Abstract Booklet

Fairplay workshop

Fluvial Aeolian InteRactions on PLAnetarY surfaces workshop

at
European Space Research and Technology Centre (ESTEC)
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Keplerlaan 1
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The Netherlands

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Deserts and river systems in Sahara: a continental-wide Mars analogue

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The Sahara being the largest and (probably) oldest desert in the World provide the amazing opportunity to see in action the processes that shaped the present-day surface of Mars. Sahara has experienced during its long geological history a large number of climatic changes from humid conditions (with savanna-type environments) to dry conditions (with hot desert environments). Therefore, since the late Miocene Sahara alternated periods with rivers, lakes, deltas swamps with periods with a strong aeolian activity and the formation of deflation surface and sand seas. The Sahara is also dominated by a cratonic landscape with a marginal mountain chain (the Atlas) and volcanic centres (Hoggar, Tibesti). The landscape is therefore broad with swells and domes resembling the Martian topography. The fluvial deposits that formed during humid period have been reworked by wind processes during the dry periods. The aeolian erosion has been extremely efficient leaving some remains of the fluvial deposits as meander belts or exhumed (inverted) channels. The leftover of the fluvial deposits is basically the coarse-grained component because the finer sediment has been removed by the wind. Sand to silt material accumulated (mostly by saltation) in the sand sheets and seas. The finer portion (able to enter the wind as suspended material) can be trapped in the large- scale atmospheric circulation. The consequence is that it enters the large-scale atmospheric circulation and has been redistributed in Sahara and in the adjacent continents (mostly Europe and South America) and oceans.

Wednesday 1st Nov.

09.15 – 09.45

Mid-Holocene aeolian-fluvial interaction: bridge conducting between climate change and sediment process in the Paiku Co basin, southern Tibetan Plateau

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The interaction between aeolian and fluvial is a crucial geomorphic process in arid regions. It occurs alternately in time and interlaces in space, controlling the regional pattern and evolution of aeolian landforms. However, sediment process and the response to climate change of aeolian-fluvial interaction are not clear. In this paper, the analysis results of an aeolian-fluvial sedimentary sequence from the Paiku Co basin in the southern Tibetan Plateau (TP) are presented. Optically Stimulated Luminescence (OSL) dating with the K-feldspar IRIR dating protocol is used to establish a chronology framework for the aeolian-fluvial sequence. Then, grain size and surface texture of quartz sand are used to discover possible sediment process and response to climate change. As a result, fluvial activity first dominated during about 5.2-4.8 ka. As the temperature decreased at ~4.8 ka, the climate began transitioning to cold and dry. With plenty of sand exposed in the riverbed, riverine sand and eolian sand were deposited due to the strengthening of mid-latitude westerlies during 4.8-4.1 ka. Therefore, on a millennial scale, the formation of aeolian sands may not only respond to the constant cold and dry climate, but rather the frequent alternation of warm and cold climates might have facilitated aeolian sand development. Moreover, the specific contents of aeolian sand, riverine sand and fluvial sediment are given in the aeolian-fluvial sedimentary sequence, which may be applied to the sedimentary model of strata in this study. Overall, this study enriches aeolian sand and hydraulic geomorphology research and is significant for highlighting sporadic desert evolution and sand control on the TP.

Wednesday 1st Nov.

09.45 – 10.00

Aeolian-Fluvial Interactions in Dunefields on and around the Tibetan Plateau: Chronology, Geomorphic evolution and Paleoclimatic Implications

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Aeolian-Fluvial Interactions (AFIs) are important surface processes in the marginal regions of dunefields The widespread AFI sedimentary records may reveal the processes, mechanisms of dunefield evolution, and may serve as analogue to understand the environmental evolution on other planetary. The dunefields with widely distributed AFIs records on and around the Tibetan Plateau (TP) are characterized with their strong linkages with glacial-interglacial cycles on sand and water supplies, and some dunefields has extreme environment like other planetary (high elevation, cold, windy, hyper-arid, and low pressure). Systemic chronologic, sedimentologic, geomorphologic and paleoclimatic studies have been conducted in the Qaidam, Taklamakan, Tengger, Ulan Buh, Hobq, and Mu Us Dunefields in the past decade. The several hundred OSL ages of AFI sedimentary records demonstrate the chronology of AFIs in different dunefields and their responses to climatic changes since ca. 300 ka. The AFIs are mainly controlled by the glacial-interglacial cycles, with intensified AFIs (mainly dune-damming and dammed lake breaching) at the cold-warm transitional stages, when glacial meltwater increase. The AFIs have significant geomorphologic implications under the background of climatic changes. Constant and widespread AFIs may preserve large amount of dune sand, and promote dunefield stabilization by reducing sand availability. For example, over 80-m-thick AFI records were archived during 18-8 ka. The eastward expansion of the Hobq during the glacial periods dammed the Yellow River in the Jin-Shaan Gorge, which caused the formation of a mega lake in the Hetao Basin at the beginning of interglacial periods (early MIS7 and MIS5).

Wednesday 1st Nov.

10.00 – 10.15

Aeolian-Fluvial Interactions on Mars - A Surface Modelling Approach

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There are thousands of Martian valley networks (VNs), which are evidence of ancient flowing rivers ~3.7 Byr ago. Analysis indicates an arid environment during this period, similar to terrestrial deserts. Geomorphological evidence indicates that these rivers were episodically active, with reactivation periods of years. In deserts on Earth, fluvial (flowing water) and aeolian (wind-blown) (AF) processes display considerable interactions, which have an impact on dune and river trajectories, morphologies, geometries, and distributions. These interactions can lead to water loss to the subsurface and the formation of sabkhas, which are interdune ponds that transform into salt flats. These pools are where primordial continental life on Earth emerged, evidenced by microbial mats. Lithified dunes and interwoven inverted river channels, and the discovery of aqueously altered lithified dunes by the Curiosity rover, indicates synergy between AF interactions on ancient Mars. Here we report the results of the pilot study examining the effects of these processes in synergy under ancient Martian conditions, using a combination of modelling and geomorphological analysis. Our Martian Aeolian-Fluvial Interactions (MAFI) model is a landscape evolution model based on a coupled implementation of the Caesar-Lisflood fluvial model, and Discrete ECogeomorphic Aeolian Landscape model (DECAL) dunes model. We conduct simulations of various scenarios to model the interactions between perennial and ephemeral rivers, actively migrating dunes, and bedrock and unconsolidated sediment terrains. These interactions have a number of salient impacts: meandering inverted channels, the sediment size and distribution of Martian rivers, the formation of interdune pools, and the preservation of Martian VNs.

Wednesday 1st Nov.

10.55 – 11.10

Network Scale Sediment Transport Modelling with the Perspective of Improved Sediment Connectivity and Delivery: A Case of small dam removal

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Human activities have significantly modified the natural courses of rivers to meet irrigation and water utilization needs. Consequently, most of the world's rivers have lost their original free-flowing state. The construction of engineering structures like dams has led to river fragmentation, restricting natural water flow, sediments, and nutrients, thereby impacting river morphology and hydrology. Furthermore, these structures have caused physical degradation of habitats and disrupted various aquatic species, including their migratory pathways. Recent reports highlighted a rapid decline in freshwater biodiversity compared to terrestrial and marine species. Consequently, there is increasing momentum in restoring rivers to their natural state through the removal of dams. However, selecting specific dams or weirs for removal remains challenging, particularly in river catchments with multiple barriers. The primary challenge involves quantifying each barrier's footprint and mutual impacts on river morphology and ecology. Challenges include data availability and model selection to initiate the removal scenario. In this study, we propose a methodology that combines the Soil & Water Assessment Tool (SWAT), drone-generated data, and the CASCADE framework (CAtchment Sediment Connectivity And DElivery) to assess the influence of barriers on sediment transport within the Eamont River catchment. We model the impact of 22 barriers on sediment flux, providing valuable insights for developing a dam removal scenario. However, the only physical weir removal in 2016 (Carlton weir) had a minimal impact, in reality, and the modelling environment. Based on the sediment trap and sediment flux in the downstream river, our modelling approach rationalises the weir/dam removal scenarios.

Wednesday 1st Nov.

11.10 – 11.25

Insights From Modelling How Aeolian-Fluvial Interactions Shape the Surface of Titan

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Fluvial and aeolian surface processes have been observed on Titan. Methane precipitation feeds fluvial landforms (FLs), 50% of which exhibit rectangular drainage patterns (a much rarer pattern on Earth typically due to conjugate faulting). We developed the Titan Aeolian-Fluvial Interactions model to simulate interacting fluvial and aeolian processes on Titan. This landscape evolution model is based on a coupled implementation of the Caesar-Lisflood fluvial model, and Discrete ECogeomorphic AeolianLandscape model (DECAL) dunes model. The Caesar-Lisflood fluvial model routes water over a digital elevation model and calculates erosion and deposition from fluvial and slope processes and changes elevations accordingly. The DECAL model is based on the Werner slab model of dunes, which simulates dune field development through self-organization. We show that although Titan dunes are potentially inactive, they are so much larger relative to rivers that dunes represent major topographic obstacles to rivers. Much like on Earth, we found that the nature of dune-river interactions are dependent on the relative orientations of dune crestlines and the river channel. In some cases, where the river ran semi-parallel to dune crests, the river could be funnelled upslope along interdune corridors, forming rectangular drainage patterns. In other cases when the relative orientations were not parallel, the river would pool and then breach the lower area of a dune crest and flood deeper into the dune field, delivering sediment in the process. These findings help our understanding of FL drainage patterns, distribution, and planforms, and suggest a mechanism for fluvial sediment delivery into dune fields.

Wednesday 1st Nov.

