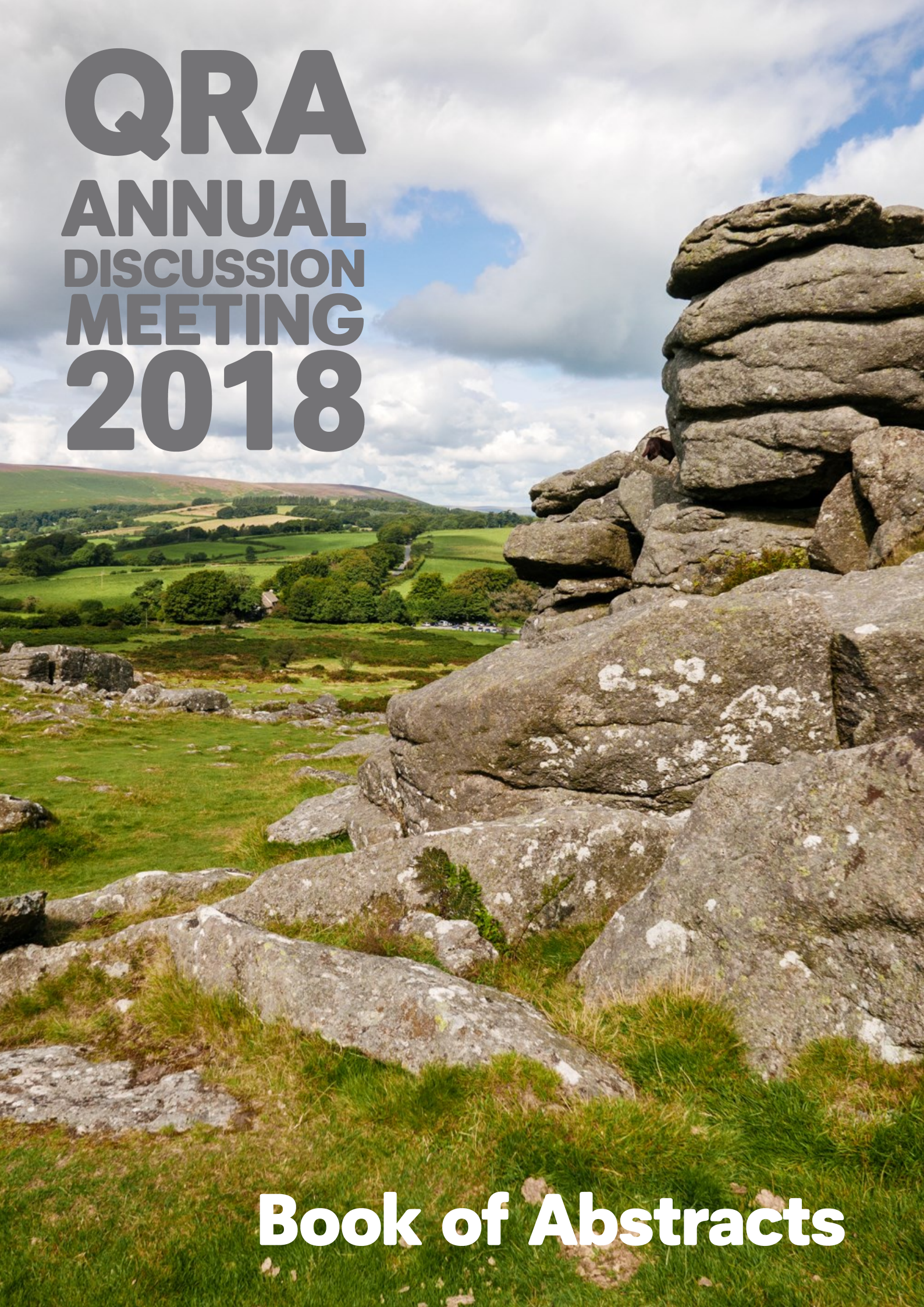
QRA ANNUAL DISCUSSION MEETING 2018



Book of Abstracts

Oral Presentations

Wednesday 3rd January			
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Keynote Speaker

Dr Susan Ivy-Ochs – ETH Zurich

Susan Ivy-Ochs [1], Julien Seguinot[2], Jochem Braakhekke[1], Giovanni Monegato[3], Guillaume Jouvet[2], Franco Gianotti[4], Kristina Hippe[1], Marcus Christl[1], Naki Akçar[5]

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Juxtaposing field evidence, isotopic dating results and ice-sheet models for the Last Glacial Maximum in the Alps

Glaciers flowing out from local ice caps and plateau ice fields in the high Alps filled the main valleys and extended onto the forelands as piedmont lobes during the Last Glacial Maximum (LGM). Beginning already nearly 200 years ago, field mapping allowed detailed reconstruction of past ice margins. Nevertheless, determination of numerical ages has only been possible in the last few decades; ^{14}C dating is well applicable S of the Alps while to the N ^{10}Be is favored due to the lack of organic remnants. Recent glacier modelling by Seguinot et al. (2018) suggests the possibility of significant disparities in the timing of reaching of the maximum extent by the various foreland lobes across the Alps. Differences in flow-path length, catchment hypsometry and glacier dynamics likely contribute to the asynchrony observed in the model results. The present data set pinpoints the culmination of the last glacial cycle, as marked by formation of the outermost moraines, at around 26-24 ka. The timing of abandonment of foreland positions is given by the ages of the innermost often lake-bounding moraines, which stabilized about 19-18 ka. Strikingly, the modelling shows strong variation in the number of oscillations of individual lobes over the last glacial cycle. Even during the LGM itself, ice margin fluctuations were much more frequent than interpreted from glacial-geological evidence. Yet at present, few sites in the Alps have detailed enough geomorphological constraints with well-dated ice-marginal positions for in depth discussion of outermost, innermost and in between moraines. We will present a comparison of field, dating and modelling results from both published and in progress sites both N and S of the Alps.

Seguinot J. et al. 2018 Modelling last glacial cycle ice dynamics in the Alps. QRA Abstract.

Professor Ed Rhodes – University of Sheffield

New developments in IRSL dating of high energy fluvial deposits

Over the past 5 years, there have been significant developments in single grain post-IR IRSL dating of potassium feldspar from fluvial sediments, including high energy contexts and situations relating to glaciation. This is significant as it provides the opportunity to date contexts where quartz OSL dating does not work well, owing to low quartz OSL signal sensitivity. This includes high mountain locations, and active tectonic contexts. As part of the post-IR iRSL dating protocol, information about the amount of light exposure to individual grains is determined; this information can be enhanced by the application of a multiple-eleveted temperaure (MET) measurement protocol. The information obtained by this type of determination is very rich, both because the approach is efficient, with up to 90% of grains providing useful post-IR IRSL signals, and because the timescales that may be determined in this way match rather well the physical processes involved in periods of grains transport and burial. Examples from California, New Zealand and the UK will be presented, and the potential for landscape development studies explored.

Dr Laura Basell - Archaeology and Palaeoecology, Queen's University Belfast

Hominins in the Tundra: Human Occupation and Landform Evolution at Doniford on the North Somerset Coast, UK

A.G. Brown, Palaeoenvironmental Laboratories,University of Southampton P.S. Toms, Geochronology Laboratories, University of Gloucestershire C. Norman, Department of Archaeology and Anthropology, University of Bristol R. Hosfield, Department of Archaeology, University of Reading P. Tanner, Department of Archaeology, University of Southampton

The tundra and steppe conditions of southern England during MIS 3-2 drove landform evolution in a world inhabited by megafuana including hominins. The coastal cliffs at Doniford, Somerset, UK have been well-known as a source of both cold stage mammalian fauna and lithic artefacts since the late 19th century. Collecting has produced an assemblage of lithics with both Palaeolithic and Mesolithic affinities which was not archaeologically coherent. This paper presents data, including a new diagnostic lithic, which resolves this archaeological contradiction, and presents a new geoarchaeological and chronometric data for S.W. England. This research demonstrates how a major period of cold climate erosion can generate a complex archaeological record where artefacts and faunal remains of different ages have become incorporated into fluvial deposits and how such a sequence can be explained using a combination of geomorphology, sedimentology and OSL dating. The paper also considers the implications of the Doniford sequence for the glaciation of southern Britain.

Dr Ella Egberts - Pre-Construct Archaeology

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Rivers through time: the geoarchaeology of the Hampshire Avon

Pleistocene river terraces are characteristic geomorphological features present in many river valleys and are the result of cyclic changes in fluvial system dynamics often related to climate oscillations and uplift (Blum and Törnqvist, 2000). They present a record of Quaternary landscape evolution and global climatic change and form the depositional context of most of the Palaeolithic evidence in northwest Europe (Wymer 1999). Modelling their formation in space and time, therefore provides a four-dimensional, geochronological framework for the archaeological record and its environmental context (Brown 2008). This paper presents the results of an extensive quartz and feldspar OSL dating program on a sequence of river terraces flanking the Hampshire Avon valley, southern England, and offers the first absolute dating of these deposits. The results allow a four-dimensional reconstruction of terrace formation and landscape evolution in this area providing a geochronological framework for the rich Palaeolithic record associated with the Avon fluvial sediments. The results demonstrate how a four-dimensional model for terrace formation is valuable in 1) understanding the spatio-temporal processes behind fluvial terrace formation in southern England and its relation to global climatic change, 2) the fine-tuning of terrace formation models, and 3) the reconstruction of the timing of hominin presence in Britain.
Blum, M. D. and Törnqvist, T. E. (2000). Fluvial responses to climate and sea-level change: a review and look forward. Sedimentology, 47, 2-48. Brown, A. G. (2008). Geoarchaeology, the four dimensional (4D) fluvial matrix and climatic causality. Geomorphology, 101, 278-297. Wymer, J. (1999). The Lower Palaeolithic occupation of Britain. Volume 1. Text. Trust for Wessex Archaeology Limited, Salisbury, 234 pp.

Dr Martin Stokes – University of Plymouth

Alberto Gomes Porto University Portugal
Ana Carracedo Plumed SUERC Glasgow University
Laura Evenstar Bristol University
Fin Stuart SUERC Glasgow University

Are Alluvial Fan Sedimentation and Erosion Patterns Controlled by African Humid Period Climate Dynamics (Cape Verde Islands, Offshore West Africa)?

We report new findings from ongoing Quaternary fluvial landscape development investigations on the tectonically inactive Cape Verde volcanic archipelago, an offshore climatic extension of the Sahara Desert. On Santo Antao Island large (6km long) coalescent coastal alluvial fans have developed along the SE volcanic edifice flank margin. These fans display an expansive relict surface incised by up to 120m. Fan incision reveals an up to 100m thick sequence of coarse grained cobble-boulder dominated fluvial sediments interbedded with a spatially extensive basaltic lava flow (undated) and tephra unit (Argon dated = 193 +/-23ka). We have characterised the fan surface morphology using 10m resolution TanDEM-X data, alongside targeted field survey and drone mapping along cross-fan transects (distal, mid and proximal fan locations). The fan surface comprises a network of fluvial bars and channels with a spatially variable relief in distal (<3m), mid (<5m) and proximal (<3.5m) surface regions. The age of the fan surface has been determined using 3He cosmogenic exposure dating targeting basalt boulders sampled from high relief fluvial barforms in distal, mid and proximal fan surface locations. Preliminary results suggest the fan surface is a composite long-lived feature that has persisted for at least 150ka but has been incised and abandoned since 10-20ka. The age distributions show an older fan surface area (>50ka) in the central distal fan and a younger fan surface area (<20ka) in central-eastern parts of the mid-proximal fan. This configuration suggests the fan surface has been built by avulsion-related fan lobe switching. We hypothesise that avulsions are related to abrupt and short duration African Humid Period hydrological events that occur every 20ka in low latitude Africa and that the longer term fan surface abandonment is base-level driven, related to global eustatic changes over a 100ka glacial-interglacial climate cycle.

Dr Rebecca M Briant - Birkbeck, University of London

Wainwright, J., Durham University, Department of Geography, Science Laboratories, South Road, Durham, DH1 3LE, UK. Maddy, D., School of Geography, Politics and Sociology, Newcastle University, Newcastle upon Tyne, NE1 7RU, UK

Metrics for model-field data comparison in landscape evolution modelling – Welland catchment case study, England

The extent to which deposition within river systems is driven by climate over glacial-interglacial timescales, and the nature of such linkages, is much debated. Answering such questions from the geological record is often limited by a lack of geochronological precision. Numerical modelling allows us to scale up what we know of climate response on short timescales to these longer timescales. To generate a robust reconstruction, relevant parameters need to be included in the model setup, and model output needs to be evaluated against the geological record. Here we introduce the model CLEOPATRA (CybErosion-based Landscape Evolution On Periglacially Altered TeRrAin), the first reduced complexity model to include periglacial processes explicitly within a river catchment. We also introduce innovative methods for evaluation, particularly the quantification of the comparison of synthetic borehole data with geological sequences using Spearman rank correlation. The model thus evaluated allows us to better determine the nature of climate linkages over the last interglacial-glacial cycle, suggesting the importance of sediment supply in driving patterns of deposition and incision, and of gelifluxion in driving sediment supply.

Dr Abi Stone - Geography Department, University of Manchester

Bateman, M. D.[2], Garzanti, E[3]., Limonta, M.[3], Radeff, G.[3], Burrough, S. L.[4], Telfer, M. W.[5]
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Reconstructing southern African landscape evolution in dunefields using a portable luminescence reader

Understanding Late Quaternary dunefield landscape evolution helps to constrain the mechanisms behind long-term changes in key climate variables such as temperature, precipitation and the wind. This understanding can better inform the mechanisms driving these variables under current and future climate change. Reconstructing changes at the dunefield scale is extremely time-consuming and resource intensive, particularly undertaking laboratory-based luminescence dating protocols. Therefore, being able to make a rapid assessment of sediment burial age using a portable luminescence reader is extremely useful. First-order estimates of sample burial age: (1) aid the in situ interpretation of sites and (2) guide targeted field sampling (or dating strategies once samples are collected) for more rigorous laboratory-based luminescence dating, including quickly (within minutes) identifying samples beyond the age-range of our protocols. In addition, the portable luminescence reader offers the possibility of producing large numbers of age estimates (1,000's as opposed to 100's currently available in the very best-dated regions) that, even if lower fidelity, are likely to give an adequate picture to assess changes at the scale of whole landscape evolution. A challenge has been translating portable luminescence reader signal intensities into an estimate of burial age. Our approach has been to use a simple linear regression between portable reader signals (background corrected) and full SAR-protocol OSL burial ages for the same samples, which serves as a calibration tool for additional undated samples. This has been applied to samples in the Namib Sand Sea (Stone et al., 2015), and this paper extends the dataset across southern Africa into the Kalahari. Results show that different regions define different regression lines and initial petrological analysis suggests a control on this from bulk sample composition. The combination of on-going widespread petrological and portable luminescence reader analysis will prove to be a very valuable tool for landscape evolution in southern Africa.

Stone, A.E.C., Bateman M.D., Thomas D.S.G. (2015) Rapid age assessment in the Namib Sand Sea using a portable luminescence reader. Quat. Geochron. 30(B): 134-140

John S. Cooper – Geography Department, Swansea University

Discovering Tir Gŵyr (The Lost Caves and Submerged Landscapes of Gower Project)

Along the Gower Peninsula's southern cliffs over 120 caves have been recorded (Davies, 1986). Between the early nineteenth and the mid twentieth centuries these caves were some of the most extensively explored and excavated in the UK, revealing many sites of international or national importance. Near the western end of this cliff line is Paviland Cave, the site of the earliest known Gravettian burial in Western Europe (Buckland, 1824; Sollas, 1913; Aldhouse-Green, 2000). Some 20 miles to the east, the fauna excavated from Bacon Hole is considered to represent a mammal assemblage-zone for the British Late Pleistocene during Marine Isotope Stage 5c (Currant & Jacobi 2001; Gilmour, Currant, Jacobi & Stringer 2007).

