EARTH AND ATMOSPHERIC SCIENCES

CROSSROADS CONFERENCE

2020

Crossroads Conference 2022

Indiana University
Earth and Atmospheric Sciences
1001 East 10th Street
Bloomington IN 47405
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Sigma Gamma Epsilon, Rho Chapter

Elizabeth Sherrill.....President

Anne Kort .....Vice President

Dr. Erika Elswick ..... Faculty Advisor

Crossroads Committee

Anne Kort .....Chair

Kenia Caro, Henry Fulghum and Elizabeth Sherrill.....

Operations Committee

Welcome

We would like to extend a special thank you to all of those participating in the 20th annual Crossroads Conference at Indiana University. This conference is a rich tradition for the Department of Earth and Atmospheric Sciences and we anticipate that this year's presentations will uphold previous standards of excellence.

We are excited to present our keynote speaker, Greg Byer from Arcadis International. Additionally, we are excited to incorporate our fifth annual career fair and we want to thank all the individuals and companies that are participating.

Finally, we want to thank our judges, career panelists, the Department of Earth and Atmospheric Sciences at Indiana University, and all of those who have volunteered their time for the preparation and execution of Crossroads 2022.

- The Crossroads Committee and members of the Rho chapter of Sigma Gamma Epsilon

Crossroads Judges

Valerie Beckham-Feller ..... Indiana Geological and Water Survey

Stanley Carpenter ..... Colonial Pipeline Co.

Ginger Davis ..... Indiana Geological and Water Survey

Joel Degenstein..... EAS Advisory Board/Retired El Paso E&P

Elizabeth Kenderes ..... IU Earth and Atmospheric Sciences

Stuart Kenderes ..... IUPUI Dept. of Earth Sciences

Sarah Pietraszek-Mattner ..... EAS Advisory Board/ExxonMobil

Cameron Stewart..... Arcadis

Allison Yanites ..... Arcadis

schedule

FRIDAY MARCH 25

MORNING

7:30-8:30..... breakfast + registration	GY 2029
8:30-8:45..... welcome	PATTON ROOM IGWS 2022
8:45-10:00..... oral session 1	PATTON ROOM IGWS 2022
10:00-11:30..... poster session 1	GY 2033
11:30-1:00 ..... career fair + lunch	GY 2029

AFTERNOON

1:00-1:45..... KEYNOTE ADDRESS	PATTON ROOM IGWS 2022
1:45-2:00 ..... break	your choice
2:00-3:30 ..... oral session 2	PATTON ROOM IGWS 2022
3:30-5:00 ..... poster session 2	GY 2033
5:00-6:30 ..... judges meeting	GY 2048
5:00-6:30 ..... break	your choice

EVENING

6:30-9:00 ..... networking dinner and awards ceremony	Switchyard Brewing Co. 419 N Walnut St, Bloomington, IN 47404

keynote speaker

IGWS ROOM 2022
1:00 - 1:45 pm

Title: Lessons Learned from a 40 Year Geoscience Career Focused on Applied Geophysics

Greg Byer

Technical Expert in Geophysical Services
Arcadis North America

Greg Byer is a Technical Expert specializing in geophysics and is located in the Indianapolis office of Arcadis US, Inc. His 40-year career in the geosciences and geological engineering started out in the Keweenaw Peninsula of Michigan where he received his B.S. in Geological Engineering from Michigan Technological University. After graduating he and his wife moved to Montana where he received his M.S. in Geology from University of Montana in Missoula, economic geology thesis topic. While in Montana, he did geophysical surveys for hire to help fund grad school, putting Michigan Tech education to good use. He spent several years in the oil & gas industry where, as an exploration geophysicist, he was given the opportunity to interpret state of the art seismic data sets from the Gulf of Mexico, creating structure contour maps and prospect mapping in an area of over 1.5 million acres. He left the oil and gas industry and entered the environmental consulting profession where he has remained to this day. Early on he found that his background in geophysics was of value to geological, environmental and groundwater supply problems while consulting in eastern Pennsylvania. After moving back to Indiana he continued to build expertise in applying geophysics to challenging geologic and environmental problems and eventually evolved into a geologist and engineer specializing in applied geophysics. He has taught geophysics at IUPUI, authored and co-authored papers and has given presentations at a variety of venues across the U.S. and is the thought leader of the Geophysics Practice Area at Arcadis, which takes on geophysical challenges in the U.S. and globally. Greg loves the outdoors, backpacking and talking dinosaurs with his grandkids.

career fair

GY 2029
11:30 am - 1:00 pm

The following companies will be represented:

Arcadis

Terracon

Indiana Geological and Water Survey

Resume Review - Dr. Sarah Pietraszek-Mattner, The Science Profession

oral sessions

IGWS ROOM 2022

Session 1 Presenters (8:45-10:00 am)

8:45 am Elizabeth Sherrill
9:00 am Henry Fulghum
9:15 am Ricardo Ely
9:30 am Allison Nelson
9:45 am Harrison Martin

Session 2 Presenters (2:00-3:30 pm)

2:00 pm Lan Luan
2:15 pm Sam Smith
2:30 pm Clarke DeLisle
2:45 pm Jake Gearon
3:00 pm Quan Nguyen

oral session 1

IGWS ROOM 2022

ELIZABETH M. SHERRILL.
Indiana University
Ph.D. Candidate, Geophysics

Probabilistic estimates of the fully coupled and transitional creep zones at Nankai and Cascadia

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Abstract: Subduction zone interfaces display a spectrum of slip behaviors including earthquakes, afterslip, slow slip events, and steady creep. Growing evidence suggests that some large earthquakes in subduction zones begin with slow slip events near or within the fully coupled zone (e.g. Ito *et al.*, 2013; Kano *et al.*, 2016; Kato *et al.*, 2012; Socquet *et al.*, 2017). To assess seismic hazard at subduction zones, it is critical to determine the spatial distribution of the coupled region of the interface and its relationship to the locations of slow slip events.