11.40 – 11.55

Infiltration on early Mars and its implications toward aeolian-fluvial interactions

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Several lines of evidence suggest that Mars has had an active hydrologic cycle with both surface and groundwater activity in the southern highlands during the late Noachian-early Hesperian era [1]. For example, the formation of layered deposits in Arabia terra have been interpreted as evaporites resulting from groundwater upwelling [1]. Such evidence implies the importance of subsurface flow in understanding the fate of water on early Mars. The fluvial and aeolian dynamics have recently been coupled to understand the mechanism behind their interaction and combined outcomes [2]. However, granular aeolian deposits are highly permeable, and state-of-art aeolian and fluvial interaction (AFI) models still lack consideration of the vadose zone hydrology [2]. The surface water can be lost to the subsurface via infiltration especially when pooling occurs due to AFI. This phenomenon has not yet been explored with the current models that assume an impermeable bedrock. Infiltration can cause less water to pond at the surface based on the type of soil texture considered. In this work we consider different infiltration types [3] as well as soil profiles such as a single layer of sand or basaltic crust, a double layer of both sand and basaltic crust, and finally a vertically heterogeneous basaltic crust with a continuously decaying hydraulic conductivity with depth [4]. For an aeolian deposit with vertical heterogeneity, a perched water table can form, leading to delayed ponding [3]. Infiltration can significantly affect the dynamics of the surface as well as subsurface flow. For these deposit types, we calculate the transient infiltration rates and ponding times for Mars. These results can help improve the Martian AFI models as well as groundwater models and can similarly be extended to study other planetary bodies such as Titan.

References: [1] Hiatt, Shadab et al. (2022), Authorea Preprints. [2] Bahia et al. (2023), LPSC 2023, Abs #1193. [3] Shadab et al (2022), Water Resources Research, 58 (11), e2022WR032963 [4] Manning and Ingebritsen (1999), Revs of Geophysics, 37(1), 127-150.

Wednesday 1st Nov.

11.55 – 12.10

Fluvial Aeolian Research Along the Colorado River in Grand Canyon, USA: Landscape Experiments and Planetary Analog Investigations

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The Grand Canyon is an iconic landscape home to ancient and modern fluvial and aeolian landforms like cliff-forming sandstones, sand sheets on the canyon rim, climbing and falling dunes along the canyon walls, and sand bars and dunes along the Colorado River that flows through the bottom of the canyon. The U.S. Geological Survey (USGS) Grand Canyon Monitoring and Research Center conducts fluvial aeolian geomorphology investigations in support of the Glen Canyon Dam Adaptive Management Program. Glen Canyon Dam regulates water flow and fluvial sediment transport in Grand Canyon. We study how aeolian, fluvial, and hillslope processes interact to redistribute Colorado River sediment. Our work has documented that burial by river-sourced aeolian sand is an important mechanism for in-situ archaeological site preservation within aeolian dunefields in the riparian zone. We evaluate how forecasted Colorado River hydrology scenarios, as well as large-scale river flow experiments such as controlled river floods or extended periods of low flow can alter the supply of river-sourced aeolian sand. Currently, in partnership with the U.S. National Park Service, we are determining effectiveness of experimental riparian vegetation management to increase aeolian transport of river-sourced sand to replenish sand deposits at campsites and archaeological sites along the river. Additionally, in collaboration with the USGS Astrogeology Science Center, we are investigating aeolian dunefields comprised of river-sourced sand in the Grand Canyon as analogs for canyon landscapes on other planets such as Valles Marineris, Mars. We welcome collaboration in these and other types of aeolian research opportunities.

Wednesday 1st Nov.

14.00 – 14.15

Martian paleochannels: Meander morphology as a key to unlocking past fluvial dynamics and paleohydrologic variability in Aeolis Dorsa

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Martian paleochannels are preserved as negative or positive relief branching networks broadly known as sinuous ridges, however, alternative terminologies have been used in the literature such as raised curvilinear structures or inverted channels. Paleochannels have provided significant insight into the paleoclimatic history of Mars yet potential discoveries into the dynamic nature of Mars' fluvial systems remain largely untapped. Comparative morphological studies between Earth and Mars provide useful information into flow characteristics integrated over time. However, without insight into the temporal dynamics of the system, meaningful interpretations can be limited. Some exceptionally preserved fluvial morphologies on Mars such as in Aeolis Dorsa display a range of geological features, including interconnected valleys and fluvial terrains, that offer a window into the character and dynamics of the ancient systems from when they were active. Substantiated and detailed interpretations of these preserved deposits offer insight into their paleohydrologic variability and fluvial dynamics, such as meander planform evolution, relative rates of bend migration, and inferred spatial distribution of point bar sedimentology. We analyze the meander morphology by using the meander shape classification developed by Russell et al., 2018 to constrain river migration rate, allowing for a more accurate reconstruction of past channel-forming flow conditions on Mars and assessment of the climate signals that controlled these conditions.

Russell, Catherine E., et al. "A novel approach for prediction of lithological heterogeneity in fluvial point-bar deposits from analysis of meander morphology and scroll-bar pattern." Fluvial Meanders and Their Sedimentary Products in the Rock Record (2018): 385-417

Wednesday 1st Nov.

14.15 – 14.30

Sediment characteristics and provenance of riverine dunes on the lower reaches of Tora River in Qaidam Basin

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In order to explore the provenance of riverine dunes in the Qaidam Basin, reveal the environmental characteristics of development and the evolution process of riverine dunes, we take the lower reaches of the Tora River as the study area and systematically analyzes the sediment characteristics in different regions and different geomorphic units. The results demonstrate that fine, medium, and very fine sand make up the majority of the sediment components. The highest content of major elements is SiO2, followed by Al2O3, while the content of trace elements is relatively rich in Ba, Sr, Zr, and Rb, demonstrating the characteristics of near source deposition; The chemical weathering level of dune sediments is still in the early stage; Seasonal river has enhanced the mixing of surface sediments in the downwind region, increased the spatial heterogeneity of most geochemical elements, and resulted in a difference in the degree of weathering of surface sediments in different banks. There is a high degree of consistency with the physical and chemical properties of surface sediments in adjacent areas, indicating that the sources of aeolian landforms within the Qaidam Basin may be similar, mostly 'in-situ sand accumulation'. Overall, there are multiple sources of surface sediment in the study area, with the primary ones being the underlying thick river and lake sediments, partially originating from the present Tora River. The shape of riverine dunes and the physicochemical characteristics of surrounding surface sediments have both been significantly influenced by modern rivers.

Wednesday 1st Nov.

14.30 – 14.45

Investigating the temporal sequence of Martian surface-forming processes in the vicinity of the Bahram Vallis and Waspam craters

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Studying the Martian geology and morphology is challenging due to the lack of field verification, so we can only use remotely sensed and derived data. Thus, the DTM-based morphometry is very important to get essential information about the surface of Mars. In this area traces of many different Martian surface-forming processes can be detected. Based on appropriate morphometric tests, we also expect to determine the temporal order in this contribution. We used MOLA, HRSC and CTX data in this work. On these datasets, we performed cross-section analysis and multi-layer segmentation. In addition we produced slope, homogeneity and geomorphon datasets. On these, we accomplished an unsupervised multi-clustering using the merged datasets. The results showed us that morphometric clustering adequately separates the ejecta and other elements of the impact crater. Furthermore, the Bahram Vallis flows through the impact crater with a slope in the inner area. This complicates the problem, but the morphometric analysis allowed us to separate the different processes that have shaped the area throughout it's evolution. Our conclusion is that the existence of the Vallis predates the impact, however different processes such as re-cutting, slip, other alluvial and sedimentological processes have affected the evolution of the area. After a detailed analysis of these, a relative chronological order has been established.

Wednesday 1st Nov.

14.45 – 15.00

Possible Young Lacustrine Deltas and Yardangs on the Martian Dichotomy Boundary

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Here we investigate potentially young (~500 Ma) fluvial and lacustrine landforms mantled or reworked by aeolian processes in a 6,000 km2 study area below the dichotomy in the martian tropics ~600 km east of Gale crater. The dichotomy boundary is believed to be associated with ancient (>3.0 Ga) fluvial reworking and transport of material from the martian highlands. The martian northern lowlands are thought to be an ancient ocean with deltaic forms although arguments have been made suggesting a lacustrine environment. We mapped and extracted morphometric information on deltas located below the dichotomy boundary using CTX and HiRISE imagery. Digital elevation models (DEMs) were created using the Aims Stereo Pipeline on four CTX stereopairs, which provided an 18 m/pixel DEM coverage. Crater statistics on six deltas indicate ages ranging from 390 to 760 Ma (mean ~575 Ma). These dates suggest relatively near term fluvial and lacustrine processes modified by aeolian processes. These deltas were long thought to be interacting with a northern ocean. However, based on morphometric analysis they appear to be Gilbert deltas suggesting an interaction with freshwater lakes through hyperpycnal flow rather than marine deltas in a northern hemisphere ocean. Crater dating of these deltas suggests liquid water could have existed on the surface during the late Amazonian, possibly marking a brief period(s) of fluvial processes in a normally arid aeolian dominated environment. This environmental change may be tied to recent obliquity oscillations. The Gilbert deltas are also associated with yardangs in lakebed deposits reworked by aeolian processes.

Wednesday 1st Nov.

15.20 – 15.35

Comparison of soil erosion rates by wind and water in a semi-arid loess soil

Itzhak Katra[1] (katra@bgu.ac.il) and Smadar Tanner[1], [1]Ben Gurion University, Israel Meni Ben-Hur, Volcani Center, Israel

Many soils are subjected to erosion by wind and water forces. A quantitative sediment flux from a specific soil due to both forces is still a challenging measure. The study aimed to drive such erosion rates in a semi-arid loess soil. Soil samples from top-and sub-layers of the soil were analyzed for physical and chemical properties, including characteristics of soil aggregation. We performed targeted laboratory experiments using a boundary layer wind-tunnel for wind erosion and rainfall simulator for water erosion. Rates of sediment flux that were calculated for the topsoil and the subsoil revealed an opposite trend between water and wind erosion. This indicates that soil erodibility strongly depends on the erosional force applied rather than a certain soil property. The study conducted in a semi-arid region and may serve as a case study under climate change scenarios, in which more (non-arid) regions will be exposed to increase soil erosion.

Wednesday 1st Nov.