Surprisingly, and considering the importance of these and many other local cave sites, the bed of the Bristol Channel surrounding the peninsula has not been archaeologically investigated, nor has there ever been a detailed marine survey of the area below Gower's cliffs. The assumption that a large plain stretched all the way from the base of Gower's southern cliffs to the coast of North Devon has been expressed and repeated over the years and has become the accepted profile of this landscape during the marine regression of the last glaciation (Aldhouse-Green, 2000).

This innovative 4 year field research and modelling study of Tir Gŵyr, the Land of Gower, is reviewing this assumption within three primary objectives:
Evaluate the excavated faunal and artefact material accumulated in various collections in the UK

Locate existing and previously unrecorded cave sites and consider their potential for delivering palaeoenvironmental information from undisturbed deposits and speleothem formations

Survey the terrain of Tir Gŵyr; the upland peninsula and the submerged landscape below the 30 mile (48 km) length of the southern cliffs fronting the Bristol Channel.

From these data an integrated series of palaeo-landscapes for Tir Gŵyr will be reconstructed. The intention is to represent landforms at various stages during the marine regression that occurred as the Devensian glaciation deepened; and also model the current marine transgression that began as the ice sheets started to retreat around 20,000 years ago.

Initial paleoclimate data is being sourced from museums, other collections and previously published radiocarbon dates relating to local fauna and flora (Burrow, 2008) but in future, data will be primarily from results obtained through the analysis of cave sediment, speleothem dating and isotope analysis; along with terrestrial samples recovered from now submerged palaeo-lake fringes and deposits from submerged caves. Combining these data will enable palaeoenvironmental scenarios to be constructed for key stages during the last 130,000 years.

The results from the project's first 18 months will be presented for discussion. Onshore, field research has already revealed many previously unknown Pleistocene landscape features including valleys, dolines, lakes and caves; with initial isotope data from speleothem samples suggesting a greener Devensian landscape than expected. Evidence from a previously unrecorded cave hints at human ritual use. Offshore, using Swansea University's marine research vessel RV Noctiluca, sonar surveying has been revealing submerged cliffs, hills, valleys, lake beds, stream beds and possible cave entrances. Landscape features so different from the current perception of a flat plain that they should help provide a better

explanation for why such a wide variety of species populated this Late Pleistocene landscape or lived in Gower's cliff face caves during much of the last 130,000 years.

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Bridges, E., 1985. Gower: The ice Age Limit. Gower, Volume Vol. 36, pp. 71-97.
Buckland, W., 1824. Reliquiæ Diluvianæ. London: John Murray.
Burrow, S., 2008. 'The Wales and Borders radiocarbon database'. Amgueddfa Cymru - National Museum Wales.. s.l.:National Musuem of Wales.
Clark, C., 2012. Pattern and timing of retreat of the last British-Irish Ice Sheet. Quaternary Science Reviews, Volume 44, pp. 112-146.
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Currant, A. Jacobi. R., 2011. The Mammal Faunas of the British Late Pleistocene. In: N. L. S. S. C. Ashton, ed. The Ancient Human Occupation of Britain. Amsterdam: Elsevier, pp. 165-180.
Davies, M., 1986. The Caves of the South Gower Coast. Swansea, Melvyn Davies.
Gilmour, M. Currant, A. Jacobi, R. Stringer, C., 2007. Recent TIMS dating results from British Late Pleistocene vertebrate faunal localities: context and interpretation. Journal of Quaternary Science, 22(8), p. 793–800.
Sollas, W., 1913. Paviland Cave; An Aurignacian Station in Wales. London: Royal Anthropological Institute.

Keynote Speaker

Professor Marie-José Gaillard - Department of Biology and Environmental Science, Linnaeus University, Kalmar, Sweden

Kathy Morrison, Department of Anthropology, University of Pennsylvania, Philadelphia, USA
Marco Madella, Department of Humanties, University Pompeu Fabra (UPF), Barcelona, Spain Nicki Whitehouse, School of Geography, Earth and Environmental Sciences, Plymouth University, UK

Past Global Land Cover and Land Use for Climate Modelling - PAGES LandCover6k

The question of whether prehistoric human impacts on land cover (i.e. anthropogenic land cover change due to land use, LULC) were sufficiently large to have a major impact on regional climates is still a matter of debate. Climate model simulations have shown that LULC data sets can have large regional impacts on climate in recent and prehistoric time (1). But there are major differences between the available LULC scenarios/data sets (2), and diagnoses of inferred carbon-cycle impacts show that none of the scenarios are realistic (3). The only way to provide a useful assessment of the potential for LULC changes to affect climate in the past, is to feed into HYDE more realistic LULC changes based on palaeovegetation and archaeological evidence. This is the goal of the LandCover6k WG. We use the REVEALS model to reconstruct LC from pollen data at a regional scale and archaeological data on settlement and land-use type and intensity (LU). This information is then fed into LULC model scenarios. The improved LULC will provide input scenarios for palaeoclimate simulations contributing to CMIP via PMIP. Such simulations are necessary to assess the impact of LULC changes and ecosystem management on future climate. We present the results of the first 3-yr phase of LandCover6k, including examples of model-data comparison using pollen-based land-cover datasets.

(1) Strandberg G, Kjellström E, Poska A, Wagner S, Gaillard M-J et al. (2014) Regional climate model simulations for Europe at 6 and 0.2 k BP: sensitivity to changes in anthropogenic deforestation. Clim. Past 10, 661–680. (2) Gaillard M-J, Sugita S, Mazier F et al (2010) Holocene land-cover reconstructions for studies on land cover-climate feedbacks. Clim. Past 6, 483-499. (3) Stocker B, Yud Z, Massae C, Joos F (2017) Holocene peatland and ice-core data constraints on the timing and magnitude of CO2 emissions from past land use. www.pnas.org/cgi/doi/10.1073/ pnas.1613889114.

Yiman Fang - Geography and Geology, School of Environmental Sciences,University of Hull

Dr. M. Jane Bunting Geography and Geology, School of Environmental Sciences,University of Hull

Novel approaches to estimating a key parameter for reconstruction of past land cover from pollen records in southeast China

The analysis of pollen records from sedimentary environment has proved of considerable value for many aspects of Quaternary research from understanding past climates to environmental archaeology. Quantitative estimations of past land-cover changes depend on a series of assumptions about the relationships between pollen deposited within the sedimentary system and the contemporary vegetation around the sedimentary area. Simplification of the pollen dispersal and deposition system using modelling methods is a useful way to develop a better understanding of complex systems. Application of these mathematical methods require parameters which need to be estimated via studying the modern pollen-vegetation relationships. A key model parameter, relative pollen productivity (RPPEs), is usually measured using the 'Extended R-value' (ERV) method. Enough amount of samples should be collected to ensure sufficient dimensions for each taxa, since the ERV method can be quite sensitive to number of sample points. However, it is time and effort consuming to do vegetation survey in the field, which makes small datasets a problem to do ERV analysis. With quicker processing capabilities of computer and much better access to remote sensed data, it is possible to find alternative methods to estimate pollen productivity. Here we present two new approaches - modified Davis method and iteration methods, and show how all three methods work in simulation and on field data for a relatively small dataset from southeast China, a region with no existing pollen productivity estimates. Results suggest that these alternative methods might open up new ways for RPP estimation for works in remote locations where only small datasets are available such as inaccessible areas or areas where land cover reconstructions are urgently needed.

Dr M. Jane Bunting – University of Hull

Dr Michelle Farrell, University of Coventry

Translating data for comparison with models: landscape-scale land cover reconstruction from pollen records using the Multiple Scenario Approach

Pollen diagrams contain a wealth of data about long term ecosystem dynamics, including changes in past land cover, population dynamics of species, habitats and functional types, and changing landscape biodiversity. These data should be of value to a wide range of end-users; examples include comparison with the outputs of Dynamic Vegetation Models run under past boundary conditions, as inputs to regional climate models, and as a framework for the development of hypotheses about past human activity and environmental impacts of such activities. However, pollen analysts often argue that their data are still underused. A key reason for the under-use of pollen diagrams in wider data model comparison is that, whilst information-rich, the pollen diagram itself is not actually very useful in most applications. Translation of pollen diagrams into spatially explicit reconstructions using widely-understood units of measurement is a non-trivial problem. At the regional scale (100km x 100km pixel reconstructions of sub-continental vegetation distribution) the REVEALS module of the Landscape Reconstruction Algorithm (LRA) has produced very promising results (e.g. Trondman et al. 2015), but many interesting processes, especially those of interest to archaeologists and ecologists, operate at a finer spatial scale. In this paper we discuss the Multiple Scenario Approach to landcover reconstruction, which uses the same underlying model of pollen dispersal and deposition as the LRA, and through case studies of the Neolithic in contrasting UK landscapes show how it can extract land cover information at a regional and local spatial scale from pollen data, both in mapped form and as numerical values. These case studies demonstrate the potential of pollen dispersal and deposition models to both improve the effectiveness of palynological data collection and to make more widely available the data contained within the great resource of existing pollen counts. Reference: Trondman, AK, et al. (2015). Pollen-based quantitative reconstructions of Holocene regional vegetation cover (plant-functional types and land-cover types) in Europe suitable for climate modelling. Global Change Biology 21(2), 676-697.

Professor Ralph Fyfe – University of Plymouth

Fyfe RM[1], Ombashi H[1], Davies H[2] & Head K[1]
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Burning and grazing as drivers of moorland vegetation over millennial time scales

Much modern ecological work describes the factors that control vegetation patterning in uplands and moorland, recording either changes over recent decades at a site or differences between plots across large regions. Whilst these provide critical insights into controls on vegetation patterning in the present, they may overlook the importance of historical contingency, i.e. the importance of past processes in patterning vegetation. Palaeoecological approaches and datasets can provide a 'long-term' view, i.e. identifying patterns over millennia. They can offer important insights that are otherwise not available through direct observation methods. This paper synthesises results from pollen and charcoal analytical studies from multiple sequences on a moorland in southwest Britain, in particular to test the relationship between upland vegetation and managed burning over the past three millennia. Traditional pollen analysis is confounded by two challenges: differentiating local patterns from regional signal, and differential production of pollen between taxa. Here 16 sets of pollen count data are transformed to estimates of local vegetation abundance using a model-based approach (the Landscape Reconstruction Algorithm) that corrects for bias in pollen production and dispersal. The results reveal clear heterogeneity of vegetation (abundance of different moorland taxa) between sites and through time. Palaeoecological indicators for burning (charcoal records) and grazing (non-pollen palynomorphs) are used to explore drivers of local vegetation. Comparison between estimates of local vegetation and normalised charcoal data show strong relationships between vegetation change and burning at four of the six sites, but relationships are site-specific. Grazing intensity, as reflected in dung indicators such as *Sodaria* sp. and *Sporormiella* sp. are being used to explore the role of grazing animals in long-term upland vegetation dynamics.

Dr Michael Grant - COARS, University of Southampton

Resolving discrepancies between palaeoecological data and palaeoclimatic models - the curious case of European Beach at its northern limit

Discussions of the factors controlling distribution of European Beech (Fagus sylvatica) in northern Europe have stimulated a considerable amount of research and debate for almost a century the past century. Within the UK it is popularly believed that arrival wasn't until c.3500 cal. BP, with expansion strongly linked to human activity. Much of this interpretation is derived from pollen data which is used to map its range expansion. Although beech is wind pollinated, it is often underrepresented in pollen diagrams. This makes identification of any local presence difficult and it is not until population expansion crosses undefined abundance threshold that a continuous pollen record is produced. Palaeoclimatic models have been used to consider the possible expansion of beech at a European scale, often predicting that beech should be found at a much more northern limit during the mid-Holocene than the available pollen data suggests. This discrepancy between the models and pollen data can be explained by three possible scenarios outputs: (1) inaccurate estimates of palaeoclimate for this period generated by the models; (2) failure of the bioclimatic model to capture the critical climatic controls on F. sylvatica during the mid-Holocene; or (3) incorrect interpretation of species distribution limits from the pollen data. This paper focuses on the latter scenario but drawing together palaeoecological data from other resources, notably plant macrofossil and charcoal data, demonstrating that Fagus is already well-established in southern England by the mid-Holocene. Most notably it shows that beech was present on the more calcareous geologies – areas where pollen records are often scarce – and expanded in areas of heavier soil types in later prehistory. This paper highlights the need to resource a larger range of palaeoecological datasets for testing current palaeoclimatic models, and the dangers of using solely pollen data to reinforce existent ideas of population expansion.

Dr Jessie Woodbridge – University of Plymouth

Jessie Woodbridge, Ralph Fyfe & Neil Roberts

Mediterranean vegetation and landscape change through the Holocene

The Mediterranean landscape has undergone significant changes throughout the Holocene. This research utilises large databases of modern pollen (Davis *et al.,* 2013) and fossil pollen from sediment cores (Leydet *et al.*, 2007-2017) as a proxy for vegetation change. Cluster analysis and community classification of pollen datasets (Woodbridge *et al*., in review) have revealed numerous closed forest/wooded vegetation types (e.g. evergreen and deciduous oak woods) and several open or scrub vegetation types (e.g. sclerophyllous scrub, steppe, grassland, parkland). Pollen-inferred landscape change indicates both short and long-term variability, which reflects temporal variations in climate, human land use and ecological dynamics. The results indicate that the Mediterranean has been a dynamic landscape throughout the Holocene with frequent changes in land cover and persistence of disturbance and drought-adapted plant assemblages within an extensively human-modified environment. The pollen-inferred vegetation reconstruction will be compared with archaeological records as proxies for human population change. This broad-scale data synthesis will allow questions regarding the extent to which the Mediterranean is a naturally dynamic and disturbance-adapted landscape or extensively culturally modified to be explored.

Davis, B.A.S., Zanon, M., Collins, P. *et al.* (2013) The European modern pollen database (EMPD) project. *Vegetation History and Archaeobotany*, 22, 521-530.
Leydet, M. *et al.* (2007-2017) *The European Pollen Database*. (online: http://www.europeanpollendatabase.net/). Accessed: May 2016.
Woodbridge, J., Roberts, N. & Fyfe, R.M. (*in review: Journal of Biogeography*) Perpetual change? pan-Mediterranean Holocene vegetation and land-cover dynamics from synthesised pollen data.

David Smith - Classics Ancient History and Archaeology, University of Birmingham

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Is the development of farmed landscapes in the late Holocene a case of econiche replacement and ecosystems engineering?

The origin and spread of insects that are associated with human landscapes, in particular farmed landscapes, is an issue of growing international importance, especially as clearance and intensification of farming continue worldwide. This paper examines the development of the beetle (Coleoptera) fauna from a range of intensively farmed archaeological landscapes in the UK. The analysis suggests that the archaeoentomological fauna of farmland typically consists of a range of very generalist species which still dominate modern farmed landscapes today. We consider what the origin for this 'farmland beetle fauna' might be. Statistical analysis suggests that there is an essential similarity of the 'core' taxa from these faunas, regardless of the period or nature of the archaeological feature involved. This suggests that, once established, this fauna is relatively stable. We will argue that this process is a clear example of human econiche replacement and ecosystem engineering. Finally, the approach taken here is applicable elsewhere in the world; therefore, we conclude with a number of suggestions for further international research strategies.