We present here a Markov chain Monte Carlo inversion of interseismic geodetic data for the upper and lower boundaries of the fully coupled and transitional creep zones of the Nankai and Cascadia subduction zones. The inversion provides the posterior probability distribution of the areas of the fault that are fully coupled and that display transitional creep above and below the fully coupled zone. We find that there is a defined boundary between the fully coupled zone and the deep transitional creep zone that is located around 20 km depth beneath Shikoku and 40 km depth beneath Kii. This boundary matches the inferred upper boundary of the episodic tremor and slip (ETS) zone at Nankai. The boundary between the fully coupled and deep transitional creep zones at Cascadia is located around 10 km depth along most of the subduction margin, but it extends down to 20 km depth around 47°N. This boundary is updip of the top of the ETS zone at Cascadia by 5-10 km depth along the entire subduction margin.

Abstract: The evolutionary development of the tribosphenic molar is considered a landmark event in mammalian history. The versatile and highly efficient combination of shearing, crushing, and grinding action permitted by this structure is the foundation from which all therian dentitions have evolved. However, comparative functional analyses of the dentitions of modern tribosphenic groups are limited and thus the diversity of tribosphenic morphology and functional adaptations remains unclear. Therefore, to infer the molar adaptations in early tribosphenic taxa, it is necessary to first establish an understanding of the morphological and functional diversity of tribosphenic molars among extant mammals. Here we test a set of simple indices of functional morphology for use in the assessment of extant tribosphenic dentitions.

We first photographed the lower molars of 25 modern tribosphenic mammals and took nine linear measurements which capture various functional aspects of tooth shape (e.g., grinding, shearing, crushing). Dietary data for each taxon was collected for additional comparison with morphology. We then used a principal component analysis to visualize the morphospace of these teeth, as well as assess the influence of each measurement on the overall diversity of diet and functional morphology. Our results recover 90% of the cumulative variance occurring in components 1-4, with a strong overlap of functional morphology across dietary categories. We recover Principal Components 1 (43%) and 2 (22%) to represent tooth width/length, and tooth height, respectively. Notably, Cristid Obliqua and Hypoflexid length are positively correlated with measures of grinding-area width, which marks a departure from the strong inverse relationship between length- and width-related features seen in the sampled teeth. Further analysis and refinement of these indices across a greater taxonomic sample are necessary to better assess the functional diversity of modern tribosphenic dentitions.

HENRY ZENKICHI FULGHUM
Indiana University
M.S. Student, Palaeontology

Assessing the diversity of extant tribosphenic molars with simple indices of functional morphology

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RICARDO C. ELY
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Introducing the early-high disparity phylogenetic comparative model

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Abstract: Morphological disparity (variance) is one of the most important subjects in evolutionary paleobiology. Modern phylogenetic comparative methods model the evolution of morphological disparity along a phylogeny largely based on four stochastic processes:

- Brownian motion (BM): stochastic diffusion leading to linear increases in disparity through time (models genetic drift, randomly moving adaptive optima).
- Directional evolution (DR): strong linear trajectories in trait evolution (models directional selection).
- Ornstein-Uhlenbeck (OU): exponential increases toward an optimal trait value and constraining disparity to a constant at the optimal trait (models stabilizing selection, developmental constraints).
- Early Burst (EB): a rapid, exponential increase in disparity followed by wide, constant disparity through time (models cases of adaptive radiations).

These models display limitations for alternate modes of evolution, particularly when disparity is concentrated earlier or later in the history of a clade ('early-high disparity'). I present a new model for cases of early-high disparity by combining EB and OU stochastic processes: an exponential increase in disparity followed by a rapid decrease towards an optimal value, where disparity severely reduces to a constant for the remainder of the process. Results are presented from Monte Carlo simulations based on a novel stochastic differential equation, followed by expected mean, variance, and covariance calculations via stochastic calculus, necessary for fitting this model and evaluating relative fit to other models based on maximum likelihood. This model has not been applied to morphological and phylogenetic data yet, as maximum likelihood optimizations are still in preliminary stages. I will instead display results for pre-existing models fitted to comparative data from ichthyosaur and trilobite datasets to evaluate the fit of EB and OU models separately (main components of the early-high disparity model).