15.35 – 15.50

The Spatial Distributions of Degraded Craters and Valley Networks on Mars as a Function of Elevation: Their Implications for Noachian Climate

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Whether Noachian Mars was either hyperarid, frigid with ice-locked low latitude glaciation or, conversely, habitable temperate with abundant precipitation and liquid surface water remains a contemporary mystery of planetary science. Either planetary evolution pathway has dramatic implications for Mars habitability. Previous research championed the concept that Noachian Mars was a frigid world dominated by low-latitude cold-locked icefields which protected underlying substrates and topography of the Southern Highlands from erosional degradation. This is known as the Late Noachian Icy Highlands (LNIH) hypothesis, which I tested by mapping distribution of degraded and fresh [2-5] km diameter craters, valley network (VN) and inverted channels within an area of interest (AOI) of $1.1x10^7$ km^2 of the Noachian Southern Highlands. Crater degradation results do not show preferential preservation of fresh craters at elevation. Crater rim - crater floor (km) depth values show greatest erosion at elevations >1 km purported LNIH Equilibrium Line Altitude (ELA). Global statistics reveal an integrated Noachian hydrological system sourced by precipitation at high altitude. Water and sediment sinks are below the 0 km crustal dichotomy. Energetics of this coupled- global system is inversely proportional to median elevation (km). Net flow is towards the Northwest into a circumpolar ocean. This study supports an ancient martian Intertropical Convergence Zone (ITCZ), and a thick atmosphere due to degassing of a reducing martian mantle and subsequent atmospheric collision-induced-absorption of CO2 and H2, bypassing the Faint Young Sun Paradox. Statistical evidence derived from geomorphological features should be used as boundary conditions for future Mars global climate models.

Wednesday 1st Nov.

15.50 – 16.05

Recent Aqueous Activity on Mars Evidenced by Transverse Aeolian Ridges in the Zhurong Exploration Region of Utopia Planitia

Jiang Wang[1] (j.wang@cug.edu.cn), Jiannan Zhao[1], Long Xiao[1] and Jun Huang[1], [1]China University of Geosciences, Wuhan

Aqueous activities on Mars have gradually declined since the Noachian. Although water can be stored in the subsurface during the latest epochs, geomorphological evidence is still limited. In this study, we used in situ imaging and spectral data acquired by China's Zhurong rover, as well as high-resolution remote-sensing data, to investigate the transverse aeolian ridges (TARs) in the Zhurong landing region of Utopia Planitia. A two-stage evolutionary scenario of the TARs is proposed and polygonal features with hydrated minerals are identified for the first time on the surface of Martian TARs. We discussed the possible formation mechanisms of the polygonal features, and proposed that they could be related to recent aqueous activity and atmosphere-surface water exchange on Mars, which sheds light on the hydrological cycle of Mars in current cold and dry climate.

Wednesday 1st Nov.

16.05 – 16.20

The Dragonfly Saltation Experiment on Titan's Dunes

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Dragonfly is NASA's 4th New Frontiers mission and will land among Titan's organic sand dunes, allowing it to sample both the chemistry of the sands themselves as well as the meteorological conditions within the sand sea. As a robotic octocopter, Dragonfly will perform surface and aerial imagery of aeolian geomorphological features among over 20 distinct landing sites over the course of its 3.3-year mission. While landed within sediments, Dragonfly will actively run its rotors at a range of speeds to apply wind stress onto the ground and thus perform an in-situ saltation threshold experiment. Sand motion will be detected by before/after imaging, and by real-time detection of shadows of blowing sand, as well as possible detection of electrical fields generated by triboelectric charging of grains.

Wednesday 1st Nov.

17.00 – 17.15

Laboratory Analog Experiments to Investigate Mars Sediment Flows

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Mars was more hydrologically active in the past, with muddy streams, debris flows, and possibly mud volcanism shaping parts of the surface. Mud deposits on Mars are important study sites: they have a high potential to preserve biosignatures and understanding these features can help scientists evaluate the paleoclimate history, especially the amount of water once active on Mars' surface. While remote sensing and terrestrial analogs have been used extensively to identify and assess sediment flow deposits on Mars, there have been very few lab studies that experimentally show what mudflows would actually look like at Mars surface conditions, where extremely low pressure and low temperature would greatly influence the rheology and morphology. In 2022, we performed over 40 sediment flow experiments in the Mars chamber facility at The Open University to investigate the effects of pressure, temperature, and composition on analog Mars mudflows. We observed that the dominant physical processes are highly dependent on the atmospheric pressure and temperature. Furthermore, Mars regolith simulant composition has clear effects on rheology and resulting deposit morphology. In this presentation, I will share our preliminary results and our future experimental plans.

Wednesday 1st Nov.

17.15 – 17.30

Limited sand production in Titan abrasion experiments: Implications and future directions

Anthony Maue (maue@nau.edu), [1]Devon Burr and [2]Joseph Levy, [1]Northern Arizona University, [2]Colgate University

Vast dune fields on Titan are evidence of aeolian processes that experiments and theory link to sand-sized particles. Sand on Titan may form via several mechanisms and is not well understood. On Earth, silicate sand eroded and transported by fluvial activity can feed into aeolian systems. The results of our Titan Tumbler abrasion experiments do not support significant production nor recycling of water ice sand during fluvial transport at Titan-like temperatures (~100 K), but caveats abound. Icy "sandstone" clasts did not disintegrate into their constituent sand-sized particles as expected. Rapid fragmentation into coarse particles dominated over the production of fines by attrition; often, far less than half the mass of the abrasion products in a given time interval represented particles smaller than 2 mm. However, this fragmentation behavior seems to be at least partly due to thermal stresses that would be unrealistic for Titan's surface. Furthermore, downstream radar backscatter trends in some of Titan's fluvial features indicate a more gradual, Earth-like abrasion rate may occur there. A natural explanation for this apparent disagreement is that the cryominerals likely present on Titan have different material properties than the water ice used in the Titan Tumbler. We examine lessons learned for consideration of future physical experiments on Titan sediment processes, including relevant materials and temperature control.

Wednesday 1st Nov.

17.30 – 17.45

From aeolian bedform migration to wind speed

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Constraining the relationship between sand flux and surface wind speed, though critical in our understanding of aeolian and atmospheric dynamics, remains challenging. Relating bedform migration rate measured from remote sensing with wind velocity could provide a means of inferring local wind regimes. This is particularly relevant on Mars where in-situ measurement of wind speed are very limited and where wind ripples migration can be measured with image correlation. Our incomplete understanding of sand transport mechanisms and martian ripple formation are the main limitations. In this study, we first relate sand flux measured from dune migration to the sand flux predicted using aeolian transport law and wind velocity data from either local stations (on Earth) or atmospheric models (on Mars). These laws are contentious when used within a dune field because most of them have been calibrated in wind tunnel, where the flow is steady and uniform and the surface is flat. Additionally, sand transport can occur during short duration wind gusts. Those spatial and temporal variations of wind speed have a strong influence on the sand flux. Also, these laws can be used to predict the saturated sand flux but we do not know how martian ripple migration rates relate to the total sand flux. To address these questions we measure of ripple and whole dune migration rates at the Nili Patera dune field. We use these measurements to test the relationships between ripple migration rates and the total sand flux derived from theory.

Wednesday 1st Nov.

17.45 – 18.00

Aeolian-fluvial-lacustrine interactions recorded in the stratigraphy of Aeolis Mons, Gale crater

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The stratigraphy preserved within Aeolis Mons in Gale crater (Mars) shows a major transition from a 100s m thick package of phyllosilicate-bearing stratigraphic units, which are composed of mudstone (with subordinate sandstones) that record deposition in lacustrine, fluvial, and aeolian settings into a sulphate-bearing unit that is hundreds of meters thick (LSu). This transition from clay minerals to sulphates is proposed to record a planet-wide change in climate from warm and wet to cold and arid. The lower stratigraphic units of the LSu contains cross-bedded then planar stratified facies that are interpreted to record a purely dry aeolian dune and sand sheets environments. However, we observe metre-scale-thick interstratified lenses within these aeolian strata that record interactions of fluvial and/or lacustrine systems in a dominantly aeolian setting. One of such lenses - the Prow - structure comprises a lower section of cross-bedding likely formed by fluvial currents, overlain by a section dominated by cm-scale ripples with convex upper surfaces, suggestive of a formation under oscillatory wind-generated waves in ponds or small ponds within an interdune setting. Higher in the succession, Curiosity investigated a metre-thick dark-toned, resistant unit set within aeolian strata - the “Marker Band” – which can be traced for tens of kilometers around Aeolis Mons. Here we observe the presence of well-defined, fully preserved symmetrical ripples. Our observations imply that arid desert conditions were episodically interrupted by establishment of lake systems either by rising groundwater or collecting upon mineralized surfaces of variable spatial extent that co-existed within the aeolian landscape.

Thursday 2nd Nov.

09.15 – 09.45

A review of the planetary analogues of late Quaternary sedimentological palaeoarchives of aeolian-fluvial interactions along the eastern fringe of the northern Sinai Peninsula-Northwestern Negev desert erg

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The encroachment of dunes over drainage basins in cold and hot deserts diverts and dams existing fluvial systems. Fully dune-blocked basins following floods form seasonal, reservoir-like, dune-dammed waterbodies that deposit suspended fluvial sediments. These waterbodies and their fine-grained sediment floors may become micro-ecological niches and following evaporation/infiltration of the waterbody, become dust emission hotspots. Dune-dam breaching leading to downstream flood surges and fluvial incision respond to gradually decreasing accommodation space often following amplified sedimentation in the reservoir-like waterbody. These Aeolian-Fluvial Interactions (AFIs), range from fully aeolian-dominated to fully fluvial-dominated processes, and are common within dunefield fringes, often dictate cyclic landscape evolution of sand bodies. The interactions result in detailed and distinct morphologies, vertical and lateral stratigraphies, and sedimentologies. The latter two are unobservable by passive, airborne remote sensing methods and therefore require field-oriented studies of AFIs. Here, we review morphological and stratigraphic signatures of dune-damming on the eastern fringe of the Nilotic-sourced northern Sinai Peninsula-northwestern Negev erg and a dunefield in the southern Qaidam basin along the Tibetan Plateau margins. We interpret high-resolution documentations of morphological and stratigraphic signatures of dune-damming that may provide planetary analogues and serve in modeling AF dynamics. We present evidence of a preserved linear dune-like morphology that internally archives vice-versa transitions between aeolian and fluvial domination; massive mixed sediment beds as evidence of a dune-dam breaching flood; sedimentary couplet successions of distal fluvially reworked loess and proximal eroded dune-sand, vertical-lateral stratigraphies of fluvial overlap over eroded dunes, and inverted exposures of interchanging waterbody floor sediments.