Kim Davies – Swansea University

K.Davies, N. Whitehouse, P.Langdon, H. Mackay, M. van Hardenbroek,
T. Fonville, K. Head, A. Henderson & A. Brown

Aquatic ecosystem response to Late Holocene human disturbance: palaeoecological and palaeoenvironmental evidence of changing biodiversity in small lakes

Humans have always been attracted to lakes as resource hotspots. In the Iron Age to Medieval Period in Ireland and Scotland, this attraction culminated in the construction of artificial islands called crannogs, in thousands of small and largely lowland lakes. The particular characteristic of this human-lake interaction was small but very actively used settlements within small and lakes that were typically sensitive to environmental change. Although we have only some ideas concerning why these crannogs were originally constructed, we can detect activities with both high-temporal and high analytical resolution which appear to have had profound effects on and within the lake environments.
Our research on crannogs characterises the prehistoric human-environment interactions associated with crannogs by analysing geochemical and biological signals preserved within both the crannog and wetland/lake sediments. Records of anthropogenic activities have been produced using lipid biomarkers of faecal matter, sedimentary DNA (*seda*DNA) and beetles. The impacts of these activities are revealed through palaeoecological proxies such as aquatic invertebrates (chironomids), siliceous algae (diatoms), pollen and fungal spores. Results of these analyses reveal short-lived construction and occupation phases from the Iron Age to the Medieval Period. The main effects of human activities that are related to both plants and animals, on the lake ecosystems are nutrient- driven increases in productivity and shifts in aquatic species to indicate more eutrophic conditions. Crannog abandonment reduces nutrient inputs and therefore levels of aquatic productivity, as evidenced by decreases in the abundance of siliceous algae. Despite returns to pre- settlement nutrient and productivity levels, the lake ecosystems do not return to their previous ecological state. Testing and quantifying the resilience of these ecosystems is key to understanding the impact of these short-lived human interactions and to assessing any persisting environmental impacts that have shaped the long-term structure of the aquatic ecosystems.

Nick Schafstall – Czech University of Life Sciences Prague

Schafstall, N.B., Whitehouse, N.J., Chiverrell, R.C., Svobodová, H., Holeksa, J., Kuosmanen, N.I., Kuneš, P., Svoboda, M. , Clear, J.L.

Historical forest dynamics in a Norway spruce forest in the High Tatra Mountains, Slovakia

Norway spruce is a dominant keystone species in the montane coniferous forests in central Europe, with important ecological and commercial value. Natural disturbances such as wind throws and bark beetle outbreaks have caused major losses in these forests in the last few decades and are becoming more frequent and severe. Holeksa et al. (2016) created a dendroecological dataset from the High Tatra Mountains in Slovakia, which shows several large disturbance events occurred in this region over the last two centuries. Comparing dendroecological data with fossil beetle records from sedimentary archives can provide more specific information on the nature of these disturbances. Reconstructed long-term disturbance patterns can then provide information for improved nature conservation and forest management, as they can make use of these natural factors of dynamics and resilience of the forest. From a forest hollow in the High Tatra Mountains in Slovakia, 12 cores were retrieved for a quantitative study on subfossil beetles (Coleoptera), covering the last 1400 years. Correlation and integration of the adjacent profiles was underpinned by repeatable down-core μXRF geochemical stratigraphy (airfall Pb and other elements). The Pb profile shows patterns likely related to Europe-wide increases in airfall pollutants ~1000 and 200 years ago. Concentrations of lithogenic elements (K, Ti and Zr) decline from the base with reducing influence of bedrock, but show three distinct peaks in the upper 20 cm likely inwash or airfall of mineral dust. Fossil pollen and charcoal records, obtained from a parallel core, together with the fossil Coleoptera, provide a record of past disturbances that can be compared to the disturbance events recorded in the dendroecological data. A diverse community of beetles was recovered, including many species of bark beetles such as *Ips typographus* and other saproxylic taxa characteristic of dead wood habitats. Changes in the forest beetle community over the last 1400 years and their relation to disturbance events in the High Tatra Mountains in Slovakia are discussed.

Holeksa, J., Zielonka, T., Zywiec, M. and Fleischer, P., 2016. Identifying the disturbance history over a large area of larch–spruce mountain forest in Central Europe. Forest Ecology and Management 361: 318-327.

Keynote Speaker

Dr Marie-France Loutre - Past Global Changes (PAGES)

A brief tour in the world of complementarity between data and models.

Data-model inter-comparison dates back the early time of models. One of the first Earth System Model of intermediate complexity, LLN-2D model (Gallée et al., 1992), was specifically designed to understand the waxing and waning of the Northern Hemisphere ice sheets. Therefore, the major output of the model, the Northern Hemisphere continental ice volume, was compared to proxy series over up to several hundred thousand years. Prior to that effort frequencies recorded in climate proxies time series were compared to those of the climate forcing. Nowadays, models and data are strongly interconnected. Data-model inter-comparison is still used to identify the processes at work in the climate system, to quantify the major forcings responsible to changes in climate and to measure how the unknowns on these forcing affect the simulated climate. For example, it was possible to demonstrate that the configuration of the ice sheets and freshwater flux from their melting at the early stage of the Last Interglacial (LIG) are playing a major role during the LIG while the role of the uncertainties on the model parameters was smaller at that time (Loutre et al., 2014). In the proxy system modelling (PSM), instead of transforming the observation (for example the stable isotope) into a record of environmental forcing (for example temperature), the observation results from the environmental variation. In other words, proxy system models are directly linked to the climate models. Latitude and monthly temperature and precipitation can be used to simulate tree rings width chronologies (Evans et al., 2013; Breitenmoser et al., 2014). Data assimilation and reanalysis combine observations or climate records and models. These methods provide physically consistent estimates for different variables, possibly on a global scale. So, data used in a simulation of the Medieval Climate Anomaly (950-1350 AD) allowed showing that modification of the atmospheric and ocean circulation can explain the pattern of the MCA (Goosse et al., 2012). Both approaches (PSM and DA) were also interestingly combined. It showed that while a linear approach for the PSM will give results as good as more sophisticated approaches for coral and □18O, it is not the case for tree ring (Dee et al., 2016). Many challenges remain to be addressed both on the modelling and the data sides, such as the complexity of the model, in particular the PSM, the chronology of the data, and the adequacy between the simulated variables and the observations with which it is compared. This presentation will thus invite to an overview of several ways through which model and data can complement each other to improve our understanding of the climate system.

Francis Rowney – University of Plymouth

Dr Nicki Whitehouse (Plymouth University) Professor Ralph Fyfe (Plymouth University) Professor Danielle Schreve (Royal Holloway, University of London) Dr Georgina Milne (Queen's University Belfast) Professor Ian Candy (Royal Holloway, University of London)

New perspectives on interglacial climates in Northwest Europe during the Middle Pleistocene

The Mid-Brunhes Transition (a shift towards glacial-interglacial cycles of greater amplitude, c. 400-500 ka BP) is the most significant climatic transition to have occurred in the last 800 ka. However, understanding of its expression in Northwest European terrestrial environments remains incomplete. Here, the thermoclimatic characteristics (summer temperatures, winter temperatures, temperature seasonality) of Middle and Late Pleistocene interglacials (c.780-125 ka, MIS 19-5e) in Britain are reassessed using a suite of coleopteran records, derived from interglacials spanning this period. Recent developments in the coleopteran mutual climate range (MCR) method (Milne et al. in prep) enable more accurate estimates of past climates, based on sub-fossil Coleoptera, than previously possible. In particular, these are facilitating reconstructions of winter temperatures which are both more accurate and statistically more constrained than previous estimates. This is an area that has previously received limited attention in the context of Northwest European interglacial climates, but one which has much to offer. Based on new coleopteran MCR reconstructions, we provide evidence that interglacial thermoclimates in Northwest Europe were broadly similar throughout the Middle and Late Pleistocene, and were unaffected by the Mid-Brunhes Transition. This has previously been shown for summer temperatures, but has not been demonstrated for winter temperatures or temperature seasonality. This leads to the suggestion that in Northwest Europe this transition may be reflected in climatic variables other than temperature, and a shift in hydroclimatic conditions appears likely. Additionally, this work highlights the intra-annual nuances of interglacial climates. In particular, the new reconstructions reveal that enhanced summer temperatures may sometimes have been accompanied by cooler winter temperatures. This is not a general pattern, but serves to suggest that terms such as interglacial ‘warmth’ and ‘intensity’ may require re-evaluation in this context.

Professor Christine Lane - Department of Geography, University of Cambridge

Philip Barker, Lancaster Environment Centre, Lancaster University, Lancaster, LA1 4YQ, U.K. Maarten Blaauw, School of Natural and Built Environment, Queen's University Belfast, U.K. Melanie Leng, Centre for Environmental Geochemistry, British Geological Survey, Environmental Science Centre, Nicker Hill, Keyworth, Nottingham, NG12 5GG, U.K. Barbara Maher, Lancaster Environment Centre, Lancaster University, Lancaster, LA1 4YQ, U.K. Darren Mark, Scottish Universities Environmental Research Centre, Rankine Avenue, Scottish Enterprise Technology Park, East Kilbride, G75 0QF, U.K. Dirk Verschuren, Limnology Unit, Department of Biology, Ghent University, K.L.Ledeganckstraat 35, Gent, 9000, Belgium. and ICDP DeepCHALLA partners

Resolving the timing, causes and impacts of past climate change in equatorial Africa: the DeepCHALLA project

A new, continuously-laminated, 214.8 metre long sediment record from Lake Challa near Mt. Kilimanjaro is anticipated to provide uniquely detailed insights into the timing, drivers and impacts of climate change in equatorial Africa over the last two glacial-interglacial cycles. As demonstrated by earlier investigation of shorter cores (Barker et al., 2011), the new DeepCHALLA record will provide opportunities for studying climate dynamics at inter-annual, decadal, millennial and glacial-interglacial time-scales. One of the most notable climate events known from other long African archives is the ‘megadrought’ interval: one or more apparently widespread and catastrophic monsoon failures that lasted for ~10-15 millennia during MIS 5. Megadroughts have been recognised and correlated from the Lake Malawi, Lake Tanganyika and Lake Bosumtwi records (e.g. Scholz et al., 2007), however chronological imprecision of these records has prevented a clear picture of their number, timing and synchronicity across the continent. Despite this lack of clarity, the impact of the megadrought(s) on freshwater resources and evolving modern human populations is now widely discussed and intervals of significant drought are built into models of human dispersal (e.g. Timmermann & Friedrich 2016 Nature). The DeepCHALLA-UK project sits within the wider DeepCHALLA International Continental Drilling Project (http://www.icdp-online.org), and will combine an integrated dating approach with a diverse array of palaeo-ecological and -hydrological reconstructions, in order to precisely time the megadrought event(s) and to diagnose the climatic and orbital boundary conditions that led to these distinctive millennial-scale climatic changes.

Barker, P.A., Hurrell, E.R., Leng, M.J., Wolff, C., Cocquyt, C., Sloane, H.J. and Verschuren, D., 2011. Seasonality in equatorial climate over the past 25 ky revealed by oxygen isotope records from Mount Kilimanjaro. Geology, 39(12), pp.1111-1114. Scholz, C.A., Johnson, T.C., Cohen, A.S., King, J.W., Peck, J.A., Overpeck, J.T., Talbot, M.R., Brown, E.T., Kalindekafe, L., Amoako, P.Y. and Lyons, R.P., 2007. East African megadroughts between 135 and 75 thousand years ago and bearing on early-modern human origins. Proceedings of the National Academy of Sciences, 104(42), pp.16416-16421. Timmermann, A. & Friedrich, T. 2016. Late Pleistocene climate drivers of early human migration. Nature 538, 92–95.

Rachael Avery – University of Southampton

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Varve Sequences from Windermere, UK: New Insights into the Deglaciation of the Lake District

The interval from the end of the Last Glacial Maximum around 19 ka to the start of the Holocene at 11.7 ka was marked by rapid climate oscillations that ultimately led to the demise of the Northern Hemisphere Ice Sheets. Understanding the dynamics of earth system behaviour through this period relies on high-resolution records that capture the relative timing of change. Annually laminated sediments, or varves, provide such temporal resolution but are rare in the early part of the deglaciation. Development of the North American Varve Chronology has enabled direct matching of sub-centennial scale climatic transitions between North America and the Greenland ice-core records through 18.2 – 12.5 cal ka BP (Ridge et al., 2012), but no deglacial varve records prior to the Lateglacial Interstadial (Windermere Interstadial, Bølling-Allerød, GI-1) are known from the Eurasian Ice Sheets. Here we present the first analysis of such a deglacial varve sequence in cores from Windermere in the Lake District, northwest England. Evidence from varved sequences from four cores in the Windermere North and South Basins are integrated with seismic stratigraphic records to reconstruct the regional deglaciation of the Lake District Ice Cap. Ice retreat, marked by a series of moraines in the South Basin, halted at ~17 ka for up to 2,300 years when the ice became pinned on a bedrock high between the two basins, forming the southern margin of the Lake District Ice Cap. Final deglaciation commenced abruptly within 250 years of the Interstadial transition and marked a change from cm-scale glaciolacustrine varves to nival varves within ~40 years in the South Basin. Rapid ice retreat up the North Basin was recorded by a series of De Geer moraines and chaotic outwash sediments. The new cores, combined with the seismic evidence, show the potential for a 2,300 year precisely dated varve chronology through Heinrich Stadial 1.

Ridge, J.C., Balco, G., Bayless, R.L., Beck, C.C., Carter, L.B., Dean, J.L., Voytek, E.B., Wei, J.H., 2012. The new North American varve chronology: A precise record of southeastern Laurentide ice sheet deglaciation and climate, 18.2-12.5 kyr BP, and correlations with Greenland ice core records. Am. J. Sci. 312, 685–722. doi:10.2475/07.2012.01

Professor James Scourse – University of Exeter

Reynolds, D.J., Cardiff University Halloran, P.R., University of Exeter Nederbragt, A., Cardiff University Wanamaker, A.D., Iowa State University Butler, P.G., University of Exeter Richardson, C.A., Bangor University Heinemeier, J., Aarhus University Eiriksson, J. , University of Iceland Knudsen, K.L., Aarhus University Hall, I.R., Cardiff University

Annually-resolved North Atlantic marine climate over the Last Millennium: the ULTRA series

Numerical climate models predict a significant weakening (~30%) in Atlantic Meridional Overturning Circulation (AMOC) over the 21st century in response to anthropogenic climate forcings. However, the lack of absolutely-dated oceanographic information prior to the modern instrumental period limits the direct assessment of the mechanistic role played by North Atlantic Ocean dynamics in previous climate transitions (e.g., Medieval Climate Anomaly-Little Ice Age, MCA-LIA). Here we present analyses of the first millennial-length, annually-resolved and absolutely-dated marine archive from the ocean (ULTRA series; Wanamaker et al., 2012; Butler et al., 2013). Our record of oxygen isotope ratios in the shell of the long-lived marine bivalve Arctica islandica (δ18O-shell) from the North Icelandic shelf (Reynolds et al. 2016) demonstrates that solar and volcanic forcing coupled with ocean circulation dynamics are key drivers of climate variability. This absolutely-dated series from the North Atlantic provides the opportunity for comparisons with annually-resolved Northern Hemisphere atmospheric series (tree-rings, ice cores) and provides a key, and unique, observational dataset for integration with coupled ocean-atmosphere model simulations.

