizes. Expedition 354 drilled seven sites along a 320 km E-W transect at 8°N allowing the restitution of an almost complete record of Himalayan erosion at the scale of the Neogene. This presentation will review the active erosion processes and sediment transport processes from Himalaya to Bangladesh delta and Bengal Fan. Sedimentological and geochemical fingerprints of the modern river sediments will be used to interpret the Bengal fan record and unravel the evolution of the Himalayan erosion since 20 million years.

Chasing bits and pieces of New Zealand from source to sink: sand provenance studies in New Zealand sedimentary systems

Kathleen Marsaglia

California State University-Northridge, USA

The MARGINS Source-to Sink paradigm holds that deep-sea sandy successions reflect the evolution of onshore fluvial and adjacent shelf systems, with the potential to record distinct eustatic, climatic, and tectonic signals. Deciphering these signals in Modern to Late Cenozoic systems increases our ability to interpret continental margin history that is preserved in ancient deep-marine successions. Recent and ongoing work demonstrates that the modern and ancient passive to active margin sedimentary systems of New Zealand are ideal places for holistic, source-to-sink sand provenance

studies. These include the South Island Bounty Fan and Canterbury Margin Systems and the North Island Waipaoa River and Hikurangi Sedimentary Systems. Petrologic data sets collected include various combinations of: 1) modern river and beach samples; 2) piston and box core samples; 3) sandy core samples from Ocean Drilling Program and Integrated Ocean Drilling Program sites; and 4) Cenozoic to Mesozoic outcrops within stream drainage basins. The sand samples include first cycle and multi-cycle detritus derived from Cenozoic sedimentary successions, as well as sediments derived from variably metamorphosed Paleozoic Mesozoic Clastic Rocks and volcanic and plutonic rocks. Sand detrital modes determined for parts of each system demonstrate a variety of processes control sand distribution and composition, including tectonism, eustasy, and shelf- and slope-parallel currents. Provenance models developed using these data will help interpret regional paleogeography and predict sandstone reservoir quality (composition and diagenesis) as petroleum exploration expands outward from New Zealand to the largely submerged landmass referred to as “Zealandia.”

Differentiation of tectonic and climatic drivers using sediment supply and provenance

Glenn R. Sharman

University of Arkansas, USA

Understanding the linkage between environmental forcings (tectonics, climate) and the resulting sedimentary response is critical to efforts to reconstruct the Earth’s history by inverting the stratigraphic record. Previous research, largely focused on sediment supply (Qs) and grain size as the de facto sedimentary signals of changing forcing mechanisms, has noted the inherent difficulty in this task given the complex way in which environmental signals are transformed by erosional landscapes. This research utilizes numerical landscape evolution modeling to illustrate how multiple sedimentary proxies (Qs and provenance) may better differentiate forcing mechanism and timing than possible via analysis of either signal alone. Specifically, while Qs reflects integrated denudation across an erosional catchment, provenance is controlled by spatially variable erosion that occurs in transient landscapes. Future efforts to integrate multiple sedimentary signals may thus yield a clearer picture of the complex relationship between external forcings and resulting stratigraphy.

Stadial-interstadial sediment flux variations captured in alluvial piedmonts of the Tian Shan

Luca Malatesta

University of Lausanne, Switzerland

Transient sediment storage and mixing of deposits of various ages during transport across alluvial piedmonts alter the clastic sedimentary record. We quantify buffering and mixing during cycles of aggradation–incision in the north piedmont of the Eastern Tian Shan. We complement existing chronologic data with 20 new luminescence ages and one cosmogenic radionuclide age of terrace abandonment and alluvial aggradation. Over the last 0.5 Myr, the piedmont deeply incised and aggraded many times per 100 kyr. Aggradation is driven by an increased flux of glacial sediment accumulated in the high range and flushed onto the piedmont by greater water discharge at stadial– interstadial transitions. After this sediment is evacuated from the high range, the reduced input sediment flux results in fluvial incision of the piedmont as fast as 9 cm/year and to depths up to 330 m. The timing of incision onset is different in each river and does not directly reflect climate forcing but the necessary time for the evacuation of glacial sediment from the high range. A significant fraction of sediments evacuated from the high range is temporarily stored on the piedmont before a later incision phase delivers it to the basin. Coarse sediments arrive in the basin with a lag of at least 7–14 kyrs between the first evacuation from the mountain and later basinward transport. The modern output flux of coarse sediments from the piedmont contains a significant amount of recycled material that was deposited on the piedmont as early as the Middle Pleistocene. Variations in temperature and moisture delivered by the Westerlies are the likely cause of repeated aggradation–incision cycles in the north piedmont instead of monsoonal precipitation. The arrival of the gravel front into the proximal basin is delayed relative to the fine-grained load and both are separated by a hiatus. This work shows, based on field observations and data, how sedimentary systems respond to climatic perturbations, and how sediment recycling and mixing can ensue.

Alluvial fans as sensitive recorders of past hydroclimate

Mitch D'Arcy

University of Potsdam, Germany

Alluvial fans are common landforms that record source-to-sink sedimentation in terrestrial basins. It has long been thought that episodes of fan aggradation and incision might be related to past climate changes, but this link has been difficult to demonstrate empirically. Here, we show that alluvial fans in two different landscapes—the SW USA and the southern Central Andes—have responded to orbitally-driven changes in precipitation rates. Fan surfaces aggraded during dry episodes and become abandoned and incised during wet episodes, and therefore capture useful information about past hydroclimate. Our observations imply that temporary increases in water flux were the primary trigger for the abandonment of fan surfaces, and we identify a threshold precipitation rate for fan incision that is adjusted to long-term climate cyclicity. Our results show that alluvial fans have rapid response timescales following climate pertubations, and a greater sensitivity to climate cycles with a shorter periodicity.

Tuesday, August 6 (Day 2)

Probing the fractured bedrock in Earth's Critical Zone

Daniella Rempe

The University of Texas at Austin, USA

Many mountainous landscapes are mantled with thin soils that overlie meters to tens of meters of weathered bedrock. This transition zone between soil and bedrock often controls how infiltrating water is partitioned between evapotranspiration and runoff, as well as the rate and pattern of chemical denudation in a landscape. This region is largely invisible to observation. As a result, the geochemical reactions and hydraulic properties that govern its structural evolution over time are poorly constrained. In this presentation, I will present results from intensive efforts to directly quantify the complex fluid and solute pathways in the weathered bedrock region and discuss the implications of our results for water and carbon cycling and landscape evolution.

Glacier loss impacts riverine sediment and organic carbon transport to the ocean

Eran Hood

University of Alaska-Southeast, USA

Riverine transport of organic carbon (OC) to the coastal ocean is an important component of the global carbon cycle because river networks transport, mineralize, and bury significant amounts of OC. The impact of riverine OC on atmospheric CO2 is influenced by extent to which particulate OC is sourced from the lithosphere versus the terrestrial biosphere. Despite the central role of glaciers in the export of water and sediment from many high-elevation and high-latitude ecosystems, their role in riverine OC cycles is poorly understood, particularly with regard to particulate OC. Here we evaluate seasonal sediment and OC budgets for three watersheds in southeast Alaska that vary in glacier coverage. We show that runoff is a first order control on OC yields and that watershed glacierization moderates the relationship between water fluxes and yields of particulate OC via its influence on catchment erosion rates. We conclude that glacier loss will impact the provenance of particulate OC, with implications for how riverine OC export affects the atmospheric CO2 reservoir.