ALLISON E. NELSON
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M.S. Student, Paleontology

An exploration of the *Canis lupus* and *Canis rufus* species boundary via morphometrics

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Abstract: Wolves have been in North America for millions of years, and through much of that time, they were across the continent. Now, their geographic range is limited, and the different groups are either separated or heavily overlapping in range (causing hybridization). There are currently four canids (dog relatives) on the Endangered Species List: San Joaquin kit fox, Santa Catalina Island fox, red wolf, and Mexican wolf. The grey wolf (*Canis lupus*) was delisted in the last few years, but recently a court ordered their reinstatement. Red wolves (*Canis rufus*) have stayed on the list, but this group may have been part of ancestral grey wolves prior to hybridization with coyotes (*Canis latrans*). This hybridization complicates determination of this species boundary. As one species is firmly on the list, and the other has had recent (successful) efforts to delist it, this species distinction matters greatly. If red wolves are found not to be a separate species, then the government support for the conservation efforts of red wolves would cease.

To determine this species boundary, analyses of subtle differences in skulls of coyotes, grey wolves, and red wolves will be performed. Geometric morphometrics with 47 landmarks have been performed on 297 museum skull specimens of red wolf (*Canis rufus*), grey wolf (*Canis lupus*), coyote (*Canis latrans*), and known hybrids between these groups. Whether this landmark scheme is able to separate out the 4 groups is still unknown, but preliminary results will be shown.

HARRISON MARTIN
Indiana University
Ph.D. Candidate, Sedimentology

After the flood: The characters, causes, and effects of recent catastrophic dam failures in central Michigan

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Abstract: In May of 2020, two dams failed catastrophically in central Michigan, causing upwards of $200M in damages and displacing >11,000 people during the COVID-19 pandemic. In this narrative-based talk, we will explore the story behind the dam's construction, the conditions that led to its failure, the journey to study the landscape changes it felt behind, and what we can learn about the future of dam failures

Through all of these, however, we chase the common thread of the interesting people involved at all levels of the story and try to humanize a "natural" disaster. Finally, we contextualize this single disaster within the greater picture of the rapidly aging American infrastructure (and its local shepherds) that we trust to protect us from a changing hydroclimate.

oral session 2

IGWS ROOM 2022

LAN LUAN
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Ph.D. Candidate, Atmospheric Sciences

Tropical tropopause layer structure and the roles of waves during QBO disruptions

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Abstract: The chemistry and radiation budget of the global stratosphere is heavily influenced by water vapor entering through the tropical tropopause layer (TTL). Particularly, lower stratospheric dewpoint temperatures around the globe closely follow variations in the tropical cold point tropopause (CPT) temperature. The quasi-biennial oscillation (QBO) is a dominant mode of zonal wind variability in the tropical stratosphere that can influence the TTL. In the canonical theory, QBO is driven by equatorial waves. But twice since its discovery – first in 2015/16 and then again in 2019/20 – the QBO was disrupted. Recent studies have shown there is increasing influence coming from extratropics that can potentially cause more QBO disruptions in the future. Here, we analyze the influences of the QBO and its disruptions on CPT temperature and TTL water vapor and investigate the roles of tropical and extratropical waves during QBO disruptions.

We analyze temperature, water vapor, and tropical upwelling fields between QBO disruptions and the westerly QBO composite using GPS-RO data, MLS observations, and ERA-5 reanalysis. We find the zonal mean CPT temperature and water vapor tend to have a different distribution during QBO disruptions. In addition, we investigate Eliassen-Palm (EP) flux field and momentum equation calculated tropical upwelling. We find that tropical waves and midlatitude Rossby waves both influence the zonal wind in the tropical lower stratosphere, but the stronger tropical upwelling is mainly caused by the midlatitude Rossby waves.

Abstract: As they circumnavigate the planet, the tropospheric jet streams wander and wind, shifting north and south. These changes in the jet streams' locations occur in part with other climate processes, like the seasonal cycle and El Niño. However, they also occur on timescales of 20-30 days, longer than the normal limit of predictability for weather forecasting, but too short to be caused by sources beyond the atmosphere. What enables the jets to persist in their locations on these longer timescales? This question matters for understanding how the atmosphere organizes itself and also for improving long-term weather forecasting.

Current theories propose that increased jet persistence stems from either an internal feedback process or stratospheric influence, or perhaps both. Yet most of the theories for understanding the jets' behavior assume that the actual jet streams behave very similarly to jet streams in a "dry" world without the complicating effects of water vapor. Using such a "dry" theoretical model of the jets, we show that this assumption sometimes falls short. Instead, in the MERRA-2 reanalysis dataset, clouds and precipitation are more important contributors than internal "dry" mechanisms to the persistence in quasi-monthly fluctuations of the Southern Hemisphere jet.

SAMUEL SMITH
Indiana University
Ph.D. Candidate, Atmospheric Science

Revisiting the Role of Diabatic Eddy Generation in the Persistence of the Southern Annular Mode

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CLARKE R. DELISLE
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Insights from a new model for river incision accounting for stochastic water and sediment discharge

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Abstract: Much of modern tectonic geomorphology focuses on interpreting patterns of bedrock river slope and using this information to make tectonic inferences. At its core, this framework often assumes that rivers are readily able to erode bedrock, and that they respond to tectonic and climatic forcing mostly through vertical incision and slope adjustment. However, bedrock rivers must also transport sediment delivered to them by surrounding hillslopes, which may act to amplify or to inhibit incision into bedrock. Rivers also adjust their width in response to climatic and tectonic controls, often much faster than slope adjustments can occur. While the importance of sediment flux and channel width has been understood for some time, these behaviors are hard to predict mechanistically and thus go unaccounted for in many models of landscape evolution. We present a model of river evolution in which channel slope and width freely evolve to optimize sediment transport and bedrock incision in response to stochastic water and sediment discharge.