BUTLER, P.G., WANAMAKER, A.D. Jr,, SCOURSE, J.D., RICHARDSON, C.A. & REYNOLDS, D.J. 2013. Variability of marine climate on the North Icelandic shelf in a 1,357-year proxy archive based on growth increments in the bivalve Arctica islandica . Palaeogeography, Palaeoclimatology, Palaeoecology 373, 141-151. REYNOLDS, D.J., SCOURSE, J.D., HALL, I.R., NEDERBRAGT, A., WANAMAKER, A.D., HALLORAN, P., BUTLER, P.G., RICHARDSON, C.A., HEINEMEIER, J., EIRÍKSSON, J. & KNUDSEN, K.L. 2016. Annually-resolved North Atlantic marine climate over the Last Millennium. Nature Communications. doi: 10.1038/ncomms13502 WANAMAKER, A.D. Jr,, BUTLER, P.G., SCOURSE, J.D., HEINEMEIER, J., EIRÍKSSON, J., KNUDSEN, K.L. & RICHARDSON, C.A. 2012. Surface changes in the North Atlantic meridional overturning circulation during the last millennium. Nature Communications 3:899 doi: 10.1038/ncomms1901

Dr Margaret Georgina Milne – AFBI

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Evaluating Mutual Climatic Range: using modern methods to assess an established technique

Despite continuing use of the Coleopteran Mutual Climate Range (MCR) technique [1] to reconstruct palaeoclimate from Coleopetran fossils, the approach has not yet been modernised light of advancements in tools and datasets. The MCR methodology relies on adequately capturing the thermal limits of modern species, using both species occurrence data and associated weather station information in the locale of the occurrence record [2]. However, this assumes that i) the species distribution information is in-tact, unbiased and can be interrogated & updated, and ii) the climate at the weather station is representative of the climate at the locality record. Until now, it was not feasible to challenge these major assumptions of the approach. To address this, we computationally recreate individual MCR species climate range envelopes using modern distributional data and interpolated climate data, using an automatic scripted process. We then reconstruct modern climate at 12 European sites from both the original envelopes and our envelopes, then comparing the results. Our approach leads to more constrained reconstructions and reveals significantly warmer winter temperatures than predicted by the original envelopes. This has the possibility to glean greater insight to other palaeoecological climate reconstructions which utilise the Coleopetran sub-fossil record. Our completely-automated approach also means that envelopes can be recreated when new data becomes available, and also allows for the consideration of including additional species.

[1] Atkinson, T.C., Briffa, K.R., and Coope, G.R., “Seasonal Temperatures in Britain during the Past 22.000 Years, Reconstructed Using Beetle Remains,” Nature 325, 587–592 (1987).
[2] Buckland, P.I. & Buckland, P.C. (2006). BugsCEP Coleopteran Ecology Package. IGBP PAGES/World Data Center for Paleoclimatology Data Contribution Series # 2006-116. NOAA/NCDC Paleoclimatology Program, Boulder CO, USA. URL:http://www.ncdc.noaa.gov/paleo/insect.html or http://www.bugscep.com

Professor Neil Loader - Department of Geography, Swansea University.

C. Bronk-Ramsey (Research Laboratory for Archaeology and the History of Art, University of Oxford) D. Davies (Department of Geography, Swansea University) D. Miles (Research Laboratory for Archaeology and the History of Art, University of Oxford) D. McCarroll (Department of Geography, Swansea University)# G.H.F. Young (Department of Geography, Swansea University)

Precise isotopic dating of tree-rings: Development and evaluation of a new dating tool in Science-based Archaeology.

A new technique for precision dating in Quaternary research is introduced. The technique is grounded in the statistically-robust matching of stable oxygen isotope ratios in tree-ring cellulose, and is capable of absolutely dating wooden artefacts with annual precision. This presentation describes the development of the master chronology and introduces the protocols for assigning a date. The method is evaluated through the application of the isotopic dating method to case studies where conventional approaches alone have been unable to provide dates. The wider scope and application of the technique is discussed in the context of the heritage management and historic dating sectors and with specific reference to the reporting of dates, the analysis of non-oak species and the combination of dating results to refine uncertainties in radiocarbon dating. Precision isotopic dating is applicable to samples previously considered "un-dateable" by conventional dendrochronology.

Dr Mary Gagen – Swansea University

Eduardo Zorita, HZG, Germany. Danny McCarrroll, Swansea University. Neil Loader, Swansea University. Iain Robertson, Swansea University. Giles Young, Swansea University.

Exploring the cloud temperature feedback through stable isotope dendroclimatology

The long term relationship between cloud cover and temperature is one of the most important climate feedbacks contributing to determining the value of climate sensitivity. Climate models still reveal a large spread in the simulation of changes in cloud cover under future warming scenarios but clarity can be aided by a picture of the past variability in cloudiness from tree rings. Stable carbon isotope ratios from tree ring records have been successfully piloted as a palaeocloud proxy in geographical areas traditionally producing strong dendroclimatological reconstructions (e.g. Gagen et al 2011) and with notable successes elsewhere too (e.g. Hafner et al 2014). An expansion of tree-ring based palaeocloud reconstructions might help to estimate past variations in periods of anomalous temperature, providing a way to model test this climate aspect. Here we present a spatio-temporal statistical analysis of a multivariate stable carbon isotope tree ring data set over Europe to assess its usefulness to reconstruct the palaeo perspective on the cloud temperature feedback.

Gagen, Mary, et al. "Cloud response to summer temperatures in Fennoscandia over the last thousand years." Geophysical Research Letters 38.5 (2011). Hafner, Polona, et al. "A 520 year record of summer sunshine for the eastern European Alps based on stable carbon isotopes in larch tree rings." Climate dynamics 43.3-4 (2014): 971-980.

Dr Giles Young – Swansea University

Reconstructing United Kingdom Summer Climate using Stable Isotopes from Oak Tree-Rings

United Kingdom (UK) summers dominated by anti-cyclonic circulation patterns are characterised by clear skies, warm temperatures, low precipitation totals, low air humidity and more enriched oxygen isotope ratios (δ18O) in precipitation. Such conditions usually result in relatively more positive (enriched) oxygen isotope ratios in tree leaf sugars and ultimately in the tree-ring cellulose formed in that year, the converse being true in cooler, wet summers dominated by westerly air flow and cyclonic conditions. There should therefore be a strong link between tree-ring δ18O and the amount of summer precipitation. Stable oxygen isotope ratios from the latewood cellulose of 40 oak trees sampled at eight locations across Great Britain produce a mean δ18O chronology that correlates strongly and significantly with summer indices of total shear vorticity, surface air pressure, and the amount of summer precipitation across the England and Wales region of the United Kingdom. The isotope-based rainfall signal is stronger and much more stable over time than reconstructions based upon oak ring widths. Using recently developed methods that are precise, efficient and highly cost-effective it is possible to measure both carbon (δ13C) and oxygen (δ18O) isotope ratios simultaneously from the same tree-ring cellulose. In our study region, these two measurements from multiple trees can be used to reconstruct summer temperature (δ13C) and summer precipitation (δ18O) with sufficient independence to allow the evolution of these climate parameters to be reconstructed with high levels of confidence. The existence of long, well-replicated oak tree-ring chronologies across the British Isles mean that it should now be possible to reconstruct both summer temperature and precipitation over many centuries and potentially millennia.

Keynote Speaker

Professor Chris Clark – University of Sheffield

Ely, J.C., University of Sheffield Bradley, S. University of Utrecht Hindmarsh, R.C.A. British Antarctic Survey and the wider BRITICE-CHRONO team

Data-modelling interactions in palaeo-glaciology; you can lead a horse to water….but when will he drink?

As an undergraduate I was inspired by the paper starting on page one of the very first issue of Quaternary Science Reviews (‘On the reconstruction of Pleistocene ice sheets’; Andrews, J.T., 1982). It set out an agenda for data-modelling interactions in what we now call palaeoglaciology. It argued that empirical geomorphological and geological data should be used in combination with the newly developing field of numerical ice sheet modelling. Indeed so, but a proverb says ‘you can lead a horse to water but you can’t make him drink’. I will outline the slow but vital growth of data-modelling interactions pondering why it has taken us so long and suggest that the horse is now very thirsty. Plans and progress on the BRITICE-CHRONO project that is reconstructing the demise of the last British-Irish Ice Sheet will be used to illustrate the talk.

Niall Gandy – The University of Leeds

Lauren Gregoire - The University of Leeds Jeremy Ely - The University of Sheffield
David Hodgson - The University of Leeds Chris Clark - The University of Sheffield
Dayton Dove - British Geological Survey Tom Bradwell - The University of Stirling

Modelling the Retreat of the Minch Palaeo Ice Stream, NW Scotland

The pattern and timing of retreat of the last British Irish Ice Sheet has been constrained in more detail than any other palaeo ice sheet through the work of the Britice-Chrono project. The Minch Palaeo Ice Stream flowed NW from the Scottish Highlands to the continental shelf edge, and retreated from 30-16ka BP. The ice stream is thought to have been laterally topographically constrained, and on a reverse slope, suggesting it may have been subject to Marine Ice Sheet Instability. Evaluating the role of these mechanisms in the timing and rate of past ice sheet retreat is important since the effects of topography and marine ice sheet instability are major sources of uncertainty in projections of Antarctic ice sheet response to climatic warming and future sea level rise. Using the palaeo record it is possible to study timescales far greater than observations of the contemporary record allow. Here, we test if topographic influence and Marine Ice Sheet Instability were influential during the retreat of the Minch Palaeo Ice Stream. We use BISICLES, an adaptive mesh ice sheet model capable of efficiently and accurately simulating marine ice sheets, to simulate the retreat of the Minch Palaeo Ice Stream. Empirical reconstructions of the ice stream were used to inform simulation set-up. We ran a series of model simulations to isolate the influence of topography on the retreat of the ice stream. Experiments with a step-change climate perturbation reveal a non-linear volume and area response, caused by instabilities from basal topography and Surface Mass Balance change. Experiments also reversed climate forcing periodically to test for instabilities in ice advance and retreat. We found that the retreat pattern of the Minch was influenced by instabilities once retreat was established, and mapped a retreat margin beyond which the simulated ice stream did not recover to LGM extent given LGM forcing. The model results have been compared to extensive geomorphological data, comparing margin geometry and spacing.

Dr Lauren Gregoire – University of Leeds

James Salter, University of Exeter, UK Daniel Williamson, University of Exeter, UK
Tamsin Edwards, The Open University, UK

Searching for the deglaciation: sampling spatio-temporal climate uncertainty for simulating ice sheet evolution

Ice sheet models fail to reproduce reconstructed patterns of Northern Hemisphere ice sheet retreat through the last deglaciation (21,000-6,000 years ago) without tuning of the climate input. This is the main barrier to understanding the role of ice sheets in past abrupt climate and sea level changes. The primary reason for this failure is the large climatic uncertainty. We developed a statistical method to systematically explore the uncertainty in the temporal and spatial evolution of climate (temperature and precipitation) through this period, by combining output from transient General Circulation Model (GCM) simulations of the last 21,000 years (from the FAMOUS and CCSM3 climate models) with proxy records of surface temperature changes. The method consists of decomposing the pattern of variability through time and space in an ensemble of transient climate simulations. Bayesian statistical methods were used to combine these patterns of variability to generate 500 time-evolving climate fields that match reconstructed temperatures within their uncertainty. With this, we ran 500 simulations of the North American ice sheet evolution from 21,000 to 6,000 years ago with the Glimmer-CISM ice sheet model, where climate and ice sheet parameters were simultaneously varied. We designed a metric to assess how well our results match the reconstructed evolution of ice sheet extent (Dyke, 2004). In the first wave of simulations, a systematic cold bias in the interior of the continent lead to a delay in the deglaciation of Alberta. The input climate was updated to optimise the simulated ice extent and the process was repeated for two further waves of simulations which produced improved results. This approach of running ensembles of simulations is crucial for understanding the response of ice sheets to past climate changes and the potential triggering of ice sheet instabilities, which lead to rapid sea level changes.

Jonathan Cripps – Simon Fraser University

Tracy Brennand, Simon Fraser University
Andrew Perkins, Simon Fraser University
Roger Denlinger, USGS Cascade Volcano Observatory
Julien Seguinot, ETH Zurich
John Gosse, Dalhousie University

Retreat of the last Cordilleran Ice Sheet over south-central British Columbia: field data and numerical models

The last Cordilleran Ice Sheet (CIS) of northwestern North American is likely a good analogue for the deglaciation of modern Greenland Ice Sheet, though a relative paucity of field studies limits its utility, particularly in its interior region. Competing conceptual models of the style of CIS deglaciation propose either regional stagnation (Fulton, 1991) or active marginal recession (e.g. Brennand and Perkins, 2017). Evidence from recent studies on the Interior Plateau, central British Columbia (BC), is here compared to results from the Parallel Ice Sheet Model (PISM; Seguinot et al., 2016). Field evidence presented from the northern Thompson Plateau region of BC include glaciotectonic moraines, ice-dammed lake sediments and landforms, grounding-line deposits and meltwater channels; these data record active ice front recession towards the north-northwest. New 10Be TCN dates give a deglacial age of c. 14.2 ka. This evidence is compared to results from the Parallel Ice Sheet Model for the CIS (Seguinot et al., 2017), showing good agreement. The reconstructed evolution of the ice-dammed lakes on the Thompson Plateau reveals potential glacial lake outburst floods. Campbell Creek, the drainage route of the largest lake at 160 km3, contains coarse boulder deposits interpreted as pendant, run-up, expansion and point bars. Downstream, a larger gravel deposit reveals upper flow regime sands and gravels, including trough-, dune-, sigmoidal and antidune cross-bedding. Numerical hydraulic modelling of this outburst flood conform well to the stage, velocities and shear stresses required to create these deposits, and reconstruct discharges in the range of 10^5 to 10^6 m^3/s. This research has elucidated more complex ice marginal and meltwater dynamics than previously proposed, and identifies the requirement for further research to be conducted on deglaciation across Interior British Columbia.

Dr Julien Seguinot - Laboratory of Hydraulics, Hydrology and Glaciology, ETH Zürich, Switzerland

Susan Ivy-Ochs[2]
[2] Laboratory of Ion Beam Physics, ETH Zürich, Switzerland

Modelled transfluences and crosswise divides of the Last Glacial Maximum alpine ice flow

During the Last Glacial Maximum (LGM), Alpine glaciers extending far onto the foreland coalesced to form a continuous ice expanse 750 km across. Ice flow was largely governed by subglacial topography, yet perched glacial deposits and high-altitude erosion marks show that Alpine glaciers occasionally flowed across major topographic features. This explains why the Alpine ice complex has alternatively been referred to as an ice cap (surface topography-controlled flow), an ice field (basal topography-controlled flow) and a network of valley glaciers. Here, we use the Parallel Ice Sheet Model (PISM) to model the entire last glacial cycle (120–0 ka) in the Alps, and analyse ice flow patterns during the LGM. The modelled fast-flow regions generally occur along the main river valleys, while ice domes and ice divides are predominantly located over major reliefs. Nevertheless, the model results depict ice flow across mountain passes (transfluences) in 55 locations, ice divide above topographic lows (hereafter referred to as crosswise divides) in 27 locations (preliminary numbers), and self-sustained ice domes characteristic of ice caps in two locations over Flüelapass and Ötztal. In the Eastern Alps, modelled transfluences and crosswise divides are generally incompatible with geological reconstructions, indicating that climate deterioration was overestimated in the model input. In the Western Alps, however, transfluences generally occur where they have been documented by geologic evidence. Interestingly, crosswise divides are often found over valley bottlenecks where glacial erosion has apparently been less efficient. These model results depict the LGM Alpine ice complex as an intermediate between ice fields and ice caps, bearing characteristics of both and perhaps no modern analogue.

Dr Bethan Davies - Royal Holloway University of London

Michael J. Hambrey[2], Neil F. Glasser[2], Tom Holt[2], Angél Rodés[3], John L. Smellie[4], Jonathan L. Carrivick[5], Simon Blockley[1]
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Holocene dynamics of Marguerite Trough Ice Stream and George VI Ice Shelf, Alexander Island, Antarctic Peninsula

We present new data regarding the past dynamics of Marguerite Trough Ice Stream, George VI Ice Shelf and valley glaciers from Ablation Point Massif on Alexander Island, Antarctic Peninsula. This ice-free oasis preserves a geological record of ice stream lateral moraines, ice-dammed lakes, ice-shelf moraines and valley glacier moraines, which we dated using cosmogenic nuclide ages. We provide one of the first detailed sediment-landform assemblage descriptions of epishelf lake shorelines, and compare our ice-stream reconstruction with numerical model outputs. Marguerite Trough Ice Stream imprinted lateral moraines against eastern Alexander Island at 120 m at Ablation Point Massif. During deglaciation, lateral lakes formed in the Ablation and Moutonnée valleys, dammed against the ice stream in George VI Sound. Exposure ages from boulders on these shorelines yielded ages of 13.9 to 9.7 ka. Following recession of the ice stream, George VI Ice Shelf formed in George VI Sound. An epishelf lake formed at 15-20 m asl in Ablation and Moutonnée valleys, dated from 9.4 to 4.6 ka, suggesting that the lake was stable and persistent for some 5000 years. Lake-level lowering occurred after this, with the lake level at 12 m at 3.1 ± 0.4 ka and at 5 m asl today. A readvance of the valley glaciers on Alexander Island at 4.4 ± 0.7 ka is recorded by valley glacier moraines overlying epishelf lake sediments. We speculate that the glacier readvance, which occurred during a period of warmth, may have been caused by a dynamic response of the glaciers to a lowering in surface elevation of George VI Ice Shelf.