Sea-level responses to rapid erosion and deposition of sediment

Ken L. Ferrier

University of Wisconsin-Madison, USA

Sea level is a critical link in feedbacks among topography, tectonics, and climate. Changes in sea level are of wide interest because of their effects on a range of geomorphic features and geologic processes: they reshape coastlines, reorganize river networks, regulate sediment deposition and organic carbon burial, set the boundary condition for landscape evolution, and modify surface loads that influence geodynamic and magmatic processes at depth. Here I review recent modeling work on the sensitivity of sea-level change to sediment erosion and deposition, with a focus on sites subject to rapid sediment redistribution. Our model results show that the fingerprint of sediment redistribution on sea-level change is complex, with significant spatial and temporal variations in both the magnitude and the sign of sea-level change. These results provide a basis for understanding a fundamental driver of landscape evolution at some of Earth's most geomorphically dynamic sites.

Mercury export from glaciated and nonglaciated watersheds of southeast Alaska, as influenced by bedrock geology, landcover, and atmospheric deposition

Sonia A. Nagorski

University of Alaska Southeast, USA

Mercury (Hg) export from glaciated watersheds to downstream freshwater and coastal ecosystems is poorly understood. Seasonal glacier melt may also be releasing legacy accumulations of anthopogenically-sourced Hg trapped in glacier ice. Here we present data on Hg concentrations, speciation, and yields out of two glaciated watersheds in the Juneau area and compare them to an adjacent non-glacial stream. The glacial rivers carried Hg largely in the particulate form, whereas the non-glacial stream carried it largely in the filtered fraction, at ~20 fold higher filtered concentration, and with a higher percent in its methylated form. However, the flux of total Hg in the glacial streams dwarfed that of the non-glacial stream. Additionally, large differences were found in both the total and methyl-Hg yields and in the seasonal patterns between the two glacial rivers, which are explained by different bedrock lithologies in the area of

the glacier termini. Differences in Hg speciation are explained by variable Hg methylation processes within the watersheds.

Tectonics and Surface Process Interaction at the Yakutat-North American collision zone

Eva Enkelmann
University of Calgary, Canada

Investigations of tectonic and surface processes have shown a relationship between climate-driven erosion and long-term exhumation of rocks. Numerical models suggest that climate shifts can change the deformation in an orogeny, but observational evidence of a spatial shift in mountain building due to tectonic-climate interaction are rare. The Yakutat–North American collision zone in SE Alaska and SW Yukon is a natural laboratory to study interaction between strong tectonics and glacial dominated erosion. The geological, geophysical, and surficial data collected on land and offshore allow us to synthesize these data. We show that focused deformation and rock exhumation occurred in the apex of the colliding Yakutat plate corner starting already prior to glaciation ca. 10 Ma. This location shifted southward through time and since ca. 2 Ma the focus of deformation is south of the plate boundary. This shift in deformation lags behind the ~2.6 Ma global climate shift and glacial intensification. The extremely high sedimentation rates caused the rheological modification of the colliding Yakutat microplate that resulted in the emergence of the fold-thrust belt. The growing coastal topography intercepted with precipitation pattern and shifted erosion and exhumation to the south.

Southeast Alaska (SEAK)--A Bedrock History of Climate-Controlled Erosion and Contributions to Terrestrial and Deep Ocean Depocenters from Paleozoic to Present

Cathy Connor
University of Alaska-Southeast, USA

Paleozoic tropical island arc clastics of the Alexander Terrane, now contribute glacial and temperate rainforest-eroded sediments to offshore depocenters, from Glacier Bay to Prince of Wales Island (Soja, 2008; Wilson, 2015; Cowan, 2010). Maritime rain-forest conditions have transformed Alexander Terrane carbonates into karst repositories for Pleistocene arctic fossil cave biota (Heaton, 2007).
Paleozoic Tracy Arm Terrane gneisses and Mesozoic Gravina Belt back-arc basin volcaniclastics, now crop out along the mainland from Haines to Ketchikan, and

underlie Juneau's northern highway system (Gehrels, 2000). Coast Shear zone tonalites and granodiorites, were intruded into them between Late Cretaceous to Paleocene and later uplifted 1-2mm/yr over the last 50 my (Stowell, 2003). Eocene subtropical climates in SEAK, drove chemical weathering and the accumulation of pockets of subtropical terrestrial sediments yielding fossil mammals and plants (Johnson, 2018). Pleistocene glaciers shaped AK/BC Boundary Peaks, incised bedrock, and plucked the source rocks for Tracy Arm fjord sediments and the offshore Baranof Fan (Zhang, 2019).

Exhumed glaciomarine sediments of the Early Holocene Gastineau Formation unconformably overlie Mesozoic bedrock in the Juneau area, and record over 420 m of post-Last Glacial Maximum uplift in northern SEAK (Miller 1975; Baichtal, 2017). Ongoing uplift, following Little Ice Age deglaciation, has elevated some depocenters (Larsen, 2005: Connor, 2009). Juneau and Stikine Icefield researchers, continue to track erosion and sediment and nutrient transport (Motyka, 2002, 2003; J Kienholz, 2019, O'Neel, 2015; Hood, 2015).

Thursday, August 7 (Day 4)

Climate and Landscape Evolution Models: What we have learned? What are the opportunities?

Nicole M. Gasparini

Tulane University, USA

Landscape evolution models (LEMs) tend to focus on large temporal and spatial scales, thus climate as a driving force and the details of how climate affects surface processes must be simplified. For example, past LEM studies exploring a transition from a dry to wet climate have modeled the dry climate with one uniform low rainfall rate and the wet climate with one uniform relatively higher rainfall rate. In contrast, LEM experiments that model rainfall distributions as a driving force have led to important process insights. For example, based on observational data, recent LEM studies have focused on the importance of fluvial sediment transport and erosion during large floods, but how extreme storms impact other surface processes is generally ignored. This talk will review past modeling studies that have incorporated climate into LEMS in various ways and identify key directions for future research, especially when linking source-to-sink sediment routing.

Landscapes under the weather: Quantifying climate's control on topographic evolution.