Thursday 2nd Nov.

09.45 – 10.00

The geomorphology of an Ancient Martian erg: from the Stimson formation, Gale crater, Mars

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The Stimson dune field accumulated on the north flank of Mount Sharp during the later infilling of Gale crater. This dune field – preserved by the Stimson formation stratigraphy – contained dunes of varying size and morphology. Here, a reconstruction of the dune field, its internal dune morphology and their spaciotemporal distribution are described. The dune field accumulated around the break-in-slope at Mount Sharp's northern base and is preserved by outcrop across a 500 m elevation range. There are four distinct outcrop groups: Emerson plateau (lowest elevation), Naukluft plateau, Murray buttes, and Greenheugh plateau (highest elevation). Emerson and Naukluft plateau outcrops represent the erg fringe: stratigraphy records predominantly smaller (150m wavelength, 10m high), simple, sinuous-crested dunes, with a palaeotransport direction toward the northeast. The Murray buttes represent a central section of the erg. This stratigraphy records migration of oblique compound dunes: primary dunes migrated north, and superimposed dunes migrated obliquely across lee slopes to the northeast. Primary dunes are interpreted to be ~40m tall, with wavelengths of 300-600m. The Greenheugh pediment records a continuation of the central erg, with fragments of higher stratigraphy. Here, in three packages bounded by two supersurfaces are the relics of: oblique compound dunes migrating north and northeast; superposed by straight-crested dunes driven south by a seasonally variable wind; superseded by sinuous-crested dunes migrating west. This portrait of an ancient dune field provides a glimpse of atmospheric processes and records complex interplay between prevailing winds and the dunes themselves during the Hesperian.

Thursday 2nd Nov.

10.00 – 10.15

Late Quaternary Mega-lake formation in the Upper Stream of the Yellow River as a Result of Dune-damming: Chronological and Sedimentological Evidences

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Dune-damming is an important process of Aeolian-Fluvial Interactions (AFIs) in the dunefields, and is common for small catchments. While the damming of large rivers by dunefield expansion is rare, which may cause great changes to geomorphology and regional environment. Paleolacustrine sediments indicate a mega Hetao paleo-lake (HTPL) developed in the Hetao Basin, Inner Mongolia, China. However, the formation time (MIS3 and MIS5) and mechanisms (mainly tectonic uplift and climatic changes) of the mega HTPL remains unclear. In this study, several lacustrine sections in the HTB and AFI sections in the Jin-Shaan Gorge are studied by luminescence dating (pIRIR). The pIRIR ages confirm the formation of the mega HTPL for at least twice, i.e., at the early stages of MIS 7 (~255-245 ka) and MIS 5 (~130-120 ka), which suggest strong linkage between periodic HTPL formation and glacial-scale climatic change. Therefore, we propose an alternative mechanism, i.e., the Hobq Dunefield expanded eastward to dam the narrow Jin-Shaan Gorge during the glacial periods when the flows of the Yellow River were weak. Then in the beginning of the interglacial periods, the basin was filled by the abruptly resumed runoff in response to increased glacial meltwater and precipitation on the northeastern Tibetan Plateau. Once the lake spills out, the loose dune-dam may be breached quickly. This reminds that the Yellow River could be dammed by some other dunefields in its upper stream, e.g., the Tengger and Ulan Buh Dunefields, during the glacial periods, facilitating the damming by the Hobq Duenfield.

Thursday 2nd Nov.

10.15 – 10.30

Multiple evolution modes of Aeolian Megaripples and implications for mars

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Martian aeolian sedimentary rocks can unveil past wind-regimes and climates. Curiosity is exploring the layered sulphate-bearing unit exposed in the lower foothills of Aeolis Mons, Gale crater. Sedimentary structures indicate these strata were predominantly deposited within aeolian dune and sandsheet environments. Here, we report enigmatic erosional surfaces embedded within the sulphate-bearing strata and discuss their processes of formation. The surfaces form a set of concave-up scour-and-fill structures (width ~60 m; amplitude ~6 m). Their cross-sectional profiles show a planar central section with limbs inclined < 20°. The scour fill consists of: (1) low-angle inclined bedsets at the base which conformably drape the scour surface, overlain by (2) light-toned, relatively-planar strata lacking distinct bounding surfaces. Nearfield observations indicate that the scour-enclosing facies are composed of fine, even-in-thickness, laterally-extensive, planar laminations which are resemble the upper scour-fill strata. We interpret these laminations as wind-ripple strata. The geometry of the scours with broad cross-sectional concave profiles, flat central portions, and similar facies outside of and within the scour-and-fill structures suggest that the scours likely formed by aeolian processes. The scour-fill do not show evidence of fluvial facies. One plausible interpretation of the scours is that they represent saucer-shaped aeolian ‘blowout’ structures. Such structures, observed in both modern and ancient aeolian settings on Earth, commonly form through wind deflation from intense winds. The absence of such scour-and-fill structures in the lower part of the aeolian sulphate-bearing succession suggests that the presence of scours may indicate transition to enhanced wind deflation.

Thursday 2nd Nov.

11.10 – 11.25

Spatio-Temporal Transitions Between Aeolian- to Fluvial-Dominated Processes that Control Landscape Evolution Along Negev Dunefield Margins: Possible Implications for Planetary Aeolian-Fluvial Environments

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Aeolian-Fluvial interactions range from aeolian- to fluvial-dominated processes, which often generate morphologies and control landscapes along dunefield margins. In the Negev dunefield (Israel) margins, transitions between aeolian- to fluvial-domination were analyzed at spatio-temporal scales. Three major global periods of strong winds (LGM, Heinrich 1, Younger Dryas) led to significant elongation episodes of straight, vegetated linear dunes. The encroaching dunes dammed ephemeral drainage basins, impounded floodwaters originated upstream of the dune-dams and deposited suspended sediments and locally eroded dunefield sand. Dune-dams following the first dune elongation were maintained by additional elongation episodes and possibly small-scale sand mobilization. In a 64 km2 basin, dune-dam waterbody deposition gradually filled-up accommodation space and formed a flat playa-like alluvial plain upstream the damming-dune. After breaching the dunefield margin dune-dam, the fluvial systems gradually propagated from the margins and spread into the dunefield. This phase represents a shift from aeolian to fluvial domination. Complete fluvial domination returned ~2-5 ky after the last dune elongation episode, reflecting climatic and environmental forced changes upon dominating geomorphological processes. Dune-damming events are generally driven by (1) global palaeowind changes controlling dune elongation, maintenance and stabilization; (2) sand availability/erodibility; (3) pre-dunefield relief and interdunal areas, and (4) increasing transmission loss as the fluvial systems gradually propagate into the dunefield. The coupling of these factors with regionally controlled rainfall determines the interplay between aeolian and fluvial processes that in turn control the type and location of the resulting deposits and morphologies. These driving forces and processes may affect certain planetary environments.

Thursday 2nd Nov.

11.25 – 11.40

The Burns formation at Meridiani Planum: a sandstone documenting alternating wet and dry episodes on Mars

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The Burns sandstone formation is a layered, S-rich sedimentary rock unit that covers a large area of Meridiani Planum on Mars. It was investigated in detail with NASA's Mars Exploration Rover (MER) Opportunity. Impacts have punctured the Burns formation. Opportunity selected a traverse to study this stratigraphy in the walls of a series of impact craters ranging from 20 m diameter Eagle crater via 160 m diameter Endurance crater to 800 m diameter Victoria crater. While the mineralogy indicates formation in a wet environment, the morphology reflects a change from a wet playa system to a dry aeolian system. Sediment layers forming when liquid water was pooling on the surface are documented by ripples whereas a later reworking of the sandstone resulted in the formation of Aeolian cross-bedding features. Fluctuating groundwater tables then resulted in diagenetic alteration of the Burns formation, which is documented in the form of mineral vugs and veins, bleached zones, or the formation of Fe oxide concretions. Here we explore whether wet and dry episodes are reflected in mineralogical and geochemical changes between the layers of the Burns formation, and whether this can be distinguished from the diagenetic overprint. This is important to understand whether the Burns formation could have preserved organic carbon compounds as potential biosignatures or whether these would have been destroyed by the alternating wet and dry conditions.

Thursday 2nd Nov.

11.40 – 11.55

A modelling tool for predicting 3D sedimentary architecture of aeolian-fluvial interactions in extra-terrestrial settings

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Aeolian sedimentary systems record past climate changes due to their sensitivity to environmental variables, such as sediment supply, wind regime, physical, chemical and biogenic stabilizing agents, and interactions with fluvial systems. Identification of fluvial deposits preserved in dominantly aeolian successions can assist the exploration of potential life signatures both on Earth and planets like Mars. River-influenced interdune deposits preserved in Precambrian aeolian systems on Earth served as hosts for microbial mats, some of the earliest known terrestrial life. Understanding how these river-influenced interdune deposits are distributed in aeolian systems can assist identification of sites and deposits that can potentially host extra-terrestrial life. However, studies of extra-terrestrial sedimentary systems are currently limited mostly to photogrammetry of 2D outcrops, plus a modest number of sediment samples. This study developed a forward stratigraphic model - the Aeolian-Dune Sedimentary Architecture Numerical Deduction (AD-SAND) – to predict 3D sedimentary architecture and facies distribution of aeolian systems. AD-SAND is a geometric-based model that can reproduce different hierarchies of sedimentary architectures and bounding surfaces of aeolian dune, interdune and associated deposits. The model can also be applied as a rule-based forward stratigraphic model, where forward modelling is based on knowledge of the behaviour of natural systems. Therefore, the model can be used as a tool to predict likely sedimentary structure and facies distribution based on information from the High-Resolution Imaging Science Experiment (HiRISE) digital elevation model and images captured by rovers. In this way, the model can assist with the search for extra-terrestrial life in fluvial-aeolian settings.