We investigate the impact of both water and sediment discharge variability under varied tectonic forcing and find equilibrium channel form is controlled by a combination of water and sediment supply variability. We use the model to document measurement biases in rates of river incision (the Sadler effect) which are observed ubiquitously in real landscapes, and to for the first time examine the drivers of variations in this effect. Our results call into question the assumptions underlying the widely used detachment-limited stream power incision model of river evolution and highlight the importance of considering channel width and sediment flux when modeling river behavior and measuring rates of erosion over landscape evolution timescales.

Abstract: Avulsions occur when a river switches its course to a more favorable path on the floodplain, sometimes with devastating effects on human societies. Yet, the question of when and why avulsions occur remains unknown because avulsions occur relatively infrequently (return intervals of 10-1000 years) leaving a considerable knowledge gap in earth science research. Prevailing theory argues that avulsions occur when sedimentation in and adjacent to the river elevates the river bed at or above the surrounding floodplain, creating a 'superelevated alluvial ridge' (Mohrig et al. 2000). Alluvial ridge superelevation is simple to compute but hard to measure, quantified by the ratio of alluvial ridge height relative to the background floodplain over the channel depth (SE=(H_AR/H_C).

Previously, measuring these low-relief landforms was impossible without *in-situ* lidar. However, with the launch of NASA's second Ice, Cloud, Land Elevation Satellite (ICESat-2) in 2018, we can finally peer beneath the riparian vegetation and accurately assess the geometries and spatial continuity of Alluvial Ridges. The advent of of space-borne lidar is a boon for geomorphic research, allowing high accuracy (RMSE = 0.75m) and resolution (0.70 m along track precision) returns even in vegetated terrain. We aim to use ICESat-2's lidar along with previously developed datasets of avulsion locations to investigate whether recently avulsed rivers are in fact superelevated. This question is critical to answer as low-land avulsions are expected to rise under anthropogenic warming scenarios.

JAKE GEARON
Indiana University
Ph.D. Student, Geomorphology

Space Lasers for Geomorphology: Using ICESat-2 to Investigate the Causes of Catastrophic River Avulsions

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QUAN NGUYEN
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M.S. Student, Atmospheric Science

Application of the Machine Learning to Tropical Cyclone Formation Detection

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Abstract: Searching for dominant large-scale conditions that govern tropical cyclone (TC) formation plays a key role in operational TC forecasting as well as the understanding of TC formation processes. Using various deep neutral network (DNN) architectures, it is found that UNet, a well-known machine learning approach for medical image segmentation applications, could provide a promising capability in capturing TC formation from climate dataset. To detect TC formation, we propose in this study a radial basis function (RBF) built from the IBTrACS best track data the UNet algorithm and apply it to the 2010-2020 TC seasons in the western and eastern Pacific basins. With a set of large-scale environments from the NCEP/NCAR reanalysis, our attempt to detect TC formation based on the Intersection-over-Union (IoU) ratio shows that UNet is optimized at the 18-24h forecast lead time and gradually deteriorated at longer lead times, with the maximum F1 score > 0.21. Some false negative and false positive issues with UNet, however, still remain that require further tuning of the UNet algorithm as more data is available. Our proposed approach opens a new direction in the application of machine learning methods to detecting extreme events beyond current classification techniques.

poster sessions

GY 2033

Poster session 1 (10:00 - 11:30 am)

Thomas Ashley

Jack Brown

James Gearon

Riley Henson

Diya Kamnani

Ya-Shien Zax Lin

James Ryan

Poster session 2 (3:30-5:00 pm)

Sam Anderson

Sophie Black

Thomas Wesley Burkle

Eric Burton

Ping-Chen Chiang

Anne Kort

McKailey Sabaj

Charles J. Salcido

poster session 1

GY 2033

Abstract: Sedimentary bed configurations that are stable under weak bedload transport conditions can be divided into two groups: (1) meso-scale features that influence flow and sediment transport through roughness and drag partitioning effects (e.g. ripples and dunes), and (2) grain-scale features that can effectively be ignored at the macroscopic scale (e.g. lower-stage plane bed and microforms). These groups produce distinct sedimentary structures and are thought to be separated by a transition in process regime characterized by the onset of flow separation and scour. However, the physical mechanisms responsible for this transition are poorly understood.

Previous studies suggest that interactions between moving particles lead to stabilized bed disturbances that initiate nonlinear coarsening. This study presents a quantitative interpretation of this hypothesis that is tested using experimental observations of particle motion over stable and unstable planar topography. We find that the microform/mesoform transition corresponds to the transition from rarefied to congested transport quantified by a dimensionless Knudsen number. Theory presented herein enables prediction of fluvial bed configuration from shear stress and grain size under weak transport conditions.