Brian Yanites

Indiana University-Bloomington, USA

Quantifying the effects of climate on topography and its evolution has been a long focus for many geomorphologists, yet the impact of both spatial and temporal patterns of climate on erosion and landscape form remains ambiguous. One topic of recent advance is quantifying the integrative effects of a distribution of weather events on landscape evolution. In this talk, I present work building on these advances from my research team. We use modern precipitation data along a latitudinal gradient in the Andes to drive landscape evolution models. From these, we calculate both along latitude and across orogen gradients in geomorphic efficiency. Next, I'll explore ongoing work coupling a landscape evolution model with physical weather and hydrologic models. This work quantifies the change in discharge distribution as an orogen grows from a low relief, low elevation landscape to developed orogen. The magnitude and style of discharge distributions varies as a function of latitude, suggesting topographic and climate interactions vary with latitude as well. Finally, we'll leave modeling world and look at recent work documenting and quantifying the geomorphic response to a significant weather event in southern Taiwan, where many meters of rainfall fell on the landscape in just four days. We quantify the aggradation and evacuation timescale along a strong topographic gradient. We find that the steepest, most tectonically impacted landscapes are impacted with both the greatest aggradation magnitude and the longest evacuated times. This suggests that the largest weather events control a second threshold in landscapes that inhibit erosion. Moreover, this threshold is influenced by tectonic activity. Such impacts are currently not included in landscape evolution models. Together, this work highlights the importance of discrete weather events, thresholds, and variability in quantifying the relationship between climate and landscapes.

High resolution Raman Spectroscopy studies of silty-turbidites

Sergio Andò

University of Milano-Bicocca, Italy

The scientific drilling of oceanic sedimentary sequences plays a fundamental part in provenance studies, paleoclimate reconstructions, and source-to-sink investigations (e.g., France-Lanord et al., 2015; Pandey et al., 2015). When studying oceanic deposits, Raman spectroscopy can and does represent an essential flexible tool for the multidisciplinary approach necessary to integrate the insight provided by different disciplines. This new user-friendly technique opens up an innovative avenue to study the composition of detrital mineral grains of any origin, complementing traditional methods of provenance analysis (e.g., sedimentary petrography, heavy minerals; Andò and Garzanti, 2014; Garzanti and Andò 2019).

For the study of pelagic or turbiditic muds, which represent the bulk of the deep-marine sedimentary record, Raman spectroscopy allows us to identify silt-sized grains down to the size of a few microns with the same precision level required in quantitative provenance analysis of sand-sized sediments (Andò et al., 2011). Silt and siltstone also represent a very conspicuous part of the stratigraphic record onshore and usually preserve original mineralogical assemblages better than more permeable interbedded sand and sandstone (Blatt, 1985). Raman spectra can be obtained on sample volumes of only a few cubic microns by a confocal micro-Raman coupled with a standard optical microscope using a 50x objective.

As case history and natural laboratory to conduct a novel exciting experiment, we have studied the Indus Fan turbiditic sediments cored in the Laxmi Basin during Expedition 355 (Arabian Sea Monsoon; Pandey et al., 2016. We have investigated thin-bedded silty-sandy turbidites and thick-bedded channelized sandy turbidites with intercalated silty overbank deposits (from Miocene to lower Pleistocene) to quantify hydraulic sorting effect in different depositional environments. We have recognised different heavy-mineral suites and compared with the modern suite of heavy minerals in the Indus River catchment to determine the provenance of detritus in the entire interval of time drilled during our expedition.

We have detected from moderately poor heavy-mineral assemblages, consisting of augitic clinopyroxene and blue-green amphibole with subordinate epidote, minor titanite, apatite, garnet, and rare hypersthene and Cr-spinel in the lower Pleistocene record of the core and rich heavy-mineral assemblages dominated by blue-green amphibole with subordinate epidote, minor garnet, diopsidic clinopyroxene, apatite, hypersthene, sillimanite, and rare titanite and kyanite in Pleistocene deposits. Petrographic and mineralogical composition of the observed sediments compares well with that of modern Indus river and delta sands, indicating provenance from the Himalayan orogen (Garzanti et al., 2005; Clift et al., 2010). Augitic pyroxene, common only in the upper part of the core and locally in slump deposits of the deepest deposits, testifies instead to sediment supply from the western Indian passive margin fed by the Tapti and Narmada Rivers.

The developing of new methodologies in the laboratory for the preparation of sediments and the introduction of new tools as Raman spectroscopy, now easily available permit a proper identification of each single grain encountered in the stratigraphic record, in different depositional environments, and open up a new frontier for future provenance studies and source to sink exploration in the deep ocean and in ancient sediments.

This abstract is an outcome of Project MIUR, Italy – Dipartimenti di Eccellenza 2018–2022.

NSF Updates

Justin Lawrence and Marguerite Toscano

National Science Foundation, USA

A river in the face of extremes – sediment generation and transport in the Bhote Koshi River valley, central Nepal

Kristen Cook
GFZ Potsdam, Germany

The Himalaya are some of the most rapidly eroding mountains in the world, generating large amounts of sediment with climatic forcing dominated by the Indian Summer Monsoon. I will present data from four monsoon seasons of monitoring of the Bhote Koshi River, a transhimalayan river in central Nepal. During this time, we have observed the impact of multiple discrete events on the generation of sediment and its delivery downstream. First, the Gorkha earthquake triggered extensive coseismic and postseismic landsliding in the valley, but the sediment transport response was short-lived and rather muted. A glacial lake outburst flood in 2016 had far greater impact on channel dynamics. This event both transported large amounts of bedload and created a short-lived pulse of suspended sediment that could be seen all the way to the mountain front. Finally, the monsoon typically triggers a number of debris flows in the valley. These are very efficient conveyers of coarse sediment to the river and can result in both short-lived local increases in bedload transport and longer-lived changes to the morphology of the river channel. Together, all of these observations highlight the complexity of the sediment generation system in this Himalayan river.

The evolution of Cordilleran topography: Records of surface uplift and the onset of orogenic collapse

Elizabeth Cassel
University of Idaho, USA

High elevation regions cover a relatively small portion of Earth's surface, but have an outsized influence on regional hydrology, continental sediment transport, and global climate. What factors control the lifespan of mountains, and what are the mechanics of the transition to orogenic collapse? The Cenozoic morphology and evolution of the Cordilleran orogen is widely studied and debated in both North and South America, particularly the timing and rates of uplift, the links to possible mantle delamination, and the controls on extensional collapse. Here we reconstruct past elevations across the Basin and Range of the western U.S. and the Central Andes of southern Peru, using hydrogen isotope ratios (δD) of paleo-precipitation preserved in volcanic glass from widespread air-fall ashes and ignimbrites. Data span from the paleo-Pacific shoreline across the Cordilleran orogen and are paired with new sanidine $^{40}Ar/^{39}Ar$ geochronology and detailed chemo- and litho-stratigraphy, providing a novel approach to interpreting changes in δD values over space and time.

Asymmetry of the Andes orogen, geometry of the subducting Nazca slab, and topographic trends across rain shadows

Pedro Val

Federal University of Ouro Preto, Brasil

Coupled deformation-surface process models predict that orogenic asymmetries may be modified by superimposition of dominant wind direction and erosion, i.e. the formation of orographic rainfall gradients across strike. However, the geometry of the subducting slab is not considered in such models even though a correlation between slab-dip and arc position exists. The latter suggests that just as the arc position changes with slab dip, the asymmetry of an orogenic wedge may consequently change as a function of it as well. In this work, we observe a positive correlation between the radius of curvature of the subducting Nazca slab and orogenic wedge asymmetry in the Andes. Given that erosion rates do not always mirror rain shadows, the slab geometry must be accounted for when assessing the climatic influences on orogenic asymmetry.