Julian Martin - Centre for Quaternary Research, Department of Geography, Royal Holloway, University of London

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Combining glacial geomorphology, sedimentology and glacier modelling to determine drivers of Late Pleistocene and Holocene glacier fluctuations, Monte San Lorenzo Ice Cap, Patagonia

Late Pleistocene and Holocene fluctuations of outlet glaciers of Monte San Lorenzo ice cap, on the eastern and leeward side of the North Patagonian Icefield, could yield insights into past climate change. Glacier modelling, alongside a clear understanding of the glacial processes and landsystems that once operated, can be used to gain these insights. Here we use a combination of geomorphology, sedimentology, cosmogenic nuclide dating, and glacier modelling to determine the drivers of past glacier change. Remotely sensed and field-based geomorphological mapping revealed large arcuate terminal moraines, lateral moraines, deltas and lake sediments in valleys north of the current ice cap. These features show a complex history of glacier-lake interaction. From our mapping, we have identified nine glacier margins, both subaerial and subaqueous. A detailed process-based sediment-landform study in an upcoming field season will feed directly into developing an accurate reconstruction of glacier-lake interactions. Cosmogenic nuclide dating of glacially transported boulders from subaerially deposited moraine ridges is currently in progress. When combined with our reconstructions of ice extent, these ages will constrain a new chronology of glacier dynamics through the late Pleistocene and Holocene for Calluqueo Glacier. Using this chronology as a point of reference with which to test a numerical glacier model (PISM) (Bueler and Brown 2009), this study will determine the main drivers of late Pleistocene and Holocene glacier dynamics at Monte San Lorenzo, and provide an envelope of past climatic conditions during this period. The aim of this talk is to present our new geomorphological mapping and provide an overview of the modelling approaches used by this study.
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Dr Timothy T Barrows – University of Exeter

Mills, S.C. School of Geography, Earth and Environmental Sciences, University of Plymouth, Plymouth, PL4 8AA Rowan, A. V. Department of Geography, University of Sheffield, Sheffield, S10 2TN Almond, P. C. Soil and Physical Sciences, Faculty of Agriculture and Life sciences, Lincoln University, Lincoln 7647

Glacial history of the Franz Josef moraine complex, West Coast, New Zealand

During the late Pleistocene, large piedmont lobes descended from the Southern Alps icefield of New Zealand onto the coastal plain. These glaciers deposited vast complexes of moraine and provide one of the most complete records of glaciation in the Southern Hemisphere. Dating the moraines has proven problematic. There are relatively few exposures with organic material suitable for radiocarbon dating meaning that existing chronologies are restricted to a few sites only. Without satisfactory dating, it is problematic to explore the climate change responsible for the series of glacier advances and retreats. In this paper we present new dating in the form of cosmogenic nuclide exposure ages and tephrochronology to constrain the ages of the moraine complex deposited by the Franz Josef Glacier. Unlike the Waiho Loop, moraines seaward of Lake Mapourika have broader crests and are less affected by fluvial undercutting, making crest preservation more likely. To determine the likely range of climate variables responsible for each dated glacier advance over the last glacial cycle, we reconstructed the positions of the glacier using a 2-D glacier energy–mass balance and ice flow model. The glacier model was applied using present-day climate relationships and tuned to simulate the observed glacier extent and estimated ice thickness and modern equilibrium line altitude. To discover the optimal values for each of the climate variables defined as model inputs, we performed sensitivity experiments using a realistic range of values for each variable based on those observed for the Franz Josef Glacier region. To simulate palaeoglacier extent and ice thickness in the past, we imposed step changes in mean annual air temperature and precipitation amount, and compared these results with glacier extents indicated by the position of terminal moraine crests. Maximum cooling of 6 °C to 7 °C without precipitation change is required to advance the ice to the maximum extent on the coastal plain. Our data-model comparison allows us to test some of the existing paradigms concerning temperature- versus precipitation-dominated glacier forcing in New Zealand.

Lauren Knight – Univeristy of Portsmouth

C.M. Boston, H. Lovell and N. Pepin (all University of Portsmouth)

Younger Dryas cirque glaciers in the Wicklow Mountains, Ireland, and the significance of local topo-climatic factors.

The Wicklow Mountains are a key region for understanding the extent of glaciation in the east of Ireland during the Younger Dryas (YD; 12.9 – 11.7 ka BP). The area has important implications for the understanding of both local and regional palaeoclimate due to its location between the mountains of western Ireland and mainland Britain, where YD climate has been inferred from glacier reconstructions. Similar work has recently been undertaken in the Mourne Mountains and Snowdonia, increasing understanding of upland glaciation during the YD. Traditionally, the Wicklow Mountains have been considered to be marginal for YD glaciation, characterised by small cirque glaciers at just a few locations. The only existing investigation of YD glacier extent is at the type-site Lough Nahanagan, where a series of moraines within the cirque lake have been radiocarbon dated to 11.5 ka BP. Here, we present the first detailed examination of YD glaciation style and extent in the Wicklow Mountains. This is compiled through a combination of geomorphological mapping, morphostratigraphy, and radiation and snowblow modelling. The combined approach allows us to establish the limits of viable YD glaciers in the Wicklow Mountains, adding to growing evidence for cirque glaciation in upland areas of Ireland during the stadial. We demonstrate that not all cirques in the Wicklow Mountains were occupied during the YD. Radiation modelling shows that cirques with southern and south-eastern aspects received high levels of solar insolation. Geomorphological evidence indicative of YD glaciation is also absent in these cirques. In contrast, all potential YD sites identified through morphostratigraphy received lower levels of solar insolation than surrounding areas due to a combination of topographic shading and aspect. Furthermore, snowblow modelling suggests that the redistribution of snow by wind played an important role in providing additional mass to the surface of some cirque glaciers. 3D reconstructions of the YD glaciers are presented along with their calculated equilibrium line altitudes (ELAs), enabling inferences about palaeoclimate to be made. We conclude that local topo-climatic factors, including solar insolation and snow blow, were critical for glacier initiation and survival during the stadial.

Dr Sven Lukas - School of Geography, Queen Mary University of London

Marie Busfield, Geography & Earth Sciences, Aberystwyth University, Aberystwyth, SY23 3DB

Solving the puzzle of an isolated high-Alpine drumlin: Hornkees, Austria

Larger streamlined landforms, in particular drumlins, are frequently found in lowland environments where they attest to fast ice flow; they are comparatively rare in upland environments where smaller streamlined landforms (i.e. flutes) and erosional landforms (e.g. ice-moulded bedrock) are much more prominent. We here report geomorphological and sedimentological field observations from a small drumlin formed during the last c. 200 years in the foreland of Hornkees, a small valley glacier in the Eastern Alps. This drumlin is located in the middle of the valley floor, upvalley of a bedrock obstacle, and consists of overridden and glaciotectonised outwash overlain by subglacial traction till of varying consistency. Using lithofacies analysis, clast fabric and clast shape data as well as structural measurements (e.g. of shear planes and fold axes) and in-situ soil penetrometer measurements we demonstrate that this drumlin is likely to represent one of the rare cases in upland environments where the primary mechanisms of fast flow and subglacial sediment deformation have been preserved and can thus be studied in detail. We present our dataset with the aim of generating discussion of these mechanisms and outline the significance of such rare cases as modern analogues not just for palaeo-studies, but also for our understanding of material properties from engineering-geological and modelling standpoints.

Dr Caroline Clason – University of Plymouth

Caroline Clason[1*], Will Blake[1], Nick Selmes[2], Geoff Millward, Alex Taylor & Stephanie Mills[1]
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Reconstructing historical deposition of environmental pollutants from glacial sediments: a case study from Isfallsglaciären, Sweden.

Glaciers can be stores for environmental pollutants that have been scrubbed from the atmosphere (Bogdal et al., 2009) or deposited onto the snow/ice surface, with the release of glacial meltwater potentially acting as a secondary source of contamination in proglacial environments years after the initial source was active (Franz & Eisenreich, 1998). Fieldwork was conducted in the Isfallsglaciären catchment of the Tarfala Valley in Arctic Sweden during the summer of 2017 as a case study for historical contaminant transport through glacier systems. Isfallsglaciären is a small polythermal glacier which has been steadily retreating over the last century (Karlén, 1973), with meltwater and sediments released from the glacier collecting in two proglacial lakes (Frontsjön and Isfallssjön). The region received fallout from the Chernobyl nuclear accident, offering an important marker to test the hypothesis of contaminant concentration in the glacier system through interaction with cryoconite and other glacial sediments. Sediment samples were collected in the supraglacial and proglacial environments and a core extruded from Isfallssjön. The sediment samples are being analysed for fallout radionuclides (FRNs) and naturally occurring radioactive elements by gamma spectrometry, and a full suite of major and minor elements by wavelength-dispersive X-Ray fluorescence, and the lake core is being analysed for FRN markers, including excess Pb-210 and Cs-137 from 1960s weapons testing and the Chernobyl nuclear accident, that can be used to construct a timeline for sediment accumulation and contamination. The ultimate goal of this research is to determine whether inorganic atmospheric pollutants are concentrated through capture by snowfall and interaction with glacial sediments, and to investigate whether contaminants released through melting are enriched in fine sediment to potentially harmful levels. This research will provide information on historical sedimentation rates and sediment sources in the Isfallsglaciären catchment, and offer an important insight into the potential vulnerability of pristine Arctic environments to contaminant-enriched sediments released from glaciers as they continue to retreat in response to a warming climate.

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Harry E. Langford - Research Fellow, Department of Geography, Environment and Development Studies, Birkbeck University of London

The Cromer Ridge, North Norfolk, England: a late Middle Pleistocene subaqueous record of a shoreward prograding ice grounding line

Two subaqueous diamictic facies dominate the Anglian sequence on the North Norfolk coast: Happisburgh diamicton (HD) and Bacton Green diamicton (BGD). The former has either folded Chalk bedrock or Chalk rafts of varying size, which are present only to the east of Sheringham. Chalk was sourced offshore from the north by erosion of a Chalk headland. The BGD has an influx of ferruginous fines, large pockets of sand and gravel and, to the west of Sheringham, of extremely chalk-rich diamictons. Sand and gravel appear to be sourced from a glacial portal to the north of Britons Lane/Sheringham. Extremely chalk-rich diamictons deposited by cohesive flow were probably sourced from an ice lobe associated with the Blakeney esker to the west; the ice lobe was responsible for the extensive erosion of Chalk between Weybourne and Huntingdon. Something happened between deposition of the HD and BGD that would explain the observed differences between them, and this I suggest was coincident with high-magnitude grain flow and subaqueous slide deposits in the Peterborough area. One of these may have been the trigger, as result of ice advance on the Lincolnshire Wolds for example, responsible for breaching at the Dover Strait and the first flood event recorded in the English Channel: although both deposits may have been in response to a different trigger event, e.g. final emplacement of Chalk rafts associated with the HD. Subsequent lowering of water level allowed terrestrial advance of ice southward along the Chalk escarpment between Weybourne and Hunstanton, thereby deforming the wet sediment to the southeast and east and building the Cromer Ridge. The emplacement of Chalk bodies in the HD topographically influenced the deposition of the BGD and its synformation deformation. Ice also advanced to the west of The Wash, sourcing a sandur at Norman Cross (southwest of Peterborough), which interdigitates with subaqueous deposits at 30 m OD.

Keynote Speaker

Professor Roland Gehrels – University of York

Sea-level changes during past centuries reconstructed from salt-marsh sediments

Salt marshes are capable of recording decimetre-scale sea-level variations with high precision and accuracy. Sea-level records derived from microfossils preserved in salt-marsh sediments are ideally suited to bridge the gap between instrumental and palaeosea-level observations. The resolution of these proxy sea-level records depends on the sedimentation rates in the marshes and is usually on the order of one or two data points per decade. High-quality sea-level reconstructions from salt-marsh sediments have now been established for coastal sites in eastern North America (Nova Scotia, Connecticut, New Jersey, North Carolina, Florida), Europe (Iceland, Scotland, England, northern Spain), New Zealand and Tasmania. New and improved records for Nova Scotia, Maine, Connecticut, the Falkland Islands and New Zealand, currently being prepared for publication, will be presented in this talk. These records are generally dated by AMS14C, but additional techniques are critical to provide chronology for the last ~400 years, including radiometric dating (210Pb, 137Cs, 241Am), stratigraphic markers (e.g., pollen, tephra, Pb concentrations, Pb isotopic ratios, metals, palaeomagnetism), high-precision Accelerator Mass Spectrometry (AMS) 14C dating and bomb-spike AMS14C analyses. Many salt-marsh records show that around the turn of the 20th century the rate of sea-level rise started to exceed the background value that prevailed during preceding centuries. The magnitude of this sea-level acceleration appears to be larger in sites in the Southern Hemisphere compared to the North Atlantic, a difference that is not well understood. The acceleration is muted in the eastern Atlantic compared to the western Atlantic. In the NW Atlantic, salt marshes contain evidence for periods of accelerated sea-level rise that pre-date the 20th century. When averaged across the globe, salt-marsh sea-level records show that the highest rates of sea-level rise of the last ~3000 years were achieved during the 20th century.

Dr Robert Barnett – University of Exeter

Bernatchez, P. Université du Québec à Rimouski, Canada. Stephenson, D.B. University of Exeter, UK. Charman, D.J. University of Exeter, UK. Gehrels, W.R. University of York, UK. Garneau, M. Université du Québec à Montréal, Canada. Strachan, K.L. University of Witwatersrand, South Africa.

Natural internal variability can double rates of secular sea-level rise across multi-decadal timescales

Rising global sea levels are a concerning consequence of global warming. However, neither the pattern nor rates of sea-level rise are uniform across the globe due to the varying influences of different mechanistic components. These complexities primarily arise from patterns of isostatic adjustment, the geophysical fingerprints of meltwater and steric contributions and multi-scalar variability driven by ocean-atmosphere modes. The contributions of these components to spatially and temporally variable sea-level rise over recent centuries to millennia remain imprecisely defined and little is known about how internal variability influences secular sea-level trends at time scales that go beyond the satellite era. Here we develop a novel statistical approach to define non-linear secular sea-level trends and quantify internal variability from residual trends within sea-level reconstruction records. We apply this technique to precise sea-level data generated from salt-marsh sediments that provide independent records of sea-level change spanning recent centuries to millennia. Our results demonstrate that natural internal variability can contribute an additional 100% to rates of secular sea-level rise across multi-decadal to centennial timescales. Defining the internal structure within these records is necessary for examining the role of natural versus anthropogenic variability and for identifying the role of processes that drive ocean mass redistribution upon background ocean volume changes.