Thursday 2nd Nov.

11.55 – 12.10

Meter-scale eolian ripples on Mars: formation mechanisms and paleoenvironmental significance

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Eolian processes on Mars form unique bedforms which are not yet fully understood. Meter-scale dark-toned ripples are widespread, covering dunes and sand patches across the planet. We present a new machine learning approach for the characterization of these bedforms using HiRISE imagery, and we discuss the results of a global wavelength survey (Vaz et al., 2023). We evaluate the results of previous surveys (Lorenz et al., 2014; Lapotre et al., 2016), and we test different models that relate the wavelength of meter-scale bedforms and atmospheric density variations on Mars. Previous studies (Lorenz et al., 2014; Lapotre et al., 2016) used "static" average atmospheric densities which are basically a function of elevation. Therefore, possible seasonal or regional atmospheric density variations were not considered. To try to address this issue we compare these values with densities derived from a GCM model. Overall, we will discuss the importance of establishing a robust relation between these variables to test formation mechanisms, and as a possible tool to explore paleoenvironmental conditions on Mars.

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Thursday 2nd Nov.

14.00 – 14.15

Multiple evolution modes of Aeolian Megaripples and implications for mars

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The megaripples formed under the condition of multi-modal grain size distribution are considered to be intermediate-scale landforms between normal ripples and dunes. Field investigation shows that the megaripples in the Qaidam Basin are diverse in scale and shape, and a single mechanism seems to be unable to explain their formation. We propose that the formation of megaripples follows three evolution modes, presenting three states: transient, steady, and unstable. Transient megaripples are characterized by small scale, a small range of grain size and a short evolution cycle, which are the result of coarse grains gathering to the crest due to sand sorting; Steady megaripples are characterized by large scale, a wide range of grain size, stratified sedimentary structure and a long evolution cycle. The bimodal sand transport mechanism of the creeping of coarse particles caused by the impact of jumping fine particles shapes the surface armouring and stratified sediment; The scale and grain size range of the unstable megaripple is between the two. The strong wind causes the coarse particles to undergo a brief saltation movement, forming a small-scale secondary ripple. To test this hypothesis, we investigated their wind regime, morphology, grain size, sedimentary structure, and age. We find that the retardation effect of coarse particles relative to fine particles controls the erosion and deposition of megaripples and affects their scale and sedimentary structure. This will help us understand the coexistence of different scale ripples and Transverse Aeolian Ridges on Mars.

Thursday 2nd Nov.

14.15 – 14.30

A New Theory for the Formation and Motion of Sand Dunes

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I propose a novel theory for the spontaneous formation of wind-driven sand dunes and related bedforms, based entirely on geometric concepts. Specifically, the inverse-square law dictates that larger accumulations of sediment have less sediment per total volume exposed to the wind. From this concept, it follows algebraically that for any nonzero sediment flux, a sediment-laden bed must shorten (i.e. contract) along the current's direction. This process elevates sediment from the bed, forming ripples and dunes. This new theory is validated by the first ever accurate predictions of barchan dune migration rates from satellite-derived measurements of a dune's windward (stoss) and leeward sides. These predictions show with very high statistical significance that a dune's migration rate be can universally inferred from its geometry by measuring dunefield bed shortening and dune surface-to-volume ratios (R2 = 0.97; P = 2.2*10-16 across 257 dunes in 9 widely different dunefields both on Earth and on Mars).

Thursday 2nd Nov.

14.30 – 14.45

Mapping Ripple Patterns on Barchan Dunes from Earth and Mars

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Sand ripples reflect local flow conditions and are present on both Earth and Mars; however, Martian ripples greatly vary in shape and size. Large ripples on Mars have meter-scale wavelengths but seemingly no coarse grains at their crests. These large ripples may be formed by saltation like Earth's impact ripples due to Mars' lower wind dynamic pressures, but another hypothesis is that these ripples are formed by the same hydrodynamic instability that forms subaqueous ripples and dunes. In this study, we apply an automatic mapping model to Martian large ripple patterns, terrestrial impact ripples and subaqueous ripples to infer the flow conditions over barchan dunes in three distinct environments. Barchan dunes from HiRISE imagery in the north polar region of Mars were filtered to remove the illumination effect, and the surrounding bedrock was masked. The ripple patterns were identified and labelled into 3 classes: straight, sinuous, and complex. Our model uses these labels to map ripple patterns over barchan dunes and attributes such as the ripple wavelength, direction, sinuosity, and defect density are extracted. The spatial distribution of these metrics on the Martian dunes are used to determine the local wind regime. The same model is applied to Earth's aeolian impact ripples and later to subaqueous ripples to compare their morphology and dynamics with those on Mars. By doing so, we hope to determine the mechanism behind the formation of Martian ripples and more broadly enhance our understanding of sand transport conditions on the red planet.

Thursday 2nd Nov.

14.45 – 15.00

Oxia Planum, Mars: A history of Aeolian activity as told by bedforms and landforms

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The landscape of Oxia Planum – the landing site of ESA's Rosalind Franklin Rover – bears extensive evidence of aeolian- (wind-driven) activity, both modern and ancient. At Oxia Planum, transverse aeolian ridges (TARs), wind streaks, dust devils, sand sheets, and periodic bedrock ridges (PBRs) hint at a complex history that, along with extensive fluvial activity (as evidenced by fluvial valley networks, sediment fans, inverted channels, and extensive phyllosilicate-bearing terrain), suggests this unassuming bit of Mars had a complex and varied history. To ensure mission success and safety, intense studies of the aeolian environment at the landing site were undertaken. To characterize the wind regime and erosional history on multiple spatial and temporal scales at Oxia Planum, we used machine learning, remote sensing, and wind modelling techniques to analyze the migration, morphometrics, distribution, and orientation of TARs, PBRs, dust devils, and windstreaks. We also used Global Circulation Model (GCM) near surface winds derived from several contemporary re-analyses of spacecraft thermal and dust opacity data to obtain the best possible understanding of the wind regime at OP. The results of these studies put into context the aeolian history of the region, from the late Noachian to the present day. They suggest regional wind shifts, extensive aeolian reworking of the surface, and exhumation of potentially astrobiologically-significant terrain.

Thursday 2nd Nov.

15.00 – 15.15

Application of Machine Learning to Cloud Mapping on Titan

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During the Cassini mission (2004-2017), some 44K images of Titan were collected by Cassini's Imaging Science Subsystem (ISS) across multiple filters. In filters such as CB3, that utilize wavelengths between near-infrared absorption bands of methane, ISS is able to see through the atmosphere to the surface. These filters allow the detection of clouds, visible as bright, transient, high-albedo streaks that appear at different latitudes depending on season. The temporal distribution of clouds throughout the mission was published by Turtle et al. (Geophysical Research Letters, 45, 5320–5328, 2018). More recently, the advent of sophisticated artificial intelligence (AI)/ machine learning (ML) algorithms and publicly available computer codes has dramatically revolutionized many areas of research, including image processing, with the promise of greatly accelerating routine tasks. We have therefore sought to experiment with the use of ML models to detect, map and parameterize Titan clouds on Cassini ISS images. In this presentation we describe initial results from application of the Mask R-CNN model to a subset of the ISS dataset, comparing the results to those previous published using human mapping. Ultimately, we believe that the use of ML techniques in planetary sciences will continue to grow. For the detection and mapping of clouds in particular, such automations hold the promise of both extracting new information from historical datasets such as Cassini/ISS, but also for on-board processing and image reduction for future missions, to allow greatly reduced, high-value data to be downloaded via the Deep Space Network, instead of raw images.

WITHDRAWN

Thursday 2nd Nov.

15.55 – 16.55

Poster

The interactions in the Sulfide/Sulfate system to understand environmental conditions for future habitability

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It is well known that aeolian processes have been and are a significant agent of surface modification on Mars. Although aeolian processes are the dominant source of surface modification, Mars is much more complex and there are other types of interactions, such as thermal stress, permafrost processes, salt weathering and chemical weathering among others. Moreover, in contrast to the scarcity of carbonate deposits, scholars discovered that sulphate-dominated sedimentary deposits are widespread on the Martian surface. This finding indicates the significant differences in the chemical properties of surface water between Mars and Earth. While the carbon cycle plays a crucial role in shaping Earth´s chemistry and climate, it is the sulphur cycle one of the greatest influences on Mars. Furthermore, sulphates have strong capacity to preserve biomarkers and paleoenvironmental conditions as it precipitated from a brine and impurities in sulphate crystals can form a barrier to radiation. However, sulfates are not primary minerals, and its presence is due to alteration processes. In this regard, in the NWA2975 Martian shergottite sulphide minerals such as pyrrhotite and mackinawite were found together with calcium hydroxide, showing an initial stage of alteration, not enough to form sulfates and to transform volcanic rocks in future soil matrix. Thus, this meteorite was selected to test different Aeolian-fluvial interactions to form sulfates. Changes in the mineral and chemical composition have been used to assess the suitability of Martian soil for future human exploration missions and the possible existence of a human colony on the red planet in future decades.

Thursday 2nd Nov.