Friday, August 9 (Day 5)

Tibetan-Himalayan uplift, Asian monsoons, and global cooling: chicken, egg, or omelette

Alexis Licht

University of Washington, USA

In their 1992 seminal paper, Raymo and Ruddiman proposed that Cenozoic global cooling is the direct consequence of the combined action of monsoons and Tibetan-Himalayan uplift. Regional uplift would have resulted in more active Asian monsoons, more denudation and chemical weathering that would have drawn atmospheric pCO2 down and paved the way to the Icehouse. In this talk, I will try to assess the validity of Raymo and Ruddiman's cooling scenario by providing a synthesis of geological and paleoclimatic data from East and South Asia. I will focus on the 50-25 million years window, covering the fall into the Oligocene Icehouse. And we will see that it is not that simple

Climatic and Tectonic controls on the Bengal Fan sediment archive

Yani Najman

Research Fellow UC Boulder, USA/Lancaster University, UK

Sediment records held in deep sea fans can provide excellent archives of their hinterland's climatic, tectonic and erosional history. The Bengal Fan is fed by the Ganges and Brahmaputra rivers. The main drivers affecting the Bengal Fan sediment archive are Eastern Himalayan tectonics, the Asian monsoon, and the onset of Northern Hemisphere Glaciation, which affects the quantity of sand that is delivered to the deep basin during interglacial versus glacial periods. The oldest sample with short geochronologic lag times (<1 Ma), which are indicative of very rapid exhumation, has a depositional age of ~3.5 Ma. The youngest sample with a long lag time (>6 Ma), has a depositional age of ~5 Ma. This increase in exhumation rates can be most easily interpreted as reflecting rapid exhumation of the eastern Himalayan syntaxis. An increase in hinterland exhumation is broadly matched by an increase in Transhimalayan arc-derived zircons since Late Pliocene. This increase cannot easily be explained by syntaxial exhumation, since the Transhimalayan source region lies upstream of the syntaxis. Alternatively, it may reflect the onset of Northern Hemisphere Glaciation. This high proportion of Transhimalayan material is also documented in Pleistocene samples, but the proportion declines again in the modern Brahmaputra sample. This decline may reflect the change from glacial to interglacial conditions, at which time glacial erosion of the Transhimalayan high ground played a less dominant role in sediment generation again.

Not Feeling the Buzz: Tectonics - Not Climate - Limits Heights of Mountains

Jane K. Willenbring

University of California San Diego, USA

The potential to rapidly erode topography at and above the glacier Equilibrium Line Altitude (ELA), irrespective of uplift rates, rock type or pre-existing topography, is explored in the glacial buzzsaw hypothesis. I will present a compilation of tectonic, topographic, and erosion rate data from Arc-Continent convergent margins where the convergence rate is known (Andes, Central America, Cascadia, British Columbia, Alaska) to show that erosion rates and elevation maxima correlate linearly with plate convergence rates. Importantly, mountain peaks in three heavily glaciated mountain ranges (Alaska, Cascadia, and South Chile) do not deviate from the trend of unglaciated mountain ranges. Because mountain ranges in different latitudes fall within the same trend, we infer that tectonics is the primary control of mountain range mass and heights–not climate. I will also demonstrate how glacial valleys are simply fluvial bedrock channels cut by water with a different viscosity.

Seismic and meteorological drivers of sediment production

Niels Hovius

GFZ Potsdam, Germany

My presentation would focus on links between erosion and external drivers, with an emphasis on precise constraints derived from detailed meteorological, seismological and geomorphic records. Such records permit the definition of simple relations between, for example, rainfall or earthquake activity and mass wasting, which can be used in forward models of landscape evolution and sediment transport. However, they also show that, in many cases, the link between meteorological or seismic driver and geomorphic response is delayed or modulated by intervening processes, including rock mass damage and healing, and groundwater flow. Using examples from across the world, I intend to show that rainfall solicits erosion in proportion to short-duration precipitation intensity; that the response to rainfall on steep hillslopes may be delayed due to the time consuming process of crack propagation; that this response is not a single instance of sediment production, but a protracted episode with many individual events; that the fluvial evacuation of this material may solicit further erosional activity on hillslopes; that the landscape response to a given meteorological perturbation is modulated by the strength of the substrate, which is a dynamic function of preceding seismic activity; and that rare, anomalous processes may disrupt normal links between climate and tectonics and erosion, leaving a profound, long-lasting imprint on topography and sediment fluxes from mountain source areas.

Abstracts (posters)

Monday and Tuesday posters (alphabetical order)

Pleistocene river aggradation and incision along the Rio Mendoza, central Andes of Argentina

Jan H. Blöthe

University of Bonn, Germany

In the arid central Andes of Argentina abundant large slope failures, fluvial terraces and broad valley fills modulate sediment dynamics by either catastrophically releasing, attenuating, or transferring sediment pulses. Along the Rio Mendoza and its tributaries

(~7500 km^2), fluvial terraces are located between ~15 and 60 m above the current river level. Whether these terraces are the result of sediment pulses induced by glacial dynamics, changes in precipitation patterns, or local controls remains subject to discussion. Published ages of a tephra layer within river terraces suggests aggradation commenced before ~100 ka, while the onset of incision remains unresolved.

Prominent terrace surfaces were sampled for Quartz-bearing clasts in order to constrain surface abandonment using cosmogenic nuclide abundances. We further compiled a landform inventory for the Rio Mendoza basin comprising >80 terraces and >100 large landslides (>0.1 km^2) to estimate the sedimentary volumes contained. Based on an empirical volume-area scaling approach, we estimate that these landforms store between 2 and 5 km^3 of sediment, enough to sustain modern sediment fluxes for several millennia.

Morphodynamics of knickpoints and turbidity currents revealed in a decade of seafloor observations

Matthieu Cartigny

Durham University, UK

In comparison to river channels little is known about submarine channels. The turbidity currents that form submarine channels are episodic, unstable and carry high sediment concentrations. Although, the resulting submarine channels are surprisingly similar to river channels, there are intriguing differences between these channels types.

One key difference is the presence of trains of knickpoints. Such knickpoints are found to be unsustainable in alluvial rivers. Yet trains of knickpoints are common in purely alluvial submarine channels. Several hypotheses have been proposed to explain this contradiction, however, all of these hypothesis remain untested due to a lack of seafloor.

Here we combine a decade of seafloor surveys (Bute Inlet, Canada) to determine the morphodynamics of knickpoints and turbidity currents. We discuss: (1) the origin of trains of knickpoints, (2) the process that drive knickpoint migration, (3) and the effect of a knickpoint on the evolution of a turbidity current.

Late Pleistocene to Holocene landscape controls on former higher lake levels in Tibet and its interactions with surface processes

Chiu Hon Chim

Hong Kong Baptist University, Hong Kong

Very rapid uplift has had a major influence on surface processes, including erosion rates and the associating sedimentological responses in the Qinghai-Tibetan Plateau. Many of the river courses in Tibet display characteristics that strongly suggest tectonic and glacial controls on their formation and evolution. It is generally agreed that the river systems appear antecedent to the uplift of the plateau (Duff and Holmes, 1993) and that they have incised the newly formed Himalayan ranges, creating a series of deep valleys.