Andy Emery - Stratigraphy Group, School of Earth and Environment, University of Leeds

David Hodgson[1], Natasha L. M. Barlow[1], Jonathan Carrivick[2], Carol Cotterill[3], Adam D. Booth[1]
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Holocene relative sea-level change: influences on sedimentary processes and stratigraphy at Dogger Bank

Dogger Bank, in the Southern North Sea, experienced marine transgression during rapid postglacial relative sea-level rise in the Holocene. The rate of relative sea-level rise and corresponding marine flooding provides an excellent analogue to study the effects of future sea-level rise on coastal realignment and inundation processes. A dense grid of 2D seismic reflection data and vibrocores acquired for the Forewind windfarm project provide a unique dataset to study these process interactions. Glacio-isostatic adjustment models show relative sea-level rise at Dogger Bank during the Holocene was not constant. The early Holocene is characterised by rapid rise, whereas during the late Holocene the rate was slower. The timing of the reduction in the rate of rise is unknown. Sea-level 'jumps', such as that prior to the 8.2ka cooling event, can also change the rate of RSL change over short time periods. Investigation of vibrocores from the south-east of Dogger Bank reveals a significant amount of palaeoenvironmental change within six metres of sediment. A transgressive sequence, from salt marsh, through intertidal flat to shallow marine sands, overlies glacial sediments. A single sea-level index point from the salt marsh peat constraints the local transgression to ~9100 ka cal BP. This generally low-energy assemblage is punctuated by high-energy events, denoted by sandier, poorly-sorted units with pebble-grade clasts. Calibration of the core stratigraphy to seismic reflection data allows the identification and correlation of seismic facies. Key transgressive surfaces have been mapped to understand the distribution and evolution of coastal geomorphology and sedimentary environment during relative sea-level rise. Diatom analysis helps to constrain sedimentary environments preserved in the cores. However, the rate of relative sea-level rise during this time is poorly constrained, therefore the roles of accommodation and supply during transgression are poorly understood. Further seismic mapping and core logging will help improve understanding these relationships.

Dr Matteo Vacchi – University of Exeter

Rita T. Melis, University of Cagliari, Italy. Matthieu Ghilardi, Aix-Marseille Université, CNRS-CEREGE, France. Giorgio Spada, Università degli Studi di Urbino, Italy. Matthieu Giaime, Aix-Marseille Université, CNRS-CEREGE, France.

Improving our current understanding of the Mediterranean isostatic pattern. New data from the bulk of the basin.

Our understanding of current rates of sea-level rise from tide gauges or satellite data, requires correction for glacio and hydro-isostatic (GIA) effects that can be quantified using observations of former sea levels. GIA related deformation in the Western Mediterranean is mainly controlled by water-loading, which resulted in a widespread subsidence, especially in the bulk of the basin (Lambeck and Purcell, 2005; Stocchi and Spada). We improved the quality of spatio-temporal sea-level reconstruction in a number of Mediterranean regions affected by minimal neotectonic activity and located in the bulk of the basin (e.g. Baleares, Corsica and Sardinia Islands) where GIA models predict the maximal hydro-isostatic contribution. In these regions, conflicting sea level histories and poor quality sea-level data did not allow to robustly assess the RSL history and, consequently, the isostatic contribution in the area (Vacchi et al., 2016). The newly assembled database increases significantly our knowledge in the RSL pattern in this portion of the Mediterranean Sea. The total plot of the index points clearly show a rapid rising rates in early-Holocene (~12.0 to ~8.0 ka BP) followed by a sudden slowdown of the rising rates between in mid-Holocene (~7.5 and ~4.0 ka BP) and eventually, by minimal changes in the late Holocene (~4.0 ka BP). However, magnitude of the rising rates shows variability among sites. The new dataset indicates that the largest isostatic contribution, recorded in southern Sardinia, is significantly lower that the one predicted by the GIA models (Lambeck and Purcell, 2005). Furthermore, data show that the isostatic pattern in the bulk of the Western Mediterranean is not uniform being affected by significant variability. This strongly conflicts with all the presently available GIA models that are currently used to assess the future sea level rise along the Mediterranean coasts.

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01

James Allard – University of Manchester

Schmidt Hammer Exposure-age Dating and the Deglacial Chronology of the Welsh Ice Cap in North-west Wales

Schmidt Hammer exposure-age dating (SHED) was employed at 59 sites of granite lithology in the Carneddau, Glyderau, Nantlle and Lleyn Peninsula mountains in North-west Wales. Arithmetic mean r-values and relative exposure ages infer vertical thinning of the Welsh Ice Cap to ~550m at ~19.47ka in the Northern Carneddau, and ~18.95ka on the Nantlle ridge. Thus inferring the exposure of Llwytmor (849m), Mynydd Mawr (698m) and the Mynydd Drws-y-coed arête (695m) as nunataks during deglaciation of the Welsh Ice Cap between ~20-18ka. A significant latitudinal relationship is evident on the Lleyn Peninsula, p = <0.01, with r-values increasing from r = 27.93±6.8 at 52.85oN on Mynydd Tir-y-cwmwd, to r = 38.93±7.48 at 53.01oN on Bwlch Mawr, relative to the northwards retreat of the Irish Sea Ice Stream. The southern Lleyn Peninsula, <52.89oN underwent deglaciation ~20.96±2.39 - 22.79±2.27ka BP, whilst ice persisted to ~400m in the Northern Lleyn Peninsula hills until ~17.98±2.5ka (arithmetic mean of samples LP-01 - LP-12). Relative exposure ages >20ka that correlate with thinning of the Welsh Ice Cap and local 36Cl dates, highlights the suitability of SHED and the granite calibration curve for the dating of granite bedrock surfaces beyond Holocene timescales (Hughes et al 2016; Tomkins et al 2016). Moreover, improvements towards the development of a robust calibration curve for Ordovician felsic ash-flow tuff lithology (p = 0.11), holds further potential for the SHED technique in geomorphological research.

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02

Natasha Barlow

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Relative sea-level variability during the late Middle Pleistocene: new evidence from eastern England

Unravelling patterns of relative sea-level change during previous interglacials enhances our understanding of ice sheet response to changing climate. Temperate-latitude estuarine environments have the potential to preserve continuous records of relative sea level from previous interglacial (warm) periods. This is important because, currently, we typically only have snapshots of sea-level highstands from low-latitude corals and raised palaeoshoreline indicators while the (continuous) deep-sea oxygen isotope record only provides indirect evidence of sea-level changes. Here, we focus on the Nar Valley in eastern England, in which is preserved evidence of a late middle-Pleistocene marine transgression more than 20 vertical metres in extent. By applying a model of coastal succession and sea-level tendencies, as used in Holocene sea-level studies, we assess the mode (abrupt versus gradual) of sea-level change recorded by the interglacial Nar Valley sequences. Compiled palaeo-stratigraphic evidence comprising foraminifera, pollen and amino acid racemization dating, suggests that the mode of sea-level change in the Nar Valley interglacial sequence was gradual, with potentially two phases of regional transgression and relative sea-level rise occurring at two separate times. The first phase occurred during the latter part of marine oxygen isotope stage (MIS) 11 from ~8 to 18 m OD; and, the second phase potentially occurred during early MIS 9 from ~-3 to 3 m OD (with long-term tectonic uplift included in these estimates). We cannot conclusively preclude an alternative MIS 11 age for these lower sediments. The lack of indicators for rapid sea-level oscillations in the Nar Valley adds weight to an argument for steady melt of the ice sheets during both MIS 9 and 11.

03

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Putting palaeo- into ecology

The British Ecological Society is a major presence in ecology in northern Europe, for both academics and conservation practitioners. It is large enough (typical annual meeting attendance is 1500-2000 people) that it supports a series of Special Interest Groups which exist to provide a focus for a specific aspect of ecology, bring together a community, support ECRs and networking, and communicate beyond the Society – examples which have had some Quaternary relevance over the years include the Peatlands Group and the Tropical Ecology Group. We have begun the process of setting up a Palaeoecology Special Interest Group, which will focus on bringing long-term ecological datasets and palaeoecological methods to the attention of a wider ecological community, and on creating opportunities for better collaboration and research across our disciplines. We believe the SIG will be of interest and benefit to Quaternary palaeoecologists of all kinds. It will benefit from the support of a large and successful learned society, which employs full time staff specialising in matters such as communication with policy makers and education and outreach, and also supports SIGs financially to arrange workshops and themed short conferences annually, which can be run in partnership with other societies such as the QRA. We are currently at the stage where we have to demonstrate that there is interest in and support for a SIG both within current BES membership and beyond it, and would ask any interested QRA members to email Jane Bunting (m.j.bunting@hull.ac.uk) to be added to our mailing list.

04

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The Potential of a Gridded Tree Ring δ18O dataset: Model Versus Measurement Comparison

Using climate proxies it is possible to evaluate the performance of general circulation models (GCMs) over longer periods than is possible using instrumental data alone. The inclusion of stable water isotope fractionation in GCMs provides a more direct comparison of GCM outputs with measured stable water isotopes (Sturm et al., 2010) and potentially proxy records of oxygen isotope variability. Tree rings provide a source of annually dated stable oxygen isotope (δ18O) values, which are strongly related to the δ18O of summer precipitation (Young et al., 2015). The δ18O of annually-resolved oak (Quercus spp.) tree ring series from across the UK, were interpolated using Empirical Bayesian Kriging (Krivoruchko, 2012), producing a gridded δ18O dataset for the last 100 years. Modelled results were compared to measured δ18O, modelled tree ring δ18O and climatic parameters. When compared to measured δ18O values, all predicted series are closely related. Spatial field correlations with climatic variables and modelled tree ring δ18O demonstrate significant correlations over large regions. With the purposeful development of a spatially homogenous dataset, the results demonstrate the potential of this method for developing a high temporal and spatial resolution δ18O field, which could be used to evaluate GCMs and to infer past climatic changes. References Krivoruchko, k, 2012. Empirical Bayesian Kriging [WWW Document]. ArcUser. URL

http://www.esri.com/news/arcuser/1012/files/ebk.pdf (accessed 6.26.17). Sturm, C., Zhang, Q., Noone, D., 2010. An introduction to stable water isotopes in climate models: benefits of forward proxy modelling for paleoclimatology. Clim. Past 6, 115–129. doi:10.5194/cpd-5-1697-2009 Young, G.H.F., Loader, N.J., McCarroll, D., Bale, R.J., Demmler, J.C., Miles, D., Nayling, N.T., Rinne, K.T., Robertson, I., Watts, C., Whitney, M., 2015. Oxygen stable isotope ratios from British oak tree-rings provide a strong and consistent record of past changes in summer rainfall. Clim. Dyn. 45, 3609–3622. doi:10.1007/s00382-015-2559-4

05

Josie E. Duffy – Swansea University

Is there a huge age trend in oak tree-ring stable isotopes?

A perceived advantage of stable isotopes in tree rings is that they do not contain long-term age-trends and thus do not need to be de-trended. However, it has recently been suggested, on the basis of comparing carbon isotope ratios from the recent rings of many trees of different size and age, that oak trees should show a strong increasing trend that persists throughout the lifetime of the tree (Brienen et al. 2017). The authors conclude that "developmental trends in broadleaf species are as large as the trends previously assigned to CO2 and climate", calling into question the credibility of work using these powerful proxy archives.

We test the prediction of a strong and persistent positive trend in stable carbon isotope ratios using living UK oak trees but also remove the complicating effects of rising CO2 levels and of anthropogenic climate change by using oak timbers that pre-date the industrial era. We find no evidence to support the prediction of a strong and consistent rising trend. On the contrary, juvenile trends are very short (Duffy et al. 2017), and about half of the pre-industrial trees show a very small rising trend and about half a similar trend in the opposite direction, as would be expected if there was no consistent age trend. The same applies to oxygen isotope ratios.

The experiment on which Brienen et al. (2017) base their results could not fully separate the effects of light level, which is the main control on carbon isotope fractionation, and of tree developmental stage (height and age). Our results clearly demonstrate that tree developmental stage is not the likely cause of the spatial variations and the predicted strong trends in oak carbon isotope time series do not exist.

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Duffy, J.E., McCarroll, D., Barnes, A., Ramsey, C.B., Davies, D., Loader, N.J., Miles, D. and Young, G.H., 2017. Short-lived juvenile effects observed in stable carbon and oxygen isotopes of UK oak trees and historic building timbers. *Chemical Geology*, *472*, 1-7.

06

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Chris Clark - Department of Geography, The University of Sheffield Richard Hindmarsh - British Antarctic Survey, Cambridge Anna Hughes - Department of Earth Science, University of Bergen and Bjerknes Centre for Climate Research Sarah Greenwood - Department of Geological Sciences, Stockholm University Sarah Bradley - Department of Geoscience and Remote sensing, Delft University of Technology

Using geomorphological and geochronological data to validate palaeo-ice sheet models: Application to the British-Irish Ice Sheet

Numerical ice sheet models are powerful tools for studying the behaviour of palaeo-ice sheets. However, limitations in the understanding and representation of glacial processes, model parameterisations, unknown boundary conditions and poorly constrained palaeo-climate forcings mean that uncertainty is inherent in using models to simulate palaeo-ice sheet behaviour. To explore this uncertainty, ensemble modelling experiments resulting in hundreds to thousands of simulations of palaeo-ice sheets are conducted, whereby each simulation is conducted with perturbations of uncertain input quantities. To assess the degree to which these simulations replicate past ice sheet behaviour, ice sheet modellers require observational data against which models can be validated. However, model-data comparison procedures are underdeveloped and underutilised, with optimal simulations from modelling experiments of palaeo-ice sheets often based on visual comparison to empirical reconstructions or discussion of the relevant literature. Here, we demonstrate quantitative approaches to model validation using the geomorphological and geochronological data collated and collected by the BRITICE-CHRONO consortium project. Three lines of evidence are used to evaluate the degree to which models replicate: (i) the position and shape of former margin positions recorded by moraines; (ii) former ice flow direction and flow switching recorded in flow-sets of subglacial bedforms; and (iii) the timing of ice-free conditions derived from geochronological data. To demonstrate the utility of these tests, we apply them to a subset of three simulations of the last British-Irish Ice Sheet from a larger ensemble. This work shows how geomorphological and geochronological data can be used to quantify model performance, and highlights the need to integrate geomorphological and geochronological evidence into palaeo-ice sheet modelling experiments.

07

Dr Marta Fiacconi – Liverpool John Moores University

Prof. Chris Hunt, Liverpool John Moores University

Tracing the past by understanding the present: patterns and processes of pollen in caves

Cave sediments may contain important long-term records of past environments and human activity. Pollen provides key evidence, since it disperses widely and is relatively durable. The interpretation of the fossil pollen record in caves is mostly based on taphonomic models which have been realised based on conventional open-air sedimentary environments. However, we still know relatively little about the dispersal and preservation of pollen into caves mostly because the number of interconnecting factors affecting these processes. We explore some of these factors in transects of surface samples from caves in the Zagros Mountains of Kurdish Iraq, including the archaeological site of Shanidar Cave. Simple sac-like caves shows clear pattern in pollen distribution with percentages of anemophilous taxa declining from the front to the rear of the cave and entomophilous taxa showing the opposite trend. This pattern is less clear at Shanidar Cave, most probably because of the geometry of the cave but also because of the disturbance and mixing of the superficial sediments caused by the large numbers of people visiting the site. Iso-lines map of pollen distribution show the highest concentrations following a path from front to back down the axis of the cave and another path from front to right, where the entrance of the second small chamber and a spring are located. This probably reflects the path tourists and animals would have taken in the cave and suggests that some of the pollen came in and was spread into the cave on visitors' animals feet. Other factors, such as the presence of a cave entrance flora, are considered but here they seem to have little influence on the pollen assemblages, contrary to that found in temperate-zone caves.