15.55 – 16.55

Poster

Investigating the Regolith Properties in Fluvial and Aeolian Environments Using Legged Semi-Autonomous Robots

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Roving planetary science missions have traditionally relied on wheels for locomotion. This can limit the ability of the rover to measure geotechnical surface properties and trafficability, negatively impacting mission operations. The Legged Autonomous Surface Science in Analogue Environments (LASSIE) project utilizes leg motors and remote sensing instruments to characterize surface properties and regolith strength in fluvial and aeolian settings analogous to Martian and Lunar environments. Field campaigns in White Sands, NM, and Mt. Hood, OR, demonstrate correlations between the leg intrusion force and crusted and icy surfaces' chemical, mineralogical, and thermophysical properties. Both crust and ice can have a substantial impact on the geotechnical properties of the regolith. However, the effect of varying mixtures of crust/ice with regolith is poorly understood. Field-collected data on shear response, grain size, composition, and moisture content will be used to create terrain models for surfaces containing crusty and icy regolith, integrated with reactive planning tools to allow the robot to provide route planning and sampling suggestions.

This work was funded as part of a NASA P-STAR grant awarded to coauthor Qian.

Thursday 2nd Nov.

15.55 – 16.55

Poster

Detecting mode of sediment transportation and fine scale shifts in provenance by Dynamic Image Analysis (DIA): a methodological study

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The sediment transportation medium, mode, energy and distance are linked to the observed grain-size and grain-shape distribution in a sedimentary deposit. Grain-size analysis has been a well-established technique for almost a century now but within the last few decades also grain-shape analysis has been gaining a firm footing in deciphering past climates and environments. By combining these two techniques, more details can be obtained. Dynamic Image Analysis (DIA) is a novel method that enables to simultaneously measure the grain-shape and grain-size properties from a sedimentary sample. Especially when studying fine sediments, this method has proven to be efficient in separating not only different depositional environments but also the wind speeds when considering aeolian deposition. Here, we aim to use DIA data in endmember modelling of size-shape distributions (EMM-SSD) to detect the mode of sediment transportation and fine-scale shifts in provenance. We analyzed topmost 10.35 m (ca. 32 ka) of a high-resolution sample set (sampled in 5-cm intervals) from the northern edge of Mangshan Loess Plateau, China. This sequence was chosen because of the high sedimentation rate (approx. 32 cm ka-1) enabling detection of rapid climatic and environmental changes. The research is on-going, and we are working with the preliminary results from the EMM-SSD.

Thursday 2nd Nov.

15.55 – 16.55

Poster

Evolution History of Mesas in the Southern Utopia Planitia and Implications for the Ancient Oceans on Mars

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As one of the prominent landforms in the Zhurong landing region, mesas are geological features with flat tops and steep marginal cliffs. The mesas are widely distributed along the dichotomy boundary. There are various interpreted origins proposed for the mesas, such as the erosion of sedimentary layers, tuyas eruptions, or surface collapse due to the catastrophic release of groundwater. We investigate the detailed morphological characteristics of the mesas on the Late Hesperian Lowland unit within the Utopia Planitia. The results indicate that the mesas in the study area are formed by the erosion of sedimentary layers and representative of the Noachian oceanic sediments. We propose an evolutionary model for the mesas. This study will provide some insights into future research of ancient ocean hypothesis of Mars and interesting targets for the exploration of the Zhurong rover.

Thursday 2nd Nov.

15.55 – 16.55

Poster

Utilizing DEM of Difference (DoD) Analysis of Drone Data for Quantifying Sand Extraction and Deposition in a Seasonal Mining Scenario

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Sand mining in riverbeds is a common practice to meet the increasing demand for construction materials. Ephemeral rivers, like the Gaula River in NW India, are activated only during the Indian monsoons making it appealing for the sand miners. The mining period typically extends from mid-November to May. However, the environmental impacts of sand mining can be significant, leading to concerns about erosion, sediment transport, and habitat disturbance. Accurate estimation of sand extraction and deposition volumes is crucial for sustainable management of these resources and assessing the potential environmental impacts. This study highlights the application of Digital Elevation Models (DEM) of Difference (DoD) generated from UAVs as an essential tool to monitor and quantify sand extraction and deposition in a seasonal mining scenario. Drone-based data acquisition offers high-resolution, cost-effective, and frequent monitoring capabilities, making it suitable for tracking dynamic changes in riverbeds during the mining season. We captured drone imagery during pre- and post-mining scenarios along an approximately 24 Km riverbed. The data is then processed to generate high-resolution DEMs for both time frames. By comparing the pre-and post-mining DEMs, the DoD analysis reveals variations in the riverbed topography, representing areas of sand extraction and deposition. The extracted sand volume will be further validated by government-provided survey data, providing a reliable basis for resource management and regulatory compliance.

Thursday 2nd Nov.

15.55 – 16.55

Poster

Mapping and Crater Counting of Geomorphological Units in The Southern Branch of Kasei Valles

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Kasei Valles is the second-largest valles on Mars. In this study, we focus on landforms formed by surface processes along the midstream of the southern branch of the valles. Our geomorphic mapping reveals the valles were temporarily obstructed by colluvial fans and a landslide, creating topographical barriers to impound fluids (e.g. lava/mudflow/water). The toe of the colluvial fans and the landslide were eroded by flights of terraces and shorelines, indicating a temporary presence of water-like liquid in the channel of the valles. The surface texture of terrace surfaces indicates that terrace staircases were probably created by water that stagnated and fluctuated for a while before the final evacuation. The chronology of these important events indicates that colluvial fans were deposited in two temporal clusters. The first colluvial fan generation was formed in the Early Amazonian period (1.74-1.14 Ga), and the second colluvial fan generation was formed in the Late-Middle Amazonian period (307 Ma). The landslide is significantly younger and is estimated to have formed ca. 122 Ma ago. The floor of the valles channel is covered by platy-textured material, was emplaced ca. 90 Ma ago as lavas or mudflows, and is the youngest studied geomorphological feature. We believe that the genesis of terraces and shorelines is associated with water (or Newtonian Fluid) that ponded behind the colluvial fan dams in the latest fluvioglacial period of Amazonian.

Thursday 2nd Nov.

15.55 – 16.55

Poster

Evidence for Early Extension and Pressure Drop Related to Magma Plumbing in Noctis Labyrinthus (Mars)

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In order to constrain the deformational history of Noctis Labyrinthus, we have investigated the spatial distribution and orientation of faults, the morphology of pit chains, and the relationship between these two types of features. We mapped the faults and grabens using HRSC ND2 nadir channel basemaps and we adapted MOLA DEM for the topography. We found that the south district of the study area hosts several sets of faults with different trends, associated with pits and pit chains. The analysis of the faults crosscutting relationship led to identifying three fault systems: i) NS and NNE-SSW faults, mainly expressed in the north, and related to coeval lateral extension from regional stress tensor, ii) EW and ENE-WSW faults, intensively displayed on the south as concentric lineaments, generated by the radial oblate stress tensor associated to the flexural uplift, related to the formation of small shield volcanoes in Syria Planum, and iii) NNW-SSE and NW-SE faults, strictly connecting the pits and likely related to external driving process probably in the Tharsis province. Additionally, we classified the pits and pit chains into four evolutionary stages according to their shape and dimension. We explain that these steep-sided depressions are the results of post-faulting events inferred to be formed by a surface collapse after a pressure drop related to the magma chamber deflation associated to the formation of the Syria Planum volcanic province. In this paper, we propose a deformational model that can explain the formation history of Noctis Labyrinthus based on structural analysis of the faults distribution and a detailed morphometric studies of pits and pit chains.

Thursday 2nd Nov.

15.55 – 16.55

Poster

The Precambrian Aeolian-Fluvial Sedimentary Record: An Analogue for Extra-Terrestrial Bodies?

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Precambrian aeolian-fluvial successions on Earth are associated with a variety of geologically unique palaeoenvironmental conditions, including a lack of both vascular vegetation and widespread bioturbation. Such successions serve as valuable analogues for extra-terrestrial sedimentary systems. However, the extent to which these conditions may have influenced patterns of sedimentation remains unclear. This study presents a quantitative comparison of the preserved sedimentary architectures of 89 globally distributed Precambrian aeolian-fluvial successions characterized by: (1) thinner aeolian dune-sets documenting the accumulation of small, rapidly migrating, barchanoid dunes; and (2) a greater occurrence of sandsheet, zibar, and wet interdune deposits, commonly interdigitated with fluvial strata. The nature of the Precambrian aeolian-fluvial stratigraphic record reflects in part the absence of sediment-stabilizing terrestrial vegetation: aeolian processes were highly active, even under markedly more humid climate regimes. Precambrian aeolian successions record greater evidence of fluvial incursions into contiguous aeolian dune fields; water tables were commonly elevated close to the level of the accumulation surface for protracted episodes, restricting the availability of dry sand for aeolian dune construction. Aqueous interactions promoted the reworking of aeolian dunes into sandsheet deposits. In the absence of vegetation, which acts to bind and baffle sediment, Precambrian aeolian processes were able to transport coarser sand fractions more readily, leading to the preferential development of coarse-grained zibar deposits. Zibars may also have formed in a low-density atmosphere, promoting saltation of coarser grains. Earth's Precambrian successions provide an indication of the types of processes and resultant deposits that might operate on Mars and other extra-terrestrial bodies.

Thursday 2nd Nov.

16.55 – 17.10

Aridification sequence and formation of sulfates in Aeolis Mons, Gale crater

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In Gale crater, the Curiosity rover is exploring the sulfate-bearing unit, a regional package hundreds of meters thick of yet mostly undefined origin. The terrains orbitally defined as part of the clay-sulfate transition and leading upward to the sulfate-bearing unit show multiple signs consistent with marked changes towards drier paleoenvironments both in the sedimentary and geochemical record. Bedrock in the basal section is marked by diverse diagenetic overprints where sedimentary structures are less visible. Further up, the rover imaged butte-forming outcrops and revealed a >100-m-thick interval with a transition into large-scale trough cross-bedded structures. Within the large-scale cross-bedded strata of most likely eolian origin, ChemCam revealed that sulfates occur in the form of diverse lithologies mostly related to nodular bedrock. The abundance of nodules and related sulfates is highly variable. Indicators of locally and intermittently wet environments, such as mudcracks in the basal section or lenses with wave ripple laminae have been identified in specific intervals. The surrounding dry eolian strata adjacent to these features are also marked by the enhanced occurrence of nodular lithologies. This association and the general stratigraphic control on the distribution of sulfate-enriched nodules is consistent with their formation within the sediments due to evaporation where a sulfate-rich water table reached or came close to the surface in a variably dry climate.