Outburst floods from palaeolakes can be one of the mechanisms to create such incision. For instance, sedimentological and geomorphological evidence of palaeolakes in southeastern Tibet suggests the existence of large palaeolakes north of the Himalayan Ranges, with lake levels high enough that extensive coalescence of adjacent lakes in the Tibetan plateau in the LGM may have occurred, consistent with the long held Pan-Lake Hypothesis (Zheng, 1996; Zhu et al. 2003).

Only patchy evidence of surface breaching of the palaeolakes, however, could be observed. While glacial dams, tectonic displacements, and other local effects on geomorphology and sedimentology of the lowering of the lake levels could have occurred, there is a lack of regional synthesis on the resultant effect of losing a significant proportion of water on the surface in the erosional rates over a relatively short period of time.

Through the study of Palaeolake Tingri, a large lake system possibly existing in south-eastern Tibet during Late Pleistocene, the concept of 'focused incision' through an outlet towards Yö Ri Gorge was examined. Topographic and sedmentological evidence suggested that Phung Chu, the present river system running through the Gorge, may have been both a cause and the consequence of ‘focused rock uplift’ (Brookfield, 1998; Clark et al., 2004; Montgomery and Stolar, 2006) that focused incision power across the Ama Drime High Himalayan Crystallines to form the current path of the river.

Climatic Controls on Sediment Transport in Monsoonal Asia

Peter D. Clift

Louisiana State University, USA

The Asian monsoon dominates the environment in South and East Asia and has been implicated in controlling erosion rates and patterns on timescales from millennial to multi-millions. In doing so they affect the structure of the mountain belts that have driven the generation of the monsoon in the first place. Stronger monsoons lead to faster focused erosion and a general aggradation of sediment in mountain valleys and on flood plains. In contrast, weaker monsoons lead to incision and reworking of older materials resulting in shredding of the original erosional signal. In the Himalaya however flood plain incision appears to be limited to the western drier parts of the foreland, not the wetter east, implying a threshold influence. Erosion of older weathered soils during dry phases can cause deposition of altered sediment offshore during dry times, the opposite of what might be expected based on understanding of weathering rates. erosion and monsoon strength do not have a linear relationship, as weaker rains can reduce vegetation and allow more ready soil erosion too. On longer timescales phases of strong monsoon, increasing erosion of the mountain can drive basin inversion and large scale recycling of the foreland, generation of unconformities and the deposition of a mixed signal in the deep water submarine fans. Deconvolving the history of erosion and environmental change from the sediment record requires an understanding of how the monsoon has influenced erosion in the past.

Characterizing physical weathering in high alpine walls using cosmogenic radionuclides

Donovan Dennis

GFZ Potsdam, Germany

Weathering mechanisms operating at or below 0°C are important contributors to the breakdown of bedrock in cold landscapes and provide source material for later sediment generation. Because frost-related weathering processes like segregation ice-wedging and freeze-thaw cracking are sensitive to small changes in temperature, they are potentially an important, though poorly-understood, control on temporal variations in erosion rates.

We employ a unique combination of cosmogenic nuclide (CN) geochemistry, numerical modelling, and field measurements to evaluate the temperature sensitivity of erosion rates in steep hillslopes, glacier headwalls, and alpine rock walls. Specifically, we use in situ-produced 10Be in quartz grains to estimate glacier headwall erosion rates, and 3He in quartz to estimate the time-integrated temperature that the rock sample experienced during exposure to cosmic rays.

Here, we present preliminary results from field sites in the European Alps, as well as initial model results on the sensitivity of CN-derived erosion rates and paleotemperatures to stochastic erosion events.

Climate and tectonic signal propagation and lake level variations in rift basins

Xiaoni Hu

Pennsylvania State University, USA

Sedimentary deposits in rift basins are important records of interacting climate and tectonic processes through Earth history. Generally, tectonics and climate influence the total sediment flux and grain size of sediment supplied from upstream erosional systems, the efficiency (or diffusivity) of sediment-transport networks, and the accommodation-creation rate within a basin. Recent studies have shown that sediment-transport dynamics can blur or overprint external signals of climate and tectonic change. This issue has not yet been directly evaluated in rift basins, despite their importance as high-resolution paleoclimate records. Here we build a simplified mass-balance model to evaluate how climate and tectonic signals of different magnitudes and periods can influence the base level variation, then ultimately be preserved in rift-basin fills. We input sinusoidal changes in sediment flux to imitate climate changes and apply pulsed signals of subsidence to represent periodic fault movements in a half graben. Key parameters of sediment profiles that are measurable in field settings, including deposit thickness, sedimentary stacking patterns, and sediment downstream-fining rate, are recorded from the model outputs to evaluate the how climate and tectonic signals are preserved. The results show that signals with lower frequency and larger magnitude have higher possibility to be preserved in sedimentary records than signals with higher frequency and smaller magnitude. Base-level variation is more possible to relate to the tectonic changes. In addition, tectonic and climate signals interfere with each other and become difficult to deconvolve when they have comparable periods and magnitudes. These preliminary results provide a framework for developing further modeling and field studies to understand the limits of climate and tectonic signal preservation in rift basins.

Revisiting Late Quaternary mega-lakes utilizing quartz OSL and K-feldspar pIRIR$_{290}$ luminescence dating, Lunggar, south-central Tibet

Tara N. Jonell

University of Queensland, Australia

The Tibetan Plateau, often referred to as “The Water Tower of Asia", is presently dotted with over one thousand lakes frequently interpreted as the last remnants of much more extensive Quaternary mega-lake systems. However, many Tibetan (mega-)lake chronologies are based on conventional radiocarbon dating now shown to be compromised by large reservoir effects varying across individual systems and throughout time. These issues necessitate the re-evaluation of paleolake reconstructions with more reliable spatial and chronological constraints, especially if the size, extent, and timing of lake growth/ decay are to be used as crucial Quaternary environmental proxies for plateau-atmosphere teleconnections.

Coupled quartz OSL and feldspar pIRIR luminescence dating offers an efficient methodology to obtain precise time constraints on prior lake levels and a powerful means to reconstruct paleolake extents utilizing a variety of sedimentary facies. Luminescence ages from elevated shoreline features and lake sediments around the Lunggar paleolake system in south-central Tibet corroborate earliest Holocene lake high-stands by ~15–10 ka, with abandonment after ~9–8 ka, and exceedingly rapid shrinkage by 4.5 ka across the west and eastern Lunggar lake systems. Feldspar pIRIR290 ages record Upper Pleistocene (42–38 ka) high-stands ~180 m above modern lake levels that highlight the utility of feldspar post-IR luminescence to date shoreline landforms lying beyond conventional quartz OSL time ranges in high-dose rate areas. Paleolake high-stand reconstructions utilizing the revised chronologies discount the traditional “pan-lake” hypothesis for the Lunggar mega-lake and indicate the western and eastern Lunggar systems have not been connected since at least ~42 ka.