08

Dr Rory Flood – American University of Cairo

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Provenance and depositional variability in the Holocene lower Ganges-Brahmaputra delta, West Bengal Sundarbans, India

The Sundarbans is one of the largest coastal wetland sites in the world and covers an area of approximately one million hectares of the western delta of the Ganges and Brahmaputra (G-B) rivers (located across Bangladesh and India). Since the late Holocene, the western delta has not been directly fluvially sourced, due to the Ganges shift to the east (present-day Bangladesh). The depositional facies (Thin Mud Facies) of the late-Holocene abandoned western region (The Sundarbans) is derived from dominant estuary-tidal dynamics, however the provenance of the associated TMF sedimentation in this far western zone (Indian Sundarbans per se) is as yet equivocal. In this study, sediment cores from the Indian Sundarbans (Saptamukhi-Thakuran estuary) were closely examined for grain-size distributions (GSDs), mineralogy through X-ray diffraction (XRD), and geochemistry with X-ray fluorescence (XRF). The TMF in the West Bengal Sundarbans has been determined to show intensively weathered, terrestrial sediment, derived principally from the Ganges Alluvial Plain (GAP). There is a predominance of quartz, mica and clay minerals, with quartz interpreted as a product of low-relief tropical weathering sourced via the G-B Rivers draining the Himalayas. Lithofacies interpreted through GSD analysis of the TMF is indicative of a muddy tidal flat environment with aggradation and a general fining-up trend between the adjacent estuaries. The sediment provenance indicates a continuing G-B sediment source, which moves westward along the Bay of Bengal, from the active delta front and is then reworked over the far-western abandoned delta by tidal–estuarine forcing.

09

Professor Ralph Fyfe – University of Plymouth

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Ecological consequences of moorland 'improvement' and development of baselines for peatland restoration

Moorlands and uplands are highly valued landscapes as they deliver a wide range of ecosystem services including: water supply to lowlands; locations for agricultural production (in particular seasonal grazing); internationally-important sinks of greenhouse gases including carbon and methane; and are locations favoured for recreational activities. They are also areas that preserve and conserve nationally-important cultural heritage, including the traces of past society. From the mid-19th century AD large areas of moorland were 'reclaimed', as part of moorland 'improvement' schemes to maximise economic production, with further enclosure and improvements following the second world war. Over the last decade major programmes of moorland 'restoration' have focussed on reversing the impacts of past moorland 'improvement', but little is known about ecological baseline conditions prior to improvement. Detailed pollen, macrofossil, testate amoebae and palaeoentomological work, alongside a programme of dating has been undertaken from within a restoration area on Exmoor. The results demonstrate a complex sub-recent (<1000 years) history of moorland land use, which had direct impacts on the ecology of the area. Significant changes in fauna and flora, including the development and subsequent loss of *Sphagnum*, and state shifts in testate amoebae assemblages, can be attributed to changing patterns of grazing, burning and drainage of the moorland. The implications of this are that land use has been complex through time, and any changes in land management (including restoration) are likely to have significant impacts on the ecology of the moorland. The notion of identifying, or restoring to, stable baselines, is discussed in the light of the palaeoecological data.

10

Madeleine Hann – University of Manchester

Mr. Stephen Watkins* Dr. Alex Whittaker * Dr. Rebecca Bell* *Earth Science and Engineering, Imperial College London

Drainage capture and reorganisation; a quantitative source to sink case study from the western Corinth Rift, central Greece

Source to sink sediment transfer is controlled by drainage organisation, therefore it is crucial to understand the occurrence, timing and mechanism of drainage reorganisation. The Corinth rift, Central Greece, which periodically becomes a lake during marine lowstands, is extending at up to 16 mm/yr., making it one of the most active rifts on Earth. The western Gulf of Corinth and its sub-basins provide a semi-closed systems in which to study the impact of sediment transport (locus and magnitude) on basin stratigraphy. For the first time, drainage reorganisation has been identified and quantitatively interpreted in the Gulf of Corinth. Tectonic uplift of the northern coastline, previously thought to be passively subsiding, is proposed as an external forcing for drainage reorganisation. Two significant catchments on the northern coast of the Gulf of Corinth were identified by fieldwork and 5 m DEM analysis: 1) the highly irregularly shaped 890 km3 Mornos River catchment, and 2) the 70 km3 Eratini River catchment, feeding the Eratini Sub-Basin. High strath terraces in both catchments show consistency with fluvial origin. River longitudinal profile re-construction from terraces illustrates a possible past drainage system, cross-cutting the modern Eratini/Mornos drainage divide. High resolution 2D seismic surveys of the Eratini Sub-Basin were used to estimate sediment volume of 7 km3, and 450 ky basin age. Total suspended sediment flux for the Eratini River has been estimated for the past 450 ky and 1 My using the empirically-derived BQART model (Syvitski & Milliman, 2007). Sediment volume in the Eratini Sub-Basin is consistent with sediment flux estimates from the current Eratini River from the past 450 ky. The results demonstrate the necessity to quantitatively consider drainage reorganisation in regions of active tectonics on Quaternary time scales, in order to understand basin stratigraphy.

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11

Dr Mark Hardiman – University of Portsmouth

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The landscape evolution of Santa Rosa Island, California, before and after Arlington Springs Man

The Late Quaternary sediments of Arlington Canyon, Santa Rosa Island, California have been the focus of intense investigation over the last several decades, spanning a range of different specialisms including archeology, palaeoecology and palaeontology. This interest has largely been driven by the discovery of two fragments of human femora found at the mouth of the canyon in 1954 (Orr, 1962). This find remains the oldest known human bones yet to be discovered in the Americas, dating to 13 ka BP (Johnson et al., 2002). Despite the international significance of the Islands no comprehensive chronostratigraphic scheme has ever been developed. Here, for the first time, an overarching stratigraphic framework is proposed for Arlington Canyon. This has been developed via the investigation of twenty sedimentary sections described both in terms of the sedimentological properties and features at both the macro (m-mm) and micro scale (mm-µm). Four phases of fluvial and alluvial sedimentation are identified and characterised between ~21 thousand years ago to the present. Our framework is underpinned by a comprehensive radiocarbon chronology. This allows sub-millennial fluvial reactions and landscape evolution to be identified and directly compared to the wider climatic and environmental backdrop of the Last Glacial-Interglacial Transition. The transition from the LGM to the Holocene is a period of rapid and complex paleoenvironmental change on Santa Rosa Island and worldwide. The sedimentology and stratigraphy of Arlington Canyon record the period of local megafaunal extinction, vegetation transition, and change in fire regime. Causal mechanisms are difficult to disentangle, but this sedimentary record provides the context and overlapping effects of human arrival and post-glacial climatic transition.

12

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Reconstructing Carbon Accumulation at Pyllau Cochion Bog, SW Wales: Assessing the Human and Climatic Impact

The world's peatlands hold ~30% of terrestrial carbon, representing an important component in the global carbon cycle. However, predicted atmospheric warming and shifts in hydrological regimes, coupled with persistent human interference, threatens to destabilise peatland carbon stocks, potentially creating a self-sustaining feedback loop that could trigger unprecedented runaway CO_2 emissions. Pyllau Cochion peat bog in Carmarthenshire, SW Wales, represents one of the most southerly, and in a warming climate, a threatened peatland in the UK. However, to date, no research has been conducted at this vulnerable site. An innovative multi-proxy palaeoecological approach is combined with a whole-basin geophysical reconstruction by GPR (Ground Penetrating Radar) to reconstruct both spatial and temporal changes in carbon accumulation. This interdisciplinary investigation, conducted in collaboration with Carmarthenshire County Council, will assess the human and climatic impacts on carbon accumulation and will inform appropriate management strategies to preserve peatland carbon stocks for the future. A radiocarbon-based age model constrains peat initiation to ca. 9900 cal yrs. BP and the charcoal record indicates that fire has been a recurrent feature of this landscape, throughout the Mesolithic and Neolithic periods, and in recent years, which is accompanied by a reduction in carbon accumulation. Future work will focus on the relationship between shifts in surface wetness and carbon accumulation at Pyllau Cochion and a nearby bog at Figyn. This research has contributed to a Heritage Lottery Funded project and the proxy reconstructions underpin a series of artist impressions of landscape changes, from the Younger Dryas to the present day, to promote public understanding of the bog sites and to conserve their future.

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Clay, G.D., Worrall, F., & Aebischer, N.J., (2015). *Carbon stocks and carbon fluxes from a 10-year prescribed burning chronosequence on a UK blanket peat*. Soil Use and Management, 31, 39-51.

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Sarah Holmes – University of Exeter

Paul Halloran - University of Exeter
Paul Butler - University of Exeter
John Aldridge - CEFAS
Johan van der Molen – NIOZ

Molluscs and Models in the North Sea

Of all marine proxies available, sclerochronology, the study of the growth bands on long-lived marine molluscs, is the only proven to provide novel, high resolution, multi-centennial, annually-resolved, absolutely-dated archives of past ocean environment, analogous to dendrochronology. This proxy is therefore extremely valuable considering that data of the marine environment is extremely spatially and temporally limited. In the shelf seas particularly, where over 90% of global fisheries are sustained, and as the interface through which society interacts with the marine environment, poor quality data is hindering the ability of decision-makers to estimate how this ecosystem will respond to pressures such as climate change impacts. As an alternative to observed data, modelling the shelf seas with biogeochemical models is used to better understand the marine environment but requires validation with empirical data. By combining the palaeoclimate records of sclerochronology with 3D and 1D modelling of the European Regional Seas Ecosystem Model (ERSEM) this research has the potential to better understand the North Sea environment and possibly improve predictions of future climate change in this region and beyond.

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Josephine Hornsey – University of Sheffield

Dr Ann Rowan, University of Sheffield; Dr Stephen Livingstone, University of Sheffield; Dr Duncan Quincey, University of Leeds; Dr Derek Fabel, SUERC; Dr David Rippin, University of York

Investigating glacier dynamics in the Himalaya; mapping and dating Little Ice Age moraines to predict glacier response to future climate change

The Himalaya contain the largest volume of glacier ice outside of the Polar regions, and these glaciers form the headwaters of the largest rivers in central Asia (Bolch et al. 2012). Predictions of future change in glacier volume and meltwater production contain large uncertainties because little is known about how these glaciers have behaved since their last advance during the Little Ice Age (LIA). Our current understanding of the LIA is relatively uncertain with only 66 moraine ages for 24 glaciers from across the entire mountain range (Rowan, 2017), and only sporadic studies into the landforms from this period. However, the data reveal that the timing and extent of the LIA advance varied regionally, likely due to the feedbacks between mass balance and high-relief topography, and the differing climatic regimes across the range. Due to increased availability of high resolution satellite and DEM data, areas which were previously inaccessible can now be mapped and analysed. Here we present initial mapping of the Late Holocene geomorphology of the Everest and Langtang catchments, and plans for fieldwork in the Everest catchment in spring 2018. Future work will involve remote sensing and fieldwork in the Garhwal catchment with the aim of developing a geochronology for all three regions, as well as remote sensing of currently inaccessible areas such as the Kashmir Himal and the Karakoram. This will feed into modelling glacier behaviour and subsequently future responses to climate change.

Bolch, T. et al., 2012. The State and Fate of Himalayan Glaciers. Science, 336(6079), pp. 310-314. Rowan, A., 2017. The 'Little Ice Age' in the Himalaya: A review of glacier advance driven by Northern Hemisphere temperature change. The Holocene, 27(2), pp. 292-308.

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Harry E. Langford - Research Fellow, Department of Geography, Environment and Development Studies, Birkbeck University of London

An alternative view of the Anglian (MIS 12) glaciation of southeastern England

The Anglian (MIS 12) diamictic facies of the North Norfolk coast can be separated into two phases (Happisburgh diamicton (HD) and Bacton Green diamicton (BGD)) that can be correlated with two phases of Anglian deposition in the Fen Basin, the two stages of degradation of the Weald–Artois anticline (WAA) to form the Dover Strait and southward migration of the eastward flux of Triassic-derived material from the English Midlands. The HD is a record of degradation of a Cretaceous Chalk headland by a southward advancing ice grounding line that emplaced folded Chalk bedrock and Chalk rafts of varying size into a subaqueous depositional environment, which was partially drained by the initial degradation of the WAA. The BGD is associated with the Weybourne diamicton (WD), Briton's Lane sand and gravel (BLSG) and the Blakeney esker (BE). The BGD was deposited subaqueously eastward of a southward subaerial ice advance along the Cretaceous Chalk escarpment. Following retreat of this ice, subaqueous conditions extended westward into the Fen Basin. Ice readvance southwards over subaqueous saturated sediments formed the WD. The BLSG and BE represent the final deposits of the Anglian glaciation of the North Norfolk coast, probably coincident with further degradation of the WAA. During the HD phase, ice impounded the pre-Anglian drainage network of the Fen Basin area at what is now The Wash, forming a lake upstream with a surface level up to at least 50 m OD, possibly 80 m. This lake was drained during initial degradation of the WAA. Subaerial deposition in the Fen Basin when The Wash was impounded during the second ice advance suggests that the system responsible for the influx of Triassic-derived material had migrated to the south of the Fen Basin area during the BGD phase, depositing the Ingham Formation in Suffolk and Letchworth Formation in Hertfordshire.

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Dr Anne Le Brocq – University of Exeter

Stephanie C. Mills, Plymouth University Kate Winter, Northumbria University Ekaterina Ardakova Clare Boston, University of Portsmouth John Hillier, Loughborough University Michael Smith David Sugden, University of Edinburgh John Woodward, Northumbria University

The Snow_blow model: Data/model comparison of snow drift in the Ellsworth Mountains, Antarctica.

Wind-driven snow redistribution can increase the spatial heterogeneity of snow accumulation on ice caps and ice sheets, and may prove crucial for the initiation and survival of glaciers in areas of marginal glaciation. We present an enhanced snowdrift model (Snow_Blow) based upon Purves (1999), which calculates spatial variations in relative snow accumulation that result from variations in topography, using a Digital Elevation Model (DEM) and wind direction as inputs. Improvements include snow redistribution using a flux routing algorithm and DEM resolution independence. Results will be presented from a data/model comparison on the Blue Ice Areas of the Ellsworth Mountains, Antarctica. Once validated, the model has the potential to determine whether redistribution of snow by wind is significant in explaining variations in estimated equilibrium line altitudes (ELAs) of glaciers and formerly glaciated areas of the UK, in both marginal and plateau icefield settings.

Purves, R.S., Mackaness, W.A. and Sugden, D.E. 1999. An approach to modelling the impact of snow drift on glaciation in the Cairngorm Mountains, Scotland. Journal of Quaternary Science, 14, 4 313-321

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Emma Lewington – The University of Sheffield

Stephen Livingstone (The University of Sheffield) Andrew Sole (The University of Sheffield)
Chris Clark (The University of Sheffield) Sarah Greenwood (Stockholm University)

Unravelling the character of meltwater drainage beneath ice sheets from the spatial distribution and morphology of subglacial meltwater corridors

While it is recognised that spatio-temporal variations in the subglacial drainage system can result in dynamic ice sheet behaviour, understanding the exact character and evolution of the subglacial hydrological system is hindered by the inaccessibility of the bed and difficulties in acquiring direct observations. Paleo-bedforms provide one solution to this, allowing the history of meltwater drainage to be reconstructed over centennial to millennial time-scales and spatially over 100s of km. The recent release of new high resolution digital elevation models (e.g. ArcticDEM) has facilitated the discovery and mapping of these features at an unprecedented level of detail and scale. This study focuses on subglacial meltwater corridors (SMCs), a feature characterised as elongated tracts of hummocky sediments often associated with eskers, glaciofluvial sediments and eroded bedrock. Existing work favours a subglacial meltwater origin for SMCs (e.g. St-Onge, 1984; Rampton et al., 2000; Utting et al., 2009); however, debate remains as to the source of the meltwater and the magnitude and duration of flow required to form these features. We use a large–scale mapping approach to gain insight into the spatial organisation, formation and evolution of palaeo - subglacial flow beneath large parts of the former Laurentide and Fennoscandian ice sheets. An automated way of identifying and mapping these features is developed using the high degree of roughness within SMCs which distinguishes them from the surrounding smooth, streamlined bed. The output is then used alongside traditional manual techniques and detailed morphological investigations to enhance understanding of subglacial hydrology and to contextualise limited observations of contemporary subglacial drainage.