Thursday 2nd Nov.

17.10 – 17.25

The geochemical and mineralogical impact of aeolian processes on fluvial deposits on the Earth and Mars

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Geochemistry and mineralogy are important tracers of sedimentary processes as they are sensitive to grain segregation and chemical alteration during transportation. We use geochemistry and mineralogy on volcaniclastic sediments to constrain the interaction between aeolian and fluvial processes in Iceland and Gale crater, Mars. Fluvial and aeolian deposits were investigated at Proximal (5 km), Medial (9 km), and Distal (12 km) distances along the Þórisjökull glacio-fluvio-aeolian system. Fluvial deposits are poorly sorted and show a change in chemistry indicative of increasing input from the volcano at the Medial/ Distal sites compared to volcanoes at the Proximal site. Aeolian reworking of the fluvial deposits at the Medial and Distal sites sorted the fluvial deposits into transverse wind ripples. The geochemistry of the aeolian deposits represents a uniform average composition of the sources in the area with the sediments lacking mineral and chemical signatures of aqueous alteration. The Stimson formation is a lithified aeolian deposit unconformably overlying the lower Mt Sharp group lacustrine units. The Stimson formation contains Mt Sharp group clasts at its base; however, the overarching geochemistry is most similar to the Bradbury fluviolacustrine units of the crater floor. Mineralogical and chemical data suggest that the original aeolian deposits contained minimal secondary alteration products with secondary alteration products forming during cementation and later diagenetic events. This suggests that on Earth and Mars aeolian processes are efficient at sorting fluvial deposits, winnowing away secondary alteration phases and preferentially recycling fluvial sandstones over lacustrine mudstones which are instead converted to dust.

Thursday 2nd Nov.

17.25 – 17.40

Coarse grains in the lithified ancient Stimson dune field interpreted as recycled grains from eroding fluvial conglomerates in Gale crater, Mars

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The lithified eolian Stimson dune field unconformably overlies the eroded fluviolacustrine sedimentary sequences of the Bradbury group and Murray formation that form the base of Mount Sharp in Gale crater, and is an ancient analog to the modern Bagnold dunes. We present grain size and geochemical comparisons to constrain the provenance of the Stimson sand. The Stimson sandstone contains coarse to very coarse sand grains (~710-1400 μm) measured in >50% of high-resolution images taken by Curiosity at contact science targets across the Naukluft and Emerson Plateaus. Due to the selective nature of eolian transport and preferential preservation of dune fore-sets, preservation of very coarse sand is rare in cross-stratified eolian sandstones. Very coarse sand was not observed within the active modern dunefield. The coarse grains in the Stimson are likely to be locally derived. The overall chemistry of the Stimson sandstone is more similar to the active dunes than the chemically variable fluvial conglomerates, so much of the sand was likely derived from a broad, well-mixed provenance. However, the coarse grains are likely proximal. We utilize ChemCam measurements, which are comparable in scale to very coarse sand, to show that chemistry of the coarsest grains in the Stimson correlates with the chemistry of the most common coarse primary minerals in the fluvial conglomerates, plagioclase and pigeonite. We interpret that the Stimson sandstone likely contains a coarse-grained contribution from eroded Bradbury-like fluvial conglomerates, which would have been eroding 100s-1000s of meters from the Stimson depositional site during eolian exhumation of Gale.

Thursday 2nd Nov.

17.40 – 17.55

Mesoscale modelling of Titan's surface winds, influenced by lakes and topography

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Titan's surface is a great place to study surface winds as its landscapes remind us of Earth, where winds persistently transform the environment, eroding surfaces, building dunes and forming waves. To investigate if Titan's surface features are similarly modified by winds, we explore how surface wind values vary with locations and seasons using an atmospheric mesoscale model. At high latitudes, we show that hydrocarbon lakes constantly evaporate methane and create local lake breezes (Rafkin & Soto 2020; Chatain+ 2022), blowing from the lake to the land. We investigate different seasons, lake sizes and shapes, and land surface properties. All simulations show that a very stable marine layer forms above the lake and that surface winds never exceed 0.2 m/s. Previous studies suggest that waves would form for surface winds stronger than 0.4 m/s (Hayes+ 2013). Our results therefore indicate that waves would not normally form over lakes (we did not study exceptional stormy weathers), which is coherent with Cassini observations of very smooth lake surfaces (Barnes+ 2011; Wye+ 2009). We recently started to study how topography affects surface winds. First simulations show that differential radiation fluxes with altitude tend to form weak upslope winds during evenings. Besides, lake breezes are strong enough to climb over the 300 m high ramparts surrounding some lakes, and simulations show that their speed is doubled while flowing down the external slope of ramparts. Next plans are to study if breaches in ramparts could create wind corridors.

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Friday 3rd Nov.

09.30 – 10.00

Valley Network Controls on Martian Aeolian Processes - Nirgal Vallis Case Study (Mars)

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Nirgal Vallis is one of the longest river valleys on Mars, stretching 700 kilometres across the Southern Highlands. Its cross section is a distinctive U-shape with a flat bottom and steep sides features. On early Mars, estimations show that the river drained up to 4800 cubic metres of water per second. Nirgal Vallis is the visible remains of this ancient river. The flat floor of Nirgal Vallis is largely covered by transverse aeolian ridges (TARs), which indicate the prevailing wind direction along the valley's path. Our study focuses on how the valley shape dictates the aeolian features currently visible from the orbit, in order to characterise the sediment transport fluxes, and its interactions with ancient Mars rivers. Our method consists, first, in identifying the TARs along the valley with the "Novelty or Anomaly Hunter – HiRISE" (NOAH-H) deep learning terrain classification algorithm, that classifies images from the HiRISE instrument with a resolution up to 0.5m. Our case study is the first to use NOAH-H in the Nirgal Vallis region – the algorithm was previously trained on Oxia Planum and Mawrth Vallis. We then use python scripts to extract the bedform edges from the classified images and finally derive the bedform orientations inside the valley, and outside its walls, to compare them. Our results indicate that wind directions inside the valley are dictated by its shape. Therefore, material transported by the wind inside the valley will be trapped, converting the valley in a sediment sink that interacted with rivers on Noachian Mars.

Friday 3rd Nov.

10.00 – 10.15

Valley topography and delta dynamics as controls on aeolian dust emissions from ice-free Greenland

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Interactions between fluvial and aeolian systems in drylands have long been recognised for their influence on spatial and temporal patterns of dust emissions. Contemporary dust emissions originating from ice-free regions within the Arctic have also been associated with fluvial (and glacio-fluvial) dynamics but the nature of cross-system interactions at high latitudes remains poorly constrained, particularly at the regional scale. Using true colour Sentinel-2AB (10 m spatial resolution) satellite imagery we mapped dust emissions from ice-free Greenland from 2016-2021 using conservative cloud and scene coverage settings. Of the c.1000 potential sources examined, active dust emission was observed from >70 locations with the frequency of dust events from each location ranging from 1 to 24 over the six years. We developed a land-surface classification of the identified dust sources that includes 3 active delta forms, 4 non-deltaic glacio-fluvial landforms and other landforms including alluvial fans, moraines and sand dunes. Fjordhead deltas are the most widespread dust sources and are associated with the highest number of dust events. The spatial distribution of dust sources maps closely to the distribution of land-terminating glaciers with fluvial outwash systems, particularly those that discharge high concentrations of suspended sediment. The nature and orientation of valley topography provides a strong control on dust plume trajectories. Given that suspended sediment delivery to proglacial floodplains and deltas is increasing and as many Greenland deltas are prograding it is expected that the extent of, and fine sediment supply to, potential dust sources will increase over the next few decades.

Friday 3rd Nov.

10.15 – 10.30

Morphology and distribution of a Low albedo, Thin, Resistant (LTR) unit in Oxia Planum: Evidence for late-stage groundwater activity at the ExoMars rover landing site

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The geology of Oxia Planum, Mars, has been under increasing scrutiny since selection as the landing site for the ExoMars Rosalind Franklin rover mission. Near the top of the local stratigraphy in Oxia Planum lies the Low albedo, Thin, Resistant (LTR) unit that mainly occupies current and former topographic lows such as ancient craters and inverted channels. This unit may have protected underlying Noachian-age phyllosilicate-bearing units, increasing the possibility of preservation potential of organic matter for future investigation by the ExoMars rover. Despite its apparent importance, the origin of the LTR unit remains unknown. We use remote sensing data, including CTX, HiRISE, CaSSIS, and MOLA data to investigate the morphology and distribution of this unit across a study area of ~50,000 km2. The LTR unit is found to be stratigraphically constrained between the older phyllosilicate-bearing unit (~4 Ga), and the younger sediment fan connected to Coogoon Vallis, which was last active ~2 Ga. This suggests the LTR unit is Hesperian to early-Amazonian in age. The LTR unit drapes over the underlying phyllosilicate-bearing unit, suggestive of a fall – not flow – depositional environment. Comparison to potential terrestrial and martian analogues show morphological similarities to paleo-ashfalls (circum-Isidis capping unit), and terrestrial sandsheets (Askja, Iceland). The LTR's resistance to erosion may be explained by rising groundwater in topographic lows, as the water table fluctuated in the Hesperian to early-Amazonian, causing cementation and preferential preservation in these regions, explaining the current distribution of LTR unit outcrops today.

Friday 3rd Nov.