THOMAS ASHLEY
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Particle collisions control bedform initiation

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JACK BROWN
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A transit through Galloway space: process dominance naturally changes as deltas grow

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Abstract: River deltas are coastal landforms that encompass valuable resources and diverse ecosystems. Conservation and resource extraction is complicated because deltas are dynamic and it is challenging to understand the relationships between boundary forcing and the resultant form. Galloway (1975) paved the way for better understanding the relationship between processes and form with his famous ternary diagram, which suggests delta morphology is a function of the relative strength of fluvial, wave and tidal energy. Using sediment flux ratios at the river mouth, we can now plot entire deltas in ternary space. However, these ratios change as deltas grow because distributary channels divide the sediment, relative angles of wave approach evolve with shorelines, and the tidal prism enlarges as delta networks expand. Thus, a delta initially characterized as river-dominated may transition to wave or tidal-dominated.

To test this idea, we reframed the Galloway diagram as sediment flux ratios at individual channel mouths to see if individual channels on the same delta evolve independently and affect delta-scale transition. Deltas were numerically produced in Delft3D using a suite of physical parameters to establish a range of relative river, wave and tidal strengths in ternary space. Analysis included extraction of river, wave and tidal flux values at each individual river channel mouth, as the delta temporally evolved. Further, an a priori delta-scale sediment flux estimate was calculated at each time step to investigate whether individual channel evolution affects delta-scale sediment flux values. Preliminary results suggest individual river mouths transit through ternary space, at times occupying space dominated by processes inconsistent with the delta-scale estimate. If wave or tide sediment fluxes are large enough, then initially river-dominated deltas will eventually transit into opposite regions of ternary space.

Abstract: We describe a novel type of surface channel that exhibits highly irregular, but consistent width to depth ratios that are orders of magnitude larger than any other observed system that we know of. These channels, described as "playa channels" or "grooves", are highly linear to curvilinear depressions which act as consistent conduits for clastic sediment and dissolved salts. Playa channels are found on large playas (also: salt pan, salt flat, salar) that exhibit filling/dessication cycles. The playa channels undergo high degrees of chemical and mechanical erosion during infrequent but large flooding events.

Self-formed channels on Earth's surface typically have bankfull width to depth ratios of 20:1 and ratios greater than 100:1 are exceedingly rare. However, we observe the width to depth ratios of 4 identified playa channels to range from 1000:1 to 5000:1 with the largest observed playa channel (Warburton Groove in Lake Eyre, AUS) displaying 100km of reach, 2-4km of width, and 0.5-1.5 meters of depth. We hypothesize the playa channels exhibit such high width to depth ratios because of the unique physio-chemical interactions and sediment transport properties of a flow which becomes more saline along its path into the playa basin.

JAMES GEARON
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Peculiar Self-Formed Channels in Salt Playas

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RILEY T. HENSON
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Land Cover Change Following Upstream-Migrating Dechannelization and Avulsion

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Abstract: Land cover change due to river avulsions may play an important role in the evolution of fluvial fan successions, and here we examine changes from retrogradational avulsions, a newly discovered avulsion mechanism. These avulsions are triggered when a channel blockage causes a backwater effect, sediment fills the channel, and flow is dechannalized onto the adjacent floodplain. This avulsion style has a diagnostic chevron-shaped flooding pattern composed of dead vegetation that moves upstream. Despite the massive forest dieoff and floodplain sedimentation during dechannelization, little is known about how these avulsions impact the surrounding environment. Focusing on a key avulsion in Papua New Guinea with a channel width of 77 meters and a slope of approximately 0.009, we spectrally mapped land cover changes in ERDAS IMAGINE using seven eight-band multispectral images from 2012 to 2021 provided by the high-resolution (1.88-2.00 m) WorldView-2 satellite from Maxar. Using image classification, we determined the mean spectral signature of healthy vegetation, water, sediment, dead vegetation, and low vegetation.

We found within the avulsion belt significant sediment deposition and vegetation die-off and regrowth exist. In 9 years, the chevron migrated 840 meters upstream, causing a cumulative 632,000 m^2 of sediment deposition and 753,900 m^2 of forest die-off. Approximately 44,000 m^2 of the forest die-off was revegetated by low vegetation in the last 3 years, indicating rapid recovery of these areas. The total area for sediment peaked in 2015, while vegetation die-off peaked in 2013 and revegetated grass in 2014. This suggests that deposition is greatest immediately before a new flow path is established and further shows evidence of vegetation regrowth after maximum die-off. These avulsions could create unique sedimentary facies in the stratigraphic archive of fluvial fans and also create significant turnover in the adjacent forest that influences ecological succession.

Abstract: Atmospheric Rivers (ARs) play a major role in the global water cycle since they are narrow filaments of high water vapor content responsible for 90% of the poleward water vapor transport to the midlatitudes. ARs have a considerable influence over the amount of precipitation received by a particular region. They have been found to be responsible for long lasting precipitation or persistent droughts and hence can prove to be an enormous threat to human life and infrastructure. Understanding their occurrence can help prepare for such situations.

A study by Mundhenk, Barnes and Maloney (2016) has shown that the seasonality associated with AR frequencies varies greatly based on location. However in this study, a single AR detection algorithm technique was used to understand all season climatology and variability of ARs. As an extension of this study, different AR algorithms will be used to perform a thorough study on the seasonal cycle of ARs to understand possible variations in seasonality arising due to the algorithm used. This might help us move towards understanding why seasonality might vary from one region to the other.