Sedimentary Response to Monsoon Variabilities in Clay Mineral and Chemical Weathering Variations in the Indus Submarine Canyon

Yuting Li

Purdue University, USA

Clay mineral assemblages, chemical weathering proxies (e.g., K/Al), and color spectral analyses are used to constrain sediment transport from the Indus River mouth to the Indus Canyon and onto the Eastern Clinoform on the shelf. We evaluate

proposed linkages between continental weathering intensity and monsoon variability since 14 ka. Clay minerals from the Indus Canyon and Eastern Clinoform are uniformly rich in smectite and illite, similar to the Holocene flood plains. A systematic enrichment of smectite in the proximal delta compared to the canyon and Eastern Clinoform argues for preferential capture of smectite close to the river mouth since 14 ka. There is a rapid shift to a more smectite-rich assemblage in the canyon and Eastern Clinoform after ~5 ka. This change is probably caused by a change in sediment sources, with less direct flux from the Himalaya and more erosion of older weathered smectite-rich sediment from the flood plains, driven by incision of the Indus and its tributaries into the flood plain as summer monsoon rains weakened. The onset of large-scale agricultural activities since ~5 ka would also have enhanced incision and erosion of flood plain sediments over the same time period.

How rivers remember: the causes and consequences of history-dependence in alluvial rivers

Claire Mastellar

Washington University St. Louis, USA / GFZ Potsdam, Germany

Bedload transport is typically treated as a process that solely dependent on concurrent flow strength. However, in some well-documented examples, fluvial transport clearly displays shortand long-term dependence on prior flow history. To explore processes leading to memory formation, we leverage numerous multi-year coarse transport records from mountain streams. In all records, we find robust temporal variations in the threshold for sediment transport, indicating strong memory effects. We find consistent dependence on prior flow magnitude, regardless of forcing (glacial melt vs. thunderstorms), suggesting that memory building processes in alluvial channels are characteristic and potentially universal. Guided by these observations, we implement a history-dependent model for fluvial transport, which we use to explore the role of these observed memory effects affect fluvial channel evolution over timescales far exceeding the observational record. We also discuss the timescales over which an evolving threshold for motion may be an important or relevant consideration.

Where ice is rock and gas is liquid: fluvial sedimentology on Saturn's moon Titan

Anthony Maue

University of Tennessee, USA

Spacecraft images of fluvial landscapes coupled with in-situ images of rounded cobbles indicate a history of sediment transport on Titan. We employ a tripartite

approach of remote sensing, field study, and laboratory experiments to constrain and quantify fluvial sedimentation processes on Titan and test possible source-to-sink pathways. Titan radar images from the NASA Cassini spacecraft exhibit anomalously bright fluvial features best explained as ephemeral braided rivers containing abundant cm-scale sediment acting as radar retroreflectors. Measurements of radar backscatter within these features suggest downstream changes in fluvial sediment properties. To provide ground truth for Cassini radar analyses, we study arid alluvial deposits on Earth to quantify how distributions of sediment size and shape correlate with radar return. We also place limits on the mechanical weathering of sedimentary ice during transport using a cryogenic abrasion mill. Our goals in studying Titan's sediment cycle include understanding the origin of water ice sediment, its weathering during transport, global trends relative to climate and composition models, and any relationship between fluvial and aeolian processes.

Bedrock fracture spacing controls on the abundance of soil-mantled and bedrock hillslopes in steep landscapes

Alexander Neely

Pennsylvania State University, USA

The amount of soil remaining in steep, rocky landscapes reflects the ability for soil production to keep pace with rapid soil erosion on steep hillslopes. Few studies quantify connections between the efficiency of soil production and environmental factors such as climate, rock type, and hillslope ecosystem, yet these insights are necessary to predict the coupling between physical and chemical denudation rates in steep landscapes. We address part of this knowledge gap by isolating rock strength controls on hillslope morphology in the San Gabriel Mountains and North San Jacinto Mountains of California. Both study areas are similarly steep, granitic, and semi-arid, but bedrock fracture density is 5-10x greater in the Eastern San Gabriel Mountains. Here, we present new detrital 10Be-derived erosion rates from steep (mean hillslope angles >35°) headwater catchments, where we used high-resolution (~10 cm) orthophotos to map the extent of soil-mantled and bare-bedrock hillslopes. For a similar range of mean hillslope angles (38-45°), catchments in the Northern San Jacinto Mountains erode at rates of 0.1-0.6 mm/yr (mean = 0.2 mm/yr), compared to 0.2-2.2 mm/yr (mean = 1.1 mm/yr) in the San Gabriel Mountains. Although eroding ~5x slower, 2x more bedrock is exposed on hillslopes in the Northern San Jacinto Mountains. Comparing the San Gabriel and Northern San Jacinto Mountains, we see that dense fracture spacing in the San Gabriel Mountains decreases the initial grainsize of hillslope sediment, which facilitates weathering, soil formation, and soil transport downslope.

Linking Holocene development of the Ganges-Brahmaputra-Meghna delta to varying monsoon strength using a mass-balance approach

Jessica Raff

Vanderbilt University, USA

We explore erosion and sediment transport history from a 15,000 sample database of Holocene delta stratigraphy using grain size and bulk geochemical data from >400 coring sites across the Ganges-Brahmaputra-Meghna delta (GBMD). We apply a mass-balance framework to these results to understand patterns of sediment source, deposition, and storage rates. Insights from this work support previous studies that suggest sediment storage on the delta was ~1.5x-2x larger in the early Holocene than the late Holocene. These variations correspond with paleoclimatic research indicating the monsoon strengthened between 12-8 kya and weakened after ~8 kya. We present results that partition these data by sub-basin (Ganges, Brahmaputra, or Meghna) over the Holocene. The sediment mass budget and grain-size characteristics of these deposits will be used to assess how sediment supplied from the Himalayan foreslope (e.g. Ganges) differed from that of the Tibet backslope (e.g., Brahmaputra) over the change in monsoon strength. We also consider the role of climate-related boundary conditions, such as alpine glacier activity, ice-dammed valley lakes, and similar integrated system responses.

Fluvial-terrace formation and sedimentary signal disruption in response to environmental perturbations

Stefanie Tofelde

University of Potsdam, Germany

Environmental conditions (climate, tectonics) of the past can potentially be reconstructed from sedimentary deposits like fill terraces or sediment deposition rates, as sediment production and transport varies with local environmental conditions. Reconstructions, however, must account for sedimentary signal modification through temporary storage and release of sediment along sediment-routing systems, in particular along alluvial rivers. Also, many records suffer from ambiguity, because variability in different environmental parameters can result in the formation of similar stratigraphy.

We performed laboratory experiments simulating a braided channel to study the simultaneous evolution of sediment discharge (as a proxy for sediment deposition rates) and terrace formation in response to changing environmental conditions. Increases in water discharge resulted in channel incision, the abandonment of terrace surfaces, and a simultaneous (but temporary) increase in sediment discharge, whereas decreases in upstream sediment supply resulted in channel incision and terrace formation in combination with a lagged reduction in sediment discharge. The combined analysis of both records allows an unambiguous identification of the forcing mechanism.