11.10 – 11.25

Origin of chlorides in fluvio-lacustrine setting on Mars and its astrobiological implications

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This study involves exploration of chloride-rich terrains on Mars to understand their origin since their hygroscopic nature enhances their potential to sustain life as compared to other minerals. The aim of this work is to reconstruct the geological evolution of one such area and understand the climatic conditions during the formation of chlorides and examine the potential of the area to sustain life-forms, if any, when the conditions on Mars became unconducive. We investigated two chloride-rich terrains within the Terra Sirenum, a topographic depression and a small patch near a previously identified chloride-rich sinuous channel. Both the areas are surrounded by a volcanic unit on the northern side and numerous, wide channels on the southern and eastern sides. Morphological examination of the areas showed that their floor is covered with bright-toned polygons. While the area near the basin boundary is rich in Fe/Mg and Al-phyllosilicates, the basin centre consists of chlorides with possible mixture of sulphates. We estimated the amount of chloride present and used Einstein's parameter for sediment discharge to determine the possible source. The chlorides within the basin were dated back to the Hesperian and implies weathering of chloride-rich rocks and their transportation to the basin which gradually desiccated. The deposits near the channel seem relatively new and a result of surface runoff. The channel morphometry does not support weathering; instead, we suggest re-distribution from an older chloride deposit. We have further modelled our findings to ascertain if the conditions were favourable to support any possible life-forms.

Friday 3rd Nov.

11.25 – 11.40

Prediction of denitrification rate in the classified geomorphic units of a large lowland river: Linear mixed models using Sentinel-2 data

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Denitrification in riverine systems is an N2O emission process; influenced by water flow and sedimentation. N2O is a potent greenhouse gas that accelerates global climate change 265 times greater than CO2. The overall aim of this study is to estimate the impact of geomorphology on biogeochemical processes like the denitrification of a large stretch (about 50 km) of a tropical river, the Padma River in Bangladesh. To find out the spatiotemporal dynamics of geomorphic units (GUs) and potential denitrification rate (PDR), first nutrient retention or export-relevant GUs were identified using NDVI. A field study was carried out in low flow (dry/winter) season to measure the PDR in each type of land use land cover (LULC) types. Based on the field-estimated PDR, different linear mixed models were developed (LMMs), and field-measured vegetation cover and soil moisture were replaced using Sentinel-2 band 11 (B11) and NDVI. Among LMMs, the random intercept model with variance structure was considered the best model in all cases that used either field (vegetation cover and soil moisture) or Sentinel-2 data (Band 11 and NDVI). The LULC played a significant role as random effects of LULC types were considered in the model estimation. Later on, the best model was applied in different seasons to estimate PDR using Sentinel-2 data which showed that seasonal variation influences the rate of PDR significantly. This type of systematic investigation of the spatial and temporal distribution of biogeochemical process measuring and monitoring will be useful for planning river restoration and ecosystem management programs.

Friday 3rd Nov.

11.40 – 11.55

Hot Springs: Windows into the Past and Present Habitability of Planets a Case Study from Tapovan Hot Spring, Himalaya

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Hot springs are geologically significant features that can provide information about the composition of the lower crust and upper mantle, as well as a region's paleoclimatic, geological, and thermal history. They are also important sites of mineral deposition, and the minerals they form can be used to constrain the conditions of their formation. On Mars, hot spring deposits are considered potential habitats for early life. The presence of evaporite deposits and morphologies related to hydrothermal spring systems on Mars has been confirmed by remote sensing instruments. However, the thorough mineralogical identification of Martian hot spring deposits is yet to be done. The north-western Himalayan hot springs provide some valuable insight into the conditions that may have led to the deposition of these mineral assemblages on different planetary surfaces. By systematically studying the composition of the hot spring water and the minerals it deposits, we can reconstruct the paleoclimatic, geological, and thermal history of the region and use this knowledge to interpolate past conditions that may have existed on Mars. This study will use spectroscopic, petrological, and geochemical techniques to characterize the analog minerals from Tapovan hot spring deposits in the north-western Himalayas. This information will be used to constrain Martian hot spring deposits' formation conditions and assess their potential as habitats for early life.

Friday 3rd Nov.

11.55 – 12.10

Gently Lifting the Veil on Martian Dust and Sand

Ralph Lorenz[1] (ralph.lorenz@jhuapl.edu), [1]Johns Hopkins Applied Physics Laboratory

Observations with sensitive photodiode detectors on the Perseverance rover to detect dust devils and track formation, and movies of the Ingenuity helicopters downwash impingement on the Martian surface, together with in situ meteorological data from InSight, give new insights into the important problem of dust-lifting and sand transport (to which dust lifting is likely coupled) on Mars. These results, together with new low-gravity wind tunnel experiments on parabolic flights and with the interpretation of the large blast pattern from lander retrorockets, indicate particle motion and visible darkening can result from aerodynamic pressures of only a few 1-5 Pascals, considerably less than may have been previously thought. Such low transport thresholds have implications for the potential rates of aeolian sediment transport.

Friday 3rd Nov.

14.00 – 14.15

Alluvial dust sources and their importance for understanding interannual variability of dust emission fluxes

Kerstin Schepanski[1] (kerstin.schepanski@fu-berlin.de), [1]Freie Universität Berlin, Berlin, Germany

Dust aerosols consist of tiny soil particles entrained into the atmosphere by wind. The interannual variability in local dust emission fluxes and hence the atmospheric dust loading is determined in concert by dust source (soil) characteristics and atmospheric conditions. Thereby, soil erodibility potential varies for different dust source types, with dust sources consisting predominantly of alluvial sediments showing significant interannual variability in sediment supply eventually modulating the atmospheric dust concentration. This presentation will discuss approaches to identify alluvial dust sources from satellite data and their implementation in numerical dust emission models.

Friday 3rd Nov.

14.15 – 14.30

The Interplay Between Dust-Driven Events and Recurring Slope Lineae on Modern-Day Mars

Daniel Mason[1] (danmason@unm.edu) and Louis Scuderi[1], [1]University of New Mexico, Albuquerque, NM, United States

The interplay between smaller-scale Martian hillslope processes such as recurring slope lineae (RSL) and smaller-scale dust-driven events such as dust devils is relatively unknown. While each process has been studied in-depth independently, there have been few studies seeking to correlate the role small-scale dust lifting, fall, and accumulation have on the formation, persistence, and fading of RSL on Mars. Recurring slope lineae are small-scale features that occur on steeper hillslopes in the lower- and mid-latitudes of Mars; they form in the springtime, grow in the summer, and fade in the autumn. Known to recur cyclically, there are several hypotheses for how RSL might form, ranging from purely dry to fully aqueous. Dust-driven events, conversely, are known to be active generally after Ls 140° each MY, generally coinciding with southern spring and summer. They predominantly occur on flatter terrain, have been known to follow certain routes across the Martian surface, and can vary in size from smaller-scale dust devils to global-scale dust storms. This study uses both CaSSIS and HRSC data, in conjunction with HiRISE imagery, to further constrain how smaller-scale dust-driven events— namely, dust devil tracks— influence the presence of RSL. Many spatial extents covered by CaSSIS, HRSC, and/or HiRISE are known to be places where RSL and/or dust devils occur, sometimes simultaneously. As such, these data form prime datasets from which to source information about both the geomorphic and atmospheric interactions between slope lineae— which may or may not be dust-centric— and dust devils— which are primarily dust-driven features.

Friday 3rd Nov.

14.30 – 14.45

The role of dust in Recurring Slope Lineae on Mars: dust deposition and wind triggers

Yann Leseigneur[1] (yann.leseigneur@ias.u-psud.fr) and [1]Mathieu Vincendon, [1]IAS - Université Paris-Saclay - CNRS

Recurring Slope Lineae (RSL) are seasonal and recurrent dark linear movements observed almost every year on steep slopes on the surface of Mars. Discovered in 2011, these movements were first interpreted as liquid water or brine that flows on slopes, creating these dark features. But recently, many studies showed that RSL may actually correspond to dry granular flows. Several dry mechanisms have thus been suggested, with a common ingredient for most of them: dust. These mechanisms fall into two main categories: dust movements (dry dust avalanches or dust lifted by winds) and granular flows of dark sand (dust just increases the contrast of RSL). The purpose of our study is to understand the role of dust in these movements. We have reanalysed the seasonal RSL activity of different sites located in both hemispheres to compare it to the dust activity. The latter is estimated through the use of both (i.) observational constraints on the quantity/variability of atmospheric dust, and (ii.) climate model predictions of surface wind stress, vertical convective winds, and dust deposit rate on the surface. These comparisons show, firstly, high spatio-temporal correlations between RSL, atmospheric dust and dust storms. Then, a deep analysis of one site in particular (Hale crater) reveals that dust deposition and winds are key factors that can both trigger the RSL formation. These findings tend to support dust movements rather than dark sand flows as the main explanation for RSL, and provide constraints to discuss the exact mechanism by which dust is mobilised.

Friday 3rd Nov.

14.45 – 15.00

Deciphering the formation processes of linear dune gullies on Mars

Lonneke Roelofs[1] (l.roelofs@uu.nl), [1]Utrecht University

Linear dune gullies are a unique surface feature on Mars. They have long and constrained channels, lack an alcove, and often end in circular depressions (pits). Satellite observations have shown that the activity of linear dune gullies is related to the presence of CO2 ice, leading to the hypothesis that these unique landforms are carved by blocks of CO2 ice. With our research, we aimed to experimentally test this hypothesis under Martian atmospheric conditions and establish a better physical understanding of how this process works. We conducted >100 experiments under Martian atmosphere in which we released CO2-ice blocks on a sloping sand bed. Our experiments show that CO2-ice blocks can move downslope by two different modes of transport, both driven by large gas fluxes produced by CO2-ice sublimation under Martian atmosphere. In general, on steep coarse-grained slopes, the blocks slide down, carving narrow and shallow gullies. Whereas, on gentle fine-grained slopes, the blocks burrow themselves into the sand in a frantic manner and slowly carve deep gullies with high and narrow levees, ending in circular pits. These two modes of transport of the CO2-ice blocks are able to explain the different morphologies of linear dune gullies on different locations, as well as the evolving morphology of certain linear dune gullies from up- to down-slope. Allowing us to reconstruct how these gullies formed based on their morphology and possibly study the grain size and slopes of Martian dunes based on the linear dune gully morphology.

Friday 3rd Nov.

15.00 – 15.15