DIYA KAMNANI
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Seasonality associated with Atmospheric Rivers

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YA-SHIEN (ZAX) LIN
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The dynamics of bedrock channel incision and lateral migration under various rates and patterns of rock uplift

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Abstract: Land cover change due to river avulsions may play an important role in the evolution of fluvial fan successions, and here we examine changes from retrogradational avulsions, a newly discovered avulsion mechanism. These avulsions are triggered when a channel blockage causes a backwater effect, sediment fills the channel, and flow is dechannalized onto the adjacent floodplain. This avulsion style has a diagnostic chevron-shaped flooding pattern composed of dead vegetation that moves upstream. Despite the massive forest dieoff and floodplain sedimentation during dechannelization, little is known about how these avulsions impact the surrounding environment. Focusing on a key avulsion in Papua New Guinea with a channel width of 77 meters and a slope of approximately 0.009, we spectrally mapped land cover changes in ERDAS IMAGINE using seven eight-band multispectral images from 2012 to 2021 provided by the high-resolution (1.88-2.00 m) WorldView-2 satellite from Maxar. Using image classification, we determined the mean spectral signature of healthy vegetation, water, sediment, dead vegetation, and low vegetation.

We found within the avulsion belt significant sediment deposition and vegetation die-off and regrowth exist. In 9 years, the chevron migrated 840 meters upstream, causing a cumulative 632,000 m^2 of sediment deposition and 753,900 m^2 of forest die-off. Approximately 44,000 m^2 of the forest die-off was revegetated by low vegetation in the last 3 years, indicating rapid recovery of these areas. The total area for sediment peaked in 2015, while vegetation die-off peaked in 2013 and revegetated grass in 2014. This suggests that deposition is greatest immediately before a new flow path is established and further shows evidence of vegetation regrowth after maximum die-off. These avulsions could create unique sedimentary facies in the stratigraphic archive of fluvial fans and also create significant turnover in the adjacent forest that influences ecological succession.

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Precursors to Cold Air Outbreaks in the Southeastern United States

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Abstract: Extreme cold air outbreaks (CAOs) are among the deadliest weather events in the US, and have profound impacts on crops as well. Being able to predict them further in advance could help communities prepare for them more; however, weather forecasts are generally unreliable beyond a week to ten days. More extreme temperatures may have stronger signals hinting at them in the past, so we may be able to predict these further in advance than other weather events.

Konrad (1996) investigated the evolution of surface temperature, surface pressures, and 500 mb height fields leading up to to wintertime CAOs in the Southeast, and correlated these at various lead times to CAO intensity. To investigate this, we are replicating these methods but with the more modern NCEP/NCAR Reanalysis to verify the results from the original. Ultimately, we plan to apply the same approach to heat waves, which are becoming even more concerning in a warming climate.

poster session 2

GY 2033

Abstract: Olduvai Gorge, Tanzania, is a world-renowned archaeological and paleontological site for its rich hominin, faunal, and lithic assemblages, which are preserved in sedimentary strata spanning from ~2.0-0.05 Ma. Despite this wealth of paleoanthropological resources, including 4 hominin species and 2 holotypes, the paleoenvironmental contexts of these remains are not well constrained, partially due to the lack of a comprehensive geological map of the fossiliferous deposits. Currently, there is no readily accessible surficial geological map of the hominin sites, and the most recent laterally-extensive stratigraphic work documenting these outcrops dates to half a century ago. Images of the walls, floor and gullies of Olduvai Gorge will be captured with small unoccupied aerial vehicles will be used to create a 3D Digital Outcrop Model (DOM) using Structure-from-Motion photogrammetry.

The DOM will be analyzed and annotated, yielding remote classification and characterization of lithological bodies and geological structures. Analysis in geospatial software will be used to identify areas where erosion is highest, providing potential targets for future excavation and/or conservation efforts. The outcome of this project will be an open-access 3D geological map of one the most important archaeological sites in the world, providing an effective and immersive tool for both research and education.

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Mapping Stratigraphy and Erosive Surfaces using UAV and Photogrammetry at Olduvai Gorge, Tanzania

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Using Detrital Thermochronology to Track the Timing and Rate of Exhumation during Sevier Deformation, Northeastern Utah

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Abstract: Thrust belt development is one of the most crucial processes in creating orogenic topography. The Wasatch Range of northeastern Utah represents a well-understood portion of the Sevier fold-and-thrust belt. In this region, the fold-and-thrust belt is characterized by a series of thrust sheets that propagate eastward commencing in the Cretaceous and continuing through the Eocene. Throughout eastward propagation of thrust sheets, deformation styles varied from compression to extension. Preliminary detrital zircon U-Pb geochronology data suggest local, thrust sheet-derived provenance for detrital sandstones bounding synorogenic conglomerate intervals. Thus, this tectonically and structurally complex region presents an ideal setting to apply low-temperature thermochronology in an effort to gain insights to changes in regional exhumation signals and rates over time. This study uses lag times from apatite fission track thermochronology which represents the difference in cooling age (AFT age) and deposition (depositional age). Moreover, the Wasatch Range provides an opportunity to test four competing hypotheses on how changes in deformation style— whether it be active thrust sheet motion, passive uplift of structures, or local extension— impact exhumation rates and signals on a regional scale. In addition to low-temperature thermochronology, detailed sedimentological and stratigraphic work, like conglomerate clast counts provide information regarding provenance of both detrital sandstones and conglomerate clasts. Utilizing low-temperature thermochronologic data in the form of lag times and conglomerate clast counts on synorogenic conglomerates provides valuable insights to which deformation regimes most heavily impact exhumation rates.