Marine Sedimentary Records of Chemical Weathering Evolution in the Western Himalaya since 17 Ma

Peng Zhou

Louisiana State University, USA

The Indus Fan derives sediment from the western Himalaya and Karakoram. Integrated Ocean Discovery Program (IODP) wells in the eastern part of the fan, coupled with an industrial well near the river mouth now allow the weathering history of the region to be reconstructed back before 16 Ma. Clay minerals, bulk sediment geochemistry and magnetic susceptibility were used to constrain degrees of chemical alteration. Diffuse Reflectance Spectroscopy (DRS) is used to measure the abundance of moisture-sensitive minerals, hematite and goethite. Indus Fan sediment is more weathered than Bengal Fan material, probably due to the slow transport and despite the drier climate. Sediment alteration was moderate and then increased from 13 to 11 Ma, remained high until 9 Ma, and then reduced from that time until 6 Ma in the context of a drying climate and reduced erosion, linked to weaker summer monsoon rainfall. This trend is not clearly linked to global cooling and reflects regional climate change. Since 6 Ma weathering has been weak but especially variable since a final reduction in weathering after 3.5 Ma linked to the onset of Northern Hemispheric Glaciation.

Thursday and Friday posters (alphabetical order)

Applying stable cosmogenic ^{21}Ne to quantify sediment transport rates in large rivers throughout the geologic record: examples from modern, Miocene and Lower Cretaceous fluvial systems

Michal Ben-Israel

Hebrew University of Jerusalem, Israel

Rivers are the most effective agent of erosion on earth, transporting massive amounts of detrital and dissolved matter into depositional basins. Therefore, the relationship between denudation of continents and the pathways of sediment transport by large rivers has been extensively examined (e.g., sediment flux gauging, basin-wide erosion rates). However, due to the complex nature of sediment storage and transport dynamics in large-scale fluvial systems, our understanding of the seemingly straightforward relationship between erosion and deposition in large rivers is limited. We apply cosmogenic ^{21}Ne to examine rates of fluvial transport in large rivers: the modern Colorado River, the Miocene Hazeva River (~18 Ma), and the Lower Cretaceous (~130 Ma) Kurnub River. We observe that fluvial transport dynamics in large rivers is complex and that sediment transport time varies significantly between extremely fast (<5000 yr) and 300 kyr. These rates and variability are in agreement with the residence time of sediments in large modern rivers deduced from U-series isotopes, suggesting that cosmogenic ^{21}Ne can be translated to transport times in these fluvial systems. Moreover, furthermore, that these rates have remained constant throughout the geologic record.

Extended Field Study of a Large Spit in an Area of High Seismicity

Nicola Brilli

Virginia Tech, USA

An extended field survey will be conducted from June-August 2019, in Yakutat, AK. The goal of this survey will be studying the evolution of a large (1 km^2) sandy spit, with specific focus on the variations in sediment strength across the spit during the study. This spit is of interest due to its location in an area of high seismic activity. Using satellite imagery, an event was identified to have eroded approximately 0.4 km^2, likely due to seismically induced liquefaction or a submarine landslide. The spit will be surveyed 2-3 times per week (with occasional offshore work), including PFFP deployments to measure sediment strength, moisture content measurements, and topographic surveying. The presentation will detail the initial results, discuss new insights on this particular site’s susceptibility to large, seismically induced, erosion events, and highlight the effects of such events on sediment transport mechanisms and the morphology of the spit.

Quantifying the role of rock strength on bedrock river morphology in Taiwan with continuous, kilometer-scale UAV surveys

Julia Carr

Penn State University, USA

Addressing the orogen-scale connections between surface and deep Earth processes requires understanding how climate, tectonics, and rock strength influence bedrock river incision. To disentangle potential feedbacks between these factors, we surveyed bedrock river channels across a gradient in metamorphic grade in Taiwan, exploiting variations in rock strength and typhoon history. Here, we present paired structural and geomorphic field surveys, including over 40 kilometers of UAV surveys across 18 different rivers. In each reach, we have characterized the fluvial and bedrock morphology at 1-5 cm resolution. Preliminary results indicate that the metamorphic fabric and intact rock strength control channel orientation and geometry, causing local variations in sediment transport capacity. Yearly repeat surveys show transport of large (up to 5 m) boulders across storm events, meter scale aggradation and erosion of gravels, and an evolution of patch grain size distribution, sorting, and roughness with time since typhoon disturbance.

U-series comminution ages constrain Quaternary sediment transport times to the Bengal Fan

Anna Clinger
University of California-Berkeley, USA

We use the uranium-series comminution age (CA) technique to explore how sediment transport times of the Ganges-Brahmaputra system have varied over the last 180 Ka. This emerging geochronometer is based on the time-dependent depletion of ^{234}U relative to ^{238}U in silt and clay-sized grains as a result of α-recoil. The CA can be used in concert with isotopic provenance indicators to track variations of both sediment source and transport time. We present preliminary ($^{234}U/^{238}U$), εNd, and $^{87}Sr/^{86}Sr$ isotopic ratios of sequentially leached sediment core samples of the Bengal Fan. We determine transport times of 10-100’s Kyrs, with the longest transport times (approaching 1 Myr; the limit of the method) occurring in the interglacial periods. We interpret this to represent a greater contribution of ‘young’ freshly comminuted sediment to the sediment load during glacial periods and/or mobilization of ‘old’ continental deposits during interglacial periods. Further work is necessary to determine where sediment storage is occurring, and for how long. This work provides quantitative evidence that sediment routing, prior to deposition at the Bengal Fan, varied in response to glacial-interglacial climate perturbations.

Developing numerical frameworks to assess the interplay between ice dynamics, glacier erosion, and subglacial sediment transport as glaciers retreat

Ian Delaney
Jet Propulsion Laboratory, USA

Subglacial sediment discharge from glaciers is both a function of the amount of sediment accumulated at the glacier bed by bedrock erosion and the capacity of meltwater to transport this sediment subglacially. In the future, glacier thinning will, in most cases, decrease a glacier's sliding velocity. This will likely result in reduced bedrock erosion. However, increased runoff and generally steeper hydraulic gradients, associated with glacier retreat, may result in the greater sediment transport capacity of subglacial meltwater. To help understand this evolution and identify when high sediment discharge may occur, a modeling framework is presented which couples models of glacier dynamics and melt, subglacial bedrock erosion and subglacial sediment transport. Results show that the regions of the glacier bed where sediment is produced and transported vary substantially as the glacier retreats. Additionally, different times of peak sediment discharge are identified for multiple scenarios.

Influence of the Paleocene-Eocene Thermal Maximum on deltaic Wilcox Group sedimentation

Kalli Dubois

University of Arkansas, USA

Understanding the effects of paleoclimate on the sedimentologic record provides insight into the potential effects of anthropogenic climate change. The Paleocene-Eocene Thermal Maximum (PETM) represents a time of rapid climatic warming and atmospheric CO2 flux. The PETM could potentially serve as an ancient analog for anthropogenic warming, but the hydroclimatic and associated sedimentologic response to the PETM is poorly understood. The Rockdale paleodelta of the Texas Gulf Coast was the site of down-dip clastic deposition of the Wilcox Group spanning the PETM. The PETM succession of the Middle-Upper Wilcox is preserved in a series of cores for which geochronology, palynology, chemostratigraphy, and sedimentology have been utilized to locate the PETM boundary and observe sedimentologic proxy changes from the onset to terminus of the hyperthermal. Preliminary data confine the PETM boundary near the base of the coarse-grained Carrizo, potentially reflecting an increase in sand supply to the coastline during the PETM. Detrital zircon geochronology, organic δ 13 C isotope chemostratigraphy, and lithologic core descriptions follow to supplement these preliminary findings.