Rampton, V.N. (2000). Large-scale effects of subglacial meltwater flow in the southern Slave Province, Northwest Territories, Canada. Canadian Journal of Earth Sciences. 37(1). 91-93. St-Onge, D.A. (1984). Surficial deposits of the Redrock Lake area, District of Mackenzie; Current Research Part A, Geological Survey of Canada. Paper 84 (1A). 271-78. Utting, D.J. Ward, B.C. & Little, E.C. (2009). Genesis of hummocks in glaciofluvial corridors near the Keewatin Ice Divide, Canada. Boreas. 38(3). 471-81.

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Dr Harold Lovell – University of Portsmouth

Clare Boston (University of Portsmouth) Stephen Livingstone (University of Sheffield)
Adam Booth (University of Leeds)

Investigating the sedimentary architecture and morphology of the Brampton kame belt using ground-penetrating radar (GPR) and high-resolution LiDAR data

Kames constitute a diverse range of glaciofluvial and glaciolacustrine landform-sediment assemblages that provide information on the style and pattern of deglaciation. The Brampton kame belt is one of the largest (>40 km2) glacio-depositional complexes in the UK and is located at the centre of the former British-Irish Ice Sheet. We present new mapping of the kame belt morphology using high-resolution LiDAR data. A large-scale survey of the kame belt subsurface sedimentary architecture was conducted using ground-penetrating radar (GPR). Using a 100 MHz Mala Geosciences 'Rough Terrain Antenna' system allowed us to test the application of GPR in investigating complex glaciofluvial landform-sediment assemblages and to provide insight into the formation of the kame belt. The full range of geomorphic features mapped from the LiDAR data were targeted, including ridges, flat-topped hills, channels and depressions. Where possible, GPR survey lines were collected both along and across features in order to provide an insight into their 3D architecture. At two locations survey lines were collected above man-made sediment exposures, which were logged in order to tie the radar data to the sedimentary facies. Initial analysis of the data demonstrates it is possible to identify large-scale sedimentary architecture, including bedding, changes in sediment type, and deformation structures (e.g. faulting and folding). It is also possible to tie radar facies to sediment facies exposed in section. Our analysis builds on existing models of kame formation by providing a better understanding of individual landform-sediment assemblages, transitions between them and spatial variations in the pattern, style and volume of kame sediments in the region.

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Solving the puzzle of an isolated high-Alpine drumlin: Hornkees, Austria

Larger streamlined landforms, in particular drumlins, are frequently found in lowland environments where they attest to fast ice flow; they are comparatively rare in upland environments where smaller streamlined landforms (i.e. flutes) and erosional landforms (e.g. ice-moulded bedrock) are much more prominent. We here report geomorphological and sedimentological field observations from a small drumlin formed during the last c. 200 years in the foreland of Hornkees, a small valley glacier in the Eastern Alps. This drumlin is located in the middle of the valley floor, upvalley of a bedrock obstacle, and consists of overridden and glaciotectonised outwash overlain by subglacial traction till of varying consistency. Using lithofacies analysis, clast fabric and clast shape data as well as structural measurements (e.g. of shear planes and fold axes) and in-situ soil penetrometer measurements we demonstrate that this drumlin is likely to represent one of the rare cases in upland environments where the primary mechanisms of fast flow and subglacial sediment deformation have been preserved and can thus be studied in detail. We present our dataset with the aim of generating discussion of these mechanisms and outline the significance of such rare cases as modern analogues not just for palaeo-studies, but also for our understanding of material properties from engineering-geological and modelling standpoints.

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Reading palaeohydrological archives over Quaternary time-scales: the Atacama Desert, Northern Chile

The large alluvial fans of the Central Depression in the hyper-arid Atacama Desert of Northern Chile provide unique opportunity to examine the geomorphology and sedimentology of flood flows generated from their Precordillera catchments over geological time-scales. The hyper-aridity preserves geomorphic features within the landscape over long time periods and in unusual detail. Catchment areas range from 100-2000km^2 in size with reliefs of up to 3km, whilst modern rainfall typically ranges from <1mm pa in the alluvial fan depositional areas to ~50 mm pa in the flood generating catchment areas. Evidence from packrat middens suggests that even the wettest periods of the Quaternary were no more than 2 times wetter, thus maintaining a likely arid – hyperarid climate for the deposits and landforms examined in this study.

We will examine field evidence from the older Pleistocene record of extensive debris flow events associated with relatively more humid periods and how these events can be subsequently modified on the fan surface by later processes to form concentrated boulder fields. We will then consider how we recognize these features and the data that can be extracted from them using a combination of geomorphic mapping using UAV, CRN geochronology, flow sedimentology and palaeohydrological modeling. We will also examine how this compares to the more arid phases of flood deposits which are dominated by extensive mud-flows which show remarkable affinity with features observed on other arid planetary bodies such as Mars, using a combination of sedimentology and drone video footage and observations from a recent active flow (January 2017) witnessed by the research team.

Keywords: palaeohydrology, alluvial fan, Atacama, climate change, mars

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Professor Anne Mather – University of Plymouth

Mather, AE and Facsimile Project Members (http://facsimile.maddyonline.co.uk)

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Prof Paul Brewer (Aberystwyth, UK), Dr Becky Briant (Birkbeck, UK), Dr Kim Cohen (Utrecht, NL)
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Model-Data comparison: The Late Pleistocene and Holocene evolution of the Rio Bergantes catchment, Spain

Quaternary fluvial archives contain a vast array of data which could be used to test increasingly sophisticated numerical landscape evolution models (LEMs). Similarly, LEMs offer new tools for the evaluation of field data and critically for the testing of often competing hypotheses. To improve our understanding of fluvial landscape development and explore synergies between field-based and modelling approaches an international research group FACSIMILE (Field and Computer Simulation in Landscape Evolution) was formed in 2014.

The first major project undertaken by the FACSIMILE group is a model-model, model-data comparison exercise using the fluvial archive of the Rio Bergantes, Spain. The Bergantes has a rich fluvial archive that has already been extensively reported within the literature. At present we have model simulations in development using a number of LEMS at varying timescales. These include CAESAR (for the last 3,000 years); CHILD (for the last 30,000 years); LAPSUS, Fluver-1D, PARALLEM (for the last 130,000 years) and Fastscape (for the last 1.2 million years). Initial results presented at our most recent meeting in Oct 2017 indicate reasonable correspondence between LEM outputs and known field conditions. However, new field data, improved model parameterisation and more robust climate proxy data are required to elucidate the complexities of modelling spatial and temporal landscape development.

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Dr Derek McDougall – University of Worcester

Virtual Glaciers and Glaciated Landscapes

‘Virtual Glaciers and Glaciated Landscapes’ is an interactive, virtual fieldwork resource that has the potential to support the teaching in schools and universities of glaciers, both past and present, and their associated geomorphological impacts. Anecdotal evidence suggests that, for some teachers and students, this topic area is perceived to be more challenging than, say, rivers and coasts. There are a number of likely reasons for this, not least being that glacial environments are remote and unfamiliar to most people. This virtual fieldwork resource addresses this by providing users with some (virtual) experience in contemporary glacial environments as well as in deglaciated settings. The trips, which can be viewed on mobile as well as desktop devices, allow the viewer to navigate through the landscape via pre-determined points, and look all around and zoom-in on features of interest. This is intrinsically a more interactive and engaging approach than simply presenting static images, and provides the basis for a range of learner activities and challenges.

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Victoria Naylor – University of Exeter

Dr Timothy Barrows Dr Stephen Palmer

Quantifying rocky coastline evolution in North Torbay, Devon using 36Cl exposure dating and Structure-from-Motion photogrammetry.

Around 75-80% of the world's coastlines can be categorised as 'rocky', and 60% of open coastlines in the UK alone can be categorised as rocky, interspersed with softer sedimentary coastlines. Rocky coastlines are often categorised by their lithology, geomorphology and very low rates of change (<1 mm yr-1). Rocky coastlines appear to have minimal vulnerability to the threat of rising sea levels and increased storminess, yet this is based on limited research, understanding and quantification of erosion and rocky coastline evolution, both globally and in the UK. North Torbay (Devon) is a good example of what is considered a resilient rocky coastline, within the UK. Areas of North Torbay, such as Hope's Nose, bear relict sea level features such as a raised beach and a distinctive shoreline platform. Dating of the raised beach is controversial and Davies in 1983 used amino-acid racemisation to place an age of 200 ka on its formation. We are reinvestigating the age of the platform and the rate of coastal erosion at this site using exposure dating. The cosmogenic nuclide 36Cl provides a means to directly date erosional landforms such as shore platforms and landslides. To better understand the morphology and evolution of the site we will use drone acquired aerial imagery for structure-from-motion photogrammetry. This research will explore how these techniques can be used to interpret coastal geomorphology in rocky coastlines settings and thus understand the mechanisms of coastal evolution over long timescales.

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Havananda Ombashi – University of Plymouth

Prof. Fyfe, R.M. - SOGEES, University of Plymouth Dr. Head, K. - SOGEES, University of Plymouth Dr. MacCleod, A. - Department of Geography and Environmental science, University of Reading, UK

A study on the relationship between identified land use changes and climate during the Bronze- and Iron Age on Great Buscombe and Spooners, Exmoor, UK

NPP and pollen identifications from peat samples from two sites on Exmoor have been carried out in order to gain new insights in how different types of land management influenced the moorland vegetation in the past. The newly retrieved data has been carried out in order to consider the relative importance of grazing, burning and small-scale arable activities on the moorland vegetation of Spooners and Great Buscombe, Exmoor, UK. Furthermore, peat humification analysis from material of a third site on Exmoor (The Chains) has been carried out in order to gain insights into the relative role of land use changes and climate on Exmoor. The study focuses on the time periods ranging from the late Neolithic to the late Iron Age and shows the significance of using palaeoecological proxies that represent different geographical scales. This time period is known for significant changes in the landscape, but the relative roles of different factors that can shape the landscape are yet to be better understood.

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Digital technology restores stolen fossils at Joint Mitnor Cave, Devon

Joint Mintor Cave is a SSSI and the type site for the Joint Mitnor Cave Mammal Assemblage Zone. Excavations of the 120,000 year old site revealed an exceptionally rich interglacial fauna, including an unusual mix of African game and temperate woodland animals. An unexcavated section of these deposits, including the remains of straight-tusked elephant, brown bear and spotted hyaena, has been maintained since 1962 by the William Pengelly Cave Studies Trust as an educational resource. Vandalism of the site in 2015 resulted in the theft of surface specimens and damage to the section. This sparked a collaborative effort to restore the site.

Specimens, similar to those stolen, were identified from the Natural History Museum (London) collections using photographs of the site before vandalism. The specimens were CT scanned to produce high resolution digital replicas, and used subsequently to develop detailed 3D prints to replace the stolen specimens. These objects were also integrated into Virtual Reality Cave database.

This highly successful collaborative project, using expertise from different specialists and institutions, opens up new avenues for using 3D data from museums' collections. It also highlights some of the current issues with security and conservation of heritage sites such as Joint Mitnor Cave.

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Modelled transfluences and crosswise divides of the Last Glacial Maximum alpine ice flow

During the Last Glacial Maximum (LGM), Alpine glaciers extending far onto the foreland coalesced to form a continuous ice expanse 750 km across. Ice flow was largely governed by subglacial topography, yet perched glacial deposits and high-altitude erosion marks show that Alpine glaciers occasionally flowed across major topographic features. This explains why the Alpine ice complex has alternatively been referred to as an ice cap (surface topography-controlled flow), an ice field (basal topography-controlled flow) and a network of valley glaciers. Here, we use the Parallel Ice Sheet Model (PISM) to model the entire last glacial cycle (120–0 ka) in the Alps, and analyse ice flow patterns during the LGM. The modelled fast-flow regions generally occur along the main river valleys, while ice domes and ice divides are predominantly located over major reliefs. Nevertheless, the model results depict ice flow across mountain passes (transfluences) in 55 locations, ice divide above topographic lows (hereafter referred to as crosswise divides) in 27 locations (preliminary numbers), and self-sustained ice domes characteristic of ice caps in two locations over Flüelapass and Ötztal. In the Eastern Alps, modelled transfluences and crosswise divides are generally incompatible with geological reconstructions, indicating that climate deterioration was overestimated in the model input. In the Western Alps, however, transfluences generally occur where they have been documented by geologic evidence. Interestingly, crosswise divides are often found over valley bottlenecks where glacial erosion has apparently been less efficient. These model results depict the LGM Alpine ice complex as an intermediate between ice fields and ice caps, bearing characteristics of both and perhaps no modern analogue.

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Dr Abi Stone - Geography Department, University of Manchester

Hydrostratigraphies in desert dunes to reconstruct past rainfall: assessing the suitability of Kalahari dunes.

Past rainfall reconstructions in dryland regions underpin our understanding of the relationship between climatic forcing and palaeohydrological response. The unsaturated zone (USZ) offers a novel and straightforward archive for palaeorainfall, coined ‘hydrostratigraphies’ in dryland environments where proxies for palaeorainfall are notoriously scarce (Stone and Edmunds, 2016). This poster presentation presents a substantial dataset of chloride tracer profiles in the sand dunes of the southwest Kalahari above the Stampriet Basin, collected in 2011, 2013 and 2016, in order to assess their potential as a proxy for rainfall in this region. The sedimentology (sand-rich sediments, which are not too well sorted and contain some silts) and semi-arid nature of the environment at present, and throughout much of the Quaternary makes these dunes a sensible target for applying attempting to produce hydrostratigraphies. However, the data suggest this region is not a suitable place to apply the hydrostratigraphy technique at the temporal resolution of decades. This poster explores the reasons for this, from chloride inputs to the nature of the mixing zone within the USZ.

Stone, A., Edmunds, W. M. (2016) Unsaturated zone hydrostratigraphies: A novel archive of past climates in dryland continental regions. Earth-Science Reviews 157, 121–144.

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Margarita Tsakiridou – University of Portsmouth

Mark Hardiman - University of Portsmouth Laura Cunningham - University of Portsmouth
David Martill - University of Portsmouth Paul C. Lincoln - University of Portsmouth

Wildfire in the British Isles during the Last Glacial-Interglacial Transition: A review of sedimentary charcoal records.

Sedimentary charcoal is the most commonly employed proxy in the study of past wildfire activity. Charcoal records over large spatiotemporal scales show that wildfire expression is often determined by an interplay between climatic, vegetation and anthropogenic drivers (Power et al., 2008). In the British Isles there has been fairly limited research focus on charcoal during the Last Glacial-Interglacial Transition (LGIT, 16-8 ka cal. BP) despite the fact that the region offers an ideal opportunity to study potential climatic controls as the climate moved from full glacial to interglacial conditions. Nevertheless, the existence of charcoal in late-glacial and post-glacial sediments has been noted in conjunction with palynological, archaeological and stratigraphic studies. Here we present the first data synthesis of published charcoal records that span the LGIT in the British Isles. Due to the variety of the methods employed for the extraction and quantification of charcoal fragments, and the diverse range of sedimentary contexts represented, no quantitative analysis is undertaken. Only the presence or absence of charcoal is recorded for each published record. The construction of time-slices maps that encapsulate the major climatic events of the LGIT shows the ubiquity of charcoal within the available records, especially in the early Holocene, but also highlights the low numbers of available macroscopic charcoal records, especially for the late-glacial. A common pattern during GS-2 and a synchronous charcoal peak centred c. 9.5 ka cal. BP in records from all over the British Isles are also noted. Future research should involve robust local wildfire history reconstructions, through contiguous sub-sampling of sedimentary sequences for macroscopic (>125μm) charcoal and the employment of statistical decomposition methods widely employed in wildfire research more globally (Higuera et al., 2009) in order to thoroughly investigate links between wildfire expression and the abrupt climatic shifts of the LGIT in the British Isles.

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