Abstract: Coastal fog plays an instrumental role in the development of western US coastal ecology, transportation sectors, urban energy, and agriculture. Despite this, research is still needed on some basic questions about coastal fog: for example, what determines how frequently fog occurs during the summer? To gain a better understanding of the formation and frequency of coastal fog, we have developed a regional climate modeling framework—a digital laboratory—to further investigate the factors that contribute to this phenomena. We have conducted two sets of simulations within this framework. In the first, which we refer to as the "Normal" simulation, the simulation uses time-varying boundary conditions that allow the model to reproduce observed weather patterns and transient weather conditions. In the second, which we refer to as the "Idealized" simulation, the simulation uses time invariant boundary conditions. By design, this run does not permit transient weather systems, diurnal cycles, and annual cycles. We produce the time-invariant boundary conditions by averaging weather conditions over all available July months, where coastal fog is prevalent. Results from these simulations show that coastal fog is present in both the "Normal" and the "Idealized" simulations. This implies that coastal fog can occur in the absence of transient weather systems; it is effectively the "default state". These results suggest that the frequency of fog occurrence in the real world may be related to the frequency of transient weather systems that disrupt the summer coastal atmosphere from this default state.

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A Regional Climate Modeling Laboratory for Understanding Coastal Fog

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Accelerating creep in Northern Japan due to erosion of locked asperities in the decade prior to the M9 Tohoku earthquake

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Abstract: The conventional "asperity model" posits that faults are partitioned into fixed velocity-weakening (VW) patches (asperities) that are locked interseismically and velocity-strengthening (VS) regions that creep stably without accumulating stress. However, studies of GPS-derived deformation in northern Japan have shown that interseismic strain in the Tohoku region did not accumulate at a constant rate (as expected) but gradually decreased from 1996 to 2011. This change in strain rate is consistent with locked asperities shrinking by ~75% in area during this period and associated accelerations in creep rate of up to 3-4 mm/yr^2. A mechanism for the erosion of asperities over time has been explored previously using quasi-dynamic numerical simulations of asperity rupture in which thermal pressurization allows rupture to extend well beyond the VW patch. Thermal pressurization causes shear stress during rapid slip to decrease to very low levels. During the interseismic period, stress gradually recovers to steady state friction at the plate rate, at which point stable creep initiates. The creep front propagates inward, effectively eroding the locked asperity. In this study we exhaustively explore the rate of asperity erosion that is required to explain the geodetic accelerations through MCMC inversions and quasi-mechanical models of asperity erosion. From the earthquake catalog, we identify 67 seismic asperities on the plate interface from earthquakes with magnitude M6.5 and larger. In the forward model, asperities are assigned a rupture size and an erosion rate. Acceleration of creep surrounding eroding asperities is computed assuming creep at constant stress. The MCMC inversion solves for the size of asperities given the rupture size, erosion rate, and time of last rupture. The result is posterior probability density functions of erosion rate of all 67 asperities. Results will be compared with theoretical and numerical predictions.

Abstract: The active Taiwan mountain belt is an excellent location to test hypotheses of how short term processes such as the elastic earthquake cycle, river incision, and exhumation aggregate to build orogens and evolve topography. As part of a larger collaborative DIMSUM project (Deformation over Intermediate, Mountain, and Seismic timescales Unified with Models), to examine mountain building in Taiwan, I am exploring the kinematics of active faulting and deformation in Taiwan using geodetic data. Improved estimates of fault slip rates and coupling can help us better understand earthquake hazards associated with the active fold-and-thrust belt, which is particularly important in heavy population density areas such as Taiwan. The goal of this study is to make an earthquake-cycle time-scale geodetic model for Taiwan and invert geodetic data for slip rates and coupling on faults using a 2-D lithospheric kinematic model. The model combines an elastic upper crust overlying a Maxwell viscoelastic lower crust and mantle. Long-term deformation rate is generated by imposing slip at the long-term rate on faults in an elastic crust over an inviscid mantle with gravitational restoring forces. Interseismic locking of faults is modeled in the traditional way with back-slip on faults above a specified locking depth. The long-term and present-day (interseismic) velocities are not the same because of interseismic locking along faults. I will also begin comparing model results with measures of long-term crustal motions, such as river incision rates and uplifted coastal terraces.