Decoupling of modern tectonics, climate, and topography in the Greater Caucasus: A perspective from 10Beerosion rates

Adam M. Forte

Louisiana State University, USA

The Greater Caucasus are a young (~5 Ma) mountain range that lies along the northern edge of the Arabia- Eurasia collision zone and are subject to order of magnitude, west to east, along-strike gradients in modern convergence (< 2 mm/yr : > 14 mm/yr) and precipitation (>2 m/yr : <0.5 m/yr) rates. Despite these alongstrike gradients, the topography and apparent exhumation history of the range is extremely similar alongstrike, suggestive of a disconnect between modern climate and shortening rates compared to topography and long-term patterns of rock uplift. Whether the apparent disconnect results from variability in erosional efficiency, changes in climate and/or tectonics through time, or additional tectonic drivers (e.g. dynamic topography) is difficult to test without quantitative measures of erosion rates throughout the range. To address this, we present new results from a suite of 10Be CRN erosion rates spanning these modern gradients. Preliminary results suggest that erosion rates show a consistent relationship with topography, suggesting that variability in erosional efficiency along-strike is likely not a viable mechanism to explain the disconnect, leaving changes in climate or tectonics as possible explanations for this apparent decoupling.

Reconstructing exhumation of the Southern Alps of New Zealand with detrital zircon fission-track and (U-Th)/He double-dating of the Waiho-1 borehole

Karl Lang

City University of New York, USA

The dual application of fission-track and (U-Th)/He thermochronology to individual detrital mineral grains permits a direct reconstruction of shallow crustal cooling from sedimentary archives. We present new double-dating results of detrital zircon grains from the Waiho-1 borehole, a sedimentary sequence representing syntectonic deposition in a foreland basin west of the Alpine Fault. Our results build upon prior work reconstructing exhumation from detrital apatite and zircon fission-track analyses (i.e. multi-mineral, not multi-method) and further demonstrates that the Southern Alps exhumation history is temporally correlated with a regional change in climate related to development of an orographic rainshadow, and not an increase in plate

convergence rate. Additionally, we demonstrate how fission-track and (U-Th)/He analytical methods are complimentary and may jointly improve the accuracy of detrital mineral studies.

What controlled Sediment Transport across the Shelf Edge during the Last Glacial Maximum?

Udita Mukherjee
Tulane University, USA

To understand the transport of the riverine sediments to the deeper marine sinks during sea-level low stands, we hypothesize that in a passive margin setting, the probability of transport of sediments across the shelf-edge during lowstand increases with the closer the LGM shoreline resided with respect to the shelf edge. The narrow eastern and broad western shelves of southern Africa give us an appropriate study area to test our research questions. We use a glacial isostatic adjustment (GIA) model to recreate the paleotopography of the southern Africa during the Last Glacial Maximum (LGM, ~21 ka), which is then used to create easily-calculated geomorphic parameters involving the morphology of the shelf-edge. Initial results suggest that if the distance between the shoreline and the continental shelf-edge is large and the shoreline is situated landward of the shelf-edge, the sediments get trapped on the continental shelf and cannot make their way to the deep ocean.

Determining catchment erosion processes using Beryllium-10 clast-age distributions

Veronica B. Prush
University of California-Davis, USA

Terrestrial cosmogenic nuclides (TCNs), produced by the bombardment of Earth's surface by cosmic rays, are widely used for age-dating and pacing surface processes. Sediments carry an inherited TCN concentration, useful for quantifying erosion and transport rates, but which must be subtracted when age-dating sedimentary landforms, such as alluvial fans. Here I present a mechanistic model of inheritance based on the contributions of episodic erosion by landsliding and steady, background erosion due to soil formation. The balance of these processes, revealed by the distribution of inheritance within a population of individual surface clasts, affects rates of soil generation and the cycling of material through the Earth's critical zone – the surficial layer upon which all terrestrial life depends. I test this inheritance model on a global compilation of alluvial fan TCN datasets. This method reveals a consistent signature of spatiotemporal clustering of landslides, important for quantifying hazard and for understanding the coupling of physical and chemical erosion.

Tracing hillslope response to climate across a tectonic gradient: a comparison of decadal and ^{10}Be-derived, millennial landslide frequencies in New Zealand

Duna Roda-Boluda

University of Potsdam, Germany

Landslides are the primary hillslope erosion mechanism, and one of the major sources of sediment in steep landscapes. Hence, understanding how the rates of landslide activity change in response to climate is crucial for geomorphological and sedimentological studies. However, it remains extremely difficult to constrain long-term or past rates of landslide activity. Here, we use, for the first time, the 10Be concentrations of landslide deposits from the Fiordland and the Southern Alps of New Zealand to estimate landslide frequencies over 102-103 yr timescales. These two areas have similar climate and climate histories, but order-of-magnitude differences in tectonically-controlled exhumation rates and erosion rates. A comparison of our long-term landslide frequency estimates with short-term landslide inventories, suggests that on the last ~2 kyr, landslide rates have slightly decreased in the Southern Alps, while in the Fiordland, they have decreased 1-2 orders of magnitude over the last ~6-16 kyr. We explore if this contrast between the two areas could be due to differences in the observation periods, hence reflecting different degrees of post-glacial hillslope adjustment; or could be suggesting that the Fiordland might be more sensitive to climatic fluctuations due to its lower uplift rate and erosion rates. Finally, we estimate the changes in catchment sediment fluxes due to these changes in hillslope erosion, and compare them with our new data set of catchment-averaged 10Be erosion rates for both areas.

Thin skinned tectonic forcing of deep marine sedimentation in the south central Pyrenean foreland basin.

Kelly D. Thomson

University of Texas at Austin, USA

The Ainsa-Jaca Basin in the South Central Pyrenees has been the focus of tectono-sedimentary research for decades. The detailed stratigraphic and structural framework provide an opportunity to investigate the forcing of deep marine sedimentation in high resolution. Here we present a synthesis of decades worth of research from the Ainsa Basin investigating the Hecho Group turbidites with new detrital zircon (DZ) U-Pb-He data. These new DZ geo/thermochronologic data constrain the provenance evolution, link the various sectors of the sediment delivery

network, and elucidate hinterland exhumation rates. These new data interpreted in conjunction with recent stable isotopic data from the Ainsa Basin, and numerical modeling of wedge top basin subsidence promote the hypothesis that the forcing of deep marine sedimentation in the Ainsa-Jaca Basin was driven by a major drainage reorganization. This reorganization of the fluvial sediment delivery network was spurred by the initiation of out-of-sequence thrusting in the fold-thrust belt.