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Estimates of Fault Slip Rates and coupling in Taiwan Using a 2-D Lithospheric Kinematic Model

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Bizarre Backbones: Evolution of lumbar vertebrae in Paleogene Mammals

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Abstract: Mammals have unique ribless vertebrae, called lumbar vertebrae, anterior to the pelvis. The morphology of lumbar vertebrae varies extensively among living mammals, but the origin and evolution of this variation is almost entirely unknown. I hypothesize that lumbar morphology has undergone a functional shift since the radiation of therian mammals, the broad group that includes all living mammals aside from the egg-laying monotremes, at the beginning of the Cenozoic. I hypothesize that the initial groups that appeared, like "condylarths" and "creodonts", had different combinations of vertebral characters when compared with extant groups. I sample lumbar vertebrae from 56 mammals: 30 from a combination of extant and Neogene mammals, and 26 from Paleogene mammals. Because many fossil specimens are unusable for quantitative measurements, I developed qualitative characters that described lumbar morphology. I coded 17 characters based on the morphology of the zygapophyses, transverse processes, neural spines, and centra. Specimens were accessed through the William R. Zooarchaeology Lab (WRAZL), descriptive papers, loans from University of Wyoming, and Morphosource.org. I calculated Gower distances to perform a principal coordinates analysis (PCO) to visualize how similarities and differences between the two sets of taxa. I then calculated three cluster plots: one for the total set of taxa, one for the Paleogene set, and one for the Neogene and younger set. I calculated these using Phylip to find the maximum parsimony tree. I found few differences between the Paleogene and modern character trees. Both trees showed that the orientation of zygapophyses and orientation of the neural spine were closely correlated. The most notable difference was the lack of correlation between presence of metapophyses and the angle of the transverse process in the Paleogene set. These results suggest that Paleogene lumbar vertebrae already showed a wide array of functional morphology.

Abstract: Barite ($BaSO_4$) is an excellent model compound for studying growth and dissolution of sparingly soluble salts. It is important to understand how barite and other similar minerals precipitate in the environment. Barite can precipitate during petroleum, shale gas, and geothermal production as well as during seawater evaporation, desalination, and mining wastewater operations because of its low solubility which can be costly to remediate. My research attempts to measure these processes by looking at the attachment and detachment rates to and from a natural barite crystal with a spiked ^{137}Barium solution at or near chemical equilibrium [Ba^{2+}]/[SO_4^{2-}]~1. With this novel approach, I, collaborating with Lei Gong and Dr. Chen Zhu, conducted batch reaction experiments at three different temperatures: 22, 50, and 80°C. Rate constants can be derived for each temperature, and this allows us to calculate activation energies near equilibrium. This will be used to test the hypothesis that the dissolution and precipitation mechanisms are different at equilibrium compared at far from equilibrium, since most studies so far only measured far-from equilibrium conditions. In addition, a previous experiment conducted by Kang *et al.* (2022) measured only barium isotope exchange rates near chemical equilibrium but did not measure sulfur isotope exchange because of a low solid to solution ratio. The Na_2SO_4 reagent that we used has a $\delta^{34}S/^{32}S$ value of -0.6±0.17‰ VCDT while the natural barite sample has $\delta^{34}S/^{32}S$ of 22.7±0.16‰ VCDT. Our new experiments have a higher solid to solution ratio so that it will allow us to measure both barium and sulfur isotope exchanges. This will allow us to test the hypothesis that sulfur exchange rates are slower than barium exchange rates near chemical equilibrium. Multiple tracer reaction rates will be informative of the reaction mechanisms.

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Deciphering Mechanisms of Stable Isotope Exchange Between Natural Barite using ^{137}Ba-Enriched Solutions with [Ba]/[SO_4] Ratios at or Near Chemical Equilibrium.

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Skull mechanics and functional morphology of *Brasilodontidae*, the sister clade to mammals

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Abstract: Triassic vertebrate assemblages of the Santa Maria Supersequence in Brazil have yielded many specimens of cynodont therapsids including members of the clade *Brasilodontidae*. Recent phylogenetic analyses place this clade as the sister clade to *Mammaliaformes*. While these specimens have been described in detail, little work has been done to quantify the skull mechanics. The skulls of the brasilodontds *Brasilodon*, *Brasilitherium*, and *Minicynodon* are analyzed to compare their functional morphology biomechanics to the Early Jurassic mammaliaformes *Morganucodon* and *Kuehneotherium*, and any similarties could be interpreted in light of the ontogenetic status of the comparable brasilodontids. We here compare the results of biomechanical and finite element analysis (FEA) of the mandibles of *Minicynodon* and *Brasilodon*, both to each other and to those of *Morganucodon* and *Kuehneotherium* from a previous study. Specimens were µCT scanned, segmented, meshed to prepare for FEA, and imported into Abaqus for FEA. Biomechanical analysis includes beam analyses such as polar moment of inertia and section modulus measurements. Beam analysis shows a trend of increasing overall strength and resistance and allometric increases in certain areas of the mandible which may indicate an ontogenetic relationship. Additionally, the trends for the brasilodontids are more similar to *Morganucodon* than *Kuehneotherium*. FEA shows a trend of generally lower stress in the dentary from *Minicynodon*, *Brasilitherium* 1043, and *Brasilodon* 628 but stress values are higher in the brasilodontids than in the mammaliaforms. Based on similar reaction forces beam analysis results, *Minicynodon* may have had a similar diet to *Morganucodon.* It is possible that increases in jaw strength may have evolved before changes in stress distribution in the dentary. Additionally, µCT-scanning has allowed a description of the postdentary bones in brasilodontids which are more pleiosmorphic when compared to mammaliaforms